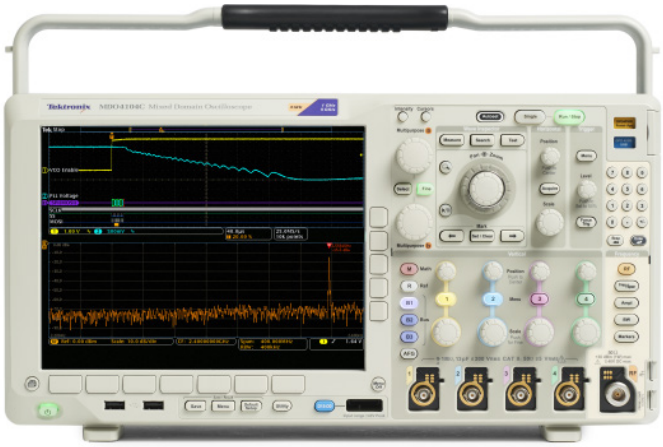
# Mixed Domain Oscilloscopes

## MDO4000C Series Datasheet



### Customizable and fully upgradable 6-in-1 integrated oscilloscope with synchronized insights into analog, digital, and RF signals

Introducing the world's highest performance 6-in-1 integrated oscilloscope that includes a spectrum analyzer, arbitrary/function generator, logic analyzer, protocol analyzer and DVM/frequency counter. The MDO4000C Series has the performance you need to solve the toughest embedded design challenges quickly and efficiently. When configured with an integrated spectrum analyzer, it is the only instrument that provides simultaneous and synchronized acquisition of analog, digital and spectrum, ideal for incorporating wireless communications (IoT) and EMI troubleshooting. The MDO4000C is completely customizable and fully upgradable so you can add the instruments you need now – or later.

## Key Performance Specifications

**1. Oscilloscope**

- 4 analog channels
- 1 GHz, 500 MHz, 350 MHz, and 200 MHz bandwidth models Bandwidth is upgradable (up to 1 GHz)
- Up to 5 GS/s sample rate
- 20 M record length on all channels
- > 340, 000 wfm/s maximum waveform capture rate
- Standard passive voltage probes with 3.9 pF capacitive loading and 1 GHz or 500 MHz analog bandwidth

**2. Spectrum Analyzer (Optional)**

- Frequency range of 9 kHz–3 GHz or 9 kHz–6 GHz Ultra-wide capture bandwidth ≥1 GHz
- Time-synchronized capture of spectrum analyzer with analog and digital acquisitions
- Frequency vs. time, amplitude vs. time, and phase vs. time waveforms

**3. Arbitrary/Function Generator (Optional)**

- 13 predefined waveform types
- 50 MHz waveform generation
- 128 k arbitrary generator record length 250 MS/s arbitrary generator sample rate

**4. Logic Analyzer (Optional) 16 digital channels**

- 20 M record length on all channels
- 60.6 ps timing resolution

**5. Protocol Analyzer (Optional)**

- Serial bus support for I2C, SPI, RS-232/422/485/UART, USB 2.0, Ethernet, CAN, LIN, FlexRay, MIL-STD-1553, and Audio standards

**6. Digital Voltmeter/Frequency Counter (Free with product registration)**

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

Tektronix®

| | MSO/DPO2000B | MDO3000 | MDO4000C | MSO/DPO5000B |
|---|---|---|---|---|
| **High-Level Description** | Advanced debug features at an affordable price | 6-in-1 integrated oscilloscope | Performance 6-in-1 integrated oscilloscope with synchronized insights into analog, digital and spectral signals | Exceptional signal fidelity with advanced analysis and math |
| **Commonly Used For** | Design and Debug<br>Education | Design and Debug<br>EMI Troubleshooting<br>Education | Design and Debug<br>EMI Troubleshooting<br>General Purpose RF Design and Integration | Advanced Design and Debug<br>USB Ethernet Compliance<br>Research |
| **Analog Bandwidth** | 70 MHz, 100 MHz, 200 MHz | 100 MHz, 200 MHz, 350 MHz, 500 MHz, 1 GHz | 200 MHz, 350 MHz, 500 MHz, 1 GHz | 350 MHz, 500 MHz, 1 GHz, 2 GHz |
| **Maximum Analog Sample Rate** | 1 GS/s | 5 GS/s | 5 GS/s | 10 GS/s |
| **Analog Channels** | 2, 4 | 2, 4 | 4 | 4 |
| **Record Length** | 1 M | 10 M | 20 M | 25 M<br>(Optional) Up to 125 M |
| **Digital Channels** | (Optional) 16 | (Optional) 16 | (Optional) 16 | (Optional) 16 |
| **Spectrum Analyzer Channel** | N/A | (Standard) 9 kHz -Analog BW<br>(Optional) 9 kHz -3 GHz | (Optional) 9 kHz -3 GHz<br>(Optional) 9 kHz -6 GHz | N/A |
| **AFG** | N/A | (Optional) Up to 50 MHz with 13 functions and arbitrary waveform generation | (Optional) Up to 50 MHz with 13 functions and arbitrary waveform generation | N/A |
| **Serial Bus Analysis** | **Trigger & Decode:** I²C, SPI, RS-232/422/485/ UART, CAN, LIN | **Trigger & Decode:** I²C, SPI, RS-232/422/485/UART, CAN, LIN, FlexRay, USB2.0, MIL-STD-1553, Audio | **Trigger & Decode:** I²C, SPI, RS-232/422/485/ UART, CAN, LIN, FlexRay, USB2.0, Ethernet, MIL-STD-1553, Audio | **Trigger & Decode:** I²C, SPI, RS-232/422/485/UART, CAN, LIN, FlexRay, USB2.0, Ethernet, MIL-STD-1553<br>**Decode Only:** USB-HSIC, MIPI D-PHY<br>**Compliance:** BroadR-Reach, USB2.0, USB-PWR, Ethernet, MOST |
| **Advanced Analysis** | | Power, Limit/Mask, Video | Power, Limit/Mask, Video, Spectrogram, Vector Signal Analysis | Power, Limit/Mask, Video, Vector Signal Analysis, Jitter |
| **Standard Probing** | 100 MHz, 12 pF or<br>200 MHz, 12 pF | 250 MHz, 3.9 pF<br>500 MHz, 3.9 pF or<br>1 GHz, 3.9 pF | 500 MHz, 3.9 pF or<br>1 GHz, 3.9 pF | 500 MHz, 3.9 pF or<br>1 GHz, 3.9 pF |

## Typical Applications

### Embedded Design

Discover and solve issues quickly by performing system level debug on mixed signal embedded systems including today's most common serial bus and wireless technologies.

### Power Design

Make reliable and repeatable voltage, current, and power measurements using automated power quality, switching loss, harmonics, ripple, modulation, and safe operating area measurements with the widest selection of power probes in an affordable solution.

### EMI Troubleshooting

Quickly track down the source of EMI in an embedded system by determining which time domain signals may be causing unwanted EMI. See in real-time the effects time domain signals have on system EMI emissions.

### Wireless Troubleshooting

Whether using Bluetooth, 802.11 Wi-Fi, ZigBee, or some other wireless technology, the MDO4000C enables viewing an entire system – analog, digital, and RF, time-synchronized to understand its true behavior. Capture an ultra-wide band in a single capture to view interactions among multiple wireless technologies, or to view an entire broadband frequency range from a modern standard like 802.11/ad.

### Education

Managing multiple instruments on a bench can be troublesome. The MDO4000C eliminates the need to manage multiple instruments by integrating six instrument types into a single instrument. The integration of a spectrum analyzer enables teaching of advanced wireless technology course work while minimizing the investment required. Full upgradability enables adding functionality over time as needs change or budgets allow.

### Manufacturing Test and Troubleshooting

Size and space constraints can play havoc on a manufacturing floor. The unique 6-in-1 MDO4000C minimizes rack or bench space by integrating multiple instruments into one small package. Integration reduces cost associated with utilizing multiple different instrument types in manufacturing test or troubleshooting stations.

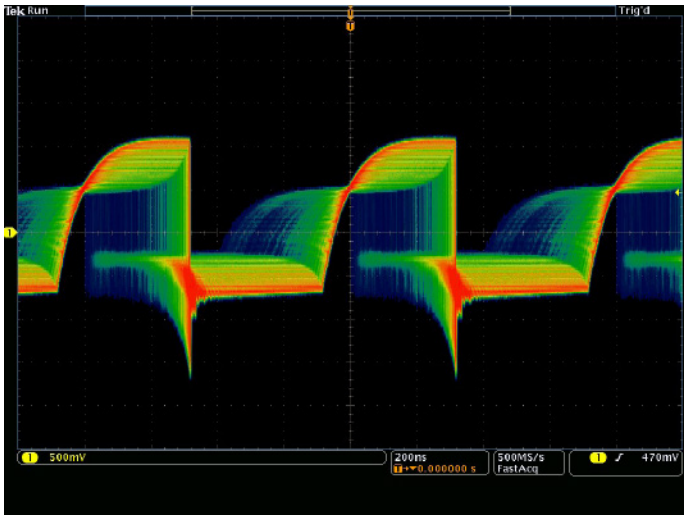
# 1. Oscilloscope

At the core of the MDO4000C Series is a world-class oscilloscope, offering comprehensive tools that speed each stage of debug – from quickly discovering anomalies and capturing them, to searching your waveform record for events of interest and analyzing their characteristics and your device's behavior.

## Digital Phosphor Technology with Fastacq™ High-Speed Waveform Capture

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.

Digital phosphor technology with FastAcq provides you with fast insight into the real operation of your device. Its fast waveform capture rate – greater than 340, 000 wfms/s – gives you a high probability of quickly seeing the infrequent problems common in digital systems: runt pulses, glitches, timing issues, and more.




**Digital phosphor technology enables a greater than 340, 000 wfm/s waveform capture rate and real-time intensity grading.**

To further enhance the visibility of rarely occurring events, intensity grading is used to indicate how often rare transients are occurring relative to normal signal characteristics. There are four waveform palettes available in FastAcq acquisition mode.

- The *Temperature* palette uses color-grading to indicate frequency of occurrence with hot colors like red/yellow indicating frequently occurring events and colder colors like blue/green indicating rarely occurring events.

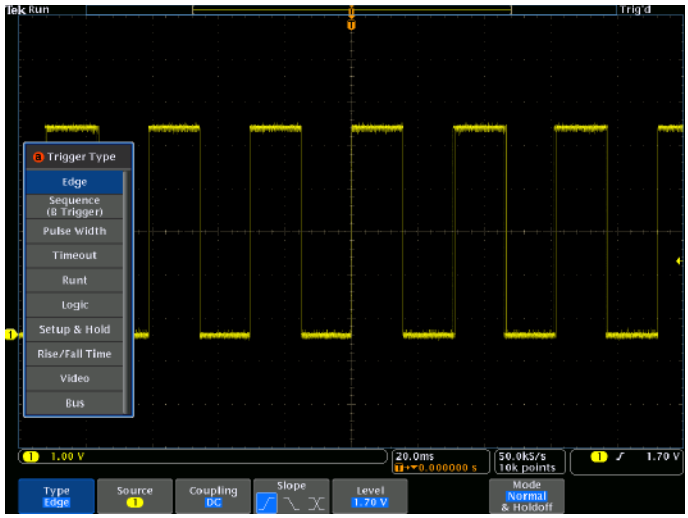
- The *Spectral* palette uses color-grading to indicate frequency of occurrence with colder colors like blue indicating frequently occurring events and hot colors like red indicating rarely occurring events.
- The *Normal* palette uses the default channel color (like yellow for channel one) along with gray-scale to indicate frequency of occurrence where frequently occurring events are bright.
- The *Inverted* palette uses the default channel color along with grayscale to indicate frequency of occurrence where rarely occurring events are bright.

These color palettes quickly highlight the events that over time occur more often or, in the case of infrequent anomalies, occur less often.

Infinite or variable persistence choices determine how long waveforms stay on the display, helping you to determine how often an anomaly is occurring.

## Triggering

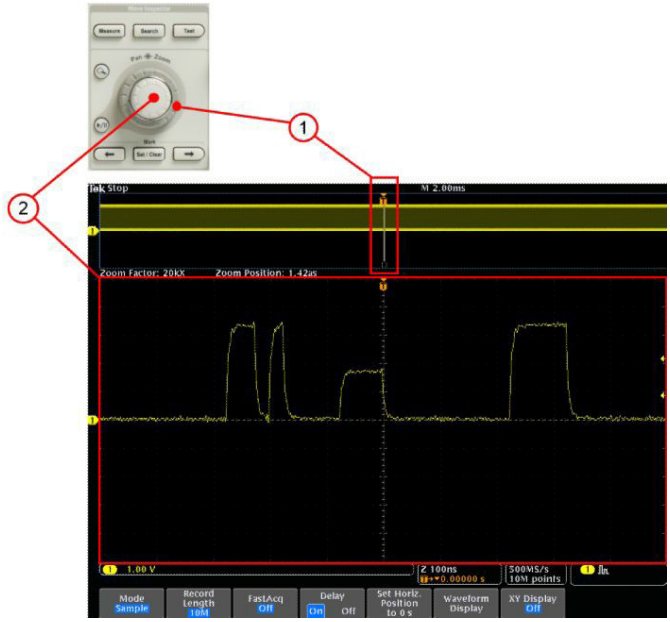
Discovering a device fault is only the first step. Next, you must capture the event of interest to identify root cause. To enable this, the MDO4000C contains over 125 trigger combinations providing a complete set of triggers – including runt, logic, pulse width/glitch, setup and hold violation, serial packet, and parallel data – to help quickly locate your event of interest. And with up to a 20 M 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 and record reliable measurements.




**Over 125 trigger combinations make capturing your event of interest easy.**

## Wave Inspector® Waveform Navigation and Automated Search

With long record lengths, a single acquisition can include thousands of screens of waveform data. Wave Inspector® , the industry's best tool for waveform navigation and automated search, enables you to find events of interest in seconds.




**Wave Inspector controls provide unprecedented efficiency in viewing, navigating, and analyzing waveform data. Zip through your long record by turning the outer pan control (1). Get details from the beginning to end in seconds. See something of interest and want to see more details? Just turn the inner zoom control (2).**

## Zoom and Pan

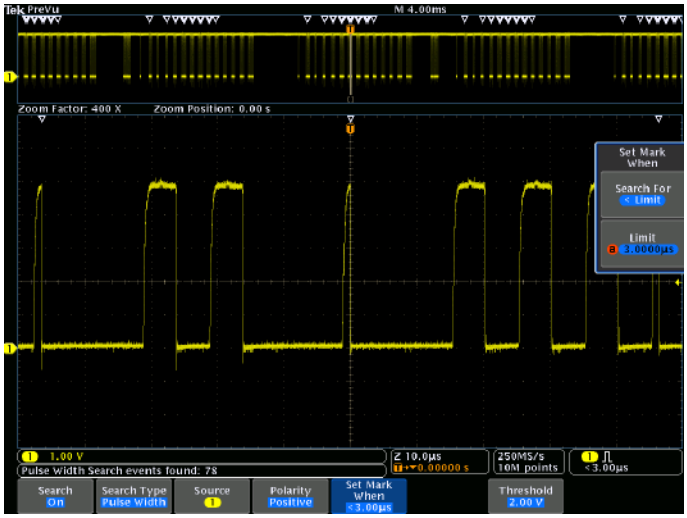
A dedicated, two-tier front-panel control provides intuitive control of both zooming and panning. The inner control adjusts the zoom factor (or zoom scale); turning it clockwise activates zoom and goes to progressively higher zoom factors, while turning it counterclockwise results in lower zoom factors and eventually turning zoom off. No longer do you need to navigate through multiple menus to adjust your zoom view. The outer control pans the zoom box across the waveform to quickly get to the portion of waveform you are interested in. The outer control also utilizes force-feedback to determine how fast to pan on the waveform. The farther you turn the outer control, the faster the zoom box moves. Pan direction is changed by simply turning the control the other way.

## User Marks

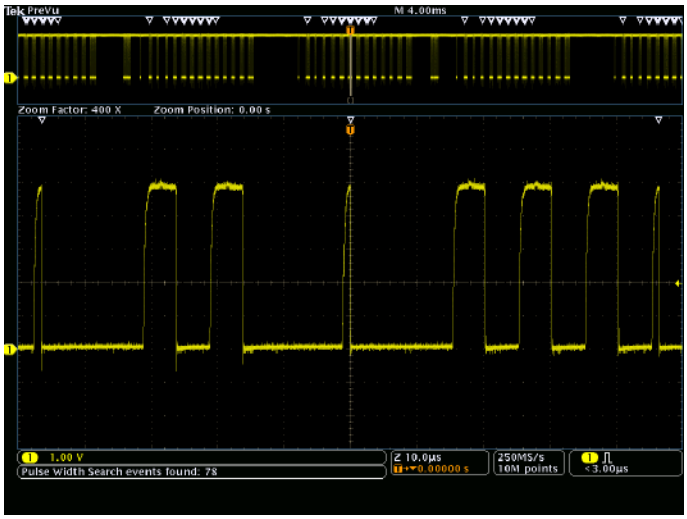
Press the **Set Mark** front-panel button to place one or more marks on the waveform. Navigating between marks is as simple as pressing the **Previous** (←) and **Next** (→) buttons on the front panel.

## Search Marks

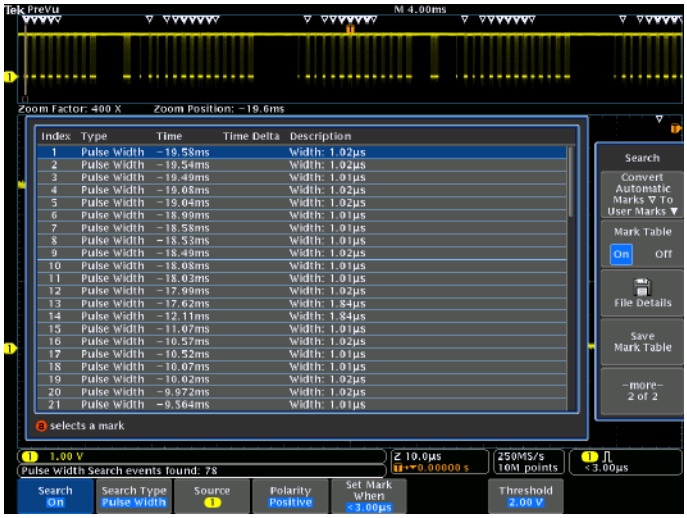
The Search button allows you to automatically search through your long acquisition looking for user-defined events. All occurrences of the event are highlighted with search marks and are easily navigated to, using the front panel Previous (←) and Next(→) buttons. Search types include edge, pulse width/glitch, timeout, runt, logic, setup and hold, rise/fall time, parallel bus, and I²C, SPI, RS-232/422/485/UART, USB 2.0, Ethernet, CAN, LIN, FlexRay, MIL-STD-1553, and I²S/LJ/RJ/TDM packet content. A search mark table provides a tabular view of the events found during the automated search. Each event is shown with a time stamp, making timing measurements between events easy.




**Search step 1: You define what you would like to find.**




**Search step 2: Wave Inspector automatically searches through the record and marks each event with a hollow white triangle. You can then use the Previous and Next buttons to jump from one event to the next.**

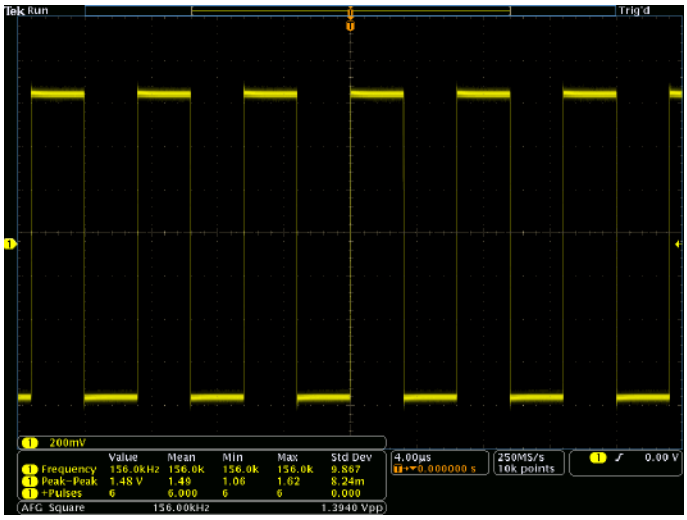



**Search step 3: The Search Mark table provides a tabular view of each of the events found by the automated search. Each event is shown with a time stamp making timing measurements between events easy.**

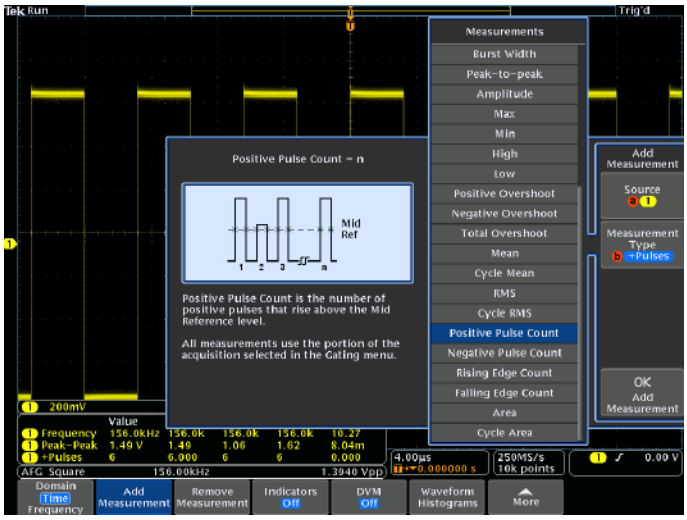
## Waveform Analysis

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, FFT analysis, waveform histograms, and trend plots for visually determining how a measurement is changing over time.




Automated measurement readouts provide repeatable, statistical views of waveform characteristics.

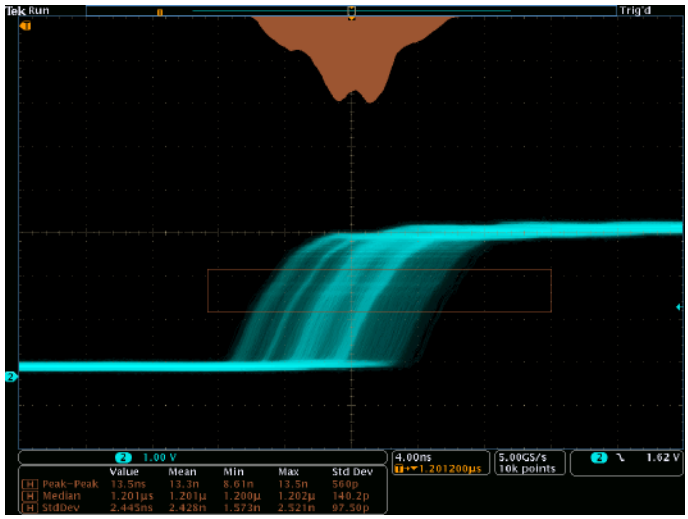



Each measurement has help text and graphics associated with it that help explain how the measurement is made.

## Waveform Histograms

show visually how waveforms vary over time. Horizontal waveform histograms are especially useful for gaining insight into how much jitter is on a clock signal, and what the distribution of that jitter is. Vertical histograms are especially useful for gaining insight into how much noise is on a signal, and what the distribution of that noise is.

Measurements taken on a waveform histogram provide analytical information about the distribution of a waveform histogram, providing insight into just how broad a distribution is, the amount of standard deviation, the mean value, etc.




Waveform histogram of a rising edge showing the distribution of edge position (jitter) over time. Included are numeric measurements made on the waveform histogram data.

## Video Design and Development (Optional)

Many video engineers have remained loyal to analog oscilloscopes, believing the intensity gradations on an analog display are the only way to see certain video waveform details. The fast waveform capture rate, coupled with its intensity-graded view of the signal, provides the same information-rich display as an analog oscilloscope, but with much more detail and all the benefits of digital scopes.

Standard features such as IRE and mV graticules, holdoff by fields, video polarity, and an Autoset smart enough to detect video signals, make these the easiest to use oscilloscopes on the market for video applications. And with high bandwidth and four analog inputs, the oscilloscope provides ample performance for analog and digital video use.

The video functionality is further extended with an optional video application module, which provides the industry's most complete suite of HDTV and custom (nonstandard) video triggers, as well as a video picture mode enabling you to see the picture of the video signal you are viewing – for NTSC and PAL signals. The optional video analysis functionality is offered free for a 30-day trial period. This free trial period starts automatically when the instrument is powered on for the first time.

**Viewing an NTSC video signal. Video picture mode contains automatic contrast and brightness settings as well as manual controls.**

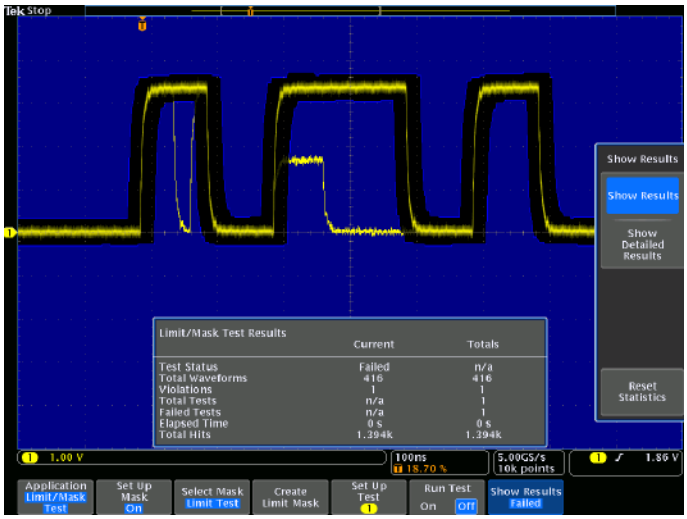
## Power Analysis (Optional)

Ever increasing consumer demand for longer battery-life devices and for green solutions that consume less power require power-supply designers to characterize and minimize switching losses to improve efficiency. In addition, the supply's power levels, output purity, and harmonic feedback into the power line must be characterized to comply with national and regional power quality standards. Historically, making these and many other power measurements on an oscilloscope has been a long, manual, and tedious process. The optional power analysis tools greatly simplify these tasks, enabling quick and accurate analysis of power quality, switching loss, harmonics, safe operating area (SOA), modulation, ripple, and slew rate (di/dt, dv/dt). Completely integrated into the oscilloscope, the power analysis tools provide automated, repeatable power measurements with a touch of a button; no external PC or complex software setup is required. The optional power analysis functionality is offered free for a 30-day trial period. This free trial period starts automatically when the instrument is powered on for the first time.

**Power quality measurement. Automated power measurements enable quick and accurate analysis of common power parameters.**

## Limit-Mask Testing (Optional)

A common task during the development process is characterizing the behavior of certain signals in a system. One method, called limit testing, is to compare a tested signal to a known good or "golden" version of the same signal with user-defined vertical and horizontal tolerances. Another common method, called mask testing, is to compare a tested signal to a mask, looking for where a signal under test violates the mask. The MDO4000C Series offers both limit and mask testing capability useful for long-term signal monitoring, characterizing signals during design, or testing on a production line. A robust set of telecommunications and computer standards are provided to test for compliance to a standard. Additionally, custom masks can be created and used for characterizing signals. Tailor a test to your specific requirements by defining test duration in number of waveforms or time, a violation threshold that must be met before considering a test a failure, counting hits along with statistical information, and actions upon violations, test failure, and test complete. Whether specifying a mask from a known good signal or from a custom or standard mask, conducting pass/fail tests in search of waveform anomalies such as glitches has never been easier. The optional limit/mask test functionality is offered free for a 30-day trial period. This free trial period starts automatically when the instrument is powered on for the first time.



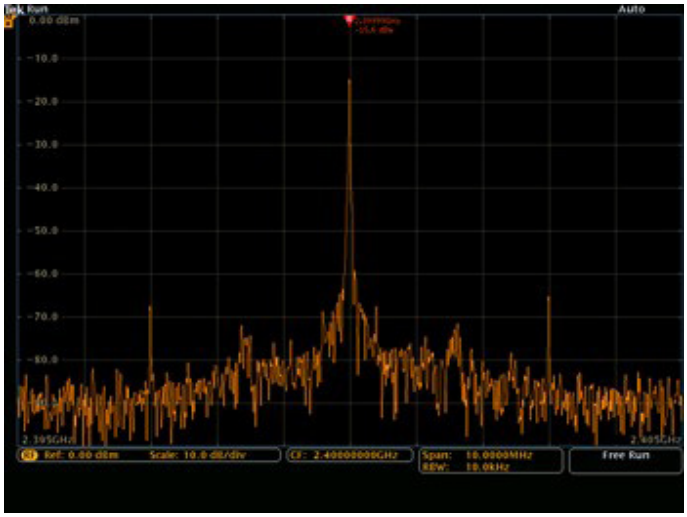

**Limit Test showing a mask created from a golden waveform and compared against a live signal. Results showing statistical information about the test are displayed.**

# 2. Spectrum Analyzer (Optional)

## Fast and Accurate Spectral Analysis

When using the optional spectrum analyzer input by itself, the MDO4000C 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.



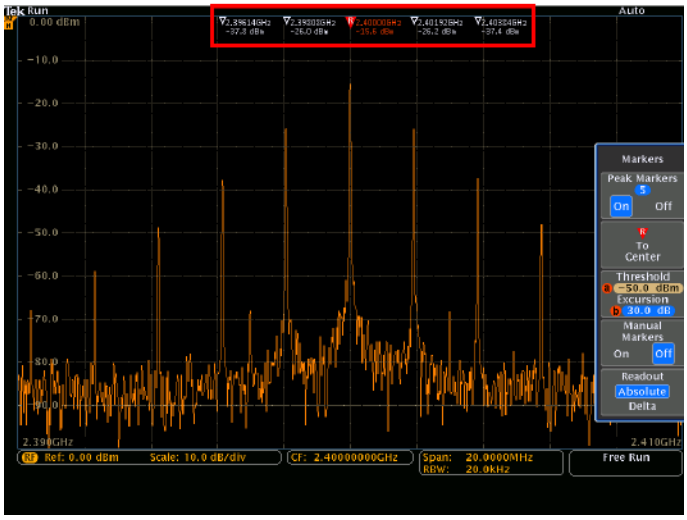

**MDO4000C frequency domain display.**

## 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 MDO4000C 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.

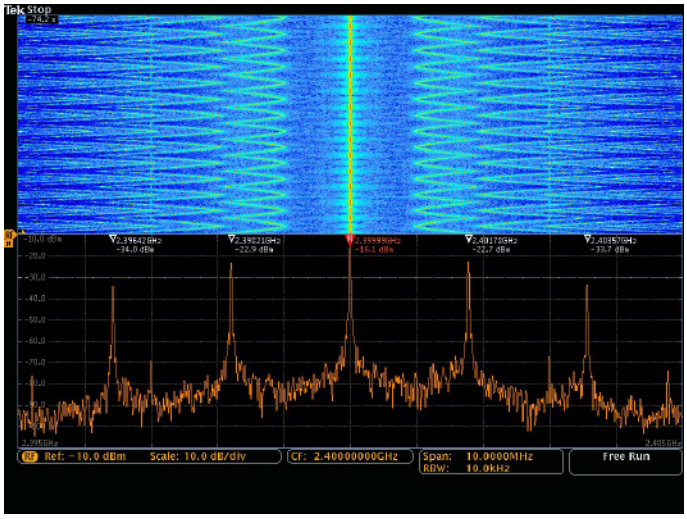



**Automated peak markers identify critical information at a glance. As shown here, the five highest amplitude peaks that meet the threshold and excursion criteria are automatically marked along with the peak's frequency and amplitude.**

## Spectrogram

The MDO4000C Series with option SA3 or SA6 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.



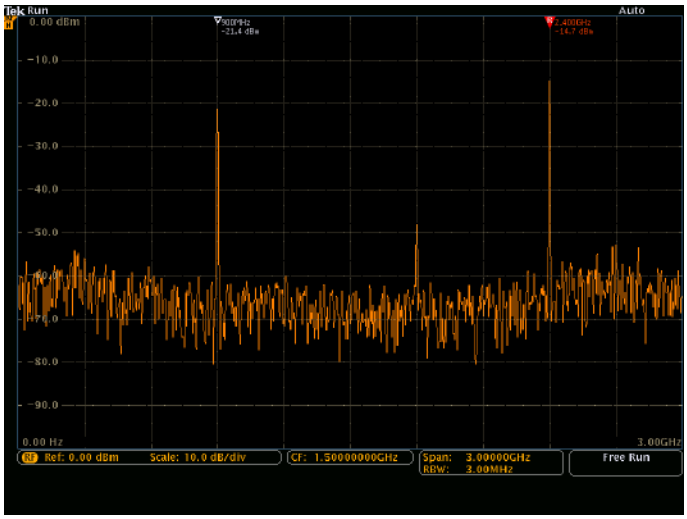

**Spectrogram display illustrates slowly moving RF phenomena. As shown here, a signal that has multiple peaks is being monitored. As the peaks change in both frequency and amplitude over time, the changes are easily seen in the Spectrogram display.**

## 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 160 MHz in some cases.

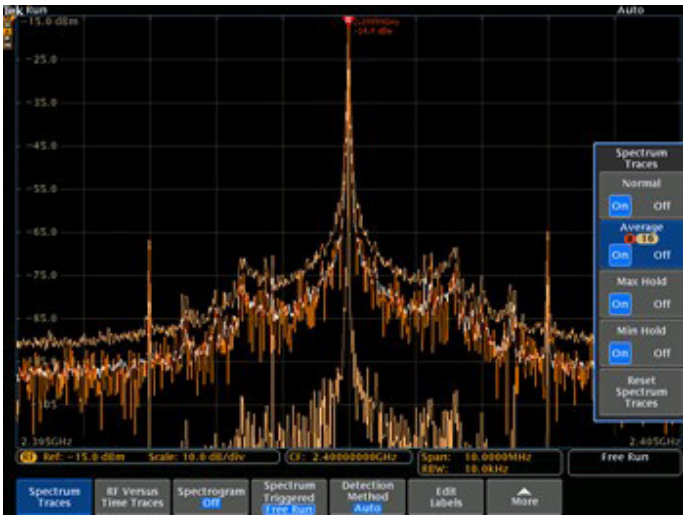
In order to address the bandwidth requirements of modern RF, the MDO4000C Series provides ≥1 GHz of capture bandwidth. At span settings of 1 GHz and below, there is no requirement to sweep the display. The spectrum is generated from a single acquisition, thus guaranteeing you'll see the events you're looking for in the frequency domain. And because the integrated spectrum analyzer has a dedicated RF input, the bandwidth is flat all the way out to 3 GHz or 6 GHz, unlike a scope FFT that rolls off to 3 dB down at the rated bandwidth of the input channel.




**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 MDO4000C Series spectrum analyzer offers four different traces or views 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**

## 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-synchronized with the active time-domain traces. However, when only the frequency domain is displayed, the spectrum analyzer 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.

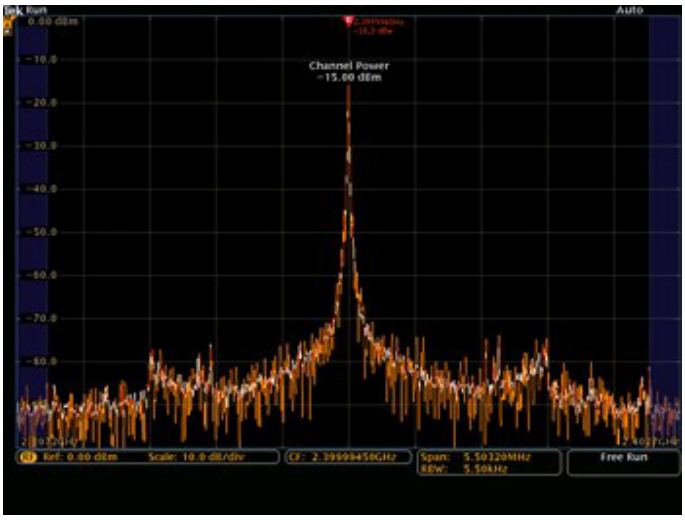
## Advanced Triggering with Analog, Digital and Spectrum Analyzer Channels

In order to deal with the time-varying nature of modern RF applications, the MDO4000C Series provides a triggered acquisition system that is fully integrated with the analog, digital and spectrum analyzer 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 spectrum analyzer input. For example, you can trigger on your RF transmitter turning on or off.

The optional MDO4TRIG application module provides advanced RF triggering. This module enables the RF power level on the spectrum analyzer 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 spectrum analyzer channel as an input to a logic trigger, enabling the oscilloscope to trigger only when the RF is on while other signals are active.

## RF Measurements

The MDO4000C 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**

## EMI Troubleshooting

EMC testing is expensive regardless of whether you purchase the equipment to perform in-house testing or you pay an external test facility to certify your product. And that assumes that your product passes the first time. Multiple visits to a test house can add significant cost and delay to your project. The key to minimizing this expense is early identification and debug of EMI issues. Traditionally, spectrum analyzers with near field probe sets have been used to identify the location and amplitude of offending frequencies, but their ability to determine the cause of the issue is very limited. Designers are increasingly using oscilloscopes and logic analyzers as EMI issues become more transient due to the complex interactions of numerous digital circuits in modern designs.

The MDO4000C, with its integrated oscilloscope, logic analyzer, and spectrum analyzer is the ultimate tool for debugging modern EMI issues. Many EMI problems are caused from events rooted in the time domain, such as clocks, power supplies, and serial data links. With its ability to provide time correlated views of analog, digital, and RF signals, the MDO4000C is the only instrument available that can discover the connection between time-domain events and offending spectral emissions.

## 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 spectrum analyzer on the MDO4000C 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.

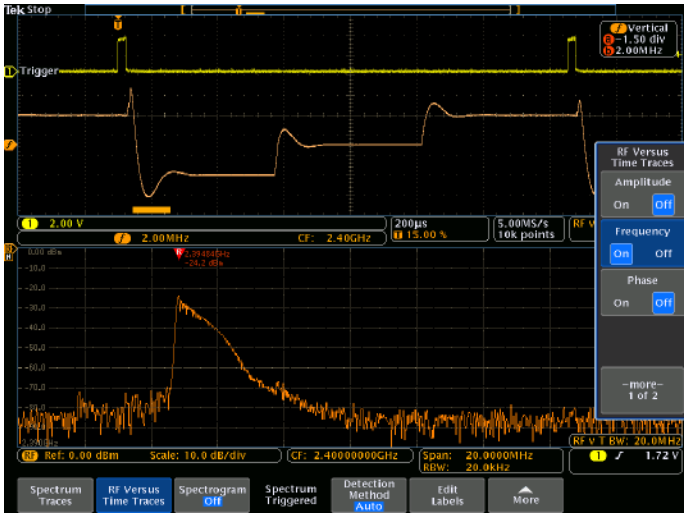
**The optional TPA-N-VPI adapter enables any active, 50 Ω TekVPI probe to be connected to the RF input.**

## Visualizing Changes in your RF Signal

The time domain graticule on the MDO4000C Series display provides support for three RF time domain traces that are derived from the underlying I and Q data of the spectrum analyzer input including:

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

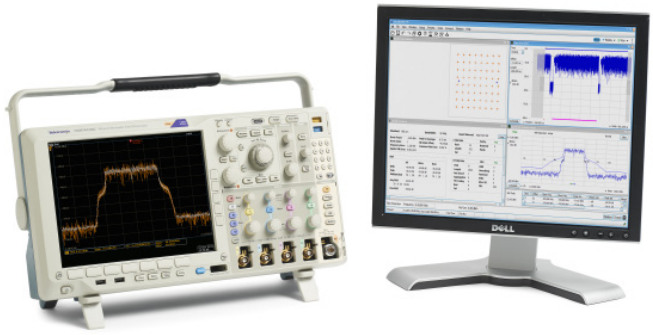
Each of these traces may be turned on and off independently, and all three may be displayed simultaneously. RF time domain traces make it easy to understand what's happening with a time-varying RF signal.




**The orange waveform in the Time Domain view is the frequency vs. time trace derived from the spectrum analyzer 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 RF Analysis

When paired with SignalVu-PC and its Live Link option, the MDO4000C Series becomes the industry's widest bandwidth Vector Signal Analyzer with up to 1 GHz capture bandwidth. Whether your design validation needs include Wireless LAN, wideband radar, high data rate satellite links, or frequency-hopping communications, SignalVu-PC vector signal analysis software can speed your time-to-insight by showing you the time-variant behavior of these wideband signals. Available analysis options include Wi-Fi (IEEE 802.11 a/b/g/j/n/p/ac) signal quality analysis, Bluetooth Tx compliance, pulse analysis, audio measurements, AM/FM/PM modulation analysis, general purpose digital modulation and more.



**MDO4000C paired with SignalVu-PC to analyze 802.11ac modulation.**

## Time Synchronized Insights into Analog, Digital, and RF

The MDO4000C Series is the world's first oscilloscope with a built in spectrum analyzer. This integration enables you to continue to use your debug tool of choice, the oscilloscope, to investigate frequency domain issues rather than having to find and re-learn a spectrum analyzer.

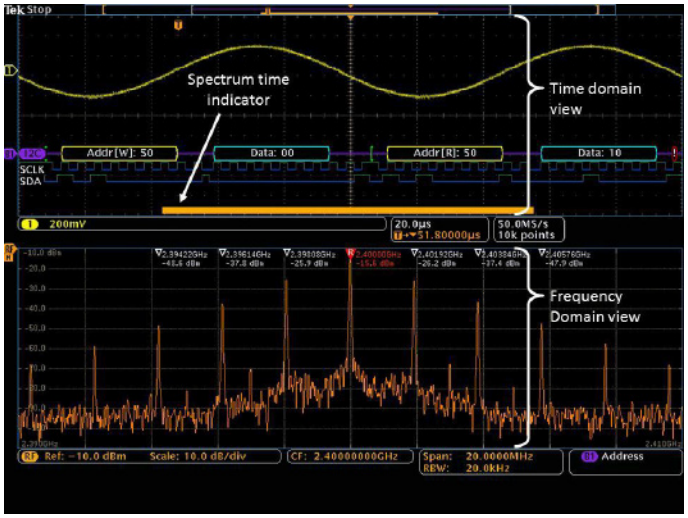
However, the power of the MDO4000C Series goes well beyond simply observing the frequency domain as you would on a spectrum analyzer. The real power is in its ability to correlate events in the frequency domain with the time domain phenomena that caused them.

When both the spectrum analyzer 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 spectrum analyzer 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 spectrum analyzer input.

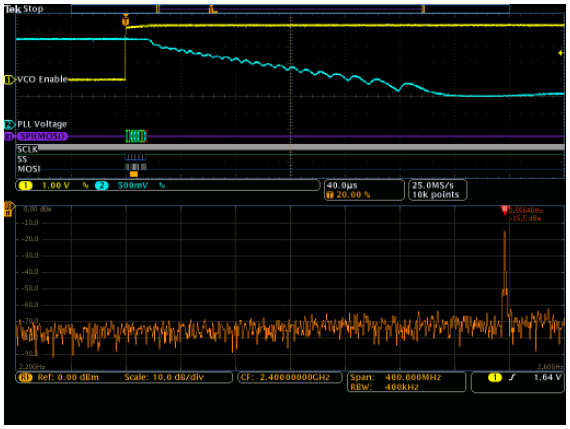
Another key difference is that with traditional oscilloscope FFTs, you can typically either get the desired view of the FFT display, or the desired view of your other time domain signals

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 MDO4000C Series, the spectrum analyzer 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.

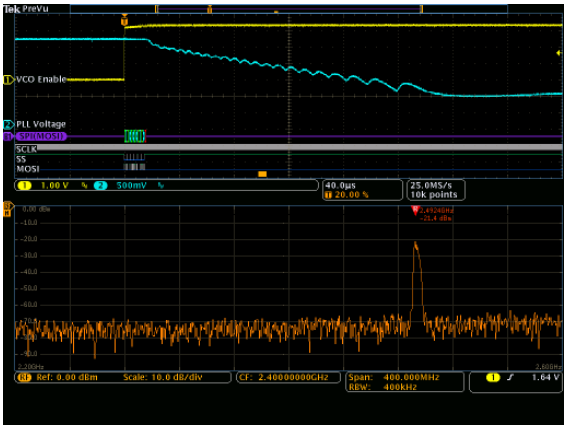
The spectrum shown in the Frequency Domain view is taken from the period of time indicated by the short orange bar in the time domain view – known as the Spectrum Time. With the MDO4000C Series, Spectrum Time can be moved through the acquisition to investigate how the RF spectrum changes over time. And this can be done while the oscilloscope is live and running or on a stopped acquisition.



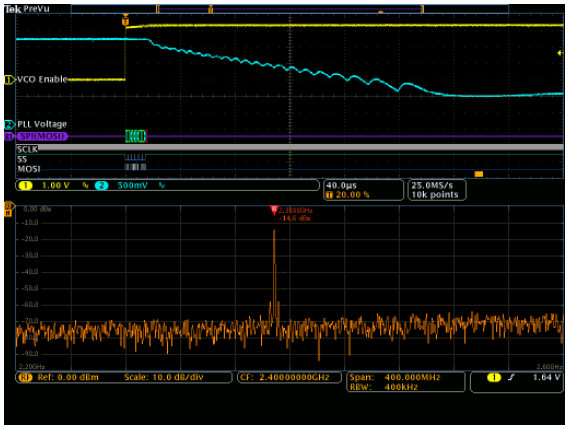

The upper half of the MDO4000C Series display shows the Time Domain view of the analog and digital channels, while the lower half shows the Frequency Domain view of the spectrum analyzer channel. The orange bar – Spectrum Time – shows the period of time used to calculate the RF spectrum.



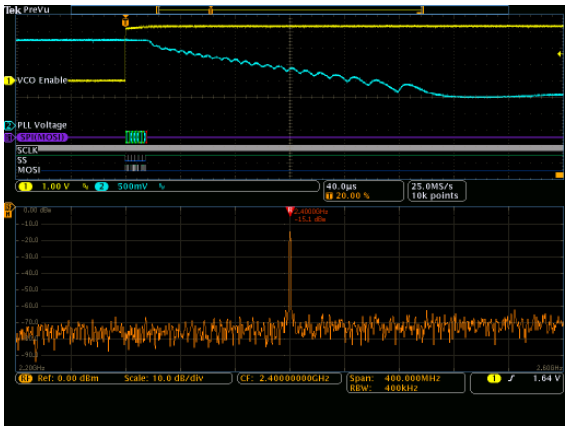

1. Time and Frequency Domain view showing the turn-on of a PLL. Channel 1 (yellow) is probing a control signal that enables the VCO. Channel 2 (cyan) is probing the VCO tune voltage. The SPI bus which is programming the PLL with the desired frequency is probed with three digital channels and automatically 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 of 2.400 GHz. Note that the RF is at 2.5564 GHz when the circuit turns on.




2. Spectrum Time is moved about 90 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 down to 2.4924 GHz.




3. Spectrum Time is moved another 160 µs to the right. At this point the spectrum shows that the PLL has actually overshot the correct frequency and gone all the way down to 2.3888 GHz.




4. The PLL eventually settles on the correct 2.400 GHz frequency about 320 µs after the VCO was enabled.

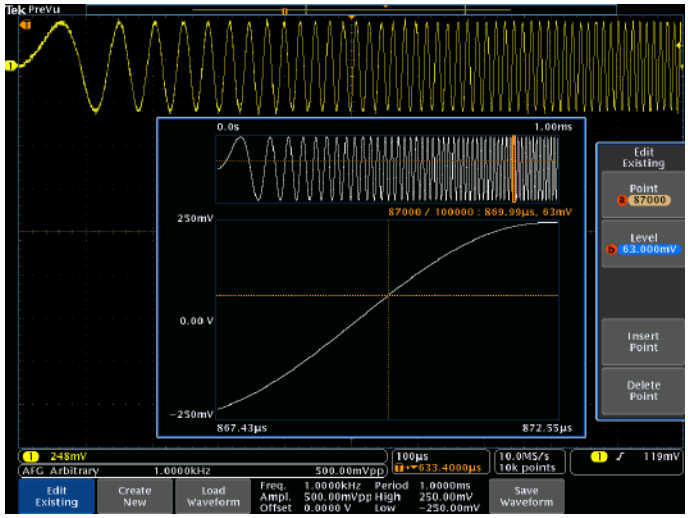
# 3. Arbitrary Function Generator (Optional)

The MDO4000C contains an optional integrated arbitrary function generator (option MDO4AFG), 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.

**Waveform type selection in the integrated AFG.**

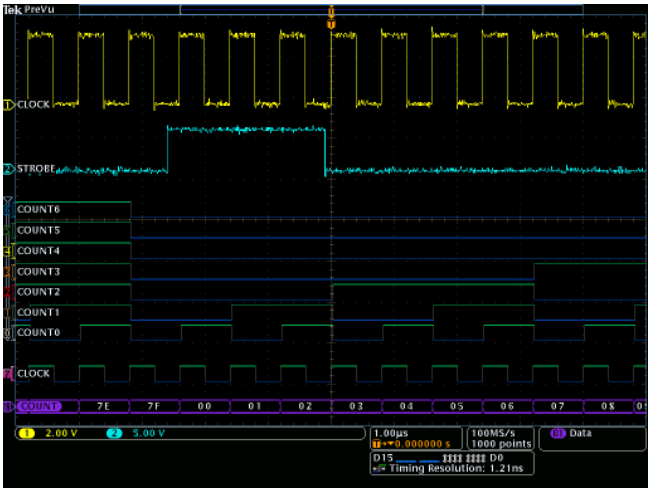
The arbitrary waveform generator provides 128 k points of record for storing waveforms from the analog input, a saved internal file location, a USB mass storage device, or from an external PC. Once a waveform is in the edit memory of the arbitrary waveform generator, it can be modified via an on-screen editor and then replicated out of the generator. The MDO4000C is compatible with Tektronix' ArbExpress PC-based waveform creation and editing software, making creation of complex waveforms fast and easy. Transfer waveform files to your MDO4000C edit memory via USB or LAN or using a USB mass storage device to be output from the AFG in the oscilloscope.




**Arbitrary waveform editor showing the point-by-point editor.**

# 4. Logic Analyzer (Optional)

The logic analyzer (option MDO4MSO) provides 16 digital channels which are tightly integrated into the oscilloscope's user interface. This simplifies operation and makes it possible to solve mixed-signal issues easily.




**The MDO4000C Series provides 16 integrated digital channels enabling you to view and analyze time-correlated analog and digital signals.**

## Color-Coded Digital Waveform Display

Color-coded digital traces display ones in green and zeros in blue. This coloring is also used in the digital channel monitor. The monitor shows if signals are high, low, or are transitioning so you can see channel activity at a glance without having to clutter your display with unneeded digital waveforms.

The multiple transition detection hardware shows you a white edge on the display when the system detects multiple transitions. White edges indicate that more information is available by zooming in or acquiring at faster sampling rates. In most cases zooming in will reveal the pulse that was not viewable with the previous settings. If the white edge is still present after zooming in as far as possible, this indicates that increasing the sample rate on the next acquisition will reveal higher frequency information than the previous settings could acquire.

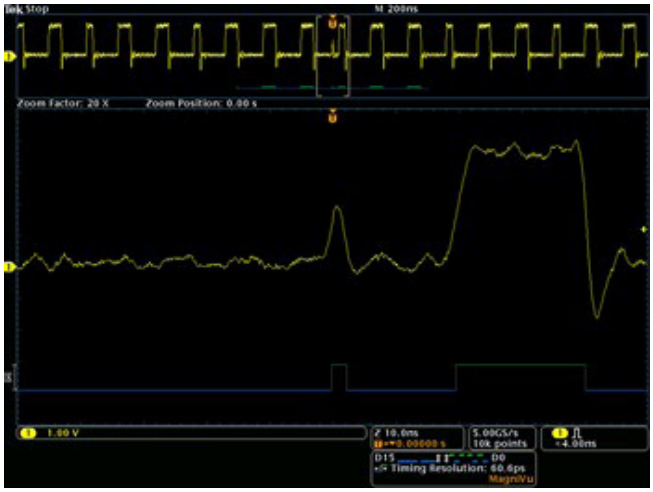
You can group digital waveforms and enter waveform labels by using a USB keyboard. By simply placing digital waveforms next to each other, they form a group.

**With color-coded digital waveform display, groups are created by simply placing digital channels together on the screen, allowing digital channels to be moved as a group.**

Once a group is formed, you can position all the channels contained in that group collectively. This greatly reduces the normal setup time associated with positioning channels individually.

## MagniVu® High-Speed Acquisition

The main digital acquisition mode on the MSO4000C Series will capture up to 20M points at 500 MS/s (2 ns resolution). In addition to the main record, the oscilloscope provides an ultra high-resolution record called MagniVu which acquires 10, 000 points at up to 16.5 GS/s (60.6 ps resolution). Both main and MagniVu waveforms are acquired on every trigger and can be switched between in the display at any time, running or stopped. MagniVu provides significantly finer timing resolution than comparable MSOs on the market, instilling confidence when making critical timing measurements on digital waveforms.




**The MagniVu high-resolution record provides 60.6 ps timing resolution, enabling you to take critical timing measurements on your digital waveforms.**

## P6616 MSO Probe

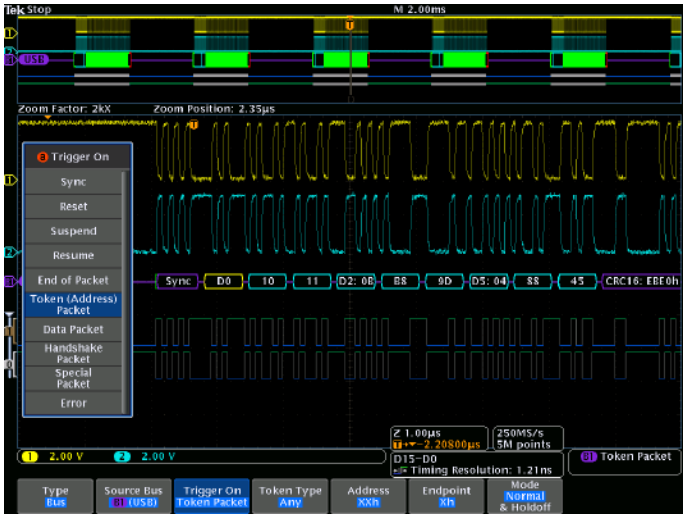
This unique probe design offers two eight-channel pods. Each channel ends with a probe tip featuring a recessed ground for simplified connection to the device under test. The coax on the first channel of each pod is colored blue making it easy to identify. The common ground uses an automotive-style connector making it easy to create custom grounds for connecting to the device under test. When connecting to square pins, the P6616 has an adapter that attaches to the probe head extending the probe ground flush with the probe tip so you can attach to a header. The P6616 offers outstanding electrical characteristics, having only 3 pF of capacitive loading, a 100 kΩ input resistance, and is capable of acquiring toggle rates >500 MHz and pulses as short as 1 ns in duration.

**The P6616 MSO probe offers two eight-channel pods to simplify connecting to your device.**

# 5. Serial Protocol Triggering and Analysis (Optional)

On a serial bus, a single signal often includes address, control, data, and clock information. This can make isolating events of interest difficult.

Automatic trigger, decode, and search on bus events and conditions gives you a robust set of tools for debugging serial buses. The optional serial protocol triggering and analysis functionality is offered free for a 30-day trial period. This free trial period starts automatically when the instrument is powered on for the first time.




**Triggering on a specific OUT Token packet on a USB full-speed serial bus. The yellow waveform is the D+ and the blue waveform is the D-. A bus waveform provides decoded packet content including Start, Sync, PID, Address, End Point, CRC, Data values, and Stop.**

## Serial Triggering

Trigger on packet content such as start of packet, specific addresses, specific data content, unique identifiers, etc. on popular serial interfaces such as I²C, SPI, USB 2.0, Ethernet, CAN, LIN, FlexRay, RS-232/422/485/UART, MIL-STD-1553, and I²S/LJ/RJ/TDM.

## Bus Display

Provides a higher-level, combined view of the individual signals (clock, data, chip enable, etc.) 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, etc.

## Bus Decoding

Tired of having to visually inspect the waveform to count clocks, determine if each bit is a 1 or a 0, combine bits into bytes, and determine the hex value? Let the oscilloscope do

### Serial bus technologies supported by the MDO4000C

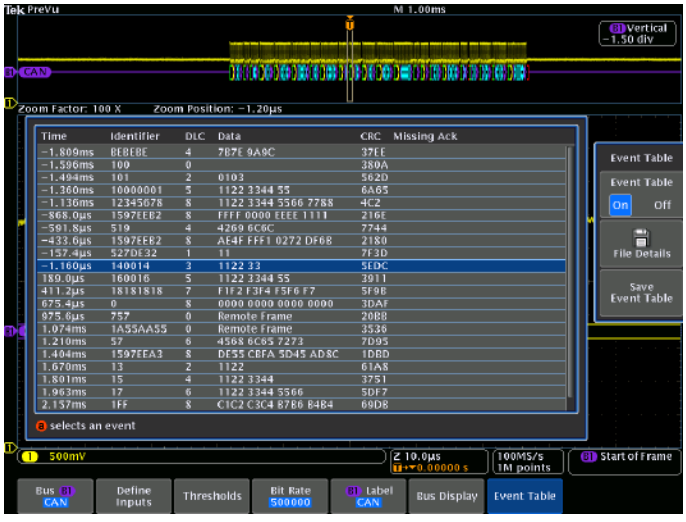
| Technology | | Trigger, Decode, Search | Order product |
|---|---|---|---|
| Embedded | I²C | Yes | DPO4EMBD |
| | SPI | Yes | DPO4EMBD |
| Computer | RS232/422/485, UART | Yes | DPO4COMP |
| USB | USB LS, FS, HS | Yes (trigger on LS FS, HS)<br>HS available only on 1 GHz models | DPO4USB |
| Ethernet | 10Base-T, 100Base-TX | Yes | DPO4ENET |
| Automotive | CAN | Yes | DPO4AUTO or DPO4AUTOMAX |
| | LIN | Yes | DPO4AUTO or DPO4AUTOMAX |
| | FlexRay | Yes | DPO4AUTOMAX |
| Military and Aerospace | MIL-STD-1553 | Yes | DPO4AERO |

it for you! Once you've set up a bus, the MSO/DPO4000C Series will decode each packet on the bus, and display the value in hex, binary, decimal (USB, Ethernet, MIL-

STD-1553, LIN, and FlexRay only), signed decimal (I2S/LJ/RJ/TDM only), or ASCII (USB, Ethernet, and RS-232/422/485/UART only) in the bus waveform.

## Event Table

In addition to seeing decoded packet data on the bus waveform itself, you can view all captured packets in a tabular view much like you would see in a software listing. Packets are time stamped and listed consecutively with columns for each component (Address, Data, etc.). You can save the event table data in .csv format.



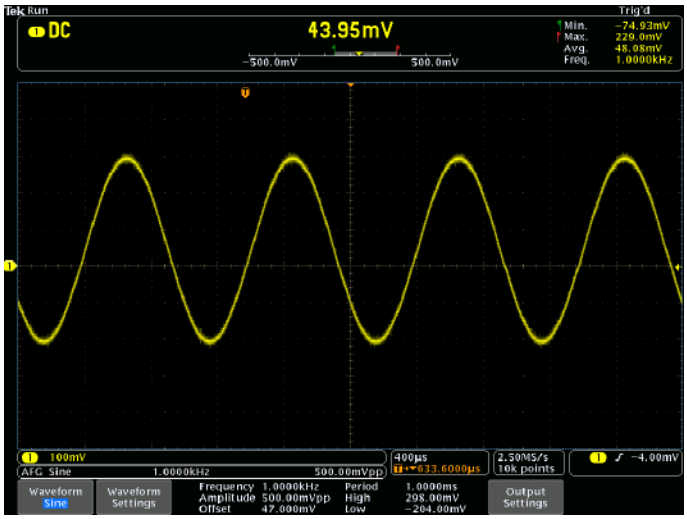

**Event table showing decoded identifier, DLC, DATA, and CRC for every CAN packet in a long acquisition.**

## Search (Serial Triggering)

Serial triggering is very useful for isolating the event of interest, but once you've captured it and need to analyze the surrounding data, what do you do? In the past, users had to manually scroll through the waveform counting and converting bits and looking for what caused the event. You can have the oscilloscope automatically search through the acquired data for user-defined criteria including serial packet content. 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.

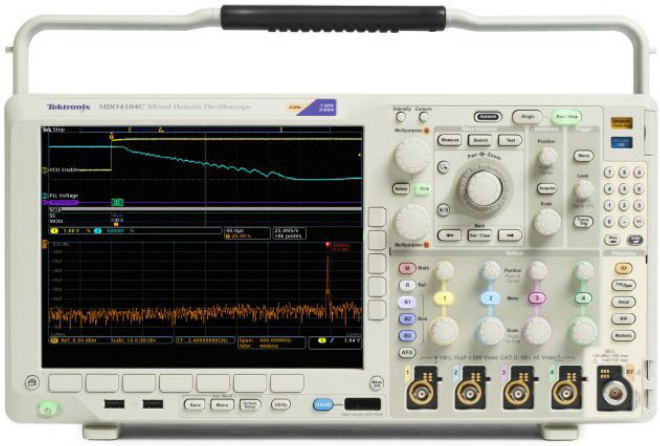
## 6. Digital Voltmeter (DVM) and Frequency Counter

The MDO4000C contains an integrated 4-digit digital voltmeter (DVM) and 5-digit 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 easy-to-read display offers you both numeric and graphical representations of the changing measurement values. The display also shows minimum, maximum, and average values of the measurement as well as the range of values measured over the previous five second interval. The DVM and frequency counter is available on any MDO4000C and is activated when you register your product.




**A DC measurement value is shown with a five second variation along with minimum, maximum, and average voltage values. The frequency of the waveform is also shown.**

## The MDO4000C Series Platform



**The MDO4000C Series is designed to make your work easier. The large, high-resolution display shows intricate signal details. Dedicated front-panel controls simplify operation. Two USB host ports on the front panel allow you to easily transfer screen shots, instrument settings, and waveform data to a USB mass storage device.**

### Large, High-Resolution Display

The MDO4000C Series features a 10.4 in. (264 mm) bright, LED backlit XGA color display for seeing intricate signal details.

### Connectivity

The MDO4000C contains a number of ports which can be used to connect the instrument to a network, directly to a PC, or other test equipment.

- Two USB 2.0 host ports on the front and two USB host ports on the rear enable easy transfer of screen shots, instrument settings, and waveform data to a USB mass storage device. A USB keyboard can also be attached to a USB host port for data entry.
- Rear USB 2.0 device port is useful for controlling the oscilloscope remotely from a PC or for printing directly to a PictBridge®-compatible printer.
- The standard 10/100/1000BASE-T Ethernet port on the rear of the instrument enables easy connection to networks, provides network and e-mail printing, and provides LXI Core 2011 compatibility. The instrument can also mount network drives for easy storage of screen images, setup files, or data files.
- A video out port on the rear of the instrument allows the display to be exported to an external monitor or projector.

## Remote Connectivity and Instrument Control

Exporting data and measurements is as simple as connecting a USB cable from the oscilloscope to your PC. Key software applications – OpenChoice® Desktop, and Microsoft Excel and Word toolbars – are included standard with each oscilloscope to enable fast and easy direct communication with your Windows PC.

The included OpenChoice Desktop enables fast and easy communication between the oscilloscope and your PC through USB or LAN for transferring settings, waveforms, and screen images.

The embedded e*Scope® 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. Transfer and save settings, waveforms, measurements, and screen images or make live control changes to settings on the oscilloscope directly from the web browser.

## Probing

The MDO4000C Series scope ships standard with passive voltage probes and uses the TekVPI probe interface.

### Standard Passive Voltage Probes

The MDO4000C Series include passive voltage probes with industry best capacitive loading of only 3.9 pF. The included TPP probes minimize the impact on devices under test and accurately deliver signals to the oscilloscope for acquisition and analysis. The probe bandwidth matches or exceeds your oscilloscope bandwidth so you can see the high-frequency components in your signal which is critical for high-speed applications. The TPP Series passive voltage probes offer all the benefits of general-purpose probes like high dynamic range, flexible connection options, and robust mechanical design, while providing the performance of active probes.

| MDO4000C Model | Included Probe |
|---|---|
| MDO4024C, MDO4034C, MDO4054C | TPP0500B: 500 MHz, 10× passive voltage probe. One per analog channel |
| MDO4104C | TPP1000: 1 GHz, 10× passive voltage probe. One per analog channel |

In addition, a low-attenuation, 2× version of the TPP probes 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).

### 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, 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, GPIB, or LAN, enabling more versatile solutions in ATE environments. The instrument provides up to 25 W of power to the front panel connectors from the internal power supply.

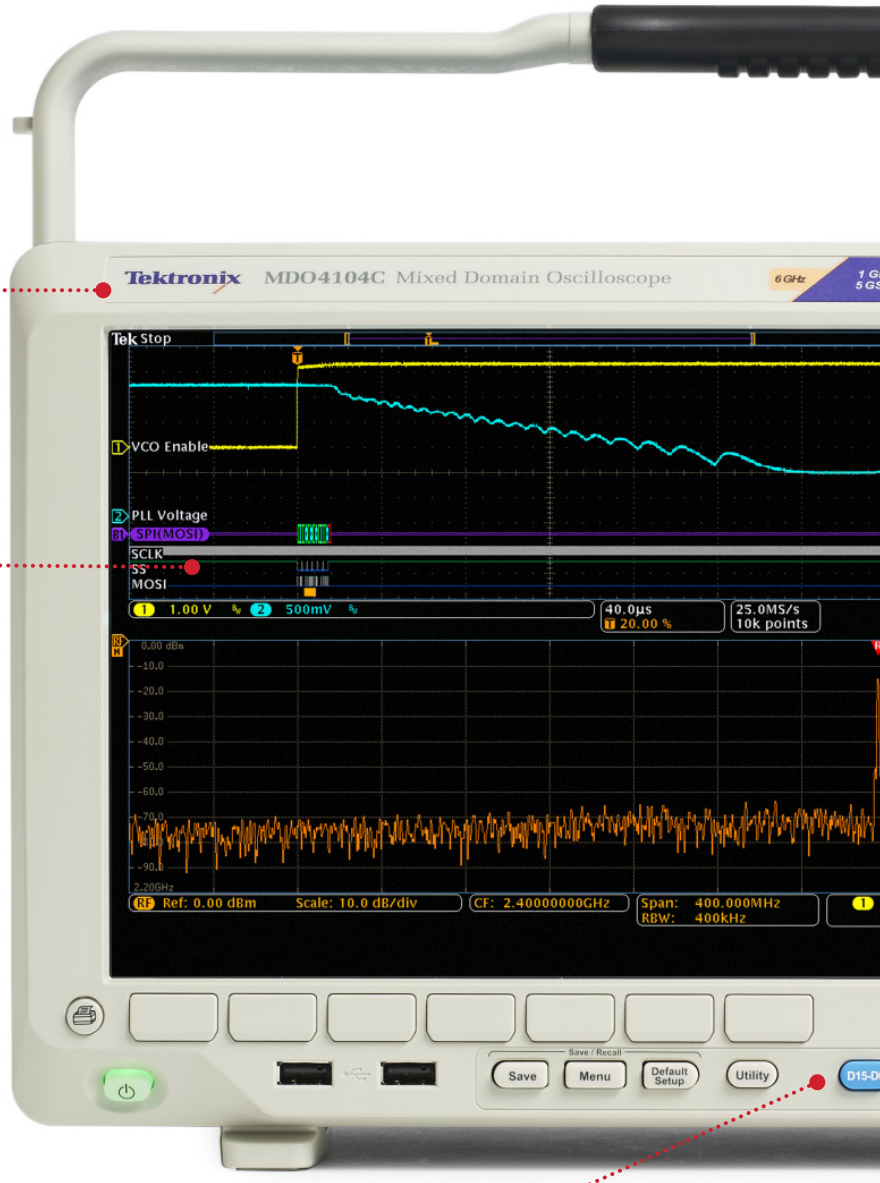
**TekVPI probe interface simplifies connecting your probes to the oscilloscope.**

# The Ultimate 6-in-1Integrated Oscilloscope,Completely C

1. Oscilloscope
2. Spectrum Analyzer
3. Arbitrary Function Generator
4. Logic Analyzer
5. Protocol Analyzer
6. Digital Voltmeter & Frequency Counter

**Mixed domain oscilloscope**
Fast acquisition, selectable record lengths, and a full suite of automated measurements help solve debug challenges quickly

**Large 10.4 inch XGA (1024×768) display**
with automatic dimming to maximize display life




**Standard ports on the rear of the instrument** include Ethernet, VGA, USB host (2) and device, AUX OUT, REFIN,and AFG output along with VESA and Kensington lock interfaces

**4 Logic Analyzer**
16 digital channels acquire with 60.6 ps resolution to make precision timing measurements on digital signals

# ustomizable and Fully Upgradable

**5 Serial Protocol Analysis and Application modules** add triggering and decode on common serial protocols, automated power measurements, and limit/mask test

**Wave Inspector** navigation and search simplifies finding areas of interest in deep records.

**AUX IN** on instruments without option SA3 or SA6 provides an auxiliary input for use as a trigger source

**3 Arbitrary Function Generator**
13 standard waveforms plus enables acquiring and replaying signals immediately without a PC

**6 Digital Voltmeter & Frequency Counter**
4-digit ACRMS, DC, and AC+DCRMS voltage measurements and 5-digit frequency counter for efficient monitoring of signals

**TekVPI™ probe interface** automates communication and provides power for advanced probes

**2 Spectrum Analyzer** provides 9 kHz – 3 GHz or 6 GHz of spectrum acquisition with synchronized insights into analog, digital, and spectral signals

# Specifications

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

## 1. Oscilloscope

| | MDO4024C | MDO4034C | MDO4054C | MDO4104C |
|---|---|---|---|---|
| Analog channels | 4 | 4 | 4 | 4 |
| Analog channel bandwidth | 200 MHz | 350 MHz | 500 MHz | 1 GHz |
| Rise time | 1.75 ns | 1 ns | 700 ps | 350 ps |
| Sample rate (1 ch) | 2.5 GS/s | 2.5 GS/s | 2.5 GS/s | 5 GS/s |
| Sample rate (2 ch) | 2.5 GS/s | 2.5 GS/s | 2.5 GS/s | 5 GS/s |
| Sample rate (4 ch)<br>Without option SA3 or SA6<br>With option SA3 or SA6 | <br>2.5 GS/s<br>2.5 GS/s | <br>2.5 GS/s<br>2.5 GS/s | <br>2.5 GS/s<br>2.5 GS/s | <br>5 GS/s<br>2.5 GS/s |
| Record length (1 ch) | 20 M | 20 M | 20 M | 20 M |
| Record length (2 ch) | 20 M | 20 M | 20 M | 20 M |
| Record length (4 ch) | 20 M | 20 M | 20 M | 20 M |
| Digital channels with MDO4MSO option | 16 | 16 | 16 | 16 |
| Arbitrary Function Generator outputs with MDO4AFG option | 1 | 1 | 1 | 1 |
| Spectrum analyzer channels with option SA3 or SA6 | 1 | 1 | 1 | 1 |
| Spectrum analyzer frequency range | | | | |
| With Option SA3<br>With Option SA6 | 9 kHz – 3 GHz<br>9 kHz – 6 GHz | 9 kHz – 3 GHz<br>9 kHz – 6 GHz | 9 kHz – 3 GHz<br>9 kHz – 6 GHz | 9 kHz – 3 GHz<br>9 kHz – 6 GHz |

### Vertical System Analog Channels

| | |
|---|---|
| **Hardware bandwidth limits** | |
| **≥350 MHz models** | 20 MHz or 250 MHz |
| **200 MHz models** | 20 MHz |
| **Input coupling** | AC, DC |
| **Input impedance** | 1 MΩ ±1% (13 pF), 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 VRMS CAT II with peaks ≤ ±425V |
| **50 Ω** | 5 VRMS with peaks ≤ ±20V |
| **DC gain accuracy** | ±1.5%, derated at 0.10%/°C above 30 °C<br>±3.0% for variable gain, derated 0.10%/°C above 30 °C |
| **Offset accuracy** | ±(0.005 * \|offset – position\| + DC Balance) |
| **DC balance** | 0.1 div with DC–50 Ω scope input impedance (50Ω BNC terminated) |
| **Channel-to-channel isolation (typical)** | Any two channels at equal vertical scale ≥100:1 at ≤100 MHz and ≥30:1 at >100 MHz up to the rated bandwidth |

**Random noise**

| Vertical scale setting | 50 Ω, RMS | | |
|---|---|---|---|
| | MDO4104C (All configurations) | MDO40x4C (with option SA3 or SA6) | MDO40x4 (without option SA3 or SA6) |
| 1 mV/div | 0.093 mV | 0.084 mV | 0.163 mV |
| 100 mV/div | 3.31 mV | 2.37 mV | 2.01 mV |
| 1 V/div | 24.27 mV | 20.62 mV | 20.51 mV |

**Offset range**

| Volts/div setting | Offset range | |
|---|---|---|
| | 1 M Ω input | 50 Ω input |
| 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 | ±10 V |
| 505 mV/div to 995 mV/div | ±5 V | ±5 V |
| 1 V/div to 10 V/div | ±100 V | ±5 V |
| 5.05 V/div to 10 V/div | ±50 V | NA |

## Horizontal system analog channels

**Time base range**

**1 GHz models (without option SA3 or SA6) and 1 GHz models (with option SA3 or SA6 with 2 channels enabled)**
400 ps to 1000 s

**≤ 500 MHz models and 1 GHz models (with option SA3 or SA6 and 4 channels enabled)**
1 ns to 1000 s

**Maximum duration at highest sample rate (all/half channels)**

**1 GHz models (without option SA3 or SA6) and 1 GHz models (with option SA3 or SA6 with 2 channels enabled)**
8/4 ms

**≤ 500 MHz models and 1 GHz models (with option SA3 or SA6 and 4 channels enabled)**
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

## 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

- **1 mV/div to 4.98 mV/div** 1.8 div
- **5 mV/div to 9.98 mV/div** 0.6 div
- **10 mV/div to 19.98 mV/div** 1.2 div
- **≤20 mV/div** 0.5 div

**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, negative, or either slope on any channel. Coupling includes DC, AC, HF reject, LF reject, and noise reject. |
| **Sequence (B-trigger)** | Trigger Delay by Time: 8 ns to 8 s. Or Trigger Delay by Events: 1 to 4, 000, 000 events. Not available when "Either" edge is selected. |
| **Pulse Width** | Trigger on width of positive or negative pulses that are >, <, =, ≠, or inside/outside a specified period of time. |
| **Timeout** | Trigger on an event which remains high, low, or either, for a specified time period (4 ns to 8 s). |
| **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. |

| Setup and hold trigger type | Description |
|---|---|
| Setup Time Range | -0.5 ns to 1.024 ms |
| Hold Time Range | 1.0 ns to 1.024 ms |
| Setup + Hold Time Range | 0.5 ns to 2.048 ms |

| | |
|---|---|
| **Rise/Fall Time** | Trigger on pulse edge rates that are faster or slower than specified. Slope may be positive, negative, or either and time range is 4.0 ns to 8 s. |
| **Video** | Trigger on all lines, odd, even, or all fields on NTSC, PAL, and SECAM video signals. |
| | Custom bi-level and tri-level sync video standards. |
| **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. |
| | Custom bi-level and tri-level sync video standards. |

**Parallel (requires option MDO4MSO)**

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 (MDO4104C with option SA3 or SA6 and ≤ 2 channels enabled or MDO4104C without SA3 or SA6) or 1.6 ns MDO4104C with option SA3 or SA6 and ≥3 channels enabled and all other 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. Number of waveforms in the envelope selectable between 1 and 2000 and infinity |
| **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. |
| **FastAcq®** | FastAcq optimizes the instrument for analysis of dynamic signals and capture of infrequent events, capturing >340, 000 wfms/son 1 GHz models and >270,000 wfms/s on 200 MHz – 500 MHz models. |

## Waveform measurements

| | |
|---|---|
| **Cursors** | Waveform and Screen |
| **DC measurement accuracy** | ±((DC Gain Accuracy) * \|reading – (Offset – Position)\| + Offset Accuracy + 0.15 div + 0.6 mV) |
| **Automatic measurements (time domain)** | 30, 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, Total 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** | 12, of which up to eight can be displayed on-screen at any one time. Waveform Count, Hits in Box, Peak Hits, Median, Max, Min, Peak-to-Peak, Mean, Standard Deviation, Sigma 1, Sigma 2, Sigma 3 |

## 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, TotalOverShoot, PeakPeak, Amplitude, RMS, CycleRMS, High, Low, Max, Min, Mean, CycleMean, Area, CycleArea, and trend plots). For example, (Intg(Ch1 – Mean(Ch1)) × 1.414 × VAR1) |

## Act on Event

| | |
|---|---|
| **Events** | None, when a trigger occurs, or when a defined number of acquisitions complete (1 to 1, 000, 000) |
| **Actions** | Stop acquisition, save waveform to file, save screen image, print, AUX OUT pulse, remote interface SRQ, e-mail notification, and visual notification |
| **Repeat** | Repeat the act on event process (1 to 1, 000, 000 and infinity) |

## Video Picture mode (optional – requires DPO4VID)

| | |
|---|---|
| **Sources** | Channel 1, Channel 2, Channel 3, Channel 4 |
| **Video standards** | NTSC, PAL |
| **Contrast and brightness** | Manual and automatic |
| **Field selection** | Odd, Even, Interlaced |
| **Picture location on screen** | Selectable × and Y location, width and height adjustment, start line and pixel and line-to-line offset control. |

## Power measurements (optional, requires DPO4PWR)

| | |
|---|---|
| **Power quality measurements** | $V_{RMS,}$ $V_{CrestFactor}$, Frequency, $I_{RMS}$, $I_{CrestFactor}$, TruePower, ApparentPower, ReactivePower, PowerFactor, PhaseAngle. |
| **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** | VRippleandIRipple. |
| **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, requires DPO4LMT)

| | |
|---|---|
| **Included standard masks[1]** | ITU-T, ANSI T1.102, USB |
| **Test source** | Limit test: Any Ch1 – Ch4 or any R1 – R4<br>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<br>Load standard mask from internal memory<br>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)<br>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 and Infinity)<br>Minimum elapsed time (from 1 second to 48 hours and 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 |

1 ≥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.

# 2. Spectrum Analyzer (requires Option SA3 or SA6)

## Spectrum analyzer input

**Span**

1 kHz –3 GHz (models with option SA3) or 1 kHz –6 GHz (models with option SA6)

Span adjustable in a 1-2-5 sequence

Variable resolution = 1% of the next span setting

**Resolution bandwidth range**

The resolution bandwidth range for windowing functions is as follows:

Kaiser (default): 20 Hz – 200 MHz

Rectangular: 10 Hz – 200 MHz

Hamming: 10 Hz – 200 MHz

Hanning: 10 Hz – 200 MHz

Blackman-Harris: 20 Hz – 200 MHz

Flat-top: 30 Hz – 200 MHz

Adjusted in a 1-2-3-5 sequence

**RBW shape factor (Kaiser)**

60 dB/3 dB shape factor: ≥ 4:1

**Reference level**

Setting range: -140 dBm to +30 dBm in steps of 1 dB

**Input vertical range**

Vertical measurement range: +30 dBm to DANL

Vertical setting of 1 dB/div to 20 dB/div in a 1-2-5 sequence

**Vertical position**

-100 divs to +100 divs

**Vertical units**

dBm, dBmV, dBµV, dBµW, dBmA, dBµA

**Displayed average noise level (DANL)**

| Frequency range | DANL |
|---|---|
| 9 kHz –50 kHz | < -116 dBm/Hz (< -123 dBm/Hz, typical) |
| 50 kHz –5 MHz | < -130 dBm/Hz (< -141 dBm/Hz, typical) |
| 5 MHz –400 MHz | < -146 dBm/Hz (< -150 dBm/Hz, typical) |
| 400 MHz –3 GHz | < -147 dBm/Hz (< -150 dBm/Hz, typical) |
| 3 GHz –4 GHz (models with option SA6 only) | < -148 dBm/Hz (< -151 dBm/Hz, typical) |
| 4 GHz –6 GHz (models with option SA6 only) | < -140 dBm/Hz (< -145 dBm/Hz, typical) |

**DANL with TPA-N-PRE preamp attached**

Preamp set to “Auto”, and Reference Level set to -40 dB

The DANL of the MDO4000C with the preamp in the Bypass state is ≤3 dB higher than the DANL of the MDO4000C without the preamp.

| Frequency range | DANL |
|---|---|
| 9 kHz –50 kHz | < -119 dBm/Hz (< -125 dBm/Hz, typical) |
| 50 kHz –5 MHz | < -140 dBm/Hz (< -146 dBm/Hz, typical) |
| 5 MHz –400 MHz | < -156 dBm/Hz (< -160 dBm/Hz, typical) |
| 400 MHz –3 GHz | < -157 dBm/Hz (< -160 dBm/Hz, typical) |
| 3 GHz –4 GHz (models with option SA6 only) | < -158 dBm/Hz (< -161 dBm/Hz, typical) |
| 4 GHz –6 GHz (models with option SA6 only) | < -150 dBm/Hz (< -155 dBm/Hz, typical) |

**Spurious response**

**2nd and 3rd harmonic distortion (>100 MHz)**
< -60 dBc (< -65 dBc, typical), with auto settings on and signals 10 dB below reference level

**2nd and 3rd harmonic distortion (9 kHz to 100 MHz )**
< -57 dBc (< -60 dBc, typical), with auto settings on, signals 10 dB below reference level, and reference level ≤ -15 dBm

**2nd order intermodulation distortion (>200 MHz)**
< -60 dBc (< -65 dBc, typical), with auto settings on and signals 10 dB below reference level

**2nd order intermodulation distortion (>100MHz to ≤200MHz)**
<-57 dBc (<-60 dBc, typical), with auto settings on and signals 10 dB below reference level.)

**2nd order intermodulation distortion (10 MHz to 100 MHz)**
< -60 dBc (< -65 dBc, typical), with auto settings on, signals 10 dB below reference level, and reference level ≤ -15 dBm

**3rd order intermodulation distortion (>10 MHz)**
< -62 dBc (<-65 dBc, typical), with auto settings on and signals 10 dB below reference level, and reference levels < -15 dBm

**3rd order intermodulation distortion (9 kHz to 10 MHz)**
< -62 dBc (<-65 dBc, typical), with auto settings on and signals 10 dB below reference level, and reference levels < -15 dBm

**A/D spurs**
< -60 dBc (< -65 dBc, typical), with auto settings on and signals 5 dB below reference level. Excludes A/D aliasing spurs

**A/D aliasing spurs**
At (5 GHz – Fin) and (8 GHz – Fin): <-55 dBc (<-60 dBc, typical), with auto settings on and signals 5 dB below reference level

**Specifications that only apply to models with option SA6**
IF Rejection: (All Input Frequencies except: 1.00 GHz to 1.25 GHz and 2 GHz to 2.4 GHz): < -55 dBc, typical

IF spurs at (5 GHz – Fin) for input frequencies from 1.00 GHz to 1.25 GHz: < -50 dBc, typical

IF spurs at (6.5 GHz -Fin) for input frequencies from 2 GHz to 2.4 GHz: < -50 dBc, typical

Image Rejection: < -50 dBc (for input frequencies from 5.5 GHz to 9.5 GHz)

**Residual response**
< -85 dBm (< -78 dBm at 2.5 GHz, 3.75 GHz, 4.0 GHz, 5.0 GHz, and typical at 6.0 GHz) with ≤ -25 dBm reference level and input terminated with 50 Ω

**Absolute amplitude accuracy**
Accuracy of power level measurements at the center frequency. At frequencies away from center frequency, add Channel Response to the Absolute Amplitude Accuracy. Applies to signal to noise ratios > 40 dB.

< ± 1.0 dB (< ±0.5 dB, typical), 18 °C –28 °C temperature range, 50 kHz to 6 GHz frequency range, reference levels -25, -20, -15, -10, -5, 0, 5, 10 dBm

< ± 1.0 dB, typical, 50 kHz to 6 GHz, all other reference levels, 18 °C –28 °C temperature range

< ±1.5 dB, typical, 50 kHz to 6 GHz, all reference levels, 0 °C to 50 °C temperature range

< ± 2.0 dB, typical, 9 kHz to 50 kHz, all reference levels, 18 °C to 28 °C temperature range

< ± 3.0 dB, typical, 9 kHz to 50 kHz, all reference levels, 0 °C to 50 °C temperature range

**Channel response**
Valid over 18 –28 °C temperature range.

Specification applies to signal-to-noise ratios > 40 dB

| Measurement center frequency range | Span | Amplitude flatness, pk-pk | Amplitude flatness, RMS | Phase linearity, RMS |
|---|---|---|---|---|
| 15 MHz –6 GHz | 10 MHz | 0.3 dB | 0.15 dB | 1.5 ° |
| 60 MHz –6 GHz | ≤ 100 MHz | 0.75 dB | 0.27 dB | 1.5 ° |
| 170 MHz –6 GHz | ≤ 320 MHz | 0.85 dB | 0.27 dB | 2.5 ° |
| 510 MHz –6 GHz | ≤ 1, 000 MHz | 1.0 dB | 0.3 dB | 3.0 ° |
| Any (for start frequency > 10 MHz) | > 1, 000 MHz | 1.2 dB | N/A | N/A |

**Absolute amplitude accuracy (AAA) and channel response (CR), with TPA-N-PRE preamp attached**

AAA: ≤ ±0.5 dB (typical), 18 °C –28 °C temperature range, 50 kHz to 6 GHz, either preamp state.

AAA: ≤ ±2.0 dB (typical), 18 °C –28 °C temperature range, 9 kHz to 50 kHz, either preamp state.

AAA: ≤ ±2.3 dB (typical), over full operating range, either preamp state.

CR: 0.0 dB

**Crosstalk to spectrum analyzer 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 1 GHz CW**

| | |
|---|---|
| **1 kHz** | < -104 dBc/Hz, (typical) |
| **10 kHz** | < -108 dBc/Hz, < -111 dBc/Hz (typical) |
| **100 kHz** | < -110 dBc/Hz, < -113 dBc/Hz (typical) |
| **1 MHz** | < -120 dBc/Hz, < -123 dBc/Hz (typical) |

**Reference frequency error (cumulative)**

Cumulative error: $1.6 \times 10^{-6}$

Includes allowances for aging per year, reference frequency calibration accuracy, and temperature stability Valid over the recommended one-year calibration interval, from 0 °C to +50 °C

**Marker frequency measurement accuracy**

$\pm((1.6 \times 10^{-6} \times \text{Marker-Frequency}) + (0.001 \times \text{span} + 2))$ Hz

Example: assuming the span is set to 10 kHz and the marker is at 1500 MHz, this would result in a Frequency Measurement Accuracy of $+/-((1.6 \times 10^{-6} \times 1500 \text{ MHz}) + (0.001 \times 10 \text{ kHz} + 2)) = \pm 2.412$ kHz.

Marker Frequency with Span/RBW ≤ 1000:1

Reference Frequency Error with Marker level to displayed noise level > 30 dB

**Frequency measurement resolution**

1 Hz

**Maximum operating input level**

| | |
|---|---|
| **Average continuous power** | +30 dBm (1 W) for reference levels ≥ -20 dBm<br>+24 dBm (0.25 W) for reference levels < -20 dBm |
| **DC maximum before damage** | ±40 VDC |
| **Maximum power before damage (CW)** | +32 dBm (1.6 W) for reference levels ≥ -20 dBm<br>+25 dBm (0.32 W) for reference levels of < -20 dBm |
| **Maximum power before damage (pulse)** | Peak Pulse Power: +45 dBm (32 W)<br>Peak Pulse Power defined as <10 µs pulse width, <1% duty cycle, and reference level of ≥ +10 dBm |

**Maximum operating input level with TPA-N-PRE preamp attached**

| | |
|---|---|
| **Average continuous power** | +30 dBm (1 W) |
| **DC maximum before damage** | ±20 VDC |
| **Maximum power before damage (CW)** | +30 dBm (1 W) |
| **Maximum power before damage (pulse)** | +45 dBm (32 W) (<10 µs pulse width, <1% duty cycle, and reference level of ≥ +10 dBm) |

**RF Power level trigger**

| | |
|---|---|
| **Frequency range** | Models with option SA3: 1 MHz to 3 GHz |
| | Models with option SA6: 1 MHz to 3.75 GHz; 2.75 GHz to 4.5 GHz, 3.5 GHz to 6.0 GHz |
| **Amplitude operating level** | 0 dB to -30 dB from Reference Level |
| **Amplitude range** | +10 dB to -40 dB from Reference Level and within the range of -65 dBm to +30 dBm |
| **Minimum pulse generation** | 10 µs On Time with a minimum settling Off Time of 10 µs |

**Spectrum analyzer to analog channel skew**

<5 ns

**RF acquisition length**

| Span | Maximum RF acquisition time |
|---|---|
| >2 GHz | 5 ms |
| >1 GHz - 2 GHz | 10 ms |
| >800 MHz - 1 GHz | 20 ms |
| >500 MHz - 800 MHz | 25 ms |
| >400 MHz - 500 MHz | 40 ms |
| >250 MHz - 400 MHz | 50 ms |
| >200 MHz - 250 MHz | 80 ms |
| >160 MHz - 200 MHz | 100 ms |
| >125 MHz - 160 MHz | 125 ms |
| <125 MHz | 158 ms |

**FFT window types, factors, and RBW accuracy**

| FFT window | Factor | RBW accuracy |
|---|---|---|
| Kaiser | 2.23 | 0.90% |
| Rectangular | 0.89 | 2.25% |
| Hamming | 1.30 | 1.54% |
| Hanning | 1.44 | 1.39% |
| Blackman-Harris | 1.90 | 1.05% |
| Flat-Top | 3.77 | 0.53% |

# 3. Arbitrary Function Generator (requires Option MDO4AFG)

**Waveforms** Sine, Square, Pulse, Ramp/Triangle, DC, Noise, Sin(x)/x (Sinc), Gaussian, Lorentz, Exponential Rise, Exponential Decay, Haversine, Cardiac, and Arbitrary.

**Sine**

| | |
|---|---|
| **Frequency range** | 0.1 Hz to 50 MHz |
| **Amplitude range** | 20 $mV_{p-p}$ to 5 $V_{p-p}$ into Hi-Z; 10 $mV_{p-p}$ to 2.5 $V_{p-p}$ into 50 Ω |
| **Amplitude flatness (typical)** | ±0.5dB at 1 kHz (±1.5 dB for<20 $mV_{p-p}$ amplitudes) |
| **Total harmonic distortion (typical)** | 1% into 50 Ω<br>2% for amplitude < 50 mV and frequencies > 10 MHz<br>3% for amplitude < 20 mV and frequencies > 10 MHz |
| **Spurious free dynamic range (SFDR) (typical)** | -40 dBc ($V_{p-p}$≥ 0.1V); -30dBc ($V_{p-p}$≤ 0.1V), 50 Ω load |

| | |
|---|---|
| **Square/Pulse** | |
| **Frequency range** | 0.1 Hz to 25 MHz |
| **Amplitude range** | 20 $mV_{p-p}$ to 5 $V_{p-p}$ into Hi-Z; 10 $mV_{p-p}$ to 2.5 $V_{p-p}$ into 50 Ω |
| **Duty cycle** | 10% to 90% or 10 ns minimum pulse, whichever is larger cycle |
| **Duty cycle resolution** | 0.1% |
| **Pulse width minimum (typical)** | 10 ns |
| **Rise/fall time (typical)** | 5 ns (10% –90%) |
| **Pulse width resolution** | 100 ps |
| **Overshoot (typical)** | < 2% for signal steps greater than 100 mV |
| **Asymmetry** | ±1% ±5 ns, at 50% duty cycle |
| **Jitter (TIE RMS) (typical)** | < 500 ps |
| **Ramp/Triangle** | |
| **Frequency range** | 0.1 Hz to 500 kHz |
| **Amplitude range** | 20 $mV_{p-p}$ to 5 $V_{p-p}$ into Hi-Z; 10 $mV_{p-p}$ to 2.5 $V_{p-p}$ into 50 Ω |
| **Variable symmetry** | 0% to 100% |
| **Symmetry resolution** | 0.1% |
| **DC** | |
| **Level range (typical)** | ±2.5 V into Hi-Z; ±1.25 V into 50 Ω |
| **Noise** | |
| **Amplitude range** | 20 $mV_{p-p}$ to 5 $V_{p-p}$ into Hi-Z;10 $mV_{p-p}$ to 2.5 $V_{p-p}$ into 50 Ω |
| **Amplitude resolution** | 0% to 100% in 1% increments |
| **Sin(x)/x (Sinc)** | |
| **Frequency range (typical)** | 0.1 Hz to 2 MHz |
| **Amplitude range** | 20 $mV_{p-p}$ to 3.0 $V_{p-p}$ into Hi-Z; 10 $mV_{p-p}$ to 1.5 $V_{p-p}$ into 50 Ω |
| **Gaussian** | |
| **Frequency range (typical)** | 0.1 Hz to 5 MHz |
| **Amplitude range** | 20 $mV_{p-p}$ to 2.5 $V_{p-p}$ into Hi-Z; 10 $mV_{p-p}$ to 1.25 $V_{p-p}$ into 50 Ω |
| **Lorentz** | |
| **Frequency range (typical)** | 0.1 Hz to 5 MHz |
| **Amplitude range** | 20 $mV_{p-p}$ to 2.4 $V_{p-p}$ into Hi-Z; 10 $mV_{p-p}$ to 1.2 $V_{p-p}$ into 50 Ω |
| **Exponential Rise/Decay** | |
| **Frequency range (typical)** | 0.1 Hz to 5 MHz |
| **Amplitude range** | 20 $mV_{p-p}$ to 2.5 $V_{p-p}$ into Hi-Z; 10 $mV_{p-p}$ to 1.25 $V_{p-p}$ into 50 Ω |
| **Haversine** | |
| **Frequency range (typical)** | 0.1 Hz to 5 MHz |
| **Amplitude range** | 20 $mV_{p-p}$ to 2.5 $V_{p-p}$ into Hi-Z; 10 $mV_{p-p}$ to 1.25 $V_{p-p}$ into 50 Ω |
| **Cardiac (typical)** | |
| **Frequency range** | 0.1 Hz to 500 kHz |
| **Amplitude range** | 20 $mV_{p-p}$ to 5 $V_{p-p}$ into Hi-Z; 10 $mV_{p-p}$ to 2.5 $V_{p-p}$ into 50 Ω |
| **Arbitrary** | |
| **Memory depth** | 1 to 128 k |
| **Amplitude range** | 20 $mV_{p-p}$ to 5 $V_{p-p}$ into Hi-Z; 10 $mV_{p-p}$ to 2.5 $V_{p-p}$ into 50 Ω |
| **Repetition rate** | 0.1 Hz to 25 MHz |
| **Sample rate** | 250 MS/s |

| | |
|---|---|
| **Frequency accuracy** | |
| **Sine wave and ramp** | 130 ppm (frequency < 10 kHz)<br>50 ppm (frequency ≥ 10 kHz) |
| **Square wave and pulse** | 130 ppm (frequency < 10 kHz)<br>50 ppm (frequency ≥ 10 kHz) |
| **Resolution** | 0.1 Hz or 4 digits, whichever is larger |
| **Amplitude accuracy** | ±[ (1.5% of peak-to-peak amplitude setting) + (1.5% of DC offset setting) + 1 mV ] (frequency = 1 kHz) |
| **DC offset** | |
| **DC offset range** | ±2.5 V into Hi-Z; ±1.25 V into 50 Ω |
| **DC offset resolution** | 1 mV into Hi-Z; 500 uV into 50 Ω |
| **Offset accuracy** | ±[(1.5% of absolute offset voltage setting) + 1 mV]; derated 3 mV for every 10 °C away from 25 °C |
| **ArbExpress®** | The MDO4000C is compatible with ArbExpress® PC-based signal generator waveform creation and editing software. Capturewaveforms on the MDO4000C oscilloscope and transfer them to ArbExpress for editing. Create complex waveforms in ArbExpress and transfer them to the arbitrary function generator in the MDO4000C for output. To download ArbExpress software, go to www.tektronix.com/downloads. |

# 4. Logic Analyzer (requires Option MDO4MSO)

## Vertical system digital channels

| | |
|---|---|
| **Input channels** | 16 digital (D15 to D0) |
| **Thresholds** | Threshold per set of 8 channels |
| **Threshold selections** | TTL, CMOS, ECL, PECL, User-defined |
| **User-defined threshold range** | ±40 V |
| **Threshold accuracy** | ±[100 mV + 3% of threshold setting] Input dynamic range $30V_{p-p}$≤200MHz$10V_{p-p}$>200MHz |
| **Minimum voltage swing** | $400mV_{p-p}$ |
| **Probe loading** | |
| **Input impedance** | 100 kΩ |
| **Input capacitance** | 3 pF |
| **Vertical resolution** | 1 bit |

## Horizontal system digital channels

| | |
|---|---|
| **Maximum sample rate (M ain)** | 500 MS/s (2 ns resolution) |
| **Maximum record length (Main)** | 20 M |
| **Maximum sample rate (MagniVu)** | 16.5 GS/s (60.6 ps resolution) |
| **Maximum record length (MagniVu)** | 10k centered on the trigger |
| **Minimum detectable pulse width** | 1 ns |
| **Channel-to-channel skew (typical)** | 200 ps (typical) |
| **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 shortground extender on each channel. This is the maximum frequency at the minimum swing amplitude. Higher toggle rates can be achieved with higher amplitudes.) |

# 5. Serial Protocol Analyzer (optional)

AutomatedSerial Triggering, Decode, and Search options for I²C, SPI, RS-232/422/485/UART, USB2.0, CAN, LIN, FlexRay, MIL-STD-1553, and Audio buses.

For more detailed information about serial bus support products please see the Serial Triggering and Analysis Application Modules data sheet.

## Trigger types

| | |
|---|---|
| **I²C** | Trigger on Start, Repeated Start, Stop, Missing ACK, Address (7 or 10 bit), Data, or Address and Data on I²C buses up to 10 Mb/s. |
| **SPI** | 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** | 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 upto 10 Mb/s. |
| **USB: Low speed** | Trigger on Sync Active, Start of Frame, Reset, Suspend, Resume, End of Packet, Token (Address) Packet, Data Packet, Handshake Packet, Special Packet, Error.<br>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.<br>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.<br>Handshake packet trigger – Any handshake type, ACK, NAK, STALL. Special packet trigger – Any special type, Reserved<br>Error trigger – PID Check, CRC5 or CRC16, Bit Stuffing. |
| **USB: Full speed** | Trigger on Sync, Reset, Suspend, Resume, End of Packet, Token (Address) Packet, Data Packet, Handshake Packet, Special Packet, Error.<br>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.<br>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.<br>Handshake packet trigger – Any handshake type, ACK, NAK, STALL. Special packet trigger – Any special type, PRE, Reserved.<br>Error trigger – PID Check, CRC5 or CRC16, Bit Stuffing.<br>Serial Protocol Analyzer (optional) |
| **USB: High speed**[2] | Trigger on Sync, Reset, Suspend, Resume, End of Packet, Token (Address) Packet, Data Packet, Handshake Packet, Special Packet, Error.<br>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.<br>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.<br>Handshake packet trigger – Any handshake type, ACK, NAK, STALL, NYET.<br>Special packet trigger – Any special type, ERR, SPLIT, PING, Reserved. SPLIT packet components that can be specified include: Hub Address<br>Start/Complete – Don't Care, Start (SSPLIT), Complete (CSPLIT) Port Address<br>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)<br>Endpoint Type – Don't Care, Control, Isochronous, Bulk, Interrupt Error trigger – PID Check, CRC5 or CRC16 |

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

| | |
|---|---|
| **Ethernet**[3] | 10BASE-T and 100BASE-TX: Trigger on Start Frame Delimiter, MAC Addresses, MAC Q-Tag Control Information, MAC Length/<br>Type, IP Header, TCP Header, TCP/IPv4/MAC Client Data, End of Packet, and FCS (CRC) Error. 100BASE-TX: Idle.<br>MAC Addresses – Trigger on Source and Destination 48-bit address values. MAC Q-Tag Control Information – Trigger on Q-Tag 32-bit value.<br>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.<br>TCP Header – Trigger on Source Port, Destination Port, Sequence Number, and Ack Number.<br>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** | 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** | 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** | 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. |
| **MIL-STD-1553** | Trigger on Sync, Word Type[3] (Command, Status, Data), Command Word (set RT Address, T/R, Sub-address/Mode, Data WordCount/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. |
| **I²S/LJ/RJ/TDM** | 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 I²S/LJ/RJ is 12.5 Mb/s. Maximum data rate for TDM is 25 Mb/s. |

## 6. Digital Voltmeter and Frequency Counter

| | |
|---|---|
| **Source** | Channel 1, Channel 2, Channel 3, Channel 4 |
| **Measurement types** | AC RMS, DC, AC+DC RMS (reads out in volts or amps); Frequency |
| **Voltage accuracy** | ±(1.5% \|reading – offset – position\|) + (0.5% \|(offset – position)\|) + (0.1 * Volts/div)) |
| **Resolution** | ACV, DCV: 4 digits<br>Frequency: 5 digits |
| **Frequency accuracy** | ±(10 µHz/Hz + 1 count) |
| **Measuring rate** | 100 times/second; measurements updated on the display 4 times/second |
| **Vertical settings autorange** | Automatic adjustment of vertical settings to maximize measurement dynamic range; available for any non-trigger source |
| **Graphical measurement** | Graphical indication of minimum, maximum, current value, and five second rolling range |

3 ≥350 MHz bandwidth models are recommended for 100BASE-TX

# General Product Specifications

## 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, Solid, Cross Hair, Frame, IRE and mV |
| **Format** | YT, XY, and simultaneous XY/YT |
| **Maximum waveform capture rate** | >340, 000 wfms/s in FastAcq acquisition mode on 1 GHz models<br>>270, 000 wfms/s in FastAcq acquisition mode on 200 MHz –500 MHz models<br>>50, 000 wfms/s in DPO acquisition mode on all models. |

## Input-output ports

| | |
|---|---|
| **USB 2.0 high-speed host port** | Supports USB mass storage devices 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), anddirect printing to all PictBridge-compatible printers. |
| **Printing** | Print PictBridge printer or to a printer that supports e-mail printing. Note: This product includes software developed by the OpenSSL Project for use in the OpenSSL Toolkit. (http://www.openssl.org/) |
| **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<br>$V_{OUT}$ (Hi): ≥2.5 V open circuit, ≥1.0 V 50 Ω toground<br>$V_{OUT}$ (Lo): ≤0.7 V into a load of≤4 mA; ≤0.25 V 50 Ω to ground<br>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 Core 2011 |
| **Version** | V1.4 |

## Software

| | |
|---|---|
| **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. Download from http://www.tek.com/downloads. |
| **IVI driver** | Provides a standard instrument programming interface for common applications such as LabVIEW, LabWindows/CVI, MicrosoftNET, and MATLAB. |

| | |
|---|---|
| **e*Scope® Web-based interface** | 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. |
| **LXI Web interface** | Connect to the oscilloscope through a standard Web browser by simply entering the oscilloscope's IP address or network name in the address bar of the browser. The Web interface enables viewing of instrument status and configuration, status and modification of network settings, and instrument control through the e*Scope Web-based remote control. All Web interaction conforms to LXI Core specification, version 1.4. |

## Power source

| | |
|---|---|
| **Power source voltage** | 100 to 240 V ±10% |
| **Power source frequency** | 50 to 60 Hz ±10% at 100 to 240 V ±10%<br>400 Hz ±10% at 115 V ±13% |
| **Power consumption** | 250 W maximum |

## Physical characteristics

**Dimensions**

| | mm | in. |
|---|---|---|
| Height | 229 | 9 |
| Width | 439 | 17.3 |
| Depth | 147 | 5.8 |

**Weight**

**Instruments without option SA3 or SA6**

| | kg | lb |
|---|---|---|
| Net | 5.5 | 12.2 |
| Shipping | 11.2 | 24.8 |

**Instruments with option SA3 or SA6**

| | kg | lb |
|---|---|---|
| Net | 5.1 | 11.2 |
| Shipping | 10.8 | 23.8 |

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

## EMC environment and safety

| | |
|---|---|
| **Temperature** | |
| **Operating** | 0 °C to +50 °C (+32 °F to 122 °F) |
| **Nonoperating** | -30 °C to +70 °C (-4 °F to 140 °F) |
| **Humidity** | |
| **Operating** | High: 40 °C to 50 °C, 10% to 60% relative humidity, Low: 0 °C to 40 °C, 10% to 90% relative humidity |
| **Nonoperating** | High: 40 °C to 60 °C, 5% to 55% relative humidity, Low: 0 °C to 40 °C, 5% to 90% relative humidity |
| **Altitude** | |
| **Operating** | 3,000 meters (9, 843 feet) |
| **Nonoperating** | 12,000 meters (39, 370 feet) |
| **Regulatory** | CE marked for the European Union and UL approved for the US and Canada |

# Ordering information

## Step 1 Choose the MDO4000C base model

### MDO4000C family

| | |
|---|---|
| **MDO4024C** | Mixed Domain Oscilloscope with (4) 200 MHz analog channels |
| **MDO4034C** | Mixed Domain Oscilloscope with (4) 350 MHz analog channels |
| **MDO4054C** | Mixed Domain Oscilloscope with (4) 500 MHz analog channels |
| **MDO4104C** | Mixed Domain Oscilloscope with (4) 1 GHz analog channels |

### Standard accessories

**Probes**

| | |
|---|---|
| **≤ 500 MHz models** | TPP0500B, 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. |
| **Any model with MDO4MSO option** | One P6616 16-channel logic probe and a logic probe accessory kit (020-2662-xx). |

**Accessories**

| | |
|---|---|
| **200-5130-xx** | Front cover |
| **016-2030-xx** | Accessory bag |
| **071-3448-xx** | Installation and Safety Instructions, printed manual (translated in English, French, Japanese, and Simplified Chinese); other product manuals are available for download at<br>Power cord<br>OpenChoice® Desktop Software (available on the Documentation CD and for download from www.tektronix.com/downloads.)<br>Calibration certificate documenting traceability to National Metrology Institute(s) and ISO9001 quality system registration |
| **103-0045-xx models with option SA3 or SA6** | N-to-BNC adapter |

### Warranty

Three-year warranty covering all parts and labor on the MDO4000C instrument. One-year warranty covering parts and labor on included probes.

## Step 2 Configure your MDO4000C by adding instrument options

### Instrument options

All MDO4000C Series instruments can be preconfigured from the factory with the following options:

| | |
|---|---|
| **MDO4AFG** | Arbitrary function generator with 13 predefined waveforms and arbitrary waveform generation |
| **MDO4MSO** | 16 digital channels; includes P6616 digital probe and accessories |
| **SA3** | Integrated spectrum analyzer with frequency range of 9 kHz to 3 GHz |
| **SA6** | Integrated spectrum analyzer with frequency range of 9 kHz to 6 GHz |
| **MDO4SEC** | Enhanced instrument security to enable password protected control of turning on/off all instrument ports and instrument firmware update functionality |

## 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, 50/60 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

All products are shipped with an Installation and Safety manual that is in English, Japanese, Simplified Chinese, and French. Full user manuals translated in each language listed below are available in PDF format from www.tektronix.com/manuals.Selecting a language option below other than L0 will include a front panel overlay in the language selected.

| | |
|---|---|
| **Opt. L0** | English front panel label |
| **Opt. L1** | French front panel overlay |
| **Opt. L2** | Italian front panel overlay |
| **Opt. L3** | German front panel overlay |
| **Opt. L4** | Spanish front panel overlay |
| **Opt. L5** | Japanese front panel overlay |
| **Opt. L6** | Portuguese front panel overlay |
| **Opt. L7** | Simplified Chinese front panel overlay |
| **Opt. L8** | Traditional Chinese front panel overlay |
| **Opt. L9** | Korean front panel overlay |
| **Opt. L10** | Russian front panel overlay |

## Service options

Tektronix offers a range of warranty and service plans to extend the life of your product and protect you from unplanned costs. Whether you want to protect yourself from accidental damage, or just save money on maintenance with a calibration plan, there is a service option available that meets your needs.

| | |
|---|---|
| **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. R5** | Repair Service 5 Years (including warranty) |
| **Opt. T3** | Three year total protection plan ensures that your equipment remains like-new regardless of what happens. |
| **Opt. T5** | Five year total protection plan ensures that your equipment remains like-new regardless of what happens. |

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.

## Step 3 Select application modules and accessories

| | |
|---|---|
| **Application modules** | Application modules are purchased as stand-alone products and can be purchased at the time of initial MDO4000C purchase or at any future time. The optional application modules functionality is offered free for a 30-day trial period. This free trial period starts automatically when the instrument is powered on for the first time.<br><br>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 safe-keeping. Transferring the license to an oscilloscope and removing the module permits the use of more than 4 applications simultaneously. |
| **DPO4BND** | Application bundle module that enables all of the functionality of the DPO4AERO, DPO4AUDIO, DPO4AUTO, DPO4COMP, DPO4EMBD, DPO4ENET, DPO4LMT, DPO4PWR, DPO4USB and DPO4VID application modules in a single module. Save money when multiple serial bus debug and analysis application modules are required and easily move the entire set of functionality from one instrument to another. |
| **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.<br><br>Signal Inputs – Any Ch1 – Ch4, Math, Ref1 – Ref4<br><br>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 I2S, 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.<br><br>Signal Inputs – Any Ch1 – Ch4, any D0 – D15<br><br>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.<br><br>Signal Inputs – LIN: Any Ch1 – Ch4, any D0 – D15; CAN: Any Ch1 – Ch4, any D0 – D15<br><br>Recommended Probing – LIN: Single ended; CAN: 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.<br><br>Signal Inputs – Any Ch1 – Ch4, any D0 – D15<br><br>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.<br><br>Signal Inputs – $I^2C$ or SPI: Any Ch1 – Ch4, any D0 – D15<br><br>Recommended Probing – Single ended |
| **DPO4ENET** | Ethernet Serial Triggering and Analysis Module. Enables triggering on packet-level information on 10BASE-T and 100BASE-TX[4] buses as wellas analytical tools such as digital views of the signal, bus views, packet decoding, search tools, and packetdecode tables with time-stamp information.<br><br>Signal Inputs – Any Ch1 – Ch4, Math, Ref1 – Ref4<br><br>Recommended Probing –10BASE-T: Single ended or differential; 100BASE-TX: Differential |
| **DPO4USB** | USB Serial Triggering and Analysis Module. Enables triggering on packet-level content for low-speed, and full-speed USB serialbuses. 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.[5]<br><br>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<br><br>Recommended Probing – Low-speed and Full-speed: Single ended or differential; High-speed: Differential |

4 ≥350 MHz bandwidth models are recommended for 100BASE-TX.
5 SB high-speed supported only on models with 1 GHz analog channel bandwidth.

| | |
|---|---|
| **DPO4PWR** | Power Analysis Application Module. Enables quick and accurate analysis of power quality, switching loss, harmonics, safeoperating 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 masks.[6] |
| **DPO4VID** | HDTV and Custom (nonstandard) Video Triggering and Video Picture Module. |
| **MDO4TRIG** | Advanced RF Power Level Triggering Module. Enables the power level on the spectrum analyzer input to be used as a source in the following trigger types: Pulse Width, Runt, Timeout, Logic, and Sequence. |

## 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. |
| **TPP0500B** | 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 |
| **SignalVu-PC-SVE** | Vector Signal Analysis Software |
| **TEK-USB-488** | GPIB-to-USB adapter |
| **ACD4000B** | Soft transit case |
| **HCTEK4321** | Hard transit case (requires ACD4000B) |
| **RMD3000** | Rackmount kit |

6 ≥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.

## Other RF probes

Contact Beehive Electronics to order: http://beehive-electronics.com/probes.html

| | |
|---|---|
| **101A** | EMC probe set |
| **150A** | EMC probe amplifier |
| **110A** | Probe cable |
| **0309-0001** | SMA probe adapter |
| **0309-0006** | BNC probe adapter |

# Step 4 Add instrument upgrades in the future

## Instrument upgrades

The MDO4000C Series products offer a number of ways to add functionality after the initial purchase. Listed below are the various product upgrades available and the method of upgrade used for each product.

**Free instrument options**

The following options are available free of charge when the MDO4000C product is registered at www.tektronix.com/mdo4register.

**Digital Voltmeter and Frequency Counter**

4-digit $AC_{rms}$, DC, $AC+DC_{rms}$ voltage measurements and 5-digit frequency counter. Unique software option key provided upon instrument registration enables the features.

**Post-purchase instrument options**

The following products are sold as stand-alone products and can be purchased at any time to add functionality to any MDO4000C product.

| | |
|---|---|
| **MDO4AFG** | Add arbitrary function generator to any MDO4000C Series product.<br>One-time, permanent upgrade to any model enabled through single-use application module hardware key. The hardware key is used to enable the feature and then is not required for future use. |
| **MDO4MSO** | Add 16 digital channels; includes P6616 digital probe and accessories.<br>One-time, permanent upgrade to any model enabled through single-use application module hardware key. The hardware key is used to enable the feature and then is not required for future use. |
| **MDO4SA3** | Add integrated spectrum analyzer with input frequency range of 9 kHz–3 GHz.<br>One-time, permanent upgrade to any model enabled through single-use application module hardware key. The hardware key is used to enable the feature and then is not required for future use. |
| **MDO4SA6** | Add integrated spectrum analyzer with input frequency range of 9 kHz–6 GHz.<br>One-time, permanent upgrade to any model enabled through single-use application module hardware key. The hardware key is used to enable the feature and then is not required for future use. |
| **MDO3SEC** | Add enhanced instrument security to enable password protected control of turning on/off all instrument ports and instrument firmware update functionality.<br>One-time, permanent upgrade to any model enabled through software option key. Software option key products require that the instrument model and serial number be provided at the time of purchase. The software option key is specific to the model and serial number combination. |

**Spectrum analyzer upgrade options**

The spectrum analyzer maximum input frequency range can be upgraded from 3 GHz to 6 GHz. This upgrade requires installation at a Tektronix service center and requires an instrument calibration.

| | |
|---|---|
| **MDO4SA3T6** | 3 GHz to 6 GHz spectrum analyzer upgrade for MDO4000C. |

| | |
|---|---|
| **Post-purchase service products** | The following upgrades can be added to any model to extend the product warranty beyond the standard warranty period. |
| **MDO4024C-R5DW** | Repair service coverage 5 years for a MDO4024C product (includes product warranty period). |
| **MDO4034C-R5DW** | Repair service coverage 5 years for a MDO4034C product (includes product warranty period). |
| **MDO4054C-R5DW** | Repair service coverage 5 years for a MDO4054C product (includes product warranty period). |
| **MDO4104C-R5DW** | Repair service coverage 5 years for a MDO4104C product (includes product warranty period). |
| **MDO4000CT3** | Three year total protection plan ensures that your equipment remains like-new regardless of what happens. Available for 30-days following the initial purchase of the instrument. |
| **MDO4000CT5** | Five year total protection plan ensures that your equipment remains like-new regardless of what happens. Available for 30-days following the initial purchase of the instrument. |

**Bandwidth upgrade options**

Instrument bandwidth can be upgraded on any MDO4000C Series product after initial purchase. Each upgrade product increases the analog bandwidth of the oscilloscope. Bandwidth upgrades are purchased based on the combination of the current bandwidth and the desired bandwidth and whether the current instrument contains an integrated spectrum analyzer. Bandwidth upgrade products include new analog probes if applicable. All analog bandwidth upgrades require installation at a Tektronix service center and an instrument calibration.

| Model to be upgraded | Instrument has option SA3 or SA6 (spectrum analyzer) | Bandwidth before upgrade | Bandwidth after upgrade | Order product |
|---|---|---|---|---|
| MDO4024C | No | 200 MHz | 350 MHz | MDO4BW2T34 |
| | | 200 MHz | 500 MHz | MDO4BW2T54 |
| | | 200 MHz | 1 GHz | MDO4BW2T104 |
| | | 350 MHz | 500 MHz | MDO4BW3T54 |
| | | 350 MHz | 1 GHz | MDO4BW3T104 |
| | | 500 MHz | 1 GHz | MDO4BW5T104 |
| MDO4034C | No | 350 MHz | 500 MHz | MDO4BW3T54 |
| | | 350 MHz | 1 GHz | MDO4BW3T104 |
| | | 500 MHz | 1 GHz | MDO4BW5T104 |
| MDO4054C | No | 500 MHz | 1 GHz | MDO4BW5T104 |
| MDO4024C | Yes | 200 MHz | 350 MHz | MDO4BW2T34-SA |
| | | 200 MHz | 500 MHz | MDO4BW2T54-SA |
| | | 200 MHz | 1 GHz | MDO4BW2T104-SA |
| | | 350 MHz | 500 MHz | MDO4BW3T54-SA |
| | | 350 MHz | 1 GHz | MDO4BW3T104-SA |
| | | 500 MHz | 1 GHz | MDO4BW5T104-SA |
| MDO4034C | Yes | 350 MHz | 500 MHz | MDO4BW3T54-SA |
| | | 350 MHz | 1 GHz | MDO4BW3T104-SA |
| | | 500 MHz | 1 GHz | MDO4BW5T104-SA |
| MDO4054C | Yes | 500 MHz | 1 GHz | MDO4BW5T104-SA |

## Contact Information: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Rev 0415


### 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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Tektronix®

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