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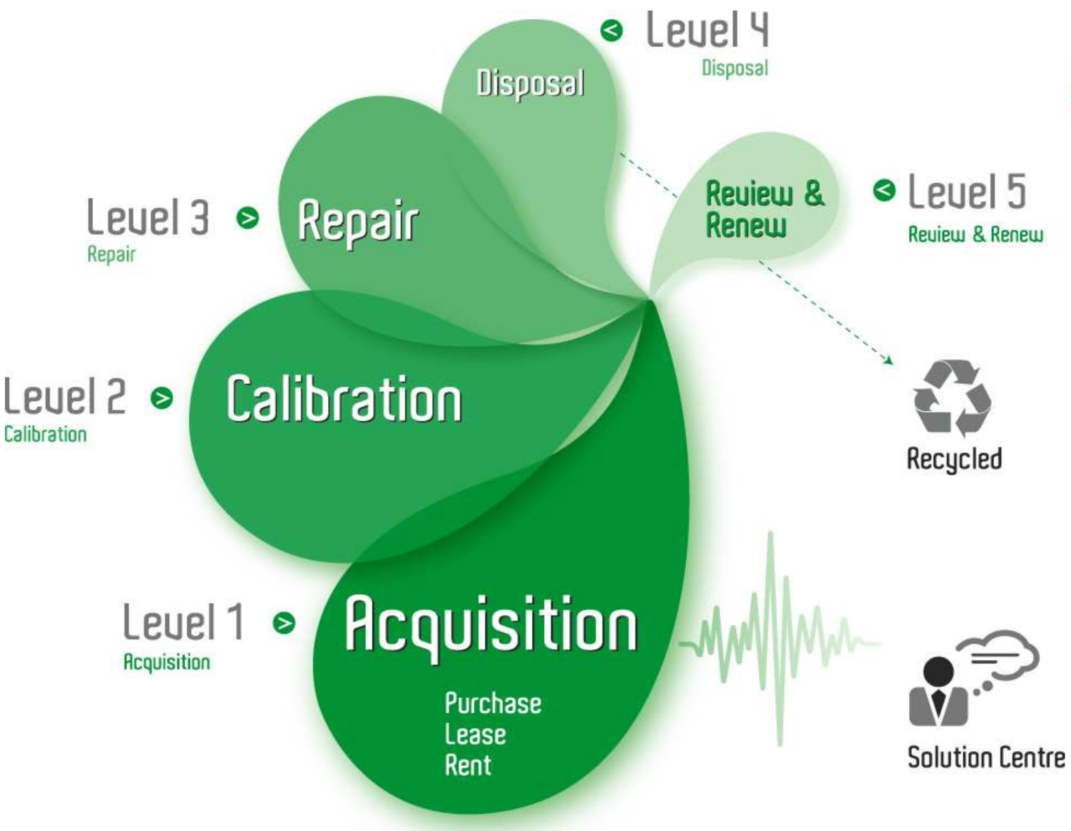


Product Lifecycle Management System

Form 080/01

Probing Solutions

PP066

High Bandwidth Passive Probe

Technical Specifications

Electrical Characteristics:

Bandwidth	DC to 7.5 GHz
Risetime:	< 47 ps
Input C:	< 0.25 pF
Input R:	500 Ω (÷10 cartridge) 1000 Ω (÷20 cartridge)
Maximum Voltage:	15 V rms
Cable Length:	1 m

Transmission Line Probing

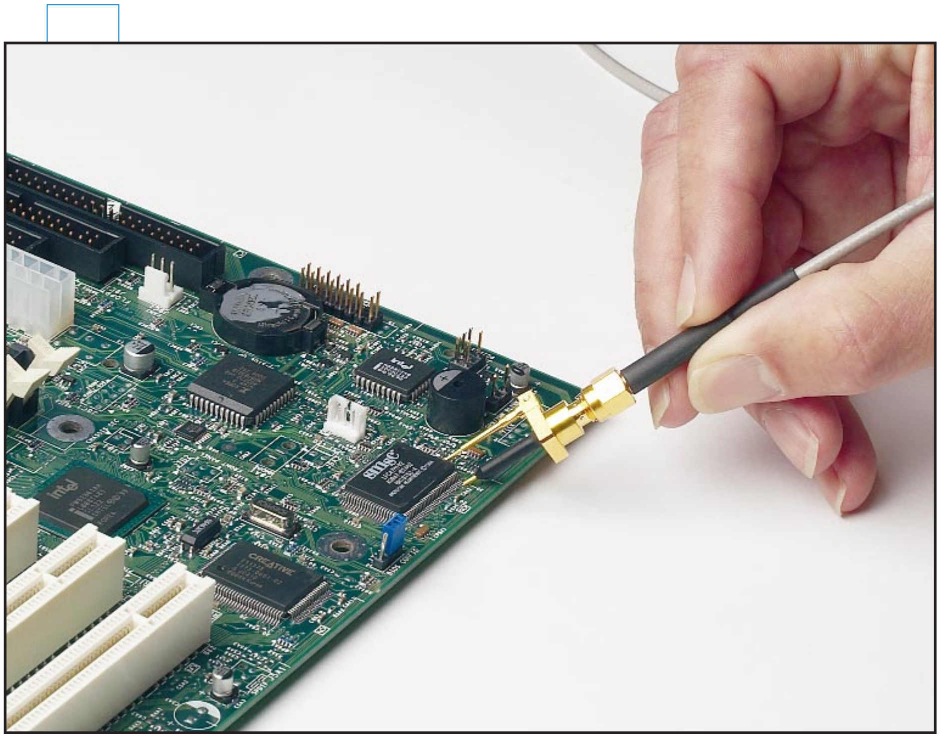
The PP066 is a high-bandwidth passive probe designed for the use with the WaveMaster™ and other high-bandwidth oscilloscopes that have 50 Ω input termination. This very low capacitance probe provides an excellent solution for higher frequency applications, especially the probing of transmission lines with 20–100 Ω impedance.

Flexibility

Interchangeable attenuator tips provide the user a choice of input resistances and sensitivities. The probe cable connection is a standard SMA. PP066 probes are suited to a wide range of design applications including probing of analog and digital IC's commonly found in computer, communications, data storage, and other high-speed designs.

Signal Integrity at High Bandwidth

When measuring very high frequencies, use of a probe with low input capacitance is the key to preserving signal integrity. A 1 pf active probe, though nominally high impedance, loads a 1 GHz signal with 159 ohm capacitive reactance ($X = 1/2\pi fC$). The PP066 preserves high bandwidth content of signals, retaining proper signal shape even for very fast edges.



The PP066 passive probe has lower circuit loading at high frequencies than an active probe.

PROBING HIGH SPEED SIGNALS

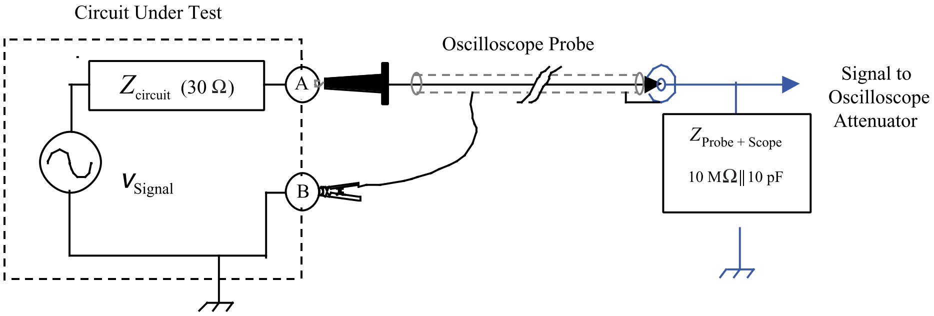
Steve Sekel, LeCroy Corporation

Accurately measuring digital waveforms with oscilloscopes becomes increasingly challenging as edge speeds become faster. Often, interconnecting the test circuit to the oscilloscope is the most difficult part of the problem. Designers frequently select an active probe as the tool of choice for this task. However, in many situations a lesser known type of passive probe can provide ***better performance at a lower cost.***

Probing any circuit for the purpose of making a measurement will change its operation. This is often the case when it comes to measuring waveforms with high frequency content. Extremely small parasitic elements added to the probe circuit can greatly distort the signal being measured.

Probe loading is usually the most significant factor that contributes to waveform distortion. Any real life voltage signal can be diagrammed as a Thévenin equivalent model represented as an ideal voltage source with a series impedance between it and the test point where the probe is connected (see the figure on back). The impedance in the probe to ground forms a voltage divider, which attenuates the measured signal. If the impedances were purely resistive, this effect could be easily compensated for by applying a scalar multiplier to the measured waveform amplitude. However, the reactive portions of the circuit's source impedance and the measurement probe create a frequency dependent attenuation that cannot be effectively corrected. As the frequency content of the signal being measured increases, even the most minute parasitic capacitance and inductance will impart significant attenuation, greatly distorting the appearance of the measured waveform.

Consider an example where we probe a fast digital signal with a 1 ns transition time using a high-quality passive probe. The input impedance of these probes is generally 1 MΩ in parallel with about 10 pF. If the source impedance of the circuit being tested is 30 Ω, the 1 MΩ resistive component of the probe creates virtually no DC attenuation. However, the effect of the capacitance is significant. Using the basic rule to translate rise time into



Simplified model of probe loading effects

frequency, 1 ns rise time corresponds to approximately 350 MHz. The capacitive reactance of 10 pF at 350 MHz is 45 Ω. So during the 1 ns transition, the impedance in the lower leg of the voltage divider would be 45 Ω rather than 1 MΩ, attenuating the signal by approximately 40%.

Since we usually cannot tolerate measurements that include 40% or greater errors, an active probe is often used to measure high-speed signals. A typical input of 1 pF capacitance for an active probe represents a tenfold improvement over a high-quality passive probe.

However, even at 1pF, the active probe can present too much loading in very fast circuits. At 3.5 GHz a 1 pf active probe loads a signal with the same 45 ohm capacitive reactance as the 10 pf passive probe caused at 350 MHz. ***In many applications, a relatively unknown type of passive probe will give better performance than an active probe, at considerably less cost.*** *These probes are known under several names including transmission line, low capacitance, low impedance, or Z_O probes. Regardless of what they are called, they all work under the same principle. In these probes, a 50 Ω controlled impedance transmission line is used in place of the probe cable. Rather than driving a 1 MΩ oscilloscope input, the probe requires the oscilloscope input to be set to 50 Ω termination. Adding a tip resistor to the transmission line provides attenuation and raises the input resistance to reduce DC loading of the circuit being measured.*

Over a specified operating range of frequencies, the input impedance of a transmission line will appear purely resistive, in this case 50 Ω. Lacking the capacitive component in the lower leg of the attenuator, no shunting capacitance is required across the tip resistor to compensate the divider.

In theory, such a probe would have zero input capacitance; Real life probes have a small capacitance, resulting from the proximity of the ground connection in relation to the tip. However, the capacitance is very low, often 0.2 pf or less.

The only potential downside to the transmission line probe is the lower input resistance. A ÷10 probe has an input resistance of 500 Ω and a ÷20 probe weighs in at 1 kΩ. This low input resistance is why many designers have avoided using them in the past. With the increasing speed of modern digital systems, the transmission line probe deserves serious consideration. Most modern high-speed digital circuits are not impacted by the resistive loading. The voltage swings tend to be lower and the ICs can drive lower impedance loads. The 1 KΩ load will not adversely affect the operation of transmission line busses, which are becoming common in modern digital systems.

One thing that you will notice when you open the package of one of these transmission line probes is the relative lack of probe interconnect accessories. There is a practical reason for this. To appreciate the high-bandwidth performance these probes can offer, it's extremely important to avoid introducing parasitic reactive elements into the input connections. If you really need to probe circuits with fast edges, forgo using probes with 10 cm ground leads, and attaching miniature SMD lead clips with 5 cm extension leads in front of the probe tips. These practices will have devastating effects on waveform fidelity, and may possibly alter the circuit operation. By providing a simple yet elegant solution to probing high-frequency signals, LeCroy's capacitance transmission line probe preserves signal fidelity and allows high-bandwidth test equipment to properly measure circuit characteristics.

Ordering Information	**Product Code**
Passive Probe 7.5 GHz	PP066
Included with PP066 probe	
PACC-AD001	SMA to BNC adapter
PP066-OM-E	PP066 Users' Manual

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