6 Oscilloscope Tricks to Get the Most Out of Your Scope
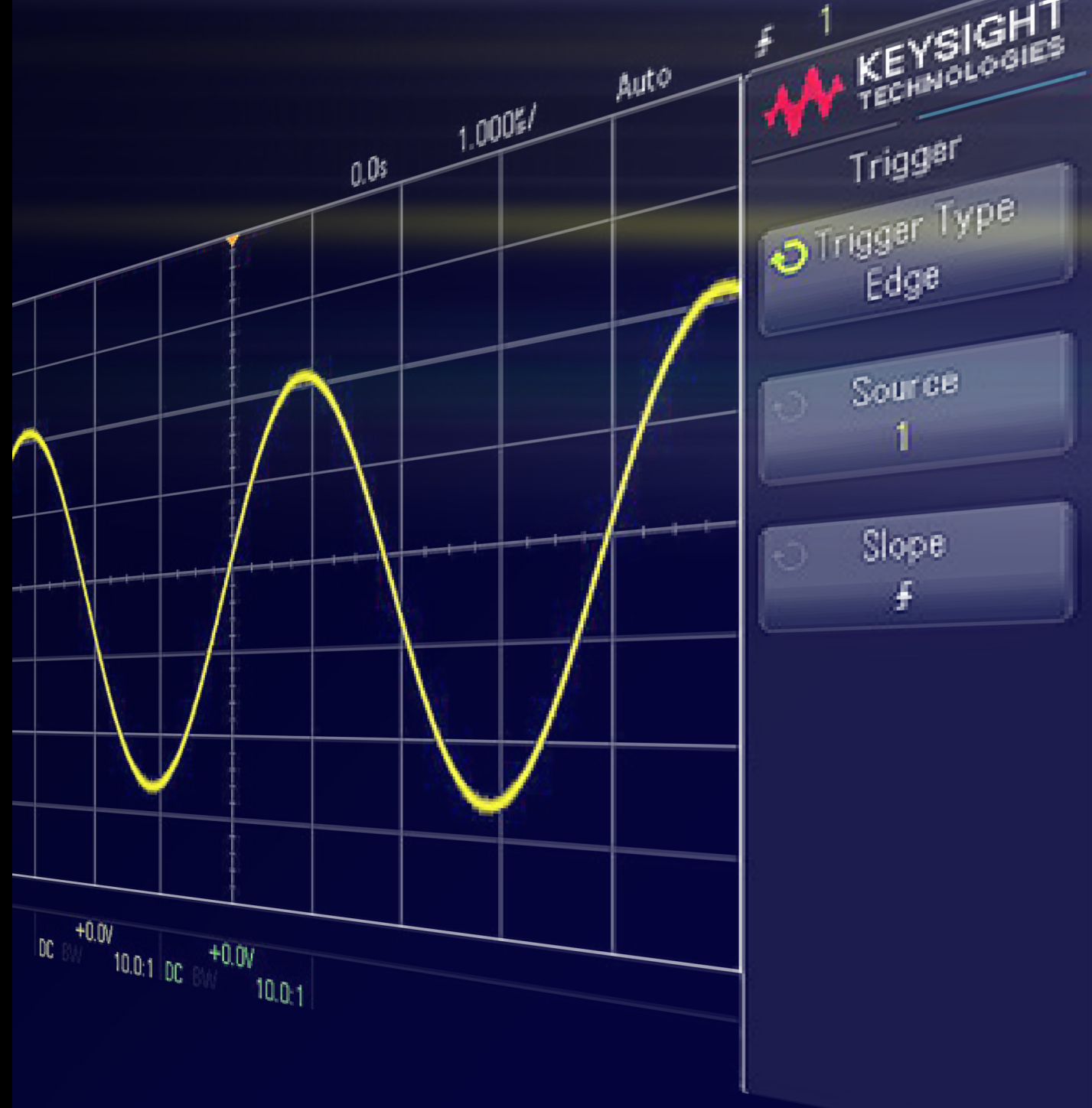
eBook

KEYSIGHT

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TIP 1

Get Started with Basic Triggering

TIP 1: Get Started with Basic Triggering

Photo Finish of Your Signals

Oscilloscope triggering is one of the most important capabilities you need to understand when trying to get the most out of your oscilloscope. It is especially important when attempting to make measurements on many of today's more complex digital signals.

Think of oscilloscope triggering as a racecar photo finish. Although it's not a repetitive event, the camera's shutter must be synchronized to the first racecar's front bumper at the instant in time that it crosses the finish line. Viewing untriggered waveforms on an oscilloscope is just like randomly taking photos of the race. Between the start and end of the race, you'll see a lot of racecars but you won't get the information you really need.

Using the scope's default trigger settings, the oscilloscope will trigger on a rising edge of the signal. This point in time is shown at center-screen (both horizontally and vertically).

Which channel you want to use as the source; the trigger level voltage setting; what kind of edge you want to trigger on (rising, falling); as well as horizontal and vertical position controls are all selectable to help you acquire 'photos' of the exact event you are looking for.
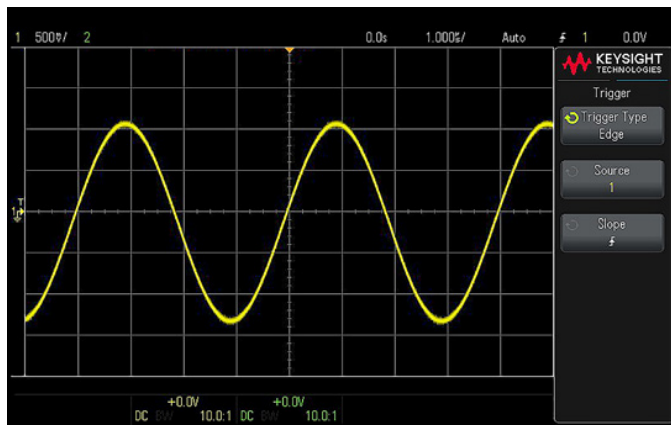
TIP 2

Remember Probing Matters

TIP 2: Remember Probing Matters

Choose the right oscilloscope probe

Probes are used to connect your oscilloscope to your device under test (DUT), and they are crucial for optimizing signal integrity. There are literally hundreds of different oscilloscope probes available, so how do you choose the right one? There's no single answer because all designs are different. But, here are some different probe characteristics you'll want to consider before making a decision.

Bandwidth

A probe's bandwidth describes how high of a frequency the probe is able to pass on to the oscilloscope. Your probes should be at least **3x to 5x** faster than the fastest signal you want to see.
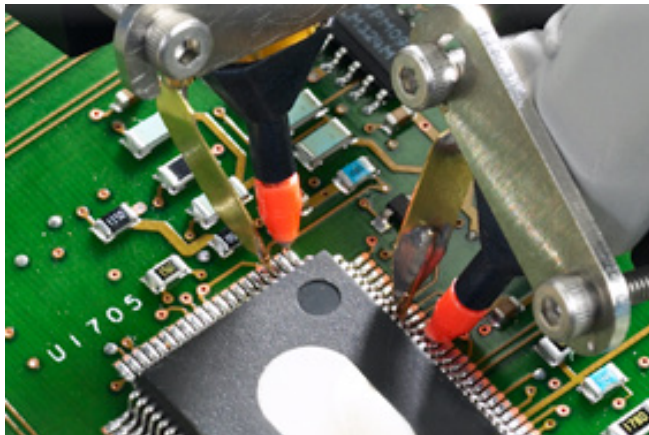
Attenuation ratio

Probes have different (sometimes switchable) attenuation ratios that change how the signals are fed into your oscilloscope. A higher attenuation ratio will allow you to look at higher voltages, but it will also make the scope's internal amplifier noise more pronounced. Low attenuation ratios means you'll see less scope noise but have more system loading distorting your signal.

Probe loading

No probe is able to perfectly reproduce your signal because when you connect a probe to a circuit, the probe becomes part of that circuit. This phenomenon is called loading. Unnecessarily loading your system can lead to inaccurate measurements and even change the shape of the waveform on your oscilloscope screen!

Resistive loading: It is a good idea to make sure the resistance of your probe is greater than ten times the resistance of the source in order to get an amplitude reduction of less than ten percent.

Capacitive loading: Make sure the specified capacitance of the probe fits within your design parameters.

Inductive loading: Reduce inductive loading (appears as ringing in your signal) by using the shortest lead possible.

Passive vs. active probes

Passive probes are typically inexpensive, easy to use, and rugged. They are a versatile and accurate type of probe.

Passive probes usually produce relatively high capacitive loading and low resistive loading. They are useful for probing signals with bandwidths less than 600 MHz. Once this frequency is surpassed, an active probe is needed.

Active probes use active components to amplify or condition a signal and require a power supply to operate. They are able to support much higher signal bandwidths. Active probes are considerably more expensive and less rugged than passive probes. Active probes also typically have less loading than passive probes.

Passive probes are great for qualitative measurements such as checking clock frequencies, browsing for bugs, etc. But, active probes excel in quantitative measurements like output ripple or rise times. **While active probes cost more than passive probes, they can make a big difference for your measurement accuracy.**

TIP 3

Scale Signals Correctly

TIP 3: Scale Signals Correctly

Horizontal scaling

Horizontal scaling is important to consider when making time-dependent measurements. When you change the horizontal scaling (time-per-division) of your signal, you are also changing the total signal acquisition time. The signal acquisition time in turn affects the sample rate of the scope. The equation that describes this relationship is:

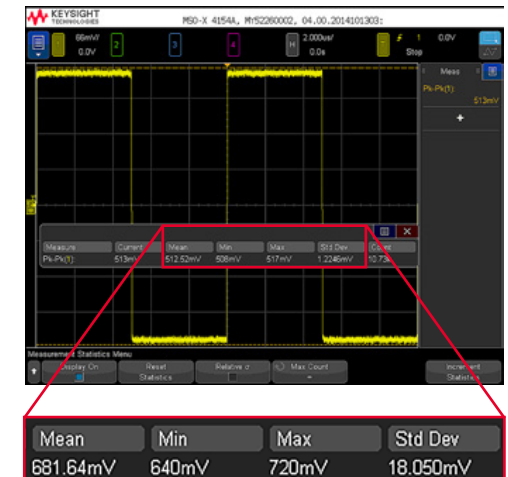**Sample Rate = Memory Depth/Acquisition Time**

Memory depth is a fixed value, and the acquisition time is fixed by adjusting the time per division setting on your oscilloscope. As the acquisition time increases, the sample rate will have to decrease in order to fit the entire acquisition into the scope's memory. Having an appropriate sample rate for time-dependent measurements (frequency, pulse width, rise time, etc.) is important.

Proper signal scaling is crucial.

The oscilloscope's sample rate and bits of resolution affect your measurement accuracy, and proper signal scaling allows you to optimize your measurements.


100 KHz clock signal   Increasing the voltage-per-division scaling

Both of these screens are showing the same signal but with different scaling—resulting measurements deliver significantly different results.

Vertical scaling

Just as horizontal scaling is important for time-specific measurements, **vertical scaling is important for vertically-dependent measurements** (peak-to-peak, RMS, max, min, etc.). By simply increasing the vertical scaling of the signal, you can get a much more accurate measurement with a standard deviation that is much smaller. Why does vertical scaling affect measurements? Just as horizontal (time-dependent) measurements are affected by sample rate, vertical (amplitude-dependent) measurements are affected by bits of resolution.
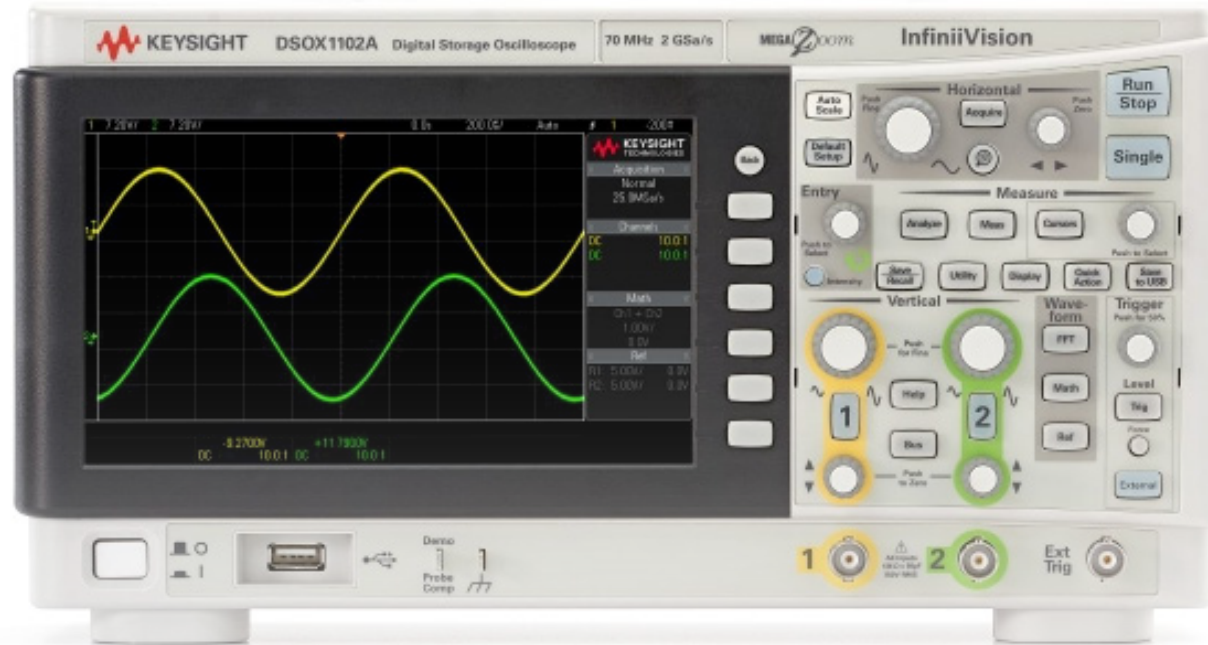
Use the Right Acquisition Mode
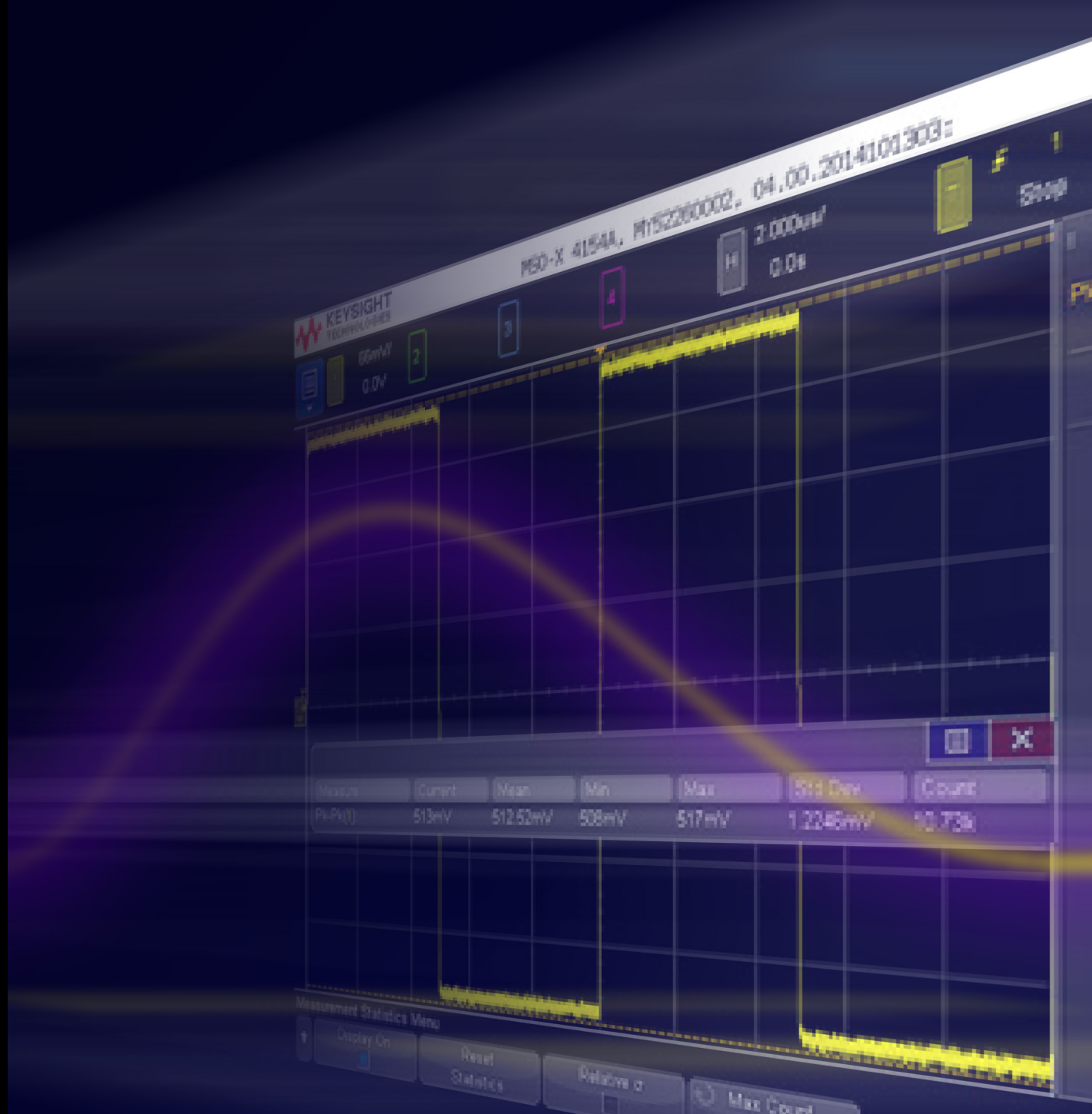
TIP 4: Use the Right Acquisition Mode

What are oscilloscope acquisition modes?

If you want confidence in your oscilloscope readings, you need to understand the strengths and weaknesses of different acquisition modes: normal, averaging, high resolution, and peak-detect acquisition. Acquisition modes are finely-tuned sampling algorithms. By varying the sample rate of the scope's analog-to-digital converter (ADC) and selectively plotting or combining sample points, different characteristics of a signal can be observed.

Normal acquisition mode

Normal acquisition mode is the default mode for oscilloscopes. The ADC samples, and the scope decimates down to the desired number of points and plots the waveform. It's best to use normal acquisition mode for day-to-day debugging tasks because it gives a good general representation of your signal. It's a safe mode to use and has no significant caveats.

Averaging acquisition mode

Averaging mode takes multiple waveform captures and averages them together. The main benefit of averaging acquisition

mode is that it averages out the random noise on your signal; this allows you to see just the underlying signal. Averaging acquisition mode should be used only with periodic signals and with a stable oscilloscope trigger. Averaging mode is great for viewing or characterizing very stable periodic waveforms.

|	
Normal mode	Ideal for day-to-day debugging.
Averaging mode	Helpful for removing random noise on synchronous, stable signals.
High-resolution mode	Useful for maximizing your bits of resolution while debugging synchronous or asynchronous signals.
Peak-detect acquisition mode	Valuable for gaining insight into unusually high or low points that may not typically be seen.
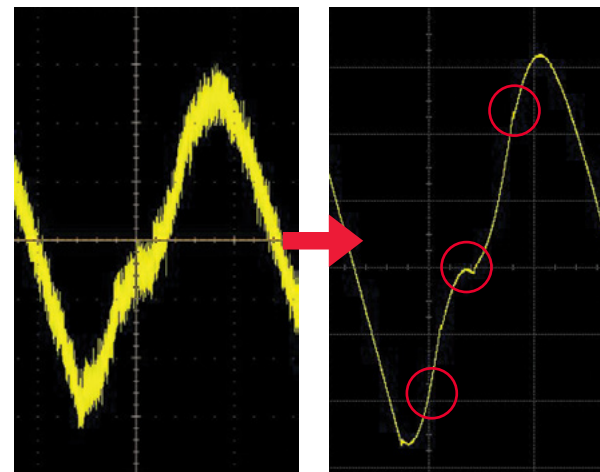
The screen on the right is with averaging and there is significantly more detail visible.

High-resolution mode

High-resolution mode is another form of averaging. However, instead of waveform-to-waveform averaging, it is **point-to-point averaging**. Essentially, the ADC oversamples the signal and averages neighboring points together. This mode uses a real-time boxcar averaging algorithm that helps reduce random noise. It also can yield a higher number of bits of resolution.

High-resolution mode isn't as effective at reducing random noise as the averaging mode discussed earlier, but it has some distinct advantages. Because high-resolution mode doesn't depend on multiple captures, it can be used with aperiodic signals and unstable triggers. This makes high-resolution mode much better than averaging mode for general-purpose debugging.
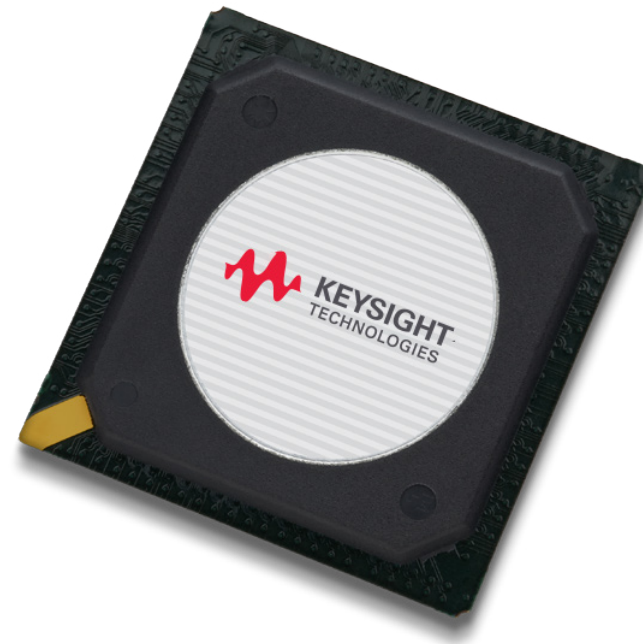
Peak-detect acquisition mode

Peak-detect acquisition mode functions similar to high-resolution mode. The ADC oversamples the signal and selectively chooses which points to display. But instead of averaging these points together, **peak-detect mode chooses the highest and the lowest points and plots them both**. This is useful because it can provide insight into any unusually high or low points that might be otherwise hidden. Peak-detect mode is best used for detecting glitches or viewing very narrow pulses.

TIP 5

See More Detail Using Advanced Triggering
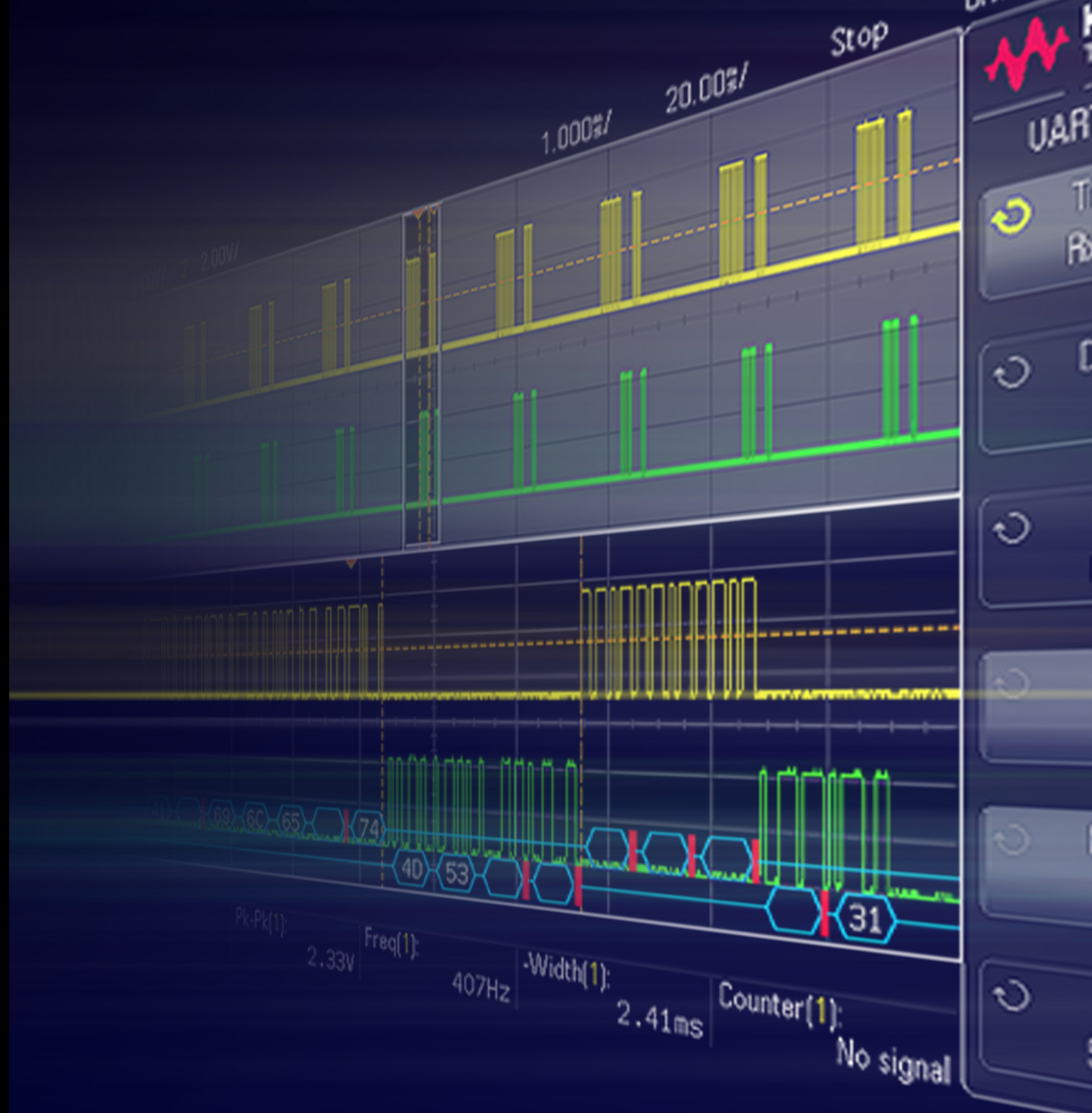
# TIP 5: See More Detail Using Advanced Triggering

In Tip 1 we talked about basic triggering, but there are many more triggering options to choose from.

Rise/fall time trigger

The rise/fall time trigger looks for a rising or falling edge transition from one level to another level in greater than or less than a certain amount of time. It triggers on signals that change state either too fast or too slow. This trigger is helpful to see if there's an impedance mismatch or some extra loading on your system that is causing your edges to be too slow.

A setup and hold time trigger is used for any data and clock signal. One oscilloscope channel probes the clock signal and another channel probes the data signal. Setup time is the time a data signal level must be present before the clock edge. Hold time is the time a data signal level must remain after a clock edge. This is an important trigger because digital designs require that the data line's state be setup (0 or 1) for a certain amount of time before the clock edge occurs. Set the trigger conditions to your specified setup and hold requirements to check for violations in your design.

Rise/fall time trigger	Helpful if there's an impedance mismatch or loading on your system that's causing your edges to be too slow.
Setup and hold time trigger	Usually used to trigger on setup and hold timing violations.
Built-in protocol triggers	Extremely useful if you are working with serial buses.
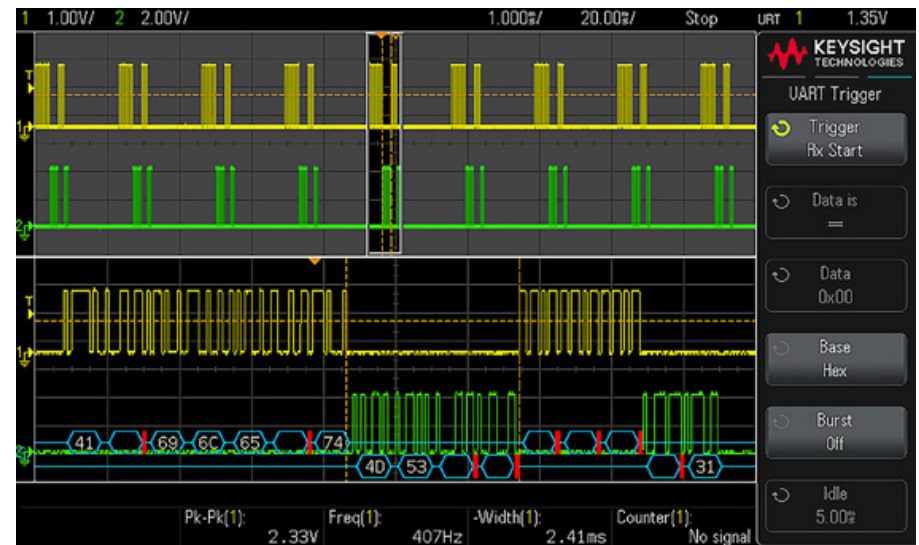
Protocol triggers

Many oscilloscopes today have built-in protocol triggers. These are extremely useful if you are working with serial buses. For each of these different buses, there is a series of different triggers (Start condition, Stop condition, Missing Ack, Address with no Ack and more).

Aerospace/Defense	ARINC 429, MIL-STD 1553, etc.
Automotive	CAN, I2C, SPI, etc.
Computer	USB, etc.

You can begin your debugging by triggering on a start condition, which will give you a stable view of the packets coming through and insight into how your system is operating. If you're getting system errors or want to prove that everything's functional, you can even **trigger exclusively on errors.** This will allow you to focus only on the areas causing problems and not waste time wading through hundreds of error-free packets. If your oscilloscope has segmented memory, you can turn it on and exclusively capture errors over very long periods of time.

TIP 6

Use Integrated Protocol Decoders for Serial Buses

TIP 6: Use Integrated Protocol Decoders for Serial Buses

Protocol decode

Depending on what type of device you're testing, you might need to test certain serial buses (such as CAN and LIN for automotive and I²C and RS-232 for embedded designs). Oscilloscopes can characterize the analog quality of these signals by making physical layer measurements.

As described in Tip 5, a protocol trigger can help capture a specific instance or event on the bus, which is tremendously useful. However, many of the serial buses used today are encoded in a hexadecimal format and can be difficult to understand. An integrated protocol decoder translates those events into a more useful format.

Hardware-based decoding

Hardware-based decoding provides a real-time update of the decode trace. This enhances the scope's probability of capturing and displaying infrequent serial bus communication errors, such as stuff bit errors, form errors, acknowledge errors, CRC errors, and error frames.

Expanded view of the hexadecimal decode trace.

Expanded view of symbolic decode trace.

Example: Above you see an oscilloscope triggering on and decoding a CAN bus in a hexadecimal format, frame 0x201. There are also two subsets of that screen, one decoded symbolically and one in its native hexadecimal format.

In this example, the oscilloscope triggered on frame ID 0x201HEX, which correlates to 010 000 0001Binary. The decoder translates captured data into useful information such as "Speed = 852.52 rpm" – instead of just bits.

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