BY HOWARD JOHNSON, PhD

Pulse-width compression

The signal in **Figure** 1 originates in a pristine state at its transmitter. After passing through a long coaxial cable, high-frequency losses within the cable round off the signal edges, making each edge somewhat less steep at the receiver than at the transmitter.

Notice what happens at Point A. The received signal does not have time to fall completely down to the bottom before it must turn around and head back up. The positive-going step at Point B therefore begins life with a head start, as if sitting on a pedestal of height H.

The pedestal reduces the distance the signal must traverse to cross its threshold. The signal at Point B, because of the pedestal effect, crosses the receiver threshold early. The degree of advancement of edge B is a predictable function of the cable's attenuation characteristics. It happens the same way every time you repeat the experiment.

The received pulse after the data slicer (following the comparator, but before sampling) comes out narrower than you would expect due to the advancement of edge B. That pulse-narrowing effect is called *pulse-width compression*.

All bandwidth-limited systems built from conductive transverse-electromagnetic-mode transmission lines exhibit a similar effect. High-frequency losses always narrow a short pulse if that pulse is preceded by a long string of ones or zeros.

You can make the degree of pulse-width compression at the output of the data slicer into an excellent indicator of transmission-line performance.

This measure of performance interests me because I've noticed in recent years how difficult it has become to probe signals at the end of a high-speed serial link.

For one thing, the signal often enters a chip from underneath on BGA balls, providing no opportunity to attach a probe. Even if you could probe the signal from vias available on the back side of the PCB (printed-circuit board), those vias may not lie sufficiently close to the receiver to afford a good view of the received signal.

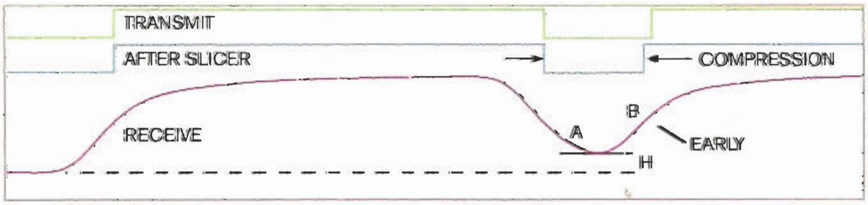

Figure 1 After receiving a long string of ones, the pulse-width-compression effect advances the positive transition at Point B.

For example, in a 6.25-Gbps link, the signal rise/fall time at the receiver is on the order of 100 to 160 psec. Suppose that the input capacitance of the receiver creates a reflection equal to 20% of the received-signal amplitude. At the receiver location, that reflection appears coincident with each rising or falling edge, delaying each edge but possibly not affecting data reception. At a via just 0.25 in. away, that same reflection appears 90 psec later, assuming a round-trip delay of 0.5 in. at 180 psec/in. This additional round-trip delay places the 20% reflection at an apparent position near the center of the data eye. At that position, the reflection may appear formidable. To overcome this timing impediment, you must place your probe within a short fraction of one rise/fall time of the bitter end of the link. You must also select a probe that does not inordinately load down the signal under test—a requirement that is becoming increasingly difficult to meet.

Pulse-width compression works well as a measure of system bandwidth because it overcomes the limitations of probe placement and loading. It also measures the whole system up to and including the data slicer.EDN

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