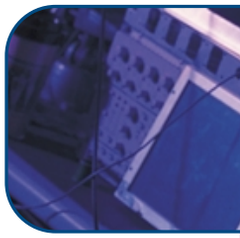
Imagine Perfect Vision



Oscilloscope Selection Guide

Tektronix

Enabling Innovation

www.tektronix.com

Oscilloscopes
Logic Analyzers
Signal Sources
Protocol Analyzers
Communications Test Equipment
Video Test Equipment
Probes
Accessories
Other Test and Measurement Equipment

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 “Resources For You” on our Web site at
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Tektronix
Enabling Innovation

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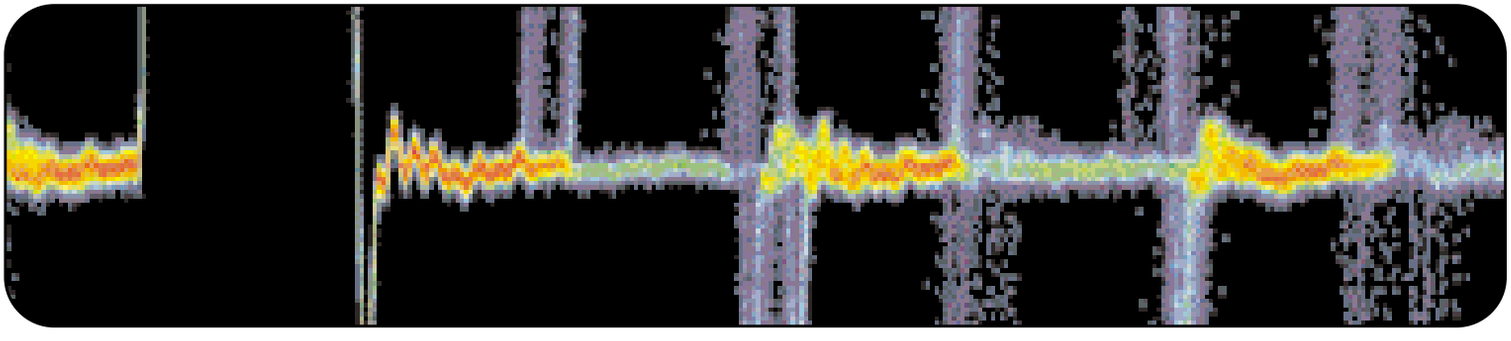
If I could...
Imagine perfect vision

With the right oscilloscope you can create better designs, in less time. You can characterize circuit performance with greater precision and confidence. You can verify system compliance more easily. And, you can streamline troubleshooting by finding the most elusive events quickly. The right oscilloscope can give you perfect vision. This selection guide is designed to help you evaluate the criteria essential to choosing the right oscilloscope for your application, and your budget.

Just imagine what perfect vision could mean to you.

If I could...

...be sure I have enough...



Higher Speeds Demand Greater Bandwidth

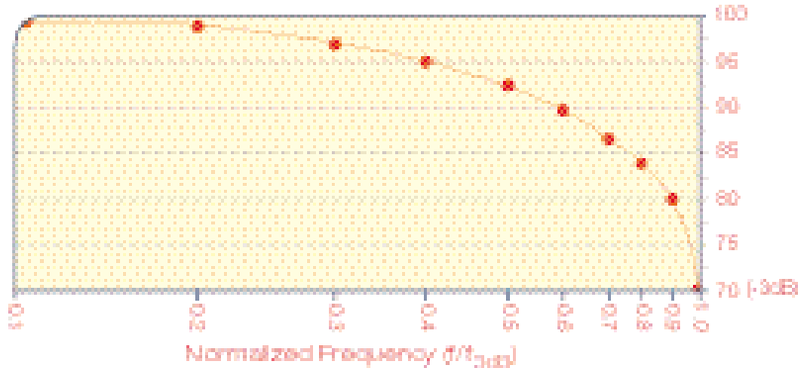
Bandwidth is the most important single criterion in choosing an oscilloscope. It determines an oscilloscope's fundamental ability to measure a signal. Without adequate bandwidth, your oscilloscope will not be able to resolve high-frequency changes. Amplitude will be distorted. Edges will vanish. Details will be lost. Without adequate bandwidth, all the features, bells and whistles will mean nothing.

Oscilloscope bandwidth is specified as the lowest frequency at which a sinusoidal input signal is attenuated to 70.7% of the signal's true amplitude. To determine the oscilloscope bandwidth required to accurately characterize signal amplitude in your specific application, apply the "5 Times Rule."

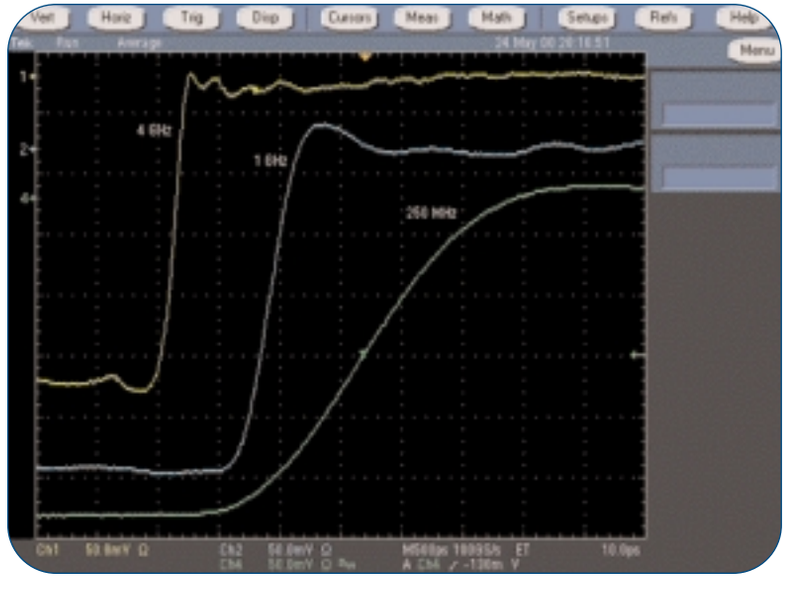
The 5 Times Rule
Oscilloscope Bandwidth Required =
Highest Frequency Component of Measured Signal x 5

An oscilloscope selected using the 5 Times Rule will give you greater than ±2% accuracy in your measurements – typically sufficient for today's applications. However, as signal speeds increase, it may not be possible to achieve this rule of thumb. Always keep in mind that the higher the instrument bandwidth, the more accurate the reproduction of your signal… and the longer the useful life of the oscilloscope. When it comes to bandwidth, you can never have too much!

Tektronix offers the widest selection of oscilloscopes available, offering bandwidths from 60 MHz up to 70 GHz and beyond. Check the Selection Guide at the right for the oscilloscopes that meet your bandwidth requirement.



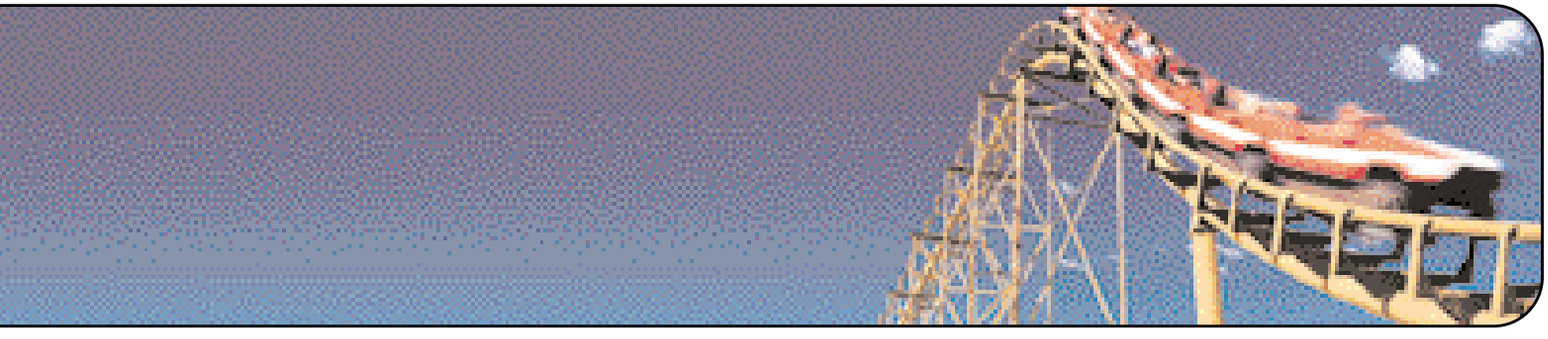
Oscilloscope bandwidth is the frequency at which a sinusoidal input signal is attenuated to 70.7% of the signal's true amplitude, known as the –3 dB point.



The higher the bandwidth, the more accurate the reproduction of your signal, as illustrated with a signal captured at 250 MHz, 1 GHz and 4 GHz bandwidth levels.

If I could...

...accurately characterize
high-speed digital signals...



In Digital Systems, Rise Time Is Paramount

In the digital world, rise time measurements are critical. Your oscilloscope must have sufficient rise time to accurately capture the details of rapid transitions.

To calculate the oscilloscope rise time required for your signal type, use the following equation:

Oscilloscope Rise Time Required = Fastest Rise Time of Measured Signal ÷ 5

Notice that this basis for oscilloscope rise time selection is similar to that for bandwidth. As in the case of bandwidth, achieving this rule of thumb may not always be possible given the extreme speeds of today's signals. Always remember that an oscilloscope with faster rise time will more accurately capture the critical details of fast transitions.

In some applications, you may know only the rise time of a signal. A constant allows you to relate the bandwidth and rise time of the oscilloscope, using the equation:

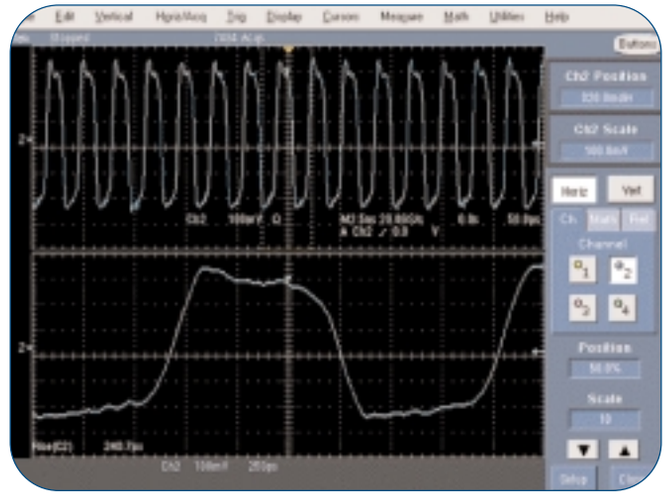
$$\text{Bandwidth} = \frac{k}{\text{Rise Time}}$$

where *k* is a value between 0.35 and 0.45, depending on the shape of the oscilloscope's frequency response curve and pulse rise time response. Oscilloscopes with a bandwidth of <1 GHz typically have a 0.35 value, while oscilloscopes with a bandwidth >1 GHz usually have a value between 0.40 and 0.45.

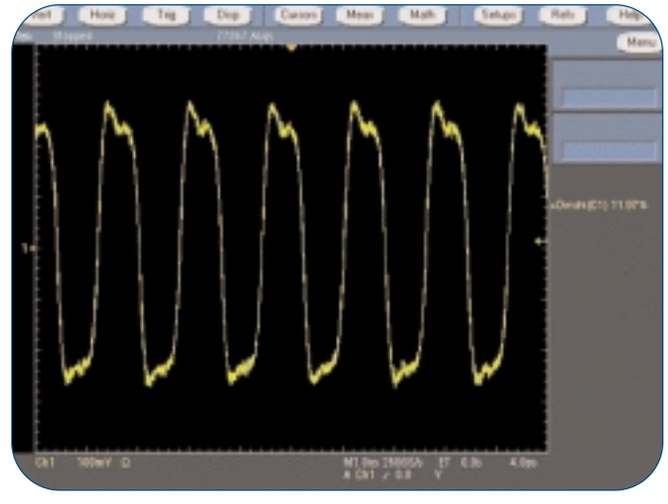
Tektronix offers oscilloscopes with rise times to match applications that range from the slower rise times of TTL logic to today's fastest CMOS, ECL and GaAs logic.

Logic Family	Typical Signal Rise Time	Calculated Signal Bandwidth	Bandwidth Required
TTL	2 ns	175 MHz	875 MHz
CMOS	1.5 ns	230 MHz	1.15 GHz
GTL	1 ns	350 MHz	1.75 GHz
LVDS	400 ps	875 MHz	4.375 GHz
ECL	100 ps	3.5 GHz	17.5 GHz
GaAs	40 ps	8.75 GHz	43.75 GHz

Some logic families produce inherently faster rise times than others, which may prove important in your selection of an oscilloscope.



Rise time characterization of a high-speed digital signal.



Fast edge rates coupled with long board traces can create high-frequency transmission line effects such as undershoot, overshoot and cross-talk. If left undetected, these signal anomalies can seriously degrade the proper functioning of a circuit.

- Sample Rate

If I could...

...be sure I'm seeing *all* the details of my signal...

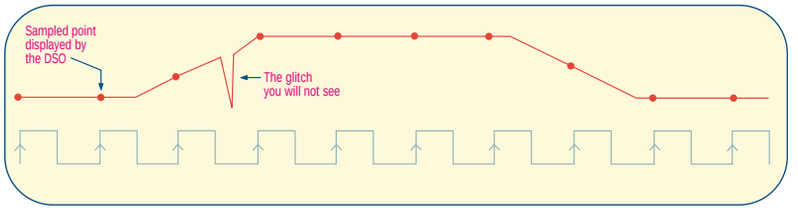
Sample Rate Equals Resolution

Sample rate – specified in Samples per second (S/s) – refers to how frequently a digital oscilloscope takes a snapshot or sample of the signal, analogous to the frames on a movie camera. The faster an oscilloscope samples (i.e., the higher the sample rate), the greater the resolution and detail of the displayed waveform and the less likely that critical information or events will be lost.

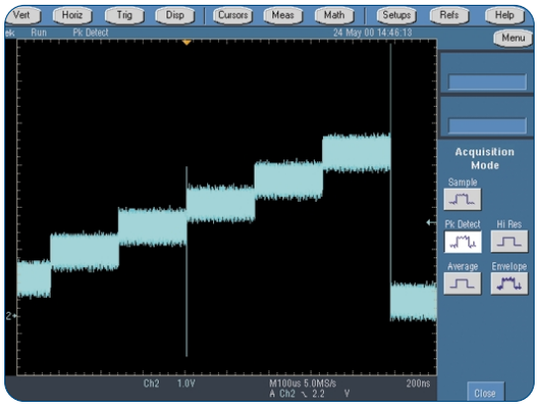
How do you calculate your sample rate requirements? The method differs based on the type of waveform you are measuring, and the method of signal reconstruction used by the oscilloscope. Most Tektronix oscilloscopes let you select either sin(x)/x interpolation for measuring sinusoidal signals, or linear interpolation for square waves, pulses and other signal types.

For accurate reconstruction using sin(x)/x interpolation, your oscilloscope should have a sample rate at least 2.5 times the highest frequency component of your signal. Using linear interpolation, sample rate should be at least 10 times the highest frequency signal component.

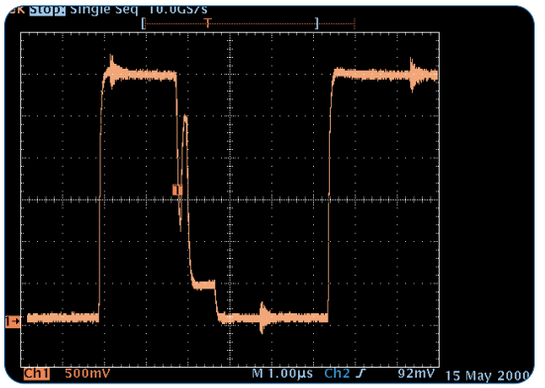
Tektronix has greatly simplified most sample rate decisions by matching the sample rate to the bandwidth of each of our oscilloscopes, ensuring a Tektronix oscilloscope for every application.



Sample rate varies with time base settings – the slower the time base setting, the slower the sample rate. Some digital oscilloscopes provide peak detect mode to capture fast transients at slow sweep speeds.



Peak detect mode enables the TDS7000 Series oscilloscope to capture transient anomalies as narrow as 100 ps.



A higher sample rate provides greater signal resolution, ensuring that you'll see narrow and intermittent events.

A clear distinction exists between sample rate and waveform capture rate.

While the sample rate indicates how frequently the oscilloscope samples the input signal within one waveform, or cycle, the waveform capture rate refers to how quickly an oscilloscope acquires waveforms. (Please refer to the "waveform capture rate" section.)

If I could...

...capture those elusive glitches
and intermittent events – the first time...

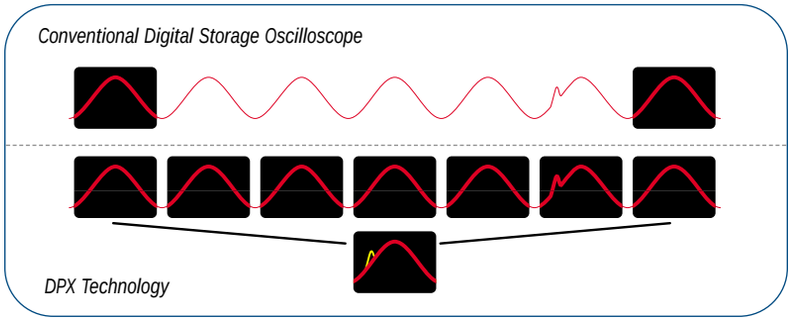
Keep Your Eyes Open

All digital oscilloscopes blink. That is, they open their eyes a given number of times per second to capture the signal, and close their eyes in between. This is the waveform capture rate, expressed as waveforms per second (wfms/s). Waveform capture rates vary greatly, depending on the type and performance level of the oscilloscope. 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.

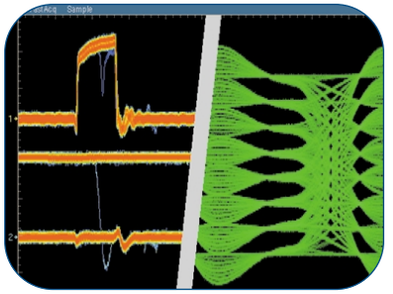
Digital storage oscilloscopes (DSOs) employ a serial-processing architecture to capture from 100 to 5,000 wfms/s. Some DSOs provide a special mode that alternates between bursting multiple captures into long memory, temporarily delivering higher waveform capture rates followed by long processing dead times that reduce the probability of capturing rare, intermittent events.

Most digital phosphor oscilloscopes (DPOs) employ a parallel-processing architecture to deliver vastly greater waveform capture rates. DPOs can acquire millions of waveforms in just seconds – hundreds of times more than the fastest DSO – significantly increasing the probability of capturing intermittent and elusive events and allowing you to see the problems in your signal more quickly. Moreover, the DPO's ability to acquire and display three dimensions of signal behavior in real time – amplitude, time and distribution of amplitude over time – results in a superior level of insight into signal behavior.

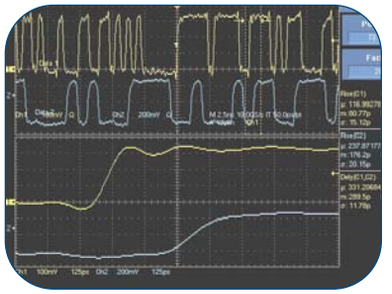
Currently, only Tektronix offers digital phosphor oscilloscopes, and delivers the highest performance solution in both DSOs and DPOs. Tektronix DPOs, enabled by our proprietary DPX™ technology, can save you hundreds of hours of troubleshooting and let you push your design to the absolute limits. The significantly higher bandwidths and sample rates of our DSOs let you capture single-shot acquisitions on all four channels simultaneously, and view up to four time-correlated events in a system.



DPX technology delivers unrivaled design insight, enabling the TDS7000 Series DPO to capture more than 400,000 waveforms per second. That's 200 times more than other digital oscilloscopes.



Tektronix' propriety DPX technology provides unprecedented waveform capture rate in the TDS7000 Series DPO, maximizing the probability of discovering hidden faults and revealing dynamic signal behavior.



The TDS6604 provides an ideal solution for non-repetitive, high-speed, multi-channel digital design applications.

DPO and DSO: General Purpose and Specialized Tools

If you are looking for the best general-purpose design and troubleshooting tool for a wide range of applications, select a DPO. DPOs are ideal for communication mask testing, digital debug of intermittent signals, repetitive digital design and timing applications.

For high performance in a single-shot, multi-channel instrument, choose a DSO. DSOs are ideal for non-repetitive, high-speed, multi-channel digital design applications. In the real world of digital design, an engineer usually examines four or more signals simultaneously, making the DSO a critical companion. If you are working with signals of less than 200 MHz and budget is a major concern, the TDS1000 and TDS2000 Series DSOs provide excellent performance and affordability.

If I could...

...capture long-duration signals
in great detail...

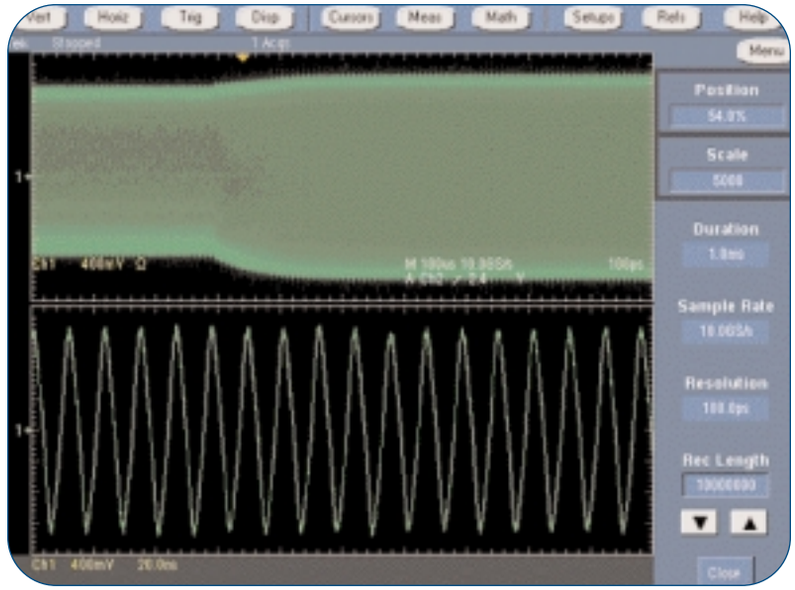
How Long Is Long Enough For You?

Record length, expressed as the number of points that comprise a complete waveform record, determines the amount of data that can be captured with each channel. Since an oscilloscope can store only a limited number of samples, the waveform duration (time) will be inversely proportional to the oscilloscope's sample rate.

$$\text{Time Interval} = \frac{\text{Record Length}}{\text{Sample Rate}}$$

Modern oscilloscopes allow you to select record length to optimize the level of detail needed for your application. If you are analyzing an extremely stable sinusoidal signal, you may need only a 500-point record length, but if you are isolating the causes of timing anomalies in a complex digital data stream, you may need a million points or more.

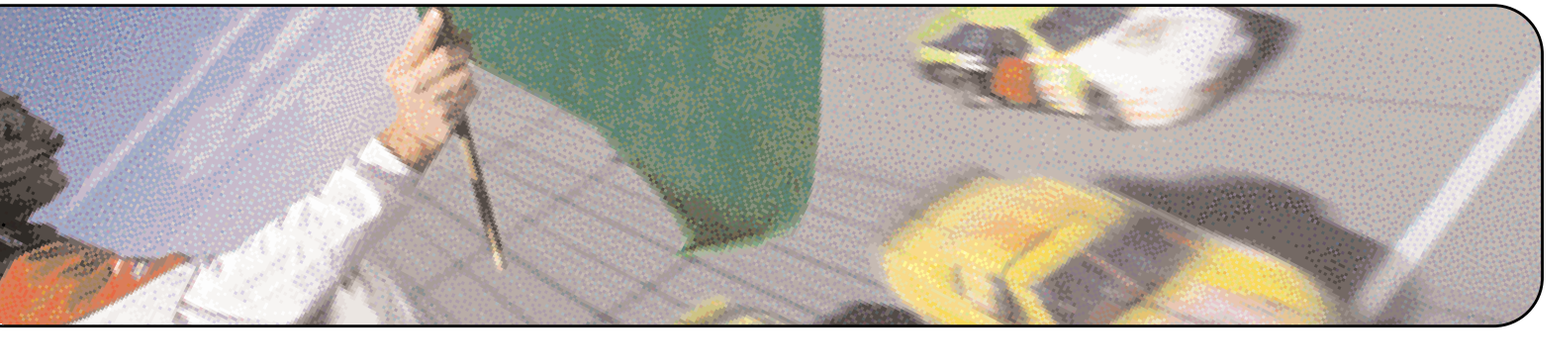
Tektronix oscilloscopes offer record lengths up to 32 million points, enabling you to tailor record length to your specific needs. In addition, many of our oscilloscopes allow you to add memory to increase the record length for specific applications.



Capturing the high frequency detail of this modulated 85 MHz carrier requires high resolution sampling (100 ps). Seeing the signal's complete modulation envelope requires a long time duration (1 ms). Using long record length (10 MB), the oscilloscope can display both.

If I could...

...trigger on any event,
even those buried deep in my signal...

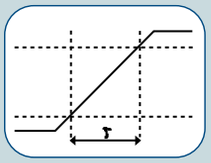


It All Starts With The Trigger

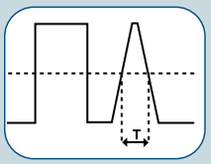
An oscilloscope's trigger function is crucial for clear signal characterization because it is what synchronizes the horizontal sweep at the correct point of the signal. Trigger controls allow you to stabilize repetitive waveforms and capture single-shot waveforms.

Edge triggering is the basic and most common type. Advanced trigger controls enable you to isolate specific events of interest to optimize the oscilloscope's sample rate and record length.

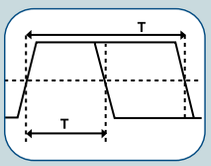
Advanced triggering capabilities on Tektronix oscilloscopes give you highly selective control. The intuitive user interface on all Tektronix oscilloscopes allows rapid setup of trigger parameters with wide flexibility in the test setup to maximize your productivity.



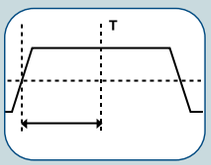
- **Slew Rate Triggering.** High frequency signals with slew rates faster than expected or needed can radiate troublesome energy. Slew rate triggering surpasses conventional edge triggering by adding the element of time and allowing you to selectively trigger on fast or slow edges.



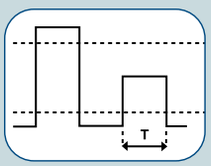
- **Glitch Triggering.** Glitch triggering allows you to trigger on digital pulses when they are shorter or longer than a user-defined time limit. This trigger control enables you to examine the causes of even rare glitches and their effects on other signals.



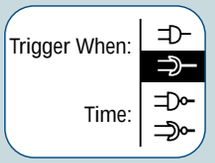
- **Pulse Width Triggering.** Using pulse width triggering, you can monitor a signal indefinitely and trigger on the first occurrence of a pulse whose duration (pulse width) is outside the allowable limits.



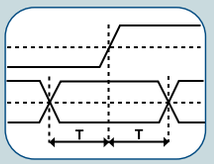
- **Time-out Triggering.** Time-out triggering lets you trigger on an event without waiting for the trigger pulse to end, by triggering based on a specified time lapse.



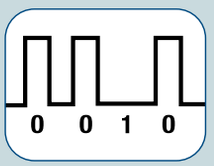
- **Runt Pulse Triggering.** Runt triggering allows you to capture and examine pulses that cross one logic threshold, but not both.



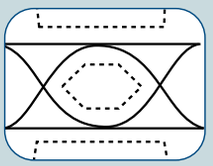
- **Logic Triggering.** Logic triggering allows you to trigger on any logical combination of available input channels – especially useful in verifying the operation of digital logic.



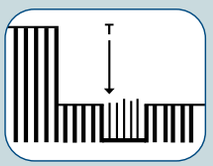
- **Setup-and-Hold Triggering.** Only setup-and-hold triggering lets you deterministically trap a single violation of setup-and-hold time that would almost certainly be missed by using other trigger modes. This trigger mode makes it easy to capture specific signal quality and timing details when a synchronous data signal fails to meet setup-and-hold specifications.



- **Serial Pattern Triggering.** Serial pattern triggering compares the series of 1s and 0s captured on a specified channel to a user-defined pattern (up to 32 bits), and when a match is made, stops the acquisition of the data stream and displays the user-defined pattern with the data around it. This trigger enables you to isolate pattern-dependent failures, simplifying the debug of serial data streams.



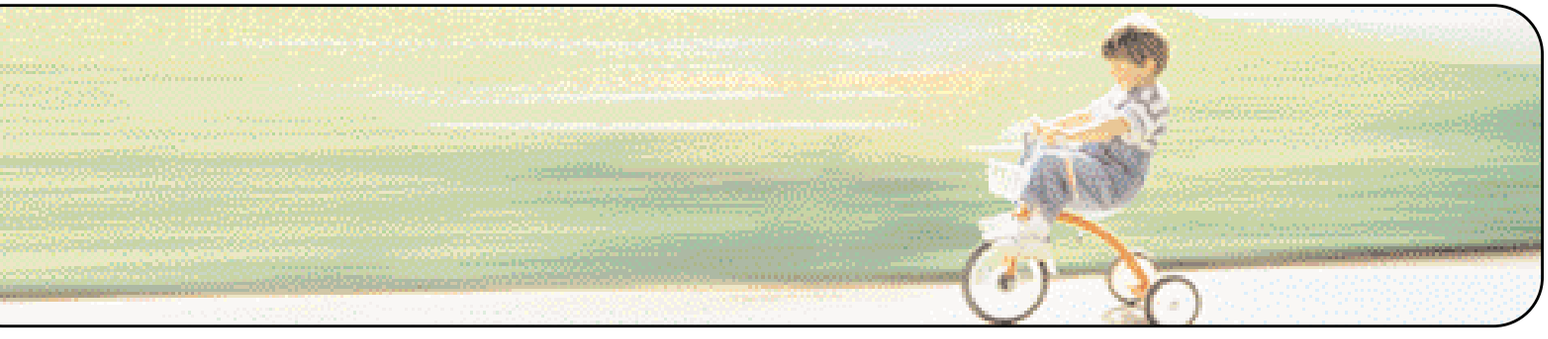
- **Communication Triggering.** Communication triggering addresses the need to acquire a wide variety of Alternate-Mark Inversion (AMI), Code-Mark Inversion (CMI), and Non-Return to Zero (NRZ) communication signals.



- **Video Triggering.** Video triggering enables you to trigger on any specific line or field on a broad array of video formats, such as NTSC, PAL, SECAM, analog HDTV and others.

If I could...

...find an oscilloscope that's simple to use,
and adaptable to my needs...



How Do You Like To Drive?

Oscilloscopes must integrate into your working environment like an extension of yourself. They should be easy to learn and easy to use, helping you work at peak efficiency and productivity to meet your critical project milestones.

Just as there is no one typical car driver, there is no one typical oscilloscope user. There are both traditional instrument users and those who have grown up in the Windows/Internet era. The key to satisfying such a broad group of users is flexibility in operating style.

Tektronix oscilloscopes offer a balance between performance and simplicity. All Tektronix oscilloscopes share a similar *front-panel layout*, with dedicated vertical, horizontal and trigger controls. An icon-rich *graphical user interface* helps you understand and intuitively use advanced capabilities. *On-line, context-sensitive help* on many Tektronix models provides a convenient, built-in reference manual.

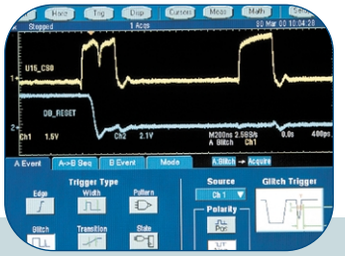
Intuitive controls allow even occasional oscilloscope users to feel as comfortable driving the oscilloscope as they do driving a car, while giving full-time users easy access to the oscilloscope's most advanced features.

Tektronix also offers such features as *touch-sensitive displays, optional keyboard and mouse control,* and *Windows graphical user interfaces* on some models.

In addition, many Tektronix oscilloscopes are *portable*, making the oscilloscope efficient in many different operating environments – in the lab or in the field.

Traditional, analog-style knobs control position, scale, intensity, etc. – precisely as you would expect.

Touch-sensitive display naturally solves issues with cluttered benches and carts, while providing access to clear, on-screen buttons.

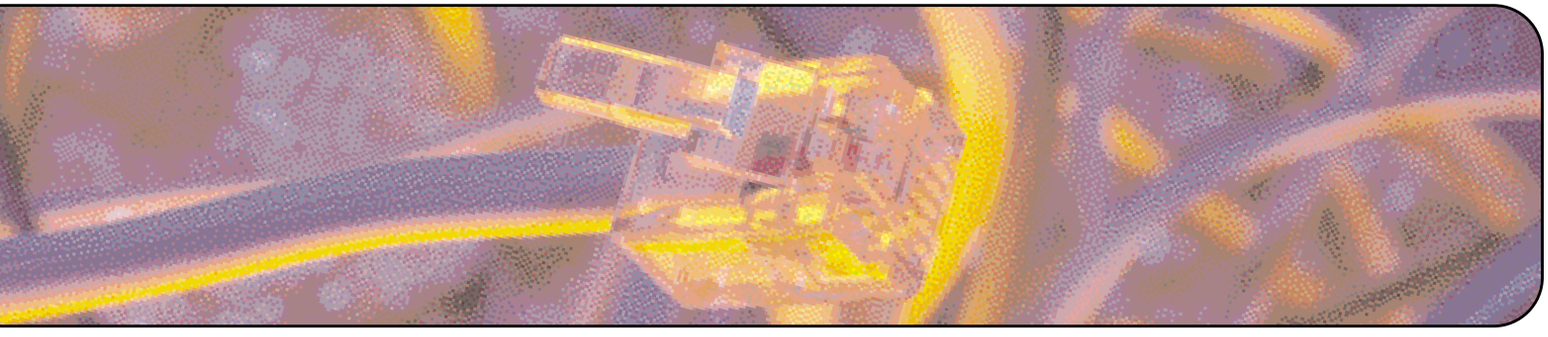


Use graphical control windows to access even the most sophisticated functions with confidence and ease.

The portability of many Tektronix oscilloscopes makes the instrument efficient in many operating environments – in the lab or in the field.

If I could...

...share my results with other
members of my engineering team...



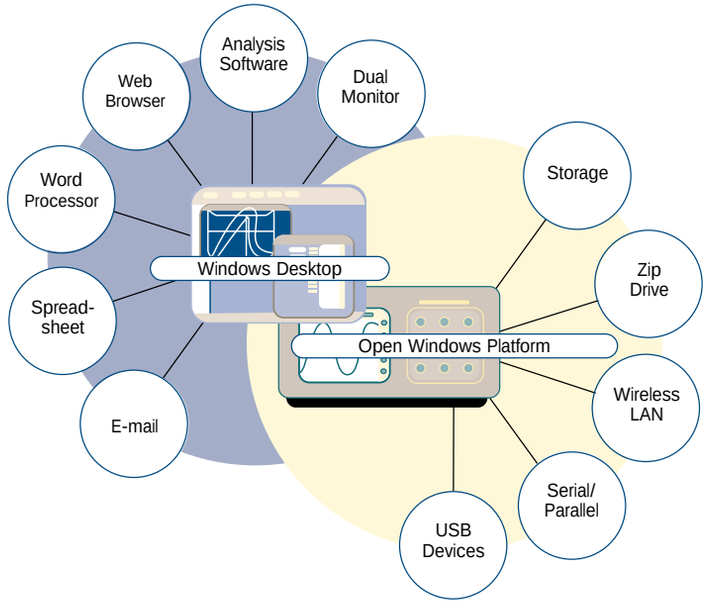
Linking the Oscilloscope With Your World

Tektronix oscilloscopes are designed to work in highly connected environments, further increasing their power as measurement and collaboration tools – and your effectiveness as an engineer.

Tektronix offers standard interfaces (GPIB, RS-232, USB, Ethernet) and network communication modules on some oscilloscopes that allow you to exploit a vast array of functionality and control within the design and test environment.

Tektronix Windows-based oscilloscopes also let you:

- Communicate via LAN with networked Windows, UNIX or Linux hosts using VXI 11.2 server/client protocol
- Increase communication speed from the oscilloscope to the Windows desktop through embedded PCI bus
- Create, edit and share documents on the oscilloscope – all while working with the instrument in the lab
- Access network printing and file sharing resources
- Access the Internet
- Send and receive e-mail

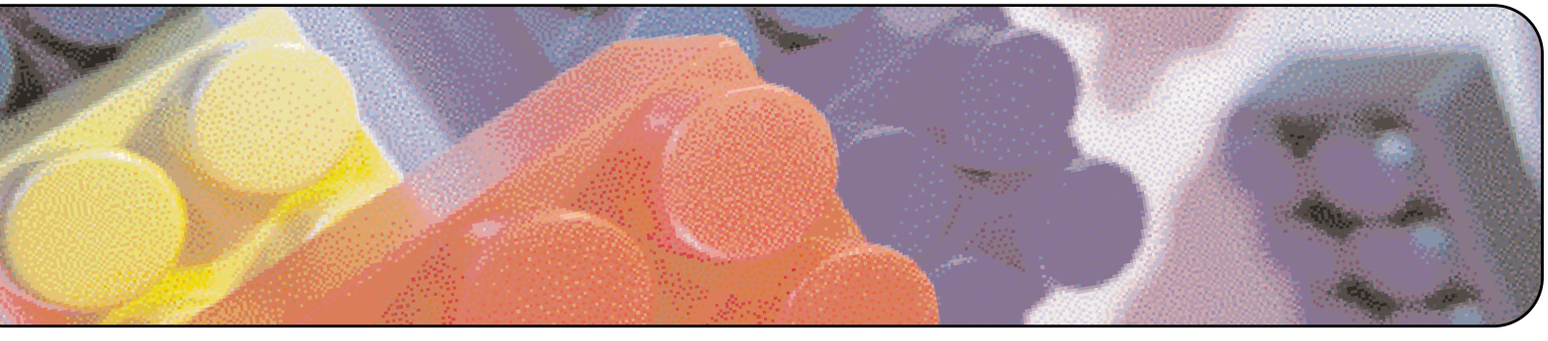


Tektronix Windows-based oscilloscopes connect people and equipment to save time and increase total work group productivity.

The TDS3000B Series' plug-in printer provides instant, portable documentation of your work.

If I could...

...have tools that can grow
as my needs change...



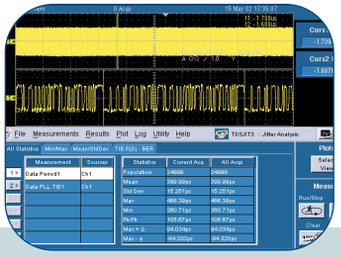
Keeping Pace With Your Ever-Changing Needs

An oscilloscope should be able to accommodate your needs as they change.

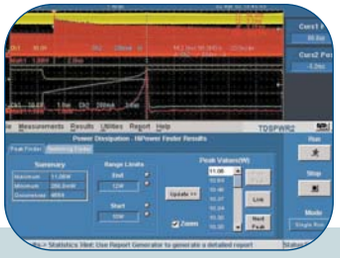
For many oscilloscope models, available application modules and software let you transform your Tektronix oscilloscope into a highly specialized analysis tool capable of performing functions such as jitter and timing analysis, micro-processor memory system verification, communications standards testing, disk drive measurements, video measurements, power measurements and much more.

Many Tektronix oscilloscopes provide an open Windows platform for an unprecedented level of expandability, flexibility and analysis. This OpenChoice™ platform provides a gateway into the engineering future, expanding the horizons of engineers and changing the way they work.

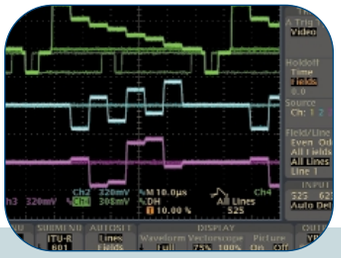
- **Jitter and Timing Analysis**
  Software packages are available to turn Tektronix oscilloscopes into leading-edge tools for jitter and timing analysis, as well as comprehensive margin timing analysis for high-speed designs.
- **Communications Standards Testing**
  A wide range of application modules, software and accessories let you equip Tektronix oscilloscopes with powerful capabilities for communications standards performance and conformance testing, from DS0 to STM-64/OC-192.
- **Disk Drive Measurements**
  Tektronix provides software packages that deliver industry-leading disk drive measurement capabilities.
- **Video Measurements**
  Equipped with available options, certain Tektronix oscilloscopes can provide the complete solution for physical layer testing of SDTV and HDTV signals, and to measure, display and analyze video waveforms and digital video signals.
- **Power Measurements**
  Tektronix oscilloscopes can be configured for power conversion applications, providing automatic calculations of True Power, Apparent Power, Power Factor, Instantaneous Power, and Energy as well as design and troubleshooting of power supplies.
- **USB 2.0 Measurements**
  Tektronix offers software that, paired with Tektronix high-performance oscilloscopes, delivers the industry's most comprehensive solution for USB 2.0 compliance testing.
- **Optical Storage Analysis**
  Software is available to transform some Tektronix oscilloscopes into ideal test tools for the design of state-of-the-art optical storage systems.
- **Analysis and Networking**
  The OpenChoice platform allows all Tektronix open-Windows oscilloscope users the flexibility to choose third-party software, develop custom applications or use proprietary software for their analysis needs.



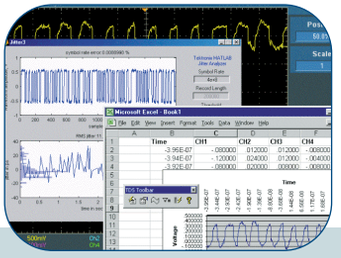
TDSJIT3 jitter analysis package rapidly characterizes the random and deterministic components of jitter in high-speed designs.



TDSPWR2 automated power measurement package delivers unparalleled velocity to power supply design.



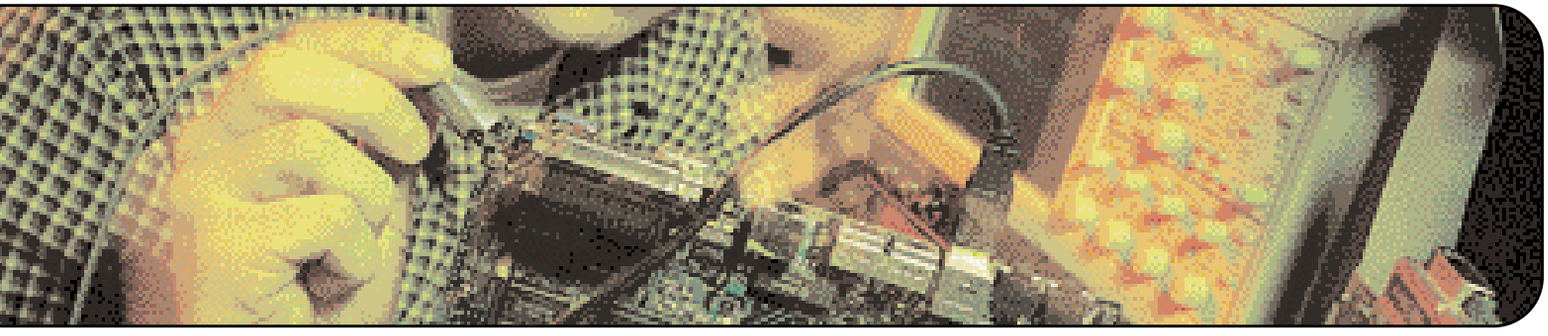
The TDS3SDI 601 serial/digital video module makes the TDS3000B Series oscilloscope a fast, tell-all tool for video troubleshooting.



Advanced analysis and productivity software, such as MATLAB, can be installed in Tektronix Windows-based oscilloscopes to accomplish local signal analysis.

If I could...

...extend my oscilloscope's performance
all the way to the device I'm testing...



Perfect Vision Begins Here

Precision measurements start at the probe tip. The right probes matched to the oscilloscope and the device-under-test (DUT) allow the signal to be brought to the oscilloscope cleanly for the greatest signal fidelity and measurement accuracy.

To ensure accurate reconstruction of your signal, try to choose a probe that, when paired with your oscilloscope, exceeds the signal bandwidth by 5 times.

Passive vs. Active

Probes actually become part of the circuit, introducing resistive, capacitive and inductive loading that inevitably alters the measurement. For the most accurate results, the goal is to select a probe with minimal loading.

For measuring typical signal and voltage levels, *passive* probes provide ease of use and a wide range of measurement capabilities at an affordable price. The pairing of a passive voltage probe with a *current* probe will provide you with an ideal solution for measuring power.

However, general-purpose passive probes cannot accurately measure signals with extremely fast rise times, and may excessively load sensitive circuits. For measuring signals with fast rise times, a high-speed *active* or *differential* probe will provide more accurate results.

Form Factor

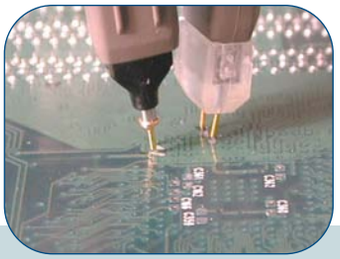
Small form factor probes provide easier access to today's densely packed circuitry.

Matching Probes

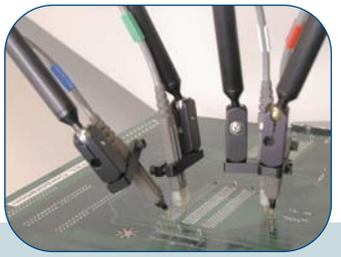
Always look for a selection of probes that are matched to your oscilloscope. This will produce the most accurate result, and enable you to access all of the power, features and capabilities of your oscilloscope.

Tektronix is the leader in probing technologies. We offer the world's most advanced high-bandwidth differential and active probes – up to 3.5 GHz differential and 6 GHz active – to access dense, high-speed circuitry with the highest signal fidelity currently achievable, all matched perfectly to Tektronix oscilloscopes.

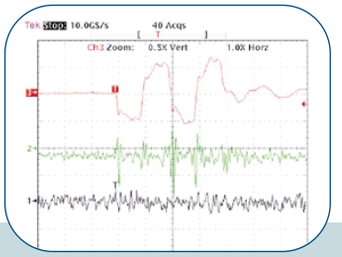
The P7260 and P7330, the world's most advanced high-bandwidth differential and active probes, enable you to access dense, high-speed circuitry with the highest signal fidelity.



Dense devices and systems require small form factor probes.



High performance probes are critical when measuring the fast clocks and edges found in today's computer buses and data transmission lines.



Differential probes can separate common-mode noise from the signal content of interest in today's fast, low-voltage applications – especially important as digital signals continue to fall below typical noise thresholds found in integrated circuits.

Tektronix Digital Oscilloscopes
...a whole new world of insight.

Our Never-ending Quest For Perfect Vision

Since Tektronix founders Howard Vollum and Jack Murdock recorded electronic signals on the world's first triggered oscilloscope, we have been driven to keep Tektronix oscilloscopes the standard to which all others aspire. To make Tektronix oscilloscopes the most valuable and productive instrument on every engineer's bench. To give you perfect vision.

We hope this guide will help you select the right oscilloscope for your application. But if you need more help, there is plenty available. Simply contact your local Tektronix representative, or visit www.tektronix.com/oscilloscopes.

Tektronix
Enabling Innovation

For answers to your questions, and further assistance in choosing the right Tektronix oscilloscope, probes and accessories for your needs, call your local Tektronix representative now. Or visit www.tektronix.com/oscilloscopes