Enhanced TDR Measurements with the SNA5000A Vector Network Analyzer from Siglent

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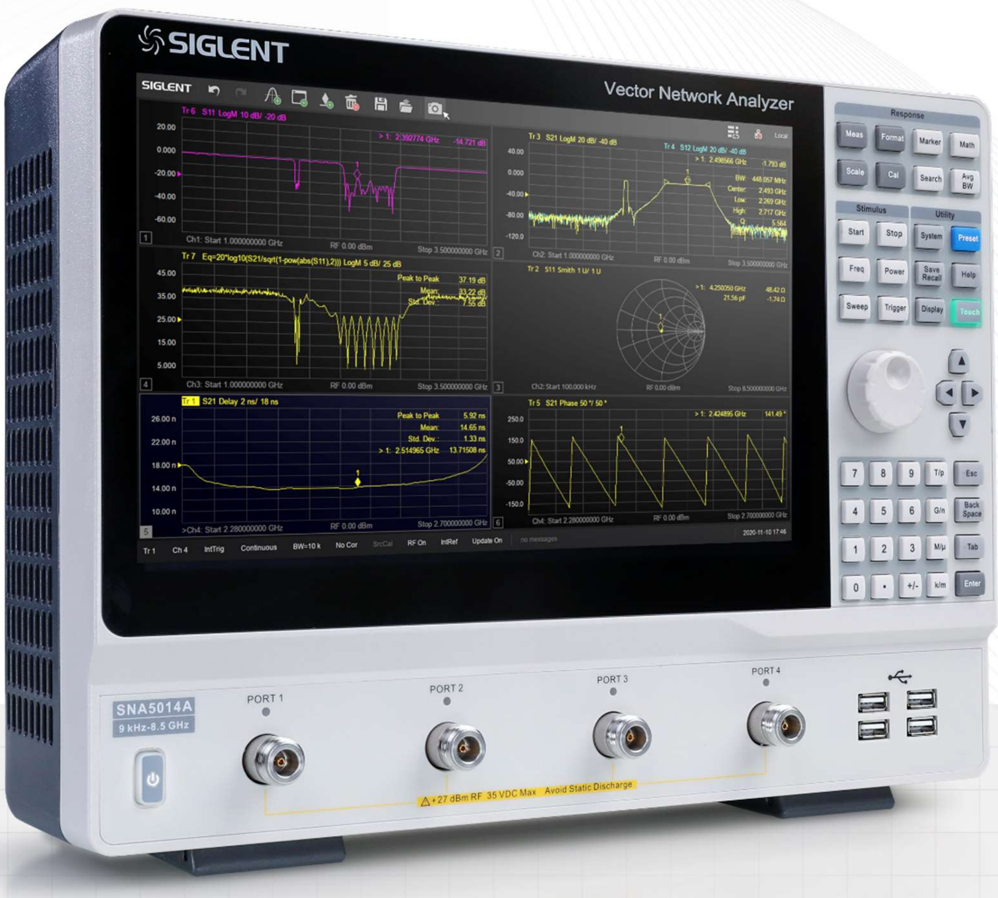

SIGLENT TECHNOLOGIES CO.,LTD

Introduction

Time Domain Reflectometry (TDR) is an important method for measuring cable and connection quality for high-speed transmissions. Some measurements that broadly fall into this category include characteristics like distance to fault as TDR makes it easy to visualize impedance changes over distance. Some of the basic analysis modes can be implemented on cable analyzers and basic spectrum analyzers, but advanced TDR measurements make it possible to evaluate much more subtle and elusive transmission quality issues. When TDR capabilities are built into a powerful multiport, multipath Vector Network Analyzer advanced visualization and analysis becomes possible. One important methodology is the use of simulated eye diagrams on high-speed communication channels. These eye diagram can be implemented on a number of device topologies with de-embedding using a 4-port network analyzer while providing important data visualizations including mask testing and injected jitter. This application note discusses the advanced TDR implementation and capabilities of the Siglent SNA5000A vector network analyzers while comparing the quality of 2 standard USB cables.

Differential Measurements and DUT Topology

As it is with many VNA measurements, configuration and calibration are two of the most important steps in acquiring quality data to guide design and improvement. Siglent's Vector Network Analyzer (**figure 1**) includes a setup wizard to simplify device configuration and calibration to de-embed cables and connections.

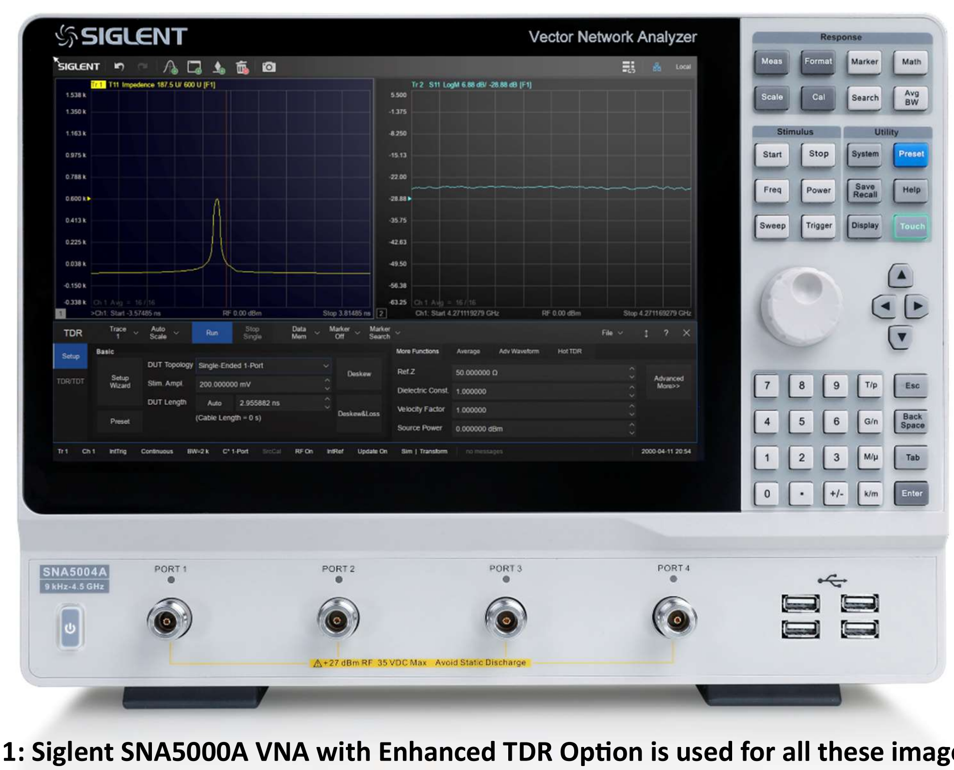

Figure 1: Siglent SNA5000A VNA with Enhanced TDR Option is used for all these images and measurements.

TDR Mode is entered through the MATH menu. Once turned on, enter the Setup Wizard to begin. The first setup step is deciding on DUT topology (**Figure 2**).

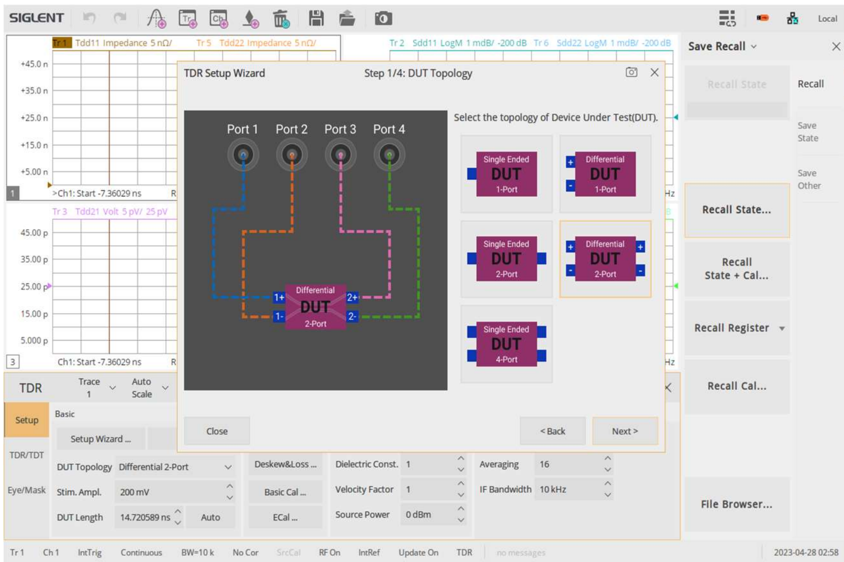

Figure 2: DUT Topology in the TDR Setup Wizard

With a 4 port VNA, complete differential measurements are possible. This is important for high performance signals and systems that routinely use differential signaling for high-speed communication. Here we will use a 2 port differential topology to test our USB cables. We have two differential SMA to USB-A connectors that we are connecting to the VNA using N to SMA cables and adaptors. The next steps in the Setup Wizard assist with calibration and deskew of these cables and connections for our selected topology. **Figure 3** shows the first open calibration wizard window. This is followed by some thru connections and optional load connections to calibrate the setup for your device. Additional mechanical calibration or Ecal can be conducted from the TRD Setup interface as well.

Once the Setup Wizard is complete, you can configure the traces on the display for the desired measurements. In this topology, you can select from the following options:

Tdd11	Tdd12	Tdc11	Tdc12
Tdd21	Tdd22	Tdc21	Tdc22
Tcd11	Tcd12	Tcc11	Tcc12
Tcd21	Tcd22	Tcc21	Tcc22

These measurements are time domain parameters where the c and d (for example in: Tcd12) indicate whether the output port and input port are configured for differential or common measurements respectively. The 1 and 2 indicate the output and input port numbers. Traditional scattering parameters, like Sdd12, can also be selected by changing the time domain option. In S parameter mode, other measurement formats including Smith charts can be shown. For our cable test, we will use Tdd12 to measure the differential transmission quality.

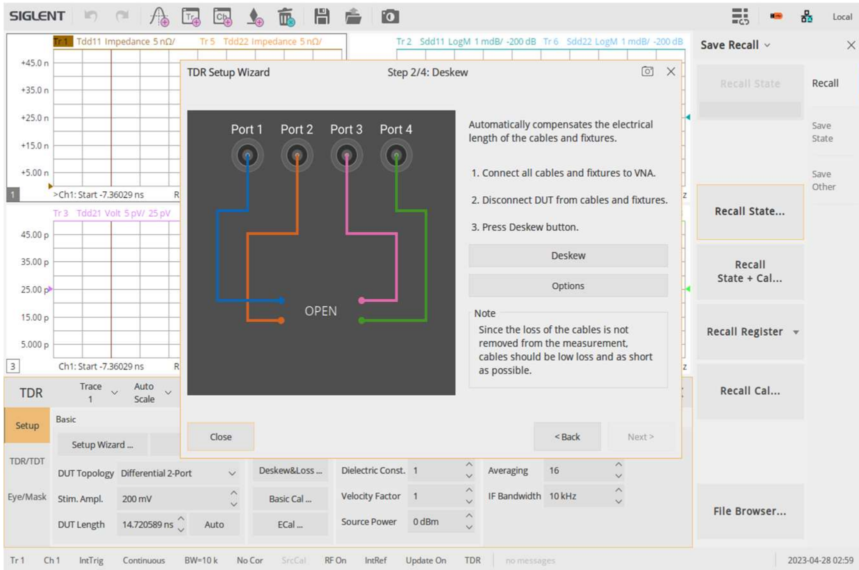

Figure 3: TDR Setup Wizard Deskew calibration

Use the Auto Scale function to scale all of the traces and we can visualize any of the parameters that are of interest. The SNA5000A can create up to 256 traces at once. Much of the analysis can be done from the view shown in **Figure 4**. The time-domain traces completely characterize the device under test. We can take a quick look to make sure our device is connected properly and measuring within established parameters. Now, we are ready to move to the eye diagram view for advanced characterization of this connection.

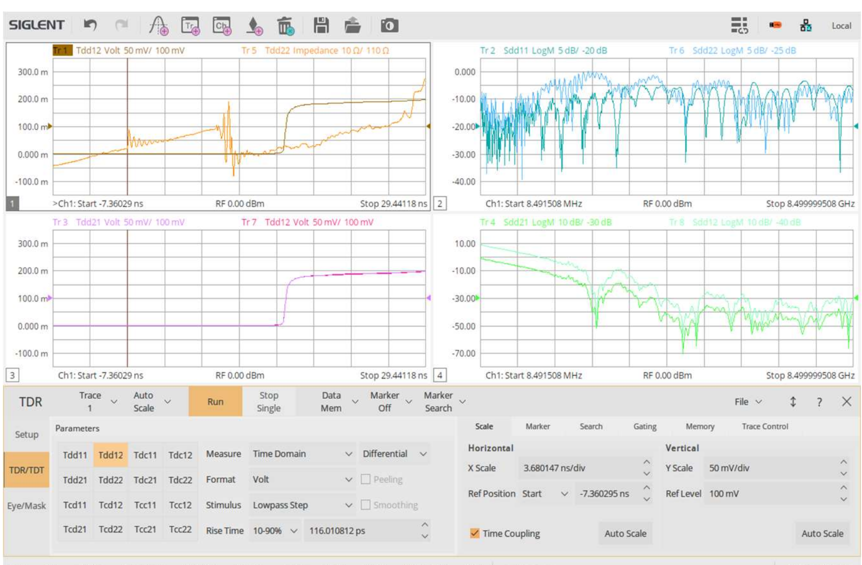

Figure 4: Tdd12 Trace Setup

Eye Diagram and Mask Testing

With the correct trace and parameter selected, we now move to the Eye/Mask step in the TDR operation by selecting the “Eye/Mask” button in the bottom left of the screen as shown in Fig**ure 4** above. Initially, let’s configure the Eye to simulate a PRBS signal at 1 GB/s. Here, we can compare the 2 cables in **Figure 5**.

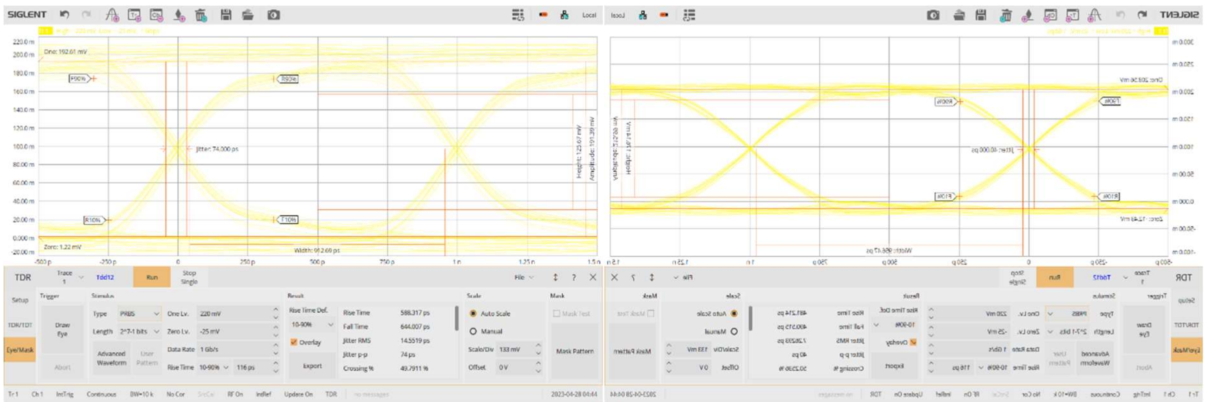

Figure 5: Cable A vs Cable B with PRBS signal simulation

It is important to note that through all of these measurements, the VNA is not sending and receiving data streams, but it is using the information gleaned from the DUT in TDR mode to generate complex simulations of how data will likely look given the characteristics of the channel. There is some difference in these views, but the PRBS signal may also be too short to reveal the differences in these cables. To look further, we can change the Stimulus type from PRBS to Statistical. This gives us a more complete look at data transmission over time and produces the images shown in **Figure 6**.

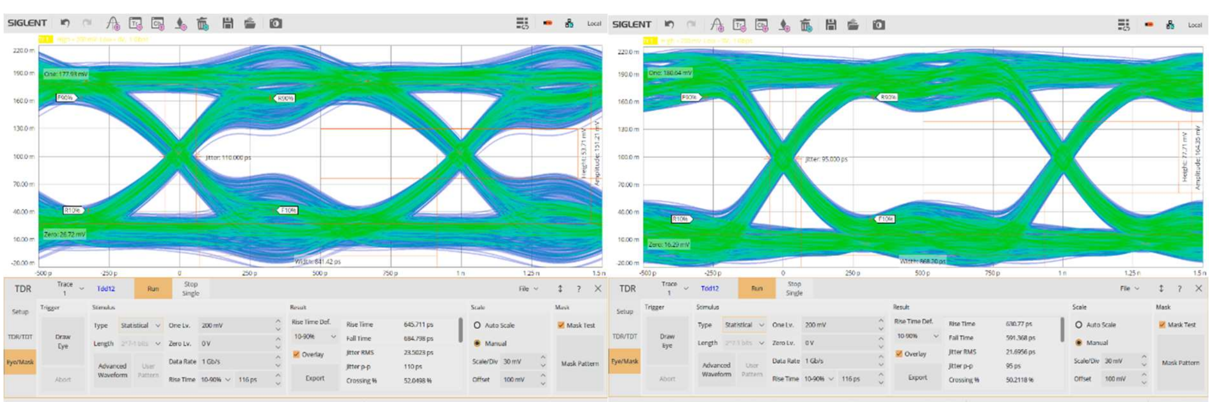

Figure 6: Cable A vs Cable B in Statistical signal simulation

Now, we can start to clearly see that Cable A has some characteristics that may affect the data transmission. We can use the custom Mask Pattern generator to objectively detail this. The Mask Pattern generator comes with more than 50 standard mask patterns for established signals as well as templates to build from with a rectangle, hexagon, octogon, or decagon shape for the eye area. Here, we built a custom hexagon mask that matches our signal levels and the cable parameters that we need to verify. **Figure 7** shows the eye patterns for cable A and B with the mask overlayed.

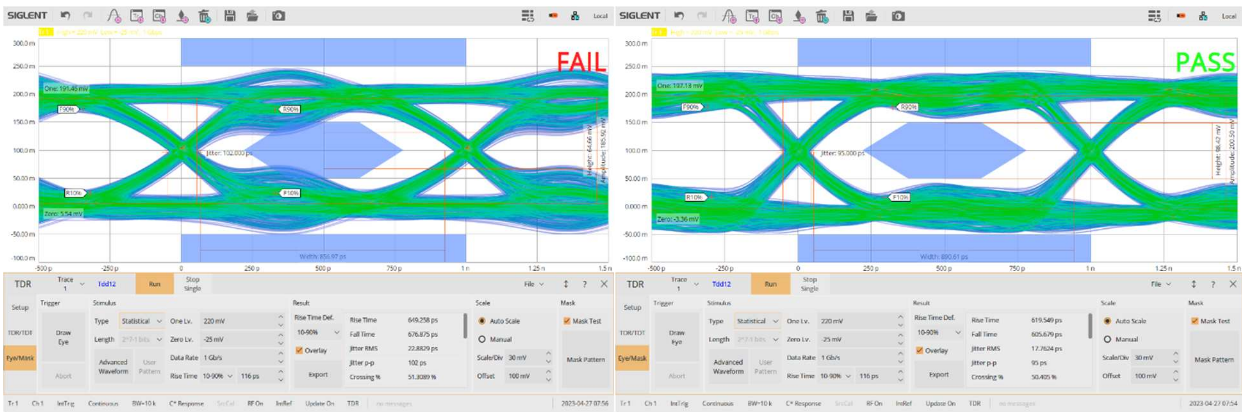

Figure 7: Cable A vs Cable B in Statistical signal simulation with custom Mask

Jitter Injection and Custom Stimulus

Now we see that cable A creates some overshoot/undershoot coming out of transitions that impedes on our eye and may occasionally reach the outside mask borders. This test still implies a very accurate signal going through our cable and connectors. What would happen if there was jitter being injected by the source? The SNA5000A can add injected jitter to this simulation automatically. Either random or periodic jitter can be injected using the Advanced Waveform button. With the addition of an element of random jitter, the results can be seen in **Figure 8**. We can see the higher Jitter measurement on the screen as well as the eyes closing up due to the signal jitter.

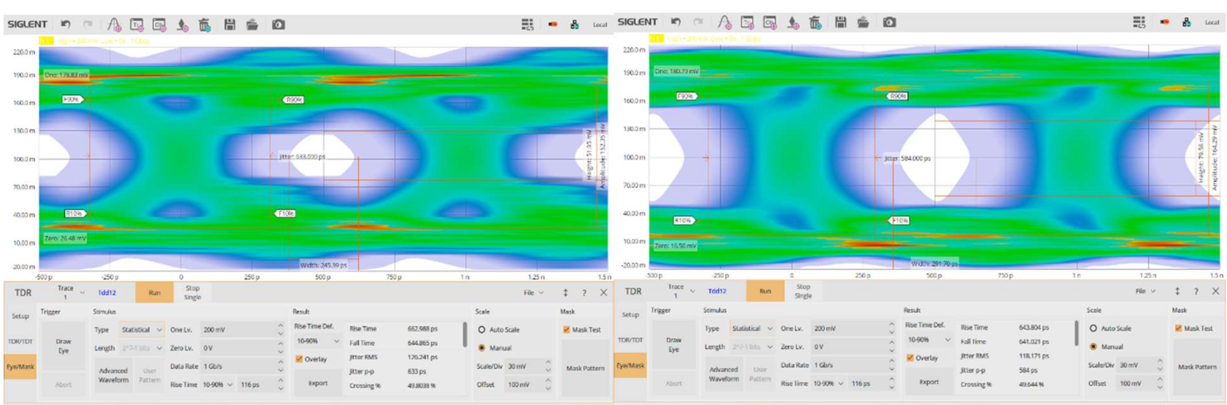

Figure 8: Cable A vs Cable B in Statistical signal simulation with injected Jitter

Through experimentation and use of the jitter injection and mask features we find that Cable B can still pass our mask test even with 50mUI of random jitter [magnitude(RMS)]. **Figure 9** shows Cable B with these settings and **Figure 10** shows the extent of the issues with Cable A under these settings.

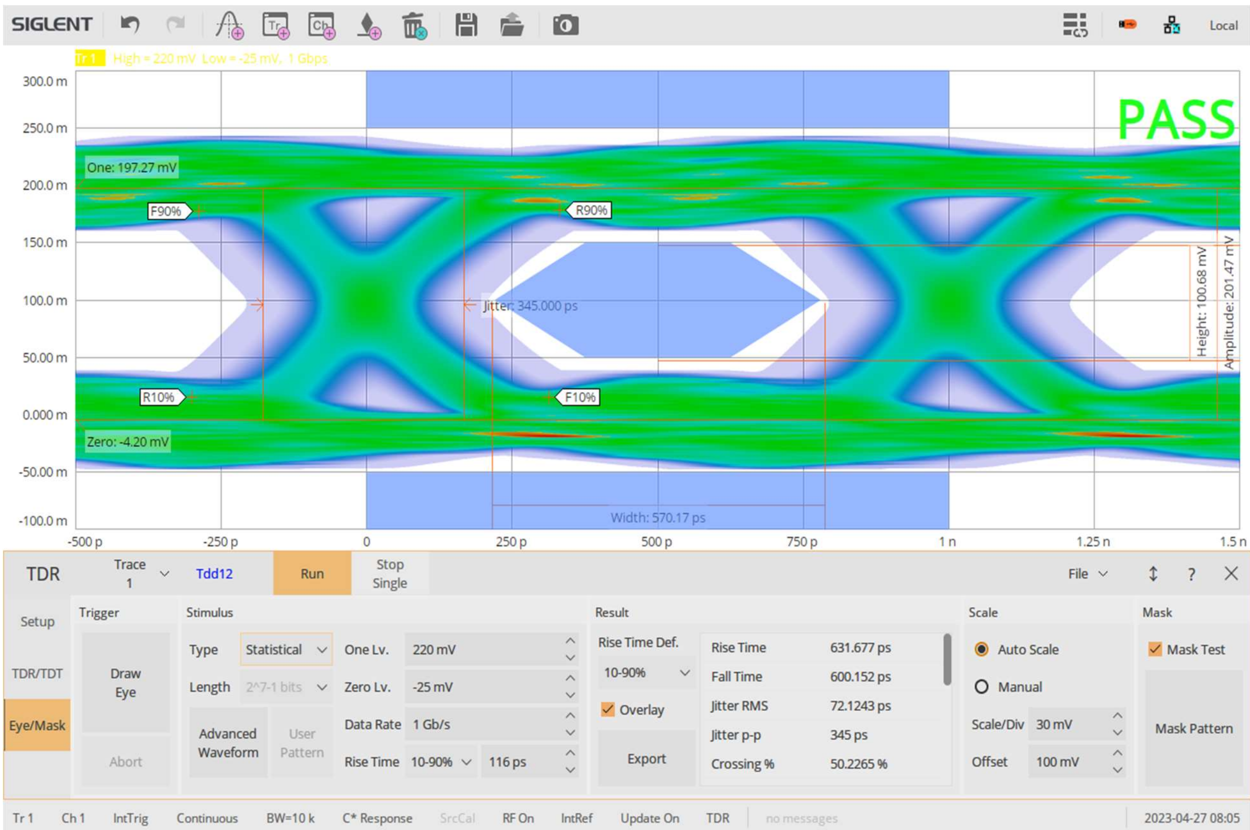

Figure 9: Cable B Passing mask test with injected Jitter

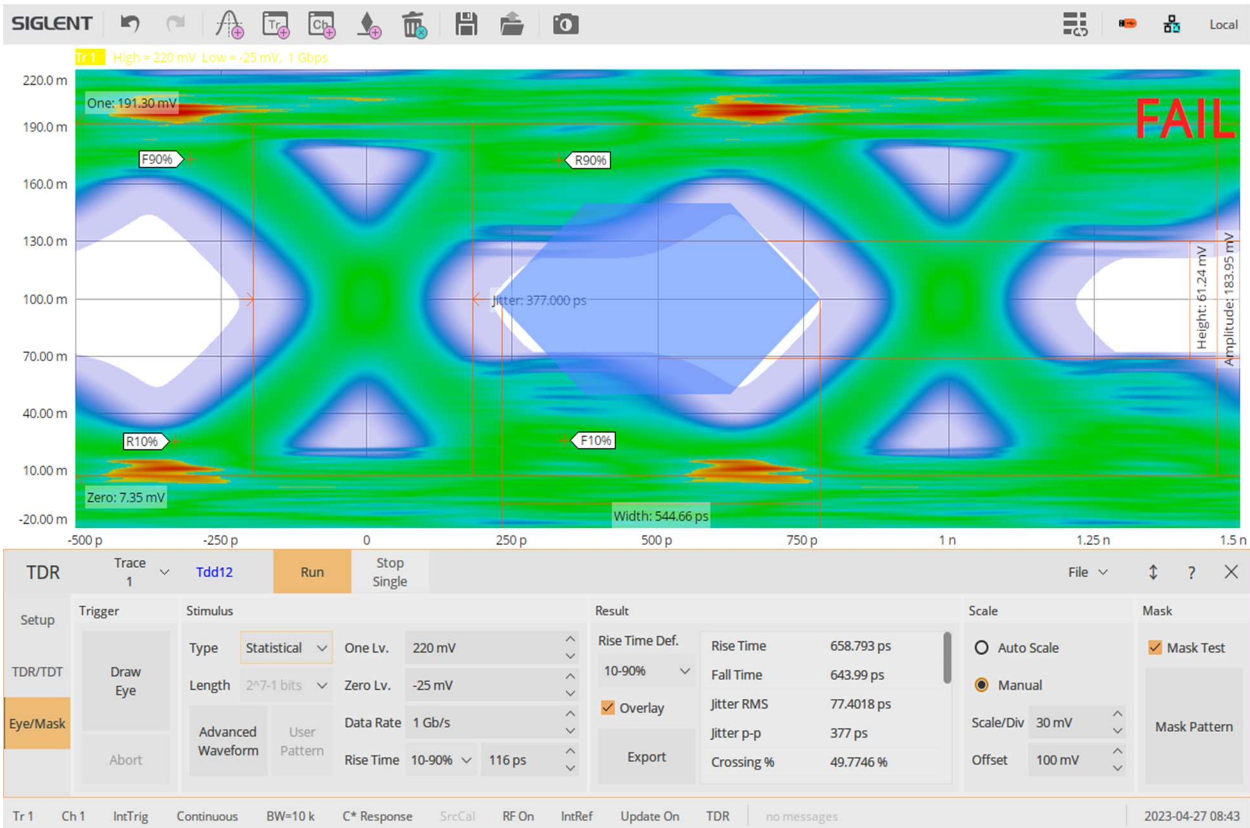

Figure 10: Cable A Failing mask test with injected Jitter

Additional customization of the eye diagram can be done by customizing the data pattern used for the simulation as well as adjusting the rise-time of the stimulus signal or the data rate. The final figure shows cable B operating at a higher bit rate and with a faster edge. This eye diagram in **Figure 11** demonstrates the ability of this cable and connector setup to operate with a faster transceiver operating at 2.5 GB/sec.

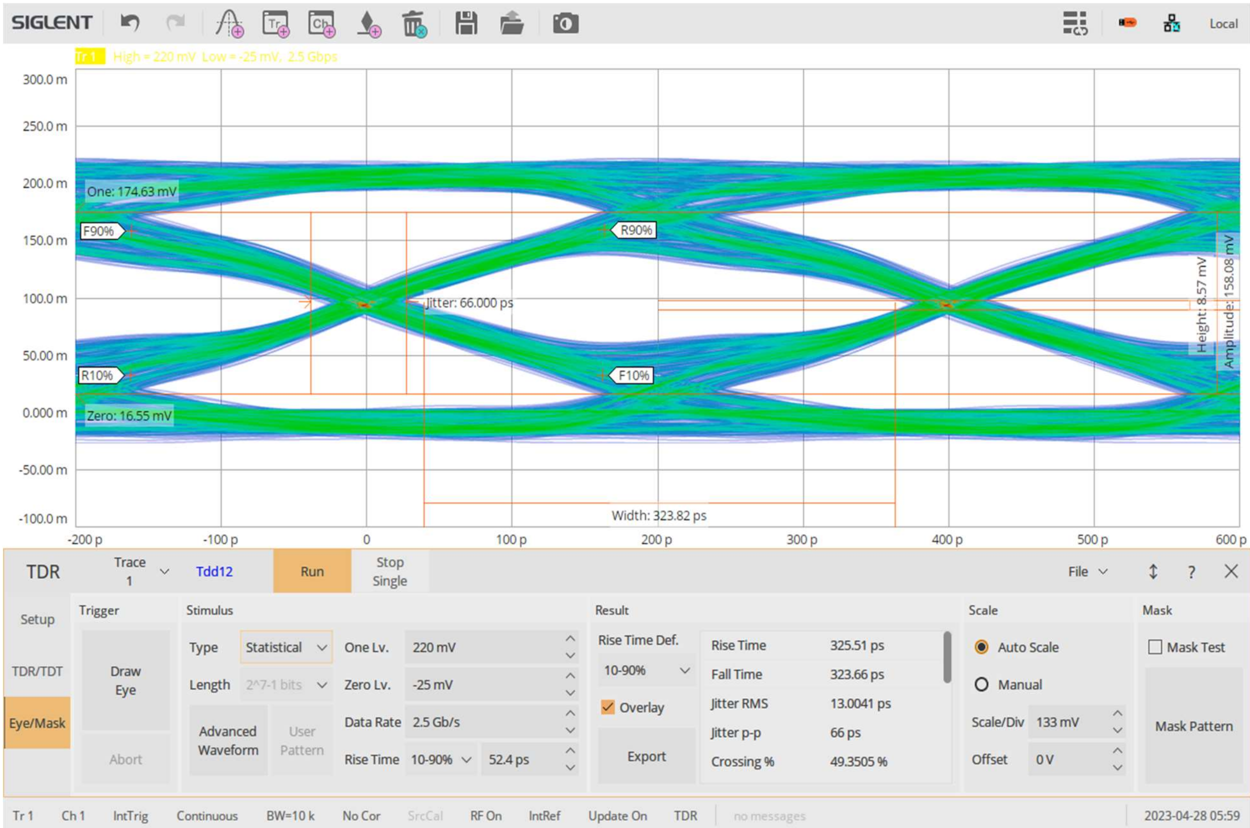

Figure 11: Cable B Operating with a faster edge at 2.5 GB/s

Conclusion

Enhanced TDR Analysis including eye diagrams, mask testing, and configurable stimulus signals are an important characterization technique for high-speed data channels and connections. Siglent's 4 port Vector Network Analyzers continue to expand in frequency range making advanced testing of faster transmission systems more easily attainable. Accurate characterization of these signals and systems requires both precision and high dynamic range, but also built-in tools that simplify configuration, calibration, customization, and visualization of critical measurements. Siglent's enhanced TDR capability on our vector network analyzers simplifies this type of advanced analysis.

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About SIGLENT

SIGLENT is an international high-tech company, concentrating on R&D, sales, production and services of electronic test & measurement instruments.

SIGLENT first began developing digital oscilloscopes independently in 2002. After more than a decade of continuous development, SIGLENT has extended its product line to include digital oscilloscopes, isolated handheld oscilloscopes, function/arbitrary waveform generators, RF/MW signal generators, spectrum analyzers, vector network analyzers, digital multimeters, DC power supplies, electronic loads and other general purpose test instrumentation. Since its first oscilloscope was launched in 2005, SIGLENT has become the fastest growing manufacturer of digital oscilloscopes. We firmly believe that today SIGLENT is the best value in electronic test & measurement.

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