Choosing the Right Scope

Understand the difference between real-time and sampling oscilloscopes.

It is important to understand the fundamental difference between real-time oscilloscopes and sampling oscilloscopes. Both instruments have an analog-to-digital converter (ADC) that samples the signal and converts the voltage level to a number. In real-time scopes, the ADC is usually an eight-bit device. When the real-time scope triggers, the ADC takes a series of samples of the signal and stores them in real time. If, for example, the ADC sampling rate is 20 Gs/s, the scope stores data at a rate of 20 GB/s (20 samples per nanosecond).

A sampling scope stores data much more slowly. Each time the sampling scope triggers, the ADC samples the signal once. The delay between triggering and sampling is increased slightly each time the sampling scope is triggered. After many triggers, a picture of the signal is captured. Essentially, the difference between the two scopes is that a real-time scope needs a signal to occur only once to capture it, while a sampling scope captures repetitive signals.

A real-time scope offers the advantage of capturing and measuring transient phenomena like an occasional glitch in a fast clock. If a serial data stream is being affected by low-speed modulation caused by power-supply noise (a very common problem), a real-time scope with long memory would be able to capture this phenomenon; it would be much more difficult to observe this phenomenon with a sampling scope.

If the setup does not demand continuous real-time throughput from the ADC, a different sampling technology can be used. Sampling scopes feature bandwidths of up to 80 GHz and may have resolutions of up to 14 bits. In comparison, real-time scopes top out at 13 GHz. Generally, you would like to use an instrument that has at least twice the bandwidth of the signal you are capturing, so sampling scopes are the tool of choice for engineers who work on 10 to 40 Gb/s data streams.

If you are trying to characterize the quality of a transmission line, the sampling scope may offer an advantage. Some sampling scopes offer time domain reflectometry capabilities. This feature sends a signal with a sharp edge down the transmission line and looks for reflections due to impedance imperfections.

On the other hand, if you are looking for sources of jitter or some other intermittent signal phenomenon, you are probably better off with a real-time scope, which can offer a variety of troubleshooting tools (see figure). In the example shown, a long stream of serial data has been captured using a single trigger. The embedded clock is numerically recovered without the added noise of hardware clock-recovery circuits, and used to “slice up” the data bits, which are then compared to an industry-standard test mask.

The signal in this margin testing example begins impinging on the mask when the mask is enlarged by 30% in both the x and y dimensions in order to perform margin testing. The center of the middle trace (blue) shows a bit that hit the top of the mask. The lower trace (yellow) displays the signal from a nearby digital line. Note that the transition of this line coincides with the vertical noise in the center of the blue trace.

A real-time scope captures 236,323 bits in a serial data stream and compares them to a mask; the mask size has been increased by 30% in both the x and y dimensions in order to perform margin testing. The center of the middle trace (blue) shows a bit that hit the top of the mask. The lower trace (yellow) displays the signal from a nearby digital line. Note that the transition of this line coincides with the vertical noise in the center of the blue trace.

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