MDO3000 Series
Mixed Domain Oscilloscope

Product Selection and Comparison Guide
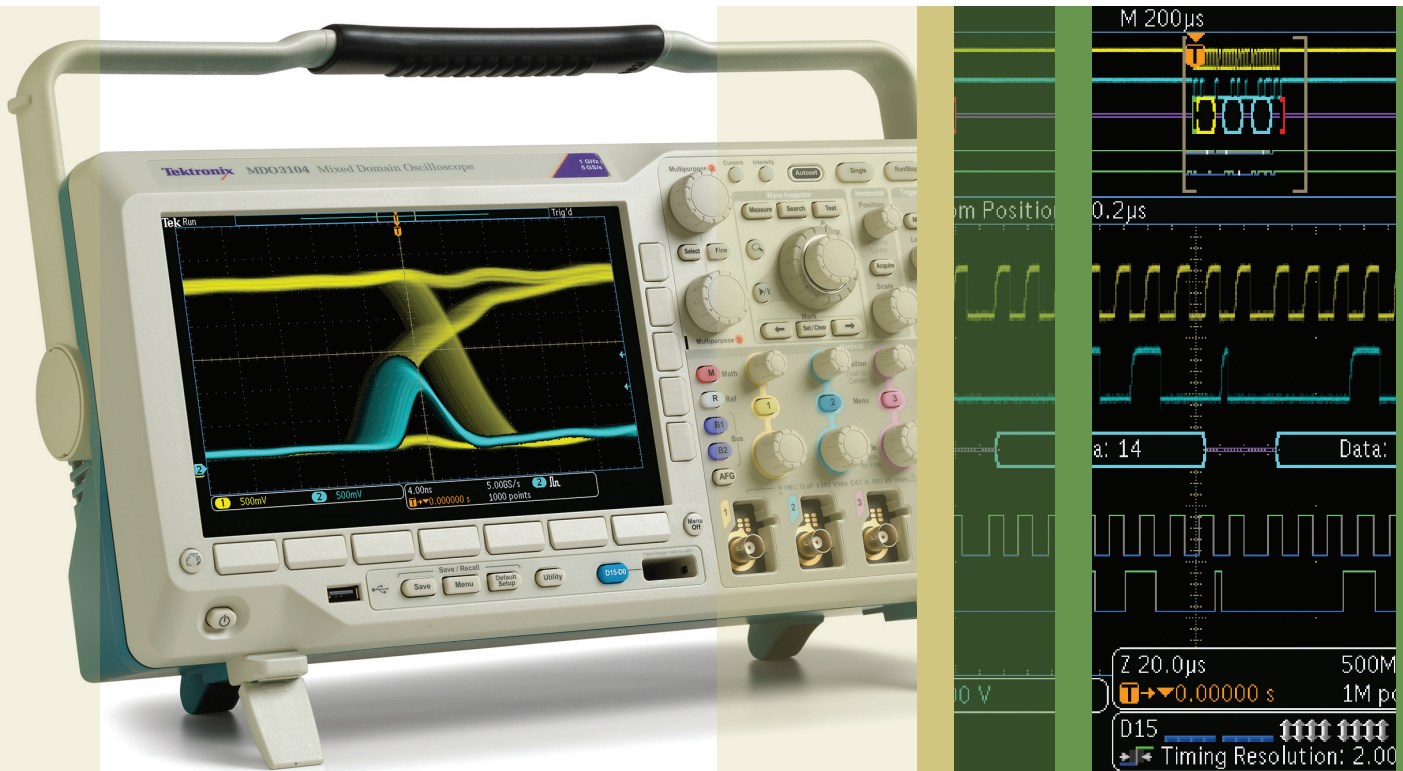
Tektronix®

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About this Guide

By definition, a mixed domain oscilloscope is both an oscilloscope and a spectrum analyzer, enabling you to see the time and frequency domains on one instrument. To help you compare the MDO3000 Series Mixed Domain Oscilloscope to other products on the market, this guide covers key considerations for oscilloscopes, spectrum analyzers and arbitrary function generators along with the benefits of instrument upgradeability.

This guide is intended to simplify the selection and comparison process. Follow these three steps to get a comprehensive, complete comparison. At the end, you'll have all of the information you need to make the best product choice including a detailed, side-by-side product comparison table.

1. Review the oscilloscope, spectrum analyzer and arbitrary function generator sections to determine and finalize your requirements.

2. Read the section on available upgrades and build a plan to fit your applications today, and tomorrow.

3. Fill in the comparison table with any products under evaluation. The key specifications and features of the MDO3000 are pre-filled to give you a head start.

What You'll Find in this Guide

- Key specifications – what they are, why they're important

- Helpful tips for determining your requirements

- Critical features to consider before purchasing

- Common test misconceptions

- Worksheet to guide your evaluation

Oscilloscope Guide

Oscilloscope Types

- **Digital Oscilloscope:** Offers two or four analog channels for visualizing changes in voltage or current over time.

- **Mixed Signal Oscilloscope (MSO):** Offers two or four analog channels, and typically 16 digital channels for visualizing logic signals. When troubleshooting a design with multiple serial or parallel communication buses, the high channel count of an MSO allows up to 20 signals to be visualized simultaneously. With a universal trigger system, the analog and digital channels are triggered at the same time to synchronize the waveforms captured on all channels, providing a distinct advantage over a separate oscilloscope and logic analyzer.

- **Mixed Domain Oscilloscope (MDO):** Offers a built-in spectrum analyzer, in addition to an oscilloscope, enabling you to see the time and frequency domains on one instrument.

Key Specifications

Listed below are the key specifications to determine an oscilloscope's performance, including a detailed definition of the specification and tips for determining what you need.

Bandwidth

All oscilloscopes have a low-pass frequency response that rolls off at higher frequencies. Oscilloscope bandwidth is specified as being the frequency at which a sinusoidal input signal is attenuated to 70.7% of the signal's true amplitude (the -3 dB point).

When measuring high-frequency or fast rise-time signals, oscilloscope bandwidth is especially important. Without adequate bandwidth, an oscilloscope will not be able to display and measure high-frequency changes. It is generally recommended that the oscilloscope's bandwidth be at least 5 times the highest frequency that needs to be measured, minimizing measurement errors due to bandwidth limitations.

Rule: *Bandwidth > 5 X Highest Signal Frequency*
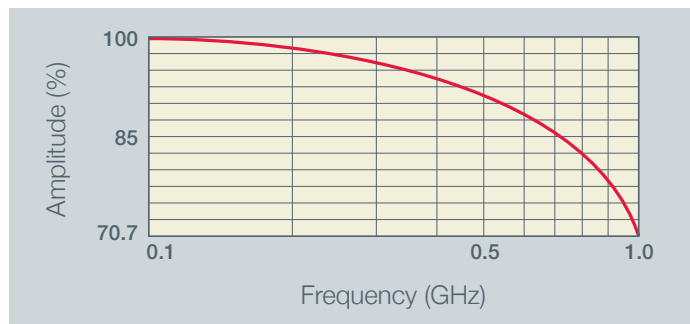
Frequency response curve for a general purpose oscilloscope

Sample Rate

Oscilloscopes sample the input signals at a frequency called the sample rate, measured in samples/second (S/sec). A faster sample rate will provide greater resolution and detail of the displayed waveform. Tektronix recommends at least 5X oversampling to ensure signal details are captured and to avoid aliasing.

Rule: Sample Rate > 5 x Required Bandwidth

⚠ *Caution: Some oscilloscope architectures interleave sample rate across channels which may result in reduced sample rate as channels are turned on. When comparing oscilloscopes, be sure to check the sample rate for your use case, particularly your specific time base settings and number of channels to be used.*

Record Length

Record length is the number of samples the oscilloscope can digitize and store in a single acquisition. Since an oscilloscope can store only a limited number of samples, the waveform duration – or length of "time" captured – will be inversely proportional to the oscilloscope's sample rate. A longer record length enables a longer time window to be captured with high resolution.

Rule: Captured Time = (Record Length) / (Sample Rate)

⚠ *Caution: Some oscilloscope architectures interleave memory across channels which results in reduced record length as additional channels are used. To compensate, these oscilloscope architectures often limit the maximum number of samples based on time base and acquisition settings, and number of channels used. When comparing oscilloscopes, be sure to check the maximum record length for your use case, particularly your specific time base settings and number of channels to be used.*

Waveform Capture Rate

Waveform capture rate refers to how quickly an oscilloscope acquires waveforms, it is expressed as waveforms per second (wfms/s). Oscilloscopes with high waveform capture rates provide significantly more visual insight into signal behavior, and dramatically increase the probability that the oscilloscope will quickly capture transient anomalies such as jitter, runt pulses, glitches and transition errors.

For Mixed Signal Oscilloscopes (MSO)

Digital Thresholds

The threshold setting on a digital channel determines if a logic signal is considered high or low at a specific point in time. Some oscilloscopes allow you to set only one digital threshold for all channels, or one threshold for each group of 8 channels. Others allow you to set a different threshold for each digital channel. Different logic families on your design – ECL, TTL, CMOS, etc. - will require different thresholds, requiring the oscilloscope to support a sufficient number of threshold settings to match the different types of logic families measured at one time.

Timing Resolution

Acquiring a signal with better timing resolution provides a more accurate timing measurement of when the signal changes. Some MSOs internally acquire digital signals with two types of acquisitions at the same time. The first acquisition is with standard timing resolution, and the second acquisition uses a high speed resolution. The standard resolution is used over a longer record length while the high speed timing acquisition offers more enhanced resolution around a narrow point of interest such as the trigger point.

Features to Consider

Oscilloscopes offer a range of different features and functions, from automated measurements and screen cursors, to automated search. Below are two features for you to consider in your next oscilloscope purchase:

Triggering Flexibility

The trigger circuit acts as a comparator. When the incoming signal matches the trigger setting, the oscilloscope generates a trigger and captures the signals on all input channels. Advanced triggers such as runt, pulse width, rise time, serial data packet and logic patterns ensure that critical events are captured.

Waveform Navigation and Search

A 10 Mpoint record length represents thousands of oscilloscope screens of information. Finding a specific event, or every instance of an event such as a runt or specific data packet, can be time-consuming on such a long record. Waveform navigation tools simplify the action of finding specific events and navigating waveform data, saving time.

Compare the MDO3000 Series

Now that you've seen the key specifications and attributes to consider when choosing an oscilloscope, here's a look at how the MDO3000 stacks up. Tektronix MDO3000 Mixed Domain Oscilloscope is the ultimate integrated 6-in-1 oscilloscope that offers a spectrum analyzer, arbitrary function generator (AFG), logic analyzer, protocol analyzer, and digital voltmeter (DVM), enabling you to quickly and cost effectively debug your designs.

Specifications

- Channels
  - o 2 or 4 analog channels
  - o Optional 16 digital channels
  - o 1 spectrum analyzer input
- Bandwidth Models
  - o 100 MHz, 200 MHz, 350 MHz, 500 MHz and 1 GHz
- Maximum Sample Rate
  - o 2.5 GS/s on 500 MHz models and below
  - o 5 GS/s on 1 GHz models
  - o 5X oversampling to ensure signal detail is captured with high resolution
- Record Length
  - o 10 Mpoints on all analog and digital channels
- Digital Channels
  - o 500 MS/s sample rate (2 ns timing resolution) for full record
  - o 8.25 GS/s MagniVu™ sample rate (121.2 ps timing resolution) around the trigger point for precision timing measurements

The MDO3000 is designed for accuracy to ensure that you can see even the smallest signal changes. Every input channel — analog, digital, spectrum analyzer — has its own precision digitizer and dedicated memory to avoid the tradeoffs found in oscilloscopes that use interleaving.

Feature Highlights
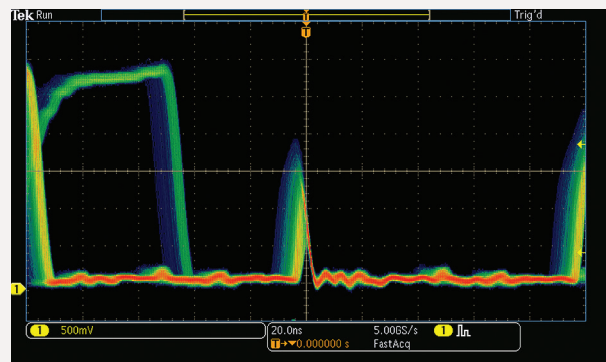
Digital Phosphor Technology with FastAcq™
Digital phosphor technology provides you with fast insight into the real operation of your device. Its fast waveform capture rate – greater than 280,000 wfm/s with FastAcq – along with color-graded display, gives you a high probability of quickly seeing the infrequent problems common in digital systems.
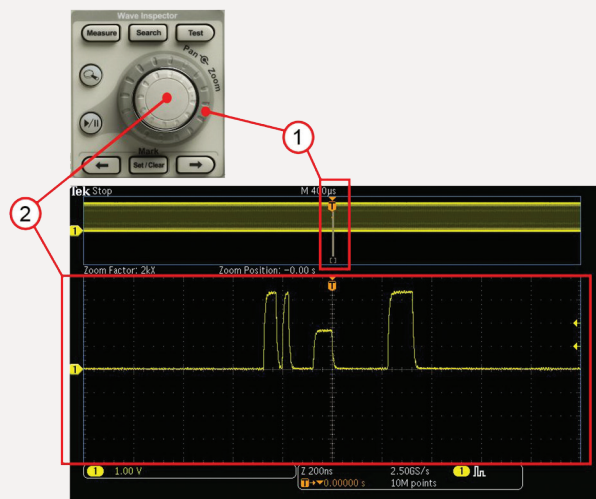
Wave Inspector® Navigation and Automated Search Tools
With Automated Search, and dedicated controls for Pan and Zoom, you can navigate your waveforms simply and easily with Wave Inspector, and find your event of interest in seconds.

Probes: Measurement Accuracy Begins at the Probe Tip

Many oscilloscopes ship standard with a set of passive voltage probes for connecting to the device-under-test (DUT). These passive voltage probes have wide dynamic range and high impedance for probing a variety of signal types with ease. Depending on the signal being measured and the desired measurement, one of the following specialty probes may also be required.

- **Current Probe:** Current probes are used to determine how much current a circuit is using. There are AC-only and AC/DC probes which measure by clamping around a current carrying conductor.

- **Active Voltage Probe:** Active probes are important for measuring high-frequency signals, especially over 500 MHz. These probes provide a low capacitive loading, typically around 1 pF, to minimize loading on the circuit under test.

- **Differential Voltage Probe:** Differential probes are used to measure the voltage difference between two signals, and are used in high-frequency digital communications and sensitive analog circuits.

- **High Voltage Probe:** High-voltage probes are necessary for measuring voltages higher than possible with standard probes – hundreds or even thousands of volts. Differential high-voltage probes are used for taking "floating" or ungrounded measurements on power systems like motor drives, lighting ballasts, and uninterruptible power supplies.

Probes are designed to mate with specific oscilloscopes, ensuring good impedance matching at the probe-oscilloscope interface. It is important to consider which probe types are needed for your specific application then check that the oscilloscope you are considering offers suitable probes. Otherwise, an expensive adapter may be required to mate an after-market probe or different manufacturer's probe to the oscilloscope.

Probes and oscilloscopes can also communicate to simplify the process of measurements. Many probes include technology that allows the oscilloscope to determine the correct scaling factor, but newer probes also let you know when a probe encounters an error, and allow you control ranging and operations like current probe degaussing from the front panel of the instrument.

⚠ *Caution: Most passive voltage probes included standard with the oscilloscope have a maximum bandwidth of 500 MHz. If using a 1 GHz bandwidth oscilloscope, a specialty active voltage probe may be required to utilize the full bandwidth of the oscilloscope. Be sure to check the exact specifications of the probe included with the oscilloscope.*

Compare the MDO3000 Series

When it comes to probing, the MDO3000 has you covered. Each MDO3000 ships standard with TPP passive voltage probes for testing right out of the box. The TPP probes will match or exceed the bandwidth of the oscilloscope, meaning no specialty probes are required to use the full bandwidth of your oscilloscope. With 3.9 pF of capacitive loading, the TPP probes are not only high impedance but also low loading to minimize the effect of the probe on your circuit's operation, offering the performance of an active probe with the flexibility of a passive probe.

If you need to measure current or differential voltage signals, or very low level signals, the MDO3000 features a TekVPI® interface to connect seamlessly to a wide range of specialty Tektronix probes. TekVPI probes feature status indicators and controls, as well as a probe menu button right on the probe compensation 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, too.

Probes Included Standard with the MDO

- TPP Series Passive Voltage Probes
    - o TPP0250: 250 MHz passive voltage probes ship standard on 100MHz, 200MHz models
    - o TPP0500B: 500MHz passive voltage probes ship standard on 350MHz, 500MHz models
    - o TPP1000: 1GHz passive voltage probes ship standard on 1GHz models
- Every TPP probe has 3.9 pF of capacitive loading, 10X attenuation, and 10 MΩ input impedance at the probe tip to minimize its effect on your circuit

Special Consideration

Protocol Analysis for Serial Buses

Options to add protocol analysis of common serial buses – I²C, SPI, RS-232, CAN, LIN, USB and more – are available on full-featured oscilloscopes. The protocol analysis function will decode a defined bus, display the bus data aligned with the individual waveforms that make up the bus, and provide extensive triggering for common bus events, saving significant time and energy over manual decode and ensuring the right bus event is captured.

When evaluating the built-in protocol analysis functions on different oscilloscopes, here are a few key parameters to consider.

- Supported serial bus standards

- Configurable settings for each serial bus

- Number of serial buses that can be decoded at one time

- Available trigger events for each serial bus

- Number of data packets that can be captured as determined by record length

- Available search tools for each serial bus

⚠ **Caution:** *Separate protocol analyzers are also available and may provide a more inexpensive option. However, be sure to check which standards are supported by the analyzer, often it's only one, and how many separate protocol analyzers will be required for each design. Another consideration is triggering. When a data packet or bus error occurs, the offline protocol analyzer will be unable to generate a trigger for your oscilloscope to capture the problem waveforms, which prevents further analysis and identification of root cause.*

Compare the MDO3000 Series

The MDO3000 offers optional protocol analysis packages for a wide range of buses, enabling you to decode your serial bus right on your oscilloscope. Now you can see when you have an error in your data transmission, but more importantly, also see why. Because the decoded bus packets are synchronized with the actual waveforms, you can identify what's causing the error and quickly identify root cause.

Serial Analysis Options for the MDO

- Protocol analysis modules are available for the following buses - I²C, SPI, RS-232/422/485/UART, CAN, LIN, FlexRay, USB2.0, MIL-STD-1553, I²S/LJ/RJ/TDM

- Decode up to 2 serial or parallel buses at once

- Extensive triggers for common bus events including start of packet, specific addresses, specific data content, and unique identifiers

- Event Table to show all captured packets in a tabular view
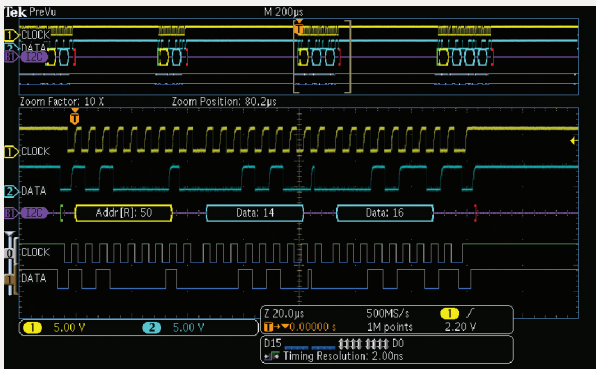
Feature Highlight
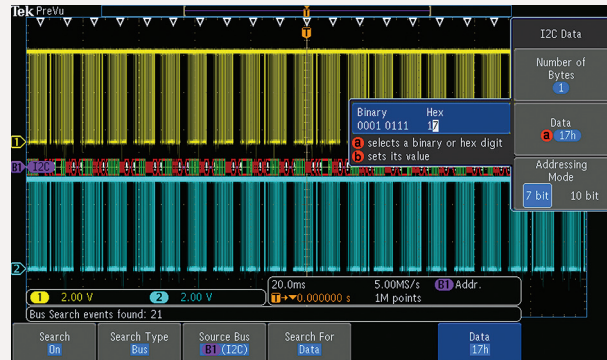
Wave Inspector® Navigation and Automated Search Tools

Wave Inspector® enables you to find every instance of your specific bus event in seconds with the built-in Automated Search function.

Spectrum Analyzer Guide

Spectrum Analyzer Types

Fundamentally, a spectrum analyzer plots the magnitude vs. frequency of an input signal over a frequency span of interest. Different classes of instruments use different techniques to acquire and build the desired display. Capture bandwidth is a key specification in understanding how these different instruments work, and it refers to the amount of spectrum that can be acquired at once, or in a single acquisition. If the user sets a span wider than the capture bandwidth, then the analyzer must make multiple acquisitions to sweep through the desired span. This might miss key information, especially on signals that are bursty, frequency hopping or use wide bandwidth modulation schemes.

- **Traditional Spectrum Analyzer:** The input signal is mixed with a local oscillator which sweeps through the desired frequency span. The resulting intermediate frequency (IF) signal passes through a Resolution Bandwidth (RBW) filter that determines the frequency resolution. The resulting amplitude from the filter is then plotted versus frequency as the RBW is swept through the span. In addition to determining frequency resolution the RBW also limits capture bandwidth. Most spectrum analyzers have capture bandwidths of 10 MHz to 25 MHz. Some higher end models have options that extend capture bandwidth to hundreds of megahertz.

- **Mixed Domain Oscilloscope (MDO):** An oscilloscope that in addition to the usual analog or digital channels also includes an integrated spectrum analyzer. While MDOs have RBW filters to determine frequency resolution, the filter does not limit capture bandwidth, making these instruments ultra wide bandwidth spectrum analyzers with up to 3.75 GHz of capture bandwidth.

- **Real-time Spectrum Analyzer (RSA):** ng power, a real-time spectrum analyzer is able to continuously acquire, process and display all spectrum activity within the capture bandwidth. RSAs introduce an important new specification called 100% Probability of Intercept (POI) that guarantees the instrument will capture RF pulses as long as they meet a minimum signal duration. RSAs are often used to analyze signals that are frequency-agile or have unknown, intermittent issues.

- **Vector Signal Analyzer (VSA):** VSAs are spectrum analyzers that use digital signal processing to extract the in-phase (I) and quadrature (Q) data of the digitized, down-converted signal. The I and Q data may be used to generate the traditional amplitude vs. frequency display, but are most often used for analyzing the quality of digital communications signals with tools like Error Vector Magnitude (EVM) measurements and Spectral Emission Mask (SEM) testing.

Key Specifications

Listed below are the critical specifications to determine a spectrum analyzer's performance, including a detailed definition of the specification and tips for determining what you need.

Capture Bandwidth

Capture bandwidth is the portion of the spectrum that can be acquired at one point in time. Capture bandwidth is important for dynamic RF signals, such as spread spectrum and frequency hopping signals. If the capture bandwidth is too narrow, only a small portion of the spectrum will be captured in one acquisition. As a result, an important event may be happening in another portion of the spectrum and not be captured.

Frequency Range

Frequency range is the range of frequencies that can be measured by the spectrum analyzer. It is worth remembering that the maximum frequency to be viewed should include the harmonics and intermodulation products of the wanted signals. The lowest frequency specification may also be important, as spectrum analyzers are often AC-coupled creating a lower cut-off point.

RBW (Resolution Bandwidth)

RBW is the minimum bandwidth over which two signals can be separated. For example, with an RBW of 20 Hz, two signals at 2.02 kHz and 2 kHz would be distinguishable. The RBW determines the spectrum analyzer's ability to resolve closely spaced frequency components.

DANL (Display Average Noise Level)

DANL is the noise generated within the spectrum analyzer itself, limiting the ability to measure low-level signals. DANL is specified in dBm at the smallest RBW setting of the spectrum analyzer. An input signal below this level cannot be detected. Some spectrum analyzers offer a pre-amplifier option to reduce the DANL of the analyzer, improving system sensitivity.

SFDR (Spurious Free Dynamic Range)

The ratio, in dB, between the largest and smallest signals simultaneously present at the spectrum analyzer input that can be measured to a given degree of accuracy. SFDR is critical because it indicates if the spurs being seen on the display are truly part of the input signal or generated by the spectrum analyzer itself. For accurate measurements on a signal, the distortions created by the spectrum analyzer must be well below the levels being measured.

Phase Noise

Phase noise is caused by instability of the spectrum analyzer's local oscillator, and affects its ability to resolve low-level signals close in to the carrier signal. Phase noise is specified in terms of dBc or dB relative to the carrier and normalized to a 1 Hz RBW. The phase noise specification is important when the phase noise of a signal source, such as a transmitter, needs to be measured. The instrument's specification should be 10 dB better than the device signal being measured to minimize effect on measurement accuracy.

Features to Consider

Spectrum analyzers offer a range of different features and functions, from automated measurements and markers, to frequency versus time traces. Below are two features for you to consider in your next spectrum analyzer purchase.

Spectrogram

In a spectrogram display the frequency is represented on the x-axis, just like a typical spectrum display. However, the y-axis represents time, and the power (amplitude) is expressed by the color. When there are multiple signals in the measured environment, or one signal with an elevated noise level or intermittent spurs, the spectrogram provides visualization of all the frequency and amplitude activity across the chosen span. A spectrogram display is ideal for monitoring slowly changing RF phenomena.

Automated Peak 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. Automated peak markers automatically place 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.

Compare the MDO3000 Series

Now that you've seen the key specifications and attributes to consider when choosing a spectrum analyzer, here's a look at how the MDO3000 stacks up.

Specifications

- Frequency Range
  - MDO3012, MDO3014 models: 9 kHz to 100 MHz
  - MDO3022, MDO3024 models: 9 kHz to 200 MHz
  - MDO3032, MDO3034 models: 9 kHz to 350 MHz
  - MDO3052, MDO3054 models: 9 kHz to 500 MHz
  - MDO3102, MDO3104 models: 9 kHz to 1 GHz
  - Frequency range upgradeable to 9 kHz to 3 GHz on all models

- Capture Bandwidth
  - MDO3012, MDO3014 models: 100 MHz
  - MDO3022, MDO3024 models: 200 MHz
  - MDO3032, MDO3034 models: 350 MHz
  - MDO3052, MDO3054 models: 500 MHz
  - MDO3102, MDO3104 models: 1 GHz
  - All models: 3 GHz with option MDO3SA

- Resolution Bandwidth (RBW): 20 Hz - 150 MHz

- Displayed Average Noise Level (DANL)
  - Specification:
    - < -109 dBm/Hz for 9 kHz - 50 kHz
    - < -126 dBm/Hz for 50 kHz – 5 MHz
    - < -138 dBm/Hz for 5 MHz – 2 GHz
    - < -128 dBm/Hz for 2 GHz - 3 GHz
  - Specification with Pre-Amplifier (TPA-N-PRE)
    - < -117 dBm/Hz for 9 kHz - 50 kHz
    - < -136 dBm/Hz for 50 kHz – 5 MHz
    - < -148 dBm/Hz for 5 MHz – 2 GHz
    - < -138 dBm/Hz for 2 GHz - 3 GHz

- Spurious Free Dynamic Range (SFDR)
  - 2nd Harmonic Distortion
    (>100 MHz) <-55 dBc (<-60 dBc typical)
  - 3rd Harmonic Distortion
    (>100 MHz) <-53 dBc (<-58 dBc typical)
  - 2nd Order Intermodulation Distortion
    (>15 MHz) <-55 dBc (<-60 dBc typical)
  - 3rd Order Intermodulation Distortion
    (>15 MHz) <-55 dBc (<-60 dBc typical)

- Phase Noise at 1 GHz CW
  - < -81 dBc/Hz at 10 kHz offset
  - < -97 dBc/Hz at 100 kHz offset
  - < -118 dBc/Hz at 1 MHz offset

Feature Highlights
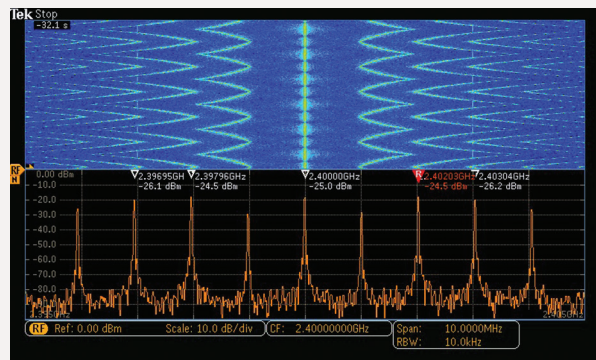
Spectrogram Display
Use the built-in spectrogram display to see how your spectrum's peaks are changing in both frequency and amplitude – ideal for monitoring slow-changing RF phenomena.
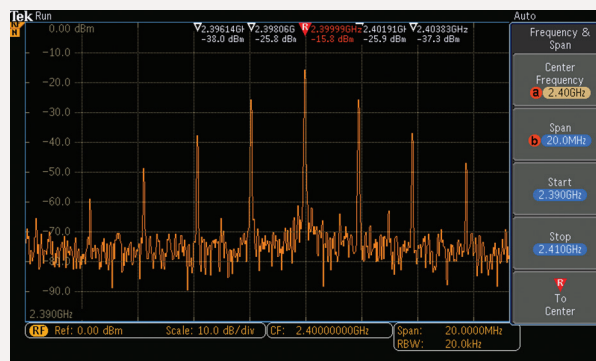
Automated Markers
Define threshold and excursion values, and the MDO3000 will automatically search your entire spectrum and mark all peaks that meet your criteria, enabling you to quickly see each peak's frequency and amplitude.

The MDO3000's wideband architecture offers up to 3 GHz instantaneous capture bandwidth. No other spectrum analyzer on the market offers a capture bandwidth of greater than 165 MHz. Now you can see your entire spectrum of interest at once, and not miss elusive spectral events because your spectrum analyzer is tuned to a different part of the spectrum.

Comparison of a Spectrum Analyzer and Oscilloscope FFT

Many oscilloscopes have the ability to perform a Fast Fourier Transform (FFT) math operation on input signals to the oscilloscope's analog channels. This provides a quick way to see a frequency domain representation of the input signal.

However, frequency coverage is often a concern when using an oscilloscope to troubleshoot a wireless system. Because the oscilloscope's front-end circuitry acts as a low pass filter, only frequency components less than the bandwidth of the oscilloscope will be viewable. For example, to see a 2.4 GHz radio output will require an oscilloscope with greater than 2.4 GHz bandwidth. To avoid attenuation of higher order frequency components, a 12 GHz oscilloscope bandwidth should be used. Also, spectrum analyzers have measurement systems that are optimized for RF signals and have dynamic ranges of 60 dBc or greater. Oscilloscopes have dynamic ranges of around 45 dBc.

Compare the MDO

The MDO3000 is designed with an independent spectrum analyzer acquisition system for the most accurate RF measurements. Now you can confidently use one instrument as an oscilloscope and spectrum analyzer without compromising on performance.

The spectrum analyzer input of the MDO3000 is available with frequency coverage up to 3 GHz, to provide coverage for the most common commercial wireless bands.
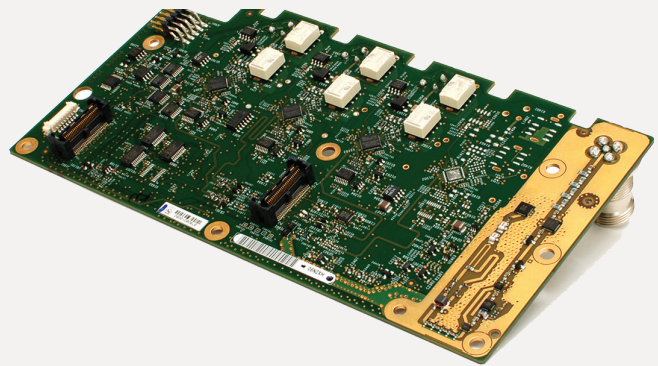
Signal Generator Guide

Signal Generator Types

- **Function Generators:** Designed to output waveforms with analog characteristics. These may range from analog waveforms such as sine and triangle to "square" waveforms. You can control amplitude, frequency, and phase as well as DC offset and rise and fall time.

- **Arbitrary/Function Generators:** These generators offer the same standard waveforms as traditional function generators, but the typically use direct digital synthesis to achieve better frequency and phase agility. They also provide the ability to generate user-defined (arbitrary) waveforms.

Key Specifications

Listed below are some common specifications that you may want to consider when choosing a signal generator for your application.

Output Frequency (Bandwidth)

Like an oscilloscope, a function generator has a bandwidth but in this case the bandwidth applies to the output channel. The function generator's bandwidth also rolls off as it approaches its specified frequency. You will find that there are different frequencies for each of the standard waveforms, so review the specifications for any waveform you plan to use.

Vertical (Amplitude) Resolution

Vertical resolution pertains to the binary word size, in bits, of the instrument's DAC, with more bits equating to higher resolution. The vertical resolution of the DAC defines the amplitude accuracy and distortion of the waveform. While more is better, there is a general trade-off for most arbitrary waveform instruments, the higher the resolution the lower the sample rate.

Sample (Clock) Rate

Sample rate, usually specified in terms of megasamples or gigasamples per second, denotes the maximum clock or sample rate at which the instrument can output waveform points. Since the arbitrary generator has a fixed record length, sample rate determines the maximum duration of arbitrary waveforms. The maximum sample rate also determines the smallest time increment that can be used to create waveforms. Typically this figure is simply the result of the calculation; $T = 1/F$, where T is the timing resolution in seconds and F is the sample rate.

Memory Depth (Record Length)

Memory depth, or record length, plays an important role in signal fidelity because it determines how many points of data can be stored to define a waveform. Deeper memory enables you to store more waveform detail and/or more cycles of the desired waveform.

Features to Consider

Signal generators offer a range of features and output capabilities. When choosing your signal generator, you should also evaluate standard waveforms, modulation capabilities, output amplitude and waveform editing software to ensure that the instrument meets your needs.

Compare the MDO3000 Series

Now that you've seen the key specifications and attributes to consider when choosing a signal generator, here's a look at how the MDO3000 integrated arbitrary function generator stacks up.
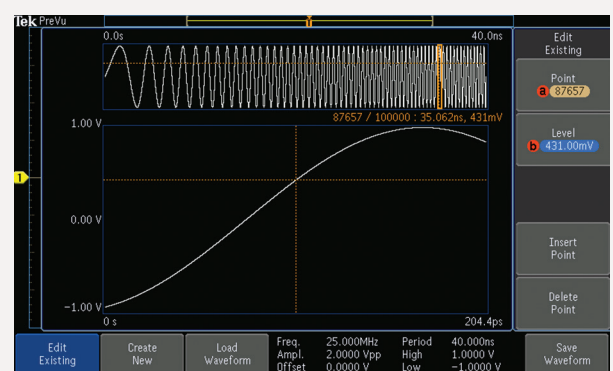
Specifications

- Waveform type
  - o Sine, Square, Pulse, Ramp, DC, Noise, Sin(x)/x (Sinc), Gaussian, Lorentz, Exponential Rise, Exponential Decay, Haversine, Cardiac, and Arbitrary.
- Arbitrary Sample Rate
  - o 250 MS/s
- Record Length
  - o 128 kpoints arbitrary record length
- Bandwidth
  - o 50 MHz (Sine), 25 MHz (Square/Pulse), 5 MHz (Gaussian, Lorentz, Exponential Rise/Fall, Haversine), 2 MHz (Sin(x)/x), 500 kHz (Ramp/Triangle)
- Amplitude Range
  - o 10mV – 2.5V* max Into 50Ω
  - o 20mV – 5V* max into Hi-Z

The MDO3000 optional, integrated arbitrary function generator is available all the time — whether the scope is measuring in the time domain or frequency domain, — which saves valuable bench space and enables closed loop testing with a single instrument.

* Varies by model.

Feature Highlights

Use the built-in waveform editor or Tektronix ArbExpress® PC-based waveform creation and editing software to make waveform creation fast and easy.

Upgrade Now or Later

The MDO3000 is completely customizable and fully upgradeable. Add functionality, increase bandwidth or spectrum analyzer frequency range over time as your needs change or budget allows.

Most engineers don't know what projects they'll be working on several years from now. Some engineers realize their current scopes will not fulfill their next design requirement anymore. The MDO3000's extensive offering of upgrades protect your investment and ensure product usefulness for years to come. For people who have insufficient budget, you could upgrade product performance and functionality whenever you can afford it. Listed below are performance and functionality upgrade options. The following products are sold as stand-alone products and can be purchased at any time to add functionality to any MDO3000 product.

Performance Upgrades

Product	Performance Upgrade
MDO3SA	**Spectrum Analyzer Frequency Range Upgrade** Increase spectrum analyzer input frequency range to 9 kHz – 3 GHz and capture bandwidth to 3 GHz.
MDO3BWxTx2* MDO3BWxTx4*	**Oscilloscope Bandwidth Upgrade** Upgrade MDO3000 Series bandwidth up to 1 GHz after initial purchase.

* Specific product to order depends on analog channel count, the current bandwidth level, and the future bandwidth level.

Functional Upgrades

These upgrades can be performed at any time, without having to send the instrument in for service. Once the upgrade is done, the instrument has the new capabilities permanently.

Product	Functional Upgrade - One-Time Permanent Upgrade
MDO3AFG	Add arbitrary function generator to any MDO3000 Series product. *One-time, permanent upgrade to any model enabled through single-use application module hardware key.*
MDO3MSO	Add 16 digital channels; includes P6316 digital probe and accessories. *One-time, permanent upgrade to any model enabled through single-use application module hardware key.*
MDO3SEC	Add password protected security to enable or disable all communication ports and firmware upgrades to any MDO3000.

Application Modules

You can always add the ability to decode and trigger on additional serial buses with application modules. Power measurements and limit/mask testing are also added with application modules.

Product	Application Modules
MDO3AERO	MIL-STD-1553 serial bus triggering and analysis module for the MDO3000
MDO3AUDIO	Audio serial triggering and analysis module for the MDO3000
MDO3AUTO	Automotive serial triggering and analysis module for the MDO3000 (CAN, LIN)
MDO3COMP	Computer serial triggering and analysis module for the MDO3000 (RS-232/422/485/UART bus support)
MDO3EMBD	Embedded serial triggering and analysis module for the MDO3000 (I^2C, SPI)
MDO3FLEX	FlexRay™ serial triggering and analysis module for the MDO3000
MDO3USB	USB2.0 (LS, FS) serial bus triggering and analysis and (HS decode – 1GHz models only) analysis module for the MDO3000
MDO3LMT	Limit/mask test for MDO3000
MDO3PWR	Automated power measurements for the MDO3000

Comparison Worksheet

To help you compare the MDO3000 Series Mixed Domain Oscilloscope to other products on the market, this worksheet provides key considerations for oscilloscopes and related instruments. When you're done, you'll have an extensive comparison sheet to print and review before making your decision.

Step 1: Select an MDO3000 Model

First, you'll need to decide on the required channel count, bandwidth and sample rate for your oscilloscope, and frequency range for your spectrum analyzer. This will then determine which MDO3000 model is best for you. The other specifications are the same for all models.

	Analog			Spectrum Analyzer	
Models	Channel	Bandwidth	Sample Rate	Input	Frequency Range Standard / Optional
MDO3012	2	100 MHz	2.5 GS/s	1	9 kHz - 100 MHz / 9 kHz - 3 GHz
MDO3014	4	100 MHz	2.5 GS/s	1	9 kHz - 100 MHz / 9 kHz - 3 GHz
MDO3022	2	200 MHz	2.5 GS/s	1	9 kHz - 200 MHz / 9 kHz - 3 GHz
MDO3024	4	200 MHz	2.5 GS/s	1	9 kHz - 200 MHz / 9 kHz - 3 GHz
MDO3032	2	350 MHz	2.5 GS/s	1	9 kHz - 350 MHz / 9 kHz - 3 GHz
MDO3034	4	350 MHz	2.5 GS/s	1	9 kHz - 350 MHz / 9 kHz - 3 GHz
MDO3052	2	500 MHz	2.5 GS/s	1	9 kHz - 500 MHz / 9 kHz - 3 GHz
MDO3054	4	500 MHz	2.5 GS/s	1	9 kHz - 500 MHz / 9 kHz - 3 GHz
MDO3102	2	1 GHz	5 GS/s	1	9 kHz - 1 GHz / 9 kHz - 3 GHz
MDO3104	4	1 GHz	5 GS/s	1	9 kHz - 1 GHz / 9 kHz - 3 GHz

Step 2: Select other Products for your Evaluation

Once you've chosen the other products, you'll be comparing them to the MDO3000. Fill in their information and features in the table below; each blue input field is editable. The details for the MDO3000 have been filled in for you. Don't forget to save the file when you're done. **Note: The cursor must be outside the form in order to save your data. Simply click outside the form and save.**

	MDO3000 Series	Option A:	Option B:
Oscilloscope			
Bandwidth	100 MHz, 200 MHz, 350MHz, 500 MHz, 1 GHz (circle one)		
Sample Rate (All Channels On) ⚠[1]	2.5 GS/s		
Record Length/ Math Record ⚠[1]	10 Mpoints on each channel/ controllable by the user		
Triggers	Edge, Sequence, Logic, Pulse Width, Runt, Timeout, Set-up and Hold, Rise/Fall Time, Parallel, Video, Serial Bus Events* (*Optional)		
Waveform Navigation Tools	Wave Inspector® pan/zoom controls and automated search		
Spectrum Analyzer			
Frequency Coverage	**Standard:** 9 kHz to oscilloscope bandwidth **Optional:** 9 kHz - 3 GHz		
Capture Bandwidth ⚠[2]	**Standard:** oscilloscope bandwidth **Optional:** 3 GHz		
Display Average Noise Level (DANL)	**Specification:** 9KHz to 50KHz: < -109 dBm/Hz 50KHz to 5MHz: < -126 dBm/Hz 5MHz to 2GHz: < -138 dBm/Hz 2GHz to 3GHz: < -132 dBm/Hz **Specification with Pre-Amplifier (TPA-N-PRE):** 9KHz to 50KHz: < -117 dBm/Hz 50KHz to 5MHz: < -136 dBm/Hz 5MHz to 2GHz: < -148 dBm/Hz 2GHz to 3GHz: < -138 dBm/Hz *Typical values are lower*		
Spurious Free Dynamic Range ⚠[3]	**2nd harmonic distortion** (>100 MHz) < -55 dBc (< -60 dBc typical) **3rd harmonic distortion** (>100MHz) < -53 dBc (< -58 dBc typical) **2nd order intermodulation distortion** (>15 MHz) < -55 dBc (< -60 dBc typical) **3rd order intermodulation distortion** (>15 MHz) < -55 dBc (< -60 dBc typical)		
Phase Noise	Specification at 1 GHz CW: < -81 dBc/Hz at 10 kHz offset < -97 dBc/Hz at 100 kHz offset < -118 dBc/Hz at 1 MHz offset		
Analysis Tools	• Automated Markers • Spectrogram • Automated RF Measurements		

(Step 2 continued)

Note: The cursor must be outside the form in order to save your data. Simply click outside the form and save.

	MDO3000 Series	Option A:	Option B:
Arbitrary Function Generator			
Number of Standard Waveforms	13		
Maximum Frequency	50 MHz (Sine)		
Arbitrary Memory Depth	128k points		
Maximum Amplitude Range	10 mV p-p to 2.5 V p-p into 50Ω 20 mV p-p to 5 V p-p into Hi-Z		
PC-based Waveform Creation Software	ArbExpress®		
Protocol Analyzer for Serial Bus			
Number of Buses Decoded at Once	2		
Supported Serial Standards ⚠[4]	I^{2}C, I^{2}S, SPI, USB, CAN, LIN, RS-232, FlexRay, Mil-Std-1553		
Search Tools	Wave Inspector® pan and zoom controls, manual marks, automated search for all available serial standards		
Logic Analyzer			
Number of Channels	16		
Number of Threshold Settings	2 (One per 8 digital channel pod)		
Maximum Timing Resolution	121.2 psec (MagniVu™)		
Digital Voltmeter			
Voltage Measurements	4-digit AC RMS, DC, AC+DC RMS		
Frequency Counter	5-digit Frequency		
Instrument Upgradeability (Post-Purchase)			
Oscilloscope Bandwidth	Yes		
Additional Serial Bus Supports	Yes		
Arbitrary Function Generator	Yes		
Digital Voltmeter	Yes		
Logic Analyzer (16 digital channels)	Yes		
Spectrum Analyzer Frequency Range	Yes		
Additional Analysis			
Power Measurements	Optional		
Limit/Mask Test	Optional		
Advanced Video Triggers and Analysis	Standard		

Cautions:

1. Some oscilloscope architectures utilize interleaving; recommend filling in specifications for when all channels are in use unless you are confident your application will not require more than two channels at a time

2. Capture bandwidth is the portion of the spectrum that can be acquired at one point in time. Most Spectrum Analyzers have a capture bandwidth of 10 MHz; performance instruments offer up to 165 MHz. Capture Bandwidth is also called Real-time Bandwidth or Maximum Analysis Bandwidth.

3. Spurious Free Dynamic Range is also known as Spurious Response. It is often reported as several different values, each one focused on a different source of spurs - harmonic distortion, third-order intermodulation, IF and Image Rejection. Choose the highest value for Spurious Free Dynamic Range; this will give you the worst case scenario.

4. Separate protocol analyzers are also available and may provide a more inexpensive option. However, be sure to check which standards are supported by the analyzer, often its only one, and how many separate protocol analyzers will be required for each design. Another consideration is triggering. When a data packet or bus error occurs, the offline protocol analyzer will be unable to generate a trigger for your oscilloscope to capture the problem waveforms, allowing for further analysis and identification of root cause.

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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