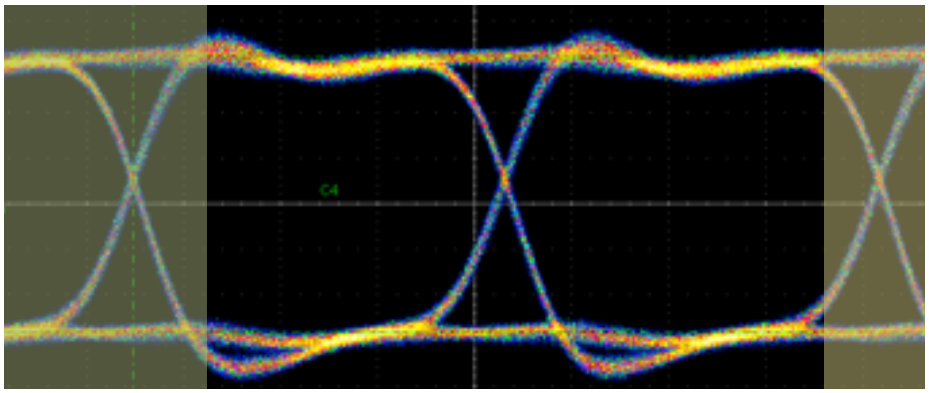

Remote Head Acquisition Improves High Speed Serial Measurement

Application Note

With serial data rates continuing to climb, it's more important than ever to minimize the impact of the measurement system's internal noise on the measured signal. As output voltages shrink in order to boost speeds, the margin between pass and fail has shrunk to the point where noise from the signal and the measurement system can combine to close the eye.

One of the most important elements in ensuring accurate measurements of the latest standards – and one that is often overlooked – is the connection between the signal access point and the oscilloscope. This connection needs to be able to handle signals over 25 Gb/s to ensure accurate results for compliance measurements while adding very little vertical noise. In this application note, we will explore the value of placing the oscilloscope's acquisition hardware, such as the sampler or front-end amplifier as close to the signal's access point as possible using a remote oscilloscope head.

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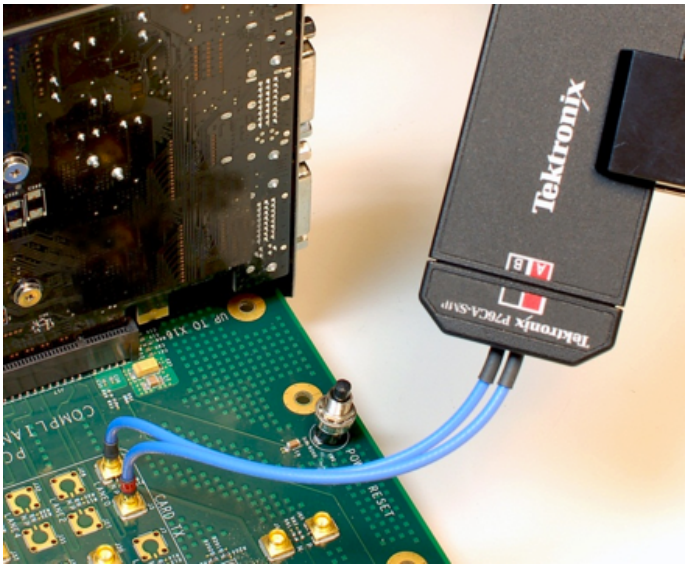

Figure 1. Connection using a Tektronix P7600 Series Remote Head.

Description of a Remote Head

What is a remote oscilloscope head? Remote heads place circuitry from the oscilloscope's front end in a module that can be located very close to the device under test (DUT). For high speed signals, the remote head has coaxial connectors forming a differential input. The remote head design significantly shortens the path from the DUT to the first stage of the scope's input circuitry. Shortening the length of the input path results in lower vertical noise, less inter-symbol interference (ISI) from the interconnects, and additional margin in the measurement. A remote head can provide as pure a signal as connecting the DUT directly to the scope's input connectors without additional loss or skew added by cables. Lastly, a remote head provides a calibrated measurement system at its input minimizing the effort required to de-embed cables from measured results, saving time and effort.

The Need for a Remote Oscilloscope Head

Faster signals need additional measurement margin to ensure that failures are truly failures vs. failure due to distortion from the measurement system. The remote head architecture provides a short and fully characterized connection from DUT to system input that minimizes signal distortion and improves the quality of the data acquired on the oscilloscope.

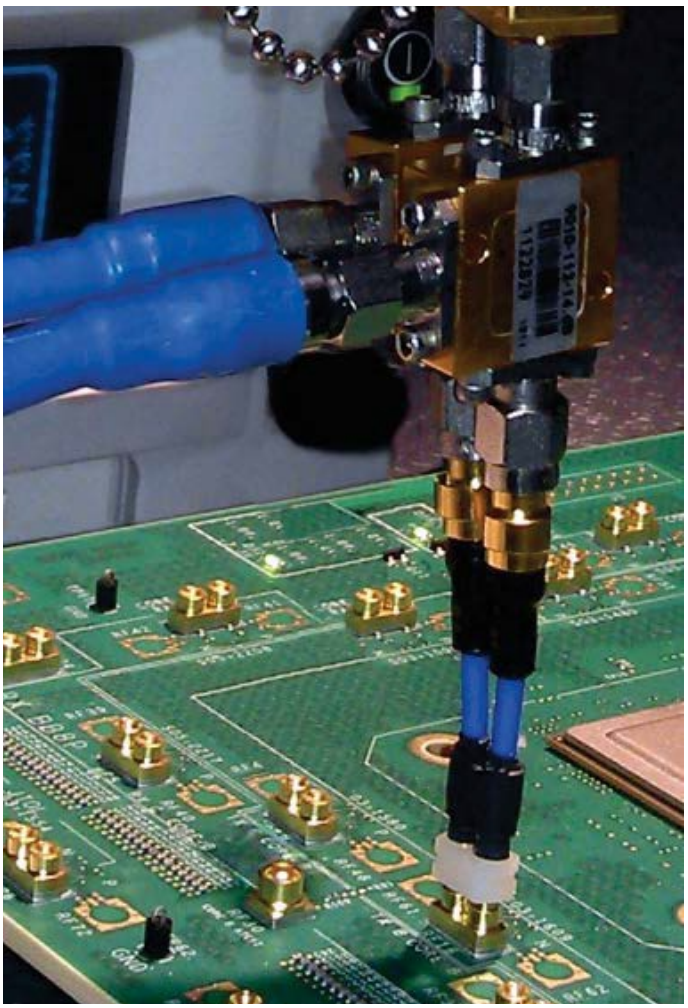

Figure 2. Tektronix 80E10 Sampling Module with remote head capability connected to a high speed device.

Actual Results

In tests with remote heads on Tektronix sampling and real-time oscilloscopes, improved measurements with lower noise, wider eye opening, and improved timing/jitter measurements were seen. These improvements show the value of having additional margin in measurements for high speed serial (HSS) signals. In this section, we will highlight the improved acquisition quality seen when using a remote head on a sampling or real-time oscilloscope. Using a HSS device with a data rate of 26 Gb/s, oscilloscope acquisitions with a remote head and with high quality coaxial cables are shown.

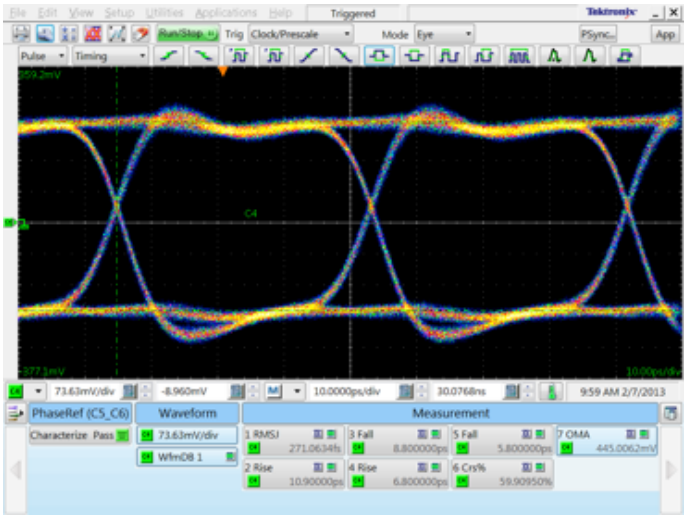

Figure 3. Eye Diagram acquired with a remote sampling head.

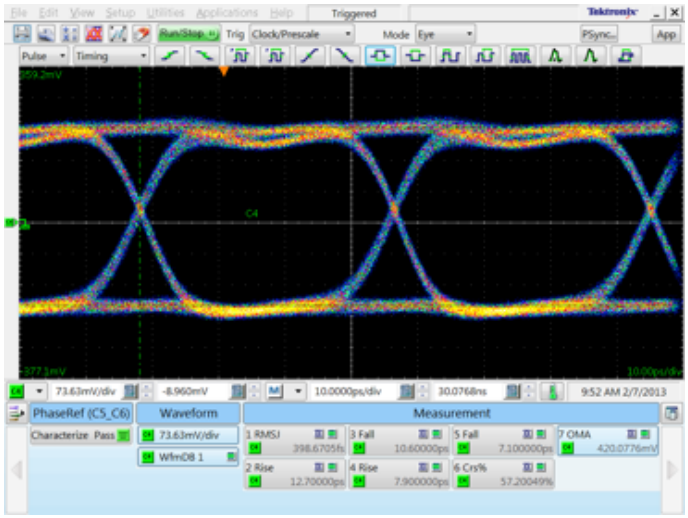

Figure 4. Eye Diagram acquired through coaxial cables.

Measurement	Remote Head	Low Loss Coaxial Cables
Eye Height (mV)	448	395
Data Dependent Jitter (ps)	1.74	2.13
Rise Time (ps) (20%-80%)	6.8	7.9
Fall Time (ps)	5.8	7.1

DSA8300 sampling oscilloscope

First we'll consider the acquisition using a DSA8300 sampling oscilloscope. The device being tested is a high speed latch driven by a data generator set to 26 Gb/s. The DSA8300 was connected to the device using 2 high quality, low-loss cables with 1.85mm connectors and a length of 24 in. (61 cm). It was also connected to the device using an 80E10B sampling module with remote head inputs. Power for the DUT was provided using a bias tee network. With the remote sampling head, the distance to the device under test (DUT) was <3 in. (7.6 cm). The test results using the two connection methods are shown above with a 26Gb/s, PRBS15 signal.

Using a remote head for this acquisition yielded a significant improvement in the measurements with lower noise, faster rise times, and lower measured jitter. In other studies, even greater impact was seen. With a 25 Gb/s signal and 24 in. (61 cm) of the best cable the rise time nearly doubled. In addition, observe the overshoot of the design as shown in Figure 3: there is approximately 15% overshoot. The measurement with a cable (Figure 4), completely hides the DUT's overshoot.

An additional benefit of the short cable length when using the remote head capability of the sampling module is minimal channel length to de-embed. The de-embedding process can be very sensitive to connector repeatability, so minimizing it is desirable.

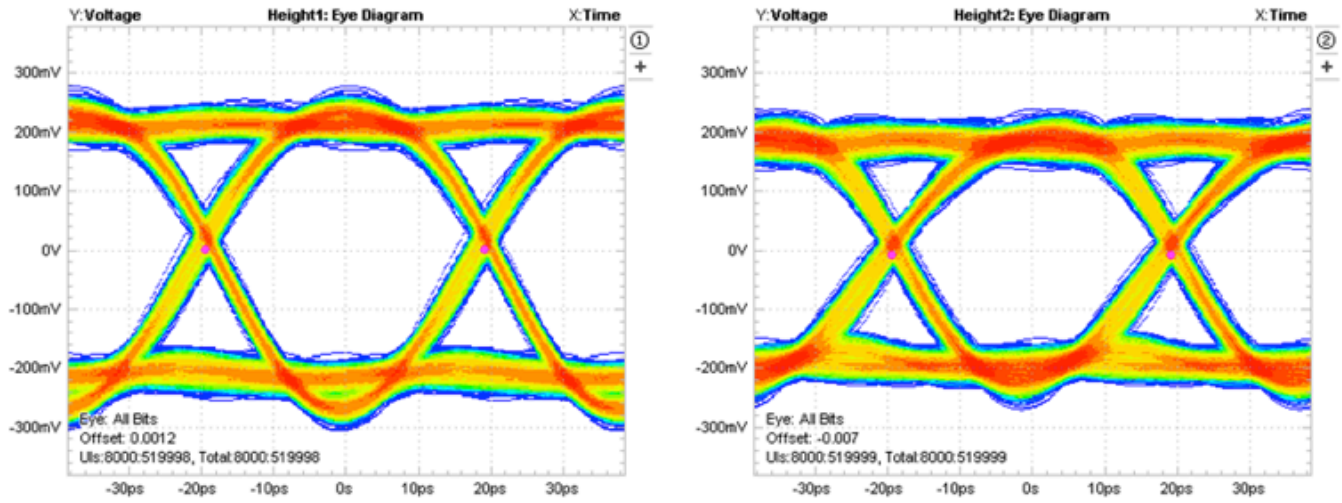

Figure 5. Comparison of Eye Diagrams acquired with the P7633 remote head (left) and using 2 phase matched, coaxial cables to the oscilloscope input (right).

Measurement	Remote Head	Coaxial Cable
Eye Height (mV)	341	281
Rise Time (ps) (20%-80%)	13.8	22.5
Fall Time (ps)	12.5	17.9

DPO73304DX Real-time Oscilloscope

A second set of experiments was conducted using a DPO73304DX real-time oscilloscope to measure the same high speed latch device driven at 26 Gb/s. Although real-time scopes generally have higher noise and inherent jitter than the DSA8300 sampling scope, a real-time scope is often used for debugging HSS signals, because it is easy to setup and run.

The test results shown above use the DPO73304DX connected to the high speed latch with a P7633 remote amplifier head and results with the scope connected to the device using 18 in. (46 cm), phase matched, coaxial cables. The connection length with the P7633 remote head was <1 in. (2.5 cm). The latch's DC bias was set using the P7633's built-in termination voltage capability, eliminating the added expense of providing a bias tee.

With the P7633 remote head connection, the eye opening of the HSS signal is 21% larger than the eye opening of the signal acquired with the coaxial cables. The larger eye opening may be a result from several factors.

- First, less signal attenuation through the short path to the remote head's amplifier input.
- Also, low additive noise of this remote head's signal path.

For differential signals, another remote head benefit is tightly matched propagation delay of the two inputs of the remote head. HSS signal acquisition can be improved using the remote head vs. 1-2 feet (30-60 cm) of the cables. Compensating the delay between channels is error prone. S-parameters for each cable modeling the loss and dispersion effects on each side of the HSS signal pair are needed. With the skew match of the remote head's inputs, these effects are automatically handled, plus the common mode rejection ratio (CMRR) of the measurement is higher with lower common mode noise.

80E10B Remote Sampling Module

The 80E10B is a small form factor, fully integrated independent 2-meter remote sampler system. The 80E10B enables locating the sampler near the DUT and ensuring the best signal fidelity. It also provides:

- Up to 50 GHz Bandwidth
- Lowest Noise for Analysis: 450 μV_{RMS} at 60 GHz, 300 μV_{RMS} at 30 GHz
- Independent Sampler Deskew
- Dual-channel Time Domain Reflectometry (TDR) capability, providing up to 12 ps incident and 15 ps reflected rise time
- Precision Microwave Connectors (3.5 mm, 2.92 mm, 2.4 mm, and 1.85 mm)

The small form factor and 2-meter cable of the sampler allow close location to the DUT and minimize the effects of cables, probes, and fixtures.

P7600 Series Remote Amplifier Head

The P7600 architecture places the input amplifier within inches of the device's test connection and minimizes any distortion of the signal without adding noise. In addition, the P7600 series remote heads provide:

- 1.2m cable length to place the remote amplifier input closer to the device under test
- A calibrated, flat response at the input connector with unique S-parameter models
- <1X attenuation setting and less than 1 mV_{RMS} additive noise
- A choice of input connectors, 2.92mm or SMP
- TriMode™ functionality providing differential, single-ended and common mode measurements without adjusting the test setup
- User settable DC termination voltage outputs to set the bias point of electronic components.

80E10B and P7600 Architectural Differences

In the architecture of the 80E10B, the high speed circuitry is placed at the front of the remote head. The circuitry from there to the oscilloscope mainframe is low-speed, providing a high-fidelity, low loss architecture. The design of the P7600 is different from the sampling head. With the P7600 remote head, the conversion to a slower digital signal is not inside the remote head. The remote head simply includes the first stage of amplification. The reader might ask, "Why is this remote head for a real-time oscilloscope an improvement over a cable?"

The remote head in the real-time oscilloscope improvements to the system's performance are two-fold:

1. The amplifier gain in the front of the system improves the overall SNR.
2. The interconnect between the remote head and the oscilloscope's digitizer includes ISI, just as a user's cable would. However, the interconnect between the remote head and the digitizer is characterized by Tektronix and its effect is removed in the DSP calibration process built into the oscilloscope. From the user's point of view, the ISI doesn't happen. This process is a significant improvement over other systems where the oscilloscope is connected to the DUT with a cable. In that case the cable introduces ISI clearly visible to the user, and at best the user has to de-embed it alone.

For more information on these products, go to www.tek.com and search for 8E10B or P7633.

Summary

As high speed serial data rates continue to increase, the need to maximize margin in measurements increases. Coaxial cables, even good quality ones can impact the measurement margin. Remote heads for oscilloscopes provide clear advantages that maximize the margin in signal integrity measurements.

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Contact List Updated June 2013

For Further Information
Tektronix maintains a comprehensive, constantly expanding collection of application notes, technical briefs and other resources to help engineers working on the cutting edge of technology. Please visit **www.tektronix.com**

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