Tektronix®

4 Series MSO

Mixed Signal Oscilloscope Datasheet

dataTec

Mess- und Prüftechnik. Die Experten.

Ihr Ansprechpartner / Your Partner:

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More Display. More Signals. More Usability.

Key performance specifications

With a remarkably innovative pinch-swipe-zoom touchscreen user interface, a high-definition display, and 4 or 6 FlexChannel® inputs that let you measure one analog or eight digital signals per channel, the 4 Series MSO is ready for today's toughest challenges, and tomorrow's too. It sets a new standard for performance, analysis, and overall user experience.

Input channels

- 4 or 6 FlexChannel® inputs
- Each FlexChannel provides:
  - One analog signal that can be displayed as a waveform view, a spectrum view, or both simultaneously
  - Eight digital logic inputs with TLP058 logic probe

Bandwidth (all analog channels)

- 200 MHz, 350 MHz, 500 MHz, 1 GHz, 1.5 GHz (upgradable)

Sample rate (all analog / digital channels)

- Real-time: 6.25 GS/s

Record length (all analog / digital channels)

- 31.25 Mpoints standard (62.5 Mpoints optional upgrade)

Waveform capture rate

- >500,000 waveforms/s

Vertical resolution

- 12-bit ADC
- Up to 16-bits in High Res mode

Standard trigger types

- Edge, Pulse Width, Runt, Timeout, Window, Logic, Setup & Hold, Rise/Fall Time, Parallel Bus, Sequence, Visual Trigger, Video (optional), RF vs. Time (optional)
- Auxiliary Trigger ≤300 V_{RMS} (Edge Trigger only)

Standard analysis

- Cursors: Waveform, V Bars, H Bars, V&H Bars
- Measurements: 36
- Spectrum View: Frequency-domain analysis with independent controls for frequency and time domains
- FastFrame™: Segmented memory acquisition mode with maximum trigger rate >5,000,000 waveforms per second
- Plots: Time Trend, Histogram, and Spectrum
- Math: Basic waveform arithmetic, FFT, and advanced equation editor
- Search: Search on any trigger criteria

Optional analysis

- Advanced Spectrum View
- RF vs. Time traces, triggers, Spectrograms, and IQ capture
- Mask/Limit Testing
- Advanced Power Measurements and Analysis
- Three-Phase Electrical Analysis (6 channel model only)

Optional protocol trigger, decode, and analysis

I^2C, SPI, eSPI, I3C, RS-232/422/485/UART, SPMI, SMBus, CAN, CAN FD, LIN, FlexRay, SENT, PSI5, CXPI, USB 2.0, eUSB2, Ethernet, EtherCAT, Audio, MIL-STD-1553, ARINC 429, Spacewire, NRZ, Manchester, SVID, SDLC, 1-Wire, MDIO, and NFC

Arbitrary/Function Generator (optional and upgradable)

- 50 MHz waveform generation
- Waveform Types: Arbitrary, Sine, Square, Pulse, Ramp, Triangle, DC Level, Gaussian, Lorentz, Exponential Rise/Fall, Sin(x)/x, Random Noise, Haversine, Cardiac

Digital voltmeter (free with product registration)

- 4-digit AC RMS, DC, and DC+AC RMS voltage measurements

Trigger frequency counter (free with product registration)

- 8-digit

Display

- 13.3 inch (338 mm) TFT color
- High Definition (1,920 x 1,080) resolution
- Capacitive (multi-touch) touchscreen

Connectivity

- USB 2.0 Host, USB 2.0 Device (5 ports); LAN (10/100/1000 Base-T Ethernet); HDMI; Requires connection to high definition display (1,920 x 1,080 resolution)

Warranty

- 3 years standard

Dimensions

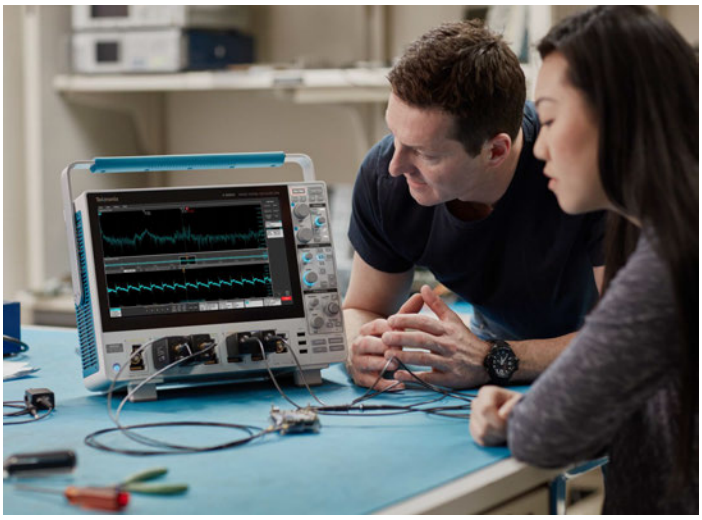
- 11.299 in (286.99 mm) H x 15.9 in (405 mm) W x 6.1 in (155 mm) D
- Weight: < 16.8 lbs. (7.6 kg)

Never let a lack of channels slow down your verification and debug process again!

The 4 Series MSO offers better visibility into complex systems by offering four and six channel models with a 13.3-inch high-definition (1,920 x 1,080) display. Many applications, such as embedded systems, three-phase power electronics, automotive electronics, power supply design, and DC-to-DC power converters, require the observation of more than four analog signals to verify and characterize device performance, and to debug challenging system issues.

Most engineers can recall situations in which they were debugging a particularly difficult problem and wanted greater system visibility and context, but the scope they were using was limited to two or four analog channels. Using a second scope involves significant effort to align trigger points, difficulty in determining timing relationships across the two displays, and documentation challenges.

And while you might assume that a six channel scope would cost 50% more than a four-channel scope, you'll be pleasantly surprised to find that six channel models are only ~20% more than four channel models. The additional analog channels can pay for themselves quickly by enabling you to keep current and future projects on schedule.



Voltage measurements on a switch-mode power supply showing the ripple voltage on one of the power rails.

FlexChannel® technology enables maximum flexibility and broader system visibility

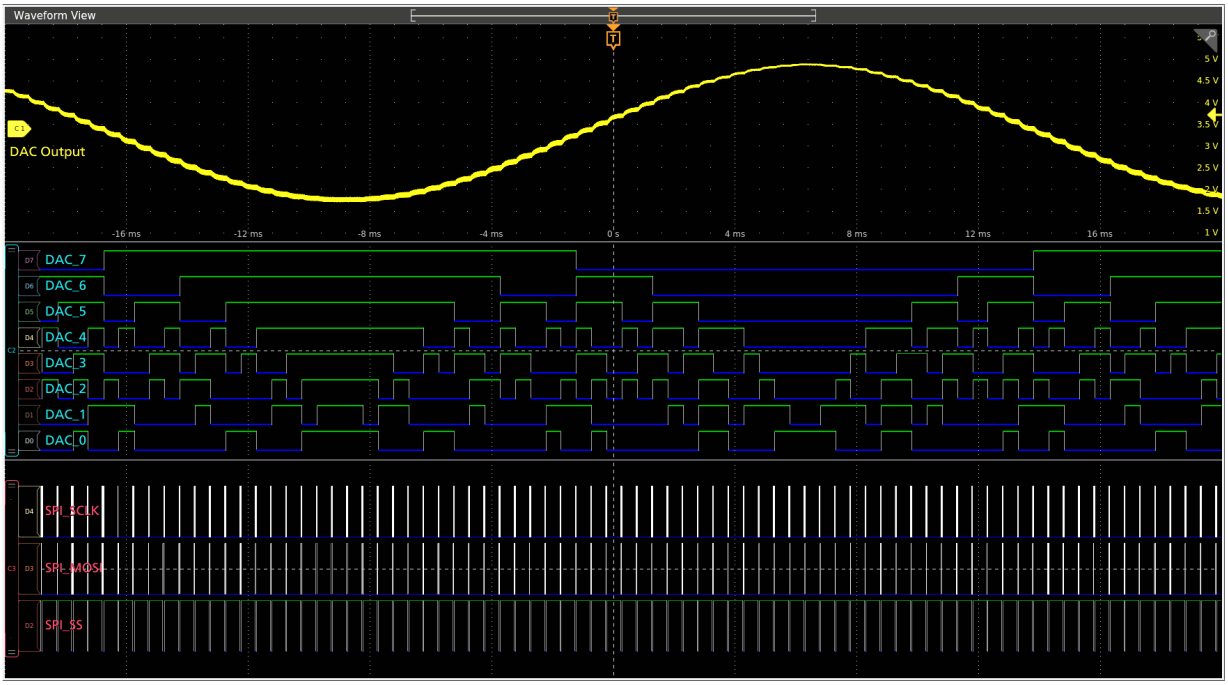
The 4 Series MSO redefines what a Mixed Signal Oscilloscope (MSO) should be. FlexChannel technology enables each channel input to be used as a single analog channel, eight digital logic inputs (with the TLP058 logic probe), or simultaneous analog and spectrum views with independent acquisition controls for each domain. Imagine the flexibility and configurability this provides.

With a six FlexChannel model, you can configure the instrument to look at six analog and zero digital signals. Or five analog and eight digital. Or four analog and 16 digital, three analog and 24 digital and so on. You can change the configuration at any time by simply adding or removing TLP058 logic probes, so you always have the right number of digital channels.

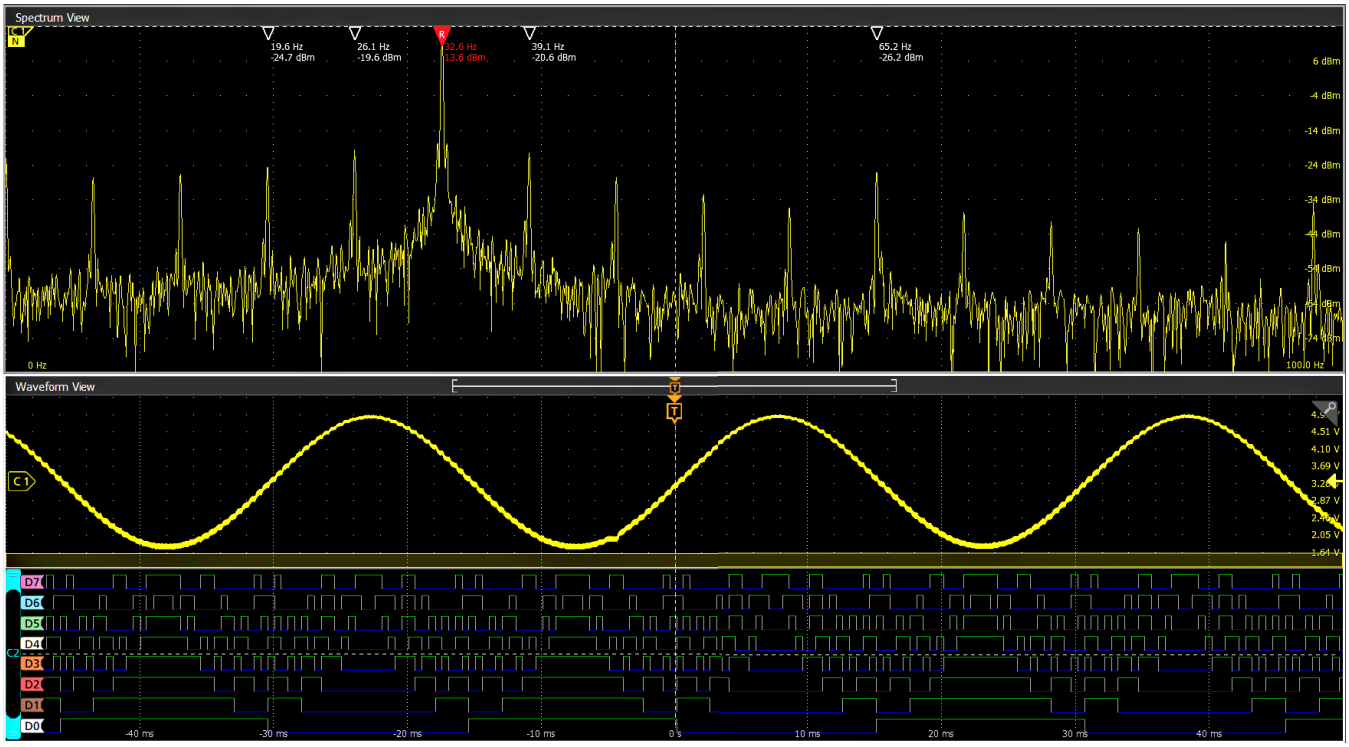
FlexChannel technology enables the ultimate in flexibility. Each input can be configured as a single analog or eight digital channels based on the type of probe you attach.

Previous-generation MSOs required tradeoffs, with digital channels having lower sample rates or shorter record lengths than analog channels. The 4 Series MSO offers a new level of integration of digital channels. Digital channels share the same high sample rate (up to 6.25 GS/s), and long record length (up to 62.5 M points) as analog channels.

The TLP058 provides eight high performance digital inputs. Connect as many TLP058 probes as you like, enabling up to a maximum of 48 digital channels.



Channel 2 has a TLP058 Logic Probe connected to the eight inputs of a DAC. Notice the green and blue color coding, where ones are green and zeros are blue. Another TLP058 Logic Probe on Channel 3 is probing the SPI bus driving the DAC. The white edges indicate higher frequency information is available by either zooming in or moving to a faster sweep speed on the next acquisition.

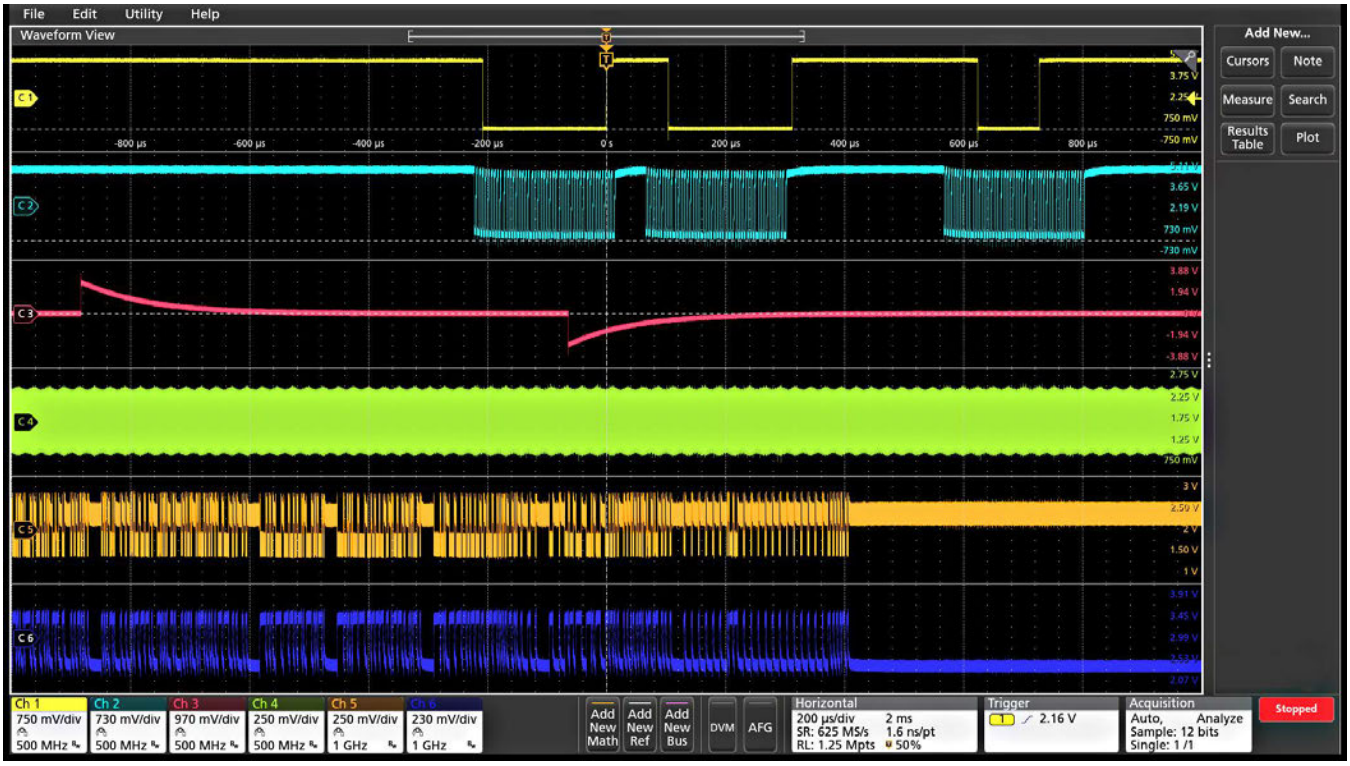


Beyond just analog and digital, FlexChannel inputs include Spectrum View. This Tektronix-patented technology enables you to simultaneously view both analog and spectral views of all your analog signals, with independent controls in each domain.

Unprecedented signal viewing capability

The stunning 13.3inch (338 mm) display is the largest display in its class. It is also the highest resolution display, with full HD resolution (1,920 x 1,080), enabling you to see many signals at once with ample room for critical readouts and analysis.

The viewing area is optimized to ensure that the maximum vertical space is available for waveforms. The Results Bar on the right can be hidden, enabling the waveform view to use the full width of the display.



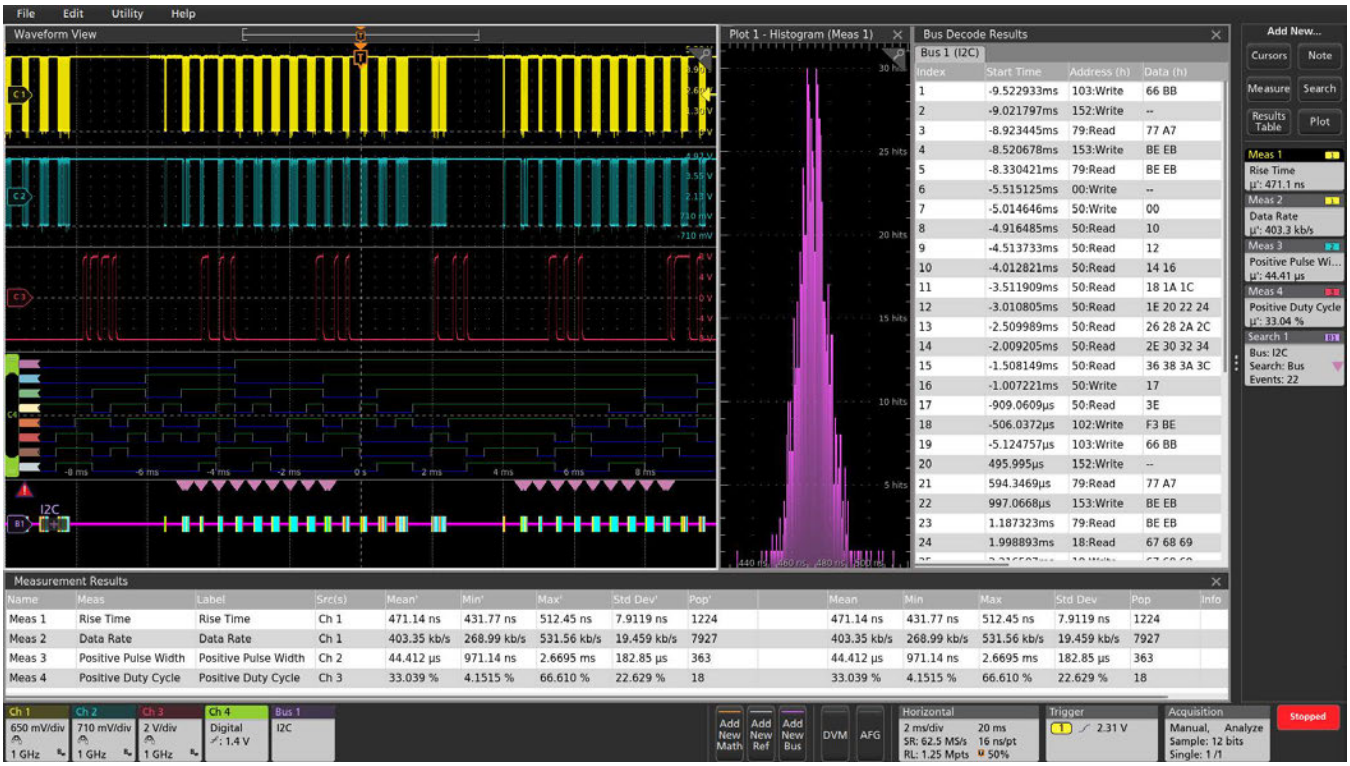
Stacked display mode enables easy visibility of all waveforms while maintaining maximum ADC resolution on each input for the most accurate measurements.

The 4 Series MSO offers a revolutionary new Stacked display mode. Historically, scopes have overlaid all waveforms in the same graticule, forcing difficult tradeoffs:

- To make each waveform visible, you vertically scale and position each waveform so that they don't overlap. Each waveform uses a small percentage of the available ADC range, leading to less accurate measurements.
- For measurement accuracy, you vertically scale and position each waveform to cover the entire display. The waveforms overlap each other, making it hard to distinguish signal details on individual waveforms

The new Stacked display eliminates this tradeoff. It automatically adds and removes additional horizontal waveform 'slices' (additional graticules) as waveforms are created and removed. Each slice represents the full ADC range for the waveform. All waveforms are visually separated from each other while still using the full ADC range, enabling maximum visibility and accuracy. And it's all done automatically as waveforms are added or removed! Channels can easily be reordered in stacked display mode by dragging and dropping the channel and waveform badges in the Settings bar at the bottom of the display. Groups of channels can also be overlaid within a slice to simplify visual comparison of signals.

The large display also provides plenty of viewing area not only for signals, but also for plots, measurement results tables, bus decode tables and more. You can easily resize and relocate the various views to suit your application.



Viewing three analog channels, eight digital channels, a decoded serial bus waveform, decoded serial packet results table, four measurements, a measurement histogram, measurements results table with statistics and a search on serial bus events - simultaneously!

Exceptionally easy-to-use user interface lets you focus on the task at hand

The Settings Bar - key parameters and waveform management

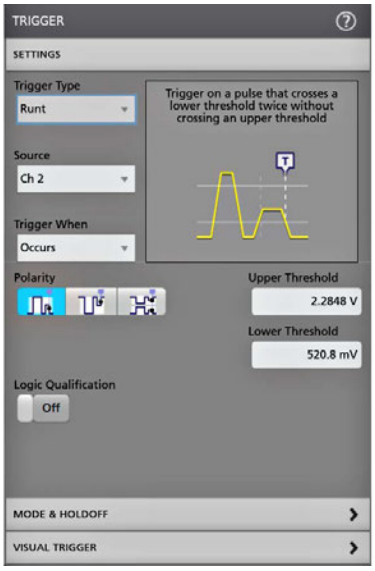
Waveform and scope operating parameters are displayed in a series of "badges" in the Settings Bar that runs along the bottom of the display. The Settings Bar provides Immediate access for the most common waveform management tasks. With a single tap, you can:

- Turn on channels
- Add math waveforms
- Add reference waveforms
- Add bus waveforms
- Enable the optional integrated Arbitrary/Function generator (AFG)
- Enable the optional integrated digital voltmeter (DVM)

The Results Bar - analysis and measurements

The Results Bar on the right side of the display includes immediate, one-tap access to the most common analytical tools such as cursors, measurements, searches, measurement and bus decode results tables, plots, and notes.

DVM, measurement and search results badges are displayed in the Results Bar without sacrificing any waveform viewing area. For additional waveform viewing area, the Results Bar can be dismissed and brought back at any time.



Configuration menus are accessed by simply double-tapping on the item of interest on the display. In this case, the Trigger badge was double-tapped to open the Trigger configuration menu.

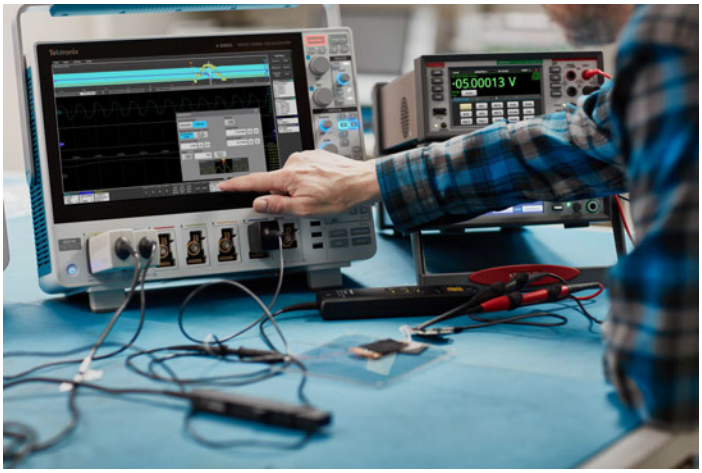
Touch interaction finally done right

Oscilloscopes have included touch screens for years, but the touch interface has been an afterthought. The 4 Series MSO display includes a capacitive touchscreen and provides the industry's first oscilloscope user interface truly designed for touch.

The touch interactions that you use with phones and tablets, and expect in a touch enabled device, are supported.

- Drag waveforms left/right or up/down to adjust horizontal and vertical position or to pan a zoomed view
- Pinch and expand to change scale or zoom in/out in either horizontal or vertical directions
- Drag items to the trash can or drag them off the edge of the screen to delete them
- Swipe in from the right to reveal the Results Bar or down from the top to access the menus in the upper left corner of the display

Smooth, responsive front panel controls allow you to make adjustments with familiar knobs and buttons, and you can add a mouse or keyboard as a third interaction method.

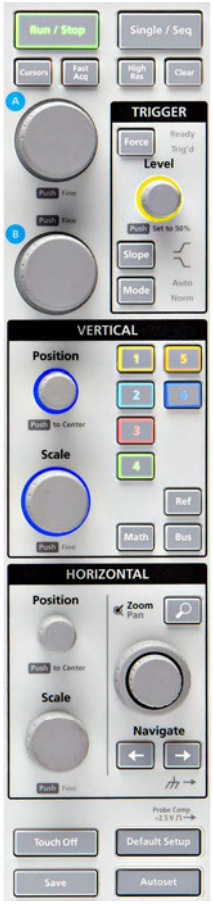


Interact with the capacitive touch display in the same way you do on your phones and tablets.

Variable font size

Historically, oscilloscope user interfaces have been designed with fixed font sizes to optimize viewing of waveforms and readouts. This implementation is fine if all users have the same viewing preferences, but they don't. Users spend a significant amount of time staring at screens, and Tektronix recognizes this. The 4 Series MSO offers a user preference for variable font sizes; scaling down to 12 points or up to 20 points. As you adjust the font size, the user interface dynamically scales so you can easily choose the best size for your application.

Comparison showing how the user interface scales as font size changes.



Efficient and intuitive front panel provides critical controls while still leaving room for the large high definition display.

Attention to detail in the front-panel controls

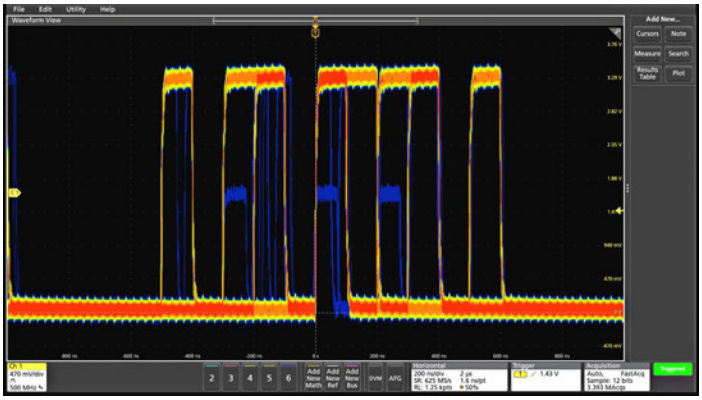
Traditionally, the front face of a scope has been roughly 50% display and 50% controls. The 4 Series MSO display fills about 75% of the face of the instrument. To achieve this, it has a streamlined front panel that retains critical controls for simple intuitive operation, but with a reduced number of menu buttons for functions directly accessed via objects on the display.

Color-coded LED light rings indicate trigger source and vertical scale/ position knob assignments. Large, dedicated Run/ Stop and Single Sequence buttons are placed prominently in the upper right, and other functions like Force Trigger, Trigger Slope, Trigger Mode, Default Setup, Auto-set and Quick-save functions are all available using dedicated front panel buttons.

Experience the performance difference

Digital Phosphor technology with FastAcq™ high-speed waveform capture

To debug a design problem, first you must know it exists. Digital phosphor technology with FastAcq provides you with fast insight into the real operation of your device. Its fast waveform capture rate - greater than 500,000 waveforms per second - gives you a high probability of seeing the infrequent problems common in digital systems: runt pulses, glitches, timing issues, and more. To further enhance the visibility of rarely occurring events, intensity grading indicates how often rare transients are occurring relative to normal signal characteristics.



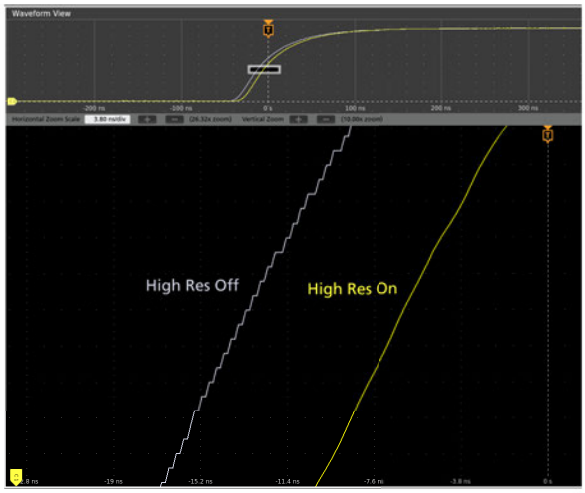
FastAcq's high waveform capture rate enables you to discover infrequent problems common in digital design.

Industry leading vertical resolution

The 4 Series MSO provides the performance to capture the signals of interest while minimizing the effects of unwanted noise when you need to capture high-amplitude signals while seeing smaller signal details. At the heart of the instrument are 12-bit analog-to-digital converters (ADCs) that provide 16 times the vertical resolution of traditional 8-bit ADCs.

A new High Res mode applies a hardware-based unique Finite Impulse Response (FIR) filter based on the selected sample rate. The FIR filter maintains the maximum bandwidth possible for that sample rate while preventing aliasing and removing noise from the oscilloscope amplifiers and ADC above the usable bandwidth for the selected sample rate. High Res mode always provides at least 12 bits of vertical resolution and extends all the way to 16 bits of vertical resolution at ≤125 MS/s sample rates.

New lower-noise front end amplifiers further improve your ability to resolve fine signal detail.



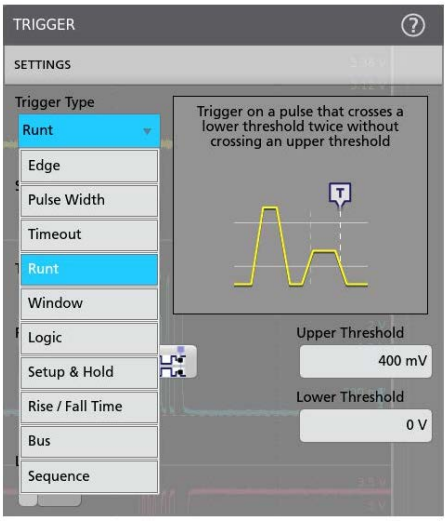
12-bit ADC, along with the new High Res mode, enable industry leading vertical resolution.

Triggering

Discovering a device fault is only the first step. Next, you must capture the event of interest to identify root cause. The 4 Series MSO provides a complete set of advanced triggers, including:

- Runt
- Logic
- Pulse width
- Window
- Timeout
- Rise/Fall time
- Setup and Hold violation
- Serial packet
- Parallel data
- Sequence
- Video
- Visual Trigger
- RF vs. Time (optional)

With up to a 62.5 Mpoint record length, you can capture many events of interest, even thousands of serial packets in a single acquisition, providing high-resolution to zoom in on fine signal details and record reliable measurements.

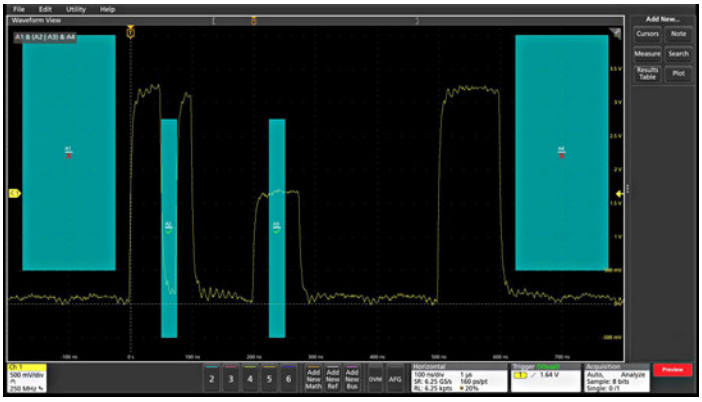


The wide variety of trigger types and context-sensitive help in the trigger menu make it easier than ever to isolate the event of interest.

Visual Trigger - finding the signal of interest quickly

Finding the right cycle of a complex bus can require hours of collecting and sorting through thousands of acquisitions for an event of interest. Defining a trigger that isolates the desired event speeds up debug and analysis efforts.

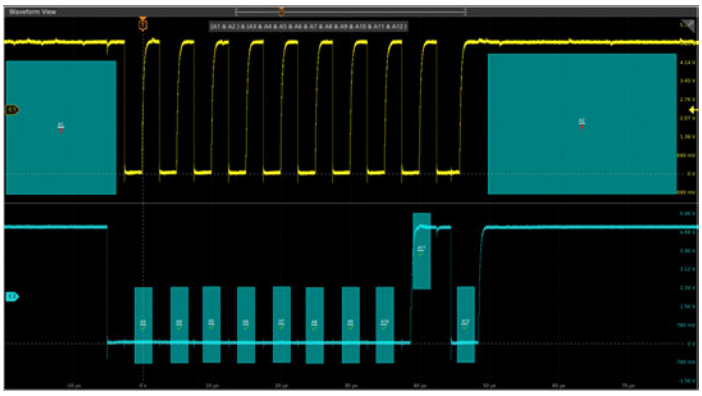
Visual Trigger extends the instrument's triggering capabilities by scanning through all waveform acquisitions and comparing them to on-screen areas (geometric shapes). You can create an unlimited number of areas using the mouse or touchscreen, and a variety of shapes (triangles, rectangles, hexagons, or trapezoids) can be used to specify the desired trigger behavior. Once shapes are created, they can be edited interactively to create custom shapes and ideal trigger conditions. Once multiple areas are defined, a Boolean logic equation can be used to set complex trigger conditions using on-screen editing features.



Visual Trigger areas isolate an event of interest, saving time by only capturing the events you want to see.

By triggering only on the most important signal events, Visual Trigger can save hours of capturing and manually searching through

acquisitions. In seconds or minutes, you can find the critical events and complete your debug and analysis efforts. Visual Trigger even works across multiple channels, extending its usefulness to complex system troubleshooting and debug tasks.



Multiple channel triggering. Visual Trigger areas can be associated with events spanning multiple channels, such as triggering on a specific burst-width on channel 1 and a specified bit pattern on channel 2.

Accurate high-speed probing

The TPP Series passive voltage probes offer all the benefits of general-purpose probes - high dynamic range, flexible connection options, and robust mechanical design - while providing the performance of active probes. Up to 1 GHz analog bandwidth enables you to see high frequency components in your signals, and extremely low 3.9 pF capacitive loading minimizes adverse effects on your circuits and is more forgiving of longer ground leads.

An optional, low-attenuation (2X) version of the TPP probe is available for measuring low voltages. Unlike other low-attenuation passive probes, the TPP0502 has high bandwidth (500 MHz) as well as low capacitive loading (12.7 pF).

The instrument includes a standard one probe per channel (TPP0250 for 200 MHz models, TPP0500B for 350 MHz and 500 MHz models, TPP1000 for 1 GHz and 1.5 GHz models).

TekVPI Probe Interface

The TekVPI® probe interface sets the standard for ease of use in probing. In addition to the secure, reliable connection that the interface provides, many TekVPI probes feature status indicators and controls, as well as a probe menu button right on the comp box itself. This button brings up a probe menu on the oscilloscope display with all relevant settings and controls for the probe. The TekVPI interface enables direct attachment of current probes without requiring a separate power supply. TekVPI probes can be controlled remotely through USB or LAN, enabling more versatile solutions in ATE environments. The 4 Series MSO provides up to 80 W of power to the front panel connectors, sufficient to power all connected TekVPI probes without the need for an additional probe power supply.

IsoVu™ Isolated Measurement System

Whether designing an inverter, optimizing a power supply, testing communication links, measuring across a current shunt resistor, debugging EMI or ESD issues, or trying to eliminate ground loops in your test setup, common mode interference has caused engineers to design, debug, evaluate, and optimize "blind" until now.

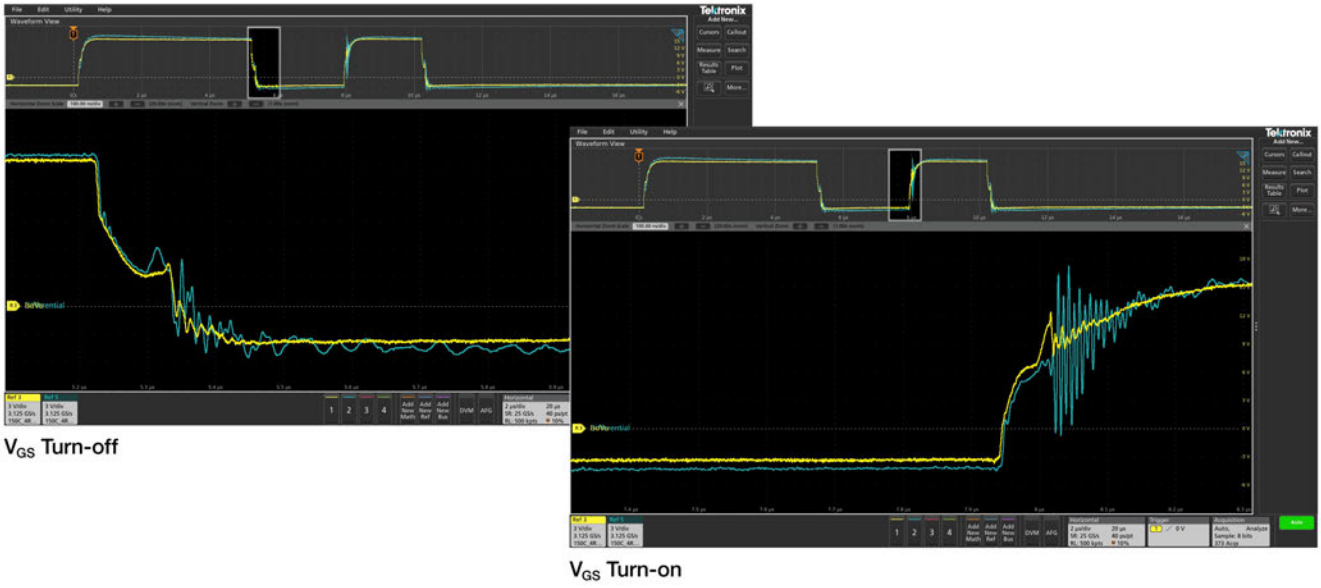
The revolutionary Tektronix IsoVu technology uses optical communications and power-over-fiber for complete galvanic isolation. When combined with the 4 Series MSO equipped with the TekVPI interface, it is the first, and only, measurement system capable of accurately resolving high bandwidth, differential signals, in the presence of large common mode voltage with:

- Complete galvanic isolation
- Up to 1 GHz bandwidth
- 1 Million to 1 (120 dB) common mode rejection at 100 MHz
- 10,000 to 1 (80 dB) of common mode rejection at full bandwidth
- Up to 2,500 V differential dynamic range
- 60 kV common mode voltage range

The Tektronix TIVP Series IsoVu™ Measurement System offers a galvanically isolated measurement solution to accurately resolve high bandwidth, differential signals up to 2,500 Vpk in the presence of large common mode voltages, with the best-in-class common mode rejection performance across its bandwidth.

High-side gate voltage measurement with IsoVu

The following image shows a comparison of the high-side gate voltage for a standard differential probe versus an optically isolated probe. For both at turn-off and turn-on, high-frequency ringing can be seen on the gate after the device's gate passes through the threshold region. Due to coupling between the gate and power loop, some ringing is expected. However, in the case of the differential probe, the ringing has a significantly higher amplitude than is measured by the optically isolated probe. This is likely due to the changing reference voltage inducing common mode currents within the probe and an artifact of a standard differential probe. While the waveform measured by the differential probe appears to pass the maximum gate voltage of the device, the more accurate measurement of the optically isolated probe makes it clear that the device is within specification. Application designers using standard differential probes for gate voltage measurements should use caution as it may not be possible to differentiate between the probing and measurement system artifact shown here and an actual violation of the device ratings. This measurement artifact may cause the designer to increase the gate resistance to slow down the switching transient and reduce the ringing. However, this would unnecessarily increase losses in the SiC device. For this reason, it is essential to have a measurement system that accurately reflects the actual dynamics of the device, in order to appropriately design the system and optimize performance.



Differential Probe (blue trace) vs. IsoVu Optically Isolated Probe (yellow trace)

Comprehensive analysis for fast insight

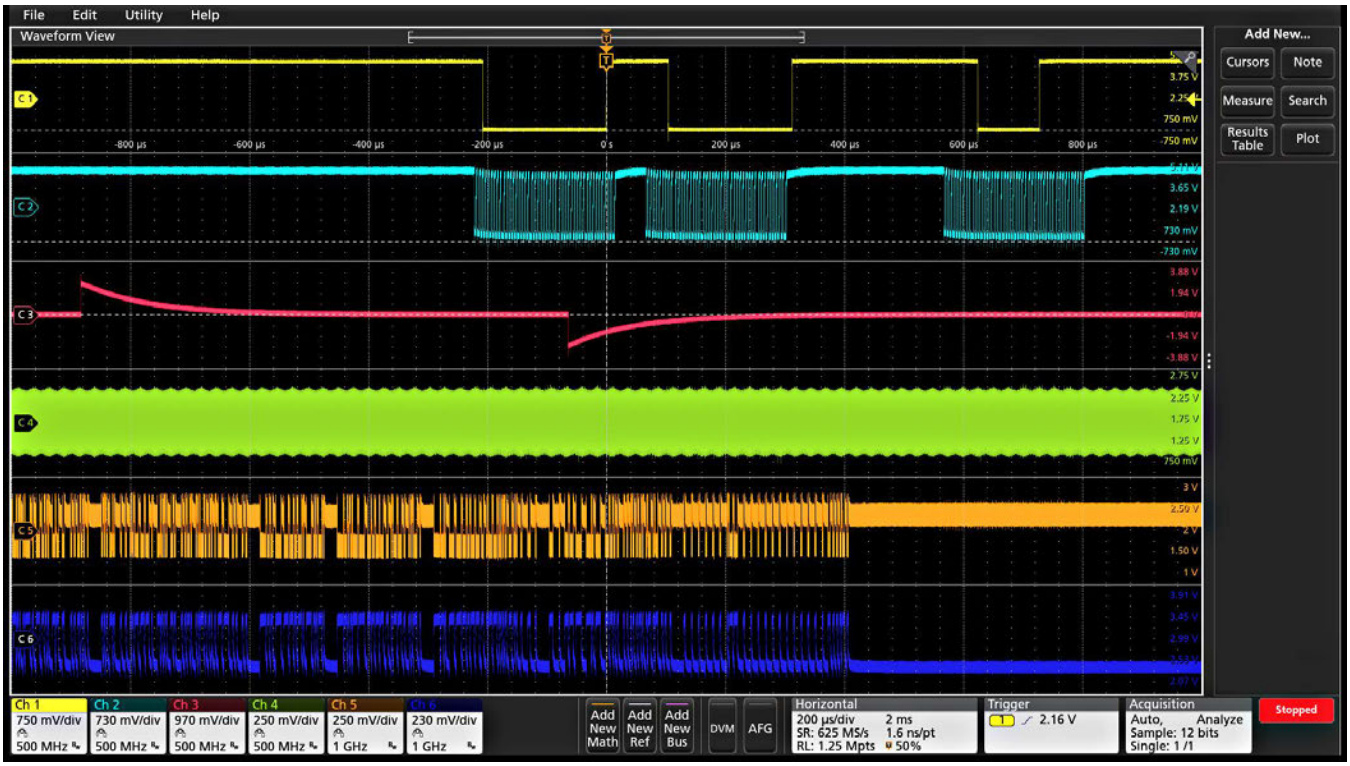
Basic waveform analysis

Verifying that your prototype's performance matches simulations and meets the project's design goals requires careful analysis, ranging from simple checks of rise times and pulse widths to sophisticated power loss analysis, characterization of system clocks, and investigation of noise sources.

The 4 Series MSO offers a comprehensive set of standard analysis tools including:

- Waveform- and screen-based cursors
- 36 automated measurements. Measurement results include all instances in the record, the ability to navigate from one occurrence to the next, and immediate viewing of the minimum or maximum result found in the record
- Basic waveform math
- Basic FFT analysis
- Advanced waveform math including arbitrary equation editing with filters and variables
- Spectrum View frequency domain analysis with independent controls for time and frequency domains
- FastFrame™ Segmented Memory enables you to make efficient use of the oscilloscope's acquisition memory by capturing many trigger events in a single record while eliminating the large time gaps between events of interest. View and measure the segments individually or as an overlay.

Standard amplitude and time measurements annotate the waveform display with visual bars and markers to indicate relative information. Measurement results tables provide comprehensive statistical views of measurement results with statistics across both the current acquisition and all acquisitions.

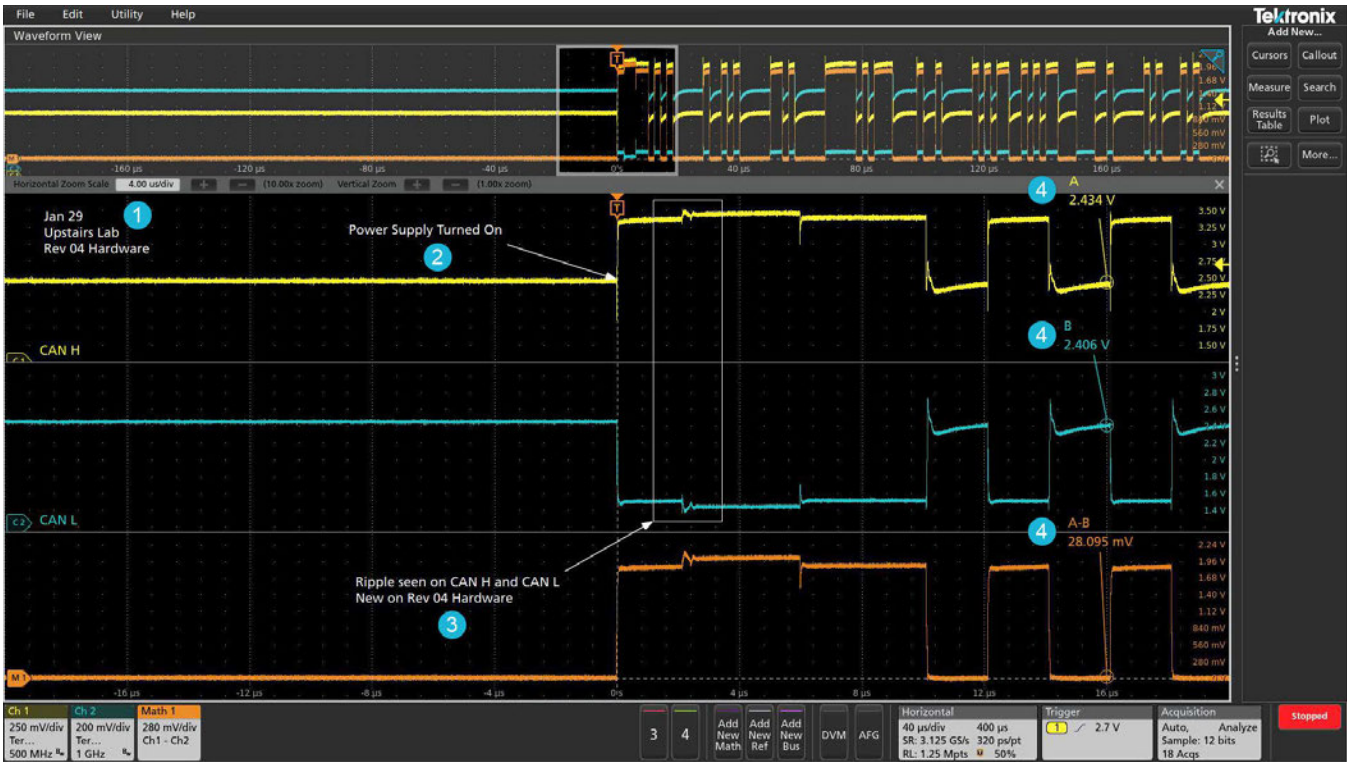


Using multiple channels to visualize multiple clock and data lines.

Callouts

1. **Note**: Write and position a text box on the screen.
2. **Arrow**: Write and position a text box, then add an arrow to a specific location on the screen.
3. **Rectangle**: Write text and outline a specific region on the screen indicated by a resizable box.
4. **Bookmark**: Create a dynamic readout at a specific time relevant to a trigger point. This readout includes text, magnitude of the signal, signal units, as well as a line and target indicating the bookmark reference point.

Documenting test results and methods is critical when sharing data across a team, recreating a measurement at a later date, or delivering a customer report. With a few taps on the screen, you can create as many custom callouts as needed; enabling you to document the specific details of your test results. With each callout, you can customize the text, location, color, font size, and font.



Easy to use callouts (Note, Arrow, Rectangle, Bookmark) that are detailing the specifics of this test setup and corresponding results.

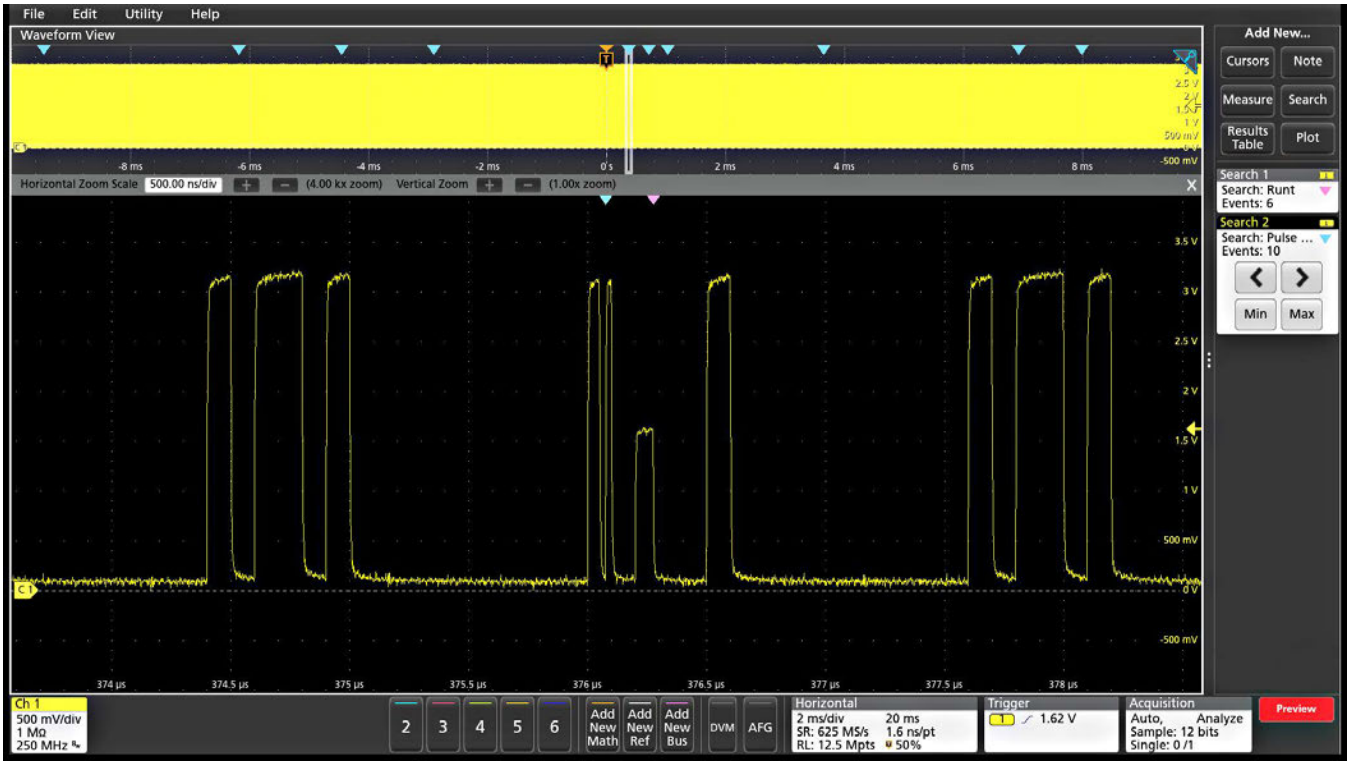
Navigation and search

Finding your event of interest in a long waveform record can be time consuming without the right search tools. With today's record lengths of many millions of data points, locating your event can mean scrolling through literally thousands of screens of signal activity.

The 4 Series MSO offers the industry's most comprehensive search and waveform navigation with its innovative Wave Inspector® controls. These controls speed panning and zooming through your record. With a unique force-feedback system, you can move from one end of your record to the other in just seconds. Or, use intuitive drag and pinch/expand gestures on the display itself to investigate areas of interest in a long record.

The Search feature allows you to automatically search through your long acquisition looking for user-defined events. All occurrences of the event are highlighted with search marks and are easily navigated to, using the Previous (←) and Next (→) buttons found on the front panel or on the Search badge on the display. Search types include edge, pulse width, timeout, runt, window, logic, setup and hold, rise/fall time and parallel/serial bus packet content. You can define as many unique searches as you like.

You can also quickly jump to the minimum and maximum value of search results by using the Min and Max buttons on the Search badge.



Earlier, FastAcq revealed the presence of a runt pulse in a digital data stream prompting further investigation. In this acquisition, Search 1 reveals that there are six runt pulses in the acquisition.

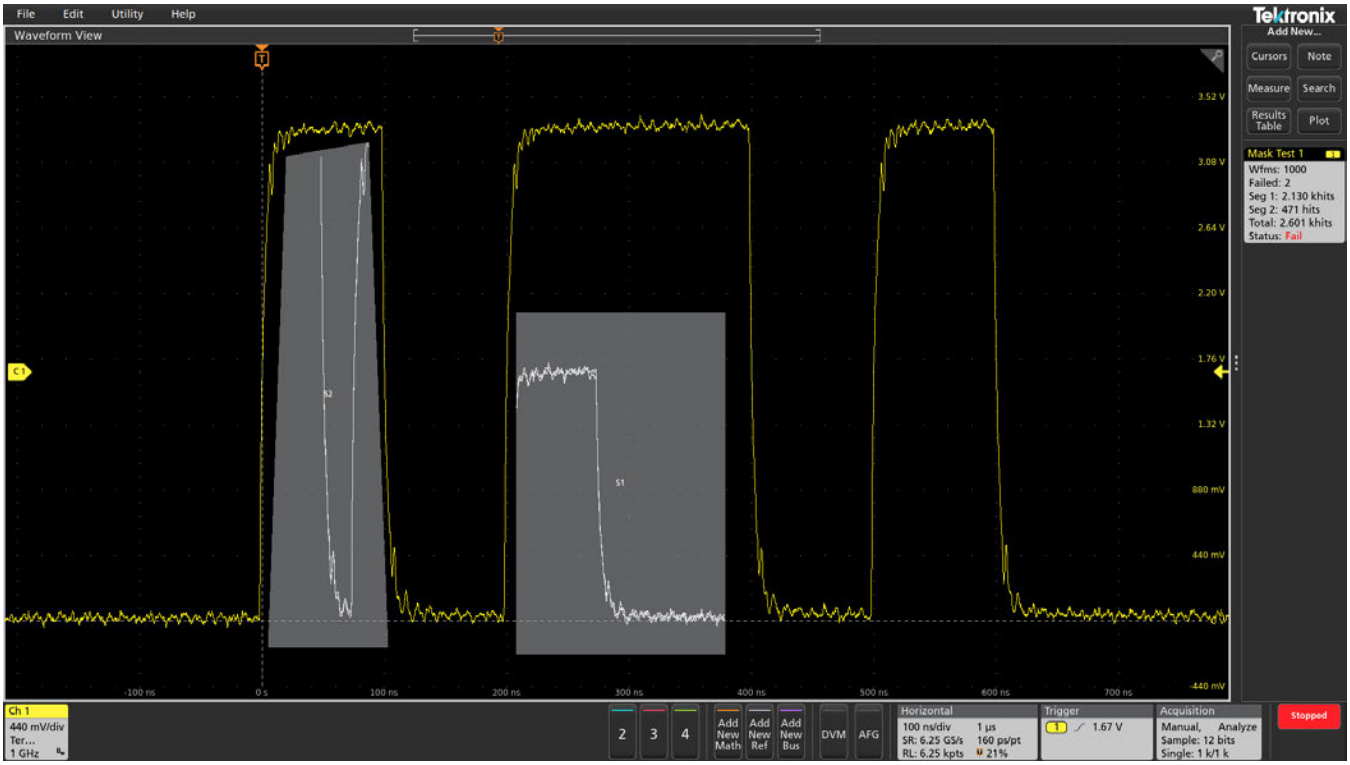
Mask and limit testing (optional)

Whether you are focused on signal integrity or setting up pass/fail conditions for production, mask testing is an efficient tool to characterize the behavior of certain signals in a system. Quickly create custom masks by drawing mask segments on the screen. Tailor a test to your specific requirements and set actions to take when a mask hit is registered, or when a complete test passes or fails.

Limit testing is an insightful way to monitor the long-term behavior of signals, helping you characterize a new design or confirm hardware performance during production line testing. Limit tests compare your live signal to an ideal, or "golden" version of the same signal with user-defined vertical and horizontal tolerances.

You can easily tailor a mask or limit test to your specific requirements by:

- Defining test duration in number of waveforms
- Setting a violation threshold that must be met before considering a test a failure
- Counting violations/failures and reporting statistical information
- Setting actions upon violations, test failure, and test complete



Custom, multiple segment mask capturing the presence of a signal glitch and runt pulse in a waveform.

Protocol decode and analysis (optional)

During debugging, it can be invaluable to trace the flow of activity through a system by observing the traffic on one or more serial buses. It could take many minutes to manually decode a single serial packet, much less the thousands of packets that may be present in a long acquisition.

And if you know the event of interest that you are attempting to capture occurs when a particular command is sent across a serial bus, wouldn't it be nice if you could trigger on that event? Unfortunately, it's not as easy as simply specifying an edge or a pulse width trigger.

Triggering on a CAN serial bus. A bus waveform provides time-correlated decoded packet content including Start, Arbitration, Control, Data, CRC and ACK while the bus decode table presents all packet content from the entire acquisition.

The 4 Series MSO offers a robust set of tools for working with the most common serial buses found in embedded design including I^2C, SPI, eSPI, I3C, RS-232/422/485/UART, SPMI, SMBus, CAN, CAN FD, LIN, FlexRay, SENT, PSI5, CXPI, USB LS/FS/HS, eUSB2.0, Ethernet 10/100, EtherCAT, Audio (I2S/LJ/RJ/TDM), MIL-STD-1553, ARINC 429, Spacewire, NRZ, Manchester, SVID, SDLC, 1-Wire, MDIO, and NFC.

Protocol search enables you to search through a long acquisition of serial packets and find the ones that contain the specific packet content you specify. Each occurrence is highlighted by a search mark. Rapid navigation between marks is as simple as pressing the Previous (←) and Next (→) buttons on the front panel or in the Search badge that appears in the Results Bar.

The tools described for serial buses also work on parallel buses. Support for parallel buses is standard in the instrument. Parallel buses can be up to 48 bits wide and can include a combination of analog and digital channels.

- Serial protocol triggering lets you trigger on specific packet content including start of packet, specific addresses, specific data content, unique identifiers, and errors.
- Bus waveforms provide a higher-level, combined view of the individual signals (clock, data, chip enable, and so on) that make up your bus, making it easy to identify where packets begin and end, and identifying sub-packet components such as address, data, identifier, CRC, and so on.
- The bus waveform is time aligned with all other displayed signals, making it easy to measure timing relationships across various parts of the system under test.
- Bus decode tables provide a tabular view of all decoded packets in an acquisition much like you would see in a software listing. Packets are time stamped and listed consecutively with columns for each component (Address, Data, and so on).

NFC decode and analysis (optional)

Evaluating the performance margins of NFC designs is often difficult due to an inability to trace the protocol-level result down to the parametric signal level. This means marginal passes may result in failures later in the test flow, especially when designs are susceptible to interference and signal integrity issues caused by design trade-offs or nearby electronics, requiring time consuming debug across multiple instruments like a protocol analyzer and RF signal analyzer.

The NFC Protocol Decode and Search option on the 4 Series MSO offers users the ability to view the transaction of the NFC link and trace the result through every step of signal manipulation in the standard, from the protocol-level down to the fundamental signal level to gain insight into exactly how your NFC chip, tag, reader, or mobile device is performing.

NFC transactions can be long. The software option uniquely uses the data coming from the hardware DDC used for Spectrum View, which allows for sample rate compression, saving transfer time and memory, allowing for 100s of milliseconds or even seconds of signal data to be captured and analyzed.

Additionally, because I/O signals are not always available to probe and trigger on from the device under test, triggering on the RF envelope itself is also a challenge considering NFC's small modulation index. With Spectrum View, you can trigger on the 13.56 MHz envelope using RF vs. Time traces and triggers, which is also unique amongst instruments.

This capability simplifies up-front design validation and also provides a powerful debugging tool in a single instrument when failures do occur.

NFC software option allows you to decode and search through their digital NFC bit stream for performing NFC analog/RF and digital pre-conformance, debug, and troubleshooting in a single instrument.

Spectrum View

It is often easier to debug an issue by viewing one or more signals in the frequency domain. Oscilloscopes have included math-based FFTs for decades in an attempt to address this need. However, FFTs are notoriously difficult to use for two primary reasons.

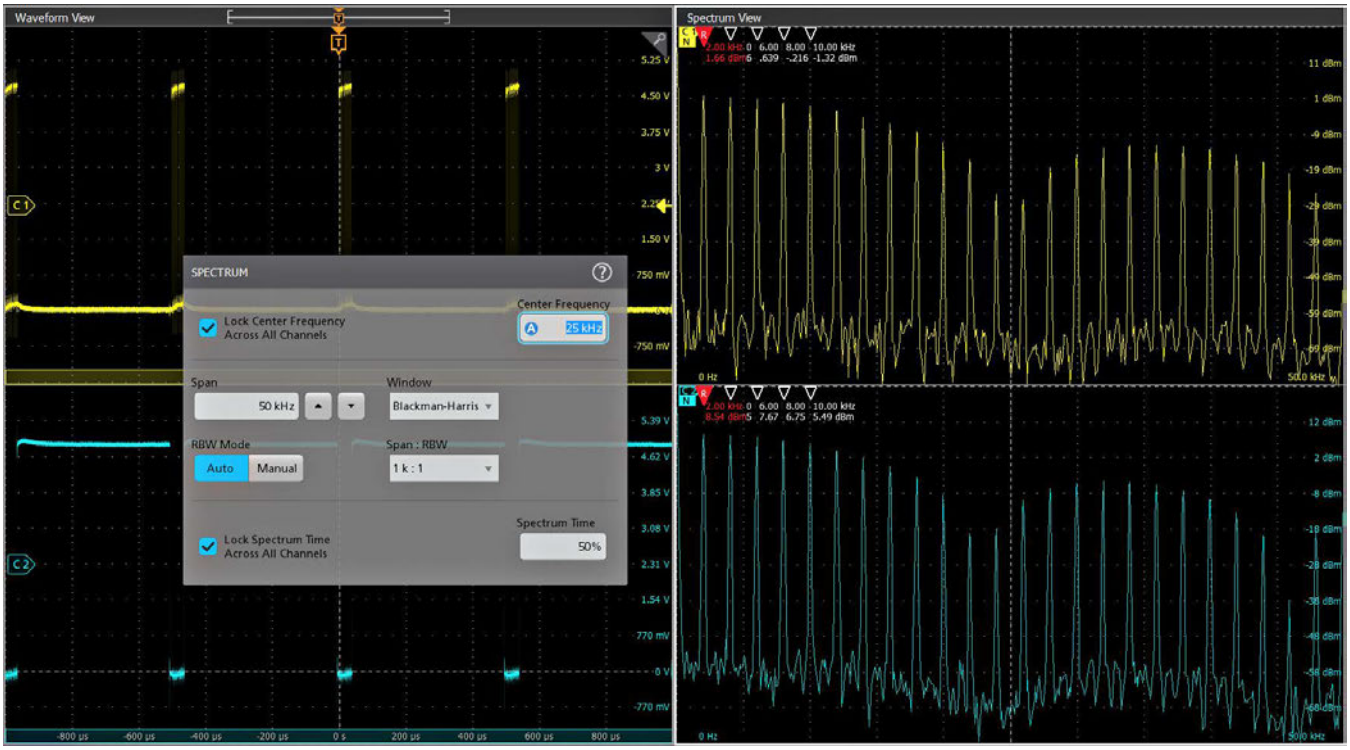
First, when performing frequency-domain analysis, you think about controls like Center Frequency, Span, and Resolution Bandwidth (RBW), as you would typically find on a spectrum analyzer. But then you use an FFT, where you are stuck with traditional scope controls like sample rate, record length and time/div and have to perform all the mental translations to try to get the view you're looking for in the frequency-domain.

Second, FFTs are driven by the same acquisition system that's delivering the analog time-domain view. When you optimize acquisition settings for the analog view, your frequency-domain view isn't what you want. When you get the frequency-domain view you want, your analog view is not what you want. With math-based FFTs, it is virtually impossible to get optimized views in both domains.

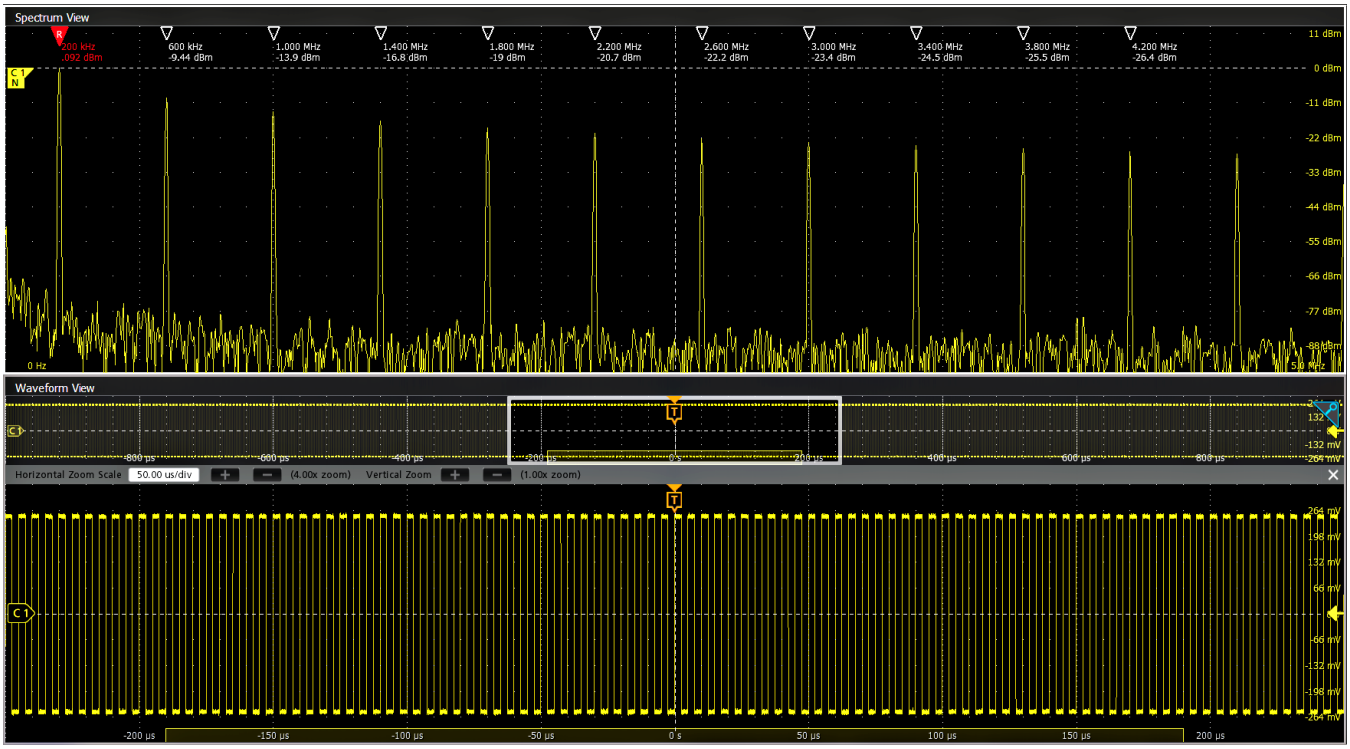
Spectrum View changes all of this. Tektronix' patented technology provides both a decimator for the time-domain and a digital downconverter (DDC) for the frequency-domain behind each FlexChannel. The two different acquisition paths let you simultaneously observe both time- and frequency-domain views of the input signal with independent acquisition settings for each domain. Other manufacturers offer various 'spectral analysis' packages that claim ease-of-use, but they all exhibit the limitations described above. Only Spectrum View provides both exceptional ease-of-use and the ability to achieve optimal views in both domains simultaneously.

Traditionally, performing RF measurements, such as RF Channel Power (CHP), Adjacent Channel Power Ratio (ACPR), and Occupied Bandwidth (OBW), required a dedicated spectrum or signal analyzer or spectrum analyzer software. This additional hardware or software leads to more complexity and higher costs. Available standard with Spectrum View, integrated RF Measurements on each channel saves users time, bench space, and costs with the ability to validate RF transmitter CHP, ACPR, and OBW directly on the oscilloscope.

Additionally, the DDC significantly reduces the required sample rate to resolve a signal compared to a conventional FFT since it becomes a function of span rather than center frequency. This allows for reduced file sizes, improved frequency resolution, and faster spectrum update rates, leading to a more responsive and accurate solution capable of capturing 10's of seconds of spectrum data.



Intuitive spectrum analyzer controls like center frequency, span and resolution bandwidth (RBW), independent from time domain controls, provide easy setup for frequency domain analysis. A spectrum view is available for each FlexChannel analog input, enabling multi-channel mixed domain analysis.



Spectrum Time gates the range of time where the FFT is being calculated. Represented by a small graphical rectangle in the time domain view, it can be positioned to provide time correlation with the time domain waveform. Perfect for conducting Mixed Domain Analysis. Up to 11 automated peak markers provide frequency and magnitude values of each peak. The Reference marker is always the highest peak shown and is indicated in red.

Visualizing changes in the RF signal (optional)

RF time domain traces make it easy to understand what's happening with a time-varying RF signal. There are three RF time domain traces that are derived from the underlying I and Q data of Spectrum View:

- Magnitude – The instantaneous amplitude of the spectrum vs. time.
- Frequency – The instantaneous frequency of the spectrum relative to the center frequency vs. time.
- Phase – The instantaneous phase of the spectrum relative to the center frequency vs. time.

Each of these traces can be turned on and off independently, and all three can be displayed simultaneously.

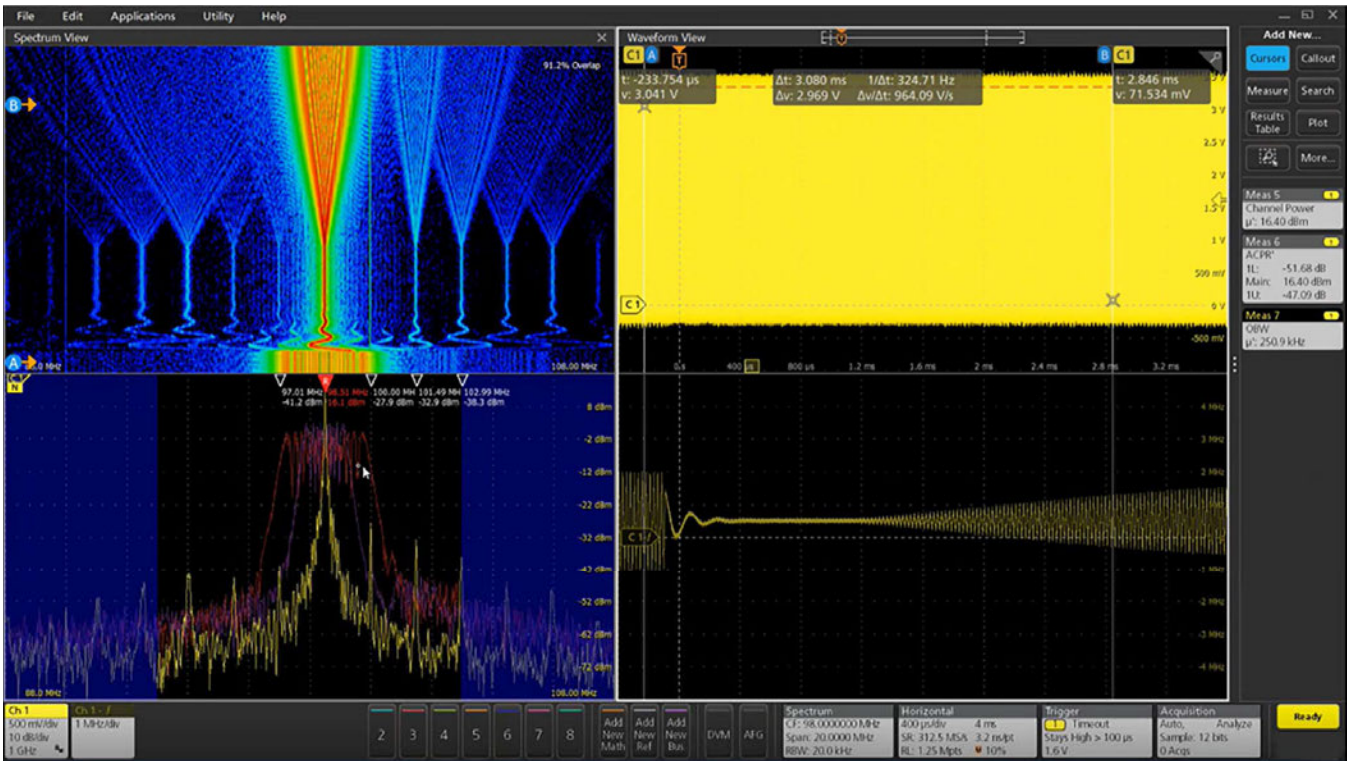
The data is stored as in-phase and quadrature (I&Q) samples and precise synchronization is maintained between the time domain data and the I&Q data.

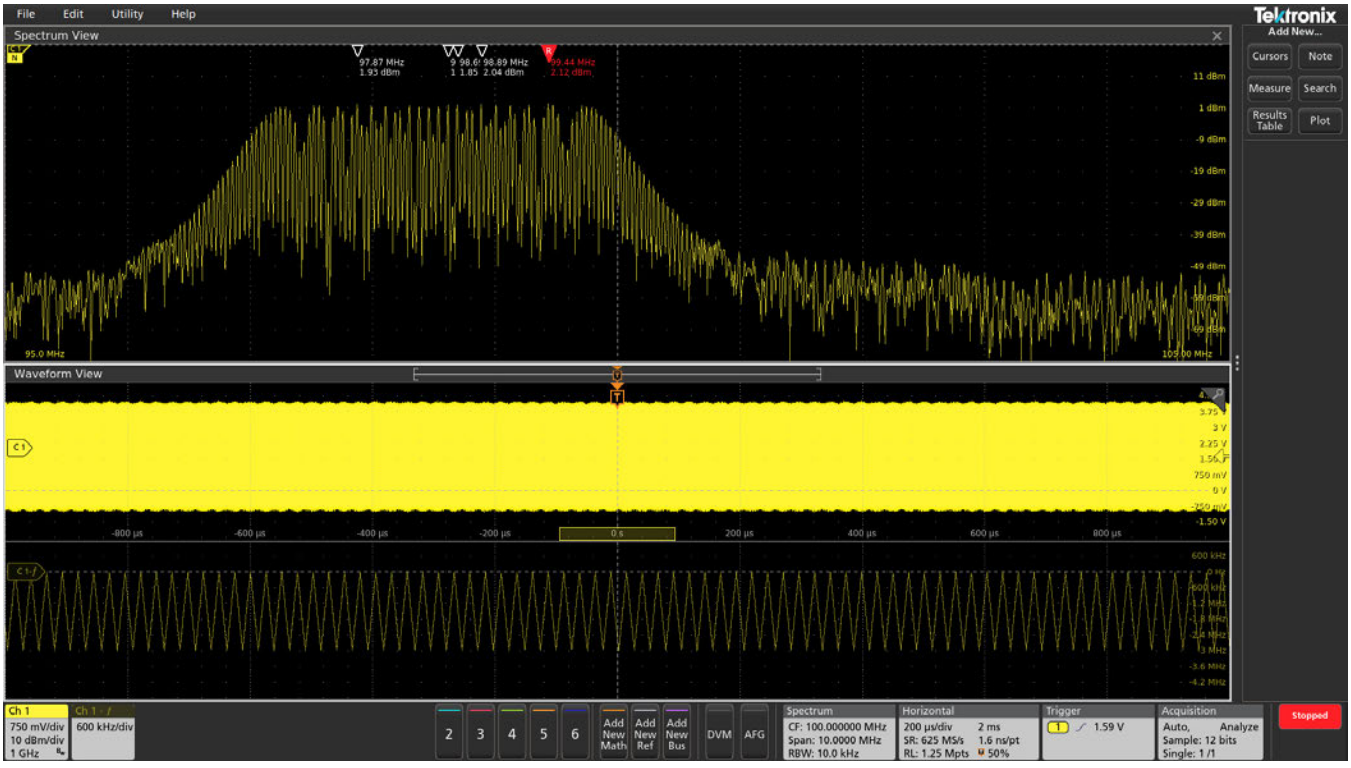
When RF vs. Time traces are activated, IQ data can be captured and exported to file for more advanced analysis within 3rd party applications.

With frequency on the x-axis, time on the y-axis, and power level indicated by variations in color, the Spectrogram display (included with option RFVT) offers enhanced insight into changes in signal amplitude and frequency content over time, allowing you to see where and when changes in spectral activity occur. This makes it ideal for displaying trends in spectral data such as when diagnosing complex spurious, frequency hopping, multi-channel, and dynamic signals.

Spectrogram benefits include:

- Ability to view all spectrum activity in a given span and acquisition immediately, without having to specify FFT overlap or Spectrum Time
- Quickly compare spectrum at different moments in time using time-correlated cursors and up to three overlaid spectrum traces
- Pinch and zoom in on spectral activity of interest with display resolution and FFT overlap automatically optimized
- Adjust center frequency, span, RBW, and amplitude color-scaling as needed to view all signals of interest
- Simultaneously view trends in multi-channel or non-contiguous spectrum by activating spectrograms on each available oscilloscope channel and independently setting center frequency and amplitude scaling





The lower trace is the frequency vs. time trace derived from the input signal. Notice that the Spectrum Time is positioned during a transition from the lowest frequency to the middle frequency, so the energy is spread across a number of frequencies. With the frequency vs. time trace, you can easily see the different frequency hops, simplifying characterization of how the device switches between frequencies.

Triggering on changes in the RF signal (optional)

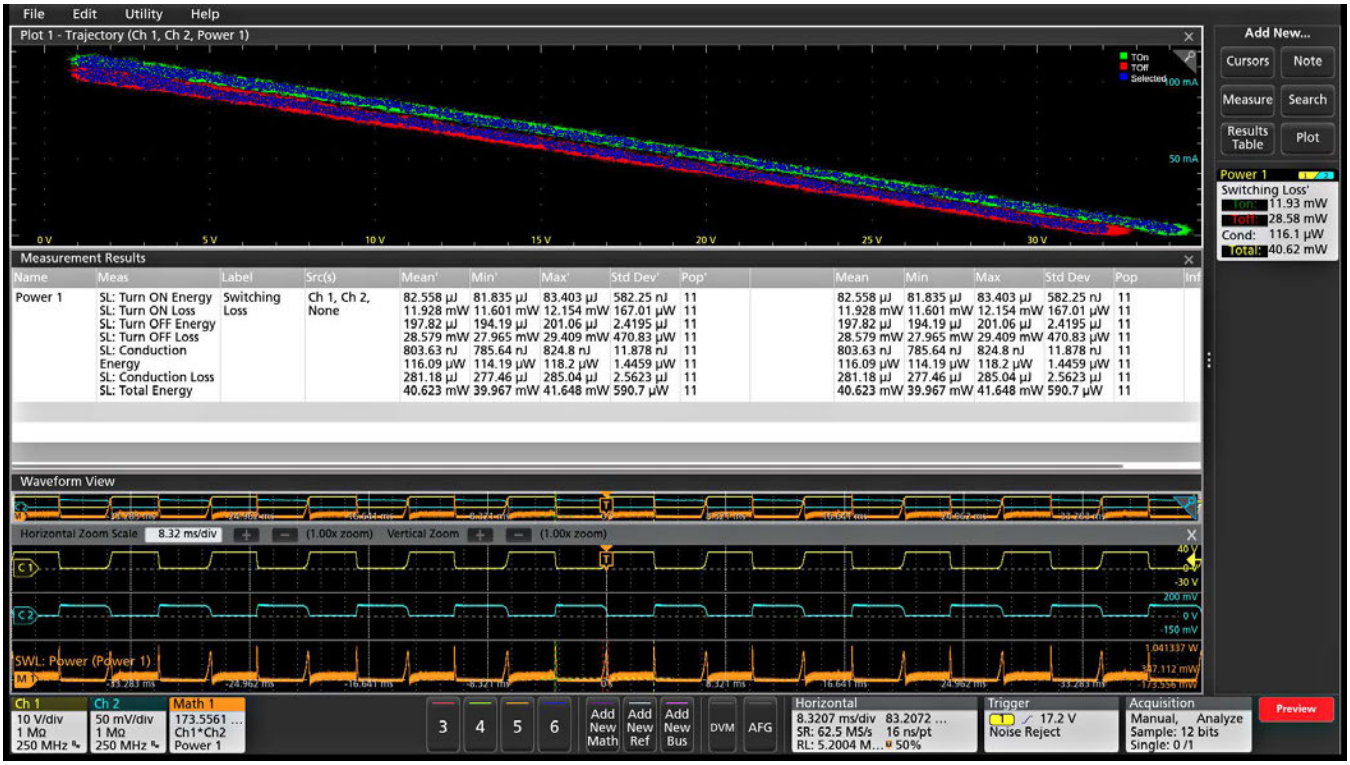
Whether you need to find the source of electromagnetic interference or understand the behavior of a VCO, hardware triggers for RF versus time make it easy to isolate, capture, and understand the RF signal behavior. Trigger on edges, pulse widths, and timeout behavior of RF magnitude vs. time and RF frequency vs. time.

Power analysis (optional)

The 4 Series MSO has also integrated the optional power analysis package into the oscilloscope automatic measurement system to enable quick and repeatable analysis of power quality, input capacitance, in-rush current, harmonics, switching loss, safe operating area (SOA), modulation, ripple, efficiency, amplitude and timing measurements, and slew rate (dv/dt and di/dt).

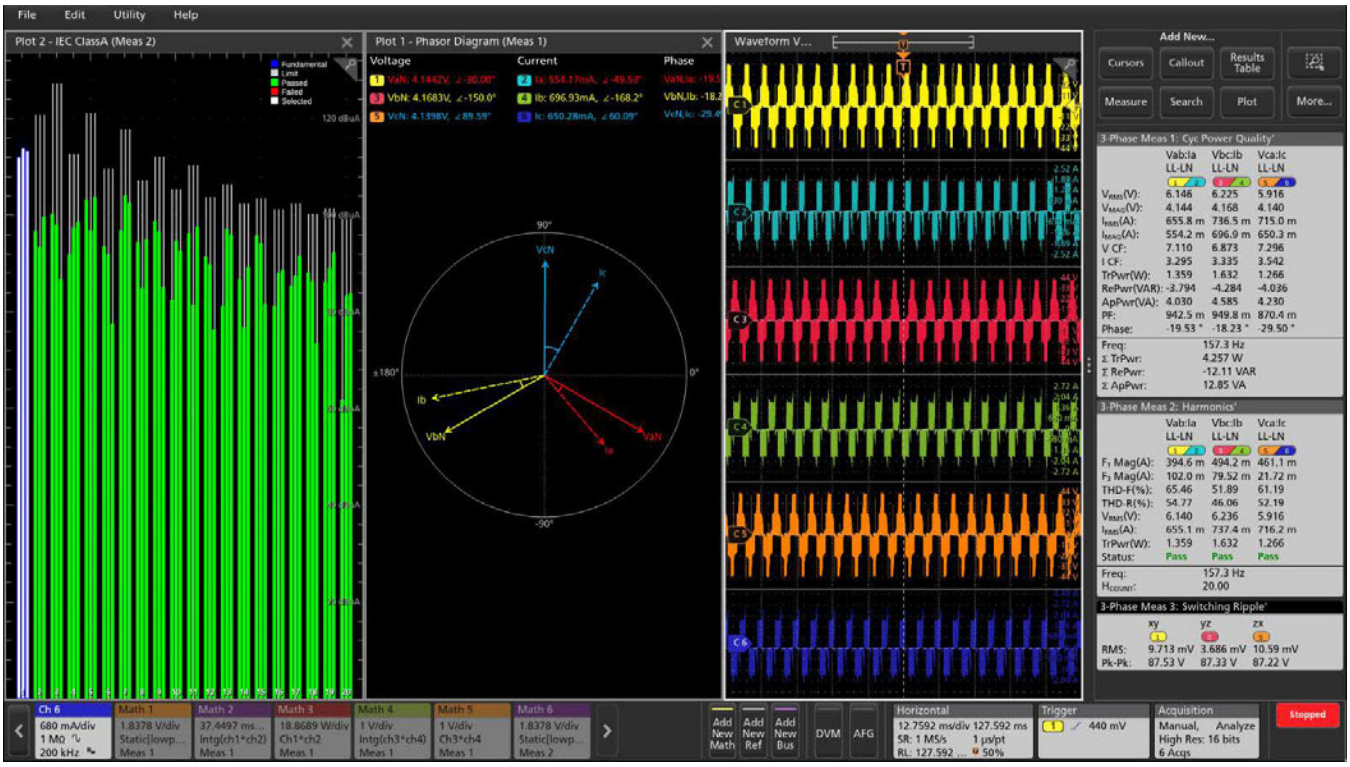
Measurement automation optimizes the measurement quality and repeatability at the touch of a button, without the need for an external PC or complex software setup.

An optional advanced power analysis package provides all the measurements delivered by power analysis package plus Magnetics measurements, Control Loop Response (Bode Plot), and Power Supply Rejection Ratio (PSRR). See the ordering information section for more information.



The Power Analysis measurements display a variety of waveforms and plots.

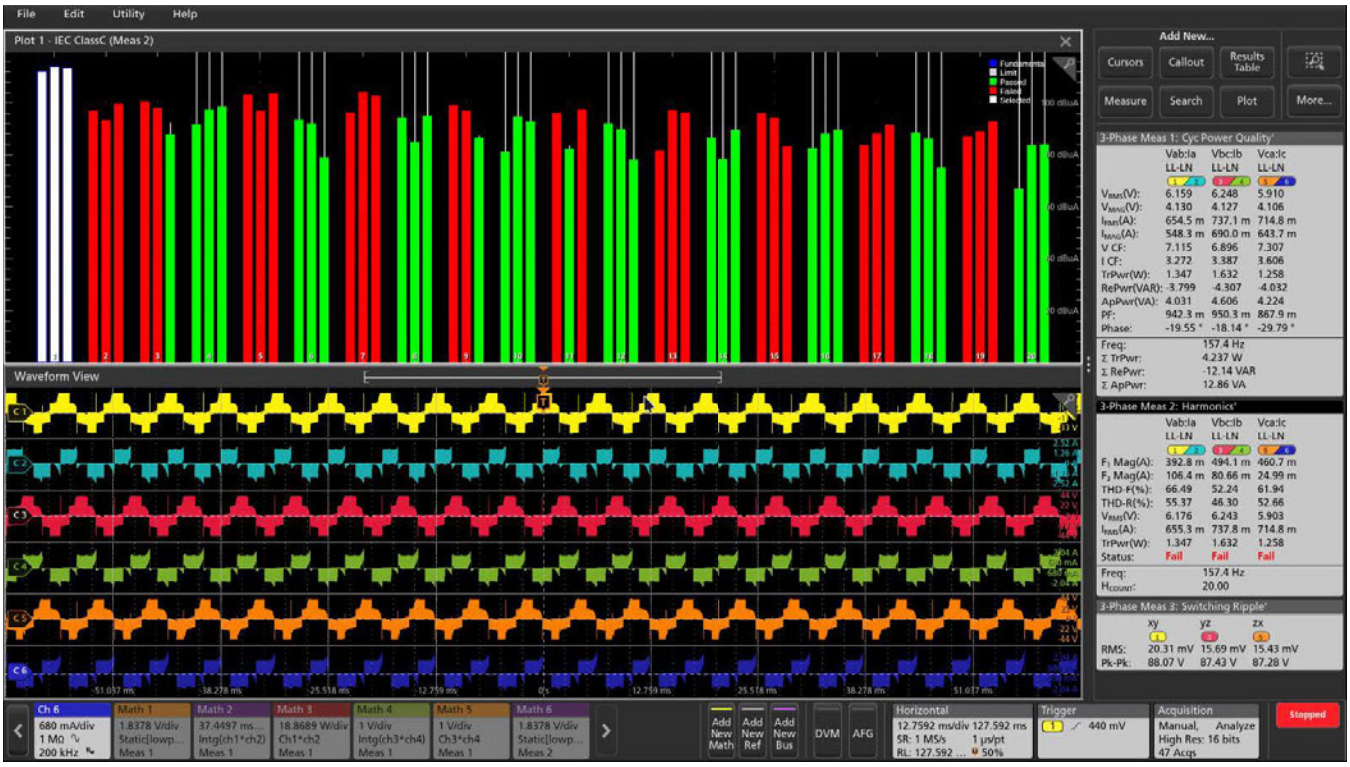
Three-phase electrical analysis (optional)



The power quality measurement provides an in-depth insight into the three-phase signals with an oscilloscope-based phasor diagram.

Measurements and analysis of the three-phase power systems are inherently more complex than on the single-phase systems. Although oscilloscopes can capture voltage and current waveforms with high sample rates, further calculations are required to generate the key power measurements from the data. The oscilloscope based three-phase solution captures the three-phase voltage and current waveforms with the higher sample rates and longer record lengths using the HiRes acquisition mode up to 16-bits. Also, the three-phase solution generates the key power test results with the support of automated measurements. The power converters based on the Pulse Width Modulation (PWM) can complicate measurements since it is very important to extract precise zero crossings for the PWM signals, thus making an oscilloscope a recommended test tool for validation and troubleshooting for designers.

The software is designed specially to automate the power analysis that simplifies the important three-phase power measurements on the PWM systems and helps the engineers to get faster insights into their designs. The three-phase analysis solution from Tektronix helps the engineer's design better and more efficient three-phase systems, taking full advantage of the advanced user interface, six analog input channels, and 'High Res' mode (16 bits) on the instrument. The solution provides fast, accurate, and repeatable results for the supported electrical measurements. It can also be configured to measure DC to three-phase AC converters, such as those used in the electric vehicles.



The harmonics plot indicates passing harmonics test results. Each set of bars contains results for phases A, B, and C for easy correlation. The set of green bars indicate a pass and the red bars indicate a fail.

Key features and specifications:

- Accurately analyze three-phase PWM signals.
- Unique oscilloscope-based phasor diagrams indicate the VRMS, IRMS, VMAG, IMAG, and phase relationships at a glance for the configured wiring pairs.
- Debug the three-phase designs by viewing the drive input / output voltage and current signals in the time domain simultaneously with the phasor diagram.
- The Three-phase Autoset feature configures the oscilloscope for the optimal horizontal, vertical, trigger, and acquisition parameters for acquiring three-phase signals.
- Measures three-phase harmonics as per the IEEE-519 standard or using custom limits.
- Quickly add and configure measurements through the intuitive drag and drop interface on the 4 Series MSO.
- Analyze Inverter and automotive three-phase designs for DC-AC topology.
- Displays the PWM filtered edge qualifier waveform during the analysis
- Displays the test results per record, or per cycle mode during analysis for specific measurements.
- Supports Time trend and Acquisition trend plots for specific measurements.
- Supports mathematical conversion of Line-to-Line to Line-to-Neutral for specific wirings.

Measurement overview

The three-phase analysis on the 4 Series MSO automates key electrical measurements which are grouped into three categories:

- Input analysis
- Output analysis
- Ripple analysis

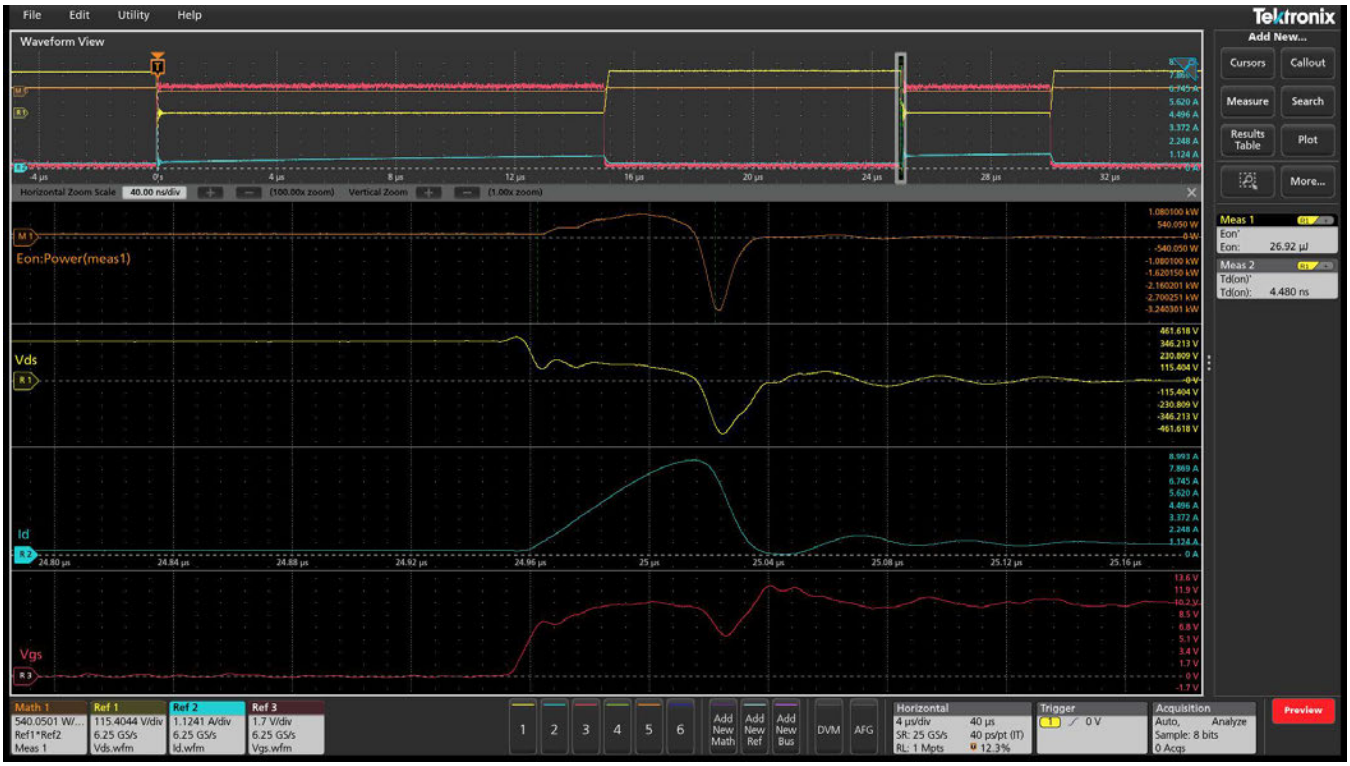
Each of these sections includes key measurements that are critical to the three-phase applications.

Wide Bandgap Double Pulse Test (optional)

The Wide Bandgap Double Pulse Test application offers precise Wide Bandgap measurements that make device and the system validation easier. It has an ability to test SiC or GaN devices and also Si MOSFET and IGBTs. The application is compatible with all the Tektronix VPI probes and when used with the Tektronix IsoVu™ probes, it helps uncover all the hidden artifacts of SiC or GaN devices at the circuit level. The application offers automated measurements as per the JEDEC and IEC standards. It offers unique features such as per-cycle analysis with annotation, flexibility with custom reference level settings, configurable integration points, and power preset that can be set based on the DUT designs.

Following measurements are performed:

- Low side switching parameters and High side diode reverse recovery measurements
- Low side and High side switching parameters



The image shows diode reverse recovery measurements with reverse recovery current and voltage captured on the high-side.

Designed with your needs in mind

Connectivity

The 4 Series MSO contains a number of ports which you can use to connect the instrument to a network, directly to a PC, or to other test equipment.

- Three USB 2.0 ports on the front and two more USB 2.0 host ports on the rear panel enable easy transfer of screen shots, instrument settings, and waveform data to a USB mass storage device. A USB mouse and keyboard can also be attached to USB host ports for instrument control and data entry.
- The rear panel USB Device port is useful for controlling the oscilloscope remotely from a PC.
- The standard 10/100/1000BASE-T Ethernet port on the rear of the instrument enables easy connection to networks and provides LXI Core 2011 compatibility.
- The HDMI port on the rear of the instrument let you duplicate the instrument display on an external monitor or projector with 1,920 x 1,080 resolution.

Remote operation to improve collaboration

Want to collaborate with a design team on the other side of the world?

Simply enter the IP address or network name of the oscilloscope and a web page will be served to the browser. Control the oscilloscope remotely in the exact same way that you do in-person using the built-in touchscreen.

The industry-standard TekVISA™ protocol interface is included for using and enhancing Windows applications for data analysis and documentation. IVI-COM instrument drivers are included to enable easy communication with the oscilloscope using LAN or USBTMC connections from an external PC.

PC-based analysis and remote connection to your oscilloscope

Get the analysis capability of an award-winning oscilloscope on your PC. Analyze waveforms anywhere, anytime. The basic license lets you view and analyze waveforms, perform many types of measurements and decode the most common serial buses - all while remotely accessing your oscilloscope. Advanced license options add capabilities such as multi-scope analysis, more serial bus decoding options, and power measurements.

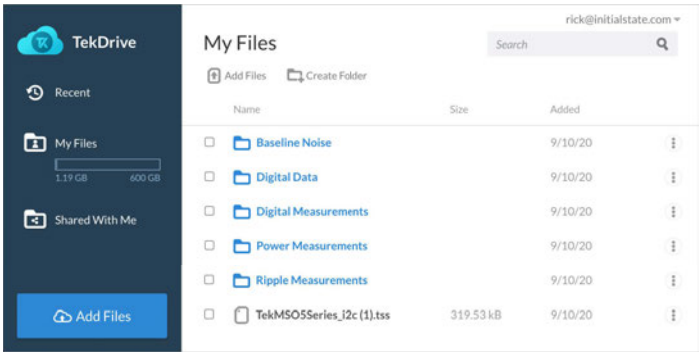
TekScope PC analysis software runs on a Windows computer with the same award-winning user experience as the 4, 5, and 6 Series MSO's

Key features of the TekScope PC analysis software include:

- Recall Tektronix oscilloscope sessions and waveform files from the equipment made by Tektronix and other vendors.
- Waveform file formats supported include .wfm, .isf, .csv, .h5, .tr0, .trc, and .bin
- Remotely connect to the Tektronix 4/5/6 Series MSO to acquire data in real-time
- Share the data remotely with your colleagues so that they can perform analysis and make measurements as if they were sitting in front of the oscilloscope
- Synchronize waveforms from the multiple oscilloscopes in real-time
- Perform advanced analysis even if your oscilloscope isn't equipped with TekScope PC analysis software

TekDrive collaborative test and measurement workspace

Using TekDrive, you can upload, store, organize, search, download, and share any file type from any connected device. TekDrive is natively integrated into the instrument for seamless sharing and recalling of files - no USB stick is required. Analyze and explore standard files like .wfm, .isf, .tss, and .csv, directly in a browser with smooth interactive waveform viewers. TekDrive is purpose built for integration, automation, and security.



TekDrive collaborative workspace - save files directly from your instrument and share across your team

Arbitrary/Function Generator (AFG)

The instrument contains an optional integrated arbitrary/function generator, perfect for simulating sensor signals within a design or adding noise to signals to perform margin testing. The integrated function generator provides output of predefined waveforms up to 50 MHz for sine, square, pulse, ramp/triangle, DC, noise, sin(x)/x (Sinc), Gaussian, Lorentz, exponential rise/fall, Haversine and cardiac. The AFG can load waveform records up to 128 k points in size from an internal file location or a USB mass storage device.

The AFG feature is compatible with Tektronix' ArbExpress PC-based waveform creation and editing software, making creation of complex waveforms fast and easy.

Digital Voltmeter (DVM) and Trigger Frequency Counter

The instrument contains an integrated 4-digit digital voltmeter (DVM) and 8-digit trigger frequency counter. Any of the analog inputs can be a source for the voltmeter, using the same probes that are already attached for general oscilloscope usage. The trigger frequency counter provides a very precise readout of the frequency of the trigger event on which you're triggering.

Both the DVM and trigger frequency counter are available for free and are activated when you register your product.

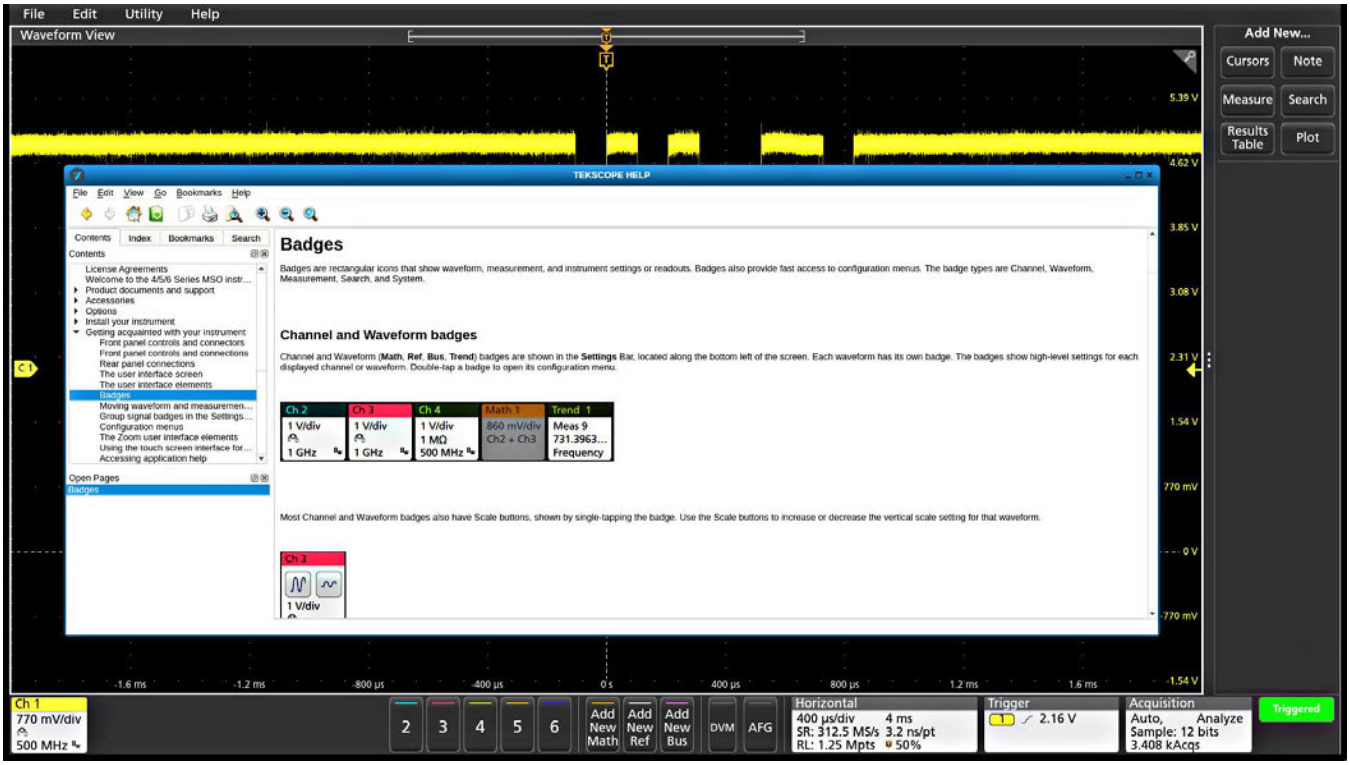
Enhanced security option

The optional 4-SEC enhanced security option enables password-protected enabling/disabling of all instrument I/O ports and firmware upgrades. In addition, option 4-SEC provides the highest level of security by ensuring that internal memory never stores user settings or waveform data, in compliance with National Industrial Security Program Operating Manual (NISPOM) DoD 5220.22-M, Chapter 8 requirements and Defense Security Service Manual for the Certification and Accreditation of Classified Systems under the NISPOM. This ensures that you can confidently move the instrument out of a secure area.

Help when you need it

Several helpful resources are included so you can get your questions answered rapidly without having to find a manual or go to a website:

- Graphical images and explanatory text are used in numerous menus to provide quick feature overviews.
- All menus include a question mark icon in the upper right that takes you directly to the portion of the integrated help system that applies to that menu.
- A short user interface tutorial is included in the Help menu for new users to come up to speed on the instrument in a matter of a few minutes.



Integrated help answers your questions rapidly without having to find a manual or go to the internet.

Specifications

All specifications are guaranteed and apply to all models unless noted otherwise.

Model overview

Oscilloscope

	MSO44	MSO46
FlexChannel inputs	4	6
Maximum analog channels	4	6
Maximum digital channels (with optional logic probes)	32	48
Auxiliary Trigger Input	≤300 V_{RMS} (Edge Trigger only)	
Bandwidth (calculated rise time)	200 MHz, 350 MHz, 500 MHz, 1 GHz, 1.5 GHz	
DC Gain Accuracy	50 Ω: ±1%, (±2.5% at 1 mV/Div and 500 µV/Div settings), de-rated at 0.100%/°C above 30 °C 1 MΩ and 250 kΩ: ±1.0%, (±2.0% at 1 mV/Div and 500 µV/Div settings)	
ADC Resolution	12 bits	
Vertical Resolution	8 bits @ 6.25 GS/s 12 bits @ 3.125 GS/s 13 bits @ 1.25 GS/s (High Res) 14 bits @ 625 MS/s (High Res) 15 bits @ 312.5 MS/s (High Res) 16 bits @ ≤125 MS/s (High Res)	
Sample Rate	6.25 GS/s on all analog / digital channels (160 ps resolution)	
Record Length (std.)	31.25 Mpoints on all analog / digital channels	
Record Length (opt.)	62.5 Mpoints on all analog / digital channels	
Waveform Capture Rate, typical	>500,000 wfms/s	
Arbitrary/Function Generator (opt.)	13 predefined waveform types with up to 50 MHz output	
DVM	4-digit DVM (free with product registration)	
Trigger Frequency Counter	8-digit frequency counter (free with product registration)	

Vertical system - analog channels

Bandwidth selections	50 Ω: 20 MHz, 250 MHz, and the full bandwidth value of your model 1 MΩ: 20 MHz, 250 MHz, 500 MHz
Input coupling	DC, AC
Input impedance	50 Ω ± 1% 1 MΩ ± 1% with 13.0 pF ± 1.5 pF
Input sensitivity range	

1 MΩ

500 µV/div to 10 V/div in a 1-2-5 sequence

50 Ω

500 µV/div to 1 V/div in a 1-2-5 sequence

500 µV/div is a 2X digital zoom of 1 mV/div or a 4x digital zoom of 2 mV/div, depending on the instrument bandwidth configuration

Maximum input voltage

50 Ω: 5 V_{RMS}, with peaks ≤ ±20 V (DF ≤ 6.25%)

1 MΩ: 300 V_{RMS}

Derate at 20 dB/decade between 4.5 MHz and 45 MHz; derate 14 dB/decade between 45 MHz and 450 MHz. Above 450 MHz, 5.5 VRMS

Effective bits (ENOB), typical

High Res mode, 50 Ω, 10 MHz input with 90% full screen

Bandwidth	ENOB
1.5 GHz	7.1
1 GHz	7.6
500 MHz	7.9
350 MHz	8.2
250 MHz	8.2
20 MHz	8.9

Random noise, RMS, typical

1.5 GHz, 1 GHz, 500 MHz, 350 MHz, 200 MHz models, High Res mode (RMS), typical

	50 Ω					1 MΩ			
V/div	1 GHz	500 MHz	350 MHz	250 MHz	20 MHz	500 MHz	350 MHz	250 MHz	20 MHz
≤1 mV/div	260 µV	200 µV	150 µV	125 µV	75.0 µV	200 µV	140 µV	120 µV	75.0 µV
2 mV/div	280 µV	200 µV	150 µV	125 µV	75.0 µV	200 µV	140 µV	120 µV	75.0 µV
5 mV/div	305 µV	235 µV	185 µV	135 µV	75.0 µV	210 µV	150 µV	130 µV	75.0 µV
10 mV/div	335 µV	275 µV	220 µV	160 µV	80.0 µV	230 µV	160 µV	150 µV	80.0 µV
20 mV/div	425 µV	360 µV	270 µV	230 µV	110 µV	280 µV	200 µV	200 µV	100 µV
50 mV/div	800 µV	800 µV	570 µV	460 µV	200 µV	520 µV	370 µV	410 µV	180 µV
100 mV/div	1.62 mV	1.23 mV	1.04 mV	1.04 mV	470 µV	1.24 mV	880 µV	930 µV	460 µV
1 V/div	13.0 mV	9.90 mV	8.95 mV	8.95 mV	3.78 mV	14.30 mV	10.20 mV	10.30 mV	5.45 mV

DC gain accuracy

50 Ohm

±2.0%[1] (±2.0% at 2 mV/div, ±4% at 1 mV/div, typical)

[1] Immediately following SPC, add 2% for every 5 °C change in ambient.

±1.0%[2] of full scale, (±1.0% of full scale at 2 mV/div, ± 2% at 1 mV/div, typical)

Position range ±5 divisions

Offset ranges, maximum

All models Input signal cannot exceed maximum input voltage for the 50 Ω input path.

Volts/div Setting	Maximum offset range, 50 Ω Input
1 mV/div - 99 mV/div	±1 V
100 mV/div - 1 V/div	±10 V

Volts/div Setting	Maximum offset range, 50 Ω Input
500 µV/div - 99 mV/div	±1 V
100 mV/div - 1 V/div	±10 V

Volts/div Setting	Maximum offset range, 1 MΩ Input
500 µV/div - 63 mV/div	±1 V
64 mV/div - 999 mV/div	±10 V
1 V/div - 10 V/div	±100 V

Offset accuracy ±(0.005 X | offset - position | + 0.2 div (0.4 div in 500 µV/div))

Crosstalk (channel isolation), typical ≥ 200:1 up to the rated bandwidth for any two channels having equal Volts/div settings

Vertical system - digital channels

Number of channels 8 digital inputs (D7-D0) per installed TLP058 (traded off for one analog channel)

Vertical resolution 1 bit

Minimum detectable pulse width, typical 1 ns

Thresholds One threshold per digital channel

Threshold range ±40 V

[2] Immediately following SPC, add 1% for every 5 °C change in ambient.

Threshold resolution	10 mV
Threshold accuracy	± [100 mV + 3% of threshold setting after calibration]
Input hysteresis, typical	100 mV at the probe tip
Input dynamic range, typical	30 V_{pp} for F_{in} ≤ 200 MHz, 10 V_{pp} for F_{in} > 200 MHz
Absolute maximum input voltage, typical	±42 V peak
Minimum voltage swing, typical	400 mV peak-to-peak
Input impedance, typical	100 kΩ
Probe loading, typical	2 pF

Horizontal system

Time base range	200 ps/div to 1,000 s/div
Sample rate range	1.5625 S/s to 6.25 GS/s (real time) 12.5 GS/s to 500 GS/s (interpolated)
Record length range	
Standard	1 kpoints to 31.25 Mpoints in single sample increments
Optional	62.5 Mpoints
Aperture uncertainty	≤ 0.450 ps + $(10^{-11}$ * Measurement Duration$)_{RMS}$, for measurements having duration ≤ 100 ms
Timebase accuracy	±2.5 x 10^{-6} over any ≥1 ms time interval

Description	Specification
Factory Tolerance	±5.0 x10^{-7} ; at calibration, 25 °C ambient, over any ≥1 ms interval
Temperature stability, typical	±5.0 x10^{-7} ; tested at operating temperatures
Crystal aging	±1.5 x 10^{-6} ; frequency tolerance change at 25 °C over a period of 1 year

Delta-time measurement accuracy, nominal

$$DTA_{pp}(typical) = 10 \times \sqrt{\left(\frac{N}{SR_1}\right)^2 + \left(\frac{N}{SR_2}\right)^2 + \left(0.450\ ps + \left(1 \times 10^{-11} \times t_p\right)\right)^2} + TBA \times t_p$$

$$DTA_{RMS} = \sqrt{\left(\frac{N}{SR_1}\right)^2 + \left(\frac{N}{SR_2}\right)^2 + \left(0.450ps + \left(1 \times 10^{-11} \times t_p\right)\right)^2} + TBA \times t_p$$

(assume edge shape that results from Gaussian filter response)

The formula to calculate delta-time measurement accuracy (DTA) for a given instrument setting and input signal assumes insignificant signal content above Nyquist frequency, where:

SR_1 = Slew Rate (1st Edge) around 1st point in measurement

SR_2 = Slew Rate (2nd Edge) around 2nd point in measurement

N = input-referred guaranteed noise limit (V_{RMS})

TBA = time base accuracy or reference frequency error

t_p = delta-time measurement duration (sec)

Maximum duration at highest sample rate	5 ms (std.) or 10 ms (opt.)
Time base delay time range	-10 divisions to 5,000 s
Deskew range	-125 ns to +125 ns with a resolution of 40 ps
Delay between analog channels, full bandwidth, typical	≤ 100 ps for any two channels with input impedance set to 50 Ω, DC coupling with equal Volts/div or above 10 mV/div
Delay between analog and digital FlexChannels, typical	3 ns when using a TLP058 and a passive probe matching the bandwidth of the scope, with no bandwidth limits applied
Delay between any two digital FlexChannels, typical	3 ns from bit 0 of a FlexChannel to bit 0 of any other FlexChannel
Delay between any two bits of a digital FlexChannel, typical	160 ps

Trigger system

Trigger modes	Auto, Normal, and Single

Trigger coupling

DC, HF Reject (attenuates > 50 kHz), LF Reject (attenuates < 50 kHz), noise reject (reduces sensitivity)

Trigger holdoff range

0 ns to 20 seconds

Edge-type trigger sensitivity, DC coupled, typical

Path	Range	Specification
1 MΩ path (all models)	0.5 mV/div to 0.99 mV/div	4.5 div from DC to instrument bandwidth
	≥ 1 mV/div	The greater of 5 mV or 0.7 div
50 Ω path, all models		The greater of 5.6 mV or 0.7 div for frequencies between DC and 500 MHz or the instrument bandwidth (whichever is lower)
		The greater of 7 mV or 0.8 div for frequencies above 500 MHz (if applicable)

Trigger jitter, typical

≤ 7 ps_{RMS} for sample mode and edge-type trigger

Trigger level ranges

This specification applies to logic and pulse thresholds.

Source	Range
Any Channel	±5 divs from center of screen
Aux In Trigger, typical	±8 V
Line	Fixed at about 50% of line voltage

Trigger types

Edge: Positive, negative, or either slope on any channel. Coupling includes DC, AC, noise reject, HF reject, and LF reject

Pulse Width: Trigger on width of positive or negative pulses. Event can be time- or logic-qualified

Timeout: Trigger on an event which remains high, low, or either, for a specified time period. Event can be logic-qualified

Runt: Trigger on a pulse that crosses one threshold but fails to cross a second threshold before crossing the first again. Event can be time- or logic-qualified

Window: Trigger on an event that enters, exits, stays inside or stays outside of a window defined by two user-adjustable thresholds. Event can be time- or logic-qualified

Logic: Trigger when logic pattern goes true, goes false, or occurs coincident with a clock edge. Pattern (AND, OR, NAND, NOR) specified for all input channels defined as high, low, or don't care. Logic pattern going true can be time-qualified

Setup & Hold: Trigger on violations of both setup time and hold time between clock and data present on any input channels

Rise / Fall Time: Trigger on pulse edge rates that are faster or slower than specified. Slope may be positive, negative, or either. Event can be logic-qualified

Video (option 4-VID): Trigger on all lines, odd, even, or all fields of NTSC, PAL, and SECAM video signals

Sequence: Trigger on B event X time or N events after A trigger with a reset on C event. In general, A and B trigger events can be set to any trigger type with a few exceptions: logic qualification is not supported, if A event or B event is

	set to Setup & Hold, then the other must be set to Edge, and Ethernet and High Speed USB (480 Mbps) are not supported
Visual trigger	Qualifies standard triggers by scanning all waveform acquisitions and comparing them to on-screen areas (geometric shapes). An unlimited number of areas can be defined with In, Out, or Don't Care as the qualifier for each area. A boolean expression can be defined using any combination of visual trigger areas to further qualify the events that get stored into acquisition memory. Shapes include rectangle, triangle, trapezoid, hexagon and user-defined.
Parallel Bus:	Trigger on a parallel bus data value. Parallel bus can be from 1 to 48 bits (from the digital and analog channels) in size. Supports Binary and Hex radices
I^2C Bus (option 4-SREMBD):	Trigger on Start, Repeated Start, Stop, Missing ACK, Address (7 or 10 bit), Data, or Address and Data on I^2C buses up to 10 Mb/s
I^3C Bus (option 4-SRI3C)	Trigger on Start, Repeated Start, Stop, Address, Data, I^3C SDR Direct, I^3C SDR Broadcast, Missing ACK, T-Bit Error, Broadcast Address Error, Hot-Join, HDR Restart, HDR Exit on I^3C buses up to 10 Mb/s
SPI Bus (option 4-SREMBD):	Trigger on Slave Select, Idle Time, or Data (1-16 words) on SPI buses up to 20 Mb/s
RS-232/422/485/UART Bus (option 4-SRCOMP):	Trigger on Start Bit, End of Packet, Data, and Parity Error up to 15 Mb/s
CAN Bus (option 4-SRAUTO):	Trigger on Start of Frame, Type of Frame (Data, Remote, Error, or Overload), Identifier, Data, Identifier and Data, End Of Frame, Missing Ack, and Bit Stuff Error on CAN buses up to 1 Mb/s
CAN FD Bus (option 4-SRAUTO):	Trigger on Start of Frame, Type of Frame (Data, Remote, Error, or Overload), Identifier (Standard or Extended), Data (1-8 bytes), Identifier and Data, End Of Frame, Error (Missing Ack, Bit Stuffing Error, FD Form Error, Any Error) on CAN FD buses up to 16 Mb/s
LIN Bus (option 4-SRAUTO):	Trigger on Sync, Identifier, Data, Identifier and Data, Wakeup Frame, Sleep Frame, and Error on LIN buses up to 1 Mb/s
FlexRay Bus (option 4-SRAUTO):	Trigger on Start of Frame, Indicator Bits (Normal, Payload, Null, Sync, Startup), Frame ID, Cycle Count, Header Fields (Indicator Bits, Identifier, Payload Length, Header CRC, and Cycle Count), Identifier, Data, Identifier and Data, End Of Frame, and Errors on FlexRay buses up to 10 Mb/s
SENT Bus (option 4-SRAUTOSEN)	Trigger on Start of Packet, Fast Channel Status and Data, Slow Channel Message ID and Data, and CRC Errors
SPMI Bus (option 4-SRPM):	Trigger on Sequence Start Condition, Reset, Sleep, Shutdown, Wakeup, Authenticate, Master Read, Master Write, Register Read, Register Write, Extended Register Read, Extended Register Write, Extended Register Read Long, Extended Register Write Long, Device Descriptor Block Master Read, Device Descriptor Block Slave Read, Register 0 Write, Transfer Bus Ownership, and Parity Error
USB 2.0 LS/FS/HS Bus (option 4-SRUSB2):	Trigger on Sync, Reset, Suspend, Resume, End of Packet, Token (Address) Packet, Data Packet, Handshake Packet, Special Packet, Error on USB buses up to 480 Mb/s
Ethernet Bus (option 4-SRENET):	Trigger on Start of Frame, MAC Addresses, MAC Q-tag, MAC Length/Type, MAC Data, IP Header, TCP Header, TCP/IPV4 Data, End of Packet, and FCS (CRC) Error on 10BASE-T and 100BASE-TX buses
Audio (I^2S, LJ, RJ, TDM) Bus (option 4-SRAUDIO):	Trigger on Word Select, Frame Sync, or Data. Maximum data rate for I^2S/LJ/RJ is 12.5 Mb/s. Maximum data rate for TDM is 25 Mb/s
MIL-STD-1553 Bus (option 4-SRAERO):	Trigger on Sync, Command (Transmit/Receive Bit, Parity, Subaddress / Mode, Word Count / Mode Count, RT Address), Status (Parity, Message Error, Instrumentation, Service Request, Broadcast Command Received, Busy, Subsystem Flag, Dynamic Bus Control Acceptance, Terminal Flag), Data, Time (RT/IMG), and Error (Parity Error, Sync Error, Manchester Error, Non-contiguous Data) on MIL-STD-1553 buses
ARINC 429 Bus (option 4-SRAERO):	Trigger on Word Start, Label, Data, Label and Data, Word End, and Error (Any Error, Parity Error, Word Error, Gap Error) on ARINC 429 buses up to 1 Mb/s

RF Magnitude vs. Time and RF Frequency vs. Time (option 4-SV-RFVT):	Trigger on edge, pulse width and timeout events

Acquisition system

Sample	Acquires sampled values
Peak Detect	Captures glitches as narrow as 640 ps at all sweep speeds
Averaging	From 2 to 10,240 waveforms
Fast Hardware Averaging	An acquisition mode for acquiring a large number of averages in a short amount of time. Fast hardware averaging optimizes the acquisition path, reducing storage truncation error and smoothing out fine scale non-linearity imperfections via an optional offset dithering technique. This feature is available through programmatic interface commands. From 2 to 1,000,000 waveforms Maximum averaging speed = 32,000 waveforms/s
Envelope	Min-max envelope reflecting Peak Detect data over multiple acquisitions
High Res	Applies a unique Finite Impulse Response (FIR) filter for each sample rate that maintains the maximum bandwidth possible for that sample rate while preventing aliasing and removing noise from the oscilloscope amplifiers and ADC above the usable bandwidth for the selected sample rate. High Res mode always provides at least 12 bits of vertical resolution and extends all the way to 16 bits of vertical resolution at ≤ 125 MS/s sample rates.
FastAcq®	FastAcq optimizes the instrument for analysis of dynamic signals and capture of infrequent events by capturing >500,000 wfms/s (one channel active; >100K wfms/s with all channels active).
Roll mode	Scrolls sequential waveform points across the display in a right-to-left rolling motion, at timebase speeds of 40 ms/div and slower, when in Auto trigger mode.
History mode	Makes use of the maximum record length, allowing you to capture many triggered acquisitions, stop when you see something of interest, and quickly review all stored triggered acquisitions.The number of available acquisitions stored in history is (Maximum record length) / (Current record length setting).
FastFrame™	Acquisition memory divided into segments. Maximum trigger rate >5,000,000 waveforms per second Minimum frame size = 50 points Maximum Number of Frames: For frame size ≥ 1,000 points, maximum number of frames = record length / frame size. For 50 point frames, maximum number of frames = 1,500,000

Waveform measurements

Cursor types

Waveform, V Bars, H Bars, V&H Bars, and Polar (XY/XYZ plots only)

DC voltage measurement accuracy, Average acquisition mode

Measurement Type	DC Accuracy (In Volts)
Average of ≥ 16 waveforms	±((DC Gain Accuracy) * |reading - (offset - position)| + Offset Accuracy + 0.1 * V/div setting)
Delta volts between any two averages of ≥ 16 waveforms acquired with the same oscilloscope setup and ambient conditions	±(DC Gain Accuracy * |reading| + 0.05 div)

Automatic measurements

36, of which an unlimited number can be displayed as either individual measurement badges or collectively in a measurement results table

Amplitude measurements

Amplitude, Maximum, Minimum, Peak-to-Peak, Positive Overshoot, Negative Overshoot, Mean, RMS, AC RMS, Top, Base, and Area

Timing measurements

Period, Frequency, Unit Interval, Data Rate, Positive Pulse Width, Negative Pulse Width, Skew, Delay, Rise Time, Fall Time, Phase, Rising Slew Rate, Falling Slew Rate, Burst Width, Positive Duty Cycle, Negative Duty Cycle, Time Outside Level, Setup Time, Hold Time, Duration N-Periods, High Time, Low Time, Time to Minimum, and Time to Maximum

Measurement statistics

Mean, Standard Deviation, Maximum, Minimum, and Population. Statistics are available on both the current acquisition and all acquisitions

Reference levels

User-definable reference levels for automatic measurements can be specified in either percent or units. Reference levels can be set to global for all measurements, per source channel or signal, or unique for each measurement

Gating

Screen, Cursors, Logic, Search, or Time. Specifies the region of an acquisition in which to take measurements. Gating can be set to Global (affects all measurements set to Global) or Local (all measurements can have a unique Time gate setting; only one Local gate is available for Screen, Cursors, Logic, and Search actions).

Measurement plots

Histogram, Time Trend, and Spectrum

Measurement limits

Pass/fail testing for user-definable limits on measurement values. Act on event for measurement value failures include Save Screen Capture, Save Waveform, System Request (SRQ), and Stop Acquisitions

Three-phase electrical analysis (option 4-3PHASE) adds the following:

Measurements

Input Analysis (Power Quality, Harmonics, Input Voltage, Input Current, Input Power)

Ripple analysis (Line ripple, Switching Ripple)

	Output analysis (Phasor Diagram)
Measurement plots	Harmonics Bar Graph, Phasor Diagram

Power analysis (option 4-PWR-BAS) and advanced power analysis (option 4-PWR) adds the following:

Measurements	Input Analysis (Frequency, V_{RMS}, I_{RMS}, voltage and current Crest Factors, True Power, Apparent Power, Reactive Power, Power Factor, Phase Angle, Harmonics, Inrush Current, Input Capacitance) Amplitude Analysis (Cycle Amplitude, Cycle Top, Cycle Base, Cycle Maximum, Cycle Minimum, Cycle Peak-to-Peak) Timing Analysis (Period, Frequency, Negative Duty Cycle, Positive Duty Cycle, Negative Pulse Width, Positive Pulse Width) Switching Analysis (Switching Loss, dv/dt, di/dt, Safe Operating Area, R_{DSon}) Output Analysis (Line Ripple, Switching Ripple, Efficiency, Turn-on Time, Turn-off Time) Magnetic Analysis (Inductance, I vs. Intg(V), Magnetic Loss, Magnetic Property)- with option 4-PWR only Frequency Response Analysis (Control Loop Response Bode Plot, Power Supply Rejection Ratio, Impedance) - with options 4-PWR only
Measurement Plots	Harmonics Bar Graph, Switching Loss Trajectory Plot, and Safe Operating Area
Measurement limits	Pass/fail testing for user-definable limits on measurement values. Act on event for measurement value failures include Save Screen Capture, Save Waveform, System Request (SRQ), and Stop Acquisitions

Waveform math

Number of math waveforms	Unlimited
Arithmetic	Add, subtract, multiply, and divide waveforms and scalars
Algebraic expressions	Define extensive algebraic expressions including waveforms, scalars, user-adjustable variables, and results of parametric measurements. Perform math on math using complex equations. For example (Integral (CH1 - Mean(CH1)) X 1.414 X VAR1)
Math functions	Invert, Integrate, Differentiate, Square Root, Exponential, Log 10, Log e, Abs, Ceiling, Floor, Min, Max, Degrees, Radians, Sin, Cos, Tan, ASin, ACos, and ATan
Relational	Boolean result of comparison >, <, ≥, ≤, =, and ≠
Logic	AND, OR, NAND, NOR, XOR, and EQV
Filtering function (standard)	Loading of user-definable filters. Users specify a file containing the coefficients of the filter.
FFT functions	Spectral Magnitude and Phase, and Real and Imaginary Spectra

FFT vertical units	Magnitude: Linear and Log (dBm) Phase: Degrees, Radians, and Group Delay
FFT window functions	Hanning, Rectangular, Hamming, Blackman-Harris, Flattop2, Gaussian, Kaiser-Bessel, and TekExp

Spectrum View

Center Frequency	Limited by instrument analog bandwidth
Span	18.6 Hz to 312.5 MHz 18.6 Hz to 500 MHz (with option 4 -SV-BW-1) Coarse adjustment in a 1-2-5 sequence
RF Measurements	Channel Power (CHP), Adjacent Channel Power Ratio (ACPR), and Occupied Bandwidth (OBW) measurements on Spectrum View trace data and display
RF vs. Time Traces	Magnitude vs. time, Frequency vs. time, Phase vs. time (with option 4-SV-RFVT)
RF vs. Time Trigger	Edge, pulse width, and timeout trigger on RF Magnitude vs. Time and RF Frequency vs. Time (with option 4-SV-RFVT)
Spectrograms	RF Frequency vs. Time vs. Amplitude display with frequency on x-axis, time on y-axis, and power level indicated by variations in color (with option 4-SV-RFVT)
Resolution Bandwidth (RBW)	18.6 µHz to 15.625 MHz 18.6 µHz to 25 MHz (with option 4-SV-BW-1)
IQ capture	The data is stored as in-phase and quadrature (I&Q) samples and precise synchronization is maintained between the time domain data and the I&Q data. When RF vs. Time traces are activated (with option 4-SV-RFVT), IQ data can be captured and exported to file for more analysis within 3rd party applications. The max acquisition time varies with span and sample rate. At 6.25 GS/s and 500 MHz span, the max acquisition time is 0.021 seconds. For 312.5 MHz span, the max acquisition time is 0.043 seconds. For 40 MHz span, the max acquisition time is 0.172 seconds. For 1 MHz span, the max acquisition time is 10.995 seconds.

Window types and factors

Window type	Factor
Blackman-Harris	1.90
Flat-Top 2	3.77
Hamming	1.30
Hanning	1.44
Kaiser-Bessel	2.23

Table continued…

Window type	Factor
Rectangular	0.89

Spectrum Time	FFT Window Factor / RBW
Reference level	Reference level is automatically set by the analog channel Volts/div setting Setting range: -42 dBm to +44 dBm
Vertical Position	-100 divs to +100 divs
Vertical units	dBm, dBµW, dBmV, dBµV, dBmA, dBµA
Horizontal scaling	Linear, Log
Multi-channel spectrum analysis	Each FlexChannel input can be configured with Spectrum View, RF vs. Time traces (with option RFVT), and Spectrogram (with option RFVT). Multiple RF measurements can be performed simultaneously across channels. Spectrum Time and Center Frequency settings can be unlocked and moved independently from each other across channels. All Spectrum View channels must share the same Span, Resolution Bandwidth and Window Type.

Search

Number of searches	Unlimited
Search types	Search through long records to find all occurrences of user specified criteria including edges, pulse widths, timeouts, runt pulses, window violations, logic patterns, setup & hold violations, rise/fall times, and bus protocol events. Search results can be viewed in the Waveform View or in the Results table.

Save

Save	Save files directly to the oscilloscope, to a remote network drive, or to your TekDrive collaboration workspace.
Waveform type	Tektronix Waveform Data (.wfm), Comma Separated Values (.csv), MATLAB (.mat)
Waveform gating	Cursors, Screen, Resample (save every nth sample)
Screen capture type	Portable Network Graphic (*.png)
Setup type	Tektronix Setup (.set)
Report type	Adobe Portable Documents (.pdf), Single File web Pages (.mht)

Session type	Tektronix Session Setup (.tss)

Display

Display type	13.3 in. (338 mm) liquid-crystal TFT color display
Display resolution	1,920 horizontal × 1,080 vertical pixels
Display modes	Overlay: traditional oscilloscope display where traces overlay each other Stacked: display mode where each waveform is placed in its own slice and can take advantage of the full ADC range while still being visually separated from other waveforms. Groups of channels can also be overlaid within a slice to simplify visual comparison of signals.
Zoom	Horizontal and vertical zooming is supported in all waveform and plot views.
Interpolation	Sin(x)/x and Linear
Waveform styles	Vectors, dots, variable persistence, and infinite persistence
Graticules	Movable and fixed graticules, selectable between Grid, Time, Full, and None
Color palettes	Normal and inverted for screen captures Individual waveform colors are user-selectable
Format	YT, XY, and XYZ
Local Language User Interface	English, Japanese, Simplified Chinese, Traditional Chinese, French, German, Italian, Spanish, Portuguese, Russian, Korean
Local Language Help	English, Japanese, Simplified Chinese

Arbitrary-Function Generator (optional)

Function types	Arbitrary, sine, square, pulse, ramp, triangle, DC level, Gaussian, Lorentz, exponential rise/fall, sin(x)/x, random noise, Haversine, Cardiac
Sine waveform	
Frequency range	0.1 Hz to 50 MHz
Frequency setting resolution	0.1 Hz
Frequency accuracy	130 ppm (frequency ≤ 10 kHz), 50 ppm (frequency > 10 kHz)

	This is for Sine, Ramp, Square and Pulse waveforms only.
Amplitude range	20 mV_{pp} to 5 V_{pp} into Hi-Z; 10 mV_{pp} to 2.5 V_{pp} into 50 Ω
Amplitude flatness, typical	±0.5 dB at 1 kHz ±1.5 dB at 1 kHz for < 20 mV_{pp} amplitudes
Total harmonic distortion, typical	1% for amplitude ≥ 200 mV_{pp} into 50 Ω load 2.5% for amplitude > 50 mV AND < 200 mV_{pp} into 50 Ω load This is for Sine wave only.
Spurious free dynamic range, typical	40 dB (V_{pp} ≥ 0.1 V); 30 dB (V_{pp} ≥ 0.02 V), 50 Ω load

Square and pulse waveform

Frequency range	0.1 Hz to 25 MHz
Frequency setting resolution	0.1 Hz
Frequency accuracy	130 ppm (frequency ≤ 10 kHz), 50 ppm (frequency > 10 kHz)
Amplitude range	20 mV_{pp} to 5 V_{pp} into Hi-Z; 10 mV_{pp} to 2.5 V_{pp} into 50 Ω
Duty cycle range	10% - 90% or 10 ns minimum pulse, whichever is larger Minimum pulse time applies to both on and off time, so maximum duty cycle will reduce at higher frequencies to maintain 10 ns off time
Duty cycle resolution	0.1%
Minimum pulse width, typical	10 ns. This is the minimum time for either on or off duration.
Rise/Fall time, typical	5.5 ns, 10% - 90%
Pulse width resolution	100 ps
Overshoot, typical	< 4 % for signal steps greater than 100 mV_{pp} This applies to overshoot of the positive-going transition (+overshoot) and of the negative-going (-overshoot) transition
Asymmetry, typical	±1% ±5 ns, at 50% duty cycle
Jitter, typical	< 60 ps TIE_{RMS}, ≥ 100 mV_{pp} amplitude, 40%-60% duty cycle

Ramp and triangle waveform

Frequency range	0.1 Hz to 500 kHz
Frequency setting resolution	0.1 Hz
Frequency accuracy	130 ppm (frequency ≤ 10 kHz), 50 ppm (frequency > 10 kHz)
Amplitude range	20 mV_{pp} to 5 V_{pp} into Hi-Z; 10 mV_{pp} to 2.5 V_{pp} into 50 Ω
Variable symmetry	0% - 100%
Symmetry resolution	0.1%

DC level range	±2.5 V into Hi-Z

	±1.25 V into 50 Ω
Random noise amplitude range	20 mV_{pp} to 5 V_{pp} into Hi-Z
	10 mV_{pp} to 2.5 V_{pp} into 50 Ω
Sin(x)/x	
Maximum frequency	2 MHz
Gaussian pulse, Haversine, and Lorentz pulse	
Maximum frequency	5 MHz
Lorentz pulse	
Frequency range	0.1 Hz to 5 MHz
Amplitude range	20 mV_{pp} to 2.4 V_{pp} into Hi-Z
	10 mV_{pp} to 1.2 V_{pp} into 50 Ω
Cardiac	
Frequency range	0.1 Hz to 500 kHz
Amplitude range	20 mV_{pp} to 5 V_{pp} into Hi-Z
	10 mV_{pp} to 2.5 V_{pp} into 50 Ω
Arbitrary	
Memory depth	1 to 128 k
Amplitude range	20 mV_{pp} to 5 V_{pp} into Hi-Z
	10 mV_{pp} to 2.5 V_{pp} into 50 Ω
Repetition rate	0.1 Hz to 25 MHz
Sample rate	250 MS/s
Signal amplitude accuracy	±[(1.5% of peak-to-peak amplitude setting) + (1.5% of absolute DC offset setting) + 1 mV] (frequency = 1 kHz)
Signal amplitude resolution	1 mV (Hi-Z)
	500 µV (50 Ω)
Sine and ramp frequency accuracy	1.3 x 10^{-4} (frequency ≤10 kHz)
	5.0 x 10^{-5} (frequency >10 kHz)

DC offset range	±2.5 V into Hi-Z ±1.25 V into 50 Ω
DC offset resolution	1 mV (Hi-Z) 500 µV (50 Ω)
DC offset accuracy	±[(1.5% of absolute offset voltage setting) + 1 mV] Add 3 mV of uncertainty per 10 °C change from 25 °C ambient

Digital volt meter (DVM)

Measurement types	DC, AC_{RMS}+DC, AC_{RMS}
Voltage resolution	4 digits
Voltage accuracy	
DC:	±((1.5% * |reading - offset - position|) + (0.5% * |(offset - position)|) + (0.1 * Volts/div)) De-rated at 0.100%/°C of |reading - offset - position| above 30 °C Signal ± 5 divisions from screen center
AC:	± 2% (40 Hz to 1 kHz) with no harmonic content outside 40 Hz to 1 kHz range AC, typical: ± 2% (20 Hz to 10 kHz) For AC measurements, the input channel vertical settings must allow the V_{PP} input signal to cover between 4 and 10 divisions and must be fully visible on the screen

Trigger frequency counter

Resolution	8-digits
Accuracy	±(1 count + time base accuracy * input frequency) The signal must be at least 8 mV_{pp} or 2 div, whichever is greater.
Maximum input frequency	10 Hz to maximum bandwidth of the analog channel The signal must be at least 8 mV_{pp} or 2 div, whichever is greater.

Processor system

Host processor	Intel x6413E at 1.5 GHz (HFM) / 3.0 GHz (Turbo). Elkhart Lake 4-Core.ARM 1.5 GHz, 32-bit, dual core processor

Operating system	Closed Linux
Internal storage	64 GB eMMC

Input-Output ports

HDMI video port	A 29-pin HDMI connector Supported resolution: 1920 x 1080 @ 60Hz (only). The monitor must be attached before powering on the instrument

Probe compensator signal, typical

Connection:	Connectors are located on the lower right-hand side of the instrument
Amplitude:	0 to 2.5 V
Frequency:	1 kHz
Source impedance:	1 kΩ

External reference input	The time-base system can phase lock to an external 10 MHz reference signal (±4 ppm).
USB interface (Host, Device ports)	Front panel USB Host ports: Three USB 2.0 Hi-Speed ports Rear panel USB Host ports: Two USB 2.0 Hi-Speed ports Rear panel USB Device port: One USB 2.0 High Speed Device port providing USBTMC support
Ethernet interface	10/100/1000 Mb/s
Auxiliary output	Rear-panel BNC connector. Output can be configured to provide a positive or negative pulse out when the oscilloscope triggers, the internal oscilloscope reference clock out, or an AFG sync pulse

Characteristic	Limits
Vout (HI)	≥ 2.5 V open circuit; ≥ 1.0 V into a 50 Ω load to ground
Vout (LO)	≤ 0.7 V into a load of ≤ 4 mA; ≤0.25 V into a 50 Ω load to ground

Kensington-style lock	Rear-panel security slot connects to standard Kensington-style lock
LXI	Class: LXI Core 2016 Version: 1.5

Power source

Power

Power consumption	400 Watts maximum

Source voltage	100 - 240 V ±10% at 50 Hz to 60 Hz

Physical characteristics

Dimensions	Height: 11.299 in (286.99 mm), feet folded in, handle to back Height: 13.8 in (351 mm) feet folded in, handle up Width: 15.9 in (405 mm) from handle hub to handle hub Depth: 6.1 in (155 mm) from back of feet to front of knobs, handle up Depth: 10.4 in (265 mm) feet folded in, handle to the back
Weight	< 16.8 lbs (7.6 kg)
Cooling	The clearance requirement for adequate cooling is 2.0 in (50.8 mm) on the right side of the instrument (when viewed from the front) and on the rear of the instrument
Rackmount configuration	7U (with optional RM4 Rackmount Kit)

Environmental specifications

Temperature

Operating	+0 °C to +50 °C (32 °F to 122 °F)
Non-operating	-30 °C to +70 °C (-22 °F to 158 °F)

Humidity

Operating	5% to 90% relative humidity (% RH) at up to +40 °C 5% to 50% RH above +40 °C up to +50 °C, noncondensing, and as limited by a maximum wet-bulb temperature of +39 °C
Non-operating	5% to 90% relative humidity (% RH) at up to +40 °C 5% to 50% RH above +40 °C up to +50 °C, noncondensing, and as limited by a maximum wet-bulb temperature of +39 °C

Altitude

Operating	Up to 3,000 meters (9,843 feet)
Non-operating	Up to 12,000 meters (39,370 feet)

EMC, Environmental, and Safety

Safety certification	US NRTL Listed - UL61010-1 and UL61010-2-030 Canadian Certification - CAN/CSA-C22.2 No. 61010.1 and CAN/CSA-C22.2 No 61010.2.030 EU Compliance - Low Voltage Directive 2014-35-EU and EN61010-1. International Compliance - IEC 61010-1 and IEC61010-2-030
Regulatory	CE marked for the European Union and CSA approved for the USA and Canada

RoHS compliant

Software

IVI driver	Provides a standard instrument programming interface for common applications such as LabVIEW, LabWindows/CVI, Microsoft .NET, and MATLAB. Compatible with Python, C/C++/C# and many other languages through VISA.
TekDrive	Upload, store, organize, search, download, and share any file type from any connected device. TekDrive is natively integrated into the instrument for seamless sharing and recalling of files - no USB stick is required. Analyze and explore standard files like .wfm, .isf, .tss, and .csv, directly in a browser. Visit *www.tek.com/software/tekdrive* to learn more.
LXI Web interface	Connect to the oscilloscope through a standard Web browser by simply entering the oscilloscope's IP address or network name in the address bar of the browser. The Web interface enables viewing of instrument status and configuration, status and modification of network settings, and instrument control through a SCPI talker/listener.
Programming Examples	Programming with the 4/5/6 Series platforms has never been easier. With a programmers manual and a GitHub site you have many commands and examples to help you get started remotely automating your instrument. See *HTTPS://GITHUB.COM/TEKTRONIX/PROGRAMMATIC-CONTROL-EXAMPLES*.

Ordering information

Use the following steps to select the appropriate instrument and options for your measurement needs.

Step 1

Start by selecting a model based on the number of FlexChannel inputs you need. Each FlexChannel input supports 1 analog or 8 digital input signals, interchangeably.

Model	Number of FlexChannels
MSO44	4
MSO46	6

Each model includes

One passive analog probe per channel:

TPP0250 250 MHz probes with 200 MHz bandwidth models
TPP0500B 500 MHz probes with 350 MHz and 500 MHz bandwidth models
TPP1000 1 GHz probes with 1 GHz and 1.5 GHz models

Installation and safety manual
Embedded Help
Power cord
Calibration certificate documenting traceability to National Metrology Institute(s) and ISO9001/ISO17025 quality system registration
Three -year warranty covering all parts and labor on the instrument.
One-year warranty covering all parts and labor on included probes

Step 2

Select a bandwidth

Configure your oscilloscope by selecting the analog channel bandwidth you need. You can upgrade it later by purchasing an upgrade option.

Bandwidth Option	Bandwidth
4-BW-200	200 MHz
4-BW-350	350 MHz
4-BW-500	500 MHz
4-BW-1000	1 GHz
4-BW-1500	1.5 GHz

Step 3

Add an option bundle

Three classes of option bundles are offered (Starter, Pro, Ultimate), providing a range of options depending on your budget and application needs. For detailed information on the current contents of each bundle, please visit our website and view the software bundle brochure at *www.tek.com/document/brochure/software-bundles-for-the-4-5-and-6-series-mso-oscilloscopes*.

1. Starter bundle offers the most common serial bus decoding, protocol analysis, and hardware enhancing options bundled together.
2. Pro bundles are application-specific (Serial trigger and decode, Power Integrity, Signal Integrity, Automotive, Military Government Aerospace) and include all options from the Starter bundle.
3. Ultimate bundle includes all options from the Starter bundle in addition to the all options from all Pro bundles.

1 Year license	Perpetual license	Bundle description
4-STARTER-1Y	4-STARTER-PER	Includes I2C, SPI, RS-232/422/UART serial trigger and analysis, AFG (Arbitrary/Function Generator)
4-PRO-SERIAL-1Y	4-PRO-SERIAL-PER	Includes 4-STARTER plus 62.5 MS/ch record length and additional select serial analysis options
4-PRO-POWER-1Y	4-PRO-POWER-PER	Includes 4-STARTER plus 62.5 MS/ch record length and select power analysis options
4-PRO-AUTO-1Y	4-PRO-AUTO-PER	Includes 4-STARTER plus 62.5 MS/ch record length and select automotive analysis options
4-PRO-MILGOV-1Y	4-PRO-MILGOV-PER	Includes 4-STARTER plus 62.5 MS/ch record length and additional select serial analysis options
4-ULTIMATE-1Y	4-ULTIMATE-PER	Includes 4-STARTER, all 4-PRO bundle options plus 62.5 MS/ch record length and RF vs Time traces, triggers, Spectrograms, and IQ capture, extended Spectrum View capture bandwidth, and video trigger options

Each purchased bundle has two duration options

- A 1-year subscription includes all features and free upgrades for the purchased bundle for one year; after which time the features are disabled. Additional 1-year subscription can be purchased for the selected bundle.
- A perpetual subscription enables all features for the purchased bundle permanently. A perpetual subscription includes 1-year of free upgrades to the bundle feature set. After the year, the feature set is frozen to those enabled by the last update made.

  Perpetual bundles can continue to receive upgrades following the 1 year activation period with the purchase of a maintenance license. Maintenance license information can be found in the maintenance license table below and must be purchased for an existing Starter, Pro, or Ultimate bundle.

Maintenance license	Description
4-STARTER-MNT-1Y	Includes Perpetual Starter Bundle updates for 1 Year
4-PRO-MNT-1Y	Includes Perpetual Pro Bundle updates for 1 Year
4-ULTIMATE-MNT-1Y	Includes Perpetual Ultimate Bundle updates for 1 Year

Step 4

Add instrument functionality

Instrument functionality can be ordered with the instrument or later as an upgrade kit.

Instrument option	Built-in functionality
4-RL-1	Extend record length to 62.5 Mpoints/channel
4 -AFG	Add Arbitrary / Function Generator
4-SEC [3]	Add enhanced security for instrument declassification and password-protected enabling and disabling of all USB ports and firmware upgrade.

Step 5

Add optional protocol triggering, decode, and search capabilities

Choose the protocol support you need today by choosing from these analysis options. You can upgrade later by purchasing an upgrade kit.

Instrument option	Protocols supported
4-RFNFC	ISO/IEC 15693, 14443A, 14443B, and FeliCa (decode and search only)
4-SRAERO	Aerospace (MIL-STD-1553, ARINC 429)
4-SRAUDIO	Audio (I^2S, LJ, RJ, TDM)
4-SRAUTO	Automotive (CAN, CAN FD, LIN, FlexRay, and CAN symbolic decoding)
4-SRAUTOSEN	Automotive sensor (SENT)
4-SRCOMP	Computer (RS-232/422/485/UART)
4-SRCXPI	CXPI (decode and search only)
4-SREMBD	Embedded (I^2C, SPI)
4-SRENET	Ethernet (10BASE-T, 100BASE-TX)
4-SRESPI	eSPI (decode and search only)
4-SRETHERCAT	EtherCAT (decode and search only)
4-SRI3C	MIPI I3C
4-SRMANCH	Manchester (decode and search only)
4-SRMDIO	MDIO (decode and search only)
4-SRNRZ	NRZ (decode and search only)
4-SRONEWIRE	One wire (1-Wire decode and search only)
4-SRPM	Power Management (SPMI)
4-SRPSI5	PSI5 (decode and search only)
4-SRSMBUS	SMBus (decode and search only)
4-SRSPACEWIRE	Spacewire (decode and search only)
4-SRSDLC	Synchronous Data Link Control Protocol (decode and search only)
4-SRSVID	SVID
4-SRUSB2	USB (USB2.0 LS, FS, HS)

Table continued…

[3] This option must be purchased at the same time as the instrument. Not available as an upgrade.

Instrument option	Protocols supported
4-SREUSB2	eUSB2.0 (decode and search only)

Differential serial bus? Be sure to check *Add analog probes and adapters* for differential probes.

Step 6

Add optional analysis capabilities

Instrument option	Advanced analysis
4-3PHASE	Three-phase electrical analysis (6 channel model only)
4-PWR	Advanced Power Measurements and Analysis (includes all 4-PWR-BAS measurements, FRA, and Magnetics)
4-MTM	Mask and Limit testing
4-VID	NTSC, PAL, and SECAM video triggering
4-PWR-BAS	Power Measurements and analysis (this option is not compatible with option 4-PS2)
4-SV-RFVT	Spectrum View RF vs. Time traces, triggers, Spectrograms, and IQ capture
4-SV-BW-1	Increase Spectrum View capture bandwidth to 500 MHz
4-PS2	Power Solution Bundle (4-PWR-BAS, THDP0200, TCP0030A, 067-1686-xx deskew fixture)
4-WBG-DPT	Wide Bandgap SiC/GaN Double Pulse Test Measurements and Analysis

Step 7

Add digital probes

Each FlexChannel input can be configured as eight digital channels simply by connecting a TLP058 logic probe to a FlexChannel input. You can order TLP058 probes with the instrument or separately.

For this instrument	Order	To add
MSO44	1 to 4 TLP058 Probes	8 to 32 digital channels
MSO46	1 to 6 TLP058 Probes	8 to 48 digital channels

Step 8

Add analog probes and adapters

Add additional recommended probes and adapters

Recommended Probe / Adapter	Description
TAP1500	1.5 GHz TekVPI® active single-ended voltage probe, ±8 V input voltage
TAP2500	2.5 GHz TekVPI® active single-ended voltage probe, ±4 V input voltage
TCP0030A	30 A AC/DC TekVPI® current probe, 120 MHz BW
TCP0020	20 A AC/DC TekVPI® current probe, 50 MHz BW
TCP0030A	30 A AC/DC TekVPI current probe, 120 MHz BW

Table continued…

Recommended Probe / Adapter	Description
TCP0150	150 A AC/DC TekVPI® current probe, 20 MHz BW
TRCP0300	30 MHz AC current probe, 250 mA to 300 A
TRCP0600	30 MHz AC current probe, 500 mA to 600 A
TRCP3000	16 MHz AC current probe, 500 mA to 3000 A
TDP0500	500 MHz TekVPI® differential voltage probe, ±42 V differential input voltage
TDP1000	1 GHz TekVPI® differential voltage probe, ±42 V differential input voltage
TDP1500	1.5 GHz TekVPI® differential voltage probe, ±8.5 V differential input voltage
THDP0100	±6 kV, 100 MHz TekVPI® high-voltage differential probe
THDP0200	±1.5 kV, 200 MHz TekVPI® high-voltage differential probe
TMDP0200	±750 V, 200 MHz TekVPI® high-voltage differential probe
TPR1000	1 GHz, Single-Ended TekVPI® Power-Rail Probe; includes one TPR4KIT accessory kit
TIVP02	Isolated Probe; 200 MHz, ±5 V to ±2500 V depending on tip; 2 meter cable
TIVP02L	Isolated Probe; 200 MHz, ±5 V to ±2500 V depending on tip; 10 meter cable
TIVP05	Isolated Probe; 500 MHz, ±5 V to ±2500 V depending on tip; 2 meter cable
TIVP05L	Isolated Probe; 500 MHz, ±5 V to ±2500 V depending on tip; 10 meter cable
TIVP1	Isolated Probe; 1 GHz, ±5 V to ±2500 V depending on tip; 2 meter cable
TIVP1L	Isolated Probe; 1 GHz, ±5 V to ±2500 V depending on tip; 10 meter cable
TPP0502	500 MHz, 2X TekVPI® passive voltage probe, 12.7 pF input capacitance
TPP0850	2.5 kV, 800 MHz, 50X TekVPI® passive high-voltage probe
TPP1000	1 GHz, 10X TekVPI® passive voltage probe, 1.3 Meter cable, 3.9 pF input capacitance
P6015A	20 kV, 75 MHz high-voltage passive probe
TPA-BNC	TekVPI® to TekProbe™ BNC adapter (recommended for connecting your existing TekProbe probes to this instrument)
TEK-DPG	TekVPI deskew pulse generator signal source
067-1686-xx	Power measurement deskew and calibration fixture

Looking for other probes? Check out the probe selector tool at *www.tek.com/probes*.

Step 9

Add accessories

Add traveling or mounting accessories

Optional Accessory	Description
HC4	Hard carrying case with instrument front protective cover
RM4	Rackmount kit
SC4	Soft carrying case with instrument front protective cover
GPIB to Ethernet Adapter	Order model 4865B (GPIB to Ethernet to Instrument Interface) directly from ICS Electronics *www.icselect.com/gpib_instrument_intfc.html*

Step 10

Select power cord option

Power Cord Option	Description
A0	North America power plug (115 V, 60 Hz)
A1	Universal Euro power plug (220 V, 50 Hz)
A2	United Kingdom power plug (240 V, 50 Hz)
A3	Australia power plug (240 V, 50 Hz)
A5	Switzerland power plug (220 V, 50 Hz)
A6	Japan power plug (100 V, 50/60 Hz)
A10	China power plug (50 Hz)
A11	India power plug (50 Hz)
A12	Brazil power plug (60 Hz)
A99	No power cord

Step 11

Add extended service and calibration options

Service Option	Description
T3	Three-year Total Protection Plan, includes repair or replacement coverage from wear and tear, accidental damage, ESD or EOS.
C3	Calibration service for 3 years. Includes traceable calibration or functional verification where applicable, for recommended calibrations. Coverage includes the initial calibration plus 2 years of calibration coverage.
T5	Five year Total Protection Plan, includes repair or replacement coverage from wear and tear, accidental damage, ESD or EOS.
R5	Standard warranty extended to 5 years. Covers parts, labor and 2-day shipping within country. Guarantees faster repair time than without coverage. All repairs include calibration and updates. Hassle free - a single call starts the process.
C5	Calibration service for 5 years. Includes traceable calibration or functional verification where applicable, for recommended calibrations. Coverage includes the initial calibration plus 4 years of calibration coverage.
D1	Calibration data report
D3	Calibration data report 3 years (with Option C3)
D5	Calibration data report 5 years (with Option C5)

Feature upgrades after purchase

Add feature upgrades in the future

You can easily add functionality after the initial purchase. Node-locked licenses permanently enable optional features on a single product. Floating licenses allow license-enabled options to be easily moved between compatible instruments.

Upgrade feature	Node-locked license upgrade	Floating license upgrade	Description
Add instrument functions	SUP4-AFG	SUP4-AFG-FL	Add arbitrary function generator
	SUP4-RL-1	SUP4-RL-1-FL	Extend record length to 62.5 Mpts / channel
Add protocol analysis	SUP4-RFNFC	SUP4-RFNFC-FL	ISO/IEC 15693 and ISO/IEC14443A (decode and search only)
	SUP4-SRAERO	SUP4-SRAERO-FL	Aerospace serial triggering and analysis (MIL-STD-1553, ARINC 429)
	SUP4-SRAUDIO	SUP4-SRAUDIO-FL	Audio serial triggering and analysis (I^2S, LJ, RJ, TDM)
	SUP4-SRAUTO	SUP4-SRAUTO-FL	Automotive serial triggering and analysis (CAN, CAN FD, LIN, FlexRay, and CAN symbolic decoding)
	SUP4-SRAUTOSEN	SUP4-SRAUTOSEN-FL	Automotive sensor serial triggering and analysis (SENT)
	SUP4-SRCOMP	SUP4-SRCOMP-FL	Computer serial triggering and analysis (RS-232/422/485/UART)
	SUP4-SRCXPI	SUP4-SRCXPI-FL	CXPI serial decoding and analysis
	SUP4-SREMBD	SUP4-SREMBD-FL	Embedded serial triggering and analysis (I^2C, SPI)
	SUP4-SRENET	SUP4-SRENET-FL	Ethernet serial triggering and analysis (10Base-T, 100Base-TX)
	SUP4-SRESPI	SUP4-SRESPI-FL	eSPI serial decoding and analysis
	SUP4-SRETHERCAT	SUP4-SRETHERCAT-FL	EtherCAT serial decoding and analysis
	SUP4-SRI3C	SUP4-SRI3C-FL	MIPI I3C serial trigger and analysis
	SUP4-SRMANCH	SUP4-SRMANCH-FL	Manchester (decode and search only)
	SUP4-SRMDIO	SUP4-SRMDIO-FL	Management Data Input/Output (MDIO) serial decoding and analysis
	SUP4-SRNRZ	SUP4-SRNRZ-FL	NRZ serial analysis
	SUP4-SRONEWIRE	SUP4-SRONEWIRE-FL	One wire (1-Wire) serial decoding and analysis
	SUP4-SRPM	SUP4-SRPM-FL	Power Management serial triggering and analysis (SPMI)
	SUP4-SRPSI5	SUP4-SRPSI5-FL	PSI5 serial analysis
	SUP4-SRSMBUS	SUP4-SRSMBUS-FL	SMBus serial decoding and analysis
	SUP4-SRSPACEWIRE	SUP4-SRSPACEWIRE-FL	Spacewire serial analysis
	SUP4-SRSDLC	SUP4-SRSDLC-FL	Synchronous Data Link Control
	SUP4-SRSVID	SUP4-SRSVID-FL	Serial Voltage Identification (SVID) serial decoding and analysis
	SUP4-SRUSB2	SUP4-SRUSB2-FL	USB 2.0 serial bus triggering and analysis (LS, FS, and HS)
	SUP4-SREUSB2	SUP4-SREUSB2-FL	Embedded USB 2.0 (eUSB 2.0) serial decoding and analysis

Table continued…

Upgrade feature	Node-locked license upgrade	Floating license upgrade	Description
Add advanced analysis	SUP4-3PHASE	SUP4-3PHASE-FL	Three-phase electrical analysis (6 channel model only)
	SUP4-MTM	SUP4-MTM-FL	Mask and Limit Testing
	SUP4-PS2	N/A	Power Solution Bundle (4-PWR, THDP0200, TCP0030A, 067-1686-xx deskew fixture)
	SUP4-PWR-BAS	SUP4-PWR-BAS-FL	Power measurements and analysis
	SUP4-PWR	SUP4-PWR-FL	Advanced power measurements and analysis (includes all SUP4-PWR-BAS measurements)
	SUP4-SV-BW-1	SUP4-SV-BW-1-FL	Increase Spectrum View capture bandwidth to 500 MHz
	SUP4-SV-RFVT	SUP4-SV-RFVT-FL	Spectrum View RF vs. Time traces, triggers, Spectrograms, and IQ capture
	SUP4-VID	SUP4-VID-FL	NTSC, PAL and SECAM video triggering
	SUP4-WBG-DPT	SUP4-WBG-DPT-FL	Wide Bandgap SiC/GaN Double Pulse Test Measurements and Analysis
Add digital voltmeter	N/A	N/A	Add digital voltmeter / trigger frequency counter (free with product registration at *www.tek.com/register4mso*)

Bandwidth upgrades after purchase

Add bandwidth upgrades in the future

You can easily upgrade the analog bandwidth of products after initial purchase. Bandwidth upgrades are purchased based on the number of FlexChannel inputs, the current bandwidth, and the desired bandwidth. All models can be upgraded in the field to any bandwidth.

Oscilloscope model owned	Bandwidth upgrade product	Upgrade option	Upgrade option description
MSO44	SUP4-BW4	4-BW2T3-4	License; Bandwidth Upgrade; Upgrade from 200 MHz to 350 MHz bandwidth on a (4) FlexChannel model; Node Locked
		4-BW2T5-4	License; Bandwidth Upgrade; Upgrade from 200 MHz to 500 MHz bandwidth on a (4) FlexChannel model; Node Locked
		4-BW2T10-4	License; Bandwidth Upgrade; Upgrade from 200 MHz to 1 GHz bandwidth on a (4) FlexChannel model; Node Locked
		4-BW2T15-4	License; Bandwidth Upgrade; Upgrade from 200 MHz to 1.5 GHz bandwidth on a (4) FlexChannel model; Node Locked
		4-BW3T5-4	License; Bandwidth Upgrade; Upgrade from 350 MHz to 500 MHz bandwidth on a (4) FlexChannel model; Node Locked
		4-BW3T10-4	License; Bandwidth Upgrade; Upgrade from 350 MHz to 1 GHz bandwidth on a (4) FlexChannel model; Node Locked
		4-BW3T15-4	License; Bandwidth Upgrade; Upgrade from 350 MHz to 1.5 GHz bandwidth on a (4) FlexChannel model; Node Locked
		4-BW5T10-4	License; Bandwidth Upgrade; Upgrade from 500 MHz to 1 GHz bandwidth on a (4) FlexChannel model; Node Locked
		4-BW5T15-4	License; Bandwidth Upgrade; Upgrade from 500 MHz to 1.5 GHz bandwidth on a (4) FlexChannel model; Node Locked
		4-BW10T15-4	License; Bandwidth Upgrade; Upgrade from 1 GHz to 1.5 GHz bandwidth on a (4) FlexChannel model; Node Locked

Table continued…

Oscilloscope model owned	Bandwidth upgrade product	Upgrade option	Upgrade option description
MSO46	SUP4-BW6	4-BW2T3-6	License; Bandwidth Upgrade; Upgrade from 200 MHz to 350 MHz bandwidth on a (6) FlexChannel model; Node Locked
		4-BW2T5-6	License; Bandwidth Upgrade; Upgrade from 200 MHz to 500 MHz bandwidth on a (6) FlexChannel model; Node Locked
		4-BW2T10-6	License; Bandwidth Upgrade; Upgrade from 200 MHz to 1 GHz bandwidth on a (6) FlexChannel model; Node Locked
		4-BW2T15-6	License; Bandwidth Upgrade; Upgrade from 200 MHz to 1.5 GHz bandwidth on a (6) FlexChannel model; Node Locked
		4-BW3T5-6	License; Bandwidth Upgrade; Upgrade from 350 MHz to 500 MHz bandwidth on a (6) FlexChannel model; Node Locked
		4-BW3T10-6	License; Bandwidth Upgrade; Upgrade from 350 MHz to 1 GHz bandwidth on a (6) FlexChannel model; Node Locked
		4-BW3T15-6	License; Bandwidth Upgrade; Upgrade from 350 MHz to 1.5 GHz bandwidth on a (6) FlexChannel model; Node Locked
		4-BW5T10-6	License; Bandwidth Upgrade; Upgrade from 500 MHz to 1 GHz bandwidth on a (6) FlexChannel model; Node Locked
		4-BW5T15-6	License; Bandwidth Upgrade; Upgrade from 500 MHz to 1.5 GHz bandwidth on a (6) FlexChannel model; Node Locked
		4-BW10T15-6	License; Bandwidth Upgrade; Upgrade from 1 GHz to 1.5 GHz bandwidth on a (6) FlexChannel model; Node Locked

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