PicoScope® 9300 Series

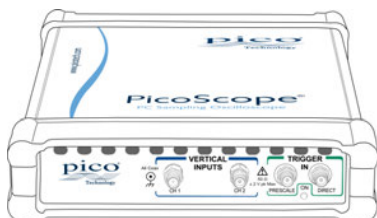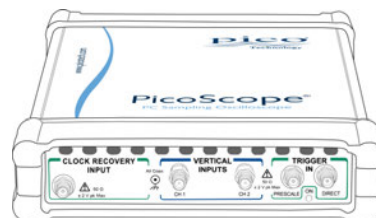## PC Sampling Oscilloscopes

User's Guide

1   Welcome

Thank you for buying a Pico Technology product!

The PicoScope 9300 Series of PC Sampling Oscilloscopes from Pico Technology is a range of wide-bandwidth compact units designed to replace traditional benchtop electrical sampling oscilloscopes costing many times the price.
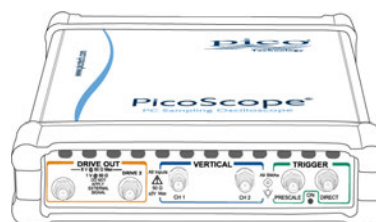
The PicoScope 9301
dual-channel sampling oscilloscope

The PicoScope 9302
dual-channel sampling oscilloscope
with 11.3 Gb/s recovery trigger
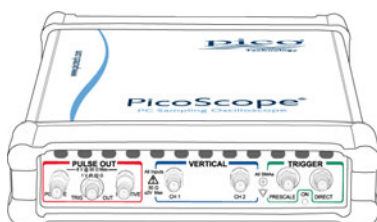
The PicoScope 9311
dual-channel sampling oscilloscope
with 60 ps 6 V differential TDR/TDT
(9311-20 shown)

The PicoScope 9312
dual-channel sampling oscilloscope
with 40 ps 200 mV differential TDR/TDT
(discontinued)
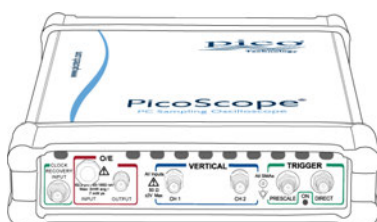
The PicoScope 9321
dual-channel electrical sampling
oscilloscope with 9.5 GHz optical to
electrical converter and 11.3 Gb/s clock
recovery
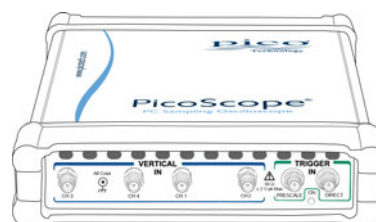
The PicoScope 9341
four-channel sampling oscilloscope

Here are some of the benefits provided by your new PicoScope 9300 PC Sampling Oscilloscope:

● **Portability.** Take the unit with you and plug it into any Windows PC.

● **Performance**
  - Two or four electrical channels with user-selectable bandwidth (reduced or full bandwidth).
  - Optical channel with typical unfiltered optical bandwidth of 9.5 GHz (PicoScope 9321).
  - 5 ps/div to 10 s/div timebase with sequential equivalent time, real time, random equivalent time and roll sampling modes.
  - More than 15 TS/s maximum hardware effective sampling rate (near 64 fs shortest sampling interval).
  - Industry-leading 1 MS/s sampling rate.
  - Up to 2.5 GHz full-function direct trigger, up to 15 GHz prescaled trigger.
  - Up to 11.3 Gbps/s clock recovery trigger (PicoScope 9302 and PicoScope 9321).
  - 60 ps / 6 V step generator with single-ended output (PicoScope 9311-15) or differential and deskewable outputs (PicoScope 9311-20).
  - 40 ps / 200 mV step generator with differential and deskewable outputs (PicoScope 9312).
  - Typical RMS noise less than 1.5 mV
  - RMS jitter less than 2 ps.
  - Up to 14 GHz pattern sync trigger with eye line mode for eye diagram averaging.
  - Internal direct trigger up to 100 MHz from channel 1 or channel 2.

● **Connectivity**
  - USB 2.0
  - LAN

● **Programmability**
  - ActiveX

● **Powerful built-in measurement capabilities.** High-resolution cursors and automatic Pulse, NRZ and RZ eye pattern measurements with statistics, histograms, automated mask test with predefined standard and custom masks, waveform processing including FFT, TDR/TDT measurements with normalization.

● **Applications.** Telecom service and manufacturing, digital system design, semiconductor characterization and testing, high-speed digital (pulse) measurements, TDR characterization of circuit boards and cables.

● **Flexibility.** Use it as a sampling oscilloscope, spectrum analyzer, communications signal analyzer or time domain reflectometer.

● **Long-term support.** Software upgrades are available to download from our website. You can also call our technical specialists for support. You can continue to use both of these services free of charge for the lifetime of the product.

● **Value for money.** You don't have to pay twice for all the features that you already have in your PC, as the PicoScope 9300 Series sampling scope contains only the special hardware you need and not the computer.

● **Convenience.** The software makes full use of the large display, storage, user interface and networking built in to your PC.

ps9300.en-13   4

2   Introduction

2.1   Overview

The **PicoScope 9300 Series** PC Sampling Oscilloscopes are wide-bandwidth sampling oscilloscopes for use with personal computers. They are fully USB 2.0 and 3.0 compatible. You can also communicate with the PicoScope 9300 over its built-in LAN interface.

The PicoScope 9300 Series scopes can be used as sampling oscilloscopes, electrical and optical communications signal analyzers, time domain reflectometers and spectrum analyzers.

For basic instructions on installing and using your oscilloscope, please refer to How to use your oscilloscope or the printed **Quick Start Guide** supplied with your instrument.

2.2   PicoScope 9300 Series models compared

	PicoScope 9300 Series model				
	9301	**9302**	**9311**	**9321**	**9341**
2 electrical inputs	•	•	•	•	
4 electrical inputs					•
Signal generator output	•	•	•	•	•
Integrated TDR/TDT (60 ps / 2.5 to 6 V)			•		
Add external PG900 TDR/TDT source	•	•	Optional*	•	•
9.5 GHz optical-electrical converter				•	
Clock recovery trigger		•		•	
Pattern sync trigger	•	•	•	•	•
USB port	•	•	•	•	•
LAN port	•	•	•	•	•
15 GHz models	9301-15	9302-15	9311-15		
20 GHz models	9301-20	9302-20	9311-20	9321-20	9341-20
25 GHz models	9301-25	9302-25			9341-25
30 GHz models	9301-30				9341-30
Discontinued 20 GHz models (still covered by this guide)	9301, 9302, 9312				

* You can use a PG900 external source in addition to the built-in TDR/TDT source.

2.3   Minimum PC requirements

For the oscilloscope to operate effectively it must be connected to a computer with these minimum requirements:

Processor	Pentium-class processor or equivalent
Memory	1 GB
Disk space	Software occupies about 50 MB
Operating system	Microsoft Windows XP (SP2), Windows Vista, Windows 7, Windows 8 (not Windows RT) or Windows 10. 32-bit and 64-bit versions.
Ports	USB 2.0 LAN

2.4   Safety information

To prevent possible electrical shock, fire, personal injury, or damage to the product, carefully read this safety information before attempting to install or use the product. In addition, follow all generally accepted safety practices and procedures for working with and near electricity.

The product has been designed and tested in accordance with the harmonized standard publication EN 61010-1:2010+A1:2019 (Safety Requirements for Electrical Equipment for Measurement, Control and Laboratory Use) and EN 61010-2-030: 2010 (Requirements for Testing and Measuring Circuits). The product left the factory in a safe condition.

The following safety descriptions are found throughout this guide:
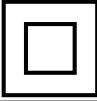
A **WARNING** identifies conditions or practices that could result in injury or death.

A **CAUTION** identifies conditions or practices that could result in damage to the product or equipment to which it is connected.

Each of these safety instructions applies to all of the 9000 Series oscilloscopes covered by this User's Guide, unless otherwise specified.

2.4.1 Symbols

These safety and electrical symbols may appear on the product or in this guide.

Symbol	Description
⎓	Direct current
∿	Alternating current
⏚	Earth (ground) terminal Terminal can be used to make a measurement ground connection. The terminal is not a safety or protective earth.
⏛	Chassis terminal
▣	Equipment protected through double insulation or reinforced insulation.
⚡	Possibility of electric shock
⚠	Caution Appearance on the product indicates a need to read these safety and operation instructions.
⚠	Static awareness. Static discharge can damage parts.
CAT	IEC 61010 overvoltage category
🗑	Do not dispose of this product as unsorted municipal waste

⚡ **WARNING**
To prevent injury or death use the product only as instructed. Protection provided by the product may be impaired if used in a manner not specified by the manufacturer.

2.4.2   Maximum input ranges

Observe all terminal ratings and warnings marked on the product.

The table below indicates the full scale measurement range and overvoltage protection range for each oscilloscope model. The full scale measurement ranges are the maximum voltages that can be accurately measured by each instrument. The overvoltage protection ranges are the maximum voltages that can be applied without damaging the oscilloscope.

WARNING
To prevent electric shock, do not attempt to measure voltages outside the specified full scale measurement range below.

Model	Full scale measurement range	Overvoltage protection		
		Input channels	**External trigger**	**Clock recovery trigger**
All PicoScope 9300 Series models	±1 V range 1 V pk-pk	±2 V	±2 V	±2 V

WARNING
Signals exceeding the voltage limits in the table below are defined as "hazardous live" by EN 61010. To prevent electric shock, take all necessary safety precautions when working on equipment where hazardous live voltages may be present.

Signal voltage limits of EN 61010		
±60 V DC	30 V AC RMS	±42.4 V pk max.

WARNING
To prevent injury or death, do not connect the oscilloscope directly to the mains (line power). To measure mains voltages, use a differential isolating probe specifically rated for mains use, such as the TA041 listed at www.picotech.com.

CAUTION
Exceeding the overload protection range on any connector can cause permanent damage to the oscilloscope and other connected equipment.

CAUTION
To prevent permanent damage, do not directly connect the high-voltage differential step generator of the PicoScope 9311 to channel inputs or other equipment. Do not remove the 20 dB pads fitted to the generator outputs, as they ensure the signal is reduced to safe levels. Do not replace the pads with smaller values unless safety is ensured by other test circuit losses and peak ratings.

2.4.3   Grounding

WARNING
The oscilloscope's ground connection through the USB cable is for measurement purposes only. The oscilloscope does not have a protective safety ground.

WARNING
Never connect the ground input (chassis) to any electrical power source. To prevent personal injury or death, use a voltmeter to check that there is no significant AC or DC voltage between the oscilloscope ground and the point to which you intend to connect it.

CAUTION
Applying a voltage to the ground input is likely to cause permanent damage to the oscilloscope, the attached computer, and other equipment.

CAUTION
To prevent measurement errors caused by poor grounding, always use the high-quality USB cable supplied with the oscilloscope.

2.4.4   External connections

WARNING
To prevent injury or death, only use the power cord and Pico approved adaptor supplied with the product. These are approved for the voltage and plug configuration in your country.

Power supply options and ratings				
PicoScope model	**USB connection**	**Ext DC power supply**		
		Voltage (V)	**Current (A pk)**	**Total power (W)**
All PicoScope 9300 Series oscilloscopes	USB 2.0. Compatible with USB 3.0.	12 V	1.7 A pk	21 W

WARNING
To prevent injury, ensure that light or laser light sources are extinguished during connection or disconnection to optical fiber inputs. Never direct an optical source towards a naked eye.

CAUTION
Take care to avoid mechanical stress or tight bend radii for all connected leads, including all coaxial leads, optical fiber and connectors. Mishandling will cause deformation of sidewalls, and will degrade performance and measurement accuracy.

2.4.5   Environment

WARNING
To prevent injury or death, do not use in wet or damp conditions, or near explosive gas or vapor.

CAUTION
To prevent damage, always use and store your oscilloscope in appropriate environments.

This product is for indoor or outdoor use, in dry locations only.

Please contact Pico technical support if you would like any advice on integrating a PicoScope into your own product or application.

	Storage	**Operating**
Temperature	−20 °C to +50 °C	+5 °C to +35 °C +15 to +25 °C (for quoted accuracy)
Humidity	Up to 95 %RH (non-condensing)	Up to 85 %RH at 35 °C (non-condensing)
Altitude	2000 m	
Pollution degree	2	

2.4.6   Care of the product

The product contains no user-serviceable parts. Repair, servicing and calibration require specialized test equipment and must only be performed by Pico Technology or an approved service provider. There may be a charge for these services unless covered by the Pico warranty.

WARNING
To prevent injury or death, do not use the product if it appears to be damaged in any way, and stop use immediately if you are concerned by any abnormal operations.

WARNING
When cleaning the product, use a soft cloth and a solution of mild soap or detergent in water. To prevent electric shock, do not allow liquids to enter the oscilloscope casing, as this will cause damage to the electronics or insulation inside.

CAUTION
Do not tamper with or disassemble the oscilloscope, connectors or accessories. Internal damage will affect performance.

CAUTION
Do not block the air vents at the back or front of the instrument as overheating will damage the oscilloscope.

CAUTION
Do not insert any objects through the air vents as internal interference will cause damage to the oscilloscope.

CAUTION
To prevent dirt ingress, fit dust caps to all unmated connectors, and remove them only during connection.

2.5   Software license conditions

The material contained in this release is licensed, not sold. Pico Technology grants a license to the person who installs this software, subject to the conditions listed below.

Access. The licensee agrees to allow access to this software only to persons who have been informed of these conditions and agree to abide by them.

Usage. The software in this release is for use only with Pico products or with data collected using Pico products.

Copyright. Pico Technology claims the copyright of, and retains the rights to, all material (software, documents etc.) contained in this release. You may copy and distribute the entire release in its original state, but must not copy individual items within the release other than for backup purposes.

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Fitness for purpose. As no two applications are the same, Pico Technology cannot guarantee that its equipment or software is suitable for a given application. It is your responsibility, therefore, to ensure that the product is suitable for your application.

Mission-critical applications. This software is intended for use on a computer that may be running other software products. For this reason, one of the conditions of the license is that it excludes use in mission-critical applications, for example life support systems.

Viruses. This software was continuously monitored for viruses during production, but you are responsible for virus-checking the software once it is installed.

Support. If you are dissatisfied with the performance of this software, please contact our technical support staff, who will try to fix the problem within a reasonable time. If you are still dissatisfied, please return the product and software to your supplier within 14 days of purchase for a full refund.

Upgrades. We provide upgrades, free of charge, from our web site at www.picotech.com. We reserve the right to charge for updates or replacements sent out on physical media.

2.6   Trademarks

Windows is a registered trademark or trademark of Microsoft Corporation, registered in the U.S. and other countries.

Pico Technology Limited and **PicoScope** are trademarks of Pico Technology Limited, registered in the United Kingdom and other countries.

PicoSample is a trademark of Pico Technology Limited.

PicoScope and **Pico Technology** are registered in the U.S. Patent and Trademark Office.

2.7   Warranty

Pico Technology **warrants** upon delivery, and for a period of 2 years unless otherwise stated from the date of delivery, that the Goods will be free from defects in material and workmanship.

Pico Technology shall not be liable for a breach of the warranty if the defect has been caused by fair wear and tear, willful damage, negligence, abnormal working conditions or failure to follow Pico Technology's spoken or written advice on the storage, installation, commissioning, use or maintenance of the Goods or (if no advice has been given) good trade practice; or if the Customer alters or repairs such Goods without the written consent of Pico Technology.

3   Product information

3.1   What do I get?

All PicoScope 9300 Series oscilloscope kits contain:

- PicoScope 9300 Series PC sampling oscilloscope
- PicoSample 3 software disc
- Quick start guide
- Power supply 12 V DC at 3.5 A, universal input
- Localized mains lead (line cord)

- USB 2.0 cable, 1.8 m
- SMA / PC3.5 / 2.92 wrench
- Storage and carry case
- LAN cable, 1 m

Some models are supplied with additional accessories:

Description	Order code	PicoScope model						
		9301	9302	9311		9312	9321	9341
				-15	-20			
18 GHz 50 SMA(m-f) connector saver adaptors (fitted to each input channel) [1]	TA170	•	•	•	•	•	•	•
30 cm precision sleeved coaxial cable	TA265			•	2	2		
10 dB 10 GHz SMA(m-f) attenuator (fitted to pulse outputs)	TA262		•				•	
20 dB 10 GHz SMA(m-f) attenuator (fitted to pulse outputs)	TA173			•	2			
40 ps tunnel diode head, rising edge	[2]					•		
40 ps tunnel diode head, falling edge	[2]					•		
60 cm 50 coaxial SMA(m-m) pulse drive cable	[2]					2		
18 GHz 50 N(f) - SMA(m) interseries adaptor (fitted to diode tunnel heads)	TA172					2		
14 GHz 25 ps TDR/TDT kit, including: • 18 GHz SMA(f) reference short • 18 GHz SMA(f) reference load	TA237			•	2	2		
14 GHz power divider kit, including: • 18 GHz 50 SMA(f-f-f) 3-resistor 6 dB power divider • 10 cm precision coaxial SMA(m-m) cable (x2)	TA238		•	•	2	2	•	

[1] Remove to interface PC3.5(m) connector directly in demanding applications. [2] Not available separately.

3.2   Optional accessories

Description	Order code	Contents
TETRIS® high-impedance 10:1 active probes	TA222	1.5 GHz 0.9 pF probe with accessory kit. 50　BNC(m) output, supplied with SMA adaptor
	TA223	2.5 GHz 0.9 pF probe with accessory kit. 50　SMA(m) output, supplied with BNC adaptor
PicoConnect 911	TA274	4 GHz ÷20 low-impedance AC RF and microwave passive probe
PicoConnect 912	TA275	4 GHz ÷20 low-impedance DC RF and microwave passive probe
PicoConnect 913	TA278	4 GHz ÷10 low-impedance AC RF and microwave passive probe
PicoConnect 914	TA279	4 GHz ÷10 low-impedance DC RF and microwave passive probe
PicoConnect 915	TA282	5 GHz ÷5 low-impedance AC RF and microwave passive probe
PicoConnect 916	TA283	5 GHz ÷5 low-impedance DC RF and microwave passive probe
PicoConnect 910 kit	PQ067	all six PicoConnect 910 probe heads with 2 cables
PicoConnect 921	TA272	6 GHz ÷20 low-impedance AC gigabit digital passive probe
PicoConnect 922	TA273	6 GHz ÷20 low-impedance DC gigabit digital passive probe
PicoConnect 923	TA276	7 GHz ÷10 low-impedance AC gigabit digital passive probe
PicoConnect 924	TA277	7 GHz ÷10 low-impedance DC gigabit digital passive probe
PicoConnect 925	TA280	9 GHz ÷5 low-impedance AC gigabit digital passive probe
PicoConnect 926	TA281	9 GHz ÷5 low-impedance DC gigabit digital passive probe
PicoConnect 920 kit	PQ066	all six PicoConnect 920 probe heads with 2 cables
Bessel–Thomson reference receiver filters.	TA120	51.8 Mb/s bit rate, 50　SMA(m-f) (OC1/STM0)
	TA121	155 Mb/s bit rate, 50　SMA(m-f) (OC3/STM1)
	TA122	622 Mb/s bit rate, 50　SMA(m-f) (OC12/STM4)
	TA123	1.250 Gb/s bit rate, 50　SMA(m-f) (GBE)
	TA124	2.488 Gb/s bit rate, 50　SMA(m-f) (OC48/STM16)/ 2.500 Gb/s bit rate, 50　SMA(m-f) (InfiniBand 2.5G)

For use with the PicoScope 9321 O/E converter, to reduce peaking and ringing. Choice of filter depends on the bit rate of the signal under analysis.

14 GHz 25 ps TDR/TDT kit	TA237	• 18 GHz SMA(f) reference short • 18 GHz SMA(f) reference load
14 GHz power divider kit	TA238	• 18 GHz 50　SMA(f-f-f) 3-resistor 6 dB power divider • 10 cm precision coaxial SMA(m-m) cable (x2)
Attenuators	TA181	3 dB attenuator 10 GHz 50　SMA(m-f)
	TA261	6 dB attenuator 10 GHz 50　SMA(m-f)
	TA262	10 dB attenuator 10 GHz 50　SMA(m-f)
	TA173	20 dB attenuator 10 GHz 50　SMA(m-f)
Interseries adaptor	TA172	18 GHz 50　N(f)-SMA(m)
Connector saver adaptor	TA170	50　SMA(m-f)
Coaxial cables	TA263	60 cm precision high-flex unsleeved coaxial cable, SMA(m-m) < 1.7 dB loss @ 10 GHz
	TA264	30 cm precision high-flex unsleeved coaxial cable, SMA(m-m) < 1.1 dB loss @ 10 GHz
	TA265	30 cm precision sleeved coaxial cable, SMA(m-m) < 1.1 dB loss @ 10 GHz

3.3   Connections

Standard oscilloscope connectors

The PicoScope 9300 Series oscilloscopes have 2.92 mm (K) connectors, compatible with both PC3.5 and SMA, on the vertical inputs. Use 2.92 mm or PC3.5 mating connectors to ensure stated high-frequency performance. Other RF connectors on the oscilloscope are SMA types.

The inputs have an impedance of 50 , so they are compatible with low-impedance oscilloscope probes having different attenuation or gain. If your probe has a BNC connector, use an SMA(m)-BNC(f) adaptor.

Connector diagrams
Front panels

**The PicoScope 9301
from left to right:**

- Channel 1 electrical input
- Channel 2 electrical input
- External prescaled trigger input
- External direct trigger input
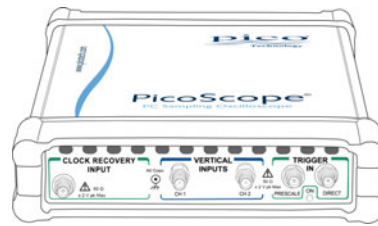
**The PicoScope 9302
from left to right:**

- Clock recovery trigger input
- Channel 1 electrical input
- Channel 2 electrical input
- External prescaled trigger input
- External direct trigger input
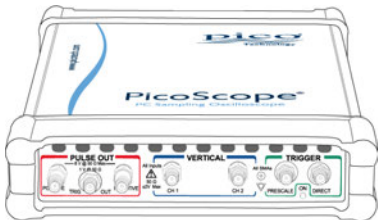
**The PicoScope 9311
from left to right:**

- Positive pulse output
- Trigger output
- Negative pulse output (9311-20 only)
- Channel 1 electrical input
- Channel 2 electrical input
- External prescaled trigger input
- External direct trigger input
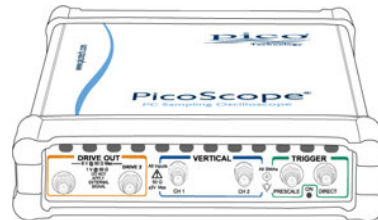
**The PicoScope 9312
from left to right:**

- Drive 1 output to tunnel diode head
- Drive 2 output to tunnel diode head
- Channel 1 electrical input
- Channel 2 electrical input
- External prescaled trigger input
- External direct trigger input
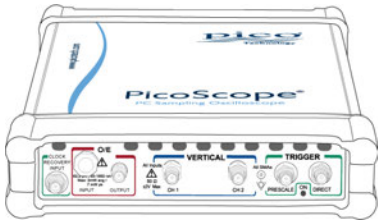
**The PicoScope 9321
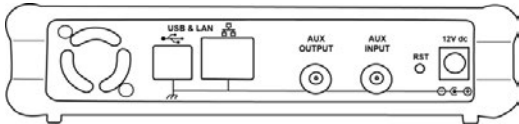from left to right:**

- Clock recovery trigger input
- Optical to electrical converter input
- Optical to electrical converter output
- Channel 1 electrical input
- Channel 2 electrical input
- External prescaled trigger input
- External direct trigger input
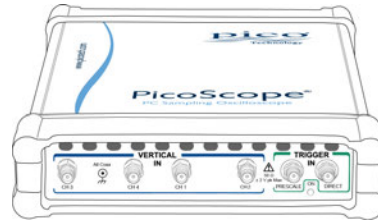
**The PicoScope 9341
from left to right:**

- Channel 3 electrical input
- Channel 4 electrical input
- Channel 1 electrical input
- Channel 2 electrical input
- External prescaled trigger input
- External direct trigger input

Rear Panel

**All PicoScope 9300 Series oscilloscopes
from left to right:**

- USB 2.0 port
- LAN port
- Auxiliary output
- Auxiliary input
- LAN reset switch
- Power socket: for use with the AC adaptor supplied with the unit

Air vents

There is a low-noise fan inside the unit which blows air through the holes on the back and front panels.

⚠ **CAUTION**
Do not block the air vents at the back or front of the instrument as overheating will damage the oscilloscope.

CAUTION
Do not insert any objects through the air vents as internal interference will cause damage to the oscilloscope.

4 How to use your oscilloscope

4.1 Connection diagrams

The following diagrams illustrate the various connection setups suitable for each model of 9300 Series oscilloscope.

Note: the arrangement of the front panel connectors varies between oscilloscope models. Always check the labels on the front panel of your scope before connecting any equipment.
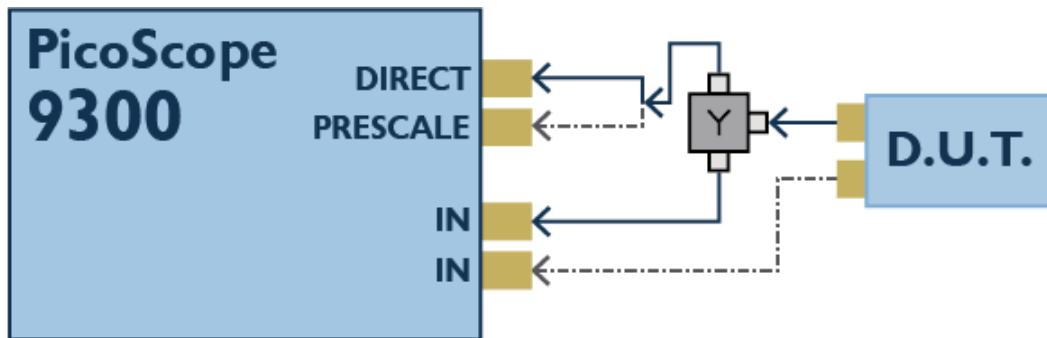

**Basic setup for all 9300 Series PicoScopes**
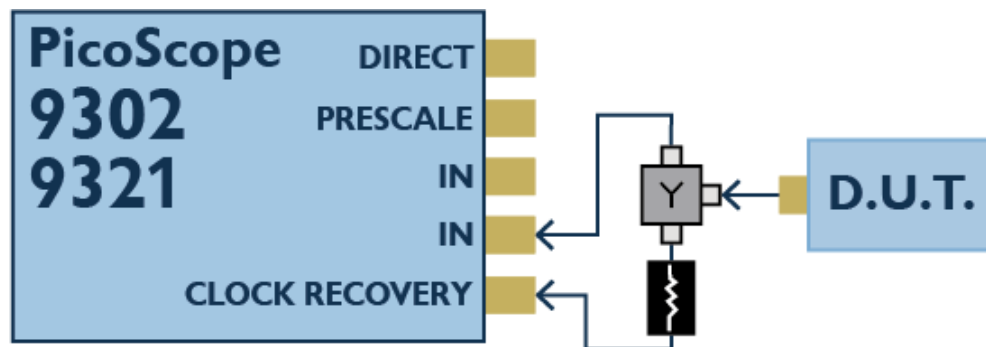
Clock recovery setup for PicoScope 9302 and 9321, single-ended data

Clock recovery locks a synthesized clock to a serial data stream, averaging out any jitter to define the expected data transition points. The recovered clock is used as the oscilloscope trigger.

The 50 ohm symmetrical power divider and coaxial attenuator should have at least 18 GHz bandwidth. The attenuator reduces a small logic reflection that can interfere with the signal being measured.
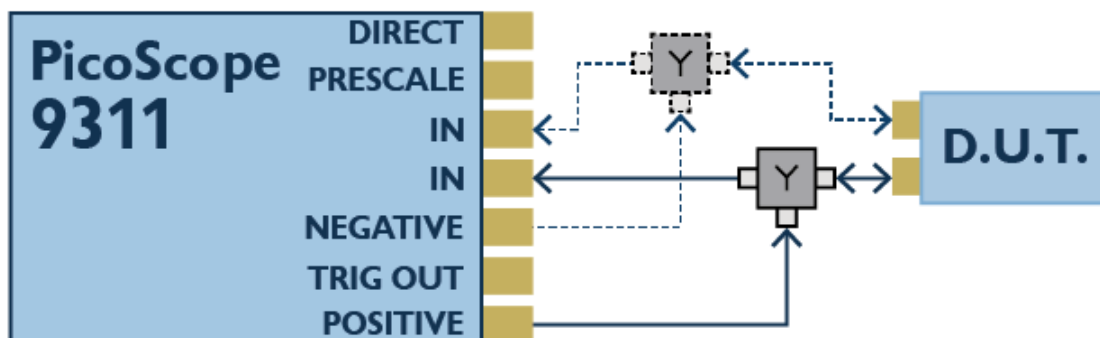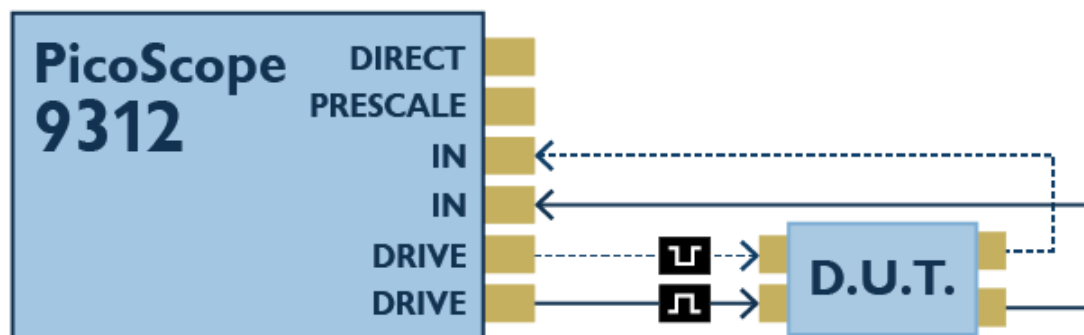

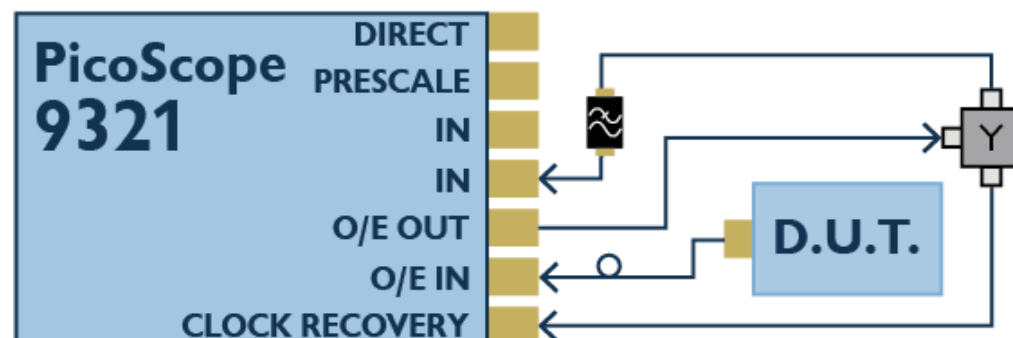**PicoScope 9311 TDR single-ended (both models) and differential (9311-20 only) setups**
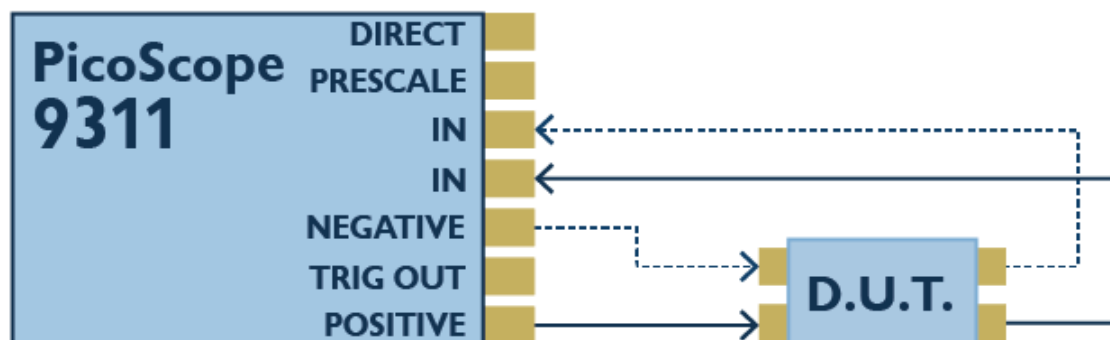
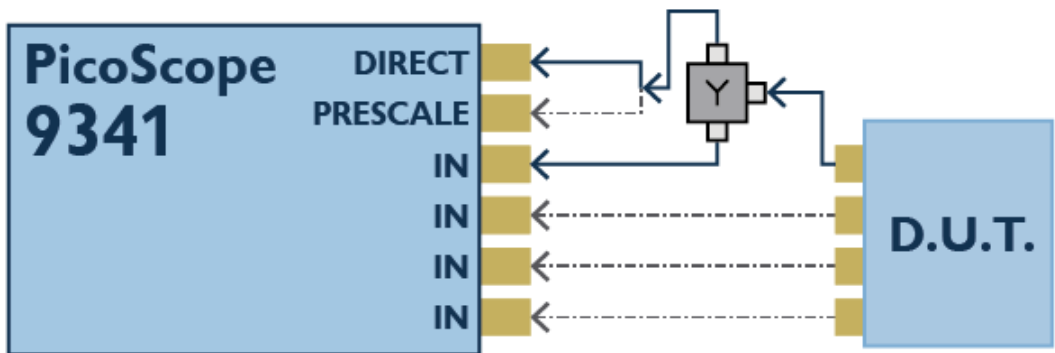**PicoScope 9311 TDT single-ended (both models) and differential (9311-20 only) setups**
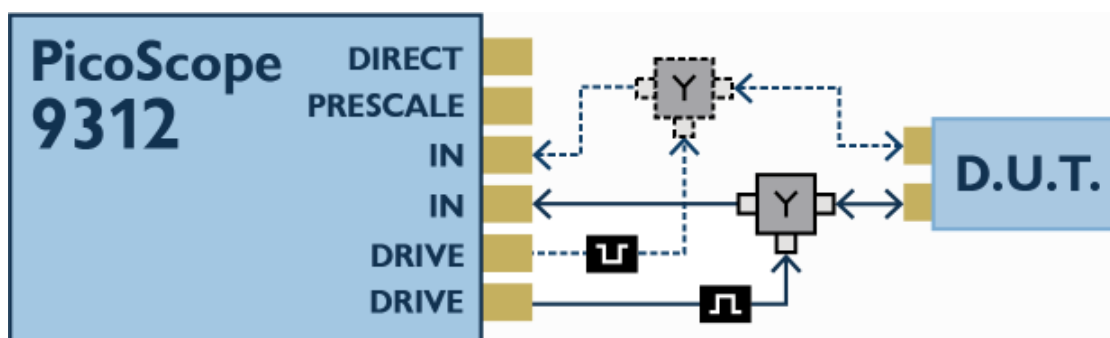
PicoScope 9312 TDR single-ended and differential setups

PicoScope 9312 TDT single-ended and differential setups

PicoScope 9321 optical input setup

PicoScope 9341 setup

|				
--------	Differential connection		Positive pulse head	
--·--·--·	Alternative connection		Negative pulse head	
	Optical connection		Low-pass filter *(optional)*	
	Divider		3 dB attenuator *(optional)*	

Diagram key

 CAUTION
Take care to avoid mechanical stress or tight bend radii for all connected leads, including all fiber and connectors for the optical fiber input on the PicoScope 9321. Mishandling will cause deformation of sidewalls, and will degrade performance and measurement accuracy.

CAUTION
To prevent permanent damage, do not directly connect the high-voltage differential step generator of the PicoScope 9311 to channel inputs or other equipment. Do not remove the 20 dB pads fitted to the generator outputs, as they ensure the signal is reduced to safe levels. Do not replace the pads with smaller values unless safety is ensured by other test circuit losses and peak ratings.

4.2   Getting started with the software

In this example we will use the oscilloscope's built-in pulse generator (labeled *Aux Out*, on the rear panel) as the signal source.

For information on installing the PicoSample 3 software, please refer to the printed **Quick Start Guide** supplied with your instrument.
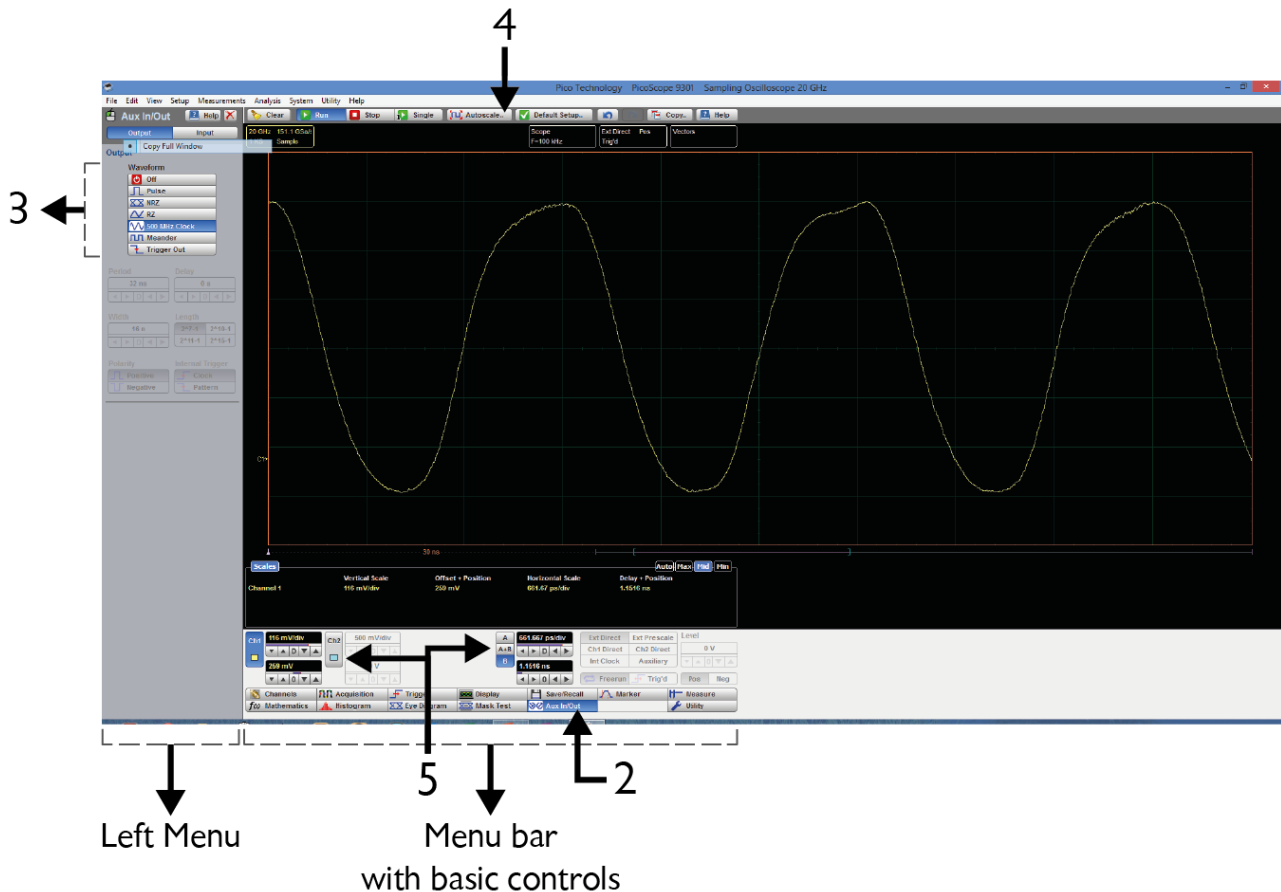
1. Connect the *Aux Out* to Channel 1.

2. Click **Aux In/Out** on the bottom menu bar. A new menu will appear on the left.

3. Select **Pulse**, **NRZ**, **RZ**, or **500 MHz Clock** from the left-hand menu.

4. Select **Autoscale** from the top menu bar.

5. Adjust the basic amplitude and timebase controls.

You have now captured your first waveform using the PicoScope 9300 Series Sampling Oscilloscope!

## 4.3   Adding measurements
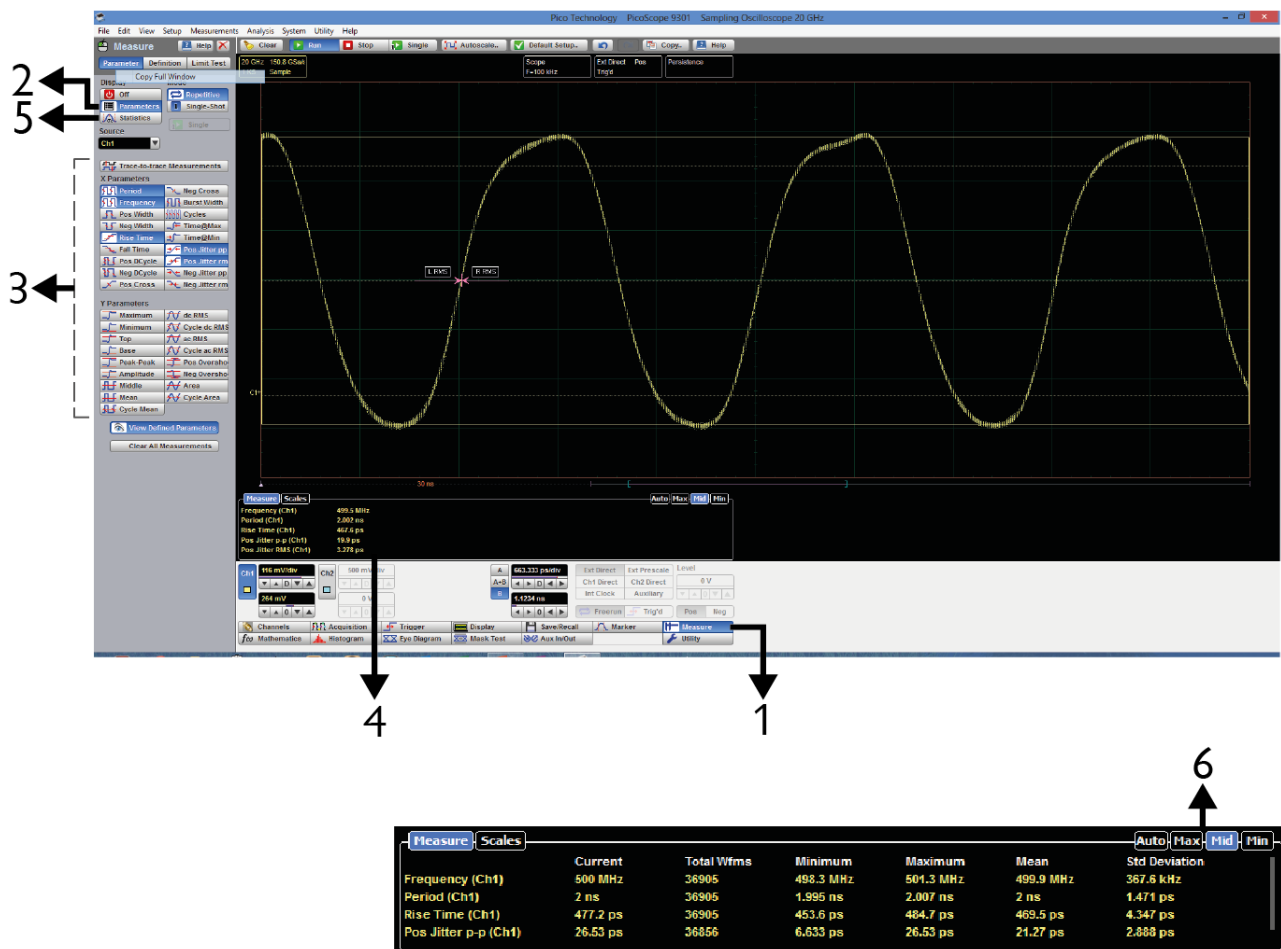
1. With the **500 MHz Clock** waveform chosen, select **Measure** from the bottom menu bar.

2. Select **Parameters** from the left-hand menu.

3. Select up to 10 defined parameters.

4. You can then view the results in the **Measurement** area beneath the waveform.

5. Select **Statistics** from the left-hand menu for a wider numeric perspective.

6. Resize the **Measurement** area by selecting the **Min**, **Mid**, **Max**, and **Auto** tabs. Each **Measurement** area tab displays different data sets.

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4.4   Configuring the display
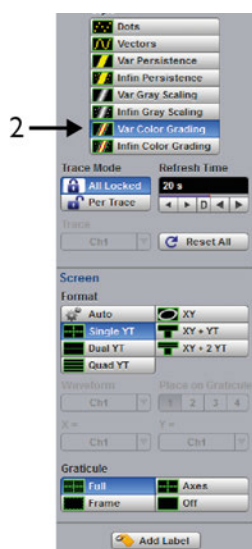
1. With the NRZ waveform chosen, select **Display** from the bottom menu bar.

2. Select **Var Color Grading** from the left-hand menu.
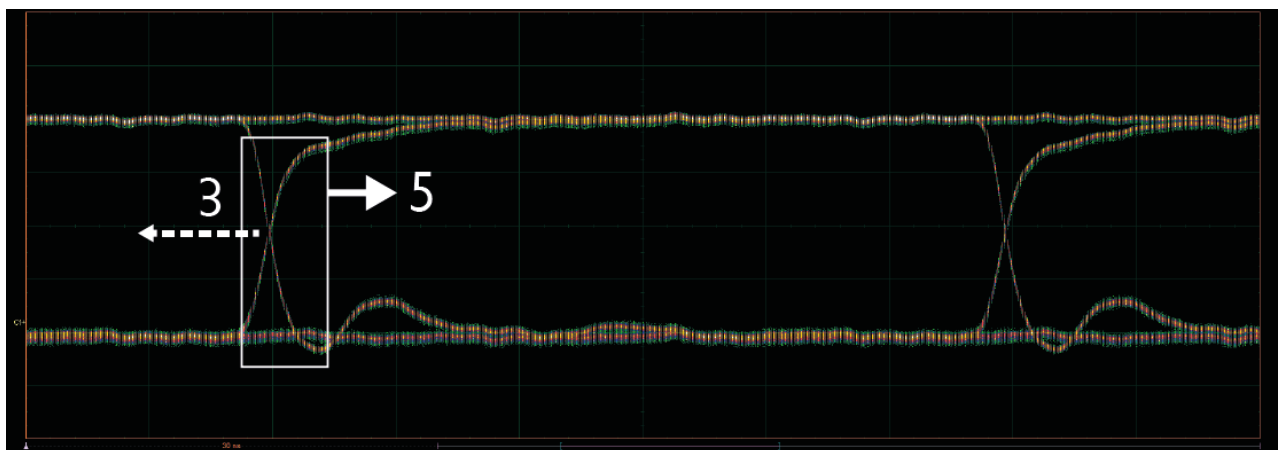
3. Click on the waveform and drag it to the left.

4. Set a faster timebase using the basic controls.

OR

5. Click outside the waveform to drag out a zoom window.

6. Click to zoom. A second 'B' timebase starts and is displayed.
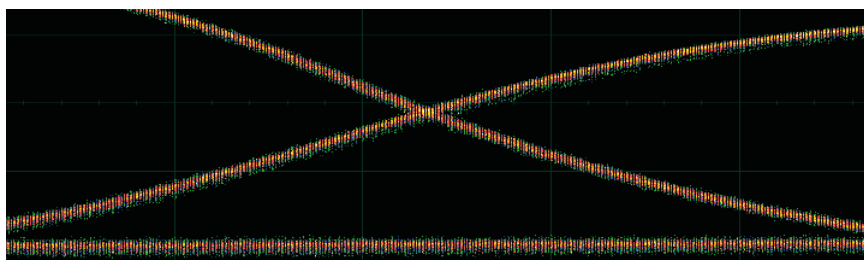
4.5   Touchscreen operation

PicoSample 3 includes enhancements for easier operation on touchscreen devices. Tap for a left-click and hold for a right-click. To zoom in, drag across the screen to draw a box, then tap inside it. You can also use the touchscreen to move traces and cursors, to position trace markers and to set and adjust the data capture area for histograms.

On the menu bar, tap **View > Touch Screen** to open the touch-friendly enlarged parameter control to the right of the main control panel. This lets you make fine adjustments to whichever parameter control is currently highlighted, either by pressing the increment buttons or by dragging the purple bar.

If you prefer, you can set the enlarged controls to float in a separate window.

The image below shows PicoSample 3's touchscreen support in action: the box defining the histogram was drawn by hand, and the enlarged parameter control is being used to control the Channel 1 voltage scale.
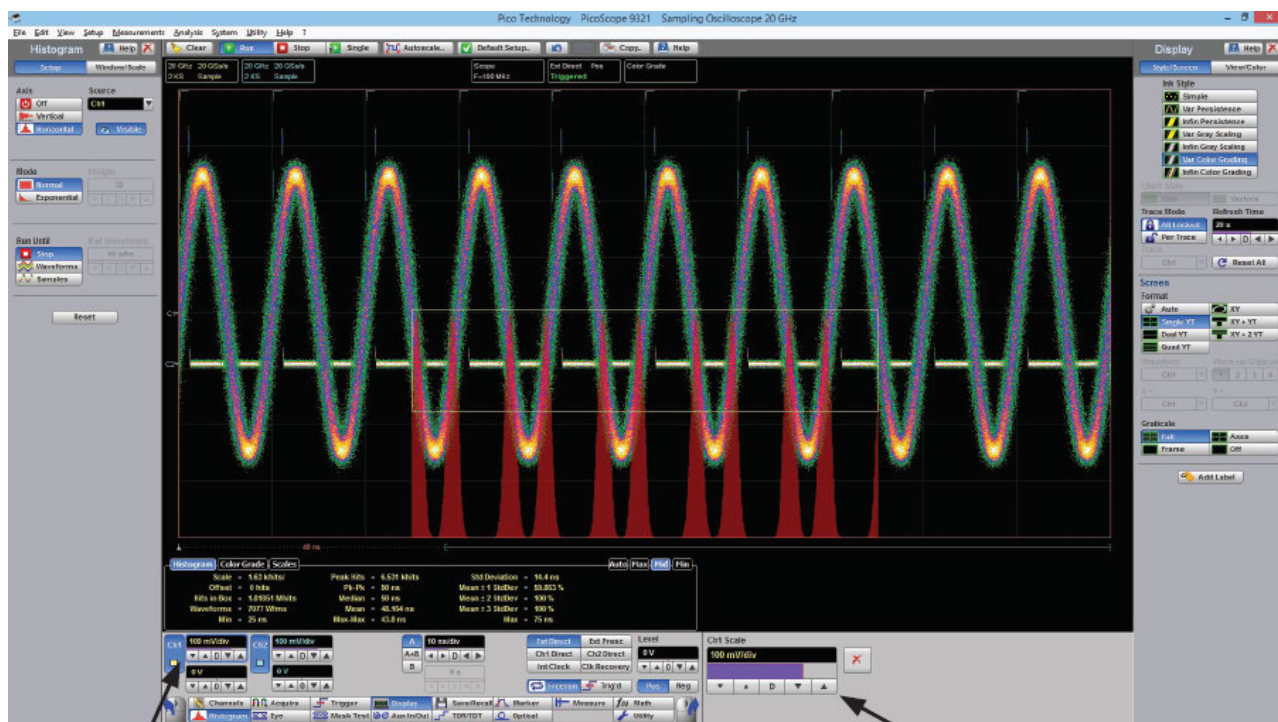
The Channel 1 voltage scale control is active (and highlighted in blue), but the buttons and the parameter overview bar are too small for easy use with the touch screen.

The enlarged parameter control has larger buttons and a much broader parameter overview bar.

4.6   Connecting using the LAN interface

Factory settings for the PicoScope 9300 Series

Current interface: USB
MAC address: See the underside of your scope.
IP address: 192.168.0.221
Subnet Mask: 255.255.255.0
Gateway: 192.168.1.27

To change the settings of the LAN interface, you must first configure the oscilloscope and then the PicoSample 3 software.

4.6.1   Configuring the oscilloscope for LAN and USB interfaces

Changing the IP properties of a PicoScope 9300 Series oscilloscope

The easiest way to change the IP properties is through the USB interface.

1.   The USB interface is the factory default. If your scope is currently set to LAN, first follow the **Set the current interface to USB** instructions below.
2.   Connect the scope to your PC using the USB cable provided.
3.   Turn on the scope.
4.   Run the PicoSample 3 software.
5.   Right click on **Help > About.. > TCP/IP Properties** to open the **TCP/IP Properties** dialog.
6.   Click **Set New TCP/IP Properties**.
7.   Enter in the new IP properties and click **Store**.

Set the current interface to LAN

1.   Turn off the scope.
2.   Press and hold the **RST** button on the rear panel of the scope.
3.   Turn on the scope.
4.   Release the **RST** button.
5.   The front-panel LED will slowly alternate between red and green. To select the LAN interface, press and release the **RST** button whilst the LED is red.
6.   After setting the current interface to LAN, you must instruct PicoSample 3 to use its LAN port. See Configuring the software for LAN and USB interfaces.

Set the current interface to USB

1.   Turn off the scope.
2.   Press and hold the **RST** button on the rear panel of the scope.
3.   Turn on the scope.
4.   Release the **RST** button.
5.   The front-panel LED will slowly alternate between red and green. To select the USB interface, press and release the **RST** button whilst the LED is green.

Switch-on sequence with a LAN interface

1.   Turn off the scope.
2.   Connect the LAN connector on the rear panel of the unit to the Local Area Network (LAN).
3.   Turn on the scope.
4.   Run the PicoSample 3 software.

Note: There is no order of switching when using a USB interface.

LED indications

The front-panel LED continually indicates the status of your scope, and may assist if you encounter difficulty when changing the control interface.

LED with a LAN interface

|	
Red, flashes for approximately 1 s	Scope connected to LAN, but PicoSample 3 software is not running.
Green, steady	Scope is working and addressing this device correctly. The PicoSample 3 software is running.
Red and green alternating, flashes for approximately 1.5 s	Scope was not connected to the LAN before it was turned on. Turn off the power and connect the LAN.

LED with a USB interface

Red, steady	Scope is not connected to PC or PC device driver is not installed. Connect the device to the PC or install the PicoSample 3 software.
Green, steady	Scope is working and addressing this device correctly. The PicoSample 3 software is running.

4.6.2 Configuring the software for LAN and USB interfaces

Once the oscilloscope has been set up, configure the PicoSample 3 software by following these instructions.

The **Measurement System** dialog enables you to set up a system that may include up to eight PicoScope 9300 Series oscilloscopes connected via LAN, and an additional one connected via USB.

1.   Start the PicoSample 3 software.
2.   Select **System** > **Measurement System** from the top menu bar.
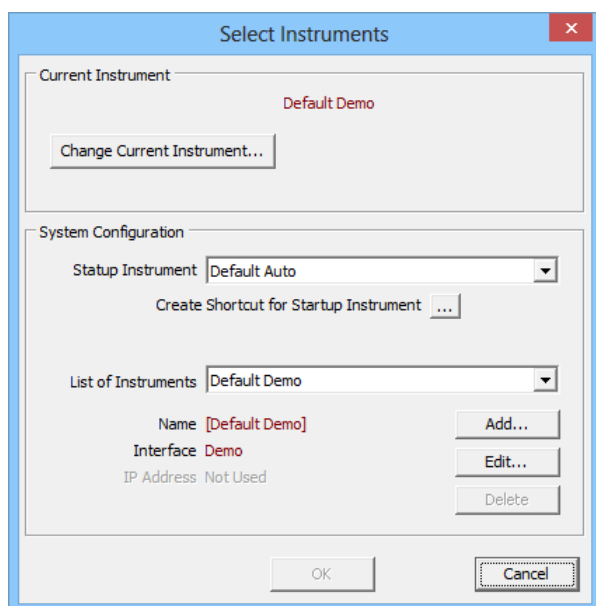
This dialog includes two panels:
- **Current Instrument**
- **System Configuration**

Current Instrument panel

To switch between the existing defined instrument connections:

1.   Click the **Change Current Instrument** button.
2.   Select your chosen instrument from the available list. After restarting, the PicoSample 3 software will automatically start with the selected instrument.
3.   Click the **OK** button from the **Measurement System** dialog.
4.   Click **Yes** from the **Confirm** dialog.

System Configuration panel

The System Configuration panel allows you to add new devices and make changes to existing connections.

The PicoSample 3 software includes three instruments by default:

Default Demo   A virtual instrument using the demonstration signal generator, for tutorial purposes.

Default LAN   The 9300 Series oscilloscope with LAN as the current selected interface. The factory LAN settings are shown at the start of this section.

Default USB   The 9300 Series oscilloscope with USB as the current selected interface.

- **Startup Instrument**

This list allows you to choose the instrument that will be used by default when the PicoSample 3 software starts.
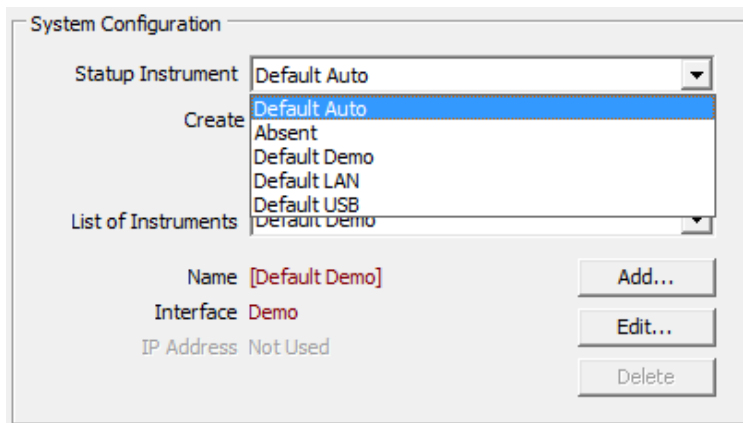
Default Auto   A connection is automatically made with the PicoScope 9300 via USB or LAN with default settings. If the connection fails, the software will revert to working in demo mode.

Absent   No automatic connection is made.

Default Demo   The software starts in demo mode using the demonstration signal generator.

Default LAN   A connection is made with the PicoScope 9300 via LAN with default settings.

Default USB   A connection is made with the PicoScope 9300 via USB with default settings.

Any other instruments connected via LAN or USB are also available in this menu.

- **Create Shortcut for Startup Instrument**

Click this button to add a shortcut for the chosen device to your desktop.
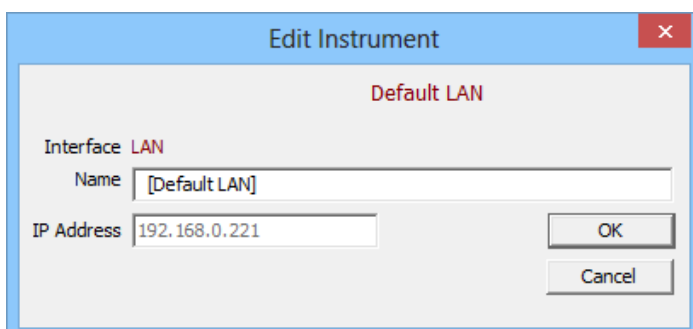
- **List of Instruments**

This list allows you to select an existing device to edit or delete. Note: you cannot delete the default instruments.

- **Add**

See [Installing a new LAN instrument](#).

- **Edit**

Click this button to open the **Edit Instrument** dialog and change the name or IP address for the selected device.
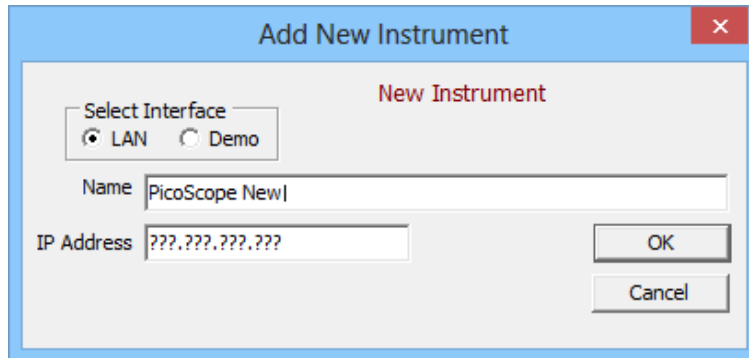

- **Delete**

Click this button to delete the selected device.

4.6.2.1   Installing a new LAN instrument

1.   Run the PicoSample 3 software in **Demo** mode.
2.   Select **System > Measurement System** from the top menu bar.
3.   Click the **Add** button.

4.   Make sure **LAN** is selected under **Select Interface**.
5.   Enter a name for your new instrument.
6.   Enter the IP address for your new instrument.
7.   Click **OK** on the **Add New Instrument** and **Measurement System** dialogs.
8.   Click **Yes** from the confirm dialog.

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5   Specifications and characteristics

Except where otherwise noted, the following specifications describe guaranteed performance within ±2 °C of the most recent auto-calibration temperature. All specifications apply after the instrument's temperature has been stabilized after 1 hour of continuous operation.

Many performance parameters are enhanced through simple automated calibrations driven by time interval or change of temperature.

Specifications marked as **typical** are not guaranteed, but indicate the performance that most units will exhibit.

For optimum performance, the instrument should have a complete verification of specifications and possible adjustment once every 12 months.

All specifications are subject to change without notice.

5.1   Electrical channels

Number of electrical channels	PicoScope 9301, 9302, 9311, 9312, and 9321, any bandwidth: Two channels. PicoScope 9341, any bandwidth: Four channels.
Number of dual-channel samplers	PicoScope 9301, 9302, 9311, 9312, and 9321, any bandwidth: One sampler. PicoScope 9341, any bandwidth: Two samplers.
Electrical channel bandwidth, 3 dB flatness	
Full bandwidth	PicoScope 9300 Series -15 models: DC to 15 GHz. PicoScope 9300 Series -20 models: DC to 20 GHz. PicoScope 9300 Series -25 models: DC to 25 GHz. PicoScope 9300 Series -30 models: DC to 30 GHz.
Middle bandwidth	PicoScope 9300 Series -30 models: DC to 20 GHz.
Narrow bandwidth	PicoScope 9300 Series -15 models: DC to 8 GHz. PicoScope 9300 Series -20 models: DC to 10 GHz. PicoScope 9300 Series -25 models: DC to 12 GHz. PicoScope 9300 Series -30 models: DC to 10 GHz.
Transition time, 10% to 90%	Calculated from $T_R = 0.35/BW$
Full bandwidth	PicoScope 9300 Series -15 models: 23.4 ps. PicoScope 9300 Series -20 models: 17.5 ps. PicoScope 9300 Series -25 models: 14.0 ps. PicoScope 9300 Series -30 models: 11.0 ps.
Middle bandwidth	PicoScope 9300 Series -30 models: 17.5 ps.
Narrow bandwidth	PicoScope 9300 Series -15 models: 43.8 ps. PicoScope 9300 Series -20 models: 35.0 ps. PicoScope 9300 Series -25 models: 29.2 ps. PicoScope 9300 Series -30 models: 35.0 ps.
RMS noise	
Full bandwidth	PicoScope 9300 Series -15 models: <1.6 mV, maximum, <1.2 mV, typical. PicoScope 9300 Series -20 models: <2.0 mV, maximum, <1.5 mV, typical. PicoScope 9300 Series -25 models: <2.5 mV, maximum, <1.9 mV, typical. PicoScope 9300 Series -30 models: <2.6 mV, maximum, <2.0 mV, typical.
Middle bandwidth	PicoScope 9300 Series -30 models: <2.0 mV, maximum, <1.5 mV, typical.
Narrow bandwidth	PicoScope 9300 Series -15 models: <0.9 mV, maximum, <0.7 mV, typical. PicoScope 9300 Series -20 models: <1.1 mV, maximum, <0.8 mV, typical. PicoScope 9300 Series -25 models: <1.3 mV, maximum, <1.0 mV, typical. PicoScope 9300 Series -30 models: <1.1 mV, maximum, <0.8 mV, typical.

	Note 1: Averaging reduces noise, until a system limitation of approximately 100 µV RMS is reached. Note 2: In the Best Flatness mode digitizing rate decreases approximately 2 times. Note 3: In the Best Flatness mode maximum RMS noise increases approximately √2 times.
Scale factors (sensitivity)	1 mV/div to 500 mV/div (full scale is 8 divisions). Adjustable in a 1-2-5-10 sequence. Also adjustable in 0.5% fine increments or better.
DC voltage accuracy	± 2% of full vertical scale ± 2 mV at a temperature within ± 3°C of vertical calibration temperature
DC offset range	Adjustable from −1.000 V to 1.000 V in 10 mV increments (coarse). Also adjustable in fine increments of 0.2 mV. Referenced to the center of display graticule.
Position	Adjustable from −5 to +5 major divisions in 0.25 major division increments (coarse). Also adjustable in fine increments of 0.01 major division.
Best Flatness	The sampler used has some passive feed-through, which can be corrected by a compensation circuit. A small amount of feed-through will remain after compensation, causing slight non-flatness in a step response. The Best Flatness control further improves flatness. This is done by taking a sample with the samplers turned on and then again with the samplers turned off. The two results are then subtracted thereby removing residual non-flatness.
ADC	16 bits
Hardware vertical resolution	40 µV/LSB without averaging.

Operating input voltage	With Digital Feedback (Single-valued signal acquisition): 1 V p-p at ± 1 V range.
	Without Digital Feedback (Multi-valued signal acquisition):
	   ± 400 mV relative to the channel offset for PicoScope 9300 Series -15, -20 and 25 models.
	   ± 300 mV relative to the channel offset for PicoScope 9300 Series -30 models.

Maximum safe input voltage	16 dBm, or ± 2 V (DC + peak AC)
Nominal input impedance	(50 ± 1)
Reflections from inputs	9% maximum for 30 ps rise time
Input connectors	2.92 mm (K) female, SMA-compatible
Input connector torque	0.45 Nm or 4 in-lb
Deskew	SW controls the difference in delay between channels. Can be nulled out with 1 ps resolution to compensate for differences in input cables or probe length. Up to 100 ns of skew can be nulled out.
Delay within channel pairs	± 2 ps maximum (Ch1 to Ch2, or Ch3 to Ch4)
Delay between channel pairs	± 2 ps maximum (Ch1/Ch2 pair to Ch3/Ch4 pair)

Sampler delay	Hardware controls delay in each sampler (for PicoScope 9341 only). Adjustable from 0 ns to 2.048 ns with 1 ps resolution. When sampler delays for both samplers are fixed on 0 ns, the Ch3/Ch4 sampler lags from Ch1/Ch2 sampler approximately on 1.5 ns.
Attenuation	Attenuation factors may be entered to scale the oscilloscope for external attenuators connected to the channel inputs.
Range	0.0001:1 to 1 000 000:1
Units	Ratio or dB
Scale	Volt, Watt, Ampere, or Unknown.
Channel-to-channel isolation	> 45 dB for input frequency DC to 8.5 GHz, > 35 dB for input frequency > 8.5 GHz to 12 GHz, > 30 dB for input frequency > 12 GHz to 20 GHz.

5.2   Optical channel (PicoScope 9321 only)

Unfiltered Optical Bandwidth	DC to 9.5 GHz typical. DC to 9 GHz guaranteed @ Full Electrical Bandwidth.
Effective Wavelength Range	750 nm to 1650 nm
Calibrated wavelengths	850 nm (MM), 1310 nm (MM/SM), 1550 nm (SM)
Transition time (10% to 90% calculated from $T_R = 0.48/BW$ optical)	51 ps, typ; 54 ps, max
RMS noise, maximum	4 µW (1310 & 1550 nm), 6 µW (850 nm) @ Full Electrical Bandwidth.
Scale Factors (Sensitivity)	1 µV/div to 400 µV/div (full scale is 8 divisions)
DC Accuracy, typical	±25 µW ±10% of full vertical scale
Maximum input peak power	+7 dBm (1310 nm)
Fiber Input	Single-mode (SM) or Multimode (MM)
Fiber input connector	FC/PC
Input Return Loss	SM: −24 dB typical MM: −16 dB typical, −14 dB maximum
Optional Filter Data Rates	51.8 Mb/s (OC1/STM0) 155 Mb/s (OC3/STM1) 622 Mb/s (OC12/STM4) 1.250 Gb/s (GBE) 2.488 Gb/s (OC48/STM16) 2.500 Gb/s (InfiniBand 2.5 G)

5.3   Sampling modes

Scope mode

In **Sequential Equivalent Time** mode the oscilloscope acquires one sample per external trigger independent of timebase settings. When a trigger is detected, a sample is taken after very short but well-defined delay. When the next external trigger occurs, a small time increment is added to this delay and the sampler takes another sample.

The oscilloscope generates the programmable delay using the internal triggerable oscillator.

TDR/TDT mode

In this variant of **Sequential Equivalent Time** mode the oscilloscope also acquires one sample per internal trigger independent of timebase settings.

The oscilloscope generates the programmable delay using the internal precise clock oscillator.

Eye

In another variant of **Sequential Equivalent Time** mode the oscilloscope also acquires one sample per external divided clock trigger independent of timebase settings.

The oscilloscope generates the programmable delay using an external clock. This mode is used for low-jitter applications on long time delays.

Random

In **Random Equivalent Time** mode the oscilloscope takes a few samples with each trigger event and eventually obtains enough samples to construct a waveform record. The instrument takes samples independent of the trigger position and displays them based on the time difference between the sample and the trigger.

Use **Random Equivalent Time** mode on repetitive signals. **Random Equivalent Time** mode lets you acquire repetitive waveforms at sample rates much higher than the base analog-to-digital converter sample rate. Random Equivalent time sampling is generally not useful for acquiring time-varying, random, or single-shot events. In this mode, sampling begins when the timebase setting (horizontal scale) is too fast to let the instrument get enough samples with which to create a waveform record using real-time sampling.

Real Time

In **Real Time** mode, the instrument acquires all the points in a waveform record after one trigger event.

Roll

Roll mode lets you see acquired data without waiting for the acquisition of a complete waveform record. It gives you immediate feedback. For slow timebase settings, Roll mode provides a rolling display similar to a strip-chart recorder.

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5.4   Timebase (Horizontal)

Timebase mode	Main, Intensified, Delayed. Available for any of the Sequential Equivalent Time sampling modes.
Scale factors	Full scale is 10 divisions
Sequential equivalent time	
Main timebase	5 ps/div to 3.2 ms/div Adjustable in a 1-2-5-10 sequence. Also adjustable in 0.1% fine increment or better.
Delayed timebases	5 ps/div to current Main Timebase setting. Adjustable in a 1-2-5-10 sequence. Also adjustable in 0.1% fine increments.
Random equivalent time	10 ns/div to 50 us/div. Adjustable in a 1-2-5-10 sequence.
Real time	2 us/div to 100 ms/div. Adjustable in a 1-2-5-10 sequence.
Roll	200 ms/div to 10 s/div. Adjustable in a 1-2-5-10 sequence.
Delta time interval accuracy	Sequential Equivalent Time: For >200 ps/div: ±0.2% of Delta Time Interval ± 10 ps. For =200 ps/div: ± 10 ps or ± 1% of Delta Time Interval ± 3 ps, whichever is smaller. Note 1: At a temperature within ± 2°C of horizontal calibration temperature. Note 2: The timebase uses a series of near 2 ns blocks. Timebase linearity and small discontinuities across these blocks contribute to the 10 ps accuracy specification. Random Equivalent Time: ±0.2% ± 4 ps of Delta Time Interval or Full Horizontal Scale, whichever is greater. Real Time: ±0.2% of Delta Time Interval or Full Horizontal Scale, whichever is greater.
Variable delay	Sequential Equivalent Time: Up to 10 000 screen widths of Delayed Timebase or 31.9968 ms, whichever is smaller. Random Equivalent Time and Real Time: Up to 8 s in a 1 μs sequence.
Pre-trigger position	Random Equivalent Time and Real Time: 10 div
Minimum delay	Sequential Equivalent Time: 30 ns typical for dual-channel models (PicoScope 9301, 9302, 9311, 9312 and 9321). 31.5 ns typical for four-channel model (PicoScope 9341).
Display units	Sequential Equivalent Time: Time or Bit Period
Time interval resolution	Sequential Equivalent Time: ≤(screen width) / (record length) or approximately 64 fs, whichever is larger. Random Equivalent Time: 4 ns min. Real Time: 1 μs min. Note: The time interval resolution is the smallest time you can resolve between two points.

5.5   Trigger

Trigger source	External Direct Trigger External Prescale Trigger Internal Direct Trigger from Channel 1 Internal Direct Trigger from Channel 2 Internal Clock Trigger (internally connected to direct trigger) External Clock Recovery Trigger (PicoScope 9302 and PicoScope 9321)
Trigger modes	Triggered: causes the scope to trigger synchronously with the trigger input signal. Freerun: causes the scope to generate its own triggers.
Trigger holdoff	
Holdoff by time	Adjustable from 1 µs to 17.11 s in a 1-2-5-10 sequence or in 4 ns fine increments.
Holdoff by events	Adjustable from 6 to (1 s × F_{TRIG}) in a 1-2-4-10 sequence or in two-event fine increments. Event frequency is limited by trigger specifications. Minimum event holdoff frequency: 10 kHz.
Internal clock repetition rate	8 ns to 60 ms in a 1-2-5-10 sequence, or in 4 ns increments.

5.5.1   External direct trigger

External direct trigger bandwidth and sensitivity	
Normal hysteresis	100 mV p-p DC to 100 MHz. Increasing linearly from 100 mV p-p at 100 MHz to 200 mV p-p at 2.5 GHz. Pulse Width: 200 ps @ 200 mV p-p.
High sensitivity hysteresis, typical	50 mV p-p at 100 MHz. Increasing linearly from 50 mV p-p at 100 MHz to 100 mV p-p at 2.5 GHz.
RMS direct trigger jitter	Scope Sampling Mode: 2.0 ps + 20 ppm of delay setting, maximum. 1.8 ps + 20 ppm of delay setting, typical. Note. Measured at 2.5 GHz trigger input with the triggering level adjusted for optimum trigger.
External direct trigger slope	Positive: triggers on rising edge Negative: triggers on falling edge
External direct trigger coupling	DC
External direct trigger level range	−1 V to 1 V
External direct trigger level resolution	1 mV
Direct trigger level accuracy	±(50 mV + | 0.1 of trigger level |)
External direct trigger hysteresis	Normal: the trigger hysteresis is set so the instrument meets the trigger sensitivity specification. High Sensitivity: hysteresis is turned off to allow a best sensitivity to high-frequency signals. This mode should not be used for noisy lower-frequency signals that may mistrigger without hysteresis.
Maximum safe external direct trigger input voltage	16 dBm, or ± 2 V (DC + peak AC)
External direct trigger nominal input impedance	(50 ± 1.5)
Direct trigger input connector	SMA(f)
Input connector torque	0.45 Nm or 4 in-lb

5.5.2   Internal direct trigger

Internal direct trigger bandwidth and sensitivity	
Normal hysteresis	100 mV p-p DC to 10 MHz. Increasing linearly from 100 mV p-p at 10 MHz to 400 mV p-p at 100 MHz. Pulse Width: 50 ns @ 400 mV p-p.
High sensitivity hysteresis, typical	50 mV p-p DC to 10 MHz. Increasing linearly from 50 mV p-p at 10 MHz to 200 mV p-p at 100 MHz.
RMS direct trigger jitter	30 ps + 20 ppm of delay setting, maximum. 25 ps + 20 ppm of delay setting, typical. Note. Measured at 100 MHz with the triggering level adjusted for optimum trigger.
Internal direct trigger slope	Positive: triggers on rising edge Negative: triggers on falling edge
Internal direct trigger coupling	DC, AC (from 1 kHz), low frequency reject (100 kHz high pass filter), high frequency reject (1 MHz low pass filter).
Internal direct trigger level range	−1 V to 1 V
Internal direct trigger level resolution	1 mV
Internal direct trigger level accuracy	±(50 mV + ∣ 0.1 of trigger level ∣)
Internal direct trigger hysteresis	Normal: the trigger hysteresis is set so the instrument meets the trigger sensitivity specification. High Sensitivity: hysteresis is turned off to allow a best sensitivity to high-frequency signals. This mode should not be used for noisy lower-frequency signals that may mistrigger without hysteresis.

5.5.3   External prescaled trigger

External prescaled trigger bandwidth and sensitivity	PicoScope 9300 Series -15, -20, -25 and -30 models: 200 mV p-p to 2 V p-p from 1 GHz to 14 GHz (sine wave input). PicoScope 9300 Series -25 models only: 200 mV p-p to 2 V p-p from 14 GHz to 15 GHz (sine wave input). PicoScope 9300 Series -30 models only: 200 mV p-p to 2 V p-p from 14 GHz to 18 GHz (sine wave input).
External prescaled trigger RMS jitter	2.0 ps + 20 ppm of delay setting at <4 GHz. 1.8 ps + 20 ppm of delay setting at ≥4 GHz.
Prescaler ratio	Divide-by-1/2/4/8 or auto
Prescaled trigger input characteristics	50 , AC coupled, fixed level zero volts
Prescaled trigger maximum safe input voltage	±2 V (DC+peak AC)
Prescaled trigger input connector	SMA(f)
Input connector torque	0.45 Nm or 4 in-lb

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5.5.4   Clock recovery trigger (PicoScope 9302 and PicoScope 9321)

Clock recovery trigger data rate and sensitivity	100 mV p-p from 6.5 Mb/s to 100 Mb/s 20 mV p-p from 100 Mb/s to 11.3 Gb/s
Recovered clock RMS trigger jitter	1 ps + 1.0% of Unit Interval, typical. 1.5 ps + 1.0% of Unit Interval, maximum.
Clock recovery trigger input characteristics	50 , AC coupled
Clock recovery trigger maximum safe input voltage	±2 V (DC+peak AC)
Clock recovery trigger input connector	SMA(f)
Input connector torque	0.45 Nm or 4 in-lb

5.5.5   Pattern sync trigger

Pattern sync trigger clock frequency	External Direct Trigger: 10 MHz to 2.5 GHz. Internal Direct Trigger: 10 MHz to 100 MHz. External Prescaled Trigger: 1 GHz to 14 GHz (PicoScope 9300 Series -15 and -20 models). 1 GHz to 15 GHz (PicoScope 9300 Series -25 and -30 models). Clock Recovery Trigger: 10 MHz to 11.3 GHz (PicoScope 9302 and PicoScope 9321).
Divider ratio	External Direct Trigger: < 250 MHz: 1; 250 MHz to < 500 MHz: 2; 500 MHz to < 1 GHz: 4; 1 GHz to 2 GHz: 8; 2 GHz to 2.5 GHz: 16. Internal Direct Trigger: : 1. External Prescaled Trigger: 1 GHz to < 2 GHz: 8; 2 GHz to 4 GHz: 16; 4 GHz to 8 GHz: 32; 8 GHz to 15 GHz: 64. Clock Recovery Trigger: < 250 MHz: 1; 250 MHz to < 500 MHz: 2; 500 MHz to < 1 GHz: 4; 1 GHz to 2 GHz: 8; 2 GHz to 4 GHz: 16; 4 GHz to 8 GHz: 32; 8 GHz to 11.3 GHz: 64 (PicoScope 9302 and 9321).
Programmable pattern length	Minimum: 7. Maximum: 8 388 607 ($2^{23}-1$)
Eye line mode	Displays averaged eye diagrams
Start bit	0 to (Pattern Length − 7) bits
Scan bits	1 to (8 388 607 − Start bit)

5.6   TDR/TDT (PicoScope 9311 and PicoScope 9312)

5.6.1   TDR/TDT (PicoScope 9311 only)

PULSE OUTPUTS	
Output channels	PicoScope 9311-15: One. PicoScope 9311-20: Two.
Output enable/disable	Outputs can be switched on and off independently for each channel
Pulse polarity	Channel 1: Positive going from zero volts. Channel 2 (PicoScope 9311-20 only): Negative going from zero volts.
Output amplitude	2.5 V to 6 V @ 50 . Adjustable in a 100 mV coarse increment, or in 5 mV fine increment.
Amplitude accuracy	± 10%
Output limits (level protection)	Output amplitude can be limited to a user-defined value from 2.5 V to 6 V to protect the device under test. Adjustable in 100 mV coarse increments or 20 mV fine increments.
Output 1 vs. output 2	Output amplitudes and limit can be selected independently or paired for both channels.
Period range	1 µs to 60 ms. Adjustable in a 1-2-5-10 sequence and 60 ms. Also adjustable in fine increments of 25 ns or 5 digits, whichever is greater.
Period accuracy	±100 ppm
Width range	200 ns to 4 µs. Adjustable in a 1-2-5-10 sequence and 4 µs. Also adjustable in 25 ns fine increments. Duty cycle: 50% or less.
Width accuracy	± 10% of width ± 100 ns
Deskew between outputs	−1 ns to 1 ns typical. Adjustable in 20 ps sequence. Also adjustable in 1 ps fine increments (PicoScope 9311-20 only).
Rise time	55 ps or less, each polarity, typical
PRE-TRIGGER OUTPUT	
Polarity	Positive-going from zero volts.
Amplitude	700 mV typical @ 50
Pre-trigger	25 ns to 35 ns typ. Adjustable in 100 ps coarse increments and 5 ps fine increments.
Pre-trigger-to-output RMS jitter	2 ps max
TDT SYSTEM	
Number of TDT channels	PicoScope 9311-15: One. PicoScope 9311-20: Two.

TDT system incident rise time (combined oscilloscope and pulse generator, 10% to 90%)	PicoScope 9311-15: *65 ps or less.* PicoScope 9311-20: *60 ps or less, each polarity.*
TDT system aberrations	*+20%, −10% or less for the first 2 ns following leading step transition*
RMS jitter	3 ps + 20 ppm of delay setting, maximum
TDT system corrected rise time	Minimum: 50 ps or 0.1 x time/div, whichever is greater, typical. Maximum: 3 x time/div, typical.
TDT system corrected aberrations	≤ 0.5% typical.
TDR SYSTEM	
Number of TDR channels	Two
TDR system incident step amplitude	50% of input pulse amplitude, typical
TDR system incident rise time (combined oscilloscope, step generator and TDR Kit, 10% to 90%)	PicoScope 9311-15: *65 ps or less.* PicoScope 9311-20: *60 ps or less, each polarity*.
TDR system incident aberrations	*+20%, −10% or less for the first 2 ns following leading step transition*
TDR system reflected step amplitude	25% of input pulse amplitude, typical from short or open
TDR system reflected rise time (combined oscilloscope, step generator and TDR Kit, 10% to 90%)	*65 ps or less @ 50 termination, each polarity*
TDR system reflected aberrations	*+20%, −10% or less for the first 2 ns following leading step transition*
TDR system corrected rise time	Minimum: 50 ps or 0.1 x time/div, whichever is greater, typical. Maximum: 3 x time/div, typical.
TDR system corrected aberration	≤ 1% typical
Scaling	
TDT vertical scale	Volts, gain (10 m/div to 100 /div)
TDR vertical scale	Volts, rho (10 mrho/div to 2 rho/div), ohm (1 ohm/div to 100 ohm/div)

Horizontal scale	Time or distance (meter, foot, inch)
Distance preset units	Propagation velocity (0.1 to 1.0) or dielectric constant (1 to 100)

5.6.2   TDR/TDT (PicoScope 9312 only)

PULSE OUTPUTS	
Output channels	Two
Output enable/disable	Outputs can be switched on and off independently for each channel
Pulse polarity	Determined by connection of external pulse heads
Output amplitude	200 mV typ @ 50
Output offset	Positive pulse base line +90 mV typical. Negative pulse base line -90 mV typical.
Period range	1 µs to 60 ms. Adjustable in a 1-2-5-10 sequence and 60 ms. Also adjustable in fine increments of 25 ns or 5 digits, whichever is greater.
Period accuracy	±100 ppm
Width range	200 ns to 4 µs. Adjustable in a 1-2-5-10 sequence and 4 µs. Also adjustable in 25 ns fine increments. Duty Cycle: 50% or less.
Width accuracy	± 10% of width ± 100 ns
Deskew between outputs	−500 ps to 500 ps typical. Adjustable in 20 ps sequence. Also adjustable in 1 ps fine increments.
Rise time	35 ps or less, each polarity, typical
TDT SYSTEM	
Number of TDT channels	Two
TDT system incident rise time (combined oscilloscope and pulse generator, 10% to 90%)	*40 ps or less,* each polarity
TDT system aberrations	*±16% or less for the first 200 ps following leading step transition*
RMS jitter	2.2 ps + 20 ppm of delay setting, maximum
TDT system corrected rise time	Minimum: 30 ps or 0.1 x time/div, whichever is greater, typical. Maximum: 3 x time/div, typical.
TDT system corrected aberrations	≤ 0.5% typical
TDR SYSTEM	
Number of TDR channels	Two
TDR system incident step amplitude	50% of input pulse amplitude, typical

TDR system incident rise time (combined oscilloscope, step generator and TDR kit, 10% to 90%)	*40 ps or less,* each polarity
TDR system incident aberrations	*±16% or less for the first 200 ps following leading step transition*
TDR system reflected step amplitude	25% of input pulse amplitude, typical from short or open
TDR system reflected rise time (combined oscilloscope, step generator and TDR kit, 10% to 90%)	45 ps or less @ 50 termination, each polarity
TDR system reflected aberrations	*±16% or less for the first 200 ps following leading step transition*
TDR system corrected rise time	Minimum: 30 ps or 0.1 x time/div, whichever is greater, typical. Maximum: 3 x time/div, typical.
TDR system corrected aberration	≤ 1% typical
Scaling	
TDT vertical scale	Volts, gain (10 m/div to 100 /div)
TDR vertical scale	Volts, rho (10 mrho/div to 2 rho/div), ohm (1 ohm/div to 100 ohm/div)
Horizontal scale	Time (40 ns/div longest) or distance (meter, foot, inch)
Distance preset units	Propagation velocity (0.1 to 1.0) or dielectric constant (1 to 100)

5.7   Acquisition

Digital feedback	Multi-valued signal: Digital feedback is off Single-valued signal: Digital feedback is on
Number of acquisition channels	Two Simultaneous acquisition
ADC resolution	16 bits
Digitizing rate	Multi-valued signal acquisition (Digital Feedback is off): DC to 1 MHz maximum. Single-valued signal acquisition (Digital Feedback is on), Best Flatness mode is off: DC to 40 kHz maximum. Single-valued signal acquisition (Digital Feedback is on), Best Flatness mode is on: DC to 20 kHz maximum. Note: The signal is sampled and digitized at a rate dictated by the trigger repetition rate and the timebase range.
Acquisition modes	Sample (normal), Average, Envelope
Average modes	Stable or Multiple
Number of averages	From 2 to 4096 in ×2 sequence
Envelope modes	Min, Max or both Min-Max values acquired over one or more acquisitions.
Number of envelopes	From 2 to 4096 in ×2 sequence and continuously.
Data record length	32 to 32 768 points/channel for single-channel mode. 32 to 16 384 points/channel for all modes in ×2 sequence. 32 to 8 192 points/channel for 3- or 4-channel mode (PicoScope 9341).

5.8   Display

Display style

Dots
Vectors
Variable Persistence: time that each data point is retained on the display. Persistence time can be varied from 100 ms to 20 s.
Infinite Persistence
Variable Gray Scaling: five levels of a single color that is varied in saturation and luminosity. Refresh time can be varied from 1 s to 200 s.
Infinite Gray Scaling
Variable Color Grading: with Color Grading selected, historical timing information is represented by a temperature or spectral color scheme providing "z-axis" information about rapidly changing waveforms. Refresh time can be varied from 1 to 200 s.
Infinite Color Grading

Graticule

Full Grid, Axes with tick marks, Frame with tick marks, Off (no graticule).

Format

Auto: automatically place, adds or deletes graticules as you select more or fewer waveforms to display.
Single YT: all waveforms are superimposed and are eight divisions high.
Dual YT: with two graticules, all waveforms can be four divisions high, displayed separately or superimposed.
Quad YT: with four graticules, all waveforms can be two divisions high, displayed separately or superimposed.
When you select dual or quad screen display, every waveform channel, memory and function can be placed on a specified graticule.
XY: displays voltages of two waveforms against each other. The amplitude of the first waveform is plotted on the horizontal X axis and the amplitude of the second waveform is plotted on the vertical Y axis.
XY + YT: displays both XY and YT pictures. The YT format appears on the upper part of the screen, and the XY format on the lower part of the screen. The YT format display area is one screen and any displayed waveforms are superimposed.
XY + 2YT: displays both YT and XY pictures. The YT format appears on the upper part of the screen, and the XY format on the lower part of the screen. The YT format display area is divided into two equal screens.

Colors

You may choose a default color selection, or select your own color set. Different colors are used for displaying selected items: background, channels, functions, waveform memories, FFTs, TDR/TDTs, and histograms.

Trace annotation

The instrument gives you the ability to add an identifying label, bearing your own text, to a waveform display. For each waveform, you can create multiple labels and turn them all on or all off. Also, you can position them on the waveform by dragging or by specifying an exact horizontal position.

5.9   Save/recall

Management	Store and recall setups, waveforms and user mask files to any drive on your PC. Storage capacity is limited only by disk space.

File extensions	Waveform files:
	    .wfm for binary format,
	    .txt for verbose format (text),
	    .txty for Y values formats (text).
	Database files: .wdb.
	Setup files: .set.
	User mask files: .pcm.

Operating system	Microsoft Windows XP (SP2), Windows Vista or Windows 7, 32-bit and 64-bit, Windows 8 (not Windows RT), 32-bit and 64-bit.
Waveform save/recall	Up to four waveforms may be stored into the waveform memories (M1 to M4), and then recalled for display.
Save to/recall from disk	You can save or recall your acquired waveforms to or from any drive on the PC. To save a waveform, use the standard Windows **Save as** dialog box. From this dialog box you can create subdirectories and waveform files, or overwrite existing waveform files. You can load, into one of the Waveform Memories, a file with a waveform you have previously saved and then recall it for display.
Save/recall setups	The instrument can store complete setups in the memory and then recall them.
Screen image	You can copy a screen image into the clipboard with the following formats: Full Screen, Full Window, Client Part, Invert Client Part, Oscilloscope Screen and Oscilloscope Screen.
Autoscale	Pressing the Autoscale key automatically adjusts the vertical channels, the horizontal scale factors, and the trigger level for a display appropriate to the signals applied to the inputs. The Autoscale feature requires a repetitive signal with a frequency greater than 1 kHz, duty cycle greater than 1%, amplitudes greater than 50 mV p-p (vertical) and 200 mV p-p (trigger). Autoscale is operative only for relatively stable input signals.

5.10   Marker

Marker type	X-Marker: vertical bars (measure time). Y-Marker: horizontal bars (measure volts). XY-Markers: waveform markers.
Marker measurements	Absolute, Delta, Volt, Watt, Rho, Time, Frequency, Distance, Phase, Slope.
Marker motion	Independent: both markers can be adjusted independently. Paired: both markers can be adjusted together.
Ratiometric measurements	Provide ratiometric measurements between measured and reference values. These measurements give results in such ratiometric units as %, dB, and degrees.

5.11   Measure

Automated measurements	Up to ten simultaneous measurements are supported at the same time.
Automatic parametric	53 automatic measurements available.
Amplitude measurements	Maximum, Minimum, Top, Base, Peak-Peak, Amplitude, Middle, Mean, Cycle Mean, DC RMS, Cycle DC RMS, AC RMS, Cycle AC RMS, Positive Overshoot, Negative Overshoot, Area, Cycle Area.
Timing measurements	Period, Frequency, Positive Width, Negative Width, Rise Time, Fall Time, Positive Duty Cycle, Negative Duty Cycle, Positive Crossing, Negative Crossing, Burst Width, Cycles, Time at Maximum, Time at Minimum, Positive Jitter p-p, Positive Jitter RMS, Negative Jitter p-p, Negative Jitter RMS.
Inter-signal measurements	Delay (8 options), Phase Deg, Phase Rad, Phase %, Gain, Gain dB.
FFT measurements	FFT Magnitude, FFT Delta Magnitude, THD, FFT Frequency, FFT Delta Frequency.
Measurement statistics	Displays current, minimum, maximum, mean and standard deviation on any displayed waveform measurements.
Method of top-base definition	Histogram, Min/Max, or User-Defined (in absolute voltage).
Thresholds	Upper, middle and lower horizontal bars settable in percentage, voltage or divisions. Standard thresholds are 10-50-90% or 20-50-80%.
Margins	Any region of the waveform may be isolated for measurement using left and right margins (vertical bars).
Measurement mode	Repetitive or Single-shot.

5.12 Mathematics

Waveform math	Up to four math waveforms can be defined and displayed using math functions F1 to F4
Categories and math operators	**Arithmetic:** Add, Subtract, Multiply, Divide, Ceil, Floor, Fix, Round, Absolute, Invert, Common, Rescale. **Algebra:** Exponentiation (e), Exponentiation (10), Exponentiation (a), Logarithm (e), Logarithm (10), Logarithm (a), Differentiate, Integrate, Square, Square Root, Cube, Power (a), Inverse, Square Root of the Sum. **Trigonometry:** Sine, Cosine, Tangent, Cotangent, Arcsine, Arc cosine, Arctangent, Arc cotangent, Hyperbolic Sine, Hyperbolic Cosine, Hyperbolic Tangent, Hyperbolic Cotangent. **FFT:** Complex FFT, FFT Magnitude, FFT Phase, FFT Real part, FFT Imaginary part, Complex Inverse FFT, FFT Group Delay. **Bit Operator:** AND, NAND, OR, NOR, XOR, XNOR, NOT. **Miscellaneous:** Autocorrelation, Correlation, Convolution, Track, Trend, Linear Interpolation, Sin(x)/x Interpolation, Smoothing. **Formula Editor.** You can build math waveforms using the Formula Editor control window.
Operands	Any channel, waveform memory, math function, spectrum, or constant can be selected as a source for one of two operands.

FFT

FFT frequency span	Frequency Span = Sample Rate / 2 = Record Length / (2 × Timebase Range)
FFT frequency resolution	Frequency Resolution = Sample Rate / Record Length
FFT windows	The built-in filters (Rectangular, Hamming, Hann, Flattop, Blackman-Harris and Kaiser-Bessel) allow optimization of frequency resolution, transients, and amplitude accuracy.
FFT measurements	Marker measurements can be made on frequency, delta frequency, magnitude, and delta magnitude. Automated FFT Measurements include: FFT Magnitude, FFT Delta Magnitude, THD, FFT Frequency, and FFT Delta Frequency.

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5.13   Histogram

Histogram axis	Vertical, or Horizontal. Both vertical and horizontal histograms, with periodically updated measurements, allow statistical distributions to be analyzed over any region of the signal.
Histogram measurement set	Scale, Offset, Hits in Box, Waveforms, Peak Hits, Pk-Pk, Median, Mean, Standard Deviation, Mean ± 1 Std Dev, Mean ± 2 Std Dev, Mean ± 3 Std Dev, Min, Max-Max, Max.
Histogram window	The histogram window determines which part of the database is used to plot the histogram. You can set the size of the histogram window to be any size that you want within the horizontal and vertical scaling limits of the scope.

5.14   Eye diagram

Eye diagram	The PicoScope 9300 can automatically characterize an NRZ and RZ eye pattern. Measurements are based upon statistical analysis of the waveform.
NRZ measurement set	AC RMS, Area, Bit Rate, Bit Time, Crossing %, Crossing Level, Crossing Time, Cycle Area, Duty Cycle Distortion (%, s), Extinction Ratio (dB, %, ratio), Eye Amplitude, Eye High, Eye High dB, Eye Width (%, s), Fall Time, Frequency, Jitter (p-p, RMS), Max, Mean, Mid, Min, Negative Overshoot, Noise p-p (One, Zero), Noise RMS (One, Zero), One Level, Peak-Peak, Period, Positive Overshoot, Rise Time, RMS, Signal-to-Noise Ratio, Signal-to-Noise Ratio dB, Zero Level.
RZ measurement set	AC RMS, Area, Bit Rate, Bit Time, Contrast Ratio (dB, %, ratio), Cycle Area, Extinction Ratio (dB, %, ratio), Eye Amplitude, Eye High, Eye High dB, Eye Opening Factor, Eye Width (%, s), Fall Time, Jitter P-p (Fall, Rise), Jitter RMS (Fall, Rise), Max, Mean, Mid, Min, Negative Crossing, Noise P-p (One, Zero), Noise RMS (One, Zero), One Level, Peak-Peak, Positive Crossing, Positive Duty Cycle, Pulse Symmetry, Pulse Width, Rise Time, RMS, Signal-to-Noise, Zero Level.

5.15   Mask test

Mask test	Acquired signals are tested for fit outside areas defined by up to eight polygons. Any samples that fall within the polygon boundaries result in test failures. Masks can be loaded from disk, or created automatically or manually.
Mask creation	You can create the following Mask: Standard predefined Mask, Automask, Mask saved on disk, Create new mask, Edit any mask.
Standard mask	Standard predefined optical or standard electrical masks can be created.
SONET/SDH	OC1/STMO (51.84 Mb/s) OC3/STM1 (155.52 Mb/s) OC9/STM3 (466.56 Mb/s) OC12/STM4 (622.08 Mb/s) OC18/STM6 (933.12 Mb/s) OC24/STM8 (1.2442 Gb/s) OC48/STM16 (2.48832 Gb/s) FEC 2666 (2.6666 Gb/s) OC192/STM64 (9.95328 Gb/s) FEC 1066 (10.664 Gb/s) FEC 1071 (10.709 Gb/s)
Fiber Channel	FC133 Electrical (132.8 Mb/s) FC133 Optical (132.8 Mb/s) FC266 Electrical (265.6 Mb/s) FC266 Optical (265.6 Mb/s) FC531 Electrical (531.35 Mb/s) FC531 Optical (531.35 Mb/s) FC1063 Electrical (1.0625 Gb/s) FC1063 Optical (1.0625 Gb/s) FC1063 Optical PI Rev13 (1.0625 Gb/s) FC1063E Abs Beta Rx.mask (1.0625 Gb/s) FC1063E Abs Beta Tx.mask (1.0625 Gb/s) FC1063E Abs Delta Rx.mask (1.0625 Gb/s) FC1063E Abs Delta Tx.mask (1.0625 Gb/s) FC1063E Abs Gamma Rx.mask (1.0625 Gb/s) FC1063E Abs Gamma Tx.mask (1.0625 Gb/s) FC2125 Optical (2.1231 Gb/s) FC2125 Optical PI Rev13 (2.1231 Gb/s) FC2125E Abs Beta Rx.mask (2.125 Gb/s) FC2125E Abs Beta Tx.mask (2.125 Gb/s) FC2125E Abs Delta Rx.mask (2.125 Gb/s) FC2125E Abs Delta Tx.mask (2.125 Gb/s) FC2125E Abs Gamma Rx.mask (2.125 Gb/s) FC2125E Abs Gamma Tx.mask (2.125 Gb/s) FC4250 Optical PI Rev13 (4.25 Gb/s) FC4250E Abs Beta Rx.mask (4.25 Gb/s) FC4250E Abs Beta Tx.mask (4.25 Gb/s) FC4250E Abs Delta Rx.mask (4.25 Gb/s) FC4250E Abs Delta Tx.mask (4.25 Gb/s) FC4250E Abs Gamma Rx.mask (4.25 Gb/s) FC4250E Abs Gamma Tx.mask (4.25 Gb/s) 10x Fiber Channel (10.5188 Gb/s)

Ethernet	1.25 Gb/s 1000Base-CX Absolute TP2 (1.25 Gb/s)
	1.25 Gb/s 1000Base-CX Absolute TP3 (1.25 Gb/s)
	GB Ethernet (1.25 Gb/s)
	2XGB Ethernet (2.5 Gb/s)
	3.125 Gb/s 10GBase-CX4 Absolute TP2 (3.125 Gb/s)
	10Gb Ethernet (9.953 Gb/s)
	10GbE 9.953 (9.953 Gb/s)
	10Gb Ethernet (10.3125 Gb/s)
	10GbE 10.3125 (10.3125 Gb/s)
	10xGB Ethernet (12.5 Gb/s)
InfiniBand	2.5G InfiniBand Cable mask (2.5 Gb/s)
	2.5G InfiniBand Driver Test Point 1 (2.5 Gb/s)
	2.5G InfiniBand Driver Test Point 10 (2.5 Gb/s)
	2.5G InfiniBand Driver Test Point 2 (2.5 Gb/s)
	2.5G InfiniBand Driver Test Point 3 (2.5 Gb/s)
	2.5G InfiniBand Driver Test Point 4 (2.5 Gb/s)
	2.5G InfiniBand Driver Test Point 5 (2.5 Gb/s)
	2.5G InfiniBand Driver Test Point 6 (2.5 Gb/s)
	2.5G InfiniBand Driver Test Point 7 (2.5 Gb/s)
	2.5G InfiniBand Driver Test Point 8 (2.5 Gb/s)
	2.5G InfiniBand Driver Test Point 9 (2.5 Gb/s)
	2.5G InfiniBand Receiver mask (2.5 Gb/s)
	InfiniBand (2.5 Gb/s)
	5.0G InfiniBand Driver Test Point 1 (5 Gb/s)
	5.0G InfiniBand Driver Test Point 6 (5 Gb/s)
	5.0G InfiniBand Transmitter Pins (5 Gb/s)
XAUI	3.125 Gb/s XAUI Far End (3.125 Gb/s)
	3.125 Gb/s XAUI Far End (3.125 Gb/s)
	XAUI-E Far (3.125 Gb/s)
	XAUI-E Near (3.125 Gb/s)
ITU G.703	DS1, 100 twisted pair (1.544 Mb/s)
	2 Mb 120, 120 twisted pair (2.048 Mb/s)
	2 Mb 75, 75 coax (2.048 Mb/s)
	DS2 110, 110 twisted pair (6.312 Mb/s)
	DS2 75, 75 coax (6.312 Mb/s)
	8 Mb, 75 coax (8.448 Mb/s)
	34 Mb, 75 coax (34.368 Mb/s)
	DS3, 75 coax (44.736 Mb/s)
	140 Mb 0, 75 coax (139.264 Mb/s)
	140 Mb 1, 75 coax (139.264 Mb/s)
	140 Mb 1 Inv, 75 coax (139.264 Mb/s)
	155 Mb 0, 75 coax (155.520 Mb/s)
	155 Mb 1, 75 coax (155.520 Mb/s)
	155 Mb 1 Inv, 75 coax (155.520 Mb/s)
ANSI T1/102	DS1, 100 twisted pair, (1.544 Mb/s)
	DS1C, 100 twisted pair, (3.152 Mb/s)
	DS2, 110 twisted pair, (6.312 Mb/s)
	DS3, 75 coax, (44.736 Mb/s)
	STS1 Eye, 75 coax, (51.84 Mb/s)
	STS1 Pulse, 75 coax, (51.84 Mb/s)
	STS3, 75 coax, (155.520 Mb/s)
RapidIO	RapidIO Serial Level 1, 1.25G Rx (1.25 Gb/s)
	RapidIO Serial Level 1, 1.25G Tx LR (1.25 Gb/s)
	RapidIO Serial Level 1, 1.25G Tx SR (1.25 Gb/s)

	RapidIO Serial Level 1, 2.5G Rx (2.5 Gb/s)
	RapidIO Serial Level 1, 2.5G Tx LR (2.5 Gb/s)
	RapidIO Serial Level 1, 2.5G Tx SR (2.5 Gb/s)
	RapidIO Serial Level 1, 3.125G Rx (3.125 Gb/s)
	RapidIO Serial Level 1, 3.125G Tx LR (3.125 Gb/s)
	RapidIO Serial Level 1, 3.125G Tx SR (3.125 Gb/s)
G.984.2	XAUI-E Far (3.125 Gb/s)
PCI Express	R1.0a 2.5G Add-in Card Transmitter Non-Transition bit mask (2.5 Gb/s)
	R1.0a 2.5G Add-in Card Transmitter Transition bit mask (2.5 Gb/s)
	R1.0a 2.5G Exp.Card Host Non-Transition bit mask (2.5 Gb/s)
	R1.0a 2.5G Exp.Card Host Transition bit mask (2.5 Gb/s)
	R1.0a 2.5G Exp.Card Module Non-Transition bit mask (2.5 Gb/s)
	R1.0a 2.5G Exp.Card Module Transition bit mask (2.5 Gb/s)
	R1.0a 2.5G Exp.Card Transmitter Non-Transition bit mask (2.5 Gb/s)
	R1.0a 2.5G Exp.Card Transmitter Transition bit mask (2.5 Gb/s)
	R1.0a 2.5G Mobile Transmitter bit mask (2.5 Gb/s)
	R1.0a 2.5G Receiver mask (2.5 Gb/s)
	R1.0a 2.5G System Board Transmitter Non-Transition bit mask (2.5 Gb/s)
	R1.0a 2.5G System Board Transmitter Transition bit mask (2.5 Gb/s)
	R1.0a 2.5G Transmitter Non-Transition bit mask (2.5 Gb/s)
	R1.0a 2.5G Transmitter Transition bit mask (2.5 Gb/s)
	R1.1 2.5G Add-in Card Transmitter Non-Transition bit mask (2.5 Gb/s)
	R1.1 2.5G Add-in Card Transmitter Transition bit mask (2.5 Gb/s)
	R1.1 2.5G Cable Receiver End Non-Transition bit mask (2.5 Gb/s)
	R1.1 2.5G Cable Receiver End Transition bit mask (2.5 Gb/s)
	R1.1 2.5G Cable Transmitter End Non-Transition bit mask (2.5 Gb/s)
	R1.1 2.5G Cable Transmitter End Transition bit mask (2.5 Gb/s)
	R1.1 2.5G Express Module System Non-Transition bit mask (2.5 Gb/s)
	R1.1 2.5G Express Module System Transition bit mask (2.5 Gb/s)
	R1.1 2.5G Express Module Transmitter Path Non-Transition bit mask (2.5 Gb/s)
	R1.1 2.5G Express Module Transmitter Path Transition bit mask (2.5 Gb/s)
	R1.1 2.5G Receiver mask (2.5 Gb/s)
	R1.1 2.5G System Board Transmitter Non-Transition bit mask (2.5 Gb/s)

	R1.1 2.5G System Board Transmitter Transition bit mask (2.5 Gb/s)
	R1.1 2.5G Transmitter Non-Transition bit mask (2.5 Gb/s)
	R1.1 2.5G Transmitter Transition bit mask (2.5 Gb/s)
	R2.0 5.0G Add-in Card 35 dB Transmitter Non-Transition bit mask (5 Gb/s)
	R2.0 5.0G Add-in Card 60 dB Transmitter Non-Transition bit mask (5 Gb/s)
	R2.0 5.0G Add-in Card 35 dB Transmitter Transition bit mask (5 Gb/s)
	R2.0 5.0G Add-in Card 60 dB Transmitter Transition bit mask (5 Gb/s)
	R2.0 5.0G Mobile Transmitter mask (5 Gb/s)
	R2.0 5.0G Receiver mask (5 Gb/s)
	R2.0 5.0G System Board Transmitter Non-Transition bit mask (5 Gb/s)
	R2.0 5.0G System Board Transmitter Transition bit mask (5 Gb/s)
	R2.0 5.0G Transmitter Non-Transition bit mask (5 Gb/s)
	R2.0 5.0G Transmitter Transition bit mask (5 Gb/s)
	R2.1 5.0G Transmitter Non-Transition bit mask (5 Gb/s)
	R2.1 5.0G Transmitter Transition bit mask (5 Gb/s)
Serial ATA	Ext Length, 1.5G 250 Cycle, Rx Mask (1.5 Gb/s)
	Ext Length, 1.5G 250 Cycle, Tx Mask (1.5 Gb/s)
	Ext Length, 1.5G 5 Cycle, Rx Mask (1.5 Gb/s)
	Ext Length, 1.5G 5 Cycle, Tx Mask (1.5 Gb/s)
	Gen1, 1.5G 250 Cycle, Rx Mask (1.5 Gb/s)
	Gen1, 1.5G 250 Cycle, Tx Mask (1.5 Gb/s)
	Gen1, 1.5G 5 Cycle, Rx Mask (1.5 Gb/s)
	Gen1, 1.5G 5 Cycle, Tx Mask (1.5 Gb/s)
	Gen1m, 1.5G 250 Cycle, Rx Mask (1.5 Gb/s)
	Gen1m, 1.5G 250 Cycle, Tx Mask (1.5 Gb/s)
	Gen1m, 1.5G 5 Cycle, Rx Mask (1.5 Gb/s)
	Gen1m, 1.5G 5 Cycle, Tx Mask (1.5 Gb/s)
	Ext Length, 3.0G 250 Cycle, Rx Mask (3 Gb/s)
	Ext Length, 3.0G 250 Cycle, Tx Mask (3 Gb/s)
	Ext Length, 3.0G 5 Cycle, Rx Mask (3 Gb/s)
	Ext Length, 3.0G 5 Cycle, Tx Mask (3 Gb/s)
	Gen1, 3.0G 250 Cycle, Rx Mask (3 Gb/s)
	Gen1, 3.0G 250 Cycle, Tx Mask (3 Gb/s)
	Gen1, 3.0G 5 Cycle, Rx Mask (3 Gb/s)
	Gen1, 3.0G 5 Cycle, Tx Mask (3 Gb/s)
	Gen1m, 3.0G 250 Cycle, Rx Mask (3 Gb/s)
	Gen1m, 3.0G 250 Cycle, Tx Mask (3 Gb/s)
	Gen1m, 3.0G 5 Cycle, Rx Mask (3 Gb/s)
	Gen1m, 3.0G 5 Cycle, Tx Mask (3 Gb/s)
Mask margin	Available for industry standard mask testing

Automask creation	Masks are created automatically for single-valued voltage signals. Automask specifies both delta X and delta Y tolerances. The failure actions are identical to those of limit testing.
Data collected during test	Total number of waveforms examined, number of failed samples, number of hits within each polygon boundary

5.16   Aux In/Out

Waveform type at the AUX OUTPUT connector	Pulse, NRZ, RZ, 500 MHz clock, Trigger Out
Pulse	Period: 8 ns to 524 µs. Width: 8 ns (at 20 ns period) to (Period − 8 ns). Delay: 0 ns to (Period − 8 ns). Polarity: Positive or Negative.

NRZ	Bit rate: 4 ns to 260 µs.
	Delay: 0 ns to (Bit time − 8 ns).
	Pattern Length: 2^7-1, $2^{10}-1$, $2^{11}-1$ or $2^{15}-1$.
	Polarity: Positive or Negative.
	Internal Trigger:
	   Clock: data clock is used as a trigger source. NRZ data steam looks like eye diagram.
	   Pattern: the pattern signal is used as a trigger source. NRZ data steam looks like pattern.

RZ	Bit rate: 8 ns to 260 µs.
	Delay: 0 ns to (bit time − 8 ns).
	Pattern Length: 2^7-1, $2^{10}-1$, $2^{11}-1$ or $2^{15}-1$.
	Polarity: Positive or Negative.
	Internal Trigger:
	   Clock: data clock is used as a trigger source. RZ data steam looks like eye diagram.
	   Pattern: the pattern signal is used as a trigger source. RZ data steam looks like pattern.

500 MHz Clock	Frequency: 500 MHz. Waveform: close to a sinusoidal clock.
Trigger Out	Allows selection of a pulse waveform synchronous to internal holdoff trigger and internal TDR clock. Negative edge is active.

5.17   Power requirements

Power supply voltage	+12 V ± 5%
Power supply current	PicoScope 9301: 1.4 A max PicoScope 9302: 1.5 A max PicoScope 9311: 1.95 A max (with maximum pulse duty cycle) PicoScope 9312: 1.5 A max PicoScope 9321: 1.7 A max PicoScope 9341: 1.7 A max

Protection	Auto shutdown on excess or reverse voltage
AC adaptor	Universal adaptor supplied

5.18   PC connection

PC connection	USB 2.0 (full speed). Also compatible with USB 3.0, USB 1.1, and LAN.

5.19   Physical characteristics

Dimensions	Width: 170 mm Height: 40 mm Depth: 260 mm
Net Weight	PicoScope 9301: 1.1 kg PicoScope 9302: 1.2 kg PicoScope 9311: 1.2 kg PicoScope 9312: 1.2 kg Pulse Head for the PicoScope 9312: 150 g PicoScope 9321: 1.2 kg PicoScope 9341: 1.3 kg

5.20   Environmental conditions

Temperature	Operating: +5°C to +35°C for normal operation, +15°C to +25°C for quoted accuracy Storage: −20°C to +50°C
Humidity	Operating: Up to 85 % relative humidity (non-condensing) at +25°C Storage: Up to 95 % relative humidity (non-condensing)

ps9300.en-13   60

6   PicoSample 3 software

The PicoSample 3 software interface provides access to commands that control all of the instrument features and functions.

Areas of the PicoSample 3 GUI

6.1   Demo Mode

If you start the PicoSample 3 software without a device connected, you have the option to use a demonstration waveform. Click **Demo** on the **Initialisation...** dialog.
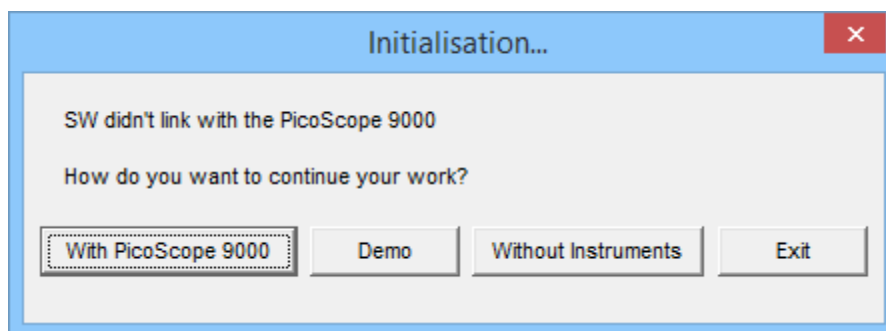
Initialisation... dialog

By default, the software will emulate the PicoScope 9301. The model can be changed through the **Help** control. See System Controls - Help for more information.

You can adjust all of the characteristics of the demonstration waveform displayed using the functions in the **Utility** menu. See Utility Menu - Demo for further information.

6.2　　Display Area

The following functions are concerned with **Display Area**:

- Live, reference, and math waveforms display here, along with cursors.
- You can drag the waveform to reposition it.
- You can drag across the waveform area to create a box for zooming.
- When **Ch1 Direct** or **Ch2 Direct** trigger source is selected you can drag the **T** icon to change the trigger level.
- You can drag markers to measure waveforms on screen.
- You can change the delay on displayed waveforms by clicking on the waveform and dragging it left or right.

6.3　　Drag and Zoom

You can use the mouse to change the vertical scale and offset, and also the horizontal scale and delay for all input channels, waveform memories, or waveform math functions that are currently displayed. You do this by holding down the left mouse button and moving the cursor until the zoom box covers the area of interest. To perform the zoom operation, release the left mouse button, move the cursor inside the zoom box and click the left mouse button. The PicoScope 9300 will change the vertical scale and vertical offset and it will change the horizontal scale and horizontal position for all displayed waveforms.

You can cancel the zoom operation by clicking anywhere outside of the zoom box. You can undo the zoom operation by clicking the **Undo** button.

You can also change the vertical offset on individual channels, waveform memories, or waveform math functions by clicking and dragging the waveform or by clicking and dragging the ground marker.

You can change the delay on displayed waveforms by clicking on the waveform and dragging it left or right.

Each channel has its own **Ground Reference Indicator** located to the left of the graticule area. The **Ground Reference Indicator** shows you where zero volts is for each electrical channel and zero watts for each optical channel. The default marker position is mid-screen for electrical channels and two graticules down from mid-screen for optical channels. During an **Autoscale**, an offset is applied to vertically center the signal.

6.4　　Main Menu

File　Edit　View　Setup　Measurements　Analysis　System　Utility　Help
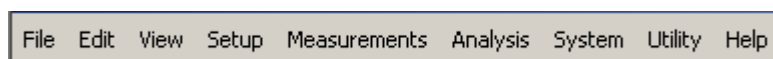
The **Main Menu** provides access to commands that control all of the instrument features and functions. When you select a feature setup command, the instrument displays the associated side menus, most of which can also be accessed from the Toolbar.

6.4.1   File

The **File** menu includes the following controls:
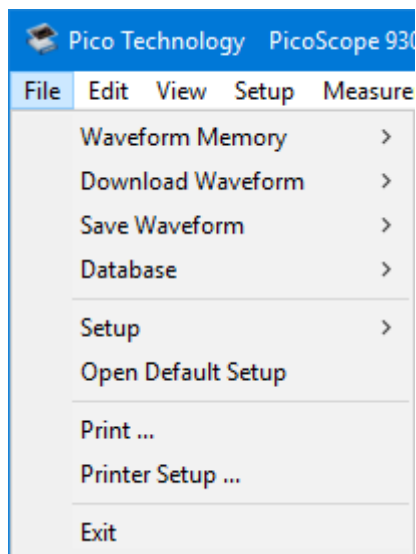
The **Waveform Memory** sub-menu recalls or clears the M1–M4 waveform memories. This sub-menu includes the following controls:
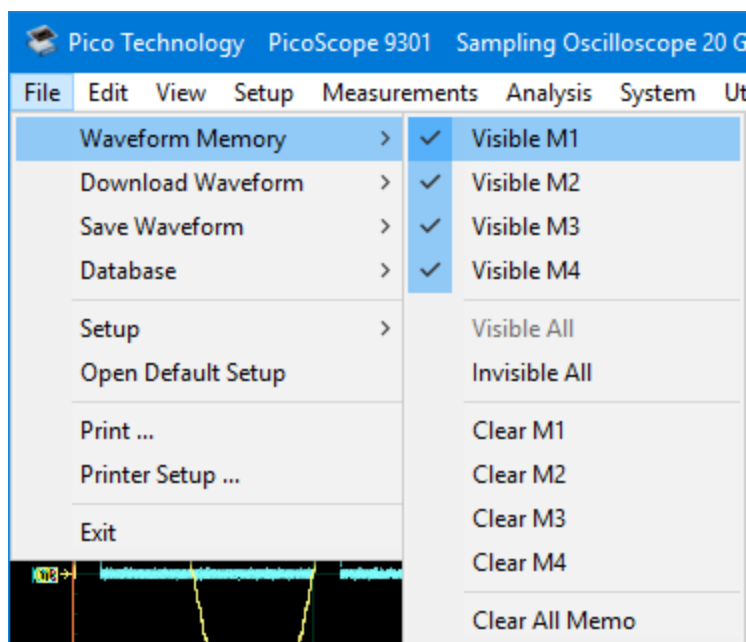
The **Download Waveform** sub-menu loads the selected file from a disk into one of the memories M1 – M4. This sub-menu includes the following controls:
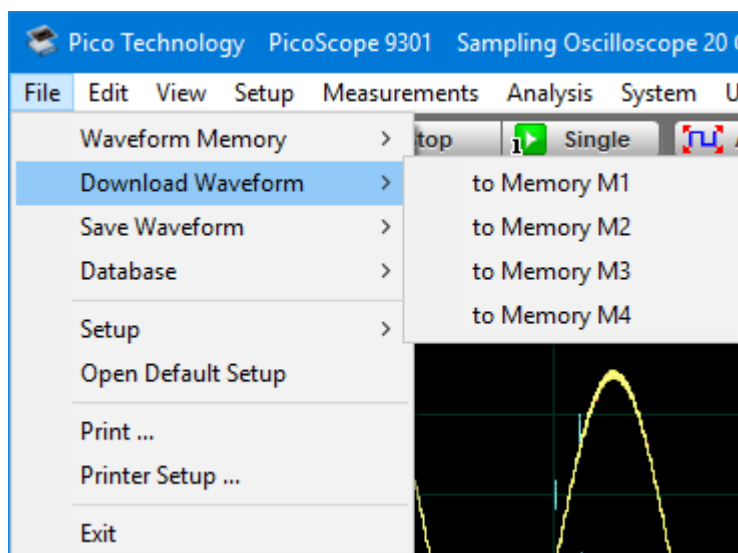
The **Save Waveform** sub-menu saves the waveform from selected source (channel Ch1-Ch4, function F1-F4 or waveform memory M1-M4) to the selected waveform memory (M1-M4), disk or database. The default location is:

```
C:\Users\<your user name>\AppData\Roaming\PicoScope
   SW\PS9300\Waveforms\Waveform Files\
```

This sub-menu includes the following controls:
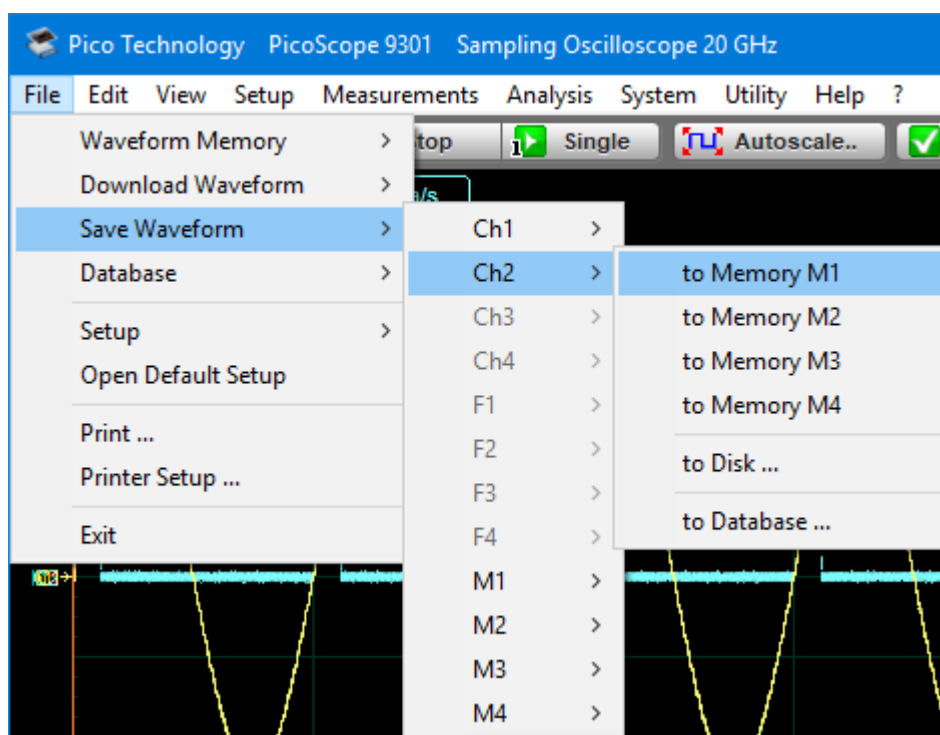
The **Database** sub-menu downloads, recalls or clears the waveform database. This database consists of all data samples displayed on the screen when the **Display Style** is set to persistence, gray scaling or color grading. It provides the data for the construction of histograms and performing mask tests. This sub-menu includes the following controls:
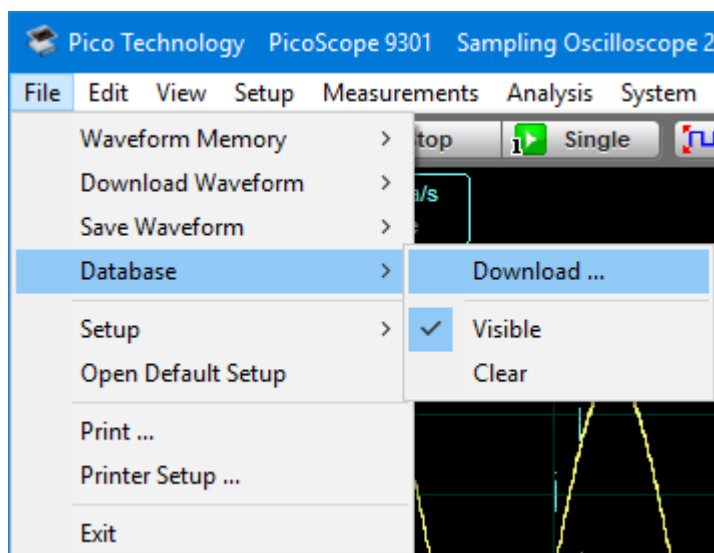
- **Download...** opens the Windows **Load Database** dialog and allows you to select a database file to recall from disk to Database Memory (**DB**).
- **Visible** makes the waveform database visible or invisible.
- **Clear** removes the selected database file from the waveform database.

The **Setup** sub-menu allows you to save and open (recall) setup. This sub-menu includes the following controls:
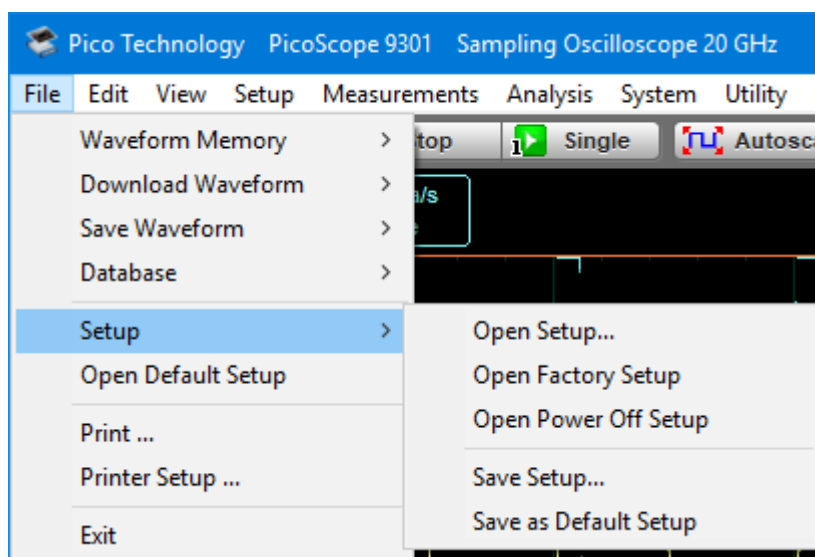
You can use the setup memories when you want to:

- **Open Setup**: you can recall a setup that you have previously saved on any drive of your PC.
- **Open Factory Setup**: returns the instrument to the manufacturer's default setting. This places the oscilloscope in a known operating condition. You may find it helpful to use the default factory settings when initially setting up the instrument to view signals, or when someone else has used the scope before you. You may also use the default settings to troubleshoot unexpected instrument behavior.
- **Open Power Off Setup:** returns the instrument to the last setting before the power supply was last switched off.

- **Save Setup:** stores the present front-panel setup to a selected setup memory. To save a current setup for later use, you can use any available drive. Use the standard Windows **Setup Files** dialog box. You can create subdirectories or new setup files, or overwrite existing setup files from this dialog box. The PicoScope 9300 uses the file extension **.set** for setup files.
- **Save as Default:** stores the present front-panel setup as the default setup.

The **Open Default Setup** command returns the instrument to its default settings. This places the oscilloscope in a known operating condition.
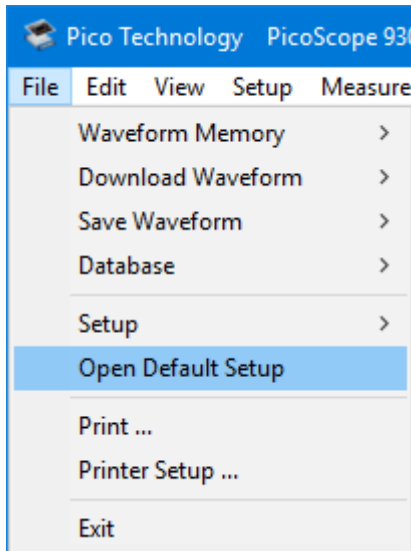
You may find it helpful to use this known operating condition when someone else has used the oscilloscope before you. If you accidentally press **Open Default Setup**, use **Undo** to return the oscilloscope to the operating condition it was in before **Open Default Setup** was pressed.

The **Print...** sub-menu allows you to select different printer options. This sub-menu includes the following controls:
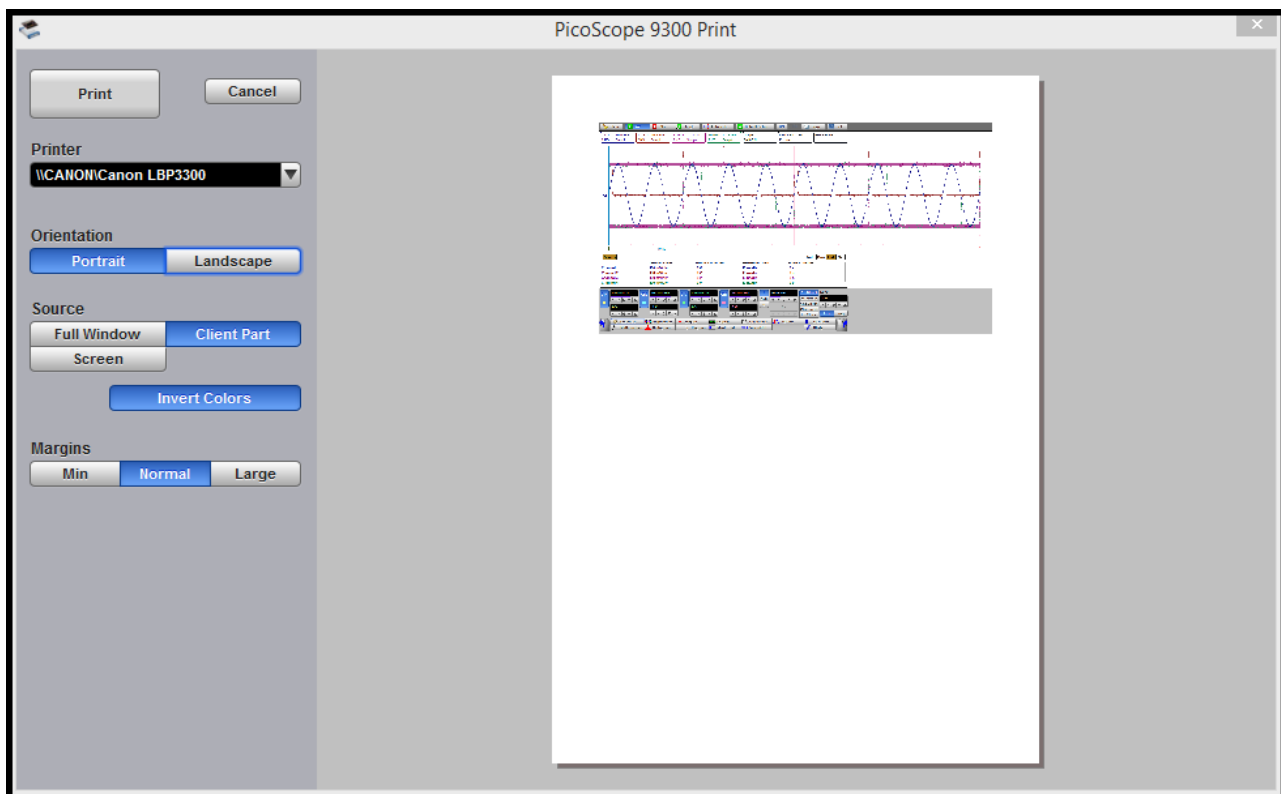
- **Print**: command button to print the output file
- **Cancel**:   anceling the file to print
- **Printer**: selects the printer you want to use
- **Orientation:** selects page orientation for printing: **Portrait** or **Landscape**.
- **Invert Colors:** this mode is used for better printing of the waveforms on white paper, and greatly reduces the usage of toner.
- **Margins:** defines the margins when printing: **Min**, **Normal** or **Large**.

Printer Setup... is a standard Windows Print Setup dialog:
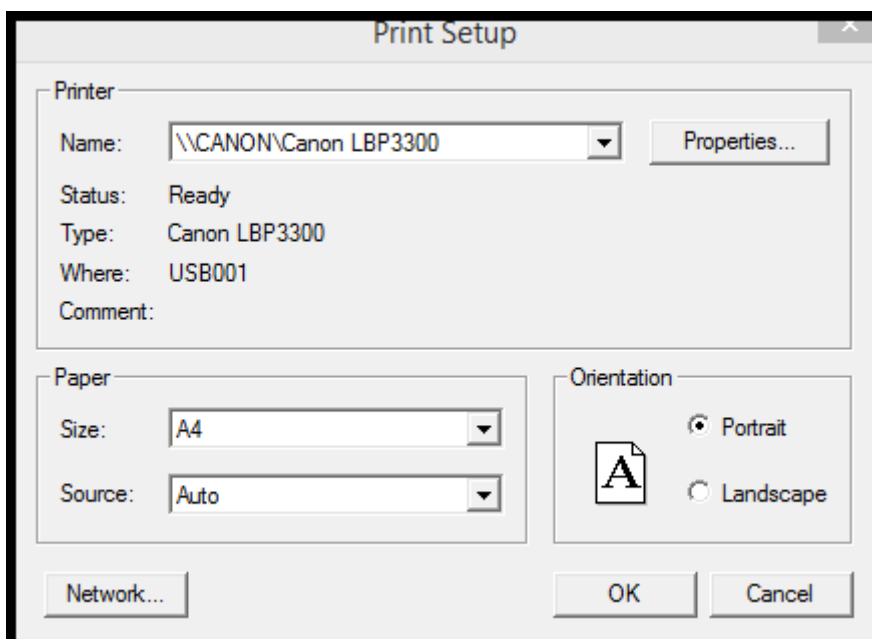
The **Exit** command closes the PicoSample 3 software:
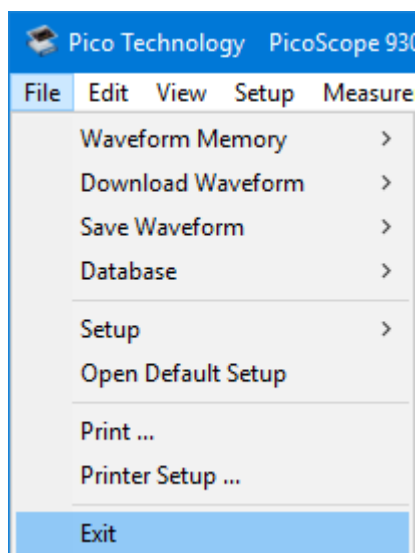
6.4.2   Edit

The **Edit** menu includes the following controls:
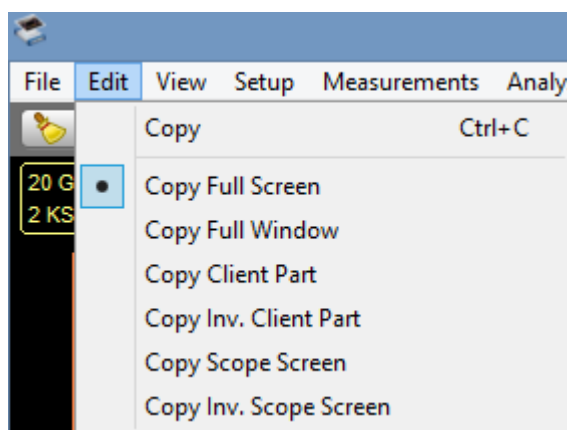
This menu allows you to copy different programming windows to the **Windows Clipboard**. From there, you can paste copied information into such **Windows** programs as **Word, Corel Draw, Paint Brush,** and **Photoshop**.

Use the **Copy** functions when preparing documentation based on usage of the PicoScope 9300.

6.4.3   View

The **View** menu allows you to configure various components of the GUI. It assigns the following items to different parts of the GUI:
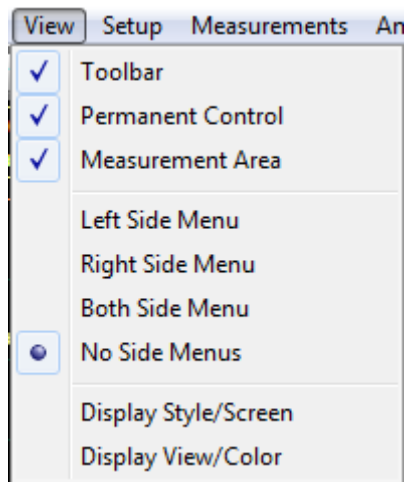
Below are shown several different options of the **View** menu:
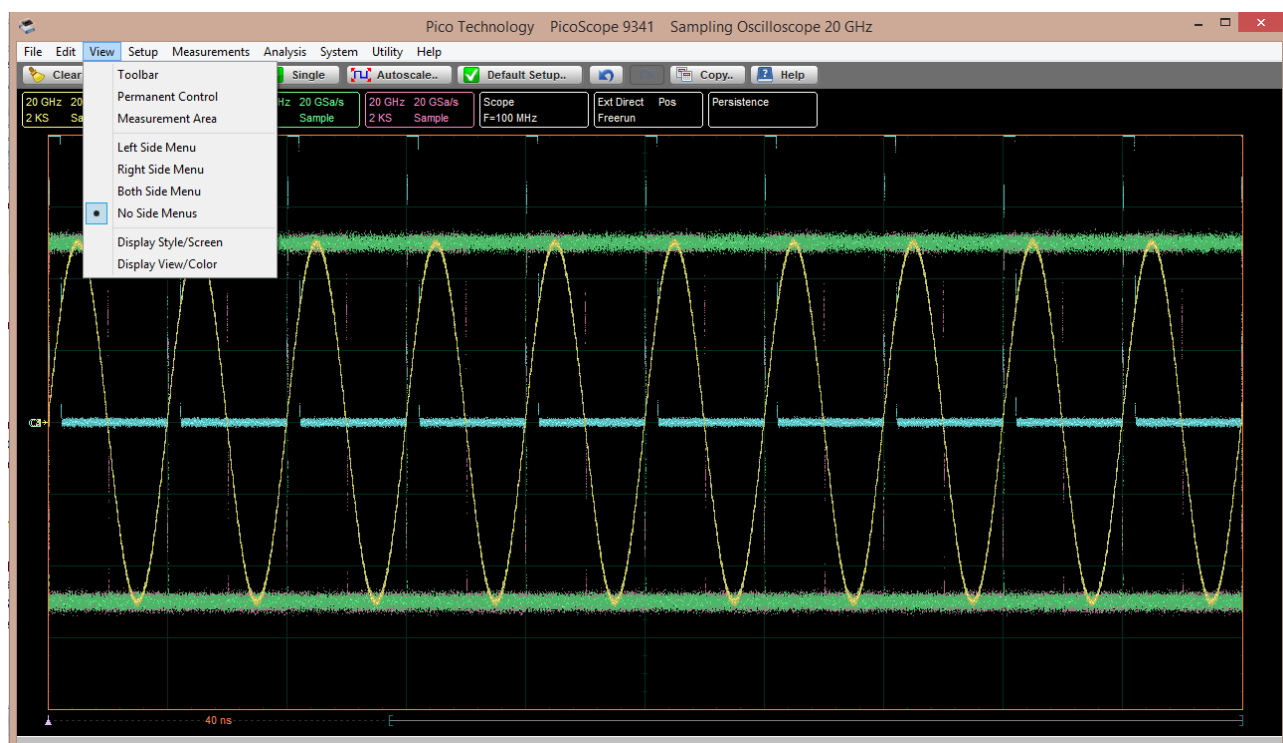
1. All options of the View menu are turned off
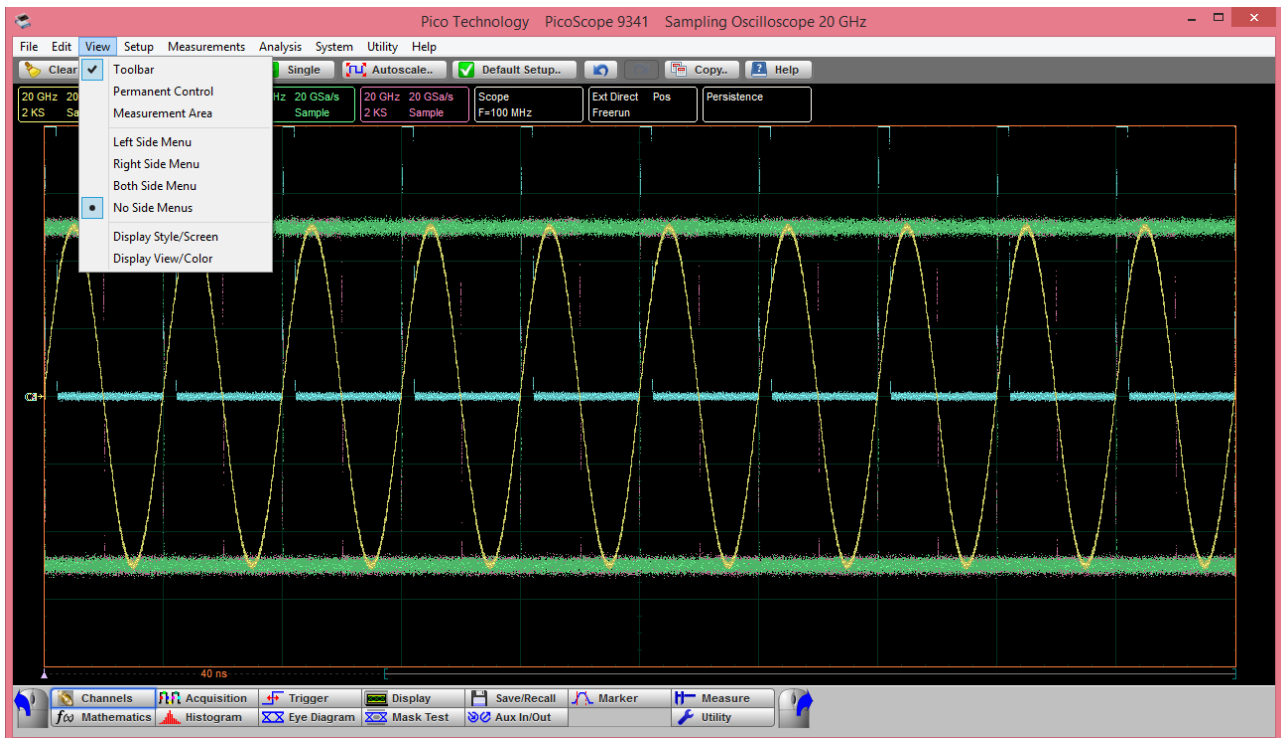
2. Toolbar is added
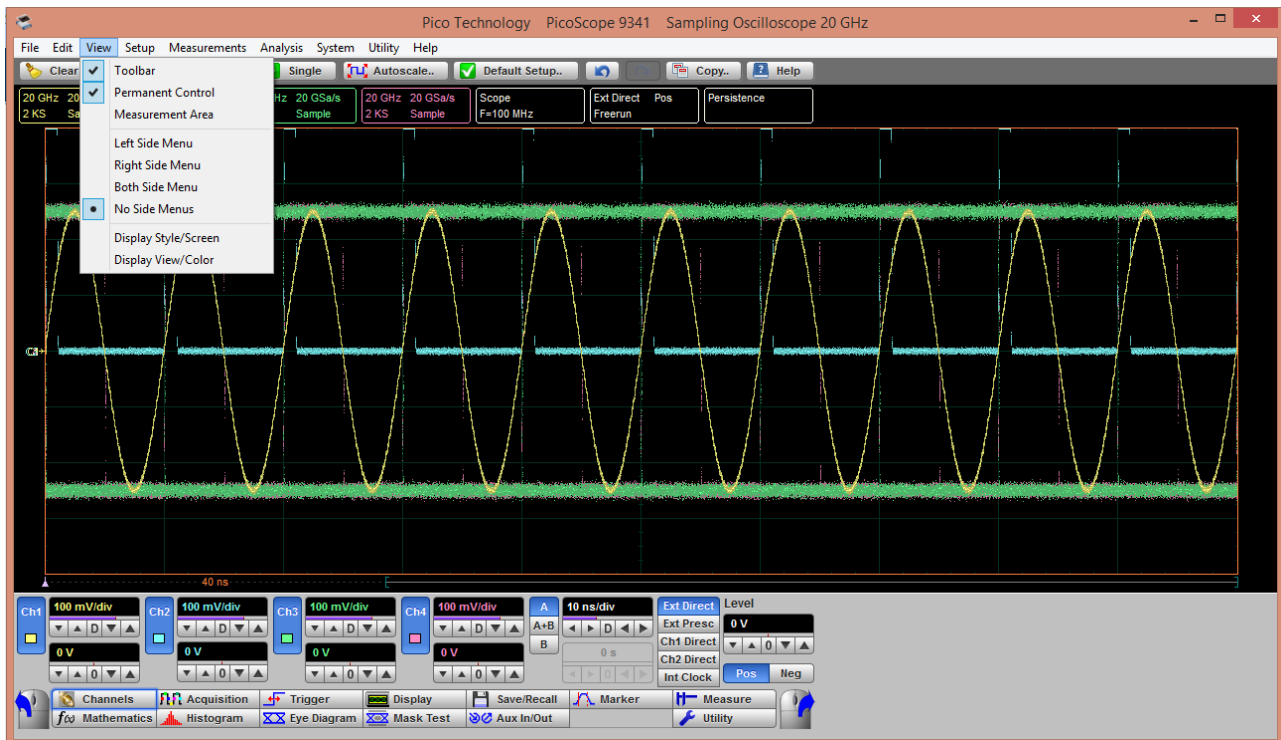
3. Permanent Control is added
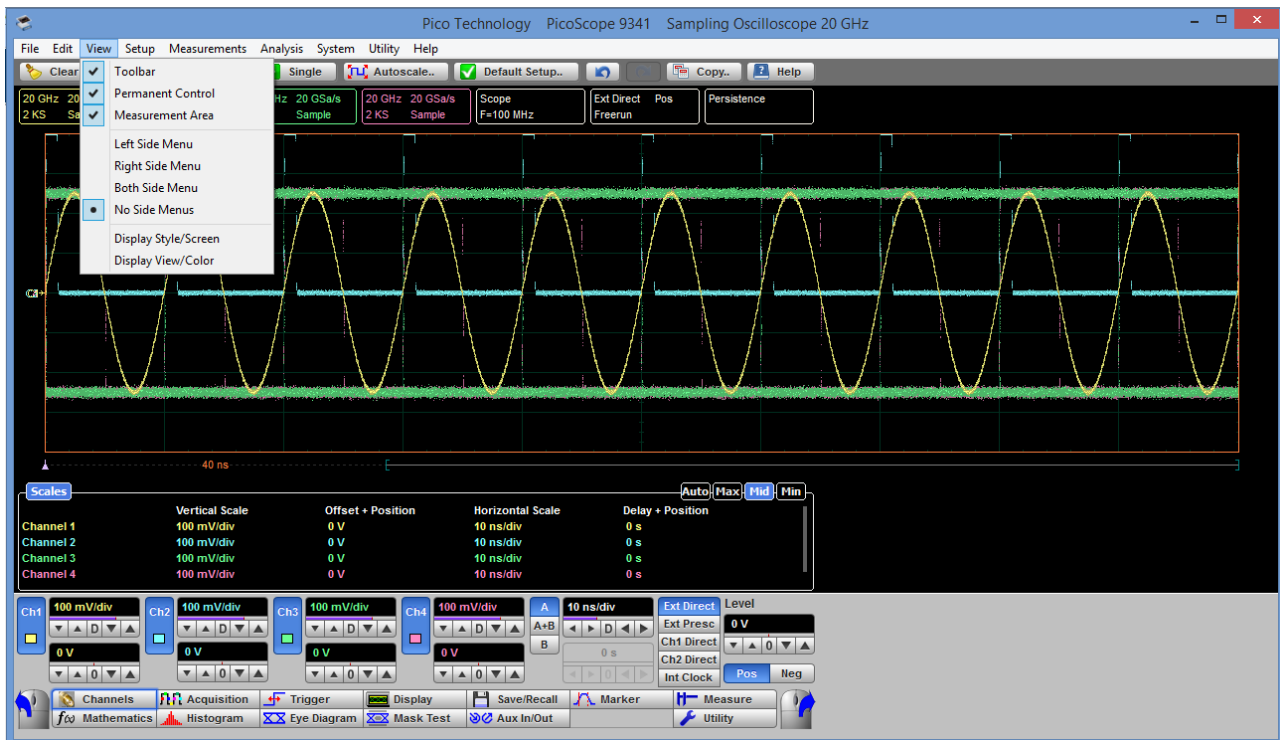
4. Measurement area is added

5. Left Side Menu is added
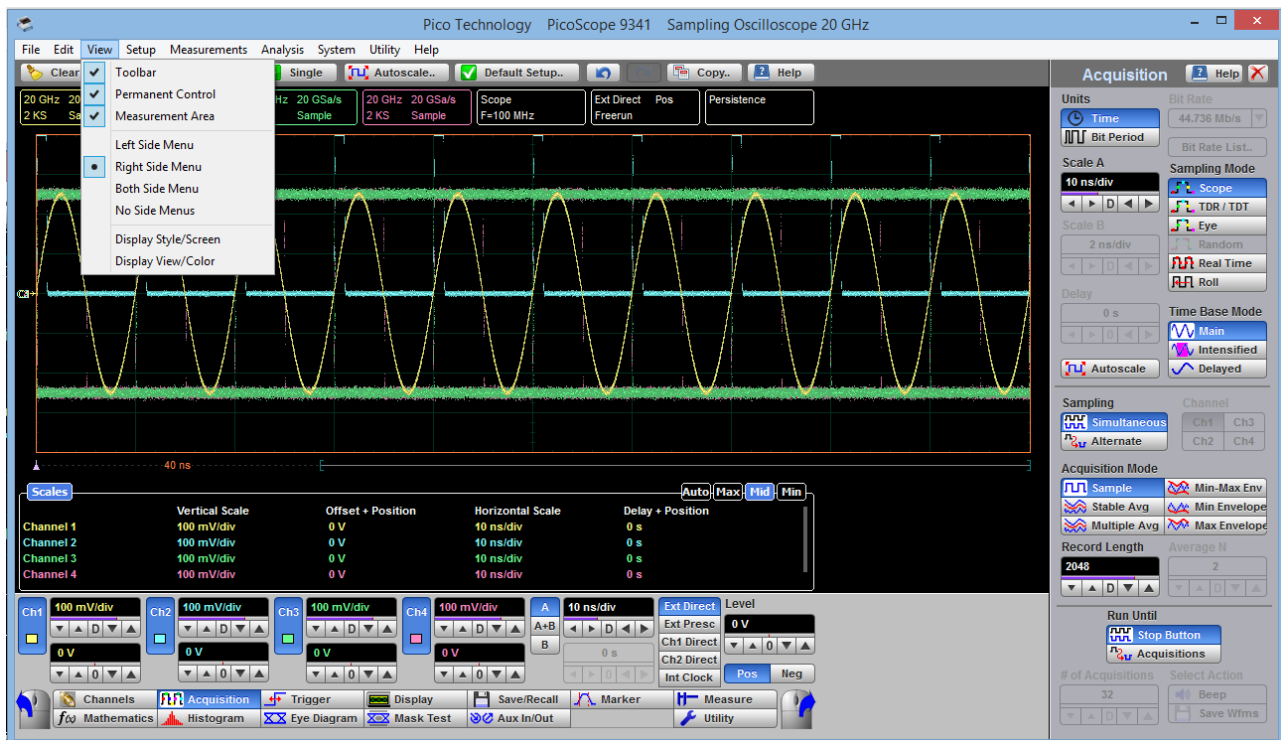
6. Right Side Menu is added
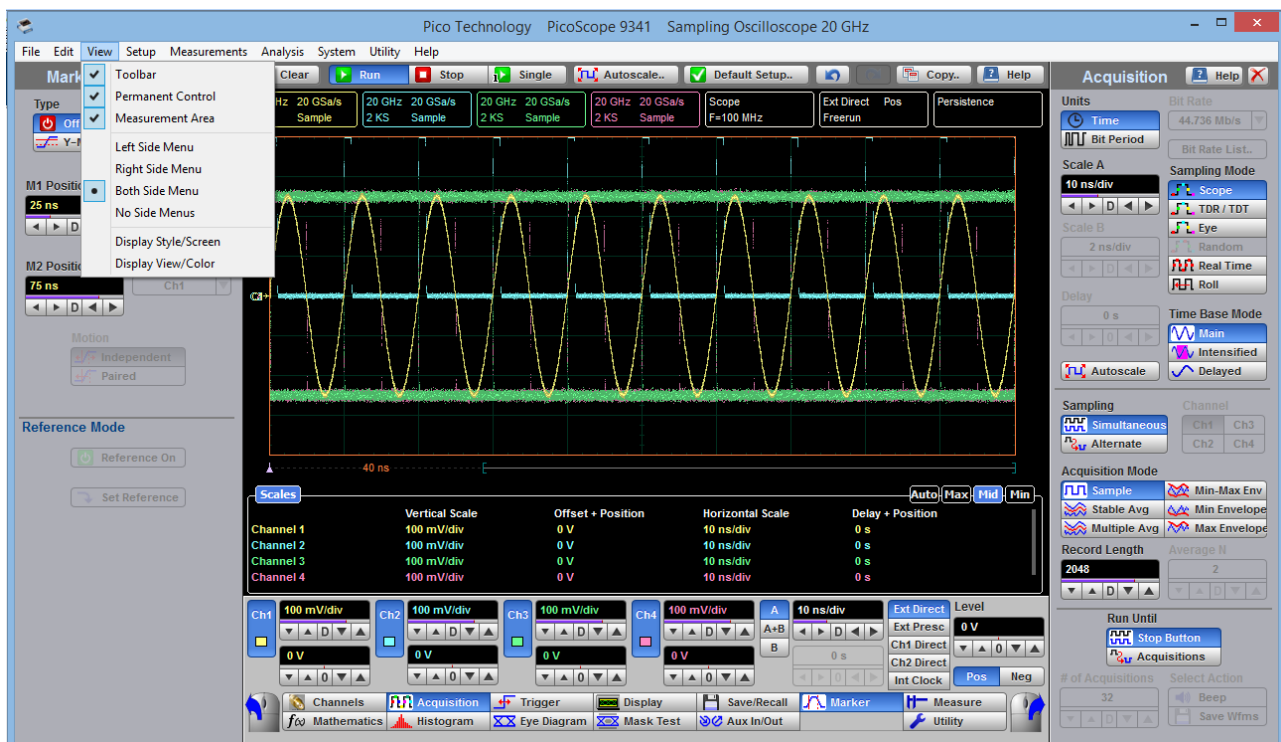
7. Both Side Menus are added

6.4.4   Setup

The **Setup** menu assigns the following items to the side menu:

- **Channel 1**
- **Channel 2**
- **Channel 3**

- **Channel 4**
- **Time Base/Acquisition**
- **Edge Trigger**
- **Advanced Trigger**
- **Aux In/Out**
- **O/E Converter** (for PicoScope 9321A only)
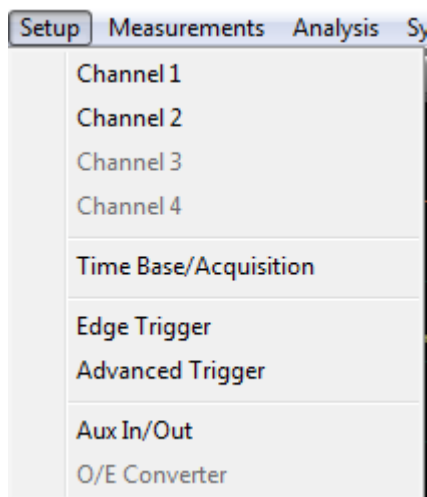
The **Setup** menu assigns the item to the left side menu if it is opened or if both side menus are opened.

The **Setup** menu assigns the item to the right side menu if only right side menu is opened.

6.4.5   Measurements

The **Measurements** menu assigns the following items to the side menu:

- **Marker**
- **Measure**
- **Histogram**
- **Eye Diagram**
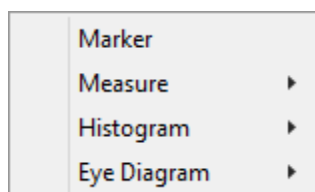
The **Measure** menu has three sub-menus that can be directly assigned to the side menu:

- **Parameter**
- **Definition**
- **Limit Test**
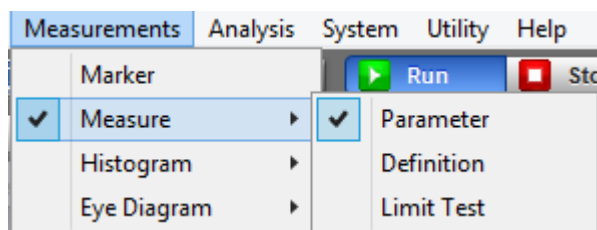
The **Histogram** menu has two sub-menus that can be directly assigned to the side menu:

- **Setup**
- **Window/Scale**
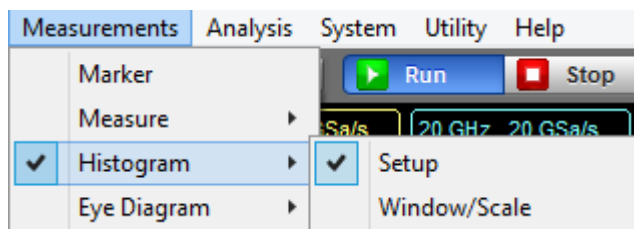
The **Eye Diagram** menu has two sub-menus that can be directly assigned to the side menu:

- **Parameter**
- **Definition**
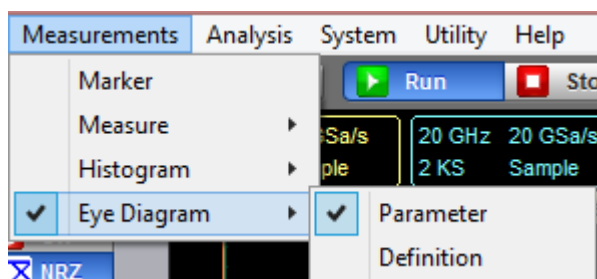
6.4.6   Analysis

The **Analysis** menu assigns the following items to the side menu:

- **Mathematics**
- **Mask Test**
- **TDR/TDT** (for PicoScope 9311 and PicoScope 9312 only)
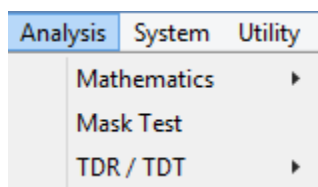
The **Mathematics** menu has two sub-menus that can be directly assigned to the side menu:

- **Function**
- **Scaling**
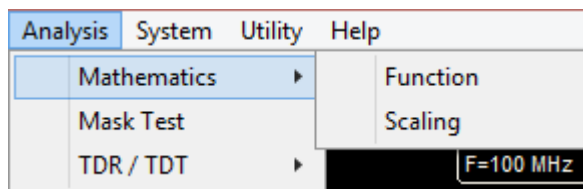
The **TDR/TDT** menu can be use with the PicoScope 9311 and PicoScope 9312 only and has two sub-menus that can be directly assigned to the side menu:

- **Stimulus**
- **Setup**
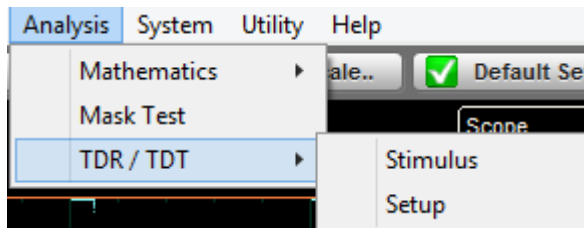
6.4.7　System

The **System** menu assigns the following items to the side menu:

- **Change Instrument**
- **Common LAN Setting**
- **Scanning LAN Instrument**
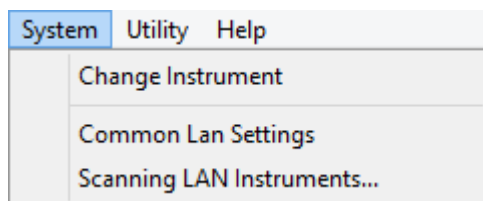
Change Instrument opens the Change Instrument dialog:
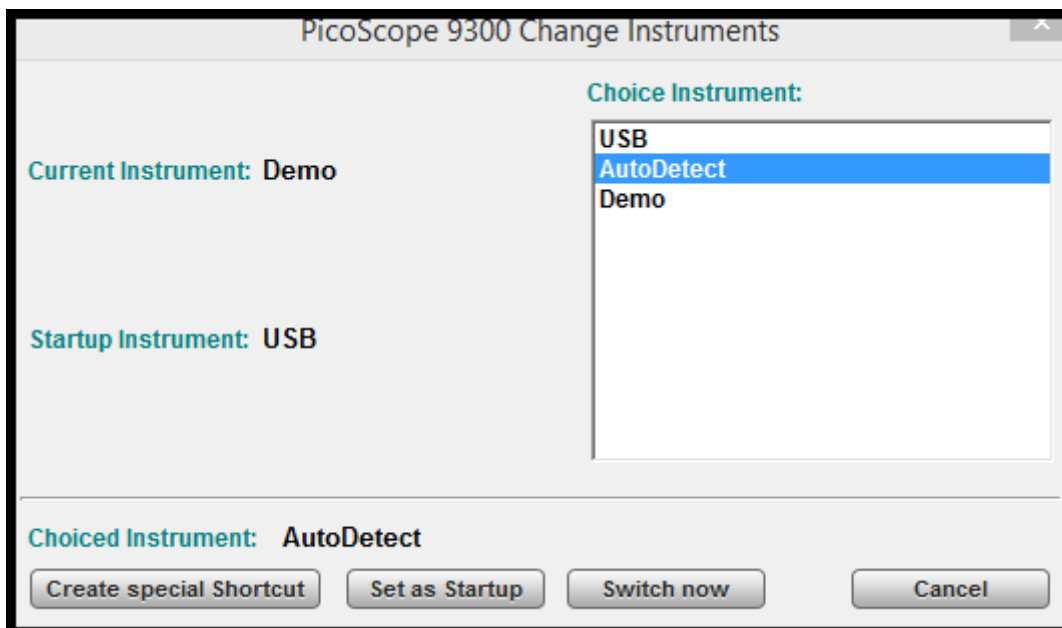
The **Change Instrument** menu allows you select the instrument that should be assigned to the program. The following options can be used:

- The instrument connected by USB
- The instrument found with AutoDetect mode
- The Demo Mode instrument

Create special Shortcut creates a shortcut to the instrument on your desktop.

Common LAN Settings opens this dialog:
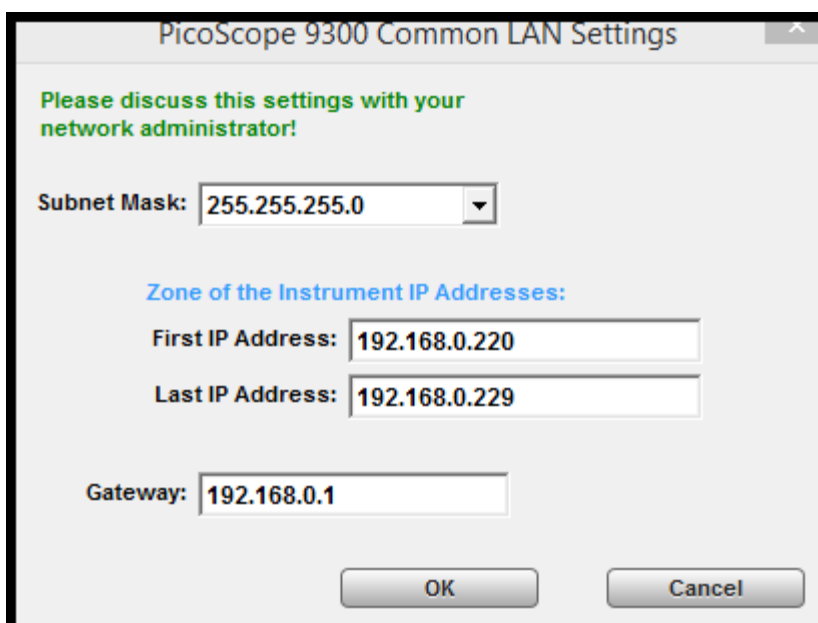
Select the settings appropriate to your LAN after consulting your network administrator.

LAN Instruments Scanning opens this dialog and starts a scan of IP addresses as defined in the **Common LAN Settings** dialog:
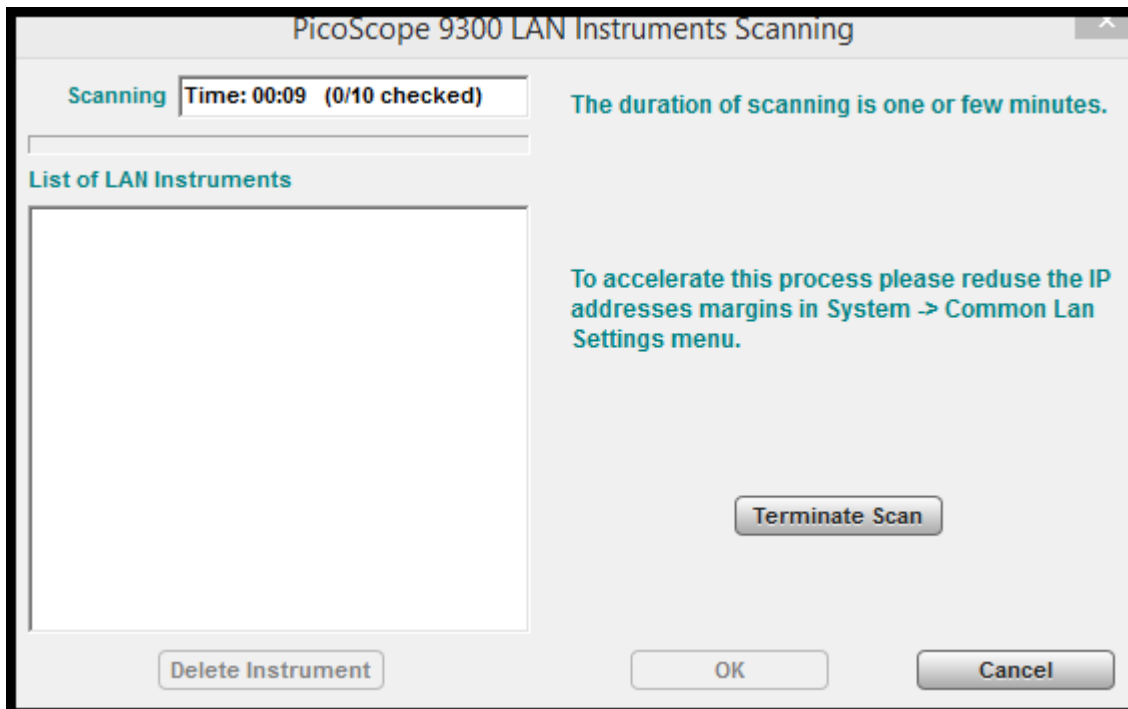
After the scan is finished, all found IP addresses will be displayed in the **List of LAN Instruments**. To confirm the scanning results, click **OK**.
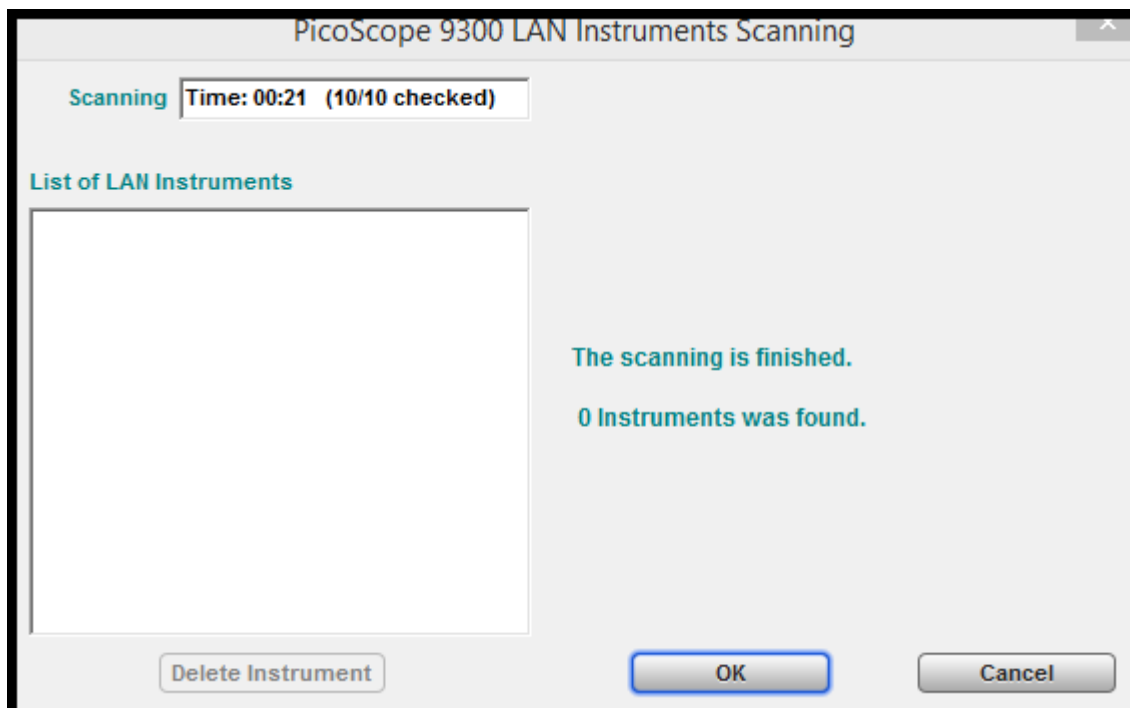
6.4.8   Utility

The **Utility** menu assigns the following items to the side menu:

- **Calibrate:** Channel 1/2, Channel 3/4 or Timebase calibration routine.
- **Demo:** In demonstration ('Demo') mode, when no scope is plugged in (see Demo mode for more information), five virtual signal generators labeled A to E are available to drive the input channels.

- **Adjustment**: This opens several menus used for the factory adjustment procedure. It is protected by a password.
- **Language**: This menu selects the language used in the PicoScope 9300 User's Guide. At the present time the only available language is English.
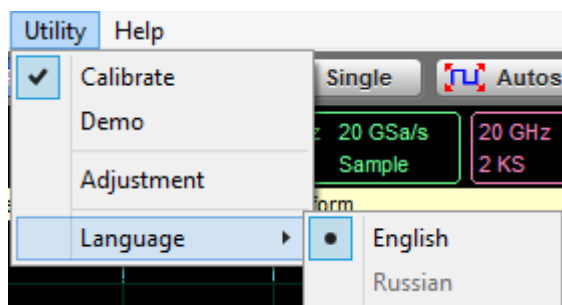
6.4.9   Help

The **Help** menu has two functions:
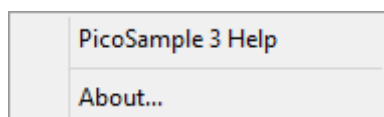
- **PicoSample 3 Help** activates the context-sensitive built-in information system on the instrument.
- **About...** shows information about the program and the instrument in use. It also allows you to change the instrument model in Demo mode, and to edit the TCP/IP properties of the instrument.

6.5   Measurement Area

There are seven tabs that can appear in the **Measurement Area** at the bottom of the oscilloscope display depending on the selected current settings. Click on each of the tab headings to view measurement results.

The list includes the following tabs:

- **Scales Tab**
- **Color Grade Tab**
- **Marker Tab**
- **Measure Tab**
- **Histogram Tab**
- **Eye Diagram Tab**
- **Mask Test Tab**

The **Measurement Area** has three height settings: **Max**imum, **Mid**dle and **Min**imum.

Max height provides 10 rows, **Mid** height provides 5 rows, and **Min** height provides 2 rows.

Measurement Area with maximum height

Measurement Area with middle height

Measurement Area with minimum height

6.6   Permanent Controls

The **Permanent Controls** are located at the bottom of the display area. They are permanent because they are the most common functions that affect the waveform display. By using the **Permanent Controls** you have a quick reference to vertical, horizontal and trigger selections.

The **Permanent Controls** are:

- 🔵 The **Channel 1-4** on/off check boxes, scale, and offset settings.
- 🔵 The **Timebase** modes, the **A** and **B** timebase scales, and delay settings.
- 🔵 Trigger source, slope, and level settings.

By clicking the right mouse button on a selected variable and choosing the **Calculator** command, you will obtain a pop-up numeric keypad allowing you to set a precise value.

Each channel has a check box allowing you to turn that channel on or off, and a set of controls allowing you to change the vertical scaling or offset. Only channels that are on are shown in matching colors.

The right-hand side of the permanent controls contains a selection of trigger controls. Trigger slope can be selected between **Pos**itive and **Neg**ative, while trigger mode can be selected between **Freerun** and **Trig'd**. You can set a particular trigger level.
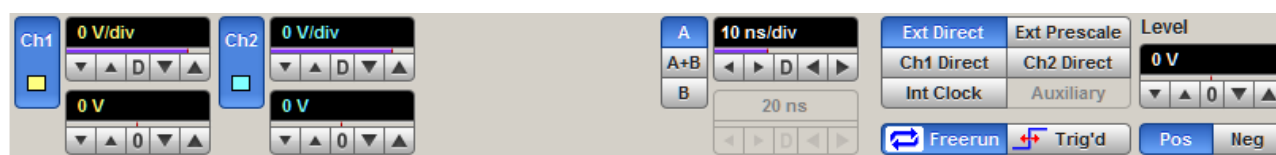
Permanent Controls

6.7   Pop-up keypad

The **Pop-up keypad** allows you to enter numeric values directly. You can use it with any numeric field in the PicoSample 3 software: just right-click on the field and select **Calculator**. You can also type variables directly into numeric fields: first type the number, then finish by typing a single letter - p, n, u, m, X, K, M, G, T. (The meanings of these letters are explained below).

1. Choose the numeric field that you wish to edit.

2. Right-click on the field to bring up the context menu.

3. Click the **Calculator** command to bring up the **Pop-up keypad.**

4. Enter the new value numerically by clicking the number keys, then click one of the multiplier buttons to complete the value. (The **X** button means a multiplier of 1). Finally, click **OK** to update the numeric field:

Special Key Definitions

Min.	Enter the minimum value of selected variable.
Mid.	Enter the middle value of selected variable.
Max.	Enter the maximum value of selected variable.
Fine	Enter the value of selected variable with fine resolution.
Coarse	Enter the value of selected variable with coarse resolution.

Numeric value keypad

Minus (-)   Changes the sign of the mantissa. Changes the sign of the exponent after you have pressed the exponent key.

Dimension keypad

p (pico)	Appends an exponent of 10^{-12} to the number you have entered.
n (nano)	Appends an exponent of 10^{-9} to the number you have entered.
u (micro)	Appends an exponent of 10^{-6} to the number you have entered.
m (milli)	Appends an exponent of 10^{-3} to the number you have entered.
K (kilo)	Appends an exponent of 10^{3} to the number you have entered.
M (mega)	Appends an exponent of 10^{6} to the number you have entered.
G (giga)	Appends an exponent of 10^{9} to the number you have entered.
T (tera)	Appends an exponent of 10^{12} to the number you have entered.
Clr (clear)	Clears any numbers you have entered.
Backspace	Use the backspace key to erase the character to the left of the insertion point.
e (Exponent)	The number you enter after pressing this key is an power of 10.

6.8   Side Menu

The side menus appear on the left and right sides of the waveform area.

Left-click a button on the toolbar to add the specified menu to the left menu area. Right-clicking sends the menu to the right menu area.

If the toolbar is not visible, display it using the **View > Toolbar** command on the **Main Menu**.

Remove a side menu by clicking the **Cancel** button .

6.9   Status Area

The **Status Area** displays acquisition status, mode, and number of acquisitions, as well as the trigger status, date, time, and quick reference to record length and horizontal parameters.

6.10   System Controls

| Clear | Run | Stop | Single | Autoscale.. | Default Setup.. | | | Copy.. | Help |

Using the **System Controls**, you control whether the oscilloscope is running or stopped. Other buttons allow you to reset the oscilloscope to its default setup, automatically configure the oscilloscope for the current signals (**Autoscale**), or erase the waveforms from the display.

The **System Controls** buttons are:

- Clear
- Run
- Stop
- Single
- Autoscale
- Default Setup
- Undo
- Redo
- Copy
- Help

6.10.1   Clear

Clear

Clicking the **Clear** button erases all channel waveform data from the graticule area. The following occurs when the display graticule is cleared:

- All channel waveform data is erased from the graticule area.
- Functions, spectra and waveform memories are not erased from the display graticule when the clear display feature is executed.
- All associated measurements and measurement statistics are reset (averaging, color-grading, mask test data, limit test data, and histogram results), if enabled.

When the instrument is running

If the instrument is running and receiving triggers, new waveform data is displayed on the next acquisition, averaging is reset; and persistence and color-grading, histograms, the mask testing database and all measurements are recalculated.

When the instrument is stopped

If the instrument is stopped, the display remains cleared of waveform data until the trigger circuit is rearmed and the instrument is triggered. Then the new data is displayed and measurements are recalculated.

6.10.2   Run, Stop and Single

The **Run** button causes the instrument to resume acquiring data. If the instrument is stopped, it starts acquiring data on the next trigger event. If the instrument is already in the run mode, it continues to acquire data on successive trigger events.

If pressing the **Run** button does not cause waveform data to display on the screen, try the following:

- Make sure a signal is connected to one of the channel and the display for that channel is turned on.
- Make sure the offset does not have the trace clipped off the display.
- Check the trigger setup conditions to make sure the trigger conditions are valid for the signal.
- Set the trigger mode to **Freerun**. **Freerun** forces the instrument to trigger, which may allow you to see enough of the signal so that you can set up the front panel properly.
- Click the **Autoscale** button.

The **Stop** button causes the oscilloscope to stop acquiring data. You can stop acquisition if you want to freeze the displayed waveform(s) for closer analysis or measurement.

The **Single** button causes the oscilloscope to perform a single waveform acquisition. Each subsequent press of the **Single** button rearms the trigger circuit. A complete acquisition cycle is performed, and any measurements are recalculated.

If all of the channels are turned off or if a trigger event is not found, the instrument will not acquire any data.

6.10.3   Autoscale

Adjusting an oscilloscope to display a stable trace of usable size and amplitude can be a time-consuming process. The **Autoscale** feature of the PicoScope 9300 can quickly give you a stable, meaningful trace display.

The **Autoscale** button causes the instrument to quickly analyze any waveforms connected to the trigger and channel inputs. Then, it sets up the vertical, horizontal, and trigger controls to best display that signal.

When you click the **Autoscale** button, you tell the PicoScope 9300 to examine the signal and adjust the following controls for optimum display:

- Vertical scale and offset
- Timebase scale and delay
- Trigger level, if appropriate to that trigger source

The PicoScope 9300 must have an available trigger source and input. For example, if you are using the **Direct Trigger Input**, and **Ext Direct** is selected in the **Trigger/Source** menu, the trigger signal must be connected to this trigger input. **Autoscale** can then set the trigger level. If you are using the **Prescale Trigger Input**, and the **Ext Prescaler** is selected in the **Trigger/Source** menu, the trigger signal must be connected to this trigger input.

When **Ext Direct** is selected in the **Trigger/Source** menu, the **Autoscale** function can find repetitive signals with:

- Frequency greater than 1 kHz
- Duty cycle greater than 1%
- Vertical amplitude greater than 50 mV p-p
- Trigger amplitude as specified

When **Ext Prescaler** is selected in the **Trigger/Source** menu, the **Autoscale** function can find repetitive signals having trigger frequency and amplitude as they are specified.

When the **Ch1 Direct** or **Ch2 Direct** is selected in the **Trigger/Source** menu, the **Autoscale** function can find repetitive signals with:

- Frequency greater than 1 kHz
- Duty cycle greater than 1%
- Vertical amplitude greater than 50 mV p-p
- Trigger amplitude as specified

Autoscale is operative only for relatively stable input signals. **Autoscale** looks for signals on all channels, even if they are turned off. It also searches for a trigger signal on the trigger inputs.

If the **Autoscale** button is pressed unintentionally, use the **Undo** button to return the instrument to the settings that existed before.

When the **Autoscale** is selected, the following controls are set:

- **Timebase Mode**: **Delayed** (**B**)
- SCALE **B:** to best display the waveform
- **Trigger**. If **Ext/Ch1/Ch2 Direct** is selected: **Freerun Mode, Positive Slope, Trigger LEVEL** to 50% amplitude point of the trigger waveform, **Normal Hysteresis**, **HOLDOFF** with minimum value. If the **Ext Prescaler** is selected: to best display waveforms.
- Vertical **OFFSET:** to best display waveforms on active channels
- Vertical **SCALE:** to best display waveforms on active channels

Autoscale options

To perform autoscale, right-click the **Autoscale** button to get the four autoscale options. Select one of them, and then the scope will perform an optional **Autoscale**.

The four **Autoscale** options are:

- **Auto.** Optimizes the autoscale algorithm for such waveforms as sine waves or pulses. Can be used for all main menus excluding the following cases:
  - Either **NRZ** or **RZ** is selected in the **Eye Diagram/Measure** menu.
  - One of the standard masks for eye-diagram waveforms is selected in the **Mask Test** menu.
- **Single-valued.** Optimizes the autoscale algorithm for such waveforms as sine waves and pulses.
- **NRZ.** Optimizes the autoscale algorithm for such waveforms as **NRZ** eye-diagrams.
- **RZ.** Optimizes the autoscale algorithm for such waveforms as **RZ** eye-diagrams.

6.10.4 Default Setup

The **Default Setup** button returns the instrument to its default settings. This places the oscilloscope in a known operating condition. You may find it helpful to use this known operating condition when someone else has used the oscilloscope before you. If you accidentally press the **Default Setup** button, use the **Undo** button to return the oscilloscope to the operating condition it was in before **Default Setup** was pressed.

Right-click on the button to get four options:

- **Default Setup**   Returns the instrument to its default settings.
- **Factory Setup**   Returns the instrument to default setting of the manufacturer.
- **Power Off Setup** Returns the instrument to the last setting before switching off the power supply.
- **Save As Default** Stores the present front-panel setup as default setup.

6.10.5 Undo, Redo

Undo **and Redo**

You may find situations where you have unintentionally selected an unnecessary control. When this happens, you can use the **Undo** button to return the oscilloscope to the previous settings. The depth of undo can be up to 100 steps.

If you later decide you didn't want to undo an action, right-click the button and select **Redo** .

6.10.6 Copy

Clicking the **Copy** button copies different programming windows to the **Windows Clipboard**. From there, you can paste copied information into such **Windows** programs as **Word, Corel Draw, Paint Brush,** and **Photoshop**.

Use the **Copy** function when preparing documentation based on usage of the PicoScope 9300.

Right-click the button to get six options:

- **Full Screen**
- **Full Window**
- **Client Part**
- **Invert Client Part**
- **Oscilloscope Screen**

ps9300.en-13   84

- **Invert Oscilloscope Screen**

6.10.7   Help

[?] Help

The **Help** button has two functions:

- Click to activate the context-sensitive built-in information system on the instrument. This changes the pointer into a context-sensitive help icon. You can then click any control to open the manual at the relevant page.
- Right-click to open the **PicoScope 9300 Help** manual or the **About...** dialog.

These options can also be accessed by clicking Help in the main menu.

About...
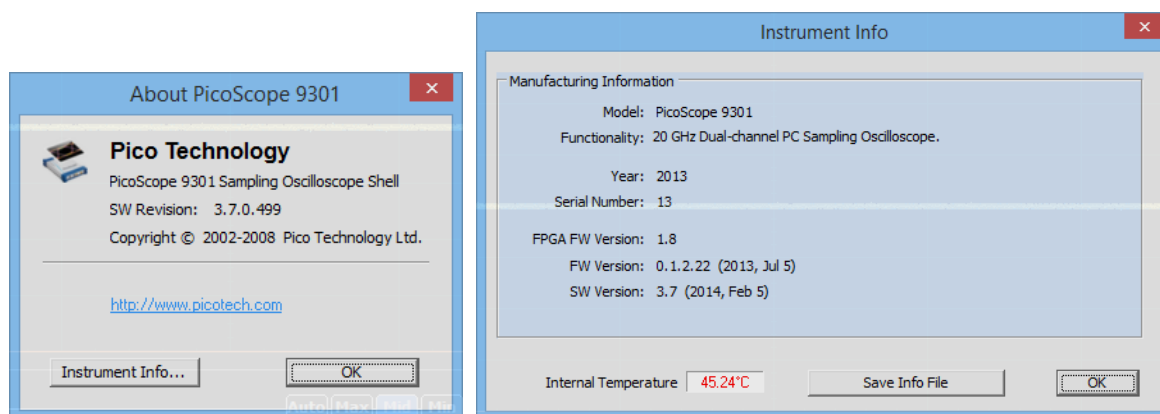
About... and Instrument Info dialogs from the Help menu

Click **About...** to view some basic information about the oscilloscope and software that you are currently using. Click the **Instrument Info...** button to view information about the connected device.

If you are using the PicoSample 3 software in **Demo mode**, without an oscilloscope connected (see Demo mode for more information), you can use the **Instrument Info** dialog to change the model of the demonstration device. The dialog shows information about the current demonstration device; click **Change Model** to select a different model. To update the software you will then need to restart PicoSample 3.
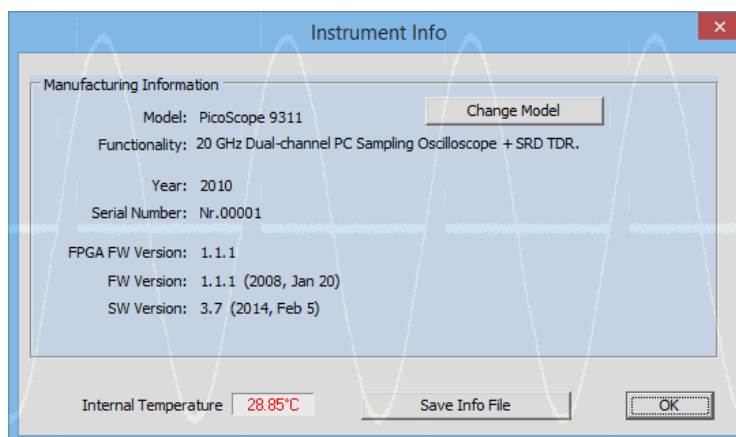
Instrument Info dialog with a demonstration device

6.11   Toolbar

The **Toolbar** includes up to 14 buttons located at the bottom of the instrument display.

The **Toolbar** is used to:

- Set up the oscilloscope operating modes (**Channels**, **Acquisition**, **Trigger**, **Display**, **Aux In/Out** and **O/E Converter** menus)
- Set up and execute waveform measurements (**Marker**, **Measure**, **Histogram**, **Eye Diagram**, **Mask Test** and **TDR/TDT** menus)
- Control file management tasks (**Save/Recall** menu)
- Perform waveform analysis (**Math** menu)
- Set up and execute instrument calibration, and to use a demo mode (**Utility** menu)

The Toolbar menu for the PicoScope 9301, 9302, and 9341 oscilloscopes

The Toolbar menu for the PicoScope 9311 and 9312 oscilloscopes

Main menu for the PicoScope 9321 oscilloscope

Clicking on any button of the **Toolbar** with the right mouse recalls the **Right Side Menu**.
Clicking on any button of the **Toolbar** with the left mouse recalls the **Left Side Menu**.

6.12   Startup

If you start the PicoSample 3 software without a device connected, the **Initialisation...** dialog will automatically appear with four buttons, as shown below.
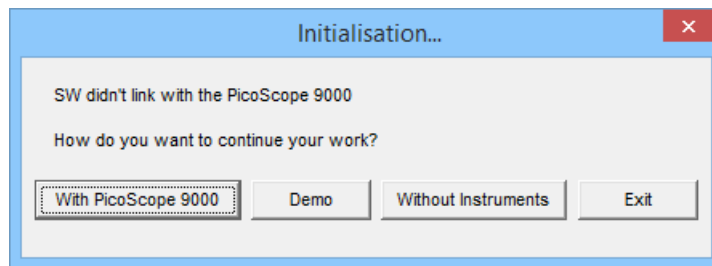
Initialisation... dialog

- **With PicoScope 9000**: Connect a PicoScope 9300 Series oscilloscope and then click this button to continue opening the software.
- **Demo**: Start the software with a demonstration waveform. See Demo Mode for more information.
- **Without Instruments**: Opens the software without a waveform, for access to basic Main Menu items.
- **Exit**: Close the software

7 Menus

7.1 Acquisition menu

Acquire
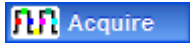
The **Acquisition** menu allows you to control the horizontal display (timebase) through the **Main**, **Intensified** or **Delayed** timebases and through the **Scale** and **Delay** functions. It also has several options for converting analog data into digital form. The **Acquisition** menu allows you to modify the way the instrument acquires the data from the input waveform by selecting the number of averages or envelopes, and record length.
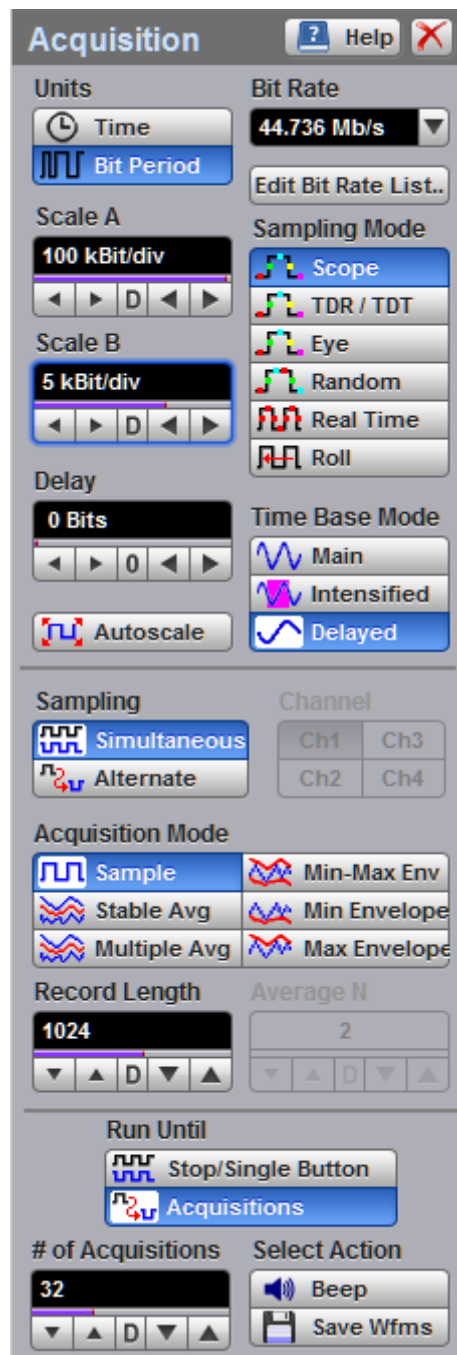
The Acquisition menu

The common timebase parameters specify a common horizontal acquisition window that is applied to all channels in parallel. These parameters are:

● The **trigger** signal that you input, and which you set the trigger system to recognize, determines the point relative to the input waveform that triggers the oscilloscope.

● The **horizontal position** you set determines the horizontal delay from the trigger point to the first sample point in the acquisition window.

● The **horizontal scale** you set, and the requirement that all waveforms fit within the 10 horizontal-division display, determines the horizontal duration of the window relative to any waveform, allowing you to scale it to contain a waveform edge, a cycle, or several cycles.

● The **record length** (along with the horizontal scale) you set for the 10-division window determines the sample interval (horizontal point spacing or resolution) on the waveform.

The **Timebase Scale**, **Record Length**, **Sample Interval** and **Resolution** are related to each other and specify the horizontal acquisition window. Relations between these horizontal elements are as follows:

Time Duration (seconds) = 10 div (window size) $\times$ Timebase Scale (sec/div)

Time Duration (seconds)
= Sample Interval (seconds/sample) $\times$ Record Length (samples)

Sample Interval (seconds/sample)
= Resolution (sec/sample)
= 1/Sample Rate (samples/sec)

These elements in formulas behave as follows:

● If **Record Length** or **Time Duration** vary, **Sample Interval** varies to accommodate them, up to the highest sample rate (lower sample interval or highest resolution).

● If you set a faster **Timebase Scale** setting, decreasing **Time Duration**, and the **Sample Interval** reaches its lower limit, the horizontal scale becomes limited to a setting compatible with the record length and the lower limit of the sample interval.

● If you attempt to set a longer **Record Length** and the **Sample Interval** reaches its lower limit, **Time Duration** remains constant and the record length becomes limited. The equation becomes:

Maximum Record Length = Time Duration / Min Sample Interval

You can control the acquisition process at any time by clicking on of the **System Controls** buttons **Run**, **Stop, Single** or **Clear Display**. For more details see **System Controls**. Using the **System Controls**, you control whether the oscilloscope is running or stopped.

7.1.1 Units
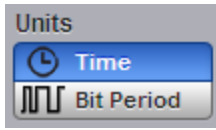
The **Units** function lets you set the instrument timebase in basic time units or in bit period (data rate) units. Bit period units provide an easy and intuitive way to display digital communication signals. Instead of having to compute the time interval required to display two bits or eyes, you can simply set the scale to two bits.

Time (Basic time units)
Allows you to set the scale units to seconds per division (*s/div*) and the delay units to seconds (*s*). The default value for basic time units is 10 ns/div.

Bit Period (Bit units)
Allows you to select from a list of standard optical and digital telecommunications rates. When selected, the timebase scale units are set to bits per division and the delay units to bits. In this mode, the instrument internally performs the calculation to convert the number of bits displayed on the screen to the time per division. For example, if you wanted to convert *x* bits per division to time per division, you would have to compute the following:

N bits/screen

Bit period = 1 / bit rate

Time/screen = N bits/screen × (bit period)

Time/division = 0.1 time/screen

The **Bit Period** is available in the **Scope** and **Eye Sampling Modes**, but is not available in the **TDR/TDT**, **Random**, **Real Time** and **Roll Sampling Modes**.

7.1.2　Bit Rate
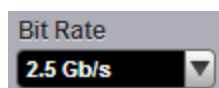
Bit Rate
2.5 Gb/s ▼

The **Bit Rate** allows the timebase to be configured for a variety of standard optical and electrical telecommunications rates. If you are measuring a signal with one of these standard rates, the scale and delay functions will coincide with this rate.

Bit rate can be selected from 44.736 Mbit/s to 43.018 41 Gbit/s. The following bit rates are standard selections when you select bit period as the horizontal (timebase) scale units.

Bit Rate	Standard	Bit Rate	Standard
44.736 Mbit/s	DS3	2.97000 Gbit/s	SDI
51.84 Mbit/s	STM0/OC1	3.00000 Gbit/s	SATA-2/SAS-2
125.0 Mbit/s	FDDI/100M Ethernet	3.07200 Gbit/s	CPRI 5x
132.813 Mbit/s	FC133	3.12500 Gbit/s	XAUI/10Gb Ethernet-LX4
139.264 Mbit/s	DS4/PDH139Mb	3.18750 Gbit/s	FC3187/10GBE Base-LX4
155.52 Mbit/s	STM1/OC3	3.25000 Gbit/s	RapidIO
265.6 Mbit/s	FC266	3.32000 Gbit/s	12x Parallel Optics
270.0 Mbit/s	SDI	4.25000 Gbit/s	FC-4250 (4x)
393.22 Mbit/s	-	5.00000 Gbit/s	PCIe-2/2x InfiniBand
466.56 Mbit/s	OC9	6.00000 Gbit/s	SATA-2/SAS-3/CEI
480.0 Mbit/s	-	6.25000 Gbit/s	2x XAUI
531.25 Mbit/s	FC531	6.37500 Gbit/s	CEI 6G+
614.4 Mbit/s	-	8.50000 Gbit/s	FC-8500 (8x)
622.08 Mbit/s	STM4/OC12	9.95328 Gbit/s	STM64/OC192/10Gb Ethernet
786.43 Mbit/s	-	10.3125 Gbit/s	10Gb Ethernet LR/ER
933.1 Mbit/s	OC18	10.5188 Gbit/s	10GFC
1.0625 Gbit/s	FC1063	10.6642 Gbit/s	STM64/OC192 FEC 1066
1.22880 Gbit/s	CPRI 2x	10.7090 Gbit/s	STM64/OC192 FEC 1071
1.24416 Gbit/s	OC24	11.0000 Gbit/s	CEI 11G
1.25000 Gbit/s	Gb Ethernet	11.0957 Gbit/s	10Gb Ethernet FEC
1.48500 Gbit/s	SDI	11.3170 Gbit/s	10GFC FEC
1.50000 Gbit/s	SATA-1/SAS-1	12.2495 Gbit/s	STM-64/OC192 SuperFEC
1.5729 Gbit/s	-	17.0000 Gbit/s	16x Fiber Channel
1.86625 Gbit/s	OC36	19.9066 Gbit/s	STM-128/OC-384
2.1231 Gbit/s	-	25.78125 Gbit/s	100Gb Ethernet / 4
2.12500 Gbit/s	FC-2125 (2x)	27.73193 Gbit/s	100Gb Ethernet / 4 FEC
2.48832 Gbit/s	STM16/OC48	39.81312 Gbit/s	STM-256/OC-768
2.5000 Gbit/s	2Gb Ethernet/InfiniBand/PCIe	42.6569 Gbit/s	FEC 4266
2.66606 Gbit/s	STM16/OC48 FEC	43.01841 Gbit/s	STM-256/OC-768 FEC
2.85760 Gbit/s	CPRI 4x		

7.1.3   Sampling Mode

Sampling Mode
- Scope
- TDR / TDT
- Eye
- Random
- Real Time
- Roll
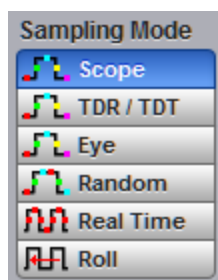
The PicoScope 9300 oscilloscopes use six sampling modes. The **Scope**, **TDR/TDT** and **Eye** sampling modes use **Sequential Equivalent Time Sampling**. **Random**, **Real Time** and **Roll** sampling modes use alternative sampling modes.

Sequential equivalent time sampling

To acquire wide-bandwidth signals the PicoScope 9300 oscilloscopes use a **Sequential equivalent time sampling** technique. When the oscilloscope acquires trace records, it bases the sampling process on a trigger event that occurs on the trigger signal. When the trigger event is detected, the oscilloscope waits a specified period of time before sampling and digitizing the first trace point. The time period is the horizontal position of the trace, which is set using the variables. After the first point is digitized, the oscilloscope waits for another trigger event before sampling and digitizing the second point of the trace record. For the second point, the waiting time between the trigger event and the sampling and digitizing of the point is increased by the sample interval. The acquisition process continues until all the points in the trace are sampled and digitized. Points are acquired in order from left to right, and each point is sampled from a separate trigger event. When all the points in the trace record have been sampled and digitized, the trace is displayed.
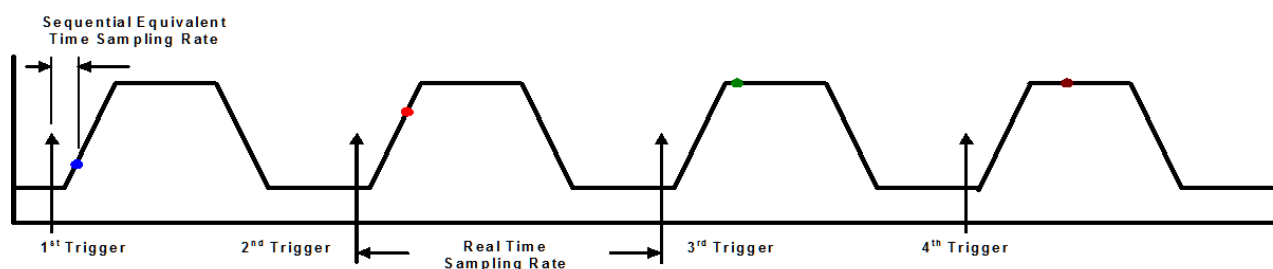
Sequential Equivalent Time Sampling

Determining the sample interval in Sequential Equivalent Time Sampling

The sample interval is the time difference represented between successive points in the trace record. This is different from the real time sampling rate, which is the actual time that it takes to sample and digitize the successive points in the trace record. Since only one point is sampled and digitized after a trigger event, the sampling rate is much slower than the sample interval.

To compute the sample interval, divide the time period that the trace record displays by the number of points in the trace record. For example, if you are display a trace at 10 ns per division, and if the trace has 1000 points (record length is equal to 1024 points), the sample interval is 10 ns multiplied by 10 (divisions) and divided by 1000 (points), or 100 ps.

All traces on the main or intensified timebases have the same record length and horizontal size. Similarly, all traces on delayed timebase share the same record length and horizontal size. This means that the PicoScope 9300 uses one sample interval for main or intensified traces and a different sample interval for delayed or dual delayed traces.

Effective sample rate

The sample interval is 1 divided by the effective sample rate. The time duration of the data in a channel memory is the time between the sample points times the number of points. For example, if the effective sample rate is 100 GS/s and the memory depth is 1000 points/10 divisions, the time between the sample points is 10 ps. 10 ps times 1000 points is 10 ns of waveform data stored in the channel memory. Because there are ten horizontal divisions on the display, set the timebase to 100 ps/div to show the whole channel memory on the display.

Time duration of the record = record length / effective sampling rate

The best hardware time interval resolution in **Sequential Equivalent Time Sampling** mode is approximately 64 fs, which is equivalent to more than 15 THz effective sampling rate.

Scope Sampling Mode

With this **Sequential Equivalent Time Sampling** the oscilloscope acquires one sample per external trigger independent of the timebase settings. When a trigger is detected, a sample is taken after very short but well-defined delay. When the next external trigger occurs, a small time increment is added to this delay and the sampler takes another sample. The oscilloscope generates the programmable delay using an internal delay generator based on a 500 MHz triggerable oscillator. Use **Scope Sampling Mode** to acquire repetitive signals having a relatively low repetition rate.

TDR/TDT Sampling Mode

In this **Sequential Equivalent Time Sampling** mode the oscilloscope also acquires one sample per internal trigger independent of timebase settings. The oscilloscope generates a programmable delay using the internal delay generator based on a precision internal 500 MHz clock oscillator. Use **TDR/TDT Sampling Mode** to acquire signals in TDR/TDT mode.

Eye Sampling Mode

In this **Sequential Equivalent Time Sampling** mode the oscilloscope acquires one sample per external direct or divided clock trigger independent of timebase settings. The oscilloscope generates a programmable delay using the internal delay generator based on an external direct or divided clock. Use **Eye Sampling Mode** to acquire repetitive signals having relatively high repetition rate, and for low-jitter application on long time delays.

Real Time Sampling

Real Time Sampling captures all of the sample points used to reconstruct a waveform during a single trigger event. It also requires a sample rate that is at least four times the highest frequency in the waveform or else you will get a distorted or aliased view of your waveform. The following figure shows how a waveform is sampled in real time.

Real Time Sampling
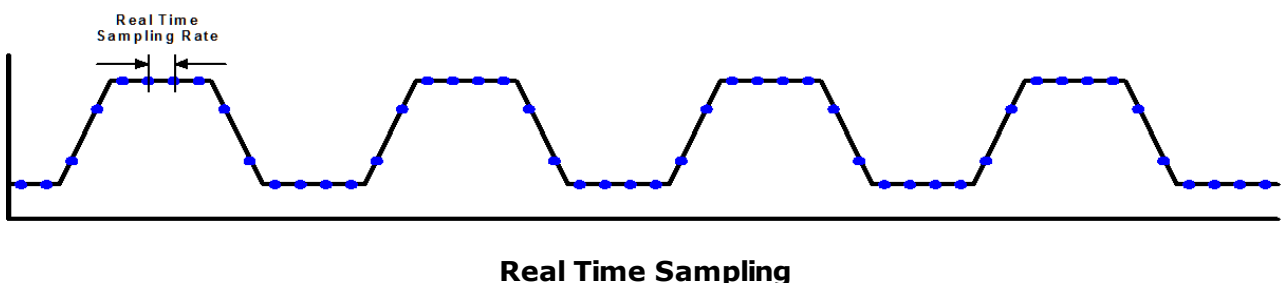
Once the trigger is armed, the oscilloscope starts acquiring data until the trigger event you have specified occurs. Because the PicoScope 9300 acquires data while the trigger is armed, waveform samples before or after the trigger event are in the oscilloscope's acquisition memory. You can configure the PicoScope 9300 oscilloscope to acquire only pre-trigger waveform samples, only post-trigger waveform samples, or both pre-trigger and post-trigger waveform samples. The maximum real time sampling rate of the PicoScope 9300 Series is 1 MHz.

Random Equivalent Time Sampling

In this sampling mode the PicoScope 9300 acquires sample points over several trigger events, requiring the input waveform to be repetitive. On each trigger event, the scope acquires more points and combines them with the previously acquired points. This creates a record of the waveform that has an effective sampling rate much higher than real time sampling rate.

The following figure shows how a waveform is sampled in **Random Equivalent Time** mode. The samples are labeled with different colors to indicate the trigger event when they were acquired. Thus, samples labeled with green were acquired during the first trigger event. Those samples labeled with brown were acquired during the second trigger event, and so on.
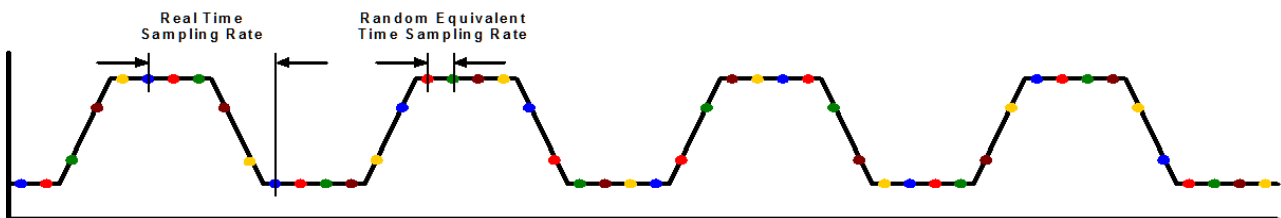
Random Equivalent Time Sampling

The real time sampling rate used in the PicoScope 9300 Series is 1 MHz, while the best hardware time interval resolution in **Random Equivalent Time Sampling** mode is 4 ns.

Roll

When **Roll** is enabled, acquisition data will be displayed in a rolling fashion starting from the right side of the display and continuing to the left side of the display (while the acquisition is running). Roll mode is a triggerless acquisition mode so there is no trigger reference and all trigger features are disabled. New data will continue rolling across the screen while the acquisition is running. If the acquisition is stopped before a full screen of data is acquired, the portion of data that has been acquired will be displayed with a time-zero reference at the right screen edge and the remaining portion of the display will be left blank. If a control change is made while the acquisition is running, the acquisition is halted and restarted and the old data is cleared from the display and measurement statistics.

Use **Roll Sampling Mode** when making manual adjustments to your low frequency waveforms, when you want to find disturbances in your low frequency waveforms, or to monitor the power-up cycle of a power supply voltage.

7.1.4   Timebase Mode
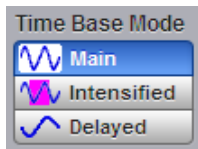
The **Timebase Mode** menu provides **Main**, **Intensified** and **Delayed** timebase modes using time windowing. The **Timebase Mode** menu is available in any of the **Sequential Equivalent Time Sampling Modes** (**Scope, TDR/TDT** or **Eye**), but not in the **Random**, **Real Time** and **Roll Sampling Modes**.

The **Timebase** windowing function is similar to the delayed sweep of traditional oscilloscopes because it turns on an expanded timebase. This expanded timebase allows you to pinpoint and to horizontally expand a portion (or two portions) of the signal for a more detailed or high-resolution analysis. It can also help you to make custom automatic measurements. Automatic measurements are made on the first occurrence of the event on the display. The windowing feature allows you to isolate individual events on the display for the automatic measurements.

Windowing includes several steps:

- Select main timebase scale (**Scale A**).
- Select intensified timebase. Select the dimension (**Scale B**) and position (**Delay**) of the delayed timebase on the main timebase trace.
- Click the **Delayed** timebase.
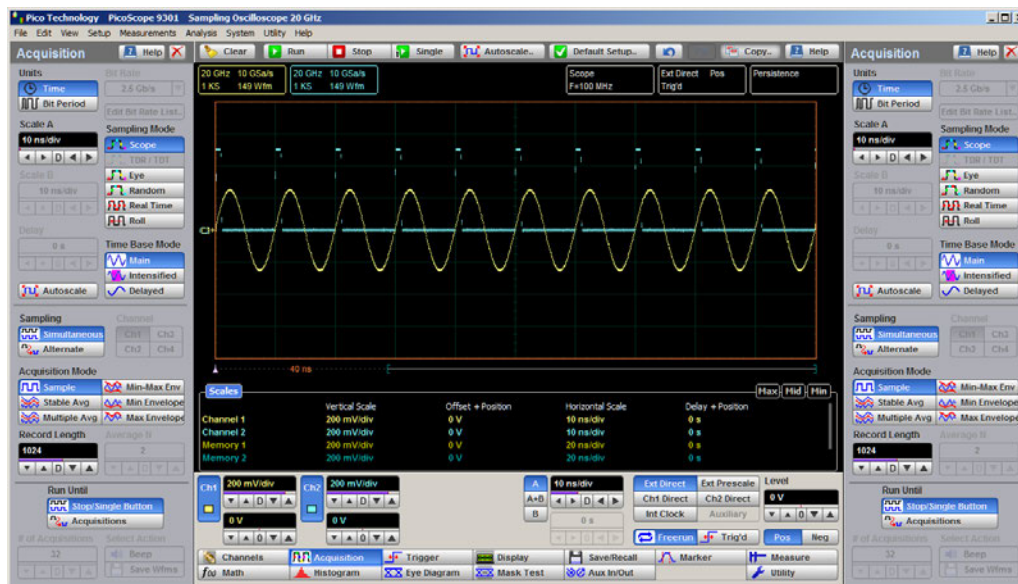
Main Timebase Mode

Intensified Timebase Mode

Delayed Timebase Mode

7.1.5   Scale A
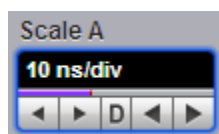
The **Scale A** function is similar to the time/div knob of the main timebase on a traditional oscilloscope. *Division* in this instance equals 1/10 of the horizontal axis. Adjusting the horizontal (timebase) scale control expands and compresses the displayed waveform horizontally.

The **Scale A** controls horizontal scaling of the waveform. You can set the main timebase scale from 10 ps/div to 10 s/div in one of three ways:

- By using the **Scale A** spin box
- By using the corresponding spin box in the **Permanent Controls Area**
- By using the **Pop-up Keypad** to quickly enter numeric data for the timebase scale using the mouse

In **Sequential Equivalent Time Sampling Modes** (**Scope**, **TDR/TDT** and **Eye**) you can set the main timebase scale from 10 ps/div to 3.2 ms/div in a 1-2-5-10 sequence. When fine mode is on, you can adjust the main timebase scaling in 0.1% increments or smaller.

In **Random Equivalent Time Sampling Mode** you can set the main timebase scale from 10 ns/div to 50 µs/div in a 1-2-5-10 sequence.

In **Real Time Sampling Mode** you can set the main timebase scale from 2 µs/div to 100 ms/div in a 1-2-5-10 sequence.

In **Roll Sampling Mode** you can set the main timebase scale from 200 ms/div to 10 s/div. Adjustable in a 1-2-5-10 sequence.

7.1.6   Scale B

The **Scale B** function is similar to the time/div knob of the delayed timebase on a traditional oscilloscope. Adjusting the delayed timebase scale control expands and compresses the displayed waveform horizontally.

Scale B is available in one of **Sequential Equivalent Time Sampling Modes** (**Scope**, **TDR/TDT** or **Eye**). You can set the main timebase scale from 10 ps/div to 3.2 ms/div in a 1-2-5-10 sequence. When fine mode is on, you can adjust the main timebase scaling in 0.1% increments or smaller. **Scale B** is not available in the **Random**, **Real Time** and **Roll Sampling Modes**.

Scale B allows you to control the time scale in one of three ways:

- By using the **Scale B** spin box
- By using corresponding spin box in the **Permanent Controls Area**
- By using the **Pop-up Keypad** to quickly enter numeric data using the mouse

> ℹ   The **Scale B** value cannot exceed the **Scale A** value.

7.1.7   Delay
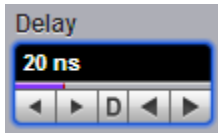
In one of **Sequential Equivalent Time Sampling Modes** (**Scope**, **TDR/TDT** or **Eye**) the **Delay** function is similar to the delay knob of the delayed timebase on a traditional oscilloscope. The **Delay** spin-box allows you to the position of delayed timebase up to maximum value of 10 divisions of main timebase in one of three ways:

- By using the **Delay** spin box
- By using corresponding spin box in the **Permanent Controls Area**
- By using the **Pop-up Keypad** for some specific settings

You can change delay value up to 10 000 screen widths of **Delayed Timebase** or 31.9968 ms, whichever is smaller. If fine mode is off, the delay can be changed in a sequence of 0.5 major divisions of the main timebase. When fine mode is on, you can change delay in a sequence of 0.001 major divisions of main timebase.

Maximum possible value of delay can be calculated from the following condition:

$$Maximum\ Delay + 10 \times Scale\ B = 10 \times Scale\ A$$

In the **Random** and **Real Time Sampling Modes, Delay** works as a digital delay control. The **Delay** value can be changed up to 8 s in 1 µs steps.

Remember that the **Delay** is a post-trigger function, because it controls the delay from the trigger. The maximum post-trigger delay varies with the sweep speed, and the minimum delay (zero delay value) is limited by the propagation delay of the trigger path. The PicoScope 9300 Series uses a digital delay, which has the advantage of being calibrated. Adjusting the delay moves the position of the input waveform horizontally. As the delay increases, the waveform moves to the left of the display graticule. As the delay decreases, the waveform moves to the right of the graticule.

7.1.8   Trigger Position
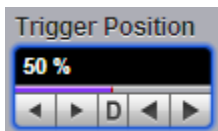
The **Trigger Position** is an adjustable feature that defines where the trigger occurs on the waveform record. It is available in the **Random** and **Real Time Sampling Modes.** The **Trigger Position** lets you choose how much the instrument acquires before and after the trigger event. The part of the record that occurs before the trigger is the pre-trigger portion, while the part that occurs after the trigger is the post-trigger portion. A longer post-trigger period may be useful when you want to see the effects an event has on your system under test. For this purpose also use the **Delay** control.

Pre-trigger data can be valuable when troubleshooting. For example, if you are trying to find the cause of an unwanted glitch in your test circuit, you can trigger on the glitch and make the pre-trigger period large enough to capture data before the glitch. By analyzing what happens before the glitch, you may uncover information that helps you find the source of the glitch.

7.1.9　Autoscale
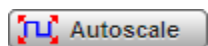
[Ⴑ⅃ Autoscale]

You can run **Autoscale** on any channels that are switched on. The **Autoscale** function, located in the **Acquisition** menu, causes the instrument to quickly analyze any waveforms connected to the channel and trigger inputs. Then it sets up the horizontal controls (timebase scale and delay) to best display that signal without changing vertical controls of the channels.

As a reference for horizontal controls, the **Acquisition Autoscale** selects the channel having the waveform with the greatest amplitude.

The PicoScope 9300 Series must have an available trigger source and input. For example, if you are using the **Direct Trigger Input**, and the **Ext Direct** is selected in the **Trigger/Source** menu, the trigger signal must be connected to this trigger input. **Autoscale** can then set the trigger level. If you are using the **Prescale Trigger Input**, and the **Ext Prescaler** is selected in the **Trigger/Source** menu, the trigger signal must be connected to this trigger input.

For more details see **Autoscale.**

7.1.10　Sampling

[Sampling — Simultaneous / Alternate]
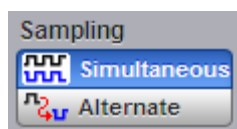
In one of the **Sequential Equivalent Time Sampling Modes** (**Scope**, **TDR/TDT** and **Eye**) the **Sampling** menu selects how the signals will be acquired if more than one channel is selected. You can specify **Simultaneous** or **Alternate** mode.

Simultaneous

When more than one channel is selected, vertical acquisition is done simultaneously for both channels from a common strobe pulse. **Simultaneous Sampling Mode** provides synchronous dual-channel acquisition with insignificant delay between channels. You can specify all functions for both channels equally from the **Acquisition** menu. You cannot use the **Deskew** variable from the **Channel** menu.

Alternate

When more than one channel is selected, the vertical acquisition switches sequentially through the selected channels. You can specify all functions for the selected channel from the **Acquisition** menu independently. For example, you can select **Stable Average** mode for channel 1 and **Min-Max Envelope** mode for channel 2. Also, you can use the **Deskew** variable from the **Channel** menu.

In **Random, Real Time** or **Roll Sampling Modes** the oscilloscope uses Simultaneous sampling only.

7.1.11　Channel

[Channel — Ch1 Ch3 / Ch2 Ch4]
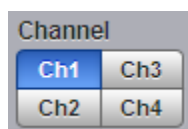
The **Channel** menu selects the waveform from one of the channels **Ch1** to **Ch4** to be controlled by the **Acquisition Mode** menu and also the **Record Length** setting. The **Channel** menu can be active only when **Alternate** is selected in the **Sampling Mode** menu.

7.1.12   Acquisition Mode
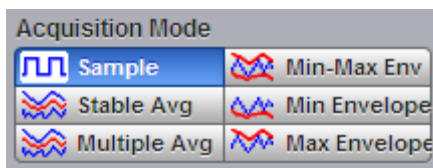
Acquisition Mode lets you choose how the oscilloscope will create points in the waveform record.

The PicoScope 9300 Series supports three basic acquisition modes:

- **Sample** (default mode) - acquires one sample point per trigger and displays results without further processing
- **Average** - calculates the average values for each record point over many waveform records
- **Envelope** - uses the highest and lowest samples across several waveform records

When you select **Stable Avg** or **Multiple Avg** mode you can enter the number of averages with the **Average N** variable. When you select **Min-Max Envelope**, **Max Envelope** or **Min Envelope** mode you can enter the number of acquisitions with the **Envelope N** variable.

Acquisition modes do not affect the data sampling itself. However, they do affect the analysis of the sampling, and therefore the way the oscilloscope combines the samples into a data point value.

Envelope and **Average** modes operate after the oscilloscope has taken two or more acquisitions. For example, each **Average** mode averages the corresponding data points from two or more waveforms, not the waveform as a whole. **Envelope** mode builds an envelope from the peak minimum and maximum values of each point on a succession of waveforms.

Side effect of averaging and enveloping

Averaging improves the accuracy of some software measurements, because the measurements are taken from averaged data. However, some measurements can be adversely affected by averaging or enveloping. For example, if you take a rise time measurement of a signal with horizontal jitter, the averaged trace will indicate an inaccurately slow reading. Be cautious when taking software measurements of averaged or enveloped traces. Use statistical measurements on the unaveraged signal to take an accurate rise time measurement on a signal with jitter.

Sample acquisition mode

This is the default mode, which is useful for acquiring fast signals.

With the **Sample** radio button pressed, the oscilloscope saves one sample during each acquisition interval. Samples are accurately acquired at precisely and uniformly programmed intervals. When the record is full, the oscilloscope acquires new samples that overwrite the previously acquired waveforms. In **Sample** mode, the sample interval varies with the timebase settings.

At slower sweep speeds, the sample interval is often so large that the oscilloscope misses information between samples (for example, repetitive glitches). In the above waveform, the **Sample** mode misses a glitch in the first peak but happens to capture it in the second.

One drawback of the **Sample** mode is that it can be fooled by aliasing because the bandwidth of the data is proportional to the timebase scale settings. As the **Nyquist Theorem** predicts, the bandwidth of the data drops as you slow the timebase.

Average modes

Pressing one of the two **Average** buttons (**Stable Average** or **Multiple Average**) lets you acquire and display a waveform that is the combined result of several acquisitions. The oscilloscope acquires data as in the **Sample** mode and then averages it according to the number of acquisitions that you specify. Each point in a record is numerically averaged with the same point in all other records. This reduces the random noise of a displayed waveform and provides a cleaner display, improves resolution of the displayed waveform, and increases measurement repeatability, all due to a more stable displayed waveform. The noise sources can average to zero over time while the underlying waveform is preserved. The effective resolution of the displayed waveform increases as more acquisitions are averaged together, provided that the input waveform is repetitive and has a stable trigger point. However, averaging reduces the throughput of the instrument. Also, the waveform is less responsive to changes, especially when you select a high number of averages. The vertical resolution can be also improved by using averages.

> ℹ️   Use the **Clear Display** button to reset the averaging process.

> ℹ️   Note that averaging is particularly useful for single-valued waveforms such as pulses or sine waves. Multi-valued waveforms, such as eye-diagrams, are not improved with averaging because the eye "collapses" to the average value between logic level one and logic level zero.

Two **Average** modes are available in the PicoScope 9300:

- **Stable Average** mode
- **Multiple Average** mode

Stable Average

Stable averaging lets you use the following algorithm:

$$A_n = A_{n-1} + \frac{x_n - A_{n-1}}{2^k}$$

where:

n	- is the current acquisition's number
A_n	- is the current acquisition's cumulative average
A_{n-1}	- is the previous acquisition's cumulative average
x_n	- is the newly acquired sample's value
k	- is the number of averages

As the number of acquisitions increases, the number of averages k increases and the size of the correction term (2^{-k}) decreases. Although the display becomes less noisy after each acquisition, the first acquisition has the greatest effect, and succeeding acquisitions have less effect as the correction term becomes smaller. For example, a change that occurs during the second acquisition shows up on the screen much sooner than one that occurs during the sixteenth. Whenever you adjust a control that affects the display, the scope starts a new averaging sequence to ensure that you will see the change immediately.

Stable averaging produces slightly less improvement—that is, a smaller signal-to-noise improvement ratio—than conventional averaging.

Signal-to-Noise Improvement Ratio with Stable and Multiple Averaging

Selected Number of Averages	Signal-to-Noise Improvement Ratio			
	Stable Average		Multiple Average	
	Linear	dB	Linear	dB
2	1.41	3.0	1.41	3.0
4	1.98	5.9	2.00	6.0
8	2.75	8.8	2.82	9.0
16	3.84	11.7	4.00	12.0
32	5.24	14.6	5.64	15.0
64	7.51	17.5	8.00	18.0
128	10.60	20.5	11.28	21.0
256	14.90	23.4	16.00	24.0
512			22.56	27.0

Multiple Average

Multiple averaging lets you use the following algorithm:

$$A_i = \frac{\sum_{m=1}^{N} A_m}{N}$$

where:

N - is the number of averages in every point

A_m - is the acquired value of the waveform at point i during acquisition cycle m

A_i - is the averaged value of the waveform at point i

When **Multiple** averaging is selected the oscilloscope works during the acquisition cycle as follows:

1. Operator selects the number of averages.

2. The oscilloscope samples and digitizes N times the i-th point of the waveform.

3. Processor calculates new averaged value at point i.

4. This procedure repeats for every point of the waveform.

Unlike the stable average mode, the multiple average mode is N times slower. However, every point of the waveform is displayed filtered from noise. The **Multiple Average** mode has the most effective Signal-to-Noise Improvement Ratio.

Envelope Modes

Three **Envelope** modes are available in the PicoScope 9300 Series:
- **Min-Max Envelope** mode
- **Max Envelope** mode
- **Min Envelope** mode

Clicking one of the envelope radio buttons (**Min-Max Envelope**, **Max Envelope** or **Min Envelope**) lets you acquire and display a waveform showing the extreme values of several acquisitions over a period of time. Thus, the oscilloscope detects peaks. You can specify a number of acquisitions over which to accumulate and display the min/max data. The oscilloscope compares the min/max values from the current acquisition with those stored from previous acquisitions up to the specified number of acquisitions. An enveloped waveform then shows the maximum excursions of the individual waveform records. This often results in a thicker waveform trace that shows the variations of the signal. Use this mode to reveal the noise band around the signal.

Because it degrades the timing information in the data by a factor of 2, **Envelope** mode is typically not suitable for FFT analysis. In addition, this mode can obscure the statistical distribution of the samples that occurred between the minimum and maximum values. However, you can create a display of this distribution by using the persistence display modes to view only peak values sampled over a period of time.

> ⓘ The **Envelope** mode requires a stable trigger for time correlation.

Min-Max Envelope. This radio button tells the oscilloscope to acquire and display the variation of both extremes - maximum and minimum.

Max Envelope. This radio button tells the oscilloscope to acquire and display the variation of maximum values.

Min Envelope. This radio button tells the oscilloscope to acquire and display the variation of minimum values.

7.1.13   Average N / Envelope N
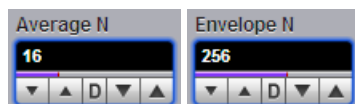
Number of Averages

The **Average N** variable changes the number of averages (records) when you select one of the two average buttons - **Stable Average** or **Multiple Average**. The number of averages can be specified from 2 to 4096 in multiples of two by one of these methods:

- By using the **Average N** control
- By using the **Pop-up Keypad** for some specific settings

> ⓘ The waveform is less responsive to changes if a large number of averages is specified.

Number of Envelopes

The **Envelope N** variable changes the number of acquisitions when you select one of the three envelope radio buttons (**Min-Max Envelope**, **Max Envelope** or **Min Envelope**). The number of acquisitions can be specified from 2 to 4096 in multiples of two or continuously using one of these methods:

- By using the **Envelope N** spin box
- By using the **Pop-up Keypad**
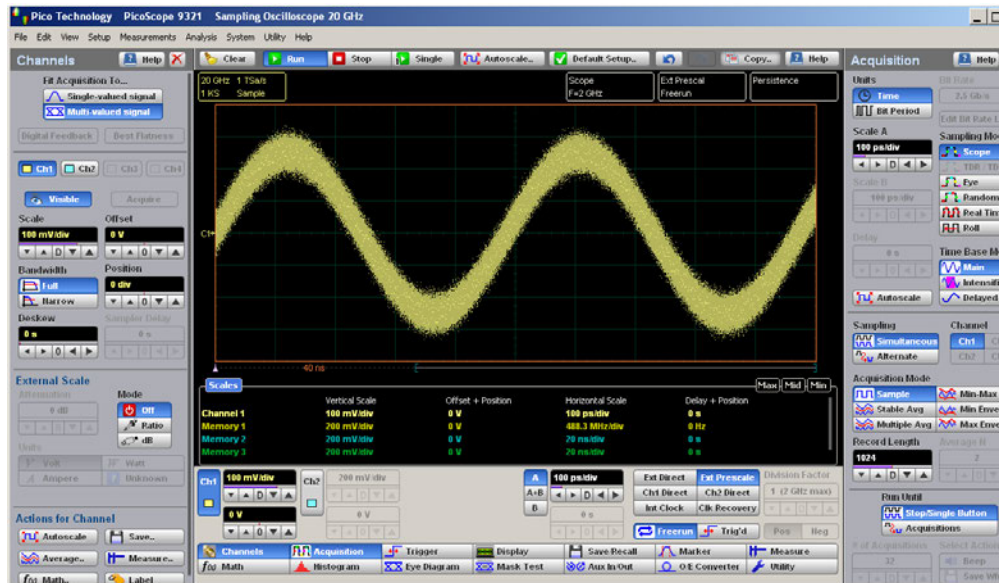
Sample Acquisition Mode with noisy waveform
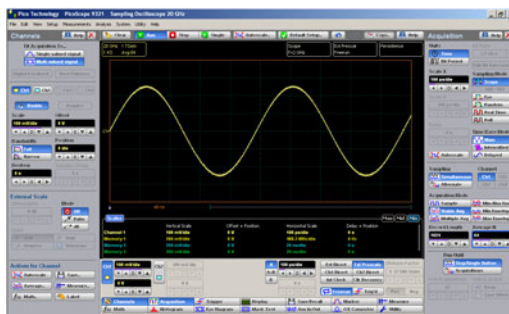
Average Acquisition Mode
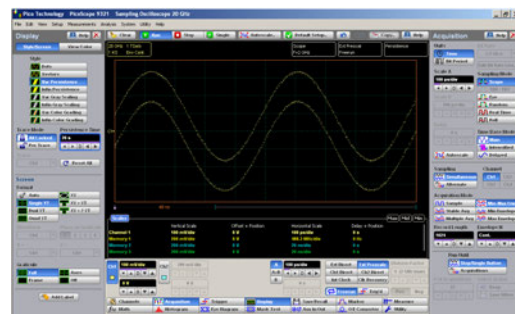
Min-Max Envelope Acquisition Mode

7.1.14   Record Length
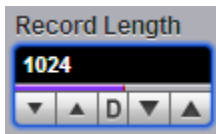
The number of samples that form a trace is called the record length. For example, if the horizontal (timebase) scale is set up as 10 ns/div, the total displayed sweep time is 100 ns. The more sampled data that is available for analysis or measurements, the greater the record length.

You can select record length with one of these methods:

● By using the **Record Length** control
● By using the **Pop-up Keypad**

Record length can be selected from 32 to 32 768 points/channel for single-channel mode, 32 to 16 384 points/channel for all modes in x2 sequence, and 32 to 8 192 points/channel for 3- or 4-channel mode (PicoScope 9341 only).
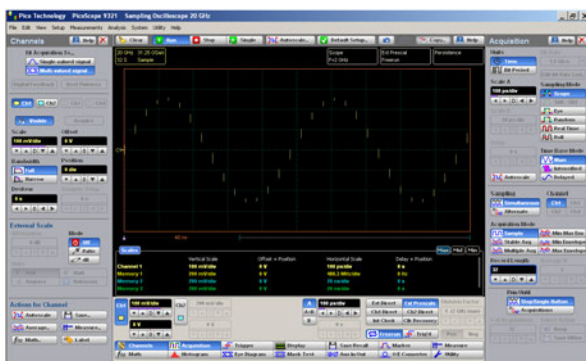
Record length with 32 samples
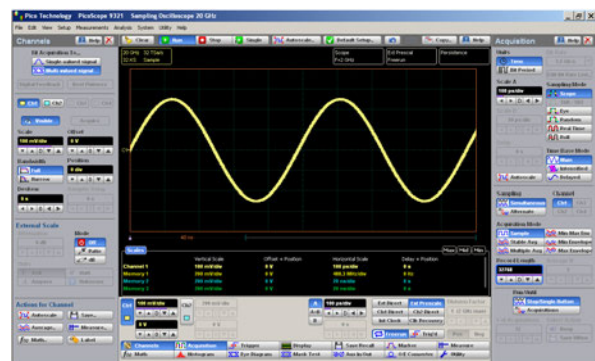
Record length with 32k samples

Fast Fourier Transform algorithms require a record length that is a power of two. The 4096-point record length is provided as a convenience, and the visual truncation is a natural result.

When **Alternate Sampling** is selected, the record length is set independently for each channel. Remember that effective sample rate and record length work together. If you combine a small record length memory depth with a high effective sample rate, you will have a very fast throughput (display update rate) but very little data in the channel memory. Because more data points need to be acquired, a waveform with a long record length takes longer to construct than one with a short record length. However, a long record length produces a waveform with higher horizontal resolution, and so a trade off exists between throughput and resolution.

You can set both the main record length and the delayed record length using the variables. All traces on the main timebase have the same record length. Delayed traces similarly share identical record lengths.

7.1.15   Run Until
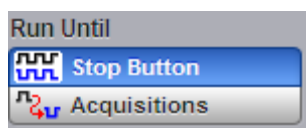
The **Run Until** control allows you to determine when the acquisition of data stops.

- **Stop Button.** If this is selected, you must press the **Stop** button to stop the acquisition of data.
- **Acquisitions.** If this is selected, acquisition is stopped when the specified number of acquisitions is reached. You can set this number using the **# of Acquisitions** control.

7.1.16   # of Acquisitions
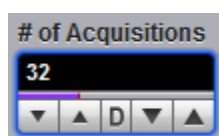
Sets the number of acquisitions. After the selected number of acquisitions is reached, the acquisition is stopped.

7.1.17   Action
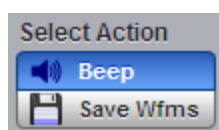
After the **Run** key is pressed, the oscilloscope makes the specified number of acquisitions, all of which will be saved to the memory. The **Action** control allows you to specify what the instrument does after acquisition is stopped. One of two actions can be selected.

Beep

Beep produces an audio tone.

Save Wfms

Save Wfms opens the **Save Waveform As** dialog, which allows you to choose one of three file formats for the saved waveform. These are:

- Binary format, with **.wfm** extension
- Verbose format, with **.txt** extension
- Y values format, with **.txty** extension

7.2   Aux In/Out menu
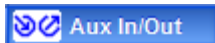
Aux In/Out

The **Aux In/Out** menu configures the **AUX INPUT** and **AUX OUTPUT** connectors on the rear panel. Some functions may not be available on certain models.
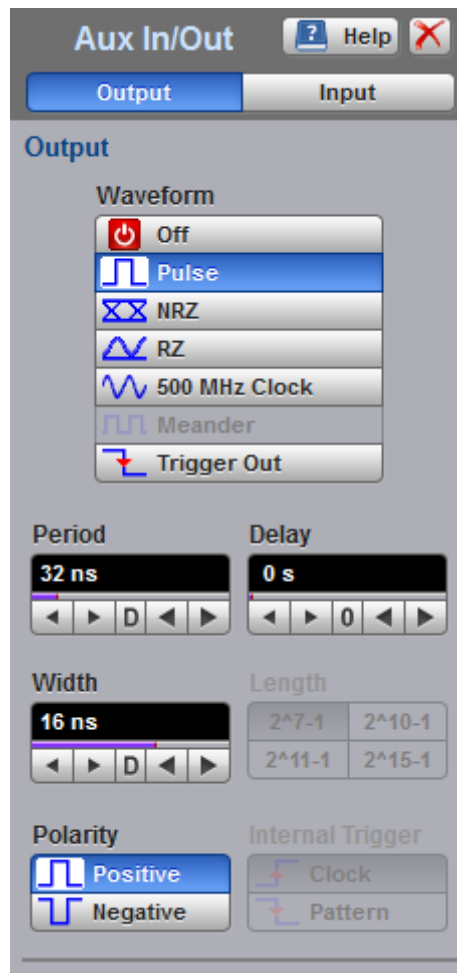
The Aux In/Out menu

7.2.1   Output

7.2.1.1   Waveform
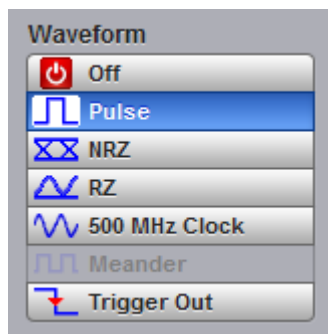
The **Waveform** menu allows you to select the waveform type produced by the **AUX OUTPUT** connector:

- Pulse: a repetitive pulse with selectable polarity.
- NRZ: a non-return-to-zero data stream.
- RZ: a return-to-zero data stream.
- 500 MHz clock: a sinusoidal clock.
- Trigger Out: a signal synchronized with the internal trigger.

7.2.1.1.1   Pulse
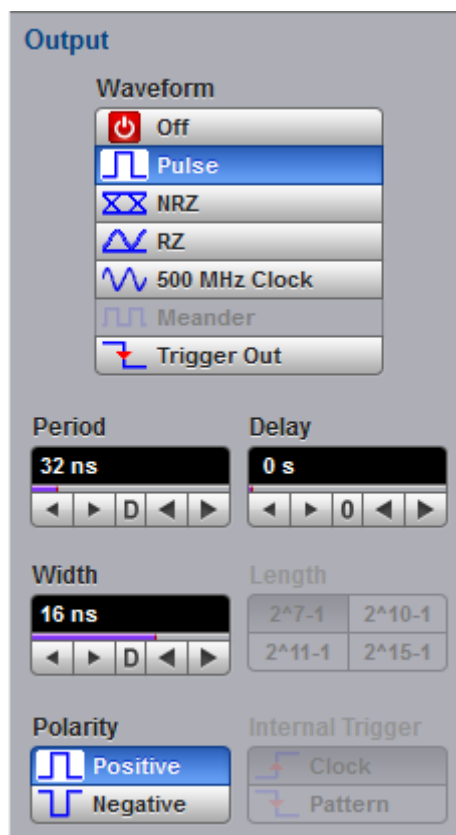
Pulse output mode allows you to select a pulse waveform type with selected polarity, period, width and delay.
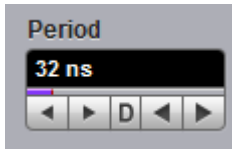
Set the repetition period of the pulse waveform from 8 ns to 524 μs.
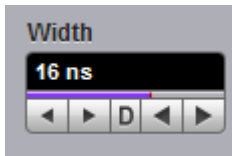
Set the pulse width from 8 ns (at 20 ns period) to (Period − 8 ns).

Set the delay of the pulse relatively to internal trigger from 0 to (Period − 8 ns).
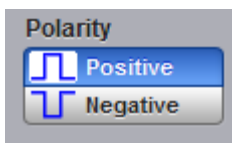
Set the polarity of the pulse output.

7.2.1.1.2   NRZ

Output

Waveform

- Off
- Pulse
- NRZ
- RZ
- 500 MHz Clock
- Meander
- Trigger Out

Bit Time
16 ns

Delay
4 ns

Width
92 ns

Length
| 2^7-1 | 2^10-1 |
| 2^11-1 | 2^15-1 |

Polarity
- Positive
- Negative

Internal Trigger
- Clock
- Pattern
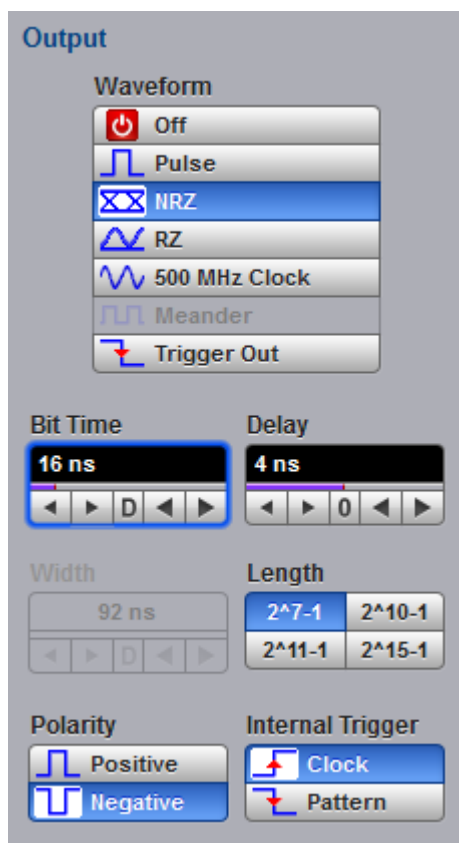
NRZ output mode allows you to select a non-return-to-zero data stream with selected polarity, bit rate, delay and pattern length.
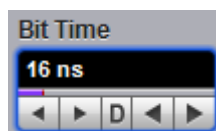
Bit Time
16 ns

Set the bit time of NRZ data stream from 4 ns to 260 μs.

Delay
0 s

Set the delay of NRZ data stream relatively to internal trigger from 0 ns to (Bit time − 8 ns).

Length
| 2^7-1 | 2^10-1 |
| 2^11-1 | 2^15-1 |
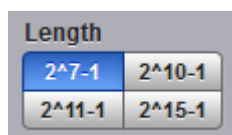
Set pattern length of NRZ data stream with four options: 2^7-1, $2^{10}-1$, $2^{11}-1$ or $2^{15}-1$.
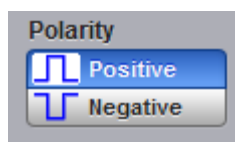
Set the polarity of NRZ data stream.
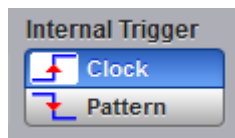
The **Internal Trigger** menu lets you controls the source of the trigger:

- **Clock**: data clock is used as a trigger source. NRZ data steam looks like eye diagram.
- **Pattern**: the pattern signal is used as a trigger source. NRZ data steam looks like pattern.

7.2.1.1.3   RZ
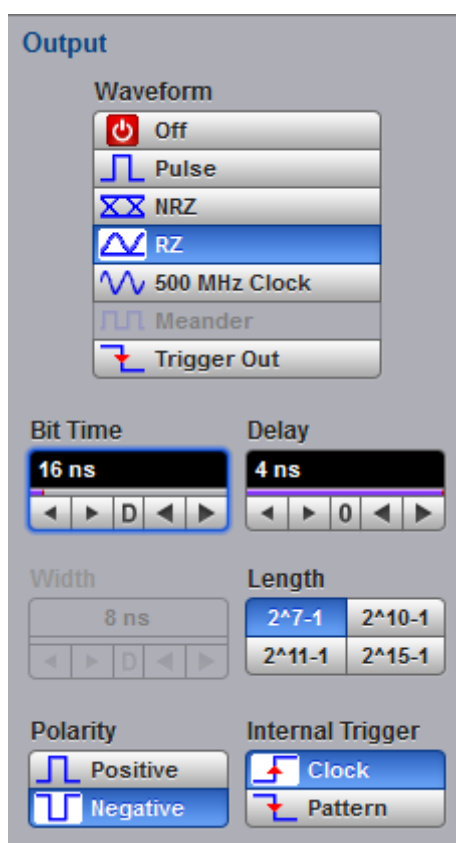
RZ output mode allows you to select a return-to-zero data stream with selected polarity, bit rate, delay and pattern length.
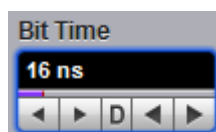
Set the bit time of RZ data stream from 8 ns to 260 µs.
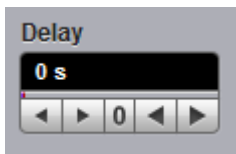
Set the delay of RZ data stream relatively to internal trigger from 0 ns to (Bit time − 8 ns).

Set pattern length of RZ data stream with four options: 2^7-1, $2^{10}-1$, $2^{11}-1$ or $2^{15}-1$.
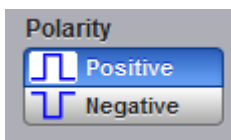
Set the polarity of RZ data stream.
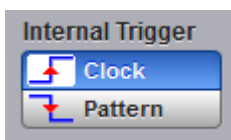
The **Internal Trigger** menu lets you controls the source of the trigger:

- **Clock**: data clock is used as a trigger source. RZ data steam looks like eye diagram.
- **Pattern**: the pattern signal is used as a trigger source. RZ data steam looks like pattern.

7.2.1.1.4   500 MHz Clock
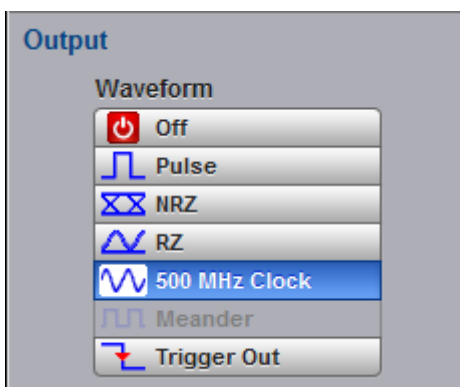
500 MHz Clock output mode allows you to select a 500 MHz waveform close to a sinusoidal clock. This clock is synchronous to the internal clock.

7.2.1.1.5   Trigger Out
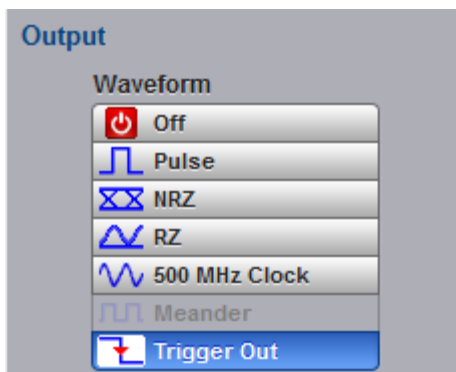
Trigger Out mode allows you to select a pulse waveform synchronous to internal holdoff trigger and internal TDR clock. Negative transient is active.

Use this signal to trigger any external TDR generator.

7.2.1.2   Internal Trigger
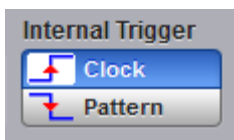
When **Trigger** is selected as the output type, the **Internal Trigger** control lets you select the source of the trigger:

- **Clock:** the clock generator
- **Pattern:** the pattern trigger generator

7.2.2   Input

The **AUX INPUT** connector is reserved for future expansion.

7.3 Channels menu

Channels

⚠ **CAUTION**
The input circuits can be damaged by electrostatic discharge. Therefore, avoid applying static discharges to the front panel input connectors. Before connecting any coaxial cable to the connectors, momentarily short the center and outer conductors of the cable together. Avoid touching the front panel input connectors without first touching the case of the instrument. Personnel should be properly grounded, and should touch the case of the instrument before touching any connector. Be sure that the instrument and PC are properly earth-grounded to prevent build-up of static charge. Repair of damage due to misuse is not covered under the warranty!

The **Channels** menu allows you to set all controls for vertical setups of all live electrical, optical and TDR/TDT waveforms.

To display the **Channels** menu, click the **Channels** button. The controls for each channel are independent. When you select the **Channels** menu, either the **Scale**, **Offset**, **Position**, **Deskew**, or **Attenuation** control is highlighted in the same color as the selected channel, indicating that the function is active.
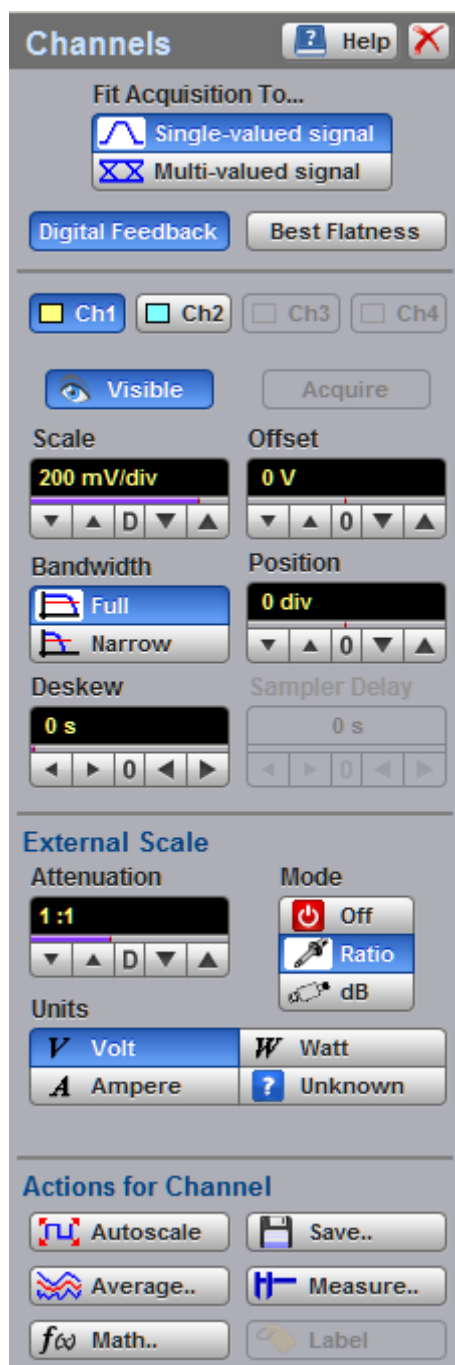
The Channels Menu

Refer to the **O/E Converter** menu for additional information on setting up the optical channel.

Refer to the **TDR/TDT** menu [TDR/TDT] for additional information on setting up TDR/TDT channels.

7.3.1   Fit Acquisition To...
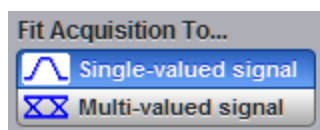
Fit Acquisition To... optimizes the setup of vertical channels depending on the type of measuring signal.

Single-valued signal

Single-valued signal optimizes the setup of vertical channels for such waveforms as sine waves or pulses. With this mode you can use a digital feedback architecture that increases input dynamic range (**Digital Feedback**). You can also use the **Best Flatness** mode proving better transient response.

Multi-valued signal

Multi-valued signal optimizes the setup of vertical channels for multi-valued waveforms such as eye diagrams. **Multi-valued signal** cannot be used in combination with **Digital Feedback** and **Best Flatness** modes. However, digitizing speed in this mode can be increased up to 1 MHz.

7.3.2   Digital Feedback
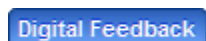
The architecture of the PicoScope 9300 Series oscilloscopes includes digital feedback. This technology is used in high-bandwidth sampling oscilloscopes to give repeatable, accurate, and operator-independent measurement results. Digital feedback technology does not require a loop gain or response control adjustment. The lack of adjustment means that the waveform you see on the display is really what's there. Additionally, digital feedback allows corrections for non-linearity in the input sampling bridge. As a result, digital feedback provides the highest vertical accuracy and linearity with a wider input dynamic range (1 V p-p at ±1 V range). However, digital feedback limits the digitizing rate to 40 kHz maximum.

Digital Feedback can be used with **Single-valued signal** mode only .

7.3.3   Best Flatness

The sampler used in the PicoScope 9300 Series has a certain amount of passive feed-through. This feed-through is corrected by a compensation circuit. A small amount of feed-through remains after compensation and this causes slight non-flatness in the step response. The **Best Flatness** control takes advantage of this to further improve flatness. This is done by taking a sample with the samplers turned on and then with the samplers turned off. The two results are then subtracted thereby removing the residual non-flatness.

Best Flatness can be used with **Single-valued signal** mode only .

7.3.4   Channel Select

Oscilloscope models in the PicoScope 9300 Series have either two or four channels. The channels are numbered 1 through 4. The instrument can simultaneously display and perform measurements on all measurement channels.

Many of the controls of the PicoScope 9300, especially the channel controls, operate on the selected channel. The instrument applies all actions that only affect one channel at a time, such as applying changes to the vertical control settings, to the selected channel. Since it is possible that all traces will be on the screen at the same time, each trace is displayed in a separate color.

Clicking the **Ch1**, **Ch2**, **Ch3**, or **Ch4** buttons:

- Toggles it between channels 1 and 4
- Assigns the function keys to the selected channel

7.3.5   Channel Display

There are two ways to add selected channels to the display and remove them again:

- Use the **Visible** button
- Use the **Ch1 – Ch4** check boxes in the **Permanent Controls Area**

Clicking the **Visible** button:

- Turns the display for the selection on or off
- Changes the label from on to off or vice versa

Turning the display off does not turn off acquisition of the selected channels. To turn off acquisition of the selected channel, use the **Acquire** button.

When the **Visible** button changes from on to off, while the **Acquire** button is on, the **Status Area** for the selected channel also changes its status from 20 GHz 10 GSa/s 1 KS Sample to . This status shows that the channel is removed from display but its acquisition is still going on.
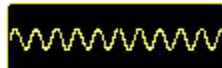
Visible turns on or off the display of the waveform for the chosen channel. When the channel display is on, a waveform is displayed for that channel, unless the offset is adjusted so the waveform is clipped off of the display. Turning a channel's display off turns off the markers, measurement define parameters, histogram window and eye window. However, turning a channel's display off doesn't turn off marker measurements, automatic measurements, histogram measurements, eye-diagram measurements or mask test. Functions and FFTs will also be available for that channel. Turning a channel off increases the display update rate for the channels that remain on.

7.3.6   Channel Acquire

Acquire

Turning the display off with the **Visible** button **Visible** does not turn off acquisition of the selected channels. To turn off acquisition of the selected channel, use the **Acquire** button.

When the **Acquire** button changes from on to off, while the **Visible** button is off, the **Status Area** for the selected channel also changes its status from to .
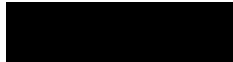
This status shows that the channel is removed from the display and its acquisition is stopped. Stopping acquisition turns off marker measurements, automatic measurements, histogram measurements, eye-diagram measurements and mask tests for the selected channel. Functions and FFTs based on this channel will be also removed.

7.3.7   Channel Scale

You can use the vertical **Scale** controls to change the volts-per-division setting for any channel to increase or decrease the amplitude of your waveform (watts per division for optical channel, rho and   per division for TDR/TDT channels). It determines the portion of the input signal presented to the acquisition system. Adjust the **Scale** to control the portion of the vertical window displayed on screen. The vertical window is always centered around the offset value that is set and not around the ground reference.

As the numeric value of the scale is increased the displayed waveform decreases in size, and as the numeric value of the scale is decreased, the waveform increases in size.

> ⓘ   The **Scale** control provides graphical scaling only; it has no effect on the vertical acquisition window.

> ⓘ   Only waveform traces from input channels can be vertically adjusted with the **Scale** control. It does not affect waveforms saved in memories, or waveform functions.
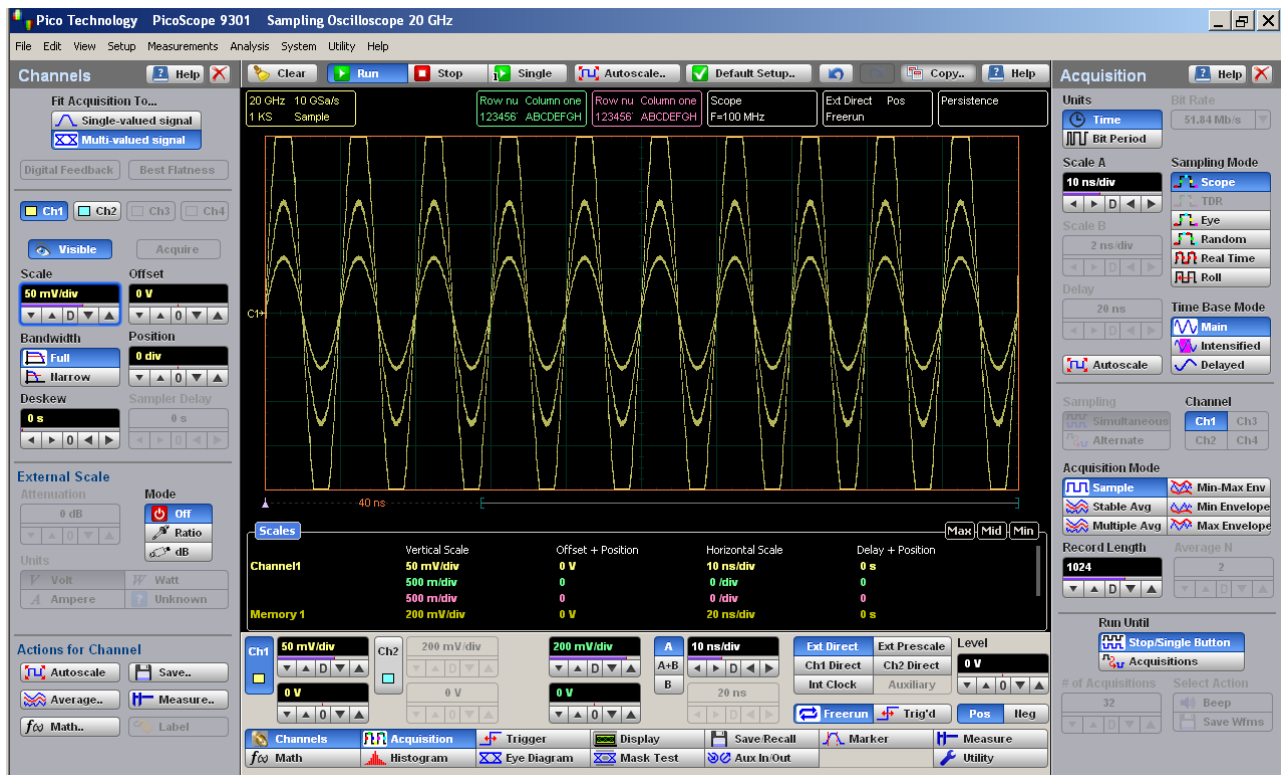
Vertical scaling of a waveform

You can set the vertical sensitivity of the selected channel in one of four ways:

- Use the **Scale** spin box
- Use the **Ch1-Ch4** spin boxes in the **Permanent Controls** area
- Use the **Drag and Zoom**
- Use the **Pop-up Keypad** to enter specific settings

You can change the vertical scaling from 1 mV/div to 500 mV/div. If fine mode is off, the vertical scaling is in a 1-2-5-10 sequence. When fine mode is on, you can change the vertical scaling with a 0.5% increment or smaller.

The **Scale** changes automatically if the attenuation factor is changed (see **Attenuation**). The units the scale is displayed in depend on the unit of measure selected with the **Units** menu. The choices for units are volts, watts, amperes, or unknown. The **Scale** changes automatically if the display graticule mode (single, dual or quad) or the attenuation factor is changed.

7.3.8 Channel Offset
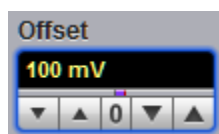
You can use the vertical **Offset** controls to move your waveform either up or down on the display. The **Offset** variable changes the vertical position of a particular channel's waveform on the display screen without modifying the waveform itself. It determines the portion of the input signal presented to the acquisition system.

The advantage of digital offset is that it is calibrated. The offset voltage is the voltage at the center of the graticule area, and the range of offset is ±1 V. As you vary the offset, the middle voltage level moves relative to zero. This moves the vertical acquisition window up and down on the waveform. With input signals that are smaller than the window, the waveform appears to move in the window. Applying a negative offset moves the vertical range down relative to the DC level of the input signal, moving the waveform up on the display. Likewise, applying a positive offset moves the vertical range up, moving the waveform down on the display.

Set the vertical offset to display the features of interest on your waveform and avoid clipping.

Each channel has its own **Ground Reference Indicator** located to the left of the graticule area. The **Ground Reference Indicator** shows you where zero volts is for each electrical channel and zero watts for each optical channel.

> ℹ️ Waveform data outside the vertical acquisition window is clipped: that is, the data is limited to the minimum and/or maximum boundaries of the vertical acquisition window. This limiting can cause inaccuracies in amplitude-related measurements.

> ℹ️ The **Offset** control affects the vertical acquisition window for the selected input channel. It does not affect waveforms saved in memories, or waveform functions.
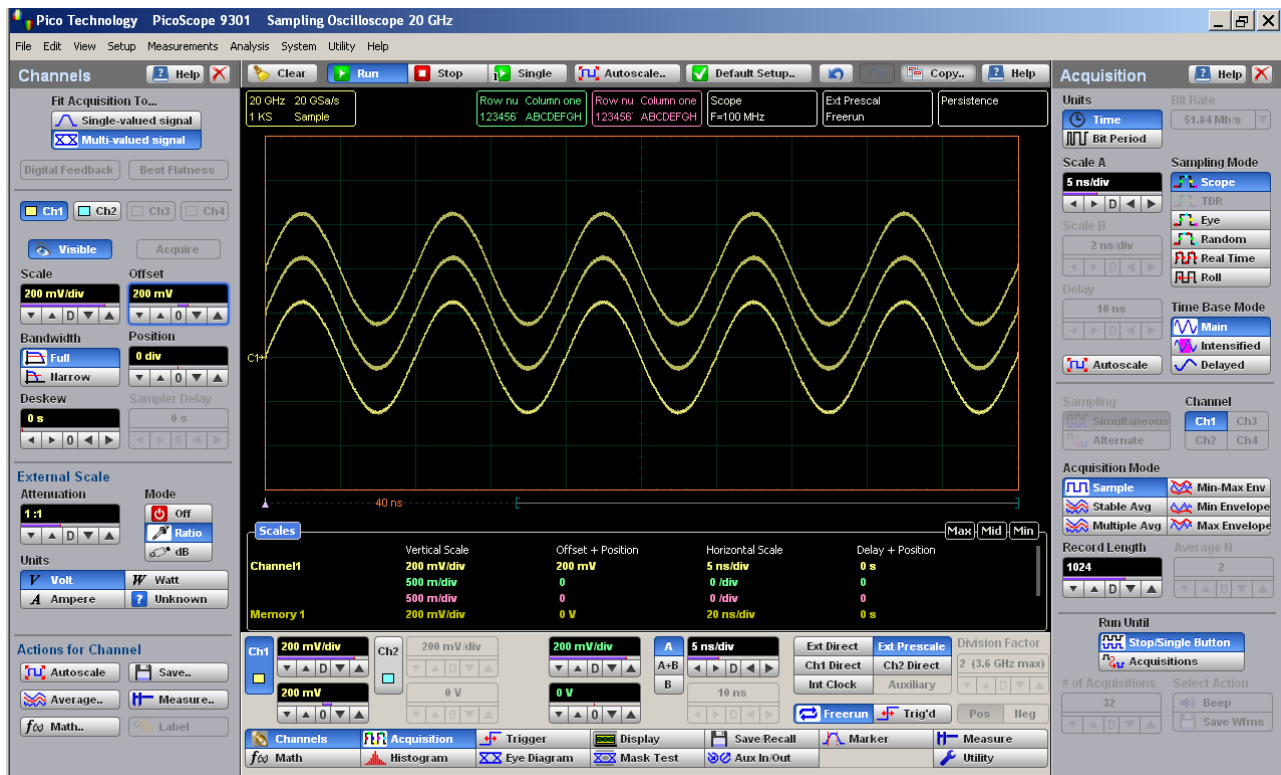
Sine-wave signal with different offsets

You can move the trace of the selected channel up or down in one of five ways:

- Use the **Offset** spin box
- Use the **Ch1** and **Ch2** offset spin boxes (plus **Ch3** and **Ch4** for the PicoScope 9341) of the **Permanent Controls Area**
- Use the **Drag and Zoom**
- Use the **Pop-up Keypad** for some specific settings
- Use a channel **Ground Reference Indicator**

If fine mode is off, the offset can be changed in 25 mV steps. When fine mode is on, you can change the offset in 1 mV steps.

The **Offset** changes automatically if the attenuation factor is changed. The units the offset voltage is displayed in depend on the unit of measure selected with the **Scale** menu. The choices for units are volts, watts, amperes, or unknown. The **Offset** changes automatically if the display graticule mode (single, dual or quad) or the attenuation factor is changed. During an **Autoscale**, an offset is applied to vertically center the signal.

7.3.9   Channel Position

Use the **Position** variable to set the vertical position of the selected channel on the display without changing its offset value. The visual effect is the same as for **Offset** but the waveform is adjusted at a later time in the signal flow.

The **Position** variable increments and decrements the waveform position by one minor graticule division, or 0.02 minor division when fine mode is on. Increasing the position value of a waveform causes the waveform to move up, and decreasing the position causes the waveform to move down.

7.3.10   Channel Bandwidth
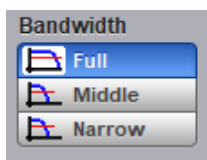
Bandwidth is the range of frequencies that an oscilloscope can acquire and display accurately (that is, with less than ±3 dB attenuation). You can use the **Bandwidth** function to select either full, middle or narrow bandwidth.

The channel bandwidth setting affects the width of the sampling pulse used by the instrument. The wider bandwidth option allows the instrument to respond to fast changes in a waveform. The increased bandwidth thus yields the highest measurement fidelity.

The narrow bandwidth offers the best sensitivity by reducing the noise on the input waveform while still maintaining good frequency response. A lower sampler bandwidth is especially useful for low-level signals that cannot be averaged, such as an eye diagram. If you do not need wide bandwidth, use the narrow bandwidth to keep the signal-to-noise ratio at the best possible level. Narrow bandwidth removes high-frequency noise from a particular channel's waveform.

The **Bandwidth** does not affect the trigger signal.

- **Full**   This button selects **Full** bandwidth.
- **Middle**   This button selects **Middle** reduced bandwidth.
- **Narrow**   This button selects **Narrow** reduced bandwidth.

7.3.11 Channel Deskew

The **Deskew** variable adjusts the skew to change the horizontal position of one active channel with respect to another on the instrument display. The **Deskew** function has a range of 0 to +100 ns. You can use the function to compensate the time offset between two or more channels, and also differences in cable or probe lengths. It also allows you to place the triggered edge at the center of the display when you are using a power divider connected between the channel and trigger inputs. Another use for deskew is when you are comparing the shapes of two waveforms rather than the actual timing difference between them: you can use the **Deskew** to overlay one waveform on top of the other.

Use the **Deskew** function only when **Alternate** is selected in the **Sampling** menu.

The **Deskew** function allows you to set the horizontal position of a waveform in one of two ways:

● Use the **Deskew** spin box
● Use the **Pop-up Keypad** to enter specific settings

If fine mode is off, you can change the deskew value in 1 ns steps. When fine mode is on, you can change the deskew value in 1 ps steps.
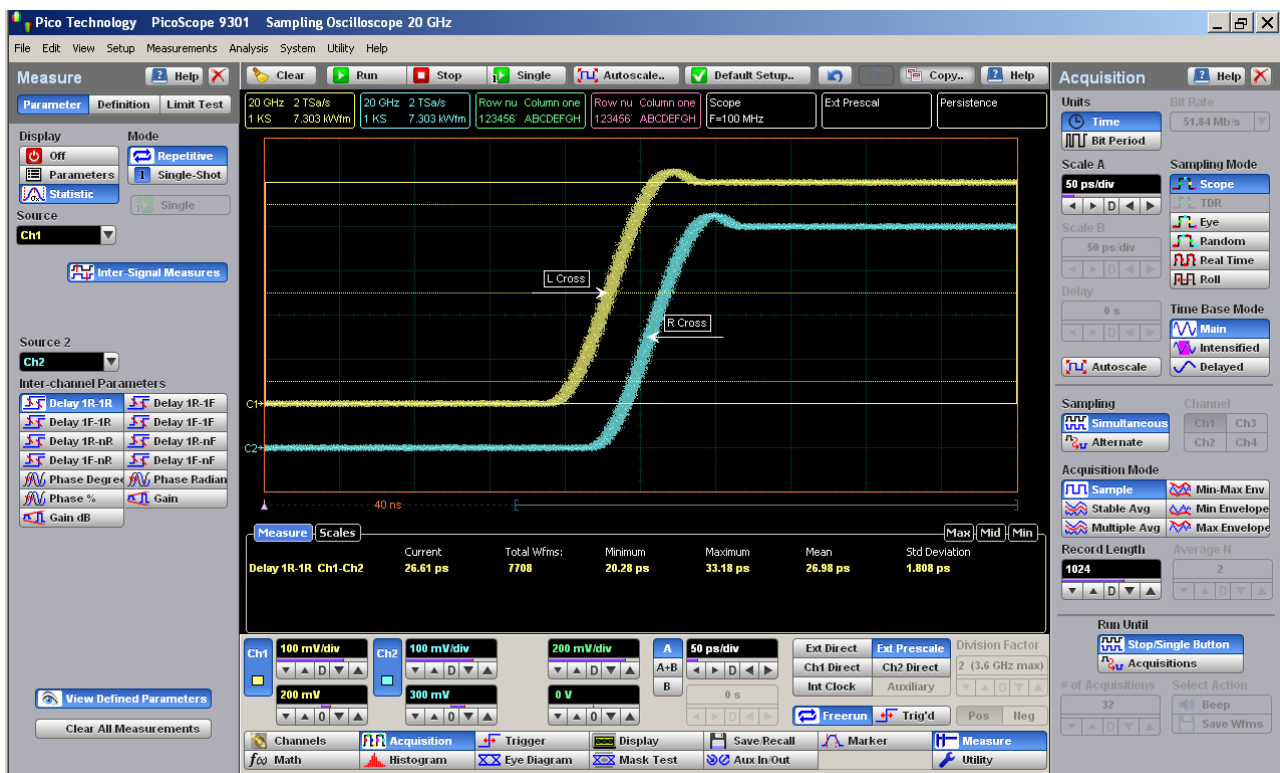
Two waveforms with entered deskew of 27 ps

7.3.12 Sampler Delay

Reserved for future use.

7.3.13 Channel Input Impedance

The input channels of the PicoScope 9300 oscilloscopes have 50 Ω input impedance with DC input coupling. This is useful for connecting to probes or circuits that require a 50 Ω termination. For example, you might choose an active probe to measure a very fast ECL, SiGe or GaAs circuit. Such a probe usually has an amplifier near the tip of the probe, which drives the signal through a 50 Ω cable. To minimize any waveform reflections, the scope input impedance must match the cable impedance as closely as possible so you would choose the 50 Ω setting for that channel's input impedance.

⚠ **CAUTION**
To avoid damage to the input of the scope, make sure you do not exceed the channel's maximum rated input voltage of ±2 V (DC + peak AC).

Using resistive divider probes you can increase the input impedance up to 5 kΩ, and using an active probe you can increase input impedance up to 10 MΩ.

7.3.14 Channel Input Coupling

The samplers used in the PicoScope 9300 Series provide only straight-DC coupling to the sampling circuits, with no protection. The PicoScope 9300 oscilloscopes specify a maximum vertical non-destructive range that limits signals to a small level of ±2 V (DC + peak AC) or 16 dBm. See **Electrical Channels. Specification and Characteristics** for exact limits.

⚠ **CAUTION**
Do not exceed the limit, even momentarily, as the input channel may be damaged.

⚠ **CAUTION**
The PicoScope 9300 Series also specifies a maximum operating input voltage (dynamic range) that, if exceeded, could cause acquisition and measurement errors due to non-linearity. This limit is equal to 1 V p-p at ±1 V range when digital feedback is used, and ±400 mV relative to channel offset without digital feedback. Do not exceed this limit.

For removing the DC component of a particular channel's waveform to view AC waveforms with large DC offsets, use external wide-bandwidth HF blocking capacitors. Use external attenuators if necessary to prevent exceeding the limits just described.

7.3.15   Channel External Scale
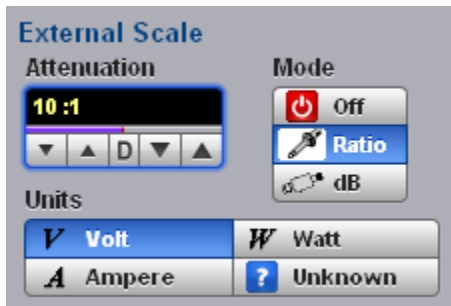
The **External Scale** functions allow you to set up a channel of the instrument to use external voltage attenuators or probes, current probes, or optical-to-electrical converters. Scaling is automatically adjusted to calculate and display information at the input side of an external device. For example, you may need to reduce the voltage level of a pulse generator that exceeds a channel's maximum input level. If you add a 20 dB attenuator, the voltage is reduced by a factor of 10:1. Although the voltage levels into the channel are within acceptable limits, your source measurements will be 1/10th of the actual source level. External scaling allows you to compensate for the 20 dB attenuation so your measurements reflect the source level prior to attenuation.

The measurement result reflects the actual value at the external device input. Once the number has been entered (1 is the default), the instrument then uses the total attenuation factor in scaling measurement results. Total attenuation is the product of the external attenuation multiplied by the hardware attenuation of the probe (or another external unit) or sampler.

When you enter attenuation, amplification, or conversion information with the **External Scale** menus, the channel settings change in the following ways:

- The unit values and amplitudes of the markers and vertical measurements reflect the signal at the input of a transducer, probe, attenuator, or amplifier. For example, you can connect an external device such as a photodiode to an electrical channel input and change the scale unit value to read watts, the unit value of the signal at the diode input.
- The maximum and minimum vertical scale settings change by a factor specified by the attenuation value entered.
- Offset minimum and maximum values change by a factor specified by the attenuation value entered.

7.3.16   External Scale Mode

You can enter attenuation or gain characteristics of an external device when configuring a channel for external scaling. The **Mode** function lets you select how you want the attenuation factor represented. Click the **Ratio** *Ratio* or **Decibel** *dB* radio buttons to choose either ratio or decibel.

The formula for calculating decibels is: ***20 log(V$_{out}$/V$_{in}$) or 10 log(P$_{out}$/P$_{in}$)***

Decibels versus voltage ratio

dB	Voltage Ratio
3 dB	1.41
6 dB	2.00
10 dB	3.16
20 dB	10
40 dB	100
60 dB	1000
120 dB	1 000 000
−80 dB	0.000 1

Changing the channel attenuation factor does not attenuate the input signal; it only changes the database for generating prompts on the display and calculating the results of the automated waveform measurements. If the input signal must be attenuated, use external attenuators.

> **ⓘ** External gain is implied when you enter negative decibel values or ratios of less than 1:1 in the **Attenuation** variable. The default attenuation value is 1:1.

7.3.17   External Scale Attenuation

The **Attenuation** variable lets you select an attenuation that matches the device connected to the instrument. When the attenuation is set correctly, the instrument maintains the current scale factors if possible. All marker values and voltage, amperage or wattage measurements will reflect the actual signal at the input to the external device.

The channel attenuation factor is used to establish a database for:

- Generating the vertical scale and offset prompts on the display
- Calculating the automated waveform measurements
- Y-marker levels
- Calculating functions

The attenuation factor can be adjusted from 0.000 1:1 to 1 000 000:1 or from −80 dB to 120 dB.

The **Attenuation** function allows you to set attenuation of the selected channel in one of two ways:

- By using the **Attenuation** spin box
- By using the **Pop-up Keypad** to enter specific settings

7.3.18   External Scale Units

The External Scale **Units** function lets you select a unit of measure that is appended to the channel scale, offset and vertical measurement values. The units are **Volt**, **Watt, Ampere,** or **Unknown**.

Use **Volt** for voltage probes or attenuators, **Ampere** for current probes, **Watt** for optical-to-electrical converters, and **Unknown** when there is no unit of measure or when the unit of measure is not one of the available choices.

7.4   Display menu

  Display

The **Display** menu controls most of the features that determine how the acquired data is displayed on the screen. You can configure the PicoScope 9300 for persistence or color-graded display style, select the graticule settings, define the waveform display area for single or multiple waveform displays, and change the color of most of the items that are displayed on the screen.
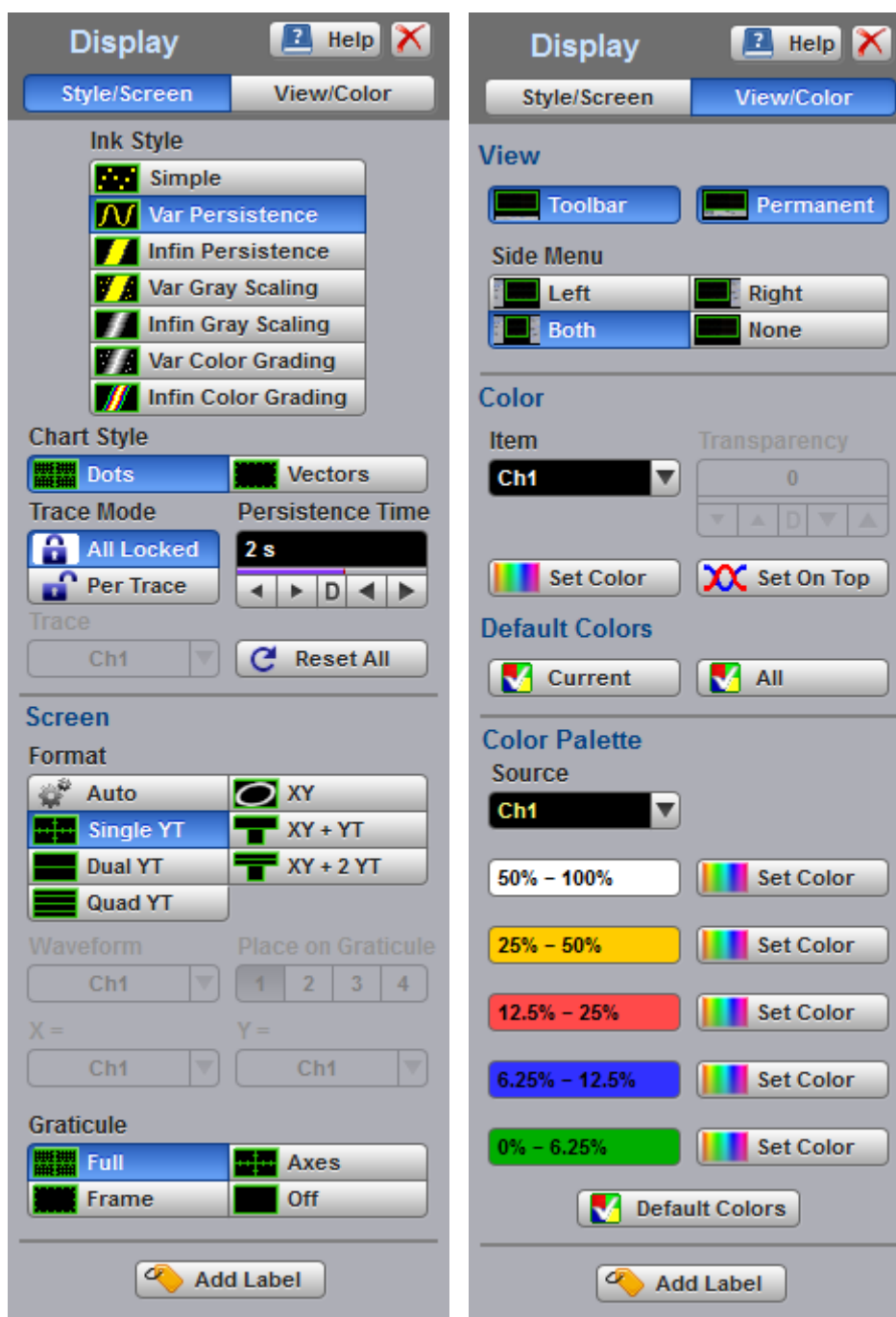
The Display menu

7.4.1   Style
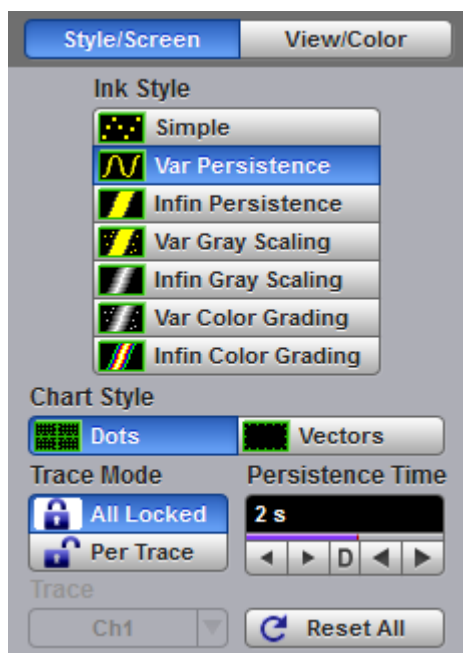
The Display Style menu

7.4.1.1   Ink Style
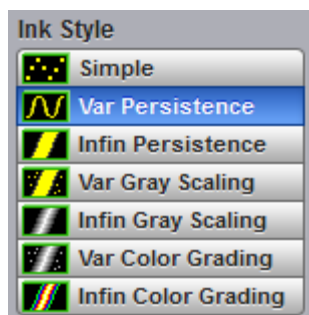
The **Ink Style** menu determines how the data is displayed. There are seven choices for drawing waveforms:

- **Simple**
- **Variable Persistence**
- **Infinite Persistence**
- **Variable Gray Scaling**
- **Infinite Gray Scaling**
- **Variable Color Grading**
- **Infinite Color Grading**

The first three of these can be used in combination with the Chart Styles.

Simple

The **Simple** ink style displays waveforms without persistence: the waveform is displayed only for one trigger event. When the next trigger event occurs, the previous waveform is erased and the newly acquired waveform is drawn on the display. Data points are plotted on the display as quickly as possible.

Display Persistence

Persistence mode keeps data points on the screen for a predetermined period of time before erasing them.
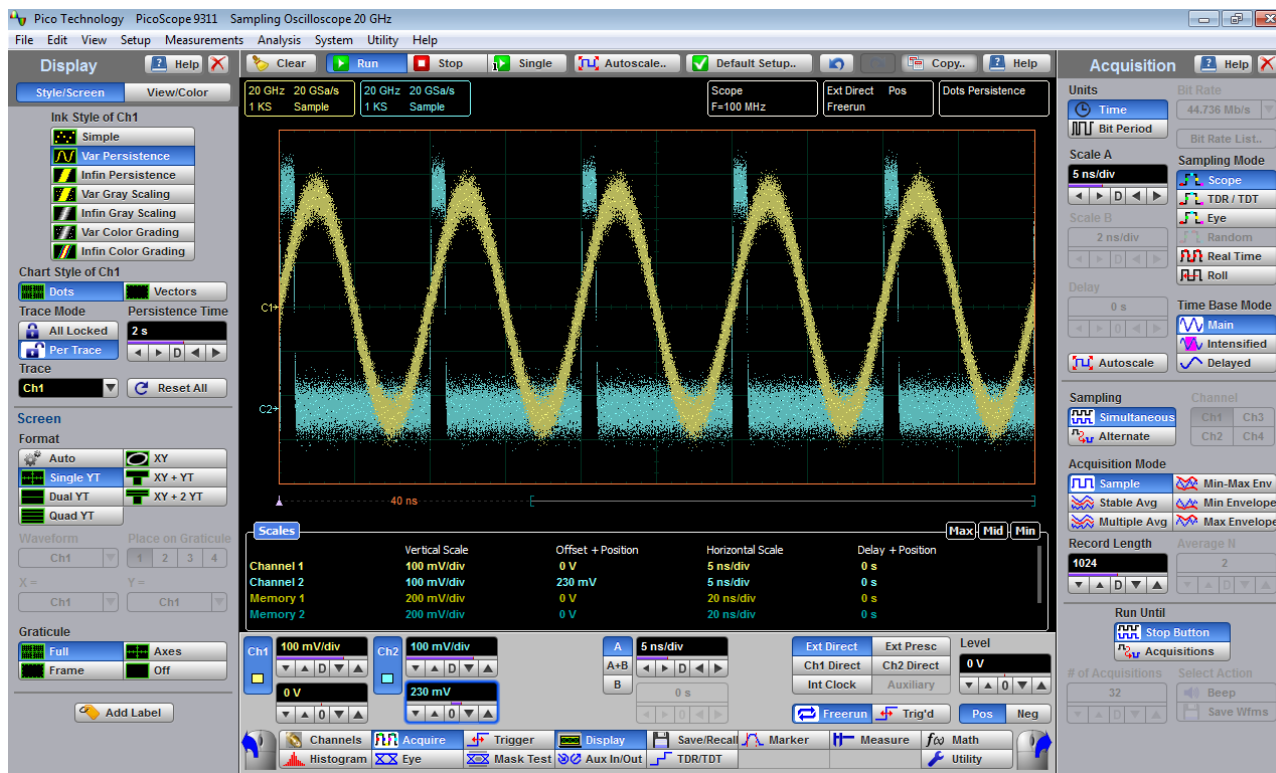
Variable Persistence Display Style

Persistence mode applies to all waveforms. Use display persistence to control how waveform data ages. By adding persistence, you can see a visual history of a waveform's acquisitions over time. Setting the persistence to minimum allows the easiest viewing of variations in the acquired waveforms. Setting the persistence to infinite allows a complete view of everything measured in the waveform. For example, you can see the accumulated peak-to-peak noise of a waveform over time, which may appear significantly different than in only one acquisition. You can see timing jitter, the variance of the waveform from the trigger event, by accumulating acquisitions on the display. By adding persistence, viewing a waveform's extremes over time is much easier.

You can have averaging and persistence on at the same time because the averaging is done before the data is sent to the display. Use the **Acquisition** menu to control averaging.

ℹ️   Waveform persistence is used only in the **Display Area**.

ℹ️   Use waveform persistence in the **Eye Diagram** and **Mask Test** menus. The **Eye Diagram** and **Mask Test** measurement algorithms are based on the statistical accumulation of the data.

The PicoScope 9300 uses two persistence settings:

- **Variable Persistence**
- **Infinite Persistence**

Variable Persistence

The **Variable Persistence** style accumulates the waveform-record points on screen and displays them for a specific time. The oldest waveform data continuously fades from the display as new waveform records are acquired.

By selecting the Variable Persistence display style, you can vary the persistence time from minimum of 100 ms to 20 s. When the persistence is set to minimum, all data points are kept on the display for 100 ms. After 100 ms all the previous data points are erased from the display, and new data points are written to the display. The longer the persistence time, the longer each data point is left on the display before it is erased from the display. You can change the persistence time with the **Persistence Time** variable.

A minimum persistence setting is used when the input signal is changing and you need immediate feedback. You can use the minimum persistence to view the fastest display update rate. For example, if you are rapidly probing a source, you may find that more persistence is useful for observing long-term changes in a signal or observing signals with low repetition rates. More persistence is useful when you are observing long-term changes in the signal or low signal repetition rates.

> ℹ️ If you are adjusting the amplitude or frequency of a signal source, you may find that more persistence (variable or infinite) is useful for observing long-term changes in a signal or observing signals with low repetition rates. If you are adjusting signal parameters, such as scale or delay, you will find that minimum persistence is useful due to the fast update rate.

When the waveform acquisition is stopped, the last acquired data points are left on the display.

If any of the following occurs while the instrument is set to Variable Persistence, the displayed waveform is redrawn and any accumulated waveforms are cleared:

- The **Clear** button is clicked
- **Autoscale** is selected
- **Default Setup** is selected
- The instrument is turned off

Infinite Persistence

When you select the **Infinite Persistence** display style, all the data points are kept on the display for an endless period of time, or until you change some control. Waveform data builds up as new data records are acquired. You can use infinite persistence for worst-case characterization of signal noise, jitter and drift, or to see a waveform's envelope, look for timing violations, and find infrequent events.

With Infinite Persistence, all sampled data points are left on the display until any of the following occurs:

- The **Clear** button is clicked
- **Autoscale** is selected
- **Default Setup** is selected
- The instrument is turned off

Gray Scaling

This mode is similar to persistence mode. The only difference is that the accumulated points are drawn in one color that is varied in saturation and luminosity (in other words, different shades of the same color). You can use the gray-scaling database with histograms, mask testing, statistical measurements, and eye diagrams. You can also use color grading to provide more visual information about the waveforms.

Gray-scaling mode uses a database the same size of the graticule area. Behind each pixel is a 16-bit counter. Each time a pixel is hit by data, the counter for that pixel is incremented. Each shade used represents a range of data counts. As the total count increases, the range of hits represented by each color also increases. The maximum count for each pixel is 65 535.

Five levels are used in gray-scaling mode. Each shade shows the number of hits per pixel over the graticule area, and represents a range of counts that depends on the total number of hits. As the total count increases, the range of hits represented by each shade also increases. The shades are fixed and cannot be changed.
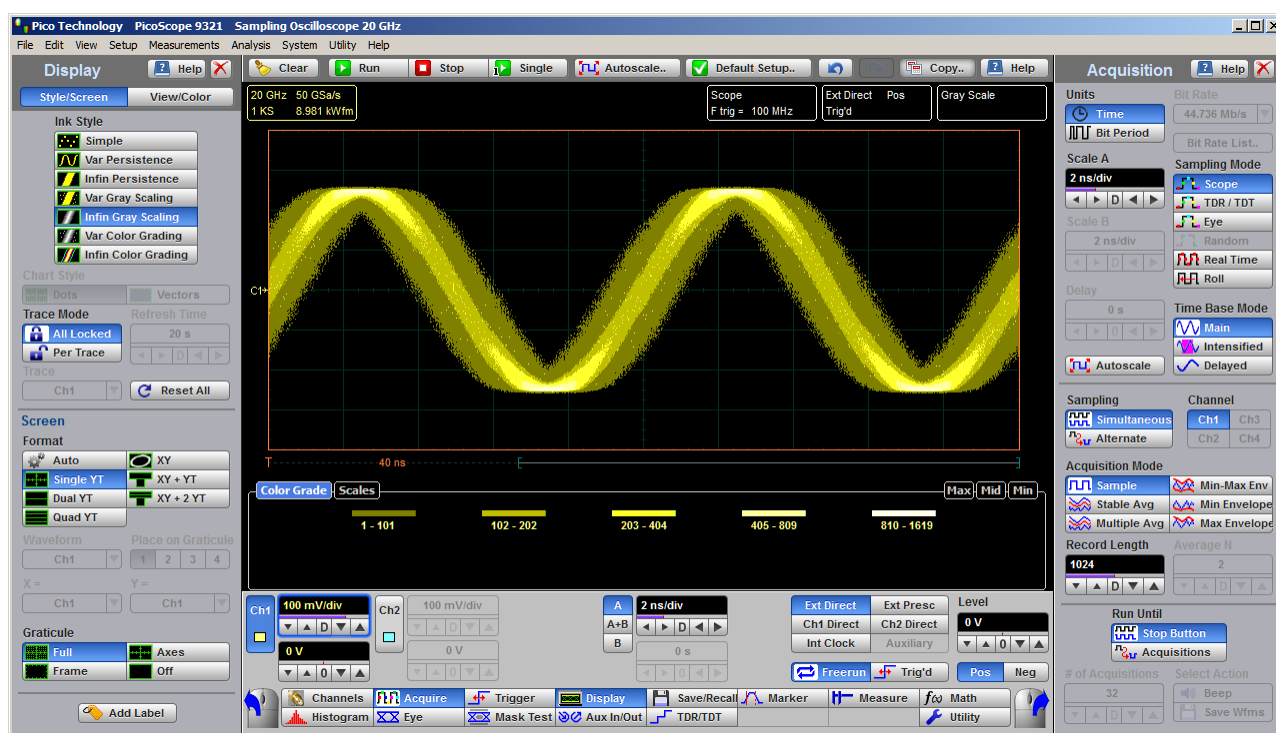
Gray-scaling Display Style

You can use gray-scaling mode to display waveforms that use the instrument measurement database. This database consists of all data samples displayed on the screen. The measurement database provides the data for the construction of histograms and performing mask tests.

If gray-scaling mode is left active for a long period of time, the waveform will become saturated with the shades that represent the highest density of data counts.

> ℹ️ Use gray-scaling in the **Eye Diagram** and **Mask Test** menus. The **Eye Diagram** and **Mask Test** measurement algorithms are based on the statistical accumulation of the data that the **Gray Scaling** mode uses internally.

Variable Gray Scaling

In the **Variable Gray Scaling** display style, the screen is not refreshed after every acquisition; instead, the screen is refreshed at a specified, selectable rate. You can vary the refresh time from minimum of 1 s to 200 s. You can change the refresh time with the **Refresh Time** variable.

If any of the following occurs while the instrument is set to the Variable Gray Scaling display style, the displayed waveform is redrawn and any accumulated waveforms are cleared:

- The **Clear** button is clicked
- **Autoscale** is selected
- **Default Setup** is selected
- The instrument is turned off

Infinite Gray Scaling

When you select the **Infinite Gray Scaling** display style, all the data points are kept on the display. With the Infinite Gray Scaling display style, all sampled data points are left on the display until any of the following occurs:

- The **Clear** button is clicked
- **Autoscale** is selected
- **Default Setup** is selected
- The instrument is turned off

You can use infinite gray-scaling for worst-case characterization of signal noise, jitter and drift, to see a waveform's envelope, look for timing violations, or to find infrequent events.

Color Grading

This mode is similar to persistence mode. The only difference is that the accumulated points are color-graded (shaded with different colors) to indicate the density of the points, and a color-graded database is built. You can use the color-graded database with histograms, mask testing, statistical measurements and eye diagrams. You can also use color grading to provide more visual information about the waveforms.

The color-grading function uses a database the same size as the graticule area. Behind each pixel is a 16-bit counter. Each time a pixel is hit by data, the counter for that pixel is incremented. Each color used for the color grade mode represents a range of data counts. As the total count increases, the range of hits represented by each color also increases. The maximum count for each counter is 65 535.

There are five colors used in the color-graded display. Each color shows the number of hits per pixel over the graticule area, and represents a range of counts, which depends on the total number of hits. As the total count increases, the range of hits represented by each color also increases. The colors can be changed from the **Color Palette** menu.
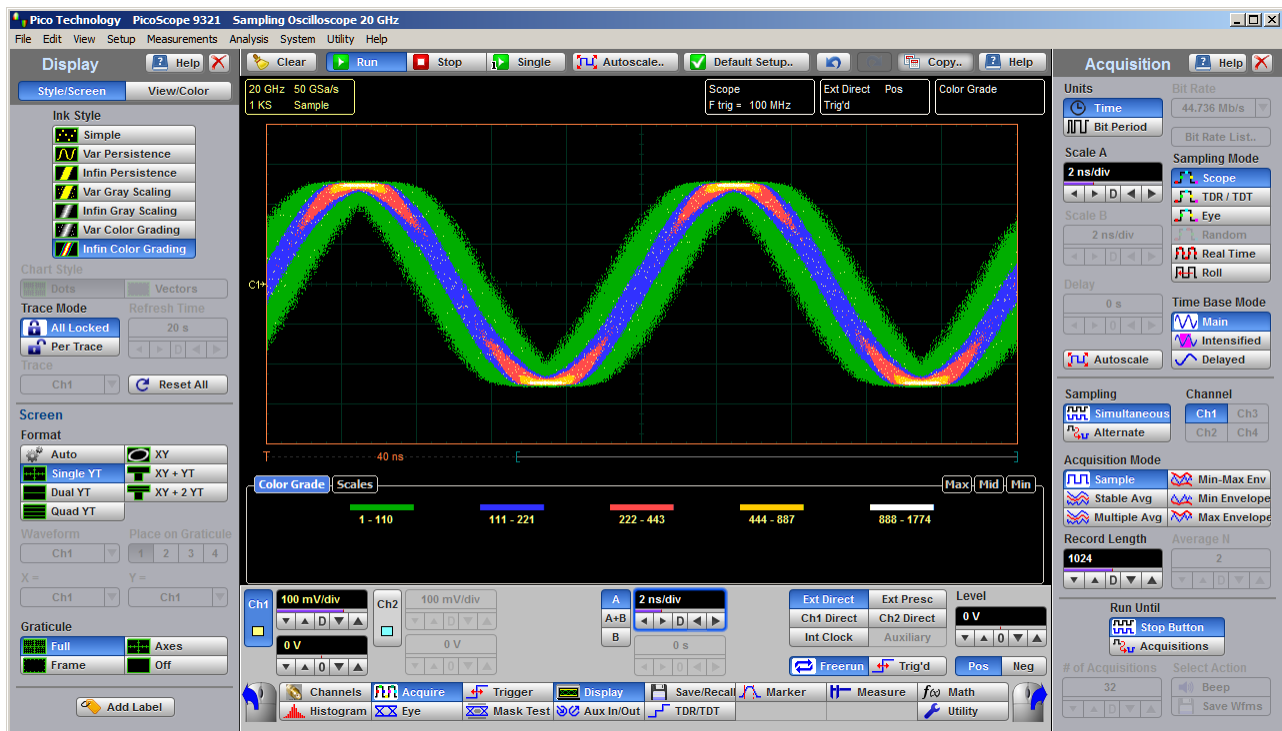
Color-grading Display Style

You can use color grading mode to display waveforms that use the instrument measurement database. This database consists of all the data samples displayed on the screen. The measurement database provides the data for the construction of histograms and performing mask tests.

If color grading is left active for a long period of time, the waveform will become saturated with the color that represents the highest density of data counts. The **Color Palette** menu displays the color levels and the range of counts each color represents. Click the **View/Color** button at the top of the **Display** menu to view the color levels.

> ℹ️ Use gray-scaling in the **Eye Diagram** and **Mask Test** menus. The **Eye Diagram** and **Mask Test** measurement algorithms are based on the statistical accumulation of the data that the **Gray Scaling** mode uses internally.

The PicoScope 9300 Series has two color-grading settings:

- **Variable Color Grading**
- **Infinite Color Grading**

Variable Color Grading

In the **Variable Color Grading** display style, the screen is not refreshed after every acquisition; instead, the screen is refreshed at a specified, selectable rate. You can vary the refresh time from the minimum of 1 s to 200 s using the **Refresh Time** variable.

If any of the following occurs while the instrument is set to the Variable Color Grading display style, the displayed waveform is redrawn and any accumulated waveforms are cleared:

- The **Clear** button is clicked
- **Autoscale** is selected
- **Default Setup** is selected
- The instrument is turned off

Infinite Color Grading

When you select the **Infinite Color Grading** display style, all the data points are kept on the display. In this style, all sampled data points are left on the display until one of the following occurs:

- The **Clear** button is clicked
- **Autoscale** is selected
- **Default Setup** is selected
- The instrument is turned off

You can use infinite color grading for worst-case characterization of signal noise, jitter and drift, to see a waveform's envelope, look for timing violations or to find infrequent events.

7.4.1.2   Chart Style

The **Chart Style** menu determines how the data points are displayed in **Simple**, **Variable Persistence** and **Infinite Persistence** modes.

Dots display

The **Dots** style displays the waveform data points but does not join them together with lines. When the waveform record length is small, the throughput of the instrument is fast enough that you can use the **Vector** style without noticing much decrease in throughput.

Dots Display Style

Vector display

The **Vector** function draws a straight line through the data points on the display. The **Vector** style gives an analog look to a digitized waveform and makes it possible to see steep edges on waveforms such as square waves. If you use the **Vector** style the approximate unaliased oscilloscope bandwidth is:

Bandwidth = Effective Sample Rate / 10

In this configuration, a waveform can alias if its highest frequency component exceeds 1/10 the sample rate. On waveforms where there are only a few dots representing the acquired data points, such as when the record length is small, you may find it easier to have a sense of what the waveform looks like.

> It is recommended to view a spectrum when **Vectors** style is enabled. However it is not recommended to view eye diagrams when **Vectors** style is enabled. For this reason, do not use the **Vectors** style in the **Eye Diagram** and **Mask Test** menus.

Vectors Display Style

7.4.1.3   Persistence Time / Refresh Time
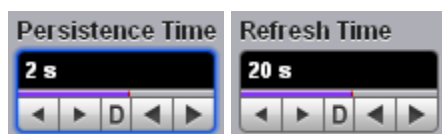
Persistence Time

The **Persistence Time** variable works when the **Variable Persistence** display is selected in the **Style** menu.

Persistence time is the amount of time for which a waveform sample appears on the display. In the **Variable Persistence** display style, a waveform sample point is displayed from 100 ms to 20 s. The default setting is 2 s.

This mode most closely simulates the phosphorescent persistence of an analog scope. Use variable persistence to view infrequent events and rapidly changing waveforms and watch the evolution of the waveform.

Refresh Time

The **Refresh Time** variable works with both the **Variable Gray Scaling** and the **Variable Color Grading** display styles. It controls how often the screen is updated with new data. The range is 1 to 200 s.

7.4.1.4   Trace Mode

The PicoScope 9300 Series gives you the choice of constraining all input channels to the same display style, or setting these for each trace individually.

- **All Locked**   Set the same display style for all traces.
- **Per Trace**   Set up traces individually.

7.4.1.5   Trace
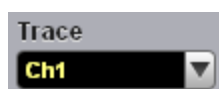
The **Trace** control selects a trace to set its display style. It is only active when **Trace Mode** is set to **Per Trace**.

7.4.1.6   Reset All

Click the **Reset All** button to return all traces to their default persistence settings.

7.4.2   Screen

The **Screen** menu lets you define the display area in different ways.
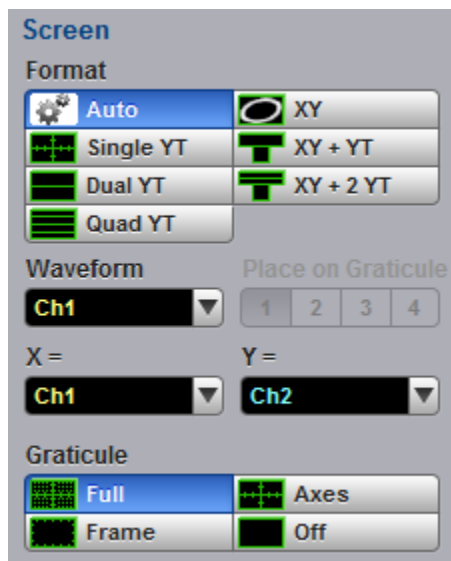
The Screen menu

7.4.2.1   Format
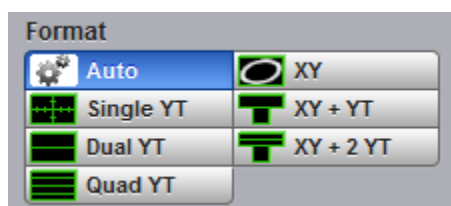
The **Format** menu determines how the instrument draws the waveforms on the display. The following formats are used in the PicoScope 9300 Series.

Auto

Auto automatically places, adds or deletes graticules as you select more or fewer waveforms to display.

Single YT

The **Single YT** format is the normal time (on the horizontal axis) versus voltage (on the vertical axis) format. The entire display area is one screen and any displayed waveforms are superimposed on top of each other.
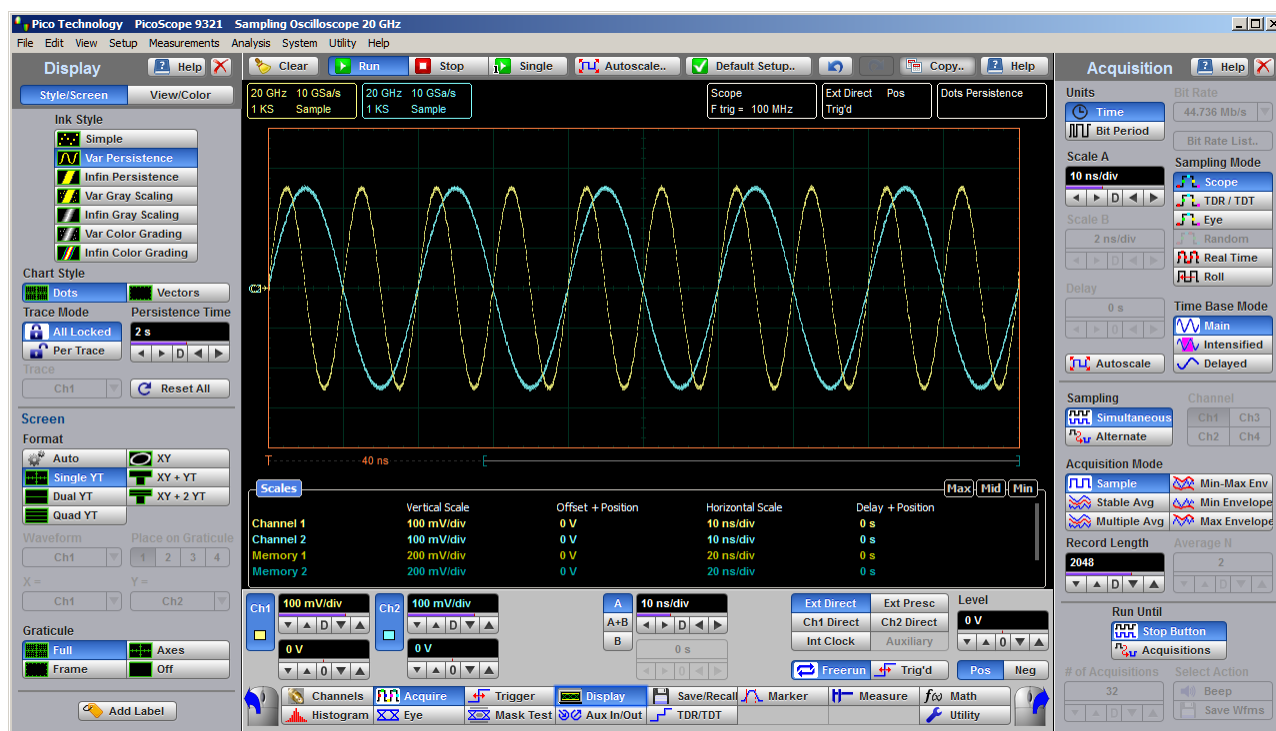
Single YT Display Format

Dual YT

The **Dual YT** format is the normal time (on the horizontal axis) versus voltage (on the vertical axis) format, but with the display area divided into two equal screens.
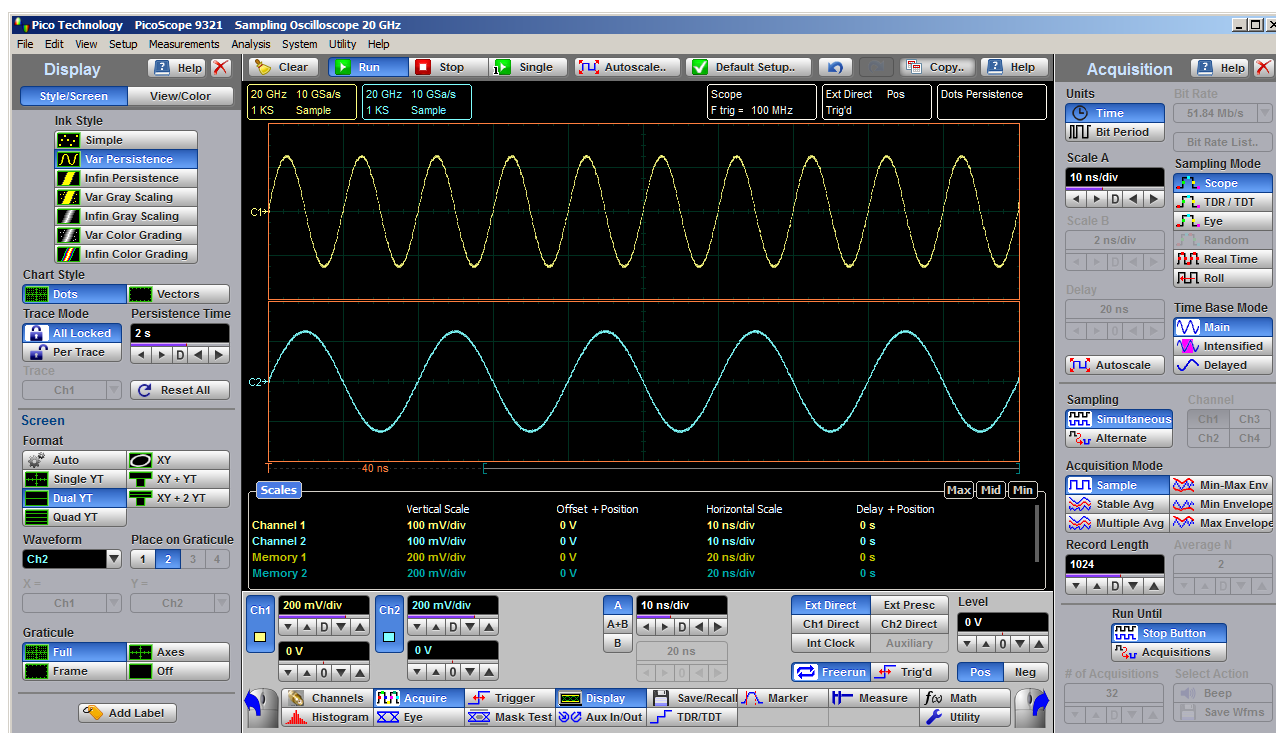
Dual YT Display Format

Quad YT

The **Quad YT** format is the normal time (on the horizontal axis) versus voltage (on the vertical axis) format, with the display area divided into four equal screens.

Quad YT Display Format

XY

The **XY** format displays the voltages of two waveforms against each other, and draws the **Source 1** versus **Source 2** display of the two selected sources. **Source 1's** amplitude is plotted on the horizontal X axis and the **Source 2's** amplitude is plotted on the vertical Y axis.
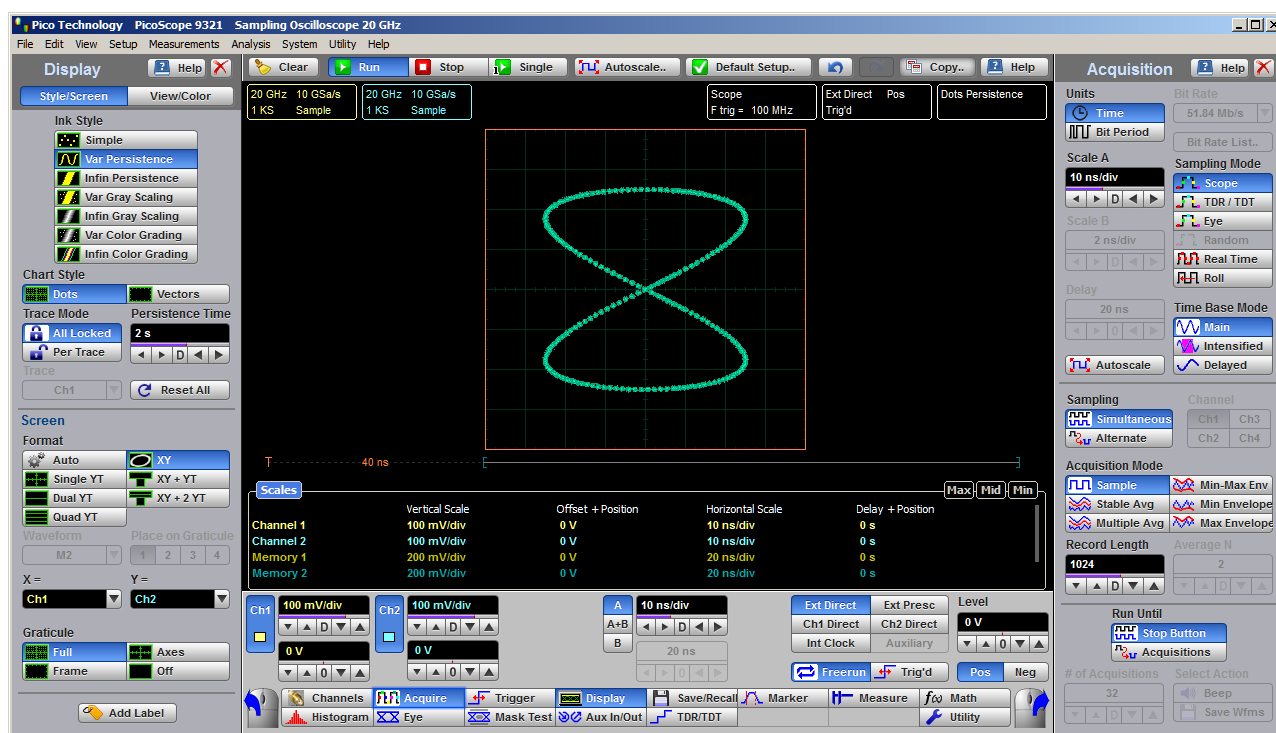
XY Display Format

XY + YT

The **XY + YT** format displays both **XY** and **YT** pictures. The **YT** format appears on the upper part of the screen, and the **XY** format on the lower part of the screen. All waveforms in the **YT** format area are superimposed on top of each other.
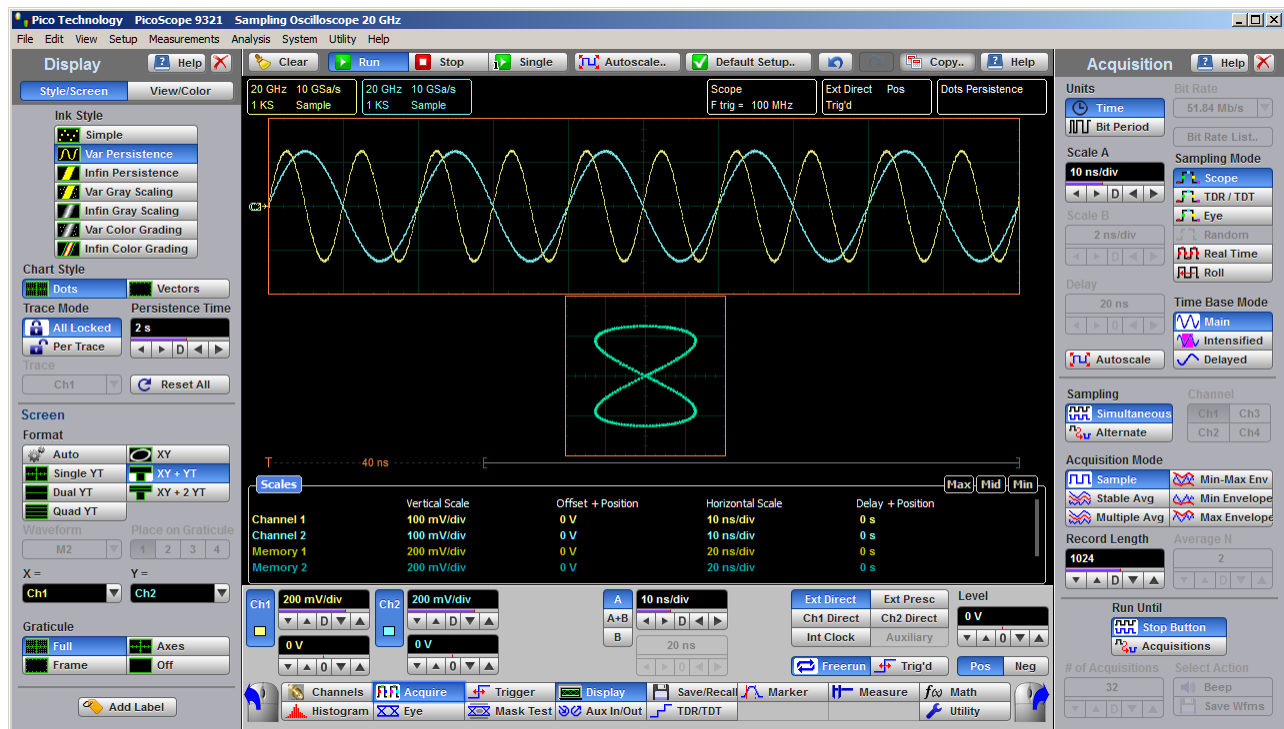
XY+YT Display Format

XY + 2 YT

The **XY + 2 YT** format displays both **YT** and **XY** pictures. The **YT** format appears on the upper part of the screen, and the **XY** format on the lower part of the screen. The **YT** format display area is divided into two equal screens.
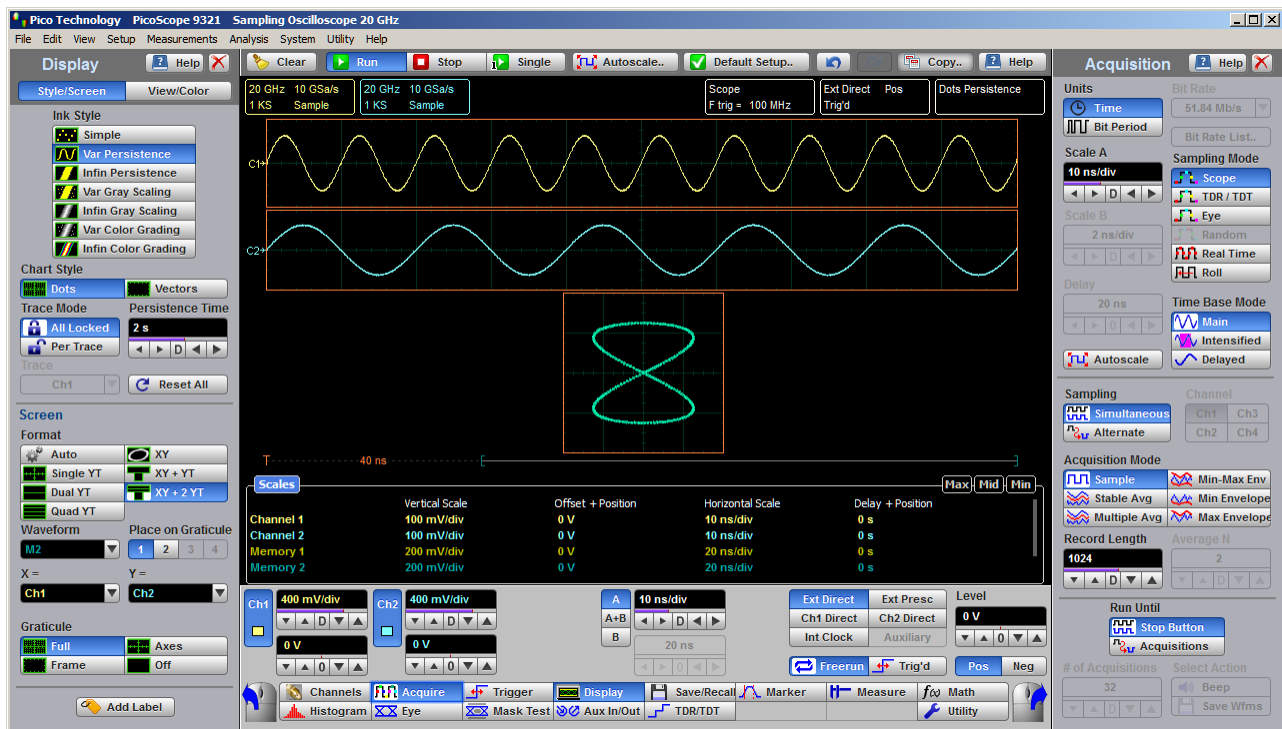
XY + 2 YT Display Format

You can use the **XY** formats to compare frequency and phase relationships between two signals. The **XY** format can also be used with transducers to display strain versus displacement, flow versus pressure, volts versus current, or voltage versus frequency.

7.4.2.2   Waveform

With the **Waveform** control, you can select the waveform that will be placed on the graticule by the **Place on Graticule** control.

You can select any of the following as the waveform source:

- Channels
- Functions
- Waveform memories
- Spectra

7.4.2.3   Place on Graticule

With the **Place on Graticule** control you can place a waveform, selected using the **Waveform** control, on any possible graticule.

You can place any waveform selected as source on any graticule. For example, you can place the **M1** waveform memory on the fourth graticule, or the **F1** function on the first graticule.

7.4.2.4   X= and Y=

These controls can be used alongside the three XY display formats.

X=

The **X=** control selects the waveform source related to the horizontal X axis. You can select the **X=** source from:

- Channels
- Functions
- Waveform memories
- Spectra

Y=

The **Y=** control selects the waveform source related to the vertical Y axis. You can select the **Y=** source from:

- Channels
- Functions
- Waveform memories
- Spectra

7.4.2.5   Graticule

The PicoScope 9300 Series has a 10 by 8 display graticule grid, which you can turn on or off. The **Graticule** menu selection is:

- **Full**   The **Full** background is a complete graticule with ten horizontal major divisions and eight vertical major divisions. Vertically one minor division is one-quarter of a major division; and horizontally, one minor division is one-fifth of a major division. There is also a cross-hair style measurement scale.
- **Axes**   Displays the outside border with an external measurement scale and an additional cross-hair style measurement scale.
- **Frame**   Displays the outside border with a measurement scale. Major and minor divisions are based on the vertical and horizontal measurement settings.

● **Off**   Turns the background graticule off. The displayed waveforms and waveform's information is not turned off.

7.4.3   View

The **View** menu turns on or off the different display areas of the GUI.
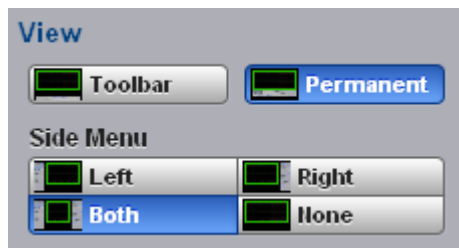
The View menu

7.4.3.1   Toolbar

Turns on or off the display the **Toolbar.**
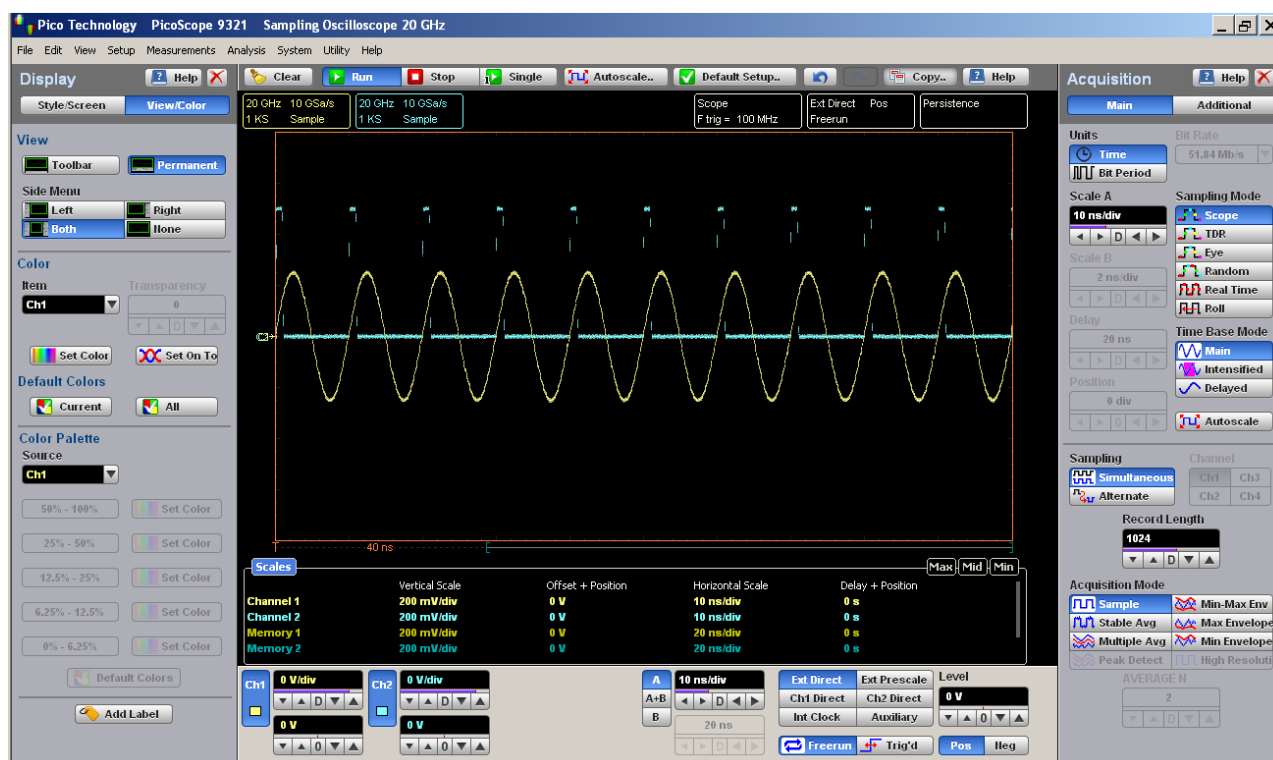
GUI with turned-off Toolbar

You can return the **Toolbar** to the **GUI** by clicking **View/Toolbar** in the **Main Menu**.

7.4.3.2   Permanent Controls

Permanent turns on or off the display of permanent controls**.**
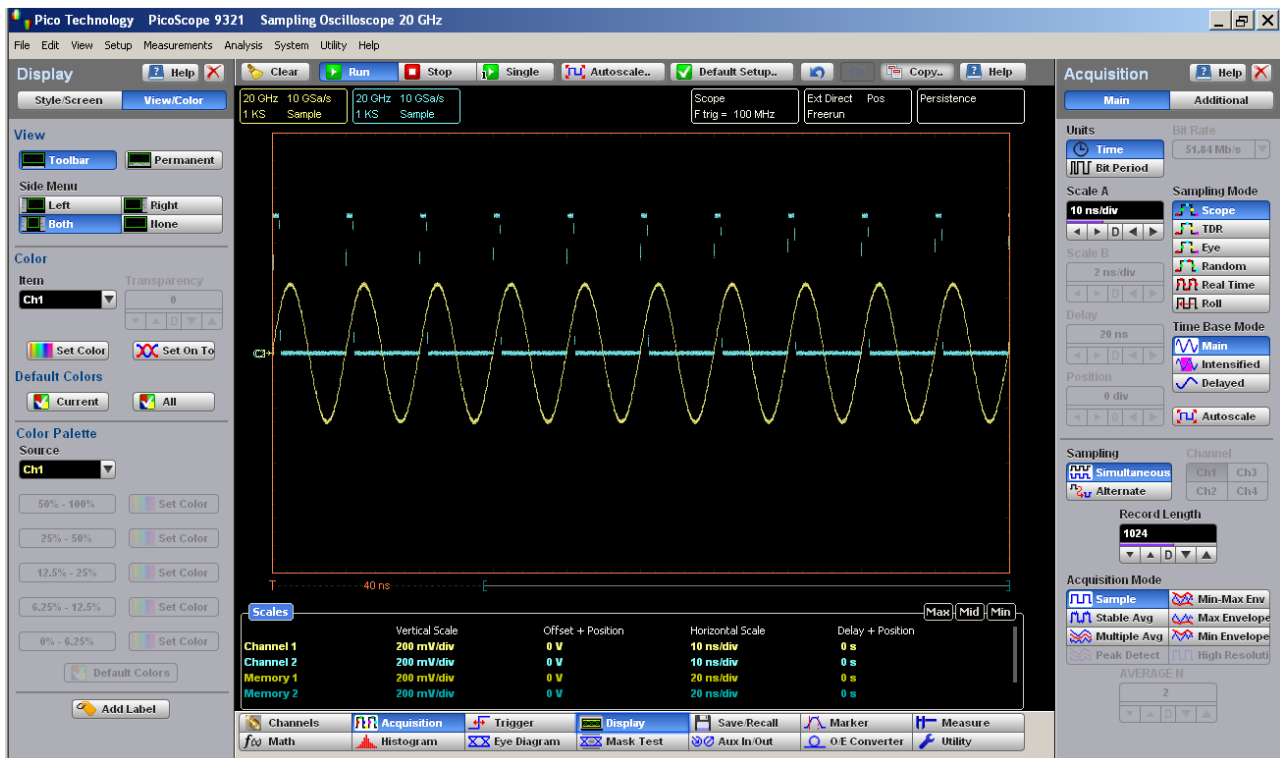
GUI with turned off Permanent controls

You can return the permanent controls to the **GUI** by clicking **View/Permanent Controls** in the **Main Menu**.

7.4.3.3   Side Menu

Side Menu turns on or off the display of **Left Side Menu**, **Right Side Menu** or both **Side Menus.**
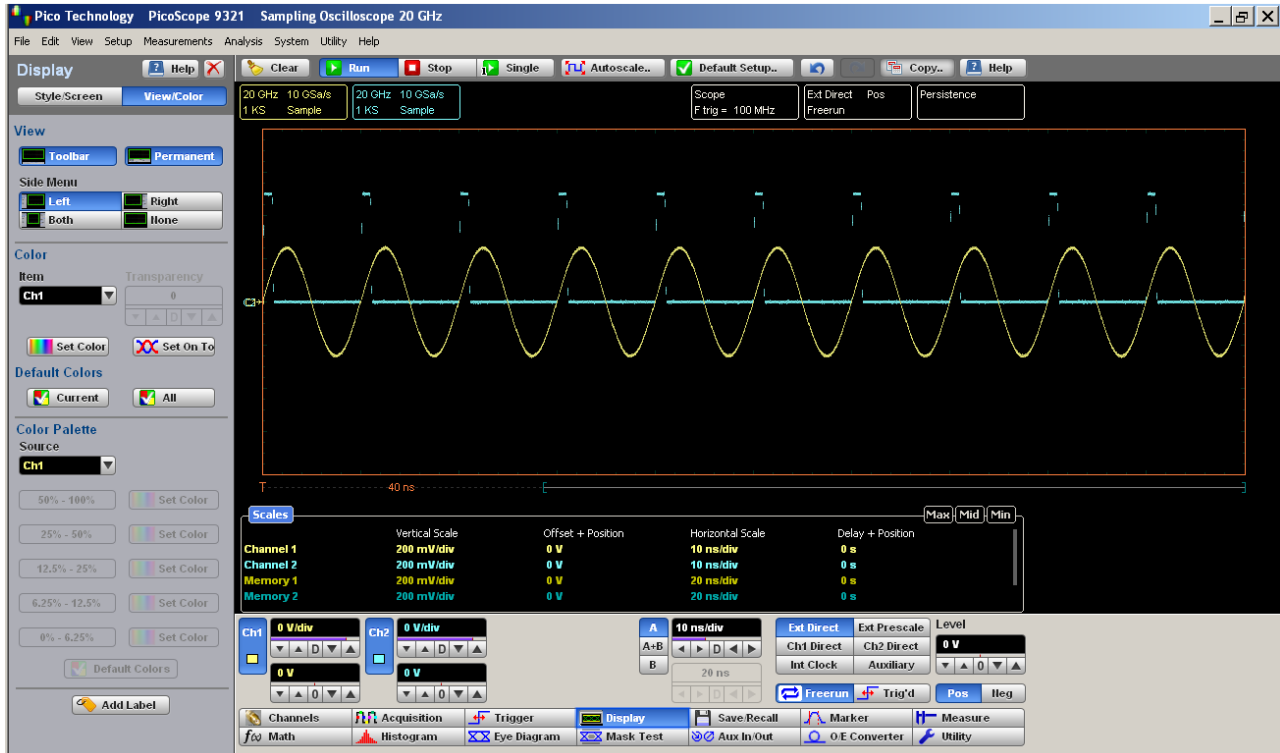
GUI with turned on Left Side Menu only
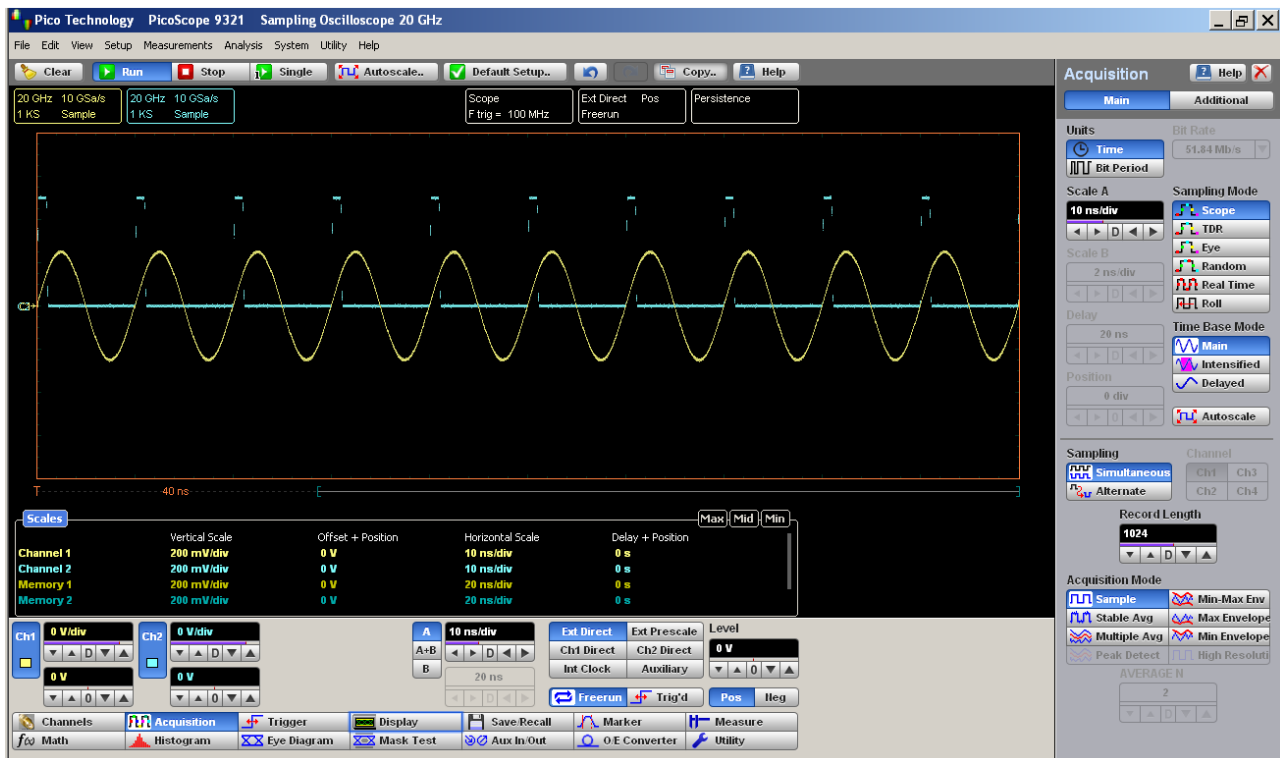
GUI with turned on Right Side Menu only
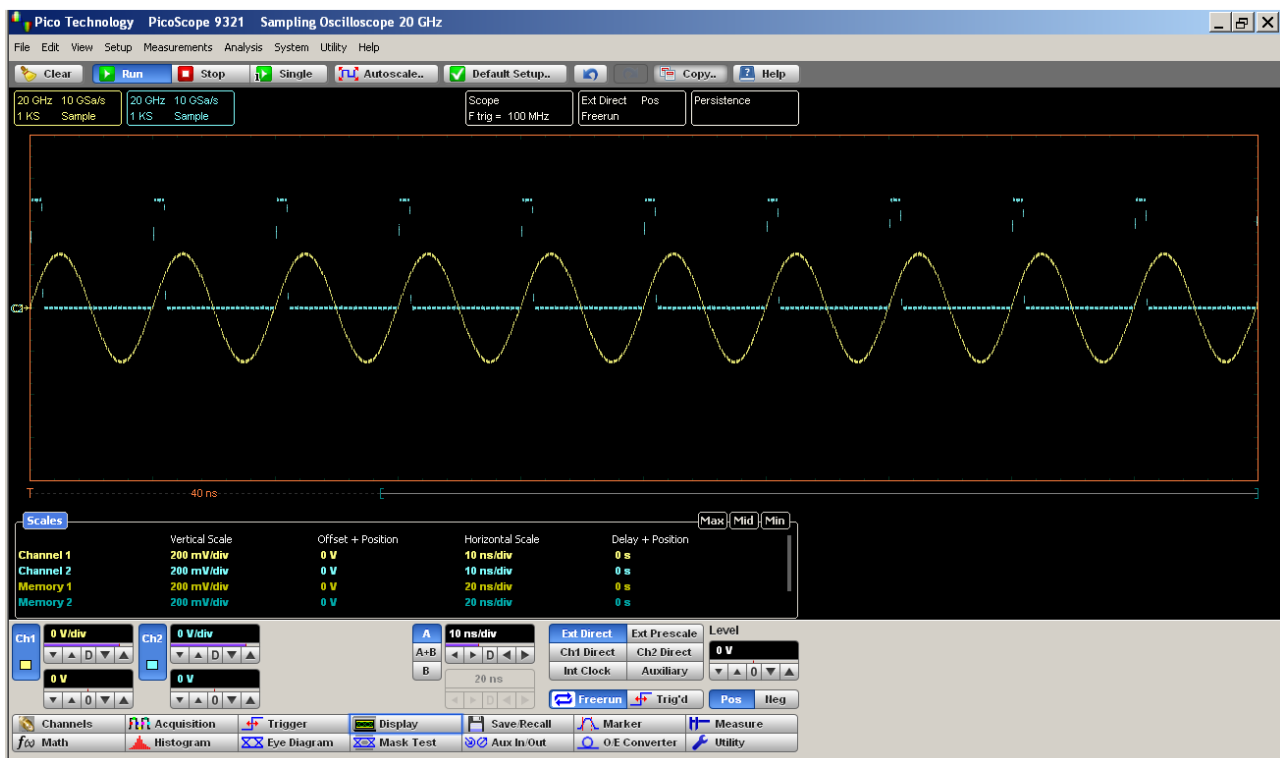
GUI with both Side Menus turned off

You can return any of the **Side Menus** to the **GUI** by clicking **View/Side Menu** in the **Main Menu**.

7.4.4   Color

The **Color** menu allows you to define the display colors and transparency of many display elements. For example, you can change the color of an input waveform channel for better visibility.
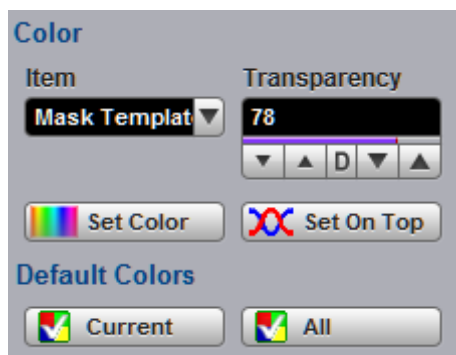
The Color menu

7.4.4.1   Item

Item allows you to choose from the list of display elements. You can modify the color of the channels, functions, display memories, spectra, histogram, graticule, or screen. The color of the selected display element can be changed with the **Set Color** button.

7.4.4.2   Set Color

Clicking the **Set Color** button recalls the Windows **Color** Dialog:

Windows Color Dialog

You can change the color of every item selected from the **Item** drop-down list box.

7.4.4.3   Set On Top

Click the **Set On Top** if you want to superimpose the display element selected from the **Item** list over all another display elements.
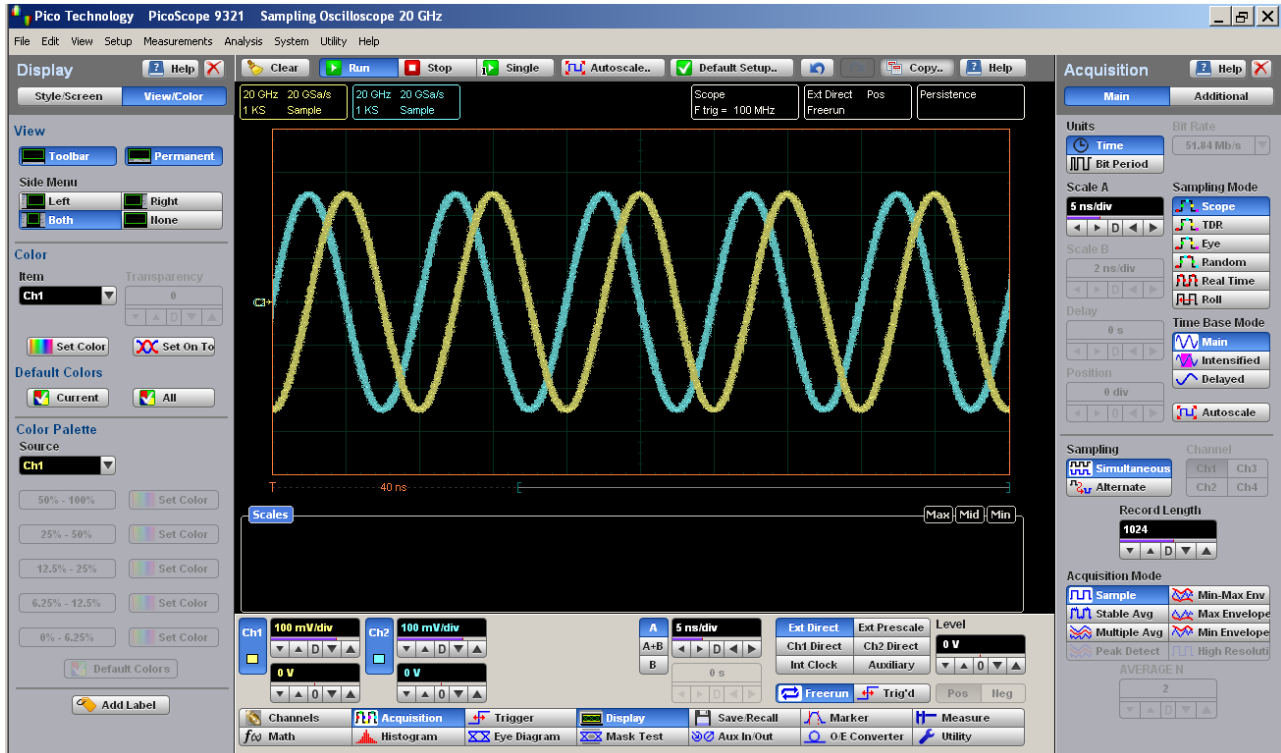
Channel 1 is superimposed on top
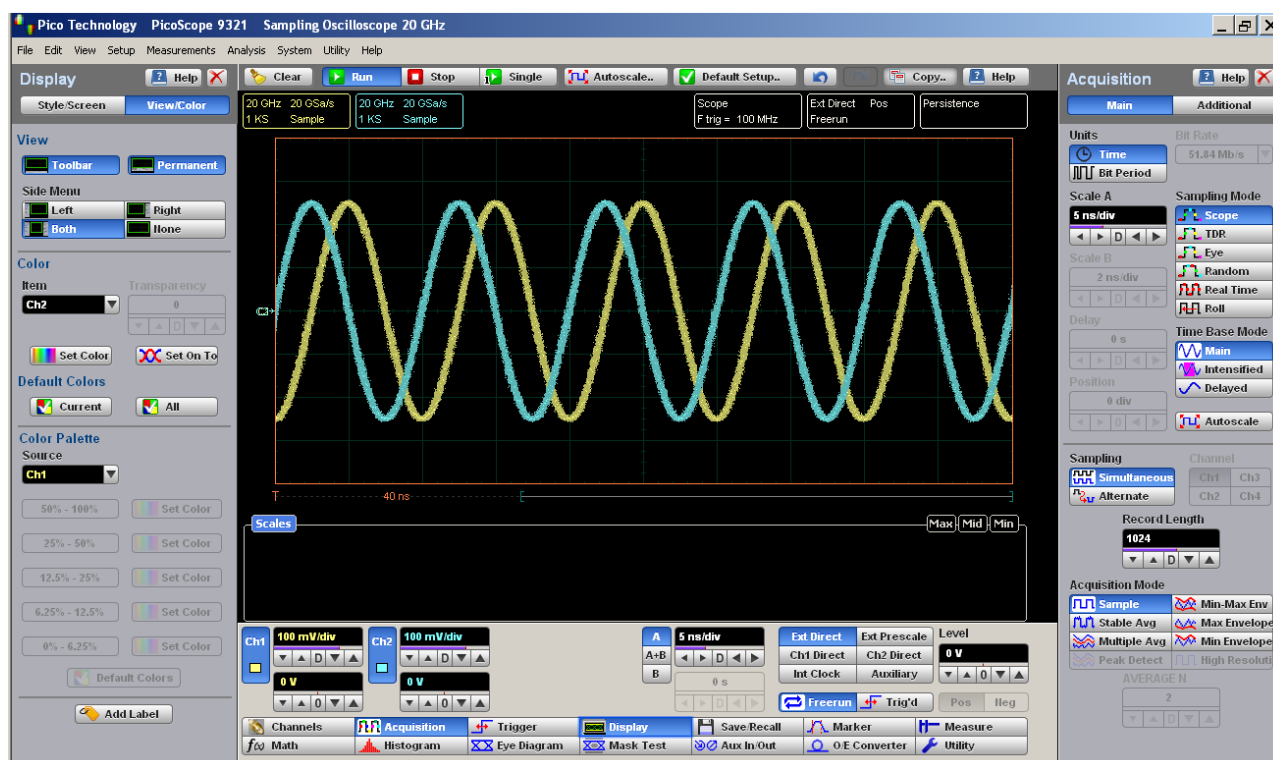
Channel 2 is superimposed on top

7.4.4.4   Transparency

You can change the transparency of several display elements selected from the **Item** menu. They are:

- **Histogram**
- **Mask**

ps9300.en-13   149

The **Transparency** control increases or decreases the transparency effect.
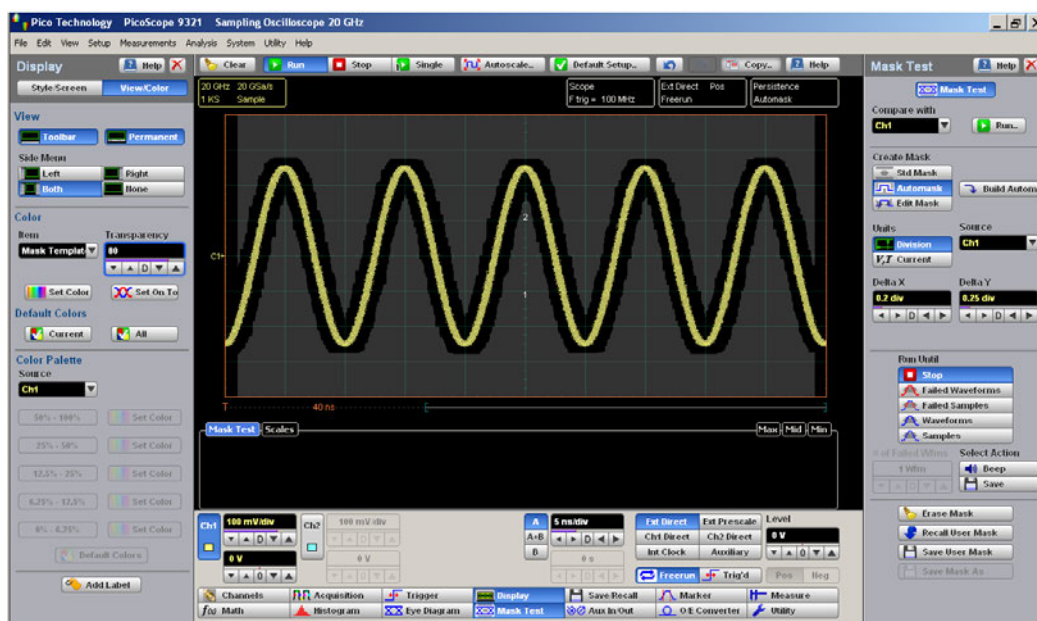
An Automask with 80% transparency
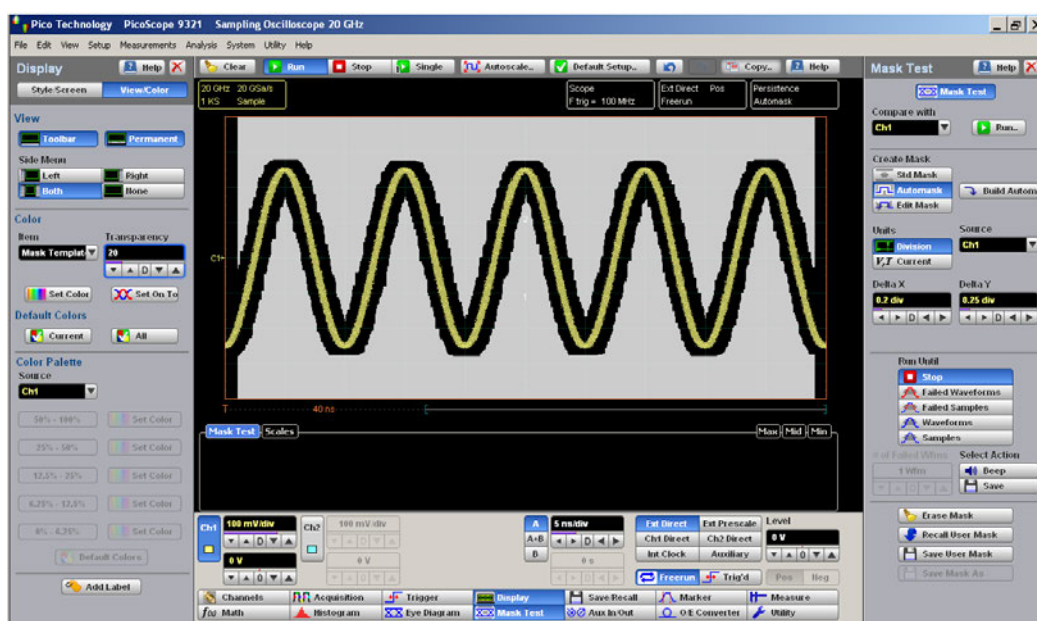
An Automask with 20% transparency

7.4.4.5   Current

Clicking the **Current** button returns the selected display element to the factory default color.

7.4.4.6   All

Clicking **All** returns all display elements to the factory default colors.

7.4.5   Color Palette

The **Color Palette** menu has a list of five colors used in the color grade display.
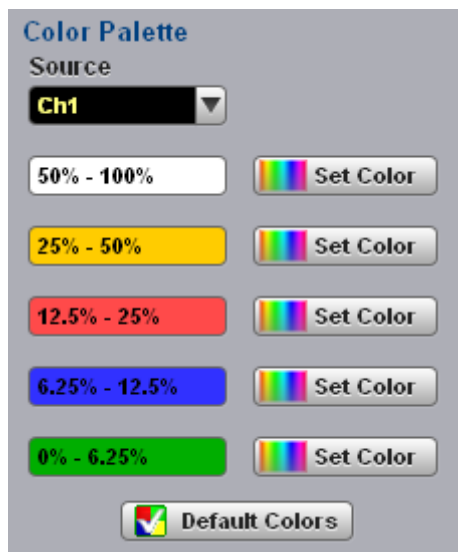
The Color Palette menu

7.4.5.1   Source

You may set the source for the color palette to any of the following:

- Channels
- Functions
- Waveform memories
- Spectra

7.4.5.2   Color Palette

The **Color Palette** menu defines the five colors used in the color grade display. The algorithm used in the PicoScope 9300 Series depends on the maximum number of hits for any pixel in the display. An example of the assignment of colors is shown in the table below. Maximum in the table represents the maximum number of hits in any bin, which for this algorithm must be at least 16.

A sample assignment of colors to hit density:

Hit density	Default color	Color
50% to 100%	White	50% - 100%
25% to 50%	Yellow	25% - 50%
12.5% to 25%	Rose	12.5% - 25%
6.25% to 12.5%	Light Blue	6.25% - 12.5%
0% to 6.25%	Green	0% - 6.25%

Click **Set Color** Set Color to recall the Windows **Color** Dialog:

Windows Color Dialog

7.4.5.3   Default Colors

 Default Colors

Clicking the **Default Colors** button returns all five colors used in the color-graded display to the factory default.

7.5   Eye Diagram menu

 Eye Diagram

The **Eye Diagram** menu allows you to perform eye diagram measurements.
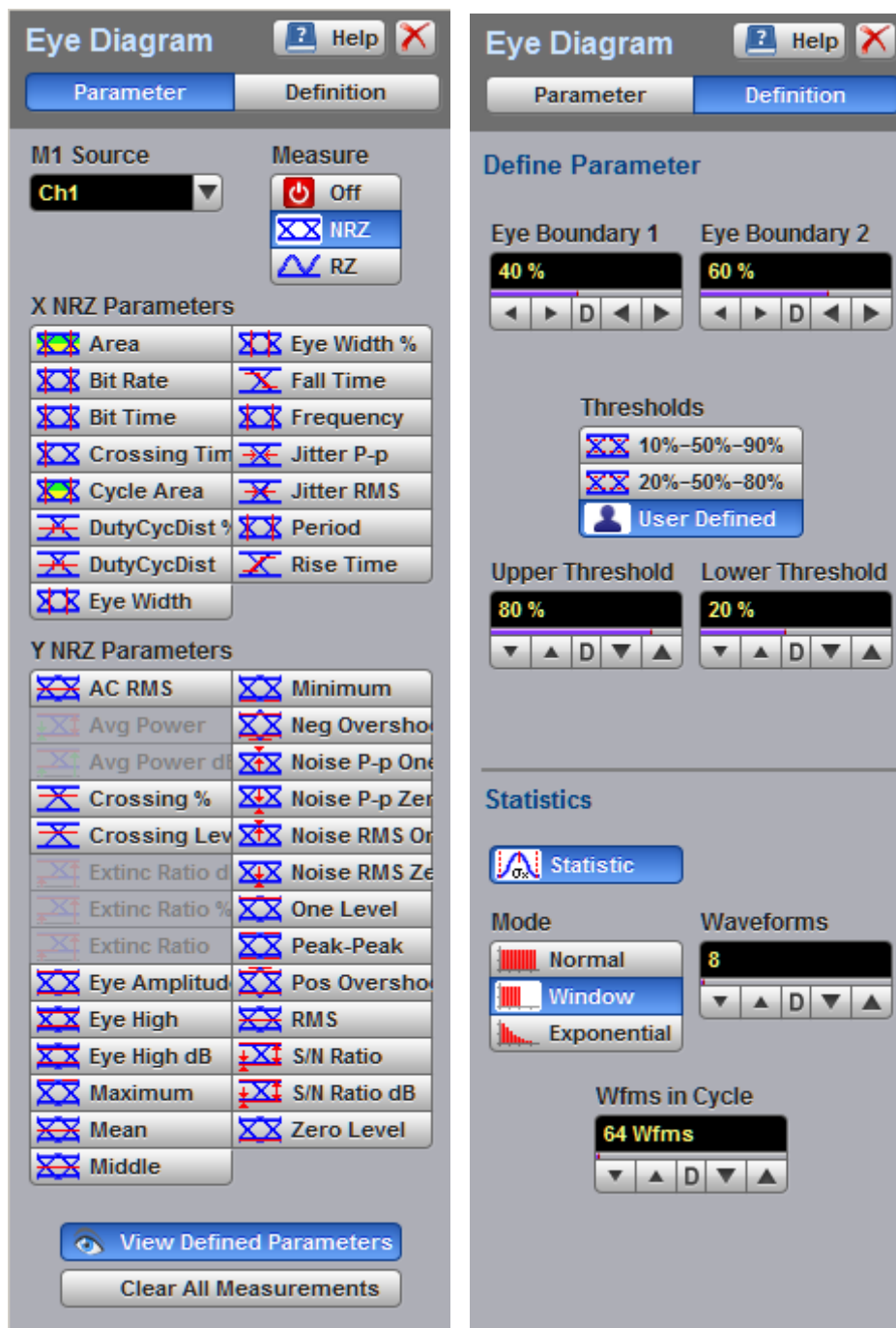
The Eye Diagram menu

> ℹ The measurement algorithms for **Eye Parameters** will only work when an eye diagram, and not a pulse, is present on the screen.

Eye measurements are based on statistical data that is acquired and stored in the measurement database. The algorithms are dependent upon histogram means calculated from the measurement database. Therefore, if you want to perform eye measurements, it is necessary that you first produce an eye diagram by triggering the instrument with a synchronous clock signal. Measurements made on a pulse waveform while in the **Eye Diagram** menu will fail.

Once the **Eye Diagram** measure menu has been selected, the measurement database is enabled. This database consists of all data samples displayed on the screen. The measurement database provides the data for the construction of histograms, generation of mask tests, and a visual representation of the eye via the color-graded display mode.

> ℹ️   Once you are in the **Eye Diagram** menu, perform an **Autoscale**. This will ensure that an optimum eye diagram is displayed on the graticule. An optimum eye diagram consists of a full display of the eye in addition to portions of the waveform preceding and following the eye.

Data is acquired, histograms are built, and absolute maximum and minimum voltage/power levels as well as relative maximum (one) and minimum (zero) voltage/power levels are determined. The crossing points of the eye are located, the threshold levels are calculated, and then, depending on the specific measurement(s) activated, the requested parametric measurements are calculated.

Eye measurements are made in a fashion similar to many of the automatic measurements built into the instruments such as **Rise** and **Fall Time**, **Peak-Peak**, and **Frequency**. Up to ten parametric measurements can be active whenever valid data exists. These measurements can include any of the eye measurements under the **X NRZ (RZ Eye) Parameters** and **Y NRZ (RZ Eye) Parameters** menus.

Eye measurements can be performed on a persistence or color-graded database.

7.5.1   Parameter
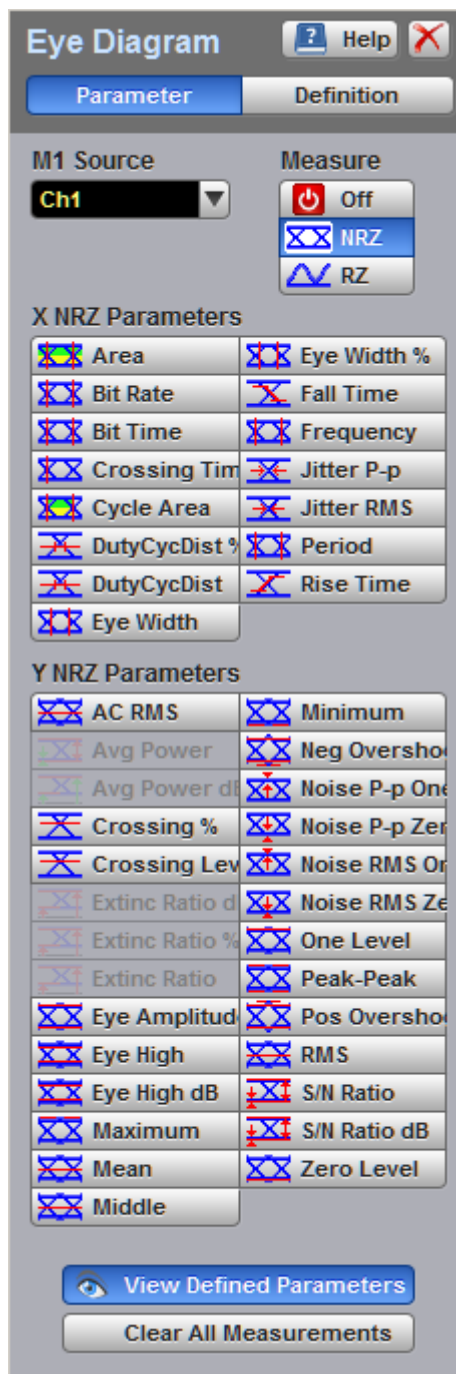
The Eye Diagram Parameter menu

7.5.1.1   Source
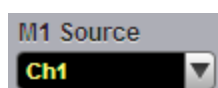
The **Source** control selects the source you are measuring. The measurement read-outs of parameters will have the same color as the selected source.

7.5.1.2   Measure

Off | NRZ
RZ | PAM4

Off

Clicking the **Off** radio button stops running the test. The Eye Window, which has a green color, disappears.

> ℹ The **Eye Boundaries** provide the time boundaries within which signal parameters for eye diagrams are measured.

NRZ

Clicking the **NRZ** radio button in the **Measure** menu starts the instrument calculating the **One Level**, **Zero Level**, **Left Crossing** and **Right Crossing** for NRZ types of signal. After the calculations are finished the **Eye Window**, which has a green color, will appear.

> ℹ **NRZ (Non-return to zero)**
>
> A type of signal coding that ensures, in any one bit period, that the signal is turned on for the entire duration of a logical one pulse and turned off (or nearly off) for the entire duration of a logical zero pulse.

NRZ

Clicking the **NRZ** radio button in the **Measure** menu starts the instrument calculating the **One Level**, **Zero Level**, **Left Crossing** and **Right Crossing** for NRZ types of signal. After the calculations are finished the **Eye Window**, which has a green color, will appear.
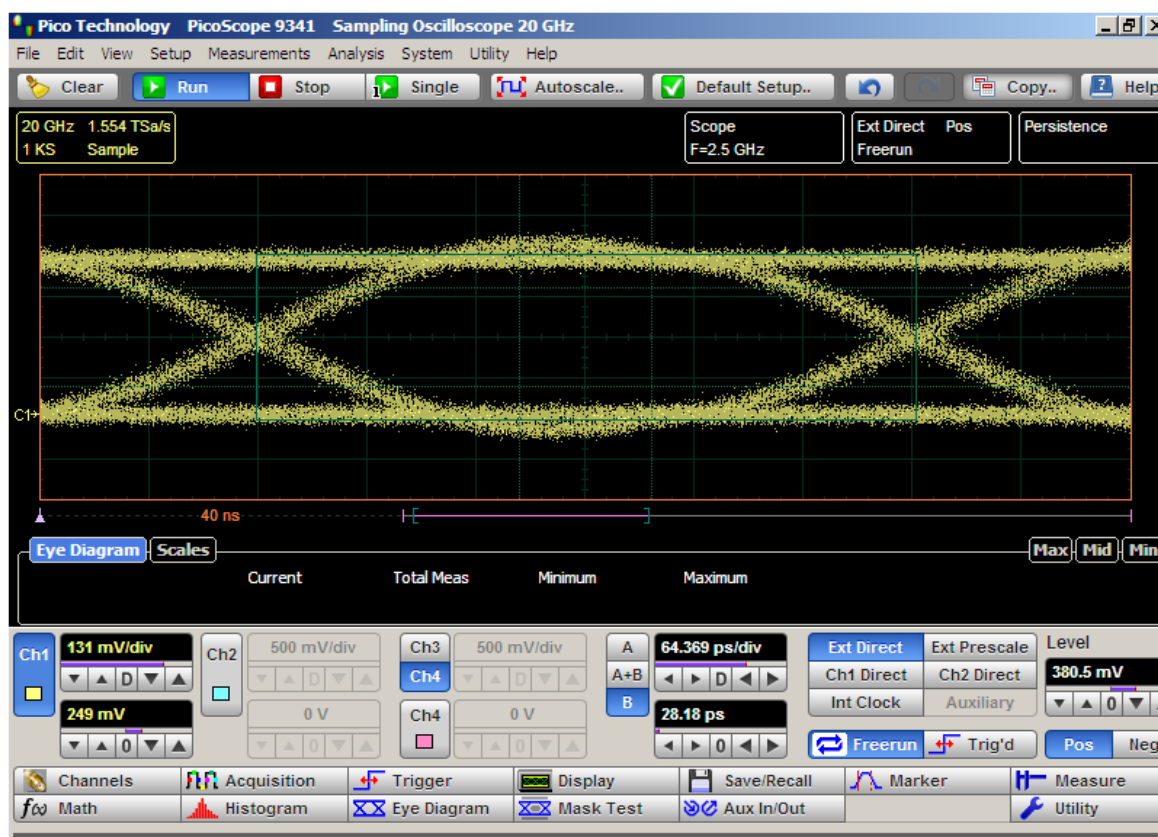
Levels, Crossings and Eye Boundaries of NRZ Eye Window

> ℹ️ **RZ (Return to zero)**
>
> A type of signal coding that ensures, in any one bit period, that the signal is turned on for the first half of a logical one pulse and turned off (or nearly off) for the second half of the logical one pulse. As with NRZ coding, the signal is turned off (or nearly off) for the entire duration of a logical zero pulse.
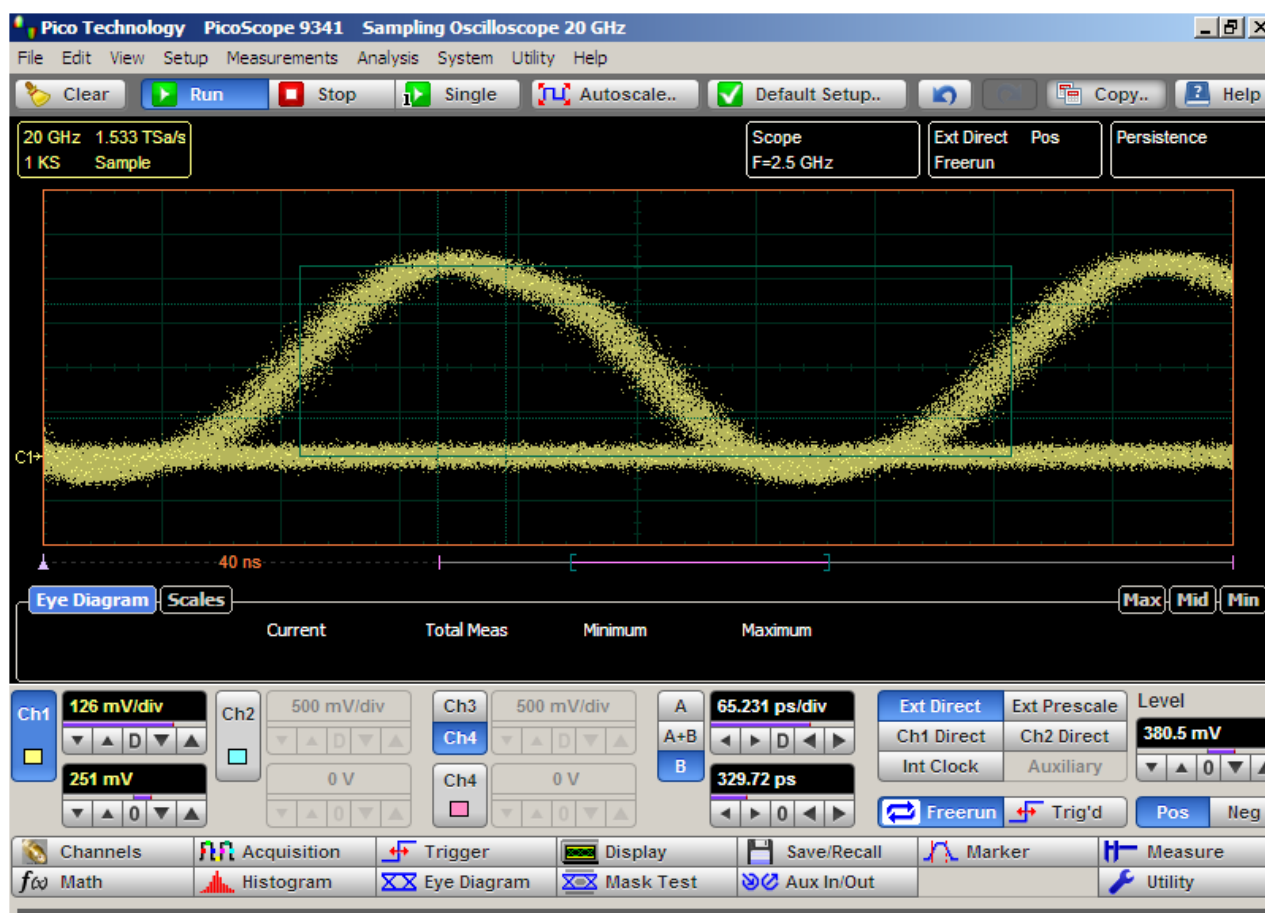
Levels, Crossings and Eye Boundaries of RZ Eye Window

PAM 4

Feature under development.

Measurements Results

The instrument displays the results of eye diagram measurements in the **Measurement Area** of the GUI. These values are displayed on tabs.

An example of the Eye Diagram Measure tab

The tabs only appear as the selected measurements are performed. For example, if you perform a **Bit Rate** measurement on channel 1, only this tab will appear on the display.

The measurement database and the graticule display will clear when you perform the following events:

- Switch between operating modes in the **Display** menu
- Change vertical and horizontal scale and position

● Click on the **Clear Display** button

The **Eye Diagram Measure tab** displays a maximum of ten measurements at one time. The measurements are listed in the order in which they were performed.

The **Measure tab** displays the following measurement statistics for each measurement:

● **Current**   The current value measured in the measurement database.
● **Total Meas**   The total number of acquired measurement cycles.
● **Minimum**   The minimum current value measured in the measurement database.
● **Maximum**   The maximum current value measured in the measurement database.

> ℹ The measurement statistics reported will vary depending on the mode of operation selected.

7.5.1.3   X NRZ Eye Parameters
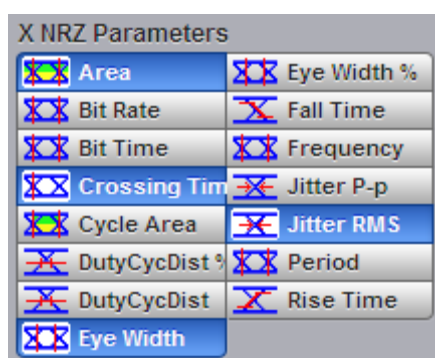
The list of **X NRZ Eye Parameters** includes fifteen eye parameters.

> ℹ You can perform up to ten simultaneous measurements on one displayed waveform.

The measurement algorithms for **X NRZ Eye Parameters** will only work when an NRZ eye diagram, and not an RZ eye diagram or a pulse, is present on the screen. Eye measurements are based on statistical data that is acquired and stored in the measurement database. The algorithms are dependent upon histogram means calculated from the measurement database. Therefore, if you want to perform eye measurements, it is necessary that you first produce an eye diagram by triggering the instrument with a synchronous clock signal. Measurements made on an RZ eye diagram or a pulse waveform while in the **X NRZ Eye Parameters** menu will fail.

7.5.1.3.1   NRZ Area

XOX Area
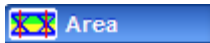
The **NRZ Area** is a measure of the area under the curve for the NRZ waveform within the full display window. The area measured above ground is positive; the area measured below ground is negative.

The **NRZ Area** is determined as follows:

$$NRZ\_Area = \frac{\Delta t}{N} \sum_{n=1}^{N} VertPos(s_n)$$

over all N samples $s_{1...N}$ in the measured region (full display window) of duration $\ddot{A}t.$

This measurement requires the use of a waveform database. When this measurement is turned on, it will automatically set the measurement system to use a waveform database if available.

7.5.1.3.2   NRZ Bit Rate

XOX Bit Rate

NRZ Bit Rate is the inverse of bit time (1/bit time). The bit time is a measure of the horizontal opening of an eye diagram at the crossing points of the eye.

To compute bit time (bit period), the crossing points of the eye are first located. Then a vertically thin measurement window is placed horizontally through the crossing points. The data within this measurement window is analyzed. This measurement window is created to be extremely small so that the width of the crossing points is not affected by the rise time and fall time of the waveform.

Once the bit period has been determined, the inverse value is calculated to determine the bit rate.

NRZ Bit Rate = 1 / NRZ Bit Time

Also see **NRZ Bit Time**.

7.5.1.3.3   NRZ Bit Time

NRZ Bit Time is a measure of the horizontal opening of an eye diagram at the crossing points of the eye.
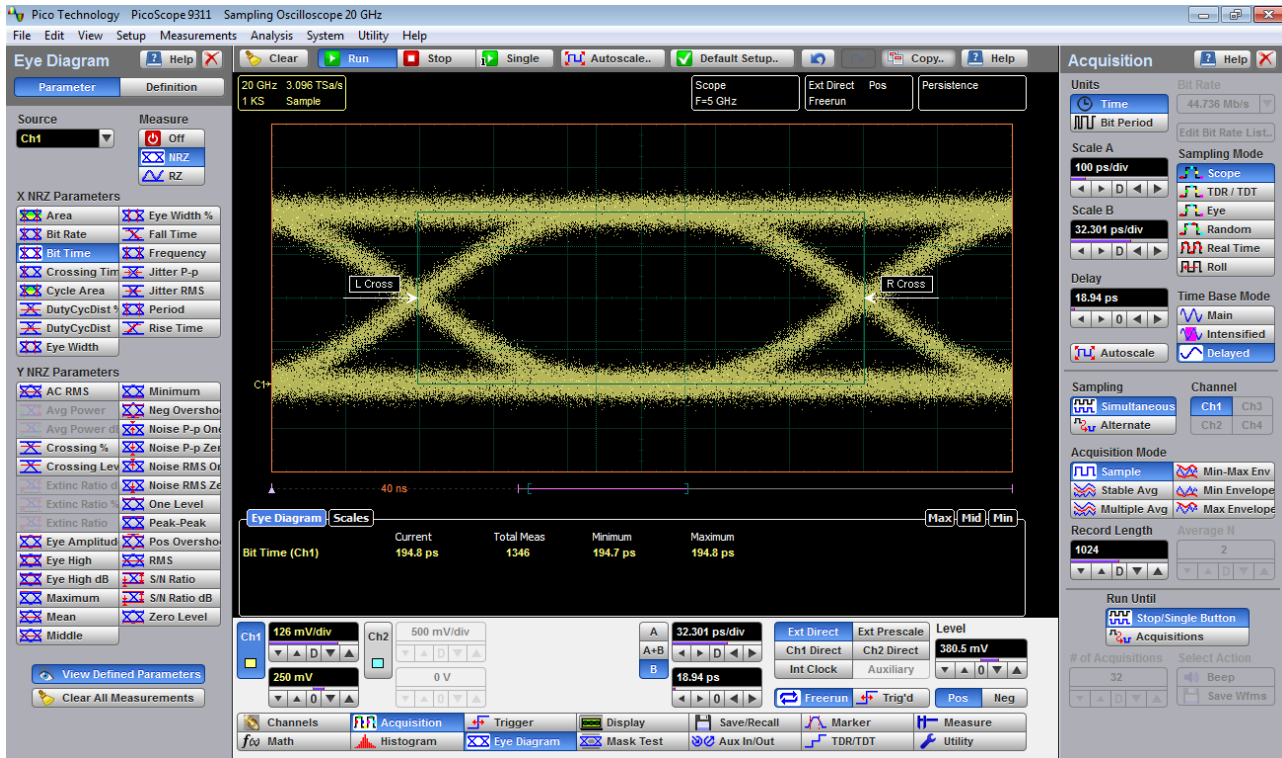
NRZ Bit Time definition

NRZ Bit Time can be determined as:

$$NRZ\ Bit\ Time = Tcross2 - Tcross1$$

where *Tcross2* and *Tcross1* are the means of the histogram of the two consecutive eye crossings (**Right Crossing** and **Left Crossing**).

This measurement requires the use of a waveform database. When this measurement is turned on, it will automatically set the measurement system to use a waveform database if available.

7.5.1.3.4   NRZ Crossing Time
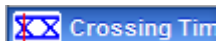
NRZ Crossing Time is a measure of the horizontal position of the leftmost eye crossing.

Data is sampled on a horizontal slice at the eye crossing, and the mean of the horizontal histogram returns the crossing time.

NRZ Crossing Time can be determined as:

$$NRZ\ Crossing\ Time = Tcross1 + Tdelay$$

This measurement requires the use of a waveform database. When this measurement is turned on, it will automatically set the measurement system to use a waveform database if available.

7.5.1.3.5 NRZ Cycle Area

NRZ Cycle Area is a measure of the area under the curve for the first NRZ bit time within the measurement region. Area measured above ground is positive; area measured below ground is negative.

The **NRZ Cycle Area** is determined as follows:

$$NRZ\_CycleArea = \frac{\Delta t}{N} \sum_{n=1}^{N} VertPos(s_n)$$

over all *N* samples $S_{1...N}$ within the measured region (eye window) of duration *Ät* between **Left Crossings** and **Right Crossings**. Neither slope nor direction is configurable.

This measurement requires the use of a waveform database. When this measurement is turned on, it will automatically set the measurement system to use a waveform database if available.

7.5.1.3.6   NRZ Duty Cycle Distortion % and NRZ Duty Cycle Distortion s
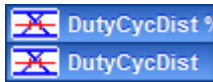
NRZ Duty Cycle Distortion is a measure of the time between the falling edge and the rising edge of the eye pattern at the middle threshold (50% level).
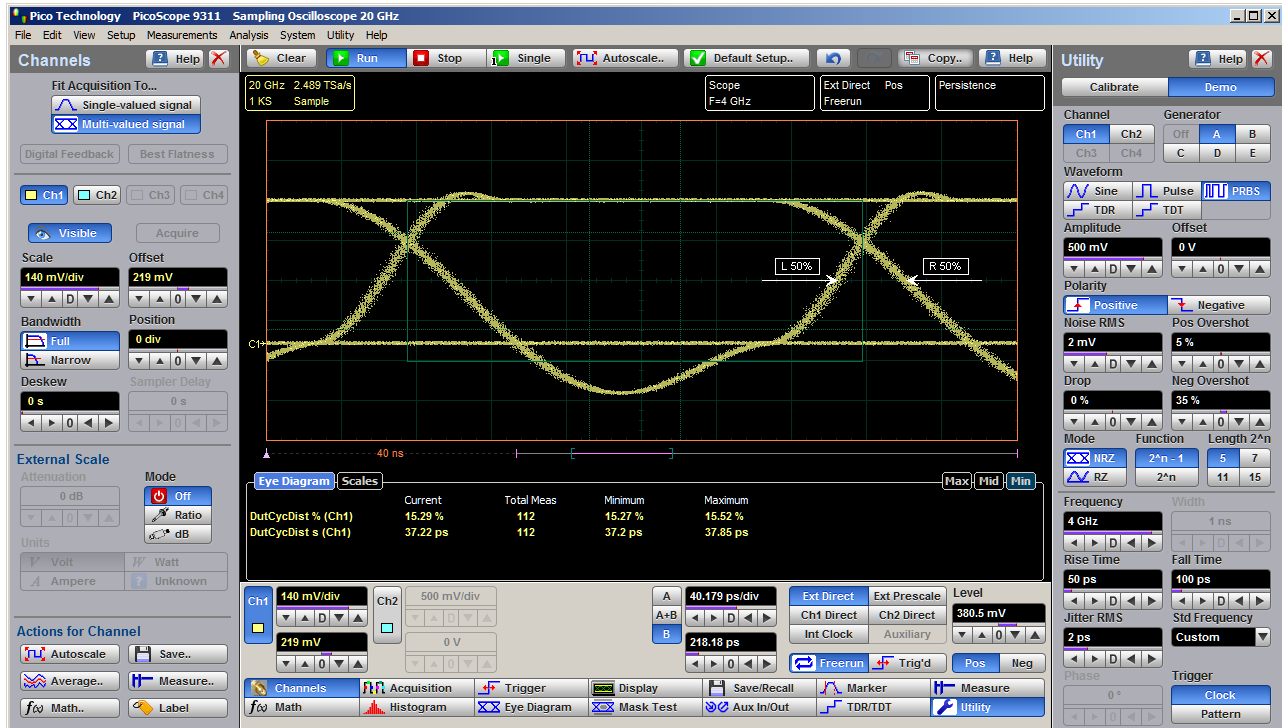
Measurement of Duty Cycle Distortion. NRZ eye diagram has significant distortion

The instrument constructs a histogram that records the time at which the rising edge and falling edge cross the middle threshold. If the falling edge and the rising edge intersect precisely at the middle thresholds, there is no duty cycle distortion. **NRZ Duty Cycle Distortion** is measured by histogram analysis at the crossing points and middle threshold.

> ℹ️ The algorithm for calculating **NRZ Duty Cycle Distortion** is dependent upon the edge that crosses the threshold first. Therefore, the falling edge may occur prior to the rising edge. Ideally, both the rising and falling edges intersect precisely at the 50% threshold level. That results in no duty cycle distortion.

NRZ Duty Cycle Distortion can be displayed in two formats: time or percent. In the time format (**DutCycDis s**), the actual time between the median falling edge and the median rising edge at the middle thresholds is determined. In the percentage format (**DutCycDis %**), the time difference is determined as a percentage of the full bit time.

The **NRZ Duty Cycle Distortion** is determined as follows:

$$NRZ\_DutyCycleDistortion = Trise_{50\,percent} - Tfall_{50\,percent}$$

$$NRZ\_DutyCycleDistortion = \frac{Trise_{50\,percent} - Tfall_{50\,percent}}{BitPeriod}$$

7.5.1.3.7 NRZ Eye Width and NRZ Eye Width %

NRZ Eye Width is a measure of the horizontal opening of an eye diagram. Ideally, the eye width would be measured between the crossing points of the eye. A horizontal time histogram is constructed to determine the mean location at the crossing points, as well as statistical distribution of the crossing points. As would be expected, noise and jitter will cause a large variance in the location of the crossing points and result in the closure of the eye.
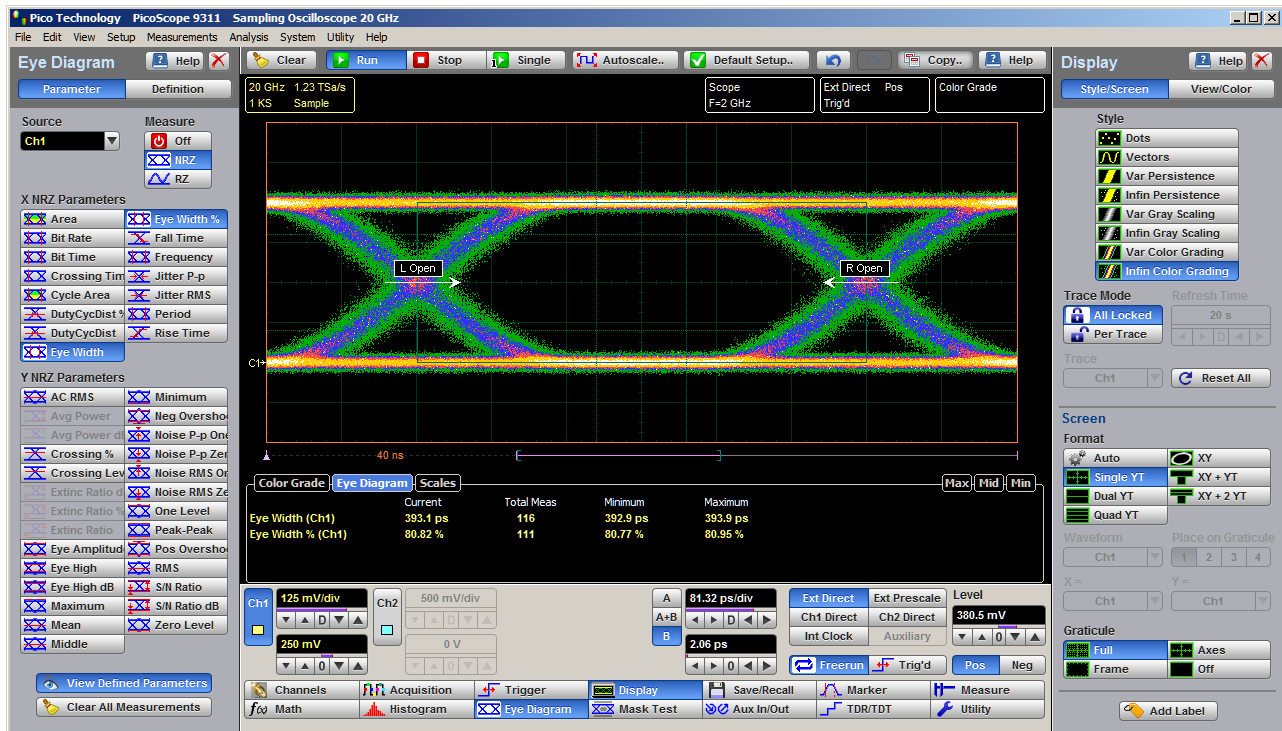
NRZ Eye Width definition

The eye width is determined using the time difference between the 3σ (standard deviation) points of the crossing point histograms (**Eye Width** measurement).

$$NRZ\_EyeWidth = (T_{cross2} - 3\sigma_{cross2}) - (T_{cross1} - 3\sigma_{cross1})$$

You can choose to view eye width as a ratio of the time difference between the 3σ points of the crossing point histograms relative to the time between adjacent crossing points (bit period). The eye width can then be expressed in percent of the bit period (**Eye Width %** measurement).

$$NRZ\_EyeWidth\_\% = \frac{(T_{cross2} - 3\sigma_{cross2}) - (T_{cross1} - 3\sigma_{cross1})}{T_{cross2} - T_{cross1}}$$

7.5.1.3.8   NRZ Fall Time
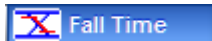
![Fall Time icon]

NRZ Fall Time is a measure of the mean transition time of the data on the downward slope of an eye diagram. The data crosses through the following three thresholds: the upper, middle, and lower thresholds, as well as through the eye crossing points.
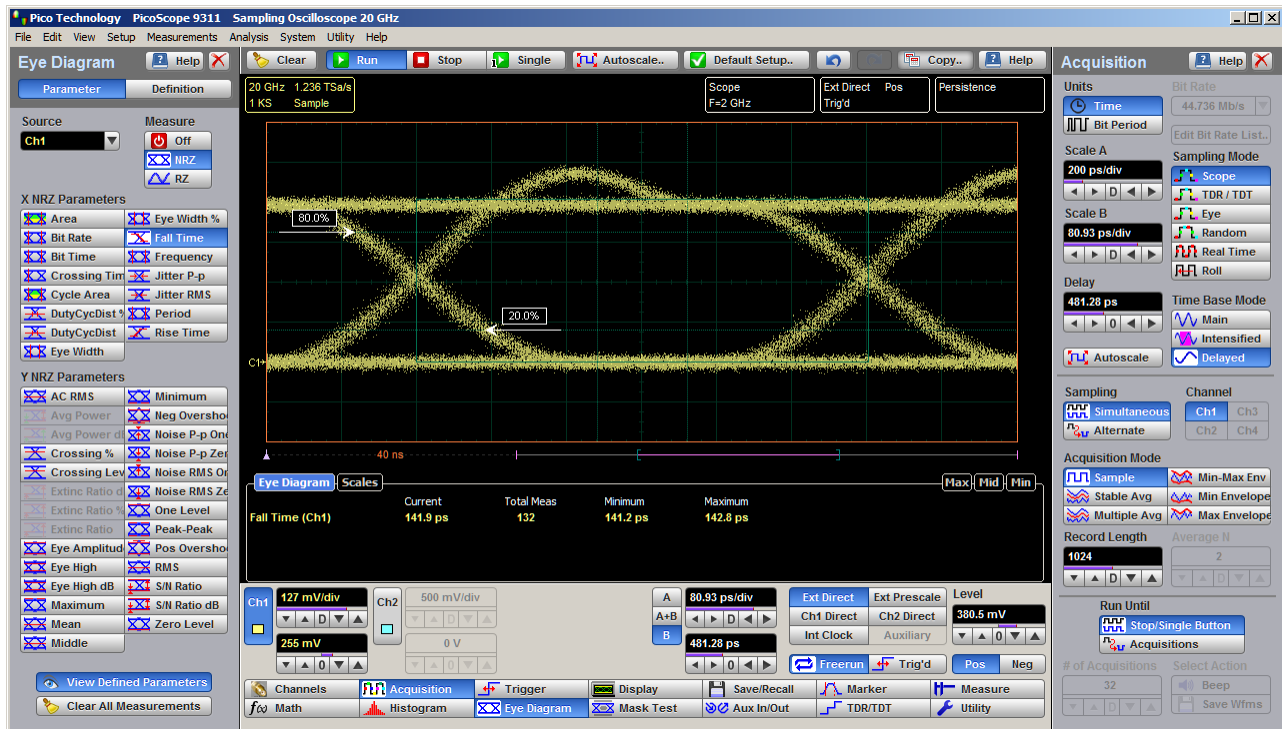
NRZ Fall Time definition

A histogram is first constructed to find the mean location of the crossing points relative to the one level and zero level. Histograms are then constructed at each of the three threshold levels (for example, the 10%, 50%, and 90% points on the transition). The instrument analyzes each histogram to determine the histogram mean at which the data crosses the separate threshold levels.

Once the scanning of the waveform is complete, and the instrument has identified the mean location for each threshold crossed, then fall time can be computed.

NRZ Fall Time
= (Time at the Lower Threshold Crossing) − (Time at the Upper Threshold Crossing)

The instrument has two standard threshold levels for which fall time may be measured. The default setting is between the 20% and 80% points on the transition, and the second is between the 10% and 90% points on the transition. The 20% to 80% transition is recommended for devices with significant pulse distortion. Also, user defined threshold levels can be selected. You can define the threshold settings that you want by going to the **Define Parameters/Thresholds** menu.

> ℹ️ If the fall time relative to the time per division is a small value, the data acquired at the threshold levels on the falling edge will not yield accurate measurement results. (The falling edge will appear very steep on the display screen).
>
> If the falling edge of your eye diagram is steep, increase the timebase (horizontal scale) on the display so that the falling edge covers at least half a graticule division. The instrument will be able to discern the data at the threshold levels, producing more accurate results.

7.5.1.3.9   NRZ Frequency
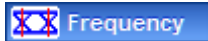
XX Frequency

NRZ Frequency is defined as half of the inverse of the time interval between two consecutive eye crossing points (i.e. the reciprocal of the **Period**). It would be the frequency of a digital signal of a 0-1-0-1... stream.

The **NRZ Frequency** is determined as follows:

$$NRZ\_Frequency = \frac{1}{2(T_{cross2} - T_{cross1})}$$

where *Tcross1* and *Tcross2* are the means of the histograms of the two crossings.

This measurement requires the use of a waveform database. When this measurement is turned on, it will automatically set the measurement system to use a waveform database if available.

7.5.1.3.10 NRZ Jitter P-p and NRZ Jitter RMS

NRZ Jitter is a measurement of the time variance of the crossing points. Horizontal time histograms are constructed to determine the location of the crossing points. An iterative process is used to narrow the histogram window to precisely determine the crossing points and the variance. The measurement window is kept extremely small so that the width of the crossing points is not influenced by the rise time and fall time of the waveform. The amount of jitter on the waveform is directly related to the width of the crossing points.
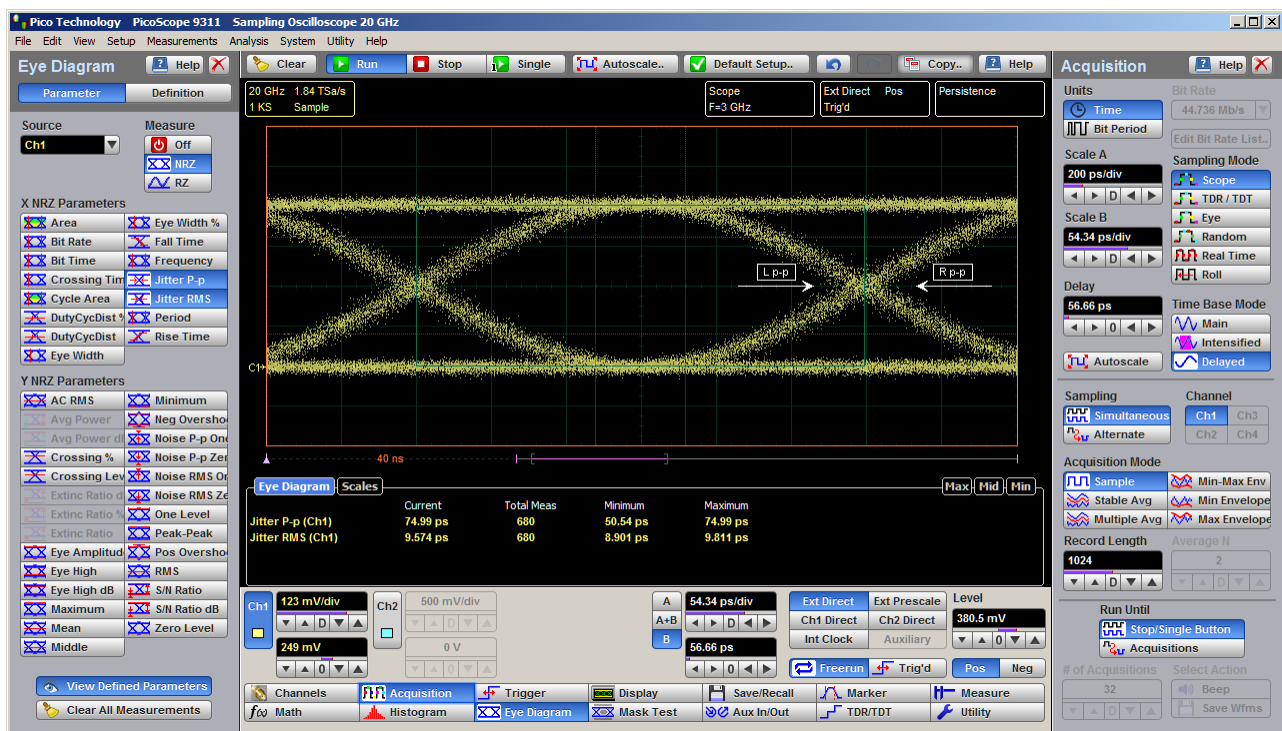
NRZ Jitter definition

NRZ Jitter can be displayed in one of two formats: peak-to-peak (**NRZ Jitter P-p** measurement) or RMS (**NRZ Jitter RMS** measurement). Both values are based on the standard deviation of the crossing point position.

NRZ Jitter peak-to peak is equal to the full width of the histogram at the eye crossing point:

$$NRZ\ Jitter\ P\text{-}p = 6\sigma\ (crossing)$$

NRZ Jitter RMS is defined as one standard deviation from the histogram mean at the eye crossing point:

$$NRZ\ Jitter\ RMS = 1\sigma\ (crossing)$$

7.5.1.3.11 NRZ Period
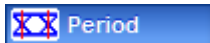
Period

NRZ Period is twice the time interval between two consecutive eye-crossing points. It would be the period of a digital signal of a 0-1-0-1... stream.

NRZ Period can be defined as:

$$NRZ\ Period = 2(Tcross2 - Tcross1) = 2(NRZ\_BitTime)$$

where *Tcross1* and *Tcross2* are the means of the histograms of the two crossings of the eye diagram (**Right Crossing** and **Left Crossing**).

This measurement requires the use of a waveform database. When this measurement is turned on, it will automatically set the measurement system to use a waveform database if available.

Also see **NRZ Bit Time**.

7.5.1.3.12 NRZ Rise Time
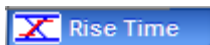
NRZ Rise Time is a measure of the mean transition time of the data on the upward slope of an eye diagram. The data crosses the lower, middle, and upper thresholds, as well as the eye crossing points.
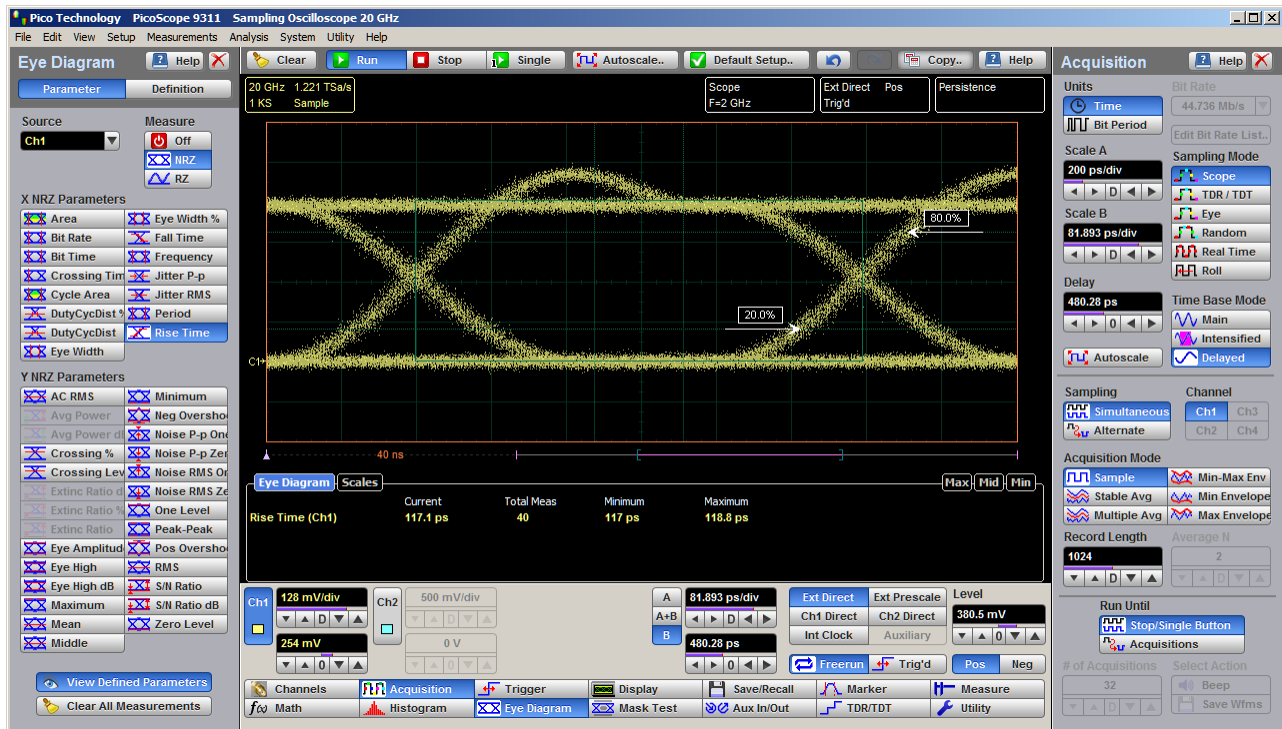
NRZ Rise Time definition

A histogram is first constructed to find the mean location of the crossing points relative to the one level and zero level. Histograms are then constructed at each of the three threshold levels (for example, the 10%, 50%, and 90% points on the transition). The instrument analyzes each histogram to determine the histogram mean at which the data crosses the separate threshold levels.

Once the scanning of the waveform is complete, and the instrument has identified the mean location for each threshold crossed, then rise time can be computed.

NRZ Rise Time = (Time at the Upper Threshold Crossing) – (Time at the Lower Threshold Crossing)

The instrument has two standard threshold levels for which fall time may be measured. The default setting is from the 10% to the 90% point on the transition, and the second is from the 20% to the 80% point on the transition. The 20% to 80% transition is recommended for devices with significant pulse distortion. Also, user defined threshold levels can be selected. You can define the threshold settings that you want by going to the **Define Parameters/Thresholds** menus.

ⓘ If the rise time relative to the time per division is a small value, the data acquired at the threshold levels on the falling edge will not yield accurate measurement results. (The rising edge will appear very steep on the display screen).

If the rising edge of your eye diagram is steep, increase the timebase (horizontal scale) on the display so that the rising edge covers at least half a graticule division. The instrument will be able to discern the data at the threshold levels, producing more accurate results.

7.5.1.4   Y NRZ Eye Parameters
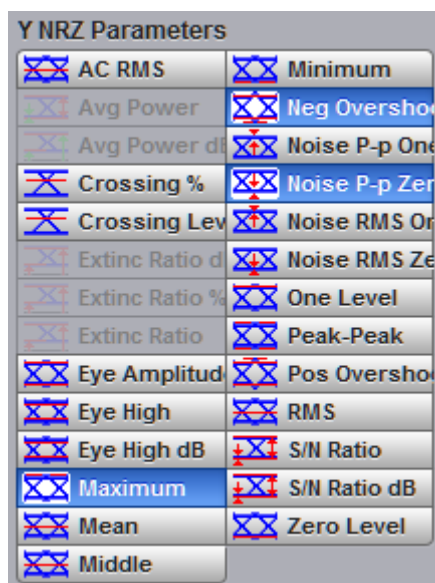
The list of **Y NRZ Eye Parameters** includes twenty-seven eye parameters. Two of the them (**Avg Power** and **Avg Power dBm**) can be used in optical models only.

> ℹ You can perform up to ten simultaneous measurements on one displayed waveform.

The measurement algorithms for **Y NRZ Eye Parameters** will only work when an NRZ eye diagram, and not an RZ eye diagram or a pulse, is present on the screen. Eye measurements are based on statistical data that is acquired and stored in the measurement database. The algorithms are dependent upon histogram means calculated from the measurement database. Therefore, if you want to perform eye measurements, it is necessary that you first produce an eye diagram by triggering the instrument with a synchronous clock signal. Measurements made on an RZ eye diagram or a pulse waveform while in the **X NRZ Eye Parameters** menu will fail.

7.5.1.4.1   NRZ AC RMS
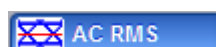
NRZ AC RMS is a measure of the root mean square amplitude, minus the DC component, of the selected waveform.

The **NRZ AC RMS** is defined as follows:

$$NRZ\_AC\_RMS = \sqrt{\frac{\sum_{i=1}^{N}\left\{[VertPos(s_n) - mean[VertPos(s)]\right\}^2}{N}}$$

where s is the set of N samples $s_{1...N}$ within the measured region.

When this measurement is turned on, it will automatically set the measurement system to use a waveform database if available.

7.5.1.4.2 NRZ Crossing % and NRZ Crossing Level
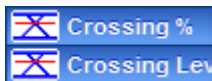
NRZ Crossing percentage is a measure of the location of the eye crossing points relative to the separation between the **One Level** (*Vone*) and the **Zero Level** (*Vzero*).

Typically, it is desirable to have the crossing points located midway between *Vone* and *Vzero*. In this case the crossing percentage would be 50% according to the following formula:

NRZ Crossing percentage = 100 (Vcross – Vzero) / (Vone – Vzero)

NRZ Crossing Level is the mean signal level at the eye crossing point:

NRZ Crossing Level = mean[VertPos(s)]

where *s* is the set of samples in a vertical slice at the eye crossing point.

Vcross is the more prevalent vertical location or amplitude of the crossing points. A horizontal histogram over the entire display is used to determine the time location of the crossing points. Narrow vertical histograms are then used to determine the vertical location of *Vcross*. The mean derived from the horizontal and vertical histogram results in *Vcross*.
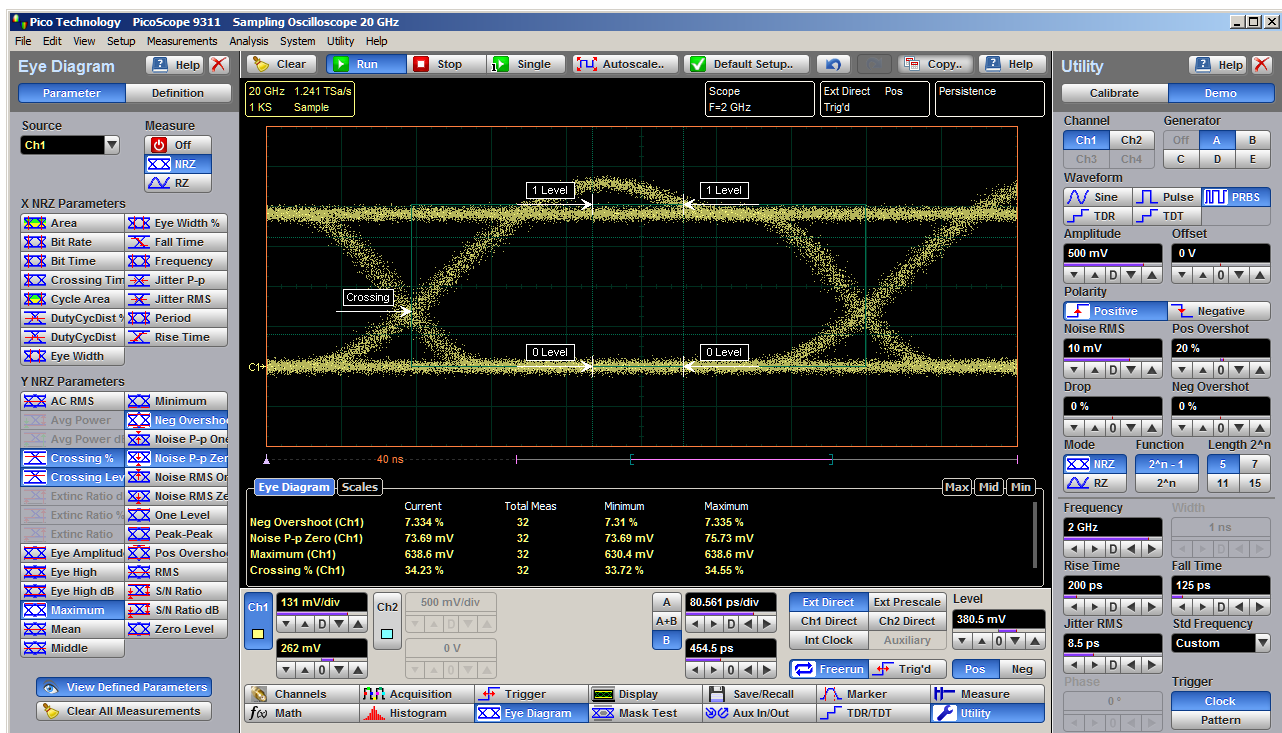
Example of eye diagram with low Crossing Level value

> ℹ️ *Vone* and *Vzero* are calculated from a histogram using data within the eye window. These measurements are made in the center of the bit period (within the **Eye Boundaries**). The default value is 20% of the NRZ bit time.

7.5.1.4.3   NRZ Extinction Ratio dB, NRZ Extinction Ratio % and NRZ Extinction Ratio

NRZ Extinction Ratio for an eye diagram is simply the ratio of the logic "high" level (*Vone* or *Pone*) to the logic "low" level (*Vzero* or *Pzero*). A very high extinction ratio typically implies that the logic low level is very small. In the case of an optical transmitter, the logic low level would approach a condition where the laser is nearly turned off.

$$NRZ\_ExtinctionRatio = \frac{Vone - Vdark}{Vzero - Vdark}$$

NRZ Extinction Ratio definition

The accuracy of the extinction ratio can be dominated by the accuracy with which the low level was measured. This in turn can be significantly affected by any noise generated by the measurement system such as external converters, DC offsets, or electrical offsets in the instrument electronics. When these offsets occur, they add to the incoming signal. This will change the values of the one and zero levels. When the extinction ratio measurement is computed, the result may appear much smaller or larger than the true value, depending on the value of the offset.

To minimize extinction ratio measurement errors due to offsets, an extinction ratio calibration is recommended. This procedure allows the instrument to identify any internal signals present and remove them during the extinction ratio calculations. After the calibration is performed, a more accurate extinction ratio measurement can be executed.

Thus the extinction ratio measurements can be defined in one of the three following formats:

$$NRZ\_ExtinctionRatio(dB) = 10\log_{10}\left(\frac{Vone - Vdark}{Vzero - Vdark}\right)$$

$$NRZ\_ExtinctionRatio(\%) = \frac{Vone - Vdark}{Vzero - Vdark} \times 100$$

$$NRZ\_ExtinctionRatio = \frac{Vone - Vdark}{Vzero - Vdark}$$

Vone (or *Pone*) and *Vzero* (*Pzero*) are determined from vertical histograms of the eye window. The histogram is typically bimodal, and *Vone* and *Vzero* correspond to the two means of the histogram. Histograms are constructed using the sampled portions of the eye diagram within the central 20% of the bit period (between the **Eye Boundaries**). One histogram is composed of data points from only the upper half of the eye diagram (one level). The second histogram is composed of data points from the lower half of the eye (zero level). The instrument analyzes the histograms and determines the histogram means.

> The vertical scale setting affects the magnitude of the offset.
>
> For best accuracy, perform the extinction ratio calibration at the vertical scale at which you will make your measurement. You can then adjust the vertical scale between and up to the next closest scale value in the 1-2-5 sequence. For example, if you set the vertical scale to 50 mV and then performed an extinction ratio calibration, you can adjust the scale between and up to 20 mV and 100 mV. If you exceed those upper and lower values, the instrument will recommend that you perform another extinction ratio calibration at the new value. This recommendation is to ensure best measurement accuracy. You will still get valid measurement results without a new extinction ratio calibration, but with potentially lower precision.

Since the extinction ratio measurement is based on the histogram means of the one and zero levels, noise on the waveform typically does not have a significant effect on the accuracy of the measurement.
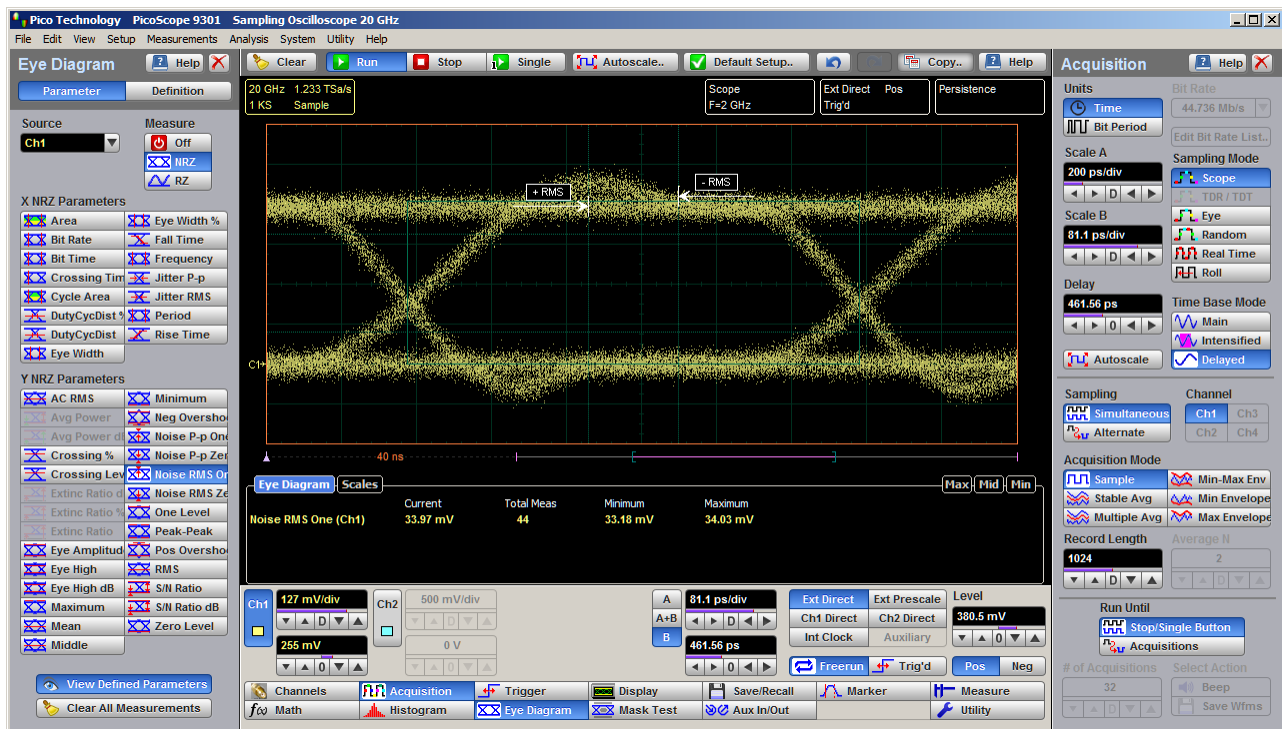
> *Vone* and *Vzero* are calculated from a histogram using data within the eye window. These measurements are made in the center of the bit period (within the **Eye Boundaries**). The default value is 20% of the NRZ bit time.

7.5.1.4.4   NRZ Eye Amplitude
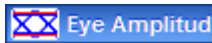
![Eye Amplitud icon]

NRZ Eye Amplitude is the difference between the logic 1 level and the logic 0 level histogram mean values of an eye diagram.
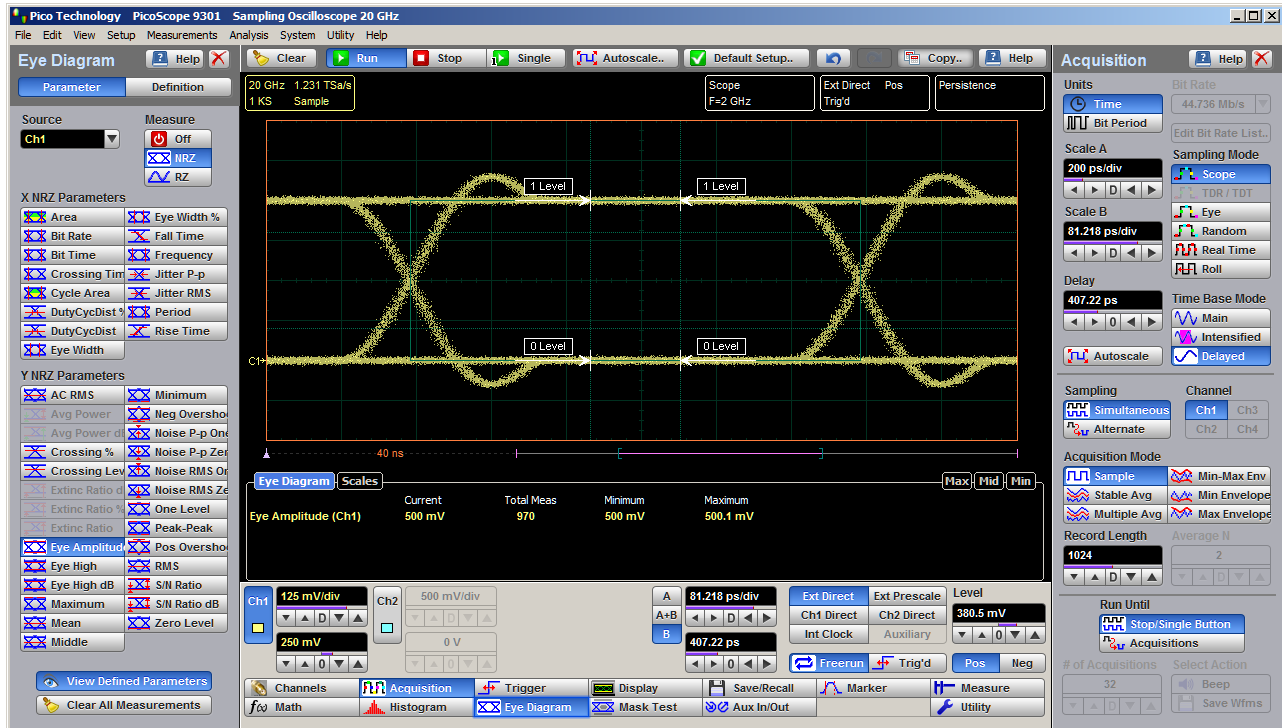
NRZ Eye Amplitude definition

> **ℹ** *Vone* and *Vzero* are calculated from a histogram using data within the eye window. These measurements are made in the center of the bit period (within the **Eye Boundaries**). The default value is 20% of the NRZ bit time.

A histogram is constructed using the sampled portion of the eye diagram within the eye window. This histogram is composed of data points from the upper and lower halves of the eye diagram. The instrument analyzes the histogram and determines the mean values of the logic 1 and logic 0 levels.

The eye amplitude is determined as follows:

NRZ Eye Amplitude = One Level – Zero Level

7.5.1.4.5 NRZ Eye Height and NRZ Eye Height dB
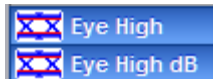
NRZ Eye Height is a measurement of the vertical opening of an eye diagram. An ideal eye opening would be measured from the one level to the zero level. However, noise on the eye will cause the eye to close. The eye height measurement determines eye closure due to noise.
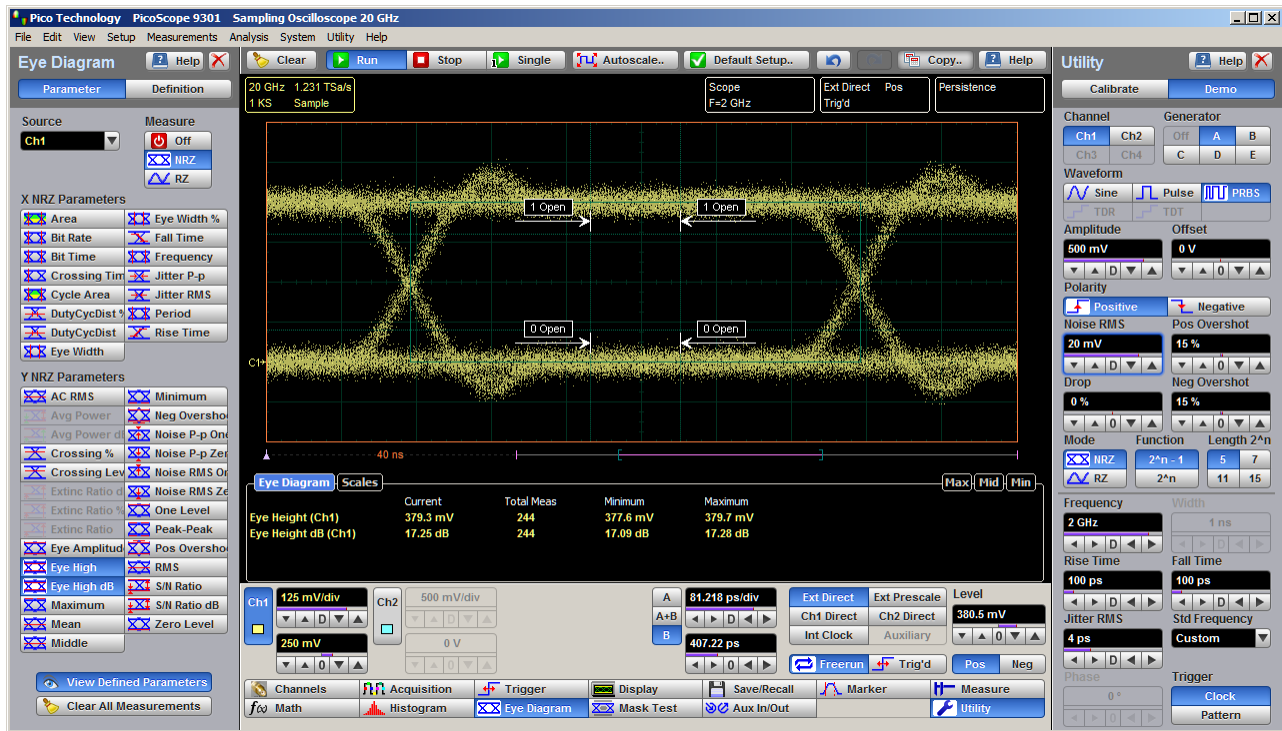
NRZ Eye Height definition

Similarly to the extinction ratio measurements, a vertical histogram is calculated on the data. *Vone* and the high-level distribution are determined, and similar patterns are determined for the low levels. The *Vone* and *Vzero* levels are the relative means of the histograms. The noise is measured through the histograms as three standard deviations ($\acute{o}$) from both the one level and zero level into the eye opening.

The eye height can be defined in one of the two following formats:

$$NRZ\_EyeHeight = (V_{one} - 3\sigma_{one}) - (V_{zero} + 3\sigma_{zero})$$

$$NRZ\_EyeHeight(dB) = -10\log_{10}\frac{(V_{zero} + 3\sigma_{zero})}{(V_{one} - 3\sigma_{one})}$$
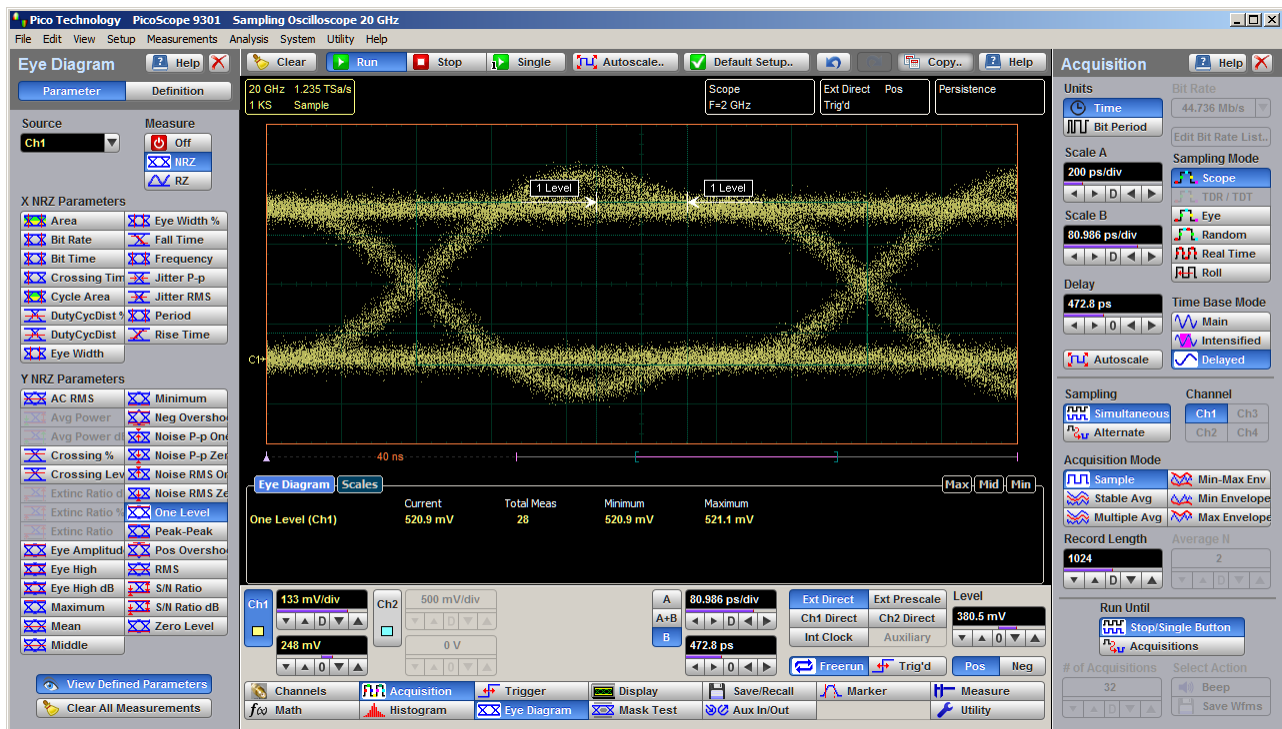
> ℹ️ *Vone* and *Vzero* are calculated from a histogram using data within the eye window. These measurements are made in the center of the bit period (within the **Eye Boundaries**). The default value is 20% of the NRZ bit time.

7.5.1.4.6   NRZ Maximum
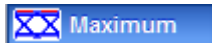
Maximum

NRZ Maximum is a measure of the maximum vertical value of the waveform that is sampled within the eye window.
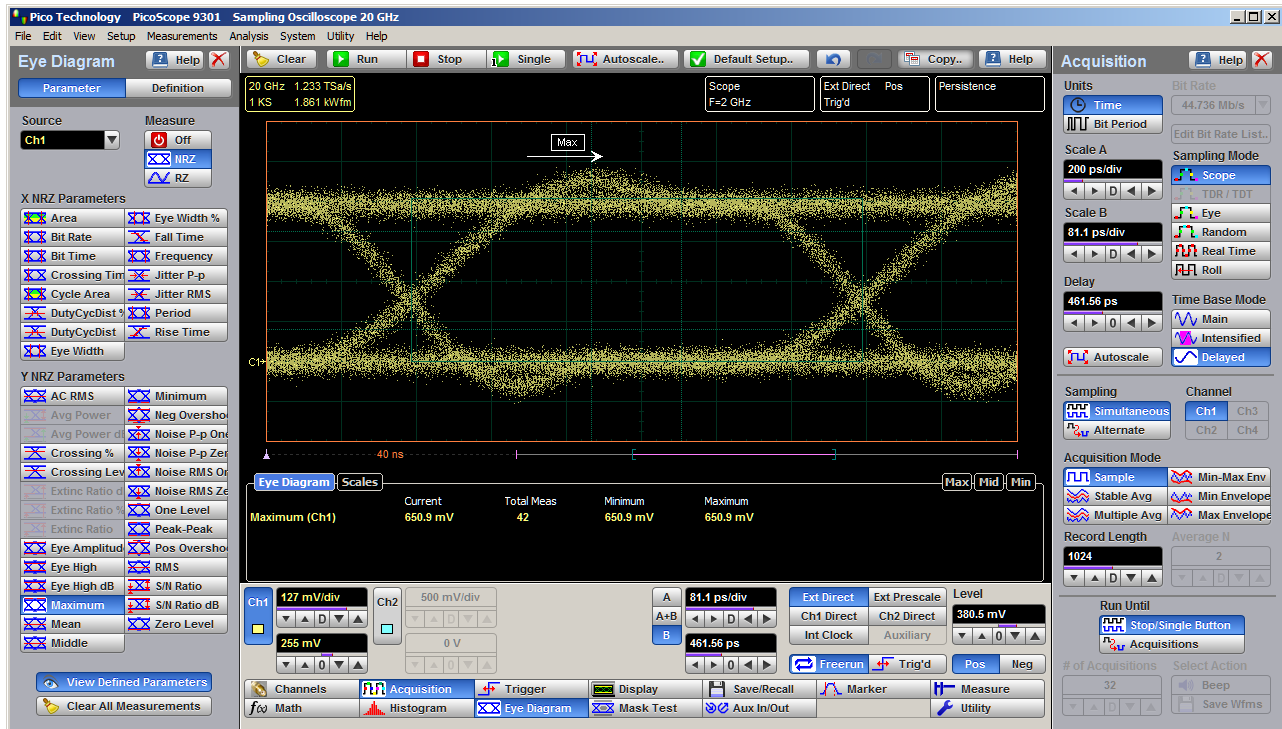
NRZ Maximum definition

The NRZ maximum eye amplitude is determined as follows:

$$NRZ\ Maximum = max[VertPos(s)]$$

where **s** is the set of samples within the eye window.

When this measurement is turned on, it will automatically set the measurement system to use a waveform database if available.

7.5.1.4.7   NRZ Mean
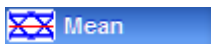
Mean

NRZ Mean is a measure of the arithmetic mean of the selected waveform within the eye window.

The NRZ mean is determined as follows:

$$NRZ\_Mean = mean[VertPos(s)] = \frac{1}{N}\sum_{i=1}^{N} VertPos(s_i)$$

over all samples $s_{1...N}$ within the eye window.

When this measurement is turned on, it will automatically set the measurement system to use a waveform database if available.

7.5.1.4.8   NRZ Middle
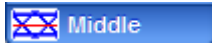
NRZ Middle is a measure of the middle level between the maximum and minimum vertical values of the eye window.
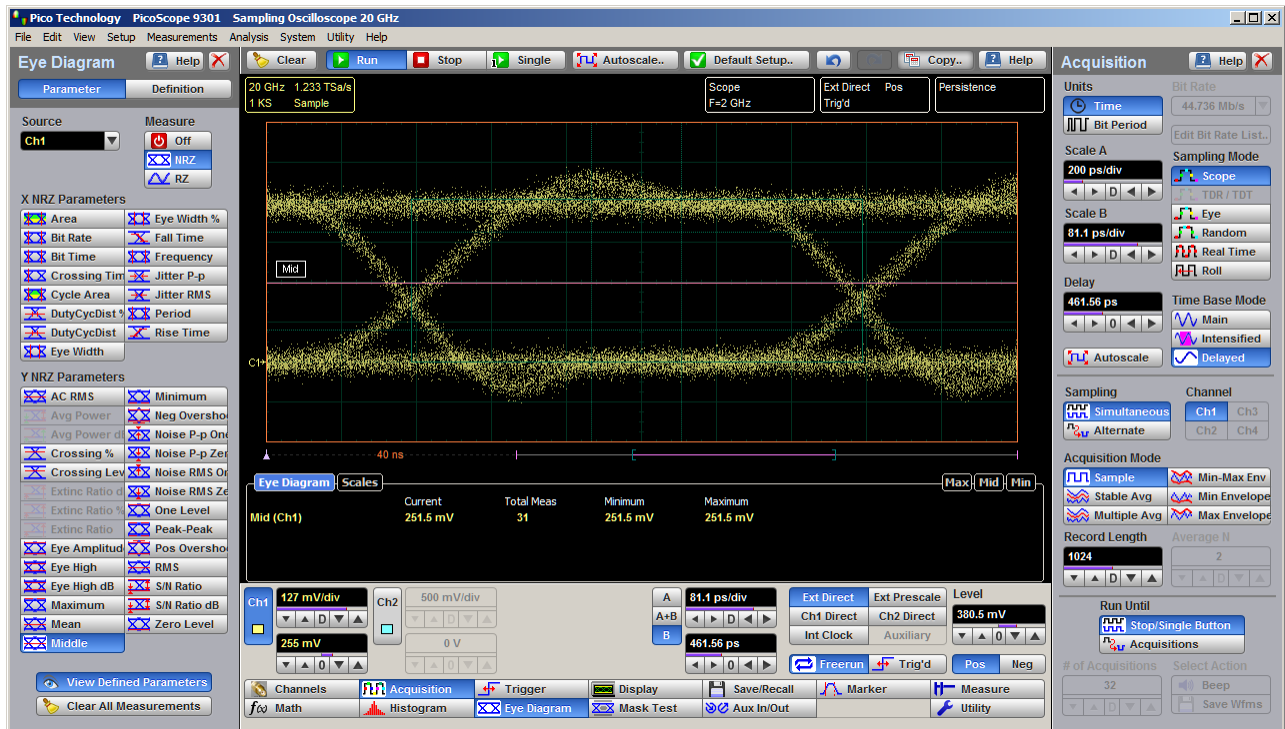
NRZ Middle definition

The NRZ middle is determined as follows:

$$NRZ\ Mid = (Max + Min) / 2$$

where *Max* and *Min* are the maximum and minimum measurements. See also **NRZ Max** and **NRZ Min**.

When this measurement is turned on, it will automatically set the measurement system to use a waveform database if available.

7.5.1.4.9   NRZ Minimum

![Minimum icon]

NRZ Minimum is a measure of the minimum vertical value of the selected waveform of the eye window.
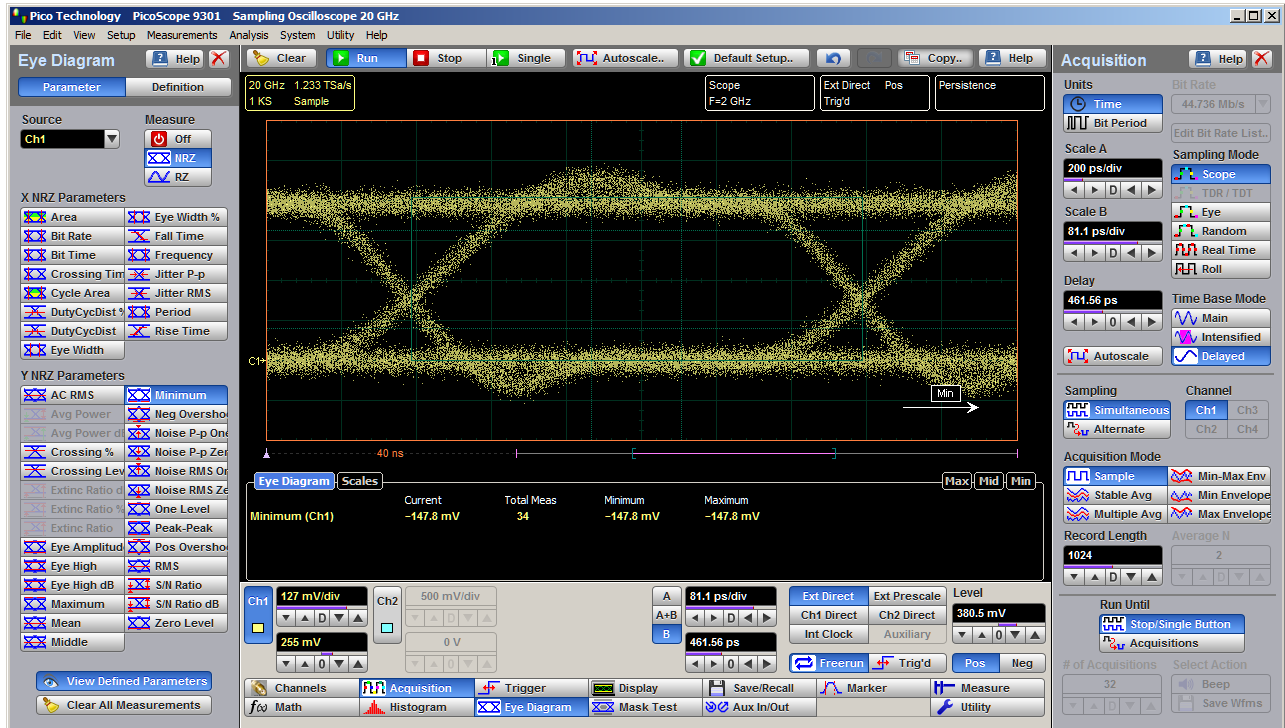
NRZ Minimum definition

The NRZ minimum eye amplitude is determined as follows:

$$NRZ\ Minimum = max[VertPos(s)]$$

where *s* is the set of samples within the eye window.

When this measurement is turned on, it will automatically set the measurement system to use a waveform database if available.

7.5.1.4.10   NRZ Negative Overshoot

![Neg Oversho icon]
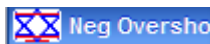
NRZ Negative Overshoot is a measure of the ratio of the minimum value of the measured signal to its amplitude, expressed as a percentage. The waveform is scanned for the minimum value within the eye window, while the amplitude is measured in the **Eye Aperture**.
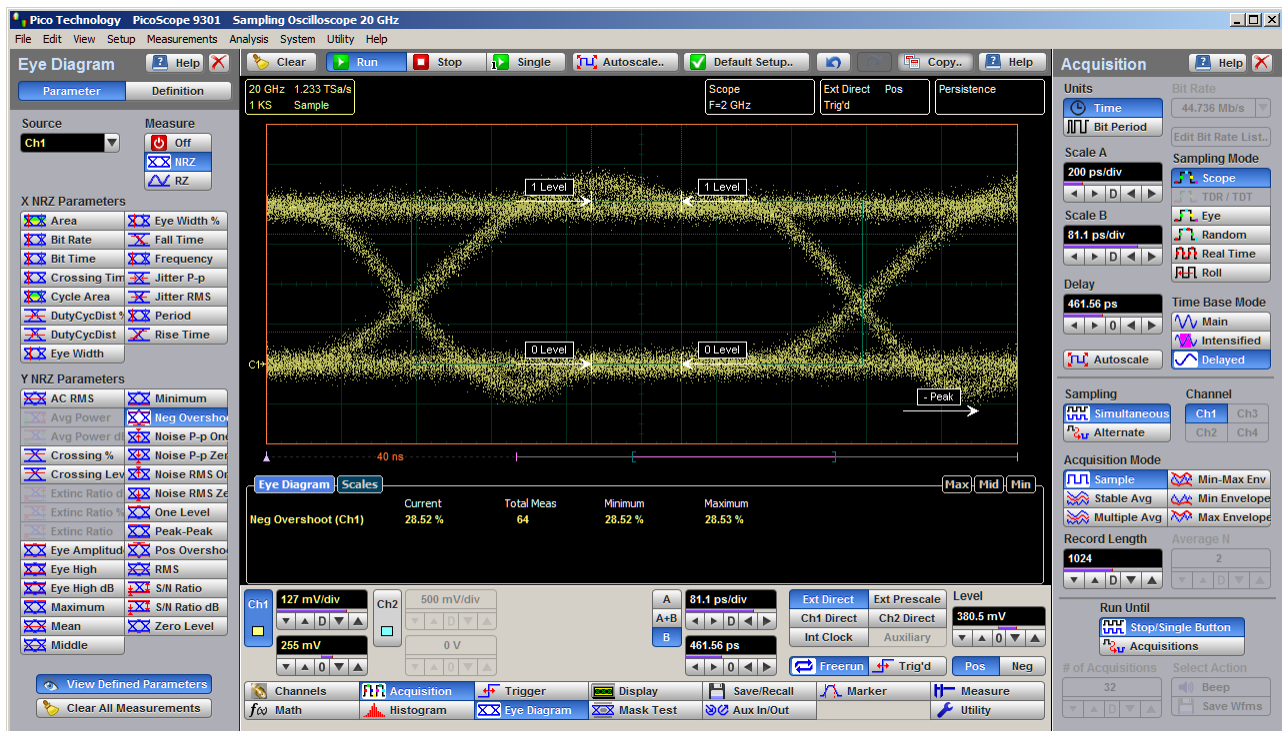
NRZ Negative Overshoot definition

The NRZ Negative Overshoot is determined as follows:

$$NRZ\_NegativeOvershoot = \frac{Vzero - V\min}{Vone - Vzero} \times 100$$

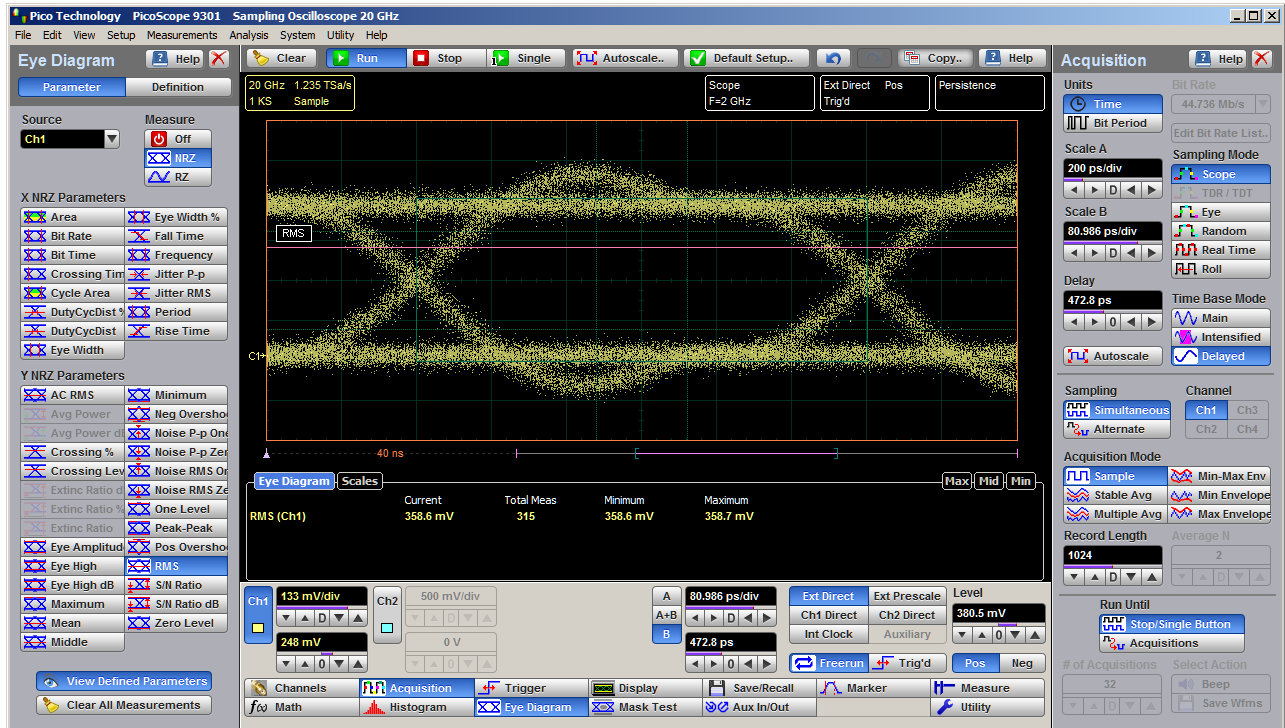where *Vmin* is the signal minimum, and *Vone* and *Vzero* are the logical 1 and 0 levels.
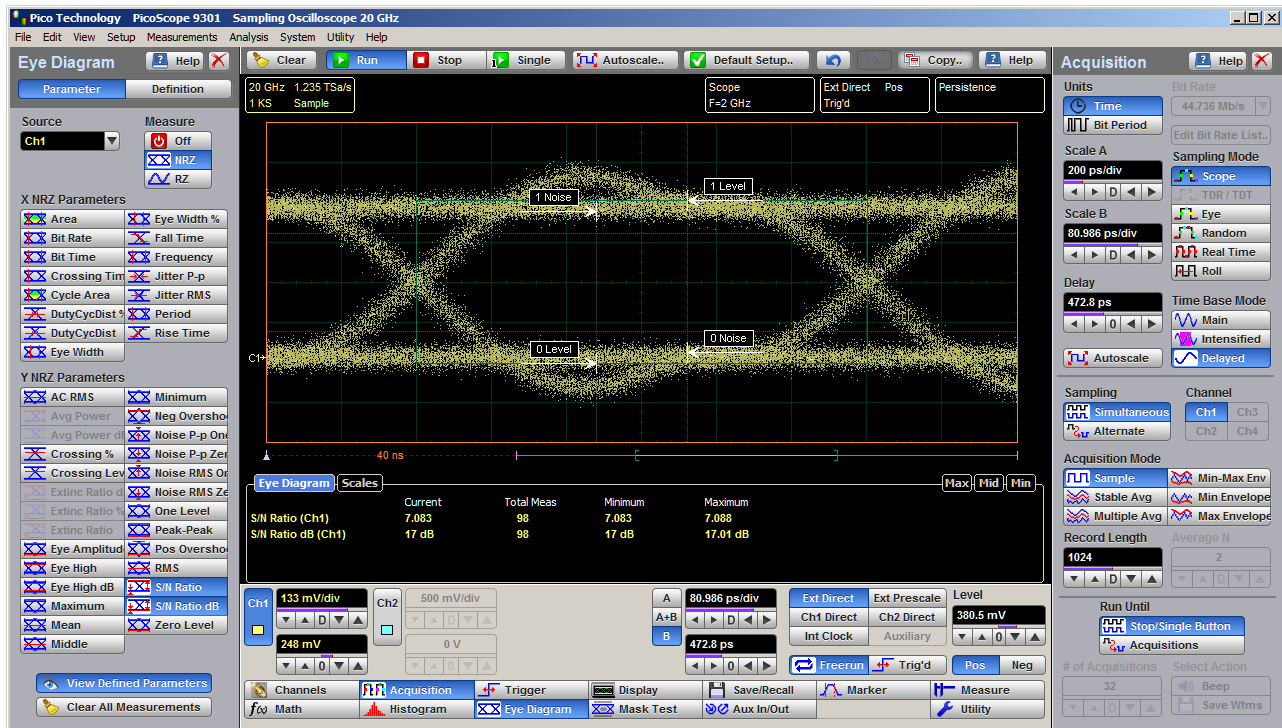
> ⓘ *Vone* and *Vzero* are calculated from a histogram using data within the eye window. These measurements are made in the center of the bit period (within the **Eye Boundaries**). The default value is 20% of the NRZ bit time.

When this measurement is turned on, it will automatically set the measurement system to use a waveform database if available.

7.5.1.4.11 NRZ Noise P-p One and NRZ Noise P-p Zero
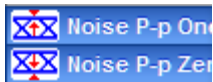
NRZ Noise P-p One is a measurement of the maximum range of the amplitude variance sampled within a fixed-width vertical slice located at the center of the **Eye Aperture** at the **One Level**.

NRZ Noise P-p Zero is a measurement of the maximum range of the amplitude variance sampled within a fixed-width vertical slice located at the center of the **Eye Aperture** at the **Zero Level**.
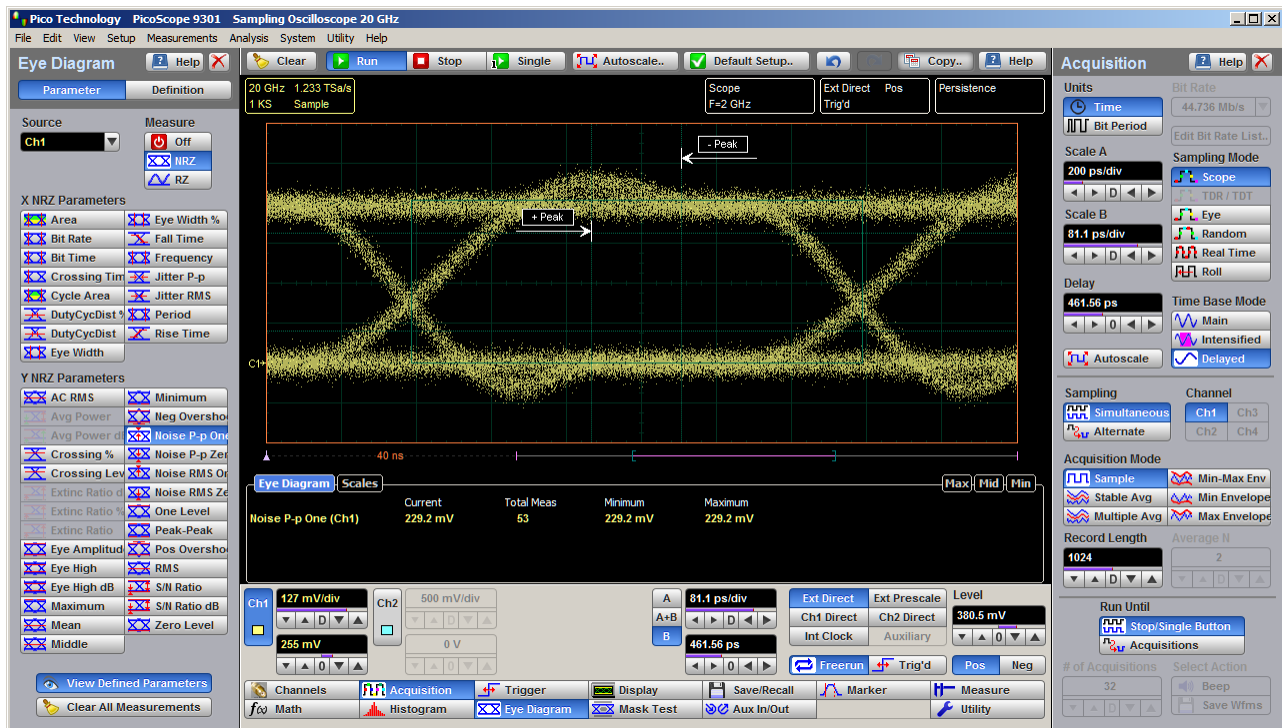
NRZ Noise P-p One definition
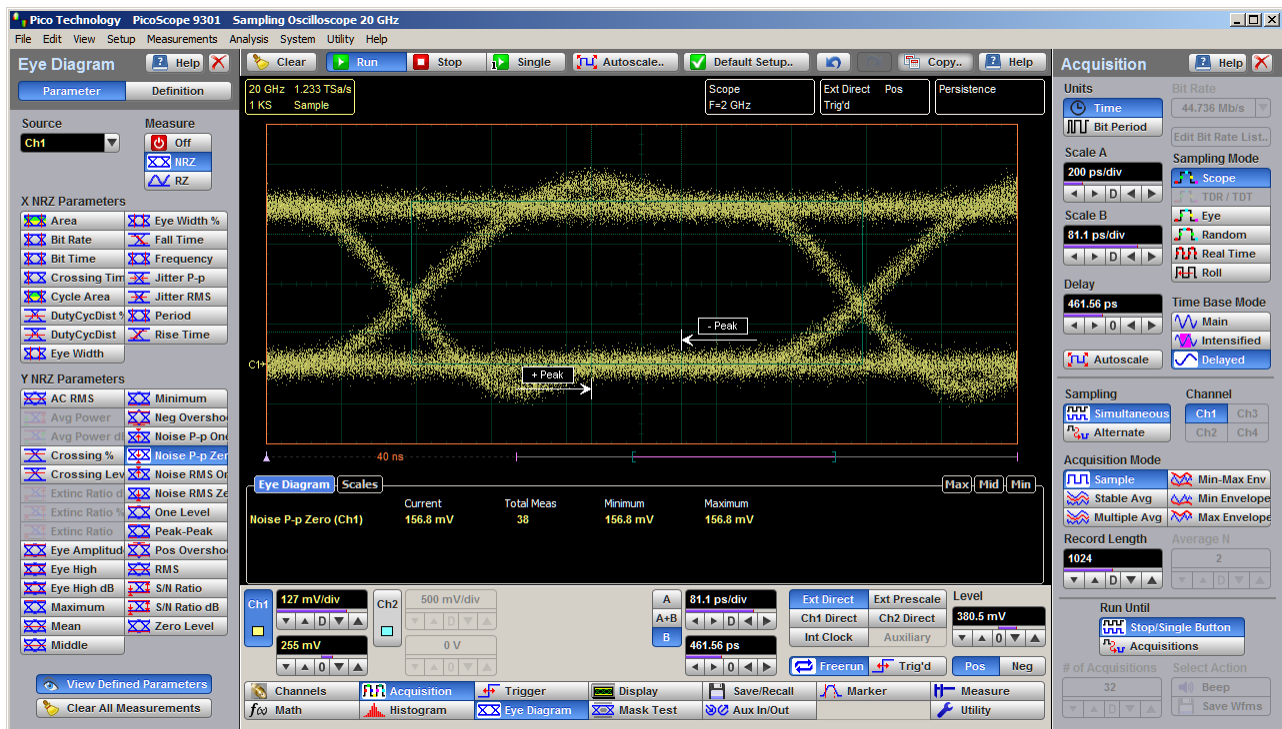
NRZ Noise P-p Zero definition

NRZ Noise P-p One is determined as follows:

NRZ Noise P-p One = One P-p

NRZ Noise P-p Zero is determined as follows:

NRZ Noise P-p Zero = Zero P-p

> *Vone* and *Vzero* are calculated from a histogram using data within the eye window. These measurements are made in the center of the bit period (within the **Eye Boundaries**). The default value is 20% of the NRZ bit time.

This measurement requires the use of a waveform database. When this measurement is turned on, it will automatically set the measurement system to use a waveform database if available.

7.5.1.4.12 NRZ Noise RMS, One and NRZ Noise RMS Zero
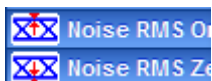
NRZ Noise RMS is a measurement of the unit standard deviation of the amplitude variance sampled within a fixed-width vertical slice located at the center of the **Eye Aperture** at the **High** (logical 1) or **Low** (logical 0) levels.

NRZ Noise RMS One definition
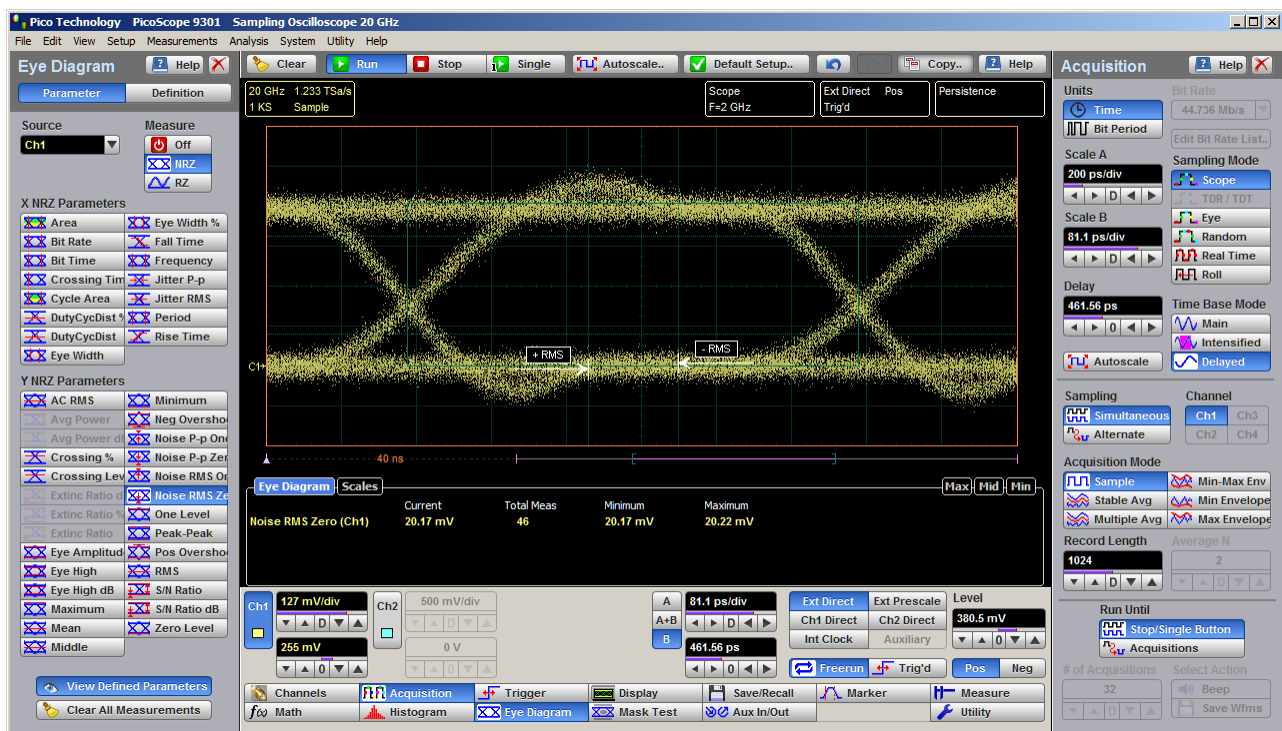
NRZ Noise RMS Zero definition

$$NRZ\ RMS = High\ \acute{o}$$

$$NRZ\ RMS = Low\ \acute{o}$$

The **Eye Aperture** is adjustable and defaults to 20% of the NRZ bit time. This measurement requires the use of a waveform database. When this measurement is turned on, it will automatically set the measurement system to use a waveform database if available.

> ℹ *Vone* and *Vzero* are calculated from a histogram using data within the eye window. These measurements are made in the center of the bit period (within the **Eye Boundaries**). The default value is 20% of the NRZ bit time.

7.5.1.4.13 NRZ One Level
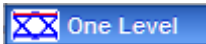
XX One Level

NRZ One Level is a measure of the mean value of the logical 1 of an eye diagram.

NRZ One Level definition

> ℹ *Vone* and *Vzero* are calculated from a histogram using data within the eye window. These measurements are made in the center of the bit period (within the **Eye Boundaries**). The default value is 20% of the NRZ bit time.

A histogram is constructed using the sampled portion of the eye diagram within the eye window. This histogram is composed of data points from only the upper half of the eye diagram. The instrument analyzes the histogram and determines histogram mean.

The **One Level** is determined as follows:

$$NRZ\ One\ Level = Histogram\ Mean$$

All data at the zero level is disregarded.

> The standard deviation that is reported on the instrument display as part of the measurement results is derived from the statistical analysis of the one level measurement result. It is not the same as the standard deviation derived from the histogram analysis of the signal.

7.5.1.4.14 NRZ Peak-Peak
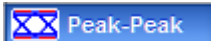
NRZ Peak-Peak is a measure of the difference between the maximum and minimum vertical values of the selected waveform within the eye window.
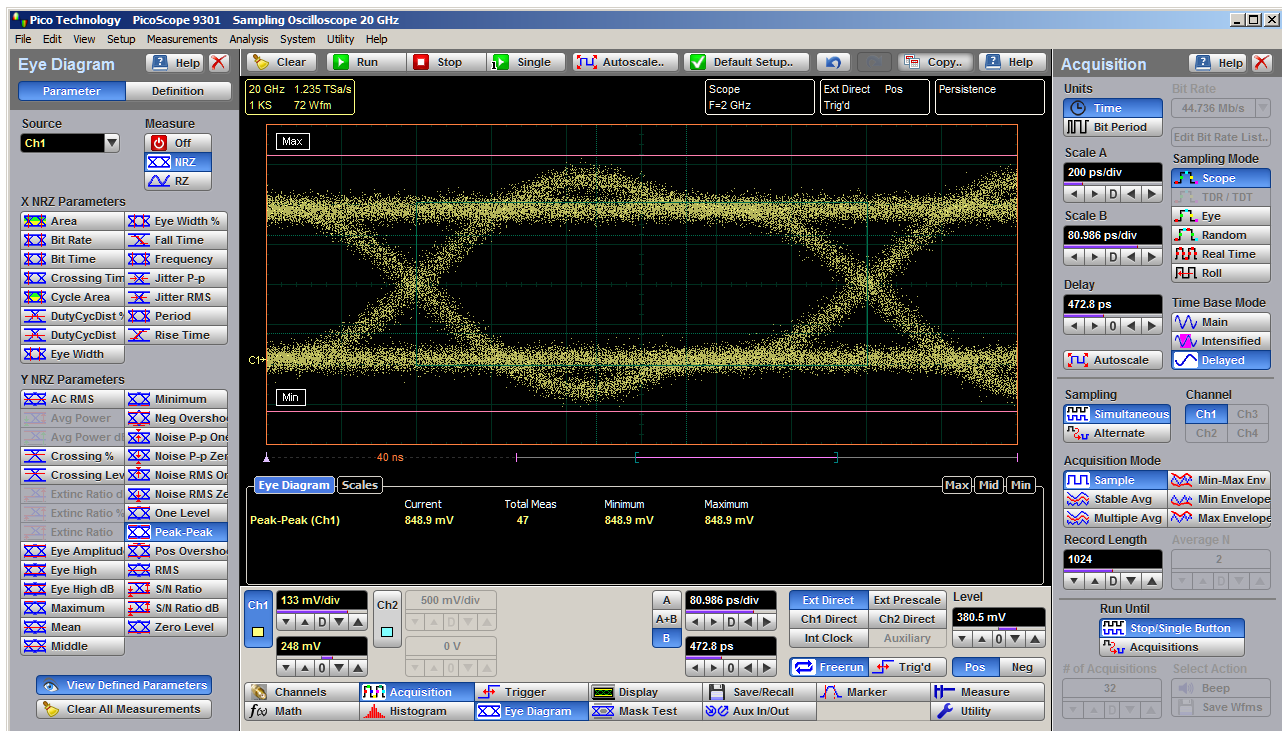
NRZ Peak-Peak definition

The **NRZ Peak-Peak** is determined as follows:

$$NRZ\ Peak\text{-}Peak = Max - Min$$

where *Max* and *Min* are the maximum and minimum measurements. See also **NRZ Max** and **NRZ Min**.

When this measurement is turned on, it will automatically set the measurement system to use a waveform database if available.

7.5.1.4.15 NRZ Positive Overshoot
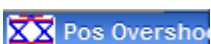
NRZ Positive Overshoot is a measure of the ratio of the maximum value of the measured signal to its amplitude, expressed as a percentage. The waveform is scanned for the maximum value within the eye window, while the amplitude is measured in the **Eye Aperture**.
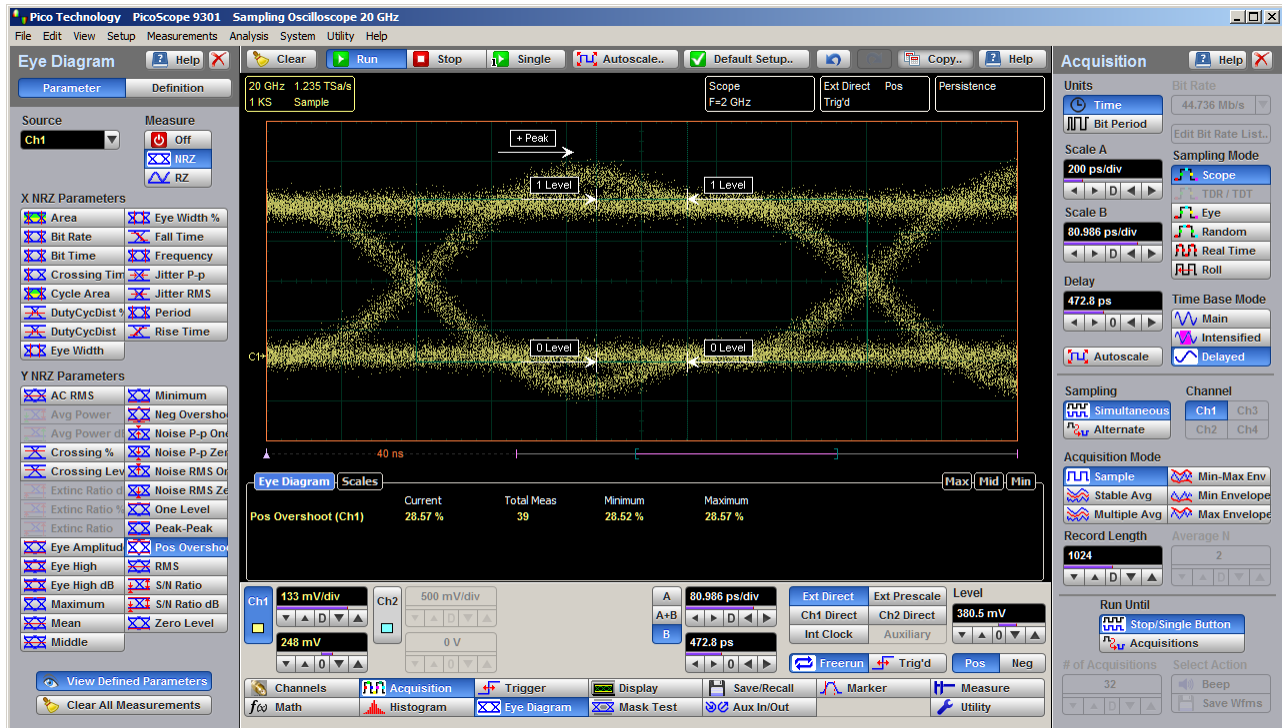
NRZ Positive Overshoot definition

The **NRZ Positive Overshoot** is determined as follows:

$$NRZ\_PositiveOvershoot = \frac{V\max - Vone}{Vone - Vzero} \times 100$$

where *Vmax* is the signal maximum, and *Vone* and *Vzero* are the logical 1 and 0 levels.

> **ℹ** *Vone* and *Vzero* are calculated from a histogram using data within the eye window. These measurements are made in the center of the bit period (within the **Eye Boundaries**). The default value is 20% of the NRZ bit time.

When this measurement is turned on, it will automatically set the measurement system to use a waveform database if available.

7.5.1.4.16 NRZ RMS

NRZ RMS is a measure of the true root mean square amplitude of the selected waveform within the eye window.

NRZ RMS definition

The **NRZ RMS** is determined as follows:

$$NRZ\_RMS = \sqrt{\frac{\sum_{n=1}^{N}[VertPos(s_n)]^2}{N}}$$

over all *N* samples within the measured region; i.e., one standard deviation of the amplitude, i.e., RMS amplitude.

When this measurement is turned on, it will automatically set the measurement system to use a waveform database if available.

ⓘ *Vone* and *Vzero* are calculated from a histogram using data within the eye window. These measurements are made in the center of the bit period (within the **Eye Boundaries**). The default value is 20% of the NRZ bit time.

7.5.1.4.17 NRZ S/N Ratio and NRZ S/N Ratio dB

S/N Ratio
S/N Ratio dB
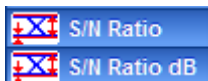
NRZ Signal to Noise is a ratio of the signal difference between one level and zero level relative to the noise present at both levels. Signal to Noise is similar in construction to a Q-factor measurement. However, noise levels contributed by the instrument cannot be removed, and therefore a slightly pessimistic Q-factor measurement may result.

NRZ Signal to Noise Ratio definition

> *Vone* and *Vzero* are calculated from a histogram using data within the eye window. These measurements are made in the center of the bit period (within the **Eye Boundaries**). The default value is 20% of the NRZ bit time.

To define the signal, histograms are constructed using the sampled portions of the eye diagram within the eye window boundaries. One histogram is composed of data points from only the upper half of the eye diagram (one level). The second histogram is composed of data points from the lower half of the eye (zero level). The instrument analyzes the histograms and determines the histogram means and standard deviations. The noise is defined as 1σ (standard deviation) of the histogram at the one and zero levels.

The RZ Signal to Noise is determined as follows:

$$NRZ\_Signal-to-Noise\_Ratio = \frac{Vone - Vzero}{\sigma_{one} + \sigma_{zero}}$$

> This measurement does not remove the effect of noise generated by the instrument. If the noise on the signal being tested is of a magnitude similar to that of the instrument or smaller, the signal-to-noise measurement error will be significant.

7.5.1.4.18 NRZ Zero Level
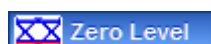
 Zero Level

NRZ Zero Level is a measure of the mean value of the logical 0 of an eye diagram.
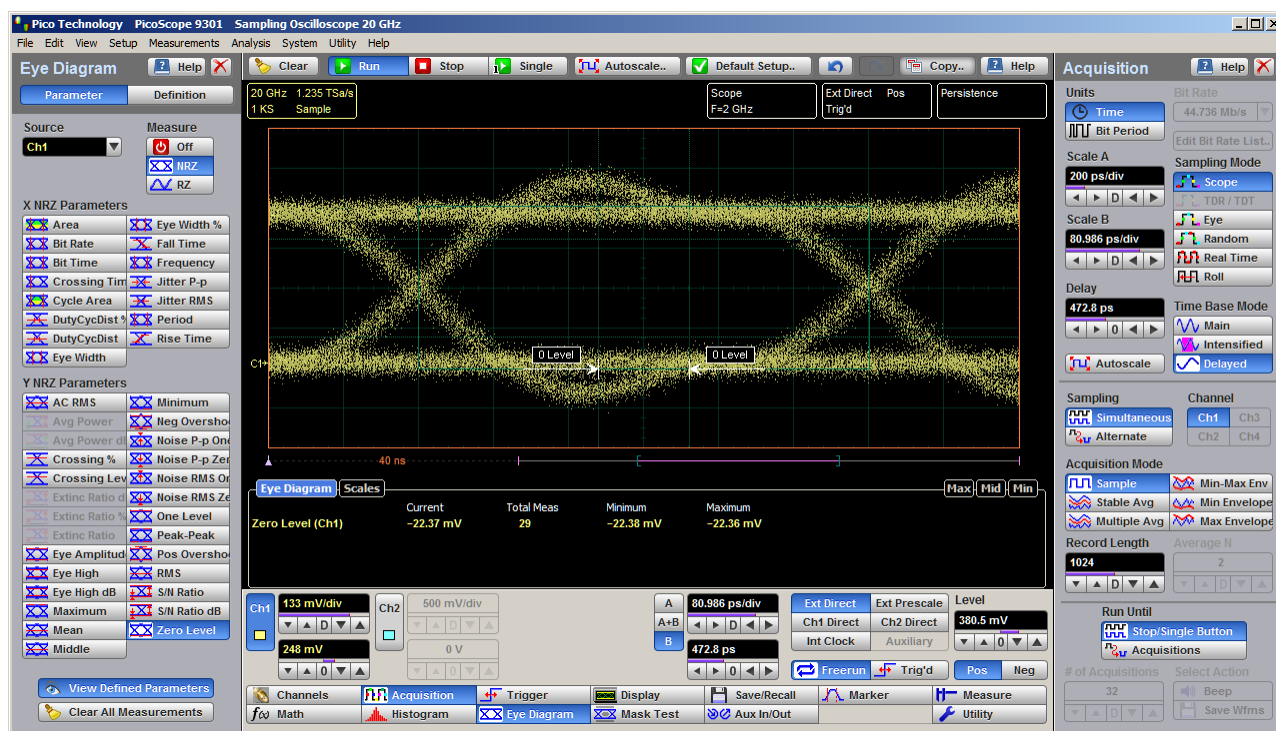
NRZ Zero Level definition

ℹ️ *Vone* and *Vzero* are calculated from a histogram using data within the eye window. These measurements are made in the center of the bit period (within the **Eye Boundaries**). The default value is 20% of the NRZ bit time.

A histogram is constructed using the sampled portion of the eye diagram within the eye window. This histogram is composed of data points from only the lower half of the eye diagram. The instrument analyzes the histogram and determines histogram mean.

The **RZ Zero Level** is determined as follows:

$$NRZ\ Zero\ Level = Histogram\ Mean$$

All data at the one level is disregarded.

ℹ️ The standard deviation that is reported on the instrument display as part of the measurement results is derived from the statistical analysis of the zero level measurement result. It is not the same as the standard deviation derived from the histogram analysis of the signal.

7.5.1.5   X RZ Eye Parameters
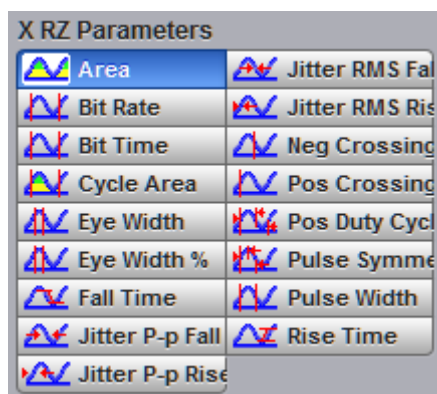
The list of **X RZ Eye Parameters** includes seventeen eye parameters.

> ℹ️ You can perform up to ten simultaneous measurements on one displayed waveform.

The measurement algorithms for **X RZ Eye Parameters** will only work when an RZ eye diagram, and not an NRZ eye diagram or a pulse, is present on the screen. Eye measurements are based on statistical data that is acquired and stored in the measurement database. The algorithms are dependent upon histogram means calculated from the measurement database. Therefore, if you want to perform eye measurements, you must first produce an eye diagram by triggering the instrument with a synchronous clock signal. Measurements made on an NRZ eye diagram or a pulse waveform while in the **X RZ Eye Parameters** menu will fail.

7.5.1.5.1   RZ Area
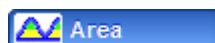
RZ Area is a measure of the area under the curve for the RZ waveform within the full display window. Area measured above ground is positive; area measured below ground is negative.

The **RZ Area** is determined as follows:

$$RZ\_Area = \frac{\Delta t}{N} \sum_{n=1}^{N} VertPos(s_n)$$

over all N samples $s_{1...N}$ within the measured region (full display window) of duration $\ddot{A}t.$

This measurement requires the use of a waveform database. When this measurement is turned on, it will automatically set the measurement system to use a waveform database if available.

7.5.1.5.2 RZ Bit Rate

 Bit Rate

The **RZ Bit Rate** is a measure of the inverse of the bit time (1/bit time or 1/period) of the RZ eye rising edges. The bit time is a measure of the time between the 50% rising edges of two consecutive eyes.
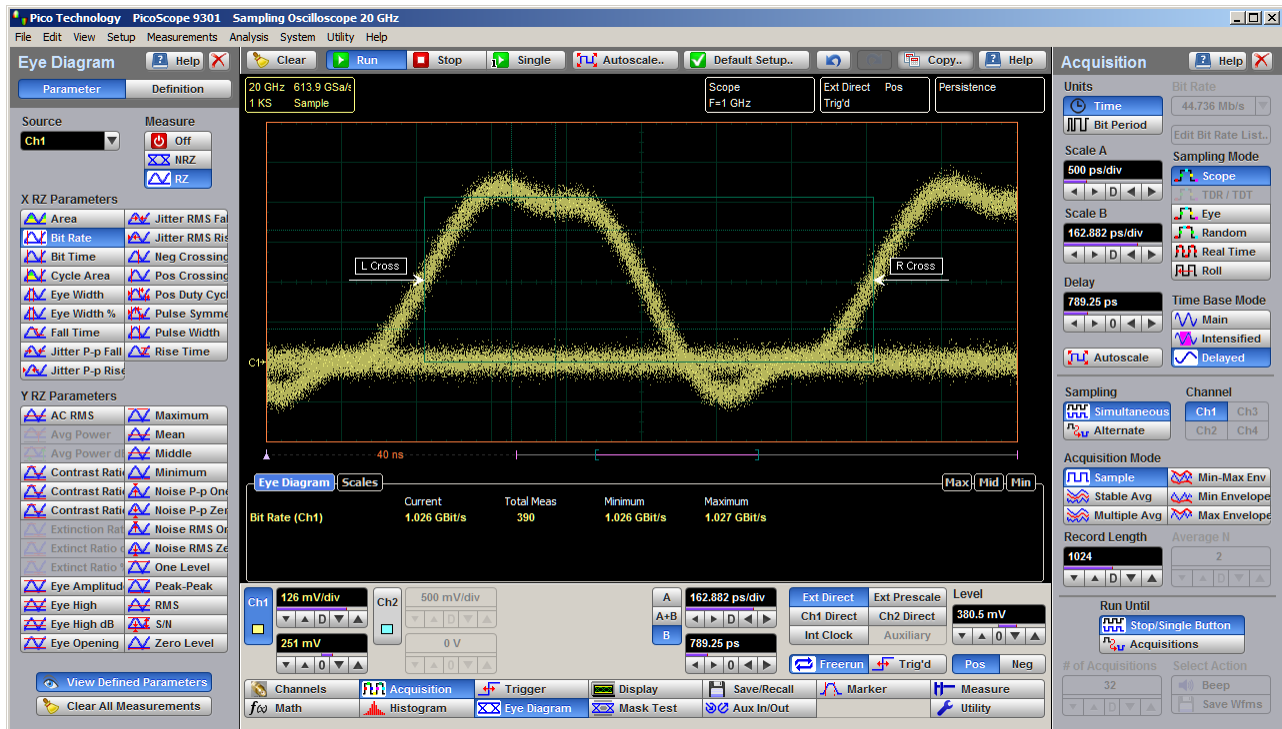
RZ Bit Rate definition

To compute bit time (period), the 50% heights of consecutive eyes are first determined. Then a vertically thin measurement window is placed horizontally through the 50% levels. The data within this measurement window is analyzed. The measurement window is created to be extremely small so that the measurement is not affected by the fall or rise time of the waveforms.

Once the bit period has been determined, the inverse value is calculated to determine the RZ bit rate:

$$RZ\_BitRate = \frac{1}{RZ\_BitTime} = \frac{1}{2(T_{RightCross} - T_{LeftCross})}$$

where $T_{RightCross}$ and $T_{LeftCross}$ are the mean of the histogram of the two consecutive crossings on the rising slope at the mid-reference level.

See also **RZ Bit Time**.

7.5.1.5.3   RZ Bit Time
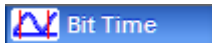
Bit Time

The **RZ Bit Time** is a measure of the time interval between two consecutive rising edges. The crossing times are computed as the mean of the histogram of the data slice at the mid-reference level.

The **RZ Bit Time** is determined as follows:

$$RZ\_BitTime = T_{RightCross} - T_{LeftCross}$$

where $T_{RightCross}$ and $T_{LeftCross}$ are the mean of the histogram of the two consecutive crossings on the rising slope at the mid-reference level.

This measurement requires the use of a waveform database. When this measurement is turned on, it will automatically set the measurement system to use a waveform database if available.

RZ Bit Time also is called **RZ Bit Period**.

7.5.1.5.4   RZ Cycle Area

Cycle Area

RZ Cycle Area is a measure of the area under the curve for the RZ waveform within the eye window. Area measured above ground is positive; area measured below ground is negative.

The **RZ Cycle Area** is determined as follows:

$$RZ\_CycleArea = \frac{\Delta t}{N} \sum_{n=1}^{N} VertPos(s_n)$$

over all *N* samples $s_{1...N}$ in the measured region (eye window) of duration *Ät* between two consecutive edges of the rising slope at the **Mid** reference level.

This measurement requires the use of a waveform database. When this measurement is turned on, it will automatically set the measurement system to use a waveform database if available.

7.5.1.5.5   RZ Eye Width and RZ Eye Width %

RZ Eye Width is a measure of the horizontal opening of an RZ eye diagram. The amount of jitter or noise that may appear on the waveform is measured to determine the actual horizontal opening of the eye.
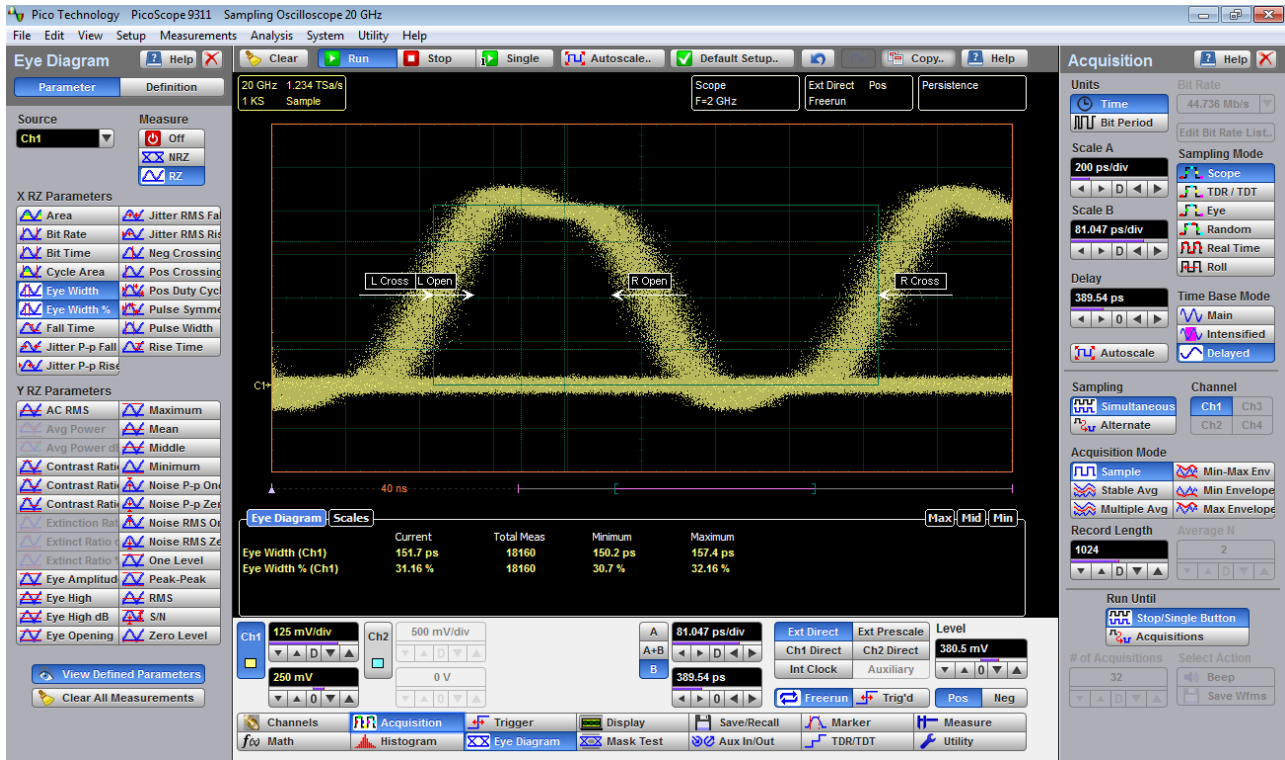
RZ Eye Width definition

To compute eye width, the 50% height of the eye is first determined. Then a vertically thin measurement window is placed horizontally through the 50% levels, and the data within this measurement window is analyzed. This measurement window is created to be extremely small so that the measurement is not affected by the rise time and fall time of the waveform.

The RZ eye width is determined using the time difference between the 3σ (standard deviation) points of the 50% level histograms.

$$RZ\_EyeWidth = (T_{Fall\,50\%} - 3\sigma) - (T_{Rise\,50\%} - 3\sigma)$$

The RZ eye width can also be expressed as the ratio of the 3σ time difference between edges to the bit time (bit period) of the eye pulses:

$$RZ\_EyeWidth\_\% = \frac{(T_{Fall\,50\%} - 3\sigma) - (T_{Rise\,50\%} + 3\sigma)}{BitTime}$$

7.5.1.5.6   RZ Fall Time
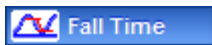
 Fall Time

RZ Fall Time is a measure of the mean transition time of the data on the downward slope of an RZ eye diagram. The data crosses through the following three thresholds: upper, middle, and lower.
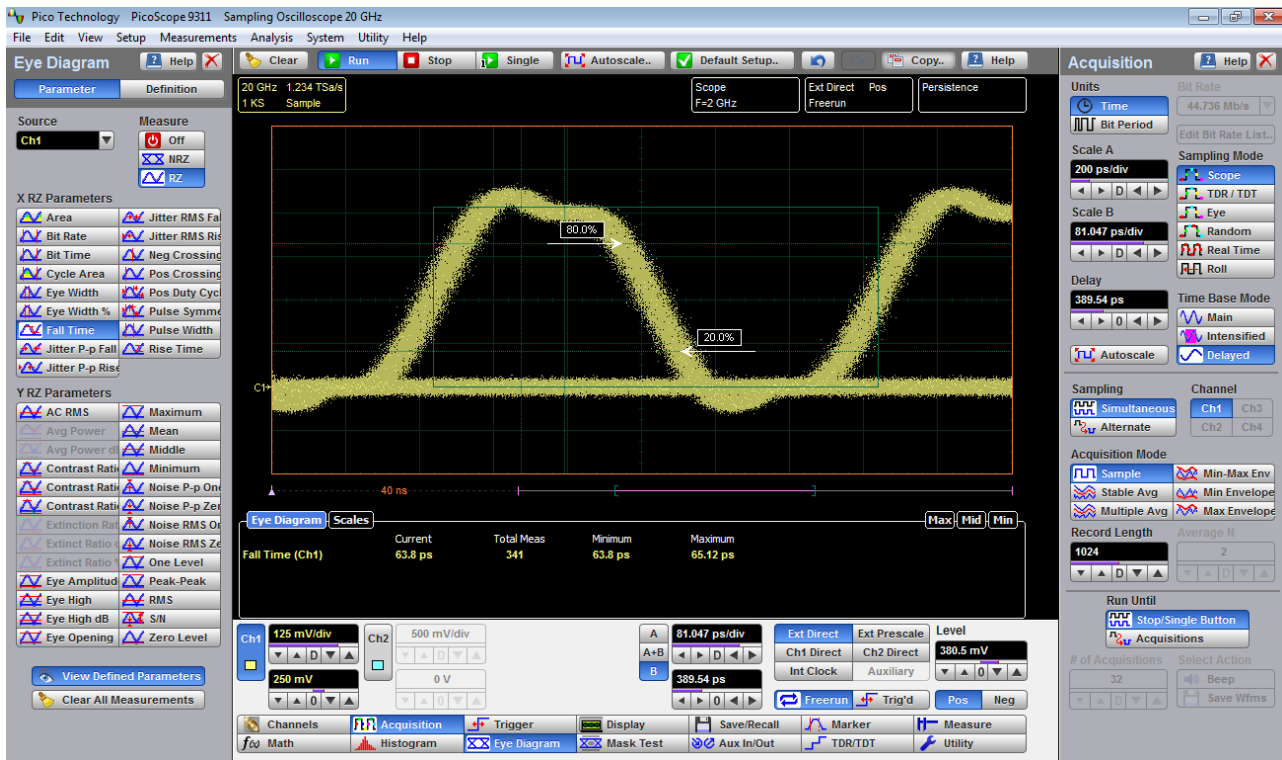
RZ Fall Time definition

A histogram is first constructed to find the mean locations of the eye one level and zero level. Histograms are then constructed at each of the three threshold levels (for example, the 20%, 50%, and 80% points on the transition). The instrument analyzes each histogram to determine the histogram mean at which the data crosses the separate threshold levels. Once the scanning of the waveform is complete, and the instrument has identified the mean location for each threshold crossed, then fall time can be computed.

RZ Fall Time = (Time at Lower Threshold Crossing) –
(Time at Upper Threshold Crossing)

The default setting for the threshold levels is the 20% to 80% points on the transition. These levels give more consistent results for eyes with distortion at the top or bottom. You can define the threshold settings that you want in the **Define Parameters** menu.

ℹ️ If the fall time relative to the time/division is a small value, the data acquired at the threshold levels on the falling edge will not yield accurate measurement results. (The falling edge will appear very steep on the display screen).

If the falling edge of your eye diagram is steep, increase the timebase (horizontal scale) on the display so that the falling edge covers at least half a graticule division. The instrument will be able to discern the data at the threshold levels, producing more accurate results.

7.5.1.5.7   RZ Jitter P-p, Fall and RZ Jitter RMS, Fall

![Jitter P-p Fall] ![Jitter RMS Fa]

RZ Jitter P-p, Fall and **RZ Jitter RMS, Fall** are the measures of signal instability relative to its ideal position in time.
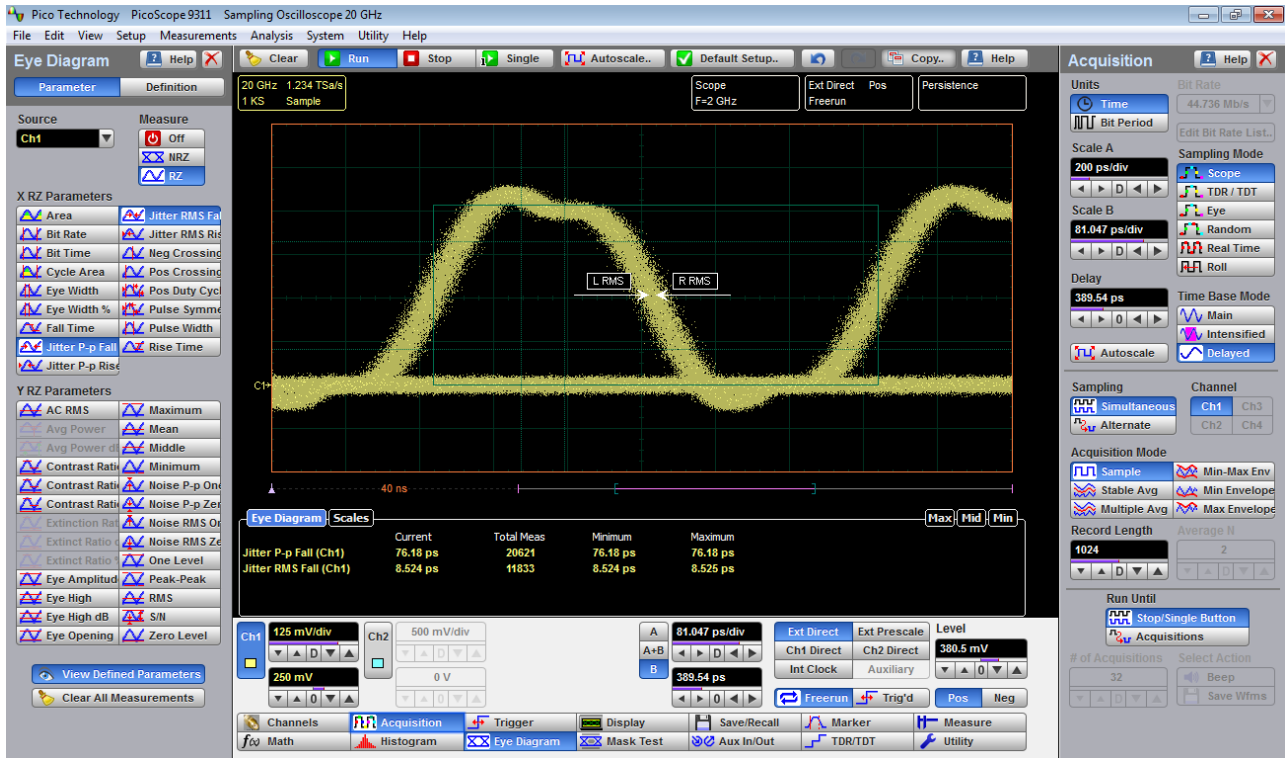
RZ Jitter P-p, Fall and RZ Jitter RMS, Fall definition

To compute jitter peak-to-peak, the standard deviation is measured at a 50% level of the first measurable falling edge. The measurement window is kept extremely small so that the width at the 50% level is not influenced by the slope of the waveform. The histograms are then analyzed to determine the amount of RMS jitter, which is defined as 1σ (standard deviation) from the histogram mean.

The RZ peak-to-peak jitter is the full width of the histogram at the eye 50% level:

RZ Jitter P-p, Fall = 6σ (crossing)

The RZ RMS jitter is defined as one standard deviation from the histogram mean at the eye crossing point:

RZ Jitter RMS, Fall = 1σ (crossing)

7.5.1.5.8   RZ Jitter P-p, Rise and RZ Jitter RMS, Rise

Jitter P-p Rise   Jitter RMS Rise

RZ Jitter P-p, Rise and **RZ Jitter RMS, Rise** are the measures of signal instability relative to its ideal position in time.
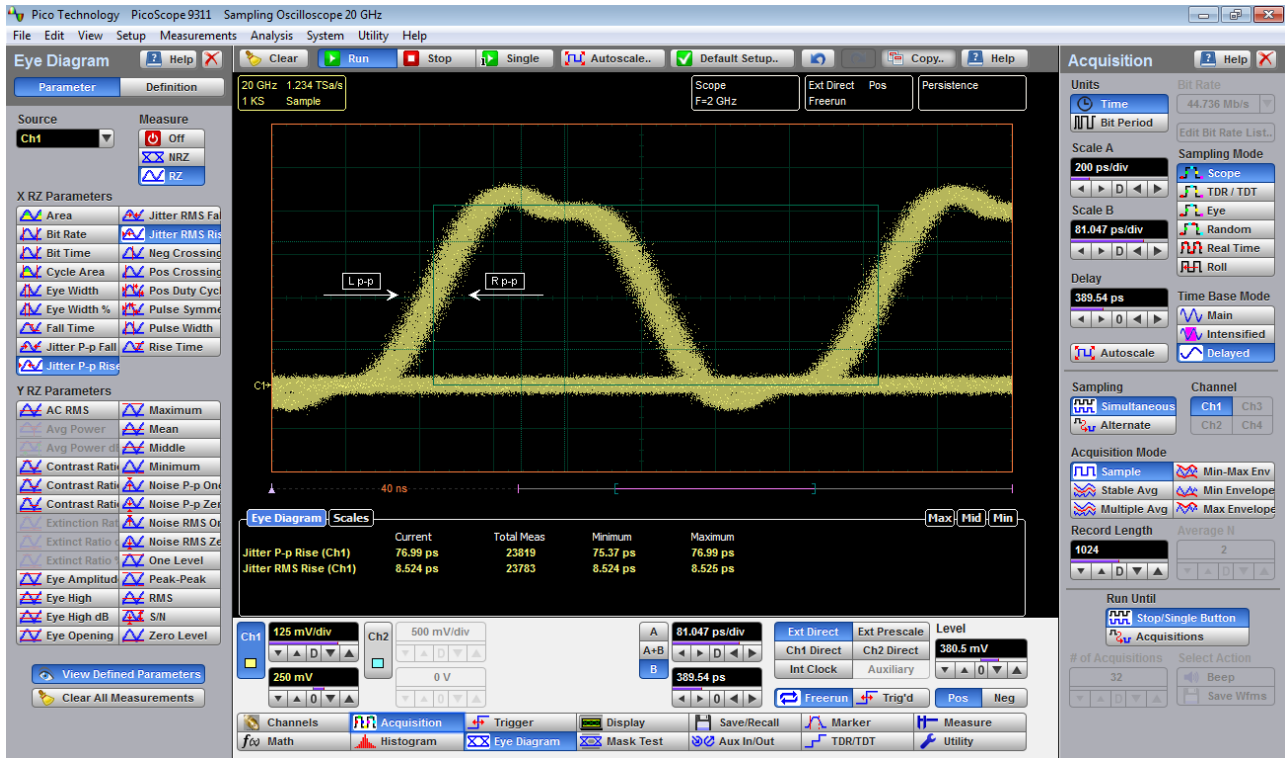
RZ Jitter P-p, Rise and RZ Jitter RMS, Rise definition

To compute jitter peak-to-peak, the standard deviation is measured at a 50% level of the left measurable rising edge. The measurement window is kept extremely small so that the width at the 50% level is not influenced by the slope of the waveform. The histograms are then analyzed to determine the amount of RMS jitter, which is defined as 1 (standard deviation) from the histogram mean.

The RZ peak-to-peak jitter is the full width of the histogram at the eye 50% level:

$$RZ\ Jitter\ P\text{-}p,\ Rise = 6\acute{\sigma}\ (crossing)$$

The RZ RMS jitter is defined as one standard deviation from the histogram mean at the eye crossing point:

$$RZ\ Jitter\ RMS,\ Rise = 1\acute{\sigma}\ (crossing)$$

7.5.1.5.9 RZ Negative Crossing

Neg Crossing

RZ Negative Crossing is a measure of the time of a negative crossing, defined as the mean of the histogram of the data sampled at the 50% reference level.
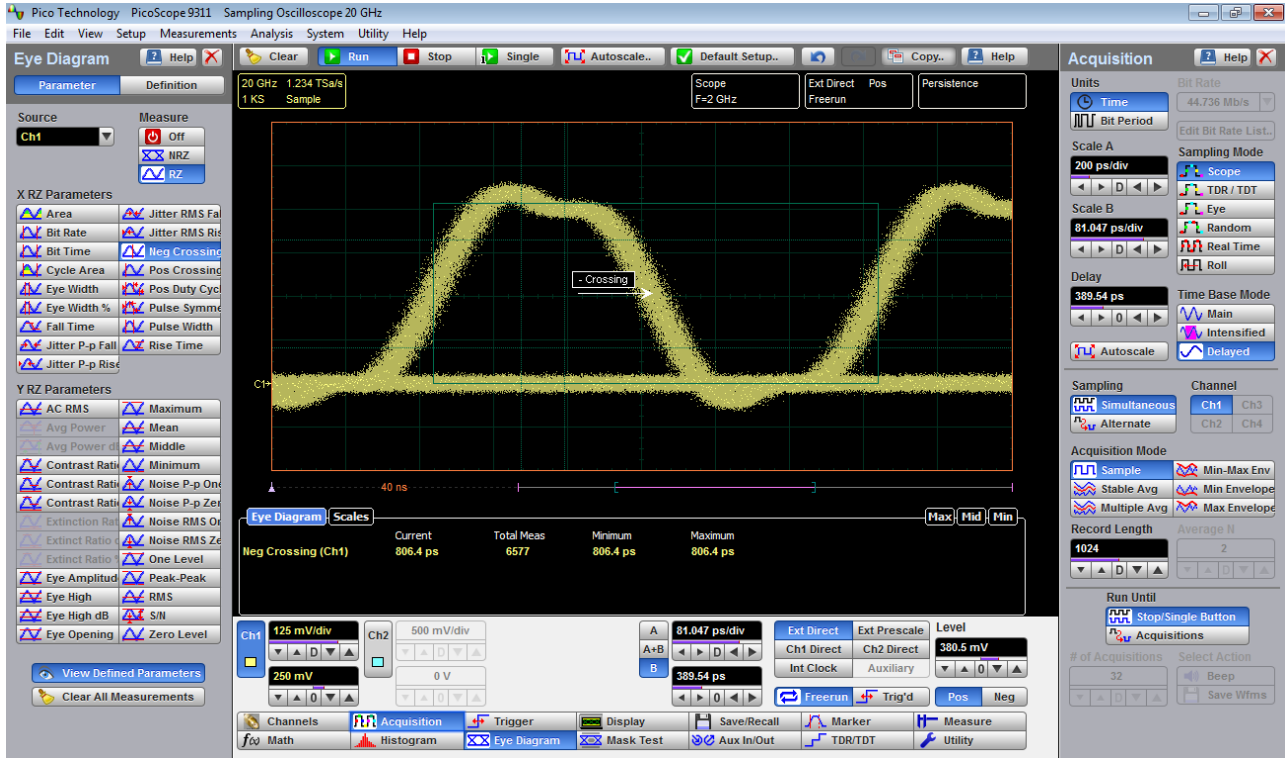
RZ Negative Crossing definition

The **RZ Negative Crossing** is determined as follows:

$$RZ\ Negative\ Crossing = T_{CrossNeg}$$

where $T_{CrossNeg}$ is the mean of the histogram of a negative crossing.

This measurement requires the use of a waveform database. When this measurement is turned on, it will automatically set the measurement system to use a waveform database if available.

7.5.1.5.10 RZ Positive Crossing

[Pos Crossing]

RZ Positive Crossing is a measure of the time of a left positive crossing, defined as the mean of the histogram of the data sampled at the 50% reference level.
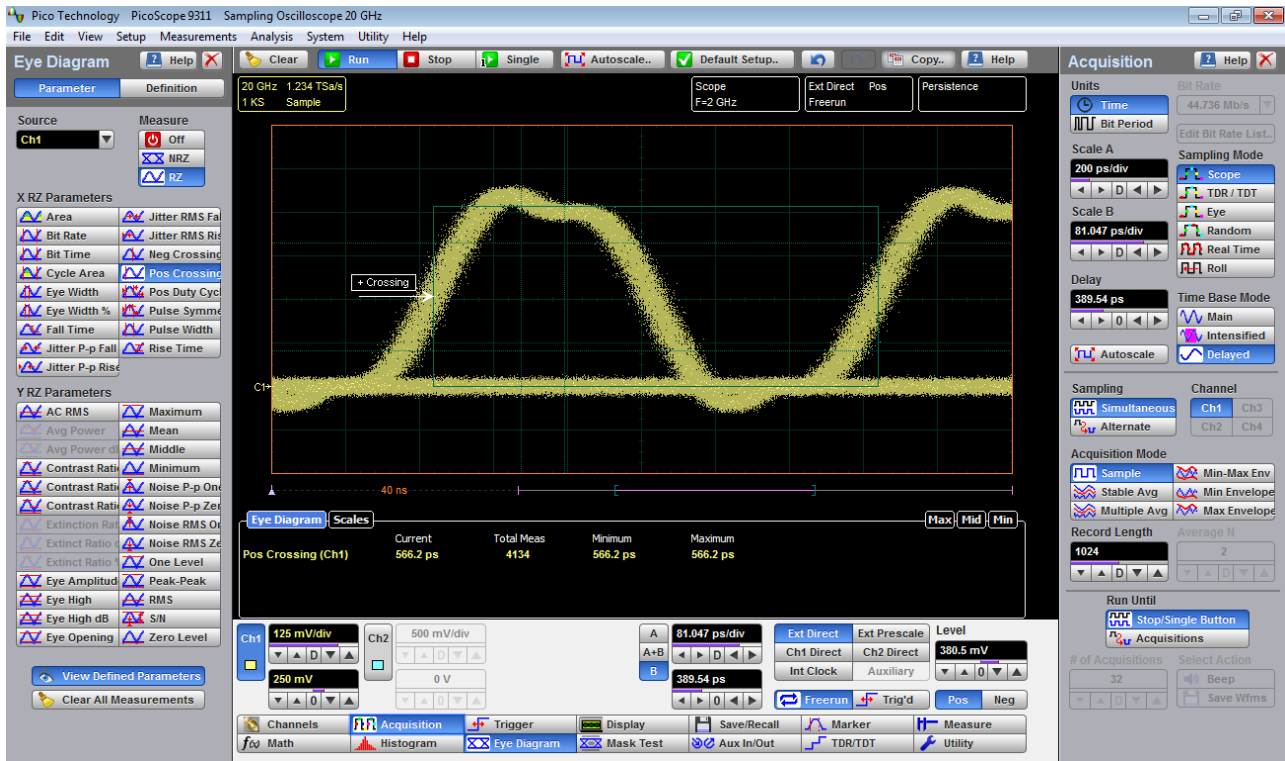
RZ Positive Crossing definition

The **RZ Positive Crossing** is determined as follows:

$$RZ\ Positive\ Crossing = T_{CrossPos}$$

where $T_{CrossPos}$ is the mean of the histogram of a positive crossing.

This measurement requires the use of a waveform database. When this measurement is turned on, it will automatically set the measurement system to use a waveform database if available.

7.5.1.5.11 RZ Positive Duty Cycle

 Pos Duty Cyc
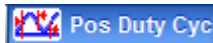
RZ Positive Duty Cycle is a measure of the ratio of the RZ positive pulse width to the RZ bit time.
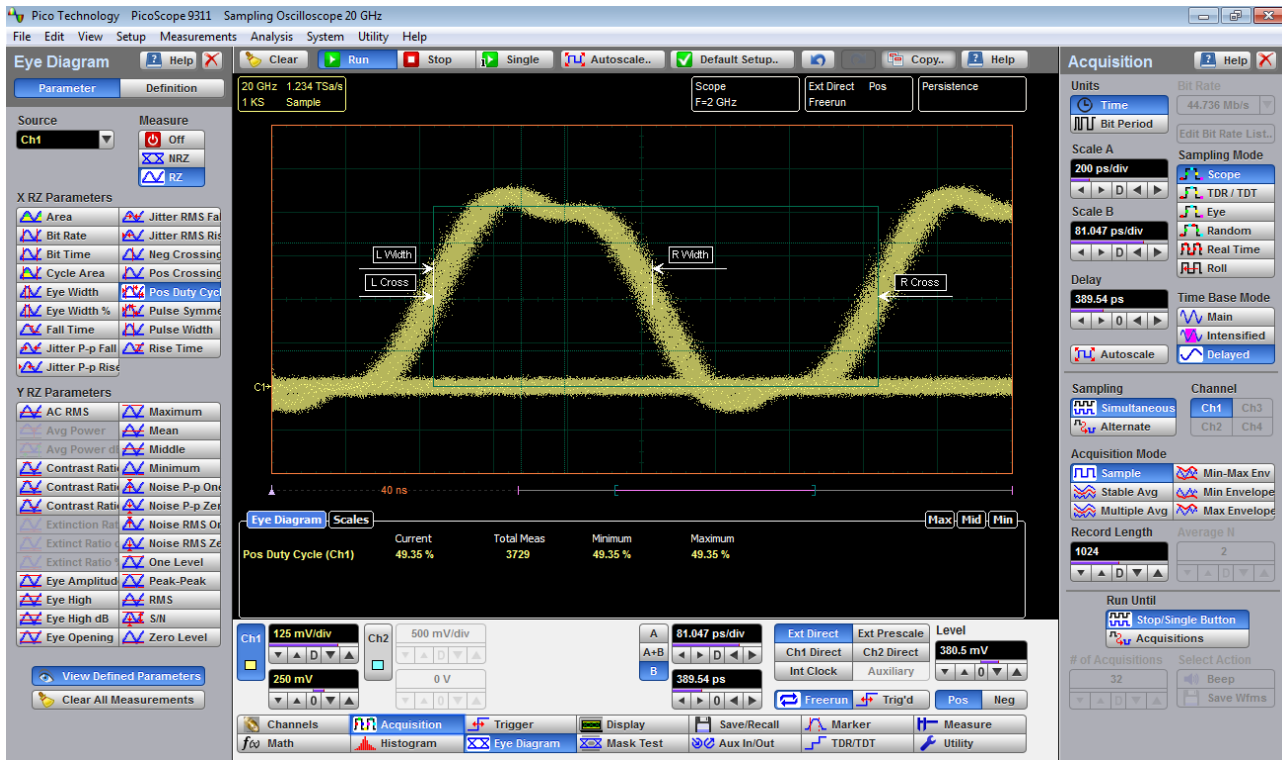
RZ Positive Duty Cycle definition

The RZ Positive Duty Cycle is determined as follows:

$$RZ\_DutyCycle = \frac{T_{Fall\,50\%} - T1_{Rise\,50\%}}{T2_{Rise\,50\%} - T1_{Rise\,50\%}} = \frac{RZ\_PositivePulseWidth}{RZ\_BitTime}$$

Where $T1_{Rise50\%}$, $T1_{Fall50\%}$ and $T2_{Rise50\%}$ are the mean of the histogram of the first three consecutive crossings at the 50% reference level.

This measurement requires the use of a waveform database. When this measurement is turned on, it will automatically set the measurement system to use a waveform database if available.

7.5.1.5.12 RZ Pulse Symmetry
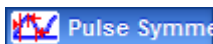
 Pulse Symme

RZ Pulse Symmetry measures to what extent the RZ pulse is symmetrical around the peak at the 50% reference level. The pulse peak is the center of the interval, sized to **Eye Aperture**, which yields the maximum mean vertical value.
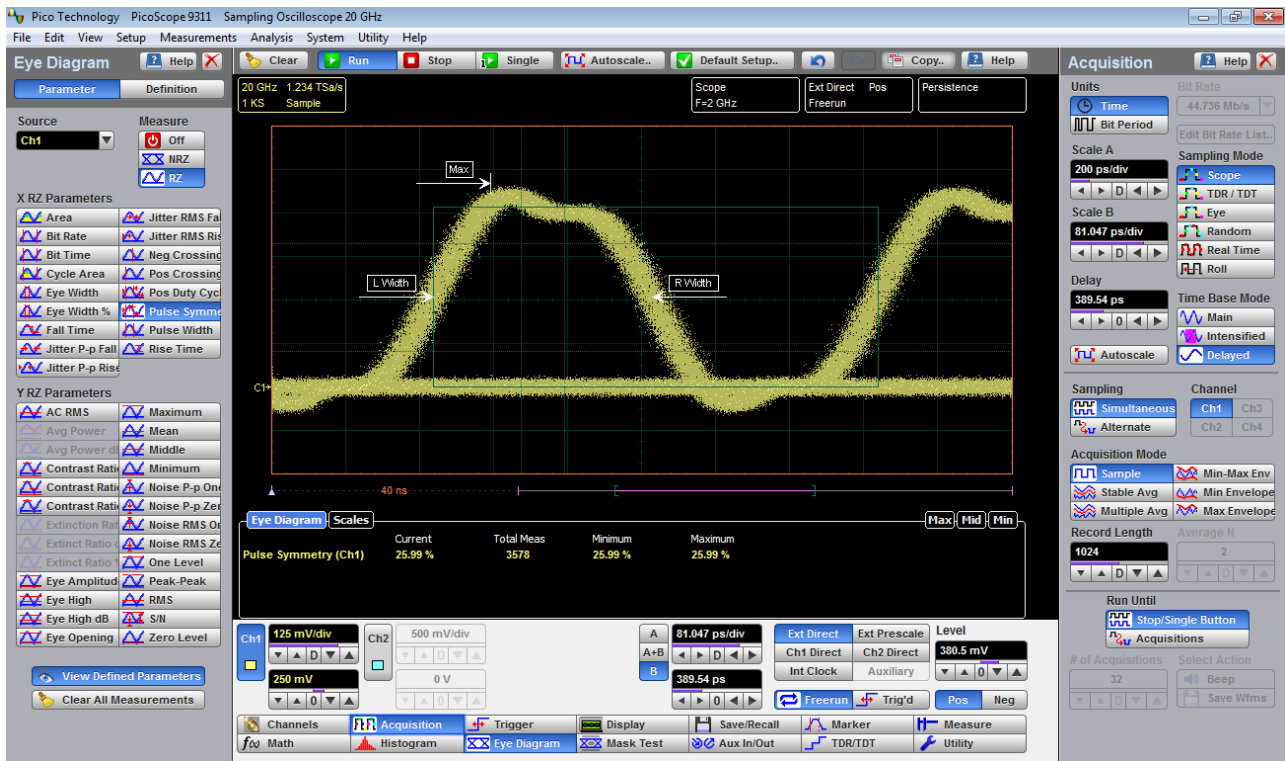
RZ Pulse Symmetry definition

The **RZ Pulse Symmetry (%)** is determined as follows:

$$RZ\_PulseSymmetry,\% = 100\frac{T_{Peak} - T_{Rise50\%}}{T_{Fall50\%} - T_{Rise50\%}}$$

where $T_{Rise50\%}$ and $T_{Fall50\%}$ are the time crossings of the RZ pulse of the 50% reference level, and T_{Peak} is the time coordinate of the pulse peak.

This measurement requires the use of a waveform database. When this measurement is turned on, it will automatically set the measurement system to use a waveform database if available.

7.5.1.5.13 RZ Pulse Width
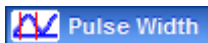
RZ Pulse Width is the time measured between histogram means of the 50% rising and 50% falling edges of an RZ eye diagram.
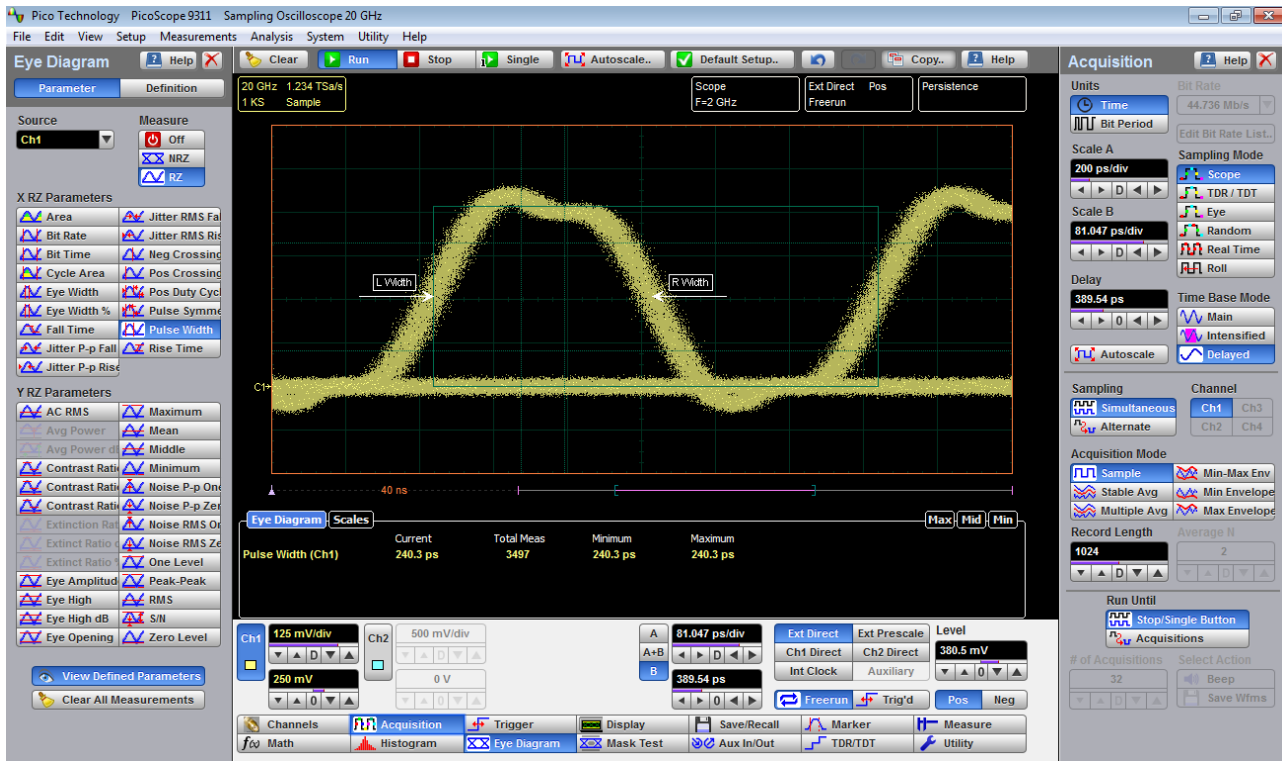
RZ Pulse Width definition

The pulse width is determined as follows:

$$RZ\ Pulse\ Width = T_{Fall50\%} - T_{Rise50\%}$$

where $T_{Fall50\%}$ and $T_{Rise50\%}$ are the time crossings of the RZ pulse at the 50% reference level.

This measurement requires the use of a waveform database. When this measurement is turned on, it will automatically set the measurement system to use a waveform database if available.

7.5.1.5.14 RZ Rise Time
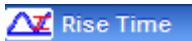
△↗ Rise Time

RZ Rise Time is a measure of the mean transition time of the data on the upward slope of an RZ eye diagram. The data crosses through the lower, middle, and upper thresholds.
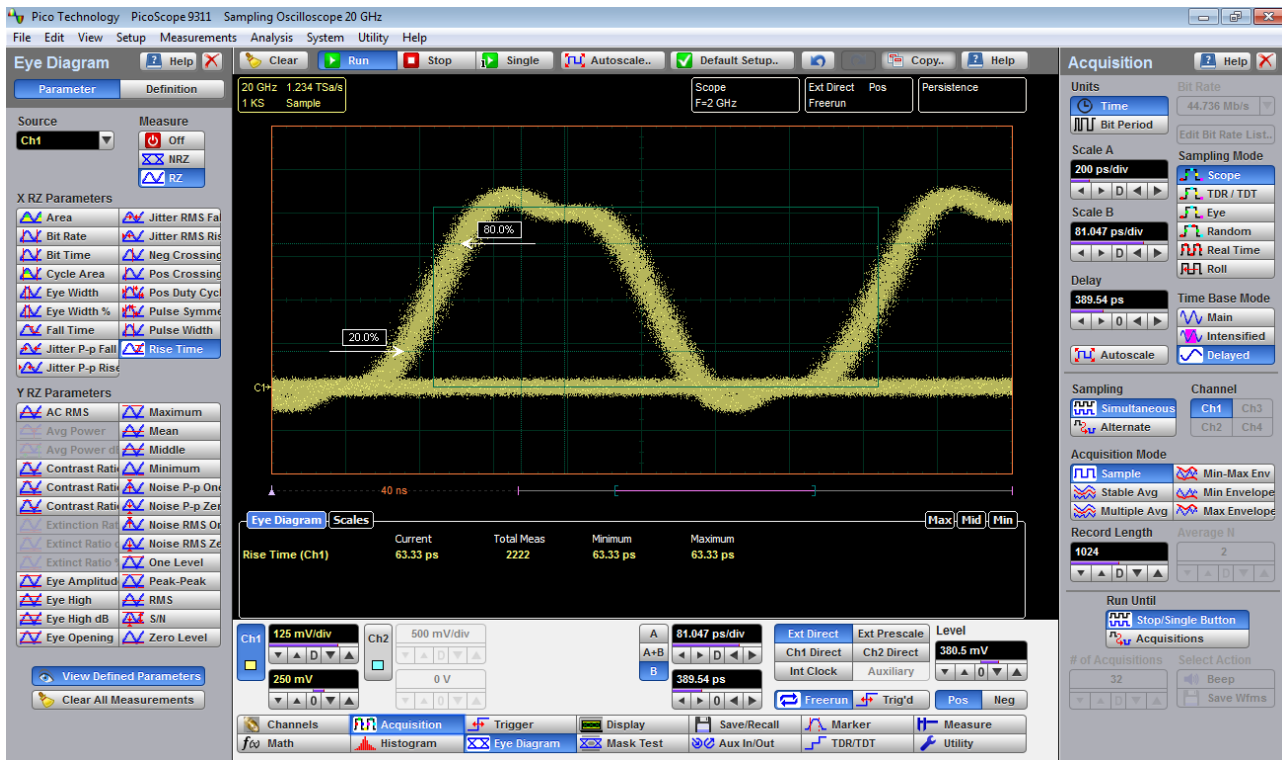
RZ Rise Time definition

A histogram is first constructed to find the mean locations of the eye one level and zero level. Histograms are then constructed at each of the three threshold levels (for example, the 20%, 50%, and 80% points on the transition). The instrument analyzes each histogram to determine the histogram mean at which the data crosses the separate threshold levels. Once the scanning of the waveform is complete, and the instrument has identified the mean location for each threshold crossed, then fall time can be computed:

RZ Rise Time = (Time at the Upper Threshold Crossing) –
(Time at the Lower Threshold Crossing)

The default setting for the threshold levels is between the 20% and 80% points on the transition. These levels give more consistent results for eyes with distortion at the top or bottom. You can define the threshold settings that you want in the **Define Parameters** menu.

> ℹ If the rise time relative to the time per division is a small value, the data acquired at the threshold levels on the falling edge will not yield accurate measurement results. (The rising edge will appear very steep on the display screen).
>
> If the rising edge of your eye diagram is steep, increase the timebase (horizontal scale) on the display so that the rising edge covers at least half a graticule division. The instrument will be able to discern the data at the threshold levels, producing more accurate results.

7.5.1.6   Y RZ Eye Parameters

The list of **Y RZ Eye Parameters** includes twenty-six eye parameters. Two of the them (**Avg Power** and **Avg Power dBm**) can be used with optical models only.

> ℹ️ You can perform up to ten simultaneous measurements on one displayed waveform.

The measurement algorithms for **Y RZ Eye Parameters** will only work when an RZ eye diagram, and not an NRZ eye diagram or a pulse, is present on the screen. Eye measurements are based on statistical data that is acquired and stored in the measurement database. The algorithms depend upon histogram means calculated from the measurement database. Therefore, if you want to perform eye measurements, it is necessary that you first produce an eye diagram by triggering the instrument with a synchronous clock signal. Measurements made on NRZ eye diagram or a pulse waveform while in the **X RZ Eye Parameters** menu will fail.

7.5.1.6.1   RZ AC RMS
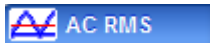
AC RMS

RZ AC RMS is a measure of the root mean square amplitude, minus the DC component, of the waveform within the eye window.
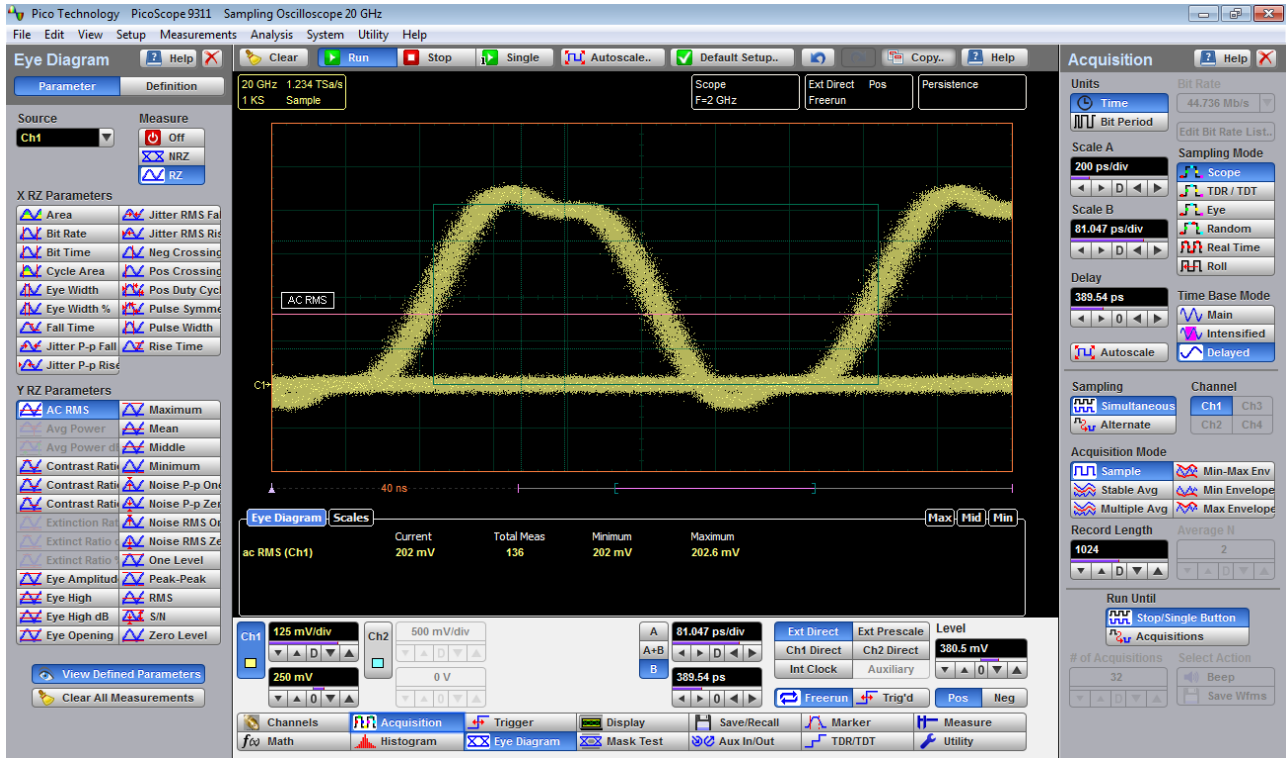
RZ AC RMS definition

The **RZ AC RMS** is determined as follows:

$$RZ\_AC\_RMS = \sqrt{\frac{\sum_{i=1}^{N}\left\langle[VertPos(s_n) - mean[VertPos(s)]]\right\rangle^2}{N}}$$

where S is the set of N samples $s_{1...N}$ within the measured region.

This measurement requires the use of a waveform database. When this measurement is turned on, it will automatically set the measurement system to use a waveform database if available.

7.5.1.6.2 RZ Contrast Ratio, RZ Contrast Ratio dB and RZ Contrast Ratio %
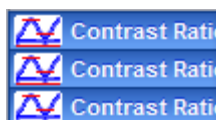
RZ Contrast Ratio is a measure of the ratio of the one level at the center of the eye diagram to the one level (after removal of the zero level contribution) found midway between eye diagram peaks. This measurement indicates how well the logic 1 levels return to the logic zero level. Like the RZ extinction ratio measurement, contrast ratio relies on determining and removing the dark level components from the measurement calculation. In order to perform an accurate contrast ratio measurement, you should first perform an extinction ratio calibration in order to minimize the dark level contribution.

RZ Contrast Ratio also is called **RZ Suppression Ratio**.

RZ Contrast Ratio measurement is made in a section of the eye referred to as the **Eye Boundaries**, and at the center of the zero level between pulses. The default value for **RZ Eye Boundaries** is the central 5% p-p of the Bit Time, or 47.5% (**Eye Boundary 1**) and 52.5% (**Eye Boundary 2**).

Histograms are constructed using the sampled portions of the eye diagram within the eye window boundaries, and within equivalent eye window boundaries positioned between eye diagram peaks. The one level histogram mean is composed of data points taken from the upper half of the eye window located within the eye diagram, the zero level histogram is composed of data points taken from the lower half of the eye window located within the eye diagram, and the remaining histogram is composed of data points taken from the eye window located between peaks. The instrument analyzes the histogram data, removes the zero level data from the between peaks histogram, then determines the ratio of the one level mean and the one level mean between peaks.

The accuracy of the contrast ratio measurement can be affected by offsets, including the dark level, generated within the instrument electronics, typically following the photodiode. When these offsets occur, they add to the incoming signal. This will change the values of the one and zero levels. When the contrast ratio measurement is computed, the result may appear much smaller or larger than the true value, depending on the value of the offset. To minimize contrast ratio measurement errors due to offsets, an extinction ratio calibration is recommended. This procedure allows the instrument to identify any internal signals present and remove them during the contrast ratio calculations. After the calibration is performed, a more accurate contrast ratio measurement can be executed.

With a valid extinction ratio calibration, the contrast ratio measurement can be computed and displayed in one of the three following formats:

$$NRZ\_ContrastRatio = \frac{OneLevel - DarkLevel}{OneLevel(between\_peaks) - DarkLevel}$$

$$NRZ\_ContrastRatio(dB) = 10\log_{10}[\frac{OneLevel - DarkLevel}{OneLevel(between\_peaks) - DarkLevel}]$$

$$NRZ\_ContrastRatio(\%) = \frac{OneLevel(between\_peaks) - DarkLevel}{OneLevel - DarkLevel} \times 100$$

where: *One Level* = One level histogram mean at eye window, *One Level (between peaks)* = Histogram mean calculated from subtraction of zero level histogram from the between peaks histogram (see figure below).
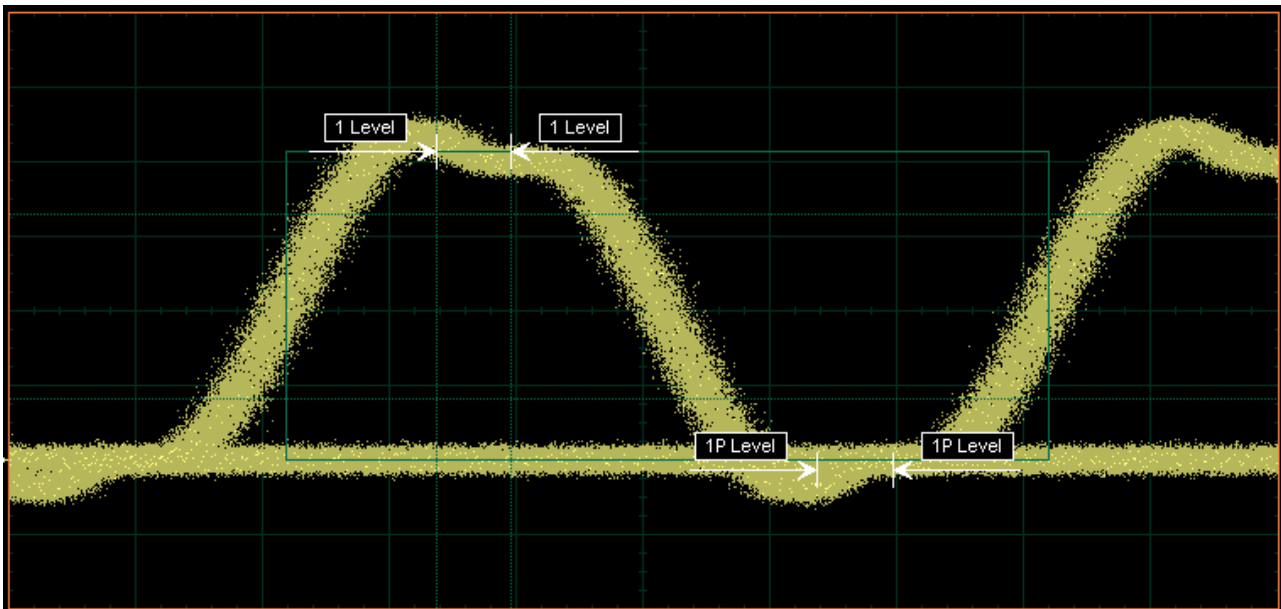
RZ Contrast Level: One Level and One Level between Peaks definition

7.5.1.6.3   RZ Extinction Ratio dB, RZ Extinction Ratio % and RZ Extinction Ratio

⟋⟍	Extinction Rat
⟋⟍	Extinct Ratio (
⟋⟍	Extinct Ratio %

RZ Extinction Ratio is a measure of the ratio of the one level and the zero level of an RZ eye diagram. The accuracy of this measurement relies on determining and removing the dark level components from the measurement calculation. In order to perform an accurate extinction ratio measurement, you should first perform an extinction ratio calibration in order to minimize the dark level contribution.

RZ Extinction Ratio measurement is made in a section of the eye referred to as **the Eye Boundaries**, and at the center of the zero level between pulses. The default value for **RZ Eye Boundaries** is the central 5% p-p of the **Bit Time**, or 47.5% (**Eye Boundary 1**) and 52.5% (**Eye Boundary 2**).

Histograms are constructed using the sampled portions of the eye diagram within the eye window boundaries. One histogram is composed of data points from only the upper half of the eye diagram (one level), and the second histogram is composed of data points from the lower half of the eye (zero level). The instrument analyzes the histograms and determines the histogram means.

The accuracy of the extinction ratio measurement can be affected by offsets, including the dark level, generated within the instrument electronics, typically following the photodiode. When these offsets occur, they add to the incoming signal. This will change the values of the one and zero levels. When the extinction ratio measurement is computed, the result may appear much smaller or larger than the true value, depending on the value of the offset. To minimize extinction ratio measurement errors due to offsets, an extinction ratio calibration is recommended. This procedure allows the instrument to identify any internal signals present and remove them during the extinction ratio calculations. After the calibration is performed, a more accurate extinction ratio measurement can be executed.

With a valid extinction ratio calibration, the extinction ratio measurement is computed and can be displayed in one of the three following formats:

$$RZ\_ExtinctionRatio(dB) = 10\log_{10}\left[\frac{OneLevel(eye\_center) - DarkLevel}{ZeroLevel(eye\_center) - DarkLevel}\right]$$

$$RZ\_ExtinctionRatio(\%) = \frac{ZeroLevel(eye\_center) - DarkLevel}{OneLevel(eye\_center) - DarkLevel} \times 100$$

$$RZ\_ExtinctionRatio = \frac{OneLevel(eye\_center) - DarkLevel}{ZeroLevel(eye\_center) - DarkLevel}$$

All three **RZ Extinction Ratio** measurements can be used in optical models only.

7.5.1.6.4   RZ Eye Amplitude
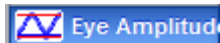
 Eye Amplitude

RZ Eye Amplitude is a measure of the difference between the logic 1 level and the logic 0 level histogram mean values of an RZ eye diagram. It differs from eye height in that it does not account for the noise on the signal.
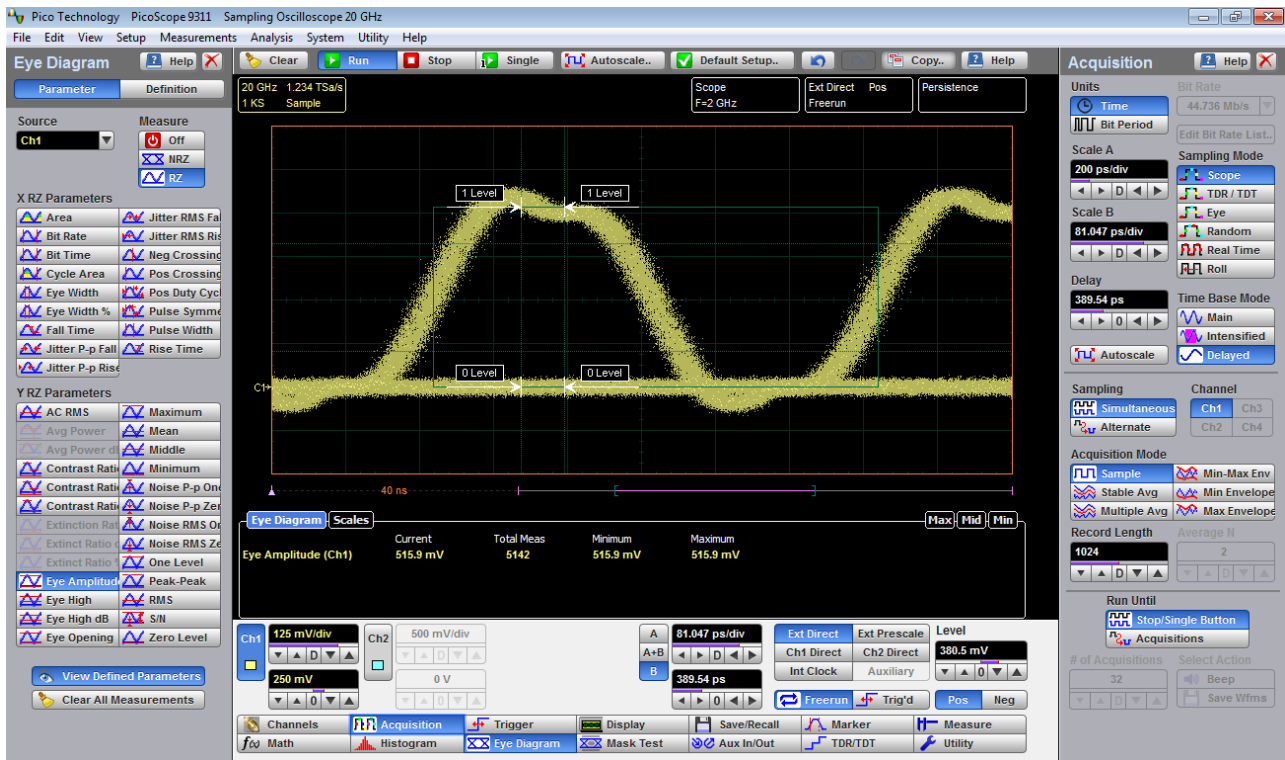
RZ Eye Amplitude definition

RZ Eye Amplitude measurement is made in a section of the eye referred to as the **Eye Boundaries**, and at the center of the zero level between pulses. The default value for **RZ Eye Boundaries** is the central 5% p-p of the **Bit Time**, or 47.5% (**Eye Boundary 1**) and 52.5% (**Eye Boundary 2**).

A histogram is constructed using the sampled portion of the eye diagram within the eye window. This histogram is composed of data points from the upper and lower halves of the eye diagram. The instrument analyzes the histogram and determines the mean values of the logic 1 and logic 0 levels.

The eye amplitude is determined as follows:

RZ Eye Amplitude = One Level – Zero Level

7.5.1.6.5   RZ Eye Height and RZ Eye Height dB
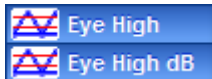
RZ Eye Height is a measure of the vertical opening of an RZ eye diagram. An ideal eye opening would be measured from the one level to the zero level, but noise on the eye causes the eye to close. The eye height measurement determines eye closure due to noise.
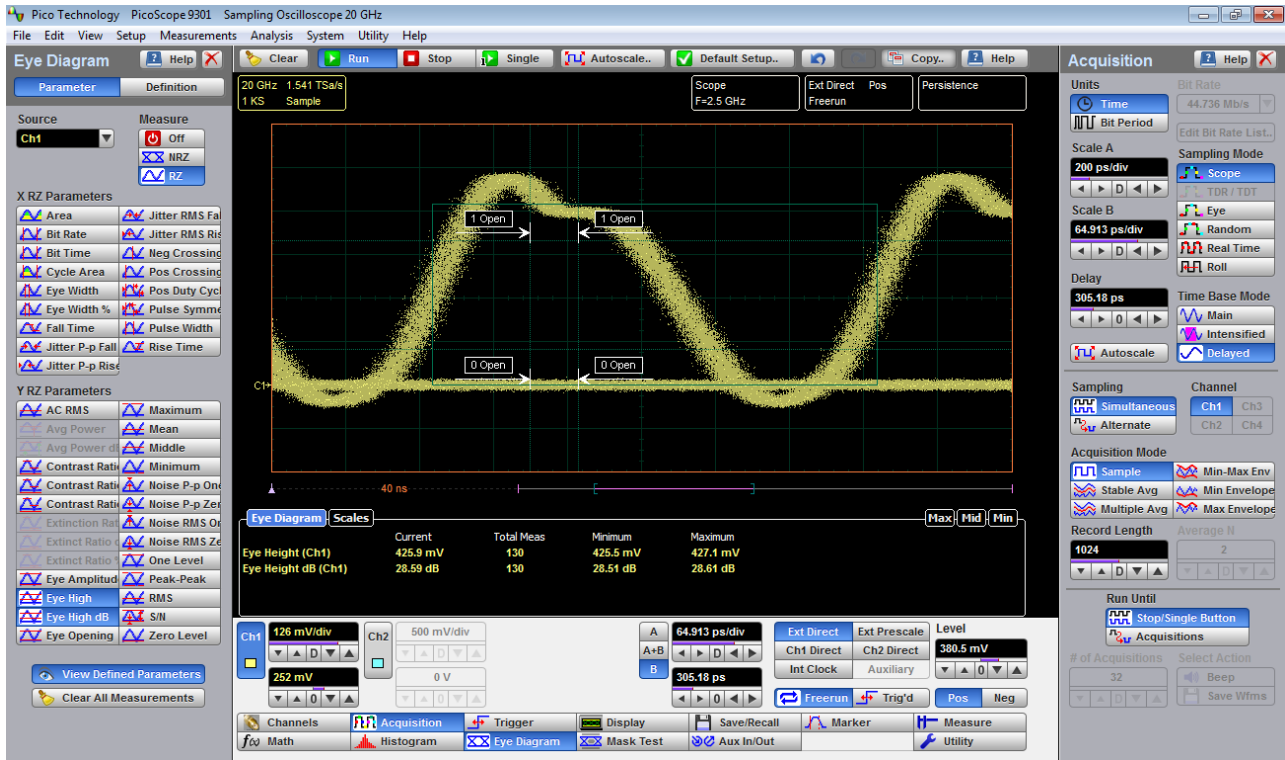
RZ Eye High definition

RZ Eye High measurement is made in a section of the eye referred to as the **Eye Boundaries**, and at the center of the zero level between pulses. The default value for **RZ Eye Boundaries** is the central 5% p-p of the **Bit Time**, or 47.5% (**Eye Boundary 1**) and 52.5% (**Eye Boundary 2**).

In order to make an accurate RZ eye height measurement, histograms are constructed to characterize both the one and zero levels and their noise levels within the eye window boundaries. The one and zero levels are the relative means of the histograms. The noise is measured through the histograms as three standard deviations (σ) from both the one level and zero level into the eye opening.

The eye height is determined as follows:

$$RZ\_EyeHeight = (OneLevel - 3\sigma_{one}) - (ZeroLevel + 3\sigma_{zero})$$

$$RZ\_EyeHeight(dB) = -10\log_{10}\frac{(ZeroLevel + 3\sigma_{zero})}{(OneLevel - 3\sigma_{one})}$$

7.5.1.6.6 RZ Eye Opening
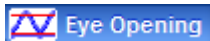
 Eye Opening

RZ Eye Opening Factor is similar to eye height. It measures the actual eye opening relative to an ideal noise-free eye. While the eye height measurement uses 3 for the noise contribution, the eye opening measurement uses 1.
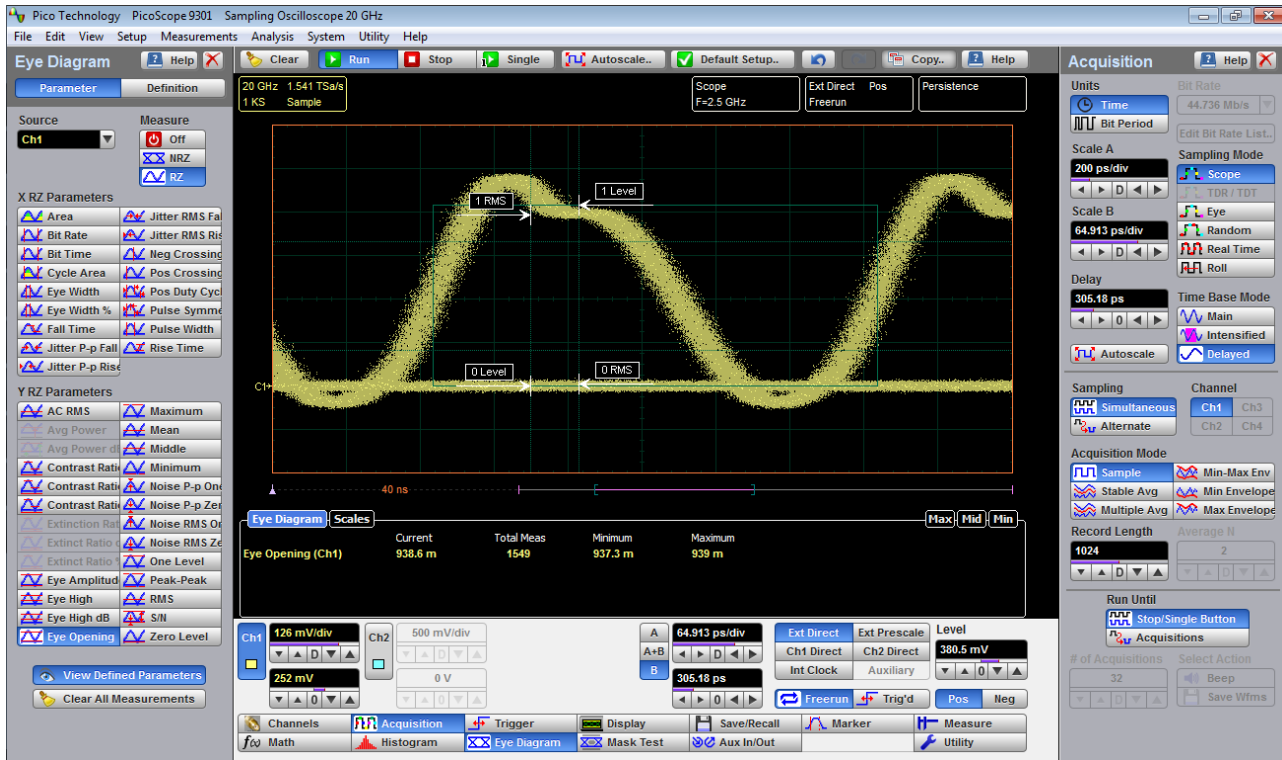
RZ Eye Opening Factor definition

The **RZ Eye Opening Factor** measurement is made in a section of the eye referred to as the **Eye Boundaries**, and at the center of the zero level between pulses. The default value for **RZ Eye Boundaries** is the central 5% p-p of the **Bit Time**, or 47.5% (**Eye Boundary 1**) and 52.5% (**Eye Boundary 2**).

The eye opening factor is determined as follows:

$$RZ\_EyeOpeningFactor = -\frac{(OneLevel - \sigma_{one}) - (ZeroLevel + \sigma_{zero})}{OneLevel - ZeroLevel}$$

7.5.1.6.7 RZ Maximum
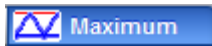
| Maximum |

RZ Maximum is a measure of the maximum vertical value of the waveform that is sampled within the eye window.
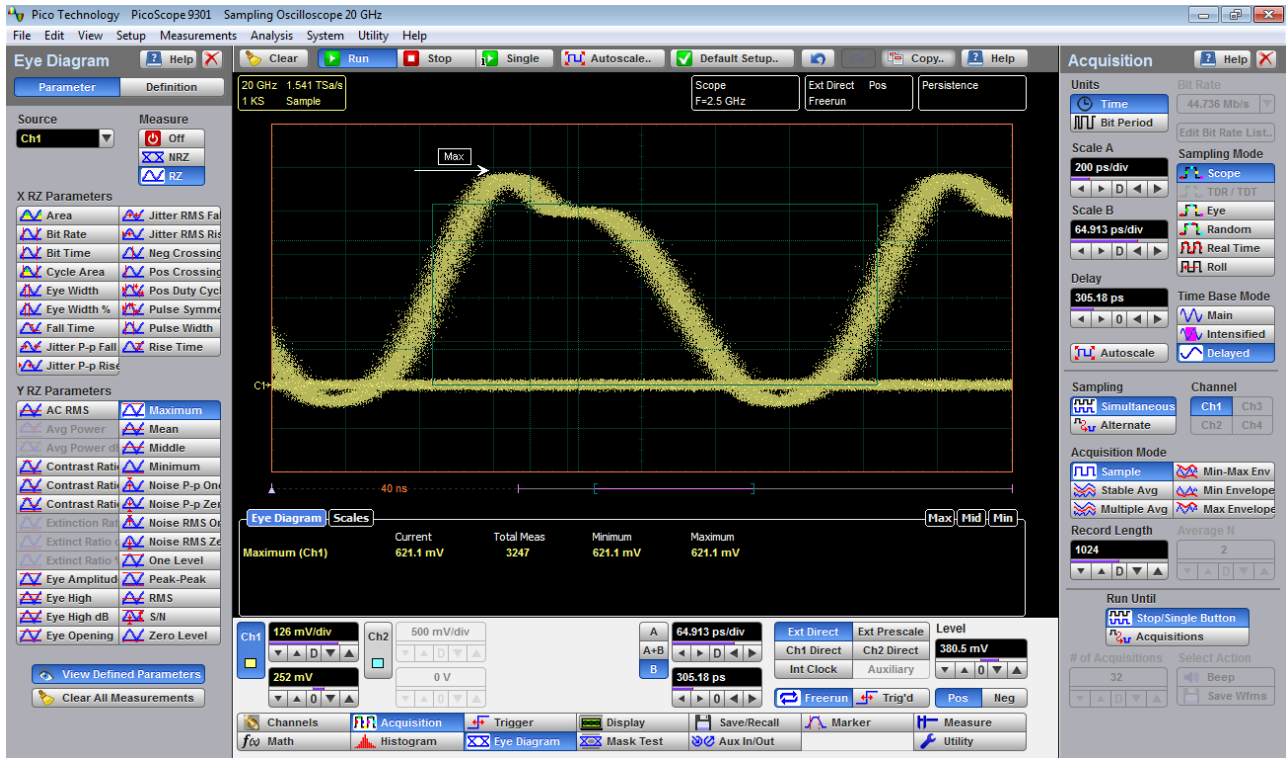
RZ Maximum definition

The RZ maximum eye amplitude is determined as follows:

$$RZ\ Maximum = max[VertPos(s)]$$

where *s* is the set of samples within the eye window.

When this measurement is turned on, it automatically sets the measurement system to use a waveform database if available.

7.5.1.6.8 RZ Mean
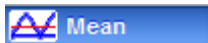


RZ Mean is a measure of the arithmetic mean of the waveform that is sampled within the eye window.
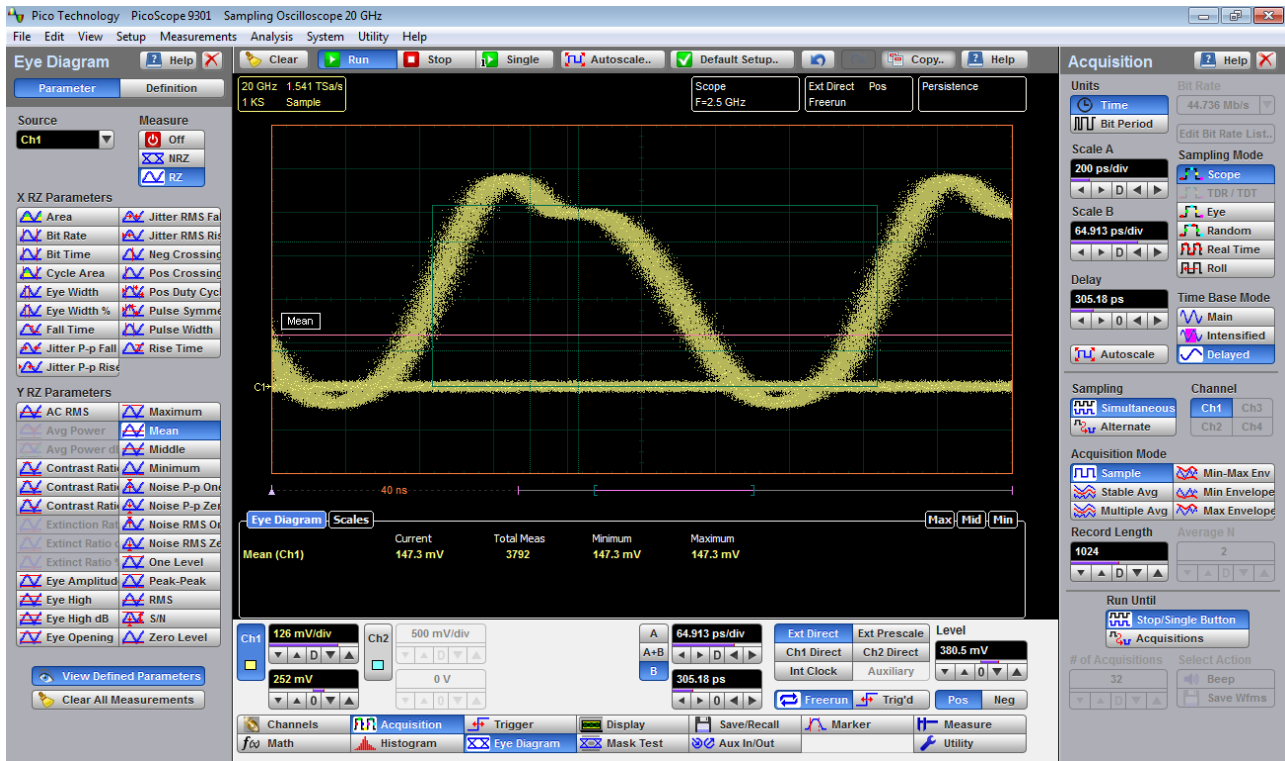
RZ Mean definition

The **RZ Mean** is determined as follows:

$$RZ\_Mean = mean[VertPos(s)] = \frac{1}{N}\sum_{i=1}^{N}VertPos(s_i)$$

over all samples $s_{i...N}$ within the eye window.

When this measurement is turned on, it automatically sets the measurement system to use a waveform database if available.

7.5.1.6.9 RZ Middle

RZ Middle is a measure of the middle level between the **Max** and **Min** vertical values of the waveform that is sampled within the eye window.
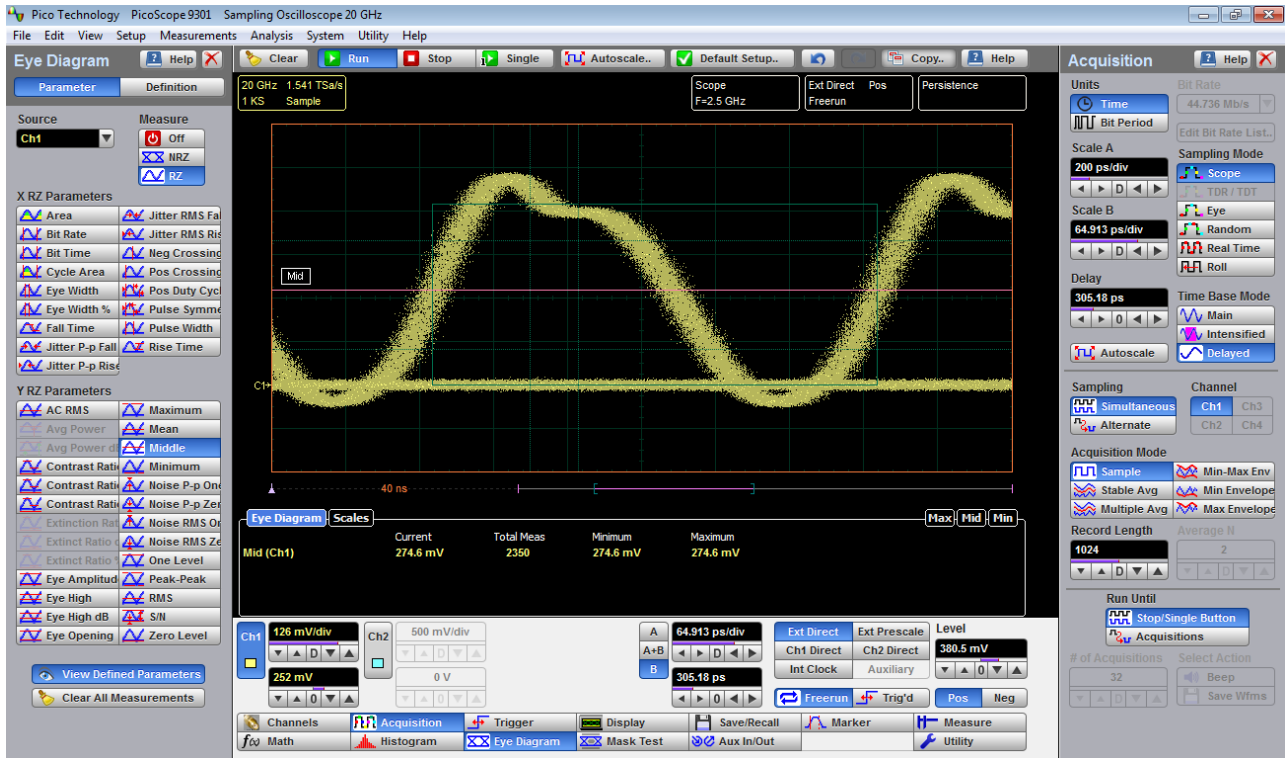
RZ Middle definition

The **RZ Middle** is determined as follows:

$$RZ\ Mid = (Max + Min) / 2$$

where *Max* and *Min* are the maximum and minimum measurements.

When this measurement is turned on, it automatically sets the measurement system to use a waveform database if available.

7.5.1.6.10 RZ Minimum

RZ Minimum is a measure of the minimum vertical value of the waveform that is sampled within the eye window.
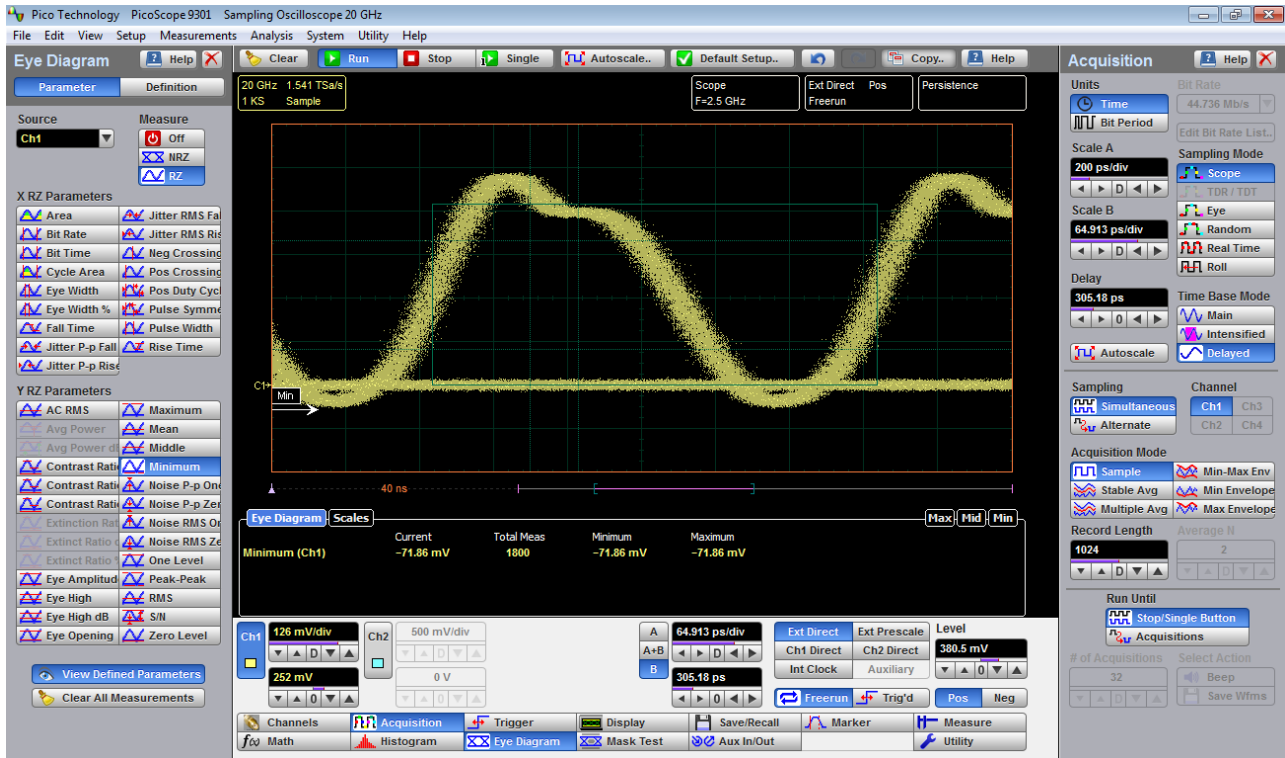
RZ Minimum definition

The RZ minimum eye amplitude is determined as follows:

$$RZ\ Minimum = max[VertPos(s)]$$

where **s** is the set of samples in the measured region. Minimum has no settable references.

When this measurement is turned on, it automatically sets the measurement system to use a waveform database if available.

7.5.1.6.11 RZ Noise P-p, One and RZ Noise P-p, Zero
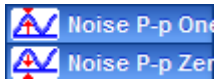
RZ Noise P-p, One is a measure of the maximum range of the data distribution sampled within a fixed **RZ Eye Boundaries** slice located at the center of the **Eye Aperture** at the **One Level**.

RZ Noise P-p, Zero is a measure of the maximum range of the data distribution sampled within a fixed **RZ Eye Boundaries** slice located at the center of the **Eye Aperture** at the **Zero Level**.
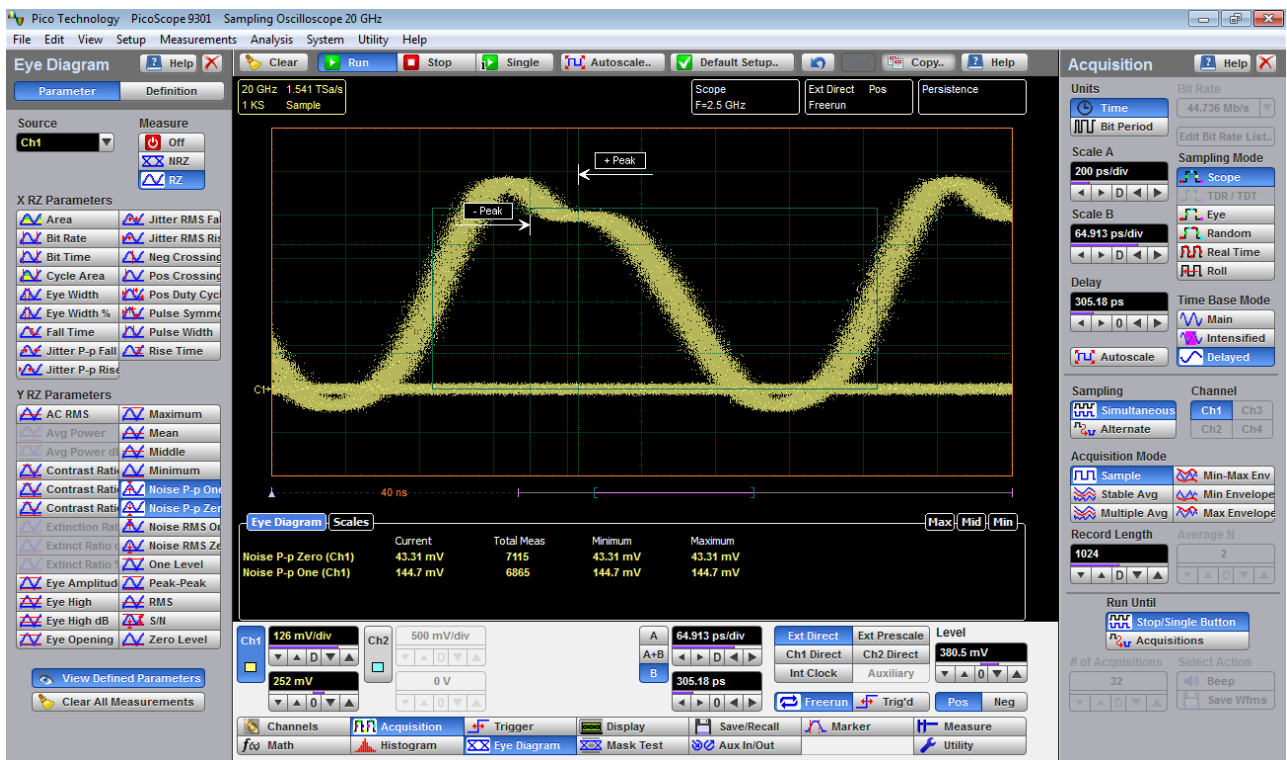
RZ Noise P-p, One definition
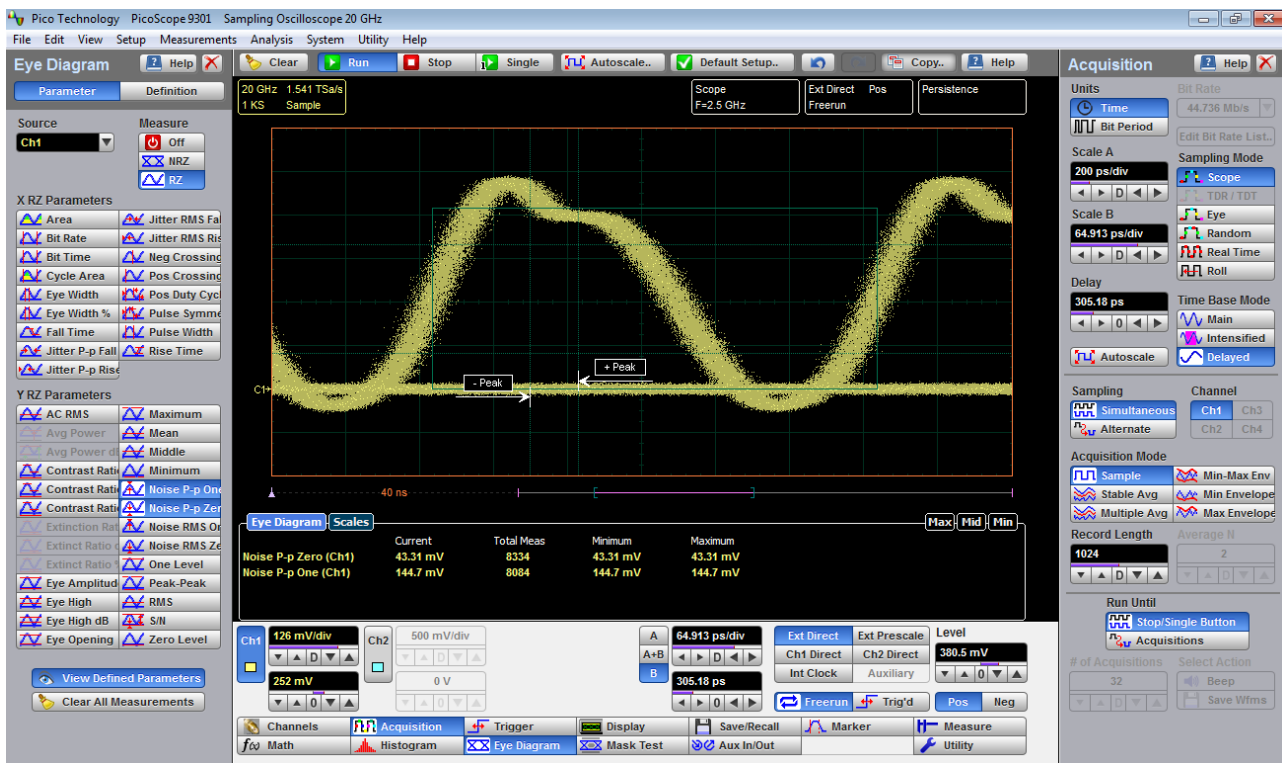
RZ Noise P-p, Zero definition

The **RZ Noise P-p** is determined as follows:

$$RZ\_Noise, P-p = \max[VertPos(s)] - \min[VertPos(s)]$$

where s is the set of samples within a fixed width vertical slice located at the center of the eye aperture at either the **High** or the **Low** level (settable: **RZ Noise P-p, One**, and **RZ Noise P-p, Zero**).

The **RZ Noise P-p, One** and **RZ Noise P-p, Zero** measurements are made in a section of the eye referred to as the **Eye Boundaries**, and at the center of the zero level between pulses. The default value for **RZ Eye Boundaries** is the central 5% p-p of the **Bit Time**, or 47.5% (**Eye Boundary 1**) and 52.5% (**Eye Boundary 2**).

This measurement requires the use of a waveform database. When this measurement is turned on, it automatically sets the measurement system to use a waveform database if available.

7.5.1.6.12 RZ Noise RMS, One and RZ Noise RMS Zero
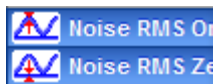
NRZ Noise RMS is a measurement of the single standard deviation of the data distribution sampled within a fixed-width vertical slice located at the center of the **Eye Aperture** at the **High** (logical 1) or **Low** (logical 0) levels.
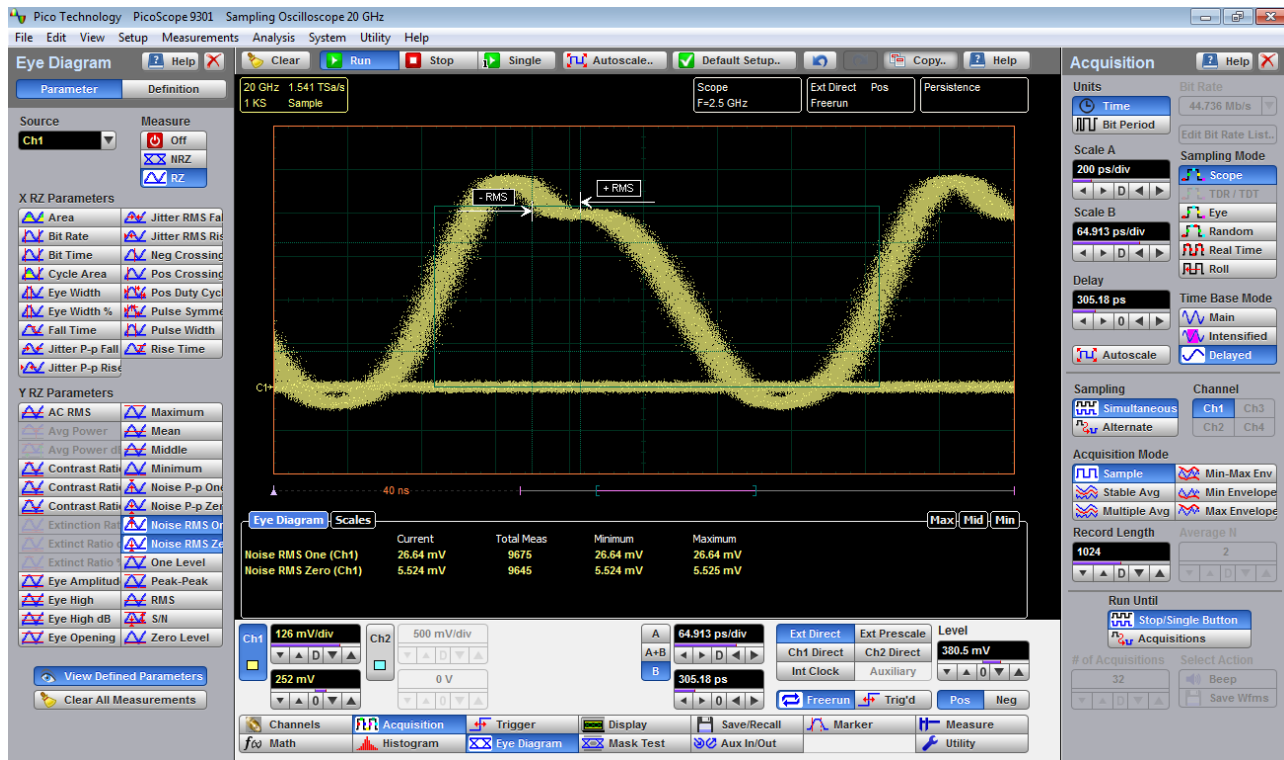
RZ Noise RMS, One definition
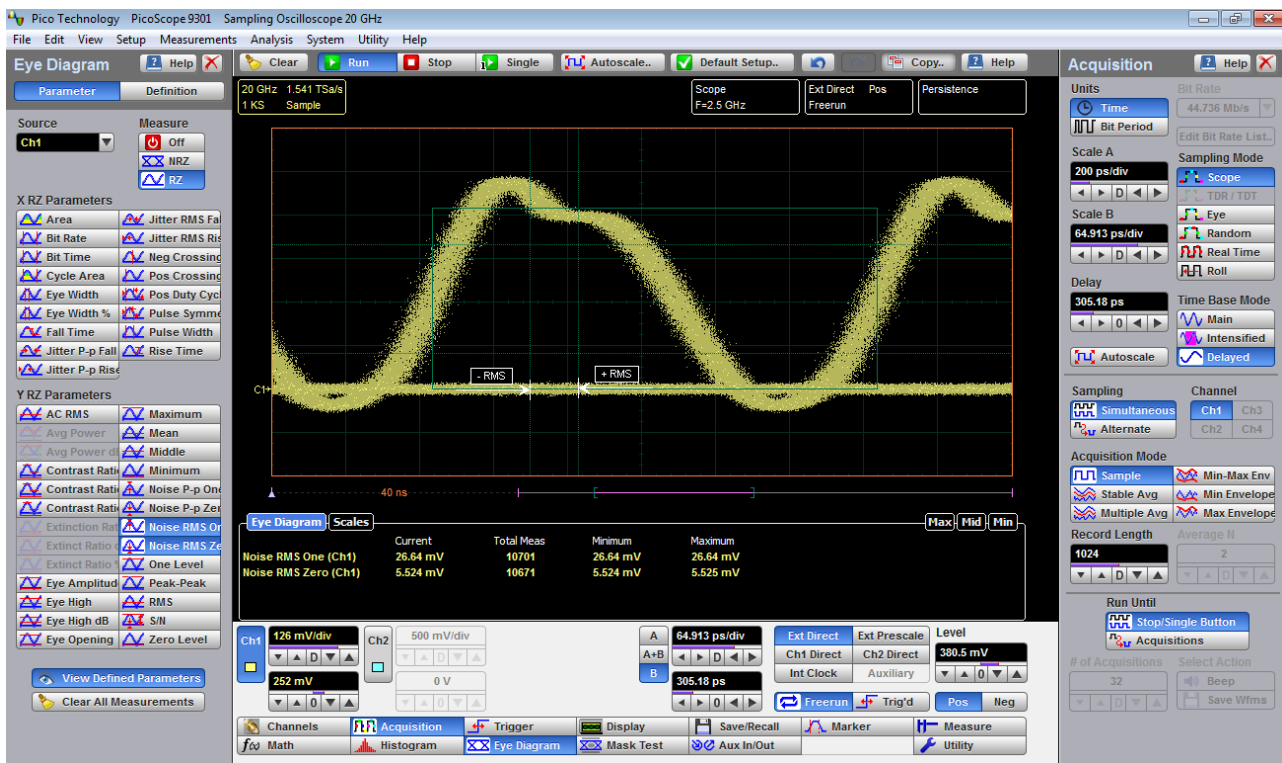
RZ Noise RMS, Zero definition

The **RZ Noise RMS** is determined as follows:

$$RZ\ RMS = High\ \acute{o}$$

$$RZ\ RMS = Low\ \acute{o}$$

The **Eye Aperture** is adjustable and defaults to 5% of the RZ pulse width. The **High** or **Low** selection for noise control in the **Measurement Setup** dialog instructs the measurement to be performed on the logical 1 or 0 levels.

This measurement requires the use of a waveform database. When this measurement is turned on, it automatically sets the measurement system to use a waveform database if available.

7.5.1.6.13 RZ One Level
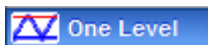
**RZ One Level** is a measure of the mean value found at the peak of the eye diagram logical 1.
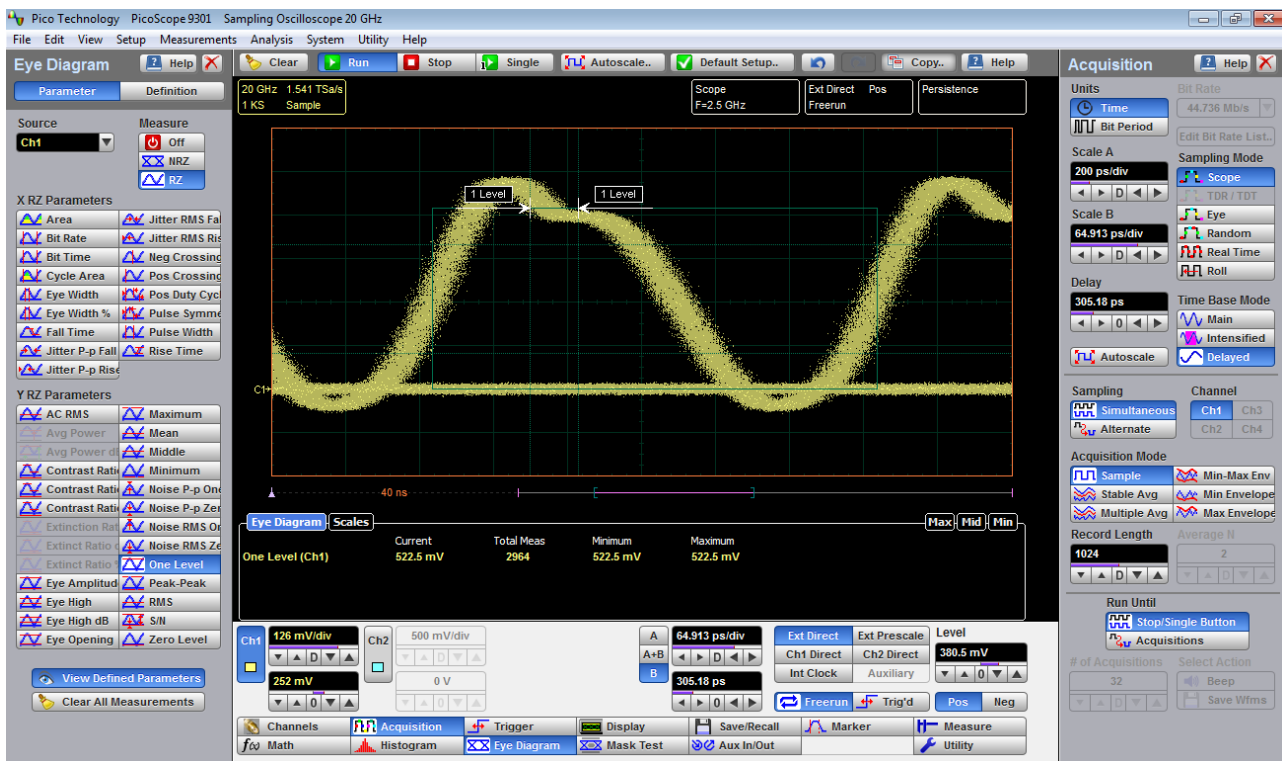
RZ One Level definition

The **RZ One Level** measurement is made in a section of the eye referred to as the **Eye Boundaries**, and at the center of the zero level between pulses. The default value for **RZ Eye Boundaries** is the central 5% p-p of the **Bit Time**, or 47.5% (**Eye Boundary 1**) and 52.5% (**Eye Boundary 2**).

A histogram is constructed using the sampled portion of the eye diagram within the eye window. This histogram is composed of data points from only the upper half of the eye diagram. The instrument analyzes the histogram and determines the histogram mean.

The **RZ One Level** is determined as follows:

RZ One Level = Histogram Mean

7.5.1.6.14 RZ Peak-Peak
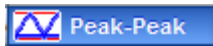
RZ Peak-Peak is a measure of the difference between the maximum and minimum vertical values of the waveform.
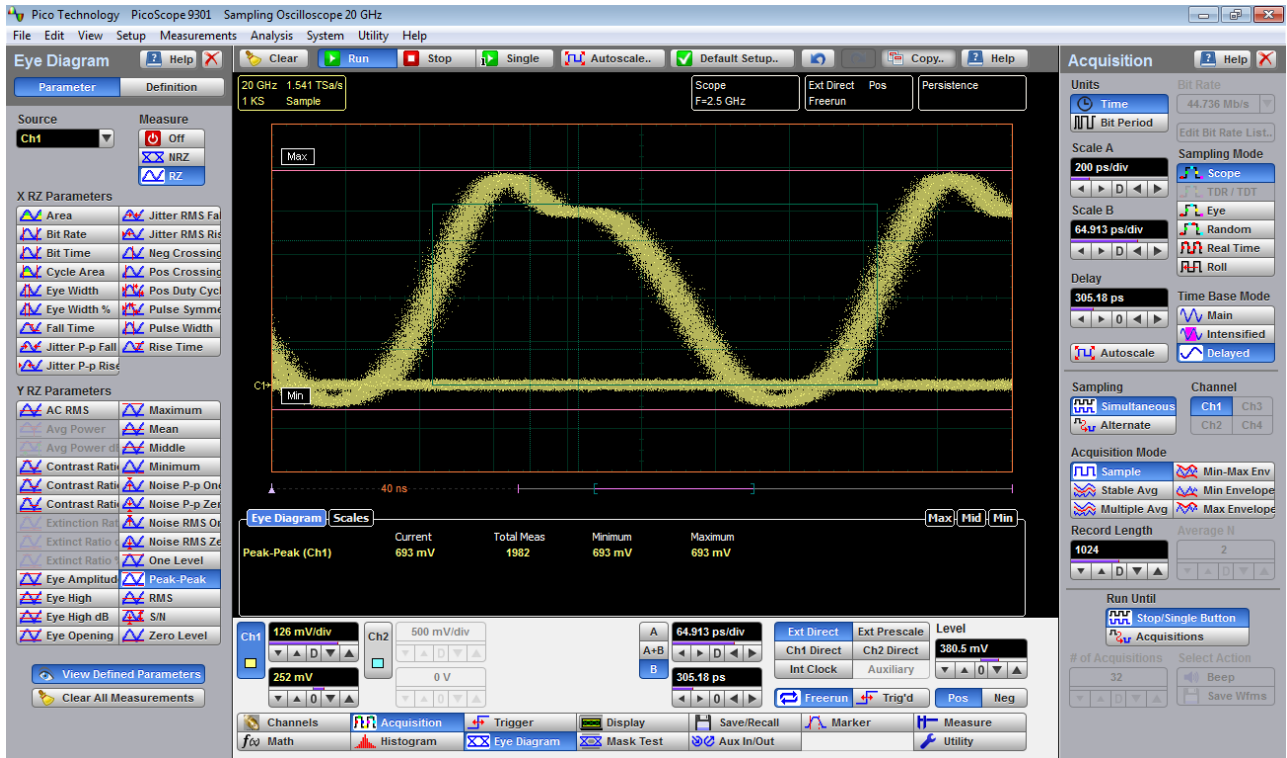
RZ Peak-Peak definition

The **RZ Peak-Peak** is determined as follows:

$$RZ\ Peak\text{-}Peak = Max - Min$$

where *Max* and *Min* are the maximum and minimum measurements.

7.5.1.6.15 RZ RMS
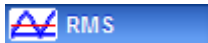
RZ RMS is a measure of the true root mean square of the waveform that is sampled within the eye window.
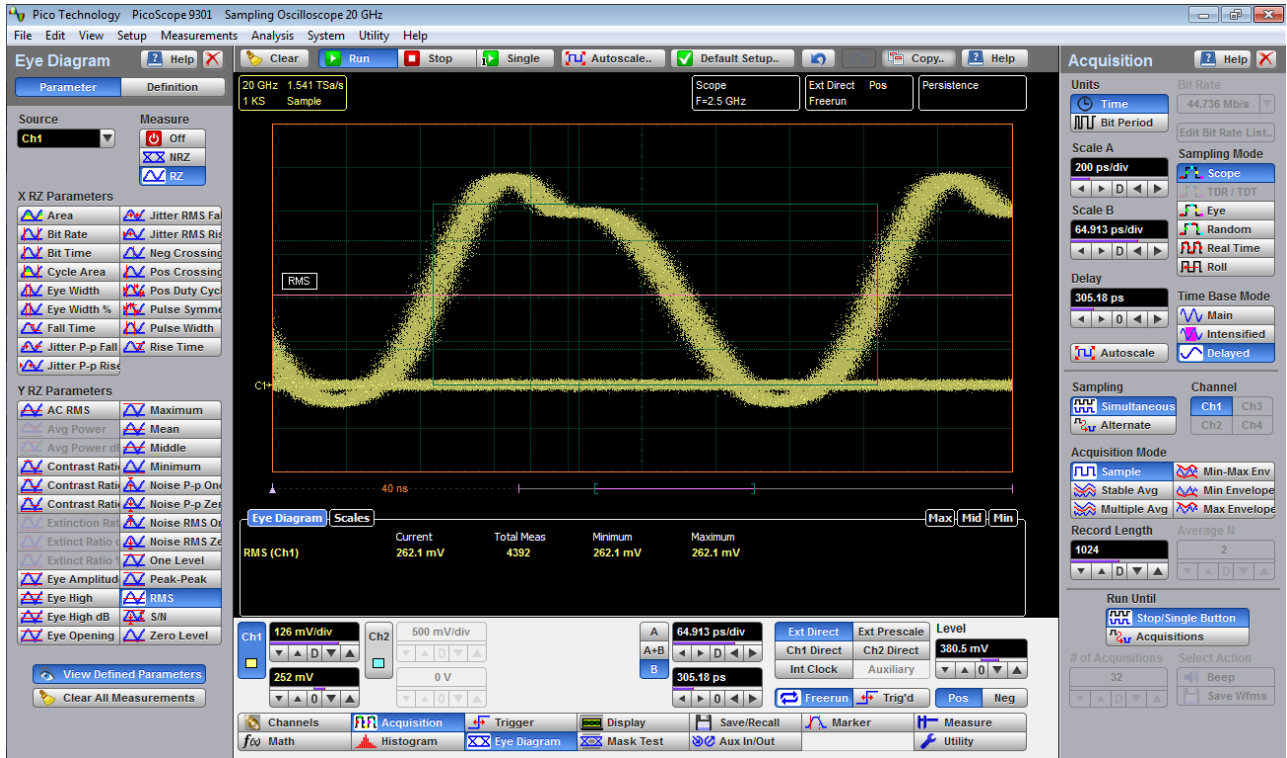
RZ RMS definition

The **RZ RMS** is determined as follows:

$$RZ\_RMS = \sqrt{\frac{\sum_{n=1}^{N}[VertPos(s_n)]^2}{N}}$$

which is the RMS amplitude over all N samples $s_{1...N}$ within the measured region (eye window); or one standard deviation of the amplitude.

When this measurement is turned on, it automatically sets the measurement system to use a waveform database if available.

7.5.1.6.16 RZ Signal to Noise

RZ Signal to Noise is a measure of the ratio of the signal difference between one level and zero level relative to the noise present at both levels. Signal-to-noise is similar in construction to a Q-factor measurement. However, noise levels contributed by the instrument cannot be removed, and therefore a slightly pessimistic **Q-factor** measurement may result.
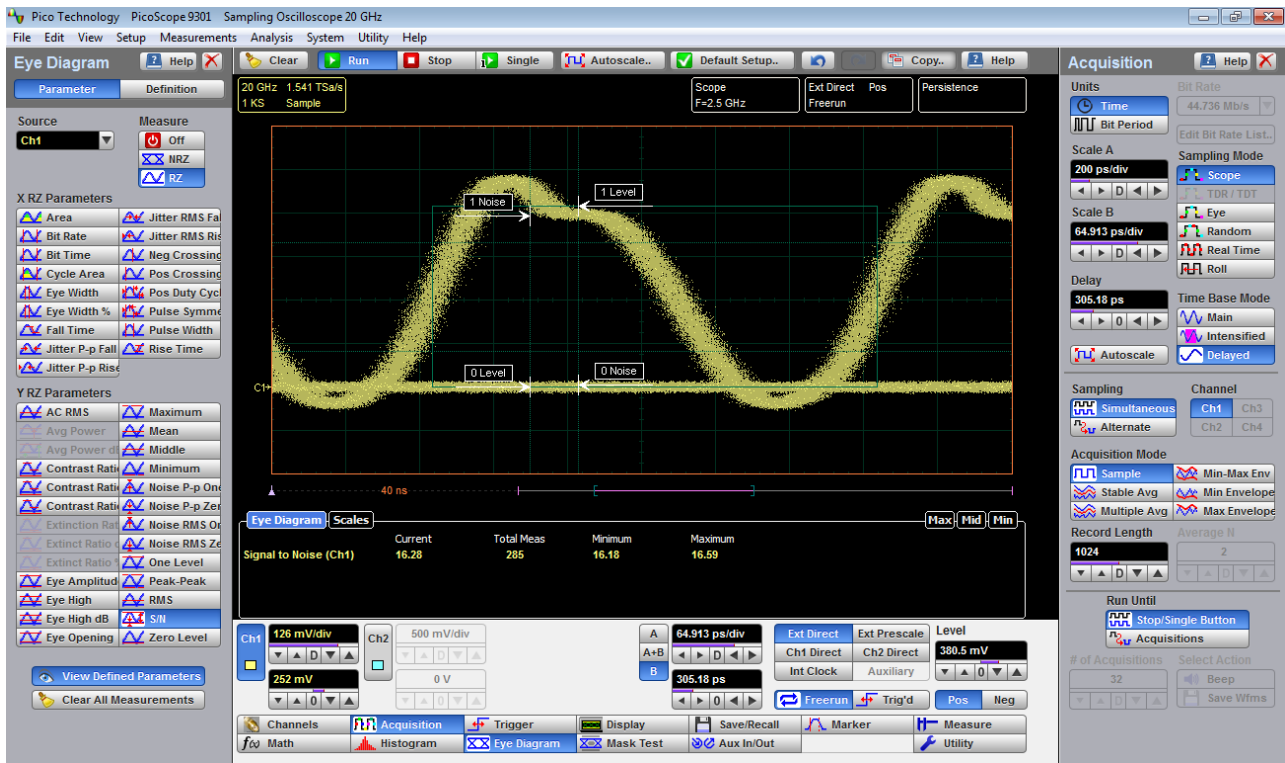
RZ Signal to Noise definition

RZ Signal to Noise ratio is computed as:

$$RZ\_Signal-to-Noise\_Ratio = \frac{OneLevel - ZeroLevel}{\sigma_{one} + \sigma_{zero}}$$

The **RZ One Level** and **Zero Level** measurements are made in a section of the eye referred to as the **Eye Boundaries**, and at the center of the zero level between pulses. The default value for **RZ Eye Boundaries** is the central 5% p-p of the **Bit Time**, or 47.5% (**Eye Boundary 1**) and 52.5% (**Eye Boundary 2**).

To define the signal, histograms are constructed using the sampled portions of the eye diagram within the eye window boundaries. One histogram is composed of data points from only the upper half of the eye diagram (one level), and the second histogram is composed of data points from the lower half of the eye (zero level). The instrument analyzes the histograms and determines the histogram means and standard deviations. The noise is defined as 1 (standard deviation) from the histogram means for the one and zero levels.

7.5.1.6.17 RZ Zero Level
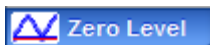
RZ Zero Level is a measure of the mean value of the logical 0 at a time position found directly below the peak of the eye diagram logical 1.
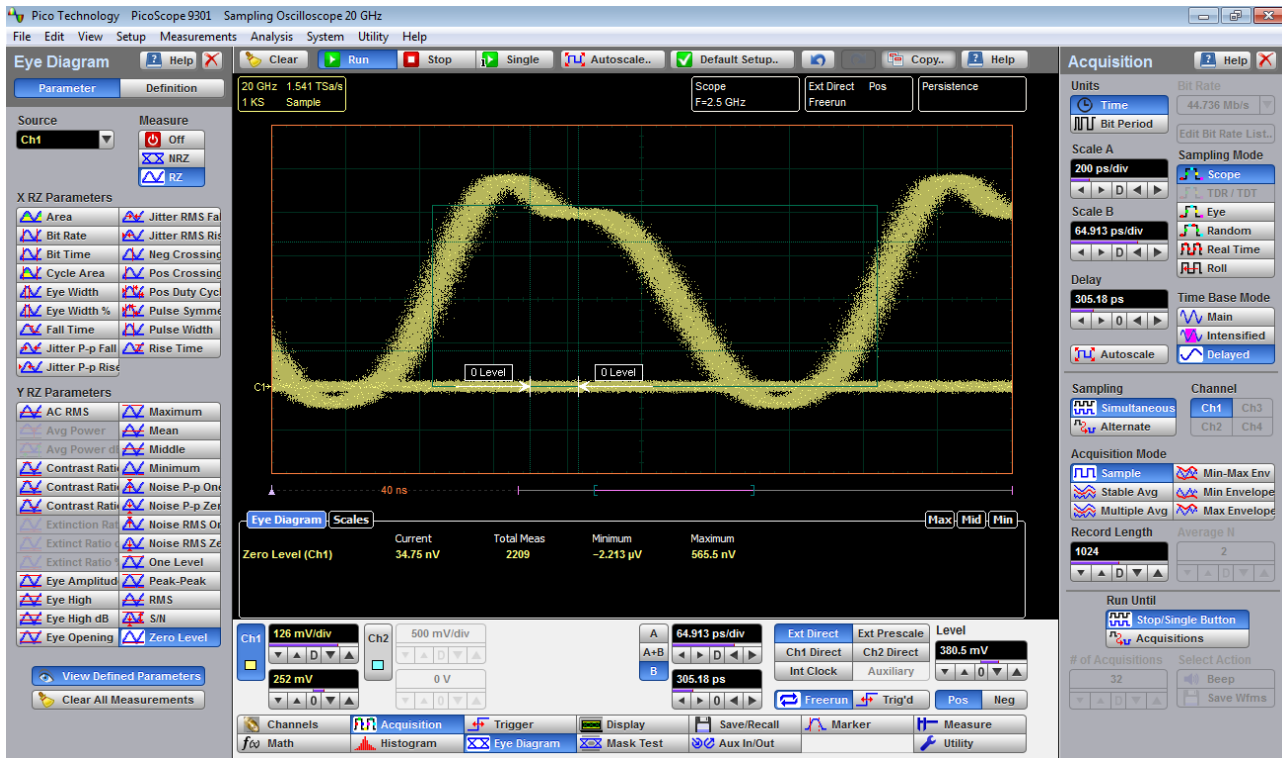
RZ Zero Level definition

The **RZ Zero Level** measurement is made in a section of the eye referred to as the **Eye Boundaries**, and at the center of the zero level between pulses. The default value for **RZ Eye Boundaries** is the central 5% p-p of the **Bit Time**, or 47.5% (**Eye Boundary 1**) and 52.5% (**Eye Boundary 2**).

A histogram is constructed using the sampled portion of the eye diagram within the eye window. This histogram is composed of data points from only the upper half of the eye diagram. The instrument analyzes the histogram and determines the histogram mean.

The **RZ Zero Level** is determined as follows:

$$RZ\ Zero\ Level = Histogram\ Mean$$

7.5.1.7 View Defined Parameters
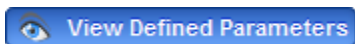
Setting **View Define Parameters** to **On** gives you a visual indicator of the calculation of the **Eye Window** placement. The **Eye Window** is green.

Setting the control to **Off** makes the **Eye Window** disappear.

7.5.1.8   Clear All Measurements
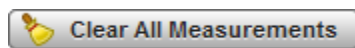
Clicking **Clear All Measurements** removes all measurement results from the **Measurement Area** located at the bottom of the oscilloscope display.

7.5.2   Definition
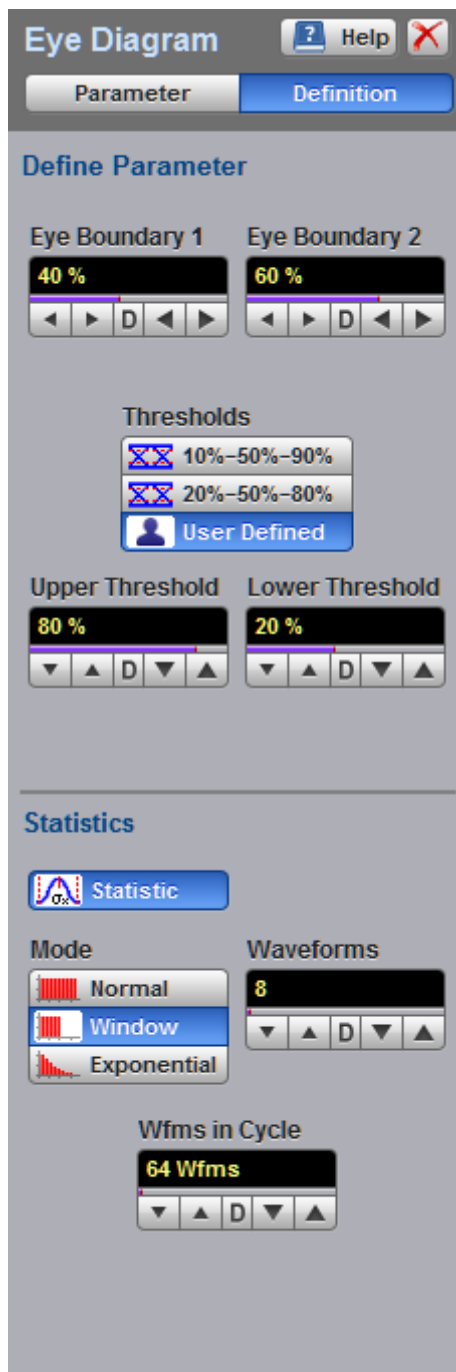
The Eye Diagram Definition menu

7.5.2.1   Define Parameters
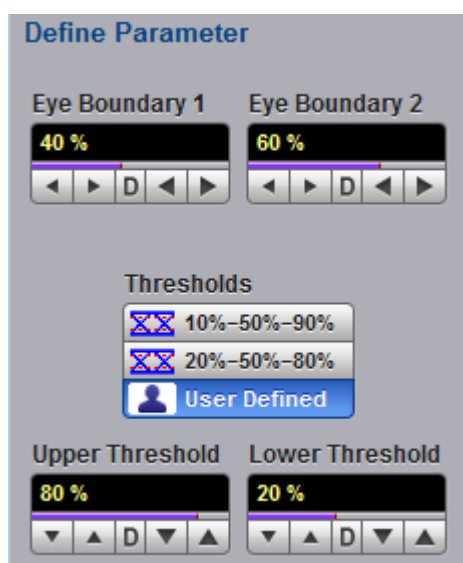
The **Define Parameters** menu sets the measurement points (boundaries and thresholds) where the automatic measurements are made. The menu influences the measurement algorithm by allowing you to use the standard measurement points, or customize the measurements with user-defined selections.

7.5.2.1.1   Eye Boundary 1 and Eye Boundary 2
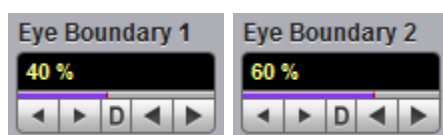
The **Eye Boundary 1** (left boundary) and the **Eye Boundary 2** (right boundary) variables set the time for the eye boundaries. These settings determine what horizontal portion of the eye will be used to generate histograms for eye diagram amplitude measurements. Both boundaries directly determine **One Level** and **Zero Level** values. You can use the instrument's default values of 40% and 60% for NRZ eye diagrams, and 47.5% and 52.5% for RZ eye diagrams, or you can enter the values you want for the boundaries.

Eye Boundary 1 allows you to set the percentage time for the left eye boundary, while **Eye Boundary 2** allows you to set the percentage time for the right eye boundary.

7.5.2.1.2   Thresholds
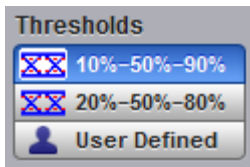
The **Thresholds** menu sets the upper, middle, and lower measurement points that the eye diagram measurements use for calculating the timing measurement results. For example, rise time is measured from the lower threshold to the upper threshold, while a RZ Pulse Width measurement is made between two middle thresholds.

Thresholds are not visible.

The three threshold choices are the standard measurement points:

- **10%-50%-90%**
- **20%-50%-80%**
- **User Defined**

The **Upper Threshold** and **Lower Threshold** variables are displayed when **User Defined** is selected. **Middle** threshold is fixed at the 50% level.

10%-50%-90% and **20%-50%-80%**

These are two standard pulse measurement thresholds for all measurements. These standard thresholds are calculated as a percentage of the **One-Zero Level** value, while the **One Level** and **Zero Level** values are calculated from the eye diagram that is on the display.

10%-50%-90% means: Lower threshold = 10%, Middle threshold = 50% and Upper threshold = 90%. Use these thresholds for typical eye diagrams.

20%-50%-80% means: Lower threshold = 20%, Middle threshold = 50% and Upper threshold = 80%. Use these thresholds for eye diagrams with excessive ringing or overshoot.

Make sure that the eye diagram is expanded vertically and horizontally so that the instrument can accurately determine the **One Level** and **Zero Level** values of the eye. However, if too much of the **One Level** and **Zero Level** of the eye diagram is on the display, it may reduce the repeatability of your measurements. A good rule of thumb is to have two divisions of **One Level** and two divisions of **Zero Level**.

User Defined

You can use the **User Defined** setting to define thresholds for eye diagrams at the positions you want.

7.5.2.1.3   Upper Threshold and Lower Threshold
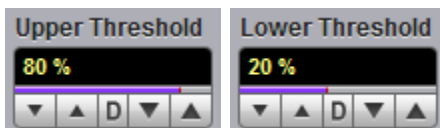
The **Upper Threshold** and **Lower Threshold** variables are displayed only when the **User Defined** option of the **Thresholds** menu is selected.
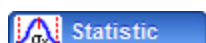
Upper Threshold can be set from 55% to 95%, while the **Lower Threshold** can be set from 5% to 45%.

ps9300.en-13   225
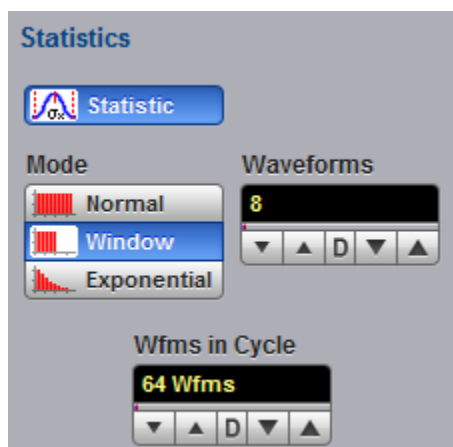
7.5.2.2   Statistics

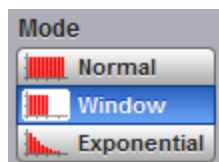Click the **Statistics** menu to open an eye diagram calculation statistics menu.

7.5.2.2.1   Statistics

On   Turns on statistical calculation for the eye diagram.

Off   Turns off statistical calculation for the eye diagram.

7.5.2.2.2   Mode

The **Mode** menu defines one of three modes for statistical calculations.

Normal   Each of the acquired waveforms has equal influence on the eye diagram statistics. The **Waveforms & Weight** variables are not active in this mode.

Window   Only the last specified number of acquired waveforms will have equal influence on the eye diagram statistics. The **Waveforms** variable specifies the number of these influenced waveforms.

Exponential   Each of the acquired waveforms has a weighted influence on the result of the eye diagram statistics. The **Weight** variable specifies the degree of this influence.

7.5.2.2.3   Waveforms & Weight
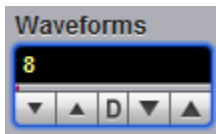
The **Waveforms** variable specifies the number of influenced waveforms when the **Window** is selected in the **Mode** menu. The **Waveforms** can be varied from 8 to 8192 in multiples of two.
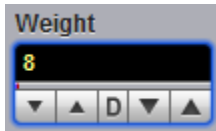
The **Weight** variable specifies the degree of influence of the latest acquired waveform against more remote waveforms. The **Weight** variable is active when **Exponential** is selected in the **Mode** menu. The **Weight** can be varied from 8 to 8192 in multiples of two.

7.5.2.2.4   Waveforms In Cycle

The **Wfms in Cycle** variable determines how many acquired waveforms will be used for the one-measurement cycle in eye diagram calculations.

The variable can be adjusted from 64 to 1024 waveforms per one-measurement cycle.

7.6 Histogram menu

A **Histogram** is a probability distribution diagram that shows the distribution of acquired data from a source within a user-definable window. The information gathered by the histogram is used to perform statistical analysis on the source. You can display the histogram either vertically for voltage measurements or horizontally for timing measurements.

The Histogram menu

Histograms are derived from the instrument measurement database. The measurement database consists of all data samples displayed on the display graticule. Every time a display sample point is acquired at a display coordinate, the counter for that coordinate is incremented. As the total count increases, the range of hits also increases. The maximum count for each counter is 63 488. If the histogram is left on for a very long time, the database will become saturated.

The most common uses for histograms are measuring and characterizing noise or jitter on displayed waveforms. Noise is measured by sizing the histogram window to a narrow portion of time and observing a vertical histogram that measures the noise on an edge. Jitter is measured by sizing the histogram window to a narrow portion of voltage and observing a horizontal histogram that measures the jitter on an edge.

When the histogram is turned on, the instrument begins to build its measurement database. Then the following events occur:

- The histogram is displayed as a series of lines on the display graticule.
- The histogram data is analyzed.
- The results of the histogram are displayed on the **Measurement Area** of the display.

The histogram is displayed as a series of horizontal or vertical lines (depending on the axis selected in the **Axis** menu). Each line is the width of one pixel on the display graticule. Each line is carefully positioned on the display graticule within the histogram window and appears above the waveforms. Therefore, the source waveform may not be viewed through the histogram waveform.

The measurement database continues to build until the instrument stops acquiring data for the histogram.

> ℹ️ The measurement database is active in the persistence or color-graded display styles.

> ℹ️ To avoid erroneous data, reset the measurement database by pressing the **Clear Display** button. Changing the vertical scale, offset, timebase scale, delay, and trigger settings will not reset the measurement database.

Histogram measurement results

You will see the histogram statistics listed in the **Measurement Area** of the **GUI**. These values are displayed on tabs.

Histogram	Marker	Scales				Max	Mid	Min
Scale = 6.4 hits/		Peak Hits = 32 hits		Std Deviation = 86.362 mV				
Offset = 0 hits		Pk-Pk = 240.62 mV		Mean ± 1 StdDev = 74.138 %				
Hits in Box = 348 hits		Median = 113.28 mV		Mean ± 2 StdDev = 100 %				
Waveforms = 1866 Wfms		Mean = 62.9 mV		Mean ± 3 StdDev = 100 %				
Min = −7.0313 mV		Max-Max = 199.22 mV		Max = 233.59 mV				
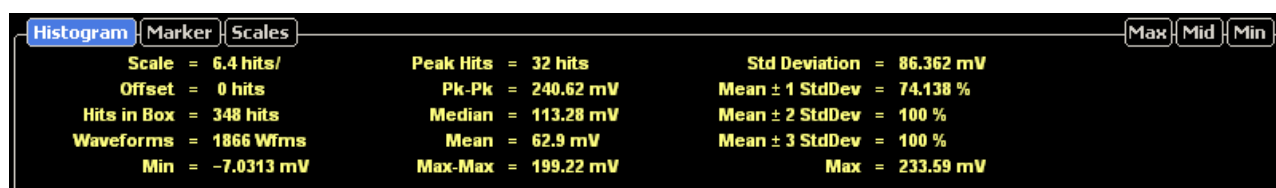
An example of the Histogram Measure tab

The tabs only appear as one of the histogram measurements is performed. For example, if you perform a vertical histogram measurement on channel 1, only this tab will appear on the display.

The measurement database and the graticule display will clear when you perform the following actions:

- Switch between operating modes in the **Display** menu.
- Change vertical and horizontal scale and position.
- Click on the **Clear Display** button.

The **Measure tab** displays the following measurement statistics for each measurement:

- **Scale**   Lists the display scale in hits per division or dB per division.

- **Offset**   Lists the offset in hits or dB. Offset is the number of hits or dB at the bottom of the display, as opposed to the center of the display.
- **Hits in Box**   The total number of samples included in the histogram box.
- **Waveforms**   The number of waveforms that have contributed to the histogram.
- **Peak Hits**   The number of hits in the histogram's greatest peak.
- **Pk – Pk**   The width of histogram. For horizontal histograms, width is the difference time between the first and last pixel columns that contains data. For vertical histograms, width is the difference in time between the first and last pixel rows that contain data.
- **Median**   50% of the histogram samples are above the median and 50% are below the median.
- **Mean**   Mean is the average value of all the points in the histogram.
- **StdDev**   The standard deviation ( ) value of the histogram.
- **Mean ± 1 StdDev** The percentage of points that are within ± 1 of the mean value.
- **Mean ± 2 StdDev** The percentage of points that are within ± 2 of the mean value.
- **Mean ± 3 StdDev** The percentage of points that are within ± 3 of the mean value.
- **Min**   Min is the minimum value of all the points in the histogram.
- **Max**   Max is the maximum value of all the points in the histogram.
- **Max-Max**   The width between the vertical histogram's greatest peak.

> ℹ The measurement statistics reported will vary depending on the mode of operation selected.

Mean and Standard Deviation

The PicoScope 9300 oscilloscope calculates the mean and standard deviation automatically. It does not rely on the assumption that the data is of a particular distribution to determine the sample mean or standard deviation. The microprocessor-controlled acquisition allows the oscilloscope to store and display every data point. Therefore, the sample mean and standard deviation are easily computed by the microprocessor using the following equations respectively:

$$\overline{X} = \frac{\sum\limits_{i=1}^{n} X_i}{n}$$

$$S = \frac{\sum\limits_{i=1}^{n} (X_i - \overline{X})^2}{n-1}$$

where: $\overline{X}$ - mean, S - standard deviation, n - number of samples, and Xi - value of each sample.

The mean for time histogram is the time from the trigger point (without taking into account minimum delay) to the sample average. The mean for voltage histograms is the average voltage with respect to the ground reference.

7.6.1   Setup

Setup

The Histogram Setup menu

7.6.1.1   Axis
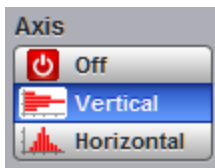
The **Axis** function turns the display of the histogram off or orients the histogram vertically or horizontally.

- **Off**   Removes the histogram and histogram value from display.
- **Vertical**   Places the histogram at the left side of the graticule, which allows for voltage measurements.
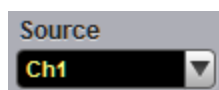- **Horizontal**   Places the histogram at the bottom of the graticule area, which allows for timing measurements.
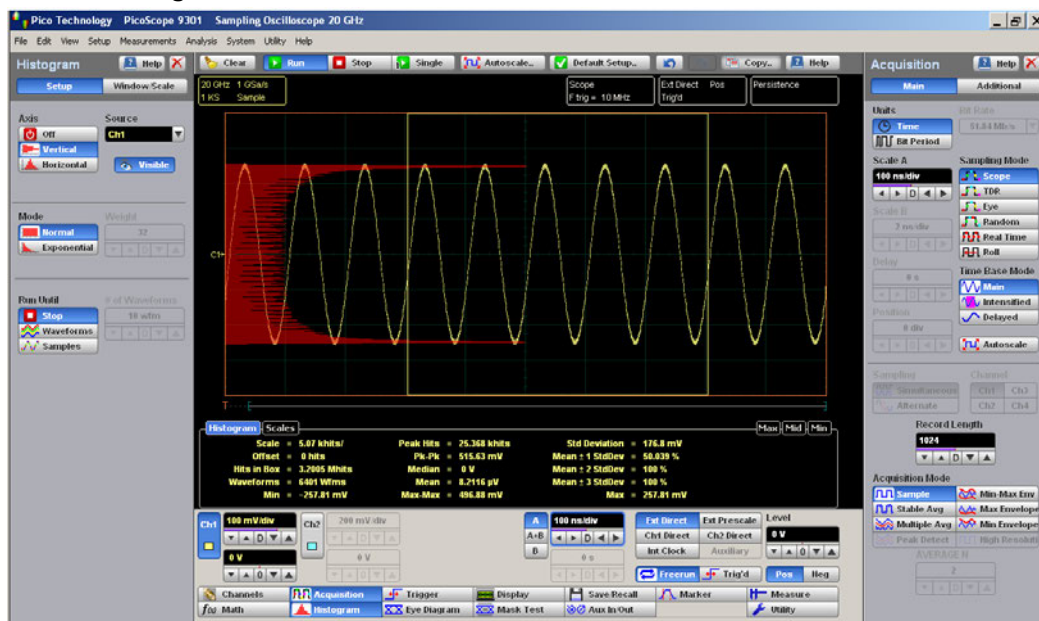
An example of the vertical histogram display
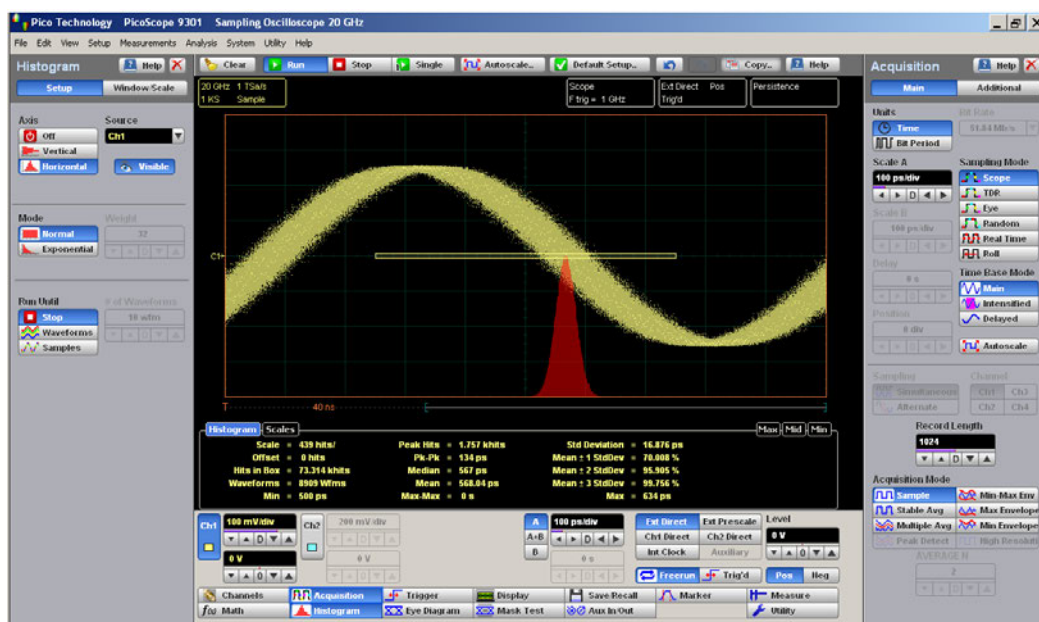
An example of the horizontal histogram display

7.6.1.2 Source

Histogram measurements can be made on only one source at a time. Select the source you want to measure using the **Source** menu. Be aware that even if the display shows only the most recent acquisitions, the measurement database keeps track of all display coordinates hit while the measurement database is building.

You can set the histogram source:

- Channel
- Function
- Waveform memory
- Spectrum

7.6.1.3 Visible

Visible turns on or off the display of a histogram and histogram window. Turning off a histogram does not turn off the measurement process.

7.6.1.4 Mode
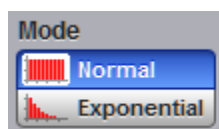
The **Mode** menu defines one of two modes that determine an algorithm for statistical calculation.

- **Normal.** When the **Normal** mode is selected, each of the acquired waveforms has equal influence on the result of the statistical calculations on the histogram. The **Weight** variable is not active in this mode.
- **Exponential.** When the **Exponential** mode is selected, each of the acquired waveforms has a weighted influence on the result of statistical calculations on the eye diagram. The **Weight** variable specifies the degree of this influence.

7.6.1.5 Weight
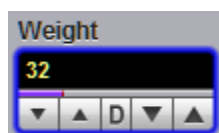
The **Weight** variable specifies the degree of influence of the nearest acquired waveform against more remote waveforms. The **Weight** variable is active when **Exponential** is selected in the **Mode** menu. The **Weight** can be varied from 8 to 8192 in multiples of two.

7.6.1.6   Run Until
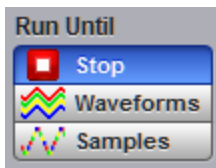
The **Run Until** menu allows you to determine when the acquisition of data stops.

- **Stop.** You must press the **Stop** key to stop the acquisition of data.
- **Waveforms.** After the number of waveforms is reached, acquisition stops.
- **Samples.** After the number of samples is reached, acquisition stops.

7.6.1.7   # of Waveforms and # of Samples

- **# of Waveforms.** Sets the number of waveforms. After the selected number of waveforms is reached, acquisition stops.
- **# of Samples.** Sets the number of samples. After the selected number of samples is reached, acquisition stops.

7.6.2 Window

Window/Scale

Common uses for histograms are measuring and characterizing noise or jitter on displayed waveforms.

Noise is measured by sizing the histogram window to a narrow portion of time and observing a vertical histogram that measures the noise on a flat section of a waveform.

Jitter is measured by sizing the histogram window to a narrow portion of voltage and observing a horizontal histogram that measures the jitter on an edge.

The histogram window determines which region of the database will be used to construct the histogram. The instrument will use only this region of the database to calculate the histogram results.

To define the histogram window, choose **Window/Scale** from the **Histogram** menu. The histogram **Window** menu allows you to select a region of the database to include in the histogram. The **Window** menu opens the histogram window markers. The markers consist of:

- Two solid vertical lines (the **Left Limit** and **Right Limit** variables)
- Two solid horizontal lines (the **Top Limit** and **Bottom Limit** variables)

You can then define the size of the histogram window within the horizontal and vertical scale limits of the instrument.
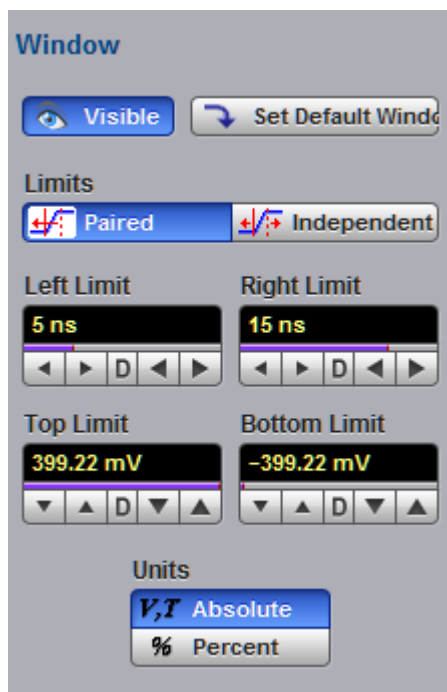
The Histogram Window menu

7.6.2.1   Visible

Visible is used to show histogram windows with both vertical and horizontal histogram limits.

Clicking **Visible** turns the display of the selection on or off.

7.6.2.2   Set Default Window
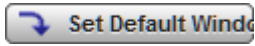
Sets the default histogram window for both vertical or horizontal histograms.

7.6.2.3   Limits

The **Limits** menu defines how the histogram window can be positioned with the **Left Limit**, **Right Limit**, **Top Limit** and **Bottom Limit** variables.

Paired

With the **Paired** method, the following conditions are used for positioning of the histogram window:

- The **Left Limit** variable changes the full histogram window to left or to right.
- The **Right Limit** variable changes the right limit of the histogram window to left or to right.
- The **Top Limit** variable changes the full histogram window up or down.
- The **Bottom Limit** variable changes the bottom limit of the histogram window up or down.

Independent

When the **Independent** is selected, each of the **Left Limit**, **Right Limit**, **Top Limit** and **Bottom Limit** variables changes the position of the corresponding limit independently.

7.6.2.4   Left Limit, Right Limit, Top Limit and Bottom Limit

Left Limit	Right Limit	Top Limit	Bottom Limit
50 ns	150 ns	–98.45 mV	–110.95 mV
◄ ► D ◄ ►	◄ ► D ◄ ►	▼ ▲ D ▼ ▲	▼ ▲ D ▼ ▲

The **Left Limit, Right Limit, Top Limit** and **Bottom Limit variables** allow you to use the histogram limits to select a region of the database.

When the **Independent** mode in the **Limits** menu is selected, the **Top Limit** and **Bottom Limit** variables move the vertical histogram limits vertically across the display, while the **Left Limit** and **Right Limit** variables move the horizontal histogram limits horizontally across the display.

When the **Paired** mode in the **Limits** menu is selected, the **Top Limit** variable moves the full histogram window up or down, and the **Left Limit** variable moves the full histogram window left or to right. At the same time the **Bottom Limit** variable moves the bottom limit of the histogram window up or down, while the **Right Limit** variable moves the right limit of the histogram window left or to right.

Because the database that the histogram is derived from is limited to the size of the graticule area, placing the histogram limits beyond the graticule area results in a histogram of only the graticule area.

For jitter measurements you would position the **Top Limit** and **Bottom Limit** histogram limits so that the histogram is built from a very narrow horizontal slice of the graticule area. For noise measurements, you would position the **Left Limit** and **Right Limit** histogram limits so that the histogram is built from a very narrow vertical slice of the graticule area.

> ℹ️ The histogram window limits are only visible when the **Histogram** menu is opened.

The default setup positions of the histogram markers as follows:

- **Left Limit** < **Right Limit**
- **Bottom Limit** < **Top Limit**

The values of **Left Limit** and **Bottom Limit** cannot be made greater than the values of **Right Limit** and **Top Limit** by repositioning the limits. The histogram window is always the area inside the boundaries of all of **Left Limit, Right Limit, Top Limit** and **Bottom Limit**, regardless of the limit values.

You can use the mouse to click and drag the histogram limits to new positions: click and hold the left mouse button while the mouse pointer is on one of the limits, then drag the marker to the position you want and release the mouse button. Clicking and dragging a limit makes it easy to quickly move the limit to the desired waveform event.

> ℹ️ The values of the limits and the position arrows are dependent upon the vertical and horizontal scale settings.

7.6.2.5   Units

Units
V,I Absolute
% Percent
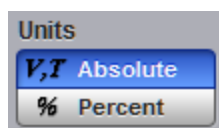
The **Units** function lets you select how you want the **Left Limit, Right Limit, Top Limit** and **Bottom Limit** variables represented.

- **Absolute.** Represents all limits in current unit.
- **Percent.** Represents all limits as percentages of the full vertical or horizontal scale.
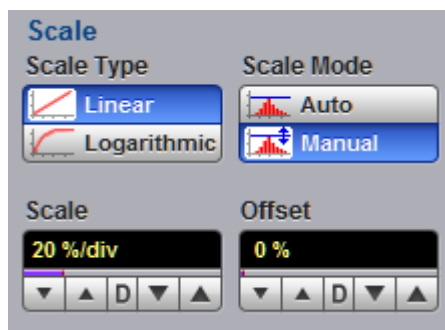
7.6.3   Scale

Window/Scale
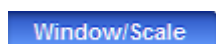
Histograms are derived from the instrument measurement database. The histogram values correspond to a row or column in the database. The database that is used to construct the histogram is dependent upon the selected source. The instrument converts the row and column numbers to time (seconds) and amplitude (volts) values using the scaling values of the selected the database source. Therefore, the histogram results from each source vary depending on the scaling of the source.

Histograms are displayed as a series of lines (vertical or horizontal). The length of each line represents the frequency or number of hits of data on that row (or column) of the display. Zero hits correspond to the left edge of the graticule (vertical histogram), or the bottom edge of the graticule (horizontal histograms).

The histogram **Scale** menu gives you access to a second-level menu that allows you to set the scale of the histogram.

Scale
Scale Type   **Scale Mode**
Linear   **Auto**
Logarithmic   **Manual**
Scale   **Offset**
20 %/div   **0 %**
▼ ▲ D ▼ ▲   ▼ ▲ D ▼ ▲

The Histogram Scale menu

7.6.3.1   Scale Type

Scale Type
Linear
Logarithmic
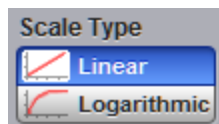
The **Scale Type** menu defines how to display histogram data. Two options can be set from the **Scale Type** menu: **Linear** and **Logarithmic**.

- **Linear.** Sets the display of the histogram results to the number of hits per division.
- **Logarithmic.** Sets the display of the histogram results to dB.

7.6.3.2 Scale Mode
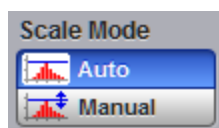
The **Scale Mode** menu determines how much of the histogram is displayed on the screen.

Auto

If the **Axis** menu is set to **Horizontal**, the **Auto** sets the base of the histogram to the bottom of the graticule area and displays the histogram using half of the graticule height.

If the **Axis** menu is set to **Vertical**, the **Auto** sets the base of the histogram to the left edge of the graticule area and displays the histogram using half of the graticule width.

Manual

Manual lets you window in on the histogram by allowing you to change the scale and offset settings. Depending on the setting of the **Scale Type** menu, the scale value is in either percent of a division or dB. By changing the scale, you can zoom in or out on the histogram. Offset allows you to pan across the histogram by moving the base of the histogram. Depending on the setting of the **Scale Type** menu, the offset value is also in either percent of peak or dB per division.

7.6.3.3 Scale

Linear scale

For the linear scale type, the scale is the percentage of the peak per division. For example, on a horizontal histogram, 20% places one-fifth of the histogram in each of eight divisions with the top of the peak (100%) at the middle of the display.

Logarithmic scale

For the log scale type, the scale is in decibels per division. The histogram is plotted according to the following formula:

$$dB = 20 \log_{10} \frac{X}{Peak}$$

where: *X* is the number of hits in a histogram row for vertical histograms, or the number of hits in a histogram column for horizontal histograms. *Peak* is the number of hits in the largest histogram column or row, and *dB* is the log value that gets plotted.

7.6.3.4   Offset
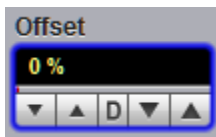
Linear offset

For the linear scale type, the offset is the percentage of the peak at the left edge or lower edge of the display. For example, on a horizontal histogram, an offset of 20% places 20% of the peak at the lower edge of the display. Therefore, 20% of the histogram will be below the display and the other 80% of the histogram will be above the lower edge of the display (displayed on the screen).

Logarithmic offset

For the log scale type, the offset is in decibels at the left edge or lower edge of the display. The histogram is plotted according to the following formula:

$$dB = 20 \log_{10} \frac{X}{Peak}$$

where: *X* is the number of hits per row for vertical histograms, or the number of hits per column for horizontal histograms. *Peak* is the number of hits in the peak, and *dB* is the log value that gets plotted.

This means 0 dB is at the peak of the histogram and the offset can only contain negative values. For example, with a horizontal histogram, an offset of −20 dB places 10% or $10^{\frac{-20}{20}}$ of the peak at the lower edge of the display.

7.7   Marker menu

Markers are movable lines on the display. You set their value by positioning them on the display. Their actual value, however, comes from internal data, so they are more precise than graticules. They use numeric readouts to present results.

You can drag markers to measure waveforms on screen.

Markers can be positioned on either:

●   A selected waveform source (input channel, waveform memory, function or spectrum)
●   Independently anywhere on the display graticule

Markers allow you to make:

●   Absolute vertical measurements (voltage, spectrum magnitude, spectrum phase, rho,)
●   Ratiometric vertical measurements
●   Absolute horizontal measurements (timing, bit period, frequency, distance)
●   Ratiometric horizontal measurements

The markers are display-limited, so you cannot move them off screen. Also, if you resize waveforms, the markers do not track. That is, a marker stays at its screen position, ignoring changes to horizontal and vertical scale and position.
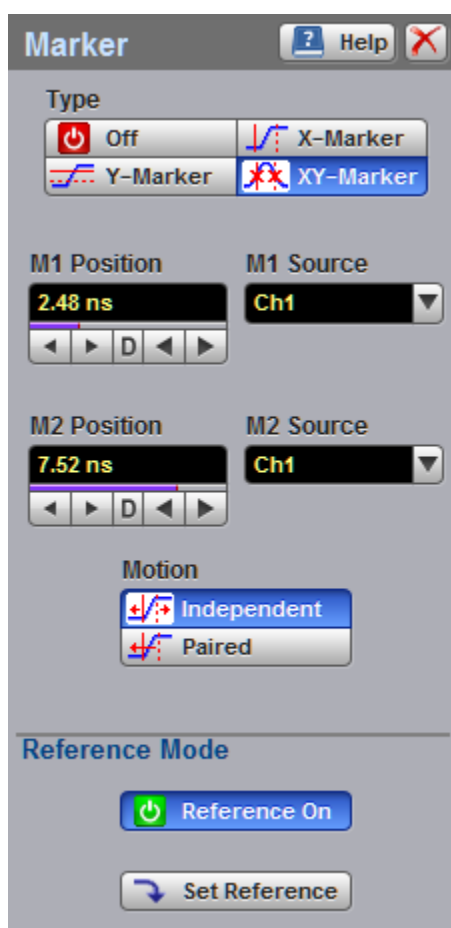
The Marker menu

The **Marker** menu allows you to turn on and position calibrated colored markers on the display. For example, you can use the **M1 Position** (solid line) control to move the **X1** marker horizontal position. The position value of the marker will be displayed in the Measurement Area of the display.

Markers can be changed to a different color in the display menu. You can use the markers to make custom measurements or to use as visual reference points on the display.

To display the **Marker** menu, click the [Marker] button in the main menu.

Marker measurement results

The **Measurement Area** of the **GUI** displays the values of the marker positions and measurements on tabs. The marker position readout is based on the units of the source waveform. The marker resolution is limited to the resolution of the display. As you move a marker, its position is displayed in the **Measurement Area**. The horizontal value (X-axis) is the time delay from the left border of the display graticule and the vertical position (Y-axis) is measured with respect to the corresponding source ground.

Marker	Scales			Max	Mid	Min
XM1 = 4.39 ns	XM2 = 8.605 ns	dXM = 4.215 ns	1 / dXM = 237.248 MHz			
YM1 = 92.68 mV	YM2 = −188.4 mV	dYM = −281.08 mV	dYM / dXM = −66.686 V / µs			
dXM = 8.36 %	dXM = 30.1 °	dYM = 425 %	dYM = 12.6 dB			

An example of the Marker Measure tab

The following information is displayed for the selected source or waveform:

- **XM1** Position of the **M1** marker (solid line). The X-axis units may be displayed in seconds, Hz, bits, meters or feet.
- **YM1** Position of the **M1** marker (solid line). The Y-axis units depend upon the channel input, and may be displayed in volts, watts, amperes, phase degrees, rho, ohms.
- **XM2** Position of the **M2** marker (dashed line). The X-axis units may be displayed in seconds, Hz, bits, meters or feet.
- **YM2** Position of the **M2** marker (dashed line). The Y-axis units depend upon the channel input; and may be displayed in volts, watts, amperes, phase degrees, rho, ohms.
- **dXM** The difference between the **M1** and **M2** marker values, if both markers are turned on. **dXM** is calculated as follows:

$$dXM = XM2 - XM1$$

where **XM2** represents the dashed line marker, and **XM1** represents the solid line marker.

If **XM1** is more positive than **XM2**, **dXM** will be a negative number, which can result in negative time interval measurements.

- **1/dXM** The instrument will also calculate and display the **1/dXM** frequency value when both X-axis markers are turned on. If **XM1** is more positive that **XM2**, **1/dMX** will display a negative frequency.
- **dYM** The difference between the **YM1** and **YM2** marker values, if both markers are turned on. **dYM** is calculated as follows:

$$dYM = YM2 - YM1$$

where **YM2** represents the dashed line marker, and **YM1** represents the solid line marker.

If **YM1** is more positive than **YM2**, **dYM** will be a negative number.

7.7.1 Type

Type	
⏻ Off	⌐ X-Marker
⌐ Y-Marker	✕✕ XY-Marker
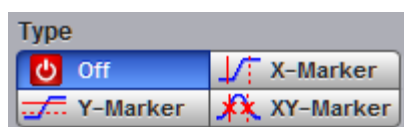
There are three types of markers:

- **X**-Markers (manual markers)
- **Y**-Markers (manual markers)
- Waveform markers

Click the button for the marker type that you need.

Off
Removes the markers and marker value from display.

X-Markers

The **X** manual markers (**XM1** and **XM2** markers) are two vertical lines you can move horizontally. The **XM1** is displayed as a solid line, and the **XM2** is displayed as dashed line.

You can position the **X**-Markers anywhere on the display, which allows you to make custom measurements. The **X**-Markers track the time values as the timebase scale is changed, which allows you to make accurate delay measurements. The position readout is based on the scale factors of the source waveform. Marker resolution is limited to the pixel resolution of the display.
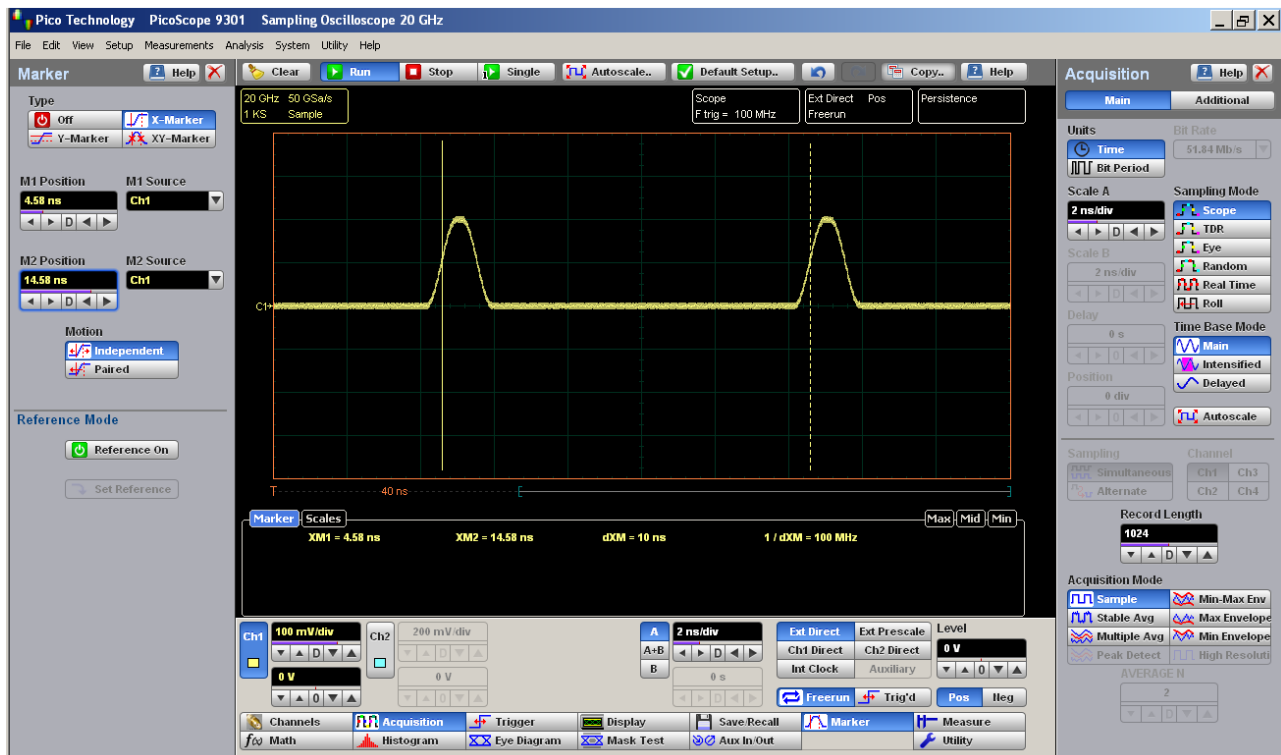
Period measurement with the X-Markers

Y-Markers

The **Y** manual markers (**YM1** and **YM2** markers) are two horizontal lines you can move vertically. The **YM1** is displayed as a solid line, and the **YM2** is displayed as a dashed line.

You can position the **Y**-Markers anywhere on the display, which allows you to make custom measurements. The **Y**-Markers track the voltage values as the vertical scale is changed, which allows you to make accurate voltage measurements. The position readout is based on the scale factors of the source waveform. Marker resolution is limited to the pixel resolution of the display.
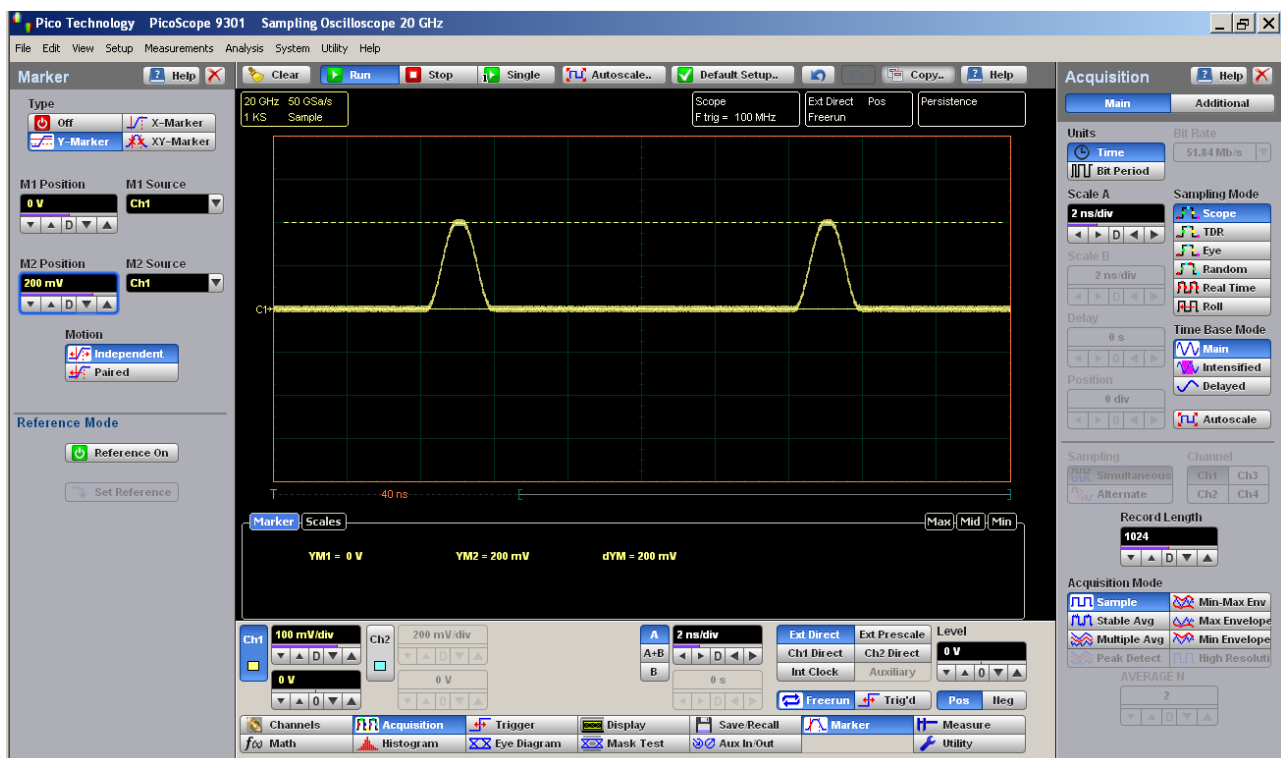
Amplitude measurement with the Y-Markers

Waveform Markers

The **XYM1** and **XYM2** are two waveform markers displayed as **X** symbols. Each marker is in effect, both a horizontal and vertical marker. Neither of these markers can be moved off the waveform. The **XY**-markers track the waveform data in memory rather than on the displayed waveform. Because the waveform data in memory has a much greater resolution than the display, the measurements you make with the **XY**-markers are much more precise than measurements made with the manual markers. The **XY**-markers track the time as changes of the source signal. This allows you to make accurate delay measurements without having both markers on the display.
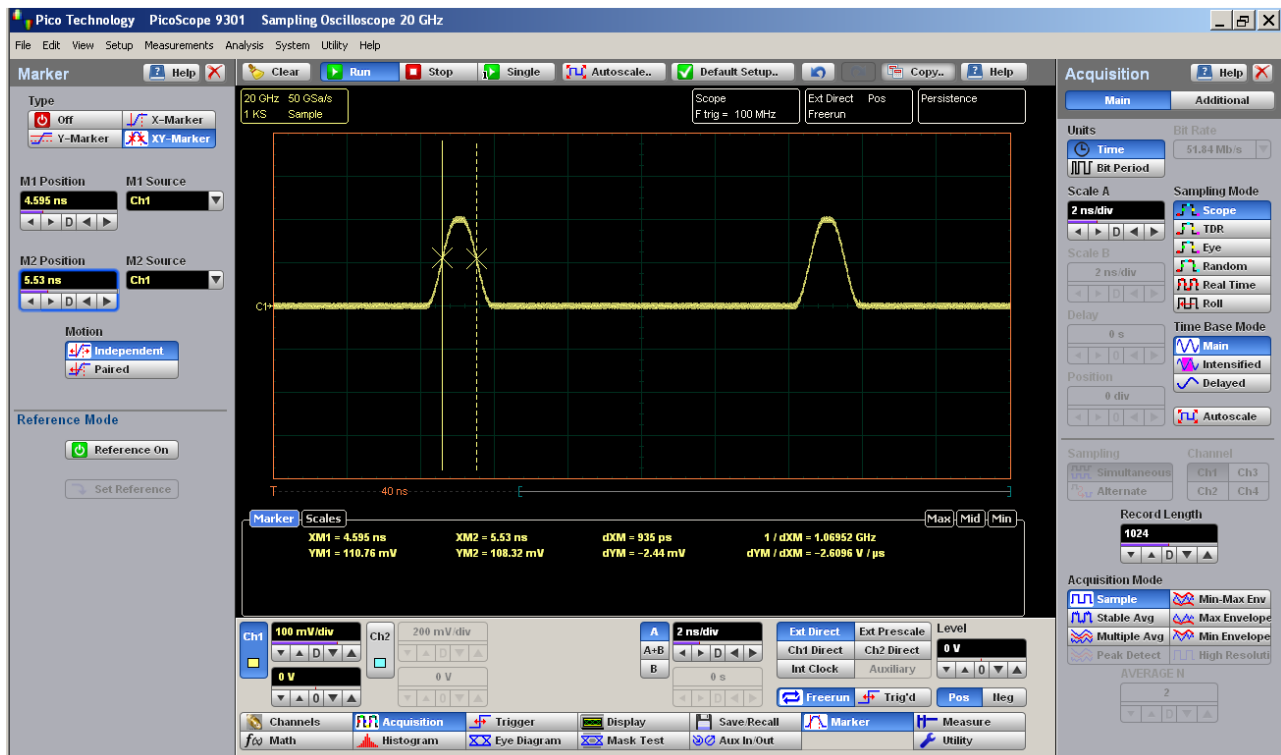
Customized measurement with the XY Markers

7.7.2   M1 Source and M2 Source

You may set the source for each marker:

- Channels
- Functions
- Waveform memories
- Spectra

For example, you could set the **M1 Source** to a waveform on channel 1, and the **M2 Source** to a waveform in memory **M1**. The scale used to position each marker on the display is based on the scale of the waveform source to which the marker is tied.

> ⓘ You cannot select a marker source that is turned off.

> ℹ️ When you are placing markers on a waveform, make sure the source is set to that waveform.

7.7.3 M1 Position and M2 Position

You can use different methods to control the positions of the markers:

- Use the spin box
- Use the mouse to click and drag markers to a new position
- Use the keyboard
- Use the **Pop-up Keypad** for quickly entering numeric data using the mouse

Manual X Markers

The **M1 Position** variable moves the **XM1** marker horizontally, and the **M2 Position** variable moves the **XM2** marker horizontally. The position of each marker is displayed in the same color as the markers.

You can make timing measurements using **X** markers on the signal. The difference between the marker's positions is the timing measurement or **dXM:**

$$dXM = XM2 - XM1$$

If **XM1** is more positive than **XM2**, **dXM** will be a negative number, which can result in negative time interval measurements. Also notice the **1/dXM** value. If you are measuring the period of a signal with the **X**-markers, then **1/dXM** is the frequency of the signal. You can also make a channel-to-channel skew measurement by placing the **XM1** marker on one channel and the **XM2** marker on another channel.

Manual Y Markers

The **M1 Position** variable moves the **YM1** marker vertically, and the **M2 Position** variable moves the **YM2** marker vertically. The position of each marker is displayed in the same color as the markers.

You can make voltage measurements on the signal by placing the **Y**-markers on the signal.

The difference between the markers is the voltage measurement or **dYM:**

$$dYM = YM2 - YM1$$

If **YM1** is more positive than **YM2**, **dYM** will be a negative number. You can also make a channel-to-channel voltage measurement by placing the **YM1** marker on one channel and the **YM2** marker on another channel.

Waveform XY Markers

The first **XY** marker is controlled by the **M1 Position** variable and the second **XY** marker is controlled by the **M2 Position** variable. The position of each marker is displayed in the same color as the markers.

Each **XY** marker has an **YM** position and **XM** position. Vertical measurements are made with the **YM** positions, and **dYM** is the difference between the **YM** positions (see *dYM = YM2 − YM1*). Timing measurements are made with the **XM** positions, and **dXM** is the difference between the **XM** positions (see *dXM = XM2 − XM1*). Notice **1/dXM**. If you are using the markers to measure the period of a signal, then **1/dXM** is the frequency of the signal. Also notice **dYM/dXM**. If you are measuring such parameters as the rise or fall of an impulse with the **XY** markers, then **dYM/dXM** is the slope of the signal.

7.7.4   Motion

There are two options for the way in which PicoScope 9300 moves the markers:

- Independent. When **Independent** motion is selected you can move each marker independently. The **M1 Position** variable moves the **XM1**, or the **YM1,** or the **XYM1** marker. The **M2 Position** variable moves the **XM2**, or the **YM2,** or the **XYM2** marker.
- Paired. When **Paired** motion is selected you can move both markers with the **M1 Position** variable simultaneously, while the difference between markers can be moved with the **M2 Position** variable.

7.7.5   Reference

The **Marker** menu provides ratiometric measurements. These measurements give results in such ratiometric units as %, dB, and degrees.

Ratiometric measurements require a reference for comparison.

You can set the reference:

1. First adjust the markers to a predetermined positional difference representing an absolute reference or position the markers on a reference waveform to define a specific parameter such as peak-to-peak voltage or period.

2. When you click the **Set Reference** button, the ratiometric values for the reference in the Marker Measure tab become 100 %, 0 dB or 360°. These values are displayed in the same color as the markers.

3. When you change position of any marker, the results will be displayed in ratiometric values.

Click the **On** button to select ratiometric measurements.

ps9300.en-13   247
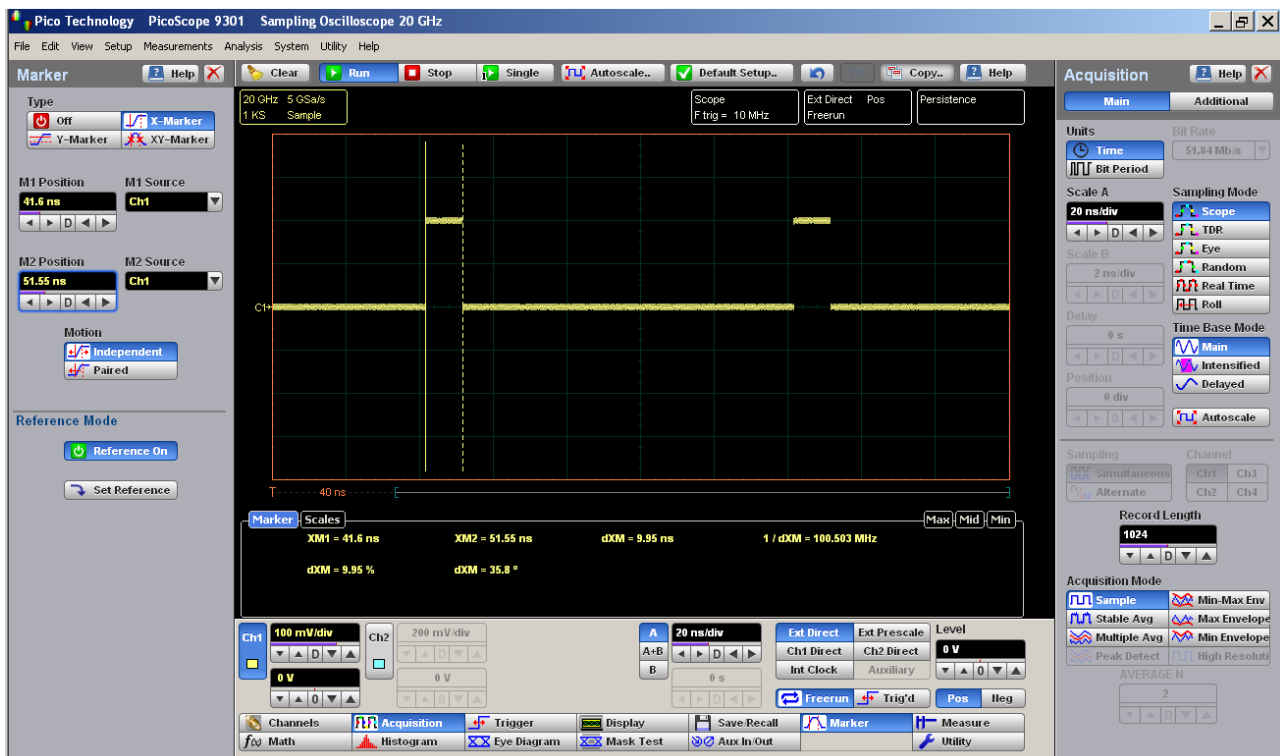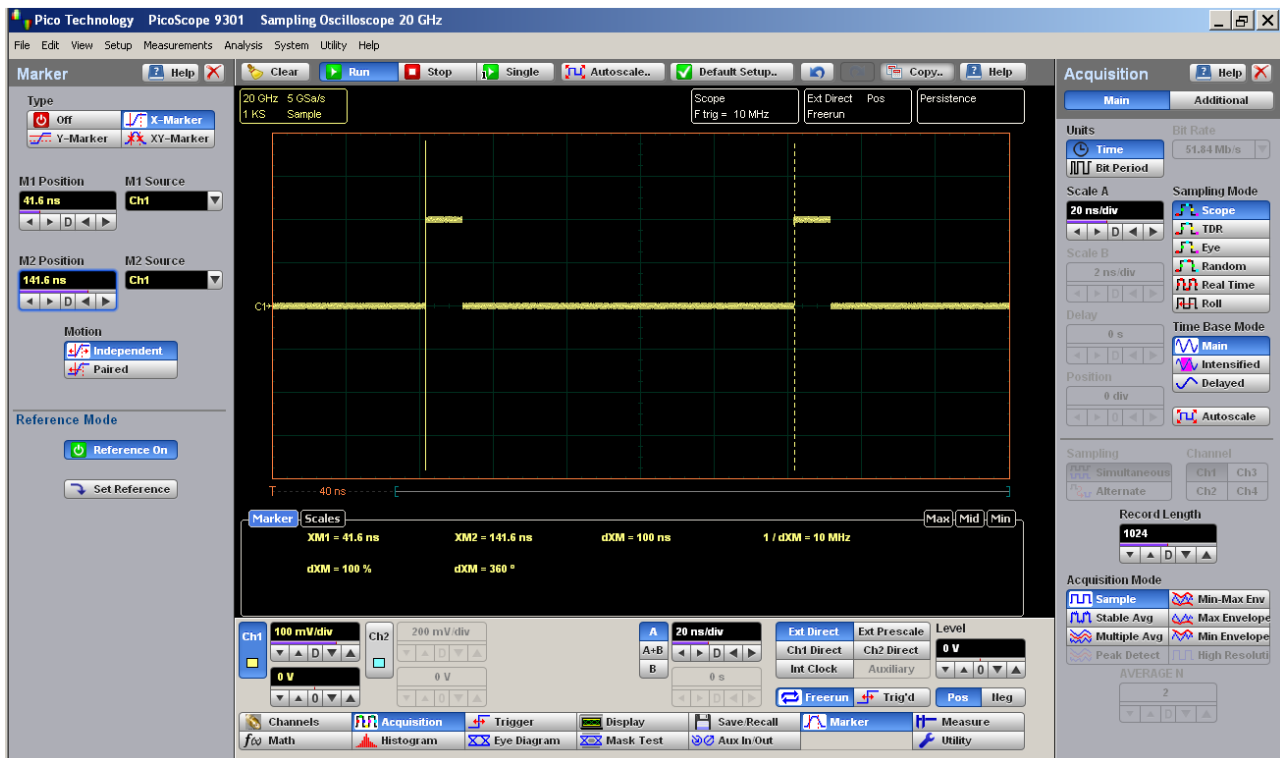
Ratiometric measurement of Duty Cycle with X Markers
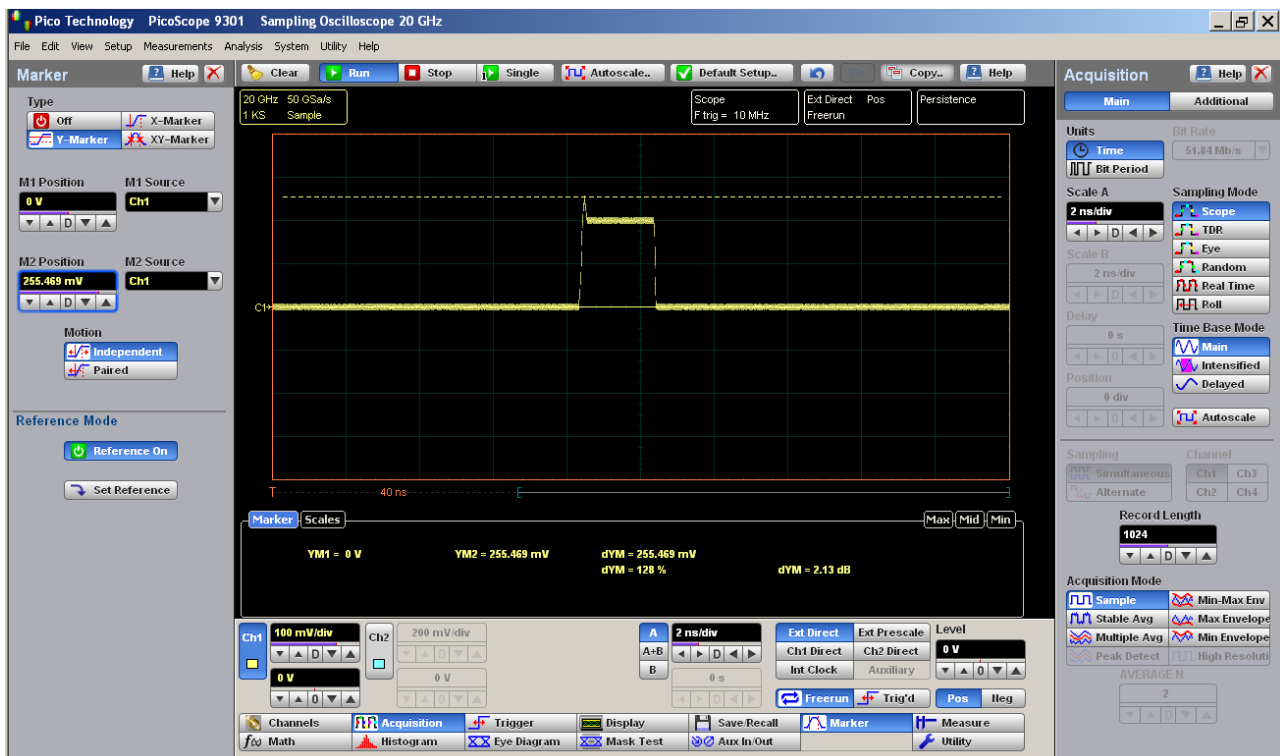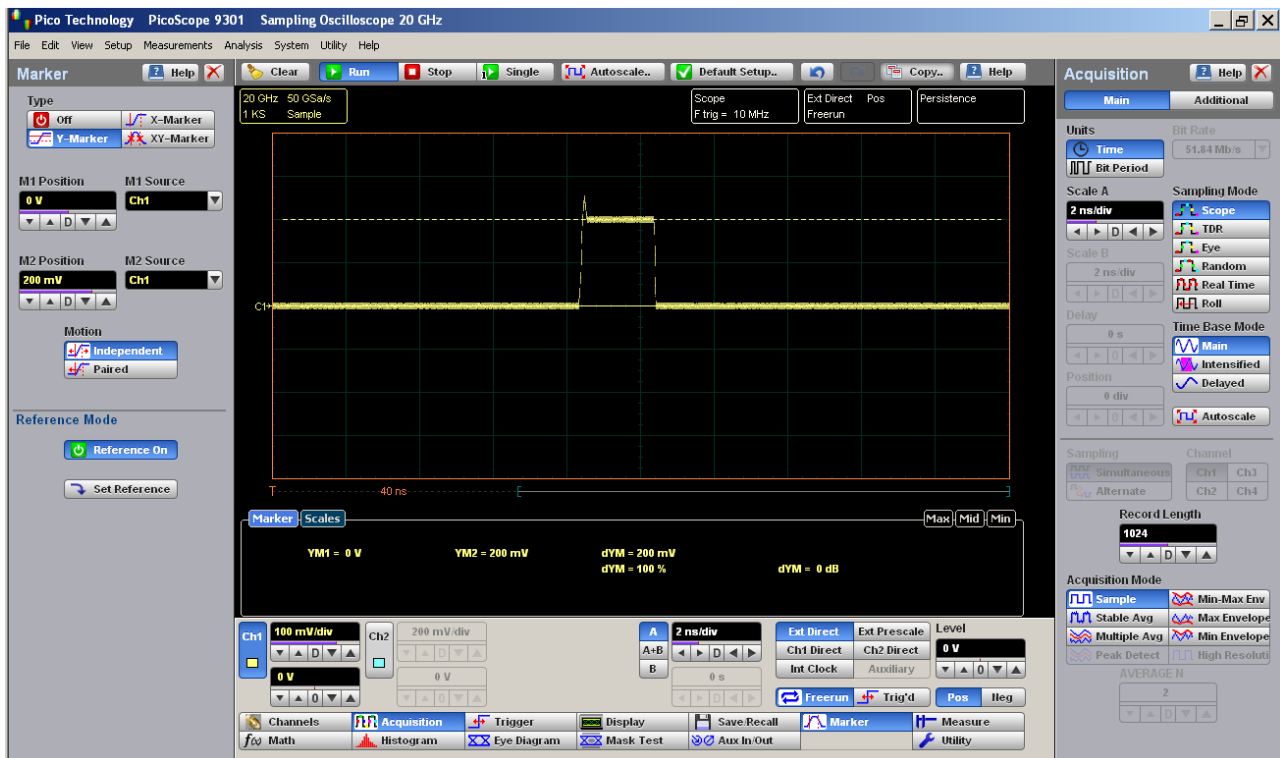
Ratiometric measurement of Overshoot with Y Markers

7.7.6   Set Reference

Set Reference

Clicking the **Set Reference** button sets the ratiometric values for the reference. As an example, they can be 100 %, 0 dB or 360°. These values are displayed in the same color as the markers. When you begin to change the position of any marker, the results will be displayed in ratiometric values.

7.8   Mask Test menu
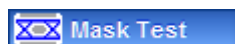
 Mask Test

There are industry standards that define the parameters for electrical and optical waveforms. Mask testing is a process you can use to verify that the displayed waveform complies with an industry standard waveform shape or with the user defined mask.

A mask is a template that consists of numbered, shaded regions on the instrument display screen. The input waveform must then remain outside these regions in order to comply with the industry standard. Any acquired data point that falls inside a mask margin appears in red.

The instrument has been designed to perform communication industry mask testing to a variety of test standards. Mask testing may be performed by a following simple procedure. This procedure loads one of several mask templates, automatically aligns the mask to the present waveform, and then determines the waveform's compliance to the mask. The size of the mask or the portion of the mask can be increased or decreased in a linear fashion to determine the waveform's margin of compliance. Both the user defined and standard (factory-installed) masks can be stored to disk for rapid switching between instrument setups. Mask testing can also activate a variety of actions upon determining a test failure.
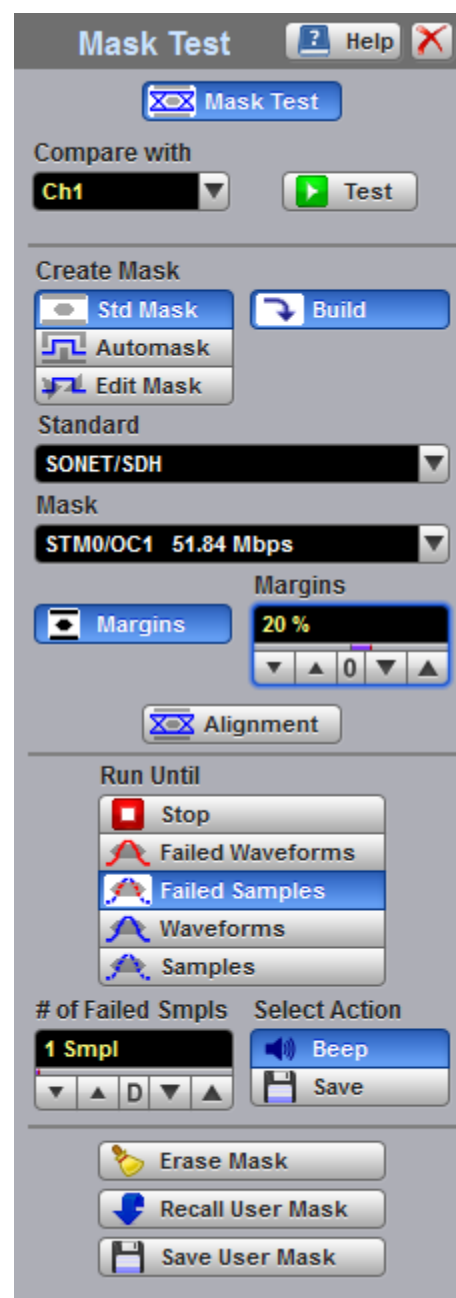
The Mask Test menu

7.8.1   Compare with
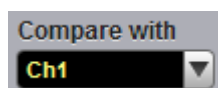
The **Compare with** menu determines which waveform the masks are compared against. You can select from any channel.

7.8.2   Test
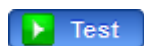
After selecting a mask, you can enable mask counting and see the results of the count. To enable mask counting, click the **Test** button.

If mask testing is on, you can read the results listed in the **Measurement Area** of the **GUI**. These values are displayed on tabs. Notice that any acquired data point that falls inside a mask or a mask margin appears in red.

The **Mask Test tab** displays the relevant test results.

Measurement Area of Mask Test

7.8.3   Create Mask
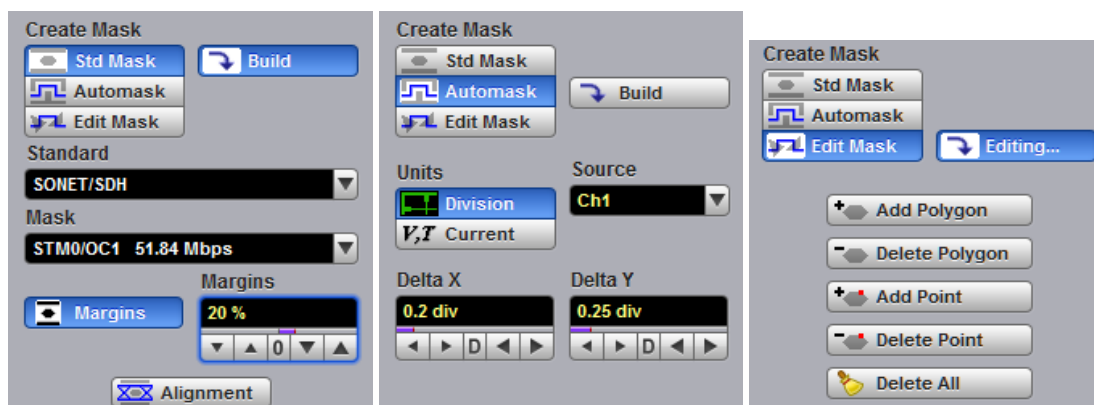
The **Create Mask** menu includes the following options:

- Select from industry-standard electrical and optical masks.
- Build an automask.
- Build a new user-defined mask.
- Edit any mask, and then save it to a memory.

7.8.3.1   Standard Mask
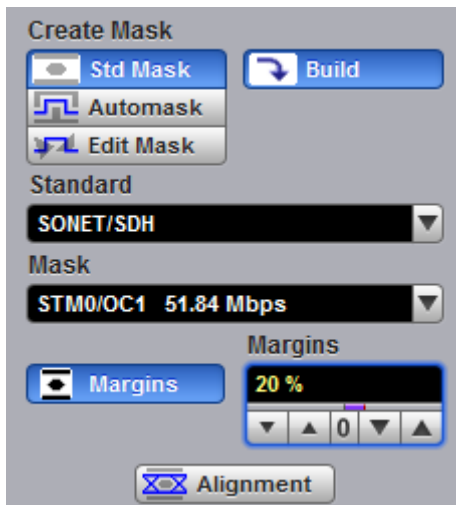
Clicking the **Std Mask** allows you to select from a variety of standard telecommunication masks.

Choose a standard to access a list of masks used for electrical or optical waveforms.
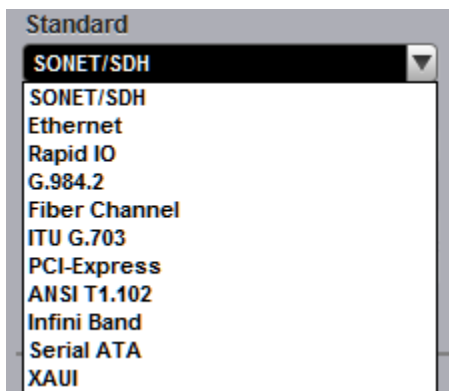
The PicoScope 9300 supports several standards for datacomms and telecomms masks. They are:

- SONET/SDH
- Ethernet
- RapidIO
- G.984.2
- Fiber Channel
- ITU G.703
- PCI Express
- ANSI T1.102
- InfiniBand
- Serial ATA
- XAUI

7.8.3.1.1 SONET/SDH Masks

Clicking the **SONET/SDH** standard opens the list of industry-standard masks.
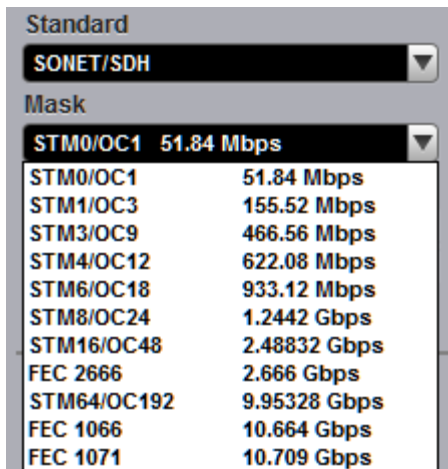
The list of industry-standard SONET/SDH masks

Any of these masks may be recalled from memory and used to test a waveform to a specific industry standard listed above. An example eye-diagram with the **STM16/OC48** industry-standard mask is shown below.
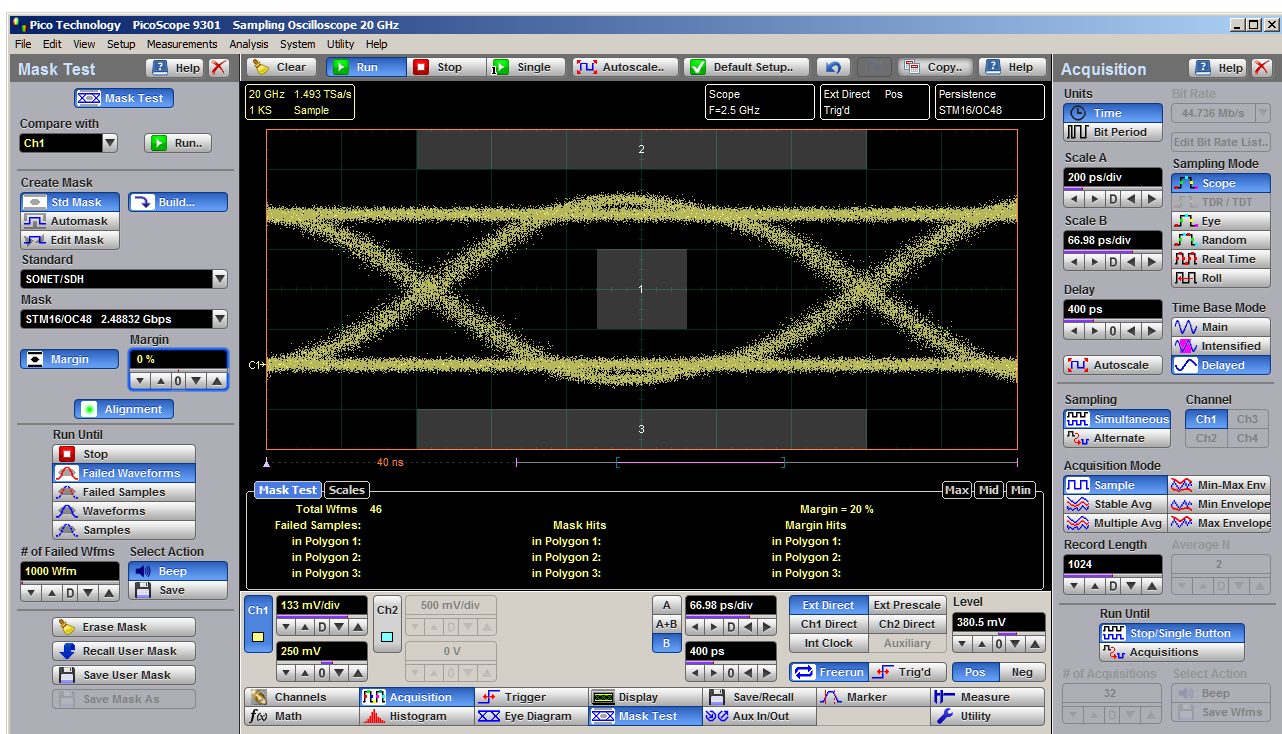
An example of eye-diagram with the STM16/OC48 SONET/SDH mask

7.8.3.1.2   Ethernet Masks

Clicking the **Ethernet** tab opens the list of industry-standard masks. Any of these masks may be recalled from memory and used to test a waveform to a specific industry standard listed above.

Standard	
Ethernet	▼
Mask	
1000Base-CX Absolute TP2 1.25 G	▼
1000Base-CX Absolute TP2	1.25 Gbps
1000Base-CX Absolute TP3	1.25 Gbps
GB Ethernet	1.25 Gbps
2xGB Ethernet	2.5 Gbps
10GBase-CX4 Absolute TP2	3.125 Gbps
10Gb Ethernet	9.953 Gbps
10GbE 9.953	9.953 Gbps
10Gb Ethernet	10.3125 Gbps
10GbE 10.3125	10.3125 Gbps
10xGB Ethernet	12.5 Gbps
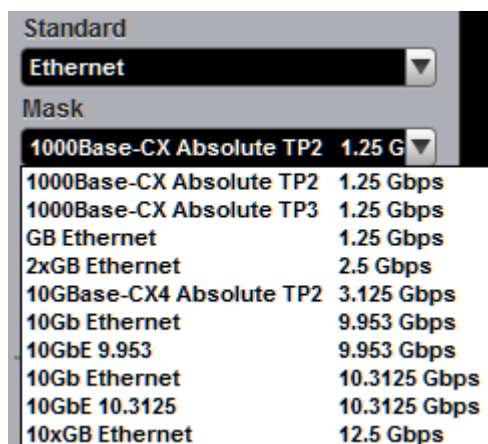
The list of industry-standard Ethernet masks

7.8.3.1.3   RapidIO Masks

Clicking the **RapidIO** tab opens the list of industry-standard masks. Any of these masks may be recalled from memory and used to test a waveform to a specific industry standard listed above.

Standard	
Rapid IO	▼
Mask	
RapidIO Serial Level I 1.25G Rx 1.2	▼
RapidIO Serial Level I 1.25G Rx	1.25 Gbps
RapidIO Serial Level I 1.25G Tx LR	1.25 Gbps
RapidIO Serial Level I 1.25G Tx SR	1.25 Gbps
RapidIO Serial Level I 2.5G Rx	2.5 Gbps
RapidIO Serial Level I 2.5G Tx LR	2.5 Gbps
RapidIO Serial Level I 2.5G Tx SR	2.5 Gbps
RapidIO Serial Level I 3.125G Rx	3.125 Gbps
RapidIO Serial Level I 3.125G Tx LR	3.125 Gbps
RapidIO Serial Level I 3.125G Tx SR	3.125 Gbps
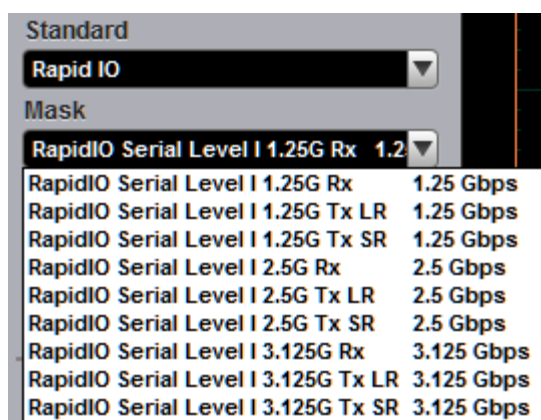
The list of industry-standard RapidIO masks

7.8.3.1.4   G.984.2 Masks

Clicking the **G.984.2** tab opens the list of industry-standard masks. One only mask may be recalled from memory and used to test a waveform to a specific industry standard listed above.
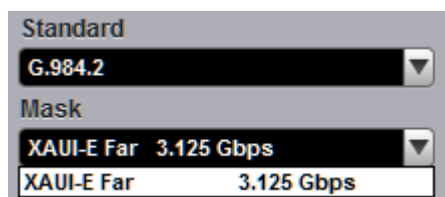
The list of industry-standard G.984.2 masks

7.8.3.1.5 Fiber Channel Masks

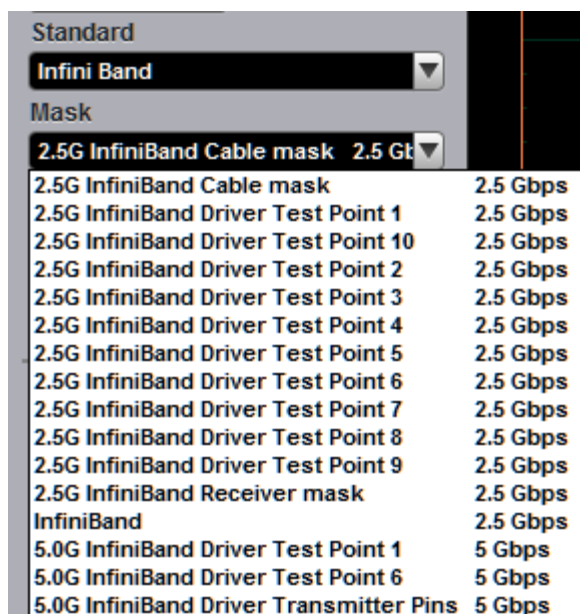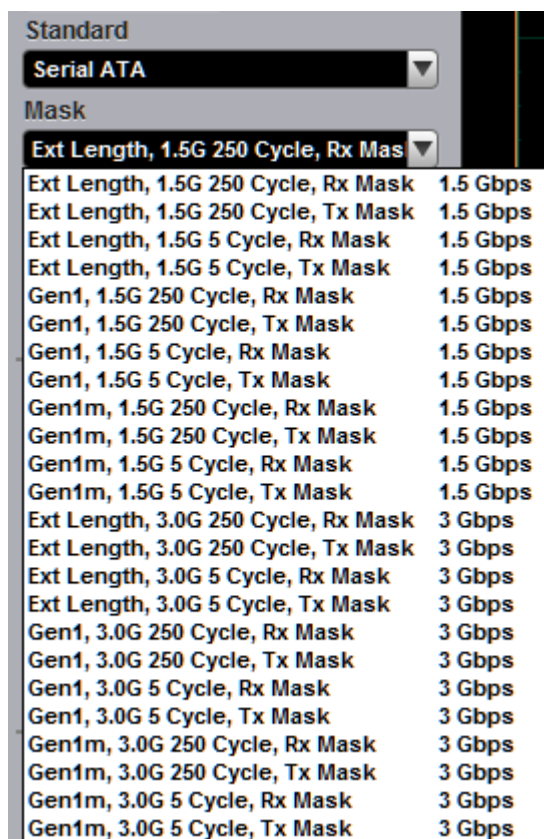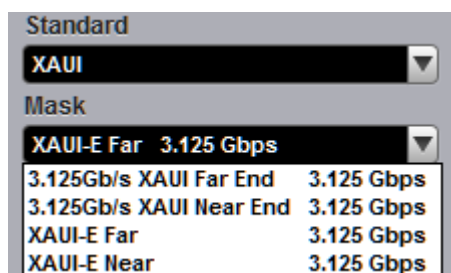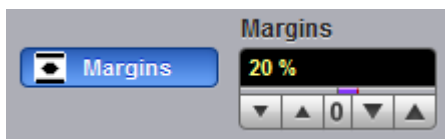Clicking the **Fiber Channel** tab opens the list of industry-standard masks. Any of these masks may be recalled from memory and used to test a waveform to a specific industry standard listed above.

FC133 Electrical	132.8 Mbps
FC133 Optical	132.8 Mbps
FC266 Electrical	265.6 Mbps
FC266 Optical	265.6 Mbps
FC531 Electrical	531.35 Mbps
FC531 Optical	531.35 Mbps
FC1063 Electrical	1.0625 Gbps
FC1063 Optical	1.0625 Gbps
FC1063 Optical PI Rev13	1.0625 Gbps
FC1063E Abs Beta Rx	1.0625 Gbps
FC1063E Abs Beta Tx	1.0625 Gbps
FC1063E Abs Delta Rx	1.0625 Gbps
FC1063E Abs Delta Tx	1.0625 Gbps
FC1063E Abs Gamma Rx	1.0625 Gbps
FC1063E Abs Gamma Tx	1.0625 Gbps
FC2125 Optical	2.1231 Gbps
FC2125 Optical PI Rev13	2.1231 Gbps
FC2125E Abs Beta Rx	2.125 Gbps
FC2125E Abs Beta Tx	2.125 Gbps
FC2125E Abs Delta Rx	2.125 Gbps
FC2125E Abs Delta Tx	2.125 Gbps
FC2125E Abs Gamma Rx	2.125 Gbps
FC2125E Abs Gamma Tx	2.125 Gbps
FC4250 Optical PI Rev13	4.25 Gbps
FC4250E Abs Beta Rx	4.25 Gbps
FC4250E Abs Beta Tx	4.25 Gbps
FC4250E Abs Delta Rx	4.25 Gbps
FC4250E Abs Delta Tx	4.25 Gbps
FC4250E Abs Gamma Rx	4.25 Gbps
FC4250E Abs Gamma Tx	4.25 Gbps
10x Fiber Channel	10.5188 Gbps

The list of industry-standard Fibre Channel masks

7.8.3.1.6 ITU G.703 Masks

Clicking the **ITU G.703** tab opens the list of industry-standard electrical masks. Any of these masks may be recalled from memory and used to test a waveform to a specific industry standard listed above.

Standard	
ITU G.703	▼

Mask	
DS1 1.544 Mbps	▼

DS1	1.544 Mbps
2 Mb 120	2.048 Mbps
2 Mb 75	2.048 Mbps
DS2 110	6.312 Mbps
DS2 75	6.312 Mbps
8 Mb	8.448 Mbps
34 Mb	34.368 Mbps
DS3	44.736 Mbps
140 Mb 0	139.264 Mbps
140 Mb 1	139.264 Mbps
140 Mb 1 Inv	139.264 Mbps
155 Mb 0	155.520 Mbps
155 Mb 1	155.520 Mbps
155 Mb 1 Inv	155.520 Mbps
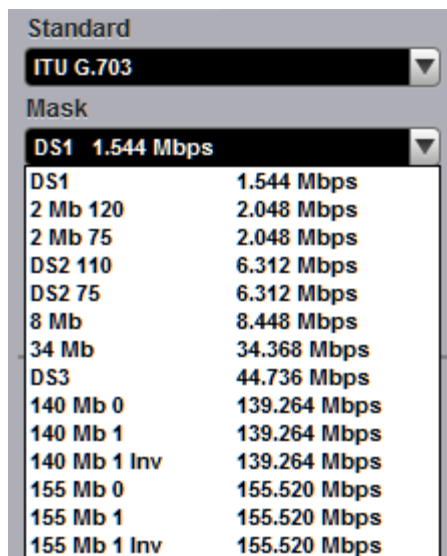
**The list of industry-standard
electrical ITU G.703 masks**

7.8.3.1.7 PCI-Express Masks

Clicking the **PCI-Express** tab opens the list of industry-standard masks. Any of these masks may be recalled from memory and used to test a waveform to a specific industry standard listed above.

Standard	
PCI-Express ▼	
Mask	
R1.0a 2.5G Add-in Card Transmitte ▼	
R1.0a 2.5G Add-in Card Transmitter Non-Transition bit	2.5 Gbps
R1.0a 2.5G Add-in Card Transmitter Transition bit	2.5 Gbps
R1.0a 2.5G Exp.Card Host Non-Transition bit	2.5 Gbps
R1.0a 2.5G Exp.Card Host Transition bit	2.5 Gbps
R1.0a 2.5G Exp.Card Module Non-Transition bit	2.5 Gbps
R1.0a 2.5G Exp.Card Module Transition bit	2.5 Gbps
R1.0a 2.5G Exp.Card Transmitter Non-Transition bit	2.5 Gbps
R1.0a 2.5G Exp.Card Transmitter Transition bit	2.5 Gbps
R1.0a 2.5G Mobile Transmitter bit	2.5 Gbps
R1.0a 2.5G Receiver mask	2.5 Gbps
R1.0a 2.5G System Board Transmitter Non-Transition bit	2.5 Gbps
R1.0a 2.5G System Board Transmitter Transition bit	2.5 Gbps
R1.0a 2.5G Transmitter Non-Transition bit	2.5 Gbps
R1.0a 2.5G Transmitter Transition bit	2.5 Gbps
R1.1 2.5G Add-in Card Transmitter Non-Transition bit	2.5 Gbps
R1.1 2.5G Add-in Card Transmitter Transition bit	2.5 Gbps
R1.1 2.5G Cable Receiver End Non-Transition bit	2.5 Gbps
R1.1 2.5G Cable Receiver End Transition bit	2.5 Gbps
R1.1 2.5G Cable Transmitter End Non-Transition bit	2.5 Gbps
R1.1 2.5G Cable Transmitter End Transition bit	2.5 Gbps
R1.1 2.5G Express Module System Non-Transition bit	2.5 Gbps
R1.1 2.5G Express Module System Transition bit	2.5 Gbps
R1.1 2.5G Express Module Transmitter Path Non-Transition bit	2.5 Gbps
R1.1 2.5G Express Module Transmitter Path Transition bit	2.5 Gbps
R1.1 2.5G Receiver mask	2.5 Gbps
R1.1 2.5G System Board Transmitter Non-Transition bit	2.5 Gbps
R1.1 2.5G System Board Transmitter Transition bit	2.5 Gbps
R1.1 2.5G Transmitter Non-Transition bit	2.5 Gbps
R1.1 2.5G Transmitter Transition bit	2.5 Gbps
R2.0 5.0G Add-in Card 35 dB Transmitter Non-Transition bit	5 Gbps
R2.0 5.0G Add-in Card 60 dB Transmitter Non-Transition bit	5 Gbps
R2.0 5.0G Add-in Card 35 dB Transmitter Transition bit	5 Gbps
R2.0 5.0G Add-in Card 60 dB Transmitter Transition bit	5 Gbps
R2.0 5.0G Mobile Transmitter mask	5 Gbps
R2.0 5.0G Receiver mask	5 Gbps
R2.0 5.0G System Board Transmitter Non-Transition bit	5 Gbps
R2.0 5.0G System Board Transmitter Transition bit	5 Gbps
R2.0 5.0G Transmitter Non-Transition bit	5 Gbps
R2.0 5.0G Transmitter Transition bit	5 Gbps
R2.1 5.0G Transmitter Non-Transition bit	5 Gbps
R2.1 5.0G Transmitter Transition bit	5 Gbps

The list of industry-standard PCI-Express masks

7.8.3.1.8   ANSI T1.102 Masks

Clicking the **ANSI T1.102** tab opens the list of industry-standard electrical masks. Any of these masks may be recalled from memory and used to test a waveform to a specific industry standard listed above.
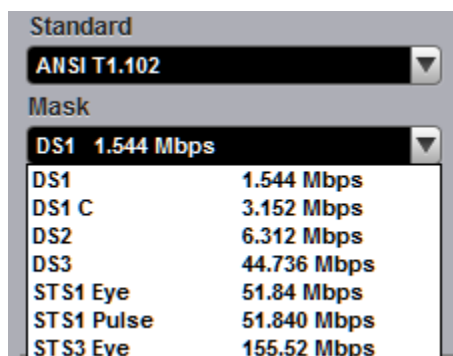
The list of industry-standard electrical ANSI T1.102 masks

7.8.3.1.9   InfiniBand Masks

Clicking the **InfiniBand** tab opens the list of industry-standard masks. Any of these masks may be recalled from memory and used to test a waveform to a specific industry standard listed above.

The list of industry-standard InfiniBand masks

7.8.3.1.10 Serial ATA Masks

Clicking the **Serial ATA** tab opens the list of industry-standard masks. Any of these masks may be recalled from memory and used to test a waveform to a specific industry standard listed above.

Standard	
Serial ATA	▼
Mask	
Ext Length, 1.5G 250 Cycle, Rx Mas	▼
Ext Length, 1.5G 250 Cycle, Rx Mask	1.5 Gbps
Ext Length, 1.5G 250 Cycle, Tx Mask	1.5 Gbps
Ext Length, 1.5G 5 Cycle, Rx Mask	1.5 Gbps
Ext Length, 1.5G 5 Cycle, Tx Mask	1.5 Gbps
Gen1, 1.5G 250 Cycle, Rx Mask	1.5 Gbps
Gen1, 1.5G 250 Cycle, Tx Mask	1.5 Gbps
Gen1, 1.5G 5 Cycle, Rx Mask	1.5 Gbps
Gen1, 1.5G 5 Cycle, Tx Mask	1.5 Gbps
Gen1m, 1.5G 250 Cycle, Rx Mask	1.5 Gbps
Gen1m, 1.5G 250 Cycle, Tx Mask	1.5 Gbps
Gen1m, 1.5G 5 Cycle, Rx Mask	1.5 Gbps
Gen1m, 1.5G 5 Cycle, Tx Mask	1.5 Gbps
Ext Length, 3.0G 250 Cycle, Rx Mask	3 Gbps
Ext Length, 3.0G 250 Cycle, Tx Mask	3 Gbps
Ext Length, 3.0G 5 Cycle, Rx Mask	3 Gbps
Ext Length, 3.0G 5 Cycle, Tx Mask	3 Gbps
Gen1, 3.0G 250 Cycle, Rx Mask	3 Gbps
Gen1, 3.0G 250 Cycle, Tx Mask	3 Gbps
Gen1, 3.0G 5 Cycle, Rx Mask	3 Gbps
Gen1, 3.0G 5 Cycle, Tx Mask	3 Gbps
Gen1m, 3.0G 250 Cycle, Rx Mask	3 Gbps
Gen1m, 3.0G 250 Cycle, Tx Mask	3 Gbps
Gen1m, 3.0G 5 Cycle, Rx Mask	3 Gbps
Gen1m, 3.0G 5 Cycle, Tx Mask	3 Gbps

The list of industry-standard Serial ATA masks

7.8.3.1.11 XAUI Masks

Clicking the **XAUI** tab opens the list of industry-standard masks. Any of these masks may be recalled from memory and used to test a waveform to a specific industry standard listed above.

Standard	
XAUI	▼
Mask	
XAUI-E Far 3.125 Gbps	▼
3.125Gb/s XAUI Far End	3.125 Gbps
3.125Gb/s XAUI Near End	3.125 Gbps
XAUI-E Far	3.125 Gbps
XAUI-E Near	3.125 Gbps

The list of industry-standard XAUI masks

7.8.3.1.12 Mask Margins

The **Margins** option is a part of each opened list of industry-standard masks. Mask margins are used to determine the margin of compliance for a standard mask. You can use both positive mask margins and negative mask margins. Positive mask margins determine how much larger you will be able to make the mask before violations will occur, while negative mask margins determine how much smaller you have to make the mask before violations no longer occur. You can then use this information to determine by what margin the waveform begins to fail to comply with industry standards.

To turn on the mask margins, check the **Margins** button on each opened list of industry-standard masks. After mask margins are enabled, use the **Margins** variable to adjust the percentage of margin you want, or use the **Pop-up Keypad** for quickly entering numeric data. You can enter a value between –100% and +100%. For example, if you want to verify that the waveform can comply with a standard mask with a 20% margin, set the margin value to 20%. You can then increase the size of the margin by increasing the percentage until violations occur.

The instrument displays the mask margins in a different color than the mask. As with a mask, any acquired data point that falls inside a mask margin appears in red. Two examples of positive and negative margins are shown in the figures below. Notice that positive margins appear outside the mask regions, while negative margins appear inside the mask regions.
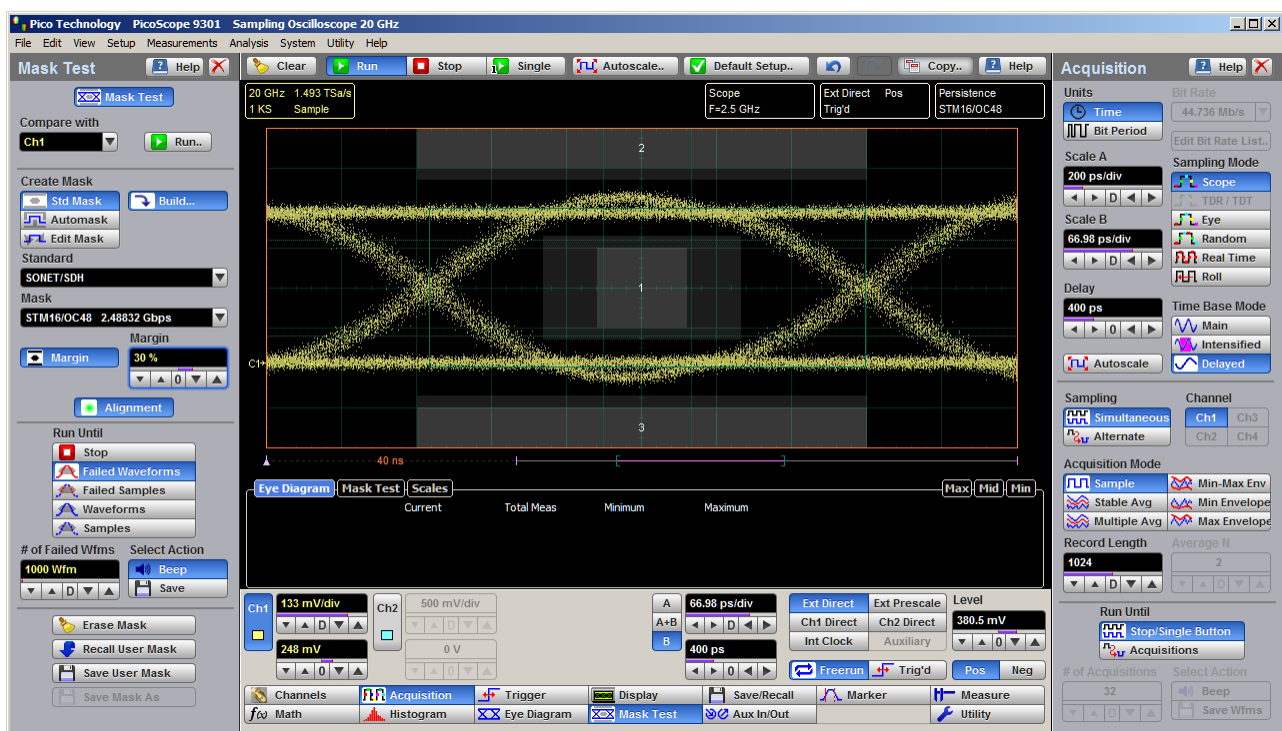
An example of eye-diagram with positive mask margins (+30%)
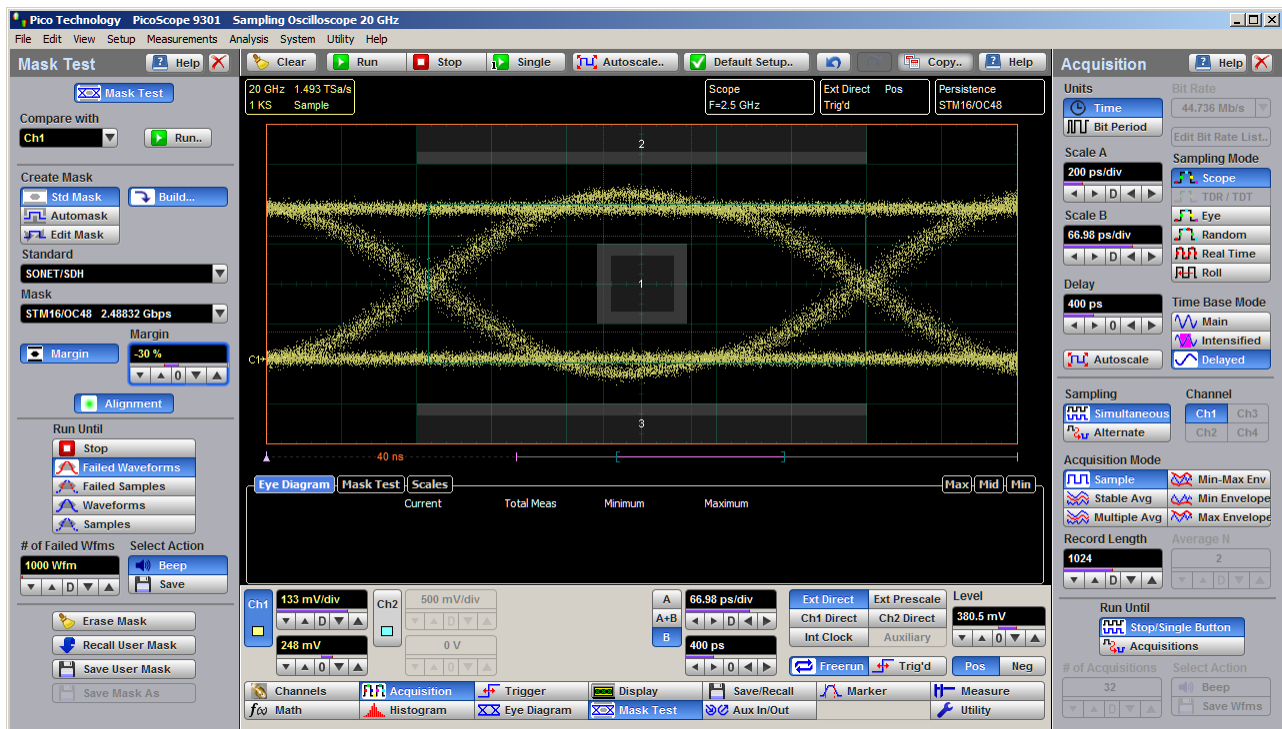
An example of eye-diagram with negative mask margins (−30%)

7.8.3.1.13 Alignment
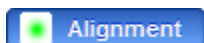
The instrument can align the **Timebase Scale** to a selected industry-standard mask. To turn on the alignment option, click the **Alignment.**

7.8.3.1.14 Build or Edit

Clicking the **Build** button builds a Standard mask or Automask.

Clicking **Edit** enters editing mode for a user-defined mask.

7.8.3.2   User-defined Masks

The **Mask Test** menu contains a mask-editing feature that allows you to create your own masks. These masks may be created using one of three methods:

● By using a reference waveform method (**Automask**). Masks are constructed by adding a **Delta X** and **Delta Y** tolerance around a reference waveform. This method is simple to use, though not as flexible as the polygon method.
● By using a polygon method for creating a unique new mask (**Edit Mask**). Using this method, polygons are created to mask off failure regions of the graticule. Up to eight polygons can be positioned in the graticule area, each with 3 to 512 sides. Very complex masks can be constructed by placing polygons within polygons. Similar to margin testing discussed above, this method allows testing of waveform failure rates to varying tolerances, because failures are listed individually for each polygon.

● By using a polygon method for modifying an existing mask (**Edit Mask**). This method involves the use of a reference waveform.

7.8.3.3   Automask
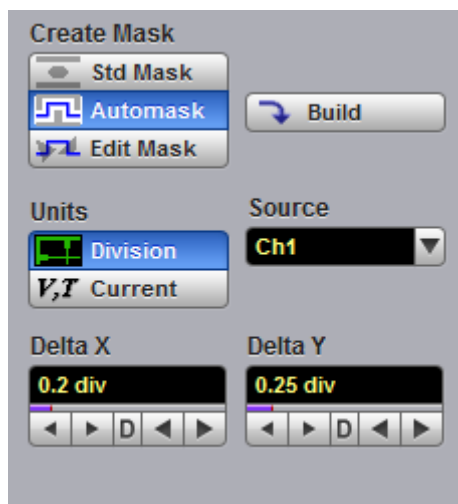
Clicking the **Automask** opens a menu for using the reference waveform method. An example of the method for a noisy impulse is shown in the figure below.
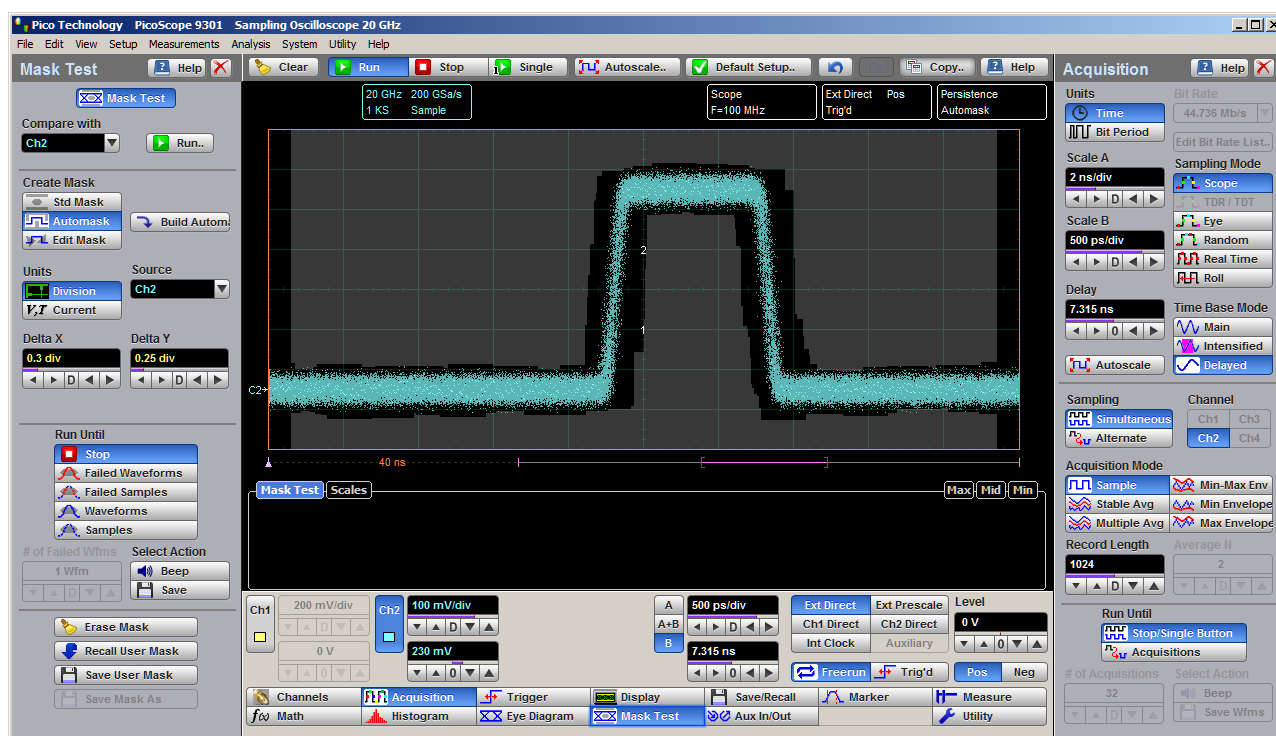
An example of Automask for a noisy pulse

7.8.3.3.1 Source
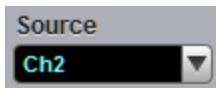
The **Source** function selects the channel, function, memory, or spectrum that the mask is scaled to.

7.8.3.3.2 Units
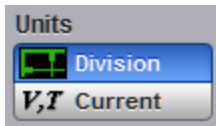
The **Units** function allows you to define **Delta X** and **Delta Y** in divisions or current source settings. Current is typically in volts and seconds or other appropriate units for the source.

7.8.3.3.3 Delta X
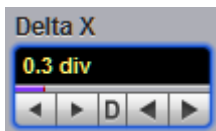
The **Delta X** variable defines the horizontal tolerance around the edges of the reference waveform.

7.8.3.3.4 Delta Y
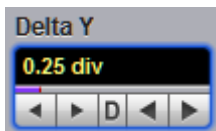
The **Delta Y** variable defines the vertical tolerance around the edges of the reference waveform.

7.8.3.4   Edit Mask
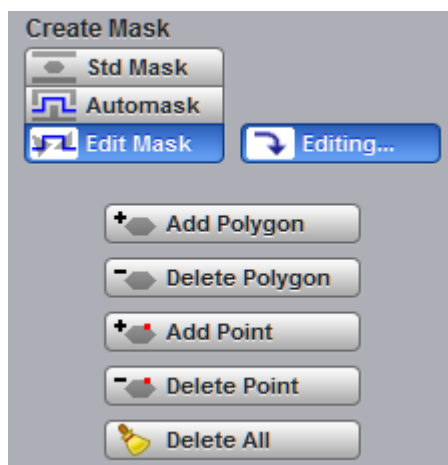
The **Edit Mask** function gives you access to a menu that allows you to construct a new mask, or edit an existing one, using the polygon method. The procedure of editing a mask function brings up a set of brief instructions on how to construct a mask.

Mask editing procedure

The following is a simple procedure for editing the **OC48/STM16** standard mask into a user-defined mask.

1. Select the **STM16/OC48** standard mask from **Standard** and **Mask** menus.
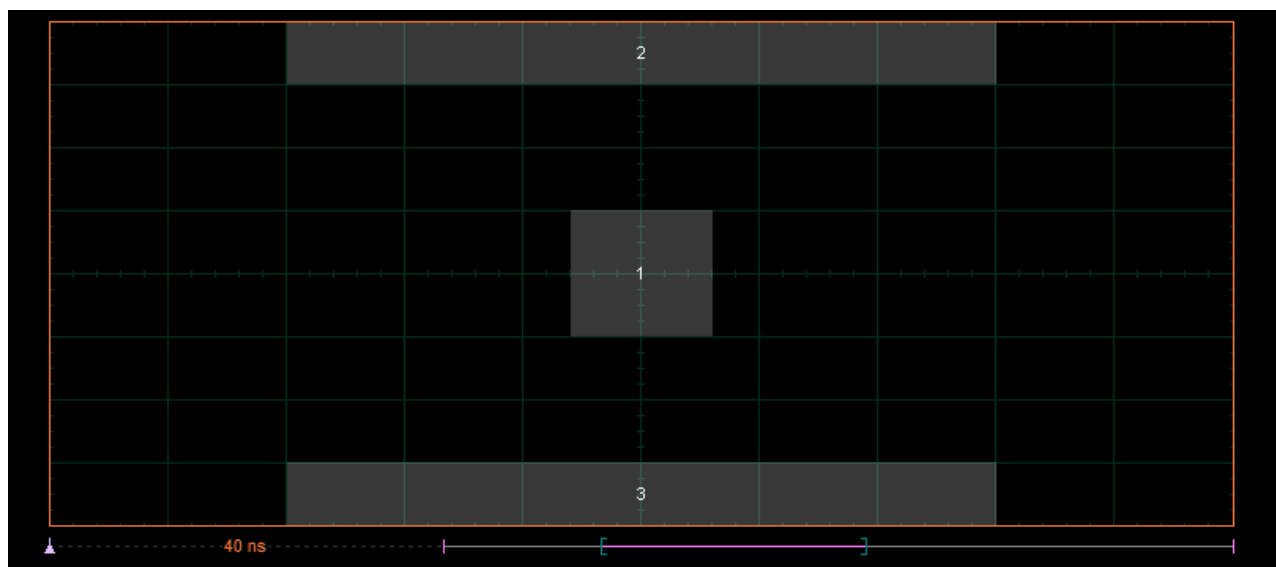
2. Click **Edit Mask** from **Create Mask** menu. Then click **Edit** ![Edit button].
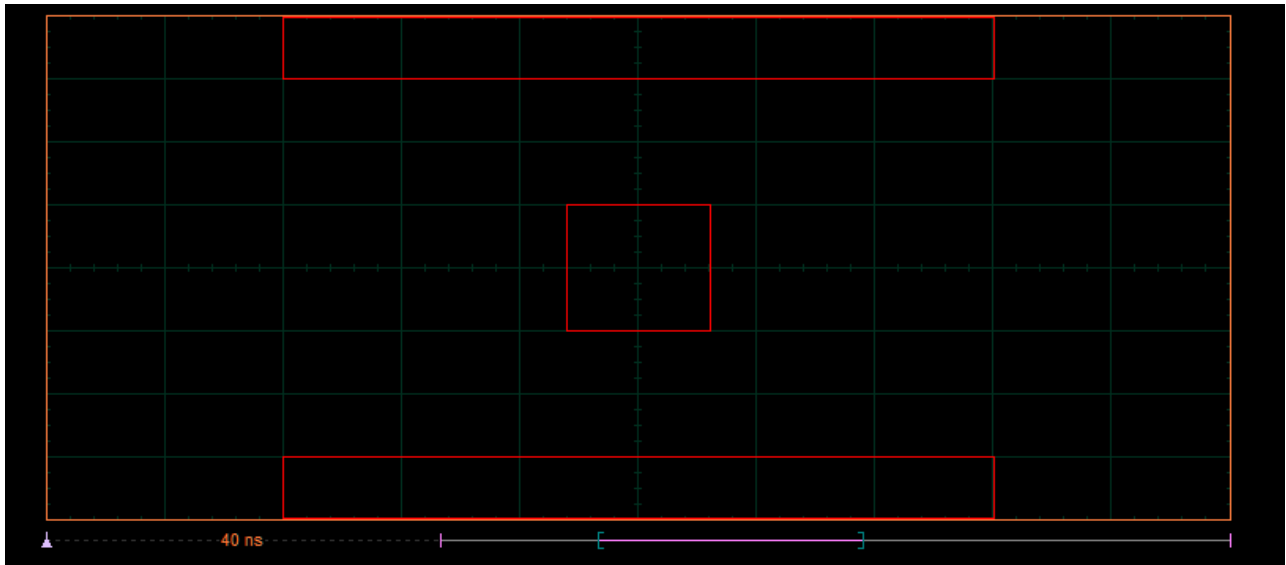
3. Click a polygon to select it, and click again on a vertex of the polygon. Note the square points on the selected polygon, which are yellow when selected, otherwise blue.
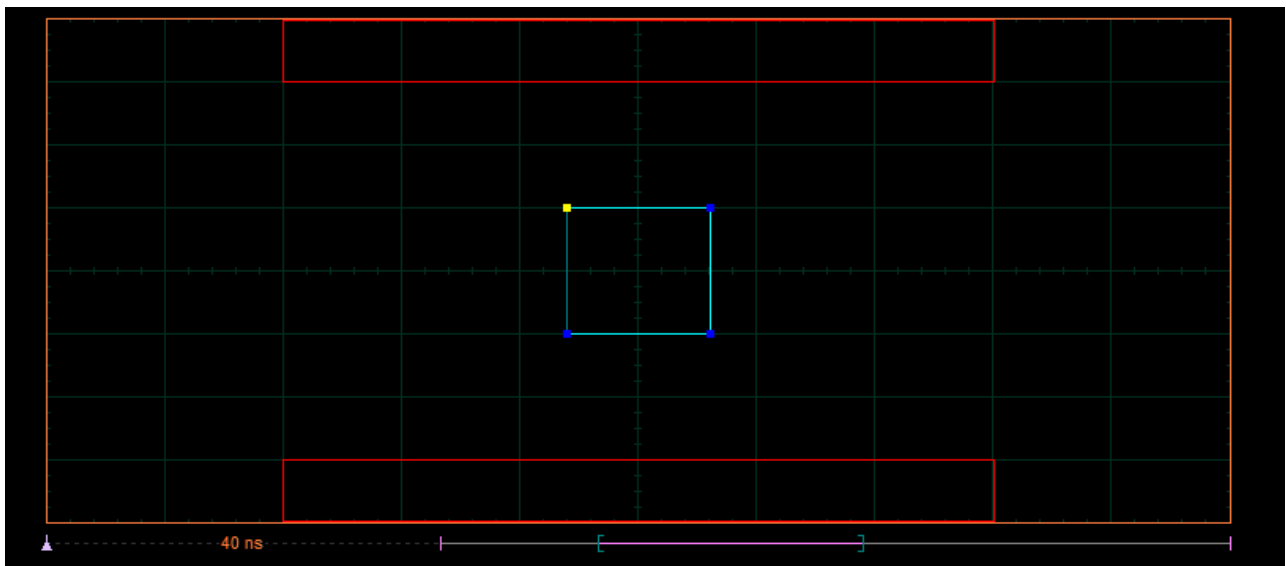
4. Click and hold the left mouse button on the selected point, then drag the mouse to move the point to the desired position. Release the mouse button when finished.
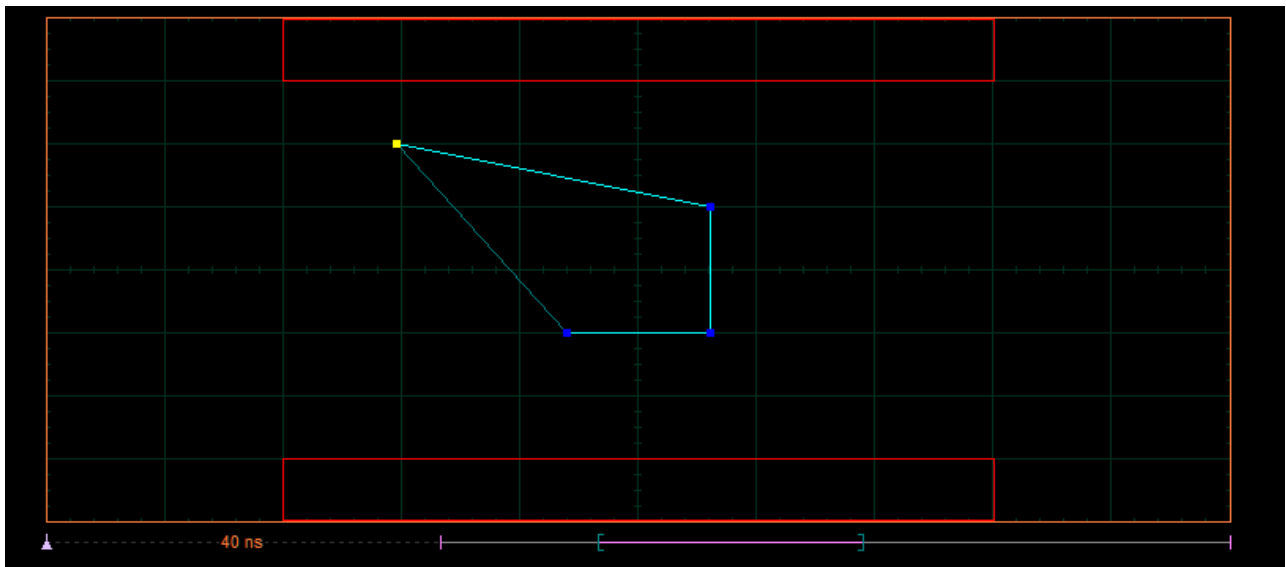
5. Click off the **Edit** button to get the edited mask as shown in the figure below.
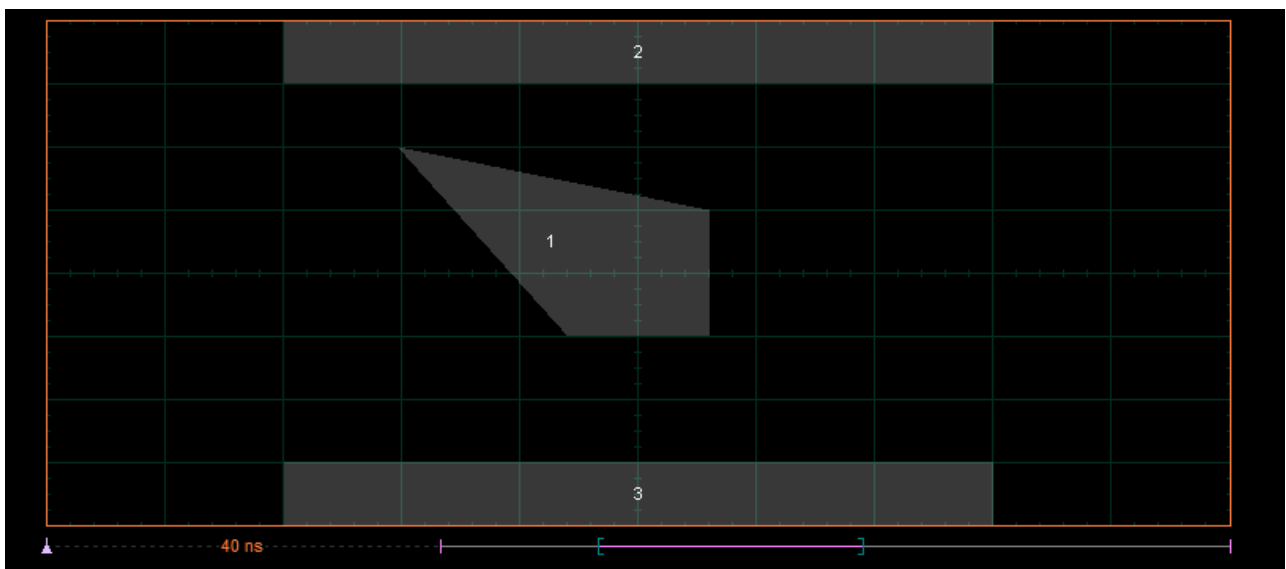
7.8.3.4.1   Add Polygon
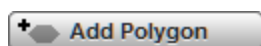
The **Add Polygon** function allows you to select one of the eight polygons that you want to create.

To add a polygon:

1. Click **Edit Mask** from **Create Mask** menu. Then click **Edit** .

2. Click the **Add Polygon** button. To create the first point of the new polygon, click on the waveform area of the screen. Move the mouse to the second point of the new polygon, then click again. Continue for all new points. You will see lines connecting all the points of the polygon. To finish the construction, right-click anywhere on the display. The polygon is now built, and the mouse is free.
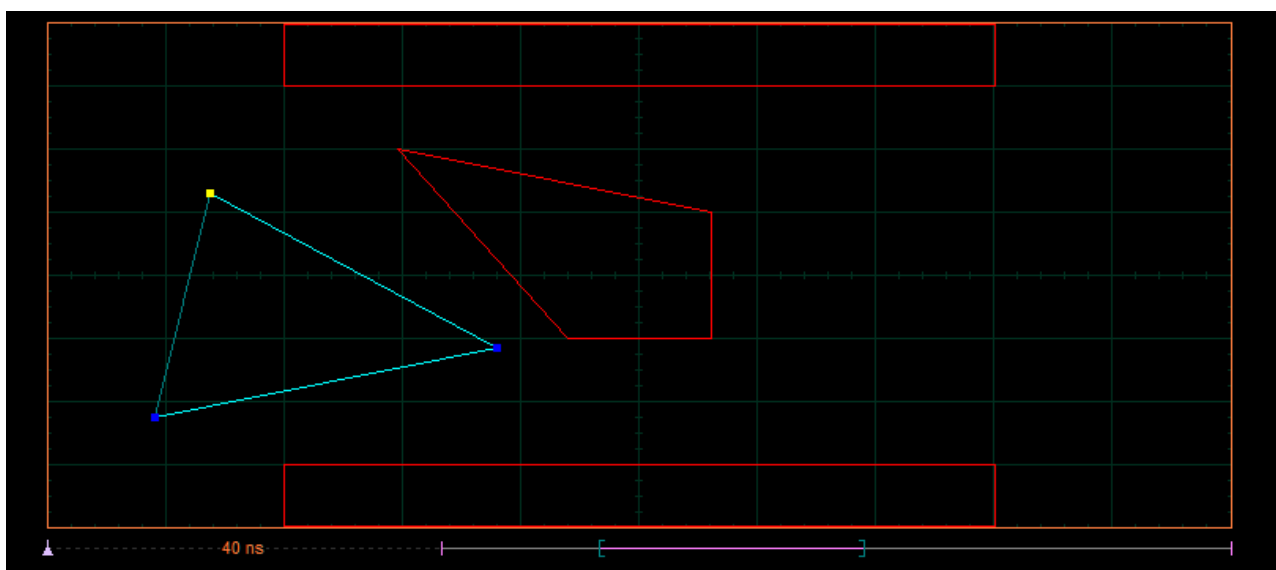
2. Click off the **Edit** button to get a mask with a new polygon. You may have up to eight polygons (see figure below).

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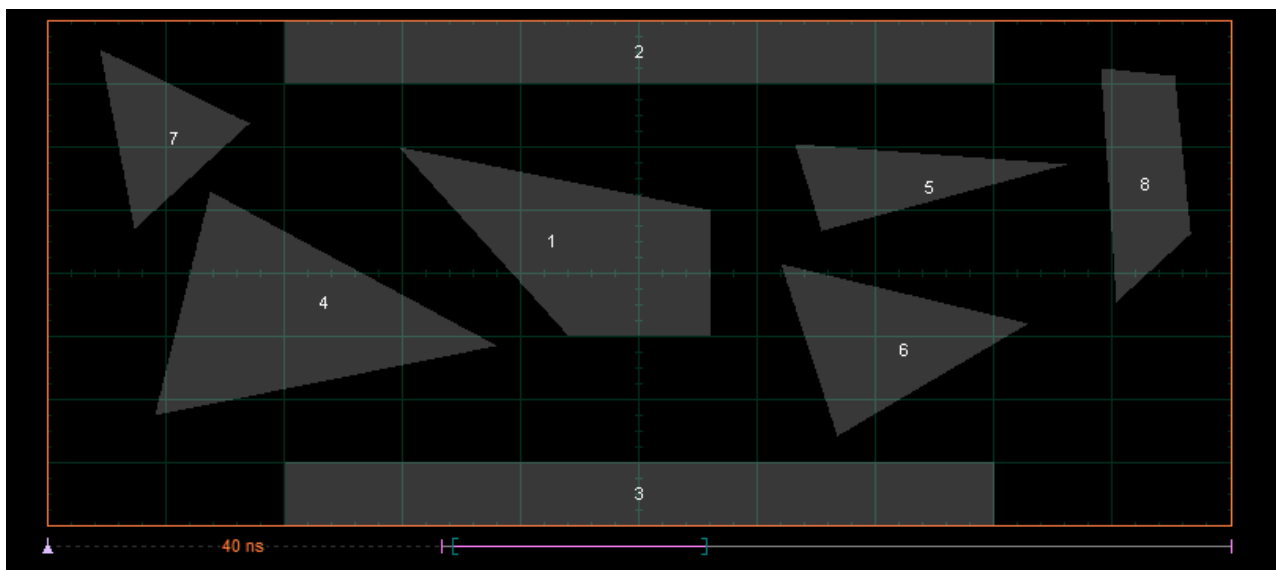
7.8.3.4.2   Delete Polygon

Delete Polygon

The **Delete Polygon** function allows you to delete one of the eight polygons.

To delete a polygon:

1. Click **Edit Mask** from **Create Mask** menu. Then click **Edit** Edit . Click on any vertex of the polygon you want to delete.
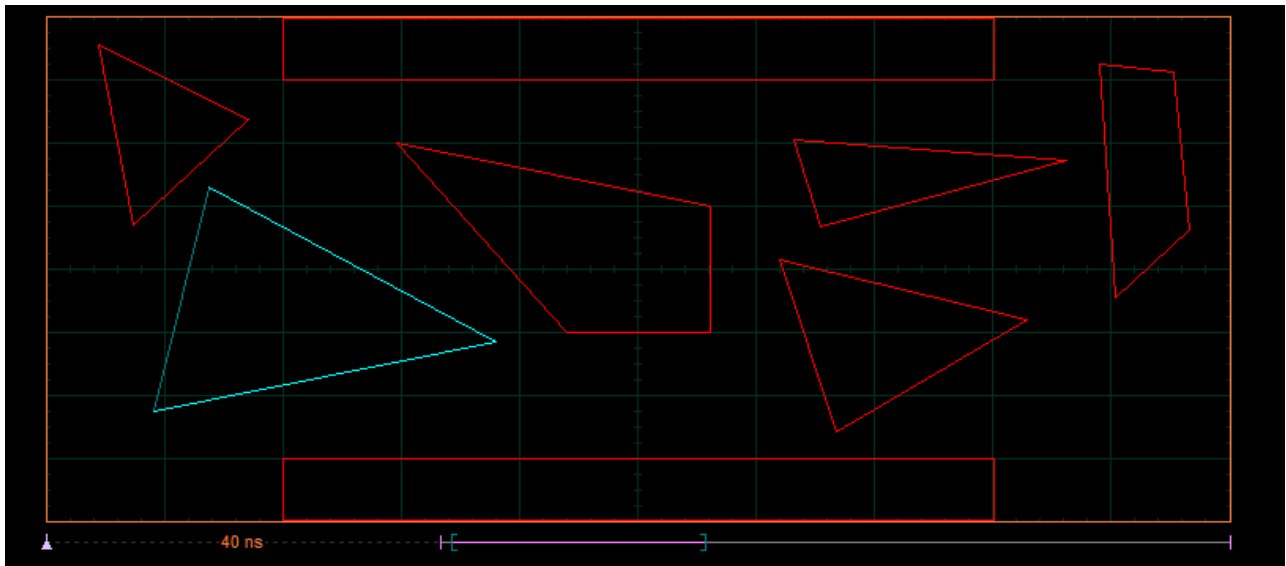
2. Click the **Delete Polygon** button. You will see the mask without the deleted polygon.
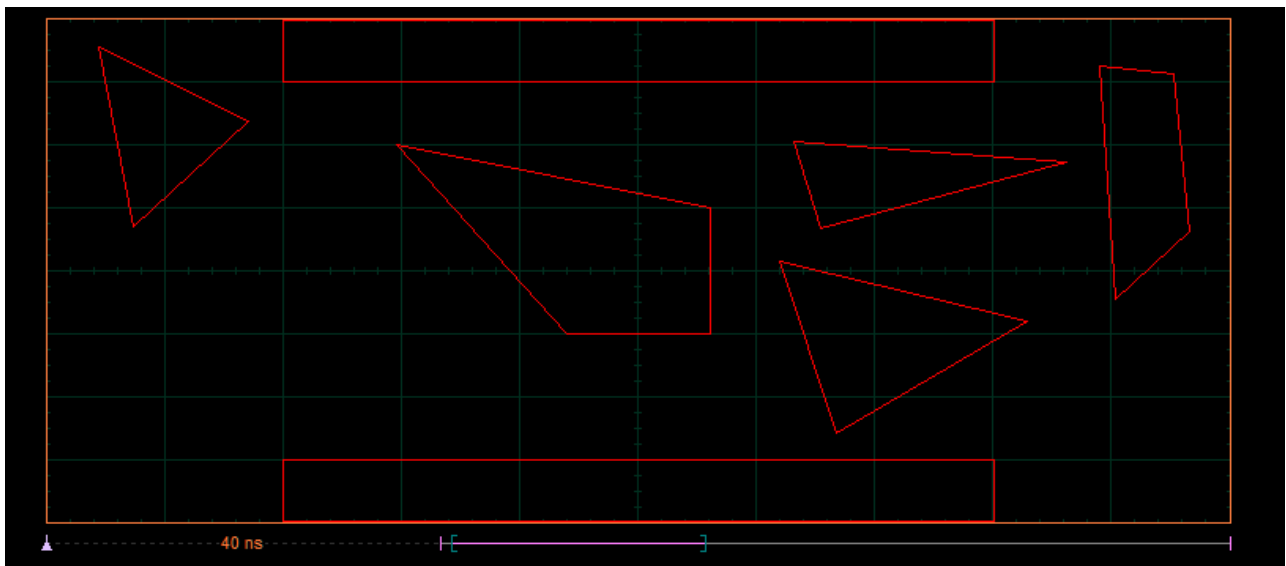
3. Click off the **Edit** button to get a mask without the deleted polygon (see figure below).
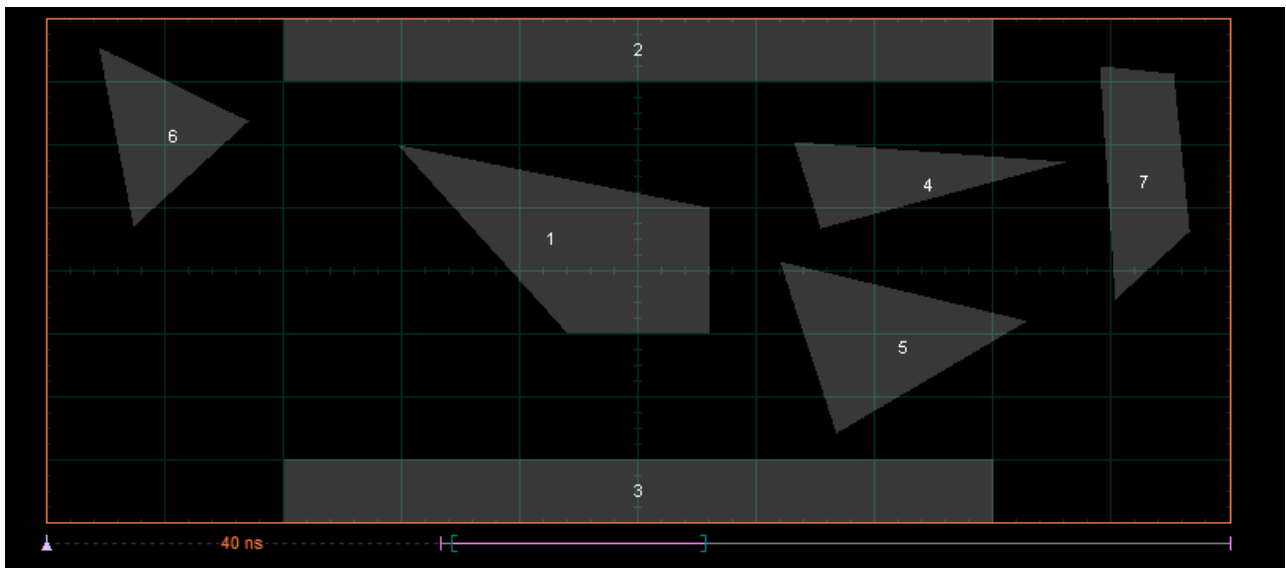
7.8.3.4.3   Add Point
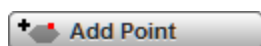
Add Point

The **Add Point** function adds a point on the selected polygon in a **Mask**.

To add a point:

1. Click **Edit Mask** from the **Create Mask** menu. Then click **Edit** Edit . Click on the polygon that you want to edit, and then click on a vertex of the polygon.
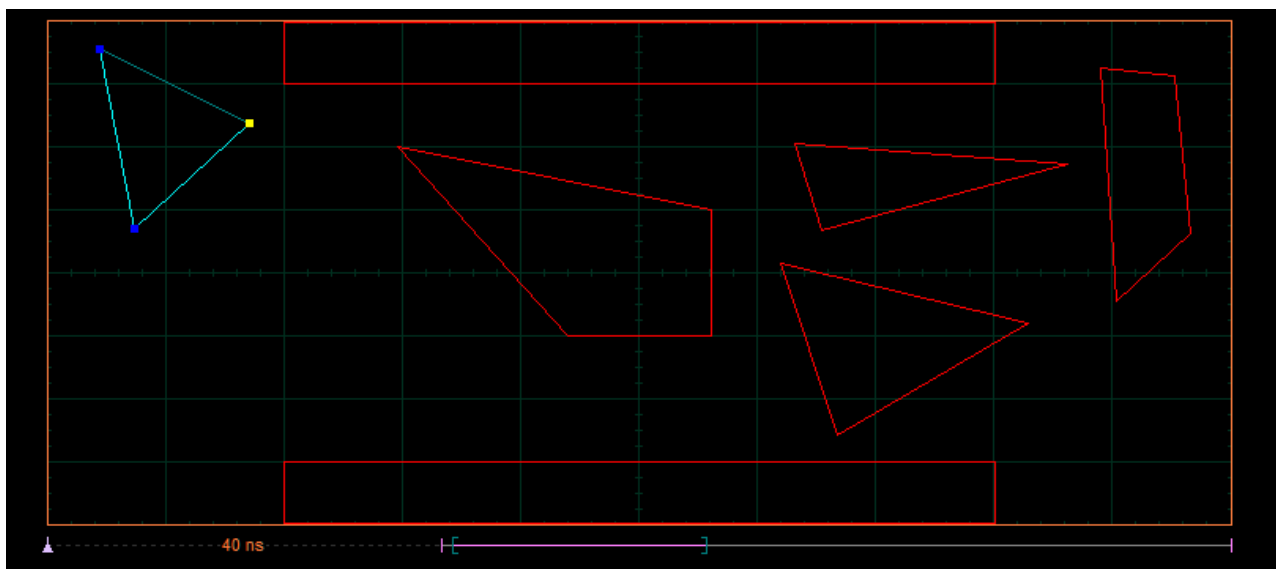
2. Click **Add Point**. A new point, highlighted in yellow, will appear counter-clockwise of the selected point. You can continue to edit this point.
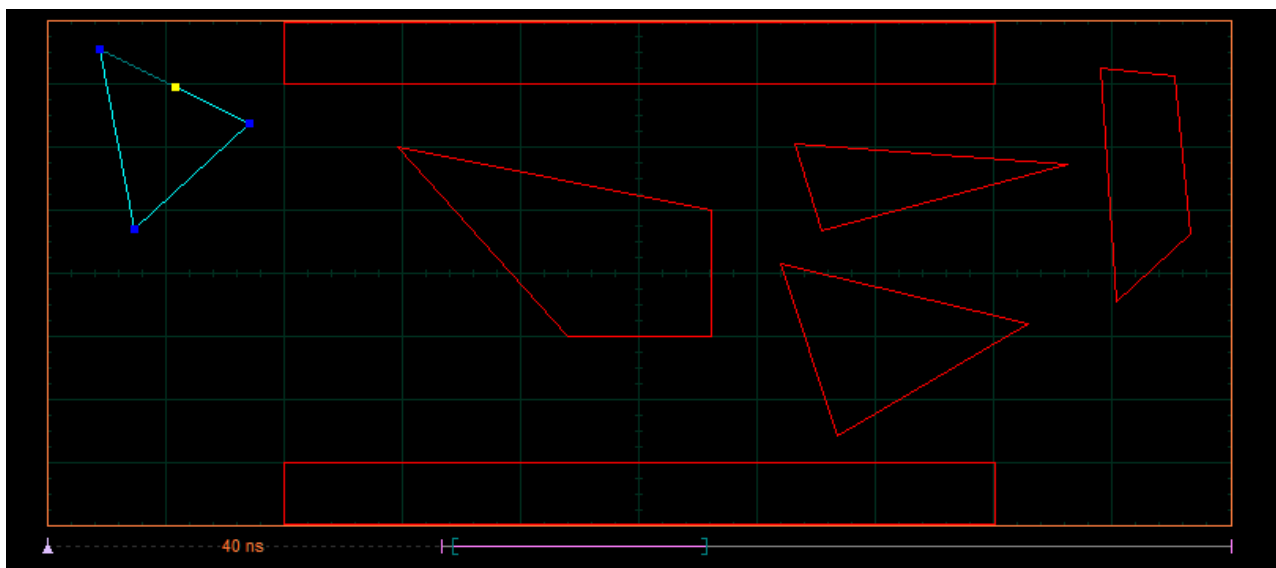
3. Click and hold the left mouse button on the new point, then drag the mouse to move it to the desired position. Release the mouse button when finished.
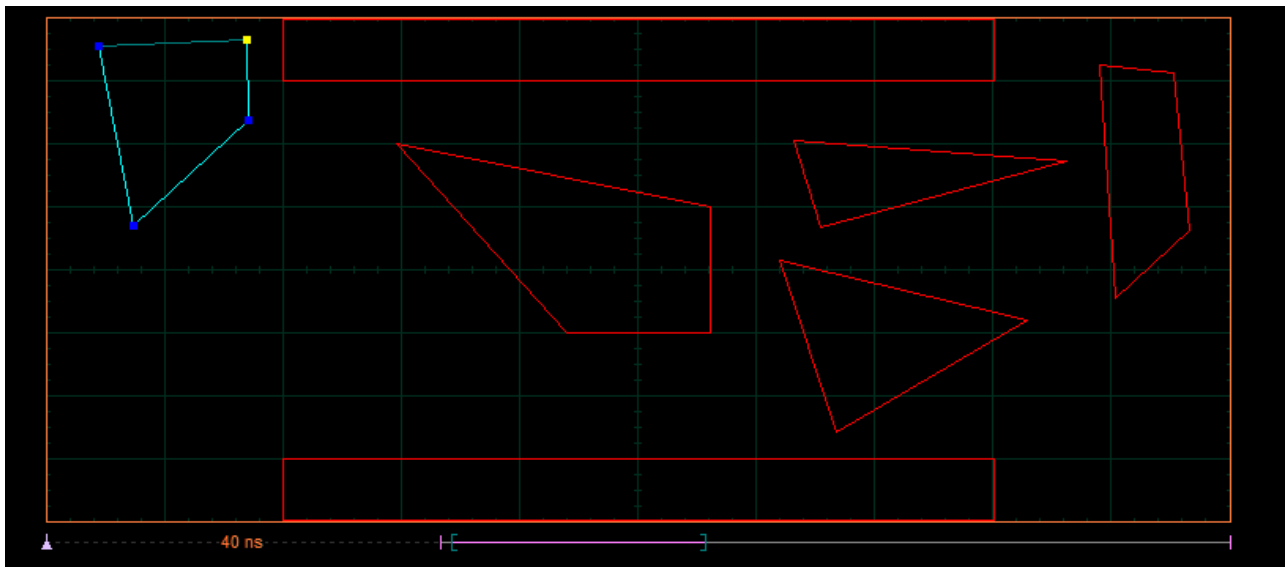
4. Click off the **Edit** button to get a mask with a polygon having an additional point (see figure below).
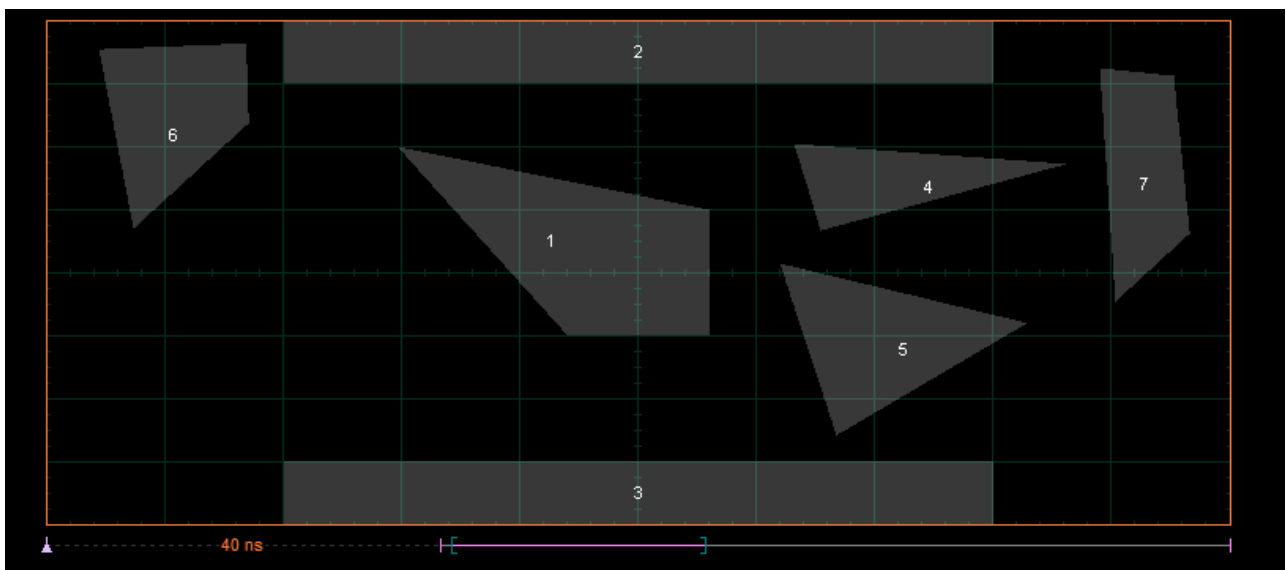
7.8.3.4.4   Delete Point

Delete Point

The **Delete Point** function deletes a point on a selected polygon of a **Mask**.

To delete a point:

1. Click **Edit Mask** in the **Create Mask** menu. Then click **Edit** Edit . Click on the polygon that you want to edit, and then click on a vertex of the polygon.
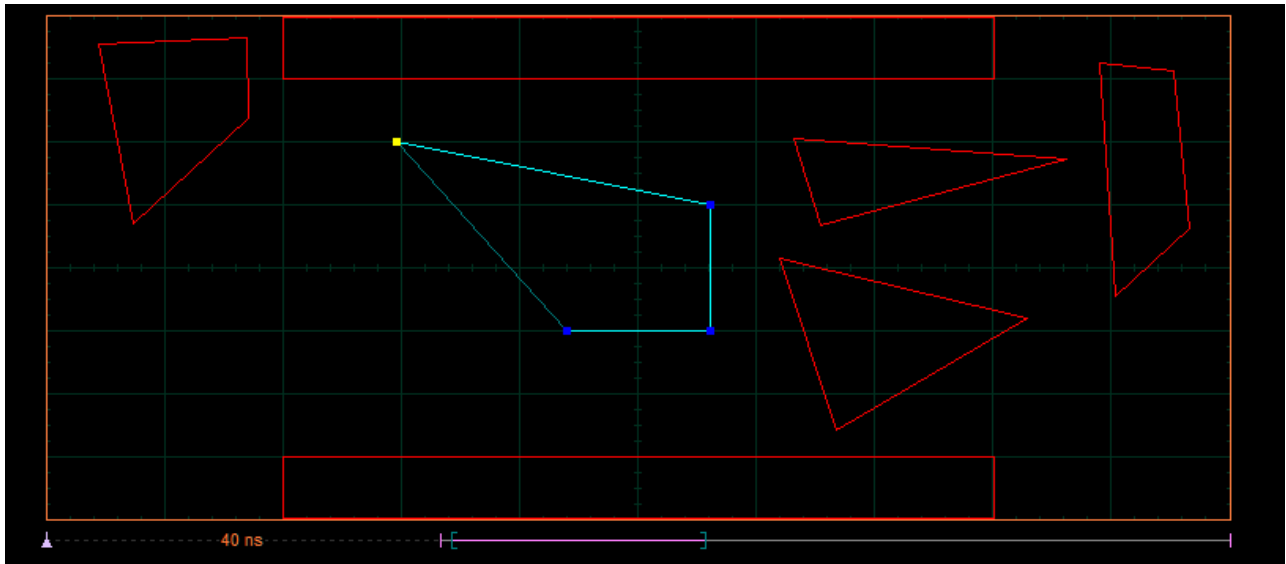
2. Click the **Delete Point** button. The point will be deleted.
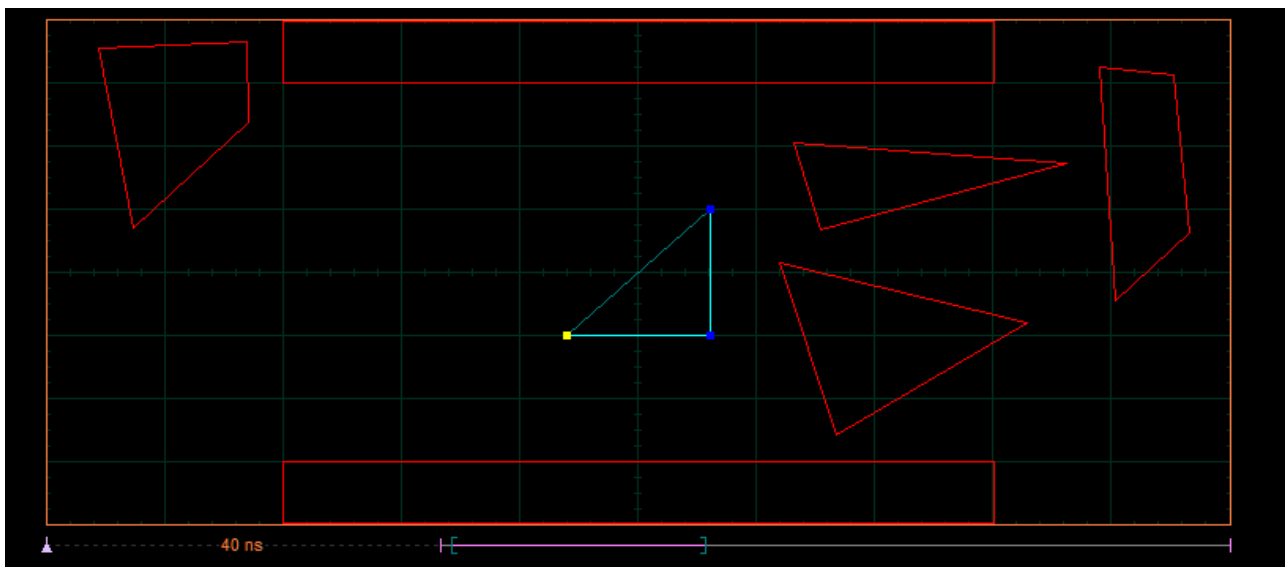
3. Click off the **Edit** button to get a mask with the modified polygon (see figure below).
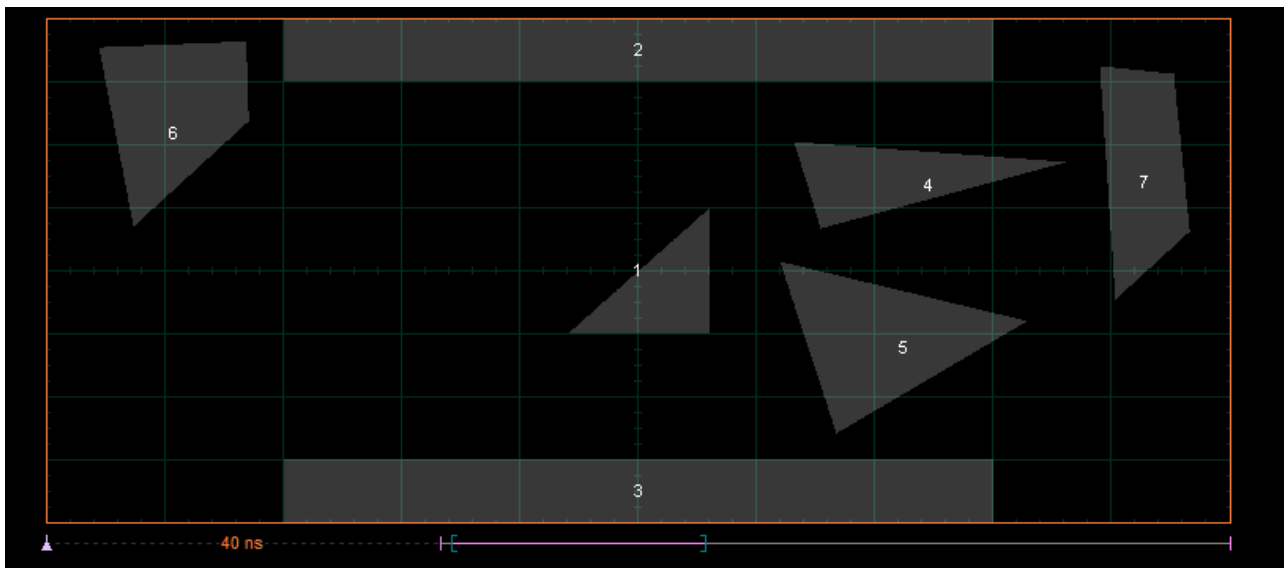
7.8.3.4.5   Delete All

The **Delete All** function allows you to delete the mask that you are editing.

To delete a mask with all polygons:

1. Click **Edit Mask** in the **Create Mask** menu. Then click **Edit** .

2. Click **Delete All**. You will see the screen without masks.

7.8.4   Run Until
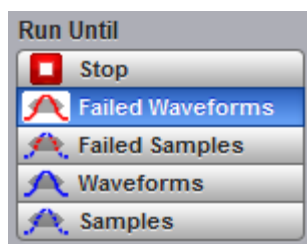
The five choices are:

- Run the test until the **Stop** button is pressed
- Run until a set number of failed waveforms occur
- Run until a set number of failed samples occur
- Run until a set number of waveforms occur
- Run until a set number of samples occur

Stop

The **Stop** function runs a mask test until the **Stop** button is pressed. Use **Stop** mode when you want the mask test to run continually and not stop after a fixed number of failures or acquisitions. For example, you may want the mask test to run overnight and not be limited by a number of failures or acquisitions.

Failed Waveforms

The **Failed Waveforms** function runs the mask test until a set number of failed waveforms are acquired. When **Failed Waveforms** is selected you can set the number of failures from the **# of Failed Wfms** variable.

Failed Samples

The **Failed Samples** function runs the mask test until a set number of failed samples are acquired. When **Failed Samples** is selected you can set the number of failed samples from the **# of Failed Smpls** variable.

Waveforms

The **Waveforms** function runs the mask test until a set number of waveforms are acquired. When **Waveforms** is selected you can set the number of waveforms from the **# of Waveforms** variable.

Samples

The **Samples** function runs the mask test until a set number of samples are acquired. When **Samples** is selected you can set the number of samples from the **# of Samples** variable.

7.8.5   # of Failed Wfms, # of Failed Smpls, # of Waveforms and # of Samples

When **Failed Waveforms** in the **Run Until** menu is selected, the **# of Failed Wfms** variable sets the number of failed waveforms. After this number is reached, acquisition stops.

When **Failed Samples** in the **Run Until** menu is selected, the **# of Failed Smpls** variable sets the number of failed samples. After this number is reached, acquisition stops.

When **Waveforms** in the **Run Until** menu is selected, the **# of Waveforms** variable sets the number of waveforms. After this number is reached, acquisition stops.

When **Samples** in the **Run Until** menu is selected, the **# of Samples** variable sets the number of samples. After this number is reached, acquisition stops.

7.8.6   Select Action
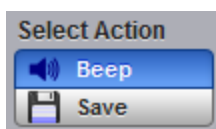
When a mask test is started, all waveforms that have data points sampled in the mask regions and margin regions (failures) are stored in the memory. The **Select Action** control allows you to specify what the instrument does after the test is completed. One of two actions can be selected.

Beep

Beep produces an audio tone when any failure occurs.

Save

Save opens the **Save Waveform As** dialog, which allows you to choose one of three file formats for the saved waveform, in the directory **Mask Test Files**. These are:

- Binary format, with **.wfm** extension
- Verbose format, with **.txt** extension
- Y values format, with **.txty** extension

7.8.7 Erase Mask
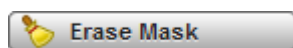
Erase Mask

The **Erase Mask** function allows you to erase the mask that is under test.

7.8.8 Recall User Mask
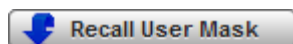
Recall User Mask

Clicking the **Recall User Mask** button recalls the **Windows Recall Mask Dialog**. You can recall a saved mask from any drive on the computer. Saved masks have the extension **.pcm**.

7.8.9 Save User Mask
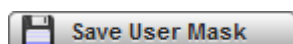
Save User Mask

Clicking the **Save User Mask** button recalls the Windows **Save Mask As Dialog**. You can save the mask to any drive on the computer. Saved masks have the extension **.pcm**.

7.9 Mathematics menu

fω Math
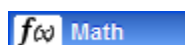
Waveform analysis

Once you have acquired or taken measurements on waveforms, the oscilloscope can mathematically combine them to create a waveform that supports your data-analysis task. For example, you can define math waveforms mathematically (+, −, ×, /). You can also differentiate or integrate a single waveform.

The PicoScope 9300 Series supports mathematical combination and functional transformation of the waveforms that it acquires. The figure below shows this concept.

Functional transformation of an acquired waveform
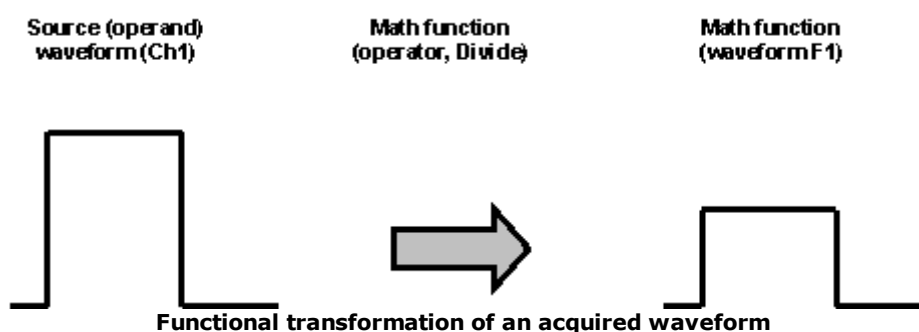
Create math waveforms to support the analysis of your channel and reference waveforms. By combining and transforming source waveforms and other data into math waveforms, you can derive the data view that your application requires.

The **Mathematics** menu allows you to define up to four math functions. Each function consists of a math operator and operands. A function is calculated on data adjusted by the calibration factor from a selected source(s), and a new waveform (called a function) is generated by the computation. You can place markers on functions, make measurements on functions, or store functions to waveform memories.
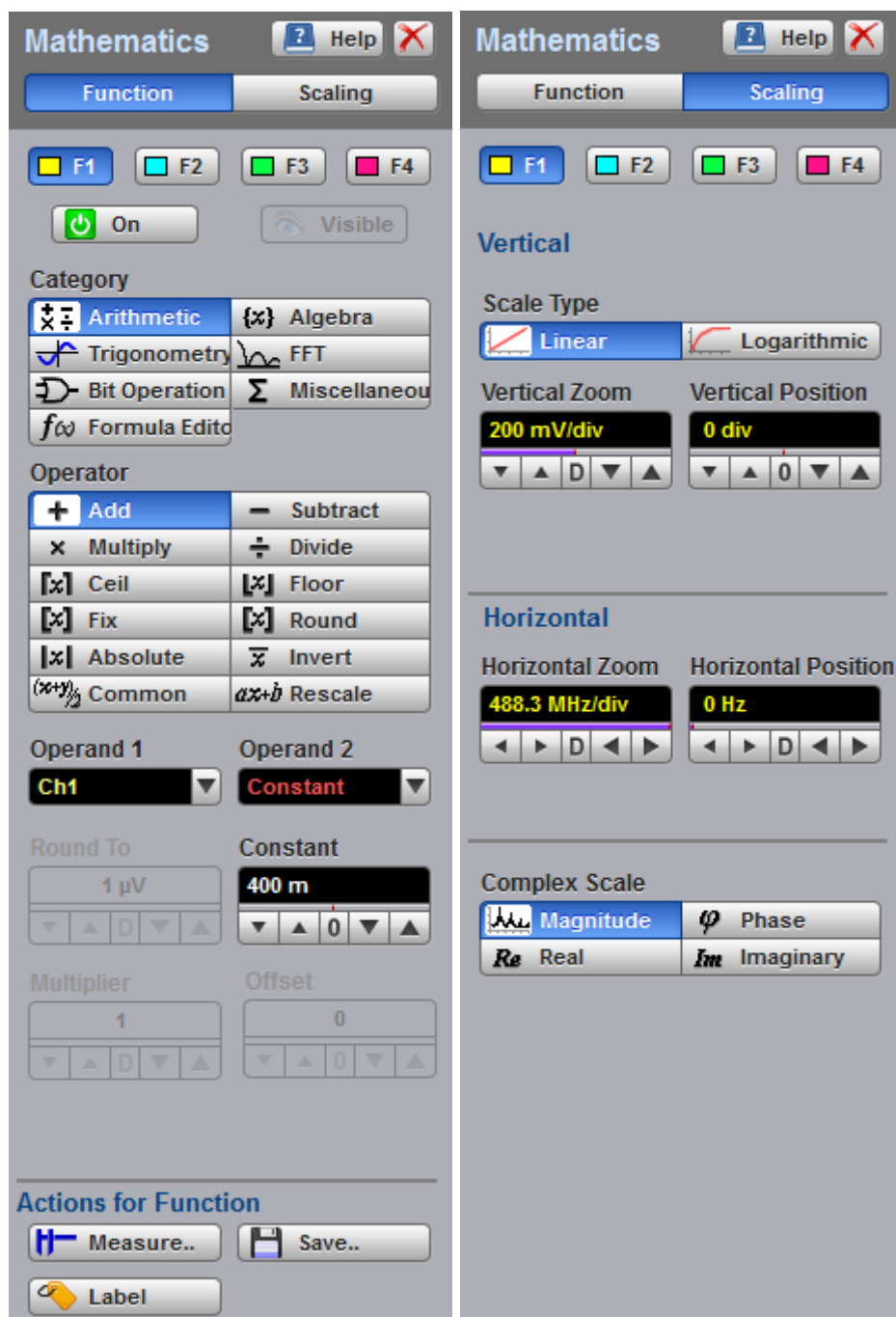
The Mathematics Menu

You can use the waveform math function capabilities to perform math operations on one or more source waveforms. For example, you can subtract channel two from channel one to make a differential measurement. Or, if one channel is measuring current and another channel is measuring voltage, you can use a function to multiply the two channels together and display the instantaneous power as a third waveform. This new waveform can then be measured with markers, or automatic measurements, such as **Peak-Peak** or **AC RMS**.

You can define up to four functions and, in most cases, a function may be used as a source for another function, so the PicoScope 9300 can perform more complex math operations. Select the function you want to define: F1 to F4. Select the operator and source(s) you want to use in the function. If the sources you have selected are active, the scope is triggered, and you will see the display update as you configure the function.

When a function is calculated, it can be displayed on the screen, evaluated with the PicoScope 9300 measurement features, stored in memory or to disk, or used as the source for another function. All math operators, such as invert, subtract, multiply, and divide, are post-processing algorithms so functions are calculated only after their sources have been acquired. All waveform math functions operate on waveform data that is on the display.

7.9.1   Function
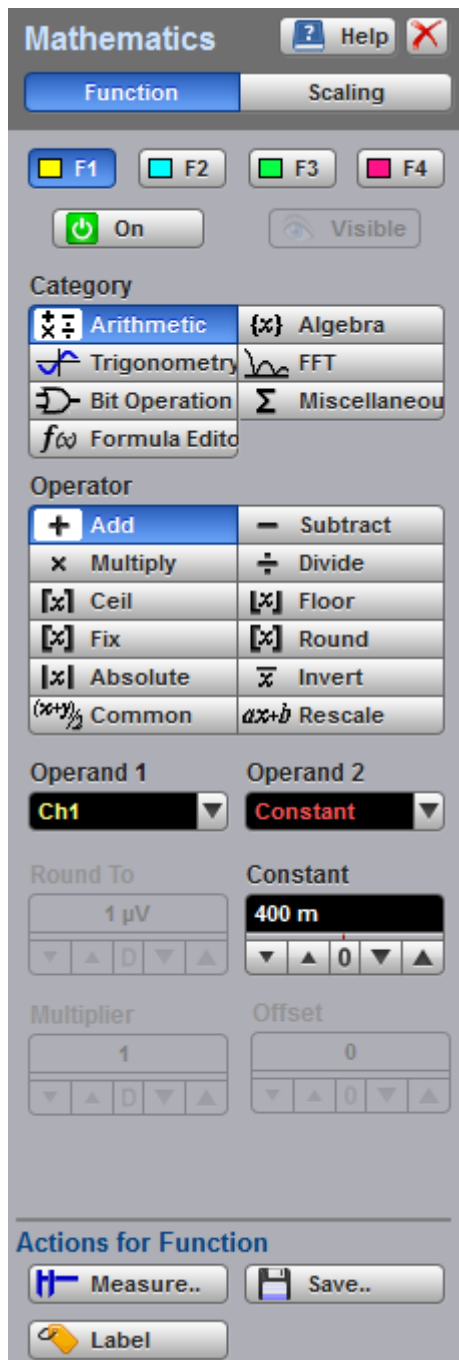
The Mathematics Menu

7.9.1.1   Select

The **Select** menu allows you to select function F1 to F4.

Clicking the F1 − F4 options:

- Selects one of the functions
- Assigns the function soft keys to the selected function

7.9.1.2   Display
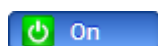
Clicking the **On** button:

- Turns the display for the selection on or off
- Changes the label from on to off or vice versa

> You can display all four functions on the screen at the same time.

7.9.1.3   Visible

Clicking the **Visible** button turns the display for the selection on or off. Turning **Visible** off does not turn off the selected function. To turn off the selected function, use the **On** button.

The **Visible** turns on or off the display of selected math waveform. Turning **Visible** off turns off the markers and defines parameters for the histogram window and eye window. However, turning **Visible** off doesn't turn off marker measurements, automatic measurements, histogram measurements, eye-diagram measurements or mask tests.

7.9.1.4   Category
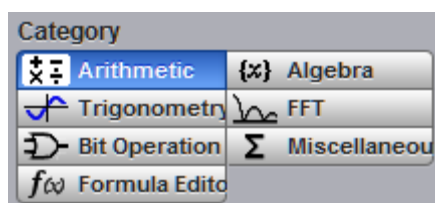
Math functions are grouped by categories. Click on the selected **Category** to see all math operators belonging to that category.

There are seven categories used in the PicoScope 9300 Series:

- Arithmetic
- Algebra
- Trigonometry
- FFT
- Bit Operation

- Miscellaneous
- Formula Editor

7.9.1.5   Operators

Each **Category** has its list of math operators.

You can select any of the math functions as a math operator to act on the operand or operands. To see the resultant waveform, select one from the **Operator** menu. A waveform math operator is a math function that requires one or two, or maybe four, sources. The operators that involve two waveform sources are: **Add**, **Subtract...**. The operators that involve one waveform source are: **Invert**, **Absolute...**

7.9.1.5.1   Arithmetic operators
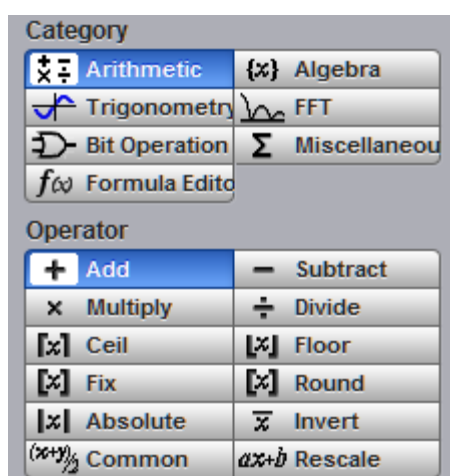
Below is a description of the twelve arithmetic operators.

Add

Adds, point by point, operand 1 and operand 2 voltage values. You can use **Add** to look at the common-mode component of differential waveforms.

Subtract

Subtracts, point by point, operand 2 from operand 1. You can use **Subtract** to make a differential measurement or to compare two waveforms.

Multiply

Multiplies, point by point, operand 1 and operand 2. Use **Multiply** to make electrical power measurements.

Divide

Divides, point by point, operand 1 by operand 2 voltage values. You can use **Divide** to measure the ratio of any two signals, for example the output voltage divided by the input voltage of an amplifier circuit.

Ceil

The **Ceil** function takes the smallest integer not less than the expression. You can use the **Round To** control.

Floor

The **Floor** function takes the largest integer not greater than the expression. The oscilloscope takes a lowest Y value for each X coordinate. You can use the **Round To** control.

Fix

The **Fix** function returns the integer portion of a number. You can use the **Round To** control.

Round

The **Round** function is used to round a numeric field to the number of decimals specified. You can use the **Round To** control.

Absolute

The **Absolute** value function makes positive all vertical values of the waveform data points on operand 1. The results provide the vertical plot data for a waveform. The horizontal scale is not changed.

Invert

Inverts the voltage values, point by point, of the waveform on operand 1. You can use **Invert** to compare the input and output of an inverting amplifier.

Common

The **Common** operation adds operand 1 and operand 2 voltage values and divides by 2, point by point.

Rescale

This function rescales the source values by a factor a and an offset b (Y=aX+b).

7.9.1.5.2   Algebraic operators
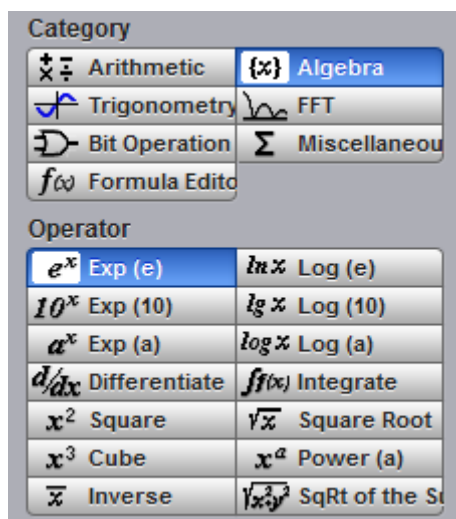
Below is a description of the fourteen algebraic operators.

Exponent (e)

The natural logarithm base *e* is raised to an exponent equal to the vertical value of a waveform data point of operand 1. Thus **Exponent (e)** exponentiates each point of the waveform. The results provide the vertical plot data for a waveform. The horizontal scale is not changed.

Exponent (10)

The base 10 is raised to an exponent equal to the vertical value of a waveform data point of operand 1. Thus **Exponent (10)** exponentiates each point of the waveform. The results provide the vertical plot data for a waveform. The horizontal scale is not changed.

Exponent (a)

The base *a* is raised to an exponent equal to the vertical value of a waveform data point of operand 1. Thus **Exponent (a)** exponentiates each point of the waveform. The results provide the vertical plot data for a waveform. The horizontal scale is not changed. Use the **Base** control to select the *a* value.

Logarithm (e)

Takes the natural logarithm (base *e*) of the absolute vertical value of each waveform data point of operand 1. The natural logarithm results provide the vertical plot data for a waveform. The horizontal scale is not changed.

Logarithm (10)

Takes the base-10 logarithm of the absolute vertical values in the waveform record of operand 1. The results provide the vertical plot data for a waveform. The horizontal scale is not changed.

Logarithm (a)

Takes the base-*a* logarithm of the absolute vertical values in the waveform record of operand 1. The results provide the vertical plot data for a waveform. The horizontal scale is not changed. Use the **Base** control to select the *a* value.

Differentiate

Calculates the discrete derivative of the vertical value of the waveform data points of operand 1. You can use **Differentiate** to measure the instantaneous slope of a waveform. The horizontal scale is not changed. This may be used to measure, for example, the slew rate of an operational amplifier.

Integrate

Calculates the integral of the vertical values of the waveform data points of operand 1. The results provide the vertical plot data for a waveform. The horizontal scale is not changed. This function can be used to calculate the area in volt-seconds under a pulse or other waveform.

Square

The **Square** operator calculates the square of the input signal.

Square Root

The **Square Root** operator calculates the square root of operand 1.

Cube

The **Cube** operator calculates the cube of the input signal.

Power (a)

The **Power (a)** operator calculates operand 1 raised to the power of *a*. Use the **Exponent** control to select the *a* value.

Inverse

The **Inverse** operator calculates the function Y = 1/X.

Square Root of the Sum

The **Square Root of the Sum** operator calculates the square root of the sum of the squares of two signals.

7.9.1.5.3   Trigonometric Operators
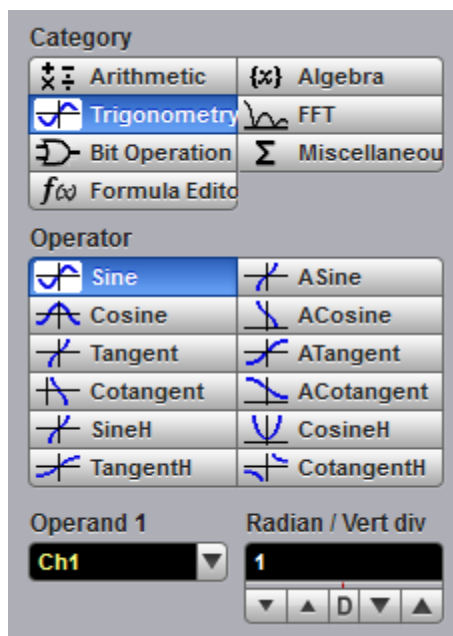
Below is a description of the twelve trigonometric operators. There are four standard trigonometric functions, four inverse trigonometric functions, and four hyperbolic functions.

You can use the **Radian/Vert div** control with many of the trigonometric operators to set the scaling of vertical divisions to radians.

Sine

The **Sine** operator calculates the function Y = sin X, where   is defined by the **Radian/Vert Unit** (V, A, W) control.

Cosine

The **Cosine** operator calculates the function Y = cos X, where   is defined by the **Radian/Vert Unit** (V, A, W) control.

Tangent

The **Tangent** operator calculates the function Y = tan X, where   is defined by the **Radian/Vert Unit** (V, A, W) control.

Cotangent

The **Cotangent** operator calculates the function Y = cot X, where   is defined by the **Radian/Vert Unit** (V, A, W) control.

ArcSine

The **ArcSine** operator calculates the function Y = arcsin X, where   is defined by the **Radian/Vert Unit** (V, A, W) control.

ArcCosine

The **ArcCosine** operator calculates the function Y = arccos X, where   is defined by the **Radian/Vert Unit** (V, A, W) control.

ArcTangent

The **ArcTangent** operator calculates the function Y = arctan X, where   is defined by the **Radian/Vert Unit** (V, A, W) control.

ArcCotangent

The **ArcCotangent** operator calculates the function Y = arccot X, where   is defined by the **Radian/Vert Unit** (V, A, W) control.

SineH

The **SineH** operator calculates the hyperbolic sine function Y = sinh (X).

CosineH

The **CosineH** operator calculates the hyperbolic cosine function Y = cosh (X).

TangentH

The **TangentH** operator calculates the hyperbolic tangent function Y = tanh (X).

CotangentH

The **CotangentH** operator calculates the hyperbolic cotangent function Y = coth (X).

7.9.1.5.4   FFT
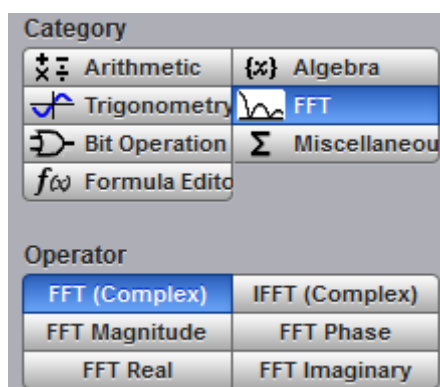
The **FFT** menu allows you to control the operation of the FFT (Fast Fourier Transform), including spectrum selection and display, and also a choice of six FFT windowing functions. Refer to the **Scaling** menu for formatting a spectrum with different complex scales, and also for scaling and positioning it.

7.9.1.5.4.1   FFT Basics

The PicoScope 9300 displays and measures signals in the time domain, where the vertical axis is amplitude and the horizontal axis is time. This is the best way to view most waveforms. However, there are times when you want to know the frequency content of a waveform.

> ℹ️ In 1807 the French mathematician Jean Baptiste Fourier developed the Fourier series and Fourier transform to solve thermodynamics problems. Using the Fourier series, any periodic waveform can be constructed by adding a DC term to a series of sine and cosine terms. You can use the Fourier transform to mathematically relate the time domain and the frequency domain.

The Discrete Fourier Transform (DFT) is used to convert sampled time domain waveform data into the frequency domain. However, the DFT is slow because it requires a large number of calculations. This led to the development of the Fast Fourier Transform (FFT), which runs faster than the DFT on digital computers.

When an FFT, or fast Fourier transform, is added to an instrument, signals can also be displayed in the frequency domain. The frequency domain allows you to see the frequency content of a signal. FFT functionality added to an instrument allows you to analyze a signal from two different, but complementary, points of view: the frequency domain and the time domain. The FFT process mathematically converts the standard (in this case repetitive) time-domain signal into its frequency components, providing spectrum analysis capabilities. Being able to quickly look at a signal's frequency components and spectrum shape is a powerful research and analysis tool.

FFT is an excellent troubleshooting aid for:

- Finding crosstalk problems
- Finding distortion problems in analog waveforms caused by non-linear amplifiers
- Adjusting filter circuits designed to filter out certain harmonics in a waveform
- Testing impulse responses of systems
- Identifying and locating noise and interference sources

The FFT display shows the amplitude for each frequency component in your waveform on the vertical axis, and frequency on the horizontal axis. The figure below illustrates what an FFT does. The FFT transforms a time record of N samples into a frequency record of N points from 0 Hz to Fs, where Fs is the sampling frequency. The resolution or the spacing between the points in the frequency record is Fs/N.
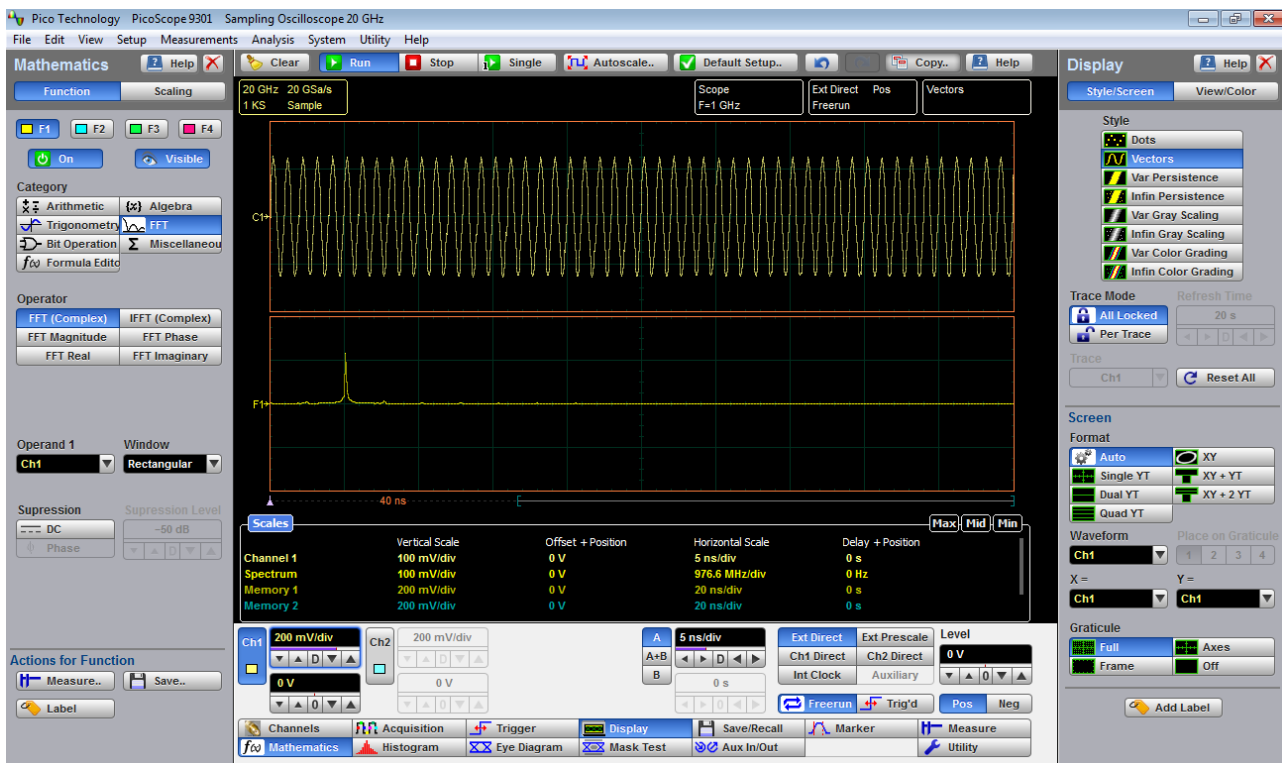
The 1 GHz sine-wave signal shown in both the Time Domain and the Frequency Domain

The frequency Fs/2 is a unique frequency referred to as the Nyquist frequency. At the Nyquist frequency there are exactly two samples on every cycle of the input signal. Signals above the Nyquist frequency become aliased, which means that they appear as signals of a lower frequency, because there are not enough sample points on each cycle of the signal to determine the correct frequency.

It turns out that the points above Fs/2 are mirror images of the points below Fs/2. They are not displayed because they do not provide any additional information. Therefore, N time samples results in N/2 displayed frequency points.

You can use the FFT capability to display both the magnitude and the phase, or the real and the imaginary parts of the frequency components of the signal, using a linear or decibel vertical scale.

> ℹ️ Use the **Scale** menu for further magnification and spanning of the FFT, and for selecting the Complex Scale of the display.

You can perform an FFT on any waveform. The record length of the waveform can be up to 32 768 points. Because the PicoScope 9300 performs FFT calculations on a complex trace record, you should use the shortest record length that provides adequate resolution, as FFT waveforms update slowly at long record lengths.

The PicoScope 9300 offers a choice of six FFT windowing functions, which modify the time-domain data to minimize "leakage" of energy across frequency components.

The five automated measurements FFT Magnitude, FFT Delta Magnitude, THD (Total Harmonic Distortion), FFT Frequency, and FFT Delta Frequency are intended for FFT waveforms. You can also use the markers to make magnitude and phase measurements on frequency domain traces.

> ⓘ   Use the **Measure** and **Marker** menus for further spectral measurements of FFT
> waveforms.

FFT Resolution

Amplitude Resolution

Amplitude resolution is influenced by the windowing function used and the vertical adjustment of the time domain waveform. For maximum amplitude resolution, the time domain waveform should be adjusted so that it is centered vertically on the graticule and is tall as possible without going beyond the graticule, above or below.

Frequency Range and Resolution

The range and resolution of the frequency spectrum displayed by the PicoScope 9300 are determined by the sample rate and record length. The sample interval is determined by the timebase and record length. You can increase the record length for better FFT resolution but all points must be on the display for them to be included in the FFT calculation. The FFT calculation time will also increase because more waveform samples must be processed.

The FFT's resolution is expressed as follows:

FFT Resolution = Effective sample rate / Record length

The FFT frequency range before scaling will be from 0 Hz to one half of the sample rate. Ensure that the sample rate is at least twice the highest anticipated frequency component of the waveform source you are measuring. Otherwise, the measurement results will exhibit aliasing and any measurements will be inaccurate.

The FFT's frequency range is expressed as follows:

FFT Frequency Range = Effective sample rate / 2

FFT Aliasing

Aliasing occurs when the input signal includes components at frequencies higher than the Nyquist frequency. These frequency components appear in the FFT waveform display as peaks at lower frequency. The higher-frequency components are reflected around the Nyquist frequency. For example, a frequency component 1 GHz above the Nyquist frequency will appear as a peak 1 GHz below the Nyquist frequency in the FFT waveform display.

You can eliminate aliasing by setting the effective sampling rate to be at least twice the highest frequency in the input signal. Increasing the record length or decreasing the timebase scale will increase the effective sampling rate.

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7.9.1.5.4.2 FFT Operators
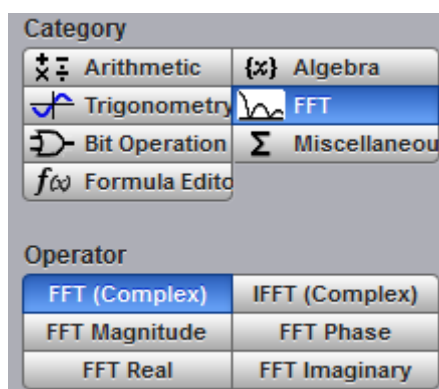
Below is a description of the six FFT operators.

FFT (Complex)

The **FFT (Complex)** operator calculates the function Y = FFT (X). This is a complex function that can be used as a source for a further **Inverse FFT**. The **Scaling/Complex Scale** menu provides selection of the display format of a waveform that has a complex value. You can select either **Magnitude, Phase, Real** or **Imaginary** complex scale.

Inverse FFT (Complex)

Inverse FFT calculates the time-domain function from its frequency-domain data (spectrum). Only a complex function can be used as a source for **Inverse FFT**.

FFT Magnitude

The peak signal amplitude is represented on a linear scale, in the same units as the input signal. You can choose **Vertical Zoom**, **Vertical Position**, **Horizontal Zoom** and **Horizontal Position** to provide complete control over the spectrum magnitude.

Use the **DC Suppression** option to reduce the DC components in the FFT spectrum of the signal.
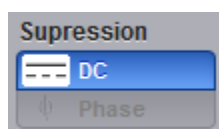
FFT Phase

The **FFT Phase** is measured with respect to a cosine whose maximum occurs at the left-hand edge of the screen, at which point it is 0°. Similarly, a positive-going sine wave starting at the left-hand edge of the screen has a −90° phase. You can display phase data as a function of frequency in degrees.

Your source waveform record may have a noise component with phase angles that randomly vary from − to + . This noise could make the phase display unusable. In such a case, use phase suppression to control the noise. You can reduce the noise phase for magnitudes below a threshold level by using the **Phase Suppression** and **Suppression Level** controls. The **Suppression Level** control allows you to adjust the phase suppression level. You specify the phase suppression level in dB with respect to a peak having maximum amplitude among other peaks. If the magnitude of the frequency is greater than this threshold, then its phase angle will be displayed. FFT magnitudes below this level will have their phase set to zero.
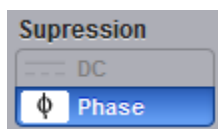
Phase suppression controls
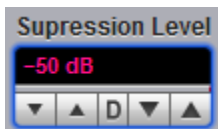
Suppression level controls

FFT Real

The **FFT Real** operator displays the linear magnitude of the real part of the spectral magnitude only. This is useful if you process the spectrum off-line and transform it back into a time-domain trace. You could save the real spectrum into a waveform memory.

FFT Imaginary

The **FFT Imaginary** operator displays the linear magnitude of the imaginary part of the spectral magnitude only. This is useful if you process the spectrum off-line and transform it back into a time-domain trace. You could save the imaginary spectrum into a waveform memory.

7.9.1.5.4.3   FFT Windows

Windowing is a technique that compensates for some of the limitations of FFT analysis. The FFT operation assumes the time record repeats infinitely. Unless there is an integral number of cycles of the sampled waveform in the record, a discontinuity is created at the end of the record.

A pure sine wave transforms into a single spectral component, but a discontinuity in the time domain causes a frequency-domain widening or spreading out of the waveform, referred to as "spectral leakage". Two figures below show a sine wave FFT with and without leakage.
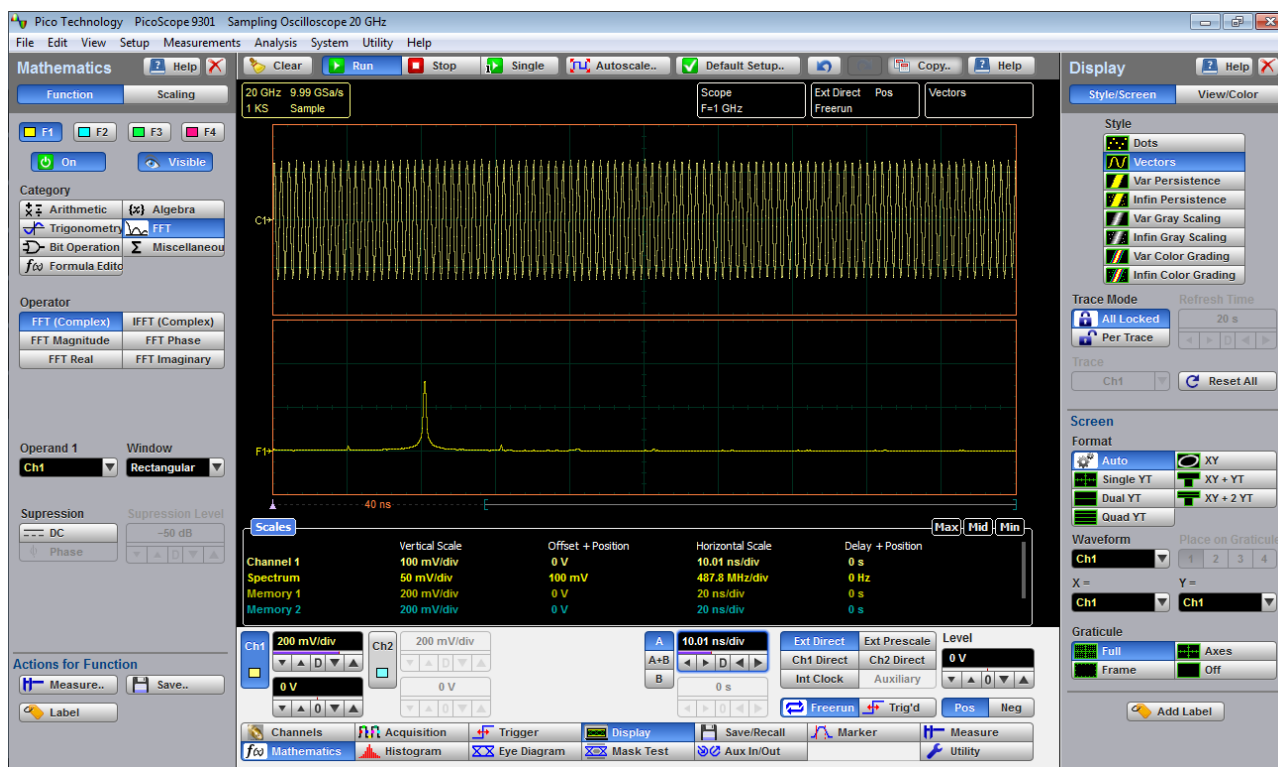
FFT with leakage

FFT having small amount of leakage

A solution to the leakage problem is to force the waveform to zero at the beginning and end of the time record so that no transient is present when the time record is replicated. This is done by multiplying the time record by a window function, which produces its own effect in the frequency domain. However, the effect produced by the window function is a big improvement over using no window function at all.

Windowing Process

The process of windowing the data is shown below. The FFT time domain record is multiplied point by point with the FFT window. When the Hann or Blackman-Harris window is used, the data point amplitudes taper to zero at the end of the record.
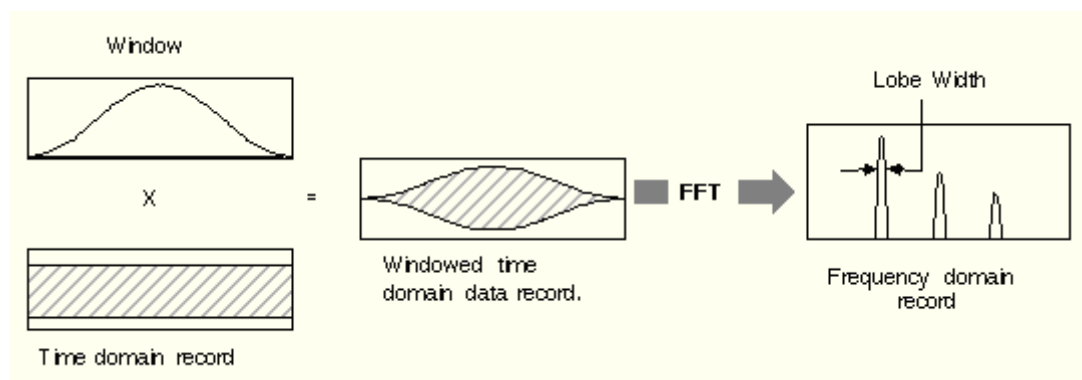
Multiplying the time domain data record by a window

> ⓘ When using windows, be sure that the most interesting parts of the signal in the time domain record are positioned in the center of the window so the tapering does not cause significant errors.

Types of FFT Window

The window type defines the bandwidth and shape of the equivalent filter associated with the FFT processing. The PicoScope 9300 provides a rectangular FFT window, which does not taper the time domain data, and five tapering FFT windows of different shapes.

The six supported FFT window functions are:

- **Rectangular** window
- **Hamming** window
- **Hann** window
- **Flattop** window
- **Blackman-Harris** window
- **Kaiser-Bessel** window

> ⓘ Remember that windows work by weighting points in the middle of the waveform record higher than those at the ends of the record.

Each time-domain FFT windowing function corresponds to a filter in the frequency domain. Each frequency domain filter has a high central lobe, or passband, whose width determines how well adjacent frequency components can be resolved. The height of the side lobes surrounding the central lobe determines how much leakage can occur.

Equations for the FFT Windows

Four windows used in the PicoScope 9300 Series (**Hamming**, **Hann**, **Flattop**, and **Blackman-Harris**) are derived from a cosine series. The window type is obtained by substituting the correct coefficients for the cosine terms into the following equation:

$$\Gamma n = \sum_{i=0}^{m} \left\{ a_i \cos\left[\frac{2\pi}{N}\left(n - \frac{N-1}{2}\right)\right] \right\}$$

where: n is the window data area, a is the array of window coefficients, N is the window length, m is the window order, i is the index to the window coefficient array, and n is the index to the window data array. n = 0 to N−1.

The table of correction coefficients for different FFT windows indicates the values to substitute into equation to obtain the various windows.

Correction coefficients for different FFT windows

Coefficients	Rectangular	Hamming	Hann	Flattop	Blackman-Harris	Kaiser-Bessel
M	0	1	1	2	3	3
a0	1.0	0.543478	0.5	0.281	0.35875	0.40243
a1	0.0	0.456522	0.5	0.521	0.48829	0.49804
a2	0.0	0.0	0.0	0.198	0.14128	0.09831
a3	0.0	0.0	0.0	0.0	0.01168	0.00122
Highest side lobe	−13 dB	−43 dB	−32 dB		−94 dB	−69 dB
3 dB Bandwidth in bins	0.89	1.3	1.44		1.92	1.72
Scallop loss	3.96 dB	1.78 dB	1.42 dB		0.81 dB	1.02 dB
Zero Phase Reference	50%	50%	50%		50%	50%

For the Rectangular window: $n = 1$.

The best window for a given application depends on various factors. Most measurements require the use of a window such as the **Hann** or **Flattop** windows, which are the appropriate windows for typical frequency analysis measurements. Choosing between different windows involves a trade-off between frequency resolution and amplitude accuracy.

For harmonic analysis of continuous-time signals, the best window choice depends on the signal characteristics and on the particular characteristics that are of most interest. The use of **Blackman-Harris**, **Kaiser-Bessel**, **Hann** or **Hamming** windows typically makes observation of harmonics easier.

The rectangular window can be typically used for impulse response testing since the beginning points are usually zero and the data tapers to zero at the end of the record. The beginning points are zero because the impulse is normally placed in the center of the time-domain record at the zero-phase reference point. Other windows can be used if desired. If phase is not important, the impulse can be placed at the beginning of the record. For this case, the window must be **Rectangular**.

Rectangular Window

The rectangular window (also referred to as the Uniform window) is effectively no window because the samples are left unchanged. All points in the record are multiplied by 1. In the frequency domain, the filter shape is sin(x)/x.
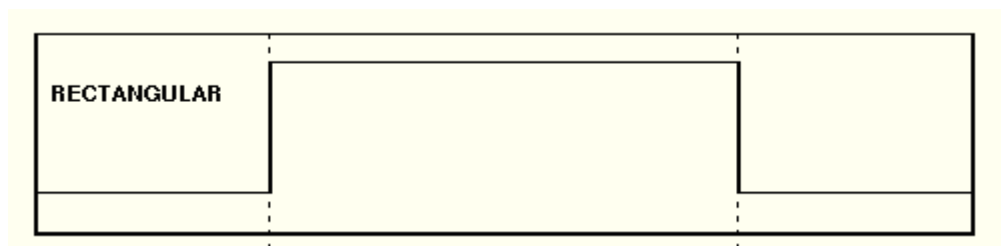
Time-domain characteristics for rectangular window

The rectangular window is useful for transient signals and signals where there are an integral number of cycles in the time record. It is the best window to use when you want to examine the frequency spectrum of a non-repetitive signal. Also, it can be typically used for impulse response testing since the beginning points are usually zero and the data tapers to zero at the end of the record. The beginning points are zero because the impulse is normally placed in the center of the time domain record at the zero phase reference point. Other windows can be used if desired. If phase is not important, the impulse can be placed at the beginning of the record. For this case, the window must be rectangular.

The rectangular window generally gives the best frequency resolution because it results in the narrowest lobe width in the FFT output record. It gains frequency resolution at the expense of amplitude accuracy if the frequency of the signal being observed has a non-integer number of cycles in the FFT time record. Signals not in this class show varying amounts of spectral leakage and scallop loss, which can be corrected by using one of the other windows.

Although the rectangular window has the potential for severe leakage problems, in some cases the waveform data in the time record has the same value at both ends of the record, thereby eliminating the transient introduced by the FFT. Such waveforms are called self-windowing. Waveforms such as sine bursts, impulses and decaying sinusoids can all be self-windowing.

Hamming Window

The **Hamming** window is a bell-shaped window. It has lower side lobes adjacent to the main lobe than, for example, the **Hann** window.
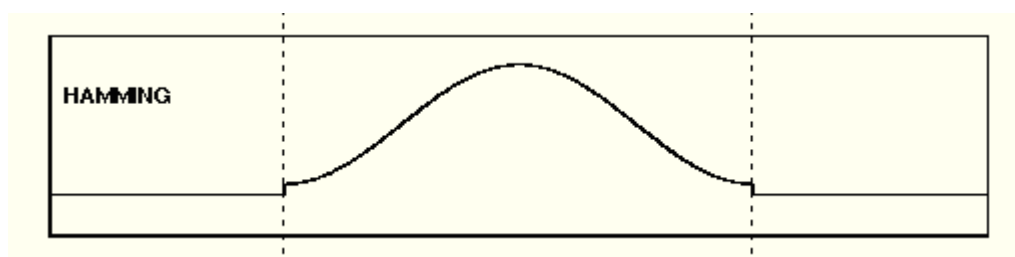
Time-domain characteristics for Hamming window

The **Hamming** window tapers the data to smaller values, but not to zero. It decreases the amount of energy spillover into adjacent frequency bins, increasing the amount of amplitude accuracy at the expense of decreasing the frequency.

Use the **Hamming** window for resolving frequencies that are very close to the same value with somewhat improved amplitude accuracy over the rectangular window.

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Hann Window

The **Hann** (or **Hanning**, or **cosine**) window is a bell-shaped window, and it looks like the first half of a sine wave. The **Hann** window multiplies the points in the center of the record by 1 and multiplies the points at the start and the end of the record by zero. It decreases the amount of energy spillover into adjacent frequency bins, increasing the amount of amplitude accuracy at the expense of decreasing the frequency resolution because of wider lobe widths. The shape of the **Hann** window is a compromise between amplitude accuracy and frequency resolution.

Time domain characteristics for Hann window
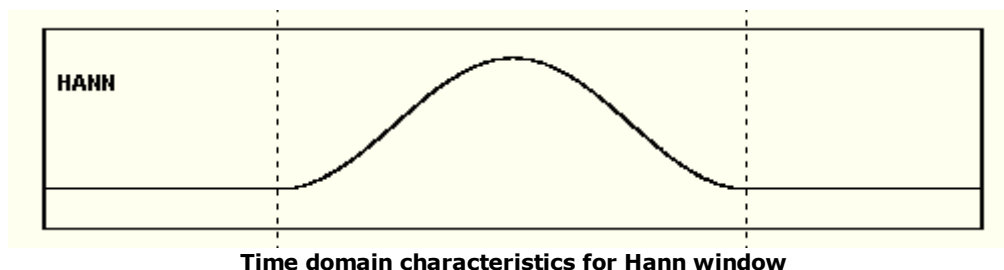
The **Hann** window is useful for frequency resolution and general-purpose use. Even though the overall shape of the time-domain signal has changed, the frequency content remains basically the same. The spectral line associated with the sinusoid spreads out a small amount in the frequency domain. It is good for resolving two frequencies that are close together or for making frequency measurements. The **Hann** window also improves amplitude accuracy.

The **Hann** window, compared to other common windows, provides good frequency resolution at the expense of somewhat less amplitude accuracy.

Flattop Window

The **Flattop** window has a fatter (and flatter) characteristic in the frequency domain. The flatter top on the spectral line in the frequency domain produces improved amplitude accuracy, but at the expense of poorer frequency resolution when compared with the **Hann** window.

The flattop window is the best window for making accurate amplitude measurements or frequency peaks.

Blackman-Harris Window

A **Blackman-Harris** window is a bell-shaped window. It reduces the leakage to a minimum, has the widest pass band (lowest frequency resolution) and lowest side lobes. It decreases the amount of energy spillover into adjacent frequency bins, increasing the amount of amplitude accuracy at the expense of decreasing the frequency resolution because of wider lobe widths.

Time domain characteristics for Blackman-Harris window
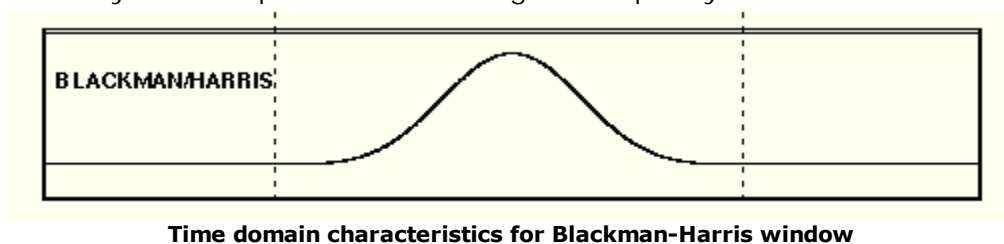
The **Blackman-Harris** window is the best window for measuring the amplitude of frequencies but worst at resolving frequencies. This window is especially good for viewing a broad spectrum.

Kaiser-Bessel Window

This window has resolution bandwidths and scallop losses close to the Blackman-Harris window. Choose the **Kaiser-Bessel** window to view the signal characteristics you are interested in.

7.9.1.5.5   Bit Operation

Bit Operation defines a logical combination of up to four sources. The sources are channels, memories and functions.

Below is a description the of seven bit operations and some auxiliary controls.

The Bit Operation menu

AND – a logical AND, conjunctive combination

NAND – a logical NOT AND

OR – a logical OR, disjunctive combination

NOR – a logical NOT OR

XOR – a logical exclusive OR

NXOR – logical negation of exclusive OR

NOT – a logical negation

Operand 1 - Operand 4

Up to four sources (operands) can be used to define the logic combination. The sources are channels, memories and functions.

Threshold 1 - Threshold 4

Use these controls to set the threshold level for the logic definition of a 1 (one) or 0 (zero) on any source. Each source can have a threshold level set which determines when a voltage value is consider to be a 1 (one) or 0 (zero). A value is considered a 1 when your waveform's voltage level is greater than the threshold level and a 0 when your waveform's voltage level is less than the threshold level.

Inverse Operand

You can invert the polarity of any source to define the necessary logic combination.

7.9.1.5.6   Miscellaneous Operators
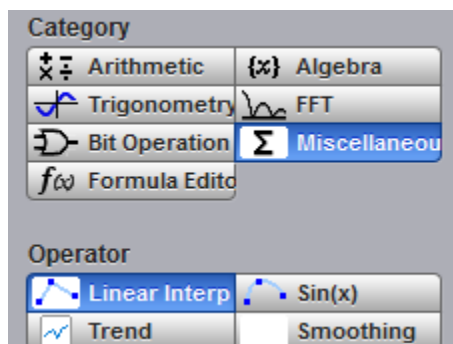
Below is a description of the four miscellaneous operators.

Interpolation

When the sample density falls to less than one sample per display column, the oscilloscope can calculate intermediate points to display a waveform. This process is called interpolation.

Linear Interpolation

Draws a line between consecutive waveform data points. It gives an analog look to a digitized waveform. For example, you can see steep edges on waveforms, such as square waves.

Sin(x)/x Interpolation

Uses a sin(x)/x digital filter that improves the reconstruction of the waveform. The reconstruction is done by adding data points between the acquired data points. This function improves accuracy of measurements. It is important for waveforms that can be bandlimited to ¼ of the current effective sample rate.

For each interpolation method use the **Upsample to** control to increase density factor from 2 to 256 points by which to interpolate (upsample).

You can also interpolate waveforms in **Scaling** mode where the waveforms can be zoomed and positioned vertically and horizontally.

When the PicoScope 9300 acquires a signal in **Equivalent Time Sampling** mode, the effective sampling rate is very high. For example, a 10 Gb/s signal with 1024 samples per unit interval will have a sample resolution of 100 ps that is equivalent to a 10 THz sampling rate. Normally, interpolation would never be needed. In some cases when a lower number of samples per bit are acquired, interpolation is helpful to view the signal. The interpolation is very helpful for **Real Time** sampling mode.

Trend

Trend represents the evolution of timing parameters as line graphs whose vertical axes are the value of the parameter, and horizontal axes the order in which the values were acquired. The information obtained from applying timing parameters can then be analyzed using the trend.

The following trend parameters can be used: Period, Frequency, Positive Width, Negative Width, Rise Time, Fall Time, Positive Duty Cycle, Negative Duty Cycle. Use the **Trend Parameter** control to select the trend parameter.

Smoothing

This allows reduction of unwanted noise and jitter on the signal with a simple, moving-average filter. N-point smoothing can be done with up to a 51-point filter. The number of points N can be selected by the **Smooth Length** variable.

The **Smooth Length** variable defines the number of points N in the moving-average filter used for the smoothing operator. N-point smoothing can be selected from 3 up to 51 points.

7.9.1.5.7   Formula Editor

The **Formula Editor** option allows you to create an arbitrary function of one or more inputs, waveform memories or other formulas. Click **Edit** to enter a new formula or edit an existing one.
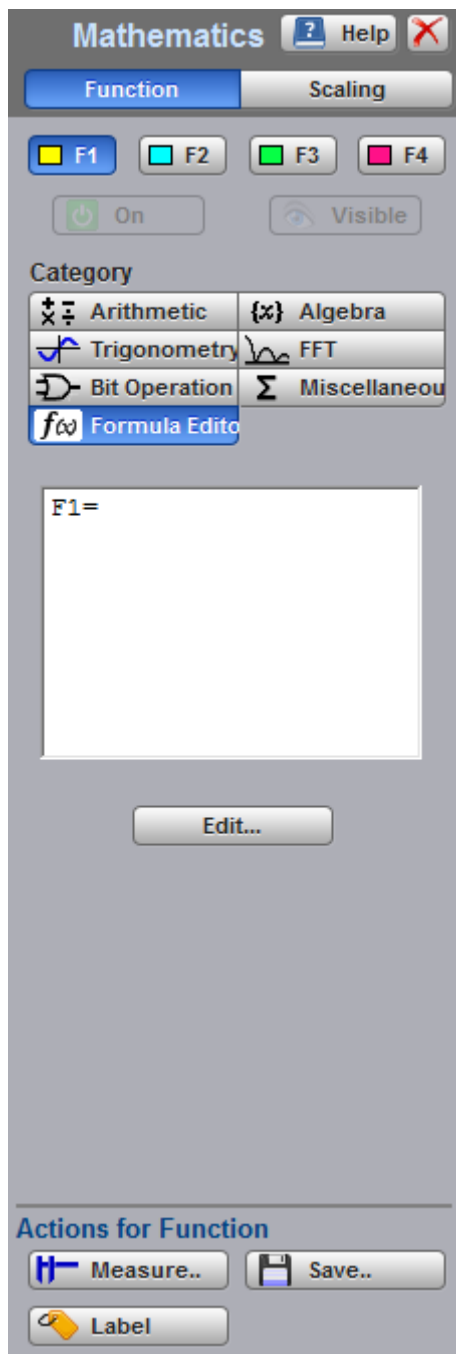
The Mathematics menu with the Formula Editor option selected
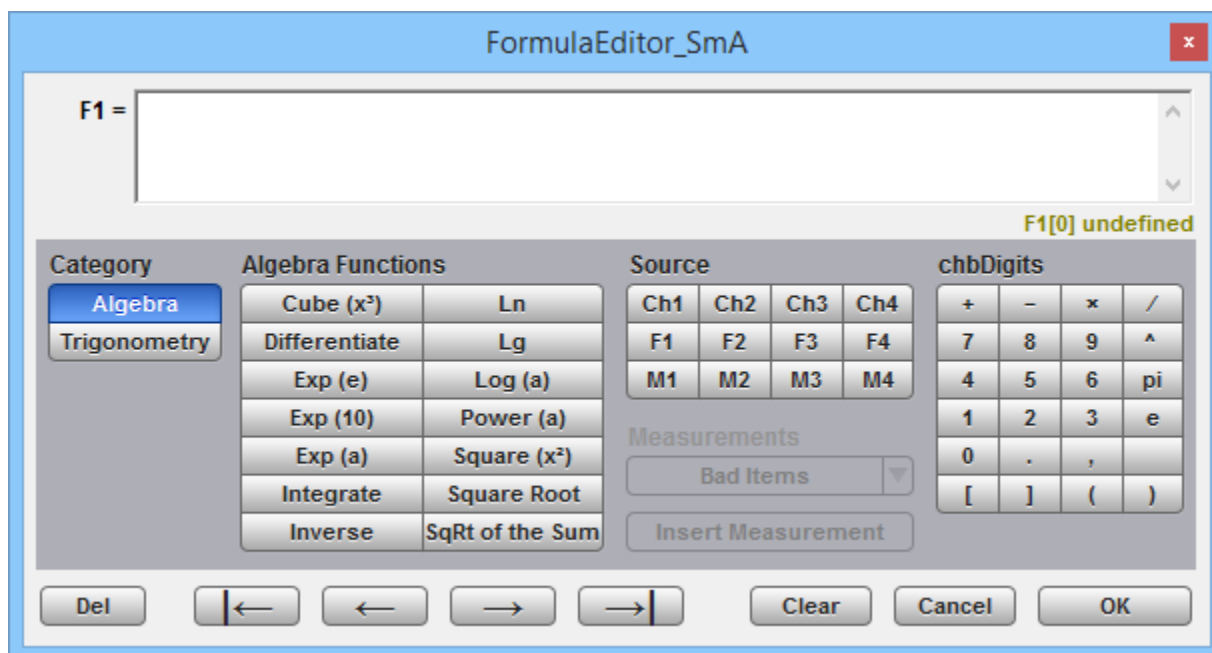
Formula Editor with algebraic functions

The formula editor above shows the algebraic functions that are displayed by default. Click **Trigonometry** to display the trigonometric functions:
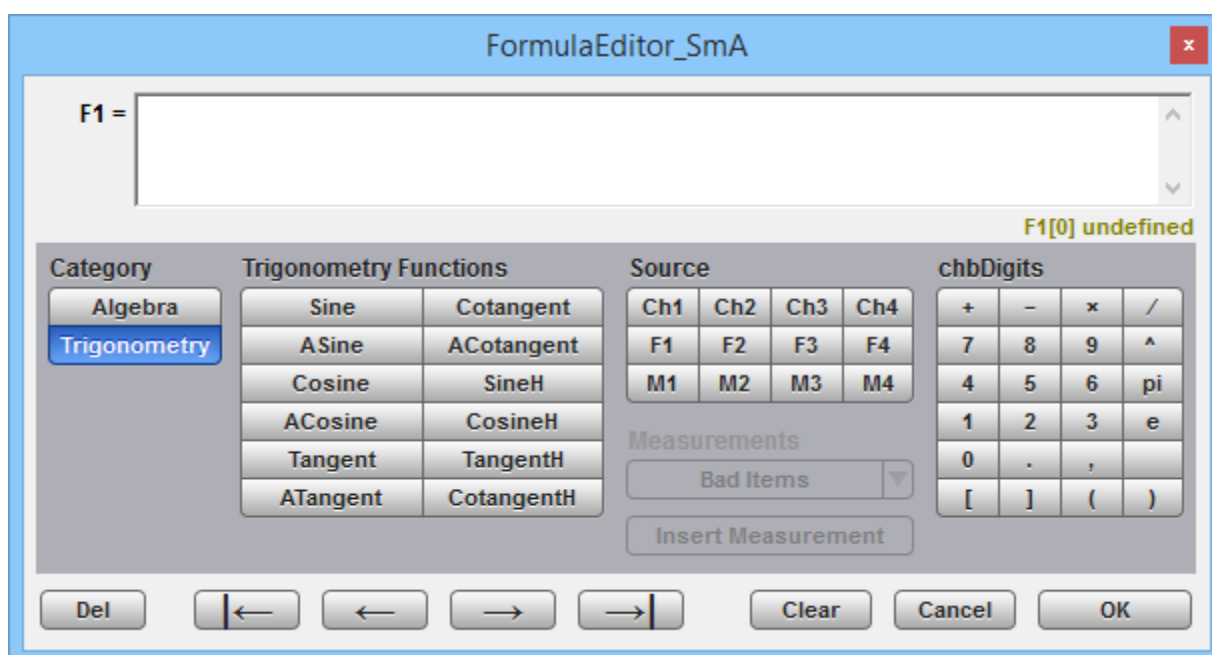
Formula Editor with trigonometric functions

7.9.1.6   Operand 1 - 4
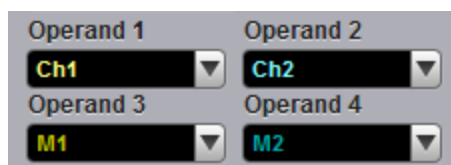
The instrument performs math functions on the source(s) (operands) you select. The math operator is performed either on operand 1, or on operand 1 and operand 2, or on operands 1 to 4. The number of operands used depends on the math operator you select. For example, **Add** requires two operands while **Invert** requires only one operand.

The **Operand 1 to 4** controls let you select from channels, functions, waveform memories or constants.

You should be aware of some conditions of the math function menu:

- If the operand waveforms have different record lengths, the function uses the shortest record length. The instrument finds the nearest point in the longer waveform record that corresponds to the current point in the shorter record. It then performs math functions on those points and skips non-corresponding points in the longer record.
- If two operands have the same timebase scale, the resulting function has the same timebase scale, which results in the proper time scale for the function.
- If two operands have different horizontal scale settings (possibly when using a waveform memory as a operand) the resulting function has the same horizontal scale as operand 1.
- Constant operands have the same time scale as the associated waveform operand.
- You can use each function as an operand for another function. This allows you to construct equations with a large number of operators and operands.

If you select a math operator that uses more than one operand, select source 2 from the **Operand 2** drop down list box. When the **Constant** option is selected in the **Operand 2** drop-down list box the **Constant** variable becomes active. You can use the **Constant** variable to control the value of operand 2 from −100 million to 100 million.

7.9.2   Scaling

Scaling

The **Scaling** menu lets you control vertical and horizontal magnification and positioning without affecting the channels and timebase scaling controls.
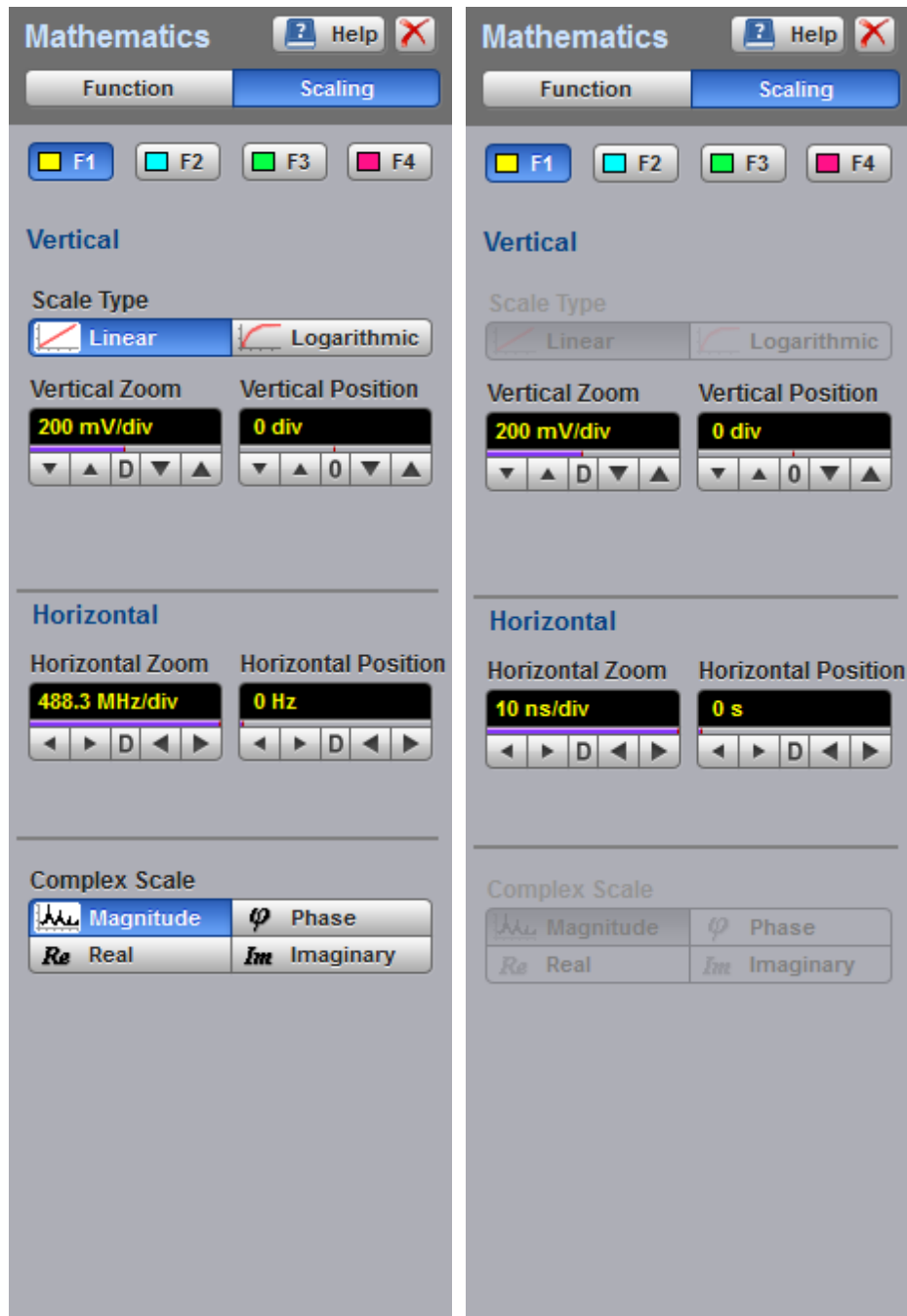
The Scaling menu for complex (left) and scalar (right) waveforms

7.9.2.1   Complex Scale
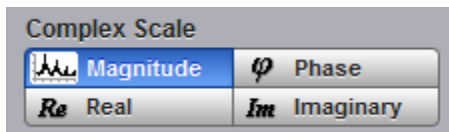
The **Complex Scale** menu selects the display format of a waveform that has a complex value. The options are:

- **Magnitude**
- **Phase**
- **Real**
- **Imaginary**

Magnitude

The peak signal amplitude is represented on a linear or logarithmic scale, in the same units as the input signal. You can choose to display data in dB or linear mode. You may display the real or imaginary parts of the spectral magnitude only. The **Vertical Position** control gives complete control over the vertical position of the spectrum.

Spectrum Magnitude of 500 MHz pulse waveform

Phase

Phase is measured with respect to a cosine whose maximum occurs at the left-hand edge of the screen, at which point it is 0°. Similarly, a positive-going sine wave starting at the left-hand edge of the screen has a −90° phase. You can display phase data as a function of frequency in degrees. You can zero the noise phase for magnitudes below a threshold level.

Real

Displays the linear magnitude of the real part of the spectral magnitude only. This is useful if you process the spectrum off-line and transform it back into a time-domain trace. You could save the real spectrum into a waveform memory.

Imaginary

Displays the linear magnitude of the imaginary part of the spectral magnitude only. This is useful if you process the spectrum off-line and transform it back into a time-domain trace. You could save the imaginary spectrum into a waveform memory.

7.9.2.2   Scale Type

The **Scale Type** menu allows you to set the scale of the vertical display. Vertical units can be either linear or logarithmic.

- **Linear.** Sets the display to the current source value. Usually this is volts, but it may also be watts or amperes.
- **Logarithmic.** Sets the display of the results to dB. Use the **Vertical Position** to set what vertical position in the magnitude spectrum will be zero dB. The following equation applies:

$$dB = 20\log_{10}\left(\frac{|X|}{X_{ref}}\right)$$

where: *X* is a complex data point in the spectrum, and *Xref* is the reference value equal to 1 V.

7.9.2.3   Vertical Zoom
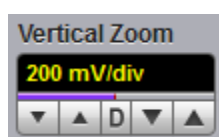
Magnitude

The **Vertical Scale** function uses software expansion to set the vertical scaling of the selected waveform. It does not affect the hardware settings in the instrument, only the appearance of the waveform.

The scaling units are mV per division or dB per division. For example, if the vertical scale is set to 10 dB/div, and a peak is two divisions high, you know that the amplitude of the frequency peak is 20 dB. When scaling is set to 0 dBV, the display is in decibels relative to a 1 V peak sine wave (0 dBV) into 50   .

Phase

The **Vertical (Phase) Scale** function uses vertical software expansion to set the phase characteristic of the spectrum. It does not affect the hardware settings in the instrument, only the appearance of the phase waveform. You can change phase scale from 4.5°/div to 90°/div.

7.9.2.4   Vertical Position

The **Vertical Position** controls use software to move the selected waveform vertically on the screen. Vertical position is the value at the center of the graticule area. If you adjust the vertical position so that a peak is at the vertical center of the graticule area, then you know that the peak magnitude is the vertical position value. For example, if the peak of the spike is at the vertical center of the graticule area and the vertical position is –20 dBV, you know that the peak magnitude is –20 dBV.

7.9.2.5   Horizontal Zoom

The **Horizontal Zoom** control allows you to zoom into a portion of the waveform record. Horizontal zooming can be entered in steps of 1-2-4-8. Changing the horizontal magnification of an FFT waveform using the **Horizontal Zoom** changes the appearance of the trace, but does not increase the horizontal (frequency) resolution.

You can also change the frequency interval and frequency range by changing the record length and horizontal scale of the time-domain waveform. If the record length increases, frequency resolution improves. When the effective sample rate increases (due to a faster horizontal size setting), frequency interval and frequency range both increase, giving the FFT waveform a broader frequency range with less frequency resolution.

7.9.2.6   Horizontal Position
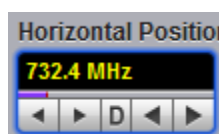
The **Horizontal Position** control allows you to move the horizontally expanded portion of the waveform record. The **Horizontal Position** variable uses software positioning.

7.10   Measure menu

With automatic measurements, you just press a few buttons and the sampling oscilloscope does the calculations for you. Because these measurements use the waveform record points directly, they are more accurate than markers or graticules.

Measurements cover voltage, timing, and FFT. Amplitude measurements are made on vertical parameters, typically voltage. They include such parameters as **Maximum**, **Peak-Peak** and **Middle**. Timing measurements are made on horizontal parameters, typically seconds or hertz. They include such parameters as **Period**, **Width** and **Rise Time**. FFT measurements are made on both vertical and horizontal parameters, typically volts and hertz. They include such parameters as **FFT Magnitude** and **FFT Frequency**. Measurements made on two channels can include amplitude and timing parameters.

Each measurement relates to the source that was active when you selected that measurement. It remains displayed until you remove it. If you turn off the source that was selected for a measurement, only the last measured result will be displayed.

The PicoScope 9300 makes measurements after every trigger event, always maintaining continuity between the measurement results and the display. This makes sure that no aberration in the waveform under observation is missed.

You can set measurement markers (thresholds and margins) on the display as defined parameters to track the measurement results. This helps you verify that the oscilloscope is measuring the correct phenomena and to aid in windowing the waveform properly for measurement.
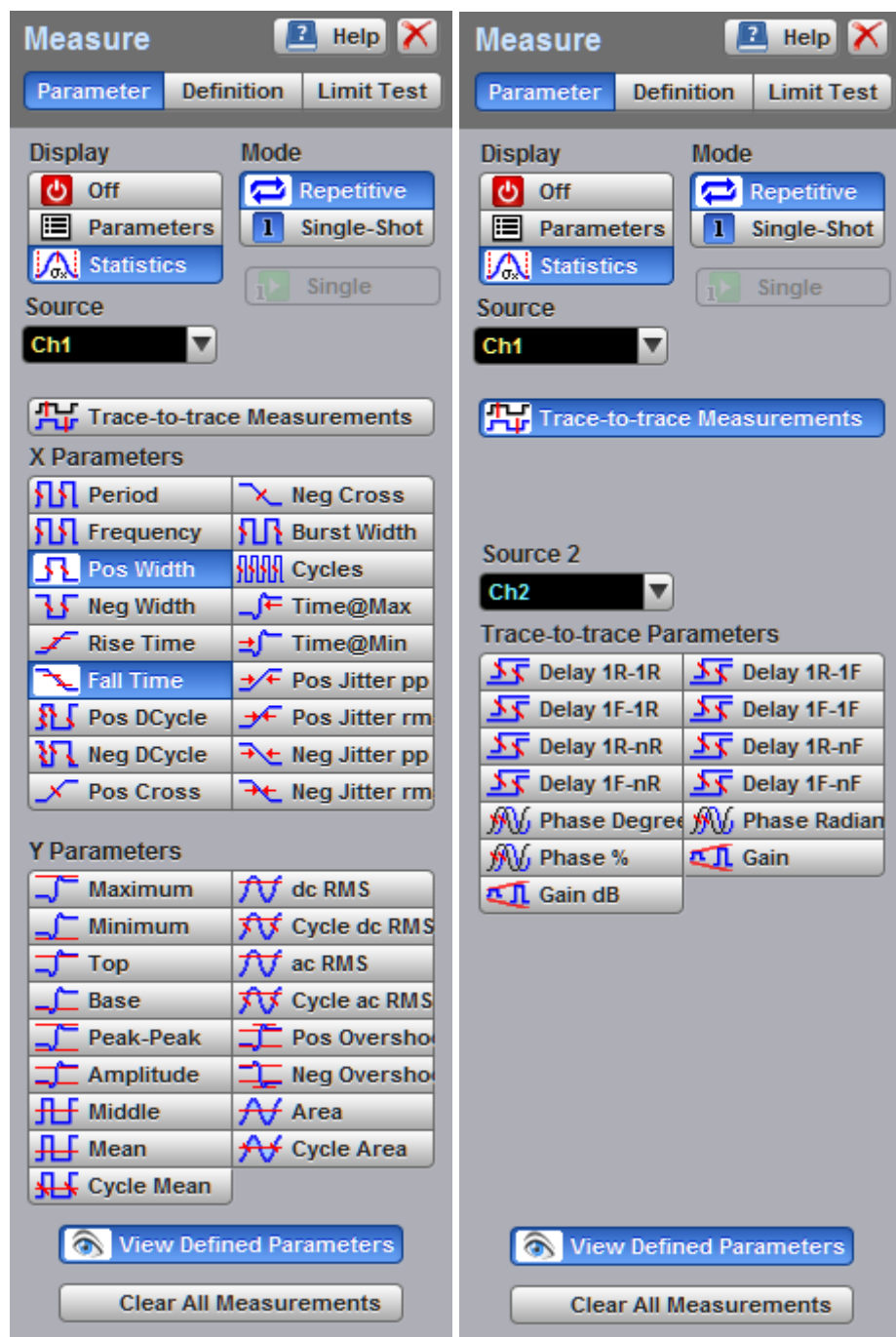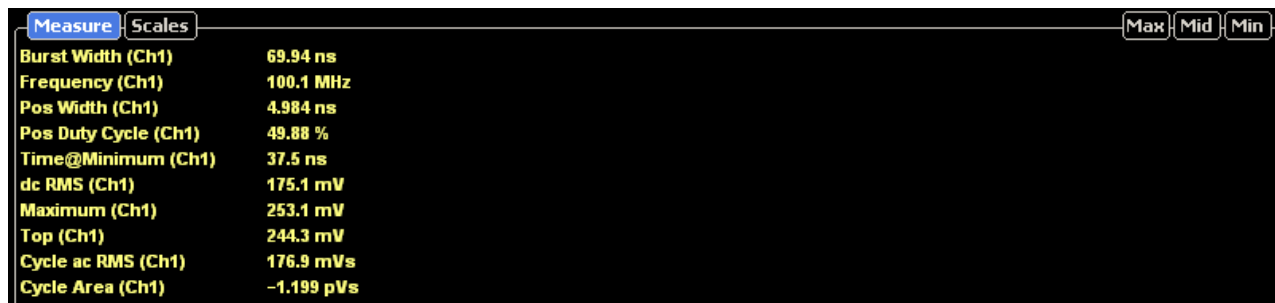
The Measure menu (1)

The Measure menu (2)

Measurement Results

The measurement readouts appear in the **Measurement Area** of the screen. These values are displayed on tabs. The readouts are continuously updated as the oscilloscope acquires new data or as you change settings. You can display as many as ten measurements of parameters, continuously updated, and as many as four statistics measurements at any one time.

Measure	Scales		Max	Mid	Min
Burst Width (Ch1)	69.94 ns				
Frequency (Ch1)	100.1 MHz				
Pos Width (Ch1)	4.984 ns				
Pos Duty Cycle (Ch1)	49.88 %				
Time@Minimum (Ch1)	37.5 ns				
dc RMS (Ch1)	175.1 mV				
Maximum (Ch1)	253.1 mV				
Top (Ch1)	244.3 mV				
Cycle ac RMS (Ch1)	176.9 mVs				
Cycle Area (Ch1)	−1.199 pVs				

Measure tab with the results of ten automated parameter measurements

	Current	Total Wfms:	Minimum	Maximum	Mean	Std Deviation
Burst Width (Ch1)	69.94 ns	1671	69.94 ns	70.05 ns	69.99 ns	14.72 ps
Frequency (Ch1)	100.1 MHz	1670	99.93 MHz	100.1 MHz	100 MHz	21.04 kHz
Pos Width (Ch1)	4.984 ns	1669	4.965 ns	5.005 ns	4.984 ns	6.032 ps
Pos Duty Cycle (Ch1)	49.88 %	1668	49.66 %	50.05 %	49.85 %	59.32 m%
Time@Minimum (Ch1)	37.5 ns	1667	7.2 ns	77.7 ns	43.12 ns	22.76 ns
dc RMS (Ch1)	175.1 mV	1666	174.9 mV	175.3 mV	175.1 mV	70.21 µV
Maximum (Ch1)	253.1 mV	1665	251.1 mV	257.6 mV	253.6 mV	1.03 mV
Top (Ch1)	244.3 mV	1664	240.3 mV	244.5 mV	243.4 mV	471.9 µV
Cycle ac RMS (Ch1)	176.9 mVs	1663	176.5 mVs	176.9 mVs	176.7 mVs	80.06 µVs

Measure tab with the results of ten statistic measurements

When the instrument cannot make the requested measurement, an "Undefined" error message is displayed instead of measurement results. Usually, this is because there are not enough sample points, there is no edge on the display, or the specified channel is turned off.

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7.10.1   Parameter

Parameter
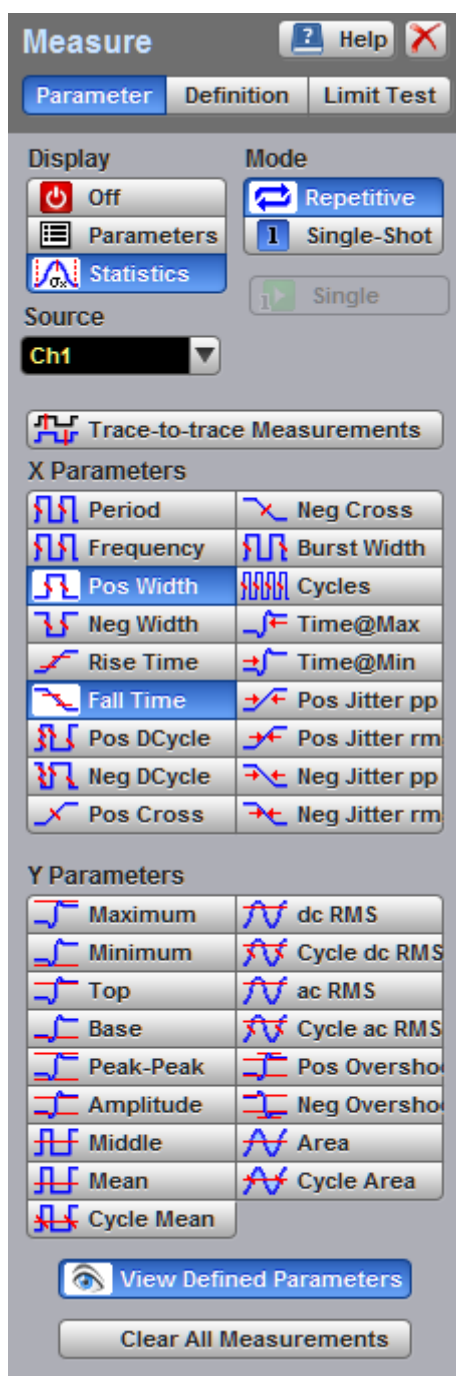
The Parameter menu

7.10.1.1 Display
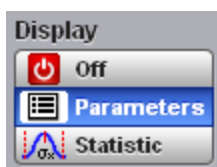
Two types of measurements are used in the PicoScope 9300:

● Measurements of parameters (**Parameters**)
● Statistics measurements (**Statistics**)

Click on the option for the type of measurement that you require. **Off** removes measurement results, annotations and markers from the display.

Statistics

The **Statistics** function calculates the minimum, maximum, mean and standard deviation of the automatic measurement results. The current value and amount of measurements are also displayed.

When you turn **Statistics** on, the minimum, maximum, mean and standard deviation values start to accumulate at the same time. All results are continuously updated; the mean, standard deviation results are also calculated and continuously updated. Minimum and maximum are the absolute extremes of the automatic measurements. Mean and standard deviation calculate the mean and standard deviation of the automatic measurement results. Mean is the statistical average of all results for a particular measurement. Standard deviation measures the dispersion of those measurement results.

The figure below shows the mean and standard deviation more graphically. Standard deviation is represented by the Greek letter sigma ( ). For a Gaussian distribution, two sigma (±1 from the mean) is where 68.3 % of the data points reside. Four sigma (±2 from the mean) is where 95.4 % of the data points reside. Six sigma (±3 from the mean) is where 99.7 % of the data points reside.

Standard deviation of a Gaussian distribution
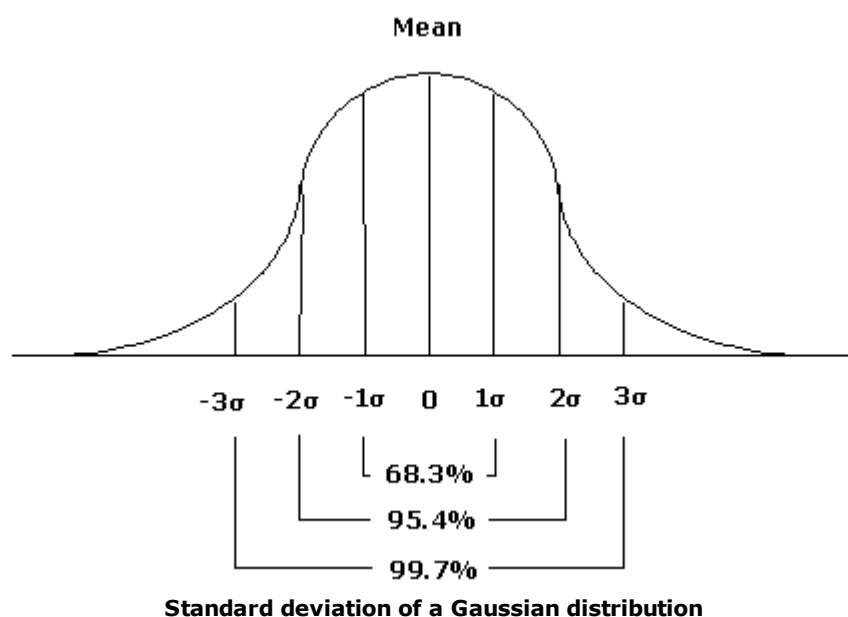
The mean is calculated as follows:

$$\mu = \frac{\sum_{i=1}^{n} X_i}{N} ,$$

where: μ - mean, *N* – the number of taken measurements, *Xi* - measurement *i-th* result.

The standard deviation is calculated as follows:

$$\sigma = \frac{\sum_{i=1}^{n} (X_i - \overline{X})^2}{N-1} ,$$

where: - standard deviation, *N* – the number of taken measurements, *Xi* - measurement *i-th* result, $\overline{X}$ - the mean.

Click the **Definition** and use the **Statistics** menu for some statistics options.

7.10.1.2 Source
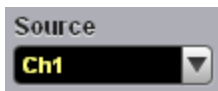
The **Source** drop-down list box selects the source you are measuring.

You can select as the source:

- channels 1 and 2
- functions 1 through 4
- waveform memories 1 through 4

The measurement readouts of each parameter will have the same color as the selected source.

7.10.1.3 Mode

Two modes are available for extracting parameters:

- **Repetitive.** This mode dynamically extracts the same number of parameters, based on successive acquisition sequences, and updates the measurements approximately every 100 ms (except at very slow repetition rates).
- **Single-shot.** Extracts up to ten parameters, based on the last acquisition, and displays the result.

7.10.1.4 Single

[📗▶ Single]

Clicking the **Single** button provides single-shot measurement of selected parameters.

7.10.2   X Parameters

The **X Parameters** are eighteen timing parameters used for pulse measurements. Once the **Top** and **Base** calculation is completed (according to the **Method** setting), most of the timing and amplitude measurements can be made.

X Parameters	
Period	Neg Cross
Frequency	Burst Width
Pos Width	Cycles
Neg Width	Time@Max
Rise Time	Time@Min
Fall Time	Pos Jitter pp
Pos DCycle	Pos Jitter rm
Neg DCycle	Neg Jitter pp
Pos Cross	Neg Jitter rm
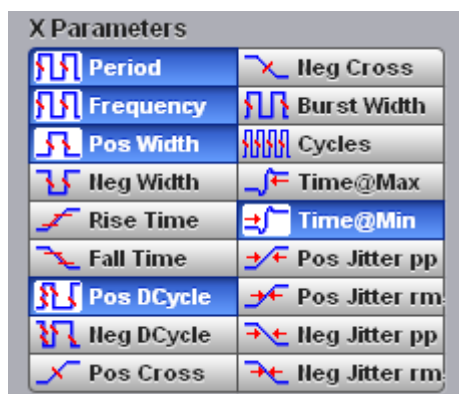
The list of X Parameters

ℹ️   You can continuously update as many as ten parameter measurements, and as many as ten statistics measurements, at any one time.

ℹ️   The pulse measurement algorithms for **X Parameters** will only work when a single-valued signal is used, and no NRZ eye diagram or RZ eye diagram is present on the screen. Measurements made on both NRZ and RZ eye diagrams will fail.

7.10.2.1 Period

 Period

Period is a measure of the time between the mid-threshold crossings of two consecutive edges of the same polarity. The PicoScope 9300 starts the measurement on the first edge on the leftmost portion of the measurement region (left margin) and stops the measurement on the last edge on the rightmost portion of the measurement region (right margin).
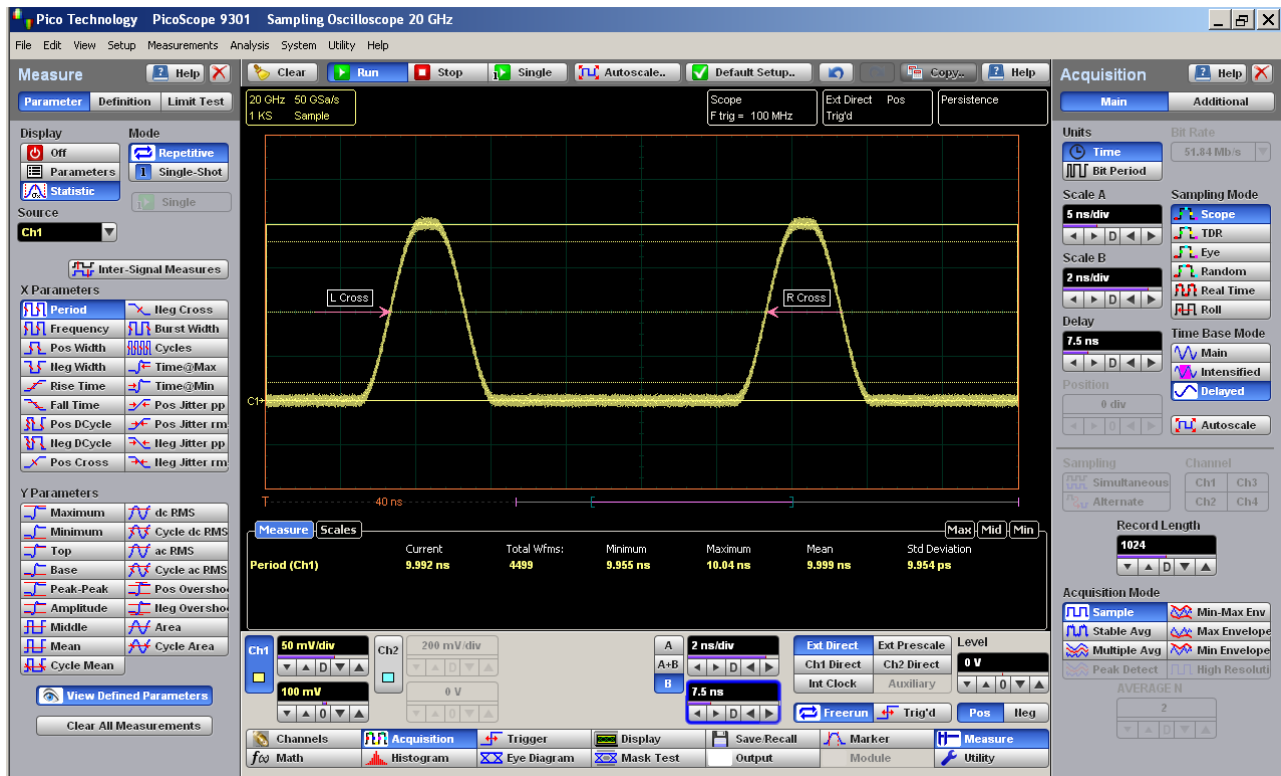
Period definition

Because the detected edges can be either rising or falling, the period is determined as follows:

$$Period = Tcross3 - Tcross1$$

where *Tcross3* and *Tcross1* are the times of the first two consecutive crossings on the same slope at the mid-reference level.

If more than one period can be found within the margins, the scope measures the average period.

> ℹ The **Margins** menu sets the margin markers to show where the scope is making the automatic measurement. All calculations of Period will be performed only inside these margins.

> ℹ Period value is affected by the **Definition** menu. In the **Thresholds** menu you can redefine the mid-threshold setting from 50% to any other level you want.

7.10.2.2 Frequency

FIF Frequency

Frequency is defined as the inverse of the period (1/period). Period is a measure of the time between the mid-threshold crossings of two consecutive edges of the same polarity. The PicoScope 9300 starts the measurement on the first edge on the leftmost portion of the measurement region (left margin) and stops the measurement on the last edge on the rightmost portion of the measurement region (right margin).
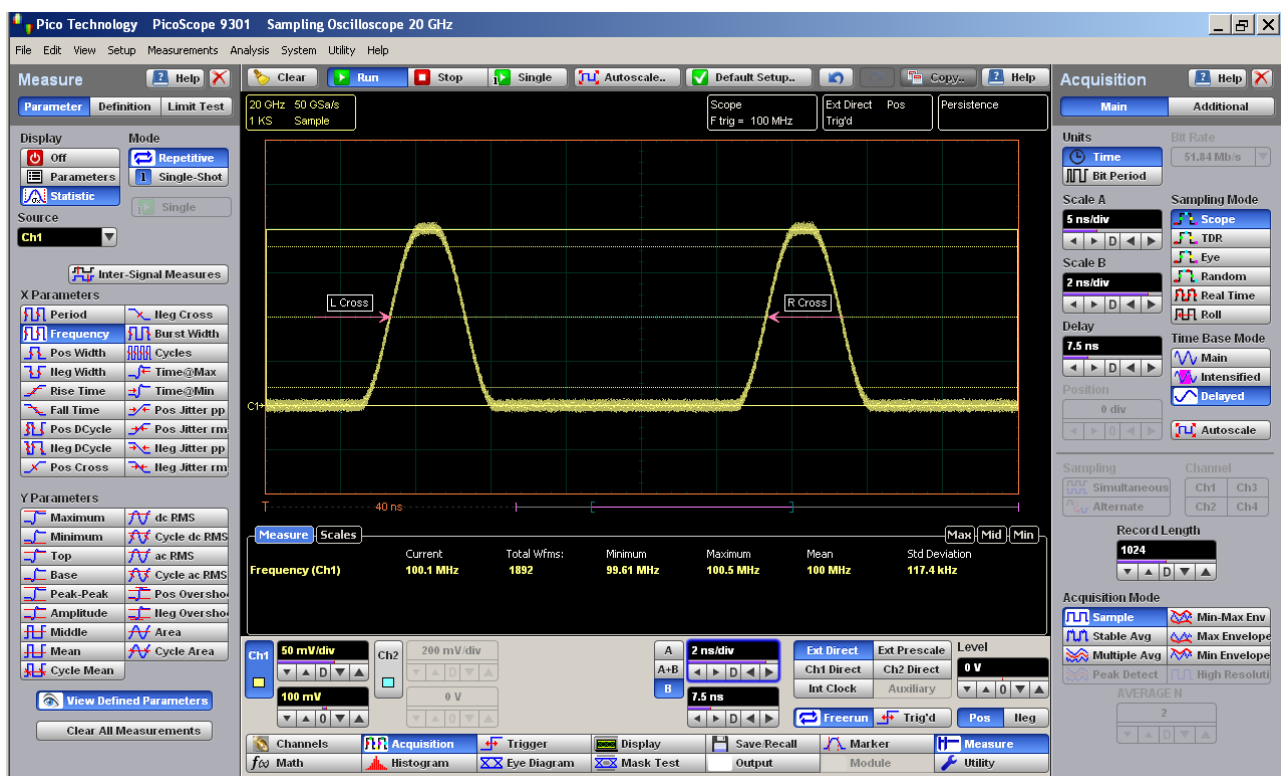
Frequency definition

Because the detected edges can be either rising or falling, the frequency is determined as follows:

$$Frequency = 1/Period = 1/(Tcross3 − Tcross1)$$

where *Tcross3* and *Tcross1* are the times of the first two consecutive crossings on the same slope at the mid-reference level.

If more than one period can be found within the margins, the scope measures the average frequency value.

> ℹ️ The **Margins** menu sets the margin markers to show where the scope is making the automatic measurement. All calculations of Frequency will be performed only inside these margins.

> ℹ️ Frequency value is affected by the **Definition** menu. In the **Thresholds** menu you can redefine the mid-threshold setting from 50% to any other level you want.

7.10.2.3 Positive Width

Pos Width

Positive Width is a measure of the time from the mid-threshold of the first rising edge to the mid-threshold of the next falling edge. The PicoScope 9300 starts the measurement on the first edge on the leftmost portion of the measurement region (left margin) and stops the measurement on the last edge on the rightmost portion of the measurement region (right margin).
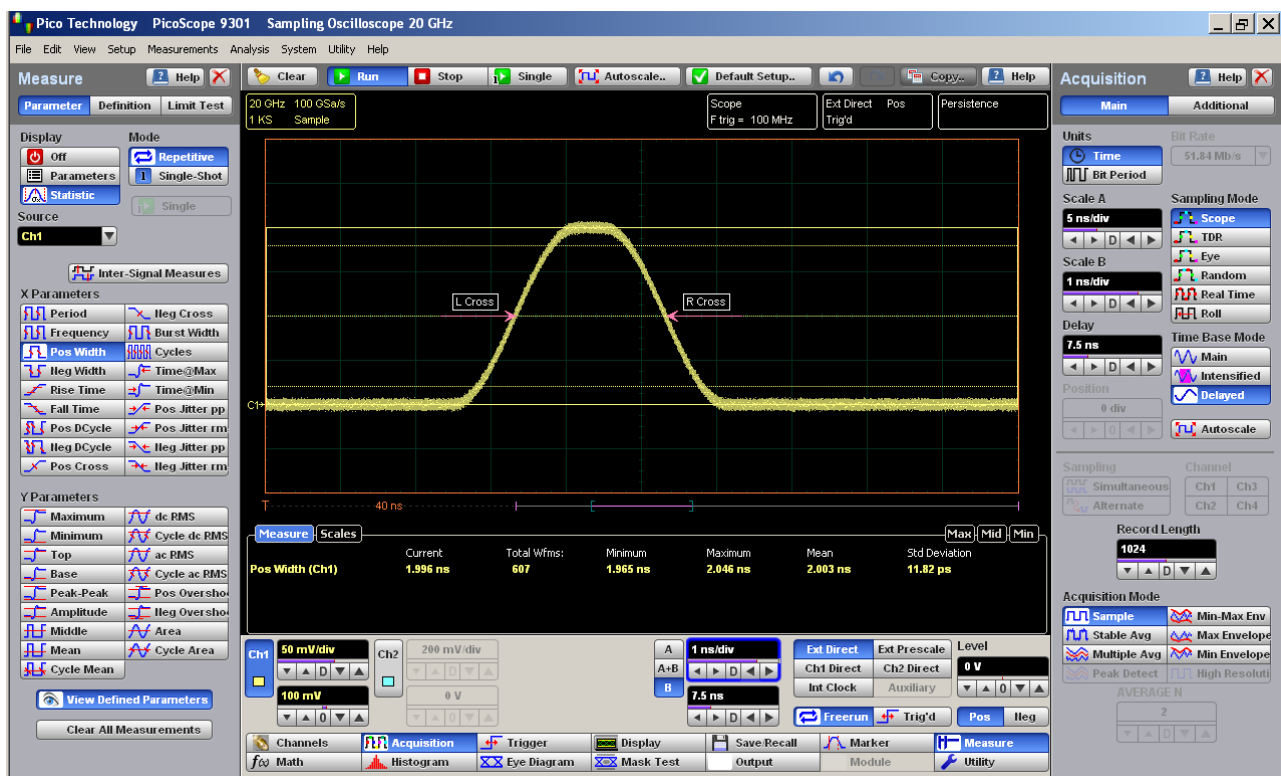
Positive Width definition

Positive pulse width is determined as follows:

$$Positive\ Width = T_{cross2} - T_{cross1}$$

where T_{cross1} and T_{cross2} are the two consecutive horizontal crossings on the first positive pulse.

If more than one positive pulse width can be found within the margins, the scope measures the average value of the positive pulse width.

> ℹ The **Margins** menu sets the margin markers to show where the scope is making the automatic measurement. All calculations of Positive Width will be performed only inside these margins.

> ℹ Positive Width value is affected by the **Definition** menu. In the **Thresholds** menu you can redefine the mid-threshold setting from 50% to any other level you want.

7.10.2.4 Negative Width

Neg Width (Negative Pulse Width) is a measure of the time from the mid-threshold of the first falling edge to the mid-threshold of the next rising edge. The PicoScope 9300 starts the measurement on the first edge on the leftmost portion of the measurement region (left margin) and stops the measurement on the last edge on the rightmost portion of the measurement region (right margin).
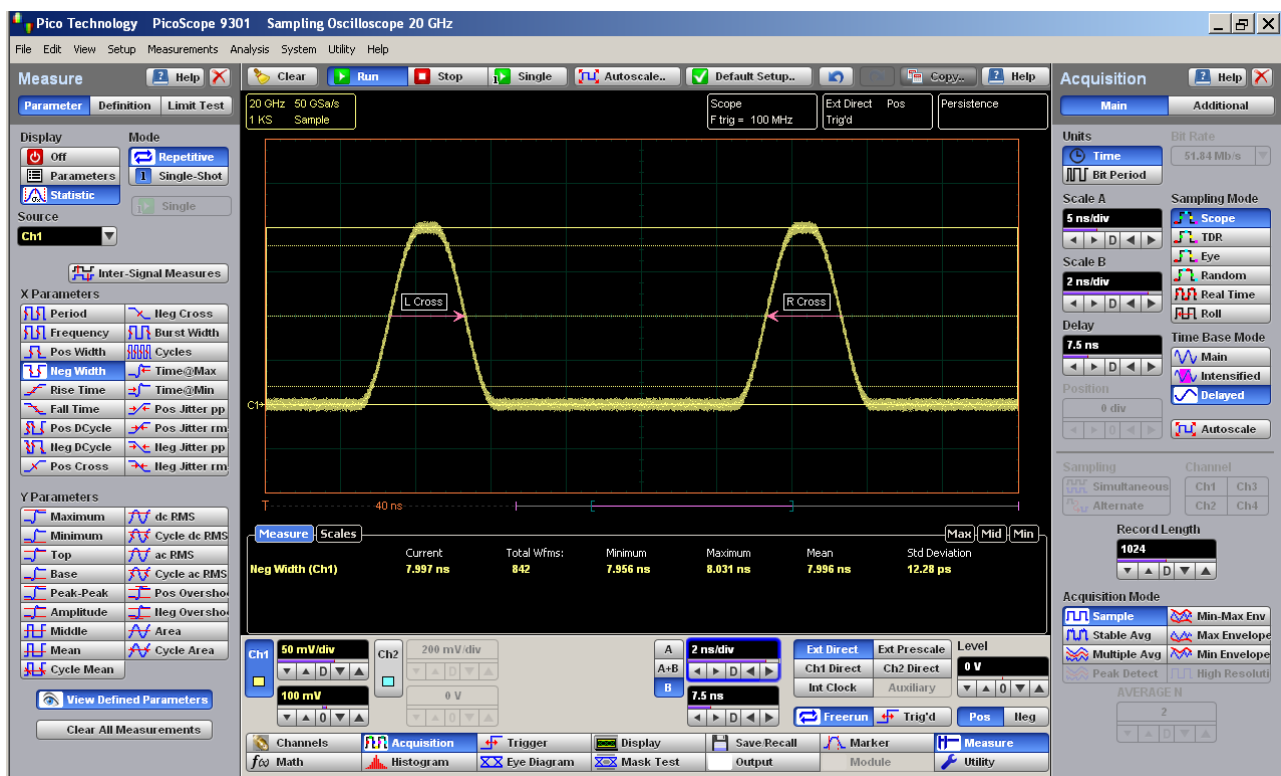
Negative Width definition

Negative pulse width is determined as follows:

$$\textit{Negative Width} = T_{cross2} - T_{cross1}$$

where T_{cross1} and T_{cross2} are the two consecutive horizontal crossings on the first negative pulse.

If more than one negative pulse width can be found within the margins, the scope measures the average value of the negative pulse width.
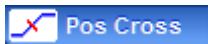
> ℹ The **Margins** menu sets the margin markers to show where the scope is making the automatic measurement. All calculations of Negative Width will be performed only inside these margins.

> ℹ Negative Width value is affected by the **Definition** menu. In the **Thresholds** menu you can redefine the mid-threshold setting from 50% to any other level you want.

7.10.2.5 Rise Time
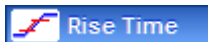
 Rise Time

Rise Time is a measure of the time at the upper threshold minus the time at the lower threshold on the edge you are measuring on. It is a measure of the transition time of the data on the positive (rising) edge of a waveform. The PicoScope 9300 starts the measurement on the first edge on the leftmost portion of the measurement region (left margin) and stops the measurement on the last edge on the rightmost portion of the measurement region (right margin).
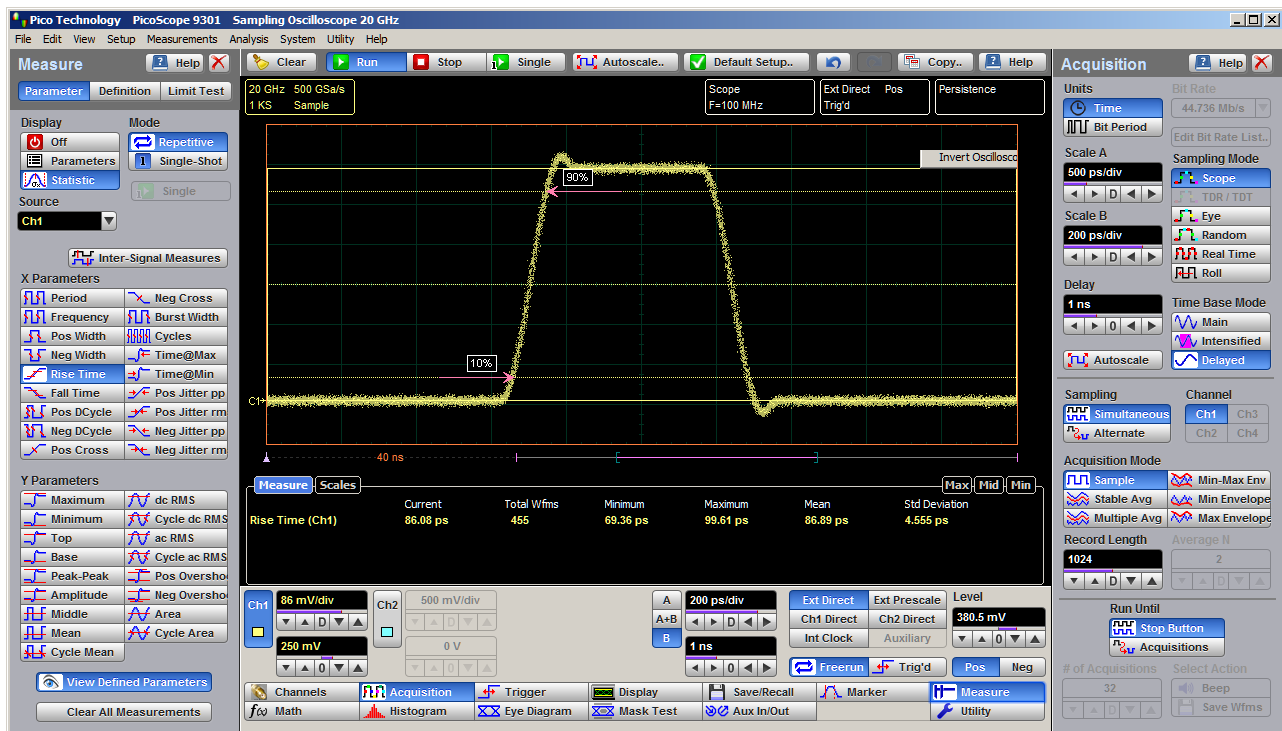
Rise Time definition

Rise Time is determined as follows:

$$Rise\ Time = T_{cross(Upper\ Threshold)} - T_{cross(Lower\ Threshold)}$$

where $T_{cross(Upper\ Threshold)}$ is the time of crossing with the upper threshold, and $T_{cross(Upper\ Threshold)}$ is the time of crossing with the lower threshold.

If more than one rise time can be found within the margins, the scope measures the average value of rise time.

The rise time will not be measured until the rising edge completes the transition through all three levels.

ℹ️ The **Margins** menu sets the margin markers to show where the scope is making the automatic measurement. All calculations of Rise Time will be performed only inside these margins.
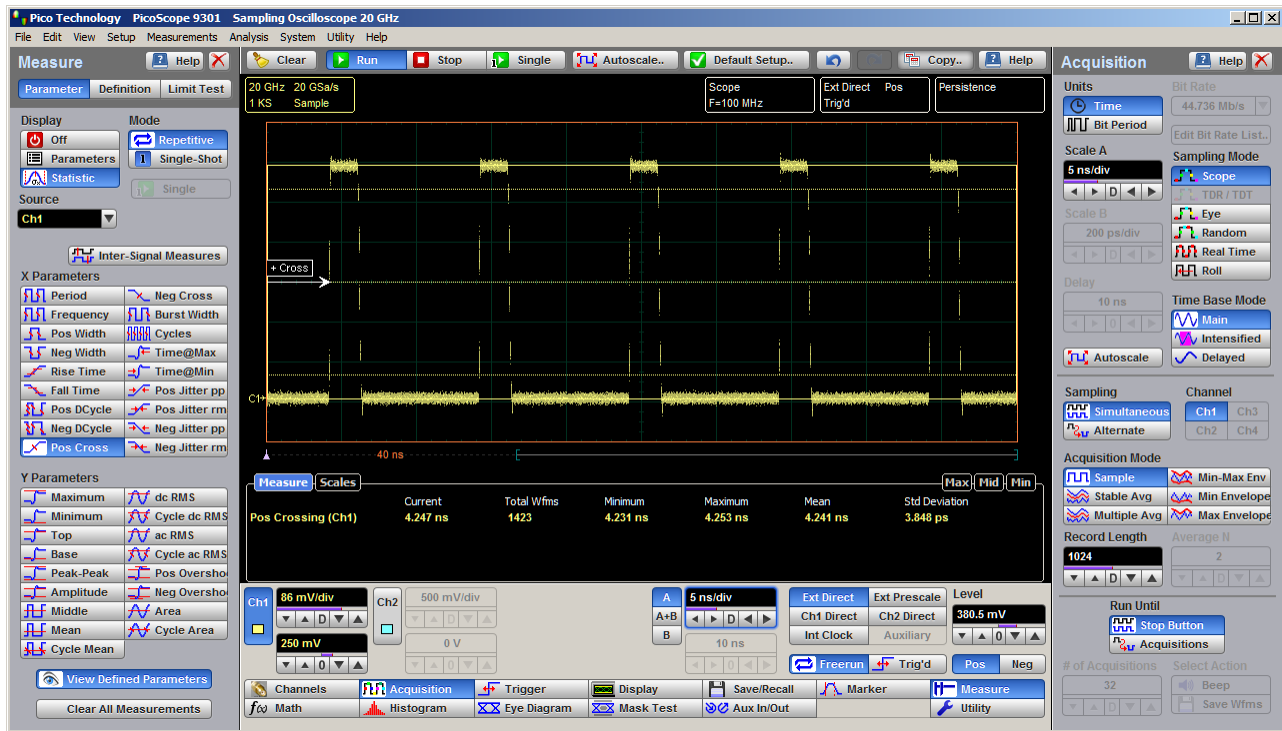

ℹ️ Rise Time value is affected by the **Definition** menu. In the **Thresholds** menu you can redefine the mid-threshold setting from 50% to any other level you want.

7.10.2.6 Fall Time
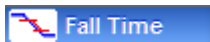
Fall Time is a measure of the time at the lower threshold minus the time at the upper threshold on the edge you are measuring on. It is a measure of the transition time of the data on the negative (falling) edge of a waveform. The PicoScope 9300 starts the measurement on the first edge on the leftmost portion of the measurement region (left margin) and stops the measurement on the last edge on the rightmost portion of the measurement region (right margin).
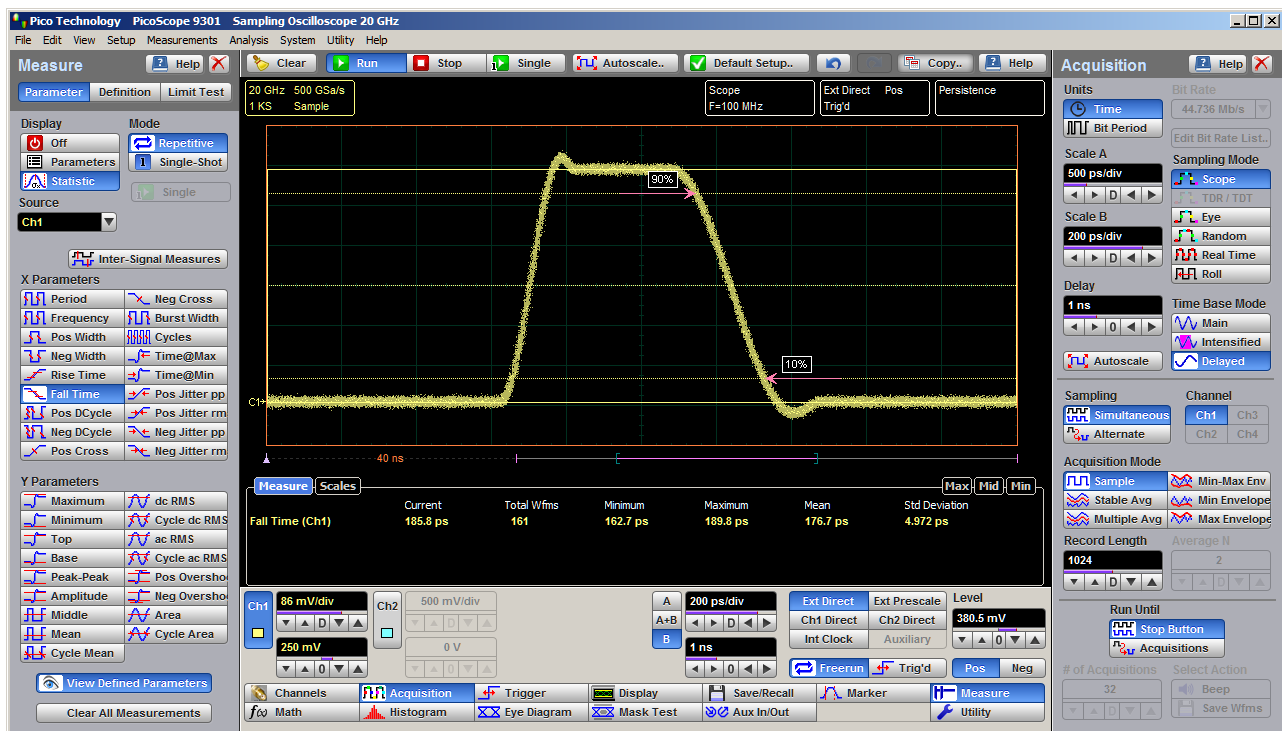
Fall Time definition

Fall Time is determined as follows:

$$Fall\ Time = T_{cross(Lower\ Threshold)} - T_{cross(Upper\ Threshold)}$$

where $T_{cross(Upper\ Threshold)}$ is the time of crossing with the lower threshold, and $T_{cross(Upper\ Threshold)}$ is the time of crossing with the upper threshold

If more than one fall time can be found within the margins, the scope measures the average value of rise time.

The fall time will not be measured until the falling edge completes the transition through all three levels.

ℹ️ The **Margins** menu sets the margin markers to show where the scope is making the automatic measurement. All calculations of Fall Time will be performed only inside these margins.

ℹ️ Fall Time value is affected by the **Definition** menu. In the **Thresholds** menu you can redefine the mid-threshold setting from 50% to any other level you want.

7.10.2.7 Positive Duty Cycle

[?][?] Pos DCycle
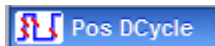
Positive Duty Cycle is defined as the ratio of the positive pulse width to the period. This is the percentage of the period that the positive pulse width occupies. The PicoScope 9300 starts the measurement on the first edge on the leftmost portion of the measurement region (left margin) and stops the measurement on the last edge on the rightmost portion of the measurement region (right margin).
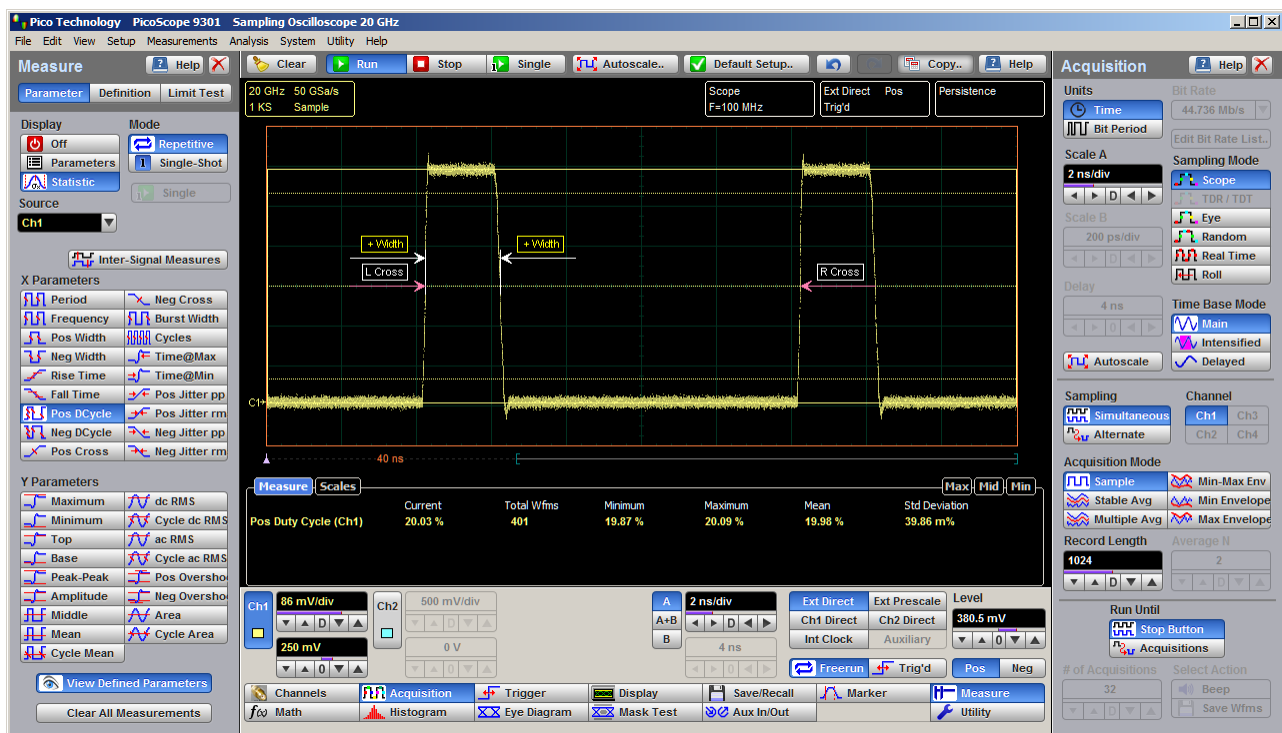
Positive Duty Cycle definition

Positive Duty Cycle is determined as follows:

Positive Duty Cycle = (Positive Width / Period) × (100%)

If more than one positive duty cycle can be found within the margins, the scope measures the average value of all positive duty cycles.

The positive duty cycle will not be measured until the period and positive pulse width complete the transition through all three levels.

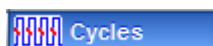> **ⓘ** The **Margins** menu sets the margin markers to show where the scope is making the automatic measurement. All calculations of Positive Duty Cycle will be performed only inside these margins.

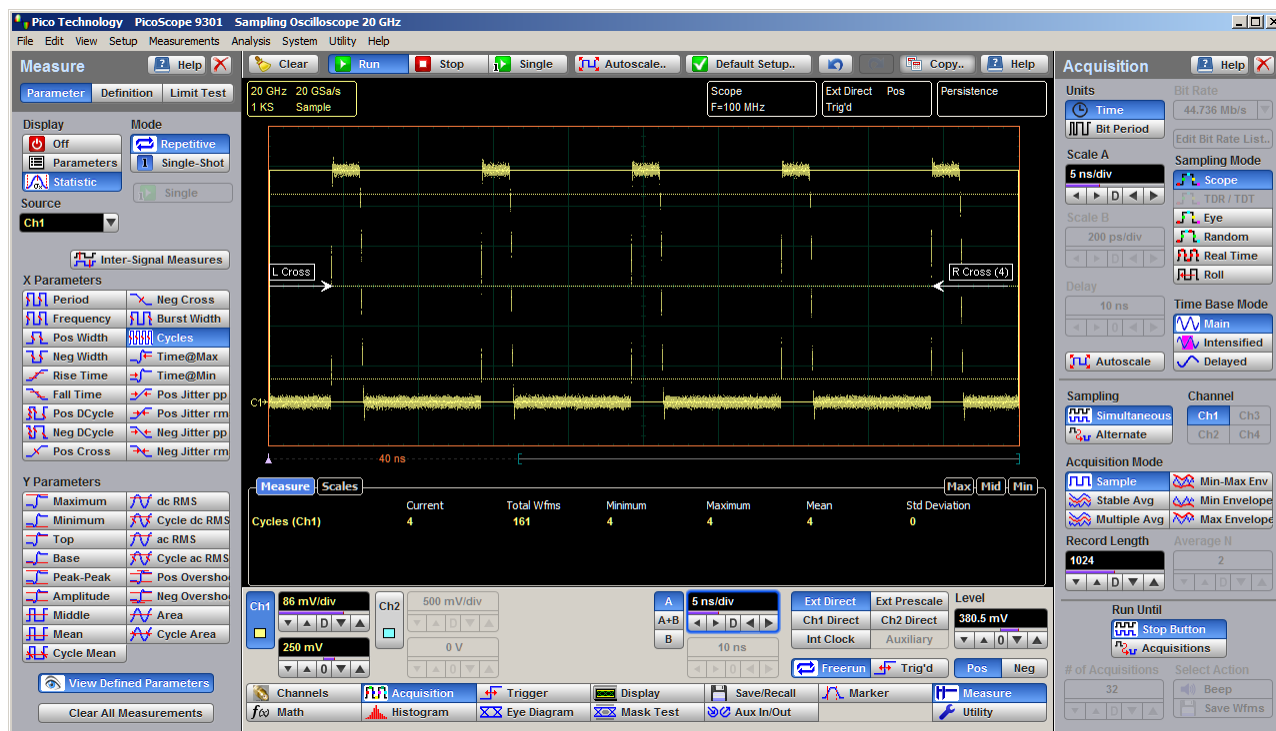> **ⓘ** Positive Duty Cycle value is affected by the **Definition** menu. In the **Thresholds** menu you can redefine the mid-threshold setting from 50% to any other level you want.

7.10.2.8 Negative Duty Cycle

🔀 Neg DCycle

Negative Duty Cycle is defined as the ratio of the negative pulse width to the period. This is the percentage of the period that the negative pulse width occupies. The PicoScope 9300 starts the measurement on the first edge on the leftmost portion of the measurement region (left margin) and stops the measurement on the last edge on the rightmost portion of the measurement region (right margin).
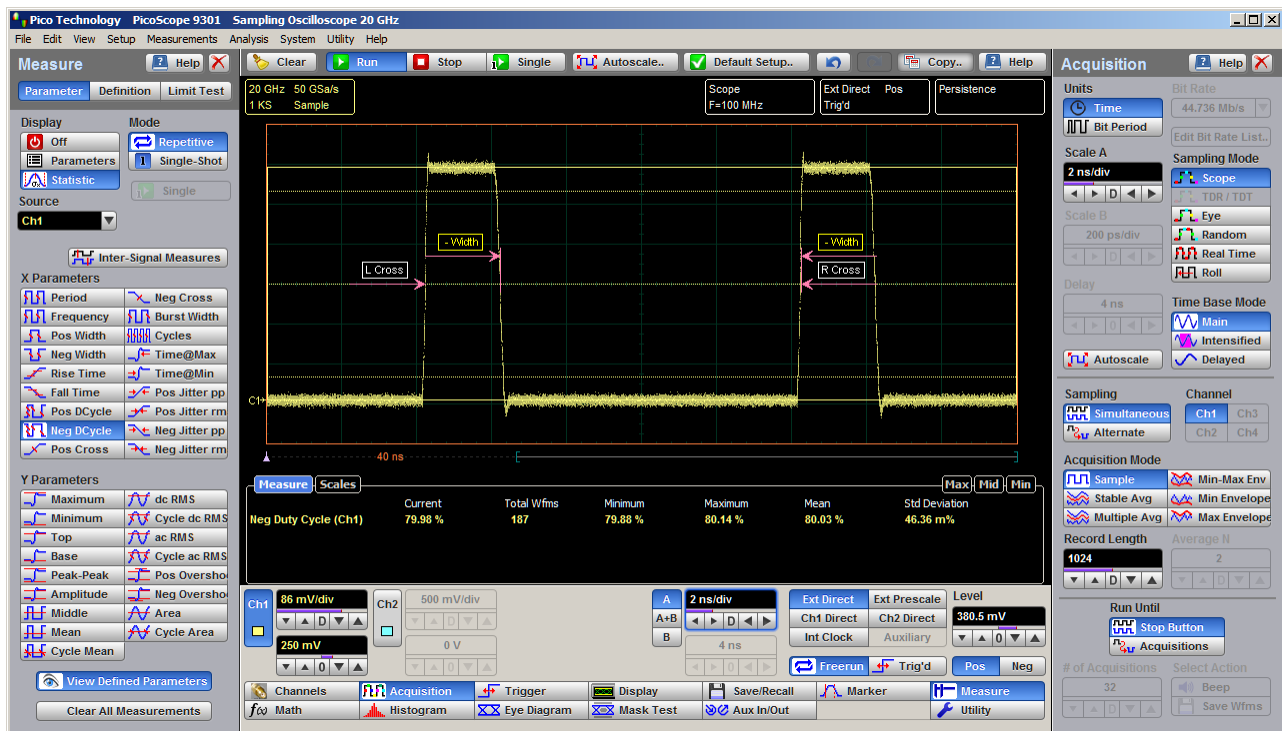
Negative Duty Cycle definition

Negative Duty Cycle is determined as follows:

$$Negative\ Duty\ Cycle = (Negative\ Width\ /\ Period) \times (100\%)$$

If more than one negative duty cycle can be found within the margins, the scope measures the average value of all negative duty cycles.

The negative duty cycle will not be measured until the period and negative pulse width completes the transition through all three levels.
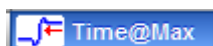
> ℹ️ The **Margins** menu sets the margin markers to show where the scope is making the automatic measurement. All calculations of Negative Duty Cycle will be performed only inside these margins.

> ℹ️ Negative Duty Cycle value is affected by the **Definition** menu. In the **Thresholds** menu you can redefine the mid-threshold setting from 50% to any other level you want.

7.10.2.9 Positive Crossing

![Pos Cross]

Positive Crossing is defined as the time of the first positive crossing of the data sampled at the mid-reference level in the measurement region. The PicoScope 9300 starts the measurement on the first leftmost portion of the measurement region (left margin) and stops the measurement on the rightmost portion of the display (right margin).

Positive Crossing definition

Positive crossing is determined as follows:

$$Positive\ Crossing = T_{cross}$$

where T_{cross} is the horizontal coordinate of the first positive crossing.
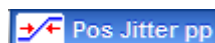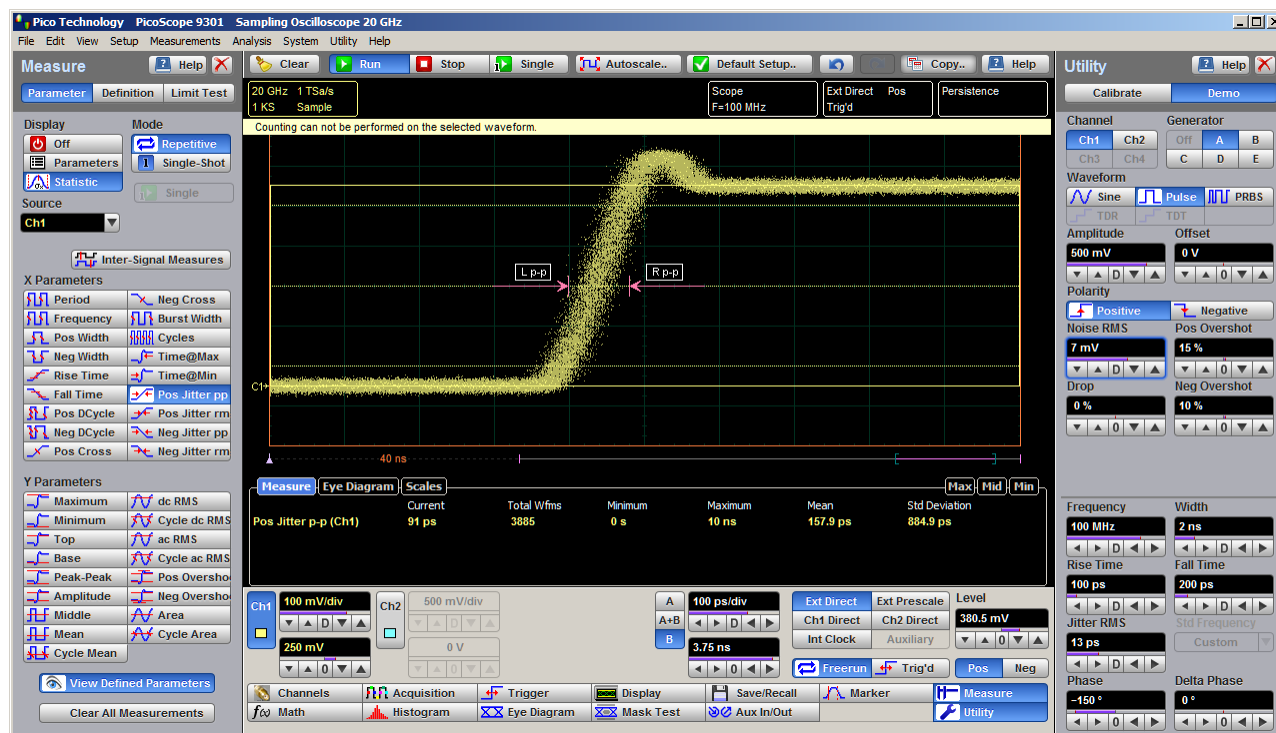
> ℹ The **Margins** menu sets the margin markers to show where the scope is making the automatic measurement. All calculations of Positive Crossing will be performed only inside these margins.

> ℹ Positive Crossing value is affected by the **Definition** menu. In the **Thresholds** menu you can redefine the mid-threshold setting from 50% to any other level you want.

7.10.2.10 Negative Crossing

 Neg Cross
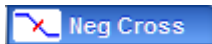
Negative Crossing is defined as the time of the first negative crossing of the data sampled at the mid-reference level in the measurement region. The PicoScope 9300 starts the measurement on the first leftmost portion of the measurement region (left margin) and stops the measurement on the last edge on the rightmost portion of the display (right margin).

Negative Crossing definition

Negative crossing is determined as follows:

$$Negative\ Crossing = T_{cross}$$

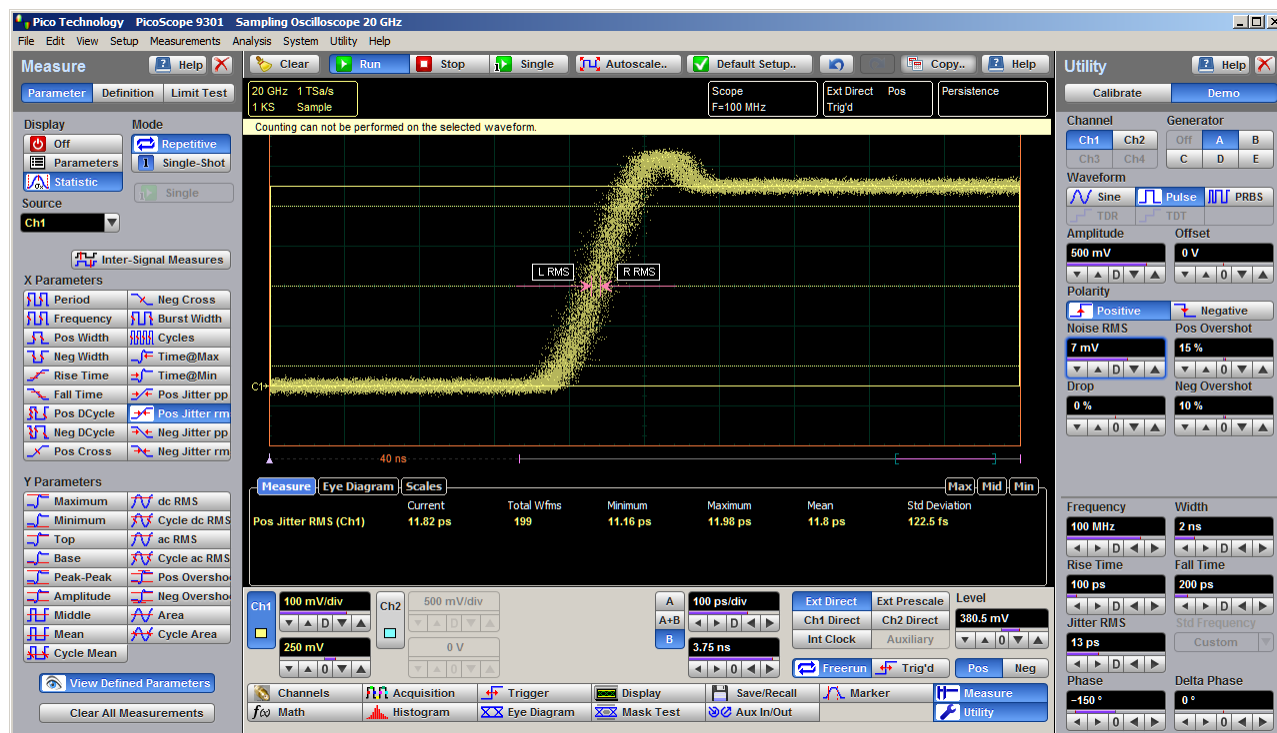where T_{cross} is the horizontal coordinate of the first negative crossing.

> ℹ️ The **Margins** menu sets the margin markers to show where the scope is making the automatic measurement. All calculations of Negative Crossing will be performed only inside these margins.

> ℹ️ Negative Crossing value is affected by the **Definition** menu. In the **Thresholds** menu you can redefine the mid-threshold setting from 50% to any other level you want.

7.10.2.11 Burst Width
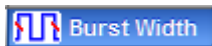
⊔⊓ Burst Width

Burst Width is defined as the time between the first and last crossings, either positive or negative, of the waveform at the mid-reference level in the measurement region. The PicoScope 9300 starts the measurement on the first leftmost portion of the measurement region (left margin) and stops the measurement on the last edge on the rightmost portion of the display (right margin).

Burst Width definition

Burst width is determined as follows:

$$Positive\ Width = T_{crossL} - T_{crossF}$$

where T_{crossL} is the horizontal coordinate of the last crossing, and T_{crossF} is the horizontal coordinate of the first crossing.
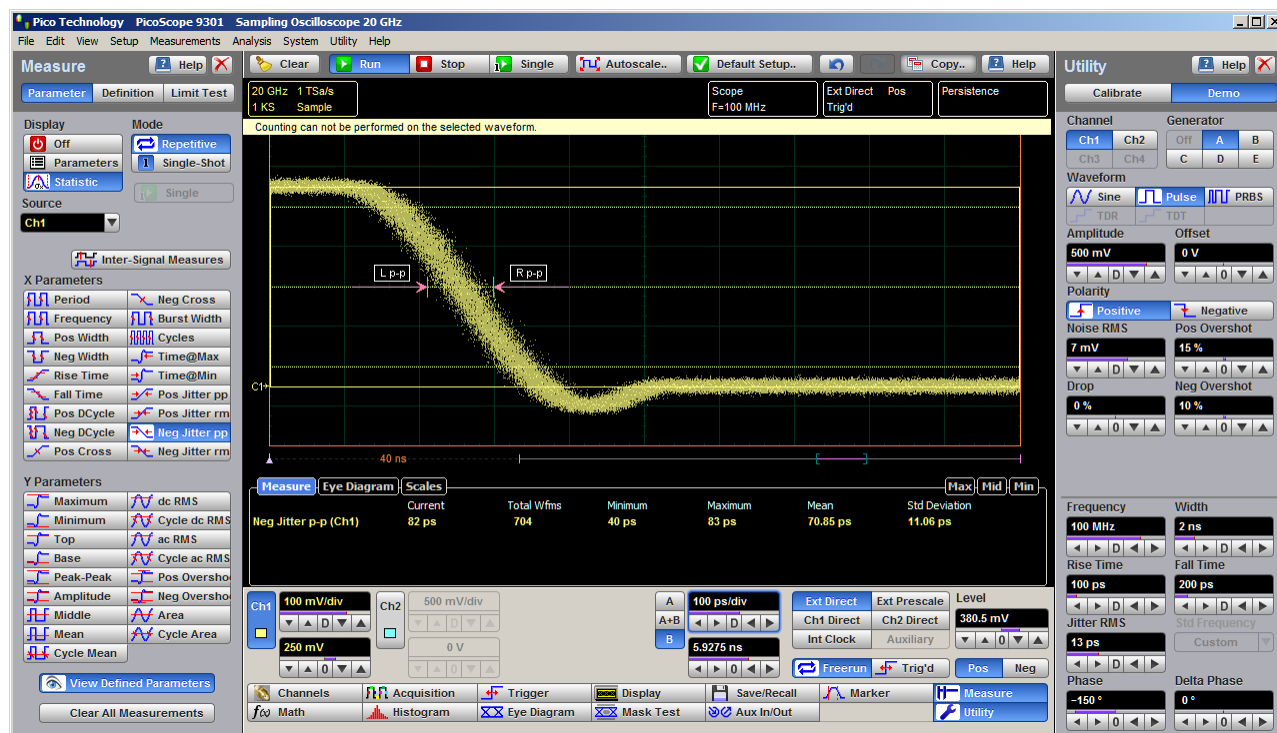
> ℹ The **Margins** menu sets the margin markers to show where the scope is making the automatic measurement. All calculations of Burst Width will be performed only inside these margins.

> ℹ Burst Width value is affected by the **Definition** menu. In the **Thresholds** menu you can redefine the mid-threshold setting from 50% to any other level you want.

7.10.2.12 Cycle

 Cycles

Cycles is defined as the number of cycles of a periodic waveform between the mid-threshold crossings of two consecutive first and last edges of the same polarity. The PicoScope 9300 starts the measurement on the first edge on the leftmost portion of the measurement region (left margin) and stops the measurement on the last edge on the rightmost portion of the measurement region (right margin). The detected edges can be either rising or falling.
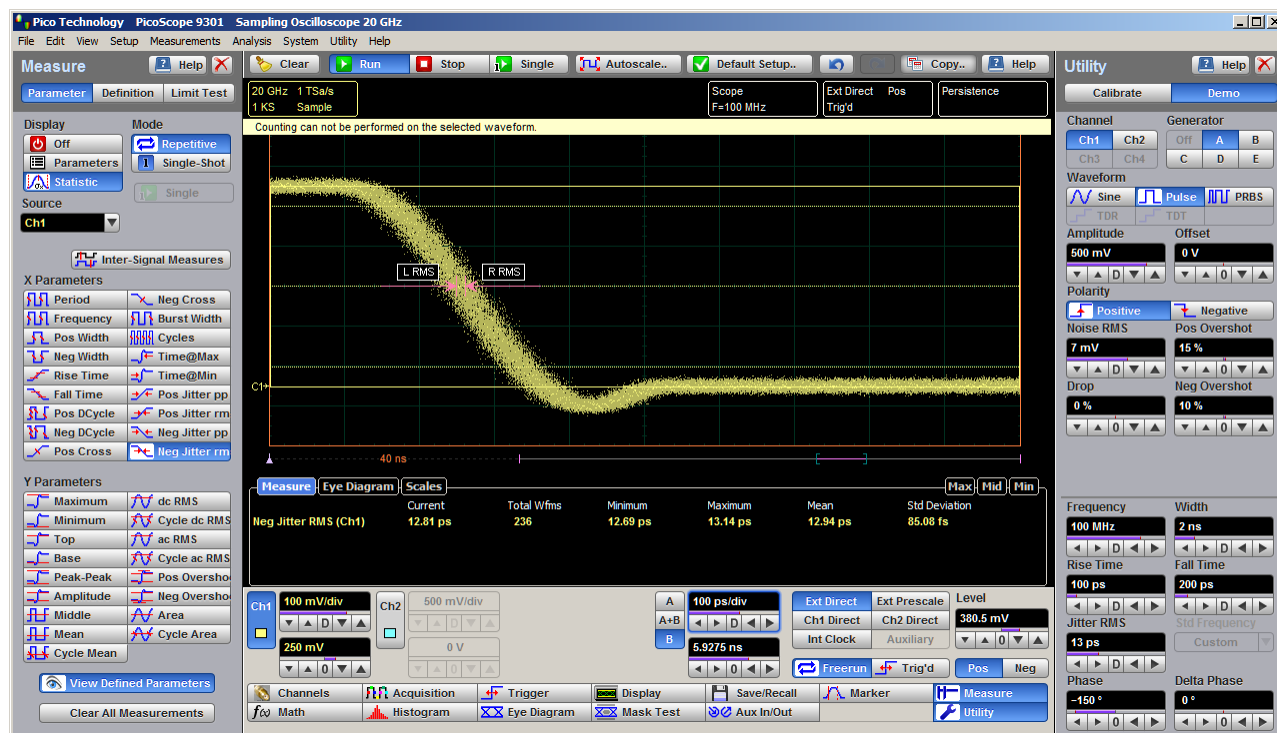

Cycle definition

> ℹ The **Margins** menu sets the margin markers to show where the scope is making the automatic measurement. All calculations of Cycle will be performed only inside these margins.

> ℹ Cycle value is affected by the **Definition** menu. In the **Thresholds** menu you can redefine the mid-threshold setting from 50% to any other level you want.

7.10.2.13 Time@Maximum

Time@Max

Time@Maximum is a measure of the time of the first occurrence of the first data sample with the maximum signal level. The PicoScope 9300 starts the measurement on the first leftmost portion of the measurement region (left margin) and stops the measurement on the last edge on the rightmost portion of the display (right margin).

The **Time@Maximum** is position-independent. Therefore, the instrument uses the entire waveform on the display graticule to determine the maximum signal level.

Time@Maximum definition

> ℹ The **Margins** menu sets the margin markers to show where the scope is making the automatic measurement. All calculations of Time@Maximum will be performed only inside these margins.

7.10.2.14 Time@Minimum

Time@Minimum is a measure of the time of the first occurrence of the first data sample with the minimum signal level. The PicoScope 9300 starts the measurement on the first leftmost portion of the measurement region (left margin) and stops the measurement on the last edge on the rightmost portion of the display (right margin).

Time@Minimum is position-independent. Therefore, the instrument uses the entire waveform on the display graticule to determine the minimum signal level.
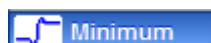

Time@Minimum definition

> The **Margins** menu sets the margin markers to show where the scope is making the automatic measurement. All calculations of Time@Minimum will be performed only inside these margins.

7.10.2.15Positive Jitter p-p

Positive Jitter p-p is a measure of peak-peak time variations of the rising edges of a pulse waveform at the middle threshold.

Positive Jitter p-p definition

Positive Jitter p-p is determined as follows:

Positive Jitter p-p = Full width of the Horizontal Histogram in the Middle Threshold

> The **Margins** menu sets the margin markers to show where the scope is making the automatic measurement. All calculations of Positive Jitter p-p will be performed only inside these margins.

7.10.2.16 Positive Jitter RMS
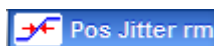
 Pos Jitter rm

Positive Jitter RMS is a measure of RMS time variations of the rising edges of a pulse waveform at the middle threshold.

Positive Jitter RMS definition

The **Positive Jitter RMS** is determined as follows:

*Positive Jitter RMS = 1ó (standard deviation) of the Horizontal Histogram in the Middle Threshold*

> The **Margins** menu sets the margin markers to show where the scope is making the automatic measurement. All calculations of Positive Jitter RMS will be performed only inside these margins.

7.10.2.17 Negative Jitter p-p
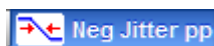
 Neg Jitter pp

Negative Jitter p-p is a measure of the peak-peak time variations of the falling edges of a pulse waveform at the middle threshold.

Negative Jitter p-p definition

The **Negative Jitter p-p** is determined as follows:

*Negative Jitter p-p = Full width of the Horizontal Histogram at the Middle Threshold*

> ℹ️ The **Margins** menu sets the margin markers to show where the scope is making the automatic measurement. All calculations of Negative Jitter p-p will be performed only inside these margins.

7.10.2.18 Negative Jitter RMS
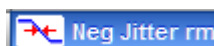
Negative Jitter RMS is a measure of the RMS time variations of the falling edges of a pulse waveform at the middle threshold.

Negative Jitter RMS definition

Negative Jitter RMS is determined as follows:

Negative Jitter RMS = 1σ (standard deviation) of the Horizontal Histogram at the Middle Threshold

> The **Margins** menu sets the margin markers to show where the scope is making the automatic measurement. All calculations of Negative Jitter RMS will be performed only inside these margins.

7.10.3   Y Parameters

The **Y Parameters** menu is a list of amplitude parameters**.** This list includes seventeen amplitude parameters used for pulse measurements. Once the **Top** and **Base** calculation is completed (according to the **Method** setting), most of the timing and amplitude measurements can be made.

Y Parameters	
Maximum	dc RMS
Minimum	Cycle dc RMS
Top	ac RMS
Base	Cycle ac RMS
Peak-Peak	Pos Oversho
Amplitude	Neg Oversho
Middle	Area
Mean	Cycle Area
Cycle Mean	
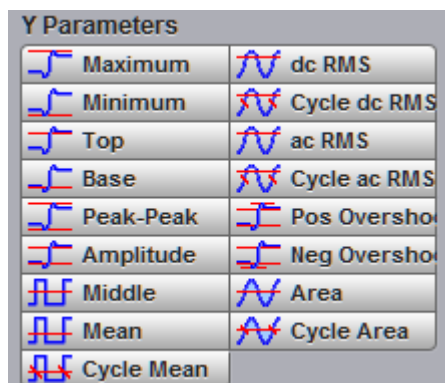
The list of Y Parameters

ⓘ You can continuously update as many as ten measurement parameters, and as many as four statistics measurements at any one time.

ⓘ The pulse measurement algorithms for **Y Parameters** will only work when a single-valued signal is used, and no NRZ eye diagram or RZ eye diagram is present on the screen. Measurements made on both NRZ and RZ eye diagrams will fail.

7.10.3.1 Maximum
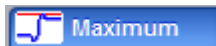
Maximum is the voltage (or power) of the absolute maximum level of the measurement region. The maximum level is taken directly from the histogram data. The PicoScope 9300 starts the measurement on the first leftmost portion of the measurement region (left margin) and stops the measurement on the rightmost portion of the display (right margin).

Maximum definition

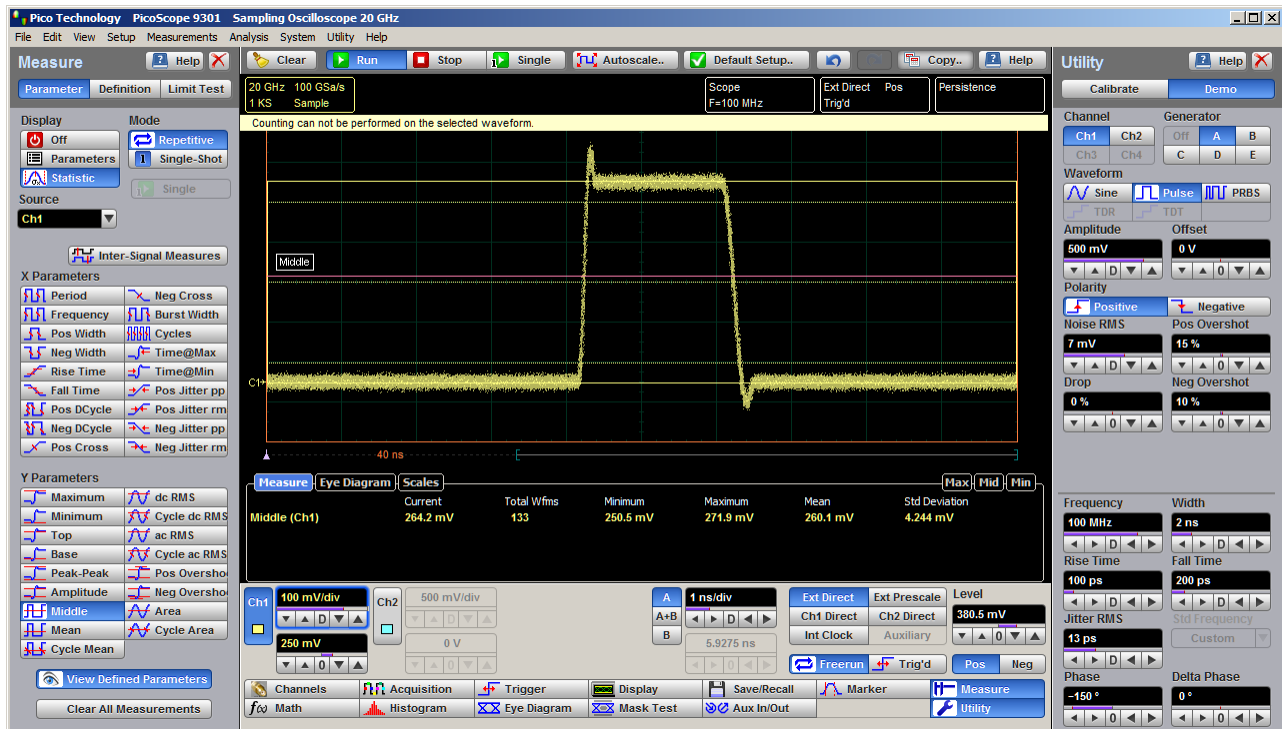ℹ️ The **Margins** menu sets the margin markers to show where the scope is making the automatic measurement. All calculations of Maximum will be performed only inside these margins.

7.10.3.2 Minimum

Minimum is the voltage (or power) of the absolute minimum level of the measurement region. The minimum level is taken directly from the histogram data. The PicoScope 9300 starts the measurement on the first leftmost portion of the measurement region (left margin) and stops the measurement on the rightmost portion of the display (right margin).
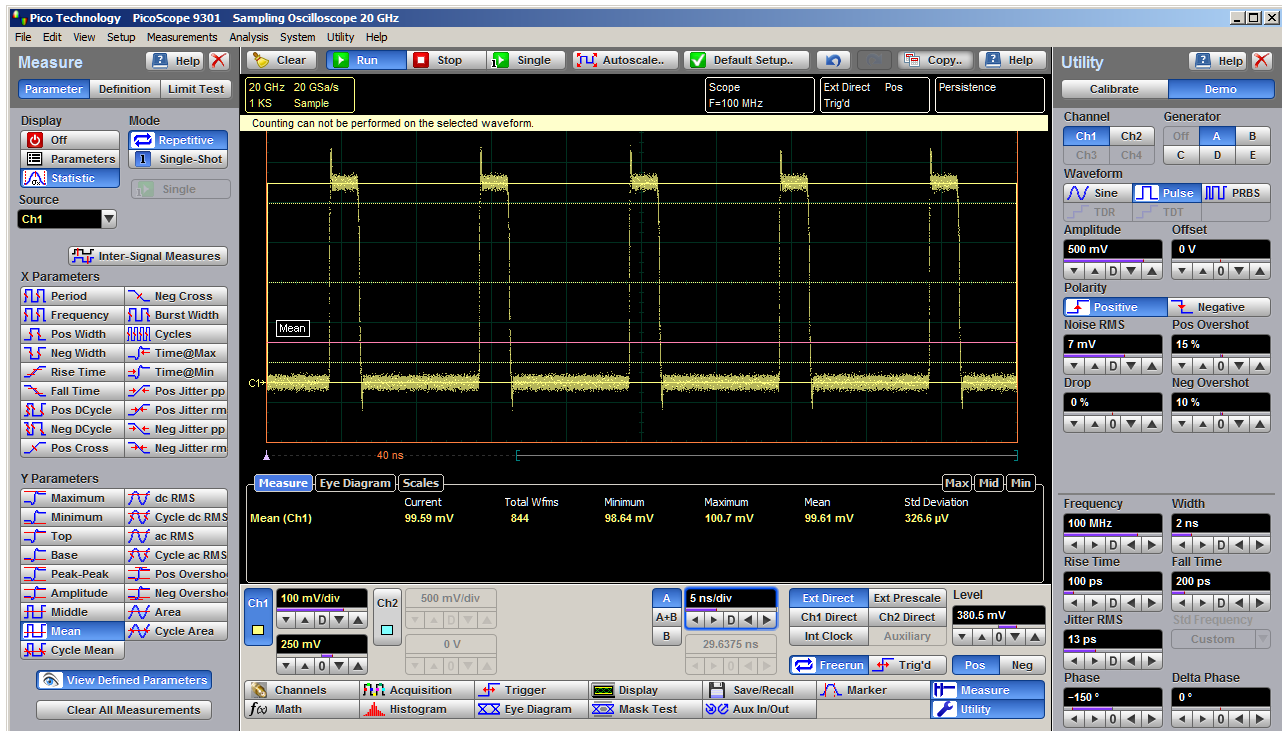

Minimum definition

ℹ️ The **Margins** menu sets the margin markers to show where the scope is making the automatic measurement. All calculations of Minimum will be performed only inside these margins.

7.10.3.3 Top

Top is the voltage of the statistical maximum level. Use the **Method** and **Thresholds** menus to customize the measurement threshold levels. **Top** may be equal to **Maximum** for many waveforms, such as triangle waveforms. The PicoScope 9300 starts the measurement on the first leftmost portion of the measurement region (left margin) and stops the measurement on the rightmost portion of the display (right margin).

Top definition

> ⓘ The **Margins** menu sets the margin markers to show where the scope is making the automatic measurement. All calculations of Top will be performed only inside these margins.

7.10.3.4 Base
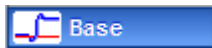
Base is the voltage of the statistical minimum level. Use the **Method** and **Thresholds** menus to customize the measurement threshold levels. **Base** may be equal to **Minimum** for many waveforms, such as triangle waveforms. The PicoScope 9300 starts the measurement on the first leftmost portion of the measurement region (left margin) and stops the measurement on the rightmost portion of the display (right margin).
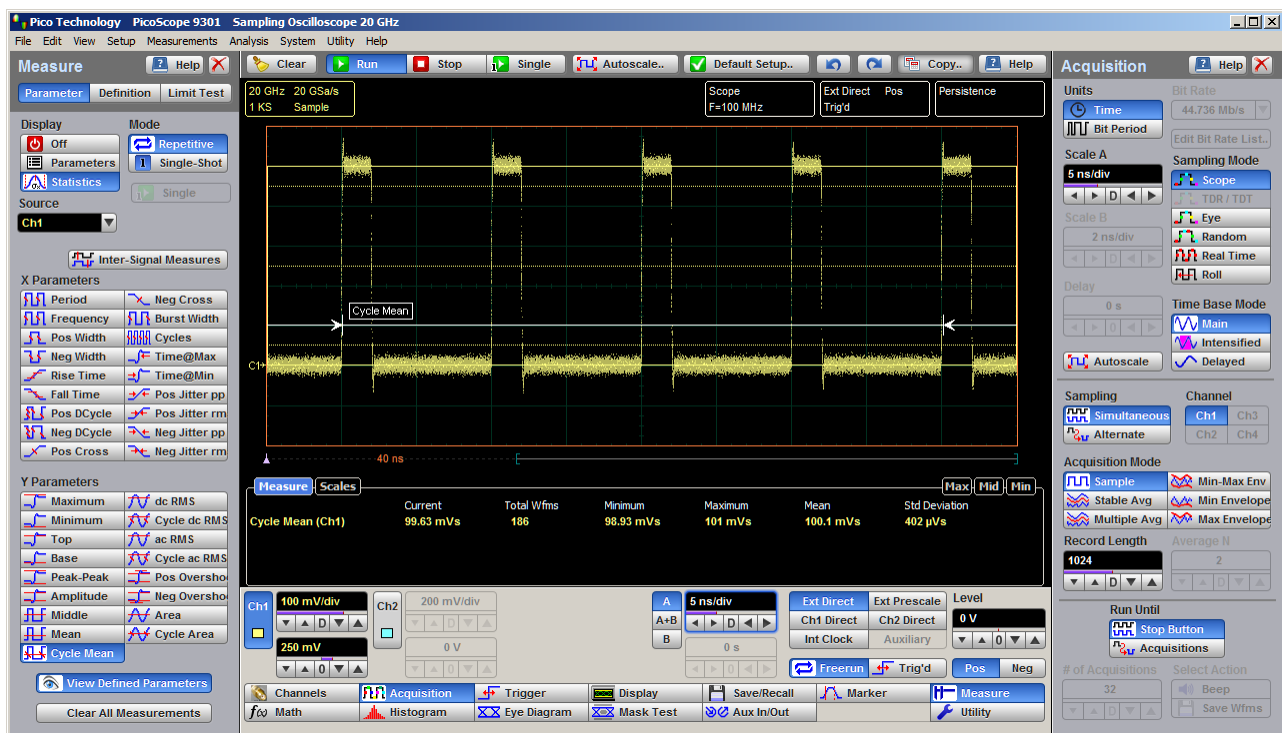

Base definition

> ℹ️ The **Margins** menu sets the margin markers to show where the scope is making the automatic measurement. All calculations of Base will be performed only inside these margins.

7.10.3.5 Peak-Peak
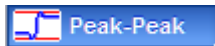
Peak-Peak is a measure of the difference between **Maximum** and **Minimum** of a displayed waveform. The PicoScope 9300 starts the measurement on the first leftmost portion of the measurement region (left margin) and stops the measurement on the rightmost portion of the display (right margin).

Peak-Peak definition

Peak-Peak is determined as follows:

Peak-Peak = Maximum − Minimum

where *Maximum* is the voltage (or power) of the absolute maximum value of the waveform, and *Minimum* is the voltage (or power) of the absolute minimum value of the waveform.

> The **Margins** menu sets the margin markers to show where the scope is making the automatic measurement. All calculations of Peak-Peak will be performed only inside these margins.

7.10.3.6 Amplitude


Amplitude is a measure of the difference between the **Top** and **Base** of a displayed pulse waveform. Use the **[Method](#)** and **[Thresholds](#)** menus to customize the measurement threshold levels. **Amplitude** may be equal to **Peak-Peak** for many waveforms, such as triangle waveforms. The PicoScope 9300 starts the measurement on the first leftmost portion of the measurement region (left margin) and stops the measurement on the rightmost portion of the display (right margin).

Amplitude definition

Amplitude is determined as follows:

$$Amplitude = Top - Base$$

where *Top* is the statistical maximum level, and *Base* is the statistical minimum level.

> ℹ️ **Top** value may be less than or equal to the maximum value of the waveform, while **Base** value may be greater than or equal to the minimum value of the waveform.

> ℹ️ The **[Margins](#)** menu sets the margin markers to show where the scope is making the automatic measurement. All calculations of Amplitude will be performed only inside these margins.

7.10.3.7 Middle
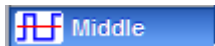
Middle is the computation of the middle point between the maximum and minimum amplitude peaks of the waveform over the measurement region. The PicoScope 9300 starts the measurement on the first leftmost portion of the measurement region (left margin) and stops the measurement on the rightmost portion of the display (right margin).

Middle definition

Middle is determined as follows:

$$Middle = (Maximum - Minimum) / 2$$

where *Maximum* is the voltage (or power) of the absolute maximum value of the waveform, and *Minimum* the voltage (or power) of the absolute minimum value of the waveform.

> ℹ️ The **Margins** menu sets the margin markers to show where the scope is making the automatic measurement. All calculations of Middle will be performed only inside these margins.

7.10.3.8 Mean

Mean is the average mean of all the waveform data over the measurement region. The PicoScope 9300 starts the measurement on the first leftmost portion of the measurement region (left margin) and stops the measurement on the rightmost portion of the display (right margin).

Mean definition

Mean is determined as follows:

$$Mean = \frac{1}{n}\sum_{i=1}^{N} V(i)$$

where *n* is the number of waveform points on screen and not the memory depth, *V(i)* is the voltage at the *i*-th point on screen.

> The **Margins** menu sets the margin markers to show where the scope is making the automatic measurement. All calculations of Mean will be performed only inside these margins.

7.10.3.9 Cycle Mean

Cycle Mean is the averaged mean of all the waveform data of one cycle of the signal over the measurement region. The average of the data values is taken of an integral number of periods. The PicoScope 9300 starts the measurement on the first leftmost portion of the measurement region (left margin) and stops the measurement on the rightmost portion of the display (right margin). See also **Mean**.

Cycle Mean definition

> ℹ️ You can customize this measurement to be made either on one waveform cycle or across all data on the display. The **Margins** menu sets the margin markers to show where the scope is making the automatic measurement. All calculations of the **Cycle Mean** value will be performed only inside these margins.

> ℹ️ Cycle Mean value is affected by the **Definition** menu. In the **Thresholds** menu you can redefine the mid-threshold setting from 50% to any other level you want.

7.10.3.10 DC RMS

 Cycle Mean

DC RMS is the root-mean-square voltage of the waveform over the measurement region. The PicoScope 9300 starts the measurement on the first leftmost portion of the measurement region (left margin) and stops the measurement on the rightmost portion of the display (right margin). The instrument can make either AC or DC RMS measurements.
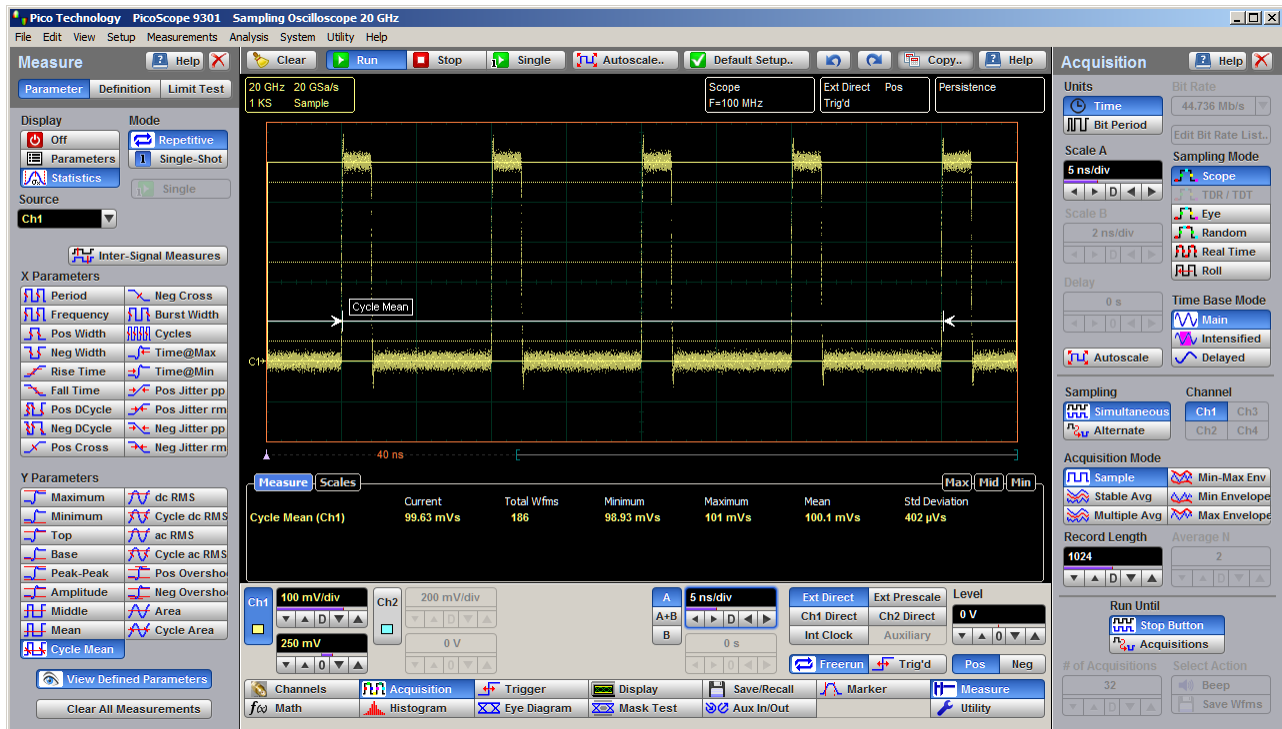

DC RMS definition

The **DC RMS** measurement is determined as follows:

$$dcRMS = \sqrt{\frac{\sum_{i=1}^{N}[V(i)]^2}{n}}$$

where: *n* is the number of waveform points on screen and not the memory depth, and *V(i)* is the voltage at the *i*-th point on screen.
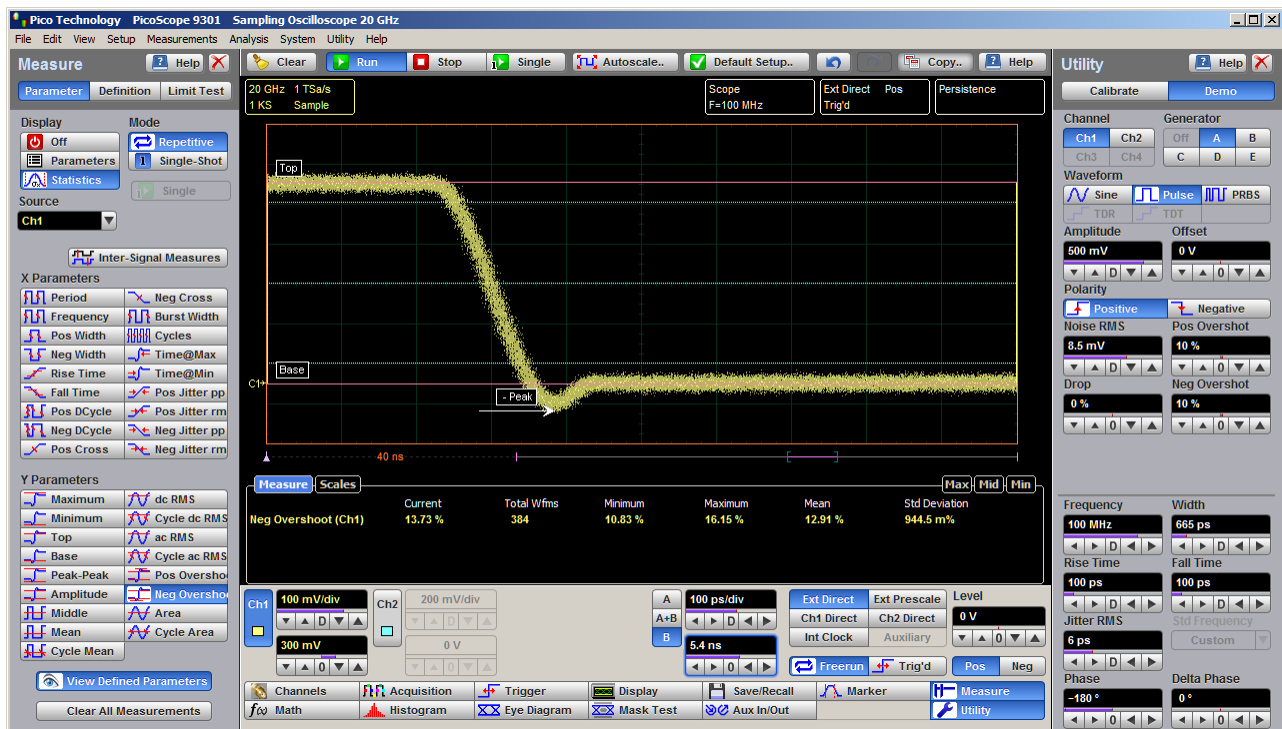
> ℹ The **Margins** menu sets the margin markers to show where the scope is making the automatic measurement. All calculations of DC RMS will be performed only inside these margins.

7.10.3.11 Cycle DC RMS
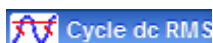
 Cycle dc RMS

Cycle DC RMS is the averaged root-mean-square voltage of one cycle of the waveform value over the measurement region. The average of the data values is taken over an integral number of periods. The PicoScope 9300 starts the measurement on the first leftmost portion of the measurement region (left margin) and stops the measurement on the rightmost portion of the display (right margin). The instrument can make either cycle AC or DC RMS measurements. See also **DC RMS**.

Cycle DC RMS definition

> ℹ️ You can customize this measurement to be made either on one waveform cycle or across all data on the display. The **Margins** menu sets the margin markers to show where the scope is making the automatic measurement. All calculations of the **Cycle DC RMS** value will be performed only inside these margins.

7.10.3.12 AC RMS

AC RMS is the root-mean-square voltage of the waveform less the mean value over the measurement region. The PicoScope 9300 starts the measurement on the first leftmost portion of the measurement region (left margin) and stops the measurement on the rightmost portion of the display (right margin). The instrument can make either AC or DC RMS measurements.
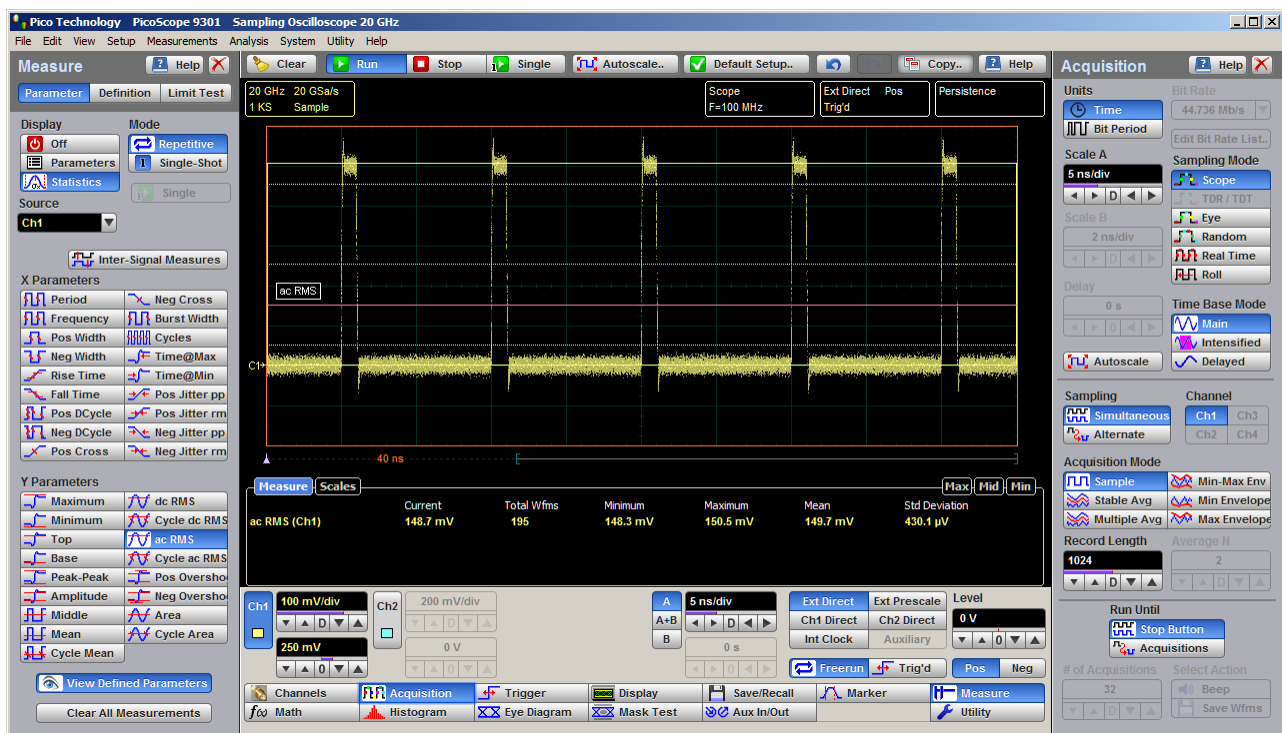
AC RMS definition

The **AC RMS** measurement is determined as follows:

$$acRMS = \sqrt{\frac{\sum_{i=1}^{N}[V(i) - Mean]^2}{n}}$$

where: *n* is the number of waveform points on screen and not the memory depth, *V(i)* is the voltage at the *i*-th point on screen, and *Mean* is an average mean voltage.

> The **Margins** menu sets the margin markers to show where the scope is making the automatic measurement. All calculations of AC RMS will be performed only inside these margins.

7.10.3.13Cycle AC RMS
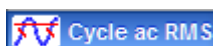
Cycle AC RMS is the averaged root-mean-square voltage of one cycle of the waveform less the cycle mean value over the measurement region. The average of the data values is taken over an integral number of periods. The PicoScope 9300 starts the measurement on the first leftmost portion of the measurement region (left margin) and stops the measurement on the rightmost portion of the display (right margin). The instrument can make either AC or DC RMS measurements. See also **AC RMS**.

Cycle as RMS definition

> You can customize this measurement to be made either on one waveform cycle or across all data on the display. The **Margins** menu sets the margin markers to show where the scope is making the automatic measurement. All calculations of the **Cycle AC RMS** value will be performed only inside these margins.

7.10.3.14 Positive Overshoot
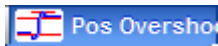
Positive Overshoot is defined as the maximum distortion that follows a positive waveform edge transition. This distortion occurs after the edge crosses through the waveform threshold levels. The PicoScope 9300 starts the measurement on the first leftmost portion of the measurement region (left margin) and stops the measurement on the rightmost portion of the display (right margin). The instrument can make both positive and negative overshoot measurements.
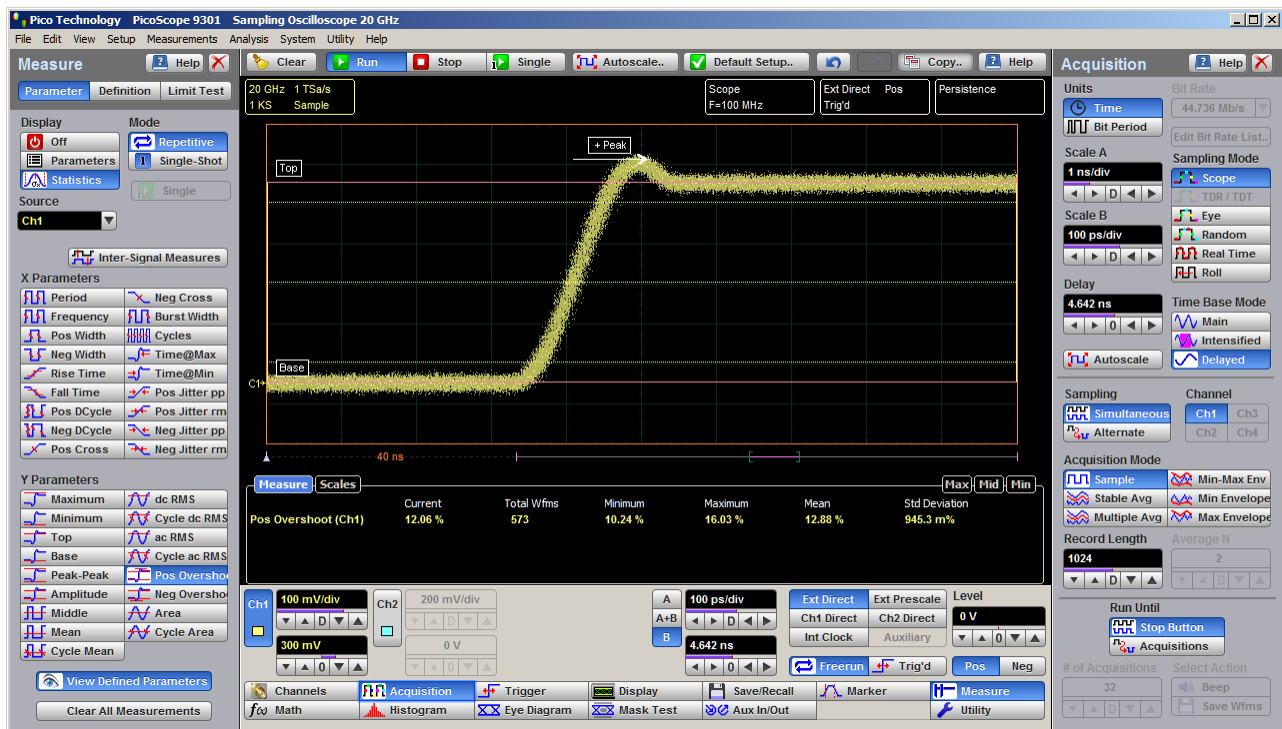
Positive Overshoot definition

Positive Overshoot is determined when the waveform edge is rising (upward slope), and is computed as follows:

$$Positive\ Overshoot = [(Maximum - Top)\ /\ Amplitude] \times 100\%$$

where: *Maximum* is the signal maximum, *Top* is the signal top value, and *Amplitude* is the signal amplitude.

> ℹ The **Margins** menu sets the margin markers to show where the scope is making the automatic measurement. All calculations of Positive Overshoot will be performed only inside these margins.

7.10.3.15 Negative Overshoot
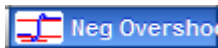
Neg Overshoot

Negative Overshoot is defined as the maximum distortion that follows a negative waveform edge transition. This distortion occurs after the edge crosses through the waveform threshold levels. The PicoScope 9300 starts the measurement on the first leftmost portion of the measurement region (left margin) and stops the measurement on the rightmost portion of the display (right margin). The instrument can make both positive and negative overshoot measurements.

Negative Overshoot definition

Negative Overshoot, determined when the waveform edge is falling, is computed as follows:

$$Negative\ Overshoot = [(Base - Minimum) / Amplitude] \times 100\%$$

where: *Minimum* is the signal minimum, *Base* is the signal base value, and *Amplitude* is the signal amplitude.

> ℹ️ The **Margins** menu sets the margin markers to show where the scope is making the automatic measurement. All calculations of Negative Overshoot will be performed only inside these margins.

7.10.3.16 Area

Area is the area under the curve of the waveform within the measurement region in vertical units multiplied by horizontal units, such as volt-seconds or watt-seconds. Area measured above ground is positive; area measured below ground is negative.

Area is determined as follows:

$$Area = \int_{Start}^{End} Waveform(t)\,dt$$

In practice the PicoScope 9300 uses the following algorithm:

$$Area = \frac{\Delta t}{N} \sum_{i=1}^{N} V(i)$$

where: *N* is the number of waveform points on screen and not the memory depth, *V(i)* is the voltage at the i-th point on screen, and Δt is the measured region duration.

> ℹ The **Margins** menu sets the margin markers to show where the scope is making the automatic measurement. All calculations of Area will be performed only inside these margins.

7.10.3.17 Cycle Area
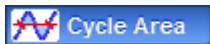
〰 **Cycle Area**

Cycle Area is the averaged area under the curve for of one cycle the waveform within the measurement region in vertical units multiplied by horizontal units, such as volt-seconds or watt-seconds. The average of the data values is taken over an integral number of periods. Area measured above ground is positive; area measured below ground is negative. See also **Area**.

**Cycle Area definition**

> ℹ The **Margins** menu sets the margin markers to show where the scope is making the automatic measurement. All calculations of Cycle Area will be performed only inside these margins.

7.10.4   Trace-to-trace Measurements
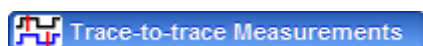
Clicking **Trace-to-trace Measurements** opens the list of parameters that can be measured with two signal sources.
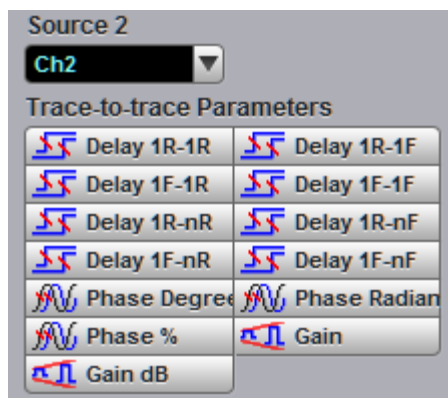
The List of Trace-to-trace Measurements

You can select as one of the sources:

- Channels 1 through 4
- Functions 1 through 4
- Waveform memories 1 through 4
- Any of the spectra

The list of measurements includes eight delay parameters, three phase parameters, and two gain parameters.

> ℹ️ You can continuously update as many as ten measurement parameters, and as many as four statistics measurements at any one time.

> ℹ️ The pulse measurement algorithms for **X Parameters** will only work when a single-valued signal is used, and no NRZ eye diagram or RZ eye diagram is present on the screen. Measurements made on NRZ and RZ eye diagrams will fail.

When the **Dual Channel Parameters...** menu is selected, the **Source** drop-down list box located on the first page of the **Measure** menu selects the reference source, while the **Source 2** drop-down list box located on the **Dual Channel Parameters** menu page selects the second source.

7.10.4.1 Source 2
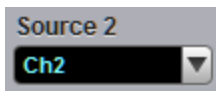
Source 2
Ch2

When the **Trace-to-trace Measurements** menu is selected, the **Source** drop-down list box located on the first page of the **Measure** menu selects the reference source, while the **Source 2** drop-down list box located on the **Trace-to-trace Measurements** menu page selects the second source.

7.10.4.2 Delay

Delay 1R-1R	Delay 1R-1F
Delay 1F-1R	Delay 1F-1F
Delay 1R-nR	Delay 1R-nF
Delay 1F-nR	Delay 1F-nF
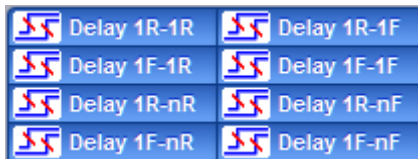
Delay is defined as the time interval between the crossings of the two mid-reference levels on the two sources of the measurement. The PicoScope 9300 starts the measurement on the first edge on the leftmost portion of the measurement region (left margin) and stops the measurement on the last edge on the rightmost portion of the measurement region (right margin).

Delay is determined as follows:

$$Delay = T_{cross2} - T_{cross1}$$

where: T_{cross2} is the horizontal crossing on the rising or falling edge of the second source, and T_{cross1} is the horizontal crossing on the rising or falling edge of the first (reference) source.

The delay will not be measured until the rising and falling edges on both sources complete the transition through all three levels.

You can select one of the eight delay options:

- **Delay 1R-1R** is the delay between the first rising edge on the reference source and the first rising edge on the second source
- **Delay 1R-1F** is the delay between the first rising edge on the reference source and the first falling edge on the second source
- **Delay 1F-1R** is the delay between the first falling edge on the reference source and the first rising edge on the second source
- **Delay 1F-1F** is the delay between the first falling edge on the reference source and the first falling edge on the second source
- **Delay 1R-nR** is the delay between the first rising edge on the reference source and the last rising edge on the second source
- **Delay 1R-nF** is the delay between the first rising edge on the reference source and the last falling edge on the second source
- **Delay 1F-nR** is the delay between the first falling edge on the reference source and the last rising edge on the second source
- **Delay 1F-nF** is the delay between the first falling edge on the reference source and the last falling edge on the second source
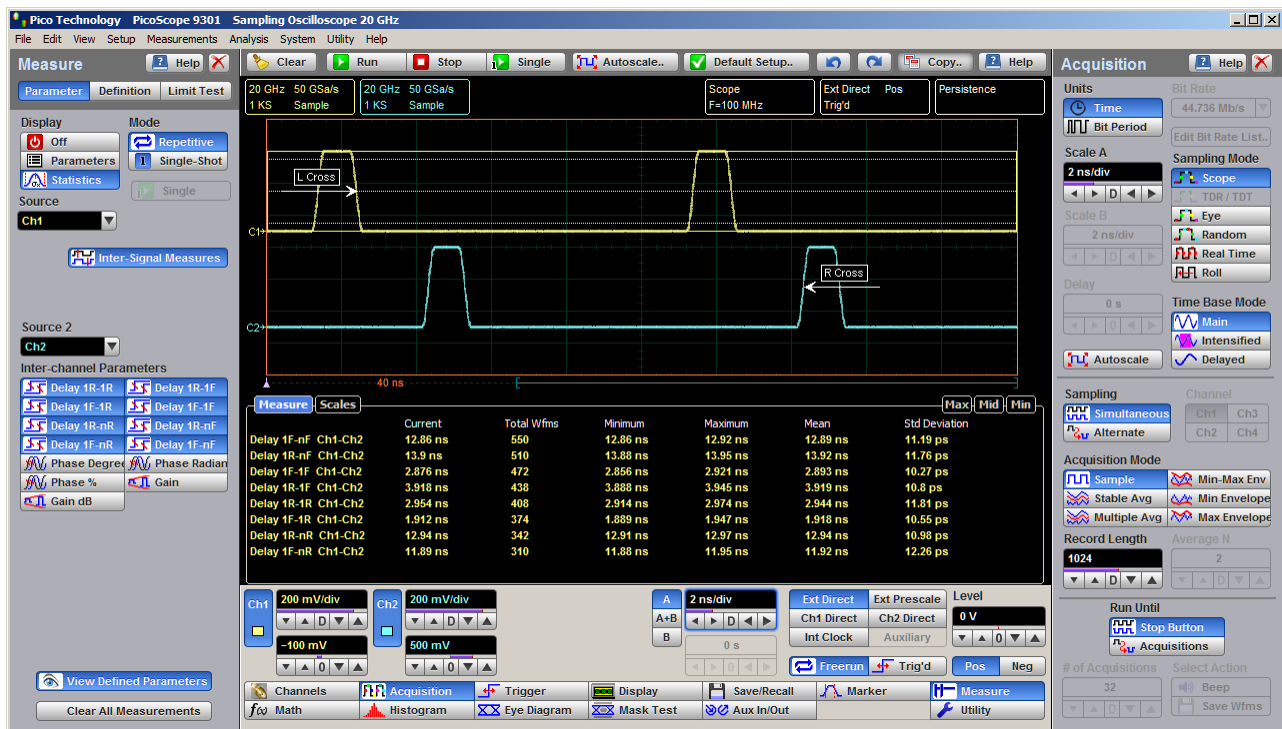
Example of Delay measurement between two waveforms

> ℹ The **Margins** menu sets the margin markers to show where the scope is making the automatic measurement. All calculations of Delay will be performed only inside these margins.

> ℹ Delay value is affected by the **Definition** menu. In the **Thresholds** menu you can redefine the mid-threshold setting from 50% to any other level you want.

7.10.4.3 Phase
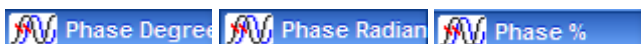
Phase is the amount by which a waveform leads or lags another in time. It is defined between the first rising edge on the reference source and the first rising edge on the second source. The PicoScope 9300 starts the measurement on the first edge on the leftmost portion of the measurement region (left margin) and stops the measurement on the last edge on the rightmost portion of the measurement region (right margin).

The **Phase** is determined as follows:

$$PhaseRad = \frac{Tcross2 - Tcross1}{Period} \times 100\%$$

$$PhaseRad = \frac{Tcross2 - Tcross1}{Period} \times 2\pi$$

$$PhaseRad = \frac{Tcross2 - Tcross1}{Period} \times 100\%$$

where: *Tcross2* - is a horizontal crossing on the first rising edge of the second source, *Tcross1* is a horizontal crossing on the first rising edge of the first (reference) source, and *Period* is a period value.

You can select one of three phase options:

- **Phase Degree** is a phase expressed in degrees, where 360° constitutes one waveform cycle
- **Phase Radian** is a phase expressed in radians, where one waveform cycle (360°) corresponds to 2 radians
- **Phase %** is a phase expressed as a percentage of one waveform cycle
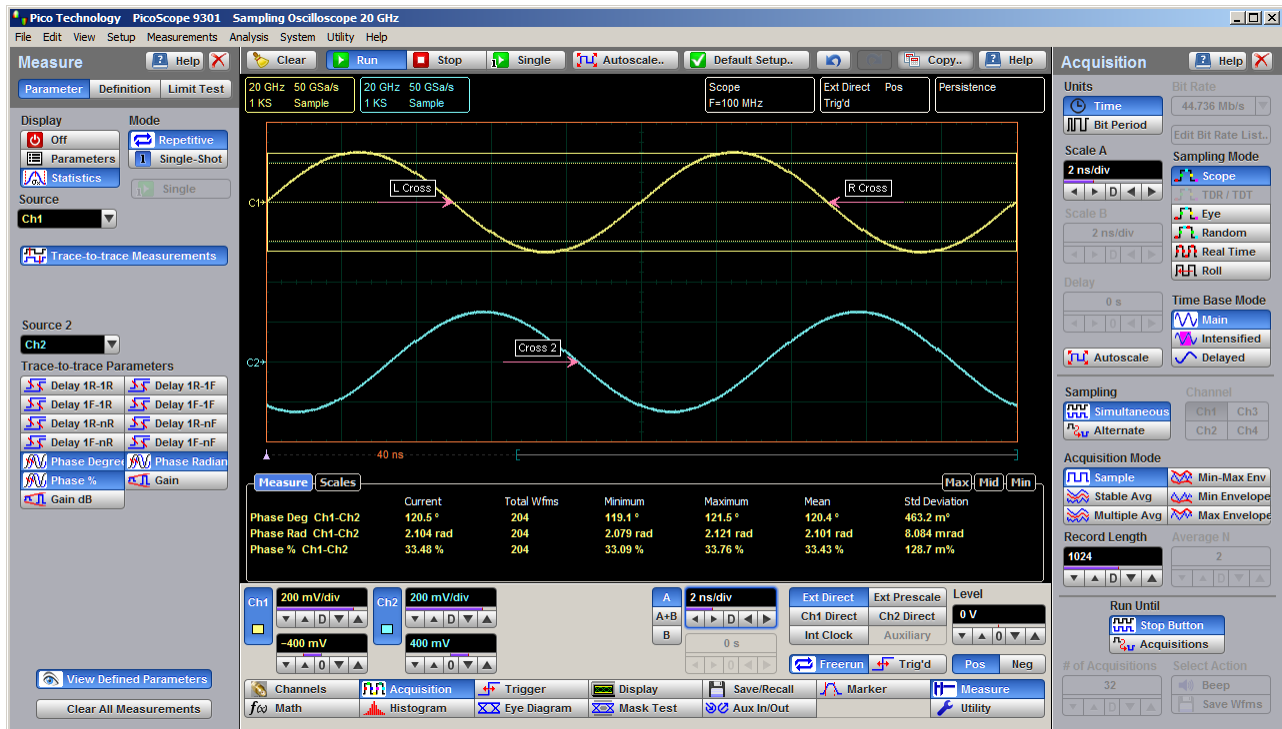
Example of phase measurement between two sine-wave waveforms

> ℹ️ Both the first (reference) and the second sources should have an equal period value when the phase measurements are performed.

> ℹ️ The **Margins** menu sets the margin markers to show where the scope is making the automatic measurement. All calculations of Phase will be performed only inside these margins.

> ℹ️ Phase value is affected by the **Definition** menu. In the **Thresholds** menu you can redefine the mid-threshold setting from 50% to any other level you want.

7.10.4.4 Gain

Gain   **Gain dB**

Gain is the amplitude gain between two selected waveforms. The PicoScope 9300 starts the measurement on the first edge on the leftmost portion of the measurement region (left margin) and stops the measurement on the last edge on the rightmost portion of the measurement region (right margin).

Gain is determined as follows:

$$Gain = \frac{Amplitude2}{Amplitude1}$$

$$Gain\_dB = 20\log_{10}\left(\frac{Amplitude2}{Amplitude1}\right)$$

where: *Amplitude1* is the amplitude measurement of the first (reference) source, and *Amplitude2* is the amplitude measurement of the second source.

You can select one of two gain options:

- **Gain** is a gain expressed as an amplitude gain between the amplitudes of two waveforms
- **Gain dB** is a gain expressed in decibels
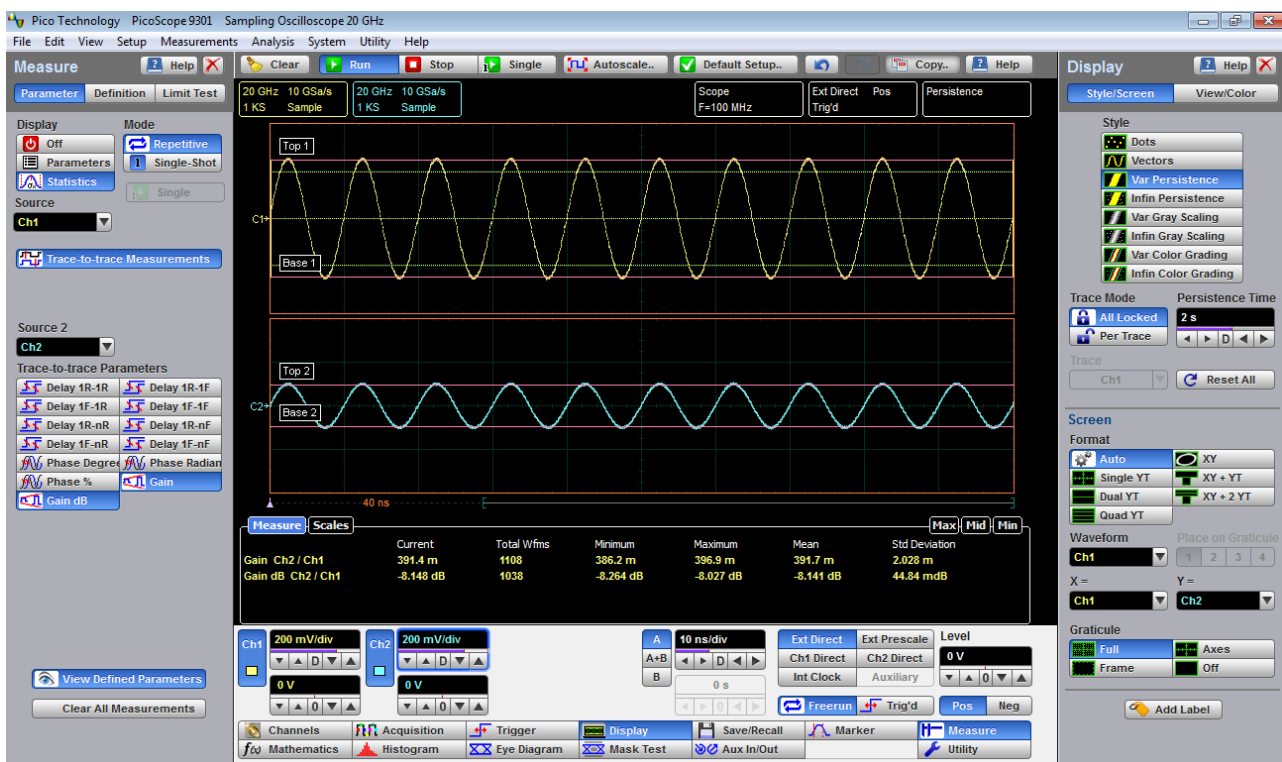
Example of gain measurement between two sine-wave signals

> ℹ️ The **Margins** menu sets the margin markers to show where the scope is making the automatic measurement. All calculations of Gain will be performed only inside these margins.

7.10.5   View Defined Parameters

The markers can be used to give you a visual indication of where you are manually setting the thresholds and margins. To use the markers to show the settings, click **View Defined Parameters**.

7.10.6   Clear All Measurements

Clicking **Clear All Measurements** removes all selected measurements and all measurement results. This function is useful when measurements were performed with waveforms from different sources.

7.10.7   Definition

Definition

The **Definition** menu sets the measurement points (thresholds and margins) where the automatic measurements are made. These measurement points can be set to the same points for all waveforms (channel waveforms, function waveforms, and waveform memories) or can be set differently for each individual waveform. The menu influences the measurement algorithm by allowing you to use the standard IEEE measurement points, or customize the measurements with the user-defined selections. The **Definition** menu also includes the **Statistics** menu for some statistics options.

The Definition menu

The **Definition** menu is different when you work in the time domain with signals or in the frequency domain with spectra.

Standard IEEE measurement points

The waveform drawing below shows some of the standard measurement points, thresholds, and parameters.
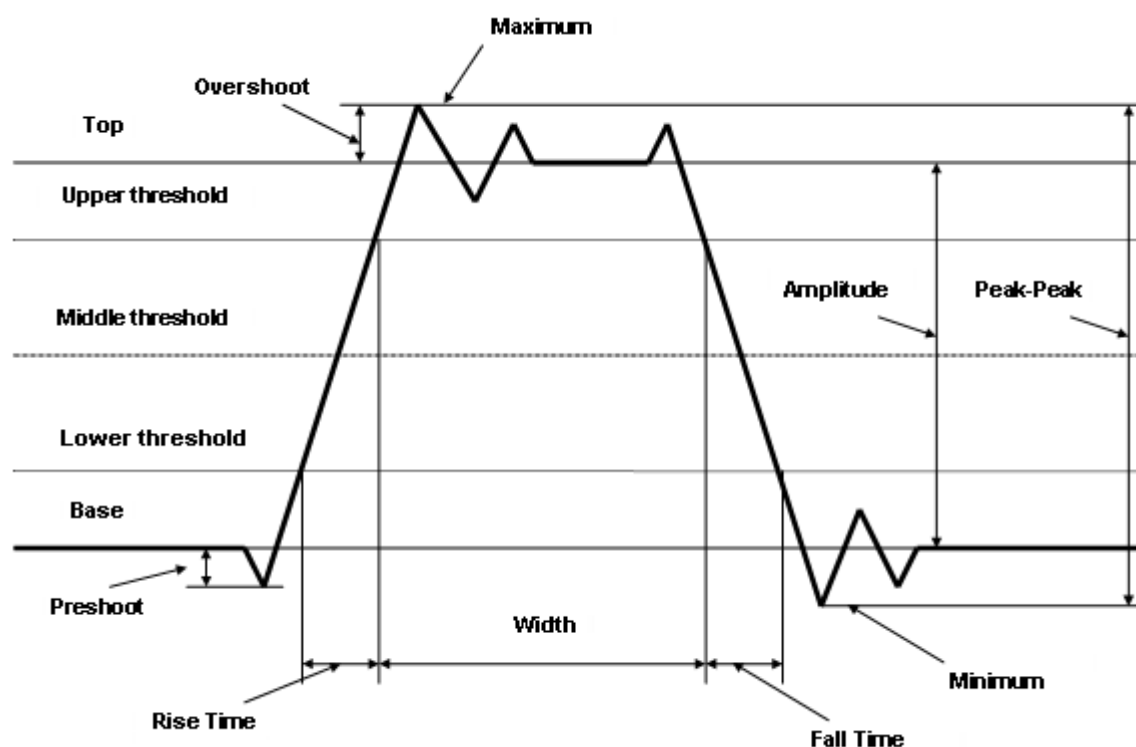
Standard IEEE measurement points

7.10.7.1 Method menu
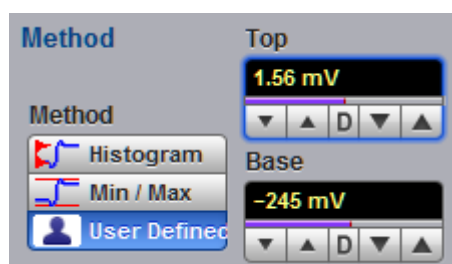
The Method menu

7.10.7.1.1 Method
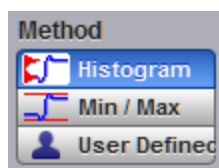
The **Method** menu sets the **Top** and **Base** vertical reference thresholds for amplitude measurements. It also sets the values from which the upper, middle and lower thresholds are calculated. The **Top** and **Base** variables are displayed when the **User Defined** method is selected. The three selections under the **Method** menu allow the user to choose the method for determining the **Top** and **Base** of the waveform.

- **Histogram.** The instrument calculates the top and base using the IEEE standards with a voltage histogram of the waveform that is on the display. The instrument finds the prevalent top and base voltage values. Make sure there is enough of the signal displayed on the screen so that the instrument can accurately determine the top and base values of the waveform. However, if too much of the top and base of the waveform are on the display, it may reduce the number of sample points on the edge of interest, which may reduce the repeatability of your measurements. A good rule of thumb is to have two divisions of top and two divisions of base.
- **Min / Max.** The absolute maximum (positive peak) of the targeted waveform is used as the **Top**, and the absolute minimum (negative peak) of the targeted waveform is used as the **Base**.
- **User Defined.** This method lets you set the top and base to a specific voltage value. The upper, middle and lower thresholds are then calculated from the voltage values you select. The **User Defined** method simplifies the threshold detection algorithm. The result is that the measurement throughput of the instrument is increased, because the instrument does not have to calculate the top and base values. After you selected the **User Defined** method, the **Top** and **Base** variables becomes active.

7.10.7.1.2 Top and Base

The **Top** and **Base** variables let you set the top and base to a specific voltage value. As an example, for a 200 mV/div vertical scale you can set the top and base voltage values from −798 mV to 798 mV in 25 mV (coarse) or 1.56 mV (fine) increments determined by the voltage range you are in.

Note that the top value cannot be less than the base value.

7.10.7.2 Thresholds menu
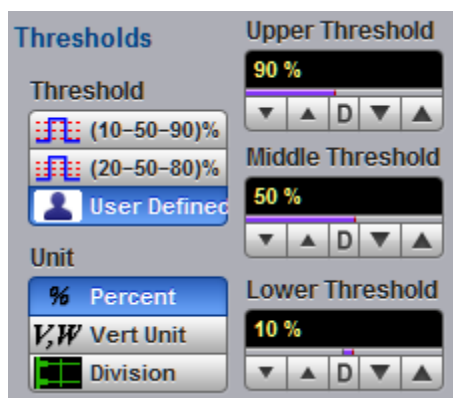
The Thresholds menu

7.10.7.2.1 Threshold
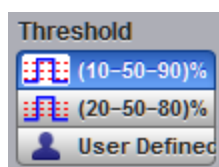
The **Threshold** control sets the measurement points that the automatic measurements use for calculating the timing measurement results. The threshold points are upper, middle, and lower. For example, rise time is measured from the lower threshold to the upper threshold, while a width measurement is made between two middle thresholds.

The three threshold choices are the standard IEEE measurement points:

- **10%-50%-90%**
- **20%-50%-80%**
- **User Defined**

By default, the PicoScope 9300 uses the IEEE thresholds of 10%, 50% and 90% for pulse measurements. A rising or falling edge is only recognized after passing through all three thresholds. You can specify your own thresholds rather than using the IEEE standard levels, but this can dramatically change the measurement results. Note that the rise and fall times for the same waveform will be faster using the 80%, 20% criteria instead of the 90%, 10% criteria. You may rely on the scope to automatically set top and base or redefine those levels yourself and use units of voltage instead of percent.

The **Upper Threshold, Middle Threshold**, and **Lower Threshold** variables are displayed only when **User Defined** is selected in the **Thresholds** menu.

10%-50%-90% and 20%-50%-80%

These are two IEEE standard pulse measurement thresholds for all measurements. These standard thresholds are calculated as a percentage of the top-base values, and the top-base values are calculated from the waveform that is on the display.

10%-50%-90% means: Lower threshold = 10 %, Middle threshold = 50 %, Upper threshold = 90 %.

20%-50%-80% means: Lower threshold = 20 %, Middle threshold = 50 %, Upper threshold = 80 %.

Make sure that the waveform is expanded vertically and horizontally so that the instrument can accurately determine the top and base values of the waveform. However, if too much of the top and base of the waveform is on the display, it may reduce the repeatability of your measurements. A good rule of thumb is to have two divisions of top and two divisions of base.

User Defined

For waveform records or portions of waveform records on which you want to make custom measurements or define thresholds in units of volts, percents or divisions, you can use the **User Defined** setting. By using units of volts, you can fix the thresholds and compare different waveform records using exactly the same, fixed threshold points.

7.10.7.2.2 Unit
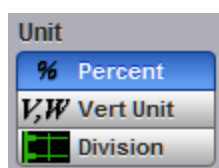
You can set the unit of measure for upper, middle, and lower thresholds to **Percent**, **Vertical Unit** or **Division**.

- **Percent.** This is calculated from the top-base values, and you can set the maximum percentage up to 200% in 1% (coarse) or 0.1% (fine) increments.
- **Vertical Unit.** This lets you set the thresholds to particular voltage (or watts) values regardless of the top-base values. For example, for a vertical scale of 200 mV/div you can set the voltage values from −797 mV to 797 m V in approximately 25 mV (coarse) or 1.56 mV (fine) increments determined by the voltage range you are in. Setting **Vertical Unit** to **V, W** simplifies the threshold detection algorithm. The result is that the measurement throughput of the instrument is increased, because the instrument does not have to calculate the voltage thresholds.
- **Division.** This lets you set the thresholds to particular voltage values regardless of the top-base values. For example, you can set the voltage values from −3.97 to 3.97 divisions in $^1/_8$ division (coarse) or $^1/_{128}$ division (fine) increments.

7.10.7.2.3 Upper, Middle and Lower Threshold
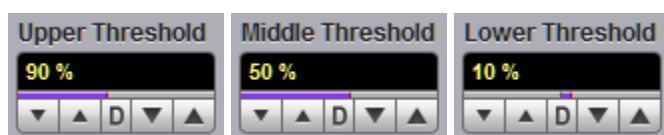
The **Upper Threshold, Middle Threshold**, and **Lower Threshold** variables are displayed only when **User Defined** is selected in the **Thresholds** menu. All variables can be selected for either **Percent**, **Volt** (or **Watts**), or **Division.**

The upper threshold value is always greater than the value of the middle threshold, and the middle threshold value is always greater than the value of the lower threshold. The instrument will not allow a threshold to cross over the adjacent threshold.

7.10.7.3 Margins

The **Margins** menu sets the left and right horizontal margins that the automatic measurements use for calculating measurement results. All calculations of measuring parameters can be performed only inside these margins.
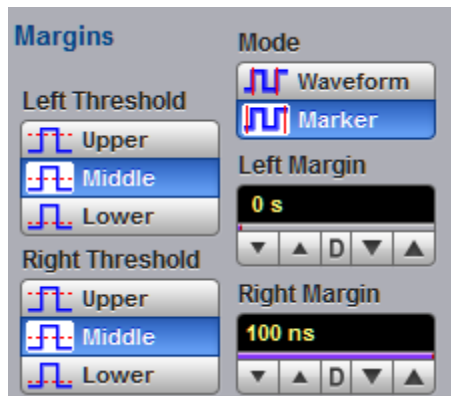
The Margins menu

The figure below demonstrates how correctly positioned margins can provide complicated user-defined horizontal measurements.
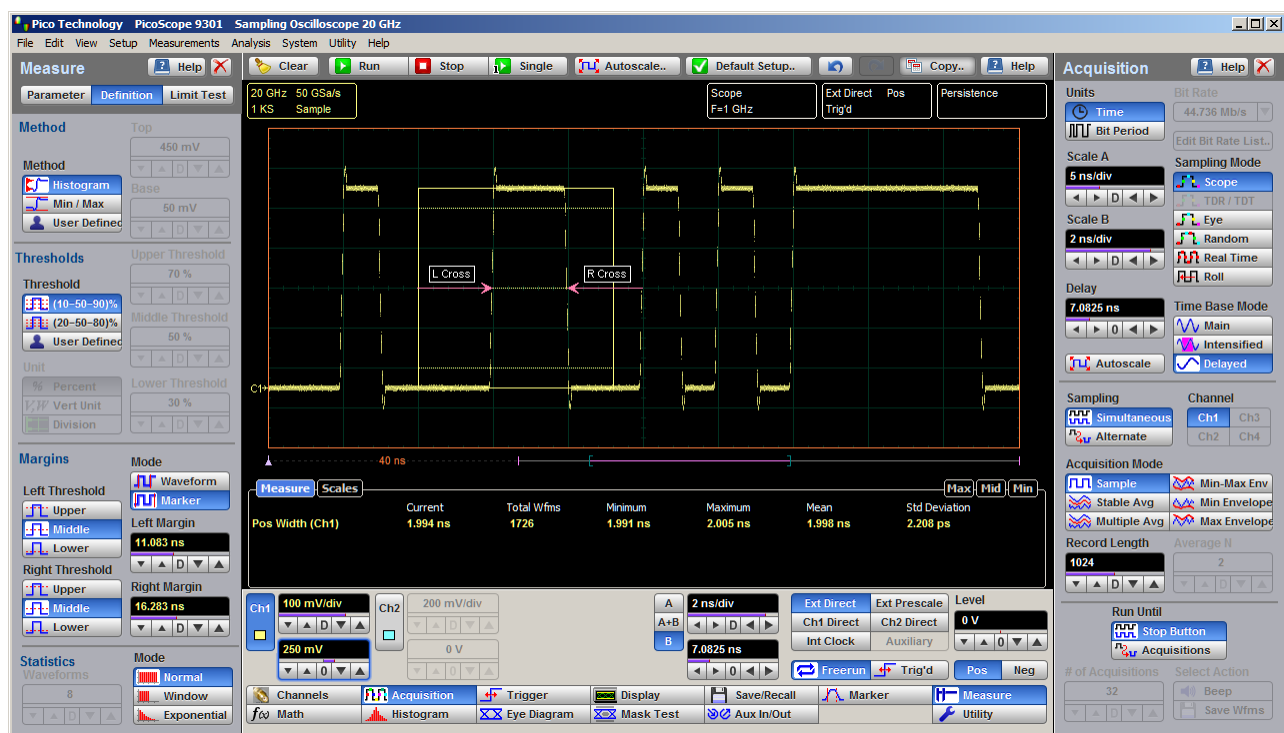
Correct position of both margins provides width measurement of second short pulse

7.10.7.3.1 Margin Mode
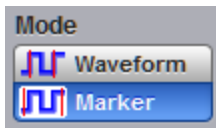
Two modes are used to set the margins:

- **Waveform.** Provides automatic setting of the left and right margins on any of the rising or falling edges of the selected waveform. The **Left Margin** and **Right Margin** variables provide positioning of both margins into any upper, middle or lower threshold with any rising or falling edge of the waveform.
- **Marker.** Provides manual setting of the left and right margins with the **Left Margin** and **Right Margin** variables.

7.10.7.3.2 Left Margin and Right Margin
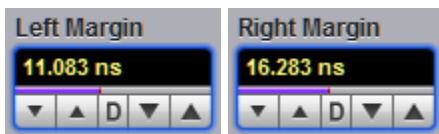
You can set the left and right margins with the **Left Margin** and **Right Margin** variables.

When **Waveform** is selected in the **Mode** menu, both variables automatically set the margins on any rising or falling edge of selected waveform. With the **Left Margin** and **Right Margin** markers you can move the left and right margins from the 1st rising (edge) up to the 256th falling (edge).

Both variables set the margins at any point of the display manually when **Marker** is selected in the **Mode** menu.

7.10.7.3.3 Left Threshold and Right Threshold

The **Left Threshold and Right Threshold** variables select crossing points on the edge of the selected waveform. Both variables can be used only when **Waveform** is selected in the **Mode** menu.

- **Upper.** A margin will be placed on the upper threshold.
- **Lower.** A margin will be placed on the lower threshold.
- **Middle.** A margin will be placed on the middle threshold.

You can change values of upper, lower, and middle thresholds from the **Thresholds** menu.

7.10.7.4 Statistics
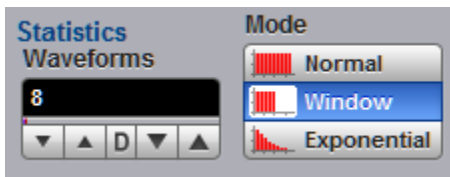
The **Statistics** menu includes modes and variables that determine the algorithm for a statistical measurement calculation. The **Statistics...** menu is active only when the **Statistics** mode of the **Display** menu is selected.

7.10.7.4.1 Statistics Mode
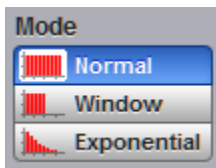
The Statistics **Mode** menu selects one of three modes that determine the algorithm for statistical measurement calculations.

- **Normal.** Each of the acquired waveforms has an equal influence on the result of the statistical measurement calculation. The **Waveforms** and **Weight** variables are not active in this mode.
- **Window.** Only a limited number of the recently acquired waveforms have an equal influence on the result of statistical measurement calculations. The **Waveforms** variable specifies the number of recently acquired waveforms used for statistical measurement calculations. Use the **Window** mode when measuring a waveform that is rapidly drifting.
- **Exponential.** Each of the acquired waveforms has a weighted influence on the result of statistical calculations on eye diagrams. Each subsequently acquired waveform has a greater influence than the preceding acquired waveforms. The **Weight** variable specifies the degree of this influence. Use the **Exponential** mode when measuring a waveform that is slowly drifting.

7.10.7.4.2 Waveforms

The **Waveforms** variable specifies the number of recently acquired waveforms used for statistical measurement calculations. The variable is active when **Window** is selected in the **Mode** menu. It can be varied from 8 to 8192 in multiples of two.

7.10.7.4.3 Weight
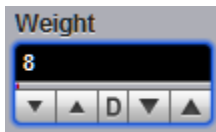
The **Weight** variable specifies the degree of influence of each recently acquired waveform against more remote waveforms. The variable is active when **Exponential** is selected in the **Mode** menu. **Weight** can be varied from 8 to 8192 in multiples of two.

7.11   O/E Converter menu
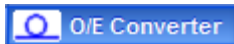
The PicoScope 9321 optical/electrical oscilloscope can be used in one of the following configurations:

- Two electrical channels and independent O/E Converter
- One electrical channel and one optical channel

The optical channel is calibrated at 850 nm, 1310 nm, and 1550 nm to provide accurate display of the received optical waveform in optical power units. In addition, the optical channel calibration can be used to provide an additional user-defined wavelength for consistent accuracy at any wavelength between 750 nm and 1650 nm using an optical source and a precision optical power meter.
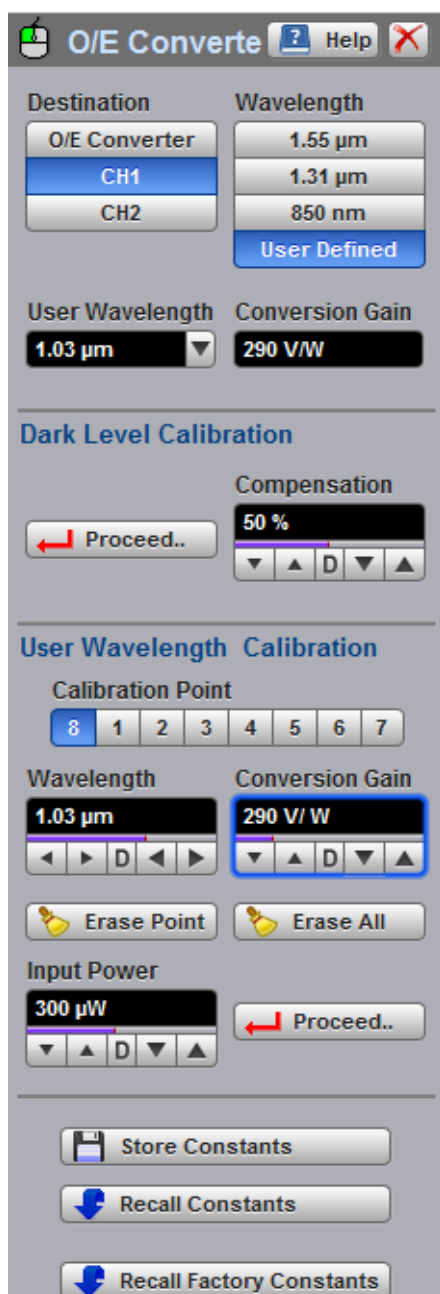
O/E Converter Menu

7.11.1   Destination
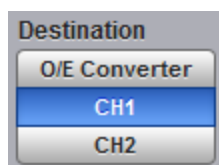
The **Destination** menu defines the optical configuration of the PicoScope 9321.

There are three types of configuration:

- **O/E Converter.** The O/E Converter works as an independent module having both input and output. The output of the converter can be used with a remote electrical instrument, for example with another oscilloscope. Two electrical channels of the PicoScope 9321 can be used at the same time.

● **Ch1.** The output of the O/E Converter should be connected to the input of the channel 1 by a 30 cm SMA(m) - SMA(m) coaxial cable. With this configuration channel 1 is an optical channel, while channel 2 is an electrical channel.
● **Ch2.** The output of the O/E Converter should be connected to the input of the channel 2 by a 30 cm SMA(m) - SMA(m) coaxial cable. With this configuration channel 2 is an optical channel, while channel 1 is an electrical channel.

To provide specified optical bandwidth, use the 30 cm precision SMA(m) - SMA(m) coaxial cable. See What do I get?

7.11.2   Wavelength
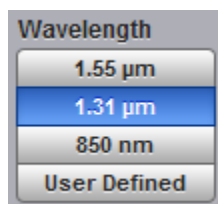
To select the optical wavelength, use the **Wavelength** menu.

Three options (**1.55 μm**, **1.31 μm** and **850 nm**) are concerned with calibrated wavelengths, while the fourth option (**User Defined**) is concerned with user-defined wavelength points. These points are defined from the **User Wavelength Calibration** menu.

When the wavelength is defined you can monitor the information about conversion gain from the **Conversion Gain** window.

When **User Defined** is selected, the **User Wavelength** drop-down list box becomes active, so you can select any from user-defined wavelength points. Selecting any of the user-defined wavelength points also opens the information about conversion gain from the **Conversion Gain** window.

Wavelength bands
Below are shown the wavelength bands and regions commonly used in the optical communications industry. The band and region ranges are listed for classification purposes, and do not necessarily imply specification of a given range.

Single-mode Systems
● **Region II:**   1260 nm to 1360 nm
● **Region IIe:**   1360 nm to 1480 nm
● **S-band:**   1530 nm to 1565 nm
● **L-band:**   1565 nm to 1625 nm
● **M-band:**   1565 nm to 1625 nm

Systems
● **Region Im:**   770 nm to 910 nm
● **Region IIm:**   1260 nm to 1380 nm

7.11.3   User Wavelength
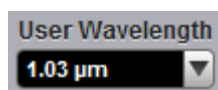
When you select **User Defined** from the **Wavelength** menu, the **User Wavelength** box becomes active, so you can select any user-defined wavelengths you have set. Selecting any of the user-defined wavelengths also opens the **Conversion Gain** window.

This option provides you with consistent accuracy at any wavelength between 750 nm and 1650 nm, using an optical source and a precision optical power meter. You can define a wavelength in the **User Wavelength Calibration** menu.

7.11.4 Conversion Gain
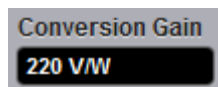
Conversion Gain is an informative window showing the conversion gain of the user-defined wavelength points selected from the **User Wavelength** drop-down list box. The value of conversion gain is defined from the **User Wavelength Calibration** menu.

7.11.5 Dark Level Calibration
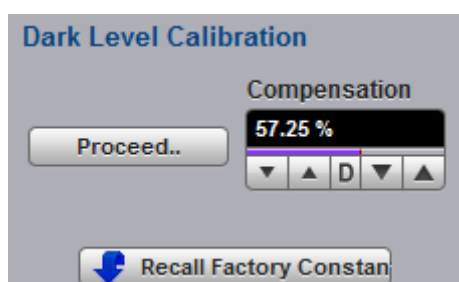
The **Dark Level Calibration** menu provides a dark-level calibration that maximize the accuracy of the extinction ratio and other optical automatic measurements you take.

7.11.5.1 Proceed
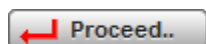
The **Proceed..** command button provides dark-level calibration.

7.11.5.2 Compensation
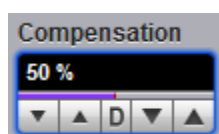
The **Compensation** control shows the result of dark-level calibration. It may also be used for manual control of dark level.

7.11.5.3 Recall Factory Constants
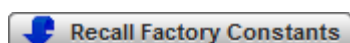
The **Recall Factory Constant** command button recalls the factory dark-level calibration value.

7.11.6   User Wavelength Calibration
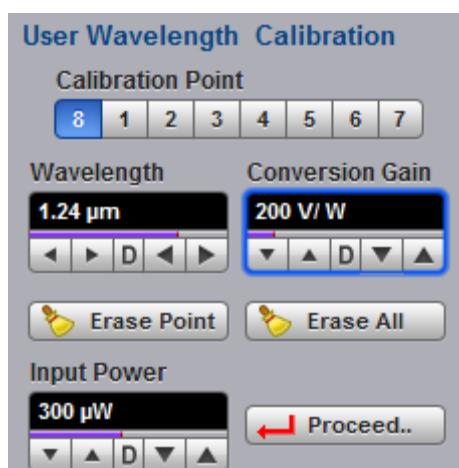
The **User Wavelength Calibration** menu allows optical channel calibration for user-defined wavelengths. You can set any wavelength between 750 nm and 1650 nm.

7.11.6.1 Calibration Point
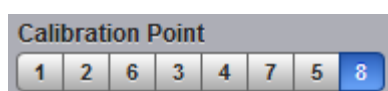
To create a new user-defined wavelength, click on empty number in the **Calibration Point** list.

To recalibrate the optical channel for the existing point click on selected number of calibration point, and then select a new value of wavelength and conversion gain.

7.11.6.2 Wavelength
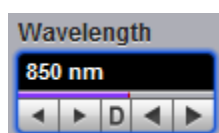
When an existing user-defined wavelength is selected from the **Calibration Point** list, the **Wavelength** control allows modification of the wavelength value.

When a new user-defined wavelength is selected from the **Calibration Point** list, the **Wavelength** control shows **Undefined,** and then the user may enter a new value of wavelength.

7.11.6.3 Conversion Gain
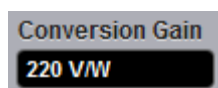
When an existing user-defined wavelength is selected from the **Calibration Point** list, the **Conversion Gain** control allows modification of the gain value.

When a new user-defined wavelength is selected from the **Calibration Point** list, the **User Wavelength** control shows **Undefined**. Then the user may enter a new value of wavelength and gain.

7.11.6.4 Input Power
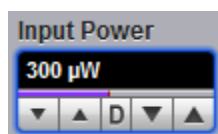
The **Input Power** control shows the calibration source power.

For user calibrations from 750 nm to 1000 nm wavelength, the calibration source power must be between 175 µW and 225 µW.

For user calibrations from 1000 nm to 1650 nm wavelength, the calibration source power must be between 375 µW and 425 µW.

7.11.6.5 Proceed
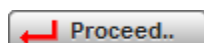
The **Proceed..** command button performs user-defined wavelength calibration.

7.11.6.6 Erase Point
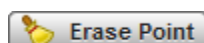
The **Erase Point** command button removes selected point from the **Calibration Point** list.

7.11.6.7 Erase All
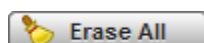
The **Erase All** command button removes all points from the **Calibration Point** list.

7.11.6.8 Store Constants
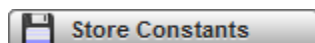
The **Store Constants** command button stores the dark-level calibration value and all user-defined wavelength calibration constants.

7.11.6.9 Recall Constants

Recall Constants

The **Recall Constants** command button recalls stored user-defined wavelength calibration constants.

7.12   Save/Recall menu

 Save/Recall

You can use any drive on the PicoScope 9300's PC for the following save/recall tasks:

- To save or recall your acquired waveforms to or from the **M1 – M4** waveform memories
- To save your acquired waveforms to a drive
- To load your saved waveforms from a drive to the **M1 – M4** display memories
- To save current front-panel setups for later recall
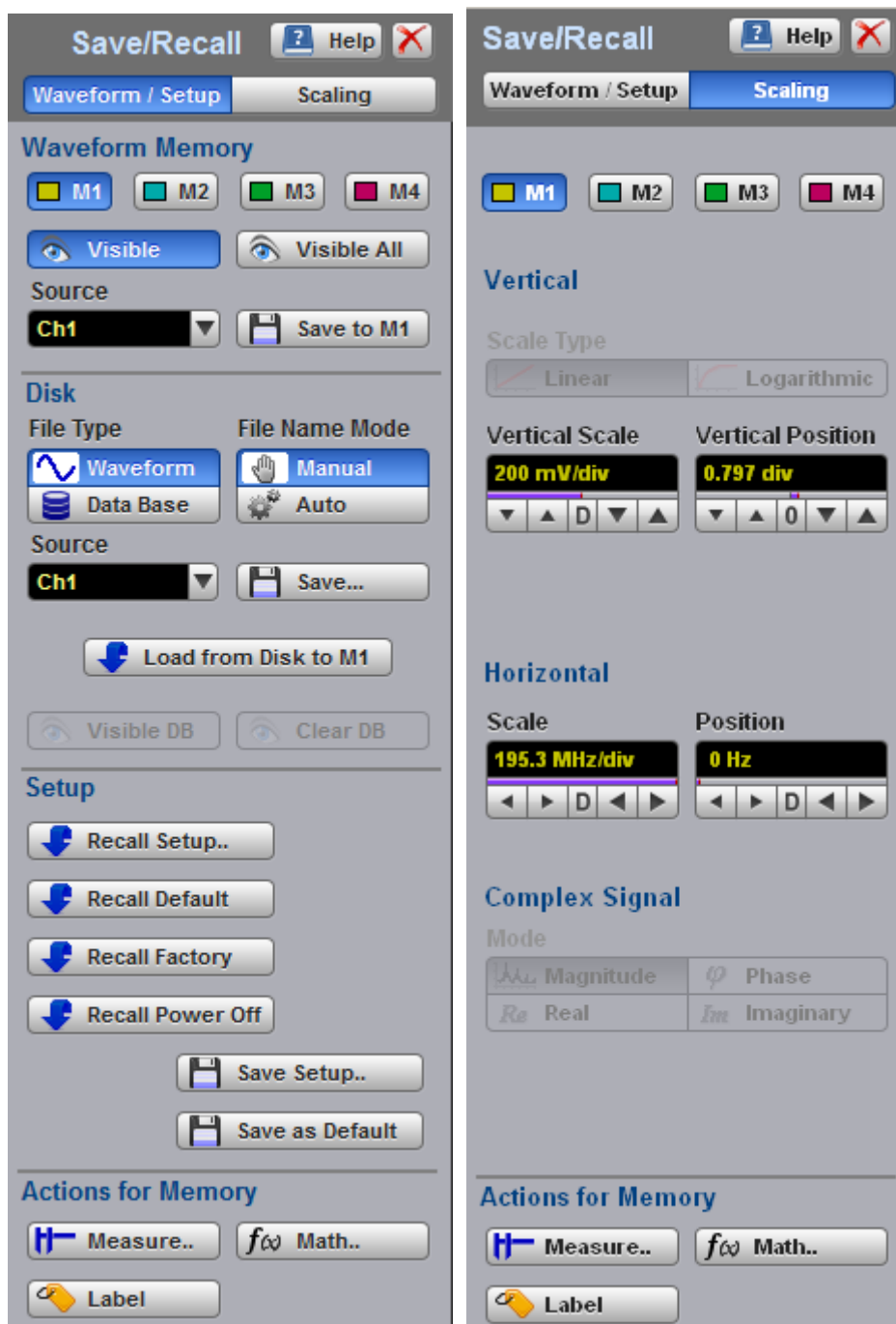
The Save/Recall menu

7.12.1   Waveform Memory
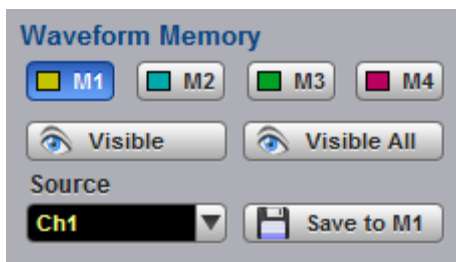
The instrument allows you to save your acquired waveforms to any of the instrument's internal drives. You can recall these waveforms at a later time and display them on the instrument's display screen. The **Waveform Memory** menu allows you to save or recall a waveform into one of the waveform memories (**M1 – M4)**, intended for display.

7.12.1.1 Memory Select
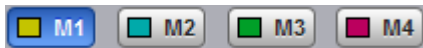
The **Waveform Memory** allows you to save or recall a waveform into one of the waveform memories (**M1 – M4)**, intended for display.

When you recall a waveform from memory, it is displayed in the default color for that memory number. However, you can change the default color in the **Display/Color** menu. The default colors are:

- **M1**: red
- **M2**: yellow-gray
- **M3**: violet.
- **M4**: gray

The waveform memories are non-volatile so the data is not lost if you turn off the power, or set the instrument to the default settings. The **M1 – M4** memories contain a single waveform record, including the horizontal and vertical scaling parameters. Therefore you can make parametric measurements on stored waveforms or use them as operands in a function. You can also recall the waveform for future comparison or analysis, save it to disk, or load it from a disk.
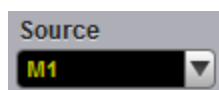
7.12.1.2 Visible
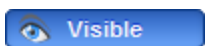
Clicking the **Visible** button turns the display for selected waveform memory on or off.
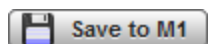
7.12.1.3 Visible All
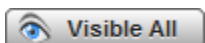
Clicking the **Visible All** button turns on the display of all four waveform memories.

7.12.1.4 Source

The **Source** menu allows you to choose the source of the waveform memory you intend to save into one of the waveform memories (**M1 – M4**). You can choose between channels, functions, spectra, and memories as the waveform sources.

7.12.1.5 Save to Memory

Clicking the **Save to Memory** button copies the selected waveform to one of the selected waveform memories (**M1 – M4**). When a waveform is saved to a memory, it overwrites any data that was previously stored in that memory. If the **Waveform Memory** menu for that memory is on, then the display is also updated.

Save to Memory saves only the current acquired data from the signal. Therefore, the recalled waveform will be displayed as a single trace. This method of saving the waveform is not the preferred process if you want to save a waveform that is using the measurement database (for example, saving a persistence or color-graded trace, or an eye diagram), and you want to recall the entire waveform.

> ℹ️   Make sure the waveform to be saved exists; that is, your source must be a channel, an active math waveform, or an active waveform memory. Display the waveform in the timebase with which you want to save it.

7.12.2 Disk
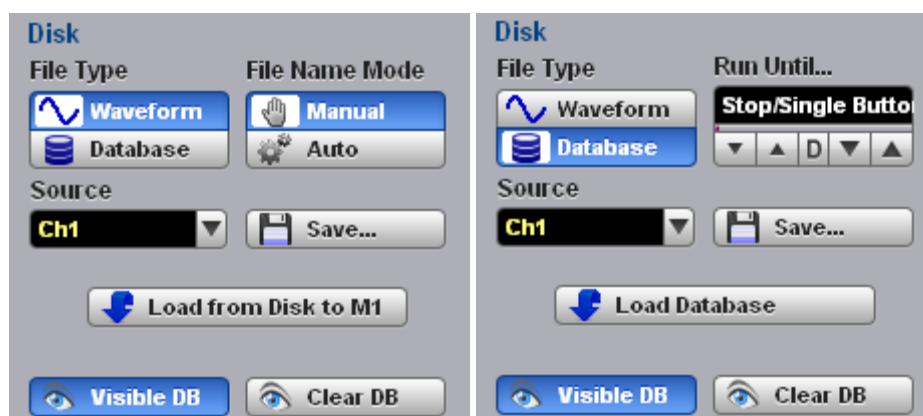
The **Disk** menu allows you to save your acquired waveform or database as an arbitrary file to disk. You can load these waveforms at a later time into the waveform memory (**M1 – M4**), and display them on the screen. Databases (**DB**) also can be loaded and displayed, but not via the waveform memory (**M1 – M4**).

Save/recall capability is helpful when you want to:

🔵 Recall a waveform for further evaluation or comparison with other waveforms.

● Extend the waveform-carrying capacity of the oscilloscope. It supports up to four channels, four waveform memories, and four math functions (including four spectra).

7.12.2.1 File Type
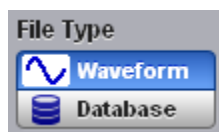
The **File Type** control selects how waveforms are stored to disk. Two options are available:

● **Waveform File**
● **Database File**

Waveform File

The **Waveform File** is used for storing the last record of the waveform data acquired by the instrument after the **Save** button was pressed. You can save acquired waveforms to a file, so that you can recall them at a later time and display them on the instrument's screen, and perform different measurements.

Database File

The **Database File** is used for storing the multiple-waveform database acquired by the instrument between clicking the **Save** button and later clicking any other control. The **Database File** is useful for saving database signals such as eye diagrams, and pulse waveforms for noise and jitter measurements with histograms. A histogram can also be saved with this mode. You can recall saved database files at a later time, display them on the instrument's screen with different display styles, and perform histogram measurements and mask tests.

> ℹ Remember that the PicoScope 9300 uses the file extension **.wfm** for waveform files, and the file extension **.wdb** for database files.

7.12.2.2 Source
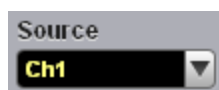
The **Source** control allows you to choose the source of the waveform you intend to save to disk. You can choose from channels, functions and memories.

7.12.2.3 File Name Mode

The **File Name Mode** control sets how the oscilloscope creates the name of the file. This control is enabled when the **File Type** control is set to **Waveform**:

The PicoScope 9300 uses two modes for generating file names:
- **Manual**
- **Auto**

Manual

The user enters the file name in the **Save Waveform As** dialog. This is also used as the base name when saving in **Auto** mode (see below).

Auto

In this mode, the PicoScope device assigns a file name consisting of a base name and a file number, separated by an underscore. The length of the file name is unlimited, while the file number must have five digits. For example, the instrument can assign the file name **abc_xxxxx.wdb** where **xxxxx** is a number from 00001 to 99999. Each time you save a waveform, the number in the file name is automatically incremented by one or by whatever is necessary to reach the next unused number. This ensures that the waveform will always be saved to a new file and protects you from inadvertently overwriting an existing file.

7.12.2.4 Run Until...
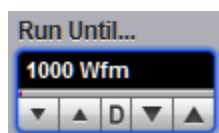
The **Run Until...** control is enabled when **File Type** is set to **Database**. It allows you to determine when the acquisition of the waveform database stops.

- **Stop Button.** When this is selected, press **Stop** ⬜ Stop to stop the acquisition of the waveform database.
- **# of Acquisitions.** When the selected number of acquisitions is met, the acquisition of the waveform database is stopped. You can select any number from 1 to 10 million.

7.12.2.5 Save
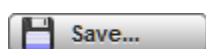
The **Save** button stores the selected waveform or waveform database to a disk.

Clicking the **Save** button does one of the following:

1. If *Waveform File* is selected in the File Type menu, while *Manual* is selected in the File Name menu.

Clicking the **Save** button opens the Windows **Load Waveform** dialog box, which allows you select the type of format you want to save the waveform as.

You can select one of three types of waveform format:

- Binary format with **.wfm** extension
- Verbose format with **.txt** extension
- Y values formats with **.txty** extensions

The **Waveform Files** dialog box also allows you to create subdirectories, rename waveform files, or overwrite existing waveform files.

The **Save** feature saves only the current acquired data from the signal. Therefore, the recalled waveform will be displayed as a single trace. This method of saving the waveform is not the preferred process if you want to save a waveform that is using the measurement database (for example, saving persistence or color-graded traces, or eye diagrams), and you want to recall the entire waveform.

> ℹ️ Remember to always copy important settings and waveforms to an external disk. If your original files are damaged or lost, you can restore the files from the backup disk.

Binary format

The binary format files (**.wfm** extension) stored using the internal format contain the vertical and horizontal scaling parameters of the original waveform. Therefore, when you recall a waveform into a waveform memory, you can still perform automatic measurements and use the markers. Because the internal format is binary, you cannot directly display its contents in a word processing or plotting program. However, you can convert the binary format file to a text file (**.txt**) for use in a spreadsheet or word processing program, by recalling a **.wfm** waveform and saving it in the text format.

Text format

The text format (**.txt**) is an ASCII text file format that uses alphanumeric characters to represent the voltage values of a waveform. This file format consists of a file header, which describes format (**.txt**) waveform horizontal and vertical scaling information and scope information. The header is followed by data, which consists of Y values separated by a carriage return and line feed. Text format files use 4 to 5 times more disk space than internal format files.

The text files are a convenient method for transferring waveforms to other software applications. You can import this file format into many spreadsheet or word processing programs.

Both

Both uses both internal and text formats. Two files are needed when you save waveform in both formats.

> ℹ️ Ensure your waveform files have the file name extension **.wfm** or **.txt**. If you specify a different extension, the instrument automatically corrects the extension.

> ℹ️ Make sure the waveform to be saved exists; that is, your source must be a channel, an active math waveform, or an active waveform memory. Display the waveform in the timebase with which you want to save it.

> ℹ️ Enter a useful comment in the file name about each waveform you save. Write the comment so that it explains the purpose of the saved file when that file is later accessed.

2. If *Waveform File* is selected in the [File Type](#) menu, while *Auto* is selected in the [File Name](#) menu.

Clicking the **Save** button stores your acquired waveforms, automatically incrementing a new number in a previous file name with its selected format(s).

3. If *Database File* is selected in the [File Type](#) menu.

Clicking the **Save** button opens the Windows **Load Waveform** dialog box, which allows you to select a file name. Only the **.cgs** file extension can be used in this case.

7.12.2.6 Load from Disk to Memory

[🔽 Load from Disk to M1]

The **Load from Disk to Memory** loads the selected file from a disk into one of the memories **M1 – M4**. Clicking the **Load from Disk to Memory** button opens the Windows **Load Waveform** dialog box and allows you to select which subdirectory, waveform, and file format you want to recall.

You can select one of three types of waveform formats:

- Binary format with **.wfm** extension
- Text format with **.txt** extension
- Both formats with **.wfm** and **.txt** extensions

7.12.3   Setup

Setup

- Recall Setup..
- Recall Default
- Recall Factory
- Recall Power Off
- Save Setup..
- Save as Default
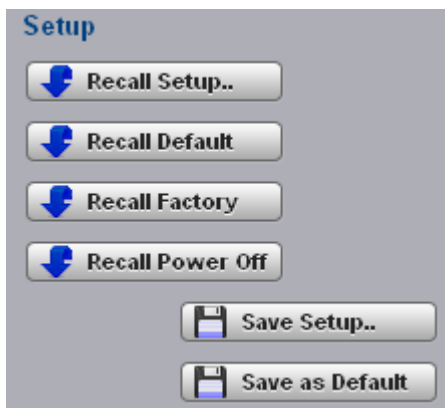
To save a current setup for later use, you can use any drive available to the PicoScope 9300's PC. When you save a setup, all of PicoScope 9300's settings, including measurements, markers, horizontal and vertical control settings, trigger configuration, color scheme, and math functions, are saved.

The **Setup** menu allows you to save and recall setups. You can use the setup memories when you want to:

- Save a series of setups to help automate a procedure. You can later recall a sequence of saved setups when you perform the procedure (for production test environments).
- Save and recall a setup that optimizes the instrument for displaying and analyzing certain signals.
- Compare waveforms by using more than one setup.
- Set the instrument to its default settings. These settings set the instrument to a known operating condition.
- Export a setup for sharing with a second instrument.

The number of setups you can save is limited only by the available space on the selected drive. Each setup uses approximately 30 kilobytes of disk space.

7.12.3.1 Recall Setup

![Recall Setup.. button]

You can recall a setup that you have previously saved on any drive of your PC.

The **Recall Setup..** button sets up the front panel by recalling a front-panel setup from a selected setup memory. Use the standard Windows **Setup Files** dialog box. The dialog box opens and allows you to select which subdirectory and setup you want to recall. Because recalling a setup will overwrite the instrument's existing configuration, you may want to save the existing setup first.
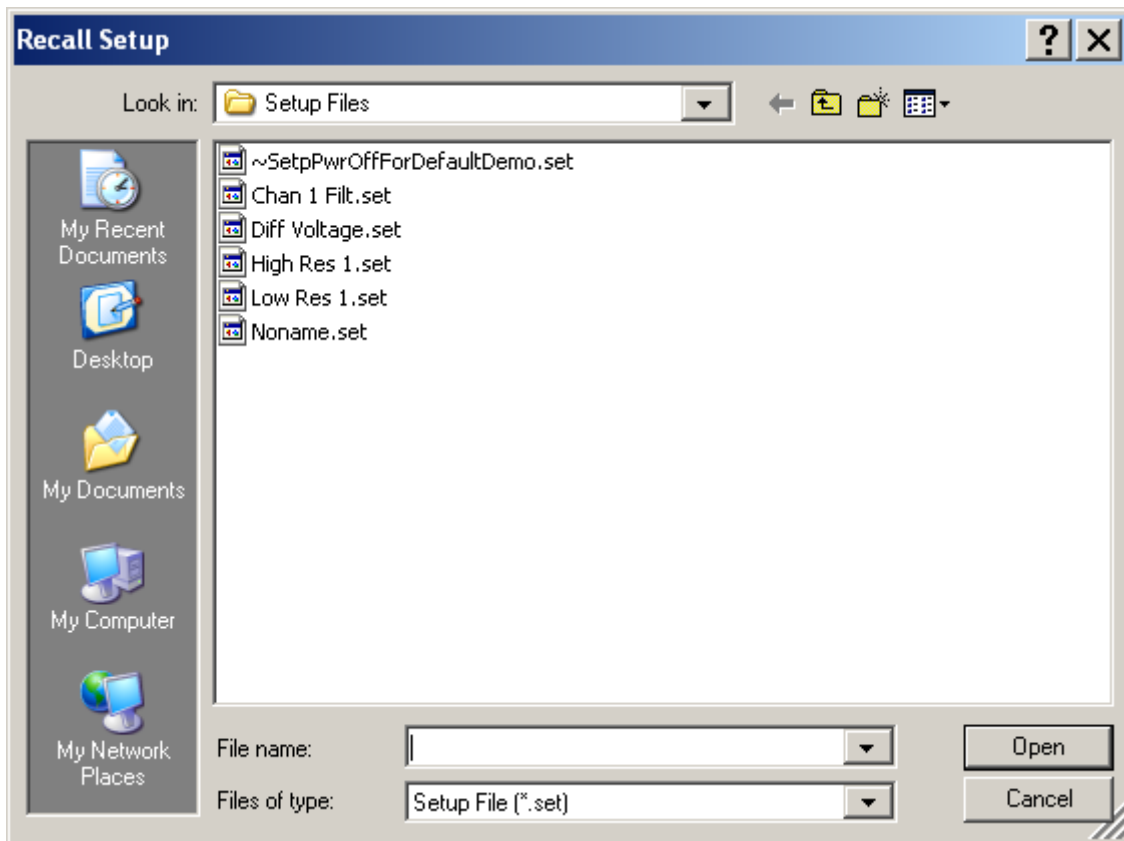
Windows Recall Setup dialog box

> ℹ️ Remember that the PicoScope 9300 uses the file extension **.set** for setup files.

Recalling a setup replaces the current setup with the recalled setup. If you do not want to lose your current setup, save it to its own setup file for later recall before you recall the new setup.

> ℹ️ Remember to always copy important settings and waveforms to an external drive. If your original files are damaged or lost, you can restore the files from the backup drive.

7.12.3.2 Initialization

Initialization allows you to return the instrument to one of its default settings. The default settings place the instrument in a known operating condition. This known operating condition is used as a starting point in the service procedures. You may find it helpful to use this known operating condition when someone else has used the scope before you, or as a starting point when setting up the instrument to view signals.

Three initialization settings are:
- **Default**
- **Factory**
- **Last Power Off**

7.12.3.2.1 Recall Default

Recall Default

The **Recall Default** button returns the instrument to its default settings. This places the oscilloscope in a known operating condition. You may find it helpful to use this known operating condition when someone else has used the oscilloscope before you. If you

accidentally press **Recall Default**, use **Undo** to return the oscilloscope to the operating condition it was in before **Recall Default** was pressed.

7.12.3.2.2 Recall Factory

Recall Factory

Clicking the **Recall Factory** button returns the instrument to the manufacturer's default setting. This places the oscilloscope in a known operating condition. You may find it helpful to use the default factory settings when initially setting up the instrument to view signals, or when someone else has used the scope before you. You may also use the default settings to troubleshoot unexpected instrument behavior.

Default Factory Setup
- **Channels**

Fit Acquisition To...	Multi-valued signal
Select	Ch1
Visible	On (for all channels)
Scale	200 mV/div (for all channels)
Offset	0 V (for all channels)
Position	0 div
Bandwidth	Full (for all channels)
Deskew	0 s (for all channels, disable)
Sampler Delay	0 s (for four-channel model only)
External Scale Mode	Off (for all channels)

- **Acquisition**

Units	Time
Scale A	10 ns/div
Sampling Mode	Scope
Timebase Mode	Main
Sampling	Simultaneous
Acquisition Mode	Sample
Record Length	1024 points (for any channel)

● **Trigger - Edge Trigger**

Source	Ext Direct
Level	0 V
Slope	Positive
Hysteresis	Normal
Mode	Freerun
Holdoff	10 µs
Holfoff By	Time
External Scale	Off

● **Display - Style/Screen**

Style	Var Persistence
Trace Mode	All Locked
Persistence Time	2 s
Format	Single YT
Graticule	Full

● **Display - View/Color**

Side Menu	Left
Default Colors	Default colors legend

● **Save/Recall - Waveform/Setup**

Waveform Memory	M1
File Type	Waveform
File Name Mode	Manual

● **Marker**

Type	Off

● **Measure**

Display	Off

● **Math - Function**

Select	F1
Category	Arithmetic
Operator	Add
Operand 1	Ch1
Operand 2	Ch2

● **Histogram**

Axis	Off
Source	Ch1

● **Eye Diagram**

Measure	Off
Source	Ch1

● **Mask Test**

Create Mask	Std Mask

7.12.3.2.3 Recall Power Off

 Recall Power Off

Clicking the **Recall Power Off** button returns the instrument to the last setting before the power supply was last switched off.

7.12.3.3 Save Setup..

 Save Setup..

The **Save Setup..** button stores the present front-panel setup to a selected setup memory. To save a current setup for later use, you can use any available drive. Use the standard Windows **Setup Files** dialog box. You can create subdirectories or new setup files, or overwrite existing setup files from this dialog box. The PicoScope 9300 uses the file extension **.set** for setup files.

> **ℹ** Enter a useful comment about each setup you save. Write the comment so that it explains the purpose of the saved file when that file is later accessed.

When you save a setup, all settings, including measurements, markers, horizontal and vertical control settings, trigger configuration, color scheme, and math functions, are saved to the disk file you have selected. The number of setups you can save is limited only by the available space on the drive. Each setup uses approximately 30 kilobytes of disk space.

> **ℹ** Ensure your setup files have the extension **.set**. If you do not specify an extension, the oscilloscope supplies one automatically. If you use a different extension, the instrument may not recognize the file as a setup file, and therefore you may have trouble saving or finding the setup file.

To recall a setup you have previously saved, use the **Recall Setup** button in the same menu.

Try to use the **Save Setup** button to save important setups!

> **ℹ** Remember always to copy important settings and waveforms to an external disk. If your original files are damaged or lost, you can restore the files from the backup disk.

7.12.3.4 Save as Default

 Save as Default

Clicking the **Save as Default** button stores the present front-panel setup as the default setup.

You can recall the saved default setup by clicking the **Default Setup** button in the **System Controls** area.

7.13   System Controls

Using the **System Controls**, you control whether the oscilloscope is running or stopped; other buttons allow you to reset the oscilloscope to its default setup, automatically configure the oscilloscope for the current signals (**Autoscale**), or erase the waveforms from the display.

The **System Controls** buttons are:

- **Clear**
- **Run**
- **Stop**
- **Single**
- **Autoscale**
- **Default Setup**
- **Undo**
- **Redo**
- **Copy**
- **Help**

7.13.1   Clear

Clicking the **Clear** button erases all channel waveform data from the graticule area. The following occurs when the display graticule is cleared:

- All channel waveform data is erased from the graticule area.
- Functions, spectra and waveform memories are not erased from the display graticule when the clear display feature is executed.
- All associated measurements and measurement statistics are reset (averaging, color-grading, mask test data, limit test data, and histogram results), if enabled.

When the instrument is running

If the instrument is running and receiving triggers, new waveform data is displayed on the next acquisition, averaging is reset; and persistence and color-grading, histograms, the mask testing database and all measurements are recalculated.

When the instrument is stopped

If the instrument is stopped, the display remains cleared of waveform data until the trigger circuit is rearmed and the instrument is triggered. Then the new data is displayed and measurements are recalculated.

7.13.2   Run, Stop and Single

The **Run** button causes the instrument to resume acquiring data. If the instrument is stopped, it starts acquiring data on the next trigger event. If the instrument is already in the run mode, it continues to acquire data on successive trigger events.

If pressing the **Run** button does not cause waveform data to display on the screen, try the following:

- Make sure a signal is connected to one of the channel and the display for that channel is turned on.
- Make sure the offset does not have the trace clipped off the display.
- Check the trigger setup conditions to make sure the trigger conditions are valid for the signal.
- Set the trigger mode to **Freerun**. **Freerun** forces the instrument to trigger, which may allow you to see enough of the signal so that you can set up the front panel properly.
- Click the **Autoscale** button.

The **Stop** button causes the oscilloscope to stop acquiring data. You can stop acquisition if you want to freeze the displayed waveform(s) for closer analysis or measurement.

The **Single** button causes the oscilloscope to perform a single waveform acquisition. Each subsequent press of the **Single** button rearms the trigger circuit. A complete acquisition cycle is performed, and any measurements are recalculated.

If all of the channels are turned off or if a trigger event is not found, the instrument will not acquire any data.

7.13.3   Autoscale

Adjusting an oscilloscope to display a stable trace of usable size and amplitude can be a time-consuming process. The **Autoscale** feature of the PicoScope 9300 can quickly give you a stable, meaningful trace display.

The **Autoscale** button causes the instrument to quickly analyze any waveforms connected to the trigger and channel inputs. Then, it sets up the vertical, horizontal, and trigger controls to best display that signal.

When you click the **Autoscale** button, you tell the PicoScope 9300 to examine the signal and adjust the following controls for optimum display:

- Vertical scale and offset
- Timebase scale and delay
- Trigger level, if appropriate to that trigger source

The PicoScope 9300 must have an available trigger source and input. For example, if you are using the **Direct Trigger Input**, and **Ext Direct** is selected in the **Trigger/Source** menu, the trigger signal must be connected to this trigger input. **Autoscale** can then set the trigger level. If you are using the **Prescale Trigger Input**, and the **Ext Prescaler** is selected in the **Trigger/Source** menu, the trigger signal must be connected to this trigger input.

When **Ext Direct** is selected in the **Trigger/Source** menu, the **Autoscale** function can find repetitive signals with:

- Frequency greater than 1 kHz
- Duty cycle greater than 1%
- Vertical amplitude greater than 50 mV p-p
- Trigger amplitude as specified

When **Ext Prescaler** is selected in the **Trigger/Source** menu, the **Autoscale** function can find repetitive signals having trigger frequency and amplitude as they are specified.

When the **Ch1 Direct** or **Ch2 Direct** is selected in the **Trigger/Source** menu, the **Autoscale** function can find repetitive signals with:

- Frequency greater than 1 kHz
- Duty cycle greater than 1%
- Vertical amplitude greater than 50 mV p-p
- Trigger amplitude as specified

Autoscale is operative only for relatively stable input signals. **Autoscale** looks for signals on both channels, even if they are turned off. It also searches for a trigger signal on the trigger inputs.

If the **Autoscale** button is pressed unintentionally, use the **Undo** button to return the instrument to the settings that existed before.

When the **Autoscale** is selected, the following controls are set:

- **Timebase Mode**: **Delayed** (**B**)
- **SCALE B:** to best display the waveform
- **Trigger**. If **Ext/Ch1/Ch2 Direct** is selected: **Freerun Mode, Positive Slope, Trigger LEVEL** to 50% amplitude point of the trigger waveform, **Normal Hysteresis**, **HOLDOFF** with minimum value. If the **Ext Prescaler** is selected: to best display waveforms.
- Vertical **OFFSET:** to best display waveforms on active channels
- Vertical **SCALE:** to best display waveforms on active channels

Autoscale options

To perform autoscale, right-click the **Autoscale** button to get the four autoscale options. Select one of them, and then the scope will perform an optional **Autoscale**.

The four **Autoscale** options are:

- **Auto.** Optimizes the autoscale algorithm for such waveforms as sine waves or pulses. Can be used for all main menus excluding the following cases:
  - Either **NRZ** or **RZ** is selected in the **Eye Diagram/Measure** menu.
  - One of the standard masks for eye-diagram waveforms is selected in the **Mask Test** menu.
- **Single-valued.** Optimizes the autoscale algorithm for such waveforms as sine waves and pulses.
- **NRZ.** Optimizes the autoscale algorithm for such waveforms as **NRZ** eye-diagrams.
- **RZ.** Optimizes the autoscale algorithm for such waveforms as **RZ** eye-diagrams.

7.13.4   Default Setup

[✓ Default Setup..]

The **Default Setup** button returns the instrument to its default settings. This places the oscilloscope in a known operating condition. You may find it helpful to use this known operating condition when someone else has used the oscilloscope before you. If you accidentally press the **Default Setup** button, use the **Undo** button to return the oscilloscope to the operating condition it was in before **Default Setup** was pressed.

Right-click on the button to get four options:

- **Default Setup**   Returns the instrument to its default settings.
- **Factory Setup**   Returns the instrument to default setting of the manufacturer.
- **Power Off Setup** Returns the instrument to the last setting before switching off the power supply.
- **Save As Default** Stores the present front-panel setup as default setup.

7.13.5   Undo, Redo

Undo [↺] **and Redo** [↻]

You may find situations where you have unintentionally selected an unnecessary control. When this happens, you can use the **Undo** [↺] button to return the oscilloscope to the previous settings. The depth of undo can be up to 100 steps.

If you later decide you didn't want to undo an action, right-click the button and select **Redo** [↻].

7.13.6   Copy
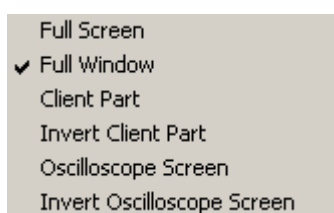
[🗐 Copy..]

Full Screen
✓ Full Window
Client Part
Invert Client Part
Oscilloscope Screen
Invert Oscilloscope Screen

Clicking the **Copy** button copies different programming windows to the **Windows Clipboard**. From there, you can paste copied information into such **Windows** programs as **Word, Corel Draw, Paint Brush, Photoshop** and so on.

Use the **Copy** function when preparing documentation based on usage of the PicoScope 9300.

Right-click the button to get six options:

- **Full Screen**
- **Full Window**
- **Client Part**
- **Invert Client Part**
- **Oscilloscope Screen**

● **Invert Oscilloscope Screen**

7.13.7   Help

[?] Help

The **Help** button has two functions:

● Click it to activate the context-sensitive built-in information system on the instrument. This changes the pointer into a context-sensitive help icon. You can then click any control to open the manual at the relevant page.
● Right-click it to open the **PicoScope 9300 Help** manual, or the **About...** and **Instrument Info** windows.

ps9300.en-13   386

7.14   TDR/TDT menu

Time Domain Reflectometry, or TDR, is a method of characterizing a transmission line or network by sending a step signal into one end and monitoring the electrical reflections.

A TDR step can also be used to make Time Domain Transmission (TDT) measurements. TDT is a technique that allows you to measure the response of a system by sending steps through a device and monitoring its output. The measurements are made on signals transmitted through the device rather than reflections from the device (as in TDR).

The **TDR/TDT** menu provides you with automatic and manual single-ended TDR and TDT measurement capability. Two models from the PicoScope 9300 series have TDR/TDT features: the PicoScope 9311 and the PicoScope 9312.

Both oscilloscopes have a 15 or 20 GHz acquisition system and differential step generators which differ in amplitude and rise time. The generators can be used as general purpose picosecond step generators for differential applications or as TDR/TDT steps.

The PicoScope 9311 includes step generators based on Step-Recovery Diodes (SRD), special microwave semiconductor diodes, having up to 6 V adjustable amplitude and less than 55 ps intrinsic 10%−90% rise time.

The PicoScope 9312 with two pulse heads is a step generator based on Tunnel Diodes (TD), very specialized diodes with a highly unusual I-V N-type characteristic, near 200 mV fixed amplitude and less than 35 ps intrinsic 10%−90% rise time.

7.14.1   PicoScope 9311 Stimulus

The **Stimulus** menu allows you to turn on or turn off both steps generators of the PicoScope 9311, and to control amplitude and timing parameters of the steps. The **Stimulus** menu includes controls for both **Positive** and **Negative** generators. Amplitude parameters are adjusted individually for each generator, while the timing parameters are common for both outputs.
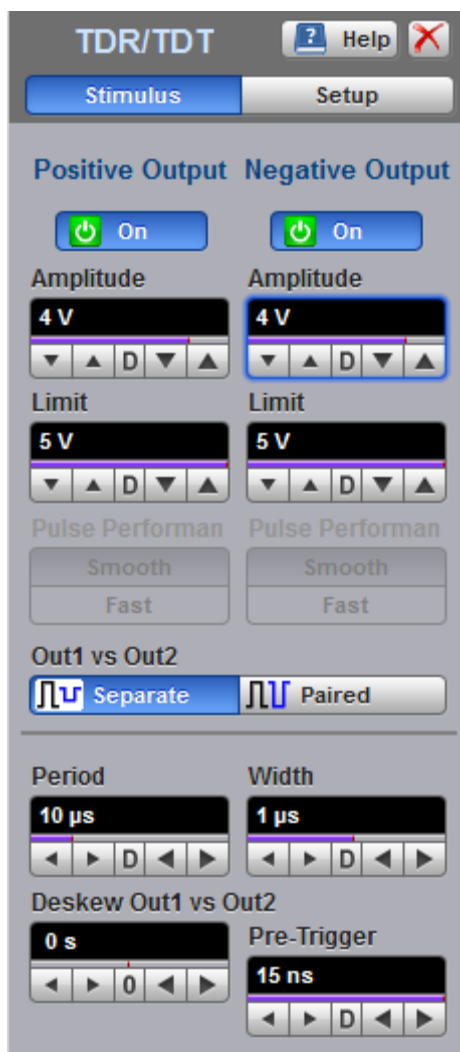
TDR/TDT Stimulus menu for PicoScope 9311 oscilloscope

⚠ **CAUTION**
Do not connect the output directly to the input of any oscilloscope channel. Overvoltage of the input circuits can be dangerous and destroy the channel.

The PicoScope 9311 is supplied with two 20 dB attenuators fitted on the outputs of step generators. With these attenuators the maximum output amplitude cannot exceed 600 mV.

NOTE
The PicoScope 9311-15 (15 GHz model) has only a positive output. When this oscilloscope is connected, the negative output controls will be grayed out.
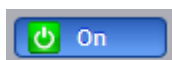
You can switch any of the selected outputs on or off. When the generator is switched on the following warning message appears.
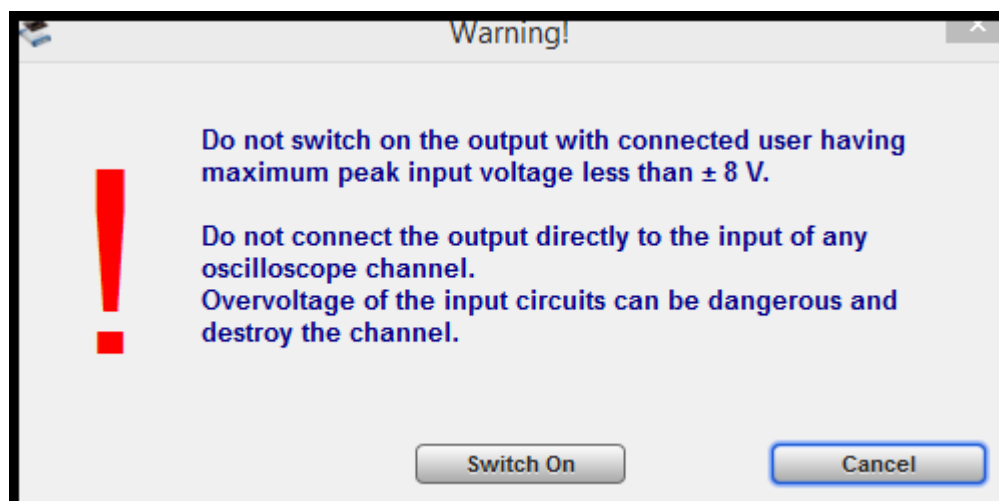
Click the **Switch On** if you agree with connection diagram and amplitude limit. Click the **Cancel** if you disagree with these conditions.

onfirm your acceptance one more time. After that you have access to the **Limit** control at its minimum value of 2.5 V.

To protect the device under test, amplitude limits can be set for both **Positive Output** and **Negative Output**. Output amplitude can be limited to a user defined value from 2.5 V to 6 V to protect the device under test, adjustable in a 100 mV coarse increment or 20 mV fine increment.

When you want to increase the limit value the following warning message appears:
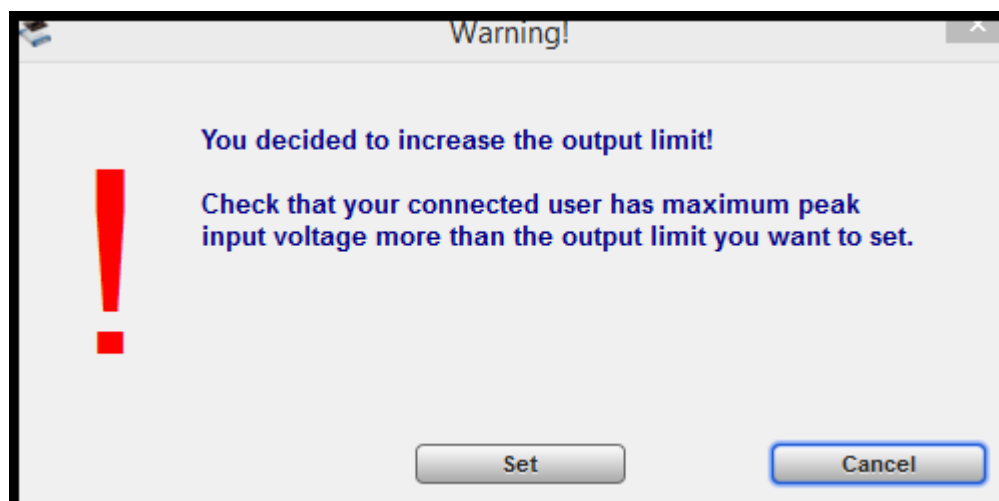
Click the **Set** if you agree with changed amplitude limit. Click the **Cancel** if you disagree with the new condition.

onfirm your acceptance once more when you change the amplitude limit:
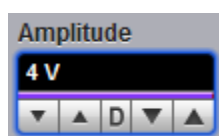
Amplitude is the low-to-high magnitude of the pulse. The **Amplitude** setting changes from 2.5 V to 6 V. Adjustable in a 100 mV coarse increment or in 5 mV fine increment. Changing the amplitude will change the high level only. Low level is always at 0 V. Offset is not affected.

- **Separate**: **Positive Output** and **Negative Output** operate as entirely separate outputs. Their amplitude and limit variables can be controlled separately.
- Paired: **Positive Output** and **Negative Output** paired operate. Their amplitude and limit variables are controlled simultaneously.
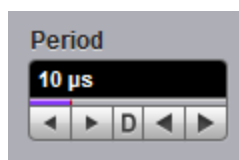
Period
10 µs

Pulse cycle time can be set as period. Period value can be set simultaneously for both outputs from 1 µs to 60 ms, adjustable in 1-2-5-10 and 60 ms coarse increments. It is also adjustable in fine increments of 25 ns or 5 digits, whichever is greater.

Width
1 µs

The absolute pulse width measured from the start of the leading edge to the start of the trailing edge. In this format, the pulse width is independent of changes in pulse period and delay. Pulse width is defined at the 50% amplitude level of the pulse.

Pulse width value can be set simultaneously for both outputs from 200 ns to 4 µs. Adjustable in 200 ns - 500 ns - 1 µs - 2 µs - 4 µs coarse increments or 25 ns fine increments.

There is a 50% duty cycle limitation for both **Positive** and **Negative Outputs**.
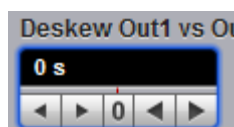
Deskew Out1 vs Ou
0 s

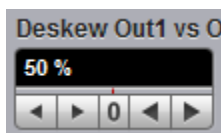Set the deskew between **Positive Output** and **Negative Output** to compensate for different cable delays. Set the deskew outputs in typical range of –1.00 ns to 1.00 ns. Adjustable in a 20 ps coarse increment or in 1 ps fine increment.
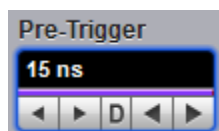
Pre-Trigger
15 ns

The output pre-trigger signal on the **TRIGGER OUTPUT** connector marks the start of the pulse period. This positive pulse has fixed near 700 mV amplitude, 25 ns to 35 ns lead-time range adjustable in 100 ps coarse increments or 5 ps fine increments.

Use this signal to pre-trigger your sampling oscilloscope.

7.14.2   PicoScope 9312 Stimulus

The **Stimulus** menu allows you to turn on or turn off both steps generators of the PicoScope 9312, and to control TD current and timing parameters of the steps. The **Stimulus** menu includes controls for both **Positive** and **Negative TD Pulse Heads**. All timing parameters are common for both outputs.
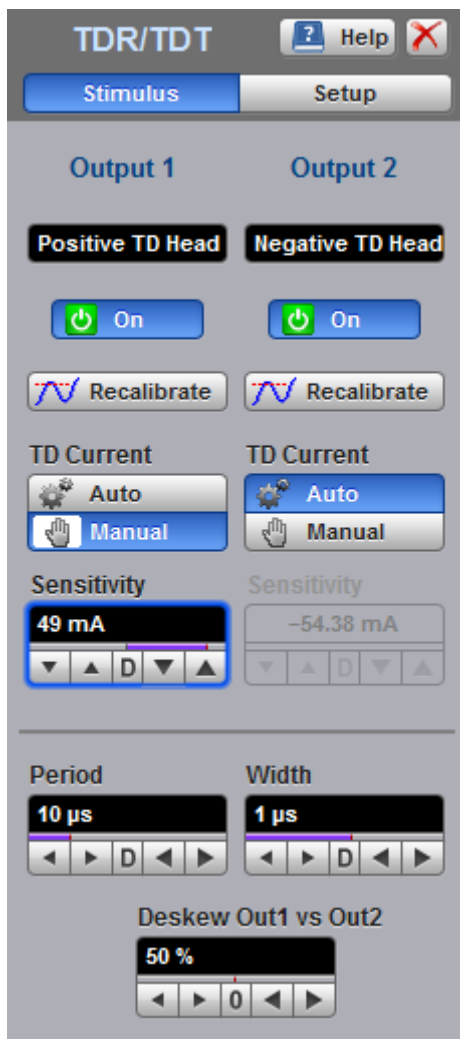
**TDR/TDT Stimulus menu for
PicoScope 9312 oscilloscope**

Connect the **Drive Input** of **TD Pulse Head** to the **Drive 1(2)** output of the PicoScope 9312 using the 60 cm SMA cable. If necessary use both TD Pulse Heads. The **Driver 1** and the **Driver 2** SMA connectors on the front panel of the PicoScope 9312 are used to power and control tunnel diodes located in the pulse heads.

A pulse generator based on TD technology may offer the following configurations:

● Single-channel pulse generator with TD Pulse Head having any polarity.
● Dual-channel pulse generator with two TD Pulse Heads having opposite polarity.
● Dual-channel pulse generator with two TD Pulse Heads having the same polarity. In this case you should request an additional TD Pulse Head.
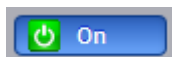
You can switch on and off any of the drive outputs with a TD Pulse Head connected.

Each drive output can sense the polarity of the connected TD Pulse Head. The drive output provides a positive current and positive drive output for a positive TD head, or a negative current and negative drive output for a negative TD head. Thus it is possible to connect a positive or negative TD head to any **Drive** output. The detected polarity of the TD Pulse Head appears in the menu area as [Positive TD Head] or [Negative TD Head].
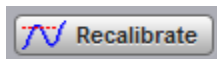
Click **Recalibrate** to find an optimal trigger point on the I-V characteristic of the tunnel diode. Use this control in case of temperature change or termination change.
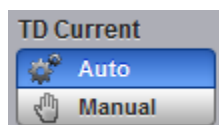
The **TD Current** controls how the instrument defines peak current of TD for selected TD Pulse Head.

- **Auto** -the instrument defines peak current automatically.
- **Manual** -the instrument controls peak current manually with the **Sensitivity** control. Use this mode for very precise tuning of TD when you need minimal jitter.
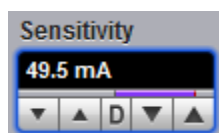
Sensitivity controls the peak current of TD manually when the **Manual** is selected from the **TD Current**.
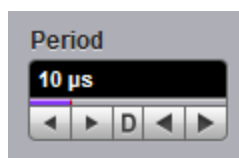
Period sets the pulse cycle time. The value can be set simultaneously for both outputs from 1 μs to 60 ms. Adjustable in 1-2-5-10 and 60 ms coarse increment. Also adjustable in fine increments of 25 ns or 5 digits, whichever is greater.
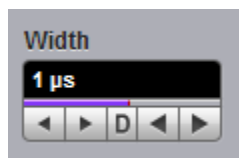
Width is the absolute pulse width measured from the start of the leading edge to the start of the trailing edge. In this format, the pulse width is independent of changes in pulse period and delay. Pulse width is defined at the 50% amplitude level of the pulse.

Pulse width value can be set simultaneously for both outputs from 200 ns to 4 μs. Adjustable in 200 ns - 500 ns - 1 μs - 2 μs - 4 μs coarse increments or 25 ns fine increments.

There is a 50% duty cycle limitation for both Positive and Negative TD Pulse Heads.

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Set the deskew between **Positive Output** and **Negative Output** to compensate for different cable delays. Set the deskew outputs in typical range of −500 ps to 500 ps. Adjustable in 20 ps coarse increments or 1 ps fine increments.

7.14.3   PicoScope 9311/9312 Setup

The **Setup** menu allows you to make TDR or TDT measurements for any configuration (single-ended, differential or common). You can select any channel and any stimulus to configure your TDR system. Depending on the test, the vertical scale can be defined in volts, gain, rho or ohm, while horizontal scale can be specified in time or distance with different dielectric properties of the transmission line.

The instrument provides a fast gain calibration and correction procedure, which easily allows you to change the rise time of the corrected step for TDR or for TDT on each of the channels.
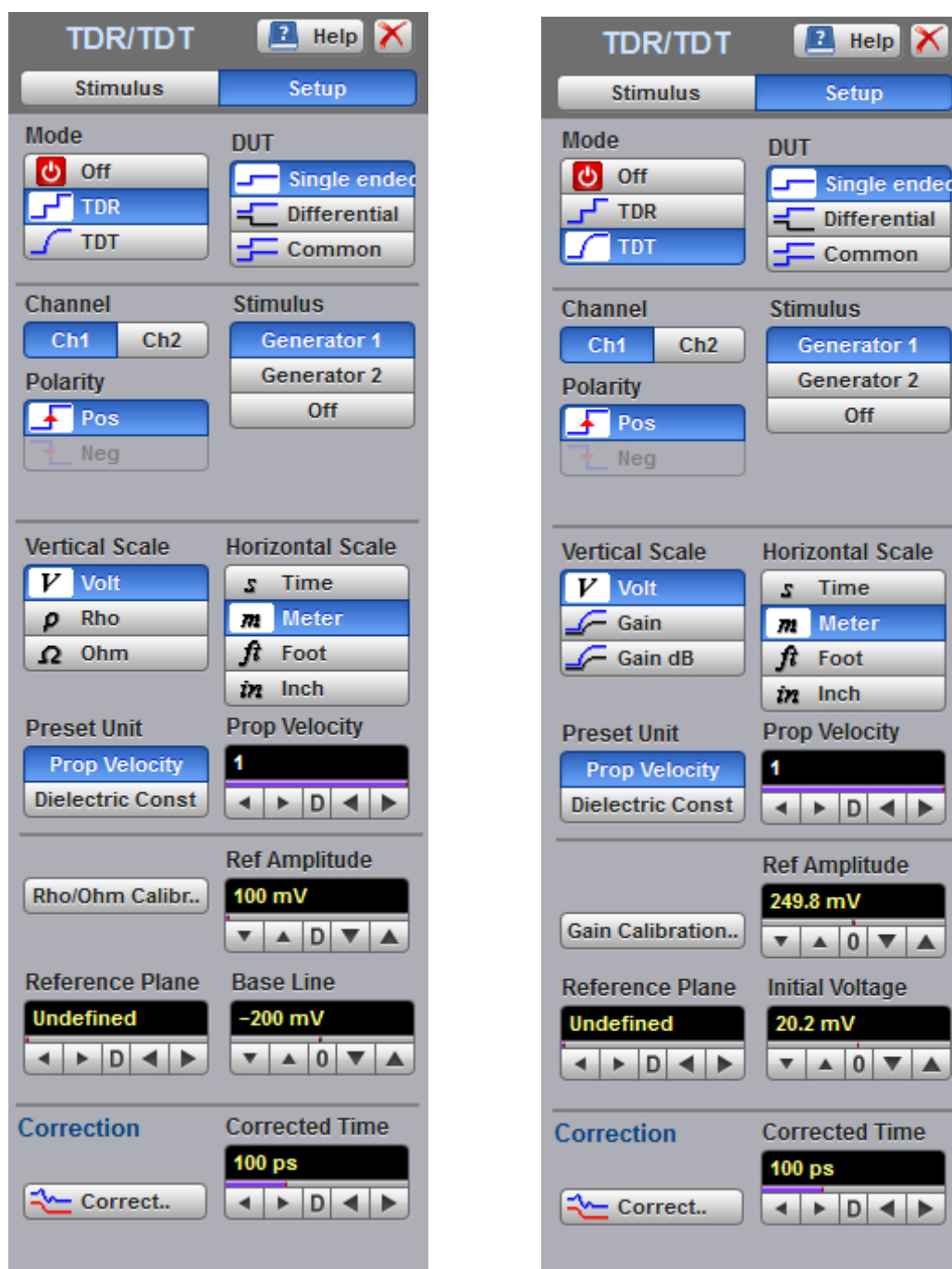
TDR/TDT Setup menu for PicoScope 9311/9312 oscilloscopes in TDR mode (left) and TDT mode (right)
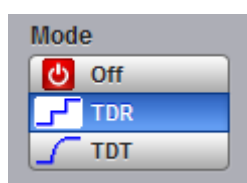
The **Mode** menu lets you control the TDR/TDT functions of the PicoScope 9311/9312. The selector turns the features to **Off**, or enables **TDR** or **TDT**. When you switch the instrument to **TDR** or **TDT** mode the acquisition system automatically switches into **Single-valued signal** acquisition with stable averaging and averaging.
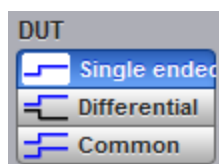
The DUT allows you to select between single-ended, differential or common TDR/TDT modes.

- **Single-ended.** One or two TDR steps are used for one or two channels. This mode is used to make two independent single-ended TDR/TDT measurements.
- **Differential.** One channel is asserting a positive going step and the other channel is asserting effectively a negative going TDR step. This mode is used to make differential TDR measurements.
- **Common.** Notice that both channels assert a positive or negative TDR step for common-mode TDR. This mode needs to have additional **TD Pulse Head** (positive or negative).
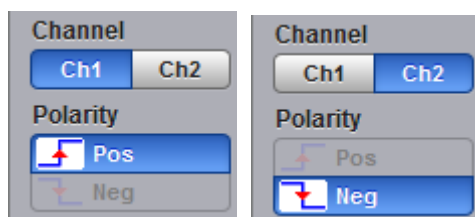
The **Channel** menu assigns the function keys to the selected channel. You can assign the **Vertical Scale**, **Ref Amplitude** and **Base Line** (**TDR** mode) or **Initial Voltage** (**TDT** mode) for selected channel.

The **Polarity** shows polarity of **TD Pulse Head** that is connected to the **Drive 1** or **Drive 2**

output. It duplicates the information from the **Stimulus** menu (Positive TD Head or

Negative TD Head).
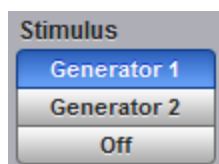
The **Stimulus** menu selects which **TD Pulse Head** will be used as a TDR/TDT step with selected channel.

The three choices are:

- **Generator 1. TD Pulse Head** connected to the **Drive 1** output is used as a **TDR/TDT** step with selected channel.
- **Generator 2. TD Pulse Head** connected to the **Drive 2** output is used as a **TDR/TDT** step with selected channel.
- **Off. TD Pulse Head** is not in use.
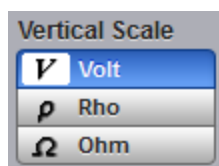
 (**TDR** mode)

The **Vertical Scale** menu selects the vertical units of measure commonly used in TDR/TDT. The menu applies to the selected channel.

Three types of vertical scale can be used in TDR mode:

- **Volt.** The vertical axis is displayed in volts.

In addition to voltage, TDR can use special scalings. The vertical axis units most appropriate to TDR measurements are either reflection coefficient (rho) or impedance (ohm).

- **Rho.** The vertical axis is displayed in reflection coefficient (rho).
- **Ohm.** The vertical axis is displayed in ohm.

Reflection Coefficient is defined as follows:

$$Rho = Er / Eo$$

where: *Er* is the measured reflected voltage

        Eo is the reflected voltage for the open reference plane.

For open circuit: *Er = Eo* and *rho = 1*.

For short circuit: *Er = −Eo* and *rho = −1*.

For 50 ohm circuit: *Er = 0* and *rho = 0* ohm.

Rho values can be converted to impedance values *Z* or back by using the following equations:

$$Z = Zo * (1 + rho) / (1 - rho),$$

$$rho = (Z - Zo) / Z + Zo$$

where: Z is the impedance of the DUT.

        Zo is the 50 ohm impedance of the transmission line.

For open circuit when *rho* = 1, *Z* = 8 .

For short circuit when *rho* = −1, *Z* = 0.

For a 50 ohm circuit, *rho* = 0 and *Z* = 50 ohm.

To use rho and ohm vertical scales, the oscilloscope should be calibrated.

 (**TDT** mode)
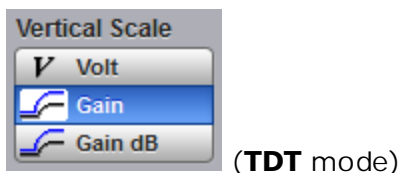
In addition to the voltage scale, **TDT** can also use **Gain** scaling.

- **Volt**
- **Gain**
- **Gain dB**

Gain is defined as follows:

$$GAIN = E / A$$

where: *E* is the measured voltage,

    A is the amplitude of the TDT step.

Horizontal Scale
s	Time
m	Meter
ft	Foot
in	Inch
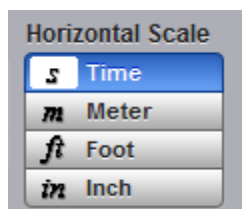
The **Horizontal Scale** menu selects one of the horizontal units of measure commonly used in TDR/TDT.

The selection between is time and distance scale:

- **Time**
- **Meter**
- **Foot**
- **Inch**

When **Meter**, **Foot** or **Inch** is selected you can use the **Preset Unit** menu, and also the Propagation Velocity/Dielectric Constant control to enter the parameters of your transmission line.

Preset Unit
- Prop Velocity
- Dielectric Const
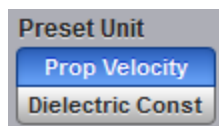
The oscilloscope allows you to specify the propagation delay, which is the fraction of the speed of light at which signals travel through your transmission line. If you know that the propagation velocity of your transmission line (cable) differs from the default, use the **Preset Unit** menu.

The two choices are:

- **Propagation Velocity**
- **Dielectric Constant**

Prop Velocity 0.8   **Diel Constant** 2.2

The **Prop**agation **Velocity** or **Diel**lectric **Constant** controls let you specify the fraction of the speed of light at which the signal passes through your transmission line or network. Both controls apply only to axis units of distance, and do not apply if your horizontal units are seconds.

Propagation velocity is relative to an air-line transmission cable, so a setting of 1.0 indicates that your transmission line or network passes signals at the same speed as an air-insulated cable. The default value of 0.7 applies to most 50 ohm coaxial cables with plastic dielectric.

You can change the value of propagation velocity from 0.1 to 1 in 0.005 steps, or the value of dielectric constant from 1 to 100 in 0.01 steps.

If you don't know the velocity but you know the dielectric constant of the transmission medium, you can convert its dielectric constant to a velocity using the following equation:

Velocity = 1 / Square Root of Dielectric Constant

The horizontal axis is now calibrated in your chosen units of measurement.

> ℹ️   Markers and measurement readouts are always expressed in the same units as the graticule axes.
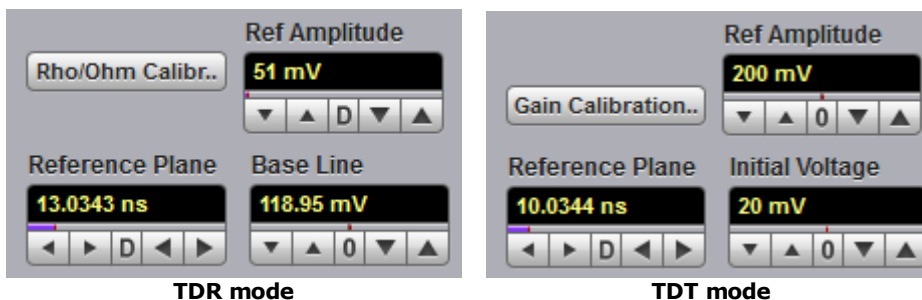
TDR mode	TDT mode

These controls allows you to calibrate the instrument for accurate **rho** and **ohm** measurements in **TDR** mode or accurate **gain** measurement in **TDT** mode.

- **Rho/Ohm Calibr...** starts the calibration procedure for the **TDR** vertical scale. Follow the instructions when the calibration process begins.
- **Gain Calibration...** starts the calibration procedure for the **TDT** vertical scale. Follow the instructions when the calibration process begins.
- **Ref Amplitude** allows automatic or manual setting of step amplitude equal to 1.00 rho.
- **Base Line** changes the vertical position of the TDR/TDT step on the display. Use **Base Line** when **Rho** mode is selected in the **Vertical Scale** menu. This feature is most useful in TDR/TDT measurements, because all changes in transmission line impedance affect the vertical placement of the trace.
- **Reference Plane** shows the horizontal position of the reference point where the transmission line begins.
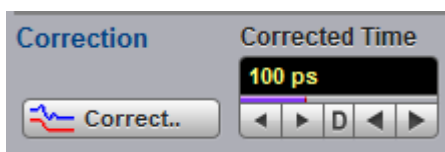
The **Correction** menu allows you to change the rise time of the corrected step for TDR or TDT measurements on each of the channels, and also to turn on or off the display of the corrected TDR or TDT trace (function).

The correction procedure corrects for sources of measurement errors concerned with TDR response. By using correction, the results become more reliable, repeatable, and accurate. In addition, performing a correction allows the instrument to simulate stimulus steps with different effective rise times. This allows you to view the effect of actual signal rise times on the magnitude of reflections from discontinuities.

- **Corrected Time** allows you to change the corrected step's rise time. This rise time value applies to both TDR and TDT corrected channels.

● **Correct...** starts correction procedure. Follow the instructions when the correction process begins.

7.15   Trigger menu

The scope trigger circuitry helps you locate the waveform you want to view. The oscilloscope uses a reference signal to determine precisely when to acquire data from the signal. The data can then be displayed as a function of time (relative to the reference signal). This reference signal is commonly referred to as a trigger.

The trigger event, when synchronized to the input signal, also defines the horizontal acquisition window. By choosing the trigger event and adjusting the horizontal position (delay between trigger event and the horizontal reference point) you control the location in the data stream (the input signal) from which the waveform record is taken.
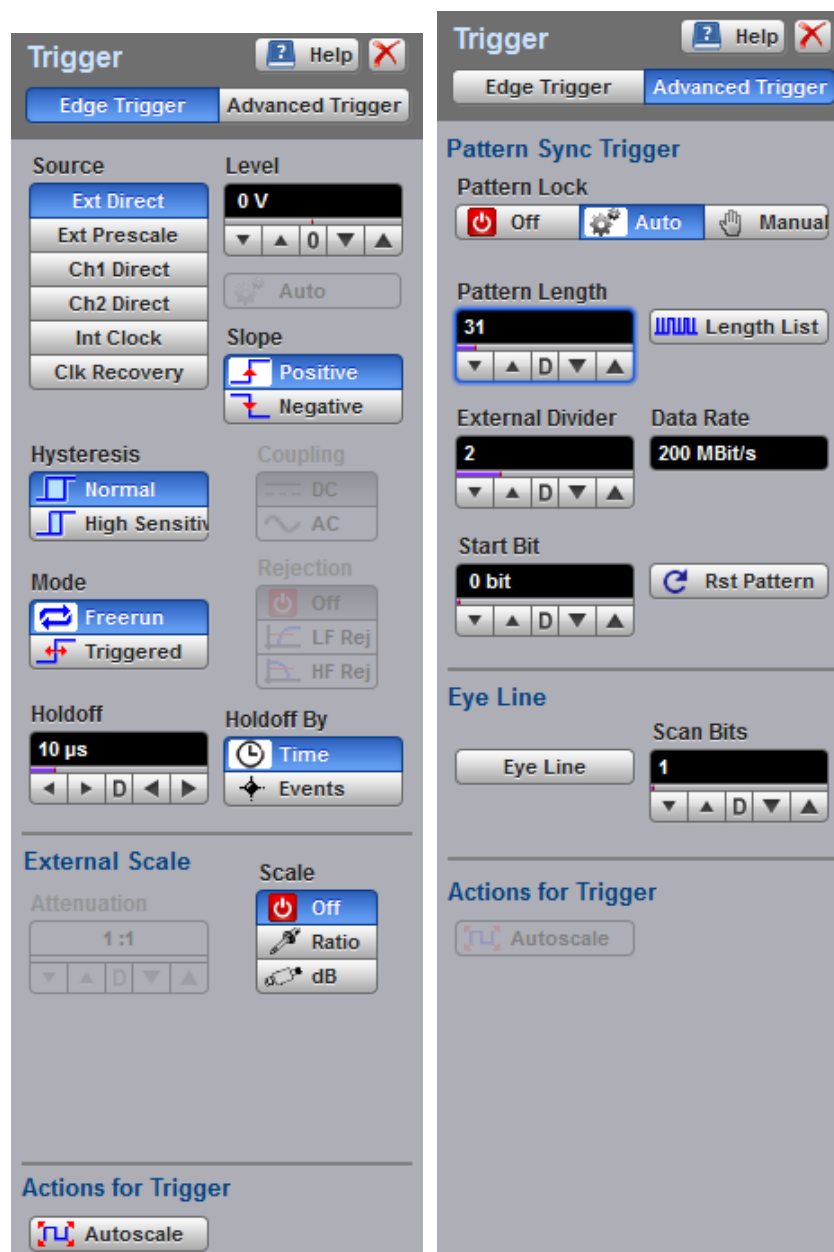
The Trigger menu

Types of trigger

There are several different types of trigger used in digitizing oscilloscopes. The PicoScope 9300 uses the following:

- Edge trigger
- Prescaled trigger
- Clock recovery trigger
- Pattern Sync trigger

Edge trigger

Edge trigger is the traditional and most often used type. It identifies a trigger condition by looking for the slope (rising or falling) and voltage level (trigger level) of the source you select. When the trigger edge crosses a predefined threshold, the oscilloscope begins to sample and acquire data from the signal. By acquiring data from the input signal, the oscilloscope can reconstruct the waveform and display it on the display screen. Edge trigger uses an external trigger source up to 2.5 GHz, and an internal trigger source up to 100 MHz.

Prescaled trigger

The prescaled trigger extends direct triggering to signals up to 14 GHz. In this mode, there is no control over the trigger level or slope. The input circuitry includes a low-jitter, high-speed, programmable frequency divider with a maximum division factor of 8. The divided signal is applied to the existing trigger circuitry. The trigger input is AC-coupled to the divider. The input threshold of the divider is set for maximum sensitivity and bandwidth, and it will operate correctly on a sine wave input from 1 GHz to 14 GHz. Square wave triggers, or other sharp-edged transitions, will function down to DC.

Clock recovery trigger

This type of trigger is used in the PicoScope 9302 and 9321. The clock recovery trigger derives a timing reference directly from the NRZ waveform to be measured. The clock recovery trigger covers the most popular electrical standards used today from 6.5 Mb/s to 11.3 Gb/s bit rates.

Pattern Sync trigger

Pattern Sync trigger is the ability of the PicoScope 9300 to internally generate and lock onto a pattern trigger. The pattern trigger is derived from the supplied clock by automatically detecting data rate, pattern length, and trigger divide ratio. The **Pattern Sync Trigger** enables **Eye Line** mode to walk through each bit of the data pattern, to average eye diagrams and to view specific bit trajectories.

External trigger inputs

Three external trigger inputs are located on the front panel:

- **Direct Trigger Input** SMA female. This input is used for edge triggering. The PicoScope 9300 provides a 0 to 2.5 GHz direct trigger bandwidth.
- **Prescale Trigger Input** SMA female. This input is used for prescaled triggering. The PicoScope 9300 provides 1 GHz to 14 GHz trigger bandwidth.
- **Clock Recovery Trigger Input** SMA female. This input is used for clock recovery triggering. The PicoScope 9302 and 9321 provides triggering on 6.5 Mb/s to 11.3 Gb/s bit rates.

> ℹ️ When using a given trigger source, you should disconnect any other trigger source from the front panel to ensure specified performance.

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Triggering process

Oscilloscopes respond to trigger signals in different ways, depending on their architecture. The PicoScope 9300 uses digital sampling oscilloscope technology to acquire and display wide-bandwidth waveforms. This type of instrument employs a triggering scheme referred to as Equivalent Time Sampling. The trigger circuit and sampler circuits operate in parallel. The sampler samples the input signal at a specific rate. The trigger circuit operates independently of the sampler circuit, and a trigger event does not have to occur at the same time as a sample point. Because the instrument knows when the trigger event happened in relation to the sampled data, it knows where to place the sampled data on the display.

The triggering scheme is based up the following characteristics:

- An external trigger signal is required. The instrument does not have the ability to synchronize directly to the signal being measured.
- The instrument must be armed and an input channel must be turned on in order to respond to a trigger. Typically the instrument will be armed if it is placed in the **Run** mode. The instrument also becomes armed if it is in **Single** acquisition mode. The single acquisition mode occurs after the instrument is placed into **Stop** mode. Click the **Single** button repeatedly to toggle the instrument modes between stop and single acquisition.
- A significant time delay occurs between the time the instrument responds to a trigger and when the instrument is armed and able to respond to another trigger. This delay is called the rearm or setup and hold time, and is on the order of 5 µs. Therefore, many trigger events can occur and are not responded to by the instrument while the rearming process takes place.
- A displayed waveform consists of several sampled points. A trigger event (edge) is required for each sampled point. For example, if the number of points making up a waveform trace is 512, then the instrument would have to respond to at least 512 trigger edges.
- A minimum time delay occurs between the time a trigger is received and when the data is actually sampled. This delay is on the order of 40 ns. Therefore, the signal at the trigger point (time 0) is usually not seen unless the data is delayed (through cable lengths or delay lines) relative to the trigger signal. The delay between the trigger event and the sample point can be longer than 30 ns. You can change the amount of delay in the **[Acquisition](#)** menu. Upon the next trigger event, a sample point is acquired at a small time increment in addition to the initial delay of 40 ns. Each additional trigger event yields sample points delayed by sequentially greater amounts of time. Therefore, after many triggers, the input waveform is reconstructed on the display screen.

The types of signals that can be viewed with these triggering requirements are divided into the following categories:

- Signals that are repetitive. The displayed waveforms are constructed from samples taken over multiple repetitions of the waveform. A trigger signal synchronous with the data is needed to control the timing of the sampling process.
- Signals that are not repetitive but are synchronous with a trigger signal. The primary example of a non-repetitive signal is the measurement of digital data streams or eye-diagrams with the oscilloscope triggered by a synchronous clock signal.

7.15.1   Edge Trigger
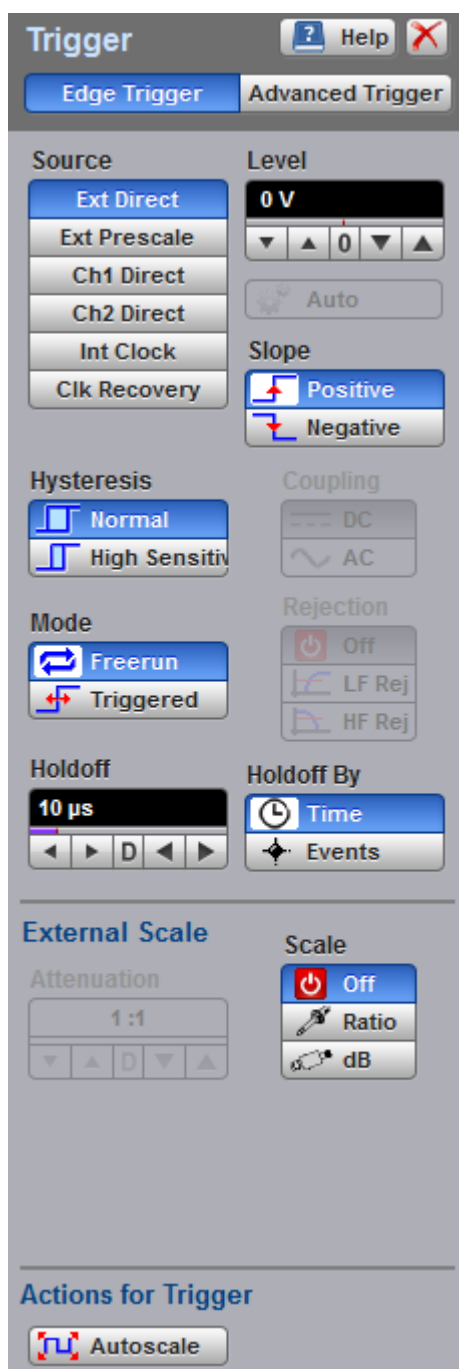
The Edge Trigger menu

7.15.1.1 Source

Source
Ext Direct
Ext Prescale
Ch1 Direct
Ch2 Direct
Int Clock
Clk Recovery
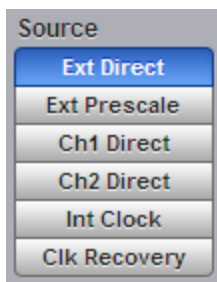
The **Source** menu specifies the signal that the trigger system monitors. The **Source** function displays a list of the available trigger sources. There are six sources that the PicoScope 9300 can use for a trigger:

- **External Direct**
- **External Prescale**
- **Channel 1 Direct**
- **Channel 2 Direct**
- **Internal Clock**
- **Clock Recovery** (for PicoScope 9302/9321 only)

Changing trigger sources while the instrument is running causes newly acquired data to overwrite existing waveforms that are on the display. However, if the instrument is stopped, changing the trigger sources does not change the display until the instrument starts running again.

External Direct

Use this selection for typical measurement applications. Select this trigger source to trigger on an external signal that you couple to the **Direct Trigger Input** (SMA female). The **External Direct** trigger source is an edge trigger, and it provides excellent performance for triggering signals up to at least 2.5 GHz. It is DC-coupled with 50   input impedance and with an adjustable threshold level from −1 V to 1 V. You can select either **Positive** or **Negative** edge as the trigger **Slope**.

⚠ **CAUTION**
To avoid damage to the **Direct Trigger Input** of the scope, make sure you do not exceed the maximum rated input voltage of ±2 V (DC + peak AC).

Using resistive divider probes you can increase the input impedance up to 5 k   , and using an active probe you can increase the input impedance up to 10 M   .

External Prescale

Connect an external trigger source to the **Prescaler Trigger Input** connector. The **External Prescale** trigger source is prescaled (divided down) before being applied to the trigger system. It has a programmable 1/2/4/8 prescaler ratio and a trigger frequency range between 1 GHz and 15 GHz. Use this selection for direct or prescaled triggering on higher frequency signals than those that can be triggered on with **External Direct**.

With the **External Prescale**, triggering is AC-coupled, 50   terminated, and has a fixed level of zero volts. Therefore, the instrument has no level or slope controls with this trigger source. If a trigger signal with a significant DC offset is used, the DC element is blocked. Certain trigger signals that reside at 0V for a long time period and then have an occasional pulse (for example, a pattern generator pattern trigger) will not perform well.

Channel 1 and **Channel 2 Direct (Internal Trigger)**

Any of the dual-channel oscilloscope channels can be used to trigger the instrument.

Note: Channel 3 and Channel 4 of the four-channel PicoScope 9341 cannot be used as a trigger source.

The **Ch1/Ch2 Direct** trigger source is an edge trigger, and it provides low-frequency performance for triggering on signals from DC to at least 100 MHz. It has an adjustable threshold level from −1 V to 1 V, selective slope, coupling, rejection and hysteresis.

Internal Clock

With the **Internal Clock** source you can trigger the instrument from the precise internal clock. The frequency of the internal clock can be changed by the **Internal Rate** control from clock periods of 8 ns to 60 ms.

Use this type of trigger source with TDR/TDT to synchronize the generation of TDR step pulses with the subsequent acquisition.

Clock Recovery (PicoScope 9302/9321).

Connect an external trigger source to the **Clock Recovery Trigger Input** connector when the **Clock Recovery** trigger source is selected. Use this source when trigger signal is an NRZ data pattern with any data rate between 6.5 Mb/s and 11.3 Gb/s.

7.15.1.2 Level
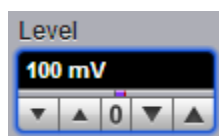
The **Level** variable specifies the voltage threshold that a signal must cross in order for the instrument to trigger on that signal. When the input signal crosses this voltage level, the instrument triggers.

Level is active when any of **Direct Trigger Sources** is selected in the **Source** menu: **External, Ch1** or **Ch2.**

You can select the trigger level in one of three ways:

- By using the **Level** spin box
- By using the **Level** spin boxes in the **Permanent Controls** area
- By using the **Pop-up Keypad** to quickly enter numeric data using the mouse

You can adjust the trigger level value between −1 V and 1 V in 10 mV steps (coarse increment) or 1 mV steps (fine increment).

> ℹ️ Perform the **Autoscale** function if you want the instrument to automatically set the trigger level to the amplitude midpoint of the trigger signal.

The trigger signal must be connected to the input channel or to the trigger input of the instrument. For example, if you are using the trigger input on the instrument front panel, the trigger signal must be connected to the front panel trigger input. **Autoscale** can then set the trigger level.

When any of the **Direct** edge triggers is in use, the trigger level setting also determines what the instrument uses as a reference to determine a high or low. A high is a voltage above the trigger level, and a low is a voltage below the trigger level.

The **Level** value changes automatically if the attenuation factor is changed.

7.15.1.3 Slope

The **Slope** menu specifies whether the instrument triggers on either the positive or negative edge of the signal. The **Slope** menu is active when any of **Direct Trigger Sources** is selected in the **Source** menu: **External, Ch1** or **Ch2.**

- **Positive**   Triggers on an edge that transitions through and above the trigger level
- **Negative**   Triggers on an edge that transitions through and below the trigger level

7.15.1.4 Hysteresis
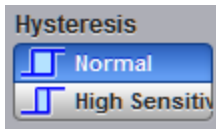
Trigger hysteresis helps to prevent false triggers from occurring on a falling edge due to noise when the rising edge is selected as the trigger edge (or on a rising edge when the falling edge is selected as the trigger edge).

The voltage through which the trigger signal must pass before the instrument is ready to accept another valid trigger is known as the arming level. Hysteresis is the voltage difference between the arming level and the trigger threshold level.

The **Hysteresis** menu is active when any of **Direct Trigger Sources** is selected in the **Source** menu: **External, Ch1** or **Ch2.**

The trigger hysteresis can be set to two modes:

- **Normal.** Hysteresis is enabled. The trigger hysteresis is set so that the instrument meets the trigger sensitivity specification. The instrument will trigger if a trigger signal crosses both the arming level and the trigger threshold level. **Normal** mode provides good trigger performance while minimizing false triggers.
- **High sensitivity.** The trigger hysteresis is turned off to allow best sensitivity to high-frequency signals. This mode should not be used for noisy lower-frequency signals that may mistrigger without hysteresis, but can result in false triggers if there is significant noise on the trigger signal, or if the trigger signal is not monotonic in the region of the trigger threshold level. The **High sensitivity** hysteresis provides at least twice better sensitivity than the **Normal** hysteresis.

7.15.1.5 Internal Rate
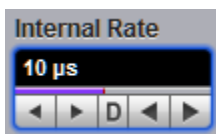
The **Internal Rate** spin-box allows you to vary the repetition rate of the internal clock from 8 ns to 60 ms. If fine mode is off, the repetition rate can be set in a 1-2-5 sequence. When fine mode is on, you can change the repetition rate in 4 ns increments.

The **Internal Rate** is used only when the **Internal Clock** source is selected.

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7.15.1.6 Mode

The trigger modes control the behavior of the instrument when not triggered. The **Mode** menu lets you select between **Freerun** and **Triggered** modes.

Freerun

With the **Freerun** mode, the trigger circuit is armed and the instrument waits for up to 400 μs for a trigger occur. If a trigger does not occur within 400 μs, the instrument triggers itself, and the data that is acquired with the trigger is displayed on the screen. Use the **Freerun** mode when you are unsure how to setup the trigger menu to trigger the instrument, or for DC trigger signals. This mode forces the instrument to trigger, giving you glimpses of the signal, which then allows you to set up the instrument to display the signal.

For waveforms whose period is greater than 400 μs the **Freerun** mode should not be used, because the scope's 400 μs timeout will always occur before your waveform trigger. For waveforms whose period is lower than 400 μs, the **Freerun** mode works similarly to the **Triggered** mode.

Use **Freerun** triggering when you are not using an external trigger and you want to view the waveform for amplitude information only. **Freerun** triggering allows the instrument to trigger as soon as the instrument is armed, and is asynchronous to the data. You can also use **Freerun** triggering to view a signal without any timing information. It is an easy way to examine the amplitude of a signal.

Triggered

In **Triggered** mode, the instrument displays data only after all of the trigger conditions are met. **Triggered** mode keeps the instrument from triggering and displaying data on the screen before a specific trigger event occurs. Use **Triggered** mode to update the display only when a trigger event occurs or for waveforms that have a fundamental period of less than 400 μs.

7.15.1.7 Coupling
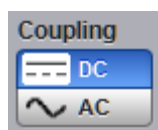
The trigger coupling determines what part of the signal is passed to the trigger circuitry. This function is available with the **Ch1 Direct** and **Ch2 Direct Trigger Sources** only.

- **DC.** This coupling passes all input signals to the trigger circuitry.
- **AC.** This coupling passes the input signals above 1 kHz to the trigger circuitry.

7.15.1.8 Rejection
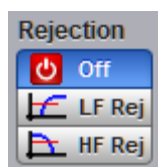
The trigger rejection determines which frequency components of the signal are passed to the trigger circuitry. This function is available with the **Ch1 Direct** and **Ch2 Direct Trigger Sources** only.

- **Off.** This mode is equivalent to "no rejection".
- **LF Rej.** This rejection attenuates signals below 100 kHz before passing the signal to the trigger circuitry.
- **HF Rej.** This rejection attenuates signals above 1 MHz before passing the signal to the trigger circuitry.

7.15.1.9 Holdoff By
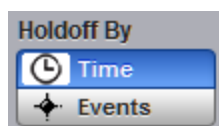
Holdoff is a period of time or an event count. It disables the trigger circuit for a given period of time or number of events after the last trigger occurred. Events are the number of occasions on which the trigger condition is met. Use holdoff to obtain a stable trigger for repetitive, composite or complex waveforms. For example, if the number or duration of sub-signals is known you can disable them by choosing an appropriate holdoff value.

Hold Off by Time

Sometimes you can achieve a stable display of complex, repetitive waveforms by placing a condition on the time between each successive trigger event. The **Holdoff** control sets the amount of time that the scope waits before re-arming the trigger circuitry. For example, if you have a burst of pulses and want to trigger on the first pulse in the burst, you can set the holdoff time to be slightly longer than the burst width.

Hold Off by Events

Select a positive or negative slope and a number of events. An event is the number of times the trigger condition is met after the last trigger. A trigger is generated when the condition is met after this number, counted from the last trigger. The count is restarted on each trigger. For example, if the event number is two, the trigger will occur on the third event.

7.15.1.10 Holdoff
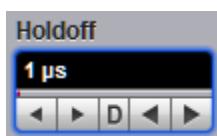
Trigger **holdoff** helps stabilize triggering. When you adjust the **Holdoff** control, the amount of time that the scope waits before re-arming the trigger circuitry also changes.

To set the trigger **Holdoff Time** manually, click **Holdoff By Time**, and then select the holdoff time. The **Holdoff** range is from 1 µs to 15.11 s in a 1-2-5-10 sequence. When fine mode is on, you can change holdoff time with 4 ns increment.

To set the trigger **Holdoff Events**, click **Holdoff By Events**, and then select necessary value. In this case the **Holdoff** range is from 6 events to 10^9 events and depends on the frequency of the events used for triggering.

7.15.1.11 External Scale
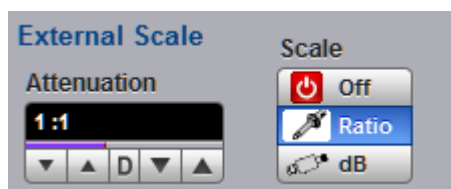
The **External Scale** functions can be used when the trigger signal level changes due to the use of an amplifier, attenuator or a probe. The attenuation factor can be entered either as a ratio or decibel value.

The **External Scale** is available with **External Direct Trigger Source** only.

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7.15.1.12Scale
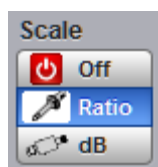
You can enter the attenuation or gain characteristics of an external device when configuring a trigger channel for external scaling. The **Scale** function controls how the probe attenuation factor is represented. There are options for either **Ratio** [Ratio icon] or **Decibel** [dB icon].

The formula for calculating decibels is: $20\ log(V_{out}/V_{in})$ or $10\ log(P_{out}/P_{in})$

Decibels versus voltage ratio

dB	Voltage Ratio
3 dB	1.41
6 dB	2.00
10 dB	3.16
20 dB	10
40 dB	100
60 dB	1000
120 dB	1 000 000
−80 dB	0.0001

ℹ Changing the attenuation factor does not attenuate the trigger signal; it only changes the database for generating prompts on the display. If the trigger signal must be attenuated, use external attenuators.

ℹ Gain is implied when you enter negative decibel values or ratios of less than 1:1 in the **Attenuation** variable. The default attenuation value is 1:1.

7.15.1.13 Attenuation
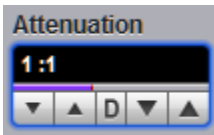
The **Attenuation** variable lets you select an amplification or attenuation that matches the device connected to the **External Direct Trigger Input** of the instrument. When the attenuation is set correctly, the instrument maintains the trigger level if possible. For example, if you want to trigger the scope with a 0 to 5 V trigger source, you can attenuate the source with a 20 dB pad to bring the level within external trigger limits. The pad lowers the source level to 0 to 0.5 V, but you can use external scaling to compensate for the 20 dB pad. This allows you to view the trigger source voltage in the trigger level spin-box as though no attenuation were present. Because of this scaling feature, you can set the scope to trigger at the precise source level you want without calculating the drop across the pad.

The trigger level attenuation factor is used to establish a database for generating the **Level** prompts on the display.

The attenuation factor is from 0.000 1:1 to 1 000 000:1 or from −80 dB to 120 dB.

The **Attenuation** function allows you to set attenuation of the selected channel in one of two ways:

- By using the **Attenuation** spin box
- By using the **Pop-up Keypad** to enter specific settings

7.15.2   Advanced Trigger

Advanced Trigger

The **Advanced Trigger** menu controls two functions:

- **Pattern Sync** trigger
- **Eye Line** mode

Pattern Sync is the ability of the PicoScope 9300 to internally generate and lock onto a pattern trigger. The pattern trigger is derived from the supplied clock by automatically detecting all of the following parameters:

- Data rate
- Pattern length
- Trigger divide ratio
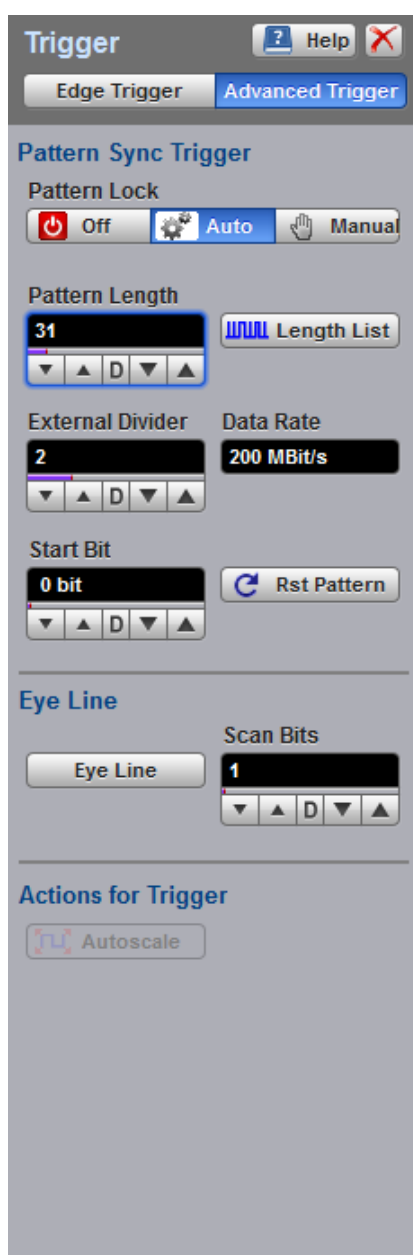
The Advanced Trigger menu

7.15.2.1 Pattern Lock
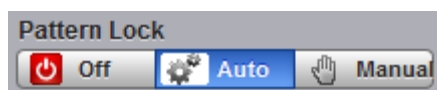
The PicoScope 9300 can internally generate a pattern trigger off the supplied clock. Any of three trigger sources can be used as a supplied clock.

The following table shows valid ranges for data rate and pattern length when using pattern lock.

External Direct Trigger	10 MHz to 2.5 GHz
Internal Direct Trigger	10 MHz to 100 MHz
External Prescaled Trigger	1 GHz to 14 GHz (-15 and -20 models) 1 GHz to 15 GHz (-25 models)
Clock Recovery Trigger	10 MHz to 11.3 GHz

Off

When **Pattern Lock** is switched to **Off**, the oscilloscope ceases pattern trigger detection and the instrument triggers off the data rate.

Auto Detect

When **Auto Detect** is switched on, the oscilloscope automatically detects data rate, pattern length, and trigger divide ratio and generates the pattern trigger. To get correct pattern lock, check the **Pattern Length List**. The pattern length you want to detect can be added to this list if necessary.

Manual

When **Manual** is switched on, the oscilloscope can manually detect data rate, pattern length, and trigger divide ratio and generates the pattern trigger. Use the **Pattern Length** control to detect the right pattern trigger when you do not have the information about data pattern length.

7.15.2.2 Pattern Length
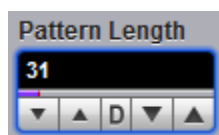
Select **Auto Detect** from the **Pattern Lock** menu to have the pattern length automatically detected.

To manually enter the pattern length, click **Manual** in the **Pattern Lock** menu. Enter the length of the test pattern in bits, which can be any value between 7 and 8 388 607 ($2^{23}-1$). Use manual entry when you do not have any information about data pattern length.

7.15.2.3 Length List
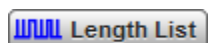
Click **Length List** to create a table with a list of pattern lengths. When **Auto Detect** is turned on, the oscilloscope automatically detects data rate, pattern length, and trigger divide ratio and generates the pattern trigger. Only pattern lengths included into the table will be used by the detection procedure.

You can modify the table to have typical or custom lengths, or you can create your own custom lengths.
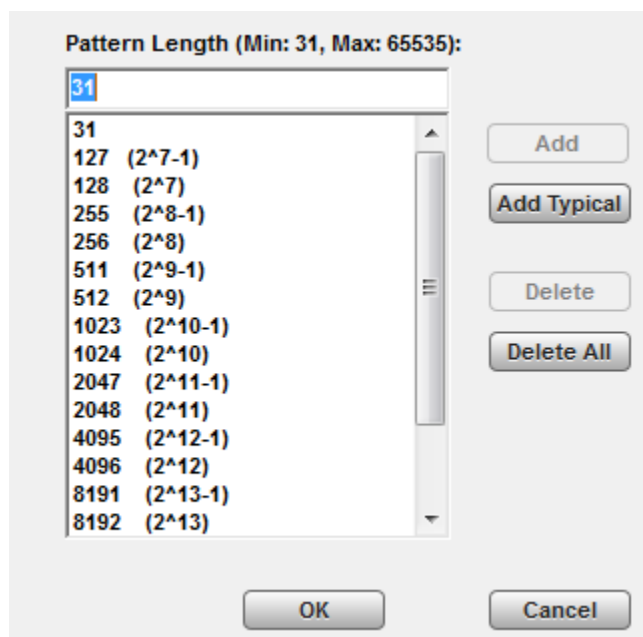
The Pattern Length List

7.15.2.4 Data Rate
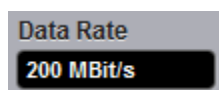
Data Rate shows information about the detected data rate.

The PicoScope 9300 uses an internal frequency counter that constantly measures the data rate taking into account the trigger divide ratio. The precision of the counter is ±50 ppm or better.

7.15.2.5 External Divider

External Divider
4
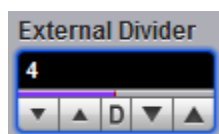
Select **Auto** in the **Pattern Lock** menu to have the trigger divide ratio automatically detected. You can also manually enter the trigger divide ratio.

The following table shows valid ranges for data rate and the trigger divide ratio when using pattern lock.

External Direct Trigger	< 250 MHz: 1 250 MHz to < 500 MHz: 2 500 MHz to < 1 GHz: 4
External Prescaled Trigger	1 GHz to < 8 GHz: 32 8 GHz to 15 GHz (typical): 64
Clock Recovery Trigger	12.3 MHz to < 1 GHz: 4 1 GHz to < 2 GHz: 8 2 GHz to < 2.7 GHz: 16

7.15.2.6 Reset Pattern
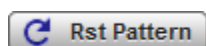
↻ Rst Pattern

Click **Rst Pattern** to reset the pattern lock procedure.

7.15.2.7 Start Bit
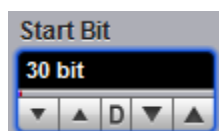
Start Bit
30 bit

Set **Start Bit** to specify the starting bit location for the scan.

When **Auto** is selected in the **Pattern Lock** menu, **Start Bit** specifies an offset in data bits from the pattern trigger. Because the internally generated pattern trigger is synchronized to an unknown bit number in the data pattern, **Start Bit** does not specify an absolute bit in the data pattern.

Use this feature to step the triggering through each bit of a pattern when **Eye Line** mode is off. This is a relative setting from an arbitrary reference pattern bit.

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7.15.2.8 Eye Line

Eye Line

Eye Line mode is used to average eye diagrams and to view specific bit trajectories. The number of averages can be set from the **Average N** of the **Acquisition Mode** menu.

Eye Line mode uses the pattern lock feature to establish a pattern sync trigger and then uses that trigger to walk through each bit of the data pattern. For eye diagrams, this allows high and low values to be separated before being averaged together. Without **Eye Line** mode, averaging an eye diagram would result in highs from one bit being averaged with lows of another bit which results in an erroneous value between the two levels.

7.15.2.9 Scan Bits
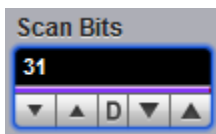
Scan Bits
31

Set **Scan Bits** to the number of bits or sub-frames you want to acquire.

7.16   Utility menu

The **Utility** menu gives access to scope calibration and demonstration ("Demo") mode settings.

7.16.1   Calibrate

The **Calibrate** menu gives access to these functions:

- Channel 1/2 calibration: sets up the Channel 1/2 sampler and the vertical converters.
- Channel 3/4 calibration: sets up the Channel 3/4 sampler and the vertical converters on 4-channel scopes only.
- Time Base: sets up the timebase for all channels.

Utility menu with Channel 1/2, Channel 3/4, and Time Base options selected

7.16.1.1 Calibration Procedure

You can calibrate the vertical and horizontal channels of the oscilloscope. Calibration can be performed for all four vertical channels and for the timebase.
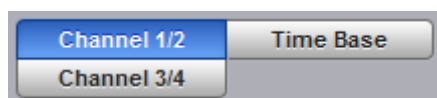
- Click **Channel 1/2** to calibrate the Channel 1 and 2 sampler and the vertical converters.
- Click **Channel 3/4** to calibrate the Channel 3 and 4 sampler and the vertical converters.
- Click **Time Base** to calibrate the timebase.
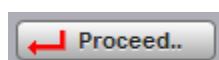
Click **Proceed...** to start the calibration procedure for the selected function.

After calibration has finished and you have confirmed the results of calibration, the following calibration constants will be shown:

- Channel 1 and Channel 2 (Channel 3 and Channel 4) calibration constants (balance) for both full and narrow bandwidth:
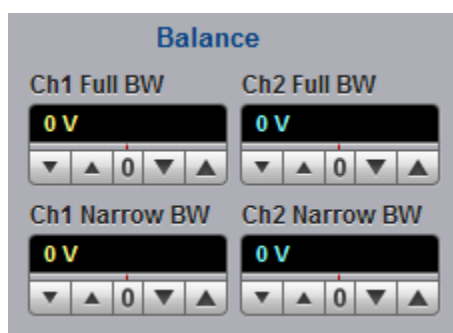
- Coarse and fine timebase calibration constants:
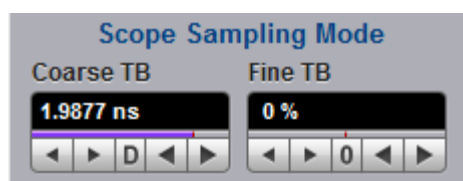
7.16.1.2 Store/Recall Calibration Constants

After each of the calibrations (Channel 1/2, Channel 3/4 or Timebase) you can later store new constants, recall all stored constants or recall factory-stored calibration constants.
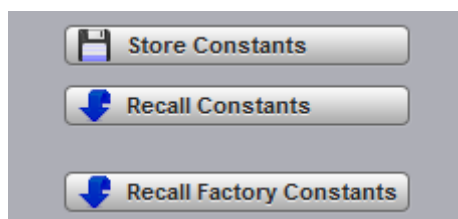
- **Store Constants** stores calibration constants to disk.
- **Recall Constants** retrieves the most recently saved calibration constants from disk.
- **Recall Factory Constants** restores calibration constants to the default (factory-stored) values. This overrides any previous changes made by the user.

7.16.1.3 Calibration Status
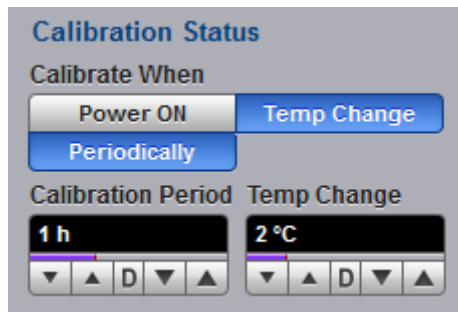
Choose when to calibrate the oscilloscope:

- **Power ON:** each time the scope is powered on.
- **Periodically:** at intervals specified by the **Calibration Period** control.
- **Temp Change:** every time the scope's internal temperature changes by more than the value set in the **Temp Change** control.

7.16.2   Demo

In demonstration ("Demo") mode, when no scope is plugged in (see Demo mode for more information), five virtual signal generators labeled A to E are available to drive the input channels. Sine, Pulse and PRBS waveforms may be set up as follows:

Utility menu with Sine, Pulse, and PRBS waveform options selected

TDR and TDT waveform options are also available on compatible scopes only:
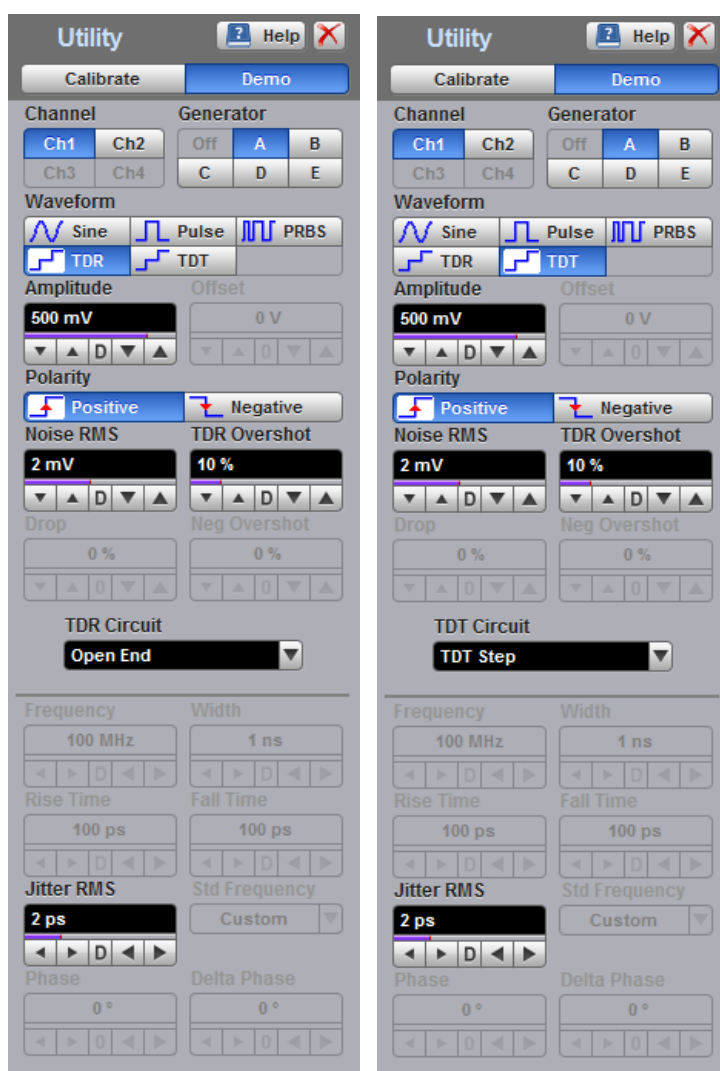
Utility menu with TDR and TDT waveform options selected

7.16.2.1 Channel
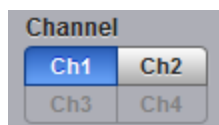
Each channel can be driven by any of the <u>Demo</u> signals from **A** to **E**.

7.16.2.2 Generator
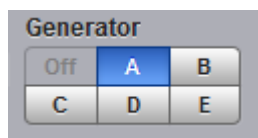
Select each of these buttons to set up one of the five <u>Demo</u> signal generators.

7.16.2.3 Waveform
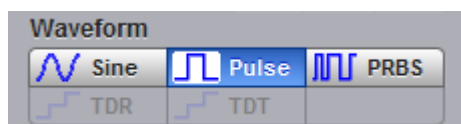
Select either **Sine**, **Pulse** or **PRBS** waveform type for each signal generator. For the PicoScope 9311 and 9312 you can also use the **TDR** and **TDT** options.

7.16.2.4 Amplitude
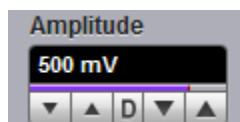
The peak-to-peak signal level.

7.16.2.5 Offset
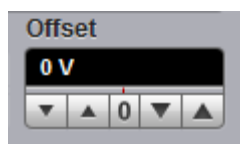
The DC offset of the signal. This is the mean voltage of a Sine signal, or the base voltage of a Pulse or PRBS signal.

7.16.2.6 Polarity

For Pulse and PRBS signals, this optionally inverts the waveform.

7.16.2.7 Noise RMS
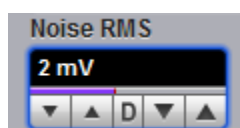
Random noise may optionally be added to each signal.

7.16.2.8 Pos Overshoot
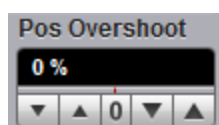
Pulse and PRBS signals may have an optional overshoot.

7.16.2.9 TDR Overshoot
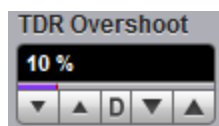
TDR and TDT signals may have an optional overshoot. This option is only available on the PicoScope 9311 and 9312 oscilloscopes.
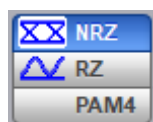
7.16.2.10 Droop
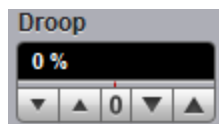
Droop is a decline in peak voltage over time, for Pulse and PRBS waveforms.
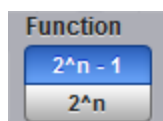
7.16.2.11 Neg Overshoot
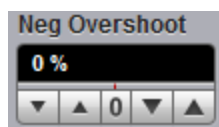
A negative overshoot can be specified for Pulse and PRBS waveforms.

7.16.2.12 Mode

A PRBS signal may be set to either an **RZ** (return to zero) or **NRZ** (non-return to zero) format. A **PAM4** signal may also be generated.
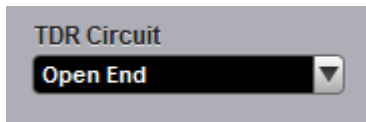
7.16.2.13 Function

The function used to generate the PRBS signal may be set to either a power of 2, or a power of 2 minus 1.

7.16.2.14 Length 2^n

The length of the PRBS polynomial may be set to **5**, **7**, **11** or **15** bits.

7.16.2.15 TDR Circuit

The [Demo signal generator](#) can emulate various external circuit conditions:

- **Off**: no device connected.
- **Open End**: an open-circuited transmission line.
- **Short End**: a short-circuited transmission line.
- **50 Ù termination**: a terminated 50 transmission line.
- **85 Ù termination**: a terminated 85 transmission line.
- **50 Ù-150 Ù-50 Ù**: a terminated 50 transmission line with a 150 discontinuity in the middle.
- **Inductance**: an inductive load.
- **Capacitance**: a capacitive load.

7.16.2.16 TDT Circuit
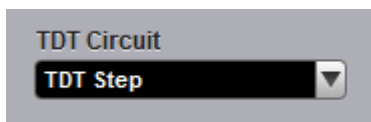
The [Demo TDT signal generator](#) can emulate the transmitted signal from various types of device under test:

- **Off**: no device connected.
- **TDT Step**: a direct connection.
- **6 dB/3 ns attenuator**: a 6 dB attenuator with 3 ns delay.
- **50 Ù-150 Ù-50 Ù**: a 50 transmission line with a 150 discontinuity in the middle.
- **Inductance**: a series inductor.
- **Capacitance**: a shunt capacitor.
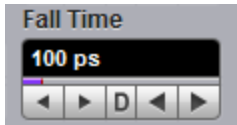
7.16.2.17 Frequency

The fundamental frequency of the [Demo](#) waveform. In PRBS mode this may be overridden by selecting a **Standard** frequency (see [Std Frequency](#) for more information).
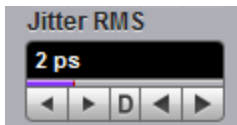
7.16.2.18 Rise Time
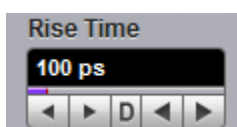
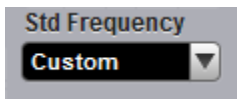Rise time of an ideal Pulse or PRBS waveform.

7.16.2.19 Fall Time

Fall Time

100 ps

Fall time of an ideal Pulse or PRBS waveform.

7.16.2.20 Jitter RMS

Jitter RMS

2 ps

An optional random time jitter may be added to the waveform.

7.16.2.21 Std Frequency

Std Frequency

Custom

For PRBS waveforms, a standard signaling frequency may be selected instead of a custom frequency, from 44.736 Mb/s to 43.01841 Gb/s.
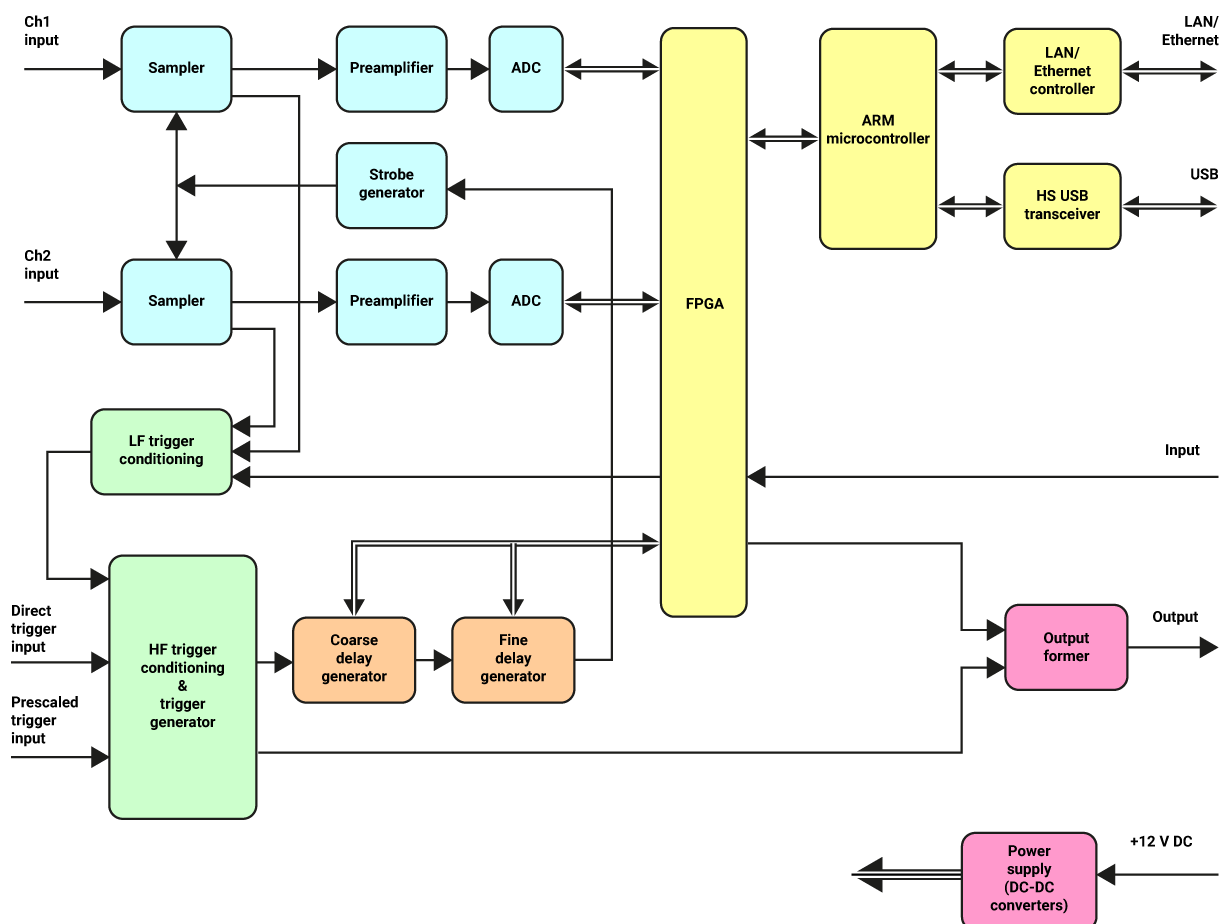
7.16.2.22 Trigger

Trigger
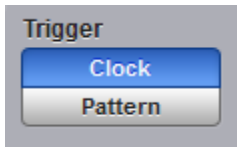
Clock

Pattern

In PRBS mode, the scope can be set to trigger on either the data **Clock** or the **Pattern** detector.

8   Theory of operation

8.1   PicoScope 9301 block diagram

The PicoScope 9301 hardware block diagram is shown in the figure below. Block-level description describes the major hardware components within the block diagram.

The PicoScope 9301 hardware block diagram
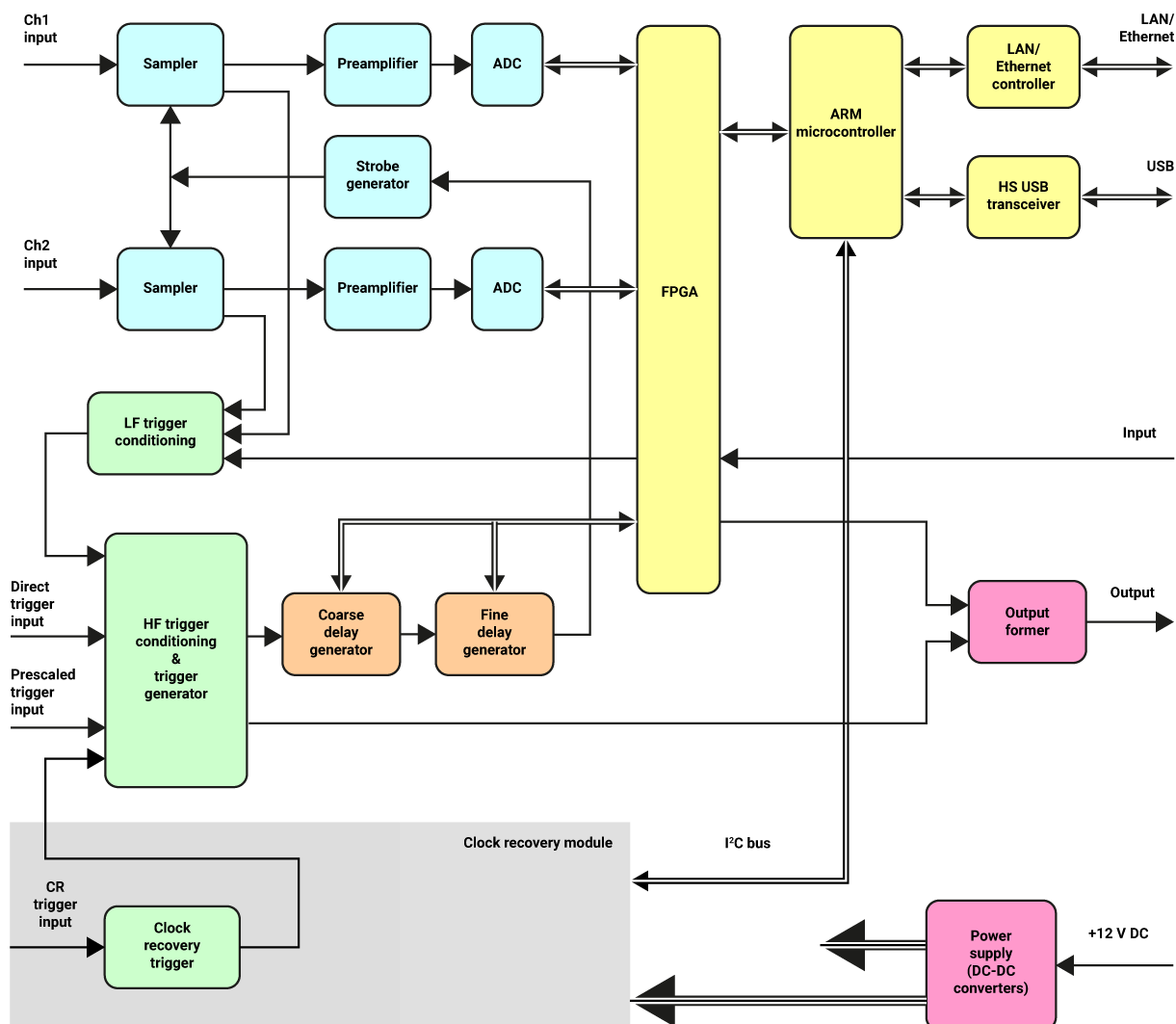
8.2   PicoScope 9302 block diagram

The PicoScope 9302 hardware block diagram is shown in the figure below. Block-level description describes the major hardware components within the block diagram.

The PicoScope 9302 hardware block diagram
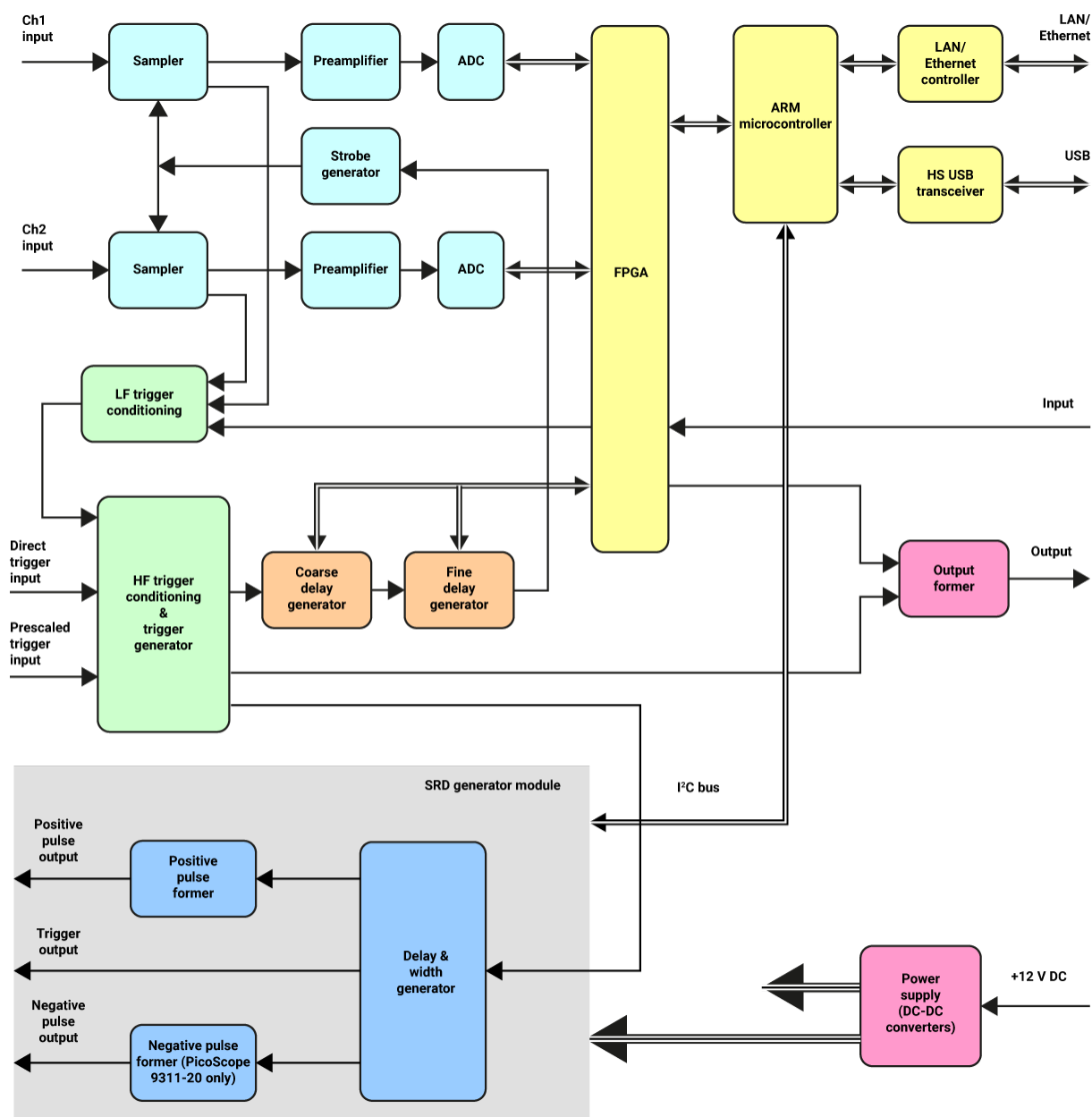
8.3   PicoScope 9311 block diagram

The PicoScope 9311 hardware block diagram is shown in the figure below. [Block-level description](#) describes the major hardware components within the block diagram.
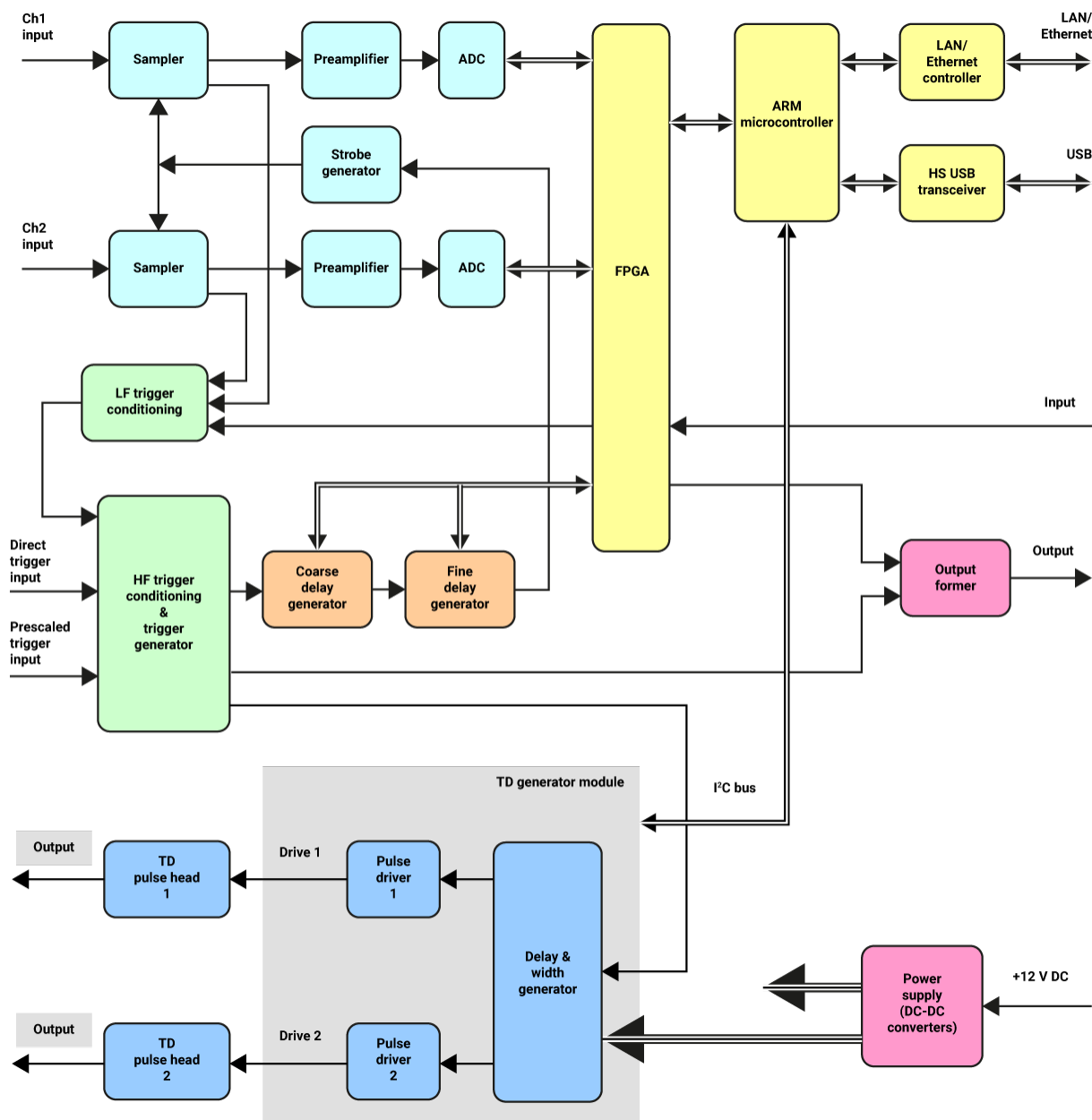

The PicoScope 9311 hardware block diagram

The PicoScope 9311 is based on the PicoScope 9301 architecture with the addition of built-in single-ended or differential TDR pulse outputs.

8.4   PicoScope 9312 block diagram

The PicoScope 9312 hardware block diagram is shown in the figure below. <u>Block-level description</u> describes the major hardware components within the block diagram.
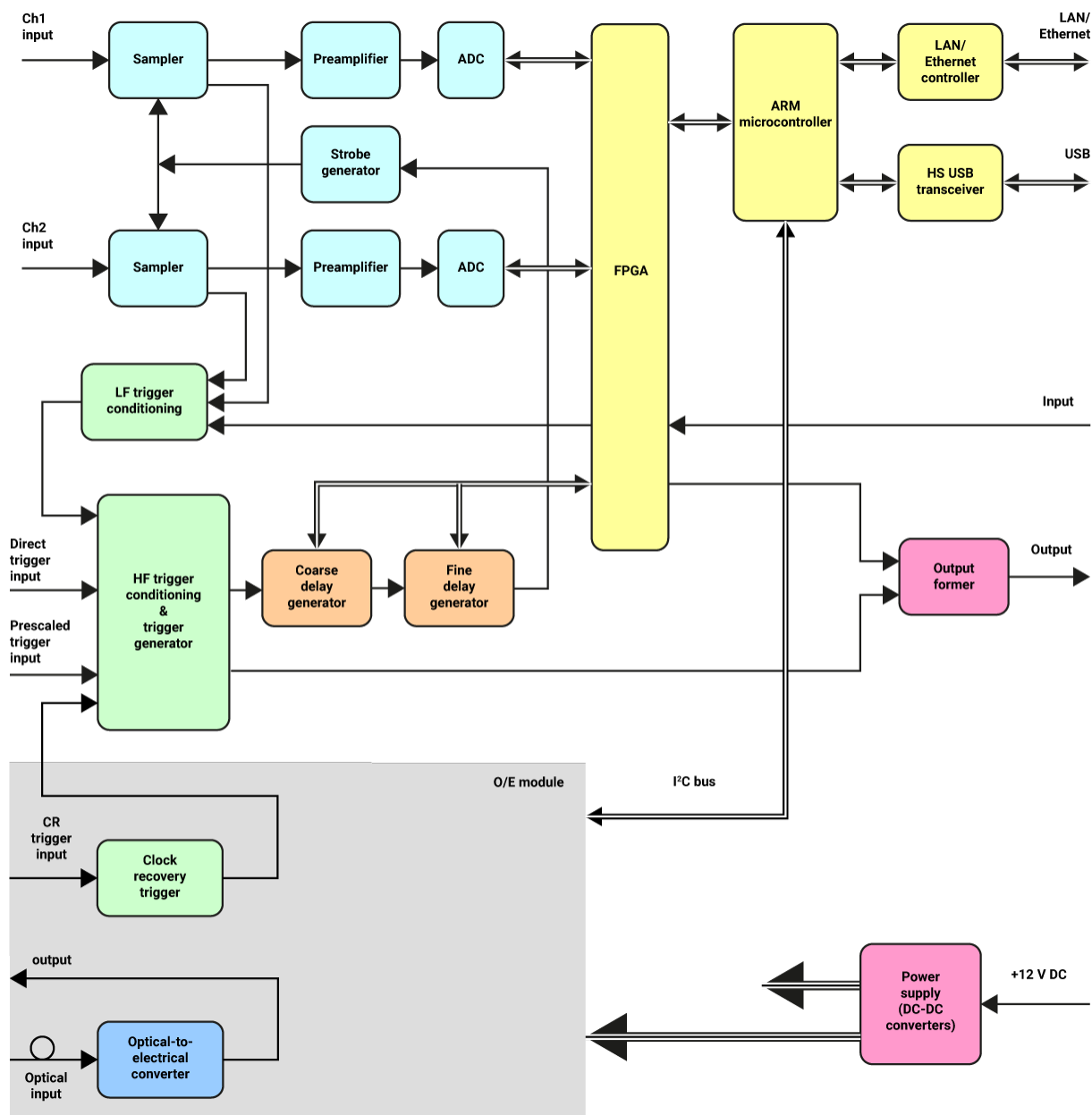

The PicoScope 9312 hardware block diagram

The PicoScope 9312 is based on the PicoScope 9301 architecture with the addition of dual Drive Out outputs. These are fed into external pulse heads, typically one positive and one negative, to produce the final high-speed differential TDR pulse.

8.5   PicoScope 9321 block diagram

The PicoScope 9321 hardware block diagram is shown in the figure below. Block-level description describes the major hardware components within the block diagram.

The PicoScope 9321 hardware block diagram
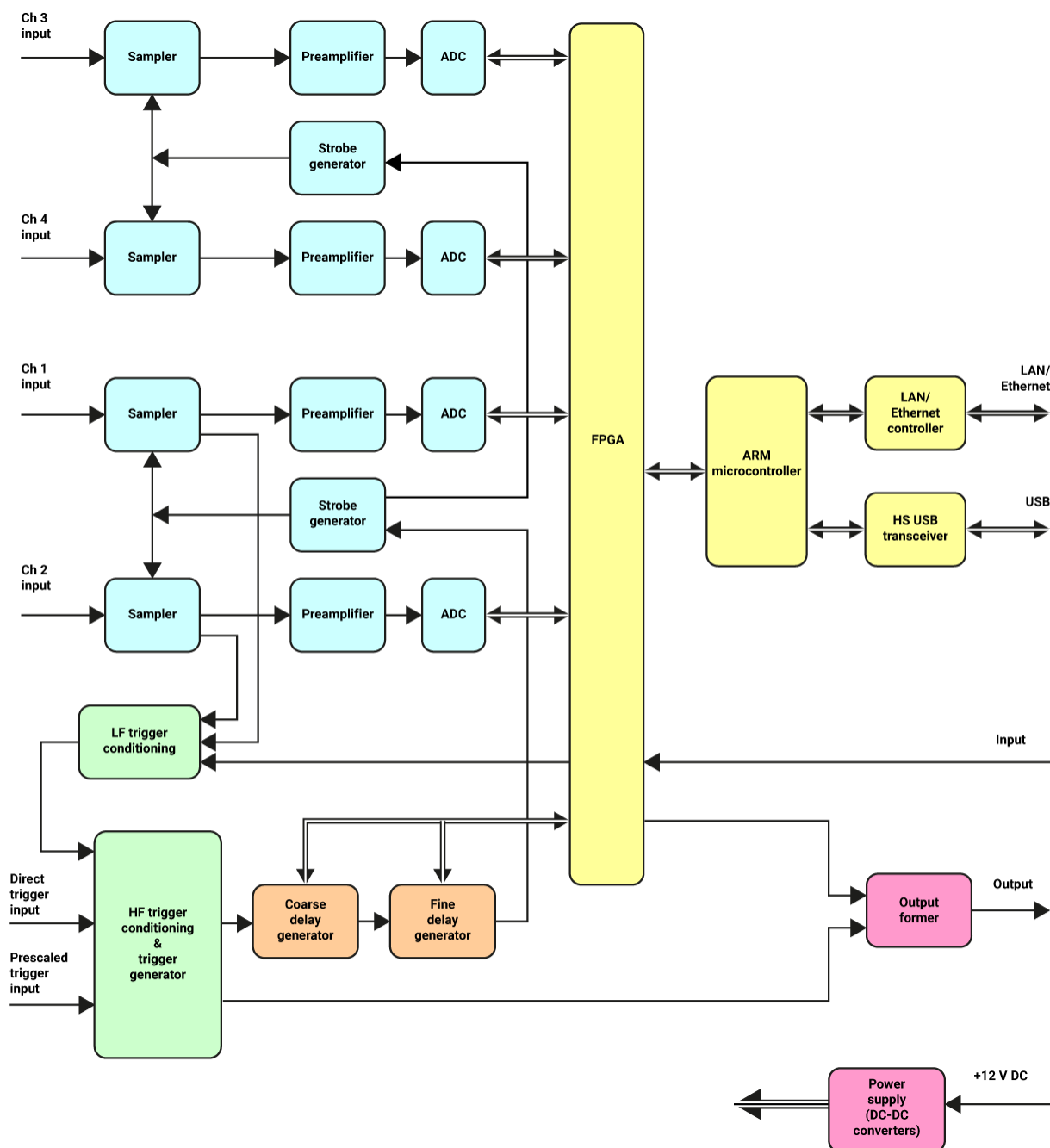
8.6   PicoScope 9341 block diagram

The PicoScope 9341 hardware block diagram is shown in the figure below. Block-level
description describes the major hardware components within the block diagram.

The PicoScope 9341 hardware block diagram

8.7   Block-level description

The hardware components of the PicoScope 9300 Series oscilloscopes are as follows.

8.7.1   Hardware components for PicoScope 9300 models

Sampler

Each of the channels consists of a diode gate and sampling capacitor. The incoming signal is applied to the input of the diode gate, which is normally biased off. When a trigger event occurs, the strobe-generator produces a pull-down, which momentarily forward biases the gate and allows the input signal to charge the capacitor.

Strobe generator

The strobe generator transforms the low frequency trigger pulse from the output of the fine delay generator into a narrow impulse that drives the sampler. The width of this impulse must be as narrow as possible because it directly affects the bandwidth of a vertical channel.

Pre-amplifiers

Two pre-amplifiers are used for each channel. The preamplifier senses the voltage on the sampling capacitor and conditions it in preparation for digitizing in the A/D converter.

ADCs

Two ADCs are used for each channel. The A/D converter tracks the peak value of the analog pulse at its input and converts it to a 16-bit digital word. These 16-bit words are put into the PC's memory, which is then read and processed by the CPU.

HF trigger conditioning and trigger generator

The trigger generator receives the trigger input from different trigger sources and sends a signal to the coarse delay generator whenever an edge meeting the trigger criteria is received when the trigger is enabled.

LF trigger conditioning

This hardware selects one of the LF trigger sources (channel 1/2, internal clock), and also trigger slope, coupling and hysteresis.

Coarse delay generator

The coarse delay generator controls the time between when it receives a trigger input from the trigger generator and when it sends an output to the fine delay generator. These delays time increase sequentially with each trigger event, allowing the trace to build up from left to right across the screen. The delay values depend on the record length and timebase setting, and are programmed by the system CPU with minimum 2 ns step.

Fine delay generator

The fine delay generator controls the time between when it receives a trigger input from the coarse delay generator and when it sends an output to the strobe generator. These delay times also increase sequentially with each trigger event, allowing the trace to build up from left to right across the screen. The delay values depend on the record length and timebase setting, and are programmed by the system CPU with minimum approximately 64 fs step.

Output former

Output former provides step, pulse or pattern signals used for different applications including TDR/TDT.

ARM microcontroller

The ARM microcontroller controls sample acquisition through the FPGA, and also controls all communication with the PC through USB and LAN interfaces.

HS USB transceiver

A standard slave USB controller for communication with PC.

LAN/Ethernet controller

Provides connection to local area network.

Power supply

The power supply provides necessary stabilized DC power voltages from incoming +12 V DC from power adaptor.

8.7.2   Hardware components for PicoScope 9302 and PicoScope 9321

Clock Recovery Trigger

The Clock Recovery hardware provides triggering from a PRBS pattern with up to 11.3 Gbps data rate.

8.7.3   Hardware components for PicoScope 9321 only

Optical-to-Electrical Converter

The Optical-to-Electrical Converter is used for the conversion of optical signals to electrical signals within a 9.5 GHz optical bandwidth.

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