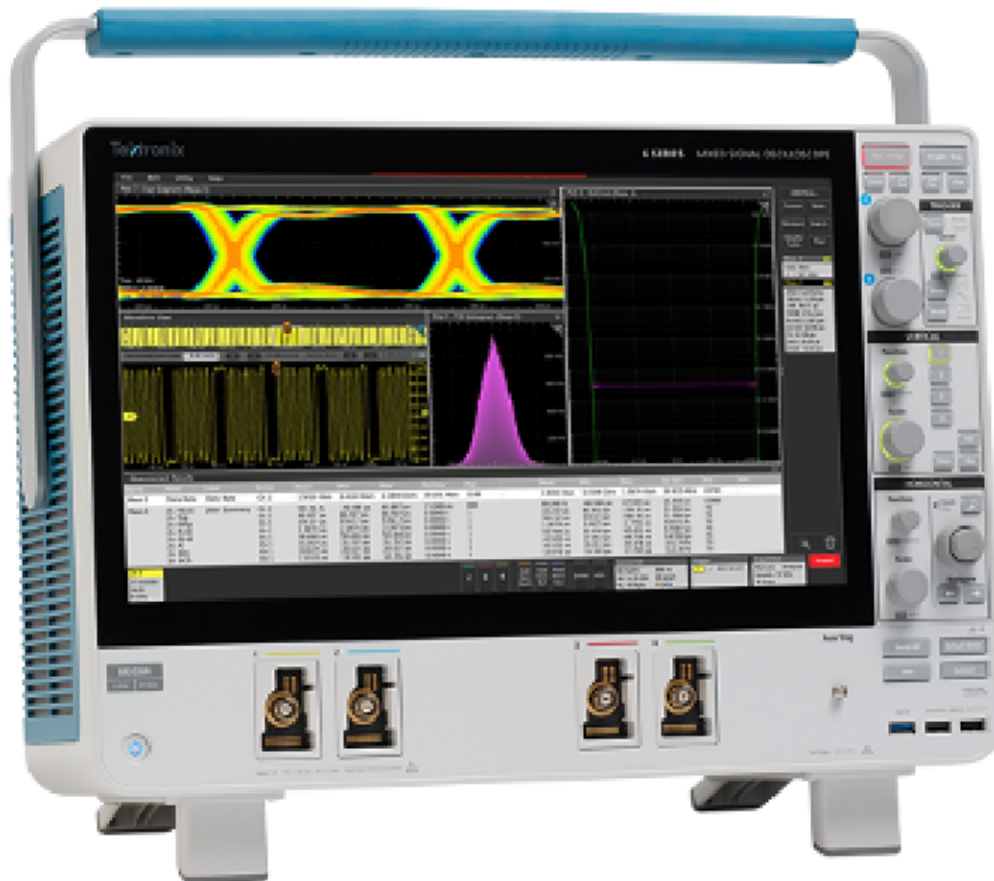


## 6 Series MSO

### Mixed Signal Oscilloscope Datasheet

*More speed. Lowest noise.  
Exceptional Measurement confidence*



## Confidence in numbers

### Input channels

- 4 FlexChannel<sup>®</sup> inputs
- Each FlexChannel provides one analog signal input or eight digital logic inputs with TLP058 logic probe

### Bandwidth

- 1 GHz, 2.5 GHz, 4 GHz, 6 GHz, 8 GHz (upgradable)

### Sample rate (all analog / digital channels)

- Real-time: 25 GS/s
- Interpolated: 2.5 TS/s

### Record length (all analog / digital channels)

- 62.5 Mpoints standard
- 125 Mpoints and 250 Mpoints optional upgrades

### 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
- Auxiliary Trigger  $\leq 5 V_{RMS}$ , 50 $\Omega$ , 400 MHz (Edge Trigger only)

### Standard analysis

- Cursors: Waveform, V Bars, H Bars, V&H Bars
- Measurements: 36
- FastFrame<sup>™</sup>: 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
- Jitter: TIE and Phase Noise

### Optional analysis <sup>1</sup>

- Advanced Jitter and Eye Diagram Analysis
- Advanced Power Analysis

### Optional serial bus trigger, decode and analysis <sup>1</sup>

- I<sup>2</sup>C, SPI, RS-232/422/485/UART, SPMI, CAN, CAN FD, LIN, FlexRay, SENT, USB 2.0, Ethernet, I<sup>2</sup>S, LJ, RJ, TDM, MIL-STD-1553, ARINC 429, SPMI

### Arbitrary/Function Generator <sup>1</sup>

- 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 <sup>2</sup>

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

### Trigger frequency counter <sup>2</sup>

- 8-digit

### Display

- 15.6-inch (396 mm) TFT color
- High Definition (1,920 x 1,080) resolution
- Capacitive (multi-touch) touchscreen

### Connectivity

- USB Host , USB Device (1 port), LAN (10/100/1000 Base-T Ethernet), Display Port, DVI-I, Video Out

### e\*Scope<sup>®</sup>

- Remotely view and control the oscilloscope over a network connection through a standard web browser

### Warranty

- 3 years standard

### Dimensions

- 12.2 in (309 mm) H x 17.9 in (454 mm) W x 8.0 in (204 mm) D
- Weight: <28.4 lbs. (12.88 kg)

<sup>1</sup> Optional and upgradeable.

<sup>2</sup> Free with product registration.

With the lowest input noise and up to 8 GHz analog bandwidth, the 6 Series MSO provides the best signal fidelity for analyzing and debugging today's embedded systems with GHz clock and bus speeds. The remarkably innovative pinch-swipe-zoom touchscreen user interface coupled with the industry's largest high definition display and 4 FlexChannel® inputs that let you measure one analog or eight digital signals per channel, the 6 Series MSO is ready for today's toughest challenges and tomorrow's too.

### FlexChannel® technology enables maximum flexibility and broader system visibility

The 6 Series MSO redefines what a Mixed Signal Oscilloscope (MSO) should be. FlexChannel technology enables each of the inputs on the instrument to be used as a single analog channel or eight digital channels. The conversion is done by simply attaching a TLP058 logic probe to any input. Imagine the flexibility and configurability this provides.

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.

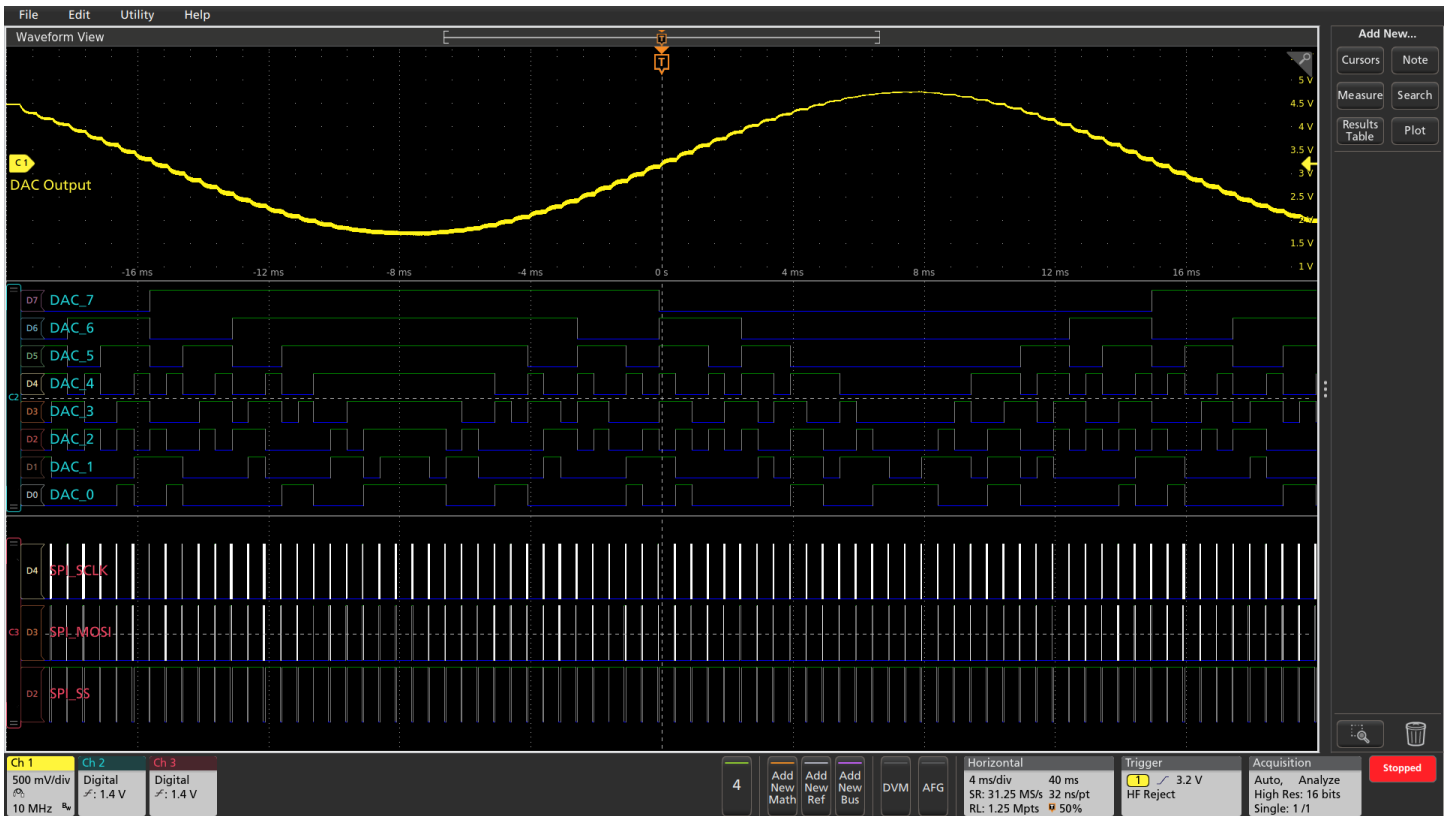


*FlexChannel technology enables the ultimate in flexibility. Each input can be configured as a single analog or eight digital channels based on the type of probe you attach.*

The 6 Series MSO offers a new level of integration of digital channels. Digital channels share the same high sample rate (up to 25 GS/s) for fine timing resolution, and long record length (up to 250 Mpoints) for long time captures as analog channels. Previous-generation MSOs required tradeoffs, with digital channels having lower sample rates or shorter record lengths than analog channels.



*The TLP058 provides eight high performance digital inputs. Connect as many TLP058 probes as you like, enabling up to a maximum of 32 digital channels.*



FlexChannel 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 FlexChannel 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.

Color-coded digital traces make it easy to determine if a logic signal is a one or a zero, even when the trace is flat across the display. Ones are displayed in green and zeros in blue. Unique multiple-transition detection hardware indicates when more than one transition occurs within a sample interval. A white bar on the trace indicates that more information is available by zooming in or acquiring at faster sampling rates. Often, zooming in will reveal a glitch that was previously hidden. Distinct thresholds can be defined for each digital channel, enabling you to easily observe different logic families, unlike other MSOs that have one or two shared thresholds across all digital channels.

## Unprecedented signal viewing capability

The stunning 15.6" (396 mm) display in the 6 Series MSO is the largest display in the industry. 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.



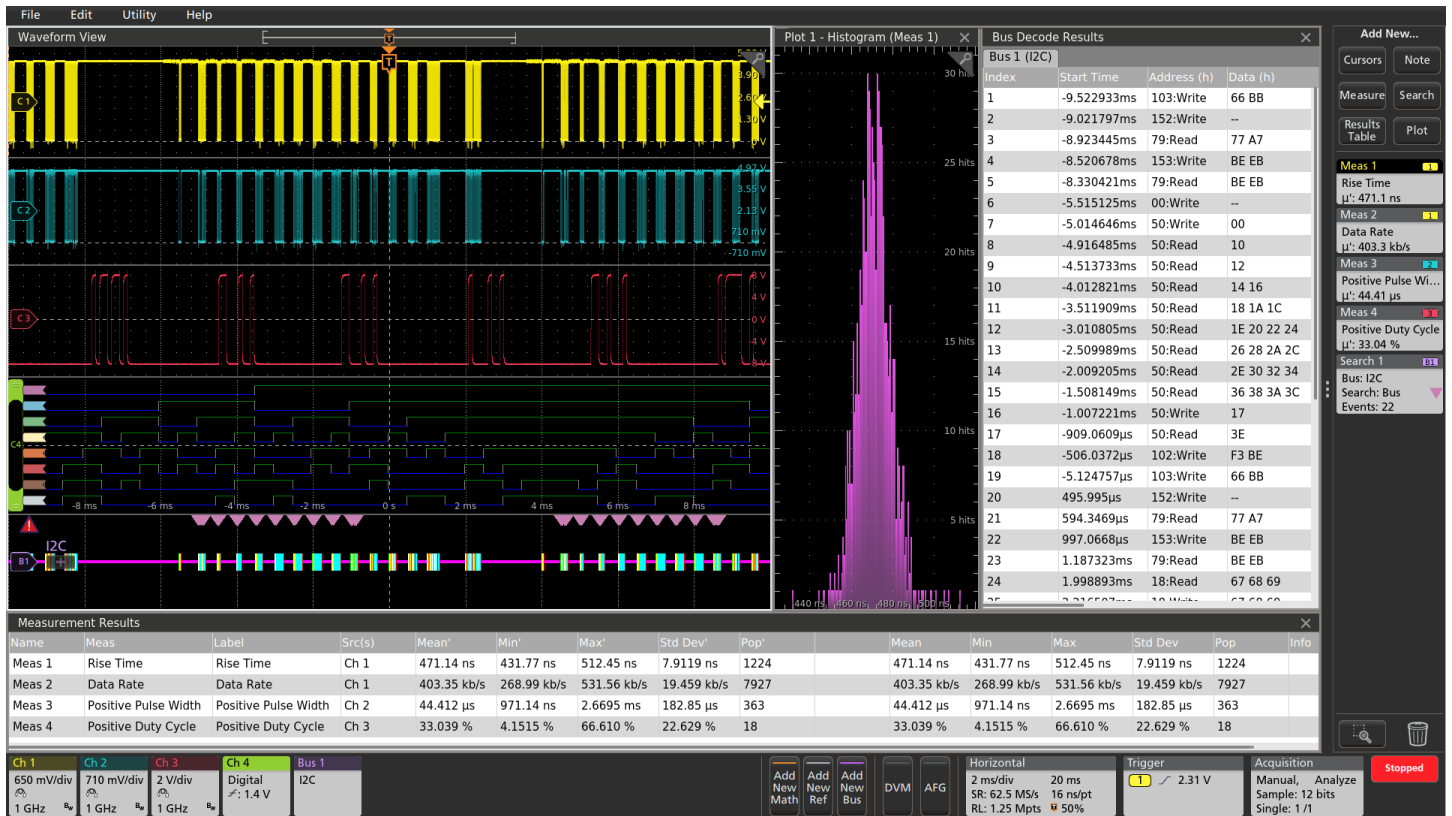
Stacked display mode enables easy visibility of all waveforms while maintaining maximum ADC resolution on each input for the most accurate measurements.

The 6 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.

The massive display in the 6 Series MSO 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

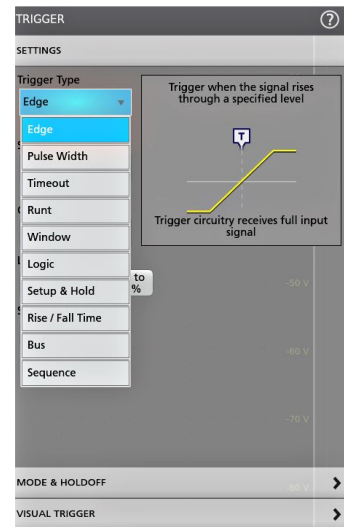
Waveform and scope operating parameters are displayed in a series of "badges" in the Settings Bar that runs along the bottom of the display. The Settings Bar provides Immediate access for the most common waveform management tasks. With a single tap, you can:

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

Scopes have included touch screens for years, but the touch screen has been an afterthought. The 6 Series MSO's 15.6" 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 in the 6 Series MSO.

- 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 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.

## Attention to detail in the front-panel controls

Traditionally, the front face of a scope has been roughly 50% display and 50% front panel. The 6 Series MSO display fills about 85% 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, Autoset and Quick-save functions are all available using dedicated front panel buttons.



Efficient and intuitive front panel provides critical controls while still leaving room for the massive 15.6" high definition display.

## Windows or not - you choose

The 6 Series MSO offers you the choice of whether to include a Microsoft Windows™ operating system. Opening an access panel on the bottom of the instrument reveals a connection for a solid state drive (SSD). When the SSD is not present, the instrument boots as a dedicated scope with no ability to run or install other programs.



When the SSD is present, the instrument boots in an open Windows 10 configuration, so you can minimize the oscilloscope application and access a Windows desktop where you can install and run additional applications on the oscilloscope. Or you can connect additional monitors and extend your desktop.

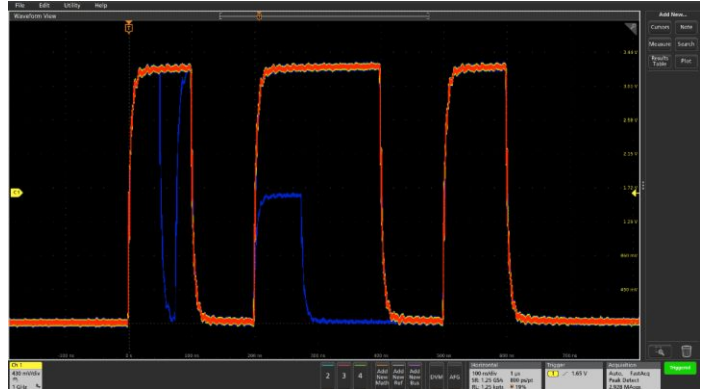
Whether you run Windows or not, the oscilloscope operates in exactly the same way with the same look and feel and UI interaction.

## Experience the performance difference

With up to 8 GHz analog bandwidth, 25 GS/s sample rates, standard 62.5 M record length and a 12-bit analog to digital converter (ADC), the 6 Series MSO has the performance you need to capture waveforms with the best possible signal fidelity and resolution for seeing small waveform details.

### 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 and low noise

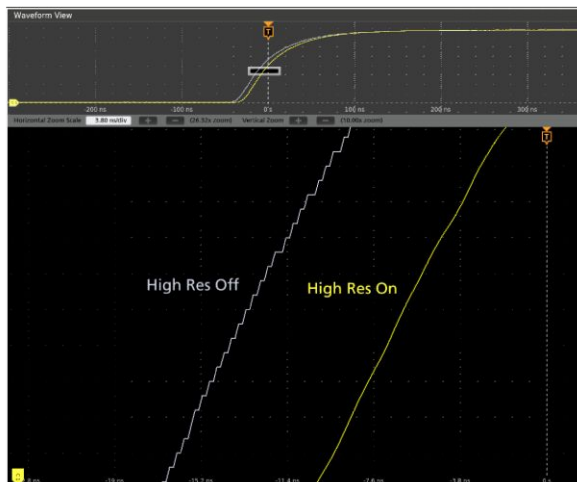
The 6 Series MSO provides the performance to capture the signals of interest while minimizing the effects of unwanted noise when you need to capture high-amplitude signals while seeing smaller signal details. At the heart of the 6 Series MSO are 12-bit analog-to-digital converters (ADCs) that provide 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 ≤ 625 MS/s sample rates and 200 MHz of bandwidth. The following table shows the number of bits of vertical resolution for each sample rate setting when in High Res.

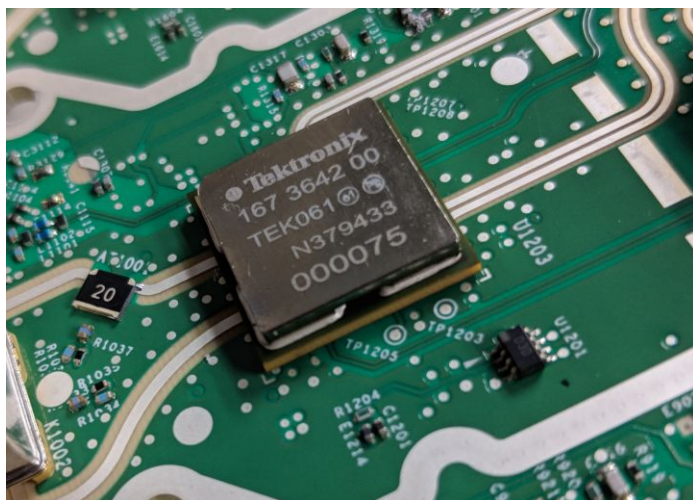
Sample rate	Number of bits of vertical resolution
25 GS/s	8
12.5 GS/s	12
6.25 GS/s	13
3.125 MS/s	14
1.25 MS/s	15
≤625 MS/s	16





The 6 Series MSOs 12-bit ADC along with the new High Res mode enable industry leading vertical resolution.

A new TEK061 front end amplifier sets a new standard for low-noise acquisition providing the best signal fidelity to capture small signals with high resolution.



A key attribute to being able to view fine signal details on small, high-speed signals is noise. The higher a measurement systems' intrinsic noise, the less true signal detail will be visible. This becomes more critical on an oscilloscope when the vertical settings are set to high sensitivity (like  $\leq 10\text{mV/div}$ ) in order to view small signals that are prevalent in high-speed bus topologies. The 6 Series MSO has a new front-end ASIC, the TEK061, that enables breakthrough noise performance at the highest sensitivity settings. The table below shows a comparison of typical noise performance of the 6 Series MSO and prior generations of Tektronix oscilloscopes in this bandwidth range.

### 50 $\Omega$ , RMS voltage, typical

Bandwidth	V/Div	6 Series MSO	DPO7000C	MSO/ DPO70000C
1 GHz	1 mV	54.8 $\mu\text{V}$	90 $\mu\text{V}^3$	N/A
	10 mV	90.9 $\mu\text{V}$	279 $\mu\text{V}$	N/A
	100 mV	941 $\mu\text{V}$	2.7 mV	N/A
4 GHz	1 mV	97.4 $\mu\text{V}$	N/A	N/A
	10 mV	192 $\mu\text{V}$	N/A	500 $\mu\text{V}$
	100 mV	1.92 mV	N/A	4.3 mV
8 GHz	1 mV	158 $\mu\text{V}$	N/A	N/A
	10 mV	342 $\mu\text{V}$	N/A	580 $\mu\text{V}$
	100 mV	3.46 mV	N/A	4.5 mV

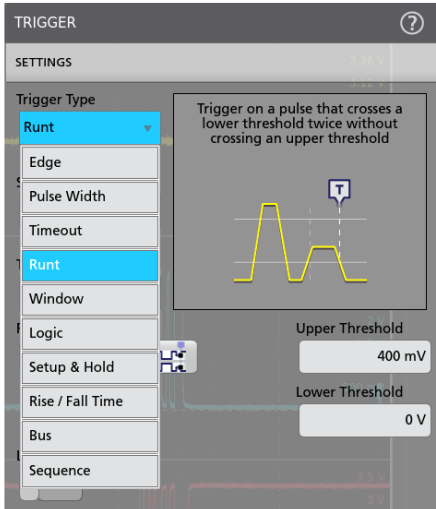
### Triggering

Discovering a device fault is only the first step. Next, you must capture the event of interest to identify root cause. The 6 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
- Visual Trigger

With up to a 250 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.

<sup>3</sup> Bandwidth limited to 200 MHz.

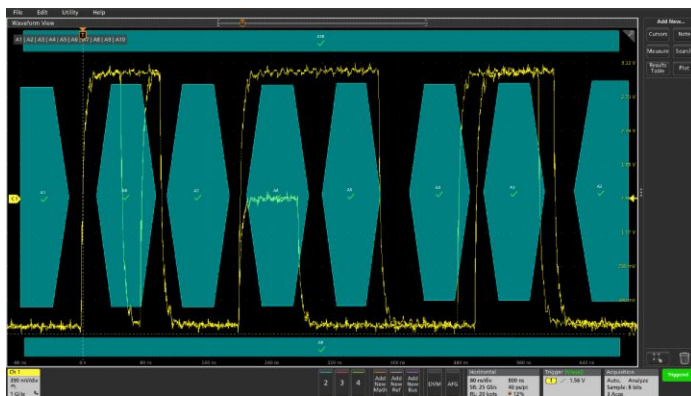


The wide variety of trigger types and context-sensitive help in the trigger menu make it easier than ever to isolate the event of interest.

### Visual trigger -Finding the signal of interest quickly

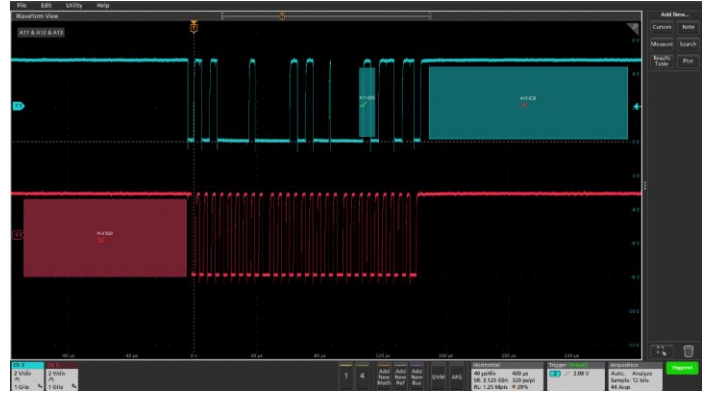
Finding the right cycle of a complex bus can require hours of collecting and sorting through thousands of acquisitions for an event of interest. Defining a trigger that isolates the desired event speeds up debug and analysis efforts.

Visual Trigger extends the 6 Series MSO's triggering capabilities by scanning through all waveform acquisitions and comparing them to on-screen areas (geometric shapes). An unlimited number of areas can be created using a 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.



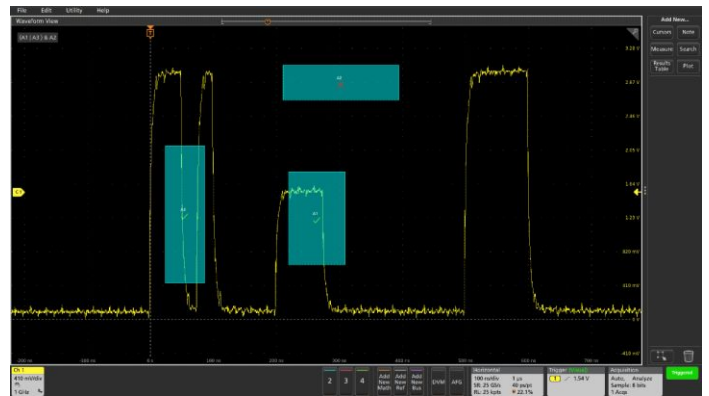
Visual Trigger areas isolate an event of interest, saving time by only capturing the events you want to see.

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 packets transmitted on two bus signals simultaneously.

Once multiple areas are defined, a Boolean logic equation can be used to set complex trigger conditions using on-screen editing features.



Boolean logic trigger qualification. Boolean logic using logical OR allows triggering on a specific anomaly in the signal.

## 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 6 Series MSO provides up to 40 W of power to the front panel connectors, sufficient to power all connected TekVPI probes without the need for an additional probe power supply.

## Convenient high speed passive voltage probing

The TPP Series passive voltage probes included with every 6 Series MSO 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).



6 Series MSOs come standard with one TPP1000 (1 GHz, 2.5 GHz models) probe per channel.

## TDP7700 Series TriMode Probes

The TDP7700 Series TriMode probes provide the highest probe fidelity available for real-time oscilloscopes. The TDP7700 is designed for use with the 6 Series MSO, with full AC calibration of the probe and tip's signal path based on unique S-parameter models. The probe communicates the S-parameters to the scope via the TekVPI probe interface and the 6 Series MSO includes them to achieve the very best signal fidelity possible from probe tip to acquisition memory. Connectivity innovations such as solder-down tips with the probe's input buffer mounted only a few millimeters from the end of the tip, the TDP7700 Series probes provide unmatched usability for connecting to today's most challenging electronic designs.



TDP7700 Series probe with a selection of available tips

With TriMode probing one probe setup makes differential, single ended, and common mode measurements accurately. This unique capability allows you to work more effectively and efficiently, switching between differential, single ended and common mode measurements without moving the probe's connection point.

## 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.

Tektronix' revolutionary IsoVu technology uses optical communications and power-over-fiber for complete galvanic isolation. When combined with the 6 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 TIVM 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.*

## 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 6 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
- FFT analysis
- Advanced waveform math including arbitrary equation editing with filters and variables
- 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.

Measurement results tables provide comprehensive statistical views of measurement results with statistics across both the current acquisition and all acquisitions.



Using measurements to characterize burst width and Frequency.

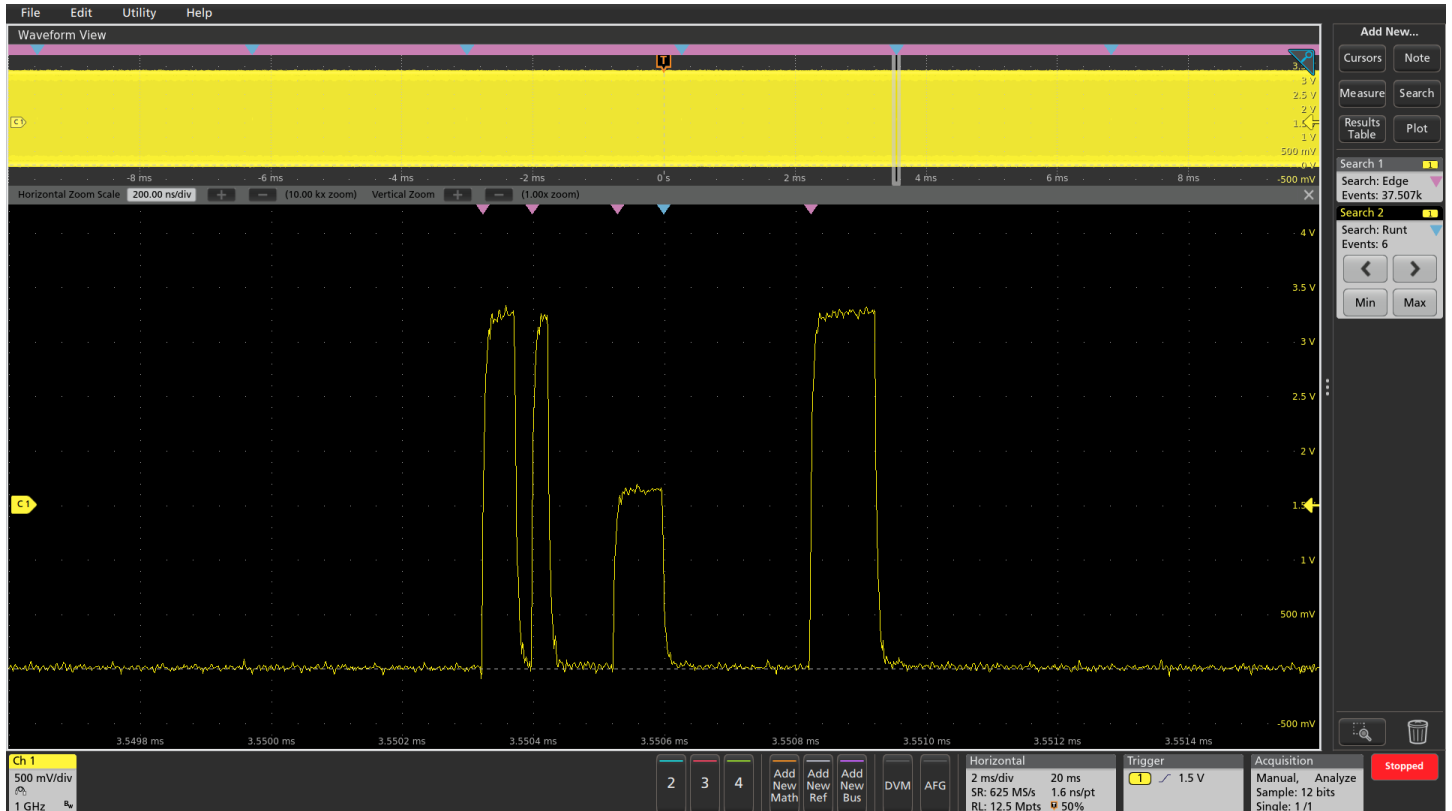
### Navigation and search

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 6 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.

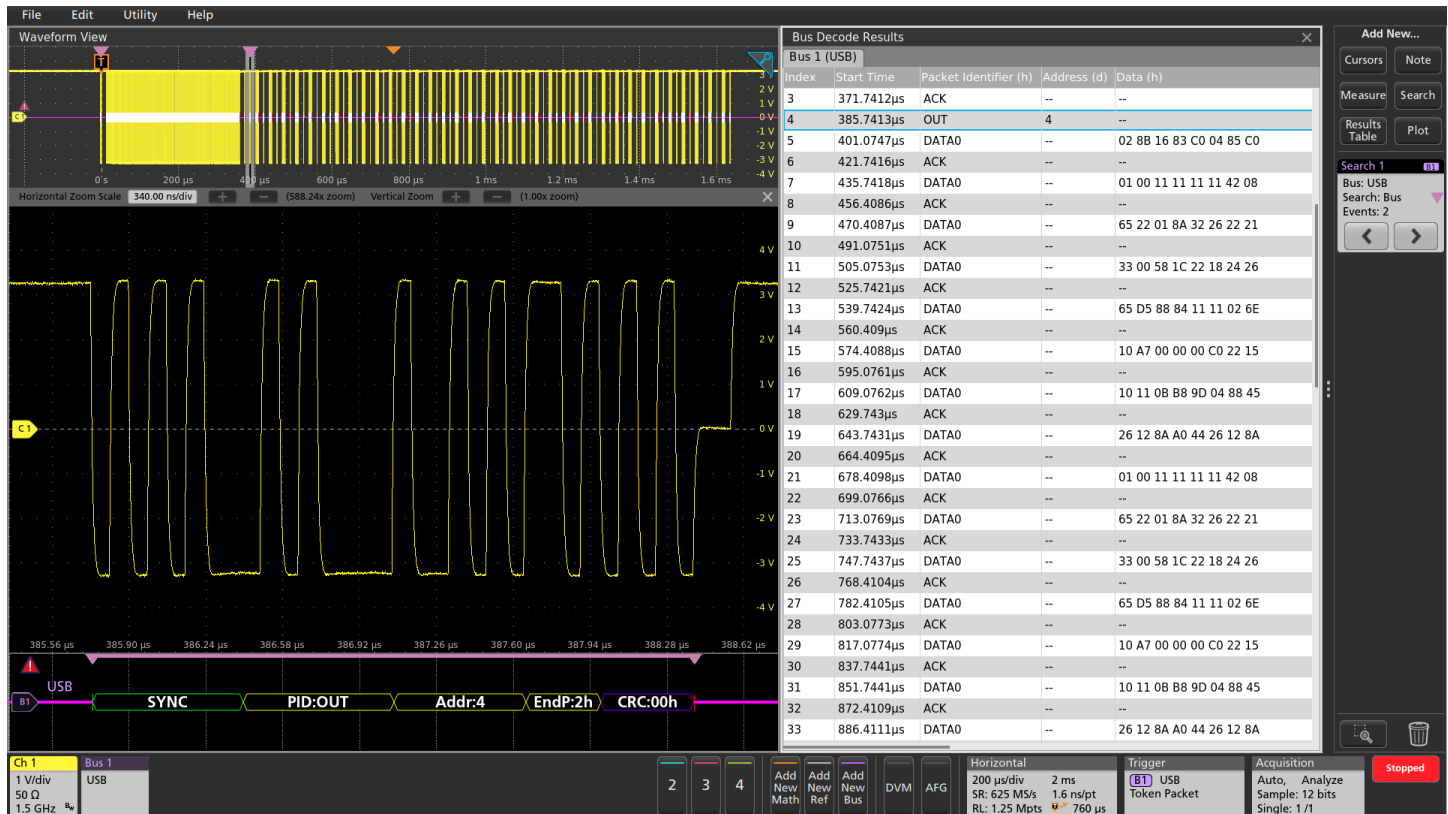


Earlier, FastAcq revealed the presence of a runt pulse in a digital data stream prompting further investigation. In this long 20 ms acquisition, Search 1 reveals that there are approximately 37,500 rising edges in the acquisition. Search 2 (run simultaneously) reveals that there are six runt pulses in the acquisition.

## Serial protocol triggering 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 USB full-speed serial bus. A bus waveform provides time-correlated decoded packet content including Start, Sync, PID, Address, End Point, CRC, Data values, and Stop, while the bus decode table presents all packet content from the entire acquisition.

The 6 Series MSO offers a robust set of tools for working with the most common serial buses found in embedded design including I<sup>2</sup>C, SPI, RS-232/422/485/UART, SPMI, CAN, CAN FD, LIN, FlexRay, SENT, USB LS/FS/HS, Ethernet 10/100, Audio (I<sup>2</sup>S/LJ/RJ/TDM), MIL-STD-1553, and ARINC 429.

Serial 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.

Parallel buses are still found in many designs. The tools described for serial buses also work on parallel buses. Support for parallel buses is standard in the 6 Series MSO. Parallel buses can be up to 32 bits wide and can include a combination of analog and digital channels.

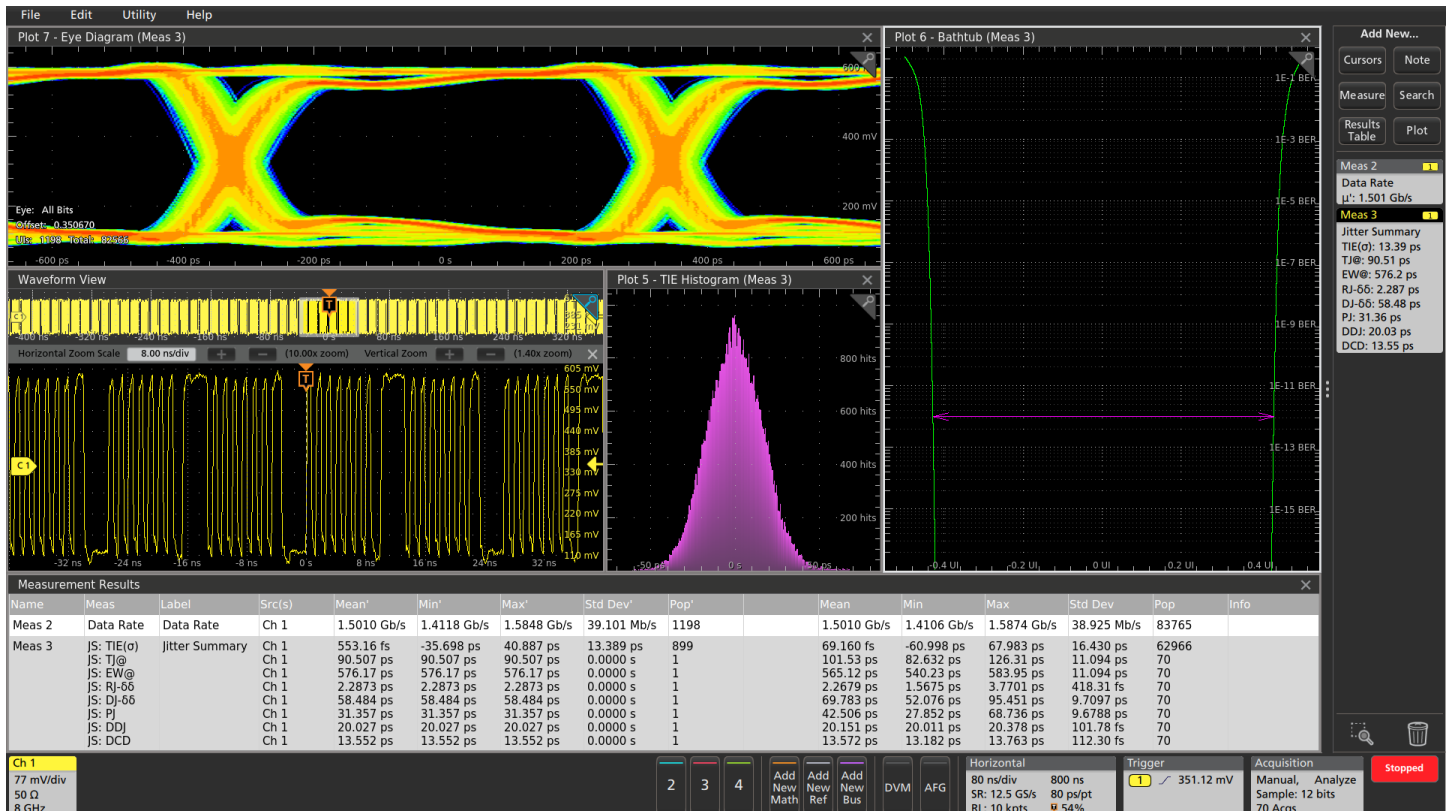
- Serial protocol triggering lets you trigger on specific packet content including start of packet, specific addresses, specific data content, unique identifiers, and errors.
- Bus waveforms provide a higher-level, combined view of the individual signals (clock, data, chip enable, and so on) that make 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).

### Jitter analysis

The 6 Series MSO has seamlessly integrated the DPOJET Essentials jitter and eye pattern analysis software package, extending the oscilloscope's capabilities to take measurements over contiguous clock and data cycles in a single-shot real-time acquisition. This enables measurement of key jitter and timing analysis parameters such as Time Interval Error and Phase Noise to help characterize possible system timing issues.

Analysis tools, such as plots for time trends and histograms, quickly show how timing parameters change over time, and spectrum analysis quickly shows the precise frequency and amplitude of jitter and modulation sources.

Option 6-DJA adds additional jitter analysis capability to better characterize your device's performance. The 31 additional measurements provide comprehensive jitter and eye-diagram analysis and jitter decomposition algorithms, enabling the discovery of signal integrity issues and their related sources in today's high-speed serial, digital, and communication system designs.



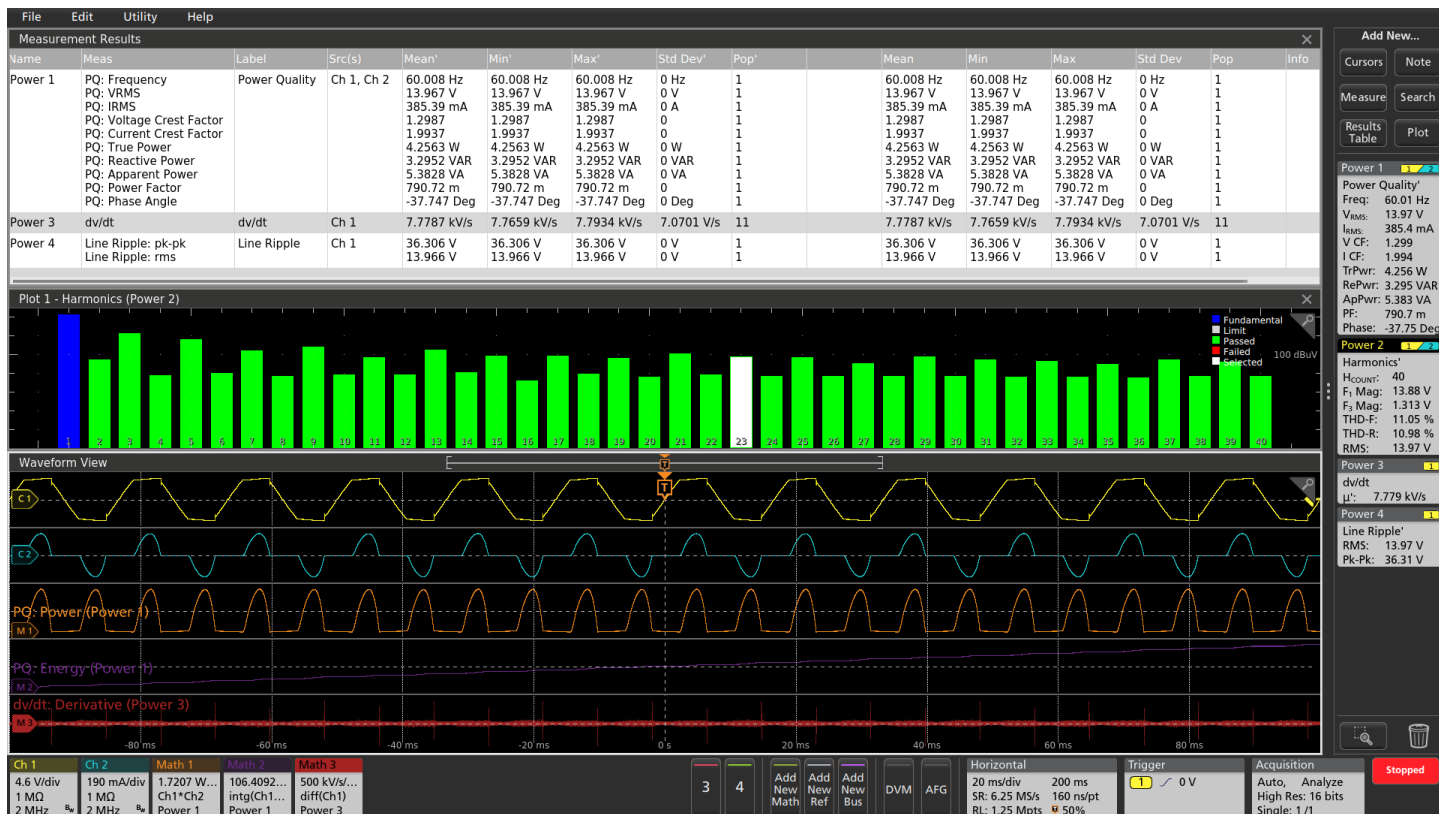
The unique Jitter Summary provides a comprehensive view of your device's performance in a matter of seconds.



## Power analysis

The 6 Series MSO has also integrated the optional 6-PWR power analysis package into the oscilloscope's 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, magnetics measurements, 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.



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

## Compliance test

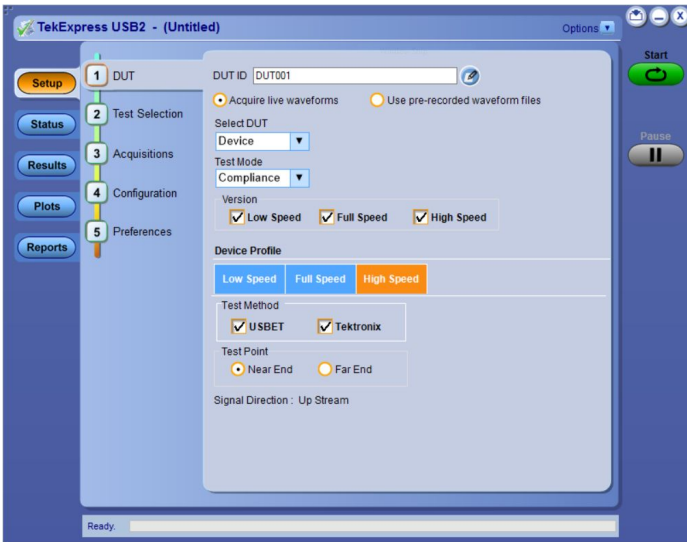
A key focus area for embedded designers is testing various embedded and interface technologies for compliance. This ensures the device passes the logo certification at plugfests and achieves successful interoperability when working with other compliant devices.

The compliance test specifications for high speed serial standards like USB, Ethernet, Memory, Display and MIPI are developed by the respective consortiums, or governing bodies. Working closely with these consortiums, Tektronix has developed oscilloscope-based compliance applications that not only focus on providing pass/fail results but also provide deeper insight into any failures by providing relevant measurement tools such as jitter and timing analysis to debug failing designs.

These automated compliance applications are built on a framework that provides:

- Complete test coverage per the specification.
- Fast test times with optimized acquisitions and test sequencing based on customized settings.

- Analysis based on previously-acquired signals, allowing the device under test (DUT) to be disconnected from the setup once all acquisitions are completed. This also allows analysis of waveforms acquired on a different oscilloscope or captured at a remote lab, facilitating a very collaborative test environment.
- Signal validation during acquisition to ensure the right signals are being captured.
- Additional parametric measurements for design debug.
- Custom eye diagram mask testing for insight into design margin.
- Detailed reports in multiple formats with setup information, results, margins, waveform screenshots and plot images.



TekExpress USB2 (Option 6-CMUSB2) DUT panel configures the DUT-specific settings



6 Series MSO running 6-CMUSB2 Compliance Measurements as per USB 2.0 Specification

## Designed with your needs in mind

### Connectivity

The 6 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.

- Two USB 2.0 and one USB 3.0 host ports on the front and four more USB host ports (two 2.0, two 3.0) on the rear 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.
- DVI-D, Display Port and VGA ports on the rear of the instrument lets you export the display to an external monitor or projector.



The I/O you need to connect the 6 Series MSO to the rest of your design environment.

## Remote operation to improve collaboration

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

The embedded e\*Scope<sup>®</sup> capability enables fast control of the oscilloscope over a network connection through a standard web browser. 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 ways you do in-person. Alternatively, you can use Microsoft Windows Remote Desktop<sup>™</sup> capability to connect directly to your oscilloscope and control it remotely.

The industry-standard TekVISA<sup>™</sup> 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.



e\*Scope provides simple remote viewing and control using common web browsers.

## Arbitrary/Function Generator (AFG)

The 6 Series MSO 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 arbitrary waveform generator provides 128 k points of record for loading saved waveforms from an internal file location or a USB mass storage device. The 6 Series MSO 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 6 Series MSO 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 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 6-SEC enhanced security option enables password-protected enabling/disabling of all instrument I/O ports and firmware upgrades. In addition, option 6-SEC provides the highest level of security by ensuring that internal memory is clear of all setup and waveform data in compliance with National Industrial Security Program Operating Manual (NISPOM) DoD 5220.22-M, Chapter 8 requirements as well as Defense Security Service Manual for the Certification and Accreditation of Classified Systems under the NISPOM. This ensures you can confidently move the instrument out of a secure area.

## Help when you need it

The 6 Series MSO includes several helpful resources 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.

The screenshot displays the TekScope user interface. A help window titled "TEKSCOPE HELP" is open, showing the "Add Measurements configuration menu overview". The help window includes a table of fields and controls:

Field or control	Description
<b>Measurement tabs</b>	The tabs along the top organize measurements by their type. The Standard tab is the default set of measurements that are built in to the instrument. Other tabs are shown when you install measurement options.
<b>Measurement description</b>	Shows a graphic and short description of the selected measurement. Use this information to verify that the selected measurement is

The background shows a digital waveform with a yellow trace. The waveform is a square wave with some overshoot. The x-axis is time, ranging from -1.6 μs to 1.6 μs. The y-axis is voltage, ranging from -3.36 V to 3.36 V. The interface includes various measurement and control buttons, such as "Add New...", "Cursors", "Note", "Measure", "Search", "Results Table", and "Plot".

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

## Specifications

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

### Model overview

#### Oscilloscope

	MSO64
FlexChannel inputs	4
Maximum analog channels	4
Maximum digital channels (with optional logic probes)	32
Bandwidth (calculated rise time)	1 GHz (400 ps), 2.5 GHz (160 ps), 4 GHz (100 ps), 6 GHz (66.67 ps), 8 GHz (50 ps)
DC Gain Accuracy	50 $\Omega$ : $\pm 2.0\%$ , ( $\pm 4.0\%$ at 1 mV/Div) 50 $\Omega$ : $\pm 1.0\%$ of full scale, ( $\pm 2.0\%$ of full scale at 1 mV/div), 1 M $\Omega$ : $\pm 1.0\%$ , ( $\pm 2.5\%$ at 1 mV/Div and 500 $\mu$ V/Div Settings) 1 M $\Omega$ : $\pm 0.5\%$ of full scale, ( $\pm 1.0\%$ of full scale at 1 mV/div and 500 $\mu$ V/div)
ADC Resolution	12 bits
Vertical Resolution	8 bits @ 25 GS/s 12 bits @ 12.5 GS/s 13 bits @ 6.25 GS/s (High Res) 14 bits @ 3.125 GS/s (High Res) 15 bits @ 1.25 GS/s (High Res) 16 bits @ $\leq 625$ MS/s (High Res)
Sample Rate	25 GS/s on all analog / digital channels (40 ps resolution)
Record Length	62.5 Mpoints on all analog / digital channels, 125 Mpoints on all analog / digital channels optional, and 250 Mpoints on all analog / digital channels optional
Waveform Capture Rate	>500,000 wfms/s (Peak Detect, Envelope acquisition mode), >30,000 wfms/s (all other acquisition modes)
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

**Input coupling** DC, AC

**Input impedance 1 M $\Omega$  DC coupled** 1 M $\Omega$   $\pm 1\%$

**Input capacitance 1 M $\Omega$  DC coupled, typical** 14.5 pF  $\pm 1.5$  pF

**Input impedance 50  $\Omega$ , DC coupled** 50  $\Omega$   $\pm 3\%$  (VSWR  $\leq 1.5:1$ , typical)

#### Input sensitivity range

**1 M $\Omega$**  500  $\mu$ V/div to 10 V/div in a 1-2-5 sequence  
Note: 500  $\mu$ V/div is a 2X digital zoom of 1 mV/div.

**50  $\Omega$**  1 mV/div to 1 V/div in a 1-2-5 sequence  
Note: 1 mV/div is a 2X digital zoom of 2 mV/div.

**Vertical system - analog channels**

**Maximum input voltage**      50  $\Omega$ : 2.5  $V_{RMS}$  at <100 mV, with peaks  $\leq \pm 20$  V (DF  $\leq 6.25\%$ )  
 50  $\Omega$ : 5  $V_{RMS}$  at  $\geq 100$  mV, with peaks  $\leq \pm 20$  V (DF  $\leq 6.25\%$ )  
 1  $M\Omega$ : 300  $V_{RMS}$   
 For 1  $M\Omega$ , derate at 20 dB/decade from 4.5 MHz to 45 MHz;  
 Derate at 14 dB/decade from 45 MHz to 450 MHz;  
 > 450 MHz, 5.5  $V_{RMS}$

**Effective bits (ENOB), typical**

**2 mV/div, High Res mode,  
 50  $\Omega$ , 10 MHz input with 90%  
 full screen**

Bandwidth	ENOB
4 GHz	5.9
3 GHz	6.1
2.5 GHz	6.2
2 GHz	6.35
1 GHz	6.8
500 MHz	7.2
350 MHz	7.4
250 MHz	7.5
200 MHz	7.75
20 MHz	8.8

**50 mV/div, High Res mode,  
 50  $\Omega$ , 10 MHz input with 90%  
 full screen**

Bandwidth	ENOB
4 GHz	7.25
3 GHz	7.5
2.5 GHz	7.6
2 GHz	7.8
1 GHz	8.2
500 MHz	8.5
350 MHz	8.8
250 MHz	8.9
200 MHz	9
20 MHz	9.8

**Vertical system - analog channels**

2 mV/div, Sample mode, 50  $\Omega$ ,  
10 MHz input with 90% full  
screen

Bandwidth	ENOB
8 GHz	5.1
74 GHz	5.3
6 GHz	5.5
5 GHz	5.65
4 GHz	5.9
3 GHz	6.05
2.5 GHz	6.2
2 GHz	6.35
1 GHz	6.8
500 MHz	7.2
350 MHz	7.3
250 MHz	7.5
200 MHz	7.3
20 MHz	7.6

50 mV/div, Sample mode,  
50  $\Omega$ , 10 MHz input with 90%  
full screen

Bandwidth	ENOB
8 GHz	6.5
7 GHz	6.6
6 GHz	6.8
5 GHz	7
4 GHz	7.2
3 GHz	7.4
2.5 GHz	7.6
2 GHz	7.7
1 GHz	8.2
500 MHz	8.4
350 MHz	8.7
250 MHz	8.8
200 MHz	7.8
20 MHz	7.9

**DC balance**

0.1 div with DC-50  $\Omega$  oscilloscope input impedance (50  $\Omega$  BNC terminated)

0.2 div at 1 mV/div with DC-50  $\Omega$  oscilloscope input impedance (50  $\Omega$  BNC terminated)

0.2 div with DC-1 M $\Omega$  oscilloscope input impedance (50  $\Omega$  BNC terminated)

**Position range**

$\pm 5$  divisions

**Vertical system - analog channels**

**Offset ranges, maximum**

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, 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 | + DC balance); Offset, position, and DC Balance in units of Volts.

**Bandwidth selections**

- 8 GHz model, 50 Ohm** 20 MHz, 200 MHz, 250 MHz, 350 MHz, 500 MHz, 1 GHz, 2 GHz, 2.5 GHz, 3 GHz, 4 GHz, 5 GHz, 6 GHz, 7 GHz, and 8 GHz
- 6 GHz model, 50 Ohm** 20 MHz, 200 MHz, 250 MHz, 350 MHz, 500 MHz, 1 GHz, 2 GHz, 2.5 GHz, 3 GHz, 4 GHz, 5 GHz, and 6 GHz
- 4 GHz model, 50 Ohm** 20 MHz, 200 MHz, 250 MHz, 350 MHz, 500 MHz, 1 GHz, 2 GHz, 2.5 GHz, 3 GHz, and 4 GHz
- 2.5 GHz model, 50 Ohm** 20 MHz, 200 MHz, 250 MHz, 350 MHz, 500 MHz, 1 GHz, 2 GHz, and 2.5 GHz
- 1 GHz model, 50 Ohm** 20 MHz, 200 MHz, 250 MHz, 350 MHz, 500 MHz, and 1 GHz
- 1M Ohm** 20 MHz (HW), 200 MHz, 250 MHz (HW), 350 MHz, and Full (500 MHz)

**Bandwidth filtering optimized for** Flatness or Step response



## Vertical system - analog channels

Random noise, RMS, typical

50  $\Omega$ , High Res mode (RMS)

V/div	1 mV/div	2 mV/div	5 mV/div	10 mV/div	20 mV/div	50 mV/div	100 mV/div	1 V/div
4 GHz	97.4 $\mu$ V	98.7 $\mu$ V	124 $\mu$ V	192 $\mu$ V	344 $\mu$ V	817 $\mu$ V	1.92 mV	16.3 mV
3 GHz	82.9 $\mu$ V	84 $\mu$ V	105 $\mu$ V	160 $\mu$ V	282 $\mu$ V	680 $\mu$ V	1.62 mV	13.6 mV
2.5 GHz	76.5 $\mu$ V	77.5 $\mu$ V	93.8 $\mu$ V	144 $\mu$ V	257 $\mu$ V	606 $\mu$ V	1.44 mV	12.1 mV
2 GHz	68.1 $\mu$ V	69.1 $\mu$ V	83.6 $\mu$ V	131 $\mu$ V	226 $\mu$ V	528 $\mu$ V	1.28 mV	10.6 mV
1 GHz	54.8 $\mu$ V	51.2 $\mu$ V	63.4 $\mu$ V	90.9 $\mu$ V	160 $\mu$ V	378 $\mu$ V	941 $\mu$ V	7.65 mV
500 MHz	39.7 $\mu$ V	39.8 $\mu$ V	48.1 $\mu$ V	65.1 $\mu$ V	115 $\mu$ V	280 $\mu$ V	666 $\mu$ V	5.6 mV
350 MHz	33.8 $\mu$ V	33.5 $\mu$ V	40 $\mu$ V	54.8 $\mu$ V	94.3 $\mu$ V	217 $\mu$ V	560 $\mu$ V	4.35 mV
250 MHz	30.8 $\mu$ V	31.2 $\mu$ V	36.1 $\mu$ V	49.9 $\mu$ V	80.3 $\mu$ V	187 $\mu$ V	482 $\mu$ V	3.75 mV
200 MHz	25.3 $\mu$ V	25.4 $\mu$ V	29.7 $\mu$ V	44 $\mu$ V	70.7 $\mu$ V	165 $\mu$ V	445 $\mu$ V	3.3 mV
20 MHz	8.68 $\mu$ V	8.9 $\mu$ V	10.4 $\mu$ V	15.1 $\mu$ V	27.5 $\mu$ V	70.4 $\mu$ V	158 $\mu$ V	1.41 mV

1 M $\Omega$ , High Res mode (RMS)

V/div	1 mV/div	2 mV/div	5 mV/div	10 mV/div	20 mV/div	50 mV/div	100 mV/div	1 V/div
500 MHz	186 $\mu$ V	202 $\mu$ V	210 $\mu$ V	236 $\mu$ V	288 $\mu$ V	522 $\mu$ V	1.25 mV	13.4 mV
350 MHz	134 $\mu$ V	138 $\mu$ V	145 $\mu$ V	163 $\mu$ V	216 $\mu$ V	391 $\mu$ V	974 $\mu$ V	10.6 mV
250 MHz	108 $\mu$ V	110 $\mu$ V	114 $\mu$ V	131 $\mu$ V	182 $\mu$ V	374 $\mu$ V	838 $\mu$ V	9.63 mV
200 MHz	106 $\mu$ V	108 $\mu$ V	109 $\mu$ V	117 $\mu$ V	149 $\mu$ V	274 $\mu$ V	674 $\mu$ V	8.01 mV
20 MHz	73 $\mu$ V	73.2 $\mu$ V	78.1 $\mu$ V	99.6 $\mu$ V	158 $\mu$ V	361 $\mu$ V	801 $\mu$ V	8.29 mV

50  $\Omega$ , Sample mode (RMS),  
typical

V/div	1 mV/div	2 mV/div	5 mV/div	10 mV/div	20 mV/div	50 mV/div	100 mV/div	1 V/div
8 GHz	158 $\mu$ V	158 $\mu$ V	208 $\mu$ V	342 $\mu$ V	630 $\mu$ V	1.49 mV	3.46 mV	29.7 mV
7 GHz	141 $\mu$ V	143 $\mu$ V	192 $\mu$ V	311 $\mu$ V	562 $\mu$ V	1.31 mV	3.11 mV	26.2 mV
6 GHz	127 $\mu$ V	127 $\mu$ V	165 $\mu$ V	274 $\mu$ V	489 $\mu$ V	1.18 mV	2.71 mV	23.6 mV
5 GHz	112 $\mu$ V	113 $\mu$ V	149 $\mu$ V	239 $\mu$ V	446 $\mu$ V	1.05 mV	2.42 mV	21.1 mV
4 GHz	97.4 $\mu$ V	98.7 $\mu$ V	134 $\mu$ V	216 $\mu$ V	402 $\mu$ V	949 $\mu$ V	2.16 mV	19 mV
3 GHz	82.9 $\mu$ V	91.1 $\mu$ V	114 $\mu$ V	188 $\mu$ V	350 $\mu$ V	846 $\mu$ V	1.9 mV	16.9 mV
2.5 GHz	76.5 $\mu$ V	77.5 $\mu$ V	103 $\mu$ V	173 $\mu$ V	323 $\mu$ V	790 $\mu$ V	1.71 mV	15.8 mV
2 GHz	69.7 $\mu$ V	70.7 $\mu$ V	93.8 $\mu$ V	158 $\mu$ V	295 $\mu$ V	706 $\mu$ V	1.6 mV	14.1 mV
1 GHz	56 $\mu$ V	57.5 $\mu$ V	80.8 $\mu$ V	127 $\mu$ V	231 $\mu$ V	534 $\mu$ V	1.18 mV	10.7 mV
500 MHz	44.5 $\mu$ V	46.7 $\mu$ V	62.7 $\mu$ V	88.8 $\mu$ V	178 $\mu$ V	444 $\mu$ V	1.06 mV	8.88 mV
350 MHz	38.8 $\mu$ V	39.3 $\mu$ V	64.2 $\mu$ V	88.8 $\mu$ V	168 $\mu$ V	419 $\mu$ V	888 $\mu$ V	8.38 mV
250 MHz	33.4 $\mu$ V	35.4 $\mu$ V	55.9 $\mu$ V	70.5 $\mu$ V	141 $\mu$ V	353 $\mu$ V	747 $\mu$ V	7.05 mV
200 MHz	33.4 $\mu$ V	37.5 $\mu$ V	63.4 $\mu$ V	106 $\mu$ V	211 $\mu$ V	528 $\mu$ V	1.06 mV	10.6 mV
20 MHz	19.4 $\mu$ V	26.6 $\mu$ V	41.9 $\mu$ V	83.8 $\mu$ V	168 $\mu$ V	419 $\mu$ V	838 $\mu$ V	8.38 mV

1 M $\Omega$ , Sample mode (RMS),  
typical

**Vertical system - analog channels**

V/div	1 mV/div	2 mV/div	5 mV/div	10 mV/div	20 mV/div	50 mV/div	100 mV/div	1 V/div
500 MHz	186 $\mu$ V	202 $\mu$ V	220 $\mu$ V	262 $\mu$ V	380 $\mu$ V	781 $\mu$ V	1.69 mV	18.3 mV
350 MHz	134 $\mu$ V	138 $\mu$ V	158 $\mu$ V	199 $\mu$ V	335 $\mu$ V	634 $\mu$ V	1.47 mV	15.8 mV
250 MHz	108 $\mu$ V	111 $\mu$ V	130 $\mu$ V	183 $\mu$ V	282 $\mu$ V	704 $\mu$ V	1.41 mV	15.6 mV
200 MHz	108 $\mu$ V	108 $\mu$ V	124 $\mu$ V	171 $\mu$ V	282 $\mu$ V	704 $\mu$ V	1.41 mV	15.4 mV
20 MHz	72.2 $\mu$ V	78.4 $\mu$ V	99.4 $\mu$ V	160 $\mu$ V	282 $\mu$ V	704 $\mu$ V	1.41 mV	14.1 mV

Crosstalk (channel isolation), typical

- $\geq 70$  dB up to 2 GHz
- $\geq 60$  dB up to 5 GHz
- $\geq 45$  dB up to 8 GHz

for any two channels set to 200 mV/div.

**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

Maximum input toggle rate 500 MHz

Minimum detectable pulse width, typical 1 ns

Thresholds One threshold per digital channel

Threshold range  $\pm 40$  V

Threshold resolution 10 mV

Threshold accuracy  $\pm [100 \text{ mV} + 3\% \text{ of threshold setting after calibration}]$

Input hysteresis, typical 100 mV at the probe tip

Input dynamic range, typical  $30 V_{pp}$  for  $F_{in} \leq 200 \text{ MHz}$ ,  $10 V_{pp}$  for  $F_{in} > 200 \text{ MHz}$

Absolute maximum input voltage, typical  $\pm 42$  V peak

Minimum voltage swing, typical 400 mV peak-to-peak

Input impedance, typical 100 k $\Omega$

Probe loading, typical 2 pF

## Horizontal system

Time base range	40 ps/div to 1,000 s/div									
Sample rate range	6.25 S/s to 25 GS/s (real time) 50 GS/s to 2.5 TS/s (interpolated)									
Record length range	Applies to analog and digital channels. All acquisition modes are 250 M maximum record length, down to 1 k minimum record length, adjustable in 1 sample increments.  Standard: 62.5 Mpoints Option 6-RL-1: 125 Mpoints Option 6-RL-2: 250 Mpoints									
Seconds/Division range	<b>Model</b>	<b>1 K</b>	<b>10 K</b>	<b>100 K</b>	<b>1 M</b>	<b>10 M</b>	<b>62.5 M</b>	<b>125 M</b>	<b>250 M</b>	
	MSO6X Standard 62.5 M	40 ps - 16 s	400 ps - 160 s	4 ns - 1000 s						
	MSO6X Option 6- RL-1 125 M	40 ps - 16 s	400 ps - 160 s	4 ns - 1000 s						
	MSO6X Option 6- RL-2 250 M	40 ps - 16 s	400 ps - 160 s	4 ps - 1000 s					40 ps - 1 ms	
Sample jitter	$\leq 0.450 \text{ ps} + (1 \times 10^{-11} \times \text{Measurement Duration})_{\text{RMS}}$ , for measurements having duration $\leq 100 \text{ ms}$									
Timebase accuracy	$\pm 1.0 \times 10^{-7}$ over any $\geq 1 \text{ ms}$ time interval									
	<b>Description</b>	<b>Specification</b>								
	Factory Tolerance	$\pm 20 \text{ ppb}$ . At calibration, 25 °C ambient, over any $\geq 1 \text{ ms}$ interval								
	Temperature stability	$\pm 20 \text{ ppb}$ . Tested at operating temperatures								
	Crystal aging, typical	$\pm 300 \text{ ppb}$ . Frequency tolerance change at 25 °C over a period of 1 year								
Delta-time measurement accuracy	$\text{DTA}_{\text{pp}}(\text{typical}) = 10 \times \sqrt{\left(\frac{N}{\text{SR}_1}\right)^2 + \left(\frac{N}{\text{SR}_2}\right)^2 + \left(0.450 \text{ ps} + \left(1 \times 10^{-11} \times t_p\right)\right)^2} + \text{TBA} \times t_p$ $\text{DTA}_{\text{RMS}} = \sqrt{\left(\frac{N}{\text{SR}_1}\right)^2 + \left(\frac{N}{\text{SR}_2}\right)^2 + \left(0.450 \text{ ps} + \left(1 \times 10^{-11} \times t_p\right)\right)^2} + \text{TBA} \times t_p$ <p>(assume edge shape that results from Gaussian filter response)</p> <p>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:</p> <p><math>\text{SR}_1</math> = Slew Rate (1<sup>st</sup> Edge) around 1<sup>st</sup> point in measurement  <math>\text{SR}_2</math> = Slew Rate (2<sup>nd</sup> Edge) around 2<sup>nd</sup> point in measurement  <math>N</math> = input-referred guaranteed noise limit (<math>V_{\text{RMS}}</math>)  <math>\text{TBA}</math> = timebase accuracy or Reference Frequency Error  <math>t_p</math> = delta-time measurement duration (sec)</p>									
Maximum duration at highest sample rate	2.5 ms (std.) or 5 ms (opt. 6-RL-1, 125 Mpoints) or 10 ms (opt. 6-RL-2, 250 Mpoints)									
Time base delay time range	-10 divisions to 5,000 s									

## Horizontal system

Deskew range	-125 ns to +125 ns with a resolution of 40 ps (for Peak Detect and Envelope acquisition modes). -125 ns to +125 ns with a resolution of 1 ps (for all other acquisition modes).
Delay between analog channels, full bandwidth, typical	≤ 10 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	< 1 ns when using a TLP058 and a TPP1000 with no bandwidth limits applied
Delay between any two digital FlexChannels, typical	320 ps
Delay between any two bits of a digital FlexChannel, typical	160 ps

## Trigger system

Trigger modes	Auto, Normal, and Single
Trigger coupling	DC, AC, HF reject (attenuates > 50 kHz), LF reject (attenuates < 50 kHz), noise reject (reduces sensitivity)

Trigger bandwidth (edge, pulse and logic), typical	Model	Trigger type	Trigger bandwidth
	MSO64 8 GHz	Edge	8 GHz
	MSO64 8 GHz	Pulse, Logic	4 GHz
	MSO64 6 GHz	Edge	6 GHz
	MSO64 6 GHz	Pulse, Logic	4 GHz
	MSO64 4 GHz, 2.5 GHz, 1 GHz:	Edge, Pulse, Logic	Product Bandwidth

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 from DC to lesser of 500 MHz or instrument BW, & 6 mV or 0.8 div from > 500 MHz to instrument bandwidth
	50 Ω path	1 mV/div to 9.98 mV/div	3.0 div from DC to instrument bandwidth
		≥ 10 mV/div	< 1.0 division from DC to instrument bandwidth
Line		Fixed	
AUX Trigger in		250 mV <sub>pp</sub> , DC to 400 MHz	

Edge-type trigger sensitivity, not DC coupled, typical	Trigger Coupling	Typical Sensitivity
	NOISE REJ	2.5 times the DC Coupled limits
	HF REJ	1.0 times the DC Coupled limits from DC to 50 kHz. Attenuates signals above 50 kHz.
	LF REJ	1.5 times the DC Coupled limits for frequencies above 50 kHz. Attenuates signals below 50 kHz.

Trigger jitter, typical	≤ 5 ps <sub>RMS</sub> for sample mode and edge-type trigger ≤ 7 ps <sub>RMS</sub> for edge-type trigger and FastAcq mode ≤ 40 ps <sub>RMS</sub> for non edge-type trigger modes ≤ 200 ps <sub>RMS</sub> for AUX trigger in, Sample acquisition mode, edge trigger ≤ 220 ps <sub>RMS</sub> for AUX trigger in, FastAcq acquisition mode, edge trigger
-------------------------	--

## Trigger system

Trigger jitter, AUX input, typical  $\leq 200$  pS<sub>RMS</sub> for sample mode and edge-type trigger  
 $\leq 220$  pS<sub>RMS</sub> for edge-type trigger and FastAcq mode

AUX In trigger skew between instruments, typical  $\pm 100$  ps jitter on each instrument with 150 ps skew;  $\leq 350$  ps total between instruments.  
 Skew improves for sinusoidal input voltages  $\geq 500$  mV

### Trigger level ranges

Source	Range
Any Channel	$\pm 5$ divs from center of screen
Aux In Trigger	$\pm 5$ V
Line	Fixed at about 50% of line voltage

This specification applies to logic and pulse thresholds.

Trigger frequency counter 8-digits (free with product registration)

### Trigger types

<b>Edge:</b>	Positive, negative, or either slope on any channel. Coupling includes DC, AC, noise reject, HF reject, and LF reject
<b>Pulse Width:</b>	Trigger on width of positive or negative pulses. Event can be time- or logic-qualified
<b>Timeout:</b>	Trigger on an event which remains high, low, or either, for a specified time period. Event can be logic-qualified
<b>Runt:</b>	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
<b>Window:</b>	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
<b>Logic:</b>	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
<b>Setup &amp; Hold:</b>	Trigger on violations of both setup time and hold time between clock and data present on any input channels
<b>Rise / Fall Time:</b>	Trigger on pulse edge rates that are faster or slower than specified. Slope may be positive, negative, or either. Event can be logic-qualified
<b>Sequence:</b>	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
<b>Visual trigger</b>	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.
<b>Parallel Bus:</b>	Trigger on a parallel bus data value. Parallel bus can be from 1 to 32 bits (from the digital and analog channels) in size. Supports Binary and Hex radices
<b>I<sup>2</sup>C Bus (option 6-SREMBD):</b>	Trigger on Start, Repeated Start, Stop, Missing ACK, Address (7 or 10 bit), Data, or Address and Data on I <sup>2</sup> C buses up to 10 Mb/s
<b>SPI Bus (option 6-SREMBD):</b>	Trigger on Slave Select, Idle Time, or Data (1-16 words) on SPI buses up to 20 Mb/s
<b>RS-232/422/485/UART Bus (option 6-SRCOMP):</b>	Trigger on Start Bit, End of Packet, Data, and Parity Error up to 15 Mb/s
<b>CAN Bus (option 6-SRAUTO):</b>	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
<b>CAN FD Bus (option 6-SRAUTO):</b>	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
<b>LIN Bus (option 6-SRAUTO):</b>	Trigger on Sync, Identifier, Data, Identifier and Data, Wakeup Frame, Sleep Frame, and Error on LIN buses up to 1 Mb/s
<b>FlexRay Bus (Option 6-SRAUTO):</b>	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
<b>SENT Bus (Option 6-SRAUTOSEN)</b>	Trigger on Start of Packet, Fast Channel Status and Data, Slow Channel Message ID and Data, and CRC Errors

## Trigger system

<b>SPMI Bus (option 6-SRPM):</b>	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
<b>USB 2.0 LS/FS/HS Bus (Option 6-SRUSB2):</b>	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
<b>Ethernet Bus (option 6-SRENET):</b>	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
<b>Audio (I<sup>2</sup>S, LJ, RJ, TDM) Bus (option 6-SRAUDIO):</b>	Trigger on Word Select, Frame Sync, or Data. Maximum data rate for I <sup>2</sup> S/LJ/RJ is 12.5 Mb/s. Maximum data rate for TDM is 25 Mb/s
<b>MIL-STD-1553 Bus (option 6-SRAERO):</b>	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
<b>ARINC 429 Bus (option 6-SRAERO):</b>	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
<b>Trigger holdoff range</b>	0 ns to 20 seconds

## Acquisition system

<b>Sample</b>	Acquires sampled values
<b>Peak Detect</b>	Captures glitches as narrow as 160 ps at all sweep speeds
<b>Averaging</b>	From 2 to 10,240 waveforms
<b>Envelope</b>	Min-max envelope reflecting Peak Detect data over multiple acquisitions
<b>High Res</b>	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 ≤ 625 MS/s sample rates.
<b>FastAcq<sup>®</sup></b>	FastAcq optimizes the instrument for analysis of dynamic signals and capture of infrequent events.  Maximum waveform capture rate:  >500,000 wfms/s (Peak Detect or Envelope Acquisition mode)  >30,000 wfms/s (All other acquisition modes)
<b>Roll mode</b>	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.
<b>FastFrame<sup>™</sup></b>	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 = 691,000

## Waveform measurements

**Cursor types** Waveform, V Bars, H Bars, and V&H Bars

DC voltage measurement accuracy, Average acquisition mode	Measurement Type	DC Accuracy (In Volts)
	Average of $\geq 16$ waveforms	$\pm((\text{DC Gain Accuracy}) *  \text{reading} - (\text{offset} - \text{position})  + \text{Offset Accuracy} + 0.05 * \text{V/div setting})$
Delta volts between any two averages of $\geq 16$ waveforms acquired with the same oscilloscope setup and ambient conditions	$\pm(\text{DC Gain Accuracy} *  \text{reading}  + 0.1 \text{ div})$	

**Automatic measurements** 36 of which an unlimited number can be displayed at once 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, and Low Time

**Jitter measurements (standard)** TIE and Phase Noise

**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 or unique for each measurement

**Gating** Isolate the specific occurrence within an acquisition to take measurements on, using either the screen or waveform cursors. Gating can be set to global for all measurements or a to local where a second type of gating can be used.

**Measurement plots** Time Trend, Histogram, and Spectrum plots are available for all standard measurements

**Jitter analysis option adds the following:**

**Measurements** Jitter Summary, TJ@BER, RJ- $\delta\delta$ , DJ- $\delta\delta$ , PJ, RJ, DJ, DDJ, DCD, SRJ, J2, J9, NPJ, F/2, F/4, F/8, Eye Height, Eye Height@BER, Eye Width, Eye Width@BER, Eye High, Eye Low, Q-Factor, Bit High, Bit Low, Bit Amplitude, DC Common Mode, AC Common Mode (Pk-Pk), Differential Crossover, T/nT Ratio, SSC Freq Dev, SSC Modulation Rate

**Measurement Plots** Eye Diagram and Jitter Bathtub

**Power analysis option 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,  $R_{DS(on)}$ )

Magnetic Analysis (Inductance, I vs. Intg(V), Magnetic Loss, Magnetic Property)

Output Analysis (Line Ripple, Switching Ripple, Efficiency, Turn-on Time, Turn-off Time)

**Measurement Plots** Harmonics Bar Graph, Switching Loss Trajectory Plot, and Safe Operating Area

## 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	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

## 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.

## Display

Display type	15.6 in. (395 mm) liquid-crystal TFT color display
resolution	1,920 horizontal × 1,080 vertical pixels (High Definition)
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
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	Grid, Time, Full, and None
Color palettes	Normal, inverted, and inverted for screen captures
Format	YT, XY, and XYZ



**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

**Amplitude range** Values are peak-to-peak voltages

Waveform	50 $\Omega$	1 M $\Omega$
Arbitrary	10 mV to 2.5 V	20 mV to 5 V
Sine	10 mV to 2.5 V	20 mV to 5 V
Square	10 mV to 2.5 V	20 mV to 5 V
Pulse	10 mV to 2.5 V	20 mV to 5 V
Ramp	10 mV to 2.5 V	20 mV to 5 V
Triangle	10 mV to 2.5 V	20 mV to 5 V
Gaussian	10 mV to 1.25 V	20 mV to 2.5 V
Lorentz	10 mV to 1.2 V	20 mV to 2.4 V
Exponential Rise	10 mV to 1.25 V	20 mV to 2.5 V
Exponential Fall	10 mV to 1.25 V	20 mV to 2.5 V
Sine(x)/x	10 mV to 1.5 V	20 mV to 3.0 V
Random Noise	10 mV to 2.5 V	20 mV to 5 V
Haversine	10 mV to 1.25 V	20 mV to 2.5 V
Cardiac	10 mV to 2.5 V	20 mV to 5 V

**Sine waveform**

**Frequency range** 0.1 Hz to 50 MHz  
**Frequency setting resolution** 0.1 Hz  
**Amplitude flatness, typical**  $\pm 0.5$  dB at 1 kHz  
 $\pm 1.5$  dB at 1 kHz for  $< 20$  mV<sub>pp</sub> amplitudes  
**Total harmonic distortion, typical** 1% for amplitude  $\geq 200$  mV<sub>pp</sub> into 50  $\Omega$  load  
2.5% for amplitude  $> 50$  mV AND  $< 200$  mV<sub>pp</sub> into 50  $\Omega$  load  
**Spurious free dynamic range, typical** 40 dB ( $V_{pp} \geq 0.1$  V); 30 dB ( $V_{pp} \geq 0.02$  V), 50  $\Omega$  load

**Square and pulse waveform**

**Frequency range** 0.1 Hz to 25 MHz  
**Frequency setting resolution** 0.1 Hz  
**Frequency accuracy** 130 ppm (frequency  $\leq 10$  kHz), 50 ppm (frequency  $> 10$  kHz)  
**Amplitude range** 20 mV<sub>pp</sub> to 5 V<sub>pp</sub> into Hi-Z; 10 mV<sub>pp</sub> to 2.5 V<sub>pp</sub> into 50  $\Omega$   
**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 ns, 10% - 90%  
**Pulse width resolution** 100 ps  
**Overshoot, typical**  $< 6\%$  for signal steps greater than 100 mV<sub>pp</sub>  
This applies to overshoot of the positive-going transition (+overshoot) and of the negative-going (-overshoot) transition  
**Asymmetry, typical**  $\pm 1\% \pm 5$  ns, at 50% duty cycle  
**Jitter, typical**  $< 60$  ps TIE<sub>RMS</sub>,  $\geq 100$  mV<sub>pp</sub> amplitude, 40%-60% duty cycle

**Arbitrary/Function Generator (optional)**

**Ramp and triangle waveform**

Frequency range	0.1 Hz to 500 kHz
Frequency setting resolution	0.1 Hz
Frequency accuracy	130 ppm (frequency $\leq$ 10 kHz), 50 ppm (frequency $>$ 10 kHz)
Amplitude range	20 mV <sub>pp</sub> to 5 V <sub>pp</sub> into Hi-Z; 10 mV <sub>pp</sub> to 2.5 V <sub>pp</sub> into 50 $\Omega$
Variable symmetry	0% - 100%
Symmetry resolution	0.1%

DC level range	$\pm$ 2.5 V into Hi-Z $\pm$ 1.25 V into 50 $\Omega$
----------------	--

Random noise amplitude range	20 mV <sub>pp</sub> to 5 V <sub>pp</sub> into Hi-Z 10 mV <sub>pp</sub> to 2.5 V <sub>pp</sub> into 50 $\Omega$
------------------------------	---

**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 <sub>pp</sub> to 2.4 V <sub>pp</sub> into Hi-Z 10 mV <sub>pp</sub> to 1.2 V <sub>pp</sub> into 50 $\Omega$

**Cardiac**

Frequency range	0.1 Hz to 500 kHz
Amplitude range	20 mV <sub>pp</sub> to 5 V <sub>pp</sub> into Hi-Z 10 mV <sub>pp</sub> to 2.5 V <sub>pp</sub> into 50 $\Omega$

**Arbitrary**

Memory depth	1 to 128 k
Amplitude range	20 mV <sub>pp</sub> to 5 V <sub>pp</sub> into Hi-Z 10 mV <sub>pp</sub> to 2.5 V <sub>pp</sub> into 50 $\Omega$
Repetition rate	0.1 Hz to 25 MHz
Sample rate	250 MS/s

Signal amplitude accuracy	$\pm$ [ (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 $\mu$ V (50 $\Omega$ )
-----------------------------	---

Sine and ramp frequency accuracy	$1.3 \times 10^{-4}$ (frequency $\leq$ 10 kHz) $5.0 \times 10^{-5}$ (frequency $>$ 10 kHz)
----------------------------------	---

DC offset range	$\pm$ 2.5 V into Hi-Z $\pm$ 1.25 V into 50 $\Omega$
-----------------	--

**Arbitrary/Function Generator (optional)**

DC offset resolution	1 mV (Hi-Z) 500 $\mu$ V (50 $\Omega$ )
DC offset accuracy	$\pm$ [ (1.5% of absolute offset voltage setting) + 1 mV ] Add 3 mV of uncertainty per 10 $^{\circ}$ C change from 25 $^{\circ}$ C ambient

**Digital volt meter (DVM)**

Measurement types	DC, AC <sub>RMS</sub> +DC, AC <sub>RMS</sub> , Trigger frequency count
Voltage resolution	4 digits
Voltage accuracy	
DC:	$\pm(1.5\% *  \text{reading} - \text{offset} - \text{position} ) + (0.5\% *  (\text{offset} - \text{position}) ) + (0.1 * \text{Volts/div})$ De-rated at 0.100%/ $^{\circ}$ C of $ \text{reading} - \text{offset} - \text{position} $ above 30 $^{\circ}$ C Signal $\pm$ 5 divisions from screen center
AC:	$\pm$ 3% (40 Hz to 1 kHz) with no harmonic content outside 40 Hz to 1 kHz range AC, typical: $\pm$ 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	$\pm(1 \text{ count} + \text{time base accuracy} * \text{input frequency})$ The signal must be at least 8 mV <sub>pp</sub> or 2 div, whichever is greater.
Maximum input frequency	Maximum bandwidth of the analog channel The signal must be at least 8 mV <sub>pp</sub> or 2 div, whichever is greater.

**Processor system**

Host processor	Intel i5-4400E, 2.7 GHz, 64-bit, dual core processor
Internal storage	$\geq$ 80 GB. Form factor is an 80 mm m.2 card with a SATA-3 interface
Operating system	Closed Linux
Solid State Drive (SSD) with Microsoft Windows 10 OS (option 6-WIN)	$\geq$ 480 GB SSD. Form factor is a 2.5-inch SSD with a SATA-3 interface. This drive is customer installable and includes the Microsoft Windows 10 Enterprise IoT 2016 LTSC (64-bit) operating system

## Input-Output ports

<b>DisplayPort connector</b>	A 20-pin DisplayPort connector; connect to show the oscilloscope display on an external monitor or projector						
<b>DVI connector</b>	A 29-pin DVI-I connector; connect to show the oscilloscope display on an external monitor or projector						
<b>VGA</b>	DB-15 female connector; connect to show the oscilloscope display on an external monitor or projector						
<b>Probe compensator signal, typical</b>							
<b>Connection:</b>	Connectors are located on the lower front right of the instrument						
<b>Amplitude:</b>	0 to 2.5 V						
<b>Frequency:</b>	1 kHz						
<b>Source impedance:</b>	1 k $\Omega$						
<b>External reference input</b>	Time-base system can phase lock to an external 10 MHz reference There are two ranges for the reference clock. The instrument can accept a high accuracy reference clock of 10 MHz +/- 2 ppm or a lower accuracy reference clock of 10 MHz +/- 1 kppm.						
<b>USB interface (Host, Device ports)</b>	Front panel USB Host ports: Two USB 2.0 High Speed ports, one USB 3.0 Super Speed port Rear panel USB Host ports: Two USB 2.0 High Speed ports, two USB 3.0 Super Speed ports Rear panel USB Device port: One USB 3.0 Super Speed Device port providing USBTMC support						
<b>Ethernet interface</b>	10/100/1000 Mb/s						
<b>Auxiliary output</b>	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						
	<table border="1"> <thead> <tr> <th>Characteristic</th> <th>Limits</th> </tr> </thead> <tbody> <tr> <td>Vout (HI)</td> <td><math>\geq 2.5</math> V open circuit; <math>\geq 1.0</math> V into a 50 <math>\Omega</math> load to ground</td> </tr> <tr> <td>Vout (LO)</td> <td><math>\leq 0.7</math> V into a load of <math>\leq 4</math> mA; <math>\leq 0.25</math> V into a 50 <math>\Omega</math> load to ground</td> </tr> </tbody> </table>	Characteristic	Limits	Vout (HI)	$\geq 2.5$ V open circuit; $\geq 1.0$ V into a 50 $\Omega$ load to ground	Vout (LO)	$\leq 0.7$ V into a load of $\leq 4$ mA; $\leq 0.25$ V into a 50 $\Omega$ load to ground
Characteristic	Limits						
Vout (HI)	$\geq 2.5$ V open circuit; $\geq 1.0$ V into a 50 $\Omega$ load to ground						
Vout (LO)	$\leq 0.7$ V into a load of $\leq 4$ mA; $\leq 0.25$ V into a 50 $\Omega$ load to ground						
<b>Kensington-style lock</b>	Rear-panel security slot connects to standard Kensington-style lock						
<b>LXI</b>	Class: LXI Core 2011 Version: 1.4						

## Power source

<b>Power</b>	
<b>Power consumption</b>	400 Watts maximum
<b>Source voltage</b>	100 - 240 V $\pm 10\%$ at 50 Hz to 60 Hz $\pm 10\%$ 115 V $\pm 10\%$ at 400 Hz $\pm 10\%$

## Physical characteristics

<b>Dimensions</b>	Height: 12.2 in (309 mm), feet folded in, handle to back
	Height: 14.6 in (371 mm) feet folded in, handle up
	Width: 17.9 in (454 mm) from handle hub to handle hub
	Depth: 8.0 in (205 mm) from back of feet to front of knobs, handle up
	Depth: 11.7 in (297.2 mm) feet folded in, handle to the back
<b>Weight</b>	< 28.4 lbs (12.88 kg)
<b>Cooling</b>	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
<b>Rackmount configuration</b>	7U

## Environmental specifications

<b>Temperature</b>	
<b>Operating</b>	+0 °C to +50 °C (32 °F to 122 °F)
<b>Non-operating</b>	-20 °C to +60 °C (-4 °F to 140 °F)
<b>Humidity</b>	
<b>Operating</b>	5% to 90% relative humidity (% RH) at up to +40 °C 5% to 55% RH above +40 °C up to +50 °C, noncondensing, and as limited by a maximum wet-bulb temperature of +39 °C
<b>Non-operating</b>	5% to 90% relative humidity (% RH) at up to +60 °C, noncondensing, and as limited by a maximum wet-bulb temperature of +39 °C
<b>Altitude</b>	
<b>Operating</b>	Up to 3,000 meters (9,843 feet)
<b>Non-operating</b>	Up to 12,000 meters (39,370 feet)

## EMC, Environmental, and Safety

<b>Regulatory</b>	CE marked for the European Union and UL approved for the USA and Canada RoHS compliant
-------------------	---

## Software

<b>Software</b>	
<b>IVI driver</b>	Provides a standard instrument programming interface for common applications such as LabVIEW, LabWindows/CVI, MicrosoftNET, and MATLAB. Compatible with Python, C/C++/C# and many other languages through VISA.
<b>e*Scope®</b>	Enables control of the oscilloscope over a network connection through a standard web browser. Simply enter the IP address or network name of the oscilloscope and a web page will be served to the browser. Transfer and save settings, waveforms, measurements, and screen images or make live control changes to settings on the oscilloscope directly from the web browser.
<b>LXI Web interface</b>	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 the e*Scope web-based remote control. All web interaction conforms to LXI Core specification, version 1.4.

## Ordering information

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

### Step 1

Start by selecting the MSO64 model.

Model	Number of FlexChannels
MSO64	4

### Each instrument includes

- Four TPP1000 1 GHz probes.
- Installation and safety manual (translated in English, Japanese, Simplified Chinese)
- Integrated online help
- Front cover with integrated accessory pouch
- Mouse
- 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

Configure your oscilloscope by selecting the analog channel bandwidth you need

Choose the bandwidth you need today by choosing one of these bandwidth options. You can upgrade it later by purchasing an upgrade kit.

Bandwidth Option	Bandwidth
6-BW-1000	1 GHz
6-BW-2500	2.5 GHz
6-BW-4000	4 GHz
6-BW-6000	6 GHz
6-BW-8000	8 GHz

## Step 3

### Add instrument functionality

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

Instrument Option	Built-in Functionality
6-RL-1	Extend record length from 62.5 Mpoints/channel to 125 Mpoints/channel
6-RL-2	Extend record length from 62.5 Mpoints/channel to 250 Mpoints/channel
6-WIN <sup>4</sup>	Add removable SSD with Microsoft Windows 10 operating system license
6-AFG	Add Arbitrary / Function Generator
6-SEC <sup>5 6</sup>	Add enhanced security for instrument declassification and password protected enabling and disabling of all USB and Ethernet ports and firmware upgrade.

## Step 4

### Add optional serial bus triggering, decode, and search capabilities

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

Instrument Option	Serial Buses Supported
6-SRAERO	Aerospace (MIL-STD-1553, ARINC 429)
6-SRAUDIO	Audio (I <sup>2</sup> S, LJ, RJ, TDM)
6-SRAUTO	Automotive (CAN, CAN FD, LIN, FlexRay)
6-SRAUTOSEN	Automotive sensor (SENT)
6-SRCOMP	Computer (RS-232/422/485/UART)
6-SREMBD	Embedded (I <sup>2</sup> C, SPI)
6-SRENET	Ethernet (10BASE-T, 100BASE-TX)
6-SRPM	Power Management (SPMI)
6-SRUSB2	USB (USB2.0 LS, FS, HS)

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

<sup>4</sup> This option is not compatible with option 6-SEC.

<sup>5</sup> This option is not compatible with option 6-WIN.

<sup>6</sup> This option must be purchased at the same time as the instrument. Not available as an upgrade.

## Step 5

### Add optional serial bus compliance testing

Choose the serial compliance testing packages you need today by choosing from these options. You can upgrade later by purchasing an upgrade kit.

Instrument Option	Serial Buses Supported
6-CMAUTOEN	Automotive Ethernet automated compliance test solution (100BASE-T1 and 1000BASE-T1). Requires option 6-WIN (SSD with Microsoft Windows 10 operating system) 2 GHz bandwidth required for 1000BASE-T1
6-CMUSB2	USB2.0 automated compliance test solution. Requires option 6-WIN (SSD with Microsoft Windows 10 operating system) Requires TDSUSBF USB test fixture 2 GHz bandwidth required for high-speed USB

## Step 6

### Add optional analysis capabilities

Instrument Option	Advanced Analysis
6-DJA	Advanced Jitter and Eye Analysis
6-PWR <sup>7</sup>	Power Measurement and Analysis
6-PS2 <sup>8 9</sup>	Power Solution Bundle (6-PWR, THDP0200, TCP0030A, 067-1686-xx deskew fixture)

## Step 7

### Add digital probes

Each FlexChannel input can be configured as eight digital channels simply by connecting a TLP058 logic probe.

For this instrument	Order	To add
MSO64	1 to 4 TLP058 Probes	8 to 32 digital channels

<sup>7</sup> This option is not compatible with option 6-PS2.

<sup>8</sup> This option is not compatible with option 6-PWR.

<sup>9</sup> This option must be purchased at the same time as the instrument. Not available as an upgrade.



## 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
TAP3500	3.5 GHz TekVPI® active single-ended voltage probe, ±4 V input voltage
TAP4000	4 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
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
TDP3500	3.5 GHz TekVPI® differential voltage probe, ±2 V differential input voltage
TDP4000	4 GHz TekVPI® differential voltage probe, ±2 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
TIVH02	Isolated Probe; 200 MHz, ±2500 V, TekVPI, 3 Meter Cable
TIVH02L	Isolated Probe; 200 MHz, ±2500 V, TekVPI, 10 Meter Cable
TIVH05	Isolated Probe; 500 MHz, ±2500 V, TekVPI, 3 Meter Cable
TIVH05L	Isolated Probe; 500 MHz, ±2500 V, TekVPI, 10 Meter Cable
TIVH08	Isolated Probe; 800 MHz, ±2500 V, TekVPI, 3 Meter Cable
TIVH08L	Isolated Probe; 800 MHz, ±2500 V, TekVPI, 10 Meter Cable
TIVM1	Isolated Probe; 1 GHz, ±50 V, TekVPI, 3 Meter Cable
TIVM1L	Isolated Probe; 1 GHz, ±50 V, TekVPI, 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
P6015A	20 kV, 75 MHz high-voltage passive probe
TPA-BNC <sup>10</sup>	TekVPI® to TekProbe™ BNC adapter
103-0503-xx	BNC-to-SMA adapter; rated to 12 GHz
TEK-DPG	TekVPI deskew pulse generator signal source
067-1686-xx	Power measurement deskew and calibration fixture
TEK-CDA	Probe compensation and deskew accessory. Perform DC compensation on TDP7700 Series TriMode probes and deskew on any TekVPI compatible probe.

Looking for other probes? Check out the probe selector tool at [www.tek.com/probes](http://www.tek.com/probes).

<sup>10</sup> Recommended for connecting your existing TekProbe probes to the 6 Series MSO.

## Step 9

Add accessories

Add traveling or mounting accessories

Optional Accessory	Description
HC5	Hard carrying case
RM5	Rackmount kit

## 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
G3	Three Year Gold Care Plan. Includes expedited repair of all product failures including ESD and EOS, access to a loaner product during repair or advanced exchange to reduce downtime, priority access to Customer Support among others.
G5	Five Year Gold Care Plan. Includes expedited repair of all product failures including ESD and EOS, access to a loaner product during repair or advanced exchange to reduce downtime, priority access to Customer Support among others.
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.
C3	Calibration service 3 Years. Includes traceable calibration or functional verification where applicable, for recommended calibrations. Coverage includes the initial calibration plus 2 years calibration coverage.
C5	Calibration service 5 Years. Includes traceable calibration or functional verification where applicable, for recommended calibrations. Coverage includes the initial calibration plus 4 years 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** The 6 Series MSO products offer many ways to 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	SUP6-AFG	SUP6-AFG-FL	Add arbitrary function generator
	SUP6-RL-1	SUP6-RL-1-FL	Extend record length to 125 Mpts / channel
	SUP6-RL-2	SUP6-RL-2-FL	Extend record length to 225 Mpts / channel
	SUP6-RL-1T2	SUP6-RL-1T2-FL	Extend record length to 125 Mpts to 250 Mpts / channel
	SUP6-WIN	N/A	Add removable SSD with Windows 10 operating system
Add protocol analysis	SUP6-SRAERO	SUP6-SRAERO-FL	Aerospace serial triggering and analysis (MIL-STD-1553, ARINC 429)
	SUP6-SRAUDIO	SUP6-SRAUDIO-FL	Audio serial triggering and analysis (I <sup>2</sup> S, LJ, RJ, TDM)
	SUP6-SRAUTO	SUP6-SRAUTO-FL	Automotive serial triggering and analysis (CAN, CAN FD, LIN, FlexRay)
	SUP6-SRAUTOSEN	SUP6-SRAUTOSEN-FL	Automotive sensor serial triggering and analysis (SENT)
	SUP6-SRCOMP	SUP6-SRCOMP-FL	Computer serial triggering and analysis (RS-232/422/485/UART)
	SUP6-SREMBD	SUP6-SREMBD-FL	Embedded serial triggering and analysis (I <sup>2</sup> C, SPI)
	SUP6-SRENET	SUP6-SRENET-FL	Ethernet serial triggering and analysis (10Base-T, 100Base-TX)
	SUP6-SRPM	SUP6-SRPM-FL	Power Management serial triggering and analysis (SPMI)
	SUP6-SRUSB2	SUP6-SRUSB2-FL	USB 2.0 serial bus triggering and analysis (LS, FS, HS)
Add serial compliance	SUP6-CMAUTOEN	SUP6-CMAUTOEN-FL	Automotive Ethernet automated compliance test solution (100BASE-T1 and 1000BASE-T1) Requires SSD with Microsoft Windows 10 operating system
	SUP6-CMUSB2	SUP6-CMUSB2-FL	USB 2.0 automated compliance test solution Requires SSD with Microsoft Windows 10 operating system
Add advanced analysis	SUP6-DJA	SUP6-DJA-FL	Advanced jitter and eye analysis
	SUP6-PWR	SUP6-PWR-FL	Advance power measurements and analysis
Add digital voltmeter	SUP6-DVM	N/A	Add digital voltmeter / trigger frequency counter (Free with product registration at <a href="http://www.tek.com/register6mso">www.tek.com/register6mso</a> )

## Bandwidth upgrades after purchase

**Add bandwidth upgrades in the future**

The analog bandwidth of 6 Series MSO products can be upgraded after initial purchase. Bandwidth upgrades are purchased based on the current bandwidth and the desired bandwidth. All bandwidth upgrades can be performed in the field by installing a software license and a new front panel label.

Model to be upgraded	Bandwidth before upgrade	Bandwidth after upgrade	Order this bandwidth upgrade
MSO64	1 GHz	2.5 GHz	SUP6-BW10T254
	1 GHz	4 GHz	SUP6-BW10T404
	1 GHz	6 GHz	SUP6-BW10T604
	1 GHz	8 GHz	SUP6-BW10T804
	2.5 GHz	4 GHz	SUP6-BW25T404
	2.5 GHz	6 GHz	SUP6-BW25T604
	2.5 GHz	8 GHz	SUP6-BW25T804
	4 GHz	6 GHz	SUP6-BW40T604
	4 GHz	8 GHz	SUP6-BW40T804
	6 GHz	8 GHz	SUP6-BW60T804



Tektronix is registered to ISO 9001 and ISO 14001 by SRI Quality System Registrar.



Product(s) complies with IEEE Standard 488.1-1987, RS-232-C, and with Tektronix Standard Codes and Formats.



Product Area Assessed: The planning, design/development and manufacture of electronic Test and Measurement instruments.

**ASEAN / Australasia** (65) 6356 3900  
**Belgium** 00800 2255 4835\*  
**Central East Europe and the Baltics** +41 52 675 3777  
**Finland** +41 52 675 3777  
**Hong Kong** 400 820 5835  
**Japan** 81 (3) 6714 3086  
**Middle East, Asia, and North Africa** +41 52 675 3777  
**People's Republic of China** 400 820 5835  
**Republic of Korea** +822 6917 5084, 822 6917 5080  
**Spain** 00800 2255 4835\*  
**Taiwan** 886 (2) 2656 6688

**Austria** 00800 2255 4835\*  
**Brazil** +55 (11) 3759 7627  
**Central Europe & Greece** +41 52 675 3777  
**France** 00800 2255 4835\*  
**India** 000 800 650 1835  
**Luxembourg** +41 52 675 3777  
**The Netherlands** 00800 2255 4835\*  
**Poland** +41 52 675 3777  
**Russia & CIS** +7 (495) 6647564  
**Sweden** 00800 2255 4835\*  
**United Kingdom & Ireland** 00800 2255 4835\*

**Balkans, Israel, South Africa and other ISE Countries** +41 52 675 3777  
**Canada** 1 800 833 9200  
**Denmark** +45 80 88 1401  
**Germany** 00800 2255 4835\*  
**Italy** 00800 2255 4835\*  
**Mexico, Central/South America & Caribbean** 52 (55) 56 04 50 90  
**Norway** 800 16098  
**Portugal** 80 08 12370  
**South Africa** +41 52 675 3777  
**Switzerland** 00800 2255 4835\*  
**USA** 1 800 833 9200

\* European toll-free number. If not accessible, call: +41 52 675 3777

**For Further Information.** Tektronix maintains a comprehensive, constantly expanding collection of application notes, technical briefs and other resources to help engineers working on the cutting edge of technology. Please visit [www.tek.com](http://www.tek.com).

Copyright © Tektronix, Inc. All rights reserved. Tektronix products are covered by U.S. and foreign patents, issued and pending. Information in this publication supersedes that in all previously published material. Specification and price change privileges reserved. TEKTRONIX and TEK are registered trademarks of Tektronix, Inc. All other trade names referenced are the service marks, trademarks, or registered trademarks of their respective companies.



16 Jul 2018 48W-61353-0

