CALIBRATING SCOPES' HIGH-FREQUENCY AMPLITUDE ACCURACY: MORE DIFFICULT THAN YOU MIGHT THINK

By Steve Sekel, LeCroy Corp

Customer questions and complaints about scope amplitude accuracy are fairly common. Customers try to measure the accuracy with a swept sine wave from a signal generator. Users shouldn't try this procedure themselves. Although the measurement sounds legitimate, the results are almost always wrong when the frequencies are higher than a couple of gigahertz.

The first problem is that you need to level the generator output at the output end of the cable. Even the best cables–those that cost more than $1000–have some amplitude loss when you get to the several-gigahertz range. The *only* way to use a signal generator to measure amplitude accuracy is to use a high-quality, calibrated power divider at the end of the cable that connects to the oscilloscope.

One output of the power divider is connected directly to the power head of an RF-power meter that is calibrated for the frequency range and power levels you are testing. If you are testing all of the volts/division ranges, this measurement often requires using more than one power head. The power-meter readings normalize the output level at each frequency step. In an automated-calibration system, you perform this procedure under computer control. It is possible but tedious to manually perform the procedure.

REFLECTIONS

The second problem, which undoubtedly occurs in many cases, is dealing with the reflections from the scope input. In reality, the user is measuring the signal with the reflections superimposed. Scope inputs are not perfect 50Ω terminations. Different attenuators switch using relays or electronic switching. Inevitably, the paths are imperfect; they introduce some reflections at different frequencies.

Scope vendors work to minimize these reflections, but they all achieve about the same performance: a VSWR (voltage-standing-wave ratio) that, over the passband, can go from a perfect 1-to-1 to about 1.35-to-1. Whenever the termination reflects energy back into the line, the reflection creates standing waves at some frequency that relates to the length of the cable. Because they exhibit reflections at different frequencies, different models of oscilloscopes measure different amplitudes from the same generator-and-cable combination.

A user can reduce this effect by installing a high-quality, 6-dB attenuator at the scope's input and attaching the power-divider output to the attenuator. The attenuator improves the return loss by 6 dB, reducing the effect of the reflection in the cable.

As you can see, the metrology required to accurately measure a scope's amplitude accuracy over frequency is complex. All scope manufacturers put considerable effort into designing and verifying the complex systems that designers use to calibrate the instruments. Attempting to manually replicate this measurement by using only a signal generator and cable can't produce results of the desired accuracy.

AUTHOR'S BIOGRAPHY

Steve Sekel is a product-marketing manager at LeCroy Corp. He has worked in the test-instrumentation industry for 28 years, serving in marketing, product-development management, and design engineering. He has a bachelor's degree in electrical engineering from Tri-State University (Angola, IN).