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Educator's Corner : Teacher's Tools

Scope Measurement Hints

Hints for Making Better Scope Measurements

These helpful application tips will assist you in getting the most out of your digitizing scope, so you can do your job not just faster but better.

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An Easy Way to Isolate the Cause of Noise Problems

In today's digital systems, noise coupled from other parts of the system is a common problem. Whether the noise is caused by a switching power supply, CRT interference, or the system clock, this measurement technique will help isolate the cause of the noise. Noise signals are tricky to analyze on a scope. Typically the scope is triggered on a signal other than the noise itself, since many times noise signals are so small that it is difficult to trigger on them directly. Figure 1 shows a noisy ground signal with the scope auto triggered.

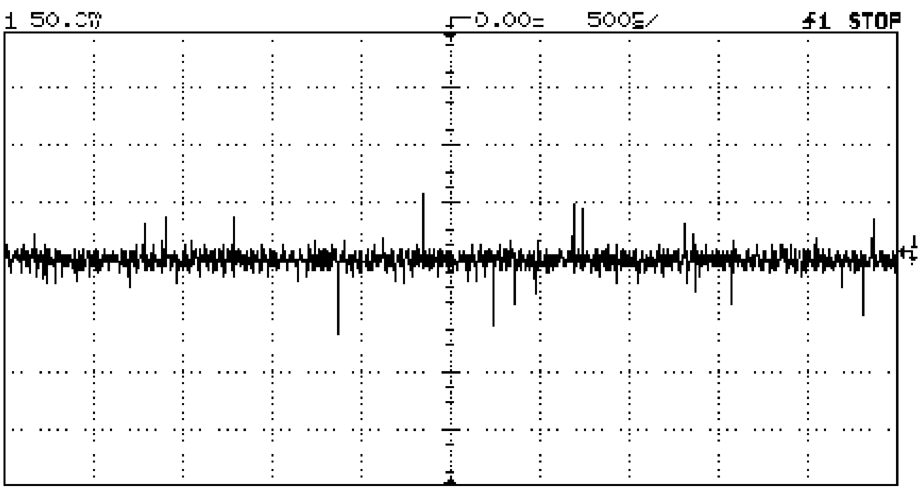

Figure 1

A solution to this problem is to trigger on the suspected noise source. See Figure 2. In this case, the 516 kHz clock signal was suspected. Triggering on the clock signal (channel 2) and viewing the noisy ground signal on channel 1 results in a trigger synchronous to the noise. Now you can use averaging to average out the asynchronous noise. Using this technique, it's easy to see that this noise is indeed due to the 516 kHz clock.

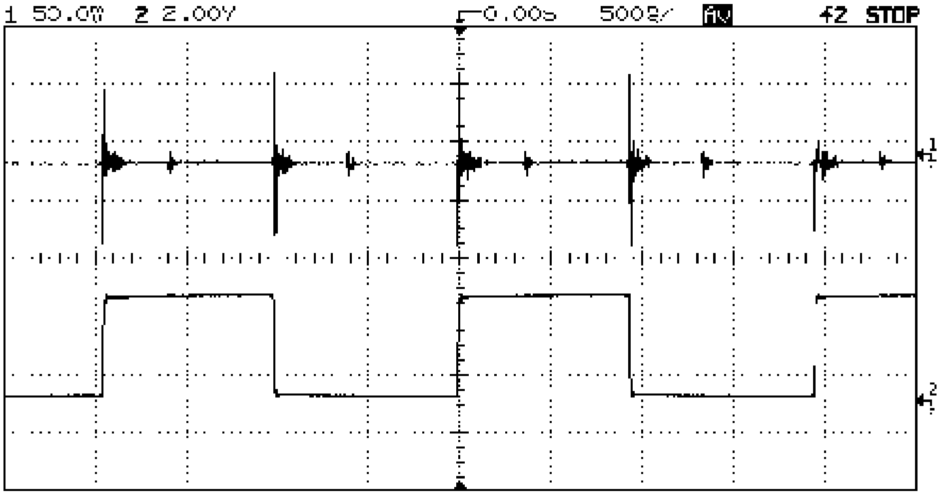

Figure 2

If there are multiple noise sources, the same technique can be used to isolate the noise components that are due to each noise source, with the contributions from all other asynchronous noise sources eliminated through averaging.

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Poor Man’s TDR

A quick and inexpensive way to check for defects in cables (LAN cables, BNC cables, etc), is to use a pulse generator and a scope as a TDR system.

Output a < 1 ns pulse from the pulse generator through a power splitter, with one end into the scope (50 ohm input) and the other into the cable under test. See set up in Figure 1.

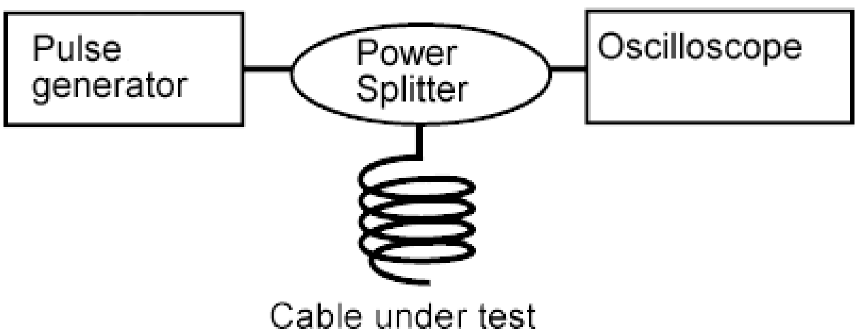

Figure 1

Perform a TDR measurement on a known good cable of the same type as the suspect cable. This will give you an idea of the appropriate response. Figure 2 shows the TDR response of a BNC cable. The first step you see is the pulse output from the generator. The second step corresponds to the unterminated end of the BNC cable. For this BNC cable the step travels out to the end of the 4.13-foot cable and back in 12.7 ns. The velocity constant is v = distance/((delta t)/2) or 4.13/((12.7)/2). In this case v is approximately 0.68 ft/ns.

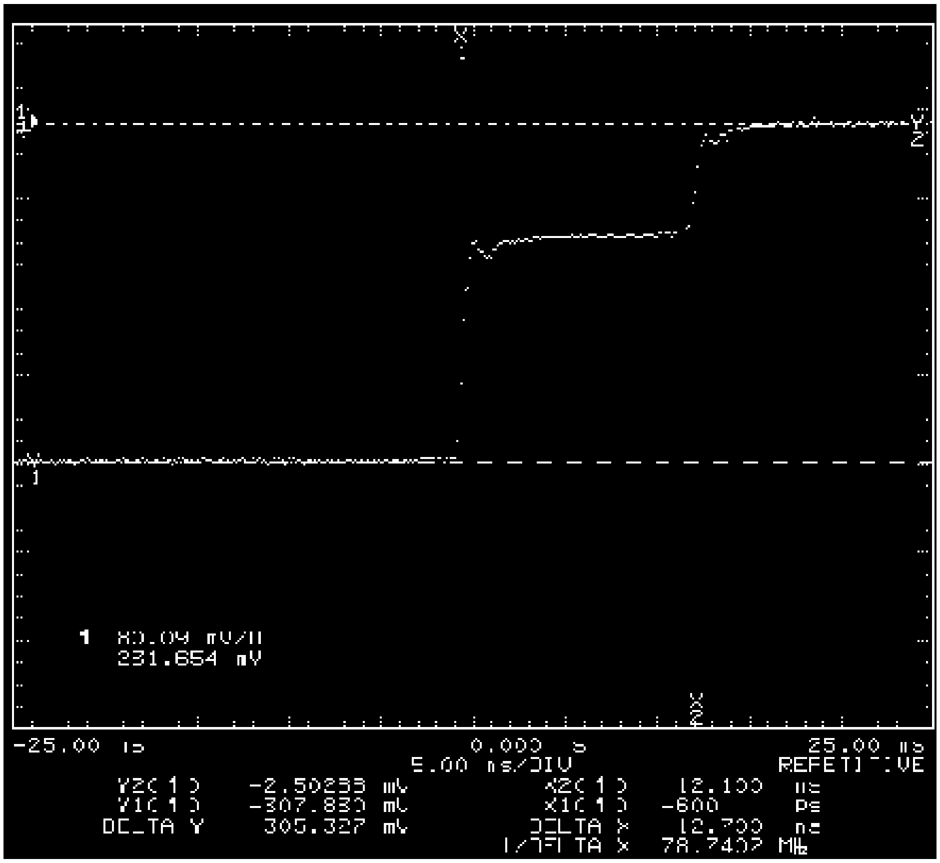

Figure 2

Now you can do a TDR measurement of the suspected cable and locate defects using the formula distance = ((delta t)/2) * v. An open circuit will show as a step up, and a short will show as a step down.

HP 54520- and HP 54540-series oscilloscopes have an AC cal signal with < 1 ns risetime. This makes it even simpler to do a poor man’s TDR. Simply substitute this cal signal for the pulse from the pulse generator.

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Probing Sanity Check

Before probing a circuit, connect your probe tip and your ground lead to the same point on your circuit (usually ground) to check for com-mon mode rejection. Ideally you should get a flat line on your scope. If you get blips (common mode noise), this inaccuracy will be reflected in your measurements. You may need to make adjustments to your probing to make a better measurement.

For instance, in the following example, shortening the ground lead did the trick.

In Figure 1 the circuit ground is probed with a 5" ground lead. In Figure 2, the same signal ground is probed with a 1/2" ground lead. The blips are no longer big enough to have much affect on your mea-surement.

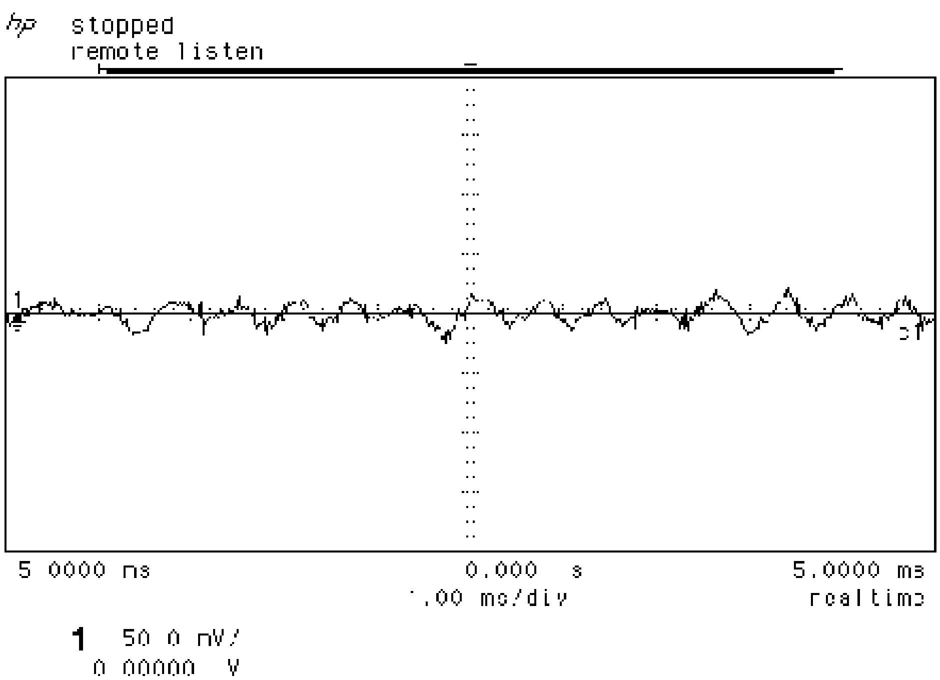
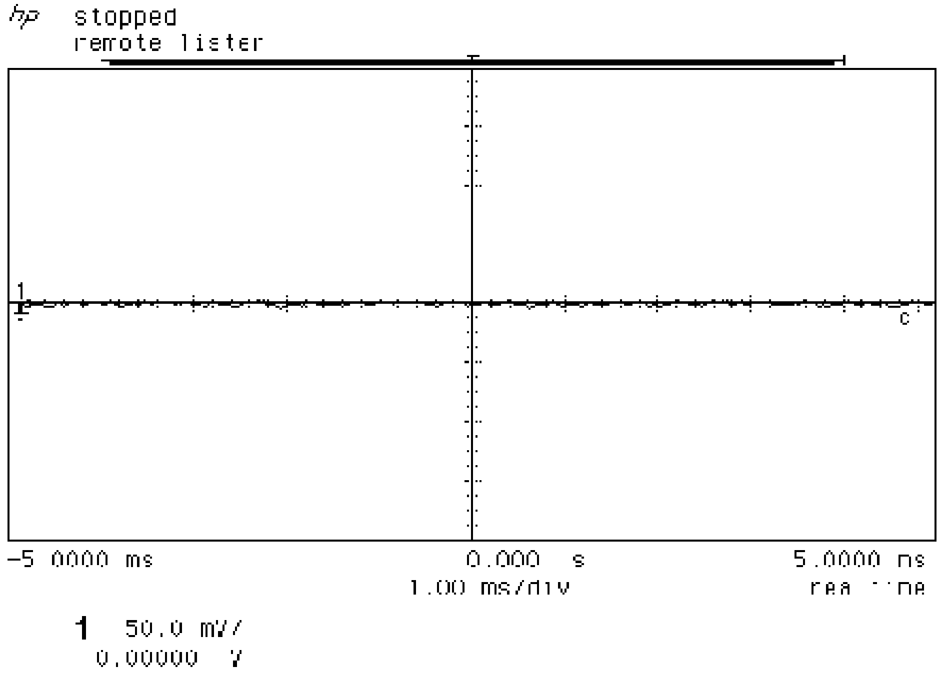


Figure 1



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Troubleshooting Infrequent Events

When trouble shooting or characterizing a circuit, take advantage of the triggering capabilities of your scope. Some scopes are able to time qualify the trigger. You can tell the scope to trigger only if it sees an event wider than, or narrower than, a specified width. This is very useful when looking for infrequent events.

For example, if you know that a strobe pulse must be at least 30 ns wide, you can set up your scope to trigger on a pulse which is < 30 ns. The trigger circuit will look at every pulse, if pulses are at least as far apart as the reset time for the trigger circuit. If the scope triggers, there's a problem. If it doesn't trigger, there isn't a problem. Scopes can process tens of millions of events per second in this way.

In Figure 1 the scope is edge triggered on a rising edge of channel 1 and the strobe pulse appears to be good (^{3} 30 ns wide).

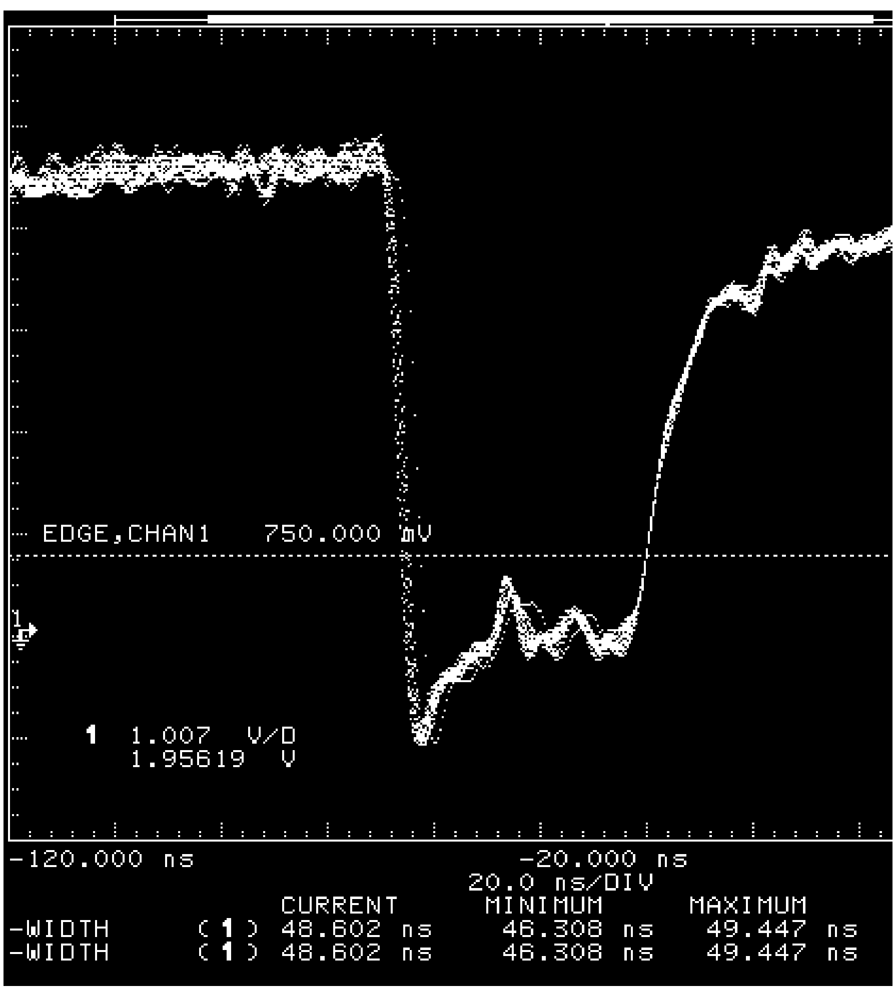
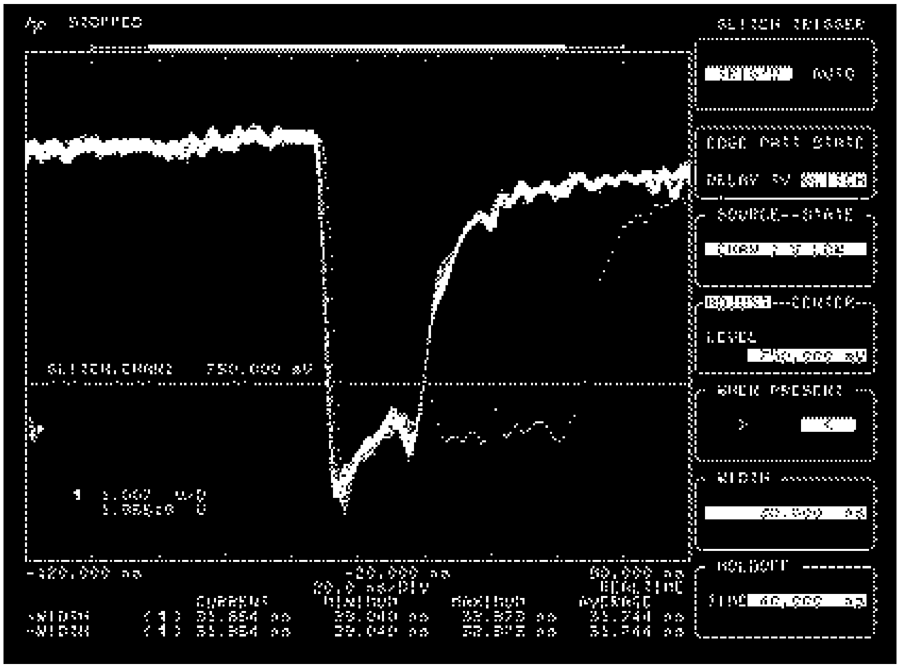


Figure 1

In Figure 2, the scope is set up to trigger on a negative-going pulse that is present for less than 30 ns. The scope triggered, verifying that sometimes the strobe pulse is bad (< 30 ns wide).



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How to prevent your scope from aliasing

Here are a few things you can do to help ensure that your oscilloscope waveform is not aliased:

1. Check for a stable trigger. Aliased waveforms sometimes appear to drift across the oscilloscope screen or look "untriggered".

2. Make sure the scope's effective sample rate is as fast as possible. Most oscilloscopes decrease their effective sample rate as the time/div is slowed. (Note that repetitive scopes can have a high effective sample rate, even with a low actual sample rate). If you suspect an aliased waveform, increase the sweepspeed to ensure that the scope is sampling as fast as possible for proper display of the waveform. For example, Figure 1 shows an aliased waveform at 5 ms/div. The actual signal is 13 MHz but the scope measures 50 Hz! At this sweepspeed the scope is sampling at 10 kSa/s, severely violating the Nyquist* criteria. Figure 2 shows the same signal at 20ns/div. At this sweepspeed the scope is sampling at 2GSa/s. The scope displays the correct signal and measures the correct frequency, 13 MHz.

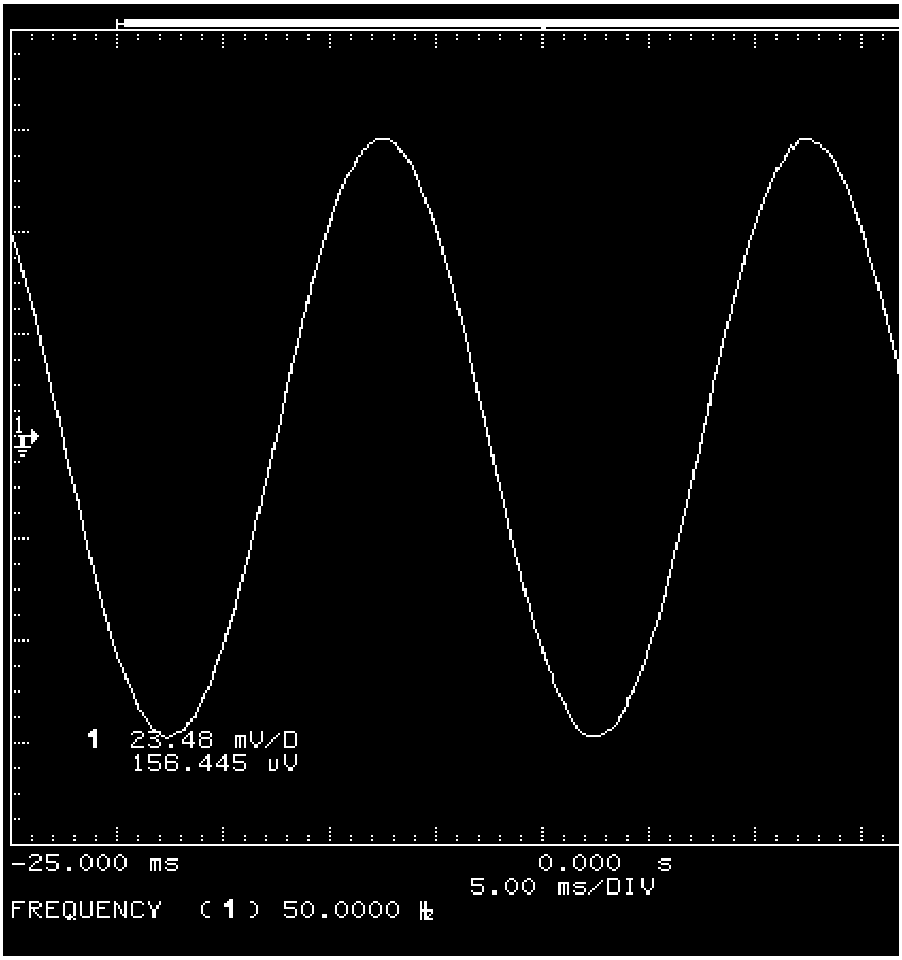
1 23.48 mV/D
156.445 uV
-25.000 ms
0.000 s
5.00 ms/DIV
FREQUENCY (1) 50.0000 Hz

Figure 1

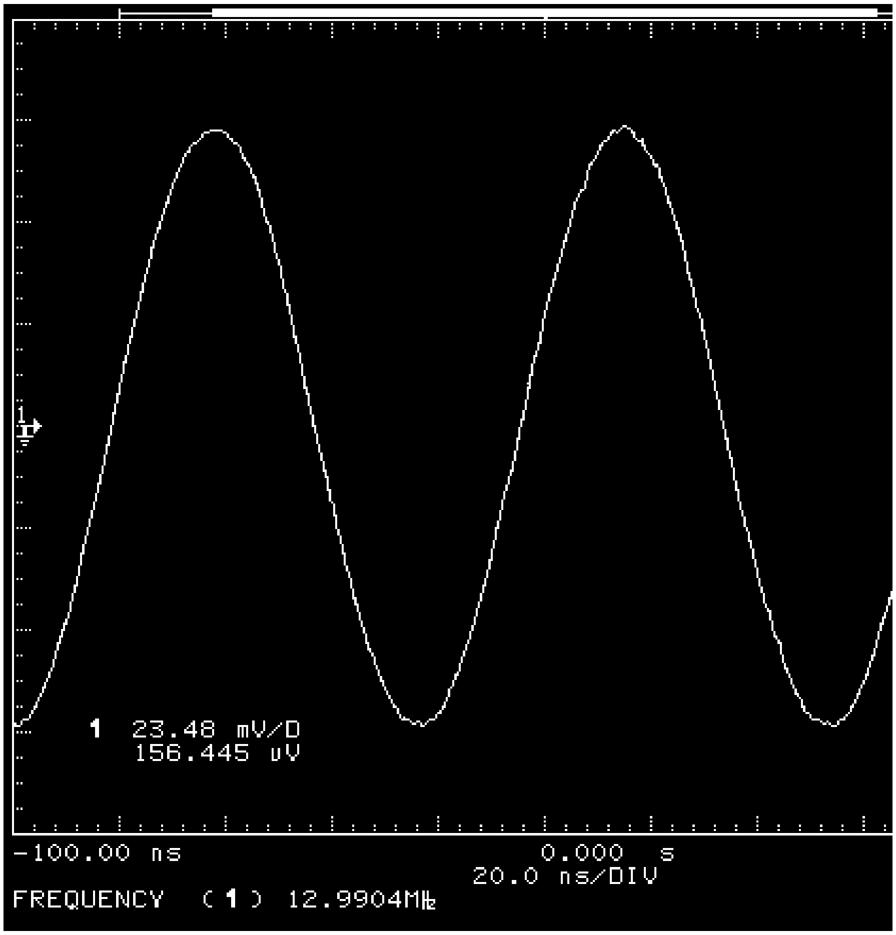
1 23.48 mV/D
156.445 uV
-100.00 ns
0.000 s
20.0 ns/DIV
FREQUENCY (1) 12.9904MHz

Figure 2

3. Some oscilloscopes employ techniques to prevent aliasing. HP 54600-series oscilloscopes use a patented proprietary algorithm to reduce aliasing. In Figure 1 the signal is aliased. Figure 3 shows the same signal on an HP 54600B oscilloscope. The waveform is not aliased at the same sweepspeed due to the anti-aliasing algorithms.

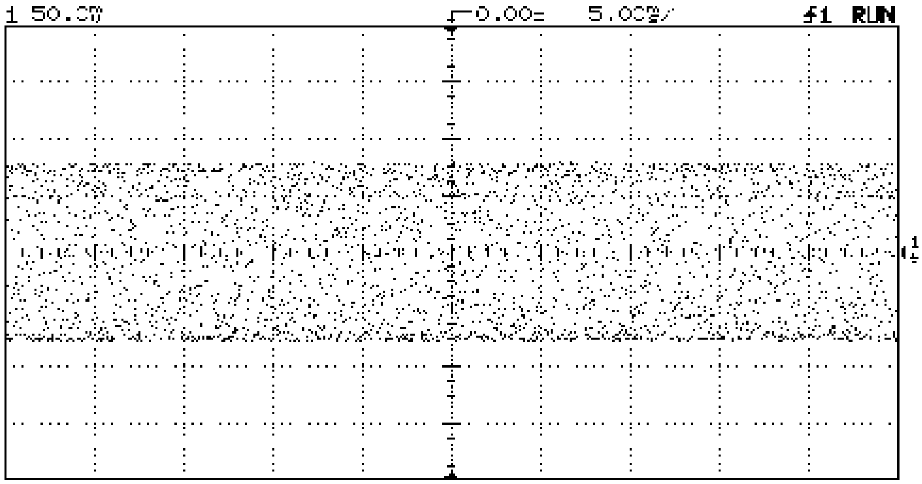

Figure 3

4. Another method for determining if aliasing is occurring is to put the scope in peak detect mode. Peak detect maintains the maximum sample rate and plots the max/min values on display. Using peak detect, no "alias" will appear.

* The Nyquist sampling theorem states that for a baseband signal to be faithfully reproduced in sampled form, the sample rate must be greater than twice the highest frequency present in the signal.

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Analyze Harmonic Distortion Using FFT

With amplifiers so widely used in electronic devices, harmonic distortion is a common problem faced by design engineers.

To characterize a prototype amplifier, you can input a spectrally pure sinewave and look at the amplifier output on your scope. In this example (Figure 1), the sinewave looks distorted. To get a different point of view, try doing an FFT of the sine wave (Figure 2). Observe the harmonics.

The FFT gives you more quantitative information on how much harmonic distortion there is in the amplifier design. The fundamental frequency is at 50 kHz. The second harmonic at 100 kHz is only 17.81 dB down from the fundamental, indicating serious harmonic distortion. Built-in FFT capability in a scope lets you take a quick look at the frequency domain, in addition to the time domain.

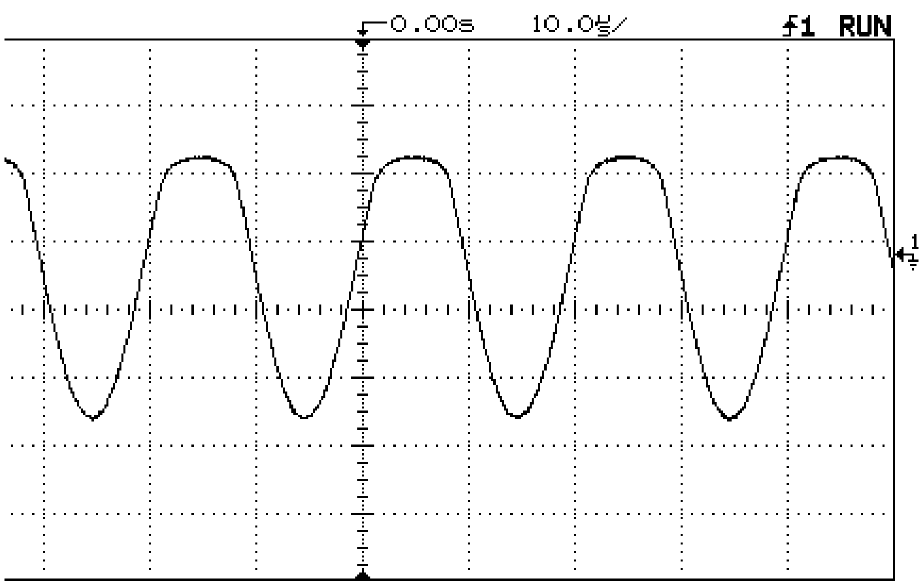
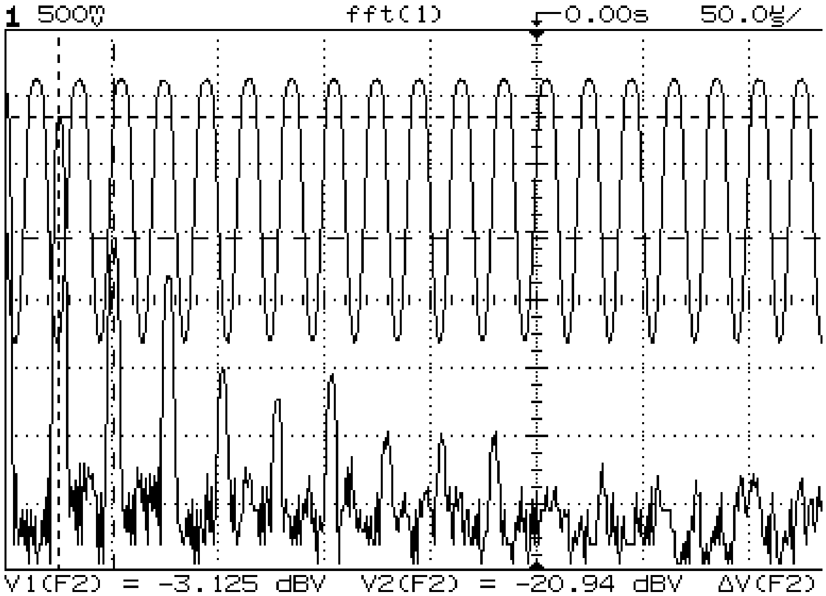


Figure 1



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Use Holdoff to Stabilize Complex Digital Waveforms

Scope users typically start out using edge triggering. In this mode, the scope will trigger on any edge that meets the setup criteria, for instance any rising edge on channel 1 at 1.5 V. The trigger event becomes the time reference for displaying the data. This presents a problem when there are many edges at different positions in the waveform that meet this criteria, as is the case with complex waveforms. The scope triggers on multiple edges and overlays the waveforms with different time references. The result is a complicated display that looks untriggered. See Figure 1.

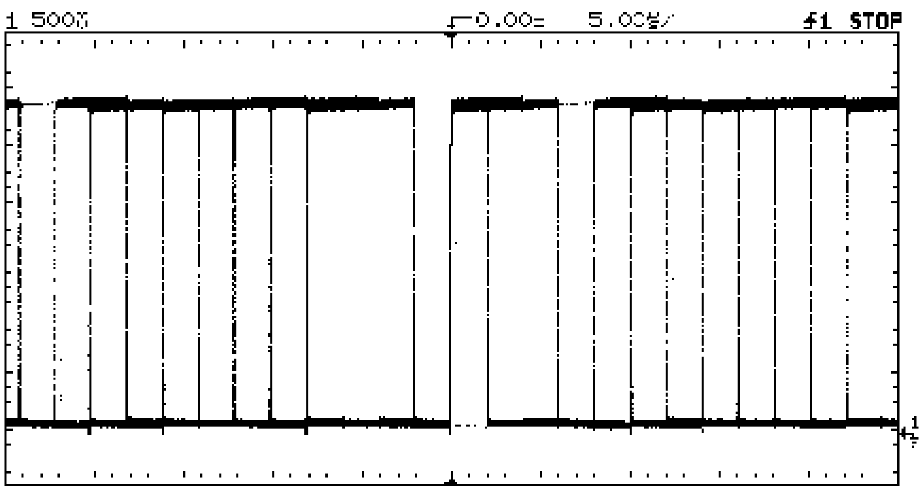
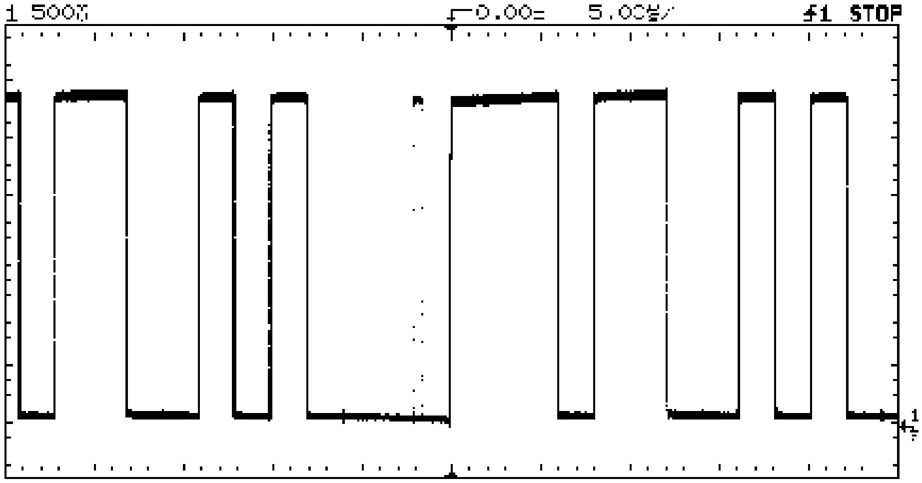


Figure 1

Try using your scope’s holdoff feature to stabilize such a waveform. When holdoff is used, the scope triggers on the first rising edge it sees, but then waits the holdoff time before re-arming the trigger to look for the next trigger event. Use a holdoff time just less than the period of the repetition of the waveform. For this example, the holdoff time is 28 microseconds. See Figure 2. The scope now triggers on the same edge every time, so the data has the same time reference each time it is displayed. It is now evident that there is an intermittent glitch.



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Capture Fast, Low-Duty-Cycle Pulses Using Peak Detect

Capturing narrow pulses such as the 2.5 ns pulse shown in Figure 1 is not a problem for high speed digitizing scopes.

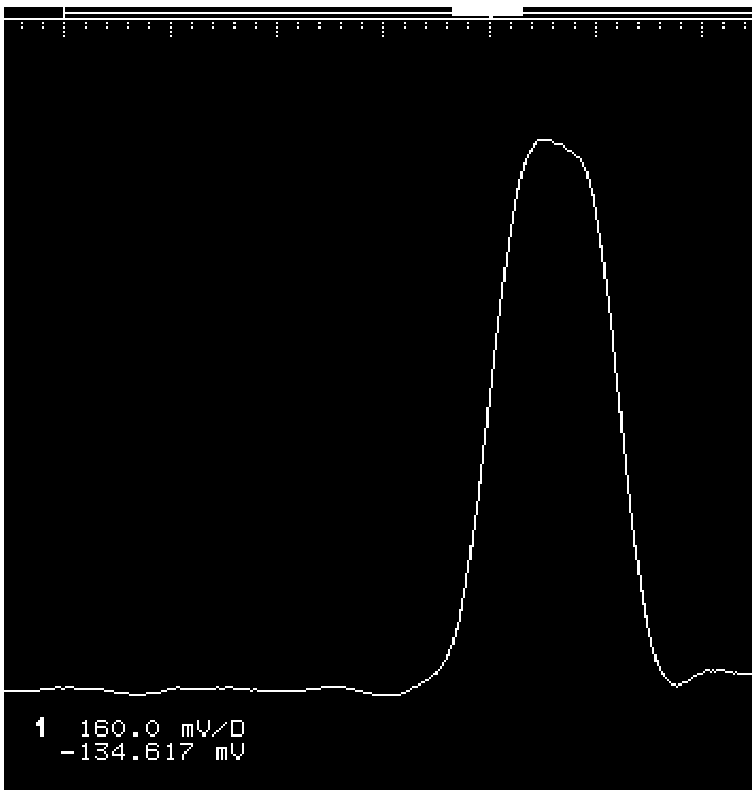

Figure 1

However, this pulse is part of a pulse train with a duty cycle of just .002%. In order to view the long time span between the narrow pulses, the sweepspeed must be reduced. With conventional sampling techniques, the scope's sample rate is reduced such that the scope is no longer able to capture points on the narrow pulses. In the example shown in Figure 2, the scope samples at 500 KSa/s on the 100 microseconds/div timebase range and only randomly catches a point on one of the narrow pulses. The statistical odds of capturing a 2.5 ns pulse with a 2 microsecond sample interval is just 0.125% per acquisition.

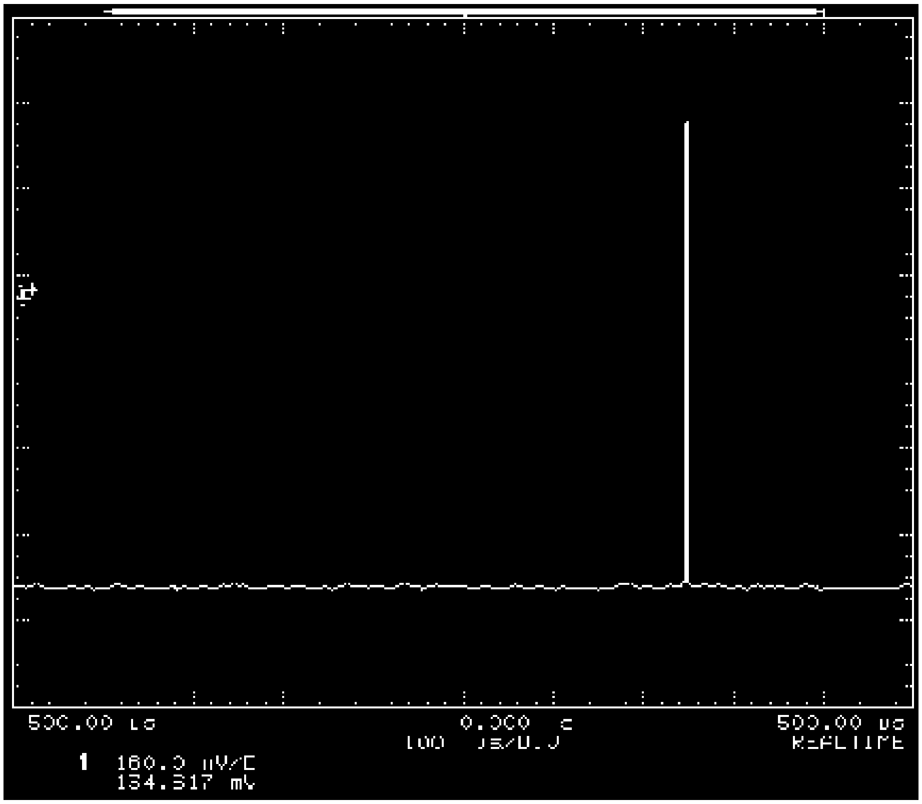

Figure 2

However, by using peak detect mode, you can capture pulse trains with widths as narrow as 1 ns with 100% confidence, regardless of your scope's sweepspeed. See Figure 3. Peak detect is a display mode that maintains the maximum sample rate of the scope independent of the sweepspeed. The max and min values are saved and displayed on the scope. Without peak detect, many of these max and min values would have been thrown away. The minimum pulse width that can be captured is a function of the sample rate of your scope.

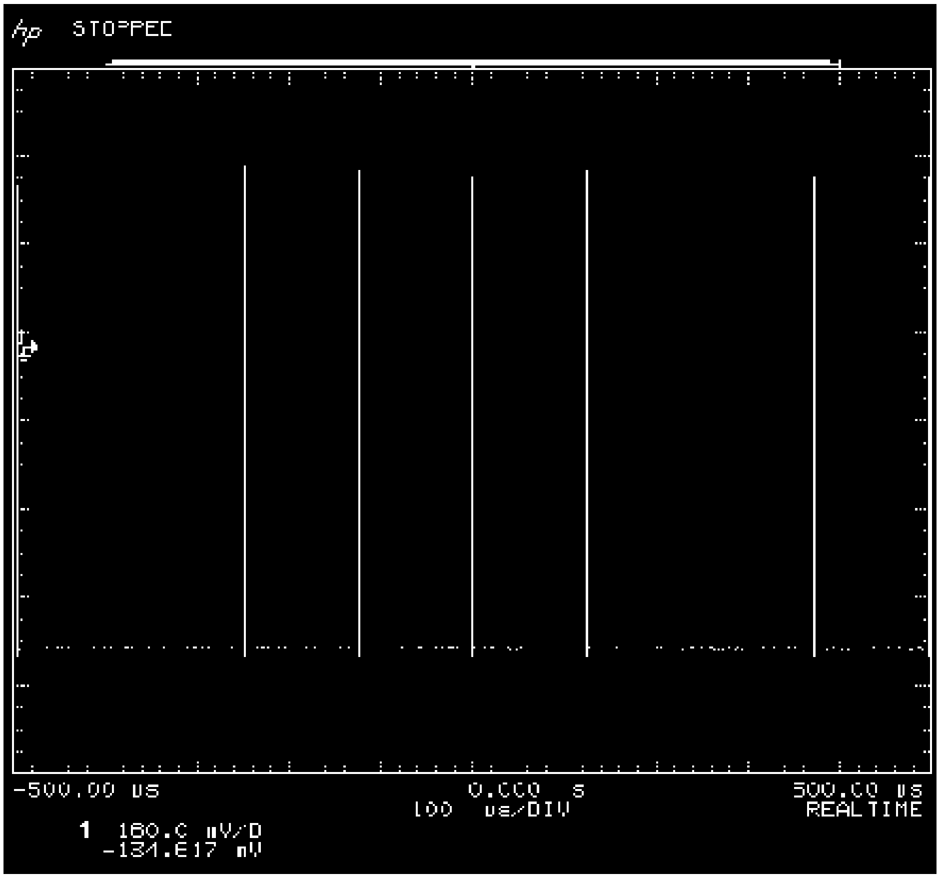

Figure 3

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