

Agilent Technologies

USB 3.0 Cable-Connector Assembly Compliance Test



Test Solution Overview Using the Agilent E5071C ENA Option TDR

Last Update 2012/12/20 (TH)

Purpose

- This slide will show how to make measurements of USB 3.0 cable & connector assemblies Compliance Tests by using the Agilent E5071C ENA Option TDR.

Agilent Digital Standards Program

Our solutions are driven and supported by Agilent experts involved in international standards committees:

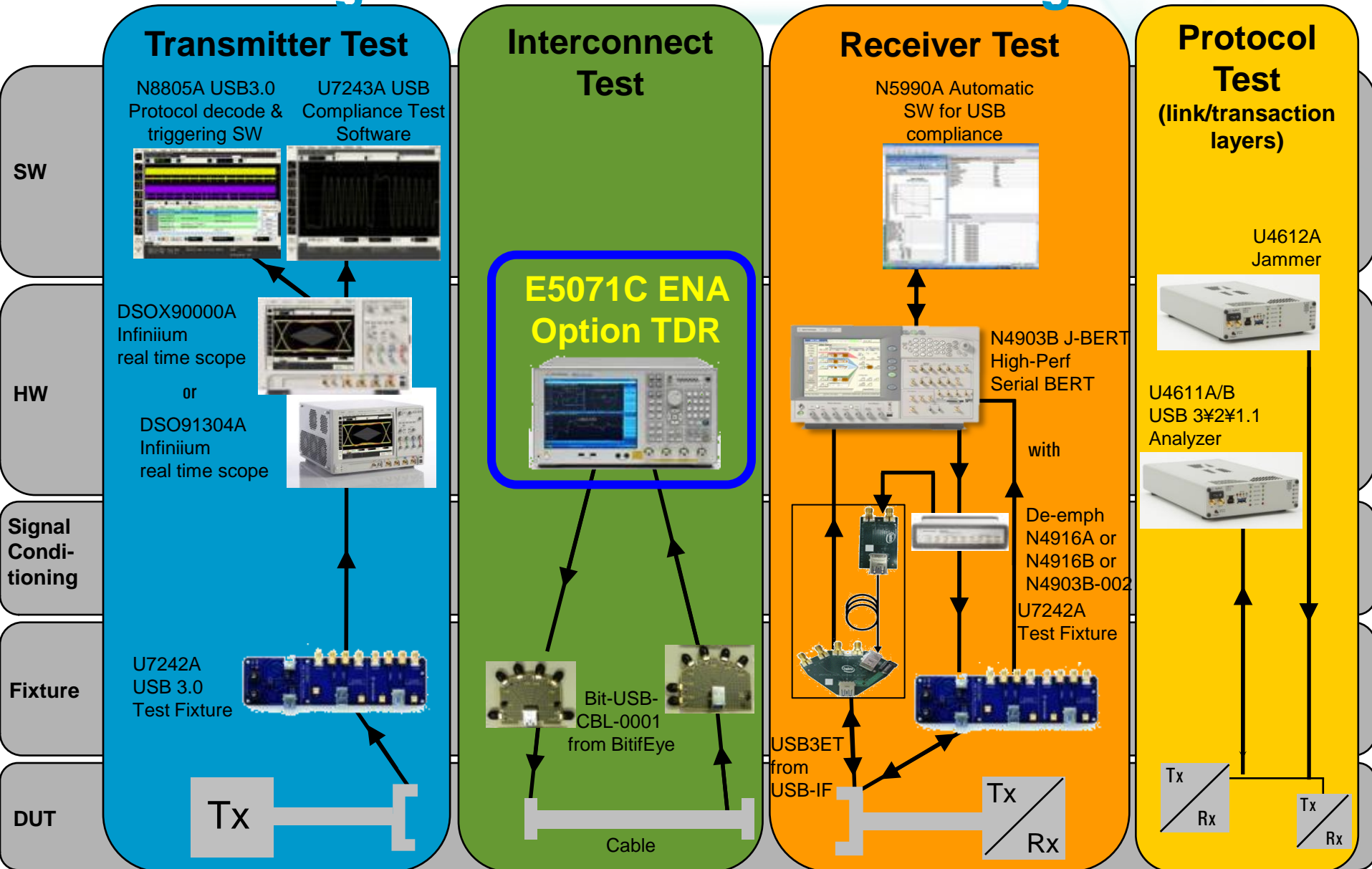
- Joint Electronic Devices Engineering Council (JEDEC)
- PCI Special Interest Group (PCI-SIG®)
- Video Electronics Standards Association (VESA)
- Serial ATA International Organization (SATA-IO)
- [USB-Implementers Forum \(USB-IF\)](#)
- Mobile Industry Processor Interface (MIPI) Alliance
- Optical Internetworking Forum (OIF)

We're active in standards meetings, workshops, plugfests, and seminars

Our customers test with highest confidence and achieve compliance faster



USB 3.0 – Agilent Total Solution Coverage

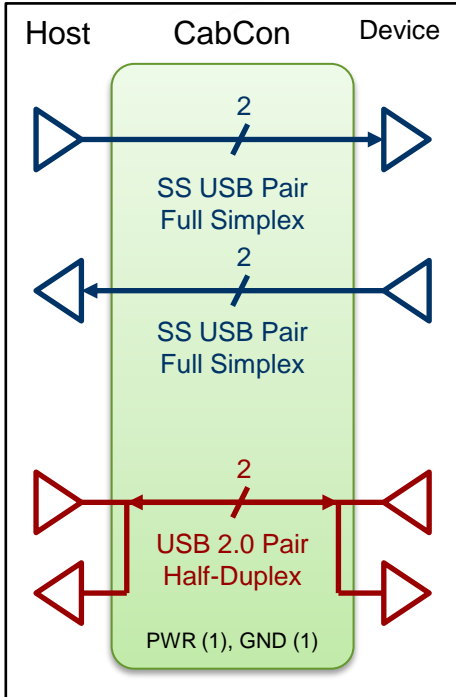


Reference Document

- Universal Serial Bus 3.0 Specification
- Universal Serial Bus 3.0 Connectors and Cable Assemblies Compliance Document

USB 3.0 Cable/Connector Compliance Test Solution

Cable Assembly



USB 3.0 Cable Assembly

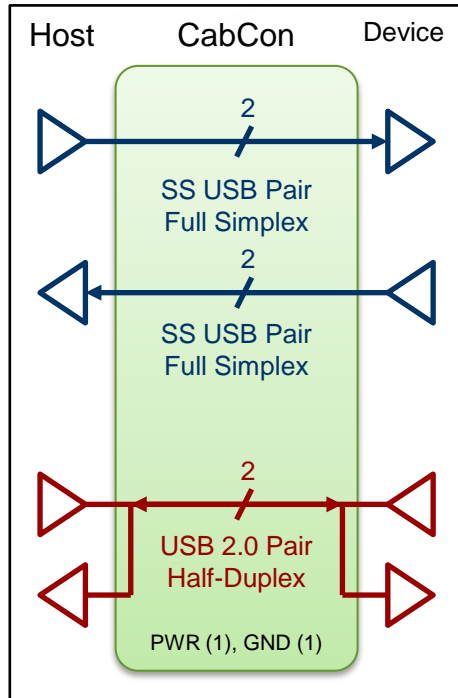
New features added to the cable assembly for SuperSpeed operation.

U-008
11

SuperSpeed USB Developers Conference Presentation, Taipei, Taiwan (April 1-2, 2010), "SuperSpeed USB Physical Layer", Howard Heck, Intel Corporation <http://www.usb.org/developers/presentations/pres0410>

USB 3.0 Cable/Connector Compliance Test Solution

Measurement Parameters



Time Domain Measurements

Mated Connector Impedance

Raw Cable Impedance

Intra-Pair Skew

D+/D- Pair Skew (USB 2.0)

D+/D- Propagation Delay (USB 2.0)

Differential Near End Crosstalk (NEXT)

Differential Crosstalk Between D+/D- and Super Speed

Frequency Domain Measurements

Differential Insertion Loss (S_{dd21})

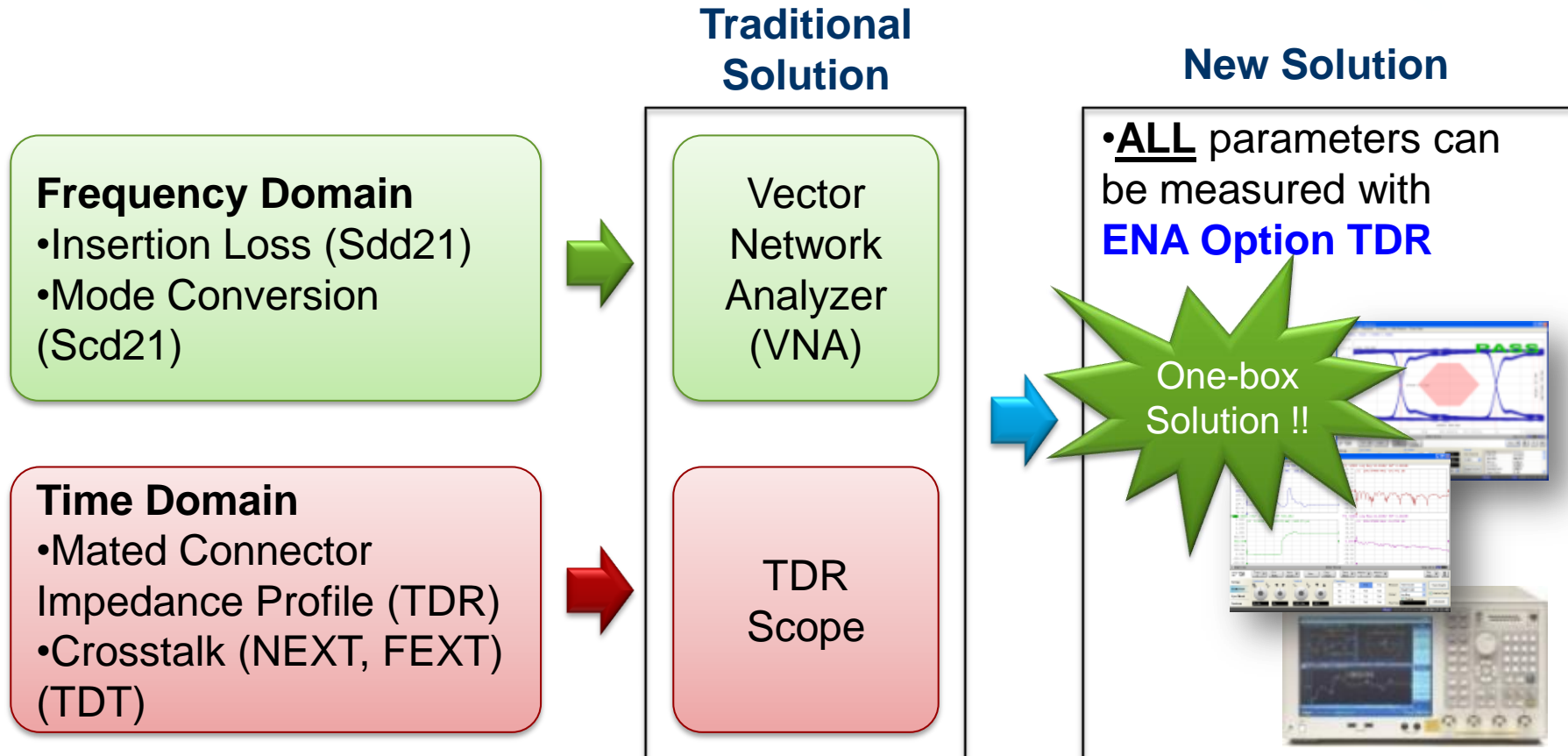
Differential-to-common Mode Conversion (S_{cd21})

D+/D- Pair Attenuation (USB 2.0)

USB 3.0 Cable/Connector Compliance Test Solution

Solution Overview

- USB 3.0 cable/connector compliance testing requires parametric measurements in both time and frequency domains



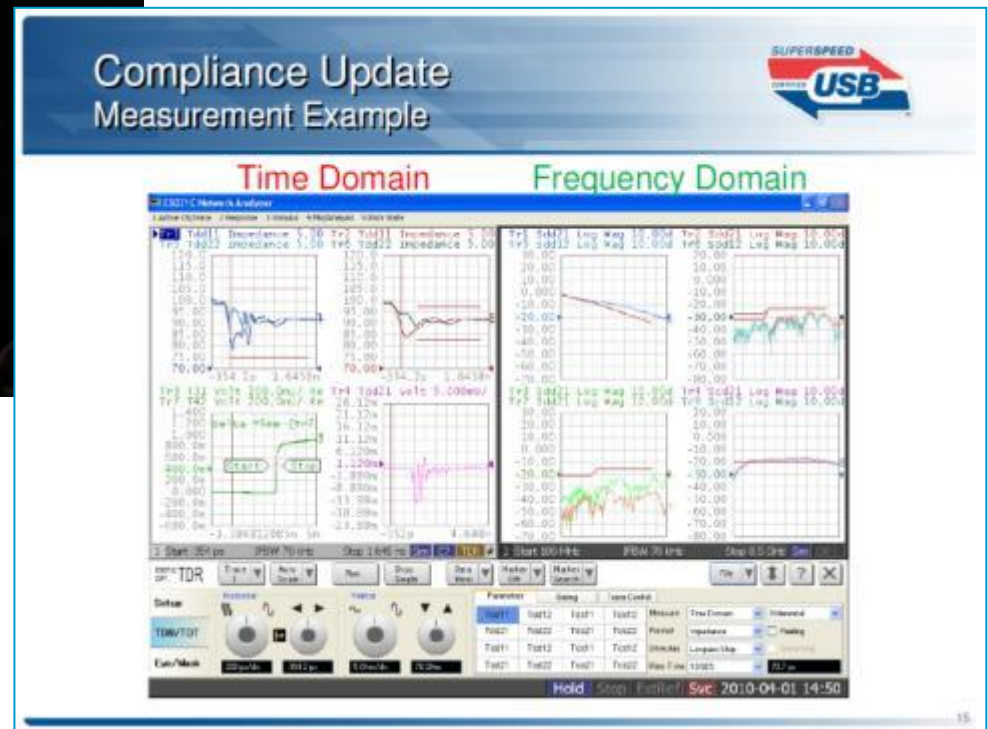
USB 3.0 Cable/Connector Compliance Test Solution

Developers Conference (Taiwan, April 2010)



“SuperSpeed USB Compliance: Overview”,
Rahman Ismail, Intel Corporation

***ENA Option TDR introduced
as recommended solution for
CabCon compliance test.***



<http://www.usb.org/developers/ssusb>

USB 3.0 Cable/Connector Compliance Test Solution

Certification Test Centers Supporting ENA Option TDR

ENA option TDR is used by USB-IF certified test centers to perform USB 3.0 connectors and cable assemblies compliance tests



USB 3.0 Cable/Connector Compliance Test Solution

ENA Option TDR Solution



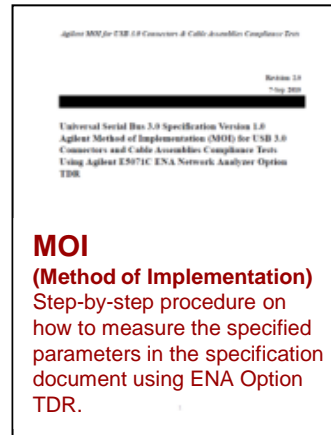
- ENA Mainframe
 - E5071C-480: 4-port, 9kHz to 8.5GHz
 - E5071C-485: 4-port, 100kHz to 8.5GHz
 - E5071C-4D5: 4-port, 300kHz to 14GHz
 - E5071C-4K5: 4-port, 300kHz 20GHz
- Enhanced Time Domain Analysis Option (E5071C-TDR)
- ECal Module
 - N4431B for E5071C-480/485
 - N4433A for E5071C-4D5/4K5

•Method of Implementation (MOI) document available for download on Agilent.com

•State files (480,485,4D5, 4K5) and cal kit definition file for official cal fixtures are also available

www.agilent.com/find/ena-tdr_compliance

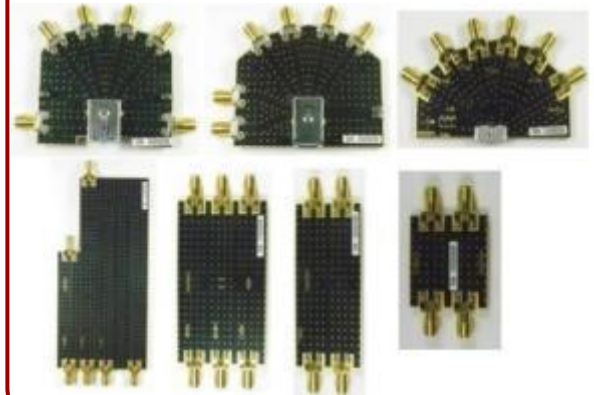
www.agilent.com/find/ena-tdr_usb3-cabcon



SuperSpeed Cable Test Fixtures

Fixtures for testing SuperSpeed cable assemblies and USB 3.0 connectors are available for purchase through Allion and BitifEye.

<http://www.usb.org/developers/ssusb/ssusbtools/>

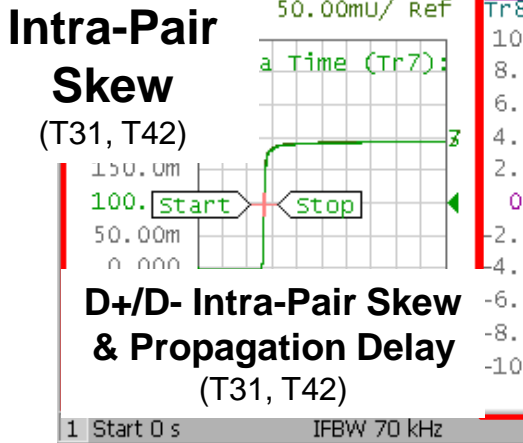
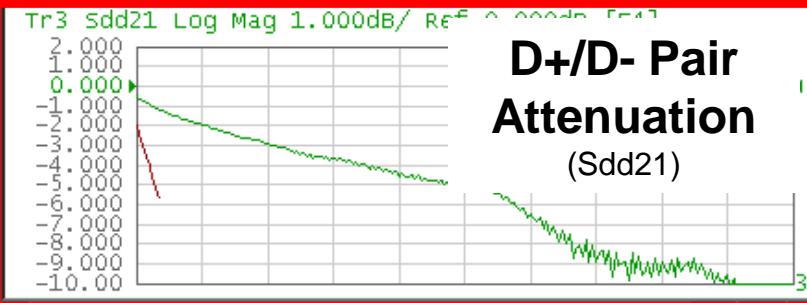
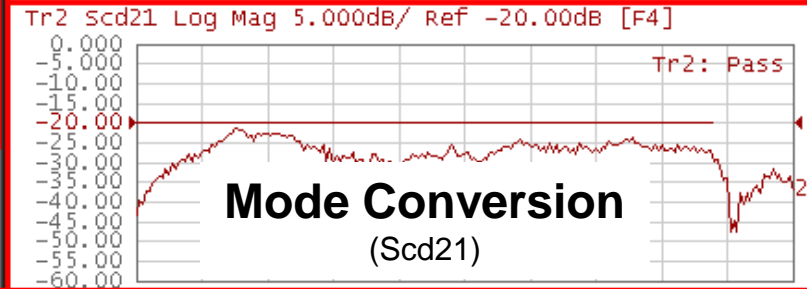
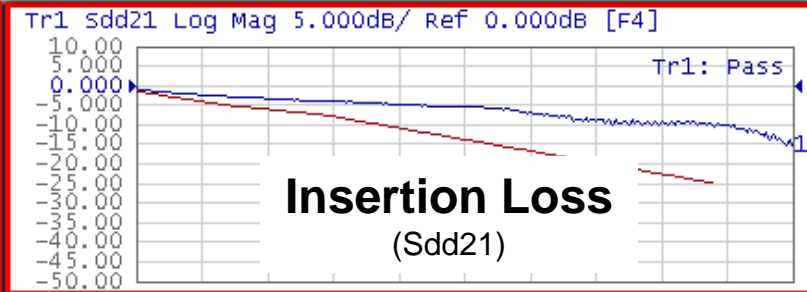
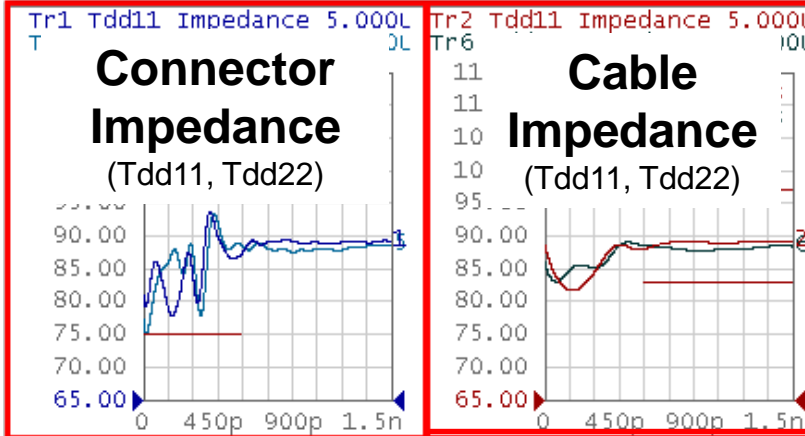


USB 3.0 Cable/Connector Compliance Test Solution

Measurement Parameters by ENA Option TDR

Time Domain

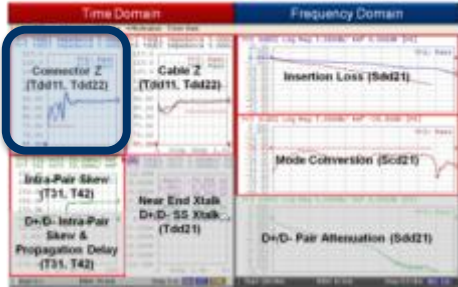
Frequency Domain



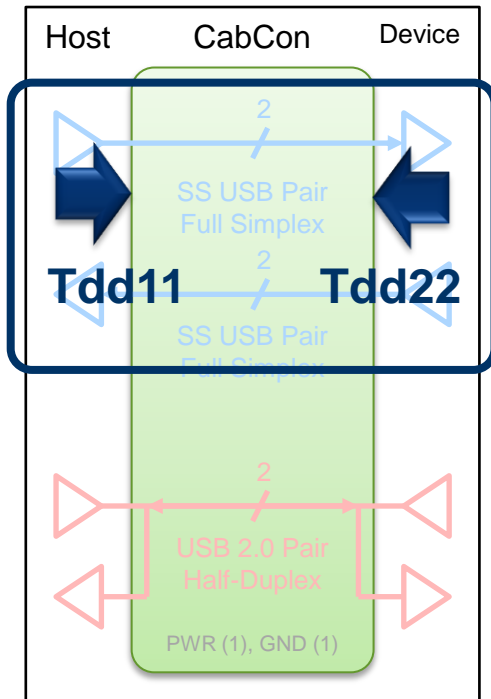
NEXT
D+/D- & SS Crosstalk
(Tdd21)

USB 3.0 Cable/Connector Compliance Test Solution

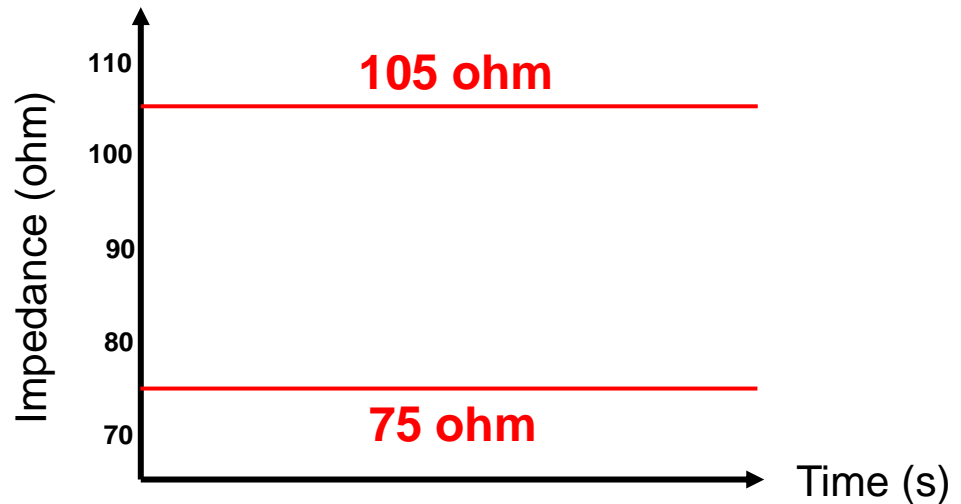
Mated Connector Impedance



- Multiple reflections from impedance mismatches cause noise at the receiver. Therefore, the impedance profile provides an indication of multiple reflection induced noise
- Impedance is the most used parameter, but is an indirect measure of the signal arriving at the receiver



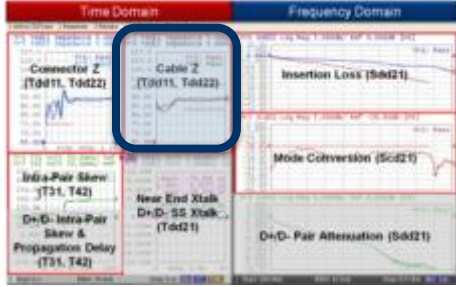
TDR with 50 ps (20-80%) rise time



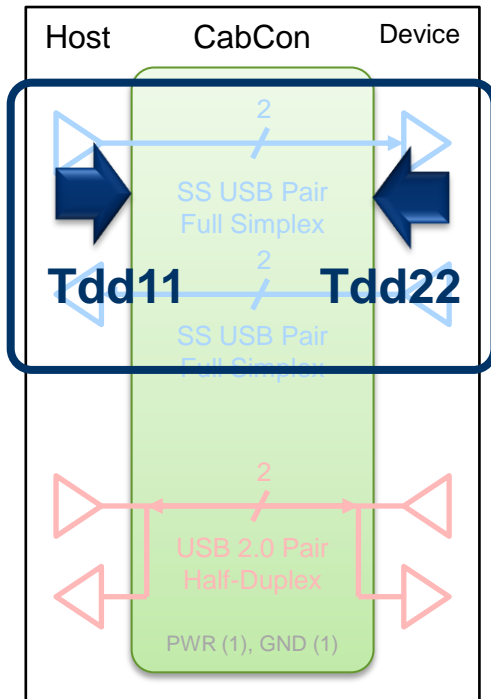
Impedance limits of a mated connector

USB 3.0 Cable/Connector Compliance Test Solution

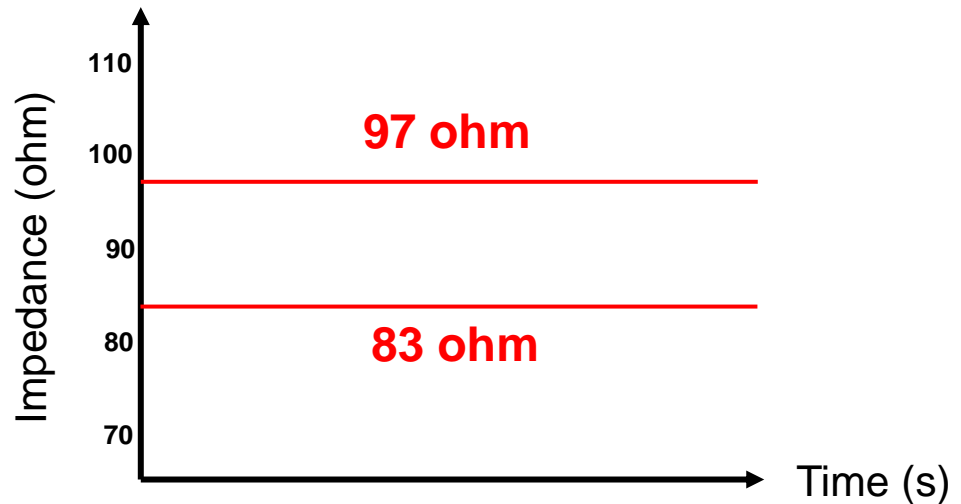
Raw Cable Impedance



- Multiple reflections from impedance mismatches cause noise at the receiver. Therefore, the impedance profile provides an indication of multiple reflection induced noise
- Impedance is the most used parameter, but is an indirect measure of the signal arriving at the receiver



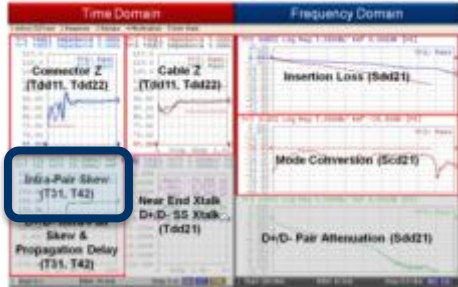
TDR with 200 ps (10-90%) rise time



Impedance limits of a raw cable

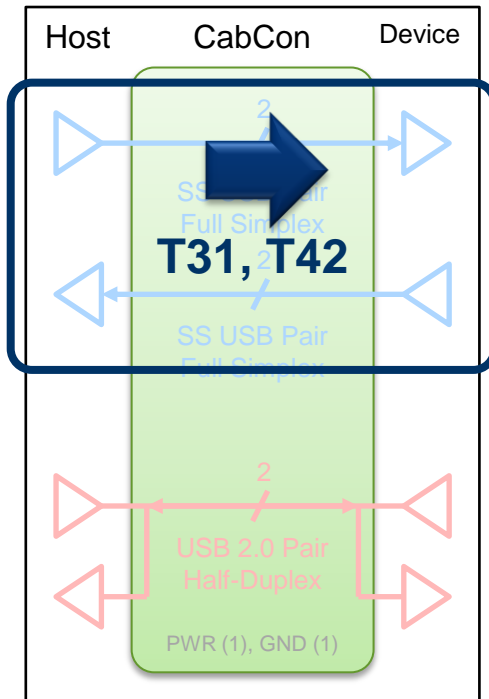
USB 3.0 Cable/Connector Compliance Test Solution

Intra-Pair Skew



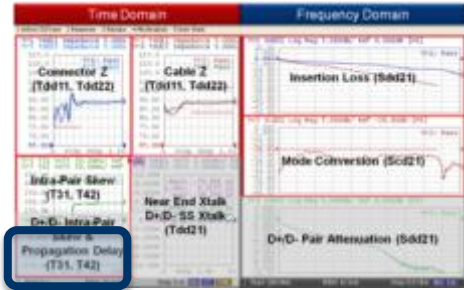
- Ensures the signal on both SS lines of a cable assembly arrive at the receiver at the same time.

- If Delta Time < 15 psec/m: Pass, else: Fail



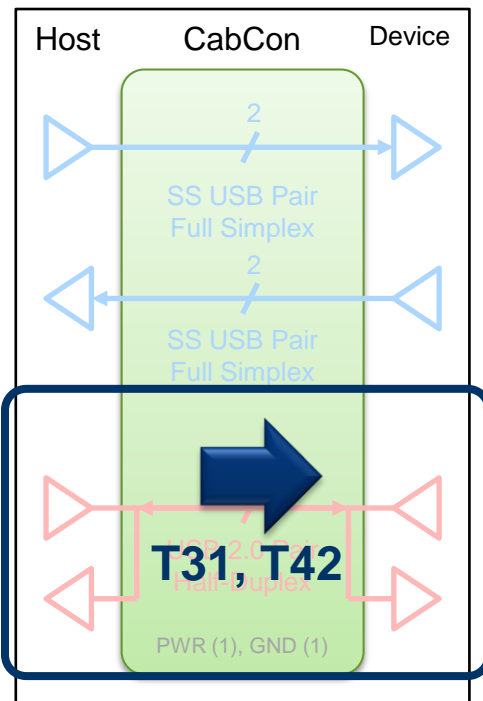
USB 3.0 Cable/Connector Compliance Test Solution

D+/D- Pair Intra-Pair Skew



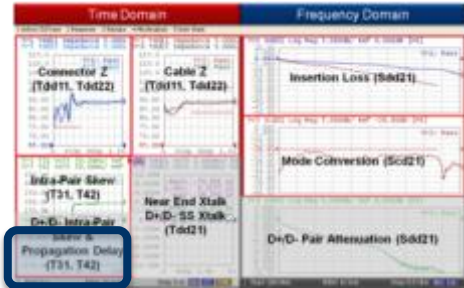
- Ensures the signal on both the D+ and D- lines of a cable assembly arrive at the receiver at the same time.

- If Delta Time < 100 psec: Pass, else: Fail

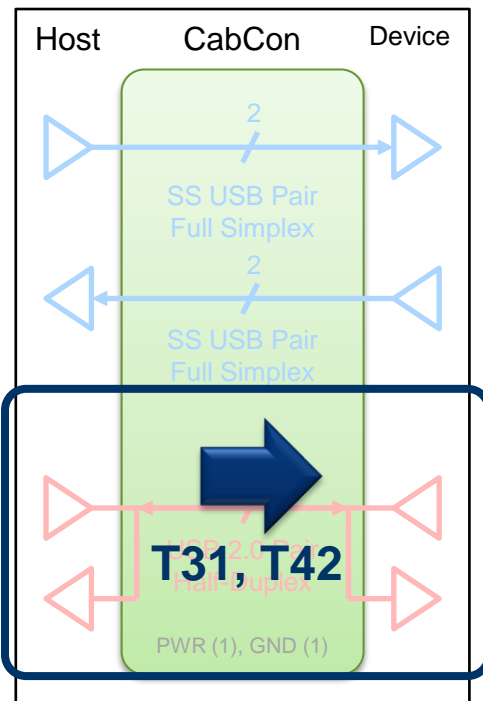


USB 3.0 Cable/Connector Compliance Test Solution

D+/D- Pair Propagation Delay



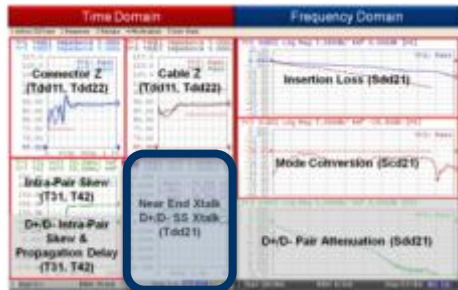
- Verifies the end-to-end propagation of the D+/D- lines of the cable assembly



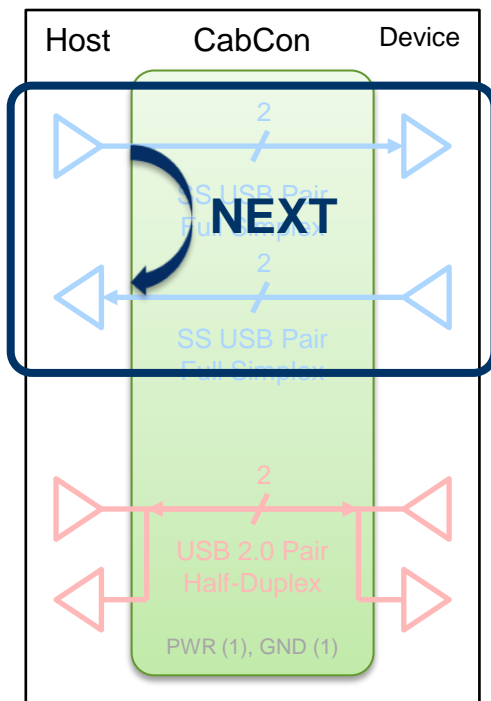
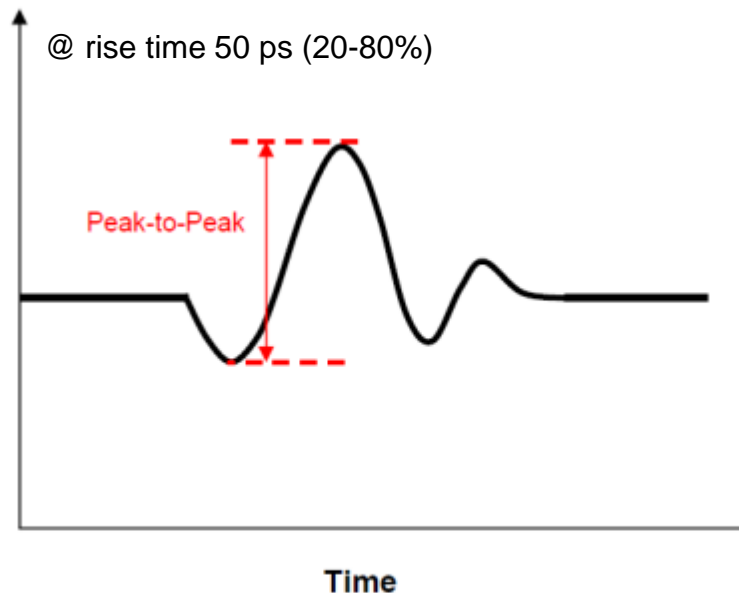
Standard-A to Standard-B	If the time at the rising edge < 26 nsec:
Standard-A to Standard-A	Pass, else: Fail
Standard-A to Micro-AB	If the time at the rising edge < 10 nsec:
Micro-AB to Micro-AB	Pass, else: Fail
Micro-AB to Standard-B	

USB 3.0 Cable/Connector Compliance Test Solution

Differential Near End Crosstalk Between SS Pairs (NEXT)



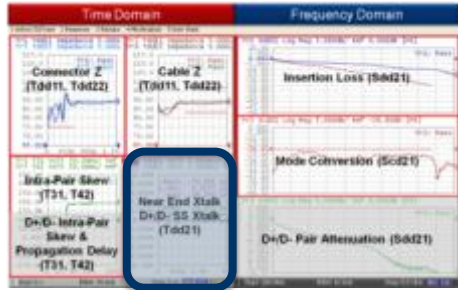
- Measure of coupling between the differential pairs
- Crosstalk can be expressed in time domain (%), or frequency domain (dB)



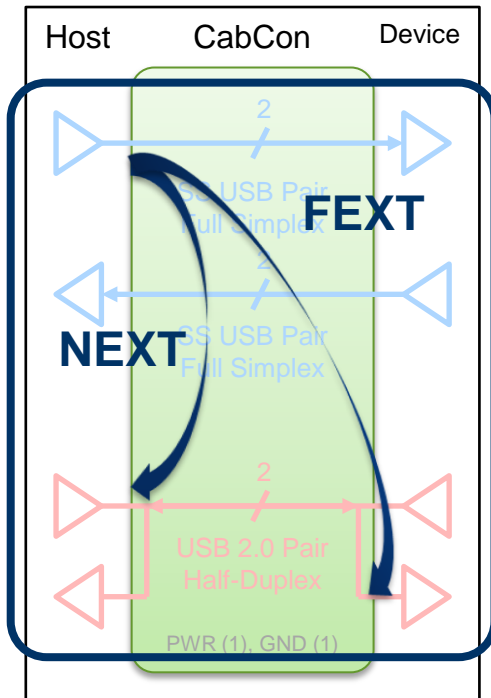
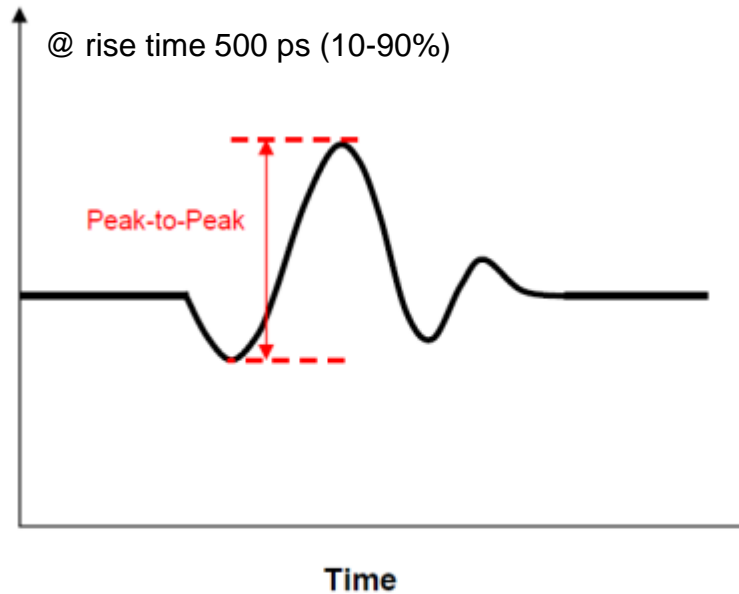
Standard-A	If p-p \leq 3.6 mV: Pass, else: Fail
Standard-B	If p-p \leq 7.2 mV: Pass, else: Fail
Micro-AB	If p-p \leq 4.8 mV: Pass, else: Fail

USB 3.0 Cable/Connector Compliance Test Solution

Differential Crosstalk Between D+/D- and SS Pairs (NEXT/FEXT)



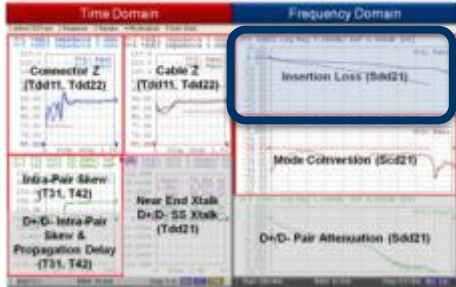
- Measure of coupling between the differential pairs
- Crosstalk can be expressed in time domain (%), or frequency domain (dB)



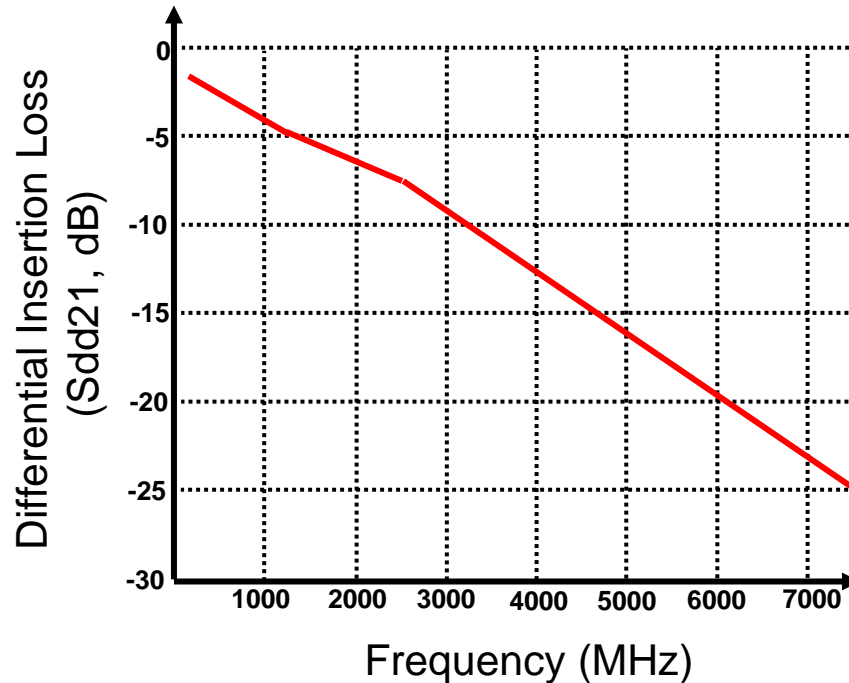
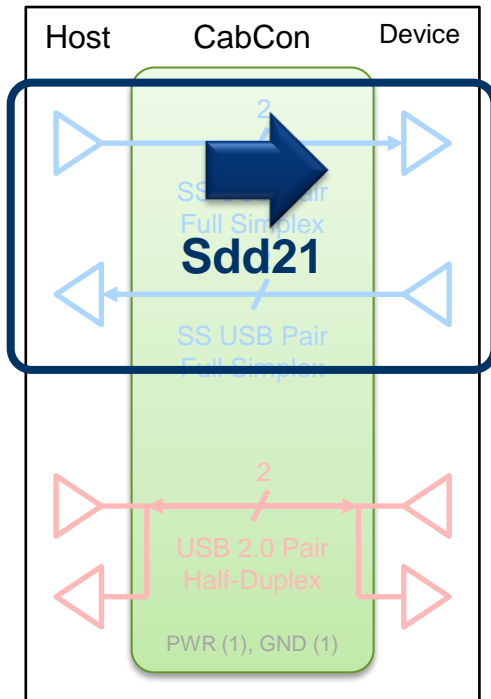
Standard-A	If p-p <= 8.0 mV: Pass, else: Fail
Standard-B	If p-p <= 8.0 mV: Pass, else: Fail
Micro-AB	If p-p <= 8.0 mV: Pass, else: Fail

USB 3.0 Cable/Connector Compliance Test Solution

SS Differential Insertion Loss (Sdd21)



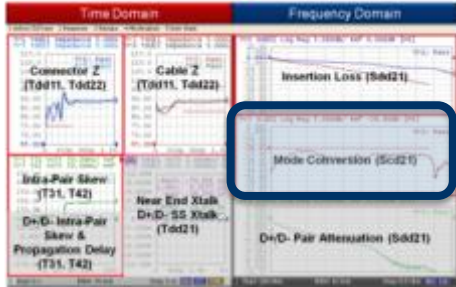
- Measure of frequency response that the differential signal sees as it propagates through the interconnect
- direct measure of the signal arriving at the receiver



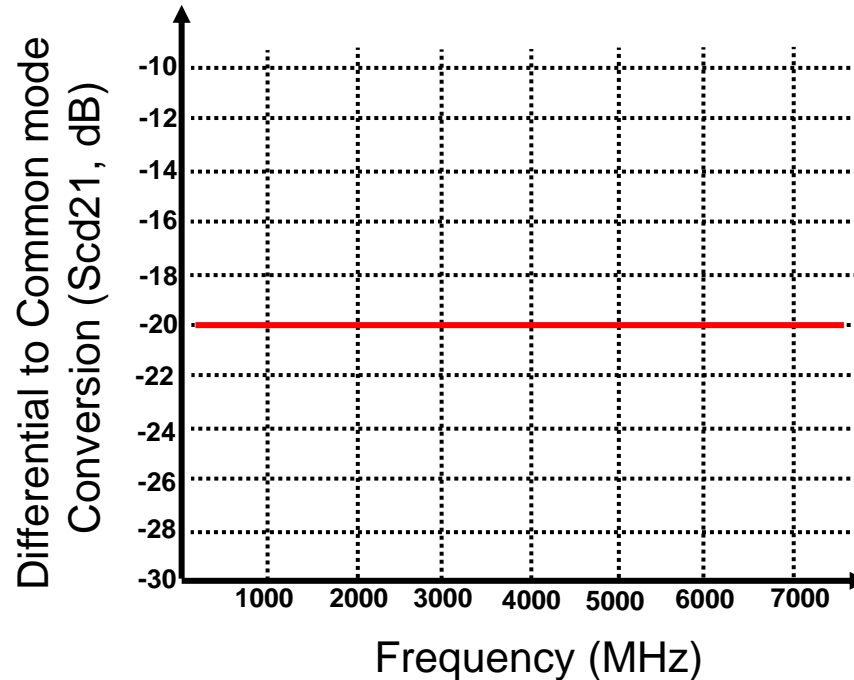
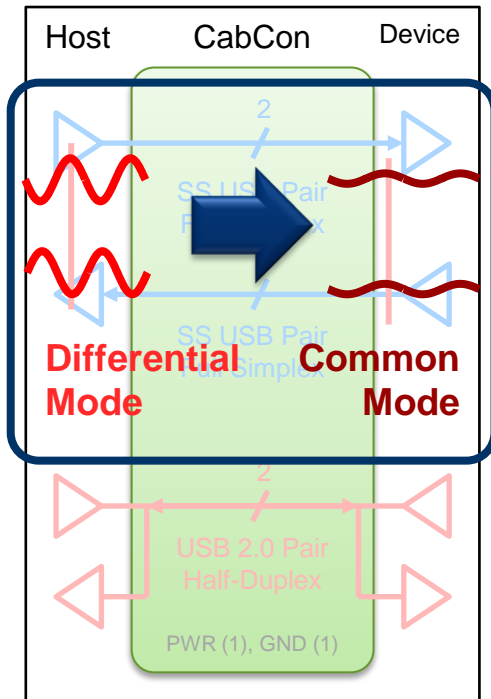
Differential Insertion Loss (Sdd21) Requirement

USB 3.0 Cable/Connector Compliance Test Solution

Differential to Common Mode Conversion (Scd21)



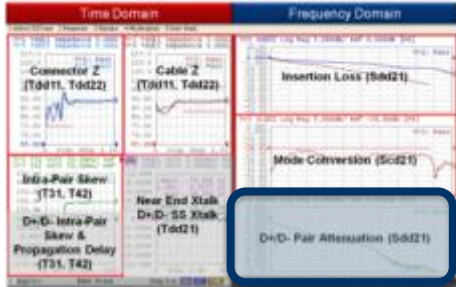
- Common-mode current is directly responsible for EMI and Scd21 is a measure of EMI generation
- Main purpose of this requirement is to limit EMI emission



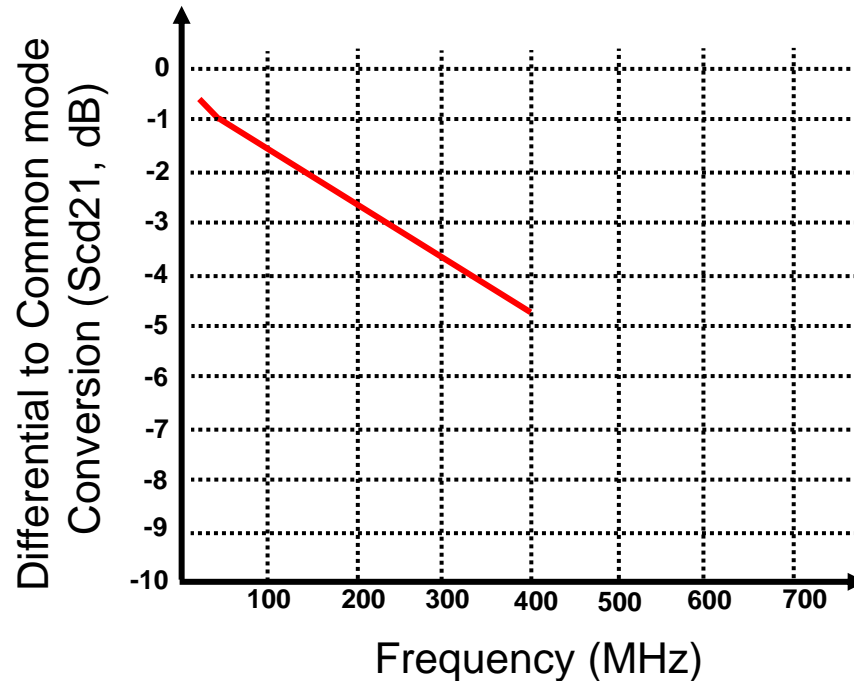
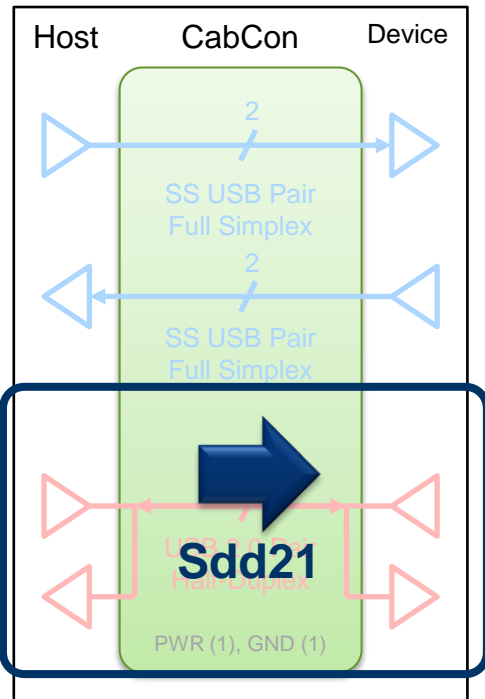
Differential-to-Common-Mode conversion (Scd21) Requirement

USB 3.0 Cable/Connector Compliance Test Solution

D+/D- Pair Attenuation



- Ensures the D+/D- pair of a cable assembly can provides adequate signal strength to the receiver to maintain a low error rate



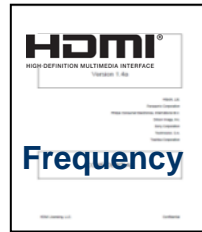
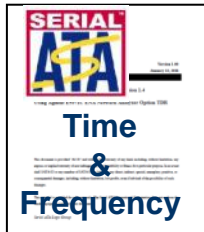
D+/D- Pair Attenuation (Sdd21) Requirement

ENA Option TDR Compliance

One-box Solution for TDR/S-parameter Compliance Test

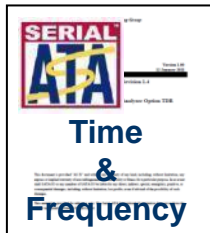
Certified MOIs

•Cable/Connector



More Standards
Currently Under
Investigation

•Transmitter/Receiver (Hot TDR)



Test Centers Support ENA Option TDR

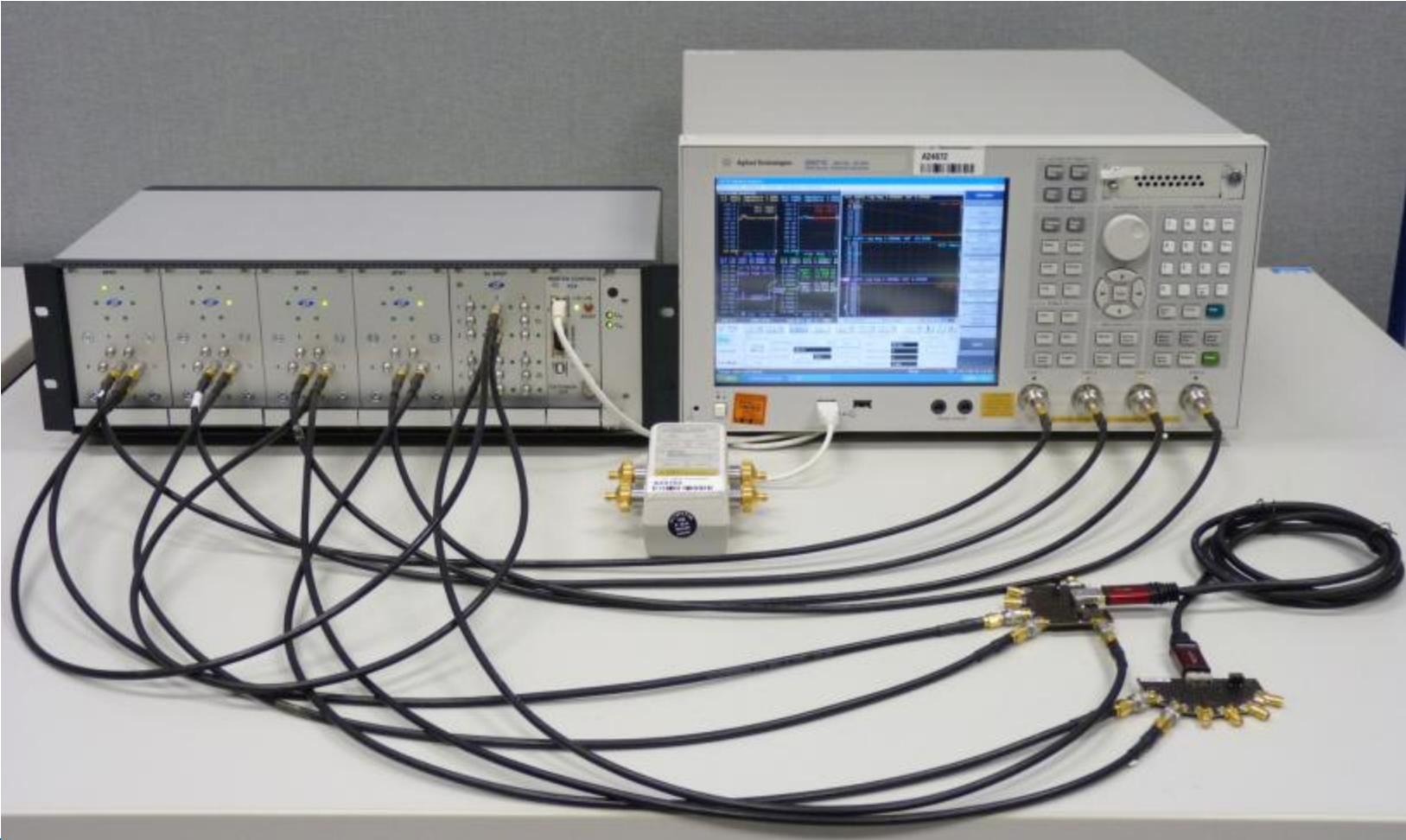
ENA Option TDR is used world wide by certified test centers of USB, HDMI, DisplayPort, and SATA



For more detail about compliance test solution by the ENA Option TDR, visit www.agilent.com/find/ena-tdr_compliance

USB 3.0 Cable Test Station

Agilent E5071C-TDR and ECal, BitifEye Switch, Software



Automated USB 3.0 Cable Test Details

Calibration and Test Procedures

The screenshot displays the N5990A Test Automation Software Platform interface. The main window is titled "USB 3.0 Cable Test - Calibration & Measurement". The interface includes a menu bar (File, Station, Sequencer, Help) and a toolbar with buttons for Configure DUT, Load, Save, Start, Abort, Pause, Print, Properties, and Log List. A status bar at the bottom shows "Ready", "Serial Bus Family", and "Cable Test Station".

The left pane shows a tree view of test items under "USB 3.0 Cable Test":

- Calibration
 - De-Embedding File Extraction
 - Definition of the calibration kit for TRL calibration.
 - Frequency Domain Calibration for 4-Port DUT
 - Time Domain Calibration for 4-Port DUT
 - Rise Time Adjustment
- Measurement (all items marked "NOT RUN")
 - B-4-1: D+/D- Pair Attenuation
 - B-4-2: D+/D- Pair Propagation Delay
 - B-4-3: D+/D- Pair Propagation Delay Skew
 - B-4-4: Differential Impedance SS1
 - B-4-4: Differential Impedance SS2
 - B-4-5: Differential Insertion Loss SS1
 - B-4-5: Differential Insertion Loss SS2
 - B-4-6: Diff. to Common Mode Conversion SS1
 - B-4-6: Diff. to Common Mode Conversion SS2
 - B-4-7: Diff. Near End Crosstalk (SS Pairs) - Input
 - B-4-7: Diff. Near End Crosstalk (SS Pairs) - Output
 - B-4-8: Near & Far End Crosstalk USB2_In - SS1_In
 - B-4-8: Near & Far End Crosstalk USB2_In - SS2_In
 - B-4-8: Near & Far End Crosstalk USB2_In - SS2_Out
 - B-4-8: Near & Far End Crosstalk USB2_Out - SS1_In
 - B-4-8: Near & Far End Crosstalk USB2_Out - SS2_In
 - B-4-8: Near & Far End Crosstalk USB2_Out - SS1_Out
 - B-4-8: Near & Far End Crosstalk USB2_Out - SS2_Out
 - Informative: Raw Cable Impedance SS1
 - Informative: Raw Cable Impedance SS2
 - Informative: Intra-Pair Skew SS1
 - Informative: Intra-Pair Skew SS2

The right pane displays the "USB 3.0 Cable Test" configuration table:

Property	Value
Repetitions	0
Connector used at the input	StandardA
Connector used at the output	MicroAB
Adjusted Rise Time to 50 ps	50 ps
Adjusted Rise Time to 200 ps	200 ps
Adjusted Rise Time to 500 ps	500 ps
Directory of calibration files on ENA	D:\Calibration Files\USB3\
Directory of calibration files on PC	C:\ProgramData\BitfEye\ValiFrame\Calibrations\USB3_Cable\

Below the table, a list of test items is shown:

- Test B-4-1: D+/D- Pair Attenuation
- Test B-4-2: D+/D- Propagation Dealy
- Test B-4-3: D+/D- Pair Prop. Delay Skew
- Test B-4-4: Differential Impedance
- Test B-4-5: Differential Insertion Loss
- Test B-4-6: Diff. To Common Mode Conversion
- Test B-4-7: Differential Near-End Crosstalk
- Test B-4-8: Near & Far-End Crosstalk
- Informative: Raw Cable Imp. & Intra-Pair Skew

The bottom pane shows a log of events:

Severity	Message	Date
Progress	Instrument Connections	9/5/2012 1:49:52 PM
Progress	Opening online connection to E5061B at TCP/IP0::192.168.0.132::inst0::INSTR	9/5/2012 1:49:52 PM
Progress	Opening online connection to TDR Switch at TCP/IP0::192.168.0.109::5025::SOCKET	9/5/2012 1:51:24 PM
Info	N5990A Test Automation Software Platform startup complete!	9/5/2012 1:51:25 PM

USB 3.0 Cable/Connector Compliance Test Solution

Summary



ENA Option TDR Cable/Connector Compliance Testing Solution is

- **One-box solution** which provides complete characterization of high speed digital interconnects (time domain, frequency domain, eye diagram)
- Similar look-and-feel to traditional TDR scopes, providing **simple and intuitive operation** even for users unfamiliar to VNAs and S-parameters
- Adopted by test labs worldwide



Questions?

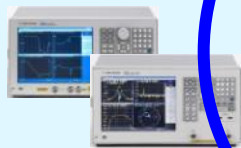


Agilent VNA Solutions

Performance



FieldFox
Handheld RF Analyzer
5 Hz to 4/6 GHz



E5061B
NA + ZA in one-box
5 Hz to 3 GHz
Low cost RF VNA
100 k to 1.5/3.0 GHz



E5071C
World's most popular economy VNA
9 kHz to 4.5, 8.5 GHz
300 kHz to 20.0 GHz



E5072A
Best performance ENA
30 kHz to 4.5, 8.5 GHz

ENA Series



PNA
Performance VNA
10 M to 20, 40, 50, 67, 110 GHz
Banded mm-wave to 2 THz



PNA-L
World's most capable value VNA
300 kHz to 6, 13.5, 20 GHz
10 MHz to 40, 50 GHz



PNA-X receiver
8530A replacement

PNA Series



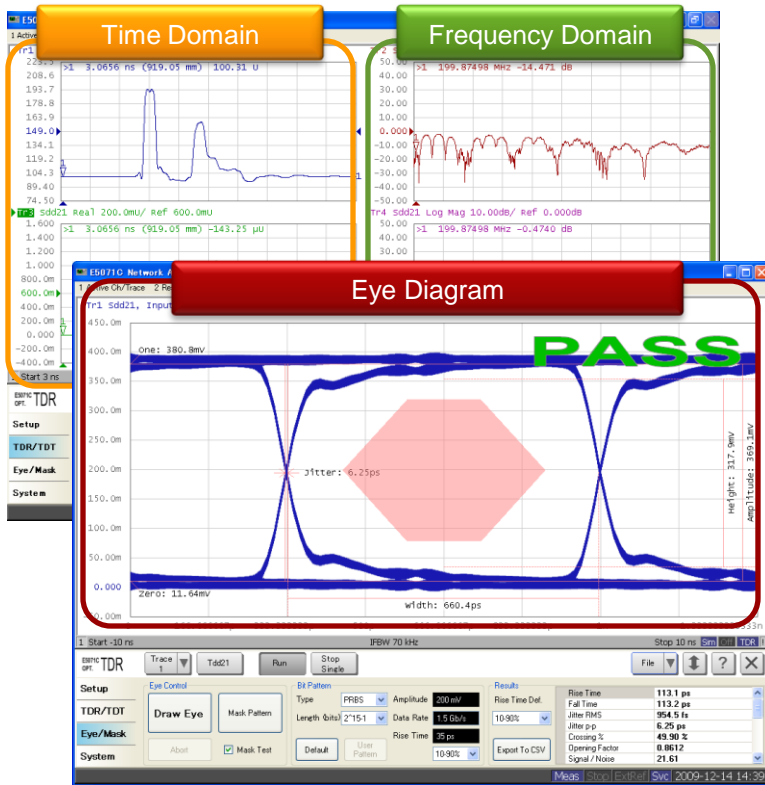
Mm-wave solutions
Up to 2 THz



PNA-X, NVNA
Industry-leading performance
10 M to 13.5/26.5/43.5/50/67 GHz
Banded mm-wave to 2 THz

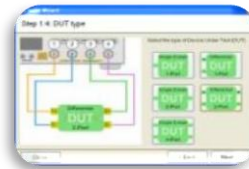
What is ENA Option TDR?

The ENA Option TDR is an application software embedded on the ENA, which provides an **one-box solution** for high speed serial interconnect analysis.



3 Breakthroughs

for Signal Integrity Design and Verification



Simple and Intuitive Operation



Fast and Accurate Measurements



ESD Robustness

What is ENA Option TDR?

[Video]

Agilent ENA Option TDR

Changing the world of Time Domain Reflectometry (TDR) Measurements

- www.youtube.com/watch?v=hwQNllyJ5hI&list=UUAJAJd97CfnCehC4jZAFkxQ&index=20&feature=plcp
- www.agilent.com/find/ena-tdr



Additional Resources



•ENA Option TDR Reference Material

www.agilent.com/find/ena-tdr

•Technical Overview (5990-5237EN)

•Application Notes

- Correlation between TDR oscilloscope and VNA generated time domain waveform (5990-5238EN)
- Comparison of Measurement Performance between Vector Network Analyzer and TDR Oscilloscope (5990-5446EN)
- Effective Hot TDR Measurements of Active Devices Using ENA Option TDR (5990-9676EN)
- Measurement Uncertainty of VNA Based TDR/TDT Measurement (5990-8406EN)
- Accuracy Verification of Agilent's ENA Option TDR Time Domain Measurement using a NIST Traceable Standard (5990-5728EN)

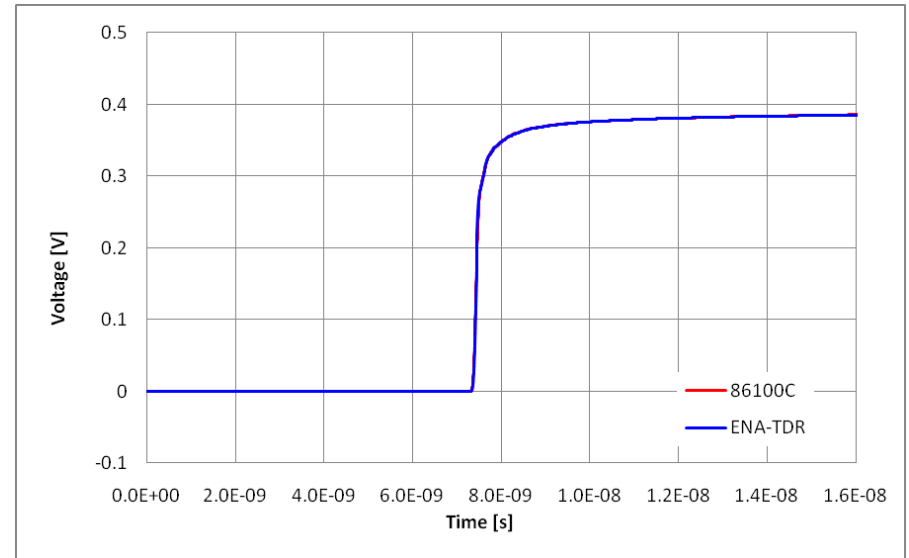
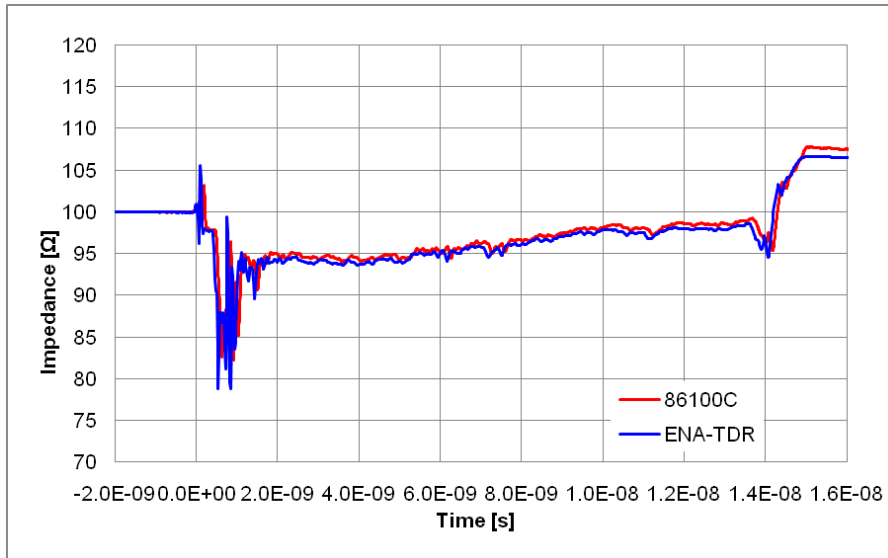
•Method of Implementation (MOI) for High Speed Digital Standards

www.agilent.com/find/ena-tdr_compliance

Measurement Correlation

TDR/TDT

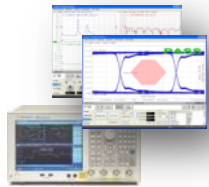
- DUT: USB3.0 Cable
- 50 ps rise time (20-80%)



Measurement Correlation

Eye Diagram

- DUT: USB3.0 Cable
- PRBS (2⁷-1) @ 5 Gbps



ENA Option TDR
(simulated)



N4903B + 86100C
(live)

