# 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. Tektronix offers a variety of probe types to meet your measurement needs. Here are some probe types and performance considerations for choosing the right probe for your application:

### Probe Type

- **Current Probes** can be used to measure current and Tektronix offers probes that measure both AC and DC and AC-only.
- **High Voltage Differential Probes** may be used to safely measure the difference between two test points where neither test point is at ground.
- **High Voltage Single-ended Probes** may be used for measuring ground reference signals up to 40 kV and some single-ended probes are designed for instruments with isolated or floating inputs for measurements that are not ground referenced.
- **Low Voltage Differential Probes** from Tektronix typically offer higher bandwidth and are used to measure lower voltage signals where neither test point is at ground.
- **Low Voltage Single-ended Probes** are used for measuring high-speed, ground referenced signals up to 12 V.
- **Passive Probes** ship standard with most oscilloscopes and provide a low cost, general purpose probing solution for a wide variety of applications.

### Probe Considerations

**Attenuation**

Attenuation is the amount by which the probe reduces the signal amplitude. Higher attenuation factors are typically used for measurements which require larger dynamic range whereas lower attenuation is used for low amplitude signals where noise may be a concern.

**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%.

$$\text{oscilloscope bandwidth} \geq 5\text{th harmonic of signal}$$

$$\text{probe bandwidth} \geq \text{oscilloscope bandwidth}$$

**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%.

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

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

## Probing Tips

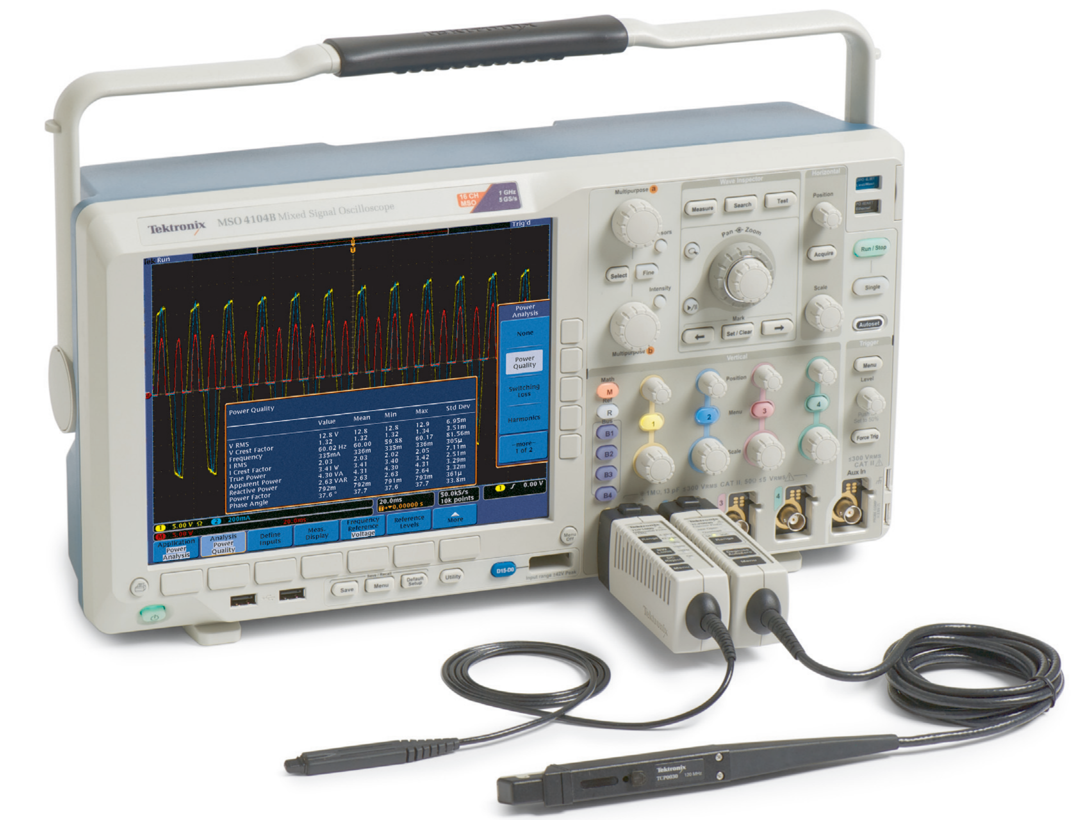
The following probing tips will help you avoid common measurement pitfalls:

- **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

**TMDP & THDP Series High-voltage Differential Probes**

- Safely measure differential signals up to 6.0 kV
- Switchable attenuation and bandwidth limits enables customization of the probe performance
- Visual and audible indicator for overrange conditions
- Up to 200 MHz bandwidth and slew rates up to 275 V/ns

**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

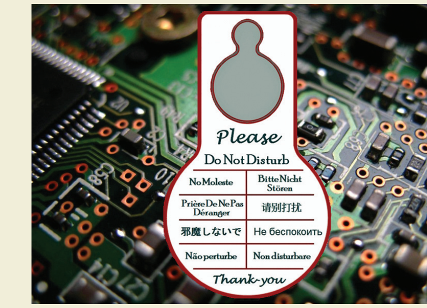
**TPP Series Passive Voltage Probes**

- < 4 pF probe capacitance with up to 1 GHz bandwidth ensures accurate measurements
- High performance probing with high dynamic range and robust mechanical design
- Built-in AC compensation optimizes signal path across the entire frequency range

**Innovative TekVPI® Probing Interface for MSO/DPO Series Oscilloscopes**

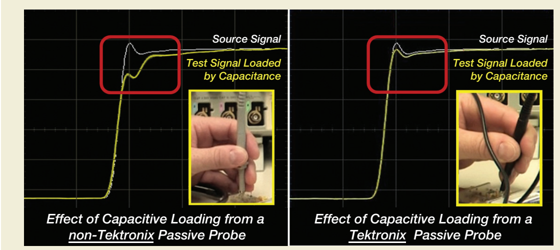
- Attach current probes directly to the oscilloscope, without using a separate power supply
- Access relevant probe settings and controls by simply pressing the probe's menu button
- Automatically view correct measurement units and scaling for your probe on the oscilloscope

## Impact of Probe Loading




Probes are vital to oscilloscope measurements because there has to be some kind of electrical connection between the test point and the oscilloscope. To produce a voltage waveform on the oscilloscope, an oscilloscope probe's tip has to draw some current from the circuit under test. Since the probe tip has to draw some current, it's going to **disturb** your circuit. Two probe specifications related to how a probe loads or disturbs your circuit are *input resistance* and *input capacitance*.

The loading of greatest concern is typically the capacitance at the probe tip. For low frequencies, this capacitance has a reactance that is very high, and the loading is not as much. As frequency increases, however, the capacitive reactance decreases, meaning the probe impedance decreases and the loading is much greater. Because of the adverse effects of capacitive loading, Tektronix includes a new series of passive probes with their oscilloscopes with industry best input capacitance of 3.9 pF.

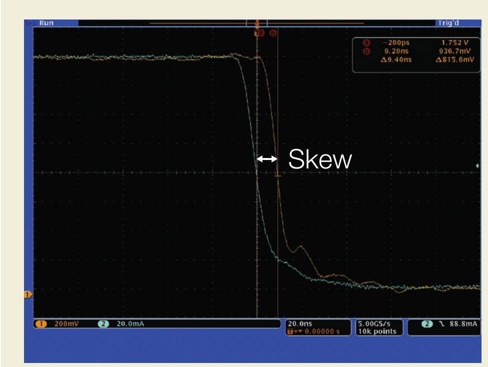



The image on the left shows the advantages of low capacitance probes. Given the time and effort spent in the design process, you don't want to second-guess the measurement system or spend additional time troubleshooting due to measurement inaccuracy. In this case, one would have to question if the effects of probe loading are the weak link in validating the design.

## 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 can a slight voltage offset. This offset may 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.

### Floating Measurements

For power measurements where signals are floating, it is important to insure that the probe is electrically isolated from the device under test. This can be accomplished by utilizing a probe isolator. Using either a transformer or an optical coupling mechanism for isolation, inadvertent connections to ground can be avoided.



03/14 EA 3GW-24992-3


Tektronix®