» 10 FACTORS IN CHOOSING A BASIC OSCILLOSCOPE

Tektronix®

10 Factors in Choosing a Basic Oscilloscope

Basic oscilloscopes are used as windows into signals for troubleshooting circuits or checking signal quality. They generally come with bandwidths from around 50 MHz to 200 MHz and are found in almost every design lab, education lab, service center and manufacturing cell.

Whether you buy a new scope every month or every five years, this guide will give you a quick overview of the key factors that determine the suitability of a basic oscilloscope to the job at hand.

There are several ways to navigate this interactive PDF document:

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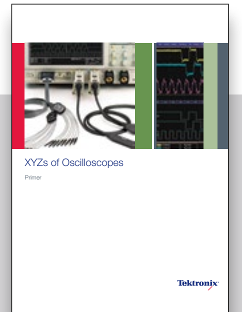
The digital storage oscilloscope

Oscilloscopes are the basic tool for anyone designing, manufacturing or repairing electronic equipment. A digital storage oscilloscope (DSO, on which this guide concentrates) acquires and stores waveforms. The waveforms show a signal's voltage and frequency, whether the signal is distorted, timing between signals, how much of a signal is noise, and much, much more.

Download ↘
For more detailed information on oscilloscope usage and specifications. Download Tektronix' "XYZ's of Oscilloscopes"



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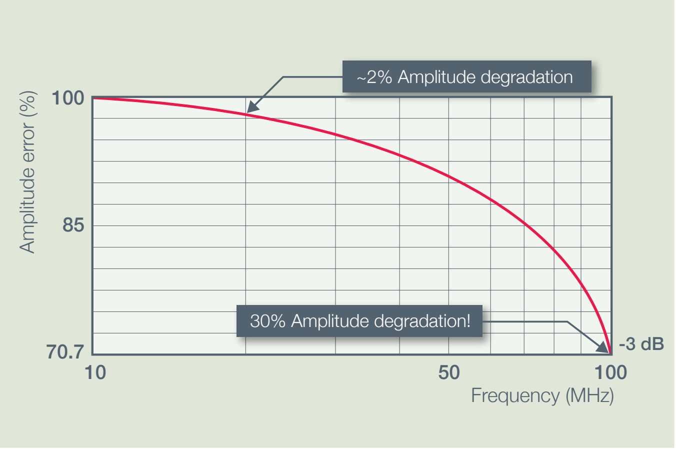
#1 BANDWIDTH

System bandwidth determines an oscilloscope's ability to measure an analog signal. Specifically it determines the maximum frequency that the instrument can accurately measure. Bandwidth is also a key determining factor in price.

Determine what you need

- For example, a 100 MHz oscilloscope is usually guaranteed to have less than 30% attenuation at 100 MHz. To ensure better than 2% amplitude accuracy, inputs should be lower than 20 MHz.
- For digital signals, measuring rise and fall time is key. Bandwidth, along with sample rate, determines the smallest rise-time that an oscilloscope can measure.
- The probe and oscilloscope form a measurement system that has an overall bandwidth. Using a low-bandwidth probe will lower the overall bandwidth so be sure to use probes that are matched to the scope.

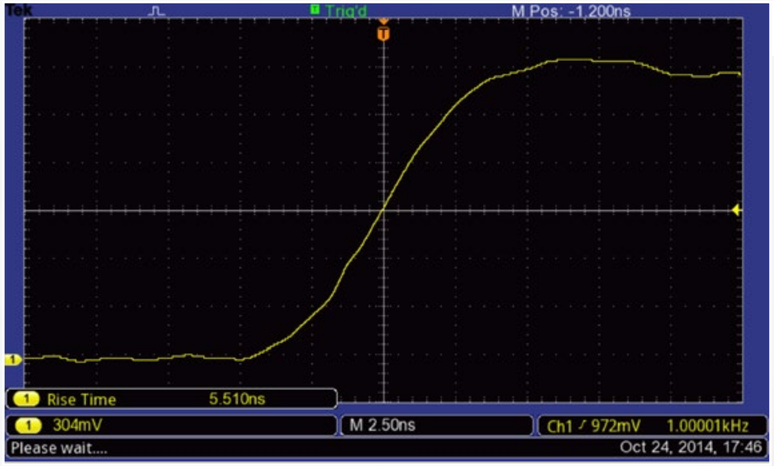


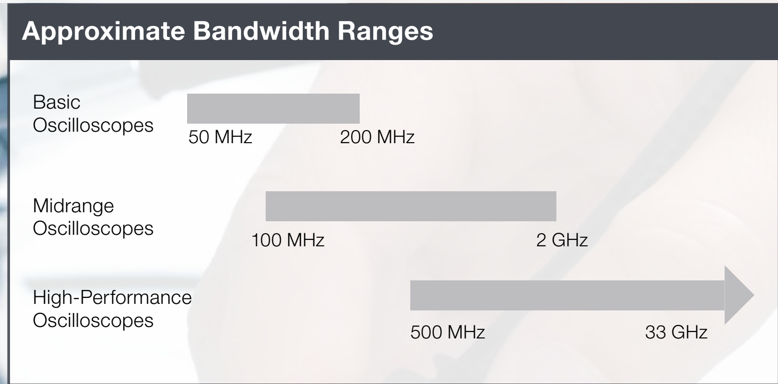
Bandwidth is defined as the frequency at which a sine-wave input signal is attenuated to 70.7% of its true amplitude (the -3 dB or 'half-power' point, shown here for a 100 MHz scope).

When selecting bandwidth, use the ‘five times rule’.

Oscilloscope Bandwidth ≥ 5 x Maximum frequency of interest

If bandwidth is too low, your oscilloscope will not resolve high-frequency changes. Amplitude will be distorted. Edges will slow down. Details will be lost.

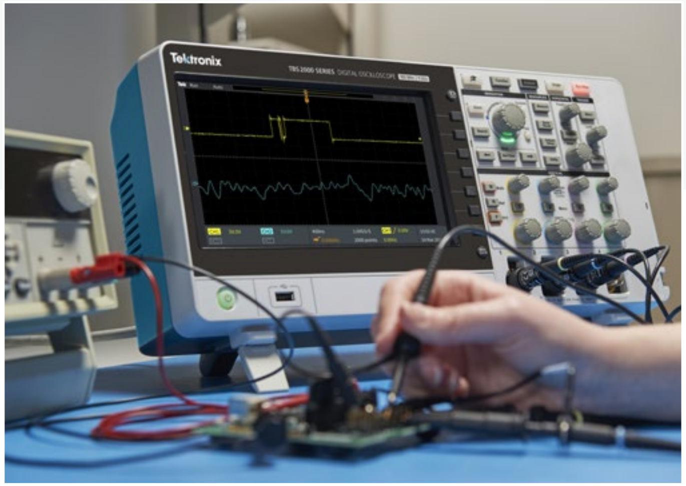




Consider a higher-performance oscilloscope

Basic oscilloscopes usually range from 50 MHz to 200 MHz. If you need more bandwidth, higher-performance instruments are available to cover from 350 MHz up to tens of gigahertz.

#2 SAMPLE RATE



The sample rate of an oscilloscope is similar to the frame rate of a movie camera. It determines how much waveform detail the scope can capture.

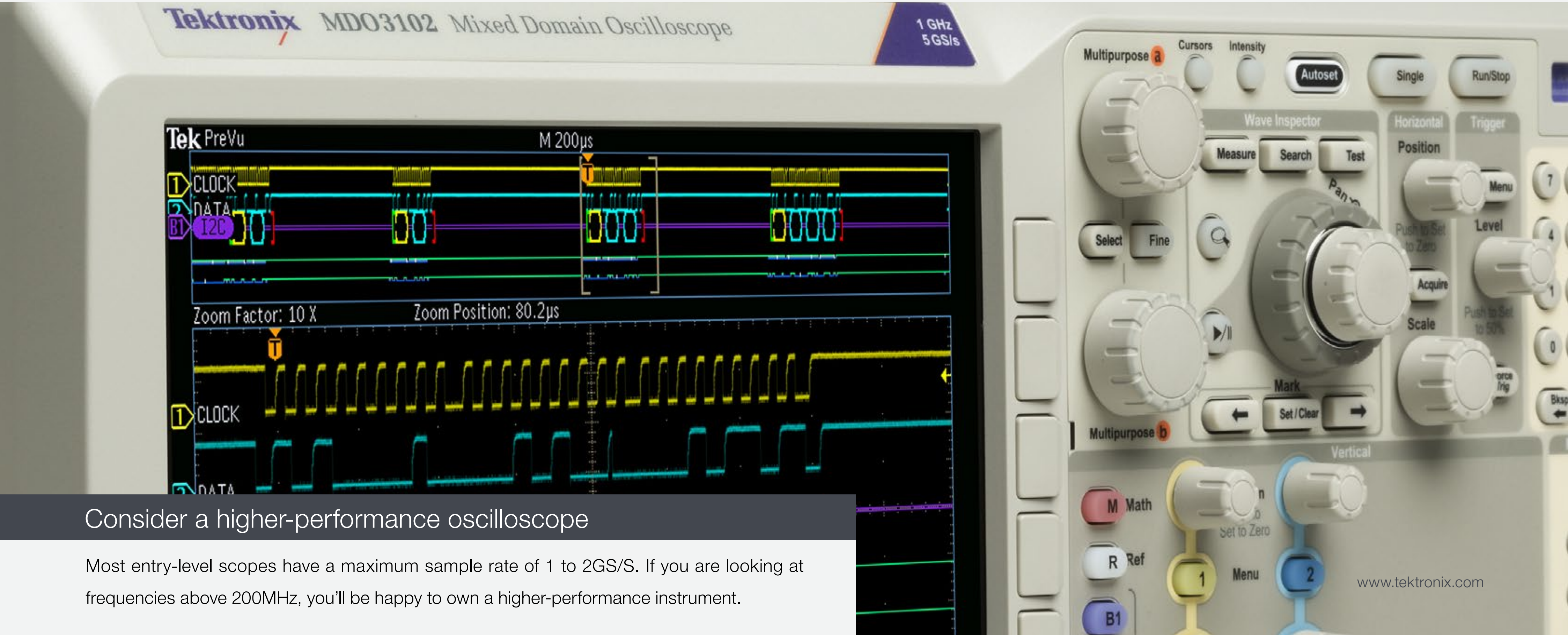
Determine what you need

- Sample rate (samples per second, S/s) is how often an oscilloscope samples the signal. Again, we recommend a ‘five times rule’: use a sample rate of at least 5x your circuit’s highest frequency component.
- Most basic scopes have a (maximum) sample rate of 1 to 2 GS/s. Remember, basic scopes have bandwidth up to 200 MHz, so scope designers usually build in 5 to 10 times oversampling at maximum bandwidth.
- The faster you sample, the less information you’ll lose and the better the scope will represent the signal under test. But the faster you will fill up your memory, too, which limits the time you can capture.

Accurate reconstruction of a signal depends on both the sample rate and the interpolation method used. Linear interpolation connects sample points with straight lines, but this approach is limited to reconstructing straight-edged signals. Sin(x)/x interpolation uses a sine function to fill in the time between real samples. It lends itself to curved and irregular signal shapes, which are far more common than pure square waves and pulses. Consequently, sin(x)/x interpolation is the preferred method for most applications.

To capture glitches you need speed!

Nyquist said that a signal must be sampled at least twice as fast as its highest frequency component to accurately reconstruct it and avoid aliasing (undersampling). Nyquist however is an absolute minimum – it applies only to sine waves, and assumes a continuous signal. Glitches are by definition not continuous, and sampling at only twice the rate of the highest frequency component is not enough.



Consider a higher-performance oscilloscope

Most entry-level scopes have a maximum sample rate of 1 to 2GS/S. If you are looking at frequencies above 200MHz, you'll be happy to own a higher-performance instrument.

#3 ENOUGH INPUT CHANNELS – AND THE RIGHT ONES

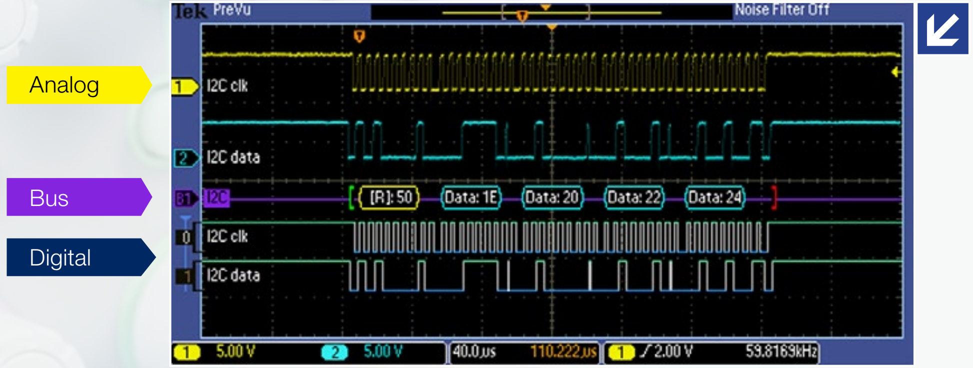
Digital oscilloscopes sample analog channels to store and display them. In general, the more channels the better, although adding channels adds to the price.

Determine what you need

- Whether to select 2 or 4 analog channels depends on your application. Two channels let you compare a component's input to its output, for example. Four analog channels let you compare more signals and provides more flexibility to mathematically combine channels mathematically (multiplying to get power, or subtracting for differential signals, for example)
- A Mixed Signal Oscilloscope adds digital timing channels, which indicate high or low states and can be displayed together as a bus waveform. Whatever you choose, all channels should have good range, linearity, gain accuracy, flatness and resistance to static discharge.
- Some instruments share the sampling system between channels to save money. But beware: the number of channels you turn on can reduce the sample rate.

Choose enough channels

The more time-correlated analog and digital channels your scope has, the more points in a circuit you can measure at the same time and the easier it is to decode a wide parallel bus, for instance. The example shows 2 analog, 2 digital and 1 decoded bus waveforms.

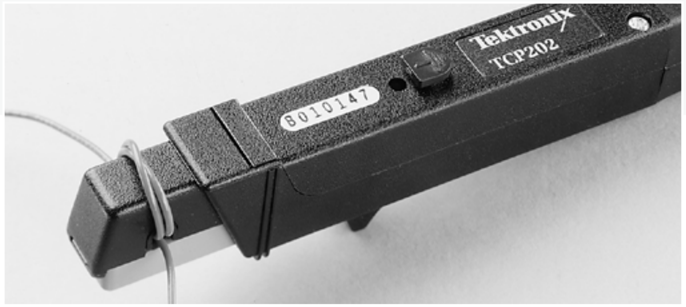


Consider a higher-performance oscilloscope

The latest Mixed Domain Oscilloscopes add a built-in spectrum analyzer with a dedicated RF input for making measurements in the frequency domain. Some oscilloscopes also include built-in function generators.

Some oscilloscopes offer isolated input channels to simplify floating measurements. Unlike ground-referenced oscilloscopes, the input connector shells are isolated from each other and from earth ground.

#4 COMPATIBLE PROBES



Good measurements begin at the probe tip. The scope and probe work together as a system, so be sure to consider probes when selecting an oscilloscope.

- During measurements probes actually become a part of the circuit, introducing resistive, capacitive, and inductive loading that alters the measurement. To minimize the effect it's best to use probes that are designed for use with your scope.
- Select passive probes that have sufficient bandwidth. The probe's bandwidth should match that of the oscilloscope.
- A broad range of compatible probes will allow you to use your scope in more applications. Check to see what's available for the scope before you buy.

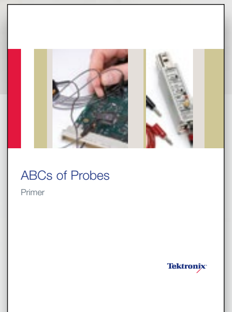
Probing for Answers: Do you plan to measure voltage, current or both? What frequency is your signal? How large is the amplitude? Do you need to measure the signal differentially? What you want to do determines the probes you need.

Use the right probe for the job

- **Passive probes** Probes with 10X attenuation present a controlled impedance and capacitance to your circuit, and are suitable for most ground-referenced measurements. They are included with most oscilloscopes – you'll need one for each input channel.
- **High-voltage differential probes** Differential probes allow a ground-referenced oscilloscope to take safe, accurate floating and differential measurements. Every lab should have at least one!
- **Logic probes** Logic probes deliver digital signals to the front end of a Mixed Signal Oscilloscope. They include "flying leads" with accessories designed to connect to small test points on a circuit board.
- **Current Probes** Adding a current probe enables the scope to measure current, of course, but it also enables it to calculate and display instantaneous power.

Download

For more detailed information on types of probes and specifications. Download Tektronix' "ABCs of Probes"

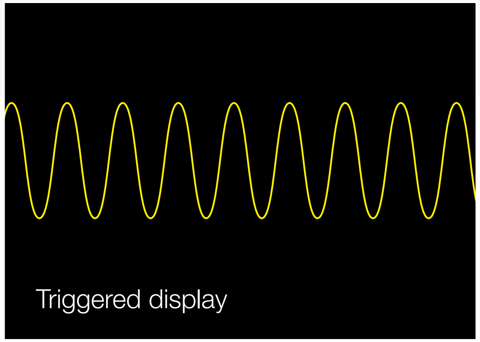


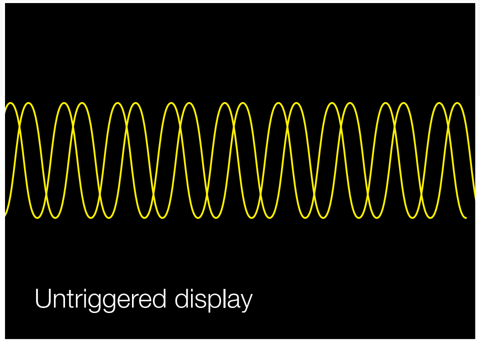
Consider a higher-performance oscilloscope

Analyzing high-speed communications signals requires high-bandwidth active probes and will require an oscilloscope with hundreds of MHz, or even GHz of bandwidth.

#5 TRIGGERING

Triggering gives a stable display and lets you zero in on specific parts of complex waveforms.


Triggered display


Untriggered display

Watch the Video

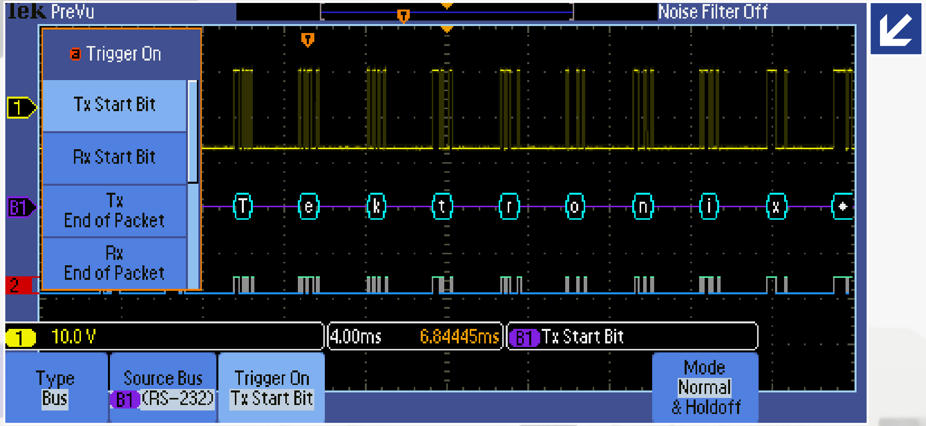
Determine what you need

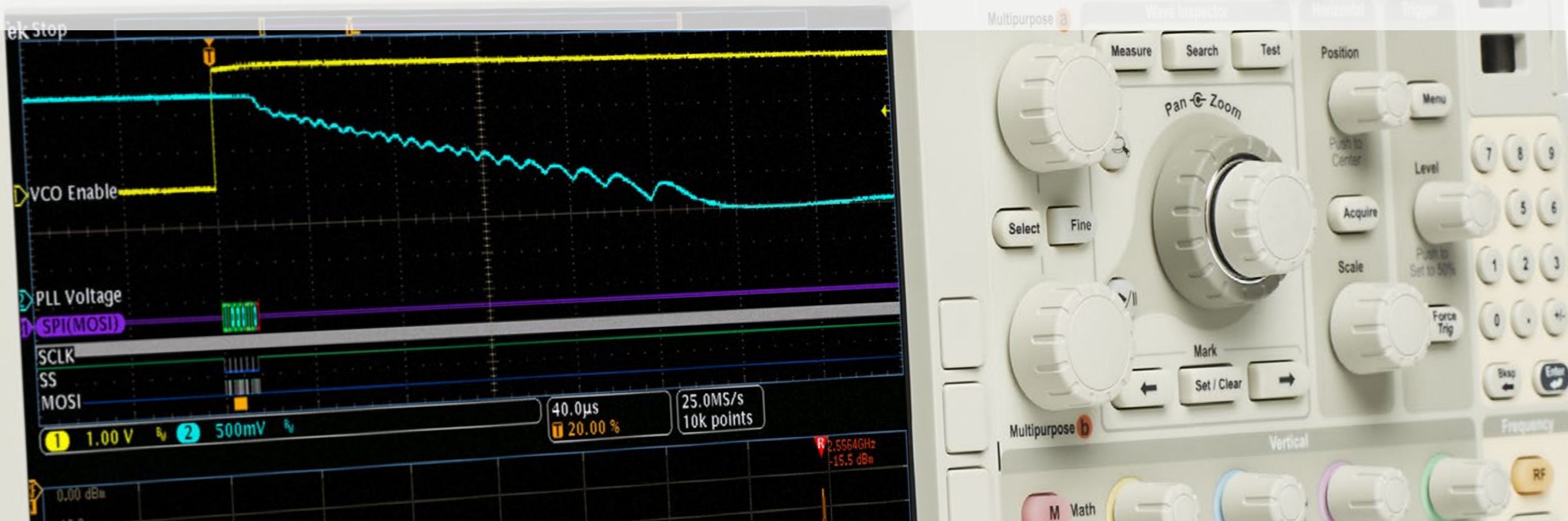
- All oscilloscopes provide edge triggering, and most offer pulse width triggering.
- To acquire anomalies and make best use of the scope's record length, look for a scope that offers advanced triggering on more challenging signals.
- The wider the range of trigger options available the more versatile the scope (and the faster you get to the root cause of a problem!):
  - Digital/pulse triggers: pulse width, runt pulse, rise/fall time, setup-and-hold
  - Logic triggering
  - Serial data triggers: embedded system designs use both serial (I2C, SPI,CAN/LIN…) and parallel buses.
  - Video triggering

Triggering synchronizes the horizontal sweep at the correct point in the signal, rather than just starting the next trace at the point where the present trace happens to finish. A single trigger acquires all input channels simultaneously

Advanced triggers find the right information

Triggering lets you isolate a group of waveforms to see what is going wrong. Specialized triggers can respond to specific conditions in the incoming signal – making it easy to detect, for example, a pulse that is narrower than it should be.



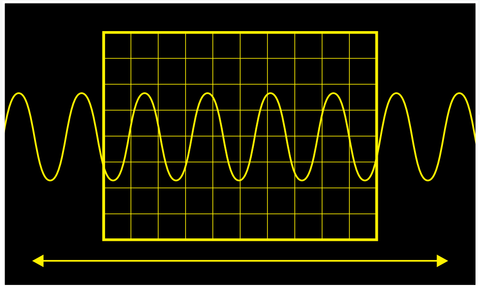


Consider a higher-performance oscilloscope

Sequence triggering can help capture more elusive signal events. It is sometimes called "A then B" triggering and can be used to acquire based on a multi-channel sequence.

Triggering on data being transferred on high speed versions of systems buses like USB and Ethernet requires higher bandwidth and sample rate than is available on basic oscilloscopes.

#6 RECORD LENGTH



Record length is the number of points in a complete waveform record. A scope can store only a limited number of samples so, in general, the greater the record length the better.

Determine what you need

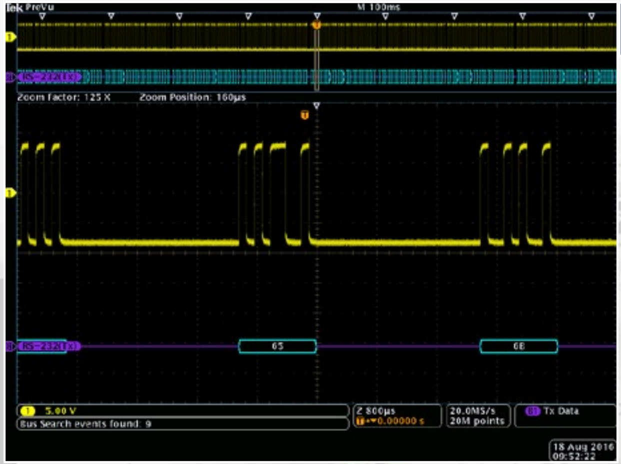
- Time captured = record length/sample rate. So, with a record length of 1 Mpoints and a sample rate of 250 MS/sec, the oscilloscope will capture 4 ms.
- Today's scopes allow you to select the record length to optimize the level of detail needed for your application.
- A good basic scope will store over 2,000 points, which is more than enough for a stable sine-wave signal (needing perhaps 500 points). But to find the causes of timing anomalies in a complex digital data stream consider 1 Mpoints or more.
- Zoom & Pan allows you to zoom in on an event of interest, and pan the area backwards and forwards in time.
- Search & Mark lets you search through the entire acquisition and automatically mark every occurrence of a user-specified event.

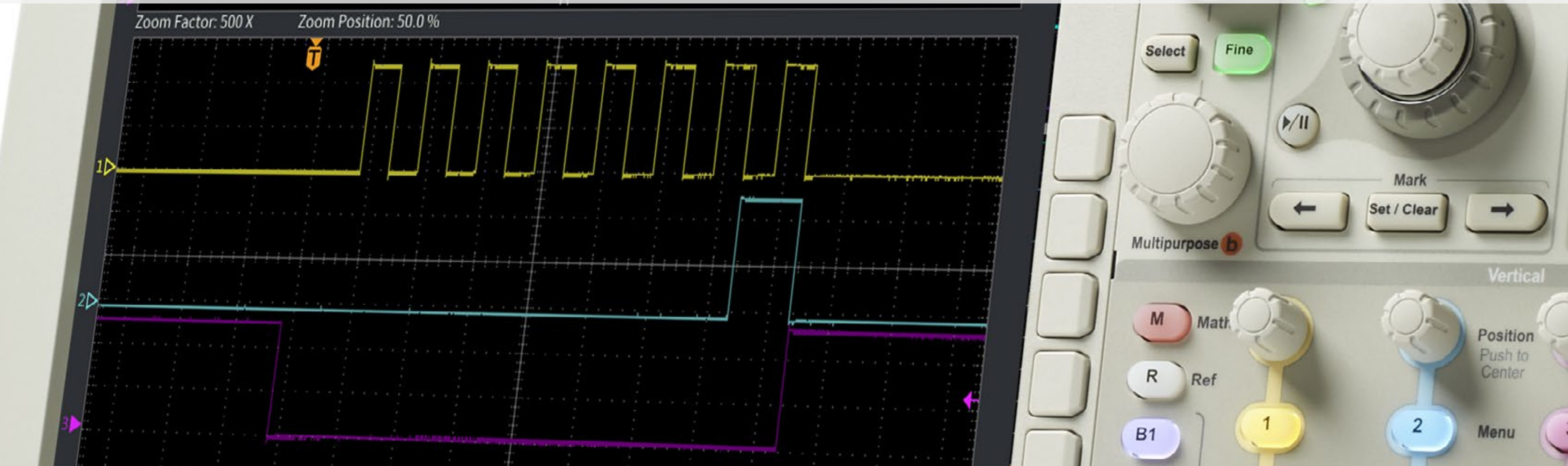
Oscilloscopes with record lengths in the millions of points can show many screens worth of signal activity, essential for examining complex waveforms.

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. **Time Interval = Record Length / Sample Rate**

See the bigger picture

Long record length lets you see a long time window, and lets you zoom in to see signal detail with good resolution.





Consider a higher-performance oscilloscope

Oscilloscopes are available with millions of points of data and manually searching for events can become impractical. Some scopes include search functions that let you search long records for specific events.

#7 AUTOMATED MEASUREMENTS AND ANALYSIS

Automated waveform measurements make it easier to obtain accurate numerical readings.

Determine what you need

- Most scopes offer front-panel buttons and/or screen-based menus to take accurate automated measurements.
- Basic choices on most scopes include amplitude, period and rise/fall time. Many digital scopes also provide mean and RMS calculations, duty cycle, and other math operations.
- Measurement “gating” allows you to determine the section of the waveform used to calculate measurements.
- Channel math functions let you add, subtract and multiply waveforms. Use waveform multiplication to multiply voltage and current to get power. Use subtraction to approximate a differential measurement.
- A Fast Fourier Transform (FFT) feature will let you see the frequency spectrum of an acquired waveform.

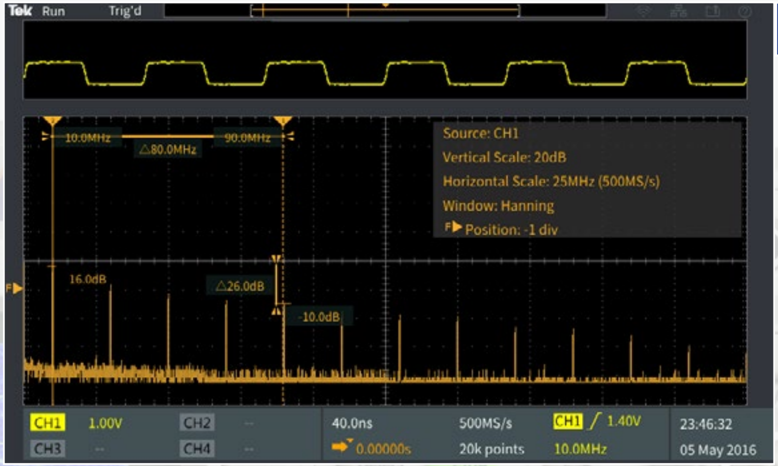
Examples of fully automated waveform measurements:

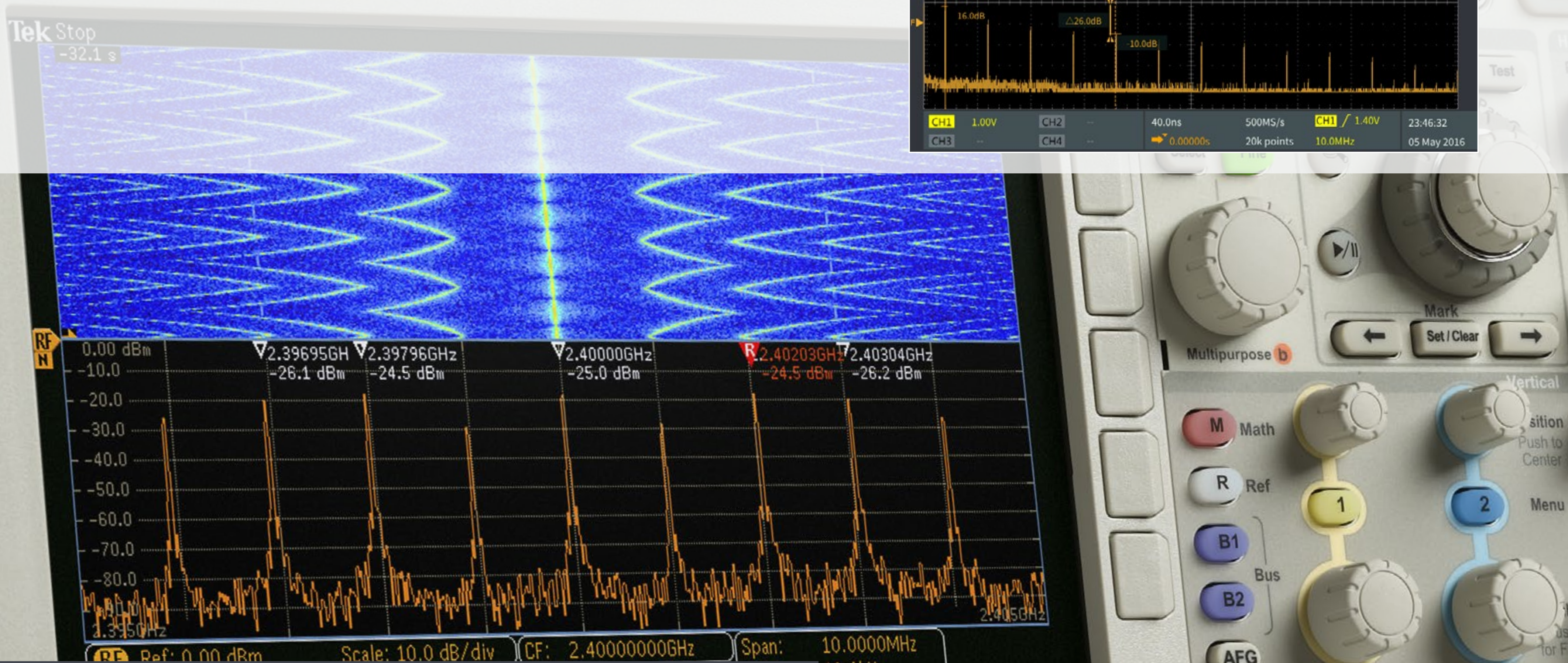
Time	Frequency	Period	Rise Time	Fall Time
	Delay	Phase	Positive Pulse Width	Negative Pulse Width
	Positive Duty Cycle	Negative Duty Cycle	Burst Width	
Amplitude	Peak-to-peak	Amplitude	Max	Min
	High	Low	Positive Overshoot	Negative Overshoot
	Mean	Cycle Mean	RMS	Cycle RMS
Others	Positive Pulse Count	Negative Pulse Count	Rising Edge Count	Falling Edge Count
	Area	Cycle Area	Phase	Delay FR
	Delay FF	Delay RR		

Automated measurements appear as on-screen alphanumeric readouts, and are more accurate than direct graticule interpretation

A Window into the Frequency Domain

Basic oscilloscopes often include an FFT function that lets you view the spectrum of the acquired waveform. This is useful for trying to determine the source of noise, for example.





Consider a higher-performance oscilloscope

A basic oscilloscope does not have enough dynamic range to look at small RF signals like a spectrum analyzer can. Mixed Domain Oscilloscopes, on the other hand, have dedicated spectrum analyzer inputs that allow you to clearly see small RF signals.

#8 EASY OPERATION

Oscilloscopes should be easy to operate, even for occasional users. The user interface is a large part of the 'time to answer' calculation.

Determine what you need

- Frequently-used adjustments should have dedicated knobs.
- AUTOSET and/or DEFAULT buttons will make for instant setup.
- The scope should be responsive, reacting quickly to changing events.
- There should be support for your own language, including the menu system, built-in help, manuals and ideally front-panel overlays.

Many people don't use a scope every day. Intuitive controls allow even occasional users to feel comfortable with the scope while giving full-time users easy access to advanced features. Many oscilloscopes are portable – for use in the lab or in the field.

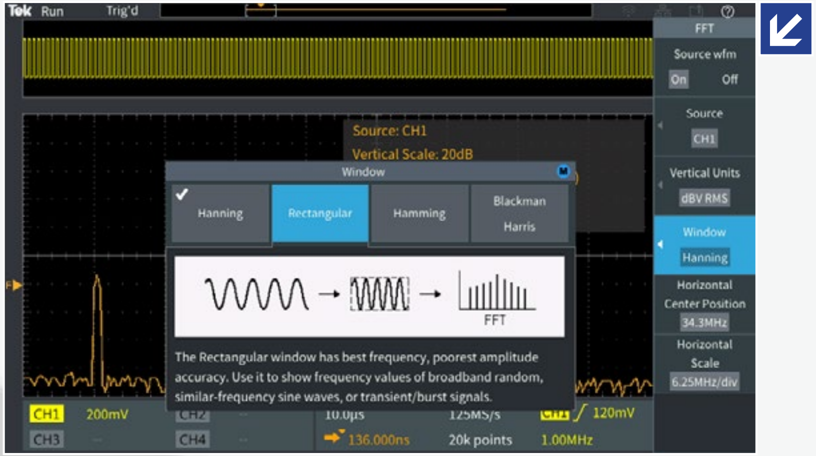
Especially for Education

A relatively new development in the world of scopes is the ability to display lab procedures and tips right on the display. It also provides report-generating facilities to help students get more out of their labs.

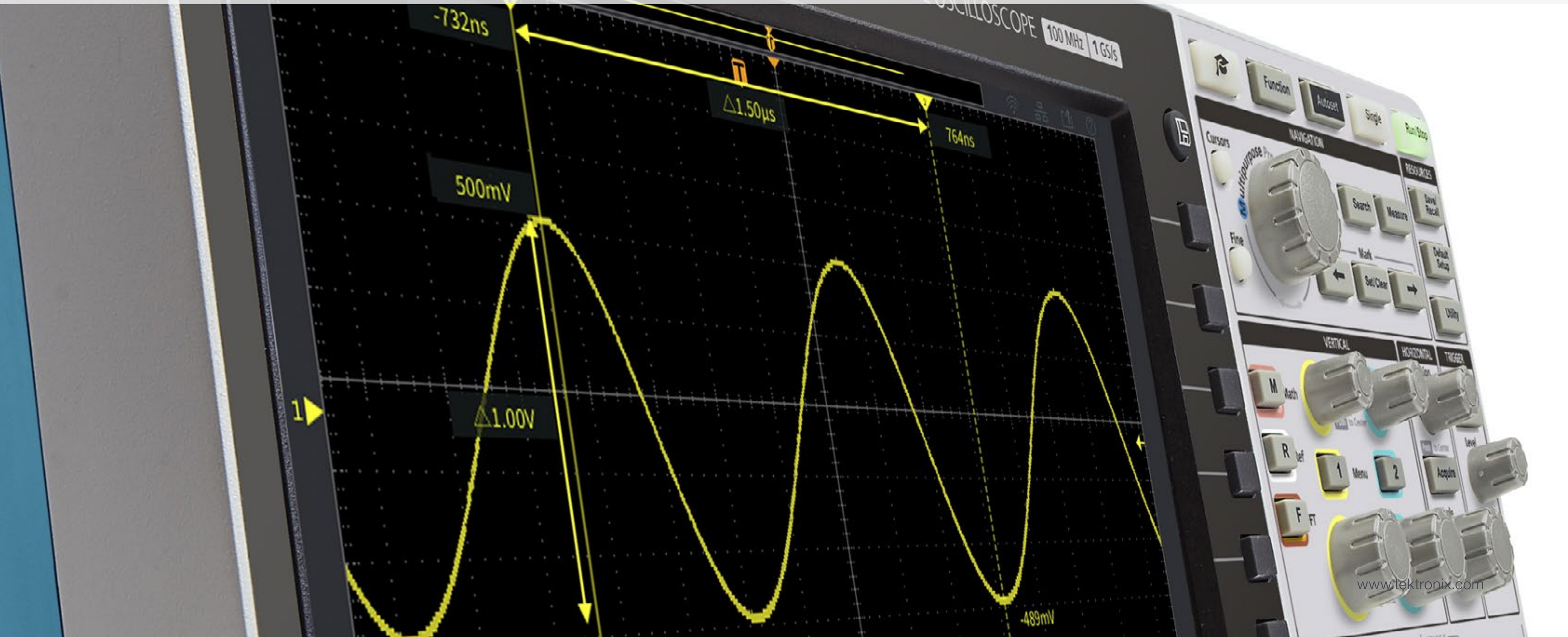
Watch the Video

Controls that match your way of working

Oscilloscopes should give you different ways to operate the instrument. Built-in help can provide a convenient, built-in reference manual, while smart menus give easy access to multifunction, context-sensitive commands.



An icon-rich graphical user interface helps you understand and intuitively use advanced capabilities.



#9 CONNECTIVITY

Connecting a scope to a computer directly or transferring data via portable media allows advanced analysis, and simplifies documenting and sharing results.

Determine what you need

- Will you need to produce reports? Many oscilloscopes can produce .JPG, .BMP, or, PNG files that can easily be incorporated.
- Check for compatibility with third-party analysis, documentation software. Can the instrument produce .CSV files for offline analysis?
- Look for a complete, well-written programmer's manual and check for programming examples. If you ever want to write your own control programs, you'll really appreciate a solid programmer's manual.
- Many scopes come with software or make it available for download to help capture screens, collect waveform data, or save instrument setups
- See what's available for your favorite programming environment. Readily available drivers can save you significant time and effort.
- If you are planning to build the scope into a rack system at some point, check to make sure a rack mount kit is available
- Some scopes offer a VGA output, to allow you to connect an external monitor for easier group viewing
- Wi-Fi support: enables communication with the scope without having to connect cables

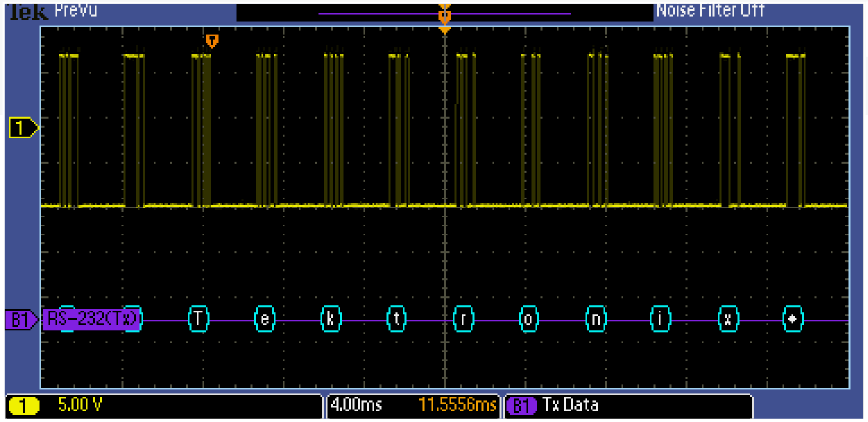
Standard interfaces can include USB, Ethernet, GPIB, Wi-Fi, or RS-232. USB is currently the most common interface, since it is included on most computers and is convenient to use. Ethernet is electrically robust and allows for remote connection over the Internet.

Ask about interfaces

Interfaces enable you to integrate your oscilloscope with the rest of your working environment:

- USB host port: quick & easy data storage, printing, and connecting a USB keyboard
- USB device port for easy connection to a PC or direct printing to a printer
- Ethernet port for network connectivity, plus compatible software to capture screen-shots, waveform data and measurement results
- Video port to export the oscilloscope display to a monitor or projector
- Wi-Fi support allows communication to the scope without having to run cables

#10 SERIAL BUS DECODING



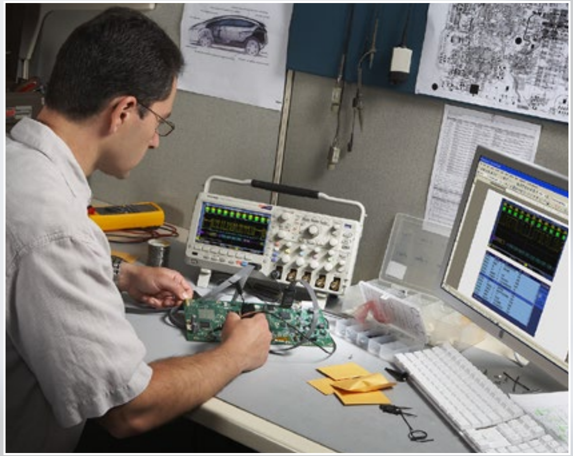
Most system-level (computer to computer) communication is transferred over serial data links. Even on today's circuit boards, much of the chip-to-chip data is transferred over serial buses.

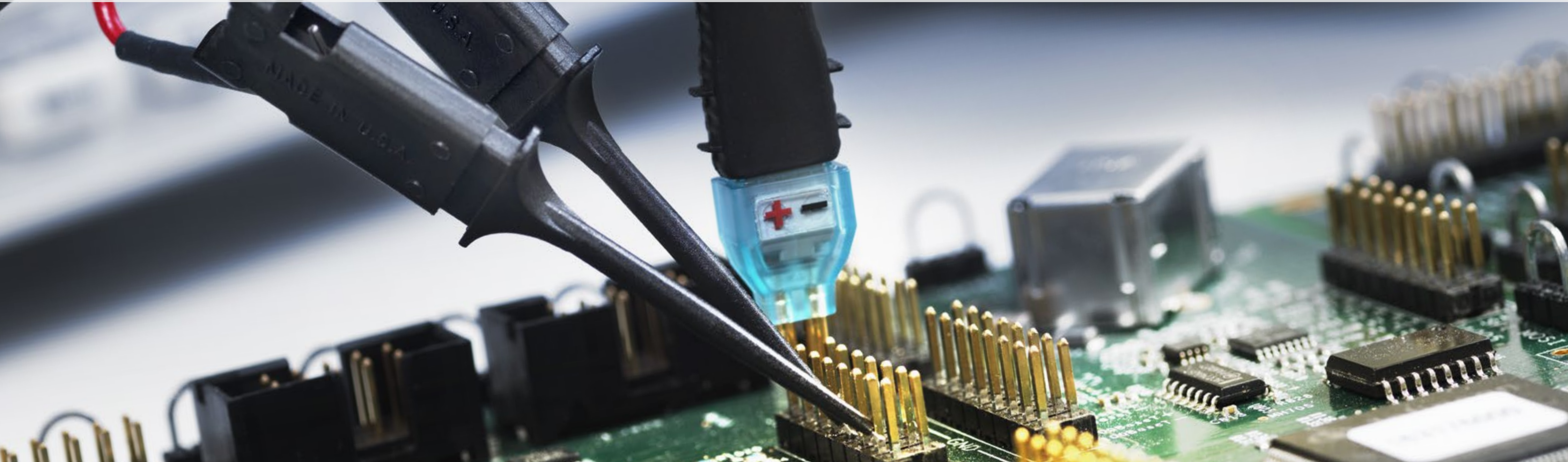
Determine what you need

- Some scopes are able to decode serial buses and display data time-correlated with other waveforms. Automatic decoding is much less time-consuming and less error-prone than hand decoding.
- Decoded chip-to-chip buses such as I2C and SPI can help provide a more complete view of your board.
- Decoded RS-232/UART or CAN/LIN can provide a view of system-level communications.
- In addition to decoding, some scopes provide the ability to trigger and search for serial data values. These capabilities help speed troubleshooting.

Think about your future needs

Complex electronic designs are driving innovation across many industries today. Your scope should have all the features your application needs – now and in the future.





Consider a higher-performance oscilloscope

There are generally more serial buses supported on higher performance scopes, for example, higher-speed buses like USB and Ethernet requires higher bandwidth and sample rate than is usually available on basic oscilloscopes.

#11

SUPPORT: THE 11TH FACTOR

After you've studied all the specs and features, take some time to look into the after-sale support you can expect.

- A comprehensive manufacturer's web site in your language
- Customer support via email, on-line chat or phone
- A broad network of distributors
- Downloadable manuals
- A reputable and easily-accessible repair and calibration organization
- Application notes to help you understand technology and learn about specific measurements
- Software and drivers

Many of these support avenues can be used to help with the research phase, too. Taking advantage of these support resources during the selection process will help you avoid post-purchase surprises later on.

Contact Information:

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