Mixed Domain Oscilloscopes

MDO4000 Series Datasheet

Introducing the world's first and only oscilloscope with a built-in spectrum analyzer. For the first time ever, you can capture time-correlated analog, digital, and RF signals for a complete system view of your device. See both the time and frequency domain in a single glance. View the RF spectrum at any point in time to see how it changes over time or with device state. Solve the most complicated design issues, quickly and efficiently, with an oscilloscope as integrated as your design.

Winner of 10+ industry awards

Key performance specifications

- 4 analog channels
  - 1 GHz, 500 MHz, 350 MHz, and 100 MHz bandwidth models
- 16 digital channels
  - MagniVu™ high-speed acquisition provides 60.6 ps fine timing resolution
- 1 RF channel
  - 50 kHz to 3 GHz or 50 kHz to 6 GHz frequency range models
  - Ultra-wide capture bandwidth ≥1 GHz
- Standard passive voltage probes with 3.9 pF capacitive loading and 500 MHz or 1 GHz analog bandwidth

Key features

- Mixed-domain analysis
  - Time-correlated analog, digital, and RF signal acquisitions in a single instrument
  - Wave Inspector® controls provide easy navigation of time-correlated data from both the time and frequency domains
  - Amplitude, frequency, and phase vs. time waveforms derived from RF input
  - Selectable spectrum time to discover and analyze how RF spectrum changes over time - even on a stopped acquisition
- Spectral analysis
  - Dedicated front-panel controls for commonly performed tasks
  - Automated peak markers identify frequency and amplitude of spectrum peaks
  - Manual markers enable non-peak measurements
  - Trace types Include: Normal, Average, Max Hold, and Min Hold
  - Detection types include: +Peak, -Peak, Average, and Sample
  - Spectrogram display enables easy observation and insight into slowly changing RF phenomena
  - Automated measurements include: Channel Power, Adjacent Channel Power Ratio (ACPR), and Occupied Bandwidth (OBW)
  - Trigger on RF power level
  - Triggered or Free Run spectral analysis
- Optional serial triggering and analysis - serial protocol trigger, decode, and search for I^{2}C, SPI, USB, Ethernet, CAN, LIN, FlexRay, RS-232/422/485/UART, MIL-STD-1553, and I^{2}S/LJ/RJ/TDM

Tektronix®

- 10.4 in. (264 mm) bright XGA color display
- Small footprint and lightweight - Only 5.8 in. (147 mm) deep and 11 lb. (5 kg)

Connectivity

- Two USB 2.0 host ports on the front panel and two on the rear panel for quick and easy data storage, printing, and connecting a USB keyboard
- USB 2.0 device port on the rear panel for easy connection to a PC or direct printing to a PictBridge®-compatible printer
- Integrated 10/100/1000BASE-T Ethernet port for network connection and video out port to export the oscilloscope display to a monitor or projector

Optional application support

- Advanced RF triggering
- Power analysis
- Limit and mask testing
- HDTV and custom video analysis

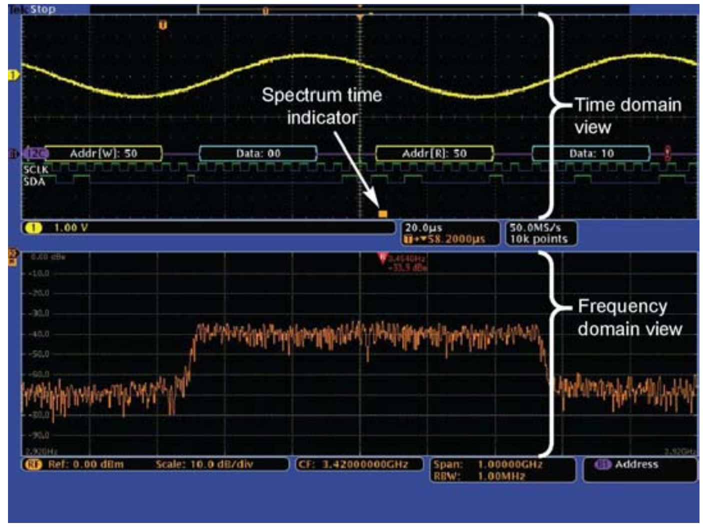
Introducing the Mixed Domain Oscilloscope

Based on the industry-standard MSO4000B Oscilloscope Series, you can now use your tool of choice, the oscilloscope, to look at the frequency domain rather than having to find and re-learn a spectrum analyzer. However, the power of the MDO4000 Series goes well beyond simply observing the frequency domain as you would on a spectrum analyzer. The real power is in its ability to correlate events in the frequency domain with the time domain phenomena that caused them.

When both the RF channel and any analog or digital channels are on, the oscilloscope display is split into two views. The upper half of the display is a traditional oscilloscope view of the Time Domain. The lower half of the display is a Frequency Domain view of the RF input. Note that the Frequency Domain view is not simply an FFT of the analog or digital channels in the instrument, but is the spectrum acquired from the RF input.

Another key difference is that with traditional oscilloscope FFTs, you can typically either get the desired view of the FFT display, or the desired view of your other time domain signals of interest, but never both at the same time. This is because traditional oscilloscopes only have a single acquisition system with a single set of user settings such as record length, sample rate, and time per division that drive all data views. But with the MDO4000 Series, the RF input has its own acquisition system that is independent, but time correlated, to the analog and digital channel acquisition systems. This allows each domain to be configured optimally, providing a complete time correlated system view of all analog, digital, and RF signals of interest.

The spectrum shown in the Frequency Domain view is taken from the period of time indicated by the short orange bar in the time domain view – known as the Spectrum Time. With the MDO4000 Series, Spectrum Time can be moved through the acquisition to investigate how the RF spectrum changes over time. And this can be done while the oscilloscope is live and running or on a stopped acquisition.



The upper half of the MDO4000 Series display shows the Time Domain view of the analog and digital channels, while the lower half shows the Frequency Domain view of the RF channel. The orange bar - Spectrum Time - shows the period of time used to calculate the RF spectrum.

Figures 1 through 4 show a simple everyday application – tuning of a PLL. This application illustrates the powerful connection between the time domain and the frequency domain that the MDO4000 Series provides. With its wide capture bandwidth and ability to move Spectrum Time throughout the acquisition, this single capture includes the same spectral content as approximately 1,500 unique test setups and acquisitions on a traditional spectrum analyzer. For the first time ever, correlating events, observing interactions, or measuring timing latencies between the two domains is exceptionally easy, giving you quick insight to your design's operation.

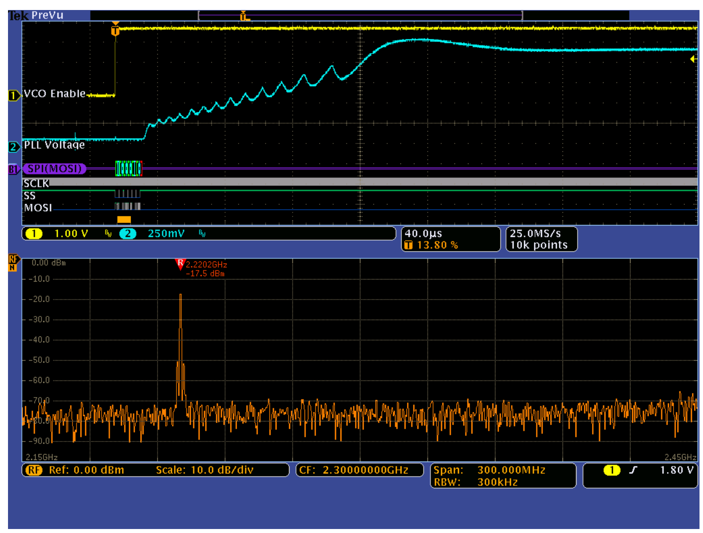


Figure 1 - Time and Frequency Domain view showing the turn-on of a PLL. Channel 1 (yellow) is probing a control signal that enables the VCO. Channel 2 (cyan) is probing the VCO tune voltage. The SPI bus which is programming the PLL with the desired frequency is probed with three digital channels and automatically decoded. Notice Spectrum Time is placed after the VCO was enabled and coincident with the command on the SPI bus telling the PLL the desired frequency.

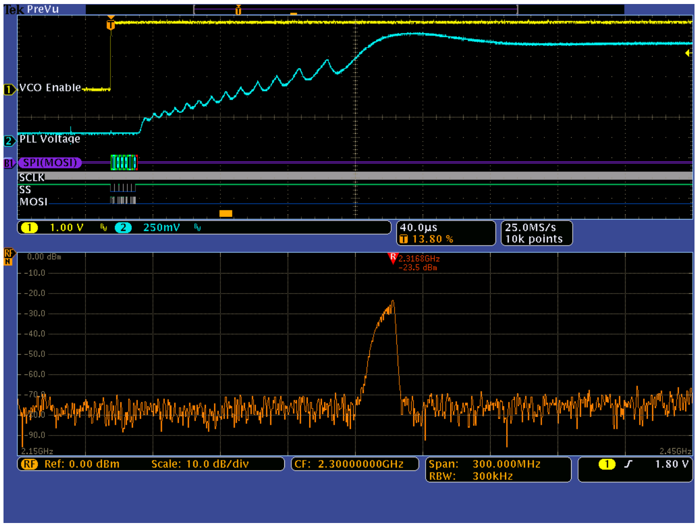


Figure 2 - Spectrum Time is moved about 60 µs to the right. At this point, the spectrum shows that the PLL is in the process of tuning to the correct frequency (2.400 GHz). It has made it up to 2.3168 GHz.

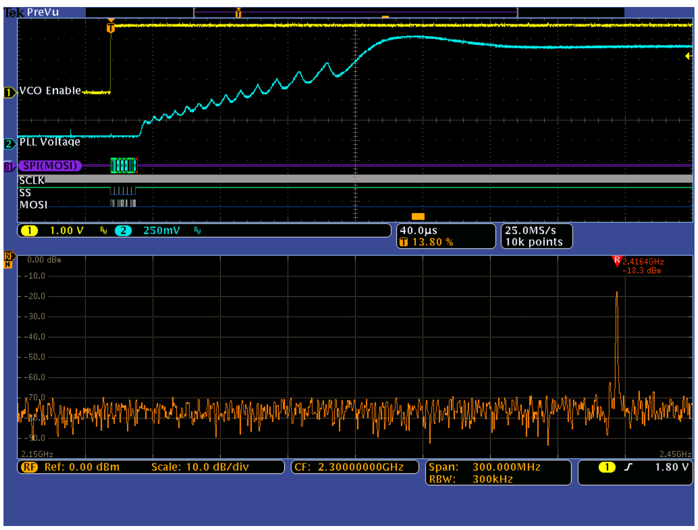


Figure 3 - Spectrum Time is moved another 120 µs to the right. At this point the spectrum shows that the PLL has actually overshot the correct frequency and gone all the way to 2.4164 GHz.

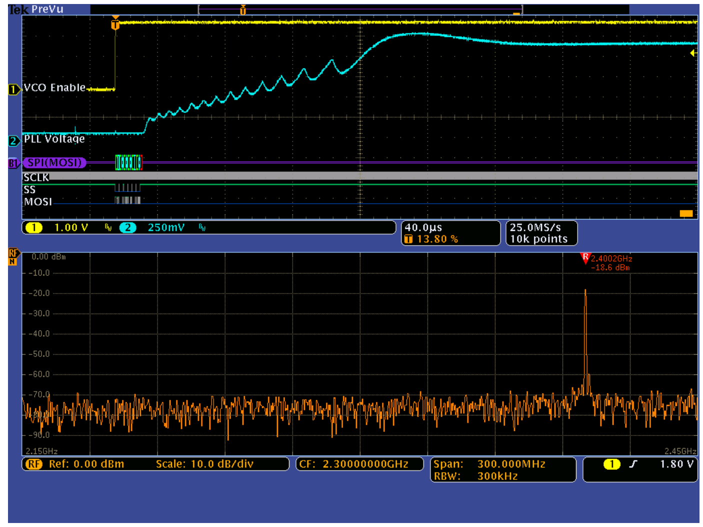


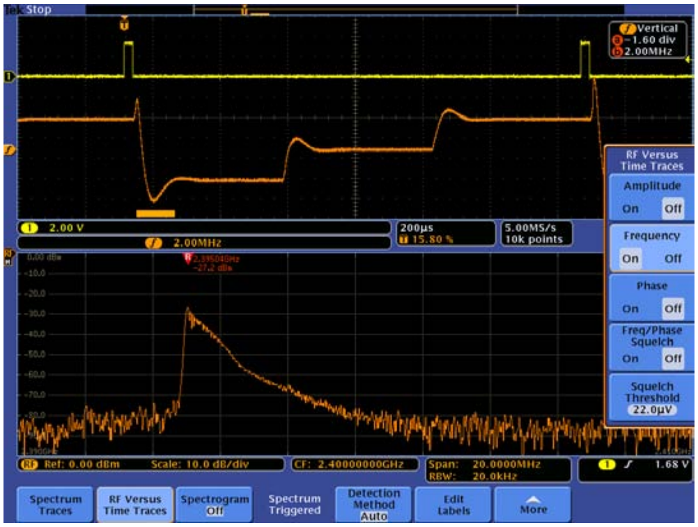
Figure 4 - The PLL eventually settles on the correct 2.400 GHz frequency about 340 µs after the VCO was enabled.

Visualizing changes in your RF signal

The time domain graticule on the MDO4000 Series display provides support for three RF time domain traces that are derived from the underlying I and Q data of the RF input including:

- Amplitude - The instantaneous amplitude of the RF input vs. time
- Frequency - The instantaneous frequency of the RF input, relative to the center frequency vs. time
- Phase - The instantaneous phase of the RF input, relative to the center frequency vs. time

Each of these traces may be turned on and off independently, and all three may be displayed simultaneously. RF time domain traces make it easy to understand what's happening with a time-varying RF signal.



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

Advanced triggering with RF, analog, and digital channels

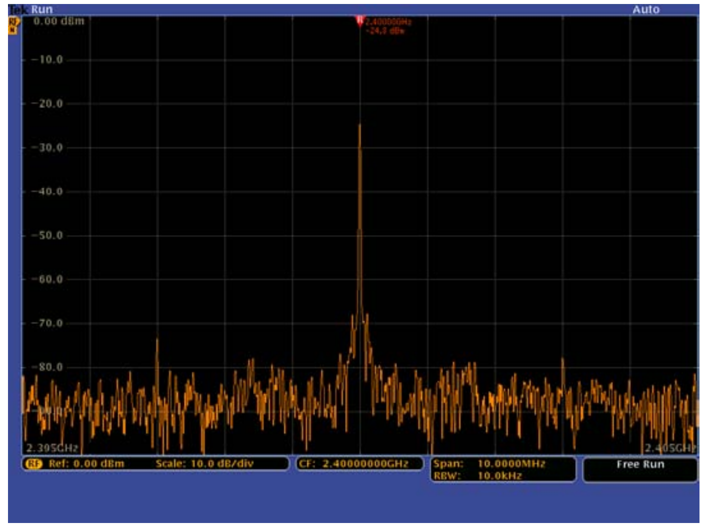
In order to deal with the time-varying nature of modern RF applications, the MDO4000 Series provides a triggered acquisition system that is fully integrated with the RF, analog, and digital channels. This means that a single trigger event coordinates acquisition across all channels, allowing you to capture a spectrum at the precise point in time where an interesting time domain event is occurring. A comprehensive set of time domain triggers are available, including Edge, Sequence, Pulse Width, Timeout, Runt, Logic, Setup/Hold Violation, Rise/Fall Time, Video, and a variety of parallel and serial bus packet triggers. In addition, you can trigger on the power level of the RF input. For example, you can trigger on your RF transmitter turning on.

The optional MDO4TRIG application module provides advanced RF triggering. This module enables the RF input power level to be used as a source for Sequence, Pulse Width, Timeout, Runt, and Logic trigger types. For example, you can trigger on a RF pulse of a specific length or use the RF channel as an input to a logic trigger, enabling the oscilloscope to trigger only when the RF is on while other signals are active.

Fast and accurate spectral analysis

When using the RF input by itself, the MDO4000 Series display becomes a full-screen Frequency Domain view.

Key spectral parameters such as Center Frequency, Span, Reference Level, and Resolution Bandwidth are all adjusted quickly and easily using the dedicated front-panel menus and keypad.



MDO4000 frequency domain display.

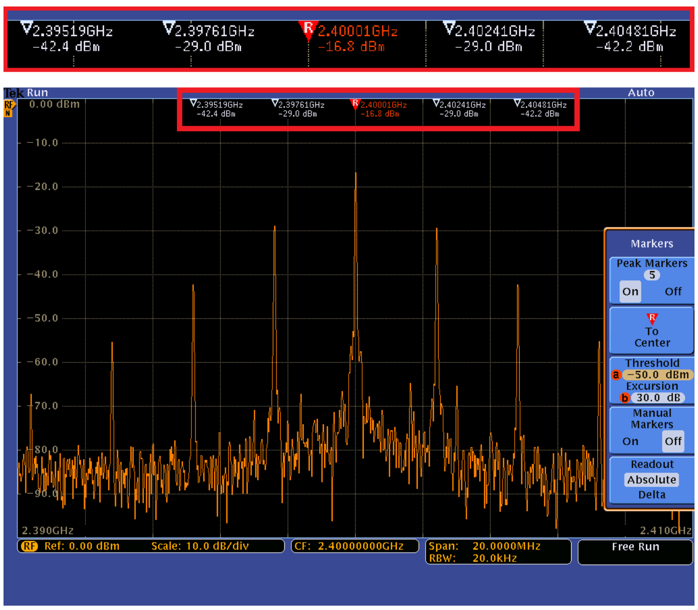
Key spectral parameters are adjusted quickly with the dedicated front-panel menus and keypad.

Intelligent, efficient markers

In a traditional spectrum analyzer, it can be a very tedious task to turn on and place enough markers to identify all your peaks of interest. The MDO4000 Series makes this process far more efficient by automatically placing markers on peaks that indicate both the frequency and the amplitude of each peak. You can adjust the criteria that the oscilloscope uses to automatically find the peaks.

The highest amplitude peak is referred to as the reference marker and is shown in red. Marker readouts can be switched between Absolute and Delta readouts. When Delta is selected, marker readouts show each peak's delta frequency and delta amplitude from the reference marker.

Two manual markers are also available for measuring non-peak portions of the spectrum. When enabled, the reference marker is attached to one of the manual markers, enabling delta measurements from anywhere in the spectrum. In addition to frequency and amplitude, manual marker readouts also include noise density and phase noise readouts depending on whether Absolute or Delta readouts are selected. A "Reference Marker to Center" function instantly moves the frequency indicated by the reference marker to center frequency.

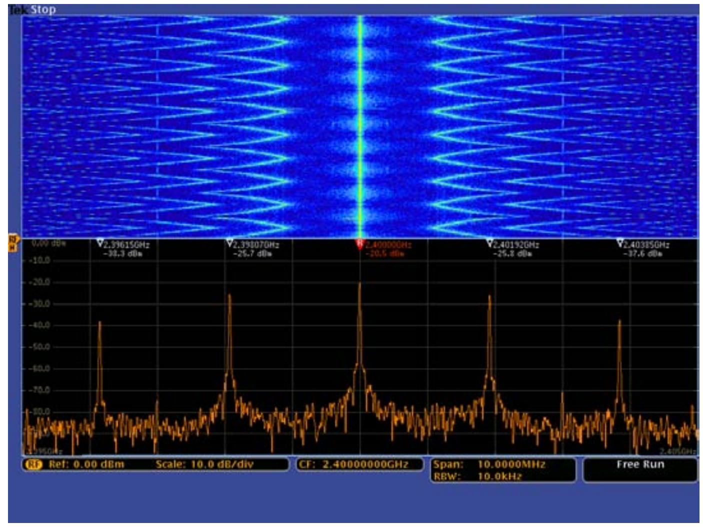


Automated peak markers identify critical information at a glance. As shown here, the five highest amplitude peaks that meet the threshold and excursion criteria are automatically marked along with the peak's frequency and amplitude.

Spectrogram

The MDO4000 Series includes a spectrogram display which is ideal for monitoring slowly changing RF phenomena. The x-axis represents frequency, just like a typical spectrum display. However, the y-axis represents time, and color is used to indicate amplitude.

Spectrogram slices are generated by taking each spectrum and "flipping it up on its edge" so that it's one pixel row tall, and then assigning colors to each pixel based on the amplitude at that frequency. Cold colors (blue, green) are low amplitude and hotter colors (yellow, red) are higher amplitude. Each new acquisition adds another slice at the bottom of the spectrogram and the history moves up one row. When acquisitions are stopped, you can scroll back through the spectrogram to look at any individual spectrum slice.



Spectrogram display illustrates slowly moving RF phenomena. As shown here, a signal that has multiple peaks is being monitored. As the peaks change in both frequency and amplitude over time, the changes are easily seen in the Spectrogram display.

Triggered versus Free Run operation

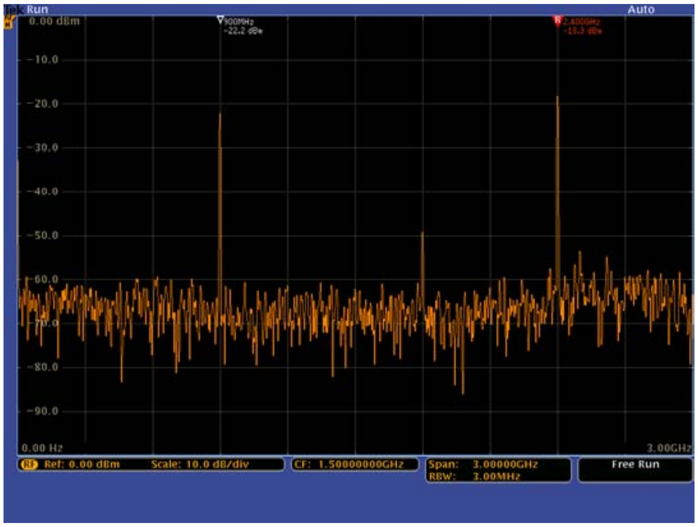
When both the time and frequency domains are displayed, the spectrum shown is always triggered by the system trigger event and is time correlated with the active time-domain traces. However, when only the frequency domain is displayed, the RF input can be set to Free Run. This is useful when the frequency domain data is continuous and unrelated to events occurring in the time domain.

Ultra-wide capture bandwidth

Today's wireless communications vary significantly with time, using sophisticated digital modulation schemes and, often, transmission techniques that involve bursting the output. These modulation schemes can have very wide bandwidth as well. Traditional swept or stepped spectrum analyzers are ill equipped to view these types of signals as they are only able to look at a small portion of the spectrum at any one time.

The amount of spectrum acquired in one acquisition is called the capture bandwidth. Traditional spectrum analyzers sweep or step the capture bandwidth through the desired span to build the requested image. As a result, while the spectrum analyzer is acquiring one portion of the spectrum, the event you care about may be happening in another portion of the spectrum. Most spectrum analyzers on the market today have 10 MHz capture bandwidths, sometimes with expensive options to extend that to 20, 40, or even 140 MHz in some cases.

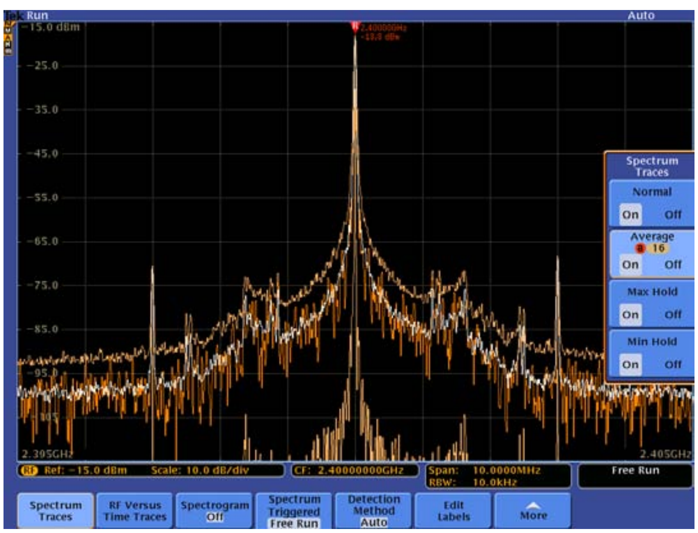
In order to address the bandwidth requirements of modern RF, the MDO4000 Series provides ≥1 GHz of capture bandwidth. At span settings of 1 GHz and below, there is no requirement to sweep the display. The spectrum is generated from a single acquisition, thus guaranteeing you'll see the events you're looking for in the frequency domain.



Spectral display of a bursted communication both into a device through Zigbee at 900 MHz and out of the device through Bluetooth at 2.4 GHz, captured with a single acquisition.

Spectrum traces

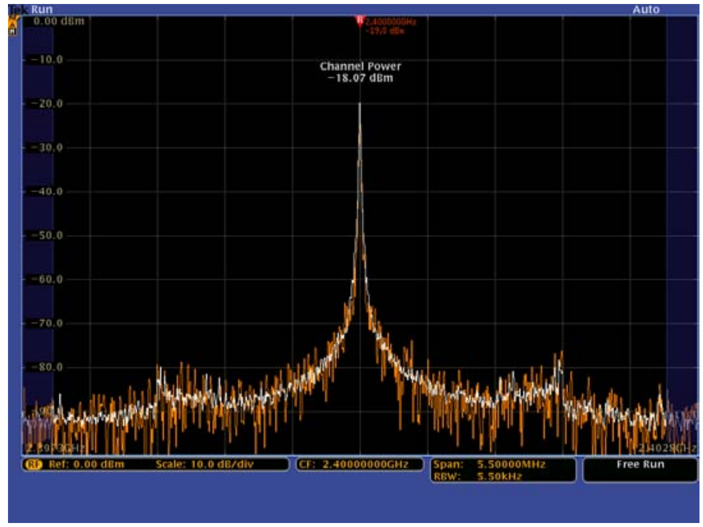
The MDO4000 Series offers four different traces or views of the RF input including Normal, Average, Max Hold, and Min Hold. You can set the detection method used for each trace type independently or you can leave the oscilloscope in the default Auto mode that sets the detection type optimally for the current configuration. Detection types include +Peak, -Peak, Average, and Sample.



Normal, Average, Max Hold, and Min Hold spectrum traces

RF measurements

The MDO4000 Series includes three automated RF measurements - Channel Power, Adjacent Channel Power Ratio, and Occupied Bandwidth. When one of these RF measurements is activated, the oscilloscope automatically turns on the Average spectrum trace and sets the detection method to Average for optimal measurement results.



Automated Channel Power measurement

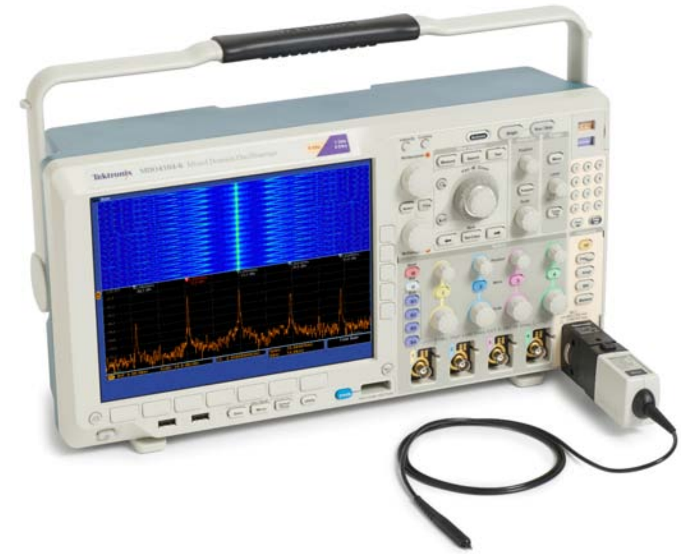
Advanced RF measurements

The MDO4000 can save the baseband I and Q data from RF acquisitions to a .TIQ file. These files can then be imported into Tektronix' SignalVu-PC and RSAVu analysis packages for further modulation analysis on many wireless standards.

RF probing

Signal input methods on spectrum analyzers are typically limited to cabled connections or antennas. But with the optional TPA-N-VPI adapter, any active, 50 Ω TekVPI probe can be used with the RF input on the MDO4000 Series. This enables additional flexibility when hunting for noise sources and enables easier spectral analysis by using true signal browsing on an RF input.

In addition, an optional preamplifier accessory assists in the investigation of lower-amplitude signals. The TPA-N-PRE preamplifier provides 12 dB nominal gain across the 9 kHz - 6 GHz frequency range.



The optional TPA-N-VPI adapter enables any active, 50 Ω TekVPI probe to be connected to the RF input.

The TPA-N-PRE preamplifier provides 12 dB nominal gain across the 9 kHz - 6 GHz frequency range.

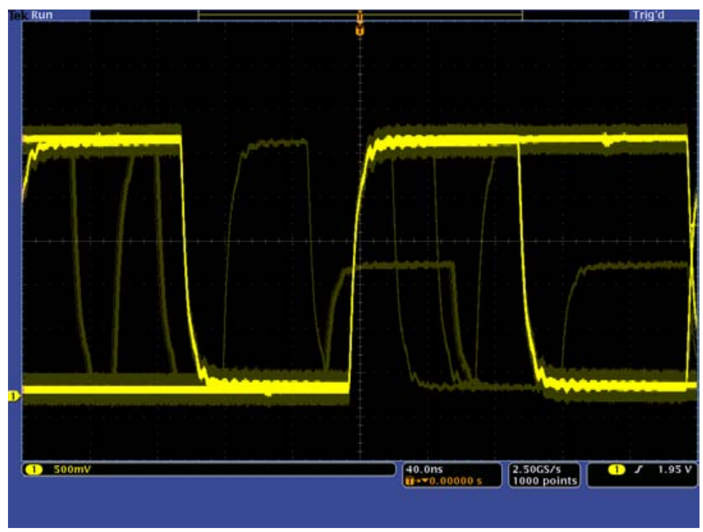
Built on the award-winning MSO4000B Series of Mixed Signal Oscilloscopes

The MDO4000 Series provides you with the same comprehensive set of features available in the MSO4000B Mixed Signal Oscilloscope Series. This robust set of tools will help you speed through every stage of debugging your design - from quickly discovering an anomaly and capturing it, to searching your waveform record for the event and analyzing its characteristics and your device's behavior.

Discover

To debug a design problem, first you must know it exists. Every design engineer spends time looking for problems in their design, a time-consuming and frustrating task without the right debug tools.

The industry’s most complete visualization of signals provides fast insight into the real operation of your device. A fast waveform capture rate – greater than 50,000 waveforms per second – enables you to see glitches and other infrequent transients within seconds, revealing the true nature of device faults. A digital phosphor display with intensity grading shows the history of a signal’s activity by intensifying areas of the signal that occur more frequently, providing a visual display of just how often anomalies occur.



Discover – Fast waveform capture rate - over 50,000 wfm/s - maximizes the probability of capturing elusive glitches and other infrequent events.

Capture

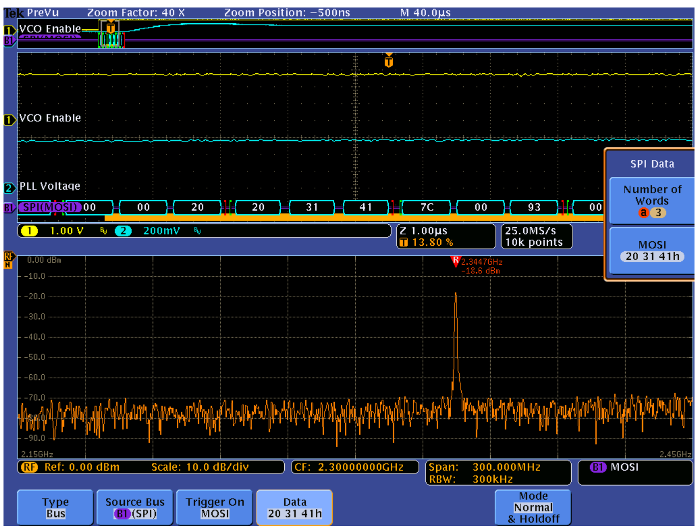
Discovering a device fault is only the first step. Next, you must capture the event of interest to identify root cause.

Accurately capturing any signal of interest begins with proper probing. Low-capacitance probes are included with the oscilloscope, one for each analog channel. These industry-first high-impedance passive voltage probes have less than 4 pF of capacitive loading to minimize the affect of the probe on your circuit's operation, offering the performance of an active probe with the flexibility of a passive probe.

A complete set of triggers - including runt, timeout, logic, pulse width/glitch, setup/hold violation, serial packet, and parallel data - help you quickly find your event. With up to a 20M point record length, you can capture many events of interest, even thousands of serial packets, in a single acquisition for further analysis while maintaining high resolution to zoom in on fine signal details.

From triggering on specific packet content to automatic decode in multiple data formats, the oscilloscope provides integrated support for the industry's broadest range of serial buses - I^{2}C, SPI, USB, Ethernet, CAN, LIN, FlexRay, RS-232/422/485/UART, MIL-STD-1553, and I^{2}S/LJ/RJ/TDM. The ability to decode up to four serial and/or parallel buses simultaneously means you gain insight into system-level problems quickly.

To further help troubleshoot system-level interactions in complex embedded systems, the oscilloscope offers 16 digital channels in addition to its analog channels. Since the digital channels are fully integrated into the oscilloscope, you can trigger across all input channels, automatically time correlating all analog, digital, serial, and RF signals. The MagniVu™ high-speed acquisition on these channels enables you to acquire fine signal detail (up to 60.6 ps resolution) around the trigger point for precision timing measurements. MagniVu is essential for making accurate timing measurements for setup and hold, clock delay, signal skew, and glitch characterization.



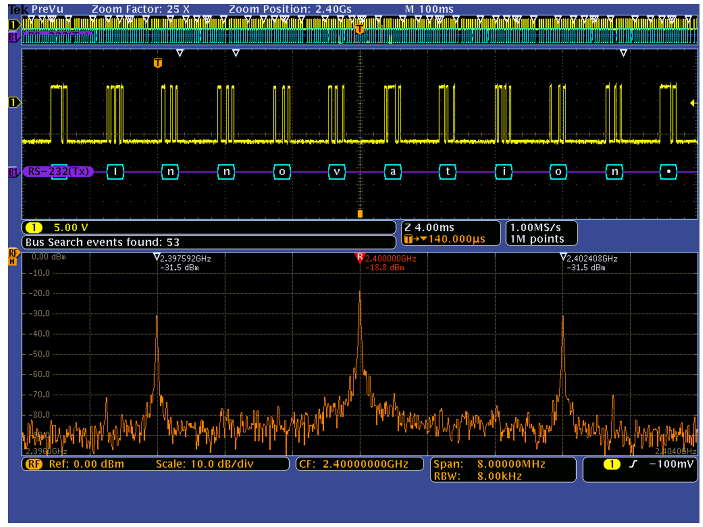
Capture - Triggering on a specific transmit data packet going across a SPI bus. A complete set of triggers, including triggers for specific serial packet content, ensures you quickly capture your event of interest.

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 pushing beyond a million data points, locating your event can mean scrolling through thousands of screens of signal activity.

The innovative Wave Inspector® controls give you the industry's most comprehensive search and waveform navigation capability. 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. User marks allow you to mark any location that you may want to reference later for further investigation. Or, automatically search your record for criteria you define. Wave Inspector will instantly search your entire record, including analog, digital, serial-bus, and RF-versus-time data.

Along the way it will automatically mark every occurrence of your defined event so you can quickly move between events.



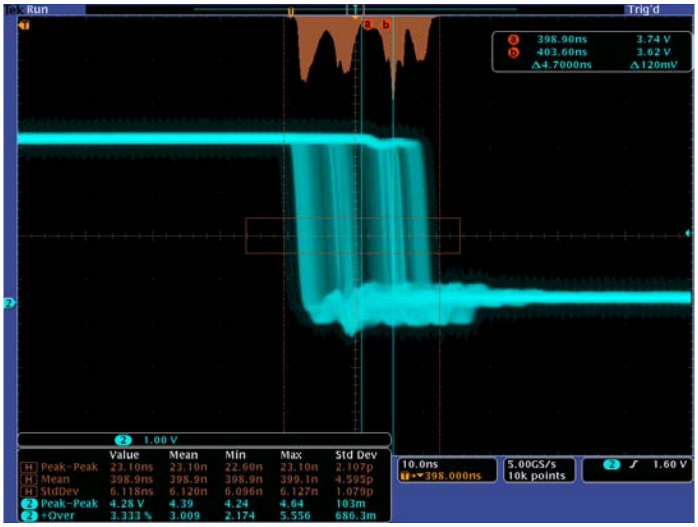
Search – RS-232 decode showing results from a Wave Inspector search for data value "n". Wave Inspector controls provide unprecedented efficiency in viewing and navigating waveform data.

Analyze

Verifying that your prototype's performance matches simulations and meets the project's design goals requires analyzing its behavior. Tasks can range from simple checks of rise times and pulse widths to sophisticated power loss analysis and investigation of noise sources.

The oscilloscope offers a comprehensive set of integrated analysis tools including waveform- and screen-based cursors, automated measurements, advanced waveform math including arbitrary equation editing, spectral math, FFT analysis, and trend plots for visually determining how a measurement is changing over time. Specialized application support for serial bus analysis, power supply design, and video design and development is also available.

For extended analysis, National Instrument's LabVIEW SignalExpress® Tektronix Edition provides over 200 built-in functions including time and frequency domain analysis, limit testing, data logging, and customizable reports.



Analyze – Waveform histogram of a falling edge showing the distribution of edge position (jitter) over time. Included are numeric measurements made on the waveform histogram data. A comprehensive set of integrated analysis tools speeds verification of your design's performance.

Specifications

All specifications apply to all models unless noted otherwise.

Model overview

	MDO4014-3	MDO4034-3	MDO4054-3	MDO4054-6	MDO4104-3	MDO4104-6
Analog channels	4	4	4	4	4	4
Analog channel bandwidth	100 MHz	350 MHz	500 MHz	500 MHz	1 GHz	1 GHz
Rise time	3.5 ns	1 ns	700 ps	700 ps	350 ps	350 ps
Sample rate (1 ch)	2.5 GS/s	2.5 GS/s	2.5 GS/s	2.5 GS/s	5 GS/s	5 GS/s
Sample rate (2 ch)	2.5 GS/s	2.5 GS/s	2.5 GS/s	2.5 GS/s	5 GS/s	5 GS/s
Sample rate (4 ch)	2.5 GS/s	2.5 GS/s	2.5 GS/s	2.5 GS/s	2.5 GS/s	2.5 GS/s
Record length (1 ch)	20M	20M	20M	20M	20M	20M
Record length (2 ch)	20M	20M	20M	20M	20M	20M
Record length (4 ch)	20M	20M	20M	20M	20M	20M
Digital channels	16	16	16	16	16	16
RF channels	1	1	1	1	1	1
RF channel frequency range	50 kHz - 3 GHz	50 kHz - 3 GHz	50 kHz - 3 GHz	50 kHz - 6 GHz	50 kHz - 3 GHz	50 kHz - 6 GHz

RF channel

Real-time capture bandwidth	≥1 GHz
Span	1 kHz - 3 GHz or 1 kHz - 6 GHz, in a 1-2-5 sequence
Resolution bandwidth	20 Hz - 10 MHz in a 1-2-3-5 sequence
Reference level	-140 dBm to +30 dBm in steps of 5 dBm
Vertical scale	1 dB/div to 20 dB/div in a 1-2-5 sequence
Vertical position	-10 divs to +10 divs
Vertical units	dBm, dBmV, dBµV, dBµW, dBmA, dBµA
Displayed average noise level (DANL)	
50 kHz - 5 MHz	< -130 dBm/Hz (< -134 dBm/Hz typical)
5 MHz - 3 GHz	< -148 dBm/Hz (< -152 dBm/Hz typical)
3 GHz - 6 GHz	< -140 dBm/Hz (< -143 dBm/Hz typical)
Spurious response	
2nd and 3rd harmonic distortion (>30 MHz)	< -55 dBc (< -60 dBc typical)
2nd order intermodulation distortion	< -55 dBc (< -60 dBc typical)
3rd order intermodulation distortion	< -60 dBc (< -63 dBc typical)
Other A/D spurs	< -55 dBc (< -60 dBc typical)
Image and IF Rejection	< -50 dBc (< -55 dBc typical)
Residual response	< -78 dBm

Crosstalk to RF channel from oscilloscope channels	
≤1 GHz input frequencies	< -68 dB from ref level
>1 GHz - 2 GHz input frequencies	< -48 dB from ref level
Phase noise at 2 GHz CW	
10 kHz	< -90 dBc/Hz, < -95 dBc/Hz (typical)
100 kHz	< -95 dBc/Hz, < -98 dBc/Hz (typical)
1 MHz	< -113 dBc/Hz, < -118 dBc/Hz (typical)
Level measurement uncertainty	for input level +10 dBm to - 50 dBm
20 °C - 30 °C	< ±1 dB (< ±0.5 dB typical)
Over operating range	< ±1.5 dB
Residual FM	≤100 Hz peak-to-peak in 100 ms
Maximum operating input level	
Average continuous power	+30 dBm (1 W)
DC maximum before damage	±40 V DC
Maximum power before damage (CW)	+33 dBm (2 W)
Maximum power before damage (pulse)	+45 dBm (32 W) (<10 μs pulse width, <1% duty cycle, and reference level of ≥ +10 dBm)
Power level trigger	
Frequency range	1 MHz - 3 GHz or 1 MHz - 6 GHz
Amplitude range	+30 dBm to -40 dBm
Limits	With CF 1 MHz - 3.25 GHz: -35 dB from ref level
	With CF >3.25 GHz: -15 dB from ref level
Minimum pulse duration	10 μs On Time with a minimum settling Off Time of 10 μs
RF to analog channel skew	<5 ns
Frequency domain trace types	Normal, Average, Max Hold, Min Hold
Time domain trace types	Amplitude vs. Time, Frequency vs. Time, Phase vs. Time
Detection methods	+Peak, -Peak, Average, Sample
Automatic markers	One to eleven peaks identified based on user-adjustable threshold and excursion values
Manual markers	Two manual markers indicating frequency, amplitude, noise density, and phase noise
Marker readouts	Absolute or Delta

RF acquisition length

Span	Maximum RF acquisition time
>2 GHz	2.5 ms
>1 GHz - 2 GHz	5 ms
>800 MHz - 1 GHz	10 ms
>500 MHz - 800 MHz	12.5 ms
>400 MHz - 500 MHz	20 ms
>250 MHz - 400 MHz	25 ms
>200 MHz - 250 MHz	40 ms
>160 MHz - 200 MHz	50 ms
>125 MHz - 160 MHz	62.5 ms
<125 MHz	79 ms

FFT windows

FFT window	Factor
Kaiser	2.23
Rectangular	0.89
Hamming	1.30
Hanning	1.44
Blackman-Harris	1.90
Flat-Top	3.77

Vertical system analog channels

Hardware bandwidth limits

- ≥350 MHz models: 20 MHz or 250 MHz
- 100 MHz models: 20 MHz

Input coupling: AC, DC

Input impedance: 1 MΩ ±1%, 50 Ω ±1%

Input sensitivity range

- 1 MΩ: 1 mV/div to 10 V/div
- 50 Ω: 1 mV/div to 1 V/div

Vertical resolution: 8 bits (11 bits with Hi Res)

Maximum input voltage

- 1 MΩ: 300 V_{RMS} CAT II with peaks ≤ ±425 V
- 50 Ω: 5 V_{RMS} with peaks ≤ ±20 V

DC gain accuracy: ±1.5%, derated at 0.10%/°C above 30 °C

Channel-to-channel isolation: Any two channels at equal vertical scale ≥100:1 at ≤100 MHz and ≥30:1 at >100 MHz up to the rated bandwidth

Offset range

Volts/div setting	Offset range	
	1 MΩ input	50 Ω
1 mV/div to 50 mV/div	±1 V	±1 V
50.5 mV/div to 99.5 mV/div	±0.5 V	±0.5 V
100 mV/div to 500 mV/div	±10 V	±10V
505 mV/div to 995 mV/div	±5 V	±5 V
1 V/div to 5 V/div	±100 V	±5 V
5.05 V/div to 10 V/div	±50 V	NA

Vertical system digital channels

Input channels	16 digital (D15 to D0)
Thresholds	Per-channel thresholds
Threshold selections	TTL, CMOS, ECL, PECL, User Defined
User-defined threshold range	±40 V
Threshold accuracy	±[100 mV + 3% of threshold setting]
Maximum input voltage	±42 V_{peak}
Input dynamic range	30 V_{p-p} ≤200 MHz 10 V_{p-p} >200 MHz
Minimum voltage swing	400 mV
Probe loading	100 kΩ in parallel with 3 pF
Vertical resolution	1 bit

Horizontal system analog channels

Time base range	
1 GHz models	400 ps to 1000 s
≤ 500 MHz models	1 ns to 1000 s
Maximum duration at highest sample rate (all/half channels)	
1 GHz models	8/4 ms
≤ 500 MHz models	8/8 ms
Time-base delay time range	-10 divisions to 5000 s
Channel-to-channel deskew range	±125 ns
Time base accuracy	±5 ppm over any ≥1 ms interval

Horizontal system digital channels

Maximum sample rate (Main)	500 MS/s (2 ns resolution)
Maximum record length (Main)	20M points
Maximum sample rate (MagniVu)	16.5 GS/s (60.6 ps resolution)
Maximum record length (MagniVu)	10k points centered around the trigger
Minimum detectable pulse width (typical)	1 ns
Channel-to-channel skew (typical)	200 ps
Maximum input toggle rate	500 MHz (Maximum frequency sine wave that can accurately be reproduced as a logic square wave. Requires the use of a short ground extender on each channel. This is the maximum frequency at the minimum swing amplitude. Higher toggle rates can be achieved with higher amplitudes.)

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 holdoff range	20 ns to 8 s
Trigger sensitivity	
Internal DC coupled	

Trigger source	Sensitivity
1 MΩ path (all models)	For 1 mV/div to 4.98 mV/div; 0.75 div from DC to 50 MHz, increasing to 1.3 div at rated bandwidth
50 Ω path (≤500 MHz models)	For ≥5 mV/div; 0.4 div from DC to 50 MHz, increasing to 1 div at rated bandwidth
50 Ω path (1 GHz models)	0.4 div from DC to 50 MHz, increasing to 1 div at rated bandwidth

Trigger level ranges	
Any input channel	±8 divisions from center of screen, ±8 divisions from 0 V when vertical LF reject trigger coupling is selected
Line	The line trigger level is fixed at about 50% of the line voltage.
Trigger frequency readout	Provides 6-digit frequency readout of triggerable events.
Trigger types	
Edge	Positive or negative slope on any channel. Coupling includes DC, AC, HF reject, LF reject, and noise reject.
Sequence (B-trigger)	Trigger Delay by Time: 4 ns to 8 s. Or Trigger Delay by Events: 1 to 4,000,000 events.
Pulse Width	Trigger on width of positive or negative pulses that are >, <, =, ≠, or inside/outside a specified period of time.
Runt	Trigger on a pulse that crosses one threshold but fails to cross a second threshold before crossing the first again.
Logic	Trigger when any logical pattern of channels goes false or stays true for specified period of time. Any input can be used as a clock to look for the pattern on a clock edge. Pattern (AND, OR, NAND, NOR) specified for all input channels defined as High, Low, or Don’t Care.
Setup and Hold	Trigger on violations of both setup time and hold time between clock and data present on any of the analog and digital input channels.
Rise/Fall Time	Trigger on pulse edge rates that are faster or slower than specified. Slope may be positive, negative, or either.
Video	Trigger on all lines, odd, even, or all fields on NTSC, PAL, and SECAM video signals.
Extended Video (optional)	Trigger on 480p/60, 576p/50, 720p/30, 720p/50, 720p/60, 875i/60, 1080i/50, 1080i/60, 1080p/24, 1080p/24sF, 1080p/25, 1080p/30, 1080p/50, 1080p/60, and custom bi-level and tri-level sync video standards.
I^2C (optional)	Trigger on Start, Repeated Start, Stop, Missing ACK, Address (7 or 10 bit), Data, or Address and Data on I^2C buses up to 10 Mb/s.
SPI (optional)	Trigger on SS active, Start of Frame, MOSI, MISO, or MOSI and MISO on SPI buses up to 50.0 Mb/s.
RS-232/422/485/UART (optional)	Trigger on Tx Start Bit, Rx Start Bit, Tx End of Packet, Rx End of Packet, Tx Data, Rx Data, Tx Parity Error, and Rx Parity Error up to 10 Mb/s.
USB: Low speed (optional)	Trigger on Sync Active, Start of Frame, Reset, Suspend, Resume, End of Packet, Token (Address) Packet, Data Packet, Handshake Packet, Special Packet, Error. Token packet trigger - Any token type, SOF, OUT, IN, SETUP; Address can be specified for Any Token, OUT, IN, and SETUP token types. Address can be further specified to trigger on ≤, <, =, >, ≥, ≠ a particular value, or inside or outside of a range. Frame number can be specified for SOF token using binary, hex, unsigned decimal and don't care digits. Data packet trigger - Any data type, DATA0, DATA1; Data can be further specified to trigger on ≤, <, =, >, ≥, ≠ a particular data value, or inside or outside of a range. Handshake packet trigger - Any handshake type, ACK, NAK, STALL. Special packet trigger - Any special type, Reserved Error trigger - PID Check, CRC5 or CRC16, Bit Stuffing.

USB: Full speed (optional)	Trigger on Sync, Reset, Suspend, Resume, End of Packet, Token (Address) Packet, Data Packet, Handshake Packet, Special Packet, Error. Token packet trigger - Any token type, SOF, OUT, IN, SETUP; Address can be specified for Any Token, OUT, IN, and SETUP token types. Address can be further specified to trigger on ≤, <, =, >, ≥, ≠ a particular value, or inside or outside of a range. Frame number can be specified for SOF token using binary, hex, unsigned decimal and don't care digits. Data packet trigger - Any data type, DATA0, DATA1; Data can be further specified to trigger on ≤, <, =, >, ≥, ≠ a particular data value, or inside or outside of a range. Handshake packet trigger - Any handshake type, ACK, NAK, STALL. Special packet trigger - Any special type, PRE, Reserved. Error trigger - PID Check, CRC5 or CRC16, Bit Stuffing.
USB: High speed (optional)[1]	Trigger on Sync, Reset, Suspend, Resume, End of Packet, Token (Address) Packet, Data Packet, Handshake Packet, Special Packet, Error. Token packet trigger - Any token type, SOF, OUT, IN, SETUP; Address can be specified for Any Token, OUT, IN, and SETUP token types. Address can be further specified to trigger on ≤, <, =, >, ≥, ≠ a particular value, or inside or outside of a range. Frame number can be specified for SOF token using binary, hex, unsigned decimal and don't care digits. Data packet trigger - Any data type, DATA0, DATA1, DATA2, MDATA; Data can be further specified to trigger on ≤, <, =, >, ≥, ≠ a particular data value, or inside or outside of a range. Handshake packet trigger - Any handshake type, ACK, NAK, STALL, NYET. Special packet trigger - Any special type, ERR, SPLIT, PING, Reserved. SPLIT packet components that can be specified include: ▪ Hub Address ▪ Start/Complete - Don't Care, Start (SSPLIT), Complete (CSPLIT) ▪ Port Address ▪ Start and End bits - Don't Care, Control/Bulk/Interrupt (Full-speed Device, Low-speed Device), Isochronous (Data is Middle, Data is End, Data is Start, Data is All) ▪ Endpoint Type - Don't Care, Control, Isochronous, Bulk, Interrupt Error trigger - PID Check, CRC5 or CRC16.
Ethernet (optional)[2]	10BASE-T and 100BASE-TX: Trigger on Start Frame Delimiter, MAC Addresses, MAC Q-Tag Control Information, MAC Length/ Type, IP Header, TCP Header, TCP/IPv4/MAC Client Data, End of Packet, and FCS (CRC) Error. 100BASE-TX: Idle. MAC Addresses - Trigger on Source and Destination 48-bit address values. MAC Q-Tag Control Information - Trigger on Q-Tag 32-bit value. MAC Length/Type - Trigger on ≤, <, =, >, ≥, ≠ a particular 16-bit value, or inside or outside of a range. IP Header - Trigger on IP Protocol 8-bit value, Source Address, Destination Address. TCP Header - Trigger on Source Port, Destination Port, Sequence Number, and Ack Number. TCP/IPv4/MAC Client Data - Trigger on ≤, <, =, >, ≥, ≠ a particular data value, or inside or outside of a range. Selectable number of bytes to trigger on from 1-16. Byte offset options of Don't Care, 0-1499.
CAN (optional)	Trigger on Start of Frame, Frame Type (data, remote, error, overload), Identifier (standard or extended), Data, Identifier and Data, End of Frame, Missing ACK, or Bit Stuffing Error on CAN signals up to 1 Mb/s. Data can be further specified to trigger on ≤, <, =, >, ≥, or ≠ a specific data value. User-adjustable sample point is set to 50% by default.
LIN (optional)	Trigger on Sync, Identifier, Data, Identifier and Data, Wakeup Frame, Sleep Frame, Errors such as Sync, Parity, or Checksum Errors up to 100 kb/s (by LIN definition, 20 kb/s).
FlexRay (optional)	Trigger on Start of Frame, Type of Frame (Normal, Payload, Null, Sync, Startup), Identifier, Cycle Count, Complete Header Field, Data, Identifier and Data, End of Frame or Errors such as Header CRC, Trailer CRC, Null Frame, Sync Frame, or Startup Frame Errors up to 100 Mb/s.

1 High-speed support only available on models with 1 GHz analog channel bandwidth.

2 ≥350 MHz bandwidth models are recommended for 100BASE-TX

MIL-STD-1553 (optional)	Trigger on Sync, Word Type [3] (Command, Status, Data), Command Word (set RT Address, T/R, Sub-address/Mode, Data Word Count/Mode Code, and Parity individually), Status Word (set RT Address, Message Error, Instrumentation, Service Request Bit, Broadcast Command Received, Busy, Subsystem Flag, Dynamic Bus Control Acceptance (DBCA), Terminal Flag, and Parity individually), Data Word (user-specified 16-bit data value), Error (Sync, Parity, Manchester, Non-contiguous data), Idle Time (minimum time selectable from 2 μs to 100 μs; maximum time selectable from 2 μs to 100 μs; trigger on < minimum, > maximum, inside range, outside range). RT Address can be further specified to trigger on =, ≠, <, >, ≤, ≥ a particular value, or inside or outside of a range.
I^2S/LJ/RJ/TDM (optional)	Trigger on Word Select, Frame Sync, or Data. Data can be further specified to trigger on ≤, <, =, >, ≥, ≠ a specific data value, or inside or outside of a range. Maximum data rate for I^2S/LJ/RJ is 12.5 Mb/s. Maximum data rate for TDM is 25 Mb/s.
Parallel	Trigger on a parallel bus data value. Parallel bus can be from 1 to 20 bits (from the digital and analog channels) in size. Binary and Hex radices are supported.

Acquisition system

Acquisition Modes

Sample	Acquire sampled values.
Peak Detect	Captures glitches as narrow as 800 ps (1 GHz models) or 1.6 ns (≤500 MHz models) at all sweep speeds
Averaging	From 2 to 512 waveforms included in average.
Envelope	Min-max envelope reflecting Peak Detect data over multiple acquisitions.
Hi Res	Real-time boxcar averaging reduces random noise and increases vertical resolution.
Roll	Scrolls waveforms right to left across the screen at sweep speeds slower than or equal to 40 ms/div.

Waveform measurements

Cursors	Waveform and Screen.
Automatic measurements (time domain)	29, of which up to eight can be displayed on-screen at any one time. Measurements include: Period, Frequency, Delay, Rise Time, Fall Time, Positive Duty Cycle, Negative Duty Cycle, Positive Pulse Width, Negative Pulse Width, Burst Width, Phase, Positive Overshoot, Negative Overshoot, Peak to Peak, Amplitude, High, Low, Max, Min, Mean, Cycle Mean, RMS, Cycle RMS, Positive Pulse Count, Negative Pulse Count, Rising Edge Count, Falling Edge Count, Area and Cycle Area.
Automatic Measurements (frequency domain)	3, of which one can be displayed on-screen at any one time. Measurements include Channel Power, Adjacent Channel Power Ratio (ACPR), and Occupied Bandwidth (OBW)
Measurement statistics	Mean, Min, Max, Standard Deviation.
Reference levels	User-definable reference levels for automatic measurements can be specified in either percent or units.
Gating	Isolate the specific occurrence within an acquisition to take measurements on, using either the screen, or waveform cursors.
Waveform histogram	A waveform histogram provides an array of data values representing the total number of hits inside of a user-defined region of the display. A waveform histogram is both a visual graph of the hit distribution as well as a numeric array of values that can be measured. Sources - Channel 1, Channel 2, Channel 3, Channel 4, Ref 1, Ref 2, Ref 3, Ref 4, Math Types - Vertical, Horizontal
Waveform histogram measurements	Waveform Count, Hits in Box, Peak Hits, Median, Max, Min, Peak-to-Peak, Mean, Standard Deviation, Sigma 1, Sigma 2, Sigma 3

3 Trigger selection of Command Word will trigger on Command and ambiguous Command/Status words. Trigger selection of Status Word will trigger on Status and ambiguous Command/Status words.

Waveform math

Arithmetic	Add, subtract, multiply, and divide waveforms.
Math functions	Integrate, Differentiate, FFT.
FFT	Spectral magnitude. Set FFT Vertical Scale to Linear RMS or dBV RMS, and FFT Window to Rectangular, Hamming, Hanning, or Blackman-Harris.
Spectrum math	Add or subtract frequency-domain traces.
Advanced math	Define extensive algebraic expressions including waveforms, reference waveforms, math functions (FFT, Intg, Diff, Log, Exp, Sqrt, Abs, Sine, Cosine, Tangent, Rad, Deg), scalars, up to two user-adjustable variables and results of parametric measurements (Period, Freq, Delay, Rise, Fall, PosWidth, NegWidth, BurstWidth, Phase, PosDutyCycle, NegDutyCycle, PosOverShoot, NegOverShoot, PeakPeak, Amplitude, RMS, CycleRMS, High, Low, Max, Min, Mean, CycleMean, Area, CycleArea, and trend plots), e.g.,(Intg(Ch1 - Mean(Ch1)) × 1.414 × VAR1).

Power measurements (optional)

Power Quality Measurements	V_{RMS}, $V_{Crest\ Factor}$, Frequency, I_{RMS}, $I_{Crest\ Factor}$, True Power, Apparent Power, Reactive Power, Power Factor, Phase Angle.
Switching loss measurements	
Power loss	T_{on}, T_{off}, Conduction, Total.
Energy loss	T_{on}, T_{off}, Conduction, Total.
Harmonics	THD-F, THD-R, RMS measurements. Graphical and table displays of harmonics. Test to IEC61000-3-2 Class A and MIL-STD-1399, Section 300A.
Ripple measurements	V_{Ripple} and I_{Ripple}.
Modulation Analysis	Graphical display of +Pulse Width, –Pulse Width, Period, Frequency, +Duty Cycle, and –Duty Cycle modulation types.
Safe operating area	Graphical display and mask testing of switching device safe operating area measurements.
dV/dt and dI/dt measurements	Cursor measurements of slew rate.

Limit/Mask testing (optional)

Included standard masks[4]	ITU-T, ANSI T1.102, USB
Test source	Limit test: Any Ch1 - Ch4 or any R1 - R4
	Mask test: Any Ch1 - Ch4
Mask creation	Limit test vertical tolerance from 0 to 1 division in 1 m division increments; Limit test horizontal tolerance from 0 to 500 m division in 1 m division increments
	Load standard mask from internal memory
	Load custom mask from text file with up to 8 segments
Mask scaling	Lock to Source ON (mask automatically re-scales with source-channel settings changes)
	Lock to Source OFF (mask does not re-scale with source-channel settings changes)
Test criteria run until	Minimum number of waveforms (from 1 to 1,000,000; Infinity)
	Minimum elapsed time (from 1 second to 48 hours; Infinity)
Violation threshold	From 1 to 1,000,000
Actions on test failure	Stop acquisition, save screen image to file, save waveform to file, print screen image, trigger out pulse, set remote interface SRQ
Actions on test complete	Trigger out pulse, set remote interface SRQ
Results display	Test status, total waveforms, number of violations, violation rate, total tests, failed tests, test failure rate, elapsed time, total hits for each mask segment

4 ≥350 MHz bandwidth models are recommended for mask testing on telecomm standards >55 Mb/s. 1 GHz bandwidth models are recommended for mask testing on high-speed (HS) USB.

Software

NI LabVIEW SignalExpress™ Tektronix Edition	A fully interactive measurement software environment optimized for your Tektronix oscilloscope, enables you to instantly acquire, generate, analyze, compare, import, and save measurement data and signals using an intuitive drag-and-drop user interface that does not require any programming. Standard support for acquiring, controlling, viewing, and exporting your live analog-channel signal data is permanently available through the software. The full version (SIGEXPTE) adds additional signal processing, advanced analysis, mixed signal, sweeping, limit testing, and user-defined step capabilities and is available for a 30-day trial period standard with each instrument.
OpenChoice® Desktop	Enables fast and easy communication between a Windows PC and your oscilloscope using USB or LAN. Transfer and save settings, waveforms, measurements, and screen images. Included Word and Excel toolbars automate the transfer of acquisition data and screen images from the oscilloscope into Word and Excel for quick reporting or further analysis.
IVI driver	Provides a standard instrument programming interface for common applications such as LabVIEW, LabWindows/CVI, Microsoft .NET, and MATLAB.
e*Scope® Web-based remote control	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.
LXI Class C Web interface	Connect to the oscilloscope through a standard Web browser by simply entering the oscilloscope's IP address or network name in the address bar of the browser. The Web interface enables viewing of instrument status and configuration, status and modification of network settings, and instrument control through the e*Scope Web-based remote control. All Web interaction conforms to LXI Class C specification, version 1.3.

Display system

Display type	10.4 in. (264 mm) liquid-crystal TFT color display
Display resolution	1,024 horizontal × 768 vertical pixels (XGA)
Interpolation	Sin(x)/x
Waveform styles	Vectors, Dots, Variable Persistence, Infinite Persistence.
Graticules	Full, Grid, Cross Hair, Frame, IRE and mV.
Format	YT and simultaneous XY/YT
Maximum waveform capture rate	>50,000 wfm/s.

Input/output ports

USB 2.0 high-speed host port	Supports USB mass storage devices, printers and keyboard. Two ports on front and two ports on rear of instrument.
USB 2.0 device port	Rear-panel connector allows for communication/control of oscilloscope through USBTMC or GPIB (with a TEK-USB-488), and direct printing to all PictBridge-compatible printers.
LAN port	RJ-45 connector, supports 10/100/1000 Mb/s
Video out port	DB-15 female connector, connect to show the oscilloscope display on an external monitor or projector. XGA resolution.
Probe compensator output voltage and frequency	Front-panel pins
Amplitude	0 to 2.5 V
Frequency	1 kHz
Auxiliary out	Rear-panel BNC connector V_{OUT} (Hi): ≥2.5 V open circuit, ≥1.0 V 50 Ω to ground V_{OUT} (Lo): ≤0.7 V into a load of ≤4 mA; ≤0.25 V 50 Ω to ground Output can be configured to provide a pulse out signal when the oscilloscope triggers, the internal oscilloscope reference clock out, or an event out for limit/mask testing.
External reference input	Time-base system can phase lock to an external 10 MHz reference (10 MHz ±1%)

Kensington-style lock	Rear-panel security slot connects to standard Kensington-style lock.
VESA mount	Standard (MIS-D 100) 100 mm VESA mounting points on rear of instrument.

LAN eXtensions for Instrumentation (LXI)

Class	LXI Class C
Version	V1.3

Power source

Power source voltage	100 to 240 V ±10%
Power source frequency	50 to 60 Hz ±10% at 100 to 240 V ±10%
	400 Hz ±10% at 115 V ±13%
Power consumption	225 W maximum

Physical characteristics

Dimensions

	mm	in.
Height	229	9.0
Width	439	17.3
Depth	147	5.8

Weight

	kg	lb.
Net	5	11
Shipping	10.7	23.6

Rackmount configuration	5U
Cooling clearance	2 in. (51 mm) required on left side and rear of instrument

EMC, environment, and safety

Temperature

Operating	0 ºC to +50 ºC (+32 ºF to 122 ºF)
Nonoperating	-20 ºC to +60 ºC (-4 ºF to 140 ºF)

Humidity

Operating	High: 40 ºC to 50 ºC, 10% to 60% relative humidity Low: 0 ºC to 40 ºC, 10% to 90% relative humidity
Nonoperating	High: 40 ºC to 60 ºC, 5%to 60% relative humidity Low: 0 ºC to 40 ºC, 5% to 90% relative humidity

Altitude

Operating	3,000 meters (9,843 feet)
Nonoperating	9,144 meters (30,000 feet)

Regulatory

Electromagnetic compatibility	EC Council Directive 2004/108/EC
Safety	UL61010-1:2004, CAN/CSA-C22.2 No. 61010.1: 2004, Low Voltage Directive 2006/95/EC and EN61010-1:2001, IEC 61010-1:2001, ANSI 61010-1-2004, ISA 82.02.01

Ordering information

MDO4000 family

MDO4014-3	Mixed Domain Oscilloscope with (4) 100 MHz analog channels, (16) digital channels, and (1) 3 GHz RF input
MDO4034-3	Mixed Domain Oscilloscope with (4) 350 MHz analog channels, (16) digital channels, and (1) 3 GHz RF input
MDO4054-3	Mixed Domain Oscilloscope with (4) 500 MHz analog channels, (16) digital channels, and (1) 3 GHz RF input
MDO4054-6	Mixed Domain Oscilloscope with (4) 500 MHz analog channels, (16) digital channels, and (1) 6 GHz RF input
MDO4104-3	Mixed Domain Oscilloscope with (4) 1 GHz analog channels, (16) digital channels, and (1) 3 GHz RF input
MDO4104-6	Mixed Domain Oscilloscope with (4) 1 GHz analog channels, (16) digital channels, and (1) 6 GHz RF input

Standard accessories

Probes

≤ 500 MHz models	TPP0500, 500 MHz bandwidth, 10X, 3.9 pF. One passive voltage probe per analog channel.
1 GHz models	TPP1000, 1 GHz bandwidth, 10X, 3.9 pF. One passive voltage probe per analog channel.
All models	One P6616 16-channel logic probe and a logic probe accessory kit (020-2662-xx).

Accessories

200-5130-xx	Front cover
103-0045-00	N-to-BNC adapter
063-4367-xx	Documentation CD
016-2030-xx	Accessory bag
—	User manual
—	Power cord
—	OpenChoice® Desktop Software
—	NI LabVIEW SignalExpress™ Tektronix Edition Software
—	Calibration certificate documenting traceability to National Metrology Institute(s) and ISO9001 quality system registration

Warranty

Three-year warranty covering all parts and labor, excluding probes.

Application Modules

Application modules have licenses which can be transferred between an application module and an oscilloscope. The license may be contained in the module; allowing the module to be moved from one instrument to another. Or, the license can be contained in the oscilloscope; allowing the module to be removed and stored for safekeeping. Transferring the license to an oscilloscope and removing the module permits the use of more than 4 applications simultaneously.

DPO4AERO	Aerospace Serial Triggering and Analysis Module. Enables triggering on packet-level information on MIL-STD-1553 buses as well as analytical tools such as digital views of the signal, bus views, packet decoding, search tools, and packet decode tables with time-stamp information. Signal Inputs - Any Ch1 - Ch4, Math, Ref1 - Ref4 Recommended Probing - Differential or single ended (only one single-ended signal required)
DPO4AUDIO	Audio Serial Triggering and Analysis Module. Enables triggering on packet-level information on I^2S, LJ, RJ, and TDM audio buses as well as analytical tools such as digital views of the signal, bus views, packet decoding, search tools, and packet decode tables with time-stamp information. Signal Inputs - Any Ch1 - Ch4, any D0 - D15 Recommended Probing - Single ended
DPO4AUTO	Automotive Serial Triggering and Analysis Module. Enables triggering on packet-level information on CAN and LIN buses as well as analytical tools such as digital views of the signal, bus views, packet decoding, search tools, and packet decode tables with time-stamp information. Signal Inputs - LIN: Any Ch1 - Ch4, any D0 - D15; CAN: Any Ch1 - Ch4, any D0 - D15 Recommended Probing - LIN: Single ended; CAN: Single ended or differential
DPO4AUTOMAX	Extended Automotive Serial Triggering and Analysis Module. Enables triggering on packet-level information on CAN, LIN, and FlexRay buses as well as analytical tools such as digital views of the signal, bus views, packet decoding, search tools, packet decode tables with time-stamp information, and eye diagram analysis software. Signal Inputs - LIN: Any Ch1 - Ch4, any D0 - D15; CAN: Any Ch1 - Ch4, any D0 - D15; FlexRay: Any Ch1 - Ch4, any D0 - D15 Recommended Probing - LIN: Single ended; CAN, FlexRay: Single ended or differential
DPO4COMP	Computer Serial Triggering and Analysis Module. Enables triggering on packet-level information on RS-232/422/485/UART buses as well as analytical tools such as digital views of the signal, bus views, packet decoding, search tools, and packet decode tables with time-stamp information. Signal Inputs - Any Ch1 - Ch4, any D0 - D15 Recommended Probing - RS-232/UART: Single ended; RS-422/485: Differential
DPO4EMBD	Embedded Serial Triggering and Analysis Module. Enables triggering on packet-level information on I^2C and SPI buses as well as analytical tools such as digital views of the signal, bus views, packet decoding, search tools, and packet decode tables with time-stamp information. Signal Inputs - I^2C: Any Ch1 - Ch4, any D0 - D15; SPI: Any Ch1 - Ch4, any D0 - D15 Recommended Probing - Single ended
DPO4ENET	Ethernet Serial Triggering and Analysis Module. Enables triggering on packet-level information on 10BASE-T and 100BASE-TX [5] buses as well as analytical tools such as digital views of the signal, bus views, packet decoding, search tools, and packet decode tables with time-stamp information. Signal Inputs - Any Ch1 - Ch4, Math, Ref1 - Ref4 Recommended Probing - 10BASE-T: Single ended or differential; 100BASE-TX: Differential

5 ≥350 MHz bandwidth models are recommended for 100BASE-TX

DPO4USB	USB Serial Triggering and Analysis Module. Enables triggering on packet-level content for low-speed, full-speed, and high-speed USB serial buses. Also enables analytical tools such as digital views of the signal, bus views, packet decoding, search tools, and packet decode tables with time-stamp information for low-speed, full-speed, and high-speed USB serial buses. [6]
	Signal Inputs - Low-speed and Full-speed: Any Ch1 - Ch4, any D0 - D15; Low-speed, Full-speed, and High-speed: Any Ch1 - Ch4, Math, Ref1 - Ref4
	Recommended Probing - Low-speed and Full-speed: Single ended or differential; High-speed: Differential
DPO4PWR	Power Analysis Application Module. Enables quick and accurate analysis of power quality, switching loss, harmonics, safe operating area (SOA), modulation, ripple, and slew rate (dI/dt, dV/dt).
DPO4LMT	Limit and Mask Testing Application Module. Enables testing against limit templates generated from "golden" waveforms and mask testing using custom or standard telecommunications or computer masks. [7]
DPO4VID	HDTV and Custom (nonstandard) Video Triggering Module.
MDO4TRIG	Advanced RF Power Level Triggering Module. Enables the power level on the RF input to be used as a source in the following trigger types: Pulse Width, Runt, Timeout, Logic, and Sequence.

Instrument options

Power cord and plug options

Opt. A0	North America power plug (115 V, 60 Hz)
Opt. A1	Universal Euro power plug (220 V, 50 Hz)
Opt. A2	United Kingdom power plug (240 V, 50 Hz)
Opt. A3	Australia power plug (240 V, 50 Hz)
Opt. A5	Switzerland power plug (220 V, 50 Hz)
Opt. A6	Japan power plug (100 V, 110/120 V, 60 Hz)
Opt. A10	China power plug (50 Hz)
Opt. A11	India power plug (50 Hz)
Opt. A12	Brazil power plug (60 Hz)
Opt. A99	No power cord

Language options

Opt. L0	English manual
Opt. L1	French manual
Opt. L2	Italian manual
Opt. L3	German manual
Opt. L4	Spanish manual
Opt. L5	Japanese manual
Opt. L6	Portuguese manual
Opt. L7	Simplified Chinese manual
Opt. L8	Traditional Chinese manual

6 USB high-speed supported only on models with 1 GHz analog channel bandwidth.

7 ≥350 MHz bandwidth models are recommended for mask testing on telecomm standards >55 Mb/s. 1 GHz bandwidth models are recommended for mask testing on high-speed (HS) USB.

Opt. L9	Korean manual
Opt. L10	Russian manual
Opt. L99	No manual

Language options include translated front-panel overlay for the selected language(s).

Service options

Opt. C3	Calibration Service 3 Years
Opt. C5	Calibration Service 5 Years
Opt. D1	Calibration Data Report
Opt. D3	Calibration Data Report 3 Years (with Opt. C3)
Opt. D5	Calibration Data Report 5 Years (with Opt. C5)
Opt. G3	Complete Care 3 Years (includes loaner, scheduled calibration, and more)
Opt. G5	Complete Care 5 Years (includes loaner, scheduled calibration, and more)
Opt. R5	Repair Service 5 Years (including warranty)
Opt. SILV900	Standard warranty extended to 5 years

Probes and accessories are not covered by the oscilloscope warranty and service offerings. Refer to the datasheet of each probe and accessory model for its unique warranty and calibration terms.

Recommended accessories

Probes

Tektronix offers over 100 different probes to meet your application needs. For a comprehensive listing of available probes, please visit www.tektronix.com/probes.

TPP0500	500 MHz, 10X TekVPI® passive voltage probe with 3.9 pF input capacitance
TPP0502	500 MHz, 2X TekVPI passive voltage probe with 12.7 pF input capacitance
TPP0850	2.5 kV, 800 MHz, 50X TekVPI passive high-voltage probe
TPP1000	1 GHz, 10X TekVPI passive voltage probe with 3.9 pF input capacitance
TAP1500	1.5 GHz TekVPI active single-ended voltage probe
TAP2500	2.5 GHz TekVPI active single-ended voltage probe
TAP3500	3.5 GHz TekVPI active single-ended voltage probe
TCP0030	120 MHz TekVPI 30 Ampere AC/DC current probe
TCP0150	20 MHz TekVPI 150 Ampere AC/DC current probe
TDP0500	500 MHz TekVPI differential voltage probe with ±42 V differential input voltage
TDP1000	1 GHz TekVPI differential voltage probe with ±42 V differential input voltage
TDP1500	1.5 GHz TekVPI differential voltage probe with ±8.5 V differential input voltage
TDP3500	3.5 GHz TekVPI differential voltage probe with ±2 V differential input voltage
THDP0200	±1.5 kV, 200 MHz TekVPI high-voltage differential probe
THDP0100	±6 kV, 100 MHz TekVPI high-voltage differential probe
TMDP0200	±750 V, 200 MHz TekVPI high-voltage differential probe

P5100A	2.5 kV, 500 MHz, 100X high-voltage passive probe
P5200A	1.3 kV, 50 MHz high-voltage differential probe

Accessories

TPA-N-PRE	Preamplifier, 12 dB nominal Gain, 9 kHz - 6 GHz
119-4146-00	Near field probe set, 100 kHz - 1 GHz
119-6609-00	Flexible monopole antenna
TPA-N-VPI	N-to-TekVPI adapter
077-0585-xx	Service manual (English only)
TPA-BNC	TekVPI® to TekProbe™ BNC adapter
TEK-DPG	TekVPI Deskew pulse generator signal source
067-1686-xx	Power measurement deskew and calibration fixture
SIGEXPTE	National Instruments LabVIEW Signal Express™ Tektronix Edition software – full version
FPGAView-A-MSO	Support for Altera FPGAs
FPGAView-X-MSO	Support for Xilinx FPGAs
TEK-USB-488	GPIB-to-USB adapter
ACD4000B	Soft transit case
HCTEK54	Hard transit case (requires ACD4000B)
RMD5000	Rackmount kit

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.

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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.tektronix.com.

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