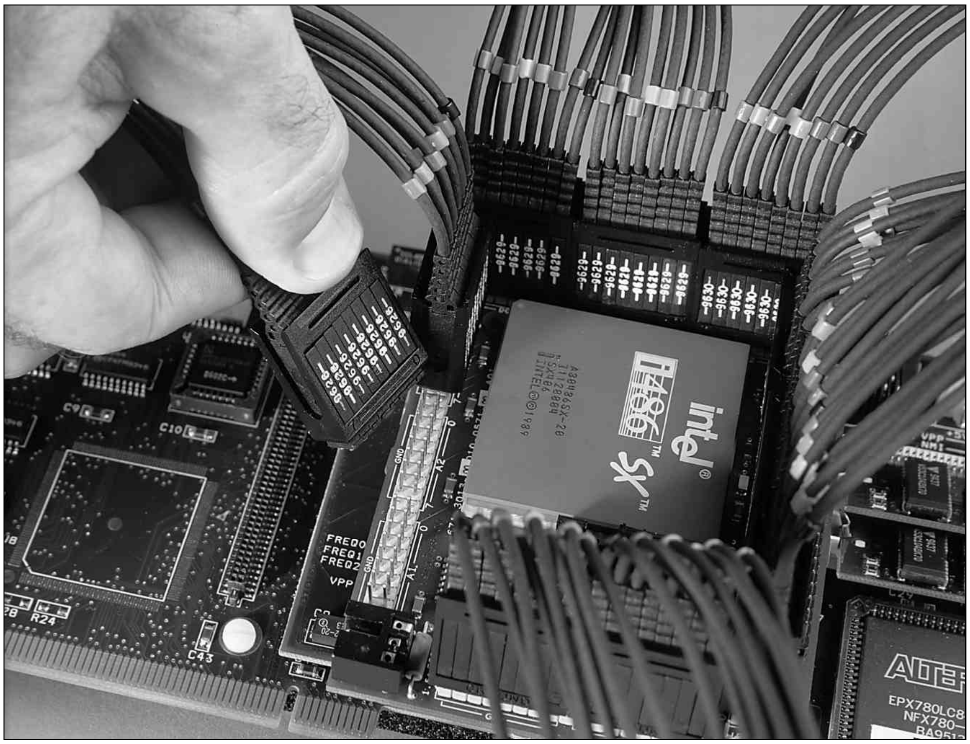
Tektronix

Technical Brief

Active Attenuator Probing



As clock speeds in today's microprocessor-based designs approach 200 MHz and circuit boards become more tightly packed, the need for test instruments with minimal probe loading becomes increasingly important. Connecting probes to such high speed circuits can cause timing shifts and/or signal integrity problems which, in turn, may preclude accurate characterizations of the circuit-under-test or prevent the discovery of the "real" problem. Fast edges driven into the probe's capacitance can prevent proper circuit operation at higher bus speeds. The last thing a digital circuit designer needs while verifying timing margins or troubleshooting design problems is signal degradation caused by the very measurement instruments being used to test or characterize the circuit.

Connecting a multi-channel logic analyzer to a microprocessor-based design can be especially daunting. Literally hundreds of channels need to be connected in an incredibly small space. Probe leads begin to look like spaghetti over the device being tested, giving rise to the potential for cross-talk and other transmission line effects. One loose or intermittent connection can upset the entire test operation. Moreover, fabrication processes used for today's high-speed designs – such as those used for GTL and high-speed CMOS – are less tolerant of the capacitive loads introduced by conventional 8 to 10 picofarad (pF) logic analyzer probes.

What's needed is a probing solution that allows examination of the high-speed signals without causing significant signal degradation. In addition, the probing solution should match the advanced analysis capabilities of today's most sophisticated logic analyzers. The Tektronix TLA 700 Series supports both high-speed timing (2 GS/s) and state analysis (200 MHz) for hundreds of channels while setting new standards in reduced probe loading.

The Tektronix P6417 and P6434 probes, designed specifically for the TLA 700 Series, provide superior performance on high-speed signals with a capacitance of only 2 pF. They also provide the bandwidth needed to accurately capture high-speed signals. Fast edges and runt pulses are not "filtered" by the probe and signal edges are more accurately placed. Complete isolation between channels is provided by using coaxial cable from each probe tip to its connection with the instrument. This shielding prevents outside interference and ensures a more reliable circuit analysis.

Technical Overview

The TLA 700 Series probes are best thought of as active attenuator probes. The circuitry in the probe tip, or "podlet," is entirely passive, but the rest of the attenuation circuit includes active circuitry in the logic analyzer module (see Figure 1).

Conventional, logic analyzer probes are passive attenuator probes. In such probes, the input signal is buffered by an RC (resistor-capacitor) network in the podlet as shown in Figure 2. This RC network drives the captured signal down the probe cable to the logic analyzer where another RC network is connected to an AC ground, creating a typical attenuation of as high as 10:1. This attenuated input drives one input of a comparator to determine whether the signal is high or low as compared with the selected threshold. The time constant of the RC network in the podlet must match the time constant of the RC network in the logic analyzer to keep the impedances of the two networks consistently proportional over the full range of operating frequencies and maintain a constant attenuation factor. The capacitive component of the RC network in the logic analyzer includes the capacitance of the probe cable and circuit board traces. The capacitance in the podlet is increased to match the time constant of this network and bulk capacitance. This results in a probe that presents an unfavorably large capacitive load to the user circuit.

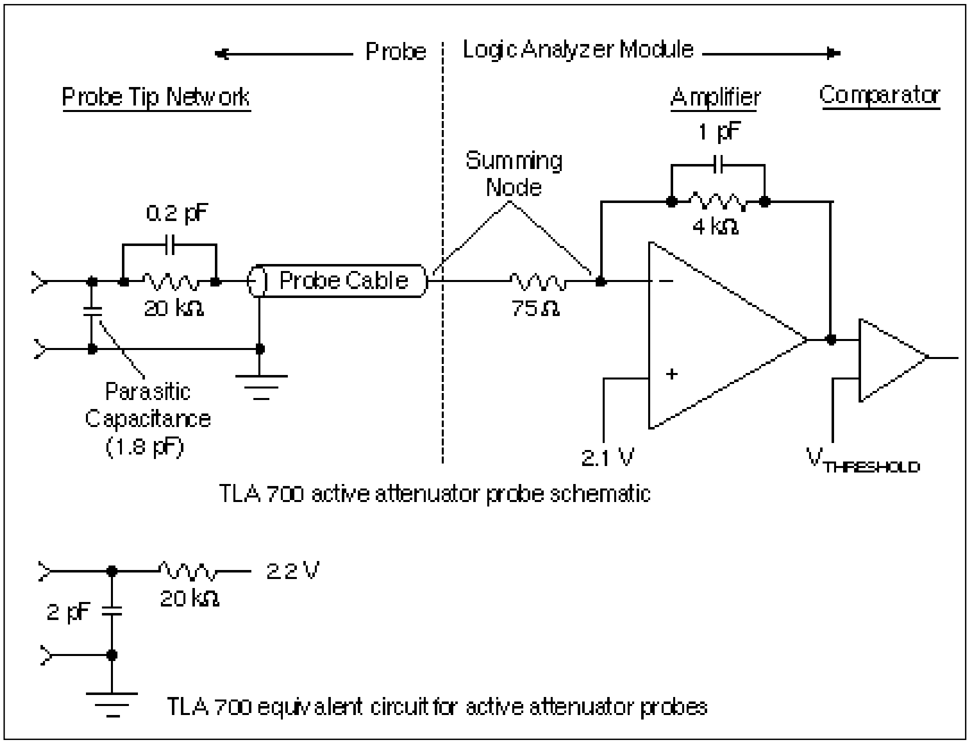


Figure 1. Schematic and equivalent circuit diagrams of the TLA 700 Series "active attenuator" probes.

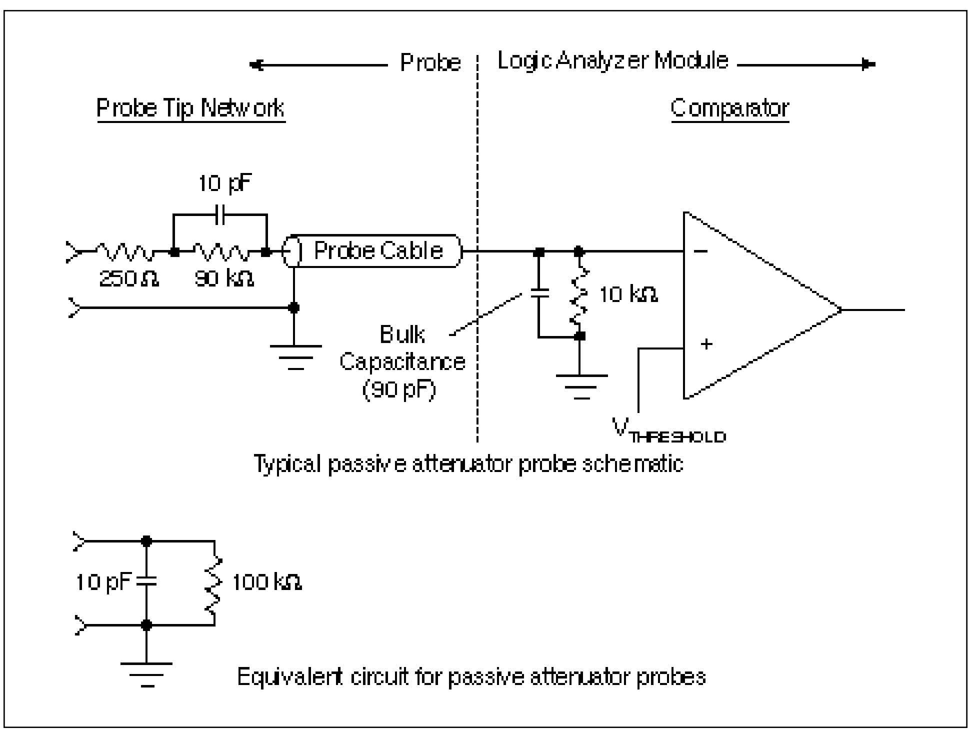


Figure 2. Schematic and equivalent circuit diagrams of conventional passive attenuation probes.

By way of contrast, the TLA 700 Series probes have an RC network in the podlet similar to conventional passive attenuation probes. The podlet RC network drives the summing node of an amplifier. Active attenuation comes from the feedback RC network in the amplifier circuitry. The output of this active attenuator circuit drives a comparator that determines whether the input signal is high or low as compared with a user-selected threshold.

Benefits of Active Attenuator Probes

Active attenuation probes provide several important benefits to circuit designers:

- They hold a voltage of about 2.2 V on the logic analyzer side of the probe which minimizes the effects of DC loading on the circuit. Even though the DC resistance of the podlet is 20 kΩ, it's 20 kΩ to 2.2 V, not to ground, making it easier for today's logic families to drive the signal to the "high" state.

- They minimize the effect of cable and stray capacitances on matching RC time constants. The RC time constant of the podlet only needs to match the time constant of the amplifier's RC feedback network. Because of the summing node, the probe cable and circuit board capacitances can essentially be ignored – the feedback of the amplifier takes care of them. This also means that a much smaller capacitor can be used on the podlet end.
- They dramatically reduce capacitive loading on the circuit. As frequencies rise, the capacitor in a probe's RC network is the major contributor to circuit loading – as seen in the expression: $X_C = 1/(2\pi fC)$. Because the summing node allows a much smaller capacitor to be used in the podlet end of the probe, the input capacitance the circuit "sees" is much less than the input capacitance of the typical passive attenuation probe. In fact, the capacitor in the podlet of TLA 700 Series probes is so small it becomes only a small portion of the input capacitance presented to the circuit-under-test. The majority of the probe's capacitive loading comes from stray capacitances around the input of the probe.
- They also provide a much higher signal bandwidth than has ever been offered in logic analyzer probes. Most conventional passive attenuation probes have a maximum signal bandwidth of about 150 MHz. This inhibits their ability to accurately capture and display fast edges as frequencies rise. The TLA 700 Series probes, on the other hand, have an analog bandwidth of 350 MHz, providing for 200 MHz synchronous acquisitions – performance that simply isn't possible with today's passive attenuation probes.
- They enable the logic analyzer to offer much better input timing characteristics. The combination of high signal bandwidth and low circuit loading enables the TLA 700 Series probes to deliver much faster edges directly to the input circuit of the logic analyzer with very little signal degradation. It's a significant factor in enabling the TLA 700 Series logic analyzer modules to deliver setup-and-hold windows as small as 2 ns. The typical setup-and-hold window for most conventional analyzers is, at minimum, 4 ns. In addition, because the TLA probes can deliver faster edges to the logic analyzer, acquisitions are less susceptible to errors in threshold voltages.

The Next Generation Probing Solution

The active attenuator probing solution from Tektronix elevates logic analyzer probing to the same level of sophistication as the latest microprocessor-based designs. With much lower capacitive loading than conventional logic analyzer probes, the TLA 700 Series solution provides the superior physical and electrical characteristics needed to meet the challenges of the next-generation hardware debug environment.

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