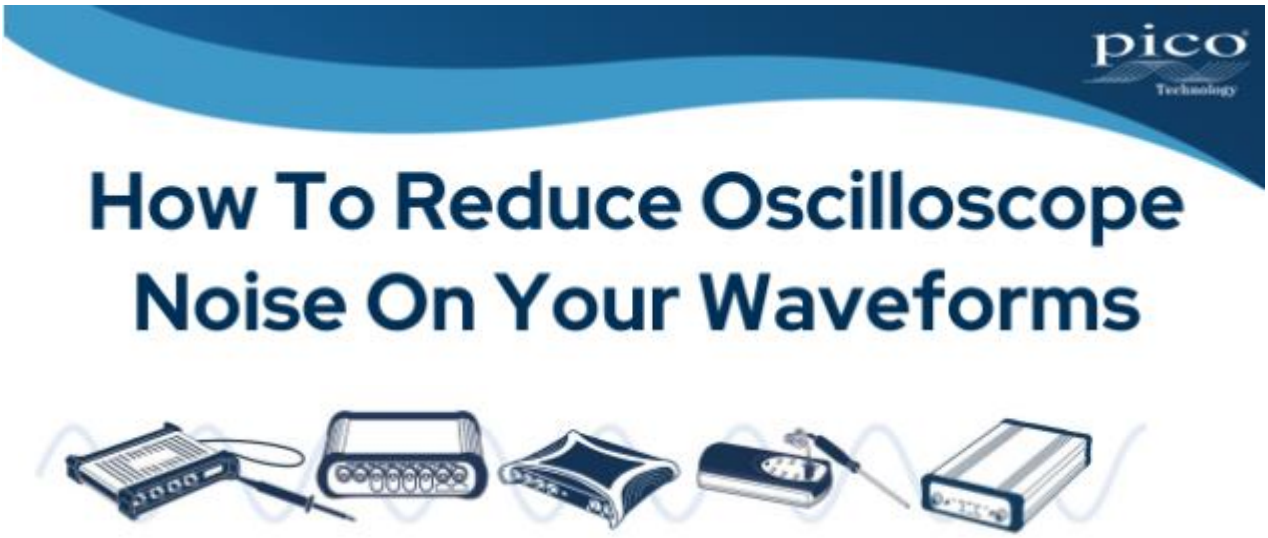
How To Reduce Oscilloscope Noise On Your Waveforms

By Pico Technology Staff



When a trace looks noisy, the oscilloscope itself is only one possible cause. The unwanted signal may be:

- **Generated by the device under test**, such as semiconductor noise, switching ripple or clock-related interference.
- **Picked up from the surrounding environment**, including power wiring, switch-mode power supplies, Wi-Fi, mobile phones and nearby digital circuits.
- **Added by the measurement system**, including the probe, cabling, grounding arrangement and the oscilloscope's own input noise.

Effective noise reduction and knowing how to reduce oscilloscope noise on your trace starts at the device under test and follows the signal all the way through the probe and oscilloscope input to the displayed waveform. Simply applying an averaging function in the software may make the trace look cleaner without establishing where the noise came from, or whether it was real.

By isolating interference, using the right **PicoScope Oscilloscope** for your measurements, or combining these with the noise-reduction features in our **PicoScope 7 Software**, you will get the best measurement accuracy from your scope.

Explore PicoScope Oscilloscopes

Phase 1: Establish Whether The Noise Is Real

You must determine if your signal noise originates in your device or the measurement system. To isolate the source, start with just the scope and check each part of your measurement system in turn:

1. Disconnect and short the oscilloscope input to establish the baseline noise floor on your selected range and bandwidth. 2. Connect your probe to the input without attaching it to the active circuit, and short the probe tip to

its ground lead. This will show any noise picked up by the probe as an antenna. 3. Connect the probe ground lead to the ground of the device under test, and probe that same ground point with the probe tip. This will show any noise resulting from a ground-loop between your device under test and the oscilloscope. 4. Connect the complete measurement system to your test point.

This reveals whether the dominant noise comes from the oscilloscope input, the probe acting as an antenna, your grounding arrangement, the device itself or external connections like power supplies.

Phase 2: Review Environment And Physical Infrastructure

Reliable low-noise measurement starts with the right environment and physical infrastructure, through to the oscilloscope, and its placement relative to the device under test.

Position Your Oscilloscope Closer

A USB oscilloscope offers a distinct advantage over a traditional benchtop scope as you can place it right next to your device under test, while your PC is placed farther away. This keeps your analog signal paths as short as possible without forcing you to work around a bulky benchtop setup. Learn **why your next scope should be a USB oscilloscope**.

Keep Cables Short

Long cables add capacitance, introduce inductance and pick up interference. Keep all analog cables as short as practical. Use coaxial cable for low-level signals where impedance permits, and twisted pairs for differential or low-frequency sensors.

Where appropriate, a correctly terminated 50 Ω coaxial cable offers excellent noise immunity. However, apply caution as a 50 ohm termination can heavily load circuits designed to drive high-impedance inputs. Saelig has a wide range of BNC cables and adaptors to choose from.

Reduce Environmental Pickup

Sensitive analog circuits pick up electromagnetic interference from nearby laptop power supplies, wireless routers, USB hubs and mains cables. By moving your device and measurement leads away from these sources, you can relocate equipment one item at a time to identify what is causing interference. Learn about common causes of **oscilloscope noise**.

Use Shielding

For sensitive measurements, place your device inside a grounded conductive enclosure. A metal project box is ideal, but any continuous conductive container can serve as a temporary Faraday shield. You can also use flexible conductive foil, as long as you insulate your assembly to prevent short circuits. Connect the enclosure to the circuit reference at a single point. This shielding is highly effective against electric fields and radio-frequency interference, but less effective against low-frequency magnetic fields, where increasing distance or changing orientation works best.

Find And Remove Ground Loops Safely

Ground loops occur when multiple connections provide different paths to a common reference. The resulting currents appear as a 60 Hz hum or switching noise. For example, a USB scope connected to a mains-powered laptop and an earthed device under test forms a loop.

Note that battery operation does not isolate your scope; BNC ground shells remain common. Never connect a standard ground clip to a floating or high-voltage point. For high-common-mode measurements, always use a correctly rated differential probe.

Minimize The Probe's Ground-Loop Area

Once external ground paths have been eliminated, check the ground connection at the probe itself. A standard 10 cm ground clip creates a large loop area that acts as a magnetic antenna and picks up environmental noise.

This loop also adds inductance, causing ringing and apparent high-frequency noise that is not actually present in your circuit. Reducing this loop can dramatically clean up waveforms, often revealing that what looked like power-supply noise was actually ground-loop pickup.

For measurements like power-rail ripple or clock edges, replace the long ground lead with a probe-tip ground spring, a short ground blade or a very short, soldered ground connection.

Choose Probe Attenuation

A passive 10:1 probe reduces the signal amplitude reaching the input to one-tenth, and the scope scales the display accordingly. While 10:1 probes offer higher bandwidth and lower loading, they reduce your signal-to-noise ratio. This is because the oscilloscope's internal input noise is not attenuated. If you reduce a 100 mV signal to 10 mV before the input, it occupies a smaller portion of active voltage range. The measurement then requires greater input gain, making the scope's internal noise more prominent.

When measuring low-frequency, low-amplitude signals from low-impedance sources, a 1:1 probe or direct coaxial connection provides a much better signal-to-noise ratio. Select the lowest probe attenuation that still provides sufficient bandwidth, voltage capability and low circuit loading from Pico's range of oscilloscope probes.

Use Pseudo-Differential Measurements For Low-Voltage Circuits

For low-voltage signals with common-mode interference, you can use two channels as a basic differential measurement. Connect Channel A and Channel B to each side of the signal, with both probe grounds sharing the same safe reference. Then, create a math channel in our software using A – B to cancel common-mode noise.

This technique is recommended when a true differential probe is unavailable; however, its common-mode rejection is limited by differences in probe attenuation and gain. For best results, use matched probes, identical input ranges, same bandwidth limits and matched compensation. Because channel grounds are common inside the scope, never connect them to different potentials.

Phase 3: Check Analog Front-End Settings

Another method to reduce oscilloscope noise from your waveforms is to optimize the acquisition settings. This will capture the signal with maximum useful resolution and minimum unwanted bandwidth.

Use As Much Input Range As Possible

The selected voltage range dictates measurement resolution. Setting channels to a broad range (e.g., 5 V for a 1 V signal) to prevent overlap on screen wastes valuable ADC codes.

Instead, select the smallest voltage range that fully accommodates your waveform, including any overshoot. In **PicoScope 7 Software**, use Auto Arrange Axes to scale and separate traces visually. This lets you position waveforms on screen without sacrificing vertical resolution.

Use Hardware Offset To Reveal Small Variations On A DC Level

When measuring small AC variations riding on a large DC bias, the DC level can force you onto a wider input range, reducing resolution. For example, a CAN Low signal moves between 1.5 V and 2.5 V, changing by only 1 V.

Using hardware offset to subtract 2 V in the analog front end lets you select a much smaller input range (e.g., –0.5 V to +0.5 V). This provides maximum ADC codes across the active signal range. Unlike display-shifting, hardware offset modifies the signal before digitization, improving resolution.

Use AC Coupling For Ripple And Noise On DC Rails

Measuring millivolt-level ripple on a 12 V power rail requires an input range that can contain the full 12 V, obscuring detail. AC coupling inserts an internal capacitor in the input path to block the DC component. This lets you measure small ripples over a highly sensitive range, turning a fuzzy line into a detailed waveform. However, AC coupling creates a high-pass response. This can attenuate very-low-frequency drift or load transients. Use DC coupling if you need to measure slow rail drift or absolute voltage levels.

Limit The Measurement Bandwidth

If your signal's frequency is limited, there is no benefit in capturing high-frequency noise above that range. Enabling a switchable 20 MHz hardware bandwidth limiter restricts unwanted out-of-band energy before digitization.

A larger number of bandwidth filter options are available on the **PicoScope 3000E Series**, **PicoScope 5000E Series** and **PicoScope 6000E Series**, allowing the measurement bandwidth to be more closely tailored to the application, which will optimize noise performance.

For low-frequency work, the **PicoScope 4262 Oscilloscope** offers an ultra-low 200 kHz bandwidth limit.

Phase 4: Apply Digital Post-Processing

The final step to reduce oscilloscope noise is to apply software processing, which reduces noise while preserving the information that matters. All of the features listed below are available in the latest version of software.

Use Software Filters

Once you've optimized physical settings, software-based digital signal processing can further reduce noise without altering your raw data.

Using **Math Channels**, you can apply four filter types:

- **Lowpass filters** to attenuate high-frequency noise
- **Highpass filters** to block low-frequency hum
- **Bandpass filters** to isolate specific signal bands
- **Bandstop filters** to reject narrow-band interference.

Displaying scope and spectrum views simultaneously helps you determine whether the noise is broadband or a discrete switching spur, so you can select a targeted filter. Note that filtering can affect timing: applying a lowpass filter to a 1 MHz square wave cleans the trace but can slow the rise time from 10 ns to 33 ns.

Apply Resolution Enhancement

Resolution Enhancement is a noise-reduction technique for increasing the effective vertical resolution of the scope at the expense of high-frequency signal detail. In some oscilloscope operating modes, the software may reduce the number of samples available to maintain display performance.

For Resolution Enhancement to work, the signal must contain a small amount of Gaussian noise. In many practical applications, this noise is naturally present in the signal.

The resolution enhancement feature uses a moving-average filter. This acts as a low-pass filter with a good step response and a gradual roll-off from the passband to the stopband.

When applied appropriately, this post-processing technique can significantly increase the effective resolution of a noisy trace while preserving the fundamental shape of a sine wave. Learn how to use **Resolution Enhancement.**

Select The Correct Form Of Averaging

For repetitive signals with a stable trigger, **Waveform Averaging** suppresses random noise while preserving the repeatable waveform. **PicoScope 7 Software** can display the active trace and an averaged math channel simultaneously, letting you compare real-time behavior against the averaged baseline.

If your target event changes timing relative to the trigger, use single-shot capture instead of averaging. This prevents high-speed jitter, glitches and transients from being blurred or removed.

For non-repetitive signals, use spectrum averaging in spectrum mode to reveal persistent components below the noise floor. Our spectrum mode supports:

1. Average to show continuous underlying signals
2. Peak hold to capture intermittent emissions
3. Instantaneous display to track live spectral changes

Select an appropriate FFT window – such as flat-top for amplitude accuracy, or Blackman-Harris to find small spurs. Learn how to use **Waveform Averaging**.

Phase 5: Choose A Low-Noise Oscilloscope

No measurement technique can compensate for a noisy oscilloscope front end. High ADC resolution provides little benefit if internal noise, distortion or crosstalk obscure the signal. When comparing instruments, evaluate:

- RMS input noise floor
- Effective number of bits (ENOB)
- Spurious-free dynamic range (SFDR)
- Whether resolution is native hardware or software-filtered.

For low-frequency precision, the **PicoScope 4262** provides a noise floor of 8.5 µV RMS on its most sensitive range. Meanwhile, the **PicoScope 5000E Series** offers native 16-bit hardware resolution with a noise floor of just 22 µV RMS at 20 MHz bandwidth, and more than 73 dB SFDR.

