BY HOWARD JOHNSON, PhD

Eye of the probe

My differential probe touches two surface-level signal traces, directly adjacent to the input balls of a 2.5-Gbps digital deserializer in a large BGA package (**Reference 1**). The signal arrives from an optical-to-electrical converter some 6 in. away.

Figure 1 illustrates one-half of that measurement setup as a single-ended circuit, omitting all complementary differential-circuit elements.

Capacitor C_3 represents the surface-mount soldering pad and ball at the periphery of the BGA package. Inside, the signal traverses 1.25 in. of internal BGA-substrate routing before reaching an on-die end termination and the input capacitance, C_4, of the receiver.

In this circuit, I suspect, my probes significantly affect the measurement. To test that theory, I took the measurement first using one and then two probes in tandem.

The two probe models in **Figure 1** each depict one complementary half of a differential probe. For Probe 1, the model includes three parts. Inductor L_1 represents the size and shape of the probe tips. Internal resistor R_1 damps internal resonances. High-end probes often include such a resistive feature. Capacitor C_1 models the overall input capacitance of the probe head. The voltage at C_1 is the voltage that Probe 1 "sees." The voltage at C_2 is the voltage that Probe 2 sees. Your probe manufacturer may have a different circuit that best represents the effects of your probe. With only Probe 1 connected, **Figure 1** plots the voltage at C_1 in red. Now, connect Probe 2. Adding Probe 2 to the circuit changes the voltage at C_2 and C_1 to the orange waveform. Obviously, the second probe affects the results, confirming my suspicions. Each probe loads the circuit and corrupts the physical measurement.

So, how can you discern the "real signal" at C_3 with no probes attached? The purpose of simulation is to make this determination. By crosschecking physical and simulation techniques, you can overcome many measurement deficiencies.

First, work on the accuracy of your modeling until your simulated waveforms with a simulated probe match physical measurements taken through the eyes of a physical probe. Once you achieve that correlation, you may infer that the simulated waveform with no probes attached (green waveform) is the real McCoy. **EDN**

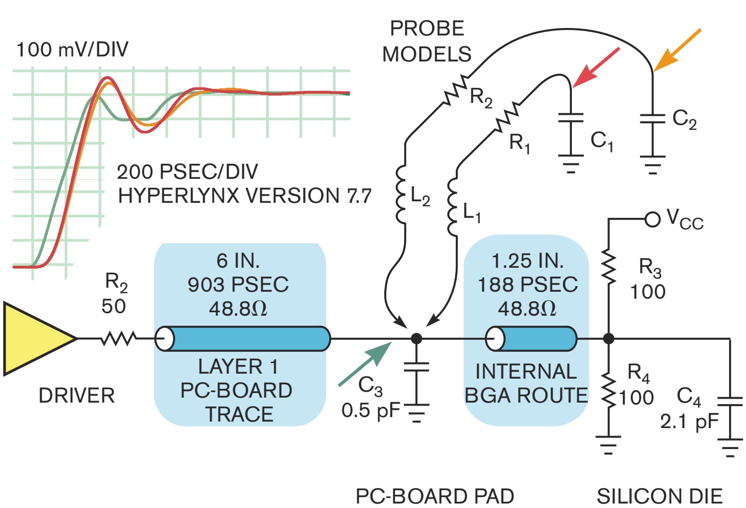

Figure 1 A second probe changes the observed waveform.

REFERENCE

1 Johnson, Howard, "Eye don't like it," *EDN*, Nov 9, 2006, pg 34, www.edn.com/article/CA6387033.

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