MXO 4 Series Oscilloscope User Manual

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1335533702
Version 15

ROHDE&SCHWARZ
Make ideas real

This manual describes the following MXO 4 series models with firmware version 2.7.x.x:
- MXO 4 (1335.5050K04)

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1335.5337.02 | Version 15 | MXO 4 Series

Throughout this manual, products from Rohde & Schwarz are indicated without the ® symbol.

Contents

1 Safety and regulatory information

The product documentation helps you to use the product safely and efficiently.

Where do I find safety information?

Safety information is part of the product documentation. It warns you of potential dangers and gives instructions on how to prevent personal injury or damage caused by dangerous situations. Safety information is provided as follows:

- In Section 1.1, "Safety instructions", on page 21. The same information is provided in many languages in printed format. The printed "Safety Instructions" for "Oscilloscopes and Accessories" are delivered with the instrument and the probes.
- Throughout the documentation, safety instructions are provided when you need to take care during setup or operation.

Intended use

The MXO 4 product is designed for measurements on circuits that are only indirectly connected to the mains or not connected at all. It is not rated for any measurement category.

The product is intended for the development, production and verification of electronic components and devices in industrial, administrative, and laboratory environments. Use the product only for its designated purpose. Observe the operating conditions and performance limits stated in the specifications document.

Target audience

The target audience of this document includes developers and technicians, administrators and maintenance personnel using oscilloscopes and probes. The required skills and experience of the users depend on the test setup and application of the product.

1.1 Safety instructions

Products from the Rohde & Schwarz group of companies are manufactured according to the highest technical standards. To use the products safely, follow the instructions provided here and in the product documentation. Keep the product documentation nearby and offer it to other users.

Use the product only for its intended use and within its performance limits. Intended use and limits are described in the product documentation such as the specifications document, manuals and the printed "Safety Instructions" document. If you are unsure about the appropriate use, contact Rohde & Schwarz customer support.

Using the product requires skilled persons or specially trained personnel. These users also need sound knowledge of at least one of the languages in which the user interfaces and the product documentation are available.

Reconfigure or adjust the product only as described in the product documentation or the specifications document. Any other modifications can affect safety and are not permitted.

Never open the casing of the product. Only service personnel authorized by Rohde & Schwarz are allowed to repair the product. If any part of the product is damaged or broken, stop using the product. Contact Rohde & Schwarz customer support at https://www.rohde-schwarz.com/support.

In these safety instructions, the term "product" covers instruments (oscilloscopes), probes and their accessories.

Lifting and carrying the instrument

Check the specifications document for the maximum weight of the instrument. A single person can only carry a maximum of 18 kg safely depending on age, gender and physical condition. If your instrument is heavier than 18 kg, do not move or carry it by yourself.

Use the instrument handles to move or carry the instrument. Do not use the mounted accessories instead of the handles. Accessories are not designed to carry the weight of the instrument.

To move the instrument safely, you can use lifting or transporting equipment such as lift trucks and forklifts. Follow the instructions provided by the equipment manufacturer.

Choosing the operating site

Only use the product indoors. The product casing is not waterproof. Water that enters can electrically connect the casing with live parts, which can lead to electric shock, serious personal injury or death if you touch the casing.

If Rohde & Schwarz provides accessories designed for outdoor use of your product, e.g. a protective cover, you can use the product outdoors.

You can operate the product up to an altitude of 2000 m above sea level. If a higher altitude is permissible, the value is provided in the specifications document. The product is suitable for pollution degree 2 environments where nonconductive contamination can occur. For more information on environmental conditions such as ambient temperature and humidity, see the specifications document.

Setting up the product

Always place the product on a stable, flat and level surface with the bottom of the product facing down. If the product is designed for different positions, secure the product so that it cannot fall over.

If the product has foldable feet, always fold the feet completely in or out to ensure stability. The feet can collapse if they are not folded out completely or if the product is moved without lifting it. The foldable feet are designed to carry the weight of the product, but not an extra load.

If stacking is possible, keep in mind that a stack of products can fall over and cause injury.

If you mount products in a rack, ensure that the rack has sufficient load capacity and stability. Observe the specifications of the rack manufacturer. Always install the products from the bottom shelf to the top shelf so that the rack stands securely. Secure the product so that it cannot fall off the rack.

Connecting the product

Before connecting the interfaces or measuring inputs of the product to other products or electrical circuits, make sure that the other products or electrical circuits provide special protection against electric shock. This protection principle is referred to as SELV (safety extra-low voltage) and is based on a low voltage level and increased insulation. Exceptions are indicated by a measurement category on the product and given in the specifications document.

Connecting to power and grounding

The mains power supply input of the instrument complies with overvoltage category II. Connect the product to a fixed installation used to supply energy-consuming equipment such as household appliances and similar loads. Keep in mind that electrically powered products have risks, such as electric shock, fire, personal injury or even death.

Take the following measures for your safety:

- Do not use an isolating transformer to connect the instrument to the mains power supply.
- Before switching on the product, ensure that the voltage and frequency indicated on the product match the available power source. If the power adapter does not adjust automatically, set the correct value and check the rating of the fuse.
- If a product has an exchangeable fuse, its type and characteristics are indicated next to the fuse holder. Before changing the fuse, switch off the product and disconnect it from the power source. How to change the fuse is described in the product documentation.
- Only use the power cable delivered with the product. It complies with country-specific safety requirements. Only insert the plug into an outlet with protective conductor terminal.
- Only use intact cables and route them carefully so that they cannot be damaged. Check the power cables regularly to ensure that they are undamaged. Also ensure that nobody can trip over loose cables.
- If you connect the product to an external power supply, use the one delivered with the product or recommended in the product documentation. The external power supply must conform to the country-specific regulations.
- Ensure that you can disconnect the product from the power source at any time. Pull the power plug to disconnect the product. The power plug must be easily accessible. If the product is integrated into a system that does not meet these requirements, provide an easily accessible circuit breaker at the system level.
- Replace parts that are relevant to safety only by original parts, e.g. power cables or fuses.

Performing measurements

Take the following measures for your safety:

- To ascertain a voltage-free state, use an appropriate voltage tester. Any measurement setup including an oscilloscope is not suitable for this purpose.
- The maximum input voltage on channel inputs and the external trigger input must not exceed the value specified in the specifications document.
- Observe all voltage and current ratings of the instrument, the probes, and the accessories. Exceeding the allowed voltages can lead to an electric shock.
  Limits and ratings are marked on the products and listed in the specifications documents.
  Consider that the rated voltage depends on the frequency. The voltage limitation curves or values are provided in the specifications document.
- Never cause any short circuits when measuring sources with high output currents.
- Use only probes and accessories that comply with the measurement category (CAT) of your measurement task. If the product is rated for any measurement category, the permitted category is indicated on the product and in the specifications document. If you use other than Rohde & Schwarz accessories, make sure that they are suitable for the instrument and the measurement task.
- Set the correct attenuation factor on the instrument according to the probe being used. Otherwise, the measurement results do not reflect the actual voltage level, and you might misjudge the actual risk.
- When working with high voltages and current probes, observe the additional operating conditions specified in these safety instructions.
- The probe pins are extremely pointed and can easily penetrate clothes and the skin. Handle the probe pins with great care. To exchange a probe pin, use tweezers or pliers to avoid injuries. When transporting the accessories, always use the box supplied with the probe.
- Prevent the probe from receiving mechanical shock. Avoid putting excessive strain on the probe cable or exposing it to sharp bends. Touching a broken cable during measurements can cause injuries.
- Set up all probe connections to the instrument before applying power.

Working with hazardous voltages

Voltages higher than 30 V RMS, or 42 V peak, or 60 V DC are regarded as hazardous contact voltages. Direct contact with them can cause serious injuries.

Make sure that only electrically skilled persons use the products for measurements on hazardous contact voltages. These working conditions require special education and experience to perceive risks and to avoid hazards which electricity can create.

When working with hazardous contact voltages, use protective measures to preclude direct contact with the measurement setup:

- Do not touch exposed connections and components when power is applied.
- Switch off the test circuit while connecting and disconnecting probe leads.
- Use only insulated voltage probes, test leads and adapters.
- Make sure that the input leads fulfill the safety requirements for your measurement.

The delivered input leads might have a jacket wear indicator that indicates a worn jacket by different jacket color. In this case, do not use the input lead. Replace it with a new one.

- When connecting to the DUT, keep your fingers behind finger guard. Remove jewelry, watches, and other metallic objects. Only use 4 mm safety banana plugs.

Using optical isolated probe systems

Optical isolated probes are classified as class 1 laser product. Class 1 lasers are safe under all conditions of normal use. The product fully contains the beam of a higher-class laser. Take the following measures for your safety:

- To avoid exposure to the laser beam, never remove any covers from the probe head or probe receiver, and never disassemble the product.
- Check the product before using to ensure that it is undamaged. If you have dropped the product or exposed it to excessive mechanical stress, always check the product. Do not use the product if any component is damaged.
- Send the product to service regularly.

Optical isolated probes measure differential voltages. The test circuit can have a different potential. The common mode voltage between the potentials of the DUT and the oscilloscope can be much higher than the differential voltage and is not measured by the probe. To avoid the risk of electrical shock, use protective measures:

- Always de-energize the test circuit before installing or removing the tip module.
- Never exceed the differential voltage rating.
- When measuring on a test circuit with high common mode voltage, use a tripod to hold the probe head.
- Keep the probe head and the tip cable away from circuits with different potential to prevent arc flash caused by a different potential.

Working with current probes

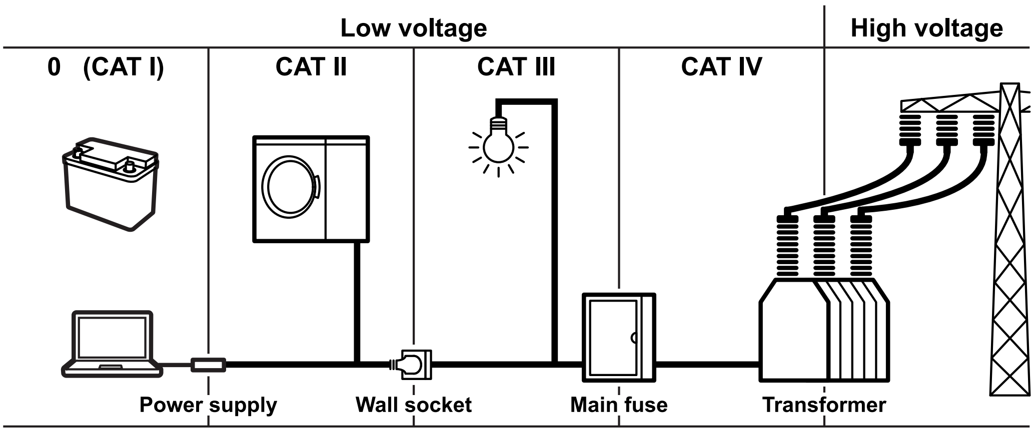
When working with current probes, you can measure high-frequency currents or currents that contain high-frequency components.

- Switch off the test circuit while connecting the probe.
- Do not attach the clamp to bare unisolated conductors. To avoid injury from a short circuit, measure at a location on an insulated wire where the insulation is sufficient for the circuit voltage.
- Connect the probe only to the secondary side of a breaker. With this measure, you can avoid injury if a short circuit occurs.
- The following effects can cause burns and fire or damage to the measurement site:
  - Eddy current loss can cause heating of the sensor head.
  - Dielectric heating can cause heating of cord insulation and other materials.
- When measuring current that includes a high-frequency component, consider the derating characteristics of the probe. Do not measure any current that exceeds the rated current.
- Using the probes with high frequencies or strong magnetic fields may cause the device to become abnormally hot, resulting in fire, equipment damage, or burns.

Measurement categories

IEC 61010-2-030 defines measurement categories that rate instruments on their ability to resist short transient overvoltages that occur in addition to the working voltage. Use the measurement setup only in electrical environments for which they are rated.

- 0 - Instruments without rated measurement category
  For measurements performed on circuits not directly connected to mains, for example, electronics, circuits powered by batteries, and specially protected secondary circuits. This measurement category is also known as CAT I.
- CAT II:
  For measurements performed on circuits directly connected to the low-voltage installation by a standard socket outlet, for example, household appliances and portable tools.
- CAT III:
  For measurements performed in the building installation, such as junction boxes, circuit breakers, distribution boards, and equipment with permanent connection to the fixed installation.
- CAT IV:
  For measurements performed at the source of the low-voltage installation, such as electricity meters and primary overcurrent protection devices.



Cleaning the product

Use a dry, lint-free cloth to clean the product. When cleaning, keep in mind that the casing is not waterproof. Do not use liquid cleaning agents.

Meaning of safety labels

Safety labels on the product and its accessories warn against potential hazards.

	Potential hazard Read the product documentation to avoid personal injury or product damage.

	Electrical hazard Indicates live parts. Risk of electric shock, fire, personal injury or even death.

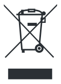
	Protective conductor terminal Connect this terminal to a grounded external conductor or to protective ground. This connection protects you against electric shock if an electric problem occurs.

1.2 Labels on the product

Labels on the casing inform about:

- Personal safety, see "Meaning of safety labels" on page 26
- Product and environment safety, see Table 1-1
- Identification of the product

Table 1-1: Labels regarding product and environment safety

	Chassis grounding terminal
	Take care when handling electrostatic sensitive devices.
	Labeling in line with EN 50419 for disposal of electrical and electronic equipment after the product has come to the end of its life. For more information, see "Disposing of electrical and electronic equipment" on page 1639.

1.3 Warning messages in the documentation

A warning message points out a risk or danger that you need to be aware of. The signal word indicates the severity of the safety hazard and how likely it will occur if you do not follow the safety precautions.

WARNING

Potentially hazardous situation. Could result in death or serious injury if not avoided.

CAUTION

Potentially hazardous situation. Could result in minor or moderate injury if not avoided.

NOTICE

Potential risks of damage. Could result in damage to the supported product or to other property.

1.4 CE declaration of conformity

The CE declaration of conformity of the instrument is delivered with the product. Keep the document for further reference.

The current version of this CE declaration of conformity is available at:

www.rohde-schwarz.com/company-documents/mxo4/

1.5 Where to find key documents on Rohde & Schwarz

Certificates issued to Rohde & Schwarz that are relevant for your country are provided at www.rohde-schwarz.com/key-documents, e.g. concerning:

- Quality management
- Environmental management
- Information security management
- Accreditations

1.6 Korea certification class A

이 기기는 업무용(A급) 전자파 적합기기로서 판매자 또는 사용자는 이 점을 주의하시기 바라며, 가정외의 지역에서 사용하는 것을 목적으로 합니다.

2 Preface

2.1 Key features

The MXO 4 series oscilloscope is the first of a new generation of oscilloscopes with next generation technology.

Using the MXO 4, you can:

- Acquire, process and display signals with unrivaled speed.
- Detect signal details, faults and anomalies instantly.
- Increase your statistical confidence.

The MXO 4 series oscilloscopes utilize advanced technologies:

- Fastest update rate of up to 4.5 million waveforms/s thanks to MXO-EP ASIC
- 12 bit ADC at all sample rates, and 18 bit vertical resolution in HD mode
- Deep standard memory: 400 Mpoints per channel
- High-precision digital trigger with best-in-class trigger jitter, also available in HD mode
- Nearly zero blind time: up to 99% real-time signal activity capture
- Lowest measurement noise
- Eco-friendly design: low power consumption, automatic power-up capability, scarcely audible

Features and applications help achieve fast and accurate results, for example:

- Segmented memory & history mode to analyze previous acquisitions
- Superior spectrum analysis with 45 000 FFT/s, which allows capture of spurious spectrum events
- Integrated arbitrary waveform generator
- Logic analysis with 16 digital channels
- Dual-path serial protocol analysis
- Frequency response analysis (Bode plots)
- Large high-resolution touchscreen, R&S SmartGrid, configurable toolbar, intuitive navigation
- Wide selection of compatible probes

2.2 Documentation overview

This section provides an overview of the MXO 4 user documentation.

2.2.1 Manuals and instrument help

You find the manuals on the product page at:

www.rohde-schwarz.com/manual/mxo4

Getting started manual

Introduces the MXO 4 and describes how to set up the product. A printed English version is included in the delivery.

User manual and help

Contains the description of all instrument modes and functions. It also provides an introduction to remote control, a complete description of the remote control commands with programming examples, and information on maintenance and instrument interfaces. Includes the contents of the getting started manual.

The contents of the user manual are available as help in the MXO 4. The help offers quick, context-sensitive access to the complete information on the instrument and its firmware.

The user manual is available for download or immediate display on the internet.

Safety instructions

Provides safety information in many languages. The printed document is delivered with the product.

Instrument security procedures manual

Deals with security issues when working with the MXO 4 in secure areas. It is available for download on the internet.

Service manual

Describes the performance test for checking compliance with rated specifications, firmware update, adjustments, installing options and maintenance. The service manual is available for registered users on the global Rohde & Schwarz information system (GLORIS, https://gloris.rohde-schwarz.com).

2.2.2 Specifications and product brochure

The specifications document, also known as the data sheet, contains the technical specifications of the MXO 4. It also lists the firmware applications and their order numbers, and optional accessories. The product brochure provides an overview of the instrument and deals with the specific characteristics.

www.rohde-schwarz.com/brochure-datasheet/mxo4

2.2.3 Calibration certificate

The document is available on https://gloris.rohde-schwarz.com/calcert. You need the device ID of your instrument, which you can find on a label on the rear panel.

2.2.4 Release notes, open source acknowledgment

The release notes list new features, improvements and known issues of the current firmware version, and describe the firmware installation. The open source acknowledgment document provides verbatim license texts of the used open source software. It can also be read directly on the instrument.

www.rohde-schwarz.com/firmware/mxo4

2.2.5 Application notes, application cards, videos

Various documents and videos deal with special applications or background information on particular topics.

R&S®MXO 4 - Mediacenter

Find various videos on Rohde & Schwarz products and test and measurement topics on YouTube: https://www.youtube.com/@Rohde-Schwarz

2.3 Options described in this document

In addition to the base unit, the following options are described in this documentation:

Type	Designation	Order No.
R&S MXO4-B1	MSO	1335.4130.02
R&S MXO4-B6	Waveform and pattern generator	1335.4147.02
R&S MXO4-K12	Basic jitter analysis	1335.6091.02
R&S MXO4-K31	Power analysis	1335.5566.02
R&S MXO4-K36	Frequency response analysis	1335.5572.02
R&S MXO4-K500	Bus analysis	1335.5243.02
R&S MXO4-K510	Triggering and decoding low speed serial buses: I2C, SPI, UART/RS-232/RS-422/RS-485, QUAD-SPI, NRZ clocked, NRZ unclocked, Manchester	1335.5195.02
R&S MXO4-K520	Triggering and decoding automotive protocols: CAN, CAN FD, CAN XL, LIN, SENT	1335.5550.02
R&S MXO4-K530	Decoding aerospace protocols: ARINC 429, MIL-STD-1553, SpaceWire	1335.5208.02

Type	Designation	Order No.
R&S MXO4-K550	Decoding MIPI low speed protocols: SPMI, RFFE, I3C	1335.5214.02
R&S MXO4-K560	Decoding automotive Ethernet: 10BASE-T1S	1335.5943.02

3 Getting Started

3.1 Preparing for use

Here, you can find basic information about setting up the instrument for the first time or when changing the operating site.

3.1.1 Lifting and carrying

See: "Lifting and carrying the instrument" on page 22.

3.1.2 Unpacking and checking

1. Unpack the product carefully.
2. Retain the original packing material. Use it when transporting or shipping the product later.
3. Using the delivery notes, check the equipment for completeness.
4. Check the equipment for damage.

   If the delivery is incomplete or equipment is damaged, contact Rohde & Schwarz.

3.1.3 Choosing the operating site

Specific operating conditions ensure proper operation and avoid damage to the product and connected devices. For information on environmental conditions such as ambient temperature and humidity, see the specifications document.

For safety information, see "Choosing the operating site" on page 22.

Electromagnetic compatibility classes

The electromagnetic compatibility (EMC) class indicates where you can operate the product. The EMC class of the product is given in the specifications document.

- Class B equipment is suitable for use in:
  - Residential environments
  - Environments that are directly connected to a low-voltage supply network that supplies residential buildings
- Class A equipment is intended for use in industrial environments. It can cause radio disturbances in residential environments due to possible conducted and radiated disturbances. It is therefore not suitable for class B environments.

If class A equipment causes radio disturbances, take appropriate measures to eliminate them.

3.1.4 Setting up the product

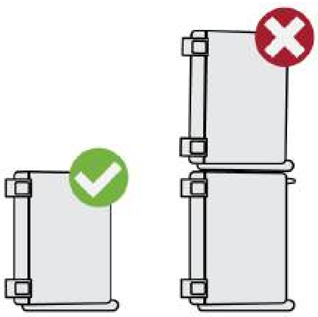
When setting up the instrument, follow the safety instructions:

- "Setting up the product" on page 22
- "Intended use" on page 21

3.1.4.1 Placing the product on a bench top

For standalone operation, place the instrument on a horizontal bench with even, flat surface. The instrument can be used in horizontal position, standing on its feet, or with the support feet on the bottom extended.

To place the product on a bench top

1. Place the product on a stable, flat and level surface.
2. **CAUTION!** The top surface of the product is too small for stacking. If you stack another product on top of the product, the stack can fall over and cause injury.
   If you want to save space, mount several products in a rack.
   
3. **CAUTION!** Foldable feet can collapse. For safety information, see "Setting up the product" on page 22.
   Always fold the feet completely in or out. With folded-out feet, do not place anything on top or underneath.
4. **NOTICE!** Overheating can damage the product.
   Prevent overheating as follows:
   - Keep a minimum distance of 10 cm between the fan openings of the product and any object in the vicinity to provide sufficient airflow and ventilation.
   - Do not place the product next to heat-generating equipment such as radiators or other products.

3.1.4.2 Mounting the product on a monitor arm

You can mount the oscilloscope to a monitor arm with VESA mount.

► **NOTICE!** Only use a VESA mount compatible with standard 100 mm × 100 mm pattern.

Mount the VESA mount of the monitor arm to the VESA mounting holes on the rear panel of the oscilloscope.

3.1.4.3 Mounting the product in a rack

To prepare the rack

1. Observe the requirements and instructions in "Setting up the product" on page 22.
2. **NOTICE!** Insufficient airflow can cause overheating and damage the product.

   Design and implement an efficient ventilation concept for the rack.

To mount the oscilloscope in a rack

1. Use a rackmount kit to prepare the instrument for rack mounting.
   a) Order the rackmount kit designed for your oscilloscope. For the order number, see specifications document.
   b) Mount the rackmount kit. Follow the assembly instructions provided with the rackmount kit.
2. Lift the product to shelf height. If the rack is high, use a safe climbing aid when placing on upper shelves.
3. Grip the product by the handles. Slide the product onto the shelf until the rack brackets fit closely to the rack.
4. Tighten all screws at the rack brackets with a tightening torque of 1.2 Nm to secure the product at the rack.

To unmount the product from a rack

1. Loosen the screws at the rack brackets.
2. Remove the product from the rack.
3. If placing the product on a bench top again, unmount the rackmount kit from the product. Follow the instructions provided with the rackmount kit.

3.1.5 Considerations for test setup

Observe safety instructions, see "Performing measurements" on page 24.

Cable selection and electromagnetic interference (EMI)

Electromagnetic interference (EMI) can affect the measurement results.

To suppress electromagnetic radiation during operation:

- Use high-quality shielded cables, for example, double-shielded RF and LAN cables.
- Always terminate open cable ends.
- Ensure that connected external devices comply with EMC regulations.

Measuring accessories

Use only probes and measuring accessories that comply with IEC 61010-031.

Signal input and output levels

Information on signal levels is provided in the specifications document. Keep the signal levels within the specified ranges to avoid damage to the product and connected devices.

Preventing electrostatic discharge (ESD)

Electrostatic discharge is most likely to occur when you connect or disconnect a DUT.

► **NOTICE!** Electrostatic discharge can damage the electronic components of the product and the device under test (DUT).

Ground yourself to prevent electrostatic discharge damage:

a) Use a wrist strap and cord to connect yourself to ground.
b) Use a conductive floor mat and heel strap combination.

During operation, if the firmware observes a serious unexpected disturbance (e.g. due to ESD), it resets some hardware components and initiates a new alignment to ensure proper instrument functioning. Then it restores the user settings to the state before the disturbance.

3.1.6 Connecting to power

For safety information, see "Connecting to power and grounding" on page 23.

The MXO 4 can be used with different AC power voltages and adapts itself automatically to it.

The nominal ranges are indicated on a label near the power connector on the instrument and in the specifications document.

1. Plug the AC power cable into the AC power connector on the rear panel of the product. Only use the AC power cable that is delivered with the product.
2. Plug the AC power cable into a power outlet with ground contact.

3.1.7 Connecting to LAN

For remote operation of the instrument using a computer, you need a local area network (LAN) connection.

Network environment

Before connecting the product to a LAN, consider the following:

- Install the latest firmware to reduce security risks.
- For internet or remote access, use secured connections if applicable.
- Ensure that the network settings comply with the security policies of your company. Contact your local system administrator or IT department before connecting your product to your company LAN.
- When connected to the LAN, the product may potentially be accessed from the internet, which may be a security risk. For example, attackers might misuse or damage the product.

To connect a LAN cable

► Connect an RJ-45 cable to the LAN connector on the rear panel, and to the LAN.

For supported LAN interfaces, refer to the specifications document.

By default, the MXO 4 is configured to use DHCP. Configuration of a static IP address is not required.

3.1.8 Connecting external devices

3.1.8.1 Connecting USB devices

You can use USB connectors to connect various devices:

- Connect a keyboard and a mouse for operation and data entry, alternatively or in addition to the touchscreen functionality.
- Connect USB flash drives to save screenshots, and to transfer files to and from the instrument without a network connection.

► Connect the USB device to any of the USB connectors.

You can connect or disconnect USB devices during operation of the instrument.

3.1.8.2 Connecting external monitors

Using the HDMI connector on the rear panel, you can connect an external monitor or projector to the oscilloscope.

1. **NOTICE!** Missing ground contact can damage the oscilloscope.

Ensure that the monitor and the oscilloscope are connected to a ground contact.
See also: Section 3.1.6, "Connecting to power", on page 36.

2. **NOTICE!** Use only standard-compliant monitor cables.

   Connect the monitor or projector to a display connector.

   The oscilloscope recognizes the external monitor. During the running session, you can disconnect the monitor and connect it again.

If the monitor provides touch functionality, an additional connection can be required, e.g. a USB connection. Refer to the documentation of your monitor.

The oscilloscope outputs a Full HD image with 1920x1080 pixel. The instrument's display is duplicated. If the screen resolution of the monitor is set higher than the instrument's resolution, the application window uses a 1920x1080 area of the monitor display. For full-screen display, adjust the monitor's screen resolution.

3.1.9 Switching on or off

The instrument is switched on or off with the power switch and the [Power] key. The [Power] key is located in the bottom left corner of the front panel. The power switch is located at the rear panel of the instrument.

Table 3-1: Overview of power states

Status	LED	Power switch
Off	● (unlighted)	[0] (off)
Standby	● yellow	[I] (on)
Ready	● green	[I] (on)

To switch on the product

The product is off but connected to power.

1. Set the switch on the power supply to position [I].

   The power key on the front panel lights up.

2. Press the [Power] key on the front panel.

   The instrument performs a system check, boots the operating system, and then starts the MXO 4 firmware.
   The [Power] key turns green and the illuminated keys on the front panel light up. If the previous session was terminated regularly, the oscilloscope uses the last settings.

Before you start measurements, be sure to comply with the warm-up phase specified in the specifications document.

To shut down the product

The product is in the ready state.

► Press the [Power] key.

All current settings are saved, and the software shuts down. The [Power] key turns yellow. The standby power supplies only the power switch circuits.

The "Power" icon in the "Menu" shuts down only the firmware application. To shut down the instrument completely, use the [Power] key.

Remote command for firmware shutdown: `SYSTem:EXIT` on page 818.

To disconnect from power

The product is in the standby state.

1. **NOTICE!** Risk of data loss. If you disconnect the product from power when it is in the ready state, you can lose settings and data. Shut it down first.

   Set the switch on the power supply to position [0].

   The LED of the [Power] key is switched off.

2. Disconnect the product from the power source.

3.2 Instrument tour

This section describes the front, rear and side view of the instrument including all function keys and connectors.

3.2.1 Front view

This section provides an overview of the MXO 4 front panel.

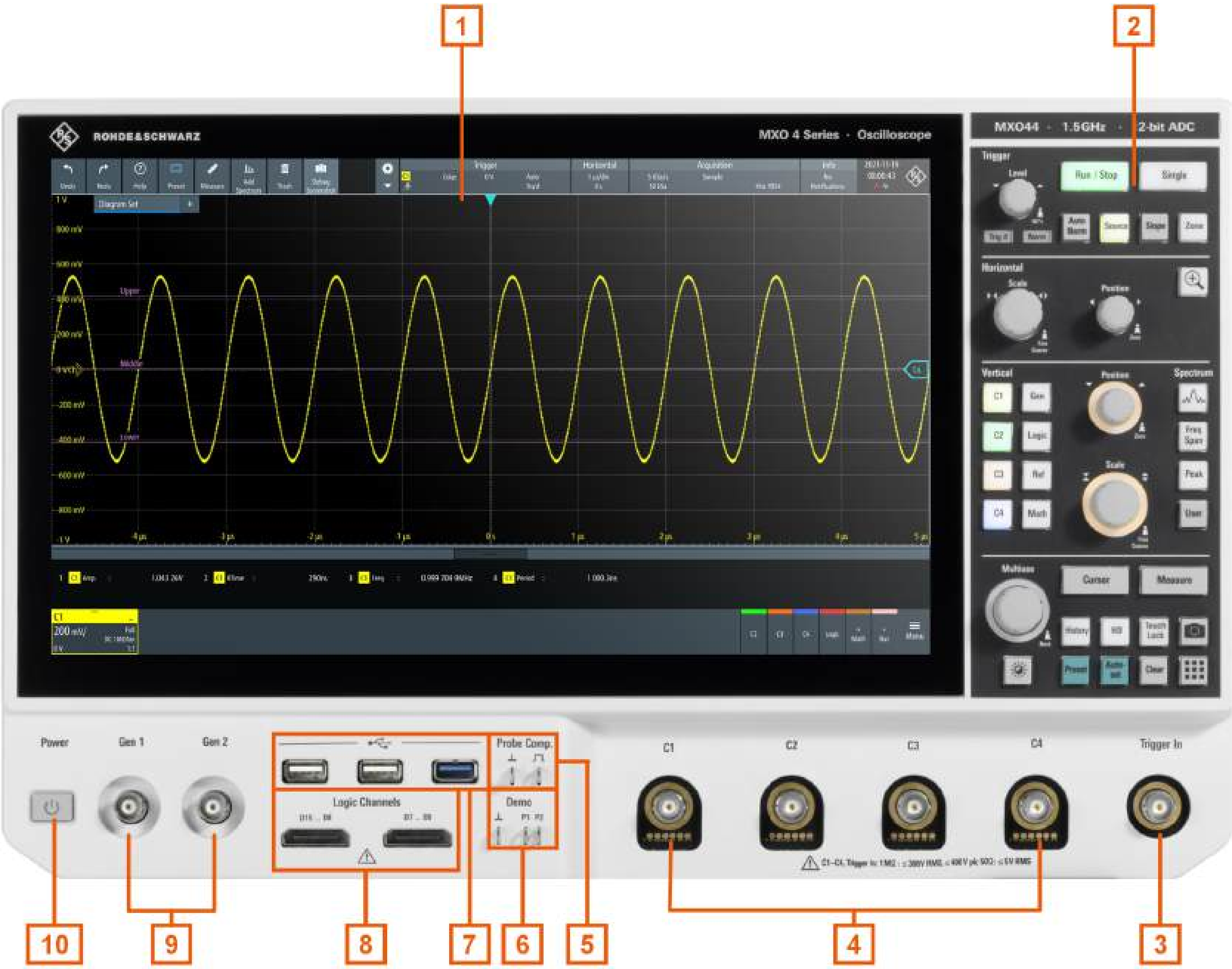


Figure 3-1: Front panel of MXO 4

1 = Display
2 = Keys and controls
3 = BNC connector for external trigger input
4 = Analog input channels
5 = Connectors for probe compensation
6 = Connectors for demo signal output
7 = USB connectors
8 = Connectors for logic probe (R&S MXO4-B1 Mixed Signal Option)
9 = BNC connector for optional function generator output (R&S MXO4-B6 arbitrary waveform generator option)
10 = [Power] key

3.2.1.1 Input connectors

Analog channel inputs

The MXO 4 has 4 channel inputs to connect the input signals.

You can connect probes with Rohde & Schwarz probe interface or BNC connectors. The input impedance is selectable, the values are 50 Ω and 1 MΩ.

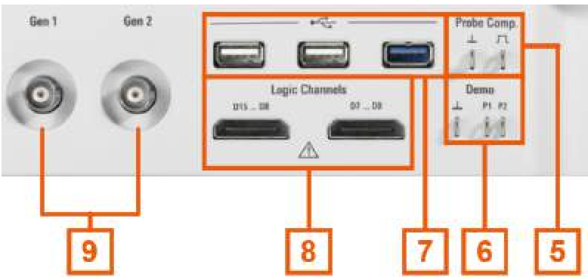
The maximum input voltage on channel inputs is:
- 400 V (V_p) and 300 V (RMS) at 1 MΩ input impedance
- 30 V (V_p) and 5 V (RMS) at 50 Ω input impedance

Trigger In
The external trigger input is a BNC connector that is used to control the measurement by an external signal. The trigger level can be set from -5 V to 5 V.

For the external trigger input, the maximum input voltage is 400 V (V_p) and 300 V (RMS) at 1 MΩ input impedance.

Transient overvoltages on all input connectors must not exceed 400 V (V_p).

3.2.1.2 Other connectors on the front panel



Gen1, Gen2: Function generator
BNC output of the function generator, requires option R&S MXO4-B6.

Logic Channels
Two connectors for logical probes with 8 digital channels each (D0 to D7 and D8 to D15). Using logic channels requires the Mixed Signal Option R&S MXO4-B1.

The maximum input voltage is 40 V (Vp) at 100 kΩ input impedance. The maximum input frequency for a signal with the minimum input voltage swing and medium hysteresis of 800 mV (Vpp) is 400 MHz.

USB
One USB 3.1 gen1 and two USB 2.0 high-speed interfaces type A . They are used to connect a mouse or keyboard, a USB flash drive for storing and reloading instrument settings and measurement data, and to update the firmware.

Demo
The pins are intended for demonstration purposes.

Probe Comp.
Probe compensation terminal to adjust passive probes to the input channel.

⎍	Square-wave signal for probe compensation.
⊥	Ground connector for probes.

3.2.2 Side view

Figure 3-2: Side view of MXO 4

1 = Grounding terminal

Grounding terminal ⏚
4 mm banana jack to connect ground of DUT and test fixtures, and wrist strap.

3.2.3 Rear view

On the rear panel of the MXO 4, you find more connectors and the power supply switch.

Figure 3-3: Rear panel view of MXO 4

1 = Trigger Out connector
2 = Ref. In 10MHz
3 = Ref. Out
4 = LAN connector
5 = HDMI display output
6 = USB B connector, type B
7 = USB connector
8 = AC power supply connector and main power switch
9 = Kensington lock slot to secure the instrument against theft
10 = VESA mounting holes to mount the instrument on a monitor arm

Trigger Out
BNC output that can function as pass/fail output or trigger output.

Ref. In 10MHz
BNC input connector for 10 MHz reference frequency signals.

Ref. Out
BNC output for 10 MHz frequency reference. Can be switched between internal and external reference.

See also: "Menu" > "Horizontal" > "Setup" tab > "Ref Clock"

LAN
8-pin connector RJ-45 used to connect the instrument to a Local Area Network (LAN). It supports up to 1 Gbit/s.

HDMI
HDMI Version 2.0 connector for an external monitor or projector. The monitor shows the complete content of the instrument's screen.

USB B
USB 3.1 gen1 interface of type B (device USB), to be used for remote control of the instrument.

USB
Two USB 3.1 gen1 interfaces of type A.

AC power supply connector and mains power switch
The instrument supports a wide range power supply. It automatically adjusts to the correct range for the applied voltage. There is no line voltage selector.

The AC mains power switch disconnects the instrument from the AC power line.

When you power up the instrument, be sure to comply with the warm-up phase specified in the specifications document before you start measurements.

3.2.4 Keys and controls

For an overview of the front panel keys, see Figure 3-1.

3.2.4.1 Power key

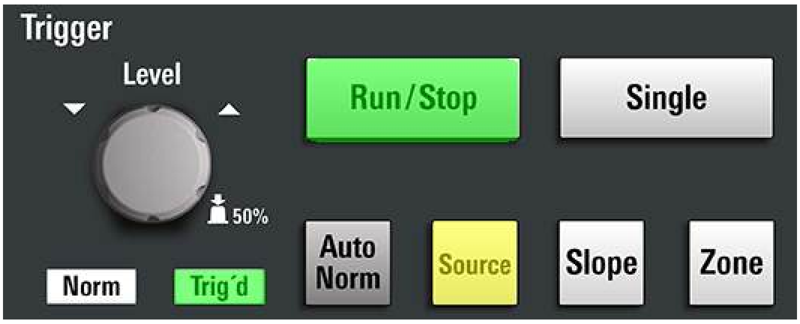
The [Power] key is located on the lower left corner of the front panel. It starts up and shuts down the instrument's software.

The light of the key shows the instrument state, see Section 3.1.9, "Switching on or off", on page 38.

Remote command: `SYSTem:SHUTdown` on page 818.

3.2.4.2 Trigger controls

The keys and knob in the Trigger functional block adjust the trigger and start or stop acquisition.



[Level]
The rotary knob sets the trigger level for all trigger types that require one level. For trigger types with two levels, the knob sets the lower level. Turn clockwise to move up the trigger level. Press the knob to set the trigger level to 50% of the signal amplitude.

Remote command:
`TRIGger:EVENt<ev>:LEVel<n>[:VALue]` on page 895

[Run / Stop]
Starts and stops the continuous acquisition.

The [Run / Stop] key lights green when the acquisition is running. When the acquisition is stopped, the key lights red.

Remote command:
`RUN` on page 852
`STOP` on page 852

[Single]
Starts a defined number of acquisitions.

The [Single] key lights green when the acquisition is running. When the acquisition is stopped, the key lights red.

Press the key again to stop a running acquisition. To set the number of acquisitions, select "Menu" > "Acquisition", and set "N-single/Avg count".

Remote command:
`SINGle` on page 852

[Auto Norm]
Toggles the trigger mode between "Auto" and "Normal". The current setting is shown on the trigger label.

Auto	The instrument triggers repeatedly after a time interval if the trigger conditions are not fulfilled. If a real trigger occurs, it takes precedence. The time interval depends on the timebase.
Norm	The instrument acquires a waveform only if a trigger occurs. The "Norm" indicator turns green.

Remote command:
`TRIGger:MODE` on page 919

[Source]
Toggles the trigger source: C1, C2, C3, etc. The key lights up in the color of the selected channel.

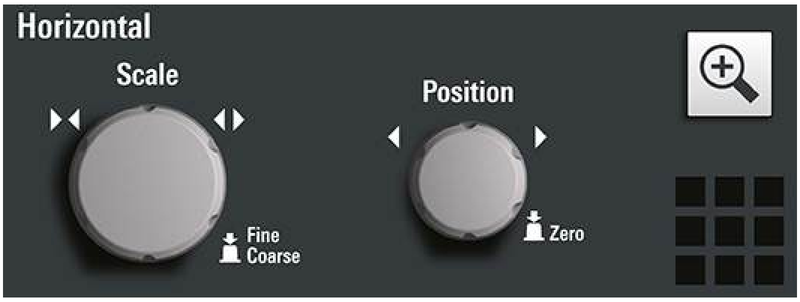
[Slope]
Toggles the trigger slope or trigger polarity, dependent on the trigger type. The current setting is shown on the trigger label.

[Zone]
Opens the configuration for the zone trigger. A zone trigger combines the trigger condition with the intersection or non-intersection of one or more zones or masks.

Remote command:
`TRIGger:ZONE:EXPRession[:DEFine]` on page 929

3.2.4.3 Horizontal controls

The rotary knobs in the Horizontal functional block adjust the horizontal parameters. These settings are effective for all channel waveforms. In addition, a [Zoom] key is available.



[Position]
The rotary knob changes the horizontal position of the waveforms. Turn clockwise to move the waveforms to the right. To set the value to zero, press the knob. The current value is shown in the "Horizontal" label above the diagram.

The horizontal position defines the zero point of the diagram. It is the time distance to the reference point, which marks the rescaling center of the horizontal scale.

In a spectrum diagram, the knob changes the center frequency.

Remote command:
`TIMebase:HORizontal:POSition` on page 854
`CALCulate:SPECtrum<sp>:FREQuency:CENTer` on page 1037

[Scale]
The rotary knob adjusts the horizontal scale for all signals. The horizontal scale is also known as timebase.

Turn clockwise to stretch the waveforms. Doing so, the scale value *time/div* decreases. Press the knob to toggle between coarse and fine scale adjustment.

In a spectrum diagram, the knob changes the span.

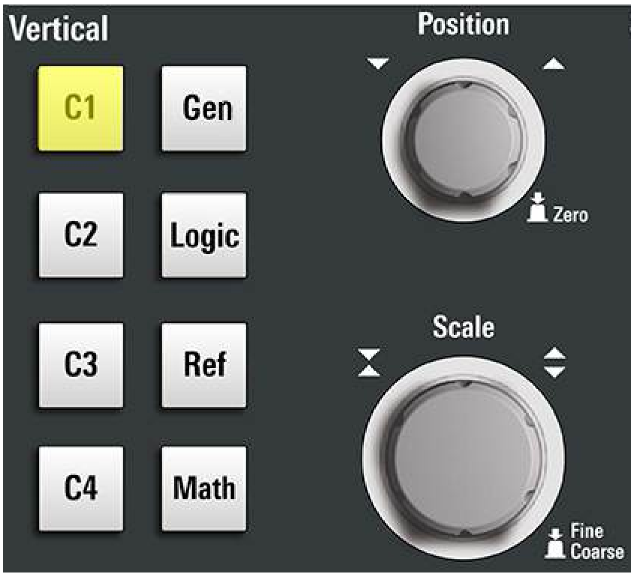
Remote command:
TIMebase:SCALe on page 853
CALCulate:SPECtrum<sp>:FREQuency:SPAN on page 1038

[Zoom]
Activates a zoom and supports the zoom setup.

If no zoom is on, the first press opens a zoom diagram for the active diagram. If at least one zoom is shown, the keypress opens the "Zoom" dialog. If only one zoom is defined, the next press closes the dialog and removes the zoom. If several zooms are defined and the dialog is open, the key toggles the zooms.

3.2.4.4 Vertical controls

The keys and knobs in the Vertical functional block select a signal and adjust the vertical scale and position of the selected signal.



[C<n>]
Turns on and selects a channel. If the channel is active, the key lights up in the corresponding channel color.

The effect of the keypress depends on state of the channel:
- If channel is off: turns on the channel and selects it.
- If the channel is on and in focus (selected): opens the corresponding channel dialog.
- If the channel is on, but not in focus (not selected): selects the channel waveform.
- If the channel is selected, and the dialog is open: turns off the channel, and closes the dialog.

The vertical rotary knobs are focused on the selected waveform. They are illuminated in the color of the selected waveform.

Remote command:
CHANnel<ch>:STATe on page 862

[Position]
The vertical [Position] knob changes the vertical offset or the position of the selected waveform. The horizontal axis and the selected waveform are moved vertically. You can select whether the knob changes the offset or the position in the "Menu" > "Settings" > "Frontpanel" > "Knobs" dialog.

- Position indicates the vertical location in divisions.
- Offset moves the vertical center of the selected channel to the offset value.

If the selected waveform is a math or reference waveform, serial bus, or logic channel, the knob changes its vertical position.

The knob lights up in the color of the selected waveform. Turn clockwise to move up the waveform. To set the value to zero, press the knob.

The current offset value is shown in the channel icon.

Remote command:
`CHANnel<ch>:POSition` on page 863
`CHANnel<ch>:OFFSet` on page 863

[Scale]
Sets the vertical scale, which defines the displayed amplitude of the selected waveform.

The [Scale] knob lights up in the color of the selected waveform.

Turn the knob clockwise to stretch the waveform. Doing so, the scale value V/div decreases. Press the knob to toggle between fine and coarse adjustment. For analog waveforms, the scale value is shown in the signal icon.

To get the maximum resolution of the waveform amplitude, make sure that the waveforms cover most of the diagram's height.

Remote command:
`CHANnel<ch>:SCALe` on page 862
`CALCulate:MATH<m>:VERTical:SCALe[:VALue]` on page 961
`REFCurve<rc>:SCALe` on page 972

[Gen]
Opens the "Waveform Generator" dialog, if option R&S MXO4-B6 is installed.

The waveform generator can generate various function and arbitrary waveforms, sweeps, and parallel patterns. For detailed characteristics, refer to the specifications document.

[Logic]
Opens the "Logic" dialog to configure and enable the logic buses L1 to L4. A logic bus (or parallel bus) has up to 16 logic (digital) channels. If logic buses are active, pressing the key toggles these buses.

The key lights up if at least one logic bus is enabled.

[Ref]
Opens the "Reference" dialog box, where you can configure and display reference waveforms. Press the key repeatedly to switch the reference waveform.

If a reference waveform is selected, the vertical rotary knobs are illuminated in white or light gray (default colors), depending on the selected waveform.

[Math]
Opens the "Math" dialog, where you can configure the calculation of mathematical waveforms using various mathematic operations on other waveforms. Press the key repeatedly to toggle the selected math waveform. If no math waveform is active, the key closes the dialog.

If a math waveform is selected, the vertical rotary knobs are illuminated in blue (default color).

3.2.4.5 Spectrum keys

[Spectrum]
Opens and closes the "Spectrum" dialog. The key lights up if a spectrum is active.

[Freq Span]
Opens and closes the overlay menu to configure the spectrum settings.

[Peak]
Opens the overlay menu to identify the peaks and to create a peak list of a spectrum. If the "Spectrum" dialog is open, the keypress opens and closes the peak list.

[User]

Performs the action that is assigned to the key in "Settings" > "Front panel" > "Hard-keys". You can assign one of the following functions to the key:

- Force trigger (default)
- Save a saveset with instrument settings
- Load a saveset with instrument settings

3.2.4.6 Analysis keys

The controls in the bottom functional block have various functions.

[Multiuse]
The multiuse knob changes the element that is in focus. It lights up when a function is active on the knob.

- If a numeric entry field in a dialog has the focus: turn to increase or decrease the value. Press the knob to toggle fine and coarse increment.
- If a cursor set has the focus: press to toggle the cursor line, and turn to adjust its position.
- If a zoom has the focus: press to toggle the edges of the zoom, and turn to adjust its position.
- If a gate has the focus: press to toggle the complete gate and the edges of the gate, and turn to adjust its position.
- To change the intensity, press the [Intensity] key and turn the knob.

[Intensity]
Adjusts the intensity of the waveforms on the screen: Press the [Intensity] key and turn the [Multiuse] knob. The current value is shown in the input box in the upper right corner of the screen.

[Cursor]
Starts a cursor measurement: sets vertical and horizontal cursors in the active diagram, and displays results of the cursor measurement. If cursors are already set, the keypress opens the "Cursor" dialog, where you can adjust the settings. The next keypress closes the dialog.

Cursors are markers which are placed at points of interest on a waveform. The instrument measures the cursor positions and delta values between parallel cursors.

If cursors are already set but not in focus, pressing the key sets the focus on the cursor set. You can adjust the cursor lines using the [Multiuse] knob.

If a cursor set has the focus, the key opens the "Cursor" dialog. If one cursor set is "On", the next press closes the dialog. If several cursors are "On", pressing the key toggles the cursor sets.

[Measure]
Opens the "Measurement" dialog, where you can set up various measurements. If the dialog is open, pressing the key closes the dialog.

[History]
Activates the history and opens the history player. The next keypress closes the player. The history shows stored acquisitions that were acquired before the current one. The key is illuminated as long as the history is active.

[HD]
Activates the high definition mode and opens the "HD Mode" dialog box.

If the dialog is open, pressing the key closes the dialog. If the dialog is closed, the key disables the high definition mode. The key is illuminated as long as the HD mode is active.

[Touch Lock]
Locks the touchscreen to prevent unintended use. When the touchscreen is off, the key is illuminated. Press again to unlock the touchscreen.

Camera
Performs the action that is assigned to the key in "Settings" > "Front panel" > "Hardkeys". By default, the key saves a screenshot of the waveform display.

[Preset]
Resets the instrument to a predefined state and starts the continuous acquisition. All measurements, mask tests, zoom, and most individual settings are deleted, and all channels except for channel 1 are disabled.

You can define preset configurations and save them to a file. The [Preset] key can be configured to set either factory defaults or a user-defined preset configuration.

[Autoset]
The instrument analyzes the enabled channel signals, and adjusts appropriate horizontal, vertical, and trigger settings to display stable waveforms.

In particular, the horizontal scale is set to a common value for all active channels, record length and sample rate are set to automatic detection. Vertical scale and offset are set for each channel individually. Probe settings, channel coupling and impedance remain unchanged. The trigger source is set to the signal with the lowest frequency, and the trigger type to positive edge. The trigger level is adjusted, and the trigger position is set to the reference point. Measurements, math and spectrum waveforms are kept. Undo and redo of an autoset is possible.

[Clear]
Deletes all measurement results including long-term measurement and statistics, all waveforms, and the history.

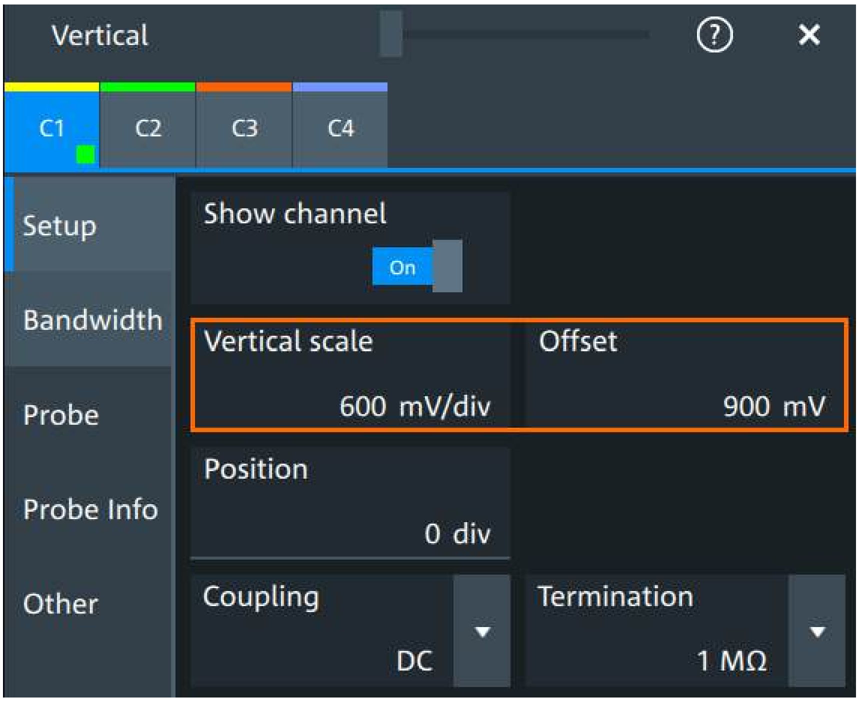
Apps
Opens the "Apps" dialog, where you can start an application, serial protocol or another analysis function.

3.2.5 Checking the functionality

To check if the instrument works correctly, you can use the probe compensation signal and check the displayed signal.

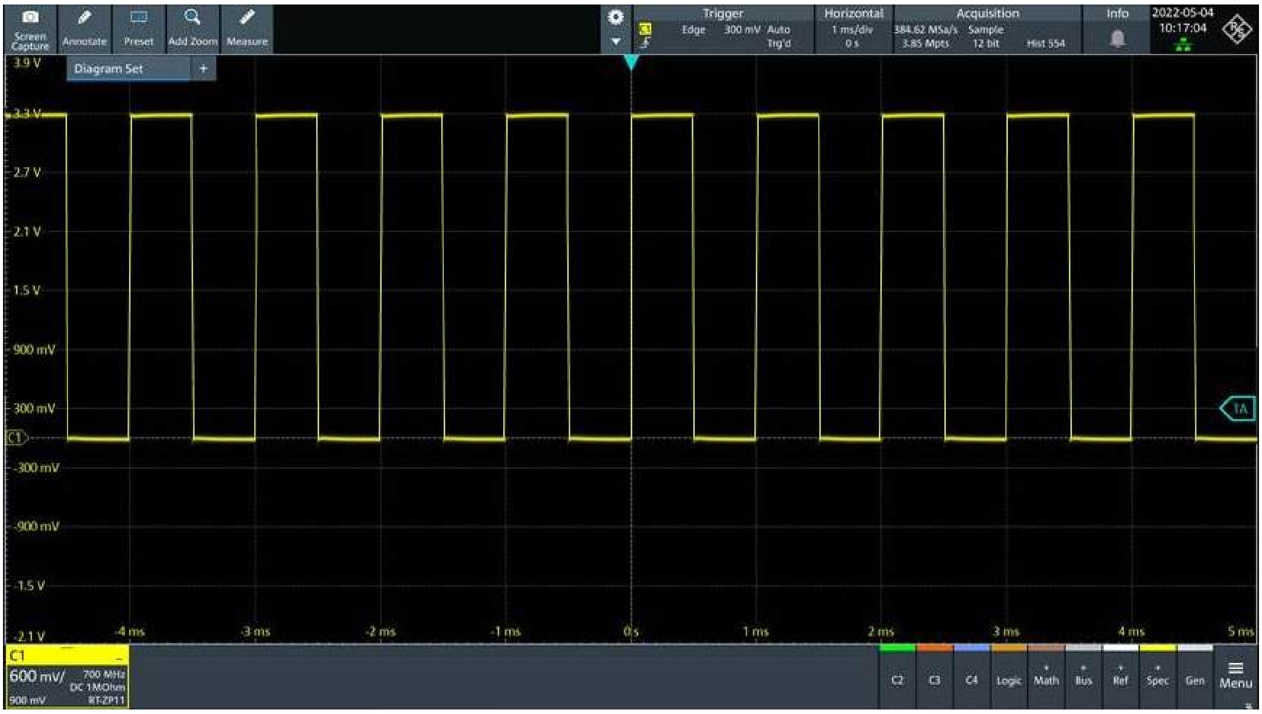
1. Perform a self-alignment of the instrument:
   a) Warm up the instrument. The minimum warm-up time is indicated in the specifications document.
   b) Remove all probes from the input connectors.
   c) Open the "Menu", and select "Settings" > "Maintenance" > "Alignment".
   d) Tap "Start Alignment". Wait until the alignment has finished successfully.
2. Connect the probe's ground connector to the ground pin ⊥, and the tip to the square wave pin ⎍.
3. Press the [Preset] key.
4. Connect the probe to the input connector [C1].

   The instrument recognizes the probe, and a signal is displayed in the diagram.
5. Tap the signal icon of C1 to open the vertical settings.
6. In the "Vertical" > "Setup" dialog, adjust the following:
   - "Vertical scale" = 600 mV/div
   - "Offset" = 900 mV



7. Turn the horizontal [Scale] knob to set the horizontal scale to 1 ms/div.
8. Press the [Source] key to set the trigger source to C1. The color of the key indicates the selected channel.

9. Turn the [Level] knob to set the trigger level to 300 mV.
10. Check the rectangle signal on the screen. The displayed signal should have an amplitude of about 3.3 V, which covers 5.5 divisions.



11. Repeat steps 4 to 10 for all other channels. Make sure to adjust the vertical settings for the connected channel, and also to set the trigger source to the connected channel.

4 Operating the instrument

There are three ways to operate the MXO 4.

Manual operation

Use the touchscreen, keys and rotary knobs, or an optional mouse and/or keyboard. The principles of manual operation are explained in this section.

Remote control

Create programs to automatize repeating settings, tests, and measurements. The instrument is connected to a computer that runs the program.

This way of operation is described in: Section 18, "Remote control commands", on page 802.

Remote operation

For remote monitoring and operation of the instrument, a VNC server is installed on the MXO 4. You need a LAN connection to the computer, and a VNC client or web browser to connect to the instrument.

For details, refer to Section 17, "Network operation", on page 770.

4.1 Means of manual interaction

The MXO 4 provides the following means of manual interaction, which you can use alternatively or complementary:

- Touchscreen:
  Using the touchscreen allows for direct interaction with the instrument. Use your finger to place waveforms on the screen, mark areas for zoom, set parameters in dialogs, enter data, and much more. The control elements and actions on the screen are based on common concepts, and you easily become familiar with the user interface.

  Tapping the screen works like clicking mouse buttons:
  - Tap = click: Selects a waveform or parameter, or provokes an action.
  - Double-tap = double-click: Has the same effect as touch and hold, it opens the on-screen keyboard or keypad, or a specific editor if available.
- Function keys and rotary knobs:
  The front panel provides frequently used functions and controls to operate the instrument. Use knobs to set levels and scales, and keys to initiate actions and to open dialogs.
- Optional mouse and/or keyboard
  These devices work in the normal manner.

4.2 Touchscreen display

4.2.1 Information on the display

The GUI shows the waveforms and measurement results, and also information and everything that you need to control the measurements. All waveform-related GUI elements are explained in this section. An overview of control elements - like dialog, toolbar - is given in Section 4.2.2, "Control elements on the GUI", on page 58.

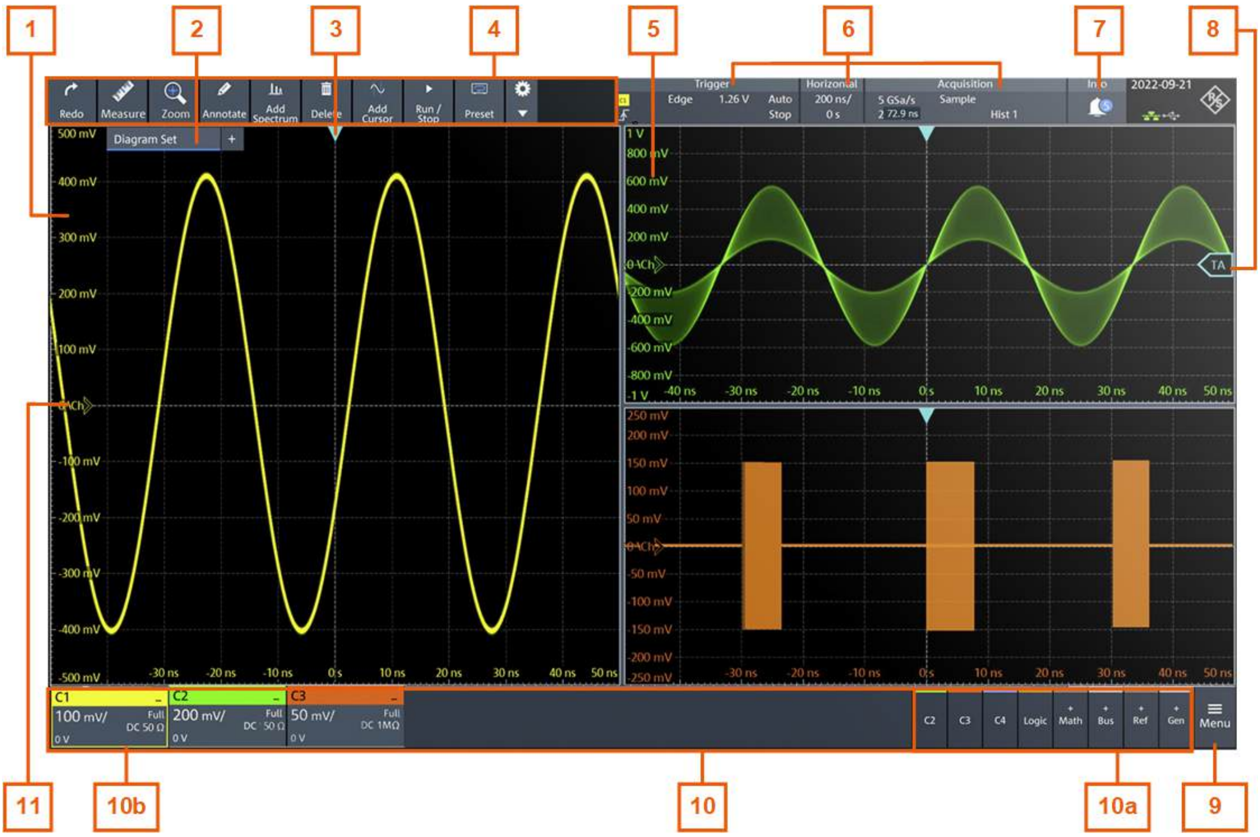


Figure 4-1: Information in the graphical user interface

1 = Diagram
2 = Layout
3 = Trigger position
4 = Toolbar
5 = Grid
6 = Trigger, horizontal and acquisition label
7 = Info
8 = Trigger level
9 = Menu
10 = Signal bar with signal activators (10a), and active waveforms (10b)
11 = Channel markers indicate the ground levels

Diagram
A diagram shows one or more waveforms: analog and digital channels, reference and math waveforms, tracks, and serial buses. Zoom details, spectrum and other special waveforms are shown in separate diagrams. One diagram can hold up to 16 analog waveforms, i.e. analog channels, reference and math waveforms, and tracks.

To arrange the diagrams on the screen, the Rohde & Schwarz SmartGrid function helps you to find the target place simply and quickly. For details, see Section 4.5, "Rohde & Schwarz SmartGrid", on page 63. You can also adjust the diagram size by dragging the diagram border.

Layout tab
A layout shows a set of diagrams and result tables. You can configure up to four layout tabs using the SmartGrid functionality. For details, see Section 4.5, "Rohde & Schwarz SmartGrid", on page 63.

Grid
The grid shows the vertical and horizontal divisions. The division lines are labeled with the correspondent values. The grid labels have the color of the waveform to which they belong. If several waveforms are shown in one diagram, the grid has the color of the selected waveform.

Trigger position and trigger level
The blue markers show the horizontal position of the trigger and the vertical trigger level. You can touch and move the trigger markers in the diagram to set the positions. The trigger point is the zero point of the diagram.

The trigger position can be moved outside the diagram.

Trigger
The "Trigger" label shows the main trigger settings. If you tap the label, the corresponding dialog opens.

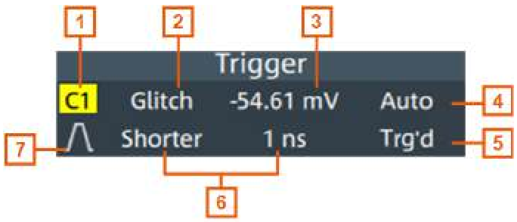


Figure 4-2: Trigger label

1 = Trigger source
2 = Trigger type
3 = Trigger level
4 = Trigger mode
5 = Trigger state
6 = Trigger type specific settings
7 = Trigger slope

See also: Section 7.1.1, "Trigger information", on page 160.

Horizontal

The "Horizontal" label shows the main timebase settings. If you tap the label, the corresponding dialog opens.

Figure 4-3: Horizontal label

1 = Time scale
2 = Horizontal position

Acquisition

The "Acquisition" label shows the main acquisition settings, and the progress of long acquisitions. If you tap the label, the corresponding dialog opens.

Figure 4-4: Acquisition label

1 = Sample rate (before interpolation)
2 = Record length. A yellow warning icon indicates insufficient memory.
3 = Acquisition mode
4 = Number of acquired waveforms
5 = Resolution. Active high definition mode is indicated by "HD".

Info

The "Info" button on the toolbar points to the status messages and other information. To open the message box, tap the button.

See also: Section 4.12, "Information and notifications", on page 77.

Signal bar

The signal bar is the control center for all waveforms. All enabled waveforms are shown on the left side of the signal bar. On the right side of the signal bar, you see the signal activators of inactive waveforms. Tap a signal activator to enable the waveform.

Each waveform is represented by a signal icon. If the waveform is shown in a diagram, the signal icon displays its main vertical and probe settings. If you tap a signal icon, the dialog with vertical settings for this waveform opens. If you tap the "Minimize" icon on the signal icon, the waveform switches from the diagram area to the signal icon: the icon is grayed out. See Section 4.4, "Working with waveforms", on page 61 for a detailed description.

In Figure 4-1, the signal icons C1, C2 and C3 show the main settings, and the waveforms are displayed in diagrams.

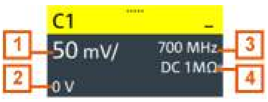


Figure 4-5: Signal label

1 = Vertical scale
2 = Offset
3 = Bandwidth
4 = Coupling and termination

If many waveforms are active, then waveforms of the same type are grouped in one signal icon. Tap the group icon to open the individual signal icons.

4.2.2 Control elements on the GUI

The GUI provides everything that you need for control, to analyze waveforms, and to get measurement results. Figure 4-6 shows the control elements at a glance.

Figure 4-6: Control elements on the graphical user interface

1 = Toolbar
2 = Tab in a dialog
3 = Dialog
4 = Result table
5 = Signal bar
6 = Menu

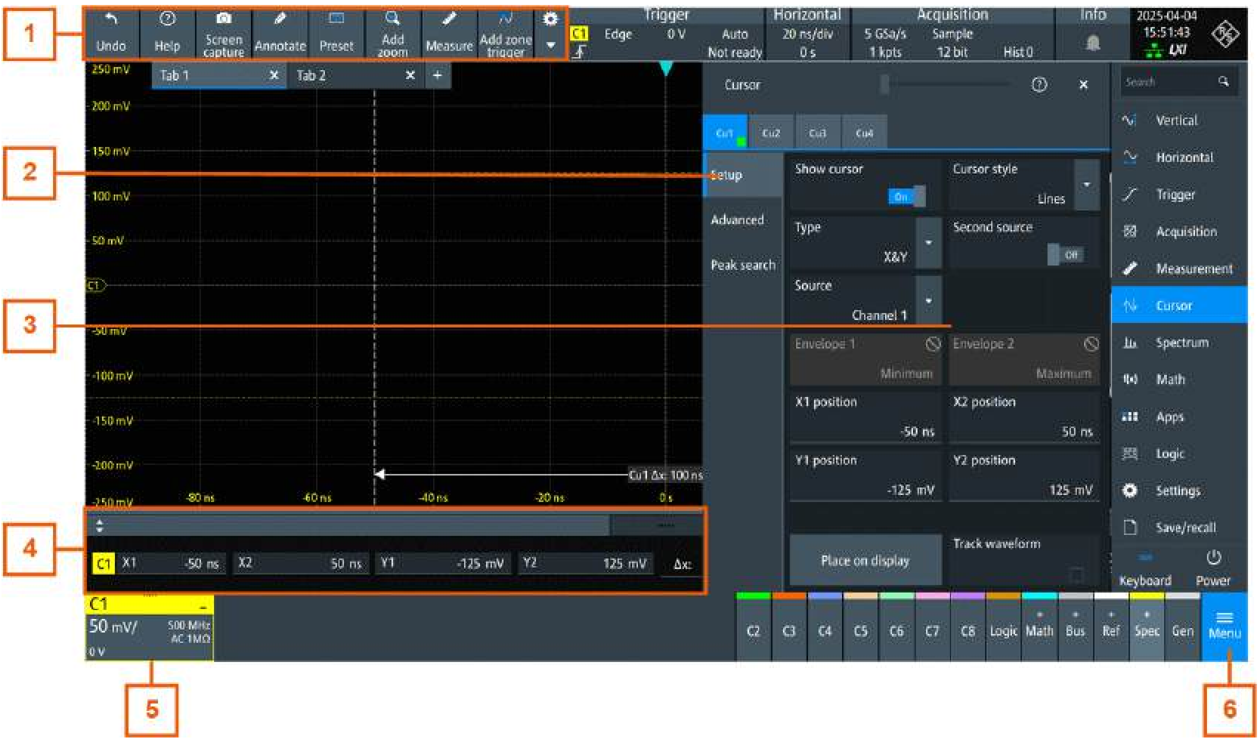


Figure 4-7: Control elements on the graphical user interface

1 = Toolbar
2 = Tab in a dialog
3 = Dialog
4 = Result table
5 = Signal bar
6 = Menu

Toolbar (1)

The icons on the toolbar provide quick and easy access to the most important functionality. For a detailed description, refer to Section 4.6, "Toolbar", on page 65.

If you adjust the settings of an analyzing function, e.g., cursor measurement, the overlay menu is shown instead of the icons. The overlay menu provides the most important settings of the current action. If you need more settings, "Setup" opens the corresponding dialog.

Dialog (2, 3)

The tabs of the dialogs contain all task-oriented settings and operations, and buttons for calling related tabs. The usage of dialogs is described in Section 4.8, "Using dialogs", on page 72.

Result table (4)

If you perform cursor or automatic measurements, the result table shows the results of the action below the diagrams. You can move the result tables to the left or right of the diagrams.

See also: Section 4.10, "Displaying results", on page 75.

Signal bar (5)

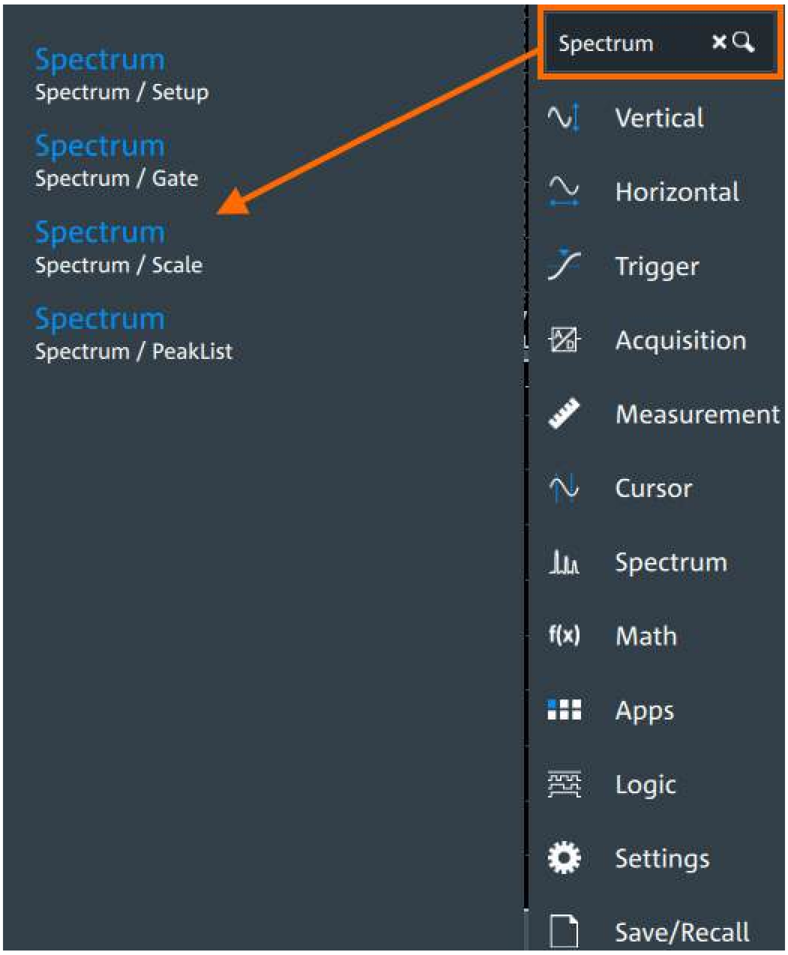
The signal bar summarizes all waveforms as described in "Signal bar" on page 57.

Menu (6)

The menu provides access to the complete functionality of the MXO 4.

At the bottom of the menu, you find the "Keyboard" icon to open the on-screen keyboard. The "Power" icon shuts down the firmware.

At the top of the menu, you can find a search field for a quick access to any parameter you need. A list of all found results is shown on the left side of the menu. Tap the result entry and the dialog containing this parameter opens.



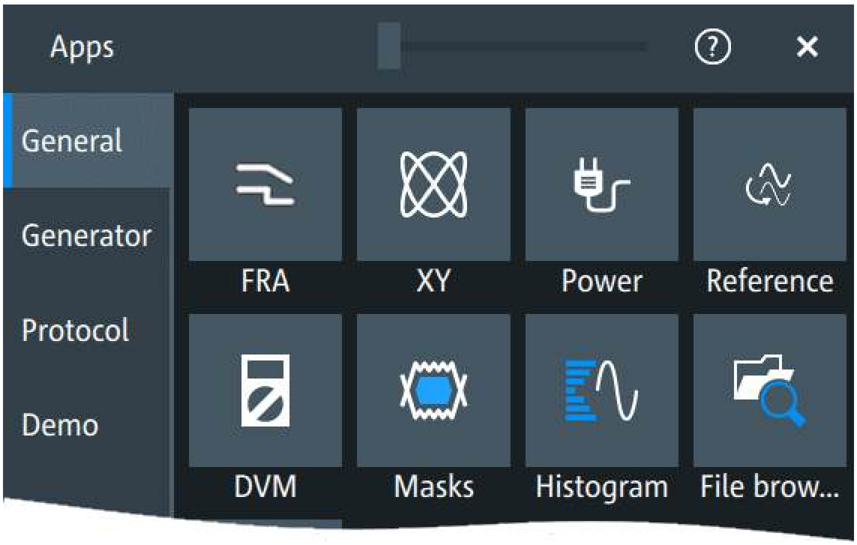
4.3 Applications

The "Apps" dialog provides fast access to all available applications, for example, to serial protocols, frequency response analysis or file browser.

► To open the "Apps" dialog:

- Open "Menu" > "Apps".

- Press the [Apps] key on the front panel.



4.4 Working with waveforms

The MXO 4 can create and display many waveform types. The most important are:

- Channel waveforms:
  For each input channel, one channel waveform is shown.
- Reference waveforms:
  Four waveforms can be used as reference for comparison and analysis.
- Math waveforms:
  Five mathematic waveforms can be created with mathematic operations performed on channel, reference, and other math waveforms.
- Zoom waveforms:
  Show the details of waveforms.
- Digital waveforms:
  The Mixed Signal Option R&S MXO4-B1 provides 16 digital channels grouped in two logic probes (pods) with 8 channels each.

Waveform handling

The MXO 4 can show and analyze many waveforms. To handle this multitude while keeping track of it, the MXO 4 provides intelligent support:

- The color system helps to distinguish the waveforms.
  The color of the vertical rotary knobs indicates the signal that is focused (selected). The color of each waveform can be changed, the color of its signal icon and of the illuminated keys is adjusted to the new color. Alternatively, a color table can be assigned to a waveform.
  Settings: "Menu" > "Settings" > "Appearance" > "Colors" tab.
- You can arrange the waveforms in one diagram, or in separate diagrams. The Rohde & Schwarz SmartGrid function helps to arrange the waveforms.

See also: "Diagram" on page 56.

Waveform states

Depending on its place on the screen and the effect of settings, a waveform has one of the following states:

- Off
- Active:
  The waveform is shown in a diagram
- Selected:
  One of the active waveforms that has the focus. In each diagram, one of the assigned waveforms is selected – it appears "on top" in the diagram, and the grid labels have the color of the selected waveform.
  The vertical [Position] and the [Scale] knobs are illuminated with the color of the selected waveform.
- Minimized:
  The waveform signal icon is greyed out, and the waveform is removed from the diagram.

To switch a waveform on

A channel waveform is activated when you connect the probe. You can switch it on and off according to your needs.

► Choose one of the following ways:
  - Press the channel key.
  - Select the signal activator in the signal bar.
  - In the "Vertical" dialog box, select the channel. Tap "Show channel" > "On".

  The waveform is now active, selected, and is shown in the diagram.

Remote command: `CHANnel<ch>:STATe` on page 862

To select a waveform

► Choose one of the following ways:
  - Tap the waveform in the waveform diagram.
  - Tap the signal icon.
  - To select a channel, reference, or math waveform, press the corresponding key.

  Note: Zoom waveforms in zoom diagrams cannot be selected.

To minimize a waveform

► Tap the "Minimize" icon in the upper right corner of the waveform's signal icon in the signal bar.

  The waveform disappears from the diagram and the signal icon turns lighter gray.

To arrange a waveform using the SmartGrid

See Section 4.5, "Rohde & Schwarz SmartGrid", on page 63.

To switch off a waveform

► Do one of the following:
- Tap the "Delete" icon in the toolbar, and then signal icon of the waveform. You can also tap the waveform directly. If several waveforms overlap or lie close together, a selection list is shown.
- To switch off a minimized waveform, tap the "Close" icon in the upper right corner of the signal icon.
- If the waveform is an input channel:
  - Disable "Show channel" in the "Vertical" > "Setup" tab.
  - Select the channel. Then press its channel key twice.

Remote command: `CHANnel<ch>:STATe` on page 862

4.5 Rohde & Schwarz SmartGrid

The Rohde & Schwarz SmartGrid helps to create and arrange the diagrams on the screen with drag&drop. The diagram layout depends on the position where you drop the signal icon, in relation to an existing diagram.

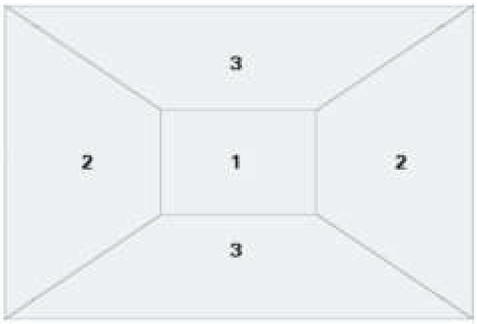


Figure 4-8: SmartGrid positions

1 = In the existing diagram, overlay of signal
2 = New diagram on the left or right
3 = New diagram above or below

The diagram configuration is deleted when you use "Preset" or `*RST`.

Working with layouts

A SmartGrid configuration of one or more diagrams is called "tab" or "layout". You can define several layouts and switch between them.

1 = Tab 1 (layout 1, blue underline indicates that the set is currently displayed)
2 = Tab 2 (layout 2)
3 = Tap to remove a layout
4 = Tap to add a layout

You can add up to four layouts at the upper left corner of the screen:

1. Tap on the ⊞ icon next to the layout.

   A new layout is created.

2. To change the layout name, touch and hold the tab name. The on-screen keyboard opens to enter the new name. Names must be unique.

3. To remove the layout, tap on the ☒ next to the layouts title.

To arrange a waveform using the SmartGrid

1. Select the layout that you want to rearrange.

2. Drag the signal icon to the diagram area, and move it around.
   The Rohde & Schwarz SmartGrid appears and a blue or highlighted area shows where the waveform will be placed.

3. Drop the waveform in the target area.
   The waveform appears in an existing or in a new diagram, and it is selected for further actions.

4. To change the size of a diagram, touch the border between two diagram frames and drag it to the required position.

5. If a diagram is empty, you see a trash can icon in the diagram center. Use the icon to delete the diagram, or drag waveform icons into the diagram.

Remote commands: see Section 18.7.2, "SmartGrid", on page 819.

4.6 Toolbar

The toolbar provides direct access to important control and measurement functions.

By default, the toolbar shows the most frequently used functions. You can configure the content of the toolbar, see Section 4.6.2, "Configuring the toolbar", on page 65.

4.6.1 Using the toolbar

Using the toolbar is easy and straightforward.

Some of the toolbar functions are one-click actions. These actions are performed immediately when you tap the icon.

Other toolbar functions are analyzing functions. These actions are interactive actions.

To use analyzing functions (interactive actions)

1. Tap the icon of the function in the toolbar.
2. Check and adjust the settings in the overlay menu.
3. Select the source waveform if needed. For zoom, drag a rectangle, or tap the diagram to define the zoom area.
4. If the overlay menu does not close automatically, tap the ☒ icon.

4.6.2 Configuring the toolbar

You can configure the content of the toolbar so that only the required functions are displayed.

The toolbar configuration is part of the user preferences. It is retained when you switch off and on the instrument, and you can save it in the user preferences and user-defined preset.

1. To open the toolbar configuration, tap the icon in the toolbar:

2. Select the required toolbar functions:

a) In the "Show/Hide tools" section, disable all functions that you do not need.
b) In the "Show/Hide tools" section, enable the functions that you want to add to the toolbar.
c) In the "Drag to rearrange tools" section, move the icons to arrange them as required.

3. To empty the toolbar, select "Deslect all".
4. To get the factory configuration of the toolbar, select "Restore default".

A detailed description of the toolbar functions is given in Section 4.6.3, "Toolbar functions", on page 66.

Remote commands:

- `DISPlay:TOOLbar:COUNt?` on page 825
- `DISPlay:TOOLbar:DESelect` on page 825
- `DISPlay:TOOLbar:RESTore` on page 826

4.6.3 Toolbar functions

This section describes all toolbar functions.

You can configure the content of the toolbar, see Section 4.6.2, "Configuring the toolbar", on page 65.

Undo
Undoes the last setting actions step by step. On a keyboard, you can use the shortcut [Ctrl]+[Z].

Some actions cannot be revoked: locking the touchscreen with [Touch Lock], and saving data.

The undo stack is deleted when reloading settings from file, and during reference waveform actions (save, load and preset with active reference waveform).

Redo
Recovers the undo steps in reverse order. On a keyboard, you can use the shortcut [Ctrl]+[Y].

Help
Enables the context help display. The help window opens when you tap a parameter.

See also: "To display the context help" on page 80.

Recall
Opens a window to select and load instrument settings that were previously stored in a saveset.

Save setup
Saves the current instrument settings in a saveset.

You can reload the saveset using the "Recall" toolbar icon, or using "Menu" >"Save/recall" > "Recall" tab > "Saveset".

The filename is created according to the autonaming pattern, defined in "Menu" > "Settings" > "Save / Recall" > "Autonaming" tab.

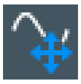
Screenshot
Saves a screenshot of the current display using the settings defined in "Menu" >"Save/recall" > "Save" tab > "Screenshot".

Annotate
Displays drawing tools for marking areas on the diagram, and for adding text. You can also select the color.

See also: Section 4.11, "Adding annotations", on page 76.

Clear
Deletes all measurement results including all waveforms and statistics.

Remote command:
`DISPlay:CLR` on page 846

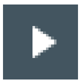


Autoset
Performs an autoset. The instrument analyzes the enabled channel signals, and adjusts appropriate horizontal, vertical, and trigger settings to display stable waveforms.

The icon has the same functionality as the corresponding key on the front panel. It is useful when you operate the instrument remotely.

Preset
Resets the instrument to a predefined state and starts the continuous acquisition. All measurements, mask tests, zoom, and most individual settings are deleted, and all channels except for channel 1 are disabled.

The icon has the same functionality as the corresponding key on the front panel. It is useful when you operate the instrument remotely.



Run / stop and Run single
Starts and stops the continuous acquisition, or starts a defined number of acquisition cycles. The icons have the same functionality as the corresponding keys on the front panel. They are useful when you operate the instrument remotely.

Force trigger
Starts an immediate single acquisition. If the acquisition is running in normal mode and no valid trigger occurs, use "Force trigger" to confirm that a signal is available. Then you can use the displayed waveform to determine how to trigger on it.

Add zoom
Adds a zoom diagram, an area of the acquired waveform which is visually enlarged. Click a diagram to create a zoom or draw a rectangle to define the range of the zoom.

Add cursor
Adds a cursor set. Select the cursor type and the source to be measured.

See also: Section 10.1, "Cursor measurements", on page 254.

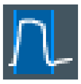
Measure
Adds one or more measurements to the waveform.

Tap the icon, and select the category and the measurements in the overlay menu. Select the waveform to be measured, and close the overlay menu.

Add mask
Starts the on-screen mask definition and the testing against the defined mask.

Tap the icon and draw a rectangle for the first mask segment. Use the overlay menu to add more segments to the mask, to create more masks, and to edit mask segments on the display. You can also move the mask segments on the screen.

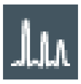
Histogram
Creates a histogram. Tapping the icon opens the overlay menu, where you select the histogram type. Tap a diagram, or drag a rectangle on the diagram to define the histogram window. The histogram for the selected waveform is created.



Add gate

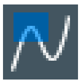
Creates a new gate.

Tap the icon, and then tap the diagram or draw a rectangle to define the limits of the gate. The "Gate" dialog opens, where you can adjust the geate settings and add measurements to use the gate.



Edit spectrum

Edit the existing spectrum settings in the overlay menu.



Add zone trigger

Defines a zone trigger, which combines the trigger condition with the intersection or non-intersection of one or more zones.

See also: Section 7.9, "Zone trigger", on page 195.

Delete

Removes waveforms, diagrams, zooms, trigger zones and other elements from the display.

Tap the "Delete" icon. A recycle bin icon marks all objects that can be deleted. Tap this icon to remove an object. Tap the "Delete" icon again to disable the function.

File browser

Opens the file browser dialog.

See: Section 13.7, "File browser dialog", on page 429.

DVM

Starts the digital voltmeter application.

See: Section 12.4, "Digital voltmeter", on page 390.

XY

Starts the XY-plot application.

See: Section 12.5, "XY-plot", on page 393.

Get signals

Imports the active channel waveforms from the connected oscilloscope.

See Section 17.2, "ScopeSync", on page 772.

Image viewer

Starts the screenshot viewer.

See: Section 13.6.3, "Image viewer", on page 429.

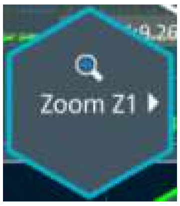
Gen1, Gen2

Turns on or off the waveform generator. For better visibility, a gererator icon is darker than the other icons in the toolbar.

4.7 Using the selection menu

The selection menu, or comb menu, helps select objects on the screen if several objects are close beside. These objects are, for example, waveforms, zoom edges, gate limits, trigger zones and cursor lines. When you tap or click a point in a diagram, the firmware determines the objects around the point and provides an appropriate menu. Each found object is represented by a comb. The selection menu is created and arranged anew at each finger tap, there are no predefined positions for the objects.

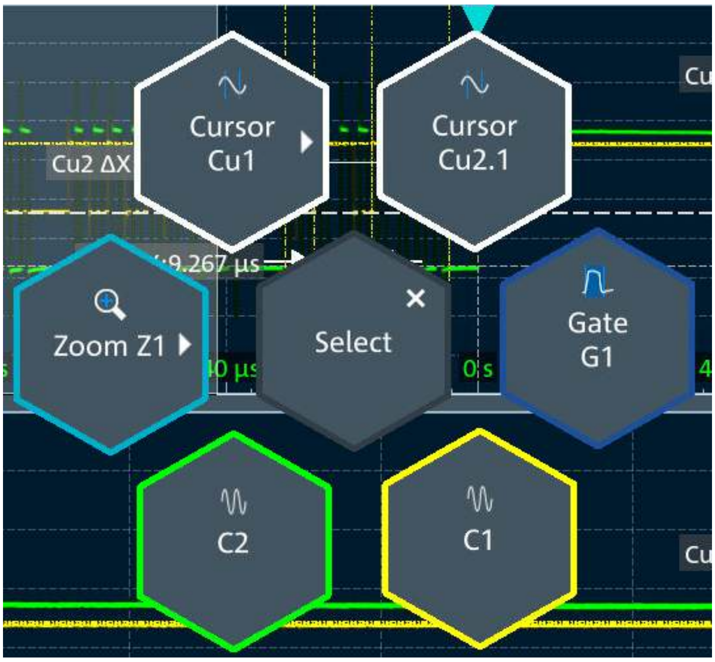
Table 4-1: Selection menu icons

Symbol	Description
	Comb
	: indicates that a submenu is available. If more than 6 objects are detected, related objects are grouped to submenus. Tap on the object group to display the submenu
	: indicates that there are more than 6 objects that are available. In this case some of the objects are not directly displayed. Tap on one of the combs and rotate the selection to display all the choices.

To use the selection menu

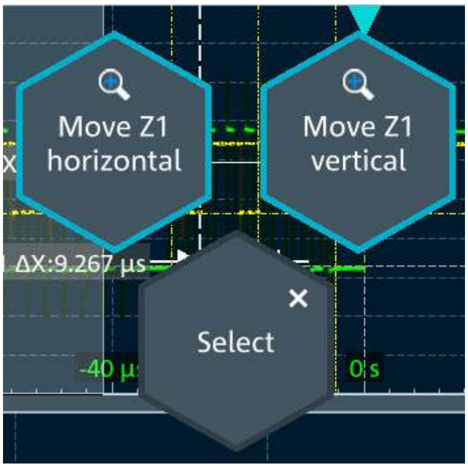
1. Tap the screen at the point of interest.

   The selection menu provides all objects that were found around the point. In the image below, the objects of "Cursor Cu1" and "Zoom Z1" are grouped in submenus.



2. Select the comb of the needed object, or object group.
3. If you have selected an object, the object gets the focus. Change its position directly on the screen or with the [Multiuse] knob, or perform other actions depending on the selected object.
4. If you have selected an object group, the submenu opens.

   The image shows the submenu of "Zoom Z1".



5. In the submenu, select the comb of the needed object.
6. Modify the selected object as required.

4.8 Using dialogs

All functionality is provided in dialogs as known from computer programs. This section provides an overview of the accessing methods and describes how to use the dialogs.

Each dialog has icons in the upper right corner:

	Closes the dialog.
	Opens the help window for the dialog.
	Shift sideways to change the transparency of the dialog.

For direct access to important control and measurement functions, use the toolbar, see Section 4.6, "Toolbar", on page 65.

To open a dialog

► Perform one of the following actions:
- Open the "Menu", and select the menu entry.
- Press the function key on the front panel.
- Double-tap a result to open the corresponding settings dialog.
- To open the "Vertical" dialog of a waveform, tap the signal icon.
- Tap the "Horizontal", "Acquisition" or "Trigger" label to open the corresponding dialog.

To close a dialog

► Tap the "Close" icon in the upper right corner.

4.9 Entering data

To set parameter values and enter other data, you use the various knobs and the on-screen keypad or keyboard.

To use scale, position and level knobs

The instrument has dedicated rotary knobs to set vertical and horizontal positions and scale, and the trigger level.

1. Turn the knob to change the value.
2. Press the knob:
   - [Scale]: to toggle the increment.
   - [Position]: to set to zero.
   - [Level]: to set the trigger level to 50% of the signal.

To enter values with the on-screen keypad

To enter numeric values and units in dialogs, an on-screen keypad is available.

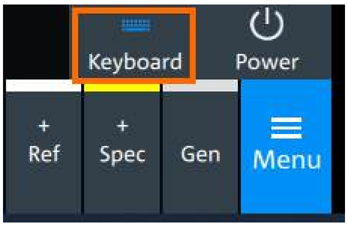
1. Double-tap the entry field. The on-screen keypad opens.

2. Enter a numeric value using the following methods:
   - To use the default value, tap "Reset" (if available).
   - To get the value that was used before the keypad was displayed, tap "CE".
   - To use the minimum or maximum value, tap "Min" or "Max", respectively.
   - To increase the displayed value in fixed steps, tap "Inc".
     To decrease the value in fixed steps, tap "Dec".
   - To enter a user-defined value, tap the numbers and complete the entry by tapping the unit button.
     – "±" changes the sign of the value.
   - To calculate a value, tap the calculator to display the arithmetic operators. Use the displayed fields to calculate your values.

3. To activate caps lock when you enter a text value, double-tap the shift key (up arrow key).
4. Tap ↵ to complete the entry.

To enable the on-screen keyboard

1. Tap "Menu".
2. Tap on "Keyboard" to enable the on-screen keyboard.



If the on-screen keyboard is enabled, the keyboard icon is colored blue. If it is disabled, the color is white.

To enter data with the on-screen keyboard

1. Double-tap the entry field to open the on-screen keyboard.

2. Enter the text as you would on a normal keyboard.
   - To change the language, tap . The current language is shown on the blank key.
   - To display numbers and signs, tap .
3. Tap to complete the entry or to minimize the keyboard.

4.10 Displaying results

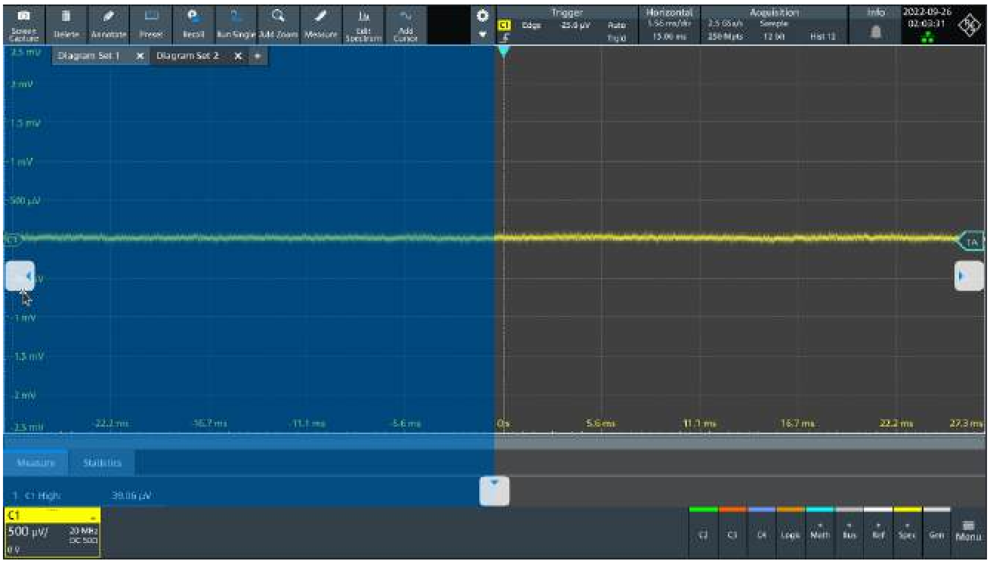
The results of measurements, protocol decoding and others are displayed immediately.

The font size can be adjusted.

To arrange the results on the display

1. Touch and hold the "....." field on top of the results table.

2. Drag on the screen. The SmartGrid indicates where the result table can be placed. Drop the box on one of the buttons. The results are shown at the left the right, or below the diagrams.



To open the corresponding settings

► Double-tap one of the result values.

The corresponding dialog opens.

To adjust the font size of results

1. Open the "Menu" > "Settings" > "Appearance" dialog.
2. Select the "Dialogs" tab.
3. Set the "Result dialog" > "Font size".

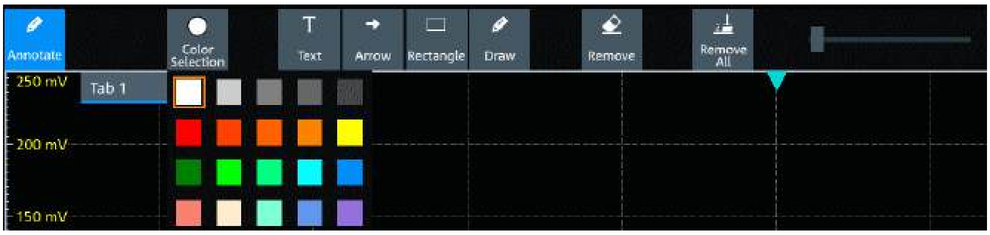
4.11 Adding annotations

The MXO 4 provides an easy way to add annotations to the screen. With the toolbar "Annotate" you can add text, forms or even draw.

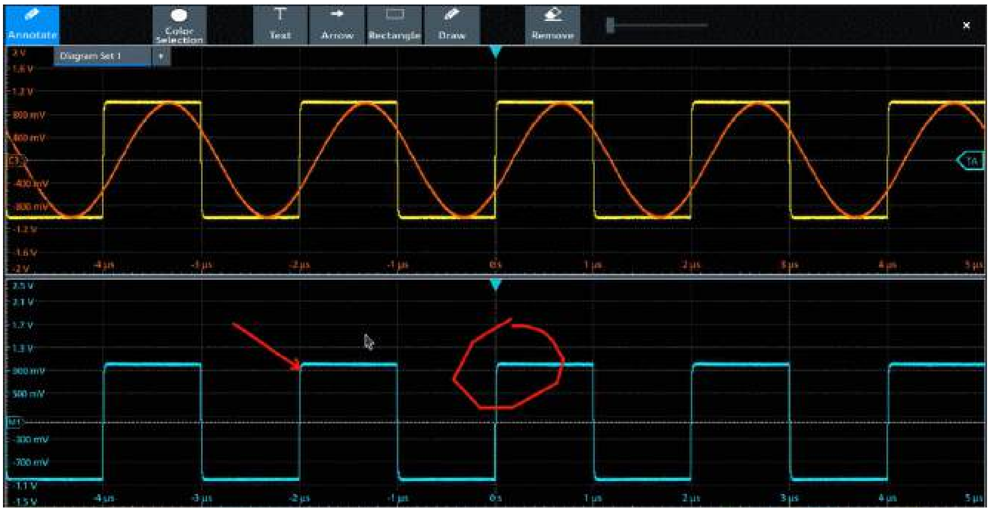
To add an annotation

1. On the toolbar, tap on the "Annotate" icon.

The annotation overlay menu opens.



2. Tap "Color selections" and select the color that you want to use for your annota-tions.
3. Add one or more of the following:
   - One of the predefined forms: "Arrow" or "Rectangle"
   - "Text": adds a text element to the screen and opens on-screen keyboard. You can change the text later, by tapping on an existing annotation and typing in the new text.
   - "Draw": you can draw any form on the screen.



4. To move one of the annotations, tap on it and drag it to the required position.

To remove an annotation

1. In the "Annotate" overlay menu, tap on "Remove".
2. Tap on any existing "Arrow", "Rectangle" or "Text" annotation to remove it.
3. The "Remove" function, acts as an eraser on drawings: it enables you to erase only certain parts of your drawing. Drag your finger over any part of your drawing to erase it.
4. To remove all annotations from the screen, tap on "Remove All".

Remote commands: see Section 18.7.4, "Annotations", on page 826.

4.12 Information and notifications

The MXO 4 provides various information:

- Instrument information, e.g. connection status, firmware version
- Notifications, e.g. status messages, incompatible settings, insuffcient memory
- Progress information, e.g. for long acquisitions, data saving

Instrument information

In the upper right corner of the screen, you see the Rohde & Schwarz logo, date and time, the symbolic information on LAN connection and the notifications status.

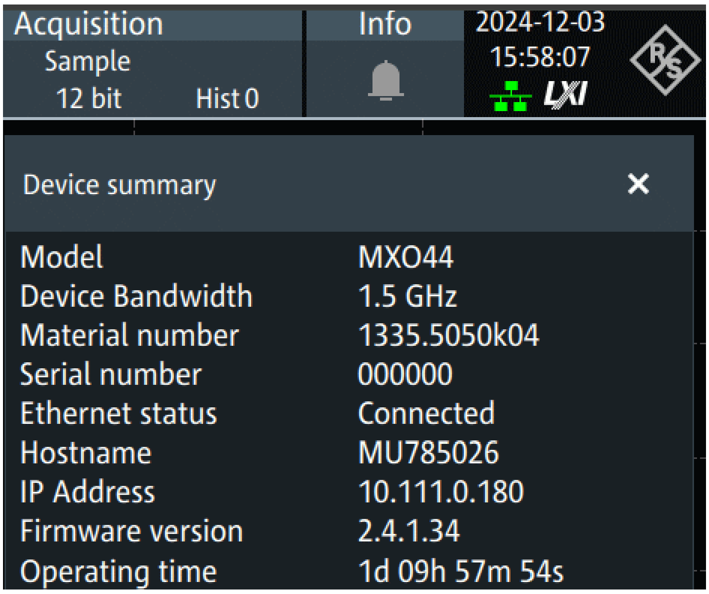

The connection status icon in the upper right corner indicates the status of the LAN connection.

- Green indicates that the instrument is connected to the LAN.
- Red indicates a connection error - mostly the LAN cable is not connected.

- Blinking indicates that the device indicator on the instrument's homepage is switched on, and a device identification command was sent.

► To see the instrument information, select the Rohde & Schwarz logo.

You can find information about the instrument model, bandwidth, network settings, firmware version and operating time.



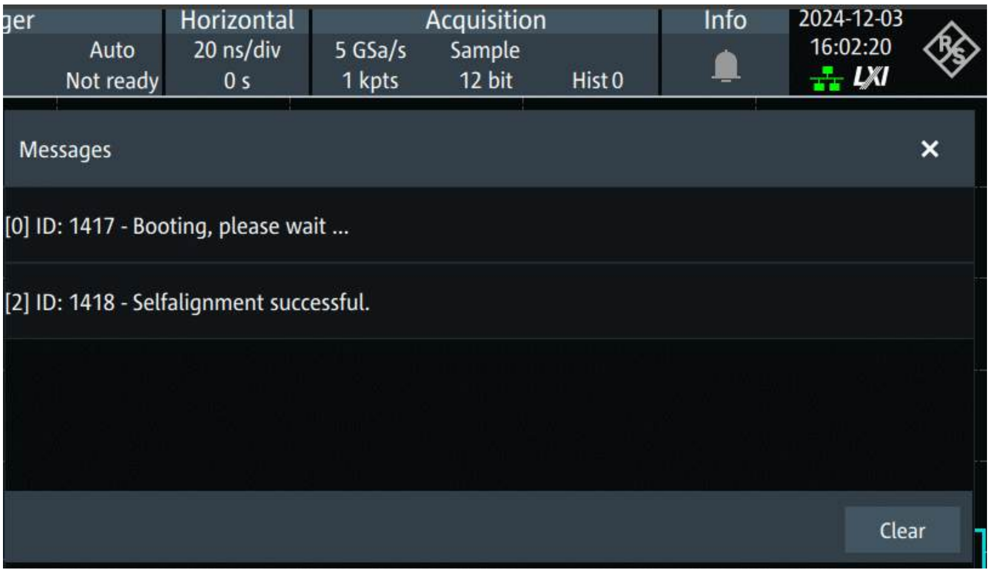
► To hide the date and time or change the display format, select the date/time display.

Notifications

Notifications are status messages, information on mismatching settings, insufficient memory and similar information. They are displayed for a few seconds and saved.

► To read the notifications, select "Info".

You can delete the list of notifications.



Progress information

If an acquisition, operation or process takes more time until results are displayed, a progress bar or symbol indicates that a process is running.

The progress of saving operations and update or creation of a reference waveform is shown in a progress bar. You can cancel the process. A notification informs about the result.

Figure 4-9: Progress bar for saving waveform data

The progress of running acquisitions is shown in the acquisition label. A circle indicates the state of the current, incomplete acquisition. Progress in roll mode, average mode and single acquisition with N > 1 is indicated by a progress bar and counter.

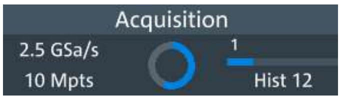


Figure 4-10: Progress of incomplete long acquisition in average mode, Run Single = 5, first acquisition is finished

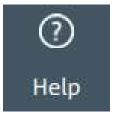
4.13 Getting user assistance

If you need information on the functionality, you can use the integrated product help. It provides contextual information on a setting or dialog. If the help window is open, you can browse and search for further information using links, table of contents, and search.

4.13.1 Displaying help

To display the context help

1. Enable the "Help" icon on the toolbar.



2. Tap the parameter for which you need information.

   The "Help" window opens and displays the comprehensive description and the corresponding remote command. You can browse the help for further information.

To open a dialog help

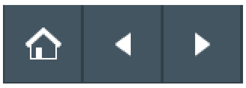
1. Open a dialog.
2. Tap the "Help" icon in the dialog header.
3. Tap a subtab or menu item.

   The help window opens with the dialog help page, where you can select the topics.

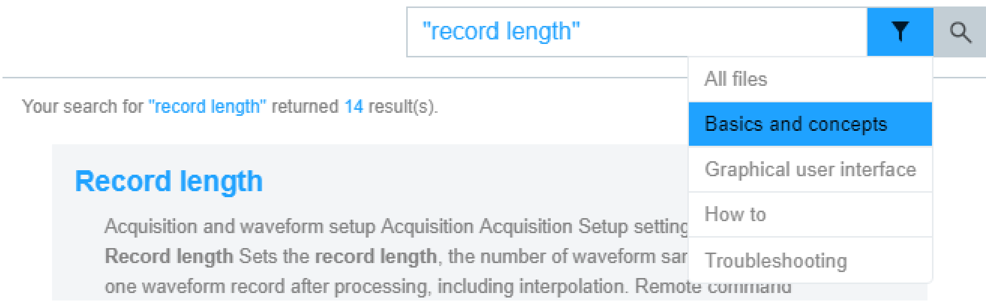
4.13.2 Using help

You can find a specific information and navigate the contents by following means:

- Table of contents
- Buttons in the help window title:

  – "Home": Go to the start page
  – "Back", "Forward": Browse the pages that you visited before
- Search with filter:

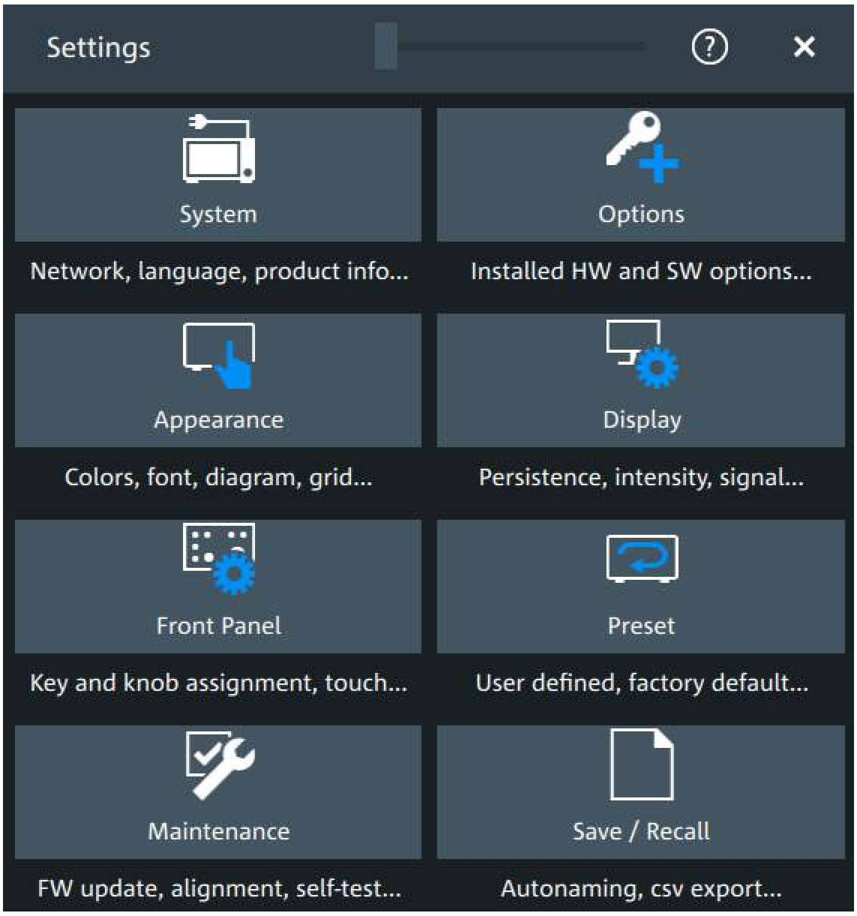


– Enter the word to be found, or a phrase in quotes.
– Tap the filter icon and select the information type.

5 Instrument setup

Access: "Menu" > "Settings".

In the "Settings" dialog, you can adapt various instrument settings to your requirements, such as language, display appearance, and assign functions to some keys.



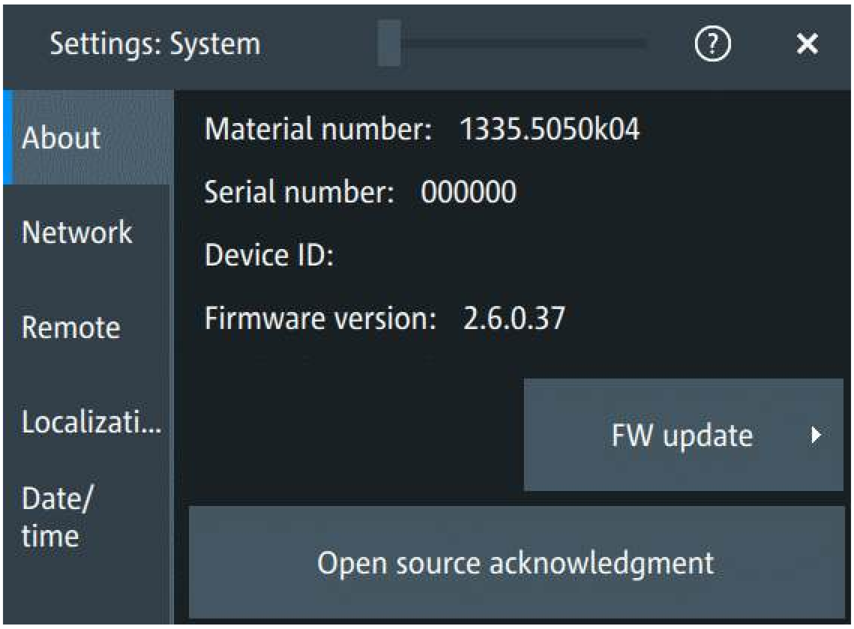
The following settings and procedures are described in the current section:

5.1 System settings

In the "Settings" > "System" dialog box, you find all instrument, firmware and network-related information. Here you can also set the language that is used in the dialogs.

5.1.1 About settings

Access: "Menu" > "Settings" > "System" > "About".



Instrument
Displays general information about the instrument, including:

- "Material number"
- "Serial number"
- "Device ID"
- "Firmware version"

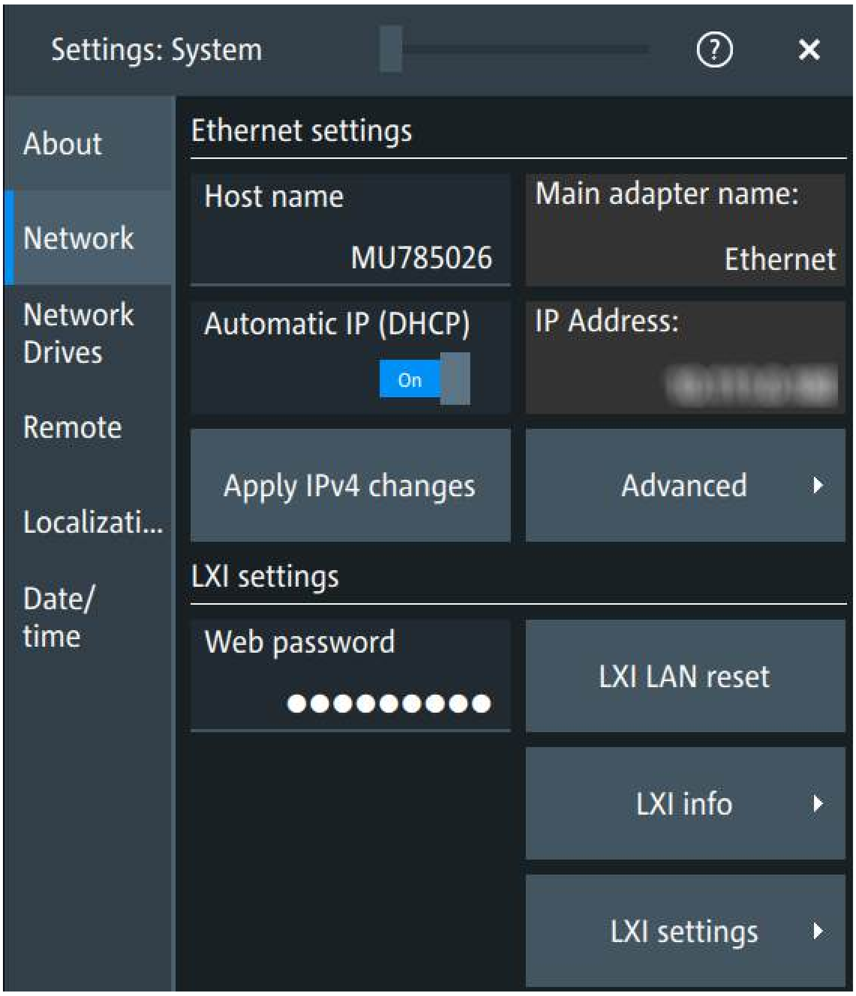
Remote command:
`*IDN?` on page 811

FW update
Opens the "FW update" dialog box. See Section 5.7.1, "Firmware update", on page 109.

Open source acknowledgment
Displays the "Open Source Acknowledgment" document.

5.1.2 Network settings

Access: "Menu" > "Settings" > "System" > "Network".



Host name

Indicates the currently defined host name. This value is required to configure the instrument for work in a network.

You can change the host name here. After changing the host name, you have to reboot the instrument.

NOTICE! Risk of network problems. Incorrect configuration of the host name can create network problems. Consult your network administrator before changing the name.

Remote command:

`SYSTem:COMMunicate:NET[:HOSTname]` on page 817

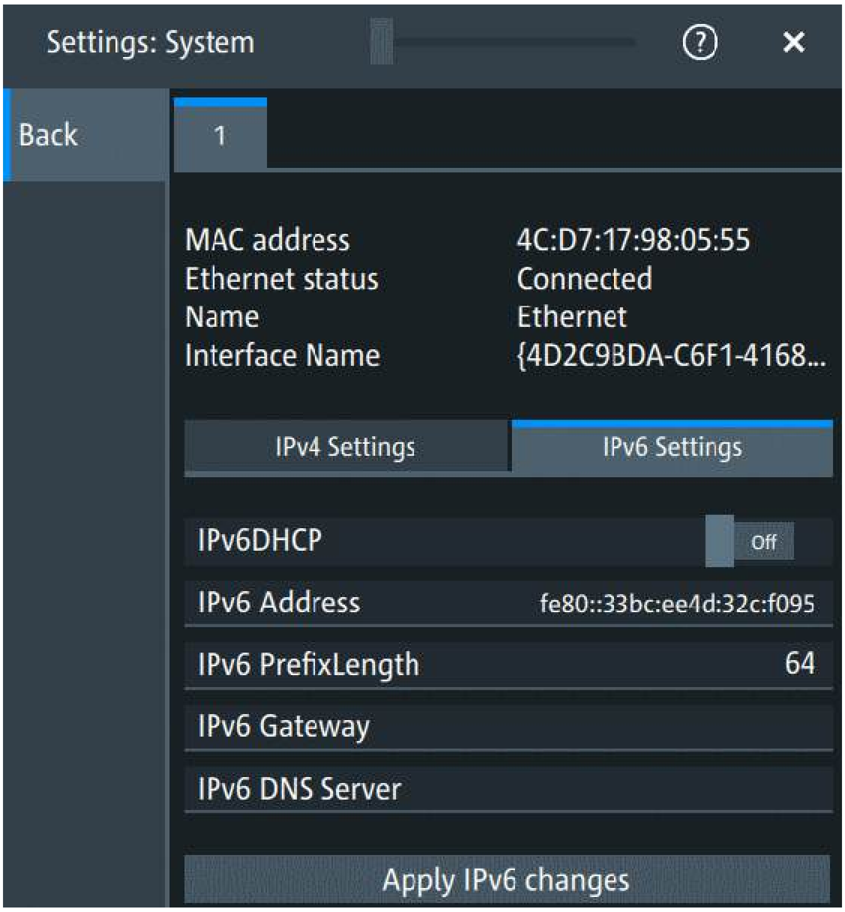
Automatic IP (DHCP)

If enabled, the IP address of the oscilloscope is obtained automatically.

IP address

Shows the current IP address of the instrument. If "Automatic IP (DHCP)" is "Off", you can change the IP address here. For complete manual configuration, select "Advanced". See also: Section 17.1, "Connecting the instrument to the network (LAN)", on page 770.

Advanced
Opens a dialog box to configure the network connection.



You need these settings to configure the LAN connection manually, without DHCP.

NOTICE! Connection errors can affect the entire network. Make sure to assign valid address information before connecting the instrument to the LAN. Contact your network administrator to obtain a valid IP address and other connection data.

See also: Section 17.1, "Connecting the instrument to the network (LAN)", on page 770.

Web password
Password for LAN configuration. The default password is *LxiWebIfc*.

LXI LAN reset
Resets the LAN configuration to its default configuration. Use the reset when you cannot access the instrument via LAN due to invalid configuration.

The LAN settings are configured in the "Advanced" dialog, or using the instrument's web browser (see Section 17.3, "Web interface", on page 783).

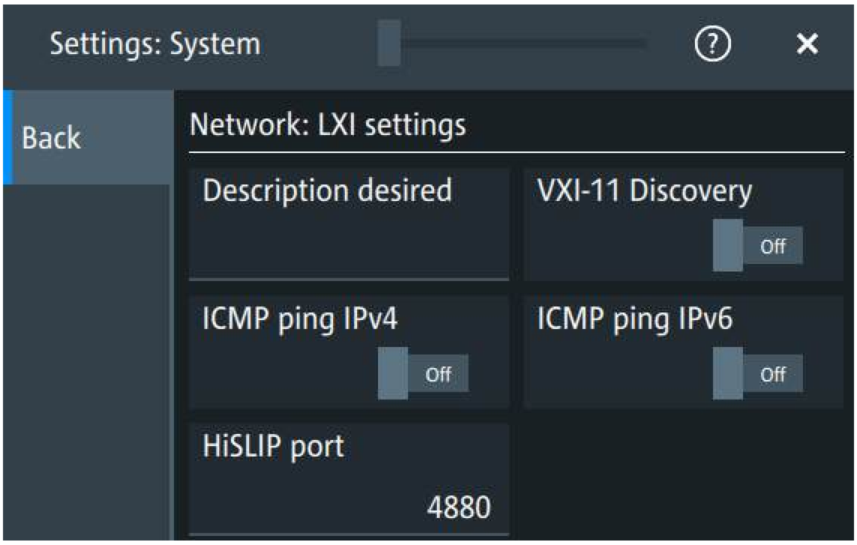
The LAN reset uses the LAN Configuration Initialize (LCI) reset mechanism for the instrument. According to the LXI standard, a LAN reset must set the following network parameters to a default state:

Parameter	Value
TCP/IP mode	DHCP + auto IP address
Dynamic DNS	Enabled
ICMP ping	Enabled
Password for LAN configuration	LxiWebIfc

LXI info
Opens a dialog with relevant LXI information. You can reload the information, for example, after changing connection data in the instrument's web browser.

For information on the LXI standard, refer to the LXI website at https://www.lxistandard.org.

LXI settings
Opens a dialog with important LXI settings. These settings are also available in the instrument's web browser.



Description desired ← LXI settings
Network description of the instrument.

VXI-11 Discovery ← LXI settings
Enables the automatic detection in a LAN via the VXI-11 discovery protocol and programming by IVI drivers.

ICMP ping IPv4, ICMP ping IPv6 ← LXI settings
Enables the ping utility to verify the connection between the LXI-compliant instrument and another device. Ping is useful for diagnosing IP network or router failures. The ping utility is not password-protected.

HiSLIP port ← LXI settings
Sets the port that is used by the High Speed LAN Instrument Protocol (HiSLIP).

5.1.3 Network drive mapping

You can map up to 8 network drives or shared folders to the MXO 4 and store the measurement data directly in one of these folders.

Requirements:

- The MXO 4 and the target folder must be in the same network. Connection is established via DHCP. Direct connection is not supported.
- You need administrative rights and credentials to access the folder.
- Make sure that the network connection is not restricted by security settings.

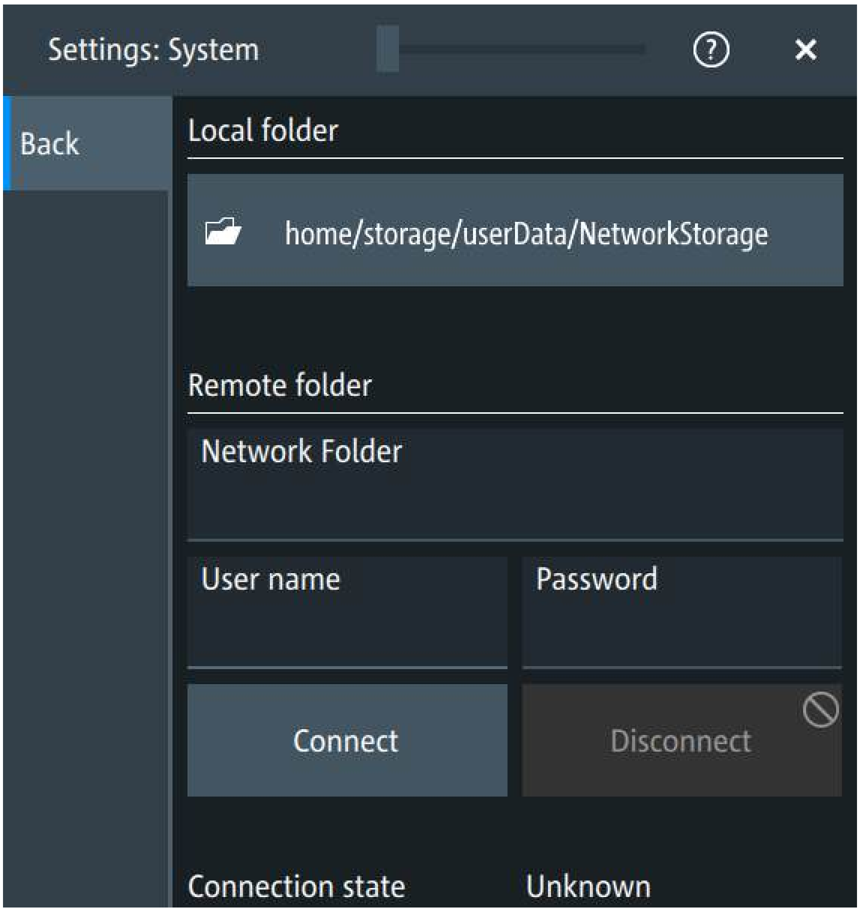
5.1.3.1 Connecting a network drive

1. Open "Menu" > "Settings" > "System" > "Network Drives".
2. Select "+ Add".
3. Tap the "Empty" button.
4. Enter the "Local folder" on the MXO 4, the "Network folder", and access credentials. For details, see Section 5.1.3.2, "Network drive settings", on page 87.
5. Tap "Connect".

If you want to connect a folder on your personal computer, share this folder and give full permissions to all users before you connect the folder to the MXO 4: Folder properties > "Sharing" > "Advanced Sharing".

5.1.3.2 Network drive settings

Access: "Menu" > "Settings" > "System" > "Network Drives" > "+ Add" > select drive



Local folder
Set the local folder on the MXO 4, to which the network folder is mapped. Under this name, you find the connected folder in the file browser on the instrument and in the "File manager" of the web interface.

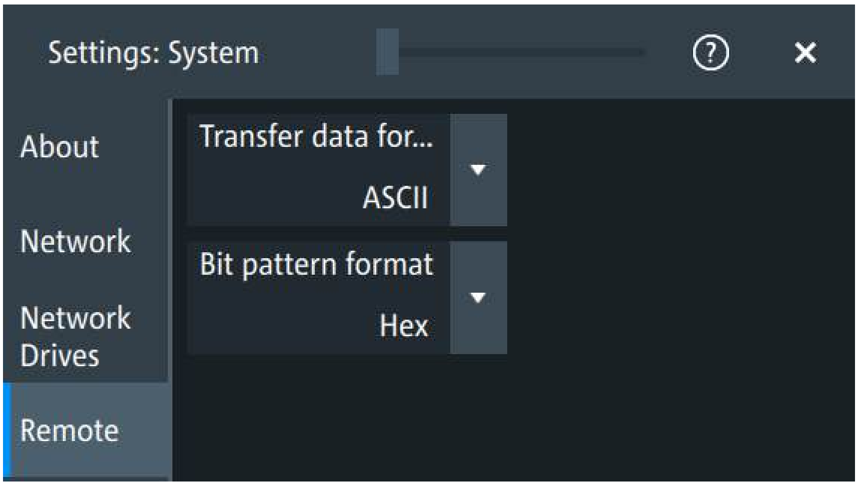
Network folder
Sets the network folder that is mapped to the local folder. Use the full path in UNC syntax, for example, `\\net1\data\team1\osc`.

User name, Password
Enter the user name and the password to access the network folder.

Connect, Disconnect, Connection state
Connect or disconnects the remote network folder to the local folder. An "Info" message informs on success or failure, and the overall connection state is shown in the dialog.

5.1.4 Remote settings

Access: "Menu" > "Settings" > "System" > "Remote".



The following settings are required for remote control and data transfer via a connected computer.

Transfer data format
Selects the data format that is used for transmission of waveform data from the MXO 4 to the controlling computer.

If you need physical data (e.g. in Volt or Ampere) for further analysis, use the floating point formats for export. No data conversion is needed.

"Ascii"	Data values are returned in ASCII format as a list of comma-separated values in floating point format.
"FLOAT"	Binary format. Up to 7 significant digits are stored (32 bit). If there are more than 7 digits, the number is rounded off.
"DOUBLE"	Binary format. Up to 15 significant digits of the numbers (64 bit) are stored.
"INT8/16/32"	Signed integer data with length 8/16/ 32 bit.

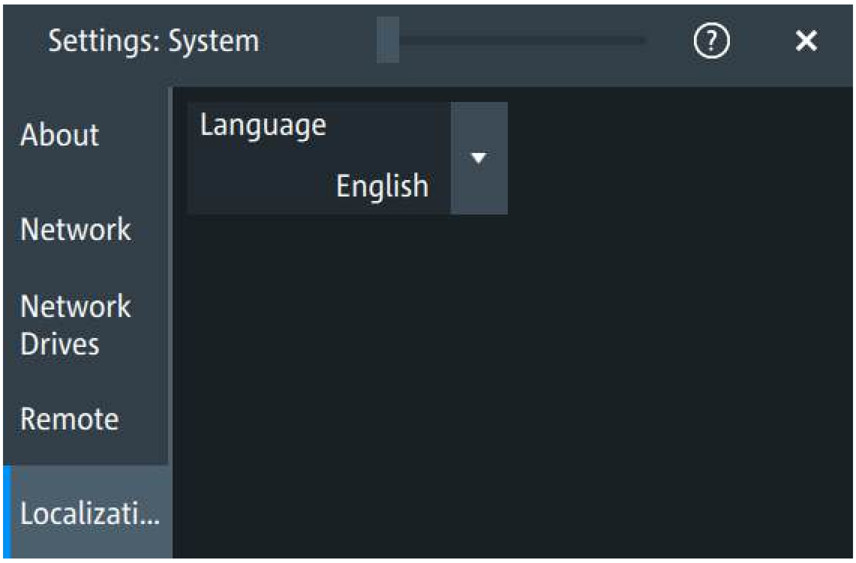
Remote command:
`FORMat[:DATA]` on page 814

Bit pattern format
Sets the format for all bit pattern queries.

Remote command:
`FORMat:BPATtern` on page 815

5.1.5 Localization settings

Access: "Menu" > "Settings" > "System" > "Localization".

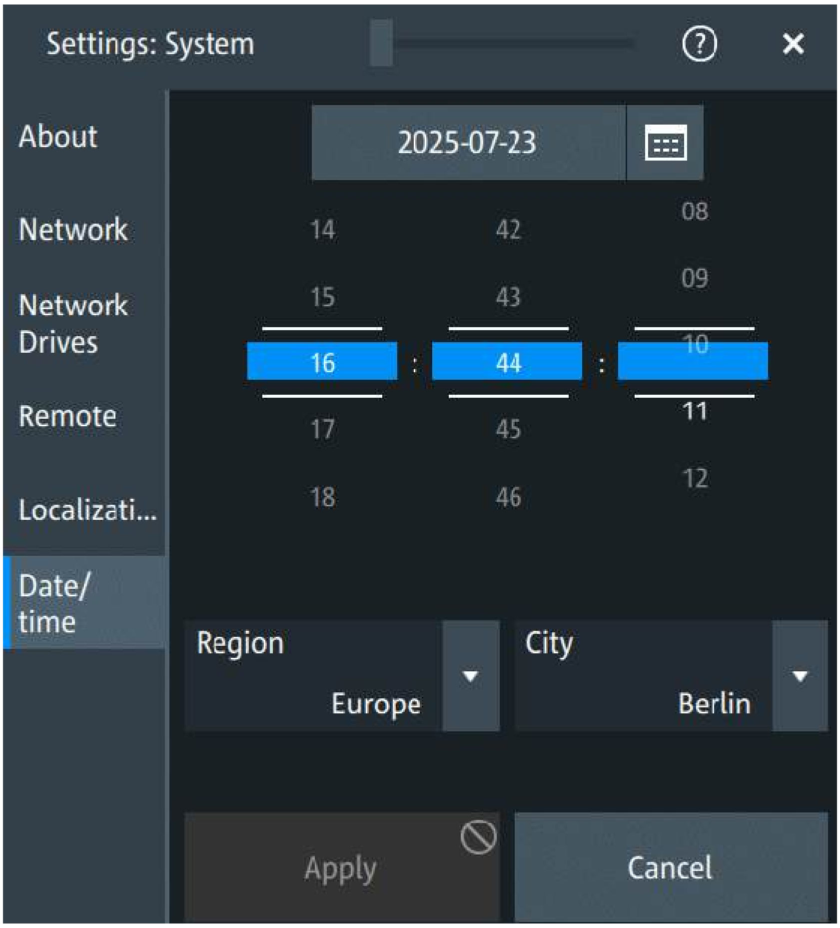


Language
Selects the language in which the menu, dialogs, results and other screen information is displayed. You can change the language on runtime.

Available languages are, for example, English, German, French, Japanese. For a complete list of supported languages, refer to the specifications document.

5.1.6 Date and time settings

Access: "Menu" > "Settings" > "System" > "Date/time".



The instrument uses the system time of the operating system, but you can change date and time for the MXO 4 firmware.

1. To change the date:
   a) Tap the date button.
   b) Select the date in the calendar.
   c) Tap the blue calendar icon to close the calendar.
2. To change the time, move the hour, minute and second sliders to the required values.
3. Adjust the "Region" and "City" to indicate your location.
4. Tap "Apply".

Remote command:
- `SYSTem:DATE` on page 817
- `SYSTem:TIME` on page 818

5.2 Option settings

Additional options for the MXO 4 are enabled using a license key. To obtain the license key, consult your sales representative.

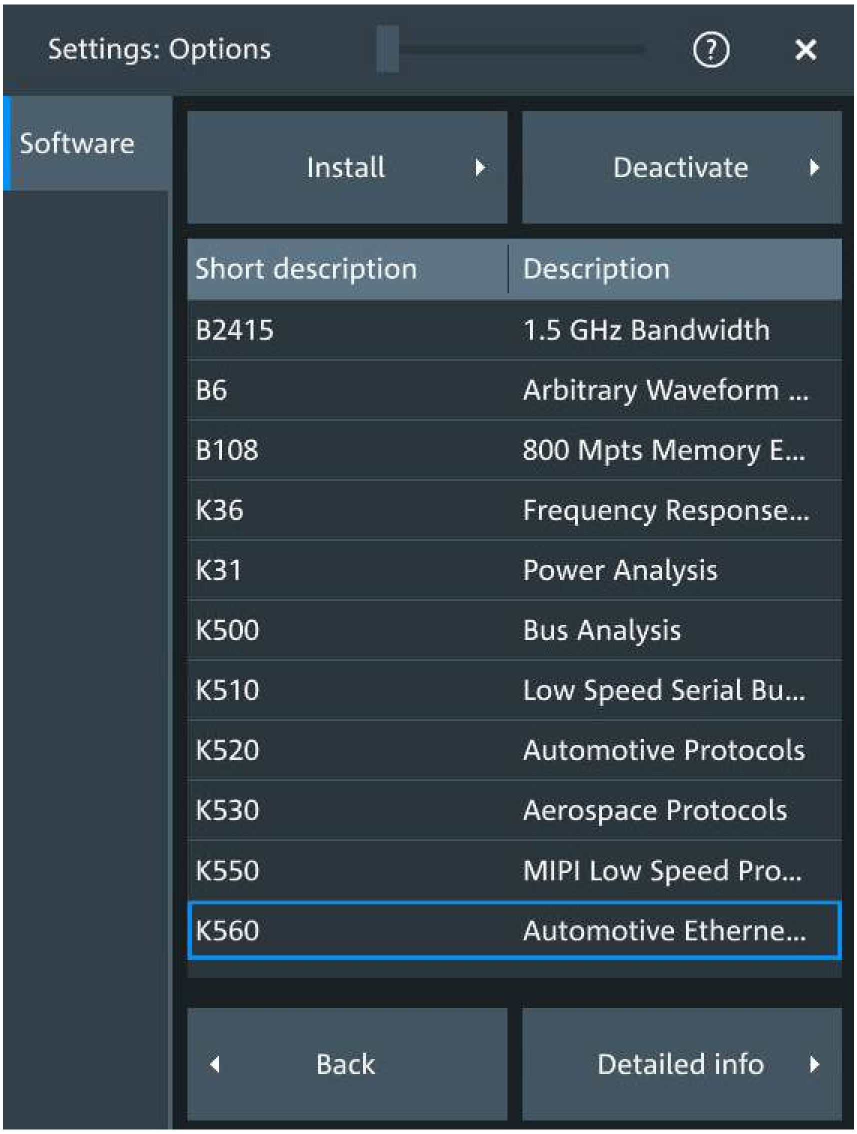
You can obtain registered or unregistered licenses.

Unregistered licenses

Unregistered licenses are not assigned to a particular instrument. The instrument accepts only registered licenses. If your license is delivered unregistered, use the online tool R&S License Manager to register the license for your instrument. The registration of a permanent license is irreversible, so ensure that you register it for the correct instrument. The address of the tool is https://extranet.rohde-schwarz.com/service. For registration, you need the device ID of the instrument on which the option will be installed.

5.2.1 Software options settings

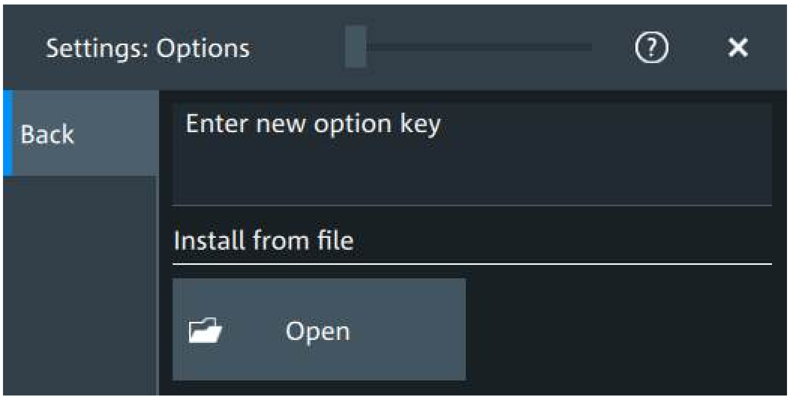
Access: "Settings" > "Options" > "Software"



In this dialog, you can access settings for installing and deactivating options. In the "Detailed Info" dialog, you can get an overview of all options installed on your MXO 4.

5.2.1.1 Install options

Access: "Settings" > "Options" > "Software" > "Install"



In the "Install" tab, you can install new options using license keys.

Enter new option key
Enter the license key here to activate the option. For license keys delivered as a file, use "Install from file" on page 94.

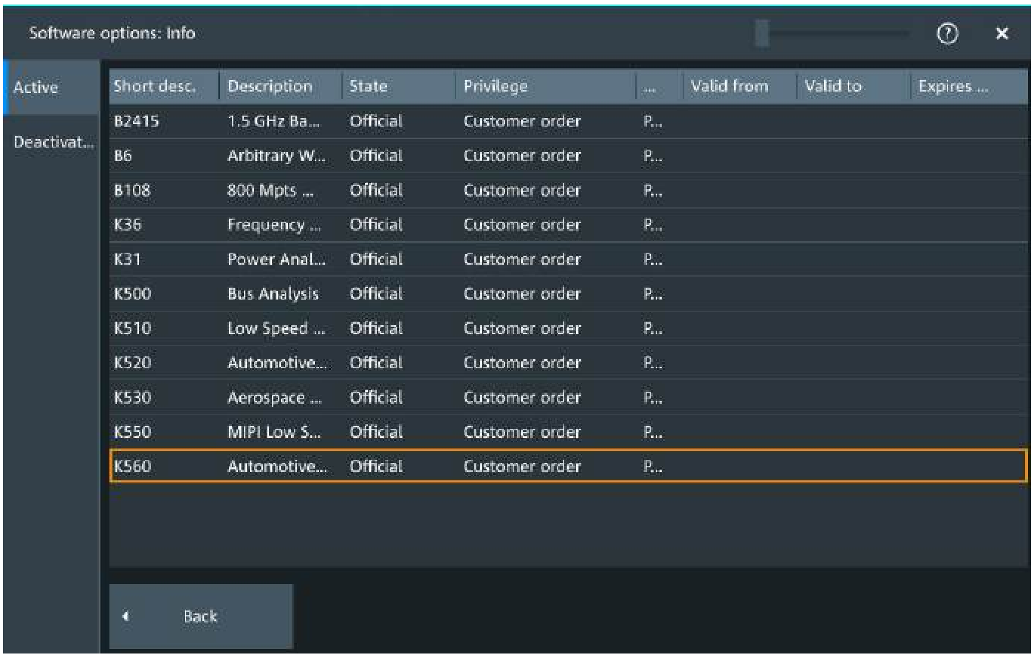
Install from file
If you got a license file, install the license here.

Tap "Open" to open the file selection dialog, or enter the complete path and filename.

5.2.1.2 Deactivate options

Access: "Settings" > "Options" > "Software" > "Deactivate"

When you deactivate an option, note the response key, or to save the response to a file. For deactivation, use the "Deactivate" dialog.



5.3 Appearance settings

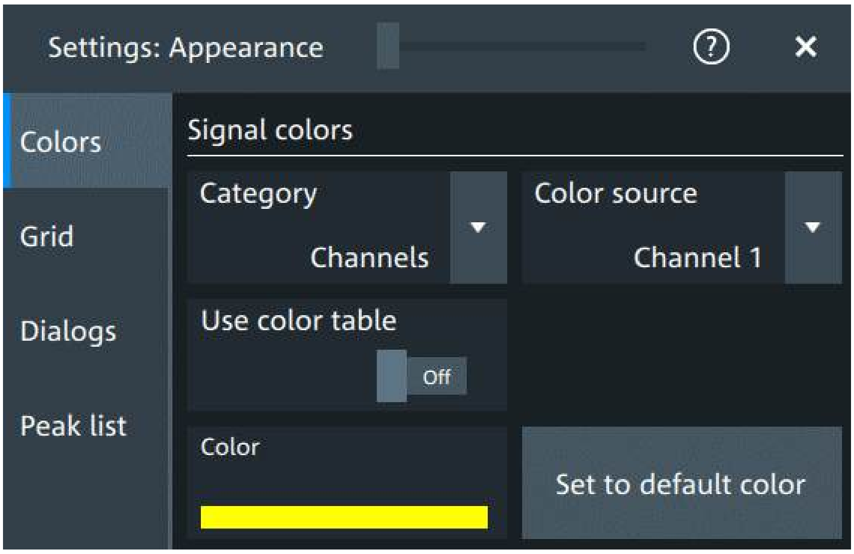
In the "Settings" > "Appearance" dialog box, you define the look and feel of the display element, e.g. waveform colors, result position, or grid behavior.

Appearance settings are not included in user-defined presets. To reset all appearance settings at once, use the factory preset.

5.3.1 Colors

Access: "Settings" > "Appearance" > "Colors"

By default, various colors are assigned to the different waveform types for better visibility and distinguishability. You can change the color assignment and assign another color or a color table to waveforms. For digital channels, you can select any color, or use the default color with state coloring.



Category
Selects the category of the waveform, e.g. "Channels", "Math", "Reference".

You can then select one of the waveforms of the selected category with "Color source".

Color source
Selects the waveform to which the color or the color table is assigned.

Use color table
If enabled, the selected waveform is displayed according to its assigned color table.

If disabled, the selected color is displayed, and the intensity of the signal color varies according to the cumulative occurrence of the values.

The setting is not available for digital channels and parallel buses.

Remote command:
`DISPlay:COLor:SIGNal:USE` on page 839

Assigned color table

Assigns a color table to the source waveform instead of a dedicated color. Color tables define the color of the waveform pixels depending on the cumulative occurrence of the associated values.

The following color tables are provided:

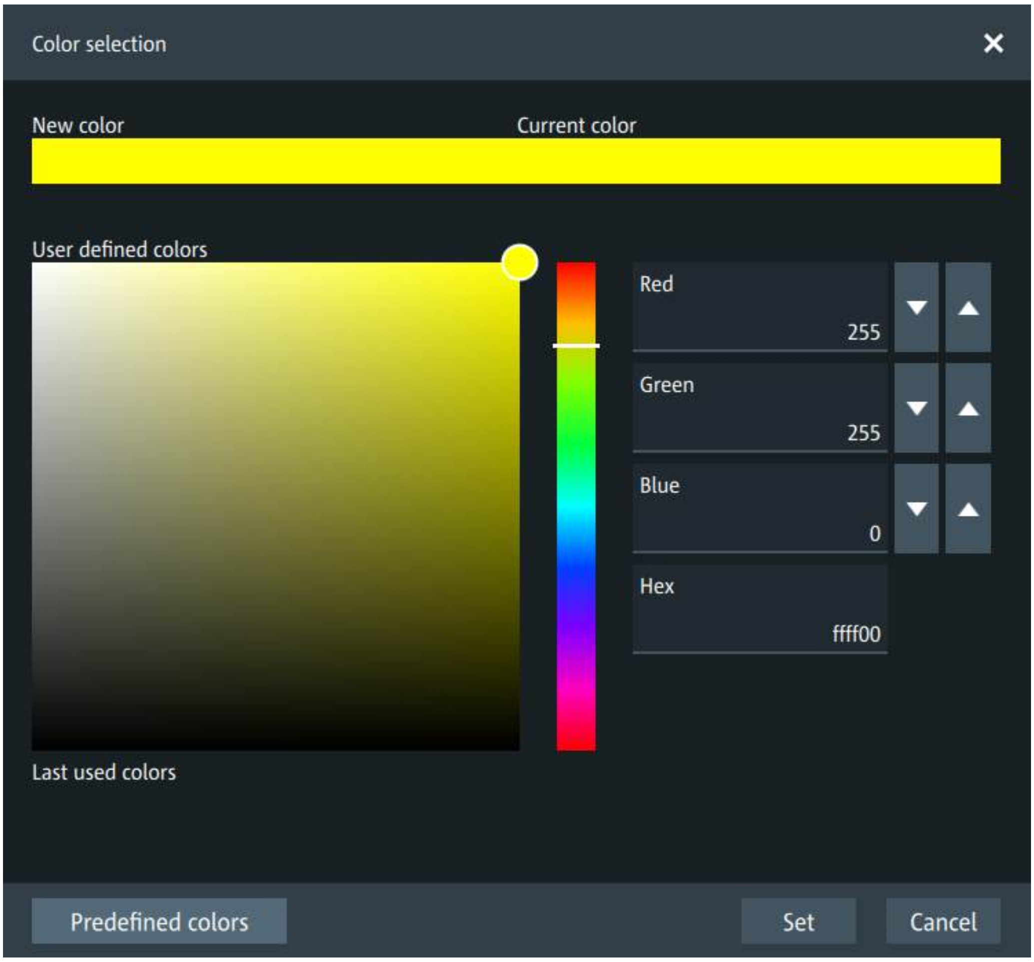
- "False colors": color changes gradually in a wide color spectrum.
- "Single Event": single events and seldom events appear yellow, a higher cumulative occurrence is shown with blue color. This view helps to identify specific events.
- "Spectrum": colors display the wavelengths of the light. Low cumulative occurrence is displayed blue like high wavelength.
- "Temperature": color changes gradually from blue (low temperature) to red (high temperature) with increasing cumulative occurrence.

Remote command:
`DISPlay:COLor:SIGNal:ASSign` on page 839

Color

Shows the current color of the selected waveform. To change the color, tap the button.

In the "Color" dialog, you can pick from a list of basic colors. To define another color, select "User defined colors", and adjust the color settings.



The color of the waveform, its signal icon, and the illuminated keys are adjusted to the new color. If the waveform is a spectrum, the knobs for vertical scale and position retain the color of the spectrum's source.

Remote command:
`DISPlay:COLor:SIGNal:COLor` on page 838

Set to default color

Resets the color of the selected waveform to the factory default.

Remote command:
`DISPlay:COLor:SIGNal:COLor <Signal>,DEF`

Use state coloring

The setting is available for digital channels and logic buses.

If enabled, the high and low levels and the state transition get different predefined colors.

If disabled, you can select a color for the digital channel or bus. The channel is displayed with the selected color, and the high level has a thicker line than the low level.

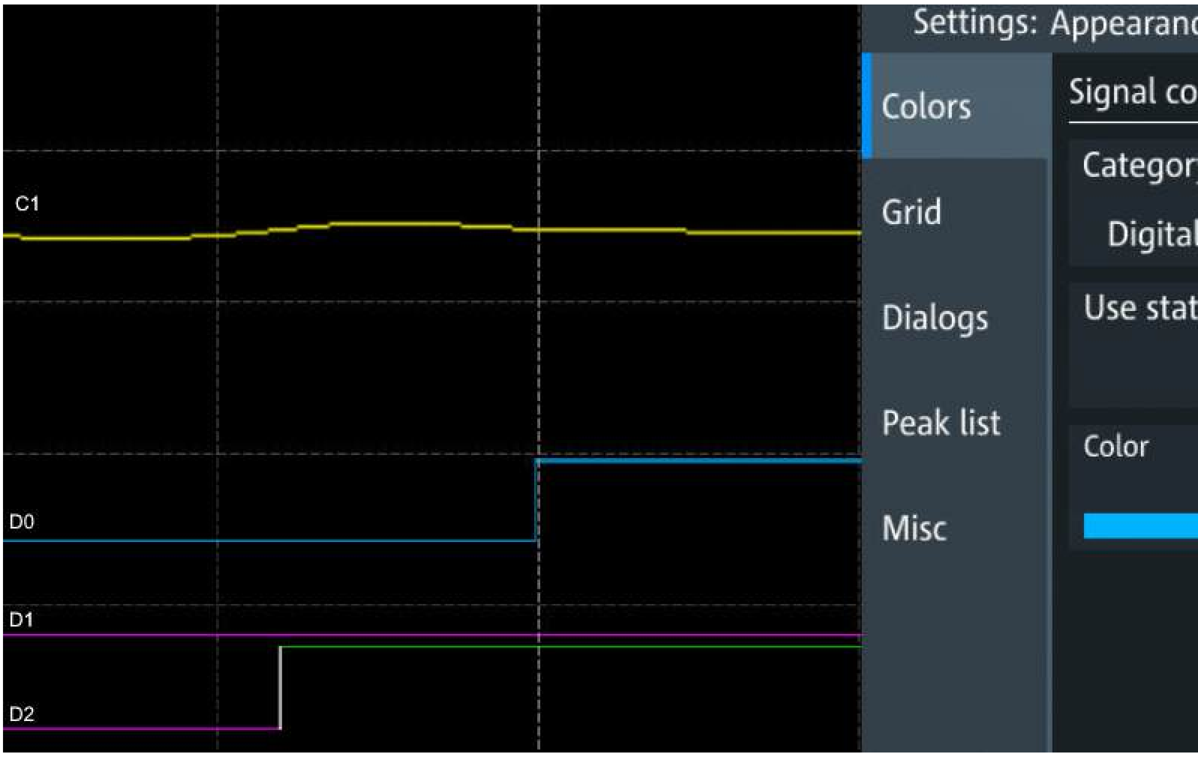
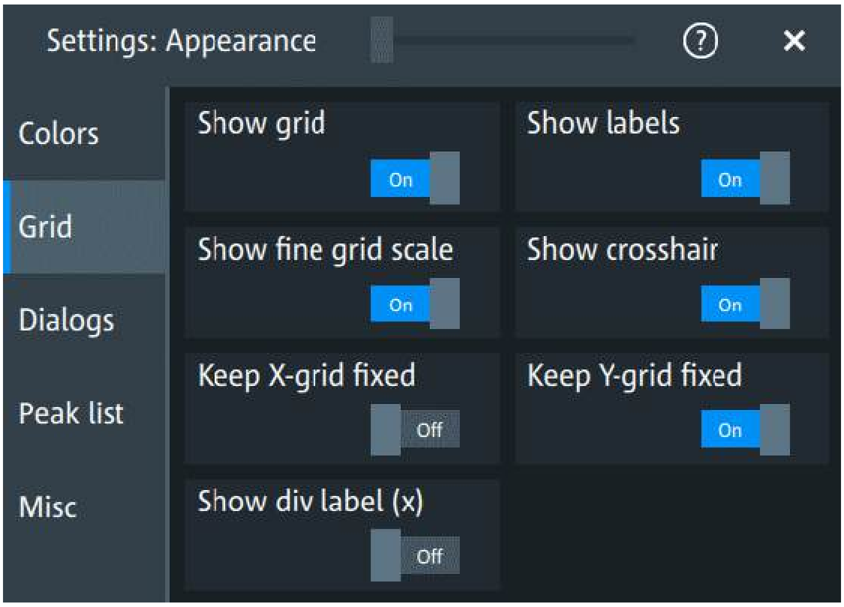


Figure 5-1: D0 has a selected color (blue). D1 and D2 have state coloring. D1 is on low level, D2 changes from low to high.

5.3.2 Grid

Access: "Settings" > "Appearance" > "Grid"



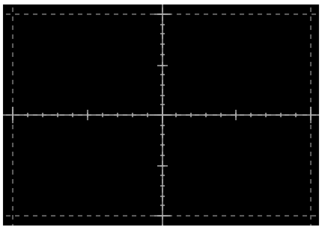
Show grid
If selected, a grid is displayed in the diagram area. A grid helps you associate a specific data point to its exact value on the x- or y-axis.

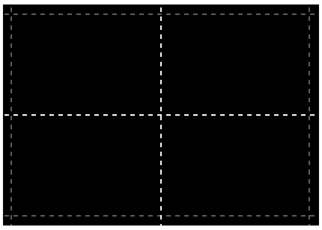
Remote command:
DISPlay:DIAGram:GRID on page 841

Show labels
If selected, labels mark values on the x- and y-axes in specified intervals in the diagram.

Remote command:
DISPlay:DIAGram:LABels on page 841

Show fine grid scale
If selected, the crosshair is displayed as a ruler with scale markers. If disabled, the crosshair is shown as dashed lines.





Remote command:
DISPlay:DIAGram:FINegrid on page 841

Show crosshair
If selected, a crosshair is displayed in the diagram area. A crosshair allows you to select a specific data point by its coordinates.

Remote command:
DISPlay:DIAGram:CROSshair on page 841

Keep X-grid fixed
If enabled, the vertical grid lines remain in their position when the horizontal position is changed. Only the values at the grid lines are adapted.

Remote command:
DISPlay:DIAGram:XFIXed on page 842

Keep Y-grid fixed
If enabled, the horizontal grid lines remain in their position when the position of the curve is changed. Only the values at the grid lines are adapted.

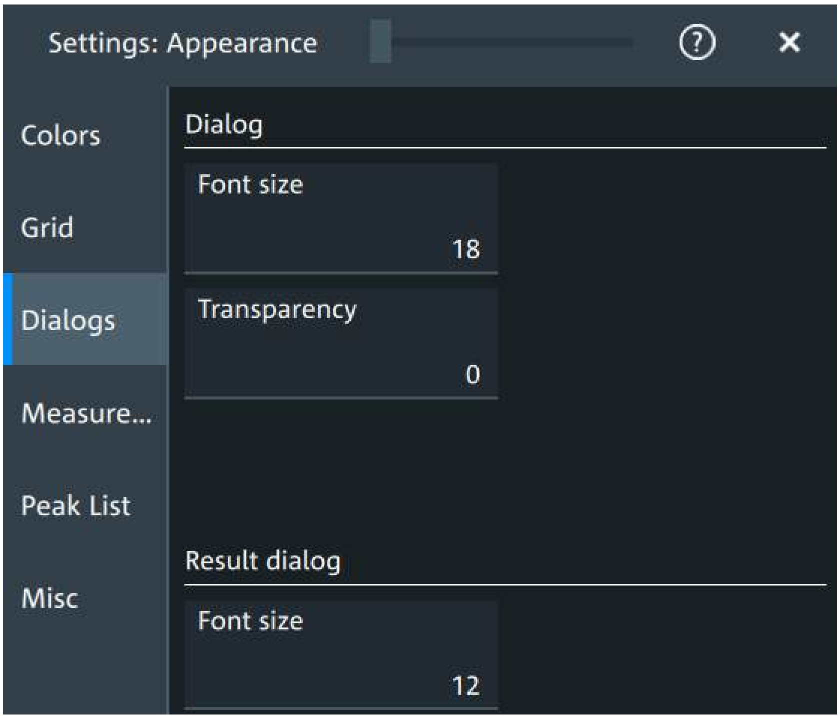
Fixed horizontal grid lines correspond to the behavior of traditional oscilloscopes.

Remote command:
DISPlay:DIAGram:YFIXed on page 842

Show div label (x)
If selected, the time scale value is shown at the diagram bottom instead of the horizontal grid labels. For example, 10 ns/div is shown instead of the values 0, 10, 20, 30... ns.

5.3.3 Dialogs

Access: "Settings" > "Appearance" > "Dialogs"



Font size (Dialog)
Sets the font size of the text in dialog boxes.

Remote command:
DISPlay:DIALog:FONTsize on page 842

Transparency (Dialog)
Sets the transparency of the dialog box background. For high transparency values, you can see the waveform display in the background, and possibly check the effect of the changed setting. For lower transparency values, readability in the dialog box improves.

You can also set the dialog transparency by moving the transparency bar at the top of the dialog.

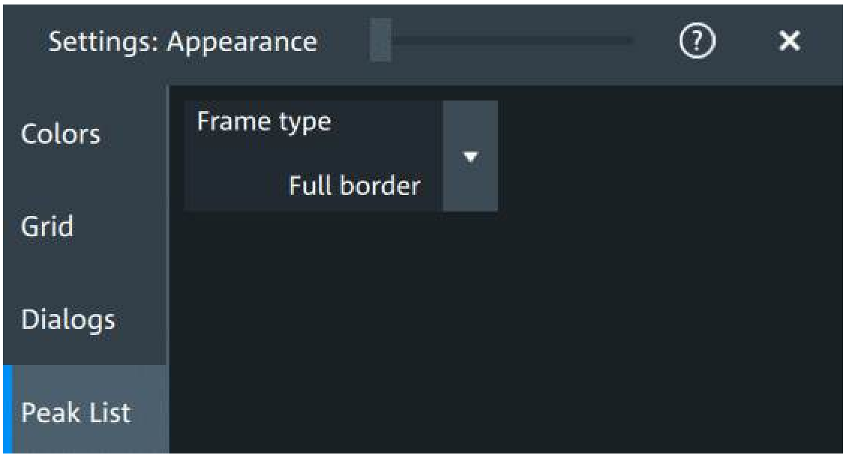
Remote command:
DISPlay:DIALog:TRANsparency on page 843

Font size (Result dialog)
Sets the font size of the text in result tables.

Remote command:
DISPlay:RESult:FONTsize on page 843

5.3.4 Peak list

Access: "Settings" > "Appearance" > "Peak list"



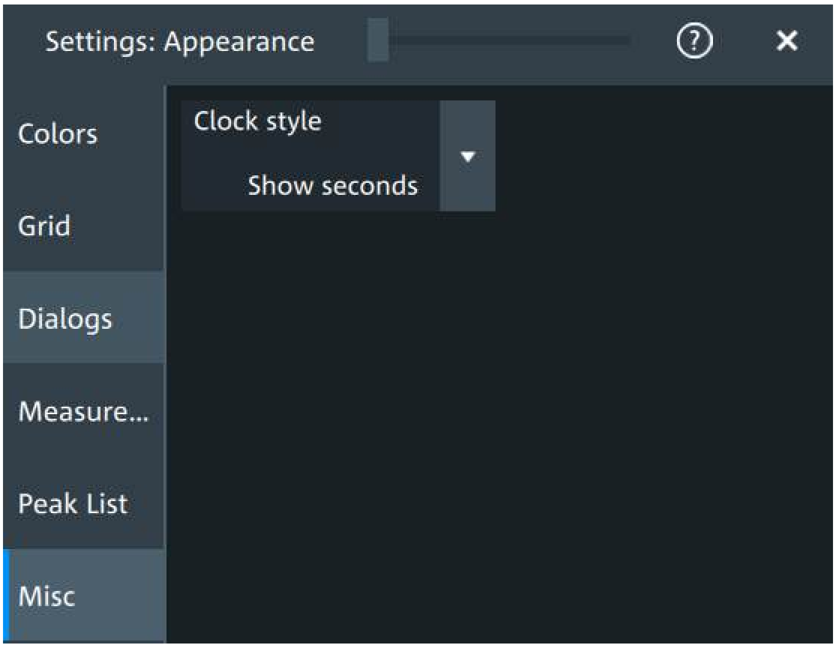
Peak list settings apply to peak list measurements. They are visible when the peak list for spectrum measurements is enabled.

Frame type
Defines the layout of the labels, full border or none.

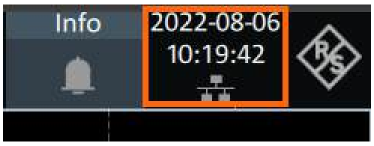
Remote command:
CALCulate:SPECtrum<sp>:PLISt:LABel:BORDer on page 843

5.3.5 Miscellaneous

Access: "Settings" > "Appearance" > "Misc"



Clock style
Select how the clock in the upper right corner of the screen is displayed:



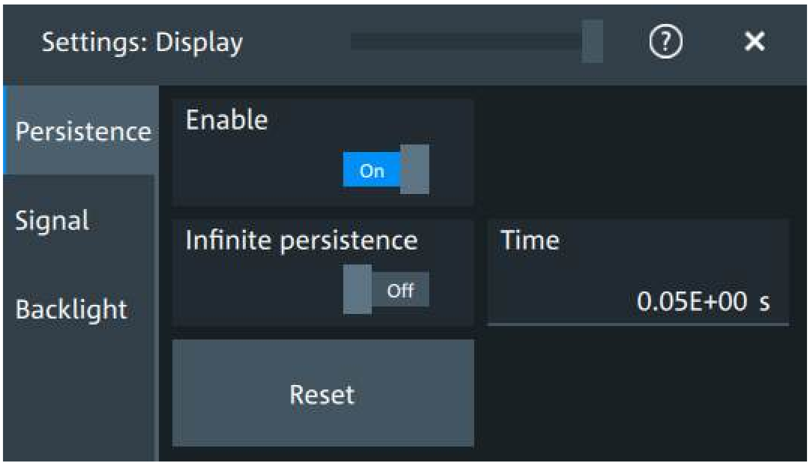
- "Show seconds": format is hh:mm:ss
- "Hide seconds": format is hh:mm
- "Hide clock": no time is shown

5.4 Display settings

In the "Settings" > "Display" dialog, you can define the display settings like brightness and signal intensity.

5.4.1 Persistence settings

Access: "Menu" > "Settings" > "Display" > "Persistence".



Enable
If enabled, each new data point in the diagram area remains on the screen for the duration that is defined using Time, or as long as Infinite persistence is enabled.

If disabled, the waveform points are displayed only for the current acquisition.

Remote command:
`DISPlay:PERSistence[:STATe]` on page 845

Infinite persistence
If infinite persistence is enabled, each new waveform point remains on the screen until this option is disabled. Use infinite persistence to display rare events in the signal.

Remote command:
`DISPlay:PERSistence:INFinite` on page 844

Time
Sets a time factor that controls how long the waveforms points fade away from the display. Thus, the MXO 4 emulates the persistence of analog phosphor screens.

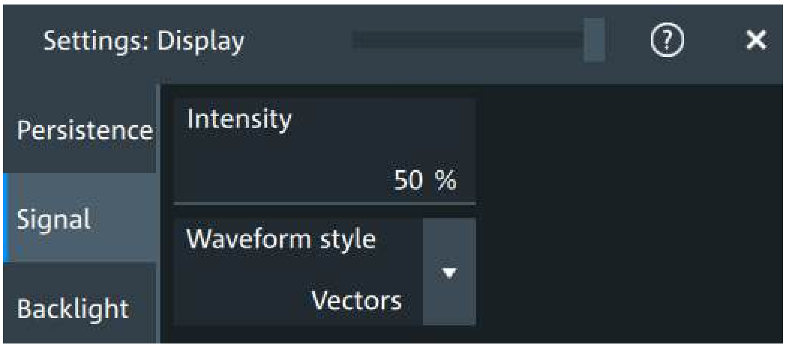
Remote command:
`DISPlay:PERSistence:TIME` on page 844

Reset
Resets the display, removing persistent all waveform points.

Remote command:
`DISPlay:PERSistence:RESet` on page 844

5.4.2 Signal settings

Access: "Menu" > "Settings" > "Display" > "Signal".



Intensity
The intensity determines the strength of the waveform line in the diagram. Enter a percentage between 0 (not visible) and 100% (strong). The default value is 50%.

You can also use the [Intensity] knob to adjust the waveform intensity directly.

Remote command:
`DISPlay:INTensity` on page 845

Waveform style
Selects the style in which the waveform is displayed.

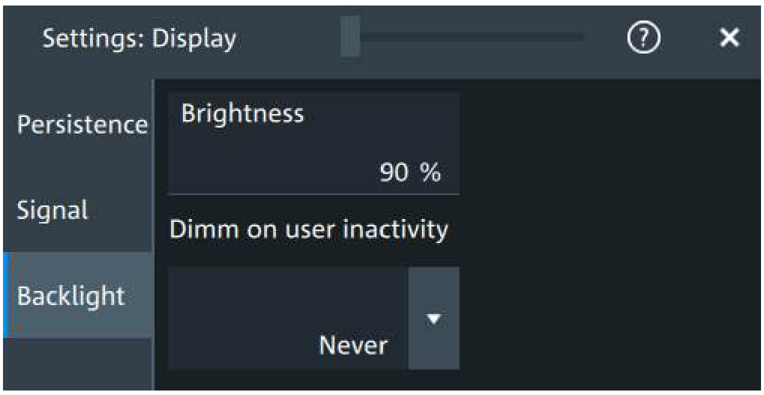
"Vectors" The individual waveform points are connected by a line.
Define the strength of the line using the [Intensity] knob.

"Dots" Only the individual waveform points are displayed.
To see the dots of one waveform, perform one acquisition with [Single] and N=1 (N-single/Avg count). During continuous acquisition, or a [Single] acquisition with N > 1, the dots of multiple subsequent waveforms are displayed on the screen, and the waveform looks like a line.

Remote command:
`DISPlay:DIAGram:STYLe` on page 845

5.4.3 Backlight settings

Access: "Menu" > "Settings" > "Display" > "Backlight".



Brightness
Sets the background luminosity of the touchscreen.

Remote command:
`DISPlay:BACKlight[:BRIGtness]` on page 846

Dimm on user inactivity
Selects a time, after which the monitor brightness is reduced, if the instrument was inactive. Remote control of the instrument is also considered as an activity.

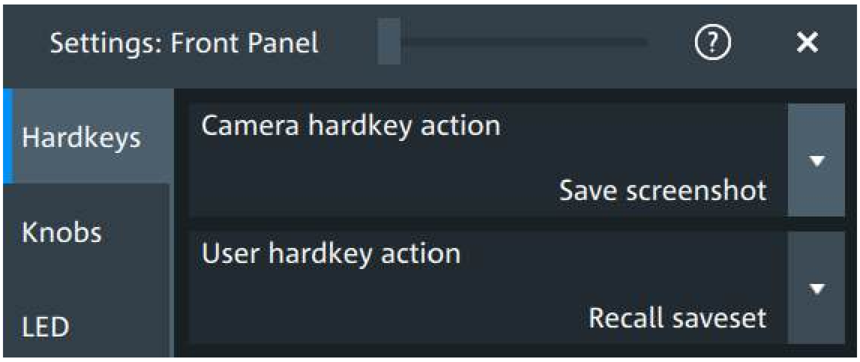
Remote command:
`DISPlay:BACKlight:DIMMing` on page 846

5.5 Front panel settings

In the "Front panel" dialog box, you can assign functions to keys and knobs and adjust the brightness of the keys.

5.5.1 Hardkeys: function assignment

Access: "Settings" > "Front panel" > "Hardkeys"



Camera hardkey action
The Camera key on the bottom right is a shortcut key that initiates an associated action.

You can assign one of the following actions:
- Save screenshot
- Open screenshot setup

Configure the settings for the selected action.
- Screenshots: "Save/recall" key > "Save" tab > "Screenshot", see Section 13.6, "Screenshots", on page 425.

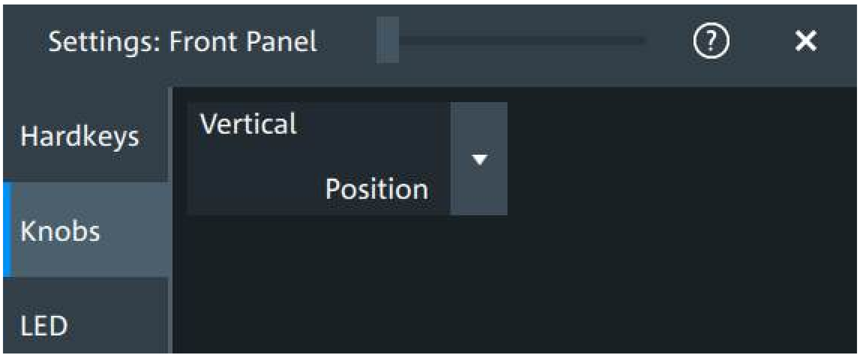
User hardkey action
The [User] key below the spectrum keys is a shortcut key that initiates an associated action.

You can assign one of the following actions:
- Force trigger
- Save saveset
- Recall saveset

For details of saveset configuration, see Section 13.1, "General and measurement settings: savesets", on page 397.

5.5.2 Knobs

Access: "Settings" > "Front panel" > "Knobs"

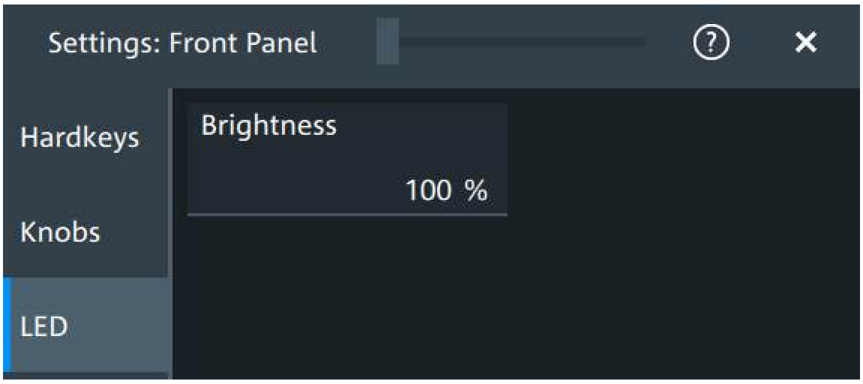


Vertical
The vertical Position knob can change the waveform position or the offset of the selected waveform. Select the action that you want to perform.

See also: "[Position]" on page 48.

5.5.3 LED

Access: "Settings" > "Front panel" > "LED".



Brightness
Defines the luminosity of illuminated front panel keys and knobs.

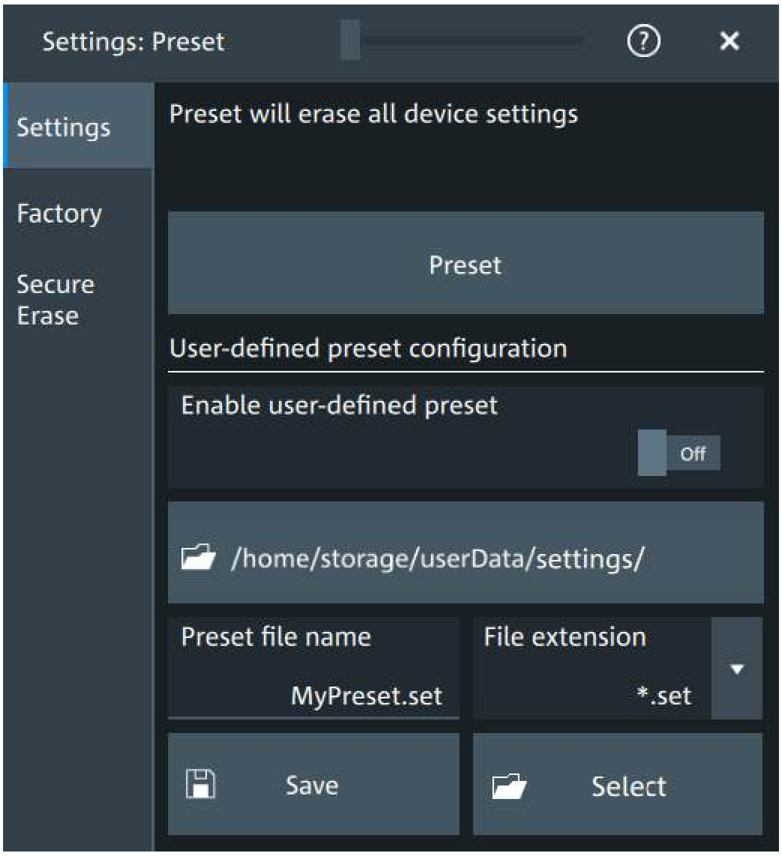
5.6 Preset setup

The preset sets the MXO 4 to a default configuration, or to a user-defined configuration. A user-defined preset file is one of the saveset files, which are stored locally. It contains the measurement setup, while the user's display settings are not included. You can save the current configuration to a preset file, and enable the saved preset file to be applied with the "Preset" toolbar icon.

See also: Section 13.1, "General and measurement settings: savesets", on page 397.

5.6.1 Preset settings

Access: "Menu" > "Settings" > "Preset" > "Settings".



Preset
Set the MXO 4 to a default configuration, or to a user-defined configuration.

Enable user-defined preset
If enabled, the settings from the selected saveset are restored when the [Preset] key is pressed.

If disabled, [Preset] sets the instrument to the factory defaults.

Remote command:
USERdefined:PRESet[:ENABle] on page 849

Preset file selection
Select the saveset file that contains the required settings.

<Directory>	Shows the currently used directory. To change the directory, tap the button and select the correct directory in the file dialog.
"Preset file name"	Enter the filename of the preset file. This file is loaded on user-defined preset. The filename is also used when you save a preset file with "Save".
"File extension"	The file extension is `.set`.

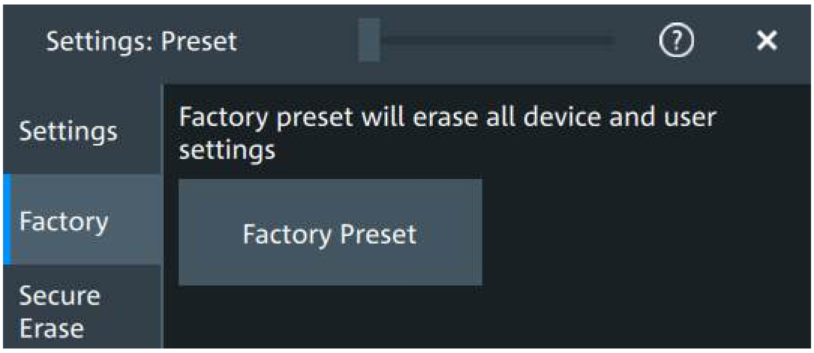
Remote command:
USERdefined:PRESet:NAME on page 849
USERdefined:PRESet:OPEN on page 849

Select, Save
"Select" opens the file selection dialog, where you can select the directory and enter the filename of the preset file. "Save" saves the current settings immediately to the file that is named in "Preset file name" in the current directory.

Remote command:
USERdefined:PRESet:SAVE on page 849

5.6.2 Factory preset

Access: "Menu" > "Settings" > "Preset" > "Factory".



Factory preset
Resets the MXO 4 to the factory default settings, to the initial state. Factory settings comprise all instrument settings.

Remote command:
SYSTem:PRESet on page 818

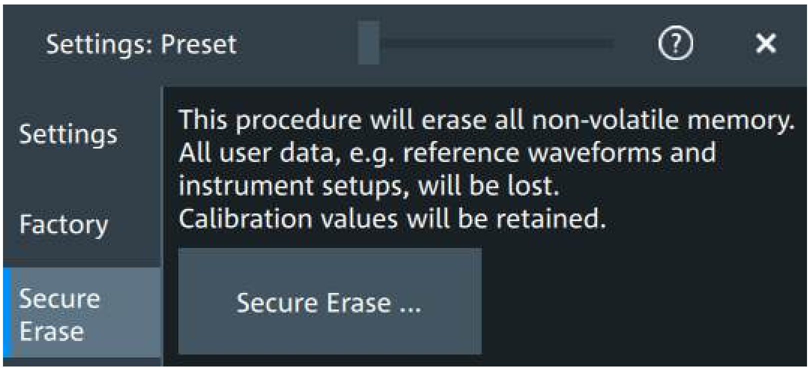
5.6.3 Secure erase

Access: "Menu" > "Settings" > "Preset" > "Secure erase"

To purge all non-volatile memory, a special delete function is available. This function erases all user data, including instrument setups and reference waveforms. Calibration data is retained on the instrument. The instrument reboots after erasing the data.

The procedure is required if user data must not leave the test area with the instrument, e.g. when working in highly secured environments.

For more information, refer also to "MXO 4 Instrument Security Procedures". It is available for download on the Rohde & Schwarz webpage.



5.6.4 Restoring settings

When you have changed many settings, and you are not sure which settings are causing which effect, you can restore the default settings and start anew. The following methods are available:

- Saving the settings as a user-defined preset and rest the settings to user-defined default values
- Restoring all settings on the MXO 4 to the factory-defined values
- Loading settings from a file

To save a user-defined preset

1. Open the "Menu" > "Settings" > "Preset" tab.
2. Enter a name for the preset file. Select the file format.
3. Tap "Save preset file".

   Note: If you want to store the file in another directory than the displayed one, select "Save as". See also: Section 13.7, "File browser dialog", on page 429.

To rest the settings to user-defined default values

1. Open the "Menu" > "Settings" > "Preset" > "Settings" tab.
2. In "Preset file name", enter the name of the file that contains the required settings.

3. To use these settings as preset values, select "Enable user-defined preset".
4. Tap "Preset".

   To preset the instrument whenever needed, press the [Preset] key.

To restore all settings to the factory defaults

1. Open the "Menu" > "Settings" > "Preset" > "Factory" tab.
2. Tap the "Factory preset" button.

   All settings on the MXO 4 are reset to their factory-defined values.
   As long as no user-defined preset file is loaded and "Enable user-defined preset" is disabled, the preset also resets the settings to factory defaults.

5.7 Maintenance settings

In the "Settings" > "Maintenance" dialog box, you can update the firmware, perform self-alignment.

5.7.1 Firmware update

Access: "Menu" > "Settings" >"Maintenance" > "FW update".

Your instrument is delivered with the latest firmware version. Firmware updates are provided on the internet at:

www.rohde-schwarz.com/firmware/mxo4.

The "Release Notes" describe the improvements and modifications of all firmware versions. They also explain how to update the firmware. They are available along with the firmware on the same web page.

Remote commands:

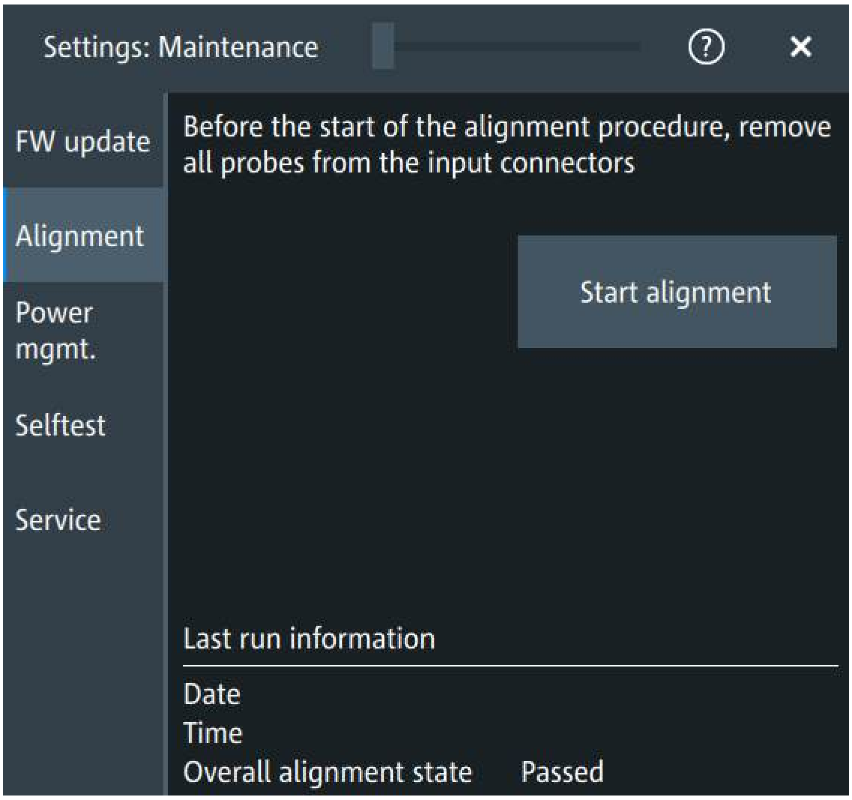
- `SYSTem:FW:FILepath` on page 818
- `SYSTem:FW:STARt` on page 818

5.7.2 Alignment

When data from several input channels is displayed at the same time, it can be necessary to align the data. Alignment is done vertically or horizontally to synchronize the time bases or amplitudes and positions. Perform an alignment, for example, when strong temperature changes occur (> 5°).

5.7.2.1 Alignment settings

Access: "Menu" > "Settings" > "Maintenance" > "Alignment"



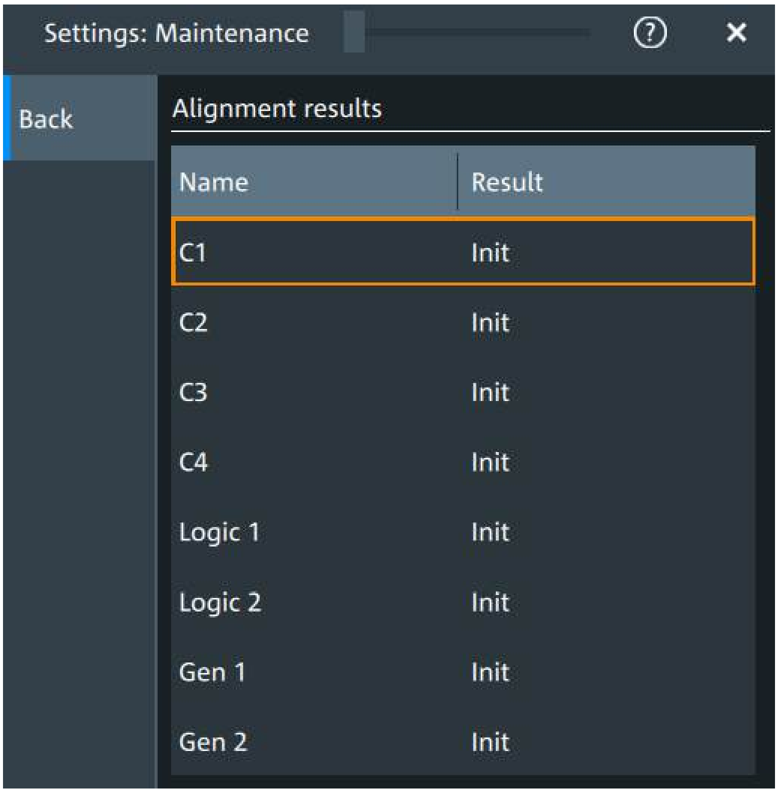
Start alignment
Starts the self-alignment procedure for all channels.

Date, Time, Overall alignment state
Show the date, time and the summary result of the self-alignment process: not aligned, passed or failed. Detailed results are provided on the "Alignment results" tab.

Remote command:
`CALibration:DATE?` on page 850
`CALibration:TIME?` on page 850
`CALibration:RESult?` on page 851

Show results
Opens a dialog to display the alignment results.

For each channel, the results of the individual alignment steps are shown for all technical channel component. In case you require support, you may be asked to provide this information.



5.7.2.2 Performing a self-alignment

The self-alignment aligns the data from several input channels vertically and horizontally to synchronize the timebases, amplitudes and positions. The self-alignment process includes a basic hardware check.

Recommendation on performing the self-alignment:

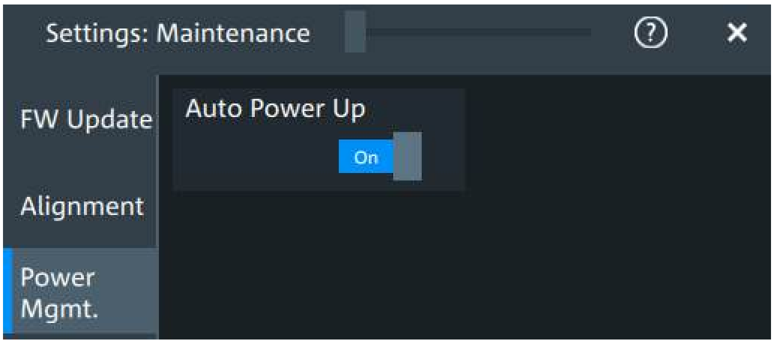
- When putting the instrument into operation for the first time
- After a firmware update
- Once a week
- When major temperature changes occur (> 5°)

1. Warm up the instrument before you start the self-alignment. The minimum warm-up time is indicated in the specifications document.
2. Remove the probes from the input connectors.
3. Open "Menu" > "Settings" > "Maintenance".
4. In the "Alignment" tab, tap "Start alignment".

   The alignment is performed, the process can take several minutes. A message box informs you about the running process, wait until this message box closes.
   The overall pass/fail result is shown in the "Overall alignment state" field.

5.7.3 Power management

Access: "Menu" > "Settings" > "Maintenance" > "Power mgmt."



Auto power up

If enabled, the instrument powers up automatically when it is connected to the mains voltage, and after a power outage. If disabled, the instrument also powers up after a power outage if it was running when the power outage occurred.

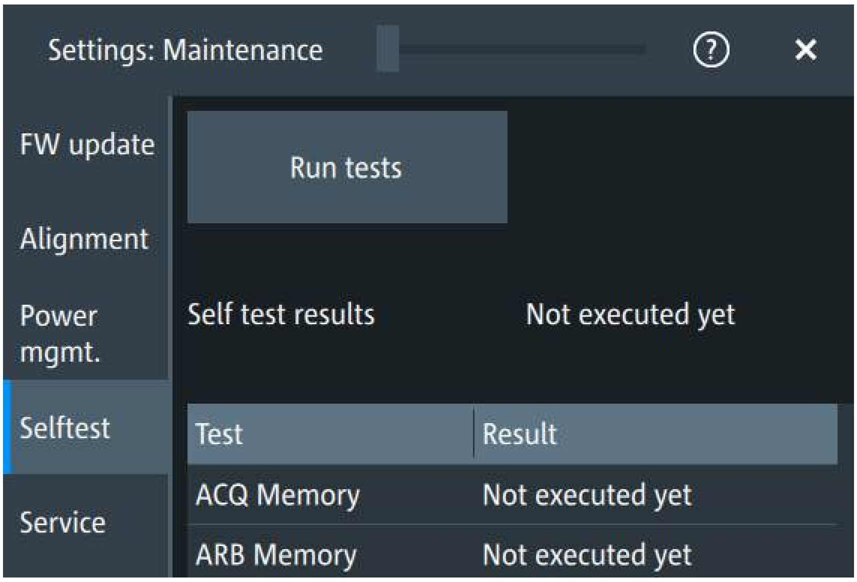
Remote command:

`SYSTem:APUP` on page 851

5.7.4 Self-test

The instrument's selftest checks the hardware for correct operation. Perform the self-test if you suspect problems in hardware operation.

Access: "Settings" > "Maintenance"> "Selftest"



The selftest can take several minutes. The summary result is shown in the "Selftest results" field, and the results of the single tests are shown in the "Result" column of the test table.

Run tests
Starts the selftest.

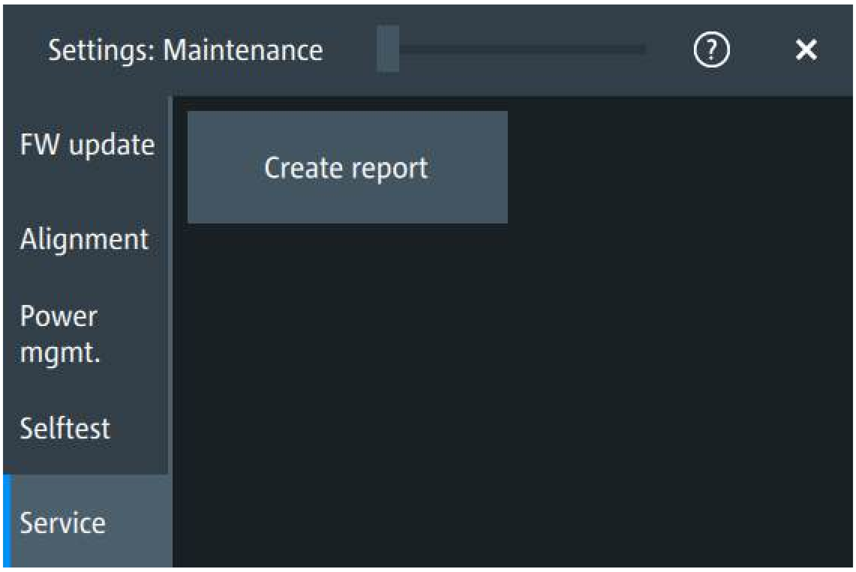
Remote command:
*TST? on page 813

Selftest results
Shows the summary result of the self-test: pass or fail.

Test table
The table shows the available tests and their particular tests results. This can be helpful in case you need support.

5.7.5 Service

Access: "Menu" > "Settings" > "Maintenance" > "Service"



Create report
Creates a service report.

The service report is a ZIP file with a complete bug report, all relevant setup information, reporting and log files, alignment files, and the instrument configuration.

If a USB flash drive is connected, the report is saved on the USB flash drive. Otherwise, the report is saved in the user data folder `/home/storage/userData`.

See also: Section 19.4, "Information for technical support", on page 1637.

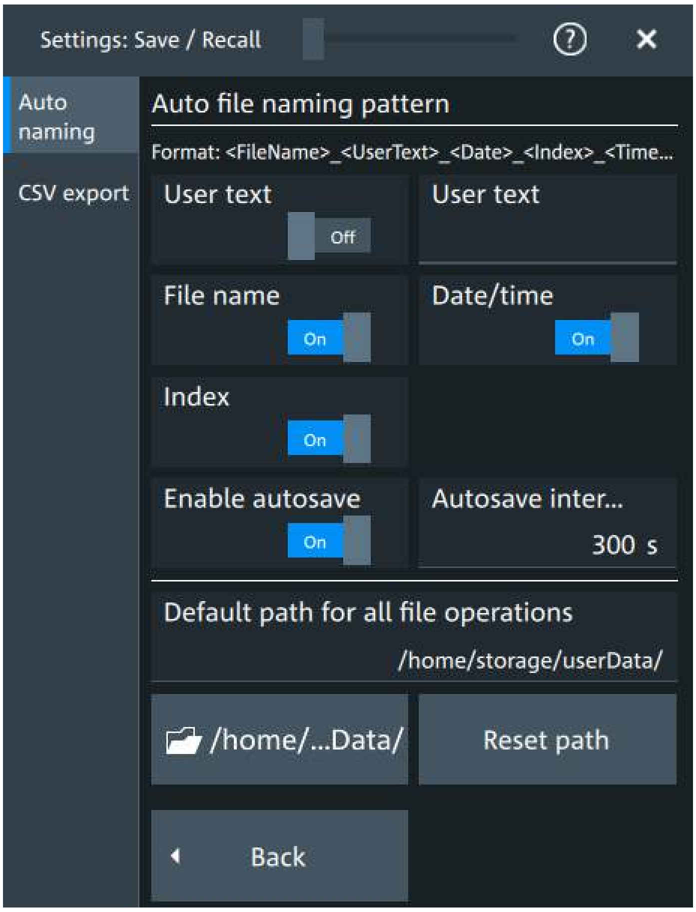
Remote command:
SERVice:REPort on page 851

5.8 Save / recall settings

5.8.1 Autonaming

Access: "Menu" > "Settings" > "Save/Recall" > "Autonaming" tab.

5.8.1.1 Autonaming settings



In the "Autonaming" tab, you can define the pattern for automatic filename generation. This name is used as the default filename. The default path is the storage location for all saved files and their subdirectories. The local directory for user data is `/home/storage/userData`, the path to a USB storage device is `/run/media/usb/<MyDriveName>/`.

User text
If enabled, inserts the specified user text after the prefix.

Remote command:
`MMEMory:AUTonaming:USERtext` on page 848
`MMEMory:AUTonaming:TEXT` on page 849

File name

If enabled, inserts the default filename. The filename indicates the type of data that is saved, for example, RefCurve.

Remote command:
`MMEMory:AUTonaming:PREFix` on page 847

Date/time

If enabled, the current date and time are inserted in the filename pattern.

Remote command:
`MMEMory:AUTonaming:TIME` on page 847

Index

If enabled, inserts an index.

Remote command:
`MMEMory:AUTonaming:INDex` on page 847

Enable autosave

Enables the automatic saving of the waveform. With "Autosave interval", you can define the time interval for the automatic saving.

Remote command:
`MMEMory:AUSave:ENABle` on page 847
`MMEMory:AUSave:INTerval` on page 847

Default path for all file operations

Defines the path that is displayed in the file selection dialog box for loading and storing operations. Locally, all user data is written to `/home/storage/userData`. You can create subfolders in this folder. The path to a USB storage device is `/run/media/usb/<MyDriveName>/`.

To switch the directory quickly, double-tap the path button. Use the symbols on the left of the file explorer box to change the directory.

Remote command:
`MMEMory:AUTonaming:DEFaultpath` on page 848

Reset path

Resets the default file path to the factory default.

Remote command:
`MMEMory:AUTonaming:RESPath` on page 848
`MMEMory:AUTonaming:RESall` on page 848

5.8.1.2 Defining default file paths and names

When a save or load operation is performed, a default filename and path is provided. You can configure which path is used, and how the filename is generated. In the file selection dialog box, you can change the folder and name as desired.

To define the default file path

1. Tap "Menu" > "Settings".
2. Select the "Save/Recall" tab.
3. Select the "Autonaming" tab.
4. Double-tap the path button.

   The directory selection dialog box is opened.
5. Select the folder in which the data is stored by default. Use the symbols on the left of the file explorer box to switch to often used directories.
   Alternatively, you can tap the "Default path for all file operations" field and type the path.
6. To restore the factory-set default path, tap "Reset" next to the path field.

To define the automatic filename pattern

The automatic filename pattern can consist of the following elements:

<FileName>_<UserText>_<Date>_<Index>_<Time>

The prefix depends on the data type to be stored and cannot be changed by the user. The other elements can be enabled or disabled as required.

1. Tap "Menu" > "Settings".
2. Select the "Save/Recall" tab.
3. Select the "Autonaming" tab.
4. If you want to exclude the "File name", "Date/time" or an "Index" (serial number), disable the corresponding option.
5. To insert a user-defined text after the prefix, enable "User text". Enter the text in the edit field.

   The specified elements are used to generate the default filename for the next storage operation.

5.8.2 CSV export

Access: "Menu" > "Settings" > "Save/Recall" > "CSV export" tab.

Currently, there are no active settings in this dialog.

6 Acquisition and waveform setup

6.1 Horizontal setup

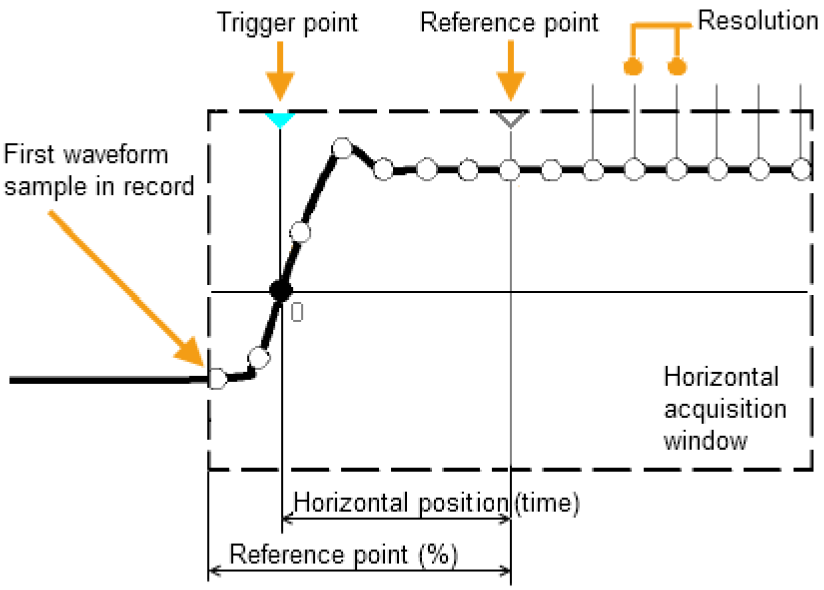
The "Horizontal" dialog provides the timebase configuration for channel and spectrum waveforms.

6.1.1 About the horizontal system

Horizontal settings, also known as timebase settings, adjust the waveforms in horizontal direction.

Typically, the trigger is the determining point of the waveform record. In many scenarios, you want to analyze the waveform some time before or after the trigger. To adjust the horizontal acquisition window to the waveform section of interest, you can use the following parameters:

- The **horizontal position** defines the time distance of the trigger point (the zero point of the diagram) to the reference point. Changing the horizontal position, you can move the trigger point, even outside the screen.
- The **reference point** is the rescaling center of the time scale on the screen. If you modify the time scale, the reference point remains fixed on the screen, and the scale is stretched or compressed to both sides of the reference point.



Unlike vertical settings, which are waveform-specific, the horizontal settings apply to all active waveforms.

Timebase settings are interdependent:

*Timebase range = Time scale * Number of divisions*

The number of divisions is 10, which is the only constant parameter.

6.1.2 Horizontal Setup settings

Access: "Menu" > "Horizontal" > "Setup" tab, or tap the "Horizontal" label above the diagram.

Time scale
Sets the horizontal scale, the time per division, for all waveforms in the time domain, for example, channel and math waveforms.

Increase the scale to see a longer time interval of the waveform. Decrease the scale to see it in more detail. The scale has a point that remains fixed on the screen when the scale value is changing: the reference point.

Remote command:
`TIMebase:SCALe` on page 853

Timebase range
Sets the time of one acquisition, which is the time across the 10 divisions of the diagram: *Acquisition time = Time scale * 10 divisions*.

Changing the acquisition time changes the time scale, too.

For long timebases, the acquisition progress is shown in the acquisition label.

Remote command:
`TIMebase:RANGe` on page 853

Position
Defines the time distance between the reference point and the trigger point, which is the zero point of the diagram. The horizontal position is also known as trigger offset.

If you want to see a section of the waveform some time before or after the trigger, enter this time as horizontal position. The requested waveform section is shown around the reference point. Use positive values to see waveform sections after the trigger - the waveform and the diagram origin move to the left.

Remote command:
`TIMebase:HORizontal:POSition` on page 854

Reference point
Sets the position of the reference point in % of the screen. It defines which part of the waveform is shown.

The reference point marks the rescaling center of the time scale on the screen. If you modify the time scale, the reference point remains fixed on the screen, and the scale is stretched or compressed to both sides of the reference point. If the "Position" is 0, the trigger point is on the reference point.

The reference point is not marked in the diagram.

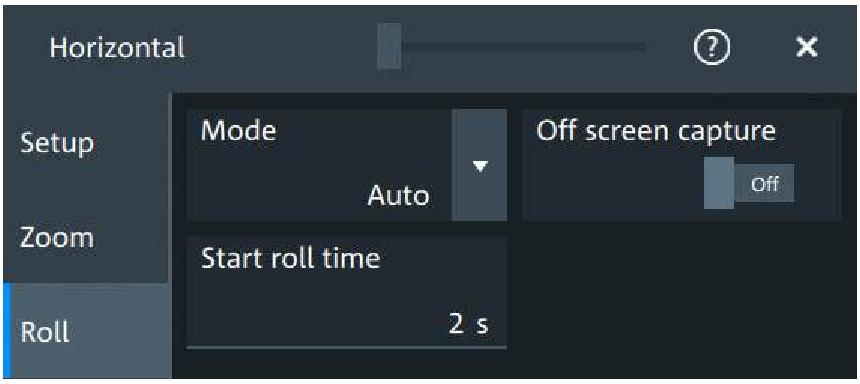
Remote command:
`TIMebase:REFerence` on page 854

6.1.3 Zoom settings

The zoom settings are described in Section 9.1, "Zoom", on page 217.

6.1.4 Roll mode

Access: "Menu" > "Horizontal" > "Roll" tab.



In this dialog, you can define the behavior of the roll mode.

Roll mode and acquisition setup

The settings "SR mode" and "RL mode" can affect the display of the waveform display in roll mode if these settings are set to "Manual". The resulting acquisition time is centered on the screen center.

If the acquisition time (*record length / sample rate*) is longer than the timebase range, the roll mode starts invisibly, outside the right screen edge. The data appears with some delay.

If the acquisition time is shorter than the timebase range, there is a gap from the right screen edge to the beginning of the data. If "SR mode" and "RL mode" are set to "Auto", the instrument optimizes the acquisition settings.

Roll mode settings

Progress bar

The "Roll" progress bar in the "Acquisition" label shows how the record length is filled. The bar turns green when all samples are acquired, and the record is filled.

Left = incomplete roll waveform
Middle = roll completed with "Off screen capture" = Off
Right = roll completed with "Off screen capture" = On

Mode

Selects, if the roll mode is started automatically by the instrument or if it is turned off.

In roll mode, the instrument shows the waveforms immediately, without waiting for the complete acquisition of the waveform record. If the timebase is slow - at long time scale values - the roll mode saves time waiting for the waveform display. The instrument displays the newly acquired waveform points at the right edge of the display and moves the waveform to the left.

The roll mode has the following restrictions:
- Roll mode disables persistence.
- Event actions are not possible.

The instrument activates the roll mode automatically if the following conditions are fulfilled:
- "Timebase range" exceeds the defined "Start roll time".
- "Acquisition mode" is set to "Sample" or "Peak detect".
- Actual sample rate ≤ 0.05 * sample rate of the instrument, i.e. ≤ 250 Msample/s or 125 Msample/s depending on the number of active channels.
- "N-single/Avg count" = 1.
- Fast segmentation is disabled.
- Event actions are disabled.
- All serial buses are disabled.
- All mask tests are disabled.

Measurement statistics evaluate the currently displayed waveform. Therefore, "Measure all events" is enabled automatically in roll mode.

See also: "Roll mode and acquisition setup" on page 119.

Remote command:
`TIMebase:ROLL:ENABle` on page 854
`TIMebase:ROLL:STATe?` on page 855

Start roll time

Sets the minimum acquisition time for the automatic start of the roll mode.

The instrument activates the roll mode automatically if the "Timebase range" exceeds the value of the "Start roll time".

Remote command:
`TIMebase:ROLL:MTIMe` on page 855

Off screen capture
If enabled, the analyzable waveform in roll mode is extended. You can run the roll mode, stop the acquisition after some time, and analyze the data that is on the display and in the unvisible area on the left.

If "Off screen capture" = Off, the analyzable record length is the value that is set in the "Acquisition" > "Setup" tab. The record length determines the length of the displayed waveform.

If "Off screen capture" = On, the whole acquisition memory can be used. After the defined record length is filled, more data is recorded at the left of the completed record length until you stop the acquisition or the acquisition memory is filled.

The current number of recorded data points is shown in the progress bar when the bar is green, or returned by the remote command `ACQuire:ROLLmode:POINts?`. See also: "Roll mode and acquisition setup" on page 119.

The "Roll" progress bar in the "Acquisition" label shows how the record length is filled.

After stopping the acquisition, you can analyze the complete roll waveform, including the invisible part:
- Increase the "Time scale" to see a longer part of the waveform.
- Scroll the waveform: tap and drag the waveform to the right.

If you want to save the waveform, disable "Off screen capture". When the needed data is displayed, save the waveform. Thus, one record length is saved. With active "Off screen capture", the amount of data cannot be limited.

Remote command:
`ACQuire:ROLLmode:OSCapture` on page 855
`ACQuire:ROLLmode:POINts?` on page 855

6.1.5 Reference clock

Access: "Menu" > "Horizontal" > "Setup" tab > "Ref Clock"

The oven-controlled crystal oscillator (OCXO) produces a 10 MHz internal reference signal with precise and stable frequency. You can output this clock signal for synchronization of other instruments. Conversely, you can also use an external 10 MHz reference signal. The input and output connectors for reference signals are on the rear panel of the instrument.

Use external ref. clock
Enables the use of an external 10 MHz reference signal instead of the internal reference clock.

Remote command:
`SENSe[:ROSCillator]:SOURce` on page 893

Output 10 MHz ref. signal
Sends the internal reference clock signal to the Ref. Out connector.

If "Use external ref. clock" is enabled, the external reference signal is output instead of the internal clock.

Remote command:
`SENSe[:ROSCillator]:OUTPut[:ENABle]` on page 893

6.2 Acquisition

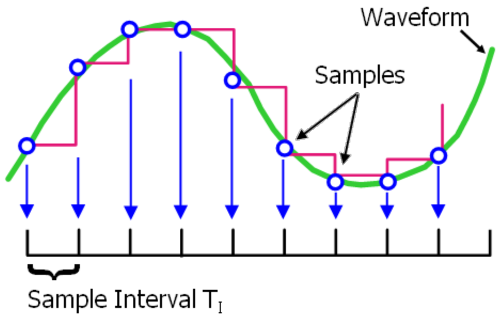
Access: "Menu" > "Acquisition".

Acquisition settings define the processing of the captured samples in the instrument.

6.2.1 About the acquisition system

Sampling and processing

The A/D converter samples the continuous signal under test at specific points in time and captures digital values. The converter is working at a constant rate specified in GHz.



The captured values are processed according to the acquisition settings. The result is a waveform record that contains **waveform samples** and is stored in the **waveform memory**. The waveform samples are displayed on the screen and build up the waveform.

The number of waveform samples in one waveform record is called **record length**. The rate of recording waveform samples - the number of waveform samples per second - is the **sample rate**. The higher the sample rate, the better the resolution is and the more details of the waveform are visible.

Sample rate = 1 / Resolution

The sample rate can be the same as the constant rate of the A/D converter, or higher, or lower. To get a higher sample rate, interpolation is used. Several interpolation methods are available. Other processing methods reduce the sample rate, or build the resulting waveform from several consecutive acquisitions of the signal. These methods are called acquisition modes.

Minimum sample rate and aliasing

A sufficient resolution is essential for correct reconstruction of the waveform. If the signal is undersampled, aliasing occurs - a false waveform is displayed. To avoid aliasing and accurately reconstruct a signal, the sample rate must be at least 3 to 5 times the fastest frequency component of the signal. A higher sample rate increases signal fidelity, increases the chance to capture glitches and other signal anomalies, and improves the zoom-in capabilities.

Interleaving

The MXO 4 achieves its highest sample rate of 5 Gsample/s by interleaving two channels: channels 1 and 2 are interleaved, and also channel 3 and 4. Interleaving assumes that only one of the paired channels is used - either channel 1 or channel 2, and either channel 3 or 4. If the second channel of a pair is used (on display, or as trigger source, math source, or measurement source), the interleaving mode is disabled. Without interleaving, the channels work with 2.5 Gsample/s and reduced bandwidth.

6.2.2 Acquisition Setup settings

Access: "Menu" > "Acquisition" > "Setup" tab.

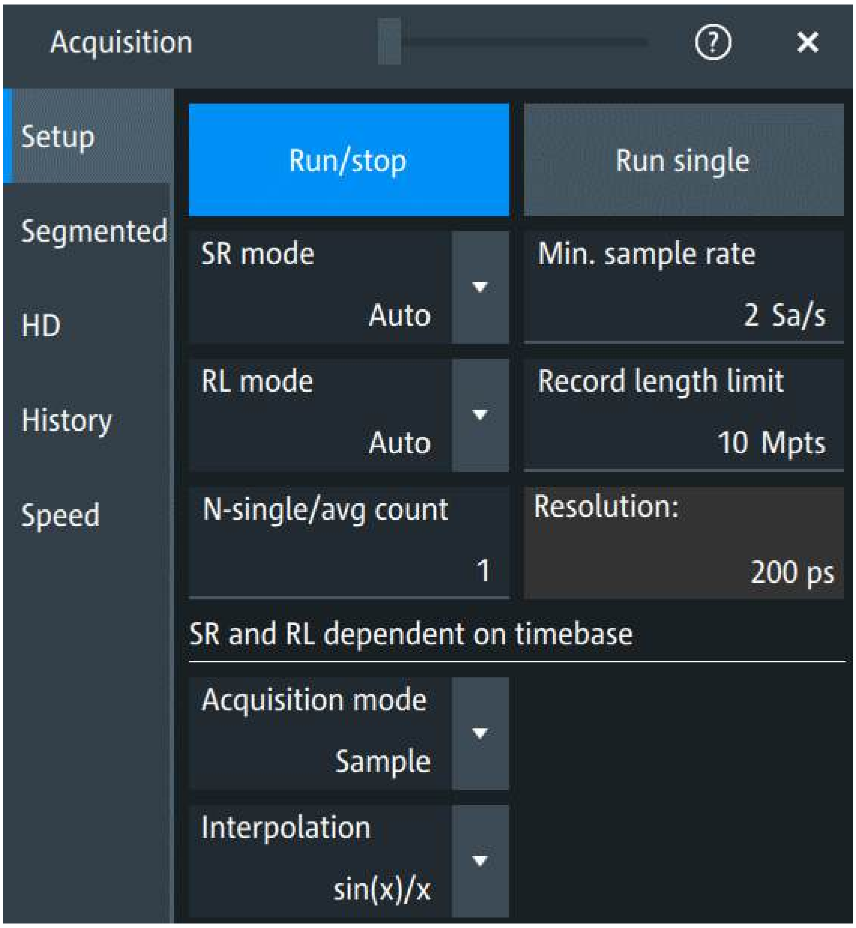


Figure 6-1: Acquisition settings: automatic sample rate and record length

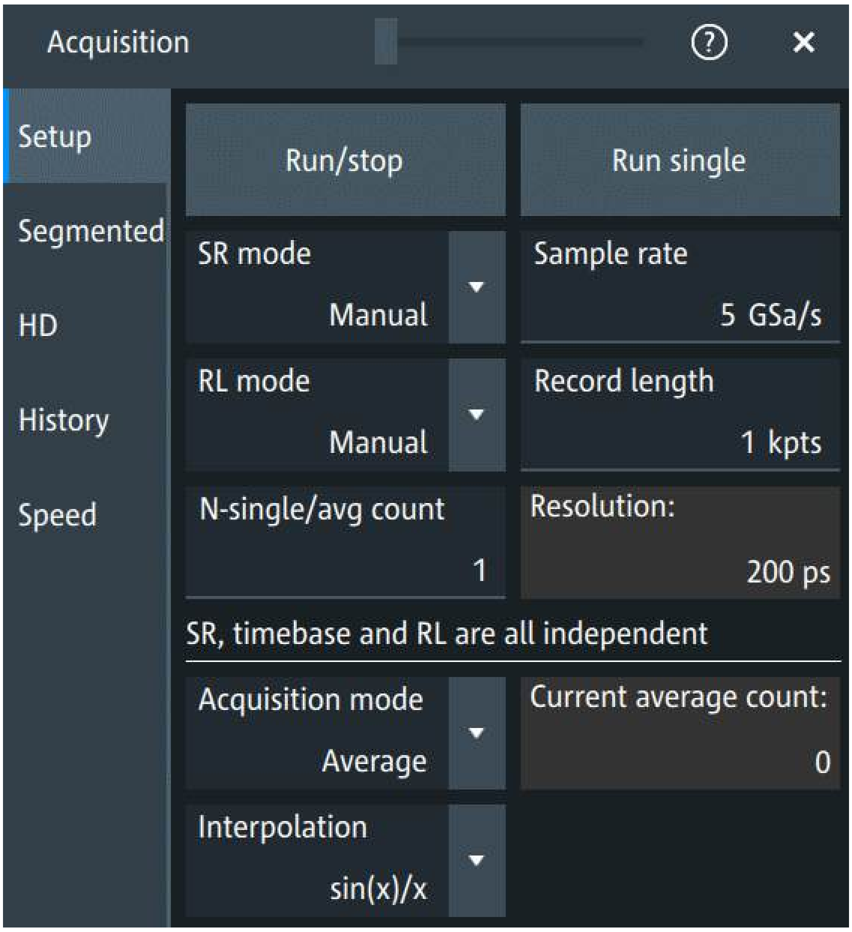


Figure 6-2: Acquisition settings: manual sample rate and record length

Run/Stop

Starts and stops the continuous acquisition.

The [Run / Stop] key lights green when the acquisition is running. When the acquisition is stopped, the key lights red.

Remote command:
`RUN` on page 852
`STOP` on page 852

Run Single

Starts a defined number of acquisitions.

The [Single] key lights green when the acquisition is running. When the acquisition is stopped, the key lights red.

To set the number of acquisitions, set "N-single/Avg count" in the "Acquisition" setup. The acquisition progress is shown in the acquisition label, see "Progress information" on page 79.

Remote command:
`SINGle` on page 852

SR mode
Defines how the sample rate is set.

The sample rate considers the samples of the ADC, and the processing of the captured samples including interpolation.

"Auto" Sample rate is determined automatically and changes due to instrument internal adjustments due to other setting changes. You can set a minimum sample rate with Min. sample rate.

"Manual" The sample rate is manually defined with Sample rate.

Remote command:
`ACQuire:SRATe:MODE` on page 860

Min. sample rate
Sets the minimum value of the sample rate for calculation in automatic sample rate mode. It is the sample rate of the processed waveform record including interpolation.

Remote command:
`ACQuire:SRATe:MINimum` on page 860

Sample rate
Sets the number of waveform points per second in manual sample rate mode. It is the sample rate of the processed waveform record including interpolation.

The sample rate in the dialog differs from the sample rate that is shown in the acquisition label above the diagram. The value in the acquisition label shows the sample rate of the acquisition itself, before interpolation. It is the ADC sample rate or an integer decimated value of the ADC sample rate, which allows you to estimate whether the signal was sufficiently sampled in the acquisition.

Remote command:
`ACQuire:SRATe[:VALue]` on page 860

RL mode
Selects the mode of the waveform record length adjustment.

The record length is the number of waveform samples that are stored in one waveform record after processing, including interpolation. It determines the length of the displayed waveform.

"Auto" Record length is determined automatically and changes due to instrument internal adjustments due to other setting changes. You can set a maximum record length with Record length limit.

"Manual" The waveform record length is manually defined with Record length.

Remote command:
`ACQuire:POINts:MODE` on page 858

Record length limit
Sets the maximum value of the record length for calculation in automatic record length mode.

Remote command:
`ACQuire:POINts:MAXimum` on page 858

Record length

Sets the record length in manual record length mode.

If the record length value is too high in combination with other settings and activated features, the memory is not sufficient to process the data. In this case, a warning information is shown in the dialog.

Remote command:
`ACQuire:POINts[:VALue]` on page 858
`ACQuire:POMemory?` on page 859

N-single/Avg count

The acquisition and average count has several effects:

- It sets the number of waveforms acquired with "Run single".
- It defines the number of waveforms used to calculate the average waveform. Thus, the instrument acquires sufficient waveforms to calculate the correct average if "Average" is enabled for waveform arithmetic. The higher the value is, the better the noise is reduced.
- It sets the number of acquisitions to be acquired in a fast-segmentation acquisition series, and in the history.
- It is the "Finished" criteria for a mask test.

The setting is read-only if "Segmented" > "Acquire maximum" is "On". See also "Acquire maximum" on page 129.

Remote command:
`ACQuire:COUNt` on page 857

Resolution

Shows the current resolution.

The resolution is the time between two waveform samples in the waveform record. It considers the processing of the captured samples including interpolation. A fine resolution with low values produces a more precise waveform record. The resolution is the reciprocal of the sample rate.

Remote command:
`ACQuire:RESolution?` on page 859

Acquisition mode

Sets how the waveform is built from the captured samples.

"Sample"	Usually, most signals are displayed optimally with this acquisition mode but very short glitches can remain undiscovered by this method.
"Peak detect"	The minimum and the maximum of n samples are recorded as waveform points, the other samples are discarded. Thus the instrument can detect fast signal peaks at slow time scale settings that would be missed with other acquisition modes.
"Envelope"	Each acquisition is done in peak detection mode, and the minimum and maximum values in a sample interval over some consecutive acquisitions build the envelope. The resulting diagram shows two envelope waveforms: the minimums (floor) and maximums (roof).

"Average" The average is calculated from the data of the current acquisition and a specific number of consecutive acquisitions before. The method reduces random noise. It requires a stable, triggered and repetitive signal.
The number of acquisitions for average calculation is defined with N-single/Avg count.
If the waveform is clipped, the instrument shows a distorted average waveform to indicate the clipping. Adjust the vertical scale to avoid the clipping. The acquisition progress is shown in the acquisition label.

Remote command:
`ACQuire:TYPE` on page 861

Current Average count
Shows the current number of acquired waveforms that contribute to the average, for Acquisition mode = "Average".

Remote command:
`ACQuire:AVERage?` on page 856

Interpolation
Selects the interpolation method.

If the defined sample rate ("Sample rate") is higher than the ADC sample rate, interpolation adds points between the captured samples of the waveform by various mathematic methods. The selected interpolation method is also used for zooming.

"Linear" Two adjacent ADC sample points are connected by a straight line, the interpolated points are located on the line. You see a polygonal waveform similar to the real signal, and also the ADC sample points as vertexes.

"sin (x)/x" Two adjacent ADC sample points are connected by a sin(x)/x curve, and also the adjoining sample points are considered by this curve. The interpolated points are located on the resulting curve. This interpolation method is precise and shows the best signal curve.

"Sample/Hold" The ADC sample points are displayed like a histogram. For each sample interval, the voltage is taken from the sample point and considered as constant, and the intervals are connected with vertical lines. Thus, you see the discrete values of the ADC - the measured samples.

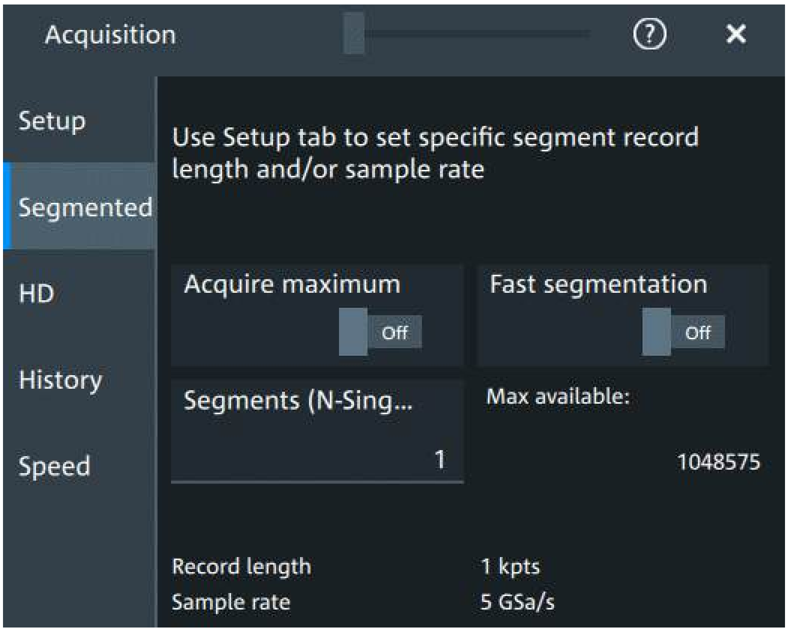
Remote command:
`ACQuire:INTerpolate` on page 857

6.2.3 Segmentation settings

Access: "Menu" > "Acquisition" > "Segmented" tab.

You can acquire a limited number of segments, or the maximum number.

In the R&S ScopeStudio software, acquisition settings and functions that need an acquisition take effect if the channel source is a simulated waveform, created by the generator. If the channel source is loaded from a file, the acquisition-related settings can be imported with the data from the oscilloscope, either as a saveset, or included in a session. Changing imported acquisition-related settings has no effect.



Acquire maximum
The setting takes effect for N-single acquisitions ("Run single"). During continuous acquisition ("Run / stop"), the history is used completely.

If "On", "Segments (N-Single)" is set to the maximum number of available segments. Thus, the history is filled completely with an N-single acquisition. "Segments (N-Single)" is read-only, you cannot change the value. The number of available segments depends on current the number of active channels, sample rate, record length, and other settings.

If "Off", set the number of segments in "Segments (N-Single)", which is the same setting as "N-single/Avg count" on the "Setup" tab. Thus you can acquire a fast segmentation acquisition series and history of defined length with "Run single".

You can stop the running acquisition before the series is completed.

The number of acquired waveforms is shown in the "History" dialog, when the history is active.

Remote command:
ACQuire:SEGMented:MAX on page 889

Fast segmentation
If fast segmentation is enabled, the acquisitions are performed as fast as possible, without processing and displaying the waveforms. When acquisition has been stopped, the data is processed and the latest waveform is displayed. Older waveforms are stored in segments. You can display and analyze the segments using the history.

Remote command:
ACQuire:SEGMented:STATe on page 890

Segments (N-Single)
See "N-single/Avg count" on page 127.

Max available
Shows the maximum number of segments that can be captured with current sample rate and record length settings.

6.2.4 High definition mode

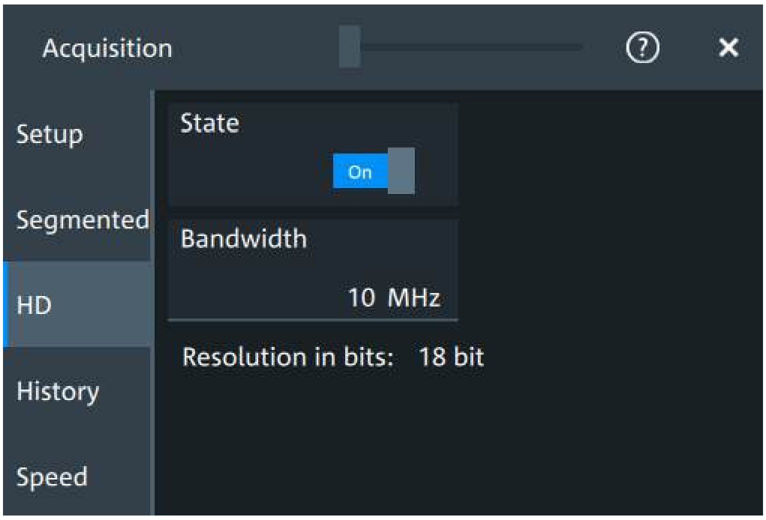
The high definition mode increases the numeric resolution of the waveform signal by using digital filtering, leading to reduced noise. The higher vertical resolution reduces quantization noise and acquires waveforms of higher accuracy with finer details of the signal to be seen. The high definition is also applied to the digital trigger, thus the MXO 4 can trigger with the same high resolution with which they can display signals.

The maximum numeric resolution in high definition mode is 18 bit. The actual value depends on the selected bandwidth. Increasing the bandwidth reduces the resulting digital resolution. For dependencies and details, refer to the MXO 4 specifications.

The number of vertical resolution bits defines the number of vertical levels that the acquisition samples are mapped to (quantization). For example, 16 bits of resolution represent 65536 voltage quantization levels, while 8 bits of resolution represent only 256 voltage levels. The waveform values are recorded with a word length of 16 bit, except for peak detect decimation.

6.2.4.1 High definition settings

Access: "Menu" > "Acquisition" > "HD" tab.



High definition is a special acquisition mode of the oscilloscope. This mode has only one setting - the filter bandwidth.

State
Enables high definition mode, which increases the numeric resolution of the waveform signal.

Remote command:
`HDEFinition:STATe` on page 891

Bandwidth
Sets the filter bandwidth for the high definition mode.

Increasing the bandwidth reduces the resulting digital resolution. For dependencies and details, refer to MXO 4 specifications.

Remote command:
`HDEFinition:BWIDth` on page 890

Resolution in bits
Displays the resulting vertical resolution in high definition mode. The higher the filter bandwidth, the lower the resolution.

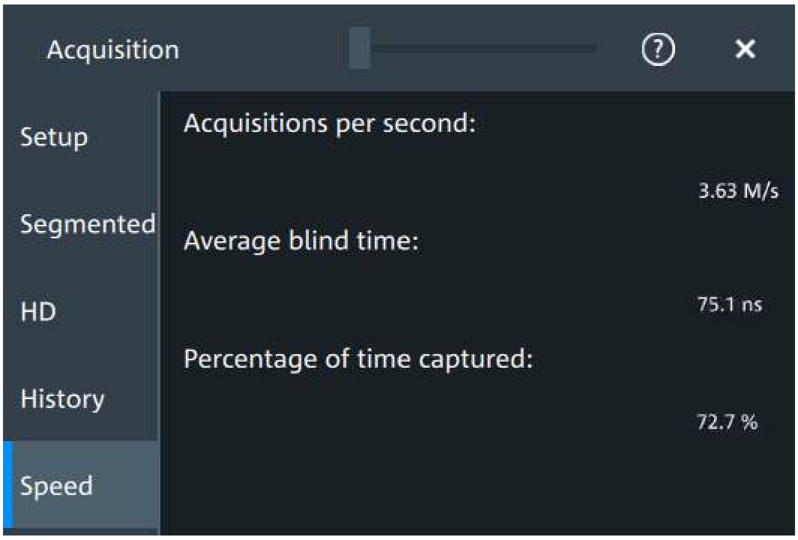
Remote command:
`HDEFinition:RESolution?` on page 890

6.2.5 History settings

The history settings are described in Section 9.3.2, "History setup", on page 234.

6.2.6 Speed

Access: "Menu" > "Acquisition" > "Speed" tab.



The "Speed" dialog shows information on the current acquisition performance values of the MXO 4.

You can see the number of "Acquisitions per second", "Average blind time" and the "Percentage of time captured".

6.3 Vertical setup

The controls and parameters of the vertical system adjust the vertical scale and position of the waveform, and the waveform display. The probe settings also belong to the vertical setup.

The signal icons at the bottom of the display show the most important actual settings for each channel.

The signal icon also indicates if the incoming data is clipped before processing, i.e. the input range of the ADC is exceeded.

There are several ways to adjust vertical settings:

- Use the keys and knobs in the Vertical functional block of the front panel to select the channel, to scale the waveform, and to set the position or offset.
  See Section 3.2.4.4, "Vertical controls", on page 47.
- Use the "Vertical" dialog to adjust all vertical settings. See:
  - Section 6.3.2, "Vertical Setup settings", on page 133
  - Section 6.3.3, "Bandwidth settings", on page 136
  - Section 6.4, "Probes", on page 138
  - Section 6.3.5, "Other vertical settings", on page 137
- On the touchscreen, you can adjust the vertical settings directly on the screen:
  - Drag one finger vertically on the screen to change the position of the selected channel waveform.
  - Spread or pinch two fingers in vertical direction to change the vertical scale of the selected waveform.

6.3.1 About the vertical system

The controls and parameters of the vertical system are used to scale and position the waveform vertically.

Vertical scale and resolution

Vertical scale and vertical position directly affect the resolution of the waveform amplitude. The vertical scale corresponds to the ADC input range. To get the full resolution of the ADC, set up the waveforms to cover most of the height of the diagram.

With an MXO 4, you work with multiple diagrams, and each diagram obtains the full vertical resolution, no matter where the diagram is placed. Therefore, use a separate diagram for each waveform instead of the traditional setup that arranges the waveforms side by side in one diagram.

Bandwidth

For analog applications, the highest signal frequency determines the required oscilloscope bandwidth. The oscilloscope bandwidth should be higher than the maximum frequency included in the analog test signal to measure the amplitude with very little measurement error. To avoid aliasing, the oscilloscope bandwidth should be at least 3 times higher than the maximum frequency included in the signal.

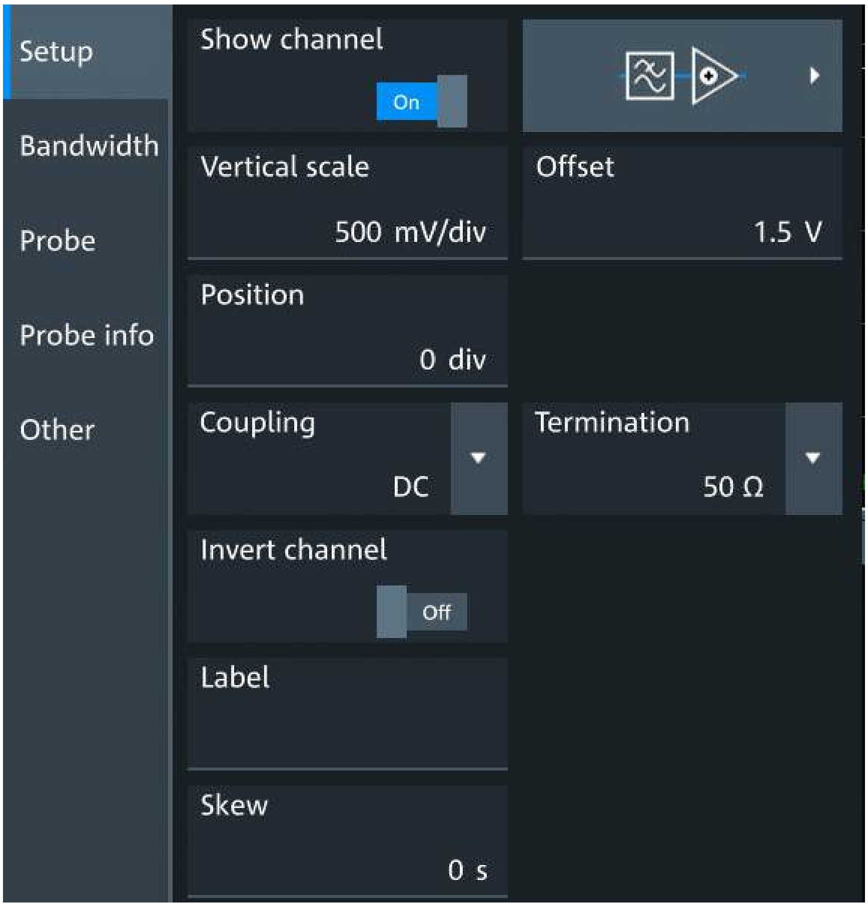
Most test signals are more complex than a simple sine wave and include several spectral components. A digital signal, for example, is built up of several odd harmonics. For digital signals, the oscilloscope bandwidth should be at least 5 times higher than the clock frequency to be measured.

The oscilloscope is not a stand-alone system. You need a probe to measure the signal of interest, and the probe has a limited bandwidth, too. The combination of oscilloscope and probe creates a system bandwidth. To reduce the effect of the probe on the system bandwidth, the probe bandwidth should exceed the bandwidth of the oscilloscope, the recommended factor is 1.5 x oscilloscope bandwidth.

6.3.2 Vertical Setup settings

Access: "Menu" > "Vertical" > "Setup" tab

The "Setup" tab provides all basic vertical settings. The channels are listed in horizontal subtabs. Make sure to select the correct channel tab before you enter the settings.



Show channel
Switches the selected channel signal on or off.

The signal icon opens on the signal bar. The waveform of the last acquisition is displayed in the diagram.

Remote command:
CHANnel<ch>:STATe on page 862

Signal flow (graphical button)
Opens a dialog that shows the signal flow as currently configured. In addition, the main settings are shown for information.

Vertical scale
Sets the vertical scale, which defines the displayed amplitude of the selected waveform.

The unit depends on the connected probe.

The current value is shown in the signal icon. Vertical scale directly affects the resolution of the waveform amplitude. To get the best resolution of the ADC, set the waveforms to cover most of the height of the diagram.

Remote command:
CHANnel<ch>:SCALe on page 862

Offset

Sets the offset voltage, which corrects an offset-affected signal. The vertical center of the selected channel is shifted by the offset value and the signal is repositioned within the diagram.

To set the offset automatically, use [Autoset]. The current value is shown in the signal icon.

Use the offset to measure small AC voltages that are overlaid by higher DC voltages. Unlike AC coupling, the DC part of the signal is not lost with offset setting.

If an active probe is connected, the offset limit is defined by the probe. Refer to the documentation of the probe for allowed values.

If a Rohde & Schwarz differential probe is connected, set the common-mode offset to compensate for a common DC voltage applied to both input sockets (referenced to the ground socket). Thus, you can measure on differential signals with high common mode levels. You can measure the common mode input voltage using the R&S ProbeMeter.

Remote command:
`CHANnel<ch>:OFFSet` on page 863

Position

Moves the selected signal up or down in the diagram. While the offset sets a voltage, position is a graphical setting given in divisions. The visual effect is the same as for offset.

Remote command:
`CHANnel<ch>:POSition` on page 863

Coupling

Sets the filter for the input signal. The coupling determines what part of the signal is used for waveform analysis and triggering.

The selected coupling is shown in the signal icon.

"DC" Passes both DC and AC components of the signal.

"AC" Connection through DC capacitor, removes DC and very low-frequency components. AC coupling is useful if the DC component of a signal is of no interest. The waveform is centered on zero volts.

If AC coupling is set, the attenuation of passive probes has no effect, and voltage is applied to the instrument with factor 1:1. Observe the voltage limits, otherwise you can damage the instrument.

Remote command:
`CHANnel<ch>:COUPling` on page 863

Termination

Selects the input impedance of the channel input according to the connected probe.

Connection with 50 Ω termination is used to connect, for example, active probes. Connection with 1 MΩ termination is used to connect standard passive probes.

Remote command:
`CHANnel<ch>:COUPling` on page 863

Invert channel
Turns the inversion of the signal amplitude on or off. To invert means to reflect the voltage values of all signal components against the ground level.

Inversion is indicated in the signal icon by a line above the channel name.

Remote command:
`CHANnel<ch>:INVert` on page 864

Label
Defines a label text. The label is shown at the waveform on the right edge of the display.

Remote command:
`DISPlay:SIGNal:LABel` on page 864

Skew
Sets a skew value to compensate for the delay of the measurement setup or from the circuit specifics that the instrument cannot compensate automatically. It affects only the selected input channel.

Delay differences between channels are caused by the different length of cables, probes, and other sources. Correct deskew values are important for accurate triggering. Signals that are routed over lines with different lengths have a different propagation delay. This delay can lead to a non-synchronous waveform display.

Remote command:
`CHANnel<ch>:SKEW:TIME` on page 865

6.3.3 Bandwidth settings

Access: "Menu" > "Vertical" > "Bandwidth" tab

The "Bandwidth" tab provides all settings that affect the bandwidth of the measurement system. The channels are listed in horizontal subtabs. Make sure to select the correct channel tab before you enter the settings.

Bandwidth
Sets the bandwidth limit. The specified bandwidth indicates the range of frequencies that the instrument can acquire and display accurately with less than 3 dB attenuation. Frequencies above the limit are removed from the signal, and noise is reduced.

The selected bandwidth is shown on the signal icon.

For basic information, see also: "Bandwidth" on page 133.

"Full" At full bandwidth, all frequencies in the instrument's frequency range are acquired and displayed. Full bandwidth is used for most applications. However, at full bandwidth, the displayed bandwidth can be less than the instrument bandwidth depending on the connected probe, the number of active channels and other settings.

"xx MHz" Frequencies above the selected limit are removed to reduce noise.

Remote command:
`CHANnel<ch>:BANDwidth` on page 865

Probe type, Probe bandwidth
Shows the type of the connected probe and its bandwidth. The probe is recognized automatically, or selected in the "Probe" tab. See Section 6.4.1, "Common probe settings", on page 138.

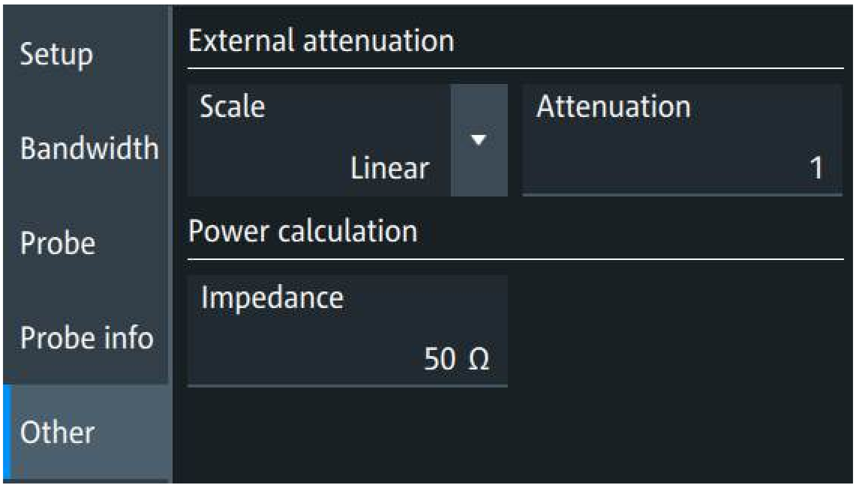
Effective bandwidth
Shows the effective bandwidth of probe and oscilloscope system.

6.3.4 Probe settings

See Section 6.4, "Probes", on page 138.

6.3.5 Other vertical settings

Access: "Menu" > "Vertical" > "Other" tab



External Attenuation: Scale, Attenuation
Consider a voltage divider that is part of the DUT before the measuring point. The external attenuation is included in the measurement, and the instrument shows the results that would be measured before the divider. External attenuation can be used with all probes.

"Scale" Select linear or logarithmic attenuation scale.

"Attenuation" Enter the attenuation of the voltage divider according to the selected scale. The conversion from linear to logarithmic values depends on the "Vertical unit" of the probe:
For voltage-based unit (V and A):
$attenuation\ (dB) = 20 * log_{10}(attenuation\ factor)$
For power-based unit (W):
$attenuation\ (dB) = 10 * log_{10}(attenuation\ factor)$

Remote command:
`CHANnel<ch>:EATScale` on page 866
`CHANnel<ch>:EATTenuation` on page 866

Impedance
Sets the impedance of the connected probe for power calculations and measurements.

The value is used, for example, for scale calculation in the spectrum diagram.

Remote command:
`CHANnel<ch>:IMPedance` on page 866

6.4 Probes

With MXO oscilloscopes, you can use various probe types. Mostly these probes are passive and active voltage probes. The instrument can detect many probes and read out the probe-specific parameters, for example, bandwidth and attenuation.

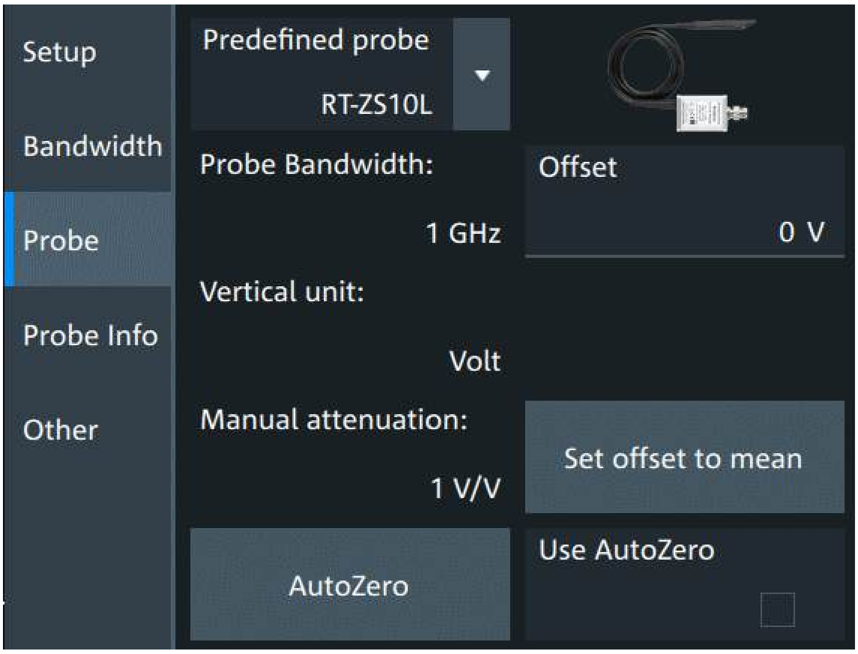
You find all settings that are relevant for the connected probe in the "Vertical" > "Probe" tab. The settings on the "Probe" tab change according to the type of the attached probe. Probes with Rohde & Schwarz probe interface (probe box), and also many other passive voltage probes, are recognized by the instrument. The oscilloscope reads out the main characteristics of the probe and displays them. Other probes cannot be detected, but their characteristics are known to the instrument. These known probes are called "Predefined probes". Probes that are not recognized automatically and not predefined are unknown probes, they require manual setting of measurement unit and attenuation.

The complete characteristic of the connected probe is shown on the "Vertical" > "Probe Info" tab.

6.4.1 Common probe settings

Access: "Menu" > "Vertical" > "Probe" tab

Most the settings in the "Probe" tab are available for all probes. For some probe types, additional settings are needed. These settings are described in the sections for the individual probe types.



An external attenuation can be set on the "Other" tab, see Section 6.3.5, "Other vertical settings", on page 137.

The common probe settings are:

Predefined probe, name and type of the probe

The model name and type of a detected probe are shown in the dialog.

If the instrument cannot recognize the probe, "None" is indicated in the "Predefined probe" list. Select the used probe on the list. The corresponding bandwidth, and attenuation or gain are shown.

If the probe is not detected and not listed as predefined probe, it is an unknown probe. To configure these probes, set "Predefined probe" to "User-Defined". Then adjust the Vertical unit and Attenuation.

Remote command:
`PROBe<ch>:SETup:NAME?` on page 870
`PROBe<ch>:SETup:TYPE?` on page 871
`PROBe<ch>:SETup:STATe?` on page 870
`PROBe<ch>:SETup:ATTenuation:DEFProbe` on page 868

Probe bandwidth

Shows the bandwidth of the connected probe. For probes that are not detected or predefined, set the bandwidth manually.

Remote command:
PROBe<ch>:SETup:BANDwidth? on page 869

Offset
Channel offset that is also set on "Vertical" > "Setup" tab. See "Offset" on page 135.

Vertical unit
Shows the unit of the connected probe if the probe is detected or predefined. For unknown probes, select the unit that the probe can measure.

Remote command:
PROBe<ch>:SETup:ATTenuation:UNIT on page 869

Attenuation
Shows the attenuation of the connected probe if the probe is detected or predefined. If the probe is unknown to the instrument, set the correct attenuation of the probe in "Manual attenuation".

The vertical scaling and measured values are multiplied by this factor so that the displayed values are equal to the actual measured signal values.

Make sure to set the attenuation factor on the instrument according to the probe being used. Otherwise, the measurement results do not reflect the actual voltage level, and you might misjudge the actual risk.

Remote command:
PROBe<ch>:SETup:ATTenuation[:AUTO]? on page 867
PROBe<ch>:SETup:ATTenuation:MANual on page 867

Set offset to mean
Compensates automatically for a DC component of the input signal using the result of a background mean measurement.

The result is shown in "Offset". The function is probe-independent and supports quick and convenient measurements of input signals with different DC offsets. It detects offset values even when the signal is out of the current measurement range. It also sets the zero level to the determined DC offset in the middle of the screen and thus prevents clipping of the waveform.

Remote command:
PROBe<ch>:SETup:OFFSet:TOMean on page 869

AutoZero, Use AutoZero
Voltage probes can have a zero error. The zero error is the voltage appearing at the probe output when nothing is connected to the probe. If a zero error occurs, it results in an external offset and the waveform is not displayed around 0 V.

To correct the zero error of voltage probes, short the signal pin and the ground pin together. Then tap "AutoZero". While the alignment is running, the instrument switches to DC coupling to display the waveform correctly.

To correct the zero error, enable "Use AutoZero".

If a current probe is connected, the function demagnetizes the probe's sensor head and sets the waveform to zero position.

Remote command:
PROBe<ch>:SETup:OFFSet:AZERo on page 870
PROBe<ch>:SETup:OFFSet:USEautozero on page 870

6.4.2 Setup for passive probes

Passive probes are the most widely used probes for voltage measurements with oscilloscopes. If a passive probe is connected, the probe attenuation is read out and shown in the "Probe" tab.

Passive probes require compensation, see Section 6.4.9, "Adjusting passive probes", on page 158.

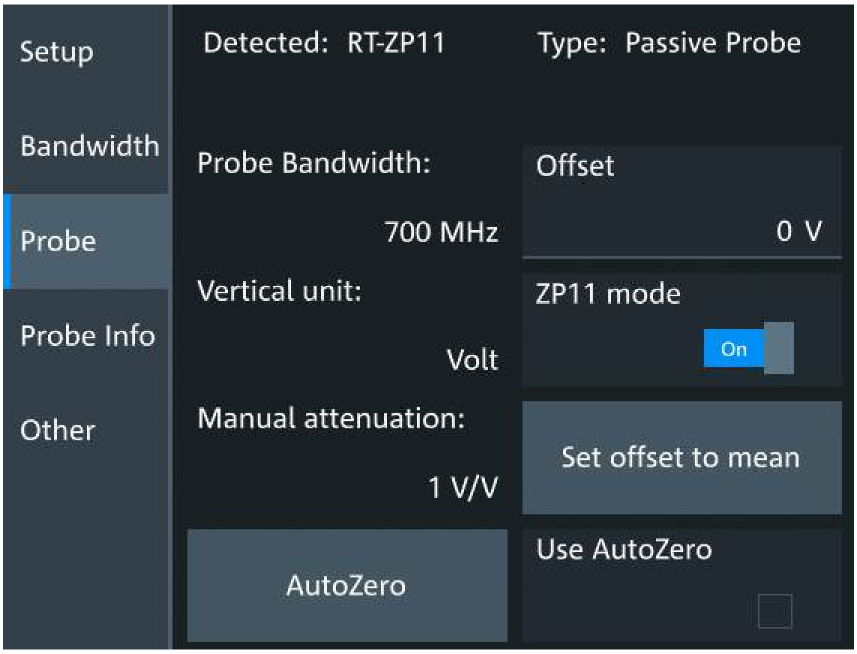


Figure 6-3: Passive probe R&S RT-ZP11, detected by the oscilloscope

The settings for passive probes are common settings, which are available for all probe types. See Section 6.4.1, "Common probe settings", on page 138 for description of the settings.

For R&S RT-ZP11, a special setting is available.

ZP11 mode
Enable if R&S RT-ZP11 is connected to adjust the probe bandwidth to 700 MHz.

If you use 500 MHz passive probe, e.g. R&S RT-ZP10, disable the setting.

6.4.3 Setup for active voltage probes

Active voltage probes with Rohde & Schwarz probe interface have an integrated data memory that contains identification data and individual probe correction parameters.

The MXO 4 can detect these probes and read out the data. Furthermore, the Rohde & Schwarz probe interface provides special features: the micro button and the ProbeMeter.

Active voltage probes that are offered by Rohde & Schwarz but not equipped with a Rohde & Schwarz probe interface are known to the MXO 4 as predefined probes.

6.4.3.1 Settings for the Rohde & Schwarz probe interface

The Rohde & Schwarz probe interface provides special features: the micro button and the ProbeMeter.

MicroButton
The micro button is located on the probe head. Pressing this button, you initiate an action on the instrument directly from the probe. The button is disabled during internal automatic processes, for example, during self-alignment, autoset, and level detection.

Select the action that you want to start from the probe.

"Run continuous"
Starts or stops the acquisition (same as Run / Stop key).

"Run single" Starts a defined number of acquisitions (same as [Single] key).

"Autoset" Starts the autoset procedure (same as Autoset key).

"Auto zero" Starts an auto zero measurement.

"Offset to mean"
Performs an automatic compensation for a DC component of the input signal using the result of a background mean measurement.

"Save image to file"
Saves the current display as image according to the image settings.

"No action" Select this option to prevent unwanted actions due to unintended usage of the micro button.

"Find trigger level" Sets the trigger level automatically to *0.5 * (MaxPeak – MinPeak)*.

"Probe mode" Only available if a R&S RT-ZM modular probe is connected. Sets the measurement mode of the modular probe.

"Probe setup" Opens the probe setup on the screen.

Remote command:
`PROBe<ch>:SETup:MODE` on page 872

ProbeMeter
Activates the integrated R&S ProbeMeter on probes with Rohde & Schwarz probe interface.

The R&S ProbeMeter is a voltmeter. It measures DC voltages between the probe tip and ground connection or between the probe tips with very high precision. The measurement runs continuously and in parallel to the measurements of the oscilloscope.

If a single-ended or power rail probe is connected, the ProbeMeter measures DC voltages between the probe tip and ground connection and enables ground-referenced measurements of voltages.

If a differential probe is connected, you can select if the ProbeMeter measures differential and common mode voltages, or single-ended voltages. See "Display" on page 144.

Remote command:
`PROBe<ch>:PMETer:STATe` on page 874
`PROBe<ch>:PMETer:RESults:SINGle?` on page 874
`PROBe<ch>:PMETer:RESults:COMMon?` on page 875
`PROBe<ch>:PMETer:RESults:DIFFerential?` on page 875
`PROBe<ch>:PMETer:RESults:NEGative?` on page 875
`PROBe<ch>:PMETer:RESults:POSitive?` on page 876

6.4.3.2 Setup for R&S RT-ZD differential probes

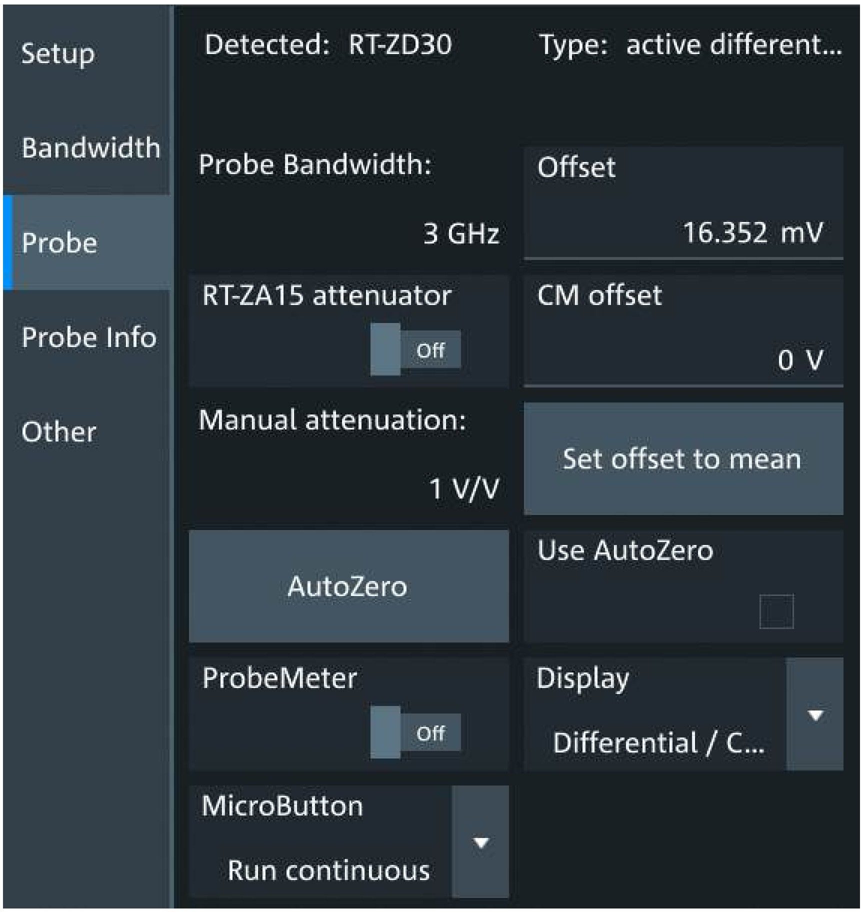


Figure 6-4: Probe setup for active differential probe R&S RT-ZD30

Most settings are common settings, which are available for all probe types. See Section 6.4.1, "Common probe settings", on page 138 for description of these settings.

R&S RT-ZD differential probes have the Rohde & Schwarz probe interface and support its functions. For details, see Section 6.4.3.1, "Settings for the Rohde & Schwarz probe interface", on page 142.

The "Offset" is the differential offset, see "Offset" on page 135.

Specific settings for R&S RT-ZD probes are the following:

CM offset
Sets the common-mode offset to compensate for a common DC voltage that is applied to both input sockets (referenced to the ground socket). The setting is available for Rohde & Schwarz differential probes and for modular probes in CM measurement mode.

Offset compensation is particularly helpful for measurements on differential signals with high common mode levels, for example, current measurements using a shunt resistor. You can measure the common mode input voltage using the R&S ProbeMeter.

Remote command:
`PROBe<ch>:SETup:CMOFfset` on page 873

RT-ZA15 attenuator
If you use the external attenuator R&S RT-ZA15 together with one of the differential active probes R&S RT-ZD10/20/30, enable "RT-ZA15 attenuator" to include the external attenuation in the measurements.

Remote command:
`PROBe<ch>:SETup:ZAXV` on page 874

Display
Selects the voltage to be measured by the ProbeMeter of differential active probes:

- "Differential / Common Mode":
  Differential voltage is the voltage between the positive and negative signal sockets. Common mode voltage is the mean voltage between the signal sockets and the ground socket. It measures the voltage level relative to ground, for example, to check the operating voltage window.
- "Single Ended Pos/Neg":
  Measures the voltage between the positive/negative signal socket and the ground. The ProbeMeter always measures the common mode and differential voltages. Single-ended voltages are calculated values:
  $V_p = V_{cm} + 0.5 * V_{in}$ and $V_n = V_{cm} - 0.5 * V_{in}$

Remote command:
`PROBe<ch>:SETup:DISPlaydiff` on page 873

6.4.3.3 Setup for R&S RT-ZPR power rail probes

R&S RT-ZPR power rail probes are designed for power integrity measurements. They can measure small signals in the millivolt range with large DC-offset components.

R&S RT-ZPR power rail probes have the Rohde & Schwarz probe interface and support the ProbeMeter, but not the micro button. For details, see Section 6.4.3.1, "Settings for the Rohde & Schwarz probe interface", on page 142.

R&S RT-ZPR probes require 50 Ω input termination.

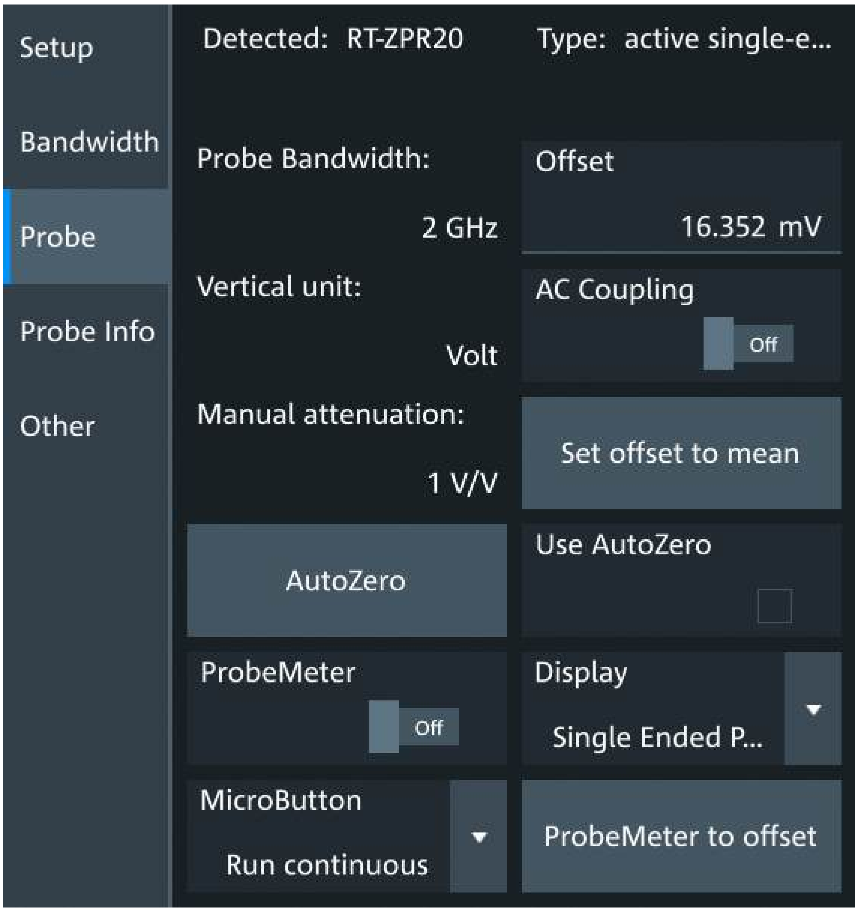


Figure 6-5: Probe setup for power rail probe R&S RT-ZPR20

Most settings are common settings, which are available for all probe types. See Section 6.4.1, "Common probe settings", on page 138 for description of these settings.

The "Offset" is the channel offset, see "Offset" on page 135.

Specific settings for R&S RT-ZPR probe are the following:

AC Coupling

Enables AC coupling in R&S RT-ZPR power rail probes, which removes DC and very low-frequency components. The R&S RT-ZPR probe requires 50 Ω input termination, for which the channel AC coupling is not available. The probe setting allows AC coupling also at 50 Ω inputs.

Remote command:
`PROBe<ch>:SETup:ACCoupling` on page 872

ProbeMeter to offset

Sets the measured ProbeMeter value as offset. Thus, the value is considered in measurements.

Remote command:
PROBe<ch>:SETup:OFFSet:TOPMeter on page 883

6.4.3.4 Setup for R&S RT-ZHD high-voltage differential probes

R&S RT-ZHD high-voltage differential probes are designed to measure safely high-voltage floating circuits using a grounded oscilloscope. They extend the measurement capability of oscilloscopes to measure electronic power converters, inverters, motor speed controls, switch mode power supplies and many other applications.

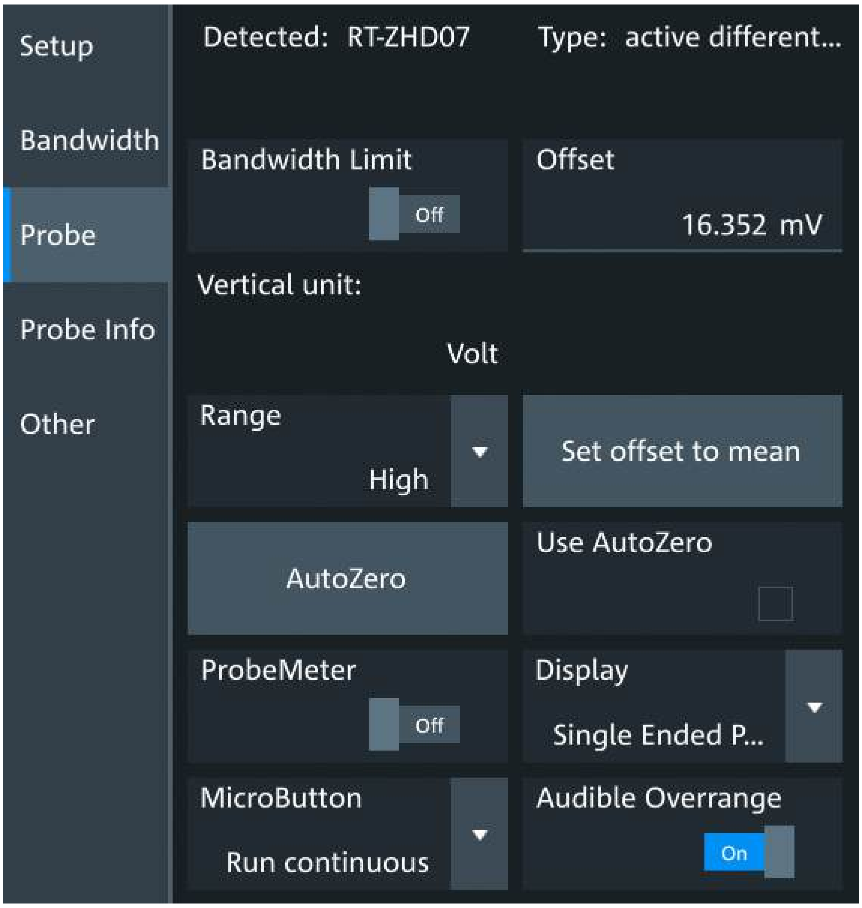


Figure 6-6: Setup for high-voltage differential probe R&S RT-ZHD07

Most settings are common settings, which are available for all probe types. See Section 6.4.1, "Common probe settings", on page 138 for description of these settings.

Bandwidth and attenuation values are indicated on the probe control box. The "Offset" is the differential offset, see "Offset" on page 135.

R&S RT-ZHD high-voltage differential probes have the Rohde & Schwarz probe interface and support its functions. For details, see Section 6.4.3.1, "Settings for the Rohde & Schwarz probe interface", on page 142.

Specific settings for R&S RT-ZHD probes are the following:

Bandwidth limit
Activates the lowpass filter in the probe control box. The filter frequency depends on the probe type and is indicated on the probe control box.

You can set the filter on the probe control box or at the oscilloscope.

Remote command:
`PROBe<ch>:SETup:ADVanced:FILTer` on page 876

Range
Sets the voltage range of an R&S RT-ZHD probe. You can set the range on the probe control box or at the oscilloscope.

"Auto"	The voltage range is set only at the oscilloscope with "Vertical scale".
"Low"	Sets the lower voltage range of the connected probe. The range values depend on the probe type and are indicated on the probe control box.
"High"	Sets the higher voltage range of the connected probe. The range values depend on the probe type and are indicated on the probe control box.

Remote command:
`PROBe<ch>:SETup:ADVanced:RANGe` on page 877

Audible overrange
Activates the acoustic overrange warning in the probe control box. You can also activate the sound directly on the probe control box.

Remote command:
`PROBe<ch>:SETup:ADVanced:AUDioverload` on page 876

6.4.4 Setup for current probes

The setup and adjustment of current probes depends on the output connector of the probe: BNC or Rohde & Schwarz probe box.

Current probes R&S RT-ZCxx

The current probes **R&S RT-ZCxx** have BNC connectors. They are known to the MXO 4 as predefined probes, see "Predefined probe, name and type of the probe" on page 139. Demagnetizing and zero adjustment is done on the probe, see the probe's User Manual for details. Make sure to demagnetize and adjust the probe before taking measurements.

Current probes R&S RT-ZCxxB

Current probes **R&S RT-ZCxxB** have a Rohde & Schwarz probe interface; they are powered and remotely controlled by the oscilloscope.

When the probe is connected, demagnetization is performed automatically.

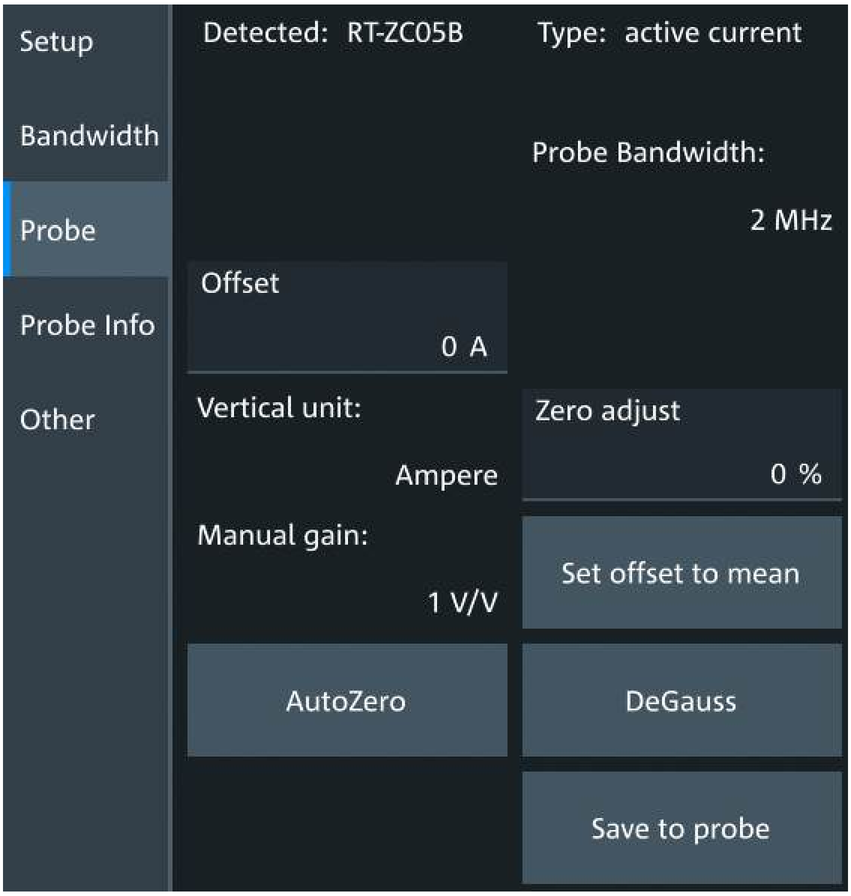


Figure 6-7: Setup for current probe R&S RT-ZC05B

Most settings are common settings, which are available for all probe types. See Section 6.4.1, "Common probe settings", on page 138 for description of these settings.

Current probes are adjusted by the following functions.

Gain, Manual gain

Shows the gain of the connected probe if the probe is detected or predefined. For unknown current probes, set the correct gain of the probe.

The vertical scaling and measured values are multiplied by this factor so that the displayed values are equal to the actual measured signal values.

Remote command:
`PROBe<ch>:SETup:GAIN:AUTO?` on page 881
`PROBe<ch>:SETup:GAIN:MANual` on page 881

DeGauss

Demagnetizes the core if it has been magnetized by switching the power on and off, or by an excessive input. Always carry out demagnetizing before measurement.

The demagnetizing process takes about one second. During demagnetizing, a demagnetizing waveform is displayed.

Demagnetizing is done automatically when R&S RT-ZCxxB is connected to the oscilloscope, or when "AutoZero" is performed.

Remote command:
`PROBe<ch>:SETup:DEGauss` on page 882

Zero adjust
Zero adjust corrects the effect of an offset caused by temperature drift, and compensates for the remanence. The setting is only available if DC coupling is set.

To set the waveform to zero level by the instrument, use "AutoZero". The detected value is displayed.

Alternatively, you can adjust the value manually until the waveform is set to zero level. Make sure to demagnetize the probe before zero adjustment.

The value is given in percent of the maximum range, which is internally defined. The actual setup range depends on the temperature drift, the measured current and other variables, and it can change over time. If you measure high currents, the probe core magnetizes, which impairs the measurement results. Therefore, repeat "AutoZero" before the measurement.

Remote command:
`PROBe<ch>:SETup:OFFSet:ZADJust` on page 882

Save to probe
Saves the zero adjust value in the probe box. If you connect the probe to another channel or to another Rohde & Schwarz oscilloscope, the value is read out again, and you can use the probe without further adjustment.

Remote command:
`PROBe<ch>:SETup:OFFSet:STPRobe` on page 882

6.4.5 Modular probes

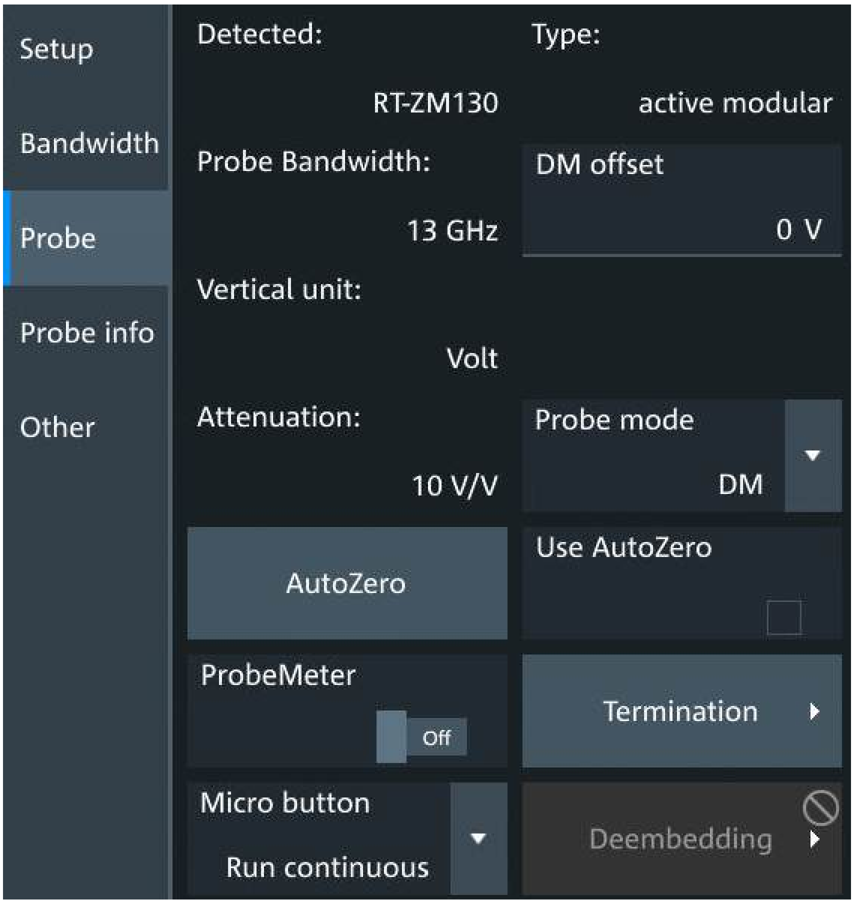
The probes of the R&S RT-ZM family are modular probes. They have a probe head and a probe amplifier connected by a cable, and various probe tip modules and tip cables for different applications. R&S RT-ZM probes are equipped with Rohde & Schwarz probe interface, and provide special features: R&S ProbeMeter, micro button, and a wide offset compensation range.

The following common probe settings are available:

- "Probe bandwidth" on page 139
- "Vertical unit" on page 140
- "Attenuation" on page 140
- "AutoZero, Use AutoZero" on page 140

The R&S RT-ZM probes support the following features of the Rohde & Schwarz probe interface:

- "MicroButton" on page 142
- "ProbeMeter" on page 142



The specific functions of modular probes are described in the following sections:

6.4.5.1 Setup parameters of modular probes

Access: "Menu" > "Vertical" > "Probe" tab, and R&S RT-ZM probe is connected to the channel

Probe mode

Sets the measurement mode of modular probes.

The modular probes of the R&S RT-ZM family have a multimode function. You can switch between single-ended, differential and common mode measurements without reconnecting or resoldering the probe. You can set the probe mode in the dialog, and you can assign the probe mode setting to the micro button.

If you use the R&S RT-ZMA30 browser module, only DM measurements are possible because this module has no ground connector.

The measurement modes are:

"DM" Differential-mode input voltage (V_{dm}), the voltage between the positive and negative input terminal.

$$V_{dm} = V_p - V_n$$

"CM" Common-mode input voltage (V_{cm}), the mean voltage between the positive and negative input terminal vs. ground.

$$V_{cm} = \frac{V_p + V_n}{2}$$

"P" Positive single-ended input voltage (V_p). The voltage between the positive input terminal and the ground.

"N" Negative single-ended input voltage (V_N). The voltage between the negative input terminal and the ground.

Remote command:
PROBe<ch>:SETup:PRMode on page 878

DM Offset, CM Offset, P Offset, N Offset

Compensate offset voltages. The dialog shows the offset of the selected probe mode.

The offset of the selected probe mode is used as the channel offset and considered automatically for correction. For example, in CM mode, the common mode offset is used as the channel offset.

"DM Offset" Compensates a DC voltage applied between the positive (V_p) and the negative (V_n) input terminal at the probe tip.

"CM Offset" Compensates a DC voltage applied to both input terminals referenced to ground.

"P Offset" Compensates a DC voltage applied to the positive input terminal (V_p) referenced to ground.

"N Offset" Compensates a DC voltage applied to the negative input terminal (V_n) referenced to ground.

Remote command:
PROBe<ch>:SETup:DMOFfset on page 878
PROBe<ch>:SETup:CMOFfset on page 873
PROBe<ch>:SETup:NOFFset on page 879
PROBe<ch>:SETup:POFFset on page 879

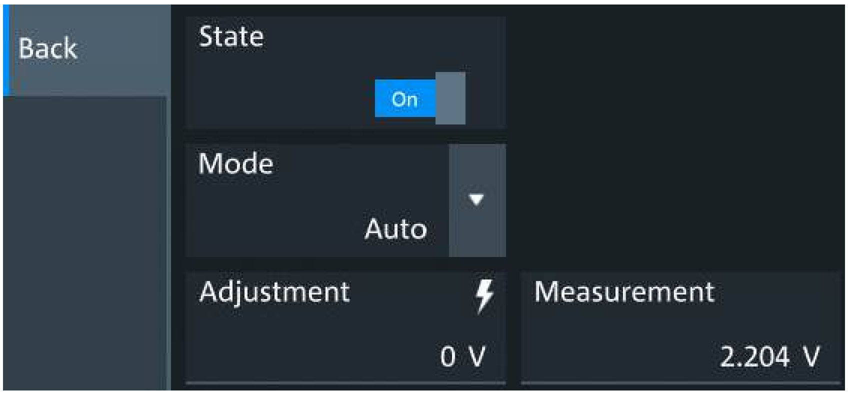
6.4.5.2 Termination voltage with R&S RT-ZMA40 SMA module

Access: "Menu" > "Vertical" > "Probe" tab > "Termination"

Termination voltage is relevant if you use the R&S RT-ZMA40 SMA module. The SMA module applies a termination voltage (±4 V) to the DUT to enable measurements against a common mode DC voltage instead of ground. This measurement is required for many digital signal standards.

The termination voltage can be controlled at the oscilloscope. Therefore, connect the V_T terminal of the R&S RT-ZM probe amplifier to the V_T terminal of the R&S RT-ZMA40

SMA module using the red DC lead (see R&S RT-ZM User Manual). The required termination voltage is measured and adjusted automatically, but can also be set manually.



State

Activates control of the termination voltage.

Remote command:
PROBe<ch>:SETup:TERM:STATe on page 880

Mode

Selects the voltage that is used for termination.

In auto mode, the instrument uses the measured common mode voltage for termination. In manual mode, you can enter the voltage to be used for termination. Use the manual mode if you know the common mode voltage of the DUT.

Remote command:
PROBe<ch>:SETup:TERM:MODE on page 880

Adjustment

Sets the voltage to be used for termination correction in manual termination mode.

Remote command:
PROBe<ch>:SETup:TERM:ADJust on page 879

Measurement

Shows the measured common mode voltage.

Remote command:
PROBe<ch>:SETup:TERM:MEASure? on page 880

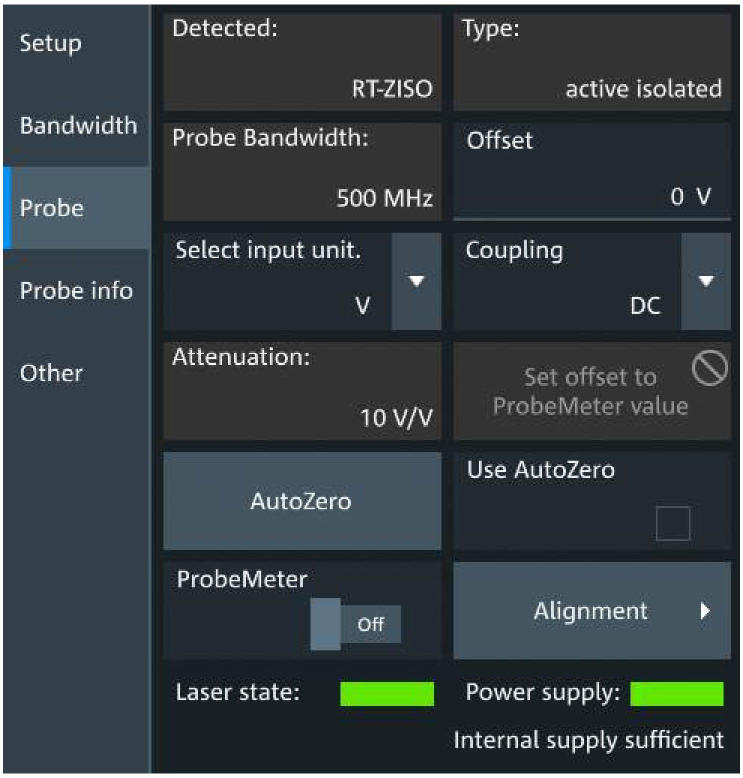
6.4.6 Setup for optical isolated probe systems

The R&S RT-ZISO is an optical isolated probe system. It consists of the probe head with exchangeable tip module, probe receiver, and scope connector cable. The probe head is permanently connected to the probe receiver by an optical cable, which is an optical isolated cable with multifiber system. To connect the probe receiver to the MXO 4, the scope connector cable is used. This cable provides the required supply voltage and transmits the measurement data and control signals simultaneously.

The power consumption of the probes is monitored by the power monitor. See Section 6.4.8.1, "Power monitor", on page 157 for details.

6.4.6.1 Setup parameters of optical isolated probes

Access: "Menu" > "Vertical" > "Probe" tab > select channel with connected R&S RT-ZISO probe.



Most settings are common settings, which are available for all probe types. See Section 6.4.1, "Common probe settings", on page 138 for description of these settings.

The dialog also shows some vertical settings

- "Offset". See "Offset" on page 135 for details.
- "Coupling". See "Coupling" on page 135 for details.

Set the vertical scale in the "Setup" tab. The probe adjusts its attenuation automatically.

Select input unit

Sets the unit of the R&S RT-ZISO signal.

Remote command:
`PROBe<ch>:SETup:ADVanced:UNIT` on page 883

Set offset to ProbeMeter value

Sets the measured R&S ProbeMeter value as offset. Thus, the value is considered in measurements.

The function is available if ProbeMeter is active.

Remote command:
`PROBe<ch>:SETup:ADVanced:PMToffset` on page 877

Alignment
Opens the "Alignment" dialog. See Section 6.4.6.2, "Alignment", on page 154.

Laser state
The color indicates the current status of the laser:

- Green: the laser is working.
- Yellow: the laser needs service, but is still working.
- Red: defective laser, send it to your Rohde & Schwarz service center.

Remote command:
`PROBe<ch>:SETup:LASer:STATe?` on page 883

Power supply
Indicates wether the power supply of the R&S RT-ZISO is sufficient.

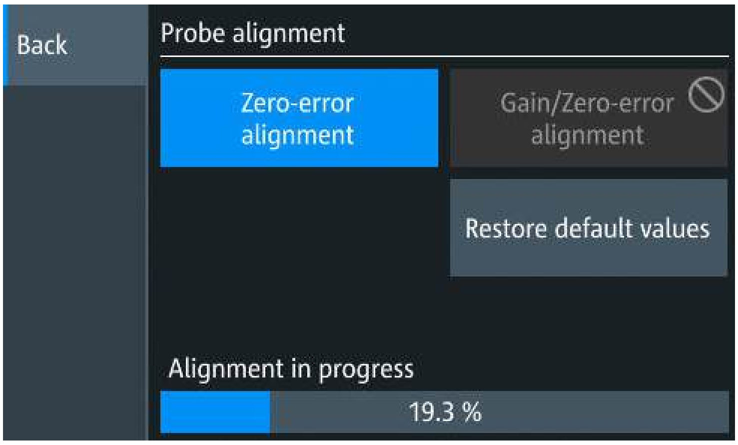
Details on power consumption are given in the power monitor. See Section 6.4.8.1, "Power monitor", on page 157.

6.4.6.2 Alignment

Access: "Menu" > "Vertical" > "Probe" tab > select channel with connected R&S RT-ZISO probe > "Alignment".

The dialog provides functions to correct the zero point and gain errors.

Align the probe before first use, and when the ambient conditions have been changed, for example, when strong temperature changes occur (> 5°).



The progress of the alignment process is shown in a progress bar below the buttons.

Zero-error alignment
Performs a self-alignment and corrects the zero point error of the R&S RT-ZISO probe.

Tip modules are not affected by the alignment. Attaching or removing the tip module does not change the process or result.

The alignment can take about a minute, the progress is shown in the dialog. Wait until the process has been finished. After successful alignment, the correction data is automatically written to the non-volatile flash of the probe.

Remote command:
PROBe<ch>:SETup:ALIGnment:ZERO:EXECute on page 884

Gain/Zero-error alignment
Corrects the zero point error and the gain error of the R&S RT-ZISO probe.

Tip modules are not affected by the alignment. Attaching or removing the tip module does not change the process or result.

The alignment can take about a minute, the progress is shown in the dialog. Wait until the process has been finished. After successful alignment, the correction data is automatically written to the non-volatile flash of the probe.

Remote command:
PROBe<ch>:SETup:ALIGnment:GAIN:EXECute on page 884

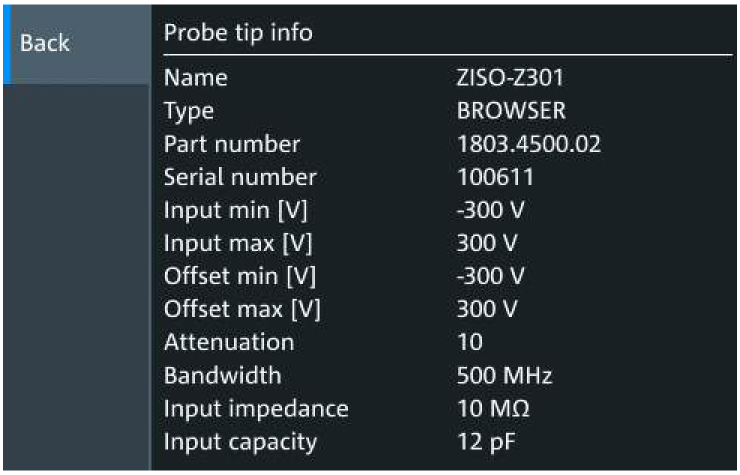
Restore default values
Resets the zero point and gain error correction to the factory default values.

Remote command:
PROBe<ch>:SETup:ADVanced:RDEFaults on page 884

6.4.6.3 Tip info dialog

Access: "Menu" > "Vertical" > "Probe" > select channel with connected R&S RT-ZISO probe > "Tip info"

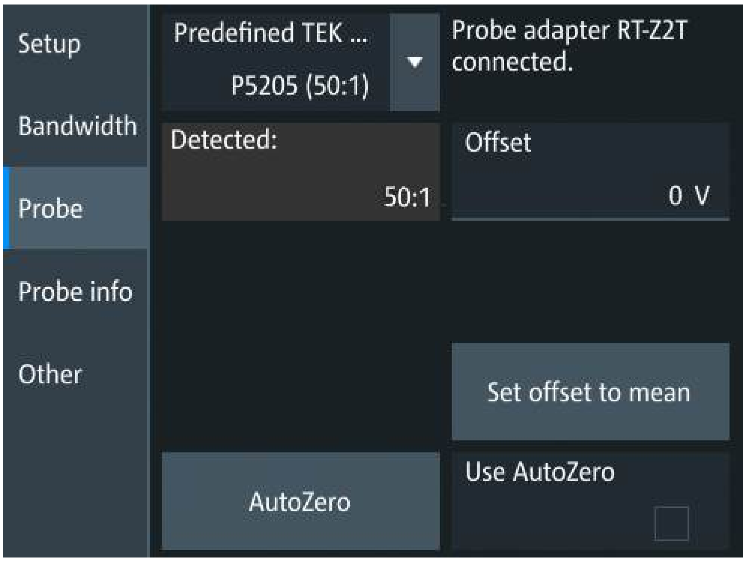
The dialog shows the characteristics of the tip modules that are connected to the probes.



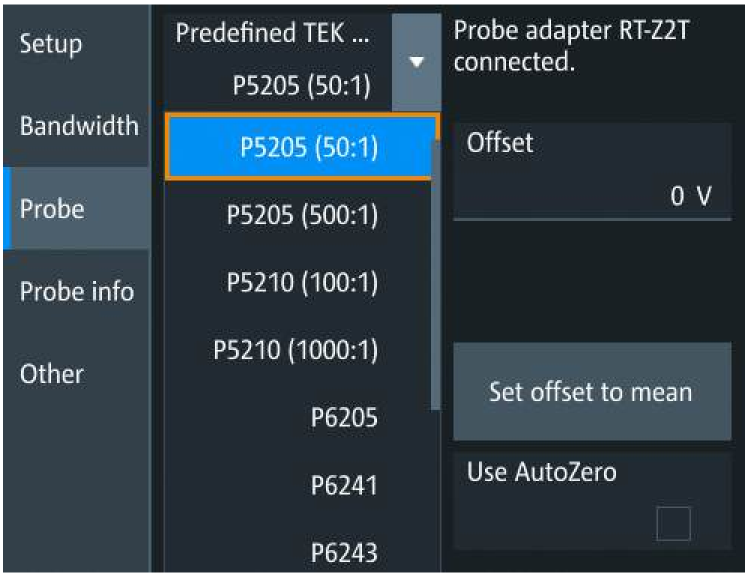
6.4.7 Probe adapter R&S RT-Z2T

Using the R&S RT-Z2T probe interface adapter, you can connect selected Tektronix active probes with TekProbe BNC™ level II interface.

1. Connect the R&S RT-Z2T adapter to the channel input.
2. Connect the probe to the adapter.
   The instrument identifies the adapter.
3. Select "Menu" > "Vertical" > "Probe" tab.

   The dialog shows that the R&S RT-Z2T probe interface adapter is connected, and supported Tektronix probes are listed as "Predefined probe".
4. Select the "Predefined probe" in the "Probe" tab.

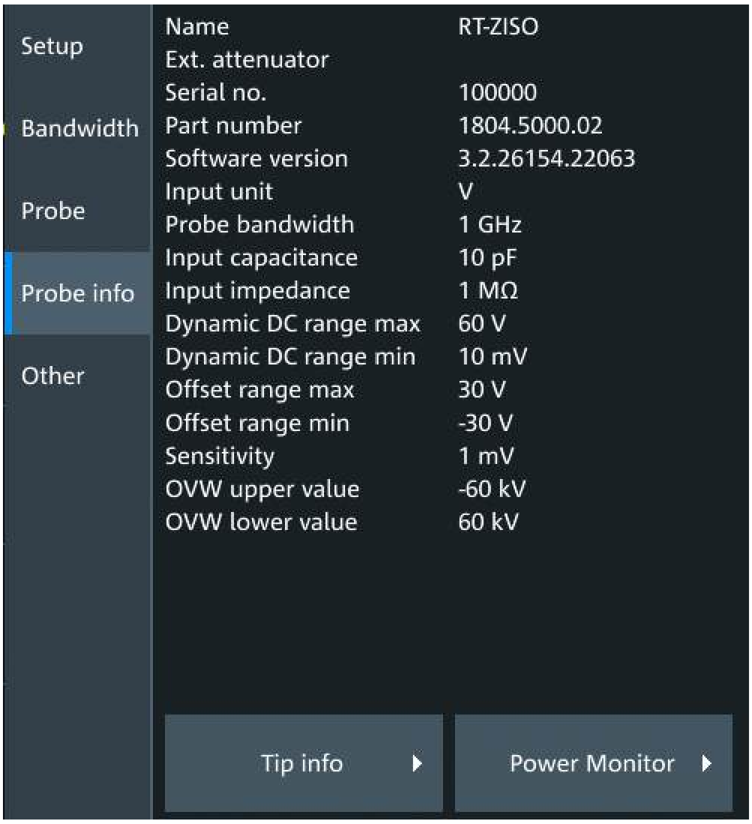
See also: "Predefined probe, name and type of the probe" on page 139.

The power consumption of the R&S RT-Z2T probe interface adapter in the "Power Monitor": "Vertical" > "Probe Info" > "Power Monitor".

6.4.8 Probe info

The dialog shows general information on the connected probe, for example, type, serial number, and part number. Below, electrical characteristics are shown, like bandwidth, attenuation, input capacitance and impedance, voltage and DC offset range.

For a specification of the probe parameters, refer to the specifications document.

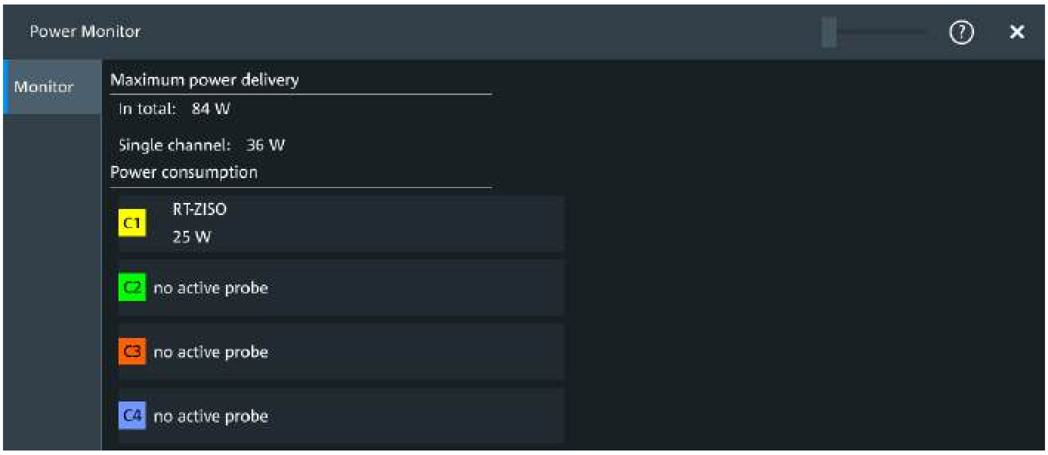


Remote commands: Section 18.8.6.7, "Probe attributes", on page 886.

6.4.8.1 Power monitor

The power monitor informs about the connected probes and their power consumption. The maximum available power per rail and per single channel are also shown.

If you use several R&S RT-ZISO probes, the power of the instrument can be insuffcient to power all probes. The power monitor notifies you of insufficient power. To solve the problem, you can remove redundant probes, or use the external power supplies to power the R&S RT-ZISO probes.



6.4.8.2 Tip info

The "TIP info" button and dialog are available if an R&S RT-ZISO probe is connected to the channel. See Section 6.4.6.3, "Tip info dialog", on page 155 for details.

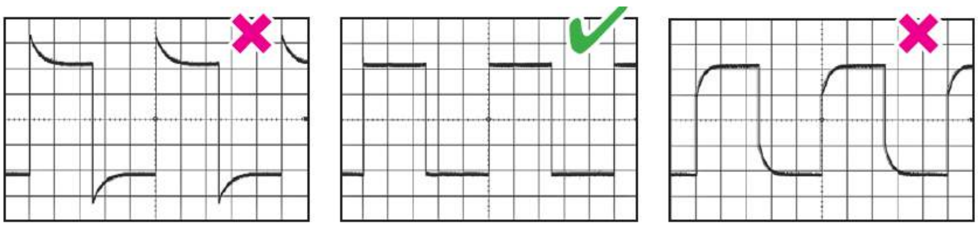
6.4.9 Adjusting passive probes

When using a passive probe, you have to compensate it when you connect it to the instrument the first time. Compensation matches the probe cable capacitance to the oscilloscope input capacitance to assure good amplitude accuracy from DC to upper bandwidth limit frequencies. A poorly compensated probe reduces the performance of the probe-oscilloscope system and introduces measurement errors resulting in distorted waveforms and inaccurate results.

Two connector pins are located on the front panel. The ⊥ pin is on ground level. The ⎍ pin supplies a square wave signal with 1 kHz for low frequency probe compensation.

1. Connect the BNC connector of the probe to one of the channel inputs.
2. Connect the probe's ground connector to the ground compensation pin, and the probe tip to the signal pin.
3. Press [Autoset].

   A square wave appears on the display.
4. Adjust the compensation trimmer of the probe to optimum square wave response. For details, refer to the documentation of your probe.



7 Trigger

This section describes the trigger capabilities of the MXO 4.

7.1 Basics of triggering

Triggering means to capture the interesting part of the relevant waveforms, and the trigger point is the determining point in the waveform record. Choosing the right trigger type and configuring all trigger settings correctly allows you to detect various incidents in analog, digital, and protocol signals.

How the oscilloscope triggers

A trigger occurs if the complete set of trigger conditions is fulfilled. The instrument acquires continuously and keeps the sample points to fill the pre-trigger part of the waveform record. When the trigger occurs, the instrument continues acquisition until the post-trigger part of the waveform record is filled. Then it stops acquiring and waits for the next trigger. When a trigger is recognized, the instrument does not accept another trigger until the acquisition is complete and the holdoff time has expired.

Trigger setup on the oscilloscope

A simple trigger setup includes:

- Source of the trigger signal
- Trigger type selection and setup
- Horizontal position of the trigger, see: Section 6.1.1, "About the horizontal system", on page 117
- Trigger mode

The MXO oscilloscopes provide various trigger types for troubleshooting and signal analysis, for example, edge trigger, glitch trigger, interval trigger, pattern trigger, and much more.

For complex tasks like verifying and debugging designs, advanced trigger settings are available:

- Filter to remove high or low frequencies from the trigger signal.
- Hysteresis to avoid unwanted trigger events caused by noise.
- Holdoff to define exactly which trigger event causes the trigger.

- Trigger sequences to combine several event conditions.

Action on trigger

A trigger can initiate one or more actions, for example, a trigger out signal, saving a screenshot or saving waveform data. All available actions can be initiated at the same time.

Trigger sequence

A trigger sequence joins two or more separate trigger conditions with an optional delay time and an optional reset time or reset condition. Similar setups are also known as multi-step triggers or A/B trigger.

7.1.1 Trigger information

Information on the most important trigger settings is shown in the trigger label above the diagram. If you tap the trigger label, the "Trigger" dialog opens.

If you trigger on a single event, the trigger label shows:
- Trigger source
- Trigger type
- Trigger level
- Trigger mode
- Edge or polarity, and important trigger-type specific settings
- Trigger state

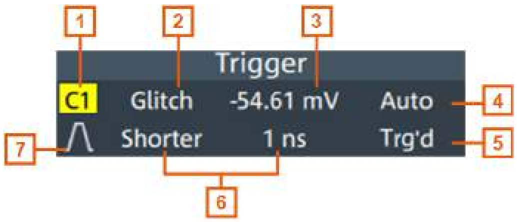


Figure 7-1: Trigger label on the toolbar

1 = Trigger source
2 = Trigger type
3 = Trigger level
4 = Trigger mode
5 = Trigger state
6 = Trigger type specific settings
7 = Trigger slope

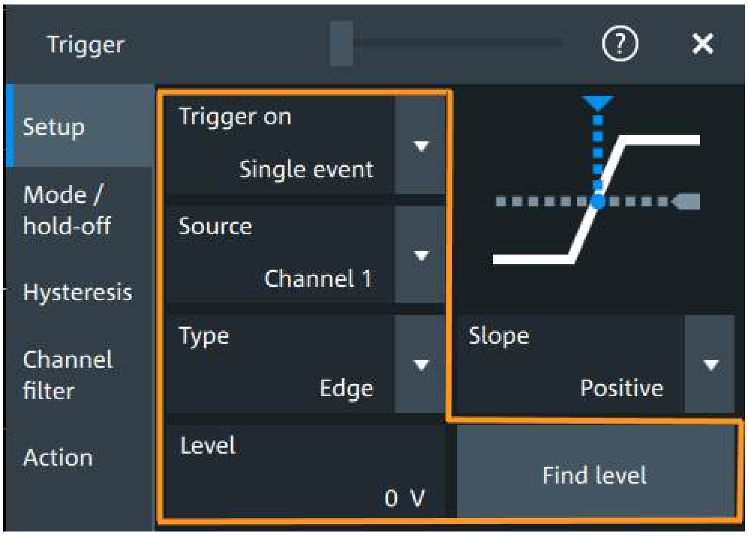
If you trigger on a sequence, the trigger label shows:
- Sequence type
- Trigger mode
- Trigger state

7.2 Common trigger settings

Access: "Menu" > "Trigger" > "Setup" tab

The common trigger settings are the trigger sequence, trigger source, the trigger type, and the trigger level. To set the trigger level automatically, use "Find level".

These common settings are set once for a single event. In a trigger sequence, they are specific for each condition.



Depending on the trigger type, additional settings are needed. They are explained in the trigger-type specific sections, see Section 7.4, "Trigger types", on page 165.

Trigger on

Selects, if you want to trigger on a single event, or on a series of events.

Remote command:

`TRIGger:MEVents:MODE` on page 894

Source

Selects the source of the trigger signal for the selected trigger event. The trigger source works even if it is not displayed in a diagram.

Available sources depend on the trigger sequence setting. If you trigger on a single event, all inputs can be used as trigger source. If you trigger on a sequence, only analog channels can be set as trigger source for A, B, and R-events.

The trigger source can be:
- Channel <n>: an analog input channel
- Extern: external analog signal connected to the external trigger input. For the external trigger source, the analog edge trigger is available.

- Line: The instrument generates the trigger from the AC power input and synchronizes the signal to the AC power frequency. Use this source if you want to analyze signals related to the power line frequency, such as lighting equipment and power supply devices. For the line trigger source, the edge trigger type is available.
- Digital channels D0 to D15
  If the MSO option is installed, you can trigger on digital channels. Digital channels are only available for triggering on single event.
- Serial buses
  If one or more serial protocol options are installed, you can trigger on various conditions in the bus signal. If the hardware trigger is supported for a protocol, triggering on single event is possible. For all protocols, the software trigger is supported in a "A → Serial bus". hardware and software trigger have different trigger settings.

For the state trigger, this source is the "Clock source", the clock signal.

For the setup & hold trigger, this source is the "Data source", the data signal.

Remote command:
`TRIGger:EVENt<ev>:SOURce` on page 895

Type
Selects the trigger type. In a trigger sequence, the trigger type is set for each condition.

The current trigger type is shown on the button and in the trigger label above the diagram.

The following trigger types are available:
- Edge trigger, see page 166
- Glitch trigger, see page 168
- Width trigger, see page 170
- Runt trigger, see page 171
- Window trigger, see page 173
- Timeout trigger, see page 175
- Interval trigger, see page 176
- Slew rate trigger, see page 178
- Setup & Hold, see page 180
- State trigger, see page 182
- Pattern trigger, see page 183

If the external trigger input is used as the trigger source, the analog edge trigger is the only available trigger type.

For digital channels, the edge, width, timeout, state and pattern trigger are available.

Remote command:
`TRIGger:EVENt<ev>:TYPE` on page 894

Level
Sets the voltage level or threshold for the trigger.

You can also drag the trigger level marker on the display, or turn the [Level] knob. To set the trigger level to 50% of the signal amplitude, press the [Level] knob.

For the setup & hold trigger, this level sets the voltage level for the data signal. At this level, the setup and hold time are measured.

For the timeout trigger, the trigger level is the threshold for the high and low signal states.

Runt, window and slew rate triggers require two trigger levels (upper and lower), which are defined as specific settings.

Remote command:
`TRIGger:EVENt<ev>:LEVel<n>[:VALue]` on page 895
`TRIGger:ANEDge:LEVel` on page 899 (for external trigger source)

Find level
Sets the trigger level automatically to *0.5 * (MaxPeak – MinPeak)*.

In a trigger sequence, "Find level" affects all active events of the sequence (A, B, and R event).

The function is not available for trigger sources "Extern" and "Line".

Remote command:
`TRIGger:FINDlevel` on page 895

7.3 Trigger sequence

With MXO 4, you can trigger on a single trigger event, or on a sequence of events. A trigger sequence consists of at least two event conditions and additional conditions defining when the trigger occurs.

All trigger sequences require that analog input channels C<n> are set as trigger source for the A-trigger. The instrument checks all trigger settings for compatibility and adjusts them if they do not fit.

The following trigger types are only available for triggering on single event:

- Setup & Hold
- State
- Pattern

A → B → R sequence

The trigger sequence "A → B → R", for example, consists of two subsequent events: A-trigger and B-trigger with optional B-trigger delay and count. In addition, an optional reset condition R can be configured: timeout or R-trigger condition. A-, B-, and R-triggers are configured in the same way.

After the A-trigger conditions have been met, and an optional delay has passed, the B-trigger with independent conditions is enabled. The instrument waits until one or a specified number of B-trigger conditions occur. If the reset condition is not fulfilled, the latest B-trigger causes the trigger event, and then the sequence starts again. The B-trigger can only cause the trigger event if it occurs after the A-trigger and after the delay time.

If you expect, for example, an irregular B-trigger, you can configure a reset condition to restart the sequence. The reset condition can be a simple timeout, and/or a reset event that is defined in the same way as the A- and B-trigger conditions.

7.3.1 Sequence setup

Access: "Menu" > "Trigger" > "Setup" tab > "Trigger on" = "Sequence"

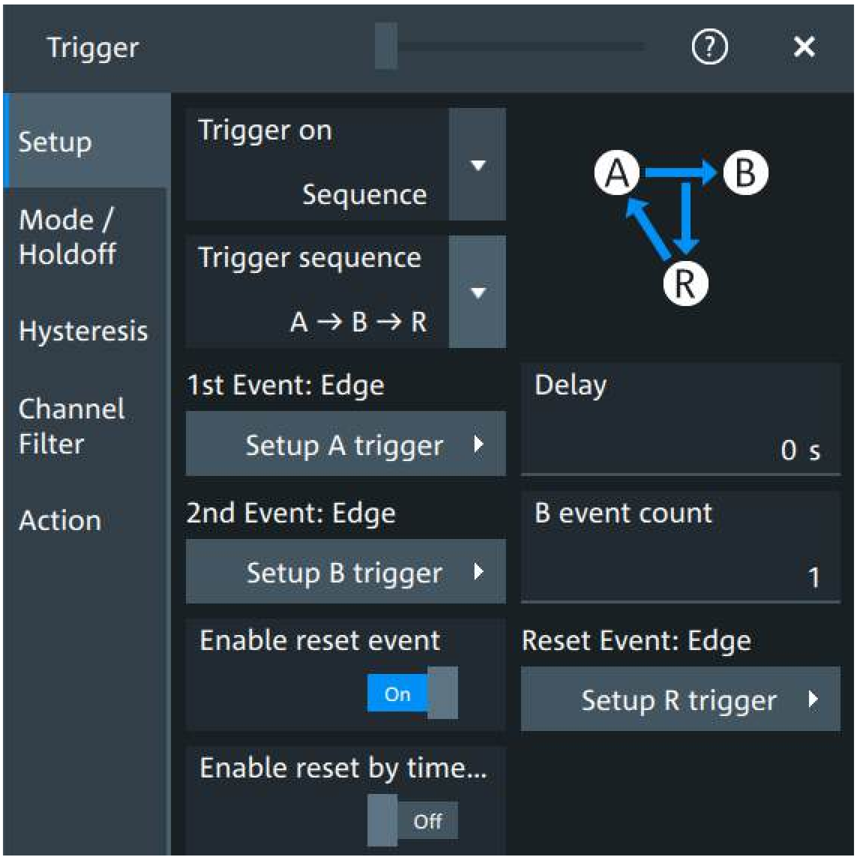


Figure 7-2: Trigger setup dialog with selected A → B → R sequence

Trigger sequence
Selects the type of the trigger sequence.

"A → B → R" Triggers if all conditions of A- and B-events, as well as additional delay and count, and optional reset timeout and/or R-event conditions are fulfilled.
B-trigger and R-trigger are configured in the same way as the A-trigger. You can configure a delay between the A- and B-trigger, and define a number of fulfilled B-trigger conditions to be ignored. The reset condition R can be a timeout or a trigger condition, or a combination of both.

"A → Zone Trigger" Triggers if the conditions of the A-event and the zone trigger are fulfilled.
See Section 7.9, "Zone trigger", on page 195

"A → Serial bus" Triggers if the conditions of the A-event and the serial bus are fulfilled.
See Section 14.1.5, "Trigger", on page 440.

Remote command:
`TRIGger:MEVents:AEVents` on page 896

Delay
Sets the time that the instrument waits after an A-trigger until it recognizes B-triggers.

Remote command:
`TRIGger:MEVents:SEQuence<se>:DELay` on page 897

B event count
Sets the number of B-trigger conditions to be fulfilled after an A-trigger. The last B-trigger causes the trigger event. The waiting time for B-triggers can be restricted with a reset condition: timeout or reset event.

Remote command:
`TRIGger:MEVents:SEQuence<se>:COUNt` on page 896

Enable reset event
If enabled, the trigger sequence is restarted by the R-trigger condition if the specified number of B-triggers does not occur before the R-trigger conditions are fulfilled.

Remote command:
`TRIGger:MEVents:SEQuence<se>:RESet:EVENt` on page 897

Enable reset by time, Reset timeout
If reset timeout is enabled, the instrument waits for the "Reset timeout" time for the specified number of B-triggers. If no trigger occurs during that time, the sequence is restarted with the A-trigger.

Remote command:
`TRIGger:MEVents:SEQuence<se>:RESet:TIMeout[:ENABle]` on page 898
`TRIGger:MEVents:SEQuence<se>:RESet:TIMeout:TIME` on page 897

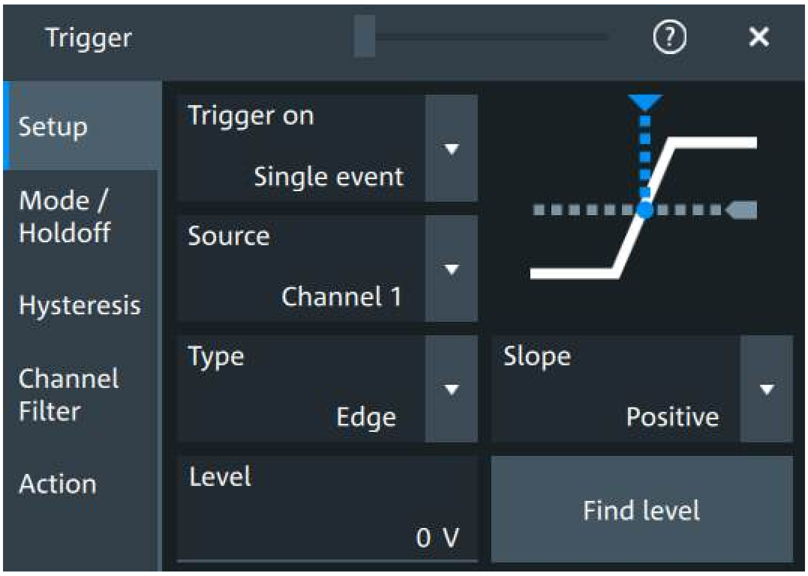
7.4 Trigger types

7.4.1 Edge trigger

Access: "Menu" > "Trigger" > "Setup" tab > "Type = Edge"

The edge trigger is the most common trigger type. The trigger occurs when the signal from the trigger source passes the trigger level in the specified direction (slope).

This section describes the trigger-type specific settings. For settings that apply to all trigger types, see Section 7.2, "Common trigger settings", on page 161.



Level
See "Level" on page 162.

Remote command:
`TRIGger:EVENt<ev>:LEVel<n>[:VALue]` on page 895

Slope
Sets the edge direction for the trigger.

"Positive"	Selects the rising edge, which is a positive voltage change.
"Negative"	Selects the falling edge, which is a negative voltage change.
"Either"	Selects the rising and falling edge. After starting an acquisition, the instrument triggers on the first identified edge.

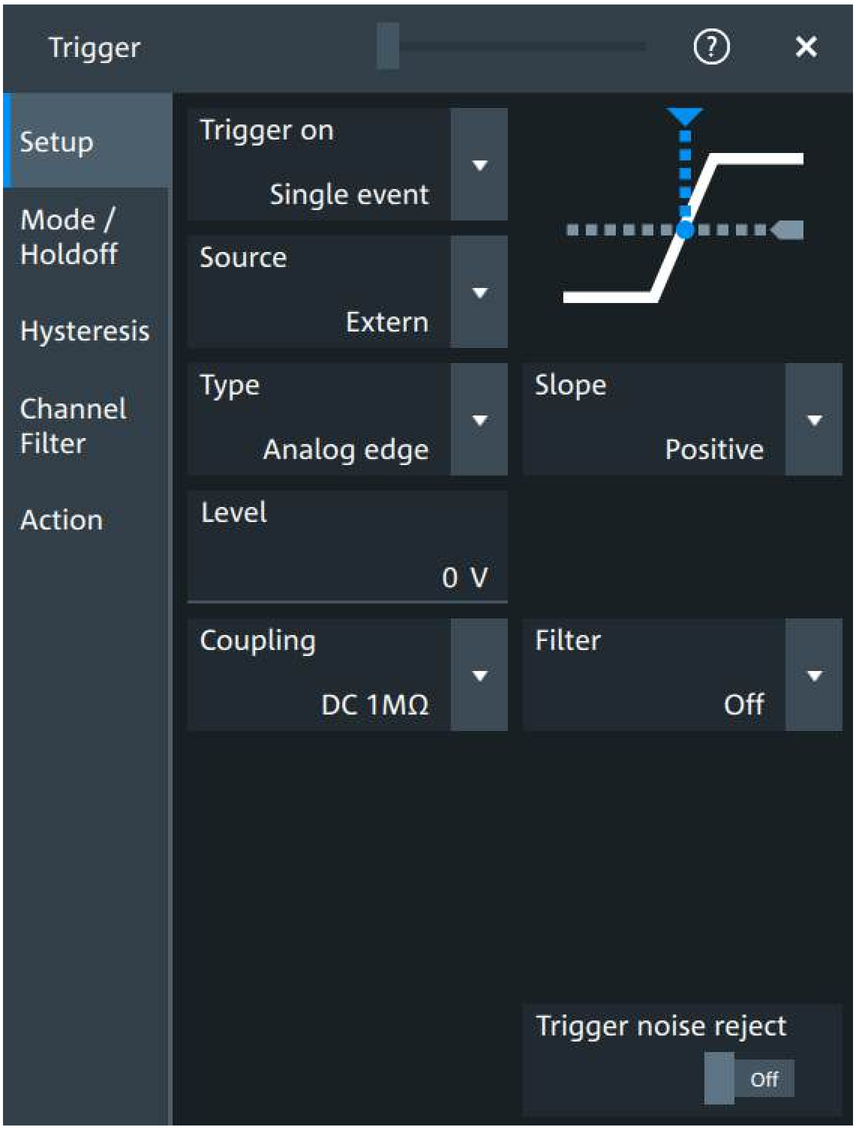
Remote command:
`TRIGger:EVENt<ev>:EDGE:SLOPe` on page 898

7.4.2 Edge trigger on external trigger source

Access: "Menu" > "Trigger" > "Setup" tab > "Source" = "Extern" > "Type = Analog Edge"

If an external trigger signal is connected to the Trigger In connector, and the trigger source is set to "Extern", the analog edge trigger is available. Triggering on an external source is only possible if you trigger on a single event but not for sequences.

This section describes the trigger-type specific settings. For settings that apply to all trigger types, see Section 7.2, "Common trigger settings", on page 161.



The "Slope" and "Level" are the same settings as for the edge trigger, see:

- "Level" on page 162
- "Slope" on page 166

Specific settings for the analog edge trigger are the following:

Coupling

Sets the connection of the external trigger signal, i.e. the input impedance and a termination. The coupling determines what part of the signal is used for triggering.

"DC 50 Ω"	Connection with 50 Ω termination, passes both DC and AC components of the signal.
"DC 1 MΩ"	Connection with 1 MΩ termination, passes both DC and AC components of the signal.
"AC 1 MΩ"	Connection with 1 MΩ termination through DC capacitor, removes DC and very low-frequency components. The waveform is centered on zero volts.

Remote command:
`TRIGger:ANEDge:COUPling` on page 899

Filter, Cut-off

Selects the filter mode for the external trigger signal, and sets the cut-off frequency.

"Off"	The trigger signal is not filtered.
"LF reject"	Frequencies lower than the "Cut-off" frequency are rejected, higher frequencies pass the filter.
"RF reject"	Frequencies higher than the "Cut-off" frequency are rejected, lower frequencies pass the filter.

Remote command:
`TRIGger:ANEDge:FILTer` on page 899
`TRIGger:ANEDge:CUToff:HIGHpass` on page 899
`TRIGger:ANEDge:CUToff:LOWPass` on page 900

Trigger noise reject

Enables an automatic hysteresis on the trigger level to avoid unwanted trigger events caused by noise.

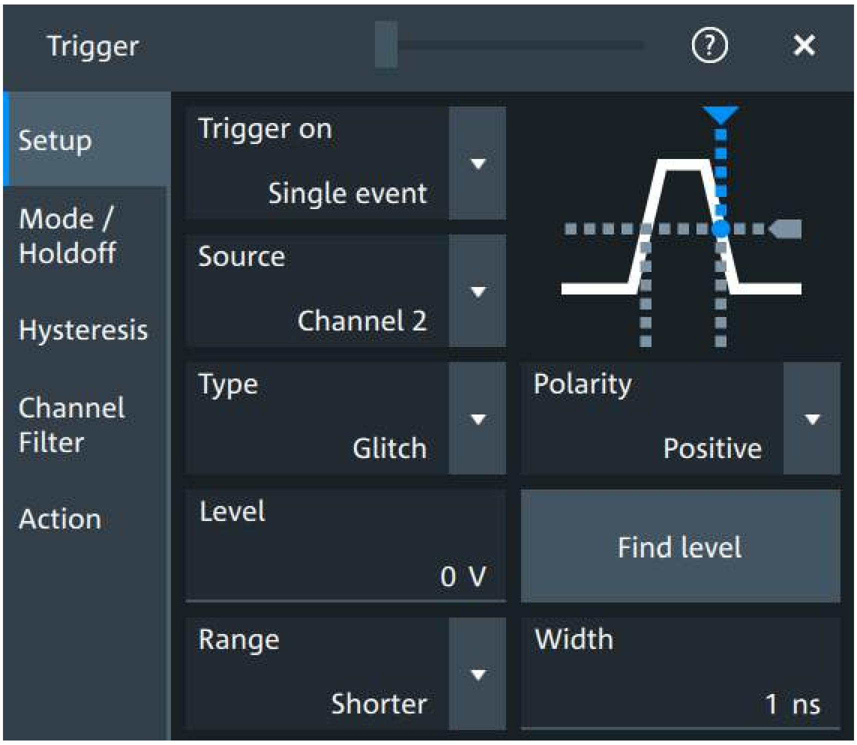
Remote command:
`TRIGger:ANEDge:NREJect` on page 900

7.4.3 Glitch trigger

Access: "Menu" > "Trigger" > "Setup" tab > "Type = Glitch"

The glitch trigger detects pulses shorter or longer than a specified time. It identifies deviation from the nominal data rate and helps to analyze causes of even rare glitches and their effects on other signals.

This section describes the trigger-type specific settings. For settings that apply to all trigger types, see Section 7.2, "Common trigger settings", on page 161.



Level

See "Level" on page 162.

Remote command:
TRIGger:EVENt<ev>:LEVel<n>[:VALue] on page 895

Polarity

Sets the polarity of a pulse, which is the direction of the first pulse slope.

"Positive" Selects positive going pulses, the width is defined from the rising to the falling slopes.

"Negative" Selects negative going pulses, the width is defined from the falling to the rising slopes.

"Either" Selects both positive and negative going pulses.

Remote command:
TRIGger:EVENt<ev>:GLITch:POLarity on page 900
TRIGger:EVENt<ev>:RUNT:POLarity on page 904

Range

Selects how the time limit of the runt pulse is defined.

Remote command:
TRIGger:EVENt<ev>:GLITch:RANGe on page 901

Width

Sets the length of a glitch. The instrument triggers on pulses shorter or longer than this value, depending on the value set with "Range".

You need to know the expected pulse widths of the circuit to set the glitch width correctly.

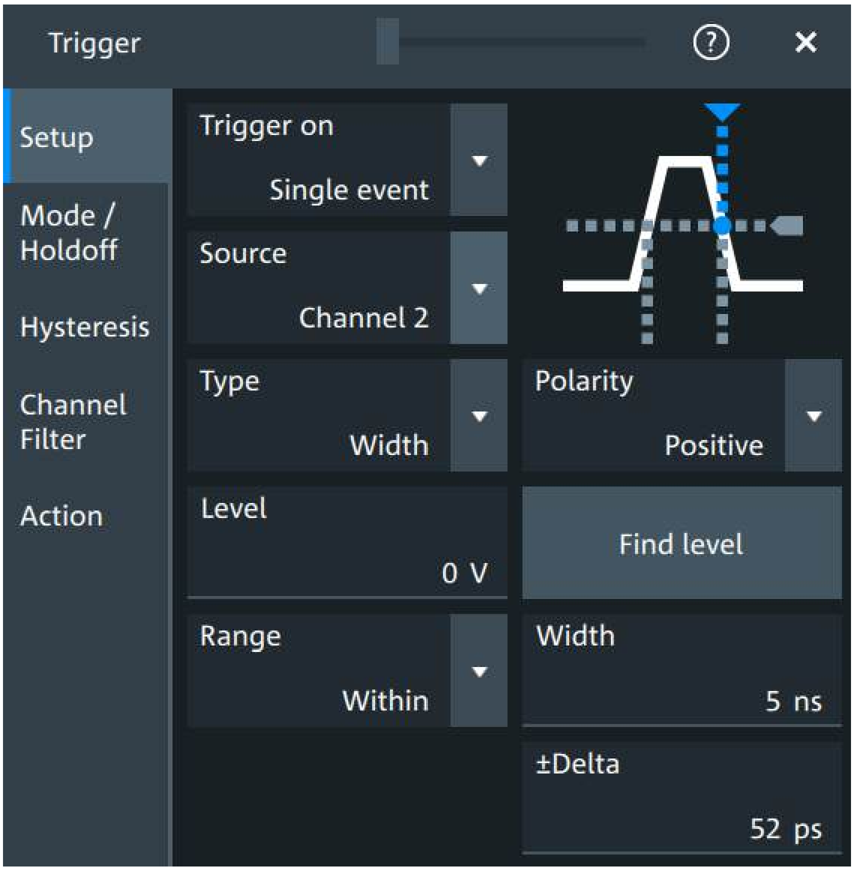
Remote command:
`TRIGger:EVENt<ev>:GLITch:WIDTh` on page 901

7.4.4 Width trigger

Access: "Menu" > "Trigger" > "Setup" tab > "Type = Width"

The width trigger compares the pulse width (duration) with given time limits. It detects pulses with an exact pulse width, pulses shorter or longer than a given time, and also pulses inside or outside the allowable time range. The pulse width is measured at the trigger level.

This section describes the trigger-type specific settings. For settings that apply to all trigger types, see Section 7.2, "Common trigger settings", on page 161.



Level
See "Level" on page 162.

Remote command:
`TRIGger:EVENt<ev>:LEVel<n>[:VALue]` on page 895

Polarity

Sets the polarity of a pulse, which is the direction of the first pulse slope.

"Positive" Selects positive going pulses, the width is defined from the rising to the falling slopes.

"Negative" Selects negative going pulses, the width is defined from the falling to the rising slopes.

"Either" Selects both positive and negative going pulses.

Remote command:
TRIGger:EVENt<ev>:WIDTh:POLarity on page 902

Range

Selects how the range of a pulse width is defined.

"Longer" Triggers on pulses longer than the given "Width".

"Shorter" Triggers on pulses shorter than the given "Width".

"Within" Triggers on pulses inside a given range. The range of the pulse width is defined by "±Delta" related to "Width".

"Outside" Triggers on pulses outside a given range. The range definition is the same as for "Within" range.

Remote command:
TRIGger:EVENt<ev>:WIDTh:RANGe on page 902

Width

For the ranges "Within" and "Outside", the width defines the center of a range which is defined by the limits "±Delta".

For the ranges "Shorter" and "Longer", the width defines the maximum and minimum pulse width, respectively.

Remote command:
TRIGger:EVENt<ev>:WIDTh:WIDTh on page 902

±Delta

Defines a range around the width value.

The combination "Range" = "Within" and "±Delta" = 0 triggers on pulses with a pulse width that equals "Width".

The combination "Range" = "Outside" and "±Delta" = 0 means to trigger on pulse widths ≠ "Width".

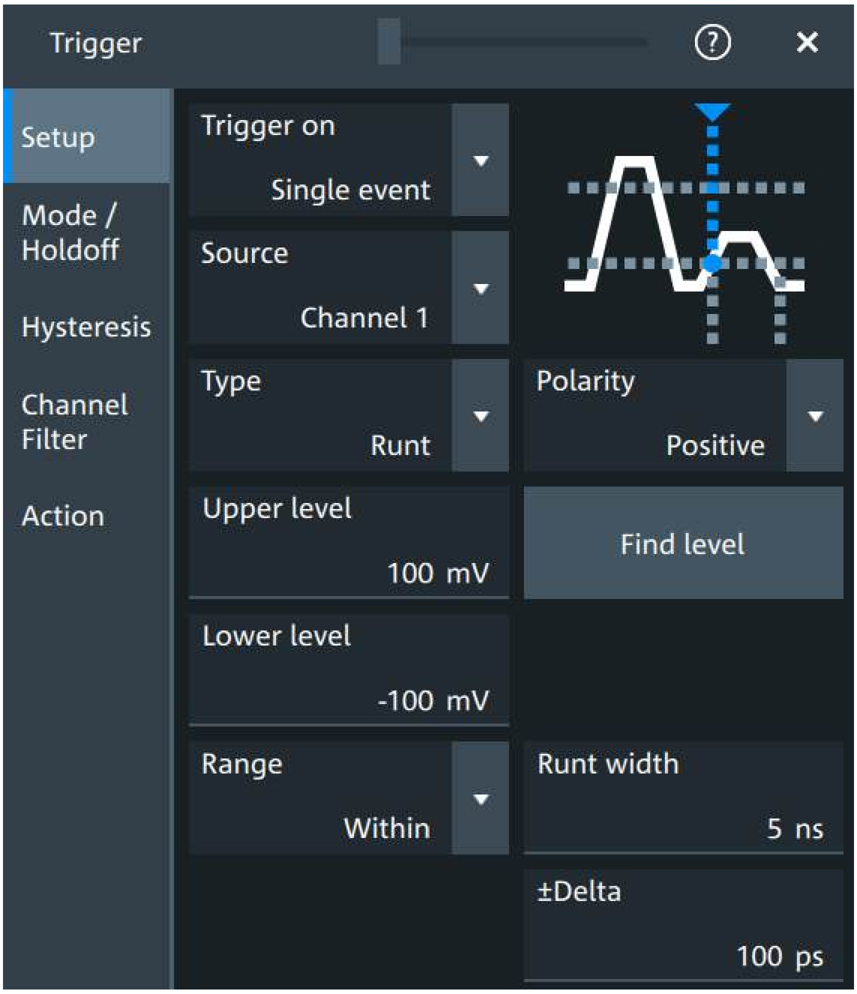
Remote command:
TRIGger:EVENt<ev>:WIDTh:DELTa on page 902

7.4.5 Runt trigger

Access: "Menu" > "Trigger" > "Setup" tab > "Type = Runt"

A runt is a pulse lower than normal in amplitude. The amplitude crosses the first threshold twice in succession without crossing the second one. For example, this trigger can detect logic, digital, and analog signals remaining below a specified threshold amplitude because I/O ports are in undefined state.

This section describes the trigger-type specific settings. For settings that apply to all trigger types, see Section 7.2, "Common trigger settings", on page 161.



Polarity
Sets the polarity of a pulse, which is the direction of the first pulse slope.

"Positive" Selects positive going pulses, the width is defined from the rising to the falling slopes.

"Negative" Selects negative going pulses, the width is defined from the falling to the rising slopes.

"Either" Selects both positive and negative going pulses.

Remote command:
`TRIGger:EVENt<ev>:GLITch:POLarity` on page 900
`TRIGger:EVENt<ev>:RUNT:POLarity` on page 904

Upper level
Sets the upper voltage limit.

Remote command:
`TRIGger:EVENt<ev>:LEVel<n>:RUNT:UPPer` on page 903

Lower level
Sets the lower voltage limit.

Remote command:
`TRIGger:EVENt<ev>:LEVel<n>:RUNT:LOWer` on page 903

Range
Selects how the time limit of the runt pulse is defined.

"Any runt"	Triggers on all runts fulfilling the level condition, without time limitation.
"Longer"	Triggers on runts longer than the given "Runt width".
"Shorter"	Triggers on runts shorter than the given "Runt width".
"Within"	Triggers if the runt length is inside a given time range. The range is defined by "Runt width" and "±Delta".
"Outside"	Triggers if the runt length is outside a given time range. The range definition is the same as for "Within" range.

Remote command:
`TRIGger:EVENt<ev>:RUNT:RANGe` on page 904

Runt width
For the ranges "Shorter" and "Longer", the runt width defines the maximum and minimum pulse width, respectively.

For the ranges "Within" and "Outside", the runt width defines the center of a range which is defined by "±Delta".

Remote command:
`TRIGger:EVENt<ev>:RUNT:WIDTh` on page 905

±Delta
Defines a range around the runt width value.

Remote command:
`TRIGger:EVENt<ev>:RUNT:DELTa` on page 904

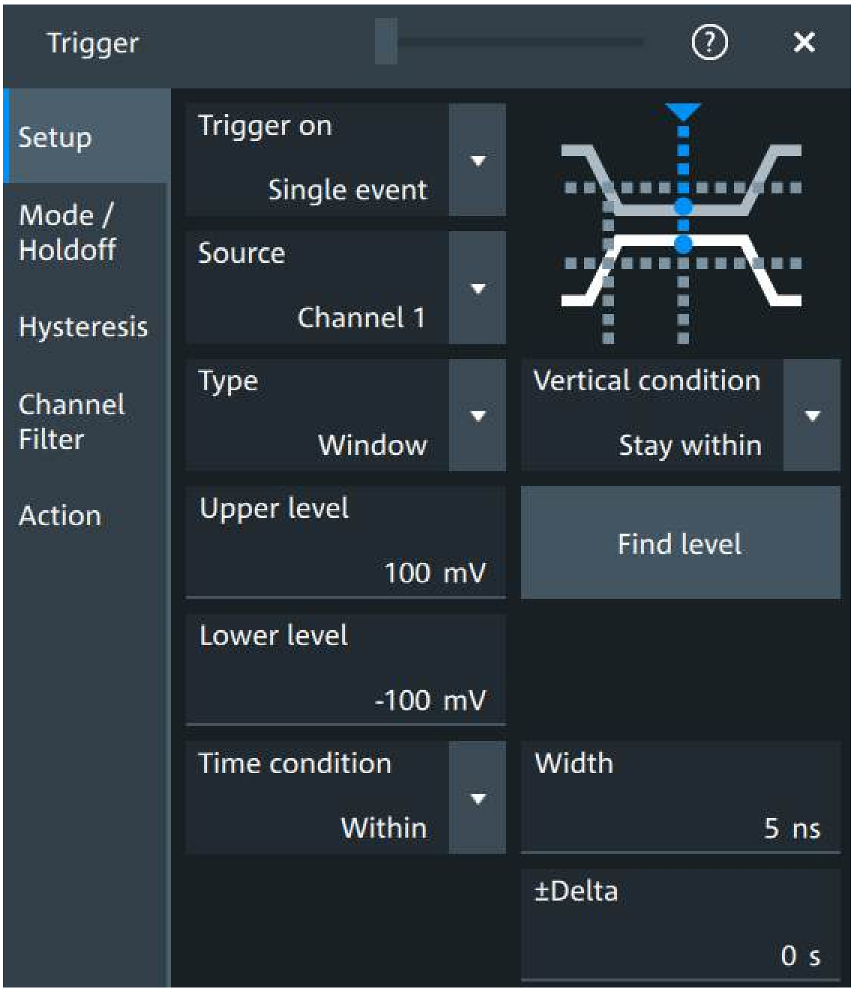
7.4.6 Window trigger

Access: "Menu" > "Trigger" > "Setup" tab > "Type = Window"

The window trigger checks the signal run in relation to a "window". The window is formed by the upper and lower voltage levels. The trigger condition is fulfilled, if the waveform enters or leaves the window, or if the waveform stays inside or outside for a time longer or shorter than specified.

With the window trigger, you can display longer transient effects.

This section describes the trigger-type specific settings. For settings that apply to all trigger types, see Section 7.2, "Common trigger settings", on page 161.



Vertical condition

Selects how the signal run is compared with the window.

"Enter"	Triggers when the signal crosses the upper or lower level and thus enters the window made up of these two levels.
"Exit"	Triggers when the signal leaves the window.
"Stay within"	Triggers if the signal stays between the upper and lower level for a specified time. The time is defined in various ways by the "Time condition".
"Stay outside"	Triggers if the signal stays above the upper level or below the lower level for a specified time. The time is also defined by the "Time condition".

Remote command:

TRIGger:EVENt<ev>:WINDow:RANGe on page 907

Upper level

Sets the upper voltage limit.

Remote command:

TRIGger:EVENt<ev>:LEVel<n>:WINDow:UPPer on page 906

Lower level
Sets the lower voltage limit.

Remote command:
`TRIGger:EVENt<ev>:LEVel<n>:WINDow:LOWer` on page 906

Time condition
Available for "Vertical condition" = "Stay within"/"Stay outside".

Selects how the time limit of the window is defined.

"Within"	Triggers if the signal stays inside or outside the vertical window limits at least for the time *Width - Delta* and for *Width + Delta* at the most.
"Outside"	"Outside" is the opposite definition of "Within". The instrument triggers if the signal stays inside or outside the vertical window limits for a time shorter than *Width - Delta* or longer than *Width + Delta*.
"Shorter"	Triggers if the signal crosses vertical limits before the specified "Width" time is reached.
"Longer"	Triggers if the signal crosses vertical limits after the specified "Width" time is reached.

Remote command:
`TRIGger:EVENt<ev>:WINDow:TIME` on page 907

Width
For the ranges "Within" and "Outside", the width defines the center of a time range which is defined by the limits "±Delta".

For the ranges "Shorter" and "Longer", it defines the maximum and minimum time lapse, respectively.

Remote command:
`TRIGger:EVENt<ev>:WINDow:WIDTh` on page 908

±Delta
Defines a range around the width value.

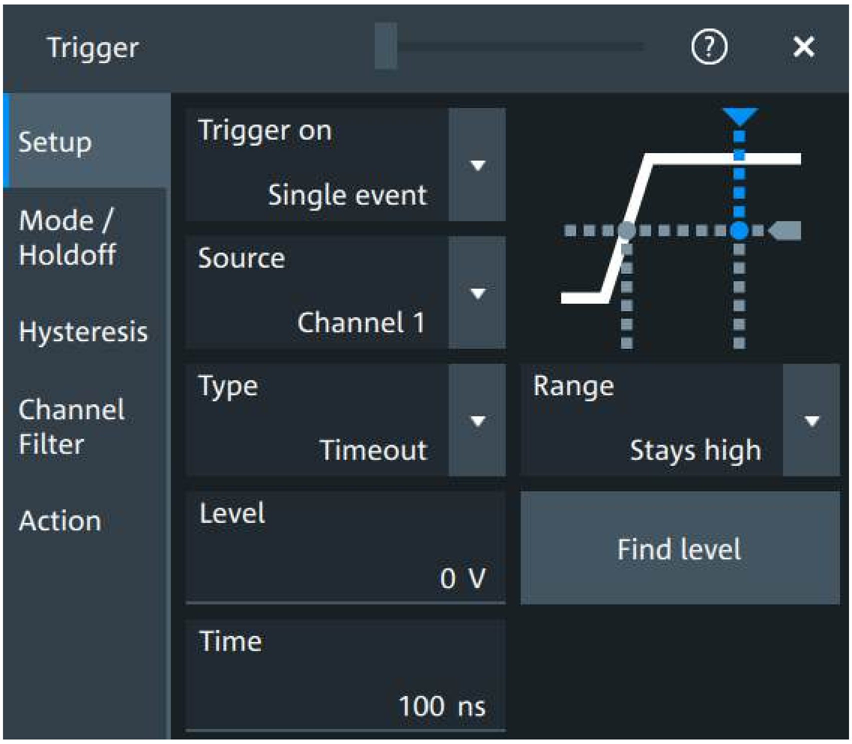
Remote command:
`TRIGger:EVENt<ev>:WINDow:DELTa` on page 906

7.4.7 Timeout trigger

Access: "Menu" > "Trigger" > "Setup" tab > "Type = Timeout"

The timeout trigger checks if the signal stays above or below the threshold voltage for a specified time lapse. In other words, the trigger occurs if the trigger source does not have the expected transition within the specified time.

This section describes the trigger-type specific settings. For settings that apply to all trigger types, see Section 7.2, "Common trigger settings", on page 161.



Level
Sets the threshold for the high and low signal states.

Remote command:
TRIGger:EVENt<ev>:LEVel<n>[:VALue] on page 895

Range
Sets the relation of the signal level to the trigger level for the timeout trigger.

"Stays high"	The signal level stays above the trigger level.
"Stays low"	The signal level stays below the trigger level.
"High or low"	The signal level stays above or below the trigger level.

Remote command:
TRIGger:EVENt<ev>:TIMeout:RANGe on page 908

Time
Sets the time limit for the timeout at which the instrument triggers.

Remote command:
TRIGger:EVENt<ev>:TIMeout:TIME on page 909

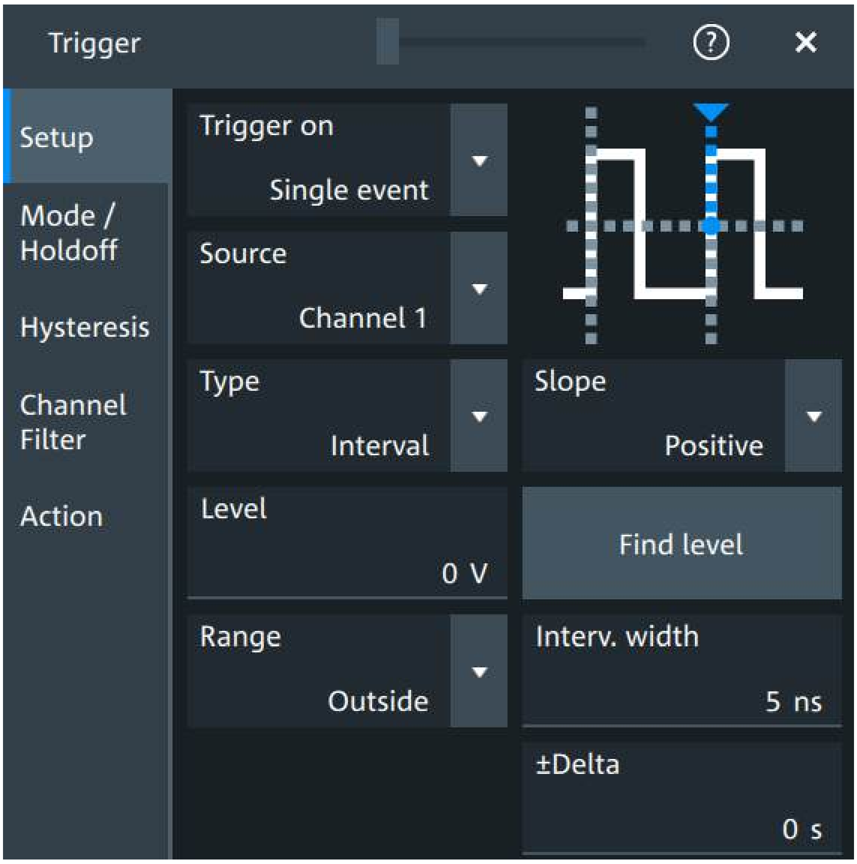
7.4.8 Interval trigger

Access: "Menu" > "Trigger" > "Setup" tab > "Type = Interval"

The interval trigger analyzes the time between two pulses.

The interval trigger can analyze either rising or falling edges, but searching for an interval is also possible for both edges at the same time ("Either").

This section describes the trigger-type specific settings. For settings that apply to all trigger types, see Section 7.2, "Common trigger settings", on page 161.



Level

See "Level" on page 162.

Remote command:

`TRIGger:EVENt<ev>:LEVel<n>[:VALue]` on page 895

Slope

Sets the edge for the trigger. You can analyze the interval between positive edges or between negative edges.

Remote command:

`TRIGger:EVENt<ev>:INTerval:SLOPe` on page 910

Range

Selects how the range of an interval is defined:

"Within" Triggers on pulse intervals inside a given range. The range is defined by "Interv. width" and "±Delta".

"Outside" Triggers on intervals outside a given range. The range definition is the same as for "Within" range.

"Shorter"	Triggers on intervals shorter than the given "Interv. width".
"Longer"	Triggers on intervals longer than the given "Interv. width".

Remote command:
`TRIGger:EVENt<ev>:INTerval:RANGe` on page 910

Interv. width
Sets the time between two pulses for the interval trigger.

Remote command:
`TRIGger:EVENt<ev>:INTerval:WIDTh` on page 910

±Delta
Defines a range around the "Interv. width" value.

Remote command:
`TRIGger:EVENt<ev>:INTerval:DELTa` on page 909

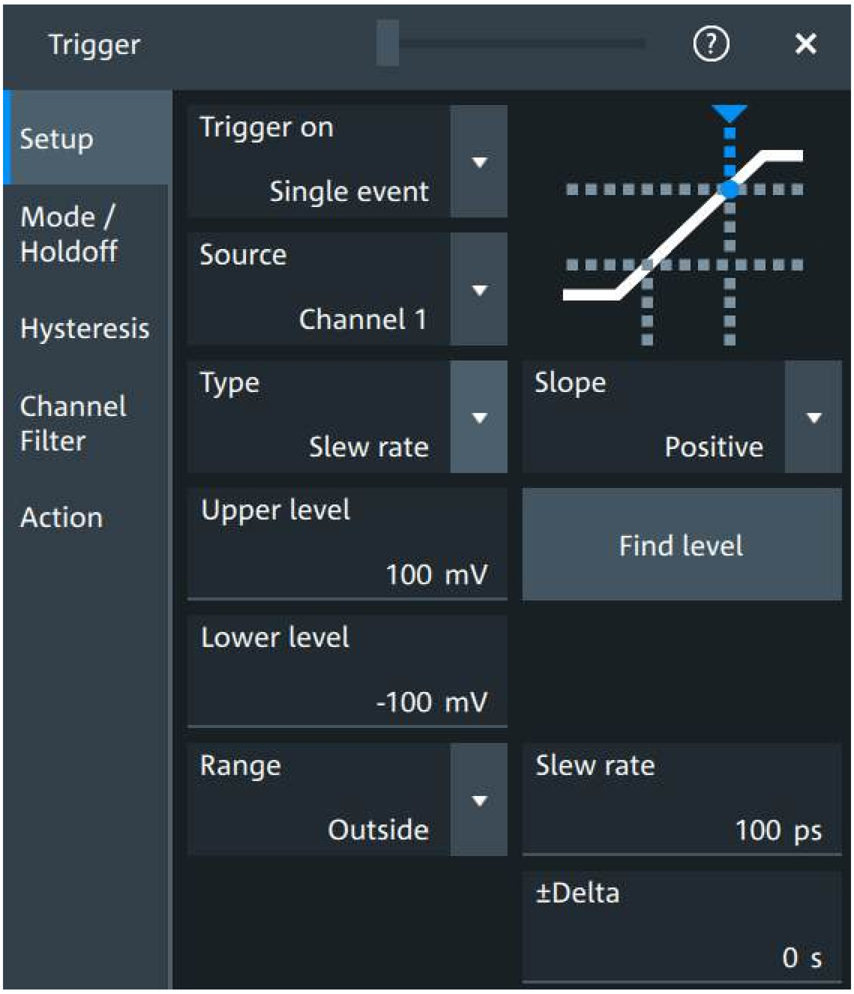
7.4.9 Slew rate trigger

Access: "Menu" > "Trigger" > "Setup" tab > "Type = Slew rate"

The slew rate trigger is also known as transition trigger. It triggers if the transition time from the lower to higher voltage level (or vice versa) is shorter or longer as defined, or outside or inside a specified time range.

The slew rate trigger finds slew rates faster than expected or permissible to avoid over-shooting and other interfering effects. It also detects slow edges violating the timing in pulse series.

This section describes the trigger-type specific settings. For settings that apply to all trigger types, see Section 7.2, "Common trigger settings", on page 161.



Slope

Sets the edge direction for the trigger.

"Positive" Selects the rising edge, which is a positive voltage change.

"Negative" Selects the falling edge, which is a negative voltage change.

"Either" Selects the rising and falling edge. After starting an acquisition, the instrument triggers on the first identified edge.

Remote command:

`TRIGger:EVENt<ev>:SLEW:SLOPe` on page 913

Upper level

Sets the upper voltage threshold. When the signal crosses this level, the slew rate measurement starts or stops depending on the selected slope.

Remote command:

`TRIGger:EVENt<ev>:LEVel<n>:SLEW:UPPer` on page 911

Lower level

Sets the lower voltage threshold. When the signal crosses this level, the slew rate measurement starts or stops depending on the selected slope.

Remote command:
`TRIGger:EVENt<ev>:LEVel<n>:SLEW:LOWer` on page 911

Range
Selects how the time limit for the slew rate is defined. The time measurement starts when the signal crosses the first trigger level - the upper or lower limit depending on the selected slope. The measurement stops when the signal crosses the second level.

"Within"	Triggers on slew rates inside a given time range. The range is defined by "Slew rate" and "±Delta".
"Outside"	Triggers on slew rates outside a given time range. The range definition is the same as for "Within" range.
"Shorter"	Triggers on slew rates shorter than the given "Slew rate" limit.
"Longer"	Triggers on slew rates longer than the given "Slew rate" limit.

Remote command:
`TRIGger:EVENt<ev>:SLEW:RANGe` on page 912

Slew rate
For the ranges "Within" and "Outside", the slew rate defines the center of a range which is defined by the limits "±Delta".

For the ranges "Shorter" and "Longer", the slew rate defines the maximum and minimum slew rate limits, respectively.

Remote command:
`TRIGger:EVENt<ev>:SLEW:RATE` on page 913

±Delta
Defines a time range around the given slew rate.

Remote command:
`TRIGger:EVENt<ev>:SLEW:DELTa` on page 912

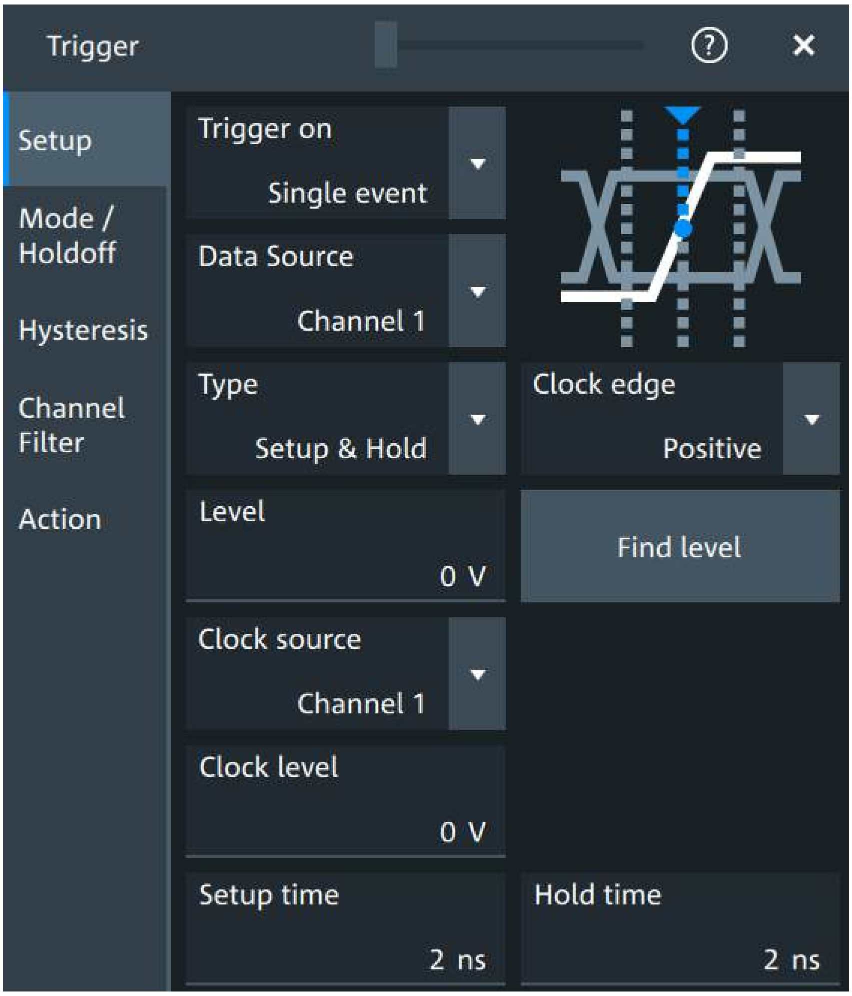
7.4.10 Setup & Hold

Access: "Menu" > "Trigger" > "Setup" tab > "Type = Setup & Hold"

The setup & hold trigger analyzes the relative timing between two signals: a data signal and the synchronous clock signal. Many systems require, that the data signal must be steady for some time before and after the clock edge, for example, the data transmission on parallel interfaces. With this trigger type, you can also test the time correlation of sideband and in-band signals.

The setup & hold trigger is also known as Data2Clock trigger.

This section describes the trigger-type specific settings. For settings that apply to all trigger types, see Section 7.2, "Common trigger settings", on page 161.



Data source

Selects the input channel of the data signal.

Remote command:

`TRIGger:EVENt<ev>:SOURce` on page 895

Level

Sets the voltage level for the data signal. At this level, the setup and hold time are measured.

Remote command:

`TRIGger:EVENt<ev>:LEVel<n>[:VALue]` on page 895

Clock source

Selects the input channel of the clock signal.

Remote command:

`TRIGger:EVENt<ev>:SETHold:CSOurce[:VALue]` on page 914

Clock edge

Sets the edge of the clock signal. Edge and level define the time reference point.

"Positive"	Rising edge, a positive voltage change.
"Negative"	Falling edge, a negative voltage change.
"Both"	Both the rising and the falling edge.

Remote command:
`TRIGger:EVENt<ev>:SETHold:CSOurce:EDGE` on page 913

Clock level
Sets the voltage level for the clock signal.

Both the clock level and the clock edge define the starting point for calculation of the setup and hold time.

Remote command:
`TRIGger:EVENt<ev>:SETHold:CSOurce:LEVel` on page 914

Setup time
Sets the minimum time **before** the clock edge while the data signal must stay steady above or below the data level.

Remote command:
`TRIGger:EVENt<ev>:SETHold:STIMe` on page 915

Hold time
Sets the minimum time **after** the clock edge while the data signal must stay steady above or below the data level.

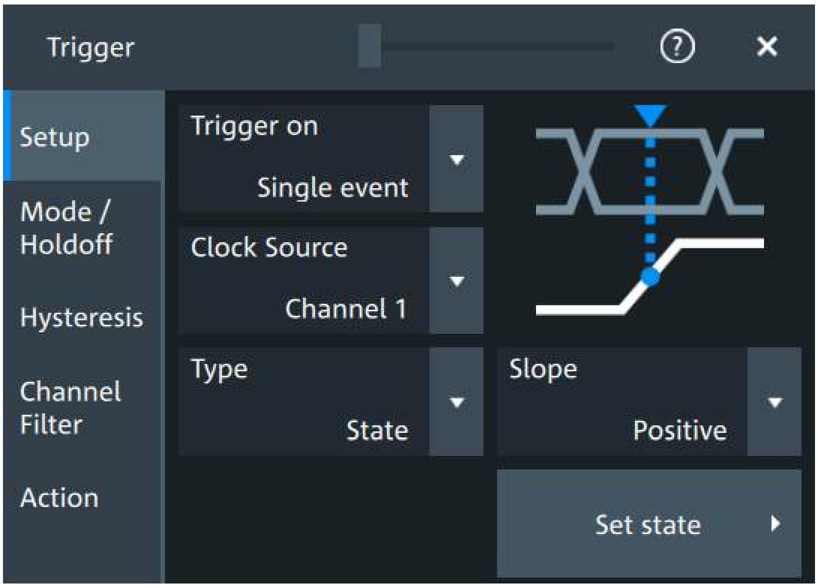
Remote command:
`TRIGger:EVENt<ev>:SETHold:HTIMe` on page 914

7.4.11 State trigger

Access: "Menu" > "Trigger" > "Setup" tab > "Type = State"

The state trigger verifies if the channel states match the defined pattern at the clock edge. The trigger occurs if the logical combination of the input channels is true at the crossing point of the selected clock edge and the trigger level.

This section describes the trigger-type specific settings. For settings that apply to all trigger types, see Section 7.2, "Common trigger settings", on page 161.



1. Select the "Clock source" and the "Slope".
2. Tap "Set state".
See Section 7.4.12.2, "Settings for state and pattern trigger of analog channels", on page 185 for setting details.

Slope

Sets the edge direction for the trigger.

"Positive" Selects the rising edge, which is a positive voltage change.

"Negative" Selects the falling edge, which is a negative voltage change.

"Either" Selects the rising and falling edge. After starting an acquisition, the instrument triggers on the first identified edge.

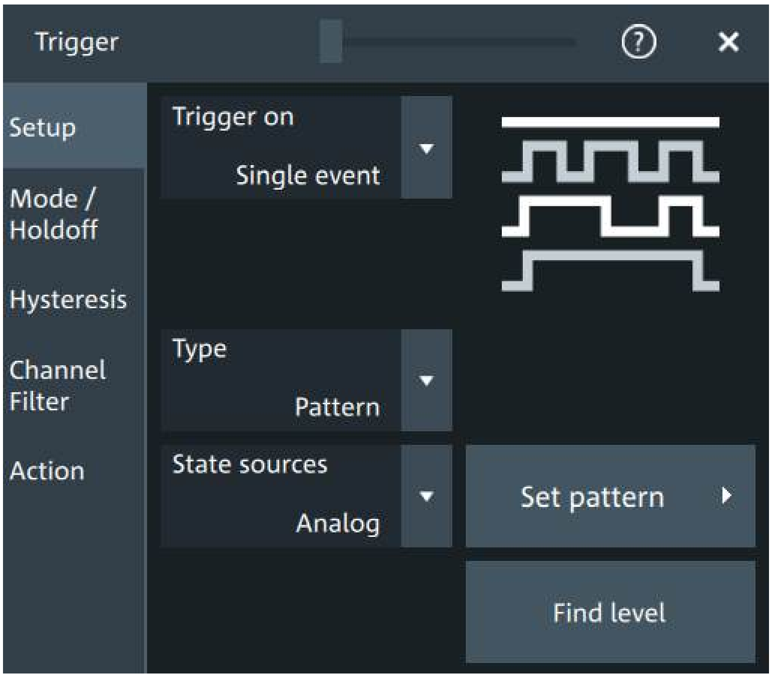
Remote command:
`TRIGger:EVENt<ev>:STATe:SLOPe` on page 916

7.4.12 Pattern trigger

Access: "Menu" > "Trigger" > "Setup" tab > "Type = Pattern"

The pattern trigger works like a logic trigger. It provides logical combinations of the input channels and can be used for verifying the operation of digital logic. If the channel states match the desired pattern, the pattern trigger occurs.

This section describes the trigger-type specific settings. For settings that apply to all trigger types, see Section 7.2, "Common trigger settings", on page 161.



► Tap "Set pattern".
See Section 7.4.12.2, "Settings for state and pattern trigger of analog channels", on page 185 for setting details.

7.4.12.1 General settings

State sources
Selects if the source of the trigger for the pattern type is an "Analog" or "Digital" channel.

Remote command:
`TRIGger:EVENt<ev>:PATTern:QUALify:SOURces` on page 918

Set pattern
Opens a dialog for setting the pattern by defining the channel stated and logic operator..

For analog channels, see Section 7.4.12.2, "Settings for state and pattern trigger of analog channels", on page 185.

For digital channels, see Section 7.4.12.3, "Settings for state and pattern trigger of digital channels", on page 187.

Find level
Sets the trigger level automatically to *0.5 * (MaxPeak – MinPeak)*.

In a trigger sequence, "Find level" affects all active events of the sequence (A, B, and R event).

The function is not available for trigger sources "Extern" and "Line".

Remote command:
TRIGger:FINDlevel on page 895

7.4.12.2 Settings for state and pattern trigger of analog channels

Access for state trigger: "Menu" > "Trigger" > "Setup" tab > "Type = State" > "Set state"

Access for pattern trigger: "Menu" > "Trigger" > "Setup" tab > "Type = Pattern" > "Set pattern"

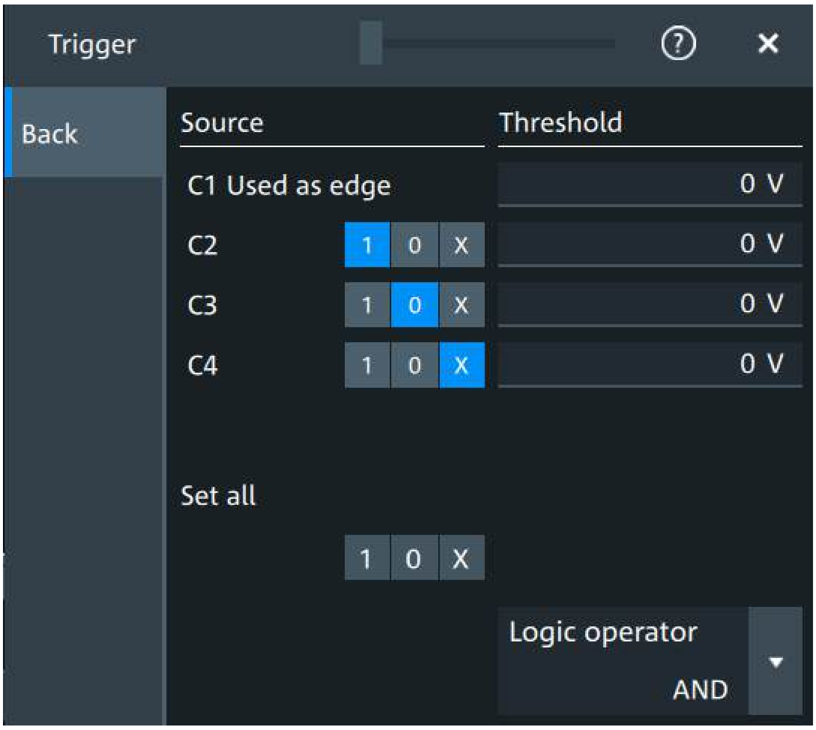


Figure 7-3: Detailed settings for state trigger

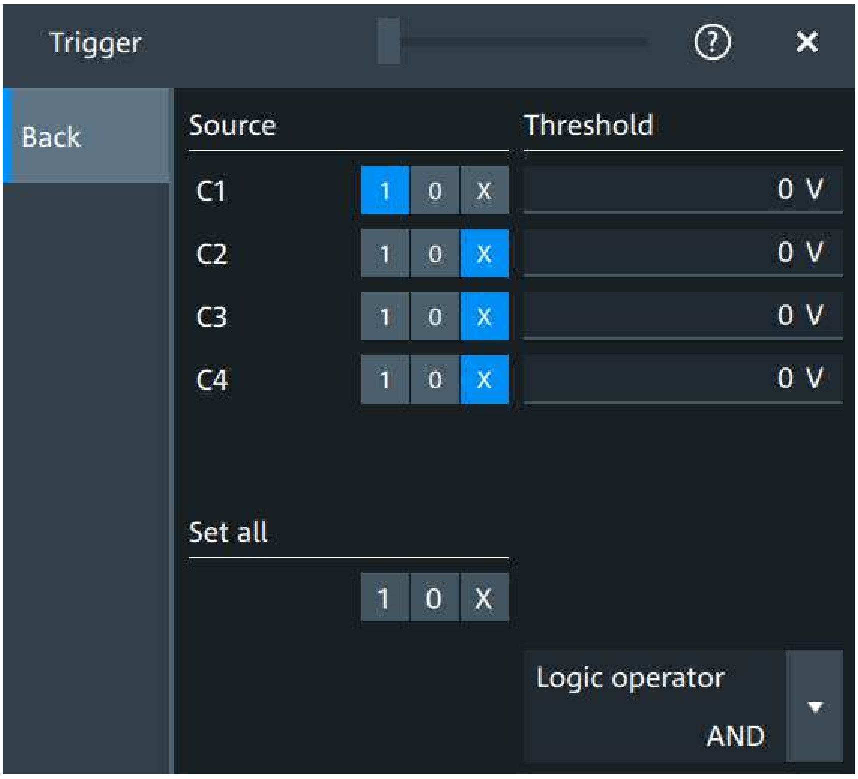


Figure 7-4: Detailed settings for pattern trigger

Source: channel states
Set the state for each channel. For the state trigger, the clock source is indicated and does not get a state.

Remote command:
`TRIGger:EVENt<ev>:STATe:QUALify:ANALog:CHAN<n>:HLX` on page 915
`TRIGger:EVENt<ev>:PATTern:QUALify:ANALog:CHAN<n>:HLX` on page 917

Threshold
Set the threshold for each channel.

Remote command:
`TRIGger:EVENt<ev>:LEVel<n>[:VALue]` on page 895

Set all
Sets all channels to the selected state.

Logic Operator
Defines the logic combination of the channels and their states.

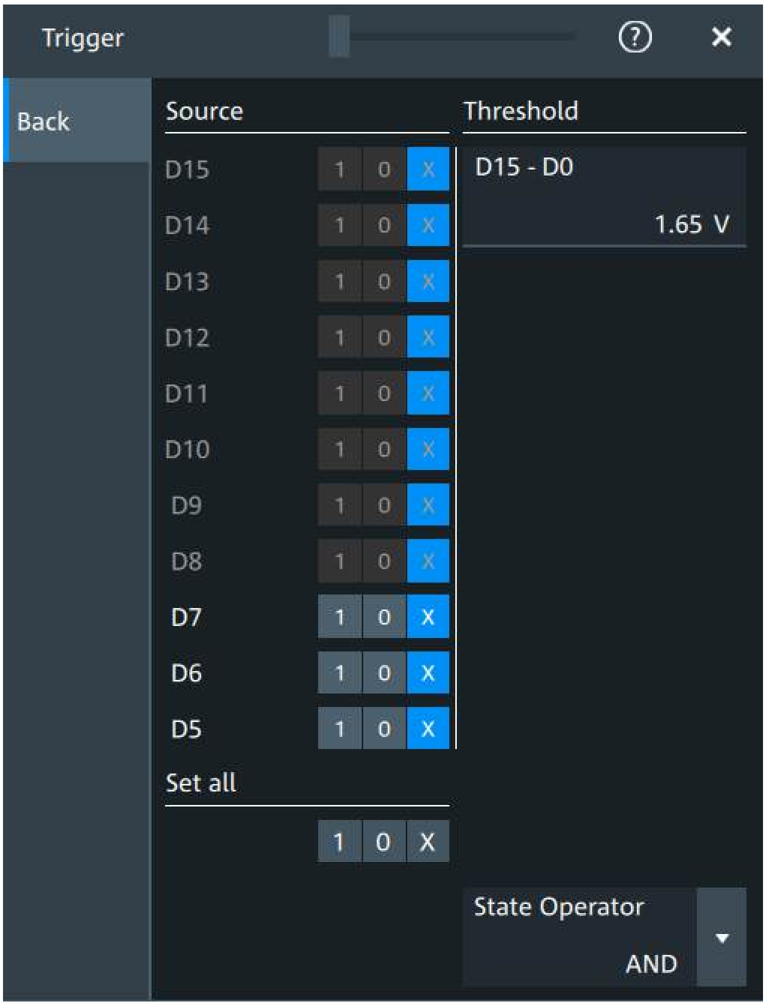
- "AND": logical AND, conjunctive combination
- "OR": logical OR, disjunctive combination

Remote command:
`TRIGger:EVENt<ev>:STATe:QUALify:LOGic` on page 916
`TRIGger:EVENt<ev>:PATTern:QUALify:LOGic` on page 918

TRIGger:EVENt<ev>:PATTern:QUALify:DIGital:LOGic on page 918
TRIGger:EVENt<ev>:STATe:QUALify:DIGital:LOGic on page 916

7.4.12.3 Settings for state and pattern trigger of digital channels

Access: "Menu" > "Trigger" > "Setup" tab > "Type = Pattern" > "Set pattern"



Source: channel states
Set the state for each channel.

Remote command:
TRIGger:EVENt<ev>:PATTern:QUALify:DIGital:CHAN<n>:HLX on page 917
TRIGger:EVENt<ev>:STATe:QUALify:DIGital:CHAN<n>:HLX on page 917

Set all
Sets all channels to the selected state.

Logic Operator
Defines the logic combination of the channels and their states.

- "AND": logical AND, conjunctive combination
- "OR": logical OR, disjunctive combination

Remote command:
TRIGger:EVENt<ev>:STATe:QUALify:LOGic on page 916
TRIGger:EVENt<ev>:PATTern:QUALify:LOGic on page 918
TRIGger:EVENt<ev>:PATTern:QUALify:DIGital:LOGic on page 918
TRIGger:EVENt<ev>:STATe:QUALify:DIGital:LOGic on page 916

7.4.13 Line trigger

Access: "Menu" > "Trigger" > "Setup" tab > "Source" = "Line"

The line trigger is an edge trigger that triggers on the AC power input and synchronizes the signal to the AC power frequency. It is not a trigger type but rather a special trigger source. Use the line source if you want to analyze signals related to the power line frequency, such as lighting equipment and power supply devices.

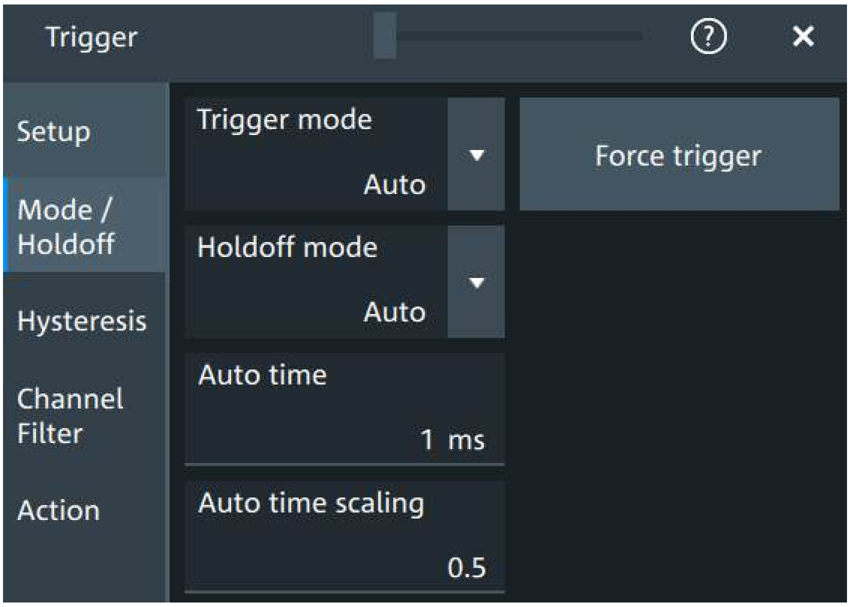
Slope
Selects the rising or falling edges of the AC power input.

Remote command:
TRIGger:EVENt<ev>:EDGE:SLOPe on page 898

7.5 Trigger mode / holdoff

Access: "Trigger" menu > "Mode / holdoff" tab

Holdoff conditions define a waiting time after the current trigger until the next trigger can be recognized.



Trigger mode

Sets the trigger mode which determines the behavior of the instrument if no trigger occurs. The current setting is shown on the trigger label.

In a trigger sequence, the trigger mode affects only the A-trigger.

To toggle quickly between "Auto" and "Normal" mode, use the [Auto Norm] key on the front panel (in "Trigger" section).

"Auto" The instrument triggers repeatedly after a time interval if the trigger conditions are not fulfilled. If a real trigger occurs, it takes precedence. This mode helps to see the waveform even before the trigger conditions are set correctly. The waveform on the screen is not synchronized, and successive waveforms are not triggered at the same point of the waveform. The time interval depends on the timebase settings.

"Normal" The instrument acquires a waveform only if a trigger occurs, that is, if all trigger conditions are fulfilled. If no trigger occurs, no waveform is acquired and the last acquired waveform is displayed. If no waveform was captured before, none is displayed.
When no trigger has been found for longer than one second, a message box appears that shows the time elapsed since the last trigger.

"Free run" The instrument starts acquisition immediately and triggers after a short time interval independent of the timebase settings and faster than in "Auto" mode. Real triggers are ignored. Use this mode if the "Auto" mode is too slow.

Remote command:
`TRIGger:MODE` on page 919

Force trigger

Provokes an immediate single acquisition. Force the trigger if the acquisition is running in normal mode and no valid trigger occurs. Thus, you can confirm that a signal is available and use the waveform display to determine how to trigger on it.

Remote command:
`TRIGger:FORCe` on page 919

Holdoff mode

Selects the method to define the holdoff condition.

The trigger holdoff defines when the next trigger after the current will be recognized. Thus, it affects the next trigger to occur after the current one. Holdoff helps to obtain stable triggering when the oscilloscope is triggering on undesired events.

Holdoff settings are not available if the trigger source is an external trigger input or serial bus, and if you trigger on a sequence of events.

Example:

For example, you want to analyze the first pulse in a burst of several pulses. At first, you select a sufficiently slow time base to display the entire burst. Then, you set the holdoff time a little longer than the length of the burst. Now, each trigger corresponds to the first pulse in successive bursts, and you can change the time base to display the waveform in more detail.

The following methods are available:

"Time" Defines the holdoff directly as a time period. The next trigger occurs only after the "Holdoff time" has passed.

"Events" Defines the holdoff as a number of trigger events. The next trigger only occurs when this number of events is reached. The number of triggers to be skipped is defined in "Holdoff events".

"Random" Defines the holdoff as a random time limited by "Minimum time" and "Maximum time". For each acquisition cycle, the instrument selects a new random holdoff time from the specified range.
Random holdoff prevents synchronization to discover effects invisible with synchronized triggering, for example, the features of a pulse train.

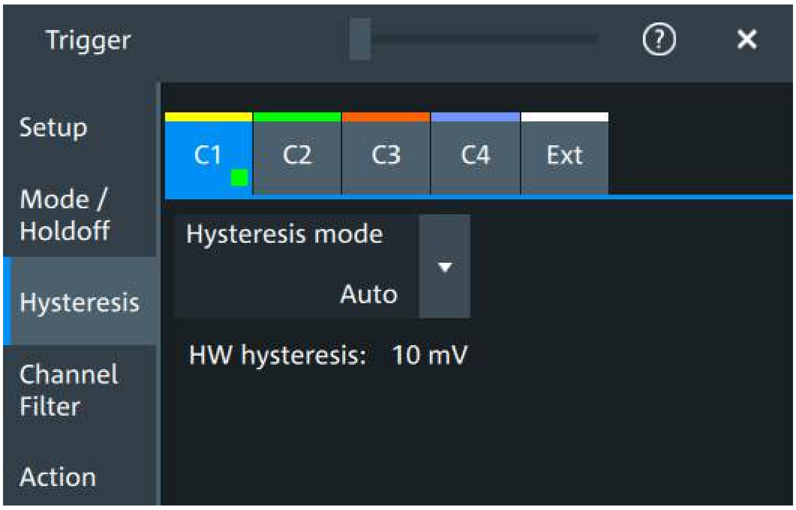
"Auto" The holdoff time is calculated automatically based on the current horizontal scale.
"Auto time scaling" defines the factor that the horizontal scale is multiplied with.
"Auto time" shows the resulting holdoff time: *Auto time* = *Auto time scaling* * *Horizontal scale*.

"Off" No holdoff

Remote command:
`TRIGger:HOLDoff:MODE` on page 920
`TRIGger:HOLDoff:TIME` on page 922
`TRIGger:HOLDoff:EVENts` on page 921
`TRIGger:HOLDoff:MAX` on page 921
`TRIGger:HOLDoff:MIN` on page 922
`TRIGger:HOLDoff:AUTotime?` on page 920
`TRIGger:HOLDoff:SCALing` on page 921

7.6 Hysteresis

Access: "Menu">"Trigger" > "Hysteresis"



The rejection of noise by setting a hysteresis avoids unwanted trigger events caused by noise oscillation around the trigger level. You can select the hysteresis mode and value for each channel separately.

HW hysteresis
Displays the hysteresis that is set by the instrument in automatic hysteresis mode.

Remote command:
`TRIGger:NOISe<m>:EFFective?` on page 923

Hysteresis mode
Selects how the hysteresis is set.

"Auto" Automatic mode is the recommended mode. The hysteresis is set by the instrument to reject the internal noise of the instrument.

"Manual" The hysteresis is defined directly in absolute or relative values.

Remote command:
`TRIGger:NOISe<m>:MODE` on page 923

Size mode
Selects whether the hysteresis is defined in absolute or relative values. The setting is available only in manual hysteresis mode.

Remote command:
`TRIGger:NOISe<m>:MODE` on page 923

Absolute hysteresis
Defines a range in absolute values around the trigger level. If the signal oscillates inside this range and thus crosses the trigger level, no trigger event occurs.

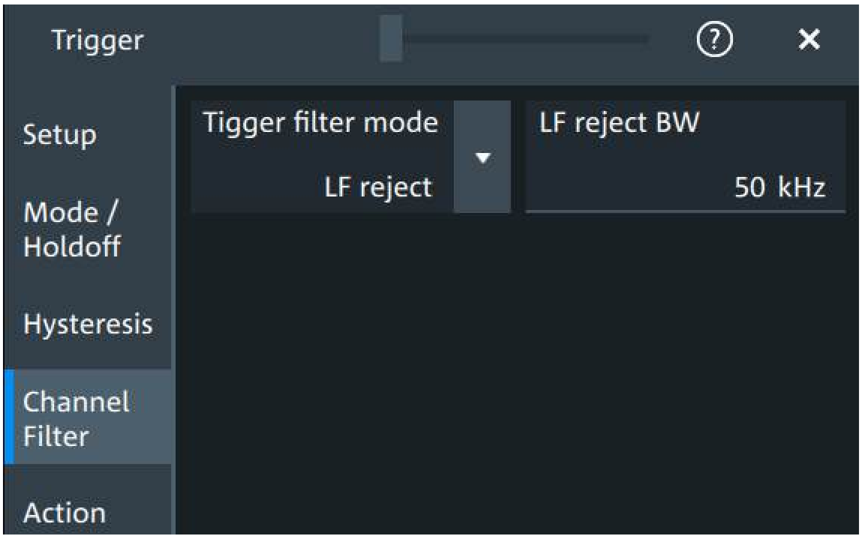
Remote command:
`TRIGger:NOISe<m>:ABSolute` on page 922

Relative hysteresis
Defines a range in divisions around the trigger level in division or as percentage. If the signal oscillates inside this range and thus crosses the trigger level, no trigger event occurs.

Remote command:
TRIGger:NOISe<m>:PERDivision on page 923
TRIGger:NOISe<m>:RELative on page 924

7.7 Channel filter

Access: "Menu">"Trigger" > "Channel filter"



Trigger filter mode
Selects the filter mode for the trigger channel.

"Off" The trigger signal is not filtered.

"LF reject" Frequencies lower than the "LF reject BW" are rejected, higher frequencies pass the filter.

"RF reject" Frequencies higher than the "RF reject BW" are rejected, lower frequencies pass the filter.

Remote command:
TRIGger:FILTermode on page 924

LF reject BW
Sets the limit frequency limit for the highpass filter of the trigger signal. Frequencies lower than this value are rejected, higher frequencies pass the filter.

Remote command:
TRIGger:LFReject on page 925

RF reject BW

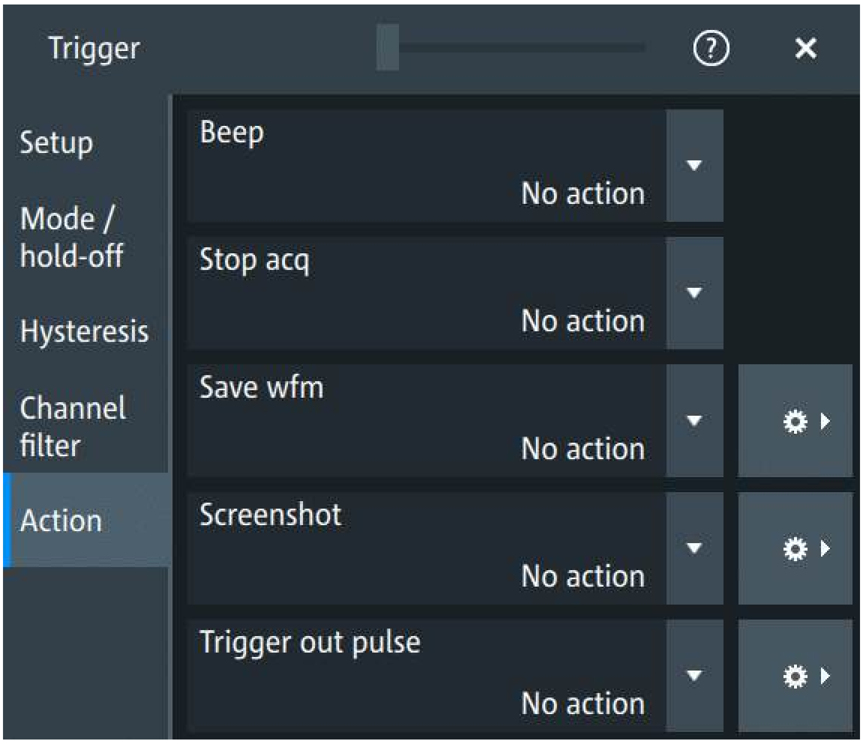
Sets the limit frequency limit for the lowpass filter of the trigger signal. Frequencies higher than this value are rejected, lower frequencies pass the filter.

Remote command:

`TRIGger:RFReject` on page 925

7.8 Actions on trigger

Access: "Menu" > "Trigger" > "Action" tab



The action settings define what happens when a trigger occurs. All available actions can be initiated at the same time. To activate an action, set it to "On trigger".

Beep

Generates a beep sound.

Remote command:

`TRIGger:ACTions:BEEP` on page 925

Stop acq

Stops the acquisition when a trigger occurs.

Remote command:

`TRIGger:ACTions:STOP` on page 927

Save wfm
Saves the waveform data to a file according to the folder, filename and extension settings in the "Menu" > "Save/recall" > "Save" > "Waveform" dialog.

To select the waveforms and adjust the file path, tap the settings icon.

See also Section 13.2.2, "Saving waveforms", on page 406.

Remote command:
`TRIGger:ACTions:WFMSave` on page 928

Screenshot
Saves a screenshot according to the settings in the "Menu" > "Save/recall" > "Save" > "Screenshot" dialog.

To adjust the screenshot settings, tap the settings icon.

See also Section 13.6, "Screenshots", on page 425.

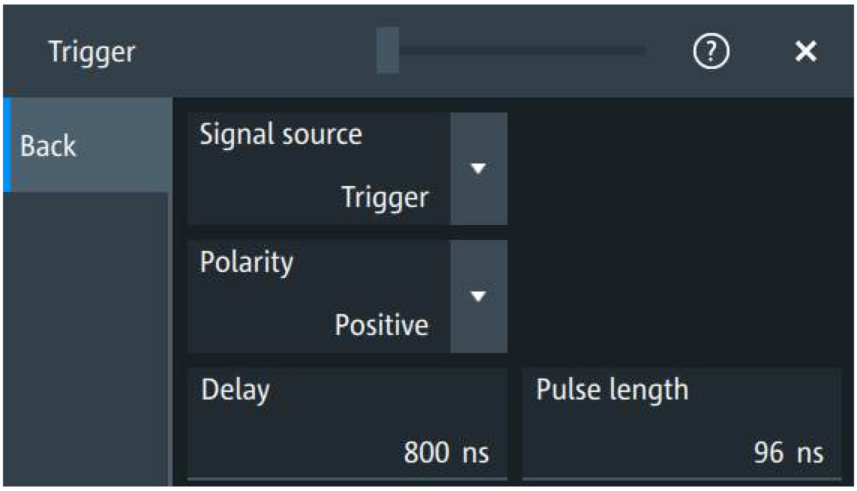
Remote command:
`TRIGger:ACTions:SCReenshot` on page 927

Trigger out pulse
Selects, if a pulse is provided to the [Trigger Out] connector on the rear panel. The trigger-out signal is used to synchronize the measurements of other instruments.

To adjust the outgoing signal, tap the settings icon.

Remote command:
`TRIGger:ACTions:OUT:STATe` on page 926

Settings for the trigger out pulse
In this dialog you can adjust the trigger out pulse.



Signal source ← Settings for the trigger out pulse
Defines when the trigger out signal is initiated: at the trigger point, when waiting for the trigger, or when the post-trigger time is finished.

Remote command:
`TRIGger:ACTions:OUT:SOURce` on page 926

Polarity ← Settings for the trigger out pulse
Sets the polarity of the trigger out pulse, which is the direction of the first pulse edge.

Remote command:
TRIGger:ACTions:OUT:POLarity on page 927

Delay ← Settings for the trigger out pulse
Defines the delay of the first pulse edge to the trigger point. The minimum delay is 600 ns.

Remote command:
TRIGger:ACTions:OUT:DELay on page 926

Pulse length ← Settings for the trigger out pulse
Sets the length of the trigger out pulse.

Remote command:
TRIGger:ACTions:OUT:PLENgth on page 927

7.9 Zone trigger

The zone trigger triggers on the intersection or non-intersection of the signal and one or more zones. The zone can be applied to any active input signal like the normal hardware trigger, and also to math waveforms, XY-plots and normal spectrum traces. So, the zone trigger works in the time domain and in the frequency domain.

You can use the zone trigger, for example, to solve the following tasks:

- Triggering on differential math signals.

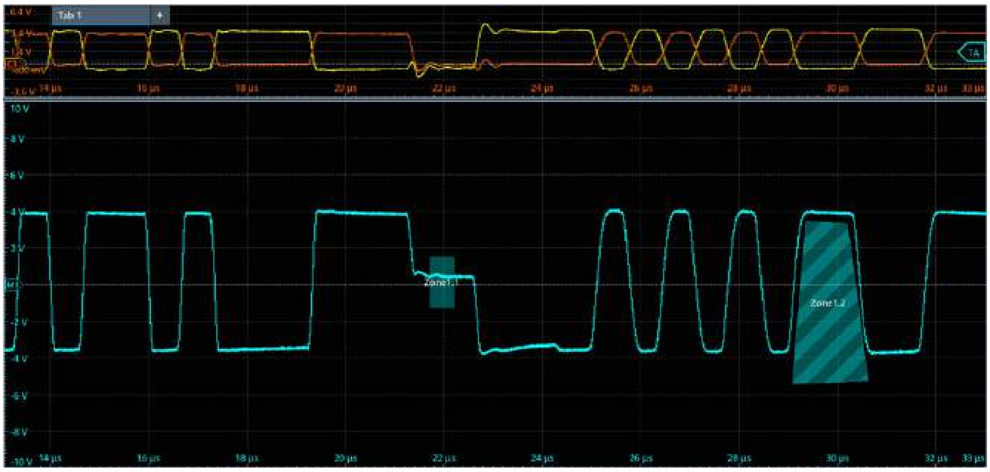


Figure 7-5: Zone trigger on math

- Trigger if a peak in the spectrum occurs: define a zone in the spectrum diagram to filter amplitude peaks.

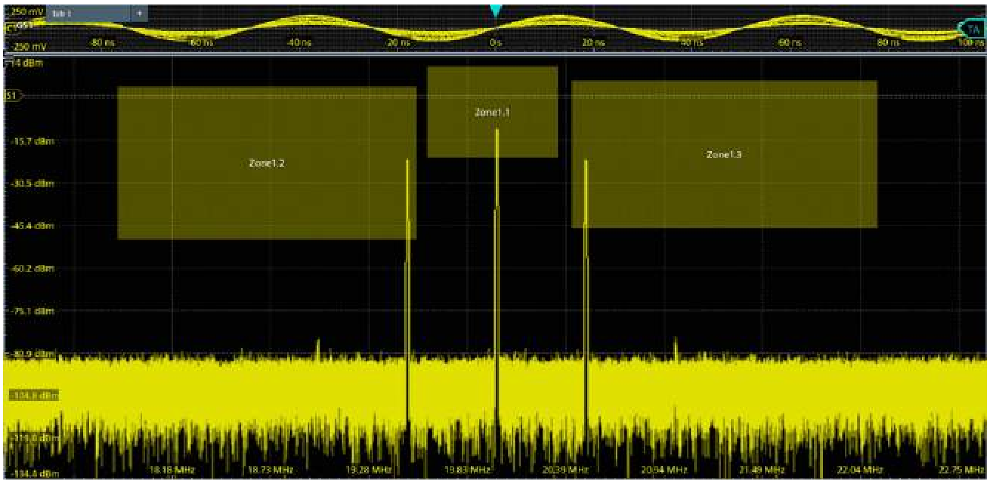


Figure 7-6: Zone trigger on spectrum

- Separate rising and falling edges: define a zone around the base or top of the digital signal.

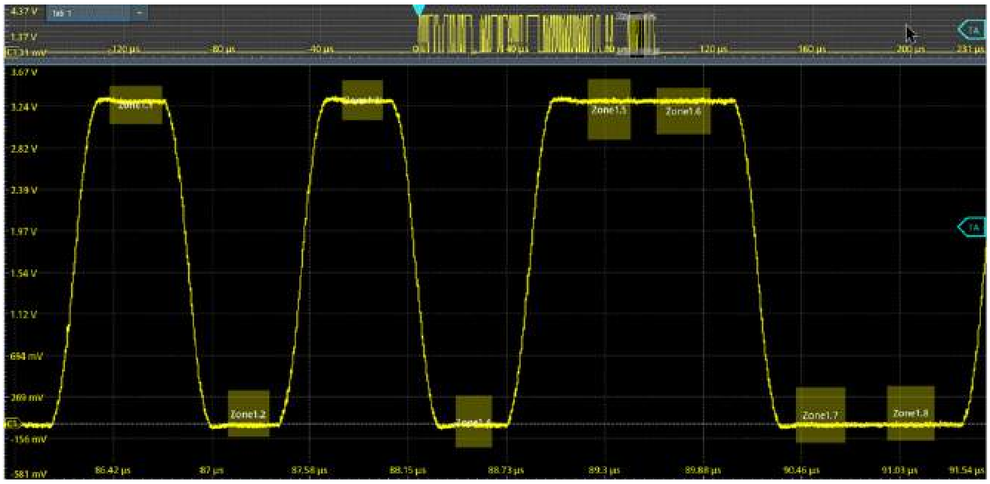


Figure 7-7: Zone trigger on digital serial pattern

- Zoom on a trigger event, even when capturing large amounts of time.

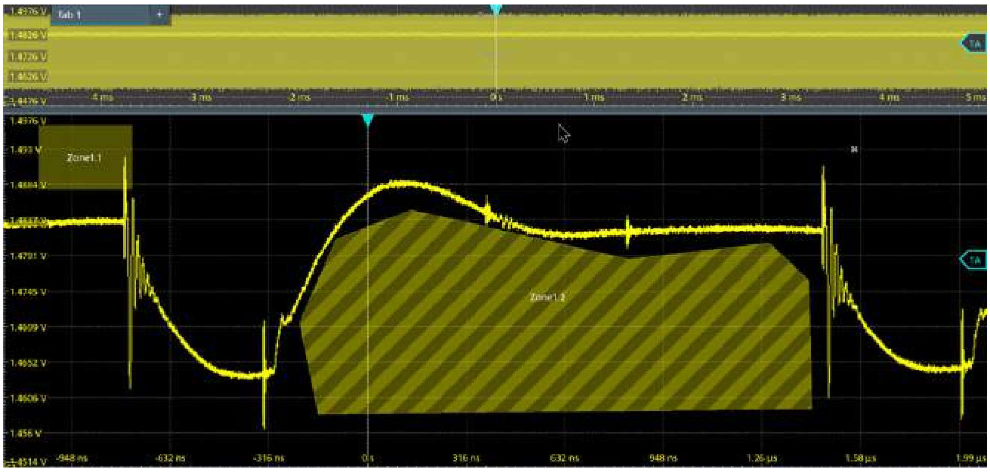


Figure 7-8: Zoom on a zone trigger in the mV and ns range

- Filter events in the history after the acquisition has finished.

The zone trigger is the second step of the "A → ZoneTrigger" trigger sequence and acts like a filter on previous acquisitions. The A-trigger condition and then the zone condition must be fulfilled independently.

Note that the trigger mode applies only to the A-trigger. If only the zone trigger conditions are relevant for the trigger, you can set the trigger mode to "Free run". Thus, you can use the zone trigger to trigger on a spectrum trace without triggering on a signal in the time domain, or you can analyze DC signals.

When an acquisition fulfills the complete trigger definition including the zone trigger, the acquisition is kept in the history memory. Otherwise, the acquisition is discarded. Moreover, you can apply the zone trigger to stored history waveforms that were acquired without zone trigger and thus filter the history waveforms on replay.

Trigger zone definition

With the MXO 4, you can define up to 4 trigger zones. A zone consists of up to 8 areas associated with a single source. In total, 32 areas can be defined.

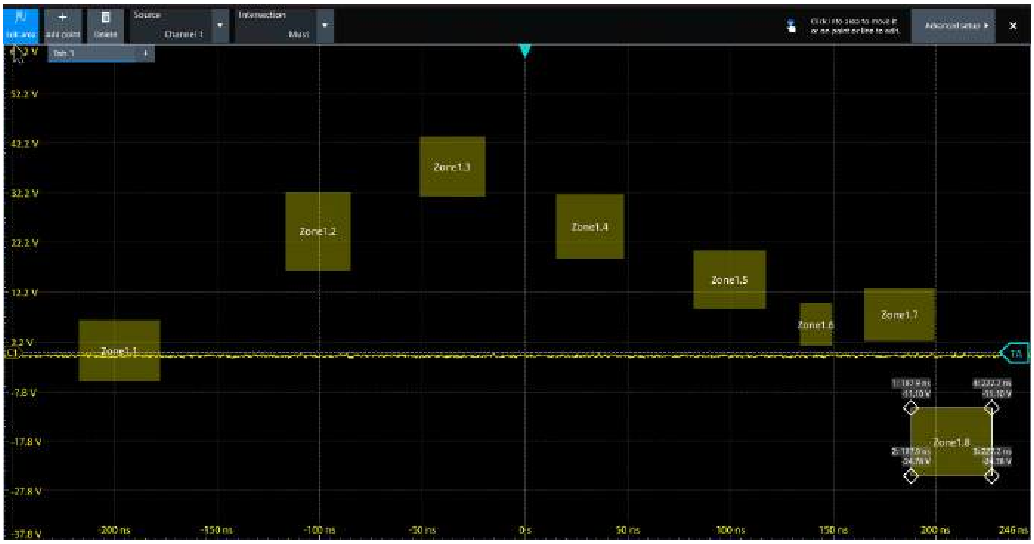


Figure 7-9: 1 trigger zone with 8 areas

The zone is applied to the diagram onto which it is drawn and has the color of the source. All areas of the zone have to be in the same diagram. If a zone is shown in a diagram for which it is not applied, for example in a zoom diagram, it is shown in a gray color.

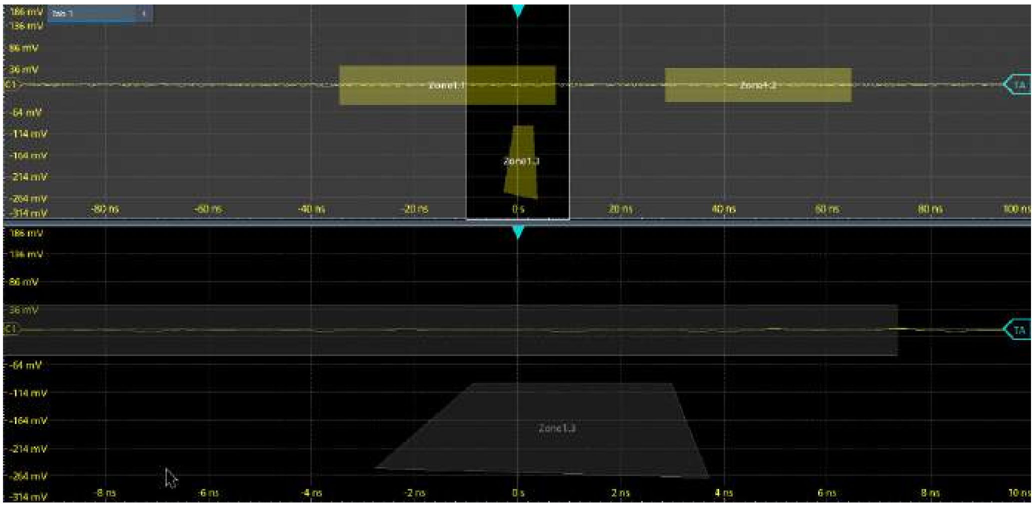


Figure 7-10: Trigger zone and a zoom diagram

Trigger zones can be applied to different sources, for example, the source of zone 1 is channel 1, and the source of zone 2 is a math signal. For the zone trigger condition, the zones are combined by Boolean operators: AND, OR, XOR, NOT. Thus, you can trigger on different waveform types simultaneously.

Trigger area definition

An area is a graphical shape on the screen, defined by pixels. It is a part of the zone for a trigger. The area has the following characteristics:

- An area is a polygon that is applied against a captured waveform. All areas of the same zone have the same source.

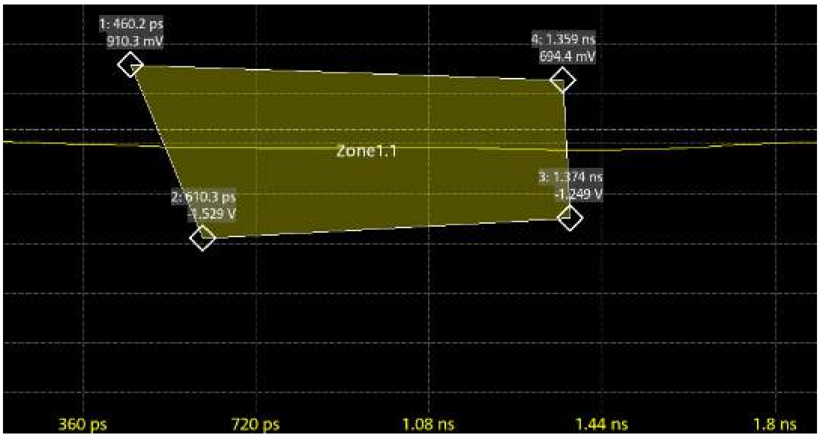


Figure 7-11: 1 area of a trigger zone

- An area can be defined from 3 up to 16 sides.

Figure 7-12: Area sizes

1 = 3 point area with "Intersection" = "Must not"
2 = 16 point area with "Intersection" = "Must"

- A zone area can have only one range in y-direction at a certain time point. If a shape is not valid, the invalid point is marked red, and an attention symbol is shown at the area name.

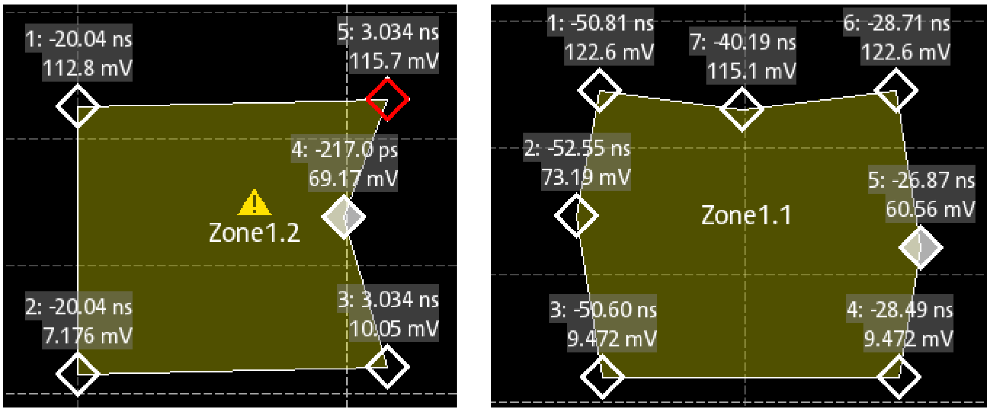


Figure 7-13: Invalid zone area (left) and valid zone area (right)

To check the validity in remote control, use ZONE<m>:AREA<n>:VALid? and ZONE<m>:AREA<n>:POINt<o>:VALid?.

- Next to each point, the number of the point and the horizontal and vertical values are shown.

Figure 7-14: Area point definition

1 = Number of the point
2 = Horizontal and vertical values of the point

- An area has a defined intersect condition, defining if the signal must intersect the area to allow the instrument to trigger, or if it must not intersect the area.
  On the screen, an area that fulfills a "Must" condition has a solid fill in the color of the source channel. An area that fulfills a "Must not" also has the same color as the source channel, but is striped.

7.9.1 Using trigger zones and areas

You can define the trigger zones on the display through the toolbar:

To add trigger zones and areas

1. Tap the "Add zone trigger" icon on the toolbar.

The trigger zone toolbar opens.
Alternatively, you can use the Zone key on the front panel.

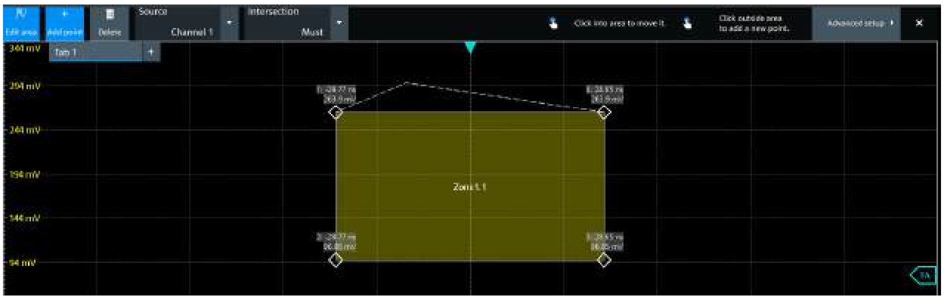
2. Select the "Source" of the zone, the signal to which the zone condition is applied.
3. Select if the signal must violate the zone to cause a trigger ("Intersect" = "Must"), or vice versa ("Intersect" = "Must not").
4. Tap "Add zone".
5. Draw a rectangle in the diagram to create the first area of a new zone trigger.
6. To add more areas to the zone, tap "Add Area".

7. Draw a rectangle in the same diagram to add a new trigger area.
8. Select if the signal must violate the area to cause a trigger (must intersect), or vice versa (must not intersect).
9. You can add more areas and further more zones to the zone trigger.

   Make sure to draw them in the correct diagram because zones affect only the diagram where they were defined.

To edit an existing area

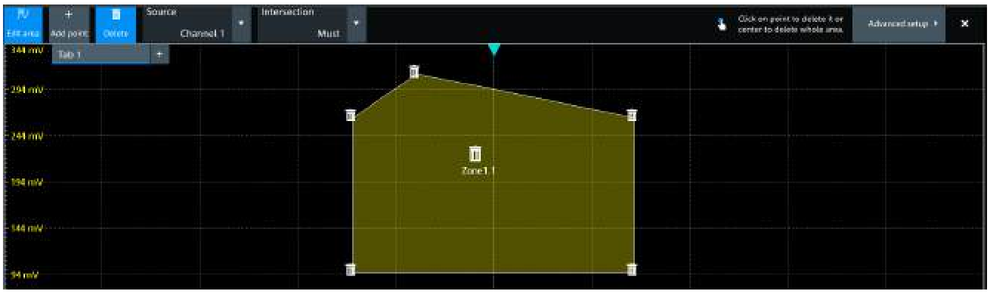
1. Tap an existing zone area.
2. To change the shape of the zone area, tap the corner points of the zone on the SmartGrid.
3. Move the point to the required coordinates on the SmartGrid.
4. If necessary, add more points to the zone area:
   a) In the toolbar, tap "Add point".



   b) Tap outside of the area to add the new point.
   c) If necessary, add more points.
   d) If necessary to change the coordinates of a point, tap on it and move it.

To delete an area or point

1. Tap an existing zone area.
2. In the "Edit area" toolbar, tap the delete icon.
3. Tap on the area that you want to delete or edit.



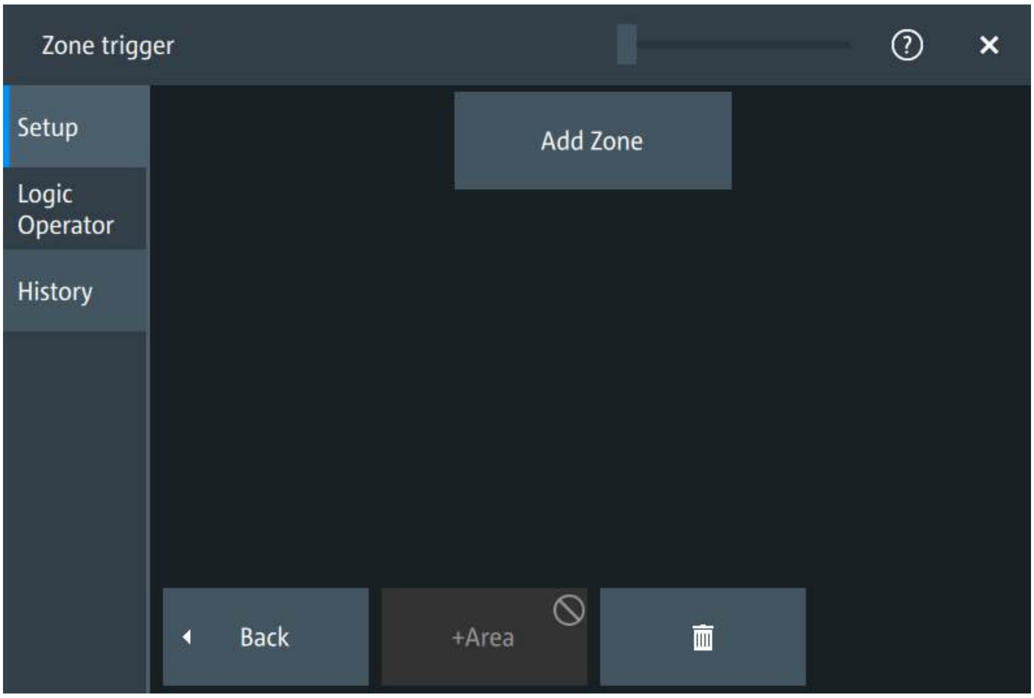
Delete icons appear at the area points and in the middle of the area.

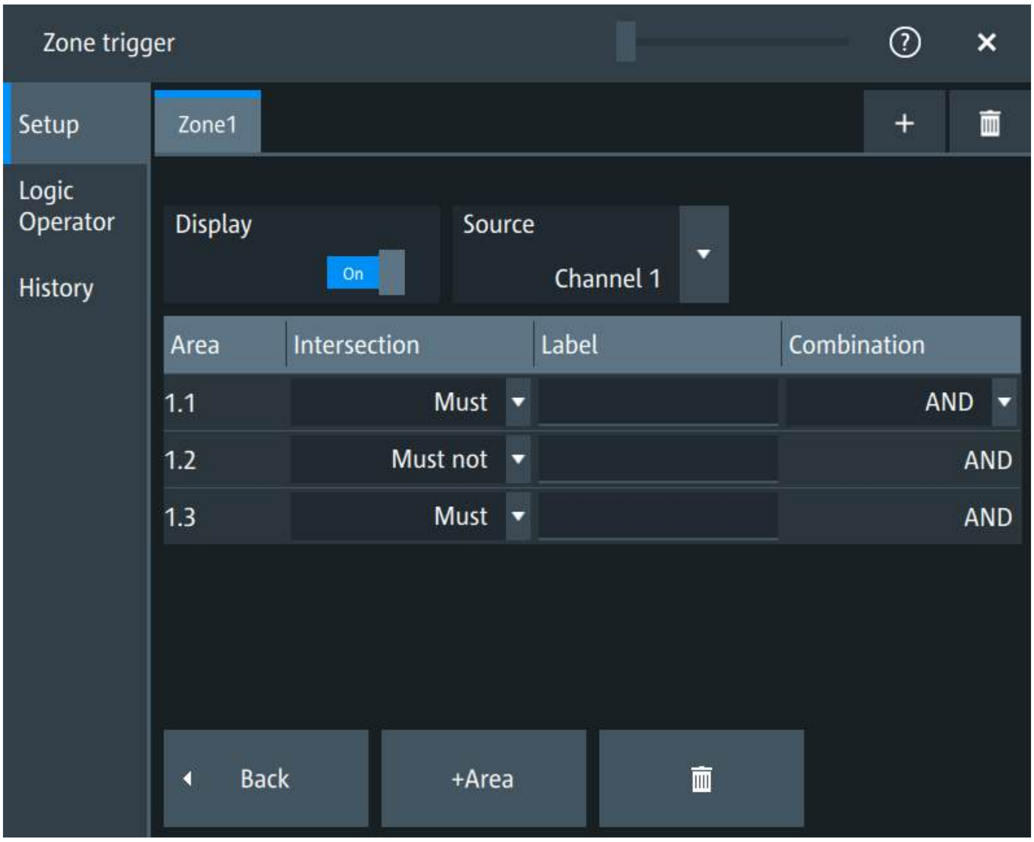
4. To delete a point from the area, tap on the "Delete" icon on top of the point.
5. To delete the whole area, tap the "Delete" icon in the middle of the area next to the area "Label".

7.9.2 Zone trigger settings

Access: "Menu" > "Trigger" > "Setup" tab > select sequence with zone trigger > "Setup Z trigger" > "Setup" tab, or: Toolbar > "Add zone trigger" icon > "Advanced setup".

In this dialog, you can add zones and areas to your zone trigger and adjust their shapes.





Add zone, ⊞
Adds a new trigger zone. You can add up to four zones.

Remote command:
`ZONE<m>:ADD` on page 928

Display
Enables the display of the zone on the screen.

Remote command:
`ZONE<m>[:VISible]` on page 935

Source
Sets the source of the zone trigger. The zone can be applied to any active input signal, math waveform, XY-plot, normal spectrum trace and power waveforms.

Remote command:
`ZONE<m>:SOURce` on page 934

Area
Defines the area and its condition for the zone.

"Add area"	Adds a new area to the zone. You can add up to 8 areas.
"Intersect"	Defines if the signal must intersect the area to allow the instrument to trigger, or if it must not intersect the area.
"Label"	Defines a label for the selected area.

"Combination" Sets the logic combination that applies to all areas in a zone. Available are "AND" or "OR".
Example: If three areas are defined and the combination is "OR", then the Boolean state of the zone is Zone1 = Area1 OR Area2 OR Area3..

Remote command:
ZONE<m>:AREA<n>:ADD on page 929
ZONE<m>:AREA<n>:COUNt? on page 929
ZONE<m>:AREA<n>:INTersect on page 930
ZONE<m>:AREA<n>:LABel on page 930
ZONE<m>:ACOMbination on page 929

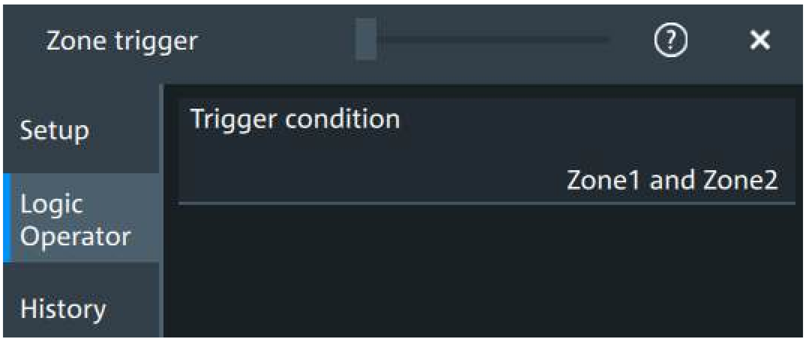
Delete icon
Enables the removal of areas of the zone.

You can also delete all current areas with "Delete All".

Remote command:
ZONE<m>:REMove on page 934
ZONE<m>:AREA<n>:REMove on page 933

7.9.3 Logic operator settings

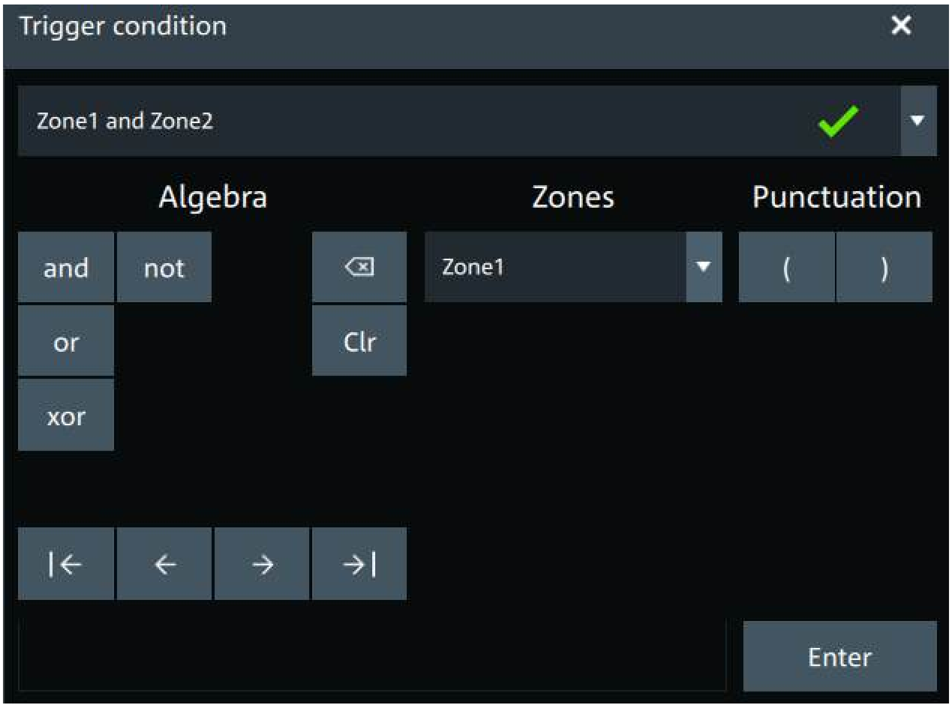
Access: "Menu" > "Trigger" > "Setup" tab > select sequence with zone trigger > "Setup Z trigger" > "Logic Operator" tab.



Trigger condition
Sets a logical expression for the trigger condition between different defined zones.

If all required zones are defined, you can type the logical expression directly, or use the trigger condition editor.

Double-tap the "Trigger condition" field to open the editor:



The keys of the "Trigger condition" editor are described in Trigger condition keys.

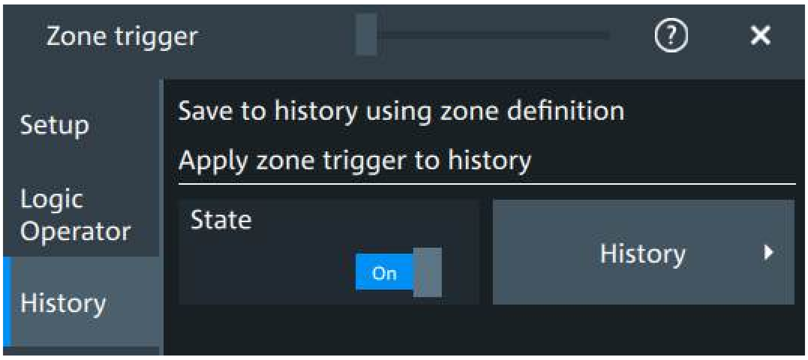
Table 7-1: Trigger condition keys

Icon	Description
and	And
not	Must not intersect
or	Or
xor	Exclusive or
Zone	Selects the zone
Clr	Clear expression in editor
(	Left bracket to enclose operands
)	Right bracket to enclose operands
|←	Moves cursor to beginning
←	Moves cursor 1 step to the left
→	Moves cursor 1 step to the right
→|	Moves cursor to end

Remote command:
`TRIGger:ZONE:EXPRession[:DEFine]` on page 929

7.9.4 History settings

Access: "Menu" > "Trigger" > "Setup" tab > select sequence with zone trigger > "Setup Z trigger" > "History" tab.



When a zone trigger is defined, the history saves only acquisitions that fulfill the complete trigger condition including the zone trigger condition. On the other hand, you can use the current zone trigger definition to filter the history replay.

Apply zone trigger to history
If enabled, the instrument applies the zone trigger condition to the acquisitions that are stored in the history memory. Tap "History" to open the history player and analyze the filtered waveforms.

Using "Apply zone trigger to history", you can:
- Acquire waveforms with high speed and filter them afterwards in the history.
- Change the zone trigger condition after acquisition.

Remote command:
`TRIGger:ZONE:HIStory` on page 934

8 Signal configuration

8.1 Reference level setup

Some measurements and analysis tasks require reference levels to obtain the measurement points, e.g. time measurements or timing reference. You can define 4 sets of reference levels. During configuration of the analysis task, you select which set of reference levels is used.

Access: "Menu" > "Apps" > "General" tab > "Signal config" > "Reference level" tab

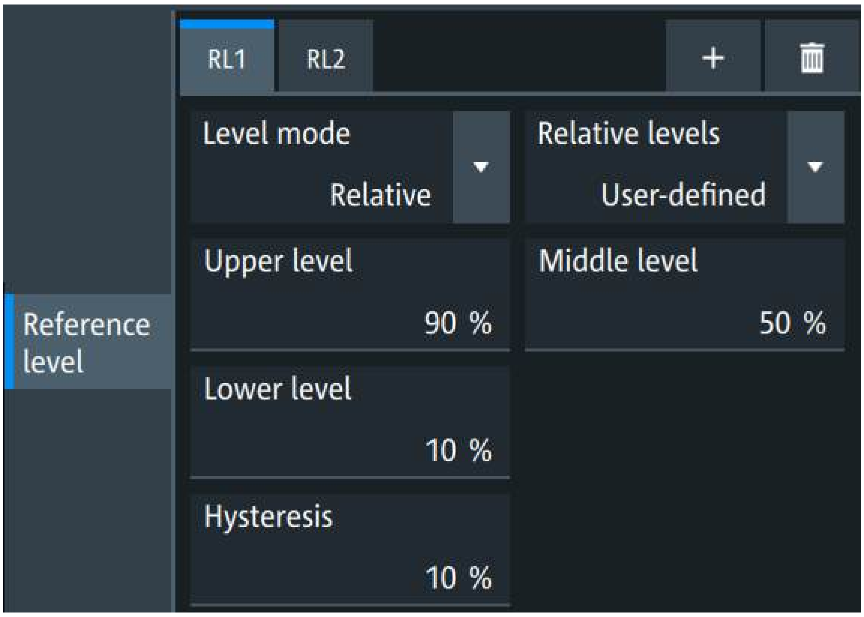


Figure 8-1: Relative reference level settings

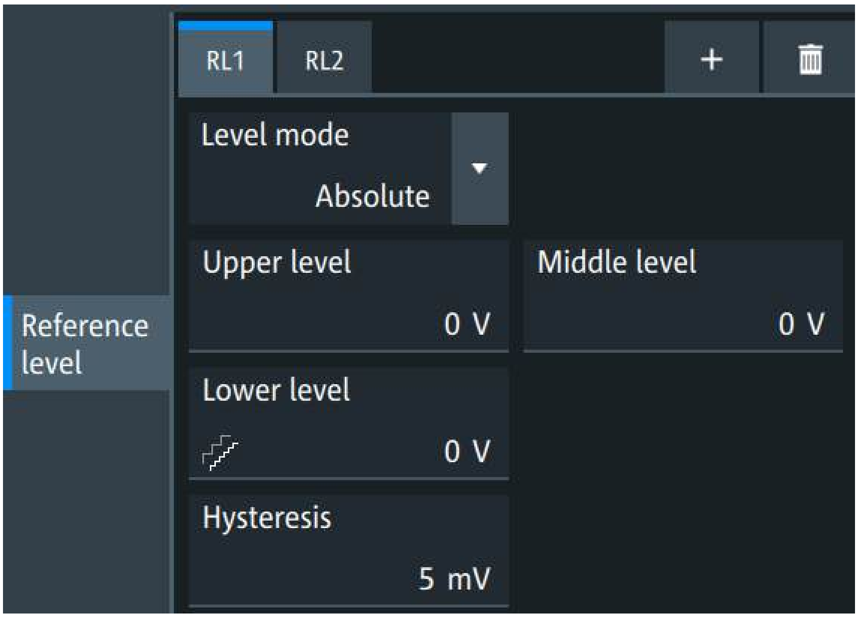


Figure 8-2: Absolute reference level settings

RLx
Select the correct reference level tab before you enter the settings.

You can add up to 4 reference levels.

Remote command:
`REFLevel<rl>:ENABle` on page 935

Level mode
Defines if the reference level is set in absolute or relative values.

Remote command:
`REFLevel<rl>:LMODe` on page 936

Absolute Level mode
In the absolute mode, the reference values are set in absolute values with the unit of the vertical axis.

Upper level, Middle level, Lower level ← Absolute Level mode
Set the lower, middle and upper reference signal levels.

Remote command:
`REFLevel<rl>:ABSolute:LLEVel` on page 936
`REFLevel<rl>:ABSolute:MLEVel` on page 937
`REFLevel<rl>:ABSolute:ULEVel` on page 937

Relative Level mode
In the relative mode, the reference values are set as percentages of the signal amplitude.

Relative levels ← Relative Level mode
Selects the lower, middle and upper reference levels, defined as percentages of the signal amplitude.

Available relative levels:

- 5/50/95
- 10/50/90
- 20/50/80
- User defined: Enter "Upper level", "Middle level", and "Lower level".

For example, for "5/50/95" the levels are set to the following values:

- Lower level = 5% of the signal amplitude
- Middle level = 50% of the signal amplitude
- Upper level = 95% of the signal amplitude

Remote command:
`REFLevel<rl>:RELative:MODE` on page 938

Upper level, Middle level,Lower level ← Relative Level mode
Define the reference levels in percent, if "Level mode" is set to "User-defined".

Remote command:
`REFLevel<rl>:RELative:LOWer` on page 938
`REFLevel<rl>:RELative:MIDDle` on page 938
`REFLevel<rl>:RELative:UPPer` on page 939

Hysteresis
Defines a hysteresis for the middle reference level. A rise or fall from the middle reference value that does not exceed the hysteresis is rejected as noise.

Remote command:
`REFLevel<rl>:ABSolute:HYSTeresis` on page 936
`REFLevel<rl>:RELative:HYSTeresis` on page 937

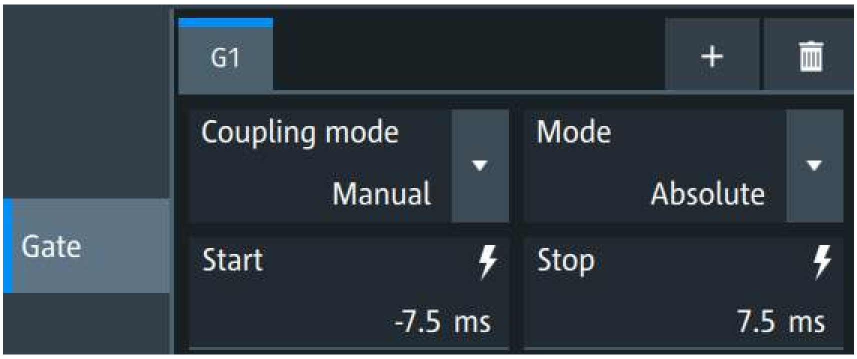
8.2 Gate setup

Gate areas limit various measurements to a user-defined range of the waveform.

You can define up to 8 separate gates. You can define absolute or relative limit values, or use an existing zoom, cursor set or spectrum as a gate.

Then, you assign the gates to analysis tasks, for example, to measurements or power analysis.

Access: "Menu" > "Apps" > "General" tab > "Signal config" > "Gate" tab



Add

Creates a new gate.

Remote command:
`GATE<g>:ENABle` on page 940

Coupling mode

The gate coupling mode selects how the gate area is defined.

"Manual" Manually define the gate with a user-defined start and stop values.

"Cursor" Cursor coupling is available if a cursor is defined. The gate area is defined by the cursor lines of an active cursor measurement.
If several cursor measurements are enabled, select the "Cursor" to be used for gating. The start and stop values of the gate are adjusted to the values of the cursor line positions. The measurement is limited to the part of the waveform between the cursor lines.

"Zoom" Zoom coupling is available if a zoom is defined. The gate area is defined identically to the zoom area - if you change the zoom, the gate changes as well.
If several zoom diagrams are defined, select the "Zoom" diagram to be used for gating. The start and stop values of the gate are adjusted to the values of the zoom positions.

"Spectrum" Spectrum coupling is available if a spectrum is enabled.
If several spectrums are enabled, select the "Spectrum" diagram to be used for gating.

Remote command:
`GATE<g>:GCOupling` on page 940
`GATE<g>:CURSor` on page 941
`GATE<g>:ZDIagram` on page 941

Mode, Start, Stop

Selects if the gate settings are configured using absolute or relative values.

"Absolute" The gate is defined by absolute start and stop values with "Start" and "Stop".

"Relative" The gate's start and stop values are defined by a percentage of the value range with "Relative start" and "Relative stop".

Lightning symbols in the value fields indicate that the gate is not yet assigned to any measurement.

Remote command:
`GATE<g>:MODE` on page 942
`GATE<g>:ABSolute:STARt` on page 942
`GATE<g>:ABSolute:STOP` on page 942
`GATE<g>:RELative:STARt` on page 942
`GATE<g>:RELative:STOP` on page 942

8.3 Timing reference

The timing reference is the clock that is used for jitter measurements, for example. You can configure up to 4 timing references. The clock can be a captured clock signal, or it can be recovered from the data signal by software CDR.

8.3.1 General settings of the timing reference

Access: "Menu" > "Apps" > "General" tab > "Signal config" > "Timing reference".

Type

Defines the origin of the clock signal - either an existing clock signal or waveform, or a clock generated by clock data recovery (CDR).

"Explicit Clock" The clock is an existing clock signal.

"Software CDR" The clock is generated by a software algorithm.

Remote command:
`TREFerence<m>:TYPE` on page 949

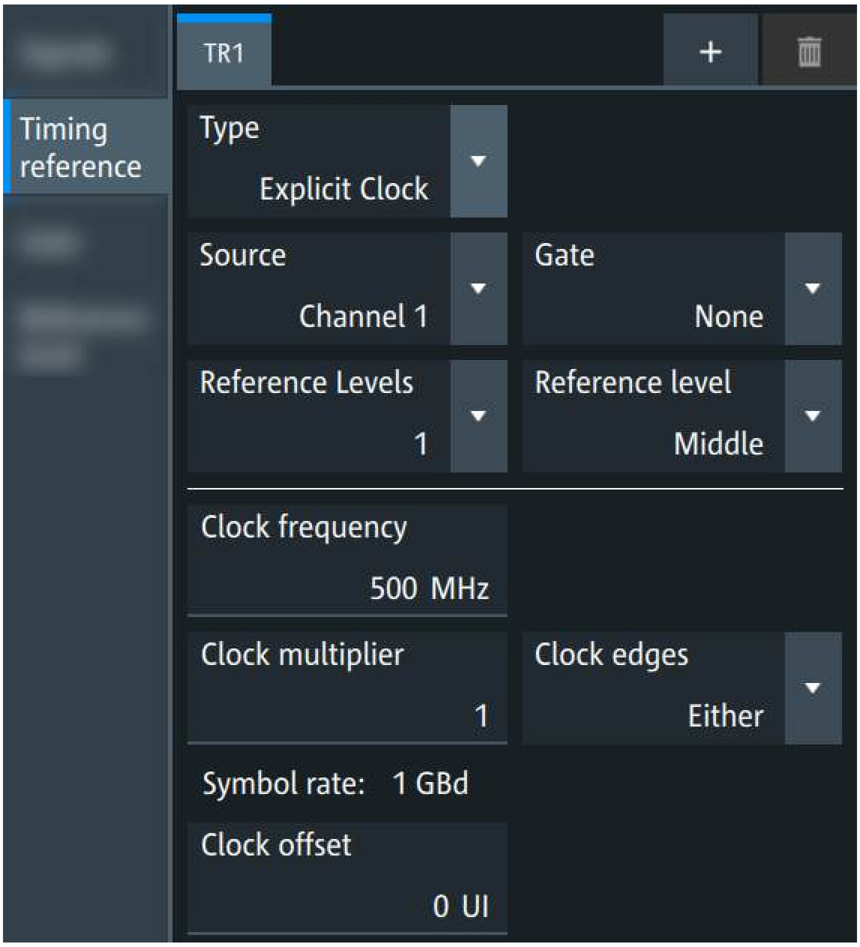
Reference levels

Selects the set of reference levels that is used for the timing reference measurements.

Remote command:
`TREFerence<m>:RFLSet` on page 948

8.3.2 Explicit clock signal

Access: "Menu" > "Apps" > "General" tab > "Signal config" > "Timing reference" > "Type" = "Explicit Clock".



Reference level

Selects the reference level that is used for the timing reference measurement if the clock is an existing clock signal.

Remote command:

`TREFerence<m>:REFLevel` on page 948

Source

Selects the clock source if the clock is an existing clock signal.

Remote command:

`TREFerence<m>:SOURce` on page 949

Clock frequency

Sets the frequency of the clock signal. The setting is relevant if the clock is an explicit clock signal.

Remote command:

`TREFerence<m>:CLK:FREQuency` on page 946

Clock multiplier
Sets a value for the clock multiplier, which is the ratio of an internal clock rate to the externally supplied clock. It defines the number of samples per clock interval. The setting is relevant if the clock is an explicit clock signal.

Remote command:
`TREFerence<m>:CLK:FACTor` on page 946

Clock edges
Sets the clock edges that are used for measurements. The setting is relevant if the clock is an explicit clock signal.

"Positive"	The positive clock slope can be used, for example, for single data rate (SDR) signals with bit start at the positive clock edge.
"Negative"	The negative clock slope can be used, for example, for SDR signals with bit start at the negative clock edge.
"Either"	Both edges can be used for double data rate (DDR) signals.

Remote command:
`TREFerence<m>:EDGE` on page 947

Symbol rate
Shows the symbol rate of the data signal. The setting is relevant if the clock is an explicit clock signal.

SymbolRate = *ClockFrequency* * *Multiplier* * *EdgeCount*, where EdgeCount = 2 for either slope and EdgeCount = 1 for positive and negative slopes.

Remote command:
`TREFerence<m>:SYMRate` on page 949

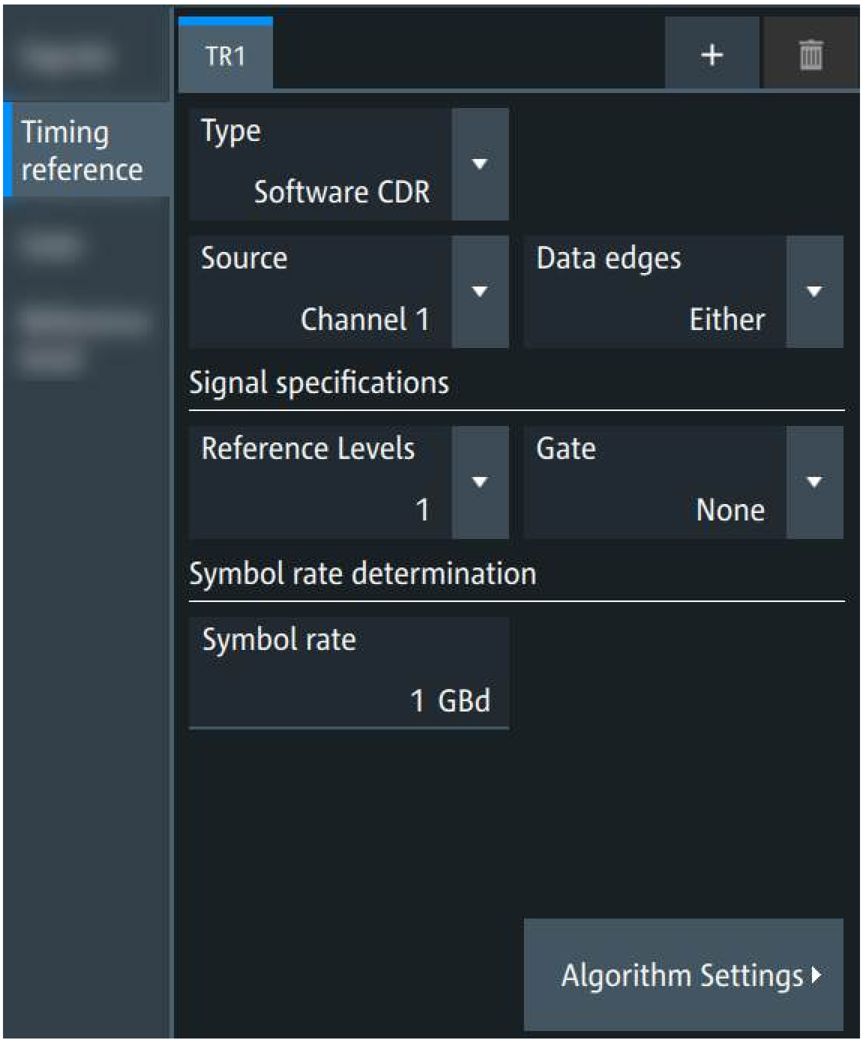
Clock offset
Sets the offset between the clock edge and the data edge in unit intervals. The setting is relevant if the clock is an explicit clock signal.

Remote command:
`TREFerence<m>:CLK:OFFSet` on page 947

8.3.3 Clock data recovery by software CDR

Access: "Menu" > "Apps" > "General" tab > "Signal config" > "Timing reference" > "Type" = "Software CDR".

If "Type" is set to "Software CDR", you need to set up the algorithm for the clock data recovery.



Data edges

Selects the edges of the data stream that are used for the clock recovery.

- "Either": Both positive and negative edges are used.
- "Positive" or "Negative": Only one edge direction is used. Use one of these settings if the other edge delivers unreliable results.

Remote command:

`TREFerence<m>:EDGE` on page 947

Symbol rate

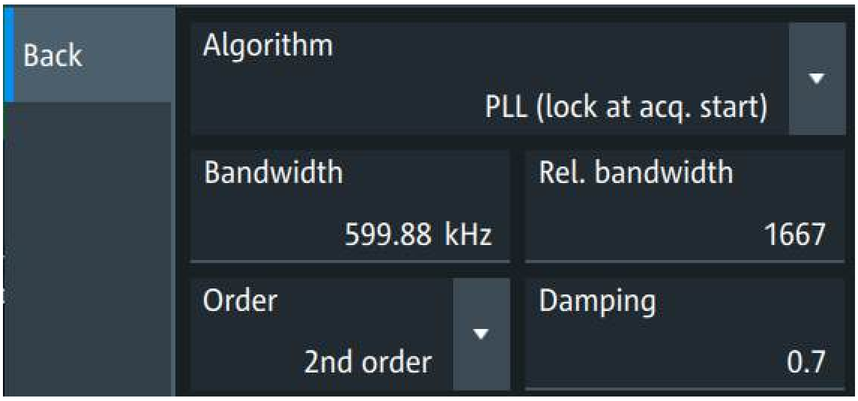
Sets the quiescent frequency of the PLL. It corresponds to the data rate of the data stream from which the clock is to be recovered.

Remote command:

`TREFerence<m>:SYMRate` on page 949

Algorithm

Sets the software algorithm that is used for software clock data recovery.



"Constant freq." CDR uses the nominal symbol rate to generate the clock signal. The method assumes that the frequency of the signal is constant during the complete acquisition.

"PLL" PLL is the phase-locked loop control system. It can follow slow deviations in the frequency of the data stream. Thus, it acts as a highpass filter regarding the jitter that remains on the signal.

"Feed Forward" The feed-forward algorithm is a mathematical optimization method used for clock data recovery. It is faster than PLL, i.e., the settling time is shorter. Feed forward is also more precise than PLL.

"PLL (lock at acq. start)" Phase-locked loop control system, which is locked at the acquisition start.

Remote command:
`TREFerence<m>:CDR:SOFTware:ALGorithm` on page 943

Clock resync

Enables continuous synchronization of the clock with the data signal. At constant clock frequency without resync, the clock starts at the first detected edge and clocks with the given or estimated bit rate or symbol rate. With synchronization, the clock searches for the next edge and synchronizes to this edge. Thus, the sampling points are not exactly at constant frequency but aligned to the defined edges of the data signal.

Remote command:
`TREFerence<m>:CDR:SOFTware:CFRequency:CRSYnc` on page 944

Bandwidth

Sets the PLL bandwidth. It defines the part of the spectrum that the PLL can follow during synchronization. The PLL bandwidth is usually defined by the transmission standard.

Remote command:
`TREFerence<m>:CDR:SOFTware:BWIDth` on page 944

Rel. bandwidth

Sets the relative bandwidth, which is the ratio of the nominal bit rate to the PLL bandwidth.

Remote command:
`TREFerence<m>:CDR:SOFTware:RELBwidth` on page 945

Order

Sets the order of the PLL: first or second order. PLL of higher order can compensate for more complex jitter behavior.

Remote command:
TREFerence<m>:CDR:SOFTware:PLL:ORDer on page 945

Damping

Sets the damping factor, which is only relevant for second order PLL.

Remote command:
TREFerence<m>:CDR:SOFTware:PLL:DAMPing on page 944

Initial phase sync

Available for "Algorithm" = "PLL".

Defines the phase reference for the first clock edge.

"First data edge"	The first clock edge matches the first edge of the data signal.
"First sample"	The first clock edge matches the first sample of the waveform at the left border of the display.

Remote command:
TREFerence<m>:CDR:SOFTware:PLL:SYNC on page 945

Selected results

Available for "Algorithm" = "PLL".

The PLL requires some time to synchronize to the phase of the data stream. You can select when the CDR algorithm returns clock edges:

"All"	All clock edges are used.
"After initial sync."	The clock edges of the synchronization time are discarded; results are gathered after initial synchronization of the CDR. Thus, meaningful TIE measurement results can be obtained.

Remote command:
TREFerence<m>:CDR:SOFTware:SELResults on page 946

9 Waveform analysis

This chapter describes general methods to check and analyze waveforms. These are:

9.1 Zoom

The zoom magnifies a part of the waveform to view more details. The zoom is applied to all waveforms that are visible in a diagram.

For each diagram, you can define one zoom area.

- You can define the zoom by drawing, moving and adjusting the zoom area on the touchscreen.
- You can precisely define the size of the zoom area by entering start and stop values in a dialog box.

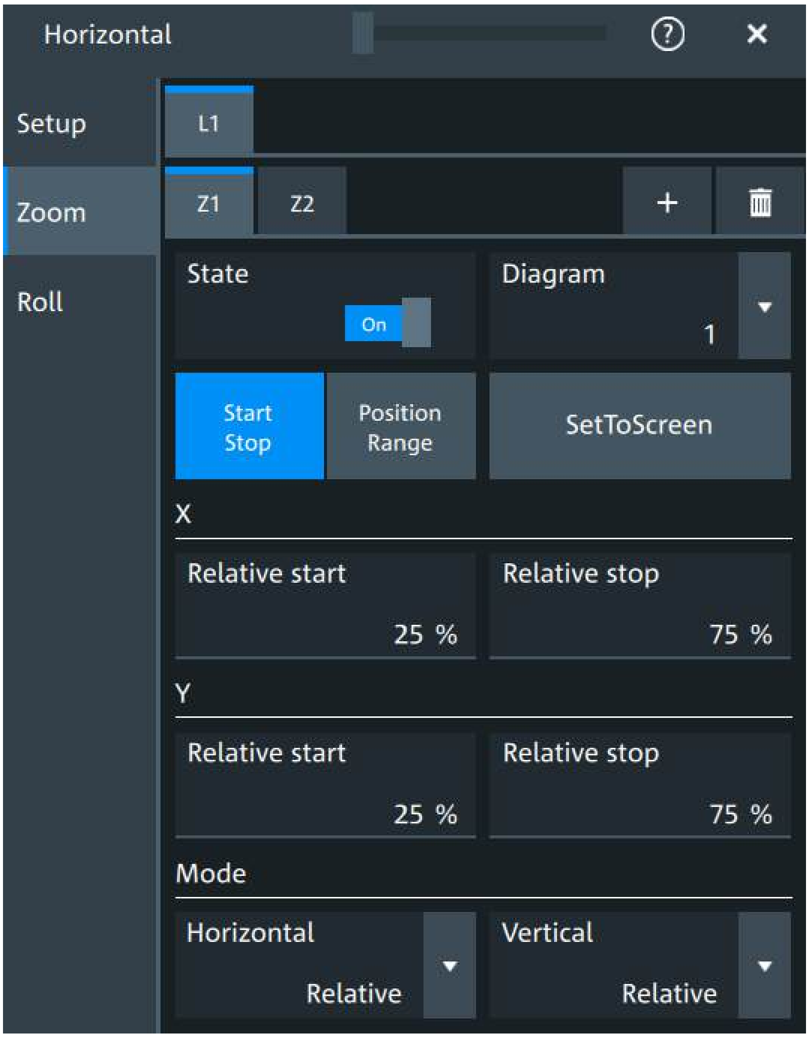
Zoomed waveforms are shown in separate zoom diagrams, in addition to the waveform diagrams. On the original waveform diagram, a rectangle indicates the zoomed section of the waveform - this is the zoom area. You can modify the zoom area by moving the rectangle as a whole, and by moving its edges. To toggle between these modes, tap the zoom area. You can also set exact positions.

Zoom areas can be used for gating, for example, to define a measurement gate. You can set the gate exactly to the limits of the zoom.

9.1.1 Zoom settings

Access: "Menu" > "Horizontal" > "Zoom" tab.

The "Zoom" tab allows you to specify start and stop values for the x- and y-axes. The acquired data within these ranges is zoomed.



Tabx

Selects one of the enabled SmartGrid layouts.

Zx

Selects the zoom window. You can add up to 4 different zooms.

State

Enables the zoom.

Remote command:

`LAYout<ly>:ZOOM<zo>[:ENABle]` on page 951

Diagram

Indicates which of the waveform diagrams is selected for zooming. The number is displayed on the screen in the middle of each diagram.

Remote command:

`LAYout<ly>:ZOOM<zo>:SOURce` on page 956

Start Stop, Position range
Selects how the window for the zoom diagram is defined. You can select between defining "Start Stop" values or "Position range".

Start Stop
The "Start Stop" tab allows you to specify start and stop values for the x- and y-axes. The acquired data within these ranges is zoomed.

According to the selected "Mode", absolute or relative values are used.

"Start", "Relative start"
Defines the lower limit of the zoom area on the axis.

"Stop", "Relative stop"
Defines the upper limit of the zoom area on the axis.

Remote command:
`LAYout<ly>:ZOOM<zo>:HORizontal:ABSolute:STARt` on page 953
`LAYout<ly>:ZOOM<zo>:HORizontal:RELative:STARt` on page 955
`LAYout<ly>:ZOOM<zo>:HORizontal:ABSolute:STOP` on page 953
`LAYout<ly>:ZOOM<zo>:HORizontal:RELative:STOP` on page 955
`LAYout<ly>:ZOOM<zo>:VERTical:RELative:STARt` on page 958
`LAYout<ly>:ZOOM<zo>:VERTical:ABSolute:STARt` on page 957
`LAYout<ly>:ZOOM<zo>:VERTical:RELative:STOP` on page 958
`LAYout<ly>:ZOOM<zo>:VERTical:ABSolute:STOP` on page 957

Position range
If "Position range" is selected, you specify the x and y position of center point of the zoom area plus a range for the x- and y-axes. The area defined by that point and the ranges is zoomed. You can set absolute values or relative values (in percent of the screen, depending on the "Mode" selection.

"Range" Defines the width or height of the zoom area.

"Position" Defines the x or y value of the centerpoint of the zoom area.

Remote command:
`LAYout<ly>:ZOOM<zo>:HORizontal:ABSolute:POSition` on page 952
`LAYout<ly>:ZOOM<zo>:HORizontal:RELative:POSition` on page 954
`LAYout<ly>:ZOOM<zo>:HORizontal:ABSolute:SPAN` on page 952
`LAYout<ly>:ZOOM<zo>:HORizontal:RELative:SPAN` on page 954
`LAYout<ly>:ZOOM<zo>:VERTical:ABSolute:POSition` on page 956
`LAYout<ly>:ZOOM<zo>:VERTical:RELative:POSition` on page 958
`LAYout<ly>:ZOOM<zo>:VERTical:ABSolute:SPAN` on page 956
`LAYout<ly>:ZOOM<zo>:VERTical:RELative:SPAN` on page 959

Set to screen
Sets the zoom area to the whole screen.

Remote command:
`LAYout<ly>:ZOOM<zo>:SSCReen` on page 959

Mode

Defines if absolute or relative values are used to specify the "Horizontal" (x-axis) and the "Vertical" (y-axis) values.

Remote command:
LAYout<ly>:ZOOM<zo>:HORizontal:MODE on page 954
LAYout<ly>:ZOOM<zo>:VERTical:MODE on page 957

9.1.2 Zooming for details

To define the zoom area on the touchscreen

For graphical zooming, you use your finger on the screen.

1. On the toolbar, tap the "Add zoom" icon.

   The zoom overlay menu opens.

2. Draw a rectangle in the diagram that defines the zoomed area.
   While you drag your finger on the screen, a dotted rectangle indicates the current zoom area.

   The indicated area is magnified in a new zoom diagram. The original diagram shows the zoom area as a rectangle.

3. If the position of the zoom area is not correct, drag the rectangle in the overview to the correct position.

4. If the size of the zoom area is not yet ideal, tap the rectangle in the overview diagram.
   Now, 4 white lines indicate the edges of the zoom area. A dashed white line indicates the selected edge, which you can adjust.

5. Touch the edge that you want to move. Drag it to the required position.

To create a zoom using the zoom dialog box

► If you want to create a new, unconfigured zoom, tap the "Add" icon.

To define the zoom area numerically using start/stop values

1. Open "Menu" > "Horizontal".

2. In the "Zoom" tab, select "Start Stop".

3. Select a value for "Mode" > "Horizontal" to define "Absolute" or "Relative" x-axis values. Relative values cause the zoom area to adapt to the input values dynamically.
4. For "X", define the "Relative start" and "Relative stop" values. They define the lower and upper borders of the zoom area on the x-axis.
5. Select the "Mode" > "Vertical" to define "Absolute" or "Relative" y-axis values.
6. For "Y", define the "Relative start" and "Relative stop" values. They define the lower and upper borders of the zoom area on the y-axis.

   When you close the dialog box, the specified area is magnified in a new zoom diagram. The original diagram is displayed with the zoom area indicated as a rectangle.

To define the zoom area numerically using position and range values

1. Open "Menu" > "Horizontal".
2. In the "Zoom" tab, select "Position range".
3. Select "Mode" > "Horizontal" to define "Absolute" or "Relative" x-axis values. Relative values cause the zoom area to adapt to the input values dynamically.
4. Under "X" > "Position", define the x-value of the center point of the zoom area.
5. Under "X" > "Range", define the width of the zoom area.
6. Select the "Mode" > "Vertical" to define "Absolute" or "Relative" y-axis values.
7. Under "Y" >"Position", define the y-value of the center point of the zoom area.
8. Under "Y" > "Range", define the height of the zoom area.

   When you close the dialog box, the specified area is magnified in a new zoom diagram. The original diagram is displayed with the zoom area indicated as a rectangle.

9.2 Mathematics

Math waveforms are calculated waveforms. You can define up to 5 math waveforms and display them on the screen, and use it as source for further analysis.

It is calculated out of one or two analog channels, or another math waveform using several predefined operations. You can define up to 5 equations. The complete configuration is called equation set and can be saved for later use.

You can analyze math waveforms in the same way as channel waveforms: use zoom, perform automatic and cursor measurements, and save as reference waveform.

You can store a math waveform as a reference waveform and restore it later. See Section 9.4, "Reference waveforms", on page 239.

9.2.1 Creating math waveforms

Math waveforms are created and displayed in addition to the channel and other waveforms. They can also be used for analysis, e.g. measurements, even if the math waveform is not active.

1. Open "Menu" > "Math" > "Setup".
   Alternatively, press the [Math] key.
2. Define the mathematic operation with one of the following methods:
   - Use basic operations in "Operator" subtab.
   - Define a filtered waveform in the "Filter" subtab.
   - Create a mathematic equation in the formula editor on the "Equation" subtab.
3. Enable "Display".

   The math waveform is displayed on the screen. A green dot in the math waveform tab indicates that the waveform is active.

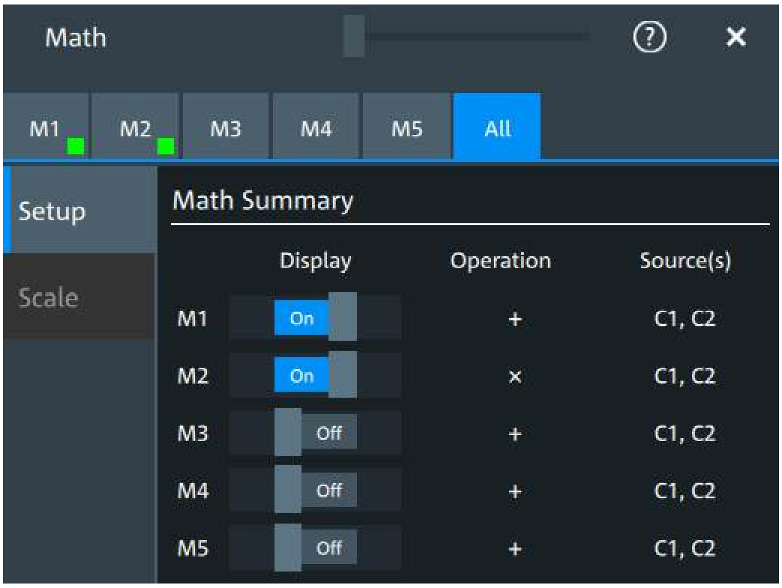
4. To change the vertical scaling of the math waveform, open the "Scale" tab.
5. Set the "Scale mode" to "Manual".
6. Enter the "Vertical scale" factor (per division). If necessary, add a "Vertical offset".
   Default is the automatic scaling.
7. Close the "Math" dialog box.

9.2.2 General math waveforms settings

Access: "Menu" > "Math" > "Setup" tab

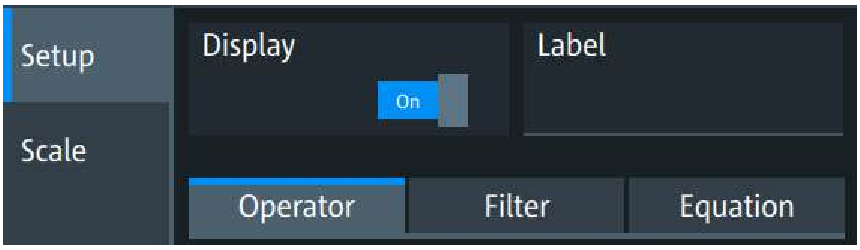
You can define up to 5 different math waveforms. Each waveform is defined in a separate tab in the "Math" dialog.

You can find a summary of the state and operations of all math waveforms in the "All" tab.



This section describes the general settings in the "Setup" tab. The subtabs for the definition of the mathematic operation are explained separately:

- Section 9.2.3, "Operator settings", on page 223
- Section 9.2.4, "Filter settings", on page 225
- Section 9.2.5, "Equations", on page 227



Display
Activates the selected Math channel and displays the defined math waveforms.

Remote command:
`CALCulate:MATH<m>:STATe` on page 960

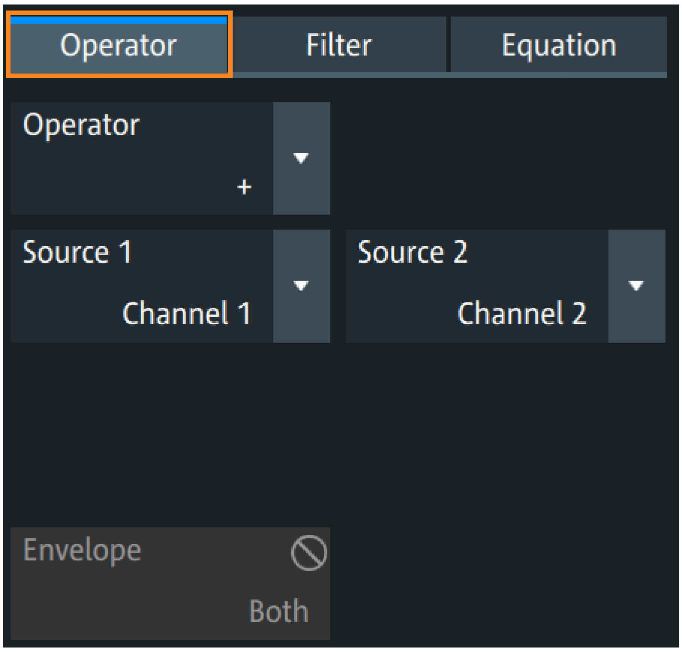
Label
Defines a label for the selected math waveform.

Remote command:
`CALCulate:MATH<m>:LABel` on page 961

9.2.3 Operator settings

Access: "Menu" > "Math" > "Setup" tab > "Operator".

To create simple math waveforms, use the settings in the "Operator" subtab. It provides common math functions.



Operator

Defines the type of operation to be performed on the selected signal sources.

The following functions are available:

"+"	Adds the values of 2 sources (channel or math waveform).
"-"	Subtracts source 2 from source 1.
"x"	Multiplies the two sources.
"/"	Divides source 1 by source 2.
"1/x"	Calculates the reciprocal of the source.
"- x"	Calculates the negative value of the source.
"|x|"	Determines the absolute value of the source.
"Δx/Δt"	Differentiates the source value relating to the time value. Not possible on envelope waveforms and waveforms with "Peak detect" decimation.
"Integral"	Calculates the definite integral of the source.
"log(x)"	Calculates the logarithm of the source value based on 10.
"ln(x)"	Calculates the natural logarithm of the source value (based on e).
"ld(x)"	Calculates the binary logarithm of the source value (binary logarithm, based on 2).
"x^2"	Squares the source. If the source contains negative values that have been clipped, then the result contains positive clipping.
"√x"	Calculates the square root of the source. Note that the square root of a negative number is undefined and the result is clipped.
"Rescale"	Rescaling of x.

Remote command:
CALCulate:MATH<m>[:EXPRession][:DEFine] on page 960

Source 1, Source 2
Defines the signal source to be evaluated by the math function.

a, b
Define the values for the rescale function, if "Operator" = "Rescale"

"a"	Multiplication factor
"b"	Offset of the signal source on the y-axis.

Noise reject
Only available for "Operator" = "Δx/Δt".

Sets the number of neighboring samples that are skipped for differentiation.

To suppress noise effects during differentiation, it can be useful not to consider two directly neighboring points to calculate *dx* (x_n-x_{n-1}). Instead, some samples in-between are skipped and a point a few samples further is used (e.g. x_n-x_{n-3}).

Envelope wfm selection
Selects the upper or lower part of the input waveform for mathematic calculation, or a combination of both.

Remote command:
CALCulate:MATH<m>:ENVSelection on page 962

9.2.4 Filter settings

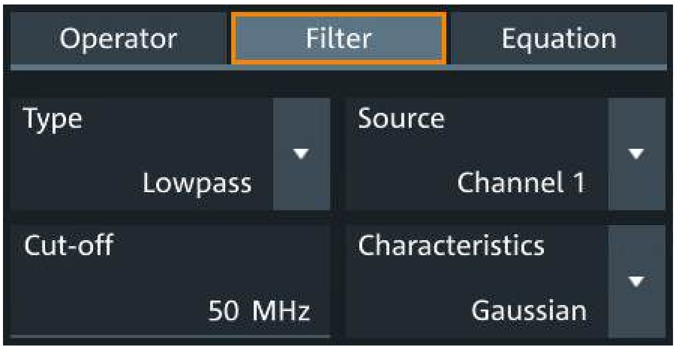
Access: "Menu" > "Math" > "Setup" > "Filter" tab

The finite impulse response filter is a filter to create filtered math waveforms with low-pass, highpass, or bandpass. The filter requires additional settings.

You can set up the filter in the "Filter" tab, or enter the filter formula in the formula editor. For details, see Table 9-3.

You can also define the filter coefficients in a CSV file and use the file for filtering. See "Bandpass and bandstop FIR filter with CSV file" on page 226.

In remote control, filter settings are defined in the expression string, see CALCulate:MATH<m>[:EXPRession][:DEFine] on page 960.



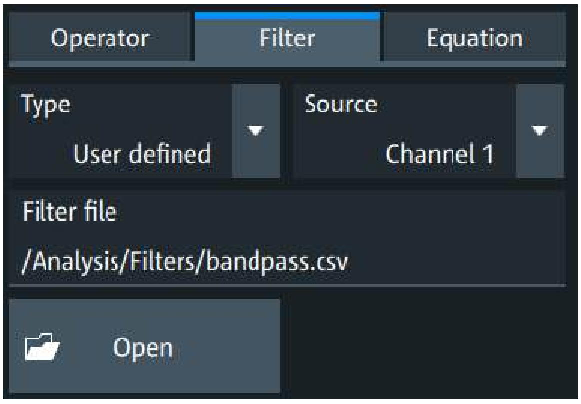
Bandpass and bandstop FIR filter with CSV file

To define a bandpass or bandstop, you need a CSV file that contains the comma-separated filter coefficients in one row. The maximum number of filter coefficients is 100 000 taps. No other parameters are allowed in the file.

To create the CSV file, we recommend using the MATLAB Filter Design & Analysis tool. In the tool, enter the filter type, filter order and filter frequencies. Alternatively, you can create the filter and the CSV file with Python.

Make sure to set the sample frequency in MATLAB or Python and the sample rate at the oscilloscope to the same value. If the values differ, the filter is shifted in frequency.

On the MXO 4, select "Menu" > "Math" > "Setup" > "Filter", the filter "Type" = "User defined", and load the CSV file.



All settings on the "Filter" tab are explained below.

Type
Selects if the filter is a highpass, lowpass, or user-defined filter (bandpass/bandstop filter defined in a CSV file).

Source 1
Selects the input channel of the signal.

Cut-off
Sets the limit frequency for the filter.

Cutoff frequency for lowpass filter

The cutoff frequency depends on the horizontal resolution and the filter characteristics. The cutoff frequency range for the lowpass filter is:

$f_c = (0.01 \ldots 0.2) * f_a$ for Gaussian FIR filter

$f_c = (0,01 \ldots 0.4) * f_a$ for rectangular FIR filter

Cutoff frequency for highpass filter

The highpass filter is always rectangular. The cutoff frequency range for the highpass filter is:

$f_c = (0,01 \ldots 0.4) * f_a$

Where: f_c = cutoff frequency to be set for the lowpass filter, and f_a = reciprocal of the resolution, or sample rate of the postprocessing system (including, for example, interpolation).

Characteristics

Selects if a Gaussian or a rectangular shape is used for the lowpass filter. The highpass filter always uses a rectangular shape.

Filter file, Open

If the "User defined" filter type is selected, choose the file with the filter coefficients. Select "Filter file" to type the path and filename, or tap "Open" to select the file in the file browser.

For information on filter files, see "Bandpass and bandstop FIR filter with CSV file" on page 226.

9.2.5 Equations

In the "Equation" tab, you can enter complex formulas to define a math waveform. The formula editor helps to enter formulas easily with correct syntax, using a large selection of operators and signal sources.

1. In the "Math" dialog, open the "Equation" tab.
2. Double-tap on "Math formula" to display the formula editor.

9.2.5.1 Math formula editor

Using the formula editor you can define math functions freely, using a selection of operators and signal sources.

9-1 shows an overview of the math formula dialog and its different sections. The separate functions are described below.

For a procedure to create equations, see Section 9.2.5.2, "Defining a formula in the formula editor", on page 231.

Figure 9-1: Math formula editor overview

1 = Math expression
2 = Numeric
3 = Unit
4 = Source
5 = Filters
6 = Algebra
7 = Math punctuation
8 = "Enter": press to complete the equation entry . The button is grayed out if the expression is not valid.
9 = Information display: additional information about the selected function is displayed.
10 = Cursor keys

Math expression

Use the various buttons of the editor to assemble the equation. If you know the exact syntax, you can also type the equation. You can see immediately whether the input is complete and correct.

We recommend connecting a keyboard to type the equations.

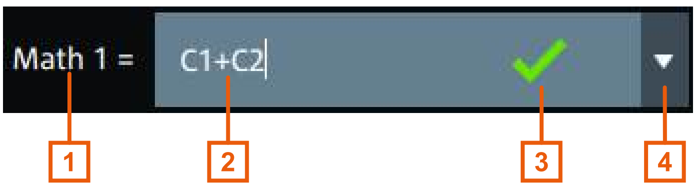


Figure 9-2: Math expression line

1 = Indicates the math waveform that is configured, e.g "Math 1" = "M1"
2 = Math expression input field
3 = Displays the status of the current expression: valid or not
4 = Displays a list of the last 20 used expressions

Buttons of the formula editor and their usage

Table 9-1: Source

Unit	Description
Analog channels	All analog channel waveforms of the device
Other math waveforms	All math waveforms of the device
Track channels	All track waveforms of a device
Reference	All reference waveforms of the device for which the source of reference is an analog channel (e.g. R3)

Table 9-2: Unit

Unit	Description
A	Ampere: the unit for electrical current.
V	Volt: the unit for electrical difference of potential
W	Watt: the unit for power. It is used to quantify the rate of energy transfer.
Ohm	Ohm: the unit for electrical resistance
Siemens	Siemens: the unit for electrical conductance
S	Second: the unit for time
Hz	Hertz: the unit for frequency, the number of occurrences of a repeating event per second.
dBm	dBm: the unit for power level. dBm is expressed in decibels (dB) with reference to 1 milliwatt (mW).
dB	dB: the unit for power gain, expressed in the base-10 logarithm of the ratio between two power levels.
dBµV	dBµV: the unit for voltage level. dBµV is expressed in decibels (dB) relative to 1µV across 50Ω resistance.
dBV	dBV: the unit for voltage level. dBV is expressed in decibels (dB) relative to 1V across 50Ω resistance
Degree	Degree: the unit for an angle. A degree is a measure of angle equal to 1/360 of a full rotation.
rad	Radian: the unit for an angle. 2π radians make up a full rotation.

If you type the unit, put it in square brackets, for example *C1[A]*C3[V]*. Additional parenthesizes are required if you want to assign the unit to the result of the equation, for example *(C1*C3)[W]*

Table 9-3: Filters

Value	Usage/Comment *FormulaEditor expression*
FIR highpass	*FIR(highpass,source,limit,shape)*: source = input channel of the signal, limit = cutoff frequency shape = rectangle for the highpass filter **Example:** *FIR(highpass,C2,3e+09,rectangle)* Sets a rectangle highpass filter on Channel 2 with a 3 GHz cutoff frequency
FIR lowpass	*FIR(lowpass,source,limit,shape)* source = input channel of the signal limit = cutoff frequency shape = Gaussian or rectangle for the lowpass filter **Example:** *FIR(lowpass,C1,1e+07,gaussian)* Sets a Gaussian lowpass filter on Channel 1 with a 10 MHz cutoff frequency
FIR user defined	*FIR(userdef,source,path)* source = input channel of the signal path = string containing the path and filename of the filter file. The file contains the comma-separated filter coefficients. **Example:** *FIR(userdef,Ch1,"/run/media/usb/<MyDriveName>//bandpass.csv")* Sets a bandpass on channel 1 with filter coefficients saved in the `bandpass.csv` file.

Table 9-4: Numeric

Icon	Description	Usage/Comment *FormulaEditor expression*
0...9	Numeric characters	
 Backspace	Erases the character before the cursor	
Clr	Clear expression in editor	Restart editing
e	Math. constants, Euler number	Euler number: 2.7182...
π	Math. constants, Pi	Pi: 3.14159...
.	Decimal point	
±	Changes the sign of the equation	

Table 9-5: Algebra

Icon	Description	Usage/Comment *FormulaEditor expression*
+	Addition	
-	Subtraction	
*	Multiplication	

Icon	Description	Usage/Comment *FormulaEditor expression*
/	Division	
a^b	Exponentiation with base a	a: base, b: exponent *a^b*
|x|	Absolute x value	*abs(x)*
√x	Square root of x	*sqrt(x)*
x^2	x*x	*pow(x)*
1/x	Reciprocal of x	*1/(x)*
d/dx	Derivation of x	*Derivation(x,y)* With x = waveform and y = number of skipped samples (noise reject)
∫xdx	Integral of x	*integral(x)*
ax+b	Scaling of x	*Rescale(x,a,b)* With x = waveform, a= gain factor, and b= constant
$\log_{10}$	Decimal logarithm (base 10)	*log(x)*
$\log_e$	Natural logarithm (base e)	*ln(x)*
$\log_2$	Binary logarithm (base 2)	*ld(x)*

Table 9-6: Math punctuation

Icon	Description	Usage/Comment *FormulaEditor expression*
(	Left bracket	Enclose operands
)	Right bracket	Enclose operands
,	Comma	Separates operands
[	Left square bracket	Enclose unit
]	Right square bracket	Enclose unit

Table 9-7: Cursor keys

Icon	Description
|←	Moves cursor to beginning
←	Moves cursor 1 step to the left
→	Moves cursor 1 step to the right
→|	Moves cursor to end

9.2.5.2 Defining a formula in the formula editor

1. Open the "Menu" > "Math" dialog.

2. Select the "Equation" tab.
3. Double-tap the editing area.

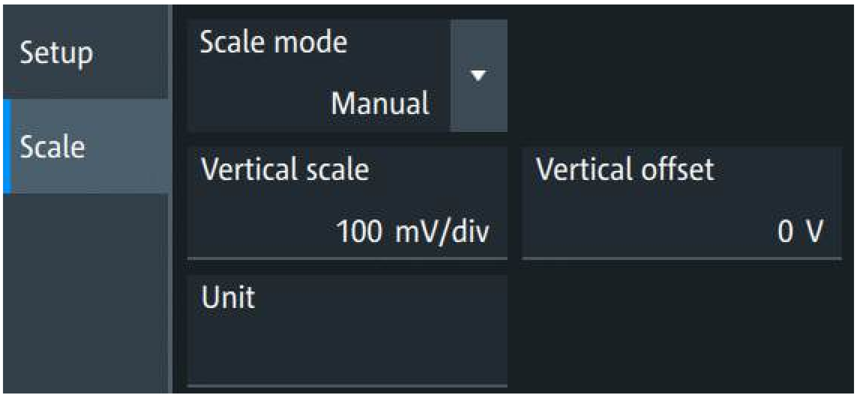
   The "Formula Editor" is displayed.
4. Enter the math formula including all required signal sources and operators by selecting the corresponding keys in the editor. For details on the available keys, see Section 9.2.5.1, "Math formula editor", on page 227.
5. To perform a rescaling function, proceed as follows:
   a) Select the rescaling function using the "ax+b" key.
   b) Behind the left bracket, insert the signal source using one of the following keys:
      - "Cx" for a channel
      - "Mx" for a math function
      - "Rx" for a reference waveform
   c) After the first comma, insert the "a" value, i.e. the scaling factor, using the number keys.
   d) After the second comma, insert the "b" value, i.e. the scaling offset, using the number keys.

   The resulting expression could be, for example: `rescale(C1,3,4)`
6. To insert a unit, press "Unit". Select a value from the list.

   If you type the unit, put it in square brackets, for example *C1[A]*C3[V]*. Additional parenthesizes are required if you want to assign the unit to the result of the equation, for example *(C1*C3)[W]*

9.2.6 Scale settings for math waveforms

Access:"Menu" > "Math" > "Scale" tab



Scale mode

By default, the vertical scale is adapted to the current measurement results automatically to provide an optimal display. However, if necessary, you can define scaling values manually to suit your requirements.

"Manual" Enter the required values for "Vertical scale" and "Vertical offset".

"Auto" "Vertical scale" and "Vertical offset" are read-only.

Remote command:
`CALCulate:MATH<m>:VERTical:SCALe:MODE` on page 963

Vertical scale
Sets the scale of the y-axis in the math function diagram. The value is defined as "<unit> per division", e.g. *50 mV/div*. In this case, the horizontal grid lines are displayed in intervals of 50 mV.

If Scale mode is set to "Auto", this setting is read-only.

Remote command:
`CALCulate:MATH<m>:VERTical:SCALe[:VALue]` on page 961

Vertical offset
Sets a voltage offset to adjust the vertical position of the math function on the screen. Negative values move the waveform up, positive values move it down.

If Scale mode is set to "Auto", this setting is read-only.

Remote command:
`CALCulate:MATH<m>:VERTical:OFFSet` on page 962

Unit
Sets a user-defined unit for the math operation.

Remote command:
`CALCulate:MATH<m>:UNIT` on page 962

9.3 History

The history accesses the data of previous acquisitions and provides them for further analysis.

9.3.1 About history

If a continuous acquisition runs, the captured data is stored in the sample memory and the current acquisition is processed and shown on the display. After the acquisition is stopped, the history accesses the captured samples that were stored, displays these samples as history waveforms, and makes them available for further analysis. It considers all channels that were enabled during the running acquisition.

When a new single acquisition is started, the memory is cleared and written anew. In continuous acquisition, stopping and starting the acquisition does not clear the memory, and the history memory is continued. When the memory is full, new acquisitions are stored, and the oldest are removed (first in, first out). The history memory is cleared when the acquisition parameters are changed. To clear the history memory on demand, use the "Clear" tool on the toolbar.

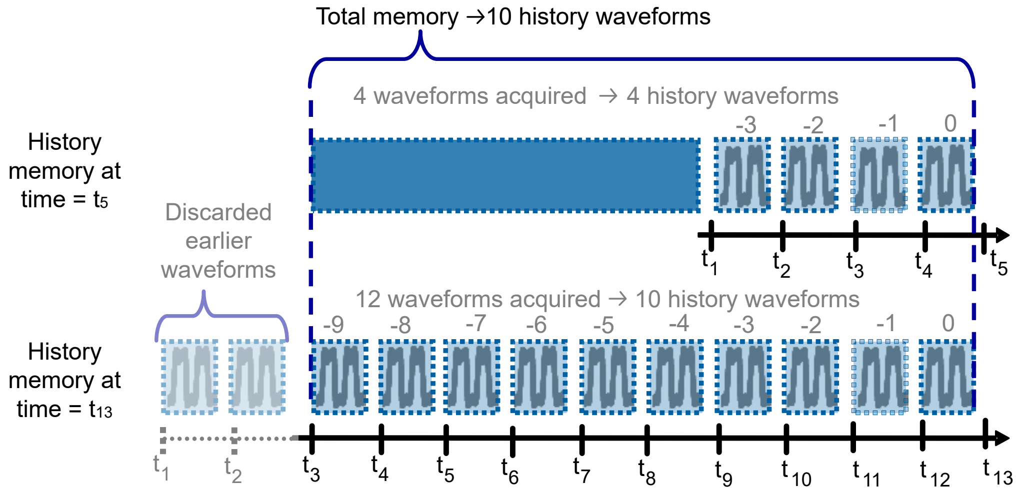


Figure 9-3: History memory. In this example, the memory can store 10 waveforms.

The number of stored history waveforms depends on the memory size, the number of enabled channels, and the record length. The shorter the record length, the less the number of channels, and the larger the memory, the more history waveforms are saved.

You can work with history waveforms in the same way as with the waveform of the latest acquisition: use zoom, cursors, measurements, create math waveforms and so on. You can also save a single history waveform for further analysis.

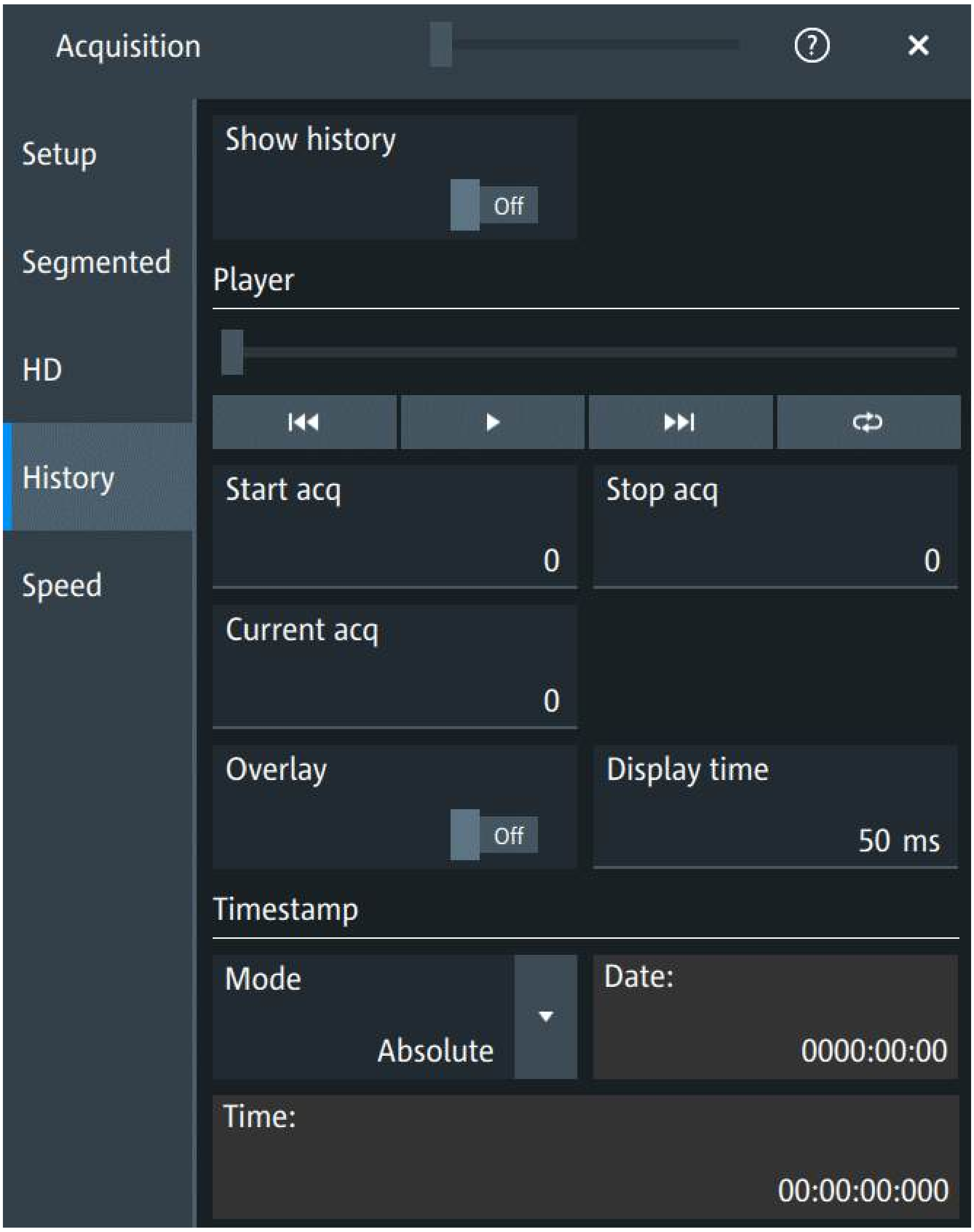
9.3.2 History setup

The "History" dialog contains the complete functionality on history viewing and information.

The most important information and functions are also provided in the quick-access history dialog box.

In the R&S ScopeStudio software, acquisition settings and functions that need an acquisition take effect if the channel source is a simulated waveform, created by the generator. If the channel source is loaded from a file, the acquisition-related settings can be imported with the data from the oscilloscope, either as a saveset, or included in a session. Changing imported acquisition-related settings has no effect.

Access: "Menu" > "Acquisition" > "History" tab.



Show history

Enables the history mode and allows you to save history waveforms to file.

The history display is enabled automatically when you press the [History] button.

To disable the history, you can also close the quick-access "History" dialog box.

Remote command:
ACQuire:HISTory[:STATe] on page 968

Player

The player can be used to control the playback of the history waveforms.

	Sets the oldest acquisition in the sample memory as "Start acq" and "Current acq".
	Starts and stops the replay of the history waveforms from "Start acq" to "Stop acq".
	Sets the newest acquisition in the sample memory as "Stop acq" and "Current acq". This acquisition always has the index "0".
	"Auto repeat": If selected, the playback of the selected history segments repeats automatically. See also: "Auto repeat" on page 238.

Remote command:
ACQuire:HISTory:PLAY on page 965

Start acq

Sets the index of the first (oldest) acquisition to be displayed or exported. The index is always negative.

Remote command:
ACQuire:HISTory:STARt on page 966

Stop acq

Sets the index of the last (newest) acquisition to be displayed or exported. The newest acquisition of the complete acquisition series always has the index "0".

Remote command:
ACQuire:HISTory:STOP on page 966

Current acq

Accesses a particular acquisition in the memory to display it, or to save it. The newest acquisition always has the index "0". Older acquisitions have a negative index.

If a history replay is running, the field shows the number of the currently shown acquisition.

Remote command:
ACQuire:HISTory:CURRent on page 965

Overlay

Displays the segments with infinite persistence. Thus, you can see all data points of all displayed segments of a player cycle.

It is the same setting as "Infinite persistence" on page 102.

Display time

Sets the display time for one acquisition. The shorter the time, the faster the replay is.

The setting takes effect for usual history replay and the display of a fast segmentation series via the history.

Remote command:
`ACQuire:HISTory:TPACq` on page 966

Time stamp
The time stamp shows the time of the currently displayed history acquisition. Thus, the time relation between acquisitions is always available.

The time stamp "Mode" can be absolute or relative:
- In "Absolute" mode, the instrument shows the date and the daytime of the current acquisition.
- In "Relative" mode, the time difference to the newest acquisition (index = 0) is shown.

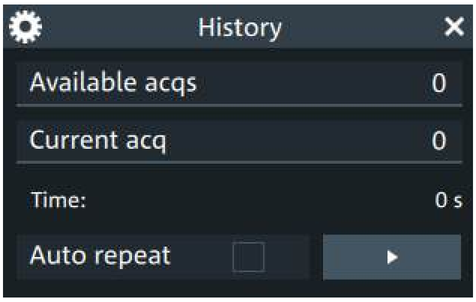
During history replay, the time value is displayed and updated if the replay speed ("Display time") is slow enough, that is 40 ms or slower.

The quick-access history dialog box always shows the time according to the "Mode" that is selected in the "Acquisition" > "History" tab.

Remote command:
`ACQuire:HISTory:TSDate?` on page 967
`ACQuire:HISTory:TSABsolute?` on page 966
`ACQuire:HISTory:TSRelative?` on page 967
`ACQuire:HISTory:TSRReference?` on page 967

9.3.3 Quick access history dialog

The quick access history dialog is visible when the history is active. Closing the dialog disables the history display ("Show history" = "Off")



Available acqs
Number of acquisitions that is saved in the memory and available for history viewing. It is also the number of acquisitions in a fast segmentation acquisition series.

Remote command:
`ACQuire:AVAilable?` on page 856

Current acq
Index of the current acquisition, same as Current acq in the history setup.

Time
Shows the timestamp of the current acquisition. See "Time stamp" on page 237.

Auto repeat
If selected, the playback of the selected history segments repeats automatically.

Remote command:
`ACQuire:HISTory:REPLay` on page 965

Play
Starts and stops the replay of the history waveforms. See also: "Player" on page 236.

9.3.4 Using history

You can access the history of waveforms in two ways:

- Display a particular acquisition.
- Replay all or a part of the saved waveforms to track the signal run.

To open the history and get information

1. Press the [History] key on the front panel.

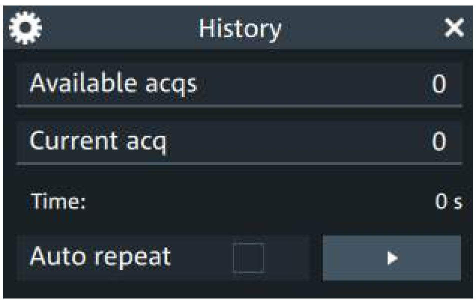
   A running acquisition is stopped, the history mode is enabled and the quick-access "History" dialog box is displayed. The [History] key lights up as long as the history mode is active.

2. Open the full configuration dialog box:
   - Tap the icon.
   - Open "Menu" > "Acquisition" dialog > "History" tab.

To display a particular acquisition

You can analyze a selected history waveform, and save it to a file.

► In the quick-access "History" dialog, enter the number of the required acquisition in the "Current acq" field. The newest acquisition always has the index "0", older acquisitions have a negative index.



Alternatively, you can configure and start the history display from the "History" configuration dialog:

1. Open the "History" configuration tab.
2. If the history mode is off (the [History] key is not illuminated), select "Show history".
3. Drag the slider to the required acquisition. The current number is shown in the "Current acq" field.
   Alternatively, enter the number of the required acquisition in the "Current acq" field.

To save a single history waveform

1. Select and display the required history waveform as described in "To display a particular acquisition" on page 238.
2. Save the selected waveform using "Save/recall" > "Save" tab > "Waveform". For details, see Section 13.2, "Waveform data", on page 401.

To replay history waveforms

If you want to see the complete acquisition series without any setup, simply tap in the quick-access "History" dialog box. For specific analysis of history data, use the history "Viewer" setup.

1. Open the "History" configuration dialog tab.
2. If the history mode is off, enable "Show history".
3. Tap  to start.

To exit the history

► Choose one of the following ways:
- Close the quick-access "History" dialog box.
- In the "History" configuration tab, disable "Show history".
- Start the acquisition.

9.4 Reference waveforms

You can configure up to 4 reference waveforms to display stored waveforms. Any active signal, mathematical waveform or spectrum can be stored as a reference waveform. It can then be loaded again later to restore the waveform on the screen.

9.4.1 Working with reference waveforms

Reference waveforms can be displayed in addition to the signal waveforms. Reference waveforms can be loaded only from REF files.

To display a reference waveform

1. In the "Menu" > "Apps" > "General" tab, select "Reference".
   Alternatively, press the [Ref] key.
2. Select the tab for the reference waveform that you want to display, e.g. "R1".
3. Load a stored reference waveform as described in To load a reference waveform.
   Alternatively, select a source that you want to display as a reference:
   a) In the "Setup" tab, select "Source".
   b) Select the "Source" from the selection list. The list shows all active waveforms that you can save as references.
   c) Tap the "Create/Update" button to update the current reference waveform with the source data.
4. Tap the "Show" button.

   The reference waveform is displayed on the screen.
5. A reference waveform can have its own scaling settings or it can be scaled according to the source settings. By default, the scaling of the reference waveform is coupled to the source settings. Also, you can stretch it or compress it in vertical and horizontal directions.
   If necessary, change the settings on the "Vertical" and "Rescale" tabs of the "Reference waveform" dialog.
   To restore the original settings, tap the "Set to original" in the "Vertical" tab.
   For a description of the scaling settings, see Section 9.4.2.4, "Rescale settings", on page 246.

To save a reference waveform

1. In the "Menu" > "Apps" > "General" tab, select "Reference".
   Alternatively, press the [Ref] key.
2. Select the tab for the reference waveform that you want to store, e.g. "R1".
3. Display and configure the reference waveform as described in "To display a reference waveform" on page 240.
4. Tap "File extension" to select the file format.
   Note that reference waveforms can be loaded only from REF files. CSV files are meant for further processing in other applications.
5. To save the waveform, tap "Save as".
6. Enter a filename and select the directory. The file type is defined according to the selection in the previous steps.

   The source settings of the reference waveform and the current scaling settings are stored to the specified file.

To load a reference waveform

Note: Reference waveforms can be loaded only from REF files.

1. In the "Menu" > "Apps" > "General" tab, select "Reference".
   Alternatively, press the [Ref] key.
2. Select the tab for the reference waveform that you want to load ("R1/2/3/4").
3. In the "Setup" tab, select "Open".
4. Select the file from the file selection dialog box.
5. To load the waveform from the specified file, tap "Open".

   The selected waveform is loaded as the specified reference waveform.

9.4.2 Settings for reference waveforms

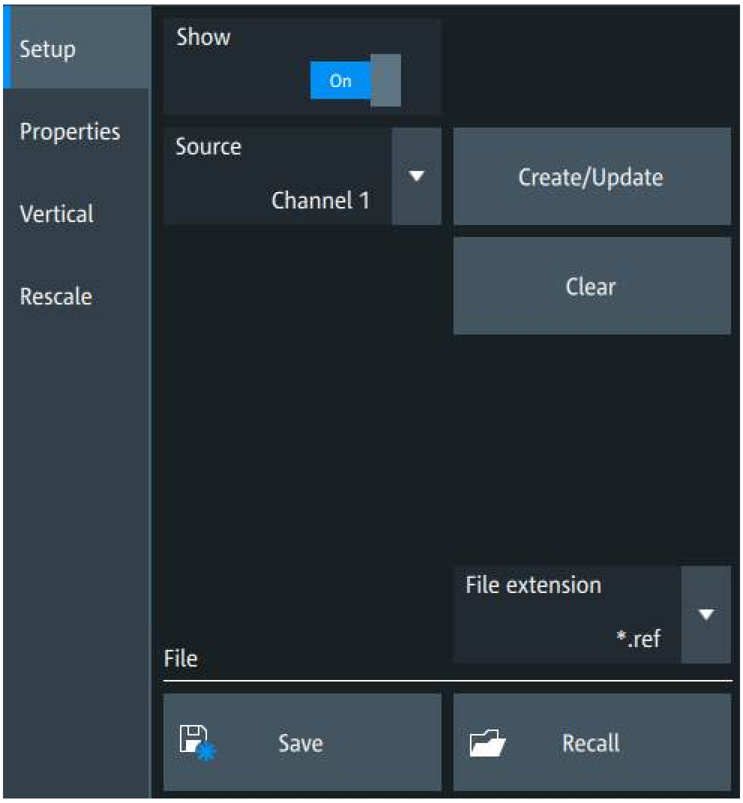
To compare waveforms and analyze differences between waveforms, you can use up to 4 reference waveforms.

You can save an unlimited number of reference waveforms and load them for further use.

The display of a reference waveform is independent from the display of the source waveform; you can move, stretch and compress the curve vertically and horizontally.

9.4.2.1 Reference waveform setup

Access: "Menu" > "Apps" > "General" tab > "Reference" > "Setup" tab



In the "Setup" tab, you select the target reference waveform and its source.

R1/2/3/4
Each tab contains the settings for one of the available reference waveforms.

Show
Enables the display of the reference waveform in the diagram. Before you can display it, create the reference waveform.

Remote command:
`REFCurve<rc>:STATe` on page 971

Source
Selects the source waveform from the active waveforms, e.g. input channels, math waveforms, or spectrum.

Remote command:
`REFCurve<rc>:SOURce` on page 970

Create/Update
Copies the selected source waveform with all its settings to the memory of the reference waveform. If there is a previously defined reference waveform in this memory, it is updated by the current source waveform. If the acquisition is running, the reference waveform is a snapshot.

A progress bar informs you about the process.

Remote command:
`REFCurve<rc>:UPDate` on page 971

Clear
Deletes the selected reference waveform. It disappears from the display, and its memory is deleted.

Remote command:
`REFCurve<rc>:CLEar` on page 968

File extension
Selects the file format. Currently, only REF files are supported.

Save as
Saves the reference waveform. The complete reference waveform is stored in a REF file and can be reloaded later.

A progress bar informs you about the process.

See also:
- Section 13.2, "Waveform data", on page 401
- Section 13.2.3, "Waveform export files", on page 409

Remote command:
`REFCurve<rc>:NAME` on page 969
`REFCurve<rc>:SAVE` on page 970
To abort the saving, use `REFCurve<rc>:ABORt` on page 968.

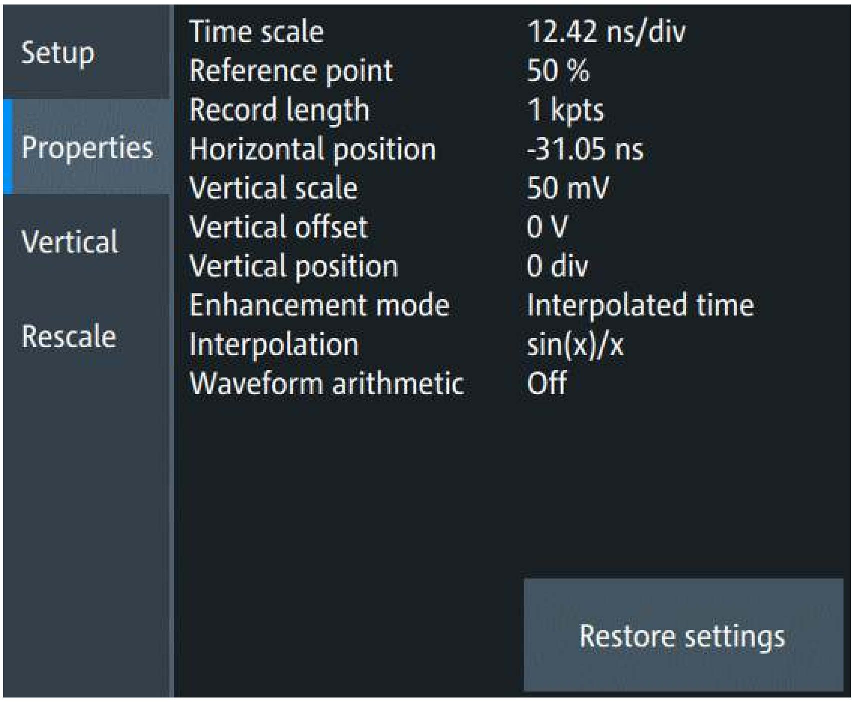
Open
Opens a file selection dialog box and loads the selected reference waveform file.

Note that reference waveforms can be loaded only from REF files.

Remote command:
`REFCurve<rc>:OPEN` on page 969

9.4.2.2 Reference waveform properties

Access: "Menu" > "Apps" > "General" tab > "Reference" > "Properties" tab



A reference waveform can be scaled, stretched and positioned in the diagram. The "Properties" tab shows the original settings of the reference waveform, which are stored together with the waveform data.

The following settings are displayed:

- Time scale
- Reference point
- Record length
- Position
- Vertical scale
- Offset
- Position
- Enhancement mode
- Interpolation
- Waveform arithmetic

Enhancement mode

The enhancement mode is taken from the source waveform of the reference. The enhancement mode is set automatically by the instrument and depends on the sample rate. As long as the waveform sample rate is not higher than the ADC sample rate, the instrument works automatically in real time mode (RT). At higher waveform sample rates, the instrument changes to interpolated time mode (IT), where interpolation adds waveform points between the captured ADC samples by various mathematical methods, see Interpolation.

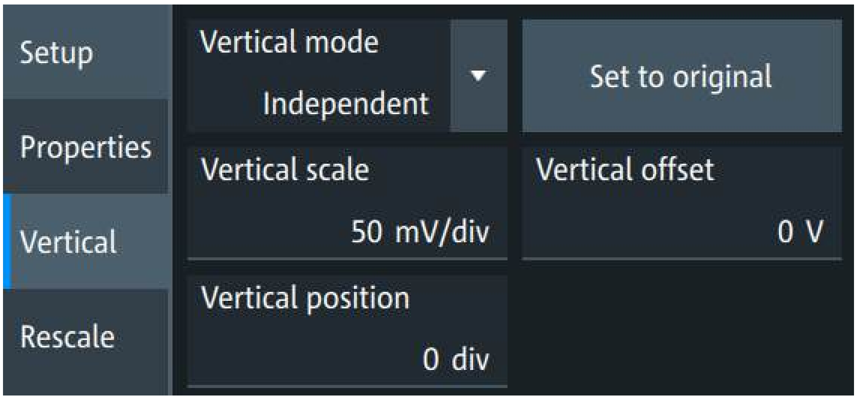
Waveform arithmetic
The waveform arithmetic is taken from the source waveform of the reference, and it cannot be changed for the reference. Waveform arithmetic builds the resulting waveform from several consecutive acquisitions of the signal. The arithmetic methods are envelope and average, which are set in the Acquisition mode.

Restore settings
Applies the original settings of the reference waveform to the horizontal and vertical settings of the selected waveform.

Remote command:
`REFCurve<rc>:RESTore` on page 970

9.4.2.3 Vertical settings for reference waveforms

Access: "Menu" > "Apps" > "General" tab > "Reference" > "Vertical" tab



Vertical mode
Selects the type of vertical settings:

"Coupled to source"	Vertical position and scale of the source are used.
"Independent"	Scaling and position can be set specific to the reference waveform.

Remote command:
`REFCurve<rc>:VMODe` on page 975

Set to original
Available, if "Vertical mode" = "Independent".

Restores the original vertical settings of the reference waveform.

Remote command:
`REFCurve<rc>:TOORiginal` on page 975

Vertical scale
Available, if "Vertical mode" = "Independent".

Sets the vertical scale, which defines the displayed amplitude of the selected waveform.

The unit of the reference is the same as the unit of the source waveform.

Remote command:
REFCurve<rc>:SCALe on page 972

Vertical offset
The vertical offset moves the reference waveform vertically. Enter a value with the unit of the waveform.

Remote command:
REFCurve<rc>:OFFSet on page 969

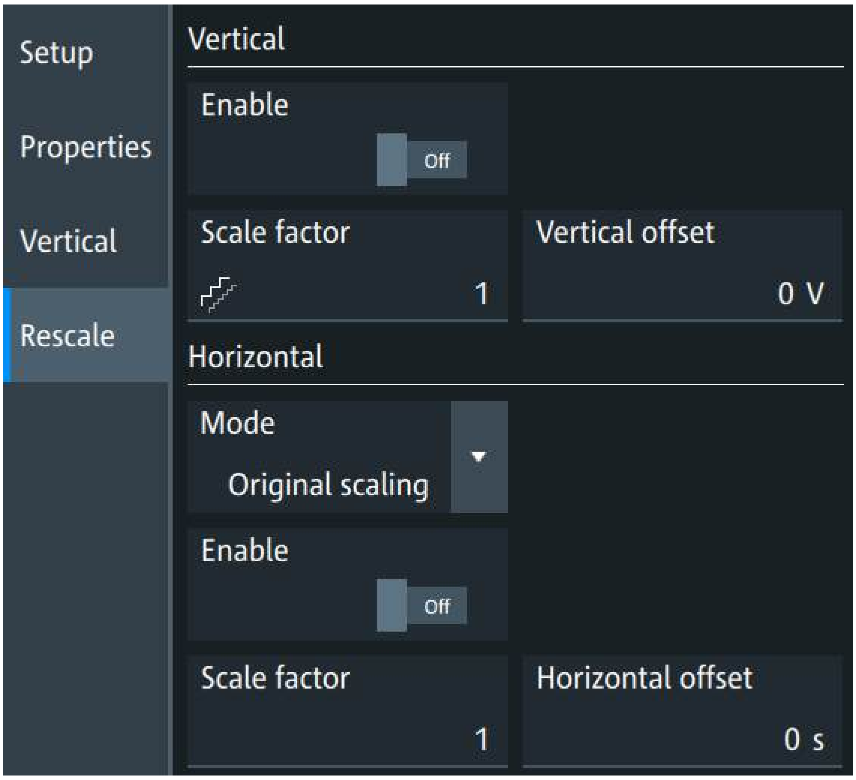
Vertical position
Available, if "Vertical mode" = "Independent".

Moves the reference waveform up or down in the diagram.

Remote command:
REFCurve<rc>:POSition on page 972

9.4.2.4 Rescale settings

Access: "Menu" > "Apps" > "General" tab > "Reference" > "Rescale" tab



In the "Rescale" tab you can adjust the vertical and horizontal scaling of the reference waveform.

Vertical
Stretching and offset change the display of the waveform independent of the vertical scale and position.

Enable ← Vertical
If enabled, the vertical offset and factor are applied to the reference waveform.

Remote command:
`REFCurve<rc>:RESCale:VERTical:STATe` on page 974

Scale factor ← Vertical
Sets the vertical scale factor. A factor greater than 1 stretches the waveform vertically, a factor lower than 1 compresses the curve.

Remote command:
`REFCurve<rc>:RESCale:VERTical:FACTor` on page 974

Vertical offset ← Vertical
The vertical offset moves the reference waveform vertically. Enter a value with the unit of the waveform.

Like vertical offset of a channel waveform, the offset of a reference waveform is subtracted from the measured value. Negative values shift the waveform up, positive values shift it down.

Remote command:
`REFCurve<rc>:RESCale:VERTical:OFFSet` on page 974

Horizontal
Stretching and offset change the display of the waveform independent of the horizontal settings of the source waveform and of the horizontal diagram settings.

Mode ← Horizontal
Selects the type of horizontal settings:

"Original scaling"	Horizontal scaling and reference point of the source waveform are used.
"Adjust to X Axis"	The current horizontal settings of the diagram are used.

Remote command:
`REFCurve<rc>:HMODe` on page 972

Enable ← Horizontal
If enabled, the horizontal offset and factor are applied to the reference waveform.

Remote command:
`REFCurve<rc>:RESCale:HORizontal:STATe` on page 973

Scale factor ← Horizontal
Sets the horizontal scale factor. A factor greater than 1 stretches the waveform horizontally, a factor lower than 1 compresses the curve.

Remote command:
`REFCurve<rc>:RESCale:HORizontal:FACTor` on page 973

Horizontal offset ← Horizontal
Moves the waveform horizontally. Enter a value with a time unit suitable for the time scale of the diagram.

Positive values shift the waveform to the right, negative values shift it to the left.

Remote command:
`REFCurve<rc>:RESCale:HORizontal:OFFSet` on page 973

9.5 Waveform histograms

Histograms are used to plot density of data. They show graphically how often which signal values occur. The histogram accumulates the measured y-values (vertical histogram), or the occurrence of a sample at a given time on the x-axis (horizontal histogram). The data is accumulated during the running acquisition cycle.

You can analyze the complete waveform by a histogram, or a part of it by defining a histogram window. The maximum count of a waveform value is assigned to the full height (histogram peak). All other count values are displayed relative to the maximum.

You can define up to 8 histograms. They are created quickly using the toolbar icon and overlay menu, or in the "Histogram" app dialog.

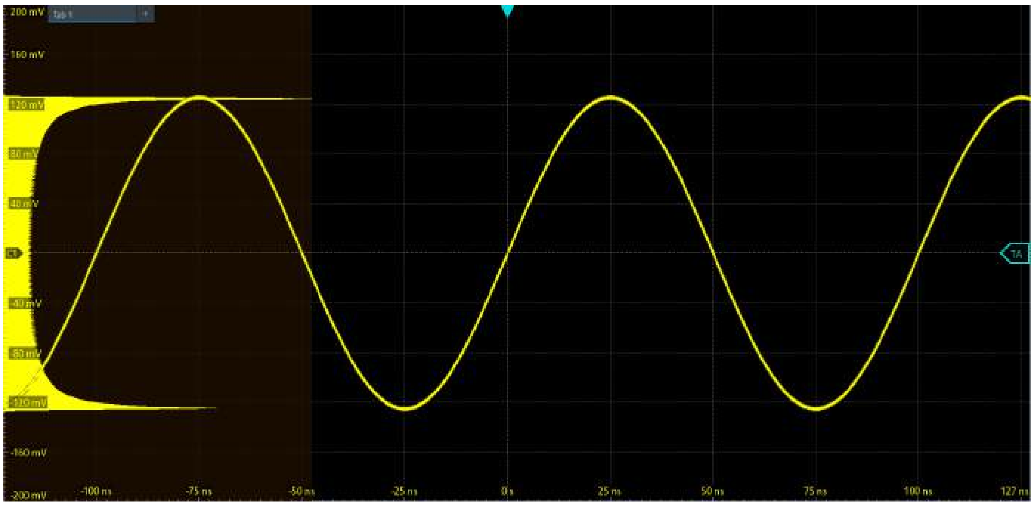


Figure 9-4: Full histogram

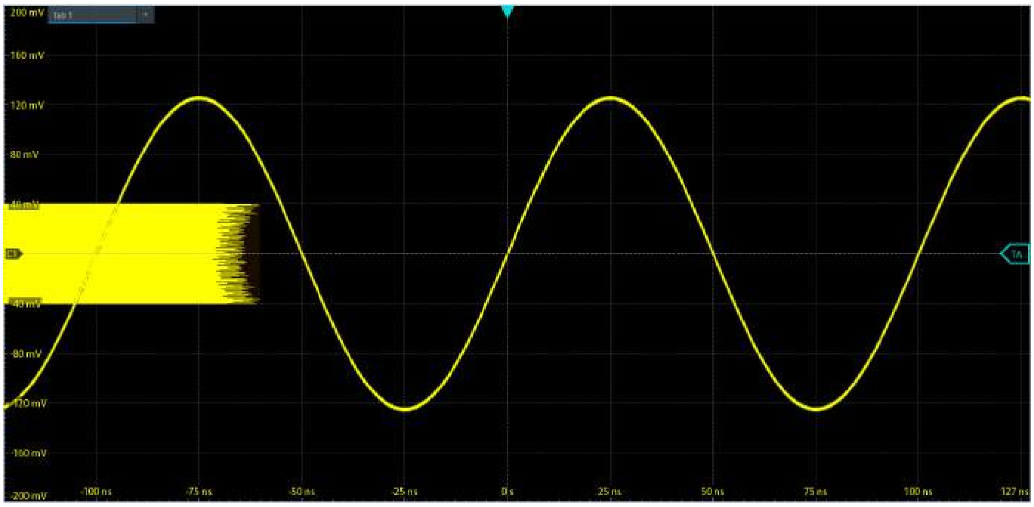


Figure 9-5: Histogram window

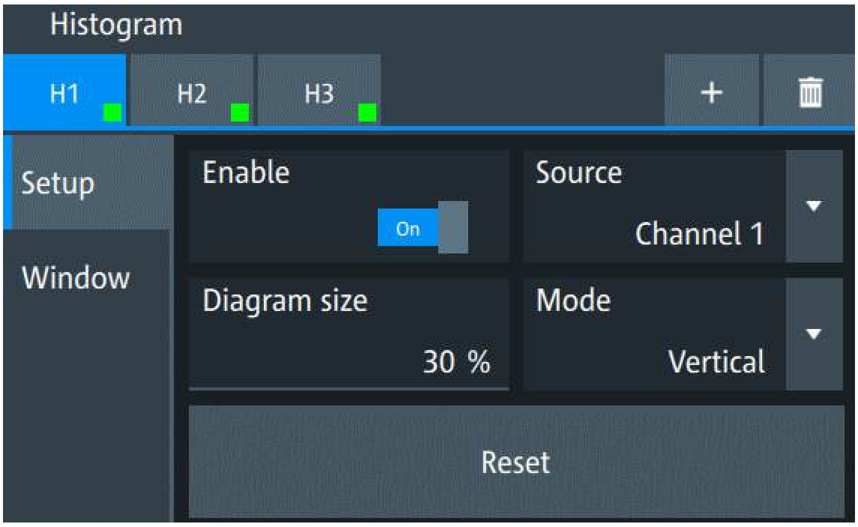
9.5.1 Histogram settings

Access: "Menu" > "Apps" > "General" tab > "Histogram".

The general histogram setup is done in the "Setup" tab. To analyze a part of the wave-form, use the "Window" tab.

9.5.1.1 Setup for histograms

Access: "Menu" > "Apps" > "General" tab > "Histogram" > "Setup" tab



Enable
Enables or disables the histogram evaluation and display. The histogram settings are kept until the histogram is deleted.

Remote command:
HISTogram<m>:ENABle on page 978

Source
Defines the source, the waveform that is analyzed by the histogram. Any analog channel waveform, math or reference waveform can be selected.

Remote command:
HISTogram<m>:SOURce on page 979

Diagram size
Defines the size of the histogram in percent of the diagram width or height.

Mode
Defines the type of histogram.

A vertical histogram has horizontal bars that show the occurrence of the vertical values.

A horizontal histogram has vertical bars the show the occurrence of a sample at a given time on the x-axis. This histogram type is in particular relevant for histogram windows.

Remote command:
HISTogram<m>:MODE on page 978

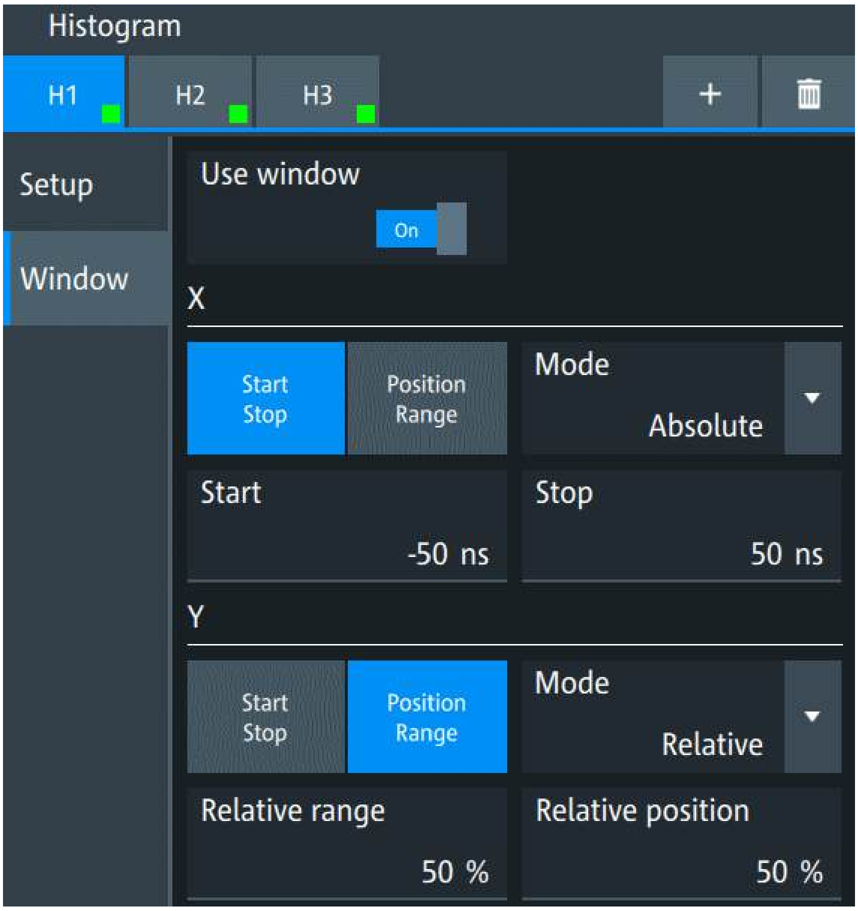
Reset
Restarts the calculation of the selected histogram.

To reset all histograms and measurements, select "Clear" on the toolbar.

Remote command:
HISTogram<m>:RESet on page 979

9.5.1.2 Window settings for histograms

Access: "Menu" > "Apps" > "General" tab > "Histogram" > "Window" tab



Use window

When you use a histogram window, the analyzed part of the source waveform is limited vertically and horizontally.

Remote command:

`HISTogram<m>:WINDow:ENABle` on page 980

Start Stop | Position Range

Select whether you want to use start and stop values to limit the histogram window, or the center position and range of the window. The selections can be different for the vertical and horizontal limit.

Mode

Defines whether the window limits are entered as absolute or relative values.

Remote command:

`HISTogram<m>:WINDow:HORizontal:MODE` on page 980

`HISTogram<m>:WINDow:VERTical:MODE` on page 980

Start, Stop, Range, Position

Set the horizontal window limits as absolute values: start and stop, or center position and range of the window.

Remote command:
HISTogram<m>:WINDow:HORizontal:ABSolute:STARt on page 980
HISTogram<m>:WINDow:HORizontal:ABSolute:STOP on page 980
HISTogram<m>:WINDow:HORizontal:ABSolute:POSition on page 980
HISTogram<m>:WINDow:HORizontal:ABSolute:SPAN on page 980

Relative start, Relative stop, Relative range, Relative position
Set the horizontal window limits as relative values in % of the diagram width: start and stop, or center position and range of the window.

Remote command:
HISTogram<m>:WINDow:HORizontal:RELative:STARt on page 981
HISTogram<m>:WINDow:HORizontal:RELative:STOP on page 981
HISTogram<m>:WINDow:HORizontal:RELative:POSition on page 981
HISTogram<m>:WINDow:HORizontal:RELative:SPAN on page 981

Start, Stop, Range, Position
Set the vertical window limits as absolute values: start and stop, or center position and range of the window. The values remain unchanged if you change the unit of the y-axis.

Remote command:
HISTogram<m>:WINDow:VERTical:ABSolute:STARt on page 981
HISTogram<m>:WINDow:VERTical:ABSolute:STOP on page 981
HISTogram<m>:WINDow:VERTical:ABSolute:POSition on page 981
HISTogram<m>:WINDow:VERTical:ABSolute:SPAN on page 981

Start, Stop, Range, Position
Set the vertical window limits as relative values in % of the diagram height: start and stop, or center position and range of the window. The values remain unchanged if you change the unit of the y-axis.

Remote command:
HISTogram<m>:WINDow:VERTical:RELative:STARt on page 982
HISTogram<m>:WINDow:VERTical:RELative:STOP on page 982
HISTogram<m>:WINDow:VERTical:RELative:POSition on page 982
HISTogram<m>:WINDow:VERTical:RELative:SPAN on page 982

9.5.2 Creating histograms

To create a histogram quickly with toolbar icons

1. Select the waveform for which you need a histogram.
2. Tap the histogram icon on the toolbar.
3. Select the histogram type on the overlay menu: vertical or horizontal. See "Mode" on page 250.
4. Tap the diagram with the waveform to be measured, or draw a rectangle on the screen to define the window for histogram calculation.

The histogram range is shown in the diagram and a histogram with the selected waveform as a source is defined and displayed.

5. To adjust the histogram range:
   a) Double-tap the histogram.
   b) Tap "Setup" on the overlay menu.
   c) Adjust the start and stop values.

To create and configure a histogram in the dialog box

1. Select "Menu" > "Apps" > "General" tab > "Histogram".

2. To create a histogram, tap the "Add" icon in the upper right corner of the dialog box.
3. Select a "Source" for the histogram. The source can be any analog input signal, math or reference waveform.
4. Define the histogram "Mode": vertical for an amplitude, horizontal for a time-based histogram.
5. If you need to evaluate only a part of the waveform:
   a) Select the "Window" tab.
   b) Enter the start value and the stop value in x and in y direction, either as absolute or relative values. Alternatively, you can enter the center position of the window, and its range.
   c) Enable "Use window".
6. On the "Setup" tab, enable the histogram.

9.5.3 Exporting histograms

You can export histogram data, see Section 13.3, "Histogram data export", on page 418.

10 Measurements

Using the MXO 4 you can perform and display different measurements simultaneously, based on the active signal or math waveforms. The color of the results in the result table corresponds with the source waveform color.

10.1 Cursor measurements

10.1.1 Cursors and results of cursor measurements

Cursor measurements determine the results at the current cursor positions. The cursors can be positioned manually, or can be configured to follow the waveform. You can measure on one waveform, on two different waveforms, or on multiple different waveforms (sources).

Up to 2 cursor sets can be configured and displayed. Each cursor set consists of a pair of horizontal or vertical cursor lines, or both. Cursor lines can be coupled so that the initially defined distance is always maintained.

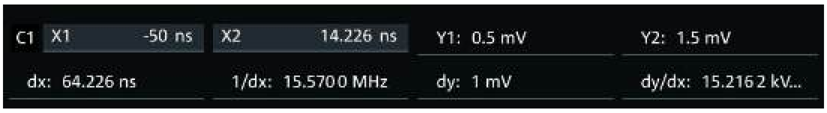
The cursors are displayed in the diagrams of the source waveform only, or in all diagrams. For each measurement, labels can be defined for the cursors. By default, the cursor lines are labeled as Cu1.1 and Cu1.2.

How to set up cursor measurements is described in Section 10.1.2, "Using cursors", on page 255. The Section 10.1.3, "Settings for cursor measurements", on page 257 provides a detailed description of all settings.

For details on using the result table, see Section 4.10, "Displaying results", on page 75.

10.1.1.1 Cursor measurements on time-based waveforms

The cursor for measurement on time-based waveforms returns the following results. The results are displayed automatically when a cursor measurement is enabled.



Label	Description
"X1, X2"	Time at the position of the vertical cursors.
"Y1, Y2"	Vertical values of the waveform at the position of the horizontal cursors in V or A.

Label	Description
"Δx"	Difference between the vertical cursor (time) values
"1/Δx"	Inverse time difference
"Δy"	Difference between the horizontal cursor values
"Δy/Δx"	Slope of the waveform between the cursors (if measured on one source)

For measurements on multiple waveforms, the Y-values are measured on each source waveform.

10.1.2 Using cursors

You can start cursor measurements in the toolbar, or using the [Cursor] key. For detailed configuration, use the "Cursor" dialog.

10.1.2.1 Starting a simple cursor measurement

To add cursors using the toolbar

1. Tap the "Add cursor" icon on the toolbar.

2. Select the channel that you want to apply the cursor to.
   Tap the waveform that you want to measure. Alternatively, you can draw a rectangle in the diagram to position the cursor lines.

   The cursor lines appear and the cursor results are displayed in the result table.

To display cursors using the [Cursor] key

1. Select the waveform that you want to measure.
2. Press the [Cursor] key.

   The cursor lines and the measurement results are displayed.

10.1.2.2 Configuring a cursor measurement

To modify the position of the cursor lines, you can drag the lines on the screen. In addition, various settings are possible to refine the measurement.

The complete configuration of cursor measurements is provided in the "Cursor" dialog. The settings of the dialog are described in Section 10.1.3, "Settings for cursor measurements", on page 257.

1. To open the "Cursor" dialog, use one of these ways:
   - Select "Menu" > "Cursor".

- Press the [Cursor] key.
- Double-tap in the results table (but not on a result).

2. Select the "Setup" tab.
3. Select the subtab for the cursor set that you want to use.
4. Select the Source mode.
5. Depending on the selected "Source mode", select one, two or several sources - the measured waveforms. Available sources are shown in the source list.
6. For single source and second source mode, select the "Type": X (vertical), Y (horizontal), or XY (both).
7. If the acquisition mode is set to "Envelope" or "Peak detect", select which horizontal cursor is positioned to the maximum and which to the minimum envelope values.
8. Define the exact position of the cursor lines:
   a) Enter the X-position for each vertical cursor.
   b) To position the horizontal cursors automatically, select "Track waveform". The Y-position follows the waveforms.
   In this case, Cu 1.1 indicates the current maximum, Cu 1.2 indicates the current minimum. If both horizontal and vertical cursor lines are displayed, the horizontal cursors are placed at the crossing points of the vertical cursor lines with the waveform. If you adjust the vertical cursor lines, the horizontal cursors follow.
   c) If "Track waveform" is off, enter the Y-position for each horizontal cursor.
9. To display the cursor in all diagrams that are in the same domain as the selected source (time or spectrum), enable "Show in all diagrams" in the "Advanced" tab.
10. To keep the distance between the vertical cursors when one cursor is moved, enable "X" or "Y" in the "Advanced" tab.
11. To set the cursors for a spectrum measurement to peak values, select the "Peak search" tab.
    Tap one of the buttons to place the cursors on the selected peak value. For details, see Section 10.1.3.3, "Peak search tab", on page 262.
12. Tap "Show cursor" in the "Setup" tab to activate the cursor measurement.

    The cursors lines and the results are displayed. For details on cursor measurement results, see Section 10.1.1, "Cursors and results of cursor measurements", on page 254.

10.1.2.3 Configuring the cursor display

By default, the cursors are displayed as lines in the diagrams and labeled according to the syntax: Cu<cursor set number>.<1|2>

For example, the cursors for the cursor set 2 are labeled 2.1 and 2.2. The horizontal and the vertical cursors lines have the same labels.

You can change the default cursor display and labels.

To set the cursor style

1. Select "Menu" > "Cursor".
2. Select the subtab for the cursor set you want to configure.
3. Select the "Setup" tab.
4. Select the "Cursor style". See also: "Cursor style" on page 258.

To add labels to cursor lines

1. Select "Menu" > "Cursor".
2. Select the subtab for the cursor set you want to configure.
3. Select the "Advanced" tab.
4. Enter a label for "Vertical cursor 1", "Vertical cursor 2", "Horizontal cursor 1", "Horizontal cursor 2".
5. Enable "Show label".

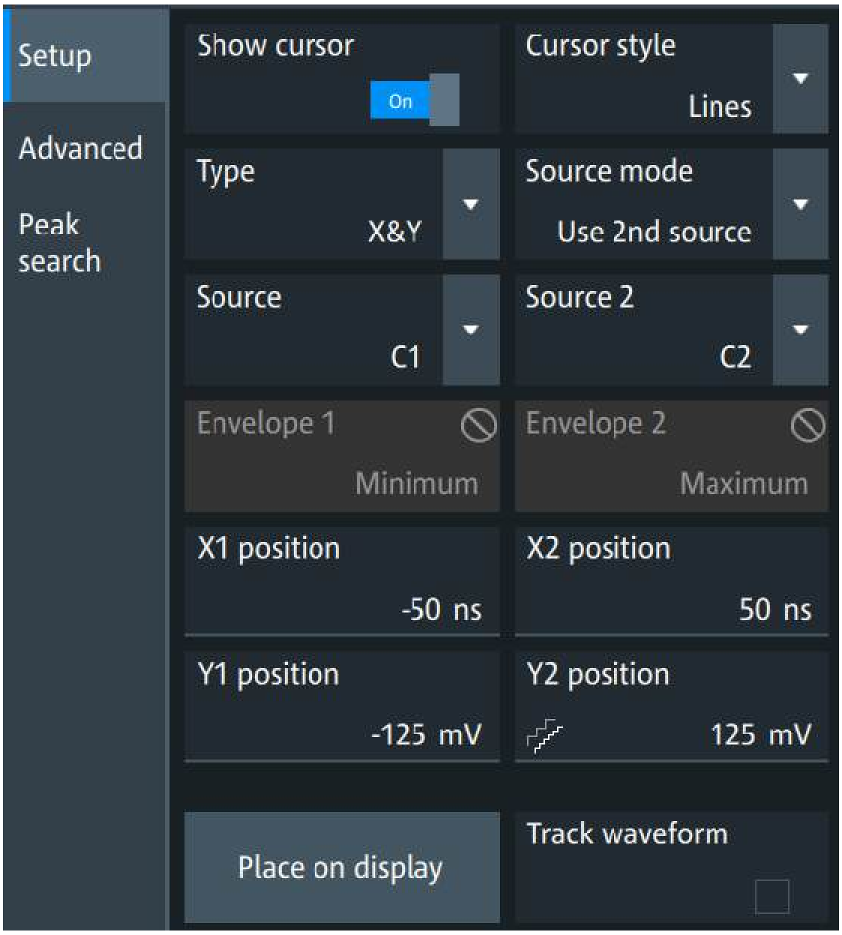
10.1.3 Settings for cursor measurements

Cursor measurements are configured in the "Cursor" dialog.

10.1.3.1 Setup tab

Access: "Menu" > "Cursor" > "Setup" tab

You can define up to 2 cursor sets (or cursor measurements). Each cursor set is configured on a separate tab.



Show cursor

Enables the selected cursor measurement.

Remote command:

CURSor<cu>:STATe on page 1024

Cursor style

Defines how the cursor is displayed in the diagram.

"Lines" The cursors are displayed as lines.

"Line & Rhombus"
The cursors are displayed as lines. The intersections of the cursors with the waveforms are displayed by rhombus-shaped points.

"VLine & Rhombus"
Vertical line and rhombus: the cursors are displayed as vertical lines. The intersections of the cursors with the waveforms are displayed by rhombus-shaped points.

"Rhombus" The intersections of the cursors with the waveforms are displayed by rhombus-shaped points.

Remote command:

CURSor<cu>:STYLe on page 1035

Type

Defines the cursor type to be used for the measurement.

"X" (vertical cursors)
: Both vertical cursor lines are set automatically to the trigger position, and you can reposition them manually. Not available for measurements on multiple sources.

"Y" (horizontal cursors)
: Horizontal cursors are positioned automatically along the waveform and can be adjusted manually. Not available for measurements on multiple sources.

"X&Y" (both vertical and horizontal cursors)
: Horizontal cursors are positioned automatically along the waveform and vertical cursors are set to the trigger position. You can reposition all cursor lines manually.

Remote command:
`CURSor<cu>:FUNCtion` on page 1024

Source mode

Selects the number of sources that you want to measure. The dialog adapts to the selected mode.

"Single source"	The cursor lines are set on one waveform.
"Use 2nd source"	The cursor lines are set on two waveforms. The second cursor lines Cu2 are set on the second source to measure differences between the two waveforms.
"Multiple sources"	Several waveforms are selected to be measured with one cursor set. The cursor type is always "X&Y", and "Track waveform" is active. For each waveform, the Y-value at the position of the vertical cursor line is measured.

Remote command:
`CURSor<cu>:SMODe` on page 1024

Source

Defines the source of the cursor measurement. Various waveform types can be measured. The available sources are listed.

Remote command:
`CURSor<cu>:SOURce` on page 1025

Source 2

Selects a second source for the cursor measurement if "Source mode" is set to "Use 2nd source". The second cursor lines Cu2 measure on the second source. Using a second source, you can measure differences between two channels with cursors.

Remote command:
`CURSor<cu>:SSOurce` on page 1026

Select sources

Select the waveforms to be measured if "Source mode" is set to "Multiple sources". The selection dialog lists all possible active sources.

Remote command:
CURSor<cu>:SOURce on page 1025

Envelope 1, Envelope 2
Define which horizontal cursor is positioned to the maximum and which to the minimum envelope values.

Envelope selection is effective under the following conditions:
- The acquisition mode of the cursor source waveform is set to envelope or peak detect, see Acquisition mode.
- Both horizontal and vertical cursors are enabled (Type = "X&Y").
- Track waveform is enabled.

"Minimum"	The horizontal cursor is set to the crossing point of the vertical cursor line with the minimum waveform envelope.
"Maximum"	The horizontal cursor is set to the crossing point of the vertical cursor line with the maximum waveform envelope.

Remote command:
CURSor<cu>:X1ENvelope on page 1031
CURSor<cu>:X2ENvelope on page 1031

X1 position, X2 position
Define the left and right position of the vertical cursor lines.

Remote command:
CURSor<cu>:X1Position on page 1026
CURSor<cu>:X2Position on page 1026

Y1 position, Y2 position
Define the upper and lower position of the horizontal cursor lines.

If Track waveform is enabled, the user setting is disabled and the Y-position is determined by the instrument.

Remote command:
CURSor<cu>:Y1Position on page 1027
CURSor<cu>:Y2Position on page 1028

Track waveform
If enabled, the horizontal cursor lines track the waveform. If the waveform changes, e.g. during a running measurement, the cursors move along with it.

The function is available if both horizontal and vertical cursors are displayed. The horizontal cursor lines are positioned to the crossing points of the vertical cursors with the waveform. For cursor measurements on multiple sources, tracking is always active.

Tracking disables the Y-coupling (coupling horizontal cursor lines) and the Y-position settings.

In envelope or peak detect acquisition mode, the envelope is tracked.

Remote command:
CURSor<cu>:TRACking[:STATe] on page 1028

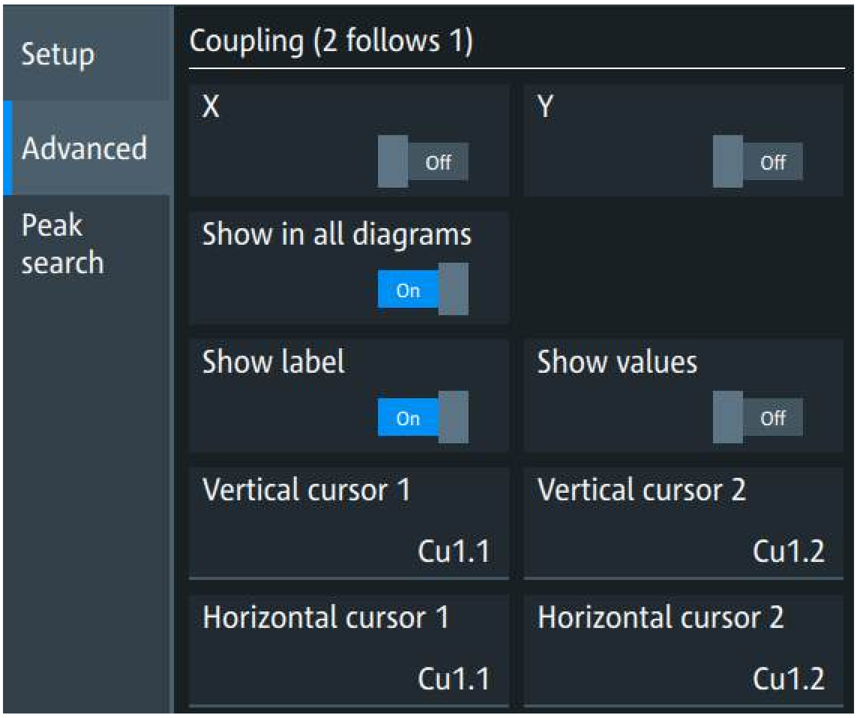
Place on display
Resets the cursors to their initial positions. Reset is helpful if the cursors have disappeared from the display or need to be moved for a larger distance.

Remote command:
`CURSor<cu>:SSCReen` on page 1028

10.1.3.2 Advanced settings

Access: "Menu" > "Cursor" > "Advanced" tab

The settings in the "Advanced" cursor tab configure the behavior and display of cursor lines, and labels for the lines.



X, Y
Couple the horizontal or vertical cursor lines so that the distance between the two lines remains the same if one cursor is moved. "X" couples the vertical cursor lines, and "Y" couples the horizontal cursor lines.

Remote command:
`CURSor<cu>:XCOupling` on page 1030
`CURSor<cu>:YCOupling` on page 1031

Show in all diagrams
Shows the enabled cursor measurements in all active diagrams of the time domain.

In the spectrum domain, the setting is disabled. The cursors are shown only on the source spectrum of the measurement.

Remote command:
`CURSor<cu>:SIAD` on page 1030

Show label
Shows the cursor labels in the diagram.

Remote command:
CURSor<cu>:LABel on page 1029

Show values
Shows the measured values in the cursor labels.

Remote command:
CURSor<cu>:DISPlay:VALues on page 1030

Vertical cursor 1, Vertical cursor 2
Defines the label to be displayed with the vertical cursor lines. By default, the cursors are labeled as Cu1.1, Cu1.2, Cu2.1, ...

Remote command:
CURSor<cu>:VERTical<n>:LABel on page 1029

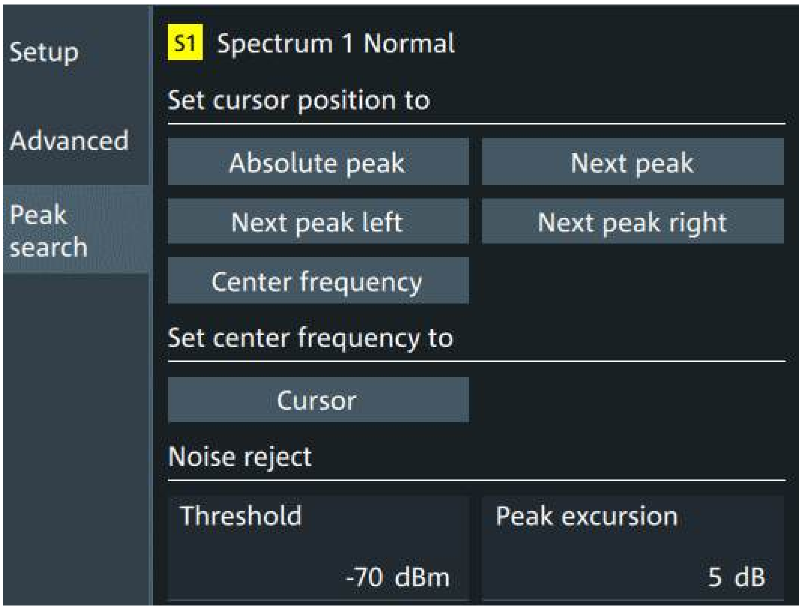
Horizontal cursor 1, Horizontal cursor 2
Defines the label to be displayed with the horizontal cursor lines. By default, the cursors are labeled as Cu1.1, Cu1.2, Cu2.1, ...

Remote command:
CURSor<cu>:HORizontal<n>:LABel on page 1029

10.1.3.3 Peak search tab

Access: "Menu" > "Cursor" > "Peak search" tab

The settings on this tab are only available in spectrum mode, i.e. the source of the cursor measurement is a spectrum. In this case, the cursors can indicate the results of a peak search on the waveform. Changing the noise reject settings, you can define which peaks are detected.



Absolute peak
Sets both cursors to the absolute peak value.

Remote command:
`CURSor<cu>:MAXimum[:PEAK]` on page 1034

Next peak
Cursor 2 is set to the next smaller absolute peak from the current position.

Remote command:
`CURSor<cu>:MAXimum:NEXT` on page 1034

Next peak left
Cursor 2 is set to the next peak to the left of the current position.

Remote command:
`CURSor<cu>:MAXimum:LEFT` on page 1034

Next peak right
Cursor 2 is set to the next peak to the right of the current position.

Remote command:
`CURSor<cu>:MAXimum:RIGHt` on page 1034

Center frequency
Sets the vertical cursor line Cu1 to the center frequency.

Remote command:
`CURSor<cu>:FFT:TOCenter` on page 1034

Set center frequency to
Sets the center frequency to the frequency value that is measured at cursor line Cu1.

Remote command:
`CURSor<cu>:FFT:SETCenter` on page 1033

Threshold
Sets an absolute threshold as an additional condition for the peak search. Only peaks that exceed the threshold are detected.

This setting is only available for spectrum waveforms. It is valid for cursor measurements, spectrum measurements and peak search.

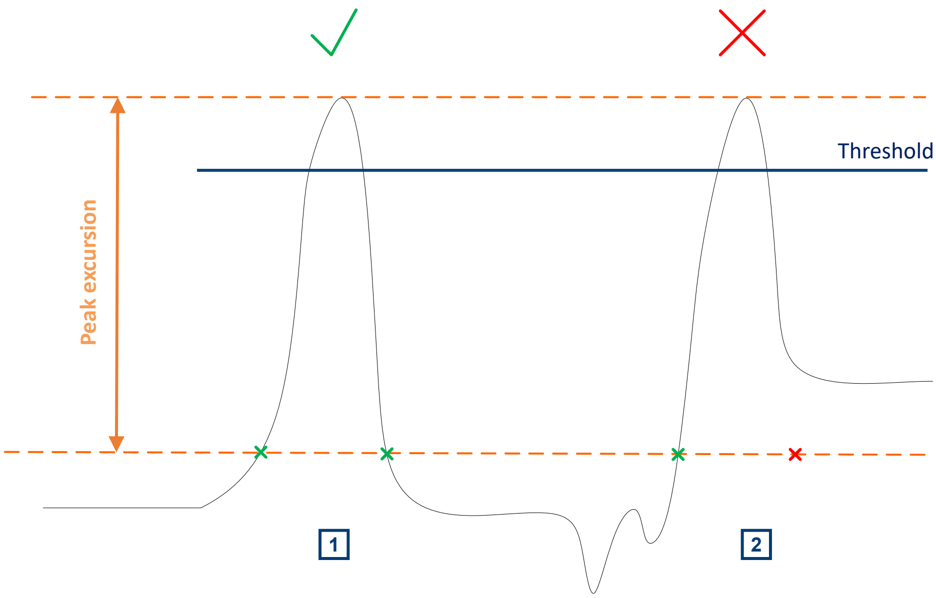
Remote command:
`CALCulate:SPECtrum<sp>:THReshold` on page 1042

Peak excursion
Defines a minimum level value by which the waveform must drop left and right of the local maximum to be listed as a peak. Enter a peak excursion value to omit close by peaks and list just the highest peak.

This setting is only available for spectrum waveforms. It is valid for cursor measurements, spectrum measurements and peak search.

Example:

In the figure below, 2 peaks are shown, that rise above the defined "Threshold". Peak 1 fulfills the defined "Peak excursion" value and is counted as a peak. Peak 2 does not fulfill the defined "Peak excursion" value on the right and is not counted as a peak.



Remote command:
`CALCulate:SPECtrum<sp>:PEXCursion` on page 1042
`CURSor<cu>:PEXCursion` on page 1035

10.2 Automatic measurements

You can perform up to 16 different measurements simultaneously. Available sources and measurement types depend on the selected category. For example, protocol measurements need a serial bus as source. For most measurement types, specific settings are available to configure it.

10.2.1 Measurement setup in general

10.2.1.1 Starting an automatic measurement

There are several methods to start a measurement, each with slightly different effects:

- Using the "Measure" icon on the toolbar:
  See: "To start a measurement using the toolbar icon" on page 265.

- Pressing the [Measure] key on the front panel.
- Using the "Measurement" dialog.
  See: "To add a new measurement in the measurement dialog" on page 265.

To start a measurement using the toolbar icon

1. Tap the "Measure" icon on the toolbar.

   The measurement overlay menu opens.

2. Select the "Category".
3. Tap on the measurements that you want to perform. You can scroll left and right through the measurement list, to view all available measurements for the selected "Category".
4. Select the source that you want to apply the measurement on.
5. If needed, click on "Setup" to configure further measurements.

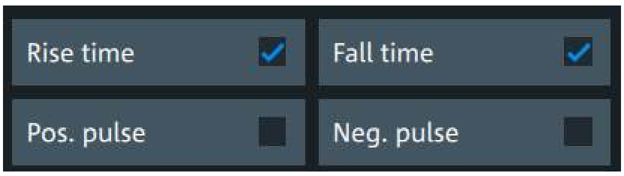
   The measurement results are displayed.

To add a new measurement in the measurement dialog

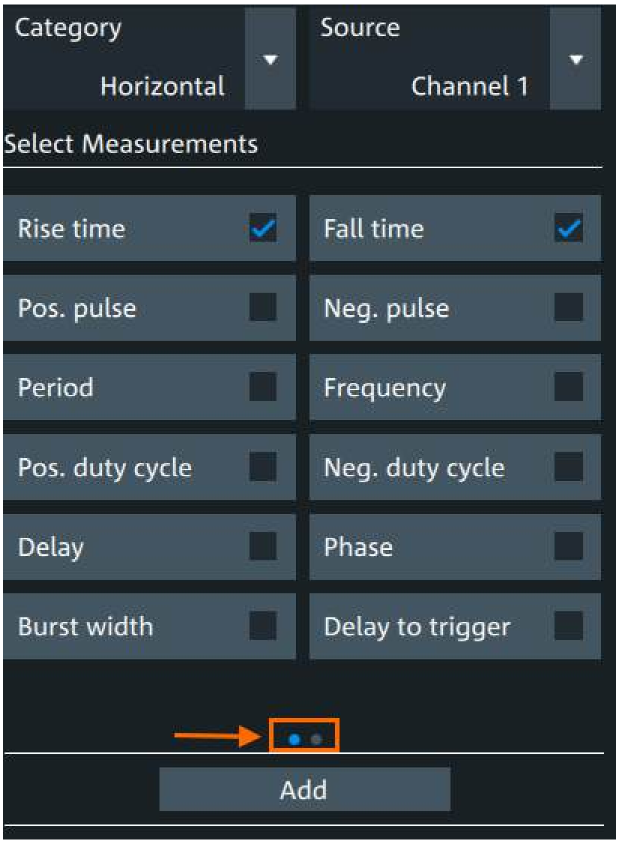
1. Press the [Measure] key to open the measurement dialog.
2. In the "Setup" tab, press "+ Add".

   A dialog opens to select the measurements.
3. Select the "Source" for the measurement.
4. Select the "Category" of the measurement that you want to add, e.g. "Horizontal".

   All available measurements for this category are displayed. For more details on the available measurement types, see Section 10.2.4.1, "Overview of amplitude/time measurements", on page 273.
5. Tap on a measurement from the list to enable it.
   Selected measurements are marked with a blue check mark in their checkbox.

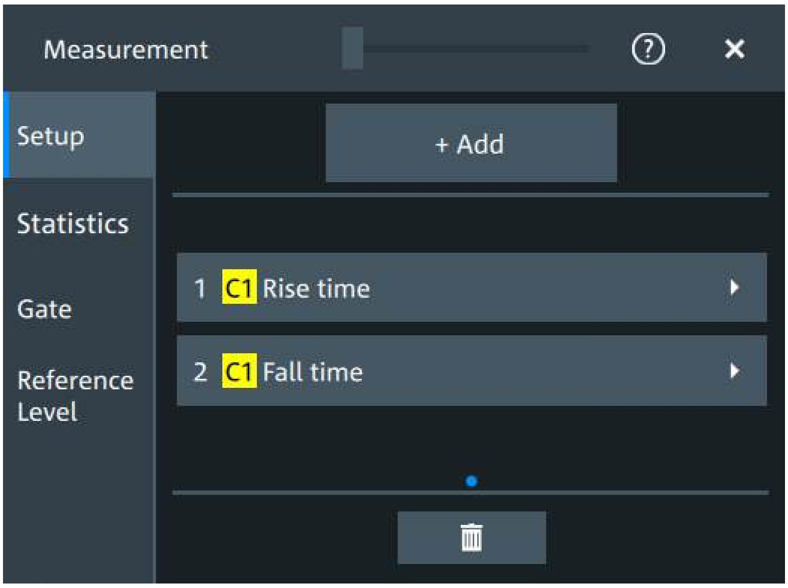
   

6. The measurements of some categories are listed on several tabs. To switch between the tabs, press the points at the bottom of the list.



7. Tap "+ Add" to add the selected measurements.

   All selected measurements are enabled.

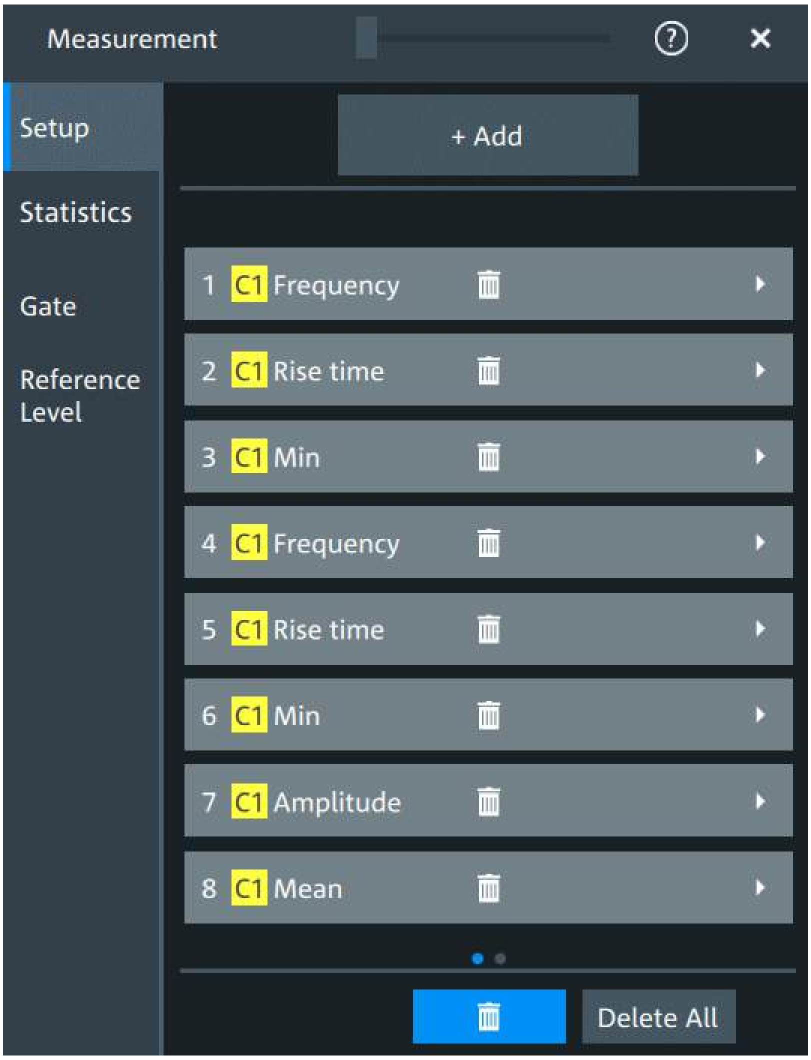


To delete a measurement

1. Press the [Measure] key to open the measurement dialog.

2. In the "Setup" tab, tap 🗑.

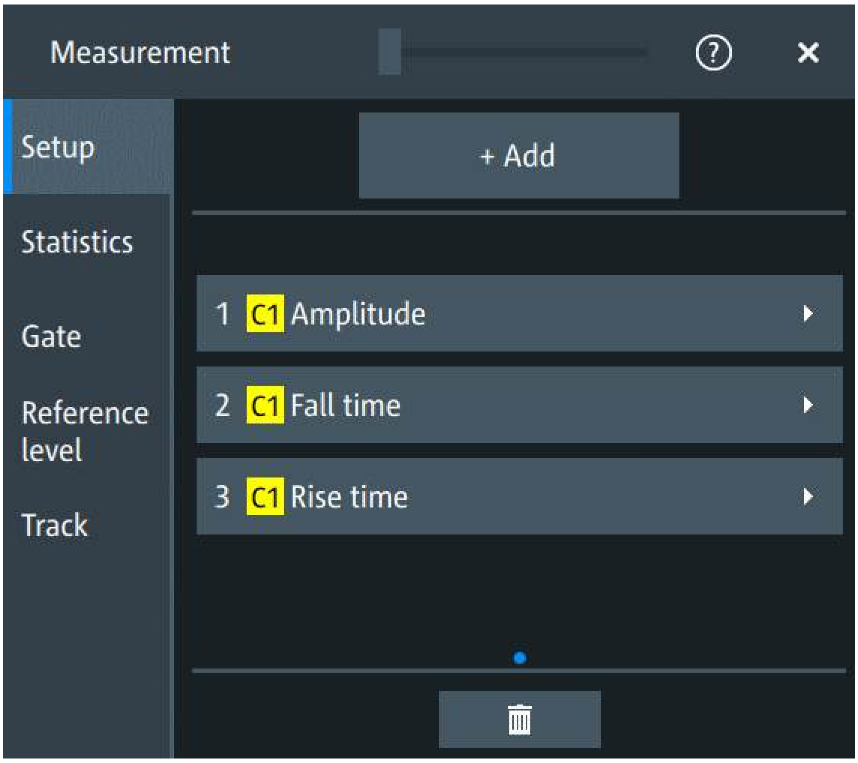
   A delete icon appears in the selection button of each measurement.



3. Tap the button of the measurement that you want to delete. Alternatively, tap "Delete All" to delete all measurements.

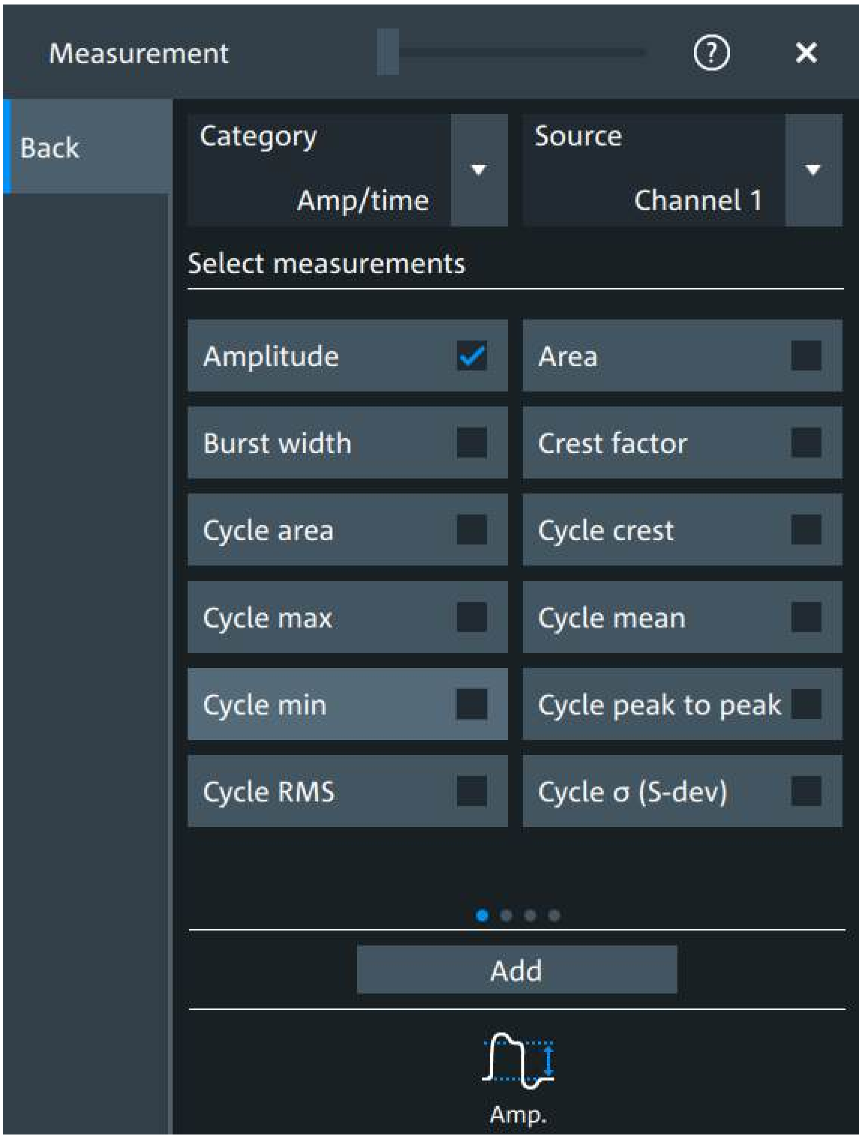
10.2.1.2 Setup tab

Access: "Menu" > "Measurement" > "Setup" tab.



+ Add

Opens a dialog to select the measurements.



Category ← + Add
Selects the measurement category. Some measurements are listed in more than one category.

For an overview of the available categories and measurements, see Section 10.2.4.1, "Overview of amplitude/time measurements", on page 273.

Source ← + Add
Sets the source of the measurement.

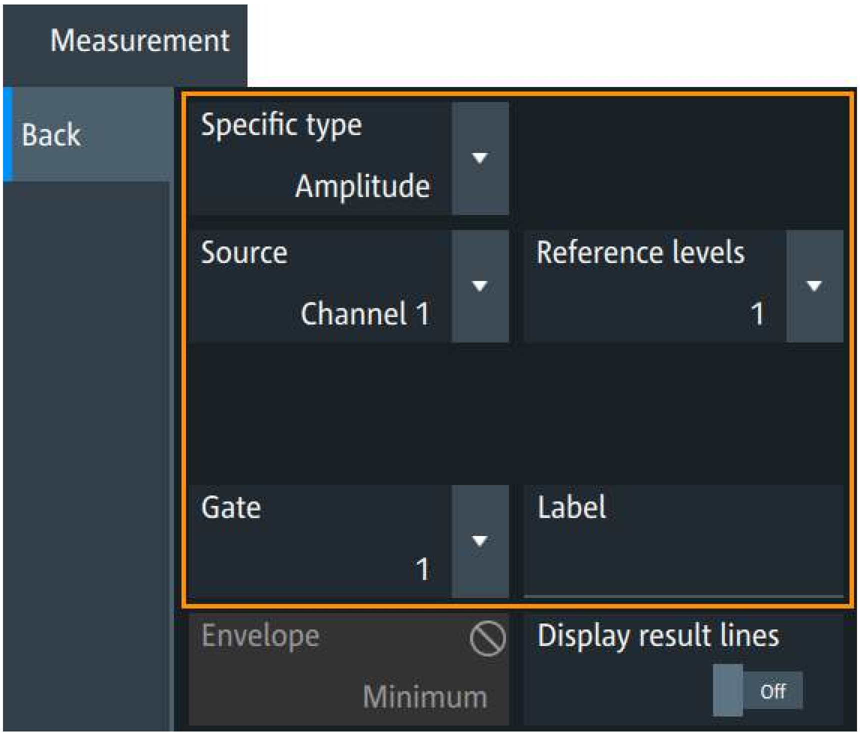
Remote command:
`MEASurement<mg>:SOURce` on page 1004

Delete icon
Enables the removal of measurements. You can delete a single measurement by tapping on the "Delete" icon next to it.

You can also delete all current measurements with "Delete All".

10.2.1.3 Common settings of measurement types

When you select an added measurement in the "Setup" tab, a dialog with more setting opens. Some of these settings are common for many or all measurement types, independent of their category, others are specific for the selected measurement type. This section describes the common settings.



Specific type
Selects the type of measurement that you want to define the settings for. The list provides all measurement types of the same category.

Remote command:
`MEASurement<mg>:MAIN` on page 1005

Source
Sets the source of the measurement.

In setup/hold measurements, this source is the "Data source".

Remote command:
`MEASurement<mg>:SOURce` on page 1004

Reference levels
Selects the set of reference levels that is used for the measurement and for the first measurement source. Each source of the measurement can have its own reference level set. For most measurements, one source is needed. For delay measurements, for example, two measurement sources are required, and each source can have its own reference levels.

Only the numbers of defined reference level sets are listed. Define the reference level set before you select it, see Section 8.1, "Reference level setup", on page 207.

Remote command:
`MEASurement<mg>:REFLevel<rl>:REFerence` on page 1009

Gate
Assigns a gate to the selected measurement to limit the measurement range. Define a gate before you select it, see Section 8.2, "Gate setup", on page 209.

Alternativley, you can assign the gates to measurements in the "Gate" tab, see Section 10.2.3, "Gate settings for measurements", on page 272.

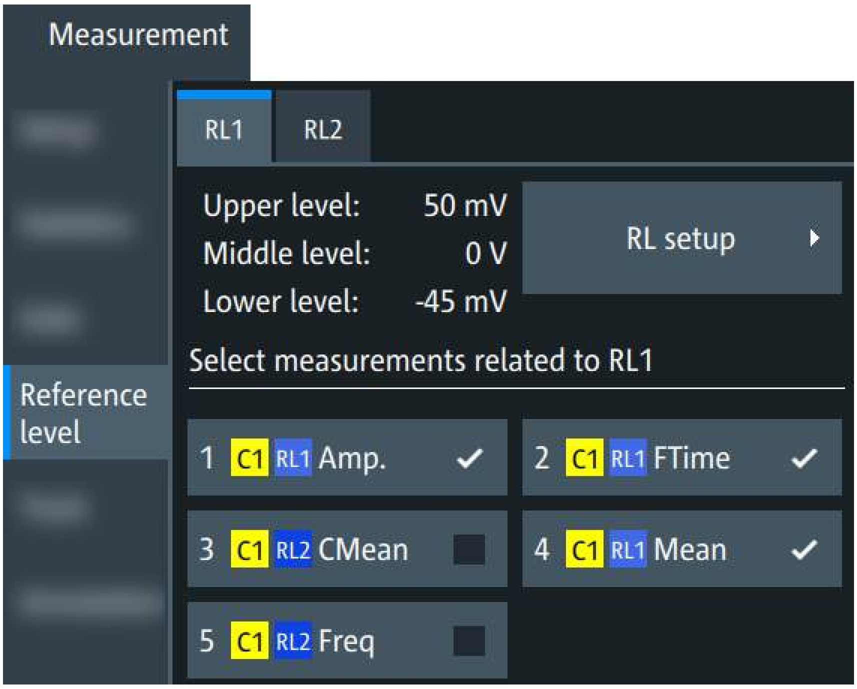
Remote command:
`MEASurement<mg>:GATE` on page 1009

Label
Adds a user-defined label to the measurement.

10.2.2 Reference levels for measurements

Access: "Menu" > "Measurement" > "Reference level" tab

Measurements require reference levels to obtain the measurement points, e.g. time measurements or pulse count. The dialog shows the definition of the selected reference level set and all active measurements. If no reference level set has been defined before, or the correct definition is missing, select "RL setup" and configure the the reference level set before you assign it. See Section 8.1, "Reference level setup", on page 207 for details.



1. Select the RL subtab, e.g. "RL1".
2. Select the measurements that use the selected reference level set.

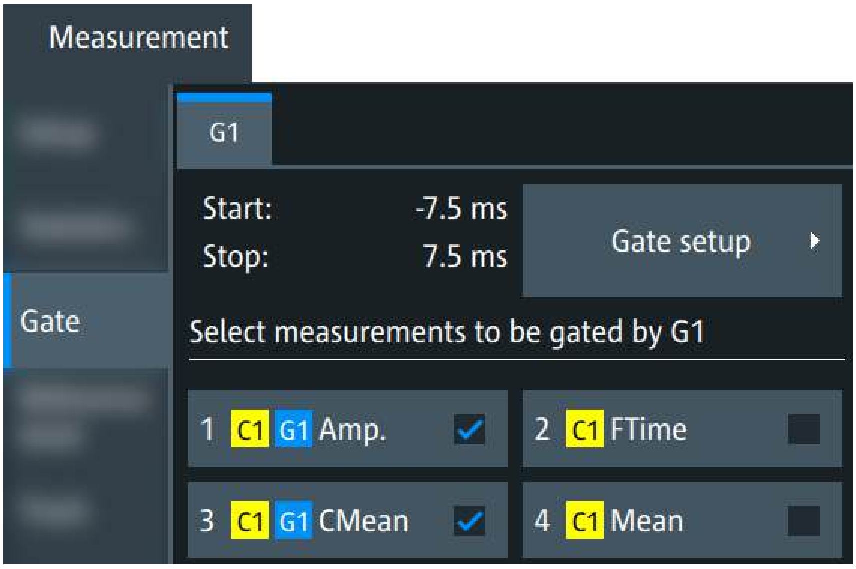
Remote command: `MEASurement<mg>:REFLevel<rl>:REFerence` on page 1009

10.2.3 Gate settings for measurements

Access: "Menu" > "Measurement" > "Gate" tab.

You can limit the measurements to a user-defined range of the waveform. The dialog shows the limits of the selected gate and all active measurements. If no gate has been defined before, or the correct gate is missing, select "Gate setup" and configure the gate before you assign it. See Section 8.2, "Gate setup", on page 209 for details.

1. Select the gate subtab, e.g. "G1".
2. Select the measurements to be limited by the selected gate.



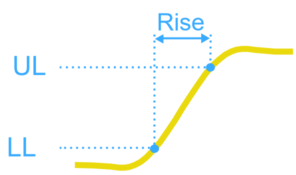
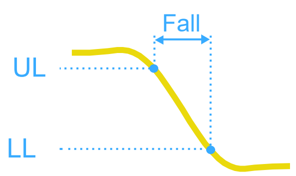
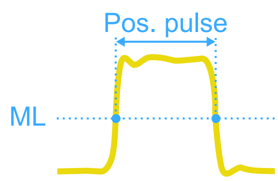
Remote command: `MEASurement<mg>:GATE` on page 1009.

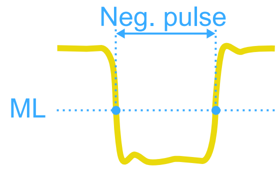
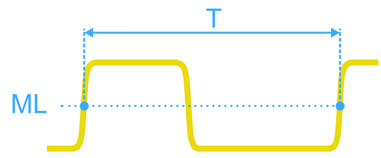
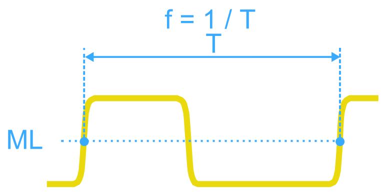
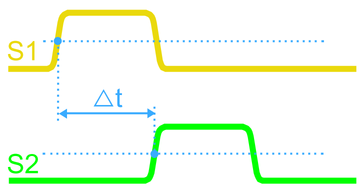
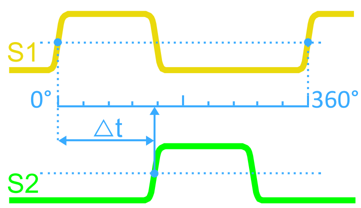
10.2.4 Amplitude/time measurements

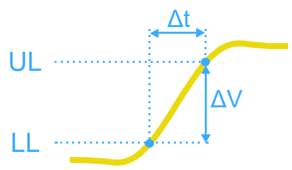
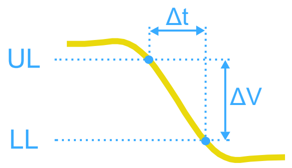
10.2.4.1 Overview of amplitude/time measurements

The MXO 4 provides many measurement types in the "Amp/time" category to measure time, amplitude and area characteristics, and to count pulses and edges.

Horizontal measurements (time)

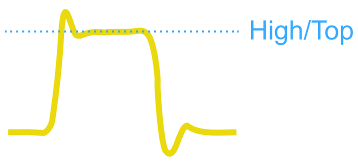
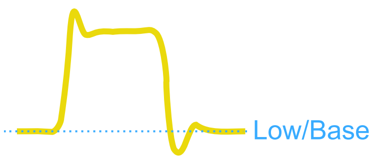
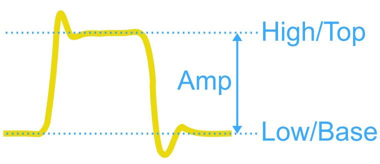
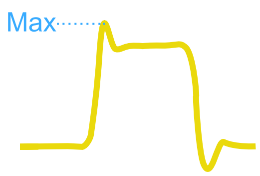
Meas. type	Label	Description	Formula, graphic
Rise Time	RTime	Rise time of the first rising edge, the time it takes the signal to rise from the lower reference level to the upper reference level. Measurement of all events in the acquisition is possible.	
Fall Time	FTime	Fall time of the first falling edge, the time it takes the signal to fall from the upper reference level to the lower reference level. Measurement of all events in the acquisition is possible.	
Pos. pulse	PPuls	Duration of the first positive pulse: time between a rising edge and the following falling edge measured on the middle reference level. Measurement of all events in the acquisition is possible.	

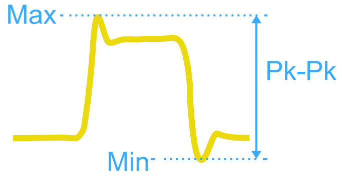
Meas. type	Label	Description	Formula, graphic
Neg. pulse	NPuls	Duration of the first negative pulse: time between a falling edge and the following rising edge measured on the middle reference level. Measurement of all events in the acquisition is possible.	
Period	T	Time between the first two consecutive waveform edges of the same direction, measured on the middle reference level. The measurement requires at least one complete period of a triggered signal. Measurement of all events in the acquisition is possible.	
Frequency	Freq	Frequency of the signal, reciprocal value of the measured period.	
Delay	Delay	Time difference between two slopes of the same or different waveforms, measured on the middle reference level. A negative result indicates that the slope of the second source comes before the slope of the first source.	
Phase	Phs in °	Phase difference between two waveforms, measured on the middle reference level. *Phase = Delay / Period * 360*	
Burst width	Bst	Duration of one burst, measured on the middle reference level from the first edge to the last edge.	
Setup Hold Setup/Hold time	Setup Hold SHT	Setup and Hold time measurements with positive and/or negative clock edge, measured on the middle reference level. See "Setup/Hold time measurement" on page 279.	
Setup/Hold ratio	SHR	Setup/Hold ratio measurement with positive and/or negative clock edge.	*SHR = Setup / (Setup + Hold)*
Delay to trigger	DTO	Time between the trigger point and the next signal slope, measured on the middle reference level. Slope direction can be selected. If the edge is to the left of the trigger (before trigger), the result is negative.	

Meas. type	Label	Description	Formula, graphic
Slew rate rising	SRRise in V/s = V*Hz	Steepness of the rising edge: voltage difference between the lower and higher reference level, divided by the rise time.	*SRRise = ΔV / Δt* 
Slew rate falling	SRFall in V/s = V*Hz	Steepness of the falling edge: voltage difference between the higher and lower reference level, divided by the fall time.	*SRFall = ΔV / Δt* 
Pos. duty cycle	PDCyc	Width of the first positive pulse in relation to the period in %.	$PDCyc = \frac{T_{PosPulse}}{T_{Period}} \times 100\%$
Neg. duty cycle	NDCyc	Width of the first negative pulse in relation to the period in %.	$PDCyc = \frac{T_{NegPulse}}{T_{Period}} \times 100\%$

Vertical measurements (amplitude)

The unit of most amplitude measurement results depends on the measured source.

Meas. type	Label	Description	Formula, graphic
High	High	High level of the displayed waveform - the upper maximum of the sample distribution, or the mean value of the high level of a square wave without overshoot. The measurement requires at least one complete period of the signal. Also known as top level.	
Low	Low	Low level of the displayed waveform - the lower maximum of the sample distribution, or the mean value of the low level of a square wave without overshoot. The measurement requires at least one complete period of the signal. Also known as base level.	
Amplitude	Amp	Difference between the high level and the low level of the signal. The measurement requires at least one complete period of the signal.	
Max	Max	Maximum value within the displayed waveform.	

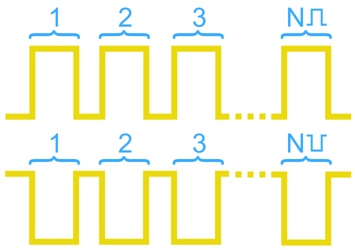
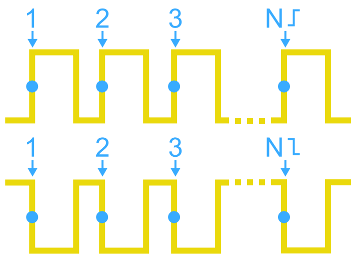
Meas. type	Label	Description	Formula, graphic
Min	Min	Minimum value within the displayed waveform.	
Peak to peak	PTP	Difference of maximum and minimum values.	
Mean	Mean	Arithmetic average of the complete displayed wave-form.	$Mean = \frac{1}{N}\sum_{k=1}^{N} x^k$
RMS	RMS	RMS (root mean square) value of the voltage of the complete displayed waveform.	$RMS = \sqrt{\frac{1}{N}\sum_{k=1}^{N} {x_k}^2}$
σ (S-dev/AC-RMS)	σ	Standard deviation of one cycle, usually of the first, left-most signal period.	$\sigma = \sqrt{\frac{1}{N-1}\sum_{k=1}^{N}(x_k - Mean)^2}$
Crest factor	Crest	The crest factor is also known as the peak-to-aver-age ratio. It is the maximum value divided by the RMS value of the displayed waveform.	$Crest = \frac{Max\,\lvert x_k\rvert}{RMS}$
Pos. Overshoot	P.OS	Overshoot of a square wave after a rising edge. It is calculated from measurement values High, local Max and Amplitude.	$OSpos = \frac{Max_{local} - High}{Amplitude} \times 100\%$
Neg. Overshoot	N.OS	Overshoot of a square wave after a falling edge. It is calculated from measurement values Low, local Min and Amplitude.	$OSneg = \frac{Low - Min_{local}}{Amplitude} \times 100\%$
Cycle mean	CMean	Mean value of one cycle	
Cycle RMS	CRMS	RMS (root mean square) value of one cycle	
Cycle σ(S-dev)	Cycσ	Standard deviation of one cycle	
Cycle max	CMax	Maximum value of one cycle	
Cycle min	CMin	Minimum value of one cycle	
Cycle peak to peak	CPTP	Peak-to-peak value of one cycle: the difference of CMax and CMin	
Cycle crest	CCrest	Crest factor of one cycle	

Area and cycle measurements

All cycle measurements require that at least one complete period of the signal is acquired. Cycle measurements can be found in the "Amp/time" category.

Meas. type	Label	Description/result	
Area	Area	Area between the waveform and ground. T_{Eval}: evaluation time, time of a full waveform or limited by a gate	$Area = \frac{T_{Eval}}{N_{Eval}} \times \sum_{k=1}^{N_{Eval}} x(k)$
Cycle area	CArea	Area between the waveform and ground, measured for one period, see also "Area" measurement.	
Cycle Amp	CAmp	Amplitude of one cycle	

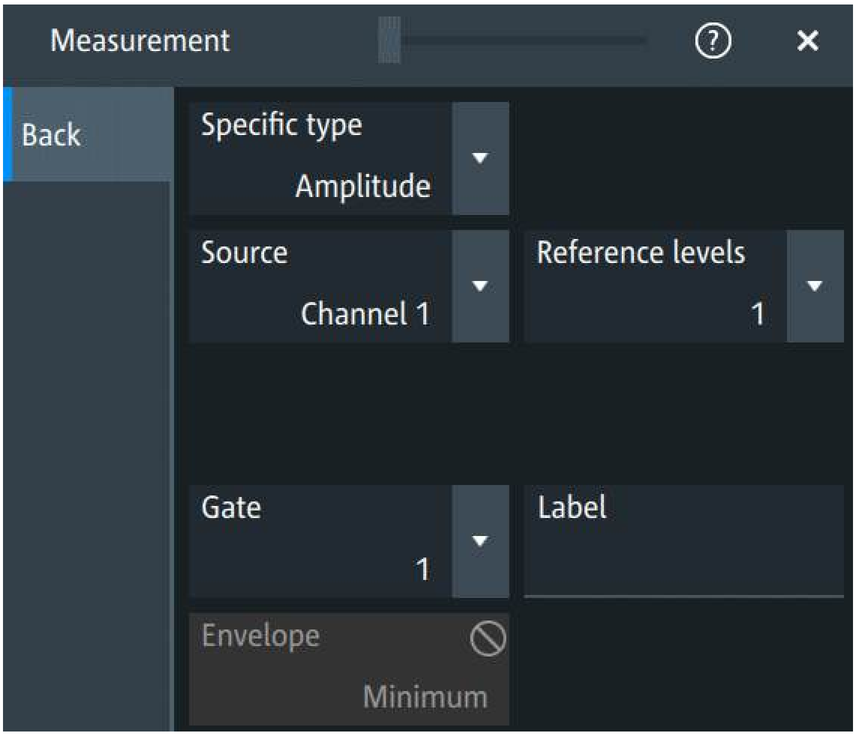
Counting

Meas. type	Label	Description/result	
Pulse count	PCount	The number of positive or negative pulses of the waveform, or of both positive and negative pulses. The mean value of the signal is determined. If the signal passes the mean value, an edge is counted. A positive pulse is counted if a rising edge and a following falling edge are detected. A negative pulse is counted if a falling edge and a following rising edge are detected.	
Edge count	EdCo	The number of positive or negative edges, or of both positive and negative edges. The mean value of the signal is determined, and an edge is counted every time the signal passes the mean value.	

10.2.4.2 Settings for amplitude/time measurements

You can define additional parameters for some measurements.

Access: "Menu" > "Measurement" > "Setup" tab > add measurement > select measurement.



For a description of common measurement settings, see:

- "Specific type" on page 270
- "Source" on page 270
- "Reference levels" on page 271
- "Gate" on page 271
- "Label" on page 271

Envelope

This setting is only available for measurements on envelope waveforms, see Acquisition mode.

"Both" The upper and the lower envelope are used in measurements. For time measurements, the averages of min and max values are used, that is, the measurement is performed on the average waveform built from the upper and lower envelope.

"Maximum" Measurements are performed on the upper envelope.

"Minimum" Measurements are performed on the lower envelope.

Remote command:
`MEASurement<mg>:ENVSelect` on page 1006

Display result lines

Enables the measurement annotations for the selected measurement. These annotations are, for example, periods, maximum and minimum values, relevant reference levels, and more.

See also: Section 10.2.7, "Annotation for measurements", on page 291.

Remote command:
MEASurement<mg>:DISPlay:RESults on page 1005

Pulse count
Available, if "Specific type" is set to "Pulse train".

Sets the number N of positive pulses for the "Pulse train" measurement. This measurement measures the duration of N positive pulses from the rising edge of the first pulse to the falling edge of the N-th pulse.

Remote command:
MEASurement<mg>:AMPTime:PTCount on page 1007

Pulse slope
Available, if "Specific type" is set to "Pulse count".

Sets the first slope of the pulses to be counted.

"Positive"	Positive pulses are counted.
"Negative"	Negative pulses are counted.
"Either"	Both positive and negative pulses are counted.

Remote command:
MEASurement<mg>:AMPTime:PSLope on page 1008

Edges slope
Available, if "Specific type" is set to "Edge count", "Phase", or "Delay to trigger".

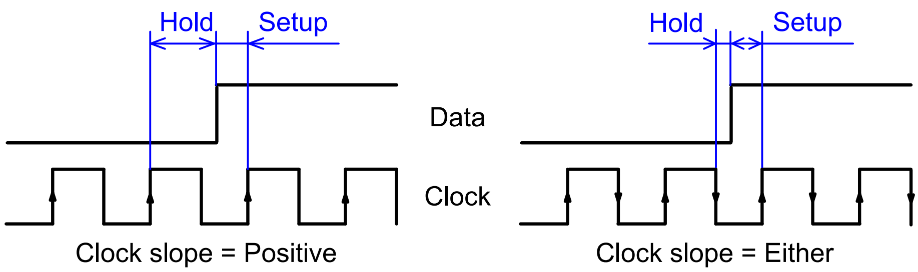
Sets the edge direction to be used for the selected measurement: positive, negative, or either edge.

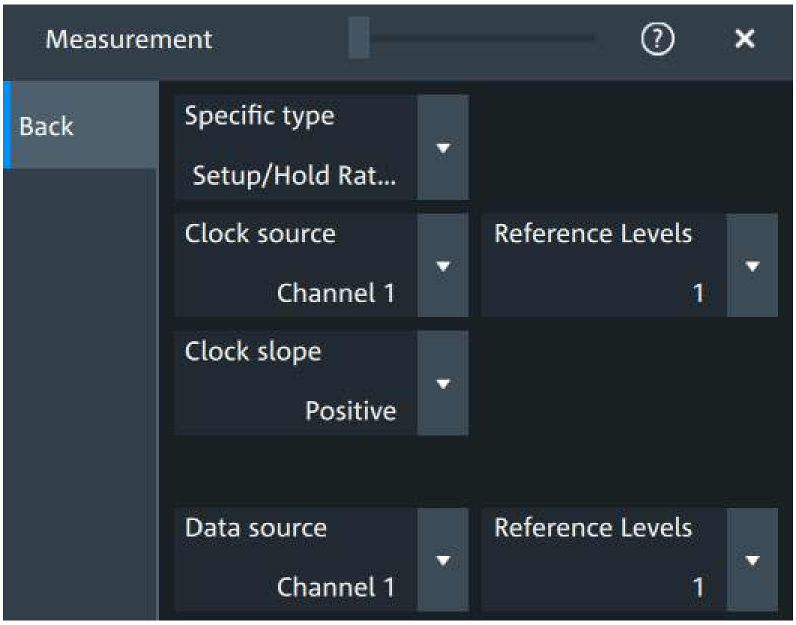
Remote command:
MEASurement<mg>:AMPTime:ESLope on page 1007
MEASurement<mg>:AMPTime:DELay<n>:SLOPe on page 1009

Setup/Hold time measurement
Setup/Hold measurements analyze the relative timing between two signals: a data signal and the synchronous clock signal. Setup time is the time that the data signal is steady before the clock edge - the time between a data transition and the next specified clock edge. Hold time is the time that the data signal is steady after the clock edge - the time between a data transition and the previous specified clock edge.

"Setup/Hold time" measures and displays the setup and hold durations. "Setup/Hold ratio" measurements return the ratio of the setup time to the sum of hold and setup time: $T_{Setup} / (T_{Setup} + T_{Hold})$.

The clock edge can be defined, the polarity of the data signal does not matter.





Source 2, Clock source ← Setup/Hold time measurement
Sets the waveform used as the clock for the setup/hold measurement, or the second source waveform for delay and phase measurements.

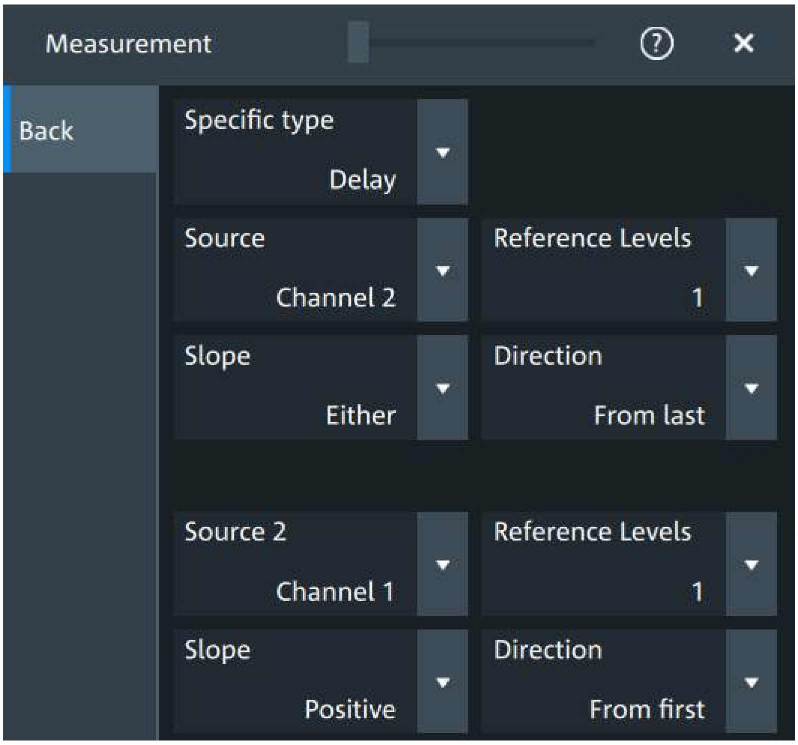
Remote command:
`MEASurement<mg>:SSRC` on page 1005

Clock slope ← Setup/Hold time measurement
Sets the edge of the clock from which the setup and hold times are measured: positive, negative, or either of them. If "Either" is selected, the clock edges next to the data edge are considered regardless of the clock slope.

Remote command:
`MEASurement<mg>:AMPTime:CSLope` on page 1007

Data source ← Setup/Hold time measurement
Sets the source for the data signal. See also: "Source" on page 270.

Delay measurement
The specific settings for delay measurement allow you to measure the time between any two slopes at any reference level. Therefore, the reference levels and the slopes must be defined for each source individually. The measurement result is negative if the edge of the second source comes before the edge of the first source.

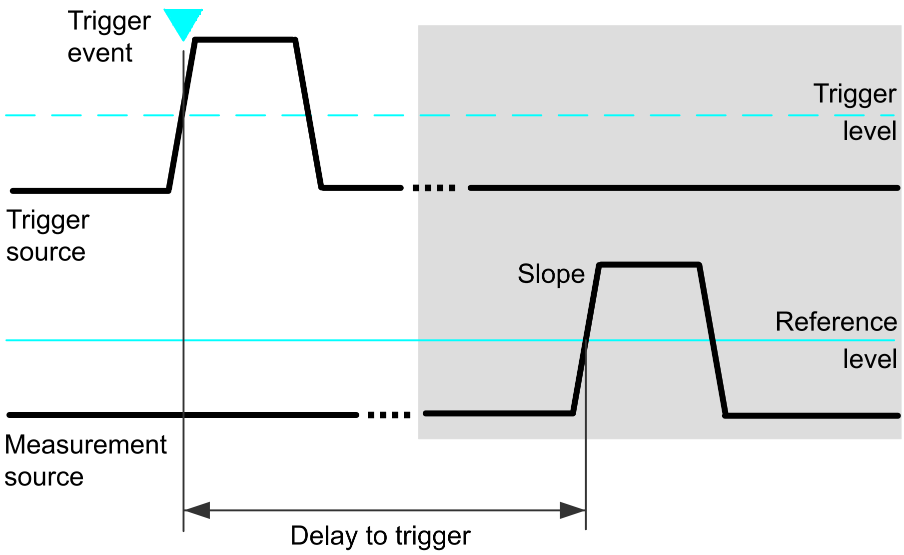


Slope ← Delay measurement
See "Edges slope" on page 279.

Direction ← Delay measurement
Selects the direction for counting slopes for each source: from the beginning of the waveform, or from the end.

Remote command:
`MEASurement<mg>:AMPTime:DELay<n>:DIRection` on page 1008

Delay to trigger measurement settings
Delay to trigger measures the time between the trigger point and the following slope of a waveform. The delay between the trigger and the slope can be high compared to the accuracy of the acquisition, and the trigger point can even be outside of the current acquisition.



To configure the trigger conditions, use the trigger setup.

"Edges slope" Sets the edge direction to be used for delay measurement: positive, negative, or either edge.

Remote command:
`MEASurement<mg>:AMPTime:DTOTrigger<n>:SLOPe` on page 1008

Unit (slew rate measurements)
Sets the denominator of the unit for slew rate measurements.

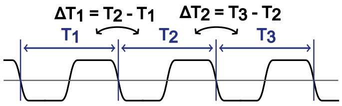
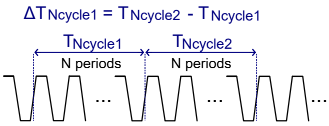
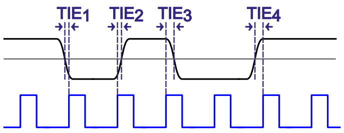
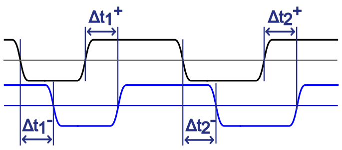
10.2.5 Basic jitter analysis (option R&S MXO4-K12)

10.2.5.1 Overview of basic jitter measurements

The specific measurements for basic jitter analysis are provided in the "Jitter" category.

Table 10-1: Jitter measurements

Meas. type	Label	Description	Formula, graphic
Cycle-cycle duty cycle	CCDCyc	Difference between the duty cycle of two adjacent cycles. The measurement is based on the duty cycle measurement. You can select the pulse polarity for the duty cycle measurement.	$\Delta R_{Cyc\ k} = R_{Cyc\ k+1} - R_{Cyc\ k}$ for $k = 1,...,K-1$
Cycle-cycle width	CCWid	Difference between the pulse width of two adjacent cycles. The measurement is based on the pulse width measurement. You can select the pulse polarity to be measured.	$\Delta T_{Pulse\ k} = T_{Pulse\ k+1} - T_{Pulse\ k}$ for $k = 1,...,K-1$

Meas. type	Label	Description	Formula, graphic
Cycle-cycle jitter	CCJit	Difference between the periods of two adjacent cycles. The measurement is based on the period measurement. You can select the slope and the reference level on which the period is measured.	$\Delta T_{Period\ k} = T_{Period\ k+1} - T_{Period\ k}$ for $k = 1,...,K-1$ 
N-cycle jitter	NCJit	Difference between the time of two adjacent groups of N cycles (periods) each. You can select the slope and the reference level on which the time is measured, and the number of periods in the groups.	$\Delta T_{Ncycle\ k} = T_{Ncycle\ k+1} - T_{Ncycle\ k}$ for k = *cycle group index* 
Time interval error	TIE	Time difference between the slope of the input signal and the slope of a reference signal. The reference signal can be a captured clock waveform, or a clock generated by clock data recovery (CDR, software algorithm or hardware generation). You can select the slope and the reference level on which the TIE is measured.	$TIE_k = t_{Signal\ k} - t_{Clock\ k}$ for $k = 1,...,K$ 
Unit interval	UI	Period of the clock signal. If no clock signal is available, it is recovered by CDR. The period is calculated as the time difference between two consecutive clock edges of the same polarity.	$UI_k = t_{Clock\ k+1} - t_{Clock\ k}$ for $k = 1,...,K-1$
Data rate	DR	Frequency of the clock signal. If no clock signal is available, it is recovered by CDR. The measurement is based on the unit interval measurement.	$R_{Clock\ k} = 1 / UI_k$ for $k = 1,...,K-1$
Skew delay	SkwD	Delay between the edges of two interdependent waveforms. The measurement is a simplified variant of the "Delay" measurement assuming that both sources are similar except for the delay.	*Skew delay* $= \Delta t_k = t_{Source2} - t_{Source1}$ for $k = 1,...,K$ 
Skew phase	SkwP	Phase difference between the edges of two waveforms.	*Skew phase = Skew delay / Period * 360°* $= \Delta t_k / \Delta T_{Period\ k}$ ** 360°*

10.2.5.2 Settings for jitter measurements

For a description of common measurement settings, see:

- "Specific type" on page 270
- "Source" on page 270
- "Reference levels" on page 271
- "Gate" on page 271
- "Label" on page 271

Settings for cycle-cycle measurement

The cycle-cycle measurements are used to analyze the quality of clock signals. They require a few additional settings for period and pulse width measurement.

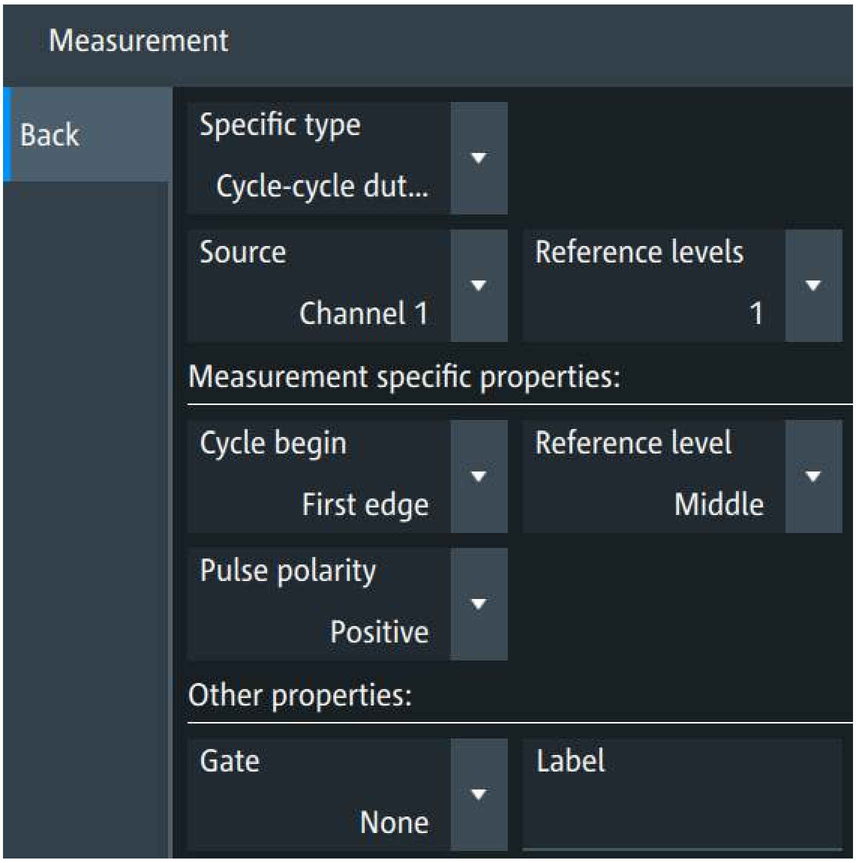


Figure 10-1: Setup for cycle-cycle duty cycle measurement

Cycle begin, Slope

For cycle-cycle jitter, N-cycle jitter, and cycle-cycle duty cycle measurements, "Cycle begin" selects the slope at which the periods and thus the jitter is measured: first edge, positive, negative or either.

For time-interval error measurements, "Slope" sets the edges of the data signal that are used for measurements: positive, negative or either.

"First edge"	Measures the period from the first edge that is found, no matter of its direction.
"Positive"	Measures the period at positive going edges.
"Negative"	Measures the period at negative going edges.
"Either"	Measures the period at both positive and negative going edges. This option is useful, for example, to check the clock stability of a double data rate clock.

Remote command:
`MEASurement<mg>:JITTer:SLOPe` on page 1012

Pulse polarity

For cycle-cycle width and the cycle-cycle duty cycle measurements, "Pulse polarity" sets the polarity of pulses for which the pulse width is measured: positive or negative.

For skew delay and skew phase measurements, "Edge polarity" sets the edge of the first waveform from which the measurements starts: positive, negative or either.

Remote command:
`MEASurement<mg>:JITTer:POLarity` on page 1011

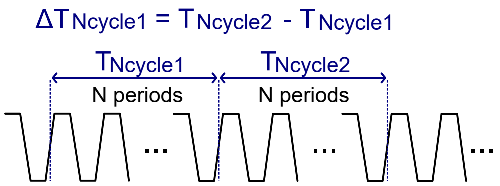
Reference level

Selects the reference level that is used for time measurements.

Remote command:
`MEASurement<mg>:JITTer:REFLevel<rl>` on page 1011

Number of cycles

Sets the number of periods (cycles) that are accumulated to measure the N-cycle jitter.



Remote command:
`MEASurement<mg>:JITTer:NCYCles` on page 1010

Settings for delay measurements

Skew delay and skew phase measurements are intended to measure the time difference between the edges of two waveforms. The measurements are simplified variants of the "Delay" and "Phase" measurements assuming that both sources are similar except for the delay.

Source 1, Source 2

"Source 1" is the reference signal, and "Source 2" is the signal compared to the reference signal.

$Skew\ delay = \Delta t_k = t_{Source2} - t_{Source1}$ for $k = 1,...,K$

See also: "Clock slope" on page 280.

Remote command:
`MEASurement<mg>:SOURce` on page 1004

Edge polarity

See "Pulse polarity" on page 285.

Relative polarity

Sets the edge of the second waveform relative to the first waveform.

"Matching" Measures from positive to positive edge or from negative to negative edge.

"Inverse" Measures from positive to negative edge or from negative to positive edge.

Remote command:
`MEASurement<mg>:JITTer:RELPolarity` on page 1012

Reference level
Selects the reference level that is used for time measurements on "Source 2".

Remote command:
`MEASurement<mg>:JITTer:REFLevel<rl>` on page 1011

Settings for data measurements

The following measurements are intended to analyze serial data:

- Time interval error
- Unit interval
- Data rate

The clock can be a captured clock signal, or it can be recovered from the data signal. The clock or CDR is configured in the "Timing reference" dialog, see Section 8.3, "Timing reference", on page 211.

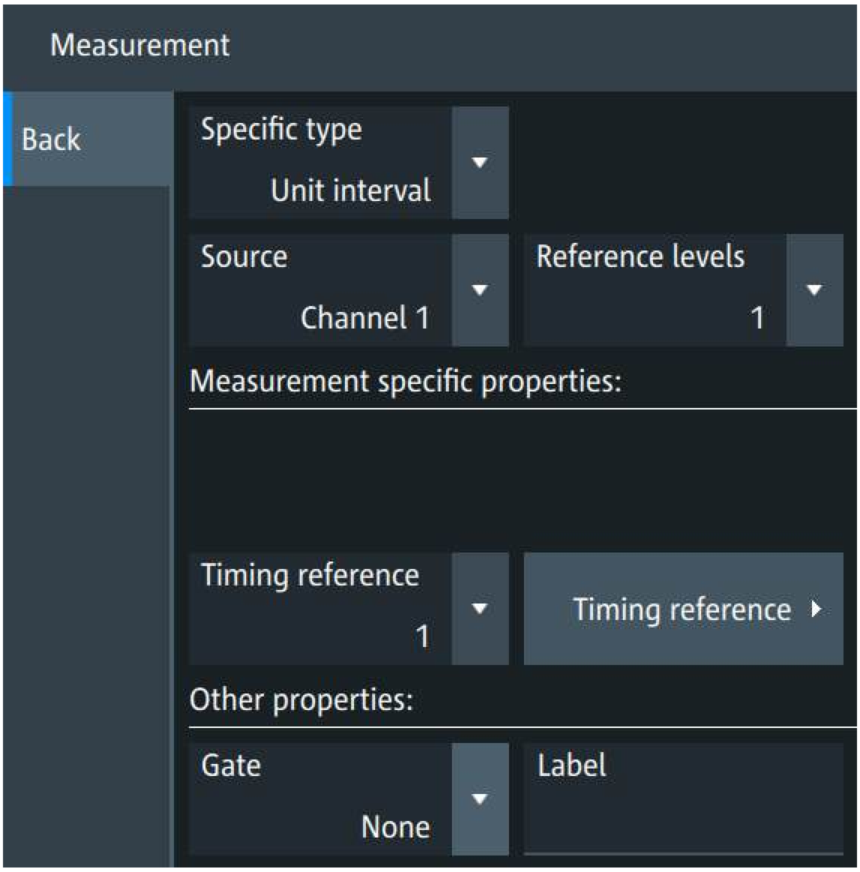


Figure 10-2: Setup for unit interval measurement

Slope

Sets the edges of the data signal that are used for measurements. The setting is relevant for time-interval error measurements.

See also: "Cycle begin, Slope" on page 284.

Timing reference

Selects the timing reference, which is one of the available clock configurations.

For configuration of the timing reference, see Section 8.3, "Timing reference", on page 211.

Remote command:

`MEASurement<mg>:JITTer:TREF` on page 1013

Unit

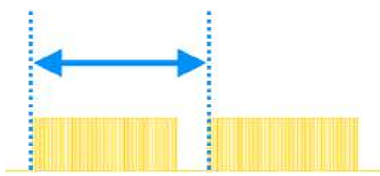
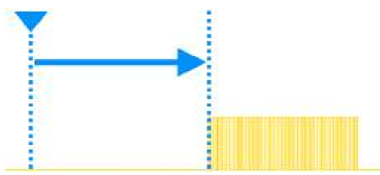
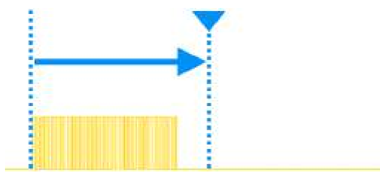
Sets the unit to bps (bit per second), or to Hz for analysis of radar signals. The setting is available for data rate measurements.

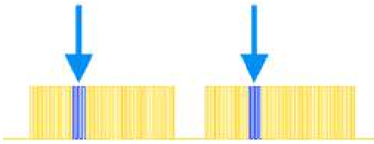
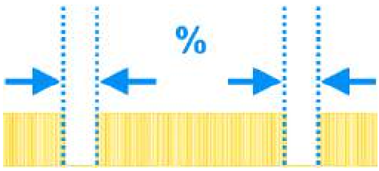
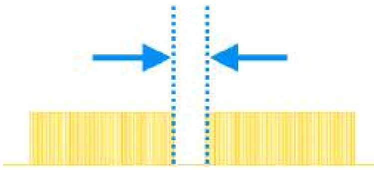
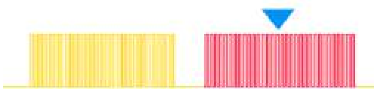
Remote command:

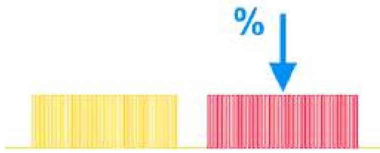
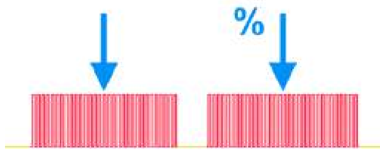
`MEASurement<mg>:JITTer:UNIT` on page 1013

10.2.6 Protocol measurements (option R&S MXO4-K500)

10.2.6.1 Overview of protocol measurements

Meas. type	Label	Description/result	
Frame/frame	F2F	The time from the start of one frame to the start of the next frame.	
Trig/frame	T2F	The time from a trigger event to the start of the next frame.	
Frame/trig	F2T	The time from the start of a frame to the next trigger event.	

Meas. type	Label	Description/result	
Field value	FVal	The value of a selected field in a frame.	
Main bit rate	BPS	The nominal bits per second (bps) in a selected frame. The measurement ignores, for example, gaps in a LIN frame or a bus park bit in an RFFE or SPMI frame.	
2nd bit rate	BPS2	Like main bit rate, but optional for protocols with multiple bit rates, e.g. CAN/CAN-XL, SPMI or RFFE write / read.	
Bus idle	Idle	Percentage of idle times between all frames in an acquisition.	
Gap	Gap	The gap time (not necessarily idle) between two frames.	
Frame count	FCnt	The number of complete frames in an acquisition.	
Frame errors	FECnt	The number of erroneous frames in an acquisition.	

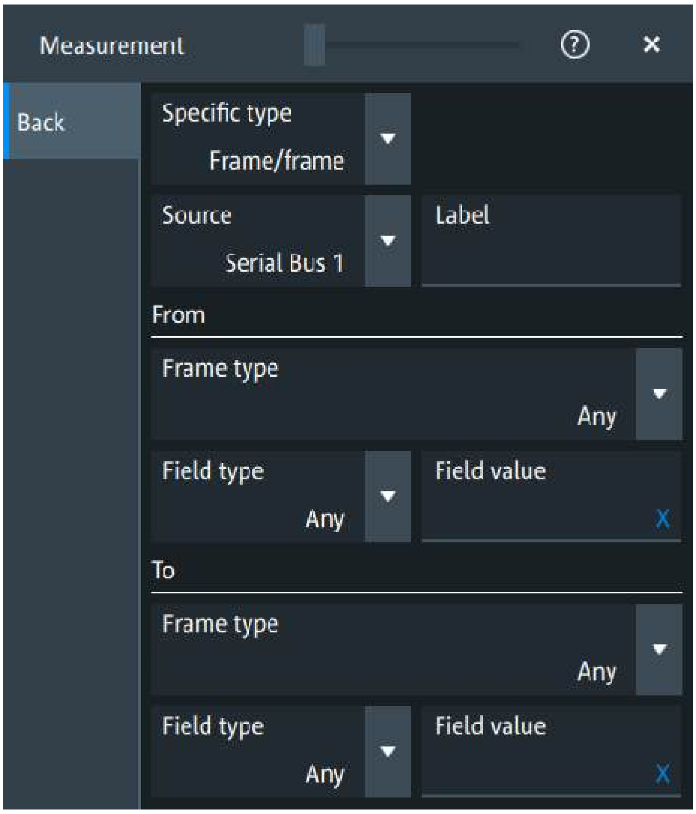
Meas. type	Label	Description/result	
FER	FER	The frame error rate, hence the percentage of erroneous frames in an acquisition.	
Cons FER	CFER	The frame error rate (percentage) of two or more consecutive erroneous frames.	

10.2.6.2 Settings for protocol measurements

You can define additional parameters for some protocol measurements.

Access: "Menu" > "Measurement" > "Setup" tab > add measurement > category "Protocol" > select measurement.

Available only, if "Source" = "Serial Bus N".



For a description of common measurement settings, see:
- "Specific type" on page 270
- "Source" on page 270

- "Label" on page 271

Frame Identification or From
"Frame Identification" is available only for the measurement types "Frame/trig", "Trig/frame" and "Field value". "Frame Identification" specifies where the measurement is executed.

"From" is available only for the measurement type "Frame/frame", which requires a "From" - "To" condition. "From" specifies where the measurement starts.

All other measurement types do not require these settings.

Frame Type ← Frame Identification or From
In a "Frame Identification", this setting specifies the type of the frame at which the measurement is executed.

In a "From" - "To" condition, this setting specifies the type of the frame at which the measurement starts.

Remote command:
`MEASurement<mg>:PROTocol:FNAMe` on page 1013

Field Type ← Frame Identification or From
In a "Frame Identification", this setting specifies the type of the field at which the measurement is executed.

In a "From" - "To" condition, this setting specifies the type of the field at which the measurement starts.

Remote command:
`MEASurement<mg>:PROTocol:FDName` on page 1014

Field Value ← Frame Identification or From
In a "Frame Identification", this setting specifies the value of the field at which the measurement is executed.

In a "From" - "To" condition, this setting specifies the value of the field at which the measurement starts.

Remote command:
`MEASurement<mg>:PROTocol:FDValue` on page 1014

To
"To" is available only for the measurement type "Frame/frame", which requires a "From" - "To" condition. "To" specifies where the measurement ends.

Frame Type ← To
Specifies the type of the frame at which the "Frame/frame" measurement ends.

Remote command:
`MEASurement<mg>:PROTocol:F2Name` on page 1014

Field Type ← To
Specifies the type of the field at which the "Frame/frame" measurement ends.

Remote command:
`MEASurement<mg>:PROTocol:FD2Name` on page 1015 (used also for Tracked)

Field Value ← To
Specifies the value of the field at which the "Frame/frame" measurement ends.

Remote command:
`MEASurement<mg>:PROTocol:FD2Value` on page 1015

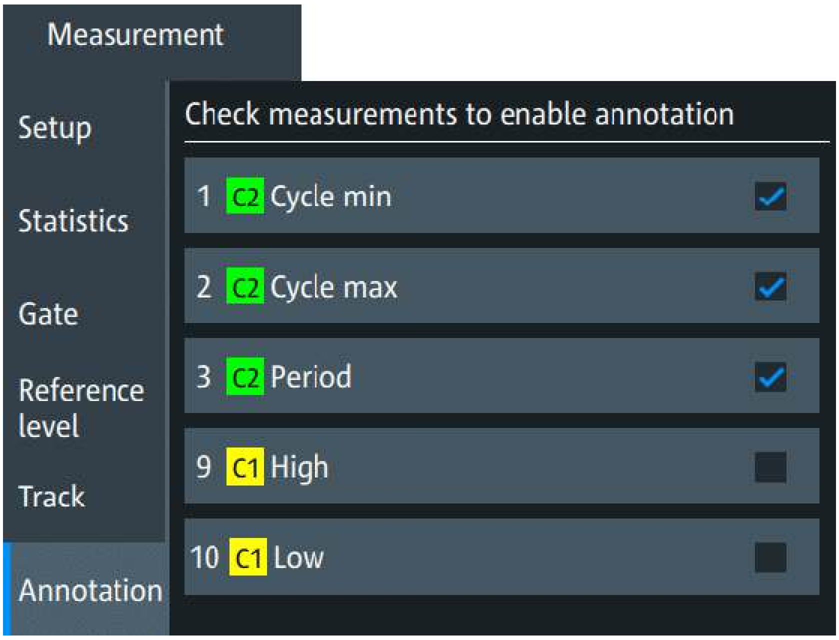
Tracked
Available only for the measurement type "Field value". This setting selects the field type to be displayed.

Remote command:
`MEASurement<mg>:PROTocol:FD2Name`, the same command is used for Field Type.

10.2.7 Annotation for measurements

Measurement annotations mark the significant places in the diagram, for example, periods, maximum and minimum values, relevant reference levels, and more. The lines help understand the measurement results.

In the "Annotation" tab, you can select the measurements to be annotated. Alternatively, you can enable "Display result lines" in the "Setup" of a selected measurement. See "Display result lines" on page 278.



The "Check measurements to enable annotations" list shows all active measurements. The list is empty if no measurement is active. Configure and activate the measurements first, then select them for annotation.

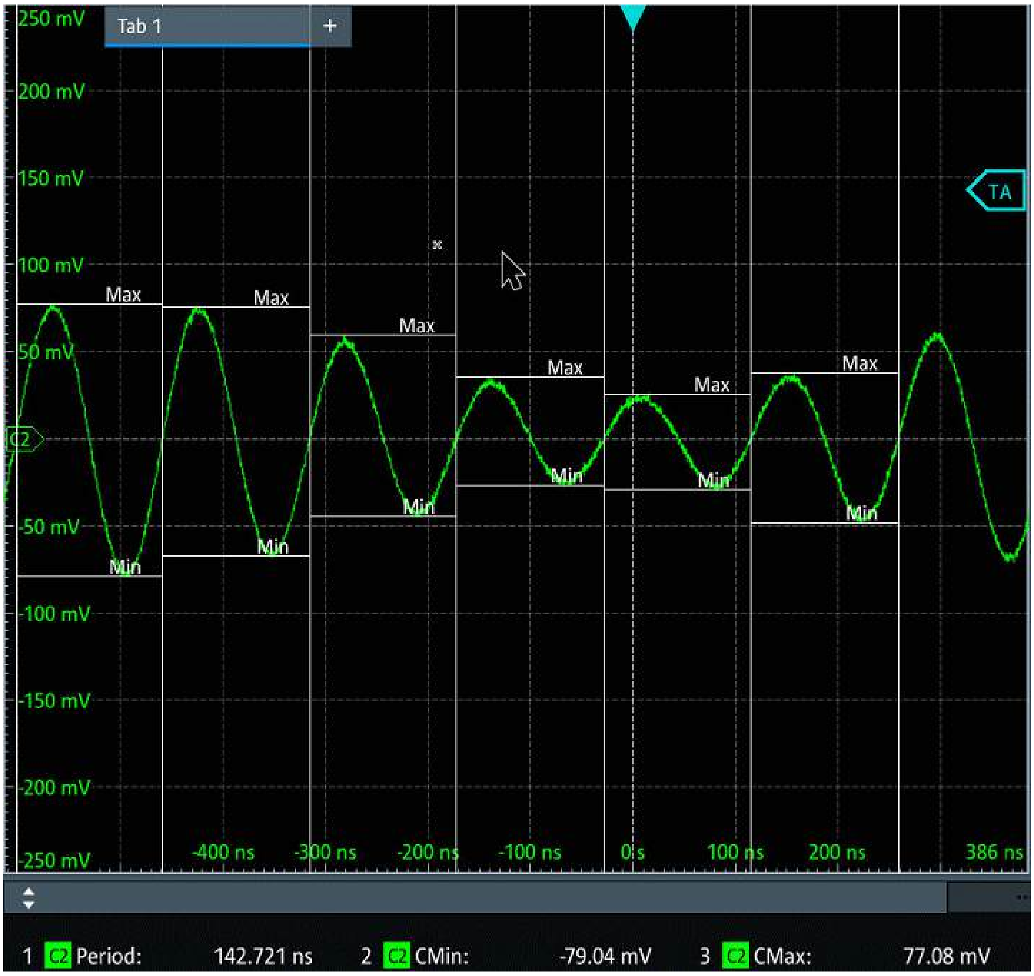


Figure 10-3: Example of annotations for cycle measurements

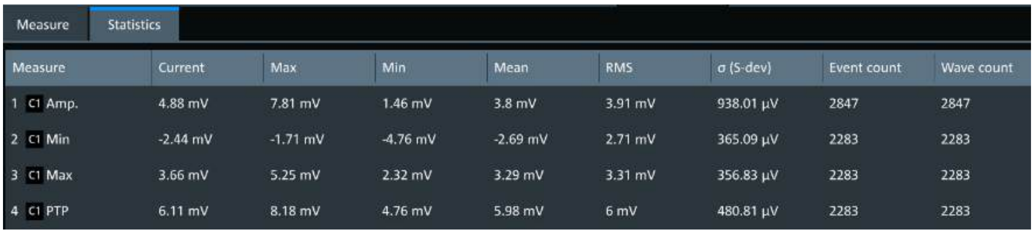
10.2.8 Measurement results

The measurement results are shown in a table below the grid.

-	No valid waveform is available, for example, if the source waveform is off.

Statistics

In addition to the current measurement results, you can enable a statistic evaluation. It returns the current, minimum and maximum measurement values, the average and standard deviation, and the number of measured waveforms. The results are shown in a separate tab below the grid. If the cursor measurement is active simultaneously, its results are shown beside the statistics results.



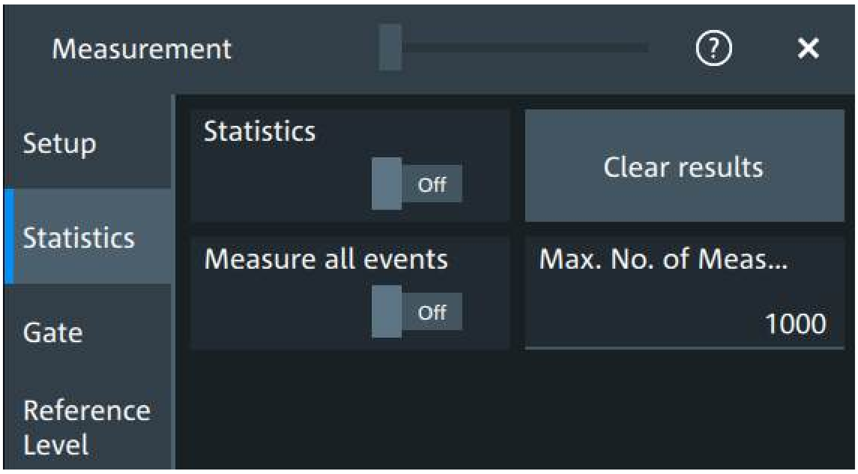
Measure	Current	Max	Min	Mean	RMS	σ (S-dev)	Event count	Wave count
1 C1 Amp.	4.88 mV	7.81 mV	1.46 mV	3.8 mV	3.91 mV	938.01 µV	2847	2847
2 C1 Min	-2.44 mV	-1.71 mV	-4.76 mV	-2.69 mV	2.71 mV	365.09 µV	2283	2283
3 C1 Max	3.66 mV	5.25 mV	2.32 mV	3.29 mV	3.31 mV	356.83 µV	2283	2283
4 C1 PTP	6.11 mV	8.18 mV	4.76 mV	5.98 mV	6 mV	480.81 µV	2283	2283

10.2.9 Analysis of measurement results

The behavior of measurement results over time can be evaluated in different ways, for example, with statistics and tracks.

10.2.9.1 Statistics

Access: "Menu" > "Measurement" > "Statistics" tab.



In addition to the current measurement results, you can enable a statistical evaluation. It returns the current, minimum and maximum measurement values, the average and standard deviation, and the number of measured waveforms. The results are shown in a separate tab below the grid. If the cursor measurement is active simultaneously, its results are shown beside the statistics results.

Statistics

Activates or deactivates the statistical evaluation for the measurement.

Remote command:

`MEASurement<mg>:STATistics[:ENABle]` on page 1018

Clear results

Deletes the statistical results for all measurements, and starts a new statistical evaluation if the acquisition is running.

Remote command:
`MEASurement<mg>:STATistics:ARESet` on page 1018
`MEASurement<mg>:CLEar` on page 1015

Measure all events

Normally, only one measurement is performed for each acquired waveform to get best performance. If "Measure all events" is enabled, more than one result is taken from one acquired waveform and the results are included in evaluation. For example, the rise time is measured on all pulses in the waveform, not only on the first.

The result table shows only the first result of the waveform, the following results are used only for evaluation. The number of considered results can be restricted: see Max. No. of events.

Measuring all events is useful when calculating statistics.

The setting affects all measurements, it is a global setting. However, if a track is enabled for a selected measurement, all results are considered for this measurement, independent from the global setting.

Remote command:
`MEASurement<mg>:MULTiple` on page 1019

Max. No. of events

Sets the maximum number of measured events per acquisition.

Remote command:
`MEASurement<mg>:MNOMeas` on page 1019

10.2.9.2 Track

A track shows the measurement results over time for an acquired waveform. The track is the graphical interpretation of all measurement values of a single acquisition. Furthermore, the track reveals trends of change in the analysis and preserves the timing relationship of the measurement results to the signal.

Tracks can be enabled for each active measurement. Enabling the track also enables "Measure all events" for the selected measurement.

To analyze tracks, you can use cursor measurements, zoom, mathematics and spectrum.

Track activation

Access: "Menu" > "Measurement" > "Track" tab.

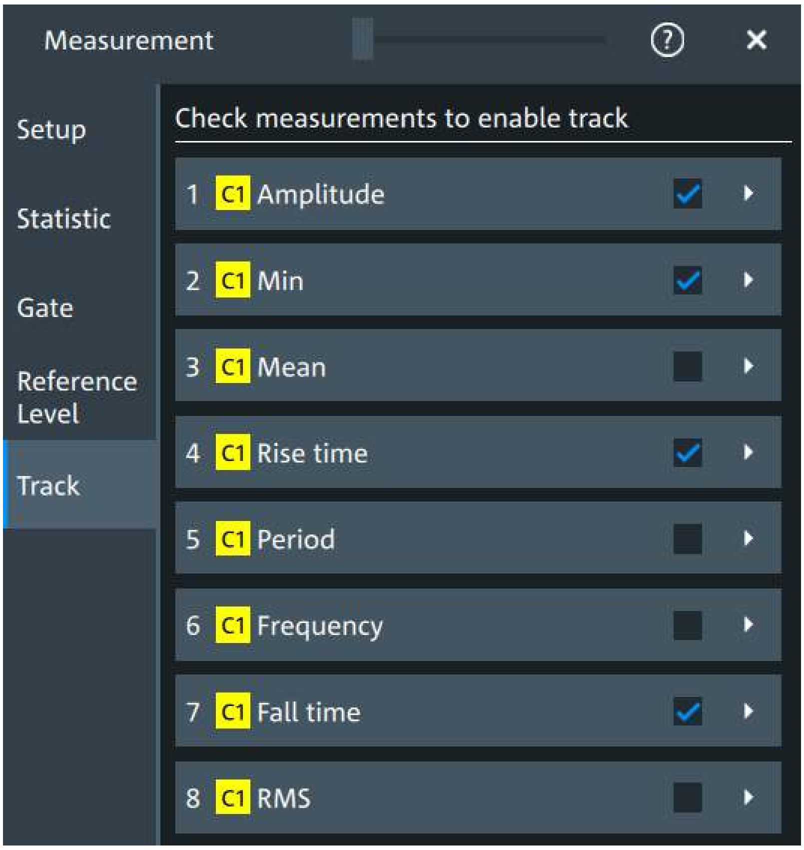


Figure 10-4: Measurement selection for tracks

Check measurements to enable track

The list shows all active measurements. The list is empty if no measurement is active. Enable the measurements first, then select them for track analysis.

Select the checkbox of a measurement to enable the track for this measurement. See also: "State" on page 296.

Tap the button to open the track settings.

Track settings

Access: "Menu" > "Measurement" > "Track" tab > tap measurement button.

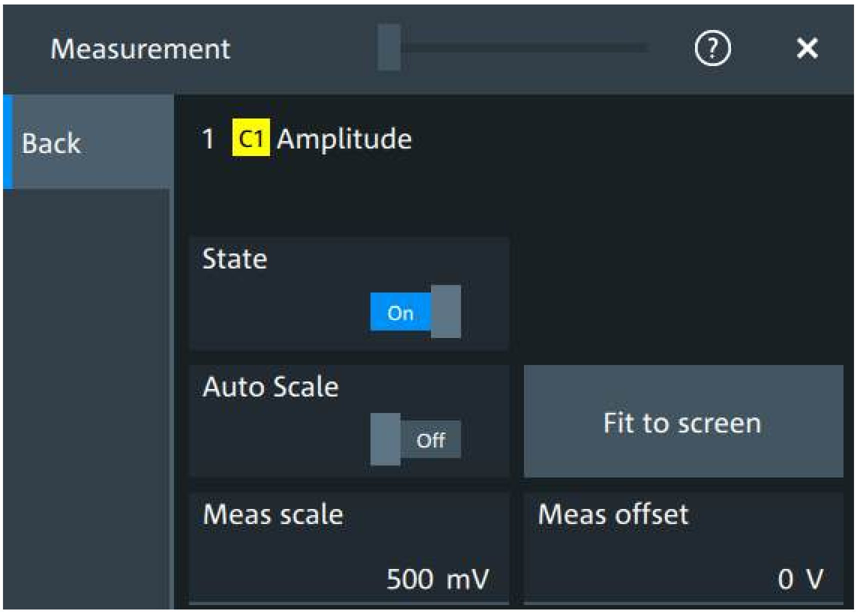


Figure 10-5: Track settings

State
Enables or disables the track for the selected measurement.

Enabling the track also enables "Measure all events" for the selected measurement.

Remote command:
`MEASurement<mg>:TRACk[:STATe]` on page 1020

Auto Scale
Performs an automatic scaling whenever the track does not fit in the diagram during the measurement period.

Remote command:
`MEASurement<mg>:TRACk:CONTiunous` on page 1020

Fit to screen
Sets the vertical scale and the offset of the track, so that the complete height of the diagram is used.

Remote command:
`MEASurement<mg>:TRACk:AUTO` on page 1020

Meas scale
Defines the vertical scale of the track diagram. If "Auto Scale" is on, the current scale value is displayed.

You can also select the track waveform and use the vertical [Scale] knob to change the scale.

Remote command:
`MEASurement<mg>:TRACk:SCALe` on page 1021

Meas offset
Defines the offset of the track waveform. If "Auto Scale" is on, the current offset value is displayed.

You can also select the track waveform and use the vertical [Position] knob to change the offset.

Remote command:
`MEASurement<mg>:TRACk:OFFSet` on page 1020

Examples of track usage

The examples in this section provide ideas on how you can use tracks for waveform analysis.

Tracks with math functions

Figure 10-6: Tracks used in math functions

The example is set up as follows:

- Waveform on channel 1
- 3 measurements on C1: positive duty cycle, period and positive pulse width
- Enable track for each measurement: Track 1 (positive duty cycle), Track 2 (period), Track 3 (positive pulse width)
- Math1 = Trk1 * Trk2
- Math2 = Math1 / 100
  Expected values: Period * Pos. duty cycle / 100 = Positive pulse width, i.e. Math2 = Trk3
- Math3 = Math2 - Trk3
  Expected values = 0

Spectrum on tracks

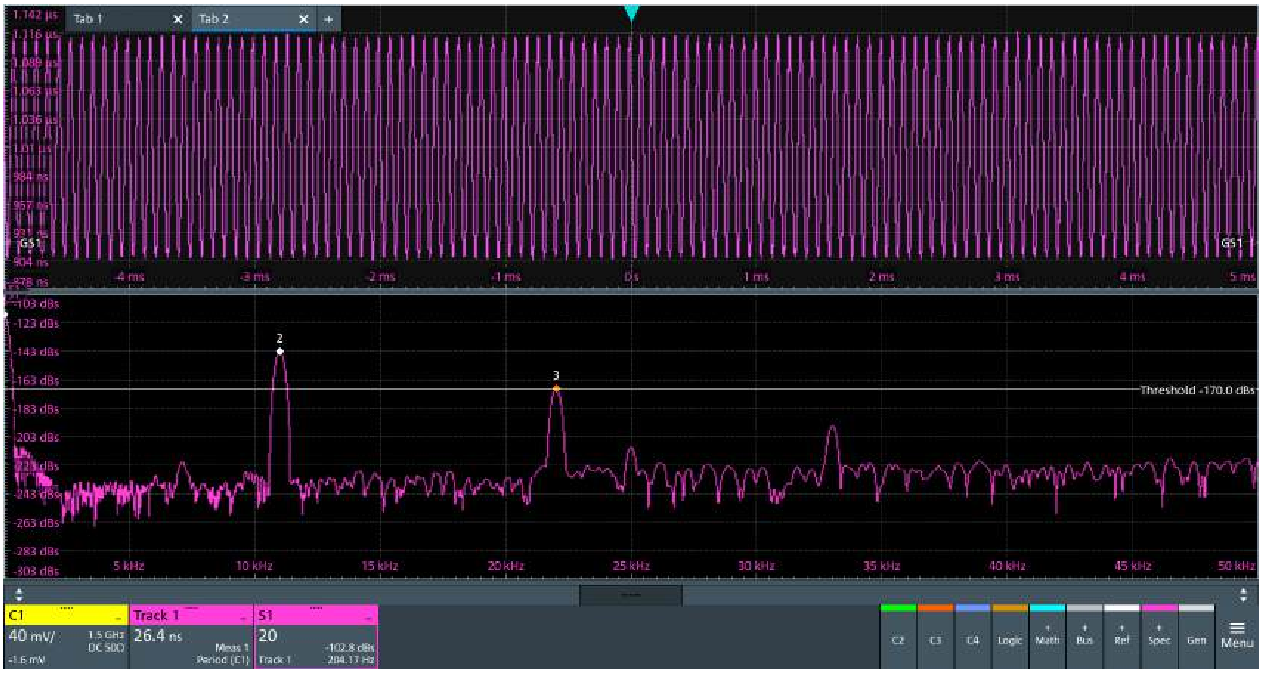


Figure 10-7: Track and spectrum on this track. C1 is not in the diagram.

The example is set up as follows:

- Waveform on channel 1
- Period measurement on C1
- Enable track for the period measurement: Track 1
- Spectrum with "Source" = Track 1
- Enable "PeakList" > "Peak on waveform"

Zoom on tracks

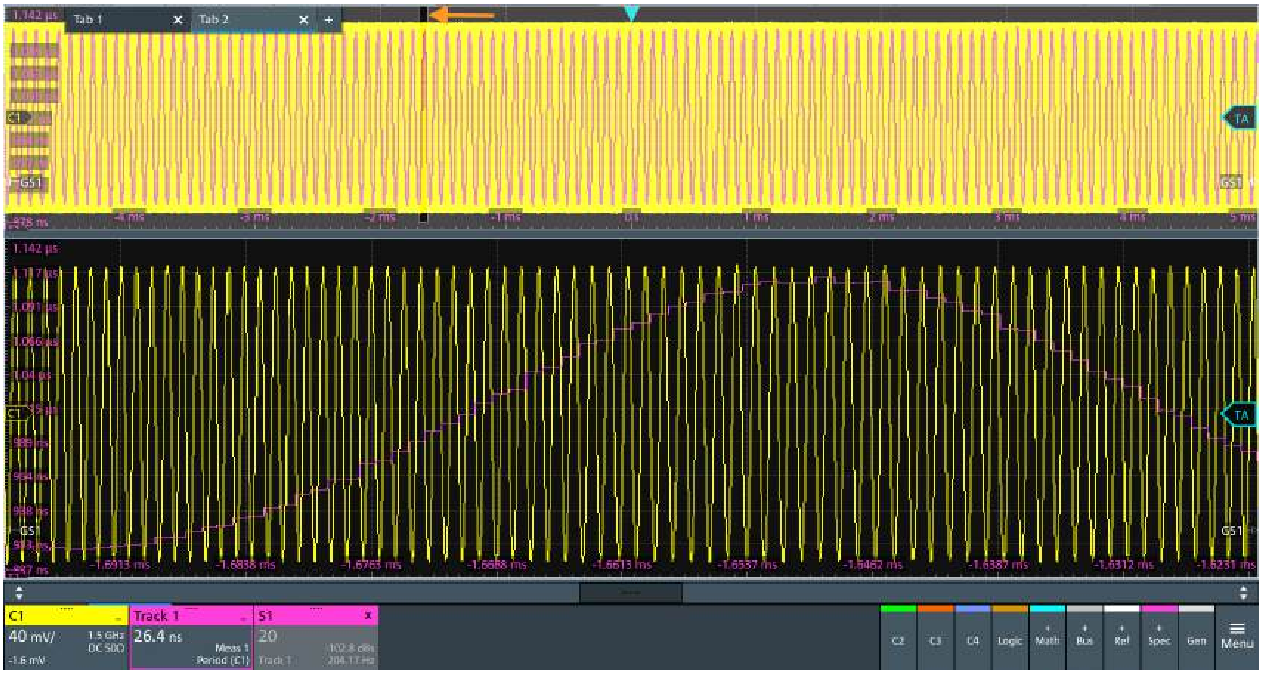


Figure 10-8: Track and C1 in the upper diagram, zoom below

The example is set up as follows:

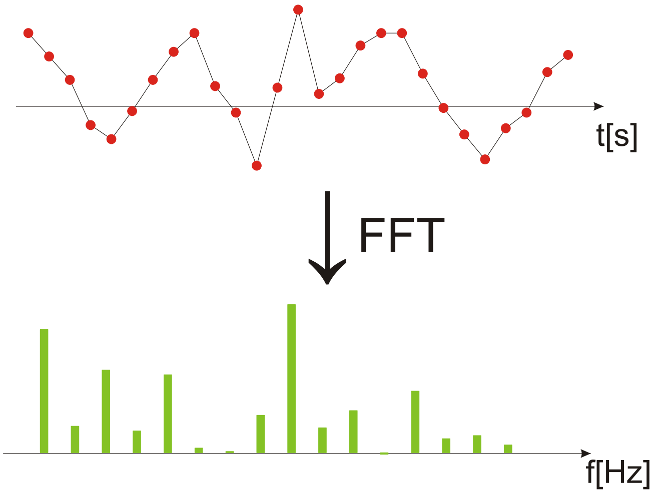
- Waveform on channel 1
- Period measurement on C1
- Enable track for the period measurement: Track 1.
- Drag and drop the track on the channel waveform.
- Create zoom.

11 Spectrum analysis

The MXO 4 provides an easy way to set up a spectrum analysis. The spectrum settings are independent of the time domain settings but the time and frequency domains are time-correlated.

11.1 Fundamentals of spectrum analysis

During spectrum analysis, a signal in the time domain is converted to a spectrum of frequencies. As a result, either the magnitude or the phase of the determined frequencies can be displayed. Spectrum analysis can be restricted to an extract of the original time base, and the results display can be restricted to a specified frequency range.



Window functions

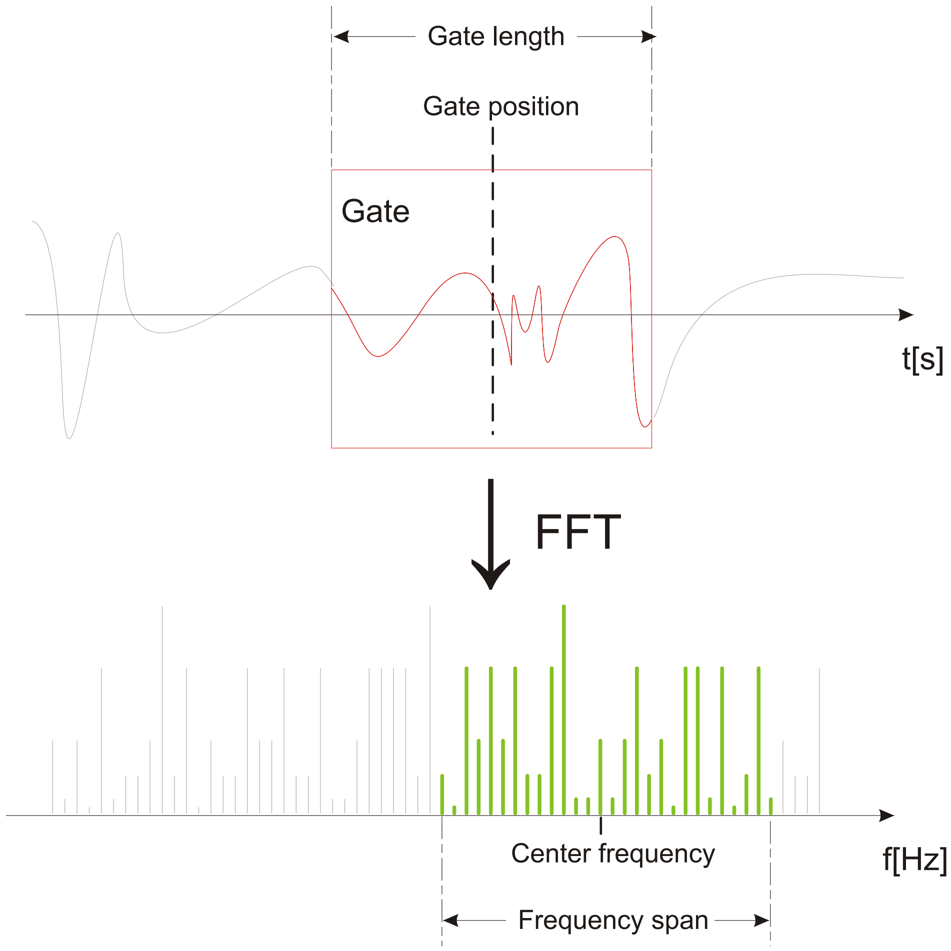
Each frame is multiplied with a specific window function after sampling in the time domain. Windowing helps minimize the discontinuities at the end of the measured signal interval and thus reduces the effect of spectral leakage, increasing the frequency resolution.

There are several window functions that can be used in FFT analysis. Each of the window functions has specific characteristics, including some advantages and some tradeoffs. Consider these characteristics carefully to find the optimum solution for the measurement task.

For details, see "Window type" on page 306.

Gating functions

You can restrict the time base of the input signal for which spectrum analysis is to be performed. You can define start and stop times for the time base extract.



Restricting the result range

You can restrict the results of the spectrum analysis to a specified frequency range. The frequency range can be defined in two ways:

- Define a center frequency and frequency span
- Define start and stop frequencies

Dependencies between spectrum parameters

Spectrum analysis in the MXO 4 is highly configurable. Several parameters, including the resolution bandwidth, frequency span and center frequency, can be defined according to your requirements. Note, however, that several parameters are correlated and not all can be configured independently of the others.

The **resolution bandwidth** defines the minimum frequency separation at which the individual components of a spectrum can be distinguished. Small values result in high precision, as the distance between two distinguishable frequencies is small. Higher values decrease the precision, but increase measurement speed.

The minimum achievable RBW depends on the integration time which is equivalent to the number of samples available for calculation. If a higher spectral resolution is required, the number of samples must be increased by using a higher sample rate or longer record length. To simplify operation, some parameters are coupled and automatically calculated, such as record length and RBW.

The **frequency span** and **center frequency** define the start and stop frequency of the spectral diagram. By default, a suitable frequency range according to the resolution bandwidth is selected, in respect to performance and precision. Span and RBW settings are coupled, so that the parameters can be adjusted automatically as necessary.

With a **Span/RBW ratio** of 100 and a screen resolution of 1000 pixels, each frequency in the spectrum is displayed by 10 pixels. A span/RBW ratio of 1000 provides the highest resolution. For full flexibility, the span/RBW coupling can also be disabled. Note, however, that a higher span/RBW ratio (i.e. low RBW values and large frequency spans) result in large amounts of data and extend the duration of the calculation.

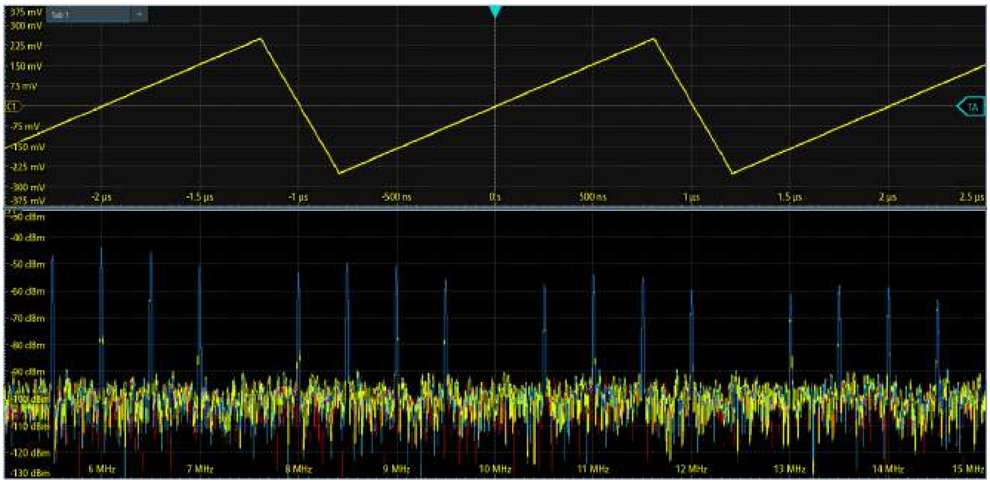
11.2 Configuring spectrum waveforms

During spectrum analysis, a signal in the time domain is converted to a spectrum of frequencies. A basic spectrum waveform can be displayed quickly. By defining additional parameters, the waveform can be configured in more detail.

To display a basic spectrum waveform

1. Press the [Spectrum] key.

   The "Setup" tab of the "Spectrum" dialog box opens.
2. Set the "Source" to the input signal.
3. Enable "Display".

4. If necessary, edit the spectrum waveform parameters as described in the following procedures.

To configure the spectrum

By default, a suitable frequency range for the expected horizontal values according to the resolution bandwidth is selected, in respect to performance and precision. Span and RBW settings are coupled. If a more precise evaluation is required, for example for postprocessing in a different application, disable the coupling and change the frequency ranges and resolution bandwidth values as required.

1. Press the [Spectrum] key.

   The "Setup" tab of the "Spectrum" dialog box opens.

2. In the "Setup" tab, specify the frequency range you want to display using one of the following methods:
   - Select "CF span". Enter a "Center" and a "Span" that define the spectrum.
   - Select "Start Stop". Enter a "Start" and "Stop" frequencies that define the spectrum.
   - Tap the "Full span" button to display the complete spectrum resulting from the FFT analysis.

3. Define the resolution bandwidth for the spectrum result.
   The resolution bandwidth defines how precise the results are, i.e. how close together the individual frequencies can be. Small values result in high precision, as the distance between two distinguishable frequencies is small. Higher values decrease the precision, but increase performance.

   You can define the RBW manually, or couple it to other settings. Do one of the following:
   - To couple the RBW to the span, enable "Auto RBW". Define the "Span/RBW" ratio, the smaller the ratio, the higher the RBW becomes to display the same frequency span.
   - Disable "Auto RBW". Enter the "RBW" manually.

4. Tap "Advanced".

5. Select the most suitable "Window type" for your source data. Window functions are multiplied with the input values and thus can improve the spectrum display. For details, see "Window type" on page 306.

To restrict the input values (gating)

You can restrict the time range for which the FFT is calculated, resulting in a restricted spectrum.

1. Open "Menu" > "Spectrum" > "Gate" tab.

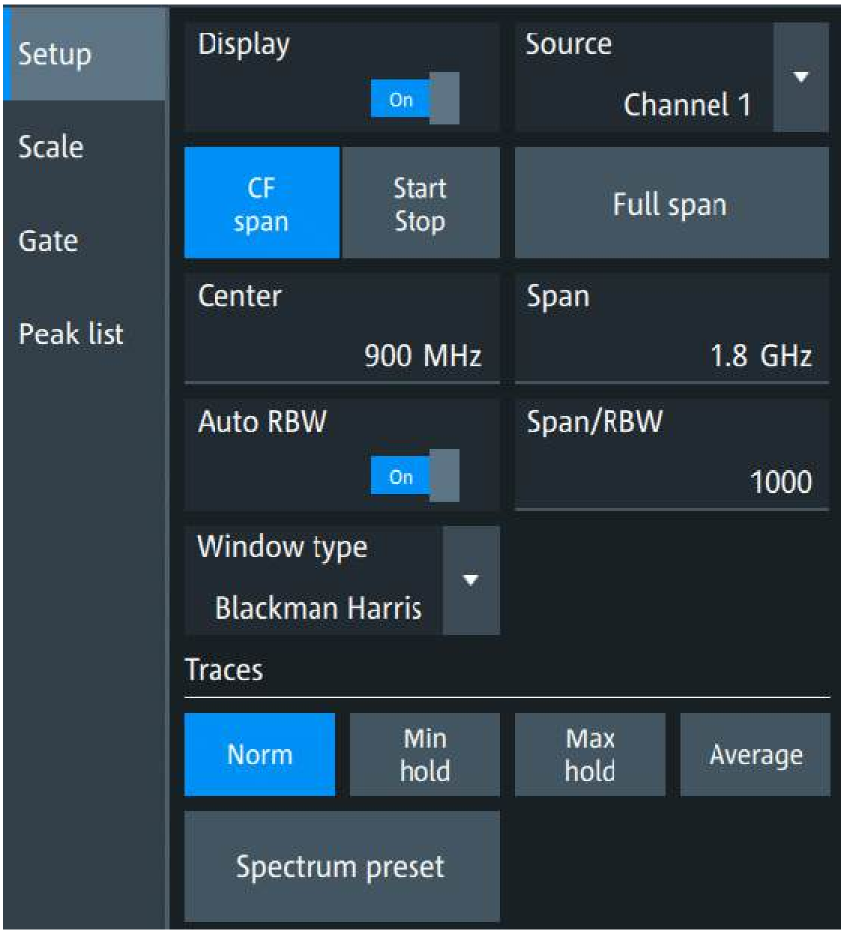
2. Enter the "Start" and the "Stop" times that define the gate area.

3. Set the "Position" and the "Width".

   The spectrum waveform displays the spectrum for the specified time span.

11.3 Spectrum setup

Access: "Menu" > "Spectrum" > "Setup" tab.



In this tab, you define the settings for the spectrum window. The display can be restricted to the results for a certain time base extract and to a specified frequency range.

The settings in this dialog are greyed out and cannot be changed, if "Coupling" is enabled in the "Scale" tab.

Display
Enables the spectrum.

Remote command:
CALCulate:SPECtrum<sp>:STATe on page 1042

Source
Selects the source for the spectrum.

Remote command:
CALCulate:SPECtrum<sp>:SOURce on page 1041

Full span
Displays the full frequency span.

CF span, Start Stop
Selects if the frequency span is defined through a "Center"/"Span" pair or through the "Start"/"Stop".

Center
Defines the position of the displayed frequency range, which is (Center - Span/2) to (Center + Span/2). The width of the range is defined using the frequency span setting.

Remote command:
`CALCulate:SPECtrum<sp>:FREQuency:CENTer` on page 1037

Span
The span is specified in Hertz and defines the width of the displayed frequency range, which is (Center - Span/2) to (Center + Span/2). The position of the span is defined using the "Center" setting.

Remote command:
`CALCulate:SPECtrum<sp>:FREQuency:SPAN` on page 1038

Start
Defines the start frequency of the displayed frequency span.

Remote command:
`CALCulate:SPECtrum<sp>:FREQuency:STARt` on page 1038

Stop
Sets the stop frequency of the displayed frequency span.

Remote command:
`CALCulate:SPECtrum<sp>:FREQuency:STOP` on page 1039

Auto RBW
Couples the frequency span to the "RBW" setting.

If span and RBW values are coupled, changing the span also changes the RBW.

Remote command:
`CALCulate:SPECtrum<sp>:FREQuency:BANDwidth[:RESolution]:AUTO` on page 1036

Span/RBW
Defines the coupling ratio for Span/RBW.

This setting is only available if "Auto RBW" is enabled.

Remote command:
`CALCulate:SPECtrum<sp>:FREQuency:BANDwidth[:RESolution]:RATio` on page 1037

RBW

Defines the resolution bandwidth. Note that the resolution bandwidth is correlated with the span, record length and acquisition time. If a constant record length is to be used, the RBW can be adapted if the required number of samples cannot be acquired.

Remote command:
`CALCulate:SPECtrum<sp>:FREQuency:BANDwidth[:RESolution][:VALue]` on page 1037

Window type

Selects the window type. Windowing helps minimize the discontinuities at the end of the measured signal interval and thus reduces the effect of spectral leakage, increasing the frequency resolution.

Various different window functions are provided in the MXO 4 to suit different input signals. Each of the window functions has specific characteristics, including some advantages and some trade-offs. Consider these characteristics carefully, to find the optimum solution for the measurement task.

Window type	Frequency resolution	Magnitude resolution	Measurement recommendation
Rectangular	Best	Worst	Separation of two tones with almost equal amplitudes and a small frequency distance
Hamming Hann	Good	Poor	Frequency response measurements, sine waves, periodic signals and narrow-band noise
Blackman Harris (default)	Good	Good	Mainly for signals with single frequencies to detect harmonics Accurate single-tone measurements Best compromise of frequency and magnitude resolutions
Gaussian	Good	Good	Weak signals and short duration
Flattop2	Poor	Best	Accurate single-tone measurements
Kaiser Bessel	Poor	Good	Separation of two tones with differing amplitudes and a small frequency distance

Remote command:
`CALCulate:SPECtrum<sp>:FREQuency:WINDow:TYPE` on page 1039

Traces

Spectrum analysis can only be performed on a maximum number of values at once. If more values must be calculated, the input signal is divided into segments, each of which is calculated separately. The segments need not to be disjunct. In this case, the arithmetic mode defines how the final result is calculated from the individual results.

The following methods are available:

"Norm" — The data of only one segment is considered. In effect, no arithmetics are processed.

"Min hold" — Determines the minimum result for each input value from the data of the current acquisition and the acquisitions before.

"Max hold" Determines the maximum result for each input value from the data of the current acquisition and the acquisitions before.

"Average" The average is calculated over the number of segments set with "Average count".

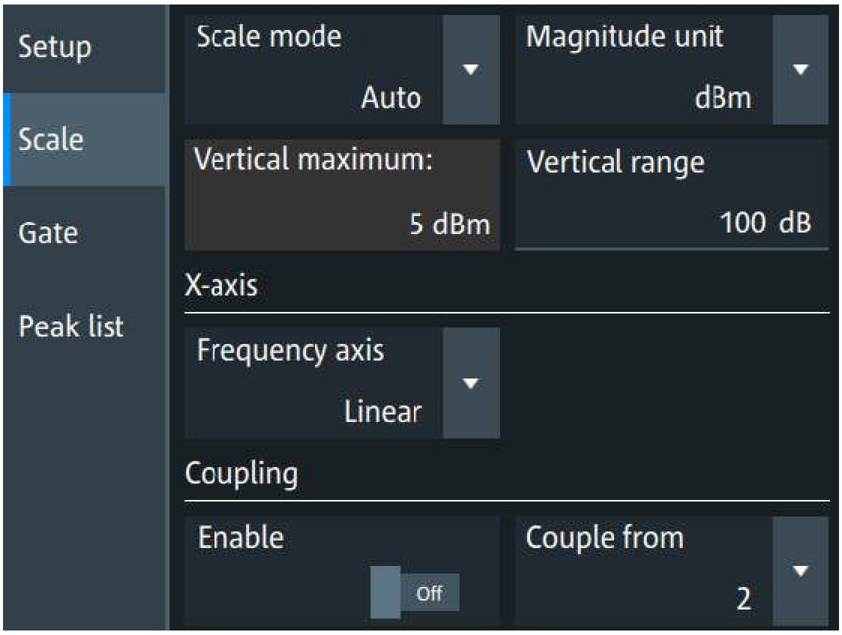
Remote command:
CALCulate:SPECtrum<sp>:WAVeform:AVERage:ENABle on page 1043
CALCulate:SPECtrum<sp>:WAVeform:AVERage:COUNt on page 1043
CALCulate:SPECtrum<sp>:WAVeform:MAXimum:ENABle on page 1043
CALCulate:SPECtrum<sp>:WAVeform:MINimum:ENABle on page 1043
CALCulate:SPECtrum<sp>:WAVeform:NORMal[:ENABle] on page 1044

Spectrum preset
Presets the spectrum measurement.

Remote command:
CALCulate:SPECtrum<sp>:PRESet on page 1041

11.4 Spectrum scale

Access: "Menu" > "Spectrum" > "Scale".



Scale mode
By default, the vertical scale is adapted to the current measurement results automatically to provide an optimal display. However, if necessary, you can define scaling values manually to suit your requirements.

Note: When you change the scaling values manually using the [Scale] rotary knob, the scale mode is set to "Manual" temporarily.

"Manual" Enter the required values for "Vertical maximum" and "Vertical range".

"Auto" "Vertical maximum" is read-only.

Magnitude unit
Sets the unit for the y-axis.

The display values are calculated for the termination impedance that is set in "Vertical" > "Other" tab > "Impedance".

Remote command:
`CALCulate:SPECtrum<sp>:MAGNitude:SCALe` on page 1041

Vertical maximum
Sets the maximum displayed value on the vertical scale.

Remote command:
`CALCulate:SPECtrum<sp>:MAGNitude:LEVel` on page 1040

Vertical range
Sets the range of the spectrum values to be displayed.

Remote command:
`CALCulate:SPECtrum<sp>:MAGNitude:RANGe` on page 1040

Frequency axis
Defines the scaling method for the frequency axis (x-axis) of the spectrogram.

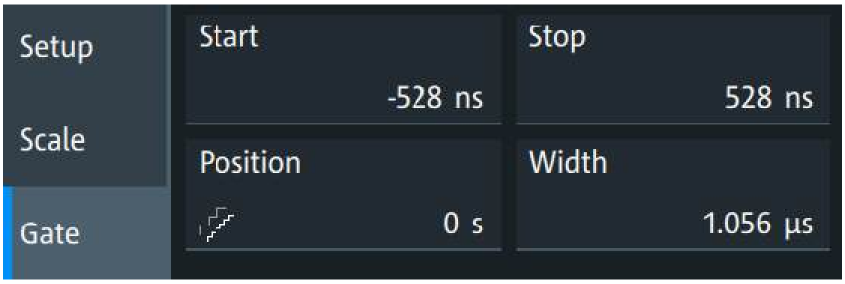
Available are logarithmic and linear scaling.

Remote command:
`CALCulate:SPECtrum<sp>:FREQuency:SCALe` on page 1038

Coupling
If the coupling is enabled, the settings of the current spectrum are coupled to the spectrum selected with "Couple from".

11.5 Spectrum gate

Access: "Menu" > "Spectrum" > "Gate"



Spectrum gating restrict the spectrum analysis to a user-defined region of the captured time domain signal.

Start

Sets the starting value for the gate.

Remote command:
CALCulate:SPECtrum<sp>:GATE:STARt on page 1044

Stop

Sets the end value for the gate.

Remote command:
CALCulate:SPECtrum<sp>:GATE:STOP on page 1045

Position

Sets the position of the displayed frequency range.

The width of the gate is defined using the "Width" setting.

Remote command:
CALCulate:SPECtrum<sp>:GATE:POSition on page 1044

Width

Defines the width of the displayed gate.

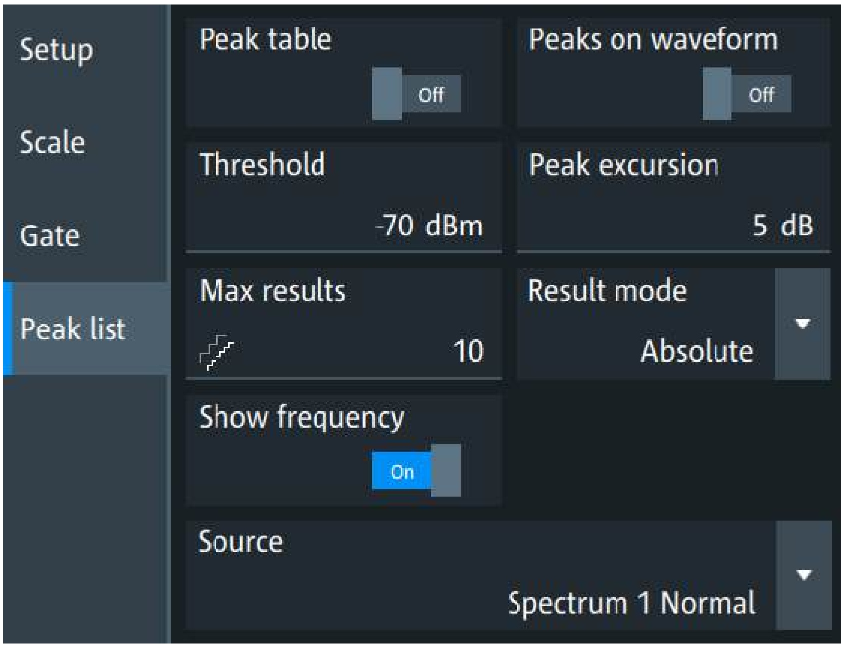
The position of the span is defined using the "Position" setting.

Remote command:
CALCulate:SPECtrum<sp>:GATE:WIDTh on page 1045

11.6 Spectrum peak list

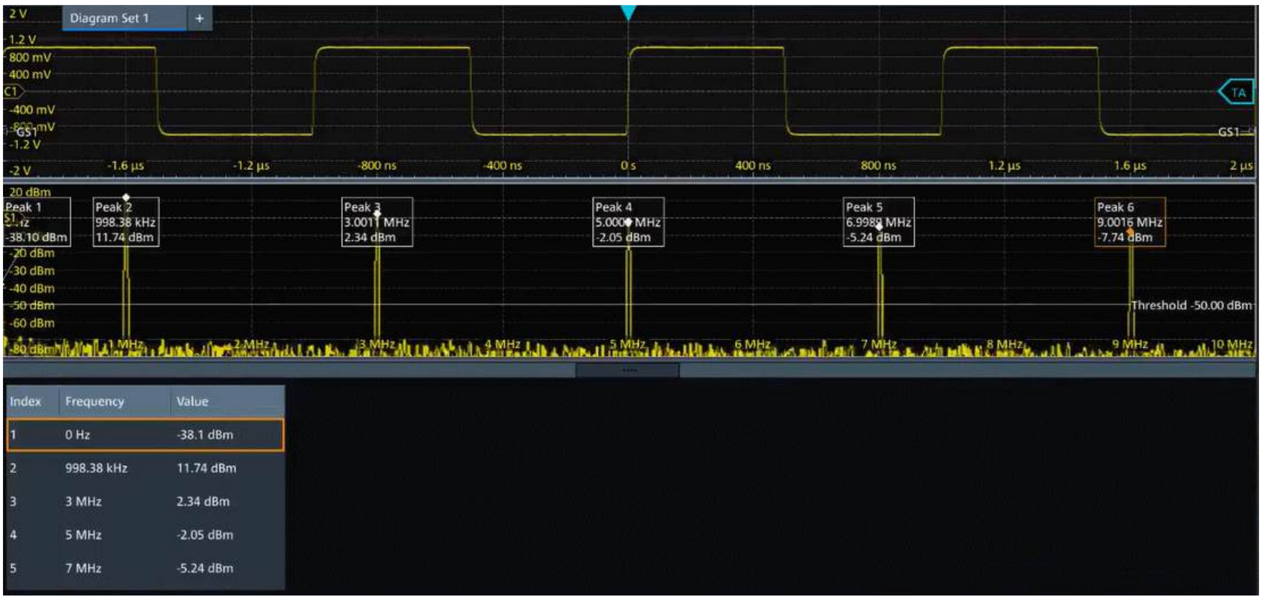
A peak list measurement detects all peaks above a user-definable threshold and optionally indicates the peaks in the spectrum diagram.

Access: "Menu" > "Spectrum" > "PeakList".



In the peak list dialog, you can define various criteria for a peak search. The peaks can be indicated in the frequency diagram by peak boxes, and the measured peak frequencies and magnitudes are listed in the peak list table.

The number of determined peaks can be defined. You can sort the results by frequency or power value, and the peak labels are adjusted accordingly.



Also, you can adjust some of the display settings, see Section 5.3.4, "Peak list", on page 100.

To analyze the peaks in a spectrum, you can also use cursors on the spectrum waveform and peak search functions. For details, see Section 10.1.3.3, "Peak search tab", on page 262.

Remote commands query peak results and to change the results display:

- CALCulate:SPECtrum<sp>:PLISt:RESult[:VALue]? on page 1047
- CALCulate:SPECtrum<sp>:PLISt:SORT:COLumn on page 1048
- CALCulate:SPECtrum<sp>:PLISt:SORT:ORDer on page 1048
- CALCulate:SPECtrum<sp>:PLISt:LABel:INVert on page 1049

Peak table

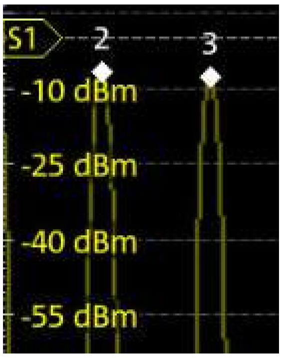
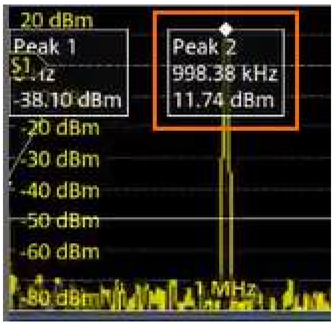
Enables the display of the peak table.

Remote command:
CALCulate:SPECtrum<sp>:PLISt[:STATe] on page 1046

Peak on waveform

Displays a box with a description for each detected peak in the spectrum, including the magnitude. If "Show frequency" is enabled, the frequency values are also displayed.

If this option is disabled, the peaks are marked on the diagram only with a point marker.

"Peak on waveform" > "Off"	"Peak on waveform" > "On"
	

Remote command:
CALCulate:SPECtrum<sp>:PLISt:SPOW on page 1047

Threshold

Sets an absolute threshold as an additional condition for the peak search. Only peaks that exceed the threshold are detected.

This setting is only available for spectrum waveforms. It is valid for cursor measurements, spectrum measurements and peak search.

Remote command:
CALCulate:SPECtrum<sp>:THReshold on page 1042

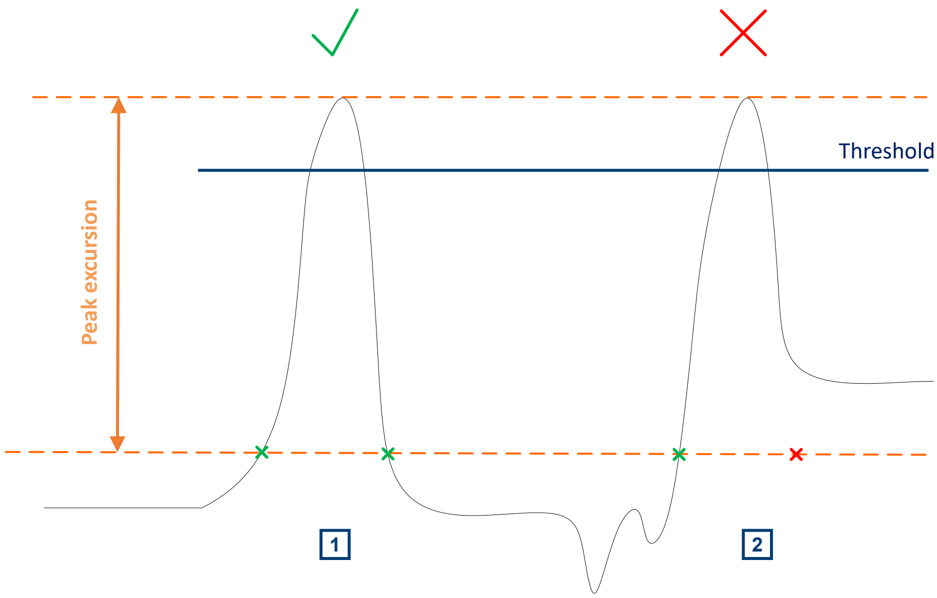
Peak excursion

Defines a minimum level value by which the waveform must drop left and right of the local maximum to be listed as a peak. Enter a peak excursion value to omit close by peaks and list just the highest peak.

This setting is only available for spectrum waveforms. It is valid for cursor measurements, spectrum measurements and peak search.

Example:

In the figure below, 2 peaks are shown, that rise above the defined "Threshold". Peak 1 fulfills the defined "Peak excursion" value and is counted as a peak. Peak 2 does not fulfill the defined "Peak excursion" value on the right and is not counted as a peak.



Remote command:
CALCulate:SPECtrum<sp>:PEXCursion on page 1042
CURSor<cu>:PEXCursion on page 1035

Max results

Sets the maximum number of measurement results that are listed in the result table.

Remote command:
CALCulate:SPECtrum<sp>:PLISt:MAXCount on page 1046

Result mode

Selects how the measurement results are displayed.

"Absolute" The peaks are shown in absolute value, dBm.

"Relative" The level of the carrier is shown in absolute value dBm. The values of the peaks are shown relatively to the carrier in dBc.

Remote command:
CALCulate:SPECtrum<sp>:PLISt:MODE on page 1046

Show frequency

Includes the frequency of the detected peak in the diagram labels.

Remote command:
CALCulate:SPECtrum<sp>:PLISt:LABel:FREQuency[:STATe] on page 1048

Source

Selects the source of the peak table. You can select one of the traces that is enabled with Traces.

Remote command:
`CALCulate:SPECtrum<sp>:PLISt:SOURce` on page 1047

12 Applications

All available applications are provided in the "Apps" dialog.

► To open an application, press the [Apps] key.

Some applications are described in other sections. See:

- Section 9.4, "Reference waveforms", on page 239
- Section 9.5, "Waveform histograms", on page 248
- Section 16, "Waveform generator (option R&S MXO4-B6)", on page 753
- Section 13.7, "File browser dialog", on page 429
- Section 14, "Protocol analysis", on page 431
- "Add scope": Section 17.2, "ScopeSync", on page 772

Also the "Demo" is available in the "Apps" dialog. It is for demonstration purposes of the functionalities of MXO 4.

12.1 Mask testing

12.1.1 About mask testing

Masks are used to determine whether the signal remains within specified limits, e.g. to uncover signal anomalies or test compliance and stability of digital signals. The limits are specified as "mask", which is laid over the input signal in the display. Thus you can easily detect where the signal violates the mask.

Mask testing with MXO 4 is hardware accelerated. It's the industry's fastest mask test with hardly any impact on the acquisition rate, thus mask violations are detected fast and reliably.

With MXO 4, you can define your own masks easily. Specific actions can be executed when mask violations occur. For error analysis, you can stop the acquisition on a failed test and use the history to look at the previous waveforms.

Mask test

A mask test consists of:

- Mask definition
- Waveform to be tested
- Actions to be taken on violation or successful completion

Mask Definition

A mask can have one or more segments. Each segment has a predefined shape: rect-angle, square, diamond, hexagon or octagon. You can change the shape by moving the edge points on the screen or change the numerical values. You can also add and remove single edge points.

A mask segment can have only one range in y-direction at a certain time point. If a shape is not valid, the invalid point is marked red, and an attention symbol is shown at the segment name.

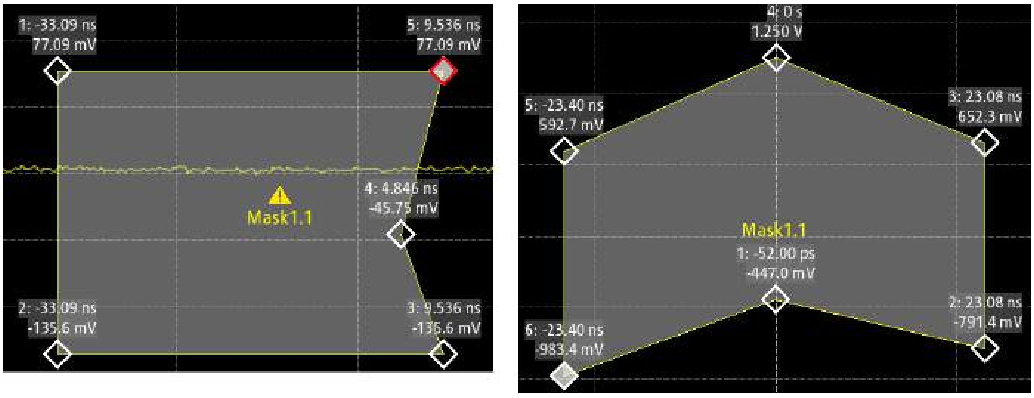
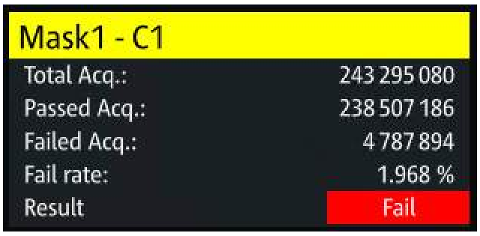


Figure 12-1: Invalid mask segment (left) and valid mask segment (right)

To check the validity in remote control, use MTESt<m>:SEGMent<n>:VALid? and MTESt<m>:SEGMent<n>:POINt<o>:VALid?.

12.1.1.1 Results of a mask test

A mask test shows the following test results:



Mask1 - C1	
Total Acq.:	243 295 080
Passed Acq.:	238 507 186
Failed Acq.:	4 787 894
Fail rate:	1.968 %
Result	Fail

Total Acq.
Number of tested acquisitions.

Remote command:
MTESt<m>:RESult:COUNt:WAVeforms? on page 1061

Passed Acq.
Number of acquisitions that passed the test.

Remote command:
MTESt<m>:RESult:COUNt:PWAVeforms? on page 1060

Failed Acq.
Number of failed acquisitions.

Remote command:
MTESt<m>:RESult:COUNt:FWAVeforms? on page 1060

Fail rate
Ratio of failed acquisitions to the number of tested acquisitions.

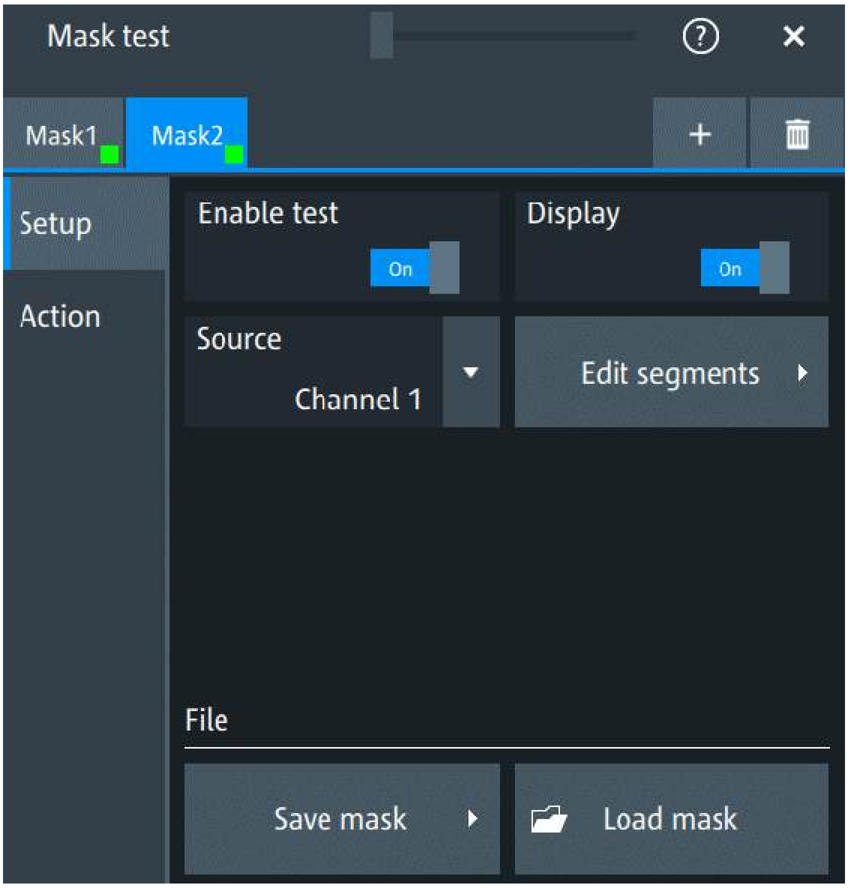
Remote command:
MTESt<m>:RESult:FRATe? on page 1061

Result
A test has failed if at least one acquisition violated the mask.

Remote command:
MTESt<m>:RESult[:RESult]? on page 1061

12.1.2 Mask test setup: general settings

Access: "Menu" > "Apps" > "General" tab > "Masks" > "Setup" tab



Add mask
Adds a mask test and opens the subtab to configure the new test.

Remote command:
MTESt<m>:ADD on page 1052

Enable test

Activates or deactivates the mask test.

If the acquisition is running, the test starts immediately. Otherwise, the test starts when acquisition is started. The testing is stopped when acquisition is stopped, or if a stop action is configured.

Remote command:
`MTESt<m>:STATe` on page 1054

Display

Displays all mask segments of the selected mask in the diagrams, or hides them.

Remote command:
`MTESt<m>:VISible` on page 1054

Source

Selects the waveform to be tested against the mask.

All analog channel waveforms, math waveforms, XY-plots and norm traces of spectrums can be tested.

Remote command:
`MTESt<m>:SOURce` on page 1053

Edit segments

Opens a dialog to add and configure the segments of the mask. See Section 12.1.3, "Mask test setup: segment definition", on page 318 for description.

Save mask

Opens a dialog to define the storage location and filename, and save the mask.

"<Folder>"	Opens a file explorer where you can select the directory where the file is saved.
"File name base"	Sets a name for the file, without extension. The name is extended with a time stamp when the file is saved. Thus, multiple "Save" actions are possible without changing the filename.
"File extension"	The format of the mask file is always `.xml`.
"Save"	Saves the file in the defined folder using the "File name base". If the specified file already exists, it is overwritten with the new data.
"Save As"	Opens a file explorer where you select the folder, the file type, enter the filename and save the file.

Remote command:
`MTESt<m>:IMEXport:NAME` on page 1052
`MTESt<m>:IMEXport:SAVE` on page 1053

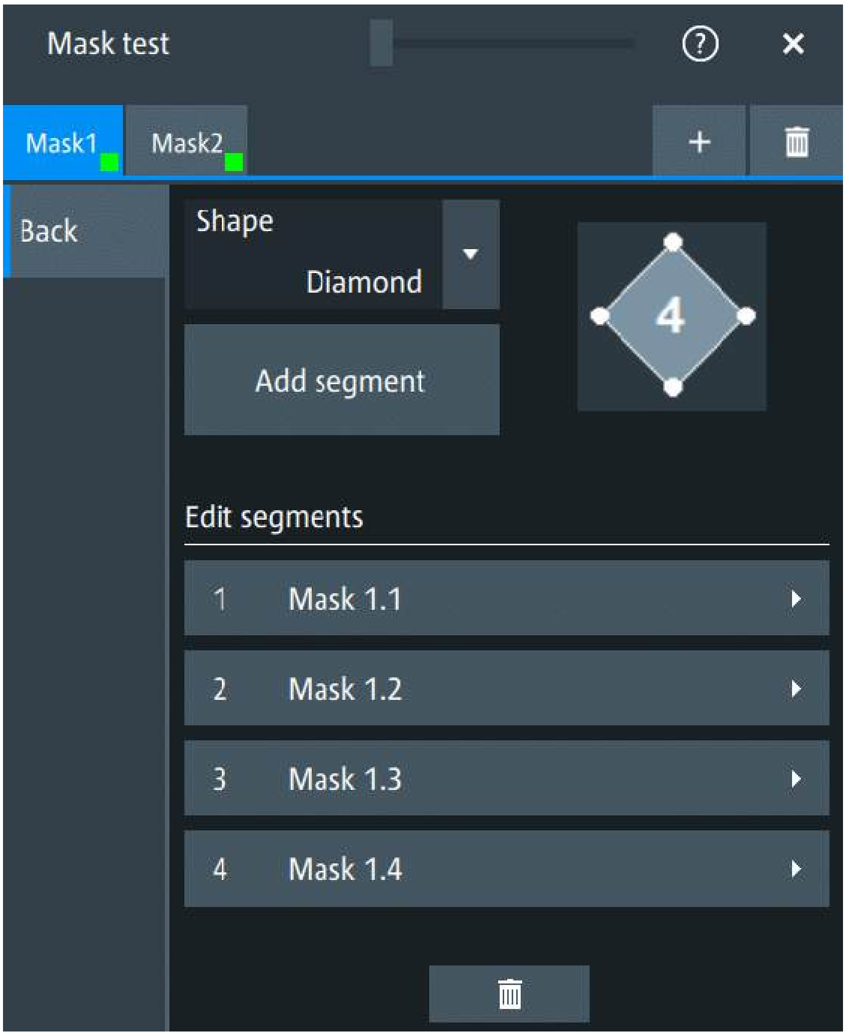
Load mask

Opens a file explorer to select a previously stored mask file. The selected mask is loaded and used for test.

Remote command:
`MTESt<m>:IMEXport:NAME` on page 1052
`MTESt<m>:IMEXport:OPEN` on page 1053

12.1.3 Mask test setup: segment definition

"Menu" > "Apps" > "General" tab > "Masks" > "Setup" tab > "Edit segments"

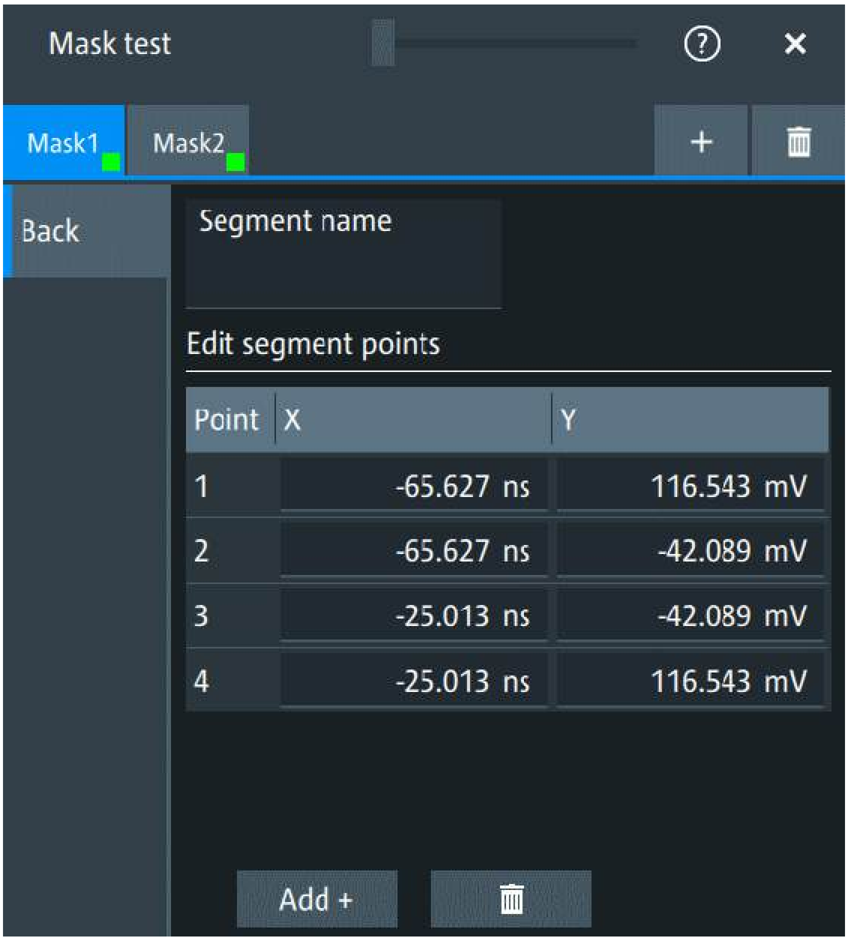


Shape
Selects the shape of the user-defined mask: rectangle, diamond, hexagon, octagon.

Add segment
Adds a new segment with the selected shape to the mask.

Remote command:
`MTESt<m>:SEGMent<n>:ADD` on page 1055

Edit segments
Dialog to edit the mask segment. For each segment, you define the coordinates of the corner points. You can add and remove points and define the shape as needed.



Point, X, Y ← Edit segments
The table shows the horizontal and vertical positions of the corner points. You can change each value.

Remote command:
`MTESt<m>:SEGMent<n>:POINt<o>:X` on page 1057
`MTESt<m>:SEGMent<n>:POINt<o>:Y` on page 1057
`POWer<m>:SOA:MTESt<n>:SEGMent<o>:POINt<p>:X` on page 1135
`POWer<m>:SOA:MTESt<n>:SEGMent<o>:POINt<p>:Y` on page 1136

Add + ← Edit segments
Appends a new point to the segment. You cannot change the order of the points.

Remote command:
`MTESt<m>:SEGMent<n>:POINt<o>:ADD` on page 1055
`MTESt<m>:SEGMent<n>:POINt<o>:COUNt?` on page 1056

Segment name ← Edit segments
Enter a name for the selected mask segment.

Delete, Delete all

switches to the delete mode. You can delete single segments or single points by selecting the delete icon in the table row. You can also delete all segments or points with "Delete all". To leave the delete mode, tap the blue delete icon.

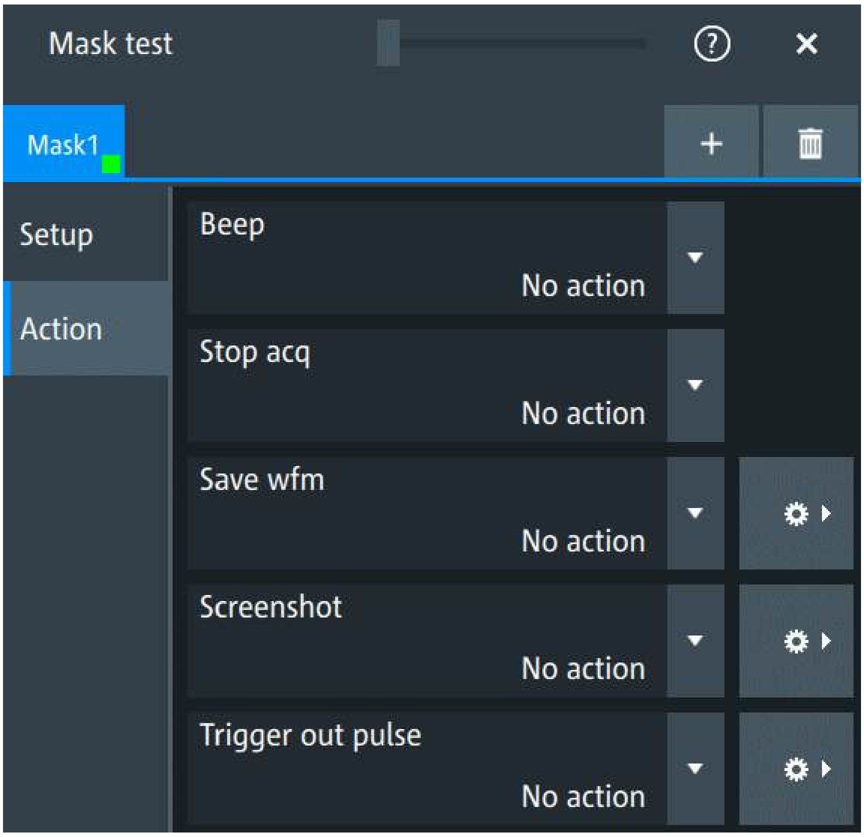
Remote command:

`MTESt<m>:SEGMent<n>:POINt<o>:REMove` on page 1056

`MTESt<m>:SEGMent<n>:REMove` on page 1057

12.1.4 Actions on mask test results

Access: "Menu" > "Apps" > "General" tab > "Masks" > "Action" tab



The action settings define what happens when an acquisition passes the mask test successfully, or when it hits the mask. All available actions can be initiated at the same time.

Beep

Generates a beep sound.

Remote command:

`MTESt<m>:ONViolation:BEEP` on page 1058

`POWer<m>:SOA:MTESt<n>:ONViolation:BEEP` on page 1137

Stop acq
Stops the acquisition on completion or violation.

Remote command:
`MTESt<m>:ONViolation:STOP` on page 1059
`POWer<m>:SOA:MTESt<n>:ONViolation:STOP` on page 1137

Save wfm
Saves the waveform data to a file according to the folder, filename and extension settings in the "Menu" > "Save/recall" > "Save" > "Waveform" dialog.

To select the waveforms and adjust the file path, tap the settings icon.

See also Section 13.2.2, "Saving waveforms", on page 406.

Remote command:
`MTESt<m>:ONViolation:WFMSave` on page 1060
`POWer<m>:SOA:MTESt<n>:ONViolation:WFMSave` on page 1138

Screenshot
Saves a screenshot according to the settings in the "Menu" > "Save/recall" > "Save" > "Screenshot" dialog.

To adjust the screenshot settings, tap the settings icon.

See also Section 13.6, "Screenshots", on page 425.

Remote command:
`MTESt<m>:ONViolation:SCReenshot` on page 1058
`POWer<m>:SOA:MTESt<n>:ONViolation:SCReenshot` on page 1137

Trigger out pulse
Selects, if a pulse is provided to the [Trigger Out] connector on the rear panel. The trigger-out signal is used to synchronize the measurements of other instruments.

To adjust the outgoing signal, tap the settings icon.

Remote command:
`MTESt<m>:ONViolation:TRIGgerout` on page 1059
`POWer<m>:SOA:MTESt<n>:ONViolation:TRIGgerout` on page 1138

12.1.5 Working with masks

This section explains step by step how mask tests are configured. For the explanation of the individual settings, see Section 12.1.2, "Mask test setup: general settings", on page 316.

12.1.5.1 Working with masks using the toolbar

To create a mask graphically using the toolbar

1. Select the "Add mask" icon on the toolbar. If the icon is not visible, configure the toolbar as described in Section 4.6.2, "Configuring the toolbar", on page 65.

2. In the "Add mask" overlay menu, select the channel that you want to test against the mask.

3. In the overlay menu, the "Add mask" function is selected. Draw the diagonal of the rectangle on the screen.
4. Now, the "Add segment" function is selected in the overlay menu. Draw another segment on the screen.
5. If you need another mask, select "Add mask". Draw the first segment of the new mask.
6. To finish the mask definition, close the overlay menu.

   The mask test is enabled by default. If the acquisition is running, the mask test starts automatically and immediately. Otherwise, start the acquisition to start the test.

To modify a mask using the toolbar

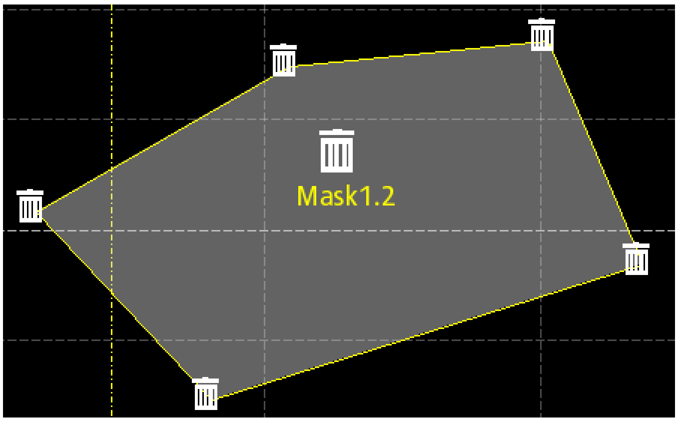
You already have created a mask and want to change its shape and add segments.

1. Select the mask segment in the diagram.

   The segment is marked and the overlay menu opens. One of the points is selected by default, and its coordinates are shown.

2. In the diagram, you can change the shape of the mask segment:
   - To move the segment, tap in the segment, hold and move it.
   - To move an edge, tap and hold the edge and move it.
   - To move a point, tap and hold the point and move it.
3. The overlay menu provides more functions.
   To add a point to the selected segment:
   a) Select "Add point" in the overlay menu.
   b) Tap outside the segment, hold and move the point to the required position.
4. To delete a segment or point:

a) Select "Delete" in the overlay menu.



b) To delete a point, tap its delete icon.
c) To delete the segment, tap the "Delete" icon inside the segment.

5. To enter the exact coordinates of a point:
   a) Select the mask segment and the point in the diagram.
   b) In the overlay menu, change the X- and Y-values.
6. To change the waveform to be tested, select "Source" in the overlay menu.

12.1.5.2 Working with masks using the dialog

1. Open the "Mask test" dialog: "Menu" > "Apps" > "General" tab > "Masks" > "Setup" tab.
   If there is already at least one defined mask, tap its result table to open the dialog.
2. Select "Delete mask" to create the first mask. To create more masks, use the ⊞ icon.
3. Select the "Source", the waveform to be tested.
4. Select "Edit segments".
5. Select the "Shape" of the new segment.
6. Select "Add segment".
   The new segment is listed in the dialog and shown in the diagram.
7. Under "Edit segments", select the segment.
8. Change the X- and Y-values as needed.
9. To name the segment, select "Segment name". Enter the name.
10. To add more points, use "Add +".
11. To delete points:
    a) Select 🗑.
    b) To delete one point, select the delete icon in its table row.

c) To delete all points, select "Delete all"
d) To leave the delete mode, tap the blue delete icon.

12. Select "Back" twice to finish the segment setup.
13. In the "Setup" tab, enable the test if it is off.
14. If the acquisition is running, the mask test starts automatically and immediately. Otherwise, start the acquisition to start the test.

12.1.5.3 Setting up a mask test

In addition to the mask definition, you can define the actions to be taken if a test has failed or completed successfully.

1. Open the "Mask test" dialog: "Menu" > "Apps" > "General" tab > "Masks".
2. Select the "Action" tab.
3. For each action, select when the action will be executed:
   - No action
   - On successful completion
   - On violation of the mask
4. For the actions "Save wfm" and "Trigger out pulse", tap the ⚙ icon and configure the settings.

12.1.5.4 Running a mask test

You can perform continuous testing with "Run / stop" or test a specified number of acquisitions with "Run single". If the test is enabled in the "Setup" tab, the test starts when the acquisition starts. The test runs until the acquisition is stopped.

12.1.5.5 Saving and loading masks

Mask definitions are remained until they are changed or deleted, or a preset is performed. If you want to keep a mask definition, you can save and reload it.

To save a mask

1. Open "Menu" > "Apps" > "General" tab > "Masks" > "Setup" tab.
2. Select "Save mask".
3. Select "Save as".
4. In the file browser, select the directory and enter the filename. The format of the mask file is always `.xml`.
5. Select "Save". If the specified file already exists, it is overwritten with the new data.

To load a mask

1. In the "Masks" >"Setup" tab, select "Load mask".
2. In the file browser, select the mask file.
3. Select "Open".

12.1.5.6 Mask testing on history waveforms

In the same way as for running acquisitions, you can set up and perform the mask testing on history waveforms.

1. Perform and finish the acquisition.
2. Define the mask, and enable the test. See Section 12.1.5.1, "Working with masks using the toolbar", on page 321 and Section 12.1.5.2, "Working with masks using the dialog", on page 323.
3. Set up the test actions. See Section 12.1.5.3, "Setting up a mask test", on page 324.
4. Select "Menu" > "Acquisition" > "History".
5. Activate "Show history".
6. Select "Play".

12.2 Frequency response analysis (option R&S MXO4-K36)

The frequency response analysis (FRA) option lets you perform low-frequency response analysis on your oscilloscope. It characterizes the frequency response of a variety of electronic devices, including passive filters and amplifier circuits. For switched-mode power supplies, it measures the control loop response (CLR) and power supply rejection ratio (PSRR).

The FRA option uses the oscilloscope's built-in waveform generator to create stimulus signals ranging from 10 mHz to 100 MHz. Measuring the ratio of the stimulus signal and the output signal of the DUT at each test frequency, the oscilloscope plots gain and phase logarithmically.

Having both time and frequency domain views allows you to monitor if the injected signal causes distortion that leads to errors in the measurement.

12.2.1 About the frequency response analysis plot

FRA plot display

The FRA plot display is divided into several sections.

Figure 12-2: FRA plot display

1 = Toolbar
2 = Progress bar
3 = FRA result table
4 = Marker value table
5 = Margin value table
6 = Exit app button
7 = Inactive waveforms
8 = Active waveforms and plots
9 = FRA controls
10 = FRA plot diagram, gain: blue color; phase: red color; amplitude: green color; reference: white color
11 = Channel diagram

Progress bar

Displays the current status of the measurement: how many points have already been displayed and the total set number of points.

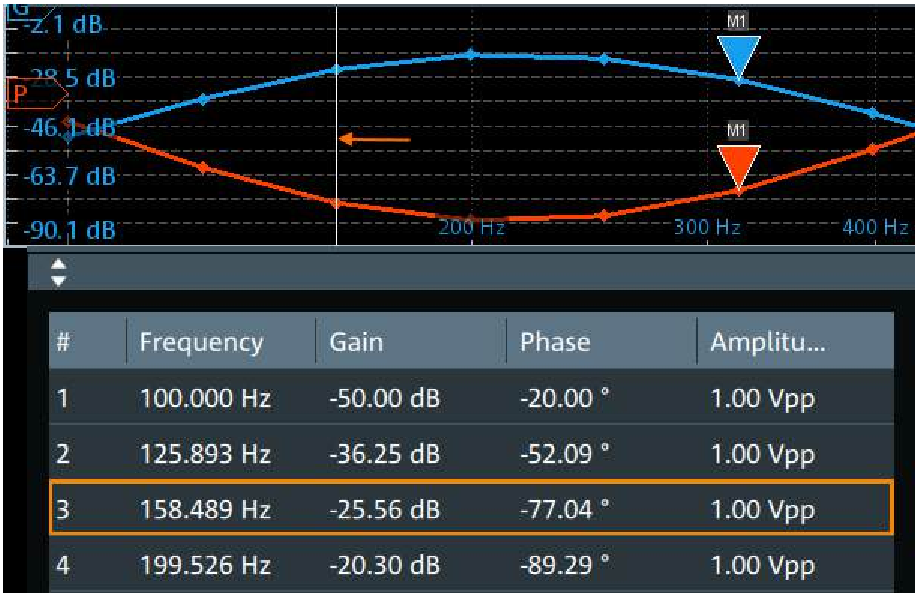
FRA plot diagram

The FRA plot diagram has the frequency presented on the x-axis. The gain (blue color waveform in the image) and phase (red color waveform) scales are on the y-axis. The gain plot represents the ratio between input and output. The phase plot shows the phase shift between input and output.

For better visibility and distinguishability, FRA waveforms and their reference wave-forms have their own color category in "Settings" > "Appearance" > "Colors" > "Cate-gory". You can change the color assignment and assign another color or a color table to FRA waveforms. See Section 5.3.1, "Colors", on page 95 for details.

FRA plot result table

In the FRA plot result table, all sample points are displayed with the respective value for the frequency, gain, phase and amplitude. If you select a sample in the table, the respective points in the FRA plot are highlighted by a white vertical helper line on the gain and the phase curve.



#	Frequency	Gain	Phase	Amplitu...
1	100.000 Hz	-50.00 dB	-20.00 °	1.00 Vpp
2	125.893 Hz	-36.25 dB	-52.09 °	1.00 Vpp
3	158.489 Hz	-25.56 dB	-77.04 °	1.00 Vpp
4	199.526 Hz	-20.30 dB	-89.29 °	1.00 Vpp

Marker value table

There are two markers available for the FRA plot. They are highlighted on the FRA plot diagram by a white line and the respective marker number 1 or 2. You can move the markers as needed.

In the marker table you can see the frequency, phase and gain values for both of them.

Remote commands:

- `FRANalysis:MARKer<m>:FREQuency` on page 1077
- `FRANalysis:MARKer<m>:GAIN?` on page 1077
- `FRANalysis:MARKer<m>:PHASe?` on page 1077

Margin value table

The margin value displays the gain and the phase margin frequency and value of the system. Higher margin values are an indicator for higher stability of the system.

Remote commands:

- `FRANalysis:MARGin:STATe` on page 1075
- `FRANalysis:MARGin:GAIN:FREQuency?` on page 1076
- `FRANalysis:MARGin:GAIN:VALue?` on page 1076
- `FRANalysis:MARGin:PHASe:FREQuency?` on page 1076
- `FRANalysis:MARGin:PHASe:VALue?` on page 1076

Vertical position and size of the waveforms

To set the position and the vertical scaling of the gain, phase or amplitude waveforms, select the waveform and use the vertical [Scale] and [Position] (upper knob) knobs.

The remote commands for setting the position and scales of the are described in Section 18.16.2.4, "Frequency response analysis diagram settings", on page 1071.

12.2.2 Using a frequency response analysis

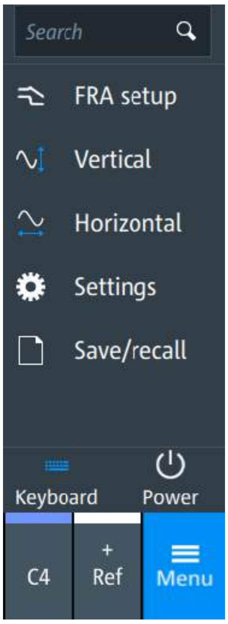
Connecting the test setup

To avoid measurement uncertainties, make sure that the cables connecting the input and the output of your DUT to the oscilloscope are of similar length.

Starting the FRA

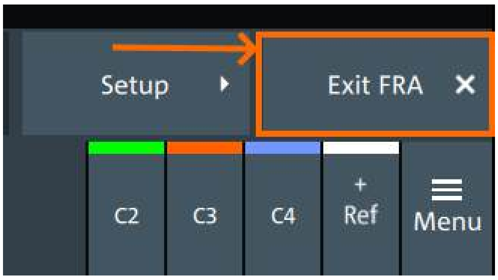
1. Press the [Apps] key.
2. In the "General" tab, tap "FRA".

   The FRA window opens. Only the settings relevant for the FRA setup are visible in the "Menu". The menu includes access to the following dialogs: "Setup", "Vertical", "Horizontal", "Settings", "Save/recall".



Closing the FRA

► Tap the "Exit FRA" button at the bottom-right corner of the display.



12.2.3 Dependencies of the measurement setup

When performing the FRA measurement, consider the following dependencies on parameters from the "Vertical" menu.

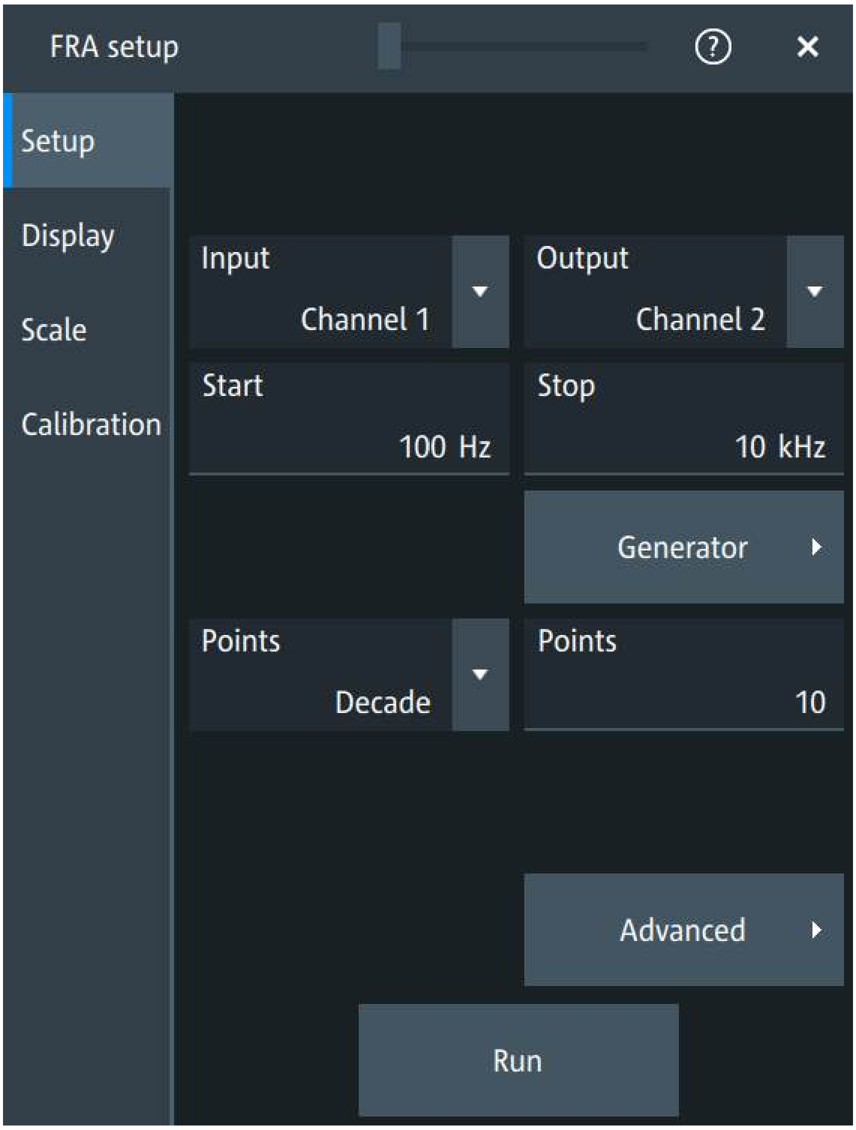
- Coupling:
  - For frequencies smaller than 10 Hz, the "Coupling" on page 135 is set to DC.
  - For frequencies higher than 10Hz, you can select a Coupling manually. The default set value is AC.
- The bandwidth value is changed to a higher value, if the selected bandwidth is smaller than double the stop frequency.
- If the bandwidth of the connected probe is lower than the "Stop" frequency, a warning is shown.

12.2.4 Settings for frequency response analysis

The following sections describe the settings that you can define for the frequency response analysis.

12.2.4.1 Setup

Access: [Apps] > "General" > "FRA" > "Setup".



The "Setup" tab provides the analysis settings and access to the generator setup and advanced settings.

Input
Sets the channel for the input signal of the DUT.

Remote command:
`FRANalysis:INPut[:SOURce]` on page 1065

Output
Sets the channel for the output signal of the DUT.

Remote command:
`FRANalysis:OUTPut[:SOURce]` on page 1067

Start, Stop
Set the start and stop frequency of the sweep.

Remote command:
FRANalysis:FREQuency:STARt on page 1063
FRANalysis:FREQuency:STOP on page 1064

Generator
See Section 12.2.4.2, "Generator settings", on page 331.

Points
Selects if the number of points is measured as total or per decade and sets the number of points.

Remote command:
FRANalysis:POINts:TOTal on page 1068
FRANalysis:POINts:MODE on page 1068
FRANalysis:POINts:LOGarithmic on page 1067

Run
Starts the frequency response analysis.

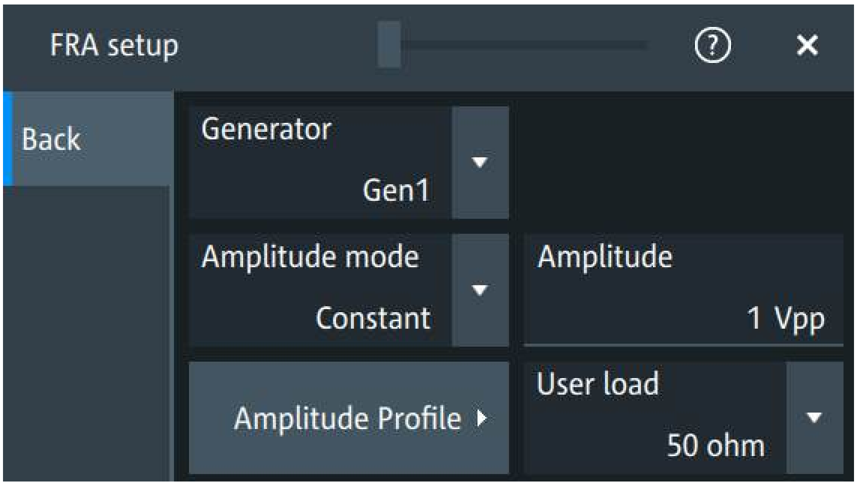
Remote command:
FRANalysis:STATe on page 1062

Repeat
Repeats the measurement, using the same parameters.

Remote command:
FRANalysis:REPeat on page 1068

12.2.4.2 Generator settings

Access: [Apps] > "General" > "FRA" > "Setup" > "Generator".



The dialog provides the settings for the generator.

Generator
Selects the built-in generator to start a frequency sweep for a defined frequency range.

Remote command:
`FRANalysis:GENerator[:CHANnel]` on page 1065

Amplitude mode
Selects, if the amplitude is a constant value ("Amplitude") or is defined as an amplitude profile.

Remote command:
`FRANalysis:AMPLitude:MODE` on page 1063

Amplitude
Sets a fixed amplitude for the frequency response analysis.

Remote command:
`FRANalysis:GENerator:AMPLitude` on page 1064

Amplitude profile
Opens a dialog to set the amplitude profile. See Section 12.2.4.3, "Amplitude profile", on page 332.

You can then define different amplitudes for different frequencies. The amplitude profile is useful when testing sensitive circuits, where the amplitude gets too high. In this case, distortion can occur.

If this function is enabled, a green-colored diagram of the amplitudes for the different frequencies can be displayed on the screen.

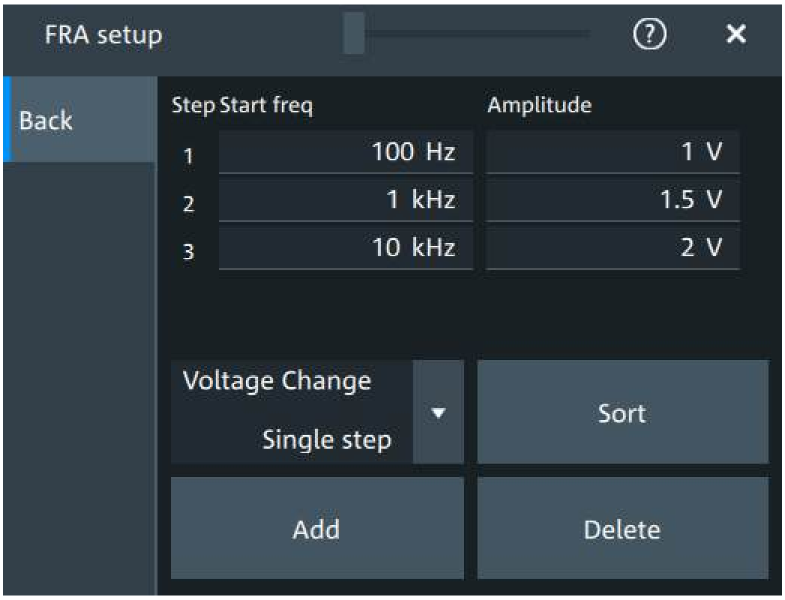
Remote command:
`FRANalysis:AMPLitude:MODE` on page 1063
`FRANalysis:AMPLitude:ENABle` on page 1073

User load
Selects the generator voltage display for 50Ω or high impedance load.

Remote command:
`FRANalysis:GENerator:LOAD` on page 1064

12.2.4.3 Amplitude profile

Access: [Apps] > "General" > "FRA" > "Setup" > "Amplitude profile".



Opens a dialog to set the amplitude profile. You can then define different amplitudes for different frequency, and also the number of points (steps) in the profile. The amplitude profile is useful when testing sensitive circuits, where the amplitude gets too high. In this case distortion can occur.

Step start freq, Amplitude

Set the frequency and amplitude values for the selected step.

Remote command:
`FRANalysis:AMPLitude:PROFile:POINt<m>:AMPLitude` on page 1070
`FRANalysis:AMPLitude:PROFile:POINt<m>:FREQuency` on page 1070

Voltage change

Selects if the voltage change is done as a single step or as a ramp.

Remote command:
`FRANalysis:AMPLitude:PROFile:MODE` on page 1070

Add

Adds a new step to the amplitude profile.

Remote command:
`FRANalysis:AMPLitude:PROFile:APOint` on page 1069
`FRANalysis:AMPLitude:PROFile:COUNt` on page 1069

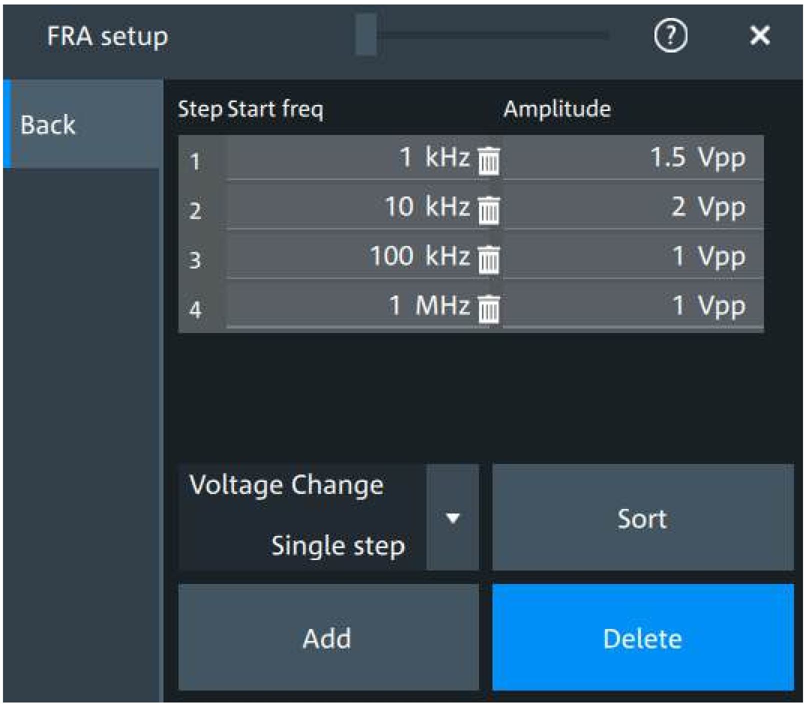
Sort

Sorts the steps in the amplitude table by frequency, starting with the lowest frequency.

Remote command:
`FRANalysis:AMPLitude:PROFile:SORT` on page 1070

Delete

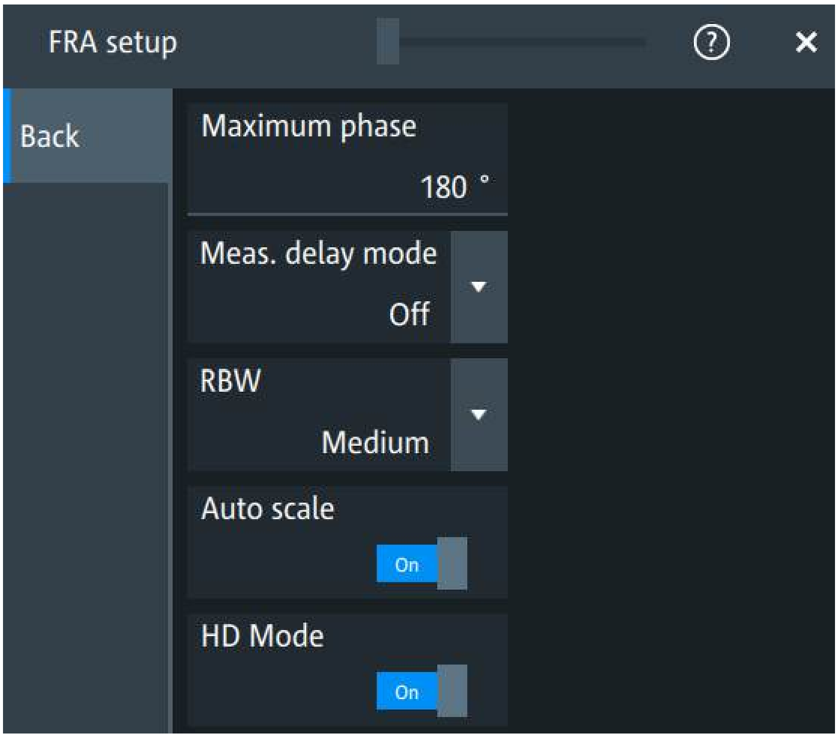
If enabled, a delete icon appears next to each step in the amplitude profile table. Tap the icon to delete the step.



Remote command:
FRANalysis:AMPLitude:PROFile:POINt<m>:REMove on page 1069

12.2.4.4 Advanced

Access: [Apps] > "General" > "FRA" > "Setup" > "Advanced".



Maximum phase

Sets the upper boundary of the vertical phase window.

The lower boundary is given by "Maximum phase" - 360°.

By default, the "Maximum phase" is set to 180° for a phase window ranging from -180° to 180° accordingly.

Remote command:
`FRANalysis:PHASe:MAXimum` on page 1068

Meas. delay mode, Delay time, Delay period

Selects the type of delay that the system waits before measuring the next point of the plot. Delay is helpful in systems that need more time to adapt to the new frequency, for example if filters with significant time group delays are present. You can select a time delay and set the "Delay time", or a period delay and set the "Delay period".

Remote command:
`FRANalysis:MEASurement:DELay:STATe` on page 1065
`FRANalysis:MEASurement:DELay:MODE` on page 1065
`FRANalysis:MEASurement:DELay[:TIME]` on page 1066
`FRANalysis:MEASurement:DELay:PERiod[:NUMBer]` on page 1066

RBW

Sets the resolution bandwidth, which determines the number of measurements that are used for creating the plot.

"High (fast)" A high RBW value is useful for obtaining a general understanding of a system's behavior over a wide frequency range. The accuracy of the measurement is not as good, but the measurement is completed fast.

"Medium" A medium RBW value is a compromise between the measurement time and measurement accuracy.

"Low (slow)" A low RBW value allows for a more detailed analysis of the system. Since more data needs to be collected, the measurement time can increase significantly.

Remote command:
`FRANalysis:MEASurement:RBW` on page 1067

Auto scale
If enabled, the vertical scaling of input and output channel is done automatically for every new measurement frequency point.

That guarantees a non-disturbed signal and a maximum of measurement resolution.

For Coupling = "DC", the channel offset is also changed to compensate the signal offset.

The function is disabled if calibration is active.

Remote command:
`FRANalysis:AUToscale` on page 1063

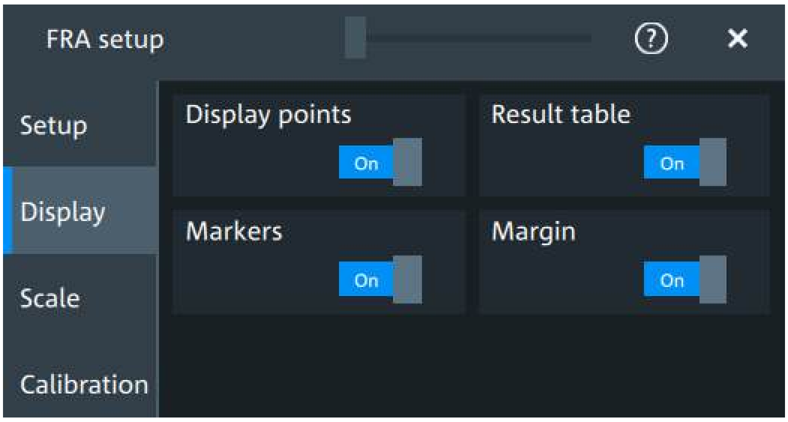
HD mode
Disables the HD mode, which is active by default. In particular, disable the HD mode if you analyze switching peaks.

The frequency in HD mode must be at least 3 times the current frequency. The bandwidth filter of the channel is adjusted automatically to the generator frequency.

Remote command:
`FRANalysis:HDEFinition[:ENABle]` on page 1065

12.2.4.5 Display

Access: [Apps] > "General" > "FRA" > "Display".



In this dialog, you can select which elements are displayed in the FRA diagram.

Display points
Enables the display of the measurement points for the frequency response analysis.

Remote command:
`FRANalysis:MEASurement:POINt[:DISPlay]` on page 1067

Result table
Enables the display of the result table for the FRA.

Remote command:
`FRANalysis:RESult:STATe` on page 1075

Markers
Enables the display of the marker table for the FRA.

Remote command:
`FRANalysis:MARKer<m>:STATe` on page 1076

Margin
Enables the display of the margin table for the FRA.

Remote command:
`FRANalysis:MARGin:STATe` on page 1075

12.2.4.6 Scale

Access: [Apps] > "General" > "FRA" > "Scale".

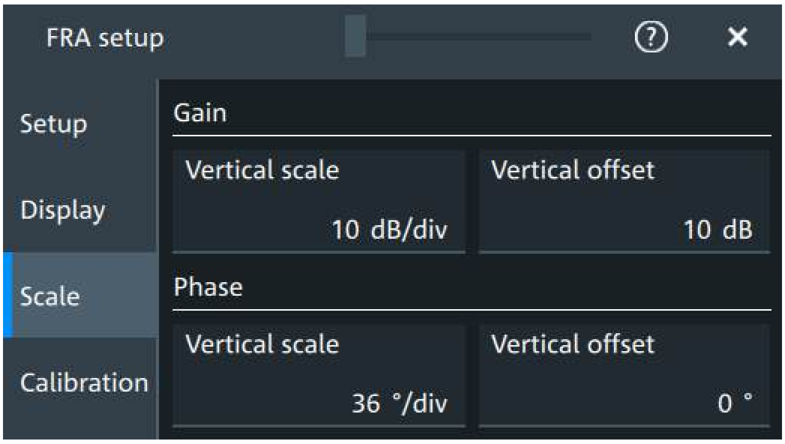


Figure 12-3: Scale dialog for Mode = Gain/Phase

Vertical scale
Sets the scale of the y-axis in the function diagram.

Remote command:
`FRANalysis:PHASe:SCALe` on page 1072
`FRANalysis:GAIN:SCALe` on page 1073

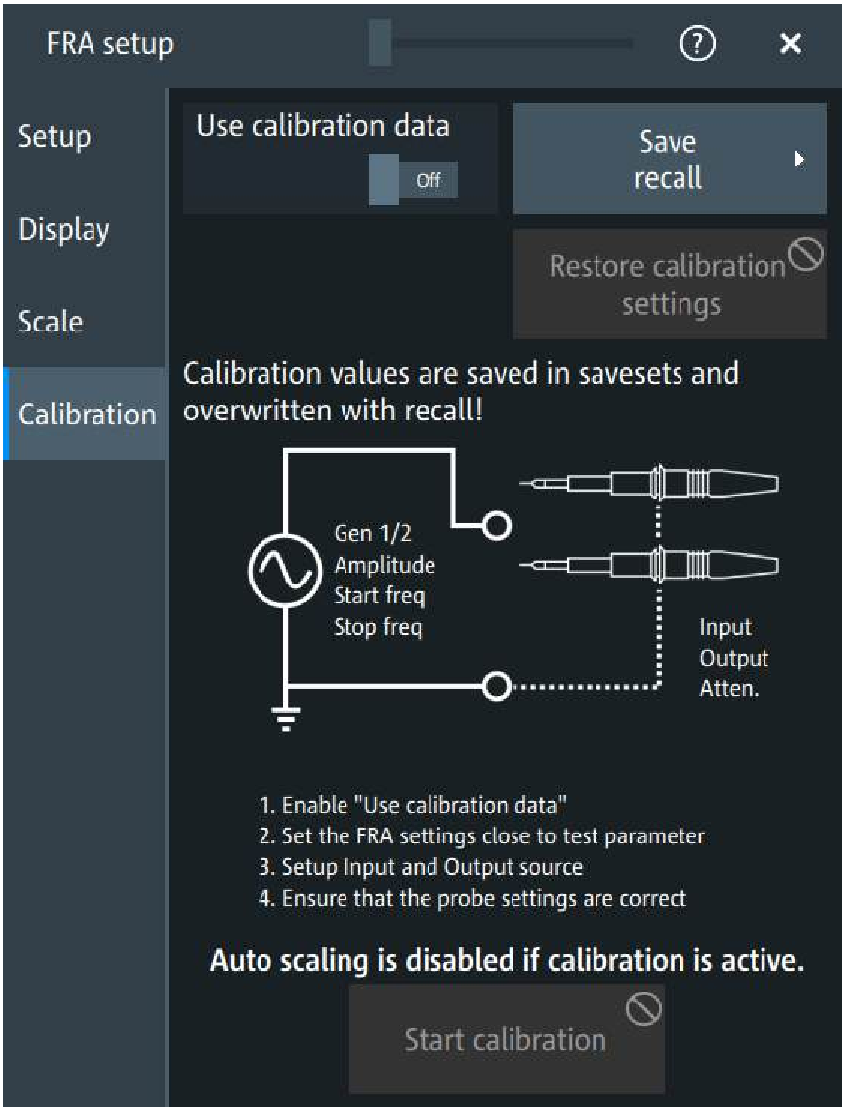
Vertical offset
Sets a voltage offset to adjust the vertical position on the screen.

Remote command:
`FRANalysis:PHASe:OFFSet` on page 1072
`FRANalysis:GAIN:OFFSet` on page 1073

12.2.4.7 Calibration

Calibration is used to compensate the electrical parameter of probes, cables, connectors or fixtures.

Access: [Apps] > "General" > "FRA" > "Calibration".



Test setup considerations

Example of a calibration test setup shows an example of a test setup, where the input probe is connected to [C1] and the output probe is connected to [C2]. The input is also connected to the ARB generator.

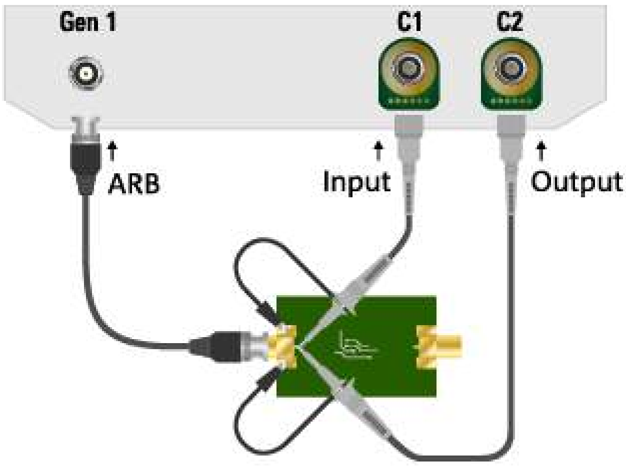


Figure 12-4: Example of a calibration test setup

Input = [C1], [Gen1]
Output = [C2]

Consider also the following:
- Calibration for FRA is only possible with probes connected to the input and output channels.
- For best FRA calibration results, shorten the DUT and place the probe tips as near as possible to each other.
- If there is a fixture for the DUT, it should be part of the calibration setup.
- If the DUT needs a termination, it is to be conducted with an external termination direct on DUT output / input.

Calibration state

Once the calibration is started, a label is shown in the toolbar.

The calibration label displays the status of the calibration. The following states are available:
- "Valid": calibration values are used
- "Invalid": device settings changed
- "Running": a calibration cycle is running
- "None": not performed or no data

Settings influencing calibration

Calibration is only valid for the settings that are active during its execution. If one of the following settings is changed, the calibration becomes "Invalid":
- "Input" and "Output" channel
- "Channel coupling" and "Bandwidth"
- "Channel scaling"

- "Generator"
- "User load"
- "Amplitude mode"
- "Amplitude profile"
- "Amplitude profile" > "Voltage change"
- "Start" frequency
- "Stop" frequency
- "Points" mode and total points
- "Meas. delay mode"
- "Delay time"
- "RBW"

If calibration is active, "Auto scale" is disabled.

To perform a calibration

1. Enable "Use calibration data".
2. Set the FRA settings close to the test parameters.
3. Select the Input and Output source.
4. Ensure that the probe settings are correct.

The following settings are available for the calibration:

Use calibration data
If enabled, the user calibration data is used for the frequency response analysis.

Remote command:
`FRANalysis:CALibration:STATe` on page 1071

Save/Recall
Opens the "Save/Recall" dialog. You can save the instrument setting in a saveset, and load existing savesets. For details, see Section 13.1, "General and measurement settings: savesets", on page 397.

The saveset includes the calibration data. If you load a saveset, the current calibration values are overwritten.

Restore calibration settings
Restores the FRA settings to the values that were selected during the calibration process. Restore allows you to perform further measurements with a valid calibration state. See also "Settings influencing calibration" on page 339.

To keep and restore calibration settings in remote control, set up and calibrate the frequency analysis, and save the instrument settings in a saveset. When you load this saveset later, the calibration data is restored together with the instrument settings.

Start calibration
Starts the calibration. The button is only enabled if there is a valid test setup.

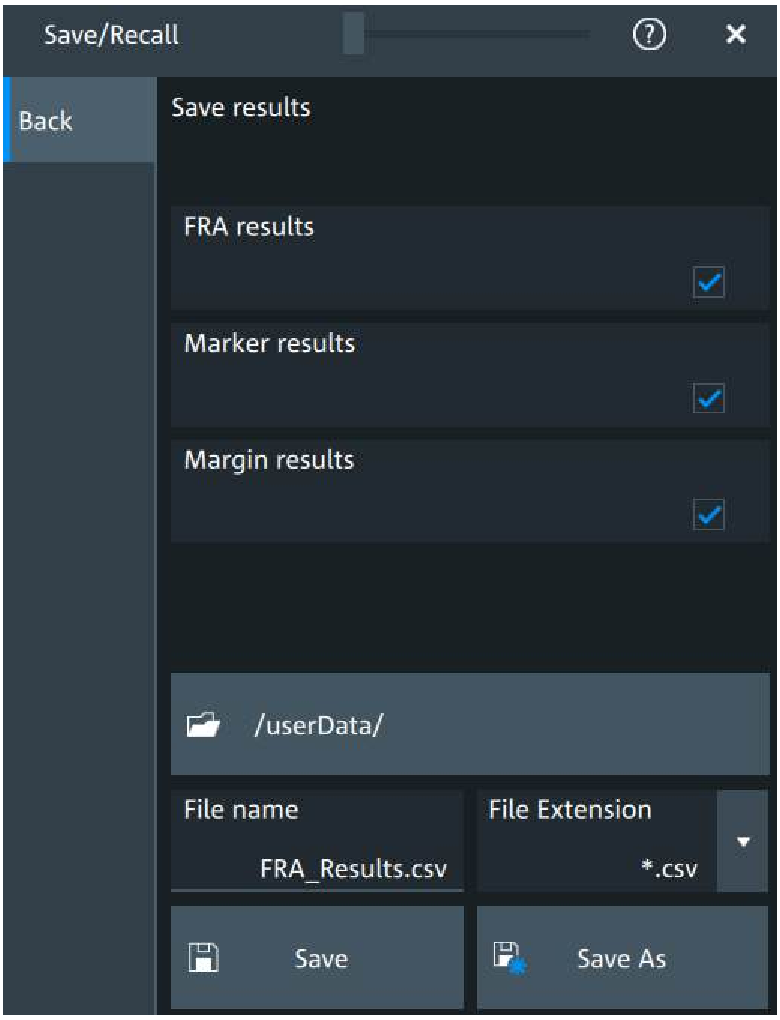
The state of the calibration process is displayed in the calibration label in the toolbar.

After a calibration is performed successfully, the calibration values are saved automatically.

Remote command:
`FRANalysis:CALibration:CALibration` on page 1071
`FRANalysis:CALibration:RESult?` on page 1071

12.2.5 Saving results of frequency response analysis

Access: [Apps] > "General" > "FRA" > "Setup" > "Save/recall" >"Results".



FRA results
In this dialog, you can select which result values you want to include in your FRA export results file.

The following options are available:
- "FRA results": includes the frequency, gain, phase and amplitude
- "Marker results": includes the marker frequency and gain

- "Margin results": includes the margin gain and phase

Remote command:
`EXPort:RESult:SELect:FRA:MARGin` on page 1083
`EXPort:RESult:SELect:FRA:MARKer` on page 1084
`EXPort:RESult:SELect:FRA:RESult` on page 1084

12.2.6 Reference waveforms of FRA curves

To compare the results of frequency resonse analysis and analyze differences between them, you can use up to 4 specific reference waveforms. These references can be created from gain and phase curves, and from other references.. The type of the source waveform is included in the reference waveform data.

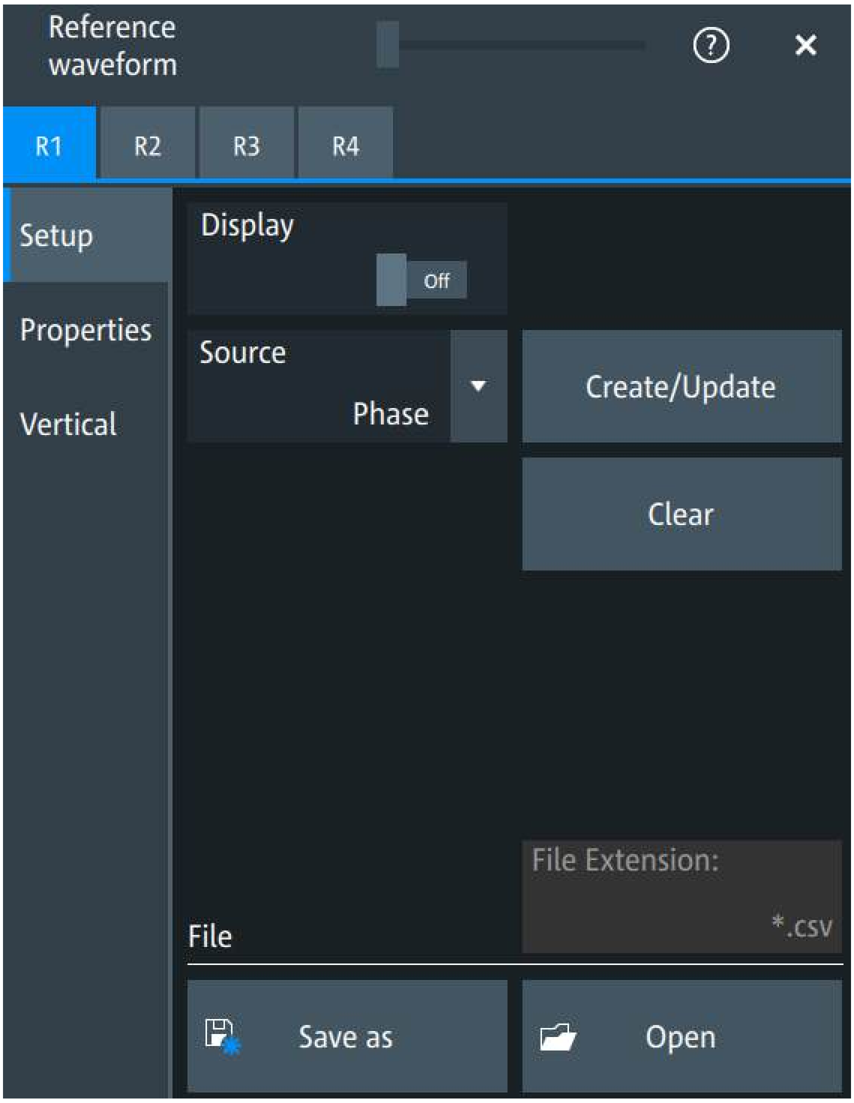
You can save an unlimited number of reference waveforms and load them for further use. Markers are also set on these reference waveforms.

The display of a reference waveform is independent from the display of the source waveform; you can move, stretch and compress the curve vertically. A loaded reference waveform is restored when you leave the FRA mode and enter it again with no preset inbetween. Reference waveforms are aligned horizontally to the actual start and stop position in the waveform diagram.

When a FRA reference waveform is selected, you can change scale and position using the knobs on the front panel.

12.2.6.1 Reference waveform setup

Access: perform a frequency response analysis and display resulting waveforms > select the "+ Ref" signal activator > "Setup" > select reference waveform



In the "Setup" tab, you select the source of the reference waveform and create the reference.

Display

Enables the display of the reference waveform in the diagram. Before you can display it, create the reference waveform.

Remote command:

`FRANalysis:REFCurve<rc>:ENABle` on page 1082

Source

Selects the source waveform of the reference from the existing frequency response waveforms, e.g. gain, phase or an other reference.

Remote command:

`FRANalysis:REFCurve<rc>:SOURce` on page 1081

Create/Update
Copies the selected source waveform with all its settings to the memory of the reference waveform. If there is a previously defined reference waveform in this memory, it is updated by the current source waveform.

A progress bar informs you about the process.

Remote command:
`FRANalysis:REFCurve<rc>:UPDate` on page 1082

Clear
Deletes the selected reference waveform. It disappears from the display, and its memory is deleted.

Remote command:
`FRANalysis:REFCurve<rc>:CLEar` on page 1079

File extension
Shows the file format. Currently, only CSV files are supported.

Save as
Opens a file explorer where you select the folder, enter the filename and save the file. The complete reference waveform is stored in a CSV file and can be reloaded later.

A progress bar informs you about the process.

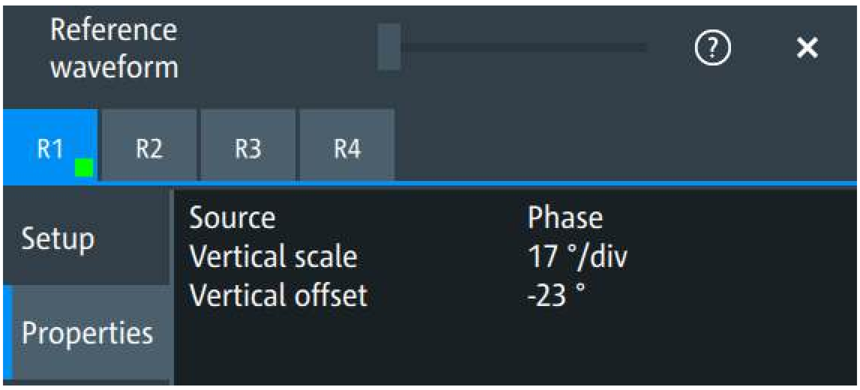
Remote command:
`FRANalysis:REFCurve<rc>:NAME` on page 1080
`FRANalysis:REFCurve<rc>:SAVE` on page 1081
To abort the saving, use `FRANalysis:REFCurve<rc>:ABORt` on page 1079.

Open
Opens a file selection dialog box and loads the selected reference file.

Remote command:
`FRANalysis:REFCurve<rc>:OPEN` on page 1081

12.2.6.2 Reference waveform properties

Access: perform a frequency response analysis and display resulting waveforms > select the "+ Ref" signal activator > "Properties" tab > select reference waveform



A FRA reference waveform can be vertically scaled and positioned in the diagram. The "Properties" tab shows the original settings of the reference waveform, which are stored together with the waveform data.

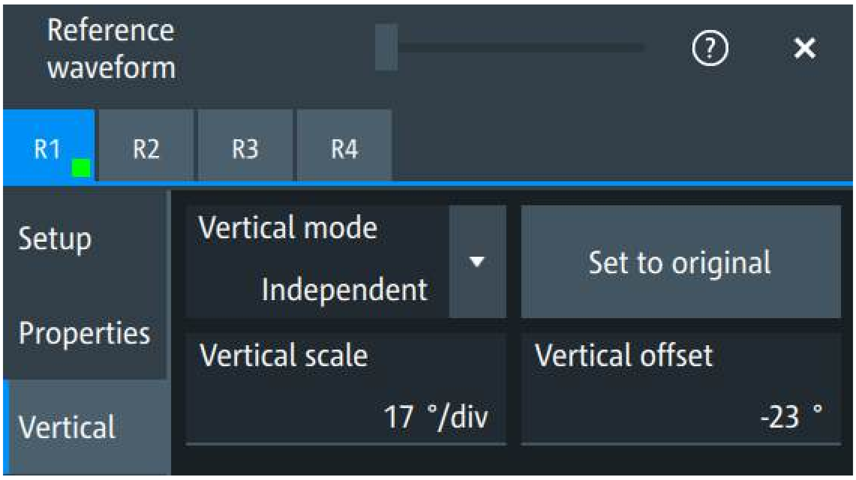
The following settings are displayed:

- Type of the source waveform
- Vertical scale and offset that are defined in the "Scale" tab (Section 12.2.4.6, "Scale", on page 337)

Remote command: `FRANalysis:REFCurve<rc>:DATA:SOURce?` on page 1080.

12.2.6.3 Vertical settings for reference waveforms

Access: perform a frequency response analysis and display resulting waveforms > select the "+ Ref" signal activator > "Vertical" tab > select reference waveform



Vertical mode
Selects the type of vertical settings:

"Coupled to source" Vertical position and scale of the source are used.

"Independent" Scaling and position can be set specific to the reference waveform.

Remote command:
`FRANalysis:REFCurve<rc>:VMODe` on page 1083

Set to original
Available, if "Vertical mode" = "Independent".

Restores the original vertical settings of the reference waveform.

Remote command:
`FRANalysis:REFCurve<rc>:TOORiginal` on page 1082

Vertical scale
Available, if "Vertical mode" = "Independent".

Sets the vertical scale, which defines the displayed amplitude of the selected waveform.

The unit of the reference is the same as the unit of the source waveform.

Remote command:
`FRANalysis:REFCurve<rc>:SCALe` on page 1081

Vertical offset
The vertical offset moves the reference waveform vertically. Enter a value with the unit of the waveform.

Remote command:
`FRANalysis:REFCurve<rc>:OFFSet` on page 1080

12.3 Power analysis (option R&S MXO4-K31)

With the MXO 4 and option R&S MXO4-K31, you can perform power analysis measurements.

For best measurement results, we recommended setting channel Bandwidth = 20 MHz.
If using the HD mode, we recommended setting Bandwidth = 100 MHz.

12.3.1 Power analysis initial settings

In the main "Power analysis" dialog, you select the required power measurements, align the channels and set the offset compensation to get correct measurements.

12.3.1.1 Select power measurements

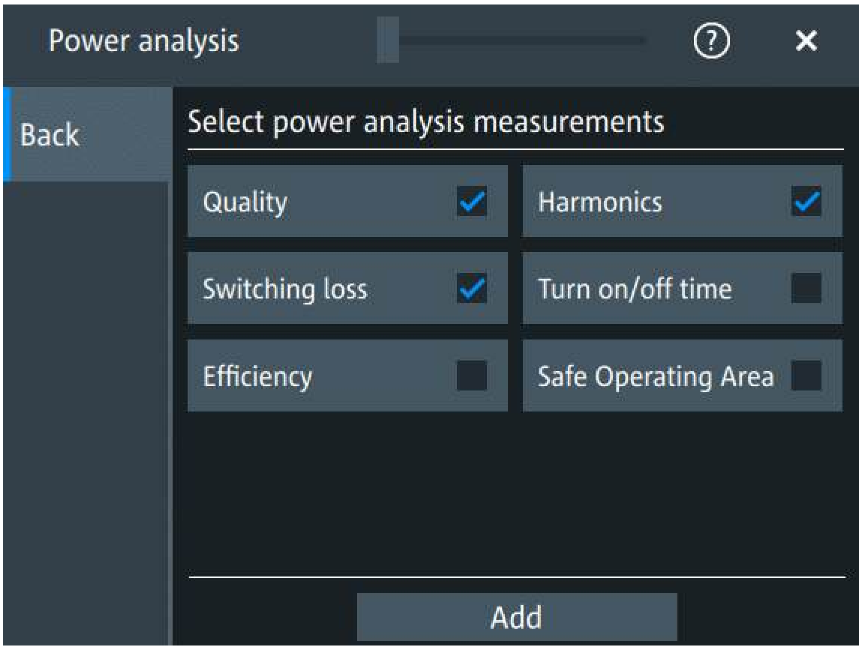
In the "Analysis" tab, you select the power analysis measurements.

You can add up to 3 power analysis measurements, including several instances of the same measurement.

From here, you can access the settings for the enabled power analysis measurements.

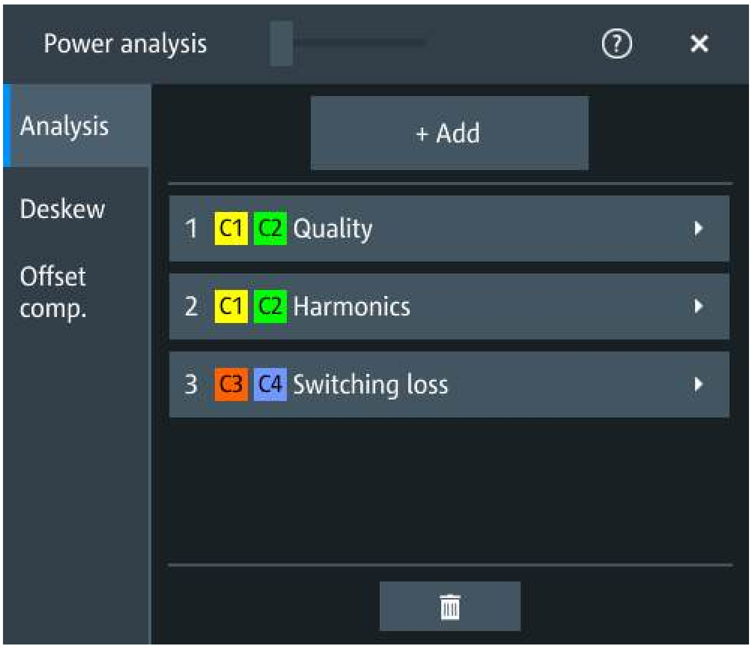
To add a new power measurement

1. Tap the "Menu" > "Apps" > "General" tab > "Power".
2. In the "Analysis" tab, tap "+ Add".



3. Tap a power measurement on the list to enable it.
4. Tap "+ Add" to add the selected measurements.

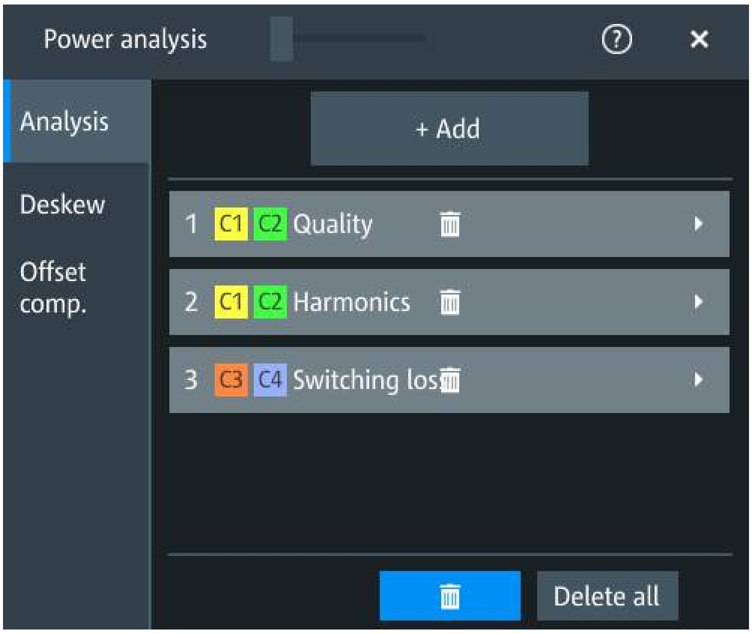
   All selected measurements are enabled.



To delete a measurement

1. Tap the "Menu" > "Apps" > "General" tab > "Power", to open the power measurement dialog.
2. In the "Analysis" tab, tap 🗑.

A delete icon appears in the selection button of each measurement.



3. Tap on the button of the power measurement that you want to delete. Alternatively, tap "Delete All" to delete all measurements.

+ Add

Opens a dialog to select the power analysis measurements. See "To add a new power measurement" on page 346.

Remote command:

POWer<m>[:ENABle] on page 1085

POWer<m>:TYPE on page 1086

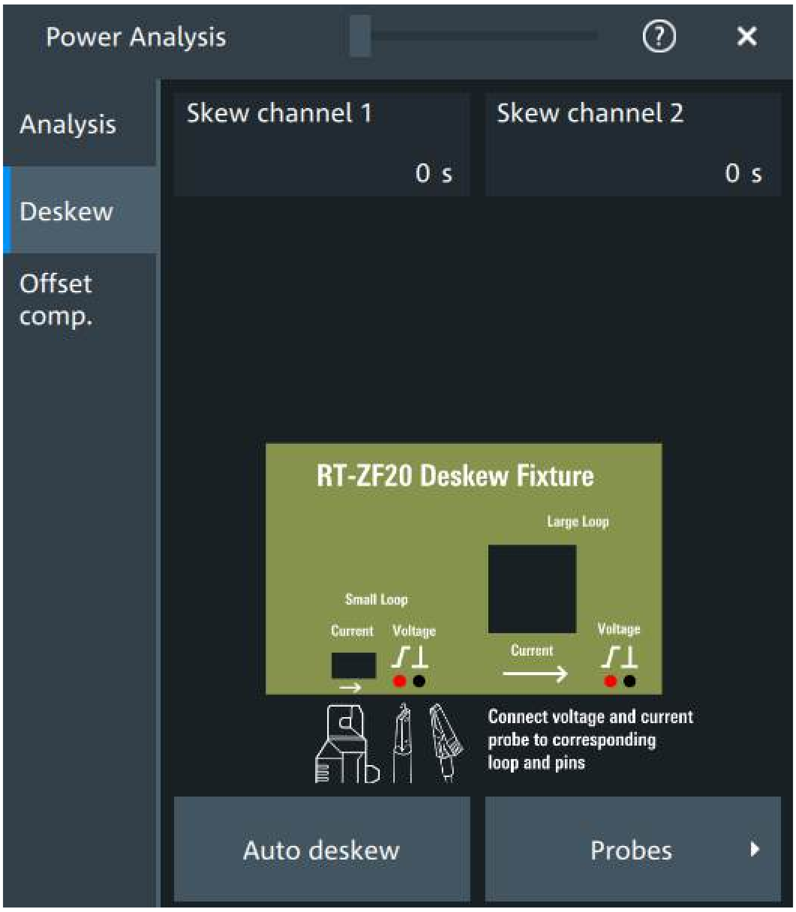
12.3.1.2 Deskew

In the dialog box you can perform a deskew of your current and voltage probes.

Required equipment:

- R&S RT-ZF20 power deskew fixture
- Rohde & Schwarz voltage probe
- Rohde & Schwarz current probe

Deskew settings



Skew channel

Sets user-defined skew settings for the channel connected to the current probe.

Alternatively, you can start an "Auto Deskew".

Auto Deskew

Starts an auto deskew. It is used to determine the trigger and scaling properties.

For an auto deskew, only Rohde & Schwarz probes are supported.

Make sure that the probes are configured correctly before you start the deskewing.

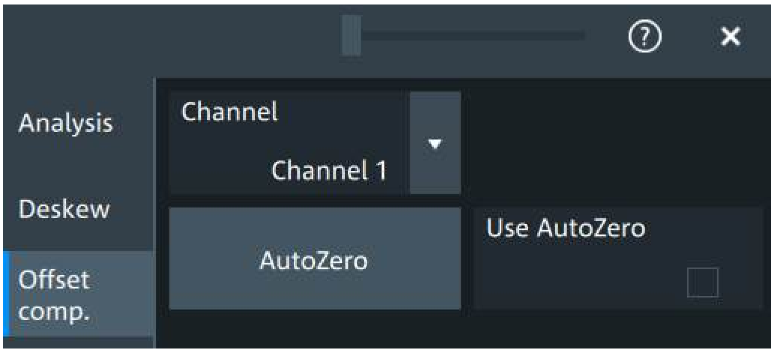
After the deskew, the result values are written in the "Skew" value of the corresponding channel.

If there are more than two active channels, you can perform automatic deskew step by step and exchange the probes connected fixture between the steps.

Remote command:
`POWer<m>:ASKew[:EXECute]` on page 1086

12.3.1.3 Offset compensation

The offset compensation adjustments are applied to all power analysis measurements.



Channel
Select the channel for the offset compensation.

Remote command:
PROBe<ch>:SETup:OFFSet:ZADJust on page 882

AutoZero, Use AutoZero
Voltage probes can have a zero error. The zero error is the voltage appearing at the probe output when nothing is connected to the probe. If a zero error occurs, it results in an external offset and the waveform is not displayed around 0 V.

To correct the zero error of voltage probes, short the signal pin and the ground pin together. Then tap "AutoZero". While the alignment is running, the instrument switches to DC coupling to display the waveform correctly.

To correct the zero error, enable "Use AutoZero".

If a current probe is connected, the function demagnetizes the probe's sensor head and sets the waveform to zero position.

Remote command:
PROBe<ch>:SETup:OFFSet:AZERo on page 870
PROBe<ch>:SETup:OFFSet:USEautozero on page 870

12.3.2 Power quality

In an electric circuit power is a measure for the rate of flow of energy at a certain point of the circuit. The active power of a circuit is the portion of energy that is transferred in one direction over a complete cycle of the AC waveform. The active power is the energy that can be used for work. In AC circuits, however, inductive and capacitive elements can store energy temporarily. This portion of the power flow known as reactive power is then returned to the source without doing any work.

The power quality analysis measurements include the active power, the reactive power, the apparent power and the power factor. The crest factors and the phase angle between the current and voltage are also measured. These properties describe the power transfer in the system and allow you to characterize the power quality of the system.

Required probes:

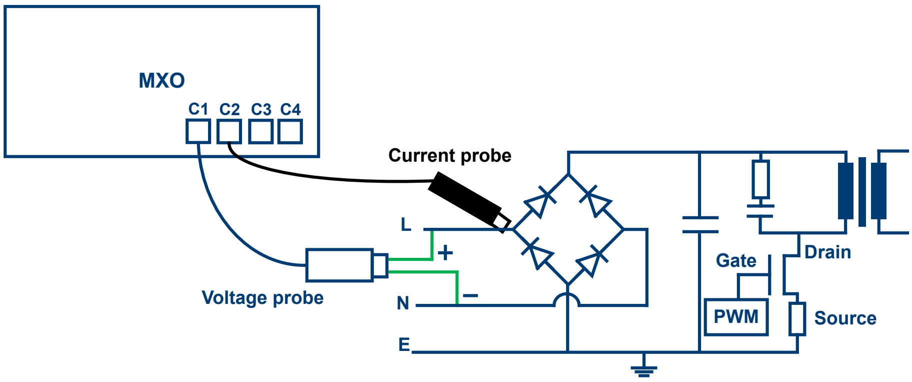
- Differential voltage probe

- Current probe

12.3.2.1 Configuring power quality

For details of the configuration settings, see Section 12.3.1.1, "Select power measurements", on page 346.

1. Add a new power quality measurement as described in "To add a new power measurement" on page 346.
2. Connect the differential voltage probe and the current probe to the oscilloscope.
3. Deskew the probes as described in Section 12.3.1.2, "Deskew", on page 348.
4. Connect the probes to the DUT:



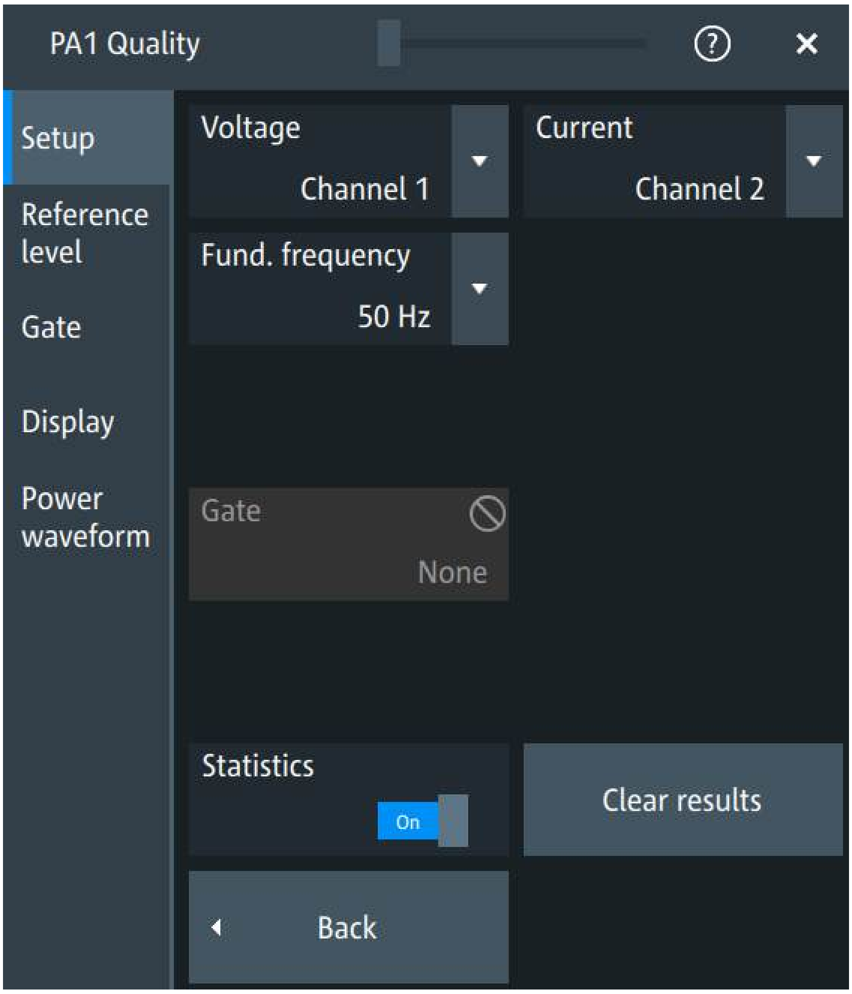
   a) Connect the positive (+) signal socket of the differential voltage probe to the line of the AC input.
   b) Connect the negative (-) signal socket of the differential voltage probe to the neutral of the AC input.
   c) Connect the current probe to the line of the AC input.
5. In the "Analysis" tab, tap the "Quality" measurement.

   The "Quality" setup dialog opens.
6. Select the correct channels for the "Voltage" and the "Current" probes.
7. Set the "Fund. Freq" according to your signal.
8. If necessary, enable "Statistics".

   On the screen, you can see the measurement waveforms of the current, the voltage and the power. Also, the result table with numeric measurement results is shown. For details, see Section 12.3.2.7, "Power quality results", on page 355.

12.3.2.2 Power quality settings

Access: "Menu" > "Apps" > "Power" > "+ Add" > "Quality" > select "Quality" > "Setup".



In the "Setup" tab, you configure the power quality measurement: select the sources, the fundamental frequency, and enable statistics.

Voltage
Selects the voltage source waveform. Analog channels and math waveforms can be used.

Remote command:
`POWer<m>:QUALity:SOURce[:VOLTage]` on page 1088

Current
Selects the current source waveform. Analog channels and math waveforms can be used.

Remote command:
`POWer<m>:QUALity:SOURce:CURRent` on page 1088

Fund. Freq
Selects the input frequency of the source signal.

Remote command:
POWer<m>:QUALity:FREQuency[:VALue] on page 1089
POWer<m>:QUALity:FREQuency:USER on page 1089

Gate
Selects the gate that is used for limiting the range of the power quality measurement.
Define a gate before you select it, see Section 8.2, "Gate setup", on page 209.

Remote command:
POWer<m>:QUALity:GATE on page 1088

Statistics
Activates or deactivates the statistical evaluation for the selected power measurement.
If statistics are enabled, the following results are calculated:

Label	Description
Current	Current value
Max	Maximum value
Min	Minimum value
Mean	Average
RMS	Root mean square
σ (S-dev)	Standard deviation
Event count	Number of measured events
Wave count	Number of waveforms (acquisitions)

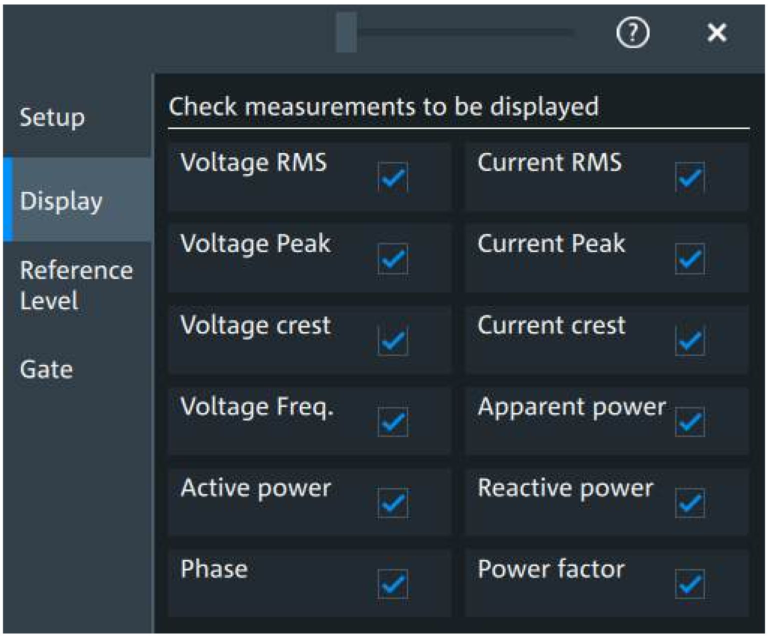
Remote command:
POWer<m>:QUALity:STATistics[:ENABle] on page 1086
POWer<m>:QUALity:STATistics:WFMCount? on page 1087
POWer<m>:SWITching:STATistics:ENABle on page 1086
POWer<m>:SWITching:STATistics:WFMCount? on page 1087
POWer<m>:EFFiciency:STATistics[:ENABle] on page 1086
POWer<m>:EFFiciency:STATistics:WFMCount? on page 1087

Clear results
Resets the statistical results for the respective power measurements, and starts a new statistical evaluation if the acquisition is running.

Remote command:
POWer<m>:QUALity:STATistics:RESet on page 1087
POWer<m>:SWITching:STATistics:RESet on page 1087
POWer<m>:EFFiciency:STATistics:RESet on page 1087

12.3.2.3 Power quality display

In this dialog, you select the power quality analysis measurements that you want to display. For more details on the different measurements, see Section 12.3.2.7, "Power quality results", on page 355.



Remote commands

- POWer<m>:QUALity:DISPlay:CURRent:CRESTfactor on page 1089
  POWer<m>:QUALity:DISPlay:CURRent:PEAK on page 1089
- POWer<m>:QUALity:DISPlay:CURRent:RMS on page 1090
- POWer<m>:QUALity:DISPlay:POWer:APParent on page 1090
- POWer<m>:QUALity:DISPlay:POWer:PFACtor on page 1090
- POWer<m>:QUALity:DISPlay:POWer:PHASe on page 1090
- POWer<m>:QUALity:DISPlay:POWer:REACtive on page 1091
- POWer<m>:QUALity:DISPlay:POWer:REALpower on page 1091
- POWer<m>:QUALity:DISPlay:VOLTage:CRESTfactor on page 1091
- POWer<m>:QUALity:DISPlay:VOLTage:FREQuency on page 1091
- POWer<m>:QUALity:DISPlay:VOLTage:PEAK on page 1092
- POWer<m>:QUALity:DISPlay:VOLTage:RMS on page 1092

12.3.2.4 Reference level

See Section 12.3.8.1, "Reference level", on page 387.

12.3.2.5 Gate

See Section 12.3.8.2, "Gate settings for power measurements", on page 389.

12.3.2.6 Power trace

For a description of the power waveform scaling, see Section 12.3.8.3, "Power waveform", on page 389.

12.3.2.7 Power quality results

The results of power quality measurements are provided in two ways:

- The diagram shows the graphical presentation of:
  – The voltage waveform
  – The current waveform
  – The power waveform, which is the product of the current and voltage waveforms
- The result table displays the numeric measurement results:

Voltage and current results

The voltage and current results are defined as follows:

Result	Description
Current / Voltage RMS	Square root of the mean of the square of the current or voltage averaged over N cycles
Voltage Frequency	Frequency of the signal
Current / Voltage Cycle Crest factor	Peak value / RMS value

Power results

The power in a system is described by several physical quantities:

Result	Unit	Formula	Description
Apparent power, |S|	VA	$\|S\| = V_{RMS} \cdot I_{RMS}$ (averaged over N cycles)	|S| is the magnitude of the vector sum of active and reactive power (the complex power S).
Reactive power, Q	VAR (Volt-Ampere reactive)	$Q = \|S\| \sin\varphi$	Power flow that is temporally stored in a system because of the inductive and capacitive elements.
Power factor, P_{Factor}	-	$P_{Factor} = \|P\| / \|S\|$	Measure of the system efficiency. The value varies between -1 and 1.
Active power, P	W	$P = V_{INSTANTENEOUS} \cdot I_{INSTANTENEOUS}$ (averaged over N cycles)	Energy of the system that can be used to do work.
Phase, φ	°	$\varphi = acos\ (P_{Factor})$	Phase angle between the current and the voltage sine waves.

Remote commands: "Power quality results" on page 1092.

12.3.3 Power harmonics

Current harmonics appear in an electric power system due to nonlinear electric loads. The harmonics can be ejected back into the AC line and disturb other equipment on the grid. To avoid this disturbance, there are often standards of compliance that consumer or industry end-products must meet.

The "Harmonics" analysis tests the devices according to the precompliance standards EN 61000-3-2, MIL-STD-1399 and RTCA DO-160.

Required probes:

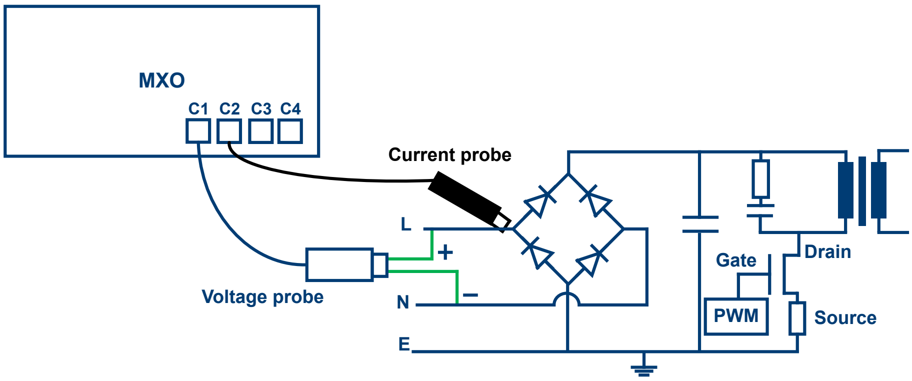
- Differential voltage probe
- Current probe

12.3.3.1 Configuring power harmonics

For details of the configuration settings, see Section 12.3.3.2, "Power harmonic settings", on page 357.

1. Add a new power quality measurement as described in Section 12.3.1.1, "Select power measurements", on page 346.
2. Connect the differential voltage probe and the current probe to the oscilloscope.
3. Deskew the probes as described in Section 12.3.1.2, "Deskew", on page 348.

4. Connect the probes to the DUT:



   a) Connect the positive (+) signal socket of the differential voltage probe to the line of the AC input.
   b) Connect the negative (-) signal socket of the differential voltage probe to the neutral of the AC input.
   c) Connect the current probe to the line of the AC input.

5. In the "Analysis" tab, tap the "Harmonics" measurement.

   The "Harmonics" setup dialog opens.

6. Select the correct channels for the "Voltage" and the "Current" probes.

7. Select the "Standard".

8. Select the "Fund. Freq" according to your signal.

   On the screen, you can see the measurement of the current, the voltage and the power. Also there is a table giving information about important measurement parameters. For details, see Section 12.3.3.6, "Power harmonic results", on page 362.

12.3.3.2 Power harmonic settings

In this tab, you configure the current harmonic measurement parameters and display settings.

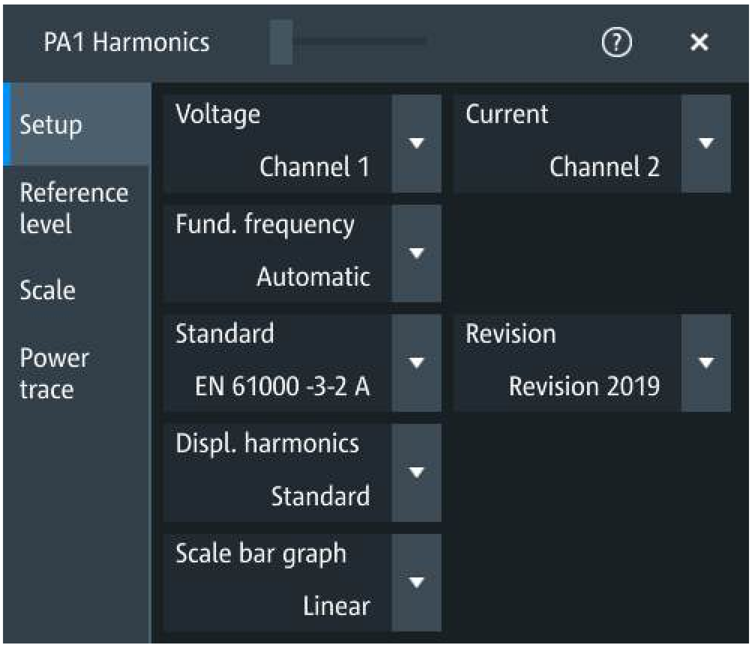


Figure 12-5: Power harmonic setup for EN 61000-3-2 A / EN 61000-3-2 B

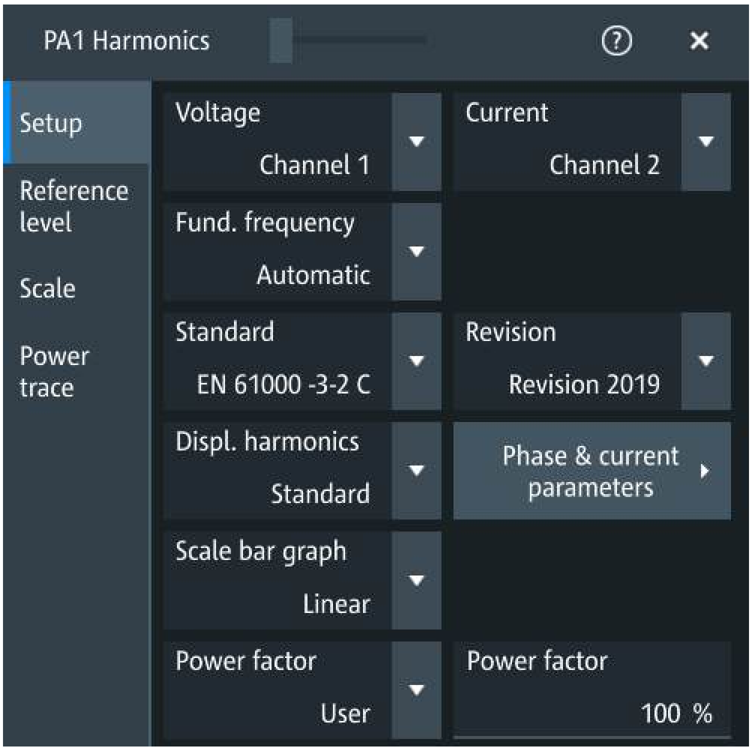


Figure 12-6: Power harmonic setup for EN 61000-3-2 C

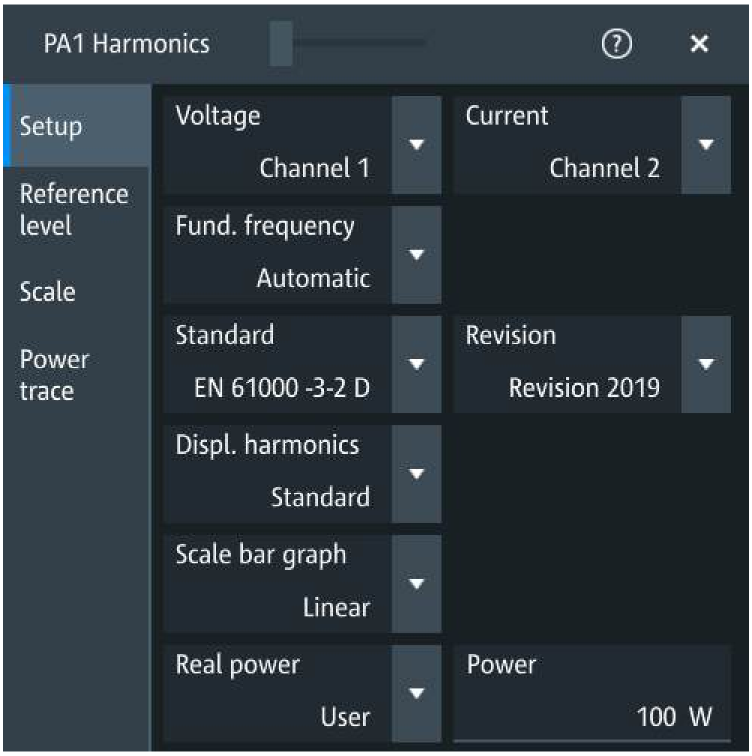


Figure 12-7: Power harmonic setup for EN 61000-3-2 D

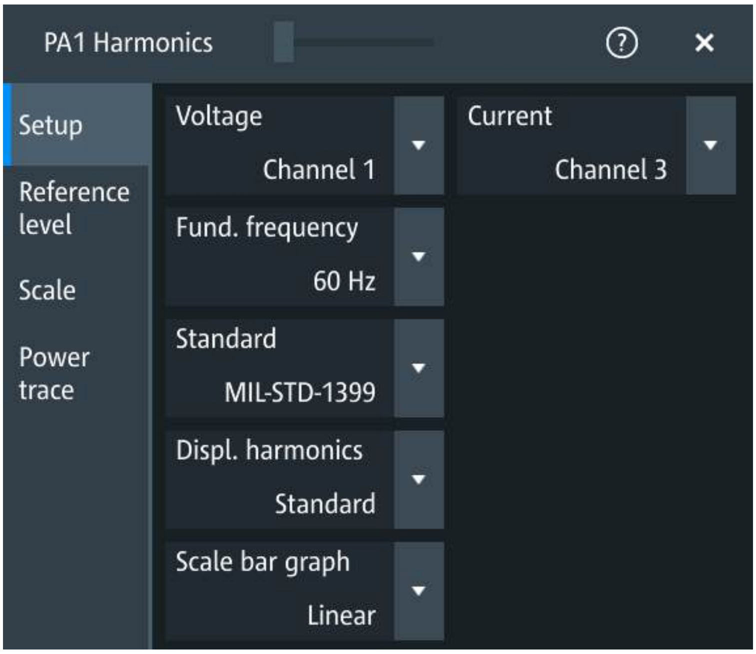


Figure 12-8: Power harmonic setup for MIL-STD-1399/ RTCA DO-160

Voltage
Selects the voltage source waveform. Analog channels and math waveforms can be used.

Remote command:
POWer<m>:HARMonics:SOURce[:VOLTage] on page 1100

Current

Selects the current source waveform. Analog channels and math waveforms can be used.

Remote command:
POWer<m>:HARMonics:SOURce:CURRent on page 1100

Fund. Freq

Selects the frequency of the input signal. The available frequencies depend on the selected Standard.

Remote command:
POWer<m>:HARMonics:FREQuency:EN on page 1101
POWer<m>:HARMonics:FREQuency:MIL on page 1102
POWer<m>:HARMonics:FREQuency:RTCA on page 1102

Standard

Select the standard in use.

For EN 61000-3-2 you can also select which "Revision" of the standard is used, "Revision 2011" or "Revision 2019".

Table 12-1: Current harmonic precompliance standards

Standard	Application
EN 61000-3-2 Class A	Balanced 3-phase equipment, household appliances (excluding equipment identified as class D), tools (excluding portable tools), dimmers for incandescent lamps, audio equipment
EN 61000-3-2 Class B	Portable tools, not professional arc welding equipment
EN 61000-3-2 Class C[1)]	Lighting equipment
EN 61000-3-2 Class D	PC, PC monitors, radio, or TV receivers with an input power less than or equal to 600W
MIL-STD-1399	Military shipboard user equipment
RTCA DO-160	Environmental tests of avionics hardware
[1)] The EN 61000-3-2 defines different limits for EN 61000-3-2 Class C equipment with an input power smaller or equal than 25W either. The limits that are implemented in the MXO 4 firmware comply with the limits of table 3 (column two) of the EN 61000-3-2 standard.	

Remote command:
POWer<m>:HARMonics:STANdard on page 1101
POWer<m>:HARMonics:REVision on page 1101

Displ. Harm.

Selects which harmonics are displayed in the bargraph: all, odd even or depending on the standard definition.

Remote command:
POWer<m>:HARMonics:DISPlay:HARMonics on page 1103

Scale bar graph

Selects a logarithmic or linear scale for the display for the harmonics bargraph.

Remote command:
`POWer<m>:HARMonics:DISPlay:BARGraph:VERTical:SCALe:TYPE`
on page 1104

Power factor

Available only for "Standard" = EN 61000-3-2 Class C.

Selects if the power factor is defined automatically, or a user-defined value ("Power factor") is used.

Remote command:
`POWer<m>:HARMonics:PFACtor[:MODE]` on page 1105
`POWer<m>:HARMonics:PFACtor:USER` on page 1105

Phase & current parameters

Shows a graphical explanation of the relative phase angle and current parameters.

Real power, Power

Available only for "Standard" = EN 61000-3-2 Class D.

Selects if the real power is defined automatically, or a user-defined value ("Power") is used.

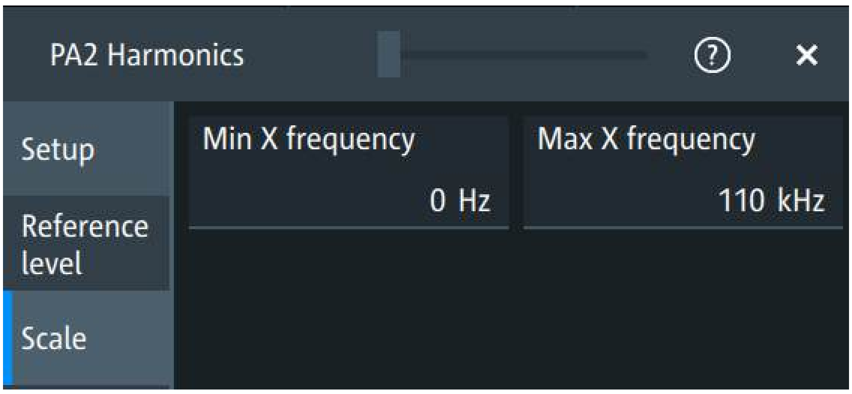
Remote command:
`POWer<m>:HARMonics:RPOWer[:MODE]` on page 1104
`POWer<m>:HARMonics:RPOWer:USER` on page 1104

12.3.3.3 Reference level

See Section 12.3.8.1, "Reference level", on page 387.

12.3.3.4 Scale

In this tab you can configure the scale for the bar graph display.



Min X frequency

Sets the start frequency of a bar graph display. At least three bars are displayed.

Remote command:
POWer<m>:HARMonics:DISPlay:FREQuency:STARt[:VALue] on page 1103

Max X frequency
Sets the stop frequency of the bar graph display. The maximum value is defined by standard and fundamental frequency.

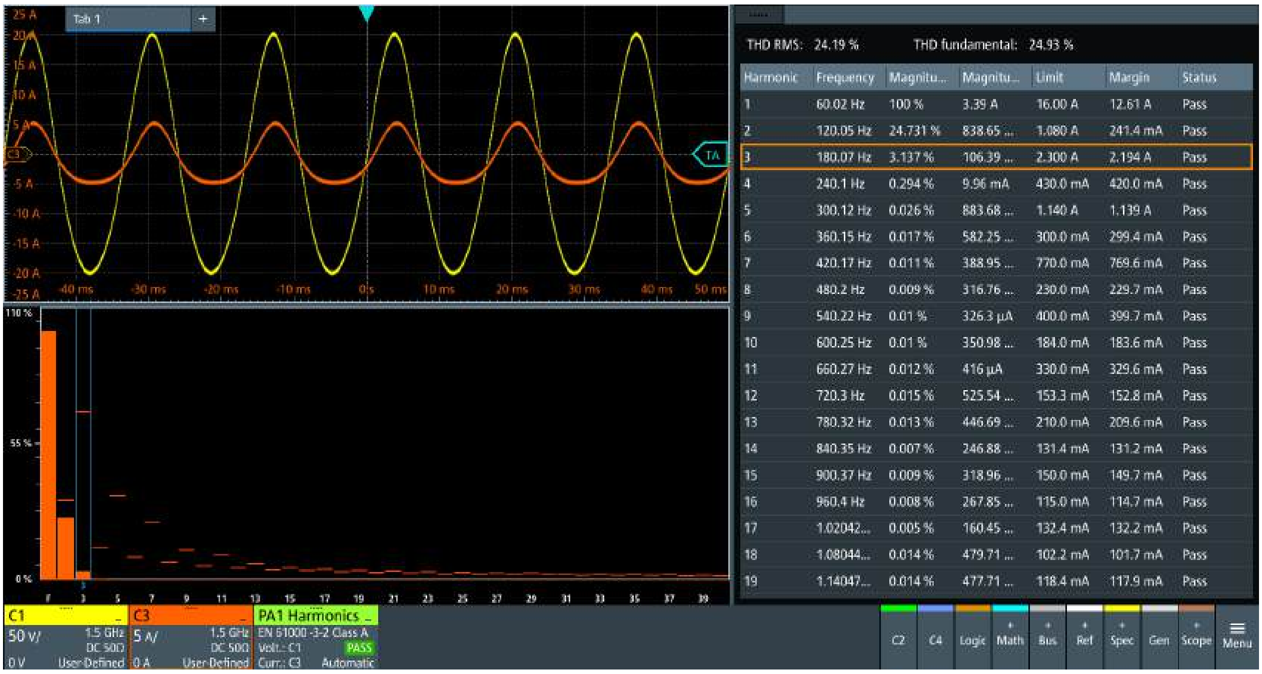
Remote command:
POWer<m>:HARMonics:DISPlay:FREQuency:STOP[:VALue] on page 1103

12.3.3.5 Power waveform

A power waveform is available if "Standard" is set to EN 61000-3-2 Class C or EN 61000-3-2 Class D.

For a description of the power waveform scaling, see Section 12.3.8.3, "Power waveform", on page 389.

12.3.3.6 Power harmonic results



The results of the harmonic measurements are provided in two ways:

- The diagram shows the graphical presentation of the voltage waveform, the current waveform and the power waveform.
- The results are a bar chart and a table with the numerical measurement results.
  The number of displayed harmonics depends on the standard definition.
  When you tap on a harmonic in the bar chart, the corresponding row in the result table is highlighted.

The current harmonic results displayed in the result table are defined as follows:

Result table	Bar chart match	Description
THD RMS	-	Total harmonic distortion relative to the RMS amplitude
THD fundamental	-	Total harmonic distortion relative to the fun-damental
Harmonic index	Value of the x-axis	The harmonic order
Frequency	-	The frequency value of the signal
Magnitude (%)	Value of the y-axis	The present value of the current harmonic
Magnitude (RMS)		The measured RMS value of the magnitude
Limit	Dark orange line	The maxim allowed value according to the selected standard
Margin		Sets the upper limit for the display of the Y scale.
Status	Bar for magnitude below limit has the color of the channel (pass) Bar for magnitude outside limit is orange (fail)	Displays, if the harmonics is within the defined limit (pass) or not (fail).

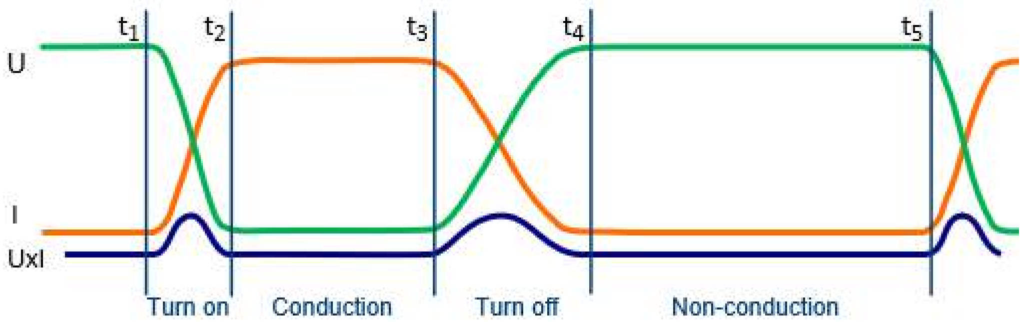
12.3.4 Switching loss

The switching loss analysis measures the power and energy losses of a switching device. The losses occur during the switching phases and the conduction phase of the switching transistor.

Required probes:

- Differential voltage probe
- Current probe

Phases of the switching cycle

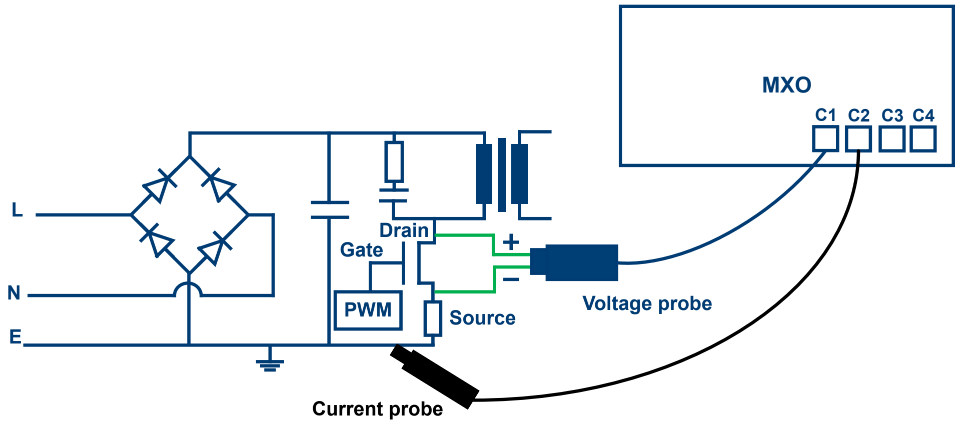


Phase	Definition Points	Description
Turn on	The area between "t_1" and "t_2"	The time after switching on the device, during which the current rises until it reaches the saturation current level.
Conduction	The area between "t_2" and "t_3"	The time during which the voltage is at the transistors saturated minimum and the current flows.
Turn off	The area between "t_3" and "t_4"	The time during which after a short delay the voltage rises until it reaches its final value.
Non conduction	The area between "t_4" and "t_5"	The time when the current does not flow. The losses during this period should be theoretically zero.

12.3.4.1 Configuring switching loss measurements

For details of the configuration settings, see Section 12.3.4.2, "Switching loss setup", on page 365.

1. Add a switching loss measurement as described in Section 12.3.1.1, "Select power measurements", on page 346.
2. Connect the differential voltage probe and the current probe to the oscilloscope.
3. Deskew the probes as described in Section 12.3.1.2, "Deskew", on page 348.
4. Connect the probes to the DUT:



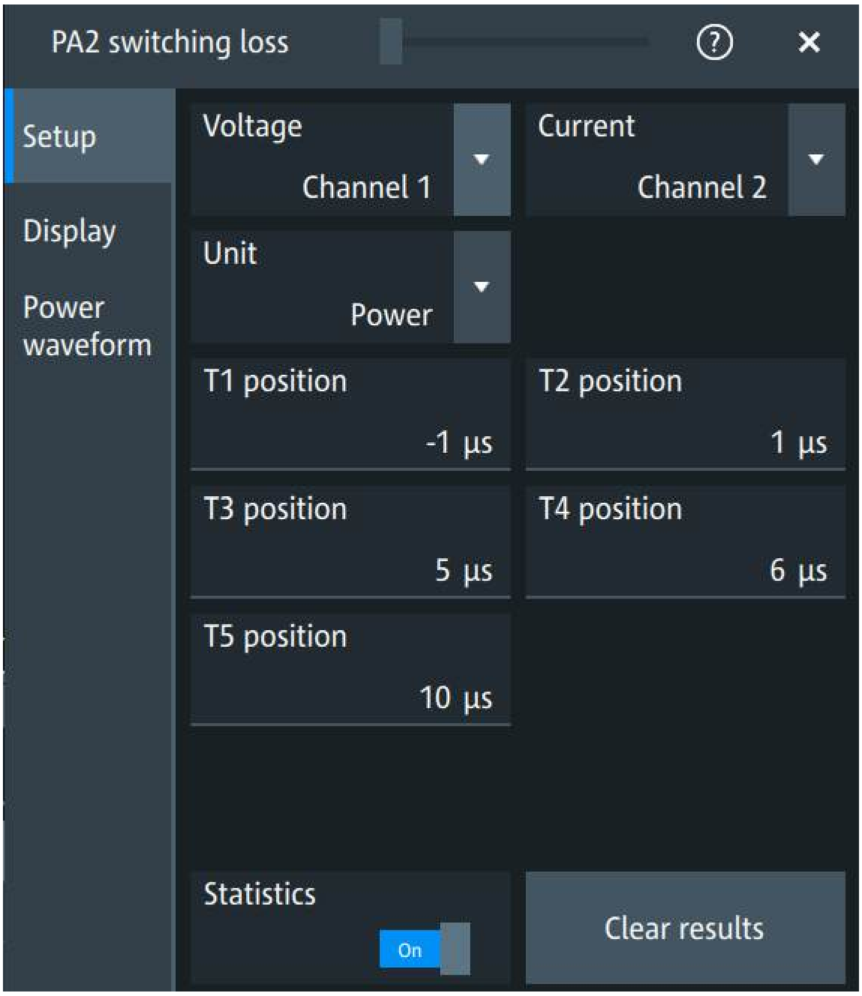
   a) Connect the positive (+) signal socket of the differential voltage probe to the drain of the transistor.
   b) Connect the negative (-) signal socket of the differential voltage probe to the source of the transistor.
   c) Connect the current probe to the source of the transistor.
5. Measure the time points of the switching cycle, for example, using cursor measurements.

6. In the signal bar, tap twice the signal icon of the switching loss power measurement to open its settings dialog.
7. Select the correct channels for the "Voltage" and the "Current" probes.
8. Set the "Unit" for the trace: power or energy.
9. Set the "T<n> position" values.
10. Enable statistics.
11. Select the "Display" tab.
12. Select the measurements that you want to see. You can also change the color of the partial measurements.
13. Select the "Power waveform" tab.
14. Adjust the scale and offset of the resulting trace if necessary.

    On the screen, you can see the measurement waveforms of the current, the voltage and the power. Also, the result table with numeric measurement results is shown. For details, see Section 12.3.4.5, "Switching loss results", on page 369.

12.3.4.2 Switching loss setup

Access: "Menu" > "Apps" > "Power" > "+ Add" > "Switching loss" > select "Switching loss" > "Setup".



In the "Setup" tab, you configure the switching loss measurement: select the sources, the time points of the switching loss cycle, and if you want to measure either power or energy.

Voltage
Selects the voltage source waveform. Analog channels and math waveforms can be used.

Remote command:
`POWer<m>:SWITching:SOURce[:VOLTage]` on page 1110

Current
Selects the current source waveform. Analog channels and math waveforms can be used.

Remote command:
`POWer<m>:SWITching:SOURce:CURRent` on page 1110

Unit
Selects the measurement type: power or energy.

Remote command:
POWer<m>:SWITching:DISPlay:TYPE on page 1110

T<n> position

T1 to T5 define the time points in the switching cycle. You can use cursor measurements to get the time values.

- T1: Start of the turn-on area, and start of the total switching cycle.
- T2: End of the turn-on area, and start of the conduction area.
- T3: End of the conduction area, and start of the turn-off area.
- T4: End of the turn-off area, and start of the non-conduction area.
- T5: End of non-conduction area, and end of the total switching cycle.

See "Phases of the switching cycle" on page 363.

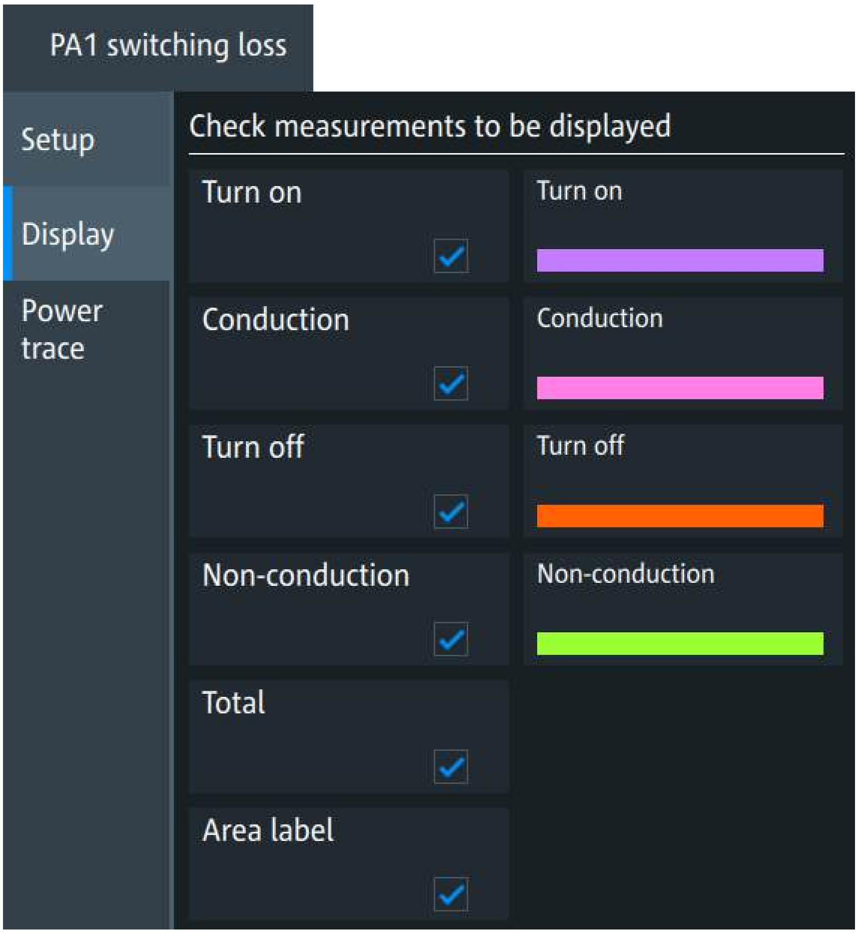
Remote command:
POWer<m>:SWITching:REGion:TOTal[:STARt] on page 1110 (T1)
POWer<m>:SWITching:REGion:TON[:STARt] on page 1110 (T1)
POWer<m>:SWITching:REGion:TON:STOP on page 1111 (T2)
POWer<m>:SWITching:REGion:CONDuction[:STARt] on page 1111 (T2)
POWer<m>:SWITching:REGion:CONDuction:STOP on page 1111 (T3)
POWer<m>:SWITching:REGion:TOFF[:STARt] on page 1111 (T3)
POWer<m>:SWITching:REGion:TOFF:STOP on page 1111 (T4)
POWer<m>:SWITching:REGion:NCONduction[:STARt] on page 1111 (T4)
POWer<m>:SWITching:REGion:NCONduction:STOP on page 1112 (T5)
POWer<m>:SWITching:REGion:TOTal:STOP on page 1112 (T5)

Statistics, Clear results

See "Statistics" on page 353 and "Clear results" on page 353.

12.3.4.3 Switching loss display

Access: "Menu" > "Apps" > "Power" > "+ Add" > "Switching loss" > select "Switching loss" > "Display".



In the "Display" dialog, you select which measurements are performed. The results are displayed in the result table. You can change the colors of the cycle areas in the diagram.

Turn on

Enables the measurements of the turn-on area, and selects the display color.

Remote command:

`POWer<m>:SWITching:DISPlay:TON[:ENABle]` on page 1112

`POWer<m>:SWITching:DISPlay:TON:COLor` on page 1113

Conduction

Enables the measurements of the conduction area, and selects the display color.

Remote command:

`POWer<m>:SWITching:DISPlay:CONDuction[:ENABle]` on page 1112

`POWer<m>:SWITching:DISPlay:CONDuction:COLor` on page 1113

Turn off

Enables the measurements of the turn-off area, and selects the display color.

Remote command:
POWer<m>:SWITching:DISPlay:TOFF[:ENABle] on page 1112
POWer<m>:SWITching:DISPlay:TOFF:COLor on page 1113

Non-conduction
Enables the measurements of the non-conduction area, and selects the display color.

Remote command:
POWer<m>:SWITching:DISPlay:NCONduction[:ENABle] on page 1112
POWer<m>:SWITching:DISPlay:NCONduction:COLor on page 1113

Total
Enables the measurements of the total switching cycle.

Remote command:
POWer<m>:SWITching:DISPlay:TOTal[:ENABle] on page 1113

Area label
Displays the names of the switching cycle areas.

Remote command:
POWer<m>:SWITching:DISPlay:LABel[:ENABle] on page 1114

12.3.4.4 Power waveform

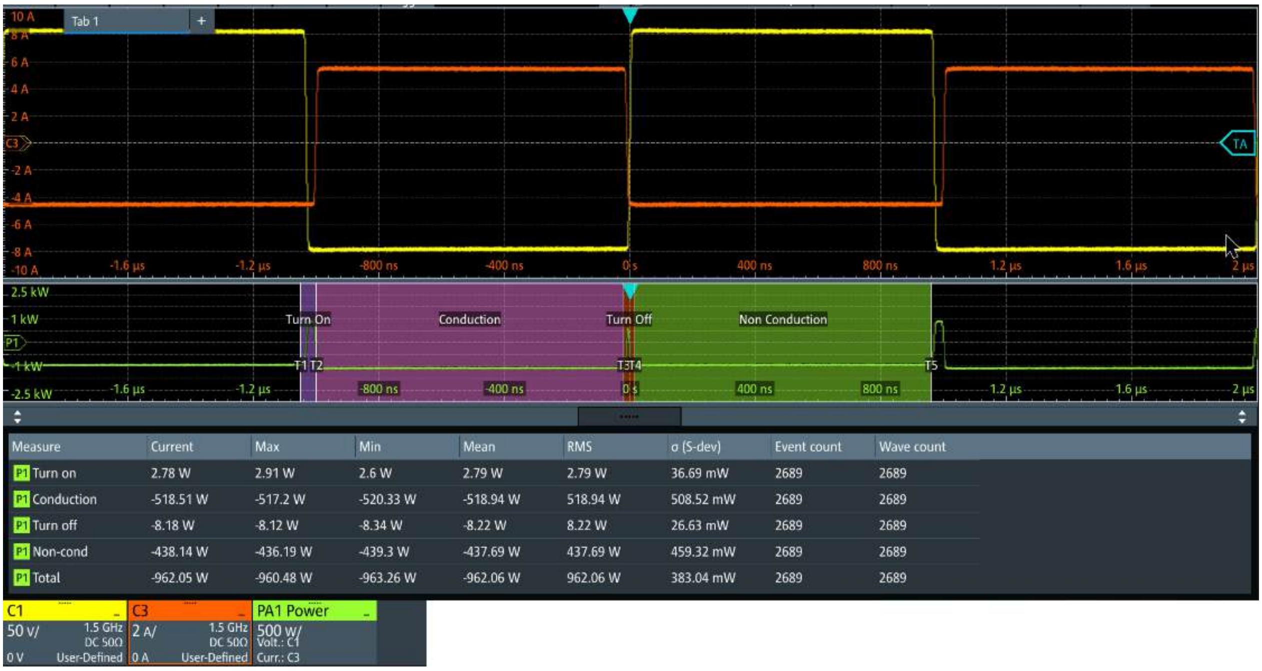
For a description of the power waveform display and scaling, see Section 12.3.8.3, "Power waveform", on page 389.

12.3.4.5 Switching loss results

The results of switching loss measurements are:

- Voltage waveform
- Current waveform
- Power waveform, which is the product of the current and voltage waveforms.
- Numeric measurement results of the selected measurement type (power or energy). The results are given for each phase of the switching cycle.

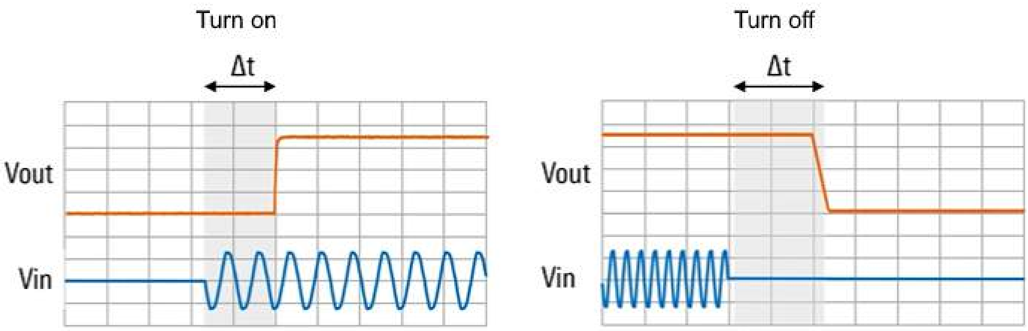
See "Phases of the switching cycle" on page 363 for an explanation of the switching cycle.



Remote commands are described in "Switching loss results" on page 1114.

12.3.5 Turn on/off time

The turn-on/off time analysis measures the time that a power supply takes to reach a certain output threshold when turned on or turned off. The output thresholds are usually a percentage of the steady state output level: 90% for turn-on, and 10% for turn-off time.



Required probes:

- AC input: differential voltage probe
- DC input: passive or differential voltage probe
- DC output: passive or differential voltage probe
  You can measure several outputs in parallel. The maximum number of output connections depends on the number of channels on the instrument: 3 outputs (4-channel instrument) or 7 outputs (8-channel instrument).

12.3.5.1 Configuring turn on/off time measurements

For details of the configuration settings, see Section 12.3.5.2, "Turn on/off setup", on page 372.

1. Add a turn on/off time measurement as described in Section 12.3.1.1, "Select power measurements", on page 346.
2. Connect all voltage probes to the oscilloscope.
3. Connect the probes to the DUT:

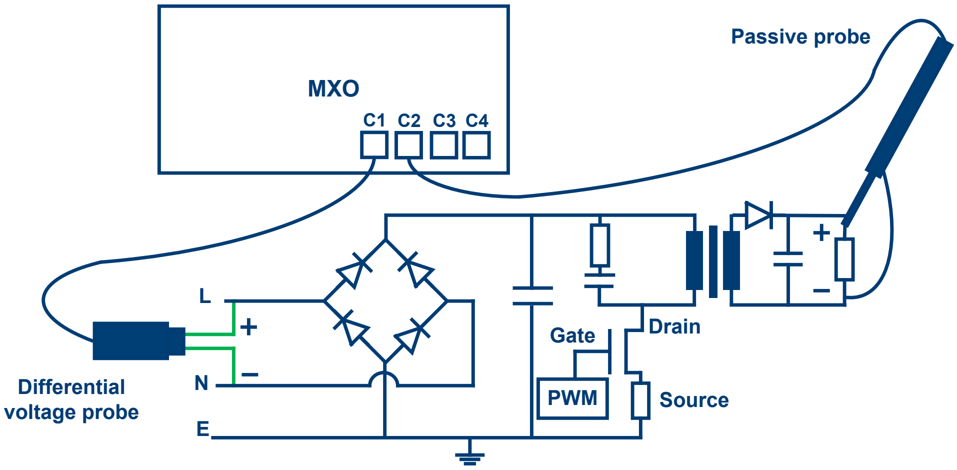


Figure 12-9: Connection with AC input

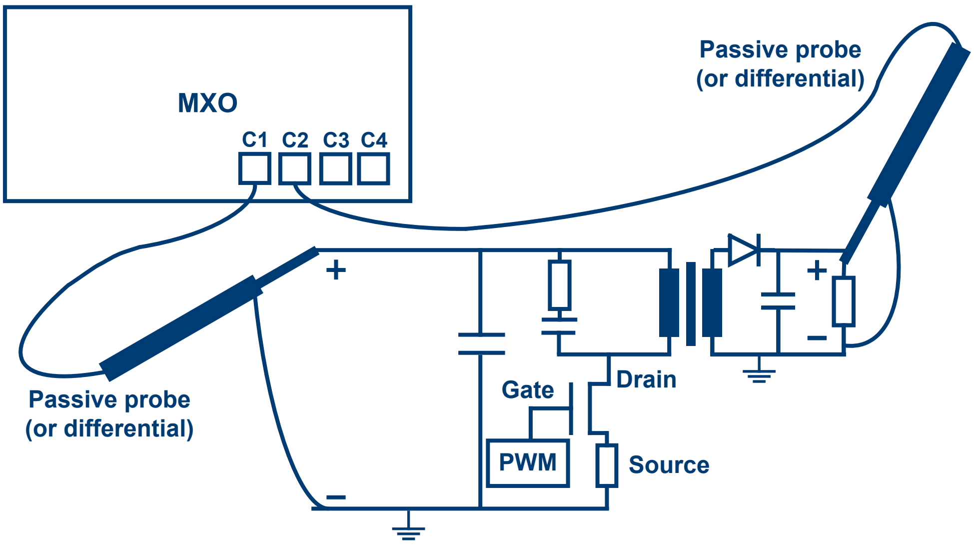


Figure 12-10: Connection with DC input

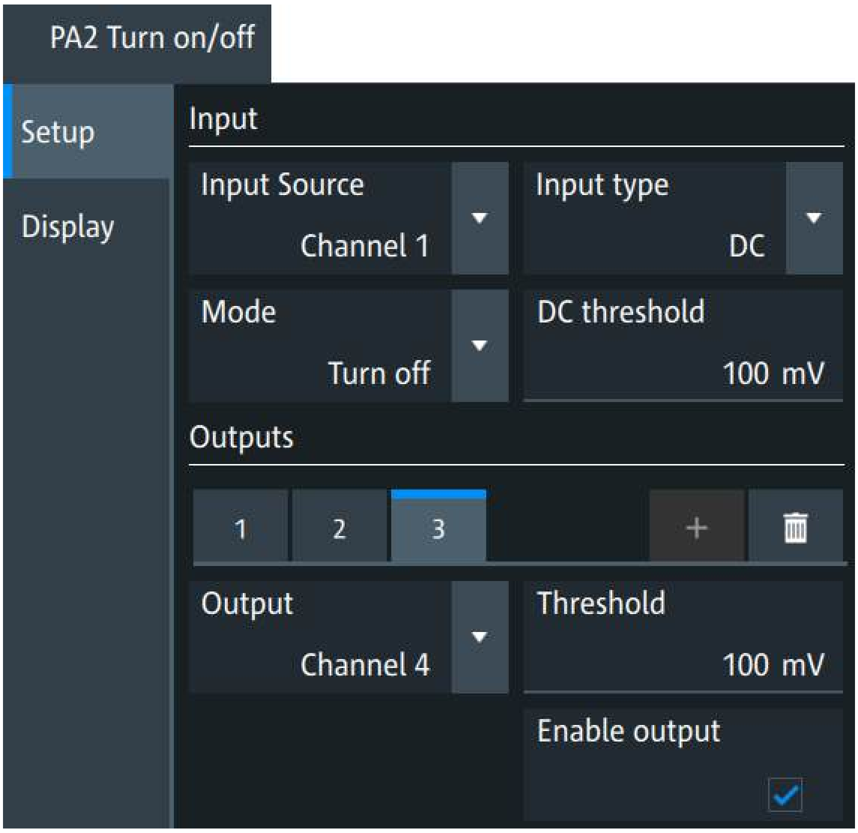
a) AC input:
Connect the positive (+) signal socket of the differential voltage probe to the line (L) of the AC input.
Connect the negative (-) signal socket of the differential voltage probe to the neutral (N) of the AC input.
b) DC input:
Connect the passive or differential voltage probe to the DC input of the power supply.
c) Outputs:
Connect the passive or differential voltage probes to the DC outputs of the power supply.

4. In the "Analysis" tab, tap the "Turn on/off time" measurement.
5. Configure the input settings:
   a) Select the correct channel for the "Input source".
   b) Select the "Mode" (turn on or turn off) and the "Input type" (AC or DC).
   c) Enter the threshold. The measurement starts when the input signal crosses this threshold.
6. Use the ⊞ to add the required number of outputs
7. Configure the outputs. For each output:
   a) Select the correct channel for the "Output".
   b) Enter the threshold. The measurement stops when the output signal crosses this threshold.
   c) Enable the output signal to see the waveform and the results.
8. Select the "Display" tab.
9. Select the outputs for which you want to see the result lines.

   On the screen, you can see the waveforms of the input and the outputs. Also, the result table with numeric measurement results is shown. For details, see Section 12.3.5.4, "Turn on/off results", on page 375.

12.3.5.2 Turn on/off setup

Access: "Menu" > "Apps" > "Power" > "+ Add" > "Turn on/off time" > select "Turn on/off time" > "Setup".



In the "Setup" tab, you configure the turn-on/off time measurement: select the sources, the thresholds, and the measurement.

Input source

Selects the channel of the input signal. Analog channels and math waveforms can be used.

Remote command:
`POWer<m>:ONOFf:INPut[:SOURce]` on page 1121

Input type

Selects whether the input signal is AC or CD.

Remote command:
`POWer<m>:ONOFf:INPut:TYPE` on page 1120

Mode

Selects the turn-on or turn-off measurement.

Remote command:
`POWer<m>:ONOFf[:TYPE]` on page 1122

DC threshold

Sets the threshold for the DC input signal.

The time starts when the first edge exceeds a positive threshold value, or falls below a negative threshold value.

Remote command:
POWer<m>:ONOFf:INPut:DC:ABSolute[:VALue] on page 1120

AC threshold
Sets the threshold for the AC input signal. You set the absolute value, the instrument uses the positive and negative values of the given absolute value.

The time starts when the signal crosses either the positive threshold value, or the negative value - the first crossing point is considered.

Remote command:
POWer<m>:ONOFf:INPut:AC:ABSolute[:VALue] on page 1120

Output
Selects the channel of the output signal. Analog channels except for the input channel and math waveforms can be used.

You can set up several outputs in parallel. The maximum number of output connections depends on the number of channels on the instrument.

Remote command:
POWer<m>:ONOFf:OUTPut<n>[:SOURce] on page 1122

Threshold
Sets the threshold for the selected output signal.

When the output signal crosses this threshold, the turn-on time ends, or the turn-off time starts.

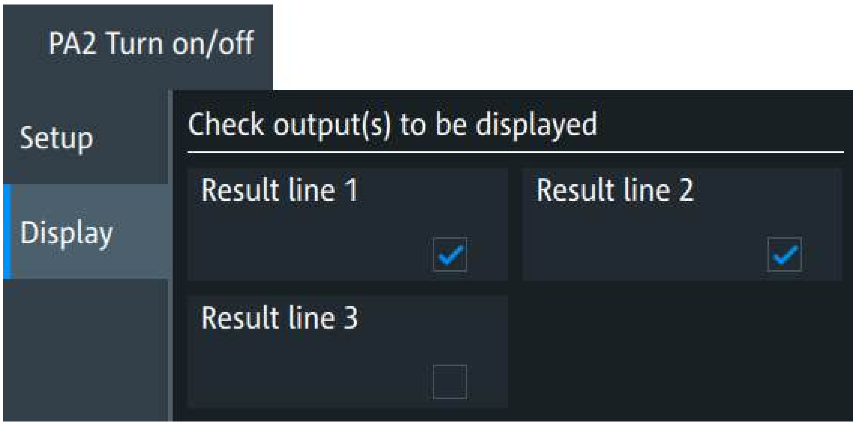
Remote command:
POWer<m>:ONOFf:OUTPut<n>:DC:ABSolute[:VALue] on page 1121

Enable output
Activates the selected output line.

Remote command:
POWer<m>:ONOFf:OUTPut<n>:DISPlay:RESult[:ENABle] on page 1122

12.3.5.3 Turn on/off display

For better understanding, you can display result lines for each output separately.



Result line <n>
Enables the display of result lines and threshold for the selected output. Result lines are only visible if the threshold is within the signal amplitude. Start and stop time are displayed with vertical dashed lines.

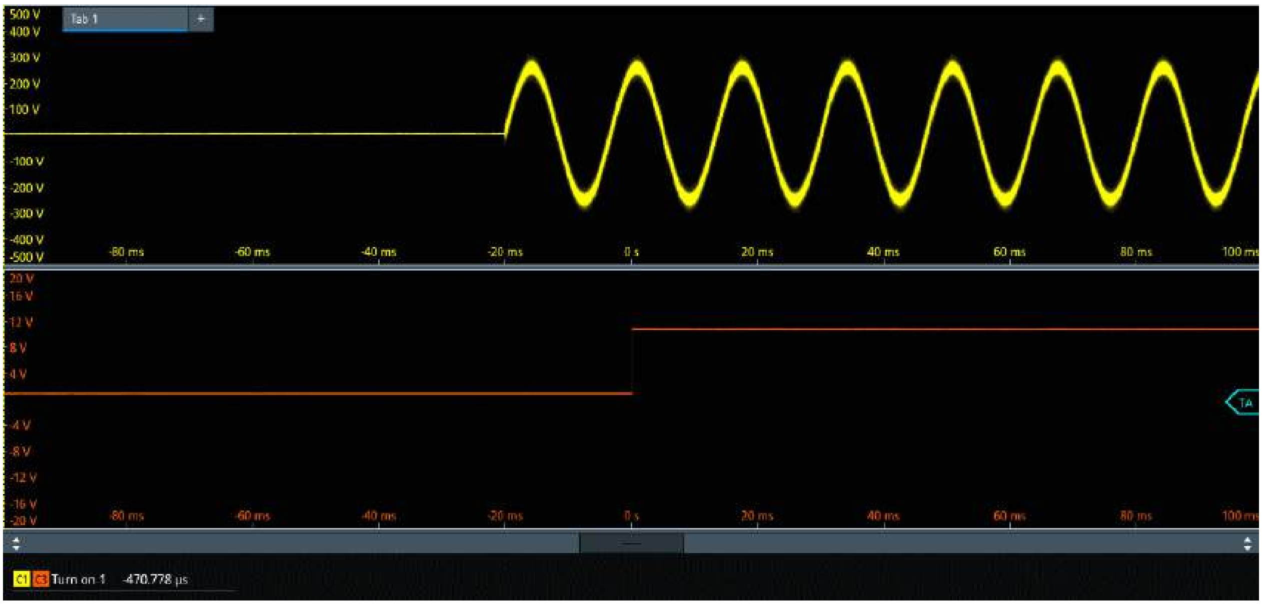
Remote command:
`POWer<m>:ONOFf:OUTPut<n>:DISPlay:RLINe[:ENABle]` on page 1123

12.3.5.4 Turn on/off results

The results of turn-on/off time measurements are:

- Input waveform
- Output waveforms
- Measured values of turn-on or turn-off time for each input-output pair.

You can visualize the measured points on the waveform, see Section 12.3.5.3, "Turn on/off display", on page 374.



Remote commands are described in "Turn on/off results" on page 1123.

12.3.6 Power efficiency

Power efficiency analysis assesses how effectively a device converts input power into useful output power. It measures the input voltage and current and the output voltage and current, calculates the input and the output power, and the ratio of output power to input power. This ratio percentage is the power efficiency.

Required probes:

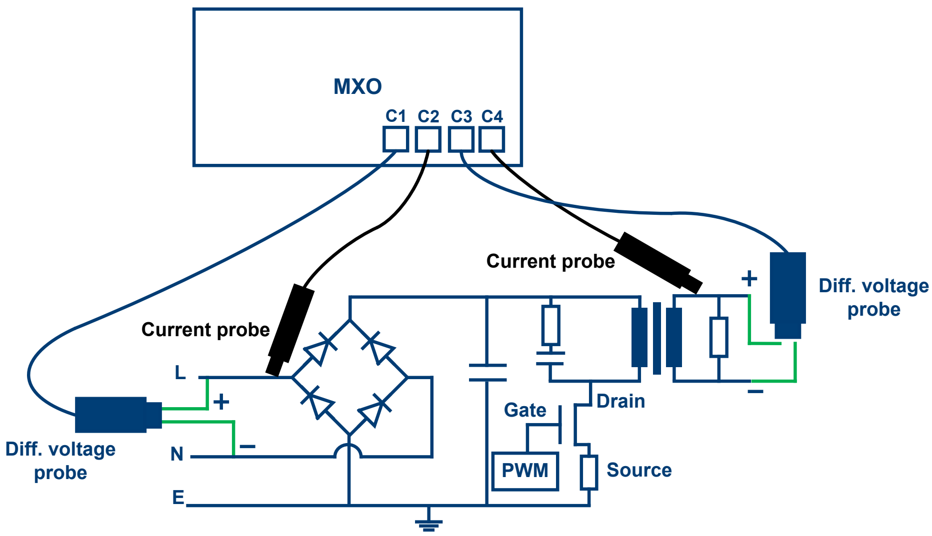
- Input: current probe and differential voltage probe
- Output: current probe and differential voltage probe

If your MXO oscilloscope has more than 4 channels, you can measure several outputs in parallel and obtain the total power and efficiency of the DUT. The maximum number of output lines is *Number of channels / 2 - 1*.

12.3.6.1 Configuring power efficiency measurements

For details of the configuration settings, see Section 12.3.6.2, "Power efficiency setup", on page 377.

1. Add a power efficiency measurement as described in Section 12.3.1.1, "Select power measurements", on page 346.
2. Connect the differential voltage probes and the current probes to the oscilloscope.
3. Deskew the probes as described in Section 12.3.1.2, "Deskew", on page 348.
4. Connect the probes to the DUT:



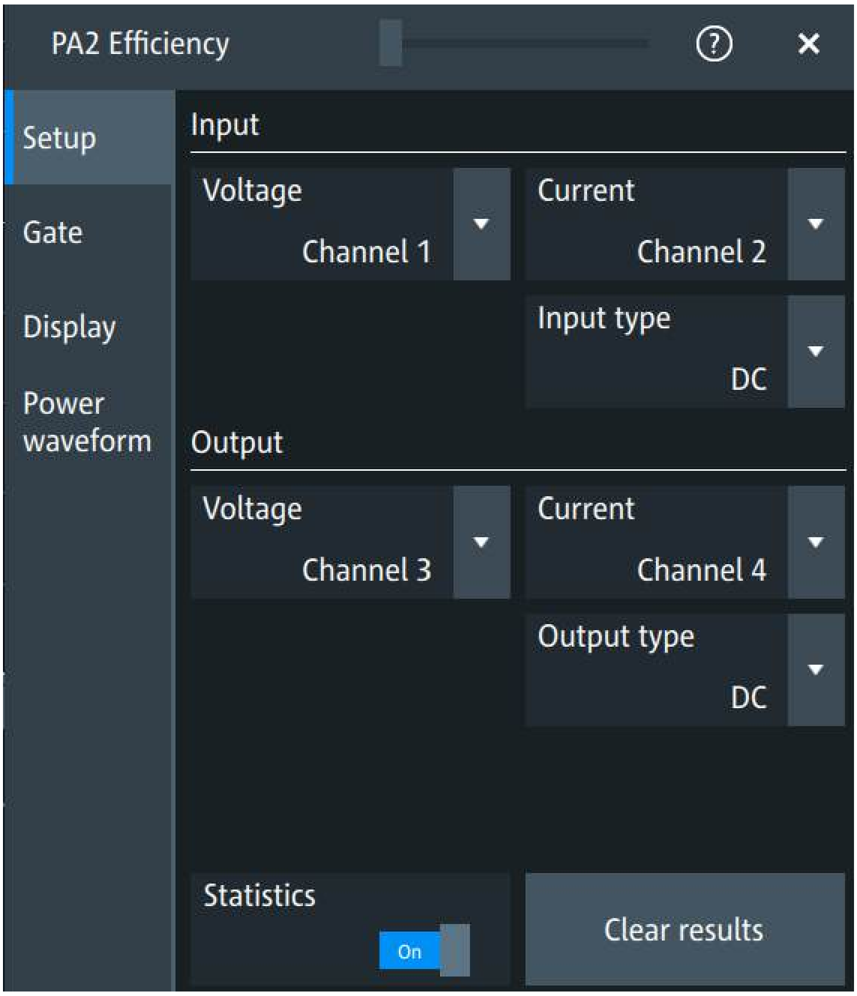
   a) Connect the positive (+) signal socket of the differential voltage probe to the line of the input.
   b) Connect the negative (-) signal socket of the differential voltage probe to the neutral of the input.
   c) Connect the current probe to the line of the input.
   d) Connect a differential voltage probe and a current probe to each output to be measured.
5. In the signal bar, tap twice the signal icon of the efficiency measurement to open its settings dialog.
6. Select the correct channels for the "Voltage" and the "Current" probes of the input and the output.
7. Selects the type of the current flow for input and output: AC or DC: "Input type" and "Output type".

8. Enable statistics.
9. Select the "Display" tab.
10. Select the measurements that you want to see.
11. Select the "Power waveform" tab.
12. Adjust the scale and offset of the resulting waveforms if necessary.

    On the screen, you can see the selected measurement waveforms of the input power and the output power. If your instrument has more than 4 channels and the DUT several outputs, you can see all output power waveforms and the total power if selected. Also, the result table with numeric measurement results is shown. For details, see Section 12.3.6.6, "Efficiency results", on page 380.

12.3.6.2 Power efficiency setup

Access: "Menu" > "Apps" > "Power" > "+ Add" > "Efficiency" > select "Efficiency" > "Setup".



In the "Setup" tab, you configure the efficiency measurement: select the sources for input and outputs and select whether they are AC or CD. Using several outputs requires more than 4 input channels. You also enable statistics here.

Voltage (Input)
Selects the voltage source waveform of the input line. Analog channels and math waveforms can be used.

Remote command:
`POWer<m>:EFFiciency:INPut<n>:VOLTage[:SOURce]` on page 1124

Current (Input)
Selects the current source waveform of the input line. Analog channels and math waveforms can be used.

Remote command:
`POWer<m>:EFFiciency:INPut<n>:CURRent[:SOURce]` on page 1124

Input type
Selects the type of the current flow: AC or DC.

Remote command:
`POWer<m>:EFFiciency:INPut<n>[:TYPE]` on page 1124

Voltage (Output)
Selects the voltage source waveform of the selected output line. Analog channels and math waveforms can be used.

Using several outputs requires more than 4 input channels.

Remote command:
`POWer<m>:EFFiciency:OUTPut<n>:VOLTage[:SOURce]` on page 1125

Current (Output)
Selects the current source waveform of the selected output line. Analog channels and math waveforms can be used.

Using several outputs requires more than 4 input channels.

Remote command:
`POWer<m>:EFFiciency:OUTPut<n>:CURRent[:SOURce]` on page 1125

Output type
Selects the type of the current flow: AC or DC.

Using several outputs requires more than 4 input channels.

Remote command:
`POWer<m>:EFFiciency:OUTPut<n>[:TYPE]` on page 1125

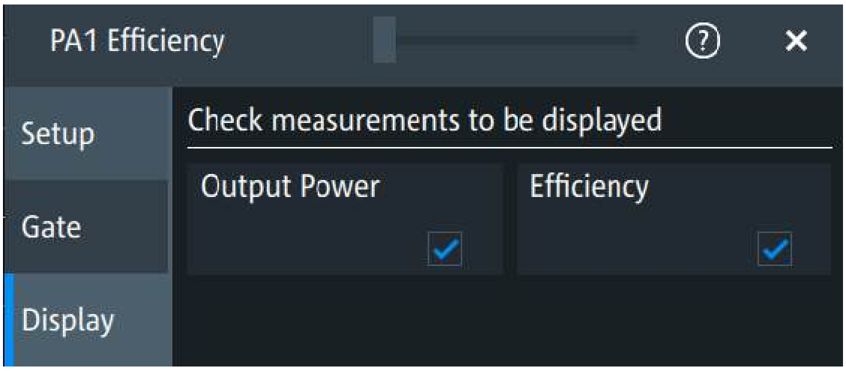
Statistics, Clear results
See "Statistics" on page 353 and "Clear results" on page 353.

12.3.6.3 Gate

See Section 12.3.8.2, "Gate settings for power measurements", on page 389.

12.3.6.4 Power efficiency display

In this dialog, you select the power efficiency measurements that you want to display. For more details on the different measurements, see Section 12.3.6.6, "Efficiency results", on page 380.

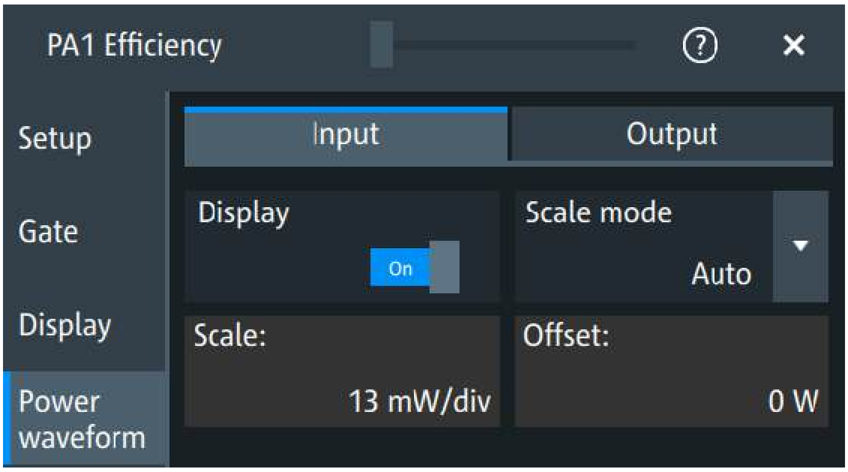


Remote commands:

- `POWer<m>:EFFiciency:DISPlay:RESult:OUTPut<n>:EFFiciency[:ENABle]` on page 1126
- `POWer<m>:EFFiciency:DISPlay:RESult:OUTPut<n>:POWer[:ENABle]` on page 1126
- `POWer<m>:EFFiciency:DISPlay:RESult:TOTal<n>:EFFiciency[:ENABle]` on page 1127
- `POWer<m>:EFFiciency:DISPlay:RESult:TOTal<n>:OPOWer[:ENABle]` on page 1127

12.3.6.5 Power waveform

You can enable and scale the input, output and total waveforms individually.



For a description of the power waveform display and scaling, see Section 12.3.8.3, "Power waveform", on page 389.

12.3.6.6 Efficiency results

The results of efficiency measurements are:

- Input current and voltage waveforms
- Output current and voltage waveforms
- Input power waveform, which is the product of the input current and input voltage waveforms.
- Output power waveforms, which are the products of the corresponding output current and output voltage waveforms.
  Using several outputs requires more than 4 input channels.
- Total power waveform, which is the sum of the output power values.
  Total power requires more than 4 input channels.
- Numeric measurement results of input power, output power, total power and efficiencies. The total efficiency is the ratio of input power to the sum of output power values.

If the input or output type is set to AC, the period is measured on the AC voltage source. If one of these measurements fails, the efficiency result is invalid.

If statistics are enabled, every period for an AC source is analyzed. Without statistics, only the first period is analyzed.

Remote commands are described in section "Efficiency results" on page 1127.

12.3.7 Safe operating area (SOA)

The safe operating area (SOA) analysis is defined by the voltage and current conditions over which a power semiconductor device is expected to operate without self-damage. The safe operating area analysis provides a diagram of the safe operating conditions of your DUT.

In parallel to the time domain diagram, an XY-plot is created, with voltage points on the x-axis, while current is shown on the y-axis. The XY-plot is tested against a mask, which represents the safe operating area.

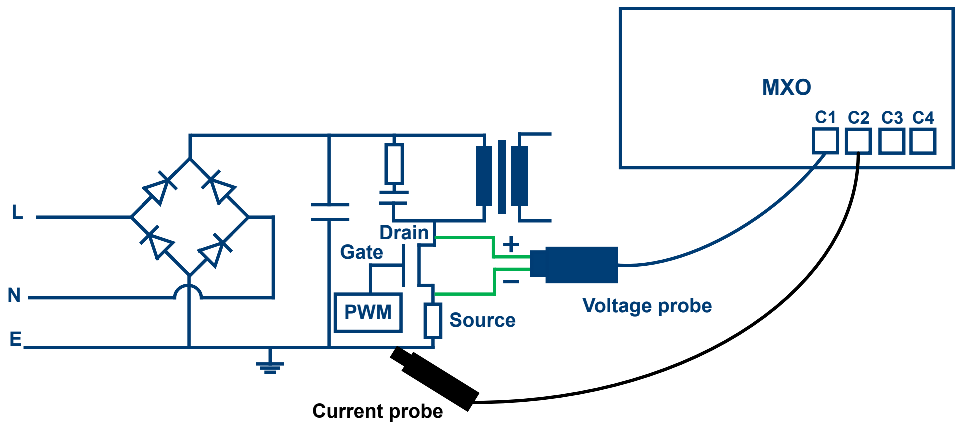
Required probes:

- Differential voltage probe
- Current probe

12.3.7.1 Configuring SOA measurements

For details of the configuration settings, see Section 12.3.7.2, "SOA setup", on page 382 and Section 12.3.7.3, "SOA masks", on page 383.

1. Add a SOA measurement as described in Section 12.3.1.1, "Select power measurements", on page 346.
2. Connect the differential voltage probes and the current probes to the oscilloscope.
3. Deskew the probes as described in Section 12.3.1.2, "Deskew", on page 348.
4. Connect the probes to the DUT:



   a) Connect the positive (+) signal socket of the differential voltage probe to the drain of the transistor.
   b) Connect the negative (-) signal socket of the differential voltage probe to the source of the transistor.
   c) Connect the current probe to the source of the transistor.
5. In the signal bar, tap twice the signal icon of the SOA measurement to open its settings dialog.
6. Select the correct channels for the "Voltage" and the "Current" probes.
7. If a SOA mask is already available, select "Open" and load the mask.
8. If no mask is available, select "Edit segments". Create the mask segments, either under "Predefined Masks" or "Limit Masks".

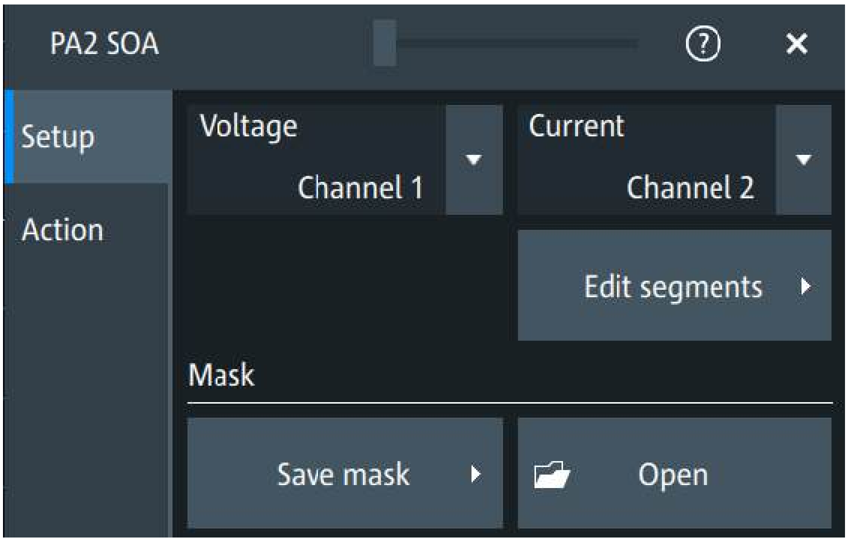
Both segment types can be combined in one mask. For more information on predefined masks, see also Section 12.1.4, "Actions on mask test results", on page 320.

9. "Save mask" if you want to keep it for further tests.
10. Select the "Action" tab.
11. Select the actions to be initiated on mask violation or successful completion of the test. You can select several actions.
12. Run the acquisitions.

    On the screen, you can see the voltage and current waveforms and the XY-diagram with the mask. Also, the result table with numeric measurement results and the test status is shown. For details, see Section 12.3.7.5, "SOA results", on page 386.

12.3.7.2 SOA setup

Access: "Menu" > "Apps" > "Power" > "+ Add" > "SOA" > select "SOA" > "Setup".



In the "Setup" tab, you configure the SOA measurement: select the sources, load and save the mask, and start creating a mask.

Voltage
Selects the voltage source waveform. Analog channels and math waveforms can be used.

In the SOA diagram, voltage points are plotted on the x-axis.

Remote command:
`POWer<m>:SOA:SOURce:VOLTage` on page 1131

Current
Selects the current source waveform. Analog channels and math waveforms can be used.

In the SOA diagram, current is plotted on the y-axis.

Remote command:
`POWer<m>:SOA:SOURce:CURRent` on page 1131

Edit segments
Opens a dialog to create and configure the SOA mask. See Section 12.3.7.3, "SOA masks", on page 383.

Save mask
Define the storage location and filename, and save the mask.

"<Folder>"	Opens a file explorer where you can select the directory where the file is saved.
"File name base"	Sets a name for the file, without extension. The name is extended with a time stamp when the file is saved. Thus, multiple "Save" actions are possible without changing the filename.
"File extension"	The format of the mask file is always `.xml`.
"Save"	Saves the file in the defined folder using the "File name base". If the specified file already exists, it is overwritten with the new data.
"Save As"	Opens a file explorer where you select the folder, the file type, enter the filename and save the file.

Remote command:
`POWer<m>:SOA:MTESt<n>:IMEXport:NAME` on page 1130
`POWer<m>:SOA:MTESt<n>:IMEXport:SAVE` on page 1131

Open
Opens a file explorer to select a previously stored mask file. The selected mask is loaded.

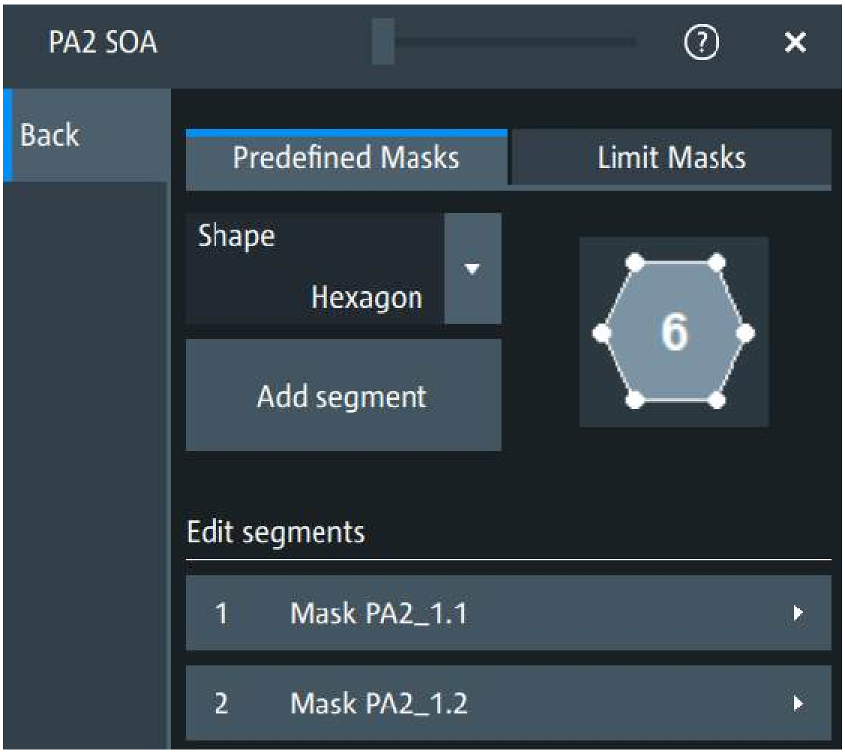
Remote command:
`POWer<m>:SOA:MTESt<n>:IMEXport:NAME` on page 1130
`POWer<m>:SOA:MTESt<n>:IMEXport:OPEN` on page 1131

12.3.7.3 SOA masks

Access: "Menu" > "Apps" > "Power" > "+ Add" > "SOA" > select "SOA" > "Setup" > "Edit segments".

You can define and edit 1 mask with up to 4 segments.

Predefined Masks
To create a predefined mask, you select the shape of a mask segment, add it and then edit the positions of the corner points.

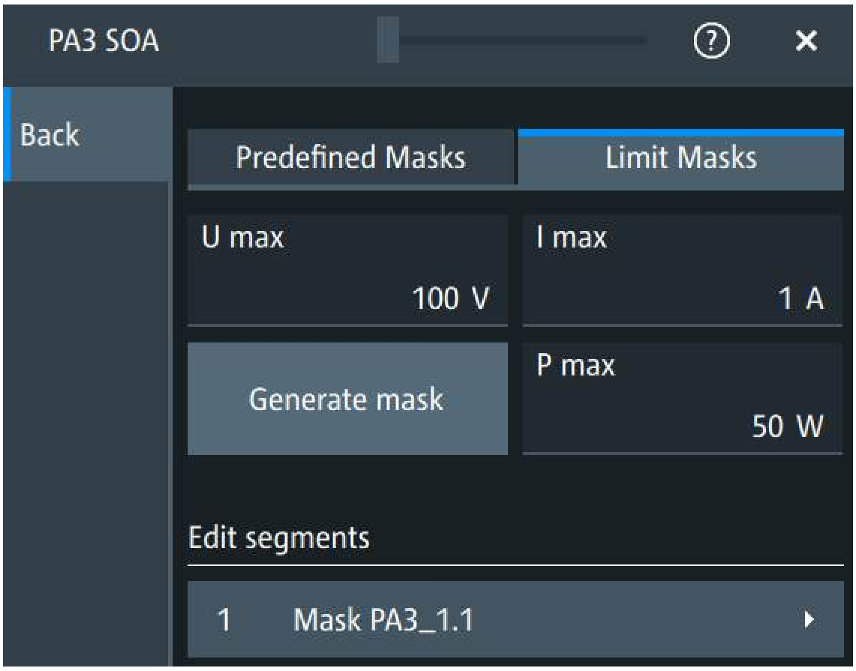


Shape ← Predefined Masks
Selects the shape of the SOA mask: rectangle, diamond, hexagon, octagon.

Add segment ← Predefined Masks
Adds a new segment with the selected shape to the mask. To adjust the size and position of the mask segment, select the segment and configure it. The procedure is the same as in the mask test application. See "Add segment" on page 318 and "Edit segments" on page 319.

Remote command:
`POWer<m>:SOA:MTESt<n>:SEGMent<o>:ADD` on page 1133
`POWer<m>:SOA:MTESt<n>:SEGMent<o>:COUNt?` on page 1133
`POWer<m>:SOA:MTESt<n>:SEGMent<o>:POINt<p>:ADD` on page 1134
`POWer<m>:SOA:MTESt<n>:SEGMent<o>:POINt<p>:COUNt?` on page 1134
`POWer<m>:SOA:MTESt<n>:SEGMent<o>:POINt<p>:REMove` on page 1135
`POWer<m>:SOA:MTESt<n>:SEGMent<o>:POINt<p>:VALid?` on page 1135
`POWer<m>:SOA:MTESt<n>:SEGMent<o>:POINt<p>:X` on page 1135
`POWer<m>:SOA:MTESt<n>:SEGMent<o>:POINt<p>:Y` on page 1136
`POWer<m>:SOA:MTESt<n>:SEGMent<o>:REMove` on page 1136

Limit Masks
You can use the values I_{max}, V_{max} and P_{max} from the transistor specification to calculate a mask. I_{max}, V_{max} and P_{max} must be positive values. The result is a mask segment in the first quadrant of the XY-diagram. You can change the generated segment like other segments: move, add and remove points.



U max ← Limit Masks
Sets the maximum voltage for the mask. The value must be positive.

Remote command:
`POWer<m>:SOA:LIMit:VMAX` on page 1133

I max ← Limit Masks
Sets the maximum current for the mask. The value must be positive.

Remote command:
`POWer<m>:SOA:LIMit:IMAX` on page 1132

P max ← Limit Masks
Sets the maximum power for the mask. The value must be positive.

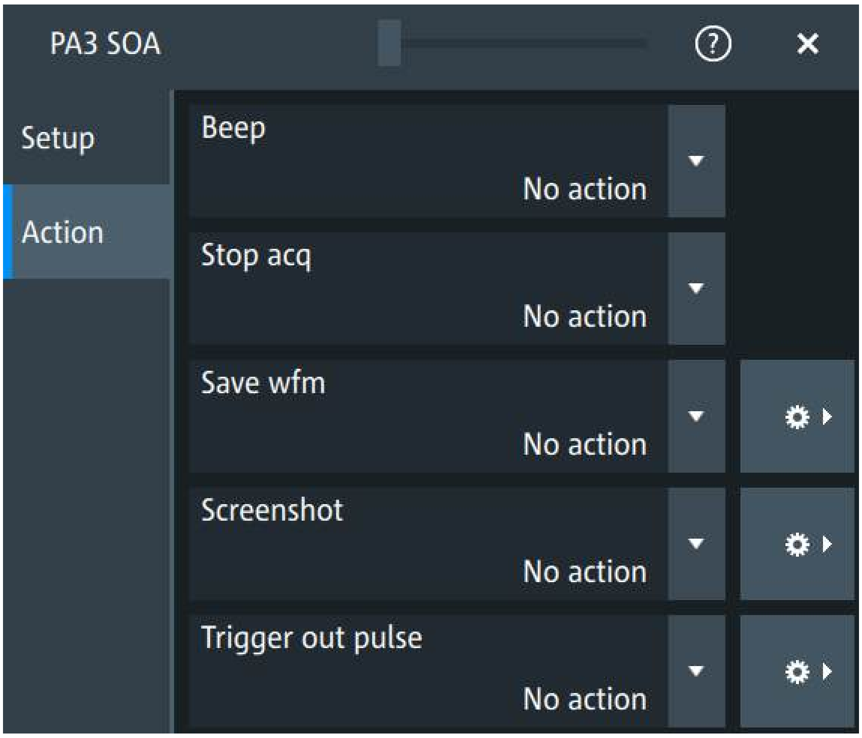
Remote command:
`POWer<m>:SOA:LIMit:PMAX` on page 1132

Generate mask ← Limit Masks
Generates a mask using the given maximum values. The result is a mask segment in the first quadrant of the XY-diagram.

Remote command:
`POWer<m>:SOA:LIMit:APPLy` on page 1132

12.3.7.4 SOA actions

The safe operating analysis uses the same actions as the general mask test. For details, see Section 12.1.4, "Actions on mask test results", on page 320.



12.3.7.5 SOA results

The results of safe operating area measurements are provided in the following ways:

- Voltage source waveform and current source waveform in the diagram
- A logarithmic or linear XY-diagram of the voltage (x-axis) and current (y-axis) waveforms. This XY-diagram is a graphical representation of the power handling capability of the DUT under various conditions.
- If a power waveform in the XY diagram violates a mask, the violation is marked.
- The result table provides the numeric results of the SOA mask test.

Table 12-2: Results of the SOA test

Result	Description
Total acq.	Number of tested acquisitions (waveforms)
Passed acq.	Number of acquisitions that have passed the mask test, i.e. they are within the defined safe operating area mask
Failed acq.	Number of acquisitions that have failed the mask test, i.e. they are out of the defined safe operating area mask
Fail rate	Ratio of failed acquisitions to the number of tested acquisitions in %
Result	Summary test status: Pass or Fail

Remote commands are described in "SOA results" on page 1139.

12.3.8 Common functions for power measurements

12.3.8.1 Reference level

Some power analysis measurements require reference levels to obtain the measurement points. Power analysis uses its own reference level set, which is independent from other measurements and is used for all power measurements.

To ensure that the correct value for the period is used for the measurements, the period is determined on a voltage channel first. This period value is then applied wherever it is required to the current waveform and to the power (Math) waveform.

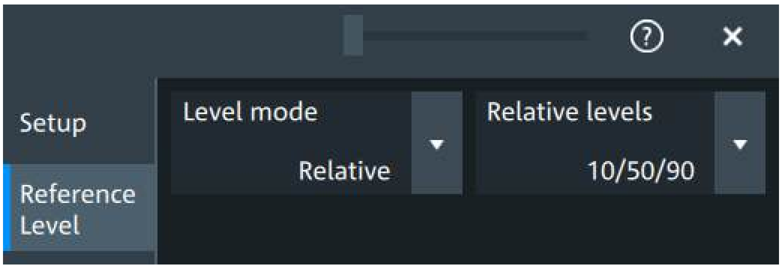


Figure 12-11: Relative reference level

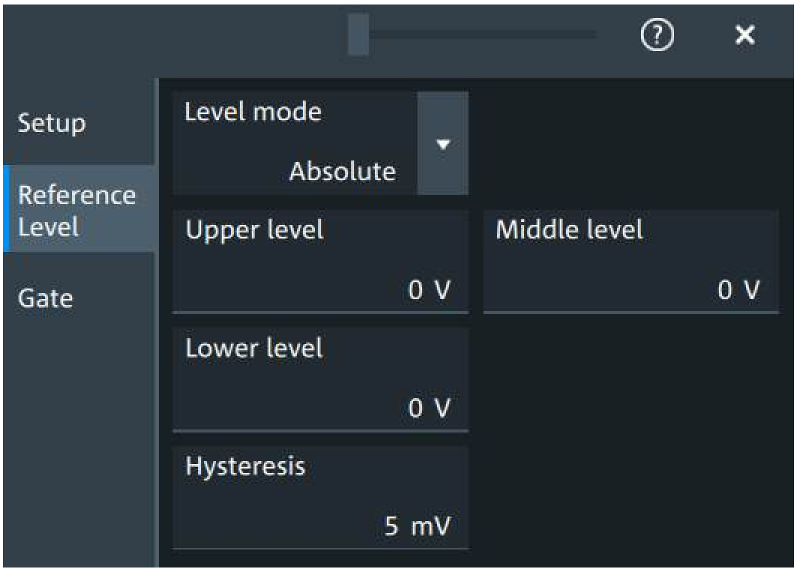


Figure 12-12: Absolute reference level

Level mode
Defines if the reference level is set in absolute or relative values.

Remote command:
POWer<m>:HARMonics:REFLevel<rl>:LMODe on page 1143
POWer<m>:QUALity:REFLevel<rl>:LMODe on page 1143

Absolute Level mode

In the absolute mode, the reference values are set as voltages, in absolute values.

Upper level, Middle level, Lower level ← Absolute Level mode

Sets the low, middle and upper reference signal levels.

Remote command:
POWer<m>:HARMonics:REFLevel<rl>:ABSolute:LLEVel on page 1142
POWer<m>:HARMonics:REFLevel<rl>:ABSolute:MLEVel on page 1143
POWer<m>:HARMonics:REFLevel<rl>:ABSolute:ULEVel on page 1143
POWer<m>:QUALity:REFLevel<rl>:ABSolute:LLEVel on page 1142
POWer<m>:QUALity:REFLevel<rl>:ABSolute:MLEVel on page 1143
POWer<m>:QUALity:REFLevel<rl>:ABSolute:ULEVel on page 1143

Relative Level mode

In the relative mode, the reference values are set as percentages of the signal amplitude.

Relative levels ← Relative Level mode

Selects the lower, middle and upper reference levels, defined as percentages of the signal amplitude.

Available relative levels:

- 5/50/95
- 10/50/90
- 20/50/80
- User defined: Enter "Upper level", "Middle level", and "Lower level".

For example, for "5/50/95" the levels are set to the following values:

- Lower level = 5% of the signal amplitude
- Middle level = 50% of the signal amplitude
- Upper level = 95% of the signal amplitude

Remote command:
POWer<m>:HARMonics:REFLevel<rl>:RELative:MODE on page 1145
POWer<m>:QUALity:REFLevel<rl>:RELative:MODE on page 1145

Upper level, Middle level,Lower level ← Relative Level mode

Define the reference levels in percent, if "Level mode" is set to "User-defined".

Remote command:
POWer<m>:HARMonics:REFLevel<rl>:RELative:LOWer on page 1144
POWer<m>:HARMonics:REFLevel<rl>:RELative:MIDDle on page 1144
POWer<m>:HARMonics:REFLevel<rl>:RELative:UPPer on page 1145
POWer<m>:QUALity:REFLevel<rl>:RELative:LOWer on page 1144
POWer<m>:QUALity:REFLevel<rl>:RELative:MIDDle on page 1144
POWer<m>:QUALity:REFLevel<rl>:RELative:UPPer on page 1145

Hysteresis

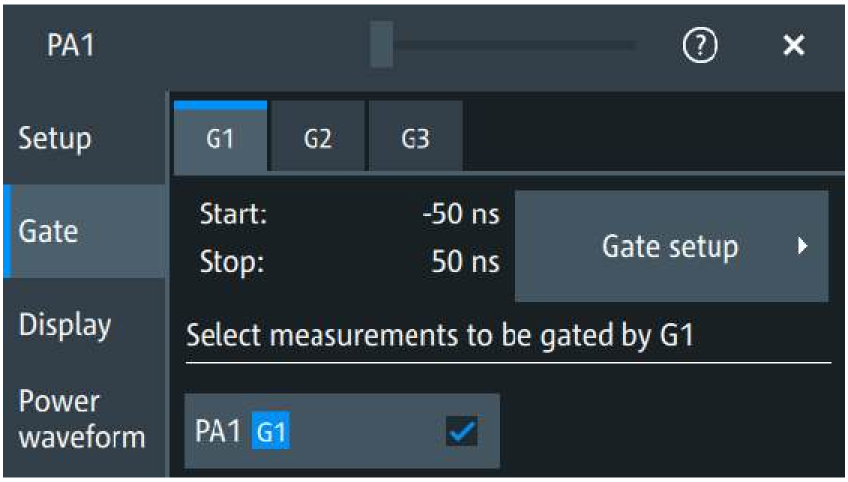
Defines a hysteresis for the middle reference level. A rise or fall from the middle reference value that does not exceed the hysteresis is rejected as noise.

Remote command:
`POWer<m>:HARMonics:REFLevel<rl>:RELative:HYSTeresis` on page 1144
`POWer<m>:HARMonics:REFLevel<rl>:ABSolute:HYSTeresis` on page 1142
`POWer<m>:QUALity:REFLevel<rl>:RELative:HYSTeresis` on page 1144
`POWer<m>:QUALity:REFLevel<rl>:ABSolute:HYSTeresis` on page 1142

12.3.8.2 Gate settings for power measurements

Access: Select power measurement > "Gate".

You can limit the some power measurement to a user-defined range of the waveform. In the "Gate" tab, you select the gate to be used for the selected power analysis. If no gate has been defined before, or the correct gate is missing, select "Gate setup" and configure the gate. See Section 8.2, "Gate setup", on page 209 for details.

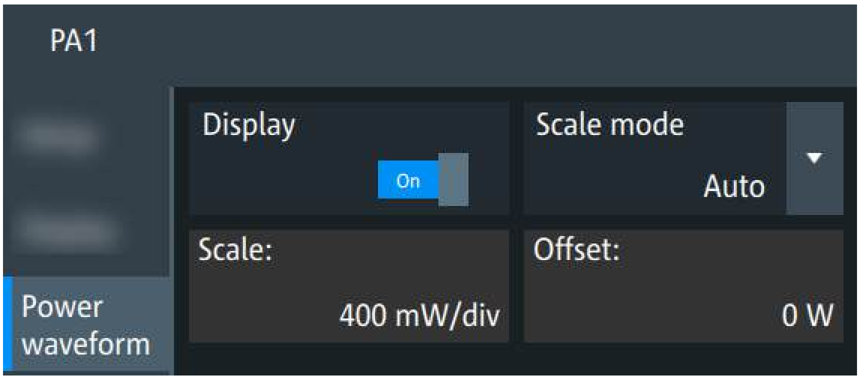


Remote commands:
- `POWer<m>:EFFiciency:GATE` on page 1126
- `POWer<m>:QUALity:GATE` on page 1088

12.3.8.3 Power waveform

Some power analysis measurements create a power waveform as one of the measurement results.

In the "Power waveform" dialog, you can change the scaling of the power waveform.



Display
Displays or hides the power waveform.

For harmonics analysis, a power waveform is available if "Standard" is set to EN 61000-3-2 Class C or EN 61000-3-2 Class D.

Remote command:
`POWer<m>:EFFiciency:DISPlay:WAVeform:INPut<n>:POWer[:ENABle]` on page 1140
`POWer<m>:EFFiciency:DISPlay:WAVeform:OUTPut<n>:POWer[:ENABle]` on page 1141
`POWer<m>:EFFiciency:DISPlay:WAVeform:TOTal<n>:OPOWer[:ENABle]` on page 1140
`POWer<m>:HARMonics:DISPlay:POWer:WAVeform:ENABle` on page 1141
`POWer<m>:QUALity:DISPlay:POWer:WAVeform:ENABle` on page 1141
`POWer<m>:SWITching:DISPlay:POWer:WAVeform[:ENABle]` on page 1141

Scale mode
Selects the scaling mode for display of the resulting waveform. By default, the instrument selects the most appropriate scale. In "Manual" mode, you can change the vertical scale and offset.

Scale
Sets the vertical scale of the resulting power waveform if "Scale mode" is set to "Manual".

Offset
Sets the offset of the resulting power waveform if "Scale mode" is set to "Manual".

12.4 Digital voltmeter

The software-based voltmeter features AC RMS, DC and DC RMS voltage measurements on a specific analog channel.

12.4.1 Using the digital voltmeter

To start a digital voltmeter measurement

1. Tap the "Menu" > "Apps" > "General" tab > "DVM", to open the digital voltmeter measurement dialog.

2. Select the channel for your measurement.
3. Select a "Filter bandwidth" from the list.
4. Set a "Measurement time".
5. Tap on a measurement to enable it. Available are "DC", "DC RMS", "AC RMS".

   The measurement results of all enabled measurements are displayed in the result table.

12.4.2 Settings of the digital voltmeter

Access: "Menu" > "Apps" > "General" tab > "DVM".

C<n>
Selects the channel which is measured by the digital voltmeter.

Filter bandwidth
Selects the filter bandwidth.

Remote command:
METer:BANDwidth on page 1148

Measurement time
Sets the measurement time. The time begins in the moment that a measurement is enabled.

Remote command:
METer:MTIMe on page 1150

Measurements
Enables the voltmeter measurements. When a measurement is enabled, the voltmeter is turned on automatically.

"DC"	Enables the DC voltage measurement.
"DC RMS"	Enables the DC RMS voltage measurement.
"AC RMS"	Enables the AC RMS voltage measurement.

Remote command:
METer:DVMeter<m>:ACRMs:ENABle on page 1148
METer:DVMeter<m>:ACRMs:RESult? on page 1148
METer:DVMeter<m>:DC:ENABle on page 1149
METer:DVMeter<m>:DC:RESult? on page 1149

METer:DVMeter<m>:DCRMs:ENABle on page 1149
METer:DVMeter<m>:DCRMs:RESult? on page 1150

All on, All off
Enables/disables all voltmeter measurements.

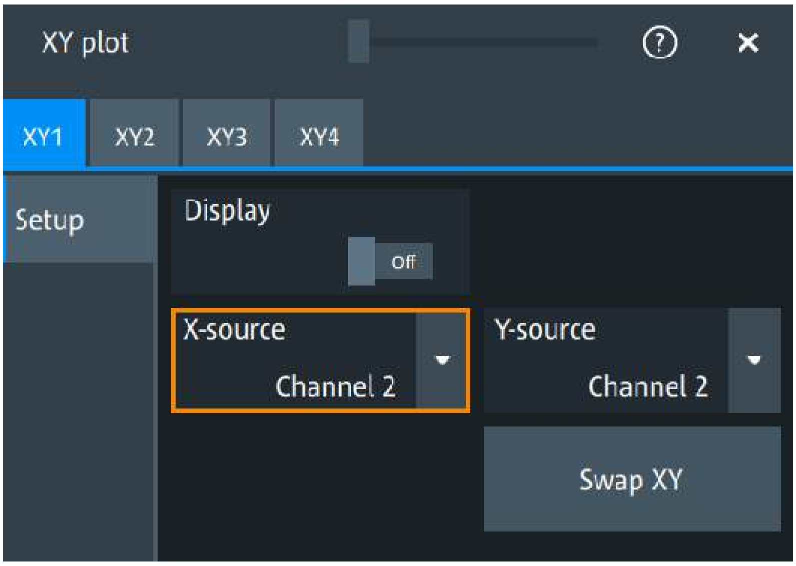
12.5 XY-plot

XY-plots combine the voltage levels of two waveforms in one diagram. They use the voltage level of a second waveform as the x-axis, rather than a time base. This allows you to perform phase shift measurements, for example. You can display up to four different XY-plots.

You can analyse XY-plots, for example, with cursor and automatic measurements, zone trigger and mask test. Available analysis methods depend on the selected sources of the XY-plot.

12.5.1 Settings for XY-plots

Access: "Menu" > "Apps" > "General" tab > "XY"



You can display up to four different XY-plots that use the voltage level of a waveform as the x-axis, rather than a time base.

Make sure to select the tab of the required XY-plot.

Display
If activated, the XY-waveform is active and shown in a diagram, or it is minimized in a signal icon.

Remote command:
XY<m>[:STATe] on page 1151

X-source, Y-source
Define the signal sources that supply the x-values and y-values of the XY-diagram.

Select from the active waveforms:

- Analog channel waveform
- Reference waveform
- Math waveform
- Track waveform (mask test and zone trigger on the resulting XY-plot is not possible)

Remote command:
XY<m>:XSOurce on page 1151
XY<m>:YSOurce on page 1151

Swap XY
Replaces the source of the x-axis with the source of the y-axis and vice versa.

Remote command:
XY<m>:SWAP on page 1150

12.5.2 Displaying an XY-diagram

To set up an XY-plot

1. Select "Menu" > "Apps".
2. In the > "General" tab, tap "XY".
3. In the "X-source" field, define the signal source that supplies the x-values of the XY-diagram.
4. In the "Y-source" field, define the signal source that supplies the y values of the XY-diagram.
5. Enable the "Display".
6. To switch the x- and y-values quickly, tap the "Swap XY" button.

13 Data and file management

This section describes how to manage general settings, waveform data, measurement results, and screenshots.

The "Save/recall" dialog provides functions for saving and restoring data.

Access to save settings and data: "Menu" > "Save/recall" > "Save" tab.

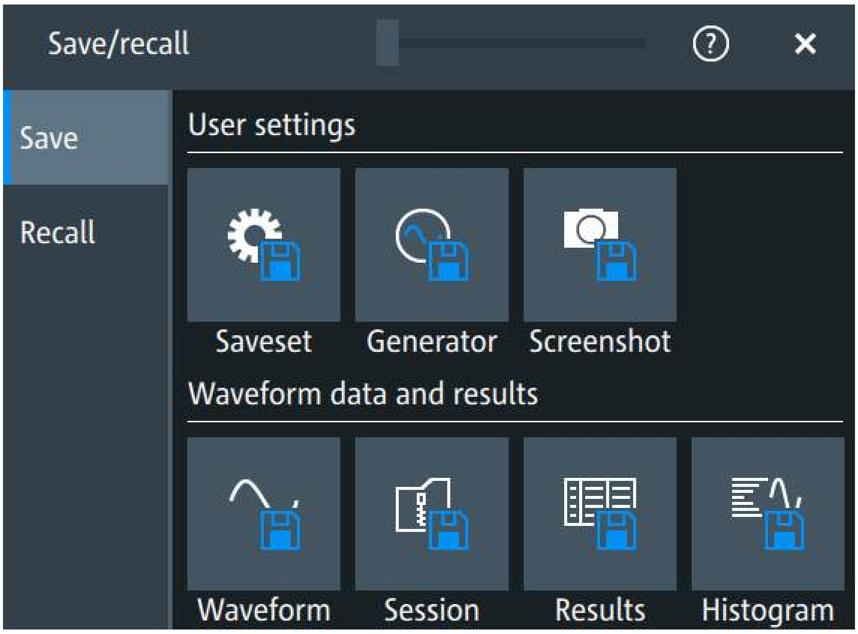


Figure 13-1: Save tab

Access to load settings and data: "Menu" > "Save/recall" > "Recall" tab.

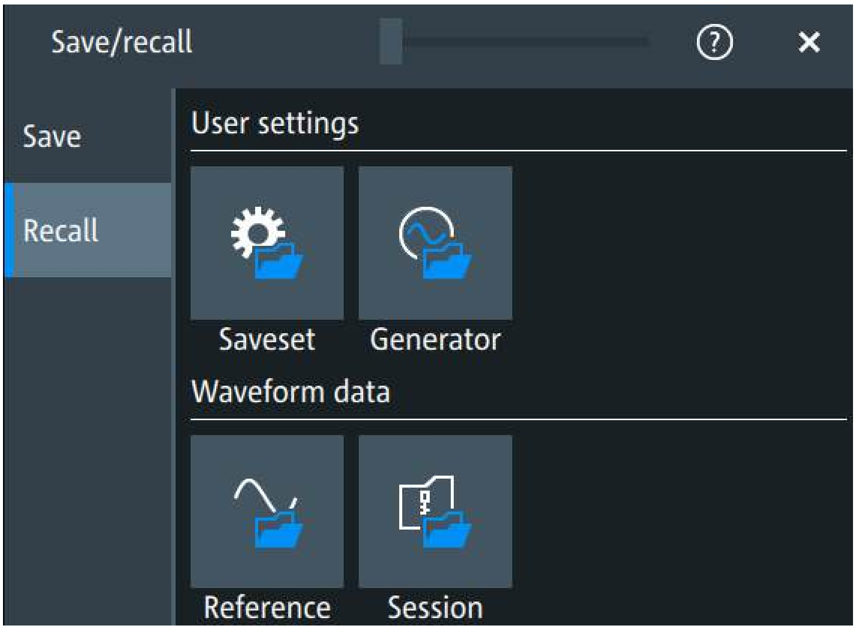


Figure 13-2: Recall tab

Using the "Save/Recall" dialog, you can store or load various data to files for further usage, analysis and reporting:

- General settings: Section 13.1, "General and measurement settings: savesets", on page 397
- Waveforms: Section 13.2, "Waveform data", on page 401
- Reference waveforms: Section 13.2, "Waveform data", on page 401 and Section 9.4, "Reference waveforms", on page 239
- Histograms: Section 13.3, "Histogram data export", on page 418
- Measurement results: Section 13.4, "Results", on page 421
- Sessions: Section 13.5, "Sessions", on page 422
- Screenshots: Section 13.6, "Screenshots", on page 425
- Decode results of serial buses: Section 14.1.7, "Export protocol results", on page 444

The [Camera] key can be configured to save or set up screenshots.

Storage locations

You can store data locally, or to a USB flash drive. For local storage, the path is always `/home/storage/userData`. The path has subdirectories to organize the data. For storage on USB flash drive, the default path is `/run/media/usb/<MyDriveName>/`. On both storage media, you can create directories to organize the data. You can also copy, paste and delete data.

On USB flash drives, the following file systems are supported: FAT32, FAT16, exFAT and NTFS.

The operating system differentiates between relative and absolute paths.

A relative path starts with your current directory and does not start with a `/`, e.g. `userData`.

An absolute path defines the location from the root directory, e.g. `/home/storage/userData`.

13.1 General and measurement settings: savesets

To repeat measurements at different times or perform similar measurements with different test data, you can save the used settings and load them again later. Furthermore, you can refer to the settings of a particular measurement when analyzing the results. Optionally, the current toolbar and dialog configuration can be included into the saveset.

Access: "Menu" > "Save/recall" > "Save" tab > "Saveset".

If you often save and load settings, try the following shortcuts:

- The "Save setup" toolbar icon saves the current settings to a file according to the settings in "Save/recall" > "Save".
- The "Recall" toolbar icon opens the dialog to select and load a setup.
- You can assign a saveset to the [Preset] key and the "Preset" function on the toolbar.
  See Section 5.6, "Preset setup", on page 106.

13.1.1 Using savesets

Savesets contain the complete general and measurement configuration. You can save an unlimited number of setting files.

To save settings to a saveset file

1. Open "Menu" > "Save/recall".
2. In the "Save" tab, tap the "Saveset" button.
   The save "Saveset" dialog opens.

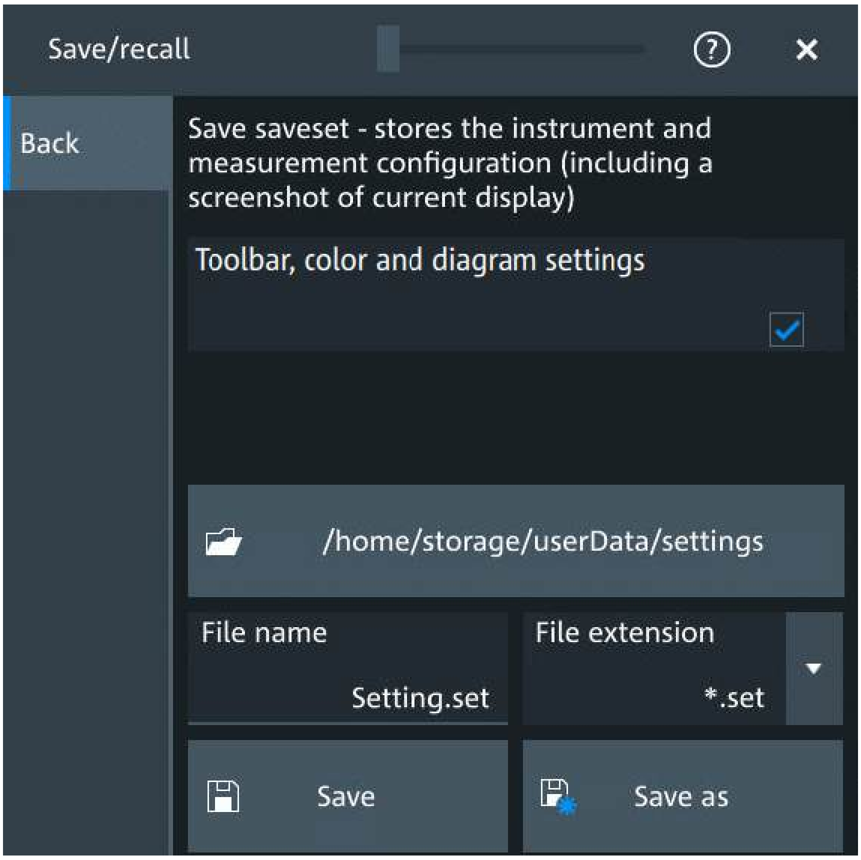


Figure 13-3: Save saveset dialog

3. If needed, enable "Toolbar, color and diagram settings".
4. Check the path on the "<Folder>" button. If the path does not fit, tap the button. Navigate to the folder, where you want to save the settings file.
5. Tap "Save to file".
   Alternatively, select "Save As" and select the destination folder and file name in the file selection dialog.

   The current settings are saved to the selected file.

To load settings from a saveset file

1. Open "Menu" > "Save/recall".
2. In the "Recall" tab, press the "Saveset" button.

   The recall "Saveset" dialog opens.

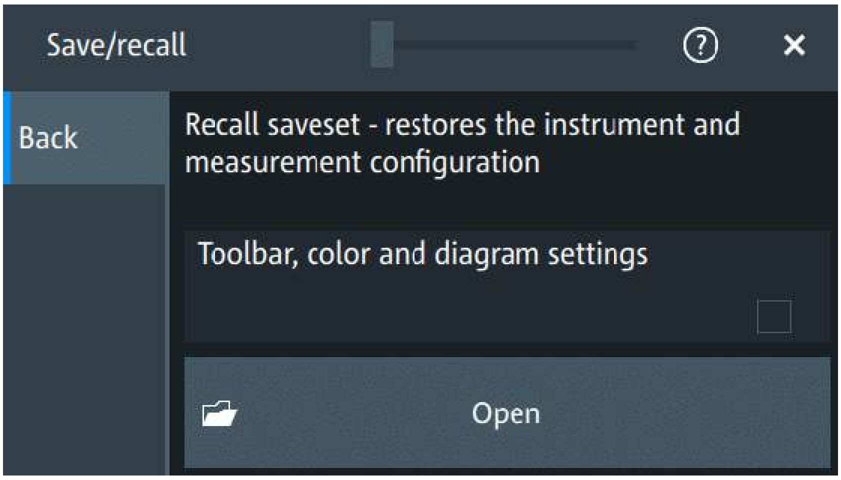


Figure 13-4: Recall saveset dialog

3. Tap "Open".
4. Navigate to the required saveset.

   The saved settings are loaded to the MXO 4.

Remote commands:
- `SAVeset:CONFig:UPReferences` on page 990
- `MMEMory:SAV` on page 988
- `MMEMory:RCL` on page 989

13.1.2 Waveform generator saveset

Generator savesets store the instruments generator configuration.

To save settings to a saveset file

1. Open "Menu" > "Save/recall".
2. In the "Save" tab, press the "Generator" button.
   The save "Gen saveset" dialog opens.

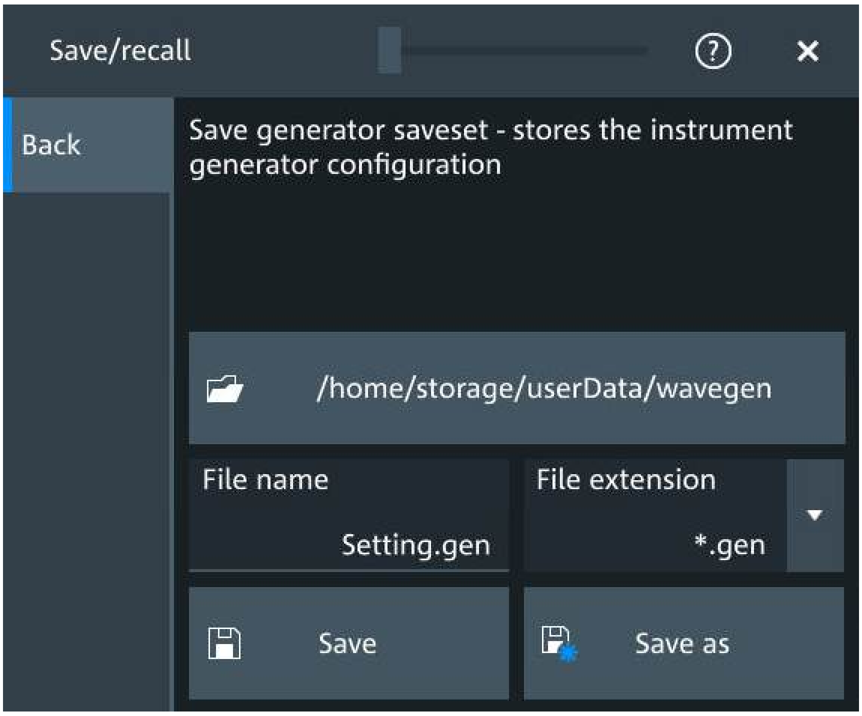


Figure 13-5: Save generator saveset dialog

3. Tap "Browse"

   The current settings are saved to the selected file.

To load settings from a saveset file

1. Open "Menu" > "Save/recall".
2. In the "Recall" tab, press the "Generator" button.

   The recall "Gen saveset" dialog opens.

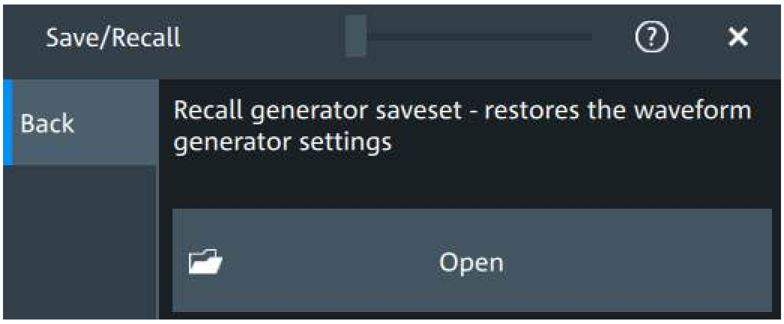


Figure 13-6: Recall generator saveset dialog

3. Tap "Open".
4. Navigate to the saveset.

   The saved settings are loaded to the MXO 4.

Remote commands:

- `GENerator:SAV` on page 991
- `GENerator:RCL` on page 990

13.2 Waveform data

You can save waveform data to files, and reload the data of REF files as reference waveforms.

13.2.1 Save waveforms: settings

Access: "Menu" > "Save/recall" > "Save" tab > "Waveform".

In this dialog, you define the storage settings for waveform data.

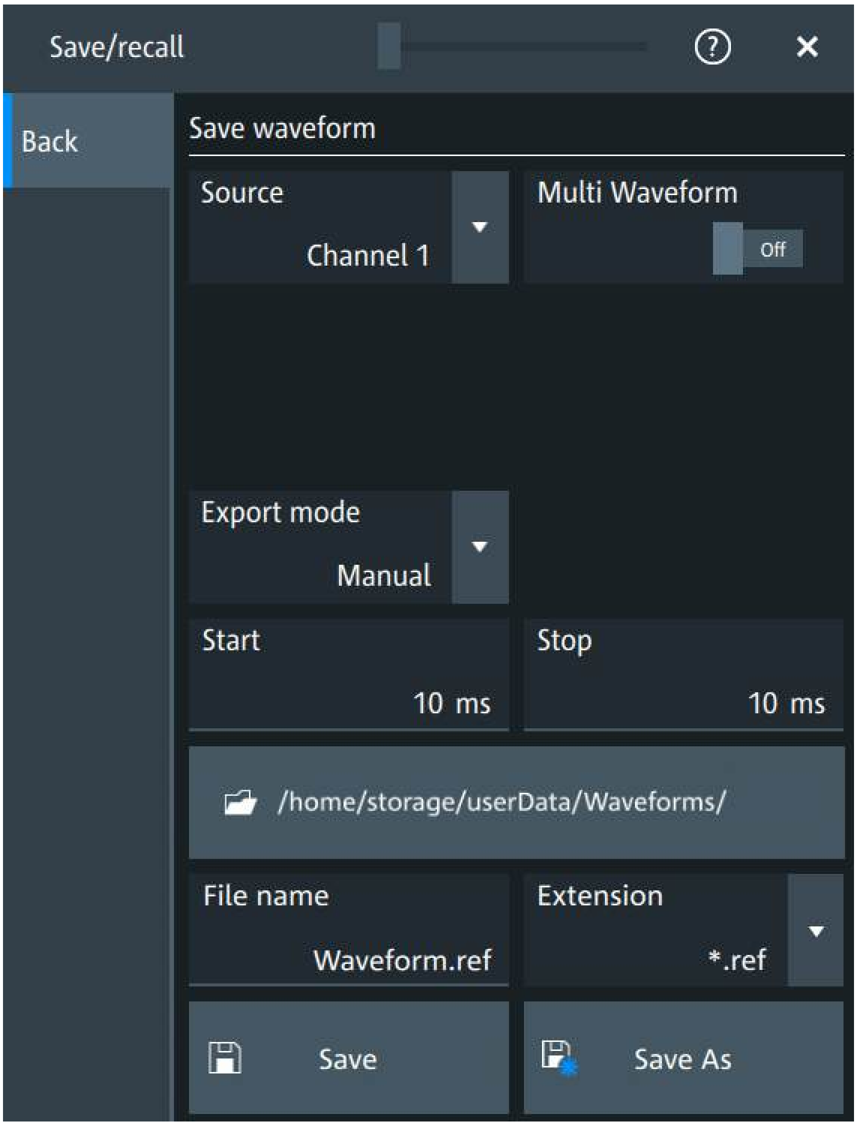


Figure 13-7: Save a single waveform

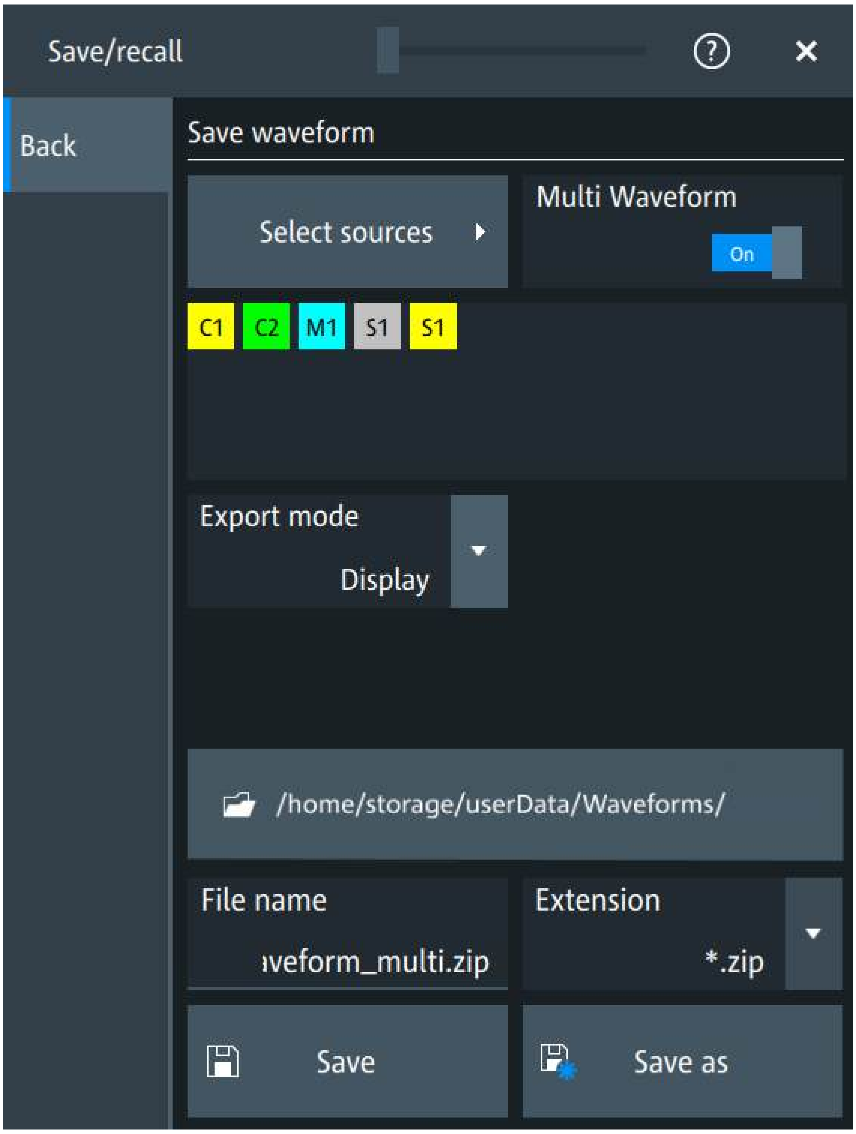


Figure 13-8: Save multiple waveforms

Source

Selects the waveform to be exported with single waveform export. The list shows all active waveforms that are available for export.

Analog and digital channels, math and reference waveforms, tracks and spectrum traces can be exported.

Remote command:
`EXPort:WAVeform:SOURce` on page 994

Multi Waveform

If set to "On", you can export several waveforms at once. Use Select sources to define the waveforms for data export. The following export formats are supported:

- REF files: One REF file per waveform is created. All REF files are combined in a ZIP file.

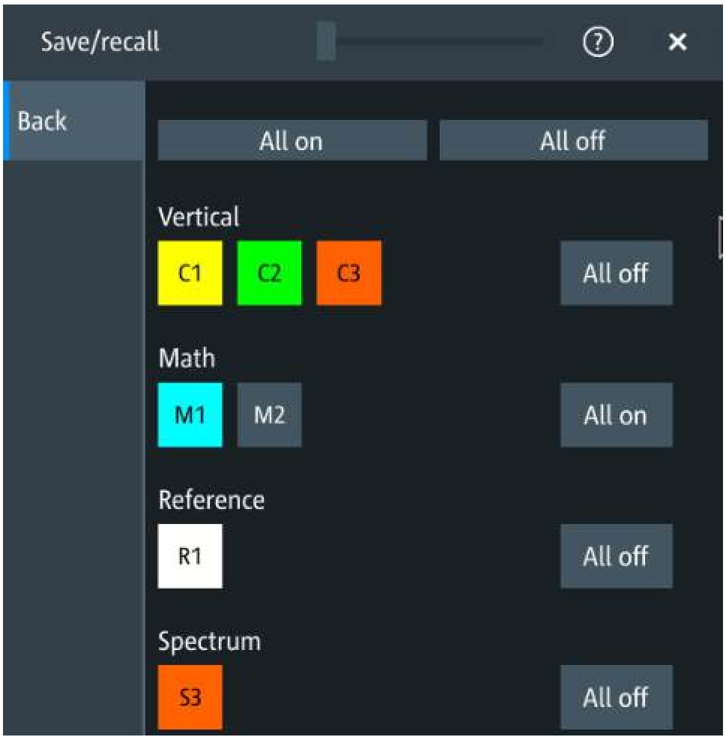
- HDF5 files: All data are written in one `.h5` file.
- CSV files: Multiple analog channels can be saved in one CSV file. Other waveform types are not supported.

For details, see Section 13.2.3, "Waveform export files", on page 409.

Select sources

The selection dialog provides all active waveforms. You can select or deselect all available waveforms at once with "All on" or "All off" on top of the dialog. You can also select or deselect all waveforms of a waveform group, using the button to the right of the group.

Analog and digital channels, math and reference waveforms, tracks and spectrum traces can be exported. Note that in CSV files, only multiple analog channels can be saved.



Remote command:
`EXPort:WAVeform:SOURce` on page 994

Export mode

Defines the part of the waveform record that has to be stored.

"Display"	Saves the waveform data that is displayed in the diagram.
"All data"	Saves the complete waveform record.
"Cursor"	Saves the data between the cursor lines if at least one cursor measurement is defined for the source waveform. If several cursor sets are defined, select the "Cursor set" to be used for export.

"Gate" Saves the data included in the measurement gate if a gated measurement is defined for the source waveform. Select the "Gate" to be used for export.

"Manual" Saves the data between user-defined "Start" and "Stop" values.

Remote command:
EXPort:WAVeform:SCOPe on page 993
EXPort:WAVeform:CURSorset on page 992
EXPort:WAVeform:GATE on page 992
EXPort:WAVeform:STARt on page 995
EXPort:WAVeform:STOP on page 995

Save settings

You define the details of the filename, extension and directory, and save the file.

A progress bar informs you about the process.

<Folder> ← Save settings

Opens a file explorer where you can select the directory where the file is saved.

The setting is used for automatic saving actions, for example, saving on trigger or mask violation. It has **no** effect on EXPort:WAVeform:SAVE.

Remote command:
EXPort:WAVeform:AUTonaming:PATH on page 992

File name base ← Save settings

Sets a name for the file, without extension. The name is extended with a time stamp when the file is saved. Thus, multiple "Save" actions are possible without changing the filename.

The setting is used for automatic saving actions, for example, saving on trigger or mask violation. It has **no** effect on EXPort:WAVeform:SAVE.

Remote command:
EXPort:WAVeform:AUTonaming:NAME on page 991

File extension ← Save settings

Selects the format of the exported file.

You can select between "*.csv" (Excel format), "*.ref" (Reference Waveform Format) and "*.h5" (HDF5 format). REF files can be reloaded as reference waveforms. See: Section 13.2.3, "Waveform export files", on page 409. If you have selected multiple waveforms other than analog channels, CSV is not available.

The setting is used for automatic saving actions, for example, saving on trigger or mask violation. It has **no** effect on EXPort:WAVeform:SAVE.

Remote command:
EXPort:WAVeform:AUTonaming:TYPE on page 992

Save ← Save settings

Saves the file in the defined folder using the "File name base". If the specified file already exists, it is overwritten with the new data.

Save As
Opens a file explorer where you select the folder, the file type, enter the filename and save the file.

Remote command:
`EXPort:WAVeform:NAME` on page 993
`EXPort:WAVeform:SAVE` on page 993

13.2.2 Saving waveforms

To save a single waveform

1. Open "Menu" > "Save/recall".
2. On the "Save" tab, tap "Waveform".

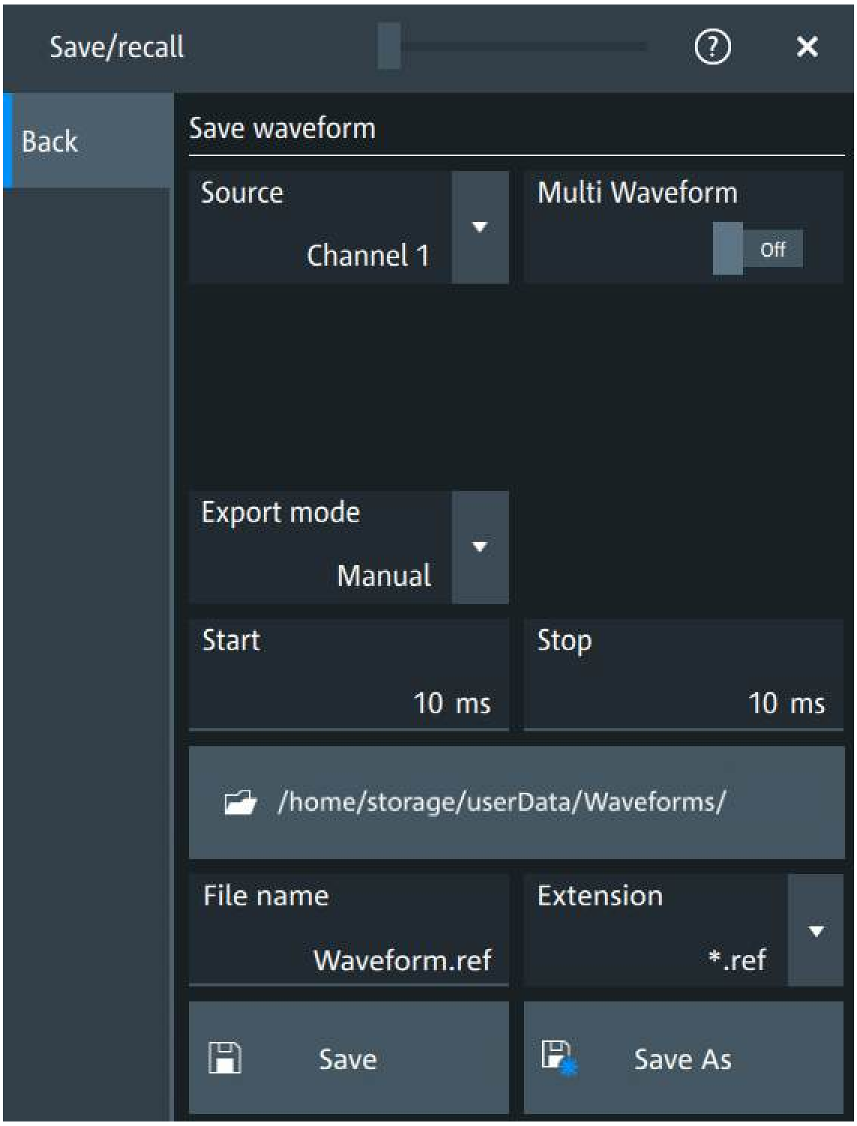


Figure 13-9: Save waveform dialog

3. Select the "Source".
4. Select the "Export mode" to define the exported part of the waveform.
5. If necessary, define the cursor, gate or start/stop values for the data.
6. Select the format of the export file: "File extension".
7. Set the "File name base".
8. Tap "Save" or "Save As".

   The selected waveform is saved to the specified file. A progress bar informs you about the saving process.

To save multiple waveforms

1. Open "Menu" > "Save/recall".
2. In the "Save" tab, tap "Waveform".
3. Enable "Multi Waveform"

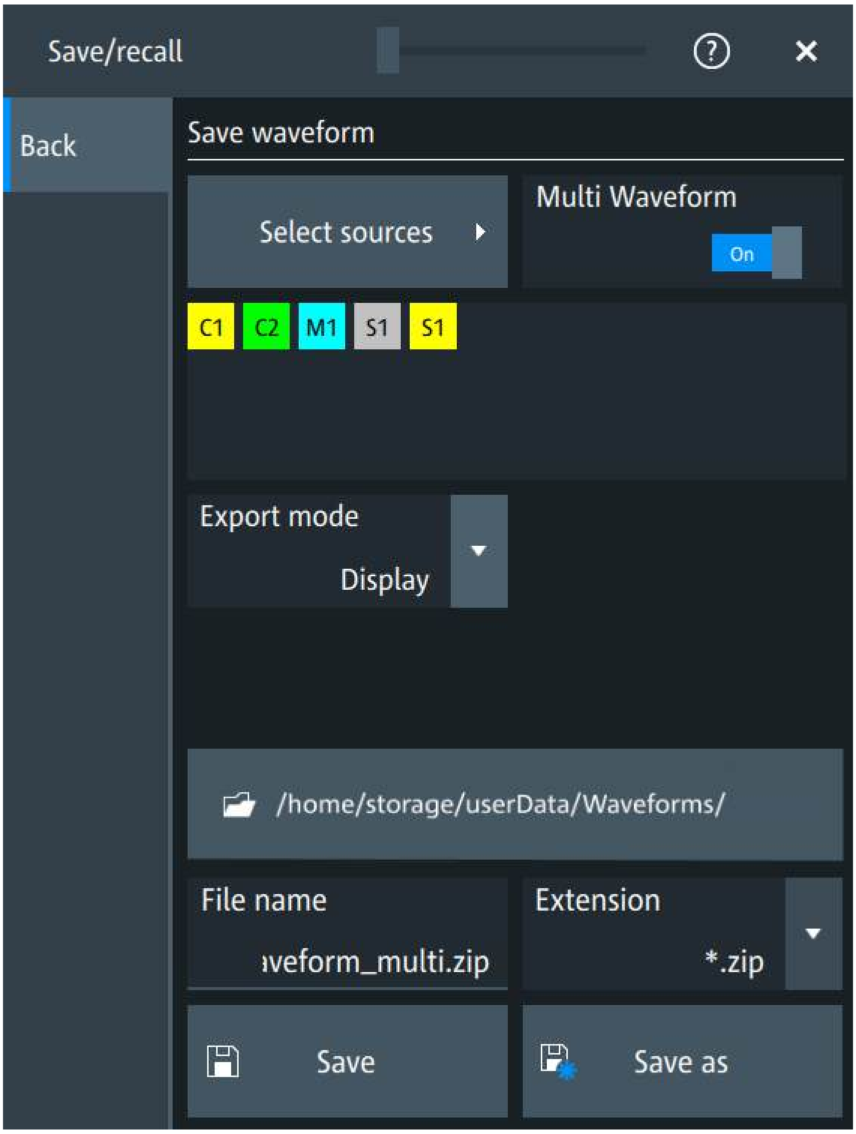
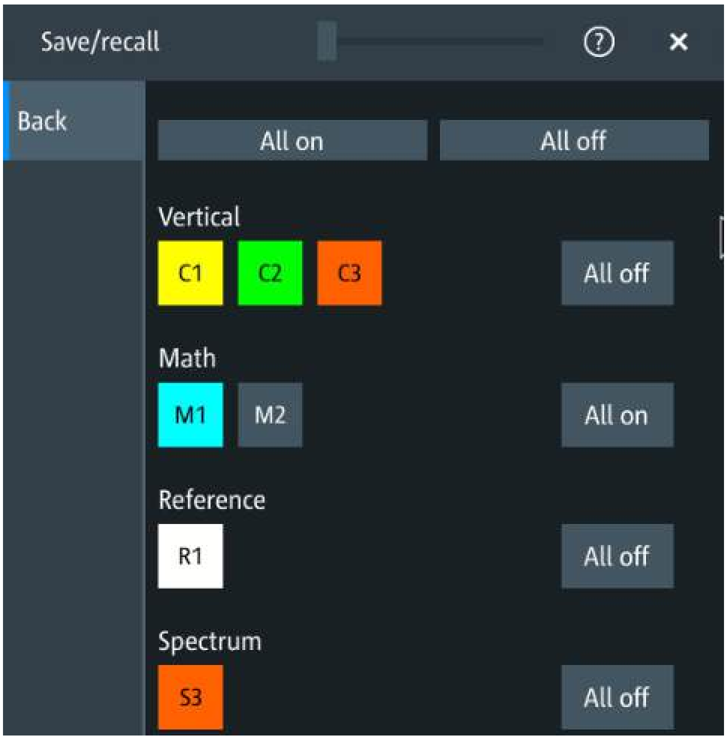


Figure 13-10: Save multiple waveforms dialog

4. Tap "Select sources".
5. Select the waveforms for export.



6. Tap "Back".
7. Select the "Export mode" to define the exported part of the waveform.
8. If necessary, define the cursor, gate or start/stop values for the data.
9. Select the format of the export file: "File extension".
10. Set the "File name base".
11. Tap "Save" or "Save As".

    The selected waveforms are saved to the specified file. A progress bar informs you about the saving process.

13.2.3 Waveform export files

You can store the waveform data in several formats:

- CSV (comma-separated values): ASCII-based format, easy access with Excel or text tools. See Section 13.2.3.1, "CSV files", on page 409.
- REF (reference waveform): binary data with XML header, can be reloaded as reference waveforms. See Section 13.2.3.2, "REF files", on page 413.
- HDF5 (`.h5`): binary container format for external processing of waveform data.

13.2.3.1 CSV files

A CSV file is a comma-separated values (CSV) text file, the waveform is stored in a table. The values are separated by commas.

You can convert the comma-separated text to columns. If you convert the data, take care of the correct number conversion, depending on the tool in use.

Content of waveform files

Header and data are written into one file. The first lines of the file contain header data, for example, time scale, vertical scale, vertical and horizontal positions. Header data is required to interpret the waveform data, and to analyze the data values of the data file.

Below the header, the waveform data follows. For each sample, one line is written. The first value is the X-value (time or frequency), the next is the Y-value in the unit indicated in the header data. For envelope or peak detect waveforms, two Y-values (minimum and maximum) are written for each sample.

	A	B	C	D	E	F
1	Model,MXO54					
2	SerialNumber,101416					
3	,					
4	SourceType,CHANNEL_TRACE					
5	SignalSource,Ch1Wfm1					
6	Resolution,2e-10					
7	RecordLength,1000					
8	HWRecordLength,1000					
9	HorizontalPosition,0					
10	TraceArithmetics,SINGLE					
11	BaseUnit,LEVEL_V					
12	BaseUnitRelative,OFF					
13	Impedance,50					
14	UserTermination,1M_OHM					
15	XStart,-1.0000000000000001e-07					
16	XStop,1.0000000000000001e-07					
17	TimebaseScale,2e-08					
37	TIME,C1					
38	-1e-07,0.0031761544099682382					
39	-9.98e-08,0.002565355484974346					
40	-9.9599999999999999e-08,0.000977278279990227					
41	-9.9399999999999999e-08,0.0008551184949914487					
42	-9.9199999999999999e-08,0.00036647935499633513					
43	-9.8999999999999999e-08,-0.0010994380649890054					
44	-9.8799999999999998e-08,-0.0018323967749816759					
45	-9.8599999999999998e-08,-0.0020767163449792324					
46	-9.8399999999999998e-08,-0.002321035914976789					
47	-9.8199999999999998e-08,-0.001954556559980454					
48	-9.7999999999999998e-08,-0.0008551184949914487					

Figure 13-11: CSV file of a time waveform, opened in Excel

	A	B	C	D	E
1	Model,MXO54				
2	SerialNumber,101416				
3	,				
4	SourceType,SPECTRUM				
5	SignalSource,SPECTRUM1_NORMAL				
6	BaseUnit,LEVEL_V				
7	BaseUnitRelative,OFF				
8	Impedance,50				
9	UserTermination,1M_OHM				
10	VerticalPosition,0				
11	VerticalScale,10				
12	VerticalOffset,-45				
13	BaseYStart,0				
14	BaseYStop,0				
15	ViewUnit,LEVEL_DBM				
16	ViewUnitRelative,OFF				
17	ViewReferenceLevel,0				
18	NumericFormat,DECIMAL				
19	CenterFreq,1000000000.0000001				
20	FreqSpan,2000000000				
33	FREQUENCY,SPECNORM1				
34	-213623.27970552444,-49.02157013180808				
35	549316.1734194754,-49.769556105402145				
36	1312255.6265444753,-53.96493039074978				
37	2075195.079669475,-61.57760265043916				
38	2838134.532794475,-70.19729413316635				
39	3601073.985919475,-73.24404760765583				
40	4364013.439044475,-75.68197528968501				
41	5126952.892169475,-91.81643862397064				

Figure 13-12: CSV file of a spectrum waveform, opened in Excel

If you export multiple analog channels at once, one column per channel is written. For envelope or peak detect waveforms, two values per channel are written.

1	Model	MXO54C							
2	SerialNumber	100864							
3									
4	SourceType	CHANNEL_TRACE		CHANNEL_TRACE		CHANNEL_TRACE		CHANNEL_TRACE	
5	SignalSource	Ch1Wfm1		Ch2Wfm1		Ch3Wfm1		Ch4Wfm1	
6	Resolution	2.00E-10		2.00E-10		2.00E-10		2.00E-10	
7	RecordLength	1000		1000		1000		1000	
8	HWRecordLength	1000		1000		1000		1000	
9	HorizontalPosition	0		0		0		0	
10	TraceArithmetics	ENVELOPE		ENVELOPE		ENVELOPE		ENVELOPE	
11	BaseUnit	LEVEL_V		LEVEL_V		LEVEL_V		LEVEL_V	
12	BaseUnitRelative	OFF		OFF		OFF		OFF	
13	Impedance	50		50		50		50	
14	UserTermination	1M_OHM		1M_OHM		1M_OHM		1M_OHM	
15	XStart	-1.00E-07		-1.00E-07		-1.00E-07		-1.00E-07	
16	XStop	1.00E-07		1.00E-07		1.00E-07		1.00E-07	
37	TIME	C1 MAX	C1 MIN	C2 MAX	C2 MIN	C3 MAX	C3 MIN	C4 MAX	C4 MIN
38	-1.00E-07	0.00586367	-0.006352309	0.002565355	-0.005130711	0.003786953	-0.005008551	0.003542634	-0.004275592
39	-9.98E-08	0.008551185	-0.003664794	0.002687515	-0.005252871	0.003542634	-0.004642072	0.003664794	-0.003909113
40	-9.96E-08	0.010750061	-0.000732959	0.003053995	-0.005008551	0.003176154	-0.00561935	0.003420474	-0.004275592
41	-9.94E-08	0.013804056	0.001588077	0.002931835	-0.005252871	0.003298314	-0.005375031	0.003786953	-0.004031273
42	-9.92E-08	0.016247251	0.004519912	0.003053995	-0.005130711	0.003053995	-0.005008551	0.003786953	-0.004764232
43	-9.90E-08	0.019179086	0.007451747	0.002565355	-0.005130711	0.003420474	-0.004764232	0.003909113	-0.004397752
44	-9.88E-08	0.021133643	0.010017102	0.002687515	-0.005130711	0.002931835	-0.004764232	0.004519912	-0.004397752
45	-9.86E-08	0.023576839	0.012582458	0.003420474	-0.004886391	0.003664794	-0.004397752	0.004275592	-0.004519912
46	-9.84E-08	0.025897874	0.015392133	0.003053995	-0.005130711	0.003664794	-0.004397752	0.004153433	-0.004031273

Figure 13-13: CSV file of four analog channels, envelope acquisition mode, opened in Excel and converted to columns

Header data

The header lines contain the following properties, depending on the type of the exported waveform (time or frequency):

Table 13-1: Header file properties in CSV files

Value	Description	Time	Frequency
Model	Model of the instrument	X	X
SerialNumber	Serial number of the instrument	X	X
SourceType	Type of the exported waveform	X	X
SignalSource	Source of the exported waveform	X	X
Resolution	Time between two samples *Resolution = 1 / Sample Rate*	X	
RecordLength	Number of samples in a waveform record of one acquisition	X	
HWRecordLength	Equivalent to the RecordLength	X	
HorizontalPosition	Horizontal position of the waveform in divisions	X	
TraceArithmetics	Arithmetic of the waveform: off, envelope, or average	X	
BaseUnit	Base unit of a mathematic waveform, for example, linear unit	X	X
BaseUnitRelative	Base unit, if a relative unit (e.g. dB) is enabled	X	X
Impedance	Input impedance, used for power calculation	X	X
UserTermination	User-defined load impedance connected to the probe	X	X
XStart	Horizontal start value of the waveform (time or frequency), as defined in the export settings	X	
XStop	Horizontal stop value of the waveform (time or frequency), as defined in the export settings	X	
TimebaseScale	Horizontal scale in seconds per division	X	
ReferencePoint	Position of the zero point in % of the screen	X	
VerticalPosition	Vertical position of the waveform in divisions	X	X
VerticalScale	Vertical scale of the waveform	X	X
VerticalOffset	Vertical offset of the waveform in Volts, or other unit	X	X
BaseYStart	Vertical start value of the waveform	X	X
BaseYStop	Vertical stop value of the waveform	X	X
ViewUnit	User-selected unit of a waveform, for example, logarithmic unit for a spectrum.	X	X
ViewUnitRelative	Indication of a relative unit. It is true if the ViewUnit implies a reference level, for example dB.	X	X
ViewReferenceLevel	Reference level for a relative unit. The value is only valid if the unit is relative (ViewUnitRelative = ON).	X	X
NumericFormat	Number format of bus values and digital channel data (bit pattern format)	X	X
EnhancementMode	Method to increase the sample rate if the required sample rate is higher than the ADC sample rate.	X	

Value	Description	Time	Frequency
InterpolationMode	Interpolation method. The value is relevant when the enhancement mode is interpolated time.	X	
CenterFreq	Center frequency of the spectrum		X
FreqSpan	Frequency span of the spectrum		X
ResolutionBW	Resolution bandwidth of the spectrum		X
FrequencyStart	Start frequency of the spectrum		X
FrequencyStop	Stop frequency of the spectrum		X
WindowType	Window used for the spectrum computation		X
GateRBWCoupling	Indication whether the record length or the resolution bandwidth is a constant for the spectrum computation		X
XAxisMode	Indicates a linear or logarithmic x-axis		X
HorizontalDivisionCount	Number of horizontal divisions	X	X
VerticalDivisionCount	Number of vertical divisions	X	X
FirmwareVersion	Firmware version that is installed on the MXO 4	X	X
DecimationMode	Method to reduce the number of data samples to achieve the required sample rate: Sample, peak detect, HiRes, RMS	X	

13.2.3.2 REF files

The REF format is a specific format, which allows you to reload the waveform data as a reference waveform. The data is saved in a zipped file that contains two files per waveform. One file is a binary file (BIN file) and contains the waveform data values. The second file is an XML file and contains the header data in several data groups. Header data is required to reload the waveform from data, or to analyze the data values of the data file.

```xml
<?xml version="1.0" encoding="UTF-8"?>
<Group Name="SignalExportBase">
  <Group Name="SignalAttributes">
    <Prop Name="SourceType" Value="CHANNEL_TRACE" UserValue="NONE" />
    <Prop Name="SignalSource" Value="Ch1Wfm1" />
    <Prop Name="Resolution" Value="2.0000000000000001e-10" />
    <Prop Name="RecordLength" Value="1000" />
    <Prop Name="HWRecordLength" Value="1000" />
    <Prop Name="HorizontalPosition" Value="0" />
    <Prop Name="TraceArithmetics" Value="SINGLE" UserValue="SINGLE" />
    <Prop Name="BaseUnit" Value="LEVEL_V" UserValue="LEVEL_V" />
    <Prop Name="BaseUnitRelative" Value="OFF" UserValue="OFF" />
                          ⋮
    <Group Name="PostProcessingBufferSampleCounts">
      <Prop Name="DeltaPreSamples" Value="25" />
      <Prop Name="PreSamples" Value="500" />
      <Prop Name="PostSamples" Value="500" />
      <Prop Name="DeltaPostSamples" Value="29" />
    </Group>
  </Group>
</Group>
```

Figure 13-14: Header file in XML format, part of the REF file container

Table 13-2: Header file properties in REF files

Value	Description
SignalAttributes Same values as in CSV files, except for Model and SerialNumber. See Table 13-1.	
SignalAttributesPostProcessing	
SignalFormat	Format of the data values in the BIN file: INT8BIT, INT16BIT, INT32BIT, FLOAT, DOUBLE
Origin	WFM_EXPORT: export of one acquisition or export of multiple acquisitions
ByteOrder	Byte order of the values in the BIN file ● LSB first: little endian, least significant byte first ● MSB first: big endian, most significant byte first
NumberOfWaveforms	Number of waveforms. always = 1
TimestampState	OFF
Timestamp	Absolute time of the waveform recording in ISO 8601 format
DecimationMode	Method to reduce the number of data samples to achieve the required sample rate
IsMinMax	If ON, then min and max values are saved for each sample. For envelope and peak detect waveforms.
IsComplex	If ON, then two values are saved for each sample (I and Q value).
TriggerOffsetToPostSampleInSec-onds	Offset between the exact trigger position and the first sample after the trigger
SignalRecordLength	Number of samples in the BIN file. If the signal is a spectrum, the value indicates the number of FFT bins. The value can differ from RecordLength and HWRecordLength because the data file has additional samples before and after the record to consider interpolation and other waveform parameters and their dependencies.

Value	Description
SignalXStart	Time of the first sample in the acquired data. Different from XStart because the data file has additional samples before and after the record, and if only part of the data is exported.
SignalXStop	Time of the last sample in the data acquired. Different from XStop because the data file has additional samples before and after the record, and if only part of the data is exported.
AdjustedResolutionBW	Actual resolution bandwidth of a spectrum waveform. Only valid if the exported waveform is a spectrum.
NoiseBandwidth	Noise bandwidth of a spectrum waveform, required for power calcu-lation. Only valid if the exported waveform is a spectrum.
ValuesPerSample	Number of y-values saved at each sampling time. The value is usu-ally 1. The value is 2, if min and max values are saved for each sam-ple, for example, for envelope waveforms.
NofQuantisationLevels	Number of quantization levels of y values
TOADone	If ON, then TriggerOffsetToPostSampleInSeconds is compensated.
SignalResolution	Time between two samples in this waveform. The value can differ from Resolution if the source is, for example, a spectrum. The value is determined automatically considering the waveform parameters and their dependencies. If the signal is a spectrum, the value indi-cates the frequency range of FFT bins.
HorizontalDomain	Domain of the x-axis (time or frequency)
PostProcessingVerticalAxisAttributes	
Range	Range of the signal in y-direction
Offset	Center of the y-range
Resolution	Resolution of the y-axis
IsLogarithmic	Indicates if the y-axis is logarithmic (ON or OFF)
PostProcessingSampleFormatAttributes	
ValueStorage	Interpretation of the data: is integer or float (floating point data)
ValueInterpretation	Indicates if the data is saved as binary ADC values (BINARY), or physical values (PHYSICAL)
SampleBitSize	Value size in bit, as used in processing
ValueBitSize	Value size of ADC data in bit
LsbExtensionBits	Number of bits the ADC value is shifted to the left in the CPU sample size
AdcValueBitSize	Number of bits of the ADC that was used to sample the signal. It does not include any additionally gained bits due to high definition mode.
IsSigned	Signed values (ON) or unsigned values (OFF)

Value	Description
PostProcessingBufferSampleCounts	
[DeltaPreSamples | PreSamples || PostSamples | DeltaPostSamples]	Indicates the distribution of the samples. || marks the trigger time. The sum of PreSamples and PostSamples matches the requested record length. DeltaSamples are additional samples that are needed for computation but they are not measured or displayed.

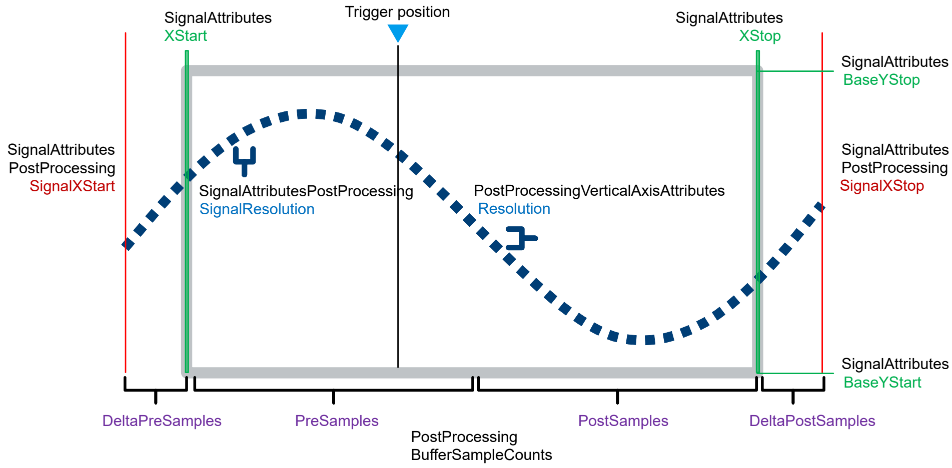


Figure 13-15: Main header properties at the waveform

Note: FractionalBits was removed in FW version 1.3.x. Reference waveforms created with older FW versions are compatible and can be reloaded.

13.2.3.3 HDF5 files

An HDF5 (`.h5`) file is a container format that contains attributes and waveform data. The format can be read by different programming languages with existing libraries. HDF5 stores binary data, thus the file size is smaller than CSV files.

Use the HDF5 format to export data from the MXO 4 and analyze the waveforms with external software.

You can save one or more waveforms in one HDF5 file.

The HDF5 file consists of several groups in a hierarchical structure. The data samples are float32 values of the physical values. No conversion is needed. For envelope and peak detect waveforms, two Y-values are written for each sample ("min" and "max").

Table 13-3: Contents and structure of the HDF5 file

Group	Subgroup	Attribute, example values, data	Description
/FileType			Type of the HDF5 file.
		Rohde&Schwarz: "MXO"	Instrument family.
		Version: "1.0"	Version of the HDF5 format.

Group	Subgroup	Attribute, example values, data	Description
/Frame			Export information.
		DateTime: "<ISO time stamp>"	Date and time of the file export.
		FirmwareVersion: "2.5.0.60"	Version of the instrument firmware.
		Model: "MXO44"	Instrument model.
		SerialNumber: "100000"	Serial number of the exporting instrument.
/Waveforms			Attributes and data.
	/Waveforms/C1		One subgroup for each waveform.
		Count: 1	Number of acquisitions, always = 1.
		NumPoints: 1000	Number of exported samples (record length of the exported waveform).
		XInc: 2e-10	Resolution, the time between two samples.
		XOrg: -1.0e-7	Horizontal start value of the waveform, time of the first sample.
		XUnit: "Time"	Unit of the horizontal axis (Time, Frequency).
		YUnit: "V"	Unit of the vertical axis.
		/Waveforms/C1/C1 Additional Info	Subgroup with further information. See "Additional info (/Waveforms/C1/C1 Additional Info)" on page 417.
		DataSet(/Waveforms/C1/C1 Data)	Data values.
		DateTime: "<ISO time stamp>"	Date and time of the trigger of this acquisition.
		TriggerOffsetToPostSampleInSeconds: 1.1e-12	Offset between the trigger time and the first sample after the trigger, in seconds.
		DataSet(/Waveforms/C1/C1 PreData)	Additional samples before the samples in DataSet, are used to settle the filters.
		DataSet(/Waveforms/C1/C1 PostData)	Additional samples after the samples in DataSet, are used to settle the filters.
	/Waveforms/C2	Analogous to /Waveforms/C1	
	/Waveforms/C3	Analogous to /Waveforms/C1	

Additional info (/Waveforms/C1/C1 Additional Info)

The `/Waveforms/C1/C1 Additional Info` group provides additional information on the waveform, which is not essential to interpret the waveform data. Most of this information is also available in the header of CSV or REF files.

Field	Description	Identical to CSV	Identical to REF
DecimationMode	Method to reduce the number of data samples to achieve the required sample rate.	X	
EnhancementMode	Method to increase the sample rate if the required sample rate is higher than the ADC sample rate.	X	
HorizontalPosition	Horizontal position of the waveform in divisions.	X	
Impedance	Input impedance, used for power calculation.	X	
InterpolationMode	Interpolation method. The value is relevant when the enhancement mode is interpolated time.	X	
Label	Channel label, currently empty.		
NofQuantisationLevels	Number of quantization levels of y values.		X
ReferencePoint	Position of the zero point in % of the screen.	X	
SignalSource	Source of the exported waveform.	X	
SourceType	Type of the exported waveform.		X
TOADone	If ON, then TriggerOffsetToPostSampleInSec-onds is compensated.	X	
TimebaseScale	Horizontal scale in seconds per division.	X	
TraceArithmetics	Arithmetic of the waveform: off, envelope, or average.	X	
UserTermination	User-defined load impedance connected to the probe.	X	
VerticalOffset	Vertical offset of the waveform in Volts, or other unit.	X	
VerticalPosition	Vertical position of the waveform in divisions.	X	
VerticalScale	Vertical scale of the waveform.	X	
XDispOrigin	X value on the left border of the screen.		
XDispRange	X value range that is shown on the screen.		
YDispOrigin	Y value of the bottom border of the screen.		
YDispRange	Y value range that is shown on the screen.		
YInc	Value of the quantization level of the Y values.		

13.3 Histogram data export

You can export the data of waveform histograms to file.

13.3.1 Histogram export files

Data of histograms is saved to one CSV file, which starts with header data followed by normalized or absolute histogram values.

The header has the following information:

- Name of the histogram
- Source waveform of the histogram
- Histogram mode: vertical or horizontal
- Normalization on or off
  - On: Data values are float values that represent the ratio of samples in a given bin to the sum of all samples. The sum of all normalized values is 1.
  - Off: Data values are integer values that represent the number of samples in a given bin.
- Histogram range: start and end values.
  - Vertical histograms: the values are given in the unit of the vertical axis
  - Horizontal histograms: the unit is s.

Example of file content

Table 13-4: Content of histogram CSV file

Normalization on	Normalization off	Number of the data row for value calculation
HistogramName,Hist1 HistogramSource,Ch1Wfm1 HistogramType,VERTICAL Normalization,OFF HistogramStart,-0.25024431956999754 HistogramEnd,0.25012215978499874 , , , DATA 0 0 100 800 100 0 0 0	HistogramName,Hist1 HistogramSource,Ch1Wfm1 HistogramType,VERTICAL Normalization,ON HistogramStart,-0.25024431956999754 HistogramEnd,0.25012215978499874 , , , DATA 0 0 0.1 0.8 0.1 0 0 0	 1 2 3 4 5 6 7 8

Data conversion

Using the header data, you can calculate the waveform value to which a histogram value belongs. The calculation is valid for vertical and horizontal histograms.

A histogram bin covers a domain of this width:

BinWidth = (HistogramStart - HistogramEnd) / NumberOfHistogramBins

BinIndex is the index of the histogram bin of interest, starting with 1. It is the number of the DATA row in the CSV file.

The center value corresponding to a histogram bin is:

*Value = (HistogramStart - HistogramEnd) * (BinIndex - 0.5) / NumberOfHistogramBins + HistogramStart*

The domain covered by the histogram bin is: *Value +/- 0.5 * BinWidth*.

For the example in Table 13-4, the voltage value that corresponds to the histogram value 800 or 0.8 (histogram bin number 4) is:

*(0.25 - (-0.25)) * (4 - 0.5) / 8 - 0.25 = -0.03125 V*

The bin width in this example is *(0.25 - (-0.25)) / 8 = 0.0625 V*.

The 4th bin with value 800 covers a voltage domain of

*-0.03125 + 0.5 * 0.0625 = 0 V* to *-0.03125 - 0.5 * 0.0625 = -0.0625 V*

13.3.2 Settings for histogram export

Access: "Menu" > "Save/recall" > "Save" tab > "Histogram".

Select histogram
Select the histogram that you want to save.

Normalization
If normalization is off, the number of samples in a given bin is exported as integer values. With normalization, the ratio of samples in a given bin to the sum of all samples is exported as float value. The sum of all normalized values is 1.

Remote command:
`EXPort:HISTogram<m>:NORMalize` on page 996

Source, X, Y
Show the basic settings of the selected histogram for information: waveform source, start and end values on the x and y-axis.

Save settings
Define the filename and storage location, and start the saving process.

"<Folder>"	Opens a file explorer where you can select the directory where the file is saved.
"File name base"	Sets a name for the file, without extension. The name is extended with a time stamp when the file is saved. Thus, multiple "Save" actions are possible without changing the filename.
"File extension"	The format of the histogram file is always `.csv`.

"Save" Saves the file in the defined folder using the "File name base". If the specified file already exists, it is overwritten with the new data.

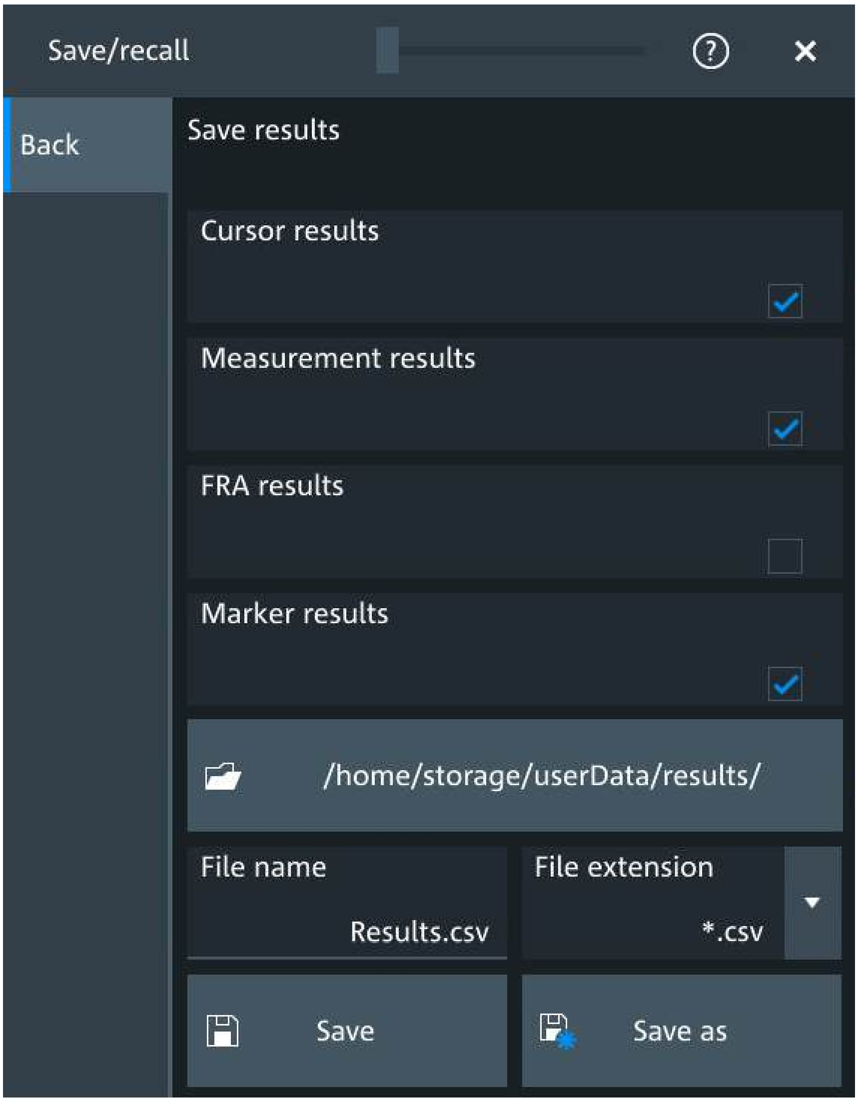
"Save As" Opens a file explorer where you select the folder, the file type, enter the filename and save the file.

A progress bar informs you about the process.

Remote command:
`EXPort:HISTogram<m>:NAME` on page 997
`EXPort:HISTogram<m>:SAVE` on page 997

13.4 Results

You can select the result tables to be saved, and define the storage settings.



To save results

1. Open "Menu" > "Save/recall".
2. In the "Save" tab, press the "Results" button.
   The save "Results" dialog opens.
3. Select the results to be saved. The "Save results" results list shows all result tables that are currently open. All results are written into one file.
4. Under "Location", enter a "File name base" and select "Save". Alternatively, select "Save As" and define the target directory and file name in the file selection dialog.

   The current results are saved to the selected file.

Remote commands:
- `EXPort:RESult:SELect:CURSor` on page 999
- `EXPort:RESult:SELect:MEASurement` on page 999
- `EXPort:RESult:NAME` on page 999
- `EXPort:RESult:SAVE` on page 999

13.5 Sessions

Sessions store the general and measurement settings and the data of active channel waveforms and reference waveforms together in a ZIP file. The user-specific display settings for the toolbar, waveform colors and diagrams can also be included.

13.5.1 Save a session

Access: "Menu" > "Save/recall" > "Save" tab > "Session"

The session file includes active channel and reference waveforms and the current measurement setup. Before saving the session, consider where you want to use the session data. In R&S ScopeStudio, all included waveforms and settings can be recalled. When recalling on an MXO oscilloscope, channel waveforms are not imported. Therefore, if you want to recall the session on an instrument, save channel waveforms as references and change the sources of analysis functions to these references before saving the session.

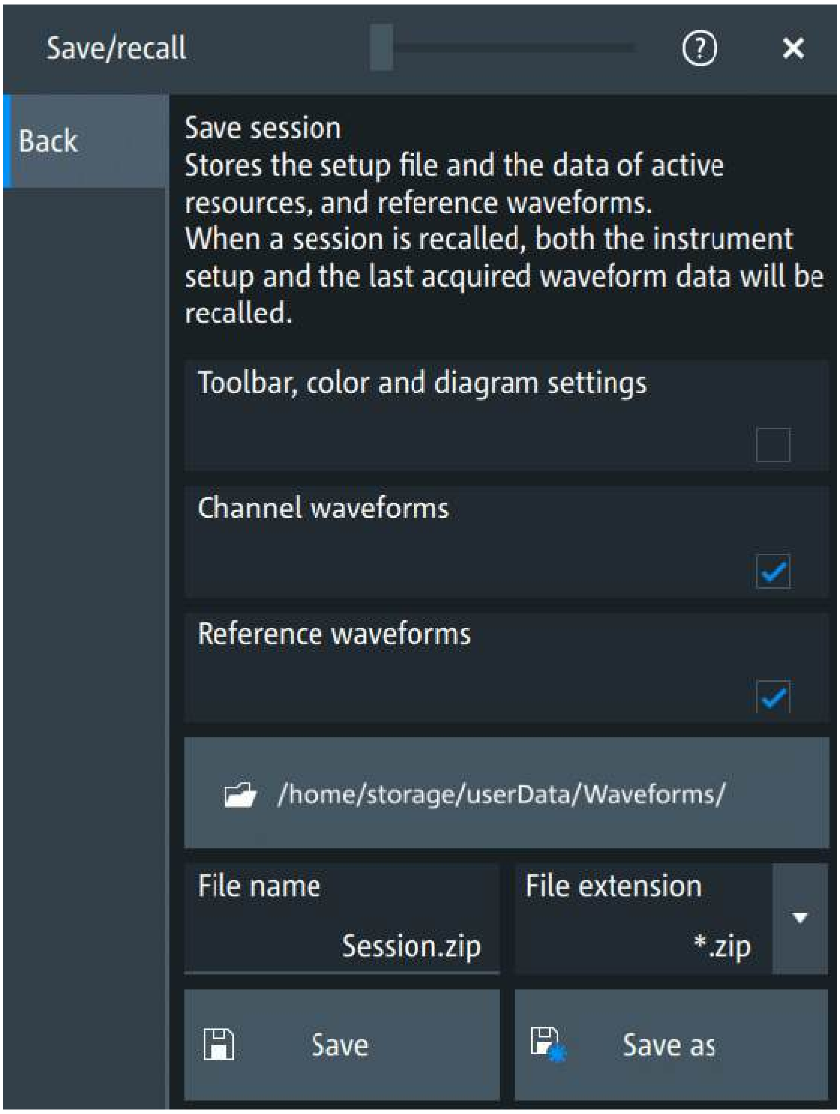


Figure 13-16: Save session dialog

Toolbar, color and diagram settings
If selected, the user-specific display settings for the toolbar, waveform colors and diagram settings are included in the session file.

Remote command:
`SESSion:USERpref` on page 998

Channel Waveforms
Select if you want to include channel waveform data in the session file.

Remote command:
`SESSion:SAVE:CHANnel` on page 998

Reference Waveforms
Select if you want to include reference waveform data in the session file.

Remote command:
`SESSion:SAVE:REFerence` on page 998

Save settings
Defines the filename and storage location.

"<Folder>"	Opens a file explorer where you can select the directory where the file is saved.
"File name base"	Sets a name for the file, without extension. The name is extended with a time stamp when the file is saved. Thus, multiple "Save" actions are possible without changing the filename.
"File extension"	The format of the session file is always `.zip`.
"Save"	Saves the file in the defined folder using the "File name base". If the specified file already exists, it is overwritten with the new data.
"Save As"	Opens a file explorer where you select the folder, the file type, enter the filename and save the file.

A progress bar informs you about the process.

Remote command:
`SESSion:SAVE[:EXECute]` on page 998
`SESSion:SAVE:ABORt` on page 998

13.5.2 Load a session

Access: "Menu" > "Save/recall" > "Recall" tab > "Session"

When you recall a session, the settings and the reference waveforms (if included in the session file) are restored. You can also restore some user-specific display settings: toolbar, waveform colors, and diagram settings. Channel waveforms are not imported even if they are included in the session file. Therefore, save channel waveforms as references and change the sources of analysis functions to these references before saving the session.

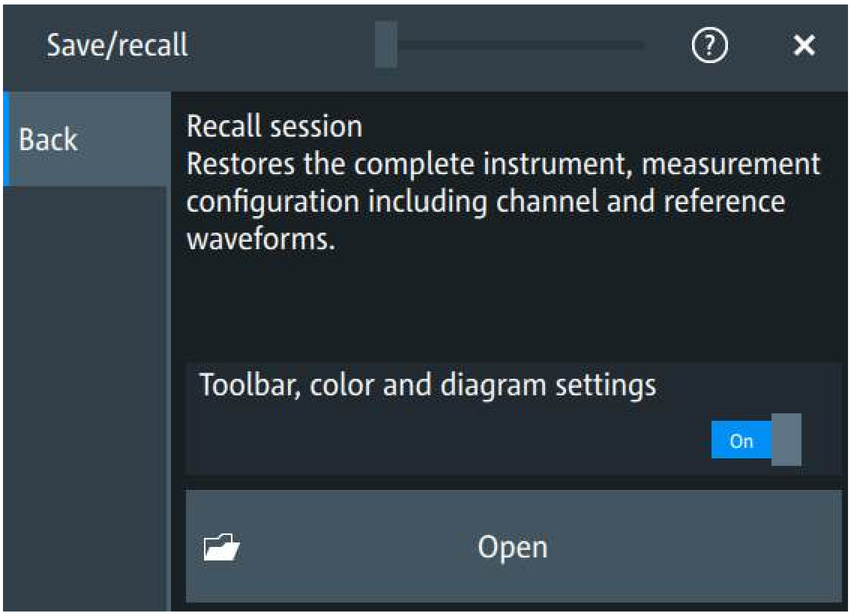


Figure 13-17: Recall session dialog

Toolbar, color and diagram settings
If selected, the user-specific display settings for the toolbar, waveform colors and diagram settings are included in the session file.

Remote command:
SESSion:USERpref on page 998

Open
Opens the file browser dialog. Select the required session file and tap "Open".

Remote command:
SESSion:LOAD[:EXECute] on page 997

13.6 Screenshots

To store the graphical results of the measurement, you can save a screenshot of the graphic area. To document current settings, the open dialog box can be included in the screenshot.

If you often save screenshots, try the following shortcuts:

- The "Screenshot" toolbar icon saves the current display to a file according to the settings in "Menu" > "Save/recall" > "Save" tab > "Screenshot".
- You can configure the [Camera] key to save screenshots by a single keypress. See also "Camera hardkey action" on page 104.

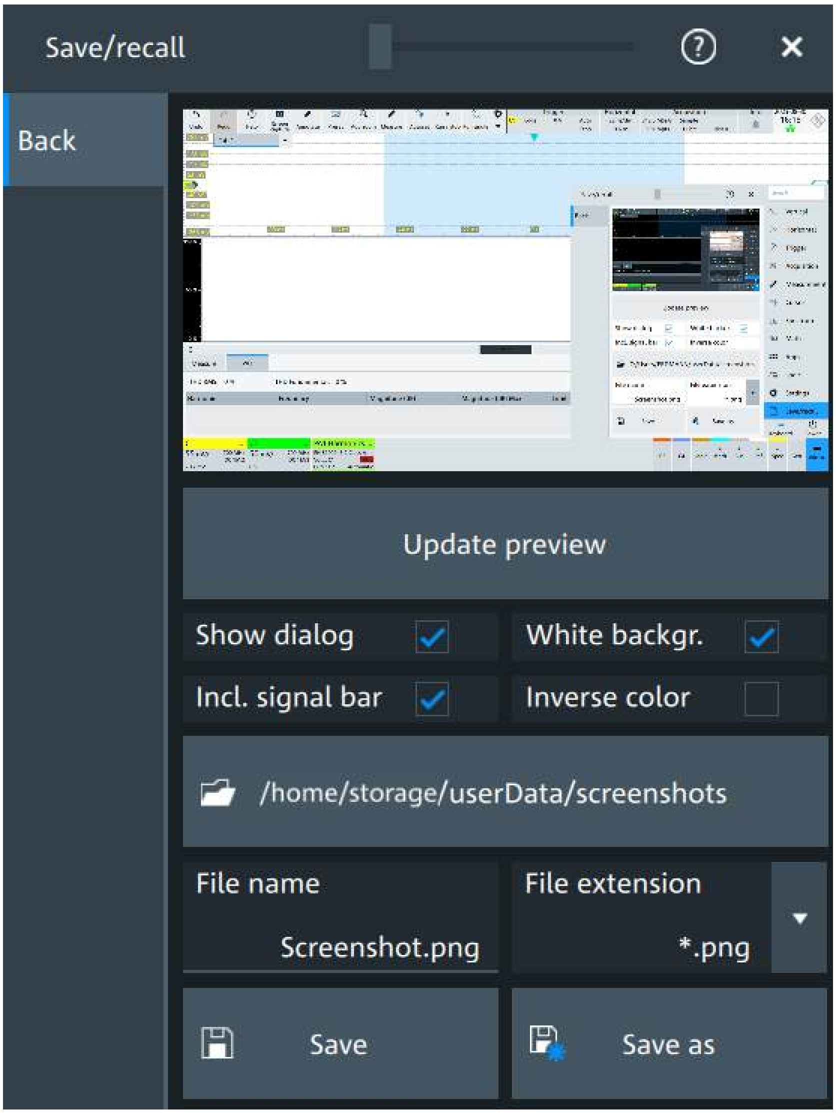
If a USB flash drive is connected, the default path of the user data directory is set to the USB flash drive. Thus, you save data to USB flash drive automatically, and you can change the directory in the file explorer at any time.

Meta information in screenshots

The meta data of the screenshot also contains instrument information. In PNG and JPEG files, meta information is saved as EXIF information and can be read, for example, using the ExifTool.

13.6.1 Screenshot settings

Access: "Menu" > "Save/recall" > "Save" tab > "Screenshot"



In the "Screenshot" dialog box, you configure the image to be saved or included in a report. You select the storage location for screenshot files. The image is created when you open the dialog box, and can be updated at any time.

You can also edit the colors of the image before saving it, and include an open dialog box or the sidebar in the image.

Preview
Shows a preview of the screenshot. The image is created when the dialog box opens.

Update
Updates the preview of the screenshot with the current display view, e.g. after changes to the settings have been made, or an additional channel has been activated.

Show setup dialog
If enabled, the currently open dialog box is included in the screenshot.

Remote command:
`HCOPy:SSD` on page 1002

White background
Inverts the background color, so you can picture waveforms with normal waveform colors on white background.

If both "White background" and "Inverse color" are enabled, the background is inverted twice, and it appears black.

"White background"	"Inverse color"	Background	Waveform and results
On	Off	White	Screen colors
Off	On	White	Inverted colors
On	On	Black	Inverted colors
Off	Off	Black	Screen colors

Remote command:
`HCOPy:WBKG` on page 1002

Include signal bar
If enabled, the screenshot shows the signal bar below the diagram area.

Remote command:
`HCOPy:ISBA` on page 1002

Inverse color
Inverts the colors of the output, i.e. a dark waveform is shown on a white background.

Remote command:
`HCOPy:DEVice<m>:INVerse` on page 1001

<Folder>
Opens the file selection dialog box. Here you can adjust the target directory where the screenshot is saved. The symbols of important target folders are listed on the left of the file explorer.

Remote command:
`HCOPy:DESTination<m>` on page 1000

File name, File extension
Sets a file name for the screenshot, and the extension of the file. You can save the screenshot as `*.jpg` or `*.png` file.

Save
Saves the current screenshot to the specified file.

13.6.2 Configuring and saving screenshots

You can select which elements are shown in the screenshot, invert the colors and the background color. A preview of the current image is shown for reference.

1. Open the "Menu" > "Save/recall" > "Save" tab > "Screenshot".
2. To enhance the images for later print on white paper, enable "White background" or "Inverse color". If you print this image later on a monochrome printer, you get a grayscaled picture. The contrast of the gray lines depends on waveform colors and the used printer.
3. To change the directory, tap "Browse" and configure the path.

   The symbols of often used target folders are listed on the left of the file explorer. By default, screenshots are saved in the `/home/storage/userData/ScreenShots` directory.
4. Tap "Save".

   The file is saved.
5. Check if the screenshot is saved to the desired directory.
6. To save further screenshots, use one of the following ways:
   - Configure the [Camera] key. Press the key to save a screenshot.
     See also Camera hardkey action.
   - Add the "Screenshot" icon to the toolbar. Tap the icon to save an image.
   - Tap "Save" in the "Screenshot" dialog box to save the image to the specified file.
   - To save the image with a dedicated filename or to another directory, tap "Browse" in the "Screenshot" dialog box.
     Select the path, enter a filename, and tap "Save".

13.6.3 Image viewer

You can look at the saved screenshots directly, without transferring them to a computer or using a dedicated software.

1. Add the "Image viewer" icon to the toolbar.
2. To view the saved screenshots, select the icon.

   You can scroll the images, brwose in other folders, and use the "Auto play" function for viewing.

13.7 File browser dialog

The file browser dialog provides a file explorer from which you can select a file to load or to save data to. You can also manage your files in this dialog.

Access: "Menu" > "Apps" > "File browser".

Path

Navigate the path elements to change the current folder. The default folder is defined in Section 5.8.1, "Autonaming", on page 114.

You can save the data in a local folder, to an external storage device (usually a USB flash drive), or to a folder on a connected network drive. The path list provides all available drives and folders.

On the left, shortcut icons provide access to often used folders.

Toolbar

The toolbar on the top provides various functions for file management.

"Filter"	Displays only the files and folders that match the current search term.
"Delete"	Deletes the selected file or folder.
"New folder"	Creates new folder in the current directory.
"Rename"	Renames the selected file.
"Find"	Searches for files within the current folder.
"Copy"	Copies the selected file.
"Paste"	Pastes the file.

File name
The file name to be loaded or stored to. Tap the file name, or tap the keyboard icon to enter the file name using the online keyboard.

The default file name for new files is defined in the "Autonaming" tab, see Section 5.8.1, "Autonaming", on page 114.

File type
The file extension of the file to be loaded or stored to.

Save, Select
Selects the specified file for the open or save operation and closes the dialog box.

Cancel
Closes the dialog box without selecting a file.

14 Protocol analysis

Using the serial protocol options for the MXO 4, you can analyze various serial protocols.

14.1 Basics of protocol analysis

With the MXO 4 oscilloscope, you can decode selected protocols.

With dual-path protocol analysis, you can set the instrument sample rate for the waveform path and the oscilloscope automatically uses another internal decoupled sample rate for the decoding path. Even with very slow sample rates, the protocol data is correctly decoded.

With the MXO 4, you can use deep memory to capture more packets. The oscilloscope can capture long time periods where the cause and result are distanced in time. Over the entire capture, signal detail is time-correlated with packet content for fast debug.

Before you can analyze a serial signal, the bus has to be configured according to the protocol and specifics of the signal. The configuration contains:

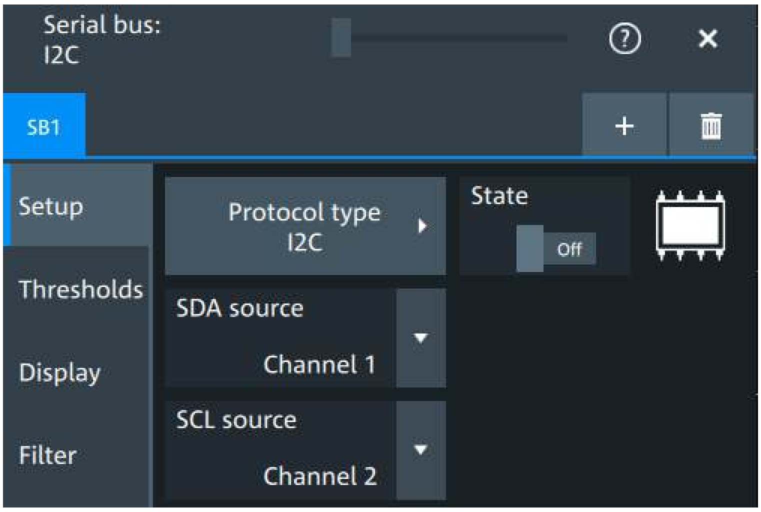
- Assignment of the data and clock lines to the input channels
- Logical thresholds
- Protocol-specific settings

Serial data can be analyzed in several ways:

- Triggering: You can trigger on various events that are typical for the selected protocol type, for example, on start and stop of messages, or on specified data patterns in the message.
  Triggering on a trigger event sequence is not supported, and holdoff settings are not available.
- Protocol decoding: The digitized signal data is displayed on the screen together with the decoded content of the messages in readable form, and the decode results are listed in a table.

14.1.1 Setup - general settings

For all protocols, configuration starts with the selection of the serial bus and the protocol.



Configuration settings are protocol-specific. They are described in the related sections.

Make sure that the tab of the correct serial bus is selected.

SB1 /SB2 /SB3 /SB4

Select the correct bus tab before you enter the settings.

Add serial bus, Delete serial bus

Use the icons on the upper right to add a new bus, or to delete the selected serial bus.

Remote command:

`SBUS<sb>:RMSBus` on page 1154 (delete)

Protocol type

Selects the protocol type to be decoded.

Remote command:

`SBUS<sb>:TYPE` on page 1153

State

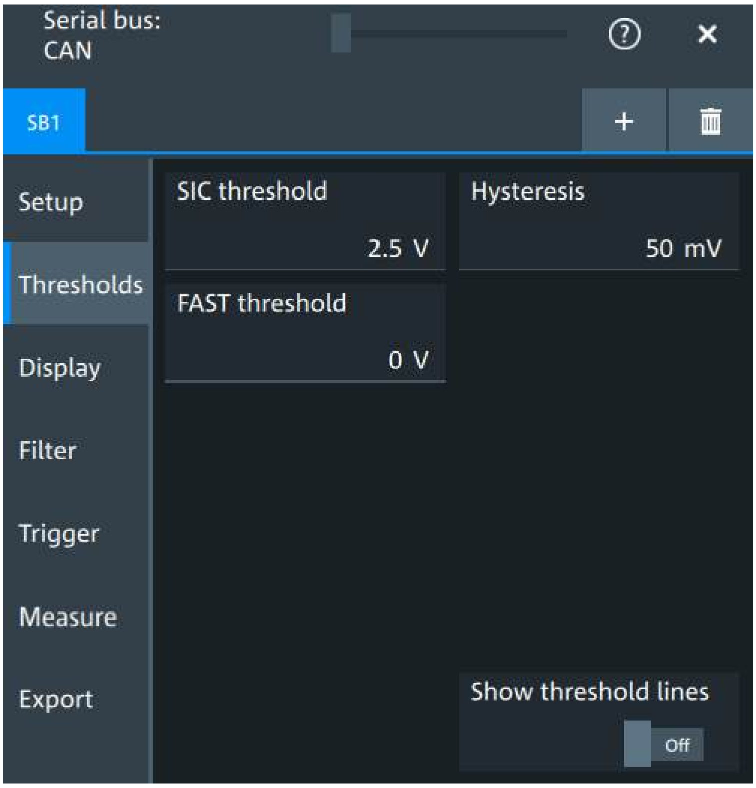
Enables the decoding of the selected bus. The signal icon of the bus appears on the signal bar.

Remote command:

`SBUS<sb>[:STATe]` on page 1152

14.1.2 Thresholds

In the "Thresholds" tab, you can set values for the threshold and hysteresis of the signal.



Show threshold lines
Enables the display of the threshold lines in the diagram.

The label of the threshold line is set according to the signal that it is referring to. It is displayed in the color of the signal channel.

Example:

When you enable "Show threshold lines", the threshold lines are shown on the display, and also the hysteresis ranges are shown for a few seconds. Afterwards only the threshold lines are visible. When you click the diagram near or on a threshold line, its hysteresis is shown again briefly.

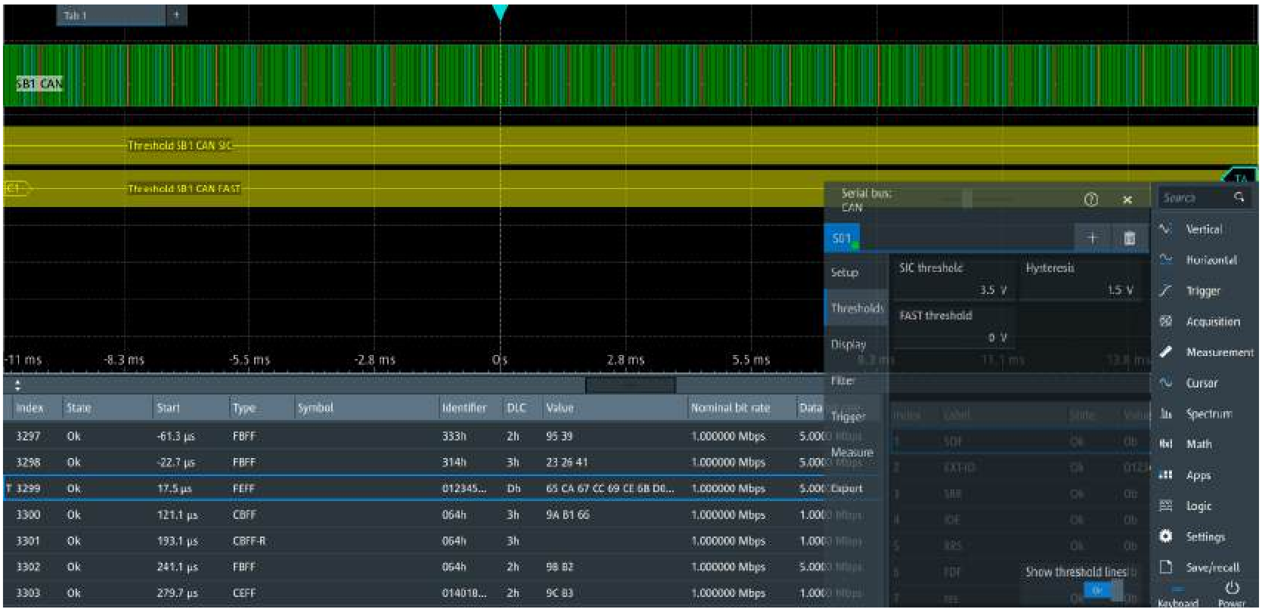


Figure 14-1: Threshold lines, shortly after enabling Show threshold lines

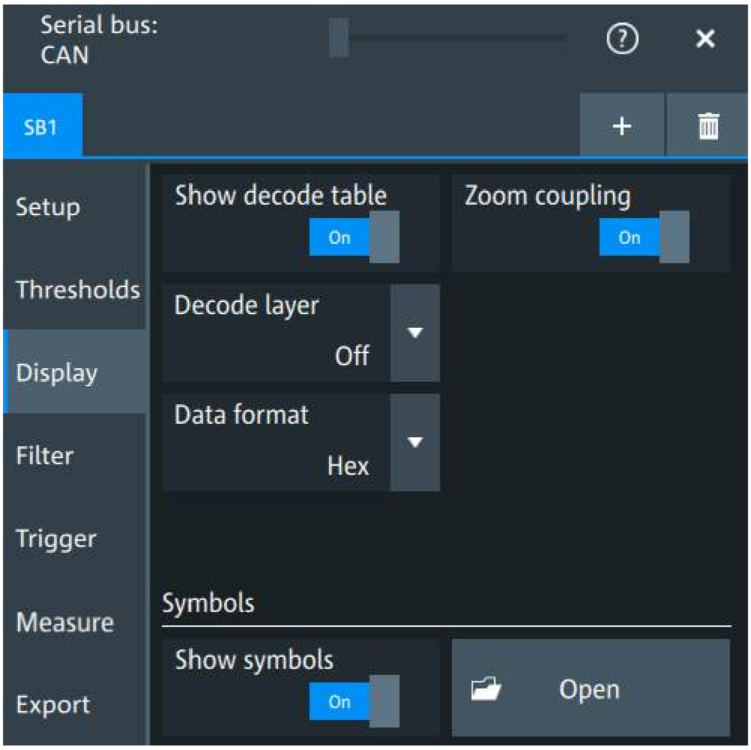
Remote command:
`SBUS<sb>:THReshold` on page 1155

14.1.3 Display

The following subsections describe the display settings and its zoom-coupling features.

14.1.3.1 Display settings

For all protocols, you can select how to display the decoded signal and its results table along with the waveform diagram.



Show decode table
Opens a table with decoded data of the serial signal. The function requires the option for the analyzed protocol.

Decode results are protocol-specific.

Remote command:
`SBUS<sb>:RESult` on page 1154

Decode layer
Selects the decode layer.

Decoding is performed in several steps, and the results are presented in the decode table. The decode layer selects an interim step for which the decoding result is shown in the honeycomb display.

The available values are protocol-specific. For example:

"Off"	Disables the display of the decode layer.
"Edges"	Enables the display of all edges.
"Bits"	Enables the display of all bits.
"Words"	Enables the display of all words.

Data format
Sets the data format for the values displayed in the decode table and in the combs of the decoded signal.

Available formats are: hex, octal, binary, ASCii, signed, unsigned.

For more information on the available formats, see Section 14.1.8, "Bit pattern editor", on page 446.

Remote command:
`SBUS<sb>:FORMat` on page 1154

Zoom coupling
Available only, if Show decode table is enabled. If you enable "Zoom coupling", the software synchronizes the decode zoom window with the result tables, as described in Section 14.1.3.2, "Display synchronization", on page 437.

Remote command:
`SBUS<sb>:ZCOupling` on page 1155

Symbols
Symbol lists are protocol-specific and not available for all protocols. Symbols are described in the respective configuration section of the protocol. For finding symbols in the decode table, enable ""Show symbols"". See also Section 14.1.3.2, "Display synchronization", on page 437.

The RC commmands for this function are also protocol-specific, for example in the I²C protocol: `SBUS<sb>:I2C:SYMBols` enables symbols, and `SBUS<sb>:I2C:NEWList` loads the symbols translation file.

14.1.3.2 Display synchronization

This section describes the synchronization (or coupling) of the following components in the display:

- The waveform diagram and its zoom window
- Decode results table with decoded frames
- Frame details table with fields of selected frame

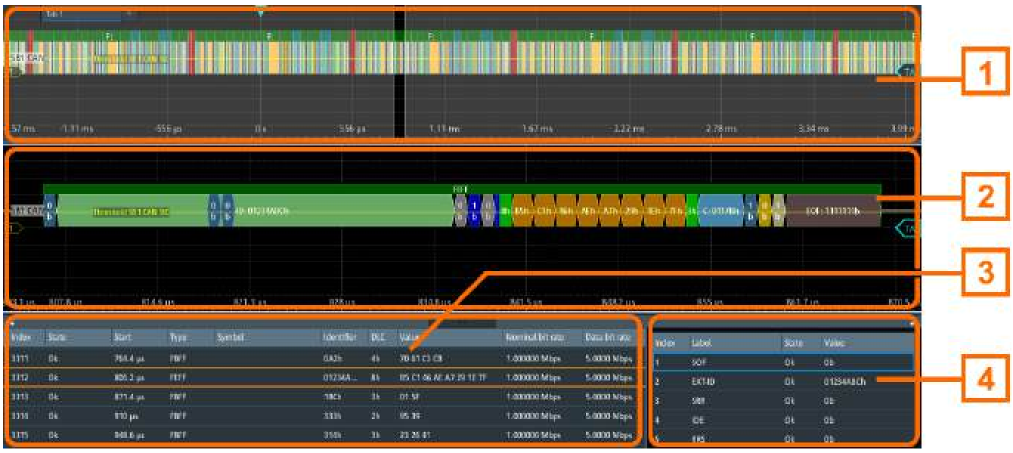


Figure 14-2: Main components in the decoded results display, here for the CAN protocol

1 = Waveform diagram, it shows an overview of some part of the acquisition, or even all of it
2 = Zoom window, it shows the zoom area selected in the waveform diagram
3 = Decode results table, it lists all frames of the acquisition
4 = Frame details table, it lists all fields of the frame selected in the results table

Prerequisites for synchronizing displayed results:

- State is enabled in the "Setup" tab
- Show decode table is enabled in the "Display" tab
- Zoom coupling is enabled in the "Display" tab
- Decoded results are available.
  The dialog shows the results for frames in the results table and for fields in the details table.

When you select a row in one of the tables, hence a decoded frame or field, the software automatically synchronizes the zoom window to display this frame or field on the screen with a margin at each side. For details of the synchronization and margin, see Figure 14-3 and Figure 14-4. The software synchronizes also the waveform diagram with the zoom window.

When you move the zoom window to the left or right, the software updates the results table to highlight the window's center frame, without resizing.

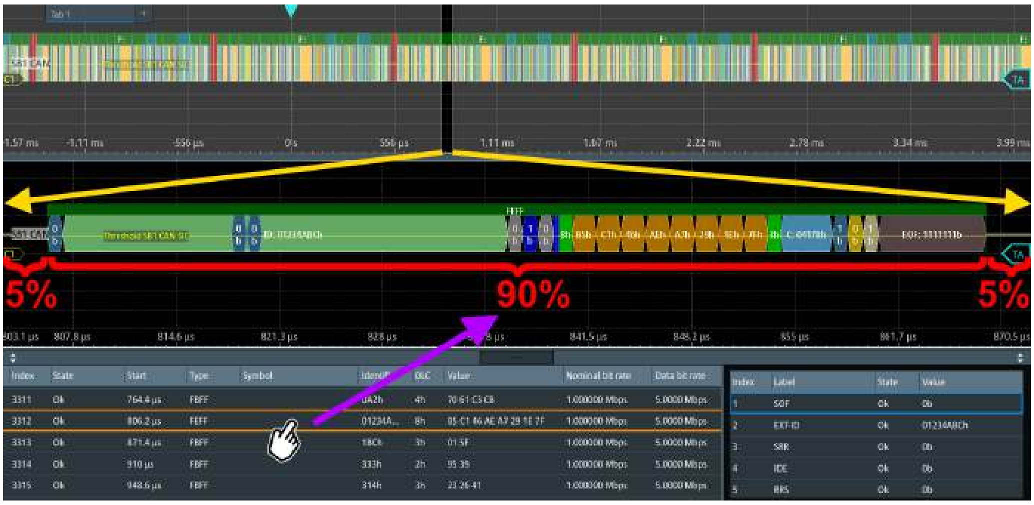


Figure 14-3: Zoom coupling of selected frame (left table)

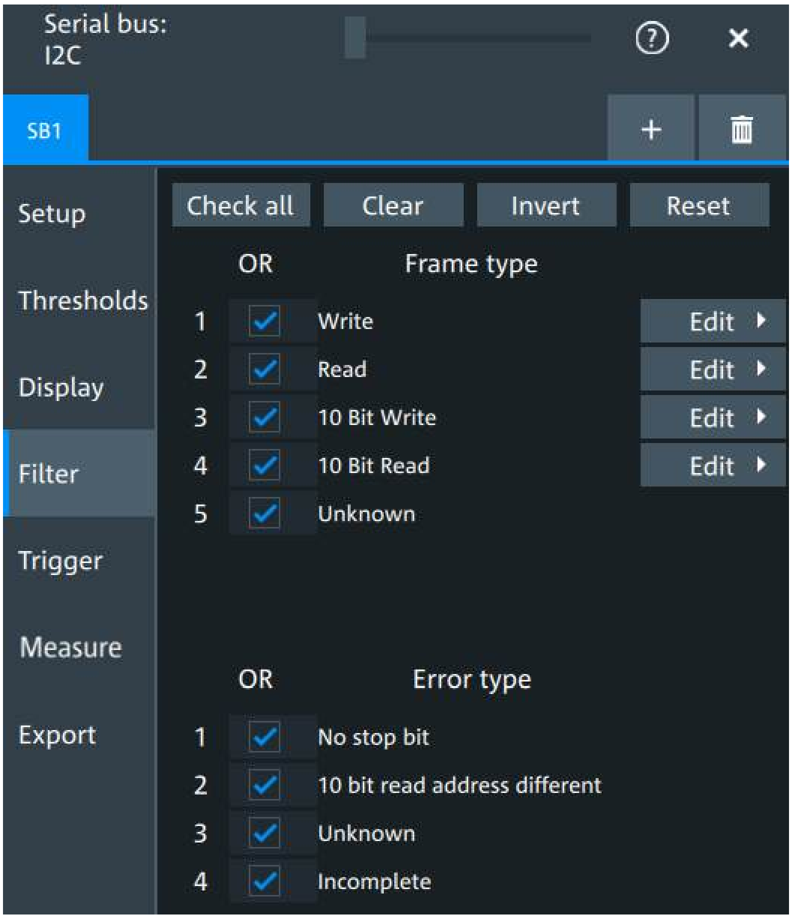
Pink arrow = Selected frame covers 90% of the zoom window's width (red scale), centered on the screen
Yellow arrows = Zoom segment, automatically selected in the diagram, covers the full zoom window's width

Figure 14-4: Zoom coupling of selected field (right table)

Pink arrow = Selected field covers 20% of the zoom window's width (red scale), centered on the screen
Yellow arrows = Zoom segment, automatically selected in the diagram, covers the full zoom window's width

14.1.4 Filter

In the "Filter" tab, you can define the settings to display only the frames that match the selected filter conditions.

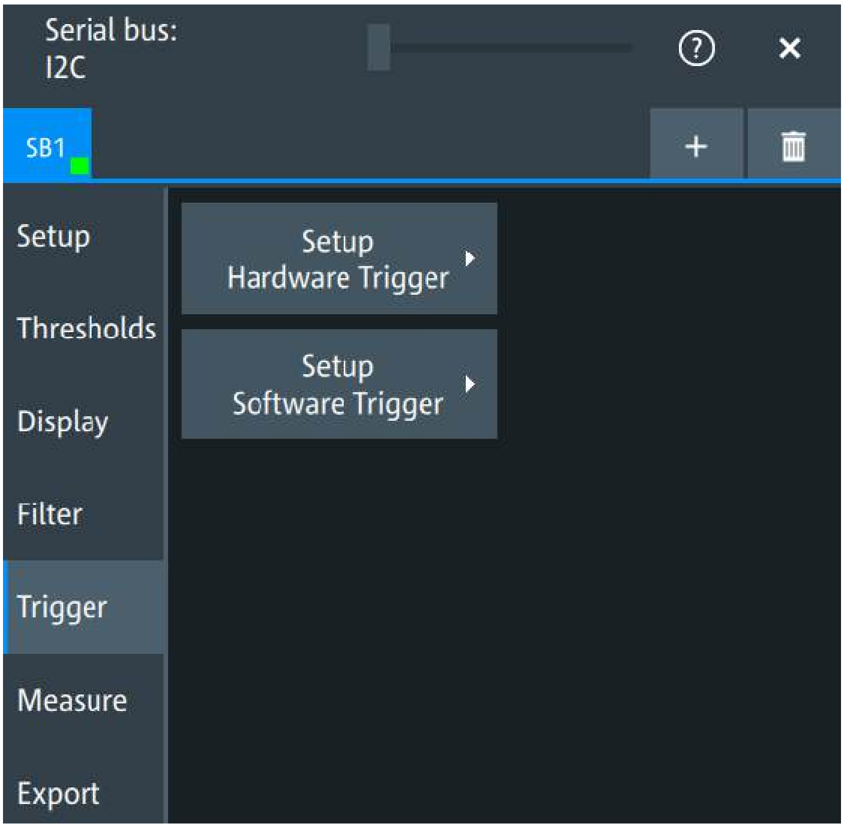


The settings are protocol-specific and are described in the corresponding protocol section.

14.1.5 Trigger

The "Trigger" tab provides functionality to quickly setup protocol triggers and navigate to the "Trigger" dialogs for further settings.

A trigger is a function that determines when the instrument starts capturing a signal. There are two primary types of triggers on the MXO 4, depending on the selected protocol: software trigger and hardware trigger.



14.1.5.1 Hardware trigger

A HW trigger is a trigger that is generated by the oscilloscope's hardware circuitry.

The protocol hardware trigger is available only for the few protocols that support it (listed below). A single click of the "Setup Hardware Trigger" button in the protocol dialog is equivalent with the following actions in the "Trigger" dialog:

1. "Trigger on" > "Single event".
2. "Source" > selects the active serial bus, for example "Serial bus 1".
3. "Type" > selects the most simple protocol-specific trigger type:
   - I²C: "Start"
   - SPI: "Start of frame"
   - UART: "Start bit"
   - LIN: "Start of frame"
   - CAN: "Start of frame"

   This action also executes the "Type" command and resets the trigger settings.

   Optionally proceed with the trigger settings in the "Trigger" dialog.

14.1.5.2 Software trigger

The protocol software trigger is a sequence "A → Serial bus" of events. Hence, it consists of two subsequent events: A-trigger and a serial bus trigger.

Loss of settings

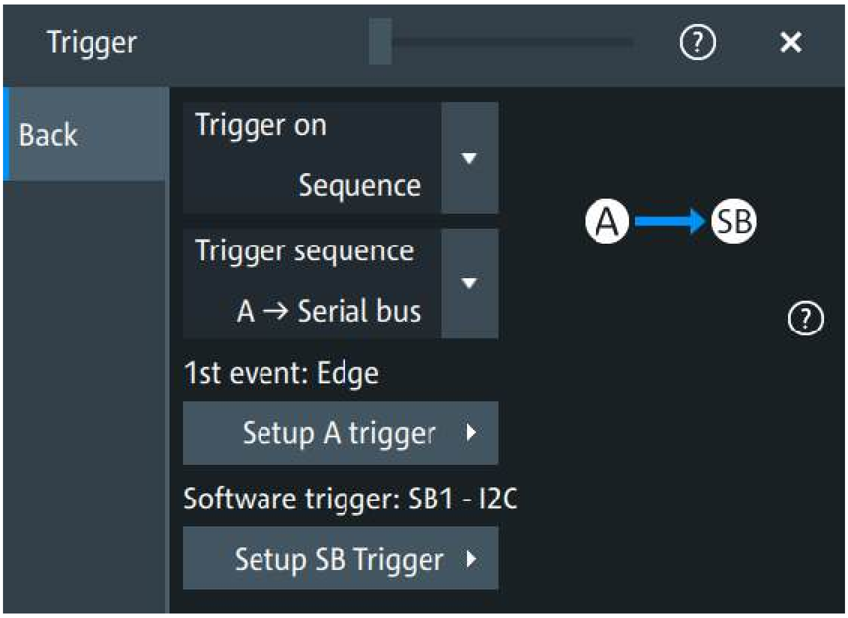
If you have already configured the SW trigger, do not click "Software Trigger" in the protocol dialog, because it overwrites your settings. Instead, use the "Trigger" dialog.

For an initial configuration, a single click of the "Software Trigger" button is equivalent with the following actions in the "Trigger" dialog:

1. "Trigger on" > "Sequence".
2. "Trigger sequence" > "A → Serial bus"
3. Configures the 1st event:
   a) Sets the "1st event" ("A trigger") to a protocol-specific trigger that is most suited for this protocol, for example "Edge".
   b) Sets the "Level" to the threshold level defined in the protocol dialog.
   c) Sets other parameters, depending on the event type and protocol requirements, for example "Slope" for "Edge", or "Time" for "Timeout".
4. Configures the software trigger:
   Preselects recommended frame types and error types, which you can change later.

After the A-trigger conditions have been met, the serial bus trigger with independent conditions is enabled. The oscilloscope waits until one or a specified number of serial bus trigger conditions occur. The serial bus trigger can only cause the trigger event if it occurs after the A-trigger.

All trigger sequences require that analog input channels C<n> are set as trigger sources for all events. The oscilloscope checks all trigger settings for compatibility and adjusts them if they do not fit.



To indicate the 1st (main, general) trigger position in the captured signal, the top of the display shows a triangular trigger marker (1 in Figure 14-5). If you enable displaying the results table (see "Show decode table" on page 436), the triggered frame is marked in the table by the letter "T" left of the frame index (2 in Figure 14-5):

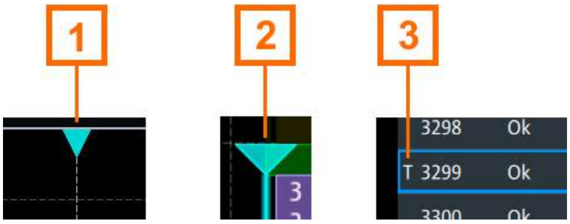


Figure 14-5: Trigger markers

1 = Triangular main trigger marker at the top of the waveform display, indicates the position of the single trigger or the position of the 1st trigger event of a trigger sequence
2 = Triangular secondary trigger marker with bold line in the zoom diagram of the decoded signal, indicates the 2nd event trigger position, hence the software trigger
3 = Letter "T" marks the 2nd event trigger position (the triggered frame) in the decode results table

The following scenarios are possible:

- 1st case, triggering on a *single event* while the source is a serial bus:
  – The main trigger marker indicates the single event trigger position.
  – There is no secondary trigger marker in the decoded signal diagram.
  – The "T" trigger marker in the protocol decode results table corresponds to the main trigger marker.

  This scenario uses the hardware trigger, which is not available for all protocols.
- 2nd case, triggering on a *single event* while the source is *not* a serial bus:
  – The main trigger marker indicates the single event trigger position.
  – There is no secondary trigger marker in the decoded signal diagram.

- There is no "T" trigger marker in the protocol decode results table.
- 3rd case, triggering on a *sequence* of "Trigger A" and "serial bus event":
  - The main trigger marker indicates the 1st event trigger position.
  - The secondary trigger marker indicates the 2nd event trigger position (software trigger).
  - The "T" trigger marker in the protocol decode results table corresponds to the 2nd event trigger position (software trigger).

Figure 14-6 shows an example of these markers.

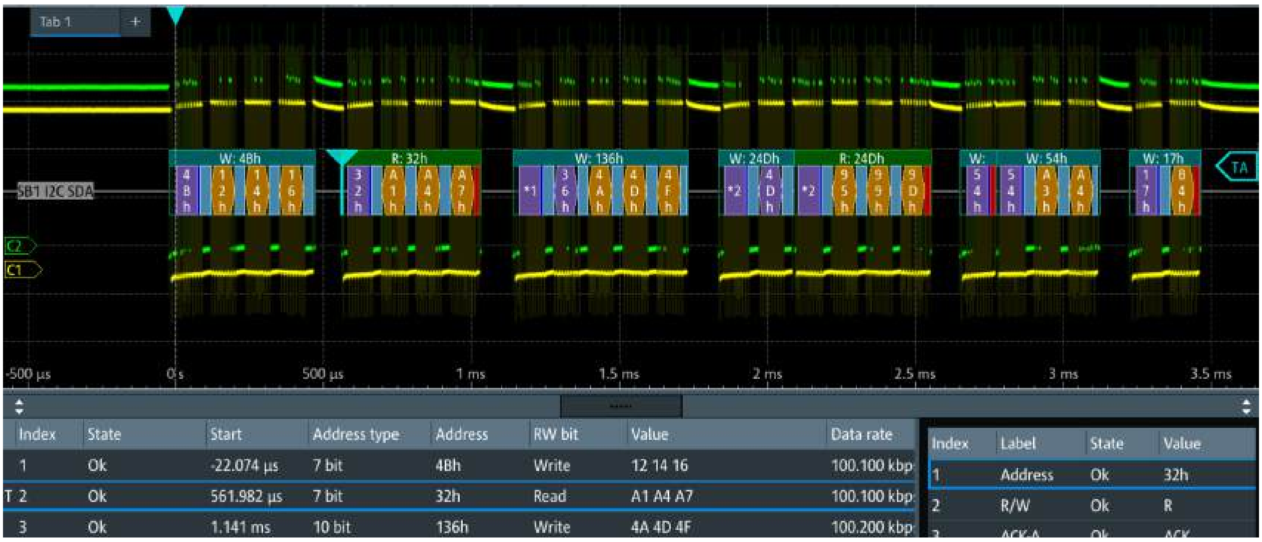


Figure 14-6: Example of sequence trigger in I2C signal with "Trigger A" (interval > 1 ms) and software trigger (first "Read" frame)

See also "Source" on page 161.

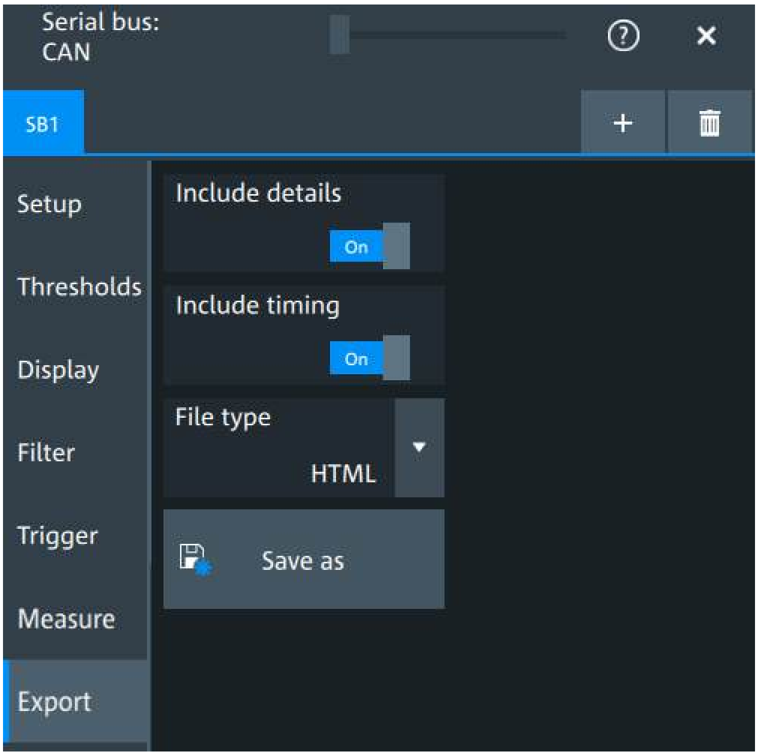
14.1.6 Measure

The "Setup Measurement" button opens the dialog for automatic measurements in the "Protocol" category for the selected serial bus.

See Section 10.2.6, "Protocol measurements (option R&S MXO4-K500)", on page 287.

14.1.7 Export protocol results

In the "Export results" tab, you can export the results and all details of the selected protocol.



Include details
If enabled, includes the detailed results for all frames in the export result file.

Remote command:
`SBUS<sb>:EXPResult:DETail` on page 1155

Include timing
If enabled, includes the frame timing in the export result file.

Remote command:
`SBUS<sb>:EXPResult:TIME` on page 1156

File type
Selects the file format.

"HTML"	Saves the results as a webpage in hypertext markup language for display in a browser.
"CSV"	Saves the results as comma-separated values in a "`.csv`" file.
"XML"	Saves the results in a file compatible with an extended markup language.
"Python"	Saves the results in a Python-compatible "`.py`" file format.

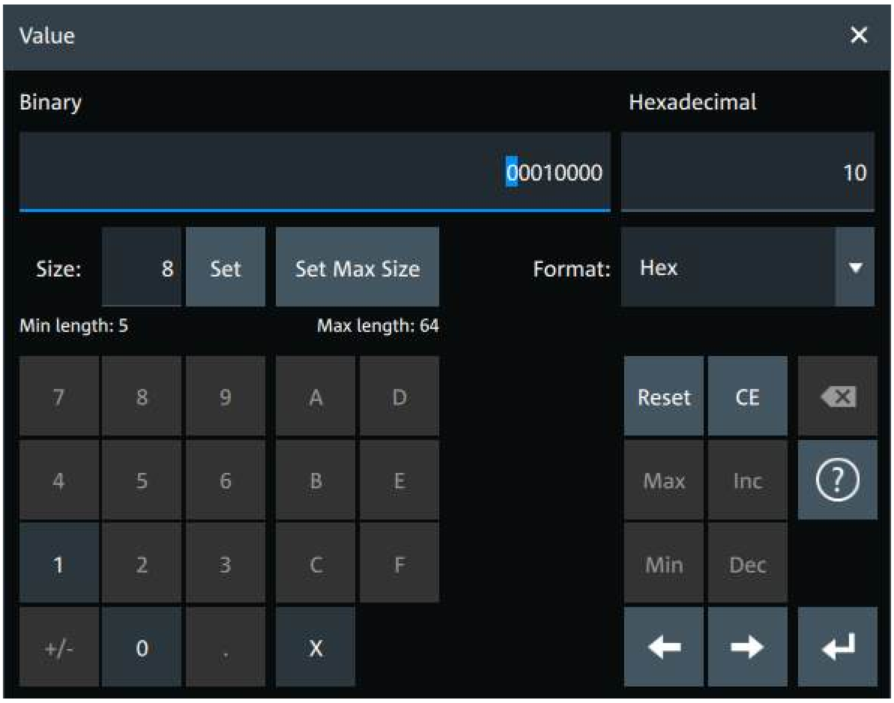
Remote command:
`SBUS<sb>:EXPResult:EXTension` on page 1156

Save as
Opens a dialog box where you can select a filename and a path for the export results file.

Remote command:
SBUS<sb>:EXPResult:SAVE on page 1156
SBUS<sb>:EXPResult:PATH on page 1157

14.1.8 Bit pattern editor

If you want to enter a specified address or data pattern, the pattern editor helps you to enter the pattern in various formats - decimal, hexadecimal, octal, binary and ASCII.



The editor at the top displays the pattern in two columns. The left column always shows binary data. For the right column, you can select the "Format". The default depends on the data specifics. You can edit data in the left or right column. The keypad adapts itself to the column format and only keys appropriate to the format are enabled.

The data is grouped and converted in bit groups. The size of a bit group depends on the address or data specifics and is set by the instrument. Groups are automatically separated by blanks. The maximum size of a bit group is 64 bit, the most common group size is 1 byte.

Format-specific information:

- Binary: 0, 1 and X (do not care) is allowed.
- Octal: Each digit represents 3 bit.
- Hex: most common format in the right column.
- ASCII: In the ASCII column, "X" is the character X. The binary X (do not care) is not allowed. If an X is included in the binary value in the left column, the ASCII column displays "§" to indicate that the value is not defined.
- Unsigned: Decimal data format without a sign for positive or negative numbers. 3 digits are grouped, and the next group is separated by a comma, e.g. 653,848.

- Signed: Decimal format with a sign for positive or negative numbers. 3 digits are grouped, where the first bit represents the sign. You can use the 2's complement format. After a group of 3 digits the next group is separated by a comma, e.g. -653,848.

14.2 SPI bus (IC electronics, option R&S MXO4-K510)

The Serial Peripheral Interface SPI is used for communication with slow peripheral devices, in particular, for transmission of data streams.

For basic information on SPI, you can also refer to a video, available on the Rohde & Schwarz YouTube channel: Understanding SPI.

Requirements

For performing SPI decode measurements, you need the following:

- MXO 4 with 4 channels. The channels can be a combination of the following:
  – Analog channels (C1-C4)
  – Logic channels (D0-D15) (requires option R&S MXO4-B1)
- Option R&S MXO4-K510

14.2.1 About the SPI protocol

A 4-channel instrument is required for full support of the SPI protocol, or the MSO option R&S MXO4-B1.

The Serial Peripheral Interface SPI is used for communication with slow peripheral devices, in particular, for transmission of data streams.

The main characteristics of SPI are:

- Main-subnode communication
- No device addressing. The sub is accessed by a chip select, or sub select line.
- No acknowledgment mechanism to confirm receipt of data
- Duplex capability

Most SPI buses have four lines, two data and two control lines:

- Clock line to all subs (SCLK)

- Sub select or Chip select line (SS or CS)
- Main data output, sub data input (MOSI or SDI)
- Main data input, sub data output (MISO or SDO)

When the main generates a clock and selects a sub device, data can be transferred in either or both directions simultaneously.

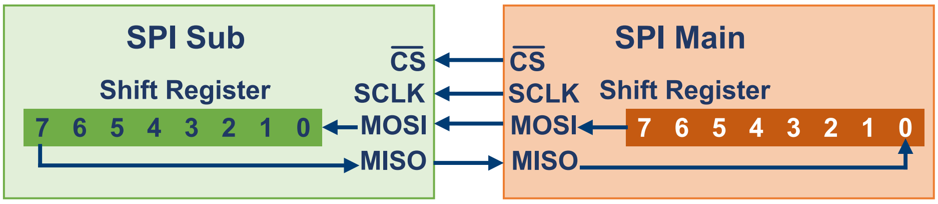


Figure 14-7: Simple configuration of SPI bus

The data bits of a message are grouped by the following criteria:

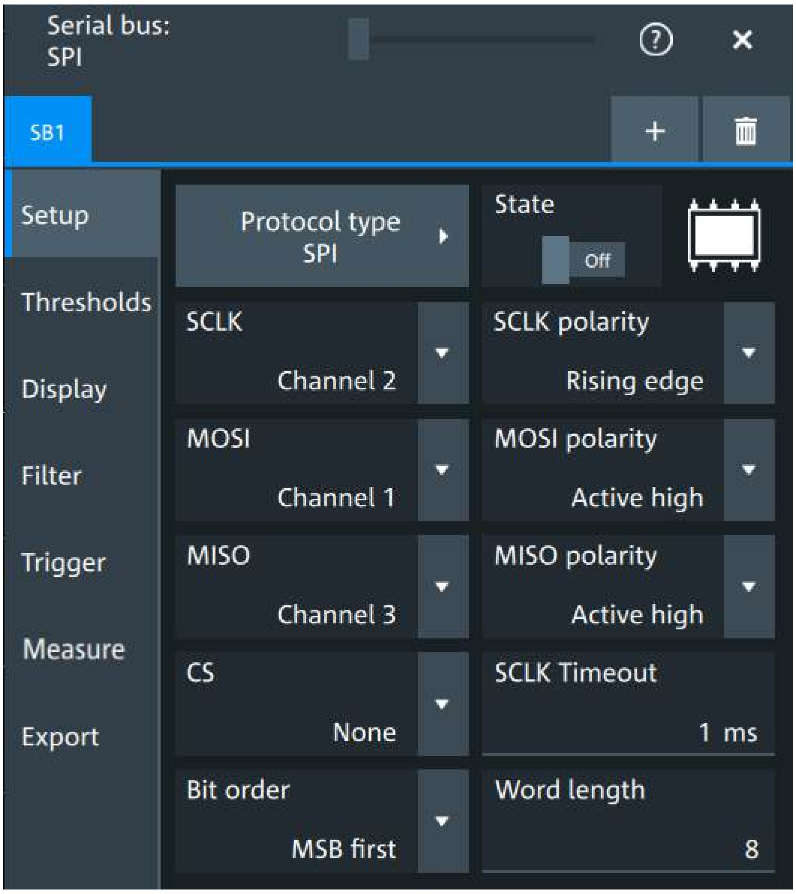
- A word contains several successive bits. The word length is defined in the protocol configuration.
- A frame contains several successive words, at least one word.

14.2.2 SPI configuration

14.2.2.1 SPI configuration settings

Access: "Menu" > "Apps" > "Protocol" tab > "SPI" > "Setup".

Make sure that the tab of the correct serial bus is selected.



Protocol type
Selects the protocol type to be decoded.

Remote command:
SBUS<sb>:TYPE on page 1153

State
Enables the decoding of the selected bus. The signal icon of the bus appears on the signal bar.

Remote command:
SBUS<sb>[:STATe] on page 1152

SCLK,MOSI,MISO,CS
Sets the input channel for the respective line:

- SCLK: clock line
- MOSI line
- MISO line
- CS: chip select

Alternatively, digital channels can be used if MSO option R&S MXO4-B1 is installed. Digital and analog channels cannot be used at the same time.

For triggering on a serial bus, analog or digital channel sources are required.

Remote command:
`SBUS<sb>:SPI:MISO:SOURce` on page 1160
`SBUS<sb>:SPI:MOSI:SOURce` on page 1161
`SBUS<sb>:SPI:SCLK:SOURce` on page 1162
`SBUS<sb>:SPI:CSELect:SOURce` on page 1159

Clock polarity
Two settings define the clock mode: the clock polarity and the clock phase. Together, they determine the edges of the clock signal on which the data are driven and sampled.

A main/subnode pair must use the same parameter pair values to communicate. The clock phase defines the slope. It selects if data is stored with the rising or falling slope of the clock. The slope marks the begin of a new bit.

Polarity: MOSI, MISO, CS
Selects if the transmitted signal for the respective line is active high (high = 1) or active low (low = 1).

For triggering on a serial bus, analog or digital channel sources are required.

Remote command:
`SBUS<sb>:SPI:MISO:POLarity` on page 1160
`SBUS<sb>:SPI:MOSI:POLarity` on page 1161
`SBUS<sb>:SPI:CSELect:POLarity` on page 1158

Bit order
Selects the bit order, which determines if the data of the messages starts with MSB (most significant bit) or LSB (least significant bit).

Remote command:
`SBUS<sb>:SPI:BORDer` on page 1158

Word length
Sets the word length (or symbol size), which is the number of bits in a message. The maximum word length is 32 bit.

Remote command:
`SBUS<sb>:SPI:WSIZe` on page 1163

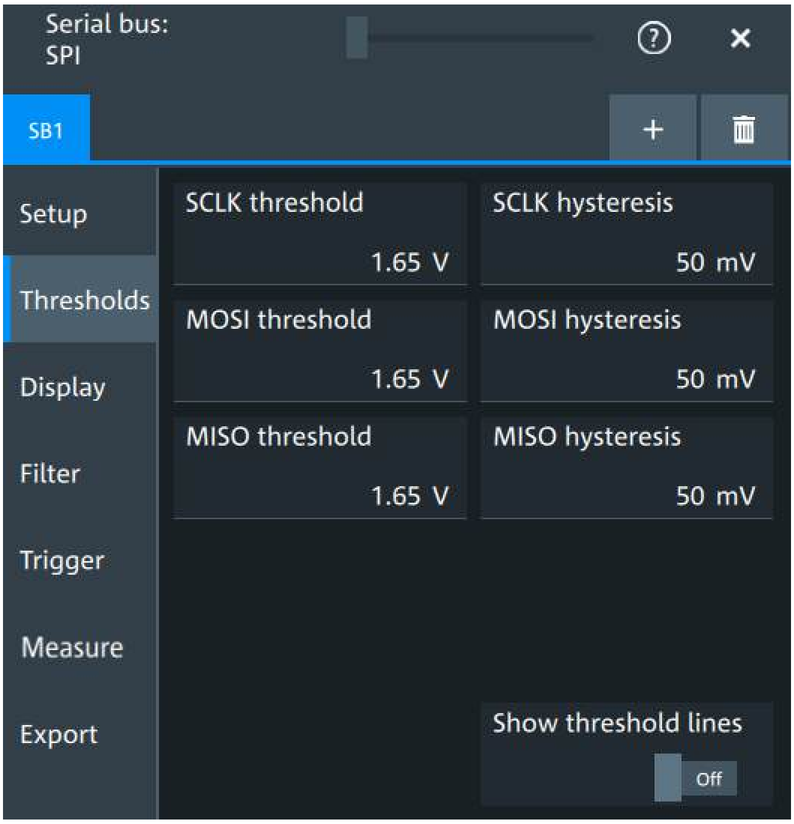
Timeout
Sets the minimum clock idle time if a timeout on the clock line SCLK is used as limiter between two frames.

This setting is only available, for "CS" = "None".

Remote command:
`SBUS<sb>:SPI:TIMeout` on page 1162

14.2.2.2 Threshold settings

Access: "Menu" > "Apps" > "Protocol" tab > "SPI" > "Thresholds".



Threshold

Sets the threshold for the SCLK, MOSI and MISO channels. Enter the value directly in the fields.

Additional to the threshold, you can also set a hysteresis.

If the signal value on the line is higher than the threshold, the signal state is high. Otherwise, the signal state is considered low if the signal value is below the threshold.

The interpretation of high and low is defined by the "Polarity: MOSI, MISO, CS" on page 450.

Remote command:
`SBUS<sb>:SPI:MISO:HYSTeresis` on page 1159
`SBUS<sb>:SPI:MOSI:HYSTeresis` on page 1160
`SBUS<sb>:SPI:SCLK:HYSTeresis` on page 1162
`SBUS<sb>:SPI:CSELect:HYSTeresis` on page 1158
`SBUS<sb>:SPI:MISO:THReshold` on page 1160
`SBUS<sb>:SPI:MOSI:THReshold` on page 1161
`SBUS<sb>:SPI:SCLK:THReshold` on page 1162
`SBUS<sb>:SPI:CSELect:THReshold` on page 1159

Show threshold lines

If enabled, the threshold lines are displayed in the diagram.

The label of the threshold line is set according to the signal that it is referring to, see also Show threshold lines.

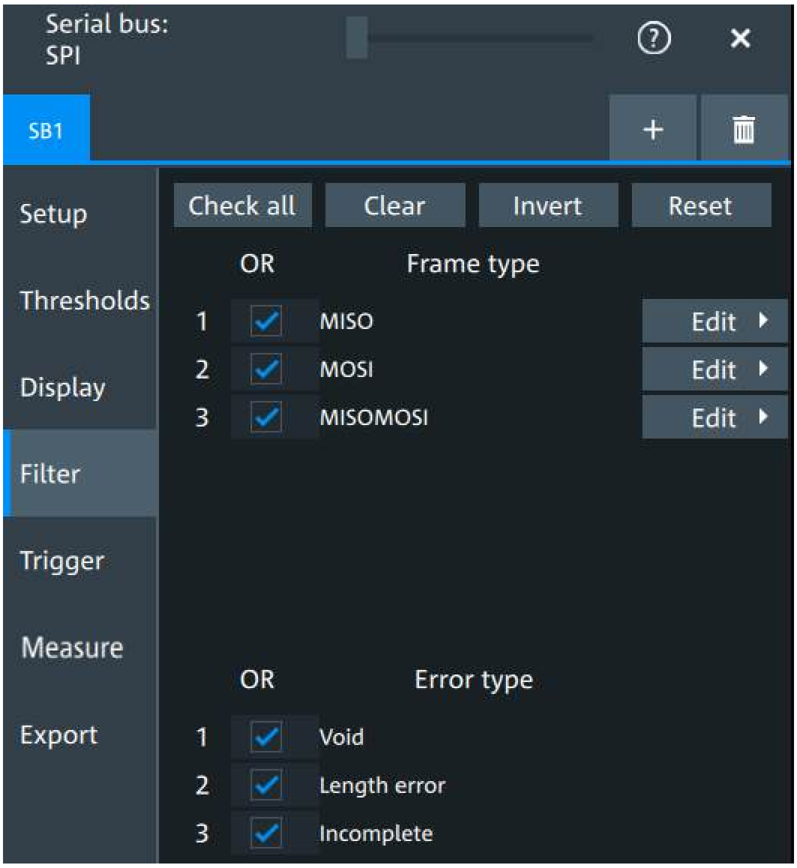
Remote command:
SBUS<sb>:THReshold on page 1155

14.2.2.3 Display settings

For details about the display settings, see Section 14.1.3.1, "Display settings", on page 435.

14.2.3 SPI filter

Access: "Menu" > "Apps" > "Protocol" tab > "SPI" > "Filter" tab



In the "Filter" tab, you can define the settings to display only the frames that match the selected filter conditions.

Check all, Clear, Invert, Preset
The following settings help you select the frames and errors you want to filter for. Only the frames and error types that match the selected filter conditions are displayed.

"Check all"	Enables the filter for all available frames and error types.
"Clear"	Disables the filter for all available frames and error types.
"Invert"	Inverts the current state of the frame and error types: all frames and error types that were enabled are disabled and vice versa.

"Preset" Presets the state of the selected frames and error types.

Remote command:
SBUS<sb>:SPI:FILTer:CHKall on page 1165
SBUS<sb>:SPI:FILTer:CLR on page 1165
SBUS<sb>:SPI:FILTer:INVert on page 1165
SBUS<sb>:SPI:FILTer:RST on page 1165

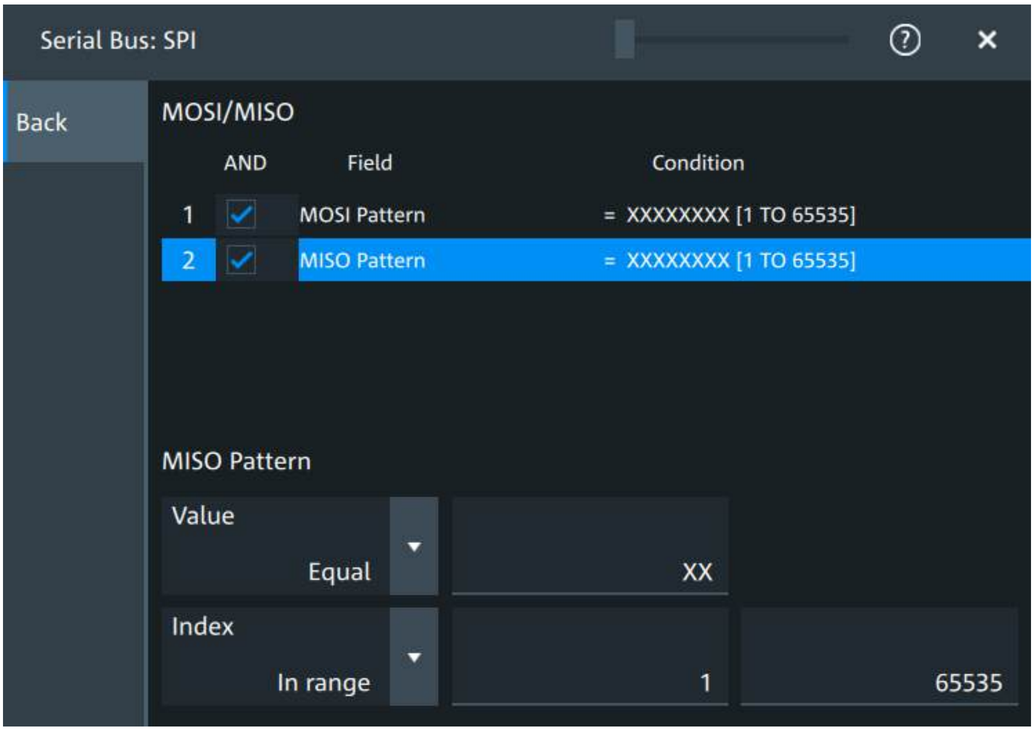
Frame type
Selects the frame type that you want to display. You can filter all enabled frame types simultaneously.

For selected frame types, you can also specify conditions for the value of the fields in the "Edit" dialog.

The available frames are "MOSI", "MISO" and "MOSI/MISO".

Remote command:
SBUS<sb>:SPI:FILTer:FRAMe<fr>:ENABle on page 1168
SBUS<sb>:SPI:FILTer:FRENable on page 1168

Edit
Opens a dialog to define the details of the selected frame.



"Field" Enables the field type that you want to filter on for the selected frame. The available fields are "MOSI Pattern" and "MISO Pattern".

Remote command:
SBUS<sb>:SPI:FILTer:FIENable on page 1167
SBUS<sb>:SPI:FILTer:FRAMe<fr>:FLD<fl>:ENABle on page 1167

"Condition" Displays the value condition for the selected field.

Remote command:
SBUS<sb>:SPI:FILTer:FRAMe<fr>:FLD<fl>:BIT on page 1166

"Data" The data setup consists of a comparison condition and one or two data patterns.

Remote command:
SBUS<sb>:SPI:FILTer:FRAMe<fr>:FLD<fl>:DMAX on page 1166
SBUS<sb>:SPI:FILTer:DMAX on page 1166
SBUS<sb>:SPI:FILTer:FRAMe<fr>:FLD<fl>:DMIN on page 1166
SBUS<sb>:SPI:FILTer:DMIN on page 1166
SBUS<sb>:SPI:FILTer:FRAMe<fr>:FLD<fl>:DOPerator on page 1167
SBUS<sb>:SPI:FILTer:DOPerator on page 1167

"Index" The index setup consists of a comparison condition and one or two index values.

Remote command:
SBUS<sb>:SPI:FILTer:FRAMe<fr>:FLD<fl>:IMAX on page 1168
SBUS<sb>:SPI:FILTer:IMAX on page 1168
SBUS<sb>:SPI:FILTer:FRAMe<fr>:FLD<fl>:IMIN on page 1169
SBUS<sb>:SPI:FILTer:IMIN on page 1169
SBUS<sb>:SPI:FILTer:FRAMe<fr>:FLD<fl>:IOPerator on page 1169
SBUS<sb>:SPI:FILTer:IOPerator on page 1169

Edit
Opens a dialog to define the details of the selected frame.

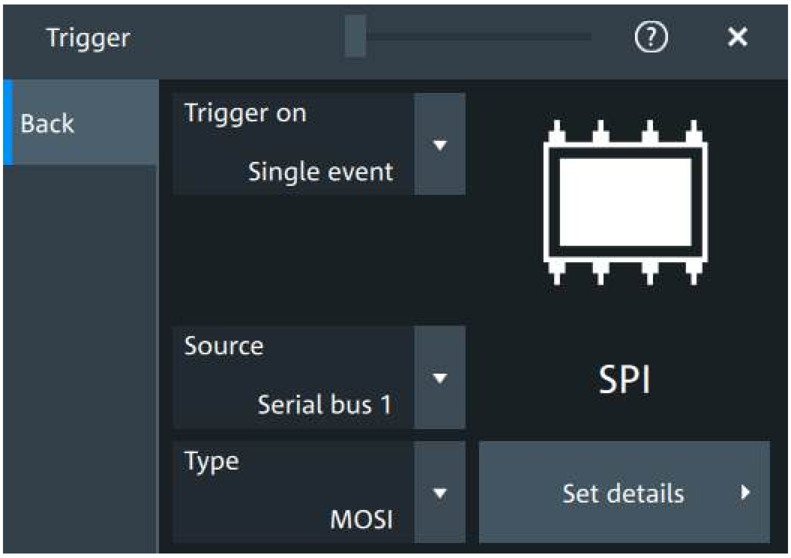
Error type
Enables filtering on the selected error type.

Available error types are "Void", "Length error" and "Incomplete".

Remote command:
SBUS<sb>:SPI:FILTer:ERRor<n>:ENABle on page 1167

14.2.4 SPI hardware trigger

Access: "Menu" > "Apps" > "Protocol" tab > "SPI" > "Trigger" tab > "Setup Hardware Trigger"



Type

Selects the trigger type for SPI analysis.

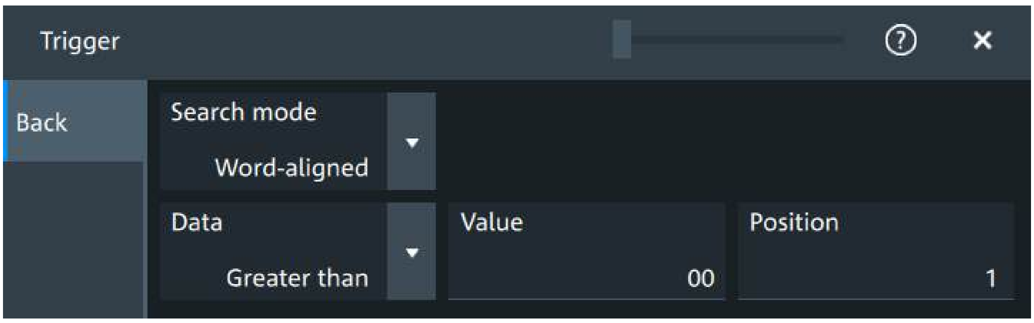
Some trigger types have additional settings that can be defined. In this case, the "Set details" button appears next to "Type" the function. Open it for a detailed definition of the trigger conditions.

"Start of frame"	Sets the trigger to the beginning of the frame.
"End of frame"	Sets the trigger to the end of the frame.
"MOSI"	Sets the trigger to a specified data pattern expected on the MOSI line. Available, if there is a channel assigned to the "MOSI" line in the "Setup" tab.
"MISO"	Sets the trigger to a specified data pattern expected on the MISO line. Available, if there is a channel assigned to the "MISO" line in the "Setup" tab.

Remote command:
`TRIGger:SBHW:SPI:TYPE` on page 1170

Data conditions

The trigger on MOSI and MISO patterns is defined in the same way:



Search mode ← Data conditions
Defines how the specified data pattern is searched.

"Bit-aligned"	Bit-by-bit: the pattern can start at any position in the message.
"Word-aligned"	The pattern is matched only at word boundaries.

Remote command:
`TRIGger:SBHW:SPI:PALignment` on page 1170

Data ← Data conditions
Selects the operator condition for the data pattern and sets the data pattern.

Remote command:
`TRIGger:SBHW:SPI:FCONdition` on page 1170
`TRIGger:SBHW:SPI:DMINpattern` on page 1171

Position ← Data conditions
Sets the number of bits or words to be ignored before the first bit or word of interest.

Remote command:
`TRIGger:SBHW:SPI:DPOSition` on page 1171

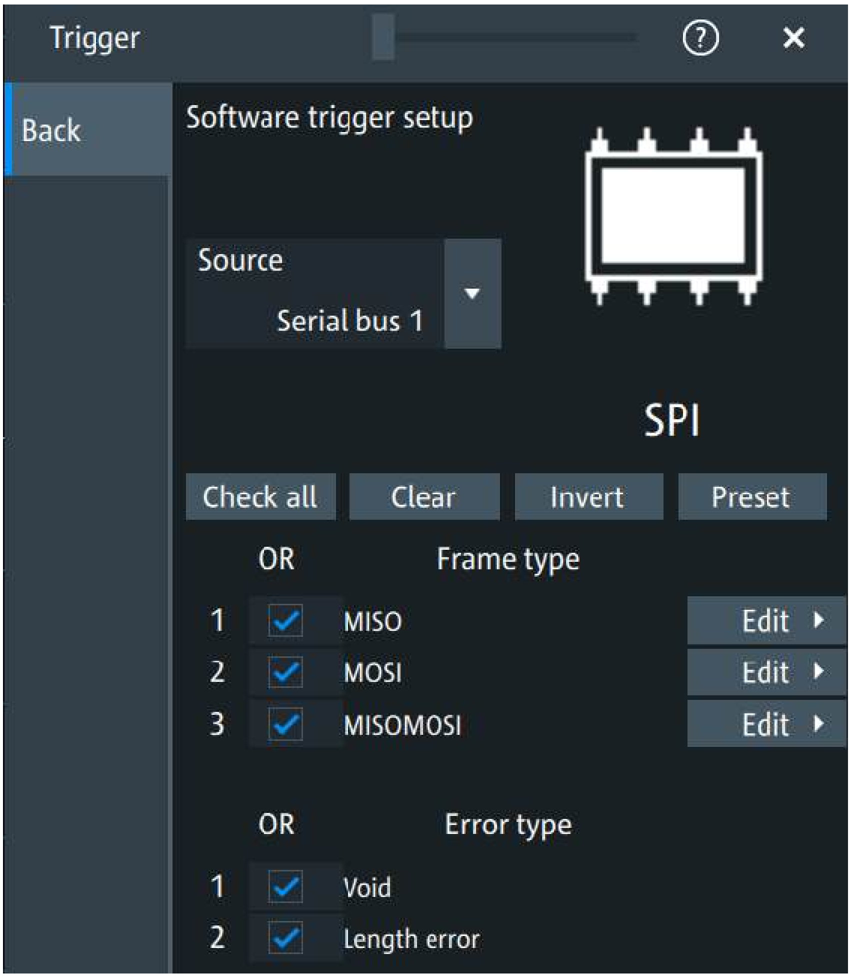
14.2.5 SPI software trigger

14.2.5.1 Setup A trigger

Before setting up the software trigger for the protocols, a trigger A event needs to be set up.

14.2.5.2 Software trigger settings

Access: "Menu" > "Apps" > "Protocol" tab > "SPI" > "Trigger" tab > "Setup Software Trigger" > "Setup SB Trigger".



In the "Software Trigger" tab, you can define the settings to trigger on the frames that match the selected filter conditions.

Check all, Clear, Invert, Preset

The following settings help you select the frames and errors you want to trigger on.

"Check all"	Enables the software trigger for all available frames and error types.
"Clear"	Disables the software trigger for all available frames and error types.
"Invert"	Inverts the current state of the frame and error types for the software trigger: all frames and error types that were enabled are disabled and vice versa.
"Preset"	Presets the state of the selected frames and error types for the software trigger.

Remote command:

`TRIGger:SBSW:SPI:CHKall` on page 1172

`TRIGger:SBSW:SPI:CLR` on page 1172

`TRIGger:SBSW:SPI:INVert` on page 1172

`TRIGger:SBSW:SPI:RST` on page 1172

Frame type

Selects the frame type that you want to trigger on. You can trigger on all enabled frame types simultaneously.

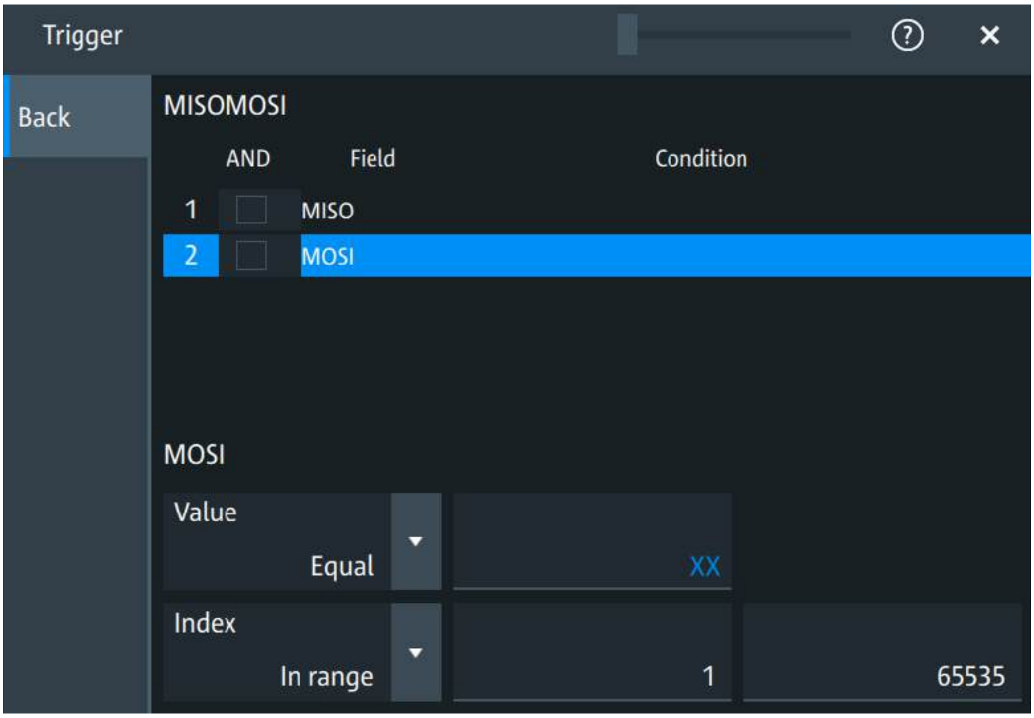
For each frame type, you can also specify conditions for the value of the fields in the "Edit" dialog.

The following frames are available: "MISO", "MOSI" and "MISO/MOSI".

Remote command:
`TRIGger:SBSW:SPI:FRENable` on page 1173
`TRIGger:SBSW:SPI:FRAMe<fr>:ENABle` on page 1173

Edit

Some trigger types have additional settings that can be defined. In this case, the "Set details" button appears next to "Type" the function. Open it for a detailed definition of the trigger conditions.



"Field"
Enables the field type that you want to trigger on for the selected frame.
The following fields are available: "MOSI" and "MISO".

Remote command:
`TRIGger:SBSW:SPI:FIENable` on page 1174
`TRIGger:SBSW:SPI:FRAMe<fr>:FLD<fl>:ENABle` on page 1174

"Condition"
Displays the value condition for the selected field.

Remote command:
`TRIGger:SBSW:SPI:BIT` on page 1173
`TRIGger:SBSW:SPI:FRAMe<fr>:FLD<fl>:BIT` on page 1173

"Value" The data setup consists of a comparison condition and one or two data patterns.

Remote command:
TRIGger:SBSW:SPI:DMAX on page 1173
TRIGger:SBSW:SPI:FRAMe<fr>:FLD<fl>:DMAX on page 1173
TRIGger:SBSW:SPI:DMIN on page 1174
TRIGger:SBSW:SPI:FRAMe<fr>:FLD<fl>:DMIN on page 1174
TRIGger:SBSW:SPI:DOPerator on page 1174
TRIGger:SBSW:SPI:FRAMe<fr>:FLD<fl>:DOPerator on page 1174

"Index" The index setup consists of a comparison condition and one or two index values.

Remote command:
TRIGger:SBSW:SPI:IMAX on page 1175
TRIGger:SBSW:SPI:FRAMe<fr>:FLD<fl>:IMAX on page 1175
TRIGger:SBSW:SPI:IMIN on page 1175
TRIGger:SBSW:SPI:FRAMe<fr>:FLD<fl>:IMIN on page 1175
TRIGger:SBSW:SPI:IOPerator on page 1176
TRIGger:SBSW:SPI:FRAMe<fr>:FLD<fl>:IOPerator on page 1176

Error type
Enables triggering on the selected error type.

The following error types are available: "Void" and "Length error".

Remote command:
TRIGger:SBSW:SPI:ERENable on page 1176
TRIGger:SBSW:SPI:ERRor<m>:ENABle on page 1176

14.2.6 Measure

The "Setup Measurement" button opens the dialog for automatic measurements in the "Protocol" category for the selected serial bus.

See Section 10.2.6.2, "Settings for protocol measurements", on page 289.

14.2.7 SPI decode results

When the configuration of the serial bus is complete, the signal can be decoded:

1. Open the "Serial Bus" dialog for the respective bus.
2. In the "Setup" tab, enable "State".
3. In the "Display" tab, enable "Show decode table".

For a description of the display settings, see also Section 14.1.3.1, "Display settings", on page 435.

For a description of how to synchronize the displayed results, see Section 14.1.3.2, "Display synchronization", on page 437.

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

Decode results table

The "Decode results" table contains information about all decoded frames.

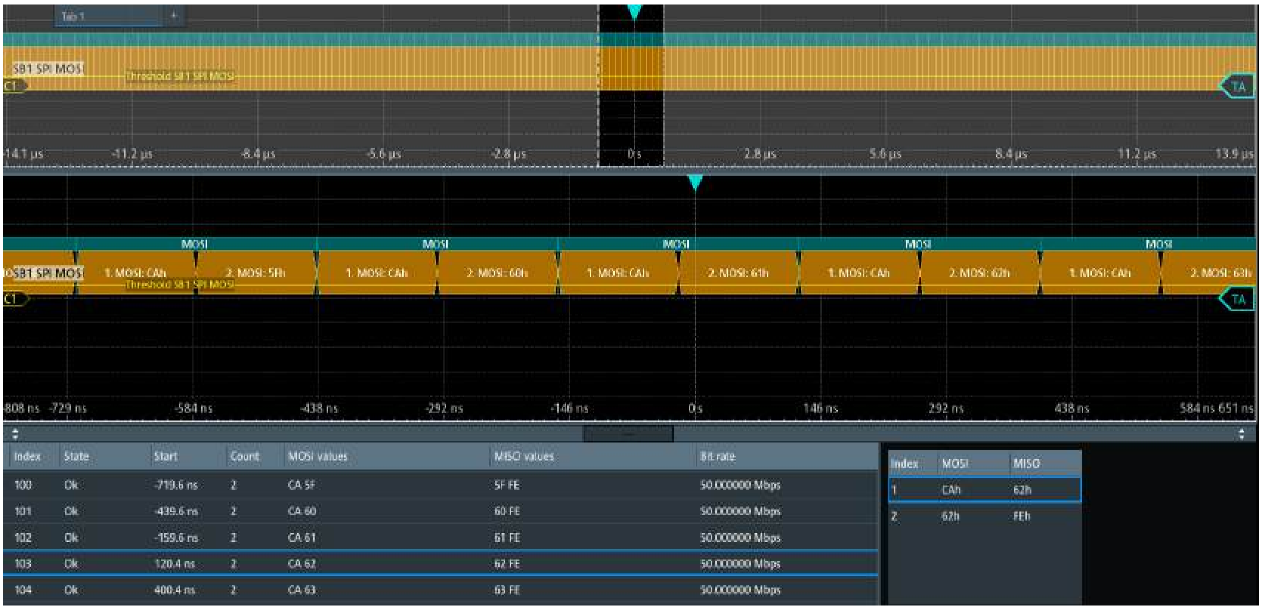


Figure 14-8: Decoded SPI signal

The decode results table contains information about all decoded frames.

Table 14-1: Content of the decode results table

Column	Description
Index	Index of the decoded frame
State	Overall state of the frame
Start	Times of frame start
Count	Number of words in the frame
MOSI values	Value of the MOSI data words. Select the data format in the "Display" tab.
MISO values	Value of the MISO data words. Select the data format in the "Display" tab.
Bit rate	Value of the bit rate

When you select a frame in the decode results table, its field content is shown in the details table to the right.

Table 14-2: Content of the frame details table

Column	Description
Index	Index of the field
MOSI	Values of the MOSI fields
MISO	Values of the MISO fields

Data format

You can select various data formats for the values displayed in the decode table and in the combs of the decoded signal.

Remote command:

- SBUS<sb>:FORMat on page 1154

Remote commands

Remote commands to retrieve decode results are described in Section 18.17.2.5, "Decode results", on page 1177.

To query the MOSI and MISO values, use the remote command SBUS<sb>:SPI:FRAMe<fr>:DATA?.

14.2.8 Performing SPI decoding

This section explains step by step how to configure and decode the SPI bus.

For more information on decoding SPI, you can also refer to the video, available on the Rohde & Schwarz YouTube channel: Decoding SPI with MXO Series Oscilloscopes.

14.2.8.1 Configuring SPI signals

For configuration, assign the lines to the input channels, and define the active states and the logical thresholds.

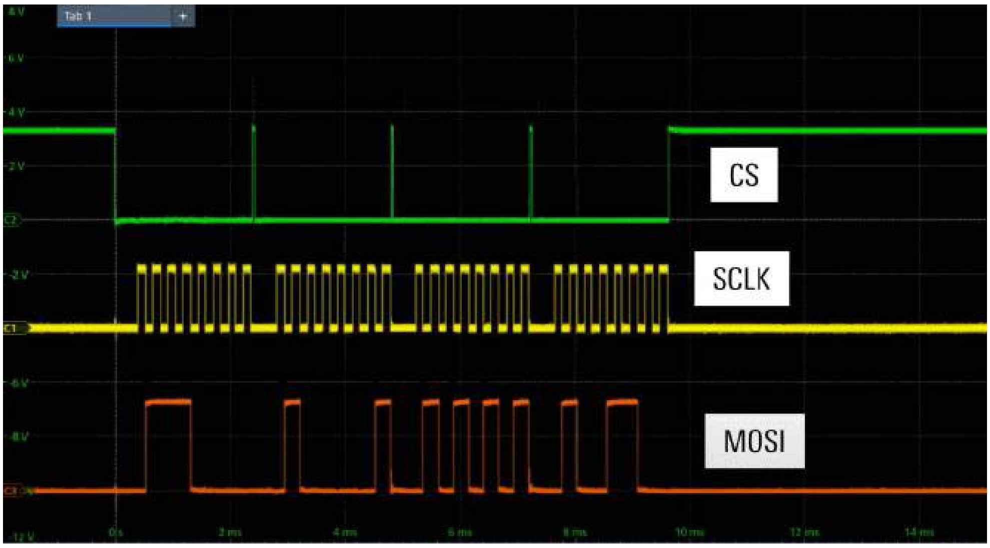
For details on configuration settings, see Section 14.2.2, "SPI configuration", on page 448.

1. Tap the "+ Bus" activator in the bottom right of the screen.

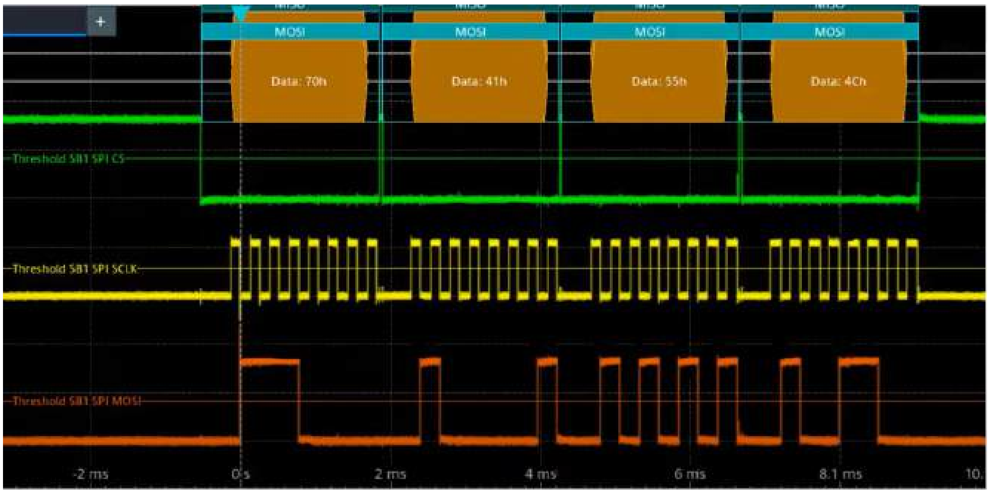
2. Select the tab of the bus that you want to set up, for example "SB1".
3. Tap the "Protocol type" button. Select the protocol: "SPI".
4. Tap on "State" to enable the decoding.

An SPI shortcut appears at the bottom left of the screen. Tap on the shortcut for a quick access to the "SPI" dialog settings.

5. Tap on each active wire and select the correct channels: "SCLK", "MOSI", "MISO", "CS".
6. Set "Bit order" to "MSB" or "LSB first".
7. Set "Clock polarity" to "Rising edge" (CPOL = 0) or "Falling edge" (CPOL = 1).
8. Set "MOSI polarity"/"MISO polarity" to "Active high"(CPHA = 0) or "Active low"(CPHA = 1).
9. Set "CS polarity" to "Active high" or "Active low".
   The typical value is "Active low", which means that the line is pulled low on message start.
10. Set the "Word length". The typical value is 8.
11. Check that the signals are on the screen.
    If not, try adjusting the vertical and horizontal settings.



12. Set the logical thresholds:
    a) Tap the "Thresholds" tab.
    b) For each wire, set the threshold value. A typical value is 1.65 V.
    c) If necessary, set the hysteresis value for the wires.
    d) Optionally, tap on "Show threshold lines".



14.2.8.2 Triggering on SPI

Prerequisites: A bus is configured for the SPI signal to be analyzed. See Section 14.2.8.1, "Configuring SPI signals", on page 461.

For details on configuration settings, see Section 14.2.2, "SPI configuration", on page 448.

1. Open "Menu" > "Trigger".
2. Set "Trigger on" to "Single event".
3. Ensure that the "Source" is set to the configured serial bus, e.g. "Serial bus 1".
4. Select the "Type".
5. Define additional settings for more complex trigger types ("MOSI"/ "MISO"):
   a) Tap on "Set details".
   b) Set the "Search mode".
   c) Set the "Data pattern" or a data range.

   In the following example a decode for triggering on "MOSI" triggered on "Data pattern" = 0x41.

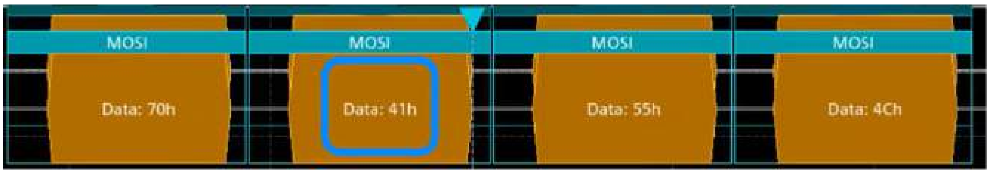


Figure 14-9: Trigger on Type= MOSI, Data pattern = 41

14.2.8.3 Exporting decode results

Once a decode has been completed, you can generate an export of all decode results.

Prerequisites: A bus is configured for the SPI and decoded.

1. Tap on the "SPI" shortcut.
2. Tap on the "Export" tab.
3. If necessary, enable "Include details".
4. If necessary, enable "Include timing".
5. Select the "File type".

   An export file is saved in the selected directory.

The SPI export file contains the following fields:

- A list of all decoded frames:
  - Index
  - Start
  - Stop
  - Source
  - State
  - Bit rate
- The details frame includes the following fields:
  - Index
  - Start time
  - Stop time
  - MOSI values
  - MISO values

Example SPI export file

```
Index,Start,Stop,State,Count,BitRate
1,-2.9e-05,-2.872e-05,'OK',2,50000000
2,-2.844e-05,-2.83e-05,'OK',1,50000000
3,-2.816e-05,-2.788e-05,'OK',2,50000000
4,-2.76e-05,-2.746e-05,'VOID',0,---

Details frame 1
Index,Start Time,Stop Time,MOSI Values,MISO Values
1,-2.9e-05,-2.886e-05,AFh,---
2,-2.886e-05,-2.872e-05,FEh,---

Details frame 2
Index,Start Time,Stop Time,MOSI Values,MISO Values
1,-2.844e-05,-2.83e-05,---,34h

Details frame 3
Index,Start Time,Stop Time,MOSI Values,MISO Values
```

```
1,-2.816e-05,-2.802e-05,CAh,F0h
2,-2.802e-05,-2.788e-05,05h,0Dh
```

14.3 QUAD-SPI bus (IC electronics, option R&S MXO4-K510)

QUAD-SPI also known as QSPI is a protocol that extends the standard SPI by using four data lanes instead of one. This protocol enables a faster data transfer.

Requirements

For performing QUAD-SPI decode measurements, you need the following:

- MXO 4 with 4 channels. The channels can be a combination of the following:
  – Analog channels (C1-C4)
  – Logic channels (D0-D15) (requires option R&S MXO4-B1)
- Option R&S MXO4-K510

14.3.1 About the QUAD-SPI protocol

Quad Serial Peripheral Interface is an extension of the standard Serial Peripheral Interface (SPI). It enhances the data transfer capabilities by utilizing four data lines instead of the single data line used in traditional SPI. This expansion significantly increases the data throughput, making it ideal for applications requiring rapid data exchange, such as memory devices, display controllers, and sensors.

Key features

Key features of Quad SPI are:

- **Increased Data Throughput**: By using four data lines (IO0, IO1, IO2, IO3), QSPI can achieve higher data transfer rates compared to standard SPI. This makes it suitable for high-speed applications.
- **Enhanced Flexibility**: Quad SPI supports various modes of operation, including single, dual, and quad modes, allowing for flexible communication tailored to specific needs.
- **Memory Mapping**: one of the standout features of QSPI is its ability to map external flash memory directly into the memory space of a microcontroller, enabling efficient and seamless data access.

QUAD SPI builds upon the traditional SPI protocol but adds complexity and speed.

Communication Lines

QUAD SPI uses six primary lines:

- SCLK (serial clock): generates the clock signal
- CS (chip select): selects the device for communication
- IO0-IO3, data lines: four lines for data transfer.

14.3.2 QUAD-SPI configuration

14.3.2.1 QUAD-SPI configuration settings

Access: "Menu" > "Apps" > "Protocol" tab > "QUAD-SPI" > "Setup".

Make sure that the tab of the correct serial bus is selected.

Protocol type
Selects the protocol type to be decoded.

Remote command:
SBUS<sb>:TYPE on page 1153

State
Enables the decoding of the selected bus. The signal icon of the bus appears on the signal bar.

Remote command:
SBUS<sb>[:STATe] on page 1152

CS, SCLK, IO n
Sets the input channel for the respective line:

- CS: chip select
- SCLK: clock line
- IO0, IO1, IO2, IO3, IO4: data lines

Remote command:
SBUS<sb>:QSPI:CSEL:SOURce on page 1183
SBUS<sb>:QSPI:IOONe:SOURce on page 1185
SBUS<sb>:QSPI:IOTHree:SOURce on page 1187
SBUS<sb>:QSPI:IOTWo:SOURce on page 1188
SBUS<sb>:QSPI:IOZero:SOURce on page 1190
SBUS<sb>:QSPI:SCLK:SOURce on page 1191

SCLK SDR Polarity
Selects if the transmitted signal for the respective line is rising or falling.

Remote command:
`SBUS<sb>:QSPI:SCLK:POLarity` on page 1191

Polarity: CS, IOx
Selects if the transmitted signal for the respective line is active high (high = 1) or active low (low = 1).

Remote command:
`SBUS<sb>:QSPI:CSEL:POLarity` on page 1183
`SBUS<sb>:QSPI:IOONe:POLarity` on page 1184
`SBUS<sb>:QSPI:IOTHree:POLarity` on page 1186
`SBUS<sb>:QSPI:IOTWo:POLarity` on page 1187
`SBUS<sb>:QSPI:IOZero:POLarity` on page 1189

Instruction
Selects the instruction mode that defines how many lanes are used to transmit data.

"Single" Only one data line is used, IO0.

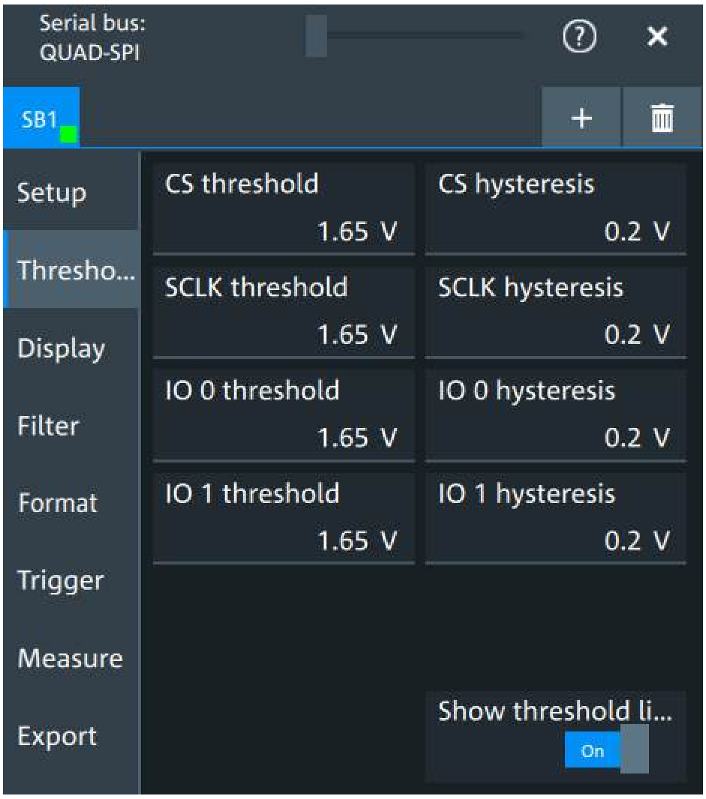
"Dual" Two lines are used for data transmission IO0 and IO1. This mode doubles the data rate compared to a single mode, as it can send or receive 2 bits per clock cycle.

"Quad" Four lines are used for data transmission IO0, IO1, IO2 and IO3. This mode provides the highest data transfer rate. This mode quadruples the data transfer rate compared to a single mode, as it can send or receive 4 bits per clock cycle.

Remote command:
`SBUS<sb>:QSPI:INSTruction` on page 1184

14.3.2.2 Threshold settings

Access: "Menu" > "Apps" > "Protocol" tab > "QUAD-SPI" > "Thresholds".



CS/SCLK/IO threshold
Set the threshold for each signal channel. Enter the value directly in the fields.

Remote command:
SBUS<sb>:QSPI:CSEL:THReshold on page 1183
SBUS<sb>:QSPI:IOONe:THReshold on page 1185
SBUS<sb>:QSPI:IOTWo:THReshold on page 1188
SBUS<sb>:QSPI:IOTHree:THReshold on page 1187
SBUS<sb>:QSPI:IOZero:THReshold on page 1190
SBUS<sb>:QSPI:SCLK:THReshold on page 1191

CS/SCLK/IO hysteresis
Set the hysteresis for each signal channel. Enter the value directly in the fields.

Remote command:
SBUS<sb>:QSPI:CSEL:HYSTeresis on page 1183
SBUS<sb>:QSPI:IOONe:HYSTeresis on page 1184
SBUS<sb>:QSPI:IOTWo:HYSTeresis on page 1187
SBUS<sb>:QSPI:IOTHree:HYSTeresis on page 1186
SBUS<sb>:QSPI:IOZero:HYSTeresis on page 1189
SBUS<sb>:QSPI:SCLK:HYSTeresis on page 1190

Show threshold lines
If enabled, the threshold lines are displayed in the diagram.

The label of the threshold line is set according to the signal that it is referring to, see also Show threshold lines.

Remote command:
SBUS<sb>:THReshold on page 1155

14.3.2.3 Display settings

For details about the display settings, see Section 14.1.3.1, "Display settings", on page 435.

Decode layer

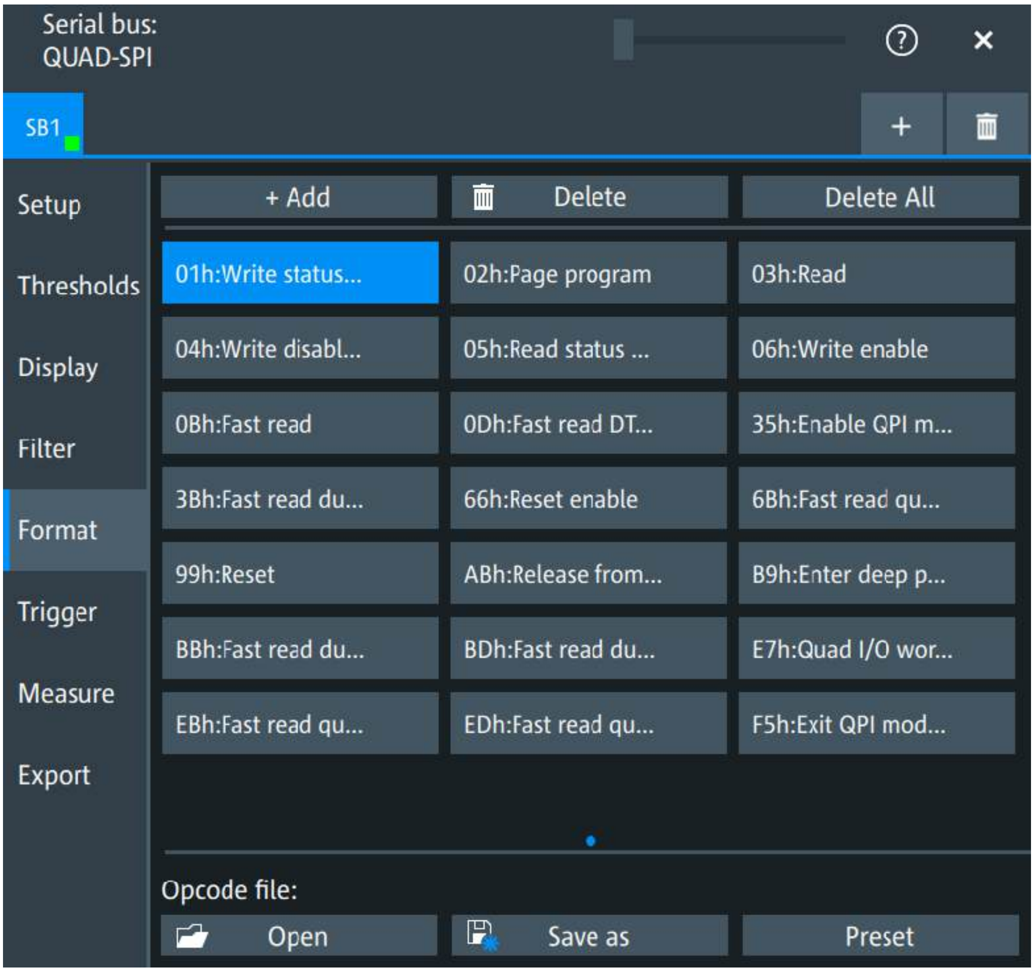
Selects the decode layer.

Decoding is performed in several steps, and the results are presented in the decode table. The decode layer selects an interim step for which the decoding result is shown in the honeycomb display.

"Off"	Disables the display of the decode layer.
"Edges"	Enables the display of all edges for each lane.
"Bits"	Enables the display of all bits for each lane.
"Merged bits"	Enables the display of the bits merged across multiple lanes.
"Words"	Enables the display of all words.

14.3.2.4 Format

Access: "Menu" > "Apps" > "Protocol" tab > "QUAD-SPI" > "Format".



In the "Format" tab, you can define the opcode file.

Opcode is a specific command byte sent from the microcontroller to the QUAD-SPI device to initiate a particular action, such as reading, writing or erasing data. The opcodes vary by device manufacturer and memory model.

Opcode files are in JSON format, and contain frame descriptions for each hexadecimal opcode value.

The following is an example from a JSON file:

```
{
   "Firmware Version": "2.2.0.0",
   "Description": "Rohde Schwarz Inc. oscilloscope Quadspi Opcode data",
   "Opcode Version": 1,
   "Opcodes": {
    "0x05,RDSR1": [
        {
            "name": "data",
            "bytes": 0,
            "ddr": false,
            "lanes": 1
        }
```

```
    ],
    "0x07,RDSR2": [
        {
            "name": "data",
            "bytes": 0,
            "ddr": false,
            "lanes": 1
        }
    ],
    "0x35,RDCR1": [
        {
            "name": "data",
            "bytes": 0,
            "ddr": false,
            "lanes": 1
        }
    ],
    "0x0D,DDRFAST READ": [
        {
            "name": "address",
            "bytes": 3,
            "ddr": true,
            "lanes": 1
        },
        {
            "name": "data",
            "bytes": 0,
            "ddr": true,
            "lanes": 1
        }
    ]
    }
}
```


Add

Adds a new item to the opcode list.

Remote command:

SBUS<sb>:QSPI:OPCode:APPend on page 1192

Delete

Deletes the currently selected opcode from the list.

Remote command:

SBUS<sb>:QSPI:OPCode:DELete on page 1192

Delete all

Deletes all defined opcodes from the list.

Remote command:

SBUS<sb>:QSPI:OPCode:DALL on page 1192

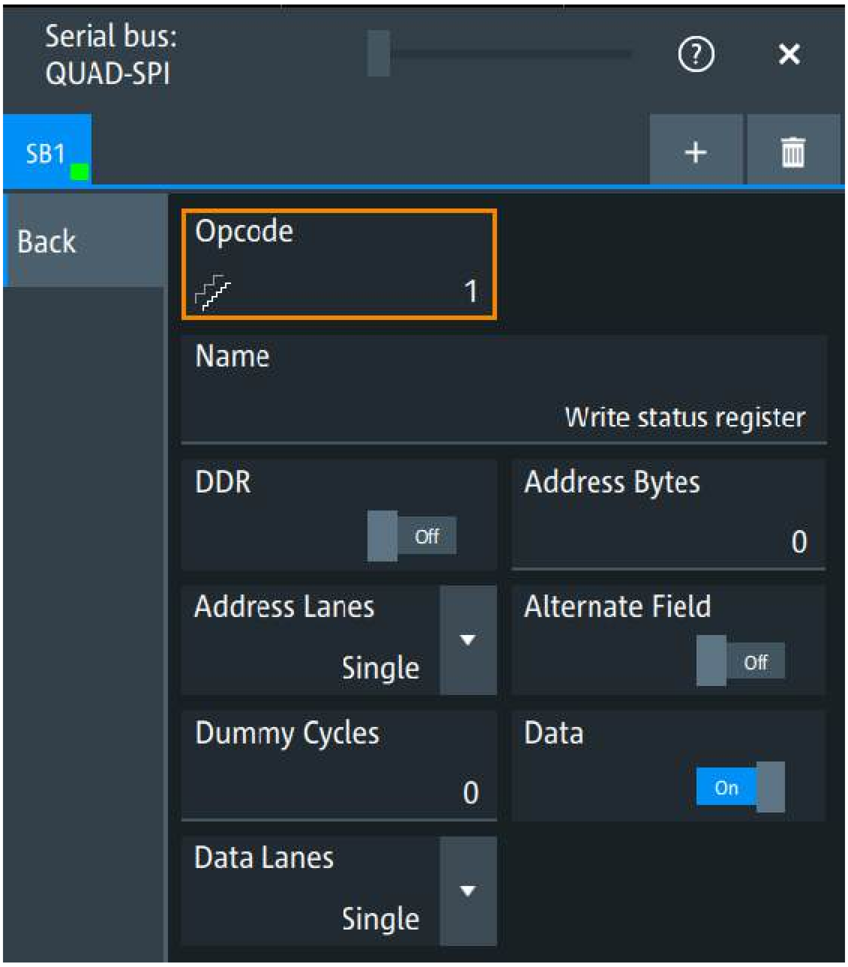
Open, Save as
Opens a dialog box where you can select a filename and a path for the export results file.

Remote command:
SBUS<sb>:QSPI:LDOPcode on page 1193
SBUS<sb>:QSPI:SVOP on page 1196

Preset
Resets the opcode fields to the predefined values.

Remote command:
SBUS<sb>:QSPI:OPCode:RESet on page 1193

Opcode settings



You can define the following settings for each opcode separately:

Opcode ← Opcode settings
Sets the opcode value.

Remote command:
SBUS<sb>:QSPI:OPCode:ITEM<n>:CODE on page 1194

Name ← Opcode settings
Sets the name for the opcode.

Remote command:
`SBUS<sb>:QSPI:OPCode:ITEM<n>:NAME` on page 1196

DDR ← Opcode settings
If enabled, the data is transferred on both the rising and falling edges of the clock signal. This method effectively doubles the data transfer rate compared to a single data rate (SDR), which transfers data only on one clock edge.

Remote command:
`SBUS<sb>:QSPI:OPCode:ITEM<n>:DDR` on page 1195

Address Bytes ← Opcode settings
Sets the address byte. It specifies the location in the flash memory where the operation (e.g., read, write) is performed.

Remote command:
`SBUS<sb>:QSPI:OPCode:ITEM<n>:ADBYtes` on page 1193

Address Lanes ← Opcode settings
Selects how many lines or lanes are used to send the address bytes to the flash memory.

"Single"	Address is sent over one serial line.
"Dual"	Address is sent over two lines.
"Quad"	Address is sent over four lines.

Remote command:
`SBUS<sb>:QSPI:OPCode:ITEM<n>:ADLanes` on page 1194

Alternative Field ← Opcode settings
Enable, if an "Alt" field is available. The alternative field can be implemented according to the preferences of the manufacturer of the device under test, for example a flash memory device.

Remote command:
`SBUS<sb>:QSPI:OPCode:ITEM<n>:ALT` on page 1194

Dummy Cycles ← Opcode settings
Sets the number of dummy cycles. Dummy cycles are clock cycles inserted after the address or other command sequences but before data transfer begins. These cycles allow the flash memory device additional time to perform internal operations or latch onto the correct data to ensure accurate read or write operations.

Remote command:
`SBUS<sb>:QSPI:OPCode:ITEM<n>:DMCYcles` on page 1195

Data ← Opcode settings
Enable, if data is being transferred in the opcode operation.

Remote command:
`SBUS<sb>:QSPI:OPCode:ITEM<n>:DATA` on page 1195

Data Lanes ← Opcode settings
Selects how many lanes are used for the data transfer.

The data lanes refer to the physical connections through which data is transmitted between the main (typically a microcontroller) and the secondary (typically a flash memory device). QUADSPI can utilize multiple data lines to increase the speed and efficiency of data transfer.

"Single" Data is sent over one serial line.

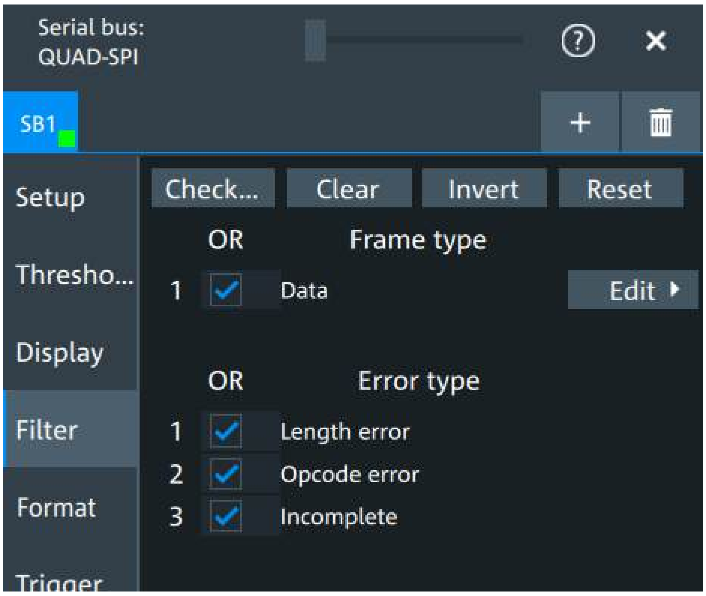
"Dual" Data is sent over two lines.

"Quad" Data is sent over four lines.

Remote command:
`SBUS<sb>:QSPI:OPCode:ITEM<n>:DTLanes` on page 1196

14.3.3 QUAD SPI filter

Access: "Menu" > "Apps" > "Protocol" tab > "QUAD-SPI" > "Filter" tab



In the "Filter" tab, you can define the settings to display only the frames that match the selected filter conditions.

Check all, Clear, Invert, Preset
The following settings help you select the frames and errors you want to filter for. Only the frames and error types that match the selected filter conditions are displayed.

"Check all" Enables the filter for all available frames and error types.

"Clear" Disables the filter for all available frames and error types.

"Invert" Inverts the current state of the frame and error types: all frames and error types that were enabled are disabled and vice versa.

"Preset" Presets the state of the selected frames and error types.

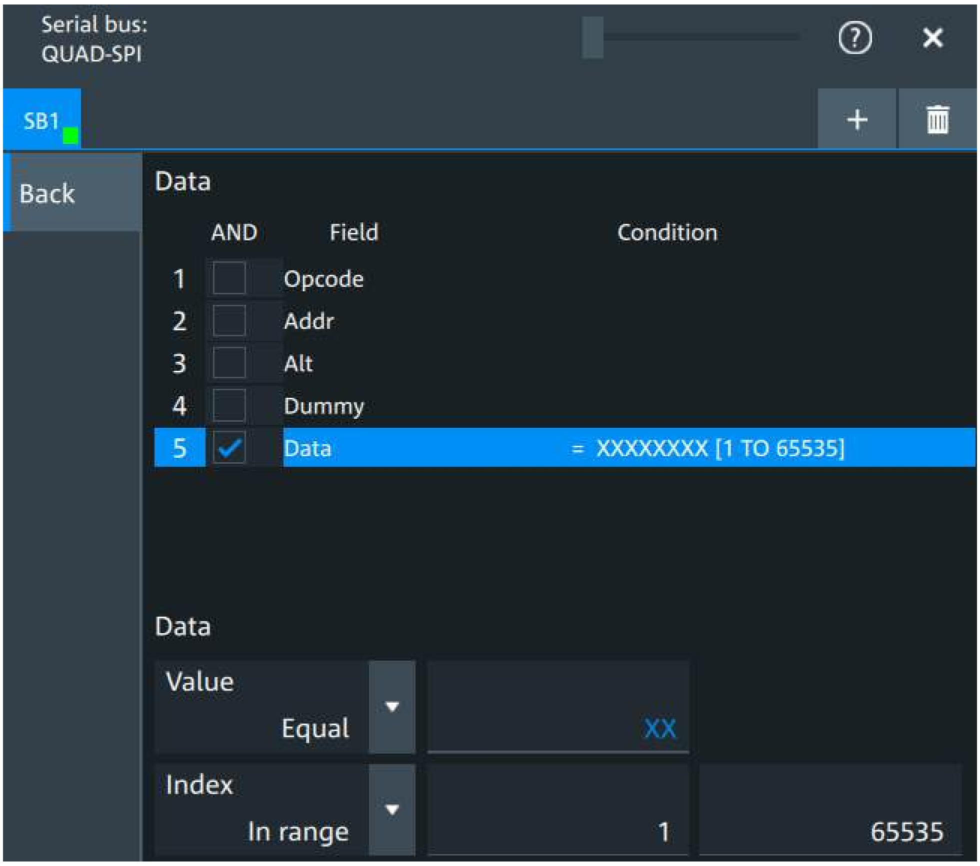
Remote command:
SBUS<sb>:QSPI:FILTer:CHKall on page 1197
SBUS<sb>:QSPI:FILTer:CLR on page 1198
SBUS<sb>:QSPI:FILTer:INVert on page 1198
SBUS<sb>:QSPI:FILTer:RST on page 1198

Frame type
Selects the frame type that you want to display. You can filter all enabled frame types simultaneously.

For selected frame types, you can also specify conditions for the value of the fields in the "Edit" dialog.

Available frame is "Data".

Edit
Opens a dialog to define the details of the selected frame.



"Field" Enables the field type that you want to filter on for the selected frame.

The available fields are:
- "Opcode"
- "Addr"
- "Alt"
- "Dummy"
- "Data"

Remote command:
SBUS<sb>:QSPI:FILTer:FIENable on page 1201
SBUS<sb>:QSPI:FILTer:FRAMe<fr>:FLD<fl>:ENABle on page 1201

"Condition" Displays the value condition for the selected field.

Remote command:
SBUS<sb>:QSPI:FILTer:BIT on page 1198
SBUS<sb>:QSPI:FILTer:FRAMe<fr>:FLD<fl>:BIT on page 1198

"Value" The data setup consists of a comparison condition and one or two data patterns.

Remote command:
SBUS<sb>:QSPI:FILTer:DMAX on page 1199
SBUS<sb>:QSPI:FILTer:FRAMe<fr>:FLD<fl>:DMAX on page 1199
SBUS<sb>:QSPI:FILTer:DMIN on page 1199
SBUS<sb>:QSPI:FILTer:FRAMe<fr>:FLD<fl>:DMIN on page 1199
SBUS<sb>:QSPI:FILTer:DOPerator on page 1199
SBUS<sb>:QSPI:FILTer:FRAMe<fr>:FLD<fl>:DOPerator on page 1199

"Index" The index setup consists of a comparison condition and one or two index values.

Remote command:
SBUS<sb>:QSPI:FILTer:IMAX on page 1200
SBUS<sb>:QSPI:FILTer:FRAMe<fr>:FLD<fl>:IMAX on page 1200
SBUS<sb>:QSPI:FILTer:IMIN on page 1200
SBUS<sb>:QSPI:FILTer:FRAMe<fr>:FLD<fl>:IMIN on page 1200
SBUS<sb>:QSPI:FILTer:IOPerator on page 1201
SBUS<sb>:QSPI:FILTer:FRAMe<fr>:FLD<fl>:IOPerator on page 1201

Error type
Enables filtering on the selected error type.

Available error types are "Length error", "Opcode error", "Incomplete".

Remote command:
`SBUS<sb>:QSPI:FILTer:ERENable` on page 1201
`SBUS<sb>:QSPI:FILTer:ERRor<n>:ENABle` on page 1201

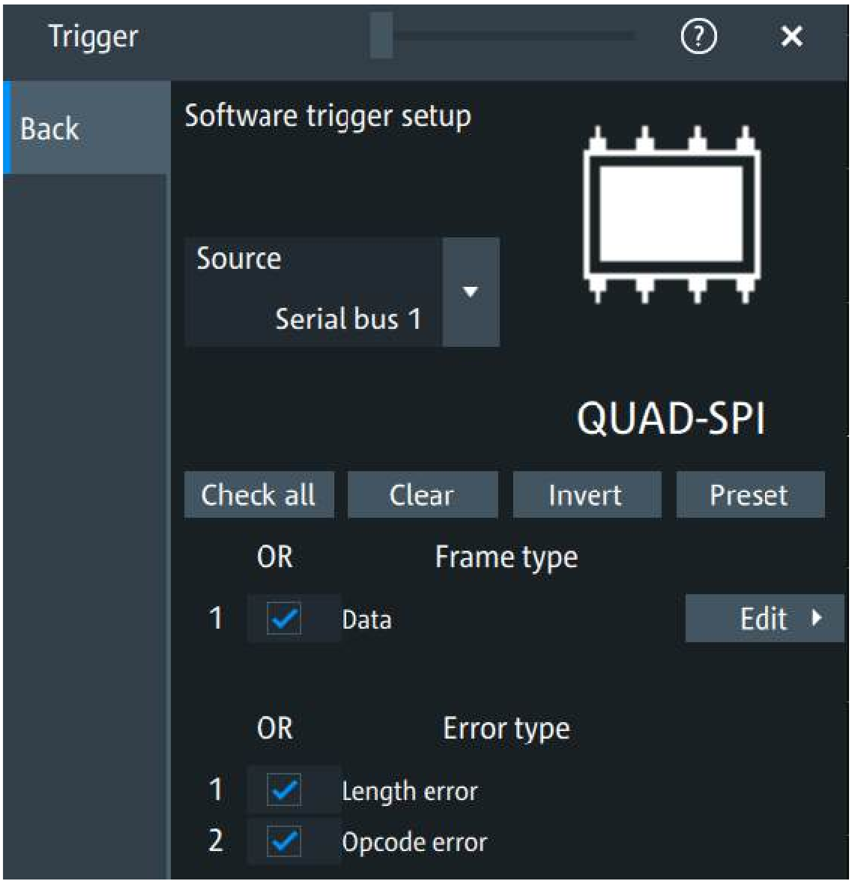
14.3.4 QUAD SPI software trigger

14.3.4.1 Setup A trigger

Before setting up the software trigger for the protocols, a trigger A event needs to be set up.

14.3.4.2 Software trigger settings

Access: "Menu" > "Apps" > "Protocol" tab > "QUAD-SPI" > "Trigger" tab > "Setup Software Trigger"



In the "Software Trigger" tab, you can define the settings to trigger on the frames that match the selected filter conditions.

Check all, Clear, Invert, Preset
The following settings help you select the frames and errors you want to trigger on.

"Check all"	Enables the software trigger for all available frames and error types.
"Clear"	Disables the software trigger for all available frames and error types.
"Invert"	Inverts the current state of the frame and error types for the software trigger: all frames and error types that were enabled are disabled and vice versa.
"Preset"	Presets the state of the selected frames and error types for the software trigger.

Remote command:
`TRIGger:SBSW:QSPI:CHKall` on page 1203
`TRIGger:SBSW:QSPI:CLR` on page 1203
`TRIGger:SBSW:QSPI:INVert` on page 1203
`TRIGger:SBSW:QSPI:RST` on page 1203

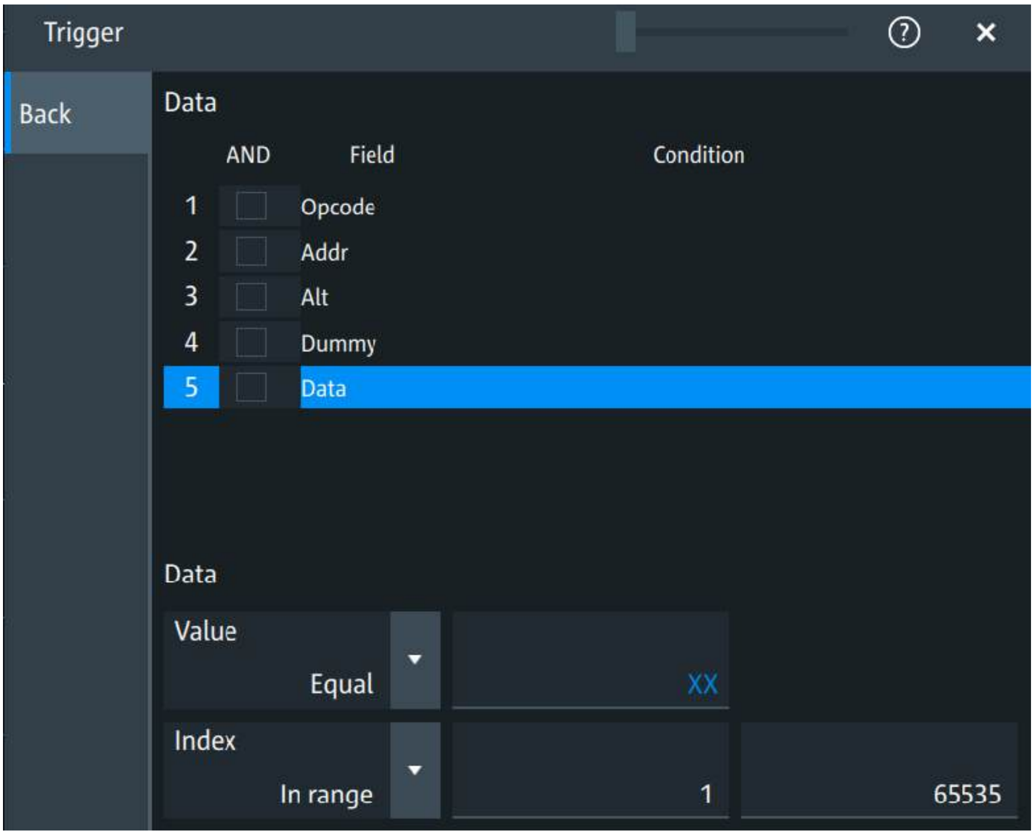
Frame type
Selects the frame type that you want to trigger on. You can trigger on all enabled frame types simultaneously.

For each frame type, you can also specify conditions for the value of the fields in the "Edit" dialog.

The available frame is "Data".

Remote command:
`TRIGger:SBSW:QSPI:FRENable` on page 1203
`TRIGger:SBSW:QSPI:FRAMe<fr>:ENABle` on page 1203

Edit
Some trigger types have additional settings that can be defined. In this case, the "Set details" button appears next to "Type" the function. Open it for a detailed definition of the trigger conditions.



"Field"
: Enables the field type that you want to trigger on for the selected frame.
The following fields are available: "Opcode", "Addr", "Alt", "Dummy" and "Data".

Remote command:
TRIGger:SBSW:QSPI:FIENable on page 1205
TRIGger:SBSW:QSPI:FRAMe<fr>:FLD<fl>:ENABle on page 1205

"Condition"
: Displays the value condition for the selected field.

Remote command:
TRIGger:SBSW:QSPI:BIT on page 1204
TRIGger:SBSW:QSPI:FRAMe<fr>:FLD<fl>:BIT on page 1204

"Value"
: The data setup consists of a comparison condition and one or two data patterns.

Remote command:
TRIGger:SBSW:QSPI:DMAX on page 1204
TRIGger:SBSW:QSPI:FRAMe<fr>:FLD<fl>:DMAX on page 1204
TRIGger:SBSW:QSPI:DMIN on page 1205
TRIGger:SBSW:QSPI:FRAMe<fr>:FLD<fl>:DMIN on page 1205
TRIGger:SBSW:QSPI:DOPerator on page 1205
TRIGger:SBSW:QSPI:FRAMe<fr>:FLD<fl>:DOPerator on page 1205

"Index" The index setup consists of a comparison condition and one or two index values.

Remote command:
TRIGger:SBSW:QSPI:IMAX on page 1206
TRIGger:SBSW:QSPI:FRAMe<fr>:FLD<fl>:IMAX on page 1206
TRIGger:SBSW:QSPI:IMIN on page 1206
TRIGger:SBSW:QSPI:FRAMe<fr>:FLD<fl>:IMIN on page 1206
TRIGger:SBSW:QSPI:IOPerator on page 1206
TRIGger:SBSW:QSPI:FRAMe<fr>:FLD<fl>:IOPerator on page 1206

Error type

Enables triggering on the selected error type.

The following error types are available: "Length error" and "Opcode error".

Remote command:
TRIGger:SBSW:QSPI:ERENable on page 1207
TRIGger:SBSW:QSPI:ERRor<m>:ENABle on page 1207

14.3.5 Measure

The "Setup Measurement" button opens the dialog for automatic measurements in the "Protocol" category for the selected serial bus.

See Section 10.2.6.2, "Settings for protocol measurements", on page 289.

14.3.6 QUAD-SPI decode results

When the configuration of the serial bus is complete, the signal can be decoded:

1. Open the "Serial Bus" dialog for the respective bus.
2. In the "Setup" tab, enable "State".
3. In the "Display" tab, enable "Show decode table".

For a description of the display settings, see also Section 14.1.3.1, "Display settings", on page 435.

For a description of how to synchronize the displayed results, see Section 14.1.3.2, "Display synchronization", on page 437.

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

Decode results table

The "Decode results" table contains information about all decoded frames.

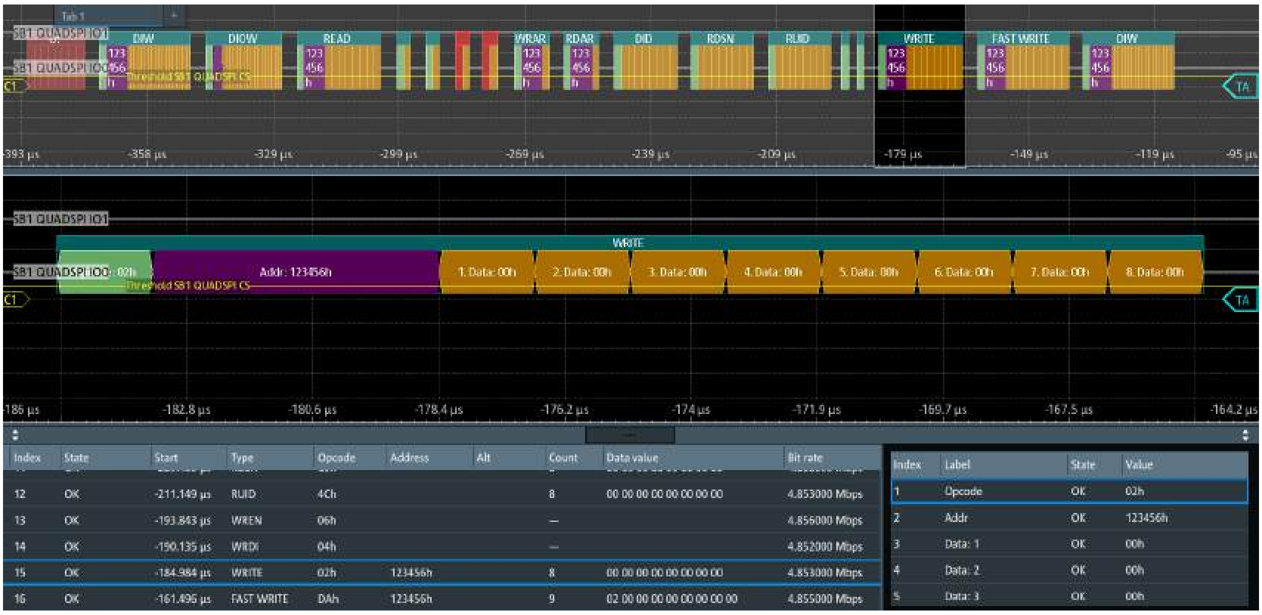


Figure 14-10: Decoded QUAD-SPI signal

The decode results table contains information about all decoded frames.

Table 14-3: Content of the decode results table

Column	Description
Index	Index of the decoded frame
State	Overall state of the frame
Start	Times of frame start
Opcode	Operation code value
Address	Address value
Alt	Value of the alternate byte
Count	Number of words in the frame
Data value	Value of the data frame. Select the data format in the "Display" tab.
Bit rate	Value of the bit rate

When you select a frame in the decode results table, its field content is shown in the details table to the right.

Table 14-4: Content of the frame details table

Column	Description
Index	Number of the decoded field
Label	Name of the field

Column	Description
State	State of the field
Value	Value of the field

Data format

You can select various data formats for the values displayed in the decode table and in the combs of the decoded signal.

Remote command:

- `SBUS<sb>:FORMat` on page 1154

Remote commands

Remote commands to retrieve decode results are described in Section 18.17.3.5, "Decode results", on page 1208.

14.3.7 Performing QUAD-SPI decoding

This section explains step by step how to configure and decode the QUAD-SPI bus.

14.3.7.1 Configuring QUAD-SPI signals

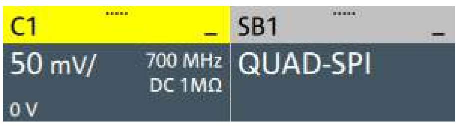
For configuration, assign the lines to the input channels, and define the active states and the logical thresholds.

For details on configuration settings, see Section 14.3.2, "QUAD-SPI configuration", on page 466.

1. Tap the "+ Bus" activator in the bottom right of the screen.

2. Select the tab of the bus that you want to set up, for example "SB1".
3. Tap the "Protocol type" button. Select the protocol: "QUAD-SPI".
4. Tap on "State" to enable the decoding.

   A "QUAD-SPI" shortcut appears at the bottom left of the screen. Tap on the shortcut for a quick access to the "QUAD-SPI" dialog settings.



5. Check that the signals are on the screen.

If not try adjusting the vertical and horizontal settings.

6. Set the logical thresholds:
   a) Tap the "Thresholds" tab.
   b) For each wire, set the threshold value. A typical value is 0.8 V.
   c) If necessary, set the hysteresis value for the wires.
   d) Optionally, tap on "Show threshold lines".

14.3.7.2 Exporting decode results

Once a decode has been completed, you can generate an export of all decode results.

Prerequisites: A bus is configured for the QUAD-SPI and decoded.

1. Tap on the "QUAD-SPI" shortcut.
2. Tap on the "Export" tab.
3. If necessary, enable "Include details".
4. If necessary, enable "Include timing".
5. Select the "File type".

   An export file is saved in the selected directory.

The QUAD-SPI export file contains the following fields:

- A list of all decoded frames:
  – Index
  – Start
  – Stop
  – State
  – Opcode
  – Address
  – Alt
  – Count
  – Bit rate
- The details frame includes the following fields:
  – Index
  – Data

Example QUAD-SPI export file

```
Index,Start,Stop,State,Opcode,Address,Alt,Count,Bit rate
1,-7.04e-05,-5.28e-05,'OK',0Ah,12345678h,0Ch,4,5000000
2,-5.28e-05,-3.52e-05,'OK',0Ah,12345678h,0Ch,4,5000000
3,-3.52e-05,-1.76e-05,'OK',0Ah,12345678h,0Ch,4,5000000
4,-1.76e-05,0,'OK',0Ah,12345678h,0Ch,4,5000000
```

```
Details frame 1
Index,Data
1,52h
2,53h
3,54h
4,55h

Details frame 2
Index,Data
1,56h
2,57h
3,58h
4,59h
```

14.4 I²C (IC electronics, option R&S MXO4-K510)

The Inter-Integrated Circuit is a simple, low-bandwidth, low-speed protocol used for communication between on-board devices, for example, in LCD and LED drivers, RAM, EEPROM, and others.

For basic information on I²C, you can also refer to a video, available on the Rohde & Schwarz YouTube channel: Understanding I2C.

Requirements

For performing I²C decode measurements, you need the following:

- MXO 4 with 2 available channels. The channels can be a combination of the following:
  – Analog channels (C1-C4)
  – Logic channels (D0-D15) (requires option R&S MXO4-B1)
- Option R&S MXO4-K510

14.4.1 About the I²C protocol

This section provides an overview of protocol characteristics, data format, address types and trigger possibilities. For detailed information, read the "I2C-bus specification and user manual" available on the NXP manuals webpage at http://www.nxp.com/.

I²C characteristics

The main characteristics of I²C are:

- Two-wire design: serial clock (SCL) and serial data (SDA) lines
- Controller/ target communication: the controller generates the clock and addresses the targets. Targets receive the address and the clock. Both controller and targets can transmit and receive data.
- Addressing scheme: each target device is addressable by a unique address. Multiple target devices can be linked together and can be addressed by the same controller.
- Read/write bit: specifies if the controller reads (=1) or writes (=0) the data.
- Acknowledge: takes place after every byte. The receiver of the address or data sends the acknowledge bit to the transmitter.

The MXO 4 supports all operating speed modes: high-speed, fast mode plus, fast mode, and standard mode.

Data transfer

The format of a simple I²C message (frame) with 7-bit addressing consists of the following parts:

- Start condition: a falling slope on SDA while SCL is high
- 7-bit address of the target device that is either written to or read from
- R/W bit: specifies if the data is written to or read from the target
- ACKnowledge bits: is issued by the receiver of the previous byte if the transfer was successful
  Exception: At read access, the controller terminates the data transmission with a NACK bit after the last byte.
- Data: several data bytes with an ACK bit after every byte
- Stop condition: a rising slope on SDA while SCL is high

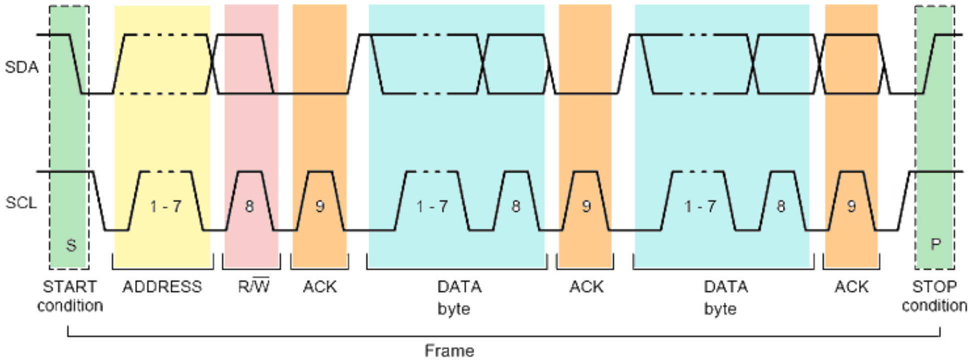


Figure 14-11: I2C write access with a 7-bit address

Address types: 7-bit and 10-bit

Target addresses can be 7 bits or 10 bits long. A 7-bit address requires 1 byte, 7 bits for the address followed by the R/W bit.

A 10-bit address for write access requires 2 bytes: the first byte starts with the reserved sequence 11110, followed by the two MSB of the address and the write bit. The second byte contains the remaining 8 LSB of the address. The target acknowledges each address byte.

Figure 14-12: 10-bit address, write access

A 10-bit address for read access requires 3 bytes. The first 2 bytes are identical to the write access address. The third byte repeats the address bits of the first byte and sets the read bit.

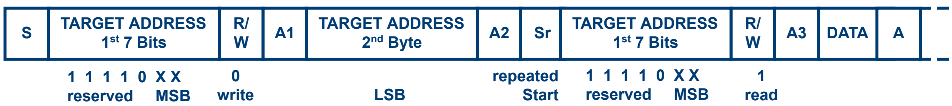


Figure 14-13: 10-bit address, read access

Trigger

The MXO 4 can trigger on various parts of I²C messages. You must connect the data and clock lines to the input channels; triggering on math and reference waveforms is not possible.

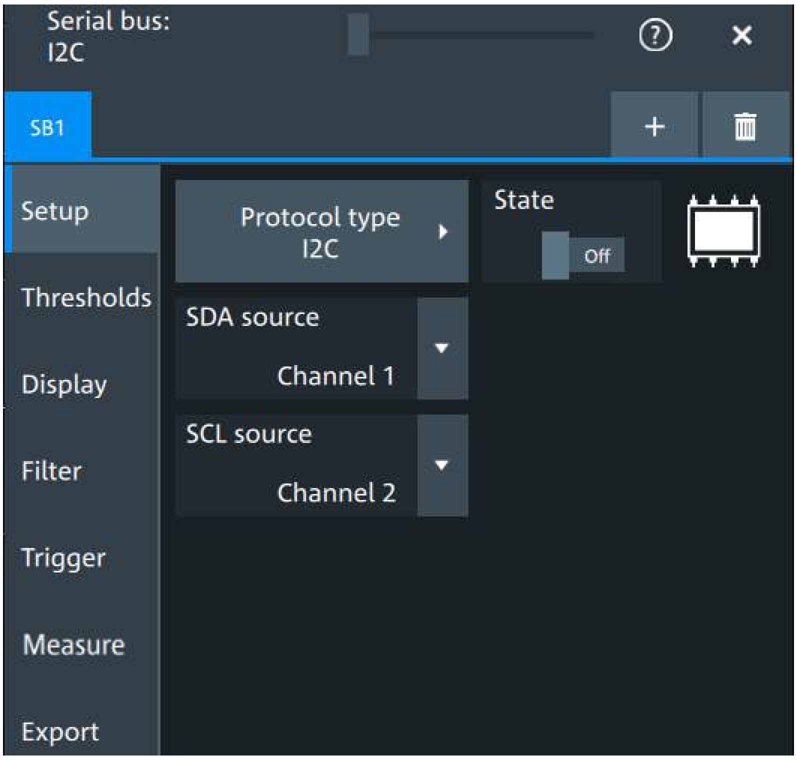
You can trigger on:

- Start or stop condition
- Repeated start condition
- Transfer direction (read or write)
- Bytes with missing acknowledge bit
- Specific data pattern in the message

14.4.2 I²C configuration

14.4.2.1 I²C configuration settings

Access: "Menu" > "Apps" > "Protocol" tab > "I2C" > "Setup".



Make sure that the tab of the correct serial bus is selected.

Protocol type
Selects the protocol type to be decoded.

Remote command:
`SBUS<sb>:TYPE` on page 1153

State
Enables the decoding of the selected bus. The signal icon of the bus appears on the signal bar.

Remote command:
`SBUS<sb>[:STATe]` on page 1152

SDA source
Sets the source channel to which the data line is connected.

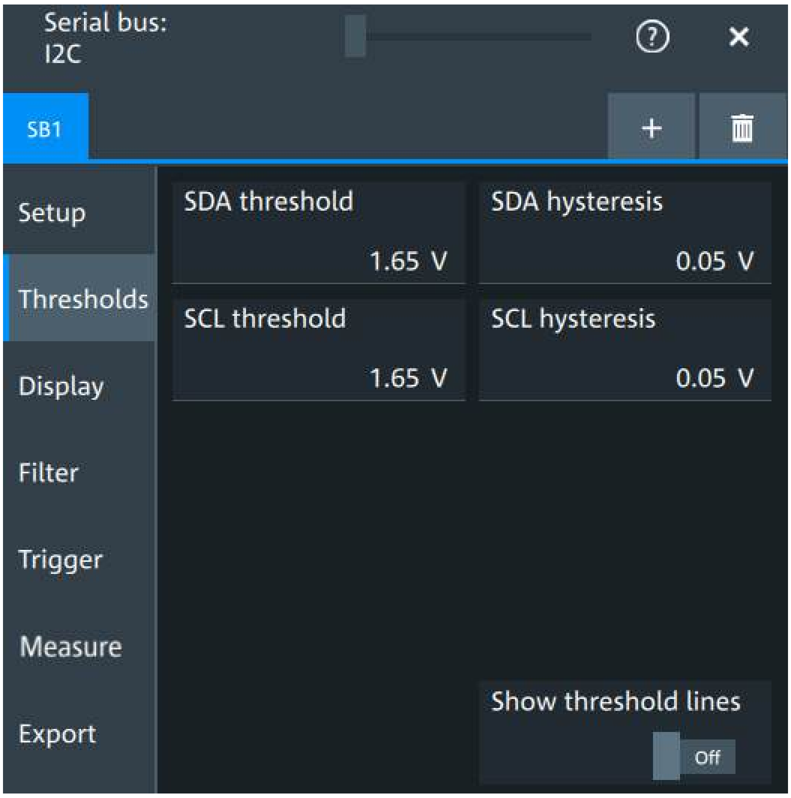
Remote command:
`SBUS<sb>:I2C:SDA:SOURce` on page 1215

SCL source
Selects the source channel to which the clock line is connected.

Remote command:
`SBUS<sb>:I2C:SCL:SOURce` on page 1214

14.4.2.2 Threshold settings

Access: "Menu" > "Apps" > "Protocol" tab > "I2C" > "Thresholds".



SDA/SCL threshold, SDA/SCL hysteresis
Set the threshold for the SDA and SCL channels. Enter the value directly in the fields.

Additional to the threshold, you can also set a hysteresis for each channel.

Remote command:
SBUS<sb>:I2C:SCL:THReshold on page 1214
SBUS<sb>:I2C:SDA:THReshold on page 1215
SBUS<sb>:I2C:SCL:HYSTeresis on page 1214
SBUS<sb>:I2C:SDA:HYSTeresis on page 1215

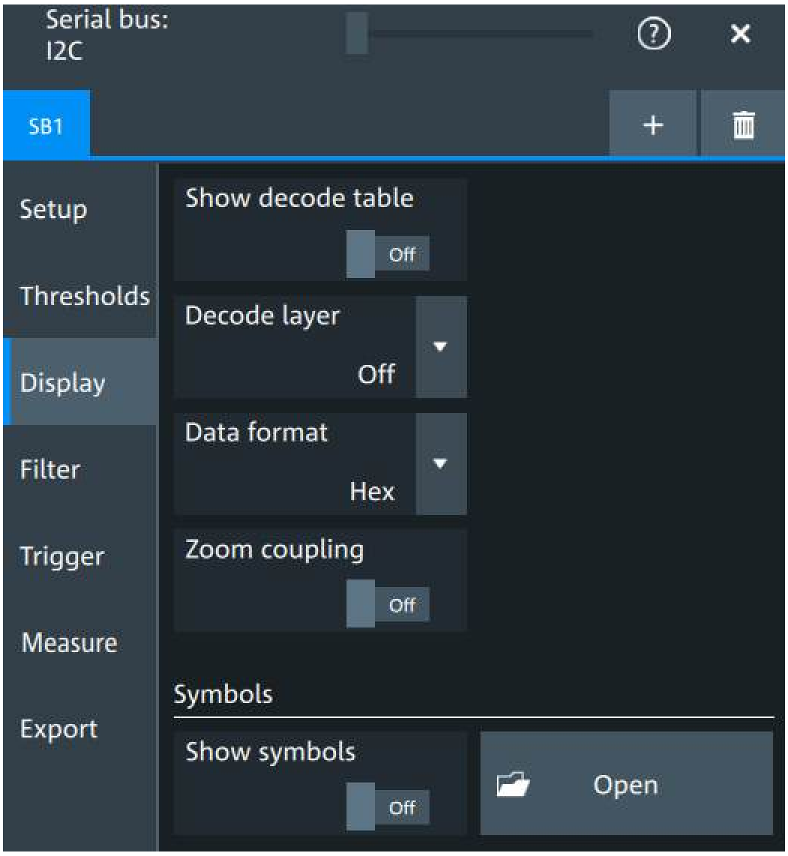
Show threshold lines
If enabled, the threshold lines are displayed in the diagram.

The label of the threshold line is set according to the signal that it is referring to, see also Show threshold lines.

Remote command:
SBUS<sb>:THReshold on page 1155

14.4.2.3 Display settings

For details about the display settings, see Section 14.1.3.1, "Display settings", on page 435.



Decode layer
Selects the decode layer.

Decoding is performed in several steps, and the results are presented in the decode table. The decode layer selects an interim step for which the decoding result is shown in the honeycomb display.

See "Decode layer" on page 436.

Data format
See "Data format" on page 436.

Zoom coupling
See "Zoom coupling" on page 437.

Show symbols
Symbol lists are protocol-specific. Label lists for I2C are available in CSV format.

For details, see I²C symbols.

Remote command:
`SBUS<sb>:I2C:SYMBols` on page 1216
`SBUS<sb>:I2C:NEWList` on page 1216

14.4.2.4 I²C symbols

For the I²C protocol, you can upload symbol lists containing IDs and a symbolic name for each node. You can load a file in one of the supported formats. Symbol lists for I²C are available in CSV format.

An I²C label file contains three values for each address:

- Address type, 7-bit or 10-bit long
- Address value
- Symbolic label: name of the address, specifying its function in the bus network.

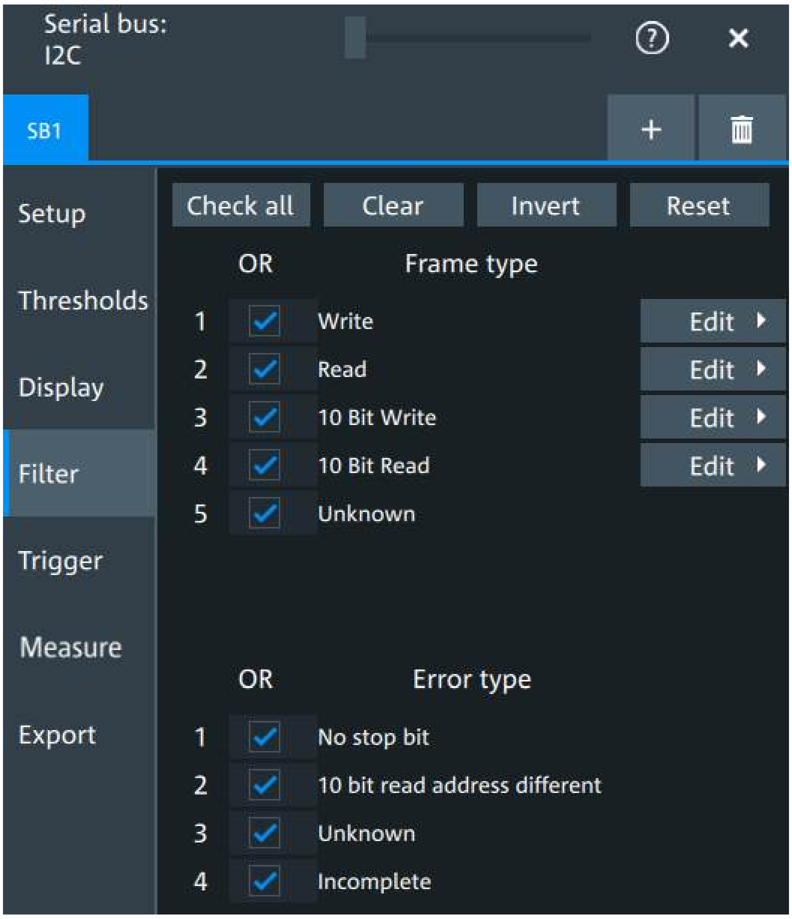
Example: I²C CSV file

```
# ---------------------------------------------------------------------------
@FILE_VERSION  = 1.00
@PROTOCOL_NAME = i2c
# --------------------------------------------------------------------------
# Labels for I2C protocol
#   Column order: Identifier type, Identifier value, Label
# --------------------------------------------------------------------------
7,0x1E,Voltage
7,38h,Pressure
7,2Ah,Temperature
7,16h,Speed
7,118,Acceleration
7,07h,HighSpeed_Master_0x3
7,51h,EEPROM
10,3A2h,DeviceSetup
10,1A3h,GatewayStatus
```

```
10,06Eh,LeftSensor
# ---------------------------------------------------------------------------
```

14.4.3 I²C filter

Access: "Menu" > "Apps" > "Protocol" tab > "I2C" > "Filter" tab



In the "Filter" tab, you can define the settings to display only the frames that match the selected filter conditions.

Check all, Clear, Invert, Preset
The following settings help you select the frames and errors you want to filter for. Only the frames and error types that match the selected filter conditions are displayed.

"Check all"	Enables the filter for all available frames and error types.
"Clear"	Disables the filter for all available frames and error types.
"Invert"	Inverts the current state of the frame and error types: all frames and error types that were enabled are disabled and vice versa.
"Preset"	Presets the state of the selected frames and error types.

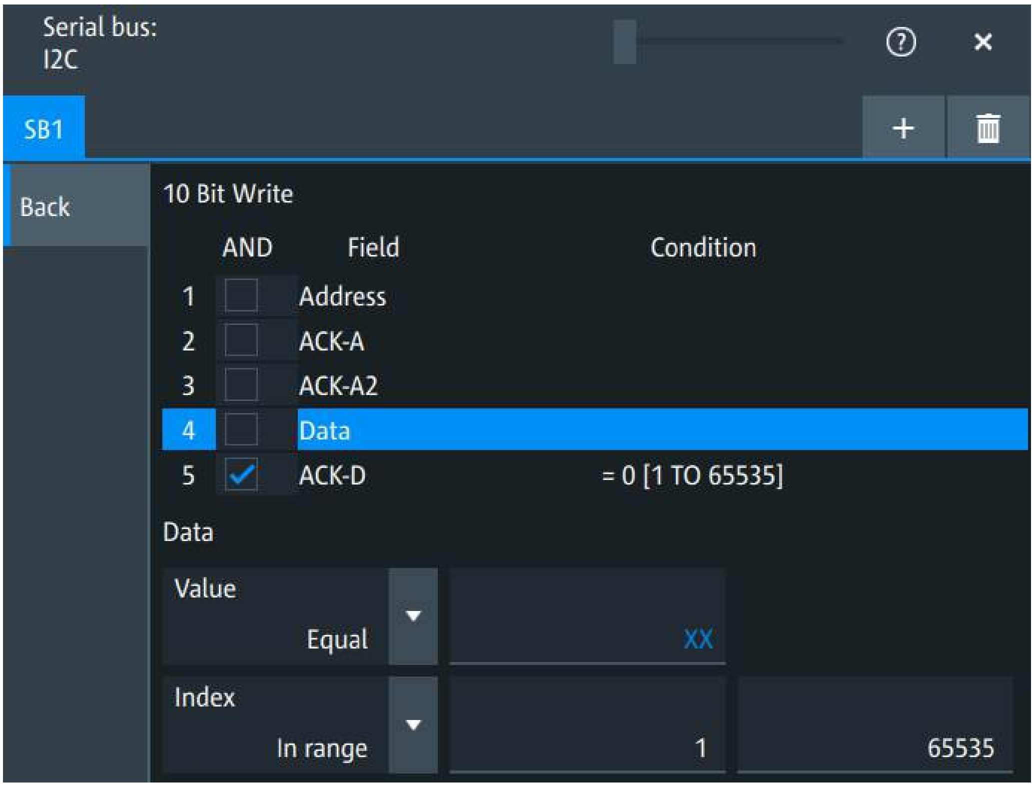
Remote command:
SBUS<sb>:I2C:FILTer:CHKall on page 1217
SBUS<sb>:I2C:FILTer:CLR on page 1218
SBUS<sb>:I2C:FILTer:INVert on page 1218
SBUS<sb>:I2C:FILTer:RST on page 1218

Frame type
Selects the frame type that you want to display. You can filter all enabled frame types simultaneously.

For selected frame types, you can also specify conditions for the value of the fields in the "Edit" dialog.

Remote command:
SBUS<sb>:I2C:FILTer:FRENable on page 1218
SBUS<sb>:I2C:FILTer:FRAMe<fr>:ENABle on page 1218

Edit
Opens a dialog to define the details of the selected frame.



"Field" Enables the field type that you want to filter on for the selected frame. The available fields are "Address", "R/W", "ACK_A", "ACK_A2", "Data", and "ACK_D".

Remote command:
SBUS<sb>:I2C:FILTer:FRAMe<fr>:FLD<fl>:ENABle on page 1222
SBUS<sb>:I2C:FILTer:FIENable on page 1222

"Condition" Displays the value condition for the selected field.

Remote command:
SBUS<sb>:I2C:FILTer:FRAMe<fr>:FLD<fl>:BIT on page 1221

"Value" The data setup consists of a comparison condition and one or two data patterns.

Remote command:
SBUS<sb>:I2C:FILTer:FRAMe<fr>:FLD<fl>:DMAX on page 1219
SBUS<sb>:I2C:FILTer:DMAX on page 1219
SBUS<sb>:I2C:FILTer:FRAMe<fr>:FLD<fl>:DMIN on page 1219
SBUS<sb>:I2C:FILTer:DMIN on page 1219
SBUS<sb>:I2C:FILTer:FRAMe<fr>:FLD<fl>:DOPerator on page 1219
SBUS<sb>:I2C:FILTer:DOPerator on page 1219

"Index" The index setup consists of a comparison condition and one or two index values.

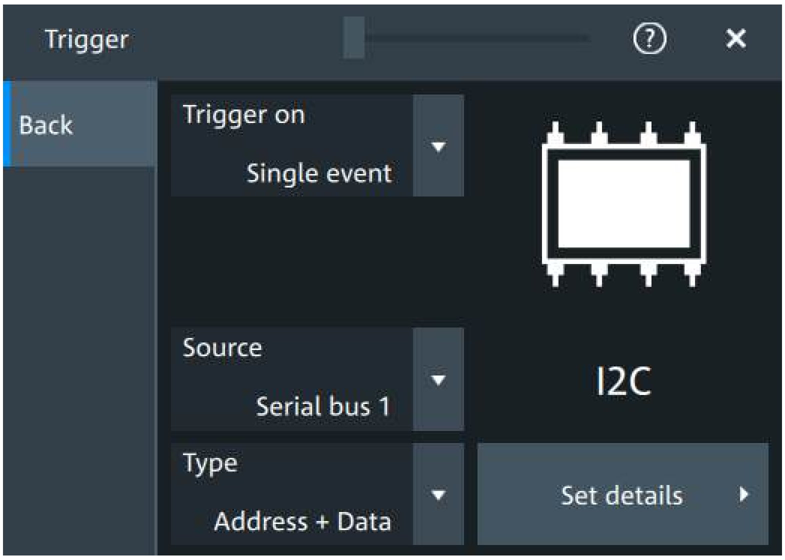
Remote command:
SBUS<sb>:I2C:FILTer:FRAMe<fr>:FLD<fl>:IMAX on page 1220
SBUS<sb>:I2C:FILTer:IMAX on page 1220
SBUS<sb>:I2C:FILTer:FRAMe<fr>:FLD<fl>:IMIN on page 1221
SBUS<sb>:I2C:FILTer:IMIN on page 1221
SBUS<sb>:I2C:FILTer:FRAMe<fr>:FLD<fl>:IOPerator on page 1221
SBUS<sb>:I2C:FILTer:IOPerator on page 1221

Error type
Enables filtering on the selected error type.

Remote command:
SBUS<sb>:I2C:FILTer:ERENable on page 1220
SBUS<sb>:I2C:FILTer:ERRor<n>:ENABle on page 1220

14.4.4 I²C hardware trigger

Access: "Menu" > "Apps" > "Protocol" tab > "I2C" > "Trigger" tab > "Setup Hardware Trigger"



Type
Selects the trigger type for I²C analysis.

Some trigger types have additional settings that can be defined. In this case, the "Set details" button appears next to "Type" the function. Open it for a detailed definition of the trigger conditions.

Remote command:
`TRIGger:SBHW:I2C:TYPE` on page 1222

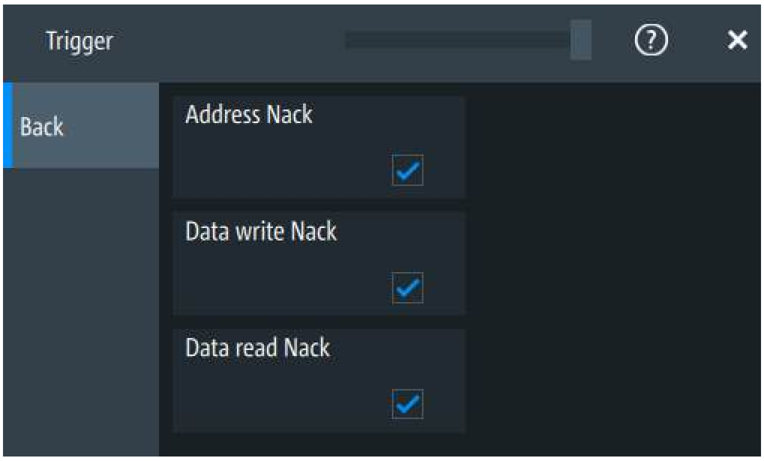
Start ← Type
Sets the trigger to the start of the message. The start condition is a falling edge on SDA while SCL is high. The trigger instant is the falling edge of the SDA line.

You can change the SDA and SCL lines here if necessary.

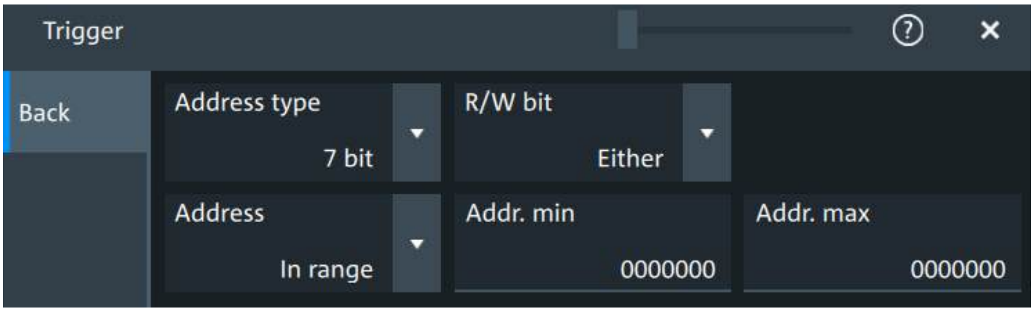
Repeated start ← Type
Sets the trigger to a repeated start - when the start condition occurs without previous stop condition. Repeated start conditions occur when a controller exchanges multiple messages with a target device without releasing the bus.

Stop ← Type
Sets the trigger to the end of the message. The stop condition is a rising slope on SDA while SCL is high.

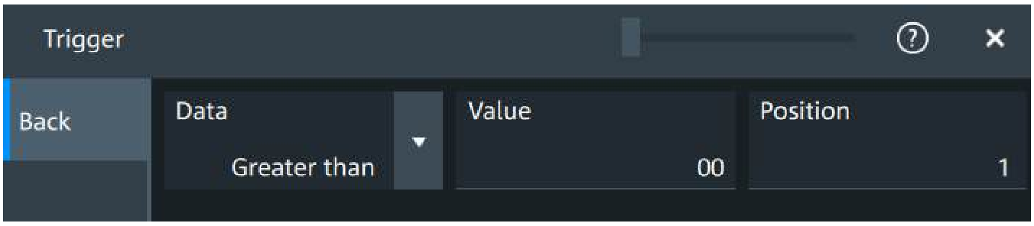
No Ack ← Type
Missing acknowledge bit: the instrument triggers if the data line remains HIGH during the clock pulse following a transmitted byte.



Address ← Type
Sets the trigger to one specific address condition or a combination of address conditions. The trigger time is the falling clock edge of the acknowledge bit after the address.



Data ← Type
Sets the trigger to one specific data condition or a combination of address conditions.



Address and data ← Type
Sets the trigger to a combination of address and data condition.

No Ack conditions

Selects which missing acknowledge bits is detected if the trigger type is set to "No Ack".

"Address Nack"
: No secondary recognizes the address.

"Data write Nack"
: The addressed secondary does not accept the data.

"Data read Nack"
: Marks the end of the read process when the primary reads data from the secondary. This Nack is sent according to the protocol definition, it is not an error.

Remote command:
`TRIGger:SBHW:I2C:ADNack` on page 1224
`TRIGger:SBHW:I2C:DWNack` on page 1226
`TRIGger:SBHW:I2C:DRNack` on page 1225

Address type

Sets the address length to be triggered on: 7 bit or 10 bit.

Remote command:
`TRIGger:SBHW:I2C:AMODe` on page 1224

R/W bit

Toggles the trigger condition between read and write access of the primary. Select "Either" if the transfer direction is not relevant for the trigger condition.

Remote command:
`TRIGger:SBHW:I2C:ACCess` on page 1223

Address

The trigger address setup consists of a comparison condition and one or two address patterns.

Defines the bit pattern of the secondary device address. The length of the entry is adjusted to the selected address type.

"Condition"
: Sets the comparison condition to a specific value or a range.

"From" Specifies the value or sets the start value of a range.

"To" Sets the maximum value of a range for "Condition" = "In range"/"Out of range".

Remote command:
TRIGger:SBHW:I2C:ADDRess on page 1224
TRIGger:SBHW:I2C:ADDTo on page 1224

Data
Specifies the trigger conditions for the data bit pattern.

"Condition" Sets the comparison condition to a specific value or a range.

"Value" Specifies the value or sets the start value of a range.
Enter the bytes in msb first bit order. The maximum pattern length is 64 bit. Waveform data is compared with the pattern byte-by-byte.

Remote command:
TRIGger:SBHW:I2C:DCONdition on page 1225
TRIGger:SBHW:I2C:DMIN on page 1225

Position
Sets the number of data bytes to be skipped after the address.

Remote command:
TRIGger:SBHW:I2C:DPOSition on page 1225

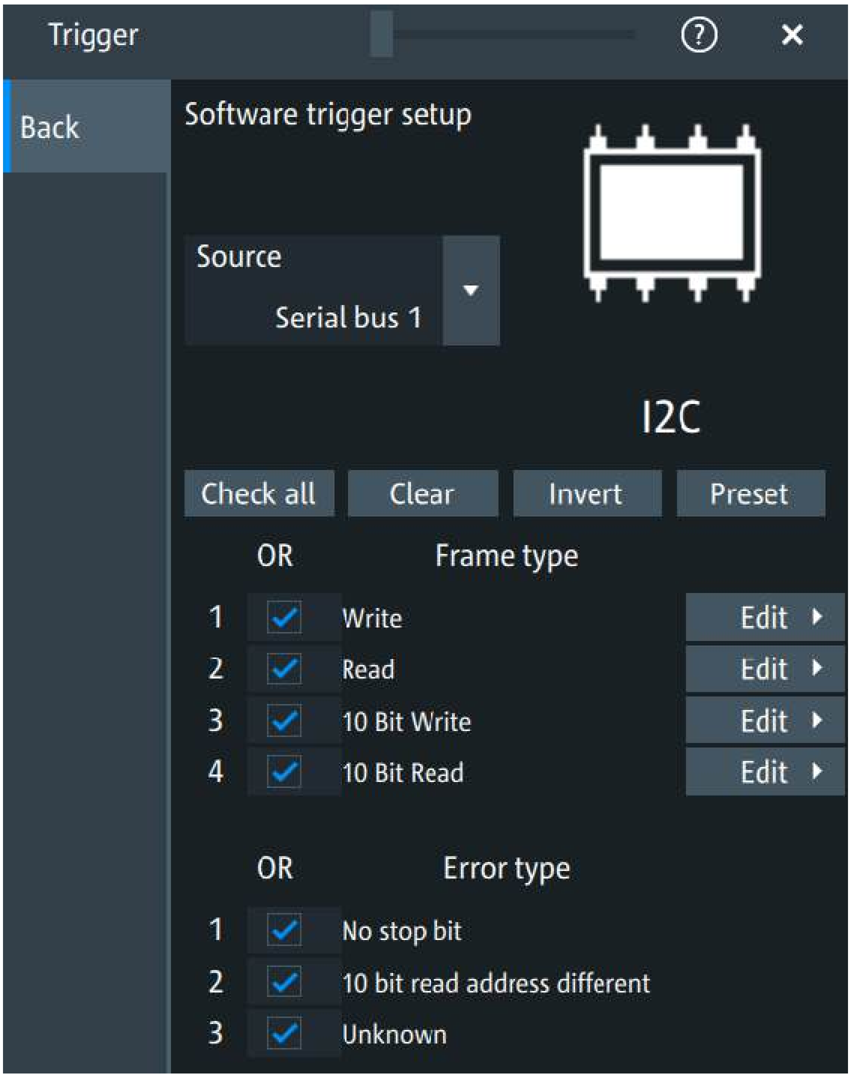
14.4.5 I²C software trigger

14.4.5.1 Setup A trigger

Before setting up the software trigger for the protocols, a trigger A event needs to be set up.

14.4.5.2 Software trigger settings

Access: "Menu" > "Apps" > "Protocol" tab > "I2C" > "Trigger" tab > "Setup Software Trigger" > "Setup SB Trigger"



In the "Software Trigger" tab, you can define the settings to trigger on the frames that match the selected filter conditions.

Check all, Clear, Invert, Preset

The following settings help you select the frames and errors you want to trigger on.

"Check all"	Enables the software trigger for all available frames and error types.
"Clear"	Disables the software trigger for all available frames and error types.
"Invert"	Inverts the current state of the frame and error types for the software trigger: all frames and error types that were enabled are disabled and vice versa.
"Preset"	Presets the state of the selected frames and error types for the software trigger.

Remote command:

`TRIGger:SBSW:I2C:CHKall` on page 1227

`TRIGger:SBSW:I2C:CLR` on page 1227

TRIGger:SBSW:I2C:INVert on page 1227
TRIGger:SBSW:I2C:RST on page 1227

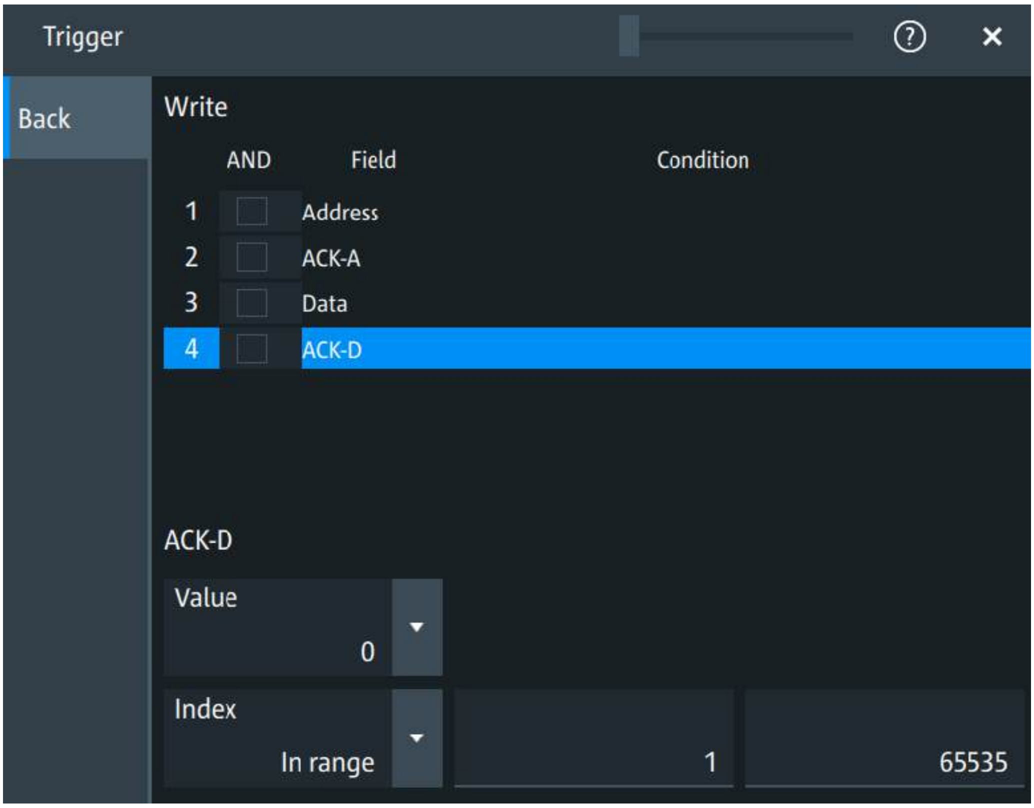
Frame type
Selects the frame type that you want to trigger on. You can trigger on all enabled frame types simultaneously.

For each frame type, you can also specify conditions for the value of the fields in the "Edit" dialog.

The following frames are available: "Write", "Read", "10 Bit Write", "10 Bit Read".

Remote command:
TRIGger:SBSW:I2C:FRENable on page 1227
TRIGger:SBSW:I2C:FRAMe<fr>:ENABle on page 1227

Edit
Some trigger types have additional settings that can be defined. In this case, the "Set details" button appears next to "Type" the function. Open it for a detailed definition of the trigger conditions.



"Field" Enables the field type that you want to trigger on for the selected frame.
The available fields are "Address", "ACK-A", "ACK-A2", "Data", "ACK-D".

Remote command:
TRIGger:SBSW:I2C:FIENable on page 1229
TRIGger:SBSW:I2C:FRAMe<fr>:FLD<fl>:ENABle on page 1229

"Condition" Displays the value condition for the selected field.

Remote command:
TRIGger:SBSW:I2C:BIT on page 1228
TRIGger:SBSW:I2C:FRAMe<fr>:FLD<fl>:BIT on page 1228

"Value" The data setup consists of a comparison condition and one or two data patterns.

Remote command:
TRIGger:SBSW:I2C:DMAX on page 1228
TRIGger:SBSW:I2C:FRAMe<fr>:FLD<fl>:DMAX on page 1228
TRIGger:SBSW:I2C:DMIN on page 1228
TRIGger:SBSW:I2C:FRAMe<fr>:FLD<fl>:DMIN on page 1228
TRIGger:SBSW:I2C:DOPerator on page 1229
TRIGger:SBSW:I2C:FRAMe<fr>:FLD<fl>:DOPerator on page 1229

"Index" The index setup consists of a comparison condition and one or two index values.

Remote command:
TRIGger:SBSW:I2C:IMAX on page 1230
TRIGger:SBSW:I2C:FRAMe<fr>:FLD<fl>:IMAX on page 1230
TRIGger:SBSW:I2C:IMIN on page 1230
TRIGger:SBSW:I2C:FRAMe<fr>:FLD<fl>:IMIN on page 1230
TRIGger:SBSW:I2C:IOPerator on page 1230
TRIGger:SBSW:I2C:FRAMe<fr>:FLD<fl>:IOPerator on page 1230

Error type
Enables triggering on the selected error type.

Remote command:
TRIGger:SBSW:I2C:ERENable on page 1231
TRIGger:SBSW:I2C:ERRor<m>:ENABle on page 1231

14.4.6 Measure

The "Setup Measurement" button opens the dialog for automatic measurements in the "Protocol" category for the selected serial bus.

See Section 10.2.6.2, "Settings for protocol measurements", on page 289.

14.4.7 I²C decode results

When the configuration of the serial bus is complete, the signal can be decoded:

1. Open the "Serial Bus" dialog for the respective bus.
2. In the "Setup" tab, enable "State".

3. In the "Display" tab, enable "Show decode table".

For a description of the display settings, see also Section 14.1.3.1, "Display settings", on page 435.

For a description of how to synchronize the displayed results, see Section 14.1.3.2, "Display synchronization", on page 437.

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

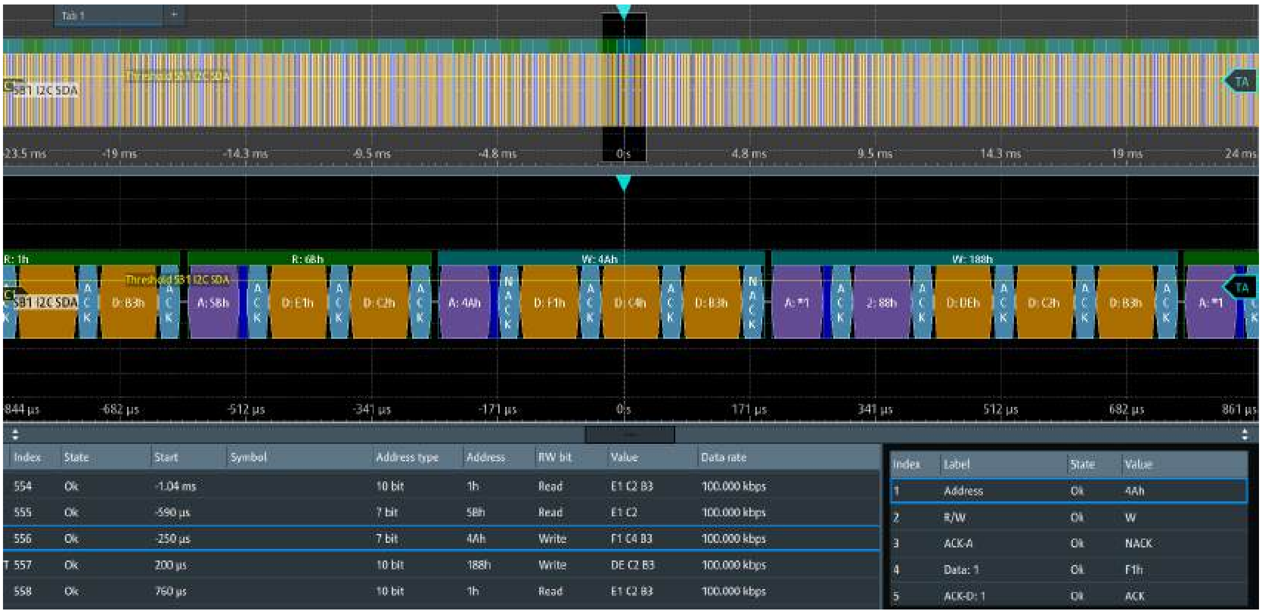


Figure 14-14: Decoded I2C signal

The decode results table contains information about all decoded frames.

Table 14-5: Content of the decode results table

Column	Description
Index	Index of the decoded frame
State	Overall state of the frame. "Insuffcient waveform length" indicates that the frame is not completely contained in the acquisition. Change the horizontal scale, or move the reference point to the left to get a longer acquisition.
Start	Time of frame start
Symbol	Symbolic label of the frame. Available only, if "Show symbols" is enabled in the "Display" tab and a symbols list is loaded.
Address type	Address length, 7 bit or 10 bit
Address	Hexadecimal value of the address

Column	Description
RW bit	Value of the read/write bit
Value	The actual data payload values. Select the data format in the "Display" tab.
Data rate	Value of the data rate

When you select a frame in the decode results table, its field content is shown in the details table to the right.

Table 14-6: Content of the frame details table

Item	Description
Index	Number of the decoded field
Label	Label (name) of each word of the data field
State	State of each word of the data field, for example "OK" or "Incomplete"
Value	Value of each word of the data field

Data format

You can select various data formats for the values displayed in the decode table and in the combs of the decoded signal.

Remote command:

- `SBUS<sb>:FORMat` on page 1154

Remote commands

Remote commands to retrieve decode results are described in Section 18.17.4.5, "Decode results", on page 1232.

14.4.8 Performing I²C decoding

This section explains step by step how to configure and decode the I²C bus.

For more information on decoding I²C, you can also refer to the video, available on the Rohde & Schwarz YouTube channel: Decoding I2C with MXO Series Oscilloscopes.

14.4.8.1 Configuring I²C signals

For configuration, assign the lines to the input channels, and define the active states and the logical thresholds.

For details on configuration settings, see Section 14.4.2, "I²C configuration", on page 487.

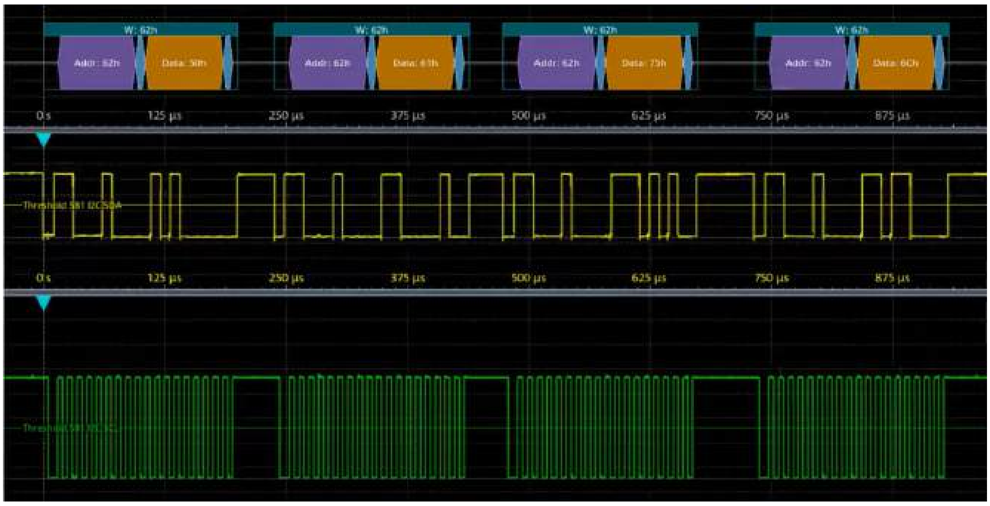
1. Tap the "+ Bus" activator in the bottom right of the screen.

2. Select the tab of the bus that you want to set up, for example "SB1".
3. Tap the "Protocol type" button. Select the protocol: "I2C".
4. Tap on "State" to enable the decoding.

   An I²C shortcut appears at the bottom left of the screen. Tap on the shortcut for a quick access to the "I2C" dialog settings.

5. Tap on each active wire and select the correct channels: "SDA source" and "SCL source".
6. Check that the signals are on the screen.
   If not try adjusting the vertical and horizontal settings.

7. Set the logical thresholds:
   a) Tap the "Thresholds" tab.
   b) For each wire, set the threshold value. A typical value is 1.65 V.
   c) If necessary, set the hysteresis value for the wires.
   d) Optionally, tap on "Show threshold lines".



14.4.8.2 Hardware triggering on I²C

Prerequisites: A bus is configured for the I²C signal to be analyzed. See Section 14.4.8.1, "Configuring I²C signals", on page 502.

1. Open "Menu" > "Trigger".
2. Set "Trigger on" to "Single event".
3. Ensure that the "Source" is set to the configured serial bus, e.g. "Serial bus 1".
4. Select the "Type".
5. Define additional settings for more complex trigger types: "No Ack", "Address", "Data", "Address + Data".
   a) Tap on "Set details".
   b) Set the "Data" condition and "Value".
   c) Set the "Position".

   In the following example a decode for triggering on triggered on "Data" = 0x75, "Position" = 1.

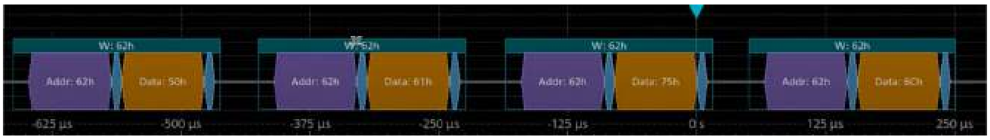


Figure 14-15: Trigger on Type=Data, Data=0x75 and Position=1

14.4.8.3 Exporting decode results

Once a decode has been completed, you can generate an export of all decode results.

Prerequisites: A bus is configured for the I²C and decoded.

1. Tap on the "I2C" shortcut.
2. Tap on the "Export" tab.
3. If necessary, enable "Include details".
4. If necessary, enable "Include timing".
5. Select the "File type".

   An export file is saved in the selected directory.

The I²C export files contain the following fields:

- A list of all decoded frames:
  - Index
  - Start
  - Stop
  - State
  - Address type
  - Address value
  - R/W bit
  - Bit rate
- The details frames include the following fields:
  - Index
  - Formatted data
  - ACK bit start
  - ACK bit

Example of an I²C export file

```
Index,Start,Stop,State,Address type,Address value,R/W bit,Bit rate
1,-0.25,-0.24945,'OK','BIT10',188h,'WRIT',100000
2,-0.24944,-0.249,'OK','BIT10',1h,'READ',100000
3,-0.24899,-0.24866,'OK','BIT7',5Bh,'READ',100000
4,-0.24865,-0.24821,'OK','BIT7',4Ah,'WRIT',100000
5,-0.2482,-0.24765,'OK','BIT10',188h,'WRIT',100000
6,-0.24764,-0.2472,'OK','BIT10',1h,'READ',100000

Details frame 1
Index,Formatted data,Ack bit start,Ack bit
1,DEh,-0.2497,'ACK'
2,C2h,-0.24959,'ACK'
3,B3h,-0.24948,'ACK'

Details frame 2
Index,Formatted data,Ack bit start,Ack bit
1,E1h,-0.24925,'ACK'
```

```
2,C2h,-0.24914,'ACK'
3,B3h,-0.24903,'ACK'

Details frame 3
Index,Formatted data,Ack bit start,Ack bit
1,E1h,-0.2488,'ACK'
2,C2h,-0.24869,'ACK'

Details frame 4
Index,Formatted data,Ack bit start,Ack bit
1,F1h,-0.24846,'ACK'
2,C4h,-0.24835,'ACK'
3,B3h,-0.24824,'NACK'

Details frame 5
Index,Formatted data,Ack bit start,Ack bit
1,DEh,-0.2479,'ACK'
2,C2h,-0.24779,'ACK'
3,B3h,-0.24768,'ACK'
```

14.5 I3C (IC electronics, option R&S MXO4-K550)

The Improved Inter-Integrated Circuit (I3C) is a low-speed MIPI protocol used for communication between chips and signaling patterns by a 2-wire serial data bus.

Requirements

For performing I3C decode measurements, you need the following:

- MXO 4 with 2 available channels. The channels can be a combination of the following:
  - Analog channels (C1-C4)
  - Logic channels (D0-D15) (requires option R&S MXO4-B1)
- Option R&S MXO4-K550

14.5.1 About the I3C protocol

This section provides an overview of protocol characteristics, data format, address types and trigger possibilities. For detailed information, read the "MIPI I3C and I3C Basic" specifications, available at www.mipi.org/groups/I3C.

I3C characteristics

The Improved Inter-Integrated Circuit (I3C) protocol is a high-speed, low-power, and low-latency interface standard. Typical applications are mobile devices, IoT devices and automotive systems, for example. It incorporates the capabilities of I²C and SPI, while offering several advantages over these protocols.

The main characteristics of I3C are:

- Significantly lower energy consumption and higher data rate than I²C, but backward compatible with it.
- 2-wire operation with a serial clock line (SCL) and a serial data line (SDA) simplifies data exchange at low pin count and reduced signal paths.
- Supports multiple devices on the same bus, enabling a multi-drop topology.
- Optional messaging modes (HDR-DDR or HDR ternary) with high data rate up to 33.33 Mbit/s.
- In-band interrupt support without requiring a separate interrupt line.
- Hot-join support for dynamic device attachment and detachment.
- Synchronous timing support and asynchronous time stamping.
- Broadcast transactions allow sending commands or data to all devices on the bus simultaneously.

The MXO 4 supports all operating speed modes: legacy I²C modes (see I²C characteristics), SDR standard mode, DDR mode and ternary mode.

Data transfer

An I3C transaction consists of the following phases:

- **Start condition**: The controlling device sends a start condition to initiate the transaction.
- **Device addressing**: The controlling device sends the address of the responding device to select the target device.
- **Command**: The controlling device sends a command to the responding device, specifying the operation to be performed (e.g., read or write).
- **Data transfer**: The responding device responds with the requested data or sends data to the controlling device.
- **Stop condition**: The controlling device sends a stop condition to terminate the transaction.

The address format is the same as in I²C: 7 bits of address, 1 bit of RnW, and 1 bit of ACK/NACK. See Section 14.4.1, "About the I²C protocol", on page 485.

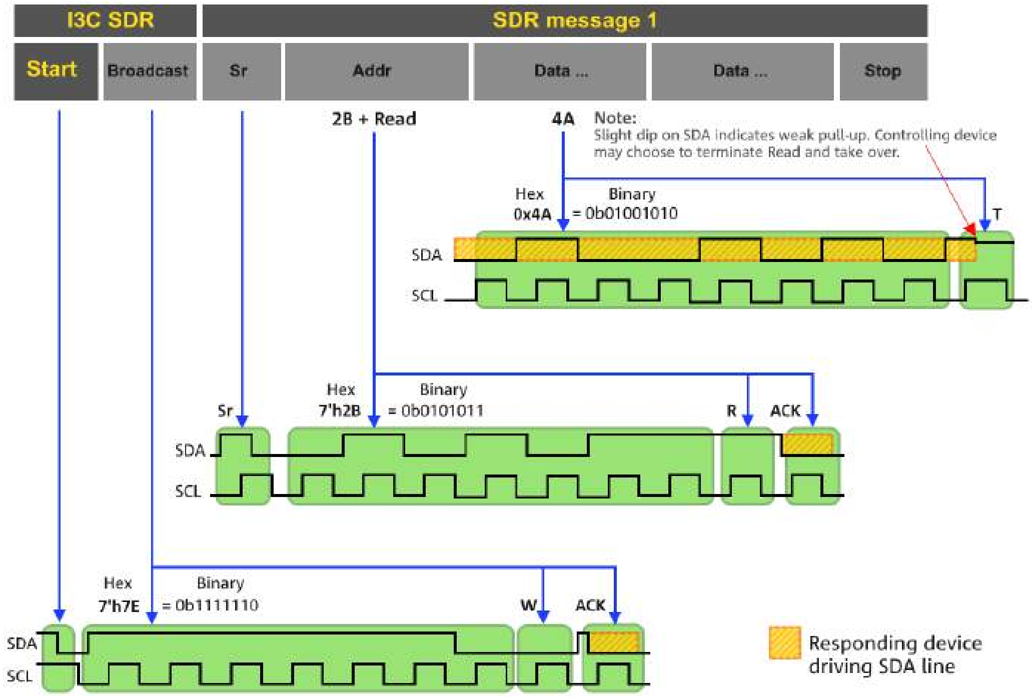


Figure 14-16: Example of using I3C coding SDR

Trigger

The MXO 4 can trigger on various parts of I3C messages. You must connect the data and clock lines to the input channels. Triggering on math and reference waveforms is not possible.

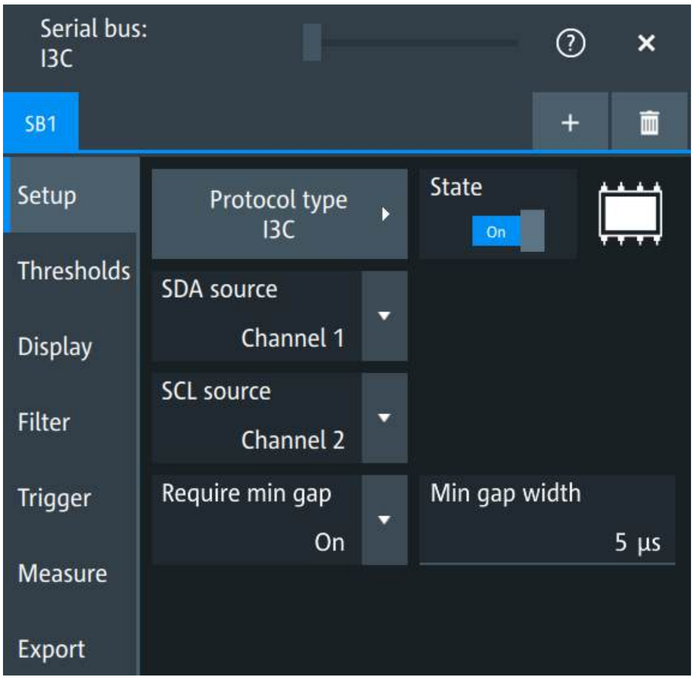
You can trigger on:

- Start or stop condition
- Repeated start condition
- Transfer direction (read or write)
- Bytes with missing acknowledge bit
- Specific target address or address range
- Specific data pattern in the message

14.5.2 I3C configuration

14.5.2.1 I3C configuration settings

Access: "Menu" > "Apps" > "Protocol" tab > "I3C" > "Setup".



Make sure that the tab of the correct serial bus is selected.

Protocol type

Selects the protocol type to be decoded.

Remote command:
SBUS<sb>:TYPE on page 1153

State

Enables the decoding of the selected bus. The signal icon of the bus appears on the signal bar.

Remote command:
SBUS<sb>[:STATe] on page 1152

SDA source

Sets the source channel to which the data line is connected.

Remote command:
SBUS<sb>:I3C:SDA:SOURce on page 1241

SCL source

Selects the source channel to which the clock line is connected.

Remote command:
SBUS<sb>:I3C:SCL:SOURce on page 1241

Require min gap
If enabled, the application requires a minimum gap on the left-hand side of the screen before the 1st decoded frame. Enabling this feature can prevent errors due to truncation of an HDR-type frame.

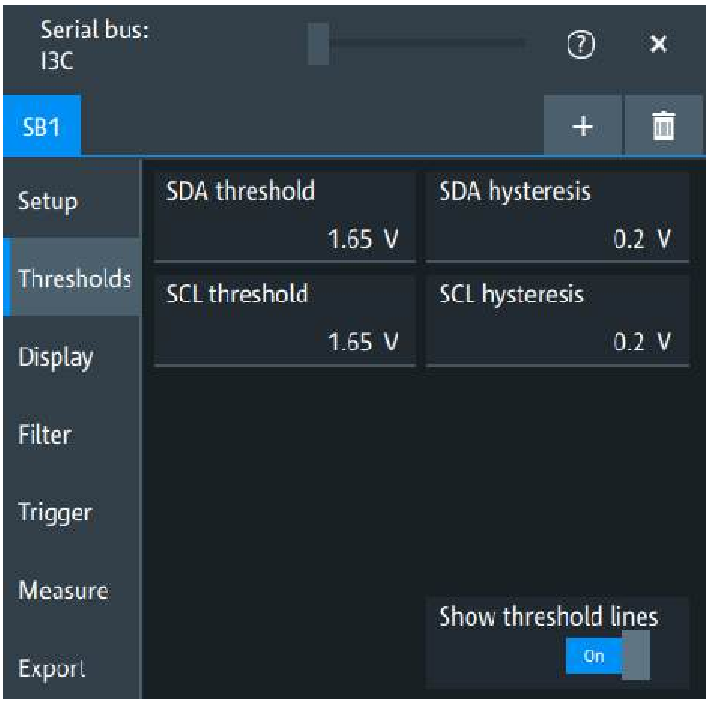
Remote command:
`SBUS<sb>:I3C:MINGap:SELect` on page 1242

Min gap width
Specifies the minimum gap width in units of time of the Require min gap, if enabled.

Remote command:
`SBUS<sb>:I3C:MINGap:WIDTh` on page 1242

14.5.2.2 Threshold settings

Access: "Menu" > "Apps" > "Protocol" tab > "I2C" > "Thresholds".



SDA/SCL threshold, SDA/SCL hysteresis
Set the threshold for the SDA and SCL channels. Enter the value directly in the fields.

Additional to the threshold, you can also set a hysteresis for each channel.

Remote command:
`SBUS<sb>:I3C:SCL:THReshold` on page 1241
`SBUS<sb>:I3C:SDA:THReshold` on page 1242
`SBUS<sb>:I3C:SCL:HYSTeresis` on page 1240
`SBUS<sb>:I3C:SDA:HYSTeresis` on page 1241

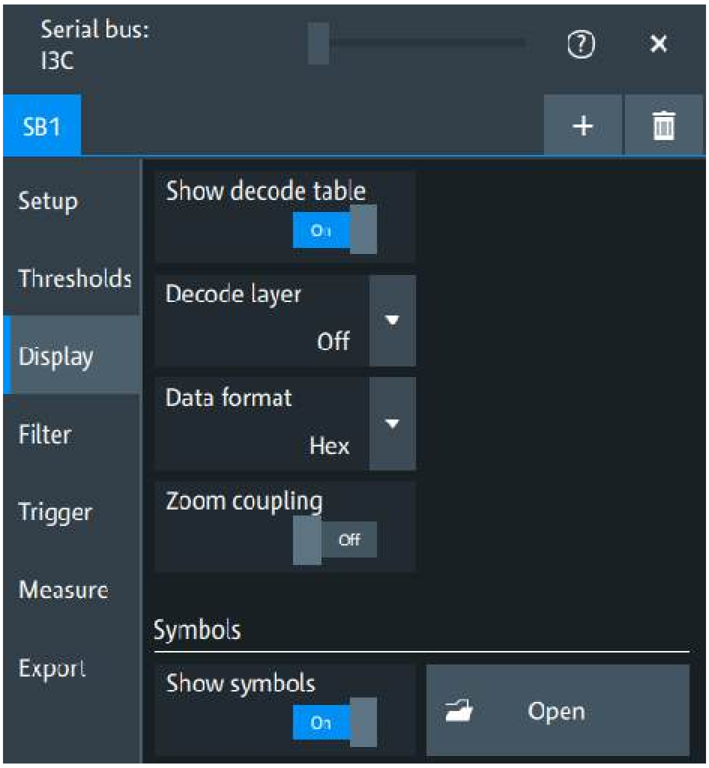
Show threshold lines
If enabled, the threshold lines are displayed in the diagram.

The label of the threshold line is set according to the signal that it is referring to, see also Show threshold lines.

Remote command:
`SBUS<sb>:THReshold` on page 1155

14.5.2.3 Display settings

For details about the display settings, see Section 14.1.3.1, "Display settings", on page 435.



Decode layer
Selects the decode layer.

Decoding is performed in several steps, and the results are presented in the decode table. The decode layer selects an interim step for which the decoding result is shown in the honeycomb display.

See "Decode layer" on page 436.

Data format
See "Data format" on page 436.

Zoom coupling
See "Zoom coupling" on page 437.

Show symbols
Symbol lists are protocol-specific. Label lists for I3C are available in CSV format.

For details, see I3C symbols.

Remote command:
`SBUS<sb>:I3C:SYMBols` on page 1243
`SBUS<sb>:I3C:NEWList` on page 1243

14.5.2.4 I3C symbols

For the I3C protocol, you can upload symbol lists containing IDs and a symbolic name for each node. You can load a file in one of the supported formats. Symbol lists for I3C are available in CSV format.

For each address, an I3C label file contains three values (or optionally two values, see "Address type" on page 512):

- Address type, 7-bit or 10-bit long
- Address value
- Symbolic label: name of the address, specifying its function in the bus network.

Example: I3C CSV file

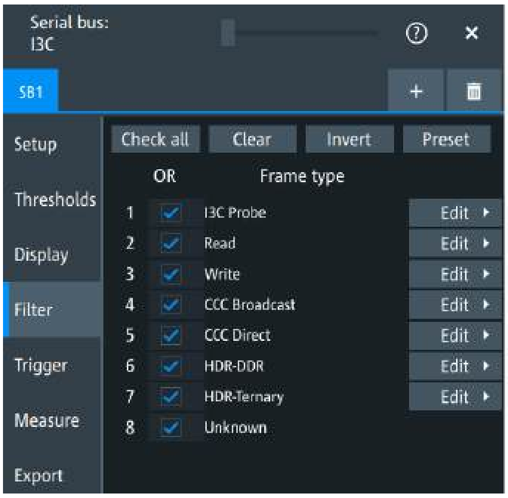
```
# ----------------------------------------------------------------------------
@FILE_VERSION  = 1.00
@PROTOCOL_NAME = i3c
# ---------------------------------------------------------------------------
# Labels for I3C protocol
#   Column order: Identifier type, Identifier value, Label
# ---------------------------------------------------------------------------
7,0x1E,Voltage
7,38h,Pressure
7,2Ah,Temperature
7,16h,Speed
7,118,Acceleration
7,07h,HighSpeed_Master_0x3
7,51h,EEPROM
10,3A2h,DeviceSetup
10,1A3h,GatewayStatus
10,06Eh,LeftSensor
# ----------------------------------------------------------------------------
```

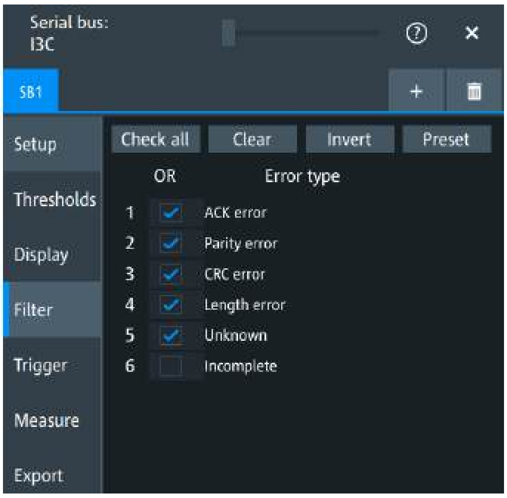
Address type

You can omit the address type, because I3C addresses are always 7-bit. Hence, the firmware also supports lines with only two entries: address value and symbolic label. For example, instead of "`7,0x1E,Voltage`", also "`0x1E,Voltage`" is valid.

14.5.3 I3C filter

Access: "Menu" > "Apps" > "Protocol" tab > "I2C" > "Filter" tab





In the "Filter" tab, you can define the settings to display only the frames that match the selected filter conditions.

Check all, Clear, Invert, Preset

The following settings help you select the frames and errors you want to filter for. Only the frames and error types that match the selected filter conditions are displayed.

"Check all"	Enables the filter for all available frames and error types.
"Clear"	Disables the filter for all available frames and error types.
"Invert"	Inverts the current state of the frame and error types: all frames and error types that were enabled are disabled and vice versa.
"Preset"	Presets the state of the selected frames and error types.

Remote command:

`SBUS<sb>:I3C:FILTer:CHKall` on page 1244

`SBUS<sb>:I3C:FILTer:CLR` on page 1245

`SBUS<sb>:I3C:FILTer:INVert` on page 1245

`SBUS<sb>:I3C:FILTer:RST` on page 1245

Frame type

Selects the frame type that you want to display. You can filter all enabled frame types simultaneously.

For selected frame types, you can also specify conditions for the value of the fields in the "Edit" dialog.

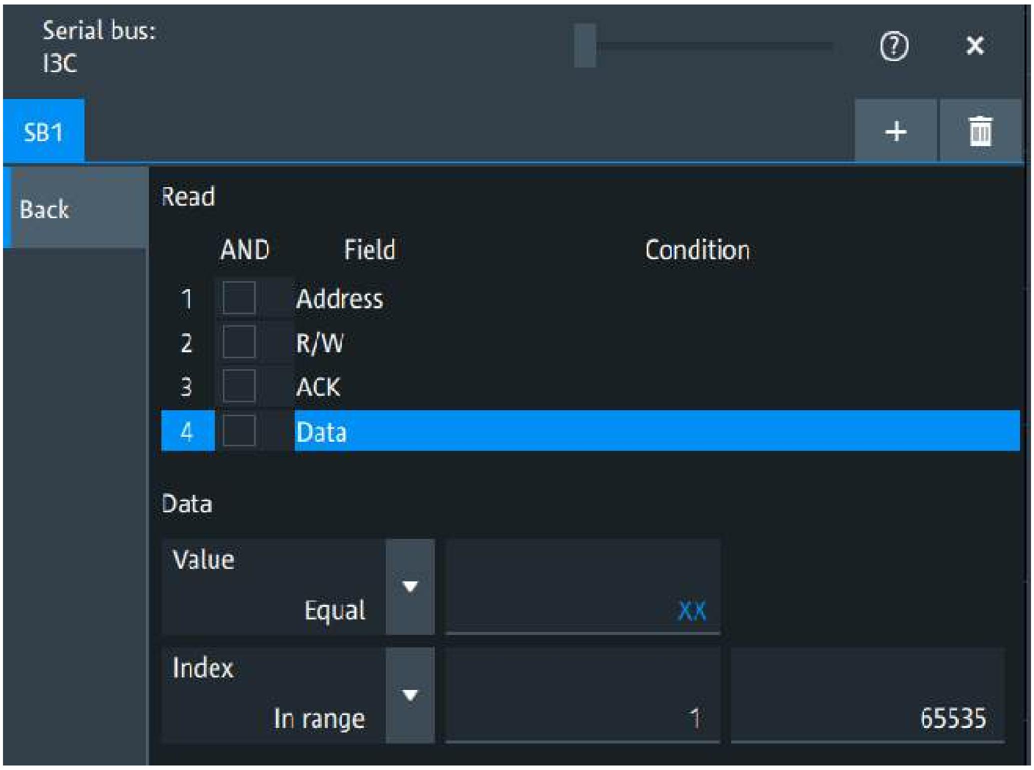
Remote command:

`SBUS<sb>:I3C:FILTer:FRENable` on page 1245

`SBUS<sb>:I3C:FILTer:FRAMe<fr>:ENABle` on page 1245

Edit

Opens a dialog to define the details of the selected frame.



"Field"

Enables the field type that you want to filter on for the selected frame. The available fields are "ACK", "Address", "CCC", "Command", "CRC", "Data", "Def Byte", "P", "R/W" and "Reserved".

Remote command:
`SBUS<sb>:I3C:FILTer:FRAMe<fr>:FLD<fl>:ENABle` on page 1249
`SBUS<sb>:I3C:FILTer:FIENable` on page 1249

"Condition"

Displays the value condition for the selected field.

Remote command:
`SBUS<sb>:I3C:FILTer:FRAMe<fr>:FLD<fl>:BIT` on page 1248

"Value"

The data setup consists of a comparison condition and one or two data patterns.

Remote command:
`SBUS<sb>:I3C:FILTer:FRAMe<fr>:FLD<fl>:DMAX` on page 1246
`SBUS<sb>:I3C:FILTer:DMAX` on page 1246
`SBUS<sb>:I3C:FILTer:FRAMe<fr>:FLD<fl>:DMIN` on page 1246
`SBUS<sb>:I3C:FILTer:DMIN` on page 1246
`SBUS<sb>:I3C:FILTer:FRAMe<fr>:FLD<fl>:DOPerator` on page 1246
`SBUS<sb>:I3C:FILTer:DOPerator` on page 1246

"Index" The index setup consists of a comparison condition and one or two index values.

Remote command:
SBUS<sb>:I3C:FILTer:FRAMe<fr>:FLD<fl>:IMAX on page 1247
SBUS<sb>:I3C:FILTer:IMAX on page 1247
SBUS<sb>:I3C:FILTer:FRAMe<fr>:FLD<fl>:IMIN on page 1248
SBUS<sb>:I3C:FILTer:IMIN on page 1248
SBUS<sb>:I3C:FILTer:FRAMe<fr>:FLD<fl>:IOPerator on page 1248
SBUS<sb>:I3C:FILTer:IOPerator on page 1248

Error type
Enables filtering on the selected error type.

Remote command:
SBUS<sb>:I3C:FILTer:ERENable on page 1247
SBUS<sb>:I3C:FILTer:ERRor<n>:ENABle on page 1247

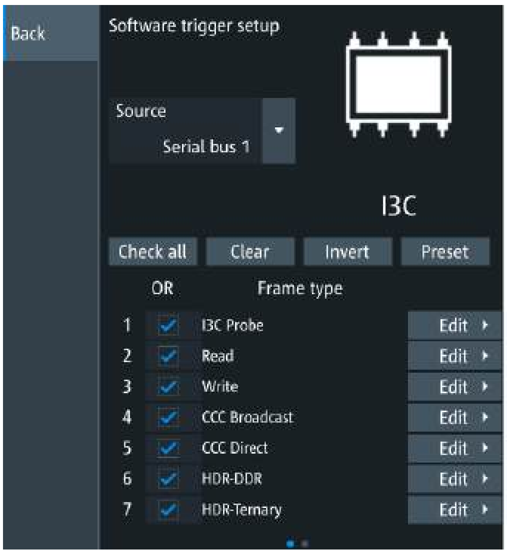
14.5.4 I3C software trigger

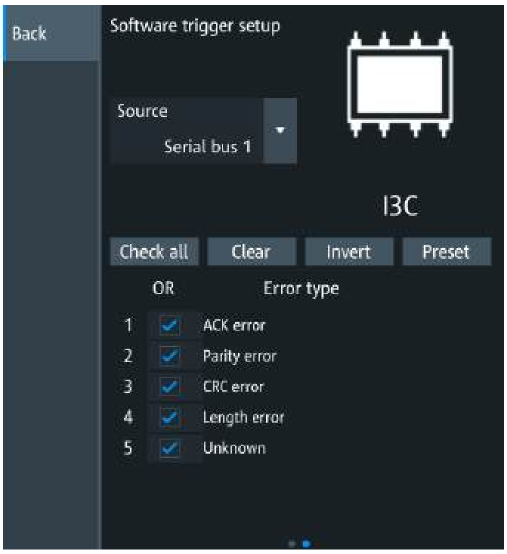
14.5.4.1 Setup A trigger

Before setting up the software trigger for the protocols, a trigger A event needs to be set up.

14.5.4.2 Software trigger settings

Access: "Menu" > "Apps" > "Protocol" tab > "I3C" > "Trigger" tab > "Setup SB Trigger"





In the "Software Trigger" tab, you can define the settings to trigger on the frames that match the selected filter conditions.

Check all, Clear, Invert, Preset

The following settings help you select the frames and errors you want to trigger on.

"Check all"	Enables the software trigger for all available frames and error types.
"Clear"	Disables the software trigger for all available frames and error types.
"Invert"	Inverts the current state of the frame and error types for the software trigger: all frames and error types that were enabled are disabled and vice versa.
"Preset"	Presets the state of the selected frames and error types for the software trigger.

Remote command:
`TRIGger:SBSW:I3C:CHKall` on page 1250
`TRIGger:SBSW:I3C:CLR` on page 1250
`TRIGger:SBSW:I3C:INVert` on page 1250
`TRIGger:SBSW:I3C:RST` on page 1250

Frame type

Selects the frame type that you want to trigger on. You can trigger on all enabled frame types simultaneously.

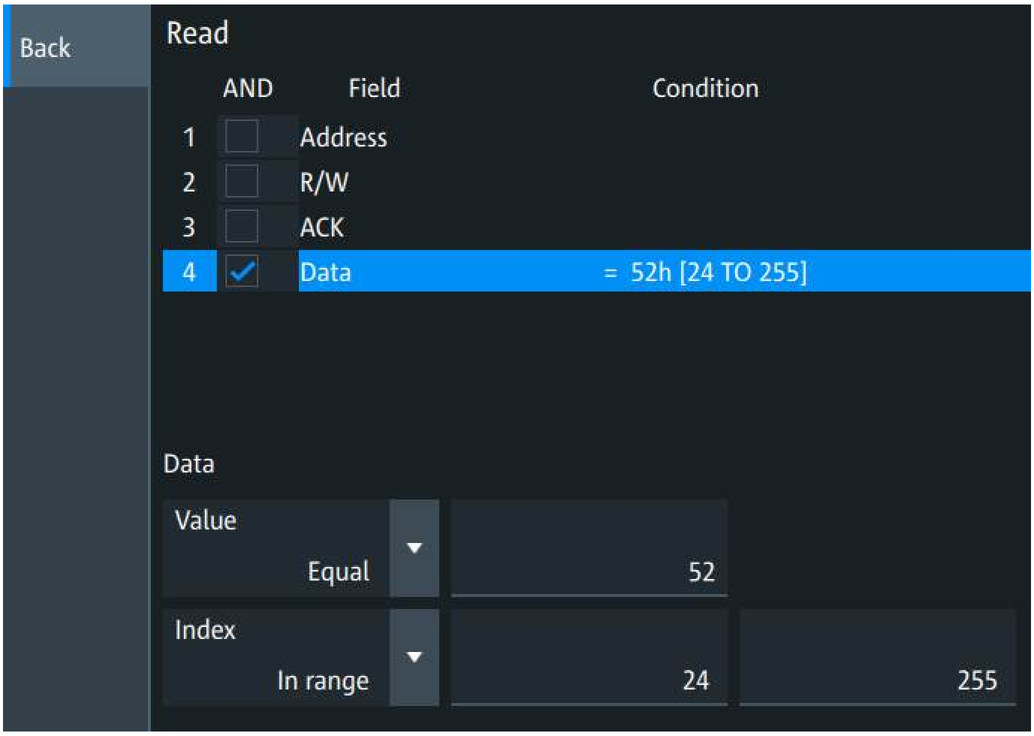
For each frame type, you can also specify conditions for the value of the fields in the "Edit" dialog.

The following frames are available: "CCC Broadcast", "CCC Direct", "HDR-DDR", "HDR-Ternary", "I3C Probe", "Read" and "Write".

Remote command:
`TRIGger:SBSW:I3C:FRENable` on page 1251
`TRIGger:SBSW:I3C:FRAMe<fr>:ENABle` on page 1251

Edit

Some trigger types have additional settings that can be defined. In this case, the "Set details" button appears next to "Type" the function. Open it for a detailed definition of the trigger conditions.



"Field"

Enables the field type that you want to trigger on for the selected frame.
The available fields are "ACK", "Address", "CCC", "Command", "CRC", "Data", "Def Byte", "P", "R/W" and "Reserved".

Remote command:
TRIGger:SBSW:I3C:FIENable on page 1252
TRIGger:SBSW:I3C:FRAMe<fr>:FLD<fl>:ENABle on page 1252

"Condition"

Displays the value condition for the selected field.

Remote command:
TRIGger:SBSW:I3C:BIT on page 1251
TRIGger:SBSW:I3C:FRAMe<fr>:FLD<fl>:BIT on page 1251

"Value"

The data setup consists of a comparison condition and one or two data patterns.

Remote command:
TRIGger:SBSW:I3C:DMAX on page 1251
TRIGger:SBSW:I3C:FRAMe<fr>:FLD<fl>:DMAX on page 1251
TRIGger:SBSW:I3C:DMIN on page 1252
TRIGger:SBSW:I3C:FRAMe<fr>:FLD<fl>:DMIN on page 1252
TRIGger:SBSW:I3C:DOPerator on page 1252
TRIGger:SBSW:I3C:FRAMe<fr>:FLD<fl>:DOPerator on page 1252

"Index" The index setup consists of a comparison condition and one or two index values.

Remote command:
TRIGger:SBSW:I3C:IMAX on page 1253
TRIGger:SBSW:I3C:FRAMe<fr>:FLD<fl>:IMAX on page 1253
TRIGger:SBSW:I3C:IMIN on page 1253
TRIGger:SBSW:I3C:FRAMe<fr>:FLD<fl>:IMIN on page 1253
TRIGger:SBSW:I3C:IOPerator on page 1254
TRIGger:SBSW:I3C:FRAMe<fr>:FLD<fl>:IOPerator on page 1254

Error type

Enables triggering on the selected error type.

Remote command:
TRIGger:SBSW:I3C:ERENable on page 1254
TRIGger:SBSW:I3C:ERRor<m>:ENABle on page 1254

14.5.5 Measure

The "Setup Measurement" button opens the dialog for automatic measurements in the "Protocol" category for the selected serial bus.

See Section 10.2.6.2, "Settings for protocol measurements", on page 289.

14.5.6 I3C decode results

When the configuration of the serial bus is complete, the signal can be decoded:

1. Open the "Serial Bus" dialog for the respective bus.
2. In the "Setup" tab, enable "State".
3. In the "Display" tab, enable "Show decode table".

For a description of the display settings, see also Section 14.1.3.1, "Display settings", on page 435.

For a description of how to synchronize the displayed results, see Section 14.1.3.2, "Display synchronization", on page 437.

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

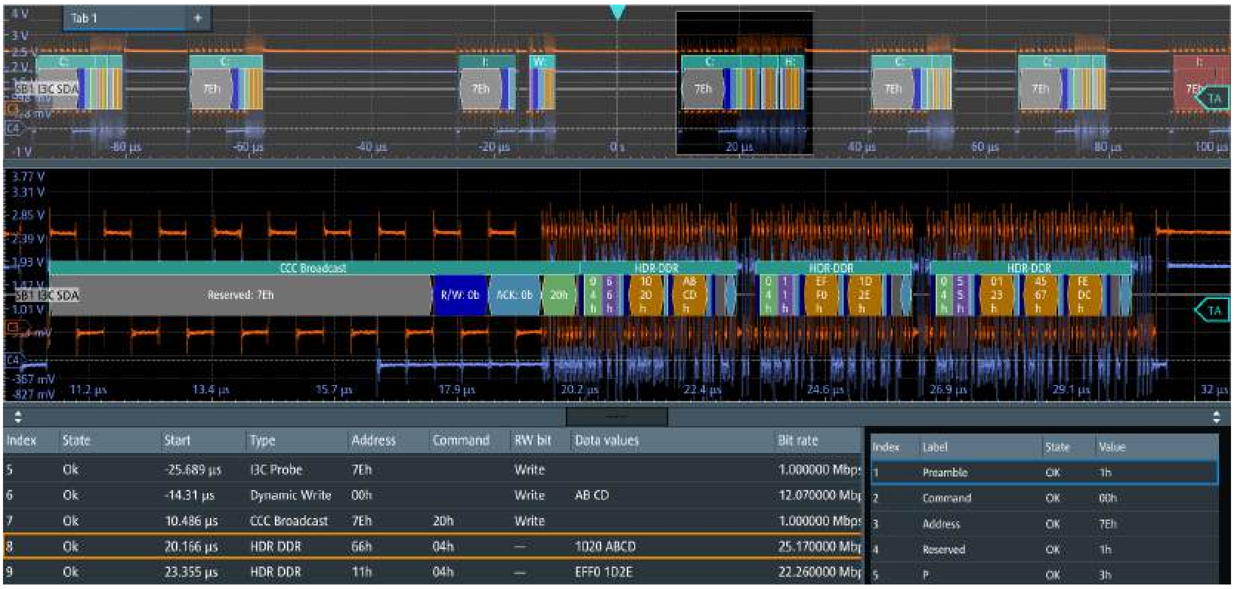


Figure 14-17: Decoded I3C signal

Purple = Address byte
Blue = R/W bit
Cyan = ACK bit
Red = NACK bit
Gold = Data byte
Turquoise = Write frame
Green = Read frame
Crimson red = Incomplete frame

The decode results table contains information about all decoded frames.

Table 14-7: Content of the decode results table

Column	Description
Index	Index of the decoded frame
State	Overall state of the frame. "Incomplete" indicates that the frame is not completely contained in the acquisition. Change the horizontal scale, or move the reference point to the left to get a longer acqui-sition.
Start	Time of frame start
Type	Frame type
Symbol	Symbolic label of the frame. Available only, if "Show symbols" is enabled in the "Display" tab and a symbols list is loaded.
Address	Value of the address field of the frame, if available
Command	Value of the command field of the frame, if available
RW bit	Value of the read/write bit
Data values	The actual data payload values. Select the data format in the "Display" tab.
Bit rate	Calculated bit rate for this frame

When you select a frame in the decode results table, its field content is shown in the details table to the right.

Table 14-8: Content of the frame details table

Item	Description
Index	Number of the decoded field
Label	Label (name) of each word of the data field
State	State of each word of the data field, for example "OK" or "Incomplete"
Value	Value of each word of the data field

Data format

You can select various data formats for the values displayed in the decode table and in the combs of the decoded signal.

Remote command:

- `SBUS<sb>:FORMat` on page 1154

Remote commands

Remote commands to retrieve decode results are described in Section 18.17.5.4, "Decode results", on page 1255.

14.5.7 Performing I3C decoding

This section explains step by step how to configure and decode the I3C bus.

For more information on decoding I3C, you can also refer to the video, available on the Rohde & Schwarz YouTube channel: Decoding I2C with MXO Series Oscilloscope.

14.5.7.1 Configuring I3C signals

For configuration, assign the lines to the input channels, and define the active states and the logical thresholds.

For details on configuration settings, see Section 14.5.2, "I3C configuration", on page 508.

1. Tap the "+ Bus" activator in the bottom right of the screen.

2. Select the tab of the bus that you want to set up, for example "SB1".
3. Tap the "Protocol type" button. Select the protocol: "I3C".
4. Tap on "State" to enable the decoding.

An I3C shortcut appears at the bottom left of the screen. Tap on the shortcut for a quick access to the "I3C" dialog settings.

5. Tap on each active wire and select the correct channels: "SDA source" and "SCL source".
6. Check that the signals are on the screen.
   If not, try adjusting the vertical and horizontal settings.

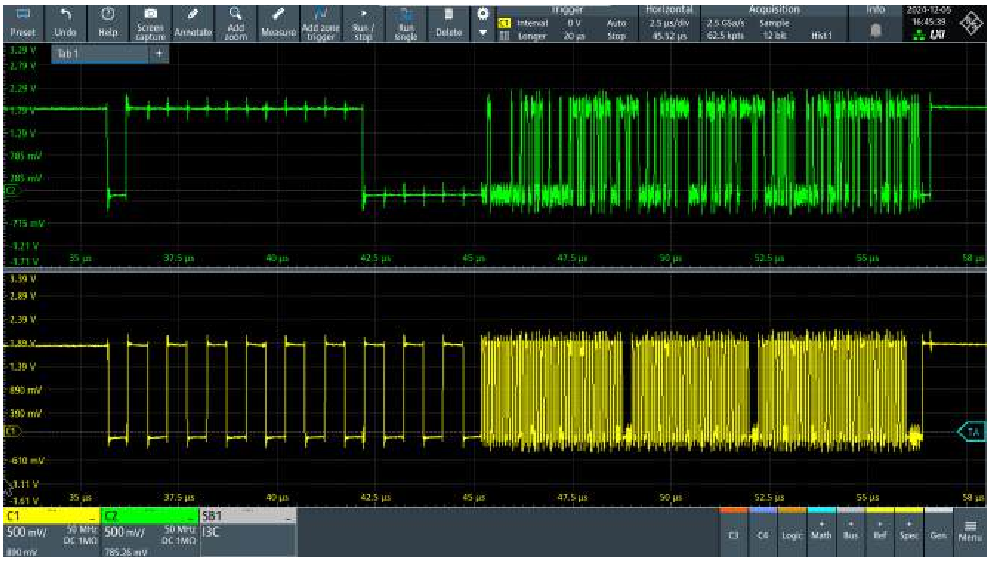
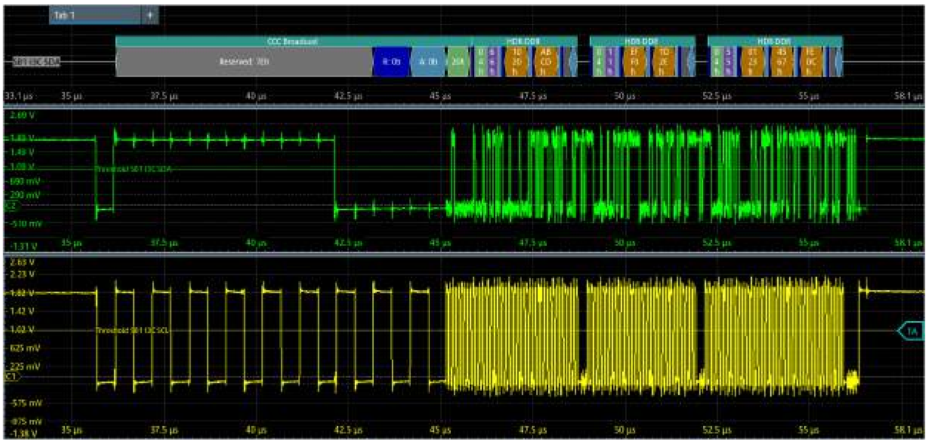


Figure 14-18: Top (C2, green): serial data line (SDA), below (C1, yellow): serial clock line (SCL)

7. Set the logical thresholds:
   a) Tap the "Thresholds" tab.
   b) For each wire, set the threshold value. A typical value is 1.65 V.
   c) If necessary, set the hysteresis value for the wires.
   d) Optionally, tap on "Show threshold lines".



14.5.7.2 Exporting decode results

Once a decode has been completed, you can generate an export of all decode results.

Prerequisites: A bus is configured for I3C and decoded.

1. Tap on the "I3C" shortcut.
2. Tap on the "Export" tab.
3. If necessary, enable "Include details".
4. If necessary, enable "Include timing".
5. Select the "File type".
6. Tap "Save as".

   A dialog opens for saving the export file in a selected directory.

The I3C export files contain the following fields:

- A list for all decoded frames:
  - "Index"
  - "Start"
  - "Stop"
  - "State" of the frame
  - "Type" of the frame
  - "Address", the value of the address field of that frame
  - "Command", the value of the command field of that frame
  - "RWBit", the value of the R/W bit of that frame
  - "CRC", the cyclic redundancy check value
  - "Bit-rate", the bit rate of the frame
- The frame details include the following fields:
  - "Label", the name of the field
  - "State", the state of the field

– "Value", the data value of the field

Example of an I3C export file

```
Index,Start,Stop,State,Type,Address,Command,RWBit,CRC,Bit-rate
1,-4.38003e-05,-3.19206e-05,'OK','BRDC',7Eh,00h,'WRIT',---,1000000
2,3.45864e-08,8.9946e-06,'OK','PROB',7Eh,---,'WRIT',---,1000000
3,1.14144e-05,1.54345e-05,'OK','WRIT',00h,---,'WRIT',---,12070000
4,3.62096e-05,4.58891e-05,'OK','BRDC',7Eh,20h,'WRIT',---,1000000
5,4.58891e-05,4.87292e-05,'OK','HDDR',66h,04h,---,05h,25170000
6,4.9079e-05,5.19291e-05,'OK','HDDR',11h,04h,---,1Fh,22270000
7,5.2279e-05,5.59291e-05,'OK','HDDR',55h,04h,---,1Bh,22280000

Details frame 1
Index,Label,State,Value
1,'Data: 1','OK',12h
2,'Data: 2','OK',34h
3,'Data: 3','OK',56h

Details frame 3
Index,Label,State,Value
1,'Data: 1','OK',ABh
2,'Data: 2','OK',CDh

Details frame 5
Index,Label,State,Value
1,'Data: 1','OK',1020h
2,'Data: 2','OK',ABCDh

Details frame 6
Index,Label,State,Value
1,'Data: 1','OK',EFF0h
2,'Data: 2','OK',1D2Eh

Details frame 7
Index,Label,State,Value
1,'Data: 1','OK',0123h
2,'Data: 2','OK',4567h
3,'Data: 3','OK',FEDCh
```

14.6 UART (IC electronics, option R&S MXO4-K510)

The Universal Asynchronous Receiver/Transmitter UART converts a word of data into serial data, and vice versa. It is the base of many serial protocols such as RS-232.

For basic information on UART, you can also refer to a video, available on the Rohde & Schwarz YouTube channel: Understanding UART.

Requirements

For performing UART decode measurements, you need the following:

- MXO 4 with 2 available channels. The channels can be a combination of the following:
  – Analog channels (C1-C4)
  – Logic channels (D0-D15) (requires option R&S MXO4-B1)
- Two probes
- Option R&S MXO4-K510

14.6.1 About the UART / RS-232 interface

The UART uses only one line, or two lines for transmitter and receiver.

Data transfer

The data is transmitted in words, also referred to as symbols or characters. Each word consists of a start bit, several data bits, an optional parity bit, and one or more stop bits. Several words can form a package, or frame. The end of a package is marked with a reserved word or by a pause between two words.

Start	Data0	Data1	Data2	Data3	Data4	[Data5]	[Data6]	[Data7]	[Data8]	[Parity]	Stop

Figure 14-19: Bit order in a UART word (symbol)

- The start bit is a logic 0.
- The stop bits and the idle state are always logic 1.

The UART protocol has no clock for synchronization. The receiver synchronizes by the start and stop bits, and the bit rate that must be known to the receiver.

Trigger

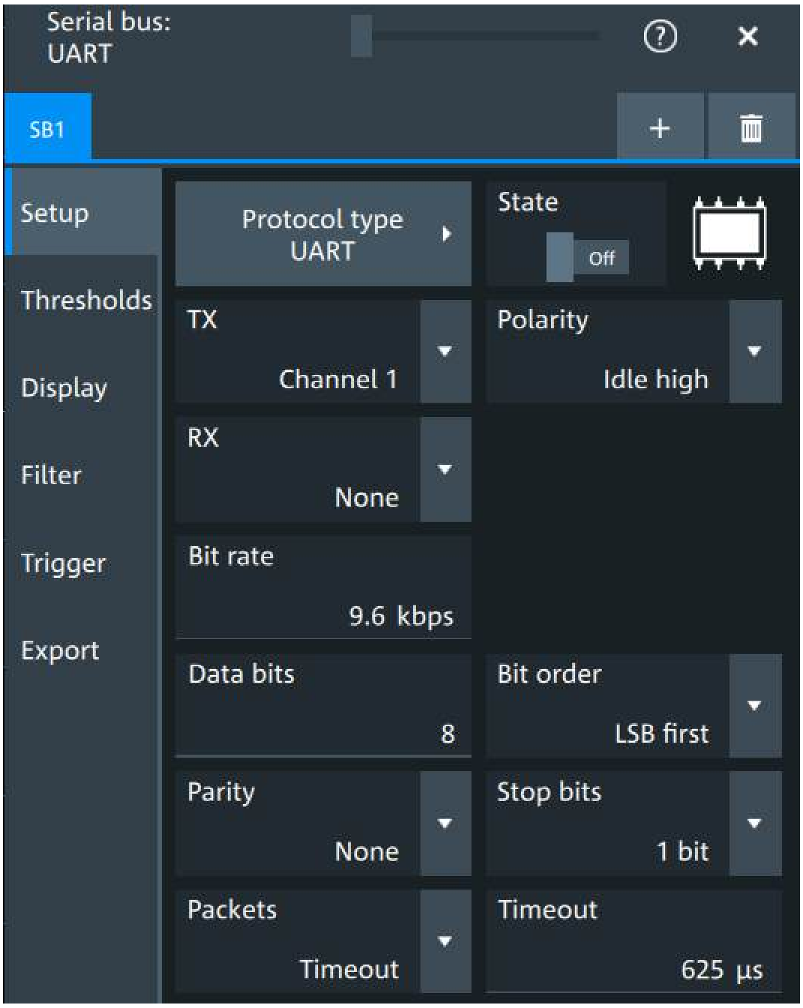
The MXO 4 can trigger on specified parts of UART serial signals:

- Start bit
- Packet start
- Parity errors, and breaks
- Stop errors
- A serial pattern at any or a specified position

14.6.2 UART configuration

14.6.2.1 UART configuration settings

Access: "Menu" > "Apps" > "Protocol" tab > "UART / RS232" > "Setup".



Protocol type

Selects the protocol type to be decoded.

Remote command:

SBUS<sb>:TYPE on page 1153

State

Enables the decoding of the selected bus. The signal icon of the bus appears on the signal bar.

Remote command:

SBUS<sb>[:STATe] on page 1152

Source: Tx, Rx
Select the input channels for the transmitter and receiver signals.

Do not combine a reference waveform with a channel or math waveform because the time correlation of these waveforms can differ.

Remote command:
`SBUS<sb>:UART:TX:SOURce` on page 1268
`SBUS<sb>:UART:RX:SOURce` on page 1266

Bit order
Selects the bit order, which determines if the data of the messages starts with MSB (most significant bit) or LSB (least significant bit).

Remote command:
`SBUS<sb>:UART:BORDer` on page 1265

Polarity
Defines the logic levels of the bus. The idle state corresponds to a logic 1. The start bit corresponds to a logic 0. "Idle high" (high=1) is used, for example, for control signals, while "Idle low" (low=1) is defined for data lines (RS-232).

Remote command:
`SBUS<sb>:UART:POLarity` on page 1266

Bit rate
Sets the number of transmitted bits per second.

Remote command:
`SBUS<sb>:UART:BITRate` on page 1264

Stop bits
Sets the number of stop bits: 1 or 1.5 or 2 stop bits are possible.

Remote command:
`SBUS<sb>:UART:SBIT` on page 1267

Data bits
Sets the number of data bits of a word in a range from 5 bits to 8 bits. If no parity bit is used, then 9 data bits are possible.

Remote command:
`SBUS<sb>:UART:SSIZe` on page 1267

Parity
Defines the optional parity bit that is used for error detection.

"None"	No parity bit is used.
"Odd"	The parity bit is set to "1" if the number of data bits set to "1" is even.
"Even"	The parity bit is set to "1" if the number of data bits set to "1" is odd.
"Mark"	The parity bit is always a logic 1.
"Space"	The parity bit is always a logic 0.
"Don't care"	The parity is ignored.

Remote command:
`SBUS<sb>:UART:PARity` on page 1265

Packets
Allows you to define packets of several words in the data stream.

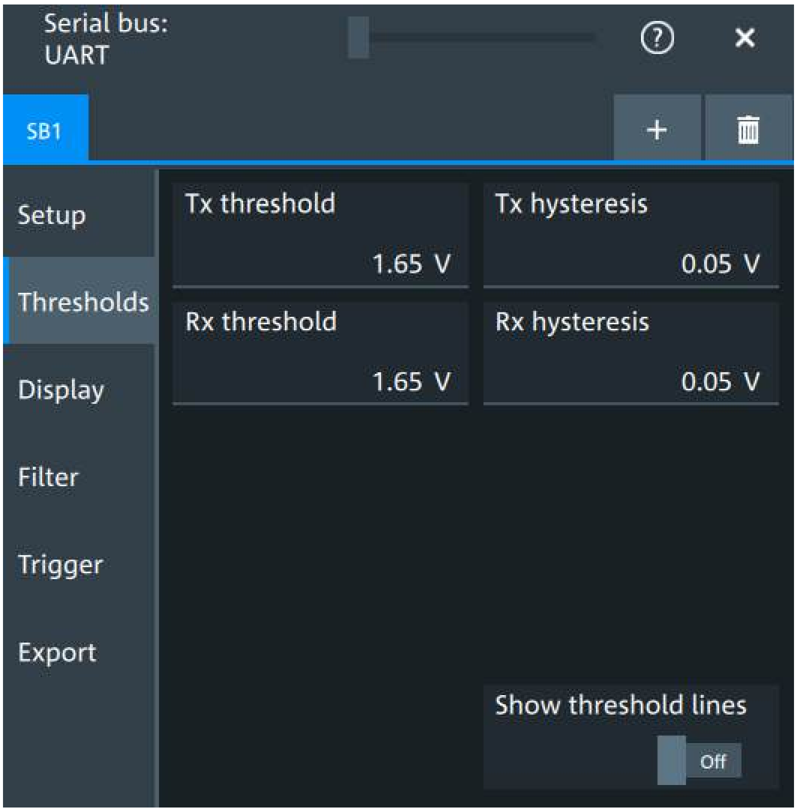
"None" Packets are not considered.

"Timeout" Defines a timeout between a stop bit and the next start bit. Enter the minimum time that marks the end of a packet.
A new packet starts with the first start bit after the timeout.

Remote command:
`SBUS<sb>:UART:PACKets` on page 1265
`SBUS<sb>:UART:TOUT` on page 1267

14.6.2.2 Threshold settings

Access: "Menu" > "Apps" > "Protocol" tab > "UART / RS232" > "Thresholds".



Threshold
Sets the threshold for the TX and RX channels. Enter the value directly in the fields.

Additional to the threshold, you can also set a hysteresis.

Remote command:
`SBUS<sb>:UART:RX:HYSTeresis` on page 1266
`SBUS<sb>:UART:RX:THReshold` on page 1267

SBUS<sb>:UART:TX:HYSTeresis on page 1268
SBUS<sb>:UART:TX:THReshold on page 1268

Show threshold lines
If enabled, the threshold lines are displayed in the diagram.

The label of the threshold line is set according to the signal that it is referring to, see also Show threshold lines.

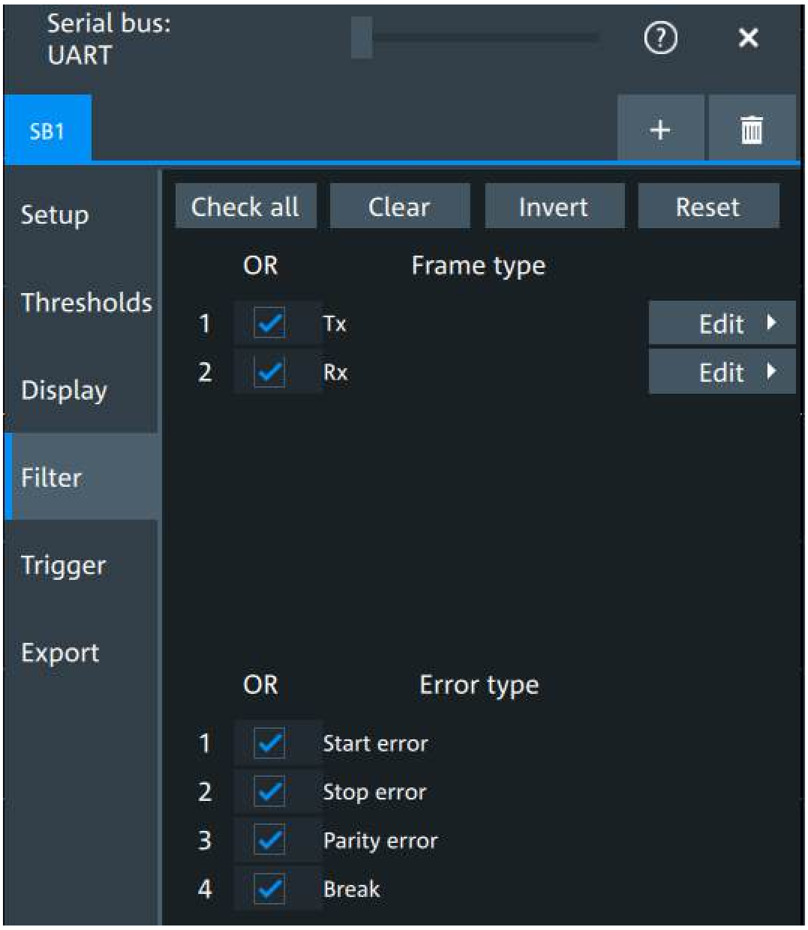
Remote command:
SBUS<sb>:THReshold on page 1155

14.6.2.3 Display settings

For details about the display settings, see Section 14.1.3.1, "Display settings", on page 435.

14.6.3 UART filter

Access:"Menu" > "Apps" > "Protocol" tab >"UART / RS232" > "Filter" tab



In the "Filter" tab, you can define the settings to display only the frames that match the selected filter conditions.

Check all, Clear, Invert, Preset

The following settings help you select the frames and errors you want to filter for. Only the frames and error types that match the selected filter conditions are displayed.

"Check all"	Enables the filter for all available frames and error types.
"Clear"	Disables the filter for all available frames and error types.
"Invert"	Inverts the current state of the frame and error types: all frames and error types that were enabled are disabled and vice versa.
"Preset"	Presets the state of the selected frames and error types.

Remote command:
`SBUS<sb>:UART:FILTer:CHKall` on page 1270
`SBUS<sb>:UART:FILTer:CLR` on page 1270
`SBUS<sb>:UART:FILTer:INVert` on page 1271
`SBUS<sb>:UART:FILTer:RST` on page 1271

Frame type

Selects the frame type that you want to display. You can filter all enabled frame types simultaneously.

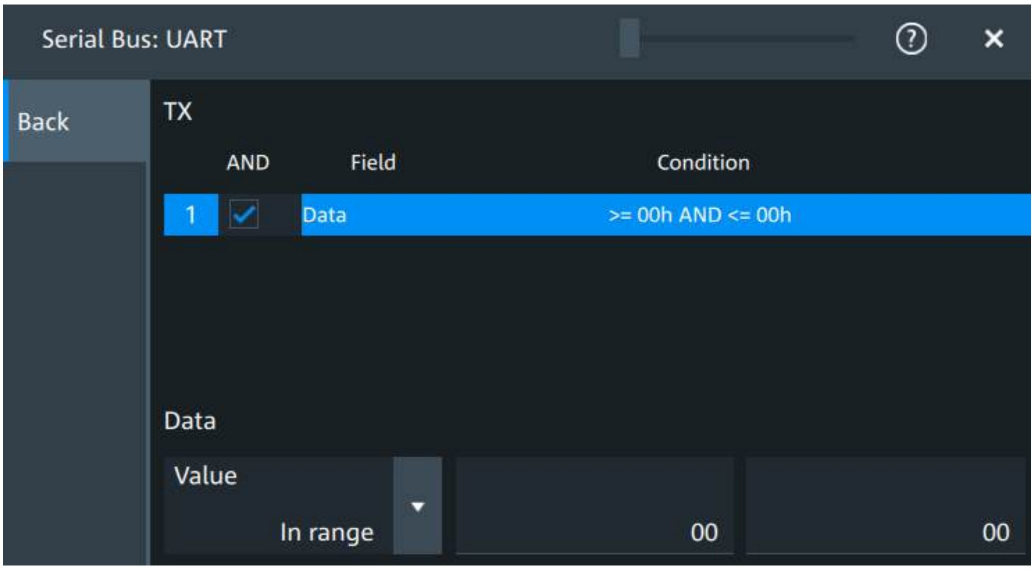
For selected frame types, you can also specify conditions for the value of the fields in the "Edit" dialog.

The available frames are "Tx", "Rx".

Remote command:
`SBUS<sb>:UART:FILTer:FRAMe<fr>:ENABle` on page 1274
`SBUS<sb>:UART:FILTer:FRENable` on page 1274

Edit

Opens a dialog to define the details of the selected frame.



"Field" Enables the field type that you want to filter on for the selected frame. The available field is "Data".

Remote command:
SBUS<sb>:UART:FILTer:FIENable on page 1275
SBUS<sb>:UART:FILTer:FRAMe<fr>:FLD<fl>:ENABle on page 1275

"Condition" Displays the value condition for the selected field.

Remote command:
SBUS<sb>:UART:FILTer:FRAMe<fr>:FLD<fl>:BIT on page 1274

"Data" The data setup consists of a comparison condition and one or two data patterns.

Remote command:
SBUS<sb>:UART:FILTer:FRAMe<fr>:FLD<fl>:DMAX on page 1274
SBUS<sb>:UART:FILTer:DMAX on page 1274
SBUS<sb>:UART:FILTer:FRAMe<fr>:FLD<fl>:DMIN on page 1273
SBUS<sb>:UART:FILTer:DMIN on page 1273
SBUS<sb>:UART:FILTer:FRAMe<fr>:FLD<fl>:DOPerator on page 1273
SBUS<sb>:UART:FILTer:DOPerator on page 1273

"Index" The index setup consists of a comparison condition and one or two index values.

Remote command:
SBUS<sb>:UART:FILTer:FRAMe<fr>:FLD<fl>:IMAX on page 1272
SBUS<sb>:UART:FILTer:IMAX on page 1272
SBUS<sb>:UART:FILTer:FRAMe<fr>:FLD<fl>:IMIN on page 1271
SBUS<sb>:UART:FILTer:IMIN on page 1271
SBUS<sb>:UART:FILTer:FRAMe<fr>:FLD<fl>:IOPerator on page 1272
SBUS<sb>:UART:FILTer:IOPerator on page 1272

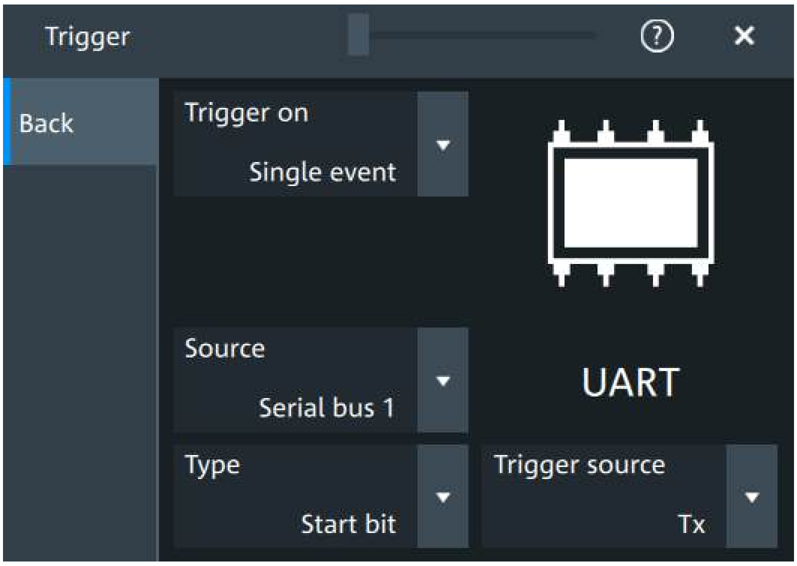
Error type
Enables filtering on the selected error type.

Available error types are "Start error", "Stop error", "Parrity error", "Break".

Remote command:
SBUS<sb>:UART:FILTer:ERRor<n>:ENABle on page 1272

14.6.4 UART hardware trigger

Access: "Menu" > "Apps" > "Protocol" tab > "UART / RS232" > "Trigger" tab > "Setup Hardware Trigger"



Data conditions
Specify the data conditions if the trigger type is set to "Data".

Data ← Data conditions
Selects the operator for the "Data" pattern.

Remote command:
`TRIGger:SBHW:UART:FCONdition` on page 1276

Value ← Data conditions
Specifies the data pattern to be found on the specified trigger source. Enter the words in MSB first bit order.

Remote command:
`TRIGger:SBHW:UART:DATA` on page 1275

Position ← Data conditions
Sets the number of words before the first word of interest. These offset words are ignored.

The setting is available if packet detection is enabled in the protocol configuration.

Remote command:
`TRIGger:SBHW:UART:DPOSition` on page 1275

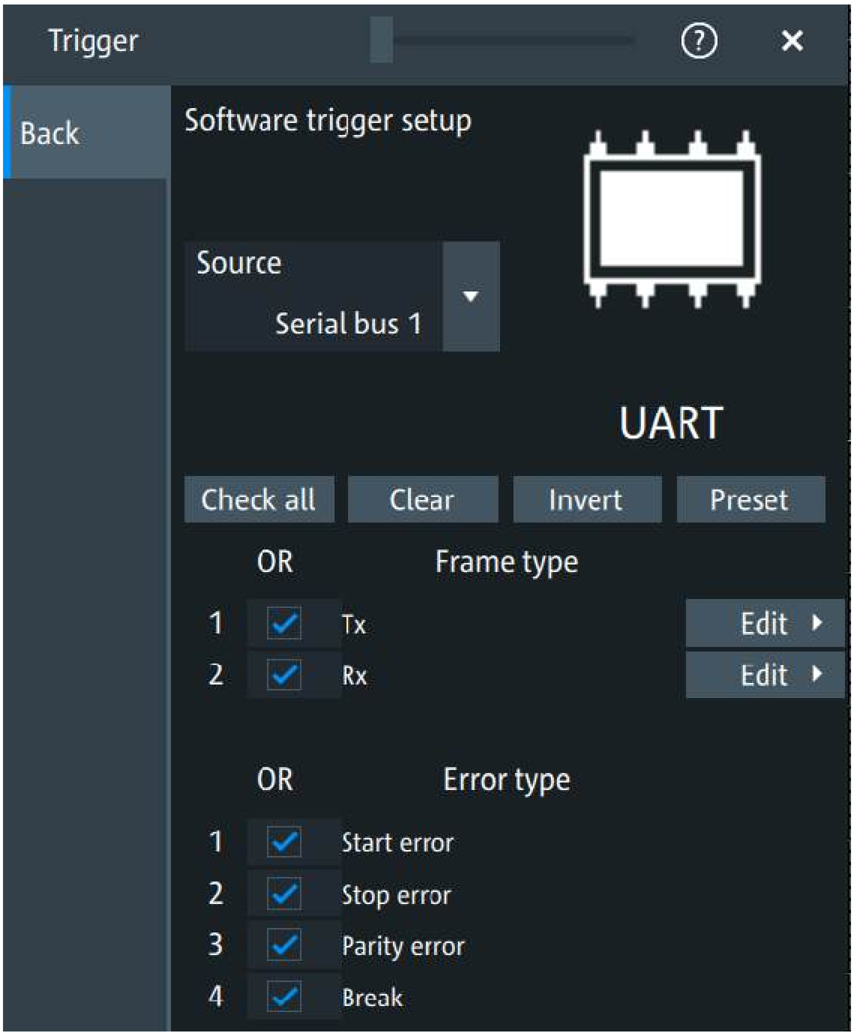
14.6.5 UART software trigger

14.6.5.1 Setup A trigger

Before setting up the software trigger for the protocols, a trigger A event needs to be set up.

14.6.5.2 Software trigger settings

Access: "Menu" > "Apps" > "Protocol" tab > "UART / RS232" > "Trigger" tab > "Setup Software Trigger" > "Setup SB Trigger".



In the "Software Trigger" tab, you can define the settings to trigger on the frames that match the selected filter conditions.

Check all, Clear, Invert, Preset

The following settings help you select the frames and errors you want to trigger on.

"Check all"	Enables the software trigger for all available frames and error types.
"Clear"	Disables the software trigger for all available frames and error types.
"Invert"	Inverts the current state of the frame and error types for the software trigger: all frames and error types that were enabled are disabled and vice versa.
"Preset"	Presets the state of the selected frames and error types for the software trigger.

Remote command:
`TRIGger:SBSW:UART:CHKall` on page 1277
`TRIGger:SBSW:UART:CLR` on page 1278
`TRIGger:SBSW:UART:INVert` on page 1278
`TRIGger:SBSW:UART:RST` on page 1278

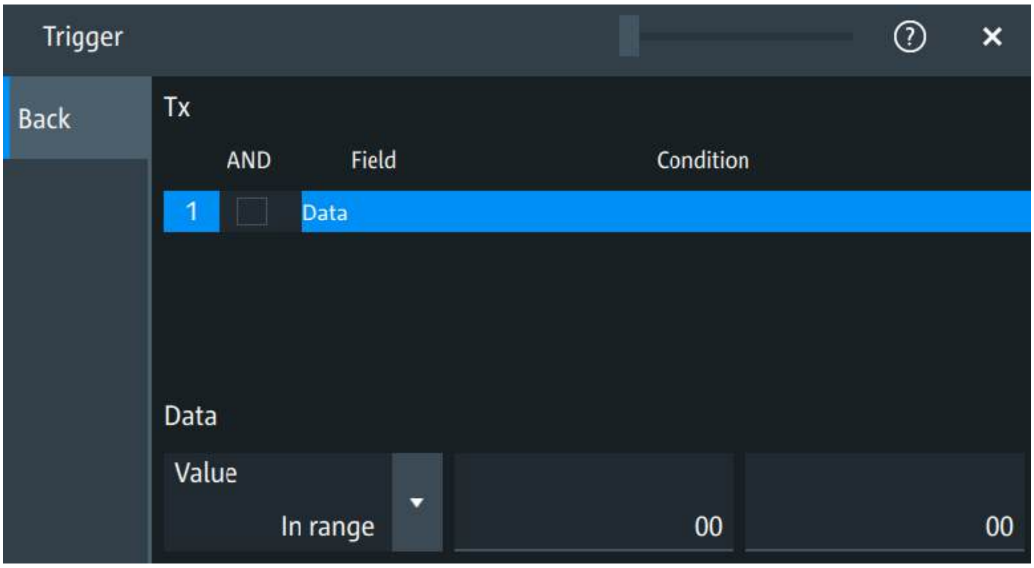
Frame type
Selects the frame type that you want to trigger on. You can trigger on all enabled frame types simultaneously.

For each frame type, you can also specify conditions for the value of the fields in the "Edit" dialog.

The following frames are available: "Tx" and "Rx".

Remote command:
`TRIGger:SBSW:UART:FRAMe<fr>:ENABle` on page 1278
`TRIGger:SBSW:UART:FRAMe<fr>:FLD<fl>:ENABle` on page 1280

Edit
Some trigger types have additional settings that can be defined. In this case, the "Set details" button appears next to "Type" the function. Open it for a detailed definition of the trigger conditions.



"Field" Enables the field type that you want to trigger on for the selected frame.
The available field is "Data".

Remote command:
`TRIGger:SBSW:UART:FIENable` on page 1280
`TRIGger:SBSW:UART:FRAMe<fr>:FLD<fl>:ENABle` on page 1280

"Condition"
: Displays the value condition for the selected field.

  Remote command:
  TRIGger:SBSW:UART:BIT on page 1279
  TRIGger:SBSW:UART:FRAMe<fr>:FLD<fl>:BIT on page 1279

"Value"
: The data setup consists of a comparison condition and one or two data patterns.

  Remote command:
  TRIGger:SBSW:UART:DMAX on page 1279
  TRIGger:SBSW:UART:FRAMe<fr>:FLD<fl>:DMAX on page 1279
  TRIGger:SBSW:UART:DMIN on page 1279
  TRIGger:SBSW:UART:FRAMe<fr>:FLD<fl>:DMIN on page 1279
  TRIGger:SBSW:UART:DOPerator on page 1280
  TRIGger:SBSW:UART:FRAMe<fr>:FLD<fl>:DOPerator on page 1280

"Index"
: The index setup consists of a comparison condition and one or two index values.

  Remote command:
  TRIGger:SBSW:UART:IMAX on page 1280
  TRIGger:SBSW:UART:FRAMe<fr>:FLD<fl>:IMAX on page 1280
  TRIGger:SBSW:UART:IMIN on page 1281
  TRIGger:SBSW:UART:FRAMe<fr>:FLD<fl>:IMIN on page 1281
  TRIGger:SBSW:UART:IOPerator on page 1281
  TRIGger:SBSW:UART:FRAMe<fr>:FLD<fl>:IOPerator on page 1281

Error type
Enables triggering on the selected error type.

The following error types are available: "Start error", "Stop error", "Parity error", "Break".

Remote command:
TRIGger:SBSW:UART:ERENable on page 1282
TRIGger:SBSW:UART:ERRor<m>:ENABle on page 1282

14.6.6 Measure

The "Setup Measurement" button opens the dialog for automatic measurements in the "Protocol" category for the selected serial bus.

See Section 10.2.6.2, "Settings for protocol measurements", on page 289.

14.6.7 UART decode results

When the configuration of the serial bus is complete, the signal can be decoded:

1. Open the "Serial Bus" dialog for the respective bus.

2. In the "Setup" tab, enable "State".
3. In the "Display" tab, enable "Show decode table".

For a description of the display settings, see also Section 14.1.3.1, "Display settings", on page 435.

For a description of how to synchronize the displayed results, see Section 14.1.3.2, "Display synchronization", on page 437.

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

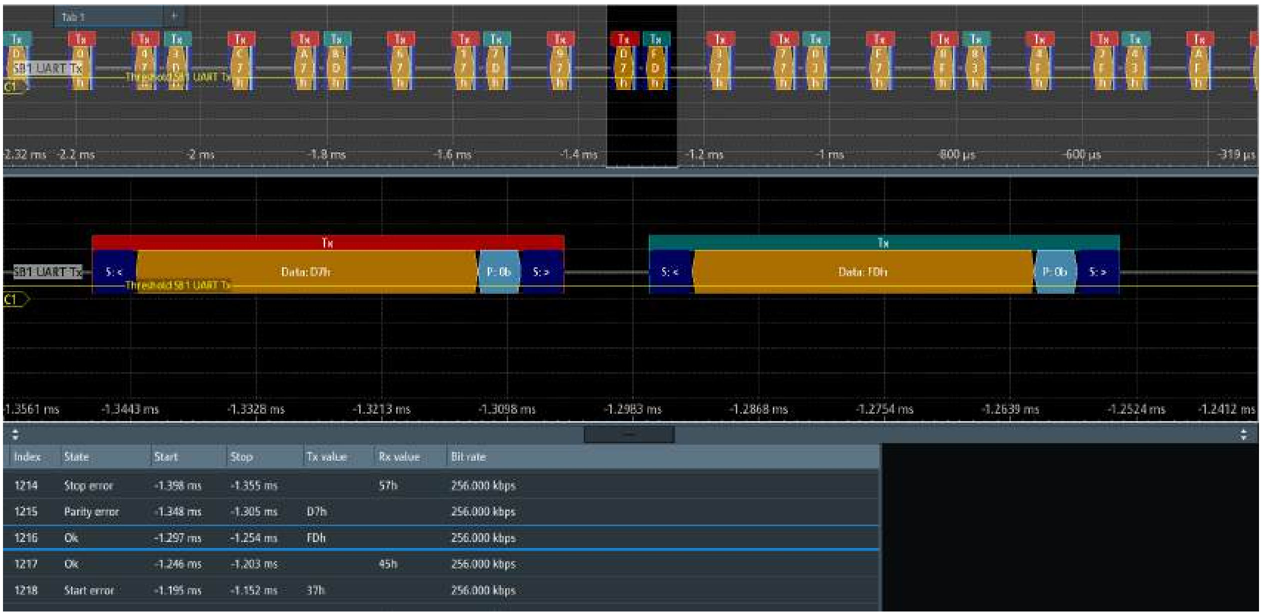


Figure 14-20: Decoded UART signal

The decode results table contains information about all decoded frames.

Table 14-9: Content of the decode results table

Column	Description
Index	Number of the decoded frames
State	Decoding state of the word. "Insuffcient waveform length" indicates that the word is not completely contained in the acquisition. Change the horizontal scale, or move the reference point to the left to get a longer acquisition.
Start	Time of the word start (start bit)
Stop	Time of the word stop (stop bit)
Tx value	Value of the Tx word. Select the data format in the "Display" tab.

Column	Description
Rx value	Value of the Rx word. Select the data format in the "Display" tab.
Data rate	Value of the data rate

Data format

You can select various data formats for the values displayed in the decode table and in the combs of the decoded signal.

Remote command:

- SBUS<sb>:FORMat on page 1154

Remote commands

Remote commands to retrieve decode results are described in Section 18.17.6.5, "Decode results", on page 1283.

14.6.8 Performing UART decoding

This section explains step by step how to configure and decode the UART bus.

For more information on decoding UART, you can also refer to the video, available on the Rohde & Schwarz YouTube channel: Decoding UART with MXO Series Oscilloscopes.

14.6.8.1 Configuring UART signals

For configuration, assign the lines to the input channels, and define the active states and the logical thresholds.

For details on configuration settings, see UART configuration.

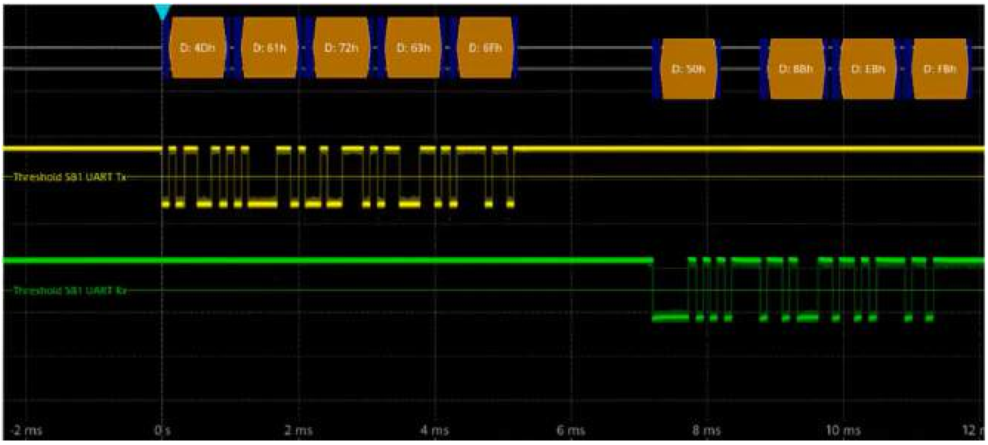
1. Tap the "+ Bus" activator in the bottom right of the screen.

2. Select the tab of the bus that you want to set up, for example "SB1".
3. Tap the "Protocol type" button. Select the protocol: "UART".
4. Tap on "State" to enable the decoding.

   An SPI shortcut appears at the bottom left of the screen. Tap on the shortcut for a quick access to the "UART / RS232" dialog settings.

5. Select the correct channels for each active line: "Tx" and "Rx".
6. Set the "Bit rate".
7. Set the "Data bits". Typical value is 7 or 8.
8. Set the "Stop bits". Typical value is 1.
9. Set the "Parity" to "None", "Odd" or "Even".
10. Set "Bit order" to "MSB" or "LSB first".
11. Set the "Packets".
12. Set the "Timeout".
13. Set the "Polarity" to "Idle high" or "Idle low".
14. Check that the signals are on the screen.
    If not try adjusting the vertical and horizontal settings.

15. Set the logical thresholds:
    a) Tap the "Thresholds" tab.
    b) For each line, set the threshold value. A typical value is 2.5 V.
    c) If necessary, set the hysteresis value for the wires.
    d) Optionally, tap on "Show threshold lines".



14.6.8.2 Exporting decode results

Once a decode has been completed, you can generate an export of all decode results.

Prerequisites: A bus is configured for the UART and decoded.

1. Tap on the "UART / RS232" shortcut.
2. Tap on the "Export" tab.
3. If necessary, enable "Include details".
4. If necessary, enable "Include timing".
5. Select the "File type".

   An export file is saved in the selected directory.

The UART export files contain the following fields:

- Index
- Start
- Stop
- Source
- State
- TX value
- RX value
- Bit rate

Example UART export file

```
Index,Start,Stop,Source,State,Tx value,Rx value,Bit rate
1,-0.0629961,-0.0629531,'TX','OK',33h,---,256000
2,-0.0629453,-0.0629023,'RX','OK',---,F5h,256000
3,-0.0628945,-0.0628516,'TX','STER',C8h,---,256000
4,-0.0628438,-0.0628008,'RX','SPER',---,28h,256000
5,-0.062793,-0.06275,'TX','PRER',A8h,---,256000
```

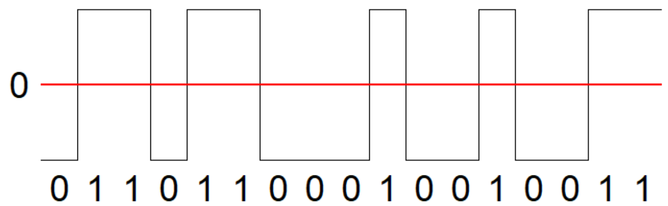
14.7 NRZ clocked & unclocked (option R&S MXO4-K510)

NRZ is a communication protocol for triggering at data rates up to 50 Mbit/s. It is suited for fast eye-diagram mask testing.

The NRZ protocol can either be **clocked** or **unclocked**. NRZ unclocked signals require a user-defined bit rate and gap time setting for triggering and decoding.

14.7.1 NRZ basics

In this line coding scheme, NRZ stands for "non-return-to-zero": The logical 1 is represented by a high voltage level, and the logical 0 is represented by a low voltage level:



The voltage remains at the same level for the entire bit period, without returning to a zero voltage level between bits. The voltage level changes only when the data bit changes.

Therefore, NRZ is an efficient protocol for high-speed serial data transmission. Its simplicity and low overhead make it a good choice for applications where data integrity and reliability are critical. It requires only half the bandwidth of the related Manchester code, which uses phase-shift keying.

14.7.2 NRZ configuration

14.7.2.1 NRZ configuration settings

Access:

- "Menu" > "Apps" > "Protocol" tab > "NRZ Clocked" > "Setup".
- "Menu" > "Apps" > "Protocol" tab > "NRZ Unclocked" > "Setup".

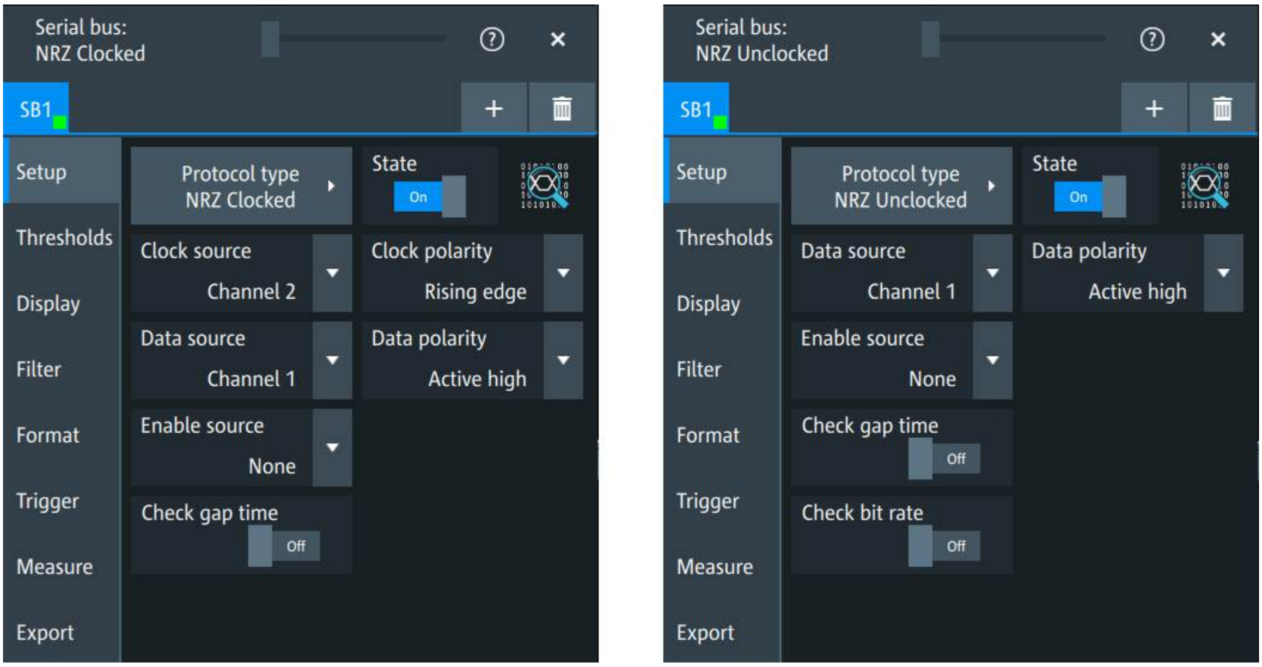


Figure 14-21: Setup dialog, left: clocked version, right: unclocked version of NRZ

Data source

Selects the source for the data signal.

Remote command:
SBUS<sb>:NRZC:DATA:SOURce on page 1287
SBUS<sb>:NRZU:DATA:SOURce on page 1314

Clock source

Available only for "NRZ Clocked".

Selects the source for the clock signal.

Remote command:
SBUS<sb>:NRZC:CLK:SOURce on page 1286

Data polarity

Selects the polarity for the data signal.

Remote command:
SBUS<sb>:NRZC:DATA:POLarity on page 1287
SBUS<sb>:NRZU:DATA:POLarity on page 1314

Clock polarity

Available only for "NRZ Clocked".

Selects the polarity for the clock signal.

Remote command:
SBUS<sb>:NRZC:CLK:POLarity on page 1286

Enable source
Selects the source of the enable signal.

If you select any source other than "None", the "Enable polarity" becomes available, which selects the polarity of the enable signal.

Remote command:
SBUS<sb>:NRZC:ENABle:SOURce on page 1287
SBUS<sb>:NRZC:ENABle:POLarity on page 1288
SBUS<sb>:NRZU:ENABle:SOURce on page 1314
SBUS<sb>:NRZU:ENABle:POLarity on page 1315

Check gap time
Enables the detection of the minimum idle time between two frames during decoding. Also enables setting the "Min gap time". If you set it, the decoder considers any longer idle time a gap.

Remote command:
SBUS<sb>:NRZC:MINGap:SELect on page 1288
SBUS<sb>:NRZU:MINGap:SELect on page 1315
SBUS<sb>:NRZC:MINGap:WIDTh on page 1288
SBUS<sb>:NRZU:MINGap:WIDTh on page 1315

Check bit rate
Available only for "NRZ Unclocked".

Enables setting the "Bit rate".
- If you define a bit rate, it is used for triggering and decoding.
- If you disable this option, the decoder calculates the bit rate.

Remote command:
SBUS<sb>:NRZU:BITRate:SELect on page 1316
SBUS<sb>:NRZU:BITRate:WIDTh on page 1316

14.7.2.2 Thresholds

Access:
- "Menu" > "Apps" > "Protocol" tab > "NRZ Clocked" > "Thresholds"
- "Menu" > "Apps" > "Protocol" tab > "NRZ Unclocked" > "Thresholds"

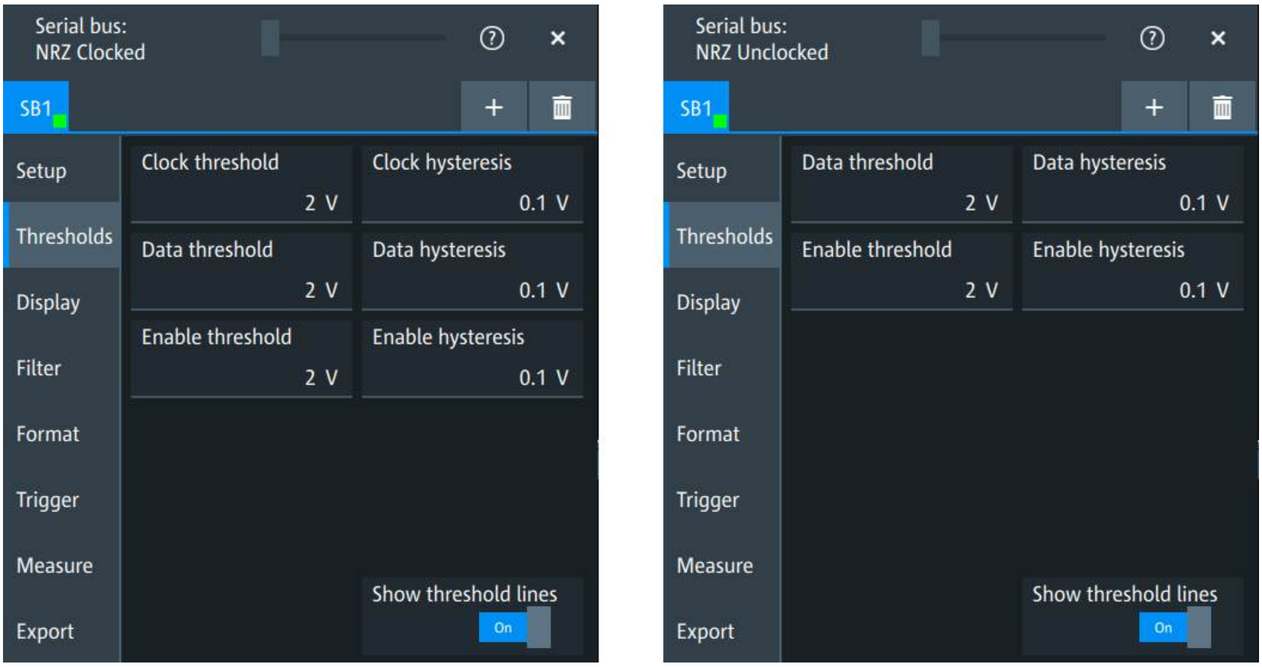


Figure 14-22: Thresholds dialog, left: clocked version, right: unclocked version of NRZ

Enter the values directly in the fields.

Data threshold, Data hysteresis

Sets the middle threshold and the hysteresis for the data source channel.

Remote command:

SBUS<sb>:NRZU:DATA:THReshold on page 1316
SBUS<sb>:NRZU:DATA:HYSTeresis on page 1317
SBUS<sb>:NRZC:DATA:THReshold on page 1289
SBUS<sb>:NRZC:DATA:HYSTeresis on page 1289

Clock threshold, Clock hysteresis

Available only for "NRZ Clocked".

Sets the middle threshold and the hysteresis for the clock source channel.

Remote command:

SBUS<sb>:NRZC:CLK:THReshold on page 1289
SBUS<sb>:NRZC:CLK:HYSTeresis on page 1289

Enable threshold, Enable hysteresis

Available only, if you have selected a source for the enable signal. See "Enable source" on page 541.

Sets the middle threshold and the hysteresis for the enable source channel.

Remote command:

SBUS<sb>:NRZC:ENABle:THReshold on page 1290
SBUS<sb>:NRZC:ENABle:HYSTeresis on page 1290

Show threshold lines
If enabled, the threshold lines are displayed in the diagram.

The label of the threshold line is set according to the signal that it is referring to, see also Show threshold lines.

Remote command:
`SBUS<sb>:THReshold` on page 1155

14.7.2.3 Display settings

For details about the display settings, see Section 14.1.3.1, "Display settings", on page 435.

Decode layer
Selects the decode layer.

Decoding is performed in several steps, and the results are presented in the decode table. The decode layer selects an interim step for which the decoding result is shown in the honeycomb display.

"Off"	Disables the display of the decode layer.
"Edges"	Enables the display of all edges.
"Bits"	Enables the display of all encoded bits.

Data format
See "Data format" on page 436.

14.7.2.4 NRZ symbols

There is no symbolic translation for NRZ protocols, because of the custom frame definitions.

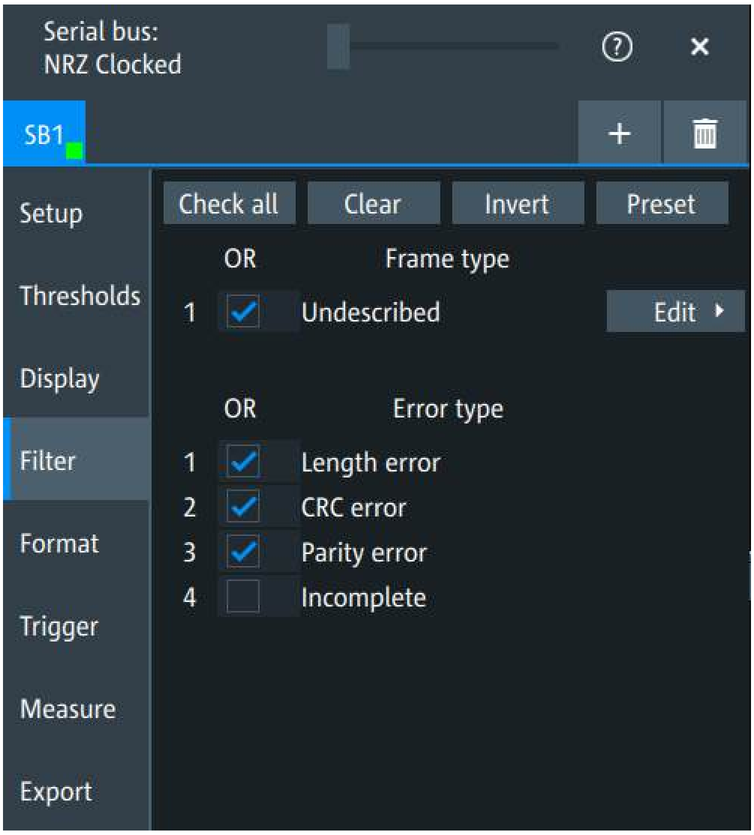
14.7.3 NRZ filter

Access:

- "Menu" > "Apps" > "Protocol" tab > "NRZ Clocked" > "Filter" tab
- "Menu" > "Apps" > "Protocol" tab > "NRZ Unclocked" > "Filter" tab

Although NRZ has a free format description according to section Section 14.7.4, "NRZ frame format configuration", on page 547, we provide a dynamic filter solution that can adapt to custom frames and fields in the decoded events.

In the "Filter" tab, you can define the settings to display only the frames that match the selected filter conditions.



Check all, Clear, Invert, Preset

The following settings help you select the frames and errors you want to filter for. Only the frames and error types that match the selected filter conditions are displayed.

"Check all"	Enables the filter for all available frames and error types.
"Clear"	Disables the filter for all available frames and error types.
"Invert"	Inverts the current state of the frame and error types: all frames and error types that were enabled are disabled and vice versa.
"Preset"	Presets the state of the selected frames and error types.

Remote command:
SBUS<sb>:NRZC:FILTer:CHKall on page 1291
SBUS<sb>:NRZU:FILTer:CHKall on page 1318
SBUS<sb>:NRZC:FILTer:CLR on page 1292
SBUS<sb>:NRZU:FILTer:CLR on page 1319
SBUS<sb>:NRZC:FILTer:INVert on page 1292
SBUS<sb>:NRZU:FILTer:INVert on page 1319
SBUS<sb>:NRZC:FILTer:RST on page 1292
SBUS<sb>:NRZU:FILTer:RST on page 1319

Enable

Enables the filtering on NRZ frames. Only the frames that match the selected filter conditions are displayed.

Remote command:
`SBUS<sb>:NRZC:FILTer:FRENable` on page 1295
`SBUS<sb>:NRZC:FILTer:FRAMe<fr>:ENABle` on page 1295
`SBUS<sb>:NRZU:FILTer:FRENable` on page 1322
`SBUS<sb>:NRZU:FILTer:FRAMe<fr>:ENABle` on page 1322

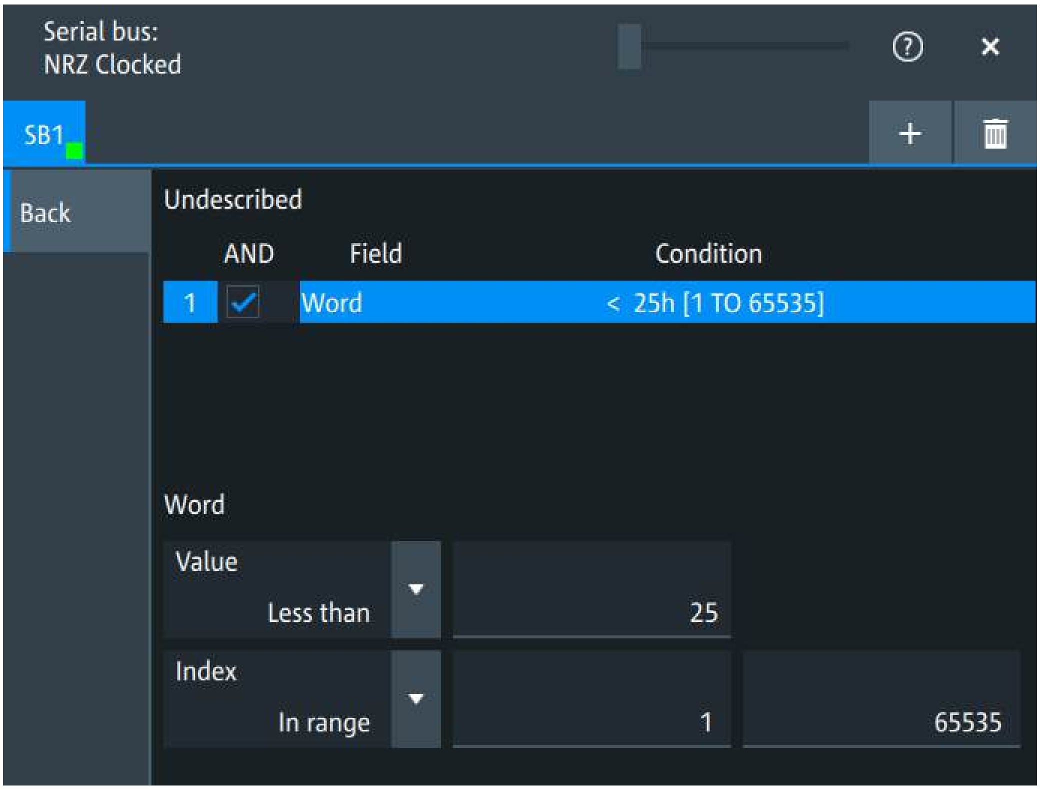
Frame type
Selects the frame type that you want to display. You can filter all enabled frame types simultaneously.

For selected frame types, you can also specify conditions for the value of the fields in the "Edit" dialog.

The only frame type available by default is "Undescribed", because the NRZ protocols support custom coding.

However, the frame formats that you define appear in this list, too. See Section 14.7.4, "NRZ frame format configuration", on page 547.

Edit
Opens a dialog to define the details of the selected frame.



"Field"
: Enables the field type that you want to filter on for the selected frame.
For the default "Undescribed" frame, the only available field type is "Word", which is the payload component of an undescribed frame.
See "Frame type" on page 545.
However, the field formats that you define appear in this list, too. See Section 14.7.4, "NRZ frame format configuration", on page 547.

Remote command:
`SBUS<sb>:NRZC:FILTer:FIENable` on page 1294
`SBUS<sb>:NRZC:FILTer:FRAMe<fr>:FLD<fl>:ENABle`
on page 1294
`SBUS<sb>:NRZU:FILTer:FIENable` on page 1321
`SBUS<sb>:NRZU:FILTer:FRAMe<fr>:FLD<fl>:ENABle`
on page 1321

"Condition"
: Displays the value condition for the selected field.

Remote command:
`SBUS<sb>:NRZC:FILTer:BIT` on page 1292
`SBUS<sb>:NRZC:FILTer:FRAMe<fr>:FLD<fl>:BIT`
on page 1292
`SBUS<sb>:NRZU:FILTer:BIT` on page 1319
`SBUS<sb>:NRZU:FILTer:FRAMe<fr>:FLD<fl>:BIT`
on page 1319

"Value"
: The data setup consists of a comparison condition and one or two data patterns.

Remote command:
`SBUS<sb>:NRZC:FILTer:DMAX` on page 1293
`SBUS<sb>:NRZC:FILTer:FRAMe<fr>:FLD<fl>:DMAX`
on page 1293
`SBUS<sb>:NRZU:FILTer:DMAX` on page 1320
`SBUS<sb>:NRZU:FILTer:FRAMe<fr>:FLD<fl>:DMAX`
on page 1320
`SBUS<sb>:NRZC:FILTer:DMIN` on page 1294
`SBUS<sb>:NRZC:FILTer:FRAMe<fr>:FLD<fl>:DMIN`
on page 1294
`SBUS<sb>:NRZU:FILTer:DMIN` on page 1321
`SBUS<sb>:NRZU:FILTer:FRAMe<fr>:FLD<fl>:DMIN`
on page 1321
`SBUS<sb>:NRZC:FILTer:DOPerator` on page 1294
`SBUS<sb>:NRZC:FILTer:FRAMe<fr>:FLD<fl>:DOPerator`
on page 1294
`SBUS<sb>:NRZU:FILTer:DOPerator` on page 1321
`SBUS<sb>:NRZU:FILTer:FRAMe<fr>:FLD<fl>:DOPerator`
on page 1321

"Index" The index setup consists of a comparison condition and one or two index values.

Remote command:
SBUS<sb>:NRZC:FILTer:IMAX on page 1295
SBUS<sb>:NRZC:FILTer:FRAMe<fr>:FLD<fl>:IMAX on page 1295
SBUS<sb>:NRZU:FILTer:IMAX on page 1322
SBUS<sb>:NRZU:FILTer:FRAMe<fr>:FLD<fl>:IMAX on page 1322
SBUS<sb>:NRZC:FILTer:IMIN on page 1296
SBUS<sb>:NRZC:FILTer:FRAMe<fr>:FLD<fl>:IMIN on page 1296
SBUS<sb>:NRZU:FILTer:IMIN on page 1323
SBUS<sb>:NRZU:FILTer:FRAMe<fr>:FLD<fl>:IMIN on page 1323
SBUS<sb>:NRZC:FILTer:IOPerator on page 1296
SBUS<sb>:NRZC:FILTer:FRAMe<fr>:FLD<fl>:IOPerator on page 1296
SBUS<sb>:NRZU:FILTer:IOPerator on page 1323
SBUS<sb>:NRZU:FILTer:FRAMe<fr>:FLD<fl>:IOPerator on page 1323

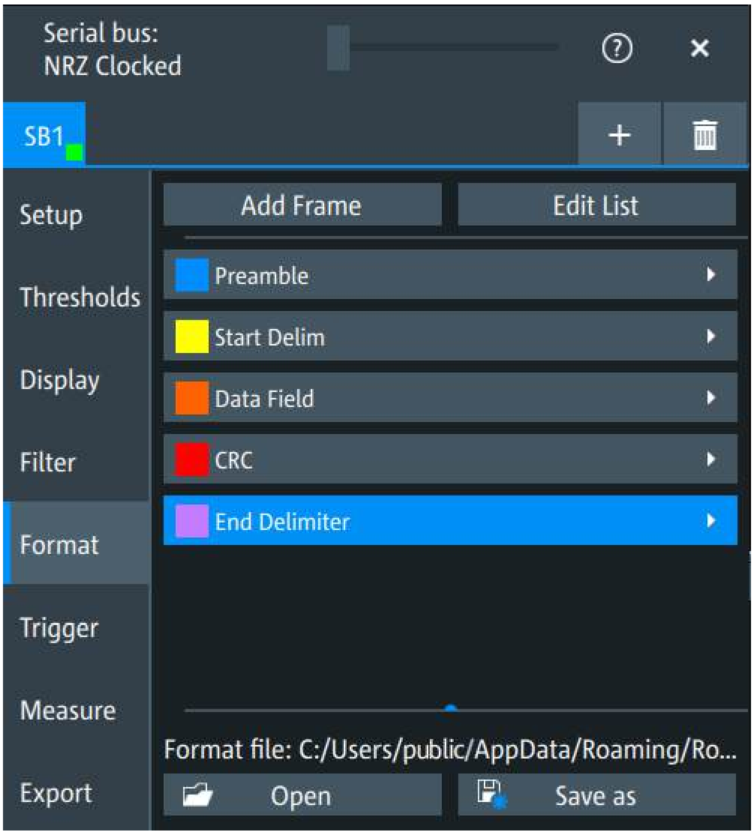
Error type
Enables filtering on the selected error type.

The available error types are "Length error", "CRC error", "Parity error", "Incomplete".

Remote command:
SBUS<sb>:NRZC:FILTer:ERENable on page 1293
SBUS<sb>:NRZC:FILTer:ERRor<n>:ENABle on page 1293
SBUS<sb>:NRZU:FILTer:ERENable on page 1320
SBUS<sb>:NRZU:FILTer:ERRor<n>:ENABle on page 1320

14.7.4 NRZ frame format configuration

This dialog enables you to describe the generic format and logical structure of your NRZ protocol. To do so, you can create customized frame descriptions of various structures and lengths.



A frame format description (or *frame description*, for short) is represented by one line in the frame format description list (or *frame list*, for short). Describing a frame format requires assigning it a name and specifying field descriptions, which must be sequential and complete. No gaps are allowed, because the field descriptions are used to calculate the start position of the next frame.

See also:

- "Frame name" on page 551
- "Frame Color" on page 552

The frame identification is executed top down, in the order in which the frame formats are described in the frame list. This provides a hierarchy of criteria for identifying frames. A frame is identified when all user-defined conditions of the field descriptions are met. See "Condition" on page 553. These conditions can be regarded as related by the Boolean `AND` operator.

A condition can also locate a synchronization pattern, specified by the equal operator in the field. For example, if you define a "Preamble" field with the condition *=FFFFFFFF*, the decoder scans the data for this pattern, and then synchronizes to it.

If no frame description is suitable to identify an incoming frame, by default such a "missed" frame is reproduced as "Undescribed Bits" in the honeycomb display. These bits are not shown in the results table.

If you have not defined an "equal" operator for any field of a frame description, you can use this description to positively identify each kind of frame. Hence, it "catches" every frame, even if there are other frame descriptions to follow in the frame list. Therefore, if you use a "catch all" frame description, we recommend to place it at the end of the frame list, otherwise it overwrites any subsequent frame description. However, instead of using a "catch all" frame description, consider using the default "Undescribed Bits" display mentioned above.

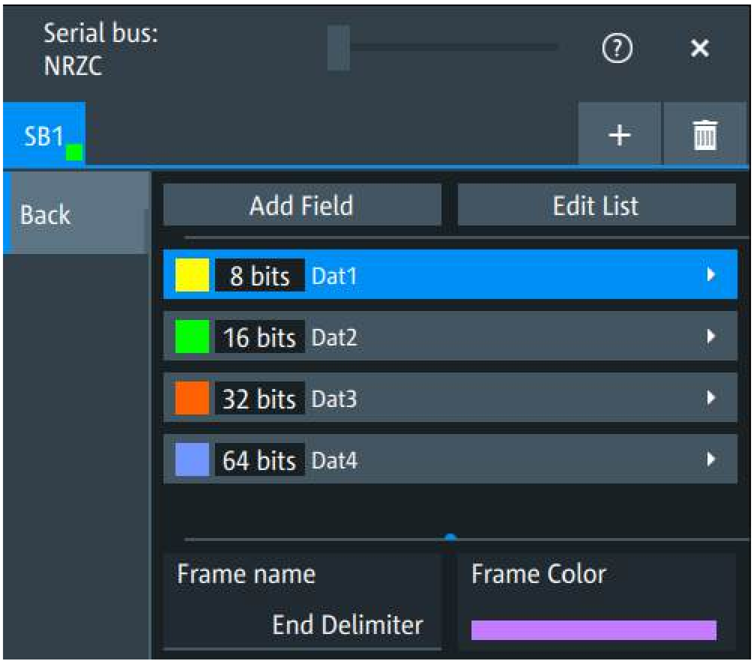
It is in your responsibility to define unambiguous descriptions for each frame type.

Add Frame

Creates a new **frame description** and adds it to the end of the frame list.

When you add a frame or when you click an existing entry in the frame list, a dialog opens that allows the following:

- Add Field
- Edit List
- Frame name
- Frame Color



When you return to the frame list by using the "Back" button, a dialog opens that allows the following:

- Add Frame
- Edit List
- Open
- Save as

The number of frame descriptions is limited to 100.

Remote command:

`SBUS<sb>:NRZC:FORMat:ADDFrame` on page 1297
`SBUS<sb>:NRZU:FORMat:ADDFrame` on page 1324

Edit List

Enables editing the frame list. If enabled, you can delete a frame description by clicking its "Delete" icon. In a list with several entries, you can move frame descriptions up or down by clicking the arrow buttons. To exit the editing mode, click "Edit List" again.

Remote command:
`SBUS<sb>:NRZC:FORMat:CLR` on page 1298
`SBUS<sb>:NRZU:FORMat:CLR` on page 1325
`SBUS<sb>:NRZC:FORMat:FCOunt?` on page 1298
`SBUS<sb>:NRZU:FORMat:FCOunt?` on page 1325

Open

Opens a dialog for loading an existing list of frame descriptions in `XML` file format.

Remote command:
`SBUS<sb>:NRZC:FORMat:LOAD` on page 1297
`SBUS<sb>:NRZU:FORMat:LOAD` on page 1324

Save as

Opens a dialog for saving your current list of frame descriptions to an `XML` file. Saved frame descriptions can support efficient and convenient working.

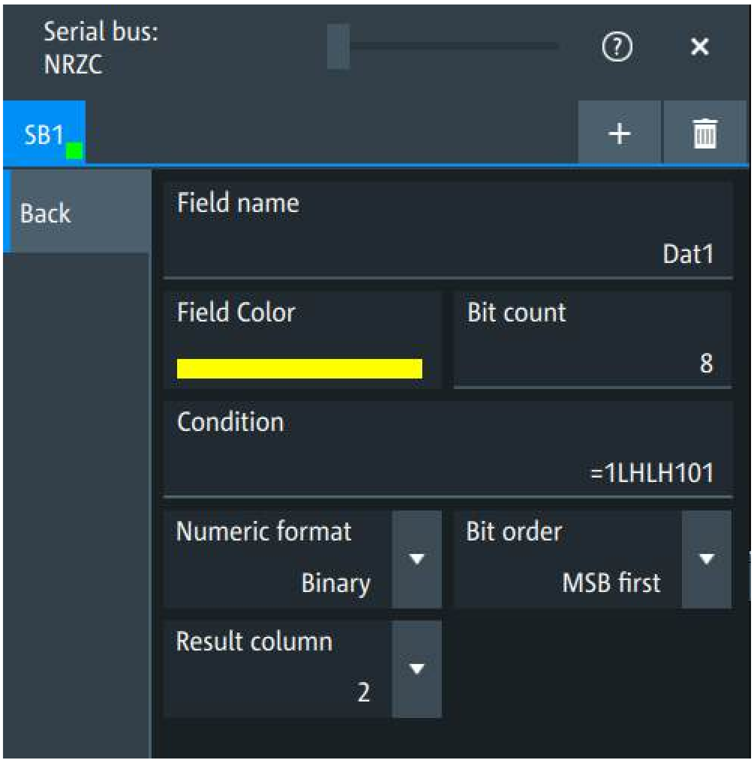
Remote command:
`SBUS<sb>:NRZC:FORMat:SAVE` on page 1297
`SBUS<sb>:NRZU:FORMat:SAVE` on page 1324

Add Field

Creates a new **field description** for the currently selected frame description and adds it to the end of the field list.

When you add a field or when you click an existing entry in the field list, a dialog opens that allows the following for describing a field:

- Field name
- Field Color
- Bit count
- Condition
- Numeric format
- Bit order
- Result column



When you return to the field list by using the "Back" button, a dialog opens that allows the following:

- Add Field
- Edit List
- Frame name
- Frame Color

The number of field descriptions is limited to 100.

Remote command:
`SBUS<sb>:NRZC:FORMat:FRAMe<fr>:ADDField` on page 1298
`SBUS<sb>:NRZU:FORMat:FRAMe<fr>:ADDField` on page 1325

Edit List
Enables editing the field list. If enabled, you can delete a field description by clicking its "Delete" icon. In a list with several entries, you can move field descriptions up or down by clicking the arrow buttons. To exit the editing mode, click "Edit List" again.

Remote command:
`SBUS<sb>:NRZC:FORMat:FRAMe<fr>:FLDCount?` on page 1298
`SBUS<sb>:NRZU:FORMat:FRAMe<fr>:FLDCount?` on page 1325

Frame name
Specifies an arbitrary name to label the currently selected frame description. Ideally, use speaking names according to the specifications of the applicable protocol standard. For example, MDIO (Management Data Input/Output) specifies the frames "READ", "WRITE", "ADDRESS". Frame names do not have to be unique and are only intended to support you.

Remote command:
SBUS<sb>:NRZC:FORMat:FRAMe<fr>:NAME on page 1299
SBUS<sb>:NRZU:FORMat:FRAMe<fr>:NAME on page 1326

Frame Color

Selects a color for labeling the currently selected frame description.

Remote command:
SBUS<sb>:NRZC:FORMat:FRAMe<fr>:COLor on page 1299
SBUS<sb>:NRZU:FORMat:FRAMe<fr>:COLor on page 1326

Field name

Specifies an arbitrary name for the currently selected field description. Ideally, use speaking names.

Field names do not have to be unique and are only intended to support you.

Remote command:
SBUS<sb>:NRZC:FORMat:FRAMe<fr>:FLD<fl>:NAME on page 1299
SBUS<sb>:NRZU:FORMat:FRAMe<fr>:FLD<fl>:NAME on page 1326

Field Color

Opens a dialog to select the color representation of different fields in the honeycomb display. Assigning specific colors can help you to interpret the decode results more easily. You can select a predefined color or specify a "User-defined color".

Remote command:
SBUS<sb>:NRZC:FORMat:FRAMe<fr>:FLD<fl>:COLor on page 1300
SBUS<sb>:NRZU:FORMat:FRAMe<fr>:FLD<fl>:COLor on page 1327

Bit count

Specifies the bit count and hence the length of the field represented by the currently selected field description. You can click the field to open a keypad dialog, which also displays the minimum and maximum permitted values. Its "Min", "Max" or "Reset" buttons can set the bit count to the minimum, maximum or reset value. The "Inc" or "Dec" button increases or decreases the value in steps of 1 or 10, depending on the selected step size button. The "CE" button sets the bit count to the value that was used before the keypad was displayed.

If, for a given bit count, the Condition value is longer, it is truncated. If the condition value is shorter, it is padded with 0. Both truncation and padding occur at the left side of the condition value and relate to the Bit order.

Examples:

- If "Condition" is "=111000" and the "Bit order" is "MSB":
  - If "Bit count" is 4, the truncated condition is "=1000"
  - If "Bit count" is 8, the padded condition is "=00111000"
- If "Condition" is "=111000" and the "Bit order" is "LSB" (accordingly, the condition in "MSB" format would be "=000111"):
  - If "Bit count" is 4, the truncated condition is "=1000" for "LSB" and "=0001" for "MSB"
  - If "Bit count" is 8, the padded condition is "=00111000" for "LSB" and "=00011100" for "MSB"

Remote command:
SBUS<sb>:NRZC:FORMat:FRAMe<fr>:FLD<fl>:BITCount on page 1300
SBUS<sb>:NRZU:FORMat:FRAMe<fr>:FLD<fl>:BITCount on page 1327

Condition
Specifies a condition for the field, typically a bit sequence that is used for pattern-matching to identify the frame.

Use this text box to apply various conditions and functionalities for a field. Among others, you can use it to identify mandatory values, such as CRC checksum or ID, which help to identify a frame. The condition value must match also the Numeric format and Bit order.

The following conditions are implemented:

"= (equal)" The **equal** operator (represented by the "=" sign) defines a pattern for the field to match. Valid condition entries are characters that match the field's defined "Format", "Bit order", and "Bits". In binary format, for example, valid characters are "1", "0", "H" (high), and "L" (low).

Three cases have to be distinguished (cases A, B1, and B2), depending on the presence of a Variable Length Array: [] in the same frame description:

- **Case A**: If there is **no** "Variable Length Array" field, then each field marked with the equal operator acts as a key to identify a frame type. Only if all these fields match up with the expected value, the frame type is identified.
- **Cases B1 and B2**: If there **is** a "Variable Length Array" field, then the equal operator has two different functionalities, depending on the position of the equal-operator field within the frame description:
  – **B1**: If the field is located *anywhere before* the "Variable Length Array" field, the condition acts as a key to identify a frame type (as in case A).
  – **B2**: If the field is located *immediately after* the "Variable Length Array" field, the condition acts as an array delimiter. (Note: If the field, which is marked with the equal operator, is located after the "Variable Length Array" field, but *not* immediately after it, the decode result is unpredictable.)

"[ ] (array)"

The **array** operator (represented by the "[" and "]" bracket signs) defines the number of permissible repetitions of the field.

Example: Fixed-Length Array: [n]

The length parameter "n" is a decimal number > 0, which determines that the field is repeated n times within the frame. If, for example, the Bit count is 8, then the array operator identifies n fields of 8-bit length, and present them in the results table and honeycomb display with the specified name and color.

A fixed-length array is treated the same as other fields, except the real length of such an array is n · bit count.

Example: Variable Length Array: []

This array operator with empty "[" and "]" bracket signs does not determine a fixed size array. The field could be repeated any number of times, including 0 times. As a result, the field and the frame are of unspecified length (a situation that covers typical use cases).

The length of the frame is then determined by the end of frame condition, which can be an operator or a gap.

For processing reasons, only one (1) variable length array is supported in a frame, and a delimiter must follow immediately in the next field after it. This is required to enable the software to correctly terminate the array. Otherwise the bits could not be assigned correctly, and it would not be possible to determine where a repletion starts and where it ends. With an end of frame condition, the software can calculate the length of one single array within a frame. But if there were more arrays, it would be impossible to know which array was how long.

The variable length array can also be the last field of a frame. In this case, no delimiter is required. If decoded successfully, the detailed view in the results table shows the elements of the array. If the field name of the array is "Data", then the detail view of result table displays the elements with an array index as "Data: 1", "Data: 2" ... etc.

If the variable length array field is selected, it is shown as array [n], where n is the actual size detected in the waveform.

As an exception to the rule, it is permissible to assign the variable length array to consecutive fields. In this case, the fields are treated as a structure which is repeated. For example, if two consecutive fields are defined as A[] and B[], the decoder creates a sequence of ABABAB until the end condition has been detected.

Note: It is possible to combine check functions in a dynamic array. In the example above, if B[] is extended by odd(1), with "1" being the index of A[], then B checks the parity for each index of A.

"crc5usb(n-m)"	The **crc 5-bit** operator performs a check for a 5-bit CRC function using the polynomial as defined by the USB standard. n and m define the index range for the CRC check. For example, if the CRC shall check fields 1 to 4, the function shall be written "crc5usb(1-5)". If the range of the CRC check includes an array, all elements in the array is included in the CRC check. If the check fails, the CRC field is marked as "CRC error" in the result details and displayed in the color red in the honeycomb display. The frame that contains the field is marked in the same way, except if another higher priority error is found within this frame.
"odd(n-m), even(n-m)"	The "**parity**" operators perform checks on odd or even parity in the given index range n to m. Odd parity is fulfilled if the count of "1" bits in the range including the parity bit is odd. Even parity is fulfilled if the count of "1" bits in the range including the parity bit is even. If the parity check fails, the parity field is marked as "CRC error" in the result details and displayed in red color in the honeycomb display. The frame that contains the field is marked in the same way, except if another higher priority error is found within this frame.
"{Block}"	The **block** operator is represented by the "{" and "}" bracket signs. Consecutive fields marked with "{Block}" and using the same name are displayed in the honeycomb display as a consecutive packet of name "Block" with the first field's color. This feature is a visual effect in the honeycomb only.

Remote command:
`SBUS<sb>:NRZC:FORMat:FRAMe<fr>:FLD<fl>:CONDition` on page 1300
`SBUS<sb>:NRZU:FORMat:FRAMe<fr>:FLD<fl>:CONDition` on page 1327

Numeric format

Selects a numerical format for the Condition value: decimal, hex, octal or binary.

The following rules apply:

- If the condition value contains at least one "H", "h", "L", "l", "X", "x", and the remaining characters only contain "1" and/or "0", the numeric format is automatically interpreted as binary, regardless of its definition.
- The wildcard characters "x" and "X" are supported only in binary format.
  Examples: If the numeric format is set to be "HEX":
  – "=1HL111000" is valid (read as binary)
  – "=0x10101" is valid (read as binary, the "x" is interpreted here as a wild card)
  – "=1010" is valid (read as HEX, with a total of 16 bits)
  – "=0x5A" is valid (read as HEX "5A", since "0x" is a valid HEX prefix; nevertheless, it is recommended to enter "5A" instead)
  – "=5X12" is invalid
  – "=1H33" is invalid

Remote command:
`SBUS<sb>:NRZC:FORMat:FRAMe<fr>:FLD<fl>:FORMat` on page 1301
`SBUS<sb>:NRZU:FORMat:FRAMe<fr>:FLD<fl>:FORMat` on page 1328

Bit order
Selects, in which order the bits of a field's Condition value are evaluated:

- "LSB first": little endian, least significant bit first
- "MSB first": big endian, most significant bit first

Remote command:
`SBUS<sb>:NRZC:FORMat:FRAMe<fr>:FLD<fl>:BITorder` on page 1301
`SBUS<sb>:NRZU:FORMat:FRAMe<fr>:FLD<fl>:BITorder` on page 1328

Result column
Determines which field is displayed in which result column of the decode table.

- Selecting "-" (no index) means that the result is not displayed.
- Selecting "1", "2" or "3" means that the result is displayed in the 1st, 2nd or 3rd result column, that the decode table supports. Each of the three result columns has to be unique for each frame type. But to display unrelated information for different frame types, you can define different result columns.

Remote command:
`SBUS<sb>:NRZC:FORMat:FRAMe<fr>:FLD<fl>:CLMN` on page 1302
`SBUS<sb>:NRZU:FORMat:FRAMe<fr>:FLD<fl>:CLMN` on page 1329

14.7.5 NRZ software trigger

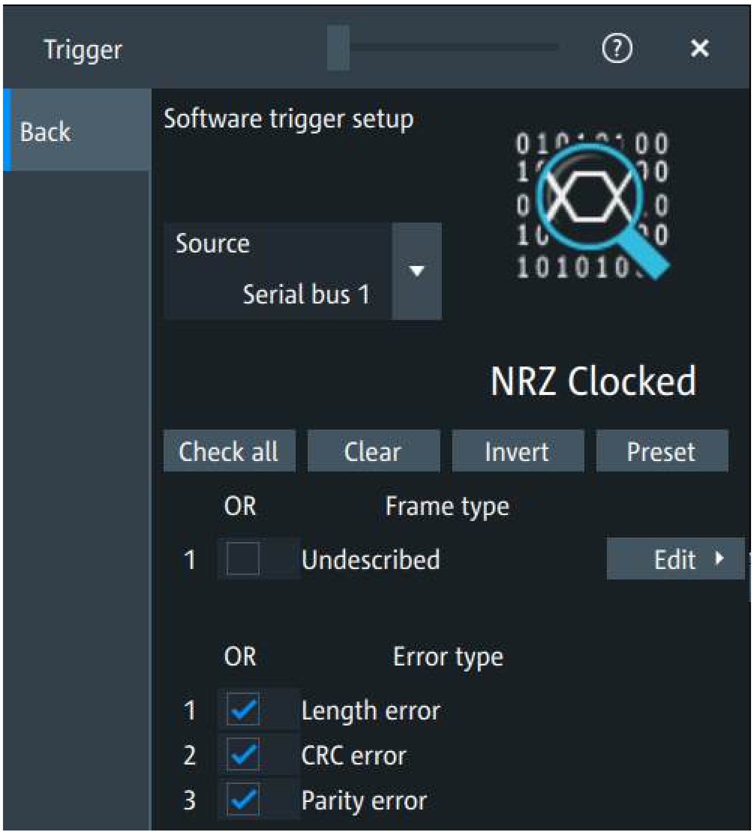
14.7.5.1 Setup A trigger

Before setting up the software trigger for the protocols, a trigger A event needs to be set up.

14.7.5.2 Software trigger settings

Access:

- "Menu" > "Apps" > "Protocol" tab > "NRZ Clocked" > "Trigger" tab > "Setup Software Trigger"
- "Menu" > "Apps" > "Protocol" tab > "NRZ Unclocked" > "Trigger" tab > "Setup Software Trigger"



In the "Software Trigger" tab, you can define the settings to trigger on the frames that match the selected filter conditions.

Check all, Clear, Invert, Preset

The following settings help you select the frames and errors you want to trigger on.

"Check all"	Enables the software trigger for all available frames and error types.
"Clear"	Disables the software trigger for all available frames and error types.
"Invert"	Inverts the current state of the frame and error types for the software trigger: all frames and error types that were enabled are disabled and vice versa.
"Preset"	Presets the state of the selected frames and error types for the software trigger.

Remote command:

`TRIGger:SBSW:NRZC:CHKall` on page 1303
`TRIGger:SBSW:NRZU:CHKall` on page 1330
`TRIGger:SBSW:NRZC:CLR` on page 1303
`TRIGger:SBSW:NRZU:CLR` on page 1330
`TRIGger:SBSW:NRZC:INVert` on page 1303
`TRIGger:SBSW:NRZU:INVert` on page 1330
`TRIGger:SBSW:NRZC:RST` on page 1304
`TRIGger:SBSW:NRZU:RST` on page 1331

Frame type
Selects the frame type that you want to trigger on. You can trigger on all enabled frame types simultaneously.

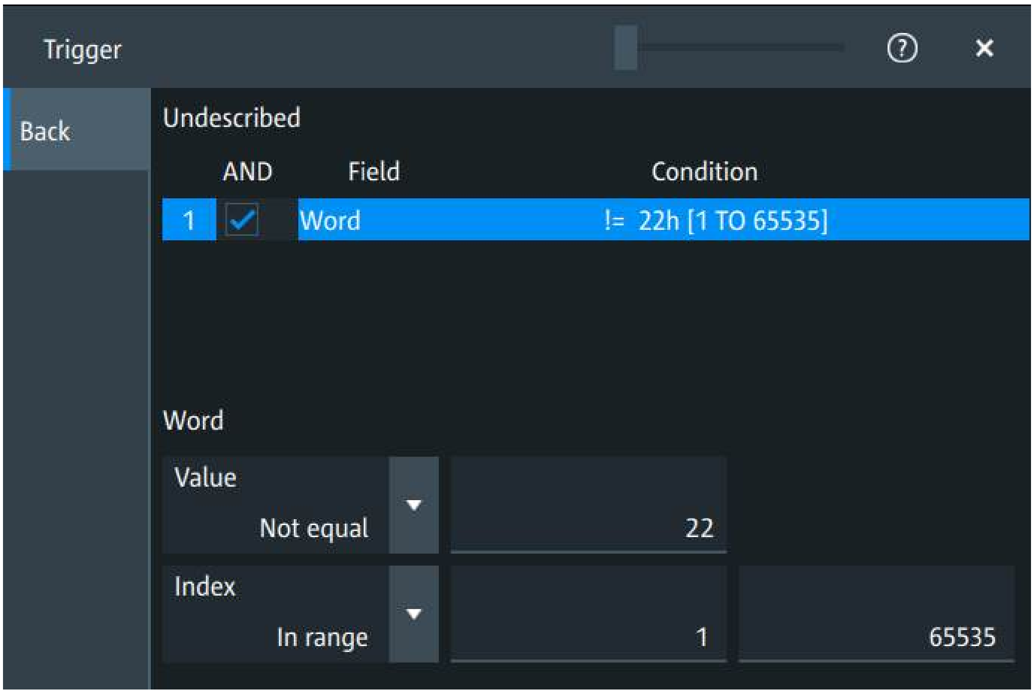
For each frame type, you can also specify conditions for the value of the fields in the "Edit" dialog.

The only frame type available by default is "Undescribed", because the NRZ protocols support custom coding.

However, the frame formats that you define appear in this list, too. See Section 14.7.4, "NRZ frame format configuration", on page 547.

Remote command:
`TRIGger:SBSW:NRZC:FRENable` on page 1304
`TRIGger:SBSW:NRZU:FRENable` on page 1331
`TRIGger:SBSW:NRZC:FRAMe<fr>:ENABle` on page 1304
`TRIGger:SBSW:NRZU:FRAMe<fr>:ENABle` on page 1331

Edit
Some trigger types have additional settings that can be defined. In this case, the "Set details" button appears next to "Type" the function. Open it for a detailed definition of the trigger conditions.



"Field"
: Enables the field type that you want to trigger on for the selected frame.
For the default "Undescribed" frame, the only available field type is "Word". See "Frame type" on page 558.
However, the field formats that you define appear in this list, too. See Section 14.7.4, "NRZ frame format configuration", on page 547.

Remote command:
`TRIGger:SBSW:NRZC:FIENable` on page 1306
`TRIGger:SBSW:NRZU:FIENable` on page 1333
`TRIGger:SBSW:NRZC:FRAMe<fr>:FLD<fl>:ENABle` on page 1306
`TRIGger:SBSW:NRZU:FRAMe<fr>:FLD<fl>:ENABle` on page 1333

"Condition"
: Displays the value condition for the selected field.

Remote command:
`TRIGger:SBSW:NRZC:BIT` on page 1304
`TRIGger:SBSW:NRZU:BIT` on page 1331
`TRIGger:SBSW:NRZC:FRAMe<fr>:FLD<fl>:BIT` on page 1304
`TRIGger:SBSW:NRZU:FRAMe<fr>:FLD<fl>:BIT` on page 1331

"Value"
: The data setup consists of a comparison condition and one or two data patterns.

Remote command:
`TRIGger:SBSW:NRZC:DMAX` on page 1304
`TRIGger:SBSW:NRZU:DMAX` on page 1331
`TRIGger:SBSW:NRZC:FRAMe<fr>:FLD<fl>:DMAX` on page 1304
`TRIGger:SBSW:NRZU:FRAMe<fr>:FLD<fl>:DMAX` on page 1331
`TRIGger:SBSW:NRZC:DMIN` on page 1305
`TRIGger:SBSW:NRZU:DMIN` on page 1332
`TRIGger:SBSW:NRZC:FRAMe<fr>:FLD<fl>:DMIN` on page 1305
`TRIGger:SBSW:NRZU:FRAMe<fr>:FLD<fl>:DMIN` on page 1332
`TRIGger:SBSW:NRZC:DOPerator` on page 1305
`TRIGger:SBSW:NRZU:DOPerator` on page 1332
`TRIGger:SBSW:NRZC:FRAMe<fr>:FLD<fl>:DOPerator` on page 1305
`TRIGger:SBSW:NRZU:FRAMe<fr>:FLD<fl>:DOPerator` on page 1332

"Index" The index setup consists of a comparison condition and one or two index values.

Remote command:
TRIGger:SBSW:NRZC:IMAX on page 1306
TRIGger:SBSW:NRZU:IMAX on page 1333
TRIGger:SBSW:NRZC:FRAMe<fr>:FLD<fl>:IMAX on page 1306
TRIGger:SBSW:NRZU:FRAMe<fr>:FLD<fl>:IMAX on page 1333
TRIGger:SBSW:NRZC:IMIN on page 1306
TRIGger:SBSW:NRZU:IMIN on page 1333
TRIGger:SBSW:NRZC:FRAMe<fr>:FLD<fl>:IMIN on page 1306
TRIGger:SBSW:NRZU:FRAMe<fr>:FLD<fl>:IMIN on page 1333
TRIGger:SBSW:NRZC:IOPerator on page 1307
TRIGger:SBSW:NRZU:IOPerator on page 1334
TRIGger:SBSW:NRZC:FRAMe<fr>:FLD<fl>:IOPerator on page 1307
TRIGger:SBSW:NRZU:FRAMe<fr>:FLD<fl>:IOPerator on page 1334

Error type
Enables triggering on the selected error type.

The available error types are "Length error", "CRC error", "Parity error".

Remote command:
TRIGger:SBSW:NRZC:ERENable on page 1307
TRIGger:SBSW:NRZU:ERENable on page 1334
TRIGger:SBSW:NRZC:ERRor<m>:ENABle on page 1307
TRIGger:SBSW:NRZU:ERRor<m>:ENABle on page 1334

14.7.6 Measure

The "Setup Measurement" button opens the dialog for automatic measurements in the "Protocol" category for the selected serial bus.

See Section 10.2.6.2, "Settings for protocol measurements", on page 289.

14.7.7 Performing NRZ decoding

This section explains step by step how to configure and decode the NRZ clocked or unclocked bus.

14.7.7.1 Configuring NRZ signals

For configuration, assign the lines to the input channels, and define the active states and the logical thresholds.

For details on configuration settings, see Section 14.7.2, "NRZ configuration", on page 539.

1. Tap the "+ Bus" activator in the bottom right of the screen.

2. Select the tab of the bus that you want to set up, for example "SB1".
3. Tap the "Protocol type" button. Select the protocol: "NRZ Clocked" or "NRZ Unclocked".
4. Tap on "State" to enable the decoding.

   A NRZC (clocked) or NRZU (unclocked) shortcut appears at the bottom left of the screen. Tap the shortcut for a quick access to the "NRZ Clocked" or "NRZ Unclocked" dialog settings.

14.7.7.2 Exporting decode results

Once a decode has been completed, you can generate an export of all decode results.

Prerequisites: A bus is configured for the NRZ protocol and decoded.

1. Tap on the "NRZ Clocked" or "NRZ Unclocked" shortcut.
2. Tap on the "Export" tab.
3. If necessary, enable "Include details".
4. If necessary, enable "Include timing".
5. Select the "File type".

   An export file is saved in the selected directory.

The NRZ export file contains the following fields:

- A list of all decoded frames:
  – `Index`
  – "State" of the frame
  – "Start"
  – "Frame type" of the frame
  – "Result 1", the result displayed in the 1st result column
  – "Result 2", the result displayed in the 2nd result column
  – "Result 3", the result displayed in the 3rd result column
  – "Bit rate", the bit rate of the frame
- The frame details include the following fields:

- "Index", the index of the field
- "State", the state of the field
- "Label", the name of the field
- "Value", the data value of the field

Example NRZC export file

```
Index,Start,Stop,State,Type,Result 1,Result 2,Result 3,Bit-rate
1,-0.019539,-0.014079,'OK','C22 WRITE',0Eh,11h,A57Eh,11900
2,-0.014079,-0.008619,'OK','C22 WRITE',1Ah,12h,EEFEh,11900
3,-0.008619,-0.00315997,'OK','C22 READ',13h,01h,ABCEh,11910
4,-0.00315997,0.0023,'OK','C45 READ',1Fh,0Ah,DEADh,11900
5,0.0023,0.0077608,'OK','C45 WRITE',0Eh,11h,A57Fh,11900
6,0.0077608,0.013221,'OK','C45 POST-READ',1Ah,12h,EEFCh,11900
7,0.013221,0.018681,'OK','C45 ADDRESS',0Ch,1Ah,CCAFh,11900
8,0.018681,0.0241433,'OK','C45 READ',13h,01h,ABCDh,11900

Details frame 1
Index,Label,State,Value
1,'PRE','OK',FFFFFFFFh
2,'ST','OK',1h
3,'OP','OK',1h
4,'PHYAD','OK',0Eh
5,'REGAD','OK',11h
6,'TA','OK',2h
7,'DATA','OK',A57Eh
8,'IDLE','OK',1h

Details frame 2
Index,Label,State,Value
1,'PRE','OK',FFFFFFFFh
2,'ST','OK',1h
3,'OP','OK',1h
4,'PHYAD','OK',1Ah
5,'REGAD','OK',12h
6,'TA','OK',2h
7,'DATA','OK',EEFEh
8,'IDLE','OK',1h

(...)
```

14.7.8 NRZ decode results

When the configuration of the serial bus is complete, the signal can be decoded:

1. Open the "Serial Bus" dialog for the respective bus.
2. In the "Setup" tab, enable "State".

3. In the "Display" tab, enable "Show decode table".

For a description of the display settings, see also Section 14.1.3.1, "Display settings", on page 435.

For a description of how to synchronize the displayed results, see Section 14.1.3.2, "Display synchronization", on page 437.

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

Decode results table

The "Decode results" table contains information about all decoded frames.

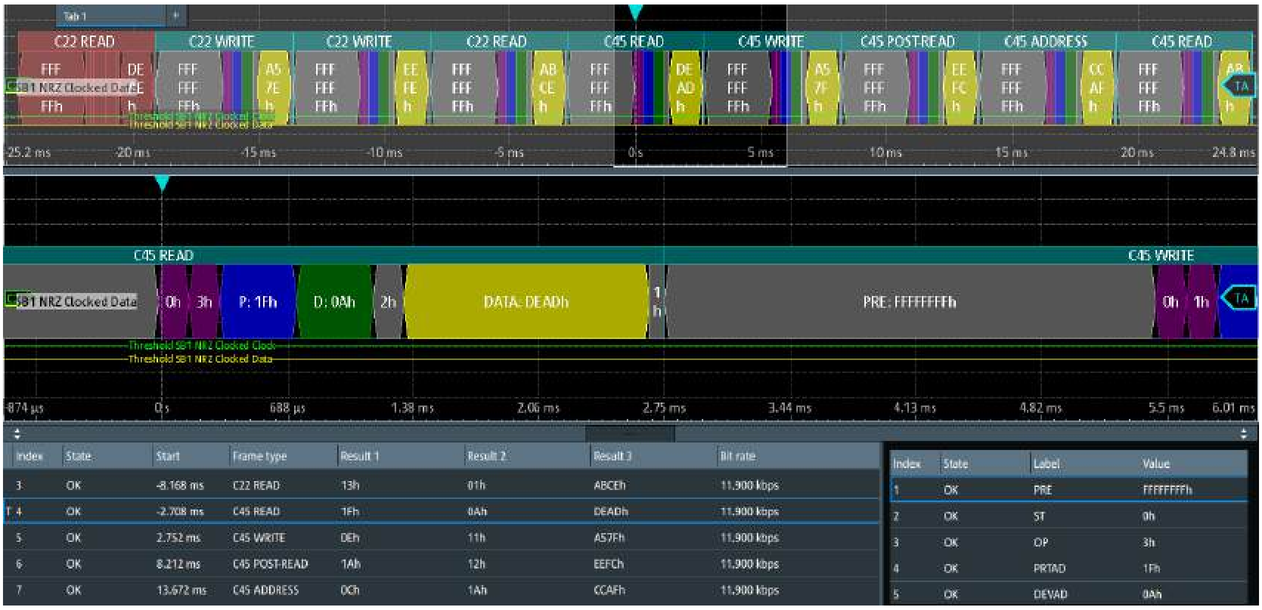


Figure 14-23: Decoded NRZ clocked signal

The decode results table contains information about all decoded frames.

Table 14-10: Content of the decode results table

Column	Description
Index	Frame count
State	Overall state of the frame
Start	Start time of the frame
Frame type	The type of the frame

Column	Description
Result	Data displayed in the 1st, 2nd and 3rd results column. For "undescribed" frames (see Frame type), you can select the data format in the "Display" tab. For other frames, the "Format" table controls the format of each field. See Section 14.7.4, "NRZ frame format configuration", on page 547.
Bit rate	Value of the bit rate

When you select a frame in the decode results table, its field content is shown in the details table to the right.

Table 14-11: Content of the frame details table

Column	Description
Index	Number of the decoded field
Label	Name of the field
State	State of the field
Value	Value of the field

Data format

You can select various data formats for the values displayed in the decode table and in the combs of the decoded signal.

Remote command:

- `SBUS<sb>:FORMat` on page 1154

Remote commands

Remote commands to retrieve decode results are described in Section 18.17.7.5, "Decode results", on page 1308 (NRZ clocked) and Section 18.17.8.5, "Decode results", on page 1335 (NRZ unclocked).

14.8 Manchester (option R&S MXO4-K510)

Manchester is a simple protocol for enhanced data integrity and reliability in serial bus communication. It is based on a self-clocked coding scheme also known as binary phase-shift keying (BPSK, or phase encoding, PE). Manchester is used in protocols such as ProfiBus (IEC 61158), DALI (Digital Addressable Lighting Interface, IEC 60929 and IEC 62386), MVB (Multifunction Vehicle Bus, part of IEC 61375 for Train Communication Networks, TCN), and Ethernet 10BASE-T (10 Mbit/s, IEEE 802.3i).

14.8.1 Manchester basics

There are two opposing data polarity conventions:

- In Manchester coding (as per G. E. Thomas), a logical 0 is expressed by a low-to-high transition, while a logical 1 is represented by a high-to-low transition. These line voltage transitions occur at the middle of each bit period.
- In "Manchester II" coding (as per IEEE 802.3), the value of each bit is the Boolean exclusive disjunction (XOR) of the original data value and the clock value. Hence, it is equivalent to inverted Manchester coding: a logical 0 is represented by a high-to-low transition, a logical 1 is represented by a low-to-high transition.

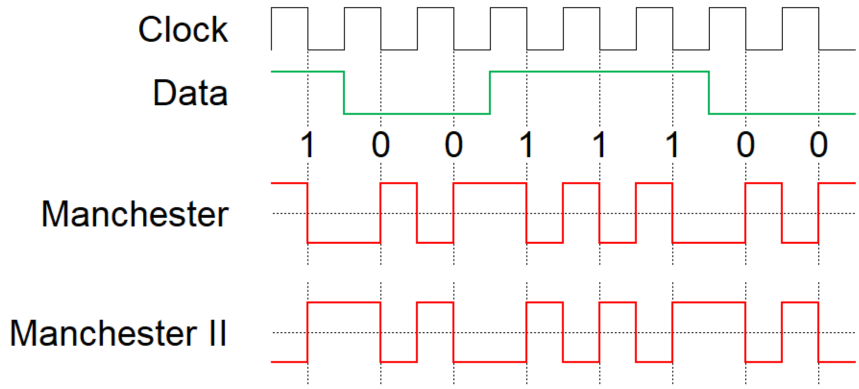


Figure 14-24: Data polarity conventions for Manchester and Manchester II

Transitions at the start of a bit period are overhead and do not represent data. Because of this overhead, Manchester coding requires twice the bandwidth of the related NRZ code.

However, the frequent transitions at the beginning and middle of bit periods support clock recovery. All transitions are directly proportional to the clock rate, allowing the signal to be self-clocked. Unless idle, the voltage level is either high or low: it does not return to a zero voltage level between bits.

14.8.1.1 Special features of Manchester coding

In practical protocols, Manchester coding appears in many variations, often employing deliberate coding violations to encode special waveform features, such as unambiguous synchronization and termination patterns. To adapt to these specific Manchester implementations and handle ambiguous signals, the option R&S MXO4-K510 uses a combination of automatic algorithms and user configurable parameters.

Quaternary Symbols

The software supports not just traditional binary symbols "0" and "1", but also arbitrary violation waveforms that use two additional symbols, yielding a total of four valid "quaternary bit" values. The two additional violation symbols are "H" (high) and "L" (low). Values of "H" correspond to a waveform lacking a transition in the center of the bit, with a physical high voltage state. Similarly, "L" violations also lack a center transition, but have a physical low voltage state. Most Manchester synchronization and termination conventions, even those containing violations, may be expressed as sequences of these four symbols. R&S MXO4-K510 uses the quaternary notation to support Manchester patterns in the honeycomb display and to describe synchronization and termination patterns in the frame description table.

Idle Conditions

The state of the signal line in between messages is the idle condition. Manchester appears in practical standards with varying idle conditions: it can idle at the high, low, or middle voltage state. High and low idle states correspond to "biphase" Manchester, while the middle voltage (often ground) adds a third state to become "ternary" Manchester. Using ternary Manchester, option R&S MXO4-K510 can usually establish the gaps between messages automatically. Using binary Manchester, the software has no way to automatically discriminate an idling bus from monotonic sequences of "H" or "L" violations. For these biphase situations, R&S MXO4-K510 offers a "Gap Time" detection feature, which allows to distinguish long intervals of non-transitions between bus idling and sequences of violations. Other differences between biphase and ternary Manchester are managed automatically by the software, with no user input required.

Edge Conventions

Most Manchester encodings establish the beginning of the first bit by a first transition, hence an "overhead" edge. The center of the bit is then marked by a second transition, which is a "sampling" edge. Some Manchester implementations, however, sample the first bit on the first edge. The option R&S MXO4-K510 attempts to automatically detect this situation. Unfortunately, it is possible to trick the algorithm with waveforms that contain many (legitimate) violations. In these situations, the user can force a "First Edge" or "Second Edge" convention for handling edges. Edge sampling according to the "First Edge" convention is more likely to appear in biphase Manchester, but the software also supports this setting for ternary Manchester situations.

Bit Rate

Typically, a single bit rate is clearly specified in Manchester protocols; however, some implementations use a variable bit rate. If you do not specify it in the "Setup" tab, R&S MXO4-K510 by default automatically estimates it. However, with an estimated (hence, undefined) bit rate, fundamental ambiguities are possible in Manchester. In particular, sequences like "0000", "1111", "0101", "1010", and many situations involving "H" and "L" violations, cannot be decoded without it. The situation becomes even less defined with eventual Manchester coding violations. In these situations, you must provide a fixed ""Bit rate"" setting to bypass the software's estimation algorithm.

14.8.2 Manchester configuration

14.8.2.1 Manchester configuration settings

Access: "Menu" > "Apps" > "Protocol" tab > "Manchester" > "Setup".

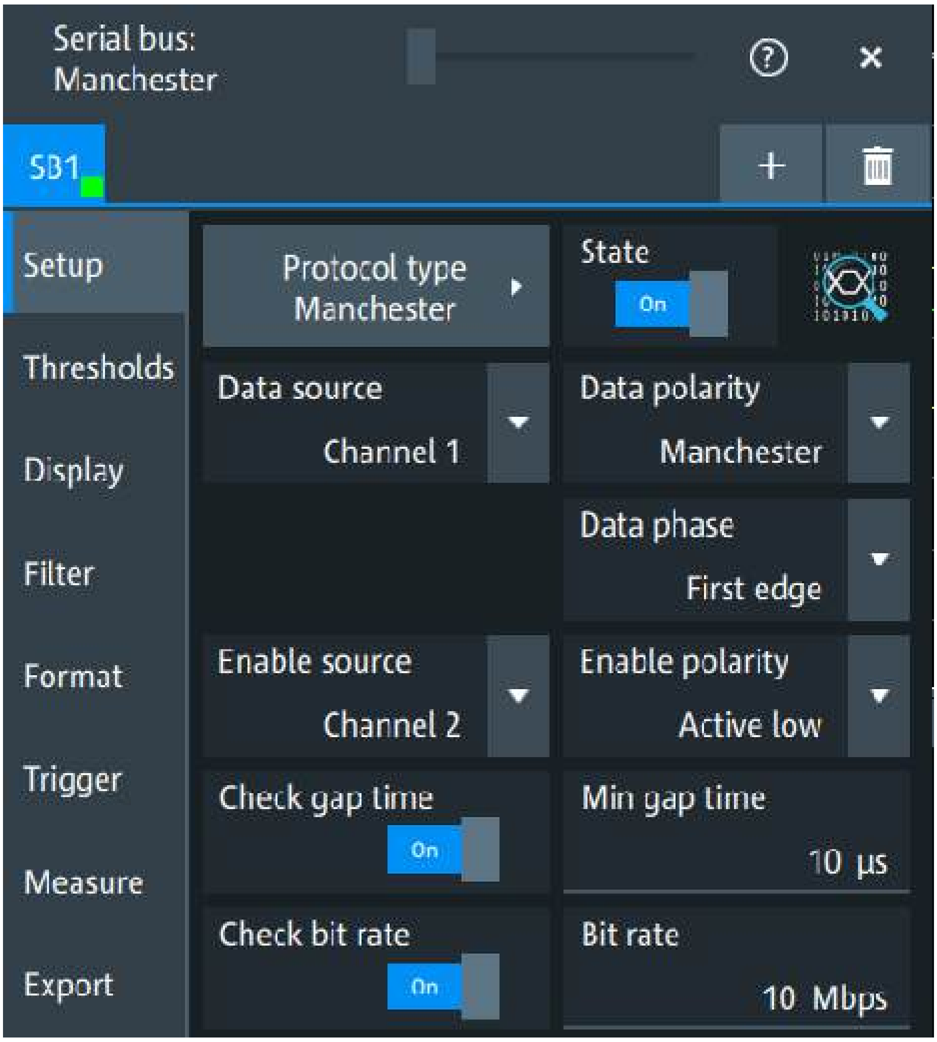


Figure 14-25: Setup dialog, Data polarity selects "Manchester" or "Manchester II"

Make sure that the tab of the correct serial bus is selected.

Protocol type
Selects the protocol type to be decoded.

Remote command:
`SBUS<sb>:TYPE` on page 1153

State

Enables the decoding of the selected bus. The signal icon of the bus appears on the signal bar.

Remote command:
SBUS<sb>[:STATe] on page 1152

Data source

Selects the source for the data signal.

Remote command:
SBUS<sb>:MANCh:DATA:SOURce on page 1341

Data polarity

Selects the polarity for the data signal, and hence the data representation convention, see Figure 14-24.

- "Manchester" (as per G. E. Thomas):
  - Low-to-high transition for logical 0
  - High-to-low transition for logical 1
- "Manchester II" (as per IEEE 802.3):
  - High-to-low transition for logical 0
  - Low-to-high transition for logical 1

Remote command:
SBUS<sb>:MANCh:DATA:POLarity on page 1341

Data phase

Defines the phase for the Manchester data signal. The available settings are:

- "First edge": the decoder captures data bits on the clock's rising edge (low-to-high transition).
  Select this option, if the 1st transition is no overhead and needs to be sampled.
- "Second edge": the decoder captures data bits on the clock's falling edge (high-to-low transition).
  Select this option, if the 1st edge is only an overhead transition from the idle state.

Note: The requirement to specify "First edge" or "Second edge" has the following background: An edge is always a transition from high to low or from low to high. In Manchester coding, however, if the signal comes from the idle state, there is right before the first valid edge always an overhead transition from idle to high or from idle to low. Some standards can regard this as a valid transition. Defining the phase avoids this potential ambiguity.
See also Special features of Manchester coding.

Remote command:
SBUS<sb>:MANCh:DATA:PHASe on page 1341

Enable source

Selects the source of the enable signal.

If you select any source other than "None", the "Enable polarity" becomes available, which selects the polarity of the enable signal.

Remote command:
SBUS<sb>:MANCh:ENABle:SOURce on page 1342
SBUS<sb>:MANCh:ENABle:POLarity on page 1342

Check gap time
Enables the detection of the minimum idle time between two frames during decoding. Also enables setting the "Min gap time". Optionally, if you set it, the decoder considers any longer idle time a gap. A known minimum gap time helps the decoder with frame synchronization.

Remote command:
SBUS<sb>:MANCh:MINGap:SELect on page 1342
SBUS<sb>:MANCh:MINGap:WIDTh on page 1343

Check bit rate
Enables setting the "Bit rate".
- If you define a bit rate, it is used for triggering and decoding.
- If you disable this option, the decoder calculates the bit rate.

Remote command:
SBUS<sb>:MANCh:BITRate:SELect on page 1343
SBUS<sb>:MANCh:BITRate:WIDTh on page 1343

14.8.2.2 Thresholds

Access: "Menu" > "Apps" > "Protocol" tab > "Manchester" > "Thresholds"

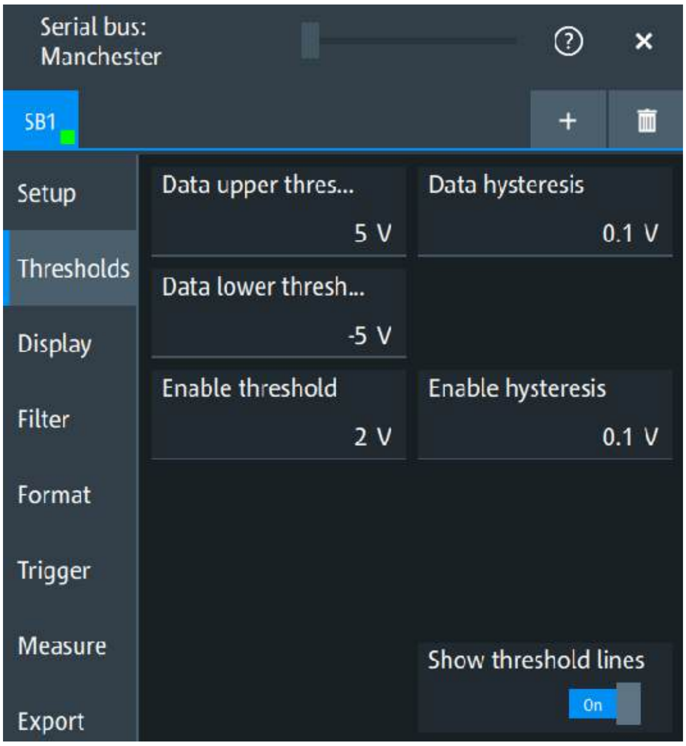


Figure 14-26: Thresholds dialog

Enter the values directly in the fields.

Data upper threshold, Data lower threshold, Data hysteresis
Sets the upper and lower threshold and the hysteresis for the data source channel.

Remote command:
`SBUS<sb>:MANCh:DATA:THUPper` on page 1344
`SBUS<sb>:MANCh:DATA:THLower` on page 1344
`SBUS<sb>:MANCh:DATA:HYSTeresis` on page 1344

Enable threshold, Enable hysteresis
Available only, if you have selected a source for the enable signal. See "Enable source" on page 568.

Sets the middle threshold and the hysteresis for the enable source channel.

Remote command:
`SBUS<sb>:MANCh:ENABle:THReshold` on page 1345
`SBUS<sb>:MANCh:ENABle:HYSTeresis` on page 1345

Show threshold lines
If enabled, the threshold lines are displayed in the diagram.

The label of the threshold line is set according to the signal that it is referring to, see also Show threshold lines.

Remote command:
`SBUS<sb>:THReshold` on page 1155

14.8.2.3 Display settings

For details about the display settings, see Section 14.1.3.1, "Display settings", on page 435.

Decode layer
Selects the decode layer.

Decoding is performed in several steps, and the results are presented in the decode table. The decode layer selects an interim step for which the decoding result is shown in the honeycomb display.

"Off"	Disables the display of the decode layer.
"Edges"	Enables the display of all edges.
"Bits"	Enables the display of all encoded bits.

Data format
See "Data format" on page 436.

14.8.2.4 Manchester symbols

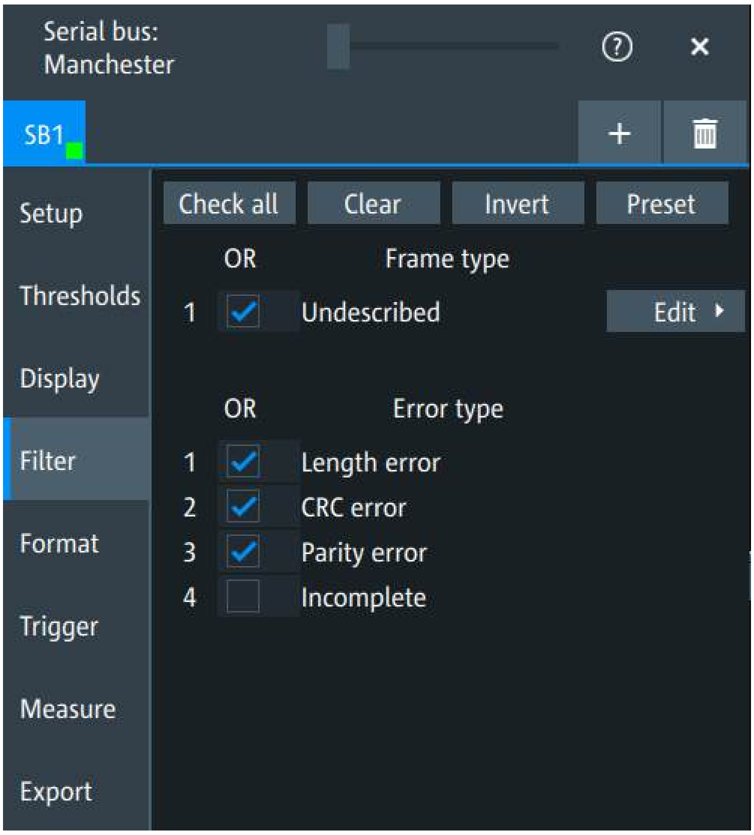
There is no symbolic translation for the Manchester protocol, because of the custom frame definitions. See Section 14.8.4, "Manchester frame format configuration", on page 574.

14.8.3 Manchester filter

Access: "Menu" > "Apps" > "Protocol" tab > "Manchester" > "Filter" tab

Although Manchester has a free format description according to section Section 14.8.4, "Manchester frame format configuration", on page 574, we provide a dynamic filter solution that can adapt to custom frames and fields in the decoded events.

In the "Filter" tab, you can define the settings to display only the frames that match the selected filter conditions.



Check all, Clear, Invert, Preset
The following settings help you select the frames and errors you want to filter for. Only the frames and error types that match the selected filter conditions are displayed.

"Check all"	Enables the filter for all available frames and error types.
"Clear"	Disables the filter for all available frames and error types.
"Invert"	Inverts the current state of the frame and error types: all frames and error types that were enabled are disabled and vice versa.

"Preset" Presets the state of the selected frames and error types.

Remote command:
SBUS<sb>:MANCh:FILTer:CHKall on page 1346
SBUS<sb>:MANCh:FILTer:CLR on page 1347
SBUS<sb>:MANCh:FILTer:INVert on page 1347
SBUS<sb>:MANCh:FILTer:RST on page 1347

Enable
Enables the filtering on Manchester frames. Only the frames that match the selected filter conditions are displayed.

Remote command:
SBUS<sb>:MANCh:FILTer:FRENable on page 1350
SBUS<sb>:MANCh:FILTer:FRAMe<fr>:ENABle on page 1350

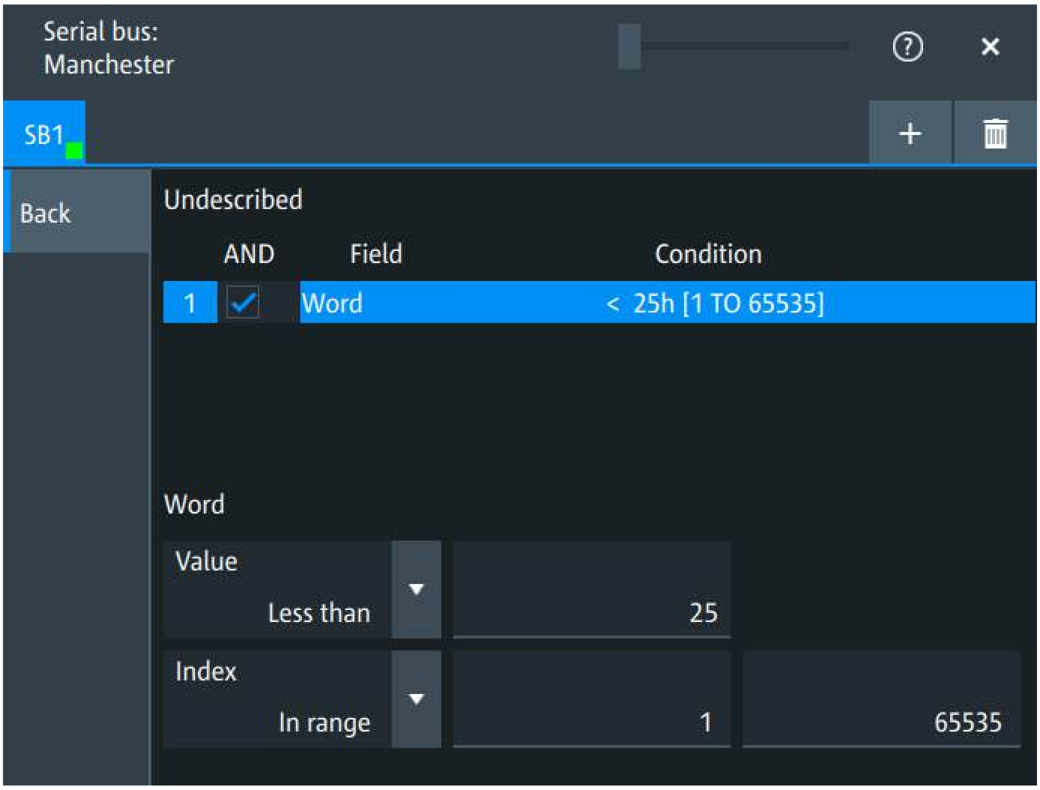
Frame type
Selects the frame type that you want to display. You can filter all enabled frame types simultaneously.

For selected frame types, you can also specify conditions for the value of the fields in the "Edit" dialog.

The only frame type available by default is "Undescribed", because the Manchester protocol supports custom coding.

However, the frame formats that you define appear in this list, too. See Section 14.8.4, "Manchester frame format configuration", on page 574.

Edit
Opens a dialog to define the details of the selected frame.



"Field"

Enables the field type that you want to filter on for the selected frame. For the default "Undescribed" frame, the only available field type is "Word", which is the payload component of an undescribed frame.
See "Frame type" on page 572.
However, the field formats that you define appear in this list, too. See Section 14.8.4, "Manchester frame format configuration", on page 574.

Remote command:
`SBUS<sb>:MANCh:FILTer:FIENable` on page 1349
`SBUS<sb>:MANCh:FILTer:FRAMe<fr>:FLD<fl>:ENABle` on page 1349

"Condition"

Displays the value condition for the selected field.

Remote command:
`SBUS<sb>:MANCh:FILTer:BIT` on page 1347
`SBUS<sb>:MANCh:FILTer:FRAMe<fr>:FLD<fl>:BIT` on page 1347

"Value" The data setup consists of a comparison condition and one or two data patterns.

Remote command:
SBUS<sb>:MANCh:FILTer:DMAX on page 1348
SBUS<sb>:MANCh:FILTer:FRAMe<fr>:FLD<fl>:DMAX on page 1348
SBUS<sb>:MANCh:FILTer:DMIN on page 1348
SBUS<sb>:MANCh:FILTer:FRAMe<fr>:FLD<fl>:DMIN on page 1348
SBUS<sb>:MANCh:FILTer:DOPerator on page 1349
SBUS<sb>:MANCh:FILTer:FRAMe<fr>:FLD<fl>:DOPerator on page 1349

"Index" The index setup consists of a comparison condition and one or two index values.

Remote command:
SBUS<sb>:MANCh:FILTer:IMAX on page 1350
SBUS<sb>:MANCh:FILTer:FRAMe<fr>:FLD<fl>:IMAX on page 1350
SBUS<sb>:MANCh:FILTer:IMIN on page 1350
SBUS<sb>:MANCh:FILTer:FRAMe<fr>:FLD<fl>:IMIN on page 1350
SBUS<sb>:MANCh:FILTer:IOPerator on page 1351
SBUS<sb>:MANCh:FILTer:FRAMe<fr>:FLD<fl>:IOPerator on page 1351

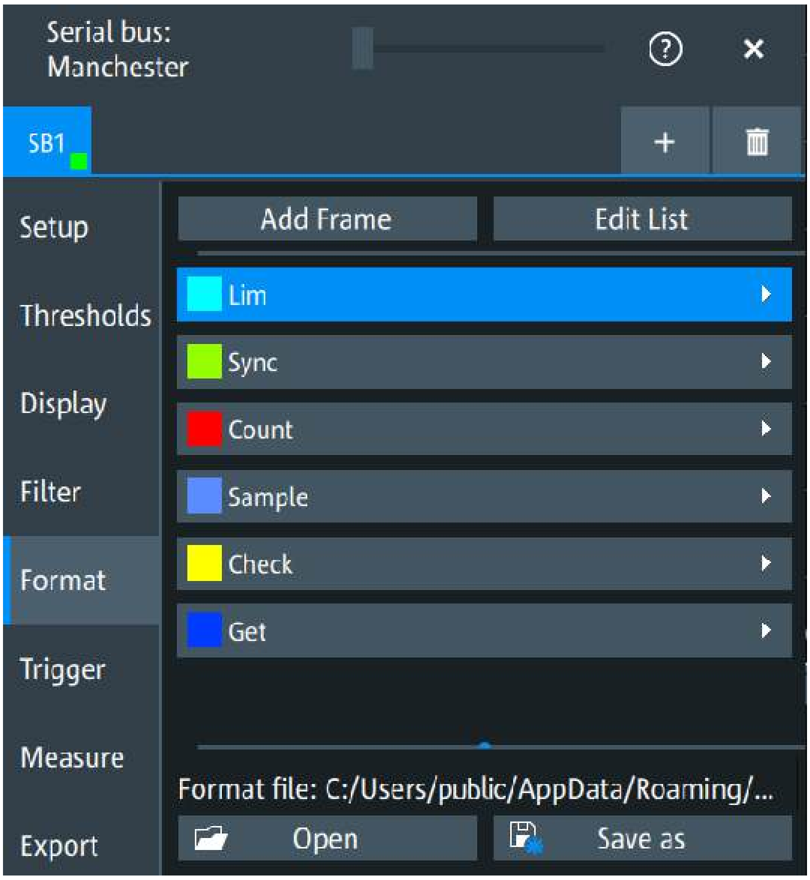
Error type
Enables filtering on the selected error type.

The available error types are "Length error", "CRC error", "Parity error", "Incomplete".

Remote command:
SBUS<sb>:MANCh:FILTer:ERENable on page 1348
SBUS<sb>:MANCh:FILTer:ERRor<n>:ENABle on page 1348

14.8.4 Manchester frame format configuration

This dialog enables you to describe the generic format and logical structure of your Manchester protocol. To do so, you can create customized frame descriptions of various structures and lengths.



A frame format description (or *frame description*, for short) is represented by one line in the frame format description list (or *frame list*, for short). Describing a frame format requires assigning it a name and specifying field descriptions, which must be sequential and complete. No gaps are allowed, because the field descriptions are used to calculate the start position of the next frame.

See also:

- "Frame name" on page 578
- "Frame Color" on page 579

The frame identification is executed top down, in the order in which the frame formats are described in the frame list. This provides a hierarchy of criteria for identifying frames. A frame is identified when all user-defined conditions of the field descriptions are met. See "Condition" on page 580. These conditions can be regarded as related by the Boolean `AND` operator.

A condition can also locate a synchronization pattern, specified by the equal operator in the field. For example, if you define a "Preamble" field with the condition *=FFFFFFFF*, the decoder scans the data for this pattern, and then synchronizes to it.

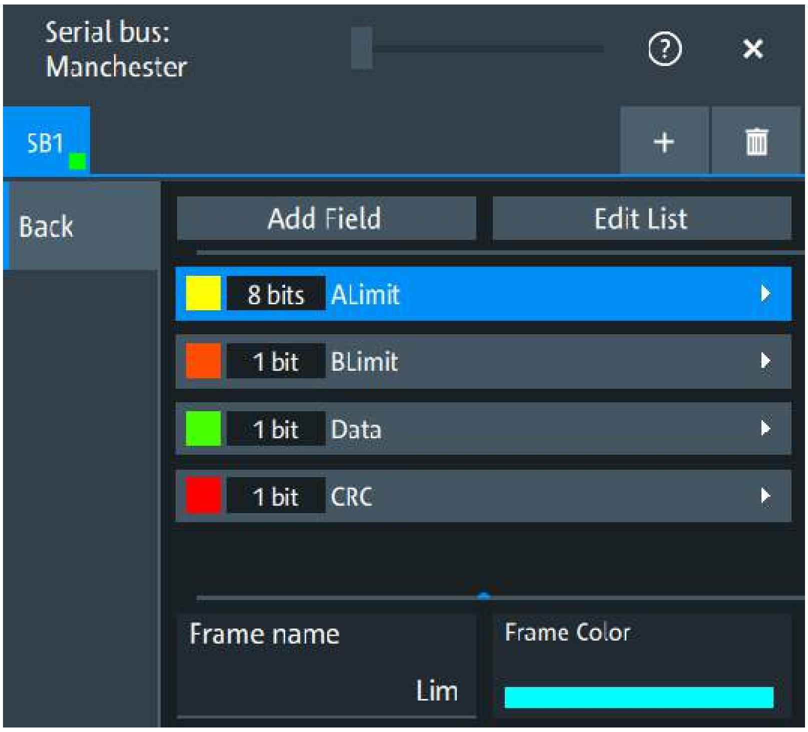
If no frame description is suitable to identify an incoming frame, by default such a "missed" frame is reproduced as "Undescribed Bits" in the honeycomb display. These bits are not shown in the results table.

If you have not defined an "equal" operator for any field of a frame description, you can use this description to positively identify each kind of frame. Hence, it "catches" every frame, even if there are other frame descriptions to follow in the frame list. Therefore, if you use a "catch all" frame description, we recommend to place it at the end of the frame list, otherwise it overwrites any subsequent frame description. However, instead of using a "catch all" frame description, consider using the default "Undescribed Bits" display mentioned above.

It is in your responsibility to define unambiguous descriptions for each frame type.

Add Frame
Creates a new **frame description** and adds it to the end of the frame list.

When you add a frame or when you click an existing entry in the frame list, a dialog opens that allows the following:
- Add Field
- Edit List
- Frame name
- Frame Color



When you return to the frame list by using the "Back" button, a dialog opens that allows the following:
- Add Frame
- Edit List
- Open
- Save as

The number of frame descriptions is limited to 100.

Remote command:
`SBUS<sb>:MANCh:FORMat:ADDFrame` on page 1352

Edit List

Enables editing the frame list. If enabled, you can delete a frame description by clicking its "Delete" icon. In a list with several entries, you can move frame descriptions up or down by clicking the arrow buttons. To exit the editing mode, click "Edit List" again.

Remote command:
SBUS<sb>:MANCh:FORMat:CLR on page 1352
SBUS<sb>:MANCh:FORMat:FCOunt? on page 1353

Open

Opens a dialog for loading an existing list of frame descriptions in XML file format.

Remote command:
SBUS<sb>:MANCh:FORMat:LOAD on page 1352

Save as

Opens a dialog for saving your current list of frame descriptions to an XML file. Saved frame descriptions can support efficient and convenient working.

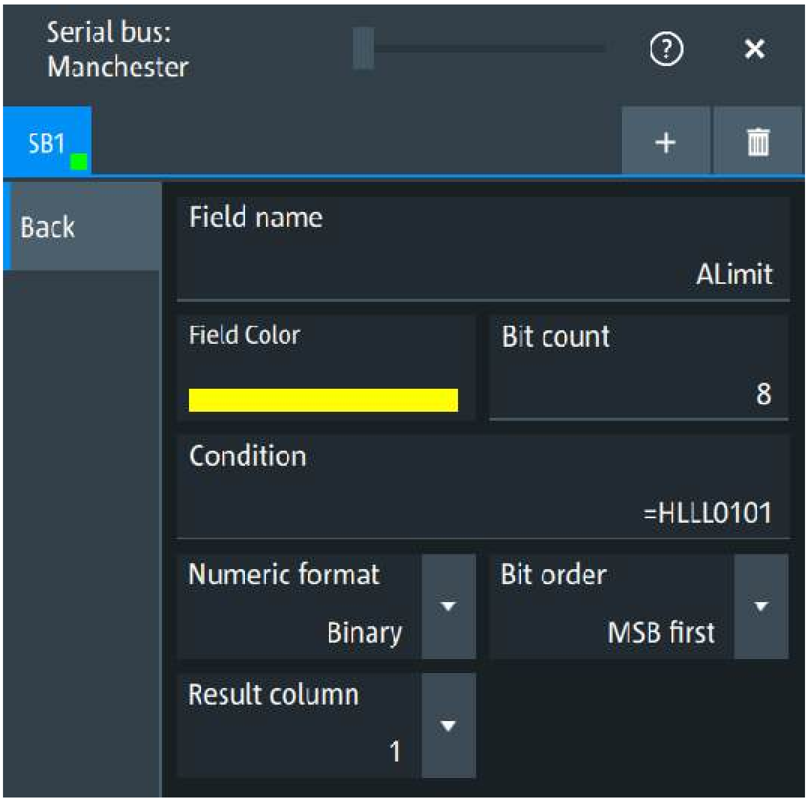
Remote command:
SBUS<sb>:MANCh:FORMat:SAVE on page 1352

Add Field

Creates a new **field description** for the currently selected frame description and adds it to the end of the field list.

When you add a field or when you click an existing entry in the field list, a dialog opens that allows the following for describing a field:

- Field name
- Field Color
- Bit count
- Condition
- Numeric format
- Bit order
- Result column



When you return to the field list by using the "Back" button, a dialog opens that allows the following:

- Add Field
- Edit List
- Frame name
- Frame Color

The number of field descriptions is limited to 100.

Remote command:
`SBUS<sb>:MANCh:FORMat:FRAMe<fr>:ADDField` on page 1353

Edit List
Enables editing the field list. If enabled, you can delete a field description by clicking its "Delete" icon. In a list with several entries, you can move field descriptions up or down by clicking the arrow buttons. To exit the editing mode, click "Edit List" again.

Remote command:
`SBUS<sb>:MANCh:FORMat:FRAMe<fr>:FLDCount?` on page 1353

Frame name
Specifies an arbitrary name to label the currently selected frame description. Ideally, use speaking names according to the specifications of the applicable protocol standard. For example, a DALI frame description can specify the frames "FW-ShortAddr-directArc", "FW-ShortAddr-cmd", "FW-GrpAddr-directArc", "FW-GrpAddr-cmd", "FW-Broadcast-directArc", "FW-Broadcast-cmd", "FW-special-cmd", and "BACKWARD". Frame names do not have to be unique and are only intended to support you.

Remote command:
SBUS<sb>:MANCh:FORMat:FRAMe<fr>:NAME on page 1353

Frame Color
Selects a color for labeling the currently selected frame description.

Remote command:
SBUS<sb>:MANCh:FORMat:FRAMe<fr>:COLor on page 1354

Field name
Specifies an arbitrary name for the currently selected field description. Ideally, use speaking names.

Field names do not have to be unique and are only intended to support you.

Remote command:
SBUS<sb>:MANCh:FORMat:FRAMe<fr>:FLD<fl>:NAME on page 1354

Field Color
Opens a dialog to select the color representation of different fields in the honeycomb display. Assigning specific colors can help you to interpret the decode results more easily. You can select a predefined color or specify a "User-defined color".

Remote command:
SBUS<sb>:MANCh:FORMat:FRAMe<fr>:FLD<fl>:COLor on page 1354

Bit count
Specifies the bit count and hence the length of the field represented by the currently selected field description. You can click the field to open a keypad dialog, which also displays the minimum and maximum permitted values. Its "Min", "Max" or "Reset" buttons can set the bit count to the minimum, maximum or reset value. The "Inc" or "Dec" button increases or decreases the value in steps of 1 or 10, depending on the selected step size button. The "CE" button sets the bit count to the value that was used before the keypad was displayed.

If, for a given bit count, the Condition value is longer, it is truncated. If the condition value is shorter, it is padded with 0. Both truncation and padding occur at the left side of the condition value and relate to the Bit order.

Examples:
- If "Condition" is "=100" and the "Bit order" is "MSB first":
  – If "Bit count" is 2, the truncated condition is "=00"
  – If "Bit count" is 4, the padded condition is "=0100"
- If "Condition" is "=100" and the "Bit order" is "LSB first" (accordingly, the condition in "MSB first" format would be "=001"):
  – If "Bit count" is 2, the truncated condition is "=00" for "LSB first" and "=00" for "MSB first"
  – If "Bit count" is 4, the padded condition is "=0100" for "LSB first" and "=0010" for "MSB first"

Remote command:
SBUS<sb>:MANCh:FORMat:FRAMe<fr>:FLD<fl>:BITCount on page 1355

Condition

Specifies a condition for the field, typically a bit sequence that is used for pattern-matching to identify the frame.

Use this text box to apply various conditions and functionalities for a field. Among others, you can use it to identify mandatory values, such as CRC checksum or ID, which help to identify a frame. The condition value must match also the Numeric format and Bit order.

The following conditions are implemented:

"= (equal)" The **equal** operator (represented by the "=" sign) defines a pattern for the field to match. Valid condition entries are characters that match the field's defined "Format", "Bit order", and "Bits". In binary format, for example, valid characters are "1", "0", "H" (high), and "L" (low).

Three cases have to be distinguished (cases A, B1, and B2), depending on the presence of a Variable Length Array: [] in the same frame description:

- **Case A**: If there is **no** "Variable Length Array" field, then each field marked with the equal operator acts as a key to identify a frame type. Only if all these fields match up with the expected value, the frame type is identified.
- **Cases B1 and B2**: If there **is** a "Variable Length Array" field, then the equal operator has two different functionalities, depending on the position of the equal-operator field within the frame description:
  – **B1**: If the field is located *anywhere before* the "Variable Length Array" field, the condition acts as a key to identify the frame type by matching the starting bits of the frame (its preamble), as in case A.
  – **B2**: If the field is located *immediately after* the "Variable Length Array" field, the condition acts as an array delimiter by matching the bit sequence immediately following the variable-length field.
  (Note: If the field, which is marked with the equal operator, is located after the "Variable Length Array" field, but *not* immediately after it, the decode result is unpredictable.)

Note: Code violations. Typically, Manchester protocols use code violations for synchronization. The states "H" and "L", supported by the equal operator in binary format, mark that a transition is expected at this bit, but only a high or low signal is found.
Examples for the MVB protocol:

- Primary delimiter: "=*1LH0LH000*"
- Secondary delimiter: "=*0000LH0LH*"

For more details on the violation symbols "H" and "L", see Section 14.8.1.1, "Special features of Manchester coding", on page 565.

Also, the length of the pattern must correspond to the bit field length, otherwise the results are unpredictable.

"[ ] (array)"

The **array** operator (represented by the "[" and "]" bracket signs) defines the number of permissible repetitions of the field.

Example: Fixed-Length Array: [n]

The length parameter "n" is a decimal number > 0, which determines that the field is repeated n times within the frame. If, for example, the Bit count is 8, then the array operator identifies n fields of 8-bit length, and present them in the results table and honeycomb display with the specified name and color.

A fixed-length array is treated the same as other fields, except the real length of such an array is n · bit count.

Example: Variable Length Array: []

This array operator with empty "[" and "]" bracket signs does not determine a fixed size array. The field could be repeated any number of times, including 0 times. As a result, the field and the frame are of unspecified length (a situation that covers typical use cases).

The length of the frame is then determined by the end of frame condition, which can be an operator or a gap.

For processing reasons, only one (1) variable length array is supported in a frame, and a delimiter must follow immediately in the next field after it. This is required to enable the software to correctly terminate the array. Otherwise the bits could not be assigned correctly, and it would not be possible to determine where a repletion starts and where it ends. With an end of frame condition, the software can calculate the length of one single array within a frame. But if there were more arrays, it would be impossible to know which array was how long.

The variable length array can also be the last field of a frame. In this case, no delimiter is required. If decoded successfully, the detailed view in the results table shows the elements of the array. If the field name of the array is "Data", then the detail view of result table displays the elements with an array index as "Data: 1", "Data: 2" ... etc.

If the variable length array field is selected, it is shown as array [n], where n is the actual size detected in the waveform.

As an exception to the rule, it is permissible to assign the variable length array to consecutive fields. In this case, the fields are treated as a structure which is repeated. For example, if two consecutive fields are defined as A[] and B[], the decoder creates a sequence of ABABAB until the end condition has been detected.

Note: It is possible to combine check functions in a dynamic array. In the example above, if B[] is extended by odd(1), with "1" being the index of A[], then B checks the parity for each index of A.

"crc5usb(n-m)"	The **crc 5-bit** operator performs a check for a 5-bit CRC function using the polynomial as defined by the USB standard. n and m define the index range for the CRC check. For example, if the CRC shall check fields 1 to 4, the function shall be written "crc5usb(1-5)". If the range of the CRC check includes an array, all elements in the array is included in the CRC check. If the check fails, the CRC field is marked as "CRC error" in the result details and displayed in the color red in the honeycomb display. The frame that contains the field is marked in the same way, except if another higher priority error is found within this frame.
"odd(n-m), even(n-m)"	The "**parity**" operators perform checks on odd or even parity in the given index range n to m. Odd parity is fulfilled if the count of "1" bits in the range including the parity bit is odd. Even parity is fulfilled if the count of "1" bits in the range including the parity bit is even. If the parity check fails, the parity field is marked as "CRC error" in the result details and displayed in red color in the honeycomb display. The frame that contains the field is marked in the same way, except if another higher priority error is found within this frame.

Remote command:
`SBUS<sb>:MANCh:FORMat:FRAMe<fr>:FLD<fl>:CONDition` on page 1355

Numeric format

Selects a numerical format for the Condition value: decimal, hex, octal or binary.

The following rules apply:
- If the condition value contains at least one "H", "h", "L", "l", "X", "x", and the remaining characters only contain "1" and/or "0", the numeric format is automatically interpreted as binary, regardless of its definition.
- The wildcard characters "x" and "X" are supported only in binary format.
  Examples: If the numeric format is set to be "HEX":
  – "=1HL111000" is valid (read as binary)
  – "=0x10101" is valid (read as binary, the "x" is interpreted here as a wild card)
  – "=1010" is valid (read as HEX, with a total of 16 bits)
  – "=0x5A" is valid (read as HEX "5A", since "0x" is a valid HEX prefix; nevertheless, it is recommended to enter "5A" instead)
  – "=5X12" is invalid
  – "=1H33" is invalid

Remote command:
`SBUS<sb>:MANCh:FORMat:FRAMe<fr>:FLD<fl>:FORMat` on page 1356

Bit order

Selects, in which order the bits of a field's Condition value are evaluated:
- "LSB first": little endian, least significant bit first
- "MSB first": big endian, most significant bit first

Remote command:
`SBUS<sb>:MANCh:FORMat:FRAMe<fr>:FLD<fl>:BITorder` on page 1356

Result column
Determines which field is displayed in which result column of the decode table.

- Selecting "-" (no index) means that the result is not displayed.
- Selecting "1", "2" or "3" means that the result is displayed in the 1st, 2nd or 3rd result column, that the decode table supports. Each of the three result columns has to be unique for each frame type. But to display unrelated information for different frame types, you can define different result columns.

Remote command:
`SBUS<sb>:MANCh:FORMat:FRAMe<fr>:FLD<fl>:CLMN` on page 1357

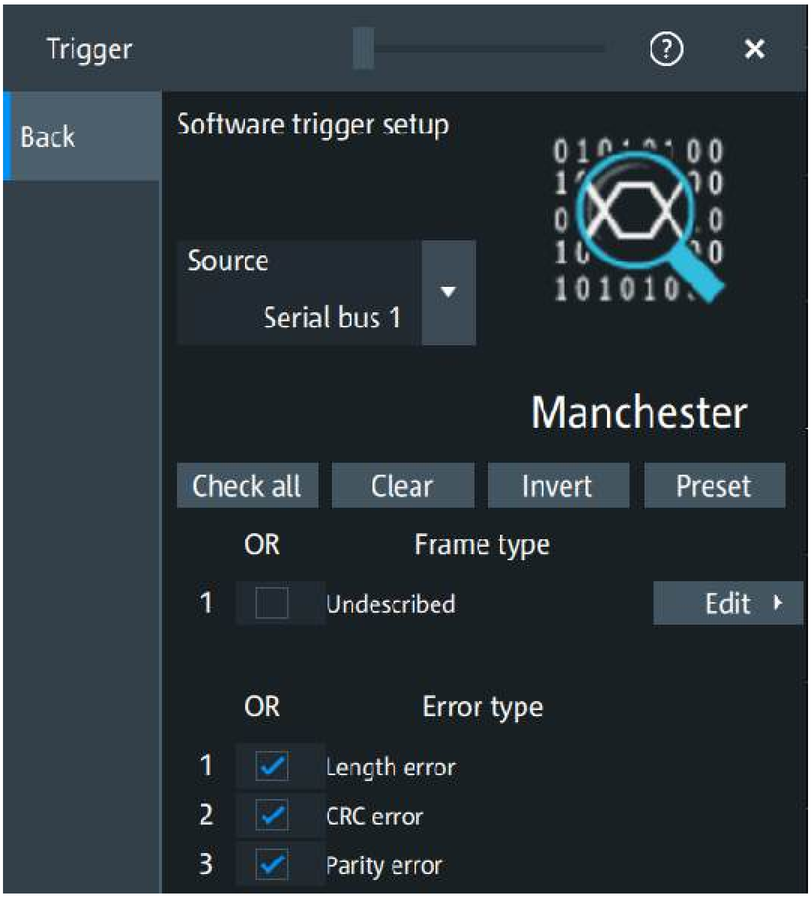
14.8.5 Manchester software trigger

14.8.5.1 Setup A trigger

Before setting up the software trigger for the protocols, a trigger A event needs to be set up.

14.8.5.2 Software trigger settings

Access: "Menu" > "Apps" > "Protocol" tab > "Manchester" > "Trigger" tab > "Setup Software Trigger"



In the "Software Trigger" tab, you can define the settings to trigger on the frames that match the selected filter conditions.

Check all, Clear, Invert, Preset

The following settings help you select the frames and errors you want to trigger on.

"Check all"	Enables the software trigger for all available frames and error types.
"Clear"	Disables the software trigger for all available frames and error types.
"Invert"	Inverts the current state of the frame and error types for the software trigger: all frames and error types that were enabled are disabled and vice versa.
"Preset"	Presets the state of the selected frames and error types for the software trigger.

Remote command:

`TRIGger:SBSW:MANCh:CHKall` on page 1358

`TRIGger:SBSW:MANCh:CLR` on page 1358

`TRIGger:SBSW:MANCh:INVert` on page 1358

`TRIGger:SBSW:MANCh:RST` on page 1358

Frame type

Selects the frame type that you want to trigger on. You can trigger on all enabled frame types simultaneously.

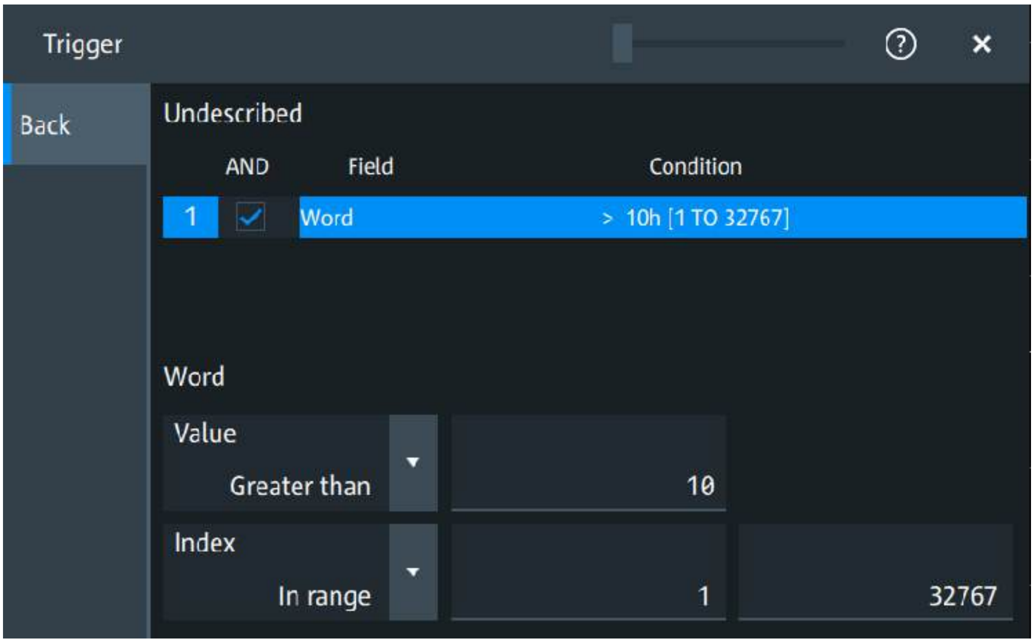
For each frame type, you can also specify conditions for the value of the fields in the "Edit" dialog.

The only frame type available by default is "Undescribed", because the Manchester protocol supports custom coding.

However, the frame formats that you define appear in this list, too. See Section 14.8.4, "Manchester frame format configuration", on page 574.

Remote command:
`TRIGger:SBSW:MANCh:FRENable` on page 1359
`TRIGger:SBSW:MANCh:FRAMe<fr>:ENABle` on page 1359

Edit
Some trigger types have additional settings that can be defined. In this case, the "Set details" button appears next to "Type" the function. Open it for a detailed definition of the trigger conditions.



"Field"

Enables the field type that you want to trigger on for the selected frame.
For the default "Undescribed" frame, the only available field type is "Word". See "Frame type" on page 584.
However, the field formats that you define appear in this list, too. See Section 14.8.4, "Manchester frame format configuration", on page 574.

Remote command:
`TRIGger:SBSW:MANCh:FIENable` on page 1360
`TRIGger:SBSW:MANCh:FRAMe<fr>:FLD<fl>:ENABle` on page 1360

"Condition" Displays the value condition for the selected field.

Remote command:
TRIGger:SBSW:MANCh:BIT on page 1359
TRIGger:SBSW:MANCh:FRAMe<fr>:FLD<fl>:BIT on page 1359

"Value" The data setup consists of a comparison condition and one or two data patterns.

Remote command:
TRIGger:SBSW:MANCh:DMAX on page 1359
TRIGger:SBSW:MANCh:FRAMe<fr>:FLD<fl>:DMAX on page 1359
TRIGger:SBSW:MANCh:DMIN on page 1360
TRIGger:SBSW:MANCh:FRAMe<fr>:FLD<fl>:DMIN on page 1360
TRIGger:SBSW:MANCh:DOPerator on page 1360
TRIGger:SBSW:MANCh:FRAMe<fr>:FLD<fl>:DOPerator on page 1360

"Index" The index setup consists of a comparison condition and one or two index values.

Remote command:
TRIGger:SBSW:MANCh:IMAX on page 1361
TRIGger:SBSW:MANCh:FRAMe<fr>:FLD<fl>:IMAX on page 1361
TRIGger:SBSW:MANCh:IMIN on page 1361
TRIGger:SBSW:MANCh:FRAMe<fr>:FLD<fl>:IMIN on page 1361
TRIGger:SBSW:MANCh:IOPerator on page 1362
TRIGger:SBSW:MANCh:FRAMe<fr>:FLD<fl>:IOPerator on page 1362

Error type
Enables triggering on the selected error type.

The available error types are "Length error", "CRC error", "Parity error".

Remote command:
TRIGger:SBSW:MANCh:ERENable on page 1362
TRIGger:SBSW:MANCh:ERRor<m>:ENABle on page 1362

14.8.6 Measure

The "Setup Measurement" button opens the dialog for automatic measurements in the "Protocol" category for the selected serial bus.

See Section 10.2.6.2, "Settings for protocol measurements", on page 289.

14.8.7 Performing Manchester decoding

This section explains step by step how to configure and decode the Manchester bus.

14.8.7.1 Configuring Manchester signals

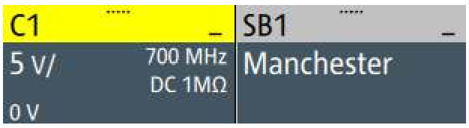
For configuration, assign the lines to the input channels, and define the active states and the logical thresholds.

For details on configuration settings, see Section 14.8.2, "Manchester configuration", on page 567.

1. Tap the "+ Bus" activator in the bottom right of the screen.

2. Select the tab of the bus that you want to set up, for example "SB1".
3. Tap the "Protocol type" button. Select the protocol: "Manchester".
4. Tap on "State" to enable the decoding.

   A Manchester shortcut appears at the bottom left of the screen. Tap the shortcut for a quick access to the "Manchester" dialog settings.



14.8.7.2 Exporting decode results

Once a decode has been completed, you can generate an export of all decode results.

Prerequisites: A bus is configured for the Manchester protocol and decoded.

1. Tap on the "Manchester" shortcut.
2. Tap on the "Export" tab.
3. If necessary, enable "Include details".
4. If necessary, enable "Include timing".
5. Select the "File type".

   An export file is saved in the selected directory.

The Manchester export file contains the following fields:

- A list of all decoded frames:
  - `Index`

  - "State" of the frame
  - "Start"
  - "Frame type" of the frame
  - "Result 1", the result displayed in the 1st result column
  - "Result 2", the result displayed in the 2nd result column
  - "Result 3", the result displayed in the 3rd result column
  - "Bit rate", the bit rate of the frame
- The frame details include the following fields:
  - "Index", the index of the field
  - "State", the state of the field
  - "Label", the name of the field
  - "Value", the data value of the field

Example Manchester export file

```
Index,State,Type,Result 1,Result 2,Result 3,Bit-rate
1,'OK','Cmd/Stat',3h,049h,1h,14280
2,'OK','Data',4h,1234h,0h,14290
3,'OK','Data',4h,5678h,1h,14280
4,'OK','Data',4h,9ABCh,0h,14280
5,'OK','Data',4h,DEF0h,1h,14280
6,'OK','Cmd/Stat',3h,000h,0h,14270
7,'OK','Cmd/Stat',3h,083h,1h,14280
8,'PAR','Cmd/Stat',3h,083h,0h,14280

Details frame 1
Index,Label,State,Value
1,'Sync','OK',3h
2,'RTA','OK',01h
3,'Info','OK',049h
4,'P','OK',1h

Details frame 2
Index,Label,State,Value
1,'Sync','OK',4h
2,'Data','OK',1234h
3,'P','OK',0h

(...)
```

14.8.8 Manchester decode results

When the configuration of the serial bus is complete, the signal can be decoded:

1. Open the "Serial Bus" dialog for the respective bus.
2. In the "Setup" tab, enable "State".

3. In the "Display" tab, enable "Show decode table".

For a description of the display settings, see also Section 14.1.3.1, "Display settings", on page 435.

For a description of how to synchronize the displayed results, see Section 14.1.3.2, "Display synchronization", on page 437.

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

Decode results table

The "Decode results" table contains information about all decoded frames.

Figure 14-27: Decoded Manchester signal

The decode results table contains information about all decoded frames.

Table 14-12: Content of the decode results table

Column	Description
Index	Frame count
State	Overall state of the frame
Start	Start time of the frame
Frame type	The type of the frame

Column	Description
Result	Data displayed in the 1st, 2nd and 3rd results column. For "undescribed" frames (see Frame type), you can select the data format in the "Display" tab. For other frames, the "Format" table controls the format of each field. See Section 14.8.4, "Manchester frame format configuration", on page 574.
Bit rate	Value of the bit rate

When you select a frame in the decode results table, its field content is shown in the details table to the right.

Table 14-13: Content of the frame details table

Column	Description
Index	Number of the decoded field
Label	Name of the field
State	State of the field
Value	Value of the field

Data format

You can select various data formats for the values displayed in the decode table and in the combs of the decoded signal.

Remote command:

- `SBUS<sb>:FORMat` on page 1154

Remote commands

Remote commands to retrieve decode results are described in Section 18.17.9.5, "Decode results", on page 1363.

14.9 CAN (automotive electronics, option R&S MXO4-K520)

CAN is the Controller Area Network, a bus system designed by Bosch for use within automotive network architecture, for example, for brake, power train and engine management. Today, it is also used in many other systems, for example, in industrial machines, aerospace, subsea, merchant marine.

With the MXO 4 you can decode frames from some of the most common CAN protocols standards:

- Classical CAN (CAN 2.0): includes the standard frame format (11-bit identifier) and the extended frame format (29-bit identifier).
- CAN FD: CAN with flexible data rate. It is an extension of the classical CAN protocol and allows for increased data rates and payloads. It is backward compatible with CAN 2.0.

- CAN XL: an advanced version of the CAN protocol designed to handle higher data rates and larger payloads compared to classical CAN and CAN FD.

Requirements

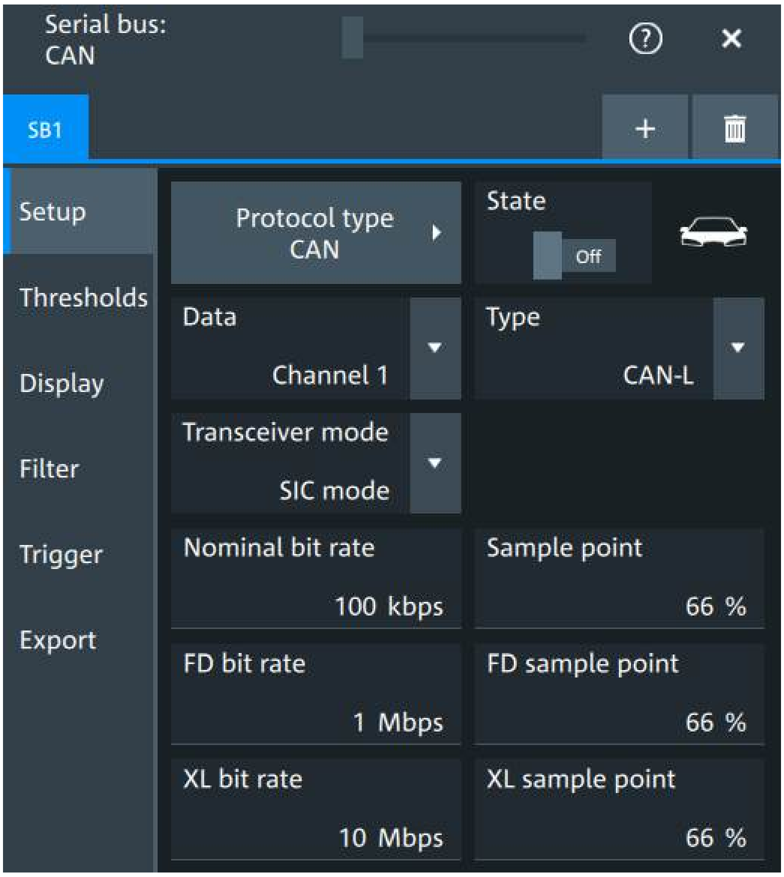
For performing CAN decode measurements, you need the following:

- MXO 4 with 1 available channel. The channel can be:
  - Analog channels (C1-C4)
  - Logic channels (D0-D15) (requires option R&S MXO4-B1)
- One probe
- Option R&S MXO4-K520

14.9.1 CAN configuration

14.9.1.1 CAN configuration settings

Access: "Menu" > "Apps" > "Protocol" tab > "CAN" > "Setup".



Make sure that the tab of the correct serial bus is selected.

Protocol type

Selects the protocol type to be decoded.

Remote command:
`SBUS<sb>:TYPE` on page 1153

State

Enables the decoding of the selected bus. The signal icon of the bus appears on the signal bar.

Remote command:
`SBUS<sb>[:STATe]` on page 1152

Data

Sets the source of the selected data line.

Remote command:
`SBUS<sb>:CAN:SOURce` on page 1369

Type
Selects the CAN-High or CAN-Low line. CAN uses both lines for differential signal transmission.

If you measure with a differential probe, connect the probe to both CAN-H and CAN-L lines, and select the data "Type" = *CAN-H*.

If you use a single-ended probe, connect the probe to either CAN_L or CAN_H, and select the data type accordingly.

Remote command:
`SBUS<sb>:CAN:TYPE` on page 1369

Transceiver mode
Selects the transceiver mode for the CAN decoding.

"SIC mode" The signal improvement capability (SIC) mode supports bit rates up to 8 Mbit/s.

"FAST mode" The fast mode supports bit rates up to 20 Mbit/s.

Remote command:
`SBUS<sb>:CAN:TRCVmode` on page 1372

Nominal bit rate
Sets the number of transmitted bits per second.

Remote command:
`SBUS<sb>:CAN:BITRate` on page 1369

Sample point
Sets the position of the sample point within the bit in percent of the nominal bit time.

Remote command:
`SBUS<sb>:CAN:SAMPlepoint` on page 1369

FD bit rate
Sets the number of transmitted bits per second for the CAN FD frame.

Remote command:
`SBUS<sb>:CAN:FDATa:DBITrate` on page 1370

FD sample point
Sets the position of the sample point within the bit in percent of the nominal bit time for the CAN FD frame.

Remote command:
`SBUS<sb>:CAN:FDATa:SAMPlepoint` on page 1370

XL bit rate
Sets the number of transmitted bits per second for the CAN XL frame.

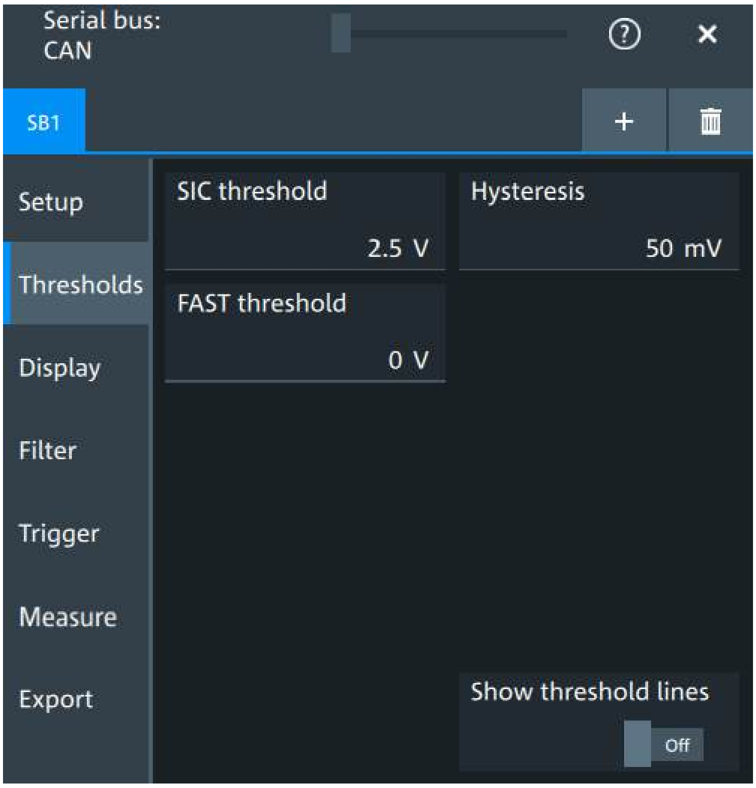
Remote command:
`SBUS<sb>:CAN:XDATa:DBITrate` on page 1371

XL sample point
Sets the position of the sample point within the bit in percent of the nominal bit time for the CAN XL frame.

Remote command:
`SBUS<sb>:CAN:XDATa:SAMPlepoint` on page 1372

14.9.1.2 Threshold settings

Access: "Menu" > "Apps" > "Protocol" tab > "CAN" > "Thresholds".



Threshold
Sets the threshold for the SIC and Fast channels. Enter the value directly in the fields.

Additional to the threshold, you can also set a hysteresis.

Remote command:
`SBUS<sb>:CAN:FAST:HYSTeresis` on page 1371
`SBUS<sb>:CAN:FAST:THReshold` on page 1371
`SBUS<sb>:CAN:SIC:HYSTeresis` on page 1370
`SBUS<sb>:CAN:SIC:THReshold` on page 1371

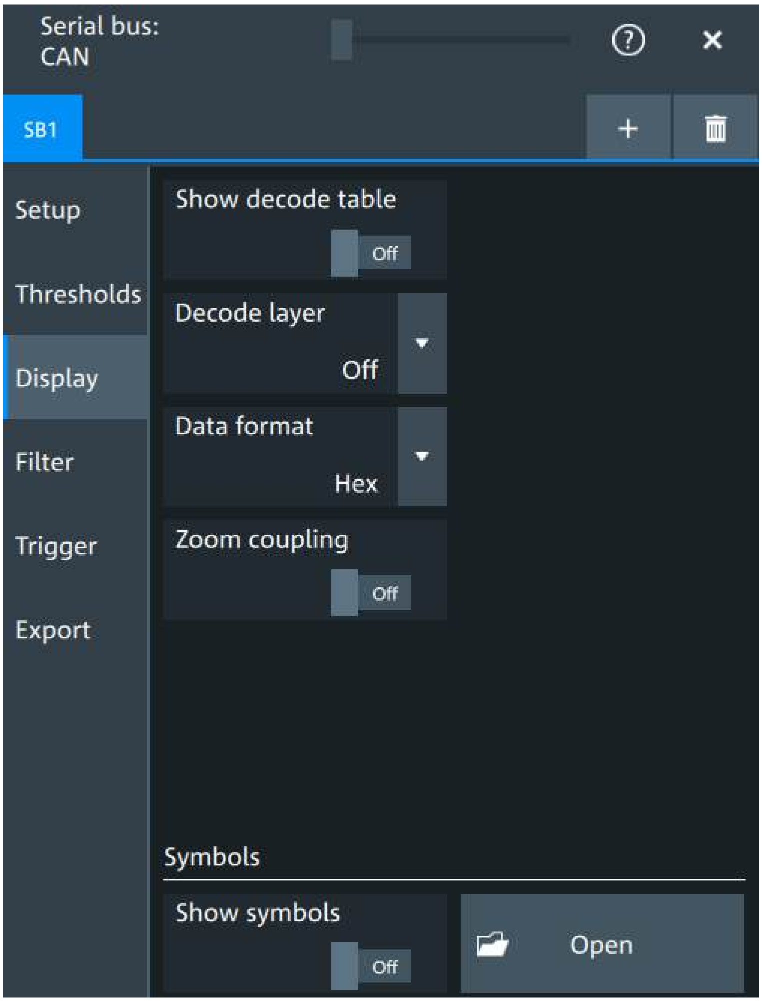
Show threshold lines
If enabled, the threshold lines are displayed in the diagram.

The label of the threshold line is set according to the signal that it is referring to, see also Show threshold lines.

Remote command:
`SBUS<sb>:THReshold` on page 1155

14.9.1.3 Display settings

For details about the display settings, see Section 14.1.3.1, "Display settings", on page 435.



Decode layer
Selects the decode layer.

Decoding is performed in several steps, and the results are presented in the decode table. The decode layer selects an interim step for which the decoding result is shown in the honeycomb display. See "Decode layer" on page 436.

Show symbols
You can load symbol lists, and activate its usage for decoding. As a result, an additional "Symbol" column appears in the "Decode results" table, containing the symbolic label.

Symbol lists for CAN are available in DBC and CSV format, see CAN symbols.

Remote command:
SBUS<sb>:CAN:SYMBols on page 1372
SBUS<sb>:CAN:NEWList on page 1373

14.9.1.4 CAN symbols

For the CAN protocol, you can upload symbol lists containing IDs and a symbolic name for each node. You can load a file in one of the supported formats: DBC and CSV.

DBC files for CAN and CAN FD

Industry standard DBC files contain more information than CSV files and translate the abstract decode results to human language. For each frame, the frame ID and the symbolic name of the ID are given. The frames are also called messages in CAN. The data of a CAN message can consist of several "signals". The DBC file provides the label, unit, start bit, length and other indicators for each signal. For state-encoded signals, the meaning of the states is given.

In the following demo example, the message "EngineData" has the decimal ID 2,166,573,756 and consists of 8 data bytes. These 8 bytes are defined as 6 signals. The first one, "PetrolLevel", starts at bit #24, has a length of 8 bit, and the unit is liter. The signal "IdleRunning" is state-encoded. It has only one bit. The binary value 0 means "Running", and the binary value 1 means "Idle".

Example: CAN DBC file section

```
BO_ 2166573756 EngineData: 8 Engine
 SG_ PetrolLevel : 24|8@1+ (1,0) [0|255] "l" ...
 SG_ EngPower : 48|16@1+ (0.01,0) [0|350] "kW" ...
 SG_ EngForce : 32|10@1+ (1,0) [0|1000] "N" ...
 SG_ IdleRunning : 23|1@1+ (1,0) [0|1] "" ...
 SG_ EngTemp : 16|7@1+ (2,-50) [-50|150] "degC" ....
 SG_ EngSpeed : 0|13@1+ (1,0) [0|8000] "rpm" ...
....
 VAL_ 2166573756 IdleRunning 0 "Running" 1 "Idle" ;
```

CSV files for CAN / CAN FD

Symbol list files are protocol-specific. A CSV label file for CAN protocols contains three values for each identifier:

- Identifier type, 11-bit or 29-bit long
- Identifier value
- Symbolic name of the identifier, specifying its function in the bus network.

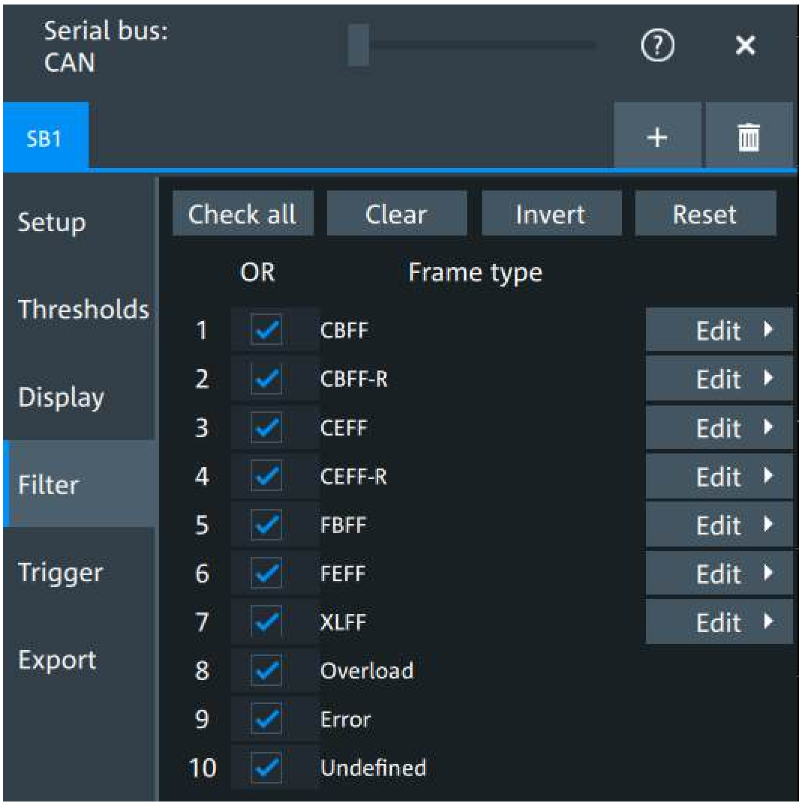
Example: CAN CSV file

```
# ----------------------------------------------------------------------------
@FILE_VERSION  = 1.00
@PROTOCOL_NAME = can
# ---------------------------------------------------------------------------
# Labels for CAN protocol
#   Column order: Identifier type, Identifier value, Label
```

```
# ---------------------------------------------------------------------------
11,064h,Diag_Response
11,1E5h,EngineData
11,0A2h,Ignition_Info
11,1BCh,TP_Console
11,333h,ABSdata
11,313h,Door_Left
11,314h,Door_Right
29,01A54321h,Throttle
29,13A00FA2h,LightState
29,0630ABCDh,Engine_Status
29,03B1C002h,Airbag_Status
29,01234ABCh,NM_Gateway
# ---------------------------------------------------------------------------
```

14.9.2 CAN filter

Access: "Menu" > "Apps" > "Protocol" tab > "CAN" > "Filter" tab



In the "Filter" tab, you can define the settings to display only the frames that match the selected filter conditions.

Check all, Clear, Invert, Preset

The following settings help you select the frames and errors you want to filter for. Only the frames and error types that match the selected filter conditions are displayed.

"Check all"	Enables the filter for all available frames and error types.
"Clear"	Disables the filter for all available frames and error types.
"Invert"	Inverts the current state of the frame and error types: all frames and error types that were enabled are disabled and vice versa.
"Preset"	Presets the state of the selected frames and error types.

Remote command:
`SBUS<sb>:CAN:FILTer:CHKall` on page 1374
`SBUS<sb>:CAN:FILTer:CLR` on page 1375
`SBUS<sb>:CAN:FILTer:INVert` on page 1375
`SBUS<sb>:CAN:FILTer:RST` on page 1375

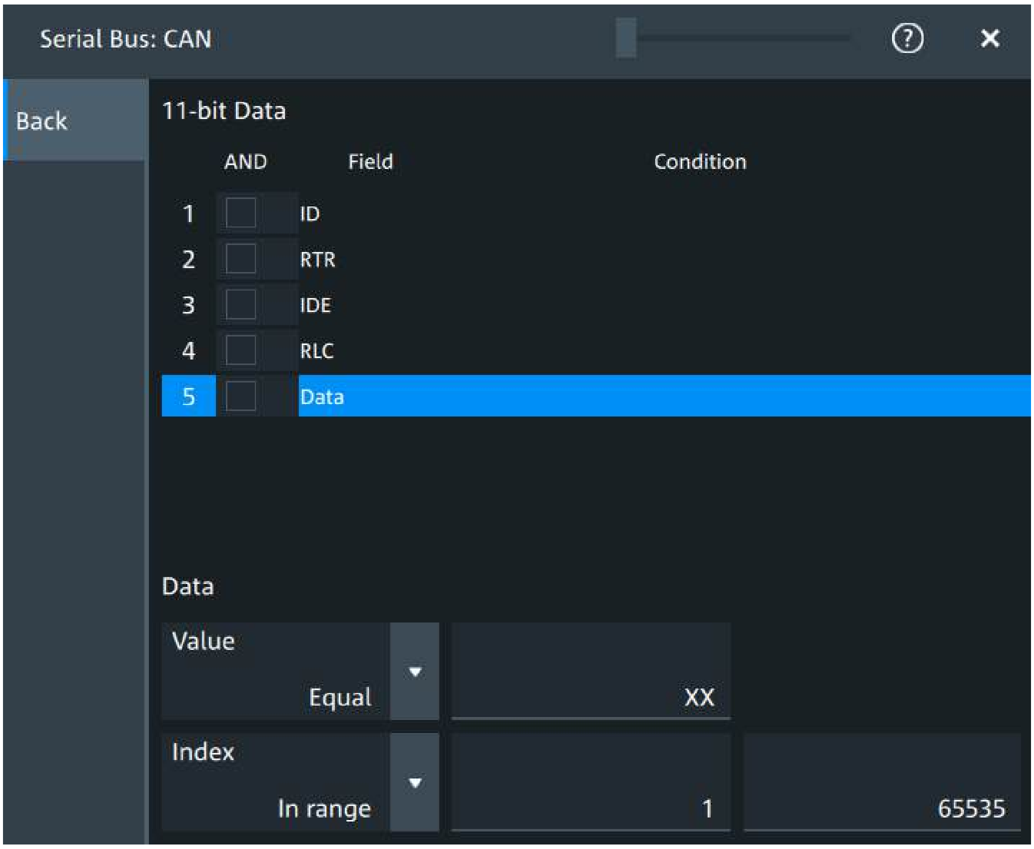
Frame type
Selects the frame type that you want to display. You can filter all enabled frame types simultaneously.

For selected frame types, you can also specify conditions for the value of the fields in the "Edit" dialog.

Available frames are "CBFF", "CBFF-R", "CEFF", "CEFF-R", "FBFF", "FEFF", "XLFF", "Overload" and "Error".

Remote command:
`SBUS<sb>:CAN:FILTer:FRENable` on page 1377
`SBUS<sb>:CAN:FILTer:FRAMe<fr>:ENABle` on page 1377

Edit
Opens a dialog to define the details of the selected frame.



"Field" Enables the field type that you want to filter on for the selected frame. The available fields are "ID", "RTR", "ITE", "RLC" and "Data".

Remote command:
`SBUS<sb>:CAN:FILTer:FIENable` on page 1377
`SBUS<sb>:CAN:FILTer:FRAMe<fr>:FLD<fl>:ENABle`
on page 1377

"Condition" Displays the value condition for the selected field.

Remote command:
`SBUS<sb>:CAN:FILTer:BIT` on page 1375
`SBUS<sb>:CAN:FILTer:FRAMe<fr>:FLD<fl>:BIT`
on page 1375

"Value" The data setup consists of a comparison condition and one or two data patterns.

Remote command:
SBUS<sb>:CAN:FILTer:DMAX on page 1376
SBUS<sb>:CAN:FILTer:FRAMe<fr>:FLD<fl>:DMAX on page 1376
SBUS<sb>:CAN:FILTer:DMIN on page 1376
SBUS<sb>:CAN:FILTer:FRAMe<fr>:FLD<fl>:DMIN on page 1376
SBUS<sb>:CAN:FILTer:DOPerator on page 1376
SBUS<sb>:CAN:FILTer:FRAMe<fr>:FLD<fl>:DOPerator on page 1376

"Index" The index setup consists of a comparison condition and one or two index values.

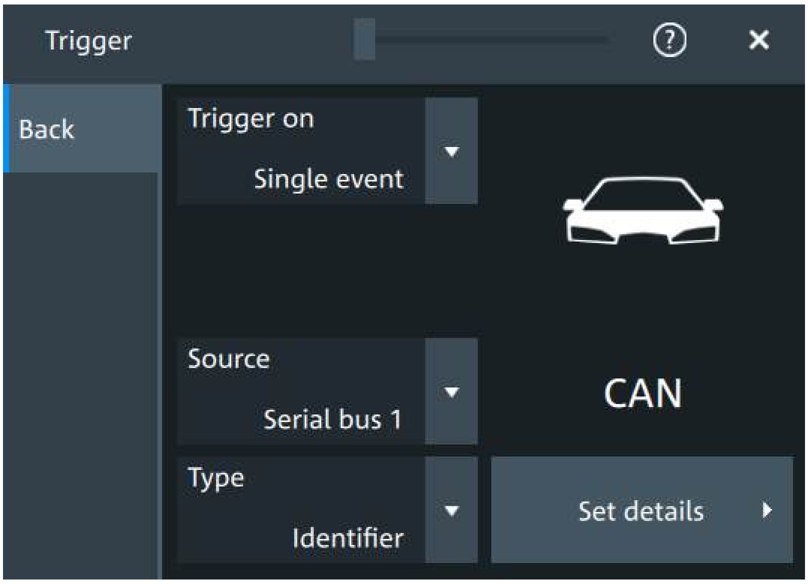
Remote command:
SBUS<sb>:CAN:FILTer:IMAX on page 1378
SBUS<sb>:CAN:FILTer:FRAMe<fr>:FLD<fl>:IMAX on page 1378
SBUS<sb>:CAN:FILTer:IMIN on page 1378
SBUS<sb>:CAN:FILTer:FRAMe<fr>:FLD<fl>:IMIN on page 1378
SBUS<sb>:CAN:FILTer:IOPerator on page 1379
SBUS<sb>:CAN:FILTer:FRAMe<fr>:FLD<fl>:IOPerator on page 1379

Error type
Enables filtering on the selected error type.

Remote command:
SBUS<sb>:CAN:FILTer:ERENable on page 1377
SBUS<sb>:CAN:FILTer:ERRor<n>:ENABle on page 1377

14.9.3 CAN hardware trigger

Access: "Menu" > "Apps" > "Protocol" tab > "CAN" > "Trigger" tab > "Setup Hardware Trigger"



Type

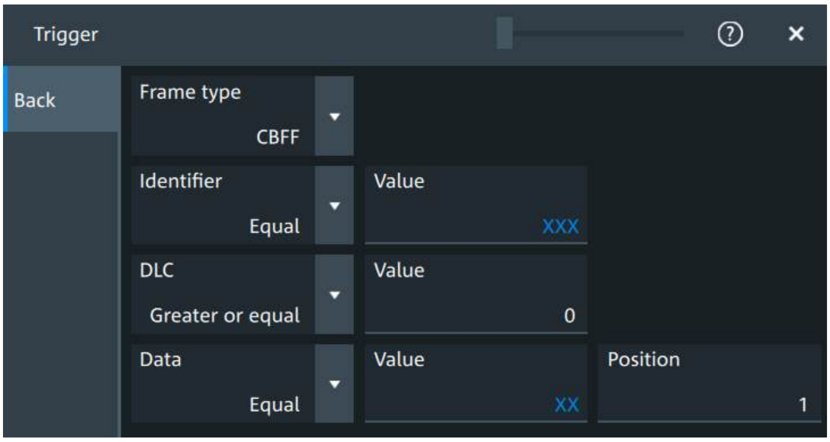
Selects the trigger type for CAN analysis.

Some trigger types have additional settings that can be defined. In this case, the "Set details" button appears next to "Type" the function. Open it for a detailed definition of the trigger conditions.

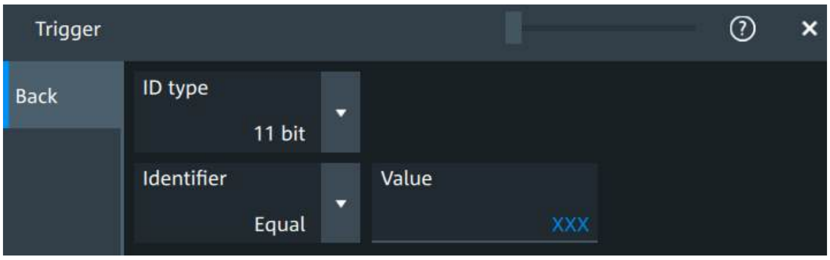
"Start of frame" Triggers on the first edge of the dominant SOF bit (synchronization bit).

"End of frame" Triggers on the end of frame.

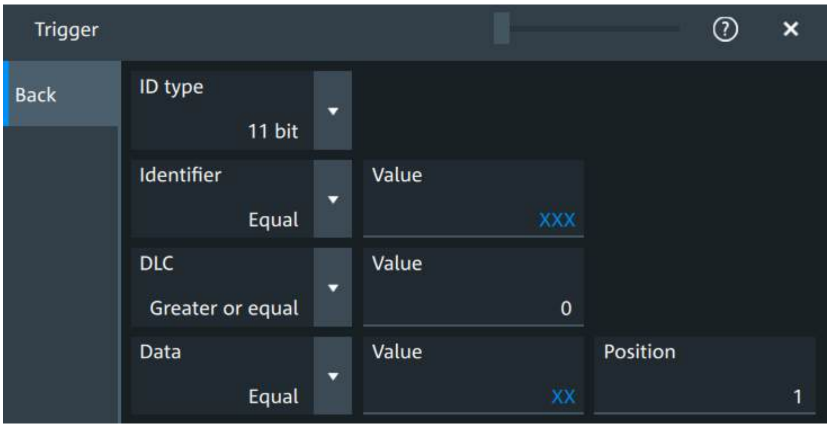
"Frame type" Triggers on a specified frame type (data, remote, error, or overload). For data and remote frames, also the identifier format is considered.



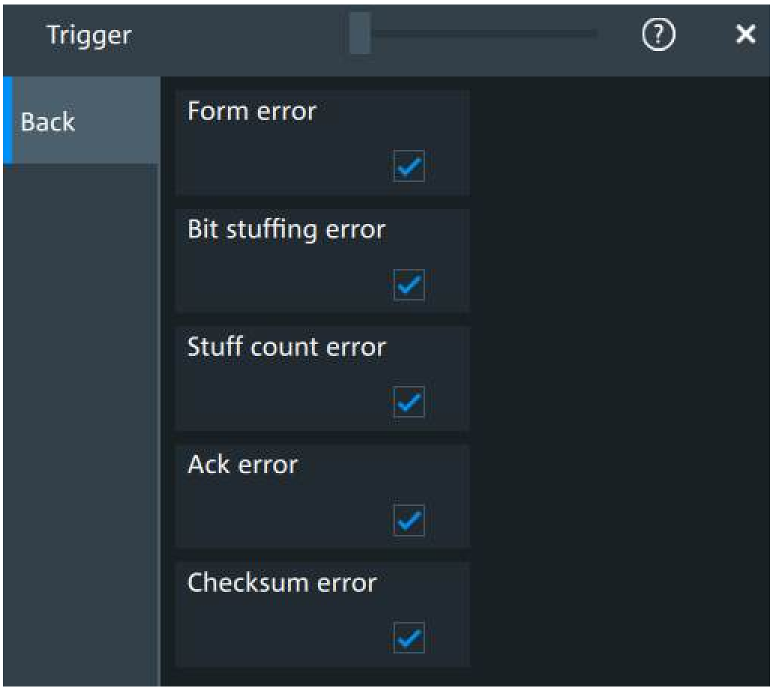
"Identifier"
Sets the trigger to a specific message identifier or an identifier range.



"Identifier + Data"
Sets the trigger to a combination of identifier and data condition. The instrument triggers at the end of the last byte of the specified data pattern.



"Error condition"
Identifies various errors in the frame.



Remote command:
TRIGger:SBHW:CAN:TYPE on page 1385

Frame type
CAN has different frame types which can be used as trigger condition. Depending on the selected frame, you can specify further parameters.

"CBFF" Classical base frame format data: supports a length of 11 bit for the CAN identifier. The data frame is the only frame for actual data transmission.

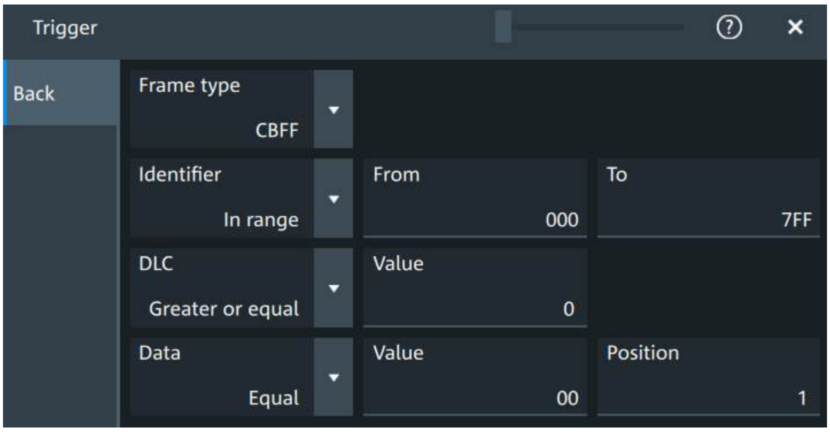


Figure 14-28: Settings for CBFF and CEFF frames

"CBFF-R" Classical base frame format remote: supports a length of 11 bit for the CAN identifier.
The remote frame initiates the transmission of data by another node. The frame format is the same as of data frames but without the data field.

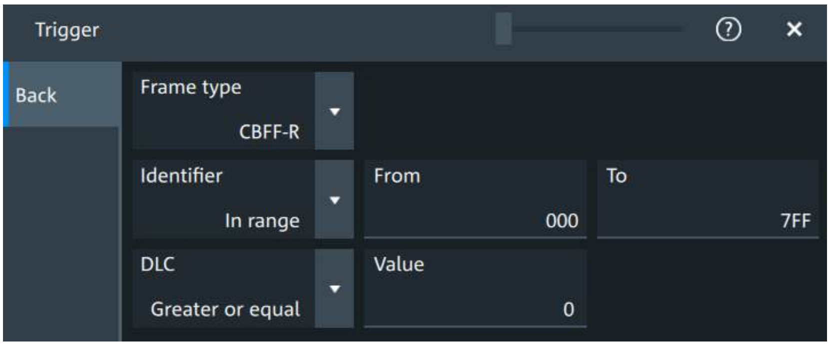


Figure 14-29: Settings for CBFF-R and CEFF-R frames

"CEFF" Classical extended frame format data: supports a length of 29 bit for the CAN identifier. The data frame is the only frame for actual data transmission.

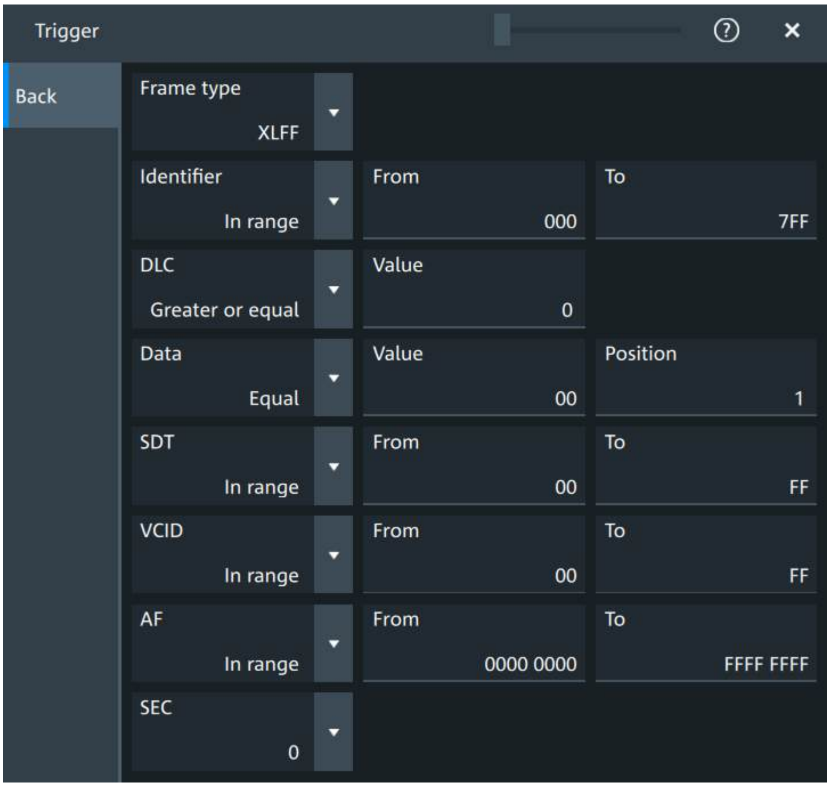
"CEFF-R" Classical extended frame format remote: supports a length of 29 bit for the CAN identifier.
The remote frame initiates the transmission of data by another node. The frame format is the same as of data frames but without the data field.

"FBFF" FD base frame format: supports a length of 11 bit for the CAN identifier.

Figure 14-30: Settings for FBFF and FEFF frames

"FEFF" FD extended frame format: supports a length of 29 bit for the CAN identifier.

"XLFF" XL frame format: supports a length of 29 bit for the CAN identifier.



"Error" When a node recognizes an error, it cancels transmission by sending an error frame.
The ID type is irrelevant for error frames.

"Overload" When a node needs a delay between data and/or remote frames, it sends and overload frame.
The ID type is irrelevant for overload frames.

Remote command:
`TRIGger:SBHW:CAN:FTYPe` on page 1383

Identifier

Specifies the identifier pattern.

"Condition" Sets the comparison condition to a specific value or a range.

"Value"/"From" Specifies the value or sets the start value of a range.

"To" Sets the maximum value of a range for "Condition" = "In range"/"Out of range".

Remote command:
`TRIGger:SBHW:CAN:ICONdition` on page 1384
`TRIGger:SBHW:CAN:IMAX` on page 1384
`TRIGger:SBHW:CAN:IMIN` on page 1384

DLC

The data length code (DLC) defines the number of data bytes to be found. You can set a fixed value for the DLC or define a minimum value.

Remote command:
TRIGger:SBHW:CAN:DLC on page 1381
TRIGger:SBHW:CAN:DLCCondition on page 1381

Data pattern
Specifies the data pattern.

"Condition" Sets the comparison condition to a specific value or a range.

"Value" Specifies the value or sets the start value of a range.

Remote command:
TRIGger:SBHW:CAN:DCONdition on page 1381
TRIGger:SBHW:CAN:DMIN on page 1382

ID type
Selects the length of the identifier:

"11 bit" Identifier length of the CAN base frame format. The instrument triggers on the sample point of the identifier extension flag (IDE) bit.

"29 bit" Identifier length of the CAN extended frame format. The instrument triggers on the sample point of the remote transmission request (RTR) bit.

"Any" The ID type and ID pattern are not relevant for the trigger condition.
If the trigger type is "Identifier", the instrument triggers on any identifier in the specified frame type.
If the trigger type is "Identifier + Data", set the "ID type" to "Any" if you want to trigger only on data.

Remote command:
TRIGger:SBHW:CAN:ITYPe on page 1385

BRS, ESI
If "Frame type" = "FBFF"/"FEFF", you can trigger on specific bits.

"BRS" The bit rate switch bit. Value 1 means that the bit rate switches from the arbitration rate to the faster data rate.

"ESI" The error state indicator bit. Set "X" if the bit is not relevant.

Remote command:
TRIGger:SBHW:CAN:FDATa:BRS on page 1382
TRIGger:SBHW:CAN:FDATa:ESI on page 1382

SDT
Specifies a value or a range for the service data unit type.

"Condition" Sets the comparison condition to a specific value or a range.

"Value"/"From" Specifies the value or sets the start value of a range.

"To" Sets the maximum value of a range for "Condition" = "In range"/"Out of range".

Remote command:
`TRIGger:SBHW:CAN:XDATa:SDT:CONDition` on page 1387
`TRIGger:SBHW:CAN:XDATa:SDT:MAX` on page 1387
`TRIGger:SBHW:CAN:XDATa:SDT:MIN` on page 1387

VCID
Specifies a value or a range for the virtual CAN network ID (VCID).

"Condition" Sets the comparison condition to a specific value or a range.

"Value"/"From" Specifies the value or sets the start value of a range.

"To" Sets the maximum value of a range for "Condition" = "In range"/"Out of range".

Remote command:
`TRIGger:SBHW:CAN:XDATa:VCID:CONDition` on page 1388
`TRIGger:SBHW:CAN:XDATa:VCID:MAX` on page 1388
`TRIGger:SBHW:CAN:XDATa:VCID:MIN` on page 1388

AF
Specifies a value or a range for the CAN XL acceptance field (AF).

"Condition" Sets the comparison condition to a specific value or a range.

"Value"/"From" Specifies the value or sets the start value of a range.

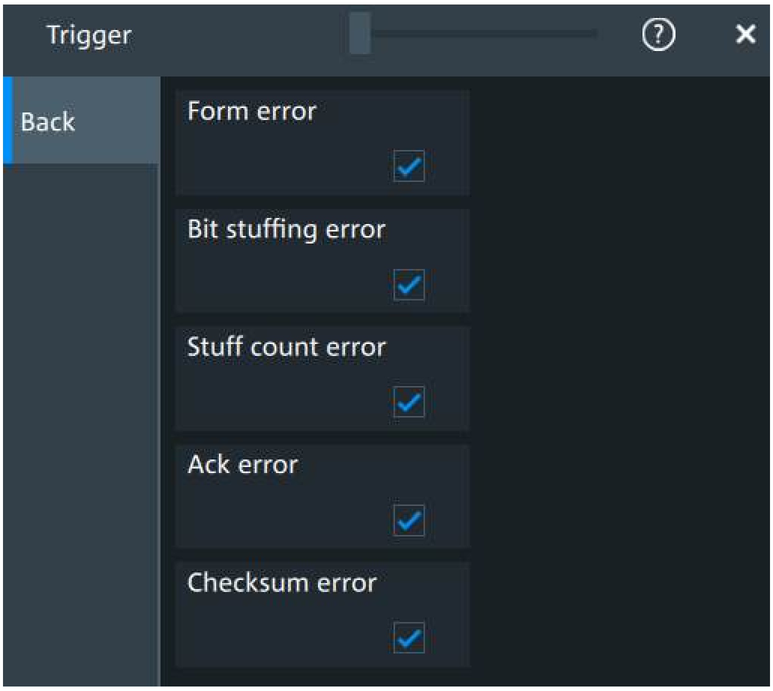
"To" Sets the maximum value of a range for "Condition" = "In range"/"Out of range".

Remote command:
`TRIGger:SBHW:CAN:XDATa:AF:CONDition` on page 1386
`TRIGger:SBHW:CAN:XDATa:AF:MAX` on page 1386
`TRIGger:SBHW:CAN:XDATa:AF:MIN` on page 1386

SEC
Sets a value for the simple extended content (SEC) field. It indicates, if the CAN XL data frame uses the CADsec protocol.

Remote command:
`TRIGger:SBHW:CAN:XDATa:SEC` on page 1388

Error conditions
If a CAN detects an error, it transmits an error flag at the next bit. The MXO 4 detects errors in the message and triggers on these errors even if no CAN node sends an error flag.



"Form error" — A form error occurs when a fixed-form bit field contains one or more illegal bits.

"Bit stuffing error" — The frame segments Start of Frame, Arbitration Field, Control Field, Data Field and CRC Sequence are coded by the bit stuffing method. The transmitter automatically inserts a complementary bit into the bitstream when it detects five consecutive bits of identical value in the bitstream to be transmitted. A stuff error occurs when the 6th consecutive equal bit level in the mentioned fields is detected.

"Stuff count error" — A stuff bit error occurs, if more than five consecutive bits of the same level occur on the bus.

"Ack error" — An acknowledgment error occurs when the transmitter does not receive an acknowledgment - a dominant bit during the ACK Slot.

"Checksum error" — CAN uses the Cyclic Redundancy Check, which is a complex checksum calculation method. The transmitter calculates the CRC and sends the result in the CRC sequence. The receiver calculates the CRC in the same way. A CRC error occurs when the calculated result differs from the received value in the CRC sequence.

Remote command:
`TRIGger:SBHW:CAN:FORMerror` on page 1383
`TRIGger:SBHW:CAN:BITSterror` on page 1380
`TRIGger:SBHW:CAN:FDATa:SCERror` on page 1383
`TRIGger:SBHW:CAN:ACKerror` on page 1380
`TRIGger:SBHW:CAN:CRCerror` on page 1381

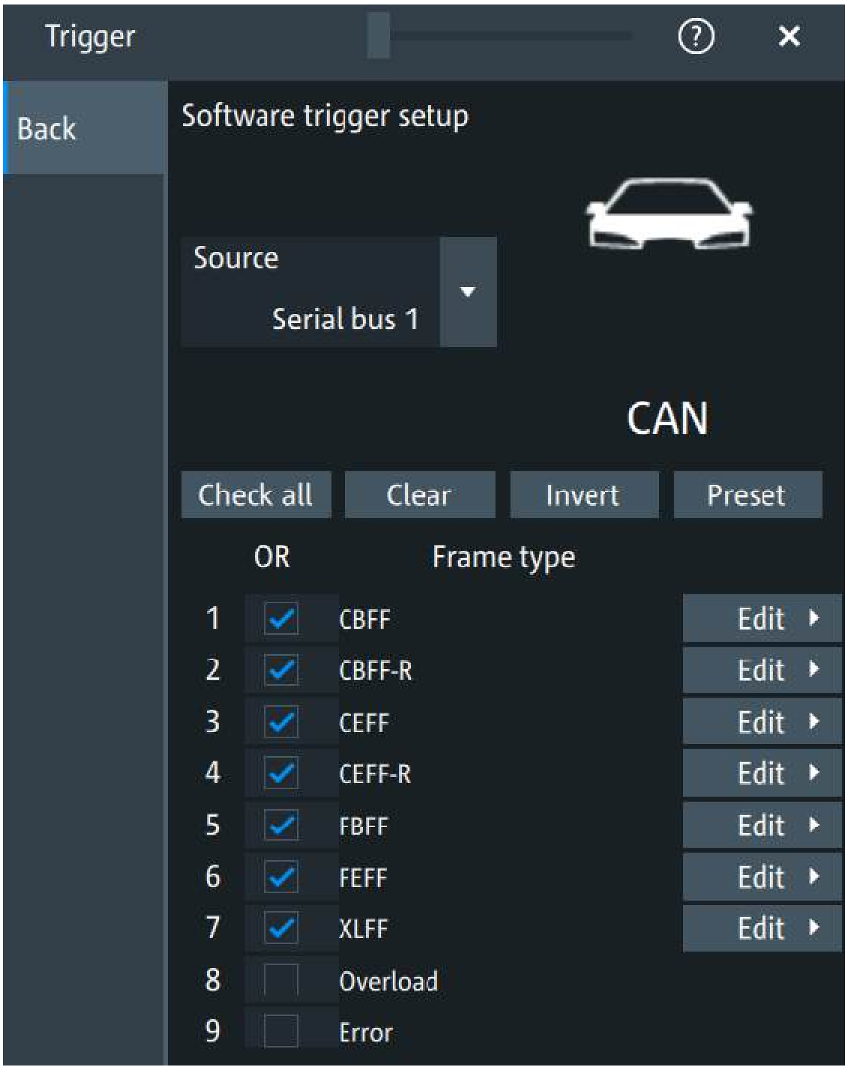
14.9.4 CAN software trigger

14.9.4.1 Setup A trigger

Before setting up the software trigger for the protocols, a trigger A event needs to be set up.

14.9.4.2 Software trigger settings

Access: "Menu" > "Apps" > "Protocol" tab > "CAN" > "Trigger" tab > "Setup Software Trigger" > "Setup SB Trigger".



In the "Software Trigger" tab, you can define the settings to trigger on the frames that match the selected filter conditions.

Check all, Clear, Invert, Preset

The following settings help you select the frames and errors you want to trigger on.

"Check all"	Enables the software trigger for all available frames and error types.
"Clear"	Disables the software trigger for all available frames and error types.
"Invert"	Inverts the current state of the frame and error types for the software trigger: all frames and error types that were enabled are disabled and vice versa.
"Preset"	Presets the state of the selected frames and error types for the software trigger.

Remote command:
`TRIGger:SBSW:CAN:CHKall` on page 1389
`TRIGger:SBSW:CAN:CLR` on page 1390
`TRIGger:SBSW:CAN:INVert` on page 1390
`TRIGger:SBSW:CAN:RST` on page 1390

Frame type

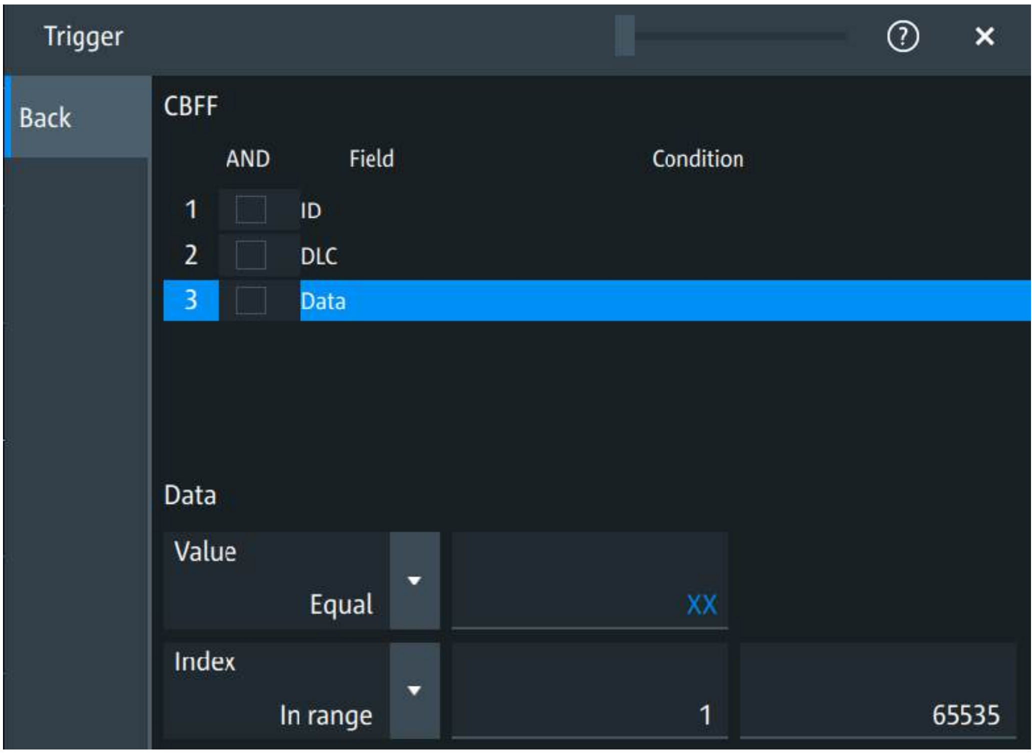
Selects the frame type that you want to trigger on. You can trigger on all enabled frame types simultaneously.

For each frame type, you can also specify conditions for the value of the fields in the "Edit" dialog.

Remote command:
`TRIGger:SBSW:CAN:FRENable` on page 1390
`TRIGger:SBSW:CAN:FRAMe<fr>:ENABle` on page 1390

Edit

Some trigger types have additional settings that can be defined. In this case, the "Set details" button appears next to "Type" the function. Open it for a detailed definition of the trigger conditions.



"Field"
: Enables the field type that you want to trigger on for the selected frame.

Remote command:
TRIGger:SBSW:CAN:FIENable on page 1392
TRIGger:SBSW:CAN:FRAMe<fr>:FLD<fl>:ENABle on page 1392

"Condition"
: Displays the value condition for the selected field.

Remote command:
TRIGger:SBSW:CAN:BIT on page 1390
TRIGger:SBSW:CAN:FRAMe<fr>:FLD<fl>:BIT on page 1390

"Value"
: The data setup consists of a comparison condition and one or two data patterns.

Remote command:
TRIGger:SBSW:CAN:DMAX on page 1391
TRIGger:SBSW:CAN:FRAMe<fr>:FLD<fl>:DMAX on page 1391
TRIGger:SBSW:CAN:DMIN on page 1391
TRIGger:SBSW:CAN:FRAMe<fr>:FLD<fl>:DMIN on page 1391
TRIGger:SBSW:CAN:DOPerator on page 1392
TRIGger:SBSW:CAN:FRAMe<fr>:FLD<fl>:DOPerator
on page 1392

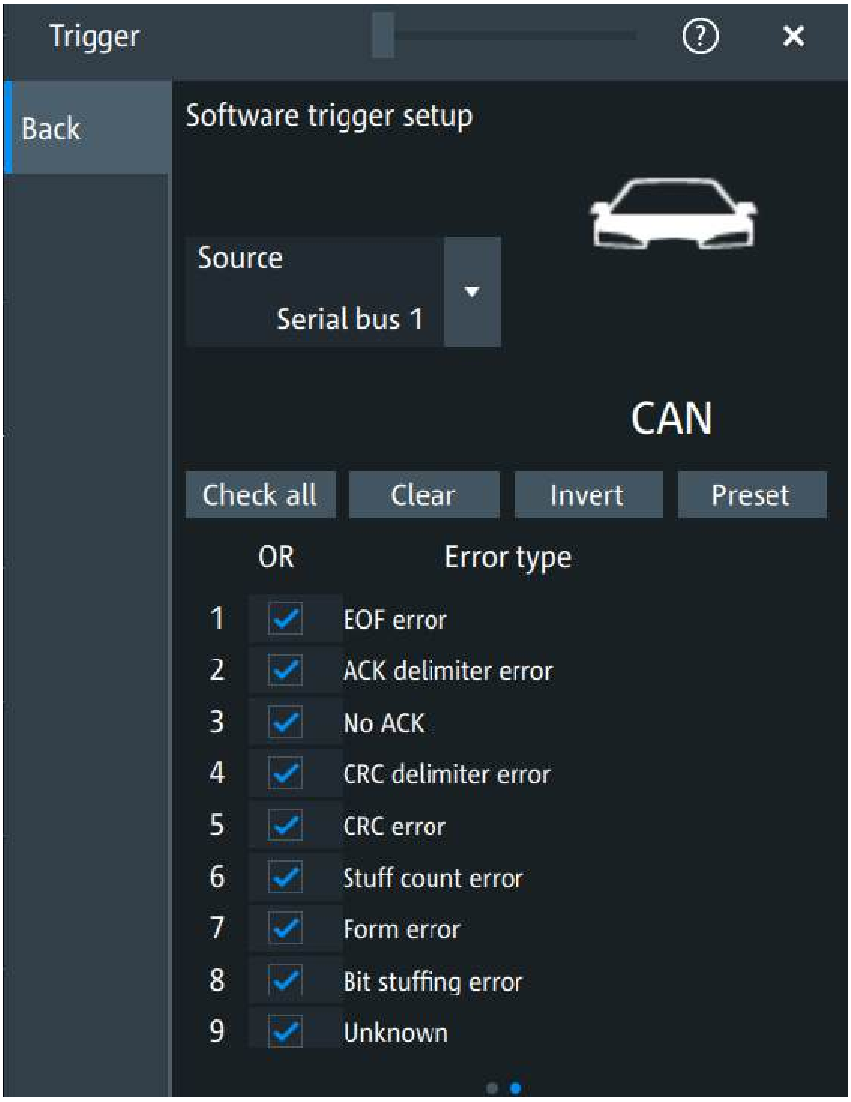
"Index"

The index setup consists of a comparison condition and one or two index values.

Remote command:
TRIGger:SBSW:CAN:IMAX on page 1392
TRIGger:SBSW:CAN:FRAMe<fr>:FLD<fl>:IMAX on page 1392
TRIGger:SBSW:CAN:IMIN on page 1393
TRIGger:SBSW:CAN:FRAMe<fr>:FLD<fl>:IMIN on page 1393
TRIGger:SBSW:CAN:IOPerator on page 1393
TRIGger:SBSW:CAN:FRAMe<fr>:FLD<fl>:IOPerator on page 1393

Error type

Enables triggering on the selected error type.



Remote command:
TRIGger:SBSW:CAN:ERENable on page 1393
TRIGger:SBSW:CAN:ERRor<m>:ENABle on page 1393

14.9.5 Measure

The "Setup Measurement" button opens the dialog for automatic measurements in the "Protocol" category for the selected serial bus.

See Section 10.2.6.2, "Settings for protocol measurements", on page 289.

14.9.6 CAN decode results

When the configuration of the serial bus is complete, the signal can be decoded:

1. Open the "Serial Bus" dialog for the respective bus.
2. In the "Setup" tab, enable "State".
3. In the "Display" tab, enable "Show decode table".

For a description of the display settings, see also Section 14.1.3.1, "Display settings", on page 435.

For a description of how to synchronize the displayed results, see Section 14.1.3.2, "Display synchronization", on page 437.

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

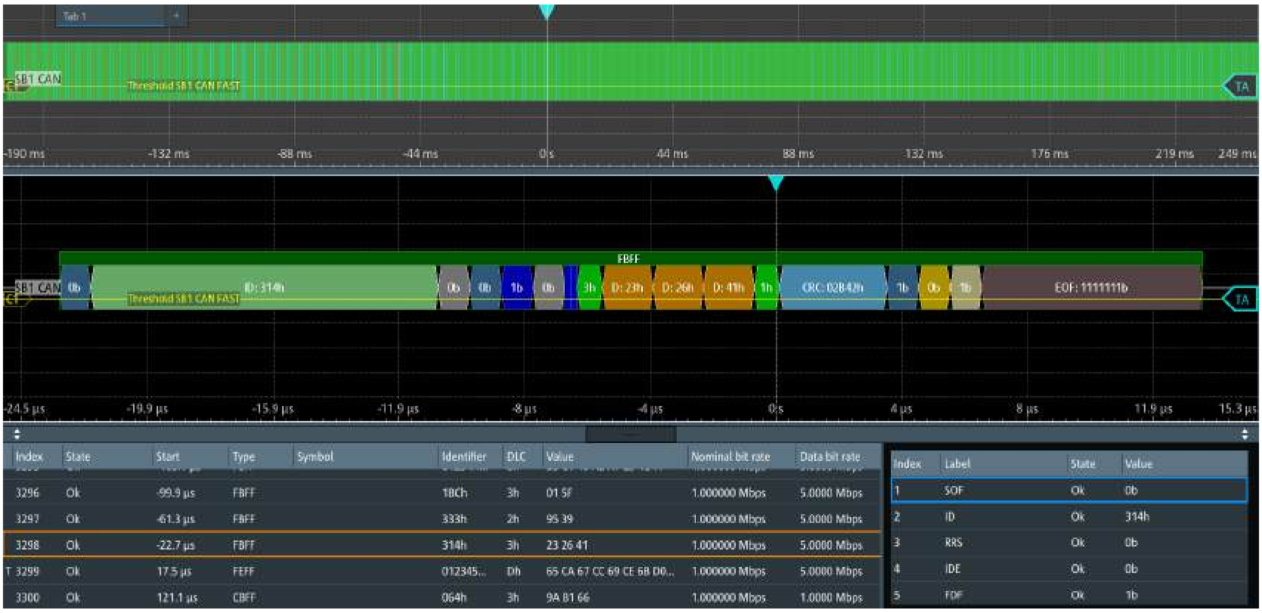


Figure 14-31: Decoded CAN signal

The decode results table contains information about all decoded frames.

Table 14-14: Content of the decode results table

Column	Description
"Index"	Number of the decoded frame
"State"	Overall state of the frame. "Insuffcient waveform length" indicates that the frame is not completely contained in the acquisition. Change the horizontal scale, or move the reference point to the left to get a longer acquisition.
"Start"	Time of frame start
"Type"	Frame type
"Symbol"	Symbolic label of the frame. Available only, if "Show symbols" is enabled in the "Display" tab and a symbols list is loaded.
"Identifier"	Identifier value in hexadecimal format. Select the data format in the "Display" tab.
"DLC"	Data length code, coded number of data bytes. Select the data format in the "Display" tab.
"Value"	Value of the data frame. Remote frames do not transmit data, therefore "- - -" is displayed. Select the data format in the "Display" tab.
"Nominal bit rate"	Number of bits per second
"Data bit rate"	Number of data bits per second

When you select a frame in the decode results table, its field content is shown in the details table to the right.

Table 14-15: Content of the frame details table

Column	Description
"Index"	Number of the decoded field
"Label"	Field type. Values depend on the decoded frame "Type", see Table 14-16.
"State"	Overall state of the frame
"Value"	Value of the field

Depending on the decoded type of frame, the following fields are available:

Table 14-16: Decoded fields, depending on the frame type

Frame	Fields
CBFF/CBFF-R	CRC: cyclic redundancy check
CEFF/CEFF-R	CRC: cyclic redundancy check
FBFF/FEFF	BRS: bit rate switch
	ESI: error state indicator
	SBC: stuff bit count
	CRC: cyclic redundancy check
XLFF	SBC: stuff bit count

Frame	Fields
	SDT: service data unit
	SEC: simple extended content
	VCID: virtual CAN network ID
	AF: acceptance field
	PCRC: preamble cyclic redundancy check
	FCRC: frame CRC

Data format

You can select various data formats for the values displayed in the decode table and in the combs of the decoded signal.

Remote command:

- `SBUS<sb>:FORMat` on page 1154

Remote commands

Remote commands to retrieve decode results are described in Section 18.17.10.5, "Decode results", on page 1394.

14.9.7 Performing CAN decoding

This section explains step by step how to configure and decode the CAN bus.

14.9.7.1 Configuring CAN signals

For configuration, assign the lines to the input channels, and define the active states and the logical thresholds.

For details on configuration settings, see Section 14.9.1, "CAN configuration", on page 591.

1. Tap the "+ Bus" activator in the bottom right of the screen.

2. Select the tab of the bus that you want to set up, for example "SB1".
3. Tap the "Protocol type" button. Select the protocol: CAN.
4. Tap on "State" to enable the decoding.

   A CAN shortcut appears at the bottom left of the screen. Tap on the shortcut for a quick access to the "CAN" dialog settings.

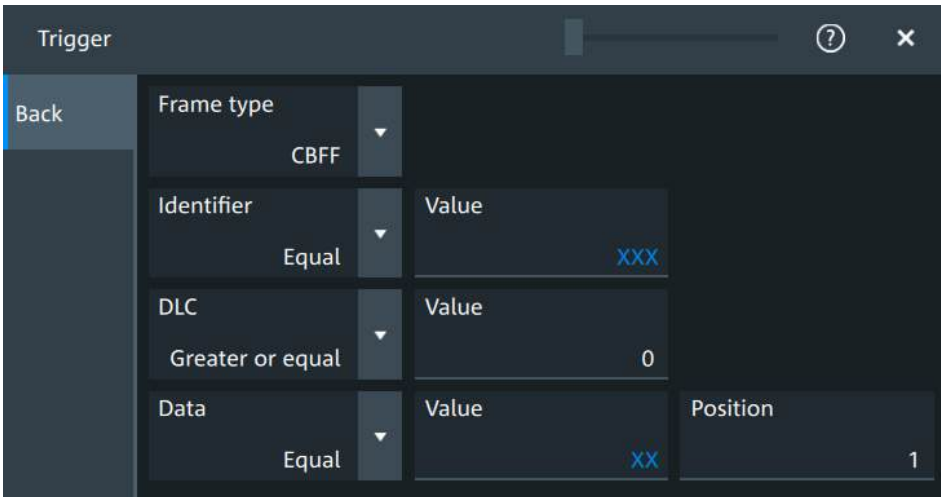
5. Tap on "Data" and select the correct channel.
6. Set the CAN "Type", depending on whether you use single-ended or differential probe:
   a) For single-ended probes, connect the probe to either CAN-L or CAN-H. Set the "Type" accordingly.
   b) For differential probes, connect the probe to both CAN-H and CAN-L lines. Set "Type" = "CAN-H".
7. Set the "Transceiver mode", according to your signal: "SIC mode" or "FAST mode".
8. Set the bit rate for
9. Check that the signals are on the screen.
   If not try adjusting the vertical and horizontal settings.
10. Set the logical thresholds:
   a) Tap "Threshold setup". The threshold dialog opens.
   b) For each wire, set the threshold value.
   c) If necessary, set the hysteresis value for the wires.
   d) Optionally, tap on "Show threshold lines".

14.9.7.2 Triggering on CAN

Prerequisites: A bus is configured for the CAN signal to be analyzed. See Section 14.9.7.1, "Configuring CAN signals", on page 615.

1. Open "Menu" > "Trigger".
2. Set "Trigger on" to "Single event".
3. Ensure that the "Source" is set to the configured serial bus, e.g. "Serial bus 1".
4. Select the "Type".
5. For "Type" = "Frame type":

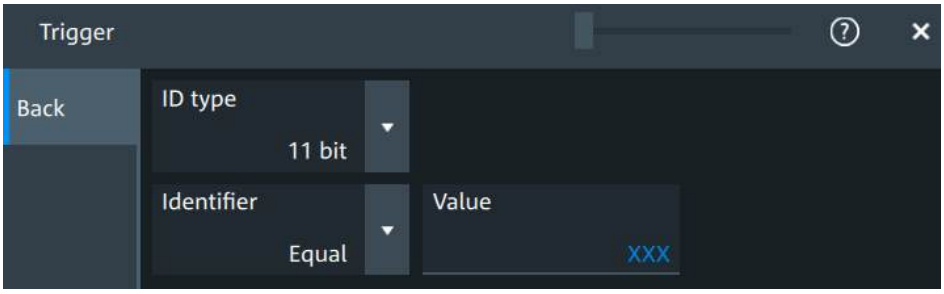
a) Tap on "Set details".



b) Select the "Frame type". According to the selected type, different settings are available.
c) Set the "Identifier" or an identifier range.
d) Set the "DLC" or a DLC range.
e) Set the "Data" or a data range.
f) Set the "ESI""ESI" value.
g) Set the "BRS" value.

6. For "Type" = "Identifier":

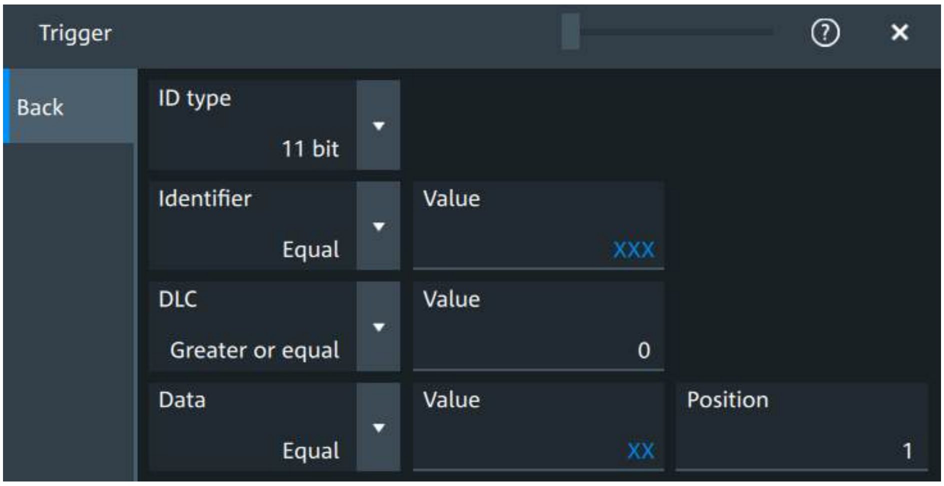
a) Tap on "Set details".



b) Select the "ID type".
c) Set the "Identifier" or an identifier range.

7. For "Type" = "Identifier + Data":

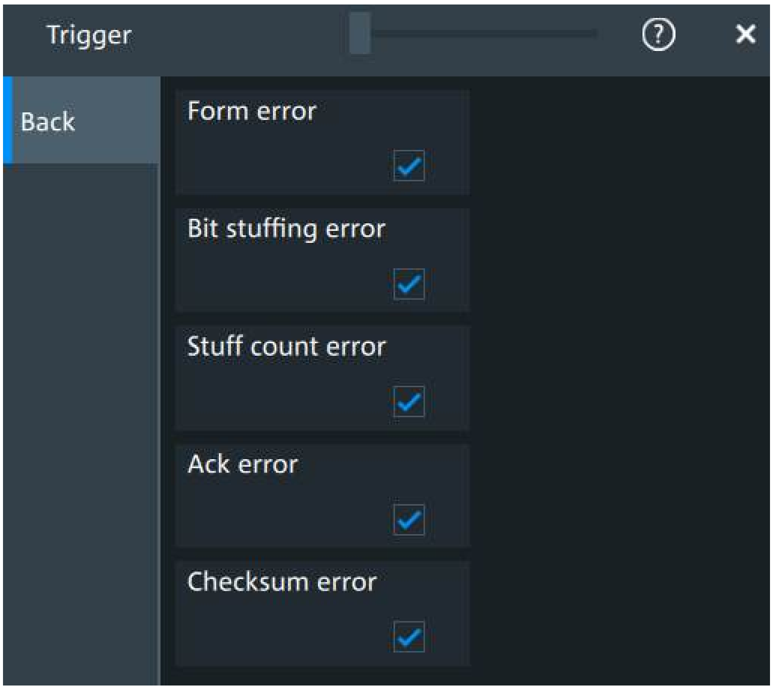
a) Tap on "Set details".



b) Select the "ID type".
c) Set the "Identifier" or an identifier range.
d) Set the "DLC" or a DLC range.
e) Set the "Data" or a data range.

8. For "Type" = "Error condition":

a) Tap on "Set details".



b) Select one or more error conditions that you want to trigger on:
   - "Form error"
   - "Bit stuffing error"
   - "Stuff count error"
   - "Ack error"
   - "Checksum error"

14.9.7.3 Exporting decode results

Once a decode has been completed, you can generate an export of all decode results.

Prerequisites: A bus is configured for the CAN and decoded.

1. Tap on the "CAN" shortcut.
2. Tap on the "Export" tab.
3. If necessary, enable "Include details".
4. If necessary, enable "Include timing".
5. Select the "File type".

   An export file is saved in the selected directory.

The CAN export files contains the following fields:
- A list of all decoded frames:
  – Index
  – Start
  – Stop
  – State
  – Type
  – ID value
  – DLC
  – Nominal bit rate
  – Data bit rate
  – CRC
  – BRS
  – ESI
  – SBC
  – SDT
  – SEC
  – VCID
  – AF
  – PCRC
- The details frames include the following fields:

- Index
- Data

Example of a CAN export file

```
Index,Start,Stop,State,Type,ID value,DLC,Nominal bit rate,Data bit rate,CRC,BRS,ESI,
  SBC,SDT,SEC,VCID,AF,PCRC
1,-0.19,-0.188,'OK','XLFF',064h,7FFh,1000000,10000000,0000AABBh,-,-,6h,FFh,1b,AAh,
  000ABCDh,01FFh
2,-0.188311,-0.188243,'OK','CBFF',064h,3h,1000000,1000000,35CEh,-,-,-,-,-,-,-,-
3,-0.188239,-0.188195,'OK','CBFR',064h,3h,1000000,1000000,5AA0h,-,-,-,-,-,-,-,-
4,-0.188191,-0.188157,'OK','FBFF',064h,2h,1000000,5000000,035FFh,0b,1b,Eh,-,-,-,-,-
5,-0.188153,-0.188075,'OK','CEFF',01401B26h,2h,1000000,1000000,32A0h,-,-,-,-,-,-,-,-
6,-0.188071,-0.188008,'OK','CEFR',01900064h,3h,1000000,1000000,32AAh,-,-,-,-,-,-,-,-
7,-0.188004,-0.187951,'OK','FEFF',01900064h,3h,1000000,5000000,032AAh,1b,0b,Fh,-,-,-,-,-
8,-0.187947,-0.187899,'OK','XLFF',064h,046h,1000000,10000000,000032AAh,-,-,6h,03h,0b,0Ah,
  0000ABCFh,1FFFh
9,-0.187895,-0.187881,'INC','ERR',---,---,1000000,1000000,-,-,-,-,-,-,-,-,-
10,-0.187877,-0.187863,'UNKN','OVER',---,---,1000000,1000000,-,-,-,-,-,-,-,-,-


Details frame 2
Index,Data
1,D0h
2,E7h
3,20h

Details frame 4
Index,Data
1,D1h
2,E8h

Details frame 5
Index,Data
1,D2h
2,E9h

Details frame 7
Index,Data
1,D3h
2,EAh
3,21h
```

14.10 LIN (automotive electronics, option R&S MXO4-K520)

The Local Interconnect Network (LIN) is a simple, low-cost bus system used within automotive network architectures. LIN is usually a subnetwork of a CAN bus. The primary purpose of LIN is the integration of uncritical sensors and actuators with low-bandwidth requirements. Common applications in a motor vehicle are the control of doors, windows, wing mirrors, and wipers.

Requirements

For performing LIN decode measurements, you need the following:

- MXO 4 with 1 available channel. The channel can be:
  - Analog channels (C1-C4)
  - Logic channels (D0-D15) (requires option R&S MXO4-B1)
- One probe
- Option R&S MXO4-K520

14.10.1 About the LIN protocol

This section provides an overview of protocol characteristics, frame format, identifiers and trigger possibilities. For detailed information, order the LIN specification on http://www.lin-subbus.org/ (free of charge).

LIN characteristics

The main characteristics of LIN are:

- Single-wire serial communications protocol, based on the UART byte-word interface
- Single primary, multiple secondaries - usually up to 12 nodes
- Primary-controlled communication: primary coordinates communication with the LIN schedule and sends the identifier to the secondaries
- Synchronization mechanism for clock recovery by secondary nodes without crystal or ceramic resonator

Data transfer

Basic communication concept of LIN:

- Communication in an active LIN network is always initiated by the primary.
- The primary sends a message header including the synchronization break, the synchronization byte, and the message identifier.
- The identified node sends the message response: one to eight data bytes and one checksum byte.
- Header and response form the message frame.

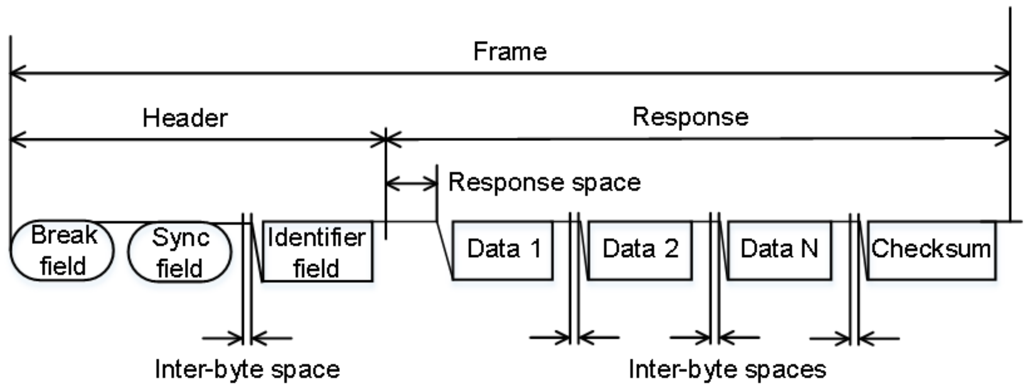


Figure 14-32: LIN frame with header and response

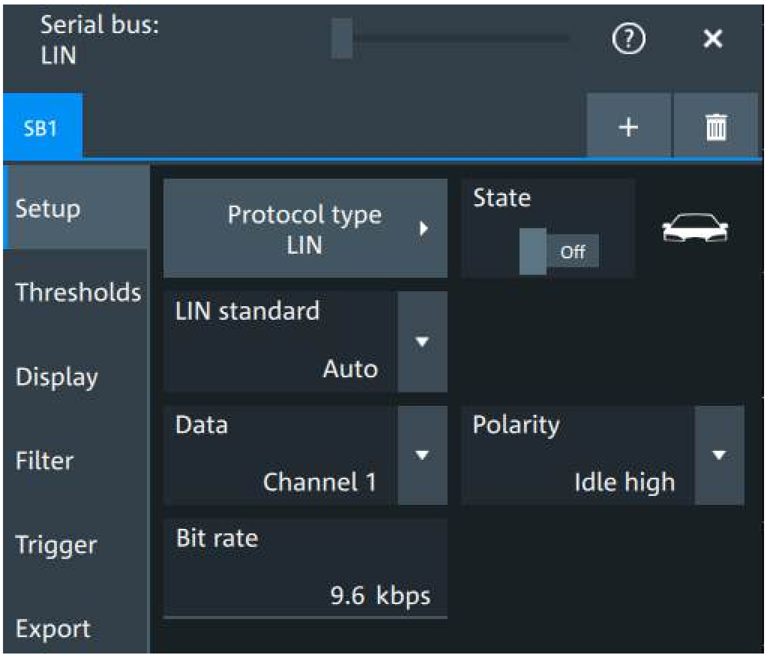
Data bytes are transmitted with LSB first.

The identifier byte consists of 6 bits for the frame identifier and two parity bits. This combination is known as protected identifier.

14.10.2 LIN configuration

14.10.2.1 LIN configuration settings

Access: "Menu" > "Apps" > "Protocol" tab > "LIN" > "Setup".



LIN standard
Selects the version of the LIN standard that is used in the DUT. The setting mainly defines the checksum version used during decoding.

The most common version is LIN v.2.x. For mixed networks, or if the standard is unknown, set the LIN standard to "Auto".

Remote command:
SBUS<sb>:LIN:STANdard on page 1409

Data
Sets the source waveform of the data line.

Remote command:
SBUS<sb>:LIN:DATA:SOURce on page 1409

Polarity
Defines the idle state of the bus. The idle state is the recessive state and corresponds to a logic high.

Remote command:
SBUS<sb>:LIN:POLarity on page 1409

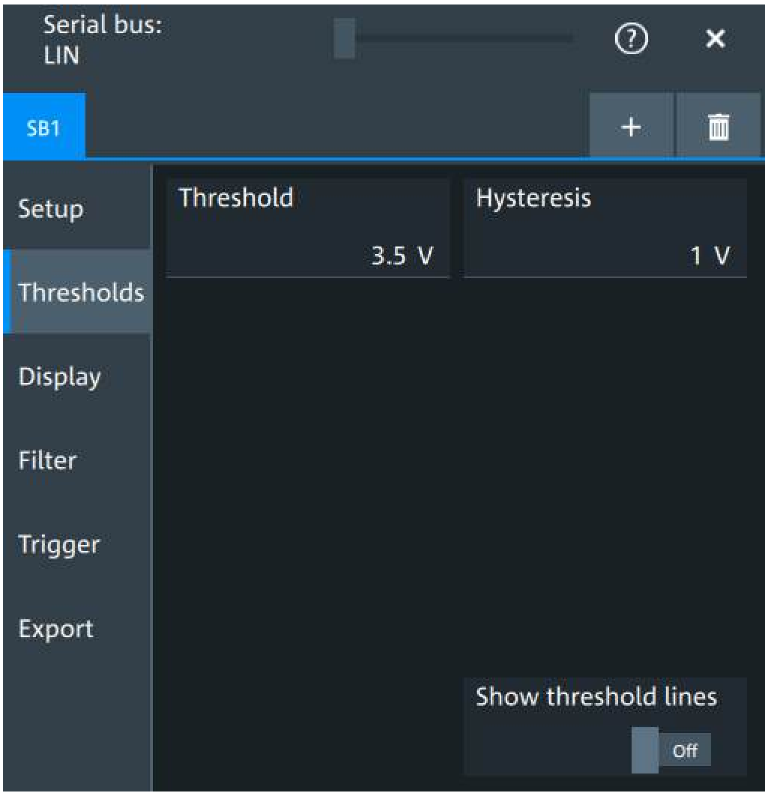
Bit rate
Sets the number of transmitted bits per second. The maximum bit rate for LIN is 20 kbit/s.

If the LIN standard is "J2602", the bit rate is 10.417 kbit/s and cannot be changed.

Remote command:
SBUS<sb>:LIN:BITRate on page 1408

14.10.2.2 Threshold settings

Access: "Menu" > "Apps" > "Protocol" tab > "LIN" > "Thresholds".



Threshold
Sets the threshold for the data channel. Enter the value directly in the fields.

Additional to the threshold, you can also set a hysteresis.

Remote command:
`SBUS<sb>:LIN:DATA:THReshold` on page 1409
`SBUS<sb>:LIN:DATA:HYSTeresis` on page 1408

Show threshold lines
If enabled, the threshold lines are displayed in the diagram.

The label of the threshold line is set according to the signal that it is referring to, see also Show threshold lines.

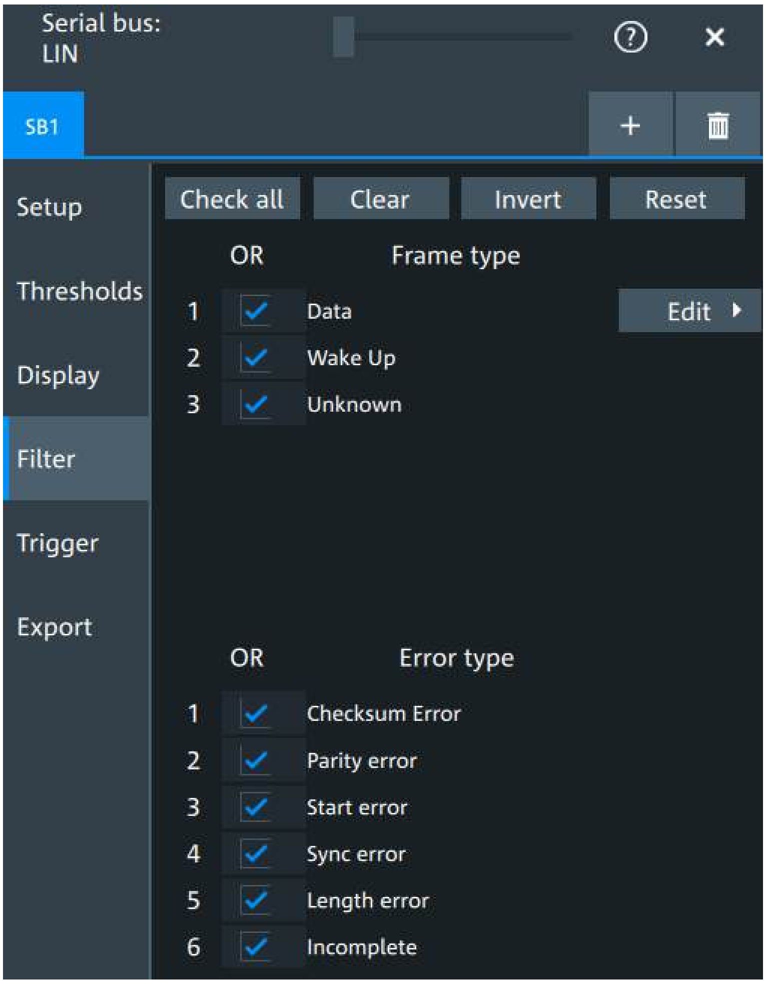
Remote command:
`SBUS<sb>:THReshold` on page 1155

14.10.2.3 Display settings

For details about the display settings, see Section 14.1.3.1, "Display settings", on page 435.

14.10.3 LIN filter

Access: "Menu" > "Apps" > "Protocol" tab > "LIN" > "Filter" tab



In the "Filter" tab, you can define the settings to display only the frames that match the selected filter conditions.

Check all, Clear, Invert, Preset

The following settings help you select the frames and errors you want to filter for. Only the frames and error types that match the selected filter conditions are displayed.

"Check all"	Enables the filter for all available frames and error types.
"Clear"	Disables the filter for all available frames and error types.
"Invert"	Inverts the current state of the frame and error types: all frames and error types that were enabled are disabled and vice versa.
"Preset"	Presets the state of the selected frames and error types.

Remote command:
`SBUS<sb>:LIN:FILTer:CHKall` on page 1411
`SBUS<sb>:LIN:FILTer:CLR` on page 1412
`SBUS<sb>:LIN:FILTer:INVert` on page 1412
`SBUS<sb>:LIN:FILTer:RST` on page 1412

Frame type

Selects the frame type that you want to display. You can filter all enabled frame types simultaneously.

For selected frame types, you can also specify conditions for the value of the fields in the "Edit" dialog.

Available frames are "Data", "Wake" and "Unknown".

Remote command:

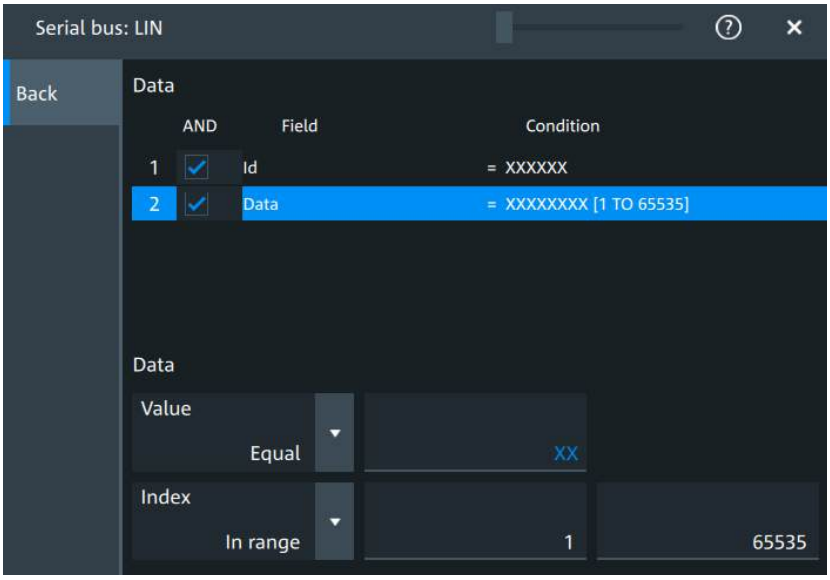
`SBUS<sb>:LIN:FILTer:FRENable` on page 1415

`SBUS<sb>:LIN:FILTer:FRAMe<fr>:ENABle` on page 1415

Edit

Opens a dialog to define the details of the selected frame.

"Field" Enables the field type that you want to filter on for the selected frame.



The available fields are "Id" and "Data".

Remote command:

`SBUS<sb>:LIN:FILTer:FIENable` on page 1414

`SBUS<sb>:LIN:FILTer:FRAMe<fr>:FLD<fl>:ENABle` on page 1414

"Condition" Displays the value condition for the selected field.

Remote command:

`SBUS<sb>:LIN:FILTer:BIT` on page 1412

`SBUS<sb>:LIN:FILTer:FRAMe<fr>:FLD<fl>:BIT` on page 1412

"Value" The data setup consists of a comparison condition and one or two data patterns.

Remote command:
SBUS<sb>:LIN:FILTer:DMAX on page 1413
SBUS<sb>:LIN:FILTer:FRAMe<fr>:FLD<fl>:DMAX on page 1413
SBUS<sb>:LIN:FILTer:DMIN on page 1413
SBUS<sb>:LIN:FILTer:FRAMe<fr>:FLD<fl>:DMIN on page 1413
SBUS<sb>:LIN:FILTer:DOPerator on page 1413
SBUS<sb>:LIN:FILTer:FRAMe<fr>:FLD<fl>:DOPerator on page 1413

"Index" The index setup consists of a comparison condition and one or two index values.

Remote command:
SBUS<sb>:LIN:FILTer:IMAX on page 1415
SBUS<sb>:LIN:FILTer:FRAMe<fr>:FLD<fl>:IMAX on page 1415
SBUS<sb>:LIN:FILTer:IMIN on page 1415
SBUS<sb>:LIN:FILTer:FRAMe<fr>:FLD<fl>:IMIN on page 1415
SBUS<sb>:LIN:FILTer:IOPerator on page 1416
SBUS<sb>:LIN:FILTer:FRAMe<fr>:FLD<fl>:IOPerator on page 1416

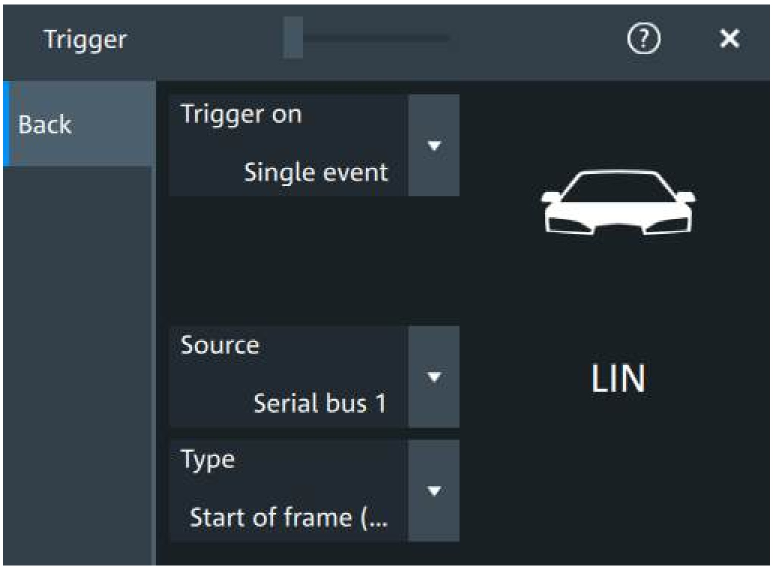
Error type
Enables filtering on the selected error type.

The available errors are "Checksum error", "Parity error","Start error", "Sync error", "Length error" and "Incomplete".

Remote command:
SBUS<sb>:LIN:FILTer:ERENable on page 1414
SBUS<sb>:LIN:FILTer:ERRor<n>:ENABle on page 1414

14.10.4 LIN hardware trigger

Access: "Menu" > "Apps" > "Protocol" tab > "LIN" > "Trigger" tab > "Setup Hardware Trigger"



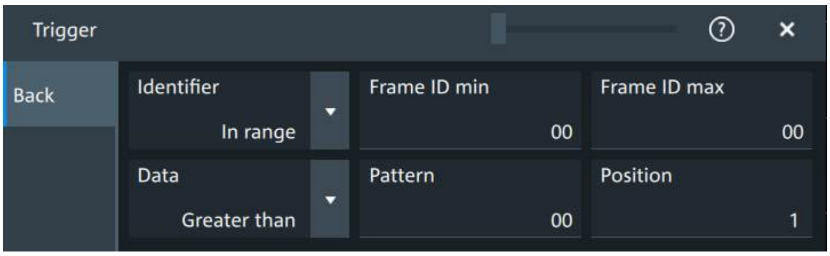
Type
Selects the trigger type for LIN analysis.

Some trigger types have additional settings that can be defined. In this case, the "Set details" button appears next to "Type" the function. Open it for a detailed definition of the trigger conditions.

"Start of frame (Sync)" Triggers on the stop bit of the sync field.

"Identifier" Sets the trigger to one specific identifier or an identifier range. Enter only the 6-bit identifier without parity bits, not the protected identifier.
Description of trigger type specific settings: Identifier setup: Condition, Frame ID min, Frame ID max.

"Identifier + Data" Sets the trigger to a combination of identifier and data condition. The instrument triggers at the end of the last byte of the specified data pattern.



The identifier conditions are the same as for the "Identifier" trigger type, see Identifier setup: Condition, Frame ID min, Frame ID max.
Data conditions are set with Data setup: Condition, Pattern, Position.

"Wake-up frame"	Triggers after a wake-up frame.
"Error condition"	Identifies various errors in the frame, see Error conditions.

Remote command:
`TRIGger:SBHW:LIN:TYPE` on page 1416

Identifier setup: Condition, Frame ID min, Frame ID max
The identifier setup consists of the condition and one or two identifier pattern.

Condition	Sets the comparison condition to a specific value or a range.
"Frame ID min"	Defines the bit pattern of the identifier. Enter only the 6-bit identifier without parity bits, not the protected identifier.
"Frame ID max"	Sets the maximum value of a range for "Condition" = "In range"/"Out of range".

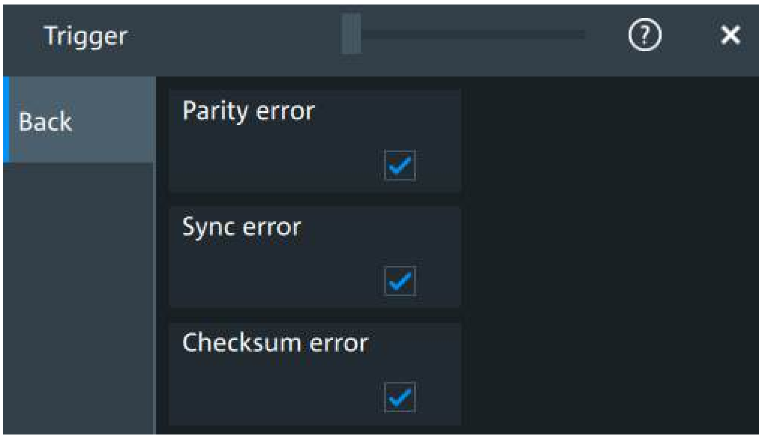
Remote command:
`TRIGger:SBHW:LIN:IMIN` on page 1417
`TRIGger:SBHW:LIN:IMAX` on page 1418
`TRIGger:SBHW:LIN:ICONdition` on page 1418

Data setup: Condition, Pattern, Position
The data setup consists of the the condition, the position of the pattern, and one data pattern.

Condition	Sets the operator to define a specific data pattern ("Equal" or "Not equal") or a range smaller or bigger than a specific pattern.
"Pattern"	Defines the data pattern.
"Position"	Sets the number of data events that are ignored, before trigger condition check of the data starts.

Remote command:
`TRIGger:SBHW:LIN:DCONdition` on page 1419
`TRIGger:SBHW:LIN:DMIN` on page 1419
`TRIGger:SBHW:LIN:DPOSition` on page 1418

Error conditions
Triggers if one or more of the following errors occur.



"Parity error"	Parity bits are the bits 6 and 7 of the identifier. They verify the correct transmission of the identifier.
"Sync error"	Synchronization error.
"Checksum error"	The checksum verifies the correct data transmission. It is the last byte of the frame response. The checksum includes not only the data but also the protected identifier (PID).

Remote command:
`TRIGger:SBHW:LIN:IPERror` on page 1417
`TRIGger:SBHW:LIN:SYERror` on page 1417
`TRIGger:SBHW:LIN:CHKSerror` on page 1419

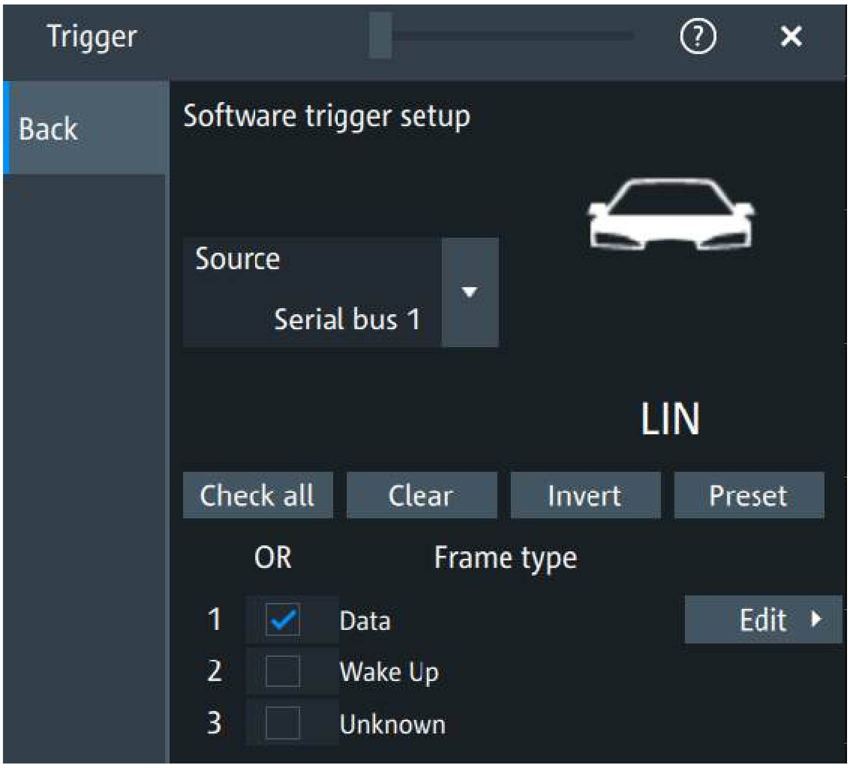
14.10.5 LIN software trigger

14.10.5.1 Setup A trigger

Before setting up the software trigger for the protocols, a trigger A event needs to be set up.

14.10.5.2 Software trigger settings

Access: "Menu" > "Apps" > "Protocol" tab > "LIN" > "Trigger" tab > "Setup Software Trigger"



In the "Software Trigger" tab, you can define the settings to trigger on the frames that match the selected filter conditions.

Check all, Clear, Invert, Preset

The following settings help you select the frames and errors you want to trigger on.

"Check all"	Enables the software trigger for all available frames and error types.
"Clear"	Disables the software trigger for all available frames and error types.
"Invert"	Inverts the current state of the frame and error types for the software trigger: all frames and error types that were enabled are disabled and vice versa.
"Preset"	Presets the state of the selected frames and error types for the software trigger.

Remote command:

`TRIGger:SBSW:LIN:CHKall` on page 1420
`TRIGger:SBSW:LIN:CLR` on page 1420
`TRIGger:SBSW:LIN:INVert` on page 1420
`TRIGger:SBSW:LIN:RST` on page 1421

Frame type

Selects the frame type that you want to trigger on. You can trigger on all enabled frame types simultaneously.

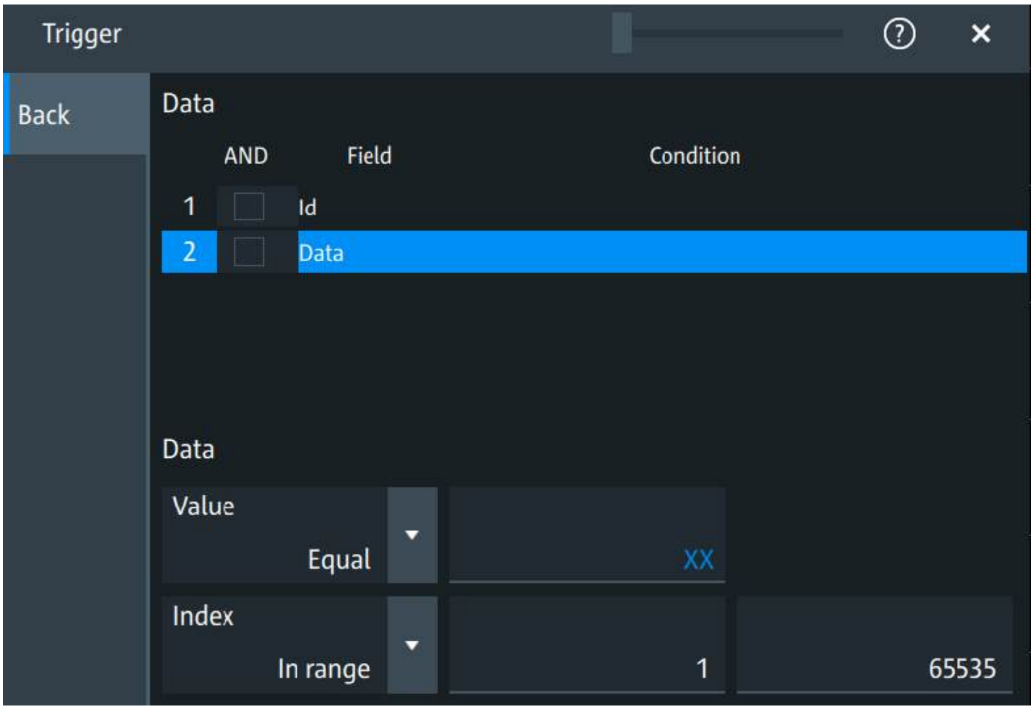
For each frame type, you can also specify conditions for the value of the fields in the "Edit" dialog.

The following frames are available: "Data", "Wake Up", "Unknown".

Remote command:
`TRIGger:SBSW:LIN:FRENable` on page 1421
`TRIGger:SBSW:LIN:FRAMe<fr>:ENABle` on page 1421

Edit

Some trigger types have additional settings that can be defined. In this case, the "Set details" button appears next to "Type" the function. Open it for a detailed definition of the trigger conditions.



"Field" Enables the field type that you want to trigger on for the selected frame.
The following fields are available:

Remote command:
`TRIGger:SBSW:LIN:FIENable` on page 1423
`TRIGger:SBSW:LIN:FRAMe<fr>:FLD<fl>:ENABle` on page 1423

"Condition" Displays the value condition for the selected field.

Remote command:
`TRIGger:SBSW:LIN:BIT` on page 1421
`TRIGger:SBSW:LIN:FRAMe<fr>:FLD<fl>:BIT` on page 1421

"Value" The data setup consists of a comparison condition and one or two data patterns.

Remote command:
TRIGger:SBSW:LIN:DMAX on page 1422
TRIGger:SBSW:LIN:FRAMe<fr>:FLD<fl>:DMAX on page 1422
TRIGger:SBSW:LIN:DMIN on page 1422
TRIGger:SBSW:LIN:FRAMe<fr>:FLD<fl>:DMIN on page 1422
TRIGger:SBSW:LIN:DOPerator on page 1422
TRIGger:SBSW:LIN:FRAMe<fr>:FLD<fl>:DOPerator on page 1422

"Index" The index setup consists of a comparison condition and one or two index values.

Remote command:
TRIGger:SBSW:LIN:IMAX on page 1423
TRIGger:SBSW:LIN:FRAMe<fr>:FLD<fl>:IMAX on page 1423
TRIGger:SBSW:LIN:IMIN on page 1424
TRIGger:SBSW:LIN:FRAMe<fr>:FLD<fl>:IMIN on page 1424
TRIGger:SBSW:LIN:IOPerator on page 1424
TRIGger:SBSW:LIN:FRAMe<fr>:FLD<fl>:IOPerator on page 1424

Error type
Enables triggering on the selected error type.

The following error types are available:"Checksum error", "Parity error","Start error", "Sync error", "Length error" and "Incomplete".

Remote command:
TRIGger:SBSW:LIN:ERENable on page 1424
TRIGger:SBSW:LIN:ERRor<m>:ENABle on page 1424

14.10.6 Measure

The "Setup Measurement" button opens the dialog for automatic measurements in the "Protocol" category for the selected serial bus.

See Section 10.2.6.2, "Settings for protocol measurements", on page 289.

14.10.7 LIN decode results

When the configuration of the serial bus is complete, the signal can be decoded:

1. Open the "Serial Bus" dialog for the respective bus.
2. In the "Setup" tab, enable "State".
3. In the "Display" tab, enable "Show decode table".

For a description of the display settings, see also Section 14.1.3.1, "Display settings", on page 435.

For a description of how to synchronize the displayed results, see Section 14.1.3.2, "Display synchronization", on page 437.

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

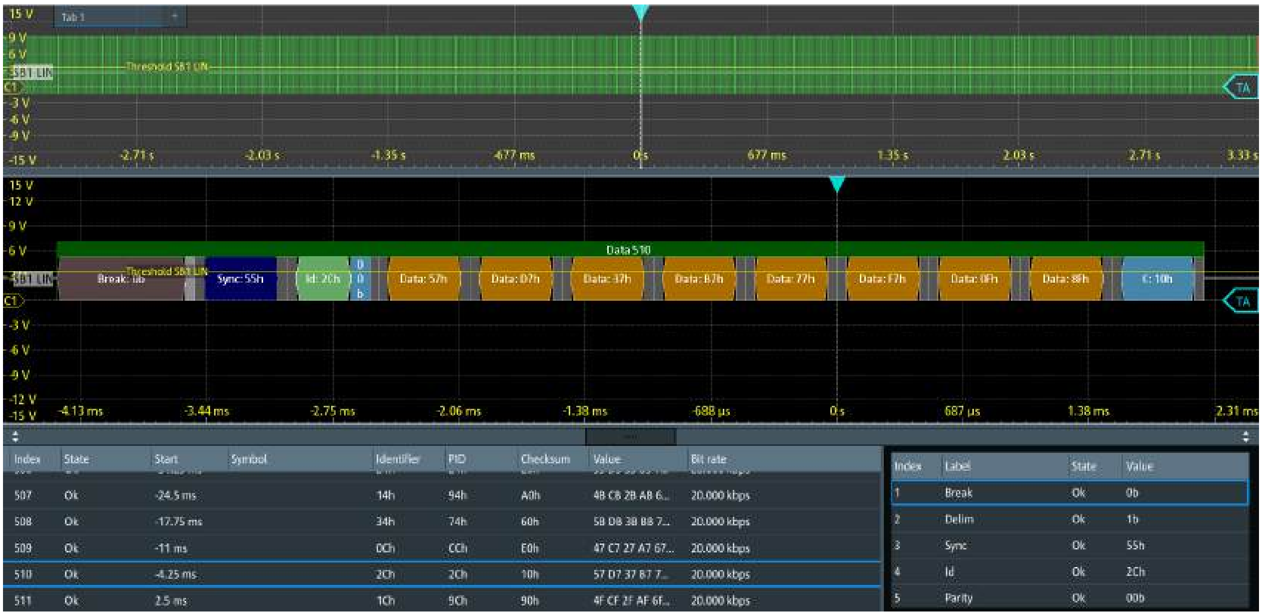


Figure 14-33: Decoded LIN signal

The decode results table contains information about all decoded frames.

Table 14-17: Content of the decode results table

Column	Description
Index	Index of the decoded frame
State	Overall state of the frame
Start	Time of frame start
Symbol	Symbolic label of the frame. Available only, if "Show symbols" is enabled in the "Display" tab and a symbols list is loaded.
Identifier	Identifier value
PID	Protected identifier
Checksum	Checksum value
Values	Value of the data bytes. Select the data format in the "Display" tab.
Bit rate	Value of the bit rate

When you select a frame in the decode results table, its field content is shown in the details table to the right.

Table 14-18: Content of the frame details table

Column	Description
Index	Index of the field
Label	Name of the field
State	State of the field
Value	Value of the field

Data format

You can select various data formats for the values displayed in the decode table and in the combs of the decoded signal.

Remote command:

- SBUS<sb>:FORMat on page 1154

Remote commands

Remote commands to retrieve decode results are described in Section 18.17.11, "LIN (option R&S MXO4-K520)", on page 1407.

14.10.8 Performing LIN decoding

This section explains step by step how to configure and decode the LIN bus.

14.10.8.1 Configuring LIN signals

For configuration, assign the lines to the input channels, and define the active states and the logical thresholds.

For details on configuration settings, see Section 14.10.2, "LIN configuration", on page 622.

1. Tap the "+ Bus" activator in the bottom right of the screen.

2. Select the tab of the bus that you want to set up, for example "SB1".
3. Tap the "Protocol type" button. Select the protocol: LIN.
4. Tap on "State" to enable the decoding.

   An SPI shortcut appears at the bottom left of the screen. Tap on the shortcut for a quick access to the "LIN" dialog settings.

5. Select the "LIN standard".
6. Select the correct channel for "Data".
7. Set the "Bit rate".
8. Check that the signals are on the screen.
   If not try adjusting the vertical and horizontal settings.
9. Set the logical thresholds:
   a) Tap "Threshold setup". The threshold dialog opens.
   b) For each wire, set the threshold value. A typical value is 3.5 V.
   c) If necessary, set the hysteresis value.
   d) Optionally, tap on "Show threshold lines".

14.10.8.2 Triggering on LIN

Prerequisites: A bus is configured for the LIN signal to be analyzed. See Section 14.10.8.1, "Configuring LIN signals", on page 635.

1. Open "Menu" > "Trigger".
2. Set "Trigger on" to "Single event".
3. Ensure that the "Source" is set to the configured serial bus, e.g. "Serial bus 1".
4. Select the "Type".
5. Define additional settings for more complex trigger types: "Identifier", "Identifier +Data".
   a) Tap on "Set details".
   b) Set the "Identifier" condition or an identifier range.
   c) Set the "Data" condition or a data range.

14.10.8.3 Exporting decode results

Once a decode has been completed, you can generate an export of all decode results.

Prerequisites: A bus is configured for the LIN and decoded.

1. Tap on the "LIN" shortcut.
2. Tap on the "Export" tab.
3. If necessary, enable "Include details".
4. If necessary, enable "Include timing".

5. Select the "File type".

   An export file is saved in the selected directory.

The LIN export file contains the following fields:

- A list of all decoded frames:
  - Index
  - Start
  - Stop
  - State
  - Identifier
  - PID
  - Checksum
  - Bit rate
- The details frames include the following fields:
  - Index
  - State
  - Value

Example of LIN export file

```
Index,Start,Stop,State,Identifier,PID,Checksum,Bit rate
1,-3.44,-3.43375,'OK',02h,C2h,D0h,20000
2,-3.43325,-3.427,'OK',22h,22h,30h,20000
3,-3.4265,-3.42025,'OK',12h,92h,B0h,20000
4,-3.41975,-3.4135,'OK',32h,72h,70h,20000
5,-3.413,-3.40675,'OK',0Ah,CAh,F0h,20000

Details frame 1
Index,State,Value
1,'OK',40h
2,'OK',C0h
3,'OK',20h
4,'OK',A0h
5,'OK',60h
6,'OK',E0h
7,'OK',10h
8,'OK',90h

Details frame 2
Index,State,Value
1,'OK',50h
2,'OK',D0h
3,'OK',30h
4,'OK',B0h
5,'OK',70h
6,'OK',F0h
```

```
7,'OK',08h
8,'OK',88h
```

14.11 SENT (automotive electronics, option R&S MXO4-K520)

Single Ended Nibble Transmission (SENT) is a serial transmission interface protocol originally specified for the communication of sensors and control units in automotive electronics.

SENT is a protocol standard governed by the Society of Automotive Engineers (SAE J2716). For detailed information, refer to the SENT standard specification on http://www.sae.org.

The SENT protocol is used exclusively in automotive applications. Examples are electrical power steering, and advanced driver assistance such as parking assist or sensing of pressure, throttle position, pedal position, airflow mass, liquid level, etc.

Requirements

For performing SENT decode measurements, you need the following:

- MXO 4 with 1 available channel. The channel can be:
  - Analog channels (C1-C4)
  - Logic channels (D0-D15) (requires option R&S MXO4-B1)
- One probe
- Option R&S MXO4-K520

14.11.1 About the SENT protocol

This section provides an overview of the protocol characteristics, encoding scheme, identifiers and trigger possibilities.

The SENT protocol transmits signal values point-to-point from a sensor to a controller (electronic control unit ECU), unidirectional. In contrast to conventional measurements, you can receive multiple data parameters via the SENT interface in a single transmission. Nevertheless, SENT is characterized by its simplicity and yet high customizability to meet the individual requirements of the applications.

SENT operates via a three-wire connection, a signal line, a supply voltage line for the sensor and a ground line. It transmits data digitally in variable timing units and evaluates the time between two falling edges (single edges). The signal is amplitude modulated with a constant amplitude voltage. Thus the influences of disturbance signals are not critical.

SENT key features

The main characteristics of SENT are:

- Serial communication protocol
- 3 wires: SENT (signal line), 5V (voltage line), GND (ground line)
- Output only, from sensor to receiver
- Point-to-point transmission, no bus
- Digital transmission
- High baud rate
- Data transmission in variable timing units of 4 bits (1 nibble) between two falling edges
- Transmitter-specific clock period (tick)
- Time measured between single falling edges

14.11.1.1 SENT transmission concept

A sensor converts the analog measured data to a digital signal, and thus transmits a series of pulses to the receiver. The receiver, e.g. an ECU processes the received signal also digitally.

The format of a SENT message frame has a fixed pulse order and a transmitter-specific clock period. The total transmission time varies depending on the clock variation of the transmitter and the transmitted data values. The data pulses embedded in the transmission sequence represent one or multiple data parameters to be communicated. The last pulses in a message frame are the CRC check pulse, allowing the receiver to perform some diagnostic tests, and an optional pause pulse.

A SENT transmission starts without a request from the receiver. Consecutive sequences are transmitted continuously after the falling edge of the last pulse.

The SENT protocol distinguishes between two channel types:

- **Fast channel:** transmits primary data, i.e. sensor readings like temperature, pressure, mass air flow, throttle position.
- **Slow channel:** transmits secondary data consisting of transfer characteristics, sensor ID, type, manufacturer diagnostic, etc.
  The slow channel transmission provides two serial message formats *Short* and *Enhanced* for customizing the secondary data.

The data of both channels is transmitted simultaneously, by including two bits of a slow channel message in the message frame of the fast channel. Even though it requires many fast channel messages to complete a slow channel message, you can use this function to transmit several slow channel messages with minimal impact on the primary sensor data and the data rate.

14.11.1.2 SENT message definitions

SENT terms

See the specific terms and definitions used in the SENT protocol:

- **Tick (clock tick):** basic unit of time
  - Transmitter-specific nominal clock period
  - 3 µs < clock tick <90 µs, with max. 20 % clock variation
- **Nibble:** minimum unit of data
  - Used to transmit data
  - Variable timing units between two falling edges

SENT fast channel

The SENT protocol enables you to transmit measurements of multiple sensors in one transmission sequence with data signals of varying length. The diagram in Figure 14-34 shows, for example, the encoding scheme for two 12-bit data signals.

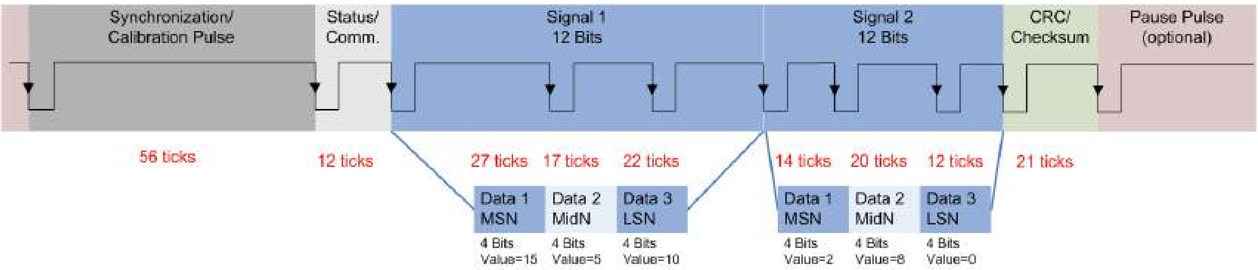


Figure 14-34: Example of a SENT transmission sequence

The format of a SENT transmission sequence consists of the following pulses:

- **Synchronization/Calibration pulse:**
  - Initial sequence of the receiver
  - The start condition is the falling edge of the last pulse (CRC or Pause)
  - The nominal pulse period is 56 clock ticks
  - Measures the actual clock variation of the transmitter and calculates the tick timing
- **Status/Communication Pulse (Nibble)**
  - One 4 bit pulse
  - Communicates status and enables the sensor to include slow channel message bits
    0: (LSB) specific application
    1: specific application
    2: Serial Data message or specific application (e.g. Infineon TLE4998S)
    3: (MSB) 1= message start; 0=Serial Data message or specific application (e.g. Infineon TLE4998S)
  - 12 to 27 clock ticks
  - Not included in CRC frame calculation

- **Data Pulses (Nibbles)**
  - One up to six 4 bit data nibbles
  - 12 to 27 clock ticks pulse period
  - Initial logic 0 time with ≥5 ticks, subsequent logical 1 with variable duration
- **CRC/Checksum**
  - One 4 bit pulse
  - Used for error checking of data nibbles (status nibble not included)
  - Detects single bit, odd number of nonconsecutive and single burst errors
- **Pause Pulse**
  - One optional pulse
  - Variable pulse length: 12 to 768 clock ticks
  - Can be used to create a transmission with a constant number of clock ticks

SENT slow channel

Short Serial Messages

For transmission of a slow channel message, 2 bits are included in a fast channel message, see the status nibble (Bit 2,3) in Figure 14-35.

A short serial message needs 16 fast channel messages until it is completely transmitted. Prerequisite for the complete transmission of the slow channel message is 16 consecutive error-free fast channel transmissions.

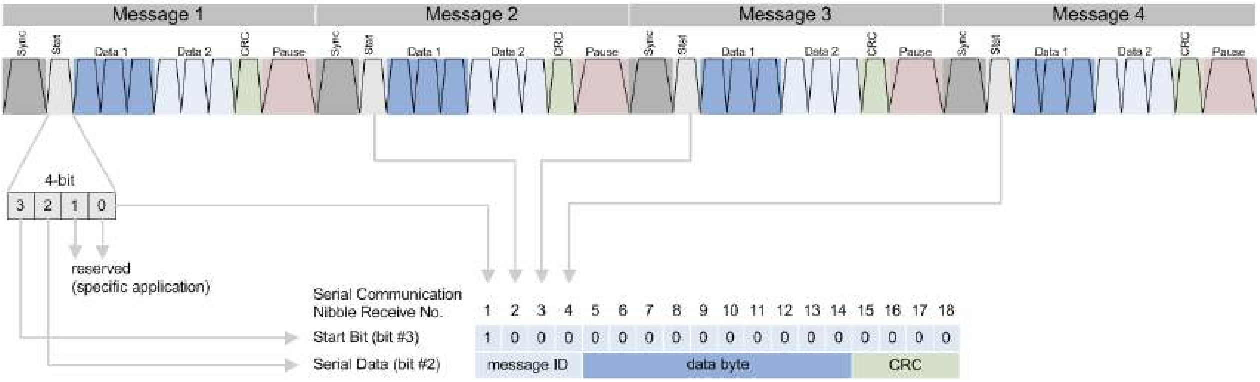


Figure 14-35: One serial message, composed of 16 SENT consecutive fast channel transmissions

Enhanced Serial Messages

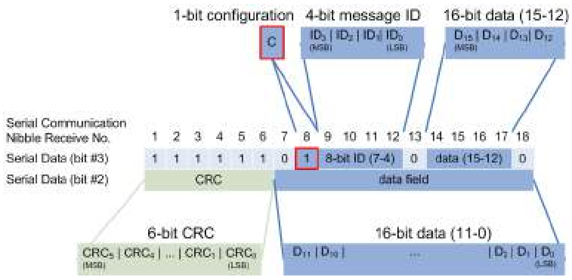
The transmission of an enhanced serial message format requires 18 fast channel transmissions. Each slow channel message is assigned a message ID, which is transmitted with the data.

The enhanced serial message format provides two alternatives for configuring the message:

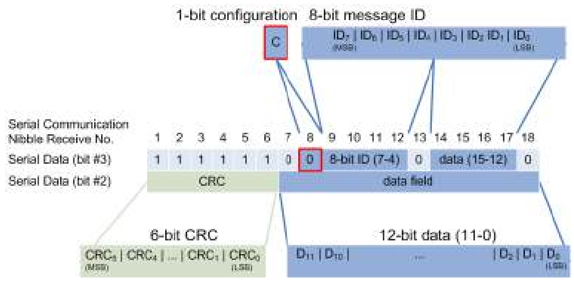
- 4-bit ID and 16-bit data
- 8-bit ID and 12-bit data

The graphs below illustrate the variants.

Table 14-19: Enhanced serial message formats



16-bit data and 4-bit message ID

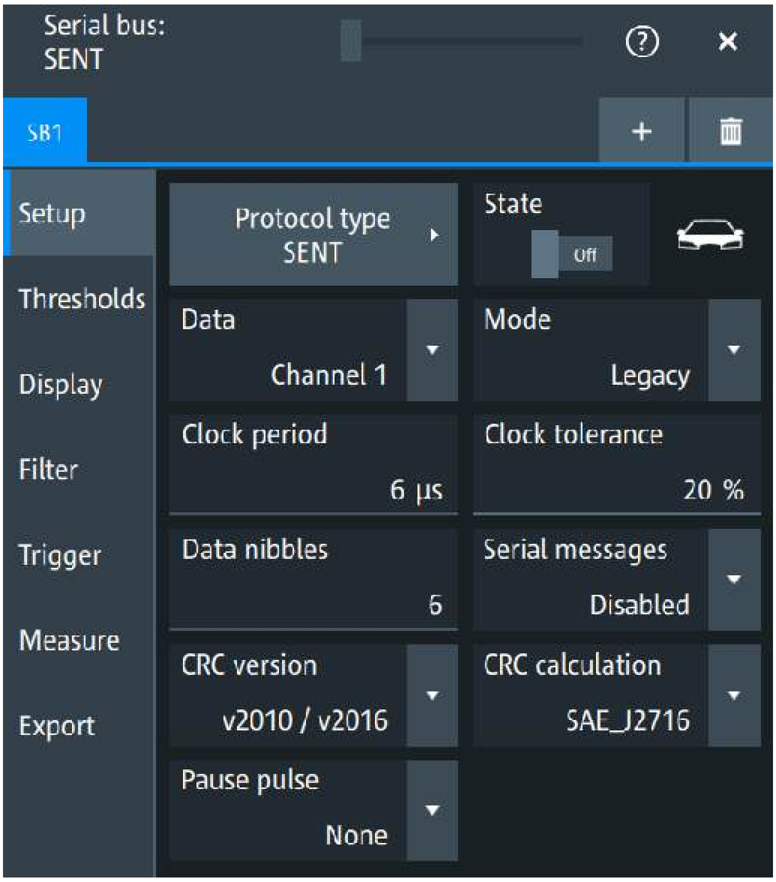


12-bit data and 8-bit message ID

14.11.2 SENT configuration

14.11.2.1 SENT configuration settings

Access: "Menu" > "Apps" > "Protocol" tab > "SENT" > "Setup".



Make sure that the tab of the correct serial bus is selected.

Protocol type

Selects the protocol type to be decoded.

Remote command:
SBUS<sb>:TYPE on page 1153

Data

Sets the source of the data line.

Remote command:
SBUS<sb>:SENT:DATA:SOURce on page 1433

Mode

Selects the operating mode of the SENT protocol.

If "Mode" = "Legacy", the "SPC" mode is not supported.

The single point calibration ("SPC") mode was introduced in the SENT 2.0 specification. If "SPC" mode is selected, the SENT protocol allows for the calibration of a sensor's output by sending a single calibrated value. It is particularly useful for applications where a sensor needs to be calibrated to ensure accurate readings. The SPC mode typically involves the transmission of a single data frame that contains the calibrated value, which can then be used by the receiving device to interpret the sensor's output correctly.

Remote command:
SBUS<sb>:SENT:MODE on page 1434

Clock period

Sets the transmitter-specific nominal clock period (clock tick).

The clock period and signal length determine the speed of transmission.

Remote command:
SBUS<sb>:SENT:CLKPeriod on page 1432

Clock tolerance

Specifies a tolerated deviation of the clock.

Remote command:
SBUS<sb>:SENT:CLKTolerance on page 1432

Data nibbles

Sets the number of data units in a single transmission sequence.

The maximum number of data nibbles is 6.

Remote command:
SBUS<sb>:SENT:DNIBbles on page 1434

Serial message

Selects if serial messages are enabled or disabled.

Remote command:
SBUS<sb>:SENT:SFORmat on page 1436

CRC version
Selects the version that the CRC check is based on.

"Legacy" Based on the CRC calculation version used earlier than 2010.

"v2010/v2016" Based on the CRC calculation version updated in 2010/2016.

Remote command:
SBUS<sb>:SENT:CRCVersion on page 1433

CRC calculation
Selects the method for CRC calculation.

"SAE_J2716" Calculates the CRC according to the SAE standard.
For this method, the checksum is calculated over all nibbles except the communication and status nibble.

"TLE_4998X" Calculates the CRC according to the standard computing method for Infineon TLE_4998X sensors.
For this method, the checksum is calculated over all nibbles except the communication nibble.

Remote command:
SBUS<sb>:SENT:CRCMethod on page 1432

Pause pulse
Determines whether a pause pulse is transmitted after the checksum nibble.

You can use this pulse to create a transmission with a constant number of clock ticks. The pause pulse length can be between a minimum of 12 clock ticks up to 768 (3*256) ticks at a maximum.

Remote command:
SBUS<sb>:SENT:PPULse on page 1435

Frame length
Determines the frame length in terms of ticks. The dialog displays this settings parameter, if the signal has a constant frame length.

Remote command:
SBUS<sb>:SENT:PPFLength on page 1435

14.11.2.2 Threshold settings

Access: "Menu" > "Apps" > "Protocol" tab > "SENT" > "Thresholds".

Threshold
Sets the threshold for the data channel. Enter the value directly in the fields.

Additional to the threshold, you can also set a hysteresis.

Remote command:
SBUS<sb>:SENT:DATA:THReshold on page 1433
SBUS<sb>:SENT:DATA:HYSTeresis on page 1433

Show threshold lines
If enabled, the threshold lines are displayed in the diagram.

The label of the threshold line is set according to the signal that it is referring to, see also Show threshold lines.

Remote command:
`SBUS<sb>:THReshold` on page 1155

14.11.2.3 Display settings

For details about the display settings, see Section 14.1.3.1, "Display settings", on page 435.

Decode layer
Selects the decode layer.

Decoding is performed in several steps, and the results are presented in the decode table. The decode layer selects an interim step for which the decoding result is shown in the honeycomb display.

Show symbols
You can load symbol lists, and activate its usage for decoding. As a result, an additional "Symbol" column appears in the "Decode results" table, containing the symbolic label.

For details, see Section 14.11.2.4, "SENT symbols", on page 645.

14.11.2.4 SENT symbols

Label lists are protocol-specific. For the SENT protocol, you can upload symbol lists as in the format shown in the following example.

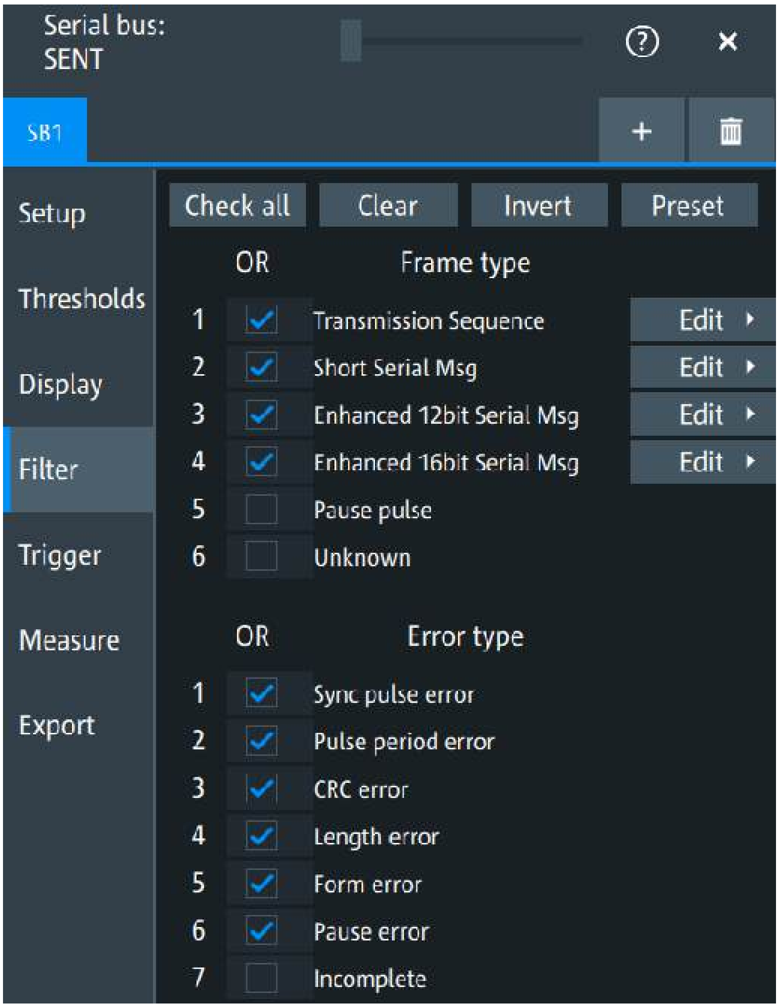
Example: SENT symbols file

```
<sb:FRAME NAME="Diagnostic Error Codes" STATE="ON">
  <!-- Start of a Frame Definition -->
  <!-- This block defines the information of a Transmission Sequence
   or Serial Message:
   NAME => Symbolic Label of the Frame
   STATE [ON/OFF] => When ON, this frame Translation is taken into consideration.
                     When OFF, this frame Translation is skipped.-->
<sb:DESCRIPTION> used to diagnose the current SENT System</sb:DESCRIPTION>
  <!-- Doesn't affect the Translation -->
<sb:ID-VALUE>01</sb:ID-VALUE>
  <!-- ID Value of the Serial Message (in decimal) -->
  <!-- Absence of the ID-VALUE field implies that the current Frame Translation
   is to be used for Transmission Sequences and not for a Serial Message -->
<sb:ID-LENGTH>8</sb:ID-LENGTH>
  <!-- ID Length of the Serial Message (in bits) -->
<sb:DATA-SIZE>12</sb:DATA-SIZE>
  <!-- Data Length of the Serial Message (in bits) -->
<sb:SIGNALS>
```

```
  <!-- This block defines the information of the Signals embedded
   in the Data Field of the Frame (Transmission Sequence or Serial Message) -->
<sb:SIGNAL ID="Diagnostic">
  <!-- Unique ID of the Signal (no effect on Translation) -->
<sb:SHORT-NAME>Diagnostic Code</sb:SHORT-NAME>
  <!-- Name of the Signal -->
<sb:DESCRIPTION></sb:DESCRIPTION>
  <!-- Info Field (no effect on Translation) -->
<sb:BIT-POSITION>11</sb:BIT-POSITION>
  <!-- Starting Bit position of the Signal
   (The whole Data Field is represented as MSB -> LSB Sequence) -->
<sb:BIT-LENGTH>12</sb:BIT-LENGTH>
  <!-- Number of Bits representing the Signal Value -->
<sb:BYTE-ORDER>MSB</sb:BYTE-ORDER>
  <!-- Byte Order of the Signal Value [MSB or LSB], Default: MSB -->
<sb:VALUE-TYPE>ENUM</sb:VALUE-TYPE>
  <!-- Representation of the Bits [ENUM, UNSIGNED_INT, INT, FLOAT, DOUBLE],
   Default: UNSIGNED_INT
   The Signal Value is calculated according to the following:
   Translated_Value = Encoded_Value * FACTOR + OFFSET -->
<sb:FACTOR>1.0</sb:FACTOR>
  <!-- Signal Factor (decimal value)-->
<sb:OFFSET>0.0</sb:OFFSET>
  <!-- Signal Offset (decimal value)-->
<sb:MIN>0</sb:MIN>
  <!-- Minimum Signal Value (decimal value) -->
<sb:MAX>4096</sb:MAX>
  <!-- Maximum Signal Value (decimal value) -->
<sb:ENUM-VALUES>
  <!-- This block is only valid (and taken into consideration)
   when the VALUE-TYPE is ENUM
   It defines the Enumeration List Translation of the Signal -->
<sb:ENUM INDEX="0" LABEL="No Error"/>
   <!-- INDEX is the Enum Value (corresponds to the Signal Value in decimal),
    LABEL is the matching Translated Signal Value -->
<sb:ENUM INDEX="1" LABEL="Channel 1 out of range high"/>
</sb:ENUM-VALUES>
  <!-- End of Signal Enumeration List Definition -->
</sb:SIGNAL>
  <!-- End of a Signal Definition -->
  <!-- More Signals can be defined here! -->
</sb:SIGNALS>
  <!-- End of list of Signals Definition -->
</sb:FRAME>
  <!-- End of Frame Definition -->
```

14.11.3 SENT filter

Access: "Menu" > "Apps" > "Protocol" tab > "SENT" > "Filter" tab



In the "Filter" tab, you can define the settings to display only the frames that match the selected filter conditions.

Check all, Clear, Invert, Preset

The following settings help you select the frames and errors you want to filter for. Only the frames and error types that match the selected filter conditions are displayed.

"Check all"	Enables the filter for all available frames and error types.
"Clear"	Disables the filter for all available frames and error types.
"Invert"	Inverts the current state of the frame and error types: all frames and error types that were enabled are disabled and vice versa.
"Preset"	Presets the state of the selected frames and error types.

Remote command:

SBUS<sb>:SENT:FILTer:CHKall on page 1438

SBUS<sb>:SENT:FILTer:CLR on page 1438

SBUS<sb>:SENT:FILTer:INVert on page 1439

SBUS<sb>:SENT:FILTer:RST on page 1439

Enable
Enables the filtering on SENT frames. Only the frames that match the selected filter conditions are displayed.

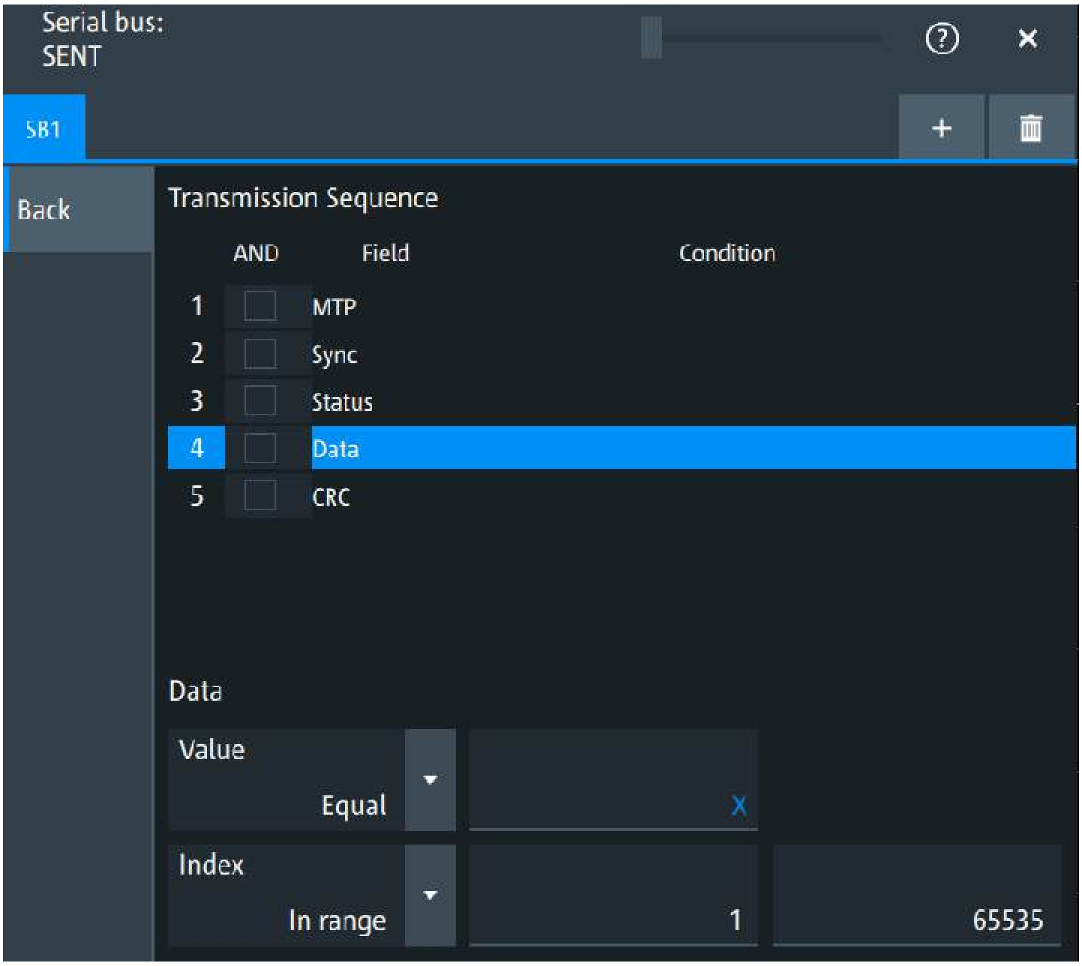
Remote command:
SBUS<sb>:SENT:FILTer:FRENable on page 1439
SBUS<sb>:SENT:FILTer:FRAMe<fr>:ENABle on page 1439

Frame type
Selects the frame type that you want to display. You can filter all enabled frame types simultaneously.

For selected frame types, you can also specify conditions for the value of the fields in the "Edit" dialog.

The following frame types are available: "Transmission Sequence", "Short Serial Msg", "Enhanced 12bit Serial Msg", "Enhanced 16bit Serial Msg", "Pause pulse", "Unknown".

Edit
Opens a dialog to define the details of the selected frame.



"Field"
Enables the field type that you want to filter on for the selected frame. The following fields are available: "MTP", "Sync", "Status", "Data", "CRC", "ID".

Remote command:
SBUS<sb>:SENT:FILTer:FIENable on page 1441
SBUS<sb>:SENT:FILTer:FRAMe<fr>:FLD<fl>:ENABle on page 1441

"Condition"
Displays the value condition for the selected field.

Remote command:
SBUS<sb>:SENT:FILTer:BIT on page 1439
SBUS<sb>:SENT:FILTer:FRAMe<fr>:FLD<fl>:BIT on page 1439

"Value"
The data setup consists of a comparison condition and one or two data patterns.

Remote command:
SBUS<sb>:SENT:FILTer:DMAX on page 1440
SBUS<sb>:SENT:FILTer:FRAMe<fr>:FLD<fl>:DMAX on page 1440
SBUS<sb>:SENT:FILTer:DMIN on page 1440
SBUS<sb>:SENT:FILTer:FRAMe<fr>:FLD<fl>:DMIN on page 1440
SBUS<sb>:SENT:FILTer:DOPerator on page 1441
SBUS<sb>:SENT:FILTer:FRAMe<fr>:FLD<fl>:DOPerator on page 1441

"Index"
The index setup consists of a comparison condition and one or two index values.

Remote command:
SBUS<sb>:SENT:FILTer:IMAX on page 1441
SBUS<sb>:SENT:FILTer:FRAMe<fr>:FLD<fl>:IMAX on page 1441
SBUS<sb>:SENT:FILTer:IMIN on page 1442
SBUS<sb>:SENT:FILTer:FRAMe<fr>:FLD<fl>:IMIN on page 1442
SBUS<sb>:SENT:FILTer:IOPerator on page 1442
SBUS<sb>:SENT:FILTer:FRAMe<fr>:FLD<fl>:IOPerator on page 1442

Error type
Enables filtering on the selected error type.

The available error types are "Sync pulse error", "Pulse period error", "CRC error", "Length error", "Form error", "Pause error", "Incomplete".

Remote command:
SBUS<sb>:SENT:FILTer:ERENable on page 1443
SBUS<sb>:SENT:FILTer:ERRor<n>:ENABle on page 1443

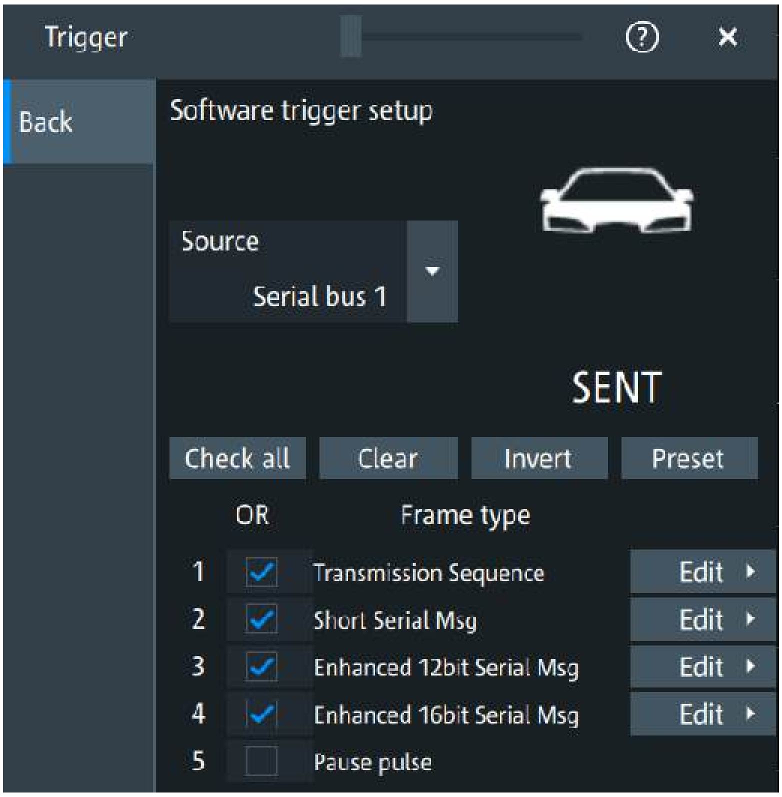
14.11.4 SENT software trigger

14.11.4.1 Setup A trigger

Before setting up the software trigger for the protocols, a trigger A event needs to be set up.

14.11.4.2 Software trigger settings

Access: "Menu" > "Apps" > "Protocol" tab > "SENT" > "Trigger" tab > "Setup Software Trigger" > "Setup SB Trigger"



In the "Software Trigger" tab, you can define the settings to trigger on the frames that match the selected filter conditions.

Check all, Clear, Invert, Preset

The following settings help you select the frames and errors you want to trigger on.

"Check all"	Enables the software trigger for all available frames and error types.
"Clear"	Disables the software trigger for all available frames and error types.
"Invert"	Inverts the current state of the frame and error types for the software trigger: all frames and error types that were enabled are disabled and vice versa.

"Preset" Presets the state of the selected frames and error types for the software trigger.

Remote command:
`TRIGger:SBSW:SENT:CHKall` on page 1444
`TRIGger:SBSW:SENT:CLR` on page 1444
`TRIGger:SBSW:SENT:INVert` on page 1444
`TRIGger:SBSW:SENT:RST` on page 1444

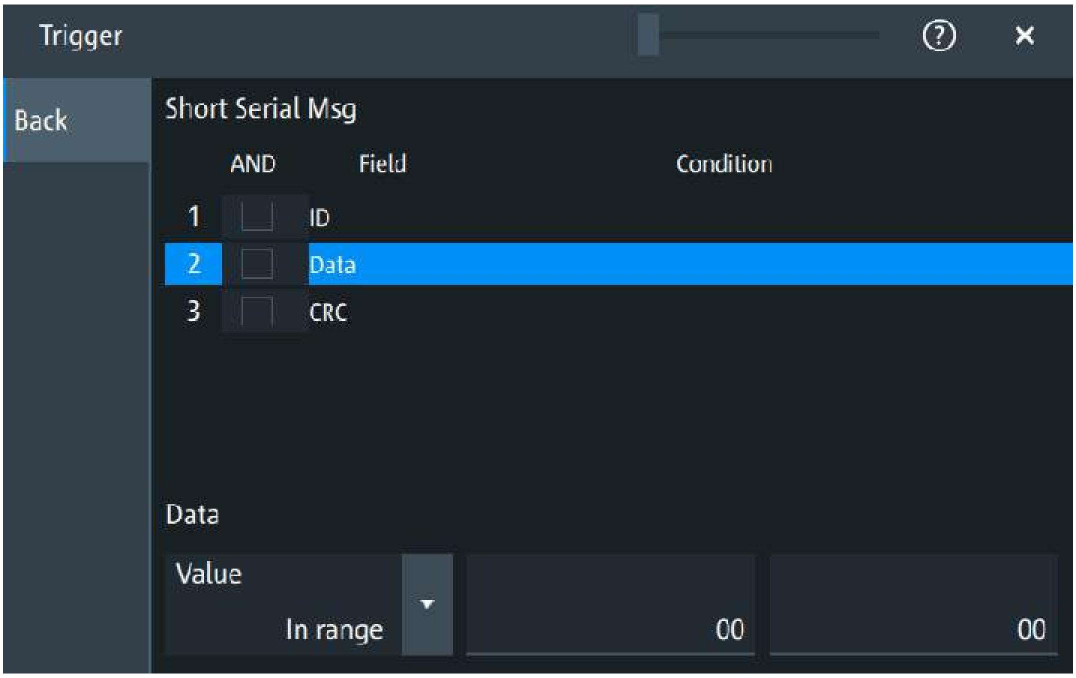
Frame type
Selects the frame type that you want to trigger on. You can trigger on all enabled frame types simultaneously.

For each frame type, you can also specify conditions for the value of the fields in the "Edit" dialog.

The following frame types are available: "Transmission Sequence", "Short Serial Msg", "Enhanced 12bit Serial Msg", "Enhanced 16bit Serial Msg", "Pause pulse", "Unknown".

Remote command:
`TRIGger:SBSW:SENT:FRENable` on page 1444
`TRIGger:SBSW:SENT:FRAMe<fr>:ENABle` on page 1444

Edit
Some trigger types have additional settings that can be defined. In this case, the "Set details" button appears next to "Type" the function. Open it for a detailed definition of the trigger conditions.



"Field" Enables the field type that you want to trigger on for the selected frame.
The following fields are available: "MTP", "Sync", "Status", "Data", "CRC", "ID".

Remote command:
TRIGger:SBSW:SENT:FIENable on page 1445
TRIGger:SBSW:SENT:FRAMe<fr>:FLD<fl>:ENABle on page 1445

"Condition" Displays the value condition for the selected field.

Remote command:
TRIGger:SBSW:SENT:BIT on page 1445
TRIGger:SBSW:SENT:FRAMe<fr>:FLD<fl>:BIT on page 1445

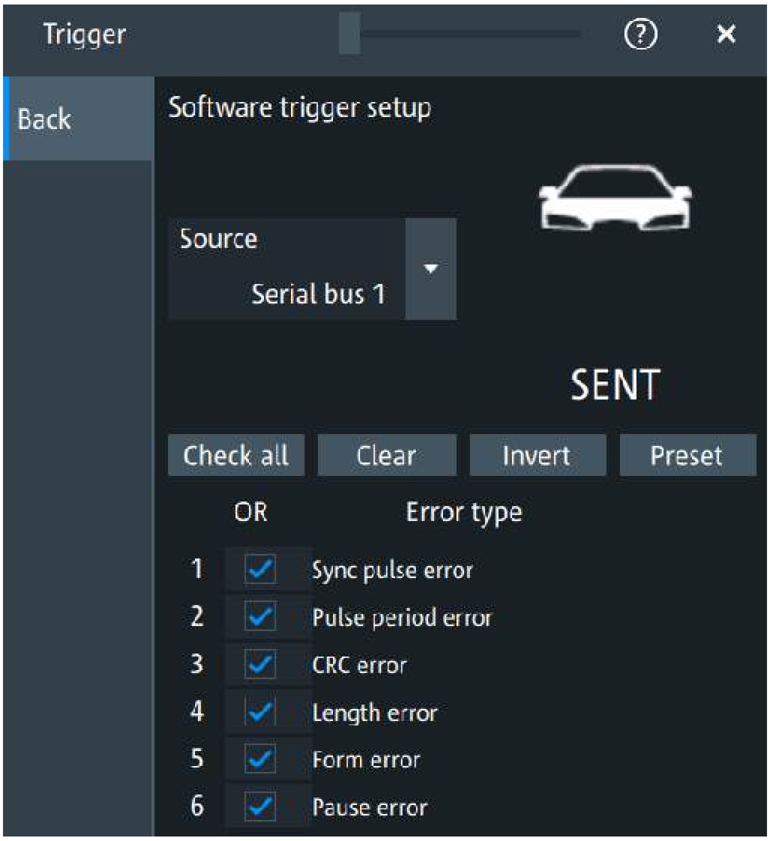
"Value" The data setup consists of a comparison condition and one or two data patterns.

Remote command:
TRIGger:SBSW:SENT:DMAX on page 1445
TRIGger:SBSW:SENT:FRAMe<fr>:FLD<fl>:DMAX on page 1445
TRIGger:SBSW:SENT:DMIN on page 1446
TRIGger:SBSW:SENT:FRAMe<fr>:FLD<fl>:DMIN on page 1446
TRIGger:SBSW:SENT:DOPerator on page 1446
TRIGger:SBSW:SENT:FRAMe<fr>:FLD<fl>:DOPerator on page 1446

"Index" The index setup consists of a comparison condition and one or two index values.

Remote command:
TRIGger:SBSW:SENT:IMAX on page 1447
TRIGger:SBSW:SENT:FRAMe<fr>:FLD<fl>:IMAX on page 1447
TRIGger:SBSW:SENT:IMIN on page 1447
TRIGger:SBSW:SENT:FRAMe<fr>:FLD<fl>:IMIN on page 1447
TRIGger:SBSW:SENT:IOPerator on page 1447
TRIGger:SBSW:SENT:FRAMe<fr>:FLD<fl>:IOPerator on page 1447

Error type
Enables triggering on the selected error type.



The following error types are available: "Sync pulse error", "Pulse period error", "CRC error", "Length error", "Form error", "Pause error".

Remote command:
`TRIGger:SBSW:SENT:ERENable` on page 1448
`TRIGger:SBSW:SENT:ERRor<m>:ENABle` on page 1448

14.11.5 Measure

The "Setup Measurement" button opens the dialog for automatic measurements in the "Protocol" category for the selected serial bus.

See Section 10.2.6.2, "Settings for protocol measurements", on page 289.

14.11.6 SENT decode results

When the configuration of the serial bus is complete, the signal can be decoded:

1. Open the "Serial Bus" dialog for the respective bus.
2. In the "Setup" tab, enable "State".
3. In the "Display" tab, enable "Show decode table".

For a description of the display settings, see also Section 14.1.3.1, "Display settings", on page 435.

For a description of how to synchronize the displayed results, see Section 14.1.3.2, "Display synchronization", on page 437.

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

Decode results table

The "Decode results" table contains information about all decoded frames.

Figure 14-36: Decoded SENT signal

The decode results table contains information about all decoded frames.

Table 14-20: Content of the decode results table

Column	Description
Index	Index of the decoded frame
State	Overall state of the frame
Start	Time of frame start
Frame type	The type of frame
Symbolic name	Symbolic label of the frame. Available only, if "Show symbols" is enabled in the "Display" tab and a symbols list is loaded.
Sync time	Synchronisation time
Status [bin]	Status value

Column	Description
Data nibbles	Values of the data nibbles. Select the data format in the "Display" tab.
ID value	Identifier value
Clock rate	Value of the clock rate

When you select a frame in the decode results table, its field content is shown in the details table to the right.

Table 14-21: Content of the frame details table

Column	Description
Index	Number of the decoded field
Label	Name of the field
State	State of the field
Value	Value of the field

Data format

You can select various data formats for the values displayed in the decode table and in the combs of the decoded signal.

Remote command:

- `SBUS<sb>:FORMat` on page 1154

Remote commands

Remote commands to retrieve decode results are described in Section 18.17.12.4, "Decode results", on page 1449.

14.11.7 Performing SENT decoding

This section explains step by step how to configure and decode the SENT bus.

14.11.7.1 Configuring SENT signals

For configuration, assign the lines to the input channels, and define the active states and the logical thresholds.

For details on configuration settings, see Section 14.11.2, "SENT configuration", on page 642.

1. Tap the "+ Bus" activator in the bottom right of the screen.

2. Select the tab of the bus that you want to set up, for example "SB1".
3. Tap "Protocol type". Select the protocol: "SENT".
4. Tap "State" to enable the decoding.

   A SENT shortcut appears at the bottom left of the screen. Tap on the shortcut for a quick access to the "SENT" dialog settings.

5. Select the correct channel for "Data".
6. Set "Bit order" to "MSB" or "LSB first".
7. Set "Clock polarity" to "Rising edge" (CPOL = 0) or "Falling edge" (CPOL = 1).
8. Set "MOSI polarity"/"MISO polarity" to "Active high"(CPHA = 0) or "Active low"(CPHA = 1).
9. Set "CS polarity" to "Active high" or "Active low".
   The typical value is "Active low", which means that the line is pulled low on message start.
10. Set the "Word length". The typical value is 8.
11. Check that the signals are on the screen.
    If not try adjusting the vertical and horizontal settings.
12. Set the logical thresholds:
    a) Tap "Threshold setup". The threshold dialog opens.
    b) Set the threshold value. A typical value is 3.5 V.
    c) If necessary, set the hysteresis value.
    d) Optionally, tap on "Show threshold lines".

14.11.7.2 Exporting decode results

Once a decode has been completed, you can generate an export of all decode results.

Prerequisites: A bus is configured for the SENT and decoded.

1. Tap on the "SENT" shortcut.
2. Tap on the "Shortcuts" tab.
3. Tap "Export results".
4. If necessary, enable "Include details".
5. If necessary, enable "Include timing".
6. Select the "File type".

   An export file is saved in the selected directory.

The SENT export files contain the following fields:

- Index
- Start
- Stop
- State
- Type
- Symbol
- Sync duration
- Status
- CRC
- ID
- MTP duration
- Sensor response time
- Bit rate

Example SENT export file

```
Index,Start,Stop,State,Type,Symbol,SyncDur,Status,CRC,ID,MTP,SensorRespTime,BR
1 -0.0534 -0.0523 'OK' 'TRSQ' 0.000280 3h Bh - - - 199900
2 -0.0521 -0.0509 'PULS' 'TRSQ' 0.000280 3h Bh - - - 199900
3 -0.050  -0.0499 'OK' 'TRSQ' 0.000280 0h Fh - - - 199900
4 -0.0496 -0.0486 'OK' 'TRSQ' 0.000280 0h 4h - - - 199900
5 -0.0483 -0.0472 'CRC' 'TRSQ' 0.000280 0h 4h - - - 199900
6 -0.0470 -0.0460 'OK' 'TRSQ' 0.000280 0h 1h - - - 199900
7 -0.0457 -0.0447 'OK' 'TRSQ' 0.000280 0h 0h - - - 199900
8 -0.0447 -0.0435 'OK' 'TRSQ' 0.000280 0h Bh - - - 199900
9 -0.0432 -0.0422 'OK' 'TRSQ' 0.000280 0h Eh - - - 199900
10 -0.041 -0.0410 'OK' 'TRSQ' 0.000280 0h 3h - - - 199900

Details frame 1
Index    State    Value
1     'OK'     14h
2     'OK'     15h
3     'OK'     16h
4     'OK'     17h
5     'OK'     18h
6     'OK'     19h
7     'OK'     1Ah
8     'OK'     1Bh

Details frame 2
Index    State    Value
1     'OK'     1Ch
2     'OK'     1Dh
3     'OK'     1Eh
4     'OK'     1Fh
5     'OK'     20h
```

```
6     'OK'     21h
7     'OK'     22h
8     'OK'     23h
9     'OK'     24h
```

14.12 ARINC 429 (aerospace electronics, option R&S MXO4-K530)

The ARINC 429 is a specification that defines the characteristics of an avionic data bus used on commercial and transport aircraft.

14.12.1 About the ARINC 429

In an ARINC 429 system, a single transmitter/source is connected to 1 to 20 receivers/sinks on one twisted wire pair. The bus uses differential signals. The ARINC 429 standard uses a simplex communication - data may be transmitted in only one direction. The information is transmitted over the bus in defined series of words.

Word Format

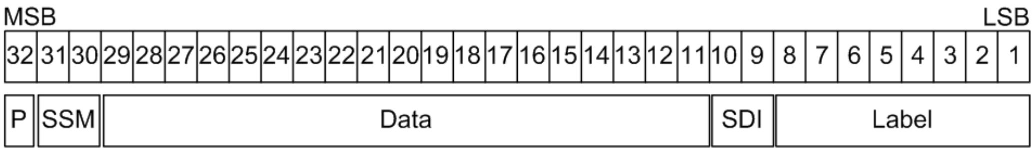


Figure 14-37: Structure of an ARINC 429 word

An ARINC 429 word is 32-bits and consists of the following parts (see Figure 14-37):

- Parity: the most significant bit (MSB). Checks if there are bit errors during the transmission. The total number of logic 1 bits for the word shall be odd.
- Sign/Status Matrix (SSM): the value of these bits depends on the data type. It may be used to report the status of hardware equipment.
- Data:
  – Binary (BNR): stores the data as a binary number.
  – Binary Coded Decimal (BCD): uses 4 data field bits to represent a decimal digit.
  – Discrete data: a combination of BNR and/ or BCD or individual bits that express specific equipment conditions.

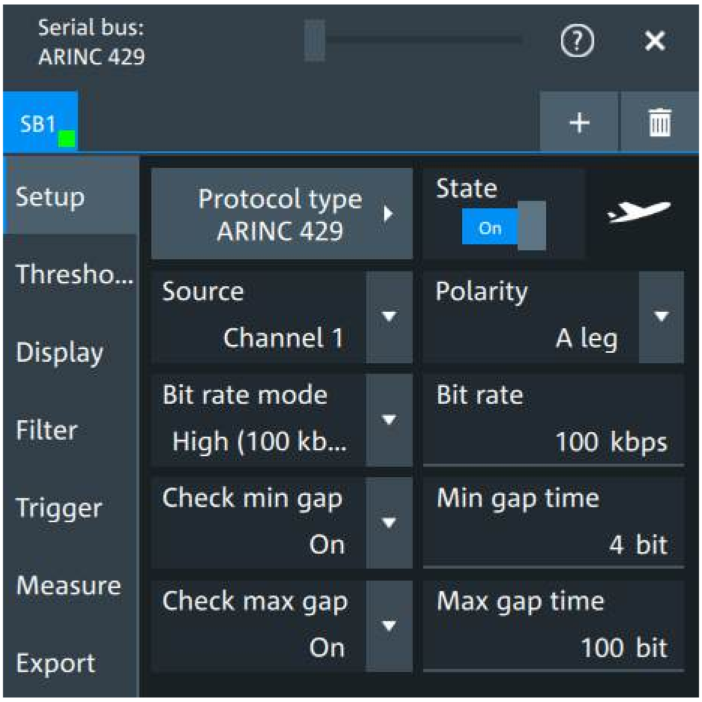
  - Maintenance data and acknowledgment
  - Williamsburg / Buckhorn protocol: a bit-oriented protocol that is used for file transfer.
- Source/Destination Identifier (SDI): indicates the intended receiver or the transmitting subsystem.
- Label: gives information about the word's data type.

For comfortable analysis, you can load an editable label list, to interpret transferred numeric values as meaningful text labels.

14.12.2 ARINC 429 configuration

14.12.2.1 ARINC 429 configuration settings

Access: "Menu" > "Apps" > "Protocol" tab > "ARINC 429" > "Setup".



Source
Sets the source of the selected data line. Usually, the source is one of the analog channels.

Remote command:
`SBUS<sb>:ARINc:SOURce` on page 1459

Polarity
Selects the wire on which the bus signal is measured : A Leg or B Leg. The setting affects the digitization of the signal.

Remote command:
SBUS<sb>:ARINc:POLarity on page 1459

Bit rate mode, Bit rate
Selects the number of transmitted bits per second. The value can be set to high speed (100 kbit/s) or low speed (12.0- 14.5 kbit/s).

Remote command:
SBUS<sb>:ARINc:BRMode on page 1458
SBUS<sb>:ARINc:BRValue on page 1458

Min gap time,Max gap time
The gap time defines the idle time between two words, which is needed for word synchronization. The beginning of the first bit after the gap marks the start of a new word.

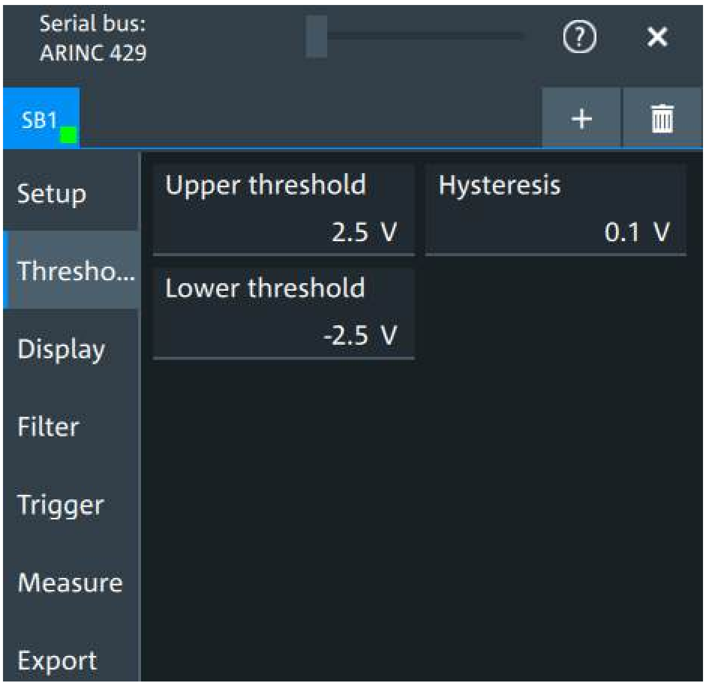
If "Check min gap" and/or "Check max gap" are enabled, the instrument detects the specified gaps during decoding.

You can define a minimum idle time "Min gap time", and/or a maximum time "Max gap time". The standard defines a minimum of 4-bit times to separate two subsequent words.

Remote command:
SBUS<sb>:ARINc:MAXGap:BITS on page 1460
SBUS<sb>:ARINc:MAXGap:SELect on page 1461
SBUS<sb>:ARINc:MINGap:BITS on page 1461
SBUS<sb>:ARINc:MINGap:SELect on page 1461

14.12.2.2 Thresholds

Access: "Menu" > "Apps" > "Protocol" tab > "ARINC 429" > "Thresholds".



Threshold
Sets the upper and lower threshold for the source channel. Enter the value directly in the fields.

Additional to the threshold, you can also set a hysteresis.

Remote command:
`SBUS<sb>:ARINc:THReshold:HIGH` on page 1459
`SBUS<sb>:ARINc:THReshold:LOW` on page 1460
`SBUS<sb>:ARINc:THReshold:HYSTeresis` on page 1459

Show threshold lines
If enabled, the threshold lines are displayed in the diagram.

The label of the threshold line is set according to the signal that it is referring to, see also Show threshold lines.

Remote command:
`SBUS<sb>:THReshold` on page 1155

14.12.2.3 Display settings

For details about the display settings, see Section 14.1.3.1, "Display settings", on page 435.

Decode layer
Selects the decode layer.

Decoding is performed in several steps, and the results are presented in the decode table. The decode layer selects an interim step for which the decoding result is shown in the honeycomb display.

"Off"	Disables the display of the decode layer.
"Ternary symbols"	Enables the display of the raw, ternary encoded symbols, consisting of the three states "-1", "0" and "+1".
"Bits"	Enables the display of all bits.
"Words"	Enables the display of all words.

Show symbols
Symbol lists are protocol-specific. Label lists for ARINC 429 are available in CSV format.

For details, see Section 14.12.2.4, "ARINC 429 symbols", on page 662.

Remote command:
`SBUS<sb>:ARINc:SYMBols` on page 1460
`SBUS<sb>:ARINc:NEWList` on page 1460

14.12.2.4 ARINC 429 symbols

Label lists are protocol-specific. An ARINC 429 label file contains two values for each identifier:

- "Arinc Label": the ARINC 429 label value that identifies the data type and the parameters associated with it. The usual data format is octal.
- "Symbolic label": symbolic name of the label, specifying its function.

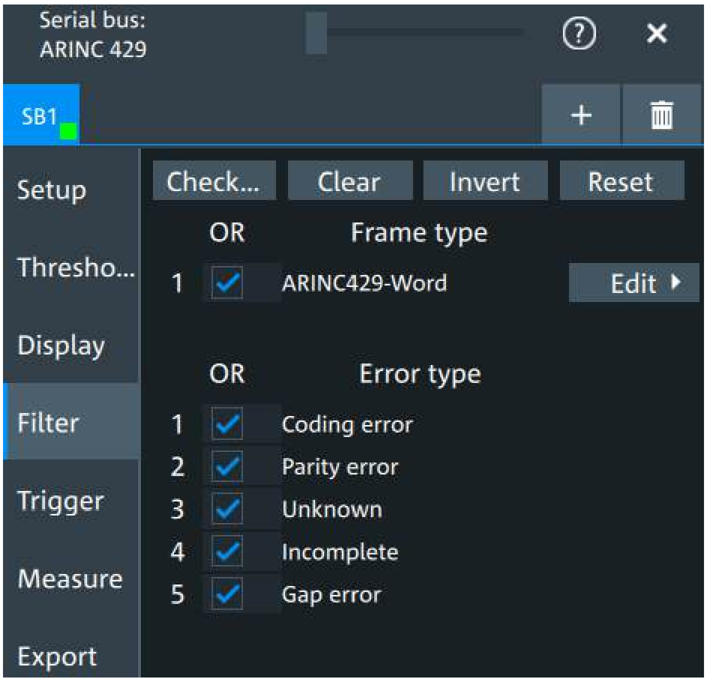
Example: ARINC 429 PTT file

```
# ----------------------------------------------------------------------------
@FILE_VERSION = 1.0
@PROTOCOL_NAME = arinc429
# ----------------------------------------------------------------------------
# Labels for ARINC 429 protocol
#   Column order: Arinc Label, Symbolic Label
# ----------------------------------------------------------------------------
# ----Definition----
001o, Distance to Go
002o, Time to Go
010o, Present Position - Latitude
011o, Present Position - Longitude
014o, Magnetic Heading
015o, Wind Speed
075o, Gross Weight
125o, Universal Time Coordinated
# ----------------------------------------------------------------------------
s
```

14.12.3 ARINC 429 filter

Access: "Menu" > "Apps" > "Protocol" tab > "ARINC 429" > "Filter" tab

In the "Filter" tab, you can define the settings to display only the frames that match the selected filter conditions.



Check all, Clear, Invert, Preset

The following settings help you select the frames and errors you want to filter for. Only the frames and error types that match the selected filter conditions are displayed.

"Check all"	Enables the filter for all available frames and error types.
"Clear"	Disables the filter for all available frames and error types.
"Invert"	Inverts the current state of the frame and error types: all frames and error types that were enabled are disabled and vice versa.
"Preset"	Presets the state of the selected frames and error types.

Remote command:
`SBUS<sb>:ARINc:FILTer:RST` on page 1464
`SBUS<sb>:ARINc:FILTer:INVert` on page 1463
`SBUS<sb>:ARINc:FILTer:CHKall` on page 1463
`SBUS<sb>:ARINc:FILTer:CLR` on page 1463

Enable

Enables the filtering on ARINC 429 frames. Only the frames that match the selected filter conditions are displayed.

Remote command:
`SBUS<sb>:ARINc:FILTer:FRENable` on page 1466
`SBUS<sb>:ARINc:FILTer:FRAMe<fr>:ENABle` on page 1466

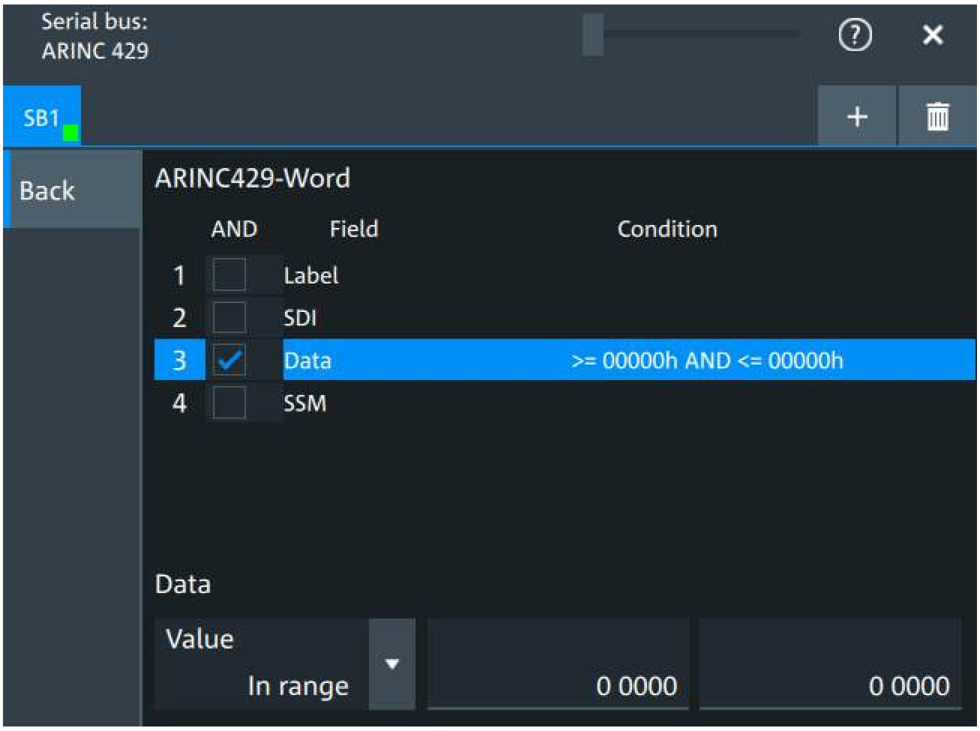
Frame type

Selects the frame type that you want to display. You can filter all enabled frame types simultaneously.

For selected frame types, you can also specify conditions for the value of the fields in the "Edit" dialog.

Edit

Opens a dialog to define the details of the selected frame.



"Field" Enables the field type that you want to filter on for the selected frame. The available fields are "Label", "SDI", "Data", "SSM".

Remote command:
SBUS<sb>:ARINc:FILTer:FIENable on page 1466
SBUS<sb>:ARINc:FILTer:FRAMe<fr>:FLD<fl>:ENABle on page 1466

"Condition" Displays the value condition for the selected field.

Remote command:
SBUS<sb>:ARINc:FILTer:BIT on page 1464
SBUS<sb>:ARINc:FILTer:FRAMe<fr>:FLD<fl>:BIT on page 1464

"Value" The data setup consists of a comparison condition and one or two data patterns.

Remote command:
SBUS<sb>:ARINc:FILTer:DMAX on page 1465
SBUS<sb>:ARINc:FILTer:FRAMe<fr>:FLD<fl>:DMAX on page 1465
SBUS<sb>:ARINc:FILTer:DMIN on page 1465
SBUS<sb>:ARINc:FILTer:FRAMe<fr>:FLD<fl>:DMIN on page 1465
SBUS<sb>:ARINc:FILTer:DOPerator on page 1465
SBUS<sb>:ARINc:FILTer:FRAMe<fr>:FLD<fl>:DOPerator on page 1465

Error type
Enables filtering on the selected error type.

The available error types are "Coding error", "Parity error", "Unknown", "Incomplete", "Gap error".

Remote command:
`SBUS<sb>:ARINc:FILTer:ERENable` on page 1464
`SBUS<sb>:ARINc:FILTer:ERRor<n>:ENABle` on page 1464

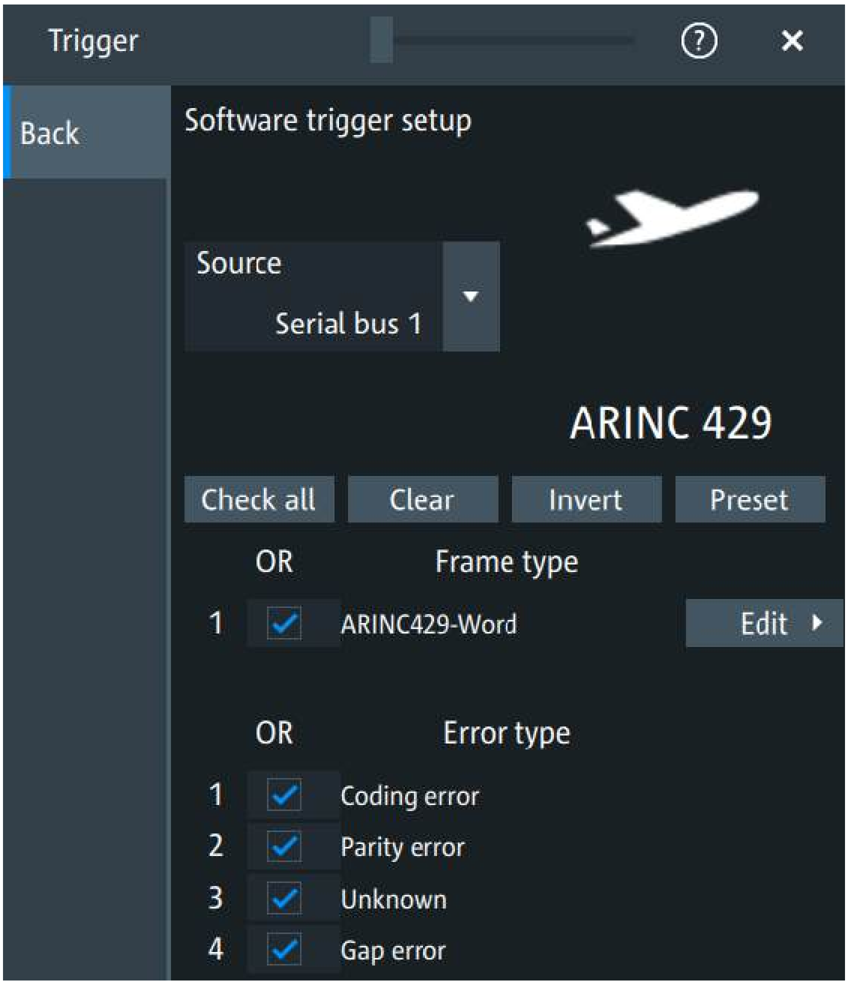
14.12.4 ARINC 429 software trigger

14.12.4.1 Setup A trigger

Before setting up the software trigger for the protocols, a trigger A event needs to be set up.

14.12.4.2 Software trigger settings

Access: "Menu" > "Apps" > "Protocol" tab > "ARINC 429" > "Trigger" tab > "Setup Software Trigger"



In the "Software Trigger" tab, you can define the settings to trigger on the frames that match the selected filter conditions.

Check all, Clear, Invert, Preset

The following settings help you select the frames and errors you want to trigger on.

"Check all"	Enables the software trigger for all available frames and error types.
"Clear"	Disables the software trigger for all available frames and error types.
"Invert"	Inverts the current state of the frame and error types for the software trigger: all frames and error types that were enabled are disabled and vice versa.
"Preset"	Presets the state of the selected frames and error types for the software trigger.

Remote command:
`TRIGger:SBSW:ARINc:CHKall` on page 1467
`TRIGger:SBSW:ARINc:CLR` on page 1467
`TRIGger:SBSW:ARINc:INVert` on page 1467
`TRIGger:SBSW:ARINc:RST` on page 1468

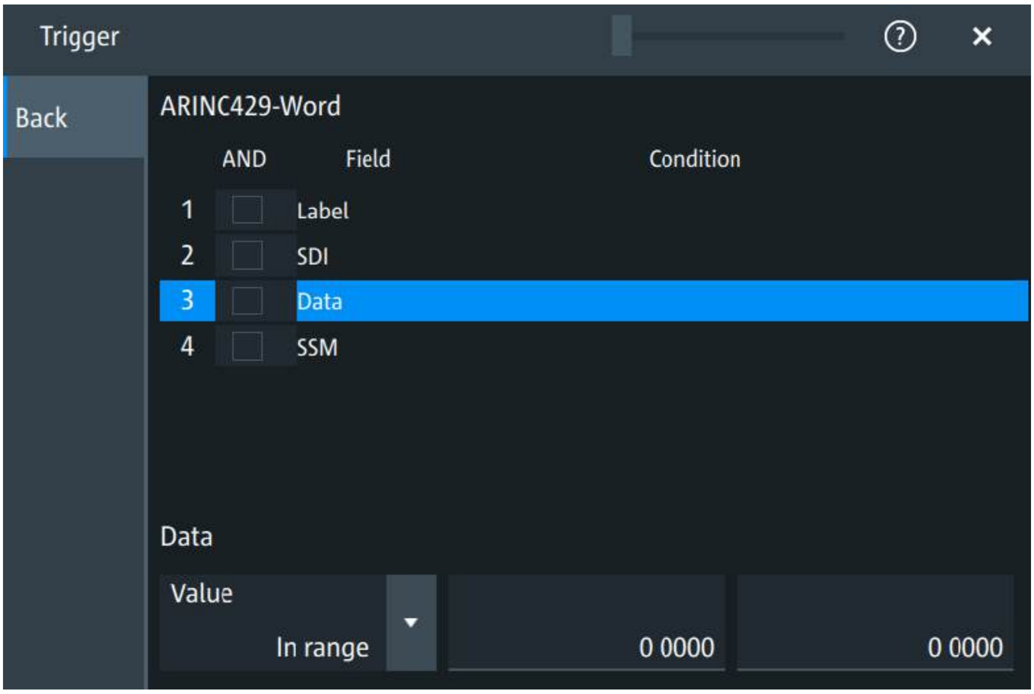
Frame type
Selects the frame type that you want to trigger on. You can trigger on all enabled frame types simultaneously.

For each frame type, you can also specify conditions for the value of the fields in the "Edit" dialog.

The following frames are available: "ARINC429-Word".

Remote command:
`TRIGger:SBSW:ARINc:FRENable` on page 1468
`TRIGger:SBSW:ARINc:FRAMe<fr>:ENABle` on page 1468

Edit
Some trigger types have additional settings that can be defined. In this case, the "Set details" button appears next to "Type" the function. Open it for a detailed definition of the trigger conditions.



"Field" Enables the field type that you want to trigger on for the selected frame.
The available fields are "Label", "SDI", "Data", "SSM".

Remote command:
`TRIGger:SBSW:ARINc:FIENable` on page 1470
`TRIGger:SBSW:ARINc:FRAMe<fr>:FLD<fl>:ENABle` on page 1470

"Condition" Displays the value condition for the selected field.

Remote command:
`TRIGger:SBSW:ARINc:BIT` on page 1468
`TRIGger:SBSW:ARINc:FRAMe<fr>:FLD<fl>:BIT` on page 1468

"Value"

The data setup consists of a comparison condition and one or two data patterns.

Remote command:
TRIGger:SBSW:ARINc:DMAX on page 1469
TRIGger:SBSW:ARINc:FRAMe<fr>:FLD<fl>:DMAX on page 1469
TRIGger:SBSW:ARINc:DMIN on page 1469
TRIGger:SBSW:ARINc:FRAMe<fr>:FLD<fl>:DMIN on page 1469
TRIGger:SBSW:ARINc:DOPerator on page 1469
TRIGger:SBSW:ARINc:FRAMe<fr>:FLD<fl>:DOPerator on page 1469

Error type
Enables triggering on the selected error type.

The available error types are "Coding error", "Parity error", "Unknown", "Gap error".

Remote command:
TRIGger:SBSW:ARINc:ERENable on page 1470
TRIGger:SBSW:ARINc:ERRor<m>:ENABle on page 1470

14.12.5 Measure

The "Setup Measurement" button opens the dialog for automatic measurements in the "Protocol" category for the selected serial bus.

See Section 10.2.6.2, "Settings for protocol measurements", on page 289.

14.12.6 ARINC 429 decode results

When the configuration of the serial bus is complete, the signal can be decoded:

1. Open the "Serial Bus" dialog for the respective bus.
2. In the "Setup" tab, enable "State".
3. In the "Display" tab, enable "Show decode table".

For a description of the display settings, see also Section 14.1.3.1, "Display settings", on page 435.

For a description of how to synchronize the displayed results, see Section 14.1.3.2, "Display synchronization", on page 437.

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

Decode results table

The "Decode results" table contains information about all decoded frames.

Figure 14-38: Decoded ARINC429 signal

The decode results table contains information about all decoded frames.

Table 14-22: Content of the decode results table

Column	Description
Index	Frame count
State	Overall state of the frame
Start	Start time of the frame
Symbol	Symbolic label of the frame. Available only, if "Show symbols" is enabled in the "Display" tab and a symbols list is loaded.
Label	The label name
SDI	The state of the SDI bits
Data	All 32 bits of the word. Select the data format in the "Display" tab.
SSM	The state of the SSM bits
32-bit word	The value of the data bytes. Select the data format in the "Display" tab.
Data rate	Value of the data rate

Data format

You can select various data formats for the values displayed in the decode table and in the combs of the decoded signal.

Remote command:

- `SBUS<sb>:FORMat` on page 1154

Remote commands

Remote commands to retrieve decode results are described in Section 18.17.13.4, "Decode results", on page 1471.

14.12.7 Performing ARINC 429 decoding

This section explains step by step how to configure and decode the ARINC 429 bus.

14.12.7.1 Configuring ARINC 429 signals

For configuration, assign the lines to the input channels, and define the active states and the logical thresholds.

For details on configuration settings, see Section 14.12.2, "ARINC 429 configuration", on page 659.

1. Tap the "+ Bus" activator in the bottom right of the screen.

2. Select the tab of the bus that you want to set up, for example "SB1".
3. Tap the "Protocol type" button. Select the protocol: "ARINC 429".
4. Tap on "State" to enable the decoding.

   An ARINC 429 shortcut appears at the bottom left of the screen. Tap the shortcut for a quick access to the "ARINC 429" dialog settings.

14.12.7.2 Exporting decode results

Once a decode has been completed, you can generate an export of all decode results.

Prerequisites: A bus is configured for the ARINC and decoded.

1. Tap on the "ARINC 429" shortcut.
2. Tap on the "Export" tab.
3. If necessary, enable "Include details".
4. If necessary, enable "Include timing".

5. Select the "File type".

   An export file is saved in the selected directory.

The ARINC export file contains the following fields:

- A list of all decoded frames:
  – Index
  – Start
  – Stop
  – Symbol
  – State
  – Label
  – SDI
  – Data
  – SSM
  – Raw Data
  – Bit rate

Example ARINC export file

```
Index,Start,Stop,Symbol,State,Label,SDI,Data,SSM,Raw Data,Bit Rate
1,-0.103,-0.10268,---,'OK',257o,3h,72470h,01b,#HC1,#HC4,#H9F,#HF5,100000
2,-0.10268,-0.10236,---,'OK',316o,0h,22608h,00b,#H02,#H0C,#H88,#H73,100000
3,-0.10236,-0.10204,---,'OK',257o,3h,72470h,01b,#HC1,#HC4,#H9F,#HF5,100000
4,-0.10204,-0.10172,---,'OK',317o,0h,62608h,00b,#H02,#H0C,#H8C,#HF3,100000
5,-0.10172,-0.1014,---,'OK',257o,3h,72470h,01b,#HC1,#HC4,#H9F,#HF5,100000
```

14.13 SpaceWire (aerospace communications, option R&S MXO4-K530)

The SpaceWire is a communication network standard used for spacecraft. It is based on the IEEE 1355 standard of communications and coordinated by the European Space Agency (ESA).

14.13.1 SpaceWire basics

The SpaceWire links are a Point-to-point (P2P) connection between a node and another node or a router. The link is full-duplex bidirectional serial data link.

The SpaceWire has two types of characters:

- Data characters containing a parity bit, a data control flag and eight bits of data.

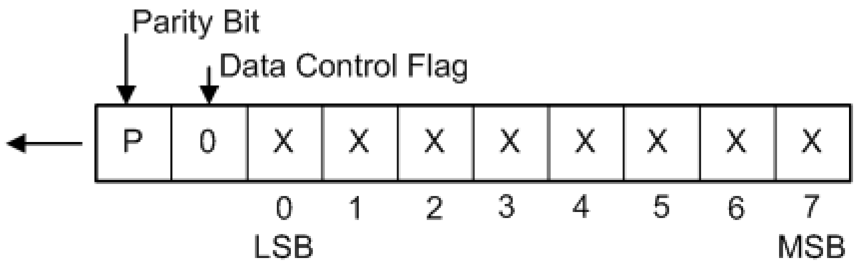


Figure 14-39: SpaceWire data characters

- Control characters containing a parity-bit, a data-control flag and the 2-bit control code. The data control flag is set to 1 and indicates that this is a control character.

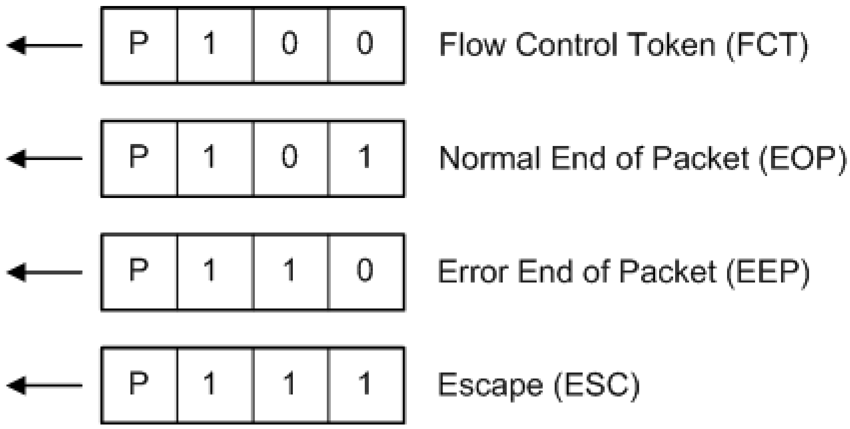


Figure 14-40: SpaceWire control characters

Also there are two control codes:

- NULL code consisting of an Escape (ESC) and a Flow Control Token (FCT)
- Time Code consisting of an ESC followed by a single data character

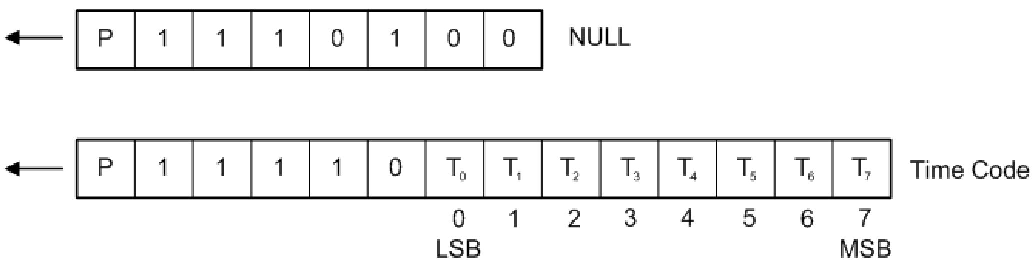
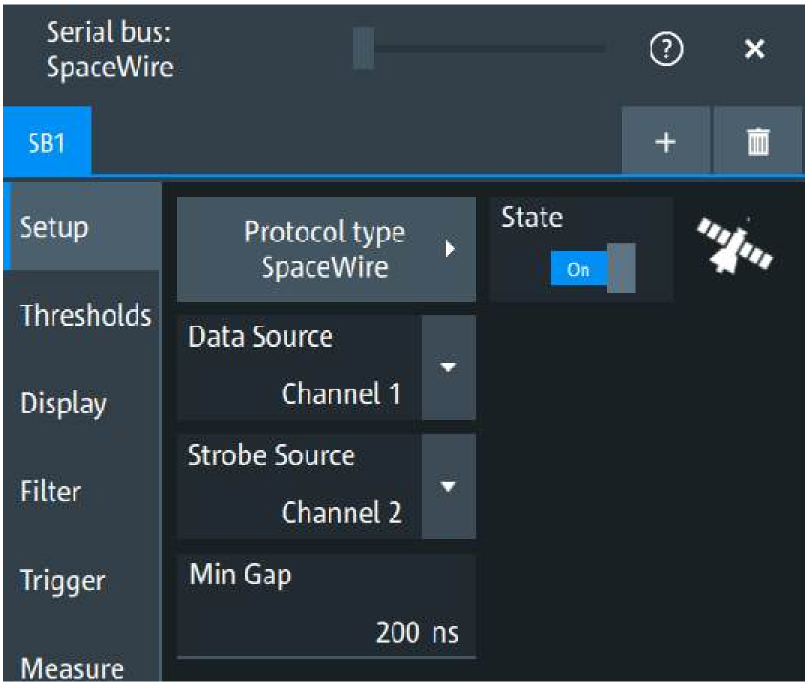


Figure 14-41: SpaceWire control codes

14.13.2 SpaceWire configuration

14.13.2.1 SpaceWire configuration settings

Access: "Menu" > "Apps" > "Protocol" tab > "SpaceWire" > "Setup".



Data Source
Selects the source for the data signal. Typically, the data source is one of the analog channels.

Remote command:
SBUS<sb>:SWIRe:DATA:SOURce on page 1476

Strobe Source
Selects the source for the strobe signal. Typically, the strobe source is an analog channel different from the data source.

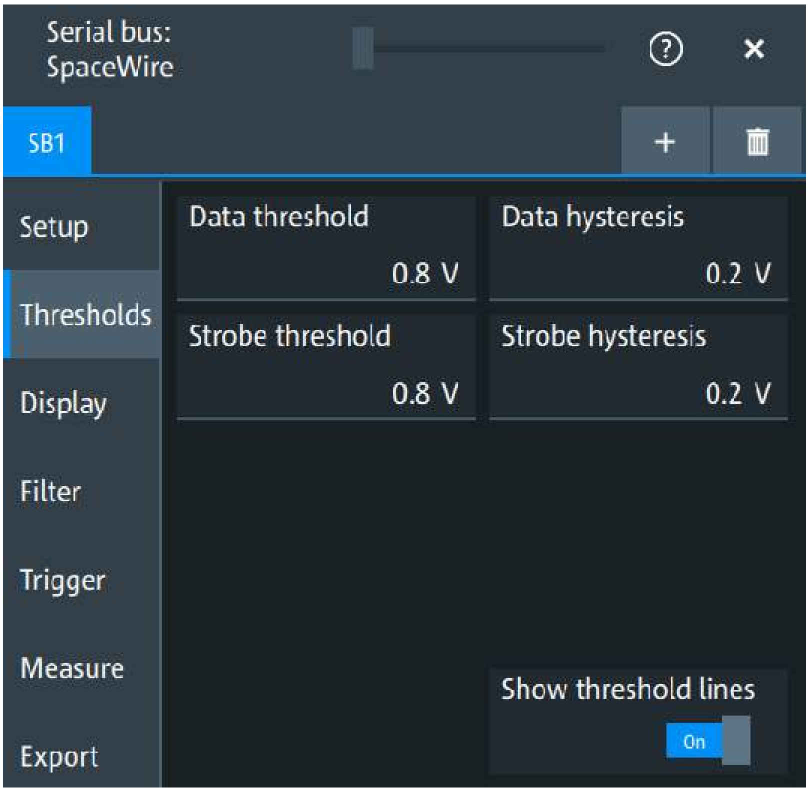
Remote command:
SBUS<sb>:SWIRe:STRBe:SOURce on page 1476

Min Gap
Specifies the minimum idle time between two frames, which is needed for synchronization. The beginning of the first bit after the gap marks the start of a new frame.

Remote command:
SBUS<sb>:SWIRe:MGAP on page 1477
SBUS<sb>:SWIRe:MINGap on page 1477

14.13.2.2 Thresholds

Access: "Menu" > "Apps" > "Protocol" tab > "SpaceWire" > "Thresholds".



Thresholds
Sets the middle threshold for the data source and strobe source channels. Enter the values directly in the fields.

Additional to the thresholds, you can also set the hysteresis for the data source and strobe source, respectively.

Remote command:
`SBUS<sb>:SWIRe:DATA:THReshold` on page 1476
`SBUS<sb>:SWIRe:DATA:HYSTeresis` on page 1476
`SBUS<sb>:SWIRe:STRBe:THReshold` on page 1477
`SBUS<sb>:SWIRe:STRBe:HYSTeresis` on page 1477

Show threshold lines
If enabled, the threshold lines are displayed in the diagram.

The label of the threshold line is set according to the signal that it is referring to, see also Show threshold lines.

Remote command:
`SBUS<sb>:THReshold` on page 1155

14.13.2.3 Display settings

For details about the display settings, see Section 14.1.3.1, "Display settings", on page 435.

Decode layer

Selects the decode layer.

Decoding is performed in several steps, and the results are presented in the decode table. The decode layer selects an interim step for which the decoding result is shown in the honeycomb display.

"Off"	Disables the display of the decode layer.
"Edges"	Enables the display of all edges.
"Binary"	Enables the display of the raw, binary encoded symbols, consisting of the states "0" and "1".

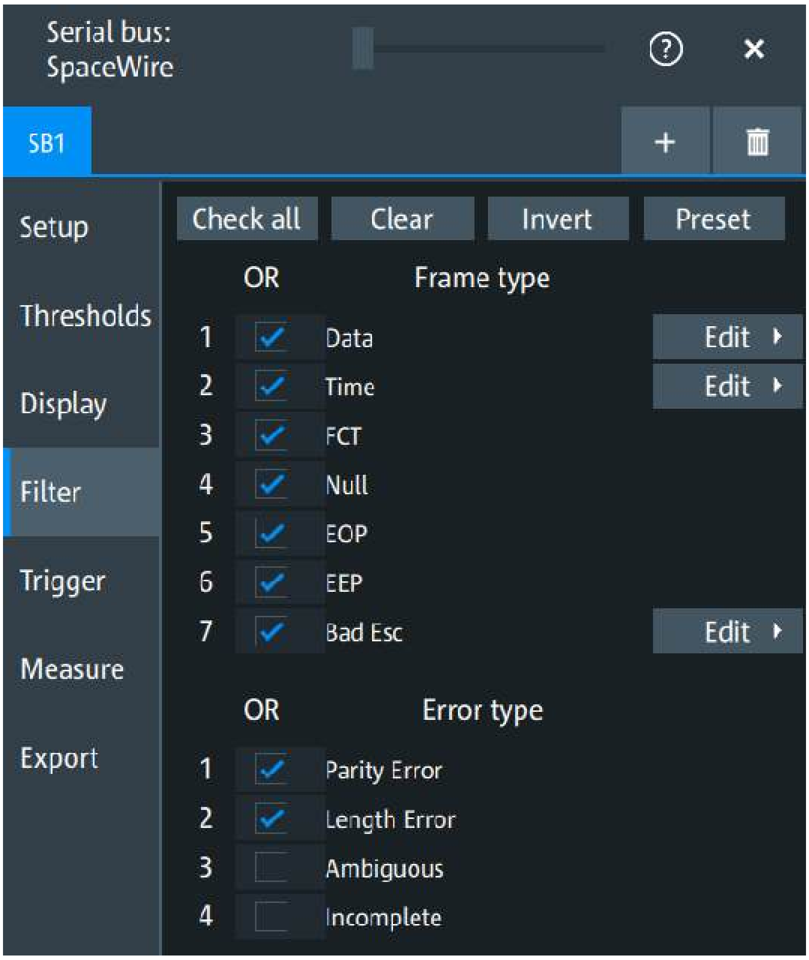
Data format

See "Data format" on page 436.

14.13.3 SpaceWire filter

Access: "Menu" > "Apps" > "Protocol" tab > "SpaceWire" > "Filter" tab

In the "Filter" tab, you can define the settings to display only the frames that match the selected filter conditions.



Check all, Clear, Invert, Preset

The following settings help you select the frames and errors you want to filter for. Only the frames and error types that match the selected filter conditions are displayed.

"Check all"	Enables the filter for all available frames and error types.
"Clear"	Disables the filter for all available frames and error types.
"Invert"	Inverts the current state of the frame and error types: all frames and error types that were enabled are disabled and vice versa.
"Preset"	Presets the state of the selected frames and error types.

Remote command:

`SBUS<sb>:SWIRe:FILTer:CHKall` on page 1479
`SBUS<sb>:SWIRe:FILTer:CLR` on page 1479
`SBUS<sb>:SWIRe:FILTer:INVert` on page 1479
`SBUS<sb>:SWIRe:FILTer:RST` on page 1479

Enable

Enables the filtering on SpaceWire frames. Only the frames that match the selected filter conditions are displayed.

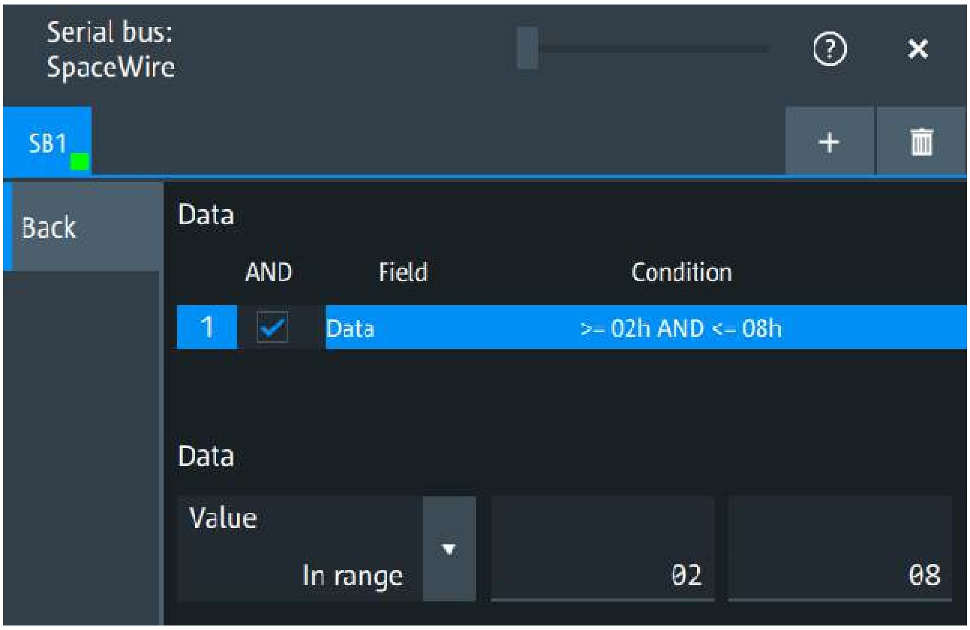
Remote command:
SBUS<sb>:SWIRe:FILTer:FRENable on page 1482
SBUS<sb>:SWIRe:FILTer:FRAMe<fr>:ENABle on page 1482

Frame type
Selects the frame type that you want to display. You can filter all enabled frame types simultaneously.

For selected frame types, you can also specify conditions for the value of the fields in the "Edit" dialog.

The available frame types are "Data", "Time", "FCT", "Null", "EOP", "EEP", "Bad Esc".

Edit
Opens a dialog to define the details of the selected frame.



"Field" Enables the field type that you want to filter on for the selected frame. The available fields are "Data", "Time", "Bad Esc".

Remote command:
SBUS<sb>:SWIRe:FILTer:FIENable on page 1481
SBUS<sb>:SWIRe:FILTer:FRAMe<fr>:FLD<fl>:ENABle on page 1481

"Condition" Displays the value condition for the selected field.

Remote command:
SBUS<sb>:SWIRe:FILTer:BIT on page 1480
SBUS<sb>:SWIRe:FILTer:FRAMe<fr>:FLD<fl>:BIT on page 1480

"Value" The data setup consists of a comparison condition and one or two data patterns.

Remote command:
SBUS<sb>:SWIRe:FILTer:DMAX on page 1480
SBUS<sb>:SWIRe:FILTer:FRAMe<fr>:FLD<fl>:DMAX on page 1480
SBUS<sb>:SWIRe:FILTer:DMIN on page 1481
SBUS<sb>:SWIRe:FILTer:FRAMe<fr>:FLD<fl>:DMIN on page 1481
SBUS<sb>:SWIRe:FILTer:DOPerator on page 1481
SBUS<sb>:SWIRe:FILTer:FRAMe<fr>:FLD<fl>:DOPerator on page 1481

Error type
Enables filtering on the selected error type.

The available error types are "Parity error", "Length error", "Ambiguous", "Incomplete".

Remote command:
SBUS<sb>:SWIRe:FILTer:ERENable on page 1480
SBUS<sb>:SWIRe:FILTer:ERRor<n>:ENABle on page 1480

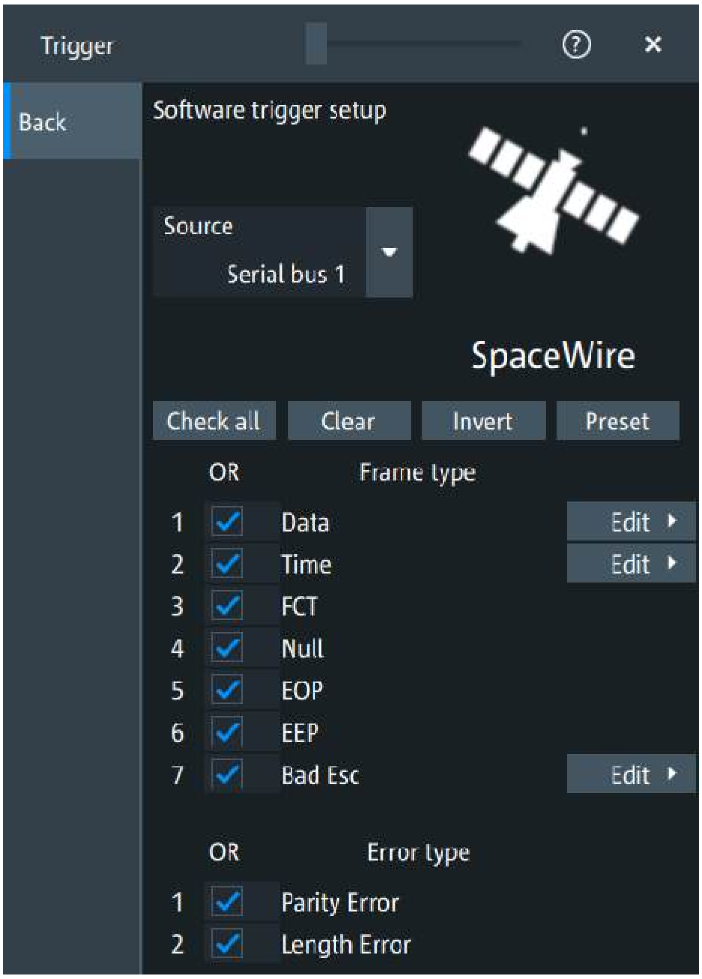
14.13.4 SpaceWire software trigger

14.13.4.1 Setup A trigger

Before setting up the software trigger for the protocols, a trigger A event needs to be set up.

14.13.4.2 Software trigger settings

Access: "Menu" > "Apps" > "Protocol" tab > "SpaceWire" > "Trigger" tab > "Setup Software Trigger"



In the "Software Trigger" tab, you can define the settings to trigger on the frames that match the selected filter conditions.

Check all, Clear, Invert, Preset

The following settings help you select the frames and errors you want to trigger on.

"Check all"	Enables the software trigger for all available frames and error types.
"Clear"	Disables the software trigger for all available frames and error types.
"Invert"	Inverts the current state of the frame and error types for the software trigger: all frames and error types that were enabled are disabled and vice versa.
"Preset"	Presets the state of the selected frames and error types for the software trigger.

Remote command:

`TRIGger:SBSW:SWIRe:CHKall` on page 1483
`TRIGger:SBSW:SWIRe:CLR` on page 1483
`TRIGger:SBSW:SWIRe:INVert` on page 1483
`TRIGger:SBSW:SWIRe:RST` on page 1483

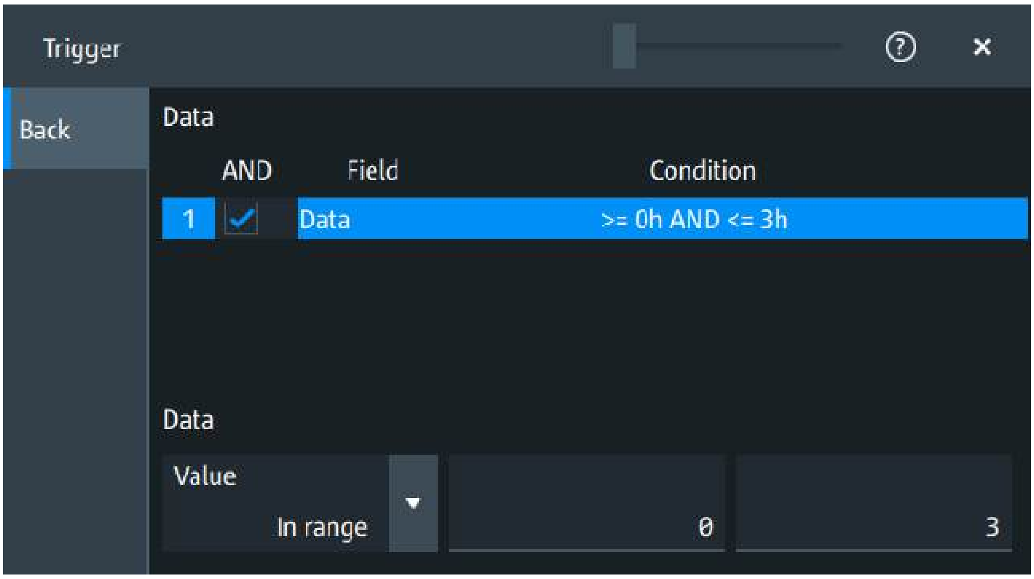
Frame type
Selects the frame type that you want to trigger on. You can trigger on all enabled frame types simultaneously.

For each frame type, you can also specify conditions for the value of the fields in the "Edit" dialog.

The following frames are available: "Data", "Time", "FCT", "Null", "EOP", "EEP", "Bad Esc".

Remote command:
`TRIGger:SBSW:SWIRe:FRENable` on page 1484
`TRIGger:SBSW:SWIRe:FRAMe<fr>:ENABle` on page 1484

Edit
Some trigger types have additional settings that can be defined. In this case, the "Set details" button appears next to "Type" the function. Open it for a detailed definition of the trigger conditions.



"Field" Enables the field type that you want to trigger on for the selected frame.
The available fields are "Data", "Time", "Code".

Remote command:
`TRIGger:SBSW:SWIRe:FIENable` on page 1485
`TRIGger:SBSW:SWIRe:FRAMe<fr>:FLD<fl>:ENABle` on page 1485

"Condition" Displays the value condition for the selected field.

Remote command:
`TRIGger:SBSW:SWIRe:BIT` on page 1484
`TRIGger:SBSW:SWIRe:FRAMe<fr>:FLD<fl>:BIT` on page 1484

"Value" The data setup consists of a comparison condition and one or two data patterns.

Remote command:
TRIGger:SBSW:SWIRe:DMAX on page 1484
TRIGger:SBSW:SWIRe:FRAMe<fr>:FLD<fl>:DMAX on page 1484
TRIGger:SBSW:SWIRe:DMIN on page 1485
TRIGger:SBSW:SWIRe:FRAMe<fr>:FLD<fl>:DMIN on page 1485
TRIGger:SBSW:SWIRe:DOPerator on page 1485
TRIGger:SBSW:SWIRe:FRAMe<fr>:FLD<fl>:DOPerator on page 1485

Error type
Enables triggering on the selected error type.

The available error types are "Parity error", "Length error".

Remote command:
TRIGger:SBSW:SWIRe:ERENable on page 1486
TRIGger:SBSW:SWIRe:ERRor<m>:ENABle on page 1486

14.13.5 Measure

The "Setup Measurement" button opens the dialog for automatic measurements in the "Protocol" category for the selected serial bus.

See Section 10.2.6.2, "Settings for protocol measurements", on page 289.

14.13.6 Performing SpaceWire decoding

This section explains step by step how to configure and decode the SpaceWire bus.

14.13.6.1 Configuring SpaceWire signals

For configuration, assign the lines to the input channels, and define the active states and the logical thresholds.

For details on configuration settings, see Section 14.13.2, "SpaceWire configuration", on page 673.

1. Tap the "+ Bus" activator in the bottom right of the screen.

2. Select the tab of the bus that you want to set up, for example "SB1".

3. Tap the "Protocol type" button. Select the protocol: "SpaceWire".
4. Tap on "State" to enable the decoding.

   A SpaceWire shortcut appears at the bottom left of the screen. Tap the shortcut for a quick access to the "SpaceWire" dialog settings.

14.13.6.2 Exporting decode results

Once a decode has been completed, you can generate an export of all decode results.

Prerequisites: A bus is configured for the SpaceWire and decoded.

1. Tap on the "SpaceWire" shortcut.
2. Tap on the "Export" tab.
3. If necessary, enable "Include details".
4. If necessary, enable "Include timing".
5. Select the "File type".

   An export file is saved in the selected directory.

The SpaceWire export file contains the following fields:

- A list of all decoded frames:
  - Data
  - Time-Code
  - Flow Control Token (FCT)
  - Null Symbol
  - End of Packet (EOP)
  - Error End of Packet (EEP)
  - Illegal Escape Code (Bad Esc)

Example SpaceWire export file

```
Index,Start,Stop,State,Type
1,-2.7928e-05,-2.6808e-05,'OK','NULL'
2,-2.6808e-05,-2.5688e-05,'OK','NULL'
3,-2.5688e-05,-2.5128e-05,'OK','FCT'
4,-2.5128e-05,-2.3728e-05,'OK','DATA'
5,-2.3728e-05,-2.2328e-05,'OK','DATA'
6,-2.2328e-05,-2.0928e-05,'OK','DATA'
7,-2.0928e-05,-1.897e-05,'OK','TCOD'
8,-1.897e-05,-1.7568e-05,'OK','DATA'
9,-1.7568e-05,-1.617e-05,'OK','DATA'
```

```
10,-1.617e-05,-1.477e-05,'OK','DATA'
11,-1.477e-05,-1.4208e-05,'OK','EEP'
```

14.13.7 SpaceWire decode results

When the configuration of the serial bus is complete, the signal can be decoded:

1. Open the "Serial Bus" dialog for the respective bus.
2. In the "Setup" tab, enable "State".
3. In the "Display" tab, enable "Show decode table".

For a description of the display settings, see also Section 14.1.3.1, "Display settings", on page 435.

For a description of how to synchronize the displayed results, see Section 14.1.3.2, "Display synchronization", on page 437.

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

Decode results table

The "Decode results" table contains information about all decoded frames.

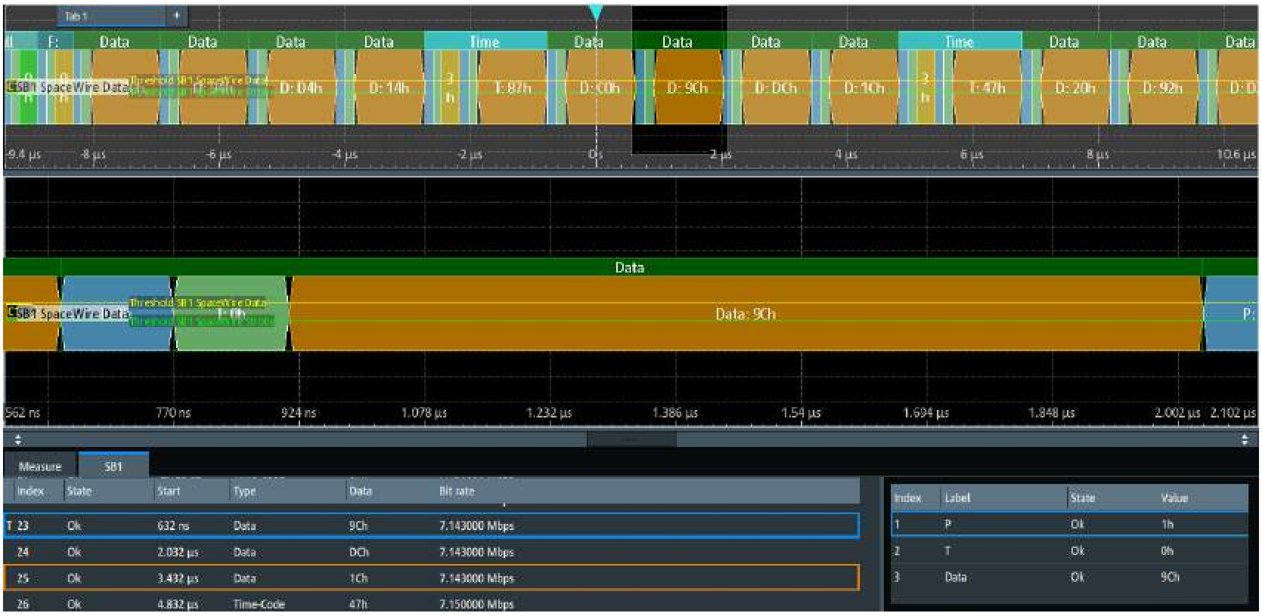


Figure 14-42: Decoded SpaceWire signal

The decode results table contains information about all decoded frames.

Table 14-23: Content of the decode results table

Column	Description
Index	Frame count
State	Overall state of the frame
Start	Start time of the frame
Type	The type of the frame
Data	Value of the data byte. Select the data format in the "Display" tab.
Bit rate	Value of the bit rate

When you select a frame in the decode results table, its field content is shown in the details table to the right.

Table 14-24: Content of the frame details table

Column	Description
Index	Number of the decoded field
Label	Name of the field
State	State of the field (OK / Not OK)
Value	Value of the field

Data format

You can select various data formats for the values displayed in the decode table and in the combs of the decoded signal.

Remote command:

- `SBUS<sb>:FORMat` on page 1154

Remote commands

Remote commands to retrieve decode results are described in Section 18.17.14.4, "Decode results", on page 1487.

14.14 MIL-1553 (aerospace electronics, option R&S MXO4-K530)

The MIL-1553 (or MIL-STD-1553) specification defines the characteristics of a serial data bus originally designed for use in the military avionics. Nowadays it is also used in spacecraft on-board data handling.

14.14.1 About the MIL-1553 protocol

The MIL-1553 bus is a 2-wire bus that uses differential signals.

A MIL-1553 system consists of the following components:

- Bus Controller (BC): initiates and coordinates the data flow in the system.
- Remote Terminal (RT): interfaces various subsystems with the data bus. A system consists of up to 31 RTs and each RT can have 31 subaddresses.
  The subaddresses 0 and 31 refer to a mode code command.
- Bus Monitor (BM) (optional): listens to all messages and can record selected data for real-time or off-line analysis.

The information is transmitted over the bus in defined series of words using Manchester code, where each bit is transmitted as high-low for a logical 1 or a low-high for a logical 0. There are three types of words: command, data and status.

Command Word

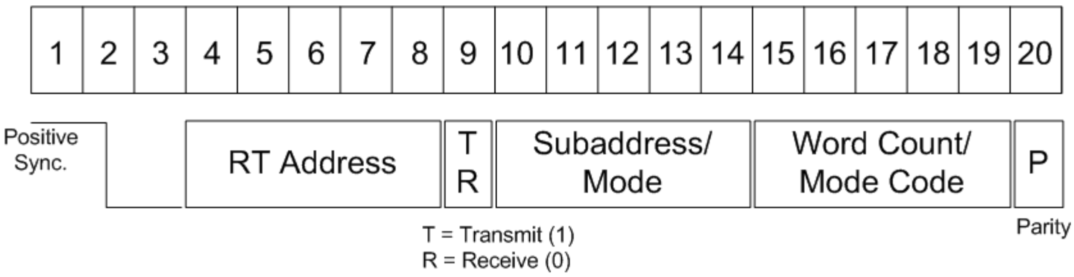


Figure 14-43: Structure of a command word

The format of a command word consists of the following parts (see Figure 14-43):

- Sync: an invalid Manchester waveform.
- Remote Terminal (RT) Address: the unique address of the corresponding RT.
- Transmit/Receive (T/R): indicates the action required from the RT.
- Subaddress/Mode Code: indicates the RT subaddress. The subaddresses 0 and 31 signalize the transmission of a mode code.
- Data Word Count /Mode Code: indicates the number of words that are sent/ received by the RT. A maximum of 32 words is allowed. This field may be used for the transmission of the mode code value.
- Parity: checks if there are bit errors during the transmission. The total number of logic 1 bits for the word (sync bits not included) shall be odd.

Data Word

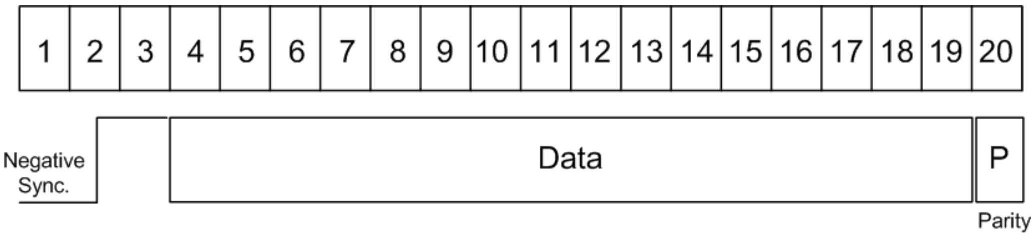


Figure 14-44: Structure of a data word

The format of a data word consists of the following parts (see Figure 14-44):

- Sync: an invalid Manchester waveform.
- Data: the transferred information (16 bit).
- Parity: checks if there are bit errors during the transmission. The total number of logic 1 bits for the word (sync bits not included) shall be odd.

Status Word

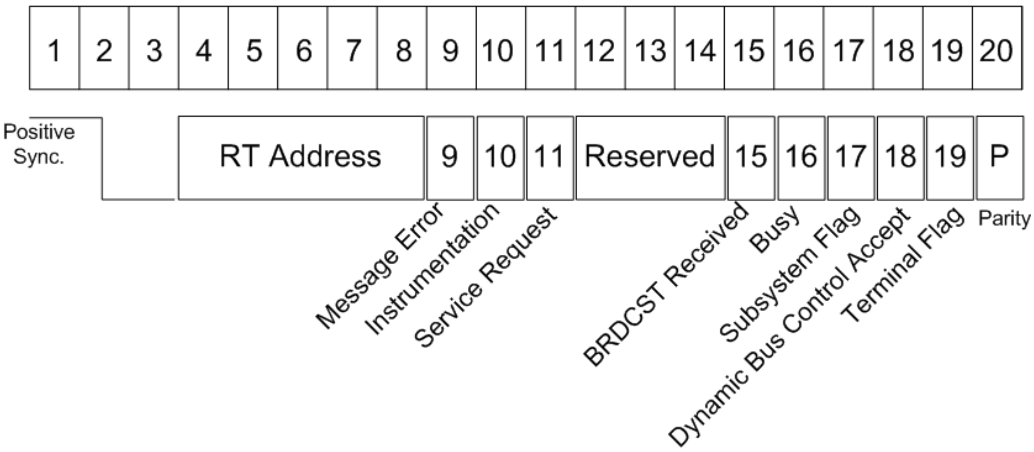


Figure 14-45: Structure of a status word

The format of a status word consists of the following parts (see Figure 14-45):

- Sync: an invalid Manchester waveform.
- Remote Terminal (RT) Address: the unique address of the corresponding RT.
- Message error: indicates an error in the command/data word transmission from the BC. A logic 1 indicates presence of a message error and a logic 0 indicates its absence.
- Instrumentation: helps to distinguish between a status word and a command word. The logic state of this bit shall be 0.
- Service Request: indicates that the RT requires service. A logic 1 indicates a presence of a service request and logic 0 indicates its absence.
- Reserved: bits reserved for future uses.
- Broadcast Command: a logic 1 indicates that the preceding valid command word was a broadcast command and a logic 0 that it was not.

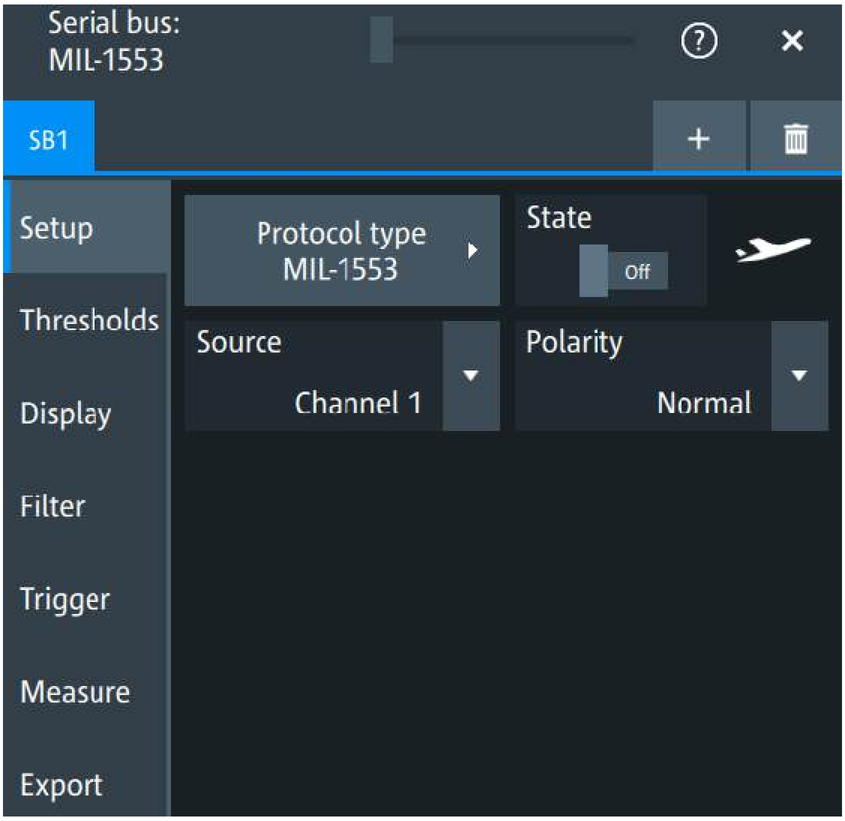
- Busy: a busy state indicates that the RT or the subsystem is not able to transfer data. A logic 1 indicates a presence of a busy condition and logic 0 indicates its absence.
- Subsystem Flag: flags a subsystem fault. A logic 1 indicates a presence of a flag and logic 0 indicates its absence.
- Dynamic Bus Control Acceptance: a logic 1 indicates acceptance of a dynamic bus control and a logic 0 a rejection.
- Terminal Flag: flags an RT fault condition. A logic 1 indicates a presence of a flag and logic 0 indicates its absence.
- Parity: checks if there are bit errors during the transmission. The total number of logic 1 bits for the word (sync bits not included) shall be odd.

For comfortable analysis, you can load an editable label list, to interpret transferred numeric values as meaningful text labels.

14.14.2 MIL-1553 configuration

14.14.2.1 MIL-1553 configuration settings

Access: "Menu" > "Apps" > "Protocol" tab > "MIL-1553" > "Setup".



Source
Sets the source of the selected data line. Usually, the source is one of the analog channels.

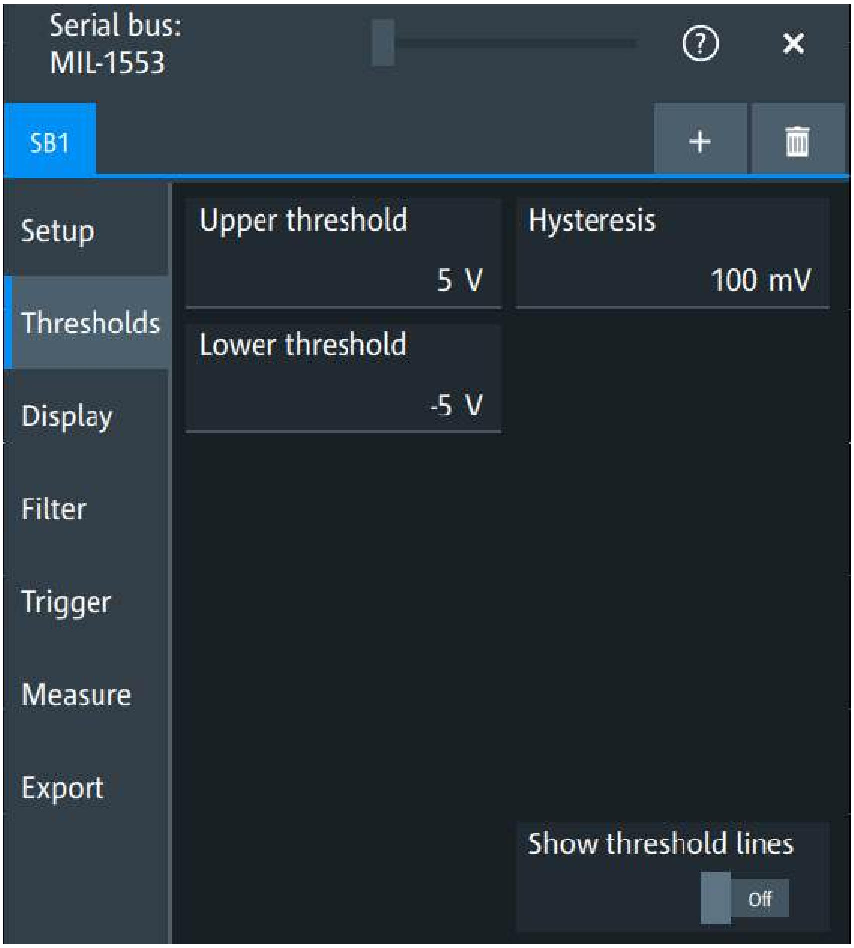
Remote command:
`SBUS<sb>:MILStd:SOURce` on page 1494

Polarity
Sets the wire on which the bus signal is measured : normal or inverted. The setting affects the digitization of the signal.

Remote command:
`SBUS<sb>:MILStd:POLarity` on page 1494

14.14.2.2 Threshold

Access: "Menu" > "Apps" > "Protocol" tab > "MIL-1553" > "Thresholds".



Threshold
Sets the upper and lower threshold for the source channel. Enter the value directly in the fields.

Additional to the threshold, you can also set a hysteresis.

Remote command:
`SBUS<sb>:MILStd:THReshold:HIGH` on page 1494
`SBUS<sb>:MILStd:THReshold:LOW` on page 1495
`SBUS<sb>:MILStd:THReshold:HYSTeresis` on page 1495

Show threshold lines
If enabled, the threshold lines are displayed in the diagram.

The label of the threshold line is set according to the signal that it is referring to, see also Show threshold lines.

Remote command:
`SBUS<sb>:THReshold` on page 1155

14.14.2.3 Display settings

For details about the display settings, see Section 14.1.3.1, "Display settings", on page 435.

Show symbols
Symbol lists are protocol-specific. Label lists for MIL-1553 are available in CSV format.

For details, see Section 14.14.2.4, "MIL-1553 symbols", on page 689.

14.14.2.4 MIL-1553 symbols

Label lists are protocol-specific. A MIL-1553 label file contains four values for each identifier:

- "RTA": hexadecimal remote terminal address value
- "Sub Addr": hexadecimal sub address value
- "Sub Address Label Name": the label name corresponding to the value of the sub-address.
- "Symbolic label": symbolic name of addressed device, specifying the device function, and the label of the sub address.

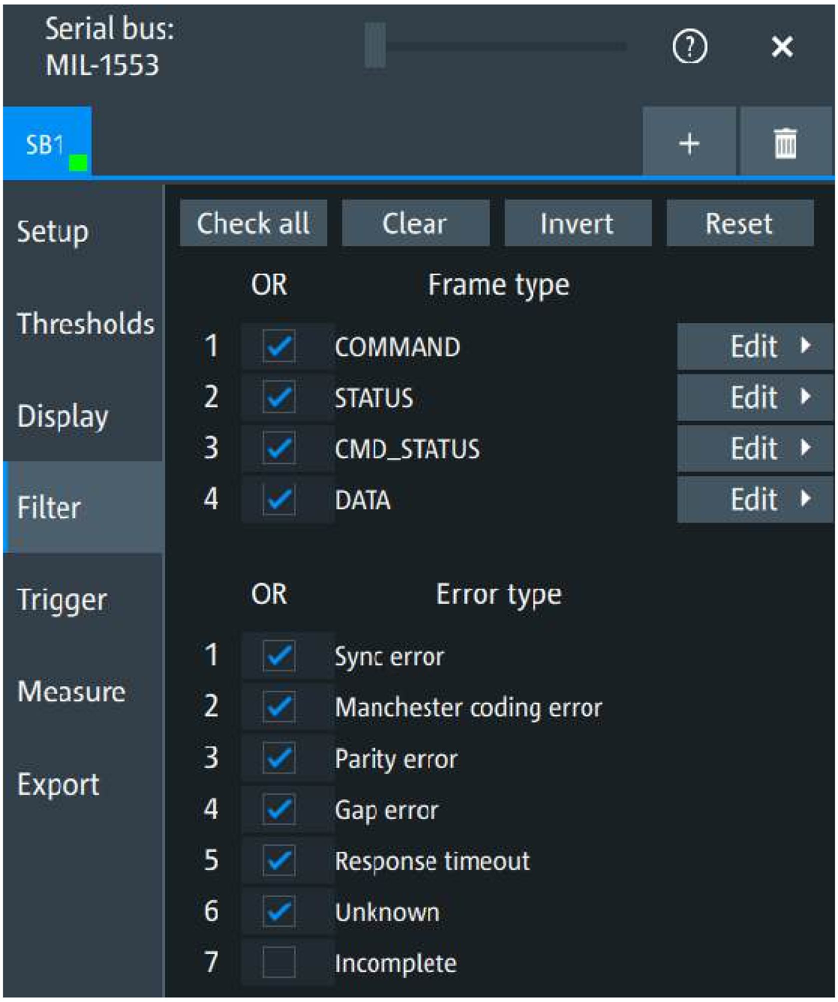
Example: MIL PTT file

```
# ------------------------------------------------------------
# Labels for MIL.1553 protocol
# Column order: RT address, RT label, Subaddress, Subaddress Label
# ----------------------------------------------------------------------
@PROTOCOL_NAME = mil1553
0Ah,Engine,01h,Thrust
03h,Main panel,07h,Altimeter
03h,Main panel,01h,Speed
0Eh,Only RTA
```

14.14.3 MIL-1553 filter

Access: "Menu" > "Apps" > "Protocol" tab > "MIL-1553" > "Filter" tab

In the "Filter" tab, you can define the settings to display only the frames that match the selected filter conditions.



Check all, Clear, Invert, Preset

The following settings help you select the frames and errors you want to filter for. Only the frames and error types that match the selected filter conditions are displayed.

"Check all"	Enables the filter for all available frames and error types.
"Clear"	Disables the filter for all available frames and error types.
"Invert"	Inverts the current state of the frame and error types: all frames and error types that were enabled are disabled and vice versa.
"Preset"	Presets the state of the selected frames and error types.

Remote command:

`SBUS<sb>:MILStd:FILTer:RST` on page 1498

`SBUS<sb>:MILStd:FILTer:INVert` on page 1497

`SBUS<sb>:MILStd:FILTer:CHKall` on page 1497

`SBUS<sb>:MILStd:FILTer:CLR` on page 1497

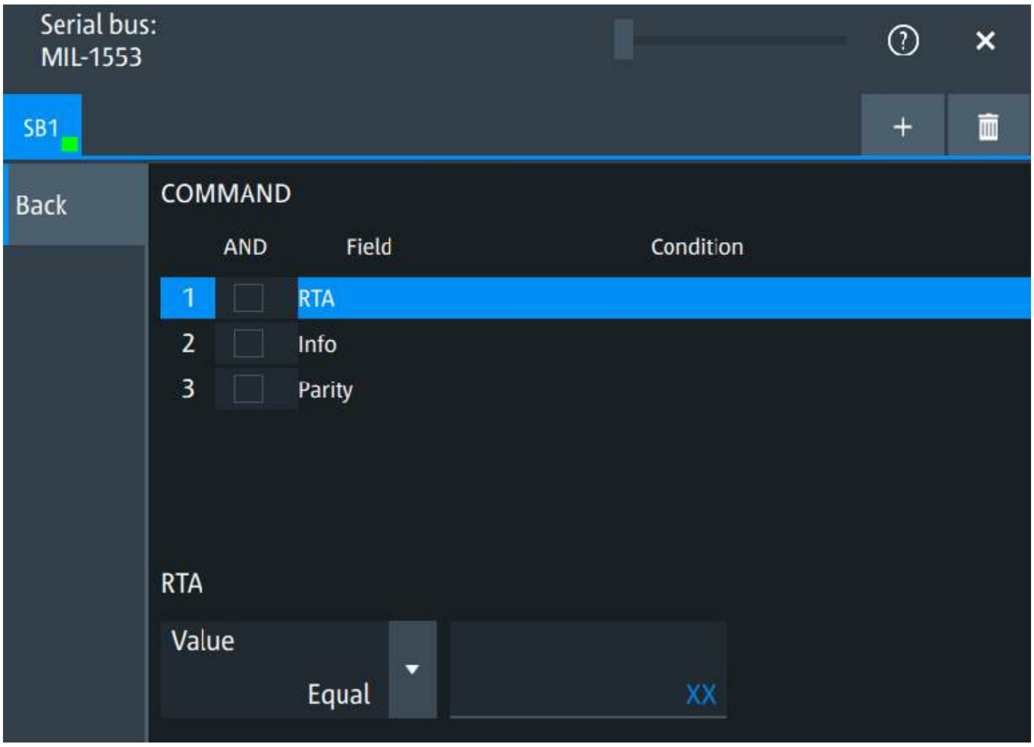
Enable
Enables the filtering on MIL-1553 frames. Only the frames that match the selected filter conditions are displayed.

Remote command:
SBUS<sb>:MILStd:FILTer:FRENable on page 1501
SBUS<sb>:MILStd:FILTer:FRAMe<fr>:ENABle on page 1501

Frame type
Selects the frame type that you want to display. You can filter all enabled frame types simultaneously.

For selected frame types, you can also specify conditions for the value of the fields in the "Edit" dialog.

Edit
Opens a dialog to define the details of the selected frame.



"Field" Enables the field type that you want to filter on for the selected frame. The available fields are "RTA", "Info", "Parity", "Data".

Remote command:
SBUS<sb>:MILStd:FILTer:FIENable on page 1501
SBUS<sb>:MILStd:FILTer:FRAMe<fr>:FLD<fl>:ENABle on page 1501

"Condition" Displays the value condition for the selected field.

Remote command:
SBUS<sb>:MILStd:FILTer:BIT on page 1498
SBUS<sb>:MILStd:FILTer:FRAMe<fr>:FLD<fl>:BIT on page 1498

"Value" The data setup consists of a comparison condition and one or two data patterns.

Remote command:
SBUS<sb>:MILStd:FILTer:DMAX on page 1499
SBUS<sb>:MILStd:FILTer:FRAMe<fr>:FLD<fl>:DMAX on page 1499
SBUS<sb>:MILStd:FILTer:DMIN on page 1499
SBUS<sb>:MILStd:FILTer:FRAMe<fr>:FLD<fl>:DMIN on page 1499
SBUS<sb>:MILStd:FILTer:DOPerator on page 1499
SBUS<sb>:MILStd:FILTer:FRAMe<fr>:FLD<fl>:DOPerator on page 1499

"Index" The index setup consists of a comparison condition and one or two index values.

Remote command:
SBUS<sb>:MILStd:FILTer:IMAX on page 1500
SBUS<sb>:MILStd:FILTer:FRAMe<fr>:FLD<fl>:IMAX on page 1500
SBUS<sb>:MILStd:FILTer:IMIN on page 1500
SBUS<sb>:MILStd:FILTer:FRAMe<fr>:FLD<fl>:IMIN on page 1500
SBUS<sb>:MILStd:FILTer:IOPerator on page 1501
SBUS<sb>:MILStd:FILTer:FRAMe<fr>:FLD<fl>:IOPerator on page 1501

Error type
Enables filtering on the selected error type.

The available error types are "Sync error", "Manchester coding error", "Parity error", "Gap error", "Response timeout", "Unknown", "Incomplete".

Remote command:
SBUS<sb>:MILStd:FILTer:ERENable on page 1498
SBUS<sb>:MILStd:FILTer:ERRor<n>:ENABle on page 1498

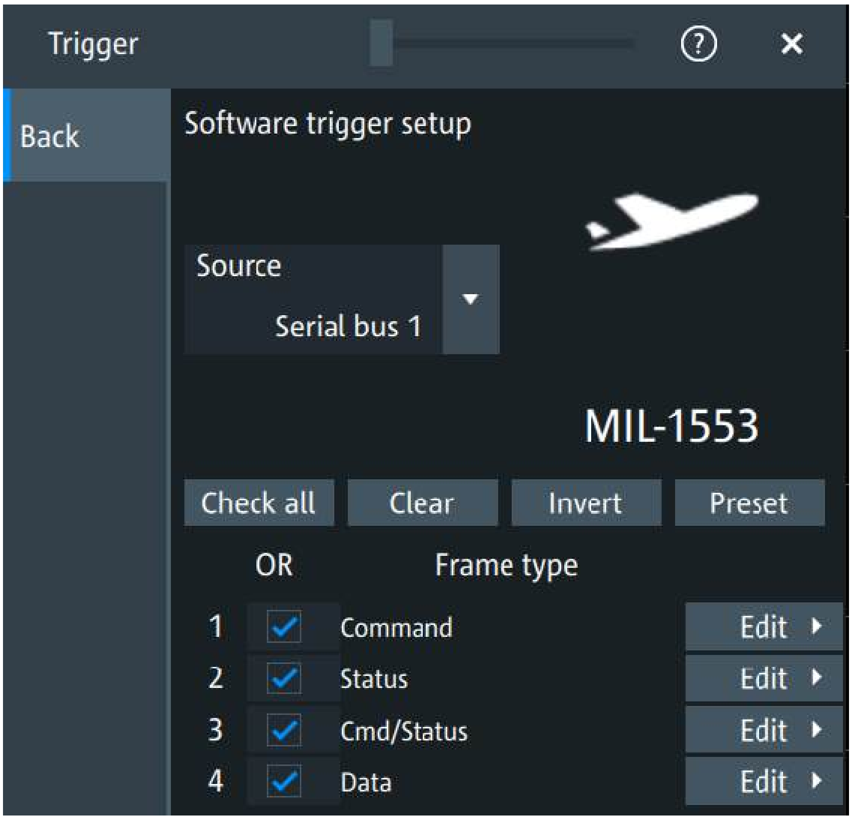
14.14.4 MIL-1553 software trigger

14.14.4.1 Setup A trigger

Before setting up the software trigger for the protocols, a trigger A event needs to be set up.

14.14.4.2 Software trigger settings

Access: "Menu" > "Apps" > "Protocol" tab > "MIL-1553" > "Trigger" tab > "Setup Software Trigger"



In the "Software Trigger" tab, you can define the settings to trigger on the frames that match the selected filter conditions.

Check all, Clear, Invert, Preset

The following settings help you select the frames and errors you want to trigger on.

"Check all"	Enables the software trigger for all available frames and error types.
"Clear"	Disables the software trigger for all available frames and error types.
"Invert"	Inverts the current state of the frame and error types for the software trigger: all frames and error types that were enabled are disabled and vice versa.
"Preset"	Presets the state of the selected frames and error types for the software trigger.

Remote command:

`TRIGger:SBSW:MILStd:CHKall` on page 1503
`TRIGger:SBSW:MILStd:CLR` on page 1503
`TRIGger:SBSW:MILStd:INVert` on page 1503
`TRIGger:SBSW:MILStd:RST` on page 1503

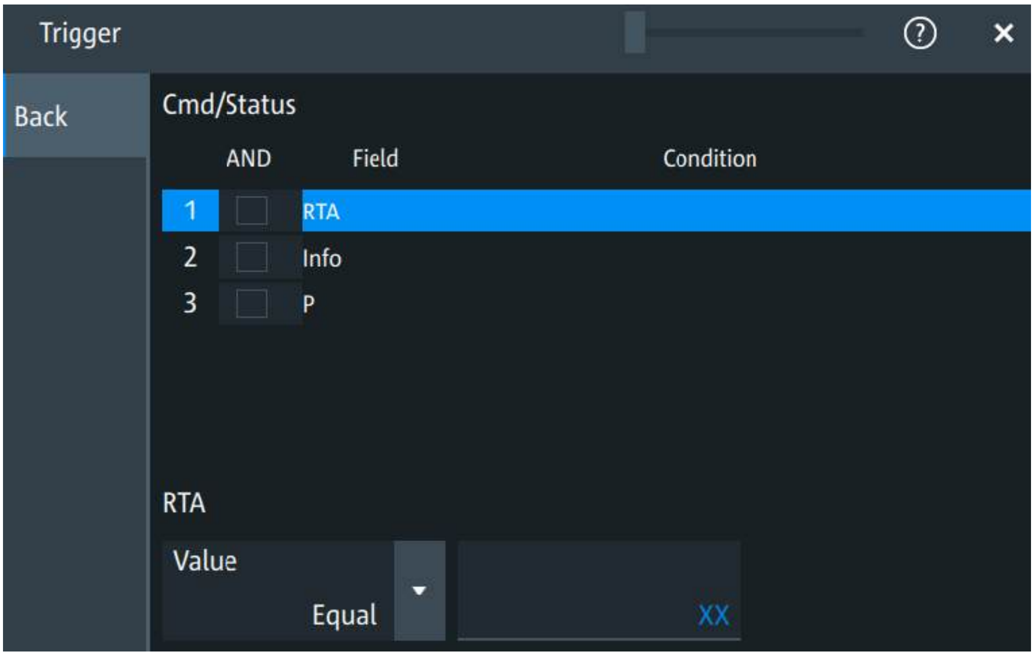
Frame type
Selects the frame type that you want to trigger on. You can trigger on all enabled frame types simultaneously.

For each frame type, you can also specify conditions for the value of the fields in the "Edit" dialog.

The following frames are available: "Command", "Status", "Cmd/Status", "Data".

Remote command:
`TRIGger:SBSW:MILStd:FRENable` on page 1503
`TRIGger:SBSW:MILStd:FRAMe<fr>:ENABle` on page 1503

Edit
Some trigger types have additional settings that can be defined. In this case, the "Set details" button appears next to "Type" the function. Open it for a detailed definition of the trigger conditions.



"Field" Enables the field type that you want to trigger on for the selected frame.
The following fields are available: "RTA", "Info", "Parity", "Data".

Remote command:
`TRIGger:SBSW:MILStd:FIENable` on page 1505
`TRIGger:SBSW:MILStd:FRAMe<fr>:FLD<fl>:ENABle` on page 1505

"Condition" Displays the value condition for the selected field.

Remote command:
`TRIGger:SBSW:MILStd:BIT` on page 1504
`TRIGger:SBSW:MILStd:FRAMe<fr>:FLD<fl>:BIT` on page 1504

"Value" The data setup consists of a comparison condition and one or two data patterns.

Remote command:
TRIGger:SBSW:MILStd:DMAX on page 1504
TRIGger:SBSW:MILStd:FRAMe<fr>:FLD<fl>:DMAX on page 1504
TRIGger:SBSW:MILStd:DMIN on page 1504
TRIGger:SBSW:MILStd:FRAMe<fr>:FLD<fl>:DMIN on page 1504
TRIGger:SBSW:MILStd:DOPerator on page 1505
TRIGger:SBSW:MILStd:FRAMe<fr>:FLD<fl>:DOPerator on page 1505

"Index" The index setup consists of a comparison condition and one or two index values.

Remote command:
TRIGger:SBSW:MILStd:IMAX on page 1505
TRIGger:SBSW:MILStd:FRAMe<fr>:FLD<fl>:IMAX on page 1505
TRIGger:SBSW:MILStd:IMIN on page 1506
TRIGger:SBSW:MILStd:FRAMe<fr>:FLD<fl>:IMIN on page 1506
TRIGger:SBSW:MILStd:IOPerator on page 1506
TRIGger:SBSW:MILStd:FRAMe<fr>:FLD<fl>:IOPerator on page 1506

Error type
Enables triggering on the selected error type.

The following error types are available: "Sync error", "Manchester coding error", "Parity error", "Gap error", "Response timeout".

Remote command:
TRIGger:SBSW:MILStd:ERENable on page 1507
TRIGger:SBSW:MILStd:ERRor<m>:ENABle on page 1507

14.14.5 Measure

The "Setup Measurement" button opens the dialog for automatic measurements in the "Protocol" category for the selected serial bus.

See Section 10.2.6.2, "Settings for protocol measurements", on page 289.

14.14.6 MIL-1553 decode results

When the configuration of the serial bus is complete, the signal can be decoded:

1. Open the "Serial Bus" dialog for the respective bus.

2. In the "Setup" tab, enable "State".
3. In the "Display" tab, enable "Show decode table".

For a description of the display settings, see also Section 14.1.3.1, "Display settings", on page 435.

For a description of how to synchronize the displayed results, see Section 14.1.3.2, "Display synchronization", on page 437.

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

Decode results table

The "Decode results" table contains information about all decoded frames.

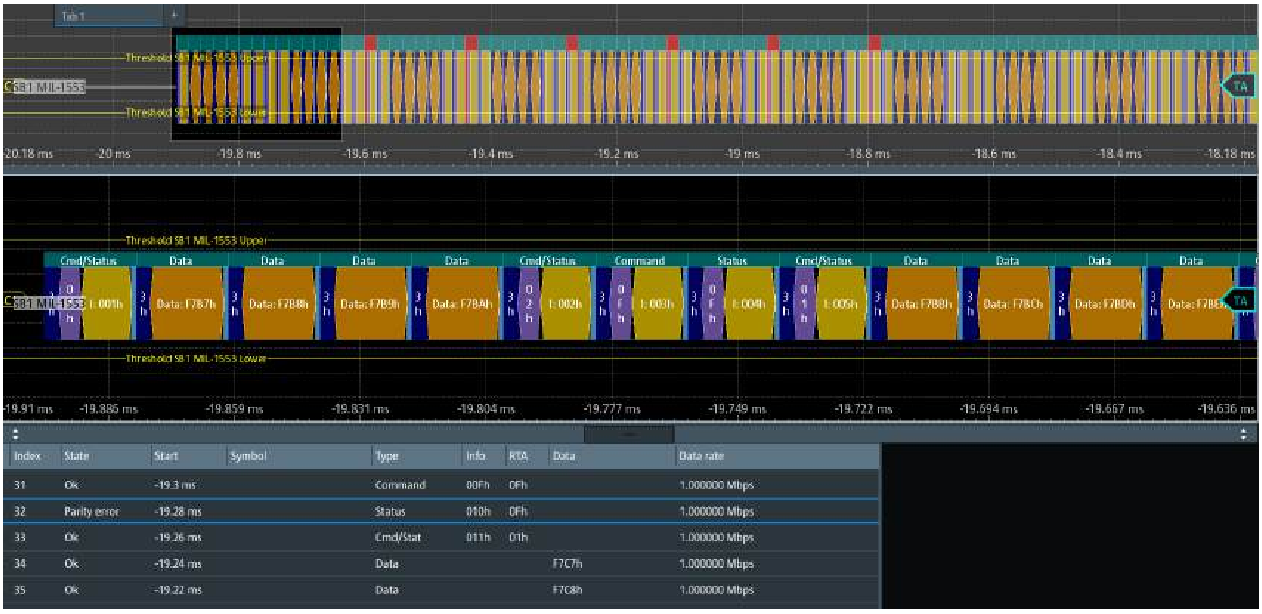


Figure 14-46: Decoded MIL-1553 signal

The decode results table contains information about all decoded frames.

Table 14-25: Content of the Decode results table

Column	Description
Index	Index of the decoded word
State	Overall state of the word
Start	Time of word start in relation to the trigger point
Symbol	Symbolic label of the frame. Available only, if "Show symbols" is enabled in the "Display" tab and a symbols list is loaded.
Type	Word type

Column	Description
Info	The hexadecimal value of the 9th to 1th bit of a command/status word
RTA	Remote terminal address
Data	The values of the data bytes. Select the data format in the "Display" tab.
Data rate	Data rate

Data format

You can select various data formats for the values displayed in the decode table and in the combs of the decoded signal.

Remote command:

- `SBUS<sb>:FORMat` on page 1154

Remote commands

Remote commands to retrieve decode results are described in Section 18.17.15.4, "Decode results", on page 1508.

14.14.7 Performing MIL-1553 decoding

This section explains step by step how to configure and decode the MIL-1553 bus.

14.14.7.1 Configuring MIL-1553 signals

For configuration, assign the lines to the input channels, and define the active states and the logical thresholds.

For details on configuration settings, see Section 14.14.2, "MIL-1553 configuration", on page 687.

1. Tap the "+ Bus" activator in the bottom right of the screen.

2. Select the tab of the bus that you want to set up, for example "SB1".
3. Tap the "Protocol type" button. Select the protocol: "MIL-1553".
4. Tap on "State" to enable the decoding.
   A MIL-1553 shortcut appears at the bottom left of the screen. Tap the shortcut for a quick access to the "MIL-1553" dialog settings.

14.14.7.2 Exporting decode results

Once a decode has been completed, you can generate an export of all decode results.

Prerequisites: A bus is configured for the MIL-1553 and decoded.

1. Tap on the "MIL-1553" shortcut.
2. Tap on the "Export" tab.
3. If necessary, enable "Include details".
4. If necessary, enable "Include timing".
5. Select the "File type".

   An export file is saved in the selected directory.

The MIL-1553 export file contains the following fields:

- A list of all decoded frames:
  - Index
  - Start
  - Stop
  - Type
  - State
  - RTA
  - Info
  - Data
  - Bit rate

Example MIL-1553 export file

```
Index,Start,Stop,Type,State,RTA,Info,Data,Bit Rate
1,-0.0199,-0.01988,'STAT','OK',1Dh,027h,---,1000000
2,-0.01988,-0.01986,'DATA','OK',---,---,F7C0h,1000000
3,-0.01986,-0.01984,'DATA','OK',---,---,F7CAh,1000000
4,-0.01984,-0.01982,'DATA','OK',---,---,F7D4h,1000000
5,-0.01982,-0.0198,'DATA','OK',---,---,F7DEh,1000000
```

14.15 SPMI (mobile electronics, option R&S MXO4-K550)

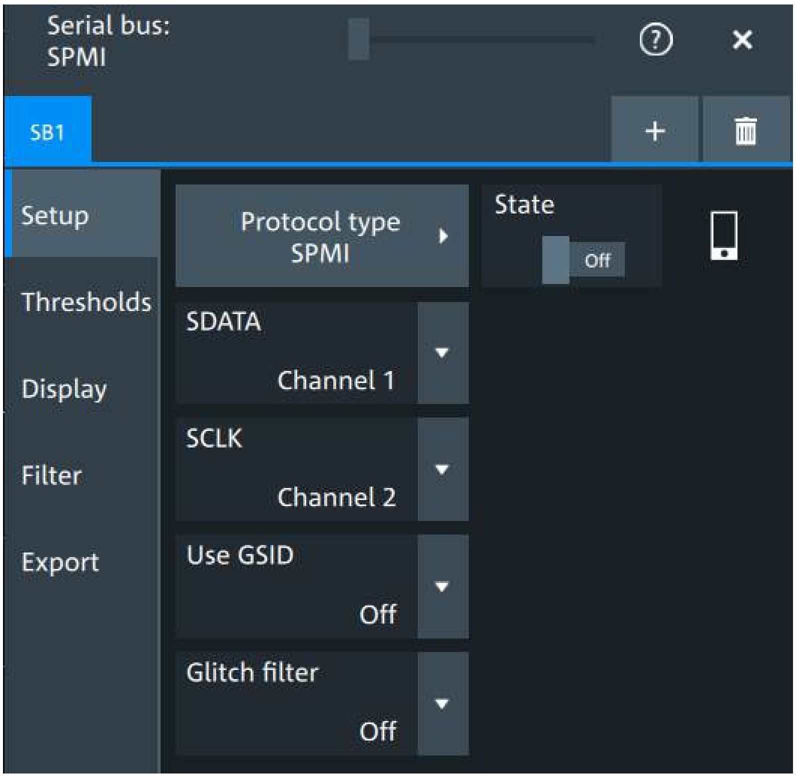
The System Power Management Interface (SPMI) is a high-speed, low-latency, bi-directional, 2-wire serial bus.

For basic information on SPMI, you can also refer to a video, available on the Rohde & Schwarz YouTube channel: Understanding SPMI.

14.15.1 SPMI configuration

14.15.1.1 SPMI configuration settings

Access: "Menu" > "Apps" > "Protocol" tab > "SPMI" > "Setup".



Make sure that the tab of the correct serial bus is selected.

Protocol type
Selects the protocol type to be decoded.

Remote command:
`SBUS<sb>:TYPE` on page 1153

SDATA
Sets the source of the data line.

Remote command:
`SBUS<sb>:SPMI:SDATa:SOURce` on page 1514

SCLK
Sets the source of the clock line.

Remote command:
`SBUS<sb>:SPMI:SCLK:SOURce` on page 1513

Use GSID, GSID (hex)
Enables the use of the group sub ID (GSID). You can then enter a value for the "GSID (hex)". If the "SA" value of a frame matches this "GSID (hex)" value, the interpreter reverses the meaning of the "ACK" field: It interprets a bit value of zero in the ACK field as an error, and a bit value of one as OK.

Remote command:
`SBUS<sb>:SPMI:GSIDenable` on page 1512
`SBUS<sb>:SPMI:GIDValue` on page 1512

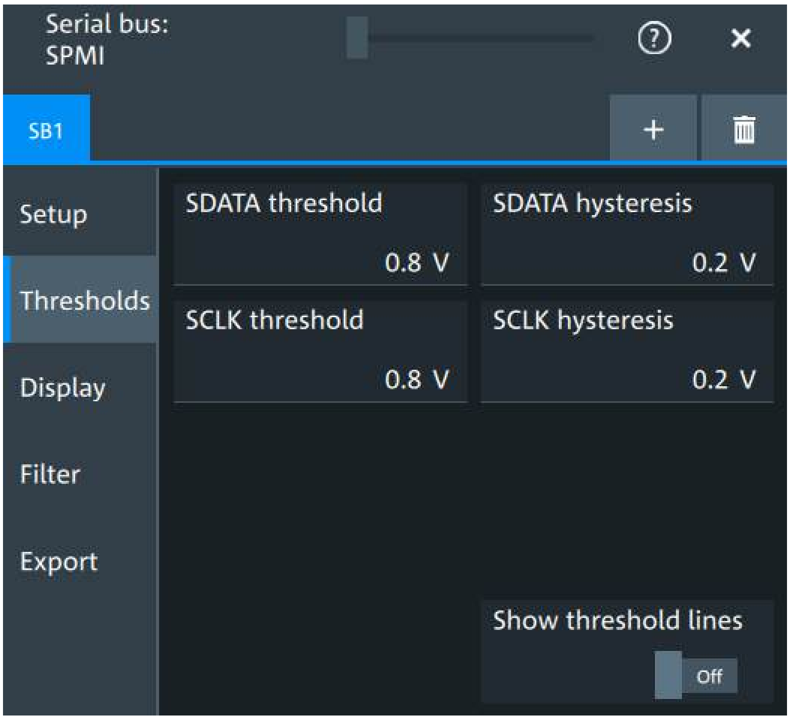
Glitch filter, Glitch width
A glitch filter can help to filter out short-duration voltage spikes/ glitches that can occur on the communication line.

If "Glitch filter" > "On" you can set the "Glitch width". Any signal transitions with a duration smaller than this value are considered a glitch and filtered out.

Remote command:
`SBUS<sb>:SPMI:GTCHenable` on page 1513
`SBUS<sb>:SPMI:GTWDith` on page 1513

14.15.1.2 Threshold settings

Access: "Menu" > "Apps" > "Protocol" tab > "SPMI" > "Thresholds".



Threshold

Sets the threshold for the data/clock channel. Enter the value directly in the fields.

Additional to the threshold, you can also set a hysteresis.

Remote command:
SBUS<sb>:SPMI:SCLK:THReshold on page 1514
SBUS<sb>:SPMI:SDATa:THReshold on page 1515
SBUS<sb>:SPMI:SCLK:HYSTeresis on page 1513
SBUS<sb>:SPMI:SDATa:HYSTeresis on page 1514

Show threshold lines

If enabled, the threshold lines are displayed in the diagram.

The label of the threshold line is set according to the signal that it is referring to, see also Show threshold lines.

Remote command:
SBUS<sb>:THReshold on page 1155

14.15.1.3 Display settings

For details about the display settings, see Section 14.1.3.1, "Display settings", on page 435.

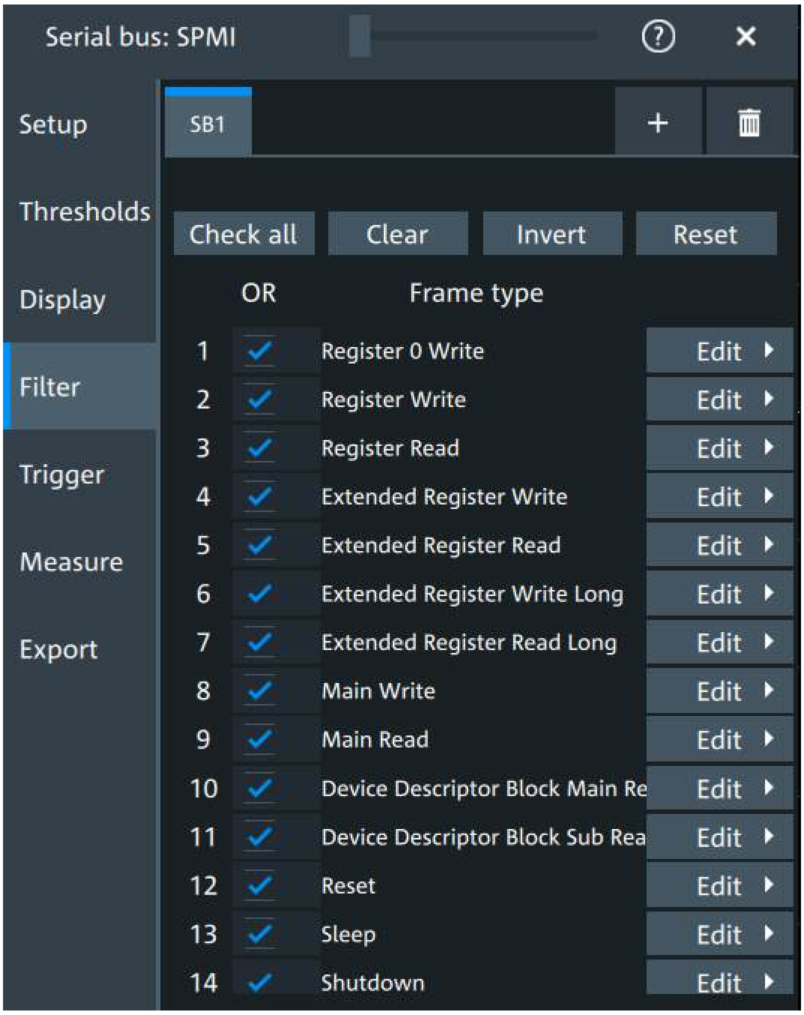
Decode layer

Selects the decode layer.

Decoding is performed in several steps, and the results are presented in the decode table. The decode layer selects an interim step for which the decoding result is shown in the honeycomb display.

14.15.2 SPMI filter

Access: "Menu" > "Apps" > "Protocol" tab > "SPMI" > "Filter" tab



In the "Filter" tab, you can define the settings to display only the frames that match the selected filter conditions.

Check all, Clear, Invert, Preset

The following settings help you select the frames and errors you want to filter for. Only the frames and error types that match the selected filter conditions are displayed.

"Check all"	Enables the filter for all available frames and error types.
"Clear"	Disables the filter for all available frames and error types.
"Invert"	Inverts the current state of the frame and error types: all frames and error types that were enabled are disabled and vice versa.

"Preset" Presets the state of the selected frames and error types.

Remote command:
SBUS<sb>:SPMI:FILTer:CHKall on page 1517
SBUS<sb>:SPMI:FILTer:CLR on page 1517
SBUS<sb>:SPMI:FILTer:INVert on page 1517
SBUS<sb>:SPMI:FILTer:RST on page 1517

Frame type

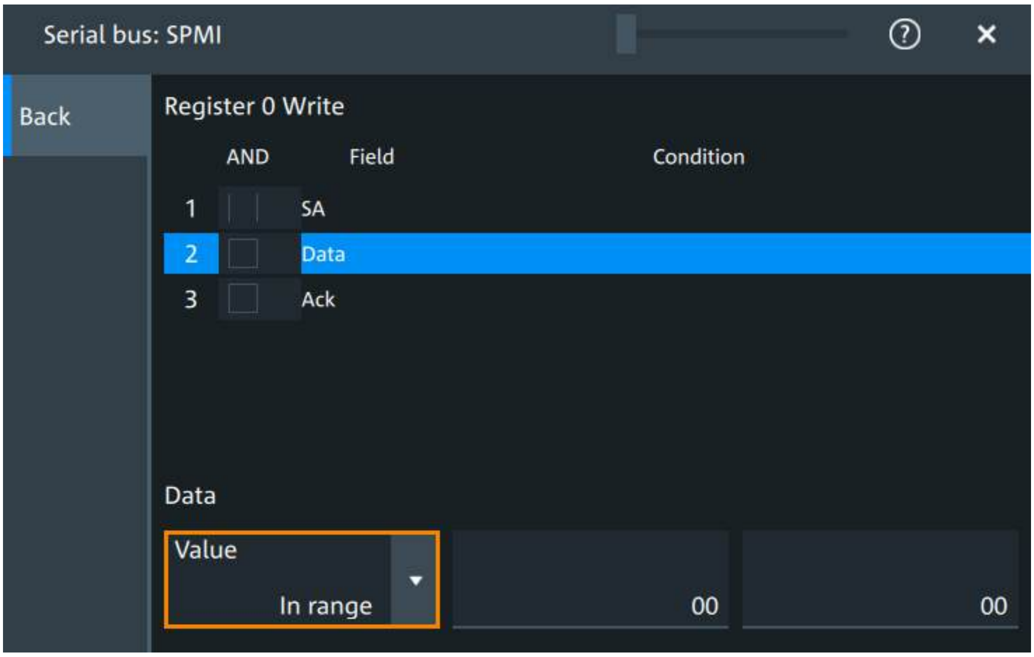
Selects the frame type that you want to display. You can filter all enabled frame types simultaneously.

For selected frame types, you can also specify conditions for the value of the fields in the "Edit" dialog.

Remote command:
SBUS<sb>:SPMI:FILTer:FRAMe<fr>:ENABle on page 1521
SBUS<sb>:SPMI:FILTer:FRENable on page 1521

Edit

Opens a dialog to define the details of the selected frame.



"Field" Enables the field type that you want to filter on for the selected frame. The available fields depend on the selected frame type.

Remote command:
SBUS<sb>:SPMI:FILTer:FIENable on page 1521
SBUS<sb>:SPMI:FILTer:FRAMe<fr>:FLD<fl>:ENABle on page 1521

"Condition" Displays the value condition for the selected field.

Remote command:
SBUS<sb>:SPMI:FILTer:BIT on page 1517
SBUS<sb>:SPMI:FILTer:FRAMe<fr>:FLD<fl>:BIT
on page 1517

"Value" The data setup consists of a comparison condition and one or two data patterns.

Remote command:
SBUS<sb>:SPMI:FILTer:DMAX on page 1518
SBUS<sb>:SPMI:FILTer:FRAMe<fr>:FLD<fl>:DMAX
on page 1518
SBUS<sb>:SPMI:FILTer:DMIN on page 1518
SBUS<sb>:SPMI:FILTer:FRAMe<fr>:FLD<fl>:DMIN
on page 1518
SBUS<sb>:SPMI:FILTer:DOPerator on page 1519
SBUS<sb>:SPMI:FILTer:FRAMe<fr>:FLD<fl>:DOPerator
on page 1519

"Index" The index setup consists of a comparison condition and one or two index values.

Remote command:
SBUS<sb>:SPMI:FILTer:IMAX on page 1520
SBUS<sb>:SPMI:FILTer:FRAMe<fr>:FLD<fl>:IMAX
on page 1520
SBUS<sb>:SPMI:FILTer:IMIN on page 1520
SBUS<sb>:SPMI:FILTer:FRAMe<fr>:FLD<fl>:IMIN
on page 1520
SBUS<sb>:SPMI:FILTer:IOPerator on page 1519
SBUS<sb>:SPMI:FILTer:FRAMe<fr>:FLD<fl>:IOPerator
on page 1519

Error type
Enables filtering on the selected error type.

Remote command:
SBUS<sb>:SPMI:FILTer:ERRor<n>:ENABle on page 1519
SBUS<sb>:SPMI:FILTer:ERENable on page 1519

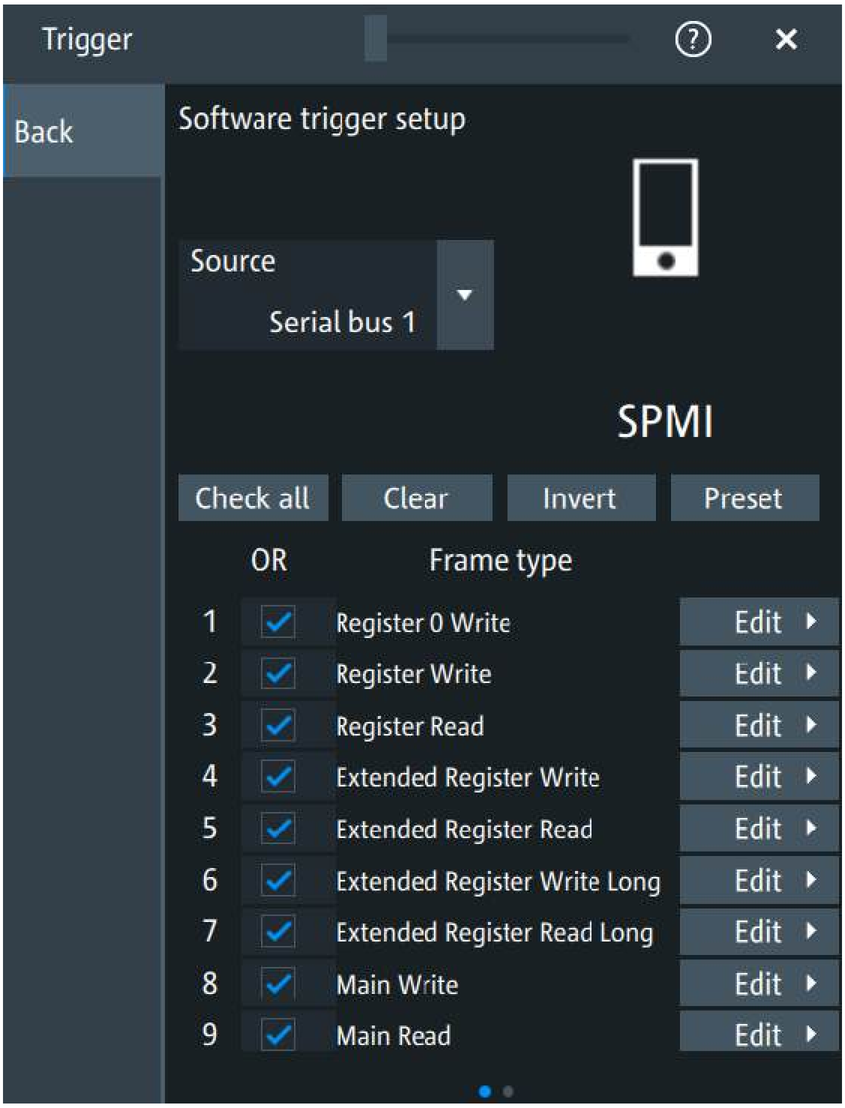
14.15.3 SPMI software trigger

14.15.3.1 Setup A trigger

Before setting up the software trigger for the protocols, a trigger A event needs to be set up.

14.15.3.2 Software trigger settings

Access: "Menu" > "Apps" > "Protocol" tab > "SPMI" > "Trigger" tab > "Setup Software Trigger" > "Setup SB Trigger".



In the "Software Trigger" tab, you can define the settings to trigger on the frames that match the selected filter conditions.

Check all, Clear, Invert, Preset

The following settings help you select the frames and errors you want to trigger on.

"Check all"	Enables the software trigger for all available frames and error types.
"Clear"	Disables the software trigger for all available frames and error types.
"Invert"	Inverts the current state of the frame and error types for the software trigger: all frames and error types that were enabled are disabled and vice versa.

"Preset" Presets the state of the selected frames and error types for the software trigger.

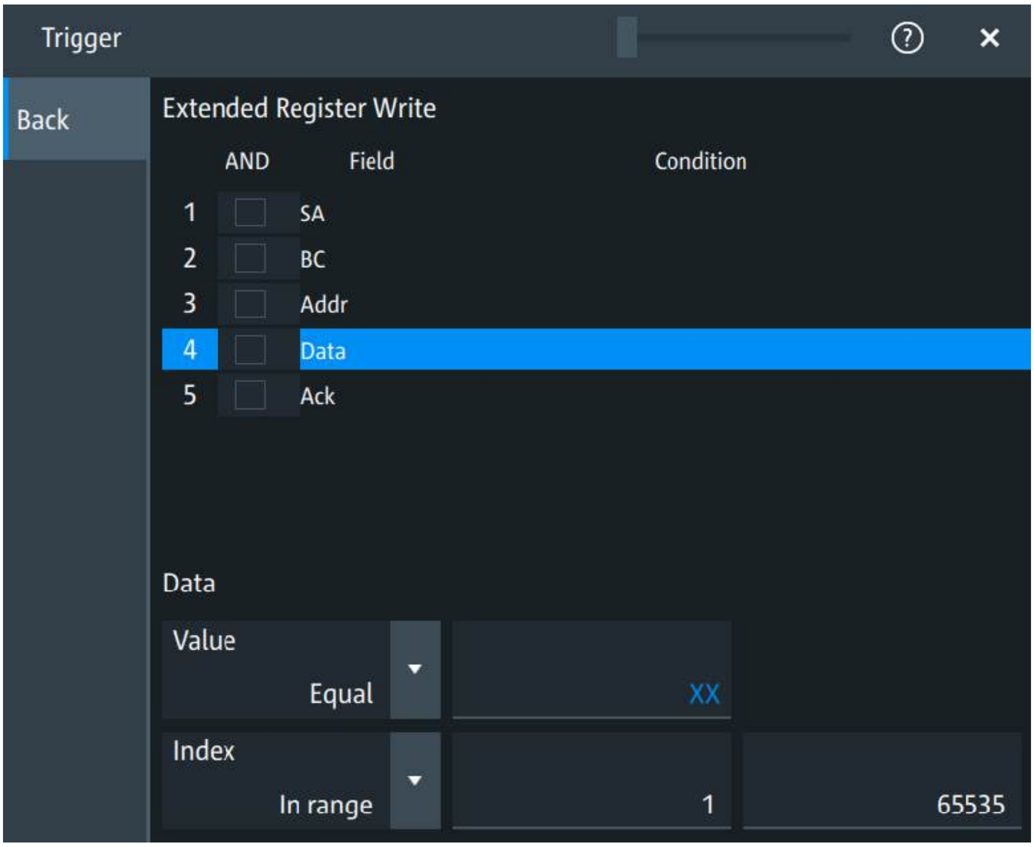
Remote command:
TRIGger:SBSW:SPMI:CHKall on page 1522
TRIGger:SBSW:SPMI:CLR on page 1522
TRIGger:SBSW:SPMI:INVert on page 1522
TRIGger:SBSW:SPMI:RST on page 1523

Frame type
Selects the frame type that you want to trigger on. You can trigger on all enabled frame types simultaneously.

For each frame type, you can also specify conditions for the value of the fields in the "Edit" dialog.

Remote command:
TRIGger:SBSW:SPMI:FRENable on page 1523
TRIGger:SBSW:SPMI:FRAMe<fr>:ENABle on page 1523

Edit
Some trigger types have additional settings that can be defined. In this case, the "Set details" button appears next to "Type" the function. Open it for a detailed definition of the trigger conditions.



"Field" Enables the field type that you want to trigger on for the selected frame.

Remote command:
TRIGger:SBSW:SPMI:FIENable on page 1525
TRIGger:SBSW:SPMI:FRAMe<fr>:FLD<fl>:ENABle on page 1525

"Condition" Displays the value condition for the selected field.

Remote command:
TRIGger:SBSW:SPMI:BIT on page 1523
TRIGger:SBSW:SPMI:FRAMe<fr>:FLD<fl>:BIT on page 1523

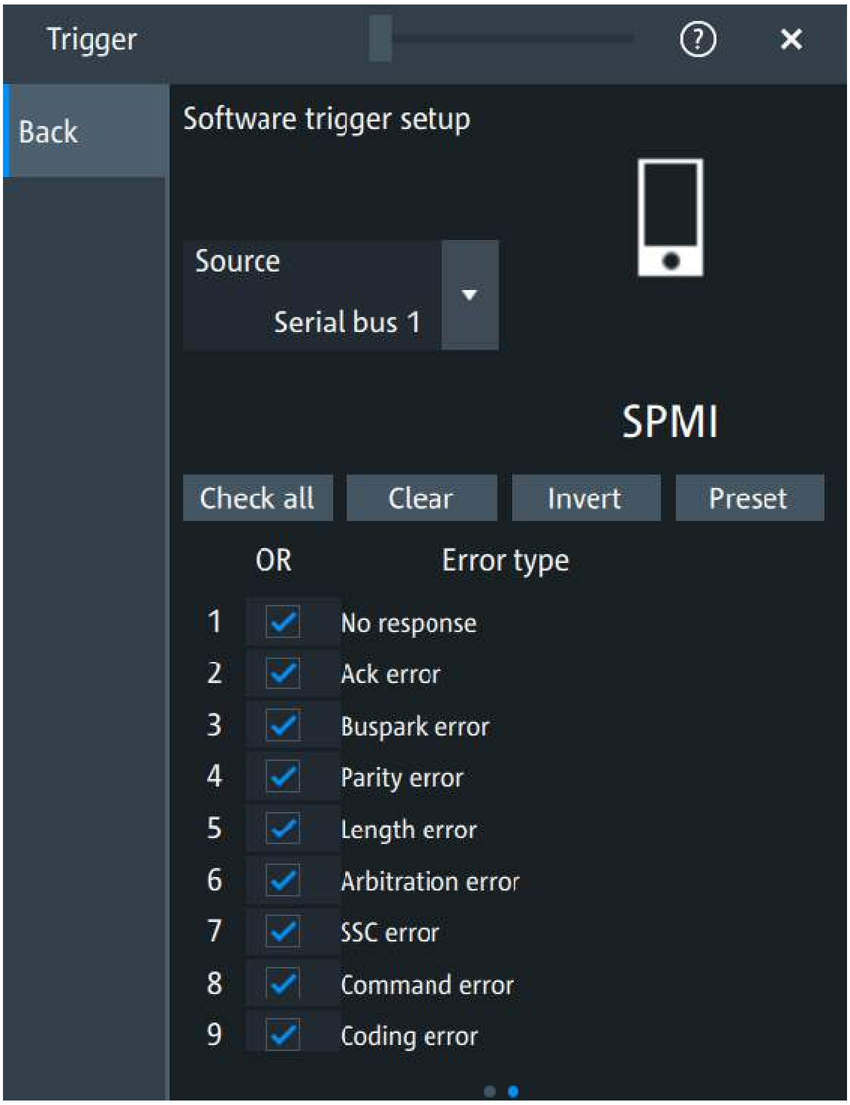
"Value" The data setup consists of a comparison condition and one or two data patterns.

Remote command:
TRIGger:SBSW:SPMI:DMAX on page 1524
TRIGger:SBSW:SPMI:FRAMe<fr>:FLD<fl>:DMAX on page 1524
TRIGger:SBSW:SPMI:DMIN on page 1524
TRIGger:SBSW:SPMI:FRAMe<fr>:FLD<fl>:DMIN on page 1524
TRIGger:SBSW:SPMI:DOPerator on page 1524
TRIGger:SBSW:SPMI:FRAMe<fr>:FLD<fl>:DOPerator on page 1524

"Index" The index setup consists of a comparison condition and one or two index values.

Remote command:
TRIGger:SBSW:SPMI:IMAX on page 1525
TRIGger:SBSW:SPMI:FRAMe<fr>:FLD<fl>:IMAX on page 1525
TRIGger:SBSW:SPMI:IMIN on page 1526
TRIGger:SBSW:SPMI:FRAMe<fr>:FLD<fl>:IMIN on page 1526
TRIGger:SBSW:SPMI:IOPerator on page 1526
TRIGger:SBSW:SPMI:FRAMe<fr>:FLD<fl>:IOPerator on page 1526

Error type
Enables triggering on the selected error type.



Remote command:
`TRIGger:SBSW:SPMI:ERENable` on page 1526
`TRIGger:SBSW:SPMI:ERRor<m>:ENABle` on page 1526

14.15.4 Measure

The "Setup Measurement" button opens the dialog for automatic measurements in the "Protocol" category for the selected serial bus.

See Section 10.2.6.2, "Settings for protocol measurements", on page 289.

14.15.5 SPMI decode results

When the configuration of the serial bus is complete, the signal can be decoded:

1. Open the "Serial Bus" dialog for the respective bus.
2. In the "Setup" tab, enable "State".
3. In the "Display" tab, enable "Show decode table".

For a description of the display settings, see also Section 14.1.3.1, "Display settings", on page 435.

For a description of how to synchronize the displayed results, see Section 14.1.3.2, "Display synchronization", on page 437.

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

Decode results table

The "Decode results" table contains information about all decoded frames.

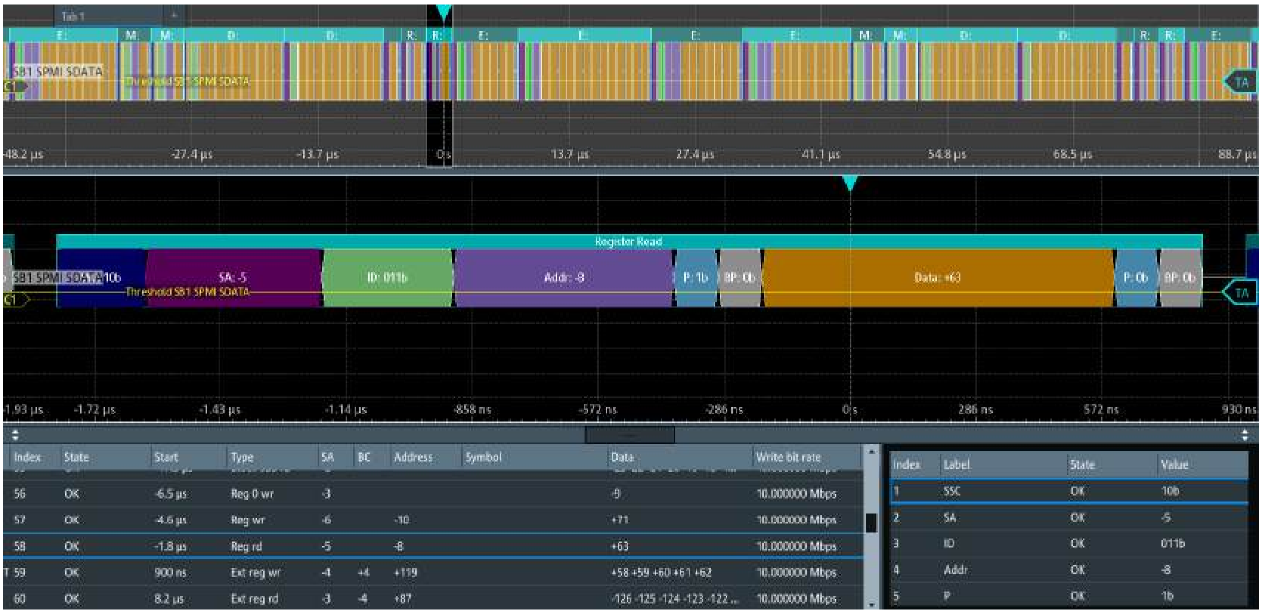


Figure 14-47: Decoded SPMI signal

The decode results table contains information about all decoded frames.

Table 14-26: Content of the decode results table

Column	Description
Index	Index of the decoded frame
State	Overall state of the frame
Start	Time of frame start
Type	The type of frame

Column	Description
SA	Secondary node address. Select the data format in the "Display" tab.
BC	Byte count value. Select the data format in the "Display" tab.
Address	Register address. Select the data format in the "Display" tab.
Symbol	Symbolic label of the frame. Available only, if "Show symbols" is enabled in the "Display" tab and a symbols list is loaded.
Data	Data value. Select the data format in the "Display" tab.
Write bit rate	Value of the write bit rate
Read bit rate	Value of the read bit rate

When you select a frame in the decode results table, its field content is shown in the details table to the right.

Table 14-27: Content of the frame details table

Column	Description
Index	Number of the decoded field
Label	Name of the field
State	State of the field
Value	Value of the field

Data format

You can select various data formats for the values displayed in the decode table and in the combs of the decoded signal.

Remote command:

- `SBUS<sb>:FORMat` on page 1154

Remote commands

Remote commands to retrieve decode results are described in Section 18.17.16, "SPMI (option R&S MXO4-K550)", on page 1511.

14.15.6 Performing SPMI decoding

This section explains step by step how to configure and decode the SPMI bus.

For more information on decoding SPMI, you can also refer to the video, available on the Rohde & Schwarz YouTube channel: Decoding SPMI with MXO Series Oscilloscopes.

14.15.6.1 Configuring SPMI signals

For configuration, assign the lines to the input channels, and define the active states and the logical thresholds.

For details on configuration settings, see Section 14.15.1, "SPMI configuration", on page 699.

1. Tap the "+ Bus" activator in the bottom right of the screen.

2. Select the tab of the bus that you want to set up, for example "SB1".
3. Tap the "Protocol type" button. Select the protocol: "SPMI".
4. Tap on "State" to enable the decoding.

   An SPMI shortcut appears at the bottom left of the screen. Tap on the shortcut for a quick access to the "SPMI" dialog settings.

14.15.6.2 Exporting decode results

Once a decode has been completed, you can generate an export of all decode results.

Prerequisites: A bus is configured for the SPMI and decoded.

1. Tap on the "SPMI" shortcut.
2. Tap on the "Export" tab.
3. If necessary, enable "Include details".
4. If necessary, enable "Include timing".
5. Select the "File type".

   An export file is saved in the selected directory.

The SPMI export file contains the following fields:

- A list of all decoded frames:
  – Index
  – Start
  – Stop
  – State
  – Type
  – SA
  – BC
  – Address

- Write bit rate
- Read bit rate

- The details frame includes the following fields:
  - Index
  - Label
  - State
  - Value

Example SPMI export file

```
Index,Start,Stop,State,Type,SA,BC,Address,Write bit rate,Read bit rate
1,-0.000405,-0.0004032,'OK','RZWR',Dh,---,---,10000000,---
2,-0.0004031,-0.0004004,'OK','RWR',Ah,---,16h,10000000,---
3,-0.0004003,-0.0003977,'OK','RRD',Bh,---,18h,10000000,10000000
4,-0.0003976,-0.0003904,'OK','ERWR',Ch,4h,77h,10000000,---
5,-0.0003903,-0.000376,'OK','ERRD',Dh,Ch,57h,10000000,10000000

Details frame 1
Index,Label,State,Value
1,'"SSC"','OK','"10b"'
2,'"SA"','OK','"Dh"'
3,'"ID"','OK','"1b"'
4,'"Data"','OK','"77h"'
5,'"P"','OK','"1b"'
6,'"BP"','OK','"0b"'
7,'"Ack"','OK','"1b"'
8,'"BP"','OK','"0b"'

Details frame 2
Index,Label,State,Value
1,'"SSC"','OK','"10b"'
2,'"SA"','OK','"Ah"'
3,'"ID"','OK','"010b"'
4,'"Addr"','OK','"16h"'
5,'"P"','OK','"1b"'
6,'"Data"','OK','"47h"'
7,'"P"','OK','"1b"'
8,'"BP"','OK','"0b"'
9,'"Ack"','OK','"1b"'
10,'"BP"','OK','"0b"'
```

14.16 RFFE (mobile electronics, option R&S MXO4-K550)

Requirements

For performing RFFE decode measurements, you need the following:

- MXO 4 with 2 available channels. The channel can be:
  - Analog channels (C1-C4)
  - Logic channels (D0-D15) (requires option R&S MXO4-B1)
- Two probes
- Option R&S MXO4-K550

14.16.1 About the RFFE protocol

The RFFE interface is specified in the "MIPI® Alliance Specification for RF Front-End Control Interface". The RFFE interface is used by the radio frequency front-end interface chips in most LTE-Advanced platforms and in smart phones in general. RFFE is a replacement for existing standards like SPI and I²C that do no meet performance requirements.

Bus structure

RFFE is a two-wire, serial interface that connects up to 4 main devices (Radio Frequency IC, RFIC) to up to 15 sub devices (front-end modules, FEM) on a single RFFE bus. A sub device has read-write capability, or it is write only. Only one of the main devices is the active main device (bus owner main device, BOM), which can initiate command sequences on the bus.

The interface has two lines: one clock signal (SCLK) controlled by the main device, and a serial bidirectional data signal (SDATA). Furthermore, a VIO supply/reference voltage from a common source is applied to all components on the bus.

Command sequences

Protocol messages are called command sequences in RFFE. The standard defines various command sequences to accomplish read and write access to sub devices and to non-active main devices. Command sequences are initiated by the BOM main device on the SDATA line.

In general, a command sequence consists of:

- Sequence start condition (SSC)

Two bits: 1 followed by 0 on SDATA while SCLK is at logic level zero.

- Command frame
  Consist of a 4-bit sub device address field (SA), followed by 8 command payload bits and a single parity bit.
- Address and/or data frames, depending on the command sequence
  A frame consists of 8 data bits or 8 register address bits, followed by a single parity bit. The number of address and data frames varies depending on the command sequence type.
- Bus park cycle (BP)
  A BP cycle is sent at the end of a command sequence, and when the device transfers control of SDATA to another device.

Between the end of a command sequence and the beginning of a new command sequence, the bus is in idle condition at least for 10 ns.

The bits are sent MSB first.

SSC	Command frame		Address and data frames		BP
	SA 4 bits	Command payload 8 bits + P	[Address frames] 8 bits + P	[Data frames] 8 bits + P	

Figure 14-48: General structure of a RFFE Write command sequence

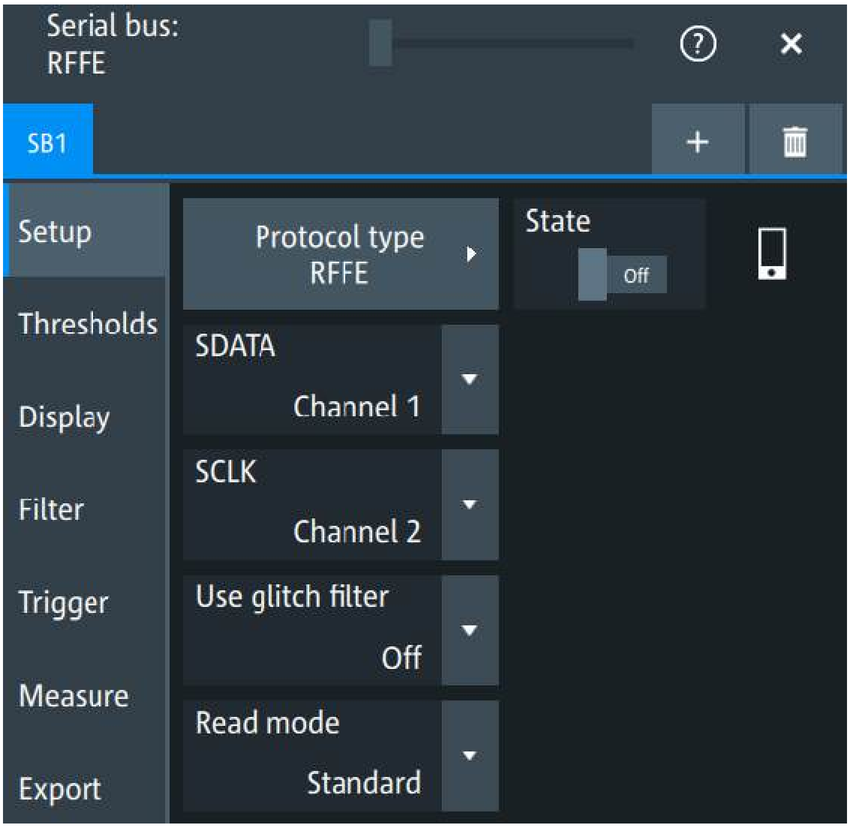
SSC	Command frame		Address and data frames			BP
	SA 4 bits	Command payload 8 bits + P	[Address frames] 8 bits + P	BP	[Data frames] 8 bits + P	

Figure 14-49: General structure of a RFFE Read command sequence

14.16.2 RFFE configuration

14.16.2.1 RFFE configuration settings

Access: "Menu" > "Apps" > "Protocol" tab > "RFFE" > "Setup".



Make sure that the tab of the correct serial bus is selected.

Protocol type

Selects the protocol type to be decoded.

Remote command:
`SBUS<sb>:TYPE` on page 1153

State

Enables the decoding of the selected bus. The signal icon of the bus appears on the signal bar.

Remote command:
`SBUS<sb>[:STATe]` on page 1152

SDATA

Sets the source of the data line.

Remote command:
`SBUS<sb>:RFFE:DATA:SOURce` on page 1535

SCLK

Sets the source of the clock line.

Remote command:
SBUS<sb>:RFFE:CLOCk:SOURce on page 1534

Use glitch filter, Glitch filter width
Enables the glitch filter on the SCLK and SDATA lines to improve decode accuracy.

The "Glitch filter width" field sets the maximum glitch width to be ignored.

Remote command:
SBUS<sb>:RFFE:GFILter on page 1535
SBUS<sb>:RFFE:GFWidth on page 1536

Read mode
Selects, if the standard or synchronous read ("sRead") mode is used.

Remote command:
SBUS<sb>:RFFE:RDMD on page 1536

14.16.2.2 Threshold settings

Access: "Menu" > "Apps" > "Protocol" tab > "RFFE" > "Thresholds".

Threshold
Sets the threshold for the data and clock channel. Enter the value directly in the fields.

Additional to the threshold, you can also set a hysteresis.

Remote command:
SBUS<sb>:RFFE:DATA:THReshold on page 1535
SBUS<sb>:RFFE:DATA:HYSTeresis on page 1534
SBUS<sb>:RFFE:CLOCk:THReshold on page 1534
SBUS<sb>:RFFE:CLOCk:HYSTeresis on page 1534

Show threshold lines
If enabled, the threshold lines are displayed in the diagram.

The label of the threshold line is set according to the signal that it is referring to, see also Show threshold lines.

Remote command:
SBUS<sb>:THReshold on page 1155

14.16.2.3 Display settings

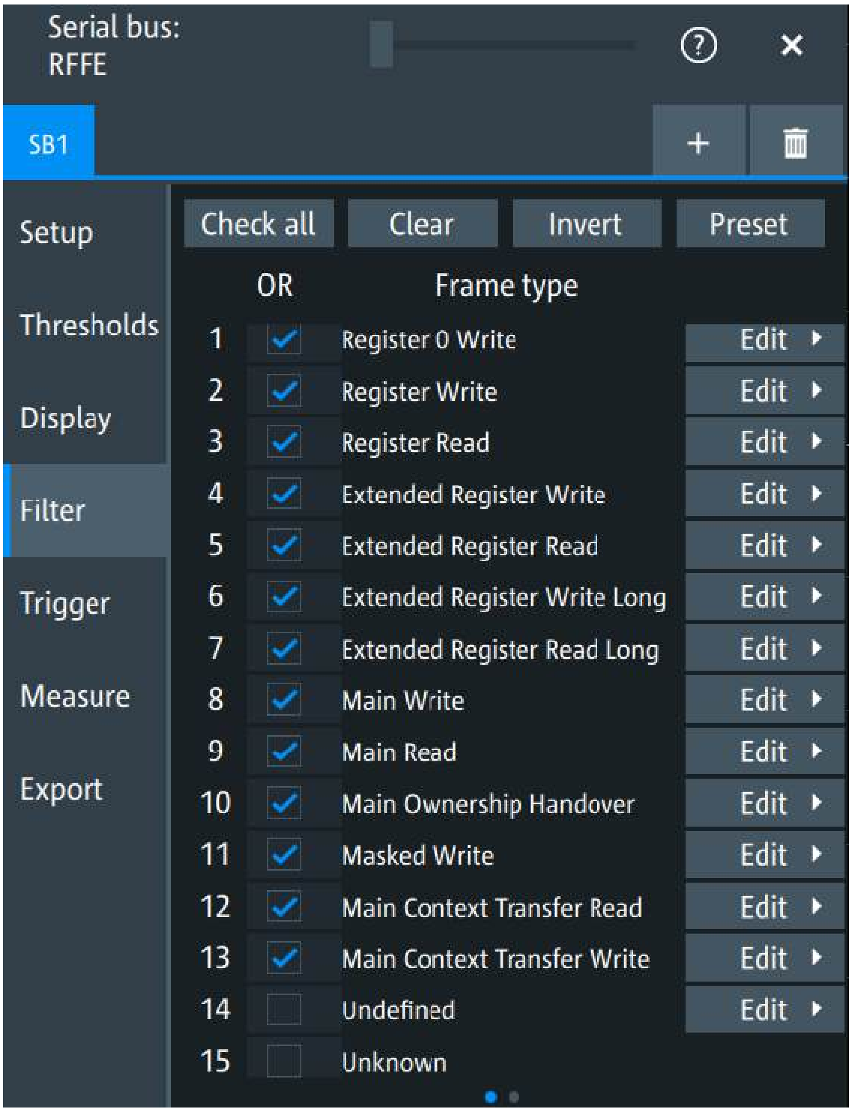
For details about the display settings, see Section 14.1.3.1, "Display settings", on page 435.

Decode layer
Selects the decode layer.

Decoding is performed in several steps, and the results are presented in the decode table. The decode layer selects an interim step for which the decoding result is shown in the honeycomb display.

14.16.3 RFFE filter

Access: "Menu" > "Apps" > "Protocol" tab > "RFFE" > "Filter" tab



In the "Filter" tab, you can define the settings to display only the frames that match the selected filter conditions.

Check all, Clear, Invert, Preset

The following settings help you select the frames and errors you want to filter for. Only the frames and error types that match the selected filter conditions are displayed.

"Check all"	Enables the filter for all available frames and error types.
"Clear"	Disables the filter for all available frames and error types.
"Invert"	Inverts the current state of the frame and error types: all frames and error types that were enabled are disabled and vice versa.
"Preset"	Presets the state of the selected frames and error types.

Remote command:
SBUS<sb>:RFFE:FILTer:CHKall on page 1537
SBUS<sb>:RFFE:FILTer:CLR on page 1538
SBUS<sb>:RFFE:FILTer:INVert on page 1538
SBUS<sb>:RFFE:FILTer:RST on page 1538

Enable
Enables the filtering on RFFE frames. Only the frames that match the selected filter conditions are displayed.

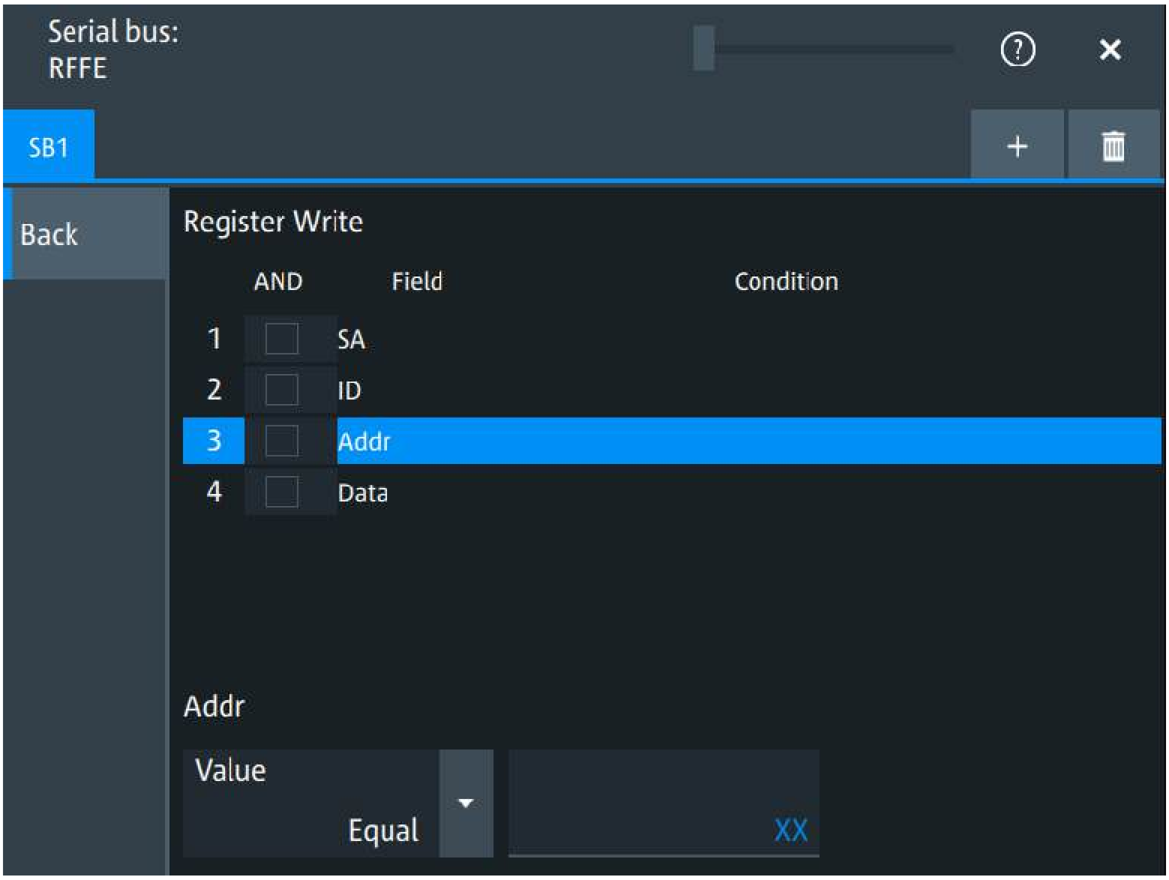
Remote command:
SBUS<sb>:RFFE:FILTer:FRENable on page 1538
SBUS<sb>:RFFE:FILTer:FRAMe<fr>:FLD<fl>:ENABle on page 1540

Frame type
Selects the frame type that you want to display. You can filter all enabled frame types simultaneously.

For selected frame types, you can also specify conditions for the value of the fields in the "Edit" dialog.

The following frames are available: "Register 0 Write", "Register Write", "Register Read", "Extended Register Write", "Extended Register Read", "Extended Register Write Long", "Extended Register Read Long", "Main Write", "Main Read".

Edit
Opens a dialog to define the details of the selected frame.



"Field"

Enables the field type that you want to filter on for the selected frame. The following fields are available: "SA", "ID", "Data", "Addr", "BC", "MID", "Data MSB", "Data LSB".

Remote command:
SBUS<sb>:RFFE:FILTer:FIENable on page 1540
SBUS<sb>:RFFE:FILTer:FRAMe<fr>:FLD<fl>:ENABle on page 1540

"Condition"

Displays the value condition for the selected field.

Remote command:
SBUS<sb>:RFFE:FILTer:BIT on page 1539
SBUS<sb>:RFFE:FILTer:FRAMe<fr>:FLD<fl>:BIT on page 1539

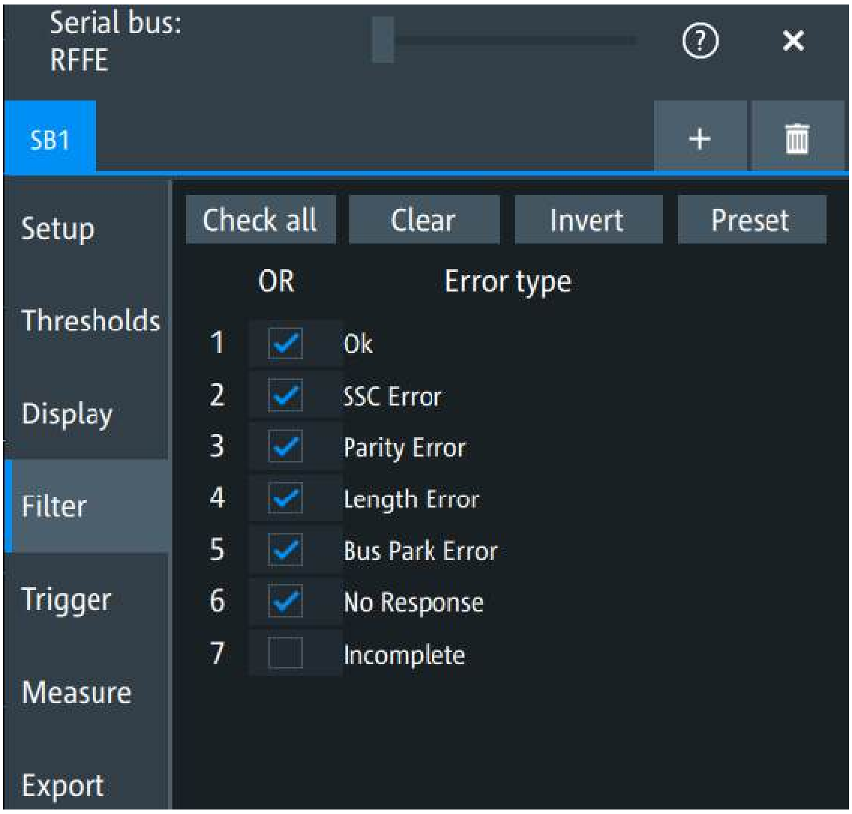
"Value" The data setup consists of a comparison condition and one or two data patterns.

Remote command:
SBUS<sb>:RFFE:FILTer:DMAX on page 1539
SBUS<sb>:RFFE:FILTer:FRAMe<fr>:FLD<fl>:DMAX on page 1539
SBUS<sb>:RFFE:FILTer:DMIN on page 1540
SBUS<sb>:RFFE:FILTer:FRAMe<fr>:FLD<fl>:DMIN on page 1540
SBUS<sb>:RFFE:FILTer:DOPerator on page 1540
SBUS<sb>:RFFE:FILTer:FRAMe<fr>:FLD<fl>:DOPerator on page 1540

"Index" The index setup consists of a comparison condition and one or two index values.

Remote command:
SBUS<sb>:RFFE:FILTer:IMAX on page 1541
SBUS<sb>:RFFE:FILTer:FRAMe<fr>:FLD<fl>:IMAX on page 1541
SBUS<sb>:RFFE:FILTer:IMIN on page 1541
SBUS<sb>:RFFE:FILTer:FRAMe<fr>:FLD<fl>:IMIN on page 1541
SBUS<sb>:RFFE:FILTer:IOPerator on page 1542
SBUS<sb>:RFFE:FILTer:FRAMe<fr>:FLD<fl>:IOPerator on page 1542

Error type
Enables filtering on the selected error type.



The following error types are available: "OK", "SSC Error", "Parity error", "Length error", "Bus park error", "No response".

Remote command:
SBUS<sb>:RFFE:FILTer:ERENable on page 1542
SBUS<sb>:RFFE:FILTer:ERRor<n>:ENABle on page 1542

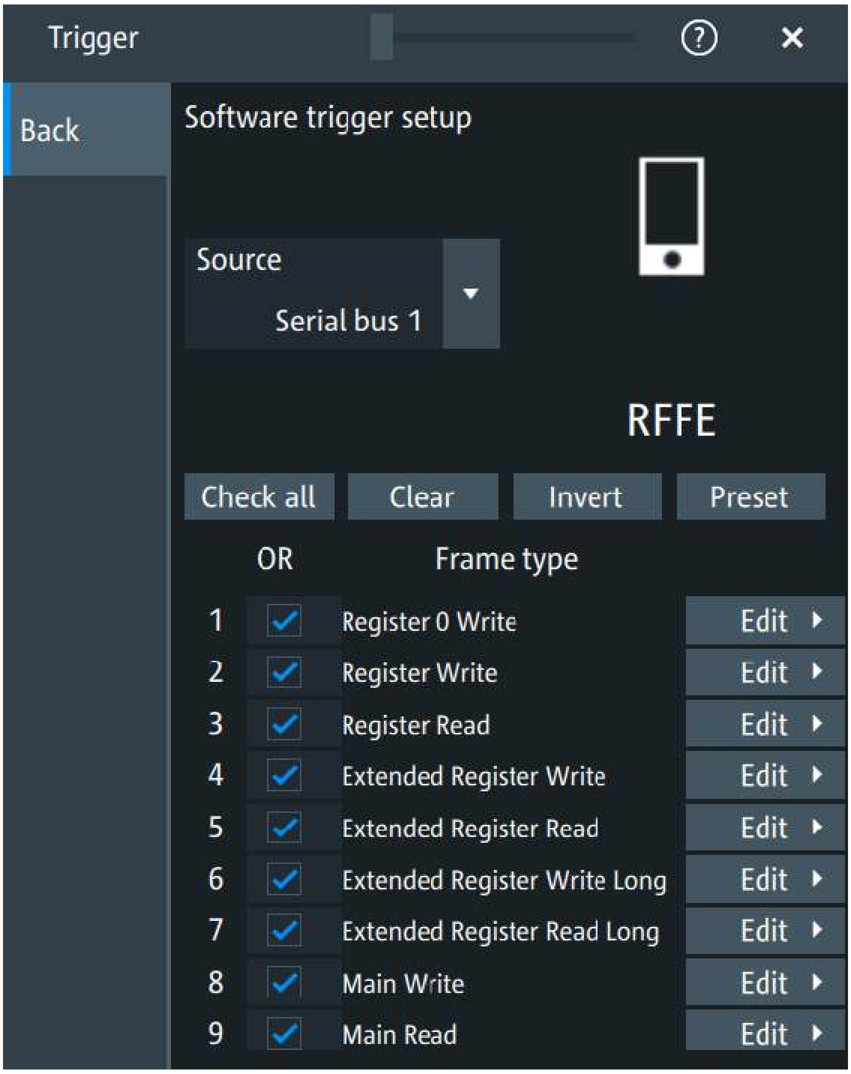
14.16.4 RFFE software trigger

14.16.4.1 Setup A trigger

Before setting up the software trigger for the protocols, a trigger A event needs to be set up.

14.16.4.2 Software trigger settings

Access: "Menu" > "Apps" > "Protocol" tab > "RFFE" > "Trigger" tab > "Setup Software Trigger" > "Setup SB Trigger"



In the "Software Trigger" tab, you can define the settings to trigger on the frames that match the selected filter conditions.

Check all, Clear, Invert, Preset

The following settings help you select the frames and errors you want to trigger on.

"Check all"	Enables the software trigger for all available frames and error types.
"Clear"	Disables the software trigger for all available frames and error types.
"Invert"	Inverts the current state of the frame and error types for the software trigger: all frames and error types that were enabled are disabled and vice versa.
"Preset"	Presets the state of the selected frames and error types for the software trigger.

Remote command:

`TRIGger:SBSW:RFFE:CHKall` on page 1543

`TRIGger:SBSW:RFFE:CLR` on page 1543

`TRIGger:SBSW:RFFE:INVert` on page 1543
`TRIGger:SBSW:RFFE:RST` on page 1544

Frame type

Selects the frame type that you want to trigger on. You can trigger on all enabled frame types simultaneously.

For each frame type, you can also specify conditions for the value of the fields in the "Edit" dialog.

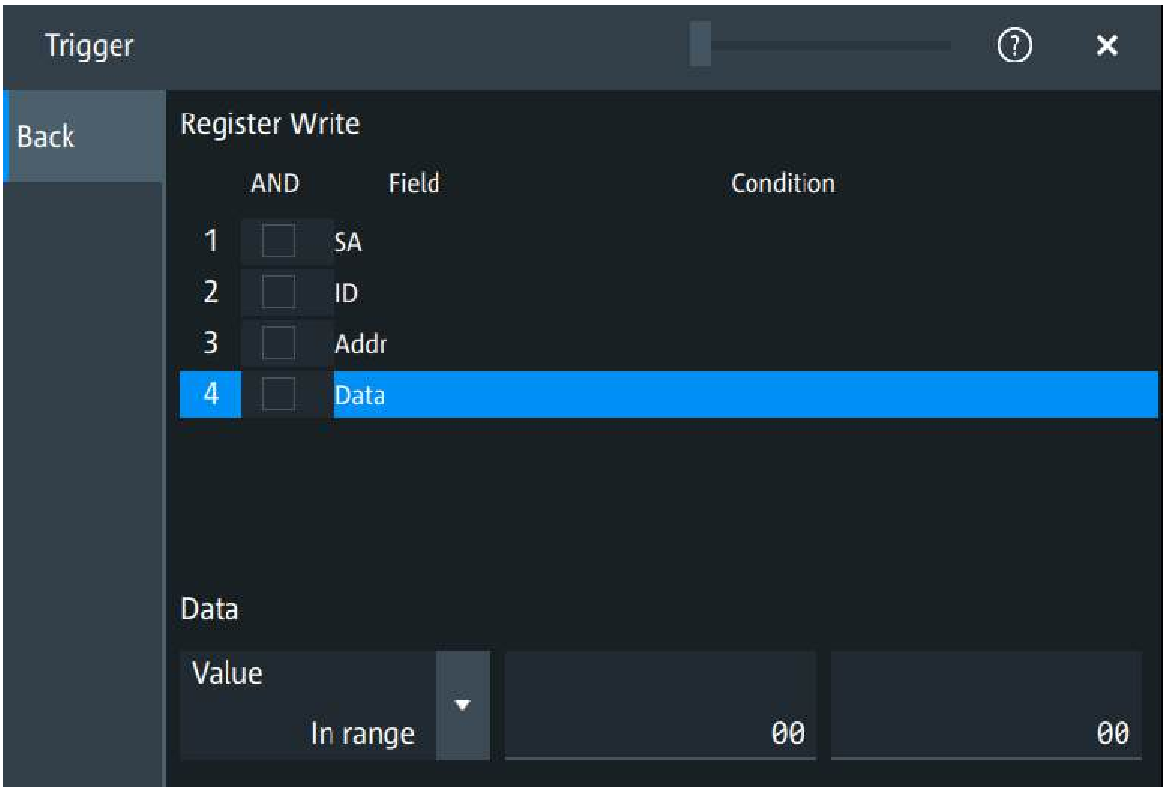
The following frames are available: : "Register 0 Write", "Register Write", "Register Read", "Extended Register Write", "Extended Register Read", "Extended Register Write Long", "Extended Register Read Long", "Main Write", "Main Read".

Remote command:

`TRIGger:SBSW:RFFE:FRENable` on page 1544
`TRIGger:SBSW:RFFE:FRAMe<fr>:ENABle` on page 1544

Edit

Some trigger types have additional settings that can be defined. In this case, the "Set details" button appears next to "Type" the function. Open it for a detailed definition of the trigger conditions.



"Field"
: Enables the field type that you want to trigger on for the selected frame.
The available fields are: "SA", "ID", "Data", "Addr", "BC", "MID", "Data MSB", "Data LSB".

Remote command:
`TRIGger:SBSW:RFFE:FIENable` on page 1546
`TRIGger:SBSW:RFFE:FRAMe<fr>:FLD<fl>:ENABle` on page 1546

"Condition"
: Displays the value condition for the selected field.

Remote command:
`TRIGger:SBSW:RFFE:BIT` on page 1544
`TRIGger:SBSW:RFFE:FRAMe<fr>:FLD<fl>:BIT` on page 1544

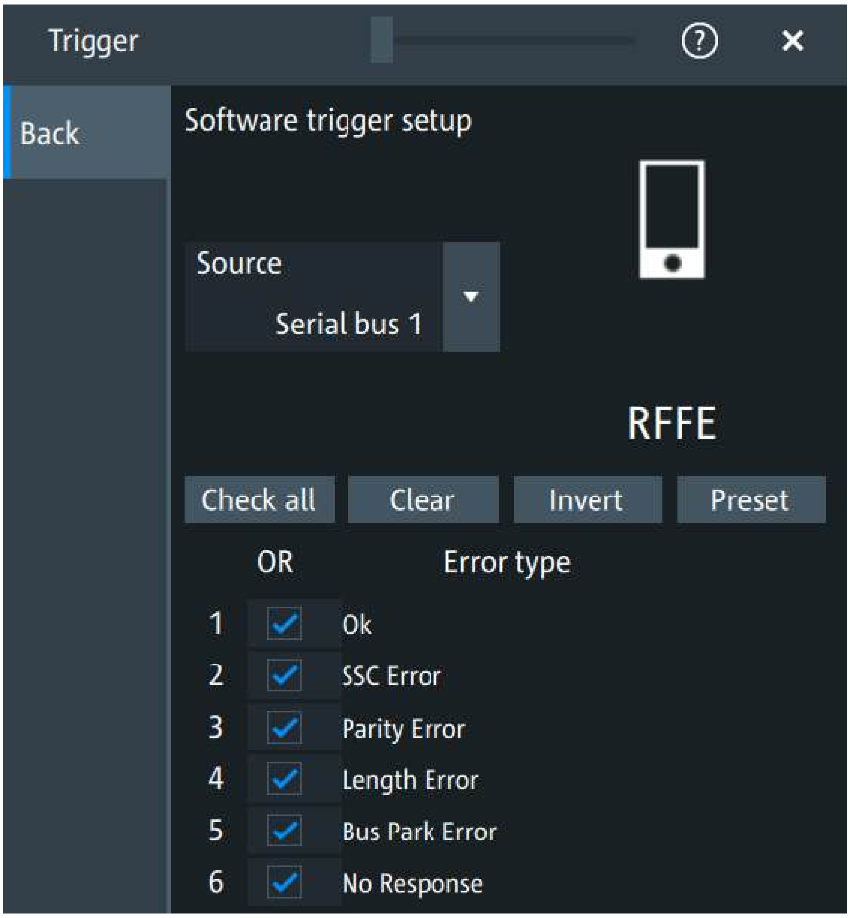
"Value"
: The data setup consists of a comparison condition and one or two data patterns.

Remote command:
`TRIGger:SBSW:RFFE:DMAX` on page 1545
`TRIGger:SBSW:RFFE:FRAMe<fr>:FLD<fl>:DMAX` on page 1545
`TRIGger:SBSW:RFFE:DMIN` on page 1545
`TRIGger:SBSW:RFFE:FRAMe<fr>:FLD<fl>:DMIN` on page 1545
`TRIGger:SBSW:RFFE:DOPerator` on page 1545
`TRIGger:SBSW:RFFE:FRAMe<fr>:FLD<fl>:DOPerator` on page 1545

"Index"
: The index setup consists of a comparison condition and one or two index values.

Remote command:
`TRIGger:SBSW:RFFE:IMAX` on page 1546
`TRIGger:SBSW:RFFE:FRAMe<fr>:FLD<fl>:IMAX` on page 1546
`TRIGger:SBSW:RFFE:IMIN` on page 1547
`TRIGger:SBSW:RFFE:FRAMe<fr>:FLD<fl>:IMIN` on page 1547
`TRIGger:SBSW:RFFE:IOPerator` on page 1547
`TRIGger:SBSW:RFFE:FRAMe<fr>:FLD<fl>:IOPerator` on page 1547

Error type
Enables triggering on the selected error type.



The following error types are available: "OK", "SSC Error", "Parity error", "Length error", "Bus park error", "No response".

Remote command:
`TRIGger:SBSW:RFFE:ERENable` on page 1547
`TRIGger:SBSW:RFFE:ERRor<m>:ENABle` on page 1547

14.16.5 Measure

The "Setup Measurement" button opens the dialog for automatic measurements in the "Protocol" category for the selected serial bus.

See Section 10.2.6.2, "Settings for protocol measurements", on page 289.

14.16.6 RFFE decode results

When the configuration of the serial bus is complete, the signal can be decoded:

1. Open the "Serial Bus" dialog for the respective bus.
2. In the "Setup" tab, enable "State".

3. In the "Display" tab, enable "Show decode table".

For a description of the display settings, see also Section 14.1.3.1, "Display settings", on page 435.

For a description of how to synchronize the displayed results, see Section 14.1.3.2, "Display synchronization", on page 437.

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

Decode results table

The "Decode results" table contains information about all decoded frames.

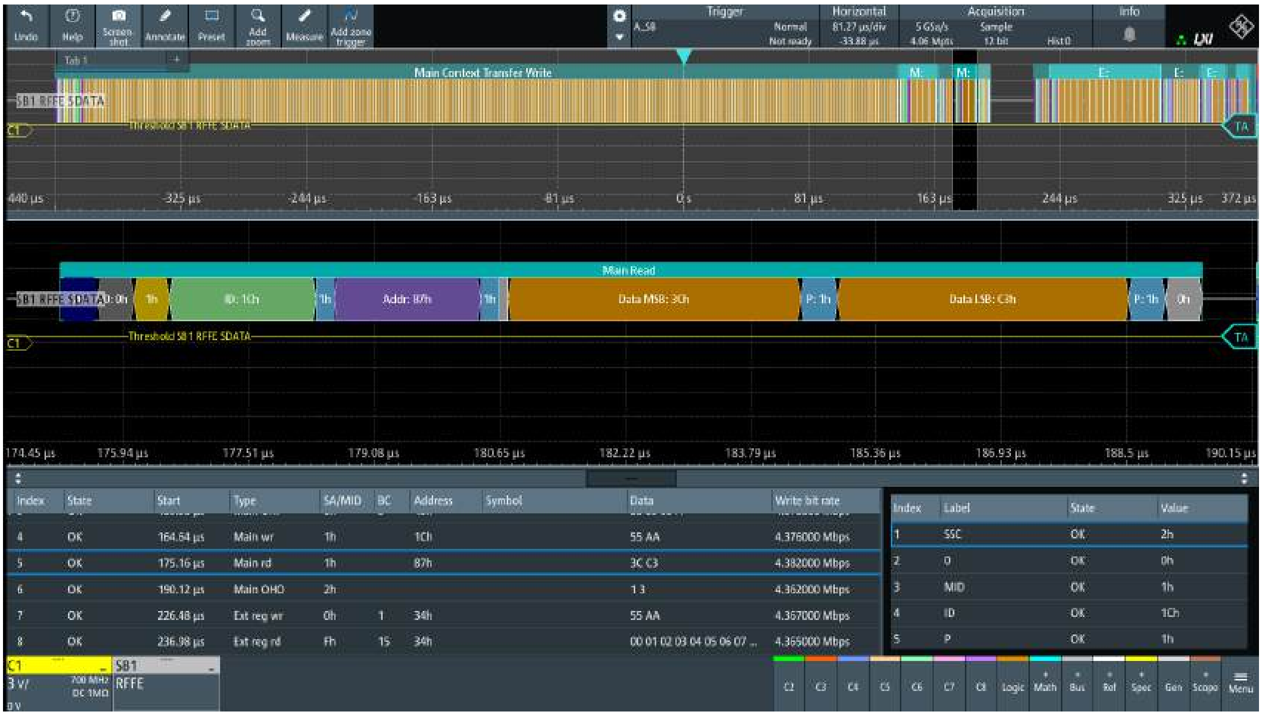


Figure 14-50: Decoded RFFE signal

The decode results table contains information about all decoded frames.

Table 14-28: Content of the decode results table

Column	Description
Index	Index of the decoded frame
State	Overall state of the frame
Start	Times of frame start
Type	The type of command

Column	Description
SA/MID	Address of the sub device
BC	Byte count
Address	Register address
Symbol	Symbolic label of the frame. Available only, if "Show symbols" is enabled in the "Display" tab and a symbols list is loaded.
Data	Values of the data bytes. Select the data format in the "Display" tab.
Write bit rate	Value of the write bit rate
Read bit rate	Value of the read bit rate

When you select a frame in the decode results table, its field content is shown in the details table to the right.

Table 14-29: Content of the frame details table

Column	Description
Index	Number of the decoded field
Label	Name of the field
State	State of the field
Data	Value of the field

Data format

You can select various data formats for the values displayed in the decode table and in the combs of the decoded signal.

Remote command:

- `SBUS<sb>:FORMat` on page 1154

Remote commands

Remote commands to retrieve decode results are described in Section 18.17.17.4, "Decode results", on page 1548.

14.16.7 Performing RFFE decoding

This section explains step by step how to configure and decode the RFFE bus.

14.16.7.1 Configuring RFFE signals

For configuration, assign the lines to the input channels, and define the active states and the logical thresholds.

For details on configuration settings, see Section 14.16.2, "RFFE configuration", on page 714.

1. Tap the "+ Bus" activator in the bottom right of the screen.

2. Select the tab of the bus that you want to set up, for example "SB1".
3. Tap the "Protocol type" button. Select the protocol: "RFFE".
4. Tap on "State" to enable the decoding.

   An SPI shortcut appears at the bottom left of the screen. Tap on the shortcut for a quick access to the "RFFE" dialog settings.

5. Tap on each active signal and select the correct channels: "SDATA" and "SCLK".
6. Set the polarity for each signal: "SDATA Polarity" and "SCLK Polarity".
7. Select the "Read mode"
8. Check that the signals are on the screen.
   If not try adjusting the vertical and horizontal settings.
9. Set the logical thresholds:
   a) Tap "Threshold setup". The threshold dialog opens.
   b) For each signal, set the threshold value. A typical value is 0.8 V.
   c) If necessary, set the hysteresis value for the signals.
   d) Optionally, tap on "Show threshold lines".

14.16.7.2 Exporting decode results

Once a decode has been completed, you can generate an export of all decode results.

Prerequisites: A bus is configured for the RFFE and decoded.

1. Tap on the "RFFE" shortcut.
2. Tap on the "Shortcuts" tab.
3. Tap "Export results".
4. If necessary, enable "Include details".
5. If necessary, enable "Include timing".
6. Select the "File type".

   An export file is saved in the selected directory.

The RFFE export files contain the following fields:

- A list of all decoded frames:
  - Index
  - Start
  - Stop
  - State
  - Type
  - SA/MID
  - BC
  - Address
  - Write bit-rate
  - Read bit-rate
- The details frame includes the following fields:
  - Index
  - Label
  - State
  - Value

Example of RFFE export file

```
Index,Start,Stop,State,Type,SA, BC,     Addr,    Write BR,     Read BR
1    -0.1000402     -0.0003965     OK     MSKW     5h     ---     2Eh     4376000     ---
2    -0.0003957     0.00013858     OK     MCTW     0h     255     3Ah     4375000     ---
3    0.00013938     0.00016396     OK     MCTR     0h     3       43h     4378000     2187000
4    0.00016464     0.00017436     OK     MWR      1h     ---     1Ch     4376000     ---
5    0.00017516     0.00018944     OK     MRD      1h     ---     87h     4382000     2190000
6    0.00019012     0.00019824     OK     MOHO     2h     ---     ---     4362000     2195000
7    0.00022648     0.00023618     OK     ERWR     0h     1       34h     4367000     ---
8    0.00023698     0.00030888     OK     ERRD     Fh     15      34h     4365000     2187000

Details frame 1
Index    Label    State    Value
1    'Mask'    'OK'    3Fh
2    'Data'    'OK'    15h

Details frame 3
Index    Label    State    Value
1    'Data: 1'    'OK'    55h
2    'Data: 2'    'OK'    83h
3    'Data: 3'    'OK'    00h
4    'Data: 4'    'OK'    FFh

Details frame 4
Index    Label    State    Value
1    'Data MSB'    'OK'    55h
2    'Data LSB'    'OK'    AAh
```

14.17 10BASE-T1S (automotive Ethernet, option R&S MXO4-K560)

10BASE-T1S technology provides a 10 Mbit/s, multidrop transmission over a single pair physical layer. It is defined in the IEEE standard 802.3cg-2019 specification.

Requirements

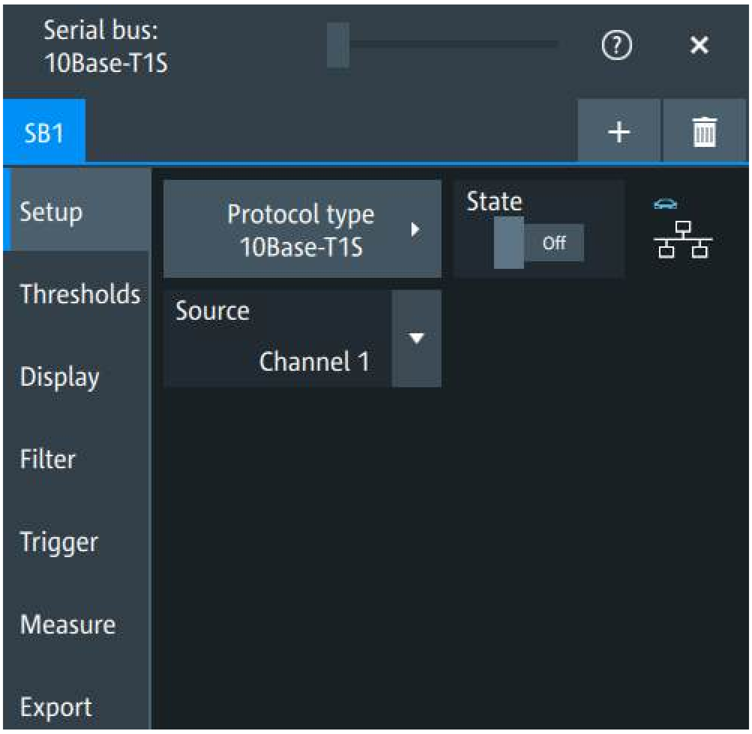
For performing 10BASE-T1S decode measurements, you need the following:

- MXO 4. One of the analog input channels is used for analysis.
- Option R&S MXO4-K560

14.17.1 10BASE-T1S configuration

14.17.1.1 10BASE-T1S configuration settings

Access: "Menu" > "Apps" > "Protocol" tab > "10BASE-T1S" > "Setup".



Make sure that the tab of the correct serial bus is selected.

Protocol type
Selects the protocol type to be decoded.

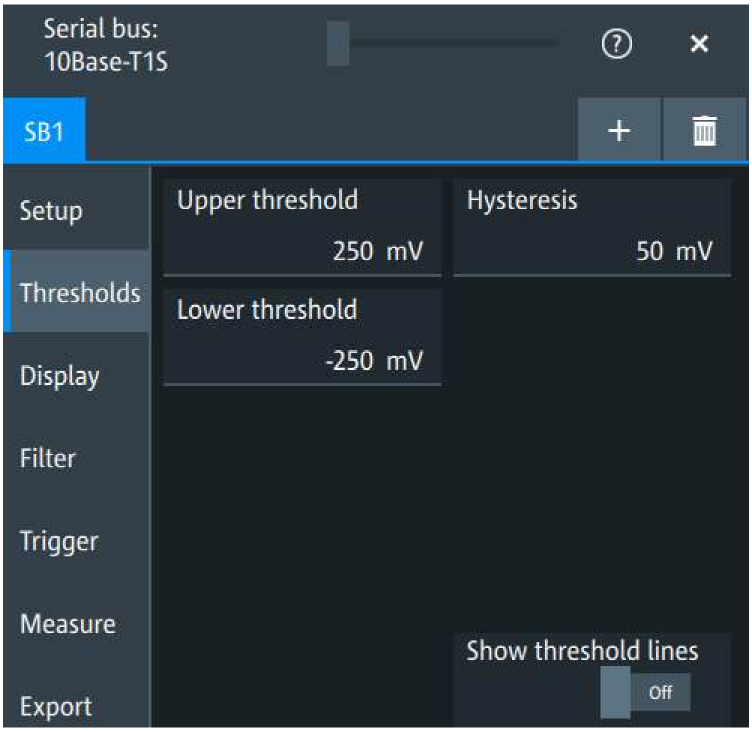
Remote command:
`SBUS<sb>:TYPE` on page 1153

Source
Selects the source channel for the 10BASE-T1S protocol. Only analog channels can be used.

Remote command:
`SBUS<sb>:TNOS:SOURce` on page 1557

14.17.1.2 Threshold settings

Access: "Menu" > "Apps" > "Protocol" tab > "10BASE-T1S" > "Thresholds".



Threshold
Sets the threshold for the data channel. Enter the value directly in the fields.

Additional to the threshold, you can also set a hysteresis.

Remote command:
`SBUS<sb>:TNOS:THReshold:LOWer` on page 1558
`SBUS<sb>:TNOS:THReshold:UPPer` on page 1558
`SBUS<sb>:TNOS:THReshold:HYSTeresis` on page 1558

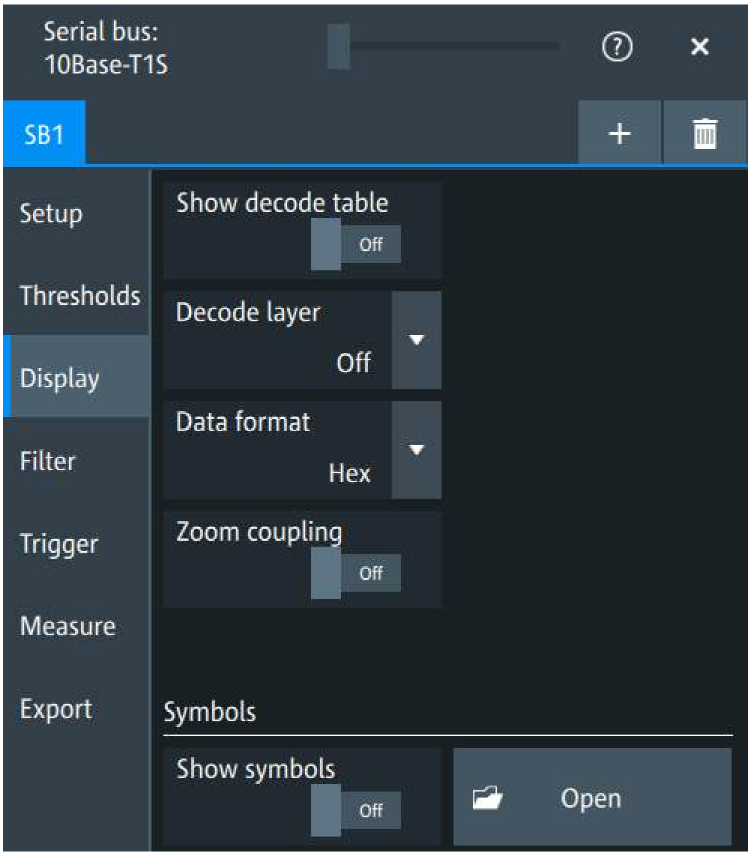
Show threshold lines
If enabled, the threshold lines are displayed in the diagram.

The label of the threshold line is set according to the signal that it is referring to, see also Show threshold lines.

Remote command:
`SBUS<sb>:THReshold` on page 1155

14.17.1.3 Display settings

For details about the display settings, see Section 14.1.3.1, "Display settings", on page 435.



Decode layer
Selects the decode layer.

Decoding is performed in several steps, and the results are presented in the decode table. The decode layer selects an interim step for which the decoding result is shown in the honeycomb display:

"Off"	Disables the display of the decode layer.
"Edges"	Enables the display of all edges.
"Bits"	Enables the display of the raw, encoded bits.
"Symbols"	Enables the display of the raw, encoded symbols.

"Descrambled bits"	Enables the display of the fully decoded and descrambled binary data, representing the original information being transmitted over the 10BASE-T1S link.

Data format

See "Data format" on page 436.

Zoom coupling

See "Zoom coupling" on page 437.

Show symbols

You can load symbol lists and activate their usage for decoding. As a result, an additional "Symbol" column appears in the "Decode results" table, containing the symbolic label.

For more details, see Section 14.17.1.4, "10BASE-T1S symbols", on page 733.

14.17.1.4 10BASE-T1S symbols

Symbol lists are protocol-specific.

A 10BASE-T1S symbol file contains two values for each Ethernet header:

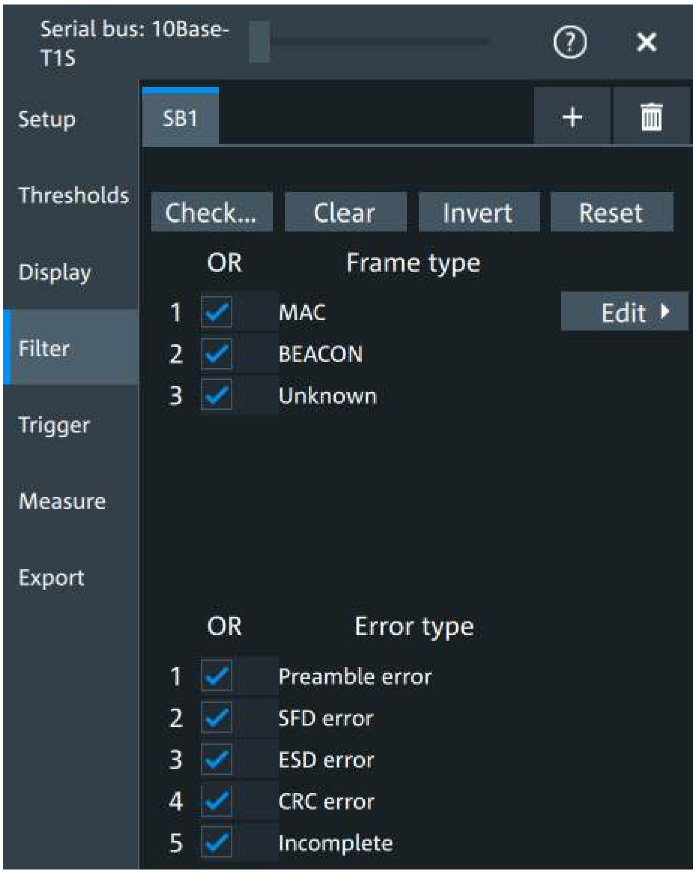
- Ethernet Header display
- Symbolic label: name of the address, specifying its function in the bus network.

```
#############################################################
# Supported MAC Address Format
# xx:xx:xx  standard 24 bit manufactory header
# xx:xx:xx:xx:xx:xx/yy  support other length headers
# yy should be the header length in decimal
# yy should be between 24 - 48
#############################################################
@PROTOCOL_NAME = ethernet
00:00:0C     Cisco
0:01:13     Olympus
0:01:14     KandaTsu
0:04:07     TopconPo
00:0B:64     KiebackP
00:1B:C5:06:C0:00/36     LuxconSy
00:1B:C5:06:D0:00/36     TesElect
00:1B:C5:06:E0:00/36     TwoDimen
00:1B:C5:06:F0:00/36     LlcEmzio
00:1F:BE     Shenzhen
00:21:8F     Avantgar
0.015625     GoliathS
0.015636574     D-Link
0.015648148     BaodingG
00:50:C2:5F:60:00/36     Cambridg
00:50:C2:5F:70:00/36     Metrolog
00:50:C2:5F:80:00/36     GrupoEpe
18:42:2F     AlcatelL
```

```
0.781273148     RiavaNet
18:46:17      SamsungE
18:8E:D5      TpVision
18:E7:F4      Apple
40:D8:55:1C:80:00/36      SensataT
40:D8:55:1C:90:00/36      Andy-L
40:D8:55:1C:A0:00/36      RigelEng
40:D8:55:1C:B0:00/36      MgSRL
40:D8:55:1C:D0:00/36      YxlonInt
40:D8:55:1C:E0:00/36      PeterHub
40:D8:55:1C:F0:00/36      OmnikNew
40:D8:55:1D:00:00/36      WebeasyB
FC:F8:B7      TronteqE
FC:FA:F7      Shanghai
FC:FE:77      HitachiR
FF:FF:FF:FF:FF:FF/48      BroadCast
```

14.17.2 10BASE-T1S filter

Access: "Menu" > "Apps" > "Protocol" tab > "10BASE-T1S" > "Filter" tab



In the "Filter" tab, you can define the settings to display only the frames that match the selected filter conditions.

Check all, Clear, Invert, Preset

The following settings help you select the frames and errors you want to filter for. Only the frames and error types that match the selected filter conditions are displayed.

"Check all"	Enables the filter for all available frames and error types.
"Clear"	Disables the filter for all available frames and error types.
"Invert"	Inverts the current state of the frame and error types: all frames and error types that were enabled are disabled and vice versa.
"Preset"	Presets the state of the selected frames and error types.

Remote command:

`SBUS<sb>:TNOS:FILTer:CHKall` on page 1559
`SBUS<sb>:TNOS:FILTer:CLR` on page 1560
`SBUS<sb>:TNOS:FILTer:INVert` on page 1560
`SBUS<sb>:TNOS:FILTer:RST` on page 1560

Frame type

Selects the frame type that you want to display. You can filter all enabled frame types simultaneously.

For selected frame types, you can also specify conditions for the value of the fields in the "Edit" dialog.

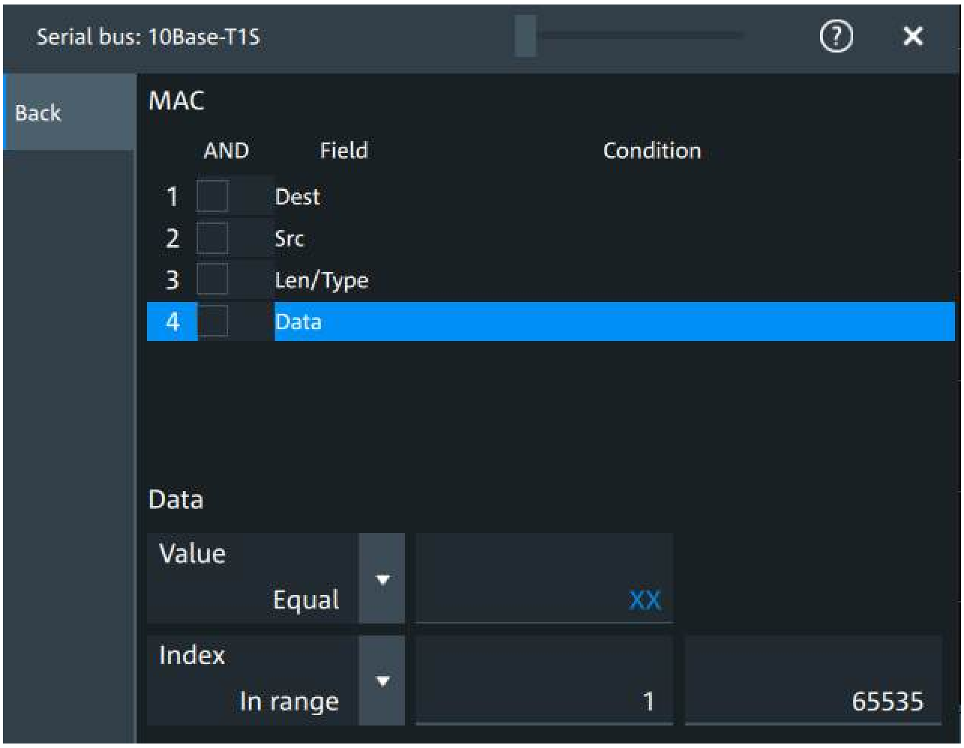
Available frames are "MAC", "BEACON" and "Unknown".

Remote command:

`SBUS<sb>:TNOS:FILTer:FRENable` on page 1564
`SBUS<sb>:TNOS:FILTer:FRAMe<fr>:ENABle` on page 1564

Edit

Opens a dialog to define the details of the selected frame.



"Field" Enables the field type that you want to filter on for the selected frame. The available fields are "Dest", "Src", "Len/Type" and "Data".

Remote command:
SBUS<sb>:TNOS:FILTer:FIENable on page 1562
SBUS<sb>:TNOS:FILTer:FRAMe<fr>:FLD<fl>:ENABle on page 1562

"Condition" Displays the value condition for the selected field.

Remote command:
SBUS<sb>:TNOS:FILTer:BIT on page 1560
SBUS<sb>:TNOS:FILTer:FRAMe<fr>:FLD<fl>:BIT on page 1560

"Value" The data setup consists of a comparison condition and one or two data patterns.

Remote command:
SBUS<sb>:TNOS:FILTer:DMAX on page 1561
SBUS<sb>:TNOS:FILTer:FRAMe<fr>:FLD<fl>:DMAX on page 1561
SBUS<sb>:TNOS:FILTer:DMIN on page 1561
SBUS<sb>:TNOS:FILTer:FRAMe<fr>:FLD<fl>:DMIN on page 1561
SBUS<sb>:TNOS:FILTer:DOPerator on page 1562
SBUS<sb>:TNOS:FILTer:FRAMe<fr>:FLD<fl>:DOPerator on page 1562

"Index" The index setup consists of a comparison condition and one or two index values.

Remote command:
SBUS<sb>:TNOS:FILTer:IMAX on page 1563
SBUS<sb>:TNOS:FILTer:FRAMe<fr>:FLD<fl>:IMAX on page 1563
SBUS<sb>:TNOS:FILTer:IMIN on page 1563
SBUS<sb>:TNOS:FILTer:FRAMe<fr>:FLD<fl>:IMIN on page 1563
SBUS<sb>:TNOS:FILTer:IOPerator on page 1564
SBUS<sb>:TNOS:FILTer:FRAMe<fr>:FLD<fl>:IOPerator on page 1564

Error type
Enables filtering on the selected error type.

Remote command:
SBUS<sb>:TNOS:FILTer:ERENable on page 1562
SBUS<sb>:TNOS:FILTer:ERRor<n>:ENABle on page 1562

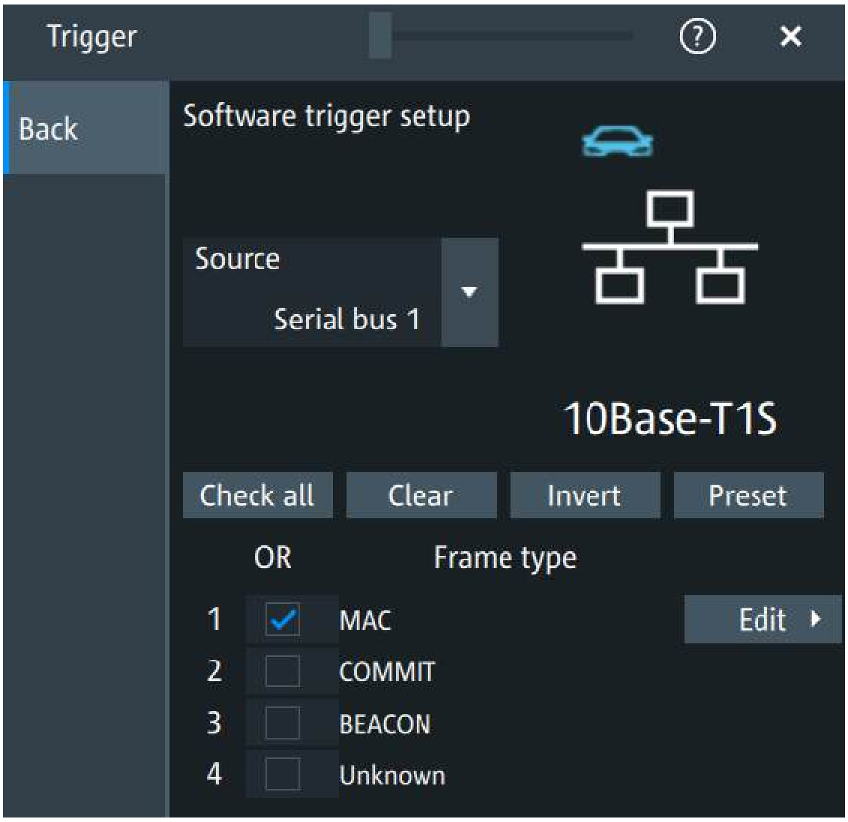
14.17.3 10BASE-T1S software trigger

14.17.3.1 Setup A trigger

Before setting up the software trigger for the protocols, a trigger A event needs to be set up.

14.17.3.2 Software trigger settings

Access: "Menu" > "Apps" > "Protocol" tab > "10BASE-T1S" > "Trigger" tab > "Setup Software Trigger"



In the "Software Trigger" tab, you can define the settings to trigger on the frames that match the selected filter conditions.

Check all, Clear, Invert, Preset

The following settings help you select the frames and errors you want to trigger on.

"Check all"	Enables the software trigger for all available frames and error types.
"Clear"	Disables the software trigger for all available frames and error types.
"Invert"	Inverts the current state of the frame and error types for the software trigger: all frames and error types that were enabled are disabled and vice versa.
"Preset"	Presets the state of the selected frames and error types for the software trigger.

Remote command:
`TRIGger:SBSW:TNOS:CHKall` on page 1565
`TRIGger:SBSW:TNOS:CLR` on page 1565
`TRIGger:SBSW:TNOS:INVert` on page 1565
`TRIGger:SBSW:TNOS:RST` on page 1566

Frame type

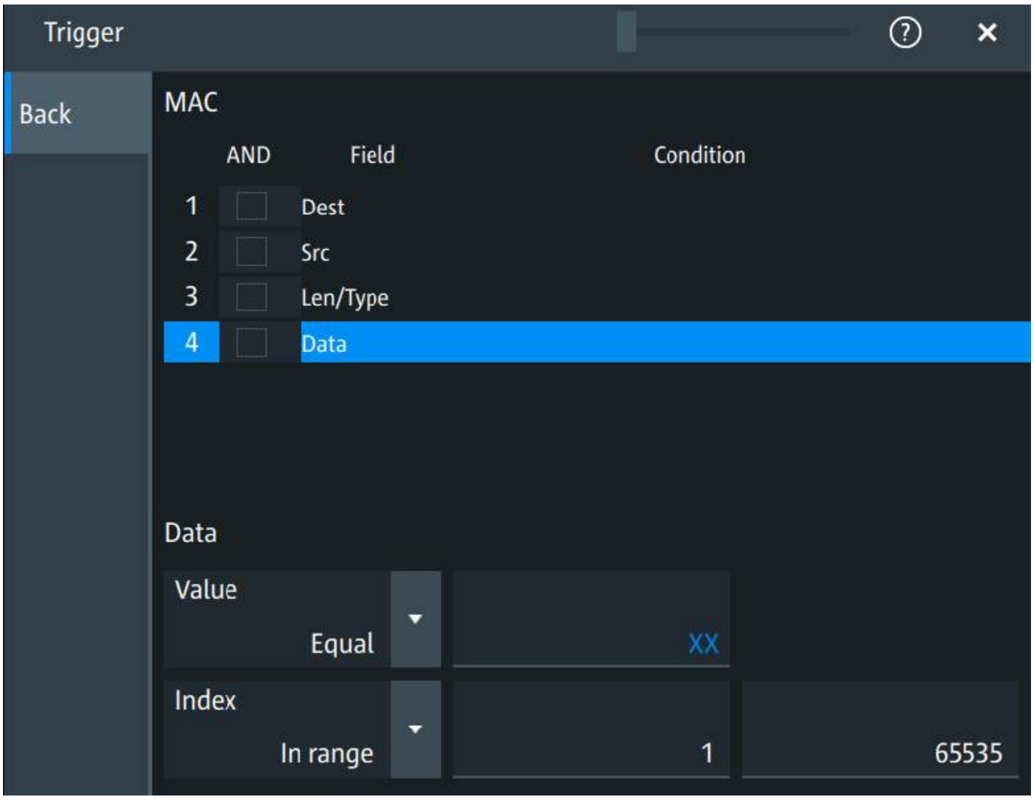
Selects the frame type that you want to trigger on. You can trigger on all enabled frame types simultaneously.

For each frame type, you can also specify conditions for the value of the fields in the "Edit" dialog.

The following frames are available: "MAC", "COMMIT", "BEACON", "Unknown".

Remote command:
`TRIGger:SBSW:TNOS:FRENable` on page 1566
`TRIGger:SBSW:TNOS:FRAMe<fr>:ENABle` on page 1566

Edit
Some trigger types have additional settings that can be defined. In this case, the "Set details" button appears next to "Type" the function. Open it for a detailed definition of the trigger conditions.



"Field" Enables the field type that you want to trigger on for the selected frame.
The following fields are available: "Dest", "Src", "Len/Type", "Data".

Remote command:
`TRIGger:SBSW:TNOS:FIENable` on page 1568
`TRIGger:SBSW:TNOS:FRAMe<fr>:FLD<fl>:ENABle` on page 1568

"Condition" Displays the value condition for the selected field.

Remote command:
`TRIGger:SBSW:TNOS:BIT` on page 1566
`TRIGger:SBSW:TNOS:FRAMe<fr>:FLD<fl>:BIT` on page 1566

"Value" The data setup consists of a comparison condition and one or two data patterns.

Remote command:
TRIGger:SBSW:TNOS:DMAX on page 1567
TRIGger:SBSW:TNOS:FRAMe<fr>:FLD<fl>:DMAX on page 1567
TRIGger:SBSW:TNOS:DMIN on page 1567
TRIGger:SBSW:TNOS:FRAMe<fr>:FLD<fl>:DMIN on page 1567
TRIGger:SBSW:TNOS:DOPerator on page 1567
TRIGger:SBSW:TNOS:FRAMe<fr>:FLD<fl>:DOPerator on page 1567

"Index" The index setup consists of a comparison condition and one or two index values.

Remote command:
TRIGger:SBSW:TNOS:IMAX on page 1568
TRIGger:SBSW:TNOS:FRAMe<fr>:FLD<fl>:IMAX on page 1568
TRIGger:SBSW:TNOS:IMIN on page 1569
TRIGger:SBSW:TNOS:FRAMe<fr>:FLD<fl>:IMIN on page 1569
TRIGger:SBSW:TNOS:IOPerator on page 1569
TRIGger:SBSW:TNOS:FRAMe<fr>:FLD<fl>:IOPerator on page 1569

Error type
Enables triggering on the selected error type.

The following error types are available: "Preamble error", "SFD error", "ESD error", "CRC error".

Remote command:
TRIGger:SBSW:TNOS:ERENable on page 1569
TRIGger:SBSW:TNOS:ERRor<m>:ENABle on page 1569

14.17.4 Measure

The "Setup Measurement" button opens the dialog for automatic measurements in the "Protocol" category for the selected serial bus.

See Section 10.2.6.2, "Settings for protocol measurements", on page 289.

14.17.5 10BASE-T1S decode results

When the configuration of the serial bus is complete, the signal can be decoded:

1. Open the "Serial Bus" dialog for the respective bus.
2. In the "Setup" tab, enable "State".
3. In the "Display" tab, enable "Show decode table".

For a description of the display settings, see also Section 14.1.3.1, "Display settings", on page 435.

For a description of how to synchronize the displayed results, see Section 14.1.3.2, "Display synchronization", on page 437.

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

Decode results table

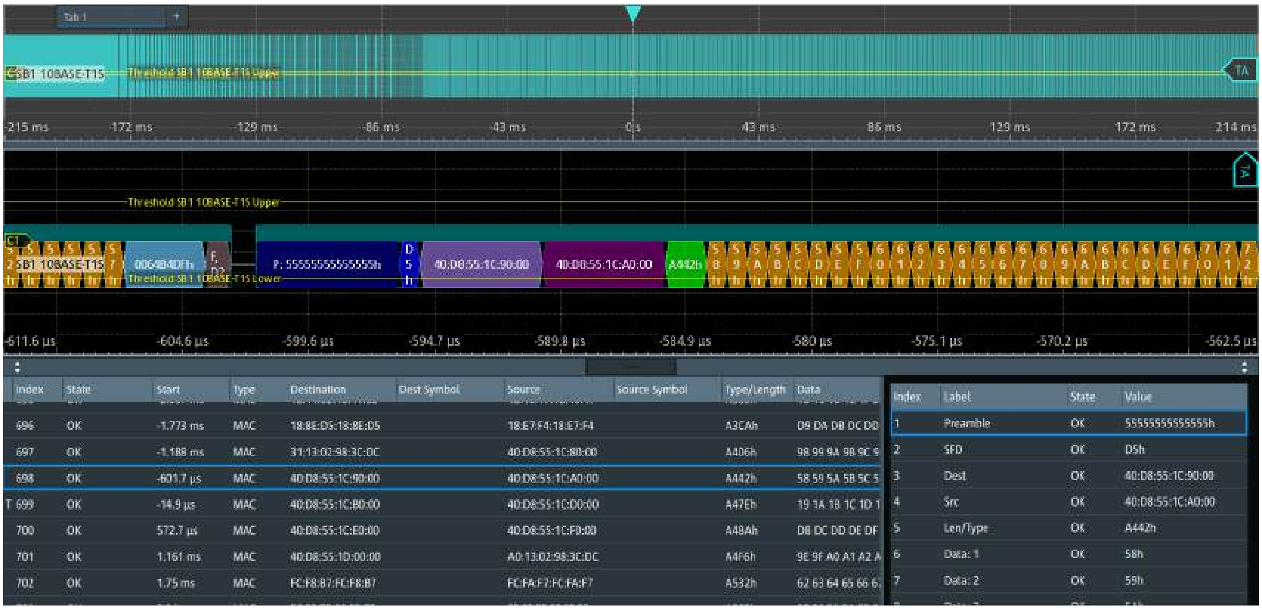


Figure 14-51: Decoded 10BASE-T1S signal

The decode results table contains information about all decoded frames.

Table 14-30: Content of the decode results table

Column	Description
Index	Frame count
State	Overall state of the frame: either OK or the relevant error condition (preamble, CRC or SFD)
Start	Start time of the frame
Type	Type of frame (e.g. Idle, MAC or data)
Destination	Destination address of the frame
Dest Symbol	Symbolic name of the destination defined in the symbol list. Available only, if "Show symbols" is enabled in the "Display" tab and a symbols list is loaded.
Source	Source address of the frame

Column	Description
Source Symbol	Symbolic name of the source defined in the symbol list. Available only, if "Show symbols" is enabled in the "Display" tab and a symbols list is loaded.
Type/Length	The sub-protocol (e.g. HTML, video, etc.) determines what meaning this field has. Since the content of this data area is not decoded, the interpretation of this field is ambivalent. It could either be the word type (specific for the sub-protocol) or the word length.
Data	Value of the data. Select the data format in the "Display" tab.
Bit rate	Value of the bit rate

When you select a frame in the decode results table, its field content is shown in the details table to the right.

Table 14-31: Content of the frame details table

Column	Description
Index	Index of the decoded field
Label	Name of the field
State	State of the field (OK / not OK)
Value	Value of the field

Data format

You can select various data formats for the values displayed in the decode table and in the combs of the decoded signal.

Remote command:

- `SBUS<sb>:FORMat` on page 1154

Remote commands

Remote commands to retrieve decode results are described in Section 18.17.18.4, "Decode results", on page 1570.

14.17.6 Performing 10BASE-T1S decoding

This section explains step by step how to configure and decode the 10BASE-T1S bus.

14.17.6.1 Configuring 10BASE-T1S signals

For configuration, assign the lines to the input channels, and define the active states and the logical thresholds.

For details on configuration settings, see Section 14.17.1, "10BASE-T1S configuration", on page 730.

1. Tap the "+ Bus" activator in the bottom right of the screen.

2. Select the tab of the bus that you want to set up, for example "SB1".
3. Tap the "Protocol type" button. Select the protocol: "10BASE-T1S".
4. Tap "State" to enable decoding.

   A 10BASE-T1S shortcut appears at the bottom left of the screen. Tap the shortcut for a quick access to the "10BASE-T1S" dialog settings.

14.17.6.2 Exporting decode results

Once a decode has been completed, you can generate an export of all decode results.

Prerequisites: A bus is configured for the 10BASE-T1S and decoded.

1. Tap on the "10BASE-T1S" shortcut.
2. Tap on the "Export" tab.
3. If necessary, enable "Include details".
4. If necessary, enable "Include timing".
5. Select the "File type".

   An export file is saved in the selected directory.

The 10BASE-T1S export file contains the following fields:

- A list of all decoded frames:
  – Index
  – Start
  – Stop
  – State
  – Type
  – Destination
  – Dest Symbol (optional)
  – Source
  – Source Symbol (optional)
  – Type/Len
  – CRC
  – Bit rate

- The details frame includes the following fields:
  - Index
  - State
  - Value

Example 10BASE-T1S export file

```
Index,Start,Stop,State,Type,Destination,Dest Symbol,Source,Source Symbol,
  Type/Len,CRC,Bit rate
1,-0.214999,-0.214971,'OK','MAC','00:00:0C:12:14:65',,'00:01:13:AB:C1:9C',
  ,00E6h,00002507h,12500000
2,-0.21497,-0.214941,'EPRM','MAC','00:01:14:06:C0:00',,'00:04:07:C6:C0:00',
  ,0122h,00004A04h,12500000
3,-0.21494,-0.21491,'ESFD','MAC','00:13:02:98:3C:CC',,'00:0B:64:06:C0:12',
  ,015Eh,00006F01h,12500000
4,-0.214909,-0.214878,'EESD','MAC','00:1B:C5:06:C0:00',,'00:1B:C5:06:D0:00',
  ,019Ah,000093FEh,12500000
5,-0.214877,-0.214846,'ECRC','MAC','00:1B:C5:06:E0:00',,'00:1B:C5:06:F0:00',
  ,01D6h,0000B8FBh,12500000

Details frame 1
Index,State,Value
1,'OK',14h
2,'OK',15h
3,'OK',16h
4,'OK',17h
5,'OK',18h
6,'OK',19h
7,'OK',1Ah
8,'OK',1Bh

Details frame 2
Index,State,Value
1,'OK',1Ch
2,'OK',1Dh
3,'OK',1Eh
4,'OK',1Fh
5,'OK',20h
6,'OK',21h
7,'OK',22h
8,'OK',23h
9,'OK',24h
```

15 Mixed signal option (MSO, R&S MXO4-B1)

The Mixed Signal Option R&S MXO4-B1 adds logic analyzer functions to the classical oscilloscope functions. Using the MSO option, you can analyze and debug embedded systems with mixed-signal designs that use analog signals and correlated digital signals simultaneously.

The Mixed Signal Option provides 16 digital channels grouped in two logic probes (pods) with 8 channels each. The instrument ensures that analog and digital waveforms are time-aligned and synchronized so that critical timing interactions between analog and digital signals can be displayed and tested. The automatic alignment compensates the skew between the probe connectors of the analog channels and the probe boxes of the digital channels.

15.1 Logic configuration

Access: "Menu" > "Logic" > "Setup" tab

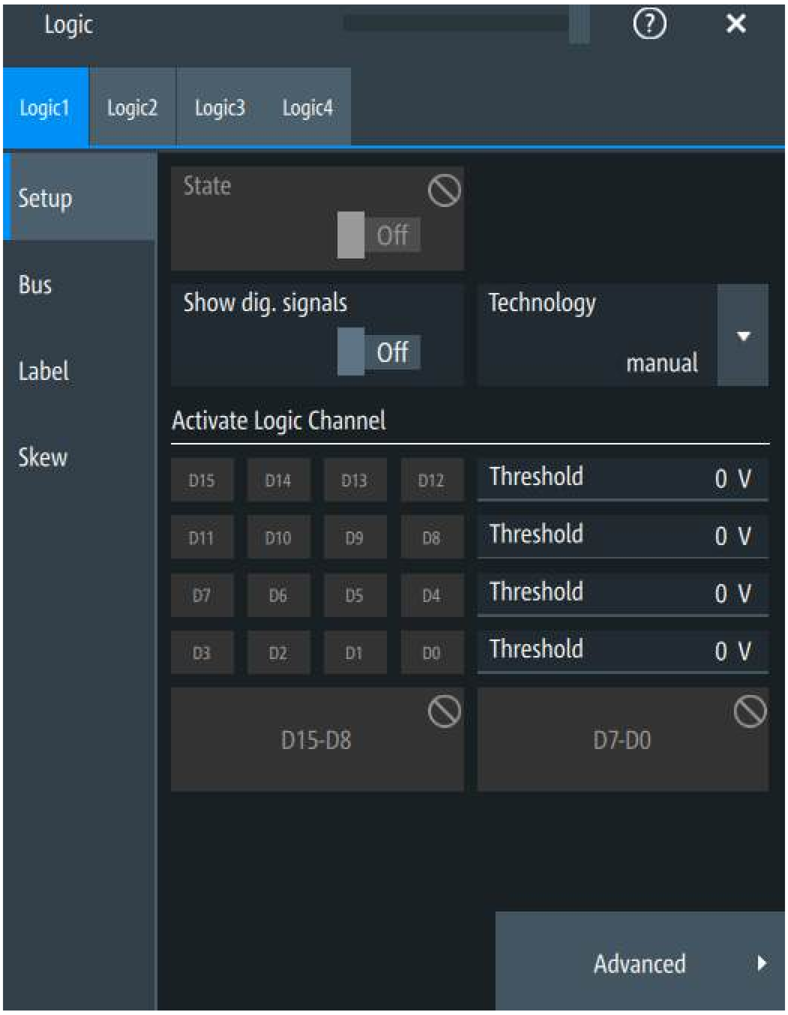
You can display digital channels individually, and you can group them and display as a logic group. 4 logic groups are available. Each digital channel can be assigned to one *active* logic only, and the instrument disables conflicting buses automatically.

For clocked buses, you can display the decoded data in a result box.

If you have configured several logic groups and you want to modify the settings, make sure that the tab of the correct logic is selected. Disable the logic before you change the settings.

15.1.1 Setup

Access: "Menu" > "Logic" > "Setup" tab



State

Enables the selected logic group. The corresponding signal icon appears on the signal bar.

If another active bus already uses the same digital channel, the instrument disables the other bus and shows a message.

Remote command:

`PBUS<pb>:STATe` on page 1589

Show dig. signals

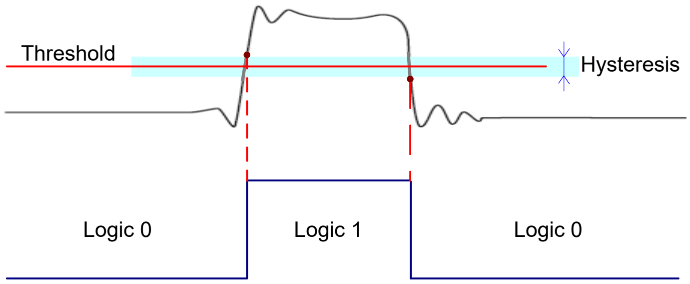
If enabled, the selected digital channels are shown in the diagram. Each channel is displayed as a logic signal.

Remote command:

`PBUS<pb>:DISPlay:SHDI` on page 1587

Technology, Threshold
Sets the logical threshold. For each sample, the instrument compares the input voltage with the threshold value. If the input voltage is above the threshold, the signal state "1" is stored. Otherwise, the signal state "0" is stored if the input voltage is below the threshold.

To avoid the change of signal states due to noise, a hysteresis is considered.



By default, the same threshold and hysteresis value are used for all digital channels and all logic buses: "Couple thresholds" is enabled.

You can also set different thresholds for the individual channel groups. As long as the buses are disabled, you can set different thresholds for each bus. Active buses use the same threshold and hysteresis values, the settings of the last activated bus take effect.

The range of threshold levels and the minimum voltage swing is given in the specifications document.

"Threshold" Enter the value directly in the field.

"Technology" Selects the threshold voltage for various types of integrated circuits from a list and applies it to all digital channels. The value is set to "Manual" if a user-defined threshold was entered directly.

Remote command:
`PBUS<pb>:TECHnology` on page 1589
`PBUS<pb>:THReshold<n>` on page 1590

Advanced
Opens a dialog for advanced threshold and hysteresis settings. You can define them in addition to the "Threshold" and "Technology".

Level coupling ← Advanced
Sets the threshold and the hysteresis for all digital channels and all buses to the same value.

Remote command:
`PBUS<pb>:THCoupling` on page 1589

Hysteresis ← Advanced
Defines the size of the hysteresis for the respective channels.

"Normal" The instrument sets a small value suitable for the signal and its settings. Use this setting for clean signals.

"Maximum" The instrument sets the maximum value that is possible and useful for the signal and its settings. Use this setting for noisy signals.

"Robust" Sets different hysteresis values for falling and rising edges to avoid an undefined state of the trigger system. Use this setting for very noisy signals.

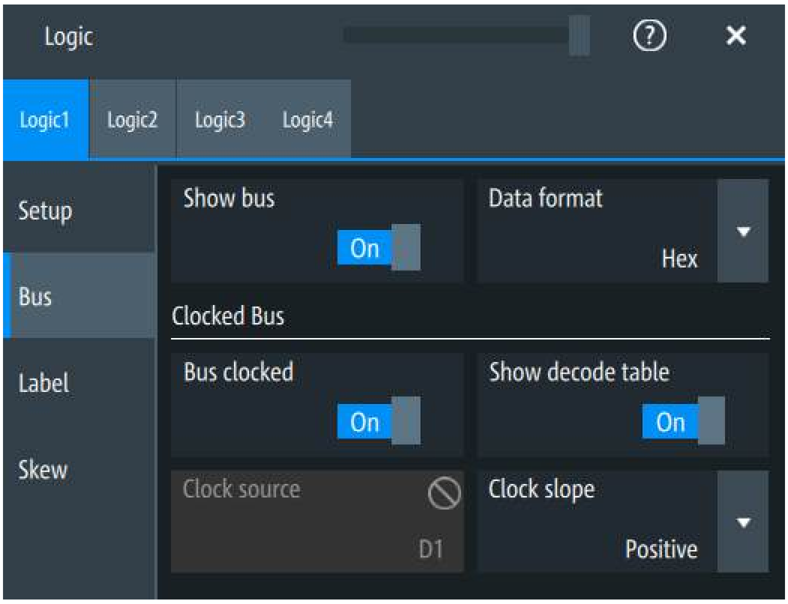
Remote command:
`PBUS<pb>:HYSTeresis<n>` on page 1587

Active logic channel
Selects the state of the respective bus channel.

Enable/Disable D7-D0,D15-D8
The buttons select or deselect all digital channels of a pod at once.

15.1.2 Bus

Access: "Menu" > "Logic" > "Bus" tab



Show bus
If enabled, the resulting bus signal and bus values are displayed in the diagram.

Remote command:
`PBUS<pb>:DISPlay:SHBU` on page 1586

Data format
Sets the data format of bus values, which are displayed in the decode table and on the comb bus display.

Available formats are: Hex, octal, binary, ASCII, string, signed, unsigned, symbolic, and auto.

Signed and Unsigned are integer data types with a maximum 16-bit length. Unsigned is used for positive integers. Signed is used for positive and negative integers.

If the target file format is BIN, you can save only signed and unsigned binary data. The data format "Signed" writes signed data; all other formats are saved as unsigned binary data.

Remote command:
PBUS<pb>:DATA:FORMat on page 1592
PBUS<pb>:DATA:HEADer? on page 1593
PBUS<pb>:DATA[:VALues]? on page 1593

Clocked bus
If a bus is a clocked bus, one of the digital channels serves as the clock of the bus.

For an unclocked bus, the logical state of the bus is determined for each sample. For a clocked bus, the logical state is determined only at the specified clock edges.

Bus clocked ← Clocked bus
Enable this option for a clocked bus.

Remote command:
PBUS<pb>:CLON on page 1584

Show decode table ← Clocked bus
If enabled, a result table is shown with decoded values and corresponding points in time of the bus signal. Each clock edge corresponds to one row in the table.

The decode table is only available for clocked buses to check the data words.

Remote command:
PBUS<pb>:DECTable:SHOW on page 1585
PBUS<pb>:DECTable:COUNt? on page 1585
PBUS<pb>:DECTable:DATA? on page 1586

Clock source ← Clocked bus
Selects the digital channel used as clock.

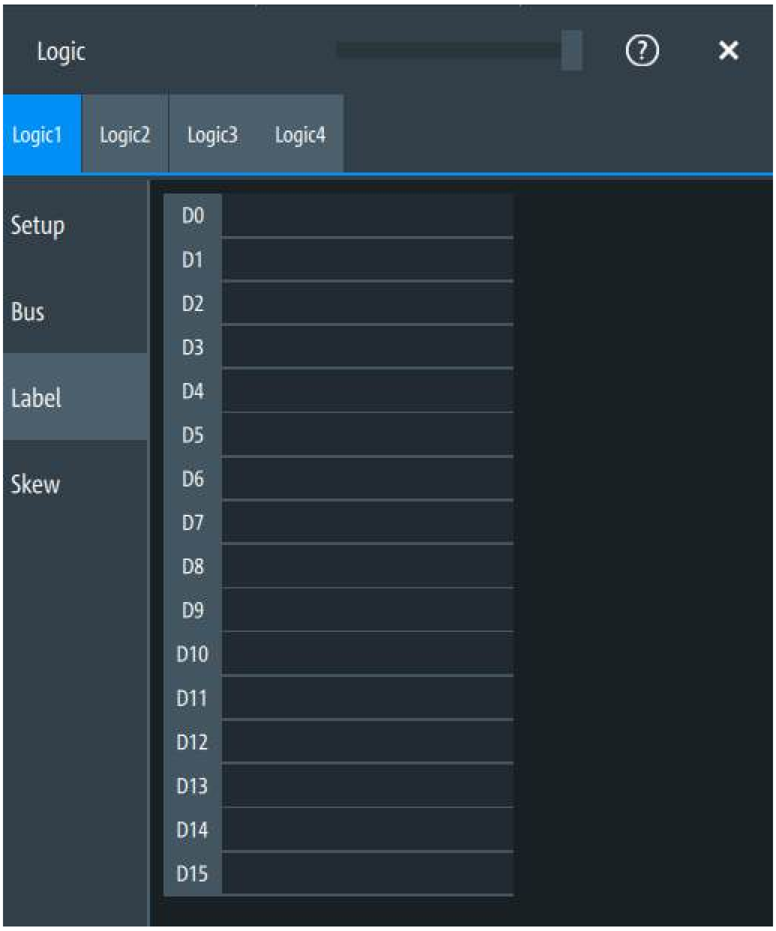
Remote command:
PBUS<pb>:CLOCk on page 1584

Clock slope ← Clocked bus
Selects the slope of the clock signal at which all digital channels of the bus are analyzed.

Remote command:
PBUS<pb>:CLSLope on page 1585

15.1.3 Label settings

Access: "Menu" > "Logic" > "Label" tab

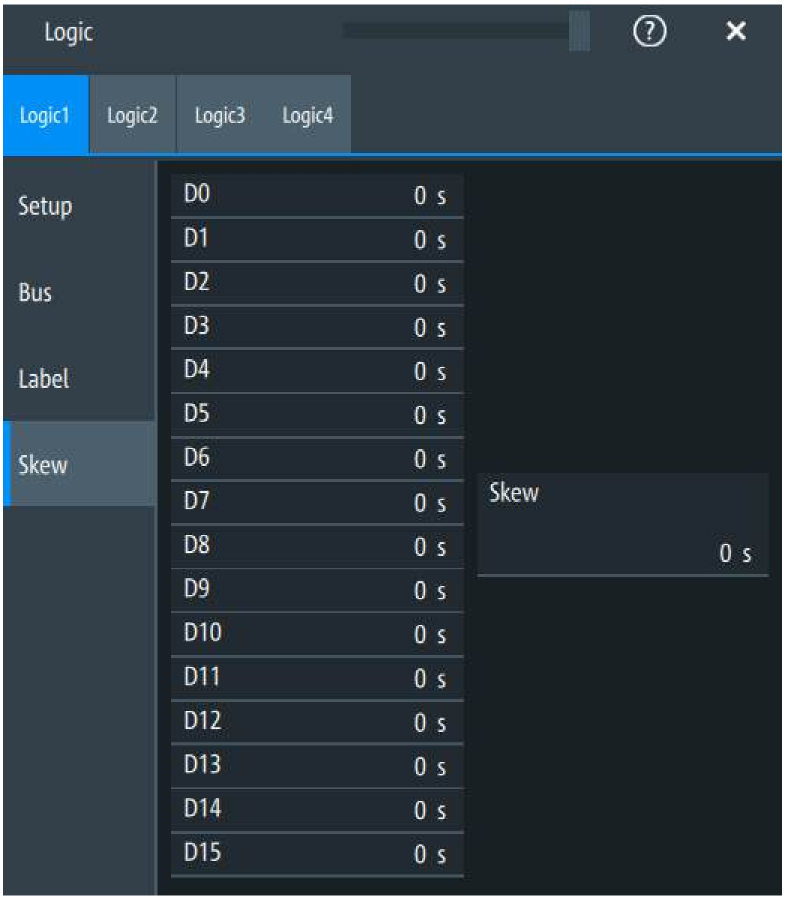


In this tab, you can enter a name for each digital channel. The name is displayed in the diagram.

`PBUS<pb>:BIT<n>:LABel` on page 1583

15.1.4 Skew settings

Access: "Menu" > "Logic" > "Skew" tab



D0-D15
Sets an individual delay for each digital channel to time-align it with other digital channels.

The skew value compensates delays that are known from the circuit specifics or caused by the different length of cables. The skew between the probe boxes of the digital channels and the probe connectors of the analog channels is automatically aligned by the instrument.

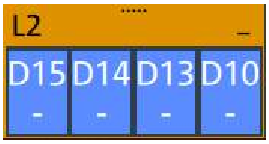
Remote command:
`PBUS<pb>:BIT<n>:SKEW` on page 1583

Skew
Sets a general delay for all digital channels.

Remote command:
`PBUS<pb>:SKEW` on page 1588

15.2 Display

Each logic group is shown in a separate diagram, and the diagrams can be minimized and arranged as usual.



You can adjust the display of the logic bus signals and the individual digital channels to optimize the analysis of bus data:

- Show the digital channels which are assigned to the bus, drag them to the optimal position, and scale them.
- Adjust size and position of the logic signal: Therefore, tap the Lx signal or the signal icon, and use the [Position] and [Scale] knobs.
- Adjust size and position of all active digital channels: Therefore, tap one of the Dx signals, and use the [Position] and [Scale] knobs.
- Show the result table of the decoded clocked bus signal.

Remote commands:

- `PBUS<pb>:DIGSignals:POSition` on page 1586
- `PBUS<pb>:DIGSignals:SCALe` on page 1586
- `PBUS<pb>:POSition` on page 1588
- `PBUS<pb>:SCALe` on page 1588

To access and analyze one or more specific acquisitions, you can use the "History" in the common way.

Furthermore, you can zoom in digital signals and bus signal in the same way as in analog waveforms.

15.2.1 Logic bus - decode table

Decoding is available for clocked buses.

The decode table shows the decoded data words of the bus signal and the corresponding time. Each clock edge corresponds to one row in the table. Beside the table, you can select the data format of the bus values.

The results can be saved to a `.csv` or `.html` file.

16 Waveform generator (option R&S MXO4-B6)

The MXO 4 includes a two-channel 100 MHz waveform generator. Each waveform generator can output simple functions, modulated sine waveform, arbitrary waveforms and sweep waveforms. It is possible to couple and synchronize the settings of the waveform generators.

The instrument preset does not affect the generator settings. Each generator has its own preset ("Default setup"). When the instrument is shut down, the waveform generator settings are stored. At the instrument start, these settings are restored but the generators are switched off. When a saveset of instrument settings is recalled, generators are also switched off but the generator settings remain unchanged.

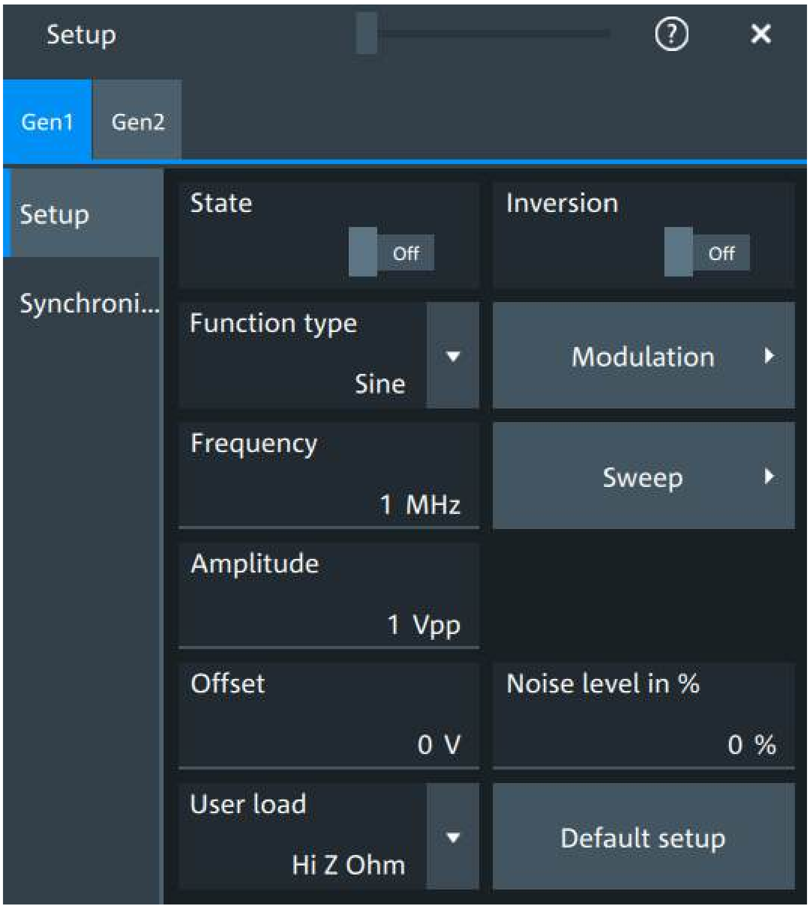
If you often switch on and off a generator, add a generator icon to the toolbar ("Gen1", "Gen2"). Tap the icon to switch on or off the generator.

16.1 Setup of the waveform generator

Access: "Gen" signal activator > "Gen"1 or "Gen"2 > "Setup" tab.

16.1.1 General settings

The "Setup" tab provides general settings like enabling the waveform generator, and setting that depend on the selected function type.



State
Enables the function generator.

If you often switch on and off a generator, use the generator icon on the toolbar ("Gen1", "Gen2").

Remote command:
`WGENerator<wg>[:ENABle]` on page 1600

Inversion
Inverts the waveform at the offset level.

Remote command:
`WGENerator<wg>:VOLTage:INVersion` on page 1598

Function type
Selects the type of waveform to be generated.

For all waveforms, you can set:

- Frequency
- Amplitude
- Offset
- Noise level in % or DC level
- User load

"Sine"	Generates a sine wave. Modulation settings and Sweep settings are available.
"Square"	Generates a square wave. You can set the Duty cycle. Modulation settings is available.
"Ramp"	Generates a ramp signal. You can set the Symmetry.
"DC"	Generates a direct current (DC) signal. You can set the DC level.
"Pulse"	Generates a pulse signal. Additional settings are the Period and the Pulse width. Modulation settings is available.
"Cardinal sine"	Generates a cardinal sine wave. No additional settings are needed.
"Cardiac"	Generates a cardiac signal. No additional settings are needed.
"Gauss"	Generates a Gaussian signal. No additional settings are needed.
"Lorentz"	Generates a Lorentz signal. No additional settings are needed.
"Haversine"	Generates a haversine function signal (great-circle distance between two points on a sphere). No additional settings are needed.
"Exp. rise"	Generates an exponential rise signal. No additional settings are needed.
"Exp. fall"	Generates an exponential fall signal. No additional settings are needed.
"Arbitrary"	Generates an arbitrary waveform, which is copied from an existing waveform, or loaded from a file. See Section 16.1.4, "Arbitrary waveforms", on page 761.

Remote command:
`WGENerator<wg>:FUNCtion[:SELect]` on page 1596

Frequency
Sets the frequency of the waveform.

The available frequency range depends on the selected "Function type", see Frequency range of the function generator waveforms.

Table 16-1: Frequency range of the function generator waveforms

"Function type"	Min frequency	Max frequency
"Sine"	0.001 Hz	100 MHz
"Square"	0.001 Hz	30 MHz
"Ramp"	0.001 Hz	1 MHz
"DC"	-	-
"Pulse"	0.001 Hz	30 MHz
"Cardinal sine"	0.001 Hz	5 MHz
"Cardiac"	0.001 Hz	1 MHz
"Gauss"	0.001 Hz	25 MHz
"Lorentz"	0.001 Hz	10 MHz

"Function type"	Min frequency	Max frequency
"Haversine"	0.001 Hz	100 MHz
"Exp.rise"	0.001 Hz	10 MHz
"Ep. fall"	0.001 Hz	10 MHz

Remote command:
WGENerator<wg>:FREQuency on page 1595

Amplitude
Sets the amplitude of the waveform.

Remote command:
WGENerator<wg>:VOLTage[:VPP] on page 1599

Offset
Sets the vertical offset of the generated waveform.

Remote command:
WGENerator<wg>:VOLTage:OFFSet on page 1599

Arbitrary Setup
Opens a menu to configure the arbitrary waveform.

See Section 16.1.4, "Arbitrary waveforms", on page 761.

Sweep
Opens a menu to configure the sweep.

See Section 16.1.3, "Sweep settings", on page 760.

Modulation
Opens a menu to configure the modulation.

See Section 16.1.2, "Modulation settings", on page 758.

Noise level in %
Sets the level of the noise in percentage of the set "Amplitude" output of the signal.

Remote command:
WGENerator<wg>:MODulation:NLPCent on page 1606

User load
Select the user load, the load of the DUT at its connection.

You can select either a "50Ω" or a "High-Z" (high input impedance) load.

Remote command:
WGENerator<wg>:OUTPut[:LOAD] on page 1596

Symmetry
Sets the symmetry of a ramp waveform, the percentage of time the waveform is rising. By changing the symmetry of the ramp, you can create, for example, triangular wave-forms.

50% defines symmetric triangles. Values <50% define triangles with a steeper rising edge leaned to the left. Values >50% define triangles with a steeper falling edge leaned to the right.

Remote command:
`WGENerator<wg>:FUNCtion:RAMP[:SYMMetry]` on page 1595

Duty cycle
Sets the duty cycle for the pulse function.

The duty cycle expresses for what percentage of the period, the signal state is high.

Remote command:
`WGENerator<wg>:FUNCtion[:SQUare]:DCYCle` on page 1596

Pulse width
Sets the pulse width, the pulse duration of the generated pulse waveform.

Remote command:
`WGENerator<wg>:FUNCtion:PULSe[:WIDTh]` on page 1595

Default setup
Presets the generator to a default setup. The default includes the following settings:

- "Function type" = "Sine"
- "Frequency" = "1 MHz"
- "Amplitude" = "1 Vpp"

Remote command:
`WGENerator<wg>:PRESet` on page 1597

DC level
Available for "Function type" = DC.

Sets the level for the DC signal.

Remote command:
`WGENerator<wg>:VOLTage:DCLevel` on page 1598

Noise level for DC
Available for "Function type" = "DC".

Sets the level of the noise for the DC signal.

Remote command:
`WGENerator<wg>:MODulation:NDCLevel` on page 1605

Period
Available for "Function type" = "Pulse".

Sets the period of the pulse waveform.

Remote command:
`WGENerator<wg>:PERiod` on page 1597

16.1.2 Modulation settings

Modulation is available only for sine and square waveforms.

Access: "Gen" signal activator > "Gen"1 or "Gen"2 > "Setup" tab > "Function type" = "Sine" or "Square" > "Modulation".

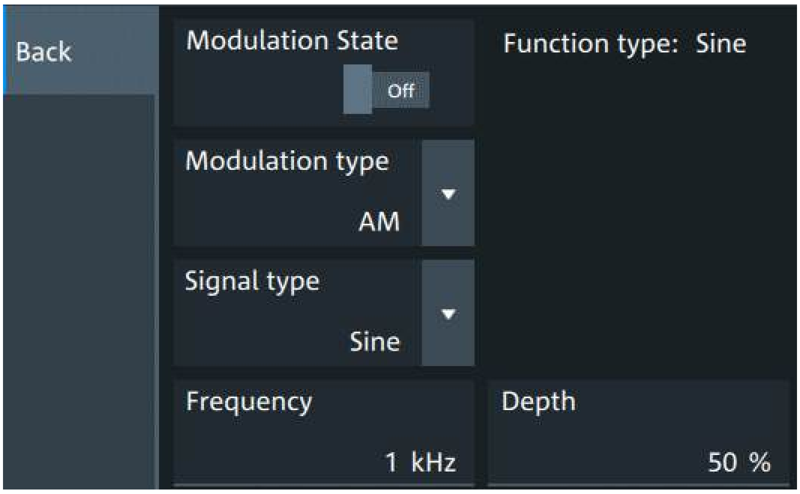


Figure 16-1: Modulation setup

Modulation state

Enables or disables modulation.

Modulation is available only for "Function type" = "Sine"/"Square".

Remote command:
`WGENerator<wg>:MODulation[:STATe]` on page 1600

Modulation type

Selects the modulation type, which defines how the carrier signal is modified.

"AM"	Amplitude modulation. The amplitude of the carrier signal is varied according to the modulation signal. Available for "Function type" = "Sine".
"FM"	Frequency modulation. The frequency of the carrier signal is varied according to the modulation signal. Available for "Function type" = "Sine".
"PWM"	Pulse width modulation. The time for which the signal is in a high state is varied according to the modulation signal. Available for "Function type" = "Square".
"FSK"	Frequency shift keying (FSK) modulation. The signal frequency switches between "Frequency 1" and "Frequency 2" at a "FSK rate". Available for "Function type" = "Sine".

Remote command:
`WGENerator<wg>:MODulation:TYPE` on page 1608

Signal type

Selects the type of the modulating signal for AM, FM or PWM modulation.

Remote command:
WGENerator<wg>:MODulation:AM[:FUNCtion] on page 1602
WGENerator<wg>:MODulation:FM[:FUNCtion] on page 1604
WGENerator<wg>:MODulation:PWM[:FUNCtion] on page 1608

Frequency

Sets the frequency of the modulating waveform for AM/FM/PWM modulation.

Remote command:
WGENerator<wg>:MODulation:AM:FREQuency on page 1601
WGENerator<wg>:MODulation:FM:FREQuency on page 1604
WGENerator<wg>:MODulation:PWM:FREQuency on page 1607

Depth

Sets the modulation depth, the percentage of the amplitude range that is used for AM modulation.

Remote command:
WGENerator<wg>:MODulation:AM:DEPTh on page 1601

Duty cycle

Sets the duty cycle for a square waveform. The duty cycle expresses for what percentage fraction of the period, the waveform is active, i.e. the signal state is high.

Remote command:
WGENerator<wg>:MODulation:AM:DCYCle on page 1601
WGENerator<wg>:MODulation:FM:DCYCle on page 1603
WGENerator<wg>:MODulation:PWM:DCYCle on page 1606

Symmetry

Sets the symmetry for the ramp modulation waveform, the percentage of time that the waveform is rising.

Remote command:
WGENerator<wg>:MODulation:AM:SYMMetry on page 1602
WGENerator<wg>:MODulation:FM:SYMMetry on page 1604
WGENerator<wg>:MODulation:PWM:SYMMetry on page 1607

Deviation

Sets the frequency deviation, the maximum difference between the FM modulated signal and the carrier signal.

Remote command:
WGENerator<wg>:MODulation:FM:DEViation on page 1603

Modulation depth

Sets the modulation depth, the percentage of the amplitude range that is used for PWM modulation.

Remote command:
WGENerator<wg>:MODulation:PWM:DEPTh on page 1607

Frequency 1/Frequency 2
Sets the frequency of the first /second signal in FSK modulated signal.

Remote command:
`WGENerator<wg>:MODulation:FSK:FONE` on page 1605
`WGENerator<wg>:MODulation:FSK:FTWO` on page 1605

FSK rate
Sets the frequency at which signal switches between "Frequency 1" and "Frequency 2".

Remote command:
`WGENerator<wg>:MODulation:FSK[:RATE]` on page 1605

16.1.3 Sweep settings

Sweep is available only for sine waveforms.

Access: "Gen" signal activator > "Gen1" or "Gen2" > "Setup" tab > "Function type" = "Sine" > "Sweep".

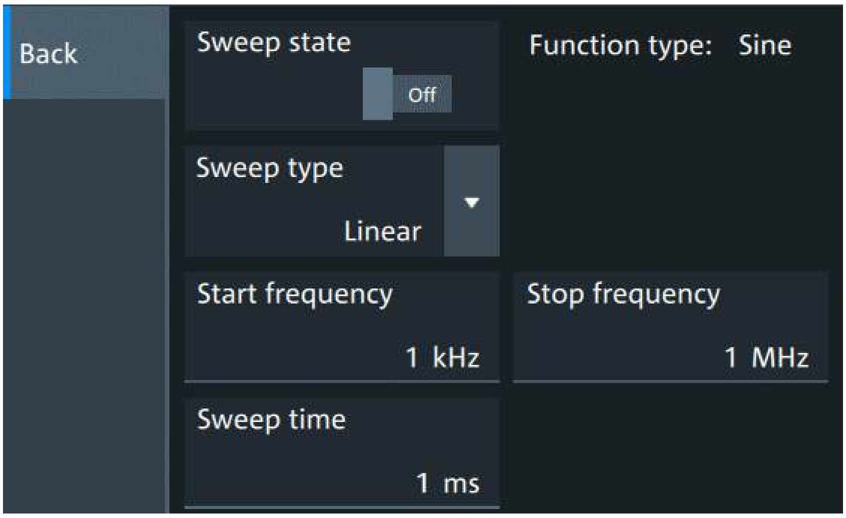


Figure 16-2: Sweep setup

In the sweep mode, the MXO 4 generates a signal whose frequency gradually changes from the "Start frequency" to the "Stop frequency" for a certain "Sweep time".

For a step-by-step description of the sweep setup, see Section 16.3.3, "Configuring a sine sweep waveform", on page 768.

Sweep state
Enables or disables the sweeping.

Remote command:
`WGENerator<wg>:SWEep[:STATe]` on page 1611

Sweep type
Sets the type of the sweep, a linear or logarithmic change of the frequency.

Remote command:
`WGENerator<wg>:SWEep:TYPE` on page 1611

Start frequency
Sets the start frequency of the sweep signal.

Remote command:
`WGENerator<wg>:SWEep:FSTart` on page 1611

Stop frequency
Sets the stop frequency of the sweep signal.

Remote command:
`WGENerator<wg>:SWEep:FEND` on page 1612

Sweep time
Sets the duration of the sweep.

Remote command:
`WGENerator<wg>:SWEep:TIME` on page 1612

16.1.4 Arbitrary waveforms

The arbitrary waveform generator allows you to output a user-defined waveform for testing your devices. An arbitrary waveform is loaded from a file. You can load CSV files that follow a defined structure, or saved reference waveforms.

See also: Section 16.3.4, "Configuring an arbitrary waveform", on page 768.

16.1.4.1 Arbitrary waveform files

You can load CSV files that have a Rohde & Schwarz WaveGen format.

Content and format of the Rohde & Schwarz arbitrary waveform CSV files

The waveform generator format can contain the following values:

- Rate
- Time value
- Voltage value

If all the values are defined, the file format is as follows:

```
Rate 5000000            //Sample rate of the arbitrary waveform.
0.000000E+000,-5.995    //Time value 1, Voltage value 1
1.237011E-005,-6.0      //Time value 2, Voltage value 2
.......
```

In this case, the rate is reflected in the "Sample Rate" field of the user interface. The total number of Time/Voltage values is reflected in the "Samples" of the user interface. Anything written after `//` is ignored as a comment.

You can define only some of the values. According to what you define, the file format looks different and is handled differently:

- With specified *Rate*:
  Time values are ignored. You can specify just rate and voltage values as below:

```
Rate 5000000                  //Sample rate of the arbitrary waveform
-5.995                        //Voltage value 1
-6.0                          //Voltage value 2
.......
```

- Without specified *Rate* and without specified *Time* values:
  The last user-defined sample rate is used to calculate the waveform. You can change the "Sample rate" in the user interface. The voltage values are then played with this sample rate.

```
-5.995                //Voltage value 1
-6.0                   //Voltage value 2
.......
```

- Without specified *Rate* and with specified *Time*:
  The timing information of the first 2 time values is used to calculate the sample rate.

Example:

Consider the following file:

```
0.000000E+000,-5.995    //Time value 1, Voltage value 1
1.237011E-005,-6.0      //Time value 2, Voltage value 2
```

The sample rate is:

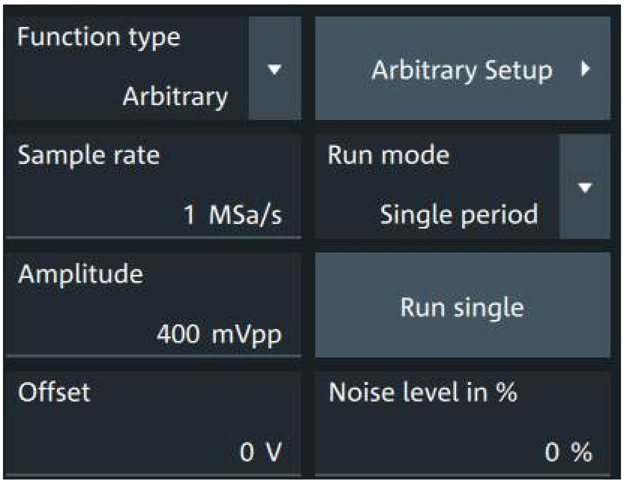
Sample rate = 1/ Time between first two samples =1 / 1.237011E-005 = 80.840KSampe/sec

16.1.4.2 Arbitrary settings

Access: "Gen" signal activator> "Gen1" or "Gen2" > "Setup" tab > "Function type" = "Arbitrary"

Access: "Gen" signal activator > "Gen"1 or "Gen"2 > "Setup" tab > "Function type" = "Arbitrary".

The following settings in the "Setup" tab and the "Arbitrary Setup" dialog are specific for generated arbitrary waveforms.



Run mode

Selects the duration for which the signal of the arbitrary generator is output after the trigger event. You can choose between a "Continuous" and "Single period" duration.

Remote command:

`WGENerator<wg>:ARBGen:RUNMode` on page 1609

Run single

Generates a single period of the arbitrary waveform if "Run mode" is set to "Single period".

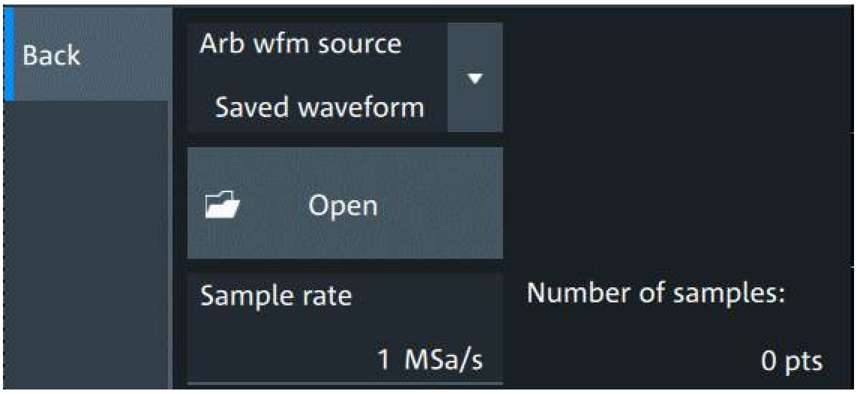
If you load the arbitrary waveform from a file, first load the file, and then connect the DUT. See also: "Open" on page 764.

Remote command:

`WGENerator<wg>:ARBGen:RUNSingle` on page 1609

Arbitrary Setup

Opens a dialog to define the arbitrary waveform.



Arb wfm source

Selects the source of the arbitrary waveform.

You can load CSV files that follow a defined structure, or saved reference waveforms.

Remote command:
`WGENerator<wg>:ARBGen[:SOURce]` on page 1610

Sample rate

Sets the sample rate for the arbitrary waveform.

If the sample rate is given in the arbitrary waveform file (CSV or REF file), the instrument displays the value here, and you can change it. If no sample rate is available in the data, you can set the required sample rate.

Remote command:
`WGENerator<wg>:ARBGen:SRATe` on page 1610

Number of samples

Displays the number of samples in the loaded waveform.

Remote command:
`WGENerator<wg>:ARBGen:SAMPles?` on page 1610

Open

Opens a dialog to select the saved waveform, and loads the file. The setting is available if "Arb wfm source" is set to "Saved waveform".

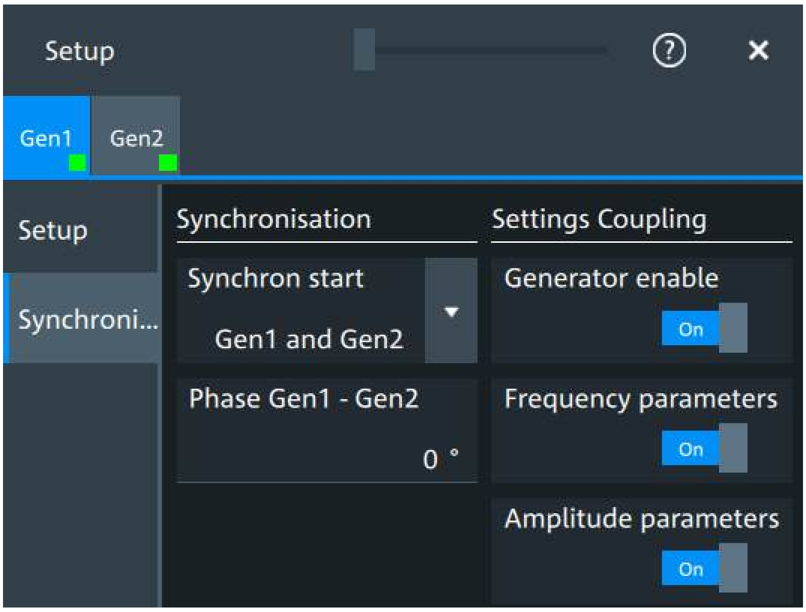
You can load CSV files, or REF waveforms (saved reference waveforms). See also: Section 16.1.4.1, "Arbitrary waveform files", on page 761.

When the file is loaded, the output voltage is set to the value of the first sample in the file. Therefore, if you want to output single periods of the arbitrary waveform, first load the waveform file, and then connect the DUT.

Remote command:
`WGENerator<wg>:ARBGen:NAME` on page 1609
`WGENerator<wg>:ARBGen:OPEN` on page 1609

16.2 Synchronize settings

Access: "Menu" > "Apps" > "Gen1" > "Synchronisation" tab.



Synchron start
Selects, which signals generated from the waveform generator are synchronized.

Selecting one of the sync options indicates that the first samples of those signals are generated at the same time, irrespective of if the generators are on or off. Selecting one of the coupling options automatically syncs the signals generated by the two waveform generators.

Remote command:
`GENerator:SYNC[:COMBination]` on page 1614

Phase Gen1 - Gen2
Sets the phase shift between the waveform of Gen1 and Gen2 when the frequency parameters of the two waveforms are coupled.

Remote command:
`WGENerator<wg>:COUPling:PHASeshift` on page 1613

Generator enable
Enables the coupling of the generators, with the selected set of parameters: amplitude and frequency.

Remote command:
`WGENerator<wg>:COUPling:STATe` on page 1613

Frequency parameters
Couples all frequency parameters of "Gen1" and "Gen2". The values are taken from the currently selected generator.

You can still change the other settings of the generators independently.

Remote command:
WGENerator<wg>:COUPling:AMPLitude on page 1613

Amplitude parameters
Couples all amplitude parameters of "Gen1" and "Gen2" including the load. The values are taken from the currently selected generator.

Remote command:
WGENerator<wg>:COUPling[:FREQuency] on page 1614

16.3 Configuring the waveform generator

This section explains step by step how to configure the waveform generator.

16.3.1 Configuring a function waveform

1. Tap the "Gen" signal activator.
2. Select the tab of the generator that you want to configure: "Gen"1 or "Gen"2.
3. In the "Setup" tab, select the "Function type" that you want to generate, e.g. "Sine".
4. Depending on the selected "Function type", configure the settings of the waveform like "Frequency" and "Amplitude".
5. If necessary, change the "User load" settings, or add "Noise level in %" to the waveform.
6. Set "State" = "On" to output the waveform at the output connector of the waveform generator.

16.3.2 Configuring a modulation waveform

Generating an AM modulated waveform

1. Tap the "Gen" signal activator.
2. Select the tab of the generator that you want to configure: "Gen"1 or "Gen"2.
3. In the "Setup" tab, set the "Function type" = "Sine".
4. Press "Modulation" to open the modulation dialog.
5. Set "Modulation type" = "AM".

6. Set the "Carrier frequency" and the "Carrier period".
7. Tap "Modulation signal", and select the required waveform.
8. Depending on the selected "Modulation signal", configure the settings of the waveform like "Modulation freq" and "Modulation depth".
9. Set "Modulation state" = "On" to enable the modulation.
10. Press "Back" to return to the "Setup" tab.
11. Set "State" = "On" to output the waveform at the output connector of the waveform generator.

Generating an FM modulated waveform

1. Tap the "Gen" signal activator.
2. Select the tab of the generator that you want to configure: "Gen"1 or "Gen"2.
3. In the "Setup" tab, set the "Function type" = "Sine".
4. Press "Modulation" to open the modulation dialog.
5. Set "Modulation type" = "FM".
6. Select the "Signal type".
7. Set the "Frequency" and the "Deviation".
8. Set "Modulation state" = "On" to enable the modulation.
9. Press "Back" to return to the "Setup" tab.
10. Set "State" = "On" to output the waveform at the output connector of the waveform generator.

Generating an FSK modulated waveform

1. Tap the "Gen" signal activator.
2. Select the tab of the generator that you want to configure: "Gen"1 or "Gen"2.
3. In the "Setup" tab, set the "Function type" = "Sine".
4. Press "Modulation" to open the modulation dialog.
5. Set "Modulation type" = "FSK".
6. Set the "Frequency 1", "Frequency 2" and the "FSK rate".
7. Set "Modulation state" = "On" to enable the modulation.
8. Press "Back" to return to the "Setup" tab.
9. Set "State" = "On" to output the waveform at the output connector of the waveform generator.

Generating a PWM modulated waveform

1. Tap the "Gen" signal activator.
2. Select the tab of the generator that you want to configure: "Gen"1 or "Gen"2.
3. In the "Setup" tab, set the "Function type" = "Square".
4. Press "Modulation" to open the modulation dialog.
5. Set "Modulation type" = "PWM".
6. Tap "Signal type", and select the required waveform.
7. Configure the settings of the waveform like "Frequency" and "Modulation depth".
8. Set "Modulation state" = "On" to enable the modulation.
9. Press "Back" to return to the "Setup" tab.
10. Set "State" = "On" to output the waveform at the output connector of the waveform generator.

16.3.3 Configuring a sine sweep waveform

1. Tap the "Gen" signal activator.
2. Select the tab of the generator that you want to configure: "Gen"1 or "Gen"2.
3. In the "Setup" tab, set "Function type" = "Sine".
4. Press "Sweep" to open the sweep dialog.
5. Select the "Sweep type".
6. Set the "Start frequency", the "Stop frequency" and the "Sweep time".
7. Set "Sweep state" = "On" to enable the sweep.
8. Press "Back" to return to the "Setup" tab.
9. Set "State" = "On" to output the waveform at the output connector of the waveform generator.

16.3.4 Configuring an arbitrary waveform

For a description of the settings, see Section 16.1.4, "Arbitrary waveforms", on page 761.

Generating an arbitrary waveform from a saved file

If you want to output single periods of the arbitrary waveform, first set up the generator, and then connect the DUT.

1. Tap the "Gen" signal activator.

2. Select the tab of the generator that you want to configure: "Gen1" or "Gen2".
3. In the "Setup" tab, set "Function type" = "Arbitrary".
4. Select "Arbitrary Setup" to open the arbitrary dialog.
5. Set the "Arb wfm source" to "Saved waveform".
6. Set the "Sample rate" if it is not defined in the file data.
7. Check "Number of samples".
8. Select "Back" to return to the "Setup" tab.
9. Select the "Run mode".
10. If "Run mode" = "Repetitive", set "State" = "On" to output the waveform at the output connector of the waveform generator.
11. If "Run mode" = "Single period":
    a) Connect the DUT.
    b) Set "State" = "On" to enable the output of the waveform generator.
    c) Tap "Run single" to output one waveform.

17 Network operation

The operating system is the basis of the instrument's firmware, it provides basic functions such as logon, password protection, virus protection, and connection to a network.

In addition to working with the MXO 4 directly with the touchscreen and the keys, you can also operate the instrument from a remote PC. Various methods of remote operation and control in a LAN network are supported:

- Using the web interface
- Using a VNC client
- Remote control with SCPI commands

You can also connect and synchronize two MXO oscilloscopes together and thus extend the number of channels. If you use R&S ScopeStudio on a computer, you can connect and synchronize two oscilloscopes to the software.

17.1 Connecting the instrument to the network (LAN)

Network environment

Before connecting the product to a LAN, consider the following:

- Install the latest firmware to reduce security risks.
- For internet or remote access, use secured connections if applicable.
- Ensure that the network settings comply with the security policies of your company. Contact your local system administrator or IT department before connecting your product to your company LAN.
- When connected to the LAN, the product may potentially be accessed from the internet, which may be a security risk. For example, attackers might misuse or damage the product.

17.1.1 Connecting the instrument to the network

There are two methods to establish a LAN connection to the instrument:

- A non-dedicated network (Ethernet) connection from the instrument to an existing network.

- A dedicated network connection (Point-to-point connection) between the instrument and a single computer.

To connect a LAN cable

► Connect an RJ-45 cable to the LAN connector on the rear panel, and to the LAN.

For supported LAN interfaces, refer to the specifications document.

17.1.2 Assigning the IP address

Depending on the network capacities, the TCP/IP address information for the instrument can be obtained in different ways.

- If the network supports the Dynamic Host Configuration Protocol (DHCP), the address is assigned automatically.
- If the network does not support DHCP, or if the instrument is set to use manual configuration, the addresses must be set manually.

By default, the instrument is configured to use DHCP and obtains all address information automatically. Thus it is safe to establish a physical connection to the LAN without any previous instrument configuration.

To assign the IP address manually on the instrument

1. **NOTICE!** Connection errors can affect the entire network. If your network does not support DHCP, or if you choose to disable dynamic TCP/IP configuration, you must assign valid address information before connecting the instrument to the LAN.
   Contact your network administrator to obtain a valid IP address.
2. Open "Menu" > "Settings".
3. Select "System" > "Network" > "Advanced".
4. Disable "Automatic IP (DHCP)".
5. Enter the address information as obtained from the network administrator.

17.1.3 Using host names

In a LAN that uses a DNS server (Domain Name System server), each computer and instrument in the LAN can be accessed via an unambiguous host name (or computer name) instead of the IP address. The DNS server translates the host name to the IP address. Host names are useful when a DHCP server is used, as a new IP address can be assigned each time the instrument is restarted.

Each instrument is delivered with an assigned host name, but you can change this name.

The default host name is the device name, a non-case-sensitive string with the following syntax: <instrument_model>-<serial_number>.

For example, the default host name of an MXO44 with serial number 123456 is MXO44-123456.

You can find the current host name, the model and the serial number in the "Device summary", when you tap the Rohde & Schwarz logo in the upper right corner of the screen. See also: Section 4.12, "Information and notifications", on page 77.

The serial number can also be found on the rear panel of the instrument. It is the third part of the device ID printed on the barcode sticker:

To change the host name

1. Open the "Menu".
2. Select "Settings" > "System" > "Network".
3. In "Host name", enter the new host name.
4. Confirm the entry.
5. Reboot the instrument.

17.2 ScopeSync

17.2.1 ScopeSync concept

Using the ScopeSync functionality, you can extend the number of channels in analysis up to 16 synchronized analog channels, or even more. ScopeSync is useful in applications such as power sequencing, power conversion, multi-phase buck converters, 6-phase motor drives, and in automotive applications. You can use most measurement and analysis functions across all channels.

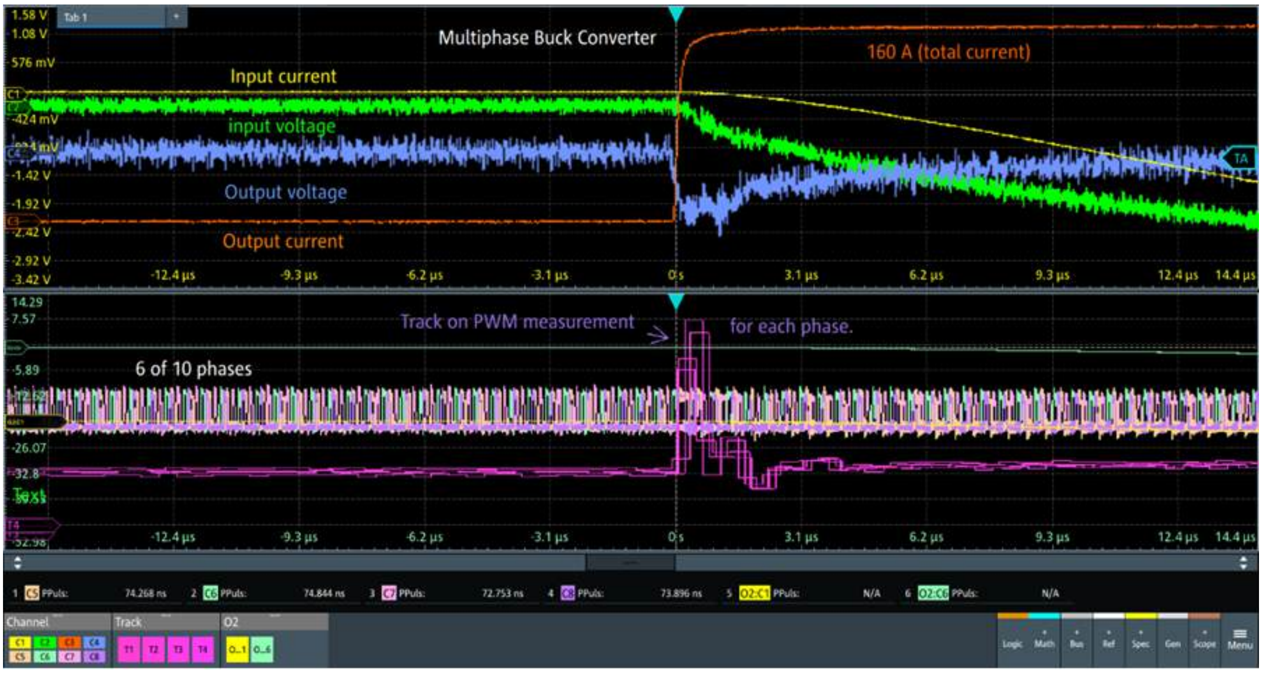


Figure 17-1: Example: analysis of multi-phase buck converter on MXO 5 with ScopeSync

The following products can be connected with ScopeSync:

- MXO 4 with 4 channels
- MXO 5 with 4 or 8 channels
- MXO 5C with 4 or 8 channels
- R&S ScopeStudio

Connections between oscilloscopes

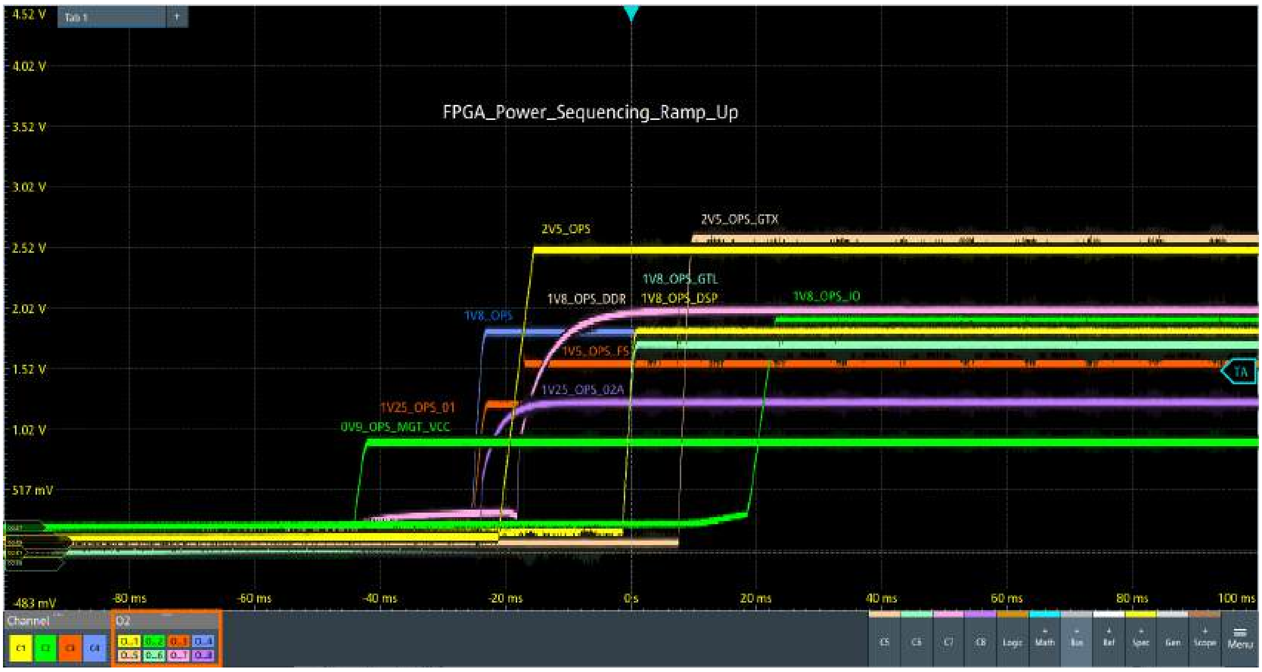
In a ScopeSync setup, scope 1 is the leading oscilloscope, where the analysis is done. Scope 2 is the connected oscilloscope. Both oscilloscopes are set up independently, and you can use the front panel keys and the touchscreen on each instrument.

ScopeSync requires several connections:

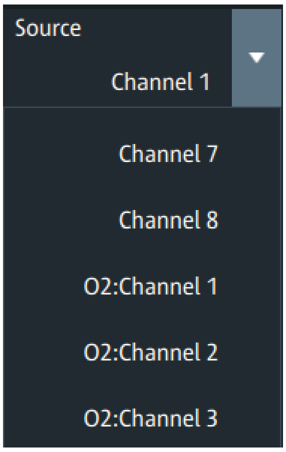
- "Ref. Out" of scope 1 to "Ref. In 10MHz" of scope 2 with BNC cable. This connection ensures the timing accuracy across the oscilloscopes.
- "Trigger Out" of scope 1 to "Trigger In" of scope 2 with BNC cable. This connection ensures trigger alignment. The trigger is set on scope 1, and scope 2 triggers when the scope 1 triggers. The trigger out delay is eliminated by a skew value that is measured during skew setup.
- LAN connection between the two oscilloscopes, either directly, via network, or using a switch. The LAN connection is for the communication of the scopes: sending commands from scope 1 to scope 2, and transferring waveforms from scope 2 to scope 1.

Synchronized waveforms on scope 1

You can select which waveforms you want to transfer from scope 2 to scope 1. After acquiring the waveforms with "Run single" or "Run/stop", you see all waveforms on scope 1 and can analyze them.



The channels of each oscilloscope are grouped in the signal bar. Select the channel group to open it. Channels of scope 2 are named "O2:C<n>", "O3:C<n>" and so on. They are available as sources along with the waveforms of scope 1, for example, for math, measurements, masks, serial buses.



Limitations

When working with ScopeSync and analyzing waveforms from a connected oscilloscope, some limitations exist.

- ScopeSync transfers only analog channels.

- You can connect one oscilloscope at a time. With a more complicated configuration, also channels of a scope 3 can be analyzed. For details, refer to the educational note on the internet, or contact our customer support.
- Waveform persistence, measurement statistics, and other functions that require repeated acquisitions are not available on waveforms of scope 2. These waveforms are handled like reference waveforms in the background.
- Up to 16 waveforms can be displayed in one diagram. If you have more waveforms, you need a second diagram to display all.
- Triggering is possible on scope 1 signals only. Scope 2 uses the external trigger.
- Before you can save and recall session files on scope 1, disconnect any connected scope in the scope list of ScopeSync. Otherwise, the save and recall functions for session files are not available
- The higher the record length of the signals on scope 2, the longer it takes to transfer the waveforms. The time also depends on the type of scope 1.
  As a rule of thumb, if scope 1 is an MXO 5, it slows down at record length > 1 Mpoint on scope 2. MXO 4 as scope 1 slows down at record length > 0.1 Mpoint on scope 2.
- The maximum record length depends on the oscilloscope model, the number of total channels, and the use of additional digital or reference waveforms on scope 1. For two MXO 5 scopes with 16 channels total, maximum record length is 100 Mpoint. For MXO 4 as scope 1 in a 12-channel configuration, maximum record length supported is 50 Mpoint.

R&S ScopeStudio connection

With R&S ScopeStudio, the oscilloscope application on a computer, you can retrieve the signals and settings from an MXO oscilloscope and analyze the waveforms on the computer. If the oscilloscope is connected to another one with ScopeSync, you can analyze the waveforms and data of both scopes.

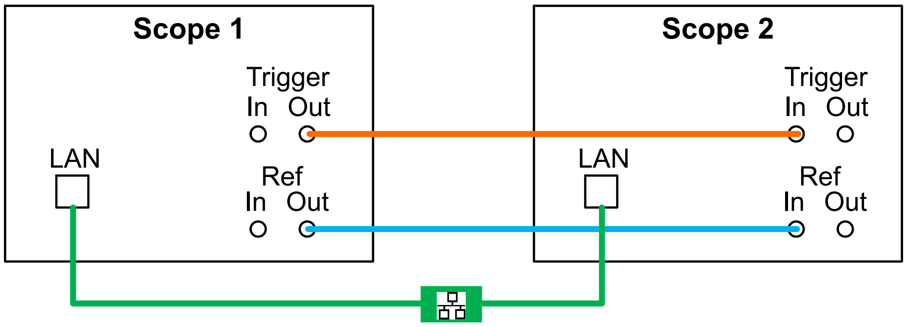
You need a working LAN connection between the computer with R&S ScopeStudio and the scope 1, usually via the network, or a direct connection. Then you can load the data from scope 1 into R&S ScopeStudio:

- "Get signals" to load all waveforms (except for digital channels).
- "Get session" to load all settings and all waveforms (except for digital channels).

17.2.2 Setting up the ScopeSync connection of two oscilloscopes

To set up the physical connection

1. Connect "Ref. Out" of scope 1 to "Ref. In 10MHz" of scope 2 with a BNC cable.
2. Connect "Trigger Out" of scope 1 to "Trigger In" of scope 2 with a BNC cable.
3. Establish a LAN connection between the two scopes. You can connect both instruments to the network, connect them directly, or use a switch.



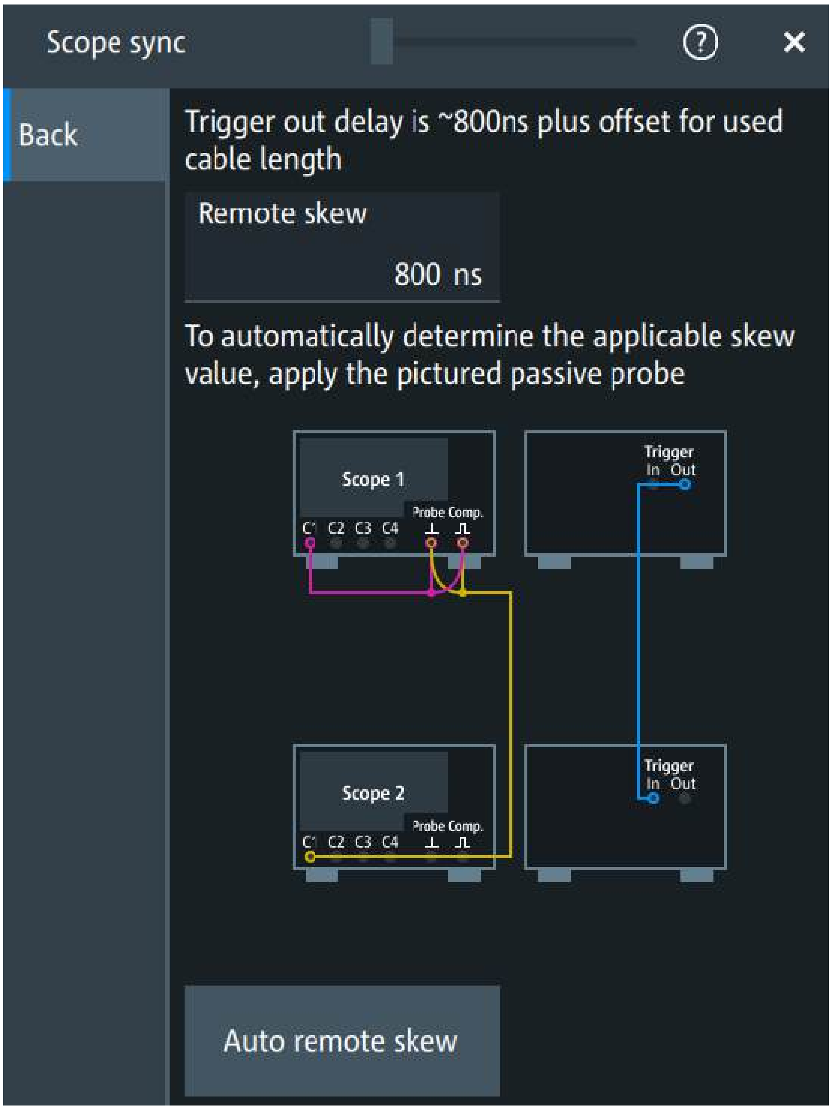
To configure the connection

All settings are described in Section 17.2.3, "ScopeSync settings", on page 778.

1. On scope 1, tap the "+ Scope" activator on the signal bar.
2. On the "Connect" tab, tap "+ Add".
3. Enter the "IP or hostname" of scope 2. To get the information, tap the Rohde & Schwarz logo on the display of scope 2.
4. Enter a name for scope 2.

   The name is added to the default name.
5. Tap "+ Add".

   The oscilloscope is added to the scope list. You can add more oscilloscopes to the list and connect them when needed.
6. To activate the connection, tap the oscilloscope in the list.
7. Tap "Connect".
8. To align the oscilloscopes, tap "Skew setup".
9. Connect two passive probes to the Probe Comp. connectors of scope 1 and to C1 on scope 1 and scope 2 as shown in the dialog.



10. Tap "Auto remote skew".

    The skew is measured and the result is written to "Remote skew" and used for alignment of the channels.
11. Tap "Back" twice to return to the "Connect" tab.
12. Select the "Channel selection" tab.
13. Tap "Select active channels" to activate all channels that are active on scope 2.

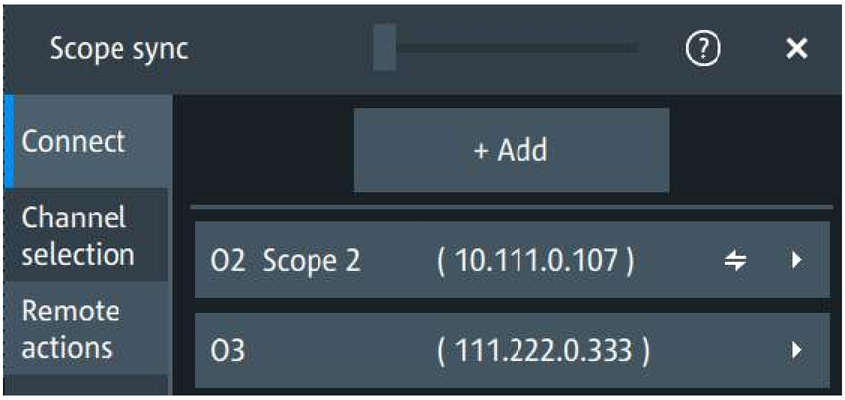
    Channels that were active on scope 2 at the time of connection are activated when you open the tab. You can also select the required channels individually.
14. Select the "Remote actions" tab.
15. Activate "Sync timebase".
16. To get the signals on scope 1, tap "Run single" or "Run/stop".

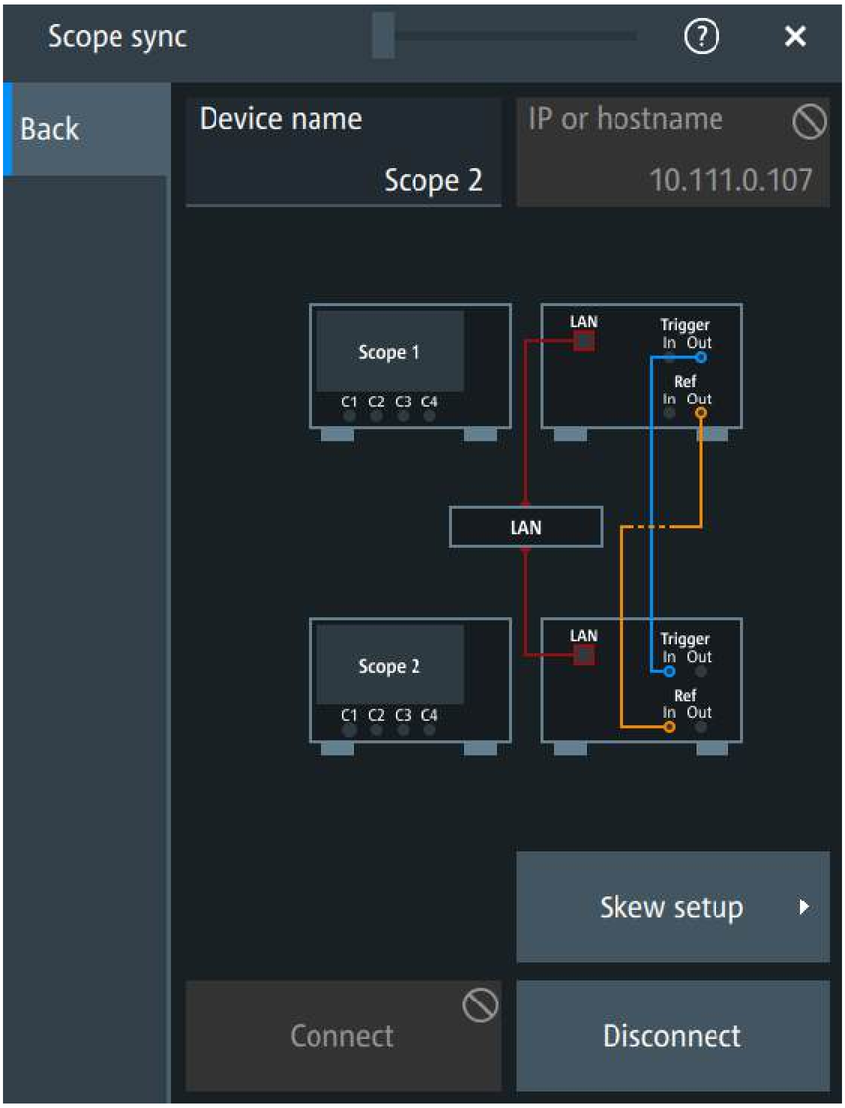
Now you can start the analysis of the signals.

17.2.3 ScopeSync settings

17.2.3.1 Connection setup

Access: "Menu" > "Apps" > "General" tab > "Add scope" > "Connect" tab





+ Add

Opens a dialog to connect several MXO oscilloscopes.

Connect the oscilloscopes as shown in the dialog, and enter the IP or hostname and a Device name. You can add up to 7 instruments to the list.

Remote command:

SYNChronize:DEVice<m>[:ENABle] on page 1617

Scope list

The list shows all oscilloscopes that were added before with their device name and IP address. The active connection is indicated with a connection symbol. Select an oscilloscope to connect or disconnect it. Only one oscilloscope can be connected at a time. When connecting a new scope, first disconnect the previous one.

Device name

Enter a name for the connected oscilloscope.

Remote command:
SYNChronize:DEVice<m>:NAME on page 1616

IP or hostname
Sets the IP address or the host name of the connected oscilloscope.

Remote command:
SYNChronize:DEVice<m>:COMMunicate:NET[:HOSTname] on page 1615

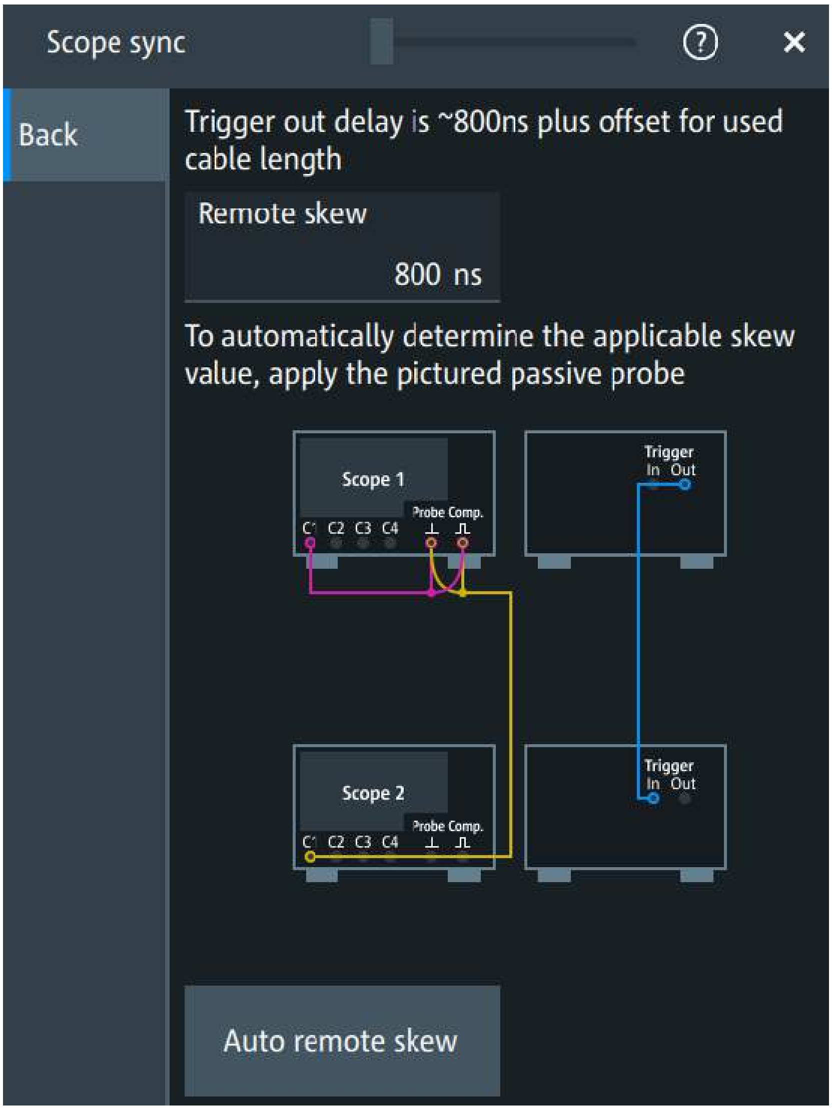
Connect
Activates the connection between the two oscilloscopes, or between the R&S ScopeStudio software and the oscilloscope.

Remote command:
SYNChronize:DEVice<m>:CONNect on page 1615

Disconnect
Terminates the active connection.

Remote command:
SYNChronize:DISConnect on page 1617

Skew setup
Opens a dialog to compensate for the delay between the scopes. The delay is caused by the trigger out delay and the cable length of the trigger out to trigger in connection.



Remote skew ← Skew setup

Shows the skew value that was measured by "Auto remote skew". If you know the skew, or measure it manually, you can also enter the value.

Remote command:

`SYNChronize:DEVice<m>:SKEW[:VALue]` on page 1617

Auto remote skew ← Skew setup

Determines the delay between the scopes automatically, and sets the skew. Connect the scopes as shown in the dialog, and tap "Auto remote skew".

Remote command:

`SYNChronize:DEVice<m>:SKEW:AUTO` on page 1616

17.2.3.2 Channel selection

Access: "Menu" > "Apps" > "General" tab > "Add scope" > "Channel selection" tab

On the "Channel selection" tab, you select the channels of scope 2 to be synchronized, displayed and analyzed. You can select active and inactive channels.

Select active channels
Selects all channels that are active on scope 2.

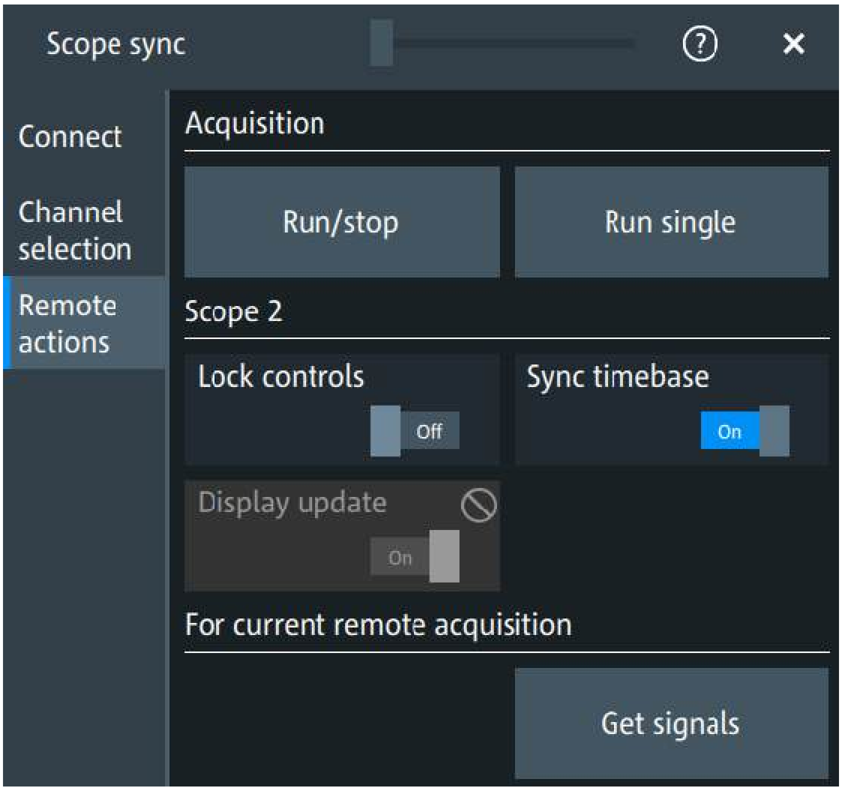
Remote command:
`SYNChronize:DEVice<m>:CHANnels` on page 1615

Deselect all
Deselects all selected channels at once.

Remote command:
`SYNChronize:DEVice<m>:CHANnels` on page 1615

17.2.3.3 Remote actions

Access: "Menu" > "Apps" > "General" tab > "Add scope" > "Remote actions" tab



Run/stop
Starts a continuous acquisition on both connected scopes, or stops the acquisition. With active ScopeSync, continuous acquisition is a series of single acquisitions: after each trigger, the acquired waveforms of selected channels are transferred to scope 1.

You can also use the Run / Stop key or the "Run / stop" toolbar function, which adapt their function if ScopeSync is active.

Remote command:
`RUN` on page 852

Run single
Starts a single acquisition on both connected scopes. It is a real single acquisition, the "N-single/Avg count" setting is ignored.

You can also use the Single key or the "Run single" toolbar function, which adapt their function if ScopeSync is active.

Remote command:
`SINGle` on page 852

Lock controls
Locks the touchscreen and the front panel keys on the connected oscilloscope.

Remote command:
`SYNChronize:DEVice<m>:LOCKcontrols` on page 1616

Sync timebase
Enables or disables the timebase synchronization.

Remote command:
`SYNChronize:DEVice<m>:TIMebasesync` on page 1617

Display update
Enables the continous display update on the actively connected oscilloscope (scope 2) when acquisition is controlled on scope 1.

The display update allows for visual comparison of the waveforms on both scopes.

"Display update" is available if "Lock controls" is on.

Remote command:
`SYNChronize:DEVice<m>:DISPlay` on page 1615

Get signals
Retrieves the waveforms of the latest acquisition from the connected oscilloscope. All selected analog channel waveforms are transferred. Digital channels and reference waveforms are not transferred.

Remote command:
`SYNChronize:LOAD[:WAVeform]` on page 1618
`SYNChronize:LOAD:ABORt` on page 1618

17.3 Web interface

If the MXO 4 is connected to a computer via LAN, you can operate the instrument from the computer. No additional tools are required, you need only a web browser.

17.3.1 Settings on the MXO 4

The "Network" tab of the "System" dialog box provides network information and settings. See Section 5.1.2, "Network settings", on page 83.

17.3.2 Web browser

The instrument's web interface works with all W3C compliant browsers.

To open the instrument's web browser

1. Open a browser on a computer connected to the instrument via LAN.
2. Type the instrument's host name or IP address in the address field of the browser on your PC, e.g. "http://11.111.11.222".

   The instrument homepage opens.

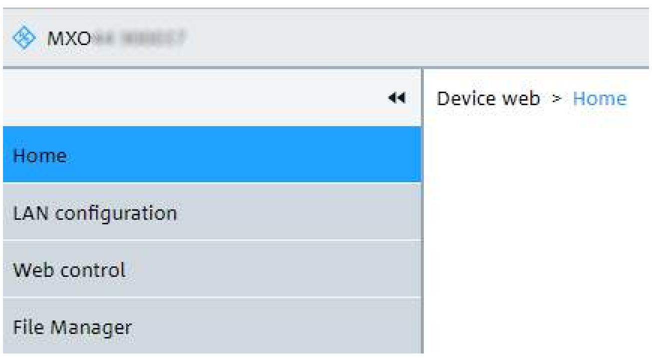
17.3.2.1 Instrument homepage

The instrument homepage displays the device information in read-only format, including DNS host names, IP address, and the VISA resource strings.

At the bottom of the homepage, you find the "Device Indicator". Activate the indicator to find the instrument. In the instrument GUI, above the waveform diagram, the connection status icon starts blinking.

The navigation menu of the browser interface has the following items:

- "LAN configuration" opens the menu with configuration pages.
- "Web control" emulates the front panel and shows the instrument display. You see a live image of the instrument, and you can operate the instrument remotely. You can use the keys, the knobs and the menus in the same way as directly on the instrument.
- "File manager" provides access to the user data that is saved on the instrument, upload and download.



17.3.2.2 LAN configuration

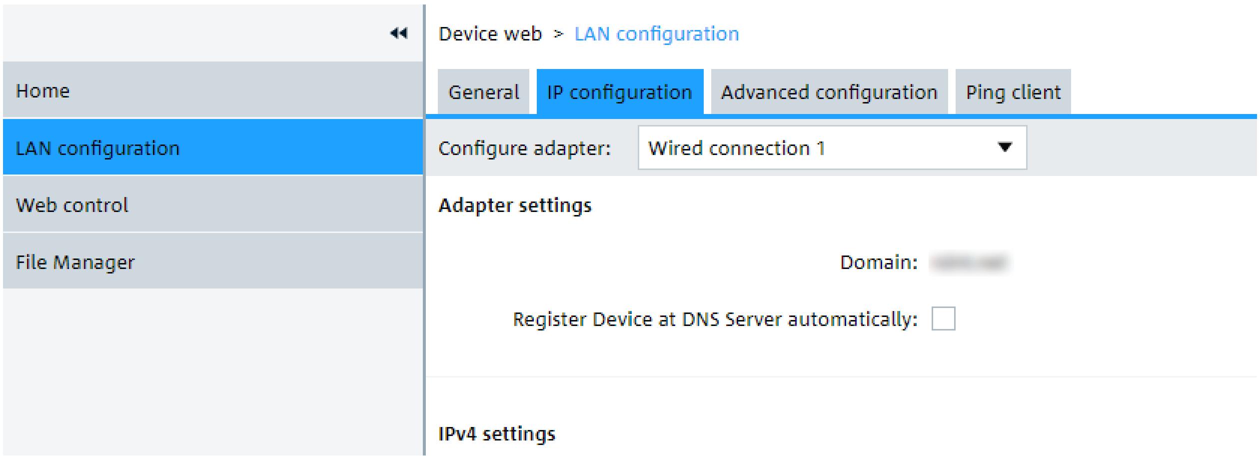
The LAN configuration consists of several parts:

- "General"
- "IP configuration" provides all mandatory LAN parameters.
- "Advanced configuration" provides LAN settings that are not declared mandatory by the standard.
- "Ping client" provides the ping utility to verify the connection between the instrument and other devices.

Changing the LAN parameters requires the "Web password" password, which is set on the instrument.

IP configuration

The "LAN Configuration > IP configuration" webpage displays all mandatory LAN parameters and allows their modification. Changing the LAN parameters requires the "Web password" password, which is set on the instrument.



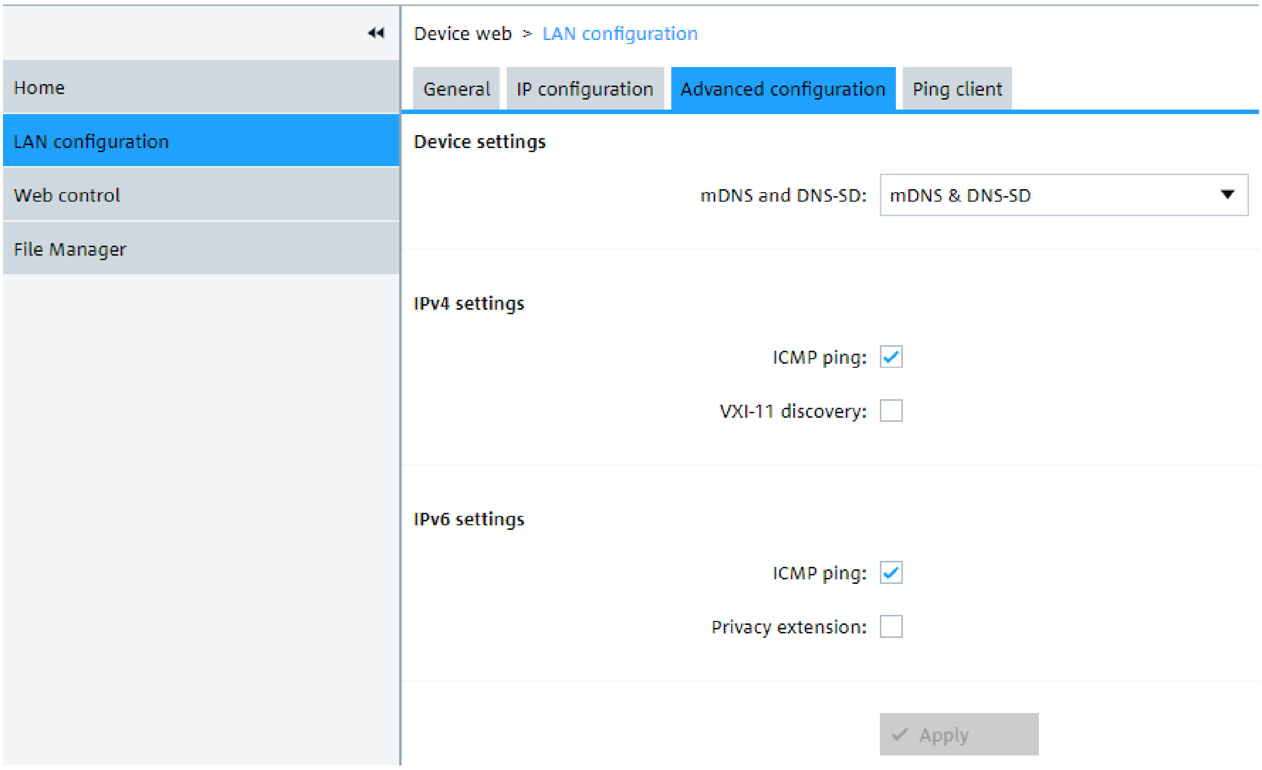
The "IP address mode" controls how the IP address for the instrument gets assigned. For the manual configuration mode, at least the static IP address, subnet mask, and default gateway are used to configure the LAN. The automatic configuration mode uses a DHCP server or Dynamic Link Local Addressing to obtain the instrument IP address.

The same settings are available on the instrument under "Menu" > "Settings" > "System" > "Network" > "Advanced".

Advanced configuration

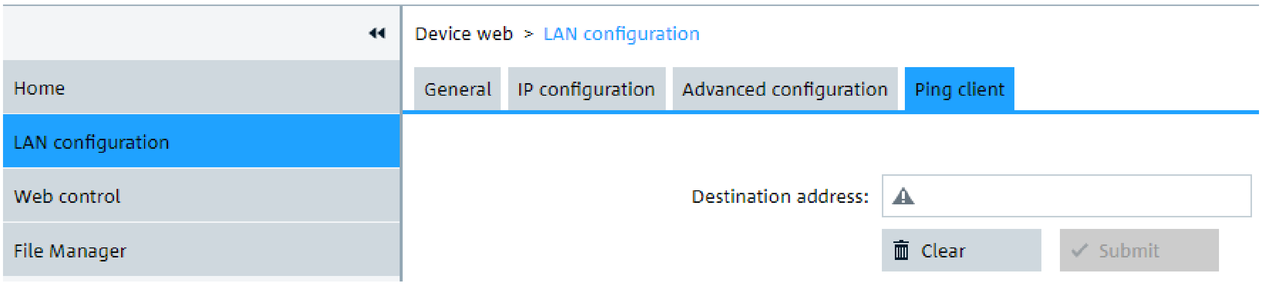
The "LAN Configuration > Advanced configuration" parameters are used as follows:

- mDNS and DNS-SD are two additional protocols: Multicast DNS and DNS Service Discovery. They are used for device communication in zero configuration networks working without DNS and DHCP.
- "ICMP ping" must be enabled to use the ping utility.
- "VXI-11" is the protocol that is used to detect the instrument in the LAN.



Ping client

Ping is a utility that verifies the connection between the instrument and another device. The ping command uses the `ICMP` echo request and echo reply packets to determine whether the LAN connection is functional. Ping is useful for diagnosing IP network or router failures. The ping utility is not password-protected.

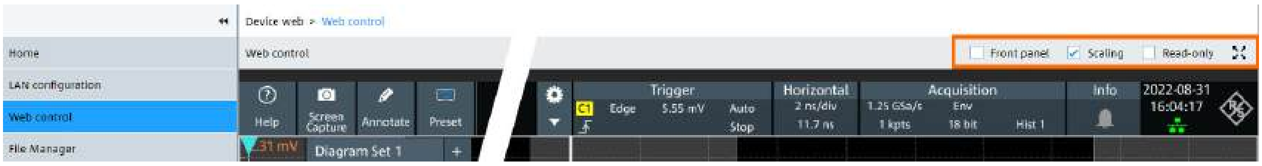


To initiate a ping between the compliant instrument and a second connected device:

1. Enable "ICMP ping" on the "Advanced configuration" page (enabled by default).
2. On the "Ping client" page, enter the IP address of the second device **without the ping command and without any further parameters** into the "Destination address" field (e.g. *11.113.11.203*).
3. Click "Submit".

17.3.2.3 Web control

"Web Control" emulates the front panel and shows the instrument display. You see a live image of the instrument, and you can operate the instrument remotely. You can use the keys, the knobs and the menus in the same way as directly on the instrument.

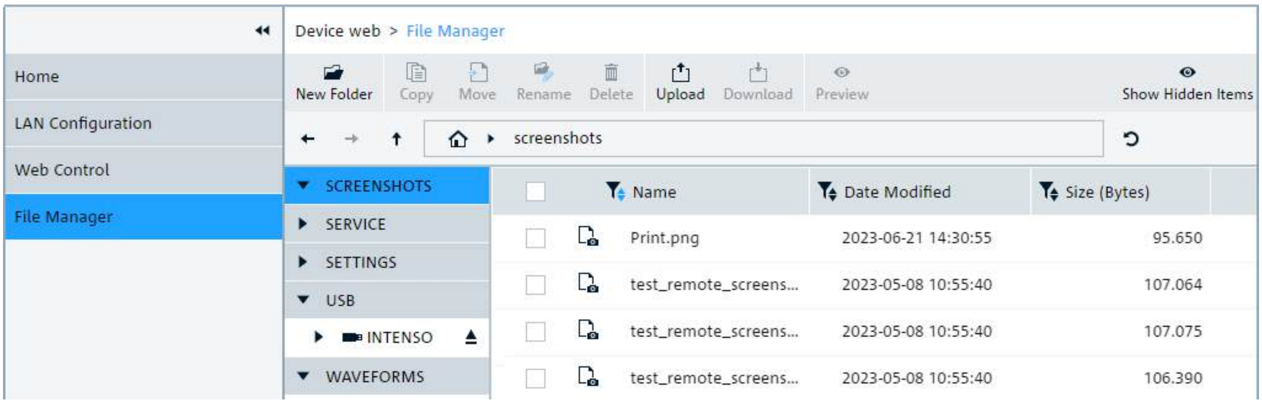


In the upper right corner above the emulated display, you see some options:

- "Front panel" hides or shows the front panel.
- "Scaling" scales the diagram to show it completely. If disabled, the diagram is shown in its original size.
- "Read-only" disables operating, only viewing is possible.
- The arrows icon hides or shows the menu.

17.3.2.4 File manager

The file manager on the instrument's webpage provides access to the user data that is stored on the instrument, or on a USB flash device connected to the instrument.



In the web file manager, you can organize the data:

- Create folders.
- Copy files within the instrument's file system, or from and to a USB flash device. Multiple files selection is possible.
- Move files within the instrument's file system, or from and to a USB flash device. Multiple files selection is possible.
- Rename files.
- Delete files.
- Upload files from the operating computer to the instrument. Multiple files can be uploaded at once.

- Download files from the instrument to the operating computer. Multiple files selection is possible.
- Preview file content of text files with maximum size of 500 kbyte.

Notes on USB flash devices

If no USB flash device is connected to the MXO 4, the "USB" folder is empty but still listed. Do NOT upload files to this main "USB" folder because data will be lost. Upload files only to the subfolders of connected USB flash devices.

After attaching a USB flash device, creating a screenshot or other actions, the file manager might not display the last change:

► Click the "Refresh" icon on the right of the address field to update the display.

The "Eject" button for USB flash devices has no function when operating the instrument remotely.

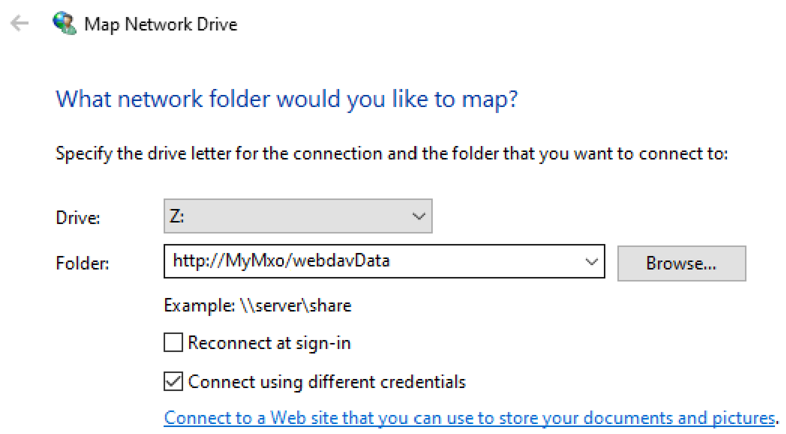
17.3.2.5 Mapping the instrument's file system as a network drive

Using web based distributed authoring and versioning (WebDAV), you can access and exchange files over the internet: move, cut, copy and paste files from the instrument to the computer and vice versa. To prepare file exchange, map the instrument's file system as a network drive in the file explorer of the operating computer:

1. Check if the connection status icon in the upper right corner of the instrument's display is green.

   If it is green, the instrument is connected to the LAN.
2. Open the file explorer on the operating computer.
3. In the left list, right-click "Network" or the entry of the operating computer, and select "Map network drive".
4. Enter the path to the instrument's file system:
   `http://<hostname>/webdavData`.
   Example: `http://MXO44-123456/webdavData`

   You can find the host name in the "Device summary", which is shown when you tap the Rohde & Schwarz logo in the upper right corner of the instrument's screen. The default host name is <instrument_model>-<serial_number>.
5. Activate "Connect using different credentials".



6. Click "Finish".
7. Leave the "User name" and "Password" empty. Click "OK".

If there are problems with the connection, check if the "WebClient" service is running: "Task Manager" > "Services" tab. If the "WebClient" service is not running, start it.

17.4 Remote operation with VNC client

If the MXO 4 is connected to a computer via LAN, you can operate the instrument from the computer using a VNC client. Therefore, install a VNC client on the computer.

To operate the instrument via VNC client:

1. Start the VNC client.
2. Enter the hostname (device name) of the instrument. You find the name in the instrument information on the oscilloscope. Tap the Rohde & Schwarz logo to show the information.
3. Connect to the instrument.

   You see the display of the oscilloscope and can use the menus, dialogs, SmartGrid and all operating means of the display.

17.5 Remote control

Remote control automates the operation of the MXO 4 using SCPI commands, scripts and programs.

For general information on remote control of Rohde & Schwarz products via SCPI, refer to www.rohde-schwarz.com/rc-via-scpi.

The following sections describe the specific basics of remote control. Definitions specified in the SCPI standard are not provided.

SCPI commands are listed and described in Section 18, "Remote control commands", on page 802.

17.5.1 Remote control interfaces and protocols

The MXO 4 supports different interfaces for remote control. The following table gives an overview.

Table 17-1: Remote control interfaces and protocols

Interface	Protocols, VISA address string	Remarks

Local Area Network (LAN)	**Protocol HiSLIP**
	VISA address string:
	`TCPIP::<host address>::hislip0[,<port>][::INSTR]`
	Protocol VXI-11
	VISA address string:
	`TCPIP::<host address>[::inst0]::[INSTR]`
		The LAN connector is located on rear panel of the instrument.
		The interface is based on TCP/IP and supports various protocols.

17.5.1.1 LAN interface

To be integrated in a LAN, the instrument is equipped with a LAN interface, consisting of a connector, a network interface card and protocols. The interface details are given in the specifications.

For remote control via a network, the PC and the instrument must be connected via the LAN interface to a common network with TCP/IP network protocol. They are connected using a commercial RJ-45 cable (shielded or unshielded twisted-pair category 5 or better). The TCP/IP network protocol and the associated network services are preconfigured on the instrument. Software for instrument control and the VISA program library must be installed on the controller.

For remote control via a network, the PC with MXO 4 and the controller PC must be connected to the LAN. The VISA program library must be installed on the controller.

IP address

Only the IP address or a valid DNS host name is required to set up the connection. The host address is part of the "VISA resource string" used by programs to identify and control the target application. The VISA resource string has the form:

`TCPIP::<host address>::hislip0[,<port>][::INSTR]` for HiSLIP protocol

`TCPIP::<host address>[::inst0][::INSTR]` for VXI-11 protocol

Where:

- `host address` identifies the MXO 4 in the network, usually the IP address. If the LAN is supported by a DNS server, the host name can be used instead of the IP address. The DNS server (Domain Name System server) translates the host name to the IP address.

- `hislip0` indicates the HiSLIP protocol.
- `inst0` is the default LAN device name. VISA supports several devices running on the instrument. On MXO 4, only one device is configured, so the LAN device name can be omitted.
- `INSTR` specifies a VISA resource of the type INSTR. By default, the VISA resource name control is set to the INSTR class.

Example: HiSLIP

IP address is *192.1.2.3*: the valid resource string is: `TCPIP::192.1.2.3::hislip0`

Instrument name is *RSRT1*: the valid resource string is: `TCPIP::RSRT1::hislip0`.

DNS host name is *MXO 4-123456*: the valid resource string is: `TCPIP::MXO 4-123456::hislip0`.

Example: VXI-11

IP address is *192.1.2.3*: the valid resource string is: `TCPIP::192.1.2.3`

Instrument name is *RSRT1*: the valid resource string is: `TCPIP::RSRT1`.

DNS host name is *MXO 4-123456*: the valid resource string is: `TCPIP::MXO 4-123456`.

17.5.2 Starting and stopping remote control

17.5.2.1 Starting a remote control session

When you switch on the instrument or start the firmware, it is always in manual operation state ("local" state).

► To start remote control:
  - Send a command from the controller.
  - VXI-11 protocol (LAN or USB interface): Use `&GTR` interface message.

While remote control is active, the settings are optimized for maximum measurement speed; the display is switched off.

Operation via the front panel is disabled.

On the screen, two buttons appear in the upper left corner: "Local" and "View".

17.5.2.2 Using the display during remote control

You can observe the screen while a remote control script is executed. Displaying the results of script execution is helpful for program test purposes but tends to slow down the measurement. Therefore it is recommended that you switch off the display in real measurement applications where a tested program script is to be executed repeatedly.

► To switch on the display, do one of the following:
- Tap the "View" button in the upper left corner of the screen.
- Use the `SYSTem:DISPlay:UPDate ON` command.

► To switch off the display, do one of the following:
- Tap the "View" button again.
- Use the `SYSTem:DISPlay:UPDate OFF` command.

17.5.2.3 Returning to manual operation

The MXO 4 switches back to manual operation when the remote connection is closed. Besides, you can return to manual operation manually or via remote control.

► To return to manual operation:
- Tap the "Local" button in the upper left corner of the screen.
- VXI-11 protocol: Use `&GTL` interface message.

17.6 Remote control - status reporting system

The status reporting system stores all information on the current operating state of the instrument, and on errors that have occurred. This information is stored in the status registers and in the error queue. Both can be queried via `STATus`... commands.

17.6.1 Hierarchy of status registers

As shown in the following figure, the status information is of hierarchical structure.

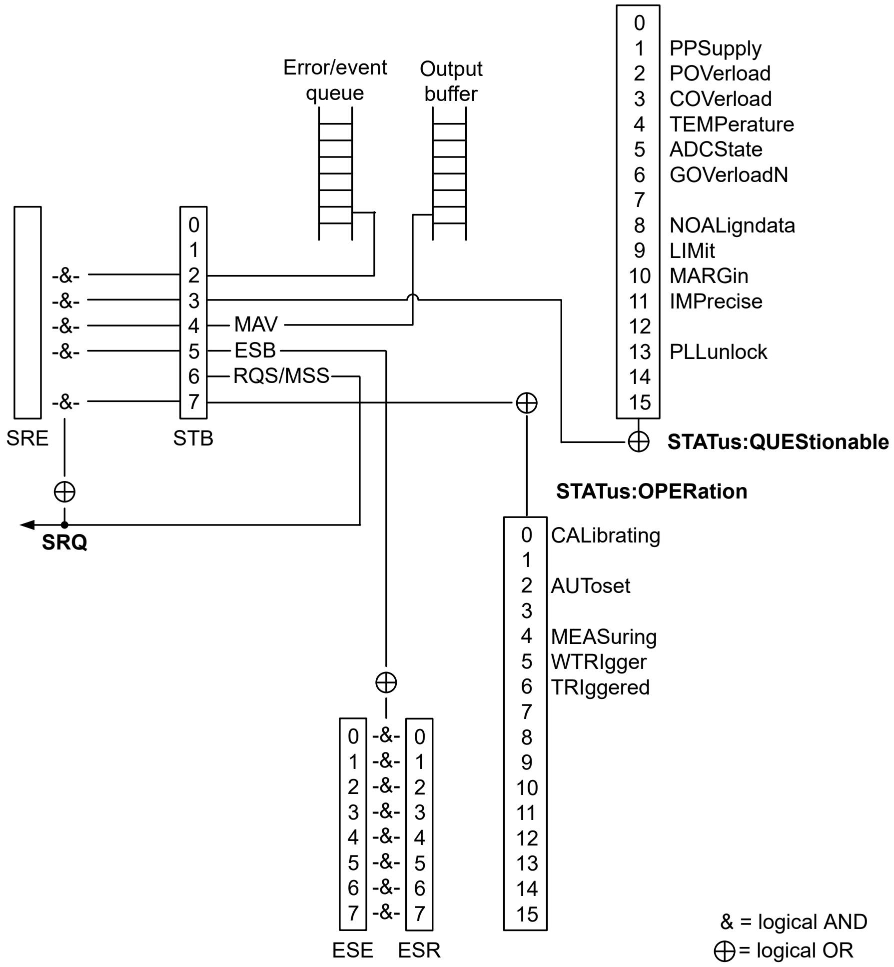


Figure 17-2: Overview of the status registers hierarchy

- **STB, SRE**
  The STatus Byte (`STB`) register and its associated mask register Service Request Enable (`SRE`) form the highest level of the status reporting system. The `STB` provides a rough overview of the instrument status, collecting the information of the lower-level registers.
- **ESR and SCPI registers**
  The STB receives its information from the following registers:
  – The Event Status Register (`ESR`) with the associated mask register standard Event Status Enable(`ESE`).
  – The `STATus:OPERation` and `STATus:QUEStionable` registers are defined by SCPI and contain detailed information on the instrument.
- **Output buffer**

The output buffer contains the messages that the instrument returns to the controller. It is not part of the status reporting system but determines the value of the MAV bit in the STB and thus is represented in the overview.

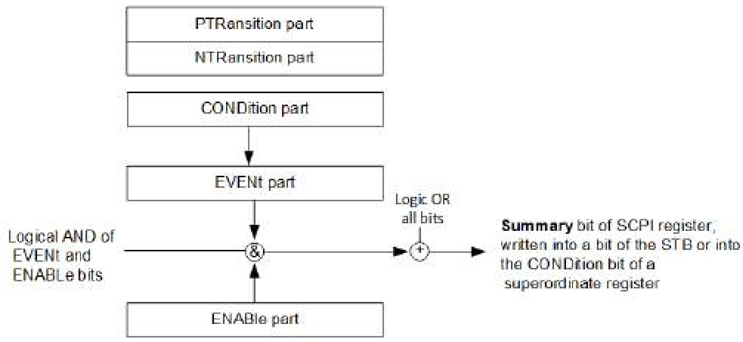
All status registers have the same internal structure.

17.6.2 Structure of a SCPI status register

The STATus:OPERation and the STATus:QUEStionable SCPI status registers consists of five parts.

The individual bits are independent of each other, i.e. each hardware status is assigned a bit number, which is valid for all five parts. Bit 15 (the most significant bit) is set to zero for all parts. Thus, the contents of the register parts can be processed by the controller as positive integers.

Description of the five status register parts



The five parts of a SCPI status register have different properties and functions:

- **CONDition**
  The CONDition part reflects the current instrument status. For summary bits, the CONDition bit mirrors the sum of the enabled EVENt bits of the next lower register.
  This register part can only be read, but not written into or cleared. Its contents are not affected by reading.
- **PTRansition / NTRansition**
  The two transition register parts define which state transition of the CONDition part (none, 0 to 1, 1 to 0 or both) is stored in the EVENt part.
  The **Positive-TRansition** part acts as a transition filter. When a bit of the CONDition part is changed from 0 to 1, the associated PTR bit decides whether the EVENt bit is set to 1.
  - PTR bit =1: the EVENt bit is set.
  - PTR bit =0: the EVENt bit is not set.

  All positive transitions are enabled by default.
  This part can be written into and read as required. Its contents are not affected by reading.

The **Negative-TRansition** part also acts as a transition filter. When a bit of the CONDition part is changed from 1 to 0, the associated NTR bit decides whether the EVENt bit is set to 1.

– NTR bit =1: the EVENt bit is set.
– NTR bit =0: the EVENt bit is not set.

All negative transitions are disabled by default.
This part can be written into and read as required. Its contents are not affected by reading.

- **EVENt**
  The EVENt part indicates whether an event has occurred since the last reading. It is the "memory" of the condition part. It allows you to detect the occurrence of events reliably, even if they have changed the state of the CONDition bit for a very brief interval. It only indicates events passed on by the transition filters.
  This part can only be read by the user. **Reading the register clears it.**
- **ENABle**
  The ENABle part determines whether the associated EVENt bit contributes to the summary bit (see below). Each bit of the EVENt part is "ANDed" with the associated ENABle bit (symbol '&'). The results of all logical operations of this part are passed on to the summary bit via an "OR" function (symbol '+').
  ENABle bit = 0: the associated EVENt bit does not contribute to the summary bit
  ENABle bit = 1: if the associated EVENt bit is "1", the summary bit is set to "1" as well.
  This part can be written into and read by the user as required. Its contents are not affected by reading.

17.6.3 Contents of the status registers

17.6.3.1 Status byte (STB) and service request enable register (SRE)

The STatus Byte (STB) is already defined in IEEE 488.2. It provides a rough overview of the instrument status by collecting the pieces of information of the lower registers. A special feature is that bit 6 acts as the sum bit of the remaining bits of the status byte.

The STB can thus be compared with the CONDition part of an SCPI register and assumes the highest level within the SCPI hierarchy.

The STB is read using the command *STB? or a serial poll.

The STatus Byte (STB) is linked to the Service Request Enable (SRE) register. Each bit of the STB is assigned a bit in the SRE. Bit 6 of the SRE is ignored. If a bit is set in the SRE and the associated bit in the STB changes from 0 to 1, a service request (SRQ) is generated. The SRE can be set using the command *SRE and read using the command *SRE?.

Table 17-2: Meaning of the bits used in the status byte

Bit No.	Meaning
0...1	Not used
2	Error Queue not empty The bit is set when an entry is made in the error queue. If this bit is enabled by the SRE, each entry of the error queue generates a service request. Thus an error can be recognized and specified in greater detail by polling the error queue. The poll provides an informative error message. This procedure is to be recommended since it considerably reduces the problems involved with remote control.
3	QUEStionable status register summary bit The bit is set if an `EVENt` bit is set in the `QUEStionable` status register and the associated `ENABle` bit is set to 1. A set bit indicates a questionable instrument status, which can be specified in greater detail by querying the `STATus:QUEStionable` status register.
4	MAV bit (message available) The bit is set if a message is available in the output queue which can be read. This bit can be used to enable data to be automatically read from the instrument to the controller.
5	ESB bit Sum bit of the event status register. It is set if one of the bits in the event status register is set and enabled in the event status enable register. Setting of this bit indicates a serious error which can be specified in greater detail by polling the event status register.
6	MSS bit (main status summary bit) The bit is set if the instrument triggers a service request. This is the case if one of the other bits of this registers is set together with its mask bit in the service request enable register SRE.
7	`STATus:OPERation` status register summary bit The bit is set if an `EVENt` bit is set in the `OPERation` status register and the associated `ENABle` bit is set to 1. A set bit indicates that the instrument is just performing an action. The type of action can be determined by querying the `STATus:OPERation` status register.

17.6.3.2 Event status register (ESR) and event status enable register (ESE)

The ESR is defined in IEEE 488.2. It can be compared with the `EVENt` part of a SCPI register. The event status register can be read out using command `*ESR?`.

The ESE corresponds to the `ENABle` part of a SCPI register. If a bit is set in the ESE and the associated bit in the ESR changes from 0 to 1, the ESB bit in the STB is set.

The ESE register can be set using the command `*ESE` and read using the command `*ESE?`.

Table 17-3: Meaning of the bits used in the event status register

Bit No.	Meaning
0	Operation complete This bit is set on receipt of the command `*OPC` exactly when all previous commands have been executed.
1	Not used

Bit No.	Meaning
2	Query error This bit is set if the controller wants to read data from the instrument without having sent a query. It is also set if the controller does not fetch requested data and sends new instructions to the instrument instead. The cause is often a query that is faulty and hence cannot be executed.
3	Device-dependent error This bit is set if a device-dependent error occurs. An error message with a number between -300 and -399 or a positive error number, which denotes the error in greater detail, is entered into the error queue.
4	Execution error This bit is set if a received command is syntactically correct but cannot be performed for other reasons. An error message with a number between -200 and -300, which denotes the error in greater detail, is entered into the error queue.
5	Command error This bit is set if a command is received, which is undefined or syntactically incorrect. An error message with a number between -100 and -200, which denotes the error in greater detail, is entered into the error queue.
6	User request This bit is set when the instrument is switched over to manual control.
7	Power on (supply voltage on) This bit is set when you turn on the instrument.

17.6.3.3 STATus:OPERation register

In the `CONDition` part, this register contains information on which actions the instrument is executing. In the `EVENt` part, it contains information on which actions the instrument has executed since the last reading.

It can be read using the commands `STATus:OPERation:CONDition?` or `STATus:OPERation[:EVENt]?`, see also Section 18.21.2, "STATus:OPERation register", on page 1619.

Table 17-4: Bits in the STATus:OPERation register

Bit No.	Meaning
0	`ALIGnment` This bit is set as long as the instrument is performing a self-alignment.
1	Not used
2	`AUToset` This bit is set while the instrument is performing an auto setup.
3	Not used
4	`MEASuring` The bit is set as long as an acquisition - sampling and postprocessing - is running. In run continuous mode, the bit is always set.

Bit No.	Meaning
5	WTRIgger Available only for single acquisitions or the first acquisition of continuous acquisitions. The wait for trigger status bit indicates that the instrument is ready to trigger, and the pre-trigger time is expired. The bit is set for as long as a measurement is running.
6	TRIggered Available only for single acquisitions or the first acquisition of continuous acquisitions. The triggered status bit indicates that the instrument has been triggered.
7 - 15	Not used

17.6.3.4 STATus:QUEStionable register

This register contains specific information on instrument operation and signal reliability. It can be read using the commands `STATus:QUEStionable:CONDition?` and `STATus:QUEStionable[:EVENt]?`.

The remote commands for the STATus:QUEStionable register are described in Section 18.21, "Status reporting", on page 1618.

Table 17-5: Bits in the STATus:QUEStionable register

Bit No.		Meaning
0	-	For future use.
1	PPSupply	This bit is set if probe power supply overload occurs.
2	POVerload	This bit is set if a probe overload occurs.
3	COVerload	This bit is set if a questionable channel overload occurs.
4	TEMPerature	This bit is set if a questionable temperature occurs.
5	ADCState	The bit is set if the signal is clipped on the upper or lower edge of the screen overflow of the ADC occurs.
6	GOVerload	This bit is set if a generator overload occurs.
7	-	For future use.
8	NOALigndata	This bit is set if no alignment data is available - the instrument is uncalibrated.
9	LIMit	This bit is set if a limit value is violated.
10	MARGin	This bit is set if a margin value is violated, and the limit value is not violated.
11	IMPRecise	This bit is set if the magnitude of the signal is too low to get reliable measurement results.
12	-	For future use.

Bit No.		Meaning
13	`PLLunlock`	This bit is set if a phase-locked loop process is unlocked. There are two reasons: • external reference is missing or defect • hardware defect of internal PLL
14	-	For future use.

17.6.3.5 Application of the status reporting system

The purpose of the status reporting system is to monitor the status of one or several instruments in a test system. In particular, it monitors continuous measurements to detect errors in the signal. The controller must receive and evaluate the information of all devices.

The following standard methods are used:

- **Service request**: An SRQ is initiated by the instrument.
- Query of a **specific register** by commands
- Query of the **error queue**

These methods are described in the following sections.

Service request

The instrument can send a service request (SRQ) to the controller. Usually, this service request initiates an interrupt at the controller, to which the control program can react appropriately.

An SRQ is initiated if one or several of bits 2, 3, 4, 5 or 7 of the STB are set and enabled in the SRE. Each of these bits combines the information of a lower-level register, the error queue or the output buffer.

The `ENABle` parts of the status registers can be set such that arbitrary bits in an arbitrary status register initiate an SRQ. To use service requests effectively, set all bits to "1" in the mask registers SRE and ESE.

The SRQ is the only possibility for the instrument to become active on its own. Configure the instrument so that it initiates a service request if errors occur. And ensure that your program reacts appropriately to service requests.

Query of a register

The STB and ESR registers contain 8 bits, the SCPI registers 16 bits. The contents of a status register are specified and transferred as a single decimal number. Therefore, each bit is assigned a weighted value. The decimal number is calculated as the sum of the weighted values of all bits in the register that are set to 1.

Bits	0	1	2	3	4	5	6	7	...
Weight	1	2	4	8	16	32	64	128	...

Example:

The decimal value 40 = 32 + 8 indicates that bits no. 3 and 5 in the status register (e.g. the QUEStionable status summary bit and the ESB bit in the STatus byte) are set.

17.6.4 Error queue

Each error state in the instrument leads to an entry in the error queue.

The error queue should be queried after every SRQ in the controller program as the entries describe the cause of an error more precisely than the status registers. Especially in the test phase of a controller program the error queue should be queried regularly since faulty commands from the controller to the instrument are recorded there as well.

17.6.5 Reset values of the status reporting system

The following table contains the commands and events that reset the status reporting system. Only *RST and SYSTem:PRESet change the functional instrument settings, all others do not.

DCL means Device clear and is a GPIB interface command. The command aborts the processing of the commands received and sets the command processing software to a defined initial state and does not change the instrument settings. In a VISA implementation, viClear translates to the DCL interface command.

All other commands are explained in the "Remote control commands" section.

Table 17-6: Resets of the status reporting system

Event	DCL **(GPIB)** **viClear (VISA)** **Device clear**	*RST **or** SYSTem:PRESet	STATus:PRESet	*CLS **Clear status**
Clear STB, ESR	-	-	-	yes
Clear SRE, ESE	-	-	-	-
Clear EVENt parts of the registers	-	-	-	yes
Clear ENABle parts of all OPERation and QUEStionable registers; Fill ENABle parts of all other registers with "1".	-	-	yes	-

Event	DCL **(GPIB)** **viClear (VISA)** **Device clear**	*RST **or** SYSTem:PRESet	STATus:PRESet	*CLS **Clear status**
Fill PTRansition parts with "1"; Clear NTRansition parts	-	-	yes	-
Clear error queue	-	-	-	yes
Clear output buffer	yes	1)	1)	1)
Clear command processing and input buffer	yes	-	-	-
1) The first command in a command line that immediately follows a <PROGRAM MESSAGE TERMINATOR> clears the output buffer.				

18 Remote control commands

This section describes all remote commands available for MXO 4 and provides examples and information how to use the commands.

For general information on remote control of Rohde & Schwarz products via SCPI, refer to www.rohde-schwarz.com/rc-via-scpi.

See also Section 17.5, "Remote control", on page 789 and Section 17.6, "Remote control - status reporting system", on page 792 for further information on remote control.

The descriptions of the remote commands assume a MXO 4 with the highest available bandwidth and number of channels. Depending on your model, some of the available command ranges can differ from the values stated in the following sections.

18.1 Conventions used in remote command description

The basics of SCPI command structure, syntax and command parameters are explained in www.rohde-schwarz.com/rc-via-scpi.

The following conventions are used in the remote command descriptions:

- *Command usage*
  If not specified otherwise, commands can be used both for setting and for querying parameters.
  If a command can be used for setting or querying only, or if it initiates an event, the usage is stated explicitly.
- *Parameter usage*
  If not specified otherwise, a parameter can be used to set a value, and it is the result of a query.
  Parameters required only for setting are indicated as "Setting parameters".
  Parameters required only to refine a query are indicated as "Query parameters".
  Parameters that are only returned as the result of a query are indicated as "Return values".
- *Conformity*
  Commands that are taken from the SCPI standard are indicated as "SCPI confirmed". All commands used by the MXO 4 follow the SCPI syntax rules.
- *Asynchronous commands*
  A command which does not automatically finish executing before the next command starts executing (overlapping command) is indicated as an "Asynchronous command".
- *Reset values (*RST)*
  Default parameter values that are used directly after resetting the instrument (`*RST` command) are indicated as "*RST" values, if available.
- *Default unit*
  The default unit is used for numeric values if no other unit is provided with the parameter.

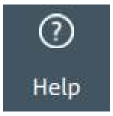
18.2 Finding the appropriate command

In the following sections, the commands are sorted according to the menu and dialog structure.

A list of all commands in alphabetical order is given in the "List of Commands" at the end of this documentation.

To find the appropriate command for a setting easily, you can use the context help:

1. Enable the "Help" icon on the toolbar.



2. Tap the parameter for which you need information.

   The "Help" window opens and displays the comprehensive description and the corresponding remote command.

3. Tap the remote command link to open the command description.

18.3 Frequently used parameters and suffixes

This chapter describes in general those parameters and suffixes that are used in several subsystems.

18.3.1 Waveform parameter

Many commands require one of the waveforms to be specified as source. The following table lists all waveforms. For each command using a waveform parameter, the available waveforms are specified in the command description.

Waveform	Description
C1 | C2 | C3 | C4 CHAN1 = C1, CHAN2 = C2, CHAN3 = C3, CHAN4 = C4	Analog channel waveforms
M1 | M2 | M3 | M4 | M5	Math waveforms
R1 | R2 | R3 | R4	Reference waveforms
XY1 | XY2 | XY3 | XY4	XY-waveforms
SBUS1 | SBUS2 | SBUS3 | SBUS4	Serial buses
D0 | D1 | D2 | ... | D14 | D15	Digital channels
PBUS1 | PBUS2 | PBUS3 | PBUS4	Digital buses
TRK1 | TRK2 | TRK3 | ... | TRK16	Track waveforms

Waveform	Description
O<n>C1 | O<n>C2 | ... | O<n>C8 (<n> = 2 to 8)	Analog channels of ScopeSync-connected oscilloscopes. Up to 7 oscilloscope connections can be configured: O2, O3, O4, ... , O8. One of these configurations can be activated at a time.
SPECMAXH1 | SPECMINH1 | SPECNORM1 | SPECAVER1 | SPECMAXH2 | SPECMINH2 | SPECNORM2 | SPECAVER2 | SPECMAXH3 | SPECMINH3 | SPECNORM3 | SPECAVER3 | SPECMAXH4 | SPECMINH4 | SPECNORM4 | SPECAVER4	Spectrum traces: SPECMAXH : Spectrum max hold SPECMINH: Spectrum min hold SPECNORM: Spectrum normal SPECAVER: Spectrum average
PA1QPOWER | PA2QPOWER | PA3QPOWER	Power waveforms of power quality analysis
PA1HPOWER1 | PA2HPOWER1 | PA3HPOWER1	Power waveforms of power harmonics analysis, only available for standards EN 61000-3-2 Class C and EN 61000-3-2 Class D
PA1SPOWER | PA2SPOWER | PA3SPOWER	Power waveforms of switching loss analysis
PA1IPOWER | PA2IPOWER | PA3IPOWER	Input power waveforms of efficieny analysis
PA1OPOWER | PA2OPOWER | PA3OPOWER	Output power waveforms of efficieny analysis
PA1SOA | PA2SOA | PA3SOA	Waveform of power safe operating area (SOA) analysis
FREF1 | FREF2 | FREF3 | FREF4	References of frequency analysis waveforms

18.3.2 Slope parameter

The slope parameter is used with several trigger and search condition commands.

Slope	Description
POSitive	Rising edge, which is a positive voltage change.
NEGative	Falling edge, which is a negative voltage change.
EITHer	Rising as well as the falling edge.

18.3.3 Polarity parameter

The polarity parameter is used with several trigger and search condition commands.

Polarity	Description
POSitive	Positive going pulses.
NEGative	Negative going pulses.
EITHer	Both positive and negative going pulses.

18.4 Programming examples

18.4.1 SmartGrid layout with zoom

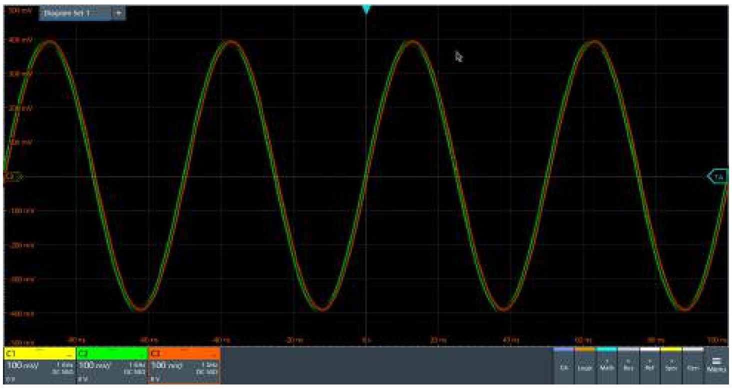
The following example uses 3 sine waves, all with frequency 20 MHz and an amplitude of ±0.4 V. The vertical scale is 100 mV/div, the time scale is 20 ns/div.

In the example, 2 layouts are created, waveforms are assigned, and zoom and spectrum are added.

For a description of the commands, see:

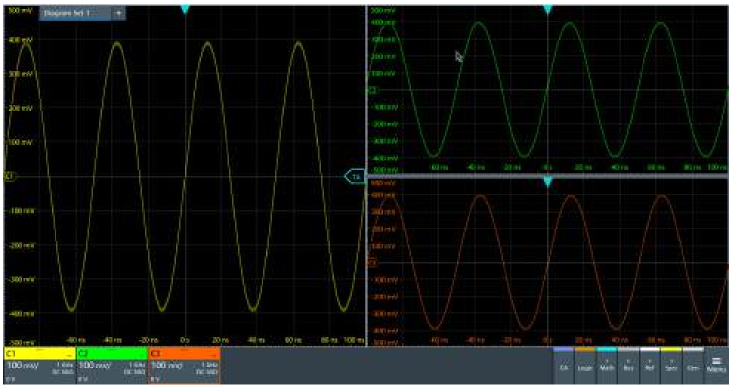
- Section 18.7.2, "SmartGrid", on page 819
- Section 18.11.1, "Zoom", on page 950
- Section 18.15.1, "Spectrum setup", on page 1036

```
//Prepare: 3 channel signals.
//Enable C1, C2 and C3.
CHAN1:STAT 1
CHAN2:STAT 1
CHAN3:STAT 1
```

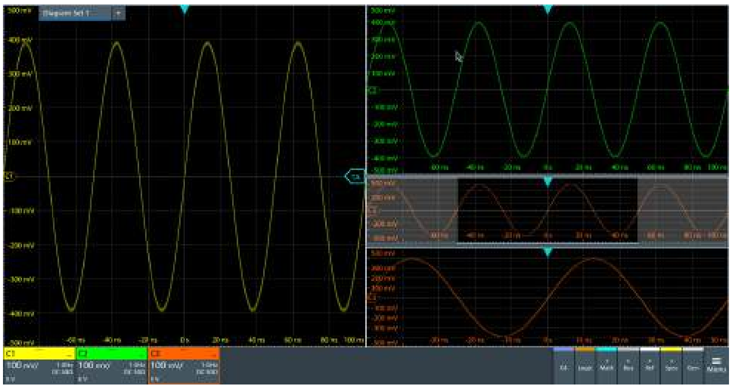


```
//Create new diagrams for C2 and C3.
//Assign sources C2 and C3 to these diagrams.
LAY:DIAG2:ENAB 1
LAY:DIAG2:SOUR C2
LAY:DIAG3:ENAB 1
LAY:DIAG3:SOUR C3
//Create new node (node 2) and assign new diagrams to that node
//Place C2 on top, C3 at bottom
LAY:NODE2:ENAB 1
LAY:NODE2:CHIL1:CONT:TYPE DIAG
LAY:NODE2:CHIL1:CONT:ID 2
LAY:NODE2:CHIL2:CONT:TYPE DIAG
LAY:NODE2:CHIL2:CONT:ID 3
LAY:NODE2:STYP VERT
//Insert node 2 into the base node (initial node)
```

```
//Diagram1 is initially located at child 1
LAY:NODE1:CHIL2:CONT:TYPE NODE
LAY:NODE1:CHIL2:CONT:ID 2
//Place both nodes side by side
LAY:NODE1:STYP HOR
```

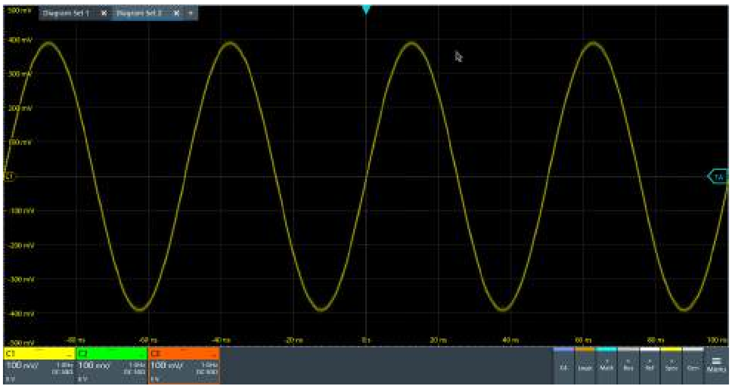


```
//Add zoom to C3. The zoom is located in diagram 3.
LAY:ZOOM:ENAB 1
LAY:ZOOM:SOUR 3
```

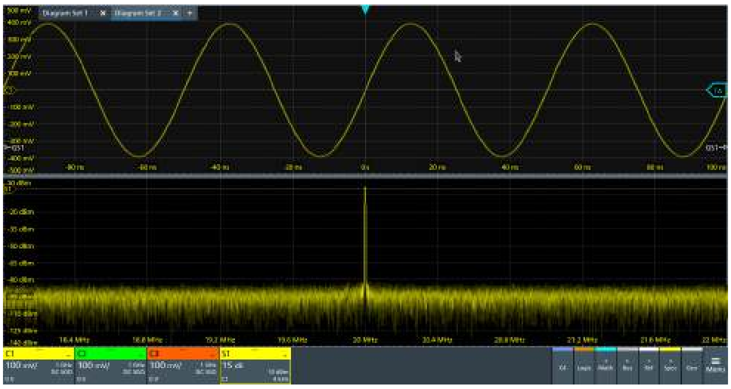


```
//Add a second layout with C1 and spectrum of C1.
//By default, the new layout is empty.
LAY2:ENAB 1
```

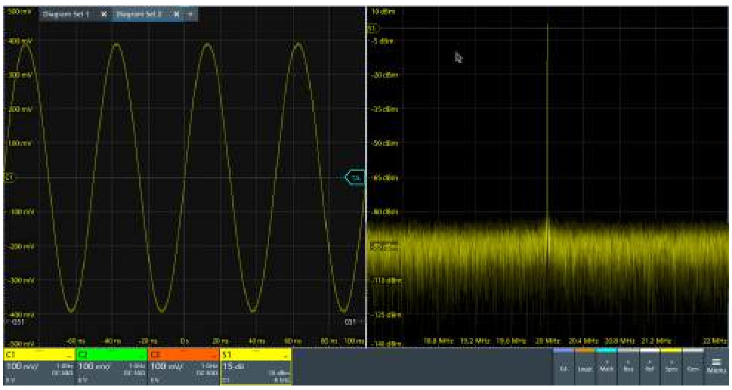
```
//Assign C1 to layout 2.
LAY2:DIAG1:SOUR C1
```



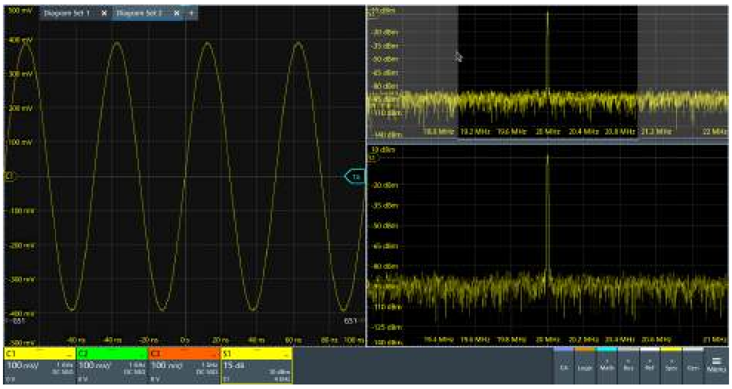
```
//Turn on spectrum of C1.
//By default, the spectrum is set below its analog source, and into the next
//free diagram (here diagram 2).
CALC:SPEC:STAT 1
CALC:SPEC:FREQ:CENT 20e6
CALC:SPEC:FREQ:SPAN 4e6
CALC:SPEC:FREQ:SCAL 15
```



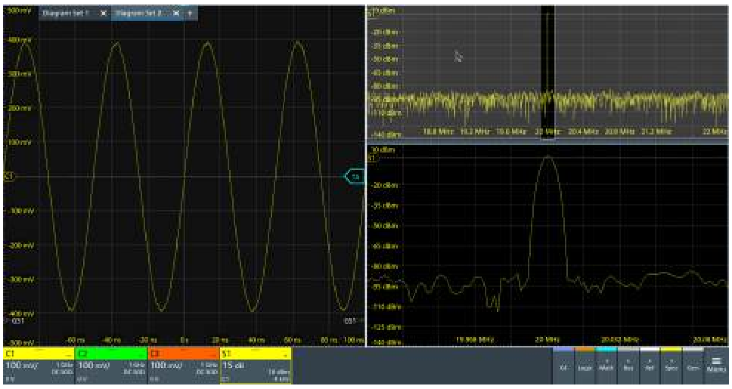
```
//Set C1 and spectrum side by side by changing the split type.
LAY2:NODE1:STYP HOR
```



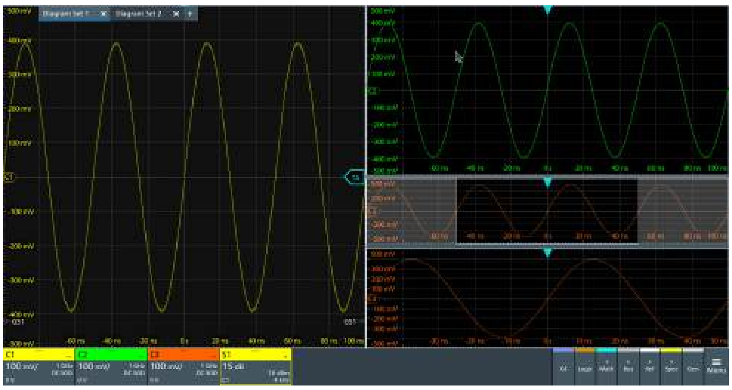
```
//Add zoom to spectrum. The zoom is located in layout 2, in diagram 2.
LAY2:ZOOM:ENAB 1
LAY2:ZOOM:SOUR 2
```



```
//Change zoom area.
LAY2:ZOOM:HOR:MODE REL
LAY2:ZOOM:HOR:REL:START 48
LAY2:ZOOM:HOR:REL:STOP 52
```



```
//Switch back to first layout (Tab 1).
LAY1:SACT
```



18.4.2 Creating a mask

The example creates a segment in mask 1 and defines the positions of the corner points.

```
:MTESt:ADD                       //Create mask 1
:MTESt:SEGMent:ADD               //Create segment 1 in mask 1
:MTESt:SEGMent:POINt:ADD         //Add 4 points at coordinate 0;0
:MTESt:SEGMent:POINt:ADD
:MTESt:SEGMent:POINt:ADD
:MTESt:SEGMent:POINt:ADD
:MTESt:SEGMent:POINt:COUNt?      //Query the number of points
-->4
:MTESt:SEGMent:POINt:X -60NS     //Set the coordinates of point 1
:MTESt:SEGMent:POINt:Y 50 MV
:MTESt:SEGMent:POINt2:X -40NS    //Set the coordinates of point 2
:MTESt:SEGMent:POINt2:Y -50 MV
:MTESt:SEGMent:POINt3:X -20NS    //Set the coordinates of point 3
:MTESt:SEGMent:POINt4:Y 100 MV   //Set the coordinates of point 4, X = 0
```

18.4.3 Saving screenshots to file

The example saves three display images in png format to the files `Print.png`, `Print_001.png`, and `Print_002.png` on USB flash drive in the directory `/run/media/usb/<MyDriveName>`. For <MyDriveName>, use the name that was defined when formatting of the USB flash drive. To get a correct screenshot, turn on the display first.

Command description in: Section 18.12.9, "Screenshots", on page 1000.

In the following example `*OPC` prevents overlapping execution of asynchronous commands.

► Connect a USB flash drive.

```
SYST:DISP:UPD ON
HCOP:DEST MMEM
HCOP:DEV:LANG PNG
*OPC?
MMEM:NAME '/run/media/usb/<MyDriveName>/Print.png'
HCOP:IMMediate; *OPC?
HCOP:IMM:NEXT; *OPC?
HCOP:IMM:NEXT; *OPC?
```

18.4.4 Data transfer in roll mode

The example shows the effects of `EXPort:WAVeform:SCOPe` and `ACQuire:ROLLmode:OSCapture` in roll mode.

Sample rate mode and record length mode are set to AUTO, and the record length is 10 M points.

```
ACQuire:SRATe:MODE AUTO
ACQuire:POINts:MODE AUTO
ACQuire:POINts?
--> 10000000
ACQuire:ROLLmode:OSCapture OFF
CHANnel1:DATA:HEADer?
--> -5,4.999999,10000000,1      //10 M points of data are transferred
ACQuire:ROLLmode:OSCapture ON
EXPort:WAVeform:SCOPe DISP      //Export of the displayed data
CHANnel1:DATA:HEADer?
--> -5,4.999999,10000000,1      //10 M points of data are transferred
EXPort:WAVeform:SCOPe ALL       //Export of all data
CHANnel1:DATA:HEADer?
--> -31.702346,4.99999999,36702346,1   //36.7 M points of data are transferred
```

18.5 Common commands

Common commands are described in the IEEE 488.2 (IEC 625-2) standard. These commands have the same effect and are employed in the same way on different devices. The headers of these commands consist of "*" followed by three letters. Many common commands are related to the Status Reporting System.

Available common commands:

***CAL?**

Starts a self-alignment of the instrument, and then queries a status response. Return values ≠ 0 indicate an error.

Return values:

<State> 0: no error
1: alignment failed
2: not aligned, e.g. init

3: device needs longer warmup time before selfalignment can start
4: input signal connected during selfalignment

Usage: Query only

***CLS**

Clear status

Sets the status byte (STB), the standard event register (ESR) and the `EVENt` part of the `QUEStionable` and the `OPERation` registers to zero. The command does not alter the mask and transition parts of the registers. It clears the output buffer.

Usage: Setting only

***IDN?**

Identification

Returns the instrument identification.

Return values:

<ID> "Rohde&Schwarz,<device type>,<part number>/<serial number>,<firmware version>"

Example: `Rohde&Schwarz,MXO4,1335.5050K04/100222,1.00.0.2`
Model assignment:

Usage: Query only

Manual operation: See "Instrument" on page 83

***OPC**

Operation complete

Sets bit 0 in the event status register when all preceding commands have been executed. This bit can be used to initiate a service request. The query writes a "1" into the output buffer when all preceding commands have been executed, which is useful for command synchronization.

***OPT?**

Option identification query

Queries the options included in the instrument. For a list of all available options and their description, refer to the specifications document.

Return values:

<Options> The query returns a list of options. The options are returned at fixed positions in a comma-separated string. A zero is returned for options that are not installed.

Usage: Query only

***RCL** <Number>

Recall

Loads the instrument settings from an intermediate memory identified by the specified number. The instrument settings can be stored to this memory using the command `*SAV` with the associated number.

The stored instrument settings do not include waveform generator settings.

It also activates the instrument settings which are stored in a file and loaded using `MMEMory:LOAD:STATe`.

***RST**

Reset

Sets the instrument to a default status. The default settings are indicated in the description of commands. Default settings are fixed, they are *not* changed by user-defined preset.

The command does not affect the waveform generator settings. To reset the generator, use `WGENerator<wg>:PRESet`.

Usage: Setting only

***SAV** <Number>

Save

Stores the current instrument settings under the specified number in an intermediate memory. The settings can be recalled using the command `*RCL` with the associated number.

Waveform generator settings are not included.

To transfer the stored instrument settings in a file, use the command `:MMEM:STOR:STAT`.

***SRE** <Contents>

Service request enable

Sets the service request enable register to the indicated value. This command determines under which conditions a service request is triggered.

Parameters:

<Contents> Contents of the service request enable register in decimal form. Bit 6 (MSS mask bit) is always 0.

Range: 0 to 255

***STB?**

Status byte query

Reads the contents of the status byte in decimal form.

Usage: Query only

***TRG**

Trigger

Triggers all actions waiting for a trigger event. In particular, *TRG generates a manual trigger signal. This common command complements the commands of the `TRIGger` subsystem.

`*TRG` corresponds to the `INITiate:IMMediate` command.

Usage: Event

***TST?**

Self-test query

Initiates self-tests of the instrument and returns an error code.

Return values:

<ErrorCode> **integer > 0 (in decimal format)**
An error occurred.

0
No errors occurred.

Usage: Query only

Manual operation: See "Run tests" on page 113

***WAI**

Wait to continue

Prevents servicing of the subsequent commands until all preceding commands have been executed and all signals have settled (see also command synchronization and `*OPC`).

Usage: Event

18.6 General remote settings

This section describes commands that affect many other remote commands in different applications of the MXO 4.

FORMat[:DATA] [<Format>],[<Length>]

Selects the data type that is used for transmission of data from analog channels, math and reference waveforms, and some measurement results from the instrument to the controlling computer.

For INT and REAL formats, use `FORMat:BORDer` to set the byte order.

If you need physical data (e.g. in Volt or Ampere) for further analysis, use the floating point formats (REAL) for export. No data conversion is needed.

Parameters:

<Format>,<Length> ASCii | REAL,32 | REAL,64 | INT,8 | INT,16 | INT,32

ASCii
Data values are returned in ASCII format as a list of comma-separated values in floating point format. The length can be omitted. It is 0, which means that the instrument selects the number of digits to be returned. The query returns both values (`ASC,0`).

REAL,32
Physical data in single precision, 32 bit floating point format. The data is stored as binary data (Definite Length Block Data according to IEEE 488.2). Each waveform value is formatted in the 32-Bit IEEE 754 floating point format.
The schema of the result string is as follows:
`#41024<value1><value2>…<value n>`, with:
`#4` = number of digits (= 4 in the example) of the following number
`1024` = number of following data bytes (= 1024 in the example)
`<value>` = 4-byte floating point values
For large data (≥ 1 GB), the result string starts with "#(data length)". The number inside the parentheses indicates the real data length in bytes.

REAL,64
Double precision, 64 bit floating point format.

INT,8 | INT,16 | INT,32
Signed integer data with length 8 bit, 16 bit, or 32 bit.
The result string has the same schema as the REAL format.
For INT,16, you can set the byte order using the command.
For digital channel data, math and histogram data, INT formats are not available.

*RST: ASCii

Example:
```
FORMat:DATA REAL,32
FORMat:DATA?
REAL,32
```

Usage: SCPI confirmed
Asynchronous command

Manual operation: See "Transfer data format" on page 89

FORMat:BORDer <ByteOrder>

Sets the endianness.

The command is only relevant for data in integer and float format.

Parameters:

<ByteOrder> LSBFirst | MSBFirst

LSB first: little endian, least significant byte first
MSB first: big endian, most significant byte first

*RST: LSBFirst

Example: A number in INT32 format is 439041101, which is hex 1A2B3C4D.
With LSBFirst (default), 4D 3C 2B 1A is returned.
With MSBFirst, 1A 2B 3C 4D is returned.

Usage: Asynchronous command

FORMat:BPATtern <BtPattFmt>

Sets the number format for remote bit pattern queries on serial protocols.

Parameters:

<BtPattFmt> DEC | HEX | OCT | BIN | ASCII | ASCii | STRG

*RST: HEX

Usage: Asynchronous command

Manual operation: See "Bit pattern format" on page 89

SYSTem:DISPlay:UPDate <DisplayUpdate>

Defines whether the display is updated while the instrument is in the remote state. If the display is switched off, the normal GUI is replaced by a static image while the instrument is in the remote state. Switching off the display can speed up the measurement. OFF is the recommended state.

Parameters:
<DisplayUpdate> OFF | ON

`ON | 1`: The display is shown and updated during remote control.
`OFF | 0`: The display shows a static image during remote control.

*RST: OFF

Example: `SYSTem:DISPlay:UPDate 1`
Switch on the display update.

Usage: Asynchronous command

SYSTem:DISPlay:MESSage:STATe <DispMessSt>

Enables and disables the display of an additional text in remote control.

To define the text, use `SYSTem:DISPlay:MESSage[:TEXT]`.

Parameters:
<DispMessSt> OFF | ON

*RST: OFF

Usage: Asynchronous command

SYSTem:DISPlay:MESSage[:TEXT] <DisplayMessage>

Defines an additional text that is displayed during remote control operation.

To enable the text display, use `SYSTem:DISPlay:MESSage:STATe`.

Parameters:
<DisplayMessage>

Usage: Asynchronous command

18.7 Instrument setup

18.7.1 System

SYSTem:COMMunicate:NET[:HOSTname] <Hostname>

Sets the host name of the instrument, which is required when configuring a network. After changing the host name, you have to reboot the instrument.

The query `SYSTem:COMMunicate:NET:HOSTname?` returns the currently defined host name.

Parameters:

<Hostname> String parameter

Usage: Asynchronous command

Manual operation: See "Host name" on page 84

SYSTem:DATE <Year>,<Month>,<Day>

Sets the date of the internal calendar.

Parameters:

<Year> Year, to be entered as a four-digit number (including the century and millennium information)

Range: 2012 to 2099
Increment: 1
*RST: 2012

<Month> Month, 1 (January) to 12 (December)

Range: 1 to 12
Increment: 1
*RST: 1

<Day> Day, 1 to the maximum number of days in the specified month

Range: 1 to 31
Increment: 1
*RST: 1

Example: `SYSTem:DATE?`
Returned value: `2022,09,28`

Usage: Asynchronous command

SYSTem:EXIT

Starts the shutdown of the firmware.

Usage: Setting only
Asynchronous command

SYSTem:FW:FILepath <FilePath>

Sets the path and the filename of the firmware installation file.

Parameters:
<FilePath> String with path and filename

Usage: SCPI confirmed
Asynchronous command

SYSTem:PRESet

Resets the instrument to the default state, has the same effect as `*RST`.

Usage: Setting only
SCPI confirmed
Asynchronous command

Manual operation: See "Factory preset" on page 107

SYSTem:SHUTdown

Starts the shutdown of the instrument (firmware and operating system).

Usage: Setting only
Asynchronous command

SYSTem:FW:STARt

Starts the firmware update. Before starting, make sure that the correct path is set with `SYSTem:FW:FILepath`.

Usage: Event
SCPI confirmed
Asynchronous command

SYSTem:TIME <Hours>,<Minutes>,<Seconds>

Returns the current time of the clock.

Parameters:
<Hours> Range: 0 to 24
Increment: 1
*RST: 1

<Minutes>	Range:	0 to 59
	Increment:	1
	*RST:	1
<Seconds>	Range:	0 to 59
	Increment:	1
	*RST:	1

Usage: Asynchronous command

18.7.2 SmartGrid

The following `LAYout` commands configure the SmartGrid. In manual operation, you configure the SmartGrid by drag and drop.See Section 4.5, "Rohde & Schwarz Smart-Grid", on page 63.

Table 18-1: Terms and definitions of SmartGrid configuration

Term	Definition
Layout	A layout is a SmartGrid configuration. Several layouts can exist but only one layout is active. By default, layouts are named "Tab <n>" on the display.
Children	A child is an area where data (data table, result table) or waveforms (diagram) are displayed. A node can also be a child. A child can be empty.
Node	A node consists of one or two children. A node is created by default with one child that has content.
Diagram	A diagram displays waveforms, the graphical visualization of data.

LAYout<ly>:COUNt?

Returns the number of available layouts, i.e. SmartGrid configurations. By default, they named "Diagram Set" on the display.

You can query the maximum number of layouts with `LAYout:COUNt? MAX`.

Suffix:

<ly>	Irrelevant, omit the suffix.

Return values:

<Count>	Number of SmartGrid configurations
Usage:	Query only Asynchronous command

LAYout<ly>[:ENABle] <State>

Creates a new SmartGrid configuration and sets it active.

Suffix:

<ly>	1...4, index of the SmartGrid layout

Parameters:

<State>	OFF | ON
Example:	See Section 18.4.1, "SmartGrid layout with zoom", on page 805.
Usage:	Asynchronous command

LAYout<ly>:ACTive <ActiveKey>

Sets the active SmartGrid configuration. The query returns the index of the active layout.

Suffix:

<ly>	Irrelevant, omit the suffix.

Parameters:

<ActiveKey>	Index of the active layout
Usage:	Asynchronous command

LAYout<ly>:SACTive

Activates the specified SmartGrid configuration. The command has the same effect as `LAYout<ly>:ACTive` but it has no query, and the active layout is specified by the suffix.

Suffix:

<ly>	1...4, index of the SmartGrid layout
Example:	See Section 18.4.1, "SmartGrid layout with zoom", on page 805.

Usage: Setting only
Asynchronous command

LAYout<ly>:LABel <Label>

Defines a name for the specified layout (SmartGrid configuration).

Suffix:

<ly> 1...4, index of the SmartGrid layout

Parameters:

<Label> String with the layout name

Usage: Asynchronous command

LAYout<ly>:DIAGram<da>:COUNt?

Returns the number of diagrams in a specified layout.

You can query the maximum number of diagrams with `LAYout<ly>:DIAGram:COUNt? MAX`.

Suffix:

<ly> 1...4, index of the SmartGrid layout

<da> Irrelevant, omit the suffix.

Return values:

<Count> Number of diagrams

Usage: Query only
Asynchronous command

LAYout<ly>:DIAGram<da>[:ENABle] <State>

Creates and displays a specified diagram in a specified layout. OFF deletes the diagram.

Suffix:

<ly> 1...4, index of the SmartGrid layout

<da> 1...8, index of the diagram

Parameters:

<State> OFF | ON

Example: See Section 18.4.1, "SmartGrid layout with zoom", on page 805.

Usage: Asynchronous command

LAYout<ly>:DIAGram<da>:SOURce <SignalKeys>

Assigns the waveforms to a diagram.

Suffix:

<ly> 1...4, index of the SmartGrid layout

<da> 1...8, index of the diagram

Parameters:

<SignalKeys> String with a comma-separated list of waveforms, e.g. `"C1, C2, M1"`

Example: See Section 18.4.1, "SmartGrid layout with zoom", on page 805.

Usage: Asynchronous command

LAYout<ly>:DIAGram<da>:LABel <Label>

Defines a name for the specified diagram in a specified layout.

Suffix:

<ly> 1...4, index of the SmartGrid layout

<da> 1...8, index of the diagram

Parameters:

<Label> String with the diagram name

Usage: Asynchronous command

LAYout<ly>:NODE<no>:COUNt?

Returns the maximum number of nodes that can be defined. This number is the maximum value for the node suffix.

Suffix:

<ly> 1...4, index of the SmartGrid layout

<no> Irrelevant, omit the suffix.

Return values:

<Count> Maximum value for the node suffix

Usage: Query only
Asynchronous command

LAYout<ly>:NODE<no>[:ENABle] <State>

Creates the specified node in the specified layout. OFF deletes the node and its children.

The query returns whether the specified node exists (1) or not (0).

Suffix:

<ly> 1...4, index of the SmartGrid layout

<no> Index of the node

Parameters:

<State>	OFF | ON

Example: See Section 18.4.1, "SmartGrid layout with zoom", on page 805.

Usage: Asynchronous command

LAYout<ly>:NODE<no>:CHILdren<o>:CONTent<p>:ID <ID>

Sets the content ID, the number of the specified content type.

For example, the "Diagram5" has Type=DIAGRAM and ID=5.

Suffix:

<ly>	1...4, index of the SmartGrid layout
<no>	Index of the node
<o>	1 | 2, child index
<p>	Irrelevant, omit the suffix.

Parameters:

<ID>	Numeric value

Example: See Section 18.4.1, "SmartGrid layout with zoom", on page 805.

Usage: Asynchronous command

LAYout<ly>:NODE<no>:CHILdren<o>:CONTent<p>:TYPE <Type>

Sets the content type for a specified child in a specified node: diagram, result table, another node, or empty.

For example, the "Diagram5" has Type=DIAGRAM and ID=5.

Suffix:

<ly>	1...4, index of the SmartGrid layout
<no>	Index of the node
<o>	1 | 2, child index
<p>	Irrelevant, omit the suffix.

Parameters:

<Type>	NONE | DIAG | DIAGRAM | RES | RESULT | NODE DIAG = DIAGRAM, RES = RESULT *RST: NONE

Example: See Section 18.4.1, "SmartGrid layout with zoom", on page 805.

Usage: Asynchronous command

LAYout<ly>:NODE<no>:RATio <SplitRatio>

Sets the size ratio of the two children in the specified node.

Suffix:

<ly> 1...4, index of the SmartGrid layout

<no> Index of the node

Parameters:

<SplitRatio> Size ratio of the children. 0.5 assigns 50% of the node size to each child. 0.3 assigns 30% to child 1% and 70% to child 2.

Range: 0 to 1
Increment: 0.0001
*RST: 0.5

Usage: Asynchronous command

LAYout<ly>:NODE<no>:STYPe <SplitType>

Creates a second child (e.g. diagram) in the node if only one child exists, and sets the splitting of the node. If two children exist, only the splitting is set.

Suffix:

<ly> 1...4, index of the SmartGrid layout

<no> Index of the node

Parameters:

<SplitType> HOR | HORizontal | VERT | VERTical

HOR = HORizontal, VERT = VERTical

*RST: NONE

Example: See Section 18.4.1, "SmartGrid layout with zoom", on page 805.

Usage: Asynchronous command

LAYout<ly>:RESult<n>:HORizontal:RATio <SplitRatio>

Sets the horizontal ratio between the cursor result table and the measurement result table inside the result display container if the results are displayed at the bottom.

Suffix:

<ly> 1...4, index of the SmartGrid layout

<n> Suffix is irrelevant, index of the result container

Parameters:

<SplitRatio> Range: 0 to 1
Increment: 0.0001
*RST: 0.8

Usage: Asynchronous command

LAYout<ly>:RESult<n>:VERTical:RATio <SplitRatio>

Sets the vertical ratio between the cursor result table and the other measurement results inside the result display container if the results are displayed on the right or left.

Suffix:

<ly>	1...4, index of the SmartGrid layout
<n>	Suffix is irrelevant, index of the result container

Parameters:

<SplitRatio>
Range: 0 to 1
Increment: 0.0001
*RST: 0.8

Usage: Asynchronous command

LAYout<ly>:RPOSition <ResultPosition>

Defines the position of the result container inside the layout.

Suffix:

<ly> 1...4, index of the SmartGrid layout

Parameters:

<ResultPosition> BOTT | BOTTOM | LEFT | RIGH | RIGHT
*RST: NONE

Usage: Asynchronous command

18.7.3 Toolbar

DISPlay:TOOLbar:COUNt?

Returns the number of tools that are currently assigned to the toolbar.

Return values:

<ToolCount>
Range: 0 to 100
Increment: 1
*RST: 8

Usage: Query only
Asynchronous command

DISPlay:TOOLbar:DESelect

Removes all tools from the toolbar.

Usage: Setting only
SCPI confirmed
Asynchronous command

DISPlay:TOOLbar:RESTore

Resets the toolbar to the factory configuration.

Usage: Setting only
SCPI confirmed
Asynchronous command

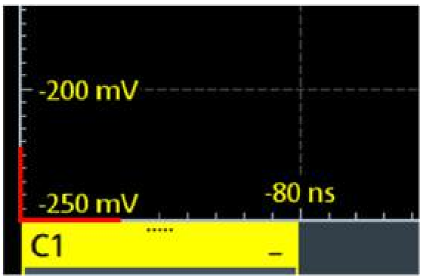
18.7.4 Annotations

The following `DISPlay:ANNotation` commands configure the annotations. With these commands you can select the type of annotation you want to add, define its value, position and color.

Defining the position of the annotation

With some of the following commands, you can define the position of the annotation on the screen. When defining the position, consider the following:

- A position is defined with two elements. The first element refers to the X dimension and the second to the Y dimension.
- The minimum position (0,0) is the lower left corner of the SmartGrid.



- The maximum position (100,100) is the upper right corner of the SmartGrid.

- The position is defined in percent with a range from 0 to 100. The minimum increment is 0.01.
- An annotation element cannot be moved outside the SmartGrid, the position is limited depending on the size of the annotation element.

Color catalog

When using annotations, you can select their color from a list of predefined colors. The following table gives an overview on the available colors and their command parameter name.

Table 18-2: Color catalog for annotations

Color	Color command parameter	Description
	`WHITe`	White
	`LGRay`	Light gray
	`MGRay`	Middle gray
	`GRAY`	Gray
	`DGRay`	Dark gray
	`RED`	Red
	`DORange`	Dark orange
	`ORANge`	Orange
	`LORange`	Light orange
	`YELLow`	Yellow
	`DGReen`	Dark green
	`GREen`	Green
	`LGReen`	Light green
	`LBLue`	Light blue
	`BLUE`	Blue
	`PINK`	Pink

Color	Color command parameter	Description
	`LPINk`	Light pink
	`TURQuoise`	Turquoise
	`LPURple`	Light purple
	`PURPle`	Purple

18.7.4.1 General settings

DISPlay:ANNotation:CLEar

Removes all existing annotations.

Usage: Setting only
Asynchronous command

DISPlay:ANNotation:COLor<m>:CATalog?

Returns the list of possible colors, see Color catalog for annotations.

Suffix:
<m> Irrelevant, omit the suffix.

Return values:
<ColorCatalog> String parameter, comma-separated values

Usage: Query only
Asynchronous command

DISPlay:ANNotation:TRANsparency <Transparency>

Sets a transparency of all annotations. For high transparency values, you can see the waveform display in the background. For lower transparency values, readability of the annotation improves.

Parameters:
<Transparency> Range: 0 to 90
Increment: 1
*RST: 0

Usage: Asynchronous command

18.7.4.2 Rectangle

DISPlay:ANNotation:RECTangle<m>:CLEar

Deletes all rectangle annotations.

Suffix:
<m> Irrelevant, omit the suffix.

Usage: Setting only
Asynchronous command

DISPlay:ANNotation:RECTangle<m>:COLor <Type>

Sets the color of the indicated rectangle annotation.

Suffix:
<m> 1 to <number of rectangle annotations>
Index of the rectangle annotation

Parameters:
<Type> WHITe | LGRay | MGRay | GRAY | DGRay | RED | DORange | ORANge | LORange | YELLow | DAGReen | GREen | LIGReen | LBLue | BLUE | PINK | LPINk | TURQuoise | LPURple | PURPle

See Color catalog for annotations.

Usage: Asynchronous command

DISPlay:ANNotation:RECTangle<m>:HEIGht <Height>

Sets the height (vertical size) of the rectangle annotation.

Suffix:
<m> 1 to <number of rectangle annotations>
Index of the rectangle annotation

Parameters:
<Height> In % of the screen.

Range: 0 to 100
Increment: 1
0 results in an invisible rectangle, 100 takes the complete height of the screen.

Usage: Asynchronous command

DISPlay:ANNotation:RECTangle<m>:HORizontal:POSition <HorizontalPos>

Sets the horizontal position of the left edge of the rectangle annotation. See also Defining the position of the annotation.

Suffix:
<m> 1 to <number of rectangle annotations>
Index of the rectangle annotation

Parameters:
<HorizontalPos> In % of the screen
Range: 0 to 99

Usage: Asynchronous command

DISPlay:ANNotation:RECTangle<m>:REMove

Removes the specified rectangle annotation from the screen.

Suffix:
<m> 1 to <number of rectangle annotations>
Index of the rectangle annotation

Usage: Setting only
Asynchronous command

DISPlay:ANNotation:RECTangle<m>:VERTical:POSition <VerticalPos>

Sets the vertical position of the lower edge of the rectangle annotation. See also Defining the position of the annotation.

Suffix:
<m> 1 to <number of rectangle annotations>
Index of the rectangle annotation

Parameters:
<VerticalPos> In % of the screen
Range: 0 to 99

Usage: Asynchronous command

DISPlay:ANNotation:RECTangle<m>:WIDTh <Width>

Sets the width (horizontal size) of the rectangle annotation.

Suffix:
<m> 1 to <number of rectangle annotations>
Index of the rectangle annotation

Parameters:

<Width> In % of the screen

Range: 0 to 100
Increment: 1
0 results in an invisible rectangle, 100 takes the complete width of the screen.

Usage: Asynchronous command

DISPlay:ANNotation:RECTangle<m>[:VALue] [<HorizontalPos>],[<VerticalPos>],[<Width>],[<Height>]

Adds a new rectangle annotation, or replaces the annotation if it already exists. If no parameters are defined, the default values are used.

All parameters are given in % of the screen.

Suffix:

<m> *
Index of the created rectangle annotation

Parameters:

<HorizontalPos> Range: 0 to 99

<VerticalPos> Range: 0 to 99

<Width> Range: 0 to 100

<Height> Range: 0 to 100

Usage: Asynchronous command

18.7.4.3 Arrow

DISPlay:ANNotation:ARRow<m>:CLEar

Deletes all arrow annotations.

Suffix:

<m> Irrelevant, omit the suffix.

Usage: Setting only
Asynchronous command

DISPlay:ANNotation:ARRow<m>:COLor <Type>

Sets the color of the indicated arrow annotation.

Suffix:

<m> 1 to <number of arrow annotations>
Index of the arrow annotation

Parameters:

<Type> WHITe | LGRay | MGRay | GRAY | DGRay | RED | DORange | ORANge | LORange | YELLow | DAGReen | GREen | LIGReen | LBLue | BLUE | PINK | LPINk | TURQuoise | LPURple | PURPle

See Color catalog for annotations.

Usage: Asynchronous command

DISPlay:ANNotation:ARRow<m>:DIRection <Type>

Sets the direction of the indicated arrow annotation from strating point to arrow tip.

Suffix:

<m> 1 to <number of arrow annotations>
Index of the arrow annotation

Parameters:

<Type> TLEFt | TRIGht | BLEFt | BRIGht

`TLEFt`: to top left
`TRIGht`: to top right
`BLEFt`: to bottom left
`BRIGht`: to bottom right

Usage: Asynchronous command

DISPlay:ANNotation:ARRow<m>:HEIGht <Height>

Sets the height (vertical size) of the arrow annotation.

Suffix:

<m> 1 to <number of arrow annotations>
Index of the arrow annotation

Parameters:

<Height> In % of the screen.

Range: 0 to 100
Increment: 1
0 results in an invisible rectangle, 100 takes the complete height of the screen.

Usage: Asynchronous command

DISPlay:ANNotation:ARRow<m>:HORizontal:POSition <HorizontalPos>

Sets the horizontal position of the left point of the arrow annotation. See also Defining the position of the annotation.

Suffix:

<m>	1 to <number of arrow annotations> Index of the arrow annotation

Parameters:

<HorizontalPos>	In % of the screen Range: 0 to 99

Usage: Asynchronous command

DISPlay:ANNotation:ARRow<m>:REMove

Removes the specified arrow annotation from the screen.

Suffix:

<m>	1 to <number of arrow annotations> Index of the arrow annotation

Usage: Setting only
Asynchronous command

DISPlay:ANNotation:ARRow<m>:VERTical:POSition <VerticalPos>

Sets the vertical position of the lower point of the arrow annotation. See also Defining the position of the annotation.

Suffix:

<m>	1 to <number of arrow annotations> Index of the arrow annotation

Parameters:

<VerticalPos>	In % of the screen Range: 0 to 99

Usage: Asynchronous command

DISPlay:ANNotation:ARRow<m>:WIDTh <Width>

Sets the width (horizontal size) of the arrow annotation.

Suffix:

<m>	1 to <number of arrow annotations> Index of the arrow annotation

Parameters:

<Width> In % of the screen

Range: 0 to 100
Increment: 1
0 results in an invisible rectangle, 100 takes the complete width of the screen.

Usage: Asynchronous command

DISPlay:ANNotation:ARRow<m>[:VALue] [<HorizontalPos>],[<VerticalPos>], [<Width>],[<Height>]

Adds a new arrow annotation, or replaces the annotation if it already exists. If no parameters are defined, the default values are used.

All parameters are given in % of the screen.

Suffix:

<m> *
Index of the created arrow annotation

Parameters:

<HorizontalPos> Range: 0 to 99

<VerticalPos> Range: 0 to 99

<Width> Range: 0 to 100

<Height> Range: 0 to 100

Usage: Asynchronous command

18.7.4.4 Text

DISPlay:ANNotation:TEXT<m>:CLEar

Deletes all text annotations.

Suffix:

<m> Irrelevant, omit the suffix.

Usage: Setting only
Asynchronous command

DISPlay:ANNotation:TEXT<m>:COLor <Type>

Sets the color of the indicated text annotation.

Suffix:

<m>	1 to <number of text annotations> Index of the text annotation

Parameters:

<Type>	WHITe | LGRay | MGRay | GRAY | DGRay | RED | DORange | ORANge | LORange | YELLow | DAGReen | GREen | LIGReen | LBLue | BLUE | PINK | LPINk | TURQuoise | LPURple | PURPle See Color catalog for annotations.

Usage: Asynchronous command

DISPlay:ANNotation:TEXT<m>:FONTsize <Fontsize>

Sets the font size of the text.

Suffix:

<m>	1 to <number of text annotations> Index of the text annotation

Parameters:

<Fontsize>	Range: 12 to 30 Default unit: px

Usage: Asynchronous command

DISPlay:ANNotation:TEXT<m>:HORizontal:POSition <HorizontalPos>

Sets the horizontal position of the left edge of the text annotation. See also Defining the position of the annotation.

Suffix:

<m>	1 to <number of text annotations> Index of the text annotation

Parameters:

<HorizontalPos>	In % of the screen Range: 0 to 99

Usage: Asynchronous command

DISPlay:ANNotation:TEXT<m>:REMove

Removes the specified text annotation from the screen.

Suffix:

<m>	1 to <number of text annotations> Index of the text annotation

Usage: Setting only
Asynchronous command

DISPlay:ANNotation:TEXT<m>:VERTical:POSition <VerticalPos>

Sets the vertical position of the lower edge of the text annotation. See also Defining the position of the annotation.

Suffix:
<m> 1 to <number of text annotations>
Index of the text annotation

Parameters:
<VerticalPos> In % of the screen
Range: 0 to 99

Usage: Asynchronous command

DISPlay:ANNotation:TEXT<m>[:VALue] [<Text>]

Adds a new text annotation or replaces the text value of an already existing text annotation.

Suffix:
<m> *
Index of the created text annotation

Parameters:
<Text> String with the annotation text

Usage: Asynchronous command

18.7.4.5 Draw

DISPlay:ANNotation:PLINe<m>:CLEar

Deletes all draw annotations.

Suffix:
<m> Irrelevant, omit the suffix.

Usage: Setting only
Asynchronous command

DISPlay:ANNotation:PLINe<m>:COLor <Type>

Sets the color of the indicated draw annotation.

Suffix:

<m> 1 to <number of draw annotations>
Index of the drawn annotation.

Parameters:

<Type> WHITe | LGRay | MGRay | GRAY | DGRay | RED | DORange | ORANge | LORange | YELLow | DAGReen | GREen | LIGReen | LBLue | BLUE | PINK | LPINk | TURQuoise | LPURple | PURPle

See Color catalog for annotations.

Usage: Asynchronous command

DISPlay:ANNotation:PLINe<m>:EXTend [<x>],[<y>]

Expands the draw item with a segment. The x and y position of the existing end point is the start point of the new segment. The segments are always a straight lines.

Suffix:

<m> 1 to <number of draw annotations>
Index of the draw annotation

Setting parameters:

<x> Horizontal position of the end point of the new segment

<y> Vertical position of the end point of the new segment

Usage: Setting only
Asynchronous command

DISPlay:ANNotation:PLINe<m>:REMove

Removes the specified draw annotation from the screen.

Suffix:

<m> 1 to <number of draw annotations>
Index of the draw annotation

Usage: Setting only
Asynchronous command

DISPlay:ANNotation:PLINe<m>[:VALue] <x1>,<y1>,<x2>,<y2>,[<xn>]

Adds a new draw annotation, or replaces the annotation if it already exists. If no parameters are defined, the default values are used.

All parameters are given in % of the screen.

Suffix:

<m> *
Index of the created draw annotation

Parameters:

<x1>	Horizontal position of the start point of the new line
<y1>	Vertical position of the start point of the new line
<x2>	Horizontal position of the endpoint of the new line
<y2>	Vertical position of the endpoint of the new line
<xn>	Vertical or horizontal position of extension points. For each point, you need two values, first the horizontal and second the vertical value. All values are separated by commas.

Usage: Asynchronous command

18.7.5 Appearance

18.7.5.1 Waveform colors

DISPlay:COLor:SIGNal:CATalog?

Returns a list of valid signal names. The signal names are needed in other DISPlay:COLor commands to set the <Signal> parameter.

Return values:

<Signals> Comma-separated list of signal names, see Section 18.3.1, "Waveform parameter", on page 803

Usage: Query only
Asynchronous command

DISPlay:COLor:SIGNal:COLor <Signal>,<Value>
DISPlay:COLor:SIGNal:COLor? <Signal>

Sets the color of the selected waveform.

Parameters:

<Value> Decimal value of the ARGB color. Use the color dialog box on the instrument to get the hex value of the color, and convert the hex value to a decimal value.
0 is fully transparent black.
4278190080 (dec) = FF000000 (hex) is opaque black.

4294967295 (dec) = FFFFFFFF (hex) is opaque white.
To reset the color to its default, use `DISPlay:COLor:SIGNal:COLor <Signal>,DEF`.

Parameters for setting and query:

<Signal> Signal name as returned by `DISPlay:COLor:SIGNal:CATalog?`.

Usage: Asynchronous command

Manual operation: See "Color" on page 96

DISPlay:COLor:SIGNal:ASSign <Signal>,<ColorTable>
DISPlay:COLor:SIGNal:ASSign? <Signal>

Assigns a color table to the source waveform instead of a dedicated color.

Parameters:

<ColorTable> String with the name of the color table.
Valid values are: `"FalseColors"`, `"Spectrum"`, `"SingleEvent"` and `"Temperature"`.

Parameters for setting and query:

<Signal> Signal name as returned by `DISPlay:COLor:SIGNal:CATalog?`.

Usage: Asynchronous command

Manual operation: See "Assigned color table" on page 96

DISPlay:COLor:SIGNal:USE <Signal>,<State>
DISPlay:COLor:SIGNal:USE? <Signal>

If enabled, the selected waveform is displayed according to its assigned color table.

If disabled, the selected color is displayed, and the intensity of the signal color varies according to the cumulative occurrence of the values.

The setting is not available for digital channels and parallel buses.

Parameters:

<State> OFF | ON

Parameters for setting and query:

<Signal> NONE | C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | FGAin | FAMPlitude | FPHase | FREF1 | FREF2 | FREF3 | FREF4 | HISTogram1 | HISTogram2 | HISTogram3 | HISTogram4 | HISTogram5 | HISTogram6 | HISTogram7 | HISTogram8 | M1 | M2 | M3 | M4 | M5 | M6 | M7 | M8 | TRK1 | TRK2 | TRK3 | TRK4 | TRK5 | TRK6 | TRK7 | TRK8 | TRK9 | TRK10 | TRK11 | TRK12 | TRK13 | TRK14 | TRK15 | TRK16 | TRK17 | TRK18 | TRK19 | TRK20 | TRK21 | TRK22 | TRK23 | TRK24 | PBUS1 | PBUS2 | PBUS3 | PBUS4 | PA1QPOWER1 | PA2QPOWER1 | PA3QPOWER1 | PA4QPOWER1 | PA5QPOWER1 | PA6QPOWER1 | PA1HPOWER1 | PA2HPOWER1 | PA3HPOWER1 | PA4HPOWER1 | PA5HPOWER1 | PA6HPOWER1 | PA1SPOWER1 | PA2SPOWER1 | PA3SPOWER1 | PA4SPOWER1 | PA5SPOWER1 | PA6SPOWER1 | PA1IPOWER | PA2IPOWER | PA3IPOWER | PA4IPOWER | PA5IPOWER | PA6IPOWER | PA1OPOWER1 | PA2OPOWER1 | PA3OPOWER1 | PA4OPOWER1 | PA5OPOWER1 | PA6OPOWER1 | PA1OPOWER2 | PA2OPOWER2 | PA3OPOWER2 | PA4OPOWER2 | PA5OPOWER2 | PA6OPOWER2 | PA1OPOWER3 | PA2OPOWER3 | PA3OPOWER3 | PA4OPOWER3 | PA5OPOWER3 | PA6OPOWER3 | PA1TOPOWER | PA2TOPOWER | PA3TOPOWER | PA4TOPOWER | PA5TOPOWER | PA6TOPOWER | PA1TOPOWER | PA2TOPOWER | PA3TOPOWER | PA4TOPOWER | PA5TOPOWER | PA6TOPOWER | PA1SOA | PA2SOA | PA3SOA | PA4SOA | PA5SOA | PA6SOA | R1 | R2 | R3 | R4 | R5 | R6 | R7 | R8 | DREF0 | DREF1 | DREF2 | DREF3 | DREF4 | DREF5 | DREF6 | DREF7 | DREF8 | DREF9 | DREF10 | DREF11 | DREF12 | DREF13 | DREF14 | DREF15 | SBUS1 | SBUS2 | SBUS3 | SBUS4 | SPECAVER1 | SPECAVER2 | SPECAVER3 | SPECAVER4 | SPECMAXH1 | SPECMAXH2 | SPECMAXH3 | SPECMAXH4 | SPECMINH1 | SPECMINH2 | SPECMINH3 | SPECMINH4 | SPECNORM1 | SPECNORM2 | SPECNORM3 | SPECNORM4 | XY1 | XY2 | XY3 | XY4 | O2C1 | O2C2 | O2C3 | O2C4 | O2C5 | O2C6 | O2C7 | O2C8 | O2R1 | O2R2 | O2R3 | O2R4 | O2R5 | O2R6 | O2R7 | O2R8 | TREF1 | TREF2 | TREF3 | TREF4 | TREF5 | TREF6 | TREF7 | TREF8 | EYE1 | EYE2 | EYE3 | EYE4 | EYE5 | EYE6 | EYE7 | EYE8

Signal name as returned by `DISPlay:COLor:SIGNal:CATalog?`.

Usage: Asynchronous command

Manual operation: See "Use color table" on page 95

18.7.5.2 Grid appearance

DISPlay:DIAGram:CROSshair <Crosshair>

If selected, a crosshair is displayed in the diagram area. A crosshair allows you to select a specific data point by its coordinates.

Parameters:
<Crosshair> OFF | ON
*RST: ON

Usage: Asynchronous command

Manual operation: See "Show crosshair" on page 98

DISPlay:DIAGram:FINegrid <ShowFineScale>

If selected, the crosshair is displayed as a ruler with scale markers. If disabled, the crosshair is shown as dashed lines.

Parameters:
<ShowFineScale> OFF | ON
*RST: ON

Usage: Asynchronous command

Manual operation: See "Show fine grid scale" on page 98

DISPlay:DIAGram:GRID <Show>

If selected, a grid is displayed in the diagram area. A grid helps you associate a specific data point to its exact value on the x- or y-axis.

Parameters:
<Show> OFF | ON
*RST: ON

Usage: Asynchronous command

Manual operation: See "Show grid" on page 98

DISPlay:DIAGram:LABels <ShowLabels>

If selected, labels mark values on the x- and y-axes in specified intervals in the diagram.

Parameters:

<ShowLabels>	OFF | ON *RST: ON

Usage: Asynchronous command

Manual operation: See "Show labels" on page 98

DISPlay:DIAGram:XFIXed <XGridFixed>

If enabled, the vertical grid lines remain in their position when the horizontal position is changed. Only the values at the grid lines are adapted.

Parameters:

<XGridFixed>	OFF | ON *RST: OFF

Usage: Asynchronous command

Manual operation: See "Keep X-grid fixed" on page 99

DISPlay:DIAGram:YFIXed <YGridFixed>

If enabled, the horizontal grid lines remain in their position when the position of the curve is changed. Only the values at the grid lines are adapted.

Fixed horizontal grid lines correspond to the behavior of traditional oscilloscopes.

Parameters:

<YGridFixed>	OFF | ON *RST: ON

Usage: Asynchronous command

Manual operation: See "Keep Y-grid fixed" on page 99

18.7.5.3 Dialog appearance

DISPlay:DIALog:FONTsize <DialogFontSize>

Sets the font size of the text in dialog boxes.

Parameters:

<DialogFontSize>	Range: 16 to 25 Increment: 1 *RST: 21

Usage: Asynchronous command

Manual operation: See "Font size (Dialog)" on page 99

DISPlay:DIALog:TRANsparency <DialogTransp>

Sets the transparency of the dialog box background. For high transparency values, you can see the waveform display in the background, and possibly check the effect of the changed setting. For lower transparency values, readability in the dialog box improves.

Parameters:

<DialogTransp> Range: 0 to 70
Increment: 1
*RST: 0

Usage: Asynchronous command

Manual operation: See "Transparency (Dialog)" on page 100

DISPlay:RESult:FONTsize <ResultFontSize>

Sets the font size of the text in result tables.

Parameters:

<ResultFontSize> Range: 16 to 25
Increment: 1
*RST: 21

Usage: Asynchronous command

Manual operation: See "Font size (Result dialog)" on page 100

18.7.5.4 Peak list appearance

CALCulate:SPECtrum<sp>:PLISt:LABel:BORDer <LabelBorder>

Defines the layout of the labels, full border or none.

Suffix:

<sp> 1...4, index of the spectrum

Parameters:

<LabelBorder> NOBorder | FULL

`FULL`: Full border

*RST: FULL

Usage: Asynchronous command

Manual operation: See "Frame type" on page 100

18.7.6 Display

18.7.6.1 Persistence

DISPlay:PERSistence:INFinite <State>

If infinite persistence is enabled, each new waveform point remains on the screen until this option is disabled. Use infinite persistence to display rare events in the signal.

Parameters:

<State> OFF | ON

*RST: OFF

Usage: Asynchronous command

Manual operation: See "Infinite persistence" on page 102

DISPlay:PERSistence:RESet

Resets the display, removing persistent all waveform points.

Usage: Setting only
Asynchronous command

Manual operation: See "Reset" on page 102

DISPlay:PERSistence:TIME <Time>

Sets a time factor that controls how long the waveforms points fade away from the display. Thus, the MXO 4 emulates the persistence of analog phosphor screens.

Parameters:

<Time> Range: 0.05 to 50
Increment: 0.05
*RST: 0.05
Default unit: s

Usage: Asynchronous command

Manual operation: See "Time" on page 102

DISPlay:PERSistence[:STATe] <State>

If enabled, each new data point in the diagram area remains on the screen for the duration defined using `DISPlay:PERSistence:TIME`, or as long as `DISPlay:PERSistence:INFinite` is enabled.

If disabled, the signal value is only displayed as long as it actually occurs.

Parameters:

<State> OFF | ON

*RST: ON

Usage: Asynchronous command

Manual operation: See "Enable" on page 102

18.7.6.2 Signal

DISPlay:INTensity <Intensity>

The intensity determines the strength of the waveform line in the diagram. Enter a percentage between 0 (not visible) and 100% (strong). The default value is 50%.

Parameters:

<Intensity> Range: 0 to 100
Increment: 1
*RST: 50
Default unit: %

Usage: Asynchronous command

Manual operation: See "Intensity" on page 103

DISPlay:DIAGram:STYLe <Style>

Selects the style in which the waveform is displayed.

Parameters:

<Style> VECTors | DOTS

VECTors
The individual data points are connected by a line.

DOTS
Only the individual data points are displayed.

*RST: VECTors

Usage: Asynchronous command

Manual operation: See "Waveform style" on page 103

18.7.6.3 Backlight

DISPlay:BACKlight[:BRIGtness] <LCDIntensity>

Sets the background luminosity of the touchscreen.

Parameters:

<LCDIntensity> Range: 5 to 100
Increment: 1
*RST: 90
Default unit: %

Usage: Asynchronous command

Manual operation: See "Brightness" on page 104

DISPlay:BACKlight:DIMMing <InactiveTime>

Selects a time, after which the monitor brightness is reduced, if the instrument was inactive. Remote control of the instrument is also considered as an activity.

Parameters:

<InactiveTime> OFF | T1Minute | T2Minutes | T3Minutes | T5Minutes | T10Minutes | T15Minutes | T20Minutes | T25Minutes | T30Minutes | T45Minutes | T1Hour | T2Hours | T3Hours | T4Hours
*RST: OFF

Usage: Asynchronous command

Manual operation: See "Dimm on user inactivity" on page 104

18.7.6.4 Clear results

DISPlay:CLR

Deletes all measurement results including all waveforms and statistics.

Usage: Setting only
Asynchronous command

Manual operation: See "Clear" on page 67

18.7.7 Save/Recall

18.7.7.1 Autonaming

MMEMory:AUTonaming:PREFix <MainNmeStemSt>
MMEMory:AUTonaming:TIME <DateTime>
MMEMory:AUTonaming:INDex <NameIndex>

Includes or excludes the prefix/ date/time /index in the filename pattern for automatic filename generation. This name is used as the default filename.

The prefix indicates the type of data that is saved, for example, RefCurve, Settings.

Parameters:
<NameIndex> OFF | ON
*RST: ON

Usage: Asynchronous command

Manual operation: See "Index" on page 115

MMEMory:AUSave:ENABle <EnableAutosave>

Enables the automatic saving of the waveform. You can set the autosave interval with `MMEMory:AUSave:INTerval`.

Parameters:
<EnableAutosave> OFF | ON
*RST: ON

Usage: Asynchronous command

Manual operation: See "Enable autosave" on page 115

MMEMory:AUSave:INTerval <AutosaveIntvl>

Defines the time interval for the automatic saving of the waveform, if `MMEMory:AUSave:ENABle` is set to `ON`.

Parameters:

<AutosaveIntvl> Range: 1 to 360000
Increment: 1
*RST: 300
Default unit: s

Usage: Asynchronous command

Manual operation: See "Enable autosave" on page 115

MMEMory:AUTonaming:USERtext <State>

If enabled, inserts the specified user text after the prefix.

You can define the text with `MMEMory:AUTonaming:TEXT`.

Parameters:

<State> OFF | ON
*RST: OFF

Usage: Asynchronous command

Manual operation: See "User text" on page 114

MMEMory:AUTonaming:DEFaultpath <Path>

Sets the path where data and settings files are stored. On the instrument, all user data is written to `/home/storage/userData`. You can create subfolders in this folder.

Parameters:

<Path> String parameter

Usage: Asynchronous command

Manual operation: See "Default path for all file operations" on page 115

MMEMory:AUTonaming:RESall

Resets all autonaming settings to the default value, including the path.

Usage: Setting only
Asynchronous command

Manual operation: See "Reset path" on page 115

MMEMory:AUTonaming:RESPath

Resets the path for file operations to the factory default path.

Usage: Setting only
Asynchronous command

Manual operation: See "Reset path" on page 115

MMEMory:AUTonaming:TEXT <NameString>

Defines a text that can be included in the autonaming pattern.

Parameters:

<NameString> String parameter

Usage: Asynchronous command

Manual operation: See "User text" on page 114

18.7.8 Preset

USERdefined:PRESet:NAME <Name>

Sets the path, the filename and the file format of the preset file.

Parameters:

<Name> String with path and file name with extension `.set`.

Example:

```
USERdefined:PRESet:NAME '/home/storage/userData/
settings/Preset_SPI.set'
```

Manual operation: See "Preset file selection" on page 107

USERdefined:PRESet:OPEN

Opens and loads the preset file that is defined with `USERdefined:PRESet:NAME`.

Usage: Event

Manual operation: See "Preset file selection" on page 107

USERdefined:PRESet:SAVE

Saves the the current settings as a preset file. You define the storage location and filename with `USERdefined:PRESet:NAME`.

Usage: Event

Manual operation: See "Select, Save" on page 107

USERdefined:PRESet[:ENABle] <Name>

If enabled, the settings from the selected saveset are restored when the [Preset] key is pressed.

If disabled, [Preset] sets the instrument to the factory defaults.

The saveset to be used as preset file is defined with USERdefined:PRESet:NAME.

Parameters:

<Name> OFF | ON

*RST: OFF

Manual operation: See "Enable user-defined preset" on page 106

18.7.9 Maintenance

Use also:

- *CAL? on page 810
- *TST? on page 813

CALibration[:ALL]

Calibration:ALL starts the self-alignment process without returning status information. To get the status, use the commands of the operation status register.

Calibration:ALL? starts the self-alignment process and returns information on the state of the self-alignment. (Same as *CAL?).

The process can take several minutes. Consider your timeout settings.

Return values:

<Result> Numeric status indicator. Return values ≠ 0 indicate an error.

Usage: Asynchronous command

CALibration:DATE?

Returns the date of the last self-alignment.

Return values:

<Date>

Usage: Query only
Asynchronous command

Manual operation: See "Date, Time, Overall alignment state" on page 110

CALibration:TIME?

Returns the time of the last self-alignment.

Return values:
<Time>

Usage: Query only
Asynchronous command

Manual operation: See "Date, Time, Overall alignment state" on page 110

CALibration:RESult?

Returns the result of the last self-alignment and the current alignment status. In remote mode, `*CAL?` provides more detailed information.

Return values:
<ResultState> PASSed | FAILed | NOALigndata
*RST: FAILed

Usage: Query only
Asynchronous command

Manual operation: See "Date, Time, Overall alignment state" on page 110

SERVice:REPort

Creates a service report.

The service report is a ZIP file with a complete bug report, all relevant setup information, reporting and log files, alignment files, and the instrument configuration.

If a USB flash drive is connected, the report is saved on the USB flash drive. Otherwise, the report is saved in the user data folder `/home/storage/userData`.

Usage: Event
Asynchronous command

Manual operation: See "Create report" on page 113

SYSTem:APUP <AutoPowerUp>

If enabled, the instrument powers up automatically when it is connected to the mains voltage.

Parameters:
<AutoPowerUp> OFF | ON
*RST: ON

Usage: Asynchronous command

Manual operation: See "Auto power up" on page 112

18.8 Acquisition and waveform setup

18.8.1 Starting and stopping acquisition

Use the following commands to start and stop acquisitions.

RUNCont
RUN

Starts the continuous acquisition.

Usage: Setting only
Asynchronous command

Manual operation: See "[Run / Stop]" on page 45

RUNSingle
SINGle

Starts a defined number of acquisition cycles. The number of cycles is set with `ACQuire:COUNt`.

Usage: Setting only
Asynchronous command

Manual operation: See "[Single]" on page 45

STOP

Stops the running acquisition.

Usage: Event
Asynchronous command

Manual operation: See "[Run / Stop]" on page 45

18.8.2 Horizontal setup

AUToscale

Performs an autoset process: analyzes the enabled channel signals, and obtains appropriate horizontal, vertical, and trigger settings to display stable waveforms.

Rohde & Schwarz does not recommend using the autoset in remote control. To adjust the oscilloscope remotely, especially for automated testing applications, use the remote commands that adjust the horizontal, vertical and trigger settings.

Usage: Event
Asynchronous command

TIMebase:SCALe <TimebaseScale>

Sets the horizontal scale, the time per division, for all waveforms in the time domain, for example, channel and math waveforms.

Parameters:

<TimebaseScale> Range: 200E-12 to 10E+3
Increment: 1E-12
*RST: 20E-9
Default unit: s/div

Usage: Asynchronous command

Manual operation: See "[Scale]" on page 46

TIMebase:RANGe <TimebaseRange>

Sets the time of one acquisition, which is the time across the 10 divisions of the diagram: *Acquisition time = Time scale * 10 divisions*.

Parameters:

<TimebaseRange> Range: 2E-9 to 100E+3
Increment: 1E-12
*RST: 200E-9
Default unit: s

Usage: Asynchronous command

Manual operation: See "Timebase range" on page 118

TIMebase:DIVisions?

Returns the number of horizontal divisions on the screen. The number cannot be changed.

Return values:

<HorizDivCnt> *RST: 10

Usage: Query only
Asynchronous command

TIMebase:HORizontal:POSition <Position>

Defines the time distance between the reference point and the trigger point, which is the zero point of the diagram. The horizontal position is also known as trigger offset.

Parameters:
<Position> Range: -159.99E-3 to 1E+26
Increment: 1E-12
*RST: 0
Default unit: s

Usage: Asynchronous command

Manual operation: See "[Position]" on page 46

TIMebase:REFerence <RescaleCtrPos>

Sets the position of the reference point in % of the screen. It defines which part of the waveform is shown.

Parameters:
<RescaleCtrPos> Range: 0 to 100
Increment: 1
*RST: 50
Default unit: %

Usage: Asynchronous command

Manual operation: See "Reference point" on page 119

18.8.3 Roll mode

TIMebase:ROLL:ENABle <Mode>

Selects, if the roll mode is started automatically by the instrument or if it is turned off.

Parameters:
<Mode> AUTO | OFF
*RST: AUTO

Usage: Asynchronous command

Manual operation: See "Mode" on page 120

TIMebase:ROLL:MTIMe <MinAcquTime>

Sets the minimum acquisition time for the automatic start of the roll mode.

Parameters:

<MinAcquTime> Range: 0.5 to 100000
Increment: 1
*RST: 2
Default unit: s

Usage: Asynchronous command

Manual operation: See "Start roll time" on page 120

ACQuire:ROLLmode:OSCapture <OffScreenCapture>

If enabled, the analyzable waveform in roll mode is extended. You can run the roll mode, stop the acquisition after some time, and analyze the data that is on the display and in the unvisible area on the left.

Parameters:

<OffScreenCapture> OFF | ON
*RST: OFF

Example: See Section 18.4.4, "Data transfer in roll mode", on page 809.

Usage: Asynchronous command

Manual operation: See "Off screen capture" on page 121

ACQuire:ROLLmode:POINts?

Returns the record length of the roll mode. In roll mode, the complete record is always captured, independently of the displayed waveform.

To process and analyze the complete roll waveform, enable `ACQuire:ROLLmode:OSCapture`.

Return values:

<RecordLength> Range: 0 to 18446744073709551615
Increment: 1
*RST: 0
Default unit: pts

Usage: Query only
Asynchronous command

Manual operation: See "Off screen capture" on page 121

TIMebase:ROLL:STATe?

Returns the status of the roll mode.

Return values:

<State> OFF | ON

*RST: OFF

Usage: Query only
Asynchronous command

Manual operation: See "Mode" on page 120

18.8.4 Acquisition setup

This section describes all remote commands for acquisition.

ACQuire:AVAilable?

Number of acquisitions that is saved in the memory and available for history viewing. It is also the number of acquisitions in a fast segmentation acquisition series.

Return values:

<AcquisitionCount> Range: 0 to 4294967295
Increment: 1
*RST: 0

Usage: Query only
Asynchronous command

Manual operation: See "Available acqs" on page 237

ACQuire:AVERage?

Returns the current number of acquired waveforms that contribute to the average.

Return values:

<CurrAverageCount>	Range:	0 to 4294967295
	Increment:	1
	*RST:	0

Usage: Query only
Asynchronous command

Manual operation: See "Current Average count" on page 128

ACQuire:COUNt <MaxAcqCnt>

Sets the acquisition and average count, which has a double effect:

- It sets the number of waveforms acquired with `RUNSingle`.
- It defines the number of waveforms used to calculate the average waveform.

Parameters:

<MaxAcqCnt>	Range:	1 to 16777215
	Increment:	1
	*RST:	1

Usage: Asynchronous command

Manual operation: See "N-single/Avg count" on page 127

ACQuire:CURRent?

Returns the current number of acquisitions that have been acquired.

Return values:

<CurrAcqCnt>	Range:	0 to 18446744073709551615
	Increment:	1
	*RST:	0

Usage: Query only
Asynchronous command

ACQuire:INTerpolate <IntpolMd>

Selects the interpolation method.

Parameters:

<IntpolMd> SINX | LINear | SMHD

LINear
Linear interpolation between two adjacent sample points

SINX
Interpolation with a sin(x)/x function.

SMHD
Sample/Hold causes a histogram-like interpolation.

*RST: SINX

Usage:	Asynchronous command
Manual operation:	See "Interpolation" on page 128

ACQuire:POINts[:VALue] <RecordLength>

Sets the record length, if ACQuire:POINts:MODE is set to MANual.

Parameters:

<RecordLength>	Range:	1000 to 800E+6
	Increment:	2
	*RST:	1000
	Default unit:	pts

Usage:	Asynchronous command
Manual operation:	See "Record length" on page 127

ACQuire:POINts:ARATe?

Returns the sample rate of the ADC, before waveform processing. The result is the interleaved sample rate or the non-interleaved one, depending on the channel usage.

Return values:

<ADCSampleRate>	Range:	5 Gsample/s (interleaved), 2,5 Gsample/s (non-interleaved)
	Default unit:	Hz

Usage:	Query only Asynchronous command

ACQuire:POINts:MAXimum <RecLengthLimit>

Sets the maximum record length, if ACQuire:POINts:MODE is set to AUTO.

Parameters:

<RecLengthLimit>	Range:	1000 to 800E+6
	Increment:	2
	*RST:	10E+6
	Default unit:	pts

Usage:	Asynchronous command
Manual operation:	See "Record length limit" on page 126

ACQuire:POINts:MODE <RecLengthMode>

Selects the mode of the waveform record length adjustment.

The record length is the number of waveform samples that are stored in one waveform record after processing, including interpolation. It determines the length of the displayed waveform.

Parameters:

<RecLengthMode> AUTO | MANual

AUTO
Record length is determined automatically and changes due to instrument internal adjustments.

MANual
The waveform record length is defined with `ACQuire:POINts[:VALue]`.

*RST: AUTO

Usage: Asynchronous command

Manual operation: See "RL mode" on page 126

ACQuire:POMemory?

The command returns 1 if the memory is not sufficient to process the data with the current settings. To solve the problem, reduce the record length or use automatic record length setting.

Return values:

<OutOfMemory> OFF | ON

*RST: OFF

Usage: Query only
Asynchronous command

Manual operation: See "Record length" on page 127

ACQuire:RESolution? [<MIN | MAX>]

Returns the current resolution.

The resolution is the time between two waveform samples in the waveform record. It considers the processing of the captured samples including interpolation. A fine resolution with low values produces a more precise waveform record. The resolution is the reciprocal of the sample rate.

You can query the minimum and maximum values with `<command>? MIN` and `<command>? MAX`.

Return values:

<Resolution>
Range: 1E-15 to 100
Increment: 1E-11
*RST: 200E-12
Default unit: s

Usage: Query only
Asynchronous command

Manual operation: See "Resolution" on page 127

ACQuire:RLReal?

Returns the internal record length used by the acquisition system.

Return values:

<HWRecordLength> Range: 2 to 4294967295
Increment: 1
*RST: 1000
Default unit: pts

Usage: Query only
Asynchronous command

ACQuire:SRATe[:VALue] <SampleRate>

Sets the number of waveform points per second if `ACQuire:SRATe:MODE` is set to MANual.

Parameters:

<SampleRate> Range: 2 to 5E+12
Increment: 1
*RST: 5E+9
Default unit: Sa/s

Usage: Asynchronous command

Manual operation: See "Sample rate" on page 126

ACQuire:SRATe:MINimum <SampleRateMin>

Sets the minimum sample rate if `ACQuire:SRATe:MODE` is set to `AUTO`.

Parameters:

<SampleRateMin> Range: 2 to 5E+12
Increment: 1
*RST: 2
Default unit: Sa/s

Usage: Asynchronous command

Manual operation: See "Min. sample rate" on page 126

ACQuire:SRATe:MODE <SampleRateMode>

Defines how the sample rate is set.

The sample rate considers the samples of the ADC, and the processing of the captured samples including interpolation.

Parameters:

<SampleRateMode> AUTO | MANual

AUTO
Sample rate is determined automatically and changes due to instrument internal adjustments. You can set a minimum sample rate with `ACQuire:SRATe:MINimum`.

MANual
The sample rate is defined with `ACQuire:SRATe[:VALue]`.

*RST: AUTO

Usage: Asynchronous command

Manual operation: See "SR mode" on page 126

ACQuire:SRReal? [<MIN | MAX>]

Returns the sample rate of the waveform after HW processing. Interpolation is not considered. This value is shown in the acquisition label above the diagram.

You can query the minimum and maximum values with `<command>? MIN` and `<command>? MAX`.

Return values:
<HWSampleRate>
Range: 2 to ADC sample rate
Increment: 1
*RST: 5E+9
Default unit: Sa/s

Usage: Query only
Asynchronous command

ACQuire:TYPE <AcquMode>

Sets how the waveform is built from the captured samples.

Parameters:
<AcquMode> SAMPle | PDETect | ENVelope | AVERage
*RST: SAMPle

Usage: Asynchronous command

Manual operation: See "Acquisition mode" on page 127

18.8.5 Vertical setup

The channel suffix <ch> selects the input channel that is affected by the command.

CHANnel<ch>:STATe <State>

Switches the selected channel signal on or off.

Suffix:
<ch> 1 to 4, index of the analog channel

Parameters:
<State> OFF | ON
*RST: OFF

Usage: Asynchronous command

Manual operation: See "[C<n>]" on page 47

CHANnel<ch>:SCALe <Scale>

Sets the vertical scale, which defines the displayed amplitude of the selected waveform.

Suffix:
<ch> 1 to 4, index of the analog channel

Parameters:
<Scale> Range: 0.001 to 1
Increment: 0.001
*RST: 0.05
Default unit: Depends on the connected probe

Usage: Asynchronous command

Manual operation: See "[Scale]" on page 48

CHANnel<ch>:RANGe <Range>

Sets the voltage range across the 10 vertical divisions of the diagram. The command is an alternative to `CHANnel<ch>:SCALe`.

Suffix:
<ch> 1 to 4, index of the analog channel

Parameters:
<Range> Range: 0.01 to 10
Increment: 0.01
*RST: 0.5
Default unit: V/div

Usage: Asynchronous command

CHANnel<ch>:OFFSet <Offset>

Sets the offset voltage, which corrects an offset-affected signal. The vertical center of the selected channel is shifted by the offset value and the signal is repositioned within the diagram.

Suffix:
<ch> 1 to 4, index of the analog channel

Parameters:
<Offset>
Range: -1 to 1
Increment: 0.01
*RST: 0
Default unit: V

Usage: Asynchronous command

Manual operation: See "[Position]" on page 48

CHANnel<ch>:POSition <Position>

Moves the selected signal up or down in the diagram. While the offset sets a voltage, position is a graphical setting given in divisions. The visual effect is the same as for offset.

Suffix:
<ch> 1 to 4, index of the analog channel

Parameters:
<Position> Positive values move up the waveform, negative values move it down.
Range: -5 to 5
Increment: 0.02
*RST: 0
Default unit: div

Usage: Asynchronous command

Manual operation: See "[Position]" on page 48

CHANnel<ch>:COUPling <Value>

Sets the connection of the channel signal, i.e. the input impedance (termination) and a filter (coupling). The command determines what part of the signal is used for waveform analysis and triggering.

Suffix:
<ch> 1 to 4, index of the analog channel

Parameters:
<Value> DC | DCLimit | AC

DC
Connection with 50 Ω termination, passes both DC and AC components of the signal.

DCLimit
Connection with 1 MΩ termination, passes both DC and AC components of the signal.

AC
Connection with 1 MΩ termination through DC capacitor, removes DC and very low-frequency components. The waveform is centered on zero volts.

Usage: Asynchronous command

Manual operation: See "Coupling" on page 135

CHANnel<ch>:INVert <InvertChannel>

Turns the inversion of the signal amplitude on or off. To invert means to reflect the voltage values of all signal components against the ground level.

Suffix:
<ch> 1 to 4, index of the analog channel

Parameters:
<InvertChannel> OFF | ON

ON: inverted waveform
OFF: normal waveform

*RST: OFF

Usage: Asynchronous command

Manual operation: See "Invert channel" on page 136

DISPlay:SIGNal:LABel <Signal>,<Label>
DISPlay:SIGNal:LABel? <Signal>

Defines and assigns a label to the specified channel waveform.

Parameters:
<Label> String with the waveform label

Parameters for setting and query:
<Signal> C1 | C2 | C3 | C4

Usage: Asynchronous command

Manual operation: See "Label" on page 136

CHANnel<ch>:SKEW:TIME <Offset>

Sets a skew value to compensate for the delay of the measurement setup or from the circuit specifics that the instrument cannot compensate automatically. It affects only the selected input channel.

Suffix:
<ch> 1 to 4, index of the analog channel

Parameters:
<Offset>
Range: -100E-9 to 100E-9
Increment: 1E-13
*RST: 0
Default unit: s

Usage: Asynchronous command

Manual operation: See "Skew" on page 136

CHANnel<ch>:BANDwidth <BandwidthLimit>

Sets the bandwidth limit. The specified bandwidth indicates the range of frequencies that the instrument can acquire and display accurately with less than 3 dB attenuation. Frequencies above the limit are removed from the signal, and noise is reduced.

Suffix:
<ch> 1 to 4, index of the analog channel

Setting parameters:
<BandwidthLimit> FULL | B2G | B1G5 | B1G | B700 | B500 | B350 | B200 | B100 | B50 | B20

FULL
Sets the bandwidth to the maximum bandwidth of the instrument. Bandwidth extension options are considered.

B700 | B500 | B350 | B200 | B100 | B50 | B20
Sets a bandwidth limit lower than the maximum. The number indicates the bandwidth limit in MHz.

B1G5 | B1G
Sets the bandwidth limit to 1500 MHz or 1000 MHz if these values are lower than the maximum.

Return values:
<Result> B2G | B1G5 | B1G | B700 | B500 | B350 | B200 | B100 | B50 | B20

Possible results, availability depends on the maximum bandwidth of the instrument and bandwidth extension options.

Usage: Asynchronous command

Manual operation: See "Bandwidth" on page 136

CHANnel<ch>:EATScale <ExtAttScl>

Sets the attenuation scale for an external divider: linear or logarithmic.

Suffix:

<ch>	1 to 4, index of the analog channel

Parameters:

<ExtAttScl>	LIN | LOG *RST: LIN

Usage: Asynchronous command

Manual operation: See "External Attenuation: Scale, Attenuation" on page 137

CHANnel<ch>:EATTenuation <ExtAtt>

Consider a voltage divider that is part of the DUT before the measuring point. The external attenuation is included in the measurement, and the instrument shows the results that would be measured before the divider. External attenuation can be used with all probes.

Suffix:

<ch>	1 to 4, index of the analog channel

Parameters:

<ExtAtt>	Values depend on the selected scale (`CHANnel<ch>:EATScale` on page 866) and the unit of the waveform. See "External Attenuation: Scale, Attenuation" on page 137. Limits below are for linear scale. Range: 0.005 to 1000000 Increment: 0.01 *RST: 1

Usage: Asynchronous command

Manual operation: See "External Attenuation: Scale, Attenuation" on page 137

CHANnel<ch>:IMPedance <Impedance>

Sets the impedance of the connected probe for power calculations and measurements.

Suffix:

<ch>	1 to 4, index of the analog channel

Parameters:

<Impedance>	Range: 0.1 to 100000 Increment: 1 *RST: 50 Default unit: Ω

Usage: Asynchronous command

Manual operation: See "Impedance" on page 138

18.8.6 Probes

This section describes all remote commands for probes.

18.8.6.1 Common probe settings

The probe suffix <ch> selects the input channel to which the probe is connected.

PROBe<ch>:SETup:ATTenuation[:AUTO]?

Returns the attenuation of a detected or predefined probe.

Suffix:

<ch> — 1 to 4, index of the analog channel

Return values:

<Attenuation>
Range: 0.001 to 1000
Increment: 0.1
*RST: 1
Default unit: V/V

Usage: Query only
Asynchronous command

Manual operation: See "Attenuation" on page 140

PROBe<ch>:SETup:ATTenuation:MANual <Attenuation>

Sets the attenuation for an unknown probe.

Suffix:
<ch> 1 to 4, index of the analog channel

Parameters:
<Attenuation> Range: 0.0001 to 10000
Increment: 0.1
*RST: 1
Default unit: V/V

Usage: Asynchronous command

Manual operation: See "Attenuation" on page 140

PROBe<ch>:SETup:ATTenuation:MODE <AttenuationMode>

Set the mode to MANual if the instrument does not detect the passive probe.

Suffix:
<ch> 1 to 4, index of the analog channel

Parameters:
<AttenuationMode> AUTO | MANual
*RST: AUTO

Usage: Asynchronous command

PROBe<ch>:SETup:ATTenuation:DEFProbe <PredefinedProbe>

Selects one of the predefined probes, or a user-defined probe.

Suffix:
<ch> 1 to 4, index of the analog channel

Parameters:
<PredefinedProbe> NONE | USER | ZC10 | ZC20 | ZC30 | ZD01A100 | ZD01A1000 | ZZ80 | ZS10L | ZD02 | ZD08 | ZC02100 | ZC021000 | ZC03 | ZD002A10 | ZD002A100 | ZD003A20 | ZD003A200 | ZC3110 | ZC311 | ZC3101 | ZH03 | ZP1X

USER
Probe is not detected and not known to the instrument. Set unit and attenuation manually.

ZC10 | ZC20 | ZC30 | ZC03
Current probes

ZD01A100 | ZD01A1000
High voltage differential probes, attenuation ratio according to the setting on the probe.
A100 = 100:1
A1000 = 1000:1

ZC02100 | ZC021000
Current probes 100 A/V or 1000 A/V according to the setting on the probe.

*RST: NONE

Usage: Asynchronous command

Manual operation: See "Predefined probe, name and type of the probe" on page 139

PROBe<ch>:SETup:ATTenuation:UNIT <Unit>

Returns the unit of the connected probe if the probe is detected or predefined. For unknown probes, you can select the required unit.

Suffix:
<ch> 1 to 4, index of the analog channel

Parameters:
<Unit> V | A | W

Voltage probe (V), current probe (A), power probe (W)

*RST: V

Usage: Asynchronous command

Manual operation: See "Vertical unit" on page 140

PROBe<ch>:SETup:BANDwidth?

Returns the bandwidth of the connected probe.

Suffix:
<ch> 1 to 4, index of the analog channel

Return values:
<Bandwidth> Range: 10000 to 20000000000
Increment: 10
*RST: 1500000000
Default unit: Hz

Usage: Query only
Asynchronous command

Manual operation: See "Probe bandwidth" on page 139

PROBe<ch>:SETup:OFFSet:TOMean

Compensates automatically for a DC component of the input signal using the result of a background mean measurement.

Suffix:
<ch> 1 to 4, index of the analog channel

Usage: Event
Asynchronous command

Manual operation: See "Set offset to mean" on page 140

PROBe<ch>:SETup:OFFSet:AZERo

Measures the zero error of the probe. Short the signal pin and the ground pin together, then send the command.

Suffix:
<ch> 1 to 4, index of the analog channel

Usage: Event
Asynchronous command

Manual operation: See "AutoZero, Use AutoZero" on page 140

PROBe<ch>:SETup:OFFSet:USEautozero <UseAutoZeroOffset>

Corrects the zero error of the probe. The zero error is detected with `PROBe<ch>:SETup:OFFSet:AZERo`.

Suffix:
<ch> 1 to 4, index of the analog channel

Parameters:
<UseAutoZeroOffset> OFF | ON
*RST: OFF

Example:
```
PROB2:SET:OFFS:AZER
PROB2:SET:OFFS:USE ON
```
Detects the zero error and uses it for correction.

Usage: Asynchronous command

Manual operation: See "AutoZero, Use AutoZero" on page 140

PROBe<ch>:SETup:NAME?

Queries the name of the probe.

Suffix:
<ch> 1 to 4, index of the analog channel

Return values:
<Name> Name string

Usage: Query only
Asynchronous command

Manual operation: See "Predefined probe, name and type of the probe" on page 139

PROBe<ch>:SETup:STATe?

Queries if the probe at the specified input channel is active (detected) or not active (not detected). To switch the probe on, use `CHANnel<ch>:STATe`.

Suffix:
<ch> 1 to 4, index of the analog channel

Return values:
<State> DETected | NDETected

*RST: NDETected

Usage: Query only
Asynchronous command

Manual operation: See "Predefined probe, name and type of the probe" on page 139

PROBe<ch>:SETup:TYPE?

Queries the class of the probe.

Suffix:
<ch> 1 to 4, index of the analog channel

Return values:
<Type> String containing the probe class, e.g. None (no probe detected), passive, current, active diff., active single-ended.

Usage: Query only
Asynchronous command

Manual operation: See "Predefined probe, name and type of the probe" on page 139

18.8.6.2 Settings for active voltage probes

The probe suffix <ch> selects the input channel to which the probe is connected.

PROBe<ch>:SETup:MODE <Mode>

The micro button is located on the probe head. Pressing this button, you initiate an action on the instrument directly from the probe. The button is disabled during internal automatic processes, for example, during self-alignment, autoset, and level detection.

Select the action that you want to start from the probe.

Suffix:
<ch> 1 to 4, index of the analog channel

Parameters:
<Mode> RCONtinuous | RSINgle | AUToset | AZERo | OTMean | SITFile | NOACtion | FTRiglevel | PRSetup

RCONtinuous
Run continuous: the acquisition is running as long as the probe button is pressed.

RSINgle
Run single: starts a defined number of acquisitions (same as [Single] key).

AUToset
Starts the autoset procedure.

AZERo
AutoZero: performs an automatic correction of the zero error.

OTMean
Set offset to mean: performs an automatic compensation for a DC component of the input signal.

SITFile
Save image to file: saves the display image in a file.

NOACtion
Nothing is started on pressing the micro button.

FTRiglevel
Sets the trigger level automatically to *0.5 * (MaxPeak – MinPeak)*. The function is not available for an external trigger source.

PRSetup
Opens the "Probes Setup" dialog box.

*RST: RCONtinuous

Usage: Asynchronous command

Manual operation: See "MicroButton" on page 142

PROBe<ch>:SETup:ACCoupling <ProbeCouplingAC>

Enables AC coupling in R&S RT-ZPR power rail probes, which removes DC and very low-frequency components. The R&S RT-ZPR probe requires 50 Ω input termination, for which the channel AC coupling is not available. The probe setting allows AC coupling also at 50 Ω inputs.

Suffix:
<ch> 1 to 4, index of the analog channel

Parameters:
<ProbeCouplingAC> OFF | ON
*RST: OFF

Usage: Asynchronous command

Manual operation: See "AC Coupling" on page 145

PROBe<ch>:SETup:CMOFfset <CMOffset>

Sets the common-mode offset to compensate for a common DC voltage that is applied to both input sockets (referenced to the ground socket). The setting is available for Rohde & Schwarz differential probes and for modular probes in CM measurement mode.

Suffix:
<ch> 1 to 4, index of the analog channel

Parameters:
<CMOffset> Range: -1E+26 to 1E+26
Increment: 0.001
*RST: 0
Default unit: V

Usage: Asynchronous command

Manual operation: See "CM offset" on page 144

PROBe<ch>:SETup:DISPlaydiff <DisplayDiff>

Selects the voltage to be measured by the R&S ProbeMeter of differential active probes:

Suffix:
<ch> 1 to 4, index of the analog channel

Parameters:
<DisplayDiff> DIFFerential | SINGleended

DIFFerential
Measures differential and common mode voltages

SINGleended
Measures the voltage between the positive/negative signal socket and the ground.

*RST: DIFFerential

Usage: Asynchronous command

Manual operation: See "Display" on page 144

PROBe<ch>:SETup:ZAXV <AttenuationZA15>

If you use the external attenuator R&S RT-ZA15 together with one of the differential active probes R&S RT-ZD10/20/30, enable "RT-ZA15 attenuator" to include the external attenuation in the measurements.

Suffix:

<ch>	1 to 4, index of the analog channel

Parameters:

<AttenuationZA15>	OFF | ON *RST: OFF
Usage:	Asynchronous command
Manual operation:	See "RT-ZA15 attenuator" on page 144

PROBe<ch>:PMETer:STATe <State>

Activates the integrated R&S ProbeMeter on probes with Rohde & Schwarz probe interface.

Suffix:

<ch>	1 to 4, index of the analog channel

Parameters:

<State>	OFF | ON *RST: OFF
Usage:	Asynchronous command
Manual operation:	See "ProbeMeter" on page 142

PROBe<ch>:PMETer:RESults:SINGle?

Returns the R&S ProbeMeter measurement result of single-ended active Rohde & Schwarz probes, the voltage measured between the probe tip and the ground.

Suffix:

<ch>	1 to 4, index of the analog channel

Return values:

<Result>	Range: -1E+26 to 1E+26 Increment: 0.001 *RST: 0 Default unit: V
Usage:	Query only Asynchronous command
Manual operation:	See "ProbeMeter" on page 142

PROBe<ch>:PMETer:RESults:COMMon?

Returns the R&S ProbeMeter measurement result of differential active R&S probes: the common mode voltage, which is the mean voltage between the signal sockets and the ground socket.

Suffix:
<ch> 1 to 4, index of the analog channel

Return values:
<Result> Range: -1E+26 to 1E+26
Increment: 0.001
*RST: 0
Default unit: V

Usage: Query only
Asynchronous command

Manual operation: See "ProbeMeter" on page 142

PROBe<ch>:PMETer:RESults:DIFFerential?

Returns the R&S ProbeMeter measurement result of differential active Rohde & Schwarz probes, the differential voltage - the voltage between the positive and negative signal sockets.

Suffix:
<ch> 1 to 4, index of the analog channel

Return values:
<Result> Range: -1E+26 to 1E+26
Increment: 0.001
*RST: 0
Default unit: V

Usage: Query only
Asynchronous command

Manual operation: See "ProbeMeter" on page 142

PROBe<ch>:PMETer:RESults:NEGative?

Returns the R&S ProbeMeter measurement result of differential active R&S probes, the voltage that is measured between the negative signal socket and the ground.

Suffix:
<ch> 1 to 4, index of the analog channel

Return values:
<Result> Range: -1E+26 to 1E+26
Increment: 0.001
*RST: 0
Default unit: V

Usage: Query only
Asynchronous command

Manual operation: See "ProbeMeter" on page 142

PROBe<ch>:PMETer:RESults:POSitive?

Returns the R&S ProbeMeter measurement result of differential active R&S probes: the voltage that is measured between the positive signal socket and the ground.

Suffix:
<ch> 1 to 4, index of the analog channel

Return values:
<Result> Range: -1E+26 to 1E+26
Increment: 0.001
*RST: 0
Default unit: V

Usage: Query only
Asynchronous command

Manual operation: See "ProbeMeter" on page 142

PROBe<ch>:SETup:ADVanced:AUDioverload <Sound>

Activates the acoustic overrange warning in the probe control box. The command is relevant for R&S RT-ZHD probes.

Suffix:
<ch> 1 to 4, index of the analog channel

Parameters:
<Sound> OFF | ON
*RST: OFF

Usage: Asynchronous command

Manual operation: See "Audible overrange" on page 147

PROBe<ch>:SETup:ADVanced:FILTer <State>

Activates the lowpass filter in the probe control box. The filter frequency depends on the probe type and is indicated on the probe control box.

Suffix:
<ch> 1 to 4, index of the analog channel

Parameters:
<State> OFF | ON
*RST: OFF

Usage: Asynchronous command

Manual operation: See "Bandwidth limit" on page 147

PROBe<ch>:SETup:ADVanced:RANGe <ProbeRange>

Sets the voltage range of an R&S RT-ZHD probe.

Suffix:
<ch> 1 to 4, index of the analog channel

Parameters:
<ProbeRange> AUTO | MHIGh | MLOW

AUTO
The voltage range is set with `CHANnel<ch>:SCALe`.

MHIGh
Sets the higher voltage range of the connected probe. To query the value, use `PROBe<ch>:SETup:ATTenuation[:AUTO]?`.

MLOW
Sets the lower voltage range of the connected probe. To query the value, use `PROBe<ch>:SETup:ATTenuation[:AUTO]?`.

*RST: AUTO

Usage: Asynchronous command

Manual operation: See "Range" on page 147

PROBe<ch>:SETup:ADVanced:PMToffset

Sets the measured ProbeMeter value as offset. Thus, the value is considered in measurements.

Suffix:
<ch> 1 to 4, index of the analog channel

Usage: Setting only
Asynchronous command

Manual operation: See "Set offset to ProbeMeter value" on page 153

18.8.6.3 Settings for modular probes

PROBe<ch>:SETup:PRMode <MeasMode>

Sets the measurement mode of modular probes.

Suffix:

<ch>	1 to 4, index of the analog channel

Parameters:

<PrbMeasMd> DMODe | CMODe | PMODe | NMODe

DMODe
Differential mode input voltage (V_{dm}), the voltage between the positive and negative input terminal.

CMODe
Common mode input voltage (V_{cm}), the mean voltage between the positive and negative input terminal vs. ground.

PMODe
Positive single-ended input voltage (V_p). the voltage between the positive input terminal and ground.

NMODe
Negative single-ended input voltage (V_N). the voltage between the negative input terminal and ground.

*RST: DMODe

Usage: Asynchronous command

Manual operation: See "Probe mode" on page 150

PROBe<ch>:SETup:CMOFfset <CMOffset>

Sets the common-mode offset to compensate for a common DC voltage that is applied to both input sockets (referenced to the ground socket). The setting is available for Rohde & Schwarz differential probes and for modular probes in CM measurement mode.

Suffix:

<ch>	1 to 4, index of the analog channel

Parameters:

<CMOffset>
Range: -1E+26 to 1E+26
Increment: 0.001
*RST: 0
Default unit: V

Usage: Asynchronous command

Manual operation: See "CM offset" on page 144

PROBe<ch>:SETup:DMOFfset <DMOffset>

Sets the differential offset to compensate a DC voltage applied between the positive (V_p) and the negative (V_n) input terminal at the probe tip.

Suffix:
<ch> 1 to 4, index of the analog channel

Parameters:
<DMOffset> Range: -1E+26 to 1E+26
Increment: 0.001
*RST: 0
Default unit: V

Usage: Asynchronous command

Manual operation: See "DM Offset, CM Offset, P Offset, N Offset" on page 151

PROBe<ch>:SETup:NOFFset <NOffset>

Sets the negative offset to compensate a DC voltage applied to the negative input terminal (V_n) referenced to ground.

Suffix:
<ch> 1 to 4, index of the analog channel

Parameters:
<NOffset> Range: -1E+26 to 1E+26
Increment: 0.001
*RST: 0
Default unit: V

Usage: Asynchronous command

Manual operation: See "DM Offset, CM Offset, P Offset, N Offset" on page 151

PROBe<ch>:SETup:POFFset <POffset>

Sets the positive offset to compensate a DC voltage applied to the positive input terminal (V_p) referenced to ground.

Suffix:
<ch> 1 to 4, index of the analog channel

Parameters:
<POffset> Range: -1E+26 to 1E+26
Increment: 0.001
*RST: 0
Default unit: V

Usage: Asynchronous command

Manual operation: See "DM Offset, CM Offset, P Offset, N Offset" on page 151

PROBe<ch>:SETup:TERM:ADJust <VoltageAdj>

Activates control of the termination voltage.

Suffix:

<ch> — 1 to 4, index of the analog channel

Parameters:

<VoltageAdj>
Range: -1E+26 to 1E+26
Increment: 0.001
*RST: 0
Default unit: V

Usage: Asynchronous command

Manual operation: See "Adjustment" on page 152

PROBe<ch>:SETup:TERM:MEASure?

Returns the measured common mode voltage.

Suffix:

<ch> — 1 to 4, index of the analog channel

Return values:

<VoltageMeas>
Range: -1E+26 to 1E+26
Increment: 0.01
*RST: 0
Default unit: V

Usage: Query only
Asynchronous command

Manual operation: See "Measurement" on page 152

PROBe<ch>:SETup:TERM:MODE <Mode>

Selects the voltage that is used for termination.

Suffix:

<ch> — 1 to 4, index of the analog channel

Parameters:

<Mode> — AUTO | MANual

AUTO: the instrument uses the measured common mode voltage for termination.
MANual: enter the voltage to be used for termination with `PROBe<ch>:SETup:TERM:ADJust`.

*RST: AUTO

Usage: Asynchronous command

Manual operation: See "Mode" on page 152

PROBe<ch>:SETup:TERM:STATe <VoltageState>

Activates control of the termination voltage.

Suffix:

<ch> 1 to 4, index of the analog channel

Parameters:

<VoltageState> OFF | ON

*RST: OFF

Usage: Asynchronous command

Manual operation: See "State" on page 152

18.8.6.4 Settings for current probes

The probe suffix <ch> selects the input channel to which the probe is connected.

PROBe<ch>:SETup:GAIN:AUTO?

Returns the gain of a detected or predefined current probe.

Suffix:

<ch> 1 to 4, index of the analog channel

Return values:

<Gain> Range: 0.001 to 1000
Increment: 0.1
*RST: 1
Default unit: A/V

Usage: Query only
Asynchronous command

Manual operation: See "Gain, Manual gain" on page 148

PROBe<ch>:SETup:GAIN:MANual <Gain>

Sets the gain for an unknown current probe.

Suffix:

<ch> 1 to 4, index of the analog channel

Parameters:

<Gain> Range: 0.0001 to 10000
Increment: 0.0001
*RST: 1
Default unit: V/V

Usage: Asynchronous command

Manual operation: See "Gain, Manual gain" on page 148

PROBe<ch>:SETup:DEGauss

Demagnetizes the core if it has been magnetized by switching the power on and off, or by an excessive input. Always carry out demagnetizing before measurement.

Suffix:
<ch> 1 to 4, index of the analog channel

Usage: Event
Asynchronous command

Manual operation: See "DeGauss" on page 148

PROBe<ch>:SETup:OFFSet:ZADJust <ZeroAdjustValue>

Set the waveform to zero position. It corrects the effect of a voltage offset or temperature drift. To set the value by the instrument, use `PROBe<ch>:SETup:OFFSet:AZERo`
.

Suffix:
<ch> 1 to 4, index of the analog channel

Parameters:
<ZroAdjVal> Range: -100 to 100
Increment: 0.1
*RST: 0
Default unit: %

Usage: Asynchronous command

Manual operation: See "Zero adjust" on page 149

PROBe<ch>:SETup:OFFSet:STPRobe

Saves the zero adjust value in the probe box. If you connect the probe to another channel or to another Rohde & Schwarz oscilloscope, the value is read out again, and you can use the probe without further adjustment.

Suffix:
<ch> 1 to 4, index of the analog channel

Usage: Event
Asynchronous command

Manual operation: See "Save to probe" on page 149

18.8.6.5 Optical isolated probes

The commands of this section are relevant for optical isolated probes. The commands are available in firmware version 2.2 and higher.

PROBe<ch>:SETup:ADVanced:UNIT <SelectUnit>

Sets the unit of the R&S RT-ZISO signal.

Suffix:
<ch> 1 to 4, index of the analog channel

Parameters:
<SelectUnit> V | A | W
*RST: V

Usage: Asynchronous command

Manual operation: See "Select input unit" on page 153

PROBe<ch>:SETup:OFFSet:TOPMeter

Sets the measured R&S ProbeMeter value as offset. Thus, the value is considered in measurements.

Suffix:
<ch> 1..8

Usage: Event
Asynchronous command

Manual operation: See "ProbeMeter to offset" on page 145

PROBe<ch>:SETup:LASer:STATe?

Returns the current status of the laser.

Suffix:
<ch> 1 to 4, index of the analog channel

Return values:
<LaserState> 1 | 2 | 3

1
The laser is working.

2
The laser needs service, but is still working.

3
Defective laser, send to your Rohde & Schwarz service center.

*RST: 1

Usage: Query only
Asynchronous command

Manual operation: See "Laser state" on page 154

PROBe<ch>:SETup:ALIGnment:GAIN:EXECute

Corrects the zero point error and the gain error of the R&S RT-ZISO probe.

To write the alignment result to the non-volatile flash of the probe, use `PROBe<ch>:SETup:ALIGnment:WRITe`.

Suffix:
<ch> 1 to 4, index of the analog channel

Usage: Event
Asynchronous command

Manual operation: See "Gain/Zero-error alignment" on page 155

PROBe<ch>:SETup:ALIGnment:ZERO:EXECute

Performs a self-alignment and corrects the zero point error of the R&S RT-ZISO probe.

To write the alignment result to the non-volatile flash of the probe, use `PROBe<ch>:SETup:ALIGnment:WRITe`.

Suffix:
<ch> 1 to 4, index of the analog channel

Usage: Event
Asynchronous command

Manual operation: See "Zero-error alignment" on page 154

PROBe<ch>:SETup:ALIGnment:WRITe

The command writes the alignment result to the non-volatile flash of the probe.

Suffix:
<ch> 1 to 4, index of the analog channel

Usage: Event
Asynchronous command

PROBe<ch>:SETup:ADVanced:RDEFaults

Resets the zero point and gain error correction to the factory default values.

Suffix:
<ch> 1 to 4, index of the analog channel

Usage: Event
Asynchronous command

Manual operation: See "Restore default values" on page 155

PROBe<ch>:SETup:TIPModel:NAME?

Returns the name of the tip module that is connected to the R&S RT-ZISO probe at the specified channel.

Suffix:

<ch>	1 to 4, index of the analog channel

Return values:

<ProbeTipModel>	UNKNOWN | Z101 | Z201 | Z202 | Z203 | Z301 | Z302 | NONE *RST: NONE

Usage: Query only
Asynchronous command

18.8.6.6 Probe adapter R&S RT-Z2T

PROBe<ch>:SETup:ADAPter?

Queries the adapter status, whether the instrument identified the adapter.

Suffix:

<ch>	1 to 4, index of the analog channel

Return values:

<Type>	NONE | Z2T *RST: NONE

Usage: Query only
Asynchronous command

PROBe<ch>:SETup:ATTenuation:TDEFprobe <TekPredefProbe>

Selects the Tektronix probe that is connected to the R&S RT-Z2T adapter.

Suffix:

<ch>	1 to 4, index of the analog channel

Parameters:

<TekPredefProbe>	NONE | P5205A50 | P5205A500 | P5210A100 | P5210A1000 | P6205 | P6241 | P6243 | P6245 | P6246A1 | P6246A10 | P6247A1 | P6247A10 | P6248A1 | P6248A10 | P6249 | P6250A5 | P6250A50 | P6251A5 | P6251A50 | P6701B | P6703B | P6711 | P6713 | TCP202 *RST: NONE

Example:

```
PROBe2:SETup:ADAPter
<-- Z2T
PROBe2:SETup:ATTenuation:TDEFprobe P5205A50
```

Checks the adapter state on channel 2, and selects the probe P5205A50.

Usage: Asynchronous command

18.8.6.7 Probe attributes

PROBe<ch>:ID:PARTnumber?

Queries the Rohde & Schwarz part number of the probe.

Suffix:
<ch> 1 to 4, index of the analog channel

Return values:
<PartNumber> Part number in a string.

Usage: Query only
Asynchronous command

PROBe<ch>:ID:PRDate?

Queries the production date of the probe.

Suffix:
<ch> 1 to 4, index of the analog channel

Return values:
<ProductionDate> Date in a string.

Usage: Query only
Asynchronous command

PROBe<ch>:ID:SRNumber?

Queries the serial number of the probe.

Suffix:
<ch> 1 to 4, index of the analog channel

Return values:

<SerialNo> Serial number in a string.

Usage: Query only
Asynchronous command

PROBe<ch>:ID:SWVersion?

Queries the version of the probe firmware.

Suffix:

<ch> 1 to 4, index of the analog channel

Return values:

<Softwareversion> Version number in a string.

Usage: Query only
Asynchronous command

PROBe<ch>:SETup:CAPacitance?

Queries the input capacitance of the probe.

Suffix:

<ch> 1 to 4, index of the analog channel

Return values:

<InputCapacity> Range: 1E-13 to 1E-07
Default unit: F

Usage: Query only
Asynchronous command

PROBe<ch>:SETup:DCRange:MAX?

Returns the maximum value of the dynamic DC range.

Suffix:

<ch> 1 to 4, index of the analog channel

Return values:

<DynDCrangeMax> Range: -1E+26 to 1E+26
Increment: 1E-12
*RST: 0
Default unit: V

Usage: Query only
Asynchronous command

PROBe<ch>:SETup:DCRange:MIN?

Returns the minimum value of the dynamic DC range.

Suffix:
<ch> 1 to 4, index of the analog channel

Return values:
<DynDCrangeMin> Range: -1E+26 to 1E+26
Increment: 1E-12
*RST: 0
Default unit: V

Usage: Query only
Asynchronous command

PROBe<ch>:SETup:IMPedance?

Queries the termination of the probe.

Suffix:
<ch> 1 to 4, index of the analog channel

Return values:
<InputImpedance> Range: 0 to 1E+9
Default unit: Ω

Usage: Query only
Asynchronous command

18.8.6.8 Probe at external trigger input

TRPRobe:SETup:ATTenuation:UNIT?

Returns the unit of the probe that is connected to the external trigger input.

Return values:
<PrbAttUnt> V | A | W
*RST: V

Usage: Query only
Asynchronous command

TRPRobe:SETup:ATTenuation[:AUTO]?

Returns the attenuation of the probe that is connected to the external trigger input.

Return values:

<PrbAttMdAuto>	Range:	0.001 to 1000
	Increment:	0.1
	*RST:	1
	Default unit:	V/V

Usage: Query only
Asynchronous command

TRPRobe:SETup:NAME?

Returns the name of the probe that is connected to the external trigger input.

Return values:
<Name> String parameter

Usage: Query only
Asynchronous command

TRPRobe:SETup:STATe?

Returns the state of the probe that is connected to the external trigger input.

Return values:
<State> DETected | NDETected
*RST: NDETected

Usage: Query only
Asynchronous command

TRPRobe:SETup:TYPE?

Returns the type of the probe that is connected to the external trigger input.

Return values:
<Type> String parameter

Usage: Query only
Asynchronous command

18.8.7 Fast segmentation

ACQuire:SEGMented:MAX <MaxAcqs>

If ON, the instrument acquires the maximum number of segments that can be stored in the memory. The maximum number depends on the current sample rate and record length settings.

If OFF, define the number of segments in a fast segmentation cycle with `ACQuire:COUNt`.

Parameters:

<MaxAcqs>	OFF | ON *RST: OFF

Usage: Asynchronous command

Manual operation: See "Acquire maximum" on page 129

ACQuire:SEGMented:STATe <State>

If fast segmentation is enabled, the acquisitions are performed as fast as possible, without processing and displaying the waveforms. When acquisition has been stopped, the data is processed and the latest waveform is displayed. Older waveforms are stored in segments. You can display and analyze the segments using the history.

Parameters:

<State>	OFF | ON *RST: OFF

Usage: Asynchronous command

Manual operation: See "Fast segmentation" on page 129

18.8.8 High definition mode

HDEFinition:BWIDth <Bandwidth>

Sets the filter bandwidth for the high definition mode.

Parameters:

<Bandwidth>	Range: 1000 to 500E+6 Increment: 1000 *RST: 100E+6 Default unit: Hz

Usage: Asynchronous command

Manual operation: See "Bandwidth" on page 131

HDEFinition:RESolution?

Displays the resulting vertical resolution in high definition mode. The higher the filter bandwidth, the lower the resolution.

Return values:

<Resolution>	Range: 0 to 18 Increment: 0.1 *RST: 0 Default unit: bit

Usage: Query only
Asynchronous command

Manual operation: See "Resolution in bits" on page 131

HDEFinition:STATe <State>

Enables high definition mode, which increases the numeric resolution of the waveform signal.

Parameters:

<State>	OFF | ON `ON`: high definition mode `OFF`: normal oscilloscope mode *RST: OFF

Usage: Asynchronous command

Manual operation: See "State" on page 131

18.8.9 Waveform data export

To set the export data format, see `FORMat[:DATA]`.

For fast export of several waveforms at once, use `EXPort:WAVeform:DATA[:VALues]?` on page 995.

CHANnel<ch>:DATA:HEADer?

Returns the header of channel waveform data, the attributes of the waveform.

Suffix:

<ch>	1 to 4, index of the analog channel

Return values:

<XStart>	1. header value: time of the first sample in s
<XStop>	2. header value: time of the last sample in s
<RecordLength>	3. header value: record length, number of samples
<ValuesPerSample>	4. header value: number of values per sample. For most waveforms, the result is 1. For peak detect and envelope waveforms, it is 2. If the number is 2, the number of returned values is twice the number of samples (record length).

Example:
```
CHAN1:DATA:HEAD?
-1E-07,9.9800000000000001E-08,1000,1
```
Start time of the data is -1E-07 = 100 ns, and end time of the data is 9.9800000000000001E-08 = 99.8 ns. The data stream has 1000 values with one value per sample.

Usage: Query only
Asynchronous command

CHANnel<ch>:DATA[:VALues]? [<Offset>[,<Length>]]

Returns the data of the channel waveform points for transmission from the instrument to the controlling computer. The data can be used in MATLAB, for example.

Without parameters, the complete waveform is retrieved. Using the offset and length parameters, data can be retrieved in smaller portions, which makes the command faster. If you send only one parameter, it is interpreted as offset, and the data is retrieved from offset to the end of the waveform.

To set the export format, use FORMat[:DATA] on page 814.

Suffix:
<ch> 1 to 4, index of the analog channel

Query parameters:
<Offset> Number of offset waveform samples to be skipped.
Range: 0 to m. Limit: n + m <= record length

<Length> Number of waveform points to be retrieved.
Range: 1 to n. Limit: n + m <= record length

Return values:
<Data> List of values according to the format and content settings.

Example: Retrieve the complete channel 1 waveform, only Y-values:
```
FORM ASC
CHAN1:DATA?
<-- -0.125000,-0.123016,-0.123016,-0.123016,-0.123016,-0.123016,...
```

Example: Retrieve the first 10 values of the waveform:
```
CHANnel:DATA:VALues? 0,10
<-- -0.10079051554203,-0.098814234137535,-0.098814234137535,
    -0.096837945282459,-0.094861663877964,-0.094861663877964,
    -0.092885382473469,-0.090909093618393,-0.090909093618393,
    -0.088932812213898
```

Example: Skip 5 samples and retrieve the next 5 samples:
```
CHANnel:DATA:VALues? 5,5
<-- -0.094861663877964,-0.092885382473469,-0.090909093618393,
    -0.090909093618393,-0.088932812213898
```

Usage: Query only
Asynchronous command

18.8.10 Reference clock

SENSe[:ROSCillator]:OUTPut[:ENABle] <ReferenceOutput>

Sends the internal reference clock signal to the Ref. Out connector.

Parameters:

<ReferenceOutput> OFF | ON

*RST: OFF

Usage: SCPI confirmed
Asynchronous command

Manual operation: See "Output 10 MHz ref. signal" on page 122

SENSe[:ROSCillator]:SOURce <RefSource>

Enables the use of an external 10 MHz reference signal instead of the internal reference clock.

Parameters:

<RefSource> INTernal | EXTernal

*RST: INTernal

Usage: Asynchronous command

Manual operation: See "Use external ref. clock" on page 121

18.9 Trigger

Trigger commands use several suffixes.

LEVel<n>, NOISe<m>

The suffix indicates the analog channel for which the command takes effect. C1 has suffix 1, C2 has suffix 2, and so on.

Event<ev>

The suffix indicates the sequence step, for which the command takes effect when you trigger on a sequence. If you trigger on a single event, the suffix = 1 and can be omitted.

- 1 = A-trigger
- 2 = B-trigger
- 3 = R-trigger (reset event)

Asynchronous commands

Some of the commands in the following section are asynchronous. An overlapping or asynchronous command does not automatically finish executing before the next command starts executing. If overlapping commands must be executed in a defined order, e.g. to avoid wrong measurement results, they must be serviced sequentially.

To prevent an overlapping execution of commands, one of the commands `*OPC`, `*OPC?` or `*WAI` can be used after the command or a command set.

For more information, see:

- www.rohde-schwarz.com/rc-via-scpi, section "Command sequence and synchronization"

18.9.1 Common trigger settings

TRIGger:MEVents:MODE <Class>

Selects, if you want to trigger on a single event, or on a series of events.

Parameters:

<Class> SINGle | SEQuence

*RST: SINGle

Usage: Asynchronous command

Manual operation: See "Trigger on" on page 161

TRIGger:EVENt<ev>:TYPE <Type>

Selects the trigger type. In a trigger sequence, the trigger type is set for each condition.

Suffix:

<ev> 1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:

<Type> EDGE | GLITch | WIDTh | RUNT | WINDow | TIMeout | INTerval | SLEWrate | ANEDge | SETHold | STATe | PATTern

ANEDge = analog edge trigger is the only trigger type if the extern trigger source is used.
For SETHold, also DATatoclock can be used.

*RST: EDGE

Usage: Asynchronous command

Manual operation: See "Type" on page 162

TRIGger:EVENt<ev>:LEVel<n>[:VALue] <Level>

Sets the trigger level for the specified event and source (channel).

If the trigger source is serial bus, the trigger level is set by the thresholds in the protocol configuration.

Suffix:

<ev>	1 = A-trigger, 2 = B-trigger, 3 = reset event
<n>	1 to 4, index of the analog channel

Parameters:

<Level>
Range: -10 to 10
Increment: 0.001
*RST: 0
Default unit: V

Usage: Asynchronous command

Manual operation: See "[Level]" on page 45

TRIGger:FINDlevel

Sets the trigger level automatically to *0.5 * (MaxPeak – MinPeak)*.

In a trigger sequence, "Find level" affects all active events of the sequence (A, B, and R event).

Usage: Event
Asynchronous command

Manual operation: See "Find level" on page 163

TRIGger:EVENt<ev>:SOURce <SourceDetailed>

Selects the source of the trigger signal for the selected trigger event. The trigger source works even if it is not displayed in a diagram.

Available sources depend on the trigger sequence setting. If you trigger on a single event, all inputs can be used as trigger source. If you trigger on a sequence, only analog channels can be set as trigger source for A, B, and R-events.

Suffix:

<ev> 1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:

<SourceDetailed>

C1 | C2 | C3 | C4
Available for single event, and A, B and R-events in a trigger sequence

EXTernanalog | LINE |
Available for single event (suffix 1)

D0 | D1 | D2 | ... | D14 | D15
Digital channels, require MSO option. Available for single event (suffix 1)

SBUS1 | SBUS2 | SBUS3 | SBUS4
Available if one or more serial protocol options are installed. If the hardware trigger is supported for a protocol, triggering on single event is possible with hardware trigger settings. For all protocols, the software trigger is supported in a "A → Serial bus" (event 2).

*RST: C1

Usage: Asynchronous command

Manual operation: See "Source" on page 161

18.9.2 Trigger sequence

TRIGger:MEVents:AEVents <Type>

Selects the type of the trigger sequence.

Parameters:

<Type> AONLy | ABR | AZ | ASB

AONLy = single event, same as `TRIGger:MEVents:MODE SINGle`
ABR = sequence A → B → R
AZ = sequence A → Zone trigger
ASB = sequence A → Serial bus

*RST: AONLy

Usage: Asynchronous command

Manual operation: See "Trigger sequence" on page 164

TRIGger:MEVents:SEQuence<se>:COUNt <Events>

Sets the number of B-trigger conditions to be fulfilled after an A-trigger. The last B-trigger causes the trigger event. The waiting time for B-triggers can be restricted with a reset condition: timeout or reset event.

Suffix:

<se> 1..3
2

Parameters:

<Events>	Range: 1 to 2147483647 Increment: 1 *RST: 1

Usage: Asynchronous command

Manual operation: See "B event count" on page 165

TRIGger:MEVents:SEQuence<se>:DELay <Delay>

Sets the time that the instrument waits after an A-trigger until it recognizes B-triggers.

Suffix:

<se> 1

Parameters:

<Delay>	Range: 0 to 50 Increment: 1E-12 *RST: 0 Default unit: s

Usage: Asynchronous command

Manual operation: See "Delay" on page 165

TRIGger:MEVents:SEQuence<se>:RESet:EVENt <State>

If enabled, the trigger sequence is restarted by the R-trigger condition if the specified number of B-triggers does not occur before the R-trigger conditions are fulfilled.

Suffix:

<se> 3

Parameters:

<State>	OFF | ON *RST: OFF

Usage: Asynchronous command

Manual operation: See "Enable reset event" on page 165

TRIGger:MEVents:SEQuence<se>:RESet:TIMeout:TIME <ResetTimeout>

The time the instrument waits for the number of B-events specified using `TRIGger:MEVents:SEQuence<se>:COUNt`, before the sequence is restarted with the A-trigger.

Suffix:

<se> Irrelevant, omit the suffix.

Parameters:

<ResetTimeout> Range: 0 to 50
Increment: 1E-12
*RST: 0
Default unit: s

Usage: Asynchronous command

Manual operation: See "Enable reset by time, Reset timeout" on page 165

TRIGger:MEVents:SEQuence<se>:RESet:TIMeout[:ENABle] <State>

If set to ON, the instrument waits for the time defined using `TRIGger:MEVents:SEQuence<se>:RESet:TIMeout:TIME` for the specified number of B-events. If no trigger occurs during that time, the sequence is restarted with the A-event.

Suffix:

<se> Irrelevant, omit the suffix.

Parameters:

<State> OFF | ON
*RST: OFF

Usage: Asynchronous command

Manual operation: See "Enable reset by time, Reset timeout" on page 165

18.9.3 Edge trigger

TRIGger:EVENt<ev>:EDGE:SLOPe <Slope>

Sets the edge direction for the trigger.

Suffix:

<ev> 1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:

<Slope> POSitive | NEGative | EITHer
*RST: POSitive

Usage: Asynchronous command

Manual operation: See "Slope" on page 166

TRIGger:ANEDge:LEVel <ExtTrigLev>

Sets the trigger level for the external trigger source.

Parameters:

<ExtTrigLev> Range: - 5 to 5
Default unit: V

Usage: Asynchronous command

Manual operation: See "Level" on page 162

TRIGger:ANEDge:COUPling <Coupling>

Sets the connection of the external trigger signal, i.e. the input impedance and a termination. The coupling determines what part of the signal is used for triggering.

Parameters:

<Coupling> DC | DCLimit | AC

DC
Connection with 50 Ω termination, passes both DC and AC components of the signal.

DCLimit
Connection with 1 MΩ termination, passes both DC and AC components of the signal.

AC
Connection with 1 MΩ termination through DC capacitor, removes DC and very low-frequency components. The waveform is centered on zero volts.

*RST: DCLimit

Usage: Asynchronous command

Manual operation: See "Coupling" on page 168

TRIGger:ANEDge:FILTer <Filter>

Selects the filter mode for the external trigger signal.

Parameters:

<Filter> OFF | LFReject | RFReject

*RST: OFF

Usage: Asynchronous command

Manual operation: See "Filter, Cut-off" on page 168

TRIGger:ANEDge:CUToff:HIGHpass <CutOffFreq>

Frequencies below the cutoff frequency are rejected, higher frequencies pass the filter.

Parameters:

<CutOffFreq>	KHZ5 | KHZ50 KHZ5 = 5 kHz KHZ50 = 50 kHz *RST: KHZ50

Usage: Asynchronous command

Manual operation: See "Filter, Cut-off" on page 168

TRIGger:ANEDge:CUToff:LOWPass <CutOffFreq>

Frequencies higher than the cutoff frequency are rejected, lower frequencies pass the filter.

Parameters:

<CutOffFreq>	KHZ50 | MHZ50 KHZ50 = 50 kHz MHZ50 = 50 MHz *RST: KHZ50

Usage: Asynchronous command

Manual operation: See "Filter, Cut-off" on page 168

TRIGger:ANEDge:NREJect <NoiseReject>

Enables an automatic hysteresis on the trigger level to avoid unwanted trigger events caused by noise.

Parameters:

<NoiseReject>	OFF | ON *RST: OFF

Usage: Asynchronous command

Manual operation: See "Trigger noise reject" on page 168

18.9.4 Glitch trigger

TRIGger:EVENt<ev>:GLITch:POLarity <Polarity>

Sets the polarity of a pulse, which is the direction of the first pulse slope.

Suffix:

<ev>	1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:

<Polarity>   POSitive | NEGative | EITHer

*RST: POSitive

Usage: Asynchronous command

Manual operation: See "Polarity" on page 169

TRIGger:EVENt<ev>:GLITch:RANGe <RangeMode>

Selects which glitches are identified: shorter or longer than the width specified using `TRIGger:EVENt<ev>:GLITch:WIDTh`.

Suffix:

<ev>   1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:

<RangeMode>   SHORter | LONGer

SHORter
Glitches shorter than the specified width are identified.

LONGer
Glitches longer than the specified width are identified.

*RST: SHORter

Usage: Asynchronous command

Manual operation: See "Range" on page 169

TRIGger:EVENt<ev>:GLITch:WIDTh <Width>

Sets the length of a glitch. The instrument triggers on pulses shorter or longer than this value, depending on the value set with `TRIGger:EVENt<ev>:GLITch:RANGe`.

Suffix:

<ev>   1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:

<Width>   Range: 1E-10 to 10000
Increment: 0.0001
*RST: 1E-09
Default unit: s

Usage: Asynchronous command

Manual operation: See "Width" on page 169

18.9.5 Width trigger

TRIGger:EVENt<ev>:WIDTh:DELTa <WidthDelta>

Defines a range around the width value.

Suffix:

<ev> 1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:

<WidthDelta> Range: 0 to 432
Increment: 5E-10
*RST: 0
Default unit: s

Usage: Asynchronous command

Manual operation: See "±Delta" on page 171

TRIGger:EVENt<ev>:WIDTh:POLarity <Polarity>

Sets the polarity of a pulse, which is the direction of the first pulse slope.

Suffix:

<ev> 1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:

<Polarity> POSitive | NEGative | EITHer
*RST: POSitive

Usage: Asynchronous command

Manual operation: See "Polarity" on page 171

TRIGger:EVENt<ev>:WIDTh:RANGe <RangeMode>

Selects how the range of a pulse width is defined.

Suffix:

<ev> 1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:

<RangeMode> WITHin | OUTSide | SHORter | LONGer
*RST: WITHin

Usage: Asynchronous command

Manual operation: See "Range" on page 171

TRIGger:EVENt<ev>:WIDTh:WIDTh <Width>

Depending on the values of `TRIGger:EVENt<ev>:WIDTh:RANGe` the width sets:

- For the ranges `Within` and `Outside`, the width defines the center of a time range which is defined by the limits "±Delta" (see `TRIGger:EVENt<ev>:WIDTh:DELTa`).

- For the ranges `Shorter` and `Longer`, it defines the maximum and minimum time lapse, respectively.

Suffix:

<ev> 1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:

<Width>
Range: 1E-10 to 10000
Increment: 1E-07
*RST: 5E-09
Default unit: s

Usage: Asynchronous command

Manual operation: See "Width" on page 171

18.9.6 Runt trigger

TRIGger:EVENt<ev>:LEVel<n>:RUNT:LOWer <Level>

Sets the lower voltage limit.

Suffix:

<ev> 1 = A-trigger, 2 = B-trigger, 3 = reset event

<n> 1 to 4, index of the analog channel

Parameters:

<Level>
Range: -10 to 10
Increment: 0.001
*RST: -0.1
Default unit: V

Usage: Asynchronous command

Manual operation: See "Lower level" on page 173

TRIGger:EVENt<ev>:LEVel<n>:RUNT:UPPer <Level>

Sets the upper voltage limit.

Suffix:

<ev> 1 = A-trigger, 2 = B-trigger, 3 = reset event

<n> 1 to 4, index of the analog channel

Parameters:

<Level>

Range: -10 to 10
Increment: 0.001
*RST: 0.1
Default unit: V

Usage: Asynchronous command

Manual operation: See "Upper level" on page 172

TRIGger:EVENt<ev>:RUNT:DELTa <WidthDelta>

Defines a range around the runt width specified using `TRIGger:EVENt<ev>:RUNT:WIDTh`.

Available if `TRIGger:EVENt<ev>:RUNT:RANGe` is set to `WITHin` or `OUTSide`.

Suffix:

<ev> 1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:

<WidthDelta>

Range: 1E-10 to 864
Increment: 1E-07
*RST: 1E-10
Default unit: s

Usage: Asynchronous command

Manual operation: See "±Delta" on page 173

TRIGger:EVENt<ev>:RUNT:POLarity <Polarity>

Sets the polarity of a pulse, which is the direction of the first pulse slope.

Suffix:

<ev> 1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:

<Polarity> POSitive | NEGative | EITHer

*RST: POSitive

Usage: Asynchronous command

Manual operation: See "Polarity" on page 169

TRIGger:EVENt<ev>:RUNT:RANGe <Mode>

Defines the time limit of the runt pulse in relation to the `TRIGger:EVENt<ev>:RUNT:WIDTh` and `TRIGger:EVENt<ev>:RUNT:DELTa` settings.

Suffix:
<ev> 1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:
<Mode> ANY | LONGer | SHORter | WITHin | OUTSide

ANY
Triggers on all runts fulfilling the level condition, without time limitation.

LONGer
Triggers on runts longer than the given runt width.

SHORter
Triggers on runts shorter than the given runt width.

WITHin
Triggers if the runt length is inside a given time range. The range is defined by runt width and ±Delta.

OUTSide
Triggers if the runt length is outside a given time range. The range is defined by runt width and ±Delta.

*RST: ANY

Usage: Asynchronous command

Manual operation: See "Range" on page 173

TRIGger:EVENt<ev>:RUNT:WIDTh <Width>

Defines the upper or lower voltage threshold.

It is not available if `TRIGger:EVENt<ev>:RUNT:RANGe` is set to `ANY`.

Suffix:
<ev> 1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:
<Width>
Range: 1E-10 to 10000
Increment: 1E-07
*RST: 5E-09
Default unit: s

Usage: Asynchronous command

Manual operation: See "Runt width" on page 173

18.9.7 Window trigger

TRIGger:EVENt<ev>:LEVel<n>:WINDow:LOWer <Level>

Sets the lower voltage limit.

Suffix:

<ev>	1 = A-trigger, 2 = B-trigger, 3 = reset event
<n>	1 to 4, index of the analog channel

Parameters:

<Level>
Range: -10 to 10
Increment: 0.001
*RST: -0.1
Default unit: V

Usage: Asynchronous command

Manual operation: See "Lower level" on page 175

TRIGger:EVENt<ev>:LEVel<n>:WINDow:UPPer <Level>

Sets the upper voltage limit.

Suffix:

<ev>	1 = A-trigger, 2 = B-trigger, 3 = reset event
<n>	1 to 4, index of the analog channel

Parameters:

<Level>
Range: 0 to 1000
Increment: 1E-06
*RST: 0.1
Default unit: V

Usage: Asynchronous command

Manual operation: See "Upper level" on page 174

TRIGger:EVENt<ev>:WINDow:DELTa <WidthDelta>

Defines a range around the width value.

Suffix:

<ev> 1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:

<WidthDelta>
Range: 0 to 432
Increment: 5E-10
*RST: 0
Default unit: s

Usage: Asynchronous command

Manual operation: See "±Delta" on page 175

TRIGger:EVENt<ev>:WINDow:RANGe <RangeMode>

Selects how the signal run is compared with the window.

Suffix:

<ev> 1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:

<RangeMode> ENTer | EXIT | WITHin | OUTSide

ENTer
Triggers when the signal crosses the upper or lower level and thus enters the window made up of these two levels.

EXIT
Triggers when the signal leaves the window.

WITHin
Triggers if the signal stays between the upper and lower level for a specified time. The time is defined with `TRIGger:EVENt<ev>:WINDow:TIME`.

OUTSide
Triggers if the signal stays above the upper level or below the lower level for a specified time. The time is defined with `TRIGger:EVENt<ev>:WINDow:TIME`.

*RST: ENTer

Usage: Asynchronous command

Manual operation: See "Vertical condition" on page 174

TRIGger:EVENt<ev>:WINDow:TIME <TimeRangeMode>

Available for `TRIGger:EVENt<ev>:WINDow:RANGe` = `WITHin` and `OUTSide`.

Selects how the time limit of the window is defined.

You can specify the width with `TRIGger:EVENt<ev>:WINDow:WIDTh` and the delta with `TRIGger:EVENt<ev>:WINDow:DELTa`.

Suffix:

<ev> 1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:

<TimeRangeMode> WITHin | OUTSide | SHORter | LONGer

WITHin
Triggers if the signal stays inside or outside the vertical window limits at least for the time *Width - Delta* and for *Width + Delta* at the most.

OUTSide
"Outside" is the opposite definition of "Within". The instrument triggers if the signal stays inside or outside the vertical window limits for a time shorter than *Width - Delta* or longer than *Width + Delta*.

SHORter
Triggers if the signal crosses vertical limits before the specified width time is reached.

LONGer
Triggers if the signal crosses vertical limits before the specified width time is reached.

*RST: WITHin

Usage: Asynchronous command

Manual operation: See "Time condition" on page 175

TRIGger:EVENt<ev>:WINDow:WIDTh <Width>

Depending on the values of `TRIGger:EVENt<ev>:WINDow:RANGe` the width sets:

- For the ranges `Within` and `Outside`, the width defines the center of a time range. The range is defined by the limits "±Delta", see `TRIGger:EVENt<ev>:WINDow:DELTa`.
- For the ranges `Shorter` and `Longer`, it defines the maximum and minimum time lapse, respectively.

Suffix:
<ev> 1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:
<Width>
Range: 1E-10 to 10000
Increment: 1E-07
*RST: 5E-09
Default unit: s

Usage: Asynchronous command

Manual operation: See "Width" on page 175

18.9.8 Timeout trigger

TRIGger:EVENt<ev>:TIMeout:RANGe <TimeoutMode>

Sets the relation of the signal level to the trigger level for the timeout trigger.

Suffix:
<ev> 1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:
<TimeoutMode> HIGH | LOW | EITHer

HIGH = stays high, the signal level stays above the trigger level.
LOW = stays low, the signal level stays below the trigger level.
EITHer = stays high or low.

*RST: HIGH

Usage: Asynchronous command

Manual operation: See "Range" on page 176

TRIGger:EVENt<ev>:TIMeout:TIME <Time>

Sets the time limit for the timeout at which the instrument triggers.

Suffix:
<ev> 1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:
<Time> Range: 1E-10 to 10000
Increment: 1E-07
*RST: 1E-07
Default unit: s

Usage: Asynchronous command

Manual operation: See "Time" on page 176

18.9.9 Interval trigger

TRIGger:EVENt<ev>:INTerval:DELTa <WidthDelta>

Sets a range around the interval width value specified with `TRIGger:EVENt<ev>:INTerval:WIDTh`.

Suffix:
<ev> 1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:
<WidthDelta> Range: 0 to 10
Increment: 1E-07
*RST: 0
Default unit: s

Usage: Asynchronous command

Manual operation: See "±Delta" on page 178

TRIGger:EVENt<ev>:INTerval:RANGe <RangeMode>

Defines the range of an interval in relation to the interval width specified using TRIGger:EVENt<ev>:INTerval:WIDTh and TRIGger:EVENt<ev>:INTerval:DELTa.

Suffix:
<ev> 1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:
<RangeMode> WITHin | OUTSide | SHORter | LONGer

WITHin
Triggers on pulses inside a given range. The range is defined by the interval width ±delta.

OUTSide
Triggers on pulses outside a given range. The range is defined by the interval width ±delta.

SHORter
Triggers on pulses shorter than the given interval width.

LONGer
Triggers on pulses longer than the given interval width.

*RST: OUTSide

Usage: Asynchronous command

Manual operation: See "Range" on page 177

TRIGger:EVENt<ev>:INTerval:SLOPe <Slope>

Sets the edge for the trigger. You can analyze the interval between positive edges or between negative edges.

Suffix:
<ev> 1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:
<Slope> POSitive | NEGative | EITHer

*RST: POSitive

Usage: Asynchronous command

Manual operation: See "Slope" on page 177

TRIGger:EVENt<ev>:INTerval:WIDTh <Width>

Sets the time between two pulses for the interval trigger.

Suffix:
<ev> 1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:

<Width>	Range: 1E-10 to 10000 Increment: 1E-07 *RST: 5E-09 Default unit: s
Usage:	Asynchronous command
Manual operation:	See "Interv. width" on page 178

18.9.10 Slew rate trigger

TRIGger:EVENt<ev>:LEVel<n>:SLEW:LOWer <Level>

Sets the lower voltage threshold. When the signal crosses this level, the slew rate measurement starts or stops depending on the selected slope.

Suffix:

<ev>	1 = A-trigger, 2 = B-trigger, 3 = reset event
<n>	1 to 4, index of the analog channel

Parameters:

<Level>	Range: -10 to 10 Increment: 0.001 *RST: -0.1 Default unit: V
Usage:	Asynchronous command
Manual operation:	See "Lower level" on page 179

TRIGger:EVENt<ev>:LEVel<n>:SLEW:UPPer <Level>

Sets the upper voltage threshold. When the signal crosses this level, the slew rate measurement starts or stops depending on the selected slope.

Suffix:

<ev>	1 = A-trigger, 2 = B-trigger, 3 = reset event
<n>	1 to 4, index of the analog channel

Parameters:

<Level> Range: -10 to 10
Increment: 0.001
*RST: 0.1
Default unit: V

Usage: Asynchronous command

Manual operation: See "Upper level" on page 179

TRIGger:EVENt<ev>:SLEW:DELTa <TimeDelta>

Defines a time range around the given slew rate.

Suffix:

<ev> 1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:

<TimeDelta> Range: 0 to 10
Increment: 1E-07
*RST: 0
Default unit: s

Usage: Asynchronous command

Manual operation: See "±Delta" on page 180

TRIGger:EVENt<ev>:SLEW:RANGe <RangeMode>

Selects how the time limit for the slew rate is defined. The time measurement starts when the signal crosses the first trigger level - the upper or lower limit depending on the selected slope. The measurement stops when the signal crosses the second level.

You can select the rate with `TRIGger:EVENt<ev>:SLEW:RATE` and set the delta with `TRIGger:EVENt<ev>:SLEW:DELTa`.

Suffix:

<ev> 1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:

<RangeMode> INSRange | OUTRange | LTHan | GTHan

INSRange
Triggers on pulses inside a given range. The range is defined by the slew rate ±delta.

OUTRange
Triggers on pulses outside a given range. The range is defined by the slew rate ±delta.

LTHan
Triggers on pulses shorter than the given slew rate.

GTHan
Triggers on pulses longer than the given slew rate.

*RST: GTHan

Usage: Asynchronous command

Manual operation: See "Range" on page 180

TRIGger:EVENt<ev>:SLEW:RATE <Time>

For `TRIGger:EVENt<ev>:SLEW:RANGe` = `INSRange` and `OUTRange`, the slew rate defines the center of a range which is defined by the limits "±Delta".

For `TRIGger:EVENt<ev>:SLEW:RANGe` = `LTHan` and `GTHan`, the slew rate defines the maximum and minimum slew rate limits, respectively. When the signal crosses this level, the slew rate measurement starts or stops depending on the selected slope (see `TRIGger:EVENt<ev>:SLEW:SLOPe`).

Suffix:
<ev> 1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:
<Time> Range: 1E-10 to 10000
Increment: 1E-07
*RST: 1E-10
Default unit: s

Usage: Asynchronous command

Manual operation: See "Slew rate" on page 180

TRIGger:EVENt<ev>:SLEW:SLOPe <Slope>

Sets the edge direction for the trigger.

Suffix:
<ev> 1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:
<Slope> POSitive | NEGative | EITHer
*RST: POSitive

Usage: Asynchronous command

Manual operation: See "Slope" on page 179

18.9.11 Setup & Hold

TRIGger:EVENt<ev>:SETHold:CSOurce:EDGE <ClockEdge>

Sets the edge of the clock signal. Edge and level define the time reference point.

Suffix:
<ev> 1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:
<ClockEdge> POSitive | NEGative | EITHer
*RST: POSitive

Usage: Asynchronous command

Manual operation: See "Clock edge" on page 181

TRIGger:EVENt<ev>:SETHold:CSOurce:LEVel <ClockLevel>

Sets the voltage level for the clock signal.

Both the clock level and the clock edge define the starting point for calculation of the setup and hold time.

Suffix:
<ev> 1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:
<ClockLevel> Range: -10 to 10
Increment: 0.001
*RST: 0
Default unit: V

Usage: Asynchronous command

Manual operation: See "Clock level" on page 182

TRIGger:EVENt<ev>:SETHold:CSOurce[:VALue] <ClockSource>

Selects the input channel of the clock signal.

Suffix:
<ev> 1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:
<ClockSource> C1 | C2 | C3 | C4
The following values are also accepted:
C1 = CHAN1 = CHANnel1, C2 = CHAN2 = CHANnel2,
C3 = CHAN3 = CHANnel3, C4 = CHAN4 = CHANnel4
*RST: C1

Usage: Asynchronous command

Manual operation: See "Clock source" on page 181

TRIGger:EVENt<ev>:SETHold:HTIMe <HoldTime>

Sets the minimum time **after** the clock edge while the data signal must stay steady above or below the data level.

Suffix:

<ev> 1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:

<HoldTime>
Range: -9.9999E-08 to 1E-07
Increment: 1E-09
*RST: 0
Default unit: s

Usage: Asynchronous command

Manual operation: See "Hold time" on page 182

TRIGger:EVENt<ev>:SETHold:STIMe <SetupTime>

Sets the minimum time **before** the clock edge while the data signal must stay steady above or below the data level.

Suffix:

<ev> 1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:

<SetupTime>
Range: -9.9999E-08 to 1E-07
Increment: 1E-09
*RST: 0
Default unit: s

Usage: Asynchronous command

Manual operation: See "Setup time" on page 182

18.9.12 State trigger

TRIGger:EVENt<ev>:STATe:QUALify:ANALog:CHAN<n>:HLX <HLX>

Set the state for each channel. For the state trigger, the clock source is indicated and does not get a state.

Suffix:

<ev> 1 = A-trigger, 2 = B-trigger, 3 = reset event

<n> 1 to 4, index of the analog channel

Parameters:

<HLX> HIGH | LOW | DONTcare

State of the individual channels

*RST: DONTcare

Example:
```
TRIG:EVEN1:SOUR C1
TRIG:EVEN1:SLOP POS
TRIG:EVEN1:STAT:QUAL:ANAL:CHAN2:HLX HIGH
TRIG:EVEN1:STAT:QUAL:ANAL:CHAN3:HLX LOW
TRIG:EVEN1:STAT:QUAL:ANAL:CHAN4:HLX HIGH
TRIG:EVEN1:STAT:QUAL:LOG AND
```

Usage: Asynchronous command

Manual operation: See "Source: channel states" on page 186

TRIGger:EVENt<ev>:STATe:QUALify:LOGic <StateOperator>

Defines the logic combination of the channels and their states.

Suffix:
<ev> 1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:
<StateOperator> AND | OR
*RST: AND

Usage: Asynchronous command

Manual operation: See "Logic Operator" on page 186

TRIGger:EVENt<ev>:STATe:SLOPe <Slope>

Sets the edge direction for the trigger.

Suffix:
<ev> 1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:
<Slope> POSitive | NEGative | EITHer
*RST: POSitive

Usage: Asynchronous command

Manual operation: See "Slope" on page 183

TRIGger:EVENt<ev>:STATe:QUALify:DIGital:LOGic <Logic>

Defines the logic combination of the channels and their states.

Suffix:
<ev> 1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:
<Logic> AND | OR
*RST: AND

Usage: Asynchronous command

Manual operation: See "Logic Operator" on page 186

TRIGger:EVENt<ev>:STATe:QUALify:DIGital:CHAN<n>:HLX <HLX>

Sets the required state for each digital channel that is used for triggering.

Suffix:

<ev>	1 = A-trigger, 2 = B-trigger, 3 = reset event
<n>	0 to 15, index of the logic channel

Parameters:

<HLX>	HIGH | LOW | DONTcare *RST: DONTcare

Usage: Asynchronous command

Manual operation: See "Source: channel states" on page 187

18.9.13 Pattern trigger

TRIGger:EVENt<ev>:PATTern:QUALify:ANALog:CHAN<n>:HLX <HLX>

Set the state for each channel. For the state trigger, the clock source is indicated and does not get a state.

Suffix:

<ev>	1 = A-trigger, 2 = B-trigger, 3 = reset event
<n>	1 to 4, index of the analog channel

Parameters:

<HLX>	HIGH | LOW | DONTcare State of the individual channels *RST: DONTcare

Example:

```
TRIG:EVEN1:PATT:QUAL:ANAL:CHAN1:HLX LOW
TRIG:EVEN1:PATT:QUAL:ANAL:CHAN2:HLX HIGH
TRIG:EVEN1:PATT:QUAL:ANAL:CHAN3:HLX LOW
TRIG:EVEN1:PATT:QUAL:ANAL:CHAN4:HLX HIGH
TRIG:EVEN1:PATT:QUAL:LOG AND
```

Usage: Asynchronous command

Manual operation: See "Source: channel states" on page 186

TRIGger:EVENt<ev>:PATTern:QUALify:DIGital:CHAN<n>:HLX <HLX>

Sets the required state for each digital channel that is used for triggering.

Suffix:

<ev> 1 = A-trigger, 2 = B-trigger, 3 = reset event

<n> 0 to 15, index of the logic channel

Parameters:

<HLX> HIGH | LOW | DONTcare

*RST: DONTcare

Usage: Asynchronous command

Manual operation: See "Source: channel states" on page 187

TRIGger:EVENt<ev>:PATTern:QUALify:LOGic <StateOperator>

Defines the logic combination of the channels and their states.

Suffix:

<ev> 1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:

<StateOperator> AND | OR

*RST: AND

Usage: Asynchronous command

Manual operation: See "Logic Operator" on page 186

TRIGger:EVENt<ev>:PATTern:QUALify:DIGital:LOGic <Logic>

Defines the logic combination of the channels and their states.

Suffix:

<ev> 1..3

Parameters:

<Logic> AND | OR

*RST: AND

Usage: Asynchronous command

Manual operation: See "Logic Operator" on page 186

TRIGger:EVENt<ev>:PATTern:QUALify:SOURces <StateSources>

Selects if the source of the trigger for the pattern type is an analog or digital channel.

Suffix:

<ev> 1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:

<StateSources> ANALog | DIGital

*RST: ANALog

Usage: Asynchronous command

Manual operation: See "State sources" on page 184

18.9.14 Trigger mode, holdoff

TRIGger:MODE <TriggerMode>

Sets the trigger mode which determines the behavior of the instrument with and without a trigger event.

Parameters:

<TriggerMode> AUTO | NORMal | FREerun

AUTO
The instrument triggers repeatedly after a time interval if the trigger conditions are not fulfilled. If a real trigger occurs, it takes precedence. The time interval depends on the time base.

NORMal
The instrument acquires a waveform only if a trigger occurs.

FREerun
The instrument triggers after a very short time interval - faster than in AUTO mode. Real triggers are ignored.

*RST: AUTO

Usage: Asynchronous command

Manual operation: See "[Auto Norm]" on page 45

TRIGger:FORCe

Provokes an immediate single acquisition. Force the trigger if the acquisition is running in normal mode and no valid trigger occurs. Thus, you can confirm that a signal is available and use the waveform display to determine how to trigger on it.

Usage: Setting only
Asynchronous command

Manual operation: See "Force trigger" on page 189

TRIGger:HOLDoff:MODE <Mode>

Selects the method to define the holdoff condition.

The trigger holdoff defines when the next trigger after the current will be recognized. Thus, it affects the next trigger to occur after the current one. Holdoff helps to obtain stable triggering when the oscilloscope is triggering on undesired events.

Holdoff settings are not available if the trigger source is an external trigger input or serial bus, and if you trigger on a sequence of events.

Parameters:

<Mode> TIME | EVENts | RANDom | AUTO | OFF

TIME
Defines the holdoff directly as a time period. The next trigger occurs only after the holdoff time has passed, which is defined using `TRIGger:HOLDoff:TIME`).

EVENts
Defines the holdoff as a number of trigger events. The next trigger occurs only when this number of events is reached. The number of triggers to be skipped is defined with `TRIGger:HOLDoff:EVENts`.

RANDom
Defines the holdoff as a random time limited by `TRIGger:HOLDoff:MIN` and `TRIGger:HOLDoff:MAX`. For each acquisition cycle, the instrument selects a new random holdoff time from the specified range.

AUTO
The holdoff time is calculated automatically based on the current horizontal scale.

OFF
No holdoff

*RST: OFF

Usage: Asynchronous command

Manual operation: See "Holdoff mode" on page 189

TRIGger:HOLDoff:AUTotime?

Returns the resulting holdoff time, if `TRIGger:HOLDoff:MODE` is set to `AUTO`: *Auto time = Auto time scaling * Horizontal scale*. The auto time scaling factor is defined with `TRIGger:HOLDoff:SCALing`.

Return values:

<AutoTime> Range: 1E-07 to 10
Increment: 0.0002
*RST: 0.001
Default unit: s

Usage: Query only
Asynchronous command

Manual operation: See "Holdoff mode" on page 189

TRIGger:HOLDoff:SCALing <AutoTimeScl>

Sets the auto time scaling factor that the horizontal scale is multipied with, if `TRIGger:HOLDoff:MODETRIGger:HOLDoff:MODETRIGger:HOLDoff:MODE` is set to `AUTO`.
*Auto time = Auto time scaling * Horizontal scale*

The next trigger occurs only after this time has passed.

Parameters:

<AutoTimeScl> Range: 0.001 to 1000
Increment: 1
*RST: 0.5

Usage: Asynchronous command

Manual operation: See "Holdoff mode" on page 189

TRIGger:HOLDoff:EVENts <Events>

Defines the number of triggers to be skipped, if `TRIGger:HOLDoff:MODETRIGger:HOLDoff:MODETRIGger:HOLDoff:MODE` is set to `EVENts`. The next trigger only occurs when this number of events is reached.

Parameters:

<Events> Range: 1 to 2147483647
Increment: 10
*RST: 1

Usage: Asynchronous command

Manual operation: See "Holdoff mode" on page 189

TRIGger:HOLDoff:MAX <RandomMaxTime>

Defines the upper limit for the random time holdoff, if `TRIGger:HOLDoff:MODE TRIGger:HOLDoff:MODETRIGger:HOLDoff:MODE` is set to `RANDom`.

Parameters:

<RandomMaxTime> Range: 1E-07 to 10
Increment: 0.0002
*RST: 0.002
Default unit: s

Usage: Asynchronous command

Manual operation: See "Holdoff mode" on page 189

TRIGger:HOLDoff:MIN <RandomMinTime>

Defines the lower limit for the random time holdoff, if TRIGger:HOLDoff:MODE TRIGger:HOLDoff:MODETRIGger:HOLDoff:MODE is set to RANDom.

Parameters:

<RandomMinTime>
Range: 1E-07 to 5
Increment: 0.0002
*RST: 0.001
Default unit: s

Usage: Asynchronous command

Manual operation: See "Holdoff mode" on page 189

TRIGger:HOLDoff:TIME <Time>

Defines the holdoff time period, if TRIGger:HOLDoff:MODE is set to TIME. The next trigger occurs only after this time has passed.

Parameters:

<Time>
Range: 1E-07 to 10
Increment: 0.0002
*RST: 0.001
Default unit: s

Usage: Asynchronous command

Manual operation: See "Holdoff mode" on page 189

18.9.15 Hysteresis

TRIGger:NOISe<m>:ABSolute <Absolute>

Defines a range in absolute values around the trigger level. If the signal oscillates inside this range and thus crosses the trigger level, no trigger event occurs.

Suffix:

<m> 1 to 4, index of the analog channel

Parameters:

<Absolute>
Range: 0 to 10000000
Increment: 0.001
*RST: 0
Default unit: V

Usage: Asynchronous command

Manual operation: See "Absolute hysteresis" on page 191

TRIGger:NOISe<m>:EFFective?

Returns the hysteresis that is set by the instrument in automatic hysteresis mode.

Suffix:
<m> 1 to 4, index of the analog channel

Return values:
<Effective> numeric value

Range: 0 to 10000000
Increment: 0.001
*RST: 0
Default unit: V

Usage: Query only
Asynchronous command

Manual operation: See "HW hysteresis" on page 191

TRIGger:NOISe<m>:MODE <Mode>

Selects whether the hysteresis is defined in absolute or relative values. The setting is available only in manual hysteresis mode.

Suffix:
<m> 1 to 4, index of the analog channel

Parameters:
<Mode> ABS | REL

*RST: ABS

Usage: Asynchronous command

Manual operation: See "Hysteresis mode" on page 191

TRIGger:NOISe<m>:PERDivision <InDivision>

Defines a range in divisions around the trigger level in division units. If the signal oscillates inside this range and crosses the trigger level thereby, no trigger event occurs.

Suffix:
<m> 1 to 4, index of the analog channel

Parameters:
<InDivision> Range: 0 to 5
Increment: 0.01
*RST: 0
Default unit: div

Usage: Asynchronous command

Manual operation: See "Relative hysteresis" on page 192

TRIGger:NOISe<m>:RELative <Relative>

Defines a range in divisions around the trigger level as percentage. If the signal oscillates inside this range and crosses the trigger level thereby, no trigger event occurs.

Suffix:

<m> 1 to 4, index of the analog channel

Parameters:

<Relative> Range: 0 to 50
Increment: 1
*RST: 0
Default unit: %

Usage: Asynchronous command

Manual operation: See "Relative hysteresis" on page 192

TRIGger:NOISe<m>[:STATe] <Mode>

Selects how the hysteresis is set.

Suffix:

<m> 1 to 4, index of the analog channel

Parameters:

<Mode> AUTO | MANual

AUTO
Automatic mode is the recommended mode. The hysteresis is set by the instrument to reject the internal noise of the instrument.

MANual
The hysteresis is defined with `TRIGger:NOISe<m>:ABSolute` or `TRIGger:NOISe<m>:RELative`.

*RST: AUTO

Usage: Asynchronous command

18.9.16 Channel filter

TRIGger:FILTermode <Mode>

Selects the filter mode for the trigger channel.

Parameters:

<Mode>	OFF | LFReject | RFReject *RST: OFF

Usage: Asynchronous command

Manual operation: See "Trigger filter mode" on page 192

TRIGger:LFReject <Bandwidth>

Sets the limit frequency limit for the highpass filter of the trigger signal. Frequencies lower than this value are rejected, higher frequencies pass the filter.

Parameters:

<Bandwidth>	Range: 50 kHz *RST: 50 kHz Default unit: Hz

Usage: Asynchronous command

Manual operation: See "LF reject BW" on page 192

TRIGger:RFReject <Bandwidth>

Sets the limit frequency limit for the lowpass filter of the trigger signal. Frequencies higher than this value are rejected, lower frequencies pass the filter.

Parameters:

<Bandwidth>	Range: 1E+3 to 500E+6 Increment: 1000 *RST: 1E+6 Default unit: Hz

Usage: Asynchronous command

Manual operation: See "RF reject BW" on page 193

18.9.17 Actions on trigger

TRIGger:ACTions:BEEP <Beep>

Generates a beep sound if the command is set to `TRIGger`.

Parameters:

<Beep>	NOACtion | TRIGger *RST: NOACtion

Usage: Asynchronous command

Manual operation: See "Beep" on page 193

TRIGger:ACTions:OUT:STATe <State>

Activates the outgoing pulse on the [Trigger Out] connector on the rear panel.

If ON, a pulse is sent out each time when a trigger occurs.

Parameters:

<State>	OFF | ON *RST: OFF

Usage: Asynchronous command

Manual operation: See "Trigger out pulse" on page 194

TRIGger:ACTions:OUT:SOURce <SignalSource>

Defines when the trigger out signal is initiated: at the trigger point, when waiting for the trigger, or when the post-trigger time is finished.

Parameters:

<SignalSource>	TRIG | TRIGGER | POST | POSTTRIGGER | WAIT | WAITTRIGGER TRIG = TRIGGER, POST = POSTTRIGGER, WAIT = WAITTRIGGER *RST: TRIG

Usage: Asynchronous command

Manual operation: See "Signal source" on page 194

TRIGger:ACTions:OUT:DELay <Delay>

Defines the delay of the first pulse edge to the trigger point. The minimum delay is 600 ns.

Parameters:

<Delay>	Range: 8E-07 to 1 Increment: 4E-09 *RST: 8E-07 Default unit: s

Usage: Asynchronous command

Manual operation: See "Delay" on page 195

TRIGger:ACTions:OUT:PLENgth <PulseLength>

Sets the length of the trigger out pulse.

Parameters:

<PulseLength> Range: 1.6E-08 to 0.05
Increment: 1.6E-08
*RST: 9.6E-08
Default unit: s

Usage: Asynchronous command

Manual operation: See "Pulse length" on page 195

TRIGger:ACTions:OUT:POLarity <Polarity>

Sets the polarity of the trigger out pulse, which is the direction of the first pulse edge.

Parameters:

<Polarity> POSitive | NEGative
*RST: POSitive

Usage: Asynchronous command

Manual operation: See "Polarity" on page 195

TRIGger:ACTions:SCReenshot <SaveScreenshot>

Saves a screenshot at each trigger if the command is set to `TRIGger`.

To configure the screenshot settings, use the commands described in Section 18.12.9, "Screenshots", on page 1000.

Parameters:

<SaveScreenshot> NOAction | TRIGger
*RST: NOAction

Usage: Asynchronous command

Manual operation: See "Screenshot" on page 194

TRIGger:ACTions:STOP <StopAcq>

Stops the running acquisition if the command is set to `TRIGger`.

Parameters:

<StopAcq> NOAction | TRIGger
*RST: NOAction

Usage: Asynchronous command

Manual operation: See "Stop acq" on page 193

TRIGger:ACTions:WFMSave <SaveWfm>

Saves the waveform data to file at each trigger if the command is set to `TRIGger`.

To define the path and file names, use the EXPort:WAVeform:AUTonaming:* commands:

- `EXPort:WAVeform:AUTonaming:NAME` on page 991
- `EXPort:WAVeform:AUTonaming:PATH` on page 992
- `EXPort:WAVeform:AUTonaming:TYPE` on page 992

Parameters:

<SaveWfm> NOAction | TRIGger

*RST: NOAction

Usage: Asynchronous command

Manual operation: See "Save wfm" on page 194

18.9.18 Zone trigger

Zone trigger commands are available since FW version 2.2.x.x.

ZONE<m>:ADD

Adds a new trigger zone.

Suffix:

<m> 1...4, index of the zone

Usage: Setting only
Asynchronous command

Manual operation: See "Add zone, " on page 203

TRIGger:ZONE:EXPRession[:DEFine] <LogicExpression>

Defines the zone trigger. The available operators for the combination between the zones are `AND | NOT | OR | XOR`.

Parameters:
<LogicExpression> String with the logical expression

Example: Prerequisite: Zone1 and Zone2 are defined.
```
TRIGger:ZONE:EXPRession 'Zone1 and Zone2'
TRIGger:ZONE:EXPRession?
<-- Zone1 and Zone2
```

Usage: Asynchronous command

Manual operation: See "[Zone]" on page 46

ZONE<m>:ACOMbination <AreaCombination>

Sets the logic combination that applies to all areas in the indicated zone.

Suffix:
<m> 1...4, index of the zone

Parameters:
<AreaCombination> AND | OR
*RST: AND

Usage: Asynchronous command

Manual operation: See "Area" on page 203

ZONE<m>:AREA<n>:ADD

Adds a new area to the trigger zone.

Suffix:
<m> 1...4, index of the zone

<n> 1...8, index of the zone area

Usage: Setting only
Asynchronous command

Manual operation: See "Area" on page 203

ZONE<m>:AREA<n>:COUNt?

Returns the number of the defined areas in the zone.

`ZONE<m>:AREA:COUNt? MAX` returns the maximum number of areas that can be created.

Suffix:
<m> 1...4, index of the zone

<n> Irrelevant, omit the suffix.

Return values:
<Count> Number of defined zone areas

Usage: Query only
Asynchronous command

Manual operation: See "Area" on page 203

ZONE<m>:AREA<n>:INTersect <Intersection>

Defines if the signal must intersect the zone to allow the instrument to trigger, or if it must not intersect the zone.

Suffix:
<m> 1...4, index of the zone

<n> 1...8, index of the zone area

Parameters:
<Intersection> MUST | NOT
*RST: MUST

Usage: Asynchronous command

Manual operation: See "Area" on page 203

ZONE<m>:AREA<n>:LABel <Label>

Defines a label for the selected area.

Suffix:
<m> 1...4, index of the zone

<n> 1...8, index of the zone area

Parameters:
<Label>

Usage: Asynchronous command

Manual operation: See "Area" on page 203

ZONE<m>:AREA<n>:VALid?

Checks the validity of the indicated zone area. The area is invalid if one of its points is invalid. See Figure 7-13.

Suffix:

<m>	1...4, index of the zone
<n>	1...8, index of the zone area

Return values:

<Valid>	OFF | ON *RST: ON

Usage: Query only
Asynchronous command

ZONE<m>:AREA<n>:POINt<o>:ADD

Adds a new point to the area at the indicated point index.

To define the coordinates of the point, use `ZONE<m>:AREA<n>:POINt<o>:X` and `ZONE<m>:AREA<n>:POINt<o>:Y`.

Suffix:

<m>	1...4, index of the zone
<n>	1...8, index of the zone area
<o>	1...16, index of the zone area point

Usage: Setting only
Asynchronous command

ZONE<m>:AREA<n>:POINt<o>:COUNt?

Queries the number of the defined points in the area.

`ZONE<m>:AREA<n>:POINt:COUNt? MAX` returns the maximum number of points that can be created.

Suffix:

<m>	1...4, index of the zone
<n>	1...8, index of the zone area
<o>	Irrelevant, omit the suffix.

Return values:

<Count>	Range: 0 to 16

Usage: Query only
Asynchronous command

ZONE<m>:AREA<n>:POINt<o>:REMove

Removes the selected point from the area.

Suffix:

<m>	1...4, index of the zone

<n> 1...8, index of the zone area

<o> 1...16, index of the zone area point

Usage: Setting only
Asynchronous command

ZONE<m>:AREA<n>:POINt<o>:X <X>

Sets the horizontal X coordinates for the selected point of the area.

Suffix:

<m> 1...4, index of the zone

<n> 1...8, index of the zone area

<o> 1...16, index of the zone area point

Parameters:

<X> Range: -1E+26 to 1E+26
Increment: 1E-06
*RST: 0
Default unit: s

Usage: Asynchronous command

ZONE<m>:AREA<n>:POINt<o>:Y <Y>

Sets the vertical Y coordinates for the selected point of the area.

Suffix:

<m> 1...4, index of the zone

<n> 1...8, index of the zone area

<o> 1...16, index of the zone area point

Parameters:

<Y> Range: -1E+26 to 1E+26
Increment: 1E-06
*RST: 0
Default unit: V

Usage: Asynchronous command

ZONE<m>:AREA<n>:POINt<o>:VALid?

Checks the validity of the selected point. See Figure 7-13.

Suffix:

<m> 1...4, index of the zone

<n> 1...8, index of the zone area

<o> 1...16, index of the zone area point

Return values:

<Valid> OFF | ON

*RST: ON

Usage: Query only
Asynchronous command

ZONE<m>:AREA<n>:REMove

Removes the selected area from the trigger zone.

Suffix:

<m> 1...4, index of the zone

<n> 1...8, index of the zone area

Usage: Setting only
Asynchronous command

Manual operation: See "Delete icon" on page 204

ZONE<m>:AREA<n>:STATe <State>

Enables the selected area.

Suffix:

<m> 1...4, index of the zone

<n> 1...8, index of the zone area

Parameters:

<State> OFF | ON

*RST: ON

Usage: Asynchronous command

ZONE<m>:COUNt? <Count>

Returns the number of zones.

`ZONE:COUNt? MAX` returns the maximum number of zones that can be created.

Suffix:

<m> Irrelevant, omit the suffix.

Return values:

<Count> Number of defined zones

Usage: Query only
Asynchronous command

ZONE<m>:DIAGram <SignDiagKey>

Selects the diagram on which the zone trigger is applied, for example layoutset1 diagram1 (`L1_D1`).

For more information about the SmartGrid definition, see Section 18.7.2, "SmartGrid", on page 819.

Suffix:

<m>	1...4, index of the zone

Parameters:

<SignDiagKey>	String that indicates the layout set and the diagram, e.g. "L1_D1".

Usage: Asynchronous command

TRIGger:ZONE:HISTory <ApplyToHistory>

Applies the zone trigger condition to the acquisitions that are stored in the history memory. Thus, you can filter the history of waveforms on zone conditions.

Parameters:

<ApplyToHistory>	OFF | ON *RST: OFF

Usage: Asynchronous command

Manual operation: See "Apply zone trigger to history" on page 206

ZONE<m>:REMove

Removes the selected trigger zone.

Suffix:

<m>	1...4, index of the zone

Usage: Setting only
Asynchronous command

Manual operation: See "Delete icon" on page 204

ZONE<m>:SOURce <Source>

Sets the source of the zone trigger.

Suffix:

<m>	1...4, index of the zone

Parameters:

<Source>	NONE | C1 | C2 | C3 | C4 | M1 | M2 | M3 | M4 | M5 | XY1 | XY2 | XY3 | XY4 | SPECNORM1 | SPECNORM2 | SPECNORM3 | SPECNORM4

Usage: Asynchronous command

Manual operation: See "Source" on page 203

ZONE<m>[:VISible] <DisplayState>

Enables the display of the zone on the screen.

Suffix:
<m> 1...4, index of the zone

Parameters:
<DisplayState> OFF | ON
*RST: ON

Usage: Asynchronous command

Manual operation: See "Display" on page 203

18.10 Signal configuration

18.10.1 Reference levels

18.10.1.1 Reference level settings

REFLevel<rl>:ENABle <First>

Enables the specified reference level.

Suffix:
<rl> 1...4, index of the reference level set

Parameters:
<First> OFF | ON

Usage: Asynchronous command

Manual operation: See "RLx" on page 208

REFLevel<rl>:LMODe <LevelMode>

Defines if the reference level is set in absolute or relative values.

Suffix:
<rl> 1...4, index of the reference level set

Parameters:
<LevelMode> ABS | REL
*RST: REL

Usage: Asynchronous command

Manual operation: See "Level mode" on page 208

REFLevel<rl>:ABSolute:HYSTeresis <HystAbs>

Defines a hysteresis for the middle reference level. A rise or fall from the middle reference value that does not exceed the hysteresis is rejected as noise.

Suffix:
<rl> 1...4, index of the reference level set

Parameters:
<HystAbs> Range: 0 to 1E+26
Increment: 0.001
*RST: 0.005
Default unit: V

Usage: Asynchronous command

Manual operation: See "Hysteresis" on page 209

REFLevel<rl>:ABSolute:LLEVel <LowerLevel>

Sets the lower reference level in absolute values. This is required, e.g., to determine a fall.

Suffix:
<rl> 1...4, index of the reference level set

Parameters:
<LowerLevel> Range: -1E+26 to 1E+26
Increment: 0.001
*RST: 0
Default unit: V

Usage: Asynchronous command

Manual operation: See "Upper level, Middle level, Lower level" on page 208

REFLevel<rl>:ABSolute:MLEVel <MiddleLevel>

Sets the middle reference level in absolute values.

Suffix:

<rl> 1...4, index of the reference level set

Parameters:

<MiddleLevel> Range: -1E+26 to 1E+26
Increment: 0.001
*RST: 0
Default unit: V

Usage: Asynchronous command

Manual operation: See "Upper level, Middle level, Lower level" on page 208

REFLevel<rl>:ABSolute:ULEVel <UpperLevel>

Sets the upper reference level in absolute values. This is required to determine a rise.

Suffix:

<rl> 1...4, index of the reference level set

Parameters:

<UpperLevel> Range: -1E+26 to 1E+26
Increment: 0.001
*RST: 0
Default unit: V

Usage: Asynchronous command

Manual operation: See "Upper level, Middle level, Lower level" on page 208

REFLevel<rl>:RELative:HYSTeresis <HystRel>

Defines a hysteresis for the middle reference level. A rise or fall from the middle reference value that does not exceed the hysteresis is rejected as noise.

Suffix:

<rl> 1...4, index of the reference level set

Parameters:

<HystRel> Range: 0 to 50
Increment: 1
*RST: 10
Default unit: %

Usage: Asynchronous command

Manual operation: See "Hysteresis" on page 209

REFLevel<rl>:RELative:LOWer <LowRefLevRel>

Sets the lower relative reference level if REFLevel<rl>:RELative:MODE is set to USER.

Suffix:
<rl> 1...4, index of the reference level set

Parameters:
<LowRefLevRel> Range: -100 to 200
Increment: 1
*RST: 10
Default unit: %

Usage: Asynchronous command

Manual operation: See "Upper level, Middle level,Lower level" on page 209

REFLevel<rl>:RELative:MIDDle <MidRefLevRel>

Sets the middle relative reference level if REFLevel<rl>:RELative:MODE is set to USER.

Suffix:
<rl> 1...4, index of the reference level set

Parameters:
<MidRefLevRel> Range: -100 to 200
Increment: 1
*RST: 50
Default unit: %

Usage: Asynchronous command

Manual operation: See "Upper level, Middle level,Lower level" on page 209

REFLevel<rl>:RELative:MODE <RelativeLevels>

The lower, middle and upper reference levels, defined as percentages of the high signal level.

Suffix:
<rl> 1...4, index of the reference level set

Parameters:
<RelativeLevels> FIVE | TEN | TWENty | USER

FIVE
5/50/95

TEN
10/50/90

TWENty
20/50/80

USER
Set the reference levels to individual values with REFLevel<rl>:RELative:LOWer, REFLevel<rl>:RELative:MIDDle, and REFLevel<rl>:RELative:UPPer.

*RST: TEN

Usage: Asynchronous command

Manual operation: See "Relative levels" on page 209

REFLevel<rl>:RELative:UPPer <UppRefLevRel>

Sets the upper relative reference level if REFLevel<rl>:RELative:MODE is set to USER.

Suffix:
<rl> 1...4, index of the reference level set

Parameters:
<UppRefLevRel> Range: -100 to 200
Increment: 1
*RST: 90
Default unit: %

Usage: Asynchronous command

Manual operation: See "Upper level, Middle level,Lower level" on page 209

18.10.1.2 Reference level results

MEASurement<mg>:REFLevel<rl>:RESult:LOWer?
MEASurement<mg>:REFLevel<rl>:RESult:MIDDle?
MEASurement<mg>:REFLevel<rl>:RESult:UPPer?

Return the lower, middle, and upper reference level, respectively.

Suffix:
<mg> 1...16, index of the measurement

<rl> Irrelevant, omit the suffix.

Return values:
<Value> Range: -1E+26 to 1E+26
Increment: 0
*RST: 0

Usage: Query only
Asynchronous command

MEASurement<mg>:REFLevel<rl>:RESult:SIGHigh?
MEASurement<mg>:REFLevel<rl>:RESult:SIGLow?

Return the high and low signal level, respectively.

Suffix:

<mg>	1...16, index of the measurement
<rl>	Irrelevant, omit the suffix.

Return values:

<SignalValue>	Range: -1E+26 to 1E+26 Increment: 0 *RST: 0

Usage: Query only
Asynchronous command

18.10.2 Gate

GATE<g>:ENABle <First>

Enables the gate.

Suffix:

<g>	1...8, index of the gate

Parameters:

<First>	OFF | ON

Usage: Asynchronous command

Manual operation: See "Add" on page 210

GATE<g>:GCOupling <CouplingMode>

The gate coupling mode selects how the gate area is defined.

Suffix:

<g>	1...8, index of the gate

Parameters:

<CouplingMode>	MANual | CURSor | ZOOM | SPECtrum

MANual
Manually define the gate with a user-defined start and stop values.

CURSor
Cursor coupling is available if a cursor is defined. The gate area is defined by the cursor lines of an active cursor measurement.

ZOOM
Zoom coupling is available if a zoom is defined. The gate area is defined identically to the zoom area - if you change the zoom, the gate changes as well.

SPECtrum
Spectrum coupling is available if a spectrum is enabled.

*RST: MANual

Usage: Asynchronous command

Manual operation: See "Coupling mode" on page 210

GATE<g>:CURSor <Cursor>

Available for `GATE<g>:GCOupling` = `CURSor`.

Selects the cursor set to be used for measurement gating. The gate area is defined by the cursor lines.

Suffix:
<g> 1...8, index of the gate

Parameters:
<Cursor> CURSOR1 | CURSor1 | CURSOR2 | CURSor2

Usage: Asynchronous command

Manual operation: See "Coupling mode" on page 210

GATE<g>:ZDIagram <SignalSource>,[<SignalSource2>]

Available for `GATE<g>:GCOupling` = `ZOOM`.

The gate area is defined identically to the zoom area for the selected zoom diagram.

Suffix:
<g> 1...8, index of the gate

Parameters:
<SignalSource>

<SignalSource2>

Usage: Asynchronous command

Manual operation: See "Coupling mode" on page 210

GATE<g>:MODE <Mode>

Selects if the gate settings are configured using absolute or relative values.

Suffix:

<g> 1...8, index of the gate

Parameters:

<Mode> ABS | REL

*RST: ABS

Usage: Asynchronous command

Manual operation: See "Mode, Start, Stop" on page 210

GATE<g>:ABSolute:STARt <Start>
GATE<g>:ABSolute:STOP <Stop>

Define the absolute start and end values for the gate, respectively.

Available, if `GATE<g>:GCOupling` = `MANUal` and `GATE<g>:MODE` =`ABS`.

Suffix:

<g> 1...8, index of the gate

Parameters:

<Stop>
Range: -1E+26 to 1E+26
Increment: 0.01
*RST: 0.01
Default unit: Depends on the underlying waveform

Usage: Asynchronous command

Manual operation: See "Mode, Start, Stop" on page 210

GATE<g>:RELative:STARt <RelativeStart>
GATE<g>:RELative:STOP <RelativeStop>

Define the relative start and end values for the gate, respectively.

Available, if `GATE<g>:GCOupling` = `MANUal` and `GATE<g>:MODE` =`REL`.

Suffix:

<g> 1...8, index of the gate

Parameters:

<RelativeStop>
Range: 0 to 100
Increment: 0.1
*RST: 100
Default unit: %

Usage: Asynchronous command

Manual operation: See "Mode, Start, Stop" on page 210

GATE<g>:SHOW <DisplayState>

If enabled, the gate area is indicated in the source diagram.

Suffix:

<g>	1...8, index of the gate

Parameters:

<DisplayState>	OFF | ON *RST: ON

Usage: Asynchronous command

18.10.3 Timing reference

TREFerence<m>:CDR:SOFTware:ALGorithm <Algorithm>

Sets the software algorithm that is used for software clock data recovery.

Suffix:

<m>	1...4, index of the timing reference

Parameters:

<Algorithm>	CFRequency | PLL | FF | PLLRlock CFRequency: constant frequency PLL: phase-locked loop control system FF: feed forward PLLRlock: PLL which is locked at the acquisition start. *RST: PLLRlock

Usage: Asynchronous command

Manual operation: See "Algorithm" on page 214

TREFerence<m>:CDR:SOFTware:BWIDth <Bandwidth>

Sets the PLL bandwidth. It defines the part of the spectrum that the PLL can follow during synchronization.

Suffix:
<m> 1...4, index of the timing reference

Parameters:
<Bandwidth>
Range: 20000 to Device specific: DoubleVal(uso::db::wfa::IDeviceConstDataWFA::DOUBLE_ITEM::MaxDeviceBandwidth)
Increment: 10
*RST: 599880
Default unit: Hz

Usage: Asynchronous command

Manual operation: See "Bandwidth" on page 215

TREFerence<m>:CDR:SOFTware:CFRequency:CRSYnc <ClockResync>

Enables continuous synchronization of the clock with the data signal.

Suffix:
<m> 1...4, index of the timing reference

Parameters:
<ClockResync> OFF | ON
*RST: OFF

Usage: Asynchronous command

Manual operation: See "Clock resync" on page 215

TREFerence<m>:CDR:SOFTware:PLL:DAMPing <Damping>

Sets the damping factor, which is only relevant for second order PLL.

Suffix:
<m> 1...4, index of the timing reference

Parameters:
<Damping>
Range: 0.5 to 2
Increment: 0.01
*RST: 0.7

Usage: Asynchronous command

Manual operation: See "Damping" on page 216

TREFerence<m>:CDR:SOFTware:PLL:ORDer <PLLOrder>

Sets the order of the PLL: first or second order. PLL of higher order can compensate for more complex jitter behavior.

Suffix:
<m> 1...4, index of the timing reference

Parameters:
<PLLOrder> FIRSt | SECond
*RST: SECond

Usage: Asynchronous command

Manual operation: See "Order" on page 216

TREFerence<m>:CDR:SOFTware:PLL:SYNC <InitialPhase>

Defines the phase reference for the first clock edge.

Suffix:
<m> 1...4, index of the timing reference

Parameters:
<InitialPhase> SAMPle | DATaedge
SAMPle: the first clock edge matches the first sample of the waveform at the left border of the display.
DATaedge: the first clock edge matches the first edge of the data signal.
*RST: DATaedge

Usage: Asynchronous command

Manual operation: See "Initial phase sync" on page 216

TREFerence<m>:CDR:SOFTware:RELBwidth <RelBw>

Sets the relative bandwidth, that is the ratio of the nominal bit rate to the PLL bandwidth.

Suffix:
<m> 1...4, index of the timing reference

Parameters:
<RelBw> Range: 10 to 6000
Increment: 1
*RST: 1667

Usage: Asynchronous command

Manual operation: See "Rel. bandwidth" on page 215

TREFerence<m>:CDR:SOFTware:SELResults <Results>

Selects when the CDR algorithm returns clock edges.

Suffix:
<m> 1...4, index of the timing reference

Parameters:
<Results> ALL | LOCKed | AISYnc

ALL: all clock edges are used.
AISYnc = LOCKed: the clock edges of the synchronization time are discarded; results are gathered after initial synchronization of the CDR.

*RST: ALL

Usage: Asynchronous command

Manual operation: See "Selected results" on page 216

TREFerence<m>:CLK:FACTor <Multiplier>

Sets a value for the clock multiplier if `TREFerence<m>:TYPE CLOCk` is set. The muliplier is the ratio of an internal clock rate to the externally supplied clock. It defines the number of samples per clock interval.

Suffix:
<m> 1...4, index of the timing reference

Parameters:
<Multiplier> Range: 1 to 100
Increment: 1
*RST: 1

Usage: Asynchronous command

Manual operation: See "Clock multiplier" on page 213

TREFerence<m>:CLK:FREQuency <Frequency>

Sets the frequency of the clock signal if `TREFerence<m>:TYPE CLOCk` is set.

Suffix:
<m> 1...4, index of the timing reference

Parameters:
<Frequency> Range: 1000 to Device specific: DoubleVal(uso::db::wfa::IDeviceConstDataWFA::DOUBLE_ITEM::MaxDeviceBandwidth)
Increment: 10
*RST: 500000000
Default unit: Hz

Usage: Asynchronous command

Manual operation: See "Clock frequency" on page 212

TREFerence<m>:CLK:OFFSet <Offset>

Sets the offset between the clock edge and the data edge if `TREFerence<m>:TYPE CLOCk` is set.

Suffix:
<m> 1...4, index of the timing reference

Parameters:
<Offset> Range: -1000 to 1000
Increment: 0.01
*RST: 0
Default unit: UI

Usage: Asynchronous command

Manual operation: See "Clock offset" on page 213

TREFerence<m>:EDGE <Edge>

Sets the clock edges that are used for measurements if `TREFerence<m>:TYPE CLOCk` is set for the indicated measurement.

Sets the data edges for clock data recovery if `TREFerence<m>:TYPE SCDR` is set for the indicated measurement.

Suffix:
<m> 1...4, index of the timing reference

Parameters:
<Edge> POSitive | NEGative | EITHer

POSitive
The positive clock slope can be used, for example, for single data rate (SDR) signals with bit start at the positive clock edge.

NEGative
The negative clock slope can be used, for example, for SDR signals with bit start at the negative clock edge.

EITHer
Can be used for double data rate (DDR) signals and clock edges. For data edges, it is the most common setting.

*RST: EITHer

Usage: Asynchronous command

Manual operation: See "Clock edges" on page 213

TREFerence<m>:ENABle <TimeRef>

Adds the indicated timing reference (ON) or removes it (OFF).

Suffix:
<m> 1...4, index of the timing reference

Parameters:
<TimeRef> OFF | ON

Usage: Asynchronous command

TREFerence<m>:GATE <Gate>

Sets the gate for the timing reference. Enable and configure a gate before you assign it (GATE<g>:ENABle =ON).

The query returns 0, if no gate is assigned.

Suffix:
<m> 1...4, index of the timing reference

Parameters:
<Gate> Number of the gate to be used

Usage: Asynchronous command

TREFerence<m>:REFLevel <ReferenceLevel>

Selects the reference level that is used for the timing reference if the indicated timing reference uses an explicit click signal.

Suffix:
<m> 1...4, index of the timing reference

Parameters:
<ReferenceLevel> UPPer | MIDDle | LOWer
*RST: MIDDle

Usage: Asynchronous command

Manual operation: See "Reference level" on page 212

TREFerence<m>:RFLSet <RefLevelSet>

Selects the set of reference levels that is used for the timing reference measurements.

Suffix:
<m> 1...4, index of the timing reference

Parameters:
<RefLevelSet> 1...4, index of the reference level set
Number of the reference level set. Define the reference level set before you use it.

Usage: Asynchronous command

Manual operation: See "Reference levels" on page 211

TREFerence<m>:SOURce <Source>

Selects the clock source if TREFerence<m>:TYPE CLOCk is set.

Sets the data source for clock data recovery if TREFerence<m>:TYPE SCDR is set for the indicated measurement.

Suffix:

<m>	1...4, index of the timing reference

Parameters:

<Source>	C1 | C2 | C3 | C4 | D0 | D1 | D2 | ... | D14 | D15 | M1 | M2 | M3 | M4 | M5 | O<n>C1 | O<n>C2 | ... | O<n>C8 (<n> = 2 to 8)

Usage: Asynchronous command

Manual operation: See "Source" on page 212

TREFerence<m>:STATe?

Returns if the specified timing reference is used by an application, e.g. by jitter measurements.

Suffix:

<m>	1...4, index of the timing reference

Return values:

<State>	OFF | ON *RST: OFF

Usage: Query only
Asynchronous command

TREFerence<m>:SYMRate <SymbolRate>

Sets the symbol rate of the data signal for the indicated timing reference.

Suffix:

<m>	1...4, index of the timing reference

Parameters:

<SymbolRate>	Range: 100000 to 5000000000 Increment: 10 *RST: 1000000000 Default unit: Bd

Usage: Asynchronous command

Manual operation: See "Symbol rate" on page 213

TREFerence<m>:TYPE <Type>

Defines the origin of the clock signal - either an existing clock signal or waveform, or a clock generated by clock data recovery (CDR).

Suffix:
<m> 1...4, index of the timing reference

Parameters:
<Type> CLOCk | SCDR

CLOCk: explicit clock signal
SCDR: software CDR

*RST: CLOCk

Usage: Asynchronous command

Manual operation: See "Type" on page 211

TRFS:COUNt?

Returns the number of defined timing references.

Return values:
<Count> Range: 1 to 4

Usage: Query only
Asynchronous command

18.11 Waveform analysis

Some of the commands in the following section are asynchronous. An overlapping or asynchronous command does not automatically finish executing before the next command starts executing. If overlapping commands must be executed in a defined order, e.g. to avoid wrong measurement results, they must be serviced sequentially.

To prevent an overlapping execution of commands, one of the commands `*OPC`, `*OPC?` or `*WAI` can be used after the command or a command set.

For more information, see:

- www.rohde-schwarz.com/rc-via-scpi, section "Command sequence and synchronization"

18.11.1 Zoom

LAYout<ly>:ZOOM<zo>[:ENABle] <State>

Enables the zoom.

Suffix:

<ly>	1...4, index of the SmartGrid layout
<zo>	1...4, index of the zoom

Parameters:

<State>	OFF | ON

Example: See Section 18.4.1, "SmartGrid layout with zoom", on page 805.

Usage: Asynchronous command

Manual operation: See "State" on page 218

LAYout<ly>:ZOOM<zo>:COUNt?

Returns the max number of available zooms.

Suffix:

<ly>	1...4, index of the SmartGrid layout
<zo>	1...4, index of the zoom

Return values:

<Count>

Usage: Query only
Asynchronous command

LAYout<ly>:ZOOM<zo>:DIAG?

Returns the index of the diagram that shows the zoomed waveform.

Suffix:

<ly>	1...4, index of the SmartGrid layout
<zo>	1...4, index of the zoom

Return values:

<ZoomDiagramKey>	String wiht the index of the zoom diagram, e.g. "9".

Usage: Query only
Asynchronous command

LAYout<ly>:ZOOM<zo>:HORizontal:ABSolute:POSition <Center>

Defines the x-value of the centerpoint of the zoom area in absolute values.

Suffix:

<ly>	1...4, index of the SmartGrid layout
<zo>	1...4, index of the zoom

Parameters:

<Center>	Range: -1E+26 to 1E+26 Increment: 0.01 *RST: 0 Default unit: Depends on the underlying waveform

Usage: Asynchronous command

Manual operation: See "Position range" on page 219

LAYout<ly>:ZOOM<zo>:HORizontal:ABSolute:SPAN <Span>

Defines the width of the zoom area in absolute values.

Suffix:

<ly>	1...4, index of the SmartGrid layout
<zo>	1...4, index of the zoom

Parameters:

<Span>	Range: 0 to 1E+26 Increment: 0.01 *RST: 0.02 Default unit: Depends on the underlying waveform

Usage: Asynchronous command

Manual operation: See "Position range" on page 219

LAYout<ly>:ZOOM<zo>:HORizontal:ABSolute:STARt <Start>

Defines the lower limit of the zoom area on the x-axis in absolute values.

Suffix:

<ly>	1...4, index of the SmartGrid layout
<zo>	1...4, index of the zoom

Parameters:

<Start>
Range: -1E+26 to 1E+26
Increment: 0.01
*RST: -0.01
Default unit: Depends on the underlying waveform

Usage: Asynchronous command

Manual operation: See "Start Stop" on page 219

LAYout<ly>:ZOOM<zo>:HORizontal:ABSolute:STOP <Stop>

Defines the upper limit of the zoom area on the x-axis in absolute values.

Suffix:

<ly>	1...4, index of the SmartGrid layout
<zo>	1...4, index of the zoom

Parameters:

<Stop>
Range: -1E+26 to 1E+26
Increment: 0.01
*RST: 0.01
Default unit: Depends on the underlying waveform

Usage: Asynchronous command

Manual operation: See "Start Stop" on page 219

LAYout<ly>:ZOOM<zo>:HORizontal:ABSolute:WIDTh <Span>

Defines the width of the zoom area in absolute values.

Suffix:

<ly>	1...4, index of the SmartGrid layout
<zo>	1...4, index of the zoom

Parameters:

<Span>
Range: 0 to 1E+26
Increment: 0.01
*RST: 0.02
Default unit: Depends on the underlying waveform

Usage: Asynchronous command

LAYout<ly>:ZOOM<zo>:HORizontal:MODE <Mode>

Defines if absolute or relative values are used to specify the x-axis values. Since the zoom area refers to the active signal, relative values ensure that the zoom area remains the same.

Suffix:

<ly>	1...4, index of the SmartGrid layout
<zo>	1...4, index of the zoom

Parameters:

<Mode>	ABS | REL *RST: ABS

Example: See Section 18.4.1, "SmartGrid layout with zoom", on page 805.

Usage: Asynchronous command

Manual operation: See "Mode" on page 220

LAYout<ly>:ZOOM<zo>:HORizontal:RELative:POSition <RelativeCenter>

Defines the x-value of the centerpoint of the zoom area in relative values.

Suffix:

<ly>	1...4, index of the SmartGrid layout
<zo>	1...4, index of the zoom

Parameters:

<RelativeCenter>	Relative position of the centerpoint (x-value) Range: 0 to 100 Increment: 0.1 *RST: 50 Default unit: %

Usage: Asynchronous command

Manual operation: See "Position range" on page 219

LAYout<ly>:ZOOM<zo>:HORizontal:RELative:SPAN <RelativeSpan>

Defines the width of the zoom area in relative values.

Suffix:

<ly>	1...4, index of the SmartGrid layout
<zo>	1...4, index of the zoom

Parameters:

<RelativeSpan>	Range: 1E-15 to 100 Increment: 0.1 *RST: 1 Default unit: %

Usage: Asynchronous command

Manual operation: See "Position range" on page 219

LAYout<ly>:ZOOM<zo>:HORizontal:RELative:STARt <RelativeStart>

Defines the lower limit of the zoom area on the x-axis in relative values.

Suffix:

<ly>	1...4, index of the SmartGrid layout
<zo>	1...4, index of the zoom

Parameters:

<RelativeStart> Range: 0 to 100
Increment: 0.1
*RST: 0
Default unit: %

Example: See Section 18.4.1, "SmartGrid layout with zoom", on page 805.

Usage: Asynchronous command

Manual operation: See "Start Stop" on page 219

LAYout<ly>:ZOOM<zo>:HORizontal:RELative:STOP <RelativeStop>

Defines the upper limit of the zoom area on the x-axis in relative values.

Suffix:

<ly>	1...4, index of the SmartGrid layout
<zo>	1...4, index of the zoom

Parameters:

<RelativeStop> Range: 0 to 100
Increment: 0.1
*RST: 100
Default unit: %

Example: See Section 18.4.1, "SmartGrid layout with zoom", on page 805.

Usage: Asynchronous command

Manual operation: See "Start Stop" on page 219

LAYout<ly>:ZOOM<zo>:HORizontal:RELative:WIDTh <RelativeSpan>

Defines the width of the zoom area in relative values.

Suffix:

<ly>	1...4, index of the SmartGrid layout
<zo>	1...4, index of the zoom

Parameters:

<RelativeSpan>	Range: 1E-15 to 100 Increment: 0.1 *RST: 1 Default unit: %
Usage:	Asynchronous command

LAYout<ly>:ZOOM<zo>:SOURce <Diagram>

Indicates which of the waveform diagrams is selected for zooming. The number is displayed on the screen in the middle of each diagram.

Suffix:

<ly>	1...4, index of the SmartGrid layout
<zo>	1...4, index of the zoom

Parameters:

<Diagram>	Index of the diagram, which is zoomed.
Example:	See Section 18.4.1, "SmartGrid layout with zoom", on page 805.
Usage:	Asynchronous command
Manual operation:	See "Diagram" on page 218

LAYout<ly>:ZOOM<zo>:VERTical:ABSolute:POSition <Center>

Defines the y-value of the centerpoint of the zoom area in absolute values.

Suffix:

<ly>	1...4, index of the SmartGrid layout
<zo>	1...4, index of the zoom

Parameters:

<Center>	Range: -1E+26 to 1E+26 Increment: 0.01 *RST: 0.01
Usage:	Asynchronous command
Manual operation:	See "Position range" on page 219

LAYout<ly>:ZOOM<zo>:VERTical:ABSolute:RANGe <Span>
LAYout<ly>:ZOOM<zo>:VERTical:ABSolute:SPAN <Span>

Defines the height of the zoom area in absolute values.

Suffix:

<ly>	1...4, index of the SmartGrid layout
<zo>	1...4, index of the zoom

Parameters:

<Span>	Range: 0 to 1E+26 Increment: 0.01 *RST: 0.01

Usage: Asynchronous command

Manual operation: See "Position range" on page 219

LAYout<ly>:ZOOM<zo>:VERTical:ABSolute:STARt <Start>

Defines the lower limit of the zoom area on the y-axis in absolute values.

Suffix:

<ly>	1...4, index of the SmartGrid layout
<zo>	1...4, index of the zoom

Parameters:

<Start>	Range: -1E+26 to 1E+26 Increment: 0.01 *RST: 0.01

Usage: Asynchronous command

Manual operation: See "Start Stop" on page 219

LAYout<ly>:ZOOM<zo>:VERTical:ABSolute:STOP <Stop>

Defines the upper limit of the zoom area on the y-axis in absolute values.

Suffix:

<ly>	1...4, index of the SmartGrid layout
<zo>	1...4, index of the zoom

Parameters:

<Stop>	Range: -1E+26 to 1E+26 Increment: 0.01 *RST: 0.01

Usage: Asynchronous command

Manual operation: See "Start Stop" on page 219

LAYout<ly>:ZOOM<zo>:VERTical:MODE <Mode>

Defines if absolute or relative values are used to specify the y-axis values. Since the zoom area refers to the active signal, relative values ensure that the zoom area remains the same.

Suffix:

<ly>	1...4, index of the SmartGrid layout
<zo>	1...4, index of the zoom

Parameters:

<Mode>	ABS | REL *RST: REL
Usage:	Asynchronous command
Manual operation:	See "Mode" on page 220

LAYout<ly>:ZOOM<zo>:VERTical:RELative:POSition <RelativeCenter>

Defines the y-value of the centerpoint of the zoom area in relative values.

Suffix:

<ly>	1...4, index of the SmartGrid layout
<zo>	1...4, index of the zoom

Parameters:

<RelativeCenter>	Range: 0 to 100 Increment: 0.1 *RST: 50 Default unit: %
Usage:	Asynchronous command
Manual operation:	See "Position range" on page 219

LAYout<ly>:ZOOM<zo>:VERTical:RELative:STARt <RelativeStart>

Defines the lower limit of the zoom area on the y-axis in relative values.

Suffix:

<ly>	1...4, index of the SmartGrid layout
<zo>	1...4, index of the zoom

Parameters:

<RelativeStart>	Range: 0 to 100 Increment: 0.1 *RST: 0 Default unit: %
Usage:	Asynchronous command
Manual operation:	See "Start Stop" on page 219

LAYout<ly>:ZOOM<zo>:VERTical:RELative:STOP <RelativeStop>

Defines the upper limit of the zoom area on the x-axis, in relative values.

Suffix:

<ly>	1...4, index of the SmartGrid layout
<zo>	1...4, index of the zoom

Parameters:

<RelativeStop>	Range: 0 to 100 Increment: 0.1 *RST: 100 Default unit: %

Usage: Asynchronous command

Manual operation: See "Start Stop" on page 219

LAYout<ly>:ZOOM<zo>:VERTical:RELative:WIDTh <RelativeSpan>
LAYout<ly>:ZOOM<zo>:VERTical:RELative:SPAN <RelativeSpan>

Defines the height of the zoom area in relative values.

Suffix:

<ly>	1...4, index of the SmartGrid layout
<zo>	1...4, index of the zoom

Parameters:

<RelativeSpan>	Range: 1E-15 to 100 Increment: 0.1 *RST: 100 Default unit: %

Usage: Asynchronous command

Manual operation: See "Position range" on page 219

LAYout<ly>:ZOOM<zo>:SSCReen

Sets the zoom area to the whole screen.

Suffix:

<ly>	1...4, index of the SmartGrid layout
<zo>	1...4, index of the zoom

Usage: Setting only
Asynchronous command

Manual operation: See "Set to screen" on page 219

18.11.2 Mathematics

For fast export of several waveforms at once, use `EXPort:WAVeform:DATA[:VALues]?` on page 995.

CALCulate:MATH<m>:STATe <First>

Activates the selected Math channel and displays the defined math waveforms.

Suffix:
<m> 1...5, index of the math waveform

Parameters:
<First> OFF | ON

Usage: Asynchronous command

Manual operation: See "Display" on page 223

CALCulate:MATH<m>[:EXPRession][:DEFine] <Expression>

Defines the math expression to be calculated for the specified math channel.

Operation	<Expression>	Comment
Addition	"C1+C2"	
Subtraction	"C1-C2"	
Multiplication	"C1*C2"	
Division	"C1/C2"	0/0 = 0 +1 / 0 = Clip+ -1 / 0 = Clip-
Inverting	"-C1"	
Absolute value	"Abs(C1)"	
Derivation	"Derivation(C1,NoiseReject)"	NoiseReject can get any value between 1 and 5000 points Default = 50
Integral	"Integral(C1)"	
Logarithm (based on 10)	"Log(C1)"	Uses the absolute value of the source in calculation. Log(0) = Clip -
Natural logarithm (based on e)	"Ln(C1)"	Uses the absolute value of the source in calculation. Log(0) = Clip -
Binary logarithm (based on 2)	"Ld(C1)"	Uses the absolute value of the source in calculation. Log(0) = Clip -

Operation	<Expression>	Comment
Square	"Pow(C1)"	
Square root	"Sqrt(C1)"	Uses the absolute value of the source in calculation.
Rescale	"Rescale(C1,a,b)"	a = scale, default = 1 b = offset, default = 0
FIR	"FIR(Type,C1,Cut-Off,Characteristics)" Examples: "FIR(highpass,C1,10000000,Gaussian)" "FIR(lowpass,C1,10000000,rectangle)"	Type = lowpass, highpass Cut-Off = limit frequency Characteristics = Gaussian, rectangle Cut-Off can get any value between 4 GHz and 1 kHz

Suffix:
<m> 1...5, index of the math waveform

Parameters:
<Expression> String with regular expression for calculation

Example: `CALC:MATH 'C1*C2'`
Defines the multiplication of waveforms channel 1 and channel 2.

Usage: Asynchronous command

Manual operation: See "Operator" on page 224

CALCulate:MATH<m>:LABel <Label>

Defines a label for the selected math waveform.

Suffix:
<m> 1...5, index of the math waveform

Parameters:
<Label> String with the label

Example: `CALCulate:MATH3:LABel 'M3AddC1C2'`

Usage: Asynchronous command

Manual operation: See "Label" on page 223

CALCulate:MATH<m>:VERTical:SCALe[:VALue] <VerticalScale>

Sets the scale of the y-axis in the math function diagram. The value is defined as "<unit> per division", e.g. *50 mV/div*. In this case, the horizontal grid lines are displayed in intervals of 50 mV.

Suffix:
<m> 1...5, index of the math waveform

Parameters:

<VerticalScale>	Range: 1E-12 to 100E+12 Increment: 1E-05 *RST: 0.5 Default unit: V

Usage: Asynchronous command

Manual operation: See "[Scale]" on page 48

CALCulate:MATH<m>:UNIT <UserUnit>

Sets a user-defined unit for the math operation.

Suffix:

<m> 1...5, index of the math waveform

Parameters:

<UserUnit> String with the base unit

Example: `CALCulate:MATH:UNIT 'A'`

Usage: Asynchronous command

Manual operation: See "Unit" on page 233

CALCulate:MATH<m>:VERTical:OFFSet <VerticalOffset>

Sets a voltage offset to adjust the vertical position of the math function on the screen. Negative values move the waveform up, positive values move it down.

Suffix:

<m> 1...5, index of the math waveform

Parameters:

<VerticalOffset>	Range: -100E12 to 100E12 Increment: 0.01 *RST: 0 Default unit: div

Usage: Asynchronous command

Manual operation: See "Vertical offset" on page 233

CALCulate:MATH<m>:ENVSelection <EnvelopeCurve>

Selects the upper or lower part of the input waveform for mathematic calculation, or a combination of both.

Suffix:

<m> 1...5, index of the math waveform

Parameters:

<EnvelopeCurve> MIN | MAX | BOTH

*RST: BOTH

Usage: Asynchronous command

Manual operation: See "Envelope wfm selection" on page 225

CALCulate:MATH<m>:VERTical:SCALe:MODE <VertSclMd>

Sets how the vertical scale is adapted to the current measurement results. By default, scaling is done automatically to provide an optimal display. However, if necessary, you can define scaling values manually to suit your requirements.

Suffix:
<m> 1...5, index of the math waveform

Parameters:
<VertSclMd> MANual | AUTO
*RST: AUTO

Usage: Asynchronous command

Manual operation: See "Scale mode" on page 232

CALCulate:MATH<m>:DATA:HEADer?

Returns the header of math waveform data, the attributes of the waveform.

Suffix:
<m> 1...5, index of the math waveform

Return values:
<XStart> 1. header value: time of the first sample in s

<XStop> 2. header value: time of the last sample in s

<RecordLength> 3. header value: record length of the waveform in samples

<ValuesPerSample> 4. header value: number of values per sample. For most waveforms, the result is 1. For peak detect and envelope waveforms, it is 2. If the number is 2, the number of returned values is twice the number of samples (record length).

Example:
```
CALC:MATH1:DATA:HEAD?
-1E-07,9.9800000000000001E-08,1000,1
```
Start time of the data is -1E-07 = 100 ns, and end time of the data is 9.9800000000000001E-08 = 99.8 ns. The data stream has 1000 values with one value per sample.

Usage: Query only
Asynchronous command

CALCulate:MATH<m>:DATA:STYPe?

Returns the signal type of the math waveform.

Suffix:
<m> 1...5, index of the math waveform

Return values:
<SignalType> MATH

Usage: Query only
Asynchronous command

CALCulate:MATH<m>:DATA[:VALues]? [<Offset>[,<Length>]]

Returns the data of the math waveform points for transmission from the instrument to the controlling computer. The data can be used in MATLAB, for example.

Without parameters, the complete waveform is retrieved. Using the offset and length parameters, data can be retrieved in smaller portions, which makes the command faster. If you send only one parameter, it is interpreted as offset, and the data is retrieved from offset to the end of the waveform.

To set the export format, use `FORMat[:DATA]`.

Suffix:
<m> 1...5, index of the math waveform

Query parameters:
<Offset> Number of offset waveform points to be skipped.

<Length> Number of waveform points to be retrieved.

Return values:
<Data> List of values according to the format and content settings.

Example: `:CALC:MATH1:DATA:VAL? 100,10`
Returns 10 points from the start index 100.

Usage: Query only
Asynchronous command

18.11.3 History

ACQuire:HISTory:CURRent <CurrentAcqIndex>

Accesses a particular acquisition in the memory to display it, or to save it. The newest acquisition always has the index "0". Older acquisitions have a negative index.

Parameters:

<CurrentAcqIndex> Range: -2147483648 to 0
Increment: 1
*RST: 0

Usage: Asynchronous command

Manual operation: See "Current acq" on page 236

ACQuire:HISTory:ISODate?

Returns the absolute date and time of the acquisition that is selected in history view in ISO 8601 format. The same format is used in the header of exported waveform data files.

See also: `ACQuire:HISTory:CURRent`).

Return values:

<DateTimeISO8601> String with absolute date and time in this order: year, month, day, hour, minutes, seconds, and milliseconds.

Example:

```
ACQ:HIST:ISOD?
<-- "2024-10-02T10:11:09.603208067"
```

Usage: Query only
Asynchronous command

ACQuire:HISTory:PLAY

Starts and stops the replay of the history waveforms.

Usage: Event
Asynchronous command

Manual operation: See "Player" on page 236

ACQuire:HISTory:REPLay <AutoRepeat>

If enabled, the replay of the history waveform sequence repeats automatically.

Otherwise, the replay stops at the stop index set with `ACQuire:HISTory:STOP` on page 966.

Parameters:

<AutoRepeat> OFF | ON
*RST: OFF

Usage: Asynchronous command

Manual operation: See "Auto repeat" on page 238

ACQuire:HISTory:STARt <StartAcqIndex>

Sets the index of the first (oldest) acquisition to be displayed or exported. The index is always negative.

Parameters:

<StartAcqIndex> Range: -2147483648 to 0
Increment: 1
*RST: 0

Usage: Asynchronous command

Manual operation: See "Start acq" on page 236

ACQuire:HISTory:STOP <StopAcqIndex>

Sets the index of the last (newest) acquisition to be displayed or exported. The newest acquisition of the complete acquisition series always has the index "0".

Parameters:

<StopAcqIndex> Range: -2147483648 to 0
Increment: 1
*RST: 0

Usage: Asynchronous command

Manual operation: See "Stop acq" on page 236

ACQuire:HISTory:TPACq <TimePerAcq>

Sets the display time for one acquisition. The shorter the time, the faster the replay is.

Parameters:

<TimePerAcq> Range: 4E-05 to 10
Increment: 1
*RST: 0.05
Default unit: s

Usage: Asynchronous command

Manual operation: See "Display time" on page 236

ACQuire:HISTory:TSABsolute?

Returns the absolute daytime of the selected acquisition (`ACQuire:HISTory:CURRent`).

For automatic parsing of the time, use `ACQuire:HISTory:ISODate?`.

Return values:

<TimeAbsString> String containing the time and unit

Example:

```
ACQ:HIST:TSAB?
<-- "10:11 9,603.208.067 s"
```

Usage: Query only
Asynchronous command

Manual operation: See "Time stamp" on page 237

ACQuire:HISTory:TSDate?

Returns the date of the selected acquisition (ACQuire:HISTory:CURRent).

For automatic parsing of the time, use ACQuire:HISTory:ISODate?.

Return values:
<DateAbsString> String parameter with acquisition date

Example:
```
ACQ:HIST:TSD?
<-- "2024:10:02"    //02 Oct 2024
```

Usage: Query only
Asynchronous command

Manual operation: See "Time stamp" on page 237

ACQuire:HISTory:TSRelative?

Returns the relative time of the current acquisition - the time difference to the newest acquisition (index = 0).

See also: ACQuire:HISTory:CURRent.

Return values:
<TimeRelativ> Range: -1E+26 to 1E+26
Increment: 1
*RST: 0
Default unit: s

Usage: Query only
Asynchronous command

Manual operation: See "Time stamp" on page 237

ACQuire:HISTory:TSRReference?

Returns the relative time of the currently selected acquisition and the internal reference time (horizontal alignment) in history view in relation to the acquisition with index 0.

Return values:
<TimeRelIntRef> Range: -1E+26 to 1E+26
Increment: 1
*RST: 0
Default unit: s

Usage: Query only
Asynchronous command

Manual operation: See "Time stamp" on page 237

ACQuire:HISTory[:STATe] <State>

Enables the history mode and allows you to save history waveforms to file.

Parameters:

<State> OFF | ON

*RST: OFF

Usage: Asynchronous command

Manual operation: See "Show history" on page 235

18.11.4 Reference waveforms

18.11.4.1 Setup

REFCurve<rc>:ABORt

Aborts a running reference waveform export, which was started with `REFCurve<rc>:SAVE`, or a running reference waveform update, which was started with `REFCurve<rc>:UPDate`.

Suffix:

<rc> 1...4, index of the reference waveform

Usage: Event
Asynchronous command

Manual operation: See "Save as" on page 243

REFCurve<rc>:CLEar

Deletes the selected reference waveform. It disappears from the display, and its memory is deleted.

Suffix:
<rc> 1...4, index of the reference waveform

Usage: Setting only
Asynchronous command

Manual operation: See "Clear" on page 243

REFCurve<rc>:NAME <Name>

Defines the name of the reference waveform file to be loaded, saved or deleted.

Suffix:
<rc> 1...4, index of the reference waveform

Parameters:
<Name>

Usage: Asynchronous command

Manual operation: See "Save as" on page 243

REFCurve<rc>:OFFSet <VerticalOffset>

The vertical offset moves the reference waveform vertically. Enter a value with the unit of the waveform.

Suffix:
<rc> 1...4, index of the reference waveform

Parameters:
<VerticalOffset> Range: -1E+26 to 1E+26
Increment: 1E-06
*RST: 0
Default unit: V

Usage: Asynchronous command

Manual operation: See "Vertical offset" on page 246

REFCurve<rc>:OPEN

Loads the reference waveform file selected by `REFCurve<rc>:NAME`. Note that reference waveforms can be loaded only from `.ref` files.

Suffix:
<rc> 1...4, index of the reference waveform

Usage: Event
Asynchronous command

Manual operation: See "Open" on page 243

REFCurve<rc>:RESTore

Applies the original settings of the reference waveform to the horizontal and vertical settings of the selected waveform.

Suffix:
<rc> 1...4, index of the reference waveform

Usage: Setting only
Asynchronous command

Manual operation: See "Restore settings" on page 245

REFCurve<rc>:SAVE

Saves the reference waveform to the file selected by `REFCurve<rc>:NAME`.

Suffix:
<rc> 1...4, index of the reference waveform

Usage: Event
Asynchronous command

Manual operation: See "Save as" on page 243

REFCurve<rc>:SOURce <Source>

Selects the source waveform from the active waveforms, e.g. input channels, math waveforms, or spectrum.

Suffix:
<rc> 1...4, index of the reference waveform

Parameters:
<Source> C1 | C2 | C3 | C4 | M1 | M2 | M3 | M4 | M5 | R1 | R2 | R3 | R4 | SPECMAXH1 | SPECMINH1 | SPECNORM1 | SPECAVER1 | SPECMAXH2 | SPECMINH2 | SPECNORM2 | SPECAVER2 | SPECMAXH3 | SPECMINH3 | SPECNORM3 | SPECAVER3 | SPECMAXH4 | SPECMINH4 | SPECNORM4 | SPECAVER4 | TRK1 | TRK2 | TRK3 | ... | TRK16 | PA1QPOWER | PA2QPOWER | PA3QPOWER | PA1HPOWER1 | PA2HPOWER1 | PA3HPOWER1 | PA1SPOWER | PA2SPOWER | PA3SPOWER | PA1SOA | PA2SOA | PA3SOA | PA1IPOWER | PA2IPOWER | PA3IPOWER | PA1OPOWER | PA2OPOWER | PA3OPOWER | O<n>C1 | O<n>C2 | ... | O<n>C8 (<n> = 2 to 8)

Usage: Asynchronous command

Manual operation: See "Source" on page 242

REFCurve<rc>:STATe <State>

Enables the display of the reference waveform in the diagram. Before you can display it, create the reference waveform.

Suffix:
<rc> 1...4, index of the reference waveform

Parameters:
<State> OFF | ON
*RST: OFF

Usage: Asynchronous command

Manual operation: See "Show" on page 242

REFCurve<rc>:UPDate

Copies the selected source waveform with all its settings to the memory of the reference waveform. If there is a previously defined reference waveform in this memory, it is updated by the current source waveform. If the acquisition is running, the reference waveform is a snapshot.

Suffix:
<rc> 1...4, index of the reference waveform

Usage: Event
Asynchronous command

Manual operation: See "Create/Update" on page 242

18.11.4.2 Scaling

REFCurve<rc>:AXIS[:XMODe] <XAxisMode>

Defines the scaling method for the frequency (x-axis) of the reference curve.

Suffix:
<rc> 1...4, index of the reference waveform

Parameters:

<XAxisMode> LIN | LOG

`LIN`: Linear scaling
`LOG`: Logarithmic scaling

*RST: LIN

Usage: Asynchronous command

REFCurve<rc>:SCALe <VerticalScale>

Sets the vertical scale, which defines the displayed amplitude of the selected waveform.

Suffix:

<rc> 1...4, index of the reference waveform

Parameters:

<VerticalScale>
Range: 1E-15 to 1E+26
Increment: 1E-05
*RST: 0.5
Default unit: Unit of the source waveform

Usage: Asynchronous command

Manual operation: See "[Scale]" on page 48

REFCurve<rc>:POSition <VertPosi>

Available, if `REFCurve<rc>:VMODe` is set to `INDependent`.

Moves the reference waveform up or down in the diagram.

Suffix:

<rc> 1...4, index of the reference waveform

Parameters:

<VertPosi>
Range: -1E+26 to 1E+26
Increment: 0.02
*RST: 0
Default unit: div

Usage: Asynchronous command

Manual operation: See "Vertical position" on page 246

REFCurve<rc>:HMODe <HorizontalMode>

Selects the coupling of horizontal settings.

Suffix:

<rc> 1...4, index of the reference waveform

Parameters:

<HorizontalMode> ORIGinal | COUPled

ORIGinal
Horizontal scaling and reference point of the source waveform are used.

COUPled
The current horizontal settings of the diagram are used.

*RST: ORIGinal

Usage: Asynchronous command

Manual operation: See "Mode" on page 247

REFCurve<rc>:RESCale:HORizontal:FACTor <ScaleFactor>

Sets the horizontal scale factor. A factor greater than 1 stretches the waveform horizontally, a factor lower than 1 compresses the curve.

Suffix:
<rc> 1...4, index of the reference waveform

Parameters:
<ScaleFactor> Range: 1E-14 to 100000000000000
Increment: 0.1
*RST: 1

Usage: Asynchronous command

Manual operation: See "Scale factor" on page 247

REFCurve<rc>:RESCale:HORizontal:OFFSet <Offset>

Moves the waveform horizontally. Enter a value with a time unit suitable for the time scale of the diagram.

Positive values shift the waveform to the right, negative values shift it to the left.

Suffix:
<rc> 1...4, index of the reference waveform

Parameters:
<Offset> Range: -5000000 to 5000000
Increment: 0.01
*RST: 0
Default unit: s

Usage: Asynchronous command

Manual operation: See "Horizontal offset" on page 248

REFCurve<rc>:RESCale:HORizontal:STATe <State>

If enabled, the horizontal offset and factor are applied to the reference waveform.

Stretching and offset change the display of the waveform independent of the horizontal settings of the source waveform and of the horizontal diagram settings.

Suffix:

<rc> 1...4, index of the reference waveform

Parameters:

<State> OFF | ON

*RST: OFF

Usage: Asynchronous command

Manual operation: See "Enable" on page 247

REFCurve<rc>:RESCale:VERTical:FACTor <ScaleFactor>

Sets the vertical scale factor. A factor greater than 1 stretches the waveform vertically, a factor lower than 1 compresses the curve.

Suffix:

<rc> 1...4, index of the reference waveform

Parameters:

<ScaleFactor> Range: -100000000 to 100000000
Increment: 0.1
*RST: 1

Usage: Asynchronous command

Manual operation: See "Scale factor" on page 247

REFCurve<rc>:RESCale:VERTical:OFFSet <Offset>

The vertical offset moves the reference waveform vertically. Enter a value with the unit of the waveform.

Like vertical offset of a channel waveform, the offset of a reference waveform is subtracted from the measured value. Negative values shift the waveform up, positive values shift it down.

Suffix:

<rc> 1...4, index of the reference waveform

Parameters:

<Offset> Range: -100000000 to 100000000
Increment: 1E-06
*RST: 0
Default unit: V

Usage: Asynchronous command

Manual operation: See "Vertical offset" on page 247

REFCurve<rc>:RESCale:VERTical:STATe <State>

If enabled, the vertical offset and factor are applied to the reference waveform.

Stretching and offset change the display of the waveform independent of the vertical scale and position.

Suffix:
<rc> 1...4, index of the reference waveform

Parameters:
<State> OFF | ON

*RST: OFF

Usage: Asynchronous command

Manual operation: See "Enable" on page 247

REFCurve<rc>:TOORiginal

Available, if `REFCurve<rc>:VMODe` is set to `INDependent`.

Restores the original vertical settings of the reference waveform.

Suffix:
<rc> 1...4, index of the reference waveform

Usage: Setting only
Asynchronous command

Manual operation: See "Set to original" on page 245

REFCurve<rc>:VMODe <VerticalMode>

Selects the coupling of vertical settings.

Suffix:
<rc> 1...4, index of the reference waveform

Parameters:
<VerticalMode> COUPled | INDependent

COUPled
Vertical position and scale of the source are used.

INDependent
Scaling and position can be set specific to the reference waveform.

*RST: INDependent

Usage: Asynchronous command

Manual operation: See "Vertical mode" on page 245

18.11.4.3 Reference waveform data export

Commands to transmit the data of reference waveforms are listed below. Commands for saving waveform data to a file are described in Section 18.12.4, "Waveform export to file", on page 991.

REFCurve<rc>:DATA:STYPe?

Suffix:

<rc>	1...4, index of the reference waveform

Return values:

<SignalType>	NONE | CHANNEL | MATH | TRACK | REFERENCE | SPECTRUM | FRA_REF

Usage: Query only
Asynchronous command

REFCurve<rc>:DATA:HEADer?

Returns header information on the reference waveform, the attributes of the waveform.

The information depends on the waveform domain, it is different for time domain and frequency domain reference waveforms. See:

- `CHANnel<ch>:DATA:HEADer?` on page 891
- `CALCulate:SPECtrum<sp>:WAVeform:NORMal:DATA:HEADer?` on page 1050

Suffix:

<rc>	1...4, index of the reference waveform

Return values:

<XStart>	1. header value: time of the first sample in s for a time domain signal, or start frequency of the first spectrum bin in Hz for a frequency domain signal
<XStop>	2. header value: time of the last sample in s for a time domain signal, or start frequency of the last spectrum bin in Hz for a frequency domain signal
<RecordLength>	3. header value: record length of the waveform in samples or bins
<ValuesPerSample>	4. header value: number of values per sample or bin. The number depends on the source waveform from which the reference waveform was created.

Example: Time domain signal:

```
REFC:DATA:HEAD?
-1E-07,9.9800000000000001E-08,1000,1
```

Start time of the data is -1E-07= -100 ns and stop time of the data is 9.9800000000000001E-08= 99.8 ns. The data stream has 1000 values with one value per sample.

Example: Frequency domain signal:

```
REFC:DATA:HEAD?
549316.1734194756,1999450683.360919,2621,1
```

Start frequency of the first spectrum bin is 549316.1734194756 = ~ 549.3 kHz and start frequency of the last spectrum bin is 1999450683.360919 = ~ 1.999 GHz. The data stream has 2621 values with one value per bin.

Usage: Query only
Asynchronous command

REFCurve<rc>:DATA[:VALues]? [<Offset>[,<Length>]]

Returns the data of the channel waveform points for transmission from the instrument to the controlling computer. The data can be used in MATLAB, for example.

Without parameters, the complete waveform is retrieved. Using the offset and length parameters, data can be retrieved in smaller portions, which makes the command faster. If you send only one parameter, it is interpreted as offset, and the data is retrieved from offset to the end of the waveform.

To set the export format, use FORMat[:DATA] on page 814.

Suffix:
<rc> 1...4, index of the reference waveform

Query parameters:
<Offset> Number of offset waveform points to be skipped.
Range: 0 to m. Limit: n + m <= record length

<Length> Number of waveform points to be retrieved.
Range: 1 to n. Limit: n + m <= record length

Return values:
<Data> List of values according to the format and content settings.

Usage: Query only
Asynchronous command

18.11.5 Waveform histograms

18.11.5.1 Histogram settings

HISTogram<m>:ADD

Creates a new histogram with the specified index.

Suffix:
<m> 1...8, index of the histogram

Usage: Setting only
Asynchronous command

HISTogram<m>:COUNt? <Count>

Returns the number of created histograms.

You can query the minimum and maximum values with `<command>? MIN` and `<command>? MAX`.

Suffix:
<m> Irrelevant, omit the suffix.

Return values:
<Count> Counted number of histograms

Usage: Query only
Asynchronous command

HISTogram<m>:ENABle <State>

Enables or disables the histogram evaluation and display. The histogram settings are kept until the histogram is deleted.

Suffix:
<m> 1...8, index of the histogram

Parameters:
<State> OFF | ON
*RST: ON

Usage: Asynchronous command

Manual operation: See "Enable" on page 249

HISTogram<m>:MODE <Mode>

Defines the type of histogram.

Suffix:
<m> 1...8, index of the histogram

Parameters:
<Mode> VERTical | HORizontal

VERTical
A vertical histogram has horizontal bars that show the occurence of amplitude, or vertical values.

HORizontal
A horizontal histogram has vertical bars that show the occurrence of a sample at a given time on the x-axis.

	*RST: VERTical
Usage:	Asynchronous command
Manual operation:	See "Mode" on page 250

HISTogram<m>:REMove

Deletes the specified histogram.

Suffix:

<m>	1...8, index of the histogram
Usage:	Setting only Asynchronous command

HISTogram<m>:RESet

Restarts the calculation of the selected histogram.

To reset all histograms and measurements, use `DISPlay:CLR`.

Suffix:

<m>	1...8, index of the histogram
Usage:	Setting only Asynchronous command
Manual operation:	See "Reset" on page 250

HISTogram<m>:SOURce <Source>

Defines the source of the histogram.

Suffix:

<m>	1...8, index of the histogram

Parameters:

<Source>	C1 | C2 | C3 | C4 | M1 | M2 | M3 | M4 | M5 | R1 | R2 | R3 | R4 | O<n>C1 | O<n>C2 | ... | O<n>C8 (<n> = 2 to 8)
Usage:	Asynchronous command
Manual operation:	See "Source" on page 250

18.11.5.2 Window settings

HISTogram<m>:WINDow:ENABle <State>

When you use a histogram window, the analyzed part of the source waveform is limited vertically and horizontally.

Suffix:

<m> 1...8, index of the histogram

Parameters:

<State> OFF | ON

*RST: OFF

Usage: Asynchronous command

Manual operation: See "Use window" on page 251

HISTogram<m>:WINDow:HORizontal:MODE <Mode>
HISTogram<m>:WINDow:VERTical:MODE <Mode>

The commands define whether the window limits are entered as absolute or relative values, in horizontal and vertical direction.

Suffix:

<m> 1...8, index of the histogram

Parameters:

<Mode> ABS | REL

*RST: ABS

Usage: Asynchronous command

Manual operation: See "Mode" on page 251

HISTogram<m>:WINDow:HORizontal:ABSolute:POSition <Value>
HISTogram<m>:WINDow:HORizontal:ABSolute:SPAN <Value>
HISTogram<m>:WINDow:HORizontal:ABSolute:STARt <Value>
HISTogram<m>:WINDow:HORizontal:ABSolute:STOP <Value>

Set the horizontal window limits as absolute values. Enter the unit of the horizontal axis together with the value.

Suffix:

<m> 1...8, index of the histogram

Parameters:

<Value> Range: -1E+26 to 1E+26
Increment: 0.01
*RST: 0 for position, 0.02 for span, -0.01 for start and 0.01 for stop

Usage: Asynchronous command

Manual operation: See "Start, Stop, Range, Position" on page 251

HISTogram<m>:WINDow:HORizontal:RELative:POSition <Value>
HISTogram<m>:WINDow:HORizontal:RELative:SPAN <Value>
HISTogram<m>:WINDow:HORizontal:RELative:STARt <Value>
HISTogram<m>:WINDow:HORizontal:RELative:STOP <Value>

Set the horizontal window limits as relative values in % of the diagram width.

Suffix:

<m> 1...8, index of the histogram

Parameters:

<Value> Range: 0 for position, start and stop, 1E-15 for span to 100
Increment: 0.1
*RST: position: 50, span: 1, start: 0, stop: 100
Default unit: %

Usage: Asynchronous command

Manual operation: See "Relative start, Relative stop, Relative range, Relative position" on page 252

HISTogram<m>:WINDow:VERTical:ABSolute:POSition <Value>
HISTogram<m>:WINDow:VERTical:ABSolute:SPAN <Value>
HISTogram<m>:WINDow:VERTical:ABSolute:STARt <Value>
HISTogram<m>:WINDow:VERTical:ABSolute:STOP <Value>

Set the vertical window limits as absolute values. Enter the unit of the vertical axis together with the value.

Suffix:

<m> 1...8, index of the histogram

Parameters:

<Value> Range: -1E+26 to 1E+26
Increment: 0.01
*RST: 0 for position, 0.02 for span, -0.01 for start and 0.01 for stop

Usage: Asynchronous command

Manual operation: See "Start, Stop, Range, Position" on page 252

HISTogram<m>:WINDow:VERTical:RELative:POSition <Value>
HISTogram<m>:WINDow:VERTical:RELative:SPAN <Value>
HISTogram<m>:WINDow:VERTical:RELative:STARt <Value>
HISTogram<m>:WINDow:VERTical:RELative:STOP <Value>

Set the vertical window limits as relative values in % of the diagram height.

Suffix:
<m> 1...8, index of the histogram

Parameters:
<Value> Range: 0 for position, start and stop, 1E-15 for span to 100
Increment: 0.1
*RST: position: 50, span: 1, start: 0, stop: 100
Default unit: %

Usage: Asynchronous command

Manual operation: See "Start, Stop, Range, Position" on page 252

18.11.5.3 Histogram data transfer

EXPort:HISTogram<m>:DATA:HEADer?

Returns the header of the histogram data, the attributes of the waveform histogram.

Suffix:
<m> 1...8, index of the histogram

Return values:
<Start> 1. header value: start value, for vertical histogram in the waveform unit, for horizontal histogram in s.

<End> 2. header value: end value, for vertical histogram in the waveform unit, for horizontal histogram in s.

<HistogrLength> 3. header value: number of histogram bins

Example:
```
EXP:HIST3:DATA:HEAD?
-0.250244,0.250122,1024
```
Start value of the histogram is about -250 mV, and end value is about 250 mV. The data stream has 1024 values, one value for each bin.

Usage: Query only
Asynchronous command

EXPort:HISTogram<m>:DATA[:VALues]?

Returns the data of the specified histogram for transmission from the instrument to the controlling computer. The data can be used in MATLAB, for example.

To set the export format, use `FORMat[:DATA]`. For histogram data, only ASCii and REAL,32 and REAL,64 are supported. The normalization setting is considered: `EXPort:HISTogram<m>:NORMalize`.

Suffix:

<m>	1...8, index of the histogram

Return values:

<Data>	Comma-separated list of values according to the format setting.

Usage: Query only
Asynchronous command

18.12 Data management

Some of the commands in the following section are asynchronous. An overlapping or asynchronous command does not automatically finish executing before the next command starts executing. If overlapping commands must be executed in a defined order, e.g. to avoid wrong measurement results, they must be serviced sequentially.

To prevent an overlapping execution of commands, one of the commands `*OPC`, `*OPC?` or `*WAI` can be used after the command or a command set.

For more information, see:

- www.rohde-schwarz.com/rc-via-scpi, section "Command sequence and synchronization"

18.12.1 Instrument settings

The Mass MEMory subsystem provides commands to access the storage media and to save and reload instrument settings.

File and directory names

The <file_name> and <directory_name> parameters are strings. Some commands use a fixed directory; for others the <file_name> can contain the complete path including the drive name and all subdirectories. If no complete path is specified, the file location is relative to the current directory, queried with `MMEMory:CDIRectory?`. The filename itself may contain the period as a separator for extensions.

File and directory names can be chosen according to Windows™ conventions. All letters and numbers are allowed, as well as the special characters "_", "^", "$", "~", "!", "#", "%", "&", "-", "{", "}", "(", ")", "@" and "`". Reserved filenames are CON, AUX, COM1, ..., COM4, LPT1, ..., LPT3, NUL and PRN.

The use of wildcards ? and * is not allowed.

MMEMory:DRIVes?

Returns the path list of available drives.

Return values:

<Drive> List of strings, for example:
Instrument only: `"/home/storage/userData"`
Instrument with connected USB flash drive:
`"/home/storage/userData","/run/media/usb/<MyDriveName>/MYD`
. MYDATA is the partition name, which is also shown in the file explorer.
Instrument with connected USB flash drive:
`"/home/storage/userData","/run/media/usb/<MyDriveName>/8AF`
. 8AF8-3EBA is an example ID. ID is used if the partition does not have a name, or the name cannot be read.

Usage: Query only

MMEMory:DCATalog? [<PathName>]

Returns the subdirectories of the current or of a specified directory.

Query parameters:

<PathName> String parameter to specify the directory. If the directory is omitted, the command queries the contents of the current directory, to be set and queried with `MMEMory:CDIRectory`.

Return values:

<FileEntry> Names of the subdirectories separated by colons. The first two strings are related to the parent directory.

Example: `MMEM:DCAT?`

Usage: Query only

MMEMory:DCATalog:LENGth? [<PathName>]

Returns the number of subdirectories of the current or of a specified directory. The number includes the parent directory strings "." and ".." and corresponds to the number of strings returned by the `MMEMory:DCATalog?` command.

Query parameters:

<PathName> String parameter to specify the directory. If the directory is omitted, the command queries the contents of the current directory, to be set and queried with `MMEMory:CDIRectory`.

Return values:

<FileEntryCount> Number of parent directories and subdirectories.

Example:
```
MMEM:DCAT:LENG?
5
```

Usage: Query only

MMEMory:CDIRectory [<DirectoryName>]

Changes the default directory for file access.

Parameters:

<DirectoryName> String parameter to specify the directory.

*RST: "\"

Example: `MMEM:CDIR '/home/storage/userData/Waveforms'`

Usage: SCPI confirmed

MMEMory:MDIRectory <DirectoryName>

Creates a new directory with the specified name.

Setting parameters:

<DirectoryName> String parameter to specify the new directory. If the path consists of several subdirectories, the complete tree is created if necessary.

Example: `MMEM:MDIR '/home/storage/userData/Waveforms'`

Usage: Setting only

MMEMory:RDIRectory <DirectoryName>

Deletes the specified directory.

Setting parameters:

<DirectoryName> String parameter to specify the directory to be deleted.
This directory must be empty, otherwise it is not deleted.

Example: `MMEM:RDIR '/home/storage/userData/Test'`

Usage: Setting only

MMEMory:CATalog? [<PathName>][, <Format>]

Returns a list of files contained in the specified directory. The result corresponds to the number of files returned by the MMEMory:CATalog:LENgth command.

Query parameters:

<PathName> String parameter to specify the directory. If the directory is omitted, the command queries directory specified with `MMEMory:CDIRectory`.

<Format> ALL | WTIMe

ALL: Extended result including file, date, time and attributes
WTIMe: Extended result including file, date, time

Return values:

<UsedMemory> Total amount of storage currently used in the directory, in bytes.

<FreeMemory> Total amount of storage available in the directory, in bytes.

<FileEntry> All files and subdirectories of the directory are listed with their filename, format and size in bytes. The first two strings are related to the parent directory.

Example:

```
MMEM:CAT? '/home/storage/userData'
529479,1831777894400,".,DIR,0","..,DIR,0",
"Backup,DIR,0","CSS,DIR,0","DATEN,DIR,0",
"Commands.jar,BIN,529479","FAVORITES,DIR,0",
"LOG,DIR,0","DATA,DIR,0","test,DIR,0",
"TotalCMD,DIR,0"
```

Usage: Query only
SCPI confirmed

MMEMory:CATalog:LENGth? [<PathName>]

Returns the number of files and subdirectories of the current or specified directory. The number includes the parent directory strings "." and ".." and it corresponds to the number of <FileEntry> strings returned by the `MMEMory:CATalog?` command.

Query parameters:

<PathName> String parameter, directory to be queried. If the directory is omitted, the current directory is queried, specified with `MMEMory:CDIRectory`.

Return values:

<Count> Number of files and subdirectories including parent directory entries.

Example:
```
MMEM:CDIR '/home/storage/userData'
MMEM:CAT:LENG?
11
```

Usage: Query only

MMEMory:COPY <FileSource>[, <FileDestination>]

Copies an existing file to a new file.

Setting parameters:

<FileSource> String parameter. Contains name and path of the file to be copied. Wildcards (* and ?) are allowed.

<FileDestination> String parameter. Contains name and path of the new file. If the file already exists, it is overwritten without notice. If no file destination is specified, the source file is written to the current directory specified with `MMEMory:CDIRectory`.

Usage: Setting only
SCPI confirmed

MMEMory:MOVE <FileSource>, <FileDestination>

Moves the specified file to a new location on the same drive and renames it.

Setting parameters:

<FileSource> String parameter, contains name and path of the file to be copied.
Wildcards (* and ?) are allowed. Therefore, specify a directory for <FileDestination>. Renaming is not possible.

<FileDestination> String parameter. Contains name and path of the new file. If no path is specified, the <FileSource> directory is used - the file is renamed.

Usage: Setting only
SCPI confirmed

MMEMory:DELete <FileName>

Removes the specified file/files. To delete directories, use `MMEMory:RDIRectory`.

Setting parameters:

<FileName> String parameter to specify the name and directory of the file to be removed. Wildcards (* and ?) are allowed.
If no path is defined, the current directory is used, specified with `MMEMory:CDIRectory`.

Example: `MMEM:DEL '*.CFG'`
Deletes all CFG files from the current directory.

Usage: Setting only
SCPI confirmed

MMEMory:DATA <FileName>, <Data>
MMEMory:DATA? <FileName>

Stores data in the specified file to the storage location specified using `MMEMory:CDIRectory`.

Parameters:

<Data> <block>

488.2 block data format. The delimiter EOI must be selected to achieve correct data transfer.
The block begins with character '#'. The next digit is the length of the length information, followed by this given number of digits providing the number of bytes in the following binary data.

Parameters for setting and query:

<FileName> String parameter, the name of the file the data is stored to.

Example: `MMEM:DATA 'abc.txt', #216This is the file`
#2: the length information has two digits.
16: the binary data has 16 bytes.

Example: `MMEM:DATA? 'abc.txt'`
Returns the data from file `abc.txt`.

MMEMory:ATTRibute <FileName>, <Attributes>
MMEMory:ATTRibute? <FileName>

Sets file attributes for the specified file/files. The command can be used for files only.

Setting parameters:

<Attributes> String with attributes and setting information.
'+' before the attribute: sets the attribute
'-' before the attribute: deletes the attribute
'R': read only
'H': hidden file

Parameters for setting and query:

<FileName> String parameter, contains name and path of the file. Wildcards (* and ?) are allowed.

Return values:

<FileEntry> String containing: "<file_name>,<file_attributes>"

MMEMory:SAV <FileDestination>

Stores the current instrument settings to the specified file.

Waveform generator settings are not included.

This command has the same effect as the combination of *SAV and MMEMory:STORe:STATe.

Parameters:

<FileDestination> String parameter specifying path and filename of the target file. Wildcards are not allowed.

Usage: Event

MMEMory:RCL <FileSource>

Restores the instrument settings from the specified file.

The stored instrument settings do not include waveform generator settings.

This command has the same effect as the combination of MMEMory:LOAD:STATe and *RCL.

Parameters:

'<FileSource>' String parameter specifying the path and filename of the source file. Wildcards are not allowed.

Usage: Event

MMEMory:STORe:STATe <MemoryNumber>, <FileName>

Stores the instrument settings from the specified internal memory to the specified file. To store the current instrument settings to the internal memory, use *SAV first.

Setting parameters:

<MemoryNumber> Number of the internal memory

Range: 1 to 99

<FileName> String parameter specifying the complete path and filename of the source file.

Usage: Setting only

MMEMory:LOAD:STATe <MemoryNumber>, <FileName>

Loads the instrument settings from the specified file to the specified internal memory. After the file has been loaded, the settings must be activated using a *RCL command.

Setting parameters:

<MemoryNumber> Number of the internal memory

Range: 1 to 99

<FileName> String parameter specifying the complete path and filename of the source file.

Usage: Setting only

MMEMory:GENerator:RCL <FilePath>

Restores the waveform generator settings from the specified file.

Parameters:
<FilePath> String parameter specifying the path and filename of the settings file.

Usage: Asynchronous command

MMEMory:GENerator:SAV <FilePath>

Stores the current waveform generator settings to the specified file.

Parameters:
<FilePath> String parameter specifying path and filename of the settings file.

Usage: Asynchronous command

18.12.2 Saveset

SAVeset:CONFig:PREView <IncludePreview>

If set to `OFF`, the saveset is stored without the preview image to reduce the file size.

Use the command each time before you save a saveset.

Parameters:
<IncludePreview> OFF | ON
*RST: ON

Usage: Asynchronous command

SAVeset:CONFig:UPReferences <UserSettings>

If ON, the user-specific display settings for the toolbar, waveform colors and diagram presentation are included in the saveset file. The setting affects the saving and the recall actions.

Parameters:
<UserSettings> OFF | ON
*RST: OFF

Usage: Asynchronous command

18.12.3 Generator saveset

GENerator:RCL <filePath>

Restores the waveform generator from the specified file.

Parameters:
<filePath> String parameter specifying the path and filename of the source file.

Usage: Asynchronous command

GENerator:SAV <filePath>

Stores the current waveform generator settings to the specified file.

Parameters:
<filePath> String parameter specifying path and filename of the target file.

Usage: Asynchronous command

18.12.4 Waveform export to file

EXPort:WAVeform:ABORt

Aborts a running waveform export, which was started with `EXPort:WAVeform:SAVE`.

Usage: Event
Asynchronous command

EXPort:WAVeform:AUTonaming:NAME <FileName>

Sets a name for the waveform file, without extension. The name is extended with a time stamp when the file is saved.

The setting is used for automatic saving actions, for example, saving on trigger or mask violation. It has **no** effect on `EXPort:WAVeform:SAVE`.

Parameters:
<FileName> String with the filename.

Usage: Asynchronous command

Manual operation: See "File name base" on page 405

EXPort:WAVeform:AUTonaming:PATH <FolderPath>

Sets the directory where the waveform file is saved. For local storage, the path is always `/home/storage/userData`.

The setting is used for automatic saving actions, for example, saving on trigger or mask violation. It has **no** effect on `EXPort:WAVeform:SAVE`.

Parameters:

<FolderPath> String with the path.

Usage: Asynchronous command

Manual operation: See "<Folder>" on page 405

EXPort:WAVeform:AUTonaming:TYPE <FileExtension>

Sets the file type of the waveform file.

The setting is used for automatic saving actions, for example, saving on trigger or mask violation. It has **no** effect on `EXPort:WAVeform:SAVE`.

Parameters:

<FileExtension> CSV | REF | ZIP | H5

*RST: REF

Usage: Asynchronous command

Manual operation: See "File extension" on page 405

EXPort:WAVeform:CURSorset <Cursorset>

Sets the cursor set to be used for limited data export if `EXPort:WAVeform:SCOPe` is set to `CURSor`.

Parameters:

<Cursorset> CURSOR1 | CURSor1 | CURSOR2 | CURSor2

Usage: Asynchronous command

Manual operation: See "Export mode" on page 404

EXPort:WAVeform:GATE

Selects the gate to be used for limited data export if `EXPort:WAVeform:SCOPe` is set to `GATE`.

Usage: Asynchronous command

Manual operation: See "Export mode" on page 404

EXPort:WAVeform:NAME <name>

Sets the path, the filename and the file format of the export file. The setting is used for save-as operations that do not use the autonaming settings.

Parameters:

<name> String with path and filename with extension `.ref`, `.csv`, `.zip`, or `.h5`. Extension `.ref` is provided for single waveform export only, while `.zip` is for export of multiple waveforms in REF format. CSV can be used for export of single waveforms, and multiple analog channels.
For local storage, the path is always `/home/storage/userData`.

Example:

```
EXP:WAV:NAME
'/home/storage/userData/Export_C1.csv'
EXP:WAV:SCOP DISP
EXP:WAV:SAVE
```

Saves the visible waveform data of channel 1 in xml format to `/home/storage/userData/Export_C1.csv`.

Usage: Asynchronous command

Manual operation: See "Save As" on page 406

EXPort:WAVeform:SAVE

Saves the waveform to the file specified with `EXPort:WAVeform:NAME`.

Usage: Event
Asynchronous command

Manual operation: See "Save As" on page 406

EXPort:WAVeform:SCOPe <Scope>

Defines the part of the waveform record that has to be stored.

Parameters:

<Scope> DISPlay | ALL | CURSor | GATE | MANual

DISPlay
Waveform data that is displayed in the diagram.

ALL
Complete waveform, which is usually longer than the displayed waveform.

CURSor
Data between the cursor lines if a cursor measurement is defined for the source waveform.

GATE
Data included in the measurement gate if a gated measurement is defined for the source waveform.

MANual
Saves the data between user-defined start and stop values to be set with EXPort:WAVeform:STARt and EXPort:WAVeform:STOP.

*RST: DISPlay

Example: See Section 18.4.4, "Data transfer in roll mode", on page 809.

Usage: Asynchronous command

Manual operation: See "Export mode" on page 404

EXPort:WAVeform:SOURce <Sources>

Selects the waveform or waveforms to be exported to file.

Parameters:

<Sources> Comma-separated list of waveforms

Possible waveform sources are:
Analog signals: C1,C2,C3,C4
Digital signals:
D0,D1,D2,D3,D4,D5,D6,D7,D8,D9,D10,D11,D12,D13,D14,D15
Math waveforms: M1,M2,M3,M4,M5
Reference waveforms: R1,R2,R3,R4
Spectrum traces: SPECMAXH1,SPECMINH1,SPECNORM1,SPECAVER1,SPECMAXH2,SPECMINH2,SPECNORM2,SPECAVER2,SPECMAXH3,SPECMINH3,SPECNORM3,SPECAVER3,SPECMAXH4,SPECMINH4,SPECNORM4,SPECAVER4
Tracks: TRK1,TRK2,TRK3, ...,TRK16
Analog channels of connected scopes (ScopeSync):
O<n>C1,O<n>C2, ... ,O<n>C8
Power waveforms: PA1QPOWER | PA2QPOWER | PA3QPOWER | PA1HPOWER1 | PA2HPOWER1 | PA3HPOWER1 | PA1SPOWER | PA2SPOWER | PA3SPOWER | PA1IPOWER | PA2IPOWER | PA3IPOWER | PA1OPOWER | PA2OPOWER | PA3OPOWER | | PA1SOA | PA2SOA | PA3SOA

Example:

```
EXP:WAV:NAME '/home/storage/userData/Export_C2.csv'
EXPort:WAVeform:SOURce C2
EXP:WAV:SCOP DISP
EXP:WAV:SAVE
```

Exports the data of channel 2 to a CSV file.

Example:

```
EXP:WAV:NAME '/home/storage/userData/Export_multi.zip'
EXPort:WAVeform:SOURce C1,C2,SPECNORM1,SPECAVER1
EXP:WAV:SCOP DISP
EXP:WAV:SAVE
```

Exports the data of channel 1, channel 2, normal and average spectrum traces to a zip file.

Usage: Asynchronous command

Manual operation: See "Source" on page 403

EXPort:WAVeform:STARt <Start>

Sets the start time value of the waveform section for export, if `EXPort:WAVeform:SCOPe` on page 993 is set to `Manual`.

Parameters:

<Start> Range: -1E+26 to 1E+26
Increment: 0.01
*RST: 0.01
Default unit: s

Usage: Asynchronous command

Manual operation: See "Export mode" on page 404

EXPort:WAVeform:STOP <Stop>

Sets the end time value of the waveform section for export, if `EXPort:WAVeform:SCOPe` on page 993 is set to `Manual`.

Parameters:

<Stop> Range: -1E+26 to 1E+26
Increment: 0.01
*RST: 0.01
Default unit: s

Usage: Asynchronous command

Manual operation: See "Export mode" on page 404

18.12.5 Fast data export

EXPort:WAVeform:DATA[:VALues]?

Starts a fast export of the selected waveforms for use in automated analysis systems. There is no corresponding `...:DATA:HEADer` command. Offset and length parameters are not available.

Select the waveforms for export with `EXPort:WAVeform:SOURce`, and the data scope with `EXPort:WAVeform:SCOPe`.

The data stream contains the pure data of the exported sources. The order of the sources can be read with `EXPort:WAVeform:SOURce?`. The order is predefined and independent of the setting order to ensure the same order for the same selection of waveforms.

Fast export is possible at low record length, depending on the instrument and active functionality. If fast export is not possible, you can export the single signals.

Parameters:

<Values> Binary format: stream of bytes, without delimiter
ASCII: comma-separated value list

Example: The following waveforms are active and acquired: C1, C2 and SPECNORM1.
Determine the number of values per waveform:

```
CHANnel1:WAVeform:DATA:HEADer? --> 1000 values
CHANnel2:WAVeform:DATA:HEADer?      --> 1000 values
CALCulate:SPECtrum1:WAVeform:NORMal:DATA:HEADer? --> 2867 values
```

Fast export of all waveforms at once as float values:

```
FORMat:DATA REAL, 32
EXPort:WAVeform:SOURce C2,C1,SPECNORM1
EXPort:WAVeform:SOURce?      --> C1,C2,SPECNORM1
EXPort:WAVeform:DATA:VALues?
--> data stream of 1000 values C1, then 1000 values C2, then 2867 values
```

If the fast export fails, use the export of single waveforms:

```
CHANnel1:WAVeform:DATA:VALues?
CHANnel2:WAVeform:DATA:VALues?
CALCulate:SPECtrum1:WAVeform:NORMal:DATA:VALues?
```

Usage: Query only
Asynchronous command

18.12.6 Waveform histograms

EXPort:HISTogram<m>:NORMalize <Normalization>

If normalization is off, the number of samples in a given bin is exported as integer values. With normalization, the ratio of samples in a given bin to the sum of all samples is exported as float value. The sum of all normalized values is 1.

The command affects all histogram exports.

Suffix:

<m> Irrelevant, omit the suffix.

Parameters:

<Normalization> OFF | ON

*RST: ON

Usage: Asynchronous command

Manual operation: See "Normalization" on page 420

EXPort:HISTogram<m>:NAME <SaveAsPath>

Sets the path, the filename and the file format of the export file for histogram. The command affects all histogram exports.

Suffix:
<m> Irrelevant, omit the suffix.

Parameters:
<SaveAsPath> String with path and file name with extension `.csv`.

Usage: Asynchronous command

Manual operation: See "Save settings" on page 420

EXPort:HISTogram<m>:SAVE

Saves the specified histogram to file. The target file is set using `EXPort:HISTogram<m>:NAME` on page 997.

Suffix:
<m> 1...8, index of the histogram

Usage: Event
Asynchronous command

Manual operation: See "Save settings" on page 420

18.12.7 Sessions

SESSion:LOAD[:EXECute] <Filepath>

Loads a session file.

To reload also user-specific display settings (if included in the session file), set `SESSion:USERpref ON`.

Setting parameters:
<Filepath> String parameter specifying path and filename of the session file.

Usage: Setting only
Asynchronous command

Manual operation: See "Open" on page 425

SESSion:SAVE:ABORt

Stops the saving process of a session file.

Usage: Setting only
Asynchronous command

Manual operation: See "Save settings" on page 424

SESSion:SAVE:CHANnel <ChWfms>

Includes the channel waveform data in the session file.

Parameters:

<ChWfms> OFF | ON

*RST: ON

Usage: Asynchronous command

Manual operation: See "Channel Waveforms" on page 423

SESSion:SAVE:REFerence <RefWfms>

Includes the reference waveform data in the session file.

Parameters:

<RefWfms> OFF | ON

*RST: ON

Usage: Asynchronous command

Manual operation: See "Reference Waveforms" on page 423

SESSion:SAVE[:EXECute] <Filepath>

Saves the current session with selected content to the specified file.

Setting parameters:

<Filepath> String parameter specifying path and filename of the target file.

Usage: Setting only
Asynchronous command

Manual operation: See "Save settings" on page 424

SESSion:USERpref <UserSettings>

If ON, the user-specific display settings for the toolbar, waveform colors and diagram presentation are included in the session file. The setting affects the saving and the recall actions.

Parameters:

<UserSettings>	OFF | ON	
	*RST:	ON

Usage: Asynchronous command

Manual operation: See "Toolbar, color and diagram settings" on page 423

18.12.8 Results

EXPort:RESult:NAME <FilePath>

Sets the path, the filename and the file format of the export file.

Parameters:

<FilePath> String with path and file name with extension `.csv`.

Usage: Asynchronous command

EXPort:RESult:SAVE

Saves the results to file. The target file is set using `EXPort:RESult:NAME`. To select the results to be exported, use `EXPort:RESult:SELect:CURSor` and `EXPort:RESult:SELect:MEASurement`.

Usage: Event
Asynchronous command

EXPort:RESult:SELect:CURSor <CursorResult>

Includes the current cursor results in the export file.

Parameters:

<CursorResult>	OFF | ON	
	*RST:	OFF

Usage: Asynchronous command

EXPort:RESult:SELect:MEASurement <MeasResult>

Includes the current automatic measurement results in the export file.

Parameters:

<MeasResult>	OFF | ON	
	*RST:	OFF

Usage: Asynchronous command

18.12.9 Screenshots

The `HCOPy` subsystem and some other commands control the output of display information for documentation purposes. The instrument allows two independent output configurations which can be set separately with the suffix.

Note that the remote mode is intended for maximum performance. Therefore, the display does not follow the remote commands constantly. To get a correct screenshot, turn the display on using `SYSTem:DISPlay:UPDate`.

HCOPy:DESTination<m> <medium>

Selects the output medium: file or clipboard.

Suffix:
<m> 1..2
Selects the output configuration.

Parameters:
<medium> MMEM | CLIPBOARD

`MMEM`: saves image to a file.
`CLIPBOARD`: directs the image to the clipboard.

*RST: MMEM

Usage: Asynchronous command

Manual operation: See "<Folder>" on page 428

MMEMory:NAME <FileName>

Defines the filename for a screenshot that is stored to a file.

Parameters:
<FileName> String parameter specifying path and filename of the screenshot.

Example: See Section 18.4.3, "Saving screenshots to file", on page 809.

Usage: SCPI confirmed
Asynchronous command

HCOPy:DEVice<m>:LANGuage <FileFormat>

Defines the file format for output of the screenshot to file.

To set the output to file, use `HCOPy:DESTination<m>` with parameter `MMEM`.

Suffix:

<m> 1..2
Selects the output configuration.

Parameters:

<FileFormat> PNG | JPG
*RST: PNG

Usage: Asynchronous command

HCOPy:DEVice<m>:INVerse <InverseColor>

Inverts the colors of the output, i.e. a dark waveform is shown on a white background.

See also `HCOPy:WBKG` and White background.

Suffix:

<m> 1..2
Selects the output configuration.

Parameters:

<InverseColor> OFF | ON
*RST: OFF

Usage: Asynchronous command

Manual operation: See "Inverse color" on page 427

HCOPy:IMMediate<m>:NEXT

Starts the output of the next display image, depending on the `HCOPy:DESTination<m>` destination setting.

If the screenshot is saved to a file, the file name used in the last saving process is automatically counted up to the next unused name. To define the file name, use `MMEMory:NAME`.

Suffix:

<m> 1..2
Selects the output configuration.

Example: See Section 18.4.3, "Saving screenshots to file", on page 809.

Usage: Asynchronous command

HCOPy:IMMediate<m>

Starts the immediate output of the display image, depending on the `HCOPy:DESTination<m>` destination setting.

To define the file name, use `MMEMory:NAME`. Existing files are overwritten by the `HCOP:IMMM` command.

To get a correct screenshot of the diagrams, results, and dialog boxes, turn on the display using `SYSTem:DISPlay:UPDate`.

Suffix:

<m>	1..2 Selects the output configuration.
Example:	See Section 18.4.3, "Saving screenshots to file", on page 809.
Usage:	Event Asynchronous command

HCOPy:ISBA <IncludeSignBarScpi>

If enabled, the screenshot shows the signal bar below the diagram area.

Parameters:

<IncludeSignBarScpi>	OFF | ON *RST: ON
Usage:	Asynchronous command
Manual operation:	See "Include signal bar" on page 427

HCOPy:SSD <ShowSetupDialog>

If enabled, the currently open dialog box is included in the screenshot.

Parameters:

<ShowSetupDialog>	OFF | ON *RST: OFF
Usage:	Asynchronous command
Manual operation:	See "Show setup dialog" on page 427

HCOPy:WBKG <WhiteBackground>

Inverts the background color, so you can picture waveforms with normal waveform colors on white background.

If both `HCOPy:WBKG` and `HCOPy:DEVice<m>:INVerse` are ON, the instrument inverts the background twice, and it appears black.

Parameters:

<WhiteBackground>	OFF | ON *RST: OFF

Usage: Asynchronous command

Manual operation: See "White background" on page 427

HCOPy:DATA?

Creates a PNG screenshot and returns the data of the image file in a binary data stream. When receiving the data, write them into a PNG file which you can open later.

Usage: Query only
Asynchronous command

18.13 Automatic measurements

This section contains all remote commands to set up automatic measurements and to analyze the measurement results.

Measurement suffix <mg>

The suffix <mg> indicates the number of the measurement for which the command takes effect.

18.13.1 General settings

MEASurement<mg>:COUNt?

Returns the maximum number of measurements, which is the maximum value for the <mg> suffix.

Suffix:

<mg>	Irrelevant, omit the suffix.

Return values:

<Count>	Maximum number of measurements

Usage: Query only
Asynchronous command

MEASurement<mg>[:ENABle] <First>

Switches the indicated measurement on or off.

Suffix:
<mg> 1...16, index of the measurement

Parameters:
<First> OFF | ON

Usage: Asynchronous command

MEASurement<mg>:SOURce <SignalSource>,[<SignalSource2>]

Sets the source of the measurement.

Suffix:
<mg> 1...16, index of the measurement

Parameters:
<SignalSource> NONE | C1 | C2 | C3 | C4 | D0 | D1 | D2 | ... | D14 | D15 | M1 | M2 | M3 | M4 | M5 | TRK1 | TRK2 | TRK3 | ... | TRK16 | PA1QPOWER | PA2QPOWER | PA3QPOWER | PA1HPOWER1 | PA2HPOWER1 | PA3HPOWER1 | PA1SPOWER | PA2SPOWER | PA3SPOWER | PA1SOA | PA2SOA | PA3SOA | PA1IPOWER | PA2IPOWER | PA3IPOWER | PA1OPOWER | PA2OPOWER | PA3OPOWER | O<n>C1 | O<n>C2 | ... | O<n>C8 (<n> = 2 to 8)

<SignalSource2> Same as <SignalSource>

Usage: Asynchronous command

Manual operation: See "Source" on page 269

MEASurement<mg>:FSRC <Source>

Defines the first measurement source.

The command is an alternative to `MEASurement<mg>:SOURce`.

Suffix:
<mg> 1...16, index of the measurement

Parameters:
<Source> See `MEASurement<mg>:SOURce` on page 1004.

Usage: Asynchronous command

MEASurement<mg>:SSRC <Source2>

Defines the second measurement source.

The command is an alternative to MEASurement<mg>:SOURce.

Suffix:

<mg>	1...16, index of the measurement

Parameters:

<Source2>	See MEASurement<mg>:SOURce on page 1004.
Usage:	Asynchronous command
Manual operation:	See "Source 2, Clock source" on page 280

MEASurement<mg>:MAIN <MeasType>

Defines the measurement type to be performed. To query the result, use MEASurement<mg>:RESult[:ACTual]? on page 1016.

Suffix:

<mg>	1...16, index of the measurement

Parameters:

<MeasType>

Amplitude/time measurements
HIGH | LOW | AMPLitude | MAXimum | MINimum | PDELta | MEAN | RMS | STDDev | CRESt | POVershoot | NOVershoot | AREA | RTIMe | FTIMe | PPULse | NPULse | PERiod | FREQuency | PDCYcle | NDCYcle | CYCarea | CYCMean | CYCRms | CYCStddev | CYCCrest | CAMPlitude | CMAXimum | CMINimum | CPDelta | PULCnt | DELay | PHASe | BWIDth | EDGEcount | SETup | HOLD | SHT | SHR | DTOTrigger | SLERising | SLEFalling

Jitter measurements
CCJitter | NCJitter | CCWidth | CCDutycycle | TIE | UINTerval | DRATe | SKWDelay | SKWPhase
Require option R&S MXO4-K12.

Measurements for serial protocols
F2F | T2F | F2T | FLDValue | MBITrate | SBITrate | BIDLe | GAP | FCNT | FEC | FER | CFER
Require option R&S MXO4-K500.

Usage:	Asynchronous command
Manual operation:	See "Specific type" on page 270

MEASurement<mg>:DISPlay:RESults <ResultLines>

Enables the measurement annotations for the selected measurement. These annotations are, for example, periods, maximum and minimum values, relevant reference levels, and more.

Suffix:
<mg> 1...16, index of the measurement

Parameters:
<ResultLines> OFF | ON
*RST: OFF

Usage: Asynchronous command

Manual operation: See "Display result lines" on page 278

MEASurement<mg>:DISPlay:REFLevel<rl>:LEVels <DisplayLevels>

Displays the reference levels of the indicated measurement.

Suffix:
<mg> 1...16, index of the measurement

<rl> Irrelevant, omit the suffix.
Reference level set is assigned to the measurement.

Parameters:
<DisplayLevels> OFF | ON
*RST: OFF

Usage: Asynchronous command

MEASurement<mg>:ENVSelect <EnvelopeCurve>

Relevant only for measurements on envelope waveforms. It selects the envelope to be used for measurement.

Prerequisites:

- `ACQuire:TYPE` is set to `ENVElope`.

Suffix:
<mg> 1...16, index of the measurement

Parameters:
<EnvelopeCurve> MIN | MAX | BOTH

MIN
Measures on the lower envelope.

MAX
Measures on the upper envelope.

BOTH
The envelope is ignored, and the waveform is measured as usual.

*RST: BOTH

Usage: Asynchronous command

Manual operation: See "Envelope" on page 278

18.13.2 Settings for amplitude/time measurements

MEASurement<mg>:AMPTime:CSLope <SetHoldClkSlp>

Sets the edge of the clock from which the setup and hold times are measured.

Suffix:
<mg> 1...16, index of the measurement

Parameters:
<SetHoldClkSlp> POSitive | NEGative | EITHer
*RST: POSitive

Usage: Asynchronous command

Manual operation: See "Clock slope" on page 280

MEASurement<mg>:AMPTime:ESLope <EdgesSlope>

Sets the edge direction to be counted: rising edges, falling edges, or both. The setting is only relevant for edge count measurement `MEASurement<mg>:MAIN` is set to `EDGecount`.

Suffix:
<mg> 1...16, index of the measurement

Parameters:
<EdgesSlope> POSitive | NEGative | EITHer
*RST: POSitive

Usage: Asynchronous command

Manual operation: See "Edges slope" on page 279

MEASurement<mg>:AMPTime:PTCount <PulseCount>

Sets the number of positive pulses for the pulse train measurement. It measures the duration of N positive pulses from the rising edge of the first pulse to the falling edge of the N-th pulse.

Suffix:
<mg> 1...16, index of the measurement

Parameters:

<PulseCount> Range: 1 to 2147483647
Increment: 1
*RST: 1

Usage: Asynchronous command

Manual operation: See "Pulse count" on page 279

MEASurement<mg>:AMPTime:PSLope <PulsesSlope>

Sets the first slope of the pulses to be counted. The setting is only relevant for pulse count measurement (`MEASurement<mg>:MAIN` is set to `PULCnt`.

Suffix:

<mg> 1...16, index of the measurement

Parameters:

<PulsesSlope> POSitive | NEGative | EITHer
*RST: POSitive

Usage: Asynchronous command

Manual operation: See "Pulse slope" on page 279

MEASurement<mg>:AMPTime:DELay<n>:DIRection <EdgeCountDir>

Selects the direction for counting slopes for each source: from the beginning of the waveform, or from the end.

Suffix:

<mg> 1...16, index of the measurement

<n> 1..2
Selects the source number.

Parameters:

<EdgeCountDir> FRFI | FRLA

`FRFI` - FRom FIrst, counting starts with the first edge of the waveform.
`FRLA` - FRom LAst, counting starts with the last edge of the waveform.

*RST: FRFI

Usage: Asynchronous command

Manual operation: See "Direction" on page 281

MEASurement<mg>:AMPTime:DTOTrigger<n>:SLOPe <DlyTrigSlp>

Sets the edge direction to be used for delay measurement.

Suffix:

<mg> 1...16, index of the measurement

<n>	1..2 Selects the source number.

Parameters:

<DlyTrigSlp>	POSitive | NEGative | EITHer *RST: POSitive

Usage: Asynchronous command

Manual operation: See "Delay to trigger measurement settings" on page 281

MEASurement<mg>:AMPTime:DELay<n>:SLOPe <Slope>

Sets the edge of each source, between which the delay is measured.

Suffix:

<mg>	1...16, index of the measurement
<n>	1..2 Selects the source number.

Parameters:

<Slope>	POSitive | NEGative | EITHer *RST: POSitive

Usage: Asynchronous command

Manual operation: See "Edges slope" on page 279

MEASurement<mg>:GATE <Gate>

Sets the gate of the indicated measurement. Enable a gate before you assign a measurement to it (`GATE<g>:ENABle =ON`).

The query returns 0, if no gate is assigned.

Suffix:

<mg>	1...16, index of the measurement

Parameters:

<Gate>	Number of the gate to be used

Usage: Asynchronous command

Manual operation: See "Gate" on page 271

MEASurement<mg>:REFLevel<rl>:REFerence <RefLevelSet>

Selects the set of reference levels that is used for the measurement and for the indicated measurement source. Each source of the measurement can have its own reference level set.

Suffix:

<mg>	1...16, index of the measurement

<rl> 1..2
Measurement source, to which the reference level set is applied. For most measurements, one source is needed. For delay measurements, for example, two measurement sources are required, and each source can have its own reference levels.

Parameters:

<RefLevelSet> Number of the reference level set. Define the reference level set before you use it.

Example:

```
MEASurement1:MAIN DELay
MEASurement1:SOURce C1,C2
MEASurement1:REFLevel1:REFerence 1
MEASurement1:REFLevel2:REFerence 2
```

Measurement 1 is a delay measurement on channel 1 and channel 2. C1 is the first source and uses reference level set 1 (RL1). C2 is the second source and uses reference level set 2 (RL2).

Usage: Asynchronous command

Manual operation: See "Reference levels" on page 271

18.13.3 Settings for jitter measurements

MEASurement<mg>:JITTer:NCYCles <NumberCycles>

Sets the number of periods (cycles) that are accumulated to measure the N-cycle jitter.

Suffix:

<mg> 1...16, index of the measurement

Parameters:

<NumberCycles> Range: 1 to 4294967295
Increment: 1
*RST: 2

Usage: Asynchronous command

Manual operation: See "Number of cycles" on page 285

MEASurement<mg>:JITTer:POLarity <Polarity>

For cycle-cycle width and the cycle-cycle duty cycle measurements, the command sets the polarity of pulses for which the pulse width is measured: POSitive or NEGative. `MEASurement<mg>:MAIN` is set to measurements CCWidth | CCDutycycle.

For skew delay and skew phase measurements, the command sets the edge of the first waveform from which the measurements starts: POSitive, NEGative or EITHer. `MEASurement<mg>:MAIN` is set to measurements SKWDelay | SKWPhase.

Suffix:

<mg> 1...16, index of the measurement

Parameters:

<Polarity> POSitive | NEGative | EITHer

*RST: POSitive

Usage: Asynchronous command

Manual operation: See "Pulse polarity" on page 285

MEASurement<mg>:JITTer:REFLevel<rl> <ReferenceLevel>

Selects the reference level that is used for the measurement and for the indicated measurement source. Each source of the measurement can have its own reference level .

Suffix:

<mg> 1...16, index of the measurement

<rl> 1..2
Measurement source, to which the reference level set is applied. For most measurements, one source is needed. For delay measurements, for example, two measurement sources are required, and each source can have its own reference levels.

Parameters:

<ReferenceLevel> UPPer | MIDDle | LOWer

*RST: MIDDle

Example:

```
MEASurement1:MAIN SKWDelay
MEASurement1:SOURce C1,C2
MEASurement1:JITTer:REFLevel1 MIDDle
MEASurement1:JITTer:REFLevel2 UPPer
```

Measurement 1 is a skew delay measurement on channel 1 and channel 2. C1 is the first source and uses the middle reference level. C2 is the second source and uses the upper reference level.

Usage: Asynchronous command

Manual operation: See "Reference level" on page 285

MEASurement<mg>:JITTer:RELPolarity <RelPolarity>

Sets the edge of the second waveform relative to the first waveform.

Suffix:

<mg> 1...16, index of the measurement

Parameters:

<RelPolarity> MATChing | INVerse

MATChing
Measures from positive to positive edge or from negative to negative edge.

INVerse
Measures from positive to negative edge or from negative to positive edge.

*RST: MATChing

Usage: Asynchronous command

Manual operation: See "Relative polarity" on page 285

MEASurement<mg>:JITTer:SLOPe <Slope>

For cycle-cycle jitter, N-cycle jitter, and cycle-cycle duty cycle measurements, the setting selects the slope at which the periods and thus the jitter is measured: FIRSt, POSitive, NEGative or EITHer. `MEASurement<mg>:MAIN` is set to measurements CCJitter | NCJitter | CCDutycycle.

For time-interval error measurements, the command sets the edges of the data signal that are used for measurements: POSitive, NEGative or EITHer. `MEASurement<mg>:MAIN` is set to TIE.

Suffix:

<mg> 1...16, index of the measurement

Parameters:

<Slope> FIRSt | POSitive | NEGative | EITHer

*RST: FIRSt

<Slope> FIRSt | POSitive | NEGative | EITHer

FIRSt
Measures the period from the first edge that is found, no matter of its direction.

POSitive
Measures the period at positive going edges.

NEGative
Measures the period at negative going edges.

EITHer
Measures the period at both positive and negative going edges. This option is useful, for example, to check the clock stability of a double data rate clock.

*RST: FIRSt

Usage: Asynchronous command

Manual operation: See "Cycle begin, Slope" on page 284

MEASurement<mg>:JITTer:TREF <TimingReference>

Selects the timing reference, which is one of the available clock configurations. The timing reference must be defined before it can be used.

Suffix:
<mg> 1...16, index of the measurement

Parameters:
<TimingReference> Range: 1 to 4

Usage: Asynchronous command

Manual operation: See "Timing reference" on page 287

MEASurement<mg>:JITTer:UNIT <Unit>

Sets the unit for data rate measurements.

Suffix:
<mg> 1...16, index of the measurement

Parameters:
<Unit> BIT_S | HZ
*RST: BIT_S

Usage: Asynchronous command

Manual operation: See "Unit" on page 287

18.13.4 Settings for protocol measurements

MEASurement<mg>:PROTocol:FNAMe <FrameName>

Sets or queries the name of the frame or the frame type, at which the oscilloscope executes or starts the measurement.

Suffix:
<mg> 1...16, index of the measurement

Parameters:
<FrameName>

Usage: Asynchronous command

Manual operation: See "Frame Type" on page 290

MEASurement<mg>:PROTocol:FDName <FieldName>

Sets or queries the name of the field or the field type, at which the oscilloscope executes or starts the measurement.

Suffix:
<mg> 1...16, index of the measurement

Parameters:
<FieldName>

Usage: Asynchronous command

Manual operation: See "Field Type" on page 290

MEASurement<mg>:PROTocol:FDValue <FieldValue>

Sets or queries the one or more values of the field, at which the oscilloscope executes or starts the measurement.

Suffix:
<mg> 1...16, index of the measurement

Parameters:
<FieldValue> List of comma separated values

Usage: Asynchronous command

Manual operation: See "Field Value" on page 290

MEASurement<mg>:PROTocol:F2Name <Frame2Name>

Sets or queries the name of the frame or the frame type, at which the oscilloscope ends the measurement in a "From" - "To" condition.

Suffix:
<mg> 1...16, index of the measurement

Parameters:
<Frame2Name>

Usage: Asynchronous command

Manual operation: See "Frame Type" on page 290

MEASurement<mg>:PROTocol:FD2Name <Field2Name>

Sets or queries the name of the field or the field type, at which the oscilloscope ends the measurement in a "From" - "To" condition.

Suffix:
<mg> 1...16, index of the measurement

Parameters:
<Field2Name>

Usage: Asynchronous command

Manual operation: See "Field Type" on page 290

MEASurement<mg>:PROTocol:FD2Value <Field2Value>

Sets or queries the one or more values of the field, at which the oscilloscope ends the measurement in a "From" - "To" condition.

Suffix:
<mg> 1...16, index of the measurement

Parameters:
<Field2Value> List of comma separated values

Usage: Asynchronous command

Manual operation: See "Field Value" on page 291

18.13.5 Results

MEASurement<mg>:CLEar

Deletes the results of all measurements.

Suffix:
<mg> Irrelevant, omit the suffix.

Usage: Setting only
Asynchronous command

Manual operation: See "Clear results" on page 293

MEASurement<mg>:RESult[:ACTual]?
MEASurement<mg>:RESult:AVG?
MEASurement<mg>:RESult:NPEak?
MEASurement<mg>:RESult:PPEak?
MEASurement<mg>:RESult:RMS?
MEASurement<mg>:RESult:WFMCount?
MEASurement<mg>:RESult:EVTCount?
MEASurement<mg>:RESult:STDDev?

Return the statistic results of the specified measurement. The measurement type is defined with `MEASurement<mg>:MAIN`.

- [:ACTual]: current measurement result
- AVG: average of the measurement results
- EVTCount: number of measurement results in the measurement
- NPEak: negative peak value of the measurement results
- PPEak: positive peak value of the measurement results
- RMS: RMS value of the measurement results
- STDDev: standard deviation of the measurement results

Suffix:
<mg> 1...16, index of the measurement

Return values:
<Result> Numeric result value

Usage: Query only
Asynchronous command

MEASurement<mg>:RESult:STARt?
MEASurement<mg>:RESult:STOP?

Return the start and stop times of the specified measurement. The parameter defines the measurement. If no parameter is specified, the result of the main measurement is returned. The main measurement is defined using `MEASurement<mg>:MAIN`.

Suffix:
<mg> 1...16, index of the measurement

Return values:
<Stop> Range: -1E+26 to 1E+26
Increment: 0
*RST: 0

Usage: Query only
Asynchronous command

MEASurement<mg>:RESult:EVENts:COUNt?

Returns the number of measured events in one acquisition.

The command is relevant for measurements of all events, see `MEASurement<mg>:MULTiple`.

Suffix:
<mg> 1...16, index of the measurement

Return values:
<Count> Number of events

Usage: Query only
Asynchronous command

MEASurement<mg>:RESult:EVENts:STARt? <EventIndex>

Returns the start time of the indicated measured event.

The command is relevant for measurements of all events, see `MEASurement<mg>:MULTiple`.

Suffix:
<mg> 1...16, index of the measurement

Setting parameters:
<EventIndex> Index number of the measured event.

Return values:
<EventStart> Range: -1E+26 to 1E+26
Increment: 0
*RST: 0

Usage: Query only
Asynchronous command

MEASurement<mg>:RESult:EVENts:STOP? <EventIndex>

Returns the end time of the indicated measured event.

The command is relevant for measurements of all events, see `MEASurement<mg>:MULTiple`.

Suffix:
<mg> 1...16, index of the measurement

Setting parameters:
<EventIndex> Index number of the measured event.

Return values:

<EventStop>	Range: -1E+26 to 1E+26 Increment: 0 *RST: 0
Usage:	Query only Asynchronous command

MEASurement<mg>:RESult:EVENts:VALue? <MeasResEvtIdx>

Returns the measured value of the indicated measured event.

The command is relevant for measurements of all events, see `MEASurement<mg>:MULTiple`.

Suffix:

<mg> 1...16, index of the measurement

Setting parameters:

<EventIndex> Index number of the measured event.

Return values:

<EventValue>	Range: -1E+26 to 1E+26 Increment: 1E-10 *RST: 0
Usage:	Query only Asynchronous command

18.13.6 Statistics

MEASurement<mg>:STATistics:RESet
MEASurement<mg>:STATistics:ARESet

Resets the statistics for all measurements.

Suffix:

<mg> Irrelevant, omit the suffix.

Usage: Setting only
Asynchronous command

Manual operation: See "Clear results" on page 293

MEASurement<mg>:STATistics[:ENABle] <GlobalEnable>

Enables statistics calculation for all measurements.

Suffix:
<mg> Irrelevant, omit the suffix.

Parameters:
<GlobalEnable> OFF | ON
*RST: OFF

Usage: Asynchronous command

Manual operation: See "Statistics" on page 293

MEASurement<mg>:MULTiple <GlobalMeassAll>

If ON, the measurement is performed repeatedly if the measured parameter occurs several times inside the acquisition or defined gate. All results are included in evaluation, e.g. in statistics. To set the number of results to be considered, use `MEASurement<mg>:MNOMeas`.

Suffix:
<mg> Irrelevant, omit the suffix.

Parameters:
<GlobalMeassAll> OFF | ON
*RST: OFF

Usage: Asynchronous command

Manual operation: See "Measure all events" on page 294

MEASurement<mg>:MNOMeas <MaxMeasPerAcq>

Sets the maximum number of measurements per acquisition if `MEASurement<mg>:MULTiple` is on. The setting affects all measurements.

Suffix:
<mg> Irrelevant, omit the suffix.

Parameters:
<MaxMeasPerAcq> Range: 2 to 1E6
Increment: 1
*RST: 1E6

Usage: Asynchronous command

Manual operation: See "Max. No. of events" on page 294

18.13.7 Tracks

MEASurement<mg>:TRACk[:STATe] <State>

Enables or disables the track for the selected measurement.

Suffix:

<mg> 1...16, index of the measurement

Parameters:

<State> OFF | ON

*RST: OFF

Usage: Asynchronous command

Manual operation: See "State" on page 296

MEASurement<mg>:TRACk:AUTO

Sets the vertical scale and the offset of the track, so that the complete height of the diagram is used.

Suffix:

<mg> 1...16, index of the measurement

Usage: Event
Asynchronous command

Manual operation: See "Fit to screen" on page 296

MEASurement<mg>:TRACk:CONTiunous <AutoScale>

Performs an automatic scaling whenever the track does not fit in the diagram during the measurement period.

Suffix:

<mg> 1...16, index of the measurement

Parameters:

<AutoScale> OFF | ON

*RST: ON

Usage: Asynchronous command

Manual operation: See "Auto Scale" on page 296

MEASurement<mg>:TRACk:OFFSet <VerticalOffset>

Sets or queries the offset of the track waveform.

If `MEASurement<mg>:TRACk:CONTiunous` is ON, use the command to query the current value.

If MEASurement<mg>:TRACk:CONTiunous is OFF, the command sets the offset.

Suffix:

<mg>	1...16, index of the measurement

Parameters:

<VerticalOffset>	Range: -1E+26 to 1E+26 Increment: 1E-06 *RST: 0 Default unit: div

Usage: Asynchronous command

Manual operation: See "Meas offset" on page 297

MEASurement<mg>:TRACk:SCALe <VerticalScale>

Sets or queries the vertical scale of the track diagram.

If MEASurement<mg>:TRACk:CONTiunous is ON, use the command to query the current value.

If MEASurement<mg>:TRACk:CONTiunous is OFF, the command sets the scale.

Suffix:

<mg>	1...16, index of the measurement

Parameters:

<VerticalScale>	Range: 1E-26 to 1E+26 Increment: 1E-05 *RST: 0.5 Default unit: V/div

Usage: Asynchronous command

Manual operation: See "Meas scale" on page 296

MEASurement<mg>:TRACk:DATA:HEADer?

Returns the header of track data, the attributes of the waveform.

Suffix:

<mg>	1...16, index of the measurement

Return values:

<XStart>	1. header value: time of the first track value in s
<XStop>	2. header value: time of the last track value in s
<RecordLength>	3. header value: number of measured events = number of points in the track waveform
<ValuesPerSample>	4. header value: number of values per sample. For tracks, the result is always 1.

Example: `MEAS1:TRAC:DATA:HEAD?`
`-1E-07,9.980000000000001E-08,1000,1`
Start time of the data is -1E-07 = -100 ns, and end time of the data is 9.980000000000001E-08= 99.8 ns. The data stream has 1000 values with one value per sample, inn other words, the track waveform has 1000 points.

Usage: Query only
Asynchronous command

MEASurement<mg>:TRACk:DATA[:VALues]? [<Offset>[,<Length>]]

Returns the data of the indicated track waveform for transmission from the instrument to the controlling computer. The data can be used in MATLAB, for example.

Without parameters, the complete waveform is retrieved. Using the offset and length parameters, data can be retrieved in smaller portions, which makes the command faster. If you send only one parameter, it is interpreted as offset, and the data is retrieved from offset to the end of the waveform.

Suffix:
<mg> 1...16, index of the measurement

Query parameters:
<Offset> Number of offset track points, which are ignored in the data transfer.

[<Length>] Number of track points to be retrieved.

Return values:
<Data> List of values according to the format and content settings.

Usage: Query only
Asynchronous command

18.14 Cursor measurements

Some of the commands in the following section are asynchronous. An overlapping or asynchronous command does not automatically finish executing before the next command starts executing. If overlapping commands must be executed in a defined order, e.g. to avoid wrong measurement results, they must be serviced sequentially.

To prevent an overlapping execution of commands, one of the commands `*OPC`, `*OPC?` or `*WAI` can be used after the command or a command set.

For more information, see:

- www.rohde-schwarz.com/rc-via-scpi, section "Command sequence and synchronization"

18.14.1 Cursor setup

CURSor<cu>:AOFF

Switches all cursors off.

Suffix:

<cu>	Irrelevant, omit the suffix.

Usage: Setting only
Asynchronous command

CURSor<cu>:COUNt?

Returns the maximum number of cursor sets, which is the maximum value for the cursor suffix.

Suffix:

<cu>	Irrelevant, omit the suffix.

Return values:

<Count> Maximum number of cursor sets

Usage: Query only
Asynchronous command

CURSor<cu>:STATe <State>

Enables the selected cursor measurement.

Suffix:

<cu> 1...2, index of the cursor set

Parameters:

<State> OFF | ON

*RST: OFF

Usage: Asynchronous command

Manual operation: See "Show cursor" on page 258

CURSor<cu>:FUNCtion <Type>

Defines the cursor type to be used for the measurement.

Suffix:

<cu> 1...2, index of the cursor set

Parameters:

<Type> VERTical | HORizontal | PAIRed

HORizontal
A pair of horizontal cursor lines. Not available for measurements on multiple sources.

VERTical
A pair of vertical cursor lines. Not available for measurements on multiple sources.

PAIRed
Both vertical and horizontal cursor line pairs.

*RST: PAIRed

Usage: Asynchronous command

Manual operation: See "Type" on page 259

CURSor<cu>:SMODe <SourceMode>

Selects the number of sources that you want to measure.

Suffix:

<cu> 1...2, index of the cursor set

Parameters:

<SourceMode> SINGle | SECond | MSOurce

SINGle
The cursor lines are set on one waveform. Select the source with CURSor<cu>:SOURce.

SECond
The cursor lines are set on two waveforms. To set the second souce, use CURSor<cu>:SSOurce.

MSOurce
Multiple waveforms are selected to be measured with one cursor set. Activates CURSor<cu>:TRACking[:STATe] and sets CURSor<cu>:FUNCtion to PAIRed. Select the sources with CURSor<cu>:SOURce.

*RST: SINGle

Usage: Asynchronous command

Manual operation: See "Source mode" on page 259

CURSor<cu>:SOURce <Signal>

Selects the cursor source or multiple sources, which are the waveforms to be measured. The query returns the waveforms sorted by category and number.

Suffix:

<cu> 1...2, index of the cursor set

Parameters:

<Signal> C1,C2,C3,C4,D0,D1,D2,D3,D4,D5,D6,D7,D8,D9,D10,D11,D12, D13,D14,D15,M1,M2,M3,M4,M5,R1,R2,R3,R4,SPECMAXH1,SPECMINH1,SPECNORM1,SPECAVER1,SPECMAXH2,SPECMINH2,SPECNORM2,SPECAVER2,SPECMAXH3,SPECMINH3,SPECNORM3,SPECAVER3,SPECMAXH4,SPECMINH4,SPECNORM4,SPECAVER4, TRK1,TRK2,TRK3, ...,TRK16,PBUS1,PBUS2,PBUS3,PBUS4,XY1,XY2,XY3,XY4 | PA1QPOWER,PA2QPOWER,PA3QPOWER,PA1HPOWER1,PA2HPOWER1,PA3HPOWER1,PA1SPOWER,PA2SPOWER,PA3SPOWER,PA1SOA,PA2SOA,PA3SOA,PA1IPOWER,PA2IPOWER,PA3IPOWER,PA1OPOWER,PA2OPOWER,PA3OPOWER | O<n>C1,O<n>C2, ... ,O<n>C8

Comma-separated list of waveforms.

Example:

```
CURSor:SOURce C1
```

Sets channel 1 as cursor source and changes CURSor<cu>:SMODe to SINGle if MSOurce was set before.

Example:

```
CURSor:SOURce C1,M1,C3
CURSor:SOURce? --> C1,C3,M1
```

Sets channel 1, 3 and math 1 as cursor sources and changes CURSor<cu>:SMODe to MSOurce if SINGle was set before.
Activates CURSor<cu>:TRACking[:STATe] for the specified cursor set.

Usage: Asynchronous command

Manual operation: See "Source" on page 259

CURSor<cu>:USSource <UseSource2>

Enables the second cursor source. To select the second source, use `CURSor<cu>:SSOurce`.

The command has the same effect as `CURSor<cu>:SMODe SECond`.

Suffix:
<cu> 1...2, index of the cursor set

Parameters:
<UseSource2> OFF | ON

Usage: Asynchronous command

CURSor<cu>:SSOurce <Source2>

Selects the second cursor source.

Suffix:
<cu> 1...2, index of the cursor set

Parameters:
<Source2> One of the possible cursor sources, see `CURSor<cu>:SOURce`.

Usage: Asynchronous command

Manual operation: See "Source 2" on page 259

CURSor<cu>:X1Position <X1Position>

Defines the position of the left vertical cursor line.

Suffix:
<cu> 1...2, index of the cursor set

Parameters:
<X1Position> Range: 0 to 500
Increment: 0.1
*RST: depends on time scale, at 25% of the time axis
Default unit: s

Usage: Asynchronous command

Manual operation: See "X1 position, X2 position" on page 260

CURSor<cu>:X2Position <X2Position>

Defines the position of the right vertical cursor line.

Suffix:
<cu> 1...2, index of the cursor set

Parameters:
<X2Position> Range: 0 to 500
Increment: 0.1
*RST: depends on time scale, at 75% of the time axis
Default unit: s

Usage: Asynchronous command

Manual operation: See "X1 position, X2 position" on page 260

CURSor<cu>:Y1Position [<Signal>]

The command usage depends on the setting of `CURSor<cu>:SMODe`.

In single source and second source mode. the command sets or queries the position of the lower horizontal cursor line. The <Signal> parameter is irrelevant. If `CURSor<cu>:TRACking[:STATe]` is enabled, the Y-positions are set automatically, and the query returns the measurement result.

In multiple source mode, tracking is always on. The command is used as query only, and you specify the signal for which you want to get the value.

Suffix:
<cu> 1...2, index of the cursor set

Parameters:
<Value> Y-position of the first horizontal cursor line.

Query parameters:
<Signal> Only relevant for `CURSor<cu>:SMODe MSource`. One of the sources that are specified with `CURSor<cu>:SOURce`.

Example:
```
CURSor2:SMODe SINGle
CURSor2:FUNCtion PAIRed
CURSor2:TRACking ON
CURSor2:Y1Position?
--> 0.123859
```
In single source mode with active tracking, the command returns the Y-value.

Example:
```
CURSor:SMODe SINGle
CURSor:FUNCtion PAIRed
CURSor:TRACking OFF
CURSor:Y1Position 0.15
```
In single source mode with disabled tracking, the command sets the Y-value.

Example:
```
CURSor2:SMODe MSOurce
CURSor2:Y1Position? C1
--> 0.123859
```
In multiple source mode, tracking is always active. The command returns the Y-value for the specified source.

Usage: Asynchronous command

Manual operation: See "Y1 position, Y2 position" on page 260

CURSor<cu>:Y2Position [<Signal>]

Defines or queries the position of the upper horizontal cursor line.The command works in the same way as `CURSor<cu>:Y1Position`.

Suffix:
<cu> — 1...2, index of the cursor set

Parameters:
<Value> — Y-position of the second horizontal cursor line.

Query parameters:
<Signal> — Only relevant for `CURSor<cu>:SMODe MSOurce`. One of the sources that are specified with `CURSor<cu>:SOURce`.

Usage: Asynchronous command

Manual operation: See "Y1 position, Y2 position" on page 260

CURSor<cu>:SSCReen

Resets the cursors to their initial positions. Reset is helpful if the cursors have disappeared from the display or need to be moved for a larger distance.

Suffix:
<cu> — 1...2, index of the cursor set

Usage: Setting only
Asynchronous command

Manual operation: See "Place on display" on page 261

CURSor<cu>:TRACking[:STATe] <TrackCurve>

If enabled, the horizontal cursor lines follow the waveform. The function is available if both horizontal and vertical cursors are displayed (`CURSor<cu>:FUNCtion PAIRed`).

Suffix:
<cu> — 1...2, index of the cursor set

Parameters:

<TrackCurve>	OFF | ON *RST: OFF

Usage: Asynchronous command

Manual operation: See "Track waveform" on page 260

CURSor<cu>:LABel <ShowLabel>

Shows the cursor labels in the diagram.

Suffix:

<cu>	1...2, index of the cursor set

Parameters:

<ShowLabel>	OFF | ON *RST: OFF

Usage: Asynchronous command

Manual operation: See "Show label" on page 262

CURSor<cu>:HORizontal<n>:LABel <Label>

Defines the label to be displayed with the horizontal cursor lines. By default, the cursors are labeled as Cu1.1, Cu1.2, Cu2.1, ...

Suffix:

<cu>	1...2, index of the cursor set
<n>	1..2 Number of the cursor line

Parameters:

<Label>	String with the cursor label

Example:

```
CURSor1:HORizontal1:LABel 'Cu1H1'
CURSor1:HORizontal2:LABel "Cu1H2"
```

Usage: Asynchronous command

Manual operation: See "Horizontal cursor 1, Horizontal cursor 2" on page 262

CURSor<cu>:VERTical<n>:LABel <Label>

Defines the label to be displayed with the vertical cursor lines. By default, the cursors are labeled as Cu1.1, Cu1.2, Cu2.1, ...

Suffix:

<cu>	1...2, index of the cursor set
<n>	1..2 Number of the cursor line

Parameters:

<Label>	String with the cursor label

Example:

```
CURSor2:VERTical1:LABel 'Cu2V1'
CURSor2:VERTical2:LABel "Cu2V2"
```

Usage: Asynchronous command

Manual operation: See "Vertical cursor 1, Vertical cursor 2" on page 262

CURSor<cu>:DISPlay:VALues <AddValuesLabel>

Shows the measured values in the cursor labels.

Suffix:

<cu>	1...2, index of the cursor set

Parameters:

<AddValuesLabel>	OFF | ON *RST: OFF

Usage: Asynchronous command

Manual operation: See "Show values" on page 262

CURSor<cu>:SIAD <ShwInAllDiags>

Shows the enabled cursor measurements in all active diagrams of the time domain.

In the spectrum domain, the setting is disabled. The cursors are shown only on the source spectrum of the measurement.

Suffix:

<cu>	1...2, index of the cursor set

Parameters:

<ShwInAllDiags>	OFF | ON *RST: ON

Usage: Asynchronous command

Manual operation: See "Show in all diagrams" on page 261

CURSor<cu>:XCOupling <Coupling>

Defines the positioning mode of the vertical cursor.

Suffix:

<cu>	1...2, index of the cursor set

Parameters:

<Coupling>	OFF | ON **ON** Moving one cursor line moves the other cursor line too. The cursor lines always remain a fixed distance.

OFF
Each cursor line is positioned independently.

*RST: OFF

Usage: Asynchronous command

Manual operation: See "X, Y" on page 261

CURSor<cu>:YCOupling <Coupling>

Defines the positioning mode of the horizontal cursor. If the horizontal cursor lines track the waveform, the y coupling is irrelevant (`CURSor<cu>:TRACking[:STATe]` is `ON`).

Suffix:
<cu> 1...2, index of the cursor set

Parameters:
<Coupling> OFF | ON

ON
Moving one cursor line moves the other cursor line too. The cursor lines always remain a fixed distance.

OFF
Each cursor line is positioned independently.

*RST: OFF

Usage: Asynchronous command

Manual operation: See "X, Y" on page 261

CURSor<cu>:X1ENvelope <EnvelopeSelect>
CURSor<cu>:X2ENvelope <EnvelopeSelect>

Define which horizontal cursor is positioned to the maximum and which to the minimum envelope values.

Prerequisites:

- `ACQuire:TYPE` is set to `ENVElope` or `PDETect`.
- `CURSor<cu>:TRACking[:STATe]` is set to `ON`.
- `CURSor<cu>:FUNCtion` is set to `PAIRed`.

Suffix:
<cu> 1...2, index of the cursor set

Parameters:
<EnvelopeSelect> MIN | MAX

MIN
The horizontal cursor is set to the crossing point of the vertical cursor with the minimum waveform envelope.

MAX
The horizontal cursor is set to the crossing point of the vertical cursor with the maximum waveform envelope.

	*RST: MAX
Usage:	Asynchronous command
Manual operation:	See "Envelope 1, Envelope 2" on page 260

18.14.2 Cursor results

CURSor<cu>:XDELta[:VALue]?

Queries the delta value (distance) of two vertical cursor lines.

Suffix:

<cu> 1...2, index of the cursor set

Return values:

<Delta>
Range: -1E+26 to 1E+26
Increment: 0.1
*RST: 0
Default unit: s

Usage: Query only
Asynchronous command

CURSor<cu>:XDELta:INVerse?

Queries the inverse value of the delta value (distance) of the two vertical cursor lines.

Suffix:

<cu> 1...2, index of the cursor set

Return values:

<DeltaInverse>
Range: -1E+26 to 1E+26
Increment: 0.1
*RST: 0
Default unit: Hz

Usage: Query only
Asynchronous command

CURSor<cu>:YDELta[:VALue]? [<Signal>]

Returns the delta value (distance) of the two horizontal cursor lines.

In multiple source mode, specify the signal for which you want to get the value.

Suffix:

<cu> 1...2, index of the cursor set

Query parameters:

<SignalValue> Only relevant for CURSor<cu>:SMODe MSource. One of the sources that are specified with CURSor<cu>:SOURce.

Return values:

<Value> Inverse value of the delta value of the two horizontal cursor lines.

Usage: Query only
Asynchronous command

CURSor<cu>:YDELta:SLOPe? [<Signal>]

Returns the inverse value of the voltage difference, the reciprocal of the vertical distance of two horizontal cursor lines: *1/ΔV*.

In multiple source mode, specify the signal for which you want to get the value.

Suffix:

<cu> 1...2, index of the cursor set

Query parameters:

<Signal> Only relevant for CURSor<cu>:SMODe MSource. One of the sources that are specified with CURSor<cu>:SOURce.

Return values:

<Value> Inverse value of the delta value of the two cursor lines.

Usage: Query only
Asynchronous command

18.14.3 Peak search using cursors

CURSor<cu>:FFT:SETCenter

Sets the center frequency to the frequency value that is measured at cursor line Cu1.

Suffix:

<cu> 1...2, index of the cursor set

Usage: Setting only
Asynchronous command

Manual operation: See "Set center frequency to" on page 263

CURSor<cu>:FFT:TOCenter

Sets the vertical cursor line Cu1 to the center frequency.

Suffix:

<cu>	1...2, index of the cursor set
Usage:	Setting only Asynchronous command
Manual operation:	See "Center frequency" on page 263

CURSor<cu>:MAXimum[:PEAK]

Sets both cursors to the absolute peak value.

Suffix:

<cu>	1...2, index of the cursor set
Usage:	Event Asynchronous command
Manual operation:	See "Absolute peak" on page 263

CURSor<cu>:MAXimum:LEFT

Cursor 2 is set to the next peak to the left of the current position.

Suffix:

<cu>	1...2, index of the cursor set
Usage:	Event Asynchronous command
Manual operation:	See "Next peak left" on page 263

CURSor<cu>:MAXimum:RIGHt

Cursor 2 is set to the next peak to the right of the current position.

Suffix:

<cu>	1...2, index of the cursor set
Usage:	Event Asynchronous command
Manual operation:	See "Next peak right" on page 263

CURSor<cu>:MAXimum:NEXT

Cursor 2 is set to the next smaller absolute peak from the current position.

Suffix:

<cu>	1...2, index of the cursor set

Usage: Event
Asynchronous command

Manual operation: See "Next peak" on page 263

CURSor<cu>:PEXCursion <Value>

Sets the minimum level by which the waveform must rise or fall so that it will be identified as a maximum or a minimum by the search functions.

Suffix:
<cu> 1...2, index of the cursor set

Parameters:
<Value>

Usage: Asynchronous command

Manual operation: See "Peak excursion" on page 263

18.14.4 Cursor appearance

CURSor<cu>:STYLe <Style>

Defines how the cursor is displayed in the diagram.

Suffix:
<cu> 1...2, index of the cursor set

Parameters:
<Style> LINes | LRHombus | VLRHombus | RHOMbus

LINes
The cursors are displayed as lines.

LRHombus
The cursors are displayed as lines. The intersections of the cursors with the waveforms are displayed by rhombus-shaped points.

VLRHombus
The cursors are displayed only as vertical lines. The intersections of the cursors with the waveforms are displayed by rhombus-shaped points.

RHOMbus
The intersections of the cursors with the waveforms are displayed by rhombus-shaped points.

*RST: LINes

Usage: Asynchronous command

Manual operation: See "Cursor style" on page 258

18.15 Spectrum analysis

18.15.1 Spectrum setup

CALCulate:SPECtrum<sp>:FREQuency:BANDwidth[:RESolution]:ADJusted?

Queries the effective resolution bandwidth.

Suffix:

<sp> 1...4, index of the spectrum

Return values:

<AdjResBW> Range: 0 to 200E+9
Increment: 0.01
*RST: 0
Default unit: Hz

Usage: Query only
Asynchronous command

CALCulate:SPECtrum<sp>:FREQuency:BANDwidth[:RESolution]:AUTO <AutoRBW>

Couples the frequency span to the "RBW" setting.

Suffix:
<sp> 1...4, index of the spectrum

Parameters:
<AutoRBW> OFF | ON
*RST: ON

Usage: Asynchronous command

Manual operation: See "Auto RBW" on page 305

CALCulate:SPECtrum<sp>:FREQuency:BANDwidth[:RESolution]:RATio <SpanRBWRatio>

Defines the coupling ratio for Span/RBW.

Available, if `CALCulate:SPECtrum<sp>:FREQuency:BANDwidth[:RESolution]:AUTO` is set to `ON`.

Suffix:
<sp> 1...4, index of the spectrum

Parameters:
<SpanRBWRatio> Range: 10 to 10000
Increment: 1
*RST: 1000

Usage: Asynchronous command

Manual operation: See "Span/RBW" on page 305

CALCulate:SPECtrum<sp>:FREQuency:BANDwidth[:RESolution][:VALue] <RBW>

Queries or defines the used resolution bandwidth.

Suffix:
<sp> 1...4, index of the spectrum

Parameters:
<RBW> Range: 0.0002 to 2000000
Increment: 0.01
*RST: 2000000
Default unit: Hz

Usage: Asynchronous command

Manual operation: See "RBW" on page 306

CALCulate:SPECtrum<sp>:FREQuency:CENTer <Center>

Defines the position of the displayed frequency range, which is (Center - Span/2) to (Center + Span/2). The width of the range is defined using the frequency span setting.

Suffix:

<sp>	1...4, index of the spectrum

Parameters:

<Center>
Range: -1E+26 to 1E+26
Increment: 0.01
*RST: 0
Default unit: HZ

Usage: Asynchronous command

Manual operation: See "[Position]" on page 46

CALCulate:SPECtrum<sp>:FREQuency:SCALe <XAxisMode>

Defines the scaling method for the frequency axis (x-axis) of the spectrogram.

Suffix:

<sp>	1...4, index of the spectrum

Parameters:

<XAxisMode>
LIN | LOG
LIN: linear scaling
LOG: logarithmic scaling
*RST: LIN

Usage: Asynchronous command

Manual operation: See "Frequency axis" on page 308

CALCulate:SPECtrum<sp>:FREQuency:SPAN <Span>

The span is specified in Hertz and defines the width of the displayed frequency range, which is (Center - Span/2) to (Center + Span/2). The position of the span is defined using the "Center" setting.

Suffix:

<sp>	1...4, index of the spectrum

Parameters:

<Span>
Range: 0 to 1E+26
Increment: 0.01
*RST: 0.02
Default unit: HZ

Usage: Asynchronous command

Manual operation: See "[Scale]" on page 46

CALCulate:SPECtrum<sp>:FREQuency:STARt <Start>

Defines the start frequency of the displayed frequency span.

Suffix:

<sp> 1...4, index of the spectrum

Parameters:

<Start> Range: -1E+26 to 1E+26
Increment: 0.01
*RST: -0.01
Default unit: HZ

Usage: Asynchronous command

Manual operation: See "Start" on page 305

CALCulate:SPECtrum<sp>:FREQuency:STOP <Stop>

Sets the stop frequency of the displayed frequency span.

Suffix:

<sp> 1...4, index of the spectrum

Parameters:

<Stop> Range: -1E+26 to 1E+26
Increment: 0.01
*RST: 0.01
Default unit: HZ

Usage: Asynchronous command

Manual operation: See "Stop" on page 305

CALCulate:SPECtrum<sp>:FREQuency:WINDow:TYPE <WindowFunction>

Selects the window type. Windowing helps minimize the discontinuities at the end of the measured signal interval and thus reduces the effect of spectral leakage, increasing the frequency resolution.

Various different window functions are provided in the MXO 4 to suit different input signals. Each of the window functions has specific characteristics, including some advantages and some trade-offs. Consider these characteristics carefully to find the optimum solution for the measurement task.

Suffix:

<sp> 1...4, index of the spectrum

Parameters:

<WindowFunction> RECTangular | HAMMing | HANN | BLACkharris | GAUSsian | FLATTOP2 | KAISerbessel

RECTangular
The rectangular window has the best frequency resolution, but a poor amplitude accuracy and is recommended for separating two tones with almost equal amplitudes and a small frequency distance.

HAMMing
The Hamming window is bell shaped and has a good frequency resolution and fair amplitude accuracy. It is recommended for frequency response measurements and sine waves, periodic signals and narrowband noise.

HANN
The Hann window is bell shaped and has a slightly worse frequency resolution but smaller sidelobe level than the Hamming window. The applications are the same.

BLACkharris
The Blackman window is bell shaped and has a poor frequency resolution, but very good amplitude accuracy. It is recommended mainly for signals with single frequencies to detect harmonics.

GAUSsian
Good frequency resolution and best magnitude resolution, recommended for weak signals and short duration

FLATTOP2
The flat top window has a poor frequency resolution, but the best amplitude accuracy and the sharpest sidelobe. It is recommended for accurate single tone amplitude measurements.

KAISerbessel
The kaiser-bessel window has a fair frequency resolution and good amplitude accuracy, and a very high sidelobe level. It is recommended for separating two tones with differing amplitudes and a small frequency distance.

*RST: BLACkharris

Usage: Asynchronous command

Manual operation: See "Window type" on page 306

CALCulate:SPECtrum<sp>:MAGNitude:LEVel <VerticalMax>

Sets the maximum displayed value on the vertical scale.

Suffix:
<sp> 1...4, index of the spectrum

Parameters:
<VerticalMax> Range: -1E+26 to 1000000000000000
Increment: 1
*RST: 10

Usage: Asynchronous command

Manual operation: See "Vertical maximum" on page 308

CALCulate:SPECtrum<sp>:MAGNitude:RANGe <VerticalRange>

Sets the range of the spectrum values to be displayed.

Suffix:
<sp> 1...4, index of the spectrum

Parameters:
<VerticalRange> Range: 0 to 1000000000000000
Increment: 0.01
*RST: 100

Usage: Asynchronous command

Manual operation: See "Vertical range" on page 308

CALCulate:SPECtrum<sp>:MAGNitude:SCALe <Unit>

Sets the unit for the y-axis.

Suffix:
<sp> 1...4, index of the spectrum

Parameters:
<Unit> LINear | DB | DBM | DBV | DBUV | DBS | DBHZ
*RST: DBM

Usage: Asynchronous command

Manual operation: See "Magnitude unit" on page 308

CALCulate:SPECtrum<sp>:PRESet

Presets the spectrum measurement.

Suffix:
<sp> 1...4, index of the spectrum

Usage: Setting only
Asynchronous command

Manual operation: See "Spectrum preset" on page 307

CALCulate:SPECtrum<sp>:SOURce <Source>

Selects the source for the spectrum.

Suffix:
<sp> 1...4, index of the spectrum

Parameters:
<Source> C1 | C2 | C3 | C4 | M1 | M2 | M3 | M4 | M5 | R1 | R2 | R3 | R4 | TRK1 | TRK2 | TRK3 | ... | TRK16 | PA1QPOWER | PA2QPOWER | PA3QPOWER | PA1SPOWER | PA2SPOWER | PA3SPOWER | O<n>C1 | O<n>C2 | ... | O<n>C8 (<n> = 2 to 8)

Usage: Asynchronous command

Manual operation: See "Source" on page 304

CALCulate:SPECtrum<sp>:STATe <State>

Enables the spectrum.

Suffix:

<sp>	1...4, index of the spectrum

Parameters:

<State>	OFF | ON *RST: OFF

Usage: Asynchronous command

Manual operation: See "Display" on page 304

CALCulate:SPECtrum<sp>:THReshold <Threshold>

Sets an absolute threshold as an additional condition for the peak search. Only peaks that exceed the threshold are detected.

Suffix:

<sp>	1...4, index of the spectrum

Parameters:

<Threshold>	Range: -500 to 500 Increment: 1 *RST: -70 Default unit: dBm

Usage: Asynchronous command

Manual operation: See "Threshold" on page 263

CALCulate:SPECtrum<sp>:PEXCursion <PeakExcursion>

Defines a minimum level value by which the waveform must drop left and right of the local maximum to be listed as a peak. Enter a peak excursion value to omit close by peaks and list just the highest peak.

Suffix:

<sp>	1...4, index of the spectrum

Parameters:

<PeakExcursion>	Range: 0 to 100 Increment: 1 *RST: 5 Default unit: dB

Usage: Asynchronous command

Manual operation: See "Peak excursion" on page 263

CALCulate:SPECtrum<sp>:WAVeform:AVERage:COUNt <AverageCount>

Sets the number of segments used for the averaging of the spectrum.

Suffix:

<sp>	1...4, index of the spectrum

Parameters:

<AverageCount>	Range: 2 to 65534 Increment: 1 *RST: 1000

Usage: Asynchronous command

Manual operation: See "Traces" on page 306

CALCulate:SPECtrum<sp>:WAVeform:AVERage:ENABle <Enable>

Enables the average trace.

Suffix:

<sp>	1...4, index of the spectrum

Parameters:

<Enable>	OFF | ON

Usage: Asynchronous command

Manual operation: See "Traces" on page 306

CALCulate:SPECtrum<sp>:WAVeform:MAXimum:ENABle <Enable>

Enables the maximum trace.

Suffix:

<sp>	1...4, index of the spectrum

Parameters:

<Enable>	OFF | ON

Usage: Asynchronous command

Manual operation: See "Traces" on page 306

CALCulate:SPECtrum<sp>:WAVeform:MINimum:ENABle <Enable>

Enables the minimum trace.

Suffix:

<sp>	1...4, index of the spectrum

Parameters:

<Enable>	OFF | ON

Usage: Asynchronous command

Manual operation: See "Traces" on page 306

CALCulate:SPECtrum<sp>:WAVeform:NORMal[:ENABle] <Enable>

Enables the normal spectrum trace.

Suffix:
<sp> 1...4, index of the spectrum

Parameters:
<Enable> OFF | ON

Usage: Asynchronous command

Manual operation: See "Traces" on page 306

18.15.2 Spectrum gate

CALCulate:SPECtrum<sp>:GATE:POSition <Center>

Sets the position of the displayed frequency range.

Suffix:
<sp> 1...4, index of the spectrum

Parameters:
<Center> Range: -1E+26 to 1E+26
Increment: 0.01
*RST: 0
Default unit: HZ

Usage: Asynchronous command

Manual operation: See "Position" on page 309

CALCulate:SPECtrum<sp>:GATE:STARt <Start>

Sets the starting value for the gate.

Suffix:
<sp> 1...4, index of the spectrum

Parameters:
<Start> Range: -1E+26 to 1E+26
Increment: 0.01
*RST: -0.01
Default unit: HZ

Usage: Asynchronous command

Manual operation: See "Start" on page 309

CALCulate:SPECtrum<sp>:GATE:STOP <Stop>

Sets the end value for the gate.

Suffix:

<sp> 1...4, index of the spectrum

Parameters:

<Stop> Range: -1E+26 to 1E+26
Increment: 0.01
*RST: 0.01
Default unit: HZ

Usage: Asynchronous command

Manual operation: See "Stop" on page 309

CALCulate:SPECtrum<sp>:GATE:WIDTh <Span>

Defines the width of the displayed gate.

Suffix:

<sp> 1...4, index of the spectrum

Parameters:

<Span> Range: 0 to 1E+26
Increment: 0.01
*RST: 0.02
Default unit: HZ

Usage: Asynchronous command

Manual operation: See "Width" on page 309

18.15.3 Peak list

CALCulate:SPECtrum<sp>:PLISt:COUNt?

Returns the current number of peak list results.

Suffix:
<sp> 1...4, index of the spectrum

Return values:
<Count>

Usage: Query only
Asynchronous command

CALCulate:SPECtrum<sp>:PLISt[:STATe] <ShowTable>

Enables the display of the peak table.

Suffix:
<sp> 1...4, index of the spectrum

Parameters:
<ShowTable> OFF | ON
*RST: OFF

Usage: Asynchronous command

Manual operation: See "Peak table" on page 311

CALCulate:SPECtrum<sp>:PLISt:MAXCount <MaxNoRess>

Sets the maximum number of measurement results that are listed in the result table.

Suffix:
<sp> 1...4, index of the spectrum

Parameters:
<MaxNoRess> Range: 1 to 1000
Increment: 1
*RST: 10

Usage: Asynchronous command

Manual operation: See "Max results" on page 312

CALCulate:SPECtrum<sp>:PLISt:MODE <ResultMode>

Selects how the measurement results are displayed.

Suffix:
<sp> 1...4, index of the spectrum

Parameters:

<ResultMode> ABS | REL

*RST: ABS

Usage: Asynchronous command

Manual operation: See "Result mode" on page 312

CALCulate:SPECtrum<sp>:PLISt:SOURce <Source>

Selects the source of the peak table. You can select one of the traces that is enabled with Traces.

Suffix:

<sp> 1...4, index of the spectrum

Parameters:

<Source> SPECMAXH1 | SPECMINH1 | SPECNORM1 | SPECAVER1 | SPECMAXH2 | SPECMINH2 | SPECNORM2 | SPECAVER2 | SPECMAXH3 | SPECMINH3 | SPECNORM3 | SPECAVER3 | SPECMAXH4 | SPECMINH4 | SPECNORM4 | SPECAVER4

Usage: Asynchronous command

Manual operation: See "Source" on page 313

CALCulate:SPECtrum<sp>:PLISt:SPOW <ShowPeaks>

Displays a box with a description for each detected peak in the spectrum, including the magnitude.

If `CALCulate:SPECtrum<sp>:PLISt:LABel:FREQuency[:STATe]` is `ON`, the frequency values are also displayed.

Suffix:

<sp> 1...4, index of the spectrum

Parameters:

<ShowPeaks> OFF | ON

*RST: OFF

Usage: Asynchronous command

Manual operation: See "Peak on waveform" on page 311

CALCulate:SPECtrum<sp>:PLISt:RESult[:VALue]?

Returns the current peak list measurement results.

Suffix:

<sp> 1...4, index of the spectrum

Return values:

<Value> Comma-separated list of results

Usage: Query only
Asynchronous command

CALCulate:SPECtrum<sp>:PLISt:SORT:COLumn <ResultColumn>

Sorts the results in the spectrum peak list table either according to the frequency or according to the value.

Suffix:
<sp> 1...4, index of the spectrum

Parameters:
<ResultColumn> FREQ | VAL
*RST: FREQ

Usage: Asynchronous command

CALCulate:SPECtrum<sp>:PLISt:SORT:ORDer <ResultOrder>

Defines if the spectrum peak list results are sorted in an ascending (increasing) or descending (decreasing) order.

Suffix:
<sp> 1...4, index of the spectrum

Parameters:
<ResultOrder> ASC | DESC
`ASC`: ascending
`DESC`: descending
*RST: ASC

Usage: Asynchronous command

CALCulate:SPECtrum<sp>:PLISt:LABel:FREQuency[:STATe] <ShowFrequency>

Includes the frequency of the detected peak in the diagram labels.

Suffix:
<sp> 1...4, index of the spectrum

Parameters:
<ShowFrequency> OFF | ON
*RST: ON

Usage: Asynchronous command

Manual operation: See "Show frequency" on page 312

CALCulate:SPECtrum<sp>:PLISt:LABel:MAXCount <MaxNumberPeaks>

Sets the maximum number of measurement results that are listed in the result table.

Suffix:
<sp> 1...4, index of the spectrum

Parameters:
<MaxNumberPeaks> Range: 1 to 100
Increment: 1
*RST: 10

Usage: Asynchronous command

CALCulate:SPECtrum<sp>:PLISt:LABel:INVert <Inverse>

Inverts the colors of the peak list labels, the peak boxes are shown with a white background.

Suffix:
<sp> 1...4, index of the spectrum

Parameters:
<Inverse> OFF | ON
*RST: OFF

Usage: Asynchronous command

CALCulate:SPECtrum<sp>:PLISt:LABel:MAXCount <MaxNumberPeaks>

Sets the maximum number of measurement results that are listed in the result table.

Suffix:
<sp> 1...4, index of the spectrum

Parameters:
<MaxNumberPeaks> Range: 1 to 100
Increment: 1
*RST: 10

Usage: Asynchronous command

CALCulate:SPECtrum<sp>:PLISt:LABel[:STATe] <ShowLabels>

Displays the labels in the peak list diagram.

Suffix:
<sp> 1...4, index of the spectrum

Parameters:
<ShowLabels> OFF | ON
*RST: ON

Usage: Asynchronous command

18.15.4 Data export of spectrum waveforms

For each of the spectrum traces, a dedicated command is available. For a description of the traces, see "Traces" on page 306.

For fast export of several waveforms at once, use `EXPort:WAVeform:DATA[:VALues]?` on page 995.

CALCulate:SPECtrum<sp>:WAVeform:AVERage:DATA:HEADer?
CALCulate:SPECtrum<sp>:WAVeform:MAXimum:DATA:HEADer?
CALCulate:SPECtrum<sp>:WAVeform:MINimum:DATA:HEADer?
CALCulate:SPECtrum<sp>:WAVeform:NORMal:DATA:HEADer?

Returns the header of spectrum data, the attributes of the waveform.

Suffix:

<sp>	1...4, index of the spectrum

Return values:

<XStart>	1. header value: start frequency of the first spectrum bin in Hz
<XStop>	2. header value: start frequency of the last spectrum bin in Hz
<RecordLength>	3. header value: record length of the waveform in bins
<ValuesPerSample>	4. header value: the number of values per bin is always = 1.

Example:

```
CALC:SPEC1:WAV:NORM:DATA:HEAD?
549316.1734194756,1999450683.360919,2621,1
```

Start frequency of the first spectrum bin is 549316.1734194756 = ~ 549.3 kHz. Start frequency of the last spectrum bin is 1999450683.360919 = ~ 1.999 GHz. The data stream has 2621 values with one value per bin.

Usage: Query only
Asynchronous command

CALCulate:SPECtrum<sp>:WAVeform:AVERage:DATA[:VALues]? [<Offset>[,<Length>]]
CALCulate:SPECtrum<sp>:WAVeform:MAXimum:DATA[:VALues]? [<Offset>[,<Length>]]
CALCulate:SPECtrum<sp>:WAVeform:MINimum:DATA[:VALues]? [<Offset>[,<Length>]]
CALCulate:SPECtrum<sp>:WAVeform:NORMal:DATA[:VALues]? [<Offset>[,<Length>]]

Returns the data of the spectrum points for transmission from the instrument to the controlling computer. The data can be used in MATLAB, for example.

Without parameters, the complete waveform is retrieved. Using the offset and length parameters, data can be retrieved in smaller portions, which makes the command faster. If you send only one parameter, it is interpreted as offset, and the data is retrieved from offset to the end of the waveform.

To set the export format, use `FORMat[:DATA]` on page 814.

Suffix:

<sp> 1...4, index of the spectrum

Query parameters:

<Offset> Number of offset waveform points to be skipped.

Range: 0 to m. Limit: n + m <= record length

<Length> Number of waveform points to be retrieved.

Range: 1 to n. Limit: n + m <= record length

Return values:

<Data> List of values according to the format and content settings.

Usage: Query only
Asynchronous command

18.16 Applications

18.16.1 Mask testing

Some of the commands in the following section are asynchronous. An overlapping or asynchronous command does not automatically finish executing before the next command starts executing. If overlapping commands must be executed in a defined order, e.g. to avoid wrong measurement results, they must be serviced sequentially.

To prevent an overlapping execution of commands, one of the commands `*OPC`, `*OPC?` or `*WAI` can be used after the command or a command set.

For more information, see:

- www.rohde-schwarz.com/rc-via-scpi, section "Command sequence and synchronization"

18.16.1.1 Mask test definition

MTESt<m>:ADD

Creates a mask test with the indicated index.

Suffix:
<m> 1 to 8, index of the mask

Example: See Section 18.4.2, "Creating a mask", on page 809.

Usage: Setting only
Asynchronous command

Manual operation: See "Add mask" on page 316

MTESt<m>:COUNt?

Returns the number of masks.

`MTESt:COUNt? MAX` returns the maximum number of masks that can be created.

Suffix:
<m> Irrelevant, omit the suffix.

Return values:
<Count> Number of defined masks

Usage: Query only
Asynchronous command

MTESt<m>:DIAGram <DiagramKey>

Sets the layout and the diagram where the mask is located and the test runs.

Suffix:
<m> 1 to 8, index of the mask

Parameters:
<DiagramKey> String with the layout-diagram key.

Example:
```
:MTESt:DIAGram?
-->"L1_D1"
```

Usage: Asynchronous command

MTESt<m>:IMEXport:NAME <Name>

Sets the path, the filename and the file format of the mask file.

Suffix:
<m> 1 to 8, index of the mask

Parameters:

<Name> String with path and file name with extension `.xml`.

Example: `MTES2:IMEX:NAME '/home/storage/userData/Masks/MyMask2.xml'`
File and path definition for mask test 2.

Usage: Asynchronous command

Manual operation: See "Save mask" on page 317

MTESt<m>:IMEXport:OPEN

Opens and loads the mask selected by `MTESt<m>:IMEXport:NAME`.

Suffix:

<m> 1 to 8, index of the mask

Usage: Event
Asynchronous command

Manual operation: See "Load mask" on page 317

MTESt<m>:IMEXport:SAVE

Saves the mask test to the file selected by `MTESt<m>:IMEXport:NAME`.

Suffix:

<m> 1 to 8, index of the mask

Usage: Event
Asynchronous command

Manual operation: See "Save mask" on page 317

MTESt<m>:REMove

Deletes the selected mask.

Suffix:

<m> 1 to 8, index of the mask

Usage: Setting only
Asynchronous command

MTESt<m>:SOURce <Source>

Selects the waveform to be tested against the mask.

Suffix:

<m> 1 to 8, index of the mask

Parameters:

<Source>	C1 | C2 | C3 | C4 | M1 | M2 | M3 | M4 | M5 | XY1 | XY2 | XY3 | XY4 | SPECNORM1 | SPECNORM2 | SPECNORM3 | SPEC-NORM4 | O<n>C1 | O<n>C2 | ... | O<n>C8 (<n> = 2 to 8)

Usage: Asynchronous command

Manual operation: See "Source" on page 317

MTESt<m>:STATe <State>

Activates or deactivates the mask test.

Suffix:

<m> 1 to 8, index of the mask

Parameters:

<State> OFF | ON

*RST: ON

Usage: Asynchronous command

Manual operation: See "Enable test" on page 317

MTESt<m>:VISible <DisplayState>

Displays all mask segments of the selected mask in the diagrams, or hides them.

Suffix:

<m> 1 to 8, index of the mask

Parameters:

<DisplayState> OFF | ON

*RST: ON

Usage: Asynchronous command

Manual operation: See "Display" on page 317

18.16.1.2 Segment definition

MTESt<m>:SEGMent<n>:ADD

Adds a new segment to the selected mask. The segment has no points, use `MTESt<m>:SEGMent<n>:POINt<o>:ADD` to add the points.

Suffix:

<m>	1 to 8, index of the mask
<n>	1 to 8, index of the segment Omit the suffix to use the next free suffix.
Example:	See Section 18.4.2, "Creating a mask", on page 809.
Usage:	Setting only Asynchronous command
Manual operation:	See "Add segment" on page 318

MTESt<m>:SEGMent<n>:COUNt?

Returns the number of segments that belong to the indicated mask.

`MTESt<m>:SEGMent:COUNt? MAX` returns the maximum number of segments that can be created.

Suffix:

<m>	1 to 8, index of the mask
<n>	Irrelevant, omit the suffix.

Return values:

<Count>	Number of defined masks
Usage:	Query only Asynchronous command

MTESt<m>:SEGMent<n>:POINt<o>:ADD

Adds a corner point to the selected mask segment at the next free suffix. The new point has the coordinates 0;0.

Suffix:

<m>	1 to 8, index of the mask
<n>	1 to 8, index of the segment
<o>	1 to *, index of the segment point
Example:	See Section 18.4.2, "Creating a mask", on page 809.
Usage:	Setting only Asynchronous command
Manual operation:	See "Add +" on page 319

MTESt<m>:SEGMent<n>:POINt<o>:COUNt?

Returns the number of points that was added to the indicated mask segment.

You can query the maximum value with `<command>? MAX`.

Suffix:

<m>	1 to 8, index of the mask
<n>	1 to 8, index of the segment
<o>	Irrelevant, omit the suffix.

Parameters:

<Count>	Number of defined points

Example: See Section 18.4.2, "Creating a mask", on page 809.

Usage: Query only
Asynchronous command

Manual operation: See "Add +" on page 319

MTESt<m>:SEGMent<n>:POINt<o>:REMove

Deletes the indicated corner point of the mask segment.

Suffix:

<m>	1 to 8, index of the mask
<n>	1 to 8, index of the segment
<o>	1 to *, index of the segment point

Usage: Setting only
Asynchronous command

Manual operation: See " Delete, Delete all" on page 320

MTESt<m>:SEGMent<n>:POINt<o>:VALid?

Checks the validity of the selected point. See "Mask Definition" on page 314.

Suffix:

<m>	1 to 8, index of the mask
<n>	1 to 8, index of the segment
<o>	1 to *, index of the segment point

Return values:

<Valid> OFF | ON

ON = valid
OFF = invalid

*RST: ON

Usage: Query only
Asynchronous command

MTESt<m>:SEGMent<n>:POINt<o>:X <X>

Sets the horizontal position of the selected corner point.

Suffix:

<m> 1 to 8, index of the mask

<n> 1 to 8, index of the segment

<o> 1 to *, index of the segment point

Parameters:

<X>
Range: -1E+26 to 1E+26
Increment: 1E-06
*RST: 0
Default unit: s

Example: See Section 18.4.2, "Creating a mask", on page 809.

Usage: Asynchronous command

Manual operation: See "Point, X, Y" on page 319

MTESt<m>:SEGMent<n>:POINt<o>:Y <Y>

Sets the vertical position of the selected corner point.

Suffix:

<m> 1 to 8, index of the mask

<n> 1 to 8, index of the segment

<o> 1 to *, index of the segment point

Parameters:

<Y>
Range: -1E+26 to 1E+26
Increment: 1E-06
*RST: 0
Default unit: V

Example: See Section 18.4.2, "Creating a mask", on page 809.

Usage: Asynchronous command

Manual operation: See "Point, X, Y" on page 319

MTESt<m>:SEGMent<n>:REMove

Deletes the specified mask segment.

Suffix:

<m> 1 to 8, index of the mask

<n> 1 to 8, index of the segment

Usage: Setting only
Asynchronous command

Manual operation: See "Delete, Delete all" on page 320

MTESt<m>:SEGMent<n>:VALid?

Checks the validity of the indicated segment. The segment is invalid if one of its points is invalid. See "Mask Definition" on page 314.

Suffix:
<m> 1 to 8, index of the mask

<n> 1 to 8, index of the segment

Return values:
<Valid> OFF | ON

ON = valid
OFF = invalid

*RST: ON

Usage: Query only
Asynchronous command

18.16.1.3 Actions

MTESt<m>:ONViolation:BEEP <Beep>

Generates a beep sound if the command is set to `SUCCess` or `VIOLation`.

Suffix:
<m> 1 to 8, index of the mask

Parameters:
<Beep> NOACtion | SUCCess | VIOLation

*RST: NOACtion

Usage: Asynchronous command

Manual operation: See "Beep" on page 320

MTESt<m>:ONViolation:SCReenshot <SaveScreenshot>

Saves the waveform data to file if the command is set to `SUCCess` or `VIOLation`.

To configure the screenshot settings, use the commands described in Section 18.12.9, "Screenshots", on page 1000.

Suffix:

<m> 1 to 8, index of the mask

Parameters:

<SaveScreenshot> NOAction | SUCCess | VIOLation

*RST: NOAction

Usage: Asynchronous command

Manual operation: See "Screenshot" on page 321

MTESt<m>:ONViolation:STOP <StopAcq>

Stops the running acquisition if the command is set to `SUCCess` or `VIOLation`.

Suffix:

<m> 1 to 8, index of the mask

Parameters:

<StopAcq> NOAction | SUCCess | VIOLation

*RST: NOAction

Usage: Asynchronous command

Manual operation: See "Stop acq" on page 321

MTESt<m>:ONViolation:TRIGgerout <TrigOutPls>

Sends an outgoing pulse to the [Trigger Out] connector if the command is set to `SUCCess` or `VIOLation`.

To configure the pulse, user the following commands:

- `TRIGger:ACTions:OUT:SOURce` on page 926
- `TRIGger:ACTions:OUT:POLarity` on page 927
- `TRIGger:ACTions:OUT:DELay` on page 926
- `TRIGger:ACTions:OUT:PLENgth` on page 927

Suffix:

<m> 1 to 8, index of the mask

Parameters:

<TrigOutPls> NOAction | SUCCess | VIOLation

*RST: NOAction

Usage: Asynchronous command

Manual operation: See "Trigger out pulse" on page 321

MTESt<m>:ONViolation:WFMSave <SaveWfm>

Saves the waveform data to file if the command is set to `SUCCess` or `VIOLation`.

To define the path and file names, use the EXPort:WAVeform:AUTonaming:* commands:

- `EXPort:WAVeform:AUTonaming:NAME` on page 991
- `EXPort:WAVeform:AUTonaming:PATH` on page 992
- `EXPort:WAVeform:AUTonaming:TYPE` on page 992

Suffix:

<m> 1 to 8, index of the mask

Parameters:

<SaveWfm> NOACtion | SUCCess | VIOLation

*RST: NOACtion

Usage: Asynchronous command

Manual operation: See "Save wfm" on page 321

18.16.1.4 Results

MTESt<m>:RESult:COUNt:FWAVeforms?

Returns the number of failed acquisitions.

Suffix:

<m> 1 to 8, index of the mask

Return values:

<AcqsFailed> Range: 0 to 10000000000000
Increment: 1
*RST: 0

Usage: Query only
Asynchronous command

Manual operation: See "Failed Acq." on page 315

MTESt<m>:RESult:COUNt:PWAVeforms?

Returns the number of acquisitions that passed the test successfully.

Suffix:

<m> 1 to 8, index of the mask

Return values:
<AcqsPassed> Range: 0 to 10000000000000
Increment: 1
*RST: 0

Usage: Query only
Asynchronous command

Manual operation: See "Passed Acq." on page 315

MTESt<m>:RESult:COUNt:WAVeforms?

Returns the number of tested acquisitions.

Suffix:
<m> 1 to 8, index of the mask

Return values:
<AcqsCompleted> Range: 0 to 10000000000000
Increment: 1
*RST: 0

Usage: Query only
Asynchronous command

Manual operation: See "Total Acq." on page 315

MTESt<m>:RESult:FRATe?

Returns the fail rate, the ratio of failed acquisitions to the number of tested acquisitions.

Suffix:
<m> 1 to 8, index of the mask

Return values:
<FailRate> Range: -1E+26 to 1E+26
Increment: 0
*RST: 0
Default unit: %

Usage: Query only
Asynchronous command

Manual operation: See "Fail rate" on page 316

MTESt<m>:RESult[:RESult]?

Returns the overall test result.

Suffix:
<m> 1 to 8, index of the mask

Return values:

<TestResult> PASS | FAIL

*RST: PASS

Usage: Query only

Asynchronous command

Manual operation: See "Result" on page 316

18.16.2 Frequency response analysis (option R&S MXO4-K36)

18.16.2.1 Frequency response analysis settings

FRANalysis:STATe <Value>

Starts the frequency response analysis.

Parameters:
<Value> RUN | STOP | OFF

Usage: Asynchronous command

Manual operation: See "Run" on page 331

FRANalysis:ENABle <State>

Enables the frequency response analysis application.

If the frequency response analysis is disabled, the instrument does not accept any `FRANalysis` command.

You can start the analysis with `FRANalysis:STATe`.

Parameters:
<State> OFF | ON

Usage: Asynchronous command

FRANalysis:AUToscale <AutoScale>

Enables the auto scaling function for each measurement.

Parameters:
<AutoScale> OFF | ON
*RST: ON

Usage: Asynchronous command

Manual operation: See "Auto scale" on page 336

FRANalysis:AMPLitude:MODE <AmplitudeMode>

Selects, if the amplitude is a constant value (`FRANalysis:GENerator:AMPLitude`) or is defined as an amplitude profile.

Parameters:
<AmplitudeMode> CONStant | PROFile
*RST: CONStant

Usage: Asynchronous command

Manual operation: See "Amplitude mode" on page 332

FRANalysis:FREQuency:STARt <StartFrequency>

Sets the start frequency of the sweep.

Parameters:

<StartFrequency>	Range: 0.01 to 100E+6 Increment: 1 *RST: 100 Default unit: Hz

Usage: Asynchronous command

Manual operation: See "Start, Stop" on page 330

FRANalysis:FREQuency:STOP <StopFrequency>

Sets the stop frequency of the sweep.

Parameters:

<StopFrequency>	Range: 0.01 to 100E+6 Increment: 1 *RST: 10000 Default unit: Hz

Usage: Asynchronous command

Manual operation: See "Start, Stop" on page 330

FRANalysis:GENerator:AMPLitude <GenAmplitude>

Sets a fixed amplitude for the frequency response analysis.

Parameters:

<GenAmplitude>	Range: 0.01 to 12 Increment: 0.1 *RST: 1 Default unit: Vpp

Usage: Asynchronous command

Manual operation: See "Amplitude" on page 332

FRANalysis:GENerator:LOAD <GenLoad>

Selects the generator voltage display for 50Ω or high impedance load.

Parameters:

<GenLoad>	FIFTy | HIZ `HIZ`: high input impedance *RST: FIFTy

Usage: Asynchronous command

Manual operation: See "User load" on page 332

FRANalysis:GENerator[:CHANnel] <GenCh>

Selects the built-in generator to start a frequency sweep for a defined frequency range.

Parameters:

<GenCh> GEN1 | GEN2

*RST: GEN1

Usage: Asynchronous command

Manual operation: See "Generator" on page 331

FRANalysis:HDEFinition[:ENABle] <HDMode>

Disables the HD mode, which is active by default. In particular, disable the HD mode if you analyze switching peaks.

Parameters:

<HDMode> OFF | ON

*RST: ON

Usage: Asynchronous command

Manual operation: See "HD mode" on page 336

FRANalysis:INPut[:SOURce] <InputChannel>

Sets the channel for the input signal of the DUT.

Parameters:

<InputChannel> C1 | C2 | C3 | C4

*RST: C1

Usage: Asynchronous command

Manual operation: See "Input" on page 330

FRANalysis:MEASurement:DELay:STATe <MeasDelay>

Enables the measurement delay.

Parameters:

<MeasDelay> OFF | ON

*RST: OFF

Usage: Asynchronous command

Manual operation: See "Meas. delay mode, Delay time, Delay period" on page 335

FRANalysis:MEASurement:DELay:MODE <MeasDelayMode>

Selects the delay mode.

Parameters:

<MeasDelayMode> TIME | PERiod

*RST: TIME

Usage: Asynchronous command

Manual operation: See "Meas. delay mode, Delay time, Delay period" on page 335

FRANalysis:MEASurement:DELay[:TIME] <MeasDelayTime>

Sets a time delay, that the system waits before measuring the next point of the plot. This is helpful in systems that need more time to adapt to the new frequency, for example if filters with significant time group delays are present.

The settings takes effect if if `FRANalysis:MEASurement:DELay:STATe` = `ON` and `FRANalysis:MEASurement:DELay:MODE` = `PERiod`.

Parameters:

<MeasDelayTime> Range: 0 to 10
Increment: 0.001
*RST: 0
Default unit: s

Example:
```
FRANalysis:MEASurement:DELay:STATe ON
FRANalysis:MEASurement:DELay:MODE TIME
FRANalysis:MEASurement:DELay 0.005
```

Usage: Asynchronous command

Manual operation: See "Meas. delay mode, Delay time, Delay period" on page 335

FRANalysis:MEASurement:DELay:PERiod[:NUMBer] <MeasDelayPeriod>

Sets a period delay, which the system waits before measuring the next point of the plot.

The settings takes effect if if `FRANalysis:MEASurement:DELay:STATe` = `ON` and `FRANalysis:MEASurement:DELay:MODE` = `PERiod`.

Parameters:

<MeasDelayPeriod> Range: 0.01 to 1000
Increment: 0.01
*RST: 1

Example:
```
FRANalysis:MEASurement:DELay:STATe ON
FRANalysis:MEASurement:DELay:MODE PERiod
FRANalysis:MEASurement:DELay:PERiod 0.05
```

Usage: Asynchronous command

Manual operation: See "Meas. delay mode, Delay time, Delay period" on page 335

FRANalysis:MEASurement:POINt[:DISPlay] <Points>

Enables the display of the measurement points for the frequency response analysis.

Parameters:

<Points> OFF | ON

*RST: ON

Usage: Asynchronous command

Manual operation: See "Display points" on page 336

FRANalysis:MEASurement:RBW <RBW>

Sets the resolution bandwidth, which determines the number of measurements that are used for creating the plot.

Parameters:

<RBW> HIGH | MID | LOW

*RST: MID

Usage: Asynchronous command

Manual operation: See "RBW" on page 335

FRANalysis:OUTPut[:SOURce] <OutputChannel>

Sets the channel for the output signal of the DUT.

Parameters:

<OutputChannel> C1 | C2 | C3 | C4

*RST: C2

Usage: Asynchronous command

Manual operation: See "Output" on page 330

FRANalysis:POINts:LOGarithmic <PtsPerDecade>

Selects the number of points that are measured per decade, if `FRANalysis:POINts:MODE` is set to `DECade`.

Parameters:

<PtsPerDecade> Range: 10 to 500

Increment: 1

*RST: 10

Usage: Asynchronous command

Manual operation: See "Points" on page 331

FRANalysis:POINts:MODE <PointsMode>

Selects, if the number of points for the FRA are measured as total or per decade.

You can set the number of points with FRANalysis:POINts:TOTal/ FRANalysis:POINts:LOGarithmic.

Parameters:

<PointsMode> TOTal | DECade

*RST: DECade

Usage: Asynchronous command

Manual operation: See "Points" on page 331

FRANalysis:POINts:TOTal <TotalPoints>

Set the total number of points for the FRA analysis, if FRANalysis:POINts:MODE on page 1068 is set to TOTal.

Parameters:

<TotalPoints> Range: 10 to 5000

Increment: 1

*RST: 100

Usage: Asynchronous command

Manual operation: See "Points" on page 331

FRANalysis:REPeat <Repeat>

Repeats the measurement, using the same parameters.

Parameters:

<Repeat> OFF | ON

*RST: OFF

Usage: Asynchronous command

Manual operation: See "Repeat" on page 331

FRANalysis:RESet

Resets the frequency response analysis.

Usage: Setting only

Asynchronous command

FRANalysis:PHASe:MAXimum <MaxPhase>

Sets the upper boundary of the vertical phase window.

The lower boundary is given by "Maximum phase" - 360°.

By default, the "Maximum phase" is set to 180° for a phase window ranging from -180° to 180° accordingly.

Parameters:

<MaxPhase> Range: 0 to 360
Increment: 1
*RST: 180
Default unit: °

Usage: Asynchronous command

Manual operation: See "Maximum phase" on page 335

18.16.2.2 Frequency response analysis amplitude profile

FRANalysis:AMPLitude:PROFile:COUNt <Value>

Sets the number of defined points for the amplitude profile.

Parameters:

<Value>

Usage: Asynchronous command

Manual operation: See "Add" on page 333

FRANalysis:AMPLitude:PROFile:APOint

Adds a new step to the amplitude profile.

Usage: Setting only
Asynchronous command

Manual operation: See "Add" on page 333

FRANalysis:AMPLitude:PROFile:POINt<m>:REMove

Removes the specified step from the amplitude profile.

Suffix:

<m> 1..*, step index

Usage: Setting only
Asynchronous command

Manual operation: See "Delete" on page 334

FRANalysis:AMPLitude:PROFile:SORT

Sorts the steps in the amplitude table by frequency, starting with the lowest frequency.

Usage:	Setting only Asynchronous command
Manual operation:	See "Sort" on page 333

FRANalysis:AMPLitude:PROFile:MODE <VoltageChange>

Selects if the voltage change is done as a single step or as a ramp.

Parameters:

<VoltageChange>	SINGle | RAMP *RST: SINGle
Usage:	Asynchronous command
Manual operation:	See "Voltage change" on page 333

FRANalysis:AMPLitude:PROFile:POINt<m>:FREQuency <Frequency>

Sets the start frequency for the selected point.

Suffix:

<m>	Index of the amplitude profile point

Parameters:

<Frequency>	Range: 0.01 to 100E6 Increment: 1 *RST: 100 Default unit: Hz
Usage:	Asynchronous command
Manual operation:	See "Step start freq, Amplitude" on page 333

FRANalysis:AMPLitude:PROFile:POINt<m>:AMPLitude <Amplitude>

Sets the amplitude for the selected point.

Suffix:

<m>	Index of the amplitude profile point

Parameters:

<Amplitude>	Range: 0 to 5.995 Increment: 0.1 *RST: 1 Default unit: Vpp
Usage:	Asynchronous command
Manual operation:	See "Step start freq, Amplitude" on page 333

18.16.2.3 Frequency response analysis calibration settings

FRANalysis:CALibration:CALibration

Runs a calibration sequence.

Usage: Event

Manual operation: See "Start calibration" on page 340

FRANalysis:CALibration:RESult?

Returns the result of the calibration.

Return values:

<States> PASS | FAIL | RUN | NOAL

PASS: the calibration is successful.
FAIL: the calibration failed.
RUN: a calibration cycle is running.
NOAL: no active calibration.

*RST: NOAL

Usage: Query only

Manual operation: See "Start calibration" on page 340

FRANalysis:CALibration:STATe <UseCalData>

If ON, the user calibration data is used for the frequency response analysis.

Parameters:

<UseCalData> OFF | ON

*RST: OFF

Manual operation: See "Use calibration data" on page 340

18.16.2.4 Frequency response analysis diagram settings

FRANalysis:PHASe:ENABle <State>

Enables the phase waveform for the frequency response analysis.

Parameters:

<State> OFF | ON

*RST: OFF

Usage: Asynchronous command

FRANalysis:PHASe:OFFSet <VerticalOffset>

Sets a vertical offset of the phase waveform.

Parameters:

<VerticalOffset>
Range: -10000 to 10000
Increment: 1
*RST: 0
Default unit: °

Usage: Asynchronous command

Manual operation: See "Vertical offset" on page 337

FRANalysis:PHASe:SCALe <VerticalScale>

Sets the vertical scale for the phase waveform.

Parameters:

<VerticalScale>
Range: 1 to 180
Increment: 1
*RST: 36
Default unit: °/div

Usage: Asynchronous command

Manual operation: See "Vertical scale" on page 337

FRANalysis:GAIN:ENABle <State>

Enables the gain waveform for the frequency response analysis.

Parameters:

<State> OFF | ON

*RST: OFF

Usage: Asynchronous command

FRANalysis:GAIN:OFFSet <VerticalOffset>

Sets a vertical offset of the gain waveform.

Parameters:

<VerticalOffset>
Range: -2000 to 2000
Increment: 1
*RST: 10
Default unit: dB

Usage: Asynchronous command

Manual operation: See "Vertical offset" on page 337

FRANalysis:GAIN:SCALe <VerticalScale>

Sets the vertical scale for the gain waveform.

Parameters:

<VerticalScale>
Range: 0.1 to 20
Increment: 1
*RST: 10
Default unit: dB/div

Usage: Asynchronous command

Manual operation: See "Vertical scale" on page 337

FRANalysis:AMPLitude:SCALe <VerticalScale>

Sets the vertical scale for the amplitude waveform.

Parameters:

<VerticalScale>
Range: 0.01 to 10
Increment: 0.01
*RST: 0.5
Default unit: Vpp/div

Usage: Asynchronous command

FRANalysis:AMPLitude:ENABle <State>

Enables the amplitude signal for the frequency response analysis. You can then define the amplitude profile of the signal.

Parameters:

<State> OFF | ON
*RST: OFF

Usage: Asynchronous command

Manual operation: See "Amplitude profile" on page 332

FRANalysis:AMPLitude:OFFSet <VerticalOffset>

Sets a vertical offset of the amplitude waveform.

Parameters:

<VerticalOffset>
Range: -100 to 100
Increment: 0.01
*RST: 5
Default unit: Vpp

Usage: Asynchronous command

FRANalysis:PHASe:DATA?

Returns the data of the phase as a list of comma-separated values in degree.

Return values:

<Data> Comma-separated list of values

Example:

```
FRAN:PHAS:DATA?
```

Result:

```
-0.07463742650985239,-0.09417628145200041,
-0.1457021392091207,-0.1914790795969807,
-0.2494368612845221,-0.3415108478964939,
-0.4350150706042513,-0.5673151547214843,
-0.7363486980048108,-0.9055923620805615,
-1.0829557075417
```

Usage: Query only
Asynchronous command

FRANalysis:FREQuency:DATA?

Returns the data of the frequency points for which gain and phase have been calculated as a list of comma-separated values in Hz.

Return values:

<Data> Comma-separated list of values

Example:

```
FRAN:FREQ:DATA?
```

Result:

```
-0.07463742650985239,-0.09417628145200041,
-0.1457021392091207,-0.1914790795969807,
-0.2494368612845221,-0.3415108478964939,
-0.4350150706042513,-0.5673151547214843,
-0.7363486980048108,-0.9055923620805615,
-1.0829557075417
```

Usage: Query only
Asynchronous command

FRANalysis:GAIN:DATA?

Returns the data of the gain as a list of comma-separated values in dB.

Return values:

<Data> Comma-separated list of values

Example:

```
FRAN:GAIN:DATA?
```

Result:

```
0.4381956630254851,0.4593246383252179,
0.461895233375762,0.4570717993766185,
0.4623802509651942,0.4533450898899926,
0.4408194360143725,0.4221600784741697,
0.4483342212879299,0.4473558449908476,
0.4915016244058707
```

Usage: Query only
Asynchronous command

18.16.2.5 Frequency response analysis results

FRANalysis:RESult:STATe <Table>

Enables the display of the result table for the FRA.

Parameters:

<Table> OFF | ON

*RST: ON

Usage: Asynchronous command

Manual operation: See "Result table" on page 337

FRANalysis:MARGin:STATe <Margins>

Enables the display of the margin table for the FRA.

Parameters:

<Margins>	OFF | ON *RST: ON

Usage: Asynchronous command

Manual operation: See "Margin" on page 337

FRANalysis:MARGin:GAIN:FREQuency?

Returns the frequency of the gain margin.

Return values:
<Frequency>

Usage: Query only
Asynchronous command

FRANalysis:MARGin:GAIN:VALue?

Returns the value of the gain margin.

Return values:
<Phase>

Usage: Query only
Asynchronous command

FRANalysis:MARGin:PHASe:FREQuency?

Returns the frequency of the phase margin.

Return values:
<Frequency>

Usage: Query only
Asynchronous command

FRANalysis:MARGin:PHASe:VALue?

Returns the value of the phase margin.

Return values:
<Phase>

Usage: Query only
Asynchronous command

FRANalysis:MARKer<m>:STATe <Markers>

Enables the display of the marker table for the FRA.

Suffix:
<m> Irrelevant, omit the suffix.

Parameters:
<Markers> OFF | ON
*RST: ON

Usage: Asynchronous command

Manual operation: See "Markers" on page 337

FRANalysis:MARKer<m>:FREQuency <Frequency>

Sets the frequency for the specified marker, which defines the horizontal marker position.

Suffix:
<m> 1..2
Selects the marker number.

Parameters:
<Frequency> Range: 0.01 to 100E+6
Increment: 1E-05
*RST: 1000
Default unit: Hz

Usage: Asynchronous command

FRANalysis:MARKer<m>:GAIN?

Returns the gain for the specified marker.

Suffix:
<m> 1..2
Selects the marker number.

Usage: Query only
Asynchronous command

FRANalysis:MARKer<m>:PHASe?

Returns the phase value for the specified marker.

Suffix:
<m> 1..2
Selects the marker number.

Usage: Query only
Asynchronous command

FRANalysis:MARKer<m>:DIFFerence:FREQuency?

Returns the delta value of the frequency between the two markers.

Suffix:
<m> Irrelevant, omit the suffix.

Return values:
<DeltaFrequency>

Usage: Query only
Asynchronous command

FRANalysis:MARKer<m>:DIFFerence:GAIN?

Returns the delta value of the gain between the two markers.

Suffix:
<m> Irrelevant, omit the suffix.

Return values:
<DeltaGain>

Usage: Query only
Asynchronous command

FRANalysis:MARKer<m>:DIFFerence:PHASe?

Returns the delta value of the phase between the two markers.

Suffix:
<m> Irrelevant, omit the suffix.

Return values:
<DeltaPhase>

Usage: Query only
Asynchronous command

FRANalysis:MARKer<m>:INDex?

Returns the point index in the plot where the specified marker is positioned.

Suffix:
<m> 1..2
Selects the marker number.

Return values:
<PointIndex> The lowest index is 0, which corresponds to line 1 in the result table.
PointIndex = # in result table - 1

Usage: Query only
Asynchronous command

FRANalysis:MARKer<m>:SSCReen

Resets the markers to their initial positions. Reset is helpful if the markers have disappeared from the display or need to be moved for a larger distance.

Suffix:

<m> Irrelevant, omit the suffix.

Usage: Setting only
Asynchronous command

18.16.2.6 Reference waveforms in frequency response analysis

FRANalysis:REFCurve<rc>:ABORt

Aborts a running reference waveform export, which was started with `FRANalysis:REFCurve<rc>:SAVE`, or a running reference waveform update, which was started with `FRANalysis:REFCurve<rc>:UPDate`.

Suffix:

<rc> 1...4, index of the reference waveform

Usage: Event
Asynchronous command

Manual operation: See "Save as" on page 344

FRANalysis:REFCurve<rc>:CLEar

Deletes the selected reference waveform. It disappears from the display, and its memory is deleted.

Suffix:

<rc> 1...4, index of the reference waveform

Usage: Setting only
Asynchronous command

Manual operation: See "Clear" on page 344

FRANalysis:REFCurve<rc>:DATA?

Returns the data of the specified reference waveform.

Suffix:
<rc> 1...4, index of the reference waveform

Return values:
<Data> Comma-separated values

Usage: Query only
Asynchronous command

FRANalysis:REFCurve<rc>:DATA:SOURce?

Returns the type of the source from which the selected reference was created.

Suffix:
<rc> 1...4, index of the reference waveform

Return values:
<LoadedSource> GAIN | PHASe | AMPLitude
*RST: GAIN

Usage: Query only
Asynchronous command

FRANalysis:REFCurve<rc>:NAME <Name>

Defines the name of the reference waveform file to be loaded, saved or deleted.

Suffix:
<rc> 1...4, index of the reference waveform

Parameters:
<Name> String with the file path, filename and extension.

Usage: Asynchronous command

Manual operation: See "Save as" on page 344

FRANalysis:REFCurve<rc>:OFFSet <VerticalOffset>

The vertical offset moves the reference waveform vertically. Enter a value with the unit of the waveform.

Suffix:
<rc> 1...4, index of the reference waveform

Parameters:

<VerticalOffset>	Range:	-100 to 100
	Increment:	1
	*RST:	5

Usage: Asynchronous command

Manual operation: See "Vertical offset" on page 346

FRANalysis:REFCurve<rc>:OPEN

Loads the reference waveform file selected by `FRANalysis:REFCurve<rc>:NAME`.

Suffix:
<rc> 1...4, index of the reference waveform

Usage: Event
Asynchronous command

Manual operation: See "Open" on page 344

FRANalysis:REFCurve<rc>:SAVE

Saves the FRA reference waveform to the file defined by `FRANalysis:REFCurve<rc>:NAME`.

Suffix:
<rc> 1...4, index of the reference waveform

Usage: Event
Asynchronous command

Manual operation: See "Save as" on page 344

FRANalysis:REFCurve<rc>:SCALe <VerticalScale>

Sets the vertical scale, which defines the displayed amplitude of the selected waveform.

Suffix:
<rc> 1...4, index of the reference waveform

Parameters:

<VerticalScale>	Range:	-100 to 100
	Increment:	1
	*RST:	0.5

Usage: Asynchronous command

Manual operation: See "Vertical scale" on page 345

FRANalysis:REFCurve<rc>:SOURce <Source>

Selects the source waveform of the reference.

Suffix:
<rc> 1...4, index of the reference waveform

Parameters:
<Source> FGAin | FPHase | FREF1 | FREF2 | FREF3 | FREF4

Usage: Asynchronous command

Manual operation: See "Source" on page 343

FRANalysis:REFCurve<rc>:ENABle <State>

Enables the display of the reference waveform in the diagram. Before you can display it, create the reference waveform.

Suffix:
<rc> 1...4, index of the reference waveform

Parameters:
<State> OFF | ON
*RST: OFF

Usage: Asynchronous command

Manual operation: See "Display" on page 343

FRANalysis:REFCurve<rc>:TOORiginal

Restores the original vertical settings of the reference waveform.

Suffix:
<rc> 1...4, index of the reference waveform

Usage: Setting only
Asynchronous command

Manual operation: See "Set to original" on page 345

FRANalysis:REFCurve<rc>:UPDate

Copies the selected source waveform with all its settings to the memory of the reference waveform. If there is a previously defined reference waveform in this memory, it is updated by the current source waveform.

Suffix:
<rc> 1...4, index of the reference waveform

Usage: Event
Asynchronous command

Manual operation: See "Create/Update" on page 344

FRANalysis:REFCurve<rc>:VMODe <VerticalMode>

Selects the type of vertical settingsfor the reference waveform.

Suffix:

<rc> 1...4, index of the reference waveform

Parameters:

<VerticalMode> COUPled | INDependent

COUPled
Vertical position and scale of the source are used.

INDependent
Scaling and position can be set specific to the reference waveform.

*RST: INDependent

Usage: Asynchronous command

Manual operation: See "Vertical mode" on page 345

FRANalysis:MARKer<m>:REFerence<rc>?

Returns the vertical value of the reference waveform at the specified marker.

Suffix:

<m> 1..2
Selects the marker number.

<rc> 1...4, index of the reference waveform

Usage: Query only
Asynchronous command

18.16.2.7 Frequency response analysis export

EXPort:RESult:SELect:FRA:MARGin <MarginResult>

If enabled, includes the margin results in the results export file of the FRA.

Parameters:

<MarginResult> OFF | ON

*RST: OFF

Usage: Asynchronous command

Manual operation: See "FRA results" on page 341

EXPort:RESult:SELect:FRA:MARKer <MarkerResult>

If enabled, includes the marker results in the results export file of the FRA.

Parameters:
<MarkerResult> OFF | ON
*RST: OFF

Usage: Asynchronous command

Manual operation: See "FRA results" on page 341

EXPort:RESult:SELect:FRA:RESult <Result>

If enabled, includes the frequency response analysis results, including the frequency, gain, phase and amplitude, in the results export file of the FRA.

Parameters:
<Result> OFF | ON
*RST: OFF

Usage: Asynchronous command

Manual operation: See "FRA results" on page 341

18.16.3 Power analysis (option R&S MXO4-K31)

Some of the commands in the following section are asynchronous. An overlapping or asynchronous command does not automatically finish executing before the next command starts executing. If overlapping commands must be executed in a defined order, e.g. to avoid wrong measurement results, they must be serviced sequentially.

To prevent an overlapping execution of commands, one of the commands `*OPC`, `*OPC?` or `*WAI` can be used after the command or a command set.

For more information, see:

- www.rohde-schwarz.com/rc-via-scpi, section "Command sequence and synchronization"

Overview of statistic results

The remote commands for the power analysis measurements can retrieve statistic results. The abbreviations in the commands have the following meaning:

Command	Description
`POWer<m>:xxx:RESult:nnn:[:ACTual]?`	Current measurement result
`POWer<m>:xxx:RESult:nnn::AVERage?`	Average of the measurement results
`POWer<m>:xxx:RESult:nnn::EVTCount?`	Number of calculated measurement results (periods)
`POWer<m>:xxx:RESult:nnn:RMS?`	RMS value of the measurement results

Command	Description
POWer<m>:xxx:RESult:nnn::PPEak?	Positive peak value of the measurement results
POWer<m>:xxx:RESult:nnn::NPEak?	Negative peak value of the measurement results
POWer<m>:xxx:RESult:xxx::STDDev?	Standard deviation of the measurement results
POWer<m>:xxx:RESult:nnn::WFMCount?	Number of calculated waveforms

18.16.3.1 General settings

POWer<m>[:ENABle] <State>

Enables the power measurement instance.

Suffix:
<m> 1...3, index of the power analysis measurement

Parameters:
<State> OFF | ON

Usage: Asynchronous command

Manual operation: See "+ Add" on page 348

POWer<m>:TYPE <Type>

Sets the type for the respective power analysis measurement.

Suffix:
<m> 1...3, index of the power analysis measurement

Parameters:
<Type> QUALity | HARMonics | SWITching | ONOFf | EFFiciency | SOA

SWITching = switching loss
ONOFf = turn on/off time
SOA = safe operating area

Example: `POW1:TYPE QUAL`
Sets the first power analysis measurement to quality.

Usage: Asynchronous command

Manual operation: See "+ Add" on page 348

POWer<m>:ASKew[:EXECute]

Performs auto deskew adjustment.

Suffix:
<m> Irrelevant, omit the suffix.

Usage: Event
Asynchronous command

Manual operation: See "Auto Deskew" on page 349

EXPort:RESult:SELect:POWer<m> <ExportResults>

If enabled, includes the results of selected power analysis measurement in the results export file.

Suffix:
<m> 1...3, index of the power analysis measurement

Parameters:
<ExportResults> OFF | ON

*RST: OFF

Usage: Asynchronous command

POWer<m>:EFFiciency:STATistics[:ENABle] <State>
POWer<m>:SWITching:STATistics:ENABle <State>
POWer<m>:QUALity:STATistics[:ENABle] <State>

The commands activate statistical calculation for the selected power measurement. Make sure that the suffix matches the selected power measurement.

Suffix:

<m>	1...3, index of the power analysis measurement

Parameters:

<State>	OFF | ON *RST: ON

Usage: Asynchronous command

Manual operation: See "Statistics" on page 353

POWer<m>:EFFiciency:STATistics:RESet
POWer<m>:SWITching:STATistics:RESet
POWer<m>:QUALity:STATistics:RESet

The commands restart statistical calculation for the selected power measurement. Make sure that the suffix matches the selected power measurement.

Suffix:

<m>	1...3, index of the power analysis measurement

Usage: Setting only
Asynchronous command

Manual operation: See "Clear results" on page 353

POWer<m>:EFFiciency:STATistics:WFMCount?
POWer<m>:SWITching:STATistics:WFMCount?
POWer<m>:QUALity:STATistics:WFMCount?

Return the number of waveforms included in the selected power analysis. Make sure that the suffix matches the selected power measurement.

Suffix:

<m>	1...3, index of the power analysis measurement

Return values:

<WaveformCount>	Number of analyzed waveforms.

Usage: Query only
Asynchronous command

Manual operation: See "Statistics" on page 353

18.16.3.2 Power quality

Power quality setup

POWer<m>:QUALity:SOURce:CURRent <CurrentSource>

Selects the current source waveform. Analog channels and math waveforms can be used.

Suffix:
<m> 1...3, index of the power analysis measurement

Parameters:
<CurrentSource> C1 | C2 | C3 | C4 | M1 | M2 | M3 | M4 | M5

Usage: Asynchronous command

Manual operation: See "Current" on page 352

POWer<m>:QUALity:SOURce[:VOLTage] <VoltageSource>

Selects the voltage source waveform. Analog channels and math waveforms can be used.

Suffix:
<m> 1...3, index of the power analysis measurement

Parameters:
<VoltageSource> C1 | C2 | C3 | C4 | M1 | M2 | M3 | M4 | M5

Usage: Asynchronous command

Manual operation: See "Voltage" on page 352

POWer<m>:QUALity:GATE <Gate>

Selects the gate that is used for limiting the range of the power quality measurement.

Enable the gate before you assign a measurement to it (`GATE<g>:ENABle =ON`).

Suffix:
<m> 1...3, index of the power analysis measurement

Parameters:
<Gate> Number of the gate to be used

Usage: Asynchronous command

Manual operation: See "Gate" on page 353

POWer<m>:QUALity:FREQuency[:VALue] <FundamFreq>

Sets the input frequency of the source signal in Hz.

Suffix:
<m> 1...3, index of the power analysis measurement

Parameters:
<FundamFreq> F50 | F60 | F400 | USER | AUTO
*RST: F50

Usage: Asynchronous command

Manual operation: See "Fund. Freq" on page 353

POWer<m>:QUALity:FREQuency:USER <FundamentalFreq>

Sets the user-defined frequency, if `POWer<m>:QUALity:FREQuency[:VALue]` is set to `USER`.

Suffix:
<m> 1...3, index of the power analysis measurement

Parameters:
<FundamentalFreq> Range: 10 to 1000000
Increment: 1
*RST: 50
Default unit: Hz

Usage: Asynchronous command

Manual operation: See "Fund. Freq" on page 353

Power quality measurement display

POWer<m>:QUALity:DISPlay:CURRent:CREStfactor <ShwCurrCrest>

Enables the current crest factor measurement for the power quality analysis.

Suffix:
<m> 1...3, index of the power analysis measurement

Parameters:
<ShwCurrCrest> OFF | ON
*RST: ON

Usage: Asynchronous command

POWer<m>:QUALity:DISPlay:CURRent:PEAK <ShwCurrPeak>

Enables the current peak measurement for the power quality analysis.

Suffix:
<m> 1...3, index of the power analysis measurement

Parameters:

<ShwCurrPeak> OFF | ON
*RST: ON

Usage: Asynchronous command

POWer<m>:QUALity:DISPlay:CURRent:RMS <ShowCurrentRMS>

Enables the current RMS measurement for the power quality analysis.

Suffix:

<m> 1...3, index of the power analysis measurement

Parameters:

<ShowCurrentRMS> OFF | ON
*RST: ON

Usage: Asynchronous command

POWer<m>:QUALity:DISPlay:POWer:APParent <ShwApparentPow>

Enables the apparent power measurement for the power quality analysis.

Suffix:

<m> 1...3, index of the power analysis measurement

Parameters:

<ShwApparentPow> OFF | ON
*RST: ON

Usage: Asynchronous command

POWer<m>:QUALity:DISPlay:POWer:PFACtor <ShwPowFact>

Enables the power factor measurement for the power quality analysis.

Suffix:

<m> 1...3, index of the power analysis measurement

Parameters:

<ShwPowFact> OFF | ON
*RST: ON

Usage: Asynchronous command

POWer<m>:QUALity:DISPlay:POWer:PHASe <ShowPhase>

Enables the power phase measurement for the power quality analysis.

Suffix:

<m> 1...3, index of the power analysis measurement

Parameters:
<ShowPhase> OFF | ON
*RST: ON

Usage: Asynchronous command

POWer<m>:QUALity:DISPlay:POWer:REACtive <ShwReactivePow>

Enables the reactive power measurement for the power quality analysis.

Suffix:
<m> 1...3, index of the power analysis measurement

Parameters:
<ShwReactivePow> OFF | ON
*RST: ON

Usage: Asynchronous command

POWer<m>:QUALity:DISPlay:POWer:REALpower <ShwActPow>

Enables the real power measurement for the power quality analysis.

Suffix:
<m> 1...3, index of the power analysis measurement

Parameters:
<ShwActPow> OFF | ON
*RST: ON

Usage: Asynchronous command

POWer<m>:QUALity:DISPlay:VOLTage:CREStfactor <ShwVoltageCrest>

Enables the voltage crest factor measurement for the power quality analysis.

Suffix:
<m> 1...3, index of the power analysis measurement

Parameters:
<ShwVoltageCrest> OFF | ON
*RST: ON

Usage: Asynchronous command

POWer<m>:QUALity:DISPlay:VOLTage:FREQuency <ShwVoltageFreq>

Enables the voltage frequency measurement for the power quality analysis.

Suffix:
<m> 1...3, index of the power analysis measurement

Parameters:

<ShwVoltageFreq> OFF | ON
*RST: ON

Usage: Asynchronous command

POWer<m>:QUALity:DISPlay:VOLTage:PEAK <ShwVoltagePeak>

Enables the voltage peak value measurement for the power quality analysis.

Suffix:

<m> 1...3, index of the power analysis measurement

Parameters:

<ShwVoltagePeak> OFF | ON
*RST: ON

Usage: Asynchronous command

POWer<m>:QUALity:DISPlay:VOLTage:RMS <ShowVoltageRMS>

Enables the voltage RMS measurement for the power quality analysis.

Suffix:

<m> 1...3, index of the power analysis measurement

Parameters:

<ShowVoltageRMS> OFF | ON
*RST: ON

Usage: Asynchronous command

Power quality results

See "Overview of statistic results" on page 1084.

POWer<m>:QUALity:RESult:CURRent:CREStfactor[:ACTual]?
POWer<m>:QUALity:RESult:CURRent:CREStfactor:AVERage?
POWer<m>:QUALity:RESult:CURRent:CREStfactor:EVTCount?
POWer<m>:QUALity:RESult:CURRent:CREStfactor:NPEak?
POWer<m>:QUALity:RESult:CURRent:CREStfactor:PPEak?
POWer<m>:QUALity:RESult:CURRent:CREStfactor:RMS?
POWer<m>:QUALity:RESult:CURRent:CREStfactor:WFMCount?
POWer<m>:QUALity:RESult:CURRent:CREStfactor:STDDev?

Returns the current crest factor, the *Peak value / RMS value* for the power quality analysis.

For details on the statistics, see "Overview of statistic results" on page 1084.

Suffix:

<m>	1...3, index of the power analysis measurement

Return values:

<StdDev>	Range:	-1E+26 to 1E+26
	Increment:	1E-10
	*RST:	0

Usage:	Query only Asynchronous command

POWer<m>:QUALity:RESult:CURRent:PEAK[:ACTual]?
POWer<m>:QUALity:RESult:CURRent:PEAK:AVERage?
POWer<m>:QUALity:RESult:CURRent:PEAK:EVTCount?
POWer<m>:QUALity:RESult:CURRent:PEAK:NPEak?
POWer<m>:QUALity:RESult:CURRent:PEAK:PPEak?
POWer<m>:QUALity:RESult:CURRent:PEAK:RMS?
POWer<m>:QUALity:RESult:CURRent:PEAK:WFMCount?
POWer<m>:QUALity:RESult:CURRent:PEAK:STDDev?

Returns the current peak value, the highest measured magnitude value for the power quality analysis.

For details on the statistics, see "Overview of statistic results" on page 1084.

Suffix:

<m>	1...3, index of the power analysis measurement

Return values:

<StdDev>	Range: -1E+26 to 1E+26 Increment: 1E-10 *RST: 0

Usage:	Query only Asynchronous command

POWer<m>:QUALity:RESult:CURRent:RMS[:ACTual]?
POWer<m>:QUALity:RESult:CURRent:RMS:AVERage?
POWer<m>:QUALity:RESult:CURRent:RMS:EVTCount?
POWer<m>:QUALity:RESult:CURRent:RMS:NPEak?
POWer<m>:QUALity:RESult:CURRent:RMS:PPEak?
POWer<m>:QUALity:RESult:CURRent:RMS:RMS?
POWer<m>:QUALity:RESult:CURRent:RMS:WFMCount?
POWer<m>:QUALity:RESult:CURRent:RMS:STDDev?

Returns the root mean square of the current for the power quality analysis.

For details on the statistics, see "Overview of statistic results" on page 1084.

Suffix:

<m>	1...3, index of the power analysis measurement

Return values:

<StdDev>	Range: -1E+26 to 1E+26 Increment: 1E-10 *RST: 0

Usage:	Query only Asynchronous command

POWer<m>:QUALity:RESult:POWer:APParent[:ACTual]?
POWer<m>:QUALity:RESult:POWer:APParent:AVERage?
POWer<m>:QUALity:RESult:POWer:APParent:EVTCount?
POWer<m>:QUALity:RESult:POWer:APParent:NPEak?
POWer<m>:QUALity:RESult:POWer:APParent:PPEak?
POWer<m>:QUALity:RESult:POWer:APParent:RMS?
POWer<m>:QUALity:RESult:POWer:APParent:WFMCount?
POWer<m>:QUALity:RESult:POWer:APParent:STDDev?

Returns the apparent power for the power quality analysis.

For details on the statistics, see "Overview of statistic results" on page 1084.

Suffix:

<m> — 1...3, index of the power analysis measurement

Return values:

<StdDev> — Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0

Usage: Query only
Asynchronous command

POWer<m>:QUALity:RESult:POWer:PFACtor[:ACTual]?
POWer<m>:QUALity:RESult:POWer:PFACtor:AVERage?
POWer<m>:QUALity:RESult:POWer:PFACtor:EVTCount?
POWer<m>:QUALity:RESult:POWer:PFACtor:NPEak?
POWer<m>:QUALity:RESult:POWer:PFACtor:PPEak?
POWer<m>:QUALity:RESult:POWer:PFACtor:RMS?
POWer<m>:QUALity:RESult:POWer:PFACtor:WFMCount?
POWer<m>:QUALity:RESult:POWer:PFACtor:STDDev?

Returns the power factor for the power quality analysis.

For details on the statistics, see "Overview of statistic results" on page 1084.

Suffix:

<m> — 1...3, index of the power analysis measurement

Return values:

<StdDev> — Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0

Usage: Query only
Asynchronous command

POWer<m>:QUALity:RESult:POWer:PHASe[:ACTual]?
POWer<m>:QUALity:RESult:POWer:PHASe:AVERage?
POWer<m>:QUALity:RESult:POWer:PHASe:EVTCount?
POWer<m>:QUALity:RESult:POWer:PHASe:NPEak?
POWer<m>:QUALity:RESult:POWer:PHASe:PPEak?

POWer<m>:QUALity:RESult:POWer:PHASe:RMS?
POWer<m>:QUALity:RESult:POWer:PHASe:WFMCount?
POWer<m>:QUALity:RESult:POWer:PHASe:STDDev?

Returns the phase for the power quality analysis.

For details on the statistics, see "Overview of statistic results" on page 1084.

Suffix:

<m>	1...3, index of the power analysis measurement

Return values:

<StdDev>	Range:	-1E+26 to 1E+26
	Increment:	1E-10
	*RST:	0

Usage: Query only
Asynchronous command

POWer<m>:QUALity:RESult:POWer:REACtive[:ACTual]?
POWer<m>:QUALity:RESult:POWer:REACtive:AVERage?
POWer<m>:QUALity:RESult:POWer:REACtive:EVTCount?
POWer<m>:QUALity:RESult:POWer:REACtive:NPEak?
POWer<m>:QUALity:RESult:POWer:REACtive:PPEak?
POWer<m>:QUALity:RESult:POWer:REACtive:RMS?
POWer<m>:QUALity:RESult:POWer:REACtive:WFMCount?
POWer<m>:QUALity:RESult:POWer:REACtive:STDDev?

Returns the reactive power for the power quality analysis.

For details on the statistics, see "Overview of statistic results" on page 1084.

Suffix:

<m>	1...3, index of the power analysis measurement

Return values:

<StdDev>	Range:	-1E+26 to 1E+26
	Increment:	1E-10
	*RST:	0

Usage: Query only
Asynchronous command

POWer<m>:QUALity:RESult:POWer:REALpower[:ACTual]?
POWer<m>:QUALity:RESult:POWer:REALpower:AVERage?
POWer<m>:QUALity:RESult:POWer:REALpower:EVTCount?
POWer<m>:QUALity:RESult:POWer:REALpower:NPEak?
POWer<m>:QUALity:RESult:POWer:REALpower:PPEak?
POWer<m>:QUALity:RESult:POWer:REALpower:RMS?
POWer<m>:QUALity:RESult:POWer:REALpower:WFMCount?
POWer<m>:QUALity:RESult:POWer:REALpower:STDDev?

Returns the active power for the power quality analysis.

For details on the statistics, see "Overview of statistic results" on page 1084.

Suffix:
<m> 1...3, index of the power analysis measurement

Return values:
<StdDev> Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0

Usage: Query only
Asynchronous command

POWer<m>:QUALity:RESult:VOLTage:CREStfactor[:ACTual]?
POWer<m>:QUALity:RESult:VOLTage:CREStfactor:AVERage?
POWer<m>:QUALity:RESult:VOLTage:CREStfactor:EVTCount?
POWer<m>:QUALity:RESult:VOLTage:CREStfactor:NPEak?
POWer<m>:QUALity:RESult:VOLTage:CREStfactor:PPEak?
POWer<m>:QUALity:RESult:VOLTage:CREStfactor:RMS?
POWer<m>:QUALity:RESult:VOLTage:CREStfactor:WFMCount?
POWer<m>:QUALity:RESult:VOLTage:CREStfactor:STDDev?

Returns the voltage crest factor, the *Peak value / RMS value* for the power quality analysis.

For details on the statistics, see "Overview of statistic results" on page 1084.

Suffix:
<m> 1...3, index of the power analysis measurement

Return values:
<StdDev> Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0

Usage: Query only
Asynchronous command

POWer<m>:QUALity:RESult:VOLTage:FREQuency[:ACTual]?
POWer<m>:QUALity:RESult:VOLTage:FREQuency:AVERage?
POWer<m>:QUALity:RESult:VOLTage:FREQuency:EVTCount?
POWer<m>:QUALity:RESult:VOLTage:FREQuency:NPEak?
POWer<m>:QUALity:RESult:VOLTage:FREQuency:PPEak?
POWer<m>:QUALity:RESult:VOLTage:FREQuency:RMS?
POWer<m>:QUALity:RESult:VOLTage:FREQuency:WFMCount?
POWer<m>:QUALity:RESult:VOLTage:FREQuency:STDDev?

Returns the voltage frequency value for the power quality analysis.

For details on the statistics, see "Overview of statistic results" on page 1084.

Suffix:
<m> 1...3, index of the power analysis measurement

Return values:

<StdDev>	Range: -1E+26 to 1E+26 Increment: 1E-10 *RST: 0

Usage: Query only
Asynchronous command

POWer<m>:QUALity:RESult:VOLTage:PEAK[:ACTual]?
POWer<m>:QUALity:RESult:VOLTage:PEAK:AVERage?
POWer<m>:QUALity:RESult:VOLTage:PEAK:EVTCount?
POWer<m>:QUALity:RESult:VOLTage:PEAK:NPEak?
POWer<m>:QUALity:RESult:VOLTage:PEAK:PPEak?
POWer<m>:QUALity:RESult:VOLTage:PEAK:RMS?
POWer<m>:QUALity:RESult:VOLTage:PEAK:WFMCount?
POWer<m>:QUALity:RESult:VOLTage:PEAK:STDDev?

Returns the voltage peak value, the highest measured magnitude value for the power quality analysis.

For details on the statistics, see "Overview of statistic results" on page 1084.

Suffix:

<m>	1...3, index of the power analysis measurement

Return values:

<StdDev>	Range: -1E+26 to 1E+26 Increment: 1E-10 *RST: 0

Usage: Query only
Asynchronous command

POWer<m>:QUALity:RESult:VOLTage:RMS[:ACTual]?
POWer<m>:QUALity:RESult:VOLTage:RMS:AVERage?
POWer<m>:QUALity:RESult:VOLTage:RMS:EVTCount?
POWer<m>:QUALity:RESult:VOLTage:RMS:NPEak?
POWer<m>:QUALity:RESult:VOLTage:RMS:PPEak?
POWer<m>:QUALity:RESult:VOLTage:RMS:RMS?
POWer<m>:QUALity:RESult:VOLTage:RMS:WFMCount?
POWer<m>:QUALity:RESult:VOLTage:RMS:STDDev?

Returns the root mean square of the voltage for the power quality analysis.

For details on the statistics, see "Overview of statistic results" on page 1084.

Suffix:

<m>	1...3, index of the power analysis measurement

Return values:

<StdDev>	Range: -1E+26 to 1E+26 Increment: 1E-10 *RST: 0

Usage: Query only
Asynchronous command

18.16.3.3 Power harmonics

Power harmonics setup

POWer<m>:HARMonics:SOURce:CURRent <CurrentSource>

Sets the channel for the current source input of the power harmonics analysis.

Suffix:
<m> 1...3, index of the power analysis measurement

Parameters:
<CurrentSource> C1 | C2 | C3 | C4 | M1 | M2 | M3 | M4 | M5

Usage: Asynchronous command

Manual operation: See "Current" on page 360

POWer<m>:HARMonics:SOURce[:VOLTage] <VoltageSource>

Sets the channel for the voltage source input of the power harmonics analysis.

Suffix:
<m> 1...3, index of the power analysis measurement

Parameters:
<VoltageSource> C1 | C2 | C3 | C4 | M1 | M2 | M3 | M4 | M5

Usage: Asynchronous command

Manual operation: See "Voltage" on page 359

POWer<m>:HARMonics:STANdard <Standard>

Sets a standard for the current harmonic measurement.

Suffix:

<m> — 1...3, index of the power analysis measurement

Parameters:

<Standard> — ENA | ENB | ENC | END | MIL | RTCA

`ENA`: EN 61000-3-2 Class A
`ENB`: EN 61000-3-2 Class B
`ENC`: EN 61000-3-2 Class C
`END`: EN 61000-3-2 Class D
`MIL`: MIL-STD-1399
`RTCA`: RTCA DO-160

*RST: ENA

Usage: Asynchronous command

Manual operation: See "Standard" on page 360

POWer<m>:HARMonics:REVision <Revision>

Selects the revision of the EN61000 standard, if `POWer<m>:HARMonics:STANdard` is set to `ENA / ENB / ENC / END`.

Suffix:

<m> — 1...3, index of the power analysis measurement

Parameters:

<Revision> — REV2011 | REV2019

*RST: REV2019

Usage: Asynchronous command

Manual operation: See "Standard" on page 360

POWer<m>:HARMonics:FREQuency:EN <FundFreqEN61000>

Sets the fundamental frequency of the input signal for the EN61000 standard, if `POWer<m>:HARMonics:STANdard` is set to `ENA / ENB / ENC / END`.

Suffix:

<m> — 1...3, index of the power analysis measurement

Parameters:
<FundFreqEN61000> F50 | F60 | AUTO

F50: 50 Hz
F60: 60 Hz
AUTO: automatically set

*RST: AUTO

Usage: Asynchronous command

Manual operation: See "Fund. Freq" on page 360

POWer<m>:HARMonics:FREQuency:MIL <FundFreqMIL>

Sets the fundamental frequency of the input signal for the MIL standard, if POWer<m>:HARMonics:STANdard is set to MIL.

Suffix:
<m> 1...3, index of the power analysis measurement

Parameters:
<FundFreqMIL> F60 | F400

F60: 60 Hz
F400: 400 Hz

*RST: F60

Usage: Asynchronous command

Manual operation: See "Fund. Freq" on page 360

POWer<m>:HARMonics:FREQuency:RTCA <FundamFreqRTCA>

Sets the fundamental frequency of the input signal for the RTCA standard, if POWer<m>:HARMonics:STANdard is set to RTCA.

Suffix:
<m> 1...3, index of the power analysis measurement

Parameters:
<FundFreqRTCA> F400 | NVF | WVF

F400: 400 Hz
NVF
WVF

*RST: F400

Usage: Asynchronous command

Manual operation: See "Fund. Freq" on page 360

POWer<m>:HARMonics:STATistics:ENABle <EnabStatistics>

Enables statistical calculation for the power harmonics analysis.

Suffix:

<m> 1...3, index of the power analysis measurement

Parameters:

<EnabStatistics> OFF | ON

*RST: ON

Usage: Asynchronous command

POWer<m>:HARMonics:DISPlay:HARMonics <DispedHarmonics>

Selects which harmonics are displayed in the bargraph: all, odd even or depending on the standard definition.

Suffix:

<m> 1...3, index of the power analysis measurement

Parameters:

<DispedHarmonics> ALL | EVEN | ODD | STANdard

*RST: STANdard

Usage: Asynchronous command

Manual operation: See "Displ. Harm." on page 360

POWer<m>:HARMonics:DISPlay:FREQuency:STARt[:VALue] <Frequency>

Sets the start frequency of a bar graph display. At least three bars are displayed.

Suffix:

<m> 1...3, index of the power analysis measurement

Parameters:

<Frequency> Range: 0 to 100000000

Increment: 1

*RST: 50

Default unit: Hz

Usage: Asynchronous command

Manual operation: See "Min X frequency" on page 361

POWer<m>:HARMonics:DISPlay:FREQuency:STOP[:VALue] <Frequency>

Sets the stop frequency of the bar graph display. The maximum value is defined by standard and fundamental frequency.

Suffix:

<m> 1...3, index of the power analysis measurement

Parameters:

<Frequency> Range: 0 to 100000000
Increment: 1
*RST: 1000
Default unit: Hz

Usage: Asynchronous command

Manual operation: See "Max X frequency" on page 362

POWer<m>:HARMonics:DISPlay:BARGraph:VERTical:SCALe:TYPE <Scaling>

Selects a logarithmic or linear scale for the display for the harmonics bargraph.

Suffix:

<m> 1...3, index of the power analysis measurement

Parameters:

<Scaling> LIN | LOG
*RST: LIN

Usage: Asynchronous command

Manual operation: See "Scale bar graph" on page 361

POWer<m>:HARMonics:RPOWer[:MODE] <ActPowMd>

Available if `POWer<m>:HARMonics:STANdard` is set to `END`.

Selects if the power factor is defined automatically, or a user-defined value is used (`POWer<m>:HARMonics:RPOWer:USER`).

Suffix:

<m> 1...3, index of the power analysis measurement

Parameters:

<ActPowMd> AUTO | USER
*RST: AUTO

Usage: Asynchronous command

Manual operation: See "Real power, Power" on page 361

POWer<m>:HARMonics:RPOWer:USER <UsrActPow>

Selects the revision of the EN61000 standard, if `POWer<m>:HARMonics:STANdard` is set to `END` and `POWer<m>:HARMonics:RPOWer:USER` is set to `USER`.

Sets a user-defined power value.

Suffix:

<m> 1...3, index of the power analysis measurement

Parameters:

<UsrActPow> Range: 0 to 10000
Increment: 1
*RST: 100
Default unit: W

Usage: Asynchronous command

Manual operation: See "Real power, Power" on page 361

POWer<m>:HARMonics:PFACtor:USER <UsrPowFact>

Available if `POWer<m>:HARMonics:STANdard` is set to `ENC` and `POWer<m>:HARMonics:PFACtor[:MODE]` is set to `USER`.

Sets a user-defined power factor.

Suffix:

<m> 1...3, index of the power analysis measurement

Parameters:

<UsrPowFact> Range: 0 to 100
Increment: 1
*RST: 100
Default unit: %

Usage: Asynchronous command

Manual operation: See "Power factor" on page 361

POWer<m>:HARMonics:PFACtor[:MODE] <PowFactMd>

Available if `POWer<m>:HARMonics:STANdard` is set to `ENC`.

Selects if the power factor is defined automatically, or a user-defined value is used (`POWer<m>:HARMonics:PFACtor:USER`).

Suffix:

<m> 1...3, index of the power analysis measurement

Parameters:

<PowFactMd> AUTO | USER
*RST: AUTO

Usage: Asynchronous command

Manual operation: See "Power factor" on page 361

Power harmonics results

POWer<m>:HARMonics:AVAilable?

Returns the number of measured harmonics.

Suffix:

<m> 1...3, index of the power analysis measurement

Return values:

<Count>

Usage: Query only
Asynchronous command

POWer<m>:HARMonics:MEASurement:FREQuency[:ACTual]?

Returns the frequency of measured harmonics.

Suffix:

<m> 1...3, index of the power analysis measurement

Return values:

<Actual> Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0

Usage: Query only
Asynchronous command

POWer<m>:HARMonics:MEASurement:REALpower[:ACTual]?

Returns the real power. Only available, if `POWer<m>:HARMonics:STANdard` on page 1101 is set to `ENC / END`.

Suffix:

<m> 1...3, index of the power analysis measurement

Return values:

<Actual> Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0

Usage: Query only
Asynchronous command

POWer<m>:HARMonics:MEASurement:THDFundament[:ACTual]?

Returns the total harmonic distortion relative to fundamental (THDF).

Suffix:
<m> 1...3, index of the power analysis measurement

Usage: Query only
Asynchronous command

POWer<m>:HARMonics:MEASurement:THDRms[:ACTual]?

Returns the total harmonic distortion relative to the RMS amplitude (THD RMS).

Suffix:
<m> 1...3, index of the power analysis measurement

Usage: Query only
Asynchronous command

POWer<m>:HARMonics:RESult<n>:VIOLation?

Queries if the value of n-th harmonic is within the defined limit for the current measurement.

Suffix:
<m> 1...3, index of the power analysis measurement

<n> 1...n, index of the harmonics

Return values:
<Harmonic>

Usage: Query only
Asynchronous command

POWer<m>:HARMonics:RESult<n>[:FREQuency]?

Returns the frequency of the n-th harmonic.

Suffix:
<m> 1...3, index of the power analysis measurement

<n> 1...n, index of the harmonics

Return values:
<Harmonic>

Usage: Query only
Asynchronous command

POWer<m>:HARMonics:RESult<n>:MAGNitude:PERCent:MAXimum?

Returns the maximum magnitude of the n-th harmonic in percent.

Suffix:

<m> 1...3, index of the power analysis measurement

<n> 1...n, index of the harmonics

Return values:

<Harmonic>

Usage: Query only
Asynchronous command

POWer<m>:HARMonics:RESult<n>:MAGNitude:PERCent:MINimum?

Returns the minimum magnitude of the n-th harmonic in percent.

Suffix:

<m> 1...3, index of the power analysis measurement

<n> 1...n, index of the harmonics

Return values:

<Harmonic>

Usage: Query only
Asynchronous command

POWer<m>:HARMonics:RESult<n>:MAGNitude:PERCent[:ACTual]?

Returns the magnitude of the n-th harmonic in percent.

Suffix:

<m> 1...3, index of the power analysis measurement

<n> 1...n, index of the harmonics

Return values:

<Harmonic>

Usage: Query only
Asynchronous command

POWer<m>:HARMonics:RESult<n>:MAGNitude:RMS:MAXimum?

Returns the maximum magnitude of the n-th harmonic in RMS.

Suffix:

<m> 1...3, index of the power analysis measurement

<n> 1...n, index of the harmonics

Return values:

<Harmonic>

Usage: Query only
Asynchronous command

POWer<m>:HARMonics:RESult<n>:MAGNitude:RMS:MINimum?

Returns the minimum magnitude of the n-th harmonic in RMS.

Suffix:

<m>	1...3, index of the power analysis measurement
<n>	1...n, index of the harmonics

Return values:
<Harmonic>

Usage: Query only
Asynchronous command

POWer<m>:HARMonics:RESult<n>:MAGNitude:RMS[:ACTual]?

Returns the magnitude of the n-th harmonic in RMS.

Suffix:

<m>	1...3, index of the power analysis measurement
<n>	1...n, index of the harmonics

Return values:
<Harmonic>

Usage: Query only
Asynchronous command

18.16.3.4 Switching loss

Switching loss setup

POWer<m>:SWITching:SOURce:CURRent <SourceCurrent>

Selects the current source waveform. Analog channels and math waveforms can be used.

Suffix:

<m>	1...3, index of the power analysis measurement

Parameters:

<SourceCurrent>	C1 | C2 | C3 | C4 | M1 | M2 | M3 | M4 | M5

Usage: Asynchronous command

Manual operation: See "Current" on page 366

POWer<m>:SWITching:SOURce[:VOLTage] <SourceVoltage>

Selects the voltage source waveform. Analog channels and math waveforms can be used.

Suffix:

<m>	1...3, index of the power analysis measurement

Parameters:

<SourceVoltage>	C1 | C2 | C3 | C4

Usage: Asynchronous command

Manual operation: See "Voltage" on page 366

POWer<m>:SWITching:DISPlay:TYPE <Unit>

Selects the measurement type: power or energy.

Suffix:

<m>	1...3, index of the power analysis measurement

Parameters:

<Unit>	POWer | ENERgy *RST: POWer

Usage: Asynchronous command

Manual operation: See "Unit" on page 366

POWer<m>:SWITching:REGion:TOTal[:STARt] <T1Position>
POWer<m>:SWITching:REGion:TON[:STARt] <T1Position>

Sets the start time for the turn on area in relation to the trigger point. This value is also the start time of the total switching cycle.

Suffix:

<m>	1...3, index of the power analysis measurement

Parameters:

<T1Position>
Range: -500 to 500
Increment: 1E-09
*RST: -1E-06
Default unit: s

Usage: Asynchronous command

Manual operation: See "T<n> position" on page 367

POWer<m>:SWITching:REGion:TON:STOP <T2Position>
POWer<m>:SWITching:REGion:CONDuction[:STARt] <T2Position>

Sets the start time for the conduction area in relation to the trigger point. This value is also end time of the turn on area.

Suffix:

<m> 1...3, index of the power analysis measurement

Parameters:

<T2Position>
Range: -500 to 500
Increment: 1E-09
*RST: 1E-06
Default unit: s

Usage: Asynchronous command

Manual operation: See "T<n> position" on page 367

POWer<m>:SWITching:REGion:CONDuction:STOP <T3Position>
POWer<m>:SWITching:REGion:TOFF[:STARt] <T3Position>

Sets the start time for the turn off area in relation to the trigger point. This value is also the end time of the conduction area.

Suffix:

<m> 1...3, index of the power analysis measurement

Parameters:

<T3Position>
Range: -500 to 500
Increment: 1E-09
*RST: 5E-06
Default unit: s

Usage: Asynchronous command

Manual operation: See "T<n> position" on page 367

POWer<m>:SWITching:REGion:TOFF:STOP <T4Position>
POWer<m>:SWITching:REGion:NCONduction[:STARt] <T4Position>

Sets the start time for the non-conduction area in relation to the trigger point. This value is also the end time of the turn off area.

Suffix:

<m> 1...3, index of the power analysis measurement

Parameters:

<T4Position>
Range: -500 to 500
Increment: 1E-09
*RST: 6E-06
Default unit: s

Usage: Asynchronous command

Manual operation: See "T<n> position" on page 367

POWer<m>:SWITching:REGion:NCONduction:STOP <T5Position>
POWer<m>:SWITching:REGion:TOTal:STOP <T5Position>

Sets the end time for the non-conduction area in relation to the trigger point. This value is also the end of the total switching cycle.

Suffix:

<m> 1...3, index of the power analysis measurement

Parameters:

<T5Position>
Range: -500 to 500
Increment: 1E-09
*RST: 1E-05
Default unit: s

Usage: Asynchronous command

Manual operation: See "T<n> position" on page 367

Switching loss display

POWer<m>:SWITching:DISPlay:CONDuction[:ENABle] <Show>
POWer<m>:SWITching:DISPlay:NCONduction[:ENABle] <Show>
POWer<m>:SWITching:DISPlay:TOFF[:ENABle] <Show>
POWer<m>:SWITching:DISPlay:TON[:ENABle] <Show>

The commands enable the measurements of the conduction area, non-conduction area, turn off area and turn on area, respectively. Results of enabled mesurements are shown in the result table.

Suffix:
<m> 1...3, index of the power analysis measurement

Parameters:
<Show> OFF | ON
*RST: ON

Usage: Asynchronous command

Manual operation: See "Turn on" on page 368

POWer<m>:SWITching:DISPlay:CONDuction:COLor <Color>
POWer<m>:SWITching:DISPlay:NCONduction:COLor <Color>
POWer<m>:SWITching:DISPlay:TOFF:COLor <Color>
POWer<m>:SWITching:DISPlay:TON:COLor <Color>

The commands set the display color of the conduction area, non-conduction area, turn off area and turn on area, respectively.

Suffix:
<m> 1...3, index of the power analysis measurement

Parameters:
<Color> Decimal value of the ARGB color. Use the color dialog on the instrument to get the hex value of the color, and convert the hex value to a decimal value.
0 is fully transparent black.
4278190080 (dec) = FF000000 (hex) is opaque black.
4294967295 (dec) = FFFFFFFF (hex) is opaque white.
Range: 0 to 4294967295
Increment: 1

Usage: Asynchronous command

Manual operation: See "Turn on" on page 368

Reset values:

Conduction	2030010343
Non-conduction	2023358259
Turn off	2030002176
Turn on	2026077439

POWer<m>:SWITching:DISPlay:TOTal[:ENABle] <ShowTotal>

Enables the measurements of the total switching cycle.

Suffix:
<m> 1...3, index of the power analysis measurement

Parameters:
<ShowTotal> OFF | ON
*RST: ON

Usage: Asynchronous command

Manual operation: See "Total" on page 369

POWer<m>:SWITching:DISPlay:LABel[:ENABle] <ShowLabel>

Displays the names of the switching cycle areas.

Suffix:
<m> 1...3, index of the power analysis measurement

Parameters:
<ShowLabel> OFF | ON
*RST: ON

Usage: Asynchronous command

Manual operation: See "Area label" on page 369

Switching loss results

See "Overview of statistic results" on page 1084.

POWer<m>:SWITching:RESult:CONDuction:ENERgy[:ACTual]?
POWer<m>:SWITching:RESult:CONDuction:POWer[:ACTual]?
POWer<m>:SWITching:RESult:NCONduction:ENERgy[:ACTual]?
POWer<m>:SWITching:RESult:NCONduction:POWer[:ACTual]?
POWer<m>:SWITching:RESult:TOFF:ENERgy[:ACTual]?
POWer<m>:SWITching:RESult:TOFF:POWer[:ACTual]?
POWer<m>:SWITching:RESult:TON:ENERgy[:ACTual]?
POWer<m>:SWITching:RESult:TON:POWer[:ACTual]?
POWer<m>:SWITching:RESult:TOTal:ENERgy[:ACTual]?
POWer<m>:SWITching:RESult:TOTal:POWer[:ACTual]?

Return the current result value of the selected measurement type.

Suffix:

<m> 1...3, index of the power analysis measurement

Return values:

<Actual> Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0

Usage: Query only
Asynchronous command

POWer<m>:SWITching:RESult:CONDuction:ENERgy:AVERage?
POWer<m>:SWITching:RESult:CONDuction:POWer:AVERage?
POWer<m>:SWITching:RESult:NCONduction:ENERgy:AVERage?
POWer<m>:SWITching:RESult:NCONduction:POWer:AVERage?
POWer<m>:SWITching:RESult:TOFF:ENERgy:AVERage?
POWer<m>:SWITching:RESult:TOFF:POWer:AVERage?
POWer<m>:SWITching:RESult:TON:ENERgy:AVERage?
POWer<m>:SWITching:RESult:TON:POWer:AVERage?
POWer<m>:SWITching:RESult:TOTal:ENERgy:AVERage?
POWer<m>:SWITching:RESult:TOTal:POWer:AVERage?

Return the average value of the selected measurement type if statistics are enabled.

Suffix:

<m> 1...3, index of the power analysis measurement

Return values:

<Average> Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0

Usage: Query only
Asynchronous command

POWer<m>:SWITching:RESult:CONDuction:ENERgy:EVTCount?
POWer<m>:SWITching:RESult:CONDuction:POWer:EVTCount?
POWer<m>:SWITching:RESult:NCONduction:ENERgy:EVTCount?
POWer<m>:SWITching:RESult:NCONduction:POWer:EVTCount?
POWer<m>:SWITching:RESult:TOFF:ENERgy:EVTCount?
POWer<m>:SWITching:RESult:TOFF:POWer:EVTCount?
POWer<m>:SWITching:RESult:TON:ENERgy:EVTCount?
POWer<m>:SWITching:RESult:TON:POWer:EVTCount?
POWer<m>:SWITching:RESult:TOTal:ENERgy:EVTCount?
POWer<m>:SWITching:RESult:TOTal:POWer:EVTCount?

Return the number of calculated measurement results of the selected measurement type if statistics are enabled.

Suffix:

<m> 1...3, index of the power analysis measurement

Return values:

<Count> Range: 0 to 4000000000
Increment: 1
*RST: 0

Usage: Query only
Asynchronous command

POWer<m>:SWITching:RESult:CONDuction:ENERgy:NPEak?
POWer<m>:SWITching:RESult:CONDuction:POWer:NPEak?
POWer<m>:SWITching:RESult:NCONduction:ENERgy:NPEak?
POWer<m>:SWITching:RESult:NCONduction:POWer:NPEak?
POWer<m>:SWITching:RESult:TOFF:ENERgy:NPEak?
POWer<m>:SWITching:RESult:TOFF:POWer:NPEak?
POWer<m>:SWITching:RESult:TON:ENERgy:NPEak?
POWer<m>:SWITching:RESult:TON:POWer:NPEak?
POWer<m>:SWITching:RESult:TOTal:ENERgy:NPEak?
POWer<m>:SWITching:RESult:TOTal:POWer:NPEak?

Return the negative peak value (minimum) of the selected measurement type if statistics are enabled.

Suffix:

<m> 1...3, index of the power analysis measurement

Return values:

<MinPeak> Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0

Usage: Query only
Asynchronous command

POWer<m>:SWITching:RESult:CONDuction:ENERgy:PPEak?
POWer<m>:SWITching:RESult:CONDuction:POWer:PPEak?

POWer<m>:SWITching:RESult:NCONduction:ENERgy:PPEak?
POWer<m>:SWITching:RESult:NCONduction:POWer:PPEak?
POWer<m>:SWITching:RESult:TOFF:ENERgy:PPEak?
POWer<m>:SWITching:RESult:TOFF:POWer:PPEak?
POWer<m>:SWITching:RESult:TON:ENERgy:PPEak?
POWer<m>:SWITching:RESult:TON:POWer:PPEak?
POWer<m>:SWITching:RESult:TOTal:ENERgy:PPEak?
POWer<m>:SWITching:RESult:TOTal:POWer:PPEak?

Return the positive peak value (maximum) of the selected measurement type if statistics are enabled.

Suffix:

<m> 1...3, index of the power analysis measurement

Return values:

<MaxPeak> Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0

Usage: Query only
Asynchronous command

POWer<m>:SWITching:RESult:CONDuction:ENERgy:RMS?
POWer<m>:SWITching:RESult:CONDuction:POWer:RMS?
POWer<m>:SWITching:RESult:NCONduction:ENERgy:RMS?
POWer<m>:SWITching:RESult:NCONduction:POWer:RMS?
POWer<m>:SWITching:RESult:TOFF:ENERgy:RMS?
POWer<m>:SWITching:RESult:TOFF:POWer:RMS?
POWer<m>:SWITching:RESult:TON:ENERgy:RMS?
POWer<m>:SWITching:RESult:TON:POWer:RMS?
POWer<m>:SWITching:RESult:TOTal:ENERgy:RMS?
POWer<m>:SWITching:RESult:TOTal:POWer:RMS?

Return the RMS value of the selected measurement type if statistics are enabled.

Suffix:

<m> 1...3, index of the power analysis measurement

Return values:

<RMS> Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0

Usage: Query only
Asynchronous command

POWer<m>:SWITching:RESult:CONDuction:ENERgy:STDDev?
POWer<m>:SWITching:RESult:CONDuction:POWer:STDDev?
POWer<m>:SWITching:RESult:NCONduction:ENERgy:STDDev?
POWer<m>:SWITching:RESult:NCONduction:POWer:STDDev?
POWer<m>:SWITching:RESult:TOFF:ENERgy:STDDev?

POWer<m>:SWITching:RESult:TOFF:POWer:STDDev?
POWer<m>:SWITching:RESult:TON:ENERgy:STDDev?
POWer<m>:SWITching:RESult:TON:POWer:STDDev?
POWer<m>:SWITching:RESult:TOTal:ENERgy:STDDev?
POWer<m>:SWITching:RESult:TOTal:POWer:STDDev?

Return the standard deviation of the selected measurement type if statistics are enabled.

Suffix:

<m> 1...3, index of the power analysis measurement

Return values:

<StdDev> Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0

Usage: Query only
Asynchronous command

POWer<m>:SWITching:RESult:CONDuction:ENERgy:WFMCount?
POWer<m>:SWITching:RESult:CONDuction:POWer:WFMCount?
POWer<m>:SWITching:RESult:NCONduction:ENERgy:WFMCount?
POWer<m>:SWITching:RESult:NCONduction:POWer:WFMCount?
POWer<m>:SWITching:RESult:TOFF:ENERgy:WFMCount?
POWer<m>:SWITching:RESult:TOFF:POWer:WFMCount?
POWer<m>:SWITching:RESult:TON:ENERgy:WFMCount?
POWer<m>:SWITching:RESult:TON:POWer:WFMCount?
POWer<m>:SWITching:RESult:TOTal:ENERgy:WFMCount?
POWer<m>:SWITching:RESult:TOTal:POWer:WFMCount?

Return the number of calculated waveforms of the selected measurement type if statistics are enabled.

Suffix:

<m> 1...3, index of the power analysis measurement

Return values:

<WaveformsCount> Range: 0 to 4000000000
Increment: 1
*RST: 0

Usage: Query only
Asynchronous command

18.16.3.5 Turn on/off time

Turn on/off setup

POWer<m>:ONOFf:INPut:AC:ABSolute[:VALue] <InputACThreshold>

Sets the threshold for the AC input signal.

Suffix:

<m> 1...3, index of the power analysis measurement

Parameters:

<InputACThreshold> Range: 0 to 1E+26
Increment: 0.001
*RST: 1
Default unit: V

Usage: Asynchronous command

Manual operation: See "AC threshold" on page 374

POWer<m>:ONOFf:INPut:DC:ABSolute[:VALue] <InputDCThreshold>

Sets the threshold for the DC input signal.

Suffix:

<m> 1...3, index of the power analysis measurement

Parameters:

<InputDCThreshold> Range: -1E+26 to 1E+26
Increment: 0.001
*RST: 1
Default unit: V

Usage: Asynchronous command

Manual operation: See "DC threshold" on page 373

POWer<m>:ONOFf:INPut:TYPE <InputType>

Selects whether the input signal is AC or CD.

Suffix:

<m> 1...3, index of the power analysis measurement

Parameters:

<InputType>	DC | AC *RST: DC

Usage: Asynchronous command

Manual operation: See "Input type" on page 373

POWer<m>:ONOFf:INPut[:SOURce] <InputSource>

Selects the source waveform of the input signal.

Suffix:

<m> 1...3, index of the power analysis measurement

Parameters:

<InputSource> C1 | C2 | C3 | C4 | M1 | M2 | M3 | M4 | M5

Usage: Asynchronous command

Manual operation: See "Input source" on page 373

POWer<m>:ONOFf:ONUMber <OutputCount>

Sets the number of outputs to be used in the measurement.

Suffix:

<m> 1...3, index of the power analysis measurement

Parameters:

<OutputCount>

Usage: Asynchronous command

POWer<m>:ONOFf:OUTPut<n>:DC:ABSolute[:VALue] <OutDCThreshold>

Sets the threshold for the selected output signal.

Suffix:

<m> 1...3, index of the power analysis measurement

<n> 1..*
Index of the output signal.

Parameters:

<OutDCThreshold>
Range: -1E+26 to 1E+26
Increment: 0.001
*RST: 1
Default unit: V

Usage: Asynchronous command

Manual operation: See "Threshold" on page 374

POWer<m>:ONOFf:OUTPut<n>:DISPlay:RESult[:ENABle] <Enable>

Activates the indicated output line.

Suffix:

<m>	1...3, index of the power analysis measurement
<n>	1..* Index of the output signal.

Parameters:

<Enable>	OFF | ON *RST: ON

Usage: Asynchronous command

Manual operation: See "Enable output" on page 374

POWer<m>:ONOFf:OUTPut<n>[:SOURce] <OutputSource>

Selects the channel of the output signal. All analog channels except for the input channel can be used. Each channel can be used only once.

Suffix:

<m>	1...3, index of the power analysis measurement
<n>	1..* Index of the output signal.

Parameters:

<OutputSource>	C1 | C2 | C3 | C4 | M1 | M2 | M3 | M4 | M5

Example:
```
POW2:ONOF:OUTP3 C4
```
Sets the 3rd output to channel 4.

Usage: Asynchronous command

Manual operation: See "Output" on page 374

POWer<m>:ONOFf[:TYPE] <Mode>

Selects the turn on or turn off measurement.

Suffix:

<m>	1...3, index of the power analysis measurement

Parameters:

<Mode>	TON | TOFF *RST: TON

Usage: Asynchronous command

Manual operation: See "Mode" on page 373

Turn on/off display

POWer<m>:ONOFf:OUTPut<n>:DISPlay:RLINe[:ENABle] <Display>

Enables the result lines for the selected output.

Suffix:

<m>	1...3, index of the power analysis measurement
<n>	1..* Index of the output signal.

Parameters:

<Display>	OFF | ON *RST: ON

Usage: Asynchronous command

Manual operation: See "Result line <n>" on page 375

Turn on/off results

POWer<m>:ONOFf:RESult<n>:TIME[:ACTual]?

Returns the measured turn-on time or turn-off time of the specified input-output pair.

Suffix:

<m>	1...3, index of the power analysis measurement
<n>	1..* Index of the output signal.

Return values:

<Time>	Range: -1E+26 to 1E+26 Increment: 0.1 *RST: 0 Default unit: s

Usage: Query only
Asynchronous command

18.16.3.6 Power efficiency

Efficiency setup

POWer<m>:EFFiciency:INPut<n>:CURRent[:SOURce] <SourceCurrent>

Selects the current source waveform of the input line.

Suffix:

<m>	1...3, index of the power analysis measurement
<n>	Irrelevant, omit the suffix.

Parameters:

<SourceCurrent>	C1 | C2 | C3 | C4 | M1 | M2 | M3 | M4 | M5

Usage: Asynchronous command

Manual operation: See "Current (Input)" on page 378

POWer<m>:EFFiciency:INPut<n>:VOLTage[:SOURce] <SourceVoltage>

Selects the voltage source waveform of the input line.

Suffix:

<m>	1...3, index of the power analysis measurement
<n>	Irrelevant, omit the suffix.

Parameters:

<SourceVoltage>	C1 | C2 | C3 | C4 | M1 | M2 | M3 | M4 | M5

Usage: Asynchronous command

Manual operation: See "Voltage (Input)" on page 378

POWer<m>:EFFiciency:INPut<n>[:TYPE] <Type>

Selects the type of the current flow: AC or DC.

Suffix:

<m>	1...3, index of the power analysis measurement
<n>	Irrelevant, omit the suffix.

Parameters:

<Type>	DC | AC *RST: DC

Usage: Asynchronous command

Manual operation: See "Input type" on page 378

POWer<m>:EFFiciency:ONUMber? [MAX]

Returns the number of available outputs.

You can query the maximum value with `<command>? MAX`.

The maximum number of output lines is *Number of channels / 2 - 1*.

Suffix:

<m>	1...3, index of the power analysis measurement

Return values:

<OutputCount>	Number of outputs
Usage:	Query only Asynchronous command

POWer<m>:EFFiciency:OUTPut<n>:CURRent[:SOURce] <SourceCurrent>

Selects the current source waveform of the selected output line.

Suffix:

<m>	1...3, index of the power analysis measurement
<n>	1..3, output index Suffix >1 requires an instrument with more than 4 channels.

Parameters:

<SourceCurrent>	C1 | C2 | C3 | C4 | M1 | M2 | M3 | M4 | M5
Usage:	Asynchronous command
Manual operation:	See "Current (Output)" on page 378

POWer<m>:EFFiciency:OUTPut<n>:VOLTage[:SOURce] <SourceVoltage>

Selects the voltage source waveform of the selected output line.

Suffix:

<m>	1...3, index of the power analysis measurement
<n>	1..3, output index Suffix >1 requires an instrument with more than 4 channels.

Parameters:

<SourceVoltage>	C1 | C2 | C3 | C4 | M1 | M2 | M3 | M4 | M5
Usage:	Asynchronous command
Manual operation:	See "Voltage (Output)" on page 378

POWer<m>:EFFiciency:OUTPut<n>[:TYPE] <Type>

Selects the type of the current flow: AC or DC.

Suffix:

<m>	1...3, index of the power analysis measurement
<n>	1..3, output index Suffix >1 requires an instrument with more than 4 channels.

Parameters:

<Type> DC | AC

*RST: DC

Usage: Asynchronous command

Manual operation: See "Output type" on page 378

Efficiency gate

POWer<m>:EFFiciency:GATE <Gate>

Sets the gate for the specified efficiency analysis. Configure the gate before you can assign it. Make sure that the suffix matches the power effciency measurement.

Suffix:

<m> 1...3, index of the power analysis measurement

Parameters:

<Gate> 0 to 8, index of the assigned gate. The value 0 indicates that no gate is assigned.

Usage: Asynchronous command

Efficiency display

POWer<m>:EFFiciency:DISPlay:RESult:OUTPut<n>:EFFiciency[:ENABle] <Show>
POWer<m>:EFFiciency:DISPlay:RESult:OUTPut<n>:POWer[:ENABle] <Show>

The commands enable the power and efficiency measurements of the selected output line.

Suffix:

<m> 1...3, index of the power analysis measurement

<n> 1..3, output index
Suffix >1 requires an instrument with more than 4 channels.

Parameters:

<Show> OFF | ON

*RST: ON

Usage: Asynchronous command

POWer<m>:EFFiciency:DISPlay:RESult:TOTal<n>:EFFiciency[:ENABle] <Show>
POWer<m>:EFFiciency:DISPlay:RESult:TOTal<n>:OPOWer[:ENABle] <Show>

The commands enable the total power and efficiency measurements of the selected output line. These measurements require an instrument with more than 4 channels.

Suffix:

<m>	1...3, index of the power analysis measurement
<n>	Irrelevant, omit the suffix.

Parameters:

<Show>	OFF | ON *RST: ON

Usage: Asynchronous command

Efficiency results

See "Overview of statistic results" on page 1084.

POWer<m>:EFFiciency:RESult:INPut:POWer[:ACTual]?
POWer<m>:EFFiciency:RESult:TOTal:EFFiciency[:ACTual]?
POWer<m>:EFFiciency:RESult:TOTal:OPOWer[:ACTual]?

Return the current result value for input power, total efficiency and total output power.

Suffix:

<m>	1...3, index of the power analysis measurement

Return values:

<Actual>	Range: -1E+26 to 1E+26 Increment: 1E-10 *RST: 0

Usage: Query only
Asynchronous command

POWer<m>:EFFiciency:RESult:INPut:POWer:AVERage?
POWer<m>:EFFiciency:RESult:TOTal:EFFiciency:AVERage?
POWer<m>:EFFiciency:RESult:TOTal:OPOWer:AVERage?

Return the average value for input power, total efficiency and total output power if statistics are enabled.

Suffix:

<m>	1...3, index of the power analysis measurement

Return values:

<Average>	Range: -1E+26 to 1E+26 Increment: 1E-10 *RST: 0

Usage: Query only
Asynchronous command

POWer<m>:EFFiciency:RESult:INPut:POWer:EVTCount?
POWer<m>:EFFiciency:RESult:TOTal:EFFiciency:EVTCount?
POWer<m>:EFFiciency:RESult:TOTal:OPOWer:EVTCount?

Return the number of calculated measurement results for input power, total efficiency and total output power if statistics are enabled.

Suffix:

<m>	1...3, index of the power analysis measurement

Return values:

<Count>	Range: 0 to 4000000000 Increment: 1 *RST: 0

Usage: Query only
Asynchronous command

POWer<m>:EFFiciency:RESult:INPut:POWer:NPEak?
POWer<m>:EFFiciency:RESult:TOTal:EFFiciency:NPEak?
POWer<m>:EFFiciency:RESult:TOTal:OPOWer:NPEak?

Return the negative peak value (minimum) for input power, total efficiency and total output power if statistics are enabled.

Suffix:

<m> 1...3, index of the power analysis measurement

Return values:

<MinPeak> Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0

Usage: Query only
Asynchronous command

POWer<m>:EFFiciency:RESult:INPut:POWer:PPEak?
POWer<m>:EFFiciency:RESult:TOTal:EFFiciency:PPEak?
POWer<m>:EFFiciency:RESult:TOTal:OPOWer:PPEak?

Return the npositive peak value (maximum) for input power, total efficiency and total output power if statistics are enabled.

Suffix:

<m> 1...3, index of the power analysis measurement

Return values:

<MaxPeak> Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0

Usage: Query only
Asynchronous command

POWer<m>:EFFiciency:RESult:INPut:POWer:RMS?
POWer<m>:EFFiciency:RESult:TOTal:EFFiciency:RMS?
POWer<m>:EFFiciency:RESult:TOTal:OPOWer:RMS?

Return the RMS value for input power, total efficiency and total output power if statistics are enabled.

Suffix:

<m> 1...3, index of the power analysis measurement

Return values:

<RMS> Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0

Usage: Query only
Asynchronous command

POWer<m>:EFFiciency:RESult:INPut:POWer:STDDev?
POWer<m>:EFFiciency:RESult:TOTal:EFFiciency:STDDev?
POWer<m>:EFFiciency:RESult:TOTal:OPOWer:STDDev?

Return the standard deviation for input power, total efficiency and total output power if statistics are enabled.

Suffix:
<m> 1...3, index of the power analysis measurement

Return values:
<StdDev> Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0

Usage: Query only
Asynchronous command

POWer<m>:EFFiciency:RESult:INPut:POWer:WFMCount?
POWer<m>:EFFiciency:RESult:TOTal:EFFiciency:WFMCount?
POWer<m>:EFFiciency:RESult:TOTal:OPOWer:WFMCount?

Return the number of calculated waveforms for input power, total efficiency and total output power if statistics are enabled.

Suffix:
<m> 1...3, index of the power analysis measurement

Return values:
<WaveformsCount> Range: 0 to 4000000000
Increment: 1
*RST: 0

Usage: Query only
Asynchronous command

18.16.3.7 Safe operating area (SOA)

SOA setup

POWer<m>:SOA:MTESt<n>:IMEXport:NAME <Name>

Sets the path, the filename and the file format of the mask file.

Suffix:
<m> 1...3, index of the power analysis measurement

<n> Irrelevant, omit the suffix.

Parameters:
<Name> String with path and file name with extension `.xml`.

Usage: Asynchronous command

Manual operation: See "Save mask" on page 383

POWer<m>:SOA:MTESt<n>:IMEXport:OPEN

Opens and loads the mask selected by `POWer<m>:SOA:MTESt<n>:IMEXport:NAME`
.

Suffix:

<m>	1...3, index of the power analysis measurement
<n>	Irrelevant, omit the suffix.

Usage: Event
Asynchronous command

Manual operation: See "Open" on page 383

POWer<m>:SOA:MTESt<n>:IMEXport:SAVE

Saves the mask test to the file selected by `POWer<m>:SOA:MTESt<n>:IMEXport:NAME`.

Suffix:

<m>	1...3, index of the power analysis measurement
<n>	Irrelevant, omit the suffix.

Usage: Event
Asynchronous command

Manual operation: See "Save mask" on page 383

POWer<m>:SOA:SOURce:CURRent <SourceCurrent>

Selects the current source waveform. Analog channels and math waveforms can be used.

Suffix:

<m>	1...3, index of the power analysis measurement

Parameters:

<SourceCurrent>	C1 | C2 | C3 | C4 | M1 | M2 | M3 | M4 | M5

Usage: Asynchronous command

Manual operation: See "Current" on page 382

POWer<m>:SOA:SOURce:VOLTage <SourceVoltage>

Selects the voltage source waveform. Analog channels and math waveforms can be used.

Suffix:

<m>	1...3, index of the power analysis measurement

Parameters:

<SourceVoltage>	C1 | C2 | C3 | C4 | M1 | M2 | M3 | M4 | M5

Usage: Asynchronous command

Manual operation: See "Voltage" on page 382

SOA mask

POWer<m>:SOA:LIMit:APPLy

Generates a mask using the given maximum values. The result is mask segment in the first quadrant of the XY-diagram.

Suffix:
<m> 1...3, index of the power analysis measurement

Usage: Setting only
Asynchronous command

Manual operation: See "Generate mask" on page 385

POWer<m>:SOA:LIMit:IMAX <CurrentMax>

Sets the maximum current for the mask.

Suffix:
<m> 1...3, index of the power analysis measurement

Parameters:
<CurrentMax> Range: 0 to 1E+26
Increment: 0.001
*RST: 1
Default unit: A

Usage: Asynchronous command

Manual operation: See "I max" on page 385

POWer<m>:SOA:LIMit:PMAX <PowerMax>

Sets the maximum power for the mask.

Suffix:
<m> 1...3, index of the power analysis measurement

Parameters:
<PowerMax> Range: 0 to 1E+26
Increment: 0.001
*RST: 50
Default unit: W

Usage: Asynchronous command

Manual operation: See "P max" on page 385

POWer<m>:SOA:LIMit:VMAX <VoltageMax>

Sets the maximum voltage for the mask.

Suffix:
<m> 1...3, index of the power analysis measurement

Parameters:
<VoltageMax> Range: 0 to 1E+26
Increment: 0.001
*RST: 100
Default unit: V

Usage: Asynchronous command

Manual operation: See "U max" on page 385

POWer<m>:SOA:MTESt<n>:SEGMent<o>:ADD

Adds a new segment to the SOA mask. Consider the order of the segments (1, 2, 3, 4) and use the next free segment index. If the specified segment index already exists, the given number is ignored and the new segment gets the next free index.

The new segment has no points. Use `POWer<m>:SOA:MTESt<n>:SEGMent<o>:POINt<p>:ADD` to add the points.

Suffix:
<m> 1...3, index of the power analysis measurement

<n> Irrelevant, omit the suffix.

<o> 1...4, index of the segment.

Usage: Setting only
Asynchronous command

Manual operation: See "Add segment" on page 384

POWer<m>:SOA:MTESt<n>:SEGMent<o>:COUNt?

Returns the number of segments that belong to the SOA mask.

Suffix:

<m>	1...3, index of the power analysis measurement
<n>	Irrelevant, omit the suffix.
<o>	Irrelevant, omit the suffix.

Return values:

<Count> Number of the mask segments

Range: 0 to 1
Increment: 1
*RST: 0

Usage: Query only
Asynchronous command

Manual operation: See "Add segment" on page 384

POWer<m>:SOA:MTESt<n>:SEGMent<o>:POINt<p>:ADD

Adds a corner point to the selected mask segment at the next free suffix. The new point has the coordinates 0;0.

Suffix:

<m>	1...3, index of the power analysis measurement
<n>	Irrelevant, omit the suffix.
<o>	1...4, index of the segment.
<p>	Index is ignored.

Usage: Setting only
Asynchronous command

Manual operation: See "Add segment" on page 384

POWer<m>:SOA:MTESt<n>:SEGMent<o>:POINt<p>:COUNt? [MAX]

Returns the number of points that was added to the indicated mask segment.

You can query the maximum value with `<command>? MAX`.

Suffix:

<m>	1..*
<n>	*
<o>	*
<p>	*

Return values:

<Count> Number of defined points

Usage: Query only
Asynchronous command

Manual operation: See "Add segment" on page 384

POWer<m>:SOA:MTESt<n>:SEGMent<o>:POINt<p>:REMove

Deletes the specified corner point of the mask segment. When a point is deleted, the remaining points are reordered similar to segment deletion (`POWer<m>:SOA:MTESt<n>:SEGMent<o>:REMove`).

Suffix:

<m> 1...3, index of the power analysis measurement

<n> Irrelevant, omit the suffix.

<o> 1...4, index of the segment.

<p> 1...9, point index

Usage: Setting only
Asynchronous command

Manual operation: See "Add segment" on page 384

POWer<m>:SOA:MTESt<n>:SEGMent<o>:POINt<p>:VALid?

Checks the validity of the selected point.

Suffix:

<m> 1...3, index of the power analysis measurement

<n> Irrelevant, omit the suffix.

<o> 1...4, index of the segment.

<p> 1...9, point index

Return values:

<Valid> OFF | ON

ON = valid
OFF = invalid

*RST: ON

Usage: Query only
Asynchronous command

Manual operation: See "Add segment" on page 384

POWer<m>:SOA:MTESt<n>:SEGMent<o>:POINt<p>:X <X>

Sets the horizontal position of the selected point.

Suffix:

<m> 1...3, index of the power analysis measurement

<n> Irrelevant, omit the suffix.

<o> 1...4, index of the segment.

<p> 1...4, index of the segment.

Parameters:

<X> Range: -1E+26 to 1E+26
Increment: 1E-06
*RST: 0
Default unit: s

Usage: Asynchronous command

Manual operation: See "Point, X, Y" on page 319

POWer<m>:SOA:MTESt<n>:SEGMent<o>:POINt<p>:Y <Y>

Sets the vertical position of the selected point.

Suffix:

<m> 1...3, index of the power analysis measurement

<n> Irrelevant, omit the suffix.

<o> 1...4, index of the segment.

<p> 1...4, index of the segment.

Parameters:

<Y> Range: -1E+26 to 1E+26
Increment: 1E-06
*RST: 0
Default unit: V

Usage: Asynchronous command

Manual operation: See "Point, X, Y" on page 319

POWer<m>:SOA:MTESt<n>:SEGMent<o>:REMove

Deletes the specified mask segment. When a segment is deleted, the remaining segments are reordered. For example, there are 3 segments (1, 2, 3). When you delete segment 2, then segment 3 gets the index 2.

Suffix:

<m> 1...3, index of the power analysis measurement

<n> Irrelevant, omit the suffix.

<o> 1...4, index of the segment.

Usage: Setting only
Asynchronous command

Manual operation: See "Add segment" on page 384

SOA actions

POWer<m>:SOA:MTESt<n>:ONViolation:BEEP <Beep>

Generates a beep sound if the command is set to `SUCCess` or `VIOLation`.

Suffix:

<m> 1...3, index of the power analysis measurement

<n> Irrelevant, omit the suffix.

Parameters:

<Beep> NOACtion | SUCCess | VIOLation

*RST: NOACtion

Usage: Asynchronous command

Manual operation: See "Beep" on page 320

POWer<m>:SOA:MTESt<n>:ONViolation:SCReenshot <SaveScreenshot>

Saves the waveform data to file if the command is set to `SUCCess` or `VIOLation`.

To configure the screenshot settings, use the commands described in Section 18.12.9, "Screenshots", on page 1000.

Suffix:

<m> 1...3, index of the power analysis measurement

<n> Irrelevant, omit the suffix.

Parameters:

<SaveScreenshot> NOACtion | SUCCess | VIOLation

*RST: NOACtion

Usage: Asynchronous command

Manual operation: See "Screenshot" on page 321

POWer<m>:SOA:MTESt<n>:ONViolation:STOP <StopAcq>

Stops the running acquisition if the command is set to `SUCCess` or `VIOLation`.

Suffix:

<m> 1...3, index of the power analysis measurement

<n> Irrelevant, omit the suffix.

Parameters:

<StopAcq> NOACtion | SUCCess | VIOLation

*RST: NOACtion

Usage: Asynchronous command

Manual operation: See "Stop acq" on page 321

POWer<m>:SOA:MTESt<n>:ONViolation:TRIGgerout <TrigOutPls>

Sends an outgoing pulse to the [Trigger Out] connector if the command is set to `SUCCess` or `VIOLation`.

To configure the pulse, user the following commands:

- `TRIGger:ACTions:OUT:SOURce` on page 926
- `TRIGger:ACTions:OUT:POLarity` on page 927
- `TRIGger:ACTions:OUT:DELay` on page 926
- `TRIGger:ACTions:OUT:PLENgth` on page 927

Suffix:

<m> 1...3, index of the power analysis measurement

<n> Irrelevant, omit the suffix.

Parameters:

<TrigOutPls> NOACtion | SUCCess | VIOLation

*RST: NOACtion

Usage: Asynchronous command

Manual operation: See "Trigger out pulse" on page 321

POWer<m>:SOA:MTESt<n>:ONViolation:WFMSave <SaveWfm>

Saves the waveform data to file if the command is set to `SUCCess` or `VIOLation`.

To define the path and file names, use the EXPort:WAVeform:AUTonaming:* commands:

- `EXPort:WAVeform:AUTonaming:NAME` on page 991
- `EXPort:WAVeform:AUTonaming:PATH` on page 992
- `EXPort:WAVeform:AUTonaming:TYPE` on page 992

Suffix:

<m> 1...3, index of the power analysis measurement

<n> Irrelevant, omit the suffix.

Parameters:

<SaveWfm> NOACtion | SUCCess | VIOLation

*RST: NOACtion

Usage: Asynchronous command

Manual operation: See "Save wfm" on page 321

SOA results

POWer<m>:SOA:RESult<n>:COUNt:FWAVeforms?

Returns the number of acquisitions that have failed the mask test, they hit the mask limits.

Suffix:

<m> 1...3, index of the power analysis measurement

<n> Irrelevant, omit the suffix.

Return values:

<AcqsFailed> Range: 0 to 10000000000000
Increment: 1
*RST: 0

Usage: Query only
Asynchronous command

POWer<m>:SOA:RESult<n>:COUNt:PWAVeforms?

Returns the number of acquisitions that have passed the mask test without violation.

Suffix:

<m> 1...3, index of the power analysis measurement

<n> Irrelevant, omit the suffix.

Return values:

<AcqsPassed> Range: 0 to 10000000000000
Increment: 1
*RST: 0

Usage: Query only
Asynchronous command

POWer<m>:SOA:RESult<n>:COUNt:WAVeforms?

Returns the number of tested acquisitions (waveforms).

Suffix:

<m> 1...3, index of the power analysis measurement

<n> Irrelevant, omit the suffix.

Return values:

<AcqsCompleted>	Range:	0 to 10000000000000
	Increment:	1
	*RST:	0

Usage: Query only
Asynchronous command

POWer<m>:SOA:RESult<n>:FRATe?

Returns the ratio of failed acquisitions to the number of tested acquisitions.

Suffix:

<m> 1...3, index of the power analysis measurement

<n> Irrelevant, omit the suffix.

Return values:

<FailRate> *RST: 0
Default unit: %

Usage: Query only
Asynchronous command

POWer<m>:SOA:RESult<n>[:RESult]?

Returns the summary test status.

Suffix:

<m> 1...3, index of the power analysis measurement

<n> Irrelevant, omit the suffix.

Return values:

<TestResult> PASS | FAIL
*RST: PASS

Usage: Query only
Asynchronous command

18.16.3.8 Power waveform

POWer<m>:EFFiciency:DISPlay:WAVeform:INPut<n>:POWer[:ENABle] <State>
POWer<m>:EFFiciency:DISPlay:WAVeform:TOTal<n>:OPOWer[:ENABle] <State>

Displays or hides the specified power waveform.

Suffix:

<m>	1...3, index of the power analysis measurement
<n>	Irrelevant, omit the suffix.

Parameters:

<State> OFF | ON

*RST: OFF

Usage: Asynchronous command

Manual operation: See "Display" on page 390

POWer<m>:EFFiciency:DISPlay:WAVeform:OUTPut<n>:POWer[:ENABle] <State>

Displays or hides the specified output power waveform.

Suffix:

<m>	1...3, index of the power analysis measurement
<n>	1..3, output index Suffix >1 requires an instrument with more than 4 channels.

Parameters:

<State> OFF | ON

*RST: OFF

Usage: Asynchronous command

Manual operation: See "Display" on page 390

POWer<m>:HARMonics:DISPlay:POWer:WAVeform:ENABle <State>
POWer<m>:QUALity:DISPlay:POWer:WAVeform:ENABle <State>
POWer<m>:SWITching:DISPlay:POWer:WAVeform[:ENABle] <State>

Displays or hides the specified power waveform.

Suffix:

<m> 1...3, index of the power analysis measurement

Parameters:

<State> OFF | ON

Usage: Asynchronous command

Manual operation: See "Display" on page 390

18.16.3.9 Reference level

POWer<m>:HARMonics:REFLevel<rl>:ABSolute:HYSTeresis <HystAbs>
POWer<m>:QUALity:REFLevel<rl>:ABSolute:HYSTeresis <HystAbs>

Defines a hysteresis for the middle reference level. A rise or fall from the middle reference value that does not exceed the hysteresis is rejected as noise.

Suffix:

<m>	1...3, index of the power analysis measurement
<rl>	1...4, index of the reference level set

Parameters:

<HystAbs>
Range: 0 to 1E+26
Increment: 0.001
*RST: 0.005
Default unit: V

Usage: Asynchronous command

Manual operation: See "Hysteresis" on page 388

POWer<m>:HARMonics:REFLevel<rl>:ABSolute:LLEVel <LowerLevel>
POWer<m>:QUALity:REFLevel<rl>:ABSolute:LLEVel <LowerLevel>

Sets the lower reference level in absolute values. This is required, e.g., to determine a fall.

Suffix:

<m>	1...3, index of the power analysis measurement
<rl>	1...4, index of the reference level set

Parameters:

<LowerLevel>
Range: -1E+26 to 1E+26
Increment: 0.001
*RST: 0
Default unit: V

Usage: Asynchronous command

Manual operation: See "Upper level, Middle level, Lower level" on page 388

POWer<m>:HARMonics:REFLevel<rl>:ABSolute:MLEVel <MiddleLevel>
POWer<m>:QUALity:REFLevel<rl>:ABSolute:MLEVel <MiddleLevel>

Sets the middle reference level in absolute values.

Suffix:

<m> 1...3, index of the power analysis measurement

<rl> 1...4, index of the reference level set

Parameters:

<MiddleLevel> Range: -1E+26 to 1E+26
Increment: 0.001
*RST: 0
Default unit: V

Usage: Asynchronous command

Manual operation: See "Upper level, Middle level, Lower level" on page 388

POWer<m>:HARMonics:REFLevel<rl>:ABSolute:ULEVel <UpperLevel>
POWer<m>:QUALity:REFLevel<rl>:ABSolute:ULEVel <UpperLevel>

Sets the upper reference level in absolute values. This is required to determine a rise.

Suffix:

<m> 1...3, index of the power analysis measurement

<rl> 1...4, index of the reference level set

Parameters:

<UpperLevel> Range: -1E+26 to 1E+26
Increment: 0.001
*RST: 0
Default unit: V

Usage: Asynchronous command

Manual operation: See "Upper level, Middle level, Lower level" on page 388

POWer<m>:HARMonics:REFLevel<rl>:LMODe <LevelMode>
POWer<m>:QUALity:REFLevel<rl>:LMODe <LevelMode>

Defines if the reference level is set in absolute or relative values.

Suffix:

<m> 1...3, index of the power analysis measurement

<rl> 1...4, index of the reference level set

Parameters:

<LevelMode> ABS | REL
*RST: REL

Usage: Asynchronous command

Manual operation: See "Level mode" on page 387

POWer<m>:HARMonics:REFLevel<rl>:RELative:HYSTeresis <HystRel>
POWer<m>:QUALity:REFLevel<rl>:RELative:HYSTeresis <HystRel>

Defines a hysteresis for the middle reference level. A rise or fall from the middle reference value that does not exceed the hysteresis is rejected as noise.

Suffix:

<m> 1...3, index of the power analysis measurement

<rl> 1...4, index of the reference level set

Parameters:

<HystRel> Range: 0 to 50
Increment: 1
*RST: 10
Default unit: %

Usage: Asynchronous command

Manual operation: See "Hysteresis" on page 388

POWer<m>:HARMonics:REFLevel<rl>:RELative:LOWer <LowRefLevRel>
POWer<m>:QUALity:REFLevel<rl>:RELative:LOWer <LowRefLevRel>

Sets the lower relative reference level if `POWer<m>:QUALity:REFLevel<rl>:RELative:MODE` is set to `USER`.

Suffix:

<m> 1...3, index of the power analysis measurement

<rl> 1...4, index of the reference level set

Parameters:

<LowRefLevRel> Range: -100 to 200
Increment: 1
*RST: 10
Default unit: %

Usage: Asynchronous command

Manual operation: See "Upper level, Middle level,Lower level" on page 388

POWer<m>:HARMonics:REFLevel<rl>:RELative:MIDDle <MidRefLevRel>
POWer<m>:QUALity:REFLevel<rl>:RELative:MIDDle <MidRefLevRel>

Sets the middle relative reference level if `POWer<m>:QUALity:REFLevel<rl>:RELative:MODE` is set to `USER`.

Suffix:

<m> 1...3, index of the power analysis measurement

<rl> 1...4, index of the reference level set

Parameters:

<MidRefLevRel> Range: -100 to 200
Increment: 1
*RST: 50
Default unit: %

Usage: Asynchronous command

Manual operation: See "Upper level, Middle level,Lower level" on page 388

POWer<m>:HARMonics:REFLevel<rl>:RELative:MODE <RelativeLevels>
POWer<m>:QUALity:REFLevel<rl>:RELative:MODE <RelativeLevels>

The lower, middle and upper reference levels, defined as percentages of the high signal level.

Suffix:

<m> 1...3, index of the power analysis measurement

<rl> 1...4, index of the reference level set

Parameters:

<RelativeLevels> FIVE | TEN | TWENty | USER

FIVE
5/50/95

TEN
10/50/90

TWENty
20/50/80

USER
Set the reference levels to individual values with `POWer<m>:QUALity:REFLevel<rl>:RELative:LOWer`, `POWer<m>:QUALity:REFLevel<rl>:RELative:MIDDle`, and `POWer<m>:QUALity:REFLevel<rl>:RELative:UPPer`.

*RST: TEN

Usage: Asynchronous command

Manual operation: See "Relative levels" on page 388

POWer<m>:HARMonics:REFLevel<rl>:RELative:UPPer <UppRefLevRel>
POWer<m>:QUALity:REFLevel<rl>:RELative:UPPer <UppRefLevRel>

Sets the upper relative reference level if `POWer<m>:QUALity:REFLevel<rl>:RELative:MODE` on page 1145 is set to `USER`.

Suffix:

<m> 1...3, index of the power analysis measurement

<rl> 1...4, index of the reference level set

Parameters:

<UppRefLevRel>	Range: -100 to 200 Increment: 1 *RST: 90 Default unit: %

Usage: Asynchronous command

Manual operation: See "Upper level, Middle level,Lower level" on page 388

18.16.3.10 Power analysis data

This section describes the commands for exporting power analysis measurement data.

POWer<m>:EFFiciency:INPut<n>:POWer:DATA:HEADer?
POWer<m>:EFFiciency:OUTPut<n>:POWer:DATA:HEADer?
POWer<m>:EFFiciency:TOTal<n>:OPOWer:DATA:HEADer?
POWer<m>:HARMonics:POWer:DATA:HEADer?
POWer<m>:QUALity:POWer:DATA:HEADer?
POWer<m>:SWITching:POWer:DATA:HEADer?

Returns the header of the power analysis waveform data. The header contains the attributes of the waveform.

For power harmonics measurements, data is only available if `POWer<m>:HARMonics:STANdard` is set to `ENC` or `END`.

Suffix:

<m>	1...3, index of the power analysis measurement

Return values:

<XStart>	1. header value: start time in s
<XStop>	2. header value: end time in s
<RecordLength>	3. header value: record length of the waveform in samples
<ValuesPerSample>	4. header value: number of values per sample. For power quality measurements, the value is 1.

Usage: Query only
Asynchronous command

POWer<m>:EFFiciency:INPut<n>:POWer:DATA[:VALues]? [<Offset>[,<Length>]]
POWer<m>:EFFiciency:OUTPut<n>:POWer:DATA[:VALues]? [<Offset>[,<Length>]]
POWer<m>:EFFiciency:TOTal<n>:OPOWer:DATA[:VALues]? [<Offset>[,<Length>]]
POWer<m>:HARMonics:POWer:DATA[:VALues]? [<Offset>[,<Length>]]
POWer<m>:QUALity:POWer:DATA[:VALues]? [<Offset>[,<Length>]]
POWer<m>:SWITching:POWer:DATA[:VALues]? [<Offset>[,<Length>]]

Returns the data of the power analysis waveform points for transmission from the instrument to the controlling computer.

Without parameters, the complete waveform is retrieved. Using the offset and length parameters, data can be retrieved in smaller portions, which makes the command faster. If you send only one parameter, it is interpreted as offset, and the data is retrieved from offset to the end of the waveform.

To set the export format, use `FORMat[:DATA]`.

Suffix:
<m> 1...3, index of the power analysis measurement

Query parameters:
<Offset> Number of offset waveform points to be skipped.

<Length> Number of waveform points to be retrieved.

Return values:
<Data> List of values according to the format and content settings.

Usage: Query only
Asynchronous command

18.16.4 Digital voltmeter

This section describes the commands for setting up and querying the results of the digital voltmeter.

METer:BANDwidth <Bandwidth>

Sets the filter bandwidth.

Parameters:

<Bandwidth> B20M | B10M | B5M | B2M | B1M | B500 | B200

`B20M`: 20 MHz
`B10M`: 10 MHz
`B5M`: 5 MHz
`B2M`: 2 MHz
`B1M`: 1 MHz
`B500`: 500 kHz
`B200`: 200 kHz

*RST: B20M

Usage: Asynchronous command

Manual operation: See "Filter bandwidth" on page 392

METer:DVMeter<m>:ENABle?

Queries the state of the voltmeter for the respective channel.

Suffix:

<m> 1 to 4, index of the analog channel

Return values:

<State> OFF | ON

*RST: OFF

Usage: Query only
Asynchronous command

METer:DVMeter<m>:ACRMs:ENABle <ACRMSResults_St>

Enables the AC RMS voltmeter measurement for the respective channel.

Suffix:

<m> 1 to 4, index of the analog channel

Parameters:

<ACRMSResults_St> OFF | ON

*RST: OFF

Usage: Asynchronous command

Manual operation: See "Measurements" on page 392

METer:DVMeter<m>:ACRMs:RESult?

Returns the result of the AC RMS voltmeter measurement.

Suffix:

<m> 1 to 4, index of the analog channel

Return values:

<Results_ACRMS> Range: -1E+26 to 1E+26
Increment: 0.1
*RST: 0
Default unit: V

Usage: Query only
Asynchronous command

Manual operation: See "Measurements" on page 392

METer:DVMeter<m>:DC:ENABle <DCResults_St>

Enables the DC voltmeter measurement for the respective channel.

Suffix:

<m> 1 to 4, index of the analog channel

Parameters:

<DCResults_St> OFF | ON
*RST: OFF

Usage: Asynchronous command

Manual operation: See "Measurements" on page 392

METer:DVMeter<m>:DC:RESult?

Returns the result of the DC voltmeter measurement.

Suffix:

<m> 1 to 4, index of the analog channel

Return values:

<Results_DC> Range: -1E+26 to 1E+26
Increment: 0.1
*RST: 0
Default unit: V

Usage: Query only
Asynchronous command

Manual operation: See "Measurements" on page 392

METer:DVMeter<m>:DCRMs:ENABle <DCRMSResults_St>

Enables the DC RMS voltmeter measurement for the respective channel.

Suffix:

<m> 1 to 4, index of the analog channel

Parameters:
<DCRMSResults_St> OFF | ON

*RST: OFF

Usage: Asynchronous command

Manual operation: See "Measurements" on page 392

METer:DVMeter<m>:DCRMs:RESult?

Returns the result of the DC RMS voltmeter measurement.

Suffix:
<m> 1 to 4, index of the analog channel

Return values:
<Results_DCRMS> Range: -1E+26 to 1E+26
Increment: 0.1
*RST: 0
Default unit: V

Usage: Query only
Asynchronous command

Manual operation: See "Measurements" on page 392

METer:MTIMe <MeasTime>

Sets the measurement time. The time begins in the moment that a measurement is enabled.

Parameters:
<MeasTime> Range: 0.05 to 1
Increment: 0.05
*RST: 0.5
Default unit: s

Usage: Asynchronous command

Manual operation: See "Measurement time" on page 392

18.16.5 XY-plot

XY<m>:SWAP

Replaces the source of the x-axis with the source of the y-axis and vice versa.

Suffix:
<m> 1 to 4, index of the XY-plot

Usage: Setting only
Asynchronous command

Manual operation: See "Swap XY" on page 394

XY<m>[:STATe] <State>

Activates an XY-waveform.

Suffix:
<m> 1 to 4, index of the XY-plot

Parameters:
<State> OFF | ON
*RST: OFF

Usage: Asynchronous command

Manual operation: See "Display" on page 393

XY<m>:YSOurce <YSource>

Defines the signal source that supplies the y-values of the XY-diagram.

Suffix:
<m> 1 to 4, index of the XY-plot

Parameters:
<YSource> NONE | C1 | C2 | C3 | C4 | M1 | M2 | M3 | M4 | M5 | R1 | R2 | R3 | R4 | TRK1 | TRK2 | TRK3 | ... | TRK16 | O<n>C1 | O<n>C2 | ... | O<n>C8 (<n> = 2 to 8)

Usage: Asynchronous command

Manual operation: See "X-source, Y-source" on page 394

XY<m>:XSOurce <XSource>

Defines the signal source that supplies the x-values of the XY-diagram.

Suffix:
<m> 1 to 4, index of the XY-plot

Parameters:
<XSource> NONE | C1 | C2 | C3 | C4 | M1 | M2 | M3 | M4 | M5 | R1 | R2 | R3 | R4 | TRK1 | TRK2 | TRK3 | ... | TRK16 | O<n>C1 | O<n>C2 | ... | O<n>C8 (<n> = 2 to 8)

Usage: Asynchronous command

Manual operation: See "X-source, Y-source" on page 394

18.17 Protocols

18.17.1 Configuration settings for all serial protocols

18.17.1.1 General settings

SBUS<sb>[:STATe] <ProtocolState>

Enables the decoding of the specified bus.

Suffix:

<sb> 1...4, index of the serial bus

Parameters:

<ProtocolState> OFF | ON

Usage: Asynchronous command

Manual operation: See "State" on page 433

SBUS<sb>:TYPE <Protocol Type>

Selects the bus type for analysis. The type of buses available depends on the installed options.

Suffix:

<sb> 1...4, index of the serial bus

Parameters:

<Protocol Type> SPI | I2C | UART | NRZC | NRZU | MANC | CAN | LIN | SENT | ARIN429 | ARINc429 | MILS1553 | MILStd | SWIR | SWIRe | SPMI | RFFE | TNOS | QSPI | I3C

SPI: SPI protocol, see Section 18.17.2, "SPI (option R&S MXO4-K510)", on page 1157.
QSPI: Quad SPI protocol, see Section 18.17.3, "QUAD-SPI (option R&S MXO4-K510)", on page 1182.
I2C: I²C protocol, see Section 18.17.4, "I²C (option R&S MXO4-K510)", on page 1213.
I3C: I3C protocol, see Section 18.17.5, "I3C (option R&S MXO4-K550)", on page 1240.
UART: UART protocol, see Section 18.17.6, "UART / RS-232 (option R&S MXO4- K510)", on page 1264.
NRZC: NRZ clocked protocol, see Section 18.17.7, "NRZ Clocked (option R&S MXO4-K510)", on page 1285.
NRZU: NRZ unclocked protocol, see Section 18.17.8, "NRZ Unclocked (option R&S MXO4-K510)", on page 1313.
MANC: Manchester protocol, see Section 18.17.9, "Manchester (option R&S MXO4-K510)", on page 1340
CAN: CAN protocol, see Section 18.17.10, "CAN (option R&S MXO4-K520)", on page 1368.
LIN: LIN protocol, see Section 18.17.11, "LIN (option R&S MXO4-K520)", on page 1407.
SENT: SENT protocol, see Section 18.17.12, "SENT (option R&S MXO4-K520)", on page 1431.
ARIN429 | ARINc429: ARINC 429 protocol, see Section 18.17.13, "ARINC 429 (option R&S MXO4-K530)", on page 1457.
MILS1553 | MILStd: MIL-1553 protocol, see Section 18.17.15, "MIL-1553 (option R&S MXO4-K530)", on page 1493.
SWIR | SWIRe: SpaceWire protocol, see Section 18.17.14, "SpaceWire (option R&S MXO4-K530)", on page 1475.
SPMI: SPMI protocol, see Section 18.17.16, "SPMI (option R&S MXO4-K550)", on page 1511.
RFFE: RFFE protocol, see Section 18.17.17, "RFFE (option R&S MXO4-K550)", on page 1533.
TNOS: Ethernet 10BASE-T1S protocol, see Section 18.17.18, "10BASE-T1S (option R&S MXO4-K560)", on page 1556.

Usage: Asynchronous command

Manual operation: See "Protocol type" on page 433

SBUS<sb>:FORMat <DataFormat>

Sets the number format for decoded data values of the indicated serial bus. It defines the format in the decode table, and in the combs of the decoded signal on the screen.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<DataFormat> HEX | OCT | BIN | ASCII | ASCii | SIGN | USIG

HEX
Hexadecimal

OCT
Octal

BIN
Binary

ASCII = ASCii
American standard code for information interchange

SIGN
Signed, e.g. 8 bits signed ranges from -128 to +127 decimal

USIG
Unsigned, e.g. 8 bits unsigned ranges from 0 to 255 decimal

*RST: HEX

Usage: Asynchronous command

Manual operation: See "Data format" on page 436

SBUS<sb>:RESult <ShwResTbl>

Enables a table with decoded data of the serial signal. The function requires the option for the analyzed protocol.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<ShwResTbl> OFF | ON

*RST: OFF

Usage: Asynchronous command

Manual operation: See "Show decode table" on page 436

SBUS<sb>:RMSBus

Deletes the specified serial bus.

Suffix:
<sb> 1...4, index of the serial bus

Usage: Setting only
Asynchronous command

Manual operation: See "Add serial bus, Delete serial bus" on page 433

SBUS<sb>:THReshold <ShwThresLines>

If enabled, the threshold lines are displayed in the diagram.

The label of the threshold line is set according to the signal that it is referring to, see also Show threshold lines.

Suffix:
<sb> 1..4

Parameters:
<ShwThresLines> OFF | ON
*RST: OFF

Usage: Asynchronous command

Manual operation: See "Show threshold lines" on page 434

SBUS<sb>:ZCOupling <ZoomCoupling>

If enabled, the protocol decode zoom and result table are synchronized.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<ZoomCoupling> OFF | ON
*RST: ON

Usage: Asynchronous command

Manual operation: See "Zoom coupling" on page 437

18.17.1.2 Export results settings

SBUS<sb>:EXPResult:DETail <IncludeDetails>

If enabled, includes the detailed results for all frames in the export result file.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<IncludeDetails> OFF | ON
*RST: ON

Usage: Asynchronous command

Manual operation: See "Include details" on page 445

SBUS<sb>:EXPResult:SAVE <FileName>

Saves the selected results to the indicated file.

Suffix:
<sb> 1...4, index of the serial bus

Setting parameters:
<FileName>

Example:
```
SBUS1:EXPResult:SAVE
'/home/storage/userData/export_10base-t1s.csv'
```

Usage: Setting only
Asynchronous command

Manual operation: See "Save as" on page 445

SBUS<sb>:EXPResult:TIME <IncludeTiming>

If enabled, includes the frame timing in the export result file.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<IncludeTiming> OFF | ON
*RST: ON

Usage: Asynchronous command

Manual operation: See "Include timing" on page 445

SBUS<sb>:EXPResult:EXTension <FileType>

Selects the file format.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<FileType> HTML | CSV | XML | PY
HTML
Hypertext markup language

CSV
Comma-separated values

XML
Extensible markup language

PY
Python

*RST: HTML

Usage: Asynchronous command

Manual operation: See "File type" on page 445

SBUS<sb>:EXPResult:PATH <Path>

Sets the path where the protocol export files are stored. On the instrument, the default path is `/home/storage/userData/Protocol`. You can create subfolders in this folder.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<Path> String parameter

Usage: Asynchronous command

Manual operation: See "Save as" on page 445

18.17.2 SPI (option R&S MXO4-K510)

Before MXO 4 can accept the specific bus commands, make sure that:

- The decoding of the specified bus is enabled with `SBUS<sb>[:STATe]`.
- The bus is set to the correct type with `SBUS<sb>:TYPE`.

18.17.2.1 Configuration

SBUS<sb>:SPI:BORDer <BitOrder>

Selects the bit order, which determines if the data of the messages starts with MSB (most significant bit) or LSB (least significant bit).

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<BitOrder> LSBF | MSBF
*RST: MSBF

Usage: Asynchronous command

Manual operation: See "Bit order" on page 450

SBUS<sb>:SPI:CSELect:HYSTeresis <Hysteresis>

Sets a value for the hysteresis for the CS channel.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<Hysteresis>

Usage: Asynchronous command

Manual operation: See "Threshold" on page 451

SBUS<sb>:SPI:CSELect:POLarity <CSPolarity>

Selects if the transmitted signal for the respective line is active high (high = 1) or active low (low = 1).

Suffix:
<sb> 1...4, index of the serial bus

Parameters:

<CSPolarity> ACTLow | ACTHigh

*RST: ACTLow

Usage: Asynchronous command

Manual operation: See "Polarity: MOSI, MISO, CS" on page 450

SBUS<sb>:SPI:CSELect:SOURce CSSource

Sets the input channel of the CS line.

Suffix:

<sb> 1...4, index of the serial bus

Parameters:

CSSource C1 | C2 | C3 | C4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | M1 | M2 | M3 | M4 | M5 | R1 | R2 | R3 | R4 | O<n>C1 | O<n>C2 | ... | O<n>C8 (<n> = 2 to 8)

Usage: Asynchronous command

Manual operation: See "SCLK,MOSI,MISO,CS" on page 449

SBUS<sb>:SPI:CSELect:THReshold <Threshold>

Sets a user-defined threshold value for the line.

Suffix:

<sb> 1...4, index of the serial bus

Parameters:

<Threshold>

Usage: Asynchronous command

Manual operation: See "Threshold" on page 451

SBUS<sb>:SPI:MISO:HYSTeresis <Hysteresis>

Sets a value for the hysteresis for the MISO channel.

Suffix:

<sb> 1...4, index of the serial bus

Parameters:

<Hysteresis>

Usage: Asynchronous command

Manual operation: See "Threshold" on page 451

SBUS<sb>:SPI:MISO:POLarity <MISOPolarity>

Selects if the transmitted signal for the respective line is active high (high = 1) or active low (low = 1).

Suffix:

<sb>	1...4, index of the serial bus

Parameters:

<MISOPolarity>	ACTLow | ACTHigh *RST: ACTHigh

Usage: Asynchronous command

Manual operation: See "Polarity: MOSI, MISO, CS" on page 450

SBUS<sb>:SPI:MISO:SOURce <MISOSource>

Sets the input channel of the MISO line.

Suffix:

<sb>	1...4, index of the serial bus

Parameters:

<MISOSource>	C1 | C2 | C3 | C4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | M1 | M2 | M3 | M4 | M5 | R1 | R2 | R3 | R4 | O<n>C1 | O<n>C2 | ... | O<n>C8 (<n> = 2 to 8)

Usage: Asynchronous command

Manual operation: See "SCLK,MOSI,MISO,CS" on page 449

SBUS<sb>:SPI:MISO:THReshold <Threshold>

Sets a user-defined threshold value for the line.

Suffix:

<sb>	1...4, index of the serial bus

Parameters:

<Threshold>

Usage: Asynchronous command

Manual operation: See "Threshold" on page 451

SBUS<sb>:SPI:MOSI:HYSTeresis <Hysteresis>

Sets a value for the hysteresis for the MOSI channel.

Suffix:

<sb>	1...4, index of the serial bus

Parameters:
<Hysteresis>

Usage: Asynchronous command

Manual operation: See "Threshold" on page 451

SBUS<sb>:SPI:MOSI:POLarity <MOSIPolarity>

Selects if the transmitted signal for the respective line is active high (high = 1) or active low (low = 1).

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<MOSIPolarity> ACTLow | ACTHigh
*RST: ACTHigh

Usage: Asynchronous command

Manual operation: See "Polarity: MOSI, MISO, CS" on page 450

SBUS<sb>:SPI:MOSI:SOURce <MOSISource>

Sets the input channel of the MOSI line.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<MOSISource> C1 | C2 | C3 | C4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | M1 | M2 | M3 | M4 | M5 | R1 | R2 | R3 | R4 | O<n>C1 | O<n>C2 | ... | O<n>C8 (<n> = 2 to 8)

Usage: Asynchronous command

Manual operation: See "SCLK,MOSI,MISO,CS" on page 449

SBUS<sb>:SPI:MOSI:THReshold <Threshold>

Sets a user-defined threshold value for the line.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<Threshold>

Usage: Asynchronous command

Manual operation: See "Threshold" on page 451

SBUS<sb>:SPI:SCLK:HYSTeresis <Hysteresis>

Sets a value for the hysteresis for the SCLK channel.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<Hysteresis>

Usage: Asynchronous command

Manual operation: See "Threshold" on page 451

SBUS<sb>:SPI:SCLK:SOURce SCLKSource

Sets the input channel of the SCLK line.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
SCLKSource C1 | C2 | C3 | C4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | M1 | M2 | M3 | M4 | M5 | R1 | R2 | R3 | R4 | O<n>C1 | O<n>C2 | ... | O<n>C8 (<n> = 2 to 8)

Usage: Asynchronous command

Manual operation: See "SCLK,MOSI,MISO,CS" on page 449

SBUS<sb>:SPI:SCLK:THReshold <Threshold>

Sets a user-defined threshold value for the line.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<Threshold>

Usage: Asynchronous command

Manual operation: See "Threshold" on page 451

SBUS<sb>:SPI:TIMeout <ClockTimeout>

Sets the minimum clock idle time if a timeout on the clock line SCLK is used as limiter between two frames.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:

<ClockTimeout>	Range:	5E-08 to 10
	Increment:	1E-06
	*RST:	0.001
	Default unit:	s

Usage: Asynchronous command

Manual operation: See "Timeout" on page 450

SBUS<sb>:SPI:WSIZe <WordLength>

Sets the word length (or symbol size), which is the number of bits in a message. The maximum word length is 32 bit.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:

<WordLength>	Range:	4 to 32
	Increment:	1
	*RST:	8

Usage: Asynchronous command

Manual operation: See "Word length" on page 450

SBUS<sb>:SPI:MISO:POSition <SPI MISO position>

Sets the vertical position of the MISO signal.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<SPI MISO position>

Usage: Asynchronous command

SBUS<sb>:SPI:MISO:SCALe <SPI MISO scale>

Set the vertical scale of the MISO signal.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<SPI MISO scale>

Usage: Asynchronous command

SBUS<sb>:SPI:MOSI:POSition <SPI MISO position>

Sets the vertical position of the MOSI signal.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<SPI MISO position>

Usage: Asynchronous command

SBUS<sb>:SPI:MOSI:SCALe <SPI MOSI scale>

Set the vertical scale of the MOSI signal.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<SPI MOSI scale>

Usage: Asynchronous command

18.17.2.2 Filter

There are two commands for each parameter, that you can use for defining the SPI settings.

For example, to set the *Frame type =MISO > Field =MISO >01100* value you can use one of the following commands:

- `SBUS:SPI:FILTer:FRAMe1:FLD1:DMIN 01100`
  Defines the parameter by using the index <m> for the frame number and <n> for the field number.
- `SBUS:SPI:FILTer:DMIN "MISO", "MISO", 01100`
  Defines the parameter by using the frame and field name.

SBUS<sb>:SPI:FILTer:CHKall

Enables the filter for all available frames and error types.

Suffix:

<sb> 1...4, index of the serial bus

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 452

SBUS<sb>:SPI:FILTer:CLR

Disables the filter for all available frames and error types.

Suffix:

<sb> 1...4, index of the serial bus

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 452

SBUS<sb>:SPI:FILTer:INVert

Inverts the current state of the frame and error types: all frames and error types that were enabled are disabled and vice versa.

Suffix:

<sb> 1...4, index of the serial bus

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 452

SBUS<sb>:SPI:FILTer:RST

Presets the state of the selected frames and error types.

Suffix:

<sb> 1...4, index of the serial bus

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 452

SBUS<sb>:SPI:FILTer:BIT <Frame>,<Field>,<Bit>
SBUS<sb>:SPI:FILTer:BIT? <Bit>
SBUS<sb>:SPI:FILTer:FRAMe<fr>:FLD<fl>:BIT <BitState>

Sets the operator for the data pattern in the selected field of the selected frame.

Suffix:
<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Parameters:
<BitState> ONE | ZERO
*RST: ZERO

Usage: Asynchronous command

Manual operation: See "Edit" on page 453

SBUS<sb>:SPI:FILTer:DMAX <Frame>,<Field>,<Data>
SBUS<sb>:SPI:FILTer:DMAX? <Data>
SBUS<sb>:SPI:FILTer:FRAMe<fr>:FLD<fl>:DMAX <Data_Max>

Sets the end value of a data pattern range if the operator is set to `INRange` or `OORANGe`.

Suffix:
<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Parameters:
<Data_Max>

Usage: Asynchronous command

Manual operation: See "Edit" on page 453

SBUS<sb>:SPI:FILTer:DMIN <Frame>,<Field>,<Data>
SBUS<sb>:SPI:FILTer:DMIN? <Data>
SBUS<sb>:SPI:FILTer:FRAMe<fr>:FLD<fl>:DMIN <Data_Min>

Specifies the data pattern, or sets the start value of a data pattern range.

Suffix:
<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Parameters:
<Data_Min>

Usage: Asynchronous command

Manual operation: See "Edit" on page 453

SBUS<sb>:SPI:FILTer:DOPerator <Frame>,<Field>,<Operator>
SBUS<sb>:SPI:FILTer:DOPerator? <Operator>
SBUS<sb>:SPI:FILTer:FRAMe<fr>:FLD<fl>:DOPerator <Data_Operator>

Sets the operator for the data pattern in the selected field of the selected frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Parameters:

<Data_Operator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

*RST: EQUal

Usage: Asynchronous command

Manual operation: See "Edit" on page 453

SBUS<sb>:SPI:FILTer:ERENable <ErrorName>,<Enabler>
SBUS<sb>:SPI:FILTer:ERENable? <Enabler>
SBUS<sb>:SPI:FILTer:ERRor<n>:ENABle <Enable>

Defines the error type to be filtered on.

Suffix:

<sb> 1...4, index of the serial bus

<n> Index of the error

Parameters:

<Enable> OFF | ON

*RST: ON

Usage: Asynchronous command

Manual operation: See "Error type" on page 454

SBUS<sb>:SPI:FILTer:FIENable <Frame>,<Field>,<Enabler>
SBUS<sb>:SPI:FILTer:FIENable? <Enabler>
SBUS<sb>:SPI:FILTer:FRAMe<fr>:FLD<fl>:ENABle <CondEnabler>

Enables or disables the checking condition for the selected field of the selected frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Parameters:

<CondEnabler> OFF | ON

*RST: OFF

Usage: Asynchronous command

Manual operation: See "Edit" on page 453

SBUS<sb>:SPI:FILTer:FRENable <Frame>,<Enabler>
SBUS<sb>:SPI:FILTer:FRENable? <Enabler>
SBUS<sb>:SPI:FILTer:FRAMe<fr>:ENABle <Enable>

Enables or disables the checking condition for the selected frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

Parameters:

<Enable> OFF | ON

*RST: ON

Usage: Asynchronous command

Manual operation: See "Frame type" on page 453

SBUS<sb>:SPI:FILTer:IMAX <Frame>,<Field>,<Data>
SBUS<sb>:SPI:FILTer:IMAX? <Data>
SBUS<sb>:SPI:FILTer:FRAMe<fr>:FLD<fl>:IMAX <Index_Max>

Sets the end value of an index range if the operator is set to `INRange`.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Parameters:

<Index_Max> Range: 1 to 65535
Increment: 1
*RST: 65535

Usage: Asynchronous command

Manual operation: See "Edit" on page 453

SBUS<sb>:SPI:FILTer:IMIN <Frame>,<Field>,<Data>
SBUS<sb>:SPI:FILTer:IMIN? <Data>
SBUS<sb>:SPI:FILTer:FRAMe<fr>:FLD<fl>:IMIN <Index_Min>

Specifies the index, or sets the start value of an index range.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Index_Min>
Range: 1 to 65535
Increment: 1
*RST: 1

Usage: Asynchronous command

Manual operation: See "Edit" on page 453

SBUS<sb>:SPI:FILTer:IOPerator <Frame>,<Field>,<Operator>
SBUS<sb>:SPI:FILTer:IOPerator? <Operator>
SBUS<sb>:SPI:FILTer:FRAMe<fr>:FLD<fl>:IOPerator <Index_Operator>

Sets the operator for the index in the selected field of the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Index_Operator>
EQUal | INRange | RANGe
*RST: INRange

Usage: Asynchronous command

Manual operation: See "Edit" on page 453

18.17.2.3 Hardware trigger

Trigger commands for serial buses affect the current trigger source. Therefore, set the trigger source to the required serial bus with `TRIGger:EVENt<ev>:SOURce` before sending the bus-specific trigger commands.

TRIGger:SBHW:SPI:TYPE <Type>

Selects the trigger type for SPI analysis.

Parameters:

<Type> FRSTart | FRENd | MOSI | MISO

FRSTart
Triggers on the beginning of the frame.

FRENd
Triggers on the end of the frame.

MOSI
Triggers on a specified data pattern in that is expected on the MOSI line.

MISO
Triggers on a specified data pattern in that is expected on the MISO line.

*RST: FRSTart

Usage: Asynchronous command

Manual operation: See "Type" on page 455

TRIGger:SBHW:SPI:PALignment <DataAlignment>

Defines how the specified data pattern is searched.

Parameters:

<DataAlignment> WORD | BIT

WORD
The pattern is matched only at word boundaries.

BIT
Bit-by-bit: the pattern can start at any position in the message.

*RST: WORD

Usage: Asynchronous command

Manual operation: See "Search mode" on page 456

TRIGger:SBHW:SPI:FCONdition <DataOperator>

Selects the operator for the MISO and MOSI pattern.

Parameters:

<DataOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan

*RST: EQUal

Usage: Asynchronous command

Manual operation: See "Data" on page 456

TRIGger:SBHW:SPI:DPOSition <DataPosition>

Sets the number of bits or words to be ignored before the first bit or word of interest. The effect is defined by `TRIGger:SBHW:SPI:PALignment`.

Parameters:

<DataPosition>	Range:	1 to 4096
	Increment:	1
	*RST:	1

Usage: Asynchronous command

Manual operation: See "Position" on page 456

TRIGger:SBHW:SPI:DMINpattern <DataPattern>

Specifies a data bit pattern, or sets the start value of a pattern range.

Parameters:
<DataPattern>

Usage: Asynchronous command

Manual operation: See "Data" on page 456

18.17.2.4 Software trigger

There are two commands for each parameter, that you can use for defining the SPI settings.

For example, to set the *Frame type =MISO* > *Field =MISO >01100* value you can use one of the following commands:

- `TRIGger:SBSW:SPI:FRAMe1:FLD1:DMIN 01100`
  Defines the parameter by using the index <m> for the frame number and <n> for the field number.
- `TRIGger:SBSW:SPI:DMIN "MISO", "MISO", 01100`
  Defines the parameter by using the frame and field name.

TRIGger:SBSW:SPI:CHKall

Enables the software trigger for all available frames and error types.

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 457

TRIGger:SBSW:SPI:CLR

Disables the software trigger for all available frames and error types.

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 457

TRIGger:SBSW:SPI:INVert

Inverts the current state of the frame and error types for the software trigger: all frames and error types that were enabled are disabled and vice versa.

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 457

TRIGger:SBSW:SPI:RST

Presets the state of the selected frames and error types for the software trigger.

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 457

TRIGger:SBSW:SPI:FRENable <Frame>,<Enabler>
TRIGger:SBSW:SPI:FRENable? <Enabler>
TRIGger:SBSW:SPI:FRAMe<fr>:ENABle <Enable>

Enables or disables the checking condition for the selected frame for the software trigger.

Suffix:

<fr> Index of the frame

Parameters:

<Enable> OFF | ON

*RST: ON

Usage: Asynchronous command

Manual operation: See "Frame type" on page 458

TRIGger:SBSW:SPI:BIT <Frame>,<Field>,<Bit>
TRIGger:SBSW:SPI:BIT? <Bit>
TRIGger:SBSW:SPI:FRAMe<fr>:FLD<fl>:BIT <BitState>

Sets the bit state of a field that only consists of one bit for the software trigger.

Suffix:

<fr> Index of the frame

<fl> Index of the field

Parameters:

<BitState> ONE | ZERO

*RST: ZERO

Usage: Asynchronous command

Manual operation: See "Edit" on page 458

TRIGger:SBSW:SPI:DMAX <Frame>,<Field>,<Data>
TRIGger:SBSW:SPI:DMAX? <Data>
TRIGger:SBSW:SPI:FRAMe<fr>:FLD<fl>:DMAX <Data_Max>

Sets the end value of a data pattern range for the software trigger, if the operator is set to `INRange` or `OORANGe`.

You can set the operator with `TRIGger:SBSW:SPI:FRAMe<fr>:FLD<fl>:DOPerator`.

Suffix:

<fr> Index of the frame

<fl> Index of the field

Parameters:

<Data_Max>

Usage: Asynchronous command

Manual operation: See "Edit" on page 458

TRIGger:SBSW:SPI:DMIN <Frame>,<Field>,<Data>
TRIGger:SBSW:SPI:DMIN? <Data>
TRIGger:SBSW:SPI:FRAMe<fr>:FLD<fl>:DMIN <Data_Min>

Specifies the data pattern, or sets the start value of a data pattern range for the software trigger.

Suffix:

<fr> Index of the frame

<fl> Index of the field

Parameters:

<Data_Min>

Usage: Asynchronous command

Manual operation: See "Edit" on page 458

TRIGger:SBSW:SPI:DOPerator <Frame>,<Field>,<Operator>
TRIGger:SBSW:SPI:DOPerator? <Operator>
TRIGger:SBSW:SPI:FRAMe<fr>:FLD<fl>:DOPerator <Data_Operator>

Sets the operator for the data pattern of the software trigger in the selected field of the selected frame.

Suffix:

<fr> Index of the frame

<fl> Index of the field

Parameters:

<Data_Operator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

*RST: EQUal

Usage: Asynchronous command

Manual operation: See "Edit" on page 458

TRIGger:SBSW:SPI:FIENable <Frame>,<Field>,<Enabler>
TRIGger:SBSW:SPI:FIENable? <Enabler>
TRIGger:SBSW:SPI:FRAMe<fr>:FLD<fl>:ENABle <CondEnabler>

Enables or disables the checking condition for the selected field of the selected frame of the software trigger.

Suffix:

<fr> Index of the frame

<fl> Index of the field

Parameters:

<CondEnabler>	OFF | ON	
	*RST:	OFF

Usage: Asynchronous command

Manual operation: See "Edit" on page 458

TRIGger:SBSW:SPI:IMAX <Frame>,<Field>,<Data>
TRIGger:SBSW:SPI:IMAX? <Data>
TRIGger:SBSW:SPI:FRAMe<fr>:FLD<fl>:IMAX <Index_Max>

Sets the end value of an index range for the software trigger if the operator is set to `INRange`.

You can set the operator with `TRIGger:SBSW:SPI:FRAMe<fr>:FLD<fl>:IOPerator`.

Suffix:

<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Index_Max>	Range:	1 to 65535
	Increment:	1
	*RST:	65535

Usage: Asynchronous command

Manual operation: See "Edit" on page 458

TRIGger:SBSW:SPI:IMIN <Frame>,<Field>,<Data>
TRIGger:SBSW:SPI:IMIN? <Data>
TRIGger:SBSW:SPI:FRAMe<fr>:FLD<fl>:IMIN <Index_Min>

Specifies the index, or sets the start value of an index range for the software trigger.

Suffix:

<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Index_Min>	Range:	1 to 65535
	Increment:	1
	*RST:	1

Usage: Asynchronous command

Manual operation: See "Edit" on page 458

TRIGger:SBSW:SPI:IOPerator <Frame>,<Field>,<Operator>
TRIGger:SBSW:SPI:IOPerator? <Operator>
TRIGger:SBSW:SPI:FRAMe<fr>:FLD<fl>:IOPerator <Index_Operator>

Sets the operator for the index in the selected field of the selected frame for the software trigger.

Suffix:

<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Index_Operator> EQUal | INRange | RANGe
*RST: INRange

Usage: Asynchronous command

Manual operation: See "Edit" on page 458

TRIGger:SBSW:SPI:ERENable <ErrorName>,<Enabler>
TRIGger:SBSW:SPI:ERENable? <Enabler>
TRIGger:SBSW:SPI:ERRor<m>:ENABle <Enable>

Defines the error type for the software trigger.

Suffix:

<m> Index of the error

Parameters:

<Enable> OFF | ON
*RST: ON

Usage: Asynchronous command

Manual operation: See "Error type" on page 459

SBUS<sb>:SPI:SWTindex?

Queries the software trigger index.

If no software trigger event has occurred, the command returns `Invalid`.

Suffix:

<sb> 1...4, index of the serial bus

Return values:

<Index> Range: 0 to 4294967295
Increment: 1
*RST: 0

Usage: Query only
Asynchronous command

SBUS<sb>:SPI:SWTTime?

Queries the software trigger time in seconds.

If no software trigger event has occured, the command returns `Invalid`.

Suffix:
<sb> 1...4, index of the serial bus

Return values:
<Time> Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0
Default unit: s

Usage: Query only
Asynchronous command

18.17.2.5 Decode results

SBUS<sb>:SPI:FCOunt?

Returns the number of decoded frames.

Suffix:
<sb> 1...4, index of the serial bus

Return values:
<Count>

Usage: Query only
Asynchronous command

SBUS<sb>:SPI:FRAMe<fr>:BITRate?

Returns the bit rate of the specified frame.

Suffix:
<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:
<PrimaryBitRate> Increment: 1
*RST: 0
Default unit: bps

Usage: Query only
Asynchronous command

SBUS<sb>:SPI:FRAMe<fr>:DATA?

Returns the data words of the specified frame in comma-separated values.

Suffix:
<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:
<FrameData> Comma-separated sequence of integer values (N, L1, R1,…, LN, RN). N is the number of word pairs in the frame, and {L1,R1}…{LN,RN} are the value pairs. The values Lx and Rx are associated with the MOSI and the MISO channel, respectively. If a channel is disabled, an empty value is returned.

Usage: Query only
Asynchronous command

SBUS<sb>:SPI:FRAMe<fr>:STARt?

Returns the start time of the specified frame.

Suffix:
<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:
<FrameStart> Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0
Default unit: s

Usage: Query only
Asynchronous command

SBUS<sb>:SPI:FRAMe<fr>:STATus?

Returns the overall state of the specified frame.

Suffix:
<sb> 1...4, index of the serial bus

<fr>	Index of the frame

Return values:

<FrameState>	OK | VOID | INComplete | LENGth

`OK`: the frame is valid.
`VOID`: the frame is empty.
`INComplete`: INComplete word. The word is cut off at the left or right side of the acquisition.
`LENGth`: The frame that was found has an unexpected length: there are either too few or too many bits in this frame.

*RST: OK

Usage: Query only
Asynchronous command

SBUS<sb>:SPI:FRAMe<fr>:STOP?

Returns the end time of the specified frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<FrameStop>
Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0
Default unit: s

Usage: Query only
Asynchronous command

SBUS<sb>:SPI:FRAMe<fr>:WCOunt?

Returns the number of words in the specified frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<FrameWordCount>
Range: 0 to 65535
Increment: 1
*RST: 0

Usage: Query only
Asynchronous command

SBUS<sb>:SPI:FRAMe<fr>:WORD<w>:FMISo?

Returns the formatted value of the specified word on the MISO line.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<w>	Index of the word

Return values:
<FormattedMISOVal>

Usage: Query only
Asynchronous command

SBUS<sb>:SPI:FRAMe<fr>:WORD<w>:FMOSi?

Returns the formatted value of the specified word on the MOSI line.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<w>	Index of the word

Return values:
<FormattedMOSIVal>

Usage: Query only
Asynchronous command

SBUS<sb>:SPI:FRAMe<fr>:WORD<w>:MISO?

Returns the data value of the specified word on the MISO line.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<w>	Index of the word

Return values:
<MISOValue> Range: 0 to 4294967295
Increment: 1
*RST: 0

Usage: Query only
Asynchronous command

SBUS<sb>:SPI:FRAMe<fr>:WORD<w>:MOSI?

Returns the data value of the specified word on the MOSI line.

Suffix:

<sb>	1...4, index of the serial bus

<fr>	Index of the frame
<w>	Index of the word

Return values:

<MOSIValue> Range: 0 to 4294967295
Increment: 1
*RST: 0

Usage: Query only
Asynchronous command

SBUS<sb>:SPI:FRAMe<fr>:WORD<w>:STARt?

Returns the start time of the specified data word.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<w>	Index of the word

Return values:

<FrameWordStart> Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0
Default unit: s

Usage: Query only
Asynchronous command

SBUS<sb>:SPI:FRAMe<fr>:WORD<w>:STOP?

Returns the end time of the specified data word.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<w>	Index of the word

Return values:

<FrameWordStop> Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0
Default unit: s

Usage: Query only
Asynchronous command

18.17.3 QUAD-SPI (option R&S MXO4-K510)

Before MXO 4 can accept the specific bus commands, make sure that:

- The decoding of the specified bus is enabled with `SBUS<sb>[:STATe]`.
- The bus is set to the correct type with `SBUS<sb>:TYPE`.

18.17.3.1 Configuration

SBUS<sb>:QSPI:CSEL:HYSTeresis <Hysteresis>

Sets a value for the hysteresis for the CS channel.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<Hysteresis>

Usage: Asynchronous command

Manual operation: See "CS/SCLK/IO hysteresis" on page 468

SBUS<sb>:QSPI:CSEL:POLarity <CSPolarity>

Selects if the transmitted signal for the respective line is active high (high = 1) or active low (low = 1).

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<CSPolarity> ACTLow | ACTHigh
*RST: ACTLow

Usage: Asynchronous command

Manual operation: See "Polarity: CS, IOx" on page 467

SBUS<sb>:QSPI:CSEL:SOURce CSSource

Sets the input channel of the CS line.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<CSSource> C1 | C2 | C3 | C4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | M1 | M2 | M3 | M4 | M5 | R1 | R2 | R3 | R4 | O<n>C1 | O<n>C2 | ... | O<n>C8 (<n> = 2 to 8)

Usage: Asynchronous command

Manual operation: See "CS, SCLK, IO n" on page 466

SBUS<sb>:QSPI:CSEL:THReshold <Threshold>

Sets a user-defined threshold value for the line.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<Threshold>

Usage: Asynchronous command

Manual operation: See "CS/SCLK/IO threshold" on page 468

SBUS<sb>:QSPI:INSTruction <Instruction>

Selects the instruction mode that defines how many lanes are used to transmit data.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<Instruction> SINGle | DUAL | QUAD
*RST: SINGle

Usage: Asynchronous command

Manual operation: See "Instruction" on page 467

SBUS<sb>:QSPI:IOONe:HYSTeresis <Hysteresis>

Sets a value for the hysteresis for the IO1 line.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<Hysteresis>

Usage: Asynchronous command

Manual operation: See "CS/SCLK/IO hysteresis" on page 468

SBUS<sb>:QSPI:IOONe:POLarity <IO1Polarity>

Selects if the transmitted signal for the respective line is active high (high = 1) or active low (low = 1).

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<IO1Polarity> ACTLow | ACTHigh
*RST: ACTHigh

Usage: Asynchronous command

Manual operation: See "Polarity: CS, IOx" on page 467

SBUS<sb>:QSPI:IOONe:POSition <QUADSPI IO1 position>

Sets the vertical position of the IO1 signal.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<QUADSPI IO1 position>

Usage: Asynchronous command

SBUS<sb>:QSPI:IOONe:SCALe <QUADSPI IO1 scale>

Set the vertical scale of the IO1 signal.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<QUADSPI IO1 scale>

Usage: Asynchronous command

SBUS<sb>:QSPI:IOONe:SOURce IO1Source

Sets the input channel of the IO 1 line.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
IO1Source C1 | C2 | C3 | C4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | M1 | M2 | M3 | M4 | M5 | R1 | R2 | R3 | R4 | O<n>C1 | O<n>C2 | ... | O<n>C8 (<n> = 2 to 8)

Usage: Asynchronous command

Manual operation: See "CS, SCLK, IO n" on page 466

SBUS<sb>:QSPI:IOONe:THReshold <Threshold>

Sets a user-defined threshold value for the line.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<Threshold>

Usage: Asynchronous command

Manual operation: See "CS/SCLK/IO threshold" on page 468

SBUS<sb>:QSPI:IOTHree:HYSTeresis <Hysteresis>

Sets a value for the hysteresis for the IO0 line.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<Hysteresis>

Usage: Asynchronous command

Manual operation: See "CS/SCLK/IO hysteresis" on page 468

SBUS<sb>:QSPI:IOTHree:POLarity <IO3Polarity>

Selects if the transmitted signal for the respective line is active high (high = 1) or active low (low = 1).

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<IO3Polarity> ACTLow | ACTHigh
*RST: ACTHigh

Usage: Asynchronous command

Manual operation: See "Polarity: CS, IOx" on page 467

SBUS<sb>:QSPI:IOTHree:POSition <QUADSPI IO3 position>

Sets the vertical position of the IO3 signal.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<QUADSPI IO3 position>

Usage: Asynchronous command

SBUS<sb>:QSPI:IOTHree:SCALe <QUADSPI IO3 scale>

Set the vertical scale of the IO3 signal.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<QUADSPI IO3 scale>

Usage: Asynchronous command

SBUS<sb>:QSPI:IOTHree:SOURce IO3Source

Sets the input channel of the IO 3 line.

Suffix:

<sb>	1...4, index of the serial bus

Parameters:

IO3Source	C1 | C2 | C3 | C4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | M1 | M2 | M3 | M4 | M5 | R1 | R2 | R3 | R4 | O<n>C1 | O<n>C2 | ... | O<n>C8 (<n> = 2 to 8)

Usage: Asynchronous command

Manual operation: See "CS, SCLK, IO n" on page 466

SBUS<sb>:QSPI:IOTHree:THReshold <Threshold>

Sets a user-defined threshold value for the line.

Suffix:

<sb>	1...4, index of the serial bus

Parameters:

<Threshold>

Usage: Asynchronous command

Manual operation: See "CS/SCLK/IO threshold" on page 468

SBUS<sb>:QSPI:IOTWo:HYSTeresis <Hysteresis>

Sets a value for the hysteresis for the IO2 line.

Suffix:

<sb>	1...4, index of the serial bus

Parameters:

<Hysteresis>

Usage: Asynchronous command

Manual operation: See "CS/SCLK/IO hysteresis" on page 468

SBUS<sb>:QSPI:IOTWo:POLarity <IO2Polarity>

Selects if the transmitted signal for the respective line is active high (high = 1) or active low (low = 1).

Suffix:

<sb>	1...4, index of the serial bus

Parameters:

<IO2Polarity> ACTLow | ACTHigh
*RST: ACTHigh

Usage: Asynchronous command

Manual operation: See "Polarity: CS, IOx" on page 467

SBUS<sb>:QSPI:IOTWo:POSition <QUADSPI IO2 position>

Sets the vertical position of the IO2 signal.

Suffix:

<sb> 1...4, index of the serial bus

Parameters:

<QUADSPI IO2 position>

Usage: Asynchronous command

SBUS<sb>:QSPI:IOTWo:SCALe <QUADSPI IO2 scale>

Set the vertical scale of the IO2 signal.

Suffix:

<sb> 1...4, index of the serial bus

Parameters:

<QUADSPI IO2 scale>

Usage: Asynchronous command

SBUS<sb>:QSPI:IOTWo:SOURce IO2Source

Sets the input channel of the IO 2 line.

Suffix:

<sb> 1...4, index of the serial bus

Parameters:

IO2Source C1 | C2 | C3 | C4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | M1 | M2 | M3 | M4 | M5 | R1 | R2 | R3 | R4 | O<n>C1 | O<n>C2 | ... | O<n>C8 (<n> = 2 to 8)

Usage: Asynchronous command

Manual operation: See "CS, SCLK, IO n" on page 466

SBUS<sb>:QSPI:IOTWo:THReshold <Threshold>

Sets a value for the hysteresis for the IO2 line.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<Threshold>

Usage: Asynchronous command

Manual operation: See "CS/SCLK/IO threshold" on page 468

SBUS<sb>:QSPI:IOZero:HYSTeresis <Hysteresis>

Sets a value for the hysteresis for the IO0 line.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<Hysteresis>

Usage: Asynchronous command

Manual operation: See "CS/SCLK/IO hysteresis" on page 468

SBUS<sb>:QSPI:IOZero:POLarity <IO0Polarity>

Selects if the transmitted signal for the respective line is active high (high = 1) or active low (low = 1).

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<IO0Polarity> ACTLow | ACTHigh
*RST: ACTHigh

Usage: Asynchronous command

Manual operation: See "Polarity: CS, IOx" on page 467

SBUS<sb>:QSPI:IOZero:POSition <QUADSPI IO0 position>

Sets the vertical position of the IO0 signal.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<QUADSPI IO0 position>

Usage: Asynchronous command

SBUS<sb>:QSPI:IOZero:SCALe <QUADSPI IO0 scale>

Set the vertical scale of the IO0 signal.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<QUADSPI IO0 scale>

Usage: Asynchronous command

SBUS<sb>:QSPI:IOZero:SOURce IO0Source

Sets the input channel of the IO 0 line.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
IO0Source C1 | C2 | C3 | C4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | M1 | M2 | M3 | M4 | M5 | R1 | R2 | R3 | R4 | O<n>C1 | O<n>C2 | ... | O<n>C8 (<n> = 2 to 8)

Usage: Asynchronous command

Manual operation: See "CS, SCLK, IO n" on page 466

SBUS<sb>:QSPI:IOZero:THReshold <Threshold>

Sets a user-defined threshold value for the line.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<Threshold>

Usage: Asynchronous command

Manual operation: See "CS/SCLK/IO threshold" on page 468

SBUS<sb>:QSPI:SCLK:HYSTeresis <Hysteresis>

Sets a value for the hysteresis for the SCLK channel.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<Hysteresis>

Usage: Asynchronous command

Manual operation: See "CS/SCLK/IO hysteresis" on page 468

SBUS<sb>:QSPI:SCLK:POLarity <SCLKPolarity>

Sets the polarity for the clock line.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<SCLKPolarity> FALLing | RISing
*RST: RISing

Usage: Asynchronous command

Manual operation: See "SCLK SDR Polarity" on page 466

SBUS<sb>:QSPI:SCLK:SOURce SCLKSource

Sets the input channel of the SCLK clock line.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
SCLKSource C1 | C2 | C3 | C4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | M1 | M2 | M3 | M4 | M5 | R1 | R2 | R3 | R4 | O<n>C1 | O<n>C2 | ... | O<n>C8 (<n> = 2 to 8)

Usage: Asynchronous command

Manual operation: See "CS, SCLK, IO n" on page 466

SBUS<sb>:QSPI:SCLK:THReshold <Threshold>

Sets a user-defined threshold value for the line.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<Threshold>

Usage: Asynchronous command

Manual operation: See "CS/SCLK/IO threshold" on page 468

18.17.3.2 Opcode

SBUS<sb>:QSPI:OPCode:APPend

Adds a new item to the opcode list.

Suffix:
<sb> 1...4, index of the serial bus

Usage: Setting only
Asynchronous command

Manual operation: See "Add" on page 471

SBUS<sb>:QSPI:OPCode:DALL

Deletes all currently defined opcodes from the list.

Suffix:
<sb> 1...4, index of the serial bus

Usage: Setting only
Asynchronous command

Manual operation: See "Delete all" on page 471

SBUS<sb>:QSPI:OPCode:DELete <Index>

Deletes the opcode with the selected index.

Suffix:
<sb> 1...4, index of the serial bus

Setting parameters:
<Index>

Usage: Setting only
Asynchronous command

Manual operation: See "Delete" on page 471

SBUS<sb>:QSPI:OPCode:RESet

Resets the opcode fields to the predefined values.

Suffix:
<sb> 1...4, index of the serial bus

Usage: Setting only
Asynchronous command

Manual operation: See "Preset" on page 472

SBUS<sb>:QSPI:LDOPcode <FileName>

Loads an opcode file from the selected file.

Suffix:
<sb> 1...4, index of the serial bus

Setting parameters:
<FileName>

Usage: Setting only
Asynchronous command

Manual operation: See "Open, Save as" on page 472

SBUS<sb>:QSPI:OPCode:SIZE?

Sets the size of the opcode, hence the number of opcodes currently defined on the table in the "Format" tab of QUAD-SPI.

Suffix:
<sb> 1...4, index of the serial bus

Return values:
<Count>

Usage: Query only
Asynchronous command

SBUS<sb>:QSPI:OPCode:ITEM<n>:ADBYtes <AddressBytes>

Sets the address byte. It specifies the location in the flash memory where the operation (e.g., read, write) is performed.

Suffix:
<sb> 1...4, index of the serial bus

<n> Index of the opcode

Parameters:
<AddressBytes> Range: 0 to 4
Increment: 1
*RST: 0

Usage: Asynchronous command

Manual operation: See "Address Bytes" on page 473

SBUS<sb>:QSPI:OPCode:ITEM<n>:ADLanes <AddressLanes>

Selects how many lines or lanes are used to send the address bytes to the flash memory.

Suffix:

<sb> 1...4, index of the serial bus

<n> Index of the opcode

Parameters:

<AddressLanes> SINGle | DUAL | QUAD

*RST: SINGle

Usage: Asynchronous command

Manual operation: See "Address Lanes" on page 473

SBUS<sb>:QSPI:OPCode:ITEM<n>:ALT <Alt>

Enable, if an alternative field is available.

Suffix:

<sb> 1...4, index of the serial bus

<n> Index of the opcode

Parameters:

<Alt> OFF | ON

*RST: ON

Usage: Asynchronous command

Manual operation: See "Alternative Field" on page 473

SBUS<sb>:QSPI:OPCode:ITEM<n>:CODE <Opcode>

Sets the opcode value.

Suffix:

<sb> 1...4, index of the serial bus

<n> Index of the opcode

Parameters:

<Opcode> Range: 0 to 255
Increment: 1
*RST: 0

Usage: Asynchronous command

Manual operation: See "Opcode" on page 472

SBUS<sb>:QSPI:OPCode:ITEM<n>:DATA <Data>

Enable, if data is being transferred in the opcode operation.

Suffix:

<sb>	1...4, index of the serial bus
<n>	Index of the opcode

Parameters:

<Data>	OFF | ON *RST: ON

Usage: Asynchronous command

Manual operation: See "Data" on page 473

SBUS<sb>:QSPI:OPCode:ITEM<n>:DDR <DDR>

If enabled, the data is transferred on both the rising and falling edges of the clock signal. This setting effectively doubles the data transfer rate compared to a single data rate (SDR), which transfers data only on one clock edge.

Suffix:

<sb>	1...4, index of the serial bus
<n>	Index of the opcode

Parameters:

<DDR>	OFF | ON *RST: OFF

Usage: Asynchronous command

Manual operation: See "DDR" on page 473

SBUS<sb>:QSPI:OPCode:ITEM<n>:DMCYcles <DummyCycles>

Sets the number of dummy cycles. Dummy cycles are clock cycles inserted after the address or other command sequences but before data transfer begins. These cycles allow the flash memory device additional time to perform internal operations or latch onto the correct data to ensure accurate read or write operations.

Suffix:

<sb>	1...4, index of the serial bus
<n>	Index of the opcode

Parameters:

<DummyCycles>	Range: 0 to 255 Increment: 1 *RST: 0

Usage: Asynchronous command

Manual operation: See "Dummy Cycles" on page 473

SBUS<sb>:QSPI:OPCode:ITEM<n>:DTLanes <DataLanes>

Selects how many lanes are used for the data transfer.

The data lanes refer to the physical connections through which data is transmitted between the main (typically a microcontroller) and the sub (typically a flash memory device). QUADSPI can utilize multiple data lines to increase the speed and efficiency of data transfer.

Suffix:

<sb>	1...4, index of the serial bus
<n>	Index of the opcode

Parameters:

<DataLanes>	SINGle | DUAL | QUAD *RST: SINGle

Usage: Asynchronous command

Manual operation: See "Data Lanes" on page 474

SBUS<sb>:QSPI:OPCode:ITEM<n>:NAME <Name>

Sets the name for the Opcode.

Suffix:

<sb>	1...4, index of the serial bus
<n>	Index of the opcode

Parameters:

<Name>

Usage: Asynchronous command

Manual operation: See "Name" on page 473

SBUS<sb>:QSPI:SVOP <FileName>

Saves the opcode file.

Suffix:

<sb>	1...4, index of the serial bus

Setting parameters:

<FileName>

Usage: Setting only
Asynchronous command

Manual operation: See "Open, Save as" on page 472

18.17.3.3 Filter

There are two commands for each parameter, that you can use for defining the QUAD SPI settings.

For example, to set the *Frame type =Data > Field =Addr >01100* value you can use one of the following commands:

- `SBUS:QSPI:FILTer:FRAMe1:FLD1:DMIN 01100`
  Defines the parameter by using the index <m> for the frame number and <n> for the field number.
- `SBUS:QSPI:FILTer:DMIN "Data", "Addr", 01100`
  Defines the parameter by using the frame and field name.

SBUS<sb>:QSPI:FILTer:CHKall

Enables the filter for all available frames and error types.

Suffix:

<sb>	1...4, index of the serial bus
Usage:	Setting only Asynchronous command
Manual operation:	See "Check all, Clear, Invert, Preset" on page 474

SBUS<sb>:QSPI:FILTer:CLR

Disables the filter for all available frames and error types.

Suffix:

<sb> 1...4, index of the serial bus

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 474

SBUS<sb>:QSPI:FILTer:INVert

Inverts the current state of the frame and error types: all frames and error types that were enabled are disabled and vice versa.

Suffix:

<sb> 1...4, index of the serial bus

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 474

SBUS<sb>:QSPI:FILTer:RST

Presets the state of the selected frames and error types.

Suffix:

<sb> 1...4, index of the serial bus

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 474

SBUS<sb>:QSPI:FILTer:BIT <Frame>,<Field>,<Bit>
SBUS<sb>:QSPI:FILTer:BIT? <Bit>
SBUS<sb>:QSPI:FILTer:FRAMe<fr>:FLD<fl>:BIT <BitState>

Sets the operator for the data pattern in the selected field of the selected frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Parameters:

<BitState> ONE | ZERO
*RST: ZERO

Usage: Asynchronous command

Manual operation: See "Edit" on page 475

SBUS<sb>:QSPI:FILTer:DMAX <Frame>,<Field>,<Data>
SBUS<sb>:QSPI:FILTer:DMAX? <Data>
SBUS<sb>:QSPI:FILTer:FRAMe<fr>:FLD<fl>:DMAX <Data_Max>

Sets the end value of a data pattern range if the operator is set to `INRange` or `OORANGe`.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Parameters:

<Data_Max>

Usage: Asynchronous command

Manual operation: See "Edit" on page 475

SBUS<sb>:QSPI:FILTer:DMIN <Frame>,<Field>,<Data>
SBUS<sb>:QSPI:FILTer:DMIN? <Data>
SBUS<sb>:QSPI:FILTer:FRAMe<fr>:FLD<fl>:DMIN <Data_Min>

Specifies the data pattern, or sets the start value of a data pattern range.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Parameters:

<Data_Min>

Usage: Asynchronous command

Manual operation: See "Edit" on page 475

SBUS<sb>:QSPI:FILTer:DOPerator <Frame>,<Field>,<Operator>
SBUS<sb>:QSPI:FILTer:DOPerator? <Operator>
SBUS<sb>:QSPI:FILTer:FRAMe<fr>:FLD<fl>:DOPerator <Data_Operator>

Sets the operator for the data pattern in the selected field of the selected frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Parameters:

<Data_Operator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

*RST: EQUal

Usage: Asynchronous command

Manual operation: See "Edit" on page 475

SBUS<sb>:QSPI:FILTer:IMAX <Frame>,<Field>,<Data>
SBUS<sb>:QSPI:FILTer:IMAX? <Data>
SBUS<sb>:QSPI:FILTer:FRAMe<fr>:FLD<fl>:IMAX <Index_Max>

Sets the end value of an index range if the operator is set to `INRange`.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Parameters:

<Index_Max> Range: 1 to 65535
Increment: 1
*RST: 65535

Usage: Asynchronous command

Manual operation: See "Edit" on page 475

SBUS<sb>:QSPI:FILTer:IMIN <Frame>,<Field>,<Data>
SBUS<sb>:QSPI:FILTer:IMIN? <Data>
SBUS<sb>:QSPI:FILTer:FRAMe<fr>:FLD<fl>:IMIN <Index_Min>

Specifies the index, or sets the start value of an index range.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Parameters:

<Index_Min> Range: 1 to 65535
Increment: 1
*RST: 1

Usage: Asynchronous command

Manual operation: See "Edit" on page 475

SBUS<sb>:QSPI:FILTer:IOPerator <Frame>,<Field>,<Operator>
SBUS<sb>:QSPI:FILTer:IOPerator? <Operator>
SBUS<sb>:QSPI:FILTer:FRAMe<fr>:FLD<fl>:IOPerator <Index_Operator>

Sets the operator for the index in the selected field of the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Index_Operator>	EQUal | INRange | RANGe *RST: INRange

Usage: Asynchronous command

Manual operation: See "Edit" on page 475

SBUS<sb>:QSPI:FILTer:ERENable <ErrorName>,<Enabler>
SBUS<sb>:QSPI:FILTer:ERENable? <Enabler>
SBUS<sb>:QSPI:FILTer:ERRor<n>:ENABle <Enable>

Defines the error type to be filtered on.

Suffix:

<sb>	1...4, index of the serial bus
<n>	index of the error

Parameters:

<Enable>	OFF | ON *RST: ON

Usage: Asynchronous command

Manual operation: See "Error type" on page 476

SBUS<sb>:QSPI:FILTer:FIENable <Frame>,<Field>,<Enabler>
SBUS<sb>:QSPI:FILTer:FIENable? <Enabler>
SBUS<sb>:QSPI:FILTer:FRAMe<fr>:FLD<fl>:ENABle <CondEnabler>

Sets the operator for the data pattern in the selected field of the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<CondEnabler>	OFF | ON *RST: OFF

Usage: Asynchronous command

Manual operation: See "Edit" on page 475

SBUS<sb>:QSPI:FILTer:FRENable <Frame>,<Enabler>
SBUS<sb>:QSPI:FILTer:FRENable? <Enabler>
SBUS<sb>:QSPI:FILTer:FRAMe<fr>:ENABle <Enable>

Enables or disables the checking condition for the selected frame.

Suffix:
<sb> 1...4, index of the serial bus

<fr> Index of the frame

Parameters:
<Enable> OFF | ON

*RST: ON

Usage: Asynchronous command

18.17.3.4 Software trigger

There are two commands for each parameter, that you can use for defining the QUAD SPI settings.

For example, to set the *Frame type =Data > Field =Addr >01100* value you can use one of the following commands:

- `TRIGger:SBSW:QSPI:FRAMe1:FLD1:DMIN 01100`
  Defines the parameter by using the index <m> for the frame number and <n> for the field number.
- `TRIGger:SBSW:QSPI:DMIN "Data", "Addr", 01100`
  Defines the parameter by using the frame and field name.

TRIGger:SBSW:QSPI:CHKall

Enables the software trigger for all available frames and error types.

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 477

TRIGger:SBSW:QSPI:CLR

Disables the software trigger for all available frames and error types.

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 477

TRIGger:SBSW:QSPI:INVert

Inverts the current state of the frame and error types for the software trigger: all frames and error types that were enabled are disabled and vice versa.

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 477

TRIGger:SBSW:QSPI:RST

Presets the state of the selected frames and error types for the software trigger.

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 477

TRIGger:SBSW:QSPI:FRENable <Frame>,<Enabler>
TRIGger:SBSW:QSPI:FRENable? <Enabler>
TRIGger:SBSW:QSPI:FRAMe<fr>:ENABle <Enable>

Enables or disables the checking condition for the selected frame for the software trigger.

Suffix:
<fr> Index of the frame

Parameters:
<Enable> OFF | ON
*RST: ON

Usage: Asynchronous command

Manual operation: See "Frame type" on page 478

TRIGger:SBSW:QSPI:BIT <Frame>,<Field>,<Bit>
TRIGger:SBSW:QSPI:BIT? <Bit>
TRIGger:SBSW:QSPI:FRAMe<fr>:FLD<fl>:BIT <BitState>

Sets the bit state of a field that only consists of one bit for the software trigger.

Suffix:
<fr> Index of the frame

<fl> Index of the field

Parameters:
<BitState> ONE | ZERO
*RST: ZERO

Usage: Asynchronous command

Manual operation: See "Edit" on page 478

TRIGger:SBSW:QSPI:DMAX <Frame>,<Field>,<Data>
TRIGger:SBSW:QSPI:DMAX? <Data>
TRIGger:SBSW:QSPI:FRAMe<fr>:FLD<fl>:DMAX <Data_Max>

Sets the end value of a data pattern range for the software trigger, if the operator is set to `INRange` or `OORANGe`.

You can set the operator with `TRIGger:SBSW:QSPI:FRAMe<fr>:FLD<fl>:DOPerator`.

Suffix:
<fr> Index of the frame

<fl> Index of the field

Parameters:
<Data_Max>

Usage: Asynchronous command

Manual operation: See "Edit" on page 478

TRIGger:SBSW:QSPI:DMIN <Frame>,<Field>,<Data>
TRIGger:SBSW:QSPI:DMIN? <Data>
TRIGger:SBSW:QSPI:FRAMe<fr>:FLD<fl>:DMIN <Data_Min>

Specifies the data pattern, or sets the start value of a data pattern range for the software trigger.

Suffix:

<fr> Index of the frame

<fl> Index of the field

Parameters:

<Data_Min>

Usage: Asynchronous command

Manual operation: See "Edit" on page 478

TRIGger:SBSW:QSPI:DOPerator <Frame>,<Field>,<Operator>
TRIGger:SBSW:QSPI:DOPerator? <Operator>
TRIGger:SBSW:QSPI:FRAMe<fr>:FLD<fl>:DOPerator <Data_Operator>

Sets the operator for the data pattern of the software trigger in the selected field of the selected frame.

Suffix:

<fr> Index of the frame

<fl> Index of the field

Parameters:

<Data_Operator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

*RST: EQUal

Usage: Asynchronous command

Manual operation: See "Edit" on page 478

TRIGger:SBSW:QSPI:FIENable <Frame>,<Field>,<Enabler>
TRIGger:SBSW:QSPI:FIENable? <Enabler>
TRIGger:SBSW:QSPI:FRAMe<fr>:FLD<fl>:ENABle <CondEnabler>

Enables or disables the checking condition for the selected field of the selected frame of the software trigger.

Suffix:

<fr> Index of the frame

<fl> Index of the field

Parameters:

<CondEnabler> OFF | ON

*RST: OFF

Usage: Asynchronous command

Manual operation: See "Edit" on page 478

TRIGger:SBSW:QSPI:IMAX <Frame>,<Field>,<Data>
TRIGger:SBSW:QSPI:IMAX? <Data>
TRIGger:SBSW:QSPI:FRAMe<fr>:FLD<fl>:IMAX <Index_Max>

Sets the end value of an index range for the software trigger if the operator is set to `INRange`.

You can set the operator with `TRIGger:SBSW:QSPI:FRAMe<fr>:FLD<fl>:IOPerator`.

Suffix:

<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Index_Max>
Range: 1 to 65535
Increment: 1
*RST: 65535

Usage: Asynchronous command

Manual operation: See "Edit" on page 478

TRIGger:SBSW:QSPI:IMIN <Frame>,<Field>,<Data>
TRIGger:SBSW:QSPI:IMIN? <Data>
TRIGger:SBSW:QSPI:FRAMe<fr>:FLD<fl>:IMIN <Index_Min>

Specifies the index, or sets the start value of an index range for the software trigger.

Suffix:

<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Index_Min>
Range: 1 to 65535
Increment: 1
*RST: 1

Usage: Asynchronous command

Manual operation: See "Edit" on page 478

TRIGger:SBSW:QSPI:IOPerator <Frame>,<Field>,<Operator>
TRIGger:SBSW:QSPI:IOPerator? <Operator>
TRIGger:SBSW:QSPI:FRAMe<fr>:FLD<fl>:IOPerator <Index_Operator>

Sets the operator for the index in the selected field of the selected frame for the software trigger.

Suffix:

<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Index_Operator> EQUal | INRange | RANGe
*RST: INRange

Usage: Asynchronous command

Manual operation: See "Edit" on page 478

TRIGger:SBSW:QSPI:ERENable <ErrorName>,<Enabler>
TRIGger:SBSW:QSPI:ERENable? <Enabler>
TRIGger:SBSW:QSPI:ERRor<m>:ENABle <Enable>

Defines the error type for the software trigger.

Suffix:

<m> Index of the error

Parameters:

<Enable> OFF | ON
*RST: ON

Usage: Asynchronous command

Manual operation: See "Error type" on page 480

SBUS<sb>:QSPI:SWTindex?

Queries the software trigger index.

If no software trigger event has occurred, the command returns `Invalid`.

Suffix:

<sb> 1...4, index of the serial bus

Return values:

<Index> Range: 0 to 4294967295
Increment: 1
*RST: 0

Usage: Query only
Asynchronous command

SBUS<sb>:QSPI:SWTTime?

Queries the software trigger time in seconds.

If no software trigger event has occured, the command returns `Invalid`.

Suffix:

<sb> 1...4, index of the serial bus

Return values:

<Time>	Range: -1E+26 to 1E+26 Increment: 1E-10 *RST: 0 Default unit: s

Usage: Query only
Asynchronous command

18.17.3.5 Decode results

SBUS<sb>:QSPI:FCOunt?

Returns the number of decoded frames.

Suffix:

<sb>	1...4, index of the serial bus

Return values:
<Count>

Usage: Query only
Asynchronous command

SBUS<sb>:QSPI:FRAMe<fr>:ADDR?

Returns the address of the specified frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<FrameAddress>	Range: 0 to 4294967295 Increment: 1 *RST: 0

Usage: Query only
Asynchronous command

SBUS<sb>:QSPI:FRAMe<fr>:ALT?

Retruns the value of the alternate byte for the specified frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<FrameAlt>	Range: 0 to 65535 Increment: 1 *RST: 0

Usage: Query only
Asynchronous command

SBUS<sb>:QSPI:FRAMe<fr>:BITRate?

Returns the bit rate of the specified frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<PrimaryBitRate>	Increment: 1 *RST: 0 Default unit: bps

Usage: Query only
Asynchronous command

SBUS<sb>:QSPI:FRAMe<fr>:DATA?

Returns the data of the specified frame in comma-separated values.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<Count>

<Values>

Usage: Query only
Asynchronous command

SBUS<sb>:QSPI:FRAMe<fr>:FLDCount?

Returns the field count for the specified frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:
<Count>

Usage: Query only
Asynchronous command

SBUS<sb>:QSPI:FRAMe<fr>:FDATa?

Returns the foramtted data value of the specified frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:
<FrameData>

Usage: Query only
Asynchronous command

SBUS<sb>:QSPI:FRAMe<fr>:FLD<fl>:VALue?

Returns the value of the specified field of the specified frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Return values:
<Value> Increment: 1
*RST: 0

Usage: Query only
Asynchronous command

SBUS<sb>:QSPI:FRAMe<fr>:FLD<fl>:FVALue?

Returns the formatted value of the specified field.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Return values:

<FormattedValue>

Usage: Query only
Asynchronous command

SBUS<sb>:QSPI:FRAMe<fr>:FLD<fl>:LABel?

Returns the label of the selected field in the specified frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Return values:

<Label>

Usage: Query only
Asynchronous command

SBUS<sb>:QSPI:FRAMe<fr>:FLD<fl>:STATe?

Returns the state of the selected field in the specified frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Return values:

<State> OK | LENGth | OPCode | INComplete

OK
The field is valid.

LENGth
The field does not have the expected length.

OPCode
The opcode value is not found in your frame description list. See Section 14.3.2.4, "Format", on page 469.

INComplete
The field is not completely contained in the acquisition. The acquired part of the field is usually valid, but cannot always be trusted.

*RST: OK

Usage: Query only
Asynchronous command

SBUS<sb>:QSPI:FRAMe<fr>:ILBL?

Returns the label of the instruction.

Suffix:
<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:
<FrameLabel>

Usage: Query only
Asynchronous command

SBUS<sb>:QSPI:FRAMe<fr>:IVALue?

Returns the instruction mode value for the specified frame.

Suffix:
<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:
<FrmInstruction> Range: 0 to 65535
Increment: 1
*RST: 0

Usage: Query only
Asynchronous command

SBUS<sb>:QSPI:FRAMe<fr>:STARt?

Returns the start time of the specified frame.

Suffix:
<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:
<FrameStart> Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0
Default unit: s

Usage: Query only
Asynchronous command

SBUS<sb>:QSPI:FRAMe<fr>:STATus?

Returns the overall state of the specified frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<FrameState> OK | LENGth | OPCode | INComplete

`OK`: the frame is valid.
`OPCode`: operation code.
`INComplete`: INComplete word. The word does not have the expected word length.
`LENGth`: The frame is not contained in the acquisition.

*RST: OK

Usage: Query only
Asynchronous command

SBUS<sb>:QSPI:FRAMe<fr>:STOP?

Returns the end time of the specified frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<FrameStop>
Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0
Default unit: s

Usage: Query only
Asynchronous command

18.17.4 I²C (option R&S MXO4-K510)

Before MXO 4 can accept the specific bus commands, make sure that:

- The decoding of the specified bus is enabled with `SBUS<sb>[:STATe]`.
- The bus is set to the correct type with `SBUS<sb>:TYPE`.

18.17.4.1 Configuration

SBUS<sb>:I2C:SCL:HYSTeresis <Hysteresis>

Sets a hysteresis value for the clock line.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<Hysteresis>

Usage: Asynchronous command

Manual operation: See "SDA/SCL threshold, SDA/SCL hysteresis" on page 488

SBUS<sb>:I2C:SCL:SOURce SCLSource

Selects the waveform source of the clock line.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
SCLSource C1 | C2 | C3 | C4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | M1 | M2 | M3 | M4 | M5 | R1 | R2 | R3 | R4 | O<n>C1 | O<n>C2 | ... | O<n>C8 (<n> = 2 to 8)

Usage: Asynchronous command

Manual operation: See "SCL source" on page 488

SBUS<sb>:I2C:SCL:THReshold <Threshold>

Sets a user-defined threshold value for the clock line.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<Threshold>

Usage: Asynchronous command

Manual operation: See "SDA/SCL threshold, SDA/SCL hysteresis" on page 488

SBUS<sb>:I2C:SDA:HYSTeresis <Hysteresis>

Sets a hysteresis value for the data line.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<Hysteresis>

Usage: Asynchronous command

Manual operation: See "SDA/SCL threshold, SDA/SCL hysteresis" on page 488

SBUS<sb>:I2C:SDA:SOURce SDASource

Sets the source channel to which the data line is connected.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
SDASource C1 | C2 | C3 | C4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | M1 | M2 | M3 | M4 | M5 | R1 | R2 | R3 | R4 | O<n>C1 | O<n>C2 | ... | O<n>C8 (<n> = 2 to 8)

Usage: Asynchronous command

Manual operation: See "SDA source" on page 488

SBUS<sb>:I2C:SDA:THReshold <Threshold>

Sets a user-defined threshold value for the data line.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<Threshold>

Usage: Asynchronous command

Manual operation: See "SDA/SCL threshold, SDA/SCL hysteresis" on page 488

SBUS<sb>:I2C:POSition <Position>

Sets the vertical position of the I^2C signal.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<Position>

Usage: Asynchronous command

SBUS<sb>:I2C:SCALe <Scale>

Set the vertical scale of the I²C signal.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<Scale>

Usage: Asynchronous command

SBUS<sb>:I2C:SYMBols <ShowSymbols>

Activates the symbol list to be used for decoding.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<ShowSymbols> OFF | ON
*RST: OFF

Usage: Asynchronous command

Manual operation: See "Show symbols" on page 490

SBUS<sb>:I2C:NEWList <FileName>

Loads a symbol list file.

Suffix:
<sb> 1...4, index of the serial bus

Setting parameters:
<FileName> String parameter with path and file name.

Example:
```
SBUS1:I2C:NEWList
'/home/storage/userData/Protocol/I2C.csv'
SBUS1:I2C:SYMBols ON
```

Usage: Setting only
Asynchronous command

Manual operation: See "Show symbols" on page 490

18.17.4.2 Filter

There are two commands for each parameter, that you can use for defining the I2C settings.

For example, to set the *Frame type =WRITe* > *Field =Address* >*Data* value you can use one of the following commands:

- `SBUS:I2C:FILTer:FRAMe1:FLD1:DMIN 01100`
  Defines the parameter by using the index <m> for the frame number and <n> for the field number.
- `SBUS:I2C:FILTer:DMIN "WRITe", "Address", 01100`
  Defines the parameter by using the frame and field name.

SBUS<sb>:I2C:FILTer:CHKall

Enables the filter for all available frames and error types.

Suffix:

<sb>	1...4, index of the serial bus
Usage:	Setting only Asynchronous command
Manual operation:	See "Check all, Clear, Invert, Preset" on page 491

SBUS<sb>:I2C:FILTer:CLR

Disables the filter for all available frames and error types.

Suffix:
<sb> 1...4, index of the serial bus

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 491

SBUS<sb>:I2C:FILTer:INVert

Inverts the current state of the frame and error types: all frames and error types that were enabled are disabled and vice versa.

Suffix:
<sb> 1...4, index of the serial bus

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 491

SBUS<sb>:I2C:FILTer:RST

Presets the state of the selected frames and error types.

Suffix:
<sb> 1...4, index of the serial bus

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 491

SBUS<sb>:I2C:FILTer:FRENable <Frame>,<Enabler>
SBUS<sb>:I2C:FILTer:FRENable? <Enabler>
SBUS<sb>:I2C:FILTer:FRAMe<fr>:ENABle <Enable>

Enables or disables the specific frame to be filtered on.

Suffix:
<sb> 1...4, index of the serial bus

<fr> Index of the frame

Parameters:
<Enable> OFF | ON
*RST: ON

Usage: Asynchronous command

Manual operation: See "Frame type" on page 492

SBUS<sb>:I2C:FILTer:DMAX <Frame>,<Field>,<Data>
SBUS<sb>:I2C:FILTer:DMAX? <Data>
SBUS<sb>:I2C:FILTer:FRAMe<fr>:FLD<fl>:DMAX <Data_Max>

Sets the end value of a data pattern range if the operator is set to `INRange` or `OORANGe`.

You can set the operator with `SBUS<sb>:I2C:FILTer:DOPerator`.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:
<Data_Max>

Usage: Asynchronous command

Manual operation: See "Edit" on page 492

SBUS<sb>:I2C:FILTer:DMIN <Frame>,<Field>,<Data>
SBUS<sb>:I2C:FILTer:DMIN? <Data>
SBUS<sb>:I2C:FILTer:FRAMe<fr>:FLD<fl>:DMIN <Data_Min>

Specifies the data pattern, or sets the start value of a data pattern range.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:
<Data_Min>

Usage: Asynchronous command

Manual operation: See "Edit" on page 492

SBUS<sb>:I2C:FILTer:DOPerator <Frame>,<Field>,<Operator>
SBUS<sb>:I2C:FILTer:DOPerator? <Operator>
SBUS<sb>:I2C:FILTer:FRAMe<fr>:FLD<fl>:DOPerator <Data_Operator>

Sets the operator for the data pattern in the selected field of the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Data_Operator>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange *RST: EQUal

Usage: Asynchronous command

Manual operation: See "Edit" on page 492

SBUS<sb>:I2C:FILTer:ERENable <ErrorName>,<Enabler>
SBUS<sb>:I2C:FILTer:ERENable? <Enabler>
SBUS<sb>:I2C:FILTer:ERRor<n>:ENABle <Enable>

Defines the error type to be filtered on.

Suffix:

<sb>	1...4, index of the serial bus
<n>	index of the error

Parameters:

<Enable>	OFF | ON *RST: ON

Usage: Asynchronous command

Manual operation: See "Error type" on page 493

SBUS<sb>:I2C:FILTer:IMAX <Frame>,<Field>,<Data>
SBUS<sb>:I2C:FILTer:IMAX? <Data>
SBUS<sb>:I2C:FILTer:FRAMe<fr>:FLD<fl>:IMAX <Index_Max>

Sets the end value of an index range if the operator is set to `INRange`.

You can set the operator with `SBUS<sb>:I2C:FILTer:IOPerator`.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Index_Max>	Range: 1 to 65535 Increment: 1 *RST: 65535

Usage: Asynchronous command

Manual operation: See "Edit" on page 492

SBUS<sb>:I2C:FILTer:IMIN <Frame>,<Field>,<Data>
SBUS<sb>:I2C:FILTer:IMIN? <Data>
SBUS<sb>:I2C:FILTer:FRAMe<fr>:FLD<fl>:IMIN <Index_Min>

Specifies the index, or sets the start value of an index range.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Index_Min> Range: 1 to 65535
Increment: 1
*RST: 1

Usage: Asynchronous command

Manual operation: See "Edit" on page 492

SBUS<sb>:I2C:FILTer:IOPerator <Frame>,<Field>,<Operator>
SBUS<sb>:I2C:FILTer:IOPerator? <Operator>
SBUS<sb>:I2C:FILTer:FRAMe<fr>:FLD<fl>:IOPerator <Index_Operator>

Sets the operator for the index in the selected field of the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Index_Operator> EQUal | INRange | RANGe
*RST: INRange

Usage: Asynchronous command

Manual operation: See "Edit" on page 492

SBUS<sb>:I2C:FILTer:BIT <Frame>,<Field>,<Bit>
SBUS<sb>:I2C:FILTer:BIT? <Bit>
SBUS<sb>:I2C:FILTer:FRAMe<fr>:FLD<fl>:BIT <BitState>

Sets the bit state of a field that only consists of one bit.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:
<BitState> ONE | ZERO

*RST: ZERO

Usage: Asynchronous command

Manual operation: See "Edit" on page 492

SBUS<sb>:I2C:FILTer:FIENable <Frame>,<Field>,<Enabler>
SBUS<sb>:I2C:FILTer:FIENable? <Enabler>
SBUS<sb>:I2C:FILTer:FRAMe<fr>:FLD<fl>:ENABle <CondEnabler>

Enables or disables the checking condition for the selected field of the selected frame.

Suffix:
<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Parameters:
<CondEnabler> OFF | ON

*RST: OFF

Usage: Asynchronous command

Manual operation: See "Edit" on page 492

18.17.4.3 Hardware trigger

Trigger commands for serial buses affect the current trigger source. Therefore, set the trigger source to the required serial bus with `TRIGger:EVENt<ev>:SOURce` before sending the bus-specific trigger commands.

TRIGger:SBHW:I2C:TYPE <Type>

Selects the trigger type for I²C analysis.

Parameters:
<Type> STARt | REPStart | STOP | NACK | ADDRess | DATA | ADAT

STARt
Start condition

REPStart
Repeated start - the start condition occurs without previous stop condition.

STOP
Stop condition, end of frame

NACK
Missing acknowledge bit. To localize specific missing acknowledge bits, use:
TRIGger:SBHW:I2C:ADNack
TRIGger:SBHW:I2C:DWNack
TRIGger:SBHW:I2C:DRNack

ADDRess
Triggers on one specific address

DATA
Triggers on a specific data

ADAT
Triggers on a combination of address and data condition.

*RST: STARt

Usage: Asynchronous command

Manual operation: See "Type" on page 494

TRIGger:SBHW:I2C:ACCess <RWBitAddress>

Toggles the trigger condition between read and write access of the primary. Select "Either" if the transfer direction is not relevant for the trigger condition.

Parameters:

<RWBitAddress> READ | WRITe | EITHer

*RST: EITHer

Usage: Asynchronous command

Manual operation: See "R/W bit" on page 496

TRIGger:SBHW:I2C:ACONdition <AddrOptor>

Sets the operator to set a specific address or an address range. The address values are set with TRIGger:SBHW:I2C:ADDRess and TRIGger:SBHW:I2C:ADDTo.

Parameters:

<AddrOptor> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

*RST: EQUal

Usage: Asynchronous command

TRIGger:SBHW:I2C:ADDRess <Address>

Triggers on the specified address, or sets the start value of an address range depending on the condition set with `TRIGger:SBHW:I2C:ACONdition`.

Parameters:
<Address>

Usage: Asynchronous command

Manual operation: See "Address" on page 496

TRIGger:SBHW:I2C:ADDTo <AddressTo>

Sets the end value of an address range if the condition is set to an address range with `TRIGger:SBHW:I2C:ACONdition`.

Parameters:
<AddressTo>

Usage: Asynchronous command

Manual operation: See "Address" on page 496

TRIGger:SBHW:I2C:ADNack <AddressNack>

Triggers if the address acknowledge bit is missing - no target recognizes the address.

Parameters:
<AddressNack> OFF | ON
*RST: ON

Usage: Asynchronous command

Manual operation: See "No Ack conditions" on page 496

TRIGger:SBHW:I2C:AMODe <AddressType>

Sets the address length to be triggered on: 7 bit or 10 bit.

Parameters:
<AddressType> BIT7 | BIT7RW | BIT7_RW | BIT10

Note that `BIT7RW` is the same address type as `BIT7_RW`.

BIT7 | BIT10
Enter only the seven or ten address bits in the address pattern.

BIT7RW | BIT7_RW
Enter seven address bits and also the read/write bit.

*RST: BIT7

Usage: Asynchronous command

Manual operation: See "Address type" on page 496

TRIGger:SBHW:I2C:DCONdition <DataOperator>

Sets the operator to set a specific data value or a data range.

Parameters:

<DataOperator>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan *RST: EQUal
Usage:	Asynchronous command
Manual operation:	See "Data" on page 497

TRIGger:SBHW:I2C:DMIN <Data>

Specifies the data bit pattern, or sets the start value of a data pattern range. Enter the bytes in MSB first bit order. The maximum pattern length is 64 bit. Waveform data is compared with the pattern byte-by-byte.

Parameters:

<Data>

Usage:	Asynchronous command
Manual operation:	See "Data" on page 497

TRIGger:SBHW:I2C:DPOSition <DataPosition>

Sets the number of data bytes to be skipped after the address.

Parameters:

<DataPosition>	Range: 1 to 4096 Increment: 1 *RST: 1
Usage:	Asynchronous command
Manual operation:	See "Position" on page 497

TRIGger:SBHW:I2C:DRNack <DataReadNack>

Triggers on the end of the read process when the controller reads data from the target. This NACK is sent according to the protocol definition, it is not an error.

Parameters:

<DataReadNack>	OFF | ON *RST: ON
Usage:	Asynchronous command
Manual operation:	See "No Ack conditions" on page 496

TRIGger:SBHW:I2C:DWNack <DataWriteNack>

Triggers if a date acknowledge bit is missing - the addressed target does not accept the data.

Parameters:

<DataWriteNack> OFF | ON

*RST: ON

Usage: Asynchronous command

Manual operation: See "No Ack conditions" on page 496

18.17.4.4 Software trigger

There are two commands for each parameter, that you can use for defining the I2C settings.

For example, to set the *Frame type =WRITe* > *Field =Address* >*Data* value you can use one of the following commands:

- `TRIGger:SBSW:I2C:FRAMe1:FLD1:DMIN 01100`
  Defines the parameter by using the index <m> for the frame number and <n> for the field number.
- `STRIGger:SBSW:I2C:DMIN "WRITe", "Address", 01100`
  Defines the parameter by using the frame and field name.

TRIGger:SBSW:I2C:CHKall

Enables the software trigger for all available frames and error types.

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 498

TRIGger:SBSW:I2C:CLR

Disables the software trigger for all available frames and error types.

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 498

TRIGger:SBSW:I2C:INVert

Inverts the current state of the frame and error types for the software trigger: all frames and error types that were enabled are disabled and vice versa.

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 498

TRIGger:SBSW:I2C:RST

Presets the state of the selected frames and error types for the software trigger.

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 498

TRIGger:SBSW:I2C:FRENable <Frame>,<Enabler>
TRIGger:SBSW:I2C:FRENable? <Enabler>
TRIGger:SBSW:I2C:FRAMe<fr>:ENABle <Enable>

Enables or disables the checking condition for the selected frame for the software trigger.

Suffix:
<fr> Index of the frame

Parameters:

<Enable>	OFF | ON *RST: ON

Usage: Asynchronous command

Manual operation: See "Frame type" on page 499

TRIGger:SBSW:I2C:BIT <Frame>,<Field>,<Bit>
TRIGger:SBSW:I2C:BIT? <Bit>
TRIGger:SBSW:I2C:FRAMe<fr>:FLD<fl>:BIT <BitState>

Sets the bit state of a field that only consists of one bit for the software trigger.

Suffix:

<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<BitState>	ONE | ZERO *RST: ZERO

Usage: Asynchronous command

Manual operation: See "Edit" on page 499

TRIGger:SBSW:I2C:DMAX <Frame>,<Field>,<Data>
TRIGger:SBSW:I2C:DMAX? <Data>
TRIGger:SBSW:I2C:FRAMe<fr>:FLD<fl>:DMAX <Data_Max>

Sets the end value of a data pattern range for the software trigger, if the operator is set to `INRange` or `OORANGe`.

You can set the operator with `TRIGger:SBSW:I2C:FRAMe<fr>:FLD<fl>:DOPerator`.

Suffix:

<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Data_Max>

Usage: Asynchronous command

Manual operation: See "Edit" on page 499

TRIGger:SBSW:I2C:DMIN <Frame>,<Field>,<Data>
TRIGger:SBSW:I2C:DMIN? <Data>
TRIGger:SBSW:I2C:FRAMe<fr>:FLD<fl>:DMIN <Data_Min>

Specifies the data pattern, or sets the start value of a data pattern range for the software trigger.

Suffix:

<fr> Index of the frame

<fl> Index of the field

Parameters:

<Data_Min>

Usage: Asynchronous command

Manual operation: See "Edit" on page 499

TRIGger:SBSW:I2C:DOPerator <Frame>,<Field>,<Operator>
TRIGger:SBSW:I2C:DOPerator? <Operator>
TRIGger:SBSW:I2C:FRAMe<fr>:FLD<fl>:DOPerator <Data_Operator>

Sets the operator for the data pattern of the software trigger in the selected field of the selected frame.

Suffix:

<fr> Index of the frame

<fl> Index of the field

Parameters:

<Data_Operator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

*RST: EQUal

Usage: Asynchronous command

Manual operation: See "Edit" on page 499

TRIGger:SBSW:I2C:FIENable <Frame>,<Field>,<Enabler>
TRIGger:SBSW:I2C:FIENable? <Enabler>
TRIGger:SBSW:I2C:FRAMe<fr>:FLD<fl>:ENABle <CondEnabler>

Enables or disables the checking condition for the selected field of the selected frame of the software trigger.

Suffix:

<fr> Index of the frame

<fl> Index of the field

Parameters:

<CondEnabler> OFF | ON

*RST: OFF

Usage: Asynchronous command

Manual operation: See "Edit" on page 499

TRIGger:SBSW:I2C:IMAX <Frame>,<Field>,<Data>
TRIGger:SBSW:I2C:IMAX? <Data>
TRIGger:SBSW:I2C:FRAMe<fr>:FLD<fl>:IMAX <Index_Max>

Sets the end value of an index range for the software trigger if the operator is set to `INRange`.

You can set the operator with `TRIGger:SBSW:I2C:FRAMe<fr>:FLD<fl>:IOPerator`.

Suffix:

<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Index_Max> Range: 1 to 65535
Increment: 1
*RST: 65535

Usage: Asynchronous command

Manual operation: See "Edit" on page 499

TRIGger:SBSW:I2C:IMIN <Frame>,<Field>,<Data>
TRIGger:SBSW:I2C:IMIN? <Data>
TRIGger:SBSW:I2C:FRAMe<fr>:FLD<fl>:IMIN <Index_Min>

Specifies the index, or sets the start value of an index range for the software trigger.

Suffix:

<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Index_Min> Range: 1 to 65535
Increment: 1
*RST: 1

Usage: Asynchronous command

Manual operation: See "Edit" on page 499

TRIGger:SBSW:I2C:IOPerator <Frame>,<Field>,<Operator>
TRIGger:SBSW:I2C:IOPerator? <Operator>
TRIGger:SBSW:I2C:FRAMe<fr>:FLD<fl>:IOPerator <Index_Operator>

Sets the operator for the index in the selected field of the selected frame for the software trigger.

Suffix:

<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Index_Operator> EQUal | INRange | RANGe

*RST: INRange

Usage: Asynchronous command

Manual operation: See "Edit" on page 499

TRIGger:SBSW:I2C:ERENable <ErrorName>,<Enabler>
TRIGger:SBSW:I2C:ERENable? <Enabler>
TRIGger:SBSW:I2C:ERRor<m>:ENABle <Enable>

Defines the error type for the software trigger.

Suffix:

<m> index of the error

Parameters:

<Enable> OFF | ON

*RST: ON

Usage: Asynchronous command

Manual operation: See "Error type" on page 500

SBUS<sb>:I2C:SWTindex?

Queries the software trigger index.

If no software trigger event has occurred, the command returns `Invalid`.

Suffix:

<sb> 1...4, index of the serial bus

Return values:

<Index> Range: 0 to 4294967295
Increment: 1
*RST: 0

Usage: Query only
Asynchronous command

SBUS<sb>:I2C:SWTTime?

Queries the software trigger time in seconds.

If no software trigger event has occured, the command returns `Invalid`.

Suffix:

<sb> 1...4, index of the serial bus

Return values:

<Time>	Range: -1E+26 to 1E+26 Increment: 1E-10 *RST: 0 Default unit: s

Usage: Query only
Asynchronous command

18.17.4.5 Decode results

SBUS<sb>:I2C:FCOunt?

Returns the number of decoded frames.

Suffix:

<sb>	1...4, index of the serial bus

Return values:

<Count>	Total number of decoded frames.

Usage: Query only
Asynchronous command

SBUS<sb>:I2C:FRAMe<fr>:AACCess?

Returns the address acknowledge bit value for the indicated frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<AddressAckBit> ACK | NACK | EITHer

*RST: EITHer

Usage: Query only
Asynchronous command

SBUS<sb>:I2C:FRAMe<fr>:ACCess?

Returns the value of the R/W bit of the indicated frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<RWBit> UNDefined | READ | WRITe | EITHer

*RST: UNDefined

Usage: Query only
Asynchronous command

SBUS<sb>:I2C:FRAMe<fr>:ACOMplete?

Returns if the address is completely contained in the acquisition.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<AddrComplete> OFF | ON

*RST: OFF

Usage: Query only
Asynchronous command

SBUS<sb>:I2C:FRAMe<fr>:ADBStart?

Returns the start time of the address acknowledge bit.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<AddrAckBtStrt>	Range: -1E+26 to 1E+26 Increment: 1E-10 *RST: 0 Default unit: s

Usage: Query only
Asynchronous command

SBUS<sb>:I2C:FRAMe<fr>:ADDRess?

Returns the device address value of the indicated frame. That is, the address value that is shown in the decoded cells and in the decode results table.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<AddressValue>	Range: 0 to 2047 Increment: 1 *RST: 0

Usage: Query only
Asynchronous command

SBUS<sb>:I2C:FRAMe<fr>:ADEVice?

Returns the pure device address of the indicated frame *without* the R/W bit.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<DeviceAddress>	Range: 0 to 1023 Increment: 1 *RST: 0

Usage: Query only
Asynchronous command

SBUS<sb>:I2C:FRAMe<fr>:AMODe?

Returns the address length.

See also `TRIGger:SBHW:I2C:AMODe` on page 1224.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<AddressType>	BIT7 | BIT7RW | BIT7_RW | BIT10 *RST: BIT7

Usage: Query only
Asynchronous command

SBUS<sb>:I2C:FRAMe<fr>:ASTart?

Returns the start time of the address for the indicated frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<AddressStart>	Range: -1E+26 to 1E+26 Increment: 1E-10 *RST: 0 Default unit: s

Usage: Query only
Asynchronous command

SBUS<sb>:I2C:FRAMe<fr>:BITRate?

Returns the primary bit rate.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<PrimaryBitRate>	Increment: 1 *RST: 0 Default unit: bps

Usage: Query only
Asynchronous command

SBUS<sb>:I2C:FRAMe<fr>:FLDCount?

Returns the number of fields in the specified frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<Count>

Usage: Query only
Asynchronous command

SBUS<sb>:I2C:FRAMe<fr>:FLD<fl>:FVALue?

Returns the formatted value of the specified field.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Return values:
<FormattedValue>

Usage: Query only
Asynchronous command

SBUS<sb>:I2C:FRAMe<fr>:FLD<fl>:LABel?

Returns the name (label) of the specified field in the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Return values:
<Label>

Usage: Query only
Asynchronous command

SBUS<sb>:I2C:FRAMe<fr>:FLD<fl>:STARt?

Returns the start time of the specified field.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Return values:

<Start>
Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0
Default unit: s

Usage: Query only
Asynchronous command

SBUS<sb>:I2C:FRAMe<fr>:FLD<fl>:STATe?

Returns the overall state of the specified field in the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Return values:

<State> OK | ADDifferent | NOSTop | UNKNown | INComplete

OK
The field has no error, it is valid.

ADDifferent
10-bit read address different. For a read access on a 10-bit address, the first address byte is sent twice, first as write, the second as read. The first 7 bits of the byte must be identical. If they are not identical, the ADDiffernt error is indicated.

NOSTop
The stop bit is missing.

UNKNown
Unknown field type detected.

INComplete
The field is not completely contained in the acquisition. The acquired part of the field is usually valid, but cannot always be trusted.

*RST: OK

Usage: Query only
Asynchronous command

SBUS<sb>:I2C:FRAMe<fr>:FLD<fl>:VALue?

Returns the data value of the specified field.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Return values:

<Value> Increment: 1
*RST: 0

Usage: Query only
Asynchronous command

SBUS<sb>:I2C:FRAMe<fr>:DATA?

Returns the data words of the specified frame as comma-separated values.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:

<Count>

<Values>

Example:
```
BUS:I2C:FRAMe4:DATA?
<-- 3,74,164,18
```

Usage: Query only
Asynchronous command

SBUS<sb>:I2C:FRAMe<fr>:RWBStart?

Returns the start time of the R/W bit

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:

<RWBitStart> Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0
Default unit: s

Usage: Query only
Asynchronous command

SBUS<sb>:I2C:FRAMe<fr>:STARt?

Returns the start time of the specified frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:

<FrameStart> Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0
Default unit: s

Usage: Query only
Asynchronous command

SBUS<sb>:I2C:FRAMe<fr>:STATus?

Returns the overall state of the frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<FrameState> OK | ADDifferent | NOSTop | UNKNown | INComplete

OK
The frame is valid.

ADDifferent
10-bit read address different. For a read access on a 10-bit address, the first address byte is sent twice, first as write, the second as read. The first 7 bits of the byte must be identical. If they are not identical, the ADDiffernt error is indicated.

NOSTop
The stop bit is missing.

UNKNown
Unknown frame type detected.

INComplete
The frame is not completely contained in the acquisition. The acquired part of the frame is usually valid, but cannot always be trusted.

*RST: OK

Usage: Query only
Asynchronous command

SBUS<sb>:I2C:FRAMe<fr>:STOP?

Returns the end time of the specified frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<FrameStop>
Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0
Default unit: s

Usage: Query only
Asynchronous command

SBUS<sb>:I2C:FRAMe<fr>:SYMBol?

Returns the symbolic label of the specified frame if the label list is enabled.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<Translation>	String with the symbolic name of the frame

Usage:	Query only Asynchronous command

18.17.5 I3C (option R&S MXO4-K550)

Before MXO 4 can accept the specific bus commands, make sure that:

- The decoding of the specified bus is enabled with `SBUS<sb>[:STATe]`.
- The bus is set to the correct type with `SBUS<sb>:TYPE`.

18.17.5.1 Configuration

SBUS<sb>:I3C:SCL:HYSTeresis <SCLHysteresis>

Sets a hysteresis value for the clock line.

Suffix:

<sb>	1...4, index of the serial bus

Parameters:

<SCLHysteresis>

Usage:	Asynchronous command

Manual operation: See "SDA/SCL threshold, SDA/SCL hysteresis" on page 510

SBUS<sb>:I3C:SCL:SOURce SCLSource

Selects the waveform source of the clock line.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
SCLSource C1 | C2 | C3 | C4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | M1 | M2 | M3 | M4 | M5 | R1 | R2 | R3 | R4 | O<n>C1 | O<n>C2 | ... | O<n>C8 (<n> = 2 to 8)

Usage: Asynchronous command

Manual operation: See "SCL source" on page 509

SBUS<sb>:I3C:SCL:THReshold <SCLThreshold>

Sets a user-defined threshold value for the clock line.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<SCLThreshold>

Usage: Asynchronous command

Manual operation: See "SDA/SCL threshold, SDA/SCL hysteresis" on page 510

SBUS<sb>:I3C:SDA:HYSTeresis <SDAHysteresis>

Sets a hysteresis value for the data line.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<SDAHysteresis>

Usage: Asynchronous command

Manual operation: See "SDA/SCL threshold, SDA/SCL hysteresis" on page 510

SBUS<sb>:I3C:SDA:SOURce SDASource

Sets the source channel to which the data line is connected.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:

SDASource	C1 | C2 | C3 | C4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | M1 | M2 | M3 | M4 | M5 | R1 | R2 | R3 | R4 | O<n>C1 | O<n>C2 | ... | O<n>C8 (<n> = 2 to 8)

Usage: Asynchronous command

Manual operation: See "SDA source" on page 509

SBUS<sb>:I3C:SDA:THReshold <SDAThreshold>

Sets a user-defined threshold value for the data line.

Suffix:

<sb> 1...4, index of the serial bus

Parameters:

<SDAThreshold>

Usage: Asynchronous command

Manual operation: See "SDA/SCL threshold, SDA/SCL hysteresis" on page 510

SBUS<sb>:I3C:MINGap:SELect <MingapSelect>

Specifies whether a minimum gap before the 1st decoded frame is required.

Suffix:

<sb> 1...4, index of the serial bus

Parameters:

<MingapSelect> OFF | ON

*RST: ON

Usage: Asynchronous command

Manual operation: See "Require min gap" on page 510

SBUS<sb>:I3C:MINGap:WIDTh <MingapWidth>

Specifies the minimum duration of the gap.

Available, if `SBUS<sb>:I3C:MINGap:SELect` is set to `ON`.

Suffix:

<sb> 1...4, index of the serial bus

Parameters:

<MingapWidth>
Range: 1E-11 to 1
Increment: 1E-11
*RST: 1E-06
Default unit: s

Usage: Asynchronous command

Manual operation: See "Min gap width" on page 510

SBUS<sb>:I3C:POSition <Position>

Sets the vertical position of the I3C signal.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<Position>

Usage: Asynchronous command

SBUS<sb>:I3C:SCALe <Scale>

Sets the vertical scale of the I3C signal.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<Scale>

Usage: Asynchronous command

SBUS<sb>:I3C:SYMBols <ShowSymbols>

Activates the symbol list to be used for decoding.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<ShowSymbols> OFF | ON
*RST: OFF

Usage: Asynchronous command

Manual operation: See "Show symbols" on page 511

SBUS<sb>:I3C:NEWList <FileName>

Loads a symbol list file.

Suffix:
<sb> 1...4, index of the serial bus

Setting parameters:
<FileName> String parameter with path and file name.

Example:
```
SBUS1:I3C:NEWList
'/home/storage/userData/Protocol/I3C.csv'
SBUS1:I3C:SYMBols ON
```

Usage: Setting only
Asynchronous command

Manual operation: See "Show symbols" on page 511

18.17.5.2 Filter

There are two commands for each parameter, that you can use for defining the I3C settings.

For example, to set the *Frame type =WRITe* > *Field =Address* >*Data* value you can use one of the following commands:

- `SBUS:I3C:FILTer:FRAMe1:FLD1:DMIN 01100`
  Defines the parameter by using the index <m> for the frame number and <n> for the field number.
- `SBUS:I3C:FILTer:DMIN "WRITe", "Address", 01100`
  Defines the parameter by using the frame and field name.

SBUS<sb>:I3C:FILTer:CHKall

Enables the filter for all available frames and error types.

Suffix:

<sb> 1...4, index of the serial bus

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 513

SBUS<sb>:I3C:FILTer:CLR

Disables the filter for all available frames and error types.

Suffix:
<sb> 1...4, index of the serial bus

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 513

SBUS<sb>:I3C:FILTer:INVert

Inverts the current state of the frame and error types: all frames and error types that were enabled are disabled and vice versa.

Suffix:
<sb> 1...4, index of the serial bus

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 513

SBUS<sb>:I3C:FILTer:RST

Presets the state of the selected frames and error types.

Suffix:
<sb> 1...4, index of the serial bus

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 513

SBUS<sb>:I3C:FILTer:FRENable <Frame>,<Enabler>
SBUS<sb>:I3C:FILTer:FRENable? <Enabler>
SBUS<sb>:I3C:FILTer:FRAMe<fr>:ENABle <Enable>

Enables or disables the specific frame to be filtered on.

Suffix:
<sb> 1...4, index of the serial bus

<fr> Index of the frame

Parameters:

<Enable> OFF | ON
*RST: ON

Usage: Asynchronous command

Manual operation: See "Frame type" on page 513

SBUS<sb>:I3C:FILTer:DMAX <Frame>,<Field>,<Data>
SBUS<sb>:I3C:FILTer:DMAX? <Data>
SBUS<sb>:I3C:FILTer:FRAMe<fr>:FLD<fl>:DMAX <Data_Max>

Sets the end value of a data pattern range if the operator is set to `INRange` or `OORANGe`.

You can set the operator with `SBUS<sb>:I3C:FILTer:DMAX`.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Parameters:

<Data_Max>

Usage: Asynchronous command

Manual operation: See "Edit" on page 513

SBUS<sb>:I3C:FILTer:DMIN <Frame>,<Field>,<Data>
SBUS<sb>:I3C:FILTer:DMIN? <Data>
SBUS<sb>:I3C:FILTer:FRAMe<fr>:FLD<fl>:DMIN <Data_Min>

Specifies the data pattern, or sets the start value of a data pattern range.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Parameters:

<Data_Min>

Usage: Asynchronous command

Manual operation: See "Edit" on page 513

SBUS<sb>:I3C:FILTer:DOPerator <Frame>,<Field>,<Operator>
SBUS<sb>:I3C:FILTer:DOPerator? <Operator>
SBUS<sb>:I3C:FILTer:FRAMe<fr>:FLD<fl>:DOPerator <Data_Operator>

Sets the operator for the data pattern in the selected field of the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Data_Operator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

*RST: EQUal

Usage: Asynchronous command

Manual operation: See "Edit" on page 513

SBUS<sb>:I3C:FILTer:ERENable <ErrorName>,<Enabler>
SBUS<sb>:I3C:FILTer:ERENable? <Enabler>
SBUS<sb>:I3C:FILTer:ERRor<n>:ENABle <Enable>

Defines the error type to be filtered on.

Suffix:

<sb>	1...4, index of the serial bus
<n>	Index of the error

Parameters:

<Enable> OFF | ON

*RST: ON

Usage: Asynchronous command

Manual operation: See "Error type" on page 515

SBUS<sb>:I3C:FILTer:IMAX <Frame>,<Field>,<Data>
SBUS<sb>:I3C:FILTer:IMAX? <Data>
SBUS<sb>:I3C:FILTer:FRAMe<fr>:FLD<fl>:IMAX <Index_Max>

Sets the end value of an index range if the operator is set to `INRange`.

You can set the operator with `SBUS<sb>:I3C:FILTer:IOPerator`.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Index_Max>
Range: 1 to 65535
Increment: 1
*RST: 65535

Usage: Asynchronous command

Manual operation: See "Edit" on page 513

SBUS<sb>:I3C:FILTer:IMIN <Frame>,<Field>,<Data>
SBUS<sb>:I3C:FILTer:IMIN? <Data>
SBUS<sb>:I3C:FILTer:FRAMe<fr>:FLD<fl>:IMIN <Index_Min>

Specifies the index, or sets the start value of an index range.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Index_Min> Range: 1 to 65535
Increment: 1
*RST: 1

Usage: Asynchronous command

Manual operation: See "Edit" on page 513

SBUS<sb>:I3C:FILTer:IOPerator <Frame>,<Field>,<Operator>
SBUS<sb>:I3C:FILTer:IOPerator? <Operator>
SBUS<sb>:I3C:FILTer:FRAMe<fr>:FLD<fl>:IOPerator <Index_Operator>

Sets the operator for the index in the selected field of the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Index_Operator> EQUal | INRange | RANGe
*RST: INRange

Usage: Asynchronous command

Manual operation: See "Edit" on page 513

SBUS<sb>:I3C:FILTer:BIT <Frame>,<Field>,<Bit>
SBUS<sb>:I3C:FILTer:BIT? <Bit>
SBUS<sb>:I3C:FILTer:FRAMe<fr>:FLD<fl>:BIT <BitState>

Sets the bit state of a field that only consists of one bit.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

<fl> Index of the field

Parameters:
<BitState> ONE | ZERO
*RST: ZERO

Usage: Asynchronous command

Manual operation: See "Edit" on page 513

SBUS<sb>:I3C:FILTer:FIENable <Frame>,<Field>,<Enabler>
SBUS<sb>:I3C:FILTer:FIENable? <Enabler>
SBUS<sb>:I3C:FILTer:FRAMe<fr>:FLD<fl>:ENABle <CondEnabler>

Enables or disables the checking condition for the selected field of the selected frame.

Suffix:
<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Parameters:
<CondEnabler> OFF | ON
*RST: OFF

Usage: Asynchronous command

Manual operation: See "Edit" on page 513

18.17.5.3 Software trigger

There are two commands for each parameter, that you can use for defining the I3C settings.

For example, to set the *Frame type =WRITe > Field =Address >Data* value you can use one of the following commands:

- `TRIGger:SBSW:I3C:FRAMe1:FLD1:DMIN 01100`
  Defines the parameter by using the index <m> for the frame number and <n> for the field number.
- `STRIGger:SBSW:I3C:DMIN "WRITe", "Address", 01100`
  Defines the parameter by using the frame and field name.

TRIGger:SBSW:I3C:CHKall

Enables the software trigger for all available frames and error types.

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 516

TRIGger:SBSW:I3C:CLR

Disables the software trigger for all available frames and error types.

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 516

TRIGger:SBSW:I3C:INVert

Inverts the current state of the frame and error types for the software trigger: all frames and error types that were enabled are disabled and vice versa.

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 516

TRIGger:SBSW:I3C:RST

Presets the state of the selected frames and error types for the software trigger.

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 516

TRIGger:SBSW:I3C:FRENable <Frame>,<Enabler>
TRIGger:SBSW:I3C:FRENable? <Enabler>
TRIGger:SBSW:I3C:FRAMe<fr>:ENABle <Enable>

Enables or disables the checking condition for the selected frame for the software trigger.

Suffix:
<fr> Index of the frame

Parameters:
<Enable> OFF | ON
*RST: ON

Usage: Asynchronous command

Manual operation: See "Frame type" on page 516

TRIGger:SBSW:I3C:BIT <Frame>,<Field>,<Bit>
TRIGger:SBSW:I3C:BIT? <Bit>
TRIGger:SBSW:I3C:FRAMe<fr>:FLD<fl>:BIT <BitState>

Sets the bit state of a field that only consists of one bit for the software trigger.

Suffix:
<fr> Index of the frame

<fl> Index of the field

Parameters:
<BitState> ONE | ZERO
*RST: ZERO

Usage: Asynchronous command

Manual operation: See "Edit" on page 516

TRIGger:SBSW:I3C:DMAX <Frame>,<Field>,<Data>
TRIGger:SBSW:I3C:DMAX? <Data>
TRIGger:SBSW:I3C:FRAMe<fr>:FLD<fl>:DMAX <Data_Max>

Sets the end value of a data pattern range for the software trigger, if the operator is set to `INRange` or `OORANGe`.

You can set the operator with `TRIGger:SBSW:I3C:FRAMe<fr>:FLD<fl>:DOPerator`.

Suffix:
<fr> Index of the frame

<fl> Index of the field

Parameters:

<Data_Max>	List of comma-separated values

Usage: Asynchronous command

Manual operation: See "Edit" on page 516

TRIGger:SBSW:I3C:DMIN <Frame>,<Field>,<Data>
TRIGger:SBSW:I3C:DMIN? <Data>
TRIGger:SBSW:I3C:FRAMe<fr>:FLD<fl>:DMIN <Data_Min>

Specifies the data pattern, or sets the start value of a data pattern range for the software trigger.

Suffix:

<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Data_Min>	List of comma-separated values

Usage: Asynchronous command

Manual operation: See "Edit" on page 516

TRIGger:SBSW:I3C:DOPerator <Frame>,<Field>,<Operator>
TRIGger:SBSW:I3C:DOPerator? <Operator>
TRIGger:SBSW:I3C:FRAMe<fr>:FLD<fl>:DOPerator <Data_Operator>

Sets the operator for the data pattern of the software trigger in the selected field of the selected frame.

Suffix:

<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Data_Operator>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange *RST: EQUal

Usage: Asynchronous command

Manual operation: See "Edit" on page 516

TRIGger:SBSW:I3C:FIENable <Frame>,<Field>,<Enabler>
TRIGger:SBSW:I3C:FIENable? <Enabler>
TRIGger:SBSW:I3C:FRAMe<fr>:FLD<fl>:ENABle <CondEnabler>

Enables or disables the checking condition for the selected field of the selected frame of the software trigger.

Suffix:

<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<CondEnabler>	OFF | ON *RST: OFF

Usage: Asynchronous command

Manual operation: See "Edit" on page 516

TRIGger:SBSW:I3C:IMAX <Frame>,<Field>,<Data>
TRIGger:SBSW:I3C:IMAX? <Data>
TRIGger:SBSW:I3C:FRAMe<fr>:FLD<fl>:IMAX <Index_Max>

Sets the end value of an index range for the software trigger if the operator is set to `INRange`.

You can set the operator with `TRIGger:SBSW:I3C:FRAMe<fr>:FLD<fl>:IOPerator`.

Suffix:

<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Index_Max>	Range: 1 to 65535 Increment: 1 *RST: 65535

Usage: Asynchronous command

Manual operation: See "Edit" on page 516

TRIGger:SBSW:I3C:IMIN <Frame>,<Field>,<Data>
TRIGger:SBSW:I3C:IMIN? <Data>
TRIGger:SBSW:I3C:FRAMe<fr>:FLD<fl>:IMIN <Index_Min>

Specifies the index, or sets the start value of an index range for the software trigger.

Suffix:

<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Index_Min>	Range: 1 to 65535 Increment: 1 *RST: 1

Usage: Asynchronous command

Manual operation: See "Edit" on page 516

TRIGger:SBSW:I3C:IOPerator <Frame>,<Field>,<Operator>
TRIGger:SBSW:I3C:IOPerator? <Operator>
TRIGger:SBSW:I3C:FRAMe<fr>:FLD<fl>:IOPerator <Index_Operator>

Sets the operator for the index in the selected field of the selected frame for the software trigger.

Suffix:

<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Index_Operator> EQUal | INRange | RANGe
*RST: INRange

Usage: Asynchronous command

Manual operation: See "Edit" on page 516

TRIGger:SBSW:I3C:ERENable <ErrorName>,<Enabler>
TRIGger:SBSW:I3C:ERENable? <Enabler>
TRIGger:SBSW:I3C:ERRor<m>:ENABle <Enable>

Defines the error type for the software trigger.

Suffix:

<m> Index of the error

Parameters:

<Enable> OFF | ON
*RST: ON

Usage: Asynchronous command

Manual operation: See "Error type" on page 518

SBUS<sb>:I3C:SWTindex?

Queries the software trigger index.

If no software trigger event has occurred, the command returns `Invalid`.

Suffix:

<sb> 1...4, index of the serial bus

Return values:

<Index> Range: 0 to 4294967295
Increment: 1
*RST: 0

Usage: Query only
Asynchronous command

SBUS<sb>:I3C:SWTTime?

Queries the software trigger time in seconds.

If no software trigger event has occured, the command returns `Invalid`.

Suffix:

<sb> 1...4, index of the serial bus

Return values:

<Time> Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0
Default unit: s

Usage: Query only
Asynchronous command

18.17.5.4 Decode results

SBUS<sb>:I3C:FCOunt?

Returns the number of decoded frames.

Suffix:

<sb> 1...4, index of the serial bus
Selects the serial bus.

Return values:

<Count> Total number of decoded frames.

Usage: Query only
Asynchronous command

SBUS<sb>:I3C:FRAMe<fr>:ADDRess?

Returns the device address value of the indicated frame. That is, the address value that is shown in the decoded cells and in the decode results table.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:

<AddressValue> Range: 0 to 65535
Increment: 1
*RST: 0

Usage: Query only
Asynchronous command

SBUS<sb>:I3C:FRAMe<fr>:ASTart?

Returns the start time of the address for the indicated frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:

<AddressStart> Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0
Default unit: s

Usage: Query only
Asynchronous command

SBUS<sb>:I3C:FRAMe<fr>:FLDCount?

Returns the number of fields in the specified frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:

<Count>

Usage: Query only
Asynchronous command

SBUS<sb>:I3C:FRAMe<fr>:BITRate?

Returns the primary bit rate.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:

<BitRate> Increment: 1
*RST: 0
Default unit: bps

Usage: Query only
Asynchronous command

SBUS<sb>:I3C:FRAMe<fr>:DATA?

Returns the data words of the specified frame in comma-separated values.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:

<Count>

<Values>

Example:

```
BUS:I3C:FRAMe4:DATA?
<-- 3,74,164,18
```

Usage: Query only
Asynchronous command

SBUS<sb>:I3C:FRAMe<fr>:RWBStart?

Returns the start time of the R/W bit

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:

<RWBitStart> Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0
Default unit: s

Usage: Query only
Asynchronous command

SBUS<sb>:I3C:FRAMe<fr>:STARt?

Returns the start time of the specified frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:

<FrameStart> Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0
Default unit: s

Usage: Query only
Asynchronous command

SBUS<sb>:I3C:FRAMe<fr>:STATus?

Returns the overall state of the frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:

<FrameState> OK | ACK | PAR | CRC | LENGth | UNKNown | INComplete

OK
The frame is valid.

ACK
Wrong acknowledgment (ACK) delimiter occurred.

PAR
Wrong parity detected.

CRC
Cyclic redundancy check failed.

LENGth
Wrong length of frame.

UNKNown
Unknown frame type detected.

INComplete
The frame is not completely contained in the acquisition. The acquired part of the frame is usually valid, but cannot always be trusted.

*RST: OK

Usage: Query only
Asynchronous command

SBUS<sb>:I3C:FRAMe<fr>:STOP?

Returns the end time of the specified frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:

<FrameStop> Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0
Default unit: s

Usage: Query only
Asynchronous command

SBUS<sb>:I3C:FRAMe<fr>:SYMBol?

Returns the symbolic label of the specified frame if the label list is enabled.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:

<Translation> String with the symbolic name of the frame

Usage: Query only
Asynchronous command

SBUS<sb>:I3C:FRAMe<fr>:ACK?

Returns the value of the acknowledge bit for the selected frame. Because this ACK bit is transmitted right after the address field, it acknowledges receiving the address.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:

<AckBitValue> ACK | NACK | EITHer
*RST: EITHer

Usage: Query only
Asynchronous command

SBUS<sb>:I3C:FRAMe<fr>:ACKStart?

Returns the start time of the acknowledge bit for the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<AckBitStart>
Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0
Default unit: s

Usage: Query only
Asynchronous command

SBUS<sb>:I3C:FRAMe<fr>:FLD<fl>:FVALue?

Returns the formatted value of the specified field for the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Return values:

<FormattedValue>

Usage: Query only
Asynchronous command

SBUS<sb>:I3C:FRAMe<fr>:FLD<fl>:LABel?

Returns the name (label) of the specified field in the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Return values:

<Label>

Usage: Query only
Asynchronous command

SBUS<sb>:I3C:FRAMe<fr>:FLD<fl>:STATe?

Returns the overall state of the specified field for the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Return values:

<State> OK | ACK | PAR | CRC | LENGth | UNKNown | INComplete

OK
The field has no error, it is valid.

ACK
Wrong acknowledgment (ACK) delimiter occurred.

PAR
Wrong parity detected.

CRC
Cyclic redundancy check failed.

LENGth
Wrong length of the field.

UNKNown
Unknown field type detected.

INComplete
The field is not completely contained in the acquisition. The acquired part of the field is usually valid, but cannot always be trusted.

*RST: OK

Usage: Query only
Asynchronous command

SBUS<sb>:I3C:FRAMe<fr>:FLD<fl>:VALue?

Returns the data value of the specified field.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Return values:

<Value> Increment: 1
*RST: 0

Usage: Query only
Asynchronous command

SBUS<sb>:I3C:FRAMe<fr>:COMMand?

Returns the selected frame's command response, which is an integer.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<Response> Range: 0 to 65535
Increment: 1
*RST: 0

Usage: Query only
Asynchronous command

SBUS<sb>:I3C:FRAMe<fr>:CRC?

Returns the cyclic redundancy check (CRC) checksum of the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<CRCValue> Range: 0 to 65535
Increment: 1
*RST: 0

Usage: Query only
Asynchronous command

SBUS<sb>:I3C:FRAMe<fr>:FADDress?

Returns the formatted address for the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<FormattedAddrVal>

Usage: Query only
Asynchronous command

SBUS<sb>:I3C:FRAMe<fr>:FCOMmand?

Returns the formatted command from the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:
<FormattedCmd>

Usage: Query only
Asynchronous command

SBUS<sb>:I3C:FRAMe<fr>:FCRC?

Returns the formatted CRC value for the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:
<FormattedCRCVal>

Usage: Query only
Asynchronous command

SBUS<sb>:I3C:FRAMe<fr>:RWBit?

Returns the value of the R/W bit of the selected frame. The value "0" denotes "Write", the value "1" denotes "Read".

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<RWBitValue>	UNDefined | READ | WRITe | EITHer
	*RST: UNDefined

Usage: Query only
Asynchronous command

SBUS<sb>:I3C:FRAMe<fr>:TYPE?

Returns the frame type of the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<FrameType>	UNKNown | PROB | READ | WRIT | BRDC | DRCT | HDDR | HTSX
	*RST: UNKNown

Usage: Query only
Asynchronous command

18.17.6 UART / RS-232 (option R&S MXO4- K510)

Before MXO 4 can accept the specific bus commands, make sure that:

- The decoding of the specified bus is enabled with `SBUS<sb>[:STATe]`.
- The bus is set to the correct type with `SBUS<sb>:TYPE`.

18.17.6.1 Configuration

SBUS<sb>:UART:BITRate <Bitrate>

Sets the number of transmitted bits per second.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<Bitrate> Range: 300 to 20000000
Increment: 1
*RST: 9600
Default unit: bps

Usage: Asynchronous command

Manual operation: See "Bit rate" on page 526

SBUS<sb>:UART:BORDer <BitOrder>

Selects the bit order, which determines if the data of the messages starts with MSB (most significant bit) or LSB (least significant bit).

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<BitOrder> LSBF | MSBF

*RST: LSBF

Usage: Asynchronous command

Manual operation: See "Bit order" on page 526

SBUS<sb>:UART:PACKets <FrmSeparation>

Defines the method of packet separation. A packet is a number of subsequent words in a date stream.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<FrmSeparation> NONE | TOUT

NONE
Packets are not considered.

TOUT
Defines a timeout between the packets. To set the timeout, use `SBUS<sb>:UART:TOUT`.

*RST: TOUT

Usage: Asynchronous command

Manual operation: See "Packets" on page 527

SBUS<sb>:UART:PARity <Parity>

Defines the optional parity bit that is used for error detection.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<Parity> NONE | ODD | EVEN | MARK | SPC | DC

MARK
The parity bit is always a logic 1.

SPC
SPaCe: The parity bit is always a logic 0.

DC
Do not care: the parity is ignored.

*RST: NONE

Usage: Asynchronous command

Manual operation: See "Parity" on page 526

SBUS<sb>:UART:POLarity <Polarity>

Defines the logic levels of the bus. The idle state corresponds to a logic 1. The start bit corresponds to a logic 0. "Idle high" (high=1) is used, for example, for control signals, while "Idle low" (low=1) is defined for data lines (RS-232).

Suffix:

<sb> 1...4, index of the serial bus

Parameters:

<Polarity> IDLLow | IDLHigh

*RST: IDLHigh

Usage: Asynchronous command

Manual operation: See "Polarity" on page 526

SBUS<sb>:UART:RX:HYSTeresis <Rx hysteresis>

Sets the hysteresis for the Tx line.

Suffix:

<sb> 1...4, index of the serial bus

Parameters:

<Rx hysteresis>

Usage: Asynchronous command

Manual operation: See "Threshold" on page 527

SBUS<sb>:UART:RX:SOURce RXSource

Selects the input channel for the receiver signal.

Suffix:

<sb> 1...4, index of the serial bus

Parameters:

RXSource C1 | C2 | C3 | C4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | M1 | M2 | M3 | M4 | M5 | R1 | R2 | R3 | R4 | O<n>C1 | O<n>C2 | ... | O<n>C8 (<n> = 2 to 8)

Usage: Asynchronous command

Manual operation: See "Source: Tx, Rx" on page 526

SBUS<sb>:UART:RX:THReshold <Rx threshold>

Sets a user-defined threshold value for the Rx line.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<Rx threshold>

Usage: Asynchronous command

Manual operation: See "Threshold" on page 527

SBUS<sb>:UART:SBIT <StopBits>

Sets the number of stop bits: 1 or 1.5 or 2 stop bits are possible.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<StopBits> B1 | B15 | B2
*RST: B1

Usage: Asynchronous command

Manual operation: See "Stop bits" on page 526

SBUS<sb>:UART:SSIZe <DataBits>

Sets the number of data bits of a word in a range from 5 bits to 8 bits. If no parity bit is used, then 9 data bits are possible.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<DataBits> Range: 5 to 9
Increment: 1
*RST: 8

Usage: Asynchronous command

Manual operation: See "Data bits" on page 526

SBUS<sb>:UART:TOUT <Timeout>

Sets the timeout between packets in a UART data stream. A new packet starts with the first start bit after the timeout.

The command is relevant if `SBUS<sb>:UART:PACKets` is set to `TOUT`.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:

<Timeout>	Range:	1E-06 to 1
	Increment:	1
	*RST:	0.000625
	Default unit:	s

Usage: Asynchronous command

Manual operation: See "Packets" on page 527

SBUS<sb>:UART:TX:HYSTeresis <Tx hysteresis>

Sets the hysteresis for the TX line.

Suffix:

<sb> 1...4, index of the serial bus

Parameters:

<Tx hysteresis>

Usage: Asynchronous command

Manual operation: See "Threshold" on page 527

SBUS<sb>:UART:TX:SOURce TXSource

Selects the input channel for the transmitter signal.

Suffix:

<sb> 1...4, index of the serial bus

Parameters:

TXSource C1 | C2 | C3 | C4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | M1 | M2 | M3 | M4 | M5 | R1 | R2 | R3 | R4 | O<n>C1 | O<n>C2 | ... | O<n>C8 (<n> = 2 to 8)

Usage: Asynchronous command

Manual operation: See "Source: Tx, Rx" on page 526

SBUS<sb>:UART:TX:THReshold <Tx threshold>

Sets a user-defined threshold value for the Tx line.

Suffix:

<sb> 1...4, index of the serial bus

Parameters:

<Tx threshold> User-defined clock threshold

Usage: Asynchronous command

Manual operation: See "Threshold" on page 527

SBUS<sb>:UART:RX:POSition <Rx position>

Sets the vertical position of the RX UART signal.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<Rx position>

Usage: Asynchronous command

SBUS<sb>:UART:RX:SCALe <Rx scale>

Set the vertical scale of the RX UART signal.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<Rx scale>

Usage: Asynchronous command

SBUS<sb>:UART:TX:POSition <Tx position>

Sets the vertical position of the TX UART signal.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<Tx position>

Usage: Asynchronous command

SBUS<sb>:UART:TX:SCALe <Tx scale>

Set the vertical scale of the TX UART signal.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<Tx scale>

Usage: Asynchronous command

18.17.6.2 Filter

There are two commands for each parameter, that you can use for defining the UART settings.

For example, to set the *Frame type =Tx > Field =Data >01100* value you can use one of the following commands:

- `SBUS:UART:FILTer:FRAMe1:FLD1:DMIN 01100`
  Defines the parameter by using the index <m> for the frame number and <n> for the field number.
- `SBUS:UART:FILTer:DMIN "Tx", "Data", 01100`
  Defines the parameter by using the frame and field name.

SBUS<sb>:UART:FILTer:CHKall

Enables the filter for all available frames and error types.

Suffix:
<sb> 1...4, index of the serial bus

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 529

SBUS<sb>:UART:FILTer:CLR

Disables the filter for all available frames and error types.

Suffix:
<sb> 1...4, index of the serial bus

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 529

SBUS<sb>:UART:FILTer:INVert

Inverts the current state of the frame and error types: all frames and error types that were enabled are disabled and vice versa.

Suffix:
<sb> 1...4, index of the serial bus

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 529

SBUS<sb>:UART:FILTer:RST

Presets the state of the selected frames and error types.

Suffix:
<sb> 1...4, index of the serial bus

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 529

SBUS<sb>:UART:FILTer:IMIN <Frame>,<Field>,<Data>
SBUS<sb>:UART:FILTer:IMIN? <Data>
SBUS<sb>:UART:FILTer:FRAMe<fr>:FLD<fl>:IMIN <Index_Min>

Specifies the index, or sets the start value of an index range.

Suffix:
<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Parameters:
<Index_Min> Range: 1 to 65535
Increment: 1
*RST: 1

Usage: Asynchronous command

Manual operation: See "Edit" on page 529

SBUS<sb>:UART:FILTer:IMAX <Frame>,<Field>,<Data>
SBUS<sb>:UART:FILTer:IMAX? <Data>
SBUS<sb>:UART:FILTer:FRAMe<fr>:FLD<fl>:IMAX <Index_Max>

Sets the end value of an index range if the operator is set to `INRange`.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Index_Max>	Range: 1 to 65535 Increment: 1 *RST: 65535

Usage: Asynchronous command

Manual operation: See "Edit" on page 529

SBUS<sb>:UART:FILTer:IOPerator <Frame>,<Field>,<Operator>
SBUS<sb>:UART:FILTer:IOPerator? <Operator>
SBUS<sb>:UART:FILTer:FRAMe<fr>:FLD<fl>:IOPerator <Index_Operator>

Sets the operator for the index in the selected field of the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Index_Operator>	EQUal | INRange | RANGe *RST: INRange

Usage: Asynchronous command

Manual operation: See "Edit" on page 529

SBUS<sb>:UART:FILTer:ERENable <ErrorName>,<Enabler>
SBUS<sb>:UART:FILTer:ERENable? <Enabler>
SBUS<sb>:UART:FILTer:ERRor<n>:ENABle <Enable>

Defines the error type to be filtered on.

Suffix:

<sb>	1...4, index of the serial bus
<n>	Index of the error

Parameters:

<Enable>	OFF | ON *RST: ON

Usage: Asynchronous command

Manual operation: See "Error type" on page 530

SBUS<sb>:UART:FILTer:DOPerator <Frame>,<Field>,<Operator>
SBUS<sb>:UART:FILTer:DOPerator? <Operator>
SBUS<sb>:UART:FILTer:FRAMe<fr>:FLD<fl>:DOPerator <Data_Operator>

Sets the operator for the data pattern in the selected field of the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Data_Operator>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange *RST: EQUal

Usage: Asynchronous command

Manual operation: See "Edit" on page 529

SBUS<sb>:UART:FILTer:DMIN <Frame>,<Field>,<Data>
SBUS<sb>:UART:FILTer:DMIN? <Data>
SBUS<sb>:UART:FILTer:FRAMe<fr>:FLD<fl>:DMIN <Data_Min>

Specifies the data pattern, or sets the start value of a data pattern range.

Suffix:

<sb>	1..4 Selects the serial bus.
<fr>	* Specifies the frame number.
<fl>	* Specifies the field number within the frame.

Parameters:

<Data_Min>

Usage: Asynchronous command

Manual operation: See "Edit" on page 529

SBUS<sb>:UART:FILTer:DMAX <Frame>,<Field>,<Data>
SBUS<sb>:UART:FILTer:DMAX? <Data>
SBUS<sb>:UART:FILTer:FRAMe<fr>:FLD<fl>:DMAX <Data_Max>

Sets the end value of a data pattern range if the operator is set to `INRange` or `OORANGe`.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:
<Data_Max>

Usage: Asynchronous command

Manual operation: See "Edit" on page 529

SBUS<sb>:UART:FILTer:BIT <Frame>,<Field>,<Bit>
SBUS<sb>:UART:FILTer:BIT? <Bit>
SBUS<sb>:UART:FILTer:FRAMe<fr>:FLD<fl>:BIT <BitState>

Sets the bit state of a field that only consists of one bit.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:
<BitState> ONE | ZERO
*RST: ZERO

Usage: Asynchronous command

Manual operation: See "Edit" on page 529

SBUS<sb>:UART:FILTer:FRENable <Frame>,<Enabler>
SBUS<sb>:UART:FILTer:FRENable? <Enabler>
SBUS<sb>:UART:FILTer:FRAMe<fr>:ENABle <Enable>

Enables or disables the checking condition for the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Parameters:
<Enable> OFF | ON
*RST: ON

Usage: Asynchronous command

Manual operation: See "Frame type" on page 529

SBUS<sb>:UART:FILTer:FIENable <Frame>,<Field>,<Enabler>
SBUS<sb>:UART:FILTer:FIENable? <Enabler>
SBUS<sb>:UART:FILTer:FRAMe<fr>:FLD<fl>:ENABle <CondEnabler>

Enables or disables the checking condition for the selected field of the selected frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Parameters:

<CondEnabler> OFF | ON

*RST: OFF

Usage: Asynchronous command

Manual operation: See "Edit" on page 529

18.17.6.3 Hardware trigger

Trigger commands for serial buses affect the current trigger source. Therefore, set the trigger source to the required serial bus with `TRIGger:EVENt<ev>:SOURce` before sending the bus-specific trigger commands.

TRIGger:SBHW:UART:DATA <DataPattern>

Specifies the data pattern to be found on the specified trigger source. Enter the words in MSB first bit order.

Parameters:

<DataPattern>

Usage: Asynchronous command

Manual operation: See "Value" on page 531

TRIGger:SBHW:UART:DPOSition <DataPosition>

Sets the number of words before the first word of interest. These offset words are ignored.

Parameters:
<DataPosition> Range: 1 to 4096
Increment: 1
*RST: 1

Usage: Asynchronous command

Manual operation: See "Position" on page 531

TRIGger:SBHW:UART:FCONdition <DataOperator>

Selects the operator for the "Data" pattern.

Parameters:
<DataOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
*RST: EQUal

Usage: Asynchronous command

Manual operation: See "Data" on page 531

TRIGger:SBHW:UART:OPERator <DataOperator>

Sets the operator for the data pattern in the selected field of the selected frame.

Parameters:
<DataOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
*RST: EQUal

Usage: Asynchronous command

TRIGger:SBHW:UART:SOURce <Source>

Selects the transmitter or receiver line as trigger source.

Parameters:
<Source> TX | RX
*RST: TX

Usage: Asynchronous command

TRIGger:SBHW:UART:TYPE <Type>

Selects the trigger type condition.

Parameters:
<Type> STBT | PCKS | DATA | PRER | BRKC | STPerror
STBT: Start bit
PCKS: Packet start
DATA: Serial pattern
PRER: Parity error
BRKC: Break condition

STPerror: Stop error

*RST: STBT

Usage: Asynchronous command

18.17.6.4 Software trigger

There are two commands for each parameter, that you can use for defining the UART settings.

For example, to set the *Frame type =Tx > Field =Data >01100* value you can use one of the following commands:

- `TRIGger:SBSW:UART:FRAMe1:FLD1:DMIN 01100`
  Defines the parameter by using the index <m> for the frame number and <n> for the field number.
- `TRIGger:SBSW:UART:DMIN "Tx", "Data", 01100`
  Defines the parameter by using the frame and field name.

TRIGger:SBSW:UART:CHKall

Enables the software trigger for all available frames and error types.

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 532

TRIGger:SBSW:UART:CLR

Disables the software trigger for all available frames and error types.

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 532

TRIGger:SBSW:UART:INVert

Inverts the current state of the frame and error types for the software trigger: all frames and error types that were enabled are disabled and vice versa.

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 532

TRIGger:SBSW:UART:RST

Presets the state of the selected frames and error types for the software trigger.

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 532

TRIGger:SBSW:UART:FRENable <Frame>,<Enabler>
TRIGger:SBSW:UART:FRENable? <Enabler>
TRIGger:SBSW:UART:FRAMe<fr>:ENABle <Enable>

Enables or disables the checking condition for the selected frame for the software trigger.

Suffix:
<fr> Index of the frame

Parameters:
<Enable> OFF | ON
*RST: ON

Usage: Asynchronous command

Manual operation: See "Frame type" on page 533

TRIGger:SBSW:UART:BIT <Frame>,<Field>,<Bit>
TRIGger:SBSW:UART:BIT? <Bit>
TRIGger:SBSW:UART:FRAMe<fr>:FLD<fl>:BIT <BitState>

Sets the bit state of a field that only consists of one bit for the software trigger.

Suffix:

<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<BitState>	ONE | ZERO *RST: ZERO

Usage: Asynchronous command

Manual operation: See "Edit" on page 533

TRIGger:SBSW:UART:DMAX <Frame>,<Field>,<Data>
TRIGger:SBSW:UART:DMAX? <Data>
TRIGger:SBSW:UART:FRAMe<fr>:FLD<fl>:DMAX <Data_Max>

Sets the end value of a data pattern range for the software trigger, if the operator is set to `INRange` or `OORANGe`.

You can set the operator with `TRIGger:SBSW:UART:FRAMe<fr>:FLD<fl>:DOPerator`.

Suffix:

<fr>	Index of the frame
<fl>	Index of the field

Parameters:
<Data_Max>

Usage: Asynchronous command

Manual operation: See "Edit" on page 533

TRIGger:SBSW:UART:DMIN <Frame>,<Field>,<Data>
TRIGger:SBSW:UART:DMIN? <Data>
TRIGger:SBSW:UART:FRAMe<fr>:FLD<fl>:DMIN <Data_Min>

Specifies the data pattern, or sets the start value of a data pattern range for the software trigger.

Suffix:

<fr>	Index of the frame
<fl>	Index of the field

Parameters:
<Data_Min>

Usage: Asynchronous command

Manual operation: See "Edit" on page 533

TRIGger:SBSW:UART:DOPerator <Frame>,<Field>,<Operator>
TRIGger:SBSW:UART:DOPerator? <Operator>
TRIGger:SBSW:UART:FRAMe<fr>:FLD<fl>:DOPerator <Data_Operator>

Sets the operator for the data pattern of the software trigger in the selected field of the selected frame.

Suffix:

<fr> Index of the frame

<fl> Index of the field

Parameters:

<Data_Operator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

*RST: EQUal

Usage: Asynchronous command

Manual operation: See "Edit" on page 533

TRIGger:SBSW:UART:FIENable <Frame>,<Field>,<Enabler>
TRIGger:SBSW:UART:FIENable? <Enabler>
TRIGger:SBSW:UART:FRAMe<fr>:FLD<fl>:ENABle <CondEnabler>

Enables or disables the checking condition for the selected field of the selected frame of the software trigger.

Suffix:

<fr> Index of the frame

<fl> Index of the field

Parameters:

<CondEnabler> OFF | ON

*RST: OFF

Usage: Asynchronous command

Manual operation: See "Frame type" on page 533

TRIGger:SBSW:UART:IMAX <Frame>,<Field>,<Data>
TRIGger:SBSW:UART:IMAX? <Data>
TRIGger:SBSW:UART:FRAMe<fr>:FLD<fl>:IMAX <Index_Max>

Sets the end value of an index range for the software trigger if the operator is set to `INRange`.

You can set the operator with `TRIGger:SBSW:UART:FRAMe<fr>:FLD<fl>:IOPerator`.

Suffix:

<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Index_Max> Range: 1 to 65535
Increment: 1
*RST: 65535

Usage: Asynchronous command

Manual operation: See "Edit" on page 533

TRIGger:SBSW:UART:IMIN <Frame>,<Field>,<Data>
TRIGger:SBSW:UART:IMIN? <Data>
TRIGger:SBSW:UART:FRAMe<fr>:FLD<fl>:IMIN <Index_Min>

Specifies the index, or sets the start value of an index range for the software trigger.

Suffix:

<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Index_Min> Range: 1 to 65535
Increment: 1
*RST: 1

Usage: Asynchronous command

Manual operation: See "Edit" on page 533

TRIGger:SBSW:UART:IOPerator <Frame>,<Field>,<Operator>
TRIGger:SBSW:UART:IOPerator? <Operator>
TRIGger:SBSW:UART:FRAMe<fr>:FLD<fl>:IOPerator <Index_Operator>

Sets the operator for the index in the selected field of the selected frame for the software trigger.

Suffix:

<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Index_Operator> EQUal | INRange | RANGe
*RST: INRange

Usage: Asynchronous command

Manual operation: See "Edit" on page 533

TRIGger:SBSW:UART:ERENable <ErrorName>,<Enabler>
TRIGger:SBSW:UART:ERENable? <Enabler>
TRIGger:SBSW:UART:ERRor<m>:ENABle <Enable>

Defines the error type for the software trigger.

Suffix:

<m>	Index of the error

Parameters:

<Enable>	OFF | ON *RST: ON

Usage:	Asynchronous command
Manual operation:	See "Error type" on page 534

SBUS<sb>:UART:SWTindex?

Queries the software trigger index.

If no software trigger event has occurred, the command returns `Invalid`.

Suffix:

<sb>	1...4, index of the serial bus

Return values:

<Index>	Range: 0 to 4294967295 Increment: 1 *RST: 0

Usage:	Query only Asynchronous command

SBUS<sb>:UART:SWTTime?

Queries the software trigger time in seconds.

If no software trigger event has occured, the command returns `Invalid`.

Suffix:

<sb>	1...4, index of the serial bus

Return values:

<Time>	Range: -1E+26 to 1E+26 Increment: 1E-10 *RST: 0 Default unit: s

Usage:	Query only Asynchronous command

18.17.6.5 Decode results

SBUS<sb>:UART:WCOunt?

Returns the number of words in the acquisition.

Suffix:
<sb> 1...4, index of the serial bus

Return values:
<Count> Total number of words.

Usage: Query only
Asynchronous command

SBUS<sb>:UART:WORD<w>:BITRate?

Returns the primary bit rate.

Suffix:
<sb> 1...4, index of the serial bus

<w> Index of the word

Return values:
<PrimaryBitRate> Increment: 1
*RST: 0
Default unit: bps

Usage: Query only
Asynchronous command

SBUS<sb>:UART:WORD<w>:RXValue?

Returns the value of the specified word on the Rx line.

Suffix:
<sb> 1...4, index of the serial bus

<w> Index of the word

Return values:
<RxValue> Range: 0 to 511
Increment: 1
*RST: 0

Usage: Query only
Asynchronous command

SBUS<sb>:UART:WORD<w>:SOURce?

Returns the line on which the specified word was transferred.

Suffix:

<sb>	1...4, index of the serial bus
<w>	Index of the word

Return values:

<WordSource> TX | RX
*RST: TX

Usage: Query only
Asynchronous command

SBUS<sb>:UART:WORD<w>:STARt?

Returns the start time of the specified word.

Suffix:

<sb>	1...4, index of the serial bus
<w>	Index of the word

Return values:

<WordStart>
Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0
Default unit: s

Usage: Query only
Asynchronous command

SBUS<sb>:UART:WORD<w>:STOP?

Returns the stop time of the specified word.

Suffix:

<sb>	1...4, index of the serial bus
<w>	Index of the word

Return values:

<WordStop>
Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0
Default unit: s

Usage: Query only
Asynchronous command

SBUS<sb>:UART:WORD<w>:STATe?

Returns the status of the specified word.

Suffix:

<sb> 1...4, index of the serial bus

<w> Index of the word

Return values:

<WordState> OK | BREak | STERror | SPERror | PRERror | INComplete

OK: the frame is valid.
`BREak`: stop bit error with 0x00 word
`STERror`: start error, incorrect start bit
`SPERror`: stop error, incorrect stop bit
`PRERror`: parity error, incorrect parity bit.
`INComplete`: The frame is not completely contained in the acquisition. The acquired part of the frame is valid.

*RST: OK

Usage: Query only
Asynchronous command

SBUS<sb>:UART:WORD<w>:TXValue?

Returns the value of the specified word on the TX line.

Suffix:

<sb> 1...4, index of the serial bus

<w> Index of the word

Return values:

<TxValue> Range: 0 to 511
Increment: 1
*RST: 0

Usage: Query only
Asynchronous command

18.17.7 NRZ Clocked (option R&S MXO4-K510)

Before MXO 4 can accept the specific bus commands, make sure that:

- The decoding of the specified bus is enabled with `SBUS<sb>[:STATe]`.
- The bus is set to the correct type with `SBUS<sb>:TYPE`.

18.17.7.1 Configuration

SBUS<sb>:NRZC:CLK:SOURce Source

Selects the source for the clock signal.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
Source C1 | C2 | C3 | C4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | M1 | M2 | M3 | M4 | M5 | R1 | R2 | R3 | R4 | O<n>C1 | O<n>C2 | ... | O<n>C8 (<n> = 2 to 8)

Usage: Asynchronous command

Manual operation: See "Clock source" on page 540

SBUS<sb>:NRZC:CLK:POLarity <CLKPolarity>

Sets the polarity for the data line.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<CLKPolarity> RISE | FALL | BOTH

RISE
Data is sampled at the rising edges of the clock signal.

FALL
Data is sampled at the falling edges of the clock signal.

BOTH
Data is sampled at the rising and falling edges of the clock signal.

*RST: RISE

Usage: Asynchronous command

Manual operation: See "Clock polarity" on page 540

SBUS<sb>:NRZC:DATA:SOURce Source

Selects the channel for the data signal source.

Suffix:

<sb> 1...4, index of the serial bus

Parameters:

Source C1 | C2 | C3 | C4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | M1 | M2 | M3 | M4 | M5 | R1 | R2 | R3 | R4 | O<n>C1 | O<n>C2 | ... | O<n>C8 (<n> = 2 to 8)

Usage: Asynchronous command

Manual operation: See "Data source" on page 540

SBUS<sb>:NRZC:DATA:POLarity <DATAPolarity>

Sets the polarity for the data line.

Suffix:

<sb> 1...4, index of the serial bus

Parameters:

<DATAPolarity> ACTLow | ACTHigh

ACTLow
The transmitted signal for the data line is active high (high = 1).

ACTHigh
The transmitted signal for the data line is active low (low = 1).

*RST: ACTHigh

Usage: Asynchronous command

Manual operation: See "Data polarity" on page 540

SBUS<sb>:NRZC:ENABle:SOURce Source

Selects the channel for the enable signal source.

Suffix:

<sb> 1...4, index of the serial bus

Parameters:

Source C1 | C2 | C3 | C4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | M1 | M2 | M3 | M4 | M5 | R1 | R2 | R3 | R4 | O<n>C1 | O<n>C2 | ... | O<n>C8 (<n> = 2 to 8)

Usage: Asynchronous command

Manual operation: See "Enable source" on page 541

SBUS<sb>:NRZC:ENABle:POLarity <ENABPolarity>

Sets the polarity for the enable line.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<ENABPolarity> ACTLow | ACTHigh

ACTLow
The transmitted signal for the enable line is active high (high = 1).

ACTHigh
The transmitted signal for the enable line is active low (low = 1).

*RST: ACTHigh

Usage: Asynchronous command

Manual operation: See "Enable source" on page 541

SBUS<sb>:NRZC:MINGap:SELect <MingapSelect>

Enables checking the minimum idle time between two frames during decoding.

To set the idle time, use the command `SBUS<sb>:NRZC:MINGap:WIDTh`.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<MingapSelect> OFF | ON

*RST: OFF

Usage: Asynchronous command

Manual operation: See "Check gap time" on page 541

SBUS<sb>:NRZC:MINGap:WIDTh <MingapWidth>

Sets the minimum duration of the idle time. Any inactivity greater than this time is interpreted as a gap and leads to a resynchronization to the signal.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:

<MingapWidth>	Range:	1E-09 to 1
	Increment:	1E-09
	*RST:	1E-05
	Default unit: s	

Usage: Asynchronous command

Manual operation: See "Check gap time" on page 541

SBUS<sb>:NRZC:CLK:THReshold <CLKThreshold>

Sets the threshold value for the digitization of the clock signal.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<CLKThreshold>

Usage: Asynchronous command

Manual operation: See "Clock threshold, Clock hysteresis" on page 542

SBUS<sb>:NRZC:CLK:HYSTeresis <CLKHysteresis>

Sets a value for the hysteresis of the clock signal.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<CLKHysteresis>

Usage: Asynchronous command

Manual operation: See "Clock threshold, Clock hysteresis" on page 542

SBUS<sb>:NRZC:DATA:THReshold <SDAThreshold>

Sets the threshold for the data channel.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<SDAThreshold>

Usage: Asynchronous command

Manual operation: See "Data threshold, Data hysteresis" on page 542

SBUS<sb>:NRZC:DATA:HYSTeresis <SDAHysteresis>

Sets the hysteresis for the data channel.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<SDAHysteresis>

Usage: Asynchronous command

Manual operation: See "Data threshold, Data hysteresis" on page 542

SBUS<sb>:NRZC:ENABle:THReshold <ENABThreshold>

Sets the threshold for the enable channel.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<ENABThreshold>

Usage: Asynchronous command

Manual operation: See "Enable threshold, Enable hysteresis" on page 542

SBUS<sb>:NRZC:ENABle:HYSTeresis <ENABHysteresis>

Sets the hysteresis for the enable channel.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<ENABHysteresis>

Usage: Asynchronous command

Manual operation: See "Enable threshold, Enable hysteresis" on page 542

SBUS<sb>:NRZC:POSition <Position>

Sets the vertical position of the NRZ clocked signal.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<Position>

Usage: Asynchronous command

SBUS<sb>:NRZC:SCALe <Scale>

Sets the vertical scale of the NRZ clocked signal.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<Scale>

Usage: Asynchronous command

18.17.7.2 Filter

There are two commands for each parameter, that you can use for defining the NRZ clocked settings.

For example, to set the *Frame type =NRZC-Frame* > *Field =Data* >*Data* value you can use one of the following commands:

- `SBUS:NRZC:FILTer:FRAMe1:FLD1:DMIN 01100`
  Defines the parameter by using the index <m> for the frame number and <n> for the field number.
- `SBUS:NRZC:FILTer:DMIN "NRZC-Frame", "Data", 01100`
  Defines the parameter by using the frame and field name.

SBUS<sb>:NRZC:FILTer:CHKall

Enables the filter for all available frames and error types.

Suffix:
<sb> 1...4, index of the serial bus

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 544

SBUS<sb>:NRZC:FILTer:CLR

Disables the filter for all available frames and error types.

Suffix:
<sb> 1...4, index of the serial bus

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 544

SBUS<sb>:NRZC:FILTer:INVert

Inverts the current state of the frame and error types: all frames and error types that were enabled are disabled and vice versa.

Suffix:
<sb> 1...4, index of the serial bus

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 544

SBUS<sb>:NRZC:FILTer:RST

Presets the state of the selected frames and error types.

Suffix:
<sb> 1...4, index of the serial bus

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 544

SBUS<sb>:NRZC:FILTer:BIT <Frame>,<Field>,<Bit>
SBUS<sb>:NRZC:FILTer:BIT? <Bit>
SBUS<sb>:NRZC:FILTer:FRAMe<fr>:FLD<fl>:BIT <BitState>

Sets the bit state of a field that only consists of one bit.

Suffix:
<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Parameters:
<BitState> ONE | ZERO
*RST: ZERO

Usage: Asynchronous command

Manual operation: See "Edit" on page 545

SBUS<sb>:NRZC:FILTer:ERENable <ErrorName>,<Enabler>
SBUS<sb>:NRZC:FILTer:ERENable? <Enabler>
SBUS<sb>:NRZC:FILTer:ERRor<n>:ENABle <Enable>

Defines the error type to be filtered on.

Suffix:
<sb> 1...4, index of the serial bus

<n> index of the error

Parameters:
<Enable> OFF | ON
*RST: ON

Usage: Asynchronous command

Manual operation: See "Error type" on page 547

SBUS<sb>:NRZC:FILTer:DMAX <Frame>,<Field>,<Data>
SBUS<sb>:NRZC:FILTer:DMAX? <Data>
SBUS<sb>:NRZC:FILTer:FRAMe<fr>:FLD<fl>:DMAX <Data_Max>

Sets the end value of a data pattern range if the operator is set to `INRange` or `OORANGe`.

You can set the operator with `SBUS<sb>:NRZC:FILTer:FRAMe<fr>:FLD<fl>:DOPerator`.

Suffix:
<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Parameters:
<Data_Max>

Usage: Asynchronous command

Manual operation: See "Edit" on page 545

SBUS<sb>:NRZC:FILTer:DMIN <Frame>,<Field>,<Data>
SBUS<sb>:NRZC:FILTer:DMIN? <Data>
SBUS<sb>:NRZC:FILTer:FRAMe<fr>:FLD<fl>:DMIN <Data_Min>

Specifies the data pattern, or sets the start value of a data pattern range.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:
<Data_Min>

Usage: Asynchronous command

Manual operation: See "Edit" on page 545

SBUS<sb>:NRZC:FILTer:DOPerator <Frame>,<Field>,<Operator>
SBUS<sb>:NRZC:FILTer:DOPerator? <Operator>
SBUS<sb>:NRZC:FILTer:FRAMe<fr>:FLD<fl>:DOPerator <Data_Operator>

Sets the operator for the data pattern in the selected field of the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Data_Operator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange
*RST: EQUal

Usage: Asynchronous command

Manual operation: See "Edit" on page 545

SBUS<sb>:NRZC:FILTer:FIENable <Frame>,<Field>,<Enabler>
SBUS<sb>:NRZC:FILTer:FIENable? <Enabler>
SBUS<sb>:NRZC:FILTer:FRAMe<fr>:FLD<fl>:ENABle <CondEnabler>

Enables or disables the checking condition for the selected field of the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<CondEnabler>	OFF | ON *RST: OFF

Usage: Asynchronous command

Manual operation: See "Edit" on page 545

SBUS<sb>:NRZC:FILTer:FRENable <Frame>,<Enabler>
SBUS<sb>:NRZC:FILTer:FRENable? <Enabler>
SBUS<sb>:NRZC:FILTer:FRAMe<fr>:ENABle <Enable>

Enables the filtering on NRZ clocked frames. Only the frames that match the selected filter conditions are displayed.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Parameters:

<Enable>	OFF | ON *RST: ON

Usage: Asynchronous command

Manual operation: See "Enable" on page 544

SBUS<sb>:NRZC:FILTer:IMAX <Frame>,<Field>,<Data>
SBUS<sb>:NRZC:FILTer:IMAX? <Data>
SBUS<sb>:NRZC:FILTer:FRAMe<fr>:FLD<fl>:IMAX <Index_Max>

Sets the end value of an index range if the operator is set to `INRange`.

You can set the operator with `SBUS<sb>:NRZC:FILTer:FRAMe<fr>:FLD<fl>:IOPerator`.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Index_Max>	Range: 1 to 65535 Increment: 1 *RST: 65535

Usage: Asynchronous command

Manual operation: See "Edit" on page 545

SBUS<sb>:NRZC:FILTer:IMIN <Frame>,<Field>,<Data>
SBUS<sb>:NRZC:FILTer:IMIN? <Data>
SBUS<sb>:NRZC:FILTer:FRAMe<fr>:FLD<fl>:IMIN <Index_Min>

Specifies the index, or sets the start value of an index range.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Index_Min>	Range: 1 to 65535 Increment: 1 *RST: 1

Usage: Asynchronous command

Manual operation: See "Edit" on page 545

SBUS<sb>:NRZC:FILTer:IOPerator <Frame>,<Field>,<Operator>
SBUS<sb>:NRZC:FILTer:IOPerator? <Operator>
SBUS<sb>:NRZC:FILTer:FRAMe<fr>:FLD<fl>:IOPerator <Index_Operator>

Sets the operator for the index in the selected field of the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Index_Operator>	EQUal | INRange | RANGe *RST: INRange

Usage: Asynchronous command

Manual operation: See "Edit" on page 545

18.17.7.3 Frame format

This section describes the commands to specify and query frame formats for the "NRZ Clocked" protocol.

For manual operation, refer to Section 14.7.4, "NRZ frame format configuration", on page 547.

SBUS<sb>:NRZC:FORMat:ADDFrame

Appendes a new frame description to the frame list.

Suffix:
<sb> 1...4, index of the serial bus

Usage: Setting only
Asynchronous command

Manual operation: See "Add Frame" on page 549

SBUS<sb>:NRZC:FORMat:LOAD <FileName>

Loads a the specified XML file with a list of frame descriptions.

Suffix:
<sb> 1...4, index of the serial bus

Setting parameters:
<FileName>

Usage: Setting only
Asynchronous command

Manual operation: See "Open" on page 550

SBUS<sb>:NRZC:FORMat:SAVE <FileName>

Saves the current list of frame descriptions to an XML file with the specified name.

Suffix:
<sb> 1...4, index of the serial bus

Setting parameters:
<FileName>

Usage: Setting only
Asynchronous command

Manual operation: See "Save as" on page 550

SBUS<sb>:NRZC:FORMat:CLR

Erases from the volatile memory all field and frame format descriptions that you have created for a specific custom protocol.

Suffix:

<sb>	1...4, index of the serial bus

Usage: Setting only
Asynchronous command

Manual operation: See "Edit List" on page 549

SBUS<sb>:NRZC:FORMat:FCOunt?

Returns the number of frame format descriptions available for a specific custom protocol.

Suffix:

<sb>	1...4, index of the serial bus

Return values:
<Count>

Usage: Query only
Asynchronous command

Manual operation: See "Edit List" on page 549

SBUS<sb>:NRZC:FORMat:FRAMe<fr>:ADDField

Appends a new field description to the selected frame description.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Usage: Setting only
Asynchronous command

Manual operation: See "Add Field" on page 550

SBUS<sb>:NRZC:FORMat:FRAMe<fr>:FLDCount?

Returns the number of field descriptions available for the seleced frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:
<Count>

Usage: Query only
Asynchronous command

Manual operation: See "Edit List" on page 551

SBUS<sb>:NRZC:FORMat:FRAMe<fr>:NAME <Name>

Specifies the name for the frame description of the selected frame.

Suffix:
<sb> 1...4, index of the serial bus

<fr> Index of the frame

Parameters:
<Name>

Usage: Asynchronous command

Manual operation: See "Frame name" on page 551

SBUS<sb>:NRZC:FORMat:FRAMe<fr>:COLor <Color>

Specifies the color for the frame description of the selected frame.

Suffix:
<sb> 1...4, index of the serial bus

<fr> Index of the frame

Parameters:
<Color> Use 32-bit RGB encoding in decimal format.

Range: 0 to 4294967295
Increment: 1
*RST: 4278255615

Usage: Asynchronous command

Manual operation: See "Frame Color" on page 552

SBUS<sb>:NRZC:FORMat:FRAMe<fr>:FLD<fl>:NAME <Name>

Specifies the name for the selected field of the selected frame.

Suffix:
<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Parameters:
<Name>

Usage: Asynchronous command

Manual operation: See "Field name" on page 552

SBUS<sb>:NRZC:FORMat:FRAMe<fr>:FLD<fl>:COLor <Color>

Specifies the color for the selected field of the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Color> Use 32-bit RGB encoding in decimal format.

Range: 0 to 4294967295
Increment: 1
*RST: 4294967040

Usage: Asynchronous command

Manual operation: See "Field Color" on page 552

SBUS<sb>:NRZC:FORMat:FRAMe<fr>:FLD<fl>:BITCount <BitCount>

Specifies the bit count, hence length, of the selected field in the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<BitCount> Range: 1 to 64
Increment: 1
*RST: 1

Usage: Asynchronous command

Manual operation: See "Bit count" on page 552

SBUS<sb>:NRZC:FORMat:FRAMe<fr>:FLD<fl>:CONDition <Condition>

Specifies a user-defined condition operator for the selected field of the selected frame. The various condition operators can identify, for example, a mandatory CRC checksum value or a frame ID.

Set the numeric format of the condition by the command `SBUS<sb>:NRZC:FORMat:FRAMe<fr>:FLD<fl>:FORMat`.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Condition> The implemented conditions are the "equal" and "array" operators.

Usage: Asynchronous command

Manual operation: See "Condition" on page 553

SBUS<sb>:NRZC:FORMat:FRAMe<fr>:FLD<fl>:FORMat <NumericFormat>

Specifies the numerical format for the condition value of the selected field in the selected frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Parameters:

<NumericFormat> DEC | HEX | OCT | BIN

DEC
Decimal format

HEX
Hexadecimal format

OCT
Octal format

BIN
Binary format

*RST: BIN

Usage: Asynchronous command

Manual operation: See "Numeric format" on page 555

SBUS<sb>:NRZC:FORMat:FRAMe<fr>:FLD<fl>:BITorder <BitOrder>

Specifies, in which order the algorithm evaluates the bits of the condition value of the selected field in the selected frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Parameters:

<BitOrder> LSBF | MSBF

LSBF
Least significant bit first

MSBF
Most significant bit first
*RST: MSBF

Usage: Asynchronous command

Manual operation: See "Bit order" on page 556

SBUS<sb>:NRZC:FORMat:FRAMe<fr>:FLD<fl>:CLMN <Column>

Specifies, in which result column of the decode table to display the selected field of the selected frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Parameters:

<Column> NONE | COL1 | COL2 | COL3

NONE
The result is not displayed.

COL1
The result is displayed in column 1.

COL2
The result is displayed in column 2.

COL3
The result is displayed in column 3.
*RST: NONE

Usage: Asynchronous command

Manual operation: See "Result column" on page 556

18.17.7.4 Software trigger

There are two commands for each parameter that you can use for defining the "NRZ Clocked" settings.

For example, to set the *Frame type =NRZC-Frame > Field =Data >Data* value you can use one of the following commands:

- `TRIGger:SBSW:NRZC:FRAMe1:FLD1:DMIN 01100`
  Defines the parameter by using the index <fr> for the frame number and <fl> for the field number.
- `TRIGger:SBSW:NRZC:DMIN "NRZC-Frame", "Data", 01100`
  Defines the parameter by using the frame and field name.

TRIGger:SBSW:NRZC:CHKall

Enables the software trigger for all available frames and error types.

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 557

TRIGger:SBSW:NRZC:CLR

Disables the software trigger for all available frames and error types.

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 557

TRIGger:SBSW:NRZC:INVert

Inverts the current state of the frame and error types for the software trigger: all frames and error types that were enabled are disabled and vice versa.

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 557

TRIGger:SBSW:NRZC:RST

Presets the state of the selected frames and error types for the software trigger.

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 557

TRIGger:SBSW:NRZC:FRENable <Frame>,<Enabler>
TRIGger:SBSW:NRZC:FRENable? <Enabler>
TRIGger:SBSW:NRZC:FRAMe<fr>:ENABle <Enable>

Enables or disables the checking condition for the selected frame for the software trigger.

Suffix:
<fr> Index of the frame

Parameters:
<Enable> OFF | ON
*RST: ON

Usage: Asynchronous command

Manual operation: See "Frame type" on page 558

TRIGger:SBSW:NRZC:BIT <Frame>,<Field>,<Bit>
TRIGger:SBSW:NRZC:BIT? <Bit>
TRIGger:SBSW:NRZC:FRAMe<fr>:FLD<fl>:BIT <BitState>

Sets the bit state of a field that only consists of one bit for the software trigger.

Suffix:
<fr> Index of the frame

<fl> Index of the field

Parameters:
<BitState> ONE | ZERO
*RST: ZERO

Usage: Asynchronous command

Manual operation: See "Edit" on page 558

TRIGger:SBSW:NRZC:DMAX <Frame>,<Field>,<Data>
TRIGger:SBSW:NRZC:DMAX? <Data>
TRIGger:SBSW:NRZC:FRAMe<fr>:FLD<fl>:DMAX <Data_Max>

Sets the end value of a data pattern range for the software trigger, if the operator is set to `INRange` or `OORANGe`.

You can set the operator with TRIGger:SBSW:NRZC:FRAMe<fr>:FLD<fl>:DOPerator.

Suffix:

<fr> Index of the frame

<fl> Index of the field

Parameters:

<Data_Max>

Usage: Asynchronous command

Manual operation: See "Edit" on page 558

TRIGger:SBSW:NRZC:DMIN <Frame>,<Field>,<Data>
TRIGger:SBSW:NRZC:DMIN? <Data>
TRIGger:SBSW:NRZC:FRAMe<fr>:FLD<fl>:DMIN <Data_Min>

Specifies the data pattern, or sets the start value of a data pattern range for the software trigger.

Suffix:

<fr> Index of the frame

<fl> Index of the field

Parameters:

<Data_Min>

Usage: Asynchronous command

Manual operation: See "Edit" on page 558

TRIGger:SBSW:NRZC:DOPerator <Frame>,<Field>,<Operator>
TRIGger:SBSW:NRZC:DOPerator? <Operator>
TRIGger:SBSW:NRZC:FRAMe<fr>:FLD<fl>:DOPerator <Data_Operator>

Sets the operator for the data pattern of the software trigger in the selected field of the selected frame.

Suffix:

<fr> Index of the frame

<fl> Index of the field

Parameters:

<Data_Operator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

*RST: EQUal

Usage: Asynchronous command

Manual operation: See "Edit" on page 558

TRIGger:SBSW:NRZC:FIENable <Frame>,<Field>,<Enabler>
TRIGger:SBSW:NRZC:FIENable? <Enabler>
TRIGger:SBSW:NRZC:FRAMe<fr>:FLD<fl>:ENABle <CondEnabler>

Enables or disables the checking condition for the selected field of the selected frame of the software trigger.

Suffix:

<fr> Index of the frame

<fl> Index of the field

Parameters:

<CondEnabler> OFF | ON
*RST: OFF

Usage: Asynchronous command

Manual operation: See "Edit" on page 558

TRIGger:SBSW:NRZC:IMAX <Frame>,<Field>,<Data>
TRIGger:SBSW:NRZC:IMAX? <Data>
TRIGger:SBSW:NRZC:FRAMe<fr>:FLD<fl>:IMAX <Index_Max>

Sets the end value of an index range for the software trigger if the operator is set to `INRange`.

You can set the operator with `TRIGger:SBSW:NRZC:FRAMe<fr>:FLD<fl>:IOPerator`.

Suffix:

<fr> Index of the frame

<fl> Index of the field

Parameters:

<Index_Max> Range: 1 to 65535
Increment: 1
*RST: 65535

Usage: Asynchronous command

Manual operation: See "Edit" on page 558

TRIGger:SBSW:NRZC:IMIN <Frame>,<Field>,<Data>
TRIGger:SBSW:NRZC:IMIN? <Data>
TRIGger:SBSW:NRZC:FRAMe<fr>:FLD<fl>:IMIN <Index_Min>

Specifies the index, or sets the start value of an index range for the software trigger.

Suffix:

<fr> Index of the frame

<fl> Index of the field

Parameters:

<Index_Min>	Range: 1 to 65535 Increment: 1 *RST: 1

Usage: Asynchronous command

Manual operation: See "Edit" on page 558

TRIGger:SBSW:NRZC:IOPerator <Frame>,<Field>,<Operator>
TRIGger:SBSW:NRZC:IOPerator? <Operator>
TRIGger:SBSW:NRZC:FRAMe<fr>:FLD<fl>:IOPerator <Index_Operator>

Sets the operator for the index in the selected field of the selected frame for the software trigger.

Suffix:

<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Index_Operator>	EQUal | INRange | RANGe *RST: INRange

Usage: Asynchronous command

Manual operation: See "Edit" on page 558

TRIGger:SBSW:NRZC:ERENable <ErrorName>,<Enabler>
TRIGger:SBSW:NRZC:ERENable? <Enabler>
TRIGger:SBSW:NRZC:ERRor<m>:ENABle <Enable>

Defines the error type for the software trigger.

Suffix:

<m>	index of the error

Parameters:

<Enable>	OFF | ON *RST: ON

Usage: Asynchronous command

Manual operation: See "Error type" on page 560

SBUS<sb>:NRZC:SWTindex?

Queries the software trigger index.

If no software trigger event has occurred, the command returns `Invalid`.

Suffix:

<sb>	1...4, index of the serial bus

Return values:

<Index>	Range:	0 to 4294967295
	Increment:	1
	*RST:	0

Usage: Query only
Asynchronous command

SBUS<sb>:NRZC:SWTTime?

Queries the software trigger time in seconds.

If no software trigger event has occured, the command returns `Invalid`.

Suffix:
<sb> 1...4, index of the serial bus

Return values:

<Time>	Range:	-1E+26 to 1E+26
	Increment:	1E-10
	*RST:	0
	Default unit:	s

Usage: Query only
Asynchronous command

18.17.7.5 Decode results

This section describes the commands to query the results of the decoding of the "NRZ Clocked" protocol.

For manual operation, refer to Section 14.7.7, "Performing NRZ decoding", on page 560 and Section 14.7.8, "NRZ decode results", on page 562.

SBUS<sb>:NRZC:FCOunt?

Returns the number of decoded frames.

Suffix:
<sb> 1...4, index of the serial bus

Return values:
<Count>

Usage: Query only
Asynchronous command

SBUS<sb>:NRZC:FRAMe<fr>:FLDCount?

Returns the number of fields available in the seleced frame.

Suffix:
<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:
<DataCount>

Usage: Query only
Asynchronous command

SBUS<sb>:NRZC:FRAMe<fr>:WBRate?

Returns the bit rate of the frame.

Suffix:
<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:
<FrameWBR> Increment: 1
*RST: 0
Default unit: bps

Usage: Query only

SBUS<sb>:NRZC:FRAMe<fr>:FLD<fl>:STATe?

Returns the overall state of the specified field in the specified frame.

Suffix:
<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Return values:
<State> OK | LENGth | CRC | PARity | INComplete

OK
The field has no error, it is valid.

LENGth
The length of the field is not as expected, indicating an error.

CRC
The CRC of the frame is not as expected, indicating an error.

PARity
Parity is not as expected, indicating an error

INComplete
The frame is incomplete.

*RST: OK

Usage: Query only
Asynchronous command

SBUS<sb>:NRZC:FRAMe<fr>:FLD<fl>:LABel?

Returns the label of the specified field in the specified frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Return values:

<Name>

Usage: Query only
Asynchronous command

SBUS<sb>:NRZC:FRAMe<fr>:FLD<fl>:VALue?

Returns the value of the specified field in the specified frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Return values:

<Value> *RST: 0

Usage: Query only
Asynchronous command

SBUS<sb>:NRZC:FRAMe<fr>:FLD<fl>:FVALue?

Returns the formatted value of the specified field in the specified frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Return values:
<FormattedValue>

Usage: Query only
Asynchronous command

SBUS<sb>:NRZC:FRAMe<fr>:STATus?

Returns the overall state of the specified frame.

Suffix:
<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:
<FrameState> OK | LENGth | CRC | PARity | INComplete

OK
The frame is valid.

LENGth
Length of the frame is not as expected, indicating an error.

CRC
The checksum of the frame is not as expected, indicating an error.

PARity
Parity is not as expected, indicating an error.

INComplete
The frame is incomplete.

*RST: OK

Usage: Query only
Asynchronous command

SBUS<sb>:NRZC:FRAMe<fr>:STARt?

Returns the start time of the specified frame.

Suffix:
<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:
<FrameStart> Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0
Default unit: s

Usage: Query only
Asynchronous command

SBUS<sb>:NRZC:FRAMe<fr>:STOP?

Returns the end time of the specified frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:

<FrameStop> Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0
Default unit: s

Usage: Query only
Asynchronous command

SBUS<sb>:NRZC:FRAMe<fr>:TYPE?

Returns the type of the specified decoded frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:

<FrameType> The frame type is undefined, because it is custom specific.

Usage: Query only
Asynchronous command

SBUS<sb>:NRZC:FRAMe<fr>:RES1?

Returns the content of the 1st result column of the specified decoded frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:

<Result1>

Usage: Query only
Asynchronous command

SBUS<sb>:NRZC:FRAMe<fr>:RES2?

Returns the content of the 2nd result column of the specified decoded frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:
<Result2>

Usage: Query only
Asynchronous command

SBUS<sb>:NRZC:FRAMe<fr>:RES3?

Returns the content of the 3rd result column of the specified decoded frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:
<Result3>

Usage: Query only
Asynchronous command

18.17.8 NRZ Unclocked (option R&S MXO4-K510)

Before MXO 4 can accept the specific bus commands, make sure that:

- The decoding of the specified bus is enabled with `SBUS<sb>[:STATe]`.
- The bus is set to the correct type with `SBUS<sb>:TYPE`.

18.17.8.1 Configuration

SBUS<sb>:NRZU:DATA:SOURce Source

Selects the channel for the data signal source.

Suffix:

<sb> 1...4, index of the serial bus

Parameters:

Source C1 | C2 | C3 | C4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | M1 | M2 | M3 | M4 | M5 | R1 | R2 | R3 | R4 | O<n>C1 | O<n>C2 | ... | O<n>C8 (<n> = 2 to 8)

Usage: Asynchronous command

Manual operation: See "Data source" on page 540

SBUS<sb>:NRZU:DATA:POLarity <DATAPolarity>

Sets the polarity for the data line.

Suffix:

<sb> 1...4, index of the serial bus

Parameters:

<DATAPolarity> ACTLow | ACTHigh

ACTLow
The transmitted signal for the data line is active high (high = 1).

ACTHigh
The transmitted signal for the data line is active low (low = 1).

*RST: ACTHigh

Usage: Asynchronous command

Manual operation: See "Data polarity" on page 540

SBUS<sb>:NRZU:ENABle:SOURce Source

Selects the channel for the enable signal source.

Suffix:

<sb> 1...4, index of the serial bus

Parameters:

Source C1 | C2 | C3 | C4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | M1 | M2 | M3 | M4 | M5 | R1 | R2 | R3 | R4 | O<n>C1 | O<n>C2 | ... | O<n>C8 (<n> = 2 to 8)

Usage: Asynchronous command

Manual operation: See "Enable source" on page 541

SBUS<sb>:NRZU:ENABle:POLarity <ENABPolarity>

Sets the polarity for the enable line.

Suffix:

<sb> 1...4, index of the serial bus

Parameters:

<ENABPolarity> ACTLow | ACTHigh

ACTLow
The transmitted signal for the enable line is active high (high = 1).

ACTHigh
The transmitted signal for the enable line is active low (low = 1).

*RST: ACTHigh

Usage: Asynchronous command

Manual operation: See "Enable source" on page 541

SBUS<sb>:NRZU:MINGap:SELect <MingapSelect>

Enables checking the minimum idle time between two frames during decoding.

To set the idle time, use the command `SBUS<sb>:NRZU:MINGap:WIDTh`.

Suffix:

<sb> 1...4, index of the serial bus

Parameters:

<MingapSelect> OFF | ON

*RST: OFF

Usage: Asynchronous command

Manual operation: See "Check gap time" on page 541

SBUS<sb>:NRZU:MINGap:WIDTh <MingapWidth>

Sets the minimum duration of the idle time. Any inactivity greater than this time is interpreted as a gap and leads to a resynchronization to the signal.

Suffix:

<sb> 1...4, index of the serial bus

Parameters:

<MingapWidth> Range: 1E-09 to 1
Increment: 1E-09
*RST: 1E-05
Default unit: s

Usage: Asynchronous command

Manual operation: See "Check gap time" on page 541

SBUS<sb>:NRZU:BITRate:SELect <BitrateSelect>

Enables setting the bit rate, which is required to trigger and decode unclocked NRZ signals.

You can set the bit rate with `SBUS<sb>:NRZU:BITRate:WIDTh`.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<BitrateSelect> OFF | ON
*RST: OFF

Usage: Asynchronous command

Manual operation: See "Check bit rate" on page 541

SBUS<sb>:NRZU:BITRate:WIDTh <BitrateWidth>

Specifies the bit rate, if enabled with `SBUS<sb>:NRZU:BITRate:SELect`.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<BitrateWidth> Range: 300 to 2000000000
Increment: 100000
*RST: 10000000
Default unit: bps

Usage: Asynchronous command

Manual operation: See "Check bit rate" on page 541

SBUS<sb>:NRZU:DATA:THReshold <SDAThreshold>

Sets the threshold for the data channel.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<SDAThreshold>

Usage: Asynchronous command

Manual operation: See "Data threshold, Data hysteresis" on page 542

SBUS<sb>:NRZU:DATA:HYSTeresis <SDAHysteresis>

Sets the hysteresis for the data channel.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<SDAHysteresis>

Usage: Asynchronous command

Manual operation: See "Data threshold, Data hysteresis" on page 542

SBUS<sb>:NRZU:ENABle:THReshold <ENABThreshold>

Sets the threshold for the enable channel.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<ENABThreshold>

Usage: Asynchronous command

SBUS<sb>:NRZU:ENABle:HYSTeresis <ENABHysteresis>

Sets the hysteresis for the enable channel.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<ENABHysteresis>

Usage: Asynchronous command

SBUS<sb>:NRZU:POSition <Position>

Sets the vertical position of the NRZ unclocked signal.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<Position>

Usage: Asynchronous command

SBUS<sb>:NRZU:SCALe <Scale>

Sets the vertical scale of the NRZ unclocked signal.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<Scale>

Usage: Asynchronous command

18.17.8.2 Filter

There are two commands for each parameter, that you can use for defining the NRZ unclocked settings.

For example, to set the *Frame type =NRZU-Frame* > *Field =Data* >*Data* value you can use one of the following commands:

- `SBUS:NRZU:FILTer:FRAMe1:FLD1:DMIN 01100`
  Defines the parameter by using the index <m> for the frame number and <n> for the field number.
- `SBUS:NRZU:FILTer:DMIN "NRZC-Frame", "Data", 01100`
  Defines the parameter by using the frame and field name.

SBUS<sb>:NRZU:FILTer:CHKall

Enables the filter for all available frames and error types.

Suffix:
<sb> 1...4, index of the serial bus

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 544

SBUS<sb>:NRZU:FILTer:CLR

Disables the filter for all available frames and error types.

Suffix:
<sb> 1...4, index of the serial bus

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 544

SBUS<sb>:NRZU:FILTer:INVert

Inverts the current state of the frame and error types: all frames and error types that were enabled are disabled and vice versa.

Suffix:
<sb> 1...4, index of the serial bus

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 544

SBUS<sb>:NRZU:FILTer:RST

Presets the state of the selected frames and error types.

Suffix:
<sb> 1...4, index of the serial bus

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 544

SBUS<sb>:NRZU:FILTer:BIT <Frame>,<Field>,<Bit>
SBUS<sb>:NRZU:FILTer:BIT? <Bit>
SBUS<sb>:NRZU:FILTer:FRAMe<fr>:FLD<fl>:BIT <BitState>

Sets the bit state of a field that only consists of one bit.

Suffix:
<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Parameters:
<BitState> ONE | ZERO
*RST: ZERO

Usage: Asynchronous command

Manual operation: See "Edit" on page 545

SBUS<sb>:NRZU:FILTer:ERENable <ErrorName>,<Enabler>
SBUS<sb>:NRZU:FILTer:ERENable? <Enabler>
SBUS<sb>:NRZU:FILTer:ERRor<n>:ENABle <Enable>

Defines the error type to be filtered on.

Suffix:
<sb> 1...4, index of the serial bus

<n> index of the error

Parameters:
<Enable> OFF | ON
*RST: ON

Usage: Asynchronous command

Manual operation: See "Error type" on page 547

SBUS<sb>:NRZU:FILTer:DMAX <Frame>,<Field>,<Data>
SBUS<sb>:NRZU:FILTer:DMAX? <Data>
SBUS<sb>:NRZU:FILTer:FRAMe<fr>:FLD<fl>:DMAX <Data_Max>

Sets the end value of a data pattern range if the operator is set to `INRange` or `OORANGe`.

You can set the operator with `SBUS<sb>:NRZU:FILTer:FRAMe<fr>:FLD<fl>:DOPerator`.

Suffix:
<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Parameters:
<Data_Max>

Usage: Asynchronous command

Manual operation: See "Edit" on page 545

SBUS<sb>:NRZU:FILTer:DMIN <Frame>,<Field>,<Data>
SBUS<sb>:NRZU:FILTer:DMIN? <Data>
SBUS<sb>:NRZU:FILTer:FRAMe<fr>:FLD<fl>:DMIN <Data_Min>

Specifies the data pattern, or sets the start value of a data pattern range.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:
<Data_Min>

Usage: Asynchronous command

Manual operation: See "Edit" on page 545

SBUS<sb>:NRZU:FILTer:DOPerator <Frame>,<Field>,<Operator>
SBUS<sb>:NRZU:FILTer:DOPerator? <Operator>
SBUS<sb>:NRZU:FILTer:FRAMe<fr>:FLD<fl>:DOPerator <Data_Operator>

Sets the operator for the data pattern in the selected field of the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Data_Operator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

*RST: EQUal

Usage: Asynchronous command

Manual operation: See "Edit" on page 545

SBUS<sb>:NRZU:FILTer:FIENable <Frame>,<Field>,<Enabler>
SBUS<sb>:NRZU:FILTer:FIENable? <Enabler>
SBUS<sb>:NRZU:FILTer:FRAMe<fr>:FLD<fl>:ENABle <CondEnabler>

Enables or disables the checking condition for the selected field of the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<CondEnabler> OFF | ON

*RST: OFF

Usage: Asynchronous command

Manual operation: See "Edit" on page 545

SBUS<sb>:NRZU:FILTer:FRENable <Frame>,<Enabler>
SBUS<sb>:NRZU:FILTer:FRENable? <Enabler>
SBUS<sb>:NRZU:FILTer:FRAMe<fr>:ENABle <Enable>

Enables the filtering on NRZ unclocked frames. Only the frames that match the selected filter conditions are displayed.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

Parameters:

<Enable> OFF | ON

*RST: ON

Usage: Asynchronous command

Manual operation: See "Enable" on page 544

SBUS<sb>:NRZU:FILTer:IMAX <Frame>,<Field>,<Data>
SBUS<sb>:NRZU:FILTer:IMAX? <Data>
SBUS<sb>:NRZU:FILTer:FRAMe<fr>:FLD<fl>:IMAX <Index_Max>

Sets the end value of an index range if the operator is set to `INRange`.

You can set the operator with `SBUS<sb>:NRZU:FILTer:FRAMe<fr>:FLD<fl>:IOPerator`.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Parameters:

<Index_Max> Range: 1 to 65535
Increment: 1
*RST: 65535

Usage: Asynchronous command

Manual operation: See "Edit" on page 545

SBUS<sb>:NRZU:FILTer:IMIN <Frame>,<Field>,<Data>
SBUS<sb>:NRZU:FILTer:IMIN? <Data>
SBUS<sb>:NRZU:FILTer:FRAMe<fr>:FLD<fl>:IMIN <Index_Min>

Specifies the index, or sets the start value of an index range.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Index_Min> Range: 1 to 65535
Increment: 1
*RST: 1

Usage: Asynchronous command

Manual operation: See "Edit" on page 545

SBUS<sb>:NRZU:FILTer:IOPerator <Frame>,<Field>,<Operator>
SBUS<sb>:NRZU:FILTer:IOPerator? <Operator>
SBUS<sb>:NRZU:FILTer:FRAMe<fr>:FLD<fl>:IOPerator <Index_Operator>

Sets the operator for the index in the selected field of the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Index_Operator> EQUal | INRange | RANGe
*RST: INRange

Usage: Asynchronous command

Manual operation: See "Edit" on page 545

18.17.8.3 Frame format

This section describes the commands to specify and query frame formats for the "NRZ Unclocked" protocol.

For manual operation, refer to Section 14.7.4, "NRZ frame format configuration", on page 547.

SBUS<sb>:NRZU:FORMat:ADDFrame

Appendes a new frame description to the frame list.

Suffix:
<sb> 1...4, index of the serial bus

Usage: Setting only
Asynchronous command

Manual operation: See "Add Frame" on page 549

SBUS<sb>:NRZU:FORMat:LOAD <FileName>

Loads a the specified XML file with a list of frame descriptions.

Suffix:
<sb> 1...4, index of the serial bus

Setting parameters:
<FileName>

Usage: Setting only
Asynchronous command

Manual operation: See "Open" on page 550

SBUS<sb>:NRZU:FORMat:SAVE <FileName>

Saves the current list of frame descriptions to an XML file with the specified name.

Suffix:
<sb> 1...4, index of the serial bus

Setting parameters:
<FileName>

Usage: Setting only
Asynchronous command

Manual operation: See "Save as" on page 550

SBUS<sb>:NRZU:FORMat:CLR

Erases from the volatile memory all field and frame format descriptions that you have created for a specific custom protocol.

Suffix:

<sb>	1...4, index of the serial bus

Usage: Setting only
Asynchronous command

Manual operation: See "Edit List" on page 549

SBUS<sb>:NRZU:FORMat:FCOunt?

Returns the number of frame format descriptions available for a specific custom protocol.

Suffix:

<sb>	1...4, index of the serial bus

Return values:
<Count>

Usage: Query only
Asynchronous command

Manual operation: See "Edit List" on page 549

SBUS<sb>:NRZU:FORMat:FRAMe<fr>:ADDField

Appends a new field description to the selected frame description.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Usage: Setting only
Asynchronous command

Manual operation: See "Add Field" on page 550

SBUS<sb>:NRZU:FORMat:FRAMe<fr>:FLDCount?

Returns the number of field descriptions available for the seleced frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:
<Count>

Usage: Query only
Asynchronous command

Manual operation: See "Edit List" on page 551

SBUS<sb>:NRZU:FORMat:FRAMe<fr>:NAME <Name>

Specifies the name for the frame description of the selected frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

Parameters:

<Name>

Usage: Asynchronous command

Manual operation: See "Frame name" on page 551

SBUS<sb>:NRZU:FORMat:FRAMe<fr>:COLor <Color>

Specifies the color for the frame description of the selected frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

Parameters:

<Color> Use 32-bit RGB encoding in decimal format.

Range: 0 to 4294967295
Increment: 1
*RST: 4278255615

Usage: Asynchronous command

Manual operation: See "Frame Color" on page 552

SBUS<sb>:NRZU:FORMat:FRAMe<fr>:FLD<fl>:NAME <Name>

Specifies the name for the selected field of the selected frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Parameters:

<Name>

Usage: Asynchronous command

Manual operation: See "Field name" on page 552

SBUS<sb>:NRZU:FORMat:FRAMe<fr>:FLD<fl>:COLor <Color>

Specifies the color for the selected field of the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Color> Use 32-bit RGB encoding in decimal format.

Range: 0 to 4294967295
Increment: 1
*RST: 4294967040

Usage: Asynchronous command

Manual operation: See "Field Color" on page 552

SBUS<sb>:NRZU:FORMat:FRAMe<fr>:FLD<fl>:BITCount <BitCount>

Specifies the bit count, hence length, of the selected field in the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<BitCount> Range: 1 to 64
Increment: 1
*RST: 1

Usage: Asynchronous command

Manual operation: See "Bit count" on page 552

SBUS<sb>:NRZU:FORMat:FRAMe<fr>:FLD<fl>:CONDition <Condition>

Specifies a user-defined condition operator for the selected field of the selected frame. The various condition operators can identify, for example, a mandatory CRC checksum value or a frame ID.

Set the numeric format of the condition by the command `SBUS<sb>:NRZU:FORMat:FRAMe<fr>:FLD<fl>:FORMat`.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Condition> The implemented conditions are the "equal" and "array" operators.

Usage: Asynchronous command

Manual operation: See "Condition" on page 553

SBUS<sb>:NRZU:FORMat:FRAMe<fr>:FLD<fl>:FORMat <NumericFormat>

Specifies the numerical format for the condition value of the selected field in the selected frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Parameters:

<NumericFormat> DEC | HEX | OCT | BIN

DEC
Decimal format

HEX
Hexadecimal format

OCT
Octal format

BIN
Binary format

*RST: BIN

Usage: Asynchronous command

Manual operation: See "Numeric format" on page 555

SBUS<sb>:NRZU:FORMat:FRAMe<fr>:FLD<fl>:BITorder <BitOrder>

Specifies, in which order the algorithm evaluates the bits of the condition value of the selected field in the selected frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Parameters:

<BitOrder> LSBF | MSBF

LSBF
Least significant bit first

MSBF
Most significant bit first
*RST: MSBF

Usage: Asynchronous command

Manual operation: See "Bit order" on page 556

SBUS<sb>:NRZU:FORMat:FRAMe<fr>:FLD<fl>:CLMN <Column>

Specifies, in which result column of the decode table to display the selected field of the selected frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Parameters:

<Column> NONE | COL1 | COL2 | COL3

NONE
The result is not displayed.

COL1
The result is displayed in column 1.

COL2
The result is displayed in column 2.

COL3
The result is displayed in column 3.

*RST: NONE

Usage: Asynchronous command

Manual operation: See "Result column" on page 556

18.17.8.4 Software trigger

There are two commands for each parameter that you can use for defining the "NRZ Unclocked" settings.

For example, to set the *Frame type =NRZU-Frame* > *Field =Data* >*Data* value you can use one of the following commands:

- `TRIGger:SBSW:NRZU:FRAMe1:FLD1:DMIN 01100`
  Defines the parameter by using the index <fr> for the frame number and <fl> for the field number.
- `TRIGger:SBSW:NRZU:DMIN "NRZC-Frame", "Data", 01100`
  Defines the parameter by using the frame and field name.

TRIGger:SBSW:NRZU:CHKall

Enables the software trigger for all available frames and error types.

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 557

TRIGger:SBSW:NRZU:CLR

Disables the software trigger for all available frames and error types.

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 557

TRIGger:SBSW:NRZU:INVert

Inverts the current state of the frame and error types for the software trigger: all frames and error types that were enabled are disabled and vice versa.

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 557

TRIGger:SBSW:NRZU:RST

Presets the state of the selected frames and error types for the software trigger.

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 557

TRIGger:SBSW:NRZU:FRENable <Frame>,<Enabler>
TRIGger:SBSW:NRZU:FRENable? <Enabler>
TRIGger:SBSW:NRZU:FRAMe<fr>:ENABle <Enable>

Enables or disables the checking condition for the selected frame for the software trigger.

Suffix:
<fr> Index of the frame

Parameters:
<Enable> OFF | ON
*RST: ON

Usage: Asynchronous command

Manual operation: See "Frame type" on page 558

TRIGger:SBSW:NRZU:BIT <Frame>,<Field>,<Bit>
TRIGger:SBSW:NRZU:BIT? <Bit>
TRIGger:SBSW:NRZU:FRAMe<fr>:FLD<fl>:BIT <BitState>

Sets the bit state of a field that only consists of one bit for the software trigger.

Suffix:
<fr> Index of the frame

<fl> Index of the field

Parameters:
<BitState> ONE | ZERO
*RST: ZERO

Usage: Asynchronous command

Manual operation: See "Edit" on page 558

TRIGger:SBSW:NRZU:DMAX <Frame>,<Field>,<Data>
TRIGger:SBSW:NRZU:DMAX? <Data>
TRIGger:SBSW:NRZU:FRAMe<fr>:FLD<fl>:DMAX <Data_Max>

Sets the end value of a data pattern range for the software trigger, if the operator is set to `INRange` or `OORANGe`.

You can set the operator with TRIGger:SBSW:NRZU:FRAMe<fr>:FLD<fl>:DOPerator.

Suffix:

<fr>	Index of the frame
<fl>	Index of the field

Parameters:
<Data_Max>

Usage: Asynchronous command

Manual operation: See "Edit" on page 558

TRIGger:SBSW:NRZU:DMIN <Frame>,<Field>,<Data>
TRIGger:SBSW:NRZU:DMIN? <Data>
TRIGger:SBSW:NRZU:FRAMe<fr>:FLD<fl>:DMIN <Data_Min>

Specifies the data pattern, or sets the start value of a data pattern range for the software trigger.

Suffix:

<fr>	Index of the frame
<fl>	Index of the field

Parameters:
<Data_Min>

Usage: Asynchronous command

Manual operation: See "Edit" on page 558

TRIGger:SBSW:NRZU:DOPerator <Frame>,<Field>,<Operator>
TRIGger:SBSW:NRZU:DOPerator? <Operator>
TRIGger:SBSW:NRZU:FRAMe<fr>:FLD<fl>:DOPerator <Data_Operator>

Sets the operator for the data pattern of the software trigger in the selected field of the selected frame.

Suffix:

<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Data_Operator>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange *RST: EQUal

Usage: Asynchronous command

Manual operation: See "Edit" on page 558

TRIGger:SBSW:NRZU:FIENable <Frame>,<Field>,<Enabler>
TRIGger:SBSW:NRZU:FIENable? <Enabler>
TRIGger:SBSW:NRZU:FRAMe<fr>:FLD<fl>:ENABle <CondEnabler>

Enables or disables the checking condition for the selected field of the selected frame of the software trigger.

Suffix:

<fr> Index of the frame

<fl> Index of the field

Parameters:

<CondEnabler> OFF | ON
*RST: OFF

Usage: Asynchronous command

Manual operation: See "Edit" on page 558

TRIGger:SBSW:NRZU:IMAX <Frame>,<Field>,<Data>
TRIGger:SBSW:NRZU:IMAX? <Data>
TRIGger:SBSW:NRZU:FRAMe<fr>:FLD<fl>:IMAX <Index_Max>

Sets the end value of an index range for the software trigger if the operator is set to `INRange`.

You can set the operator with `TRIGger:SBSW:NRZU:FRAMe<fr>:FLD<fl>:IOPerator`.

Suffix:

<fr> Index of the frame

<fl> Index of the field

Parameters:

<Index_Max> Range: 1 to 65535
Increment: 1
*RST: 65535

Usage: Asynchronous command

Manual operation: See "Edit" on page 558

TRIGger:SBSW:NRZU:IMIN <Frame>,<Field>,<Data>
TRIGger:SBSW:NRZU:IMIN? <Data>
TRIGger:SBSW:NRZU:FRAMe<fr>:FLD<fl>:IMIN <Index_Min>

Specifies the index, or sets the start value of an index range for the software trigger.

Suffix:

<fr> Index of the frame

<fl> Index of the field

Parameters:

<Index_Min> Range: 1 to 65535
Increment: 1
*RST: 1

Usage: Asynchronous command

Manual operation: See "Edit" on page 558

TRIGger:SBSW:NRZU:IOPerator <Frame>,<Field>,<Operator>
TRIGger:SBSW:NRZU:IOPerator? <Operator>
TRIGger:SBSW:NRZU:FRAMe<fr>:FLD<fl>:IOPerator <Index_Operator>

Sets the operator for the index in the selected field of the selected frame for the software trigger.

Suffix:

<fr> Index of the frame

<fl> Index of the field

Parameters:

<Index_Operator> EQUal | INRange | RANGe
*RST: INRange

Usage: Asynchronous command

Manual operation: See "Edit" on page 558

TRIGger:SBSW:NRZU:ERENable <ErrorName>,<Enabler>
TRIGger:SBSW:NRZU:ERENable? <Enabler>
TRIGger:SBSW:NRZU:ERRor<m>:ENABle <Enable>

Defines the error type for the software trigger.

Suffix:

<m> index of the error

Parameters:

<Enable> OFF | ON
*RST: ON

Usage: Asynchronous command

Manual operation: See "Error type" on page 560

SBUS<sb>:NRZU:SWTindex?

Queries the software trigger index.

If no software trigger event has occurred, the command returns `Invalid`.

Suffix:

<sb> 1...4, index of the serial bus

Return values:

<Index> Range: 0 to 4294967295
Increment: 1
*RST: 0

Usage: Query only
Asynchronous command

SBUS<sb>:NRZU:SWTTime?

Queries the software trigger time in seconds.

If no software trigger event has occured, the command returns `Invalid`.

Suffix:

<sb> 1...4, index of the serial bus

Return values:

<Time> Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0
Default unit: s

Usage: Query only
Asynchronous command

18.17.8.5 Decode results

This section describes the commands to query the results of the decoding of the "NRZ Unclocked" protocol.

For manual operation, refer to Section 14.7.7, "Performing NRZ decoding", on page 560 and Section 14.7.8, "NRZ decode results", on page 562.

SBUS<sb>:NRZU:FCOunt?

Returns the number of decoded frames.

Suffix:
<sb> 1...4, index of the serial bus

Return values:
<Count>

Usage: Query only
Asynchronous command

SBUS<sb>:NRZU:FRAMe<fr>:FLDCount?

Returns the number of fields available in the seleced frame.

Suffix:
<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:
<DataCount>

Usage: Query only
Asynchronous command

SBUS<sb>:NRZU:FRAMe<fr>:WBRate?

Returns the bit rate of the frame.

Suffix:
<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:
<FrameWBR> Increment: 1
*RST: 0
Default unit: bps

Usage: Query only

SBUS<sb>:NRZU:FRAMe<fr>:FLD<fl>:STATe?

Returns the overall state of the specified field in the specified frame.

Suffix:
<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Return values:
<State> OK | LENGth | CRC | PARity | INComplete

OK
The field has no error, it is valid.

LENGth
The length of the field is not as expected, indicating an error.

CRC
The CRC of the frame is not as expected, indicating an error.

PARity
Parity is not as expected, indicating an error

INComplete
The frame is incomplete.

*RST: OK

Usage: Query only
Asynchronous command

SBUS<sb>:NRZU:FRAMe<fr>:FLD<fl>:LABel?

Returns the label of the specified field in the specified frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Return values:

<Name>

Usage: Query only
Asynchronous command

SBUS<sb>:NRZU:FRAMe<fr>:FLD<fl>:VALue?

Returns the value of the specified field in the specified frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Return values:

<Value> *RST: 0

Usage: Query only
Asynchronous command

SBUS<sb>:NRZU:FRAMe<fr>:FLD<fl>:FVALue?

Returns the formatted value of the specified field in the specified frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Return values:
<FormattedValue>

Usage: Query only
Asynchronous command

SBUS<sb>:NRZU:FRAMe<fr>:STATus?

Returns the overall state of the specified frame.

Suffix:
<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:
<FrameState> OK | LENGth | CRC | PARity | INComplete

OK
The frame is valid.

LENGth
Length of the frame is not as expected, indicating an error.

CRC
The checksum of the frame is not as expected, indicating an error.

PARity
Parity is not as expected, indicating an error.

INComplete
The frame is incomplete.

*RST: OK

Usage: Query only
Asynchronous command

SBUS<sb>:NRZU:FRAMe<fr>:STARt?

Returns the start time of the specified frame.

Suffix:
<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:
<FrameStart> Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0
Default unit: s

Usage:	Query only Asynchronous command

SBUS<sb>:NRZU:FRAMe<fr>:STOP?

Returns the end time of the specified frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<FrameStop>	Range: -1E+26 to 1E+26 Increment: 1E-10 *RST: 0 Default unit: s
Usage:	Query only Asynchronous command

SBUS<sb>:NRZU:FRAMe<fr>:TYPE?

Returns the type of the specified decoded frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<FrameType>	The frame type is undefined, because it is custom specific.
Usage:	Query only Asynchronous command

SBUS<sb>:NRZU:FRAMe<fr>:RES1?

Returns the content of the 1st result column of the specified decoded frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<Result1>	
Usage:	Query only Asynchronous command

SBUS<sb>:NRZU:FRAMe<fr>:RES2?

Returns the content of the 2nd result column of the specified decoded frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:
<Result2>

Usage: Query only
Asynchronous command

SBUS<sb>:NRZU:FRAMe<fr>:RES3?

Returns the content of the 3rd result column of the specified decoded frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:
<Result3>

Usage: Query only
Asynchronous command

18.17.9 Manchester (option R&S MXO4-K510)

Before MXO 4 can accept the specific bus commands, make sure that:

- The decoding of the specified bus is enabled with `SBUS<sb>[:STATe]`.
- The bus is set to the correct type with `SBUS<sb>:TYPE`.

18.17.9.1 Configuration

SBUS<sb>:MANCh:DATA:SOURce <DATASource>

Selects the channel for the data signal source.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<DATASource> C1 | C2 | C3 | C4 | M1 | M2 | M3 | M4 | M5 | R1 | R2 | R3 | R4 | O<n>C1 | O<n>C2 | ... | O<n>C8 (<n> = 2 to 8)

Usage: Asynchronous command

Manual operation: See "Data source" on page 568

SBUS<sb>:MANCh:DATA:POLarity <DataPolarity>

Sets the polarity for the data line.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<DataPolarity> MANC | MANT

MANC
Selects the "Manchester" data representation convention as per G. E. Thomas: High-to-low transition for logical 1.

MANT
Selects the "Manchester II" (Manchester Two) data representation convention as per IEEE 802.3: Low-to-high transition for logical 1.

*RST: MANC

Usage: Asynchronous command

Manual operation: See "Data polarity" on page 568

SBUS<sb>:MANCh:DATA:PHASe <DataPhase>

Sets the phase for the data line.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<DataPhase> FEDGe | SEDGe

FEDGe
Selects capturing data bits on the clock's first (rising) edge.

SEDGe
Selects capturing data bits on the clock's second (falling) edge.

*RST: SEDGe

Usage: Asynchronous command

Manual operation: See "Data phase" on page 568

SBUS<sb>:MANCh:ENABle:SOURce <DATASource>

Selects the channel for the enable signal source.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<DATASource> C1 | C2 | C3 | C4 | M1 | M2 | M3 | M4 | M5 | R1 | R2 | R3 | R4 | O<n>C1 | O<n>C2 | ... | O<n>C8 (<n> = 2 to 8)

Usage: Asynchronous command

Manual operation: See "Enable source" on page 568

SBUS<sb>:MANCh:ENABle:POLarity <EnablePolarity>

Sets the polarity for the enable line.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<EnablePolarity> ACTLow | ACTHigh

ACTLow
The transmitted signal for the enable line is active high (high = 1).

ACTHigh
The transmitted signal for the enable line is active low (low = 1).

*RST: ACTHigh

Usage: Asynchronous command

Manual operation: See "Enable source" on page 568

SBUS<sb>:MANCh:MINGap:SELect <MingapSelect>

Enables checking the minimum idle time between two frames during decoding.

To set the idle time, use the command `SBUS<sb>:MANCh:MINGap:WIDTh`.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<MingapSelect> OFF | ON
*RST: OFF

Usage: Asynchronous command

Manual operation: See "Check gap time" on page 569

SBUS<sb>:MANCh:MINGap:WIDTh <MingapWidth>

Sets the minimum duration of the idle time. Any inactivity greater than this time is interpreted as a gap and leads to a resynchronization to the signal.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<MingapWidth> Range: 1E-09 to 1
Increment: 1E-09
*RST: 1E-05
Default unit: s

Usage: Asynchronous command

Manual operation: See "Check gap time" on page 569

SBUS<sb>:MANCh:BITRate:SELect <BitrateSelect>

Enables setting the bit rate.

To set the bit rate, use the command `SBUS<sb>:MANCh:BITRate:WIDTh`.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<BitrateSelect> OFF | ON
*RST: OFF

Usage: Asynchronous command

Manual operation: See "Check bit rate" on page 569

SBUS<sb>:MANCh:BITRate:WIDTh <BitrateWidth>

Sets the bit rate.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:

<BitrateWidth> Range: 300 to 2000000000
Increment: 100000
*RST: 10000000
Default unit: bps

Usage: Asynchronous command

Manual operation: See "Check bit rate" on page 569

SBUS<sb>:MANCh:DATA:THUPper <DatThresUpp>

Sets the upper threshold for the data channel.

Suffix:

<sb> 1...4, index of the serial bus

Parameters:

<DatThresUpp>

Usage: Asynchronous command

Manual operation: See "Data upper threshold, Data lower threshold, Data hysteresis" on page 570

SBUS<sb>:MANCh:DATA:THLower <DatThresLow>

Sets the lower threshold for the data channel.

Suffix:

<sb> 1...4, index of the serial bus

Parameters:

<DatThresLow>

Usage: Asynchronous command

Manual operation: See "Data upper threshold, Data lower threshold, Data hysteresis" on page 570

SBUS<sb>:MANCh:DATA:HYSTeresis <DataHysteresis>

Sets the hysteresis for the data channel.

Suffix:

<sb> 1...4, index of the serial bus

Parameters:

<DataHysteresis>

Usage: Asynchronous command

Manual operation: See "Data upper threshold, Data lower threshold, Data hysteresis" on page 570

SBUS<sb>:MANCh:ENABle:THReshold <EnabThres>

Sets the threshold for the enable channel.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<EnabThres>

Usage: Asynchronous command

Manual operation: See "Enable threshold, Enable hysteresis" on page 570

SBUS<sb>:MANCh:ENABle:HYSTeresis <EnabHyst>

Sets the hysteresis for the enable channel.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<EnabHyst>

Usage: Asynchronous command

Manual operation: See "Enable threshold, Enable hysteresis" on page 570

SBUS<sb>:MANCh:POSition <Position>

Sets the vertical position of the Manchester signal.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<Position>

Usage: Asynchronous command

SBUS<sb>:MANCh:SCALe <Scale>

Sets the vertical scale of the Manchester signal.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<Scale>

Usage: Asynchronous command

18.17.9.2 Filter

There are two commands for each parameter, that you can use for defining the Manchester settings.

For example, to set the *Frame type =Manchester-Frame* > *Field =Data* >*Data* value you can use one of the following commands:

- `SBUS:MANCh:FILTer:FRAMe1:FLD1:DMIN 01100`
  Defines the parameter by using the index <m> for the frame number and <n> for the field number.
- `SBUS:MANCh:FILTer:DMIN "Manchester-Frame", "Data", 01100`
  Defines the parameter by using the frame and field name.

SBUS<sb>:MANCh:FILTer:CHKall

Enables the filter for all available frames and error types.

Suffix:

<sb>	1...4, index of the serial bus
Usage:	Setting only Asynchronous command
Manual operation:	See "Check all, Clear, Invert, Preset" on page 571

SBUS<sb>:MANCh:FILTer:CLR

Disables the filter for all available frames and error types.

Suffix:
<sb> 1...4, index of the serial bus

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 571

SBUS<sb>:MANCh:FILTer:INVert

Inverts the current state of the frame and error types: all frames and error types that were enabled are disabled and vice versa.

Suffix:
<sb> 1...4, index of the serial bus

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 571

SBUS<sb>:MANCh:FILTer:RST

Presets the state of the selected frames and error types.

Suffix:
<sb> 1...4, index of the serial bus

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 571

SBUS<sb>:MANCh:FILTer:BIT <Frame>,<Field>,<Bit>
SBUS<sb>:MANCh:FILTer:BIT? <Bit>
SBUS<sb>:MANCh:FILTer:FRAMe<fr>:FLD<fl>:BIT <BitState>

Sets the bit state of a field that only consists of one bit.

Suffix:
<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Parameters:
<BitState> ONE | ZERO

*RST: ZERO

Usage: Asynchronous command

Manual operation: See "Edit" on page 572

SBUS<sb>:MANCh:FILTer:ERENable <ErrorName>,<Enabler>
SBUS<sb>:MANCh:FILTer:ERENable? <Enabler>
SBUS<sb>:MANCh:FILTer:ERRor<n>:ENABle <Enable>

Defines the error type to be filtered on.

Suffix:

<sb>	1...4, index of the serial bus
<n>	index of the error

Parameters:

<Enable>	OFF | ON *RST: ON

Usage: Asynchronous command

Manual operation: See "Error type" on page 574

SBUS<sb>:MANCh:FILTer:DMAX <Frame>,<Field>,<Data>
SBUS<sb>:MANCh:FILTer:DMAX? <Data>
SBUS<sb>:MANCh:FILTer:FRAMe<fr>:FLD<fl>:DMAX <Data_Max>

Sets the end value of a data pattern range if the operator is set to `INRange` or `OORANGe`.

You can set the operator with `SBUS<sb>:MANCh:FILTer:FRAMe<fr>:FLD<fl>:DOPerator`.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Data_Max>

Usage: Asynchronous command

Manual operation: See "Edit" on page 572

SBUS<sb>:MANCh:FILTer:DMIN <Frame>,<Field>,<Data>
SBUS<sb>:MANCh:FILTer:DMIN? <Data>
SBUS<sb>:MANCh:FILTer:FRAMe<fr>:FLD<fl>:DMIN <Data_Min>

Specifies the data pattern, or sets the start value of a data pattern range.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

<fl> Index of the field

Parameters:
<Data_Min>

Usage: Asynchronous command

Manual operation: See "Edit" on page 572

SBUS<sb>:MANCh:FILTer:DOPerator <Frame>,<Field>,<Operator>
SBUS<sb>:MANCh:FILTer:DOPerator? <Operator>
SBUS<sb>:MANCh:FILTer:FRAMe<fr>:FLD<fl>:DOPerator <Data_Operator>

Sets the operator for the data pattern in the selected field of the selected frame.

Suffix:
<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Parameters:
<Data_Operator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

*RST: EQUal

Usage: Asynchronous command

Manual operation: See "Edit" on page 572

SBUS<sb>:MANCh:FILTer:FIENable <Frame>,<Field>,<Enabler>
SBUS<sb>:MANCh:FILTer:FIENable? <Enabler>
SBUS<sb>:MANCh:FILTer:FRAMe<fr>:FLD<fl>:ENABle <CondEnabler>

Enables or disables the checking condition for the selected field of the selected frame.

Suffix:
<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Parameters:
<CondEnabler> OFF | ON

*RST: OFF

Usage: Asynchronous command

Manual operation: See "Edit" on page 572

SBUS<sb>:MANCh:FILTer:FRENable <Frame>,<Enabler>
SBUS<sb>:MANCh:FILTer:FRENable? <Enabler>
SBUS<sb>:MANCh:FILTer:FRAMe<fr>:ENABle <Enable>

Enables the filtering on Manchester frames. Only the frames that match the selected filter conditions are displayed.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Parameters:

<Enable>	OFF | ON *RST: ON

Usage: Asynchronous command

Manual operation: See "Enable" on page 572

SBUS<sb>:MANCh:FILTer:IMAX <Frame>,<Field>,<Data>
SBUS<sb>:MANCh:FILTer:IMAX? <Data>
SBUS<sb>:MANCh:FILTer:FRAMe<fr>:FLD<fl>:IMAX <Index_Max>

Sets the end value of an index range if the operator is set to `INRange`.

You can set the operator with `SBUS<sb>:MANCh:FILTer:FRAMe<fr>:FLD<fl>:IOPerator`.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Index_Max>	Range: 1 to 65535 Increment: 1 *RST: 65535

Usage: Asynchronous command

Manual operation: See "Edit" on page 572

SBUS<sb>:MANCh:FILTer:IMIN <Frame>,<Field>,<Data>
SBUS<sb>:MANCh:FILTer:IMIN? <Data>
SBUS<sb>:MANCh:FILTer:FRAMe<fr>:FLD<fl>:IMIN <Index_Min>

Specifies the index, or sets the start value of an index range.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Index_Min>	Range: 1 to 65535 Increment: 1 *RST: 1
Usage:	Asynchronous command
Manual operation:	See "Edit" on page 572

SBUS<sb>:MANCh:FILTer:IOPerator <Frame>,<Field>,<Operator>
SBUS<sb>:MANCh:FILTer:IOPerator? <Operator>
SBUS<sb>:MANCh:FILTer:FRAMe<fr>:FLD<fl>:IOPerator <Index_Operator>

Sets the operator for the index in the selected field of the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Index_Operator>	EQUal | INRange | RANGe *RST: INRange
Usage:	Asynchronous command
Manual operation:	See "Edit" on page 572

18.17.9.3 Frame format

This section describes the commands to specify and query frame formats for the "Manchester" protocol.

For manual operation, refer to Section 14.8.4, "Manchester frame format configuration", on page 574.

SBUS<sb>:MANCh:FORMat:ADDFrame

Appendes a new frame description to the frame list.

Suffix:

<sb>	1...4, index of the serial bus
Usage:	Setting only Asynchronous command
Manual operation:	See "Add Frame" on page 576

SBUS<sb>:MANCh:FORMat:LOAD <FileName>

Loads a the specified XML file with a list of frame descriptions.

Suffix:

<sb>	1...4, index of the serial bus

Setting parameters:

<FileName>

Usage:	Setting only Asynchronous command
Manual operation:	See "Open" on page 577

SBUS<sb>:MANCh:FORMat:SAVE <FileName>

Saves the current list of frame descriptions to an XML file with the specified name.

Suffix:

<sb>	1...4, index of the serial bus

Setting parameters:

<FileName>

Usage:	Setting only Asynchronous command
Manual operation:	See "Save as" on page 577

SBUS<sb>:MANCh:FORMat:CLR

Erases from the volatile memory all field and frame format descriptions that you have created for a specific custom protocol.

Suffix:

<sb>	1...4, index of the serial bus
Usage:	Setting only Asynchronous command
Manual operation:	See "Edit List" on page 577

SBUS<sb>:MANCh:FORMat:FCOunt?

Returns the number of frame format descriptions available for a specific custom protocol.

Suffix:
<sb> 1...4, index of the serial bus

Return values:
<Count>

Usage: Query only
Asynchronous command

Manual operation: See "Edit List" on page 577

SBUS<sb>:MANCh:FORMat:FRAMe<fr>:ADDField

Appends a new field description to the selected frame description.

Suffix:
<sb> 1...4, index of the serial bus

<fr> Index of the frame

Usage: Setting only
Asynchronous command

Manual operation: See "Add Field" on page 577

SBUS<sb>:MANCh:FORMat:FRAMe<fr>:FLDCount?

Returns the number of field descriptions available for the seleced frame.

Suffix:
<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:
<Count>

Usage: Query only
Asynchronous command

Manual operation: See "Edit List" on page 578

SBUS<sb>:MANCh:FORMat:FRAMe<fr>:NAME <Name>

Specifies the name for the frame description of the selected frame.

Suffix:
<sb> 1...4, index of the serial bus

<fr> Index of the frame

Parameters:
<Name>

Usage: Asynchronous command

Manual operation: See "Frame name" on page 578

SBUS<sb>:MANCh:FORMat:FRAMe<fr>:COLor <Color>

Specifies the color for the frame description of the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Parameters:

<Color> Use 32-bit RGB encoding in decimal format.
Range: 0 to 4294967295
Increment: 1
*RST: 4278255615

Usage: Asynchronous command

Manual operation: See "Frame Color" on page 579

SBUS<sb>:MANCh:FORMat:FRAMe<fr>:FLD<fl>:NAME <Name>

Specifies the name for the selected field of the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:
<Name>

Usage: Asynchronous command

Manual operation: See "Field name" on page 579

SBUS<sb>:MANCh:FORMat:FRAMe<fr>:FLD<fl>:COLor <Color>

Specifies the color for the selected field of the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Color> Use 32-bit RGB encoding in decimal format.

Range: 0 to 4294967295
Increment: 1
*RST: 4294967040

Usage: Asynchronous command

Manual operation: See "Field Color" on page 579

SBUS<sb>:MANCh:FORMat:FRAMe<fr>:FLD<fl>:BITCount <BitCount>

Specifies the bit count, hence length, of the selected field in the selected frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Parameters:

<BitCount> Range: 1 to 64
Increment: 1
*RST: 1

Usage: Asynchronous command

Manual operation: See "Bit count" on page 579

SBUS<sb>:MANCh:FORMat:FRAMe<fr>:FLD<fl>:CONDition <Condition>

Specifies a user-defined condition operator for the selected field of the selected frame. The various condition operators can identify, for example, a mandatory CRC checksum value or a frame ID.

Set the numeric format of the condition by the command `SBUS<sb>:MANCh:FORMat:FRAMe<fr>:FLD<fl>:FORMat`.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Parameters:

<Condition> The implemented conditions are the "equal" and "array" operators.

Usage: Asynchronous command

Manual operation: See "Condition" on page 580

SBUS<sb>:MANCh:FORMat:FRAMe<fr>:FLD<fl>:FORMat <NumericFormat>

Specifies the numerical format for the condition value of the selected field in the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<NumericFormat> DEC | HEX | OCT | BIN

DEC
Decimal format

HEX
Hexadecimal format

OCT
Octal format

BIN
Binary format

*RST: BIN

Usage: Asynchronous command

Manual operation: See "Numeric format" on page 582

SBUS<sb>:MANCh:FORMat:FRAMe<fr>:FLD<fl>:BITorder <BitOrder>

Specifies, in which order the algorithm evaluates the bits of the condition value of the selected field in the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<BitOrder> LSBF | MSBF

LSBF
Least significant bit first

MSBF
Most significant bit first

*RST: MSBF

Usage: Asynchronous command

Manual operation: See "Bit order" on page 582

SBUS<sb>:MANCh:FORMat:FRAMe<fr>:FLD<fl>:CLMN <Column>

Specifies, in which result column of the decode table to display the selected field of the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Column> NONE | COL1 | COL2 | COL3

NONE
The result is not displayed.

COL1
The result is displayed in column 1.

COL2
The result is displayed in column 2.

COL3
The result is displayed in column 3.

*RST: NONE

Usage: Asynchronous command

Manual operation: See "Result column" on page 583

18.17.9.4 Software trigger

There are two commands for each parameter that you can use for defining the "Manchester" settings.

For example, to set the *Frame type =Manchester-Frame* > *Field =Data* >*Data* value you can use one of the following commands:

- `TRIGger:SBSW:MANCh:FRAMe1:FLD1:DMIN 01100`
  Defines the parameter by using the index <fr> for the frame number and <fl> for the field number.
- `TRIGger:SBSW:MANCh:DMIN "Manchester-Frame", "Data", 01100`
  Defines the parameter by using the frame and field name.

TRIGger:SBSW:MANCh:CHKall

Enables the software trigger for all available frames and error types.

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 584

TRIGger:SBSW:MANCh:CLR

Disables the software trigger for all available frames and error types.

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 584

TRIGger:SBSW:MANCh:INVert

Inverts the current state of the frame and error types for the software trigger: all frames and error types that were enabled are disabled and vice versa.

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 584

TRIGger:SBSW:MANCh:RST

Presets the state of the selected frames and error types for the software trigger.

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 584

TRIGger:SBSW:MANCh:FRENable <Frame>,<Enabler>
TRIGger:SBSW:MANCh:FRENable? <Enabler>
TRIGger:SBSW:MANCh:FRAMe<fr>:ENABle <Enable>

Enables or disables the checking condition for the selected frame for the software trigger.

Suffix:

<fr>	Index of the frame

Parameters:

<Enable>	OFF | ON *RST: ON
Usage:	Asynchronous command
Manual operation:	See "Frame type" on page 584

TRIGger:SBSW:MANCh:BIT <Frame>,<Field>,<Bit>
TRIGger:SBSW:MANCh:BIT? <Bit>
TRIGger:SBSW:MANCh:FRAMe<fr>:FLD<fl>:BIT <BitState>

Sets the bit state of a field that only consists of one bit for the software trigger.

Suffix:

<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<BitState>	ONE | ZERO *RST: ZERO
Usage:	Asynchronous command
Manual operation:	See "Edit" on page 585

TRIGger:SBSW:MANCh:DMAX <Frame>,<Field>,<Data>
TRIGger:SBSW:MANCh:DMAX? <Data>
TRIGger:SBSW:MANCh:FRAMe<fr>:FLD<fl>:DMAX <Data_Max>

Sets the end value of a data pattern range for the software trigger, if the operator is set to `INRange` or `OORANGe`.

You can set the operator with `TRIGger:SBSW:MANCh:FRAMe<fr>:FLD<fl>:DOPerator`.

Suffix:

<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Data_Max>	
Usage:	Asynchronous command

Manual operation: See "Edit" on page 585

TRIGger:SBSW:MANCh:DMIN <Frame>,<Field>,<Data>
TRIGger:SBSW:MANCh:DMIN? <Data>
TRIGger:SBSW:MANCh:FRAMe<fr>:FLD<fl>:DMIN <Data_Min>

Specifies the data pattern, or sets the start value of a data pattern range for the software trigger.

Suffix:

<fr> Index of the frame

<fl> Index of the field

Parameters:

<Data_Min>

Usage: Asynchronous command

Manual operation: See "Edit" on page 585

TRIGger:SBSW:MANCh:DOPerator <Frame>,<Field>,<Operator>
TRIGger:SBSW:MANCh:DOPerator? <Operator>
TRIGger:SBSW:MANCh:FRAMe<fr>:FLD<fl>:DOPerator <Data_Operator>

Sets the operator for the data pattern of the software trigger in the selected field of the selected frame.

Suffix:

<fr> Index of the frame

<fl> Index of the field

Parameters:

<Data_Operator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

*RST: EQUal

Usage: Asynchronous command

Manual operation: See "Edit" on page 585

TRIGger:SBSW:MANCh:FIENable <Frame>,<Field>,<Enabler>
TRIGger:SBSW:MANCh:FIENable? <Enabler>
TRIGger:SBSW:MANCh:FRAMe<fr>:FLD<fl>:ENABle <CondEnabler>

Enables or disables the checking condition for the selected field of the selected frame of the software trigger.

Suffix:

<fr> Index of the frame

<fl> Index of the field

Parameters:

<CondEnabler> OFF | ON
*RST: OFF

Usage: Asynchronous command

Manual operation: See "Edit" on page 585

TRIGger:SBSW:MANCh:IMAX <Frame>,<Field>,<Data>
TRIGger:SBSW:MANCh:IMAX? <Data>
TRIGger:SBSW:MANCh:FRAMe<fr>:FLD<fl>:IMAX <Index_Max>

Sets the end value of an index range for the software trigger if the operator is set to `INRange`.

You can set the operator with `TRIGger:SBSW:MANCh:FRAMe<fr>:FLD<fl>:IOPerator`.

Suffix:

<fr> Index of the frame

<fl> Index of the field

Parameters:

<Index_Max> Range: 1 to 65535
Increment: 1
*RST: 65535

Usage: Asynchronous command

Manual operation: See "Edit" on page 585

TRIGger:SBSW:MANCh:IMIN <Frame>,<Field>,<Data>
TRIGger:SBSW:MANCh:IMIN? <Data>
TRIGger:SBSW:MANCh:FRAMe<fr>:FLD<fl>:IMIN <Index_Min>

Specifies the index, or sets the start value of an index range for the software trigger.

Suffix:

<fr> Index of the frame

<fl> Index of the field

Parameters:

<Index_Min> Range: 1 to 65535
Increment: 1
*RST: 1

Usage: Asynchronous command

Manual operation: See "Edit" on page 585

TRIGger:SBSW:MANCh:IOPerator <Frame>,<Field>,<Operator>
TRIGger:SBSW:MANCh:IOPerator? <Operator>
TRIGger:SBSW:MANCh:FRAMe<fr>:FLD<fl>:IOPerator <Index_Operator>

Sets the operator for the index in the selected field of the selected frame for the software trigger.

Suffix:

<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Index_Operator>	EQUal | INRange | RANGe *RST: INRange

Usage: Asynchronous command

Manual operation: See "Edit" on page 585

TRIGger:SBSW:MANCh:ERENable <ErrorName>,<Enabler>
TRIGger:SBSW:MANCh:ERENable? <Enabler>
TRIGger:SBSW:MANCh:ERRor<m>:ENABle <Enable>

Defines the error type for the software trigger.

Suffix:

<m>	index of the error

Parameters:

<Enable>	OFF | ON *RST: ON

Usage: Asynchronous command

Manual operation: See "Error type" on page 586

SBUS<sb>:MANCh:SWTindex?

Queries the software trigger index.

If no software trigger event has occurred, the command returns `Invalid`.

Suffix:

<sb>	1...4, index of the serial bus

Return values:

<Index>	Range: 0 to 4294967295 Increment: 1 *RST: 0

Usage: Query only
Asynchronous command

SBUS<sb>:MANCh:SWTTime?

Queries the software trigger time in seconds.

If no software trigger event has occured, the command returns `Invalid`.

Suffix:
<sb> 1...4, index of the serial bus

Return values:
<Time> Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0
Default unit: s

Usage: Query only
Asynchronous command

18.17.9.5 Decode results

This section describes the commands to query the results of the decoding of the "Manchester" protocol.

For manual operation, refer to Section 14.8.7, "Performing Manchester decoding", on page 587.

SBUS<sb>:MANCh:FCOunt?

Returns the number of decoded frames.

Suffix:
<sb> 1...4, index of the serial bus

Return values:
<Count>

Usage: Query only
Asynchronous command

SBUS<sb>:MANCh:FRAMe<fr>:FLDCount?

Returns the number of fields available in the seleced frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<DataCount>

Usage: Query only
Asynchronous command

SBUS<sb>:MANCh:FRAMe<fr>:WBRate?

Returns the bit rate of the frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<FrameWBR>
Range: 0 to 100000000000
Increment: 1
*RST: 0
Default unit: bps

Usage: Query only

SBUS<sb>:MANCh:FRAMe<fr>:FLD<fl>:STATe?

Returns the overall state of the specified field in the specified frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Return values:

<State> OK | LENGth | CRC | PARity | INComplete

OK
The field has no error, it is valid.

LENGth
The length of the field is not as expected, indicating an error.

CRC
The CRC of the frame is not as expected, indicating an error.

PARity
Parity is not as expected, indicating an error

INComplete
The frame is incomplete.

*RST: OK

Usage: Query only
Asynchronous command

SBUS<sb>:MANCh:FRAMe<fr>:FLD<fl>:LABel?

Returns the label of the specified field in the specified frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Return values:
<Name>

Usage: Query only
Asynchronous command

SBUS<sb>:MANCh:FRAMe<fr>:FLD<fl>:VALue?

Returns the value of the specified field in the specified frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Return values:
<Value> *RST: 0

Usage: Query only
Asynchronous command

SBUS<sb>:MANCh:FRAMe<fr>:FLD<fl>:FVALue?

Returns the formatted value of the specified field in the specified frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Return values:
<FormattedValue>

Usage: Query only
Asynchronous command

SBUS<sb>:MANCh:FRAMe<fr>:STATus?

Returns the overall state of the specified frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:

<FrameState> OK | LENGth | CRC | PARity | INComplete

OK
The frame is valid.

LENGth
Length of the frame is not as expected, indicating an error.

CRC
The checksum of the frame is not as expected, indicating an error.

PARity
Parity is not as expected, indicating an error.

INComplete
The frame is incomplete.

*RST: OK

Usage: Query only
Asynchronous command

SBUS<sb>:MANCh:FRAMe<fr>:STARt?

Returns the start time of the specified frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:

<FrameStart> Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0
Default unit: s

Usage: Query only
Asynchronous command

SBUS<sb>:MANCh:FRAMe<fr>:STOP?

Returns the end time of the specified frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<FrameStop> Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0
Default unit: s

Usage: Query only
Asynchronous command

SBUS<sb>:MANCh:FRAMe<fr>:TYPE?

Returns the type of the specified decoded frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<FrameType> The frame type is undefined, because it is custom specific.

Usage: Query only
Asynchronous command

SBUS<sb>:MANCh:FRAMe<fr>:RES1?

Returns the content of the 1st result column of the specified decoded frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<Result1>

Usage: Query only
Asynchronous command

SBUS<sb>:MANCh:FRAMe<fr>:RES2?

Returns the content of the 2nd result column of the specified decoded frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<Result2>

Usage: Query only
Asynchronous command

SBUS<sb>:MANCh:FRAMe<fr>:RES3?

Returns the content of the 3rd result column of the specified decoded frame.

Suffix:
<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:
<Result3>

Usage: Query only
Asynchronous command

18.17.10 CAN (option R&S MXO4-K520)

Before MXO 4 can accept the specific bus commands, make sure that:

- The decoding of the specified bus is enabled with `SBUS<sb>[:STATe]`.
- The bus is set to the correct type with `SBUS<sb>:TYPE`.

18.17.10.1 Configuration

SBUS<sb>:CAN:TYPE <SignalType>

Selects the CAN-High or CAN-Low line. Both lines are required for differential signal transmission used by CAN.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<SignalType> CANL | CANH
*RST: CANL

Usage: Asynchronous command

Manual operation: See "Type" on page 593

SBUS<sb>:CAN:BITRate <Bitrate>

Sets the number of transmitted bits per second.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<Bitrate> Range: 10000 to 5000000
Increment: 100
*RST: 100000
Default unit: bps

Usage: Asynchronous command

Manual operation: See "Nominal bit rate" on page 593

SBUS<sb>:CAN:SAMPlepoint <SamplePoint>

Sets the position of the sample point within the bit in percent of the nominal bit time.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<SamplePoint> Range: 30 to 90
Increment: 5
*RST: 66
Default unit: %

Usage: Asynchronous command

Manual operation: See "Sample point" on page 593

SBUS<sb>:CAN:SOURce Source

Sets the source channel to which the line is connected.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
Source With digital channels in SIC mode:
C1 | C2 | C3 | C4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | M1 | M2 | M3 | M4 | M5 | R1 | R2 | R3 | R4 | O<n>C1 | O<n>C2 | ... | O<n>C8 (<n> = 2 to 8)
Without digital channels in FAST mode:
C1 | C2 | C3 | C4 | M1 | M2 | M3 | M4 | M5 | R1 | R2 | R3 | R4 | O<n>C1 | O<n>C2 | ... | O<n>C8 (<n> = 2 to 8)

Usage: Asynchronous command

Manual operation: See "Data" on page 592

SBUS<sb>:CAN:FDATa:DBITrate <FDBitrate>

Sets the bit rate of the data phase.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<FDBitrate> Range: 10000 to 15000000
Increment: 100
*RST: 1000000
Default unit: bps

Usage: Asynchronous command

Manual operation: See "FD bit rate" on page 593

SBUS<sb>:CAN:FDATa:SAMPlepoint <FDSamplePoint>

Sets the position of the sample point within the bit in percent of the nominal bit time.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<FDSamplePoint> Range: 30 to 90
Increment: 5
*RST: 66
Default unit: %

Usage: Asynchronous command

Manual operation: See "FD sample point" on page 593

SBUS<sb>:CAN:SIC:HYSTeresis <Hysteresis>

Sets a hysteresis value for the SIC transceiver mode.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<Hysteresis>

Usage: Asynchronous command

Manual operation: See "Threshold" on page 594

SBUS<sb>:CAN:SIC:THReshold <SIC Threshold>

Sets a threshold value for the SIC transceiver mode.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<SIC Threshold>

Usage: Asynchronous command

Manual operation: See "Threshold" on page 594

SBUS<sb>:CAN:FAST:THReshold <SIC Threshold>

Sets a threshold value for the fast transceiver mode.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<SIC Threshold>

Usage: Asynchronous command

Manual operation: See "Threshold" on page 594

SBUS<sb>:CAN:FAST:HYSTeresis <Hysteresis>

Sets a hysteresis value for the fast transceiver mode.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<Hysteresis>

Usage: Asynchronous command

Manual operation: See "Threshold" on page 594

SBUS<sb>:CAN:XDATa:DBITrate <XLBitrate>

Sets the bit rate of the data phase for the CAN XL frame.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<XLBitrate> Range: 10000 to 30000000
Increment: 100
*RST: 10000000
Default unit: bps

Usage: Asynchronous command

Manual operation: See "XL bit rate" on page 593

SBUS<sb>:CAN:XDATa:SAMPlepoint <XLSamplePoint>

Sets the position of the sample point within the bit in percent of the nominal bit time for the CAN XL frame.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<XLSamplePoint> Range: 30 to 90
Increment: 5
*RST: 66
Default unit: %

Usage: Asynchronous command

Manual operation: See "XL sample point" on page 594

SBUS<sb>:CAN:TRCVmode <TransceiverMd>

Selects the transceiver mode for the CAN decoding.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<TransceiverMd> SIC | FAST
*RST: SIC

Usage: Asynchronous command

Manual operation: See "Transceiver mode" on page 593

SBUS<sb>:CAN:SYMBols <ShowSymbols>

Activates the symbol list to be used for decoding.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<ShowSymbols> OFF | ON
*RST: OFF

Usage: Asynchronous command

Manual operation: See "Show symbols" on page 595

SBUS<sb>:CAN:NEWList <FileName>

Loads a symbol list file.

Suffix:
<sb> 1...4, index of the serial bus

Setting parameters:
<FileName> String parameter with path and file name.

Example:
```
SBUS1:CAN:NEWList
'/home/storage/userData/Protocol/CAN.csv'
SBUS1:CAN:SYMBols ON
```

Usage: Setting only
Asynchronous command

Manual operation: See "Show symbols" on page 595

SBUS<sb>:CAN:POSition <CAN position>

Sets the vertical position of the CAN signal.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<CAN position>

Usage: Asynchronous command

SBUS<sb>:CAN:SCALe <CAN scale>

Set the vertical scale of the indicated CAN signal.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<CAN scale>

Usage: Asynchronous command

18.17.10.2 Filter

There are two commands for each parameter, that you can use for defining the CAN settings.

For example, to set the *Frame type =CBFF* > *Field =Data* >*Data* value you can use one of the following commands:

- `SBUS:CAN:FILTer:FRAMe1:FLD1:DMIN 01100`
  Defines the parameter by using the index <m> for the frame number and <n> for the field number.
- `SBUS:CAN:FILTer:DMIN "CBFF", "Data", 01100`
  Defines the parameter by using the frame and field name.

SBUS<sb>:CAN:FILTer:CHKall

Enables the filter for all available frames and error types.

Suffix:

<sb>	1...4, index of the serial bus
Usage:	Setting only Asynchronous command
Manual operation:	See "Check all, Clear, Invert, Preset" on page 597

SBUS<sb>:CAN:FILTer:CLR

Disables the filter for all available frames and error types.

Suffix:
<sb> 1...4, index of the serial bus

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 597

SBUS<sb>:CAN:FILTer:INVert

Inverts the current state of the frame and error types: all frames and error types that were enabled are disabled and vice versa.

Suffix:
<sb> 1...4, index of the serial bus

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 597

SBUS<sb>:CAN:FILTer:RST

Presets the state of the selected frames and error types.

Suffix:
<sb> 1...4, index of the serial bus

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 597

SBUS<sb>:CAN:FILTer:BIT <Frame>,<Field>,<Bit>
SBUS<sb>:CAN:FILTer:BIT? <Bit>
SBUS<sb>:CAN:FILTer:FRAMe<fr>:FLD<fl>:BIT <BitState>

Sets the operator for the data pattern in the selected field of the selected frame.

Suffix:
<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Parameters:
<BitState> ONE | ZERO
*RST: ZERO

Usage: Asynchronous command

Manual operation: See "Edit" on page 598

SBUS<sb>:CAN:FILTer:DMAX <Frame>,<Field>,<Data>
SBUS<sb>:CAN:FILTer:DMAX? <Data>
SBUS<sb>:CAN:FILTer:FRAMe<fr>:FLD<fl>:DMAX <Data_Max>

Sets the end value of a data pattern range if the operator is set to `INRange` or `OORANGe`.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Parameters:

<Data_Max>

Usage: Asynchronous command

Manual operation: See "Edit" on page 598

SBUS<sb>:CAN:FILTer:DMIN <Frame>,<Field>,<Data>
SBUS<sb>:CAN:FILTer:DMIN? <Data>
SBUS<sb>:CAN:FILTer:FRAMe<fr>:FLD<fl>:DMIN <Data_Min>

Specifies the data pattern, or sets the start value of a data pattern range.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Parameters:

<Data_Min>

Usage: Asynchronous command

Manual operation: See "Edit" on page 598

SBUS<sb>:CAN:FILTer:DOPerator <Frame>,<Field>,<Operator>
SBUS<sb>:CAN:FILTer:DOPerator? <Operator>
SBUS<sb>:CAN:FILTer:FRAMe<fr>:FLD<fl>:DOPerator <Data_Operator>

Sets the operator for the data pattern in the selected field of the selected frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Parameters:

<Data_Operator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

*RST: EQUal

Usage: Asynchronous command

Manual operation: See "Edit" on page 598

SBUS<sb>:CAN:FILTer:ERENable <ErrorName>,<Enabler>
SBUS<sb>:CAN:FILTer:ERENable? <Enabler>
SBUS<sb>:CAN:FILTer:ERRor<n>:ENABle <Enable>

Defines the error type to be filtered on.

Suffix:

<sb> 1...4, index of the serial bus

<n> index of the error

Parameters:

<Enable> OFF | ON

*RST: ON

Usage: Asynchronous command

Manual operation: See "Error type" on page 600

SBUS<sb>:CAN:FILTer:FIENable <Frame>,<Field>,<Enabler>
SBUS<sb>:CAN:FILTer:FIENable? <Enabler>
SBUS<sb>:CAN:FILTer:FRAMe<fr>:FLD<fl>:ENABle <CondEnabler>

Enables or disables the checking condition for the selected field of the selected frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Parameters:

<CondEnabler> OFF | ON

*RST: OFF

Usage: Asynchronous command

Manual operation: See "Edit" on page 598

SBUS<sb>:CAN:FILTer:FRENable <Frame>,<Enabler>
SBUS<sb>:CAN:FILTer:FRENable? <Enabler>
SBUS<sb>:CAN:FILTer:FRAMe<fr>:ENABle <Enable>

Enables the filtering on CAN frames. Only the frames that match the selected filter conditions are displayed.

Suffix:
<sb> 1...4, index of the serial bus

<fr> Index of the frame

Parameters:
<Enable> OFF | ON
*RST: ON

Usage: Asynchronous command

Manual operation: See "Frame type" on page 598

SBUS<sb>:CAN:FILTer:IMAX <Frame>,<Field>,<Data>
SBUS<sb>:CAN:FILTer:IMAX? <Data>
SBUS<sb>:CAN:FILTer:FRAMe<fr>:FLD<fl>:IMAX <Index_Max>

Sets the end value of an index range if the operator is set to `INRange`.

Suffix:
<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Parameters:
<Index_Max> Range: 1 to 65535
Increment: 1
*RST: 65535

Usage: Asynchronous command

Manual operation: See "Edit" on page 598

SBUS<sb>:CAN:FILTer:IMIN <Frame>,<Field>,<Data>
SBUS<sb>:CAN:FILTer:IMIN? <Data>
SBUS<sb>:CAN:FILTer:FRAMe<fr>:FLD<fl>:IMIN <Index_Min>

Specifies the index, or sets the start value of an index range.

Suffix:
<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Parameters:
<Index_Min> Range: 1 to 65535
Increment: 1
*RST: 1

Usage: Asynchronous command

Manual operation: See "Edit" on page 598

SBUS<sb>:CAN:FILTer:IOPerator <Frame>,<Field>,<Operator>
SBUS<sb>:CAN:FILTer:IOPerator? <Operator>
SBUS<sb>:CAN:FILTer:FRAMe<fr>:FLD<fl>:IOPerator <Index_Operator>

Sets the operator for the index in the selected field of the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Index_Operator>	EQUal | INRange | RANGe *RST: INRange

Usage: Asynchronous command

Manual operation: See "Edit" on page 598

18.17.10.3 Hardware trigger

Trigger commands for serial buses affect the current trigger source. Therefore, set the trigger source to the required serial bus with `TRIGger:EVENt<ev>:SOURce` before sending the bus-specific trigger commands.

TRIGger:SBHW:CAN:ACKerror <AckError>

Triggers when the transmitter does not receive an acknowledgment - a dominant bit during the ACK Slot.

Available, if `TRIGger:SBHW:CAN:TYPE` is set to `ERRC`.

Parameters:

<AckError> OFF | ON

*RST: ON

Usage: Asynchronous command

Manual operation: See "Error conditions" on page 607

TRIGger:SBHW:CAN:BITSterror <BitStuffError>

Triggers if a stuff error occurs - when the 6th consecutive equal bit level in the mentioned fields is detected.

Available, if `TRIGger:SBHW:CAN:TYPE` is set to `ERRC`.

Parameters:

<BitStuffError> OFF | ON

*RST: ON

Usage: Asynchronous command

Manual operation: See "Error conditions" on page 607

TRIGger:SBHW:CAN:BORDer <Endianness>

Sets the byte order (endianness) of the data transfer. Only for CAN protocol.

Parameters:

<Endianness> BENDian | LENDian

BENDian
Big endian, data is analyzed and evaluated in the order of reception.

LENDian
Little endian, the instrument reads the complete data, reverses the byte order of the data, and compares it with the specified data word.

*RST: BENDian

Usage: Asynchronous command

TRIGger:SBHW:CAN:CRCerror <ChecksumError>

Triggers on CRC errors. A CRC error occurs when the CRC calculated by the receiver differs from the received value in the CRC sequence.

Available, if TRIGger:SBHW:CAN:TYPE is set to ERRC.

Parameters:

<ChecksumError> OFF | ON

*RST: ON

Usage: Asynchronous command

Manual operation: See "Error conditions" on page 607

TRIGger:SBHW:CAN:DCONdition <DataOperator>

Sets the operator to set a specific data pattern or a data pattern range.

Parameters:

<DataOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, not equal, less than, less or equal than, greater than, greater or equal than. These conditions require one data pattern to be set with TRIGger:SBHW:CAN:DMIN.

*RST: EQUal

Usage: Asynchronous command

Manual operation: See "Data pattern" on page 606

TRIGger:SBHW:CAN:DLC <DLC>

Sets the data length code, the number of data bytes to be found. For complete definition, set also the operator with TRIGger:SBHW:CAN:DLCCondition.

Parameters:

<DLC> Range: CAN: 1 to 8, CAN FD: 1 to 15 (64 bytes)

Increment: 1

*RST: 0

Usage: Asynchronous command

Manual operation: See "DLC" on page 605

TRIGger:SBHW:CAN:DLCCondition <DLCOperator>

Operator to set the data length code.

The number of data bytes to be found is set with TRIGger:SBHW:CAN:DLC.

Parameters:
<DLCOperator> EQUal | GETHan

For little endian transfer direction, EQUal must be set.

*RST: GETHan

Usage: Asynchronous command

Manual operation: See "DLC" on page 605

TRIGger:SBHW:CAN:DMIN <DataPattern>

Sets a data pattern, or sets the start value of a data pattern range.

Parameters:
<DataPattern> List of comma separated values

Usage: Asynchronous command

Manual operation: See "Data pattern" on page 606

TRIGger:SBHW:CAN:FDATa:BRS <BRS_Bit>

Sets the bit rate switch bit.

Parameters:
<BRS_Bit> ONE | ZERO | DC

ONE: the bit rate switches from the bit rate of the arbitration phase to the faster data rate.

*RST: ONE

Usage: Asynchronous command

Manual operation: See "BRS, ESI" on page 606

TRIGger:SBHW:CAN:FDATa:DPOSition <DataPosition>

Defines the number of the first data byte at which the data pattern may start.

Parameters:
<DataPosition> Range: 1 to 2048
Increment: 1
*RST: 1

Usage: Asynchronous command

TRIGger:SBHW:CAN:FDATa:ESI <ESI_Bit>

Sets the error state indicator bit.

Parameters:

<ESI_Bit> ONE | ZERO | DC

DC: do not care, bit is nor relevant.

*RST: DC

Usage: Asynchronous command

Manual operation: See "BRS, ESI" on page 606

TRIGger:SBHW:CAN:FDATa:SCERror <StuffCntErr>

Triggers on stuff count errors. A stuff bit error occurs if more than five consecutive bits of the same level occur on the bus.

Available, if TRIGger:SBHW:CAN:TYPE is set to ERRor.

Parameters:

<StuffCntErr> OFF | ON

*RST: ON

Usage: Asynchronous command

Manual operation: See "Error conditions" on page 607

TRIGger:SBHW:CAN:FORMerror <FormError>

Triggers when a fixed-form bit field contains one or more illegal bits.

Available, if TRIGger:SBHW:CAN:TYPE is set to ERRC.

Parameters:

<FormError> OFF | ON

*RST: ON

Usage: Asynchronous command

Manual operation: See "Error conditions" on page 607

TRIGger:SBHW:CAN:FTYPe <FrameType>

Sets the CAN frame type.

Parameters:

<FrameType> CBFF | CBFR | CEFF | CEFR | FBFF | FEFF | XLFF | ERRor | OVERload

CBFF: classical base frame format data
CBFR: classical base frame format remote
CEFF: classical extended frame format data
CEFR: classical extended frame format remote
FBFF: FD base frame format
FEFF: FD extended frame format
XLFF: XL frame format

ERR: error
OVLD: overload

*RST: CBFF

Usage: Asynchronous command

Manual operation: See "Frame type" on page 603

TRIGger:SBHW:CAN:ICONdition <IdOperator>

Sets the operator to set a specific identifier or an identifier range.

Parameters:

<IdOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, not equal, less than, less or equal than, greater than, greater or equal than. These conditions require one identifier pattern to be set with TRIGger:SBHW:CAN:IMIN.

INRange | OORange
In range / out of range: Set the minimum and maximum value of the range with TRIGger:SBHW:CAN:IMIN and TRIGger:SBHW:CAN:IMAX.

*RST: EQUal

Usage: Asynchronous command

Manual operation: See "Identifier" on page 605

TRIGger:SBHW:CAN:IMAX <IdPattern>

Sets the end value of an identifier range if TRIGger:SBHW:CAN:ICONdition is set to INRange or OORange.

Parameters:

<IdPattern> List of comma separated values

Usage: Asynchronous command

Manual operation: See "Identifier" on page 605

TRIGger:SBHW:CAN:IMIN <IdPattern>

Specifies a message identifier pattern, or sets the start value of an identifier range.

Parameters:

<IdPattern>

Usage: Asynchronous command

Manual operation: See "Identifier" on page 605

TRIGger:SBHW:CAN:ITYPe <IdentifierType>

Selects the format of data and remote frames.

Remote frames are not available in the CAN FD protocol.

Parameters:

<IdentifierType> B11 | B29

B11
11-bit identifier (standard format). The instrument triggers on the sample point of the IDE bit.

B29
29-bit identifier (extended format). The instrument triggers on the sample point of the RTR bit.

*RST: B11

Usage: Asynchronous command

Manual operation: See "ID type" on page 606

TRIGger:SBHW:CAN:TYPE <Type>

Selects the trigger type for CAN analysis.

Parameters:

<Type> STOF | EDOF | FTYP | ID | IDDT | ERRC

STOF
STart of Frame: triggers on the first edge of the dominant SOF bit (synchronization bit).

FTYP
Frame type: triggers on a specified frame type and on the identifier format.

ID
Identifier: Sets the trigger to one specific identifier or an identifier range.
To set the identifier, use `TRIGger:SBHW:CAN:ICONdition`, `TRIGger:SBHW:CAN:IMAX`, and `TRIGger:SBHW:CAN:IMIN`.

IDDT
Identifier and data: Combination of identifier and data conditions.
To set the identifier condition, use `TRIGger:SBHW:CAN:ICONdition`, `TRIGger:SBHW:CAN:IMIN`, and `TRIGger:SBHW:CAN:IMAX`.
To set the data condition, use `TRIGger:SBHW:CAN:DCONdition` and `TRIGger:SBHW:CAN:DMIN`.

ERRC
Error condition: Define the error types with:
TRIGger:SBHW:CAN:ACKerror
TRIGger:SBHW:CAN:BITSterror
TRIGger:SBHW:CAN:CRCerror
TRIGger:SBHW:CAN:FORMerror
TRIGger:SBHW:CAN:FDATa:SCERror

*RST: STOF

Usage: Asynchronous command

Manual operation: See "Type" on page 601

TRIGger:SBHW:CAN:XDATa:AF:CONDition <AfOperator>

Sets the comparison condition for the acceptance field to a specific value or a range.

Parameters:

<AfOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, not equal, less than, less or equal than, greater than, greater or equal than. These conditions require one pattern to be set with TRIGger:SBHW:CAN:XDATa:AF:MIN.

INRange | OORange
In range / out of range: Set the minimum and maximum value of the range with TRIGger:SBHW:CAN:XDATa:AF:MIN and TRIGger:SBHW:CAN:XDATa:AF:MAX.

*RST: EQUal

Usage: Asynchronous command

Manual operation: See "AF" on page 607

TRIGger:SBHW:CAN:XDATa:AF:MAX <AfPatternTo>

Sets the end value of an acceptance field if TRIGger:SBHW:CAN:XDATa:AF:CONDition is set to INRange or OORange.

Parameters:

<AfPatternTo> List of comma separated values

Usage: Asynchronous command

Manual operation: See "AF" on page 607

TRIGger:SBHW:CAN:XDATa:AF:MIN <AfPattern>

Specifies an acceptance field pattern, or sets the start value of a range.

Parameters:
<AfPattern> List of comma separated values

Usage: Asynchronous command

Manual operation: See "AF" on page 607

TRIGger:SBHW:CAN:XDATa:SDT:CONDition <SdtOperator>

Sets the comparison condition for the service data unit type to a specific value or a range.

Parameters:
<SdtOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, not equal, less than, less or equal than, greater than, greater or equal than. These conditions require one pattern to be set with `TRIGger:SBHW:CAN:XDATa:SDT:MIN`.

INRange | OORange
In range / out of range: Set the minimum and maximum value of the range with `TRIGger:SBHW:CAN:XDATa:SDT:MIN` and `TRIGger:SBHW:CAN:XDATa:SDT:MAX`.

*RST: EQUal

Usage: Asynchronous command

Manual operation: See "SDT" on page 606

TRIGger:SBHW:CAN:XDATa:SDT:MAX <SdtPatternTo>

Sets the end value of a service data unit type range if `TRIGger:SBHW:CAN:XDATa:SDT:CONDition` is set to `INRange` or `OORange`.

Parameters:
<SdtPatternTo> List of comma separated values

Usage: Asynchronous command

Manual operation: See "SDT" on page 606

TRIGger:SBHW:CAN:XDATa:SDT:MIN <SdtPattern>

Specifies a service data unit type pattern, or sets the start value of a range.

Parameters:
<SdtPattern> List of comma separated values

Usage: Asynchronous command

Manual operation: See "SDT" on page 606

TRIGger:SBHW:CAN:XDATa:SEC <SEC_Bit>

Sets a value for the simple extended content (SEC) field. It indicates, if the CAN XL data frame uses the CADsec protocol.

Parameters:

<SEC_Bit> ONE | ZERO | DC

*RST: DC

Usage: Asynchronous command

Manual operation: See "SEC" on page 607

TRIGger:SBHW:CAN:XDATa:VCID:CONDition <VcidOperator>

Sets the comparison condition for the VCID to a specific value or a range.

Parameters:

<VcidOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, not equal, less than, less or equal than, greater than, greater or equal than. These conditions require one pattern to be set with `TRIGger:SBHW:CAN:XDATa:VCID:MIN`.

INRange | OORange
In range / out of range: Set the minimum and maximum value of the range with `TRIGger:SBHW:CAN:XDATa:VCID:MIN` and `TRIGger:SBHW:CAN:XDATa:VCID:MAX`.

*RST: EQUal

Usage: Asynchronous command

Manual operation: See "VCID" on page 607

TRIGger:SBHW:CAN:XDATa:VCID:MAX <VcidPatternTo>

Sets the end value of a VCID range if `TRIGger:SBHW:CAN:XDATa:VCID:CONDition` is set to `INRange` or `OORange`.

Parameters:

<VcidPatternTo> List of comma separated values

Usage: Asynchronous command

Manual operation: See "VCID" on page 607

TRIGger:SBHW:CAN:XDATa:VCID:MIN <VcidPattern>

Specifies a VCID pattern, or sets the start value of a range.

Parameters:

<VcidPattern> List of comma separated values

Usage: Asynchronous command

Manual operation: See "VCID" on page 607

18.17.10.4 Software trigger

There are two commands for each parameter, that you can use for defining the CAN settings.

For example, to set the *Frame type =CBFF* > *Field =Data* >*Data* value you can use one of the following commands:

- `TRIGger:SBSW:CAN:FRAMe1:FLD1:DMIN 01100`
  Defines the parameter by using the index <m> for the frame number and <n> for the field number.
- `TRIGger:SBSW:CAN:DMIN "CBFF", "Data", 01100`
  Defines the parameter by using the frame and field name.

TRIGger:SBSW:CAN:CHKall

Enables the software trigger for all available frames and error types.

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 610

TRIGger:SBSW:CAN:CLR

Disables the software trigger for all available frames and error types.

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 610

TRIGger:SBSW:CAN:INVert

Inverts the current state of the frame and error types for the software trigger: all frames and error types that were enabled are disabled and vice versa.

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 610

TRIGger:SBSW:CAN:RST

Presets the state of the selected frames and error types for the software trigger.

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 610

TRIGger:SBSW:CAN:FRENable <Frame>,<Enabler>
TRIGger:SBSW:CAN:FRENable? <Enabler>
TRIGger:SBSW:CAN:FRAMe<fr>:ENABle <Enable>

Enables or disables the checking condition for the selected frame for the software trigger.

Suffix:
<fr> Index of the frame

Parameters:
<Enable> OFF | ON
*RST: ON

Usage: Asynchronous command

Manual operation: See "Frame type" on page 610

TRIGger:SBSW:CAN:BIT <Frame>,<Field>,<Bit>
TRIGger:SBSW:CAN:BIT? <Bit>
TRIGger:SBSW:CAN:FRAMe<fr>:FLD<fl>:BIT <BitState>

Sets the bit state of a field that only consists of one bit for the software trigger.

Suffix:

<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<BitState> ONE | ZERO

*RST: ZERO

Usage: Asynchronous command

Manual operation: See "Edit" on page 610

TRIGger:SBSW:CAN:DMAX <Frame>,<Field>,<Data>
TRIGger:SBSW:CAN:DMAX? <Data>
TRIGger:SBSW:CAN:FRAMe<fr>:FLD<fl>:DMAX <Data_Max>

Sets the end value of a data pattern range for the software trigger, if the operator is set to `INRange` or `OORANGe`.

You can set the operator with `TRIGger:SBSW:CAN:FRAMe<fr>:FLD<fl>:DOPerator`.

Suffix:

<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Data_Max>

Usage: Asynchronous command

Manual operation: See "Edit" on page 610

TRIGger:SBSW:CAN:DMIN <Frame>,<Field>,<Data>
TRIGger:SBSW:CAN:DMIN? <Data>
TRIGger:SBSW:CAN:FRAMe<fr>:FLD<fl>:DMIN <Data_Min>

Specifies the data pattern, or sets the start value of a data pattern range for the software trigger.

Suffix:

<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Data_Min>

Usage: Asynchronous command

Manual operation: See "Edit" on page 610

TRIGger:SBSW:CAN:DOPerator <Frame>,<Field>,<Operator>
TRIGger:SBSW:CAN:DOPerator? <Operator>
TRIGger:SBSW:CAN:FRAMe<fr>:FLD<fl>:DOPerator <Data_Operator>

Sets the operator for the data pattern of the software trigger in the selected field of the selected frame.

Suffix:

<fr> Index of the frame

<fl> Index of the field

Parameters:

<Data_Operator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

*RST: EQUal

Usage: Asynchronous command

Manual operation: See "Edit" on page 610

TRIGger:SBSW:CAN:FIENable <Frame>,<Field>,<Enabler>
TRIGger:SBSW:CAN:FIENable? <Enabler>
TRIGger:SBSW:CAN:FRAMe<fr>:FLD<fl>:ENABle <CondEnabler>

Enables or disables the checking condition for the selected field of the selected frame of the software trigger.

Suffix:

<fr> Index of the frame

<fl> Index of the field

Parameters:

<CondEnabler> OFF | ON

*RST: OFF

Usage: Asynchronous command

Manual operation: See "Edit" on page 610

TRIGger:SBSW:CAN:IMAX <Frame>,<Field>,<Data>
TRIGger:SBSW:CAN:IMAX? <Data>
TRIGger:SBSW:CAN:FRAMe<fr>:FLD<fl>:IMAX <Index_Max>

Sets the end value of an index range for the software trigger if the operator is set to `INRange`.

You can set the operator with `TRIGger:SBSW:CAN:FRAMe<fr>:FLD<fl>:IOPerator`.

Suffix:

<fr> Index of the frame

<fl> Index of the field

Parameters:

<Index_Max>
Range: 1 to 65535
Increment: 1
*RST: 65535

Usage: Asynchronous command

Manual operation: See "Edit" on page 610

TRIGger:SBSW:CAN:IMIN <Frame>,<Field>,<Data>
TRIGger:SBSW:CAN:IMIN? <Data>
TRIGger:SBSW:CAN:FRAMe<fr>:FLD<fl>:IMIN <Index_Min>

Specifies the index, or sets the start value of an index range for the software trigger.

Suffix:

<fr> Index of the frame

<fl> Index of the field

Parameters:

<Index_Min>
Range: 1 to 65535
Increment: 1
*RST: 1

Usage: Asynchronous command

Manual operation: See "Edit" on page 610

TRIGger:SBSW:CAN:IOPerator <Frame>,<Field>,<Operator>
TRIGger:SBSW:CAN:IOPerator? <Operator>
TRIGger:SBSW:CAN:FRAMe<fr>:FLD<fl>:IOPerator <Index_Operator>

Sets the operator for the index in the selected field of the selected frame for the software trigger.

Suffix:

<fr> Index of the frame

<fl> Index of the field

Parameters:

<Index_Operator> EQUal | INRange | RANGe
*RST: INRange

Usage: Asynchronous command

Manual operation: See "Edit" on page 610

TRIGger:SBSW:CAN:ERENable <ErrorName>,<Enabler>
TRIGger:SBSW:CAN:ERENable? <Enabler>
TRIGger:SBSW:CAN:ERRor<m>:ENABle <Enable>

Defines the error type for the software trigger.

Suffix:

<m> index of the error

Parameters:

<Enable> OFF | ON

*RST: ON

Usage: Asynchronous command

Manual operation: See "Error type" on page 612

SBUS<sb>:CAN:SWTindex?

Queries the software trigger index.

If no software trigger event has occurred, the command returns `Invalid`.

Suffix:

<sb> 1...4, index of the serial bus

Return values:

<Index> Range: 0 to 4294967295
Increment: 1
*RST: 0

Usage: Query only
Asynchronous command

SBUS<sb>:CAN:SWTTime?

Queries the software trigger time in seconds.

If no software trigger event has occured, the command returns `Invalid`.

Suffix:

<sb> 1...4, index of the serial bus

Return values:

<Time> Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0
Default unit: s

Usage: Query only
Asynchronous command

18.17.10.5 Decode results

SBUS<sb>:CAN:FCOunt?

Returns the number of decoded frames for the CAN protocol analysis.

Suffix:

<sb> 1...4, index of the serial bus

Return values:

<Count> Total number of frames.

Usage: Query only
Asynchronous command

SBUS<sb>:CAN:FRAMe<fr>:FLDCount?

Returns the number of fields in the specified frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:
<Count>

Usage: Query only
Asynchronous command

SBUS<sb>:CAN:FRAMe<fr>:ACKState?

Return the states of the acknowledgment field.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<FrameAckState> OK | ERRor | UNDF
UNDF: Undefined
*RST: OK

Usage: Query only
Asynchronous command

SBUS<sb>:CAN:FRAMe<fr>:ACKValue?

Returns the value of the acknowledge slot for the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<FrameAckValue> Range: 0 to 1
Increment: 1
*RST: 0

Usage: Query only
Asynchronous command

SBUS<sb>:CAN:FRAMe<fr>:FLD<fl>:STATe?

Returns the state of the specified field in the specified frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

<fl> *
Selects the field number.

Return values:
<State> OK | EOFD | ACKD | NOACk | CRCD | CRC | SERRror | FORM | BTST | UNKNown | INComplete

OK
The field has no error, it is valid.

EOFD
Wrong end of field

ACKD
Acknowledgment delimiter error

NOACk
Field acknowledgment is missing

CRCD
Checksum delimiter error

CRC
Checksum error, cyclic redundancy check failed

SERRror
Stuff count error (CAN-FD ISO only)

FORM
Fixed-bit form error

BTST
Bit stuffing error

UNKNown
State unknown

INComplete
Field not completely contained in the acquisition.

*RST: OK

Usage: Query only
Asynchronous command

SBUS<sb>:CAN:FRAMe<fr>:FLD<fl>:LABel?

Returns the label of the specified field in the specified frame.

Suffix:
<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Return values:
<Label>

Usage: Query only
Asynchronous command

SBUS<sb>:CAN:FRAMe<fr>:FLD<fl>:VALue?

Returns the value of the specified field in the specified frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	* Index of the field

Return values:

<Value>	Increment: 1 *RST: 0

Usage: Query only
Asynchronous command

SBUS<sb>:CAN:FRAMe<fr>:FLD<fl>:FVALue?

Returns the formatted value of the specified field in the specified frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Return values:

<FormattedValue>

Usage: Query only
Asynchronous command

SBUS<sb>:CAN:FRAMe<fr>:CSSTate?

Return the states of the checksum field (CRC).

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<ChecksumState>	OK | ERRor | UNDF *RST: OK

Usage: Query only
Asynchronous command

SBUS<sb>:CAN:FRAMe<fr>:CSValue?

Returns the CRC sequence value of the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<ChecksumValue> Range: 0 to 4294967295
Increment: 1
*RST: 0

Usage: Query only
Asynchronous command

SBUS<sb>:CAN:FRAMe<fr>:DATA?

Returns the data of the specified frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<Count> Comma-separated list of values. The first value is the number of bytes, followed by the values of the data bytes.

<Values>

Example:
```
BUS1:CAN:FRAMe2:DATA?
--> 3,208,231,32
```
Returns the data of the 2nd frame: the number of data bytes is 3 (see 1st value).

Usage: Query only
Asynchronous command

SBUS<sb>:CAN:FRAMe<fr>:DLCState?

Return the states of the state of data length code.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<FrameDLCState> OK | ERRor | UNDF
*RST: OK

Usage: Query only
Asynchronous command

SBUS<sb>:CAN:FRAMe<fr>:DLCValue?

Returns the data length code of the selected frame - the number of data bytes in the frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<FrameDLCValue> Range: 0 to 2047
Increment: 1
*RST: 0

Usage: Query only
Asynchronous command

SBUS<sb>:CAN:FRAMe<fr>:FERCause?

Returns information on a form error, if the frame status query (`SBUS<sb>:CAN:FRAMe<fr>:STATus?`) returned a form error.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<FormErrorCause> NONE | CRCDerror | ACKDerror | FSBE | RESerror

`CRCDerror` = CRC delimiter error
`ACKDerror` = ACK delimiter error
`FSBE` = fixed stuff bit error (CAN FD ISO only)
`RESerror` = reserved bit error

*RST: NONE

Usage: Query only
Asynchronous command

SBUS<sb>:CAN:FRAMe<fr>:IDSTate?

Return the states of the identifier state.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<IdtfSt> OK | ERRor | UNDF

UNDF: Undefined

*RST: OK

Usage: Query only
Asynchronous command

SBUS<sb>:CAN:FRAMe<fr>:IDTYpe?

Returns the identifier type of the selected frame, the identifier format of data and remote frames.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:

<IdentifierType> B11 | B29

B11: standard format, 11 bit
B29: extended format, 29 bit

*RST: B11

Usage: Query only
Asynchronous command

SBUS<sb>:CAN:FRAMe<fr>:IDValue?

Returns the identifier value of the selected frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:

<IdtfVal> Range: 0 to 536870911
Increment: 1
*RST: 0

Usage: Query only
Asynchronous command

SBUS<sb>:CAN:FRAMe<fr>:NDBYtes?

Returns the number of data bytes.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:

<NDBytes> Range: 0 to 2048
Increment: 1
*RST: 1

Usage: Query only
Asynchronous command

SBUS<sb>:CAN:FRAMe<fr>:STARt?

Return the start time of the selected frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:

<FrameStart> Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0
Default unit: s

Usage: Query only
Asynchronous command

SBUS<sb>:CAN:FRAMe<fr>:STATus?

Returns the overall state of the selected frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:

<FrameState> OK | EOFD | ACKD | NOACk | CRCD | CRC | SERRror | FORM | BTST | UNKNown | INComplete

`OK`: the frame is valid.
`EOFD`: Wrong end of frame.
`ACKD`: Wrong ACK delimiter occurred.
`NOACK`: Acknowledge is missing.
`CRCD`: Wrong CRC delimiter occurred.
`CRC`: Cyclic redundancy check failed.
`SERRror`: Stuff count error (CAN FD ISO only).
`FORM`: Fixed-bit form error.
`BTST`: Bit stuffing error occurred.
`INSufficient`: The frame is not completely contained in the acquisition. The acquired part of the frame is valid.

*RST: OK

Usage: Query only
Asynchronous command

SBUS<sb>:CAN:FRAMe<fr>:STOP?

Return the stop time of the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<FrameStop>
Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0
Default unit: s

Usage: Query only
Asynchronous command

SBUS<sb>:CAN:FRAMe<fr>:STUFf?

Returns the value of the stuff count field.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<StuffCount>
Range: 0 to 7
Increment: 1
*RST: 0

Usage: Query only
Asynchronous command

SBUS<sb>:CAN:FRAMe<fr>:SYMBol?

Returns the symbol of the specified frame if the label list is enabled.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<Label> String with symbol of the identifier

Example: `BUS:CAN:FRAMe:SYMBol?`
Response: `Temperature`

Usage: Query only

SBUS<sb>:CAN:FRAMe<fr>:TYPE?

Returns the frame type of the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<FrameType> CBFF | CBFR | CEFF | CEFR | FBFF | FEFF | XLFF | ERRor | OVERload | UNDefined

`CBFF`: classical base frame format data
`CBFRemote`: classical base frame format remote
`CEFF`: classical extended frame format data
`CEFRemote`: classical extended frame format remote
`FBFF`: FD base frame format
`FEFF`: FD extended frame format
`XLFF`: XL frame format
`ERR`: error
`OVLD`: overload

*RST: CBFF

Usage: Query only
Asynchronous command

SBUS<sb>:CAN:FRAMe<fr>:XDATa<o>:AF?

Returns the value of the acceptance field for the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<o>	Index of the field

Return values:

<AF> Range: 0 to 4294967295
Increment: 1
*RST: 0

Usage: Query only
Asynchronous command

SBUS<sb>:CAN:FRAMe<fr>:XDATa<o>:PCRC?

Returns the value of the preamble cyclic redundant check (PCRC) for the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<o>	Index of the field

Return values:

<PCRC>	Range: 0 to 65535 Increment: 1 *RST: 0

Usage: Query only
Asynchronous command

SBUS<sb>:CAN:FRAMe<fr>:SBC?

Returns the value of the stuff bit count (SBC) field for the selected CAN XL frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<SBC>	Range: 0 to 15 Increment: 1 *RST: 0

Usage: Query only
Asynchronous command

SBUS<sb>:CAN:FRAMe<fr>:XDATa<o>:SEC?

Returns the value of the simple extended content (SEC) field for the selected CAN XL frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<o>	Index of the field

Return values:

<SEC>	Range: 0 to 1 Increment: 1 *RST: 0

Usage: Query only
Asynchronous command

SBUS<sb>:CAN:FRAMe<fr>:XDATa<o>:VCID?

Returns the value of the VCID field for the selected CAN XL frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<o>	Index of the field

Return values:

<VCID> Range: 0 to 255
Increment: 1
*RST: 0

Usage: Query only
Asynchronous command

SBUS<sb>:CAN:FRAMe<fr>:FDATa<o>:ESI?

Returns the value of the error state indicator (ESI) field for the selected frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

<o> Index of the field

Return values:

<ESI> Range: 0 to 1
Increment: 1
*RST: 0

Usage: Query only
Asynchronous command

SBUS<sb>:CAN:FRAMe<fr>:FDATa<o>:BRS?

Returns the value of the bit rate switch (BRS) field for the selected frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

<o> Index of the field

Return values:

<BRS> Range: 0 to 1
Increment: 1
*RST: 0

Usage: Query only
Asynchronous command

SBUS<sb>:CAN:FRAMe<fr>:DBITrate?

Returns the data bit rate of the frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:

<DataBitRate>	Increment: 100 *RST: 0 Default unit: bps

Usage: Query only
Asynchronous command

SBUS<sb>:CAN:FRAMe<fr>:NBITrate?

Returns the nominal bit rate of the frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<NominalBitRate>	Increment: 1 *RST: 0 Default unit: bps

Usage: Query only
Asynchronous command

SBUS<sb>:CAN:FRAMe<fr>:XDATa<o>:FCRC?

Returns the value of the frame CRC for the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<o>	Index of the field

Return values:

<FCRC>	Range: 0 to 4294967295 Increment: 1 *RST: 0

Usage: Query only
Asynchronous command

18.17.11 LIN (option R&S MXO4-K520)

Before MXO 4 can accept the specific bus commands, make sure that:

- The decoding of the specified bus is enabled with `SBUS<sb>[:STATe]`.
- The bus is set to the correct type with `SBUS<sb>:TYPE`.

18.17.11.1 Configuration

SBUS<sb>:LIN:BITRate <Bitrate>

Sets the number of transmitted bits per second. The maximum bit rate for LIN is 20 kbit/s.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<Bitrate> Range: 1000 to 20000000
Increment: 1
*RST: 9600
Default unit: bps

Usage: Asynchronous command

Manual operation: See "Bit rate" on page 623

SBUS<sb>:LIN:DATA:HYSTeresis <Hysteresis>

Sets a value for the hysteresis for the data channel.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<Hysteresis>

Usage: Asynchronous command

Manual operation: See "Threshold" on page 624

SBUS<sb>:LIN:DATA:SOURce <DataSource>

Sets the waveform of the data line.

Suffix:

<sb> 1...4, index of the serial bus

Parameters:

<DataSource> C1 | C2 | C3 | C4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | M1 | M2 | M3 | M4 | M5 | R1 | R2 | R3 | R4 | O<n>C1 | O<n>C2 | ... | O<n>C8 (<n> = 2 to 8)

Usage: Asynchronous command

Manual operation: See "Data" on page 623

SBUS<sb>:LIN:DATA:THReshold <Threshold>

Sets a user-defined threshold value for the data channel.

Suffix:

<sb> 1...4, index of the serial bus

Parameters:

<Threshold>

Usage: Asynchronous command

Manual operation: See "Threshold" on page 624

SBUS<sb>:LIN:POLarity <Polarity>

Defines the idle state of the bus. The idle state is the recessive state and corresponds to a logic 1.

Suffix:

<sb> 1...4, index of the serial bus

Parameters:

<Polarity> IDLLow | IDLHigh

*RST: IDLHigh

Usage: Asynchronous command

Manual operation: See "Polarity" on page 623

SBUS<sb>:LIN:STANdard <Standard>

Selects the version of the LIN standard.

Suffix:

<sb> 1...4, index of the serial bus

Parameters:
<Standard> V1X | V2X | J2602 | AUTO
*RST: AUTO

Usage: Asynchronous command

Manual operation: See "LIN standard" on page 622

SBUS<sb>:LIN:POSition <LIN position>

Sets the vertical position of the LIN signal.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<LIN position>

Usage: Asynchronous command

SBUS<sb>:LIN:SCALe <LIN scale>

Set the vertical scale of the indicated LIN signal.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<LIN scale>

Usage: Asynchronous command

SBUS<sb>:LIN:NEWList <FileName>

Loads a symbol list file.

Suffix:
<sb> 1...4, index of the serial bus

Setting parameters:
<FileName> String parameter with path and file name.

Example:
```
SBUS1:LIN:NEWList
'/home/storage/userData/Protocol/LIN.csv'
SBUS1:LIN:SYMBols ON
```

Usage: Setting only
Asynchronous command

SBUS<sb>:LIN:SYMBols <ShowSymbols>

Activates the symbol list to be used for decoding.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<ShowSymbols> OFF | ON
*RST: OFF

Usage: Asynchronous command

18.17.11.2 Filter

There are two commands for each parameter, that you can use for defining the LIN settings.

For example, to set the *Frame type =Data > Field =Id >00* value you can use one of the following commands:

- `SBUS:LIN:FILTer:FRAMe1:FLD1:DMIN 00`
  Defines the parameter by using the index <m> for the frame number and <n> for the field number.
- `SBUS:LIN:FILTer:DMIN "Data", "Id", 00`
  Defines the parameter by using the frame and field name.

SBUS<sb>:LIN:FILTer:CHKall

Enables the filter for all available frames and error types.

Suffix:
<sb> 1...4, index of the serial bus

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 625

SBUS<sb>:LIN:FILTer:CLR

Disables the filter for all available frames and error types.

Suffix:
<sb> 1...4, index of the serial bus

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 625

SBUS<sb>:LIN:FILTer:INVert

Inverts the current state of the frame and error types: all frames and error types that were enabled are disabled and vice versa.

Suffix:
<sb> 1...4, index of the serial bus

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 625

SBUS<sb>:LIN:FILTer:RST

Presets the state of the selected frames and error types.

Suffix:
<sb> 1...4, index of the serial bus

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 625

SBUS<sb>:LIN:FILTer:BIT <Frame>,<Field>,<Bit>
SBUS<sb>:LIN:FILTer:BIT? <Bit>
SBUS<sb>:LIN:FILTer:FRAMe<fr>:FLD<fl>:BIT <BitState>

Sets the operator for the data pattern in the selected field of the selected frame.

Suffix:
<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Parameters:
<BitState> ONE | ZERO
*RST: ZERO

Usage: Asynchronous command

Manual operation: See "Edit" on page 626

SBUS<sb>:LIN:FILTer:DMAX <Frame>,<Field>,<Data>
SBUS<sb>:LIN:FILTer:DMAX? <Data>
SBUS<sb>:LIN:FILTer:FRAMe<fr>:FLD<fl>:DMAX <Data_Max>

Sets the end value of a data pattern range if the operator is set to `INRange` or `OORANGe`.

Suffix:
<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Parameters:
<Data_Max>

Usage: Asynchronous command

Manual operation: See "Edit" on page 626

SBUS<sb>:LIN:FILTer:DMIN <Frame>,<Field>,<Data>
SBUS<sb>:LIN:FILTer:DMIN? <Data>
SBUS<sb>:LIN:FILTer:FRAMe<fr>:FLD<fl>:DMIN <Data_Min>

Specifies the data pattern, or sets the start value of a data pattern range.

Suffix:
<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Parameters:
<Data_Min>

Usage: Asynchronous command

Manual operation: See "Edit" on page 626

SBUS<sb>:LIN:FILTer:DOPerator <Frame>,<Field>,<Operator>
SBUS<sb>:LIN:FILTer:DOPerator? <Operator>
SBUS<sb>:LIN:FILTer:FRAMe<fr>:FLD<fl>:DOPerator <Data_Operator>

Sets the operator for the data pattern in the selected field of the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Data_Operator>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange *RST: EQUal

Usage: Asynchronous command

Manual operation: See "Edit" on page 626

SBUS<sb>:LIN:FILTer:ERENable <ErrorName>,<Enabler>
SBUS<sb>:LIN:FILTer:ERENable? <Enabler>
SBUS<sb>:LIN:FILTer:ERRor<n>:ENABle <Enable>

Defines the error type to be filtered on.

Suffix:

<sb>	1...4, index of the serial bus
<n>	index of the error

Parameters:

<Enable>	OFF | ON *RST: ON

Usage: Asynchronous command

Manual operation: See "Error type" on page 627

SBUS<sb>:LIN:FILTer:FIENable <Frame>,<Field>,<Enabler>
SBUS<sb>:LIN:FILTer:FIENable? <Enabler>
SBUS<sb>:LIN:FILTer:FRAMe<fr>:FLD<fl>:ENABle <CondEnabler>

Enables or disables the checking condition for the selected field of the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<CondEnabler>	OFF | ON *RST: OFF

Usage: Asynchronous command

Manual operation: See "Edit" on page 626

SBUS<sb>:LIN:FILTer:FRENable <Frame>,<Enabler>
SBUS<sb>:LIN:FILTer:FRENable? <Enabler>
SBUS<sb>:LIN:FILTer:FRAMe<fr>:ENABle <Enable>

Enables the filtering on LIN frames. Only the frames that match the selected filter conditions are displayed.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Parameters:

<Enable>	OFF | ON *RST: ON

Usage: Asynchronous command

Manual operation: See "Frame type" on page 626

SBUS<sb>:LIN:FILTer:IMAX <Frame>,<Field>,<Data>
SBUS<sb>:LIN:FILTer:IMAX? <Data>
SBUS<sb>:LIN:FILTer:FRAMe<fr>:FLD<fl>:IMAX <Index_Max>

Sets the end value of an index range if the operator is set to `INRange`.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Index_Max>	Range: 1 to 65535 Increment: 1 *RST: 65535

Usage: Asynchronous command

Manual operation: See "Edit" on page 626

SBUS<sb>:LIN:FILTer:IMIN <Frame>,<Field>,<Data>
SBUS<sb>:LIN:FILTer:IMIN? <Data>
SBUS<sb>:LIN:FILTer:FRAMe<fr>:FLD<fl>:IMIN <Index_Min>

Specifies the index, or sets the start value of an index range.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Index_Min>	Range: 1 to 65535 Increment: 1 *RST: 1

Usage: Asynchronous command

Manual operation: See "Edit" on page 626

SBUS<sb>:LIN:FILTer:IOPerator <Frame>,<Field>,<Operator>
SBUS<sb>:LIN:FILTer:IOPerator? <Operator>
SBUS<sb>:LIN:FILTer:FRAMe<fr>:FLD<fl>:IOPerator <Index_Operator>

Sets the operator for the index in the selected field of the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Index_Operator>	EQUal | INRange | RANGe *RST: INRange

Usage: Asynchronous command

Manual operation: See "Edit" on page 626

18.17.11.3 Hardware trigger

Trigger commands for serial buses affect the current trigger source. Therefore, set the trigger source to the required serial bus with `TRIGger:EVENt<ev>:SOURce` before sending the bus-specific trigger commands.

TRIGger:SBHW:LIN:TYPE <Type>

Selects the trigger type for LIN analysis.

Parameters:

<Type>	STARtframe | ID | IDDT | WKFR | ERRC

STARtframe
Start of the frame. Triggers on the stop bit of the sync field.

ID
Sets the trigger to one specific identifier or an identifier range.

IDDT
Combination of identifier and data conditions.

WKFR
Wake-up frame.

ERRC
Error condition. Define the error types with:
TRIGger:SBHW:LIN:CHKSerror
TRIGger:SBHW:LIN:IPERror
TRIGger:SBHW:LIN:SYERror

*RST: STARtframe

Usage: Asynchronous command

Manual operation: See "Type" on page 628

TRIGger:SBHW:LIN:SYERror <SyncError>

Triggers if a synchronization error occurs.

Available, if TRIGger:SBHW:LIN:TYPE is set to ERRC.

Parameters:
<SyncError> OFF | ON

*RST: ON

Usage: Asynchronous command

Manual operation: See "Error conditions" on page 629

TRIGger:SBHW:LIN:IPERror <IdParityError>

Triggers if an error occurs in the identifier parity bits. The parity bits are the bits 6 and 7 of the identifier.

Available, if TRIGger:SBHW:LIN:TYPE is set to ERRC.

Parameters:
<IdParityError> OFF | ON

*RST: ON

Usage: Asynchronous command

Manual operation: See "Error conditions" on page 629

TRIGger:SBHW:LIN:IMIN <IdPattern>

Specifies a secondary identifier pattern, or sets the start value of an identifier range.

Parameters:
<IdPattern>

Usage: Asynchronous command

Manual operation: See "Identifier setup: Condition, Frame ID min, Frame ID max" on page 629

TRIGger:SBHW:LIN:IMAX <IdPattern>

Sets the end value of an identifier range if `TRIGger:SBHW:LIN:ICONdition` is set to `INRange` or `OORange`.

Parameters:
<IdPattern>

Usage: Asynchronous command

Manual operation: See "Identifier setup: Condition, Frame ID min, Frame ID max" on page 629

TRIGger:SBHW:LIN:ICONdition <IdOperator>

Sets the operator to set a specific identifier or an identifier range.

Parameters:
<IdOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, not equal, less than, less or equal than, greater than, greater or equal than. These conditions require one identifier pattern to be set with `TRIGger:SBHW:LIN:IMIN`.

INRange | OORange
In range / out of range: Set the minimum and maximum value of the range with `TRIGger:SBHW:LIN:IMIN` and `TRIGger:SBHW:LIN:IMAX`.

*RST: EQUal

Usage: Asynchronous command

Manual operation: See "Identifier setup: Condition, Frame ID min, Frame ID max" on page 629

TRIGger:SBHW:LIN:DPOSition <DataPosition>

Sets the number of data events that are ignored, before trigger condition check of the data starts.

Parameters:
<DataPosition> Range: 1 to 4096
Increment: 1
*RST: 1

Usage: Asynchronous command

Manual operation: See "Data setup: Condition, Pattern, Position" on page 629

TRIGger:SBHW:LIN:DMIN <DataPattern>

Specifies a data pattern, or sets the start value of a data pattern range.

Parameters:
<DataPattern>

Usage: Asynchronous command

Manual operation: See "Data setup: Condition, Pattern, Position" on page 629

TRIGger:SBHW:LIN:DCONdition <DataOperator>

Sets the operator to set a specific data pattern or a data pattern range.

Parameters:
<DataOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
*RST: EQUal

Usage: Asynchronous command

Manual operation: See "Data setup: Condition, Pattern, Position" on page 629

TRIGger:SBHW:LIN:CHKSerror <ChecksumError>

Triggers on checksum errors.

Available, if `TRIGger:SBHW:LIN:TYPE` is set to `ERRC`.

Parameters:
<ChecksumError> OFF | ON
*RST: ON

Usage: Asynchronous command

Manual operation: See "Error conditions" on page 629

18.17.11.4 Software trigger

There are two commands for each parameter, that you can use for defining the LIN settings.

For example, to set the *Frame type =Data > Field =Id >00* value you can use one of the following commands:

- `TRIGger:SBSW:LIN:FRAMe1:FLD1:DMIN 00`
  Defines the parameter by using the index <m> for the frame number and <n> for the field number.
- `TRIGger:SBSW:LIN:DMIN "Data", "Id", 00`

Defines the parameter by using the frame and field name.

TRIGger:SBSW:LIN:CHKall

Enables the software trigger for all available frames and error types.

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 631

TRIGger:SBSW:LIN:CLR

Disables the software trigger for all available frames and error types.

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 631

TRIGger:SBSW:LIN:INVert

Inverts the current state of the frame and error types for the software trigger: all frames and error types that were enabled are disabled and vice versa.

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 631

TRIGger:SBSW:LIN:RST

Presets the state of the selected frames and error types for the software trigger.

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 631

TRIGger:SBSW:LIN:FRENable <Frame>,<Enabler>
TRIGger:SBSW:LIN:FRENable? <Enabler>
TRIGger:SBSW:LIN:FRAMe<fr>:ENABle <Enable>

Enables or disables the checking condition for the selected frame for the software trigger.

Suffix:
<fr> Index of the frame

Parameters:
<Enable> OFF | ON
*RST: ON

Usage: Asynchronous command

Manual operation: See "Frame type" on page 631

TRIGger:SBSW:LIN:BIT <Frame>,<Field>,<Bit>
TRIGger:SBSW:LIN:BIT? <Bit>
TRIGger:SBSW:LIN:FRAMe<fr>:FLD<fl>:BIT <BitState>

Sets the bit state of a field that only consists of one bit for the software trigger.

Suffix:
<fr> Index of the frame

<fl> Index of the field

Parameters:
<BitState> ONE | ZERO
*RST: ZERO

Usage: Asynchronous command

Manual operation: See "Edit" on page 632

TRIGger:SBSW:LIN:DMAX <Frame>,<Field>,<Data>
TRIGger:SBSW:LIN:DMAX? <Data>
TRIGger:SBSW:LIN:FRAMe<fr>:FLD<fl>:DMAX <Data_Max>

Sets the end value of a data pattern range for the software trigger, if the operator is set to `INRange` or `OORANGe`.

You can set the operator with `TRIGger:SBSW:LIN:FRAMe<fr>:FLD<fl>:DOPerator`.

Suffix:

<fr>	Index of the frame
<fl>	Index of the field

Parameters:
<Data_Max>

Usage: Asynchronous command

Manual operation: See "Edit" on page 632

TRIGger:SBSW:LIN:DMIN <Frame>,<Field>,<Data>
TRIGger:SBSW:LIN:DMIN? <Data>
TRIGger:SBSW:LIN:FRAMe<fr>:FLD<fl>:DMIN <Data_Min>

Specifies the data pattern, or sets the start value of a data pattern range for the software trigger.

Suffix:

<fr>	Index of the frame
<fl>	Index of the field

Parameters:
<Data_Min>

Usage: Asynchronous command

Manual operation: See "Edit" on page 632

TRIGger:SBSW:LIN:DOPerator <Frame>,<Field>,<Operator>
TRIGger:SBSW:LIN:DOPerator? <Operator>
TRIGger:SBSW:LIN:FRAMe<fr>:FLD<fl>:DOPerator <Data_Operator>

Sets the operator for the data pattern of the software trigger in the selected field of the selected frame.

Suffix:

<fr>	Index of the frame
<fl>	Index of the field

Parameters:
<Data_Operator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange
*RST: EQUal

Usage: Asynchronous command

Manual operation: See "Edit" on page 632

TRIGger:SBSW:LIN:FIENable <Frame>,<Field>,<Enabler>
TRIGger:SBSW:LIN:FIENable? <Enabler>
TRIGger:SBSW:LIN:FRAMe<fr>:FLD<fl>:ENABle <CondEnabler>

Enables or disables the checking condition for the selected field of the selected frame of the software trigger.

Suffix:
<fr> Index of the frame

<fl> Index of the field

Parameters:
<CondEnabler> OFF | ON
*RST: OFF

Usage: Asynchronous command

Manual operation: See "Edit" on page 632

TRIGger:SBSW:LIN:IMAX <Frame>,<Field>,<Data>
TRIGger:SBSW:LIN:IMAX? <Data>
TRIGger:SBSW:LIN:FRAMe<fr>:FLD<fl>:IMAX <Index_Max>

Sets the end value of an index range for the software trigger if the operator is set to `INRange`.

You can set the operator with `TRIGger:SBSW:LIN:FRAMe<fr>:FLD<fl>:IOPerator`.

Suffix:
<fr> Index of the frame

<fl> Index of the field

Parameters:
<Index_Max> Range: 1 to 65535
Increment: 1
*RST: 65535

Usage: Asynchronous command

Manual operation: See "Edit" on page 632

TRIGger:SBSW:LIN:IMIN <Frame>,<Field>,<Data>
TRIGger:SBSW:LIN:IMIN? <Data>
TRIGger:SBSW:LIN:FRAMe<fr>:FLD<fl>:IMIN <Index_Min>

Specifies the index, or sets the start value of an index range for the software trigger.

Suffix:

<fr> Index of the frame

<fl> Index of the field

Parameters:

<Index_Min> Range: 1 to 65535
Increment: 1
*RST: 1

Usage: Asynchronous command

Manual operation: See "Edit" on page 632

TRIGger:SBSW:LIN:IOPerator <Frame>,<Field>,<Operator>
TRIGger:SBSW:LIN:IOPerator? <Operator>
TRIGger:SBSW:LIN:FRAMe<fr>:FLD<fl>:IOPerator <Index_Operator>

Sets the operator for the index in the selected field of the selected frame for the software trigger.

Suffix:

<fr> Index of the frame

<fl> Index of the field

Parameters:

<Index_Operator> EQUal | INRange | RANGe
*RST: INRange

Usage: Asynchronous command

Manual operation: See "Edit" on page 632

TRIGger:SBSW:LIN:ERENable <ErrorName>,<Enabler>
TRIGger:SBSW:LIN:ERENable? <Enabler>
TRIGger:SBSW:LIN:ERRor<m>:ENABle <Enable>

Defines the error type for the software trigger.

Suffix:

<m> Index of the error

Parameters:

<Enable> OFF | ON
*RST: ON

Usage: Asynchronous command

Manual operation: See "Error type" on page 633

SBUS<sb>:LIN:SWTindex?

Queries the software trigger index.

If no software trigger event has occurred, the command returns `Invalid`.

Suffix:

<sb> 1...4, index of the serial bus

Return values:

<Index> Range: 0 to 4294967295
Increment: 1
*RST: 0

Usage: Query only
Asynchronous command

SBUS<sb>:LIN:SWTTime?

Queries the software trigger time in seconds.

If no software trigger event has occured, the command returns `Invalid`.

Suffix:

<sb> 1...4, index of the serial bus

Return values:

<Time> Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0
Default unit: s

Usage: Query only
Asynchronous command

18.17.11.5 Decode results

The following section describes the commands used for querying the results of the LIN decoding.

SBUS<sb>:LIN:FCOunt?

Returns the number of decoded frames.

Suffix:

<sb> 1...4, index of the serial bus

Return values:

<Count> Total number of decoded frames.

Usage: Query only
Asynchronous command

SBUS<sb>:LIN:FRAMe<fr>:FLDCount?

Returns the number of fields in the specified frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:

<Count> Total number of fields.

Usage: Query only
Asynchronous command

SBUS<sb>:LIN:FRAMe<fr>:BITRate?

Returns the primary bit rate.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:

<PrimaryBitRate> Increment: 1
*RST: 0
Default unit: bps

Usage: Query only
Asynchronous command

SBUS<sb>:LIN:FRAMe<fr>:FLD<fl>:STATe?

Returns the state of the specified field.

Suffix:

<sb> 1...4, index of the serial bus

<fr>	Index of the frame
<fl>	Index of the field

Return values:

<State> OK | WAKeup | CHCKsum | PRERror | STERror | SYERror | LNERror | UNK | INComplete

OK
The field has no error, it is valid.

WAKeup
Wakeup bit missing

CHCKsum
Checksum error

PRERror
Parity error, incorrect parity bit

STERror
Start error, incorrect start bit

SYERror
Synchronization error, incorrect synchronization bit

LNERror
Length error

UNKNown
State unknown

INComplete
Field not completely contained in the acquisition.

*RST: OK

Usage: Query only
Asynchronous command

SBUS<sb>:LIN:FRAMe<fr>:FLD<fl>:VALue?

Returns the value of the specified field.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Return values:

<Value> Increment: 1
*RST: 0

Usage: Query only
Asynchronous command

SBUS<sb>:LIN:FRAMe<fr>:FLD<fl>:FVALue?

Returns the formatted value of the specified field.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Return values:
<FormattedValue>

Usage: Query only
Asynchronous command

SBUS<sb>:LIN:FRAMe<fr>:FLD<fl>:LABel?

Returns the label of the fields in the specified frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Return values:
<Label>

Usage: Query only
Asynchronous command

SBUS<sb>:LIN:FRAMe<fr>:CSValue?

Returns the checksum value of the specified frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<ChecksumValue> Range: 0 to 255
Increment: 1
*RST: 0

Usage: Query only
Asynchronous command

SBUS<sb>:LIN:FRAMe<fr>:DATA?

Returns the data bytes of the specified frame in comma-separated values.

Suffix:
<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:
<Count>

<Values>

Example:
```
BUS:LIN:FRAMe4:DATA?
<-- 4,118,39,71,123
```

Usage: Query only
Asynchronous command

SBUS<sb>:LIN:FRAMe<fr>:IDPValue?

Returns the value of the identifier parity bits of the selected frame.

Suffix:
<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:
<IdtfParVal> Range: 0 to 3
Increment: 1
*RST: 0

Usage: Query only
Asynchronous command

SBUS<sb>:LIN:FRAMe<fr>:IDValue?

Returns the identifier value of the selected frame.

Suffix:
<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:
<IdtfVal> Range: 0 to 63
Increment: 1
*RST: 0

Usage: Query only
Asynchronous command

SBUS<sb>:LIN:FRAMe<fr>:STARt?

Returns the start time of the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<FrameStart>
Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0
Default unit: s

Usage: Query only
Asynchronous command

SBUS<sb>:LIN:FRAMe<fr>:STATus?

Returns the overall state of the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<FrameState>
OK | WAKeup | CHCKsum | PRERror | STERror | SYERror | LNERror | UNK | INComplete

`WAKeup`: wake-up frame.
`CHCKsum`: checksum error
`PRERror`: parity error in identifier
`STERror`: stop error
`SYERror`: synchronization error
`LNERror`: unexpected length
`UNK`: unknown error

*RST: OK

Usage: Query only
Asynchronous command

SBUS<sb>:LIN:FRAMe<fr>:STOP?

Returns the stop time of the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<FrameStop>
Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0
Default unit: s

Usage: Query only
Asynchronous command

SBUS<sb>:LIN:FRAMe<fr>:PIDentifier?

Returns the protected identifier of the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<Protected identifer> Range: 0 to 255
Increment: 1
*RST: 0

Usage: Query only
Asynchronous command

18.17.12 SENT (option R&S MXO4-K520)

Before MXO 4 can accept the specific bus commands, make sure that:

- The decoding of the specified bus is enabled with `SBUS<sb>[:STATe]`.
- The bus is set to the correct type with `SBUS<sb>:TYPE`.

18.17.12.1 Configuration

SBUS<sb>:SENT:CLKPeriod <ClockPeriod>

Sets the transmitter-specific nominal clock period (clock tick).

The clock period and signal length determine the speed of transmission.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<ClockPeriod> Range: 1E-06 to 0.0001
Increment: 1E-06
*RST: 6E-06
Default unit: s

Usage: Asynchronous command

Manual operation: See "Clock period" on page 643

SBUS<sb>:SENT:CLKTolerance <ClockTolerance>

Specifies a tolerated deviation of the clock.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<ClockTolerance> Range: 1 to 25
Increment: 1
*RST: 20
Default unit: %

Usage: Asynchronous command

Manual operation: See "Clock tolerance" on page 643

SBUS<sb>:SENT:CRCMethod <CRCCalculation>

Selects the method for CRC calculation.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<CRCCalculation> SAEJ | TLE

SAEJ: SAE_J2716
TLE: TLE_4998X

*RST: SAEJ

Usage: Asynchronous command

Manual operation: See "CRC calculation" on page 644

SBUS<sb>:SENT:CRCVersion <CRCVersion>

Selects the version the CRC check is based on.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<CRCVersion> LEGA | V2010

`LEGA`: Legacy
`V2010`: v2010/v2016

*RST: V2010

Usage: Asynchronous command

Manual operation: See "CRC version" on page 644

SBUS<sb>:SENT:DATA:HYSTeresis <SDATA Hyst>

Sets the hysteresis for the data channel.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<SDATA Hyst>

Usage: Asynchronous command

Manual operation: See "Threshold" on page 644

SBUS<sb>:SENT:DATA:SOURce DataSource

Sets the source of the data line.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
DataSource C1 | C2 | C3 | C4 | M1 | M2 | M3 | M4 | M5 | R1 | R2 | R3 | R4 | O<n>C1 | O<n>C2 | ... | O<n>C8 (<n> = 2 to 8)

Usage: Asynchronous command

Manual operation: See "Data" on page 643

SBUS<sb>:SENT:DATA:THReshold <SDATA Thres>

Sets the threshold for the data channel.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<SDATA Thres>

Usage: Asynchronous command

Manual operation: See "Threshold" on page 644

SBUS<sb>:SENT:DNIBbles <DataNibbles>

Sets the number of data units in a single transmission sequence.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<DataNibbles> Range: 1 to 6
Increment: 1
*RST: 6

Usage: Asynchronous command

Manual operation: See "Data nibbles" on page 643

SBUS<sb>:SENT:MODE <Mode>

Selects the operating mode of the SENT protocol.

If `Legacy` is selected, the SPC mode is not supported.

If `SPC` mode is selected, the SENT protocol allows for the calibration of a sensor's output by sending a single calibrated value.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<Mode> LEGacy | SPC
*RST: LEGacy

Usage: Asynchronous command

Manual operation: See "Mode" on page 643

SBUS<sb>:SENT:NEWList <FileName>

Loads a symbol list file.

Suffix:
<sb> 1...4, index of the serial bus

Setting parameters:
<FileName> String parameter with path and file name.

Example:
```
SBUS1:SENT:NEWList
'/home/storage/userData/Protocol/SENT.csv'
SBUS1:SENT:SYMBols ON
```

Usage: Setting only
Asynchronous command

SBUS<sb>:SENT:POSition <SENT position>

Sets the vertical position of the SENT signal.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<SENT position>

Usage: Asynchronous command

SBUS<sb>:SENT:PPFLength <FrameLength>

Specifies the fixed frame length in terms of ticks, which requires setting the pause pulse (`SBUS<sb>:SENT:PPULse`) to `PPFL`.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<FrameLength> Range: 104 to 922
Increment: 1
*RST: 256

Usage: Asynchronous command

Manual operation: See "Frame length" on page 644

SBUS<sb>:SENT:PPULse <PausePulse>

Determines whether a pause pulse is transmitted after the checksum nibble.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<PausePulse> NPP | PP | PPFL

NPP
No pause pulse is transmitted.

PP
Enables transmitting a pause pulse.

PPFL
A pause pulse is transmitted to achieve a fixed frame length, which is specified by `SBUS<sb>:SENT:PPFLength`.

*RST: NPP

Usage: Asynchronous command

Manual operation: See "Pause pulse" on page 644

SBUS<sb>:SENT:RDSL <RessDispSel>

Selects the results to be displayed.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<RessDispSel> TRSQ | SMSG | ALL

`TRSQ`: transmission sequence
`SMSG`: serial messages

*RST: ALL

Usage: Asynchronous command

SBUS<sb>:SENT:SCALe <SENT scale>

Set the vertical scale of the indicated SENT signal.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<SENT scale>

Usage: Asynchronous command

SBUS<sb>:SENT:SFORmat <SerialMessages>

Selects if serial messages are enabled or disabled.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<SerialMessages> ENABled | DISabled

*RST: DISabled

Usage: Asynchronous command

Manual operation: See "Serial message" on page 643

SBUS<sb>:SENT:SWTindex?

Queries the software trigger index.

If no software trigger event has occurred, the command returns `Invalid`.

Suffix:
<sb> 1...4, index of the serial bus

Return values:
<Index> Range: 0 to 4294967295
Increment: 1
*RST: 0

Usage: Query only
Asynchronous command

SBUS<sb>:SENT:SWTTime?

Queries the software trigger time in seconds.

If no software trigger event has occured, the command returns `Invalid`.

Suffix:
<sb> 1...4, index of the serial bus

Return values:
<Time> Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0
Default unit: s

Usage: Query only
Asynchronous command

SBUS<sb>:SENT:SYMBols <ShowSymbols>

Activates the symbol list to be used for decoding.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<ShowSymbols> OFF | ON
*RST: OFF

Usage: Asynchronous command

18.17.12.2 Filter

There are two commands for each parameter, that you can use for defining the SENT settings.

For example, to set the *Frame type =TransmissionSequence > Field =Data >01100* value you can use one of the following commands:

- `SBUS:SENT:FILTer:FRAMe1:FLD1:DMIN 01100`
  Defines the parameter by using the index <m> for the frame number and <n> for the field number.
- `SBUS:SENT:FILTer:DMIN "TransmissionSequence", "Data", 01100`
  Defines the parameter by using the frame and field name.

SBUS<sb>:SENT:FILTer:CHKall

Enables the filter for all available frames and error types.

Suffix:

<sb> 1...4, index of the serial bus

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 647

SBUS<sb>:SENT:FILTer:CLR

Disables the filter for all available frames and error types.

Suffix:

<sb> 1...4, index of the serial bus

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 647

SBUS<sb>:SENT:FILTer:INVert

Inverts the current state of the frame and error types: all frames and error types that were enabled are disabled and vice versa.

Suffix:

<sb>	1...4, index of the serial bus

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 647

SBUS<sb>:SENT:FILTer:RST

Presets the state of the selected frames and error types.

Suffix:

<sb>	1...4, index of the serial bus

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 647

SBUS<sb>:SENT:FILTer:FRENable <Frame>,<Enabler>
SBUS<sb>:SENT:FILTer:FRENable? <Enabler>
SBUS<sb>:SENT:FILTer:FRAMe<fr>:ENABle <Enable>

Enables the filtering on SENT frames. Only the frames that match the selected filter conditions are displayed.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Parameters:

<Enable>	OFF | ON
	*RST: ON

Usage: Asynchronous command

Manual operation: See "Enable" on page 648

SBUS<sb>:SENT:FILTer:BIT <Frame>,<Field>,<Bit>
SBUS<sb>:SENT:FILTer:BIT? <Bit>
SBUS<sb>:SENT:FILTer:FRAMe<fr>:FLD<fl>:BIT <BitState>

Sets the operator for the data pattern in the selected field of the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

<fl> Index of the field

Parameters:
<BitState> ONE | ZERO
*RST: ZERO

Usage: Asynchronous command

Manual operation: See "Edit" on page 648

SBUS<sb>:SENT:FILTer:DMAX <Frame>,<Field>,<Data>
SBUS<sb>:SENT:FILTer:DMAX? <Data>
SBUS<sb>:SENT:FILTer:FRAMe<fr>:FLD<fl>:DMAX <Data_Max>

Sets the end value of a data pattern range if the operator is set to `INRange` or `OORANGe`.

You can set the operator with `SBUS<sb>:SENT:FILTer:FRAMe<fr>:FLD<fl>:DOPerator`.

Suffix:
<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Parameters:
<Data_Max>

Usage: Asynchronous command

Manual operation: See "Edit" on page 648

SBUS<sb>:SENT:FILTer:DMIN <Frame>,<Field>,<Data>
SBUS<sb>:SENT:FILTer:DMIN? <Data>
SBUS<sb>:SENT:FILTer:FRAMe<fr>:FLD<fl>:DMIN <Data_Min>

Specifies the data pattern, or sets the start value of a data pattern range.

Suffix:
<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Parameters:
<Data_Min>

Usage: Asynchronous command

Manual operation: See "Edit" on page 648

SBUS<sb>:SENT:FILTer:DOPerator <Frame>,<Field>,<Operator>
SBUS<sb>:SENT:FILTer:DOPerator? <Operator>
SBUS<sb>:SENT:FILTer:FRAMe<fr>:FLD<fl>:DOPerator <Data_Operator>

Sets the operator for the data pattern in the selected field of the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Data_Operator>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange
	*RST: EQUal

Usage: Asynchronous command

Manual operation: See "Edit" on page 648

SBUS<sb>:SENT:FILTer:FIENable <Frame>,<Field>,<Enabler>
SBUS<sb>:SENT:FILTer:FIENable? <Enabler>
SBUS<sb>:SENT:FILTer:FRAMe<fr>:FLD<fl>:ENABle <CondEnabler>

Enables or disables the checking condition for the selected field of the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	1...4, index of the serial bus
<fl>	Index of the field

Parameters:

<CondEnabler>	OFF | ON
	*RST: OFF

Usage: Asynchronous command

Manual operation: See "Edit" on page 648

SBUS<sb>:SENT:FILTer:IMAX <Frame>,<Field>,<Data>
SBUS<sb>:SENT:FILTer:IMAX? <Data>
SBUS<sb>:SENT:FILTer:FRAMe<fr>:FLD<fl>:IMAX <Index_Max>

Sets the end value of an index range if the operator is set to `INRange`.

You can set the operator with `SBUS<sb>:SENT:FILTer:FRAMe<fr>:FLD<fl>:IOPerator`.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

<fl> Index of the field

Parameters:

<Index_Max> Range: 1 to 65535
Increment: 1
*RST: 65535

Usage: Asynchronous command

Manual operation: See "Edit" on page 648

SBUS<sb>:SENT:FILTer:IMIN <Frame>,<Field>,<Data>
SBUS<sb>:SENT:FILTer:IMIN? <Data>
SBUS<sb>:SENT:FILTer:FRAMe<fr>:FLD<fl>:IMIN <Index_Min>

Specifies the index, or sets the start value of an index range.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Parameters:

<Index_Min> Range: 1 to 65535
Increment: 1
*RST: 1

Usage: Asynchronous command

Manual operation: See "Edit" on page 648

SBUS<sb>:SENT:FILTer:IOPerator <Frame>,<Field>,<Operator>
SBUS<sb>:SENT:FILTer:IOPerator? <Operator>
SBUS<sb>:SENT:FILTer:FRAMe<fr>:FLD<fl>:IOPerator <Index_Operator>

Sets the operator for the index in the selected field of the selected frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Parameters:

<Index_Operator> EQUal | INRange | RANGe
*RST: INRange

Usage: Asynchronous command

Manual operation: See "Edit" on page 648

SBUS<sb>:SENT:FILTer:ERENable <ErrorName>,<Enabler>
SBUS<sb>:SENT:FILTer:ERENable? <Enabler>
SBUS<sb>:SENT:FILTer:ERRor<n>:ENABle <Enable>

Defines the error type to be filtered on.

Suffix:

<sb>	1...4, index of the serial bus
<n>	Index of the error

Parameters:

<Enable>	OFF | ON *RST: ON
Usage:	Asynchronous command
Manual operation:	See "Error type" on page 649

18.17.12.3 Software trigger

There are two commands for each parameter, that you can use for defining the SENT settings.

For example, to set the *Frame type =TransmissionSequence > Field =Data >01100* value you can use one of the following commands:

- `TRIGger:SBSW:SENT:FRAMe1:FLD1:DMIN 01100`
  Defines the parameter by using the index <m> for the frame number and <n> for the field number.
- `TRIGger:SBSW:SENT:DMIN "TransmissionSequence", "Data", 01100`
  Defines the parameter by using the frame and field name.

TRIGger:SBSW:SENT:CHKall

Enables the software trigger for all available frames and error types.

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 650

TRIGger:SBSW:SENT:CLR

Disables the software trigger for all available frames and error types.

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 650

TRIGger:SBSW:SENT:INVert

Inverts the current state of the frame and error types for the software trigger: all frames and error types that were enabled are disabled and vice versa.

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 650

TRIGger:SBSW:SENT:RST

Presets the state of the selected frames and error types for the software trigger.

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 650

TRIGger:SBSW:SENT:FRAMe<fr>:ENABle <Enable>
TRIGger:SBSW:SENT:FRENable <Frame>,<Enabler>
TRIGger:SBSW:SENT:FRENable? <Enabler>

rcset

Setting parameters:
<Frame>

Parameters for setting and query:

<Enabler>	OFF | ON

Usage: Asynchronous command

Manual operation: See "Frame type" on page 651

TRIGger:SBSW:SENT:BIT <Frame>,<Field>,<Bit>
TRIGger:SBSW:SENT:BIT? <Bit>
TRIGger:SBSW:SENT:FRAMe<fr>:FLD<fl>:BIT <BitState>

Sets the bit state of a field that only consists of one bit for the software trigger.

Suffix:

<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<BitState>	ONE | ZERO *RST: ZERO

Usage: Asynchronous command

Manual operation: See "Edit" on page 651

TRIGger:SBSW:SENT:FIENable <Frame>,<Field>,<Enabler>
TRIGger:SBSW:SENT:FIENable? <Enabler>
TRIGger:SBSW:SENT:FRAMe<fr>:FLD<fl>:ENABle <CondEnabler>

Enables or disables the checking condition for the selected field of the selected frame of the software trigger.

Suffix:

<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<CondEnabler>	OFF | ON *RST: OFF

Usage: Asynchronous command

Manual operation: See "Edit" on page 651

TRIGger:SBSW:SENT:DMAX <Frame>,<Field>,<Data>
TRIGger:SBSW:SENT:DMAX? <Data>
TRIGger:SBSW:SENT:FRAMe<fr>:FLD<fl>:DMAX <Data_Max>

Sets the end value of a data pattern range for the software trigger, if the operator is set to `INRange` or `OORANGe`.

You can set the operator with `TRIGger:SBSW:SENT:FRAMe<fr>:FLD<fl>:DOPerator`.

Suffix:

<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Data_Max>

Usage: Asynchronous command

Manual operation: See "Edit" on page 651

TRIGger:SBSW:SENT:DMIN <Frame>,<Field>,<Data>
TRIGger:SBSW:SENT:DMIN? <Data>
TRIGger:SBSW:SENT:FRAMe<fr>:FLD<fl>:DMIN <Data_Min>

Specifies the data pattern, or sets the start value of a data pattern range for the software trigger.

Suffix:

<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Data_Min>

Usage: Asynchronous command

Manual operation: See "Edit" on page 651

TRIGger:SBSW:SENT:DOPerator <Frame>,<Field>,<Operator>
TRIGger:SBSW:SENT:DOPerator? <Operator>
TRIGger:SBSW:SENT:FRAMe<fr>:FLD<fl>:DOPerator <Data_Operator>

Sets the operator for the data pattern of the software trigger in the selected field of the selected frame.

Suffix:

<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Data_Operator>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange *RST: EQUal

Usage: Asynchronous command

Manual operation: See "Edit" on page 651

TRIGger:SBSW:SENT:IMAX <Frame>,<Field>,<Data>
TRIGger:SBSW:SENT:IMAX? <Data>
TRIGger:SBSW:SENT:FRAMe<fr>:FLD<fl>:IMAX <Index_Max>

Sets the end value of an index range for the software trigger if the operator is set to `INRange`.

You can set the operator with `TRIGger:SBSW:SENT:FRAMe<fr>:FLD<fl>:IOPerator`.

Suffix:

<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Index_Max> Range: 1 to 65535
Increment: 1
*RST: 65535

Usage: Asynchronous command

Manual operation: See "Edit" on page 651

TRIGger:SBSW:SENT:IMIN <Frame>,<Field>,<Data>
TRIGger:SBSW:SENT:IMIN? <Data>
TRIGger:SBSW:SENT:FRAMe<fr>:FLD<fl>:IMIN <Index_Min>

Specifies the index, or sets the start value of an index range for the software trigger.

Suffix:

<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Index_Min> Range: 1 to 65535
Increment: 1
*RST: 1

Usage: Asynchronous command

Manual operation: See "Edit" on page 651

TRIGger:SBSW:SENT:IOPerator <Frame>,<Field>,<Operator>
TRIGger:SBSW:SENT:IOPerator? <Operator>
TRIGger:SBSW:SENT:FRAMe<fr>:FLD<fl>:IOPerator <Index_Operator>

Sets the operator for the index in the selected field of the selected frame for the software trigger.

Suffix:

<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Index_Operator>	EQUal | INRange | RANGe *RST: INRange
Usage:	Asynchronous command
Manual operation:	See "Edit" on page 651

TRIGger:SBSW:SENT:ERENable <ErrorName>,<Enabler>
TRIGger:SBSW:SENT:ERENable? <Enabler>
TRIGger:SBSW:SENT:ERRor<m>:ENABle <Enable>

Defines the error type for the software trigger.

Suffix:

<m>	Index of the error

Parameters:

<Enable>	OFF | ON *RST: ON
Usage:	Asynchronous command
Manual operation:	See "Error type" on page 652

SBUS<sb>:SENT:SWTindex?

Queries the software trigger index.

If no software trigger event has occurred, the command returns `Invalid`.

Suffix:

<sb>	1...4, index of the serial bus

Return values:

<Index>	Range: 0 to 4294967295 Increment: 1 *RST: 0
Usage:	Query only Asynchronous command

SBUS<sb>:SENT:SWTTime?

Queries the software trigger time in seconds.

If no software trigger event has occured, the command returns `Invalid`.

Suffix:

<sb>	1...4, index of the serial bus

Return values:

<Time>	Range: -1E+26 to 1E+26 Increment: 1E-10 *RST: 0 Default unit: s

Usage: Query only
Asynchronous command

18.17.12.4 Decode results

SBUS<sb>:SENT:FCOunt?

Returns the number of decoded frames.

Suffix:

<sb>	1...4, index of the serial bus

Return values:

<Count>	Total number of decoded frames.

Usage: Query only
Asynchronous command

SBUS<sb>:SENT:FRAMe<fr>:BITRate?

Returns the bit rate of the frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<BitRate>	Increment: 1 *RST: 0 Default unit: bps

Usage: Query only
Asynchronous command

SBUS<sb>:SENT:FRAMe<fr>:CSValue?

Returns the CRC sequence value of the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<ChecksumValue>	Range: 0 to 63 Increment: 1 *RST: 0

Usage: Query only
Asynchronous command

SBUS<sb>:SENT:FRAMe<fr>:DATA?

Returns the data of the specified frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<data>	Comma-separated sequence of integer values (N, D1, D2,…, DN). N is the number of nibbles in the frame, and D1…DN are the values of the nibbles.

Usage: Query only
Asynchronous command

SBUS<sb>:SENT:FRAMe<fr>:FDValues?

Returns the formatted data values.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:

<FormattedDatVals>

Usage: Query only
Asynchronous command

SBUS<sb>:SENT:FRAMe<fr>:FSCom?

Retruns the formatted status communication.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:

<FormattedStatusComm>

Usage: Query only
Asynchronous command

SBUS<sb>:SENT:FRAMe<fr>:FSDTa?

Returns the formatted symbolic data values.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:

<FormattedSymbDat>

Usage: Query only
Asynchronous command

SBUS<sb>:SENT:FRAMe<fr>:IDTYpe?

Returns the identifier type of the selected frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:

<IdentifierType> B4 | B8

B4: standard format, 4 bit
B8: extended format, 8 bit

*RST: B4

Usage: Query only
Asynchronous command

SBUS<sb>:SENT:FRAMe<fr>:IDValue?

Returns the identifier value of the selected frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:

<IdtfVal> Range: 0 to 255
Increment: 1
*RST: 0

Usage: Query only
Asynchronous command

SBUS<sb>:SENT:FRAMe<fr>:MTPDuration?

Returns the duration of the main trigger pulse (MTP), which is an additional pulse added to the frame when running in "Short PWM Code" (SPC) mode. Withpulse width modulationn (PWM), you can connect multiple sensors to the bus. The duration of the MTP defines, which sensor starts the transmission.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:

<MTPDuration> Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0
Default unit: s

Usage: Query only
Asynchronous command

SBUS<sb>:SENT:FRAMe<fr>:FLDCount?

Returns the number of fields in the specified frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:

<Count>

Usage: Query only
Asynchronous command

SBUS<sb>:SENT:FRAMe<fr>:FLD<fl>:STATe?

Returns the state of the specified field.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Return values:

<State> OK | SYNC | PULSe | CRC | LENGth | FORM | PAUSe | INComplete

*RST: OK

Usage: Query only
Asynchronous command

SBUS<sb>:SENT:FRAMe<fr>:FLD<fl>:VALue?

Returns the value of the specified field.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Return values:

<Value>
Range: 0 to 15
Increment: 1
*RST: 0

Usage: Query only
Asynchronous command

SBUS<sb>:SENT:FRAMe<fr>:FLD<fl>:FVALue?

Returns the formatted value of the specified field.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Return values:

<FormattedValue>

Usage: Query only
Asynchronous command

SBUS<sb>:SENT:FRAMe<fr>:FLD<fl>:LABel?

Returns the label of the specified field.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Return values:
<Label>

Usage: Query only
Asynchronous command

SBUS<sb>:SENT:FRAMe<fr>:PAPTicks?

Returns the number of the pulse pause clock ticks.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:
<PausePlsTicks> Range: 12 to 768
Increment: 1
*RST: 12

Usage: Query only
Asynchronous command

SBUS<sb>:SENT:FRAMe<fr>:SCOM?

Returns the value of the status/communication pulse.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:
<FrmStatusComm> Range: 0 to 15
Increment: 1
*RST: 0

Usage: Query only
Asynchronous command

SBUS<sb>:SENT:FRAMe<fr>:SDATa?

Returns the symbolic data of the frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:
<SymbolicData>

Usage: Query only
Asynchronous command

SBUS<sb>:SENT:FRAMe<fr>:SENSor?

Returns the sensor resposne time.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<SensRespTime> Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0
Default unit: s

Usage: Query only
Asynchronous command

SBUS<sb>:SENT:FRAMe<fr>:STARt?

Returns the start time of the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<FrameStart> Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0
Default unit: s

Usage: Query only
Asynchronous command

SBUS<sb>:SENT:FRAMe<fr>:STATus?

Returns the overall state of the selected frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:

<FrameState> OK | SYNC | PULSe | CRC | LENGth | FORM | PAUSe | INComplete

OK: the frame is valid.
SYNC: Synchronization error occurred.
PULse: Pulse error occurred.
CRC: Cyclic redundancy check failed.
LENGth: Irregular frame length error occurred.
FORM: Format error occurred.
INComplete: The frame is not completely contained in the acquisition. The acquired part of the frame is valid.

*RST: OK

Usage: Query only
Asynchronous command

SBUS<sb>:SENT:FRAMe<fr>:STOP?

Returns the stop time of the selected frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:

<FrameStop> Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0
Default unit: s

Usage: Query only
Asynchronous command

SBUS<sb>:SENT:FRAMe<fr>:SYMBol?

Returns the symbolic label of the specified frame if the label list is enabled.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:

<SymbolicName>

Example: `BUS:SENT:FRAMe:SYMBol?`
Response: `Air Temperature`

Usage: Query only
Asynchronous command

SBUS<sb>:SENT:FRAMe<fr>:SYNCduration?

Returns the time of the synchronization pulse.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:

<FrameSyncTime> Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0
Default unit: s

Usage: Query only
Asynchronous command

SBUS<sb>:SENT:FRAMe<fr>:TYPE?

Returns the type of SENT message.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:

<FrameType> TRSQ | SMSG | ESSM | ELSM | PAUSe | UNKNown

`TRSQ`: transmission sequence
`SMSG`: short serial message
`ESSM`: enhanced 12 bit message
`ELSM`: enhanced 16 bit message

*RST: TRSQ

Usage: Query only
Asynchronous command

18.17.13 ARINC 429 (option R&S MXO4-K530)

Before MXO 4 can accept the specific bus commands, make sure that:

- The decoding of the specified bus is enabled with `SBUS<sb>[:STATe]`.
- The bus is set to the correct type with `SBUS<sb>:TYPE`.

18.17.13.1 Configuration

SBUS<sb>:ARINc:BRMode <BitRateMode>

Sets the bit rate mode to high or low speed. You can set an exact bitrate value with `SBUS<sb>:ARINc:BRValue`.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<BitRateMode> HIGH | LOW
*RST: HIGH

Usage: Asynchronous command

Manual operation: See "Bit rate mode, Bit rate" on page 660

SBUS<sb>:ARINc:BRValue <BitRateValue>

Sets the number of transmitted bits per second.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<BitRateValue> Range: 10000 to 110000
Increment: 100
*RST: 100000
Default unit: bps

Usage: Asynchronous command

Manual operation: See "Bit rate mode, Bit rate" on page 660

SBUS<sb>:ARINc:POLarity <Polarity>

Selects the wire on which the bus signal is measured : A Leg or B Leg. The setting affects the digitization of the signal.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<Polarity> ALEG | BLEG
*RST: ALEG

Usage: Asynchronous command

Manual operation: See "Polarity" on page 659

SBUS<sb>:ARINc:SOURce Source

Sets the channel for the signal source.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
Source C1 | C2 | C3 | C4 | M1 | M2 | M3 | M4 | M5 | R1 | R2 | R3 | R4 | O<n>C1 | O<n>C2 | ... | O<n>C8 (<n> = 2 to 8)

Usage: Asynchronous command

Manual operation: See "Source" on page 659

SBUS<sb>:ARINc:THReshold:HIGH <Upper threshold>

Sets the upper threshold level of the signal.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<Upper threshold>

Usage: Asynchronous command

Manual operation: See "Threshold" on page 661

SBUS<sb>:ARINc:THReshold:HYSTeresis <Hysteresis>

Sets a hysteresis value.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<Hysteresis>

Usage: Asynchronous command

Manual operation: See "Threshold" on page 661

SBUS<sb>:ARINc:THReshold:LOW <Lower threshold>

Sets the lower threshold level of the signal.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<Lower threshold>

Usage: Asynchronous command

Manual operation: See "Threshold" on page 661

SBUS<sb>:ARINc:NEWList <FileName>

Loads a symbol list file.

Suffix:
<sb> 1...4, index of the serial bus

Setting parameters:
<FileName> String parameter with path and file name.

Example:
```
SBUS1:ARIN:NEWList
'/home/storage/userData/Protocol/ARINC.csv'
SBUS1:ARIN:SYMBols ON
```

Usage: Setting only
Asynchronous command

Manual operation: See "Show symbols" on page 661

SBUS<sb>:ARINc:SYMBols <ShowSymbols>

Activates the symbol list to be used for decoding.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<ShowSymbols> OFF | ON
*RST: OFF

Usage: Asynchronous command

Manual operation: See "Show symbols" on page 661

SBUS<sb>:ARINc:MAXGap:BITS <MaxGapBits>

Sets the value for the maximum gap between two words.

See also: `SBUS<sb>:ARINc:MAXGap:SELect` on page 1461.

Suffix:

<sb> 1...4, index of the serial bus

Parameters:

<MaxGapBits> Range: 0 to 1000
Increment: 1
*RST: 100
Default unit: bit

Usage: Asynchronous command

Manual operation: See "Min gap time,Max gap time" on page 660

SBUS<sb>:ARINc:MAXGap:SELect <MaxGapSelect>

Enables the detection of the maximum gap time during decoding.

You can specify the maximum gap time with `SBUS<sb>:ARINc:MAXGap:BITS`.

Suffix:

<sb> 1...4, index of the serial bus

Parameters:

<MaxGapSelect> OFF | ON
*RST: OFF

Usage: Asynchronous command

Manual operation: See "Min gap time,Max gap time" on page 660

SBUS<sb>:ARINc:MINGap:BITS <MinGapBits>

Sets a value for the minimum timing gap between two words.

See also: `SBUS<sb>:ARINc:MINGap:SELect`.

Suffix:

<sb> 1...4, index of the serial bus

Parameters:

<MinGapBits> Range: 0 to 100
Increment: 1
*RST: 4
Default unit: bit

Usage: Asynchronous command

Manual operation: See "Min gap time,Max gap time" on page 660

SBUS<sb>:ARINc:MINGap:SELect <MinGapSelect>

Enables the detection of the minimum idle time between two words during decoding.

To specify the minimum gap, use `SBUS<sb>:ARINc:MINGap:BITS`.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<MinGapSelect> OFF | ON
*RST: ON

Usage: Asynchronous command

Manual operation: See "Min gap time,Max gap time" on page 660

SBUS<sb>:ARINc:POSition <Position>

Sets the vertical position of the ARINC signal.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<Position>

Usage: Asynchronous command

SBUS<sb>:ARINc:SCALe <Scale>

Set the vertical scale of the indicated ARINC signal.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<Scale>

Usage: Asynchronous command

18.17.13.2 Filter

There are two commands for each parameter, that you can use for defining the ARINC 429 settings.

For example, to set the *Frame type =ARINC429-Word > Field =Data >Data* value you can use one of the following commands:

- `SBUS:ARINC:FILTer:FRAMe1:FLD1:DMIN 01100`
  Defines the parameter by using the index <m> for the frame number and <n> for the field number.
- `SBUS:ARINC:FILTer:DMIN "ARINC429-Word", "Data", 01100`
  Defines the parameter by using the frame and field name.

SBUS<sb>:ARINc:FILTer:CHKall

Enables the filter for all available frames and error types.

Suffix:

<sb> 1...4, index of the serial bus

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 663

SBUS<sb>:ARINc:FILTer:CLR

Disables the filter for all available frames and error types.

Suffix:

<sb> 1...4, index of the serial bus

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 663

SBUS<sb>:ARINc:FILTer:INVert

Inverts the current state of the frame and error types: all frames and error types that were enabled are disabled and vice versa.

Suffix:

<sb> 1...4, index of the serial bus

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 663

SBUS<sb>:ARINc:FILTer:RST

Presets the state of the selected frames and error types.

Suffix:

<sb>	1...4, index of the serial bus

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 663

SBUS<sb>:ARINc:FILTer:BIT <Frame>,<Field>,<Bit>
SBUS<sb>:ARINc:FILTer:BIT? <Bit>
SBUS<sb>:ARINc:FILTer:FRAMe<fr>:FLD<fl>:BIT <BitState>

Sets the bit state of a field that only consists of one bit.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<BitState> ONE | ZERO
*RST: ZERO

Usage: Asynchronous command

Manual operation: See "Edit" on page 664

SBUS<sb>:ARINc:FILTer:ERENable <ErrorName>,<Enabler>
SBUS<sb>:ARINc:FILTer:ERENable? <Enabler>
SBUS<sb>:ARINc:FILTer:ERRor<n>:ENABle <Enable>

Defines the error type to be filtered on.

Suffix:

<sb>	1...4, index of the serial bus
<n>	index of the error

Parameters:

<Enable> OFF | ON
*RST: ON

Usage: Asynchronous command

Manual operation: See "Error type" on page 665

SBUS<sb>:ARINc:FILTer:DMAX <Frame>,<Field>,<Data>
SBUS<sb>:ARINc:FILTer:DMAX? <Data>
SBUS<sb>:ARINc:FILTer:FRAMe<fr>:FLD<fl>:DMAX <Data_Max>

Sets the end value of a data pattern range if the operator is set to `INRange` or `OORANGe`.

You can set the operator with `SBUS<sb>:ARINc:FILTer:FRAMe<fr>:FLD<fl>:DOPerator`.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:
<Data_Max>

Usage: Asynchronous command

Manual operation: See "Edit" on page 664

SBUS<sb>:ARINc:FILTer:DMIN <Frame>,<Field>,<Data>
SBUS<sb>:ARINc:FILTer:DMIN? <Data>
SBUS<sb>:ARINc:FILTer:FRAMe<fr>:FLD<fl>:DMIN <Data_Min>

Specifies the data pattern, or sets the start value of a data pattern range.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:
<Data_Min>

Usage: Asynchronous command

Manual operation: See "Edit" on page 664

SBUS<sb>:ARINc:FILTer:DOPerator <Frame>,<Field>,<Operator>
SBUS<sb>:ARINc:FILTer:DOPerator? <Operator>
SBUS<sb>:ARINc:FILTer:FRAMe<fr>:FLD<fl>:DOPerator <Data_Operator>

Sets the operator for the data pattern in the selected field of the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Data_Operator>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange *RST: EQUal

Usage: Asynchronous command

Manual operation: See "Edit" on page 664

SBUS<sb>:ARINc:FILTer:FIENable <Frame>,<Field>,<Enabler>
SBUS<sb>:ARINc:FILTer:FIENable? <Enabler>
SBUS<sb>:ARINc:FILTer:FRAMe<fr>:FLD<fl>:ENABle <CondEnabler>

Enables or disables the checking condition for the selected field of the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<CondEnabler>	OFF | ON *RST: OFF

Usage: Asynchronous command

Manual operation: See "Edit" on page 664

SBUS<sb>:ARINc:FILTer:FRENable <Frame>,<Enabler>
SBUS<sb>:ARINc:FILTer:FRENable? <Enabler>
SBUS<sb>:ARINc:FILTer:FRAMe<fr>:ENABle <Enable>

Enables the filtering on ARINC 429 frames. Only the frames that match the selected filter conditions are displayed.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Parameters:

<Enable>	OFF | ON *RST: ON

Usage: Asynchronous command

Manual operation: See "Enable" on page 663

18.17.13.3 Software trigger

There are two commands for each parameter, that you can use for defining the ARINC 429 settings.

For example, to set the *Frame type =ARINC429-Word > Field =Data >Data* value you can use one of the following commands:

- `TRIGger:SBSW:ARINc:FRAMe1:FLD1:DMIN 01100`
  Defines the parameter by using the index <m> for the frame number and <n> for the field number.
- `TRIGger:SBSW:ARINc:DMIN "ARINC429-Word", "Data", 01100`
  Defines the parameter by using the frame and field name.

TRIGger:SBSW:ARINc:CHKall

Enables the software trigger for all available frames and error types.

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 666

TRIGger:SBSW:ARINc:CLR

Disables the software trigger for all available frames and error types.

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 666

TRIGger:SBSW:ARINc:INVert

Inverts the current state of the frame and error types for the software trigger: all frames and error types that were enabled are disabled and vice versa.

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 666

TRIGger:SBSW:ARINc:RST

Presets the state of the selected frames and error types for the software trigger.

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 666

TRIGger:SBSW:ARINc:FRENable <Frame>,<Enabler>
TRIGger:SBSW:ARINc:FRENable? <Enabler>
TRIGger:SBSW:ARINc:FRAMe<fr>:ENABle <Enable>

Enables or disables the checking condition for the selected frame for the software trigger.

Suffix:
<fr> Index of the frame

Parameters:
<Enable> OFF | ON
*RST: ON

Usage: Asynchronous command

Manual operation: See "Frame type" on page 667

TRIGger:SBSW:ARINc:BIT <Frame>,<Field>,<Bit>
TRIGger:SBSW:ARINc:BIT? <Bit>
TRIGger:SBSW:ARINc:FRAMe<fr>:FLD<fl>:BIT <BitState>

Sets the bit state of a field that only consists of one bit for the software trigger.

Suffix:
<fr> Index of the frame

<fl> Index of the field

Parameters:
<BitState> ONE | ZERO
*RST: ZERO

Usage: Asynchronous command

Manual operation: See "Edit" on page 667

TRIGger:SBSW:ARINc:DMAX <Frame>,<Field>,<Data>
TRIGger:SBSW:ARINc:DMAX? <Data>
TRIGger:SBSW:ARINc:FRAMe<fr>:FLD<fl>:DMAX <Data_Max>

Sets the end value of a data pattern range for the software trigger, if the operator is set to `INRange` or `OORANGe`.

You can set the operator with `TRIGger:SBSW:ARINc:FRAMe<fr>:FLD<fl>:DOPerator`.

Suffix:

<fr>	Index of the frame
<fl>	Index of the field

Parameters:
<Data_Max>

Usage: Asynchronous command

Manual operation: See "Edit" on page 667

TRIGger:SBSW:ARINc:DMIN <Frame>,<Field>,<Data>
TRIGger:SBSW:ARINc:DMIN? <Data>
TRIGger:SBSW:ARINc:FRAMe<fr>:FLD<fl>:DMIN <Data_Min>

Specifies the data pattern, or sets the start value of a data pattern range for the software trigger.

Suffix:

<fr>	Index of the frame
<fl>	Index of the field

Parameters:
<Data_Min>

Usage: Asynchronous command

Manual operation: See "Edit" on page 667

TRIGger:SBSW:ARINc:DOPerator <Frame>,<Field>,<Operator>
TRIGger:SBSW:ARINc:DOPerator? <Operator>
TRIGger:SBSW:ARINc:FRAMe<fr>:FLD<fl>:DOPerator <Data_Operator>

Sets the operator for the data pattern of the software trigger in the selected field of the selected frame.

Suffix:

<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Data_Operator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

*RST: EQUal

Usage: Asynchronous command

Manual operation: See "Edit" on page 667

TRIGger:SBSW:ARINc:FIENable <Frame>,<Field>,<Enabler>
TRIGger:SBSW:ARINc:FIENable? <Enabler>
TRIGger:SBSW:ARINc:FRAMe<fr>:FLD<fl>:ENABle <CondEnabler>

Enables or disables the checking condition for the selected field of the selected frame of the software trigger.

Suffix:

<fr> Index of the frame

<fl> Index of the field

Parameters:

<CondEnabler> OFF | ON

*RST: OFF

Usage: Asynchronous command

Manual operation: See "Edit" on page 667

TRIGger:SBSW:ARINc:ERENable <ErrorName>,<Enabler>
TRIGger:SBSW:ARINc:ERENable? <Enabler>
TRIGger:SBSW:ARINc:ERRor<m>:ENABle <Enable>

Defines the error type for the software trigger.

Suffix:

<m> index of the error

Parameters:

<Enable> OFF | ON

*RST: ON

Usage: Asynchronous command

Manual operation: See "Error type" on page 668

SBUS<sb>:ARINc:SWTindex?

Queries the software trigger index.

If no software trigger event has occurred, the command returns `Invalid`.

Suffix:

<sb> 1...4, index of the serial bus

Return values:

<Index>	Range:	0 to 4294967295
	Increment:	1
	*RST:	0

Usage: Query only
Asynchronous command

SBUS<sb>:ARINc:SWTTime?

Queries the software trigger time in seconds.

If no software trigger event has occured, the command returns `Invalid`.

Suffix:
<sb> 1...4, index of the serial bus

Return values:

<Time>	Range:	-1E+26 to 1E+26
	Increment:	1E-10
	*RST:	0
	Default unit:	s

Usage: Query only
Asynchronous command

18.17.13.4 Decode results

This section describes the commands to query the results of the decoding.

SBUS<sb>:ARINc:WCOunt?

Returns the number of decoded words.

Suffix:
<sb> 1...4, index of the serial bus

Return values:
<Count>

Usage: Query only
Asynchronous command

SBUS<sb>:ARINc:WORD<w>:BITRate?

Returns the bit rate of the word.

Suffix:
<sb> 1...4, index of the serial bus

<w> *
Index of the word

Return values:
<PrimaryBitRate> Increment: 1
*RST: 0
Default unit: bps

Usage: Query only
Asynchronous command

SBUS<sb>:ARINc:WORD<w>:DATA?

Returns the data of the specified word.

Suffix:
<sb> 1...4, index of the serial bus

<w> *
Index of the word

Return values:
<FrameData> Range: 0 to 524287
Increment: 1
*RST: 0

Usage: Query only
Asynchronous command

SBUS<sb>:ARINc:WORD<w>:LABel?

Returns the label of the specified word.

Suffix:
<sb> 1...4, index of the serial bus

<w> *
Index of the word

Return values:
<FrameLabel> Range: 0 to 255
Increment: 1
*RST: 0

Usage: Query only
Asynchronous command

SBUS<sb>:ARINc:WORD<w>:PATTern?

Returns all 32 bits of the specified word.

Suffix:

<sb>	1...4, index of the serial bus
<w>	* Index of the word

Return values:

<FrmDatPatt>	List of comma separated values.

Example:
```
SBUS1:ARINc:WORD1:PATTern?
#H04,#H10,#H04
```

Usage: Query only
Asynchronous command

SBUS<sb>:ARINc:WORD<w>:SDI?

Returns the source/destination identifier (SDI) bits of the specified word.

Suffix:

<sb>	1...4, index of the serial bus
<w>	* Index of the word

Return values:

<SDI>	Range: 0 to 3 Increment: 1 *RST: 0

Usage: Query only
Asynchronous command

SBUS<sb>:ARINc:WORD<w>:SSM?

Returns the sign/status matrix (SSM) bits of the specified word.

Suffix:

<sb>	1...4, index of the serial bus
<w>	* Index of the word

Return values:

<SSM>	Range: 0 to 3 Increment: 1 *RST: 0

Usage: Query only
Asynchronous command

SBUS<sb>:ARINc:WORD<w>:STARt?

Returns the start time of the specified word.

Suffix:

<sb> 1...4, index of the serial bus

<w> *
Index of the word

Return values:

<FrameStart> Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0
Default unit: s

Usage: Query only
Asynchronous command

SBUS<sb>:ARINc:WORD<w>:STATe?

Returns the overall state of the specified word.

Suffix:

<sb> 1...4, index of the serial bus

<w> *
Index of the word

Return values:

<FrameState> OK | CODE | GAP | PAR | INC | UNKN

CODE: coding error occured.
GAP: timing gap error occured.
PAR: parity error occured.
INComplete: the sequence is not completely contained in the acquisition
UNKNown: unknown frame type

*RST: OK

Usage: Query only
Asynchronous command

SBUS<sb>:ARINc:WORD<w>:STOP?

Returns the end time of the specified word.

Suffix:

<sb> 1...4, index of the serial bus

<w> *
Index of the word

Return values:

<FrameStop> Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0
Default unit: s

Usage: Query only
Asynchronous command

SBUS<sb>:ARINc:WORD<w>:SYMBol?

Returns the label name of the word ID.

Suffix:

<sb> 1...4, index of the serial bus

<w> *
Index of the word

Return values:

<Translation>

Usage: Query only
Asynchronous command

18.17.14 SpaceWire (option R&S MXO4-K530)

Before MXO 4 can accept the specific bus commands, make sure that:

- The decoding of the specified bus is enabled with `SBUS<sb>[:STATe]`.
- The bus is set to the correct type with `SBUS<sb>:TYPE`.

18.17.14.1 Configuration

SBUS<sb>:SWIRe:DATA:SOURce Source

Selects the channel for the data signal source.

Suffix:

<sb> 1...4, index of the serial bus

Parameters:

Source C1 | C2 | C3 | C4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | M1 | M2 | M3 | M4 | M5 | R1 | R2 | R3 | R4 | O<n>C1 | O<n>C2 | ... | O<n>C8 (<n> = 2 to 8)

Usage: Asynchronous command

Manual operation: See "Data Source" on page 673

SBUS<sb>:SWIRe:STRBe:SOURce <StrobeSource>

Selects the source for the strobe signal.

Suffix:

<sb> 1...4, index of the serial bus

Parameters:

<StrobeSource> C1 | C2 | C3 | C4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | M1 | M2 | M3 | M4 | M5 | R1 | R2 | R3 | R4 | O<n>C1 | O<n>C2 | ... | O<n>C8 (<n> = 2 to 8)

Usage: Asynchronous command

Manual operation: See "Strobe Source" on page 673

SBUS<sb>:SWIRe:DATA:THReshold <DataThreshold>

Sets the threshold for the data channel.

Suffix:

<sb> 1...4, index of the serial bus

Parameters:

<DataThreshold>

Usage: Asynchronous command

Manual operation: See "Thresholds" on page 674

SBUS<sb>:SWIRe:DATA:HYSTeresis <DataHysteresis>

Sets the hysteresis for the data channel.

Suffix:

<sb> 1...4, index of the serial bus

Parameters:
<DataHysteresis>

Usage: Asynchronous command

Manual operation: See "Thresholds" on page 674

SBUS<sb>:SWIRe:STRBe:THReshold <StrobeThres>

Sets the threshold value for the digitization of the strobe signal.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<StrobeThres>

Usage: Asynchronous command

Manual operation: See "Thresholds" on page 674

SBUS<sb>:SWIRe:STRBe:HYSTeresis <StrobeHyst>

Sets a value for the hysteresis of the strobe signal.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<StrobeHyst>

Usage: Asynchronous command

Manual operation: See "Thresholds" on page 674

SBUS<sb>:SWIRe:MINGap <MinGapTime>
SBUS<sb>:SWIRe:MGAP <MinGapTime>

Sets the minimum duration of a gap. Any inactivity greater than this time is interpreted as a gap and leads to a resynchronization to the signal.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<MinGapTime> Range: 1E-09 to 1
Increment: 1E-09
*RST: 2E-07
Default unit: s

Usage: Asynchronous command

Manual operation: See "Min Gap" on page 673

SBUS<sb>:SWIRe:POSition <Position>

Sets the vertical position of the SpaceWire signal.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<Position>

Usage: Asynchronous command

SBUS<sb>:SWIRe:SCALe <Scale>

Sets the vertical scale of the SpaceWire signal.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<Scale>

Usage: Asynchronous command

18.17.14.2 Filter

There are two commands for each parameter, that you can use for defining the Space-Wire settings.

For example, to set the *Frame type =SpaceWire-Frame* > *Field =Data* >*Data* value you can use one of the following commands:

- `SBUS:SWIRe:FILTer:FRAMe1:FLD1:DMIN 01100`
  Defines the parameter by using the index <m> for the frame number and <n> for the field number.
- `SBUS:SWIRe:FILTer:DMIN "SpaceWire-Frame", "Data", 01100`
  Defines the parameter by using the frame and field name.

SBUS<sb>:SWIRe:FILTer:CHKall

Enables the filter for all available frames and error types.

Suffix:

<sb>	1...4, index of the serial bus
Usage:	Setting only Asynchronous command
Manual operation:	See "Check all, Clear, Invert, Preset" on page 676

SBUS<sb>:SWIRe:FILTer:CLR

Disables the filter for all available frames and error types.

Suffix:

<sb>	1...4, index of the serial bus
Usage:	Setting only Asynchronous command
Manual operation:	See "Check all, Clear, Invert, Preset" on page 676

SBUS<sb>:SWIRe:FILTer:INVert

Inverts the current state of the frame and error types: all frames and error types that were enabled are disabled and vice versa.

Suffix:

<sb>	1...4, index of the serial bus
Usage:	Setting only Asynchronous command
Manual operation:	See "Check all, Clear, Invert, Preset" on page 676

SBUS<sb>:SWIRe:FILTer:RST

Presets the state of the selected frames and error types.

Suffix:

<sb>	1...4, index of the serial bus
Usage:	Setting only Asynchronous command
Manual operation:	See "Check all, Clear, Invert, Preset" on page 676

SBUS<sb>:SWIRe:FILTer:BIT <Frame>,<Field>,<Bit>
SBUS<sb>:SWIRe:FILTer:BIT? <Bit>
SBUS<sb>:SWIRe:FILTer:FRAMe<fr>:FLD<fl>:BIT <BitState>

Sets the bit state of a field that only consists of one bit.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<BitState>	ONE | ZERO *RST: ZERO

Usage: Asynchronous command

Manual operation: See "Edit" on page 677

SBUS<sb>:SWIRe:FILTer:ERENable <ErrorName>,<Enabler>
SBUS<sb>:SWIRe:FILTer:ERENable? <Enabler>
SBUS<sb>:SWIRe:FILTer:ERRor<n>:ENABle <Enable>

Defines the error type to be filtered on.

Suffix:

<sb>	1...4, index of the serial bus
<n>	index of the error

Parameters:

<Enable>	OFF | ON *RST: ON

Usage: Asynchronous command

Manual operation: See "Error type" on page 678

SBUS<sb>:SWIRe:FILTer:DMAX <Frame>,<Field>,<Data>
SBUS<sb>:SWIRe:FILTer:DMAX? <Data>
SBUS<sb>:SWIRe:FILTer:FRAMe<fr>:FLD<fl>:DMAX <Data_Max>

Sets the end value of a data pattern range if the operator is set to `INRange` or `OORANGe`.

You can set the operator with `SBUS<sb>:SWIRe:FILTer:FRAMe<fr>:FLD<fl>:DOPerator`.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:
<Data_Max>

Usage: Asynchronous command

Manual operation: See "Edit" on page 677

SBUS<sb>:SWIRe:FILTer:DMIN <Frame>,<Field>,<Data>
SBUS<sb>:SWIRe:FILTer:DMIN? <Data>
SBUS<sb>:SWIRe:FILTer:FRAMe<fr>:FLD<fl>:DMIN <Data_Min>

Specifies the data pattern, or sets the start value of a data pattern range.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:
<Data_Min>

Usage: Asynchronous command

Manual operation: See "Edit" on page 677

SBUS<sb>:SWIRe:FILTer:DOPerator <Frame>,<Field>,<Operator>
SBUS<sb>:SWIRe:FILTer:DOPerator? <Operator>
SBUS<sb>:SWIRe:FILTer:FRAMe<fr>:FLD<fl>:DOPerator <Data_Operator>

Sets the operator for the data pattern in the selected field of the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:
<Data_Operator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange
*RST: EQUal

Usage: Asynchronous command

Manual operation: See "Edit" on page 677

SBUS<sb>:SWIRe:FILTer:FIENable <Frame>,<Field>,<Enabler>
SBUS<sb>:SWIRe:FILTer:FIENable? <Enabler>
SBUS<sb>:SWIRe:FILTer:FRAMe<fr>:FLD<fl>:ENABle <CondEnabler>

Enables or disables the checking condition for the selected field of the selected frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Parameters:

<CondEnabler> OFF | ON

*RST: OFF

Usage: Asynchronous command

Manual operation: See "Edit" on page 677

SBUS<sb>:SWIRe:FILTer:FRENable <Frame>,<Enabler>
SBUS<sb>:SWIRe:FILTer:FRENable? <Enabler>
SBUS<sb>:SWIRe:FILTer:FRAMe<fr>:ENABle <Enable>

Enables the filtering on SpaceWire frames. Only the frames that match the selected filter conditions are displayed.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

Parameters:

<Enable> OFF | ON

*RST: ON

Usage: Asynchronous command

Manual operation: See "Enable" on page 676

18.17.14.3 Software trigger

There are two commands for each parameter, that you can use for defining the SpaceWire settings.

For example, to set the *Frame type =SpaceWire-Frame* > *Field =Data* >*Data* value you can use one of the following commands:

- `TRIGger:SBSW:SWIRe:FRAMe1:FLD1:DMIN 01100`
  Defines the parameter by using the index <fr> for the frame number and <fl> for the field number.
- `TRIGger:SBSW:SWIRe:DMIN "SpaceWire-Frame", "Data", 01100`
  Defines the parameter by using the frame and field name.

TRIGger:SBSW:SWIRe:CHKall

Enables the software trigger for all available frames and error types.

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 679

TRIGger:SBSW:SWIRe:CLR

Disables the software trigger for all available frames and error types.

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 679

TRIGger:SBSW:SWIRe:INVert

Inverts the current state of the frame and error types for the software trigger: all frames and error types that were enabled are disabled and vice versa.

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 679

TRIGger:SBSW:SWIRe:RST

Presets the state of the selected frames and error types for the software trigger.

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 679

TRIGger:SBSW:SWIRe:FRENable <Frame>,<Enabler>
TRIGger:SBSW:SWIRe:FRENable? <Enabler>
TRIGger:SBSW:SWIRe:FRAMe<fr>:ENABle <Enable>

Enables or disables the checking condition for the selected frame for the software trigger.

Suffix:

<fr>	Index of the frame

Parameters:

<Enable>	OFF | ON *RST: ON

Usage: Asynchronous command

Manual operation: See "Frame type" on page 680

TRIGger:SBSW:SWIRe:BIT <Frame>,<Field>,<Bit>
TRIGger:SBSW:SWIRe:BIT? <Bit>
TRIGger:SBSW:SWIRe:FRAMe<fr>:FLD<fl>:BIT <BitState>

Sets the bit state of a field that only consists of one bit for the software trigger.

Suffix:

<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<BitState>	ONE | ZERO *RST: ZERO

Usage: Asynchronous command

Manual operation: See "Edit" on page 680

TRIGger:SBSW:SWIRe:DMAX <Frame>,<Field>,<Data>
TRIGger:SBSW:SWIRe:DMAX? <Data>
TRIGger:SBSW:SWIRe:FRAMe<fr>:FLD<fl>:DMAX <Data_Max>

Sets the end value of a data pattern range for the software trigger, if the operator is set to `INRange` or `OORANGe`.

You can set the operator with `TRIGger:SBSW:SWIRe:FRAMe<fr>:FLD<fl>:DOPerator`.

Suffix:

<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Data_Max>

Usage: Asynchronous command

Manual operation: See "Edit" on page 680

TRIGger:SBSW:SWIRe:DMIN <Frame>,<Field>,<Data>
TRIGger:SBSW:SWIRe:DMIN? <Data>
TRIGger:SBSW:SWIRe:FRAMe<fr>:FLD<fl>:DMIN <Data_Min>

Specifies the data pattern, or sets the start value of a data pattern range for the software trigger.

Suffix:

<fr> Index of the frame

<fl> Index of the field

Parameters:

<Data_Min>

Usage: Asynchronous command

Manual operation: See "Edit" on page 680

TRIGger:SBSW:SWIRe:DOPerator <Frame>,<Field>,<Operator>
TRIGger:SBSW:SWIRe:DOPerator? <Operator>
TRIGger:SBSW:SWIRe:FRAMe<fr>:FLD<fl>:DOPerator <Data_Operator>

Sets the operator for the data pattern of the software trigger in the selected field of the selected frame.

Suffix:

<fr> Index of the frame

<fl> Index of the field

Parameters:

<Data_Operator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

*RST: EQUal

Usage: Asynchronous command

Manual operation: See "Edit" on page 680

TRIGger:SBSW:SWIRe:FIENable <Frame>,<Field>,<Enabler>
TRIGger:SBSW:SWIRe:FIENable? <Enabler>
TRIGger:SBSW:SWIRe:FRAMe<fr>:FLD<fl>:ENABle <CondEnabler>

Enables or disables the checking condition for the selected field of the selected frame of the software trigger.

Suffix:

<fr> Index of the frame

<fl> Index of the field

Parameters:

<CondEnabler> OFF | ON

*RST: OFF

Usage: Asynchronous command

Manual operation: See "Edit" on page 680

TRIGger:SBSW:SWIRe:ERENable <ErrorName>,<Enabler>
TRIGger:SBSW:SWIRe:ERENable? <Enabler>
TRIGger:SBSW:SWIRe:ERRor<m>:ENABle <Enable>

Defines the error type for the software trigger.

Suffix:

<m> index of the error

Parameters:

<Enable> OFF | ON

*RST: ON

Usage: Asynchronous command

Manual operation: See "Error type" on page 681

SBUS<sb>:SWIRe:SWTindex?

Queries the software trigger index.

If no software trigger event has occurred, the command returns `Invalid`.

Suffix:

<sb> 1...4, index of the serial bus

Return values:

<Index> Range: 0 to 4294967295
Increment: 1
*RST: 0

Usage: Query only
Asynchronous command

SBUS<sb>:SWIRe:SWTTime?

Queries the software trigger time in seconds.

If no software trigger event has occured, the command returns `Invalid`.

Suffix:

<sb> 1...4, index of the serial bus

Return values:

<Time> Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0
Default unit: s

Usage: Query only
Asynchronous command

18.17.14.4 Decode results

This section describes the commands to query the results of the decoding.

SBUS<sb>:SWIRe:FCOunt?

Returns the number of decoded frames.

Suffix:

<sb> 1...4, index of the serial bus

Return values:

<Count>

Usage: Query only
Asynchronous command

SBUS<sb>:SWIRe:FRAMe<fr>:BITRate?

Returns the bit rate of the frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:

<PrimaryBitRate> Increment: 1
*RST: 0
Default unit: bps

Usage: Query only
Asynchronous command

SBUS<sb>:SWIRe:FRAMe<fr>:DATA?

Returns the data of the specified frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:

<FrameData>

Usage: Query only
Asynchronous command

SBUS<sb>:SWIRe:FRAMe<fr>:CODParity?

If the frame has the `FCT`, `EOP`, `EEP` or `Code` field, the command returns the parity state of this field, which can take values of `OK` or `PARity`. For a description of these fields, see Section 14.13.1, "SpaceWire basics", on page 672.

If the frame has none of these fields, the command can return the states `LENGth`, `AMBiguous` or `INComplete` of the frame, as described below.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:

<ParityCode> OK | PARity | LENGth | AMBiguous | INComplete

OK
The parity check for the field covered by this parity bit passes.

PARity
The parity of the field is not correct.

LENGth
Regardless of the field, the length of the frame is not as expected, indicating an error.

AMBiguous
Regardless of the field, the frame is ambiguous.

INComplete
Regardless of the field, the frame is incomplete.

*RST: OK

Usage: Query only
Asynchronous command

SBUS<sb>:SWIRe:FRAMe<fr>:DATParity?

If the frame has the `Data` field, the command returns the parity state of this field, which can take values of `OK` or `PARity`. The `Data` field only appears in `Data` and `Time` frames, see Figure 14-39 and Figure 14-41.

If the frame has no `Data` field, the command can return the states `LENGth`, `AMBiguous` or `INComplete` of the frame, as described below.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:

<ParityData> OK | PARity | LENGth | AMBiguous | INComplete

OK
The parity check for the `Data` field passes.

PARity
The parity of the `Data` field is not correct.

LENGth
Regardless of the `Data` field, the length of the frame is not as expected, indicating an error

AMBiguous
Regardless of the `Data` field, the frame is ambiguous.

INComplete
Regardless of the `Data` field, the frame is incomplete.

*RST: OK

Usage: Query only
Asynchronous command

SBUS<sb>:SWIRe:FRAMe<fr>:ESCParity?

If the frame has the `ESC` field, the command returns the parity state of this field, which can take values of `OK` or `PARity`. See Figure 14-40.

If the frame has no `ESC` field, the command can return the states `LENGth`, `AMBiguous` or `INComplete` of the frame, as described below.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:

<ParityEscape> OK | PARity | LENGth | AMBiguous | INComplete

OK
The parity check for the ESC field passes.

PARity
The parity of the ESC field is not correct.

LENGth
Regardless of the ESC field, the length of the frame is not as expected, indicating an error.

AMBiguous
Regardless of the ESC field, the frame is ambiguous.

INComplete
Regardless of the ESC field, the frame is incomplete.

*RST: OK

Usage: Query only
Asynchronous command

SBUS<sb>:SWIRe:FRAMe<fr>:FLD<fl>:STATus?

Returns the overall state of the specified field in the specified frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Return values:

<State> OK | PARity | LENGth | AMBiguous | INComplete

OK
The parity check for the selected field passes.

PARity
Parity is not as expected, indicating an error.

LENGth
The length of the field is not as expected, indicating an error.

AMBiguous
The frame is ambiguous.

INComplete
The frame is incomplete.

*RST: OK

Usage: Query only
Asynchronous command

SBUS<sb>:SWIRe:FRAMe<fr>:FLD<fl>:TYPE?

Returns the label of the specified field in the specified frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Return values:
<Label>

Usage: Query only
Asynchronous command

SBUS<sb>:SWIRe:FRAMe<fr>:FLD<fl>:VALue?

Returns the value of the specified field in the specified frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Return values:
<Value> *RST: 0

Usage: Query only
Asynchronous command

SBUS<sb>:SWIRe:FRAMe<fr>:FLD<fl>:FVALue?

Returns the formatted value of the specified field in the specified frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Return values:
<FormattedValue>

Usage: Query only
Asynchronous command

SBUS<sb>:SWIRe:FRAMe<fr>:STATe?

Returns the overall state of the specified frame.

Suffix:

<sb>	1...4, index of the serial bus

<fr> Index of the frame

Return values:
<FrameState> OK | PARity | LENGth | AMBiguous | INComplete

OK
The frame is valid.

PARity
Parity is not as expected, indicating an error

LENGth
Length of the frame is not as expected, indicating an error

AMBiguous
The frame is ambiguous.

INComplete
The frame is incomplete.

*RST: OK

Usage: Query only
Asynchronous command

SBUS<sb>:SWIRe:FRAMe<fr>:STARt?

Returns the start time of the specified frame.

Suffix:
<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:
<FrameStart> Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0
Default unit: s

Usage: Query only
Asynchronous command

SBUS<sb>:SWIRe:FRAMe<fr>:STOP?

Returns the end time of the specified frame.

Suffix:
<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:
<FrameStop> Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0
Default unit: s

Usage: Query only
Asynchronous command

SBUS<sb>:SWIRe:FRAMe<fr>:TYPE?

Returns the type of the specified decoded frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:

<FrameType> DATA | TCOD | FCT | NULL | EOP | EEP | BADX

DATA
Data frame

TCOD
Time-code frame

FCT
Flow control token

NULL
Null symbol

EOP
End of packet

EEP
Error end of packet

BADX
Illegal escape code

*RST: DATA

Usage: Query only
Asynchronous command

18.17.15 MIL-1553 (option R&S MXO4-K530)

Before MXO 4 can accept the specific bus commands, make sure that:

- The decoding of the specified bus is enabled with `SBUS<sb>[:STATe]`.
- The bus is set to the correct type with `SBUS<sb>:TYPE`.

18.17.15.1 Configuration

SBUS<sb>:MILStd:POLarity <Polarity>

Sets the wire on which the bus signal is measured : normal or inverted. The setting affects the digitization of the signal.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<Polarity> NORMal | INVerted
*RST: NORMal

Usage: Asynchronous command

Manual operation: See "Polarity" on page 688

SBUS<sb>:MILStd:SOURce Source

Sets the channel for the signal source.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
Source C1 | C2 | C3 | C4 | M1 | M2 | M3 | M4 | M5 | R1 | R2 | R3 | R4 | O<n>C1 | O<n>C2 | ... | O<n>C8 (<n> = 2 to 8)

Usage: Asynchronous command

Manual operation: See "Source" on page 688

SBUS<sb>:MILStd:THReshold:HIGH <Threshold high>

Sets the lower threshold level of the signal.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<Threshold high>

Usage: Asynchronous command

Manual operation: See "Threshold" on page 688

SBUS<sb>:MILStd:THReshold:HYSTeresis <Hysteresis>

Sets a hysteresis value.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<Hysteresis>

Usage: Asynchronous command

Manual operation: See "Threshold" on page 688

SBUS<sb>:MILStd:THReshold:LOW <Threshold low>

Sets the lower threshold level of the signal.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<Threshold low>

Usage: Asynchronous command

Manual operation: See "Threshold" on page 688

SBUS<sb>:MILStd:NEWList <FileName>

Loads a symbol list file.

Suffix:
<sb> 1...4, index of the serial bus

Setting parameters:
<FileName> String parameter with path and file name.

Example:
```
SBUS1:MILStd:NEWList
'/home/storage/userData/Protocol/MILStd.csv'
SBUS1:MILStd:SYMBols ON
```

Usage: Setting only
Asynchronous command

SBUS<sb>:MILStd:POSition <Position>

Sets the vertical position of the MIL-1553 signal.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<Position>

Usage: Asynchronous command

SBUS<sb>:MILStd:SCALe <Scale>

Set the vertical scale of the indicated MIL-1553 signal.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<Scale>

Usage: Asynchronous command

SBUS<sb>:MILStd:SYMBols <ShowSymbols>

Activates the symbol list to be used for decoding.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<ShowSymbols> OFF | ON
*RST: OFF

Usage: Asynchronous command

18.17.15.2 Filter

There are two commands for each parameter that you can use for defining the MIL-1553 settings.

For example, to set the *Frame type =Command > Field =Info >01100* value you can use one of the following commands:

- `SBUS:MIL:FILTer:FRAMe1:FLD1:DMIN 01100`
  Defines the parameter by using the index <m> for the frame number and <n> for the field number.
- `SBUS:MIL:FILTer:DMIN "Command", "Info", 01100`
  Defines the parameter by using the frame and field name.

SBUS<sb>:MILStd:FILTer:CHKall

Enables the filter for all available frames and error types.

Suffix:
<sb> 1...4, index of the serial bus

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 690

SBUS<sb>:MILStd:FILTer:CLR

Disables the filter for all available frames and error types.

Suffix:
<sb> 1...4, index of the serial bus

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 690

SBUS<sb>:MILStd:FILTer:INVert

Inverts the current state of the frame and error types: all frames and error types that were enabled are disabled and vice versa.

Suffix:
<sb> 1...4, index of the serial bus

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 690

SBUS<sb>:MILStd:FILTer:RST

Presets the state of the selected frames and error types.

Suffix:

<sb>	1...4, index of the serial bus

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 690

SBUS<sb>:MILStd:FILTer:BIT <Frame>,<Field>,<Bit>
SBUS<sb>:MILStd:FILTer:BIT? <Bit>
SBUS<sb>:MILStd:FILTer:FRAMe<fr>:FLD<fl>:BIT <BitState>

Sets the operator for the data pattern in the selected field of the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<BitState>	ONE | ZERO *RST: ZERO

Usage: Asynchronous command

Manual operation: See "Edit" on page 691

SBUS<sb>:MILStd:FILTer:ERENable <ErrorName>,<Enabler>
SBUS<sb>:MILStd:FILTer:ERENable? <Enabler>
SBUS<sb>:MILStd:FILTer:ERRor<n>:ENABle <Enable>

Defines the error type to be filtered on.

Suffix:

<sb>	1...4, index of the serial bus
<n>	index of the error

Parameters:

<Enable>	OFF | ON *RST: ON

Usage: Asynchronous command

Manual operation: See "Error type" on page 692

SBUS<sb>:MILStd:FILTer:DMAX <Frame>,<Field>,<Data>
SBUS<sb>:MILStd:FILTer:DMAX? <Data>
SBUS<sb>:MILStd:FILTer:FRAMe<fr>:FLD<fl>:DMAX <Data_Max>

Sets the end value of a data pattern range if the operator is set to `INRange` or `OORANGe`.

You can set the operator with `SBUS<sb>:MILStd:FILTer:FRAMe<fr>:FLD<fl>:DOPerator`.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:
<Data_Max>

Usage: Asynchronous command

Manual operation: See "Edit" on page 691

SBUS<sb>:MILStd:FILTer:DMIN <Frame>,<Field>,<Data>
SBUS<sb>:MILStd:FILTer:DMIN? <Data>
SBUS<sb>:MILStd:FILTer:FRAMe<fr>:FLD<fl>:DMIN <Data_Min>

Specifies the data pattern, or sets the start value of a data pattern range.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:
<Data_Min>

Usage: Asynchronous command

Manual operation: See "Edit" on page 691

SBUS<sb>:MILStd:FILTer:DOPerator <Frame>,<Field>,<Operator>
SBUS<sb>:MILStd:FILTer:DOPerator? <Operator>
SBUS<sb>:MILStd:FILTer:FRAMe<fr>:FLD<fl>:DOPerator <Data_Operator>

Sets the operator for the data pattern in the selected field of the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Data_Operator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

*RST: EQUal

Usage: Asynchronous command

Manual operation: See "Edit" on page 691

SBUS<sb>:MILStd:FILTer:IMAX <Frame>,<Field>,<Data>
SBUS<sb>:MILStd:FILTer:IMAX? <Data>
SBUS<sb>:MILStd:FILTer:FRAMe<fr>:FLD<fl>:IMAX <Index_Max>

Sets the end value of an index range if the operator is set to `INRange`.

You can set the operator with `SBUS<sb>:MILStd:FILTer:FRAMe<fr>:FLD<fl>:IOPerator`.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Parameters:

<Index_Max> Range: 1 to 65535
Increment: 1
*RST: 65535

Usage: Asynchronous command

Manual operation: See "Edit" on page 691

SBUS<sb>:MILStd:FILTer:IMIN <Frame>,<Field>,<Data>
SBUS<sb>:MILStd:FILTer:IMIN? <Data>
SBUS<sb>:MILStd:FILTer:FRAMe<fr>:FLD<fl>:IMIN <Index_Min>

Specifies the index, or sets the start value of an index range.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Parameters:

<Index_Min> Range: 1 to 65535
Increment: 1
*RST: 1

Usage: Asynchronous command

Manual operation: See "Edit" on page 691

SBUS<sb>:MILStd:FILTer:IOPerator <Frame>,<Field>,<Operator>
SBUS<sb>:MILStd:FILTer:IOPerator? <Operator>
SBUS<sb>:MILStd:FILTer:FRAMe<fr>:FLD<fl>:IOPerator <Index_Operator>

Sets the operator for the index in the selected field of the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Index_Operator>	EQUal | INRange | RANGe *RST: INRange

Usage: Asynchronous command

Manual operation: See "Edit" on page 691

SBUS<sb>:MILStd:FILTer:FRENable <Frame>,<Enabler>
SBUS<sb>:MILStd:FILTer:FRENable? <Enabler>
SBUS<sb>:MILStd:FILTer:FRAMe<fr>:ENABle <Enable>

Enables the filtering on MIL-1553 frames. Only the frames that match the selected filter conditions are displayed.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Parameters:

<Enable>	OFF | ON *RST: ON

Usage: Asynchronous command

Manual operation: See "Enable" on page 691

SBUS<sb>:MILStd:FILTer:FIENable <Frame>,<Field>,<Enabler>
SBUS<sb>:MILStd:FILTer:FIENable? <Enabler>
SBUS<sb>:MILStd:FILTer:FRAMe<fr>:FLD<fl>:ENABle <CondEnabler>

Enables or disables the checking condition for the selected field of the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:
<CondEnabler> OFF | ON
*RST: OFF

Usage: Asynchronous command

Manual operation: See "Edit" on page 691

18.17.15.3 Software trigger

There are two commands for each parameter that you can use for defining the MIL-1553 settings.

For example, to set the *Frame type =Command > Field =Info >01100* value you can use one of the following commands:

- `TRIGger:SBSW:MIL:FRAMe1:FLD1:DMIN 01100`
  Defines the parameter by using the index <m> for the frame number and <n> for the field number.
- `TRIGger:SBSW:MIL:DMIN "Command", "Info", 01100`
  Defines the parameter by using the frame and field name.

TRIGger:SBSW:MILStd:CHKall

Enables the software trigger for all available frames and error types.

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 693

TRIGger:SBSW:MILStd:CLR

Disables the software trigger for all available frames and error types.

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 693

TRIGger:SBSW:MILStd:INVert

Inverts the current state of the frame and error types for the software trigger: all frames and error types that were enabled are disabled and vice versa.

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 693

TRIGger:SBSW:MILStd:RST

Presets the state of the selected frames and error types for the software trigger.

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 693

TRIGger:SBSW:MILStd:FRENable <Frame>,<Enabler>
TRIGger:SBSW:MILStd:FRENable? <Enabler>
TRIGger:SBSW:MILStd:FRAMe<fr>:ENABle <Enable>

Enables or disables the checking condition for the selected frame for the software trigger.

Suffix:
<fr> Index of the frame

Parameters:
<Enable> OFF | ON
*RST: ON

Usage: Asynchronous command

Manual operation: See "Frame type" on page 694

TRIGger:SBSW:MILStd:BIT <Frame>,<Field>,<Bit>
TRIGger:SBSW:MILStd:BIT? <Bit>
TRIGger:SBSW:MILStd:FRAMe<fr>:FLD<fl>:BIT <BitState>

Sets the bit state of a field that only consists of one bit for the software trigger.

Suffix:

<fr> Index of the frame

<fl> Index of the field

Parameters:

<BitState> ONE | ZERO
*RST: ZERO

Usage: Asynchronous command

Manual operation: See "Edit" on page 694

TRIGger:SBSW:MILStd:DMAX <Frame>,<Field>,<Data>
TRIGger:SBSW:MILStd:DMAX? <Data>
TRIGger:SBSW:MILStd:FRAMe<fr>:FLD<fl>:DMAX <Data_Max>

Sets the end value of a data pattern range for the software trigger, if the operator is set to `INRange` or `OORANGe`.

You can set the operator with `TRIGger:SBSW:MILStd:FRAMe<fr>:FLD<fl>:DOPerator`.

Suffix:

<fr> Index of the frame

<fl> Index of the field

Parameters:

<Data_Max>

Usage: Asynchronous command

Manual operation: See "Edit" on page 694

TRIGger:SBSW:MILStd:DMIN <Frame>,<Field>,<Data>
TRIGger:SBSW:MILStd:DMIN? <Data>
TRIGger:SBSW:MILStd:FRAMe<fr>:FLD<fl>:DMIN <Data_Min>

Specifies the data pattern, or sets the start value of a data pattern range for the software trigger.

Suffix:

<fr> Index of the frame

<fl> Index of the field

Parameters:

<Data_Min>

Usage: Asynchronous command

Manual operation: See "Edit" on page 694

TRIGger:SBSW:MILStd:DOPerator <Frame>,<Field>,<Operator>
TRIGger:SBSW:MILStd:DOPerator? <Operator>
TRIGger:SBSW:MILStd:FRAMe<fr>:FLD<fl>:DOPerator <Data_Operator>

Sets the operator for the data pattern of the software trigger in the selected field of the selected frame.

Suffix:

<fr> Index of the frame

<fl> Index of the field

Parameters:

<Data_Operator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

*RST: EQUal

Usage: Asynchronous command

Manual operation: See "Edit" on page 694

TRIGger:SBSW:MILStd:FIENable <Frame>,<Field>,<Enabler>
TRIGger:SBSW:MILStd:FIENable? <Enabler>
TRIGger:SBSW:MILStd:FRAMe<fr>:FLD<fl>:ENABle <CondEnabler>

Enables or disables the checking condition for the selected field of the selected frame of the software trigger.

Suffix:

<fr> Index of the frame

<fl> Index of the field

Parameters:

<CondEnabler> OFF | ON

*RST: OFF

Usage: Asynchronous command

Manual operation: See "Edit" on page 694

TRIGger:SBSW:MILStd:IMAX <Frame>,<Field>,<Data>
TRIGger:SBSW:MILStd:IMAX? <Data>
TRIGger:SBSW:MILStd:FRAMe<fr>:FLD<fl>:IMAX <Index_Max>

Sets the end value of an index range for the software trigger if the operator is set to `INRange`.

You can set the operator with `TRIGger:SBSW:MILStd:FRAMe<fr>:FLD<fl>:IOPerator`.

Suffix:

<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Index_Max> Range: 1 to 65535
Increment: 1
*RST: 65535

Usage: Asynchronous command

Manual operation: See "Edit" on page 694

TRIGger:SBSW:MILStd:IMIN <Frame>,<Field>,<Data>
TRIGger:SBSW:MILStd:IMIN? <Data>
TRIGger:SBSW:MILStd:FRAMe<fr>:FLD<fl>:IMIN <Index_Min>

Specifies the index, or sets the start value of an index range for the software trigger.

Suffix:

<fr>	Index of the frame
<fl>	*

Parameters:

<Index_Min> Range: 1 to 65535
Increment: 1
*RST: 1

Usage: Asynchronous command

Manual operation: See "Edit" on page 694

TRIGger:SBSW:MILStd:IOPerator <Frame>,<Field>,<Operator>
TRIGger:SBSW:MILStd:IOPerator? <Operator>
TRIGger:SBSW:MILStd:FRAMe<fr>:FLD<fl>:IOPerator <Index_Operator>

Sets the operator for the index in the selected field of the selected frame for the software trigger.

Suffix:

<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Index_Operator> EQUal | INRange | RANGe
*RST: INRange

Usage: Asynchronous command

Manual operation: See "Edit" on page 694

TRIGger:SBSW:MILStd:ERENable <ErrorName>,<Enabler>
TRIGger:SBSW:MILStd:ERENable? <Enabler>
TRIGger:SBSW:MILStd:ERRor<m>:ENABle <Enable>

Defines the error type for the software trigger.

Suffix:

<m>	Index of the error

Parameters:

<Enable>	OFF | ON *RST: ON

Usage: Asynchronous command

Manual operation: See "Error type" on page 695

SBUS<sb>:MILStd:SWTindex?

Queries the software trigger index.

If no software trigger event has occurred, the command returns `Invalid`.

Suffix:

<sb>	1...4, index of the serial bus

Return values:

<Index>	Range: 0 to 4294967295 Increment: 1 *RST: 0

Usage: Query only
Asynchronous command

SBUS<sb>:MILStd:SWTTime?

Queries the software trigger time in seconds.

If no software trigger event has occured, the command returns `Invalid`.

Suffix:

<sb>	1...4, index of the serial bus

Return values:

<Time>	Range: -1E+26 to 1E+26 Increment: 1E-10 *RST: 0 Default unit: s

Usage: Query only
Asynchronous command

18.17.15.4 Decode results

SBUS<sb>:MILStd:WCOunt?

Returns the number of decoded words.

Suffix:

<sb> 1...4, index of the serial bus

Return values:

<Count> Total number of words.

Usage: Query only
Asynchronous command

SBUS<sb>:MILStd:WORD<w>:BITRate?

Returns the bit rate of the word.

Suffix:

<sb> 1...4, index of the serial bus

<w> *
Index of the word

Return values:

<PrimaryBitRate> Increment: 1
*RST: 0
Default unit: bps

Usage: Query only
Asynchronous command

SBUS<sb>:MILStd:WORD<w>:DATA?

Return the data pattern of the specified word.

Suffix:

<sb> 1...4, index of the serial bus

<w> *
Index of the word

Return values:

<FrmDatPatt> List of comma separated values.

Usage: Query only
Asynchronous command

SBUS<sb>:MILStd:WORD<w>:INFO?

Returns the info value for the specified word.

Suffix:

<sb> 1...4, index of the serial bus

<w> *
Index of the word

Return values:

<FrameInfo> Range: 0 to 2047
Increment: 1
*RST: 0

Usage: Query only
Asynchronous command

SBUS<sb>:MILStd:WORD<w>:RTADdress?

Returns the RT address for the selected word.

Suffix:

<sb> 1...4, index of the serial bus

<w> *
Index of the word

Return values:

<FrameRta> Range: 0 to 31
Increment: 1
*RST: 0

Usage: Query only
Asynchronous command

SBUS<sb>:MILStd:WORD<w>:STARt?

Return the start time of the selected word.

Suffix:

<sb> 1...4, index of the serial bus

<w> *
Index of the word

Return values:

<FrameStart> Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0
Default unit: s

Usage: Query only
Asynchronous command

SBUS<sb>:MILStd:WORD<w>:STATus?

Returns the overall state of the selected word.

Suffix:

<sb> 1...4, index of the serial bus

<w> *
Index of the word

Return values:

<FrameState> OK | SYNC | MANC | PAR | GAP | RT | INComplete | UNKNown

`OK`: the word is valid.
`SYNC`: synchronization error occured.
`MANC`: manchester coding error occured.
`PAR`: parity error occured.
`GAP`: timing gap error occured.
`RT`: remote terminal error occured.
`INComplete`: the sequence is not completely contained in the acquisition
`UNKNown`: unknown frame type

*RST: OK

Usage: Query only
Asynchronous command

SBUS<sb>:MILStd:WORD<w>:STOP?

Returns the stop time of the selected word.

Suffix:

<sb> 1...4, index of the serial bus

<w> *
Index of the word

Return values:

<FrameStop> Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0
Default unit: s

Usage: Query only
Asynchronous command

SBUS<sb>:MILStd:WORD<w>:SYMBol?

Returns the symbolic label of the specified word if the label list is enabled.

Suffix:

<sb> 1...4, index of the serial bus

<w> *
Index of the word

Return values:

<SymbolicName>

Usage: Query only
Asynchronous command

SBUS<sb>:MILStd:WORD<w>:TYPE?

Returns the type of the specified word.

Suffix:

<sb> 1...4, index of the serial bus

<w> *
Index of the word

Return values:

<FrameType> UNKNown | DATA | CMD | STAT | CMST | IM

`CMD`: command word
`CMST`: command/status word
`IM`: inter message. Shows if there are gap errors or response timeout.

*RST: DATA

Usage: Query only
Asynchronous command

18.17.16 SPMI (option R&S MXO4-K550)

Before MXO 4 can accept the specific bus commands, make sure that:

- The decoding of the specified bus is enabled with `SBUS<sb>[:STATe]`.
- The bus is set to the correct type with `SBUS<sb>:TYPE`.

18.17.16.1 Configuration

SBUS<sb>:SPMI:GSIDenable <UseGSID>

Enables the use of the group sub ID (GSID). You can set the GSID with `SBUS<sb>:SPMI:GIDValue`.

Suffix:

<sb> 1...4, index of the serial bus

Parameters:

<UseGSID> OFF | ON

*RST: OFF

Usage: Asynchronous command

Manual operation: See "Use GSID, GSID (hex)" on page 700

SBUS<sb>:SPMI:GIDValue <GSID>

Sets a value for the group sub index. Available, if `SBUS<sb>:SPMI:GSIDenable` is set to `ON`.

Suffix:

<sb> 1...4, index of the serial bus

Parameters:

<GSID> Range: 0 to 15

Increment: 1

*RST: 0

Usage: Asynchronous command

Manual operation: See "Use GSID, GSID (hex)" on page 700

SBUS<sb>:SPMI:GTCHenable <UseGlitchFilter>

Enables the glitch filter. A glitch filter can help to filter out short-duration voltage spikes/ glitches that can occur on the communication line.

You can set the glitch filter width with `SBUS<sb>:SPMI:GTWDith`.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<UseGlitchFilter> OFF | ON
*RST: OFF

Usage: Asynchronous command

Manual operation: See "Glitch filter, Glitch width" on page 700

SBUS<sb>:SPMI:GTWDith <GlitchFilterWdt>

Sets the glitch width. Any signal transitions with a duration smaller than this value will be considered a glitch and filtered out.

This is available, if `SBUS<sb>:SPMI:GTCHenable` is set to `ON`.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<GlitchFilterWdt> Range: 1E-15 to 1000000000
Increment: 1E-10
*RST: 1E-09
Default unit: s

Usage: Asynchronous command

Manual operation: See "Glitch filter, Glitch width" on page 700

SBUS<sb>:SPMI:SCLK:HYSTeresis <Hysteresis>

Sets a value for the hysteresis for the clock line.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<Hysteresis>

Usage: Asynchronous command

Manual operation: See "Threshold" on page 701

SBUS<sb>:SPMI:SCLK:SOURce <ClockSource>

Sets the source of the clock line.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<ClockSource> C1 | C2 | C3 | C4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | M1 | M2 | M3 | M4 | M5 | R1 | R2 | R3 | R4 | O<n>C1 | O<n>C2 | ... | O<n>C8 (<n> = 2 to 8)

Usage: Asynchronous command

Manual operation: See "SCLK" on page 700

SBUS<sb>:SPMI:SCLK:THReshold <Threshold>

Sets a user-defined threshold value for the clock line.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<Threshold>

Usage: Asynchronous command

Manual operation: See "Threshold" on page 701

SBUS<sb>:SPMI:SDATa:HYSTeresis <SDATA Hyst>

Sets a value for the hysteresis for the source data channel.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<SDATA Hyst>

Usage: Asynchronous command

Manual operation: See "Threshold" on page 701

SBUS<sb>:SPMI:SDATa:SOURce <DataSource>

Sets the source of the data line.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<DataSource> C1 | C2 | C3 | C4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | M1 | M2 | M3 | M4 | M5 | R1 | R2 | R3 | R4 | O<n>C1 | O<n>C2 | ... | O<n>C8 (<n> = 2 to 8)

Usage: Asynchronous command

Manual operation: See "SDATA" on page 700

SBUS<sb>:SPMI:SDATa:THReshold <SDATA Thres>

Sets a user-defined threshold value for the source data line.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<SDATA Thres>

Usage: Asynchronous command

Manual operation: See "Threshold" on page 701

SBUS<sb>:SPMI:POSition <SPMI position>

Sets the vertical position of the SPMI signal.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<SPMI position>

Usage: Asynchronous command

SBUS<sb>:SPMI:SCALe <SPMI scale>

Sets the vertical position of the SPMI signal.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<SPMI scale>

Usage: Asynchronous command

SBUS<sb>:SPMI:SYMBols <ShowSymbols>

Activates the symbol list to be used for decoding.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<ShowSymbols> OFF | ON
*RST: OFF

Usage: Asynchronous command

SBUS<sb>:SPMI:NEWList <FileName>

Loads a symbol list file.

Suffix:

<sb> 1...4, index of the serial bus

Setting parameters:

<FileName> String parameter with path and filename.

Usage: Setting only
Asynchronous command

18.17.16.2 Filter

There are two commands for each parameter, that you can use for defining the SPMI settings.

For example, to set the *Frame type =Register 0 Write > Field =Data >00* value you can use one of the following commands:

- `SBUS:SPMI:FILTer:FRAMe1:FLD1:DMIN 00`
  Defines the parameter by using the index <m> for the frame number and <n> for the field number.
- `SBUS:SPMI:FILTer:DMIN "Register 0 Write", "Data", 00`
  Defines the parameter by using the frame and field name.

SBUS<sb>:SPMI:FILTer:CHKall

Enables the filter for all available frames and error types.

Suffix:
<sb> 1...4, index of the serial bus

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 702

SBUS<sb>:SPMI:FILTer:CLR

Disables the filter for all available frames and error types.

Suffix:
<sb> 1...4, index of the serial bus

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 702

SBUS<sb>:SPMI:FILTer:INVert

Inverts the current state of the frame and error types: all frames and error types that were enabled are disabled and vice versa.

Suffix:
<sb> 1...4, index of the serial bus

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 702

SBUS<sb>:SPMI:FILTer:RST

Presets the state of the selected frames and error types.

Suffix:
<sb> 1...4, index of the serial bus

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 702

SBUS<sb>:SPMI:FILTer:BIT <Frame>,<Field>,<Bit>
SBUS<sb>:SPMI:FILTer:BIT? <Bit>
SBUS<sb>:SPMI:FILTer:FRAMe<fr>:FLD<fl>:BIT <BitState>

Sets the operator for the data pattern in the selected field of the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<BitState> ONE | ZERO
*RST: ZERO

Usage: Asynchronous command

Manual operation: See "Edit" on page 703

SBUS<sb>:SPMI:FILTer:DMAX <Frame>,<Field>,<Data>
SBUS<sb>:SPMI:FILTer:DMAX? <Data>
SBUS<sb>:SPMI:FILTer:FRAMe<fr>:FLD<fl>:DMAX <Data_Max>

Sets the end value of a data pattern range if the operator is set to `INRange` or `OORANGe`.

You can set the operator with `SBUS<sb>:SPMI:FILTer:FRAMe<fr>:FLD<fl>:DOPerator`.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Data_Max>

Usage: Asynchronous command

Manual operation: See "Edit" on page 703

SBUS<sb>:SPMI:FILTer:DMIN <Frame>,<Field>,<Data>
SBUS<sb>:SPMI:FILTer:DMIN? <Data>
SBUS<sb>:SPMI:FILTer:FRAMe<fr>:FLD<fl>:DMIN <Data_Min>

Specifies the data pattern, or sets the start value of a data pattern range.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Data_Min>

Usage: Asynchronous command

Manual operation: See "Edit" on page 703

SBUS<sb>:SPMI:FILTer:DOPerator <Frame>,<Field>,<Operator>
SBUS<sb>:SPMI:FILTer:DOPerator? <Operator>
SBUS<sb>:SPMI:FILTer:FRAMe<fr>:FLD<fl>:DOPerator <Data_Operator>

Sets the operator for the data pattern in the selected field of the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Data_Operator>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange *RST: EQUal

Usage: Asynchronous command

Manual operation: See "Edit" on page 703

SBUS<sb>:SPMI:FILTer:ERENable <ErrorName>,<Enabler>
SBUS<sb>:SPMI:FILTer:ERENable? <Enabler>
SBUS<sb>:SPMI:FILTer:ERRor<n>:ENABle <Enable>

Defines the error type to be filtered on.

Suffix:

<sb>	1...4, index of the serial bus
<n>	Index of the error

Parameters:

<Enable>	OFF | ON *RST: ON

Usage: Asynchronous command

Manual operation: See "Error type" on page 704

SBUS<sb>:SPMI:FILTer:IOPerator <Frame>,<Field>,<Operator>
SBUS<sb>:SPMI:FILTer:IOPerator? <Operator>
SBUS<sb>:SPMI:FILTer:FRAMe<fr>:FLD<fl>:IOPerator <Index_Operator>

Sets the operator for the index in the selected field of the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Index_Operator>	EQUal | INRange | RANGe *RST: INRange

Usage: Asynchronous command

Manual operation: See "Edit" on page 703

SBUS<sb>:SPMI:FILTer:IMIN <Frame>,<Field>,<Data>
SBUS<sb>:SPMI:FILTer:IMIN? <Data>
SBUS<sb>:SPMI:FILTer:FRAMe<fr>:FLD<fl>:IMIN <Index_Min>

Specifies the index, or sets the start value of an index range.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Index_Min>	Range: 1 to 65535 Increment: 1 *RST: 1

Usage: Asynchronous command

Manual operation: See "Edit" on page 703

SBUS<sb>:SPMI:FILTer:IMAX <Frame>,<Field>,<Data>
SBUS<sb>:SPMI:FILTer:IMAX? <Data>
SBUS<sb>:SPMI:FILTer:FRAMe<fr>:FLD<fl>:IMAX <Index_Max>

Sets the end value of an index range if the operator is set to `INRange`.

You can set the operator with `SBUS<sb>:SPMI:FILTer:FRAMe<fr>:FLD<fl>:IOPerator`.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Index_Max>	Range: 1 to 65535 Increment: 1 *RST: 65535

Usage: Asynchronous command

Manual operation: See "Edit" on page 703

SBUS<sb>:SPMI:FILTer:FRENable <Frame>,<Enabler>
SBUS<sb>:SPMI:FILTer:FRENable? <Enabler>
SBUS<sb>:SPMI:FILTer:FRAMe<fr>:ENABle <Enable>

Enables the filtering on SPMI frames. Only the frames that match the selected filter conditions are displayed.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Parameters:

<Enable>	OFF | ON *RST: ON

Usage: Asynchronous command

Manual operation: See "Frame type" on page 703

SBUS<sb>:SPMI:FILTer:FIENable <Frame>,<Field>,<Enabler>
SBUS<sb>:SPMI:FILTer:FIENable? <Enabler>
SBUS<sb>:SPMI:FILTer:FRAMe<fr>:FLD<fl>:ENABle <CondEnabler>

Enables or disables the checking condition for the selected field of the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<CondEnabler>	OFF | ON *RST: OFF

Usage: Asynchronous command

Manual operation: See "Edit" on page 703

18.17.16.3 Software trigger

There are two commands for each parameter, that you can use for defining the SPMI settings.

For example, to set the *Frame type =Register 0 Write > Field =Data >00* value you can use one of the following commands:

- `TRIGger:SBSW:SPMI:FRAMe1:FLD1:DMIN 00`
  Defines the parameter by using the index <m> for the frame number and <n> for the field number.
- `TRIGger:SBSW:SPMI:DMIN "Register 0 Write", "Data", 00`
  Defines the parameter by using the frame and field name.

TRIGger:SBSW:SPMI:CHKall

Enables the software trigger for all available frames and error types.

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 705

TRIGger:SBSW:SPMI:CLR

Disables the software trigger for all available frames and error types.

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 705

TRIGger:SBSW:SPMI:INVert

Inverts the current state of the frame and error types for the software trigger: all frames and error types that were enabled are disabled and vice versa.

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 705

TRIGger:SBSW:SPMI:RST

Presets the state of the selected frames and error types for the software trigger.

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 705

TRIGger:SBSW:SPMI:FRENable <Frame>,<Enabler>
TRIGger:SBSW:SPMI:FRENable? <Enabler>
TRIGger:SBSW:SPMI:FRAMe<fr>:ENABle <Enable>

Enables or disables the checking condition for the selected frame for the software trigger.

Suffix:
<fr> Index of the frame

Parameters:
<Enable> OFF | ON
*RST: ON

Usage: Asynchronous command

Manual operation: See "Frame type" on page 706

TRIGger:SBSW:SPMI:BIT <Frame>,<Field>,<Bit>
TRIGger:SBSW:SPMI:BIT? <Bit>
TRIGger:SBSW:SPMI:FRAMe<fr>:FLD<fl>:BIT <BitState>

Sets the bit state of a field that only consists of one bit for the software trigger.

Suffix:
<fr> Index of the frame

<fl> Index of the field

Parameters:
<BitState> ONE | ZERO
*RST: ZERO

Usage: Asynchronous command

Manual operation: See "Edit" on page 706

TRIGger:SBSW:SPMI:DMAX <Frame>,<Field>,<Data>
TRIGger:SBSW:SPMI:DMAX? <Data>
TRIGger:SBSW:SPMI:FRAMe<fr>:FLD<fl>:DMAX <Data_Max>

Sets the end value of a data pattern range for the software trigger, if the operator is set to `INRange` or `OORANGe`.

You can set the operator with `TRIGger:SBSW:SPMI:FRAMe<fr>:FLD<fl>:DOPerator`.

Suffix:

<fr> Index of the frame

<fl> Index of the field

Parameters:

<Data_Max>

Usage: Asynchronous command

Manual operation: See "Edit" on page 706

TRIGger:SBSW:SPMI:DMIN <Frame>,<Field>,<Data>
TRIGger:SBSW:SPMI:DMIN? <Data>
TRIGger:SBSW:SPMI:FRAMe<fr>:FLD<fl>:DMIN <Data_Min>

Specifies the data pattern, or sets the start value of a data pattern range for the software trigger.

Suffix:

<fr> Index of the frame

<fl> Index of the field

Parameters:

<Data_Min>

Usage: Asynchronous command

Manual operation: See "Edit" on page 706

TRIGger:SBSW:SPMI:DOPerator <Frame>,<Field>,<Operator>
TRIGger:SBSW:SPMI:DOPerator? <Operator>
TRIGger:SBSW:SPMI:FRAMe<fr>:FLD<fl>:DOPerator <Data_Operator>

Sets the operator for the data pattern of the software trigger in the selected field of the selected frame.

Suffix:

<fr> Index of the frame

<fl> Index of the field

Parameters:

<Data_Operator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

*RST: EQUal

Usage: Asynchronous command

Manual operation: See "Edit" on page 706

TRIGger:SBSW:SPMI:FIENable <Frame>,<Field>,<Enabler>
TRIGger:SBSW:SPMI:FIENable? <Enabler>
TRIGger:SBSW:SPMI:FRAMe<fr>:FLD<fl>:ENABle <CondEnabler>

Enables or disables the checking condition for the selected field of the selected frame of the software trigger.

Suffix:

<fr> Index of the frame

<fl> Index of the field

Parameters:

<CondEnabler> OFF | ON

*RST: OFF

Usage: Asynchronous command

Manual operation: See "Edit" on page 706

TRIGger:SBSW:SPMI:IMAX <Frame>,<Field>,<Data>
TRIGger:SBSW:SPMI:IMAX? <Data>
TRIGger:SBSW:SPMI:FRAMe<fr>:FLD<fl>:IMAX <Index_Max>

Sets the end value of an index range for the software trigger if the operator is set to `INRange`.

You can set the operator with `TRIGger:SBSW:SPMI:FRAMe<fr>:FLD<fl>:IOPerator`.

Suffix:

<fr> Index of the frame

<fl> Index of the field

Parameters:

<Index_Max> Range: 1 to 65535
Increment: 1
*RST: 65535

Usage: Asynchronous command

Manual operation: See "Edit" on page 706

TRIGger:SBSW:SPMI:IMIN <Frame>,<Field>,<Data>
TRIGger:SBSW:SPMI:IMIN? <Data>
TRIGger:SBSW:SPMI:FRAMe<fr>:FLD<fl>:IMIN <Index_Min>

Specifies the index, or sets the start value of an index range for the software trigger.

Suffix:

<fr> Index of the frame

<fl> Index of the field

Parameters:

<Index_Min> Range: 1 to 65535
Increment: 1
*RST: 1

Usage: Asynchronous command

Manual operation: See "Edit" on page 706

TRIGger:SBSW:SPMI:IOPerator <Frame>,<Field>,<Operator>
TRIGger:SBSW:SPMI:IOPerator? <Operator>
TRIGger:SBSW:SPMI:FRAMe<fr>:FLD<fl>:IOPerator <Index_Operator>

Sets the operator for the index in the selected field of the selected frame for the software trigger.

Suffix:

<fr> Index of the frame

<fl> Index of the field

Parameters:

<Index_Operator> EQUal | INRange | RANGe
*RST: INRange

Usage: Asynchronous command

Manual operation: See "Edit" on page 706

TRIGger:SBSW:SPMI:ERENable <ErrorName>,<Enabler>
TRIGger:SBSW:SPMI:ERENable? <Enabler>
TRIGger:SBSW:SPMI:ERRor<m>:ENABle <Enable>

Defines the error type for the software trigger.

Suffix:

<m> Index of the error

Parameters:

<Enable> OFF | ON
*RST: ON

Usage: Asynchronous command

Manual operation: See "Error type" on page 707

SBUS<sb>:SPMI:SWTindex?

Queries the software trigger index.

If no software trigger event has occurred, the command returns `Invalid`.

Suffix:

<sb>	1...4, index of the serial bus

Return values:

<Index>	Range: 0 to 4294967295 Increment: 1 *RST: 0

Usage: Query only
Asynchronous command

SBUS<sb>:SPMI:SWTTime?

Queries the software trigger time in seconds.

If no software trigger event has occured, the command returns `Invalid`.

Suffix:

<sb>	1...4, index of the serial bus

Return values:

<Time>	Range: -1E+26 to 1E+26 Increment: 1E-10 *RST: 0 Default unit: s

Usage: Query only
Asynchronous command

18.17.16.4 Decode results

SBUS<sb>:SPMI:FCOunt?

Returns the number of decoded frames in the acquisition.

Suffix:

<sb> 1...4, index of the serial bus

Return values:

<Count>

Usage: Query only
Asynchronous command

SBUS<sb>:SPMI:FRAMe<fr>:ADDRess?

Returns the address of the specified frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:

<FrameADDR> Range: 0 to 65535
Increment: 1
*RST: 0

Usage: Query only
Asynchronous command

SBUS<sb>:SPMI:FRAMe<fr>:BC?

Returns the BC of the specified frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:

<FrameBC> Range: 0 to 65535
Increment: 1
*RST: 0

Usage: Query only
Asynchronous command

SBUS<sb>:SPMI:FRAMe<fr>:DATA?

Returns the data value of the specified frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:

<FrameData>

Usage: Query only

SBUS<sb>:SPMI:FRAMe<fr>:FLDCount?

Returns the field count of the specified frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:

<Count>

Usage: Query only
Asynchronous command

SBUS<sb>:SPMI:FRAMe<fr>:FLD<fl>:FVALue?

Returns the formatted value of the specified byte.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Return values:

<FormattedValue>

Usage: Query only
Asynchronous command

SBUS<sb>:SPMI:FRAMe<fr>:FLD<fl>:LABel?

Returns the label of the fields in the specified frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Return values:

<Label>

Usage:	Query only Asynchronous command

SBUS<sb>:SPMI:FRAMe<fr>:FLD<fl>:STATe?

Returns the overall state of the frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Return values:

<State>	OK | NOReponse | ACKerror | BPERror | PARerror | LENerror | ARBerror | SSCerror | CMDerror | CODerror | INComplete *RST: OK
Usage:	Query only Asynchronous command

SBUS<sb>:SPMI:FRAMe<fr>:FLD<fl>:VALue?

Returns the data value of the specified field.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Return values:

<Value>	Increment: 1 *RST: 0
Usage:	Query only Asynchronous command

SBUS<sb>:SPMI:FRAMe<fr>:RBRate?

Returns the read bit rate of the specified frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<FrameRBR>	Increment: 1 *RST: 0 Default unit: bps
Usage:	Query only

SBUS<sb>:SPMI:FRAMe<fr>:SA?

Returns the address of the specified frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<FrameSA>
Range: 0 to 65535
Increment: 1
*RST: 0

Usage: Query only
Asynchronous command

SBUS<sb>:SPMI:FRAMe<fr>:STARt?

Returns the start time of the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<FrameStart>
Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0
Default unit: s

Usage: Query only
Asynchronous command

SBUS<sb>:SPMI:FRAMe<fr>:STATus?

Returns the overall state of the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<FrameState>
OK | NOReponse | ACKerror | BPERror | PARerror | LENerror | ARBerror | SSCerror | CMDerror | CODerror | INComplete
*RST: OK

Usage: Query only
Asynchronous command

SBUS<sb>:SPMI:FRAMe<fr>:STOP?

Returns the stop time of the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<FrameStop>
Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0
Default unit: s

Usage: Query only
Asynchronous command

SBUS<sb>:SPMI:FRAMe<fr>:TYPE?

Returns the frame type.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<FrameType>
RZWR | RWR | RRD | ERWR | ERRD | ERWL | ERRL | MAWR | MARD | BMRD | BSRD | TBOW | REST | SLEP | SHUT | WAK | AUTH | INV | UNKN | ARB

RZWR: register 0 write
RWR: register write
RRD: register read
ERWR: extended register write
ERRD: extended register read
ERWL: extended register write long
ERRL: extended register read long
MAWR: main write
MARD: main read
BMRD: device descriptor block main read
BSRD: device descriptor block sub read
TBOW: transfer bus ownership
REST: reset
SLEP: sleep
SHUT: shutdown
WAK: wakeup
AUTH: authenticate
INV: invalid
UNKN: unknown
ARB: arbitration frame

*RST: RZWR

Usage: Query only
Asynchronous command

SBUS<sb>:SPMI:FRAMe<fr>:WBRate?

Returns the write bit rate of the specified frame.

Suffix:
<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:
<FrameWBR> Increment: 1
*RST: 0
Default unit: bps

Usage: Query only

SBUS<sb>:SPMI:FRAMe<fr>:SYMBol?

Returns the symbolic label of the specified frame if the label list is enabled.

Suffix:
<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:
<SymbolicName> String with symbolic name of the address
String with the symbolic name of the frame

Usage: Query only
Asynchronous command

18.17.17 RFFE (option R&S MXO4-K550)

Before MXO 4 can accept the specific bus commands, make sure that:

- The decoding of the specified bus is enabled with `SBUS<sb>[:STATe]`.
- The bus is set to the correct type with `SBUS<sb>:TYPE`.

18.17.17.1 Configuration

SBUS<sb>:RFFE:CLOCk:HYSTeresis <Hysteresis>

Sets a hysteresis for the clock line.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<Hysteresis>

Usage: Asynchronous command

Manual operation: See "Threshold" on page 716

SBUS<sb>:RFFE:CLOCk:SOURce <ClockSource>

Sets the source of the clock line.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<ClockSource> C1 | C2 | C3 | C4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | M1 | M2 | M3 | M4 | M5 | R1 | R2 | R3 | R4 | O<n>C1 | O<n>C2 | ... | O<n>C8 (<n> = 2 to 8)

Usage: Asynchronous command

Manual operation: See "SCLK" on page 715

SBUS<sb>:RFFE:CLOCk:THReshold <Threshold>

Sets a threshold value for the clock line.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<Threshold>

Usage: Asynchronous command

Manual operation: See "Threshold" on page 716

SBUS<sb>:RFFE:DATA:HYSTeresis <DATA Hyst>

Sets a hysteresis for the data.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<DATA Hyst>

Usage: Asynchronous command

Manual operation: See "Threshold" on page 716

SBUS<sb>:RFFE:DATA:SOURce DataSource

Sets the source of the data line.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
DataSource C1 | C2 | C3 | C4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | M1 | M2 | M3 | M4 | M5 | R1 | R2 | R3 | R4 | O<n>C1 | O<n>C2 | ... | O<n>C8 (<n> = 2 to 8)

Usage: Asynchronous command

Manual operation: See "SDATA" on page 715

SBUS<sb>:RFFE:DATA:THReshold <DATA Threshold>

Sets a threshold value for the data line.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<DATA Threshold>

Usage: Asynchronous command

Manual operation: See "Threshold" on page 716

SBUS<sb>:RFFE:GFILter <GlitchFilter>

Enables the glitch filter on the SCLK and SDATA lines to improve decode accuracy.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<GlitchFilter> OFF | ON
*RST: OFF

Usage: Asynchronous command

Manual operation: See "Use glitch filter, Glitch filter width" on page 716

SBUS<sb>:RFFE:GFWidth <GlitchFilterWdt>

Sets the maximum glitch width to be ignored.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<GlitchFilterWdt> Range: 1E-11 to 1E-08
Increment: 1E-11
*RST: 1E-09
Default unit: s

Usage: Asynchronous command

Manual operation: See "Use glitch filter, Glitch filter width" on page 716

SBUS<sb>:RFFE:POSition <RFFE position>

Sets the vertical position of the RFFE signal.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<RFFE position>

Usage: Asynchronous command

SBUS<sb>:RFFE:RDMD <ReadMode>

Selects, if the standard or synchronous read mode is used.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<ReadMode> STRD | SREAD

`STRD`: standard

`SREAD`: synchronous read

*RST: STRD

Usage: Asynchronous command

Manual operation: See "Read mode" on page 716

SBUS<sb>:RFFE:SCALe <RFFE scale>

Set the vertical scale of the indicated RFFE signal.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<RFFE scale>

Usage: Asynchronous command

18.17.17.2 Filter

There are two commands for each parameter, that you can use for defining the RFFE settings.

For example, to set the *Frame type =Register 0 Write* > *Field =Data >01100* value you can use one of the following commands:

- `SBUS:RFFE:FILTer:FRAMe1:FLD1:DMIN 01100`
  Defines the parameter by using the index <m> for the frame number and <n> for the field number.
- `SBUS:RFFE:FILTer:DMIN "Register 0 Write", "Data", 01100`
  Defines the parameter by using the frame and field name.

SBUS<sb>:RFFE:FILTer:CHKall

Enables the filter for all available frames and error types.

Suffix:
<sb> 1...4, index of the serial bus

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 717

SBUS<sb>:RFFE:FILTer:CLR

Disables the filter for all available frames and error types.

Suffix:
<sb> 1...4, index of the serial bus

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 717

SBUS<sb>:RFFE:FILTer:INVert

Inverts the current state of the frame and error types: all frames and error types that were enabled are disabled and vice versa.

Suffix:
<sb> 1...4, index of the serial bus

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 717

SBUS<sb>:RFFE:FILTer:RST

Presets the state of the selected frames and error types.

Suffix:
<sb> 1...4, index of the serial bus

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 717

SBUS<sb>:RFFE:FILTer:FRENable <Frame>,<Enabler>
SBUS<sb>:RFFE:FILTer:FRENable? <Enabler>
SBUS<sb>:RFFE:FILTer:FRAMe<fr>:ENABle <Enable>

Enables the filtering on RFFE frames. Only the frames that match the selected filter conditions are displayed.

Suffix:
<sb> 1...4, index of the serial bus

<fr> Index of the frame

Parameters:

<Enable> OFF | ON

*RST: ON

Usage: Asynchronous command

SBUS<sb>:RFFE:FILTer:BIT <Frame>,<Field>,<Bit>
SBUS<sb>:RFFE:FILTer:BIT? <Bit>
SBUS<sb>:RFFE:FILTer:FRAMe<fr>:FLD<fl>:BIT <BitState>

Sets the operator for the data pattern in the selected field of the selected frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Parameters:

<BitState> ONE | ZERO

*RST: ZERO

Usage: Asynchronous command

Manual operation: See "Edit" on page 718

SBUS<sb>:RFFE:FILTer:DMAX <Frame>,<Field>,<Data>
SBUS<sb>:RFFE:FILTer:DMAX? <Data>
SBUS<sb>:RFFE:FILTer:FRAMe<fr>:FLD<fl>:DMAX <Data_Max>

Sets the end value of a data pattern range if the operator is set to `INRange` or `OORANGe`.

You can set the operator with `SBUS<sb>:RFFE:FILTer:FRAMe<fr>:FLD<fl>:DOPerator`.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Parameters:

<Data_Max>

Usage: Asynchronous command

Manual operation: See "Edit" on page 718

SBUS<sb>:RFFE:FILTer:DMIN <Frame>,<Field>,<Data>
SBUS<sb>:RFFE:FILTer:DMIN? <Data>
SBUS<sb>:RFFE:FILTer:FRAMe<fr>:FLD<fl>:DMIN <Data_Min>

Specifies the data pattern, or sets the start value of a data pattern range.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:
<Data_Min>

Usage: Asynchronous command

Manual operation: See "Edit" on page 718

SBUS<sb>:RFFE:FILTer:DOPerator <Frame>,<Field>,<Operator>
SBUS<sb>:RFFE:FILTer:DOPerator? <Operator>
SBUS<sb>:RFFE:FILTer:FRAMe<fr>:FLD<fl>:DOPerator <Data_Operator>

Sets the operator for the data pattern in the selected field of the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Data_Operator>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange *RST: EQUal

Usage: Asynchronous command

Manual operation: See "Edit" on page 718

SBUS<sb>:RFFE:FILTer:FIENable <Frame>,<Field>,<Enabler>
SBUS<sb>:RFFE:FILTer:FIENable? <Enabler>
SBUS<sb>:RFFE:FILTer:FRAMe<fr>:FLD<fl>:ENABle <CondEnabler>

Enables or disables the checking condition for the selected field of the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<CondEnabler>	OFF | ON *RST: OFF

Usage: Asynchronous command

Manual operation: See "Enable" on page 718

SBUS<sb>:RFFE:FILTer:IMAX <Frame>,<Field>,<Data>
SBUS<sb>:RFFE:FILTer:IMAX? <Data>
SBUS<sb>:RFFE:FILTer:FRAMe<fr>:FLD<fl>:IMAX <Index_Max>

Sets the end value of an index range if the operator is set to `INRange`.

You can set the operator with `SBUS<sb>:RFFE:FILTer:FRAMe<fr>:FLD<fl>:IOPerator`.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Index_Max>	Range: 1 to 65535 Increment: 1 *RST: 65535

Usage: Asynchronous command

Manual operation: See "Edit" on page 718

SBUS<sb>:RFFE:FILTer:IMIN <Frame>,<Field>,<Data>
SBUS<sb>:RFFE:FILTer:IMIN? <Data>
SBUS<sb>:RFFE:FILTer:FRAMe<fr>:FLD<fl>:IMIN <Index_Min>

Specifies the index, or sets the start value of an index range.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Index_Min>	Range: 1 to 65535 Increment: 1 *RST: 1

Usage: Asynchronous command

Manual operation: See "Edit" on page 718

SBUS<sb>:RFFE:FILTer:IOPerator <Frame>,<Field>,<Operator>
SBUS<sb>:RFFE:FILTer:IOPerator? <Operator>
SBUS<sb>:RFFE:FILTer:FRAMe<fr>:FLD<fl>:IOPerator <Index_Operator>

Sets the operator for the index in the selected field of the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Index_Operator>	EQUal | INRange | RANGe *RST: INRange
Usage:	Asynchronous command
Manual operation:	See "Edit" on page 718

SBUS<sb>:RFFE:FILTer:ERENable <ErrorName>,<Enabler>
SBUS<sb>:RFFE:FILTer:ERENable? <Enabler>
SBUS<sb>:RFFE:FILTer:ERRor<n>:ENABle <Enable>

Defines the error type to be filtered on.

Suffix:

<sb>	1...4, index of the serial bus
<n>	Index of the error

Parameters:

<Enable>	OFF | ON *RST: ON
Usage:	Asynchronous command
Manual operation:	See "Error type" on page 720

18.17.17.3 Software trigger

There are two commands for each parameter, that you can use for defining the RFFE settings.

For example, to set the *Frame type =Register 0 Write > Field =Data >01100* value you can use one of the following commands:

- `TRIGger:SBSW:RFFE:FRAMe1:FLD1:DMIN 01100`
  Defines the parameter by using the index <m> for the frame number and <n> for the field number.
- `TRIGger:SBSW:RFFE:DMIN "Register 0 Write", "Data", 01100`
  Defines the parameter by using the frame and field name.

TRIGger:SBSW:RFFE:CHKall

Enables the software trigger for all available frames and error types.

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 722

TRIGger:SBSW:RFFE:CLR

Disables the software trigger for all available frames and error types.

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 722

TRIGger:SBSW:RFFE:INVert

Inverts the current state of the frame and error types for the software trigger: all frames and error types that were enabled are disabled and vice versa.

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 722

TRIGger:SBSW:RFFE:RST

Presets the state of the selected frames and error types for the software trigger.

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 722

TRIGger:SBSW:RFFE:FRENable <Frame>,<Enabler>
TRIGger:SBSW:RFFE:FRENable? <Enabler>
TRIGger:SBSW:RFFE:FRAMe<fr>:ENABle <Enable>

Enables or disables the checking condition for the selected frame for the software trigger.

Suffix:
<fr> Index of the frame

Parameters:
<Enable> OFF | ON
*RST: ON

Usage: Asynchronous command

Manual operation: See "Frame type" on page 723

TRIGger:SBSW:RFFE:BIT <Frame>,<Field>,<Bit>
TRIGger:SBSW:RFFE:BIT? <Bit>
TRIGger:SBSW:RFFE:FRAMe<fr>:FLD<fl>:BIT <BitState>

Sets the bit state of a field that only consists of one bit for the software trigger.

Suffix:
<fr> Index of the frame

<fl> Index of the field

Parameters:
<BitState> ONE | ZERO
*RST: ZERO

Usage: Asynchronous command

Manual operation: See "Edit" on page 723

TRIGger:SBSW:RFFE:DMAX <Frame>,<Field>,<Data>
TRIGger:SBSW:RFFE:DMAX? <Data>
TRIGger:SBSW:RFFE:FRAMe<fr>:FLD<fl>:DMAX <Data_Max>

Sets the end value of a data pattern range for the software trigger, if the operator is set to `INRange` or `OORANGe`.

You can set the operator with `TRIGger:SBSW:RFFE:FRAMe<fr>:FLD<fl>:DOPerator`.

Suffix:

<fr>	Index of the frame
<fl>	Index of the field

Parameters:
<Data_Max>

Usage: Asynchronous command

Manual operation: See "Edit" on page 723

TRIGger:SBSW:RFFE:DMIN <Frame>,<Field>,<Data>
TRIGger:SBSW:RFFE:DMIN? <Data>
TRIGger:SBSW:RFFE:FRAMe<fr>:FLD<fl>:DMIN <Data_Min>

Specifies the data pattern, or sets the start value of a data pattern range for the software trigger.

Suffix:

<fr>	Index of the frame
<fl>	Index of the field

Parameters:
<Data_Min>

Usage: Asynchronous command

Manual operation: See "Edit" on page 723

TRIGger:SBSW:RFFE:DOPerator <Frame>,<Field>,<Operator>
TRIGger:SBSW:RFFE:DOPerator? <Operator>
TRIGger:SBSW:RFFE:FRAMe<fr>:FLD<fl>:DOPerator <Data_Operator>

Sets the operator for the data pattern of the software trigger in the selected field of the selected frame.

Suffix:

<fr>	Index of the frame
<fl>	Index of the field

Parameters:
<Data_Operator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange
*RST: EQUal

Usage: Asynchronous command

Manual operation: See "Edit" on page 723

TRIGger:SBSW:RFFE:FIENable <Frame>,<Field>,<Enabler>
TRIGger:SBSW:RFFE:FIENable? <Enabler>
TRIGger:SBSW:RFFE:FRAMe<fr>:FLD<fl>:ENABle <CondEnabler>

Enables or disables the checking condition for the selected field of the selected frame of the software trigger.

Suffix:
<fr> Index of the frame

<fl> Index of the field

Parameters:
<CondEnabler> OFF | ON
*RST: OFF

Usage: Asynchronous command

Manual operation: See "Edit" on page 723

TRIGger:SBSW:RFFE:IMAX <Frame>,<Field>,<Data>
TRIGger:SBSW:RFFE:IMAX? <Data>
TRIGger:SBSW:RFFE:FRAMe<fr>:FLD<fl>:IMAX <Index_Max>

Sets the end value of an index range for the software trigger if the operator is set to `INRange`.

You can set the operator with `TRIGger:SBSW:RFFE:FRAMe<fr>:FLD<fl>:IOPerator`.

Suffix:
<fr> Index of the frame

<fl> Index of the field

Parameters:
<Index_Max> Range: 1 to 65535
Increment: 1
*RST: 65535

Usage: Asynchronous command

Manual operation: See "Edit" on page 723

TRIGger:SBSW:RFFE:IMIN <Frame>,<Field>,<Data>
TRIGger:SBSW:RFFE:IMIN? <Data>
TRIGger:SBSW:RFFE:FRAMe<fr>:FLD<fl>:IMIN <Index_Min>

Specifies the index, or sets the start value of an index range for the software trigger.

Suffix:

<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Index_Min>	Range: 1 to 65535 Increment: 1 *RST: 1

Usage: Asynchronous command

Manual operation: See "Edit" on page 723

TRIGger:SBSW:RFFE:IOPerator <Frame>,<Field>,<Operator>
TRIGger:SBSW:RFFE:IOPerator? <Operator>
TRIGger:SBSW:RFFE:FRAMe<fr>:FLD<fl>:IOPerator <Index_Operator>

Sets the operator for the index in the selected field of the selected frame for the software trigger.

Suffix:

<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Index_Operator>	EQUal | INRange | RANGe *RST: INRange

Usage: Asynchronous command

Manual operation: See "Edit" on page 723

TRIGger:SBSW:RFFE:ERENable <ErrorName>,<Enabler>
TRIGger:SBSW:RFFE:ERENable? <Enabler>
TRIGger:SBSW:RFFE:ERRor<m>:ENABle <Enable>

Defines the error type for the software trigger.

Suffix:

<m>	Index of the error

Parameters:

<Enable>	OFF | ON *RST: ON

Usage: Asynchronous command

Manual operation: See "Error type" on page 724

SBUS<sb>:RFFE:SWTindex?

Queries the software trigger index.

If no software trigger event has occurred, the command returns `Invalid`.

Suffix:

<sb>	1...4, index of the serial bus

Return values:

<Index>	Range: 0 to 4294967295 Increment: 1 *RST: 0

Usage: Query only
Asynchronous command

SBUS<sb>:RFFE:SWTTime?

Queries the software trigger time in seconds.

If no software trigger event has occured, the command returns `Invalid`.

Suffix:

<sb>	1...4, index of the serial bus

Return values:

<Time>	Range: -1E+26 to 1E+26 Increment: 1E-10 *RST: 0 Default unit: s

Usage: Query only
Asynchronous command

18.17.17.4 Decode results

SBUS<sb>:RFFE:FRAMe<fr>:PADone?

Returns the parity address one of the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<ParityAddr1>	OK | NORESPONSE | BPERR | PARity | LENGth | VERSion | SSC | GAP | INComplete *RST: OK

Usage: Query only
Asynchronous command

SBUS<sb>:RFFE:FRAMe<fr>:PADZero?

Returns the parity address zero of the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<ParityAddr0>	OK | NORESPONSE | BPERR | PARity | LENGth | VERSion | SSC | GAP | INComplete *RST: OK

Usage: Query only
Asynchronous command

SBUS<sb>:RFFE:FRAMe<fr>:PCTRl?

Returns the parity control of the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<ParityCtrl>	OK | NORESPONSE | BPERR | PARity | LENGth | VERSion | SSC | GAP | INComplete *RST: OK

Usage:	Query only Asynchronous command

SBUS<sb>:RFFE:FCOunt?

Returns the number of decoded frames in the current acquisition.

Suffix:

<sb>	1...4, index of the serial bus

Return values:

<Count>

Usage:	Query only Asynchronous command

SBUS<sb>:RFFE:FRAMe<fr>:ADDRess?

Returns the register address of the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<Address>	Range: 0 to 65535 Increment: 1 *RST: 0
Usage:	Query only Asynchronous command

SBUS<sb>:RFFE:FRAMe<fr>:BCOunt?

Returns the byte count of the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<BC>	Range: 0 to 256 Increment: 1 *RST: 0
Usage:	Query only Asynchronous command

SBUS<sb>:RFFE:FRAMe<fr>:DATA?

Returns the data value of the specified frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:

<Data>

Usage: Query only

SBUS<sb>:RFFE:FRAMe<fr>:FLDCount?

Returns the field count of the specified frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:

<Count>

Usage: Query only
Asynchronous command

SBUS<sb>:RFFE:FRAMe<fr>:FLD<fl>:FVALue?

Returns the formatted value of the specified field in the specified frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Return values:

<FormattedValue>

Usage: Query only
Asynchronous command

SBUS<sb>:RFFE:FRAMe<fr>:FLD<fl>:NAME?

Returns the name (label) of the specified field in the specified frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Return values:

<Label>

Usage: Query only
Asynchronous command

SBUS<sb>:RFFE:FRAMe<fr>:FLD<fl>:STATe?

Returns the overall state of the specified field in the specified frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Return values:

<State> OK | NORESPONSE | BPERR | PARity | LENGth | VERSion | SSC | GAP | INComplete

*RST: OK

Usage: Query only
Asynchronous command

SBUS<sb>:RFFE:FRAMe<fr>:FLD<fl>:VALue?

Returns the data value of the specified field in the specified frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Return values:

<Value> Increment: 1
*RST: 0

Usage: Query only
Asynchronous command

SBUS<sb>:RFFE:FRAMe<fr>:RBTRate?

Returns the read bit rate of the specified frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:

<ReadBitRate> Increment: 1
*RST: 0
Default unit: bps

Usage: Query only

SBUS<sb>:RFFE:FRAMe<fr>:SADD?

Returns the address of the specified frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:

<SA> Range: 0 to 15
Increment: 1
*RST: 0

Usage: Query only
Asynchronous command

SBUS<sb>:RFFE:FRAMe<fr>:STARt?

Returns the start time of the selected frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:

<Start> Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0
Default unit: s

Usage: Query only
Asynchronous command

SBUS<sb>:RFFE:FRAMe<fr>:STATe?

Returns the overall state of the selected frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:

<State> OK | NORESPONSE | BPERR | PARity | LENGth | VERSion | SSC | GAP | INComplete

*RST: OK

Usage: Query only
Asynchronous command

SBUS<sb>:RFFE:FRAMe<fr>:STOP?

Returns the stop time of the selected frame.

Suffix:

<sb> — 1...4, index of the serial bus

<fr> — Index of the frame

Return values:

<Stop>
Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0
Default unit: s

Usage: Query only
Asynchronous command

SBUS<sb>:RFFE:FRAMe<fr>:TYPE?

Returns the type of the selected frame.

Suffix:

<sb> — 1...4, index of the serial bus

<fr> — Index of the frame

Return values:

<Type> — RZWR | RWR | ERWR | ERWL | MWR | MSKW | MCTW | RRD | ERRD | ERRL | MRD | MCTR | MOHO | IRSUM | UNDEF | UNKN | ERRor

RZWR
Register 0 write

RWR
Register write

RRD
Register read

ERWR
Extended register write

ERRD
Extended register read

ERWL
Extended register write long

ERRL
Extended register read long

MRD
Main device read

MWR
Main device write

MOHO
Main device Ownership Handove

IRSUM
Interrupt summary and notification

MSKW
Masked write

MCTR
Main device context transfer read

MCTW
Main device context transfer write

UNDEF
Undefined frame type

UNKN
Unknown frame type

ERRor
The bits defining the command sequence are not valid, no supported command sequence

*RST: RZWR

Usage: Query only
Asynchronous command

SBUS<sb>:RFFE:FRAMe<fr>:WBTRate?

Returns the write bit rate of the specified frame.

Suffix:
<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:
<PrimaryBitRate> Increment: 1
*RST: 0
Default unit: bps

Usage: Query only

SBUS<sb>:RFFE:NEWList <FileName>

Loads a symbol list file.

Suffix:
<sb> 1...4, index of the serial bus

Setting parameters:
<FileName>

Usage: Setting only
Asynchronous command

SBUS<sb>:RFFE:FRAMe<fr>:SYMBol?

Returns the symbolic label of the specified sequence if the label list is enabled.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<SymbolicName>	String with symbolic name of the frame

Usage: Query only
Asynchronous command

SBUS<sb>:RFFE:SYMBols <ShowSymbols>

Activates the symbol list to be used for decoding.

Suffix:

<sb>	1...4, index of the serial bus

Parameters:

<ShowSymbols>	OFF | ON *RST: OFF

Usage: Asynchronous command

18.17.18 10BASE-T1S (option R&S MXO4-K560)

Before MXO 4 can accept the specific bus commands, make sure that:

- The decoding of the specified bus is enabled with `SBUS<sb>[:STATe]`.
- The bus is set to the correct type with `SBUS<sb>:TYPE`.

18.17.18.1 Configuration

SBUS<sb>:TNOS:POSition <TENBTO position>

Sets the vertical position of the 10BASE-T1S signal.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<TENBTO position>

Usage: Asynchronous command

SBUS<sb>:TNOS:SCALe <TENBTO scale>

Set the vertical scale of the indicated 10BASE-T1S signal.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<TENBTO scale>

Usage: Asynchronous command

SBUS<sb>:TNOS:SOURce <Source>

Selects the source channel for the 10BASE-T1S protocol. Only analog channels can be used.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<Source> C1 | C2 | C3 | C4 | M1 | M2 | M3 | M4 | M5 | R1 | R2 | R3 | R4 | O<n>C1 | O<n>C2 | ... | O<n>C8 (<n> = 2 to 8)

Usage: Asynchronous command

Manual operation: See "Source" on page 731

SBUS<sb>:TNOS:SYMBols <ShowSymbols>

Activates the symbol list to be used for decoding.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<ShowSymbols> OFF | ON
*RST: OFF

Usage: Asynchronous command

SBUS<sb>:TNOS:THReshold:LOWer <Lower Thres>

Sets a lower threshold.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<Lower Thres>

Usage: Asynchronous command

Manual operation: See "Threshold" on page 731

SBUS<sb>:TNOS:THReshold:HYSTeresis <Hysteresis>

Sets a value for the hysteresis.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<Hysteresis>

Usage: Asynchronous command

Manual operation: See "Threshold" on page 731

SBUS<sb>:TNOS:THReshold:UPPer <Upper Thres>

Sets an upper threshold.

Suffix:
<sb> 1...4, index of the serial bus

Parameters:
<Upper Thres>

Usage: Asynchronous command

Manual operation: See "Threshold" on page 731

SBUS<sb>:TNOS:NEWList <FileName>

Loads a symbol list file.

Suffix:
<sb> 1...4, index of the serial bus

Setting parameters:
<FileName> String parameter with path and file name.

Example:
```
SBUS1:TNOS:NEWList
'/home/storage/userData/Protocol/TNOS.csv'
SBUS1:TNOS:SYMBols ON
```

Usage: Setting only
Asynchronous command

18.17.18.2 Filter

There are two commands for each parameter, that you can use for defining the 10BASE-T1S settings.

For example, to set the *Frame type =MAC > Field =Data >00* value you can use one of the following commands:

- `SBUS:TNOS:FILTer:FRAMe1:FLD1:DMIN 00`
  Defines the parameter by using the index <m> for the frame number and <n> for the field number.
- `SBUS:TNOS:FILTer:DMIN "MAC", "Data", 00`
  Defines the parameter by using the frame and field name.

SBUS<sb>:TNOS:FILTer:CHKall

Enables the filter for all available frames and error types.

Suffix:
<sb> 1...4, index of the serial bus

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 735

SBUS<sb>:TNOS:FILTer:CLR

Disables the filter for all available frames and error types.

Suffix:
<sb> 1...4, index of the serial bus

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 735

SBUS<sb>:TNOS:FILTer:RST

Presets the state of the selected frames and error types.

Suffix:
<sb> 1...4, index of the serial bus

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 735

SBUS<sb>:TNOS:FILTer:INVert

Inverts the current state of the frame and error types: all frames and error types that were enabled are disabled and vice versa.

Suffix:
<sb> 1...4, index of the serial bus

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 735

SBUS<sb>:TNOS:FILTer:BIT <Frame>,<Field>,<Bit>
SBUS<sb>:TNOS:FILTer:BIT? <Bit>
SBUS<sb>:TNOS:FILTer:FRAMe<fr>:FLD<fl>:BIT <BitState>

Sets the operator for the data pattern in the selected field of the selected frame.

Suffix:
<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Parameters:

<BitState> ONE | ZERO

*RST: ZERO

Usage: Asynchronous command

Manual operation: See "Edit" on page 735

SBUS<sb>:TNOS:FILTer:DMAX <Frame>,<Field>,<Data>
SBUS<sb>:TNOS:FILTer:DMAX? <Data>
SBUS<sb>:TNOS:FILTer:FRAMe<fr>:FLD<fl>:DMAX <Data_Max>

Sets the end value of a data pattern range if the operator is set to `INRange` or `OORANGe`.

You can set the operator with `SBUS<sb>:TNOS:FILTer:FRAMe<fr>:FLD<fl>:DOPerator`.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Parameters:

<Data_Max>

Usage: Asynchronous command

Manual operation: See "Edit" on page 735

SBUS<sb>:TNOS:FILTer:DMIN <Frame>,<Field>,<Data>
SBUS<sb>:TNOS:FILTer:DMIN? <Data>
SBUS<sb>:TNOS:FILTer:FRAMe<fr>:FLD<fl>:DMIN <Data_Min>

Specifies the data pattern, or sets the start value of a data pattern range.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Parameters:

<Data_Min>

Usage: Asynchronous command

Manual operation: See "Edit" on page 735

SBUS<sb>:TNOS:FILTer:DOPerator <Frame>,<Field>,<Operator>
SBUS<sb>:TNOS:FILTer:DOPerator? <Operator>
SBUS<sb>:TNOS:FILTer:FRAMe<fr>:FLD<fl>:DOPerator <Data_Operator>

Sets the operator for the data pattern in the selected field of the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Data_Operator>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange *RST: EQUal

Usage: Asynchronous command

Manual operation: See "Edit" on page 735

SBUS<sb>:TNOS:FILTer:ERENable <ErrorName>,<Enabler>
SBUS<sb>:TNOS:FILTer:ERENable? <Enabler>
SBUS<sb>:TNOS:FILTer:ERRor<n>:ENABle <Enable>

rcset

Suffix:

<sb>	1..4
<n>	*

Parameters:

<Enable>	OFF | ON *RST: ON

Usage: Asynchronous command

Manual operation: See "Error type" on page 737

SBUS<sb>:TNOS:FILTer:FIENable <Frame>,<Field>,<Enabler>
SBUS<sb>:TNOS:FILTer:FIENable? <Enabler>
SBUS<sb>:TNOS:FILTer:FRAMe<fr>:FLD<fl>:ENABle <CondEnabler>

Enables or disables the checking condition for the selected field of the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<CondEnabler> OFF | ON

*RST: OFF

Usage: Asynchronous command

Manual operation: See "Edit" on page 735

SBUS<sb>:TNOS:FILTer:IMAX <Frame>,<Field>,<Data>
SBUS<sb>:TNOS:FILTer:IMAX? <Data>
SBUS<sb>:TNOS:FILTer:FRAMe<fr>:FLD<fl>:IMAX <Index_Max>

Sets the end value of an index range if the operator is set to `INRange`.

You can set the operator with `SBUS<sb>:TNOS:FILTer:FRAMe<fr>:FLD<fl>:IOPerator`.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Parameters:

<Index_Max> Range: 1 to 65535
Increment: 1
*RST: 65535

Usage: Asynchronous command

Manual operation: See "Edit" on page 735

SBUS<sb>:TNOS:FILTer:IMIN <Frame>,<Field>,<Data>
SBUS<sb>:TNOS:FILTer:IMIN? <Data>
SBUS<sb>:TNOS:FILTer:FRAMe<fr>:FLD<fl>:IMIN <Index_Min>

Specifies the index, or sets the start value of an index range.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Parameters:

<Index_Min> Range: 1 to 65535
Increment: 1
*RST: 1

Usage: Asynchronous command

Manual operation: See "Edit" on page 735

SBUS<sb>:TNOS:FILTer:IOPerator <Frame>,<Field>,<Operator>
SBUS<sb>:TNOS:FILTer:IOPerator? <Operator>
SBUS<sb>:TNOS:FILTer:FRAMe<fr>:FLD<fl>:IOPerator <Index_Operator>

Sets the operator for the index in the selected field of the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Index_Operator>	EQUal | INRange | RANGe *RST: INRange

Usage: Asynchronous command

Manual operation: See "Edit" on page 735

SBUS<sb>:TNOS:FILTer:FRENable <Frame>,<Enabler>
SBUS<sb>:TNOS:FILTer:FRENable? <Enabler>
SBUS<sb>:TNOS:FILTer:FRAMe<fr>:ENABle <Enable>

Enables the filtering on 10Base-T1S frames. Only the frames that match the selected filter conditions are displayed.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Parameters:

<Enable>	OFF | ON *RST: ON

Usage: Asynchronous command

Manual operation: See "Frame type" on page 735

18.17.18.3 Software trigger

There are two commands for each parameter, that you can use for defining the 10BASE-T1S settings.

For example, to set the *Frame type =MAC > Field =Data >00* value you can use one of the following commands:

- `TRIGger:SBSW:TNOS:FRAMe1:FLD1:DMIN 00`
  Defines the parameter by using the index <m> for the frame number and <n> for the field number.
- `TRIGger:SBSW:TNOS:DMIN "MAC", "Data", 00`
  Defines the parameter by using the frame and field name.

TRIGger:SBSW:TNOS:CHKall

Enables the software trigger for all available frames and error types.

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 738

TRIGger:SBSW:TNOS:CLR

Disables the software trigger for all available frames and error types.

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 738

TRIGger:SBSW:TNOS:INVert

Inverts the current state of the frame and error types for the software trigger: all frames and error types that were enabled are disabled and vice versa.

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 738

TRIGger:SBSW:TNOS:RST

Presets the state of the selected frames and error types for the software trigger.

Usage: Setting only
Asynchronous command

Manual operation: See "Check all, Clear, Invert, Preset" on page 738

TRIGger:SBSW:TNOS:FRENable <Frame>,<Enabler>
TRIGger:SBSW:TNOS:FRENable? <Enabler>
TRIGger:SBSW:TNOS:FRAMe<fr>:ENABle <Enable>

Enables or disables the checking condition for the selected frame for the software trigger.

Suffix:

<fr> Index of the frame

Parameters:

<Enable> OFF | ON

*RST: ON

Usage: Asynchronous command

Manual operation: See "Frame type" on page 738

TRIGger:SBSW:TNOS:BIT <Frame>,<Field>,<Bit>
TRIGger:SBSW:TNOS:BIT? <Bit>
TRIGger:SBSW:TNOS:FRAMe<fr>:FLD<fl>:BIT <BitState>

Sets the bit state of a field that only consists of one bit for the software trigger.

Suffix:

<fr> Index of the frame

<fl> Index of the field

Parameters:

<BitState> ONE | ZERO

*RST: ZERO

Usage: Asynchronous command

Manual operation: See "Edit" on page 739

TRIGger:SBSW:TNOS:DMAX <Frame>,<Field>,<Data>
TRIGger:SBSW:TNOS:DMAX? <Data>
TRIGger:SBSW:TNOS:FRAMe<fr>:FLD<fl>:DMAX <Data_Max>

Sets the end value of a data pattern range for the software trigger, if the operator is set to `INRange` or `OORANGe`.

You can set the operator with `TRIGger:SBSW:TNOS:FRAMe<fr>:FLD<fl>:DOPerator` on page 1567.

Suffix:

<fr>	Index of the frame
<fl>	Index of the field

Parameters:
<Data_Max>

Usage: Asynchronous command

Manual operation: See "Edit" on page 739

TRIGger:SBSW:TNOS:DMIN <Frame>,<Field>,<Data>
TRIGger:SBSW:TNOS:DMIN? <Data>
TRIGger:SBSW:TNOS:FRAMe<fr>:FLD<fl>:DMIN <Data_Min>

Specifies the data pattern, or sets the start value of a data pattern range for the software trigger.

Suffix:

<fr>	Index of the frame
<fl>	Index of the field

Parameters:
<Data_Min>

Usage: Asynchronous command

Manual operation: See "Edit" on page 739

TRIGger:SBSW:TNOS:DOPerator <Frame>,<Field>,<Operator>
TRIGger:SBSW:TNOS:DOPerator? <Operator>
TRIGger:SBSW:TNOS:FRAMe<fr>:FLD<fl>:DOPerator <Data_Operator>

Sets the operator for the data pattern of the software trigger in the selected field of the selected frame.

Suffix:

<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Data_Operator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

*RST: EQUal

Usage: Asynchronous command

Manual operation: See "Edit" on page 739

TRIGger:SBSW:TNOS:FIENable <Frame>,<Field>,<Enabler>
TRIGger:SBSW:TNOS:FIENable? <Enabler>
TRIGger:SBSW:TNOS:FRAMe<fr>:FLD<fl>:ENABle <CondEnabler>

Enables or disables the checking condition for the selected field of the selected frame of the software trigger.

Suffix:

<fr> Index of the frame

<fl> Index of the field

Parameters:

<CondEnabler> OFF | ON

*RST: OFF

Usage: Asynchronous command

Manual operation: See "Edit" on page 739

TRIGger:SBSW:TNOS:IMAX <Frame>,<Field>,<Data>
TRIGger:SBSW:TNOS:IMAX? <Data>
TRIGger:SBSW:TNOS:FRAMe<fr>:FLD<fl>:IMAX <Index_Max>

Sets the end value of an index range for the software trigger if the operator is set to `INRange`.

You can set the operator with `TRIGger:SBSW:TNOS:FRAMe<fr>:FLD<fl>:IOPerator`.

Suffix:

<fr> Index of the frame

<fl> Index of the field

Parameters:

<Index_Max> Range: 1 to 65535
Increment: 1
*RST: 65535

Usage: Asynchronous command

Manual operation: See "Edit" on page 739

TRIGger:SBSW:TNOS:IMIN <Frame>,<Field>,<Data>
TRIGger:SBSW:TNOS:IMIN? <Data>
TRIGger:SBSW:TNOS:FRAMe<fr>:FLD<fl>:IMIN <Index_Min>

Specifies the index, or sets the start value of an index range for the software trigger.

Suffix:

<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Index_Min>	Range: 1 to 65535 Increment: 1 *RST: 1

Usage: Asynchronous command

Manual operation: See "Edit" on page 739

TRIGger:SBSW:TNOS:IOPerator <Frame>,<Field>,<Operator>
TRIGger:SBSW:TNOS:IOPerator? <Operator>
TRIGger:SBSW:TNOS:FRAMe<fr>:FLD<fl>:IOPerator <Index_Operator>

Sets the operator for the index in the selected field of the selected frame for the software trigger.

Suffix:

<fr>	Index of the frame
<fl>	Index of the field

Parameters:

<Index_Operator>	EQUal | INRange | RANGe *RST: INRange

Usage: Asynchronous command

Manual operation: See "Edit" on page 739

TRIGger:SBSW:TNOS:ERENable <ErrorName>,<Enabler>
TRIGger:SBSW:TNOS:ERENable? <Enabler>
TRIGger:SBSW:TNOS:ERRor<m>:ENABle <Enable>

Defines the error type for the software trigger.

Suffix:

<m>	Index of the error

Parameters:

<Enable>	OFF | ON *RST: ON

Usage: Asynchronous command

Manual operation: See "Error type" on page 740

SBUS<sb>:TNOS:SWTindex?

Queries the software trigger index.

If no software trigger event has occurred, the command returns `Invalid`.

Suffix:

<sb> 1...4, index of the serial bus

Return values:

<Index> Range: 0 to 4294967295
Increment: 1
*RST: 0

Usage: Query only
Asynchronous command

SBUS<sb>:TNOS:SWTTime?

Queries the software trigger time in seconds.

If no software trigger event has occured, the command returns `Invalid`.

Suffix:

<sb> 1...4, index of the serial bus

Return values:

<Time> Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0
Default unit: s

Usage: Query only
Asynchronous command

18.17.18.4 Decode results

SBUS<sb>:TNOS:FCOunt?

Returns the number of decoded frames.

Suffix:

<sb>	1...4, index of the serial bus

Return values:

<Count>	Total number of decoded frames.

Usage: Query only
Asynchronous command

SBUS<sb>:TNOS:FRAMe<fr>:FLDCount?

Returns the number of fields in the specified frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<Count>	Total number of fields.

Usage: Query only
Asynchronous command

SBUS<sb>:TNOS:FRAMe<fr>:BITRate?

Returns the primary bit rate.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<PrimaryBitRate>	Increment: 1 *RST: 0 Default unit: bps

Usage: Query only
Asynchronous command

SBUS<sb>:TNOS:FRAMe<fr>:FLD<fl>:FVALue?

Returns the formatted value of the specified field.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Return values:
<FormattedValue>

Usage: Query only
Asynchronous command

SBUS<sb>:TNOS:FRAMe<fr>:FLD<fl>:LABel?

Returns the label of the specified field.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Return values:
<Label>

Usage: Query only
Asynchronous command

SBUS<sb>:TNOS:FRAMe<fr>:FLD<fl>:STATe?

Returns the state of the specified field.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame
<fl>	Index of the field

Return values:

<State> OK | EPRMble | ESFD | EESD | ECRC | ELEN | INComplete

OK
The field has no error, it is valid.

EPRMble
Preamble error, the hex value of the preamble field is different from 0x55555555555555 (56 alternating 0's and 1's).

ESFD
SFD error, the hex value of the SFD field is different from 0xD5

EESD
ESD error, the value of the ESD field does not correspond to the symbol pair "ESD, ESDOK"

ECRC
CRC error, the value of the FCS field does not match the calculated CRC.

ELEN
Length error, the number of bits in the specified field is higher or lower than expected.

INComplete
The frame is incomplete

*RST: OK

Usage: Query only
Asynchronous command

SBUS<sb>:TNOS:FRAMe<fr>:FLD<fl>:VALue?

Returns the value of the specified field.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

<fl> Index of the field

Return values:

<Value> Increment: 1
*RST: 0

Usage: Query only
Asynchronous command

SBUS<sb>:TNOS:FRAMe<fr>:CRC?

Returns the CRC for the specified frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:

<CRC> Range: 0 to 4294967295
Increment: 1
*RST: 0

Usage: Query only
Asynchronous command

SBUS<sb>:TNOS:FRAMe<fr>:DATA?

Returns the data for the specified frame in comma-separated values.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<Count>

<Values>

Usage: Query only
Asynchronous command

SBUS<sb>:TNOS:FRAMe<fr>:DTADdress?

Returns the destination address for the specified frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<DestAddress> Increment: 1
*RST: 0

Usage: Query only
Asynchronous command

SBUS<sb>:TNOS:FRAMe<fr>:DTSYmbol?

Returns the destination symbol for the specified frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<DestSymbNme>

Usage: Query only
Asynchronous command

SBUS<sb>:TNOS:FRAMe<fr>:FCRC?

Returns the formatted CRC for the specified frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:
<FormattedCRC>

Usage: Query only
Asynchronous command

SBUS<sb>:TNOS:FRAMe<fr>:FDATa?

Returns the formatted data for the specified frame.

Suffix:
<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:
<FormattedData>

Usage: Query only
Asynchronous command

SBUS<sb>:TNOS:FRAMe<fr>:FDTaddress?

Returns the formatted destination address of the specified frame.

Suffix:
<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:
<FormattedDestAddr>

Usage: Query only
Asynchronous command

SBUS<sb>:TNOS:FRAMe<fr>:FSRaddress?

Returns the formatted SRC address for the specified frame.

Suffix:
<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:
<FormattedSrcAddr>

Usage: Query only
Asynchronous command

SBUS<sb>:TNOS:FRAMe<fr>:FTPLenth?

Returns the formatted type length for the specified frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:
<FormattedTypLenth>

Usage: Query only
Asynchronous command

SBUS<sb>:TNOS:FRAMe<fr>:SRADdress?

Returns the source address for the specified frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:
<SourceAddress> Increment: 1
*RST: 0

Usage: Query only
Asynchronous command

SBUS<sb>:TNOS:FRAMe<fr>:SRSYmbol?

Returns the frame of the source symbol.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:
<SrcSymbNme>

Usage: Query only
Asynchronous command

SBUS<sb>:TNOS:FRAMe<fr>:STARt?

Returns the start time of the selected frame.

Suffix:

<sb>	1...4, index of the serial bus
<fr>	Index of the frame

Return values:

<FrameStart>
Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0
Default unit: s

Usage:
Query only
Asynchronous command

SBUS<sb>:TNOS:FRAMe<fr>:STATus?

Returns the state of the frame.

Suffix:

<sb>
1...4, index of the serial bus

<fr>
Index of the frame

Return values:

<FrameState>
OK | EPRMble | ESFD | EESD | ECRC | ELEN | INComplete

OK
The frame has no error, it is valid.

EPRMble
Preamble error, the hex value of the preamble field is different from 0x55555555555555 (56 alternating 0's and 1's).

ESFD
SFD error, the hex value of the SFD field is different from 0xD5

EESD
ESD error, the value of the ESD field does not correspond to the symbol pair "ESD, ESDOK"

ECRC
CRC error, the value of the FCS field does not match the calculated CRC.

ELEN
Length error, the number of bits in the specified frame is higher or lower than expected.

INComplete
The frame is incomplete

*RST: OK

Usage:
Query only
Asynchronous command

SBUS<sb>:TNOS:FRAMe<fr>:STOP?

Returns the stop time of the selected frame.

Suffix:

<sb>
1...4, index of the serial bus

<fr> Index of the frame

Return values:

<FrameStop> Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0
Default unit: s

Usage: Query only
Asynchronous command

SBUS<sb>:TNOS:FRAMe<fr>:TPLenth?

Returns the type length for the specified frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:

<TypeLenth> Range: 0 to 65535
Increment: 1
*RST: 0

Usage: Query only
Asynchronous command

SBUS<sb>:TNOS:FRAMe<fr>:TYPE?

Returns the type of the frame.

Suffix:

<sb> 1...4, index of the serial bus

<fr> Index of the frame

Return values:

<FrameType> MAC | COMMit | BEACon | UNKN
*RST: MAC

Usage: Query only
Asynchronous command

18.18 Mixed signal option (option R&S MXO4-B1)

This section describes the remote commands of MSO option R&S MXO4-B1.

Some of the commands in the following section are asynchronous. An overlapping or asynchronous command does not automatically finish executing before the next command starts executing. If overlapping commands must be executed in a defined order, e.g. to avoid wrong measurement results, they must be serviced sequentially.

To prevent an overlapping execution of commands, one of the commands `*OPC`, `*OPC?` or `*WAI` can be used after the command or a command set.

For more information, see:

- www.rohde-schwarz.com/rc-via-scpi, section "Command sequence and synchronization"

18.18.1 Digital channels

Except for `DIGital<m>:PROBe<ch>[:ENABle]`, all other `DIGital:` commands affect only the settings of the first MSO bus (Logic1). The settings of all other logic groups (Logic 2, 3,4) remain unchanged.

DIGital<m>:PROBe<ch>[:ENABle]?

Enables one digital probe.

Suffix:

<m>	0 to 15, index of the logic channel Digital channels 0 to 7 belong to probe 1, and channels 8 to 15 belong to probe 2.
<ch>	1..2 Index of the logic probe (pod)

Return values:

<ProbeConnected>	OFF | ON

Usage:	Query only Asynchronous command

DIGital<m>:HYSTeresis <Hysteresis>

Sets the hysteresis for the indicated digital channel.

The setting affects only the settings of the first MSO bus (Logic1).

You can set the hysteresis for all buses with `PBUS<pb>:HYSTeresis<n>`.

Suffix:

<m>	0 to 15, index of the logic channel

Parameters:

<Hysteresis> MAXimum | ROBust | NORMal

MAXimum
Maximum value that is possible and useful for the signal and its settings, to be used for noisy signals.

ROBust
Different hysteresis values for falling and rising edges to avoid an undefined state of the trigger system, to be used for very noisy signals.

NORMal
Small value suitable for the signal and its settings, to be used for clean signals.

Usage: Asynchronous command

DIGital<m>:LABel <Label>

Sets a name for the indicated digital channel. The name is displayed in the diagram.

The setting affects only the settings of the first MSO bus (Logic1).

You can set the label for all buses with `PBUS<pb>:BIT<n>:LABel`

Suffix:

<m> 0 to 15, index of the logic channel

Parameters:

<Label> String containing the channel name

Usage: Asynchronous command

DIGital<m>:SIZE <Size>

Sets the vertical size for the channel group to which the indicated digital channel belongs.

Suffix:

<m> 0..15
Number of the digital channel.
Channel groups: 0..3; 4..7; 8..11; 12..15

Parameters:

<Size> Number of vertical divisions per logic channel

Range: 0.2 to 10

Usage: Asynchronous command

DIGital<m>:SKEW <Skew>

Sets an individual delay for each digital channel to time-align it with other digital channels. The skew value compensates delays that are known from the circuit specifics or caused by the different length of cables.

The setting affects only the settings of the first MSO bus (Logic1).

You can set the skew for all buses with `PBUS<pb>:BIT<n>:SKEW`.

Suffix:
<m> 0 to 15, index of the logic channel

Parameters:
<Skew>

Usage: Asynchronous command

DIGital<m>:STATe <State>

Enables or disables the indicated digital channel, displays it, and enables the Logic 1 if the bus was disabled.

If another active bus already uses the selected digital channel, the instrument disables the other bus to avoid conflicts.

For Logic 1, the `DIG::STAT` command has the same effect as `PBUS<pb>:STATe`. To enable digital channels for buses 2, 3 and 4, use the `PBUS:BIT[:STAT]` command.

Suffix:
<m> 0 to 15, index of the logic channel

Parameters:
<State> OFF | ON

Usage: Asynchronous command

DIGital<m>:TECHnology <Technology>

Selects the threshold voltage for various types of integrated circuits and applies it to all digital channels.

The setting affects only the settings of the first MSO bus (Logic1).

You can set the technology value for all buses with `PBUS<pb>:TECHnology`.

Suffix:
<m> 0..15
The suffix is irrelevant.

Parameters:
<Technology> V15 | V25 | V165 | V125 | V09 | VM13 | V38 | V20 | V0 | MANual
See `PBUS<pb>:TECHnology`.

Usage: Asynchronous command

DIGital<m>:THCoupling <State>

Sets the threshold and the hysteresis for all digital channels of Logic1 to the same value.

Suffix:

<m>	Irrelevant, omit the suffix.

Parameters:

<State>	OFF | ON

Usage: Asynchronous command

DIGital<m>:THReshold <Value>

Sets the logical threshold for the channel group to which the indicated digital channel belongs.

The setting affects only the settings of the first MSO bus (Logic1).

You can set the threshold for all buses with `PBUS<pb>:TECHnology` or `PBUS<pb>:THReshold<n>`

See also: `DIGital<m>:THCoupling` on page 1582

Suffix:

<m>	0..15 Number of the digital channel. Channel groups: 0..3; 4..7; 8..11; 12..15

Parameters:

<Value>

Usage: Asynchronous command

18.18.2 Logic configuration

The following commands configure the four logic groups of R&S MXO4-B1.

PBUS<pb>:BIT<n>:LABel <Label>

Sets a name for the indicated digital channel. The name is displayed in the diagram.

Suffix:

<pb>	1...4, index of the logic group
<n>	0..15 Selects the bit of the bus word. Each bit corresponds to a digital channel.

Parameters:

<Label>	String containing the channel name
Usage:	Asynchronous command

PBUS<pb>:BIT<n>:SKEW <Skew>

Sets an individual delay for each digital channel to time-align it with other digital channels.

The skew value compensates delays that are known from the circuit specifics or caused by the different length of cables. The skew between the probe boxes of the digital channels and the probe connectors of the analog channels is automatically aligned by the instrument.

Suffix:

<pb>	1...4, index of the logic group
<n>	0..15 Selects the bit of the bus word. Each bit corresponds to a digital channel.

Parameters:

<Skew>	Range: -2E-07 to 2E-07 Increment: 2E-10 *RST: 0 Default unit: s
Usage:	Asynchronous command
Manual operation:	See "D0-D15" on page 751

PBUS<pb>:BIT<n>[:STATe] <Assigned>

Enables the selected logic group. The corresponding signal icon appears on the signal bar.

If another active bus already uses the selected digital channel, the instrument disables the other bus to avoid conflicts.

Suffix:

<pb>	1...4, index of the logic group
<n>	0..15 Selects the bit of the bus word. Each bit corresponds to a digital channel.

Parameters:

<Assigned>	OFF | ON *RST: OFF

Usage: Asynchronous command

PBUS<pb>:CLEar

Removes all assigned digital channels from the bus.

Suffix:

<pb>	1...4, index of the logic group

Usage: Setting only
Asynchronous command

PBUS<pb>:CLOCk <ClockSource>

Selects the digital channel used as clock.

Suffix:

<pb>	1...4, index of the logic group

Parameters:

<ClockSource>	D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 Clock channel *RST: D0

Usage: Asynchronous command

Manual operation: See "Clock source" on page 749

PBUS<pb>:CLON <Clocked>

Defines if the bus is a clocked bus - one of the digital channels serves as the clock of the bus.

Suffix:
<pb> 1...4, index of the logic group

Parameters:
<Clocked> OFF | ON
*RST: OFF

Usage: Asynchronous command

Manual operation: See "Bus clocked" on page 749

PBUS<pb>:CLSLope <ClockSlope>

Selects the slope of the clock signal at which all digital channels of the bus are analyzed.

Suffix:
<pb> 1...4, index of the logic group

Parameters:
<ClockSlope> POSitive | NEGative | EITHer
*RST: POSitive

Usage: Asynchronous command

Manual operation: See "Clock slope" on page 749

PBUS<pb>:DECTable:SHOW <DecodeTable>

If enabled, a result table is shown with decoded values and corresponding points in time of the bus signal. Each clock edge corresponds to one row in the table.

The decode table is only available for clocked buses to check the data words.

Suffix:
<pb> 1...4, index of the logic group

Parameters:
<DecodeTable> OFF | ON
*RST: OFF

Usage: Asynchronous command

Manual operation: See "Show decode table" on page 749

PBUS<pb>:DECTable:COUNt?

Returns the number of rows in the decode table. Each clock edge corresponds to one row in the table. The decode table is only available for clocked buses.

Suffix:
<pb> 1...4, index of the logic group

Return values:
<Count> Number of rows

Usage: Query only
Asynchronous command

Manual operation: See "Show decode table" on page 749

PBUS<pb>:DECTable:DATA?

Returns a list of decoded values and corresponding points in time from the decode table. Each data pair corresponds to one clock edge, which is one row in the table. The decode table is only available for clocked buses.

Suffix:
<pb> 1...4, index of the logic group

Return values:
<Data> Comma-separated list of values

Usage: Query only
Asynchronous command

Manual operation: See "Show decode table" on page 749

PBUS<pb>:DIGSignals:POSition <DigChanPosition>

Sets the vertical position of all active digital channels.

Suffix:
<pb> 1...4, index of the logic group

Parameters:
<DigChanPosition> Range: 0 to 4294967295
Increment: 1
*RST: 0

Usage: Asynchronous command

PBUS<pb>:DIGSignals:SCALe <RelativeHeight>

Sets the size of the display that is used by each active digital signal.

Suffix:
<pb> 1...4, index of the logic group

Parameters:
<RelativeHeight> Range: 2 to 100
Increment: 0.5
*RST: 6.25
Default unit: %

Usage: Asynchronous command

PBUS<pb>:DISPlay:SHBU <ShowBus>

If enabled, the resulting bus signal and bus values are displayed in the diagram.

Suffix:

<pb> 1...4, index of the logic group

Parameters:

<ShowBus> OFF | ON

*RST: OFF

Usage: Asynchronous command

Manual operation: See "Show bus" on page 748

PBUS<pb>:DISPlay:SHDI <ShwDigSigns>

If enabled, the selected digital channels are shown in the diagram. Each channel is displayed as a logic signal.

Suffix:

<pb> 1...4, index of the logic group

Parameters:

<ShwDigSigns> OFF | ON

*RST: OFF

Usage: Asynchronous command

Manual operation: See "Show dig. signals" on page 746

PBUS<pb>:HYSTeresis<n> <Hysteresis>

Defines the size of the hysteresis for the respective channels.

Suffix:

<pb> 1...4, index of the logic group

<n> 1..4
Selects the channel group:
1 = digital channels 0..3
2 = digital channels 4..7
3 = digital channels 8..11
4 = digital channels 12..15

Parameters:

<Hysteresis> MAXimum | ROBust | NORMal

MAXIMUM = MAXimum
Maximum value that is possible and useful for the signal and its settings

ROBUST = ROBust
Different hysteresis values for falling and rising edges to avoid an undefined state of the trigger system.

NORMAL = NORMal
The instrument sets a value suitable for the signal and its settings.

Usage: Asynchronous command

Manual operation: See "Hysteresis" on page 747

PBUS<pb>:POSition <YPosition>

Sets the position of the indicated logic group waveform.

Suffix:
<pb> 1...4, index of the logic group

Parameters:
<YPosition> Range: 0 to 100
Increment: 0.1
*RST: 50
Default unit: %

Usage: Asynchronous command

PBUS<pb>:SCALe <RelativeHeight>

Sets the size of the display that is used by the indicated logic group waveform.

Suffix:
<pb> 1...4, index of the logic group

Parameters:
<RelativeHeight> Range: 3 to 100
Increment: 0.5
*RST: 10
Default unit: %

Usage: Asynchronous command

PBUS<pb>:SKEW <SkewOffset>

Sets a general delay for all digital channels.

Suffix:
<pb> 1...4, index of the logic group

Parameters:
<SkewOffset> Range: -2E-07 to 2E-07
Increment: 2E-10
*RST: 0
Default unit: s

Usage: Asynchronous command

Manual operation: See "Skew" on page 751

PBUS<pb>:STATe <State>

Enables the selected logic group. The corresponding signal icon appears on the signal bar.

Dependencies: At least one digital channel must be enabled for the selected bus, otherwise the command does not work.

The bus is enabled automatically if the first digital channel is enabled with `PBUS<pb>:BIT<n>[:STATe]`.

Suffix:
<pb> 1...4, index of the logic group

Parameters:
<State> OFF | ON
*RST: OFF

Usage: Asynchronous command

Manual operation: See "State" on page 746

PBUS<pb>:TECHnology <Technology>

Selects the threshold voltage for various types of integrated circuits and applies it to all digital channels.

Suffix:
<pb> 1...4, index of the logic group

Parameters:
<Technology> V15 | V25 | V165 | V125 | V09 | VM13 | V38 | V20 | V0 | MANual
V15: TTL
V25: CMOS 5.0 V
V165: CMOS 3.3 V
V125: CMOS 2.5 V
V09: CMOS 1.85 V
VM13: ECL, -1.3 V
V38: PECL
V20: LVPECL
V0: Ground
MANual: Set a user-defined threshold value with `DIGital<m>:THReshold` on page 1582.
*RST: V165

Usage: Asynchronous command

Manual operation: See "Technology, Threshold" on page 747

PBUS<pb>:THCoupling <LevelCoupling>

Sets the threshold and the hysteresis for all digital channels and all buses to the same value.

For Logic 1, the command `DIGital<m>:THCoupling` has the same effect.

Suffix:
<pb> 1...4, index of the logic group

Parameters:
<LevelCoupling> OFF | ON
*RST: ON

Usage: Asynchronous command

Manual operation: See "Level coupling" on page 747

PBUS<pb>:THReshold<n> <Threshold>

Sets the logical threshold for the indicated channel group.

Alternatively you can use the following commands:

- To select from a list of predefined technologies: `PBUS<pb>:TECHnology`
- For logic 1: `DIGital<m>:THReshold`

See also `DIGital<m>:THCoupling` on page 1582.

Suffix:
<pb> 1...4, index of the logic group

<n> 1..4
Selects the channel group:
1 = digital channels 0..3;
2 = digital channels 4..7
3 = digital channels 8..11
4 = digital channels 12..15

Parameters:
<Threshold> Range: -8 to 8
Increment: 0.025
*RST: 0
Default unit: V

Usage: Asynchronous command

Manual operation: See "Technology, Threshold" on page 747

18.18.3 Digital resolution

ACQuire:DRESolution?

Returns the current digital resolution of the digital channels.

Return values:

<DigRes>	Range: 1E-15 to 100 Increment: 1E-11 *RST: 0.0005 Default unit: s

Usage: Query only
Asynchronous command

ACQuire:POINts:DVALue?

Returns the current digital record length used by each digital channel.

Return values:

<DigReclgth>	Range: 1000 to 200000000 Increment: 2 *RST: 1000 Default unit: pts

Usage: Query only
Asynchronous command

18.18.4 Export of digital data

The remote data transfer from the instrument to the controlling computer is performed using the following commands:

For fast export of several waveforms at once, use `EXPort:WAVeform:DATA[:VALues]?` on page 995.

DIGital<m>:DATA:HEADer?

Returns the header of digital channel data, the attributes of the waveform.

Suffix:

<m> 0 to 15, index of the logic channel

Return values:

<XStart>	1. header value: time of the first sample in s
<XStop>	2. header value: time of the last sample in s
<RecordLength>	3. header value: record length of the waveform in samples
<ValuesPerSample>	4. header value: number of values per sample. For digital data, the result is always 1.

Example: `DIG3:DATA:HEAD?`
`-1E-07,9.980000000000001E-08,1000,1`
Start time of the data is -1E-07 = -100 ns, and end time of the data is 9.980000000000001E-08= 99.8 ns. The data stream has 1000 values with one value per sample.

Usage: Query only
Asynchronous command

DIGital<m>:DATA[:VALues]? [<Offset>[,<Length>]]

Returns the data of the indicated digital channel for transmission from the instrument to the controlling computer. The data can be used in MATLAB, for example.

Without parameters, the complete waveform is retrieved. Using the offset and length parameters, data can be retrieved in smaller portions, which makes the command faster. If you send only one parameter, it is interpreted as offset, and the data is retrieved from offset to the end of the waveform.

Suffix:
<m> 0..15
Selects the digital channel.

Query parameters:
<Offset> Number of offset values, which are ignored in the data transfer.

<Length> Number of values to be retrieved.

Return values:
<Data> List of values according to the format and content settings.

Usage: Query only
Asynchronous command

PBUS<pb>:DATA:FORMat <DataFormat>

Sets the data format of bus values, which are displayed in the decode table and on the comb bus display.

It also sets the format for the number representation for remote data transfer with `PBUS<pb>:DATA[:VALues]?`.

Suffix:
<pb> 1...4, index of the logic group

Parameters:
<DataFormat> HEX | OCT | BIN | ASCII | ASCii | SIGN | USIG
*RST: HEX

Usage: Asynchronous command

Manual operation: See "Data format" on page 748

PBUS<pb>:DATA:HEADer?

Returns the header data of the indicated bus, the attributes of the data.

See also `DIGital<m>:DATA:HEADer?`.

Suffix:

<pb>	1...4, index of the logic group

Return values:

<XStart>	1. header value: time of the first sample in s
<XStop>	2. header value: time of the last sample in s
<RecordLength>	3. header value: record length of the waveform in samples
<ValuesPerSample>	4. header value: number of values per sample. For digital data, the result is always 1.

Usage: Query only
Asynchronous command

Manual operation: See "Data format" on page 748

PBUS<pb>:DATA[:VALues]? [<Offset>[,<Length>]]

Returns the data of the indicated logic.

Without parameters, the complete waveform is retrieved. Using the offset and length parameters, data can be retrieved in smaller portions, which makes the command faster. If you send only one parameter, it is interpreted as offset, and the data is retrieved from offset to the end of the waveform.

Requirements:

- `PBUS<pb>:STATe` is set to `ON`.
- `PBUS<pb>:DISPlay:SHBU` is set to `ON`.
- A number format is set with `PBUS<pb>:DATA:FORMat`.

Suffix:

<pb>	1...4, index of the logic group

Query parameters:

<Offset>	Number of offset waveform points to be skipped. Range: 0 to m. Limit: n + m <= record length
<Length>	Number of waveform points to be retrieved. Range: 1 to n. Limit: n + m <= record length

Return values:

<Data>	List of values according to the format and content settings.

Example:

```
PBUS:STAT ON
PBUS:DISP:SHBU ON
PBUS:DISP:BTYP COMB
PBUS:DATA:FORMat HEX
PBUS:DATA:VAL?
```

Usage: Query only
Asynchronous command

Manual operation: See "Data format" on page 748

18.19 Waveform generator (option R&S MXO4-B6)

This section describes the remote commands of the waveform generator.

The instrument preset does not affect the generator settings. Each generator has its own preset: `WGENerator<wg>:PRESet`.

Some of the commands in the following section are asynchronous. An overlapping or asynchronous command does not automatically finish executing before the next command starts executing. If overlapping commands must be executed in a defined order, e.g. to avoid wrong measurement results, they must be serviced sequentially.

To prevent an overlapping execution of commands, one of the commands `*OPC`, `*OPC?` or `*WAI` can be used after the command or a command set.

For more information, see:

- www.rohde-schwarz.com/rc-via-scpi, section "Command sequence and synchronization"

18.19.1 Waveform generator setup

18.19.1.1 General settings

WGENerator<wg>:FREQuency <Frequency>

Sets the frequency of the waveform.

Suffix:

<wg> 1...2, index of the waveform generator

Parameters:

<Frequency>
Range: 0.001 to 100E+6 or lower, depending on the function type.
Increment: 0.001
*RST: 10E+6
Default unit: Hz

Usage: Asynchronous command

Manual operation: See "Frequency" on page 755

WGENerator<wg>:FUNCtion:PULSe[:WIDTh] <PulseWidth>

Sets the pulse width, the pulse duration of the generated pulse waveform.

Suffix:

<wg> 1...2, index of the waveform generator

Parameters:

<PulseWidth>
Range: 1.65E-08 to 90000
Increment: 1
*RST: 5E-07
Default unit: s

Usage: Asynchronous command

Manual operation: See "Pulse width" on page 757

WGENerator<wg>:FUNCtion:RAMP[:SYMMetry] <RampSymmetry>

Sets the symmetry of a ramp waveform, the percentage of time the waveform is rising. By changing the symmetry of the ramp, you can create, for example, triangular waveforms.

Suffix:

<wg> 1...2, index of the waveform generator

Parameters:

<RampSymmetry>
Range: 0 to 100
Increment: 1
*RST: 50
Default unit: %

Usage: Asynchronous command

Manual operation: See "Symmetry" on page 756

WGENerator<wg>:FUNCtion[:SELect] <FunctionType>

Selects the type of waveform to be generated.

Suffix:
<wg> 1...2, index of the waveform generator

Parameters:
<FunctionType> SINusoid | SQUare | RAMP | DC | PULSe | SINC | CARDiac | GAUSs | LORNtz | HAVer | EXPRise | EXPFall | ARBitrary

SINC: cardinal sine
HAVer: haversine (great-circle distance between two points on a sphere)

*RST: SINusoid

Usage: Asynchronous command

Manual operation: See "Function type" on page 754

WGENerator<wg>:FUNCtion[:SQUare]:DCYCle <SquareDutyCycle>

Sets the duty cycle for the pulse function.

Suffix:
<wg> 1...2, index of the waveform generator

Parameters:
<SquareDutyCycle> Range: 0.01 to 99.99
Increment: 1
*RST: 50
Default unit: %

Usage: Asynchronous command

Manual operation: See "Duty cycle" on page 757

WGENerator<wg>:OUTPut[:LOAD] <Load>

Select the user load, the load of the DUT at its connection.

Suffix:
<wg> 1...2, index of the waveform generator

Parameters:
<Load> FIFTy | HIZ

FIFTy: 50Ω
HIZ: High-Z (high input impedance)

*RST: HIZ

Usage: Asynchronous command

Manual operation: See "User load" on page 756

WGENerator<wg>:PERiod <Period>

Sets the period of the pulse waveform, if `WGENerator<wg>:FUNCtion[:SELect]` is set to `PULSe`.

Suffix:
<wg> 1...2, index of the waveform generator

Parameters:
<Period>
Range: 1E-08 to 1000
Increment: 1
*RST: 1E-06
Default unit: s

Usage: Asynchronous command

Manual operation: See "Period" on page 757

WGENerator<wg>:PRESet

Presets the generator to a default setup. The default includes the following settings:

- "Function type" = "Sine"
- "Frequency" = "1 MHz"
- "Amplitude" = "1 Vpp"

Suffix:
<wg> 1...2, index of the waveform generator

Usage: Setting only
Asynchronous command

Manual operation: See "Default setup" on page 757

WGENerator<wg>:SOURce <OperationMode>

Selects the operation mode of the waveform generator-

Suffix:
<wg> 1...2, index of the waveform generator

Parameters:
<OperationMode> FUNCgen | MODulation | SWEep | ARBGenerator

FUNCgen
Enables the function generator and disables modulation, sweep, and arbitrary waveforms

MODulation
Enables the modulation, disables sweep and selects the sine function.

SWEep
Enables the sweep, disables modulation, and selects the sine function.

ARBGenerator
Selects the arbitrary function and disables modulation and sweep.

*RST: FUNCgen

Usage: Asynchronous command

WGENerator<wg>:VOLTage:DCLevel <DCLevel>

Sets the level for the DC signal, if `WGENerator<wg>:FUNCtion[:SELect]` is set to `DC`.

Suffix:
<wg> 1...2, index of the waveform generator

Parameters:
<DCLevel>
Range: -5 to 5
Increment: 0.01
*RST: 0
Default unit: V

Usage: Asynchronous command

Manual operation: See "DC level" on page 757

WGENerator<wg>:VOLTage:HIGH <High>

Sets the high signal level of the output waveform.

Suffix:
<wg> 1...2, index of the waveform generator

Parameters:
<High>
Range: -5.99 to 6
Increment: 0.1
*RST: 0.5
Default unit: V

Usage: Asynchronous command

WGENerator<wg>:VOLTage:INVersion <Inversion>

Inverts the waveform at the offset level.

Suffix:
<wg> 1...2, index of the waveform generator

Parameters:
<Inversion> OFF | ON
*RST: OFF

Usage: Asynchronous command

Manual operation: See "Inversion" on page 754

WGENerator<wg>:VOLTage:LOW <Low>

Sets the low signal level of the output waveform.

Suffix:
<wg> 1...2, index of the waveform generator

Parameters:
<Low> Range: -6 to 5.99
Increment: 0.1
*RST: -0.5
Default unit: V

Usage: Asynchronous command

WGENerator<wg>:VOLTage:OFFSet <Offset>

Sets the vertical offset of the generated waveform.

Suffix:
<wg> 1...2, index of the waveform generator

Parameters:
<Offset> Range: -5.995 to 5.995
Increment: 0.01
*RST: 0
Default unit: V

Usage: Asynchronous command

Manual operation: See "Offset" on page 756

WGENerator<wg>:VOLTage[:VPP] <Amplitude>

Sets the amplitude of the waveform.

Suffix:
<wg> 1...2, index of the waveform generator

Parameters:
<Amplitude> Range: 0.01 to 12
Increment: 0.01
*RST: 0.4
Default unit: Vpp

Usage: Asynchronous command

Manual operation: See "Amplitude" on page 756

WGENerator<wg>[:ENABle] <State>

Enables the function generator.

Suffix:

<wg>	1...2, index of the waveform generator

Parameters:

<State>	OFF | ON *RST: No effect

Usage: Asynchronous command

Manual operation: See "State" on page 754

18.19.1.2 Modulation settings

WGENerator<wg>:MODulation[:STATe] <Modulation>

Enables or disables modulation.

Suffix:

<wg>	1...2, index of the waveform generator

Parameters:
<Modulation> OFF | ON
*RST: OFF

Usage: Asynchronous command

Manual operation: See "Modulation state" on page 758

WGENerator<wg>:MODulation:AM:DCYCle <SquareDutyCycle>

Sets the duty cycle for a square waveform. The duty cycle expresses for what percentage fraction of the period, the waveform is active, i.e. the signal state is high.

Suffix:
<wg> 1...2, index of the waveform generator

Parameters:
<SquareDutyCycle> Range: 10 to 90
Increment: 1
*RST: 50
Default unit: %

Usage: Asynchronous command

Manual operation: See "Duty cycle" on page 759

WGENerator<wg>:MODulation:AM:DEPTh <Depth>

Sets the modulation depth, the percentage of the amplitude range that is used for AM modulation.

Suffix:
<wg> 1...2, index of the waveform generator

Parameters:
<Depth> Range: 0 to 100
Increment: 1
*RST: 50
Default unit: %

Usage: Asynchronous command

Manual operation: See "Depth" on page 759

WGENerator<wg>:MODulation:AM:FREQuency <Frequency>

Sets the frequency of the modulation waveform for AM frequency modulation.

Suffix:
<wg> 1...2, index of the waveform generator

Parameters:

<Frequency> Range: 0.001 to 1000000
Increment: 0.001
*RST: 1000
Default unit: Hz

Usage: Asynchronous command

Manual operation: See "Frequency" on page 759

WGENerator<wg>:MODulation:AM:SYMMetry <RampSymmetry>

Sets the symmetry for the AM ramp modulation waveform, the percentage of time that the waveform is rising.

Suffix:

<wg> 1...2, index of the waveform generator

Parameters:

<RampSymmetry> Range: 0 to 100
Increment: 1
*RST: 50
Default unit: %

Usage: Asynchronous command

Manual operation: See "Symmetry" on page 759

WGENerator<wg>:MODulation:AM[:FUNCtion] <SignalType>

Selects the type of the modulating signal for AM modulation.

Suffix:

<wg> 1...2, index of the waveform generator

Parameters:

<SignalType> SINusoid | SQUare | RAMP
*RST: SINusoid

Usage: Asynchronous command

Manual operation: See "Signal type" on page 759

WGENerator<wg>:MODulation:CARRier:FREQuency <FreqCarrierAlias>

Sets the frequency of the carrier signal for a modulation waveform.

Suffix:

<wg> 1...2, index of the waveform generator

Parameters:

<FreqCarrierAlias>	Range: 0.001 to 100000000 Increment: 0.001 *RST: 1000000 Default unit: Hz

Usage: Asynchronous command

WGENerator<wg>:MODulation:CARRier:PERiod <PeriodCarrierAlias>

Sets the period of the carrier signal for a modulation waveform.

Suffix:

<wg> 1...2, index of the waveform generator

Parameters:

<PeriodCarrierAlias>	Range: 1E-08 to 1000 Increment: 1 *RST: 1E-06 Default unit: s

Usage: Asynchronous command

WGENerator<wg>:MODulation:FM:DCYCle <SquareDutyCycle>

Sets the duty cycle for a square waveform. The duty cycle expresses for what percentage fraction of the period, the waveform is active, i.e. the signal state is high.

Suffix:

<wg> 1...2, index of the waveform generator

Parameters:

<SquareDutyCycle>	Range: 10 to 90 Increment: 1 *RST: 50 Default unit: %

Usage: Asynchronous command

Manual operation: See "Duty cycle" on page 759

WGENerator<wg>:MODulation:FM:DEViation <Deviation>

Sets the frequency deviation, the maximum difference between the FM modulated signal and the carrier signal.

Suffix:

<wg> 1...2, index of the waveform generator

Parameters:

<Deviation> Range: 0.001 to 10000000
Increment: 1
*RST: 1000
Default unit: Hz

Usage: Asynchronous command

Manual operation: See "Deviation" on page 759

WGENerator<wg>:MODulation:FM:FREQuency <Frequency>

Sets the frequency of the modulating waveform for FM modulation.

Suffix:

<wg> 1...2, index of the waveform generator

Parameters:

<Frequency> Range: 0.001 to 1000000
Increment: 0.001
*RST: 1000
Default unit: Hz

Usage: Asynchronous command

Manual operation: See "Frequency" on page 759

WGENerator<wg>:MODulation:FM:SYMMetry <RampSymmetry>

Sets the symmetry for the FM ramp modulation waveform, the percentage of time that the waveform is rising.

Suffix:

<wg> 1...2, index of the waveform generator

Parameters:

<RampSymmetry> Range: 0 to 100
Increment: 1
*RST: 50
Default unit: %

Usage: Asynchronous command

Manual operation: See "Symmetry" on page 759

WGENerator<wg>:MODulation:FM[:FUNCtion] <SignalType>

Selects the type of the modulating signal for FM modulation.

Suffix:

<wg> 1...2, index of the waveform generator

Parameters:

<SignalType> SINusoid | SQUare | RAMP
*RST: SINusoid

Usage: Asynchronous command

Manual operation: See "Signal type" on page 759

WGENerator<wg>:MODulation:FSK:FONE <Frequency1>
WGENerator<wg>:MODulation:FSK:FTWO <Frequency2>

Sets the frequency of the first /second signal in FSK modulated signal.

Suffix:

<wg> 1...2, index of the waveform generator

Parameters:

<Frequency2> Range: 0.001 to 100E+6
Increment: 1
*RST: 1000
Default unit: Hz

Usage: Asynchronous command

Manual operation: See "Frequency 1/Frequency 2" on page 760

WGENerator<wg>:MODulation:FSK[:RATE] <Rate>

Sets the frequency at which the signal switches between `WGENerator<wg>:MODulation:FSK:FONE` and `WGENerator<wg>:MODulation:FSK:FTWO`.

Suffix:

<wg> 1...2, index of the waveform generator

Parameters:

<Rate> Range: 0.001 to 1000000
Increment: 1
*RST: 1000
Default unit: Hz

Usage: Asynchronous command

Manual operation: See "FSK rate" on page 760

WGENerator<wg>:MODulation:NDCLevel <LevelDC>

Sets the DC noise level, if `WGENerator<wg>:FUNCtion[:SELect]` is set to `DC`.

Suffix:

<wg> 1...2, index of the waveform generator

Parameters:

<LevelDC>	Range: 0 to 10 Increment: 0.01 *RST: 0 Default unit: Vpp

Usage: Asynchronous command

Manual operation: See "Noise level for DC" on page 757

WGENerator<wg>:MODulation:NLABsolute?

Queries the level of the noise in volts.

Suffix:

<wg>	1...2, index of the waveform generator

Return values:

<LevAbs>	Range: 0 to 12 Increment: 0.1 *RST: 0 Default unit: Vpp

Usage: Query only
Asynchronous command

WGENerator<wg>:MODulation:NLPCent <LevelPct>

Sets the level of the noise in percentage of the set "Amplitude" output of the signal.

Suffix:

<wg>	1...2, index of the waveform generator

Parameters:

<LevelPct>	Range: 0 to 100 Increment: 0.1 *RST: 0 Default unit: %

Usage: Asynchronous command

Manual operation: See "Noise level in %" on page 756

WGENerator<wg>:MODulation:PWM:DCYCle <SquareDutyCycle>

Sets the duty cycle for a square waveform. The duty cycle expresses for what percentage fraction of the period, the waveform is active, i.e. the signal state is high.

Suffix:

<wg>	1...2, index of the waveform generator

Parameters:

<SquareDutyCycle> Range: 10 to 90
Increment: 1
*RST: 50
Default unit: %

Usage: Asynchronous command

Manual operation: See "Duty cycle" on page 759

WGENerator<wg>:MODulation:PWM:DEPTh <Depth>

Sets the modulation depth, the percentage of the amplitude range that is used for PWM modulation.

Suffix:

<wg> 1...2, index of the waveform generator

Parameters:

<Depth> Range: 0 to 100
Increment: 1
*RST: 50
Default unit: %

Usage: Asynchronous command

Manual operation: See "Modulation depth" on page 759

WGENerator<wg>:MODulation:PWM:FREQuency <Frequency>

Sets the frequency of the modulating waveform for PWM modulation.

Suffix:

<wg> 1...2, index of the waveform generator

Parameters:

<Frequency> Range: 0.001 to 1000000
Increment: 0.001
*RST: 1000
Default unit: Hz

Usage: Asynchronous command

Manual operation: See "Frequency" on page 759

WGENerator<wg>:MODulation:PWM:SYMMetry <RampSymmetry>

Sets the symmetry for the PWM ramp modulation waveform, the percentage of time that the waveform is rising.

Suffix:

<wg> 1...2, index of the waveform generator

Parameters:

<RampSymmetry>	Range:	0 to 100
	Increment:	1
	*RST:	50
	Default unit:	%

Usage: Asynchronous command

Manual operation: See "Symmetry" on page 759

WGENerator<wg>:MODulation:PWM[:FUNCtion] <SignalType>

Selects the type of the modulating signal for PWM modulation.

Suffix:

<wg> 1...2, index of the waveform generator

Parameters:

<SignalType> SINusoid | SQUare | RAMP

*RST: SINusoid

Usage: Asynchronous command

Manual operation: See "Signal type" on page 759

WGENerator<wg>:MODulation:TYPE <ModulationType>

Selects the modulation type, which defines how the carrier signal is modified.

Suffix:

<wg> 1...2, index of the waveform generator

Parameters:

<ModulationType> NONE | AM | FM | PWM | ASK | FSK

*RST: AM

Usage: Asynchronous command

Manual operation: See "Modulation type" on page 758

18.19.1.3 ARB settings

WGENerator<wg>:ARBGen:NAME <Folder>

Sets the file path and the file for an arbitrary waveform, if `WGENerator<wg>:ARBGen[:SOURce]` is set to `ARBitrary`.

Suffix:
<wg> 1...2, index of the waveform generator

Parameters:
<Folder>

Usage: Asynchronous command

Manual operation: See "Open" on page 764

WGENerator<wg>:ARBGen:OPEN

Loads the arbitrary waveform, which is selected with the `WGENerator<wg>:ARBGen:NAME` command.

Suffix:
<wg> 1...2, index of the waveform generator

Usage: Event
Asynchronous command

Manual operation: See "Open" on page 764

WGENerator<wg>:ARBGen:RUNMode <RunMode>

Sets the duration for which the signal of the arbitrary generator will be output after the trigger event.

Suffix:
<wg> 1...2, index of the waveform generator

Parameters:
<RunMode> SINGle | REPetitive
*RST: REPetitive

Usage: Asynchronous command

Manual operation: See "Run mode" on page 763

WGENerator<wg>:ARBGen:RUNSingle

Executes a single period of the arbitrary signal generator, if `WGENerator<wg>:ARBGen:RUNMode` is set to `SINGle`.

Suffix:
<wg> 1...2, index of the waveform generator

Usage: Event
Asynchronous command

Manual operation: See "Run single" on page 763

WGENerator<wg>:ARBGen:SAMPles?

Returns the number of samples in the loaded waveform.

Suffix:
<wg> 1...2, index of the waveform generator

Return values:
<NumSamples> Range: 0 to 128E+6
Increment: 10
*RST: 0
Default unit: pts

Usage: Query only
Asynchronous command

Manual operation: See "Number of samples" on page 764

WGENerator<wg>:ARBGen:SRATe <SampleRate>

Sets the sample rate for the arbitrary waveform.

Suffix:
<wg> 1...2, index of the waveform generator

Parameters:
<SampleRate> Range: 1 to 312500000
Increment: 10
*RST: 1000000
Default unit: Sa/s

Usage: Asynchronous command

Manual operation: See "Sample rate" on page 764

WGENerator<wg>:ARBGen[:SOURce] <WaveformSource>

Selects the source of the arbitrary waveform.

Suffix:
<wg> 1...2, index of the waveform generator

Parameters:
<WaveformSource> ARBitrary
*RST: ARBitrary

Usage: Asynchronous command

Manual operation: See "Arb wfm source" on page 764

18.19.1.4 Sweep settings

WGENerator<wg>:SWEep[:STATe] <Sweep>

Enables or disables the sweeping.

Suffix:
<wg> 1...2, index of the waveform generator

Parameters:
<Sweep> OFF | ON
*RST: OFF

Usage: Asynchronous command

Manual operation: See "Sweep state" on page 760

WGENerator<wg>:SWEep:TYPE <Type>

Sets the type of the sweep, a linear or logarithmic change of the frequency.

Suffix:
<wg> 1...2, index of the waveform generator

Parameters:
<Type> LIN | LOG
*RST: LIN

Usage: Asynchronous command

Manual operation: See "Sweep type" on page 761

WGENerator<wg>:SWEep:FSTart <StartFrequency>

Sets the start frequency of the sweep signal.

Suffix:
<wg> 1...2, index of the waveform generator

Parameters:
<StartFrequency> Range: 0.001 to 100E+6
Increment: 0.001
*RST: 1000
Default unit: Hz

Usage: Asynchronous command

Manual operation: See "Start frequency" on page 761

WGENerator<wg>:SWEep:TIME <Time>

Sets the duration of the sweep.

Suffix:
<wg> 1...2, index of the waveform generator

Parameters:
<Time> Range: 0.001 to 500
Increment: 1
*RST: 0.001
Default unit: s

Usage: Asynchronous command

Manual operation: See "Sweep time" on page 761

WGENerator<wg>:SWEep:FEND <StopFrequency>

Sets the stop frequency of the sweep signal.

Suffix:
<wg> 1...2, index of the waveform generator

Parameters:
<StopFrequency> Range: 0.001 to 100E+6
Increment: 0.001
*RST: 1000000
Default unit: Hz

Usage: Asynchronous command

Manual operation: See "Stop frequency" on page 761

18.19.2 Synchronize settings

WGENerator<wg>:COUPling:ALL <CoupleAll>

Enables the coupling of the generators, with the selected set of parameters: enabling, amplitude and frequency.

Suffix:
<wg> 1..2
Specifies the primary generator.

Parameters:

<CoupleAll> OFF | ON

*RST: OFF

Usage: Asynchronous command

WGENerator<wg>:COUPling:STATe <CoupleEnable>

Enables the coupling of the generators with the selected set of parameters: amplitude and frequency.

Suffix:

<wg> 1..2
Specifies the prime generator.

Parameters:

<CoupleEnable> OFF | ON

*RST: OFF

Usage: Asynchronous command

Manual operation: See "Generator enable" on page 765

WGENerator<wg>:COUPling:AMPLitude <CplAmplitude>

Enables the coupling of all amplitude parameters of the generators.

Suffix:

<wg> 1..2
Specifies the prime generator.

Parameters:

<CplAmplitude> OFF | ON

*RST: OFF

Usage: Asynchronous command

Manual operation: See "Frequency parameters" on page 765

WGENerator<wg>:COUPling:PHASeshift <PhaseShift>

Sets the phase shift between the waveform of Gen1 and Gen2 when the frequency parameters of the two waveforms are coupled.

Suffix:

<wg> 1..2
Specifies the prime generator.

Parameters:

<PhaseShift> Range: -180 to 180
Increment: 1
*RST: 0
Default unit: °

Usage: Asynchronous command

Manual operation: See "Phase Gen1 - Gen2" on page 765

WGENerator<wg>:COUPling[:FREQuency] <CplFreq>

Enables the coupling of all frequency parameters of the generators.

Suffix:

<wg> 1..2
Specifies the prime generator.

Parameters:

<CplFreq> OFF | ON
*RST: OFF

Usage: Asynchronous command

Manual operation: See "Amplitude parameters" on page 766

GENerator:SYNC[:COMBination] <Combination>

Selects which signals generated from the waveform generator are synchronized.

Parameters:

<Combination> NONE | GEN12
*RST: NONE

Usage: Asynchronous command

Manual operation: See "Synchron start" on page 765

18.20 ScopeSync

The DEVice<m> index corresponds to the number of the oscilloscope in the scope list of the "Add scope" dialog and the waveform notification, but the numbers are different. For example:

- DEVice1 is oscilloscope O2 with channel waveforms O2C1, O2C2 ...
- DEVice2 is oscilloscope O3 with channel waveforms O3C1, O3C2 ...
- DEVice6 is oscilloscope O7 with channel waveforms O7C1, O7C2 ...

SYNChronize:DEVice<m>:CHANnels <Sources>

Selects the channels of scope 2 to be synchronized, displayed and analyzed. You can select active and inactive channels.

Suffix:

<m> 1 to 7, index = n-1 of the connected oscilloscope O<n>

Parameters:

<Sources> C1,C2,C3,C4,C5,C6,C7,C8

Usage: Asynchronous command

Manual operation: See "Select active channels" on page 782

SYNChronize:DEVice<m>:COMMunicate:NET[:HOSTname] <Hostname>

Sets the IP address or the host name for the specified oscilloscope.

Suffix:

<m> 1 to 7, index = n-1 of the connected oscilloscope O<n>

Parameters:

<Hostname> String with the IP address or host name

Example: `SYNChronize:DEVice:COMMunicate:NET:HOSTname "169.254.168.172"`

Usage: Asynchronous command

Manual operation: See "IP or hostname" on page 780

SYNChronize:DEVice<m>:CONNect <State>

Activates the connection between the two oscilloscopes, or between the R&S ScopeStudio software and the oscilloscope.

Suffix:

<m> 1 to 7, index = n-1 of the connected oscilloscope O<n>

Parameters:

<State> OFF | ON

Usage: Asynchronous command

Manual operation: See "Connect" on page 780

SYNChronize:DEVice<m>:DISPlay <RemoteUpdate>

Enables the continous display update on the actively connected oscilloscope (scope 2) when acquisition is controlled on scope 1.

The display update allows for visual comparison of the waveforms on both scopes.

Suffix:
<m> 1 to 7, index = n-1 of the connected oscilloscope O<n>

Parameters:
<RemoteUpdate> OFF | ON
*RST: ON

Usage: Asynchronous command

Manual operation: See "Display update" on page 783

SYNChronize:DEVice<m>:LOCKcontrols <RemoteLock>

Locks the touchscreen and the front panel keys on the connected oscilloscope.

Suffix:
<m> 1 to 7, index = n-1 of the connected oscilloscope O<n>

Parameters:
<RemoteLock> OFF | ON
*RST: OFF

Usage: Asynchronous command

Manual operation: See "Lock controls" on page 783

SYNChronize:DEVice<m>:NAME <Name>

Defines a name for the specified oscilloscope.

Suffix:
<m> 1 to 7, index = n-1 of the connected oscilloscope O<n>

Parameters:
<Name> String with the name of the connected oscilloscope.

Usage: Asynchronous command

Manual operation: See "Device name" on page 779

SYNChronize:DEVice<m>:SKEW:AUTO

Determines the delay between the specified scope and scope 1 automatically, and sets the skew.

Suffix:
<m> 1 to 7, index = n-1 of the connected oscilloscope O<n>

Usage: Setting only
Asynchronous command

Manual operation: See "Auto remote skew" on page 781

SYNChronize:DEVice<m>:SKEW[:VALue] <Skew>

Returns the skew value that was measured by `SYNChronize:DEVice<m>:SKEW:AUTO`. If you know the skew, or measure it manually, you can also set the value.

Suffix:

<m> 1 to 7, index = n-1 of the connected oscilloscope O<n>

Parameters:

<Skew> Range: -0.02 to 0.02
Increment: 1E-13
*RST: 8E-07
Default unit: s

Usage: Asynchronous command

Manual operation: See "Remote skew" on page 781

SYNChronize:DEVice<m>:TIMebasesync <SyncTimebase>

Enables or disables the timebase synchronization.

Suffix:

<m> 1 to 7, index = n-1 of the connected oscilloscope O<n>

Parameters:

<SyncTimebase> OFF | ON
*RST: ON

Usage: Asynchronous command

Manual operation: See "Sync timebase" on page 783

SYNChronize:DEVice<m>[:ENABle] <State>

Adds or removes an oscilloscope to the scope list.

Suffix:

<m> 1 to 7, index = n-1 of the connected oscilloscope O<n>

Parameters:

<State> OFF | ON

Usage: Asynchronous command

Manual operation: See "+ Add" on page 779

SYNChronize:DISConnect

Terminates the active connection.

Usage: Event
Asynchronous command

Manual operation: See "Disconnect" on page 780

SYNChronize:LOAD:ABORt

Terminates the getting of signals.

Usage: Setting only
Asynchronous command

Manual operation: See "Get signals" on page 783

SYNChronize:LOAD[:WAVeform]

Retrieves the waveforms of the latest acquisition from the connected oscilloscope. All selected analog channel waveforms are transferred. Digital channels and reference waveforms are not transferred.

Usage: Setting only
Asynchronous command

Manual operation: See "Get signals" on page 783

18.21 Status reporting

This section describes the remote commands that are used to read the status registers.

For information on the structure, hierarchy, and contents of the status registers, see Section 17.6, "Remote control - status reporting system", on page 792.

18.21.1 General commands

STATus:PRESet

Resets the status registers.

All `PTRansition` bits are set to 1, i.e. all transitions from 0 to 1 are detected.

All `NTRansition` bits are set to 0, i.e. a transition from 1 to 0 in a `CONDition` bit is not detected.

All `EVENt` bits are set to 0.

The ENABle bits of STATus:OPERation and STATus:QUEStionable are set to 0, i.e. all events in these registers are not passed on.

Usage: Setting only
SCPI confirmed

18.21.2 STATus:OPERation register

STATus:OPERation commands provide information on the activity of the instrument.

See also: Section 17.6.3.3, "STATus:OPERation register", on page 797.

STATus:OPERation:CONDition?

Returns the bit of the action the instrument is currently executing. The contents of the STATus:OPERation register is retained.

The bit assignment is described in Section 17.6.3.3, "STATus:OPERation register", on page 797.

Usage: Query only
SCPI confirmed
Asynchronous command

STATus:OPERation:ENABle <Enable>

Controls the ENABle part of the STATus:OPERation register. The ENABle defines which events in the EVENt part of the status register are forwarded to the OPERation summary bit (bit 7) of the status byte. The status byte can be used to create a service request.

Parameters:
<Enable> Range: 1 to 65535
Increment: 1

Example: `STATus:OPERation:ENABle 5`
The ALIGnment event (bit 0) and AUToset event (bit 2) are forwarded to the OPERation summary bit of the status byte.

STATus:OPERation[:EVENt]?

The CONDition command returns information on actions the instrument is currently executing. The contents of the register is retained.

The EVENt command returns information on actions the instrument has executed since the last reading. Reading the EVENt register deletes its contents.

Bits:

- 0 = ALIGnment
- 2 = AUToset
- 4= MEASuring
- 5= WTRIgger (wait for trigger)
- 6= TRIggered

Example: For an example, see Example "Querying with STATus:OPERation:CONDition" on page 1628.

Usage: Query only
SCPI confirmed
Asynchronous command

STATus:OPERation:NTRansition <SumBit>

The command sets the bits of the NTRansition part of the STATus:OPERation register. A bit set in the NTRansition register causes a bit transition from 1 to 0 in the CONDition register to produce an entry in the EVENt register.

Reading the information does not clear the register.

Parameters:
<SumBit> Range: 0 to 65535
Increment: 1

Usage: SCPI confirmed
Asynchronous command

STATus:OPERation:PTRansition <SumBit>

The command sets the bits of the PTRansition part of the STATus:OPERation register. A bit set in the PTRansition register causes a bit transition from 0 to 1 in the CONDition register to produce an entry in the EVENt register.

Reading the information does not clear the register.

Parameters:
<SumBit> Range: 0 to 65535
Increment: 1

Usage: SCPI confirmed
Asynchronous command

18.21.3 STATus:QUEStionable registers

The commands of the `STATus:QUEStionable` subsystem control the status reporting structures of the `STATus:QUEStionable` registers.

See also: Section 17.6.3.4, "STATus:QUEStionable register", on page 798.

The query of the [:EVENt] and [:ENABLe] commands, return a list of the affected sources:

Table 18-3: Source values for STATus:QUEStionable:...:[:EVENt] and STATus:QUEStionable:...:[:ENABLe]

Bits	Source values	Description
For all bits	NONE	
	ALL	All available sources are activated
PPSupply	PRobe<m>	Active probe
POVerload	PRobe<m>	Active probe
COVerload	CHAN<m>	Analog channels
	WARNCHAN<m>	Warning overload channels
	EXTTRIGGERIN	External analog signal connected to the external trigger input
	TRIGGEROUT	Trigger out signal
TEMPerature	WINSTRUMENT	Temperature warning: indicates that the device is getting hot and should be cooled.
	EINSTRUMENT	Temperature error: the device is too hot and will automatically shut down in a few seconds.
	WGENERATOR1	Temperature warning on waveform generator 1
	WGENERATOR2	Temperature warning on waveform generator 2
ADCState	CPCHAN<m>	Positive clipping for analog channels
	CNCHAN<m>	Negative clipping for analog channels
	CPPRobe<m>	Positive clipping for probes
	CNPRobe<m>	Negative clipping for probes
GOVerload	WGENerator<m>	Available generators
LIMit	MEAS<m>	Enabled measurements
MARGin	MEAS<m>	Enabled measurements
IMPRecise	MEAS<m>	Enabled measurements
MASK	MASK<m>	Enabled masks

Some of the status commands can be used interchangeably:

Table 18-4: Overview: STATus:QUEStionable and respective CHANnel, MEASurement and WGENerator commands

STATus:QUEStionable register	MEASurement
STATus:QUEStionable:COVerload Bit: CHANnel<ch>	CHANnel<ch>:OVERload:STATus
STATus:QUEStionable:COVerload Bit: WCHannel<ch>	CHANnel<ch>:WARNoverload:STATus

STATus:QUEStionable register	MEASurement
STATus:QUEStionable:COVerload Bit: EXTTRIGGERIN	TRIGger:ANEDge:OVERload:STATus
STATus:QUEStionable:COVerload Bit: TRIGGEROUT	TRIGger:ACTions:OUT:OVERload:STATus
STATus:QUEStionable:ADCState Bit: CPCHannel<ch>	CHANnel<ch>:ADCState:STATus:PCLipping
STATus:QUEStionable:ADCState Bit: CNCHannel<ch>	CHANnel<ch>:ADCState:STATus:NCLipping
STATus:QUEStionable:PPSupply Bit: CNCHannel<ch>	CHANnel<ch>PPSupply:STATus
STATus:QUEStionable:LIMit Bit: MEASurement<mg>	MEASurement<mg>:LIMit:STATus
STATus:QUEStionable:MARGin Bit: MEASurement<mg>	MEASurement<mg>:MARGin:STATus
STATus:QUEStionable:IMPRecise Bit: MEASurement<mg>	MEASurement<mg>:IMPRecise:STATus
STATus:QUEStionable:GOVerload Bit: WGENerator<wg>	WGENerator<wg>:GOVerload
STATus:QUEStionable: TEMPerature Bit: WGENerator<wg>	WGENerator<wg>:TEMPerature

18.21.4 Reading out the CONDition part

CHANnel<ch>:OVERload:STATus:CONDition?
CHANnel<ch>:ADCState:STATus:NCLipping:CONDition?
CHANnel<ch>:ADCState:STATus:PCLipping:CONDition?
CHANnel<ch>:WARNoverload:STATus:CONDition?
CHANnel<ch>:PPSupply:STATus:CONDition?
MEASurement<mg>:IMPRecise:STATus:CONDition?
MEASurement<mg>:LIMit:STATus:CONDition?
MEASurement<mg>:MARGin:STATus:CONDition?
STATus:QUEStionable:MASK:CONDition?
TRIGger:ACTions:OUT:OVERload:STATus:CONDition?
TRIGger:ANEDge:OVERload:STATus:CONDition?
WGENerator<wg>:GOVerload:STATus:CONDition?
WGENerator<wg>:TEMPerature:STATus:CONDition?
STATus:QUEStionable:ADCState:CONDition?
STATus:QUEStionable:COVerload:CONDition?
STATus:QUEStionable:GOVerload:CONDition?

STATus:QUEStionable:IMPRecise:CONDition?
STATus:QUEStionable:LIMit:CONDition?
STATus:QUEStionable:MARGin:CONDition?
STATus:QUEStionable:PLL:CONDition?
STATus:QUEStionable:PPSupply:CONDition?
STATus:QUEStionable:TEMPerature:CONDition?

Returns the contents of the `CONDition` part of the status register to check for questionable instrument or measurement states. This part contains information on the action currently being performed in the instrument.

Reading the `CONDition` registers does not delete the contents since it indicates the current hardware status.

Return values:

<Value>	bit dependent, comma-separated values
Usage:	Query only

18.21.5 Reading out the EVENt part

CHANnel<ch>:ADCState:STATus:NCLipping[:EVENt]?
CHANnel<ch>:ADCState:STATus:PCLipping[:EVENt]?
CHANnel<ch>:OVERload:STATus[:EVENt] <Value>
CHANnel<ch>:WARNoverload:STATus[:EVENt]?
CHANnel<ch>:PPSupply:STATus[:EVENt] <Value>
MEASurement<mg>:IMPRecise:STATus[:EVENt]?
MEASurement<mg>:LIMit:STATus[:EVENt]?
MEASurement<mg>:MARGin:STATus[:EVENt]?
STATus:QUEStionable:MASK[:EVENt]?
TRIGger:ACTions:OUT:OVERload:STATus[:EVENt] <Value>
TRIGger:ANEDge:OVERload:STATus[:EVENt] <Value>
WGENerator<wg>:GOVerload:STATus[:EVENt] <Value>
WGENerator<wg>:TEMPerature:STATus[:EVENt] <Value>
STATus:QUEStionable:ADCState[:EVENt]?
STATus:QUEStionable:COVerload[:EVENt]?
STATus:QUEStionable:GOVerload[:EVENt]?
STATus:QUEStionable:IMPRecise[:EVENt]?
STATus:QUEStionable:LIMit[:EVENt]?
STATus:QUEStionable:MARGin[:EVENt]?
STATus:QUEStionable:PLL[:EVENt]?
STATus:QUEStionable:PPSupply[:EVENt]?
STATus:QUEStionable:TEMPerature[:EVENt]?

Returns the contents of the `EVENt` part of the status register to check if an event has occurred since the last reading.

Reading an `EVENt` register deletes its contents.

Return values:

<Value>	bit dependent, comma-separated values See Source values for STATus:QUEStionable:...:[:EVENt] and STATus:QUEStionable:...:[:ENABLe] for a list of the return values.
Usage:	Query only

18.21.6 Controlling the ENABle part

CHANnel<ch>:OVERload:STATus:ENABle <Value>
CHANnel<ch>:ADCState:STATus:NCLipping:ENABle <Value>
CHANnel<ch>:ADCState:STATus:PCLipping:ENABle <Value>
CHANnel<ch>:WARNoverload:STATus:ENABle <Value>
CHANnel<ch>:PPSupply:STATus:ENABle <Value>
MEASurement<mg>:IMPRecise:STATus:ENABle <Value>
MEASurement<mg>:LIMit:STATus:ENABle <Value>
MEASurement<mg>:MARGin:STATus:ENABle <Value>
TRIGger:ACTions:OUT:OVERload:STATus:ENABle <Value>
TRIGger:ANEDge:OVERload:STATus:ENABle <Value>
WGENerator<wg>:GOVerload:STATus:ENABle <Value>
WGENerator<wg>:TEMPerature:STATus:ENABle <Value>
STATus:QUEStionable:ADCState:ENABle <Value>
STATus:QUEStionable:COVerload:ENABle <Value>
STATus:QUEStionable:GOVerload:ENABle <Value>
STATus:QUEStionable:IMPRecise:ENABle <Value>
STATus:QUEStionable:LIMit:ENABle <Value>
STATus:QUEStionable:MARGin:ENABle <Value>
STATus:QUEStionable:PLL:ENABle <Value>
STATus:QUEStionable:PPSupply:ENABle <Value>
STATus:QUEStionable:TEMPerature:ENABle <Value>

Sets the `ENABle` part that allows true conditions in the EVENt part to be reported for the summary bit in the status byte.

These events can be used for a service request. If a bit in the `ENABle` part is 1, and the corresponding `EVENt` bit is true, a positive transition occurs in the summary bit. This transition is reported to the next higher level.

See Source values for STATus:QUEStionable:...:[:EVENt] and STATus:QUEStionable:...:[:ENABLe] for a list of the return values.

Parameters:

<Value>	bit dependent, comma-separated values

18.21.7 Controlling the negative transition part

CHANnel<ch>:ADCState:STATus:NCLipping:NTRansition <Value>
CHANnel<ch>:ADCState:STATus:PCLipping:NTRansition <Value>

CHANNel<ch>:OVERload:STATus:NTRansition <Value>
CHANnel<ch>:PPSupply:STATus:NTRansition <Value>
CHANnel<ch>:WARNoverload:STATus:NTRansition <Value>
MEASurement<mg>:IMPRecise:STATus:NTRansition <Value>
MEASurement<mg>:LIMit:STATus:NTRansition <Value>
MEASurement<mg>:MARGin:STATus:NTRansition <Value>
TRIGger:ACTions:OUT:OVERload:STATus:NTRansition <Value>
TRIGger:ACTions:OUT:OVERload:STATus:PTRansition <Value>
TRIGger:ANEDge:OVERload:STATus:NTRansition <Value>
WGENerator<wg>:GOVerload:STATus:NTRansition <Value>
WGENerator<wg>:TEMPerature:STATus:NTRansition <Value>
STATus:QUEStionable:ADCState:NTRansition <Value>
STATus:QUEStionable:COVerload:NTRansition <Value>
STATus:QUEStionable:GOVerload:NTRansition <Value>
STATus:QUEStionable:IMPRecise:NTRansition <Value>
STATus:QUEStionable:LIMit:NTRansition <Value>
STATus:QUEStionable:MARGin:NTRansition <Value>
STATus:QUEStionable:PLL:NTRansition <Value>
STATus:QUEStionable:PPSupply:NTRansition <Value>
STATus:QUEStionable:TEMPerature:NTRansition <Value>

Sets the negative transition filter.

If a bit is set, a transition from 1 to 0 in the condition part causes an entry to be made in the corresponding bit of the `EVENt` part of the register.

Parameters:

<Value>	Source dependent, comma-separated values

18.21.8 Controlling the positive transition part

CHANnel<ch>:ADCState:STATus:NCLipping:PTRansition <Value>
CHANnel<ch>:ADCState:STATus:PCLipping:PTRansition <Value>
CHANnel<ch>:OVERload:STATus:PTRansition <Value>
CHANnel<ch>:PPSupply:STATus:PTRansition <Value>
CHANnel<ch>:WARNoverload:STATus:PTRansition <Value>
MEASurement<mg>:IMPRecise:STATus:PTRansition <Value>
MEASurement<mg>:LIMit:STATus:PTRansition <Value>
MEASurement<mg>:MARGin:STATus:PTRansition <Value>
TRIGger:ACTions:OUT:OVERload:STATus:PTRansition <Value>
TRIGger:ANEDge:OVERload:STATus:PTRansition <Value>
WGENerator<wg>:GOVerload:STATus:PTRansition <Value>
WGENerator<wg>:TEMPerature:STATus:PTRansition <Value>
STATus:QUEStionable:ADCState:PTRansition <Value>
STATus:QUEStionable:COVerload:PTRansition <Value>
STATus:QUEStionable:GOVerload:PTRansition <Value>
STATus:QUEStionable:IMPRecise:PTRansition <Value>
STATus:QUEStionable:LIMit:PTRansition <Value>
STATus:QUEStionable:MARGin:PTRansition <Value>
STATus:QUEStionable:PLL:PTRansition <Value>

STATus:QUEStionable:PPSupply:PTRansition <Value>
STATus:QUEStionable:TEMPerature:PTRansition <Value>

Sets the positive transition filter.

If a bit is set, a transition from 0 to 1 in the condition part causes an entry to be made in the corresponding bit of the `EVENt` part of the register.

Parameters:

<Value> Source dependent, comma-separated values

18.21.9 Programming tips and examples

Example: Observing the limits violation of a measurement

The following example describes how to use the status register commands to observe if a violation of a measurement limit has occurred.

```
*SRE 8
// Enables the STATus:QUEStionable bit in the service-request (SRE)

STATus:QUEStionable:ENABle 512
// Enables the LIMIt bit of the STATus:QUEStionable register

MEASurement1:ENABle ON
MEASurement2:ENABle ON
MEASurement3:ENABle ON
// Enables measurement 1,2,3


STATus:QUEStionable:LIMit:ENABle ALL
// Enables the limit check for all active measurements

STATus:QUEStionable:LIMit:ENABle?
MEAS1,MEAS2,MEAS3
//Queries which measurement were active at the time the
//STATus:QUEStionable:LIMit:ENABle was send

*SRQ?
// A service request was sent

*STB?
72
// STATus:QUEStionable is set:
// #72= 64 + 8 = 2^6 + 2^3
// 64 : bit 6 is awlays on when a SRQ is sent
// 8: bit 3 for STATus:QUEStionable

STATus:QUEStionable:EVENt?
512
// 512= 2^9,

STATus:QUEStionable:LIMit:EVENt?
MEAS1,MEAS2
// Measurements 1 and 2 have exceeded the limit
// The event register is cleared after the query


STATus:QUEStionable:LIMit:EVENt?
NONE
// The event bit has been set to 0 after the first query
```

```
STATus:QUEStionable:LIMit:CONDition?
MEAS1,MEAS2
// Measurements 1 and 2 are still exceeding the limit


STATus:QUEStionable:EVENt?
0

// Waiting for an event
*SRQ?

// Measurement 3 exceeds the limit

STATus:QUEStionable:LIMit:CONDition?
MEAS1,MEAS2,MEAS3
// Measurements 1,2 and 3 are currently exceeding the limit


STATus:QUEStionable:LIMit:EVENt?
MEAS3
// Measurement 3 has newly  exceeded the limit
// The event register is cleared after the query
```

Example: Querying with STATus:OPERation:CONDition

The following example shows how the result of `STATus:OPERation:CONDition?` changes during a single acquisition.

```
SINGLe
// Measurement starts

STATus:OPERation:CONDition?
16
//Measuring

STATus:OPERation:CONDition?
48
//Pre trigger waiting time is over (16 Measuring + 32 WaitForTrigger)

STATus:OPERation:CONDition?
112
//Trigger is deactivated (16 Measuring + 32 WaitForTrigger + 64 Triggered)

STATus:OPERation:CONDition?
96
// Measurement has finished (32 WaitForTrigger + 64 Triggered)
```

Query OPC status in the event status register

If you activate a time-consuming operation and wait for completion with `*OPC?`, a time-out could occur before the operation is finished and you do not receive the returned

"1". In addition, the test program is blocked while waiting with `*OPC?`. It is not possible to process other (not interdependent) commands in the meantime or to communicate with other instruments.

Thus, for time-consuming operations, you can avoid blocking the communication by sending the operation complete command `*OPC`:

```
*CLS
*OPC
```

Afterwards you can poll the operation complete status in the event status register with `*ESR?`.

This query returns the content of the event status register and afterwards clears the content. See also Section 17.6.3.2, "Event status register (ESR) and event status enable register (ESE)", on page 796.

18.22 Deprecated commands

The following commands are provided for compatibility to previous oscilloscope versions only. For new remote control programs, use the specified alternative commands.

18.22.1 Base instrument

Legacy command	Replaced by	Comment
DIAGnostic:SERVice:COMPutername	SYSTem:COMMunicate:NET[:HOSTname] on page 817	Replaced since FW 2.0

18.22.2 Serial protocols

Table 18-5: Serial bus: configuration

Legacy command	Replaced by	Comment
SBUS<sb>:SPI:FILTer:ENABle SBUS<sb>:I2C:FILTer:ENABle SBUS<sb>:UART:FILTer:ENABle SBUS<sb>:CAN:FILTer:ENABle SBUS<sb>:LIN:FILTer:ENABle	-	No longer needed since FW 2.0
SBUS<sb>:CAN:DATA:HYSTeresis	SBUS<sb>:CAN:SIC:HYSTeresis SBUS<sb>:CAN:FAST:HYSTeresis	Replaced since FW 1.4
SBUS<sb>:CAN:DATA:THReshold	SBUS<sb>:CAN:SIC:THReshold SBUS<sb>:CAN:FAST:THReshold	Replaced since FW 1.4
SBUS<sb>:CAN:DATA:SOURce	SBUS<sb>:CAN:SOURce	Replaced since FW 2.0

Legacy command	Replaced by	Comment
SBUS<sb>:RFFE:CLOCk:POLarity SBUS<sb>:RFFE:DATA:POLarity SBUS<sb>:TNOS:HYSTeresis	-	No longer needed since FW 2.6
SBUS<sb>:SETReflevels SBUS<sb>:UART:EWORd	-	No longer needed since FW 2.7

Table 18-6: Serial bus: filter

Legacy command	Replaced by	Comment
SBUS<sb>:SWIRe:FILTer:IMAX SBUS<sb>:SWIRe:FILTer:FRAMe<fr>:FLD<fl>:IMAX SBUS<sb>:SWIRe:FILTer:IMIN SBUS<sb>:SWIRe:FILTer:FRAMe<fr>:FLD<fl>:IMIN SBUS<sb>:SWIRe:FILTer:IOPerator SBUS<sb>:SWIRe:FILTer:FRAMe<fr>:FLD<fl>:IOPer-ator	-	No longer needed since FW 2.7

Table 18-7: Serial bus: trigger

Legacy command	Replaced by	Comment
TRIGger:SBSW:ARINc:FRAMe<fr>:FLD<fl>:IMAX		Not supported
TRIGger:SBSW:ARINc:FRAMe<fr>:FLD<fl>:IMIN		
TRIGger:SBSW:ARINc:FRAMe<fr>:FLD<fl>:IOPerator		
TRIGger:SBSW:ARINc:IMAX		
TRIGger:SBSW:ARINc:IMIN		
TRIGger:SBSW:ARINc:IOPerator		
TRIGger:CAN:ACKerror	TRIGger:SBHW:CAN:ACKerror	Replaced since FW 2.3
TRIGger:CAN:BITSterror	TRIGger:SBHW:CAN:BITSterror	
TRIGger:CAN:BORDer	TRIGger:SBHW:CAN:BORDer	
TRIGger:CAN:CRCerror	TRIGger:SBHW:CAN:CRCerror	
TRIGger:CAN:DCONdition	TRIGger:SBHW:CAN:DCONdition	
TRIGger:CAN:DLC	TRIGger:SBHW:CAN:DLC	
TRIGger:CAN:DLCCondition	TRIGger:SBHW:CAN:DLCCondition	
TRIGger:CAN:DMIN	TRIGger:SBHW:CAN:DMIN	
TRIGger:CAN:FDATa:BRS	TRIGger:SBHW:CAN:FDATa:BRS	
TRIGger:CAN:FDATa:DPOSition	TRIGger:SBHW:CAN:FDATa:DPOSition	
TRIGger:CAN:FDATa:ESI	TRIGger:SBHW:CAN:FDATa:ESI	
TRIGger:CAN:FDATa:SCERror	TRIGger:SBHW:CAN:FDATa:SCERror	
TRIGger:CAN:FORMerror	TRIGger:SBHW:CAN:FORMerror	
TRIGger:CAN:FTYPe	TRIGger:SBHW:CAN:FTYPe	
TRIGger:CAN:ICONdition	TRIGger:SBHW:CAN:ICONdition	
TRIGger:CAN:IMAX	TRIGger:SBHW:CAN:IMAX	
TRIGger:CAN:IMIN	TRIGger:SBHW:CAN:IMIN	
TRIGger:CAN:ITYPe	TRIGger:SBHW:CAN:ITYPe	
TRIGger::CAN:TYPE	TRIGger:SBHW:CAN:TYPE	
TRIGger:CAN:XDATa:AF:CONDition	TRIGger:SBHW:CAN:XDATa:AF:CONDition	
TRIGger:CAN:XDATa:AF:MAX	TRIGger:SBHW:CAN:XDATa:AF:MAX	
TRIGger:CAN:XDATa:AF:MIN	TRIGger:SBHW:CAN:XDATa:AF:MIN	
TRIGger:CAN:XDATa:SDT:CONDition	TRIGger:SBHW:CAN:XDATa:SDT:CONDition	
TRIGger:CAN:XDATa:SDT:MAX	TRIGger:SBHW:CAN:XDATa:SDT:MAX	
TRIGger:CAN:XDATa:SDT:MIN	TRIGger:SBHW:CAN:XDATa:SDT:MIN	
TRIGger:CAN:XDATa:SEC	TRIGger:SBHW:CAN:XDATa:SEC	
TRIGger:CAN:XDATa:VCID:CONDition	TRIGger:SBHW:CAN:XDATa:VCID:CONDition	
TRIGger:CAN:XDATa:VCID:MAX	TRIGger:SBHW:CAN:XDATa:VCID:MAX	
TRIGger:CAN:XDATa:VCID:MIN	TRIGger:SBHW:CAN:XDATa:VCID:MIN	

Legacy command	Replaced by	Comment
TRIGger:I2C:ACCess TRIGger:I2C:ACONdition TRIGger:I2C:ADDRess TRIGger:I2C:ADDTo TRIGger:I2C:ADNack TRIGger:I2C:AMODe TRIGger:I2C:DCONdition TRIGger:I2C:DMIN TRIGger:I2C:DPOSition TRIGger:I2C:DRNack TRIGger:I2C:DWNack TRIGger:I2C:TYPE	TRIGger:SBHW:I2C:ACCess TRIGger:SBHW:I2C:ACONdition TRIGger:SBHW:I2C:ADDRess TRIGger:SBHW:I2C:ADDTo TRIGger:SBHW:I2C:ADNack TRIGger:SBHW:I2C:AMODe TRIGger:SBHW:I2C:DCONdition TRIGger:SBHW:I2C:DMIN TRIGger:SBHW:I2C:DPOSition TRIGger:SBHW:I2C:DRNack TRIGger:SBHW:I2C:DWNack TRIGger:SBHW:I2C:TYPE	Replaced since FW 2.3
TRIGger:LIN:CHKSerror TRIGger:LIN:DCONdition TRIGger:LIN:DMIN TRIGger:LIN:DPOSition TRIGger:LIN:ICONdition TRIGger:LIN:IMAX TRIGger:LIN:IMIN TRIGger:LIN:IPERror TRIGger:LIN:SYERror TRIGger:LIN:TYPE	TRIGger:SBHW:LIN:CHKSerror TRIGger:SBHW:LIN:DCONdition TRIGger:SBHW:LIN:DMIN TRIGger:SBHW:LIN:DPOSition TRIGger:SBHW:LIN:ICONdition TRIGger:SBHW:LIN:IMAX TRIGger:SBHW:LIN:IMIN TRIGger:SBHW:LIN:IPERror TRIGger:SBHW:LIN:SYERror TRIGger:SBHW:LIN:TYPE	Replaced since FW 2.3
TRIGger:UART:DATA TRIGger:UART:DPOSition TRIGger:UART:FCONdition TRIGger:UART:OPERator TRIGger:UART:SOURce TRIGger:UART:TYPE	TRIGger:SBHW:UART:DATA TRIGger:SBHW:UART:DPOSition TRIGger:SBHW:UART:FCONdition TRIGger:SBHW:UART:OPERator TRIGger:SBHW:UART:SOURce TRIGger:SBHW:UART:TYPE	Replaced since FW 2.3
TRIGger:SPI:DMINpattern TRIGger:SPI:DPOSition TRIGger:SPI:FCONdition TRIGger:SPI:PALignment TRIGger:SPI:TYPE	TRIGger:SBHW:SPI:DMINpattern TRIGger:SBHW:SPI:DPOSition TRIGger:SBHW:SPI:FCONdition TRIGger:SBHW:SPI:PALignment TRIGger:SBHW:SPI:TYPE	Replaced since FW 2.3

Table 18-8: Serial bus: decode resuls

Legacy command	Replaced by	Comment
SBUS<sb>:CAN:FRAMe<fr>:BSEPosition?	-	No longer needed since FW 2.1
SBUS<sb>:I2C:FRAMe<fr>:COUNt SBUS<sb>:I2C:FRAMe<fr>:BYTE<o>:ACCess SBUS<sb>:I2C:FRAMe<fr>:BYTE<o>:ACKStart SBUS<sb>:I2C:FRAMe<fr>:BYTE<o>:COMPlete SBUS<sb>:I3C:FRAMe<fr>:AACCess? SBUS<sb>:I3C:FRAMe<fr>:Access? SBUS<sb>:I3C:FRAMe<fr>:ACOMplete? SBUS<sb>:I3C:FRAMe<fr>:ADBStart? SBUS<sb>:I3C:FRAMe<fr>:ADEVice? SBUS<sb>:I3C:FRAMe<fr>:AMODe? SBUS<sb>:I3C:FRAMe<fr>:BYTE<o>:Access? SBUS<sb>:I3C:FRAMe<fr>:BYTE<o>:ACKStart? SBUS<sb>:I3C:FRAMe<fr>:BYTE<o>:COMPlete? SBUS<sb>:I3C:FRAMe<fr>:BYTE<o>:STARt? SBUS<sb>:CAN:FRAMe<fr>:SDATa? SBUS<sb>:CAN:FRAMe<fr>:SDEXport? SBUS<sb>:LIN:FRAMe<fr>:IDSTate? SBUS<sb>:SENT:FRAMe<fr>:COUNt SBUS<sb>:SENT:FRAMe<fr>:FCSValue? SBUS<sb>:SENT:FRAMe<fr>:FIDValue? SBUS<sb>:SENT:FRAMe<fr>:FPDValue? SBUS<sb>:SENT:FRAMe<fr>:FSYNc? SBUS<sb>:SENT:FRAMe<fr>:PDValue? SBUS<sb>:MILStd:WORD<w>:COUNt SBUS<sb>:RFFE:SEQuence<se>:ADDRess SBUS<sb>:RFFE:SEQuence<se>:BCOunt SBUS<sb>:RFFE:SEQuence<se>:BYTE<o>:FVALue SBUS<sb>:RFFE:SEQuence<se>:BYTE<o>:NAME SBUS<sb>:RFFE:SEQuence<se>:BYTE<o>:STATe SBUS<sb>:RFFE:SEQuence<se>:BYTE<o>:VALue SBUS<sb>:RFFE:SEQuence<se>:DATA SBUS<sb>:RFFE:SEQuence<se>:RBTRate SBUS<sb>:RFFE:SEQuence<se>:SADD SBUS<sb>:RFFE:SEQuence<se>:STARt SBUS<sb>:RFFE:SEQuence<se>:STATe SBUS<sb>:RFFE:SEQuence<se>:STOP SBUS<sb>:RFFE:SEQuence<se>:TYPE SBUS<sb>:RFFE:SEQuence<se>:WBTRate SBUS<sb>:RFFE:SEQuence<se>:WCOunt SBUS<sb>:TNOS:FRAMe<fr>:COUNt SBUS<sb>:TNOS:FRAMe<fr>:BYTE<o>:COUNt	-	No longer needed since FW 2.6

Legacy command	Replaced by	Comment
SBUS<sb>:SPI:FRAMe<fr>:COUNt?	SBUS<sb>:SPI:FCOunt?	Replaced since FW 2.6
SBUS<sb>:QSPI:FRAMe<fr>:DCOunt SBUS<sb>:QSPI:FRAMe<fr>:FLD<fl>:DVALue	SBUS<sb>:QSPI:FRAMe<fr>:FLDCount? SBUS<sb>:QSPI:FRAMe<fr>:FLD<fl>:VALue?	Replaced since FW 2.6
SBUS<sb>:I2C:FRAMe<fr>:BCOunt SBUS<sb>:I2C:FRAMe<fr>:BYTE<o>:STARt SBUS<sb>:I2C:FRAMe<fr>:BYTE<o>:VALue	SBUS<sb>:I2C:FRAMe<fr>:FLDCount? SBUS<sb>:I2C:FRAMe<fr>:FLD<fl>:STARt? SBUS<sb>:I2C:FRAMe<fr>:FLD<fl>:VALue?	Replaced since FW 2.6
SBUS<sb>:I3C:FRAMe<fr>:BCOunt	SBUS<sb>:I3C:FRAMe<fr>:FLDCount?	Replaced since FW 2.6
SBUS<sb>:UART:WORD<w>:COUNt?	SBUS<sb>:UART:WCOunt?	Replaced since FW 2.6
SBUS<sb>:CAN:FRAMe<fr>:BCOunt? SBUS<sb>:CAN:FRAMe<fr>:BYTE<o>:FVALue? SBUS<sb>:CAN:FRAMe<fr>:BYTE<o>:LABel? SBUS<sb>:CAN:FRAMe<fr>:BYTE<o>:STATe? SBUS<sb>:CAN:FRAMe<fr>:BYTE<o>:VALue? SBUS<sb>:CAN:FRAMe<fr>:COUNt?	SBUS<sb>:CAN:FRAMe<fr>:FLDCount? SBUS<sb>:CAN:FRAMe<fr>:FLD<fl>:FVALue? SBUS<sb>:CAN:FRAMe<fr>:FLD<fl>:LABel? SBUS<sb>:CAN:FRAMe<fr>:FLD<fl>:STATe? SBUS<sb>:CAN:FRAMe<fr>:FLD<fl>:VALue? SBUS<sb>:CAN:FCOunt?	Replaced since FW 2.6
SBUS<sb>:CAN:FRAMe<fr>:XDATa<o>:SBC	SBUS<sb>:CAN:FRAMe<fr>:SBC?	Replaced since FW 2.7
SBUS<sb>:LIN:FRAMe<fr>:BCOunt? SBUS<sb>:LIN:FRAMe<fr>:BYTE<o>:COUNt? SBUS<sb>:LIN:FRAMe<fr>:BYTE<o>:FVALue? SBUS<sb>:LIN:FRAMe<fr>:BYTE<o>:LABel? SBUS<sb>:LIN:FRAMe<fr>:BYTE<o>:STATe? SBUS<sb>:LIN:FRAMe<fr>:BYTE<o>:VALue? SBUS<sb>:LIN:FRAMe<fr>:COUNt?	SBUS<sb>:LIN:FRAMe<fr>:FLDCount? SBUS<sb>:LIN:FRAMe<fr>:FLDCount? SBUS<sb>:LIN:FRAMe<fr>:FLD<fl>:FVALue? SBUS<sb>:LIN:FRAMe<fr>:FLD<fl>:LABel? SBUS<sb>:LIN:FRAMe<fr>:FLD<fl>:STATe? SBUS<sb>:LIN:FRAMe<fr>:FLD<fl>:VALue? SBUS<sb>:LIN:FCOunt?	Replaced since FW 2.6
SBUS<sb>:SENT:FRAMe<fr>:NIBB<o>:STATe SBUS<sb>:SENT:FRAMe<fr>:NIBB<o>:VALue	SBUS<sb>:SENT:FRAMe<fr>:FLD<fl>:STATe? SBUS<sb>:SENT:FRAMe<fr>:FLD<fl>:VALue?	Replaced since FW 2.6
SBUS<sb>:ARINc:WORD<w>:COUNt?	SBUS<sb>:ARINc:WCOunt?	Replaced since FW 2.6
SBUS<sb>:SPMI:FRAMe<fr>:FDCount?	SBUS<sb>:SPMI:FRAMe<fr>:FLDCount?	Replaced since FW 2.6

Legacy command	Replaced by	Comment
SBUS<sb>:RFFE:FRAMe<fr>:BC? SBUS<sb>:RFFE:FRAMe<fr>:FDCount? SBUS<sb>:RFFE:FRAMe<fr>:FLD<fl>:LABel? SBUS<sb>:RFFE:FRAMe<fr>:RBRate? SBUS<sb>:RFFE:FRAMe<fr>:SA? SBUS<sb>:RFFE:FRAMe<fr>:STATus? SBUS<sb>:RFFE:FRAMe<fr>:WBRate? SBUS<sb>:RFFE:SEQuence<se>:SYMBol SBUS<sb>:RFFE:FRAMe<fr>:PADZero SBUS<sb>:RFFE:FRAMe<fr>:PADone SBUS<sb>:RFFE:FRAMe<fr>:PCTRl	SBUS<sb>:RFFE:FRAMe<fr>:BCOunt? SBUS<sb>:RFFE:FRAMe<fr>:FLDCount? SBUS<sb>:RFFE:FRAMe<fr>:FLD<fl>:NAME? SBUS<sb>:RFFE:FRAMe<fr>:RBTRate? SBUS<sb>:RFFE:FRAMe<fr>:SADD? SBUS<sb>:RFFE:FRAMe<fr>:STATe? SBUS<sb>:RFFE:FRAMe<fr>:WBTRate? SBUS<sb>:RFFE:FRAMe<fr>:SYMBol? SBUS<sb>:RFFE:FRAMe<fr>:PADZero? SBUS<sb>:RFFE:FRAMe<fr>:PADone? SBUS<sb>:RFFE:FRAMe<fr>:PCTRl?	Replaced since FW 2.6
SBUS<sb>:TNOS:FRAMe<fr>:BCOunt SBUS<sb>:TNOS:FRAMe<fr>:BYTE<o>:FVALue SBUS<sb>:TNOS:FRAMe<fr>:BYTE<o>:LABel SBUS<sb>:TNOS:FRAMe<fr>:BYTE<o>:STATe SBUS<sb>:TNOS:FRAMe<fr>:BYTE<o>:VALue	SBUS<sb>:TNOS:FRAMe<fr>:FLDCount? SBUS<sb>:TNOS:FRAMe<fr>:FLD<fl>:FVALue? SBUS<sb>:TNOS:FRAMe<fr>:FLD<fl>:LABel? SBUS<sb>:TNOS:FRAMe<fr>:FLD<fl>:STATe? SBUS<sb>:TNOS:FRAMe<fr>:FLD<fl>:VALue?	Replaced since FW 2.6

19 Maintenance and support

The instrument does not need periodic maintenance. Only the cleaning of the instrument is essential.

We advise to check the nominal data from time to time.

To protect the front panel and to transport the instrument to another workplace safely and easily, various accessories are provided. Refer to the specifications document for available covers and cases and their order numbers.

19.1 Cleaning

How to clean the product is described in "Cleaning the product" on page 26.

Do not use any liquids for cleaning. Cleaning agents, solvents, acids and bases can damage the front panel labeling, plastic parts and display.

19.2 Changing fuses

If the product does not start, it is possible that a blown fuse is the cause.

The product is protected by 2 fuses of type Size 5x20 mm, 250V~, T5H (slow-blow), IEC 60127-2 (order no. 0099.6735.00), order number 0099.6735.00.

1. **WARNING!** The fuse is part of the AC power supply. Handling the fuse while the power is on can lead to electric shock.

   Before changing the fuse:

   a) Set the switch on the power supply to position [0].
   b) Disconnect the product from the power source.

2. The fuse slot is on the rear panel between the mains switch and AC power supply connector.
   Pull out the fuse holder.

3. Check the condition of the fuse.

4. Replace the blown fuse. Only use a fuse of the specified type.

5. Insert the fuse holder into its slot until it latches.

19.3 Contacting customer support

Technical support – where and when you need it

For quick, expert help with any Rohde & Schwarz product, contact our customer support center. A team of highly qualified engineers provides support and works with you to find a solution to your query on any aspect of the operation, programming or applications of Rohde & Schwarz products.

Contact information

Contact our customer support center at www.rohde-schwarz.com/support, or follow this QR code:

Figure 19-1: QR code to the Rohde & Schwarz support page

19.4 Information for technical support

If you encounter problems that you cannot solve yourself, contact your Rohde & Schwarz support center, see Contacting customer support.

The support center finds solutions more quickly and efficiently, if you provide them with information on the instrument and an error description. To create, collect and save the required information, you can create a service report.

The service report is a ZIP file with a complete bug report, all relevant setup information, reporting and log files, alignment files, and the instrument configuration.

1. Open the "Settings" > "Maintenance" dialog.
2. Select the "Service" tab.
3. Tap "Create report".
   If a USB flash drive is connected, the report is saved on the USB flash drive. Otherwise, the report is saved in the user data folder `/home/storage/userData`.
4. Create a support ticket that describes the problem, and attach the report file.

See also: Section 5.7.5, "Service", on page 113.

19.5 Data security

If you have to send the instrument to the service, or if the instrument is used in a secured environment, consider the document "Instrument Security Procedures" that is delivered on the MXO 4 webpage.

19.6 Transporting

Lifting and carrying

See: "Lifting and carrying the instrument" on page 22

Packing

Use the original packaging material. It consists of antistatic wrap for electrostatic protection and packing material designed for the product.

If you do not have the original packaging, use similar materials that provide the same level of protection. You can also contact your local Rohde & Schwarz service center for advice.

Securing

When moving the MXO 4 in a vehicle or using transporting equipment, make sure that the MXO 4 is properly secured. Only use items intended for securing objects.

Transport altitude

Unless otherwise specified in the specifications document, the maximum transport altitude without pressure compensation is 4500 m above sea level.

19.7 Storage

Protect the product against dust. Ensure that the environmental conditions, e.g. temperature range and climatic load, meet the values specified in the specifications document.

19.8 Disposal

Rohde & Schwarz is committed to making careful, ecologically sound use of natural resources and minimizing the environmental footprint of our products. Help us by disposing of waste in a way that causes minimum environmental impact.

Disposing of electrical and electronic equipment

A product that is labeled as follows cannot be disposed of in normal household waste after it has come to the end of its life. Even disposal via the municipal collection points for waste electrical and electronic equipment is not permitted.

Figure 19-2: Labeling in line with EU directive WEEE

Rohde & Schwarz has developed a disposal concept for the eco-friendly disposal or recycling of waste material. As a manufacturer, Rohde & Schwarz completely fulfills its obligation to take back and dispose of electrical and electronic waste. Contact your local service representative to dispose of the product.

List of commands

Index