The Probe

Measurement Accuracy Begins at the Tip

Choosing the Right Probe

Probes provide a physical and electrical connection between the oscilloscope and the test point on your device. With an ideal probe, the signal at the oscilloscope input would exactly match the signal at the test point. Performance terms and considerations for choosing a probe include:

Probe Type

Several different types of probe are available, depending on the signal you need to measure.

- **Passive voltage probes** are the most common type and are useful for a wide variety of applications.
- **Active voltage probes** provide low capacitive loading, making them a good choice for measuring high frequency signals or high impedance circuits.
- **Differential voltage probes** provide a large common mode rejection ratio (CMRR) and minimal skew between inputs for measuring differential signals.
- **Current probes** can measure current, either AC only or AC and DC depending on the probe.

Attenuation

Amount by which the probe reduces signal amplitude. Higher attenuation factors typically reduce probe loading and enable the oscilloscope to measure higher voltage signals.

Bandwidth

The bandwidth of both the oscilloscope and probe should be at least five times that of the circuit being tested to ensure a sine wave amplitude error of not more than 3%.

oscilloscope bandwidth ≥ 5th harmonic of signal

probe bandwidth ≥ oscilloscope bandwidth

Rise Time

The rise time of the measurement system should be less than one fifth of the rise- or fall-time of the measured signal to ensure an error of no more than 3%.

$$t_{r,\ meas.\ sys.} \leq \frac{t_{r,\ signal}}{5}$$

$$t_{r,\ meas.\ sys.} = \sqrt{t_{r,\ oscilloscope}^2 + t_{r,\ probe}^2}$$

Linear Phase

Bandwidth limitations affect the shape of signals by delaying different frequency components by different amounts of time.

Probing Tips

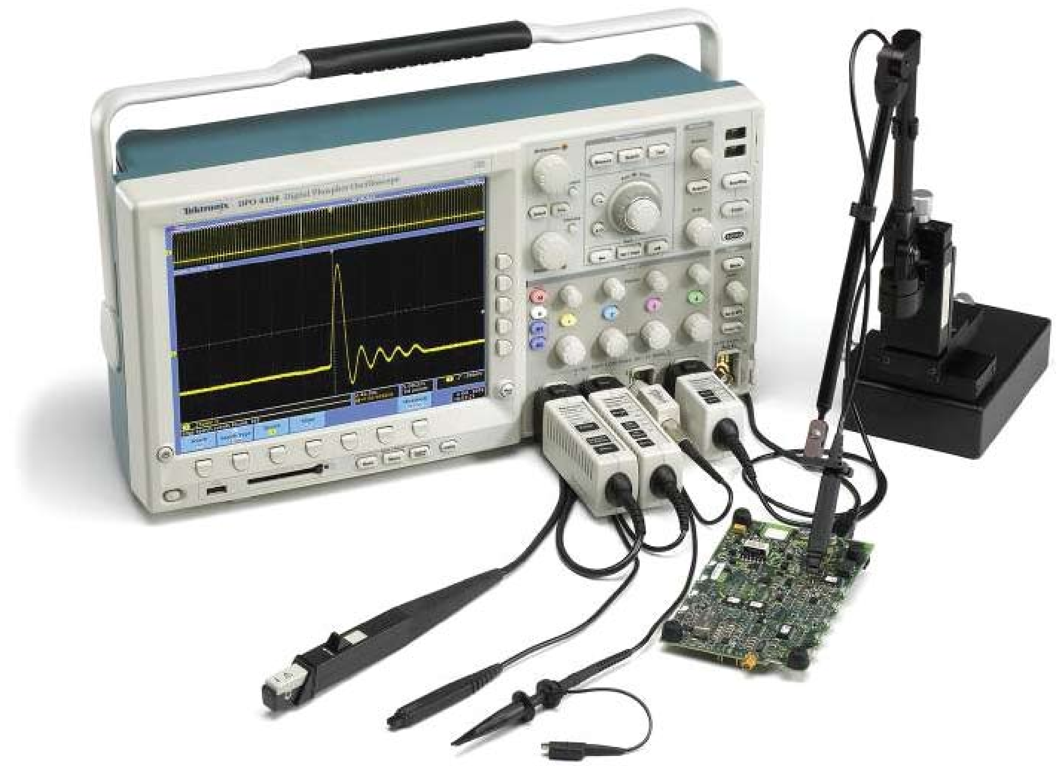
The following probing tips will help you avoid common measurement pitfalls:

- **Compensate Your Probes.** Compensation is the process of manually adjusting the ratio of the capacitances which appear in parallel with the probe's attenuator resistance to adjust AC attenuation of the signal. Compensate your probe every time you connect it to an oscilloscope channel to avoid measurement errors, especially when measuring rise- and fall-times.
- **Use appropriate probe tip adapters whenever possible.** A probe tip adapter that's appropriate to the circuit being measured makes probe connection quick, convenient, and electrically repeatable and stable.
- **Keep ground leads as short and as direct as possible.** The added inductance of an extended ground lead can cause ringing to appear on fast-transition waveforms.

Tektronix Probes

Tektronix offers over 100 different probes to match our industry-leading oscilloscopes. For help finding the right probe for your oscilloscope and application, use the Tektronix Probe Selector Tool at:

www.tektronix.com/probes



Find the Right Probe with Tektronix

TCP Series Current Probes

- Measure AC and DC current signals up to 500 A
- Split-core construction allows easy circuit connection
- Automatic units scaling and readout on the oscilloscope display
- Degauss warning indicator alerts you to perform a degauss operation

TDP Series Differential Voltage Probes

- Measure differential signals with up to 3.5 GHz bandwidth
- Excellent common mode rejection ratio (CMRR)
- Automatic units scaling and readout on the oscilloscope display
- AutoZero button automatically removes probe offset

TAP Series Active Voltage Probes

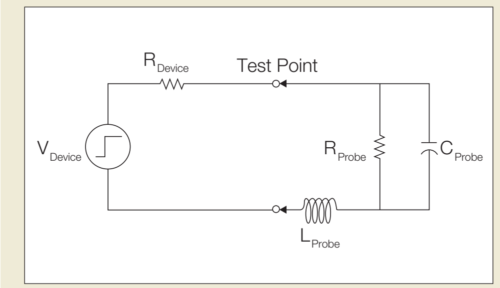
- Measure high speed signals with up to 3.5 GHz bandwidth
- < 1 pF probe capacitance minimizes probe loading
- Automatic units scaling and readout on the oscilloscope display
- AutoZero button automatically removes probe offset

Innovative TekVPI® Probing Interface for MSO/DPO Series Oscilloscopes

- Attach current probes directly to the oscilloscope, without using a separate power supply
- Access relevant probe settings and controls by simply pressing the probe's menu button
- Automatically view correct measurement units and scaling for your probe on the oscilloscope

Impact of Probe Loading

Probe loading is a measure of how the probe affects the device-under-test (DUT). The probe can be modeled as a resistor, capacitor and inductor, as seen below.



Simplified circuit diagram using Thevenin equivalent of the DUT.

Probe Resistance

At DC, the reactive impedance of the probe's capacitance is infinite and adds no loading on the DUT.

$$V_{Measured} = V_{Device} \frac{R_{Probe}}{R_{Probe} + R_{Device}}$$

Probe Capacitance

As the signal frequency increases, the probe's capacitance has the dominant effect on probe loading. Probe capacitance increases the measured rise and fall times on fast transition waveforms and decreases the measured amplitude of high frequency details in waveforms.

$$t_r \cong 2.2(R_{Device} C_{Probe})$$

Probe Inductance

The probe inductance interacts with the probe capacitance to cause ringing at a certain frequency that is determined by the L and C values.

Tip: To minimize probe loading, use a higher impedance probe (higher R_{probe}, lower C_{probe}) or measure the signal at a test point where the impedance is lower.

Considerations for Power Measurements

Eliminate Skew

Making power measurements requires using two different probes, one voltage and one current, each with its own propagation delay. The difference in the delays between the probes, known as skew, causes inaccurate amplitude and timing measurements which leads to incorrect power measurements. Some oscilloscopes allow you to deskew current and voltage measurements to minimize this problem; remember to deskew your channels every time you make a new probe connection.

Remove Your Probe Offset

Differential probes have a slight voltage offset. This offset can affect accuracy and must be removed before proceeding with measurements. Most differential voltage probes have built-in DC offset adjustment controls; remember to remove your probe offset.

Degauss Your Current Probe

Degauss removes any residual DC flux in the core of the probe's transformer, which may be caused by a large amount of input current. This residual flux results in an output offset error that can build over time resulting in inaccurate measurements; remember to degauss your probe.

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