USB 3.1 Cable-Connector Assembly Compliance Tests

Test Solution Overview Using the Keysight E5071C ENA Option TDR

Last Update 2015/02/06

KEYSIGHT TECHNOLOGIES

Purpose

- This slide will show how to make measurements of USB 3.1 cable & connector assemblies compliance tests by using the Keysight E5071C ENA Option TDR.

Keysight Digital Standards Program

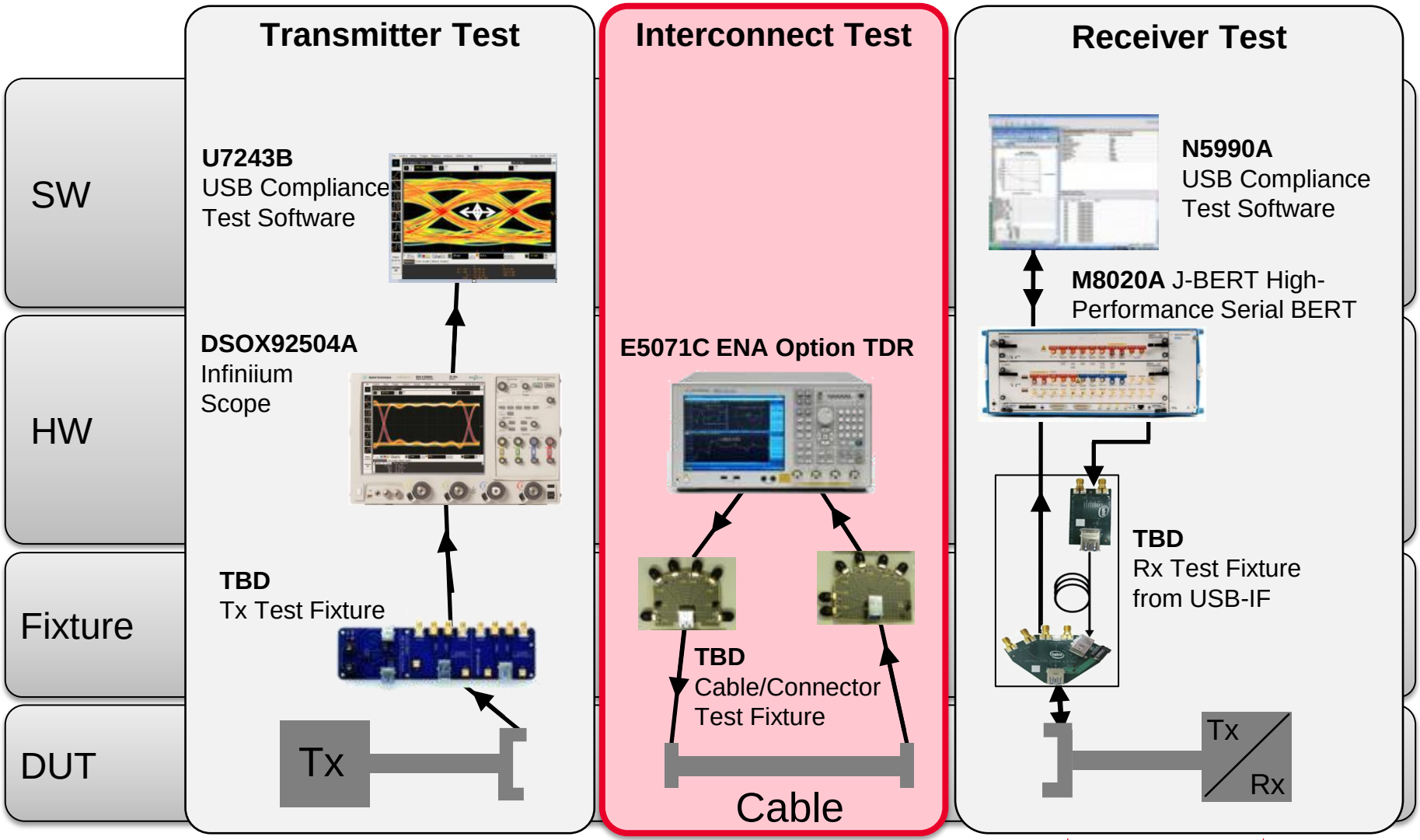
Our solutions are driven and supported by Keysight experts involved in international standards committees:

- 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 3.1 – Keysight Total Solution Coverage



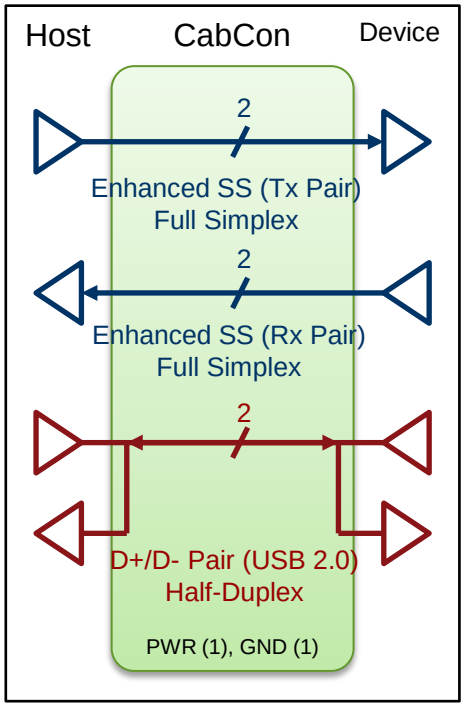
Reference Document

- Universal Serial Bus 3.1 Specification (Revision 1.0)
- Universal Serial Bus 3.1 Connectors and Cable Assemblies Compliance Document (Draft)

Note: The final USB 3.1 Connectors and Cable Assemblies Compliance Document (Revision 1.0) is not yet released. Test coverage and requirements are based on an early draft test specification and will be updated when the final test specification is complete.

USB 3.1 Cable/Connector Compliance Test

Cable Assembly

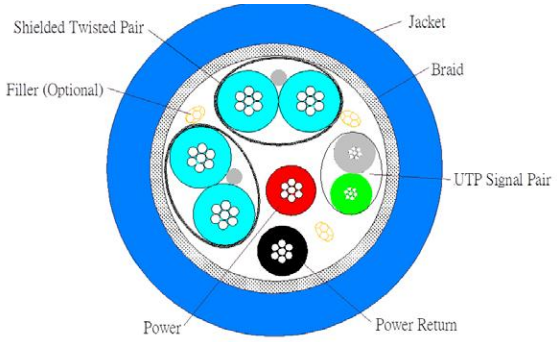


Enhanced SuperSpeed signal pairs

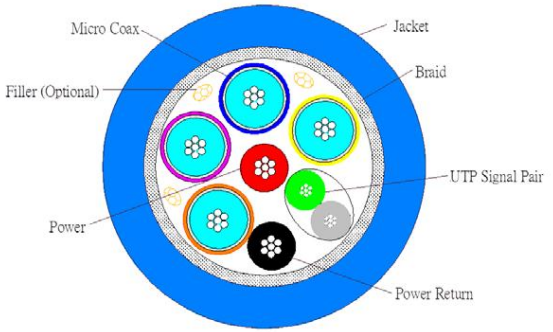
- Typically Shielded Differential Pair (SDP), twisted, or coaxial signal pairs.
- Shield is needed for signal integrity and EMI performance.

D+/D- signal pair

- Typically unshielded twisted pair (UTP).
- Intended to transmit the USB 2.0 signals.



Shielded twisted pairs

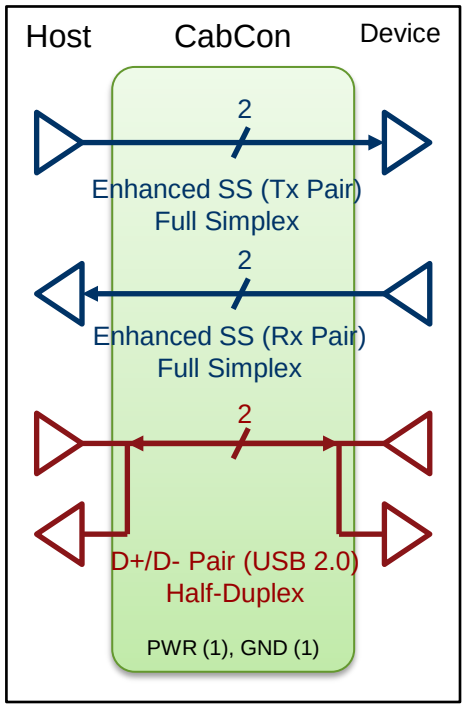


Coaxial signal pairs

USB 3.1 Cable/Connector Compliance Test

Measurement Parameters

USB 3.1 connectors and cable assemblies must meet or exceed the requirements specified by the most current version of Chapter 5 of the USB 3.1 Specification and applicable Supplements.



Time Domain Measurements

- D+/D- Pair Propagation Delay (USB 2.0)
- D+/D- Pair Propagation Delay Skew (USB 2.0)
- Differential Crosstalk between D+/D- and SS+ Signal Pairs
- [Raw Cable] Characteristic Impedance (Informative)
- [Raw Cable] Intra-Pair Skew (Informative)
- [Mated Connector] Impedance (Informative)

Frequency Domain Measurements

- D+/D- Pair Attenuation (USB 2.0)
- Channel Metrics (eH, eW, ILfitatNq, IMR and IXT)
- Differential to Common-Mode Conversion
- Cable Shielding Effectiveness
- [Raw Cable] Differential Insertion Loss (Informative)
- [Mated Cable Assembly] Differential Insertion Loss (Informative)
- [Mated Cable Assembly] Differential NEXT between SS+ Signal Pairs (Informative)
- [Mated Cable Assembly] Differential NEXT and FEXT between D+/D- pair and SS+ Signal Pairs (Informative)

Note: Normative parameters for the USB 3.1 cable assembly are highlighted in blue

USB 3.1 Cable/Connector Compliance Test

Solution Overview

- ALL normative and informative parameters specified for USB 3.1 cable/connector compliance testing can be measured with the ENA Option TDR.

Frequency Domain

- D+/D- Pair Attenuation (USB 2.0)
- Channel Metrics (eH, eW, ILfitatNq, IMR and IXT)*
- Differential to Common-Mode Conversion
- Cable Shielding Effectiveness
- [Raw Cable] Differential Insertion Loss (Informative)
- [Mated Cable Assy] Differential Insertion Loss (Informative)
- [Mated Cable Assy] Differential NEXT between SS+ Signal Pairs (Informative)
- [Mated Cable Assy] Differential NEXT and FEXT between D+/D- pair and SS+ Signal Pairs (Informative)

Time Domain

- D+/D- Pair Propagation Delay (USB 2.0)
- D+/D- Pair Propagation Delay Skew (USB 2.0)
- Differential Crosstalk between D+/D- and SS+ Signal Pairs
- [Raw Cable] Characteristic Impedance (Informative)
- [Mated Connector] Impedance (Informative)

Traditional Solution

Vector Network Analyzer (VNA)

TDR Scope

New Solution

- **ALL** parameters can be measured with **ENA Option TDR**

One-box Solution !!

* Note: Compliance standard tool from USB-IF is required for pass/fail judgment of channel metrics tests

ENA Option TDR Compliance Test Solution

Certified Test Centers using ENA Option TDR

Test Centers Support ENA Option TDR

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

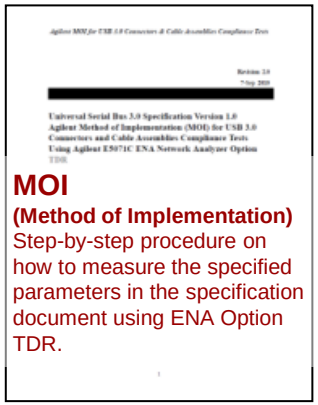
USB 3.1 Cable/Connector Compliance Test

Configuration

- ENA Mainframe (*1)
  - E5071C-4K5: 4-port, 300 kHz to 20 GHz
- Enhanced Time Domain Analysis Option (E5071C-TDR)
- ECal Module (N4433A)

*1: Opt.4K5 (20 GHz) is recommended as Type-C cable/connector requires measurements up to 15 GHz.
*2: The list above includes the major equipment required. Please contact our sales representative for configuration details.

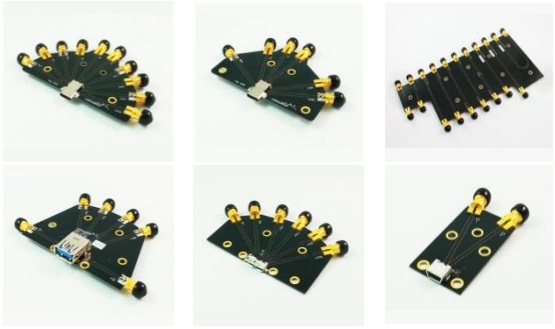
- Method of Implementation (MOI) document and state file (4K5) available for download on Keysight.com



MOI
(Method of Implementation)
Step-by-step procedure on how to measure the specified parameters in the specification document using ENA Option TDR.

USB 3.1 Test Fixtures

Fixtures for testing USB 3.1/Type-C connectors and cable assemblies are available for purchase through Luxshare-ICT.
http://web.luxshare-ict.com/en/ProductList.php?id1=22&id2=92



www.keysight.com/find/ena-tdr_compliance
www.keysight.com/find/ena-tdr_usb3_1-cabcon

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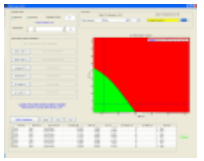
USB 3.1 Cable/Connector Compliance Test

Measurement Parameters (**Normative** & **Informative**)

Time Domain

Frequency Domain



Compliance Tool

[Raw Cable] Intra-Pair Skew (T31, T42)

D+/D- Propagation Delay Skew (T31, T42)

D+/D- Propagation Delay (Tdd21)

Diff. Crosstalk (D+/D- & SS+) (Tdd21)

D+/D- Pair Attenuation (Sdd21) **Channel Metrics** (s4p files)

Mode Conversion (Scd21)

Cable Shielding Effectiveness (Sds21, Scs21)

[Raw Cable] Characteristic Impedance (Tdd11, Tdd22)

[Mated Connector] Impedance (Tdd11, Tdd22)

[Raw Cable] Diff. Insertion Loss (Sdd21)

[Mated Cable Assy] Diff. Insertion Loss (Sdd21)

[Mated Cable Assy] Diff. NEXT (SS+) (Sdd21)

[Mated Cable Assy] Diff. NEXT & FEXT (D+/D- & SS+) (Sdd21)

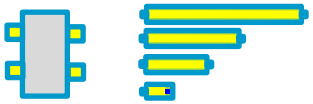
USB 3.1 Cable/Connector Compliance Test

Measurement Procedure

Step 1: Setup

•Manual or automatic setup by recalling a state file.
•State files for the ENA Option TDR will be provided for fast setup. Operators' error can be minimized.

Step 2: Calibration



Time-domain Cal	Frequency-domain Cal
ECal + De-embedding or In-fixture TRL Cal	
Adjustment of Effective Rise Time	

•Calibration for frequency-domain measurements shall be performed to remove the unwanted test fixture trace effect.
•ECal + De-embedding or TRL calibration are available with ENA Option TDR.
•Adjustment of effective rise time step is required for time-domain measurements.

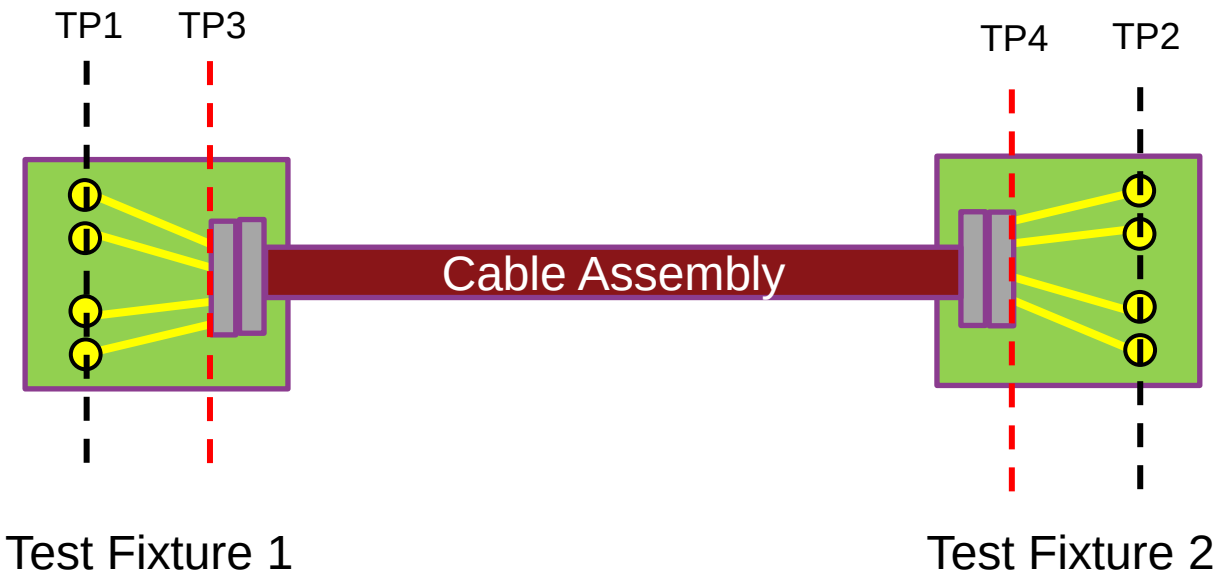
Step 3: Measurement

•The ENA Option TDR can be used to perform all measurements.
•Compliance standard tool is required for pass/fail judgment of channel metrics tests.

USB 3.1 Cable/Connector Compliance Test

Calibration

•Calibration shall be performed to remove the unwanted test fixture trace effect.
•The procedures of 2x Thru de-embedding and In-fixture TRL calibration are the official procedure introduced in the USB 3.1 Compliance Specification.

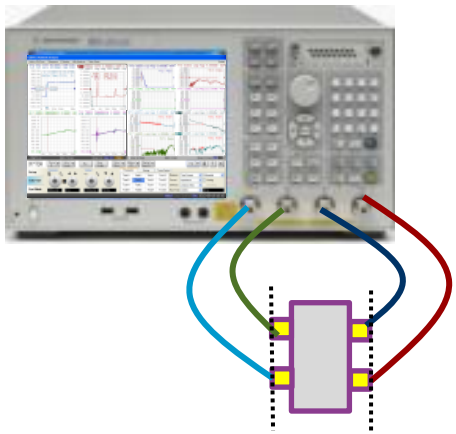


USB 3.1 Cable/Connector Compliance Test

Calibration

1. ECal + De-embedding

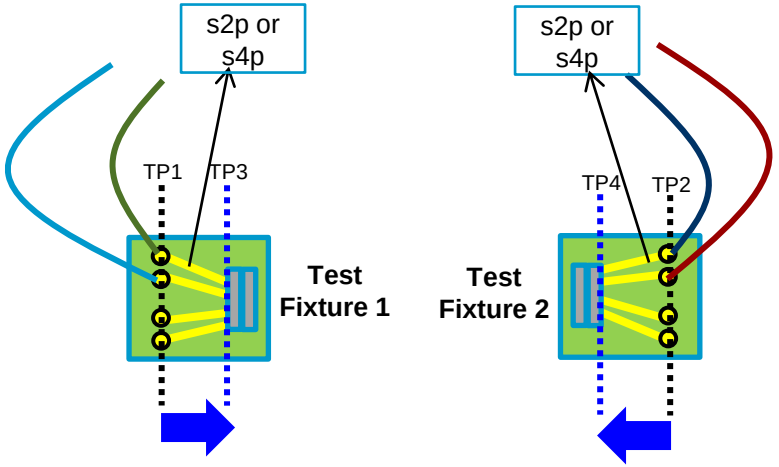
1. Full calibration with ECal



ECal (i.e. N4433A)

•Full 4-port calibration is performed using the 4-port ECal module (i.e. N4433A).
•The reference plane is established at the end of RF cables connected to the ENA's test ports.

2. De-embedding S-parameters of fixture traces



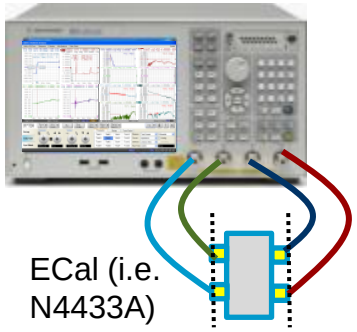
•S-parameter Touchstone files (*.s2p or .s4p) of fixture traces are excluded from total performance in frequency-domain by using the de-embedding function of the ENA.
•The reference plane is moved to the edge of USB connectors on the test fixtures (TP1->TP3 & TP2->TP4).

USB 3.1 Cable/Connector Compliance Test

Calibration

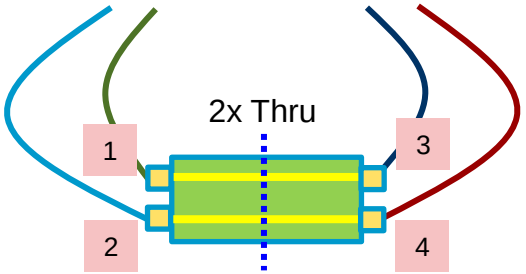
Creating de-embedding files with PLTS

1. Full calibration with ECal



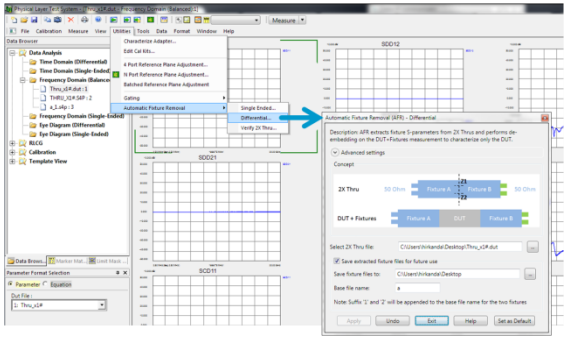
•Perform full 4-port calibration using the ECal module (i.e. N4433A).

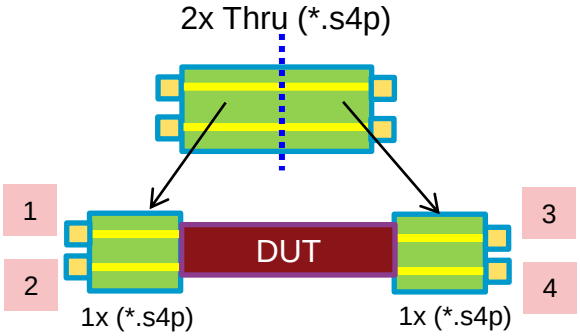
2. Measure 2x Thru standards



•Perform 4-port measurement and save 4-port S-parameter file (*.s4p).

3. Create de-embedding files by AFR with PLTS



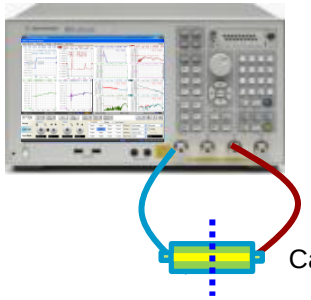


•Launch PLTS software on PC
•Import measured 4-port file (*.s4p)
•Create two de-embedding files (*.s4p)
•Change port configuration (optional)

USB 3.1 Cable/Connector Compliance Test

Calibration

2. TRL Calibration



Cal Standard

Thru — 2x Thru (Zero Length)

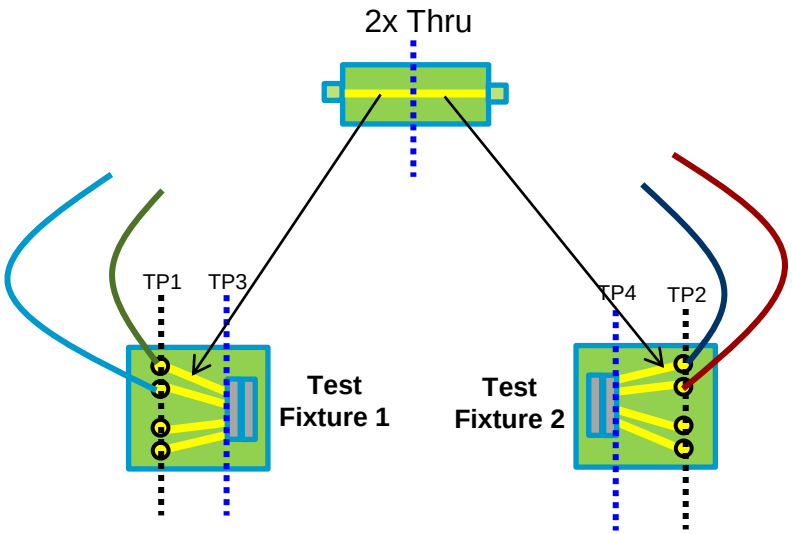
Reflection — Short

Line — Line 1 (delay 1)

Line 2 (delay 2)

Line 3 (delay 3)

Load (for lower frequency)



•TRL (Thru, Reflection, Line) calibration is performed by using the USB 3.1 official TRL calibration standards for three combinations between the ENA's test ports (Port 1&2, Port 1&3, Port 3&4).

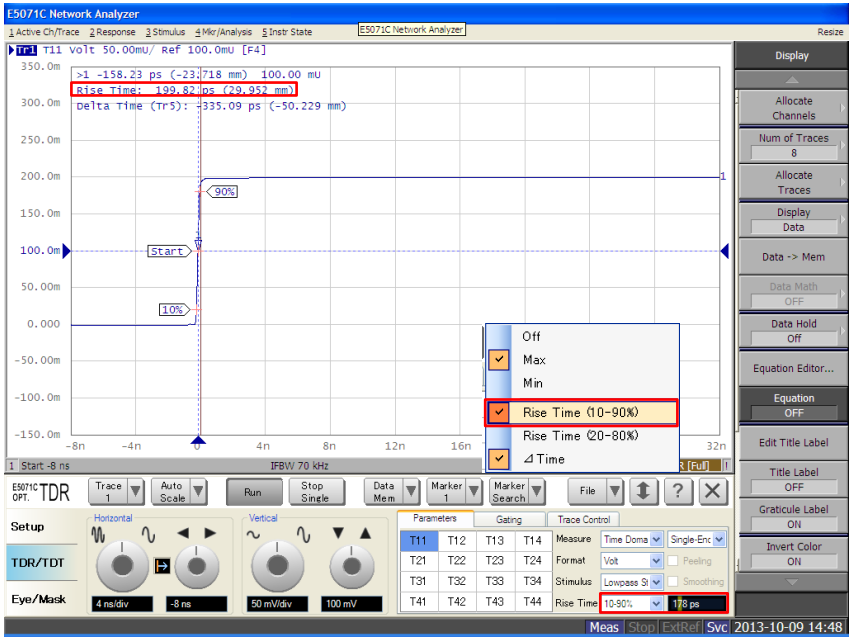
•The electrical length of 2x Thru is equal to the length of the trace between TP1 and TP3 plus the length of the trace between TP2 and TP4.
•Reference plane is set at the edge of USB connectors on the test fixtures (TP3 & TP4).

USB 3.1 Cable/Connector Compliance Test

Calibration (Adjustment of Effective Rise Time in Time Domain)

Test Items	Rise Time (%)	Target Rise Time
D+/D- Pair Propagation Delay and Skew	10 – 90 %	200 ps
Differential Crosstalk between D+/D- and SS+ Signal Pairs	10 – 90 %	500 ps
[Raw Cable] Characteristic Impedance	10 – 90 %	200 ps
[Mated Connector] Impedance	20 – 80 %	40 ps

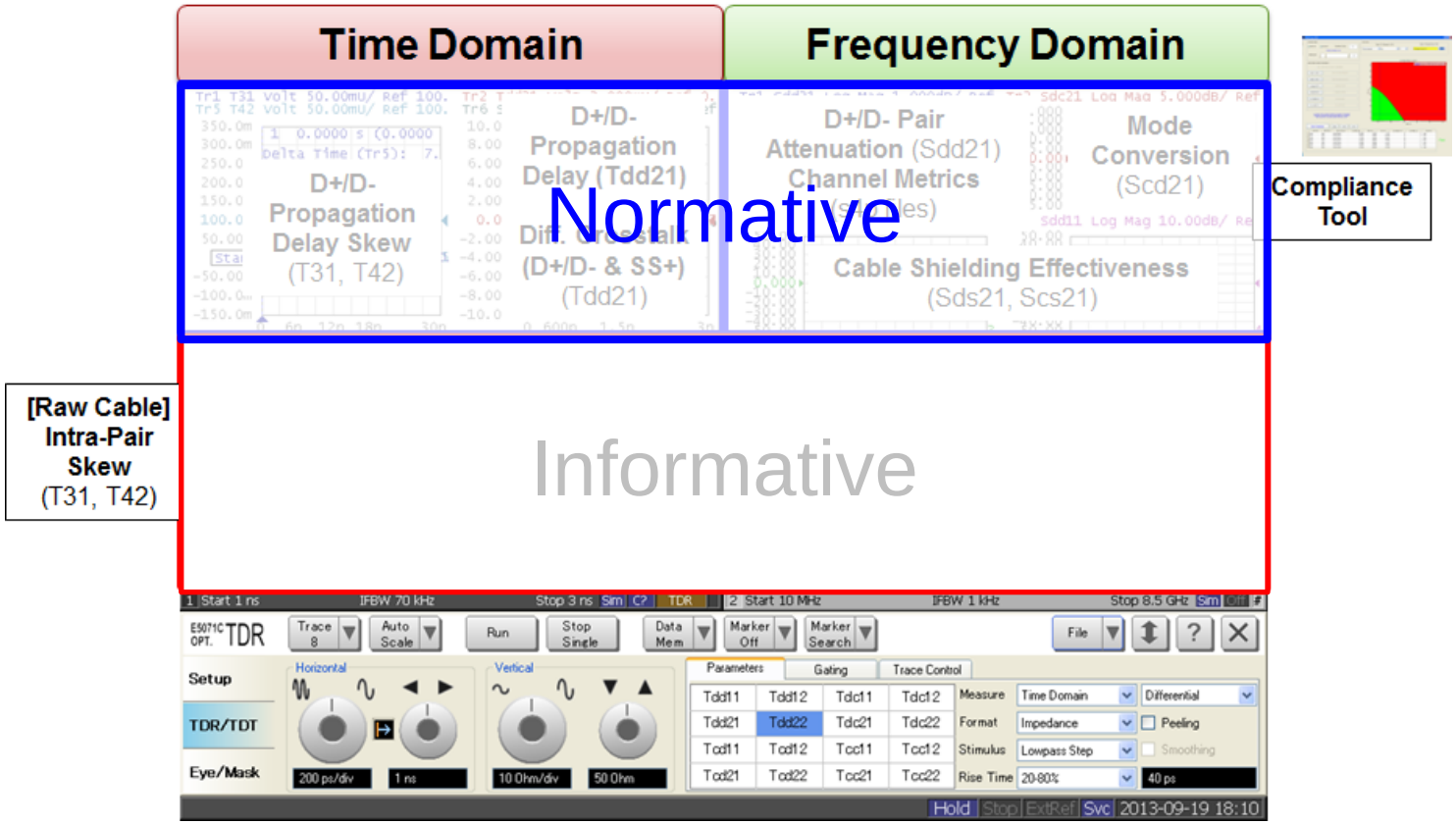
•The effective rise time for test items is specified as shown in the table.



•The effective rise time entering the USB 3.1 connector pins is adjusted for the specification in time-domain measurements.
•1x Thru standard is connected to the E5071C port with RF cables. DUT is disconnected during the adjustment procedure.

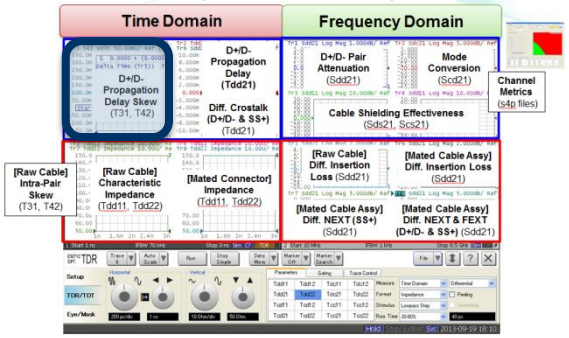
USB 3.1 Cable/Connector Compliance Test

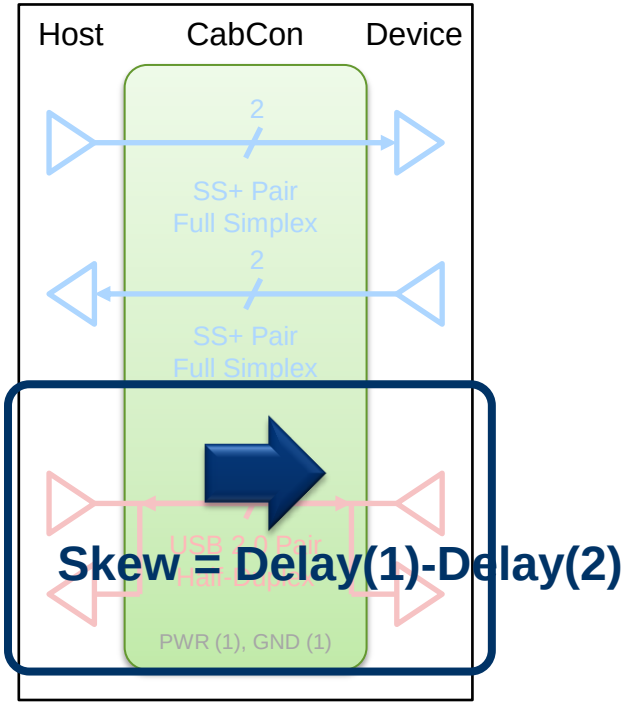
Normative Parameters



USB 3.1 Cable/Connector Compliance Test

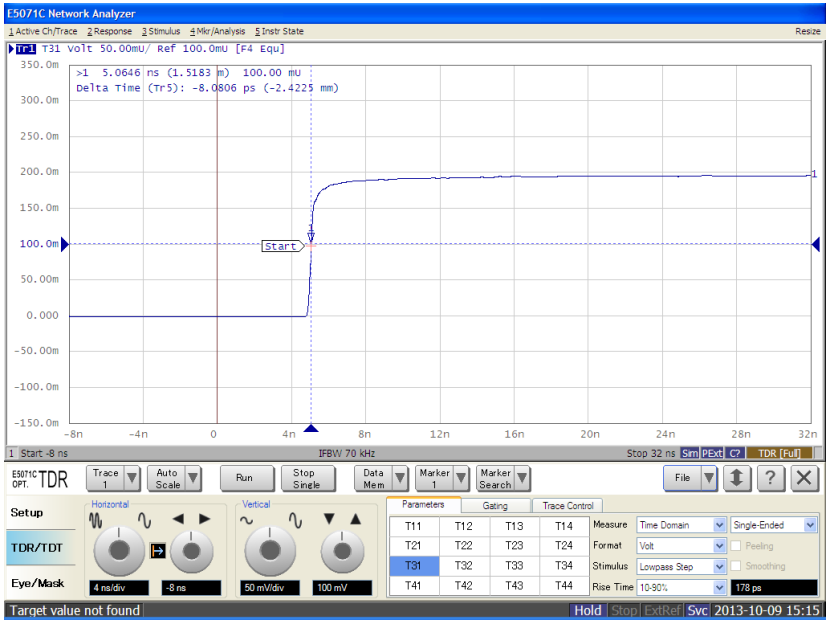
D+/D- Pair Propagation Delay Skew (**Normative**)





Skew = Delay(1)-Delay(2)

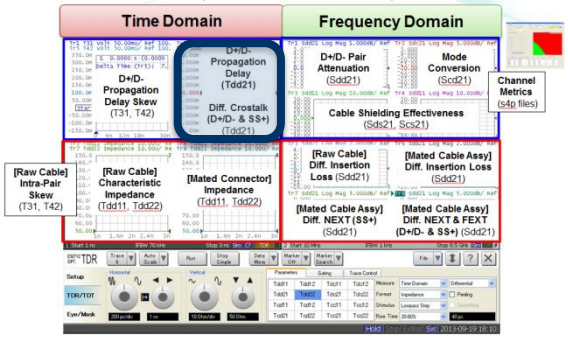
- Intra-pair skew measurement ensures the signal on both the D+ and D- lines of a cable assembly arrive at the receiver at the same time.
- If Delta Time < 100 psec, Pass. Else, Fail.

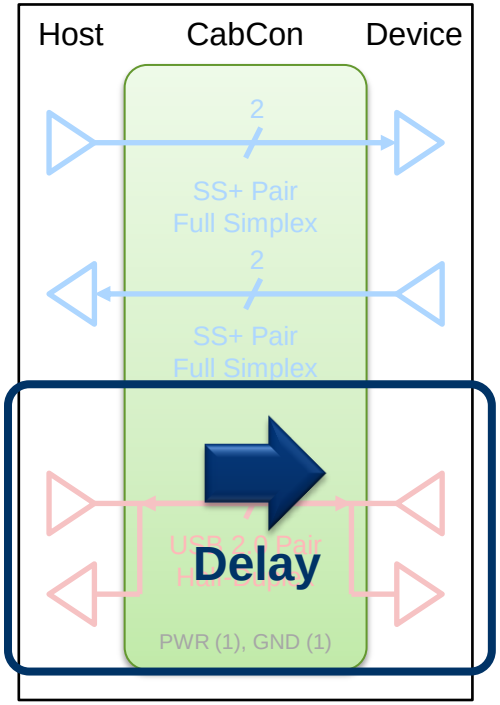


Note: Should be measured with a TDR in a differential mode using a 200 ps (10%-90%) rise.

USB 3.1 Cable/Connector Compliance Test

D+/D- Pair Propagation Delay (**Normative**)





- Propagation delay measurement verifies the end-to-end propagation of the D+/D- lines of the cable assembly.

D+/D- Pair Propagation Delay - Specification

DUT Type	Limit
Standard-A to Standard-B Standard-A to Standard-A	If the time at the rising edge is < 26 nsec, Pass. Else Fail.
Standard-A to Micro-AB Micro-AB to Micro-AB Micro-AB to Standard-B	If the time at the rising edge is < 10 nsec, Pass. Else Fail.

Note: Should be measured with a TDR in a differential mode using a 200 ps (10%-90%) rise time.

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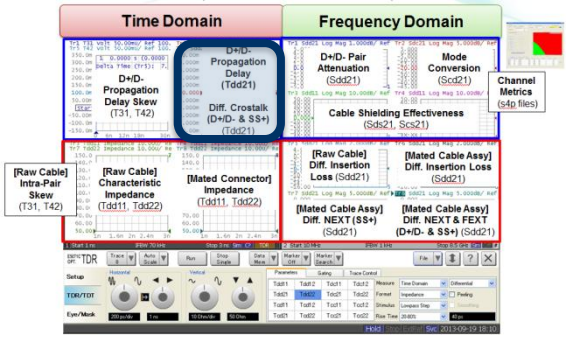
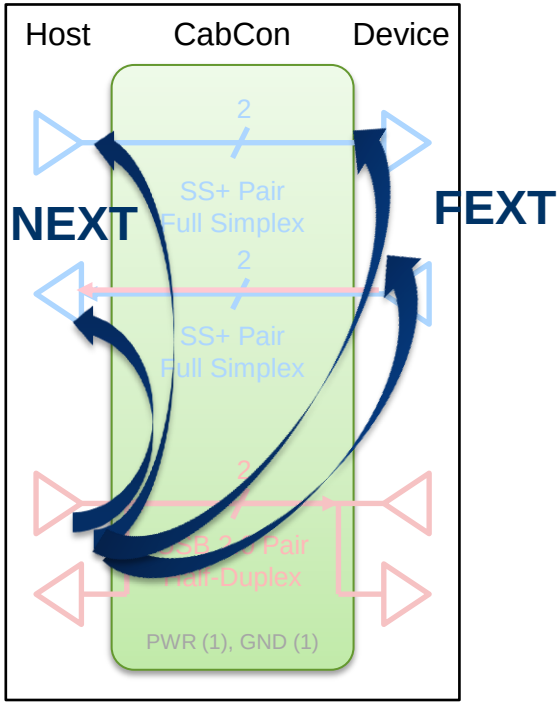
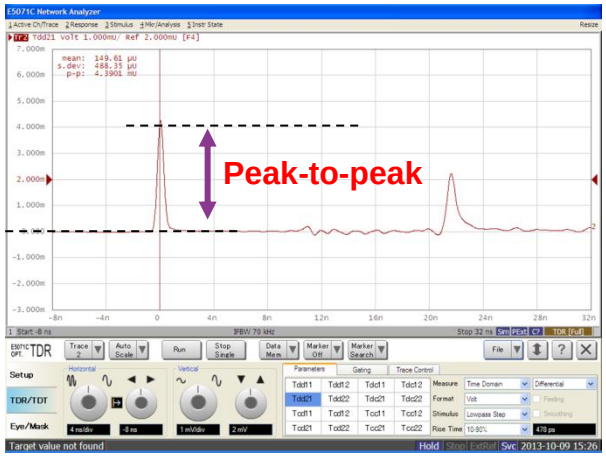
USB 3.1 Cable/Connector Compliance Test Solution

Differential Crosstalk between D+/D- and SS+ Signal Pairs (**Normative**)





- Measure of coupling between D+/D- pair and the SS+ differential pairs (Tx/Rx pair).
- Differential near-end crosstalk and far-end crosstalk shall be measured in time domain.



Crosstalk between D+/D- Pair and SS+ Pairs - Specification

DUT Type	Limit
USB 3.1 Standard-A Connector USB 3.1 Standard-B Connector USB 3.1 Micro Connector Family	2%

Note: Shall be measured with a rise time of 500 ps (10%-90%) entering the connector under test.

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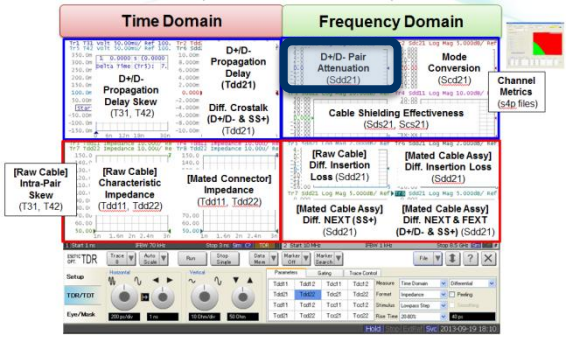
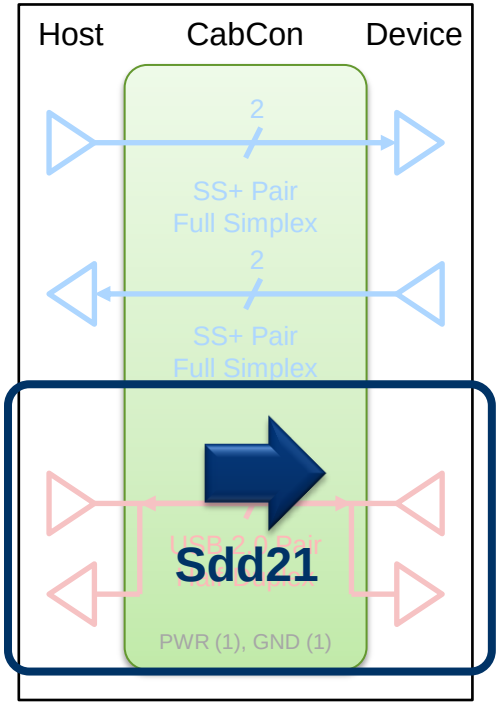
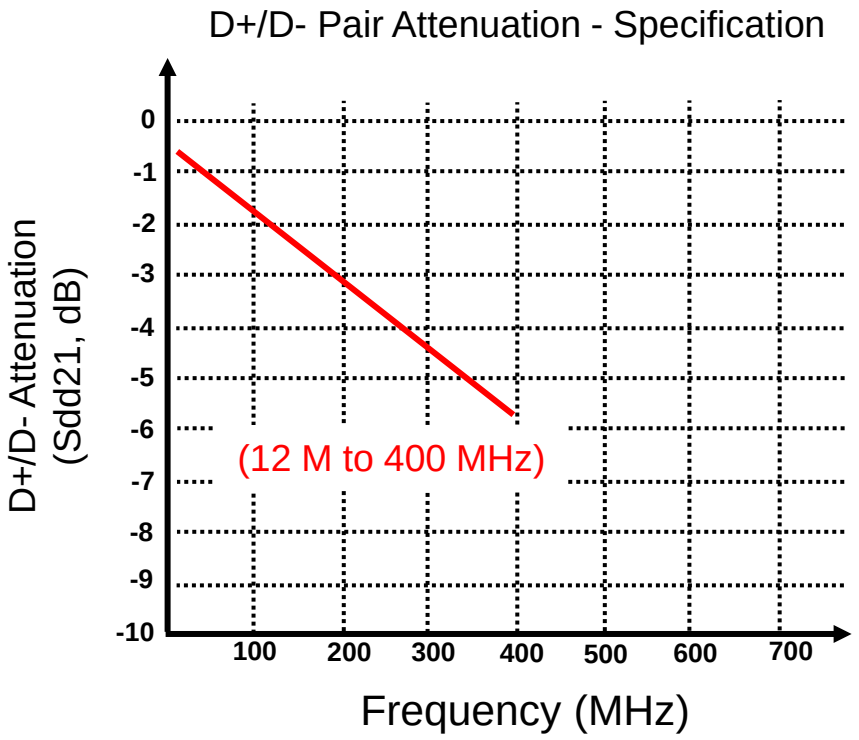
USB 3.1 Cable/Connector Compliance Test

D+/D- Pair Attenuation (**Normative**)





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



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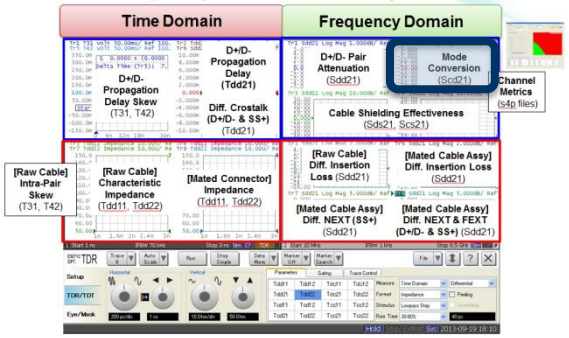
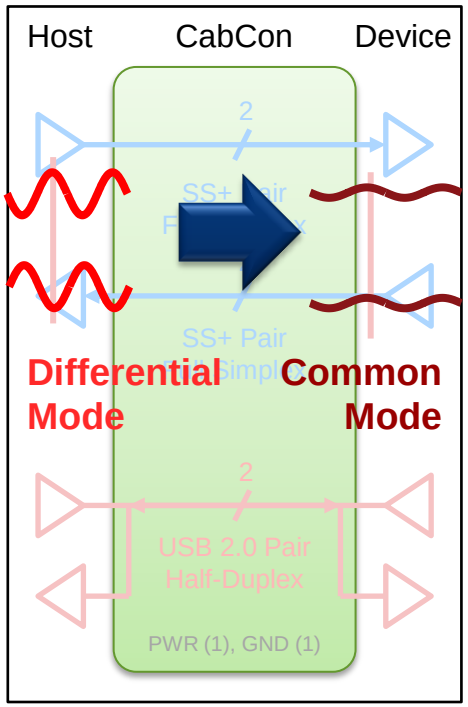
USB 3.1 Cable/Connector Compliance Test

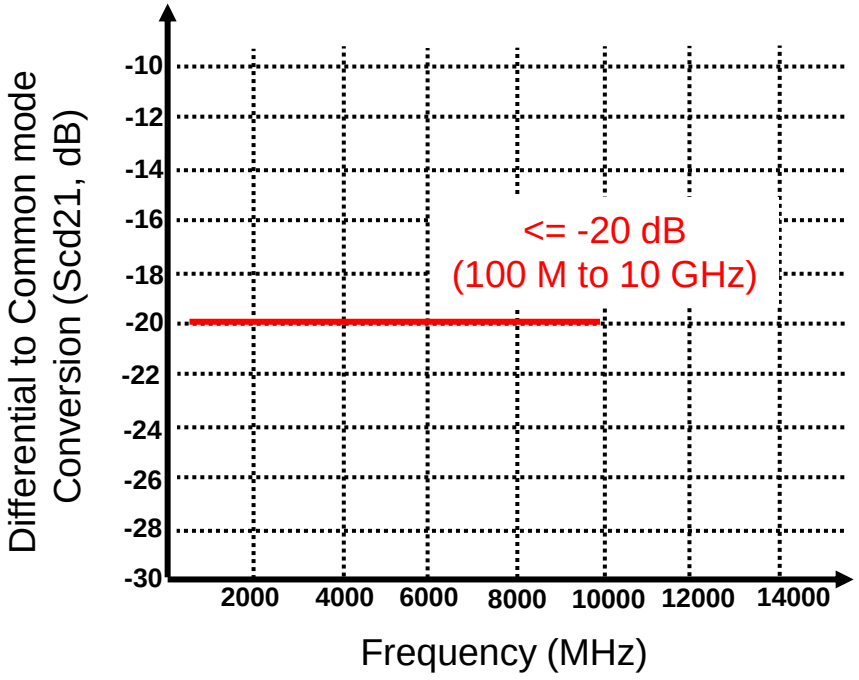
Differential to Common-Mode Conversion (**Normative**)





- 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.

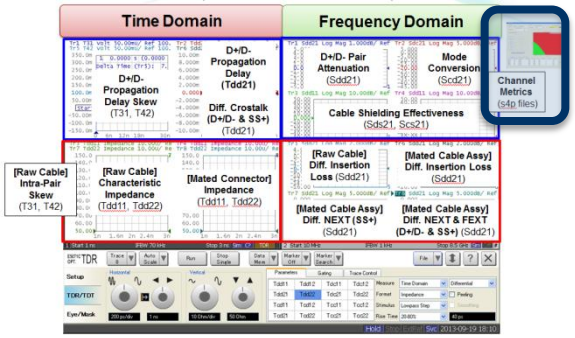
Differential to Common-Mode conversion - Specification

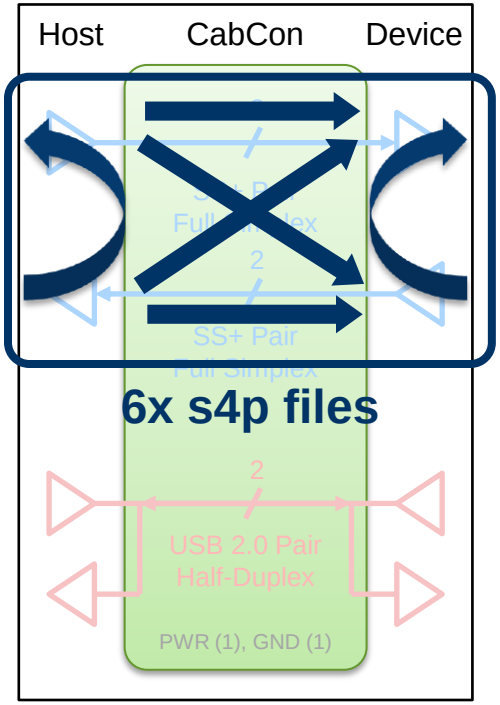


KEYSIGHT TECHNOLOGIES

USB 3.1 Cable/Connector Compliance Test

Channel Metrics (eH, eW, ILfitatNq, IMR and IXT) (**Normative**)





- Three parameters of channel metrics (ILfitatNq, IMR and IXT) and channel margin (eW, eH) are calculated for SS+ pairs.
- USB 3.1 standard tool provided by USB-IF will do the pass/fail judgment for channel metrics and channel performance based on measured Touchstone files. (6x s4p or 1x s8p file)

Channel Metrics and Channel Performance - Specification

Time domain response:

$eH = f_H(ILfitatNq, IMR, IXT) > 0$

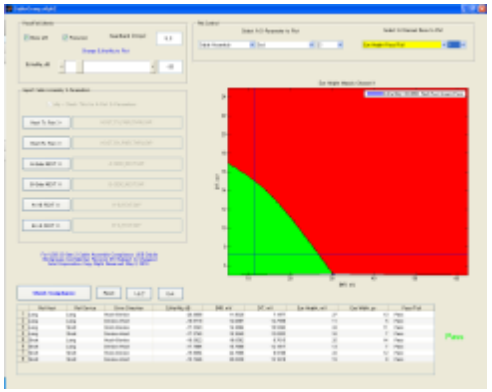
$eW = f_W(ILfitatNq, IMR, IXT) > 0$

Frequency response:

$ILfitatNq \geq -22\ dB$

$IMR \leq 60\ mV$

$IXT \leq 25\ mV$

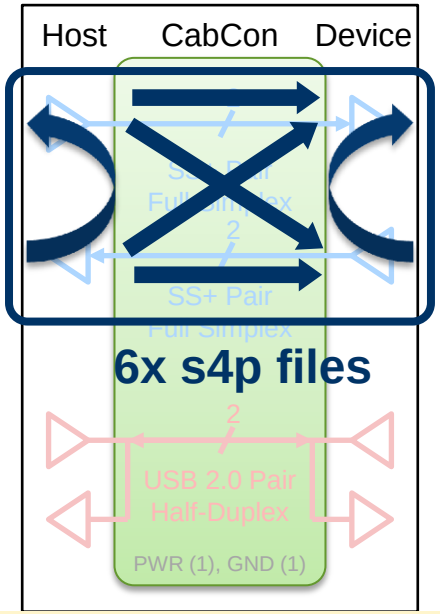


KEYSIGHT TECHNOLOGIES

USB 3.1 Cable/Connector Compliance Test

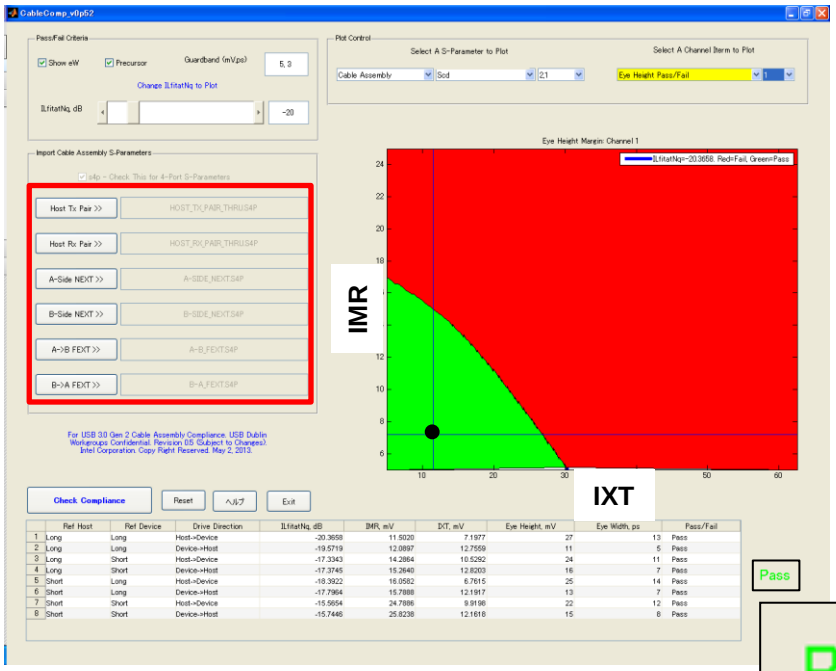
Channel Metrics (eH, eW, ILfitatNq, IMR and IXT) (**Normative**)

ENA Option TDR



Perform frequency-domain (S-parameter) measurements to save 6x 4-port Touchstone files (*.s4p) for SS+ Signal Pairs.

USB 3.1 Standard Tool

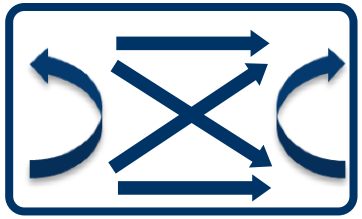


Pass

Import 6x Touchstone files (*.s4p) to do pass/fail judgment for all the combinations of reference host and device.

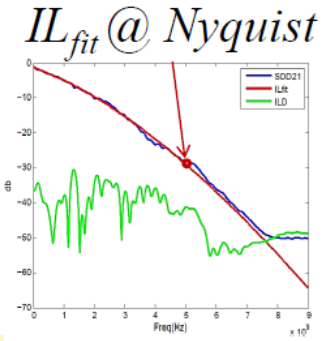
USB 3.1 Cable/Connector Compliance Test

Channel Metrics (eH, eW, ILfitatNq, IMR and IXT) (**Normative**)

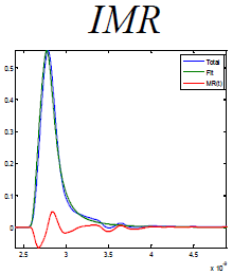


6x s4p files

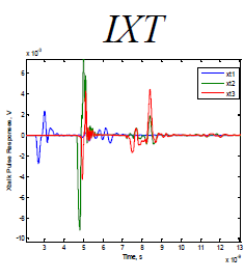
6x 4-port Touchstone S-parameter files (*.s4p) are saved and imported to the tool.



Differential insertion loss is fitted with a smooth function to obtain the insertion loss at Nyquist frequency of 5 GHz (ILfitatNq).

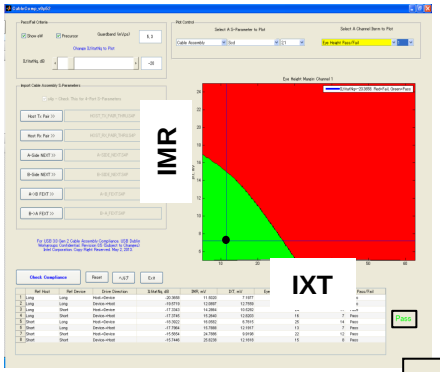


$$IMR = \frac{1}{UI}\sqrt{\int_{-\infty}^{\infty}|MR(f)|^2\,df}$$



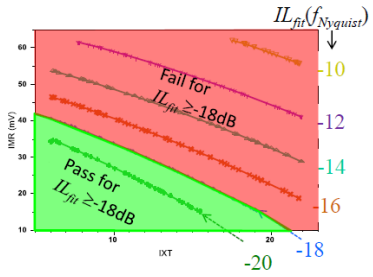
$$IXT = \frac{1}{UI}\sqrt{\int_{-\infty}^{\infty}|XT(f)|^2\,df}$$

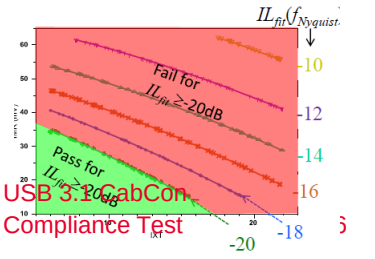
Integrated Crosstalk (IXT) and Integrated multi-reflection (IMR) response are calculated from S-parameter files.



The tool illustrates a crossing point of IXT and IMR for a given ILfitatNq. If the point is in the pass region (in green) for all 8 channels, Pass. Otherwise Fail.

Pass



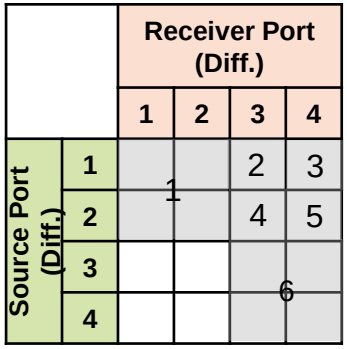


USB 3.1 Cable/Connector Compliance Test

Obtaining Multiport Touchstone Files (*snp) with Multiport VNA

- USB 3.1 standard tool requires multiport Touchstone file(s) for the pass/fail judgment of cable assemblies with 4x differential (=8x single-ended) ports.
- To improve throughput of total characterization, the 8-port VNA can create an *.s8p file with a single measurement.

4-port VNA

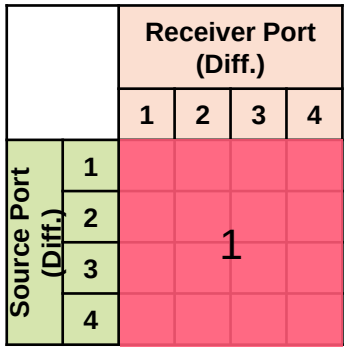


Port combinations (# of tests):

1&2, 1&3, 1&4 (3)
2&3, 2&4 (2)
3&4 (1)

=>6x 4-port tests (*.s4p)

8-port VNA



Port combinations (# of tests):

1, 2, 3, 4 (1)

=> 3x 8-port tests (*.s8p)

USB 3.1 Cable/Connector Compliance Test

Multiport Configuration with M937X PXIe VNA

Keysight PXI VNA (M937xA)

- Full two-port VNA that fits in just *one* slot.
- Performs fast, accurate measurements and reduces cost-of-test by simultaneously characterizing many devices using a single PXI chassis.

Performance

- **>114 dB** dynamic range at 9 GHz
- Less than **0.003 dB** of trace noise
- Sweep speed as fast as **16 msec** across 401 points (300 k to 9 GHz, full 2-port correction)
- Stability of 0.005 dB/deg.C

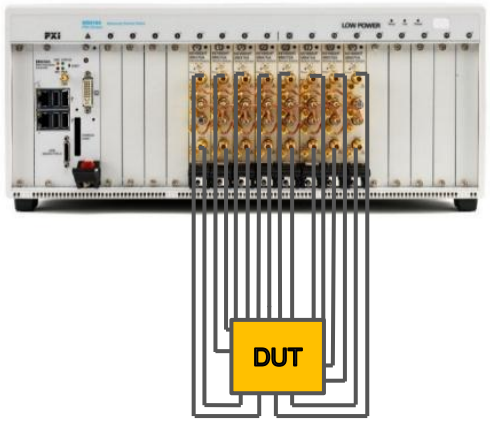
Key Features

- Six frequency models: 4, 6.5, 9, 14, 20, 26.5 GHz
- Same calibration and measurement science as the trusted FieldFox, ENA and PNA families
- **True multiport VNA with full n-port calibration**
- Simultaneous multi-site measurements with independent VNAs

USB 3.1 Cable/Connector Compliance Test

Multiport VNA Configuration

Recommended Configuration of Multiport VNA



Model / Option	Description	ea
M9373A or M9374A	300 k to 14 GHz or 20 GHz, 2-port, PXIe Vector Network Analyzer	2 (for 4-port VNA) 4 (for 8-port VNA)
M9373A-010 or M9374A-010	Time domain analysis	1 (*1)
M9373A-102 or M9374A-102	Additional VNA features (i.e. differential conversion of fixture simulators)	1 (*1)
M9373A-551 or M9374A-551	Full N-port calibrated measurement	1 (*1)
N4433A	ECal module, 300 k to 20 GHz, 4-port.	1
M9018A	18-slot PXIe chassis	1
M9037A	High-performance embedded controller	1

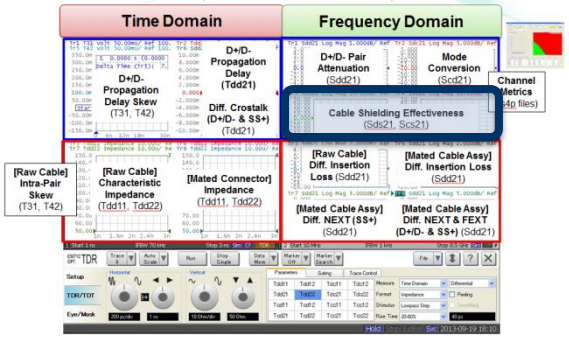
*1: At least one PXI VNA module must have option 010, 102, or 551 to enable the capabilities in a multiport configuration.
*2: The list above includes the major equipment required. Please contact our sales representative for configuration details.

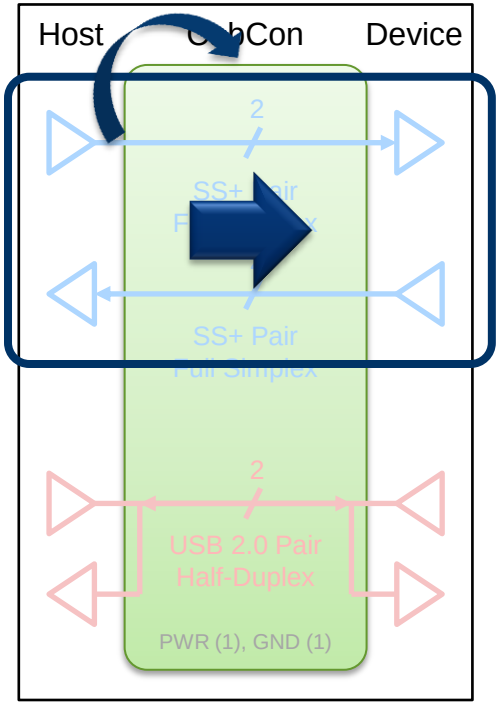
For more details of M937X PXI VNA:

[Product page] www.keysight.com/find/pxivna
[Configuration Guide] http://literature.cdn.keysight.com/litweb/pdf/5991-4885EN.pdf
[Data Sheet] http://literature.cdn.keysight.com/litweb/pdf/M9370-90002.pdf

USB 3.1 Cable/Connector Compliance Test

Cable Shielding Effectiveness (**Normative**)

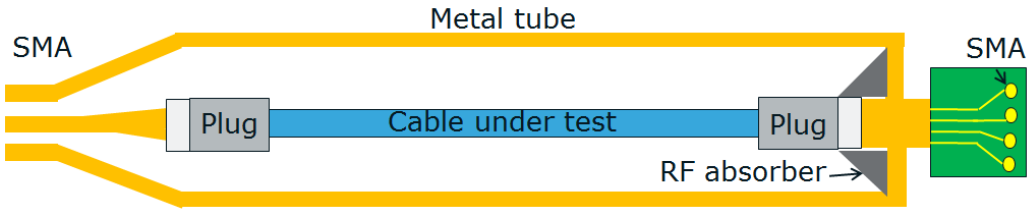




- Measures the radio frequency interference (RFI) level from the cable assembly.
- The coupling factor from differential Tx / Rx pairs to single-ended cable shield (i.e. Sds21/Scs21) is calculated.

Cable Shielding Effectiveness - Specification

DUT Type	Limit
Cable assembly	≤-40 dB (100 MHz to 10 GHz)

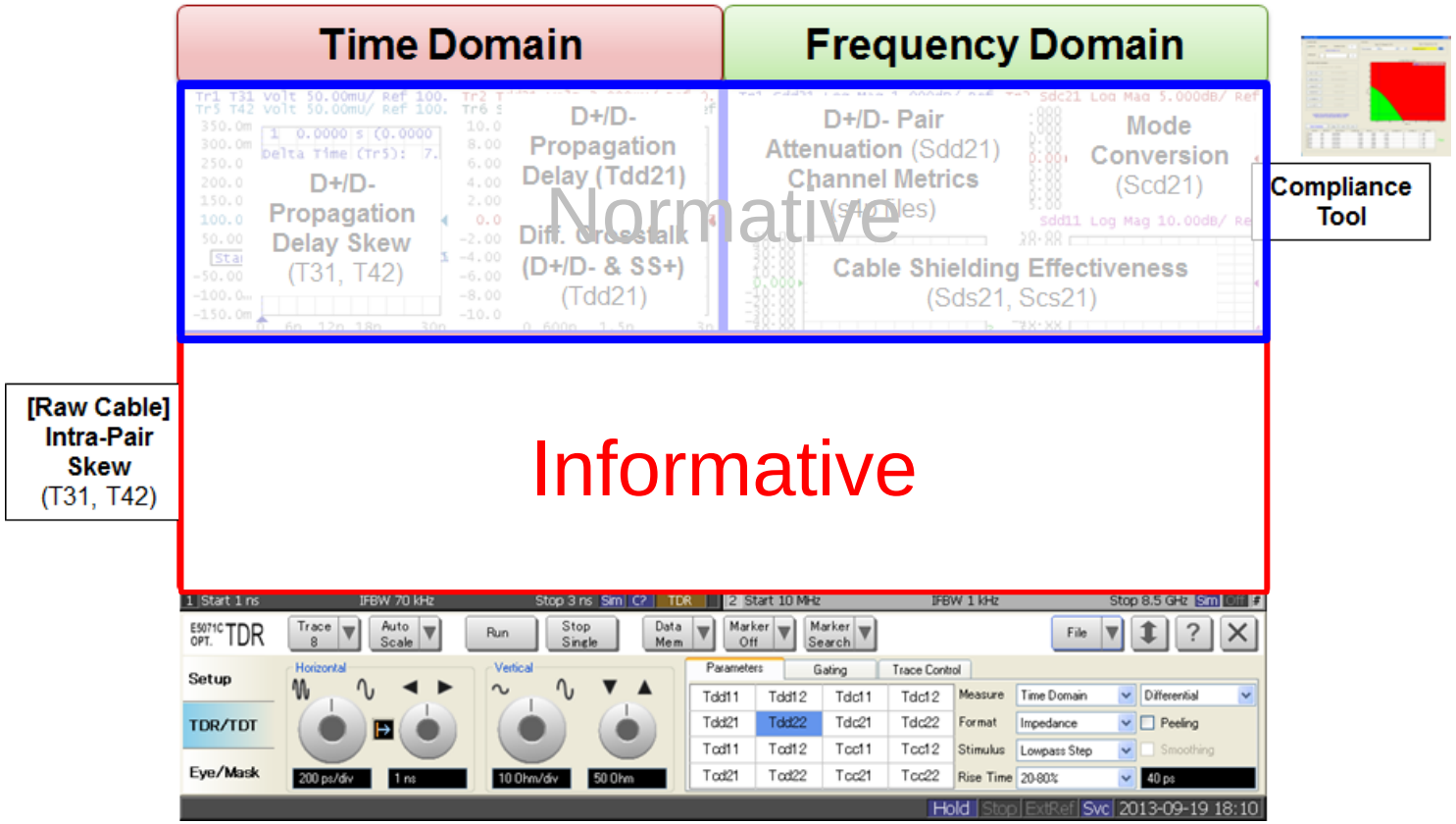


Setup for cable SE measurement (subject to change)

KEYSIGHT TECHNOLOGIES

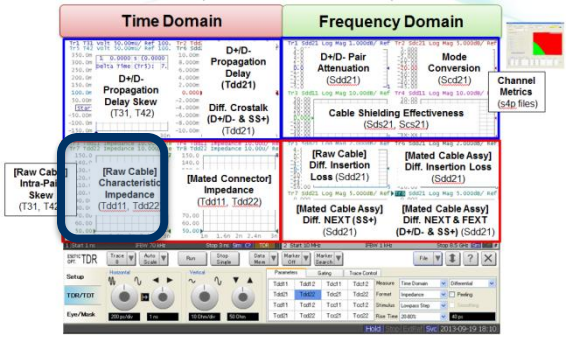
USB 3.1 Cable/Connector Compliance Test

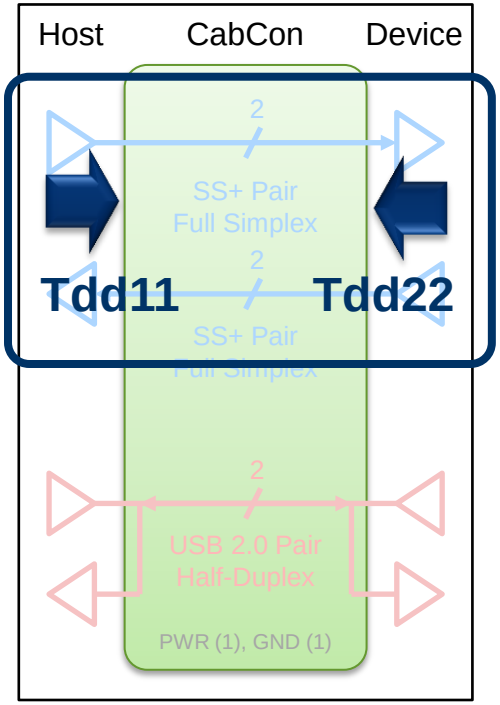
Informative Parameters



USB 3.1 Cable/Connector Compliance Test

[Raw Cable] Characteristic Impedance (**Informative**)





- 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.

[Raw Cable] Characteristic Impedance - Design Target

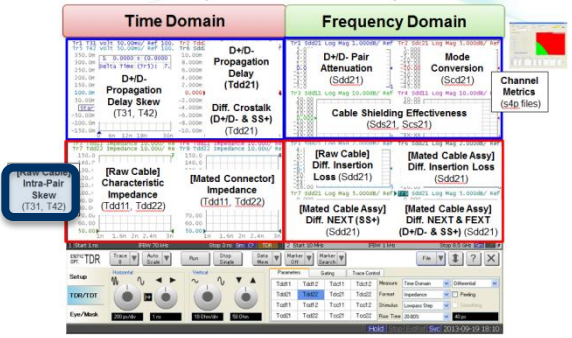
DUT Type	Limit
Shielded Differential Pair (SDP)	90 +- 5 ohm.
Single-ended coaxial SS+ signal wires	45 +- 3 ohm.

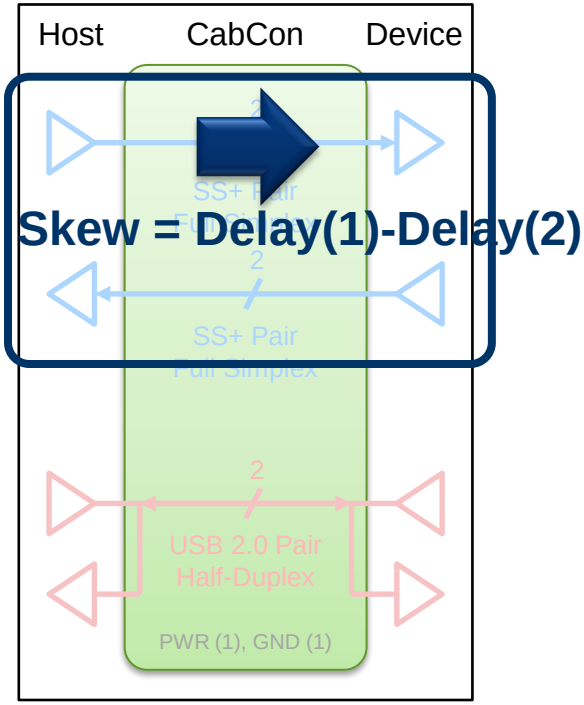
Note: Should be measured with a TDR in a differential mode using a 200 ps (10%-90%) rise time.

KEYSIGHT TECHNOLOGIES

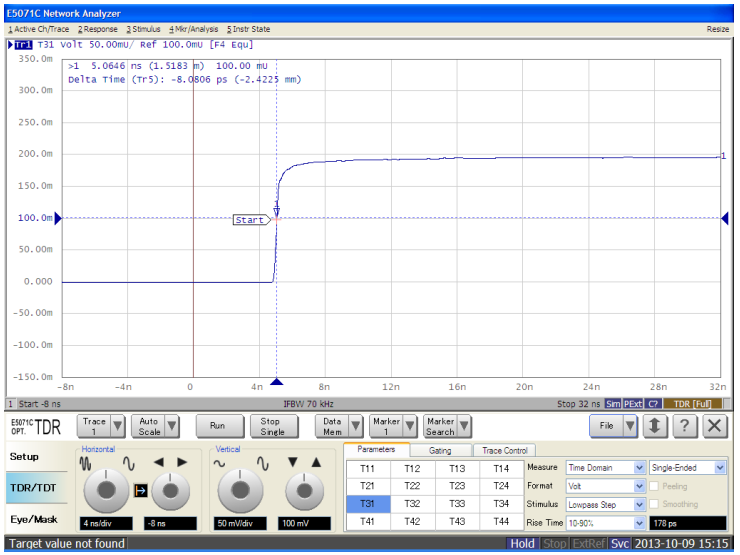
USB 3.1 Cable/Connector Compliance Test

[Raw Cable] Intra-Pair Skew (**Informative**)





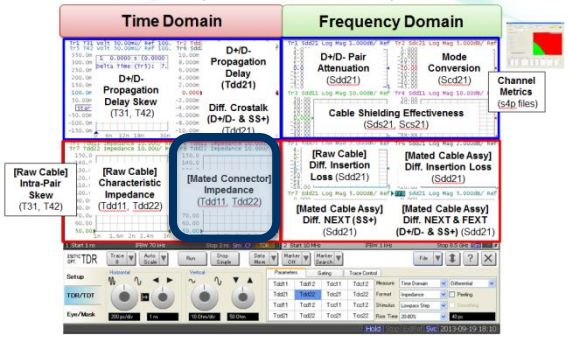
- Intra-pair skew measurement ensures the signal on both SS+ Tx+ and Tx- lines (or Rx+ and Rx- lines) of a cable assembly arrive at the receiver at the same time.
- If Delta Time < 15 ps/m: Pass, else: Fail

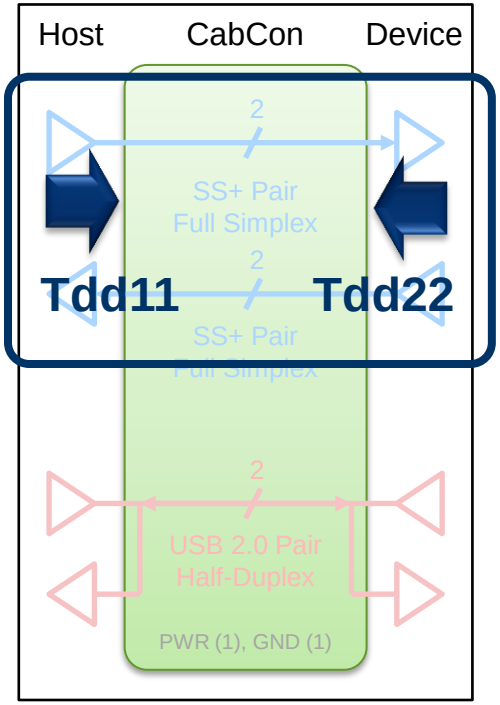


Note: Should be measured with a TDR in a differential mode using a 200 ps (10%-90%) rise time with a crossing at 50% of the input voltage.

USB 3.1 Cable/Connector Compliance Test

[Mated Connector] Impedance (**Informative**)





- 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.

[Mated Connector] Impedance - Design Target

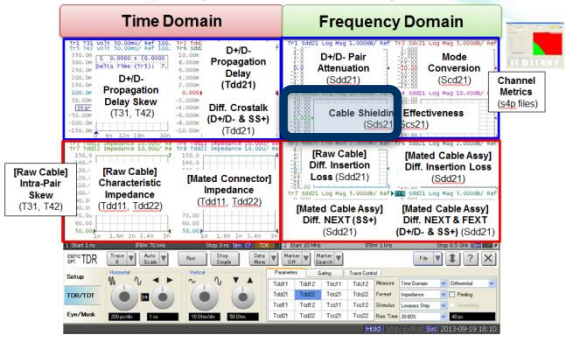
DUT Type	Limit
Mated connector	90 +- 10 ohm.

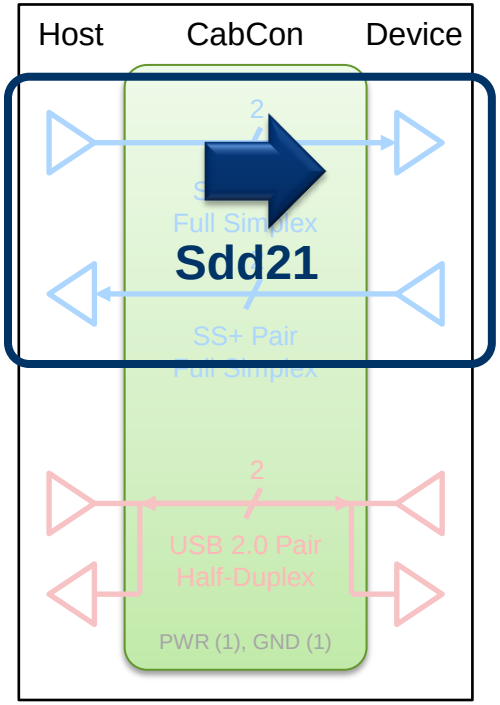
Note: Should be measured with a TDR in a differential mode using a 40 ps (20%-80%) rise time.
Note: The impedance profile is defined from the receptacle footprints through the plug cable termination area. In a case where the plug is directly attached to a device PCB, impedance profile includes the paths from the receptacle footprints to the plug footprints.

KEYSIGHT TECHNOLOGIES

USB 3.1 Cable/Connector Compliance Test

[Raw Cable] Differential Insertion Loss (**Informative**)





- Measure of frequency response that the differential signal sees as it propagates through the interconnect.
- Cable loss depends on wire gauges, plating and dielectric materials.

[Raw Cable] Differential Insertion Loss - Design Target

SDP Differential Insertion Loss Examples

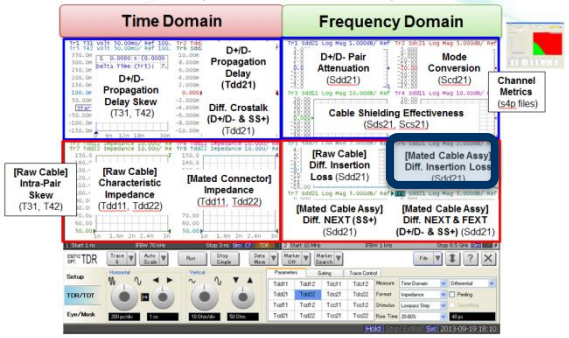
Frequency	34AWG	32AWG	30AWG	28AWG
0.625 GHz	-1.8 dB/m	-1.4 dB/m	-1.2 dB/m	-1.0 dB/m
1.25 GHz	-2.5 dB/m	-2.0 dB/m	-1.7 dB/m	-1.4 dB/m
2.50 GHz	-3.7 dB/m	-2.9 dB/m	-2.5 dB/m	-2.1 dB/m
5.00 GHz	-5.5 dB/m	-4.5 dB/m	-3.9 dB/m	-3.1 dB/m
7.50 GHz	-7.0 dB/m	-5.9 dB/m	-5.0 dB/m	-4.1 dB/m

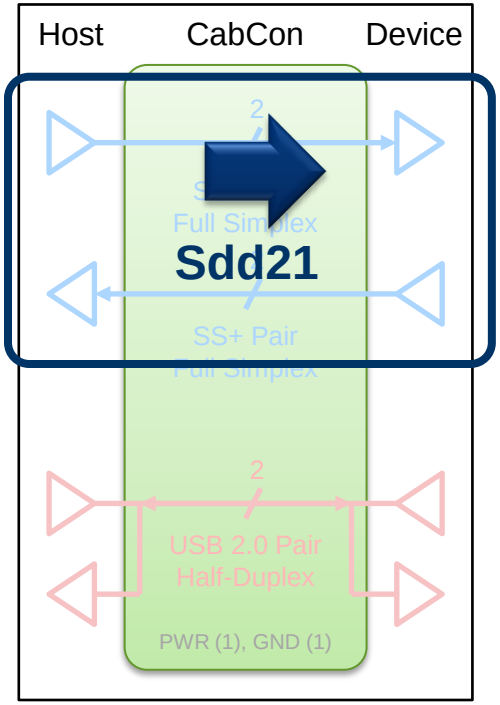
SDP Differential Insertion Loss Example with Coaxial Construction

Frequency	34AWG	32AWG	30AWG	28AWG
0.625 GHz	-1.6 dB/m	-1.3 dB/m	-1.1 dB/m	-1.0 dB/m
1.25 GHz	-2.3 dB/m	-1.8 dB/m	-1.5 dB/m	-1.3 dB/m
2.50 GHz	-3.5 dB/m	-2.7 dB/m	-2.3 dB/m	-1.9 dB/m
5.00 GHz	-5.3 dB/m	-4.2 dB/m	-3.5 dB/m	-3.1 dB/m
7.50 GHz	-7.2 dB/m	-5.5 dB/m	-4.9 dB/m	-4.2 dB/m

USB 3.1 Cable/Connector Compliance Test

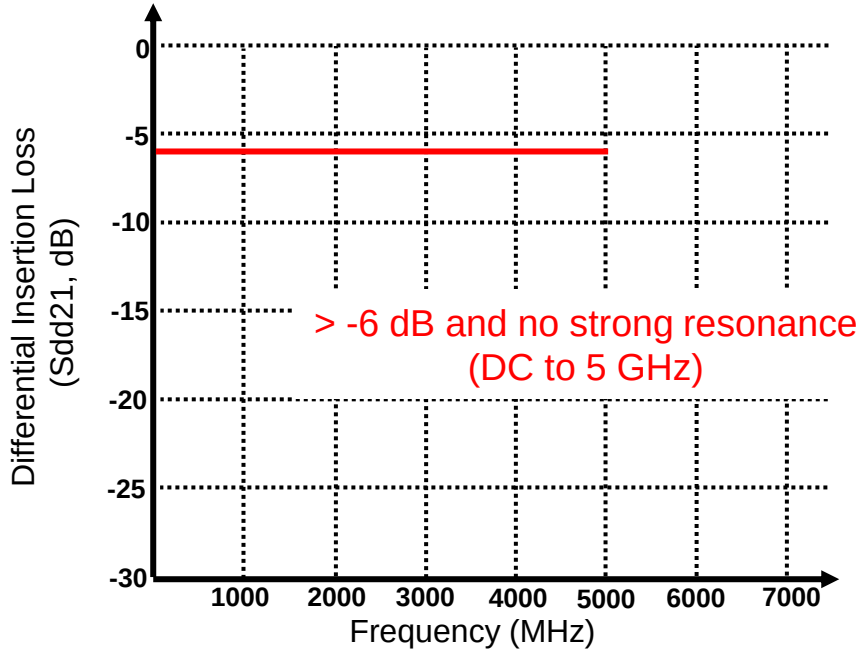
[Mated Cable Assembly] Differential Insertion Loss (**Informative**)





- Measure of frequency response that the differential signal sees as it propagates through the interconnect.

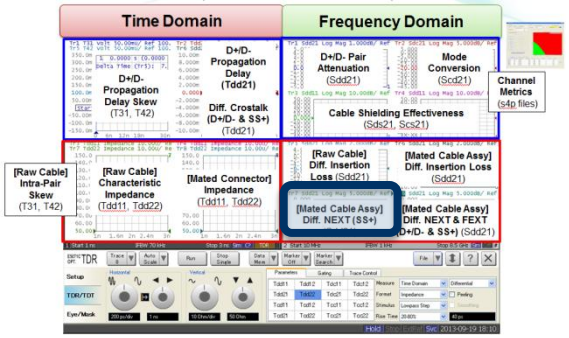
[Mated Cable Assembly] Differential Insertion Loss - Design Target

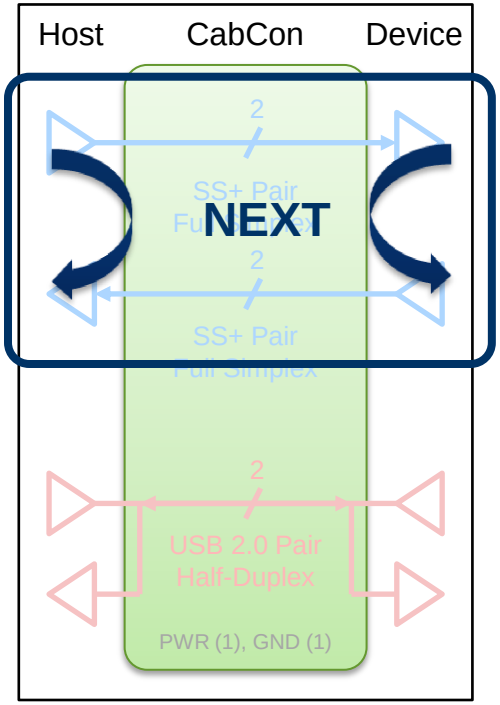


KEYSIGHT TECHNOLOGIES

USB 3.1 Cable/Connector Compliance Test

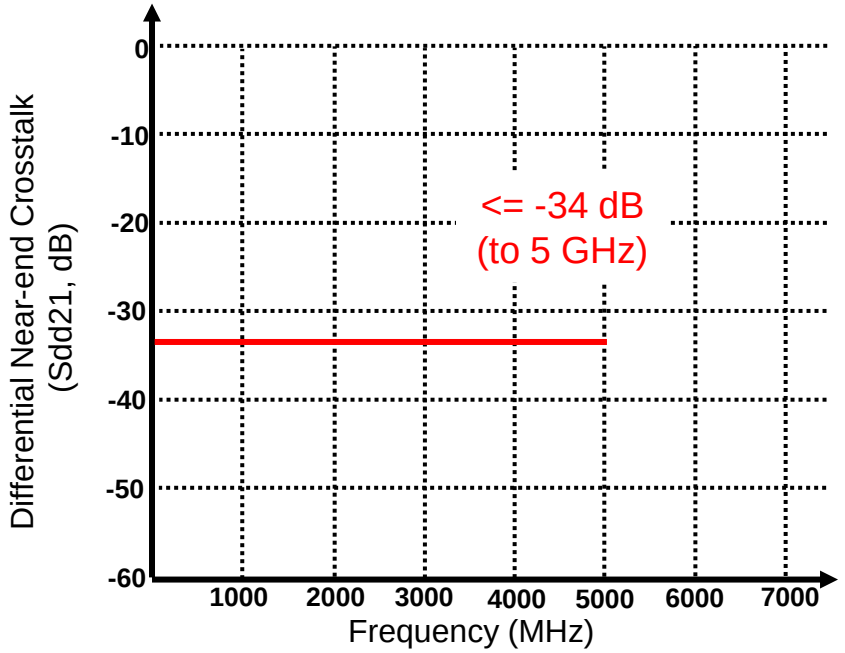
[Mated Cable Assembly] Differential NEXT between SS+ Signal Pairs (**Informative**)





- Measure of coupling between the SS+ differential pairs (Tx/Rx pair).

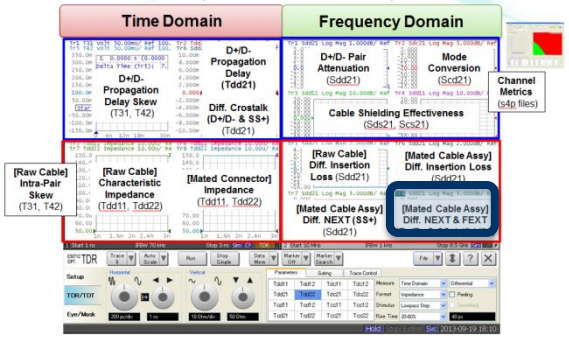
[Mated Cable Assembly] Differential NEXT - Design Target

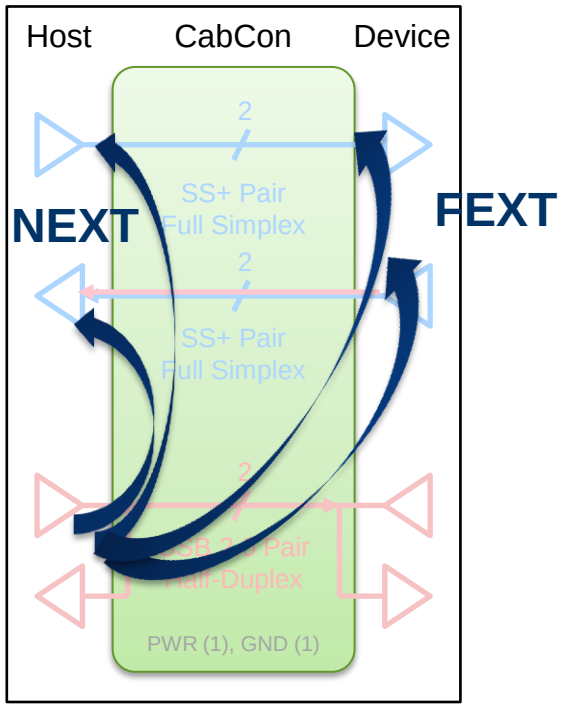


KEYSIGHT TECHNOLOGIES

USB 3.1 Cable/Connector Compliance Test

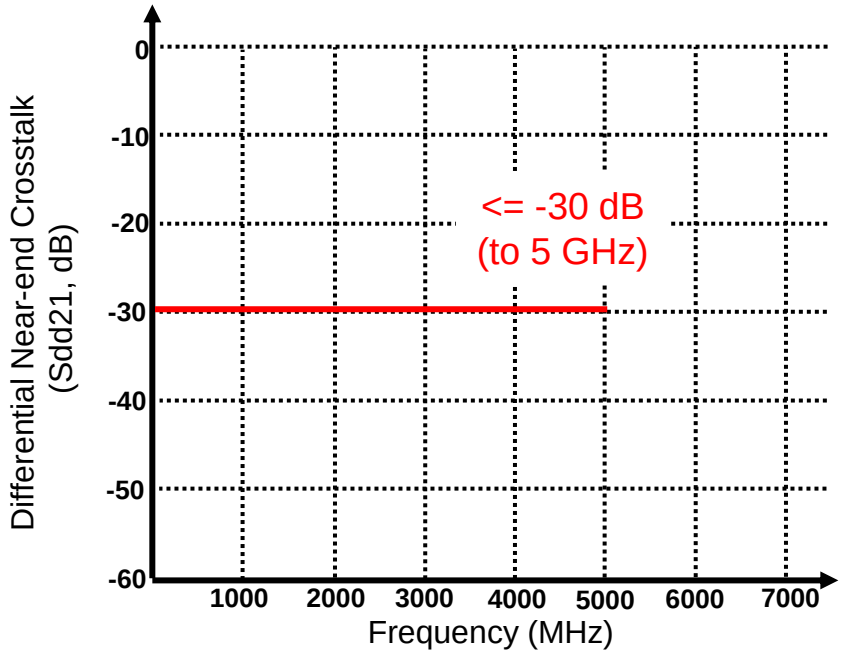
[Mated Cable Assembly] Differential NEXT & FEXT between D+/D- Pair and SS+ Signal Pairs (**Informative**)





- Measure of coupling between D+/D- pair and the SS+ differential pairs (Tx/Rx pair) in frequency domain.

[Mated Cable Assembly] Differential Crosstalk - Design Target

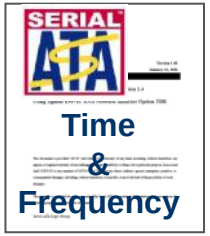


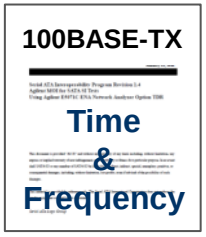
KEYSIGHT TECHNOLOGIES

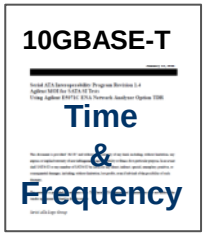
ENA Option TDR Compliance Test Solution

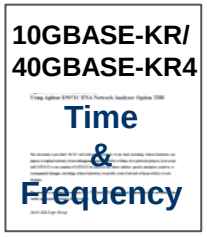
Certified MOIs available at **www.keysight.com/find/ena-tdr_compliance**

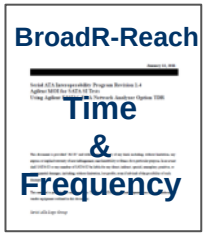
Cable/Connector/Interconnect





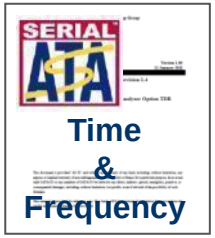


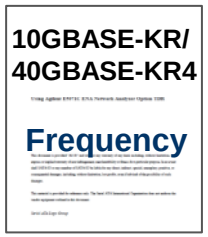


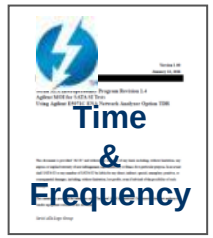


*

Transmitter/Receiver Impedance (Hot TDR/RL)







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More Standards Currently Under Investigation

* For more detail about Thunderbolt and BroadR-Reach compliance test solution using the ENA Option TDR, contact Keysight sales representative.

USB 3.1 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?

USB 3.0 => USB 3.1

Measurement Parameters

1. Time Domain Measurements

USB 3.0 (5 Gbps)	USB 3.1 (10 Gbps)	Note
D+/D- Pair Propagation Delay	D+/D- Pair Propagation Delay	No change. USB 2.0.
D+/D- Pair Propagation Delay Skew	D+/D- Pair Propagation Delay Skew	No change. USB 2.0.
Differential Crosstalk between D+/D- Pair and SS Pairs	Differential Crosstalk between D+/D- and SS+ Signal Pairs	No change.
[Raw Cable] Characteristic Impedance (Informative)	[Raw Cable] Characteristic Impedance (Informative)	Specification is changed: 83 to 97 ohm => 85 to 95 ohm.
SS Lines Intra-Pair Skew (Informative)	[Raw Cable] Intra-Pair Skew (Informative)	No change.
[Mated Connector] Impedance	[Mated Connector] Impedance (Informative)	Changed from Normative to Informative. Specification is changed: 75 to 105 ohm @ 50 ps (20-80%) => 80 to 100 ohm @ 40 ps (20-80%)

Note: normative parameters in blue, informative parameters in red.

USB 3.0 => USB 3.1

Measurement Parameters

2. Frequency Domain Measurements

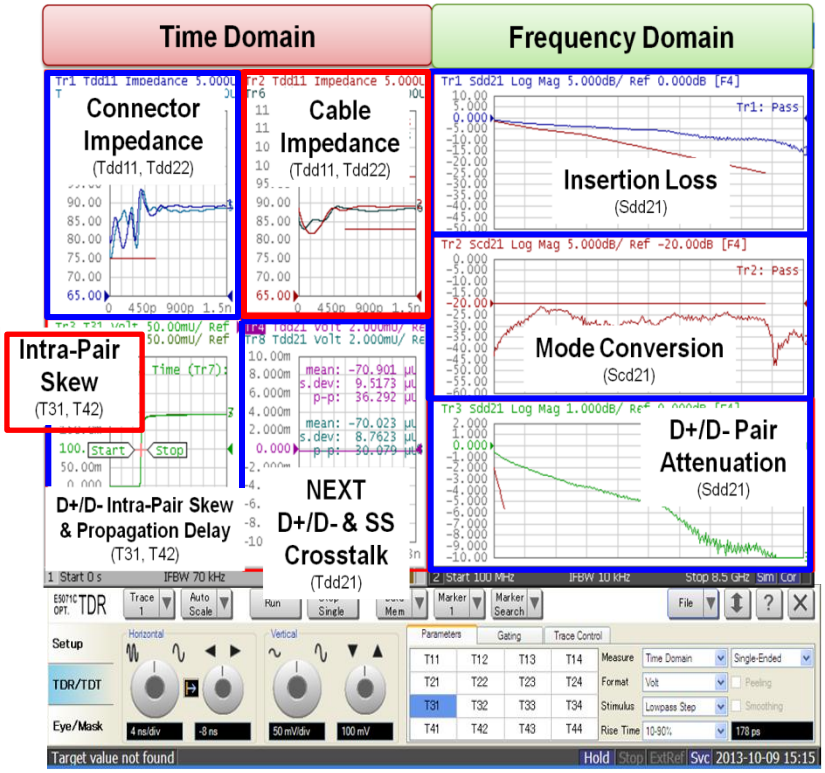
USB 3.0 (5 Gbps)	USB 3.1 (10 Gbps)	Note
D+/D- Pair Attenuation	D+/D- Pair Attenuation	No change. USB 2.0.
Differential to Common Mode Conversion	Differential to Common Mode Conversion	Frequency range is extended up to 10 GHz. (100 M to 7.5 GHz => 100 M to 10 GHz)
-	Channel Metrics (ILfitatNq, IMR, IXT, eW, eH)	Newly added for USB 3.1. Compliance test tool provided by USB-IF is necessary.
-	Cable Shielding Effectiveness	Newly added for USB 3.1.
[Raw Cable] Differential Insertion Loss (Informative)	[Raw Cable] Differential Insertion Loss (Informative)	Specification is changed. Better loss needed.
Differential Insertion Loss	[Mated Cable Assembly] Differential Insertion Loss (Informative)	Changed from Normative to Informative. Specification is changed: (=> >-6 dB (DC to 5 GHz)
Differentia Near End Crosstalk Between SS Pairs (Time domain)	[Mated Cable Assembly] Differential NEXT between SS+ Signal Pairs (Informative)	NEXT is measured in frequency domain for USB 3.1. Changed from Normative to Informative.
-	[Mated Cable Assembly] Differential NEXT and FEXT between D+/D- pair and SS+ Signal Pairs (Informative)	Crosstalk are measured in time domain as well (Normative).

Note: normative parameters in blue, informative parameters in red.

USB 3.0 => USB 3.1

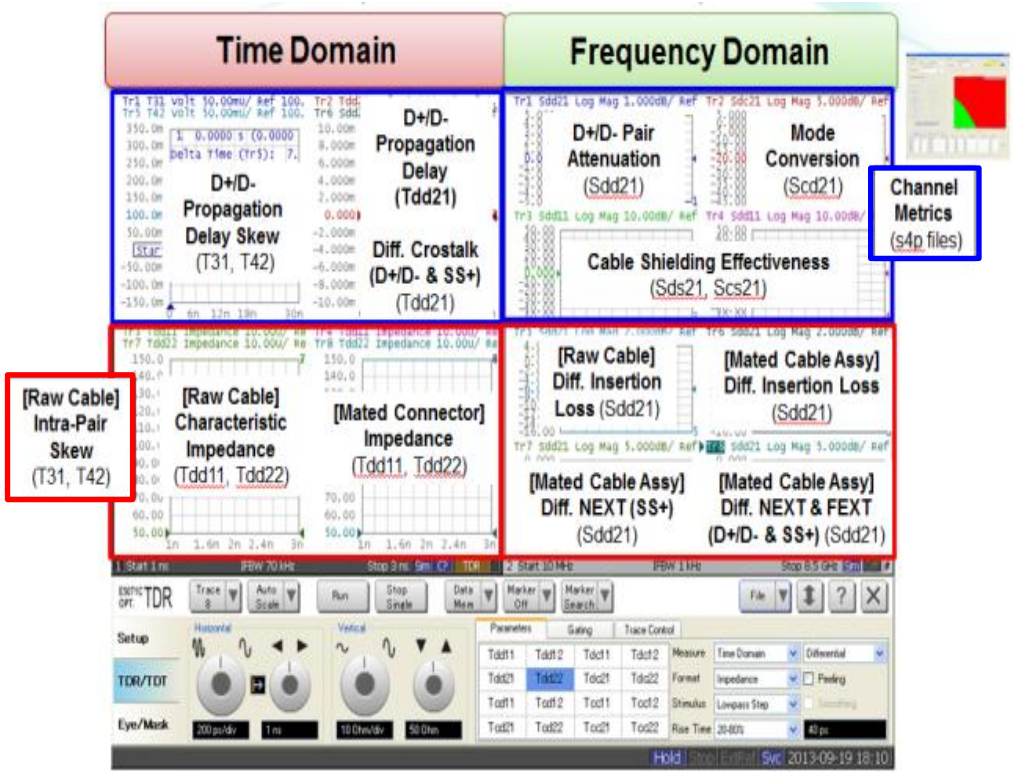
Measurement Parameters

USB 3.0



Note: Normative parameters in blue, informative parameters in red.

USB 3.1



Note: Normative parameters in blue, informative parameters in red.

Keysight VNA Solutions

Performance

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

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

Mm-wave solutions
Up to 2 THz

PNA-X receiver
8530A replacement

PNA Series

E5072A
Best performance ENA
30 kHz to 4.5, 8.5 GHz

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

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

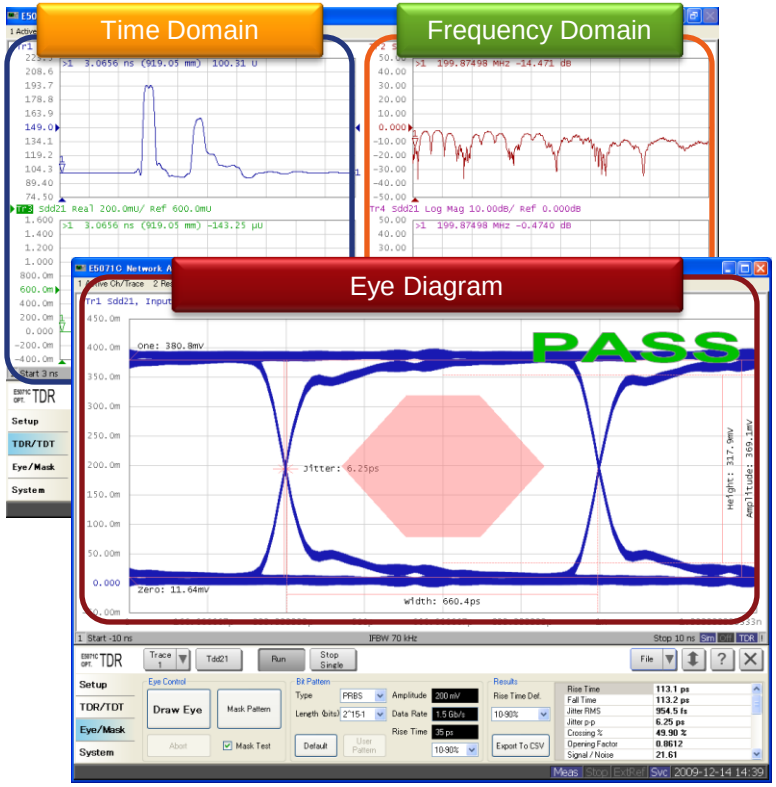
FieldFox
Handheld RF Analyzer
5 Hz to 4/6 GHz

ENA Series

KEYSIGHT TECHNOLOGIES

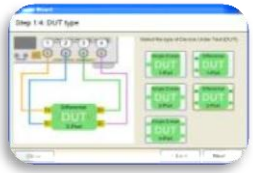
What is ENA Option TDR?

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

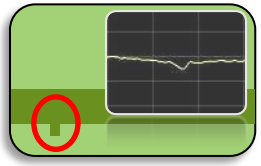


3 Breakthroughs

for Signal Integrity Design and Verification



Simple and Intuitive Operation



Fast and Accurate Measurements

ESD Robustness

What is ENA Option TDR?

[Video]

Keysight ENA Option TDR

Changing the world of Time Domain Reflectometry (TDR) Measurements

- www.youtube.com/watch?v=hwQNlyyJ5hI&list=UUAJAjd97CfnCehC4jZAfkxQ&index=20&feature=plcp
- www.keysight.com/find/ena-tdr

Additional Resources

•ENA Option TDR Reference Material

www.keysight.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 Keysight's ENA Option TDR Time Domain Measurement using a NIST Traceable Standard (5990-5728EN)

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

www.keysight.com/find/ena-tdr_compliance