

Universal Serial Bus 3.1 Specification Revision 1.0
Keysight Method of Implementation (MOI) for USB 3.1
Connectors and Cables Assemblies Compliance Tests
Using Keysight E5071C ENA Option TDR

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.

Table of Contents

1.	Revision History	4
2.	Purpose	4
3.	References	4
4.	Required Equipment	4
5.	Test Procedure	5
5.1.	Outline of Test Procedure	5
5.2.	Setup	7
5.2.1.	Recalling a State File	7
5.2.2.	Saving a State File	8
5.3.	Calibration	9
5.3.1.	ECal Calibration and De-embedding.....	9
5.3.2.	TRL Calibration.....	12
5.3.3.	Adjustment of Effective Rise Time	14
5.4.	Measurement	18
5.4.1.	D+/D- Pair Propagation Delay Skew	18
5.4.2.	D+/D- Pair Propagation Delay	19
5.4.3.	Differential Crosstalk between D+/D- and SuperSpeed Gen 2 Signal Pairs ...	20
5.4.4.	D+/D- Pair Attenuation.....	21
5.4.5.	Channel Metrics (eH, eW, ILfitatNq, IMR and IXT).....	22
5.4.6.	Differential to Common-Mode Conversion	22
5.4.7.	Cable Shielding Effectiveness	23
5.4.8.	[Raw Cable] Characteristic Impedance (Informative).....	24
5.4.9.	[Raw Cable] Intra-Pair Skew (Informative).....	24
5.4.10.	[Raw Cable] Differential Insertion Loss (Informative).....	24
5.4.11.	[Mated Connector] Impedance (Informative).....	25
5.4.12.	[Mated Cable Assembly] Differential Insertion Loss (Informative)	25
5.4.13.	[Mated Cable Assembly] Differential Near-end Crosstalk (NEXT) between SuperSpeed Gen 2 Signal Pairs (Informative).....	26
5.4.14.	[Mated Cable Assembly] Differential Near-end and Far-end Crosstalk (NEXT and FEXT) between D+/D- Pair and SuperSpeed Gen 2 Signal Pairs (Informative).....	26
6.	[Appendix] Manual Setup	27
6.1.	Channel & Trace Setup.....	27
6.2.	D+/D- Pair Propagation Delay Skew	28
6.2.1.	Parameter Setup.....	28
6.2.2.	Crosstalk Compensation	29
6.3.	D+/D- Pair Propagation Delay	30
6.4.	Differential Crosstalk between D+/D- and SuperSpeed Gen 2 Signal Pairs.....	30

Keysight MOI for USB 3.1 Connectors & Cable Assemblies Compliance Tests

6.5.	[Raw Cable] Characteristic Impedance (Informative).....	30
6.6.	[Mated Connector] Impedance (Informative).....	31
6.7.	Common Parameters Setup for Frequency-domain Measurements	31
6.8.	D+/D- Pair Attenuation.....	32
6.9.	Differential to Common-mode Conversion.....	32
6.10.	Cable Shielding Effectiveness	32
6.11.	[Raw Cable] Differential Insertion Loss (Informative).....	32
6.12.	[Mated Cable Assembly] Differential Insertion Loss (Informative)	32
6.13.	[Mated Cable Assembly] Differential Near-end Crosstalk (NEXT) between SuperSpeed Gen 2 Signal Pairs (Informative).....	33
6.14.	[Mated Cable Assembly] Differential Near-end and Far-end Crosstalk (NEXT and FEXT) between D+/D- Pair and SuperSpeed Gen 2 Signal Pairs (Informative).....	33
6.15.	Defining Limit Line Tables	33
7.	[Appendix] Defining TRL Calibration Kit	34
8.	[Appendix] De-embedding File Creation using PLTS AFR.....	39
8.1.	2x Thru Standard Measurement.....	39
8.2.	De-embedding File Creation	39

1. Revision History

Revision	Comments	Issue Date
0.50	Draft Revision.	Feb. 06, 2015

2. Purpose

This test procedure was written to explain how to use the Keysight ENA Option TDR to make the connectors and cable assemblies measurements required per USB 3.1 Specification Revision 1.0 and Connectors and Cable Assemblies Compliance Document Draft.

3. References

- Universal Serial Bus 3.1 Specification Revision 1.0 (July 26, 2013)
- Universal Serial Bus 3.1 Connectors and Cable Assemblies Compliance Document Draft

4. Required Equipment

Description	Test Equipment	QTY
Network Analyzer	Keysight E5071C ENA Series Network Analyzer <ul style="list-style-type: none"> ➤ Option 4D5 (14 GHz) or 4K5 (20 GHz) ➤ Option TDR (Enhanced time domain analysis) 	1 ea.
4-port ECal	Keysight N4433A (4-port, 20 GHz)	1 ea.
Test Fixture	USB 3.1 official test fixtures and calibration standards	1 ea.
Adapter	83059B coaxial adapter for E5071C ports	4 ea.
RF cable	3.5 mm or SMA cables of 14 GHz bandwidth or more	4 ea.
50 ohm Terminator	Termination for unused differential pairs (ex. Keysight 909D-301)	12 ea.

Note: Opt.4K5 (20GHz) is recommended as Type-C cable/connector requires measurements up to 15 GHz.

Note: 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>

5. Test Procedure

5.1. Outline of Test Procedure

1. Setup

- Automatic setup by recalling a state file or manual setup

2. Calibration

- ECal Calibration and De-embedding
- TRL Calibration
- Adjustment of Effective Rise Time

3. Measurements

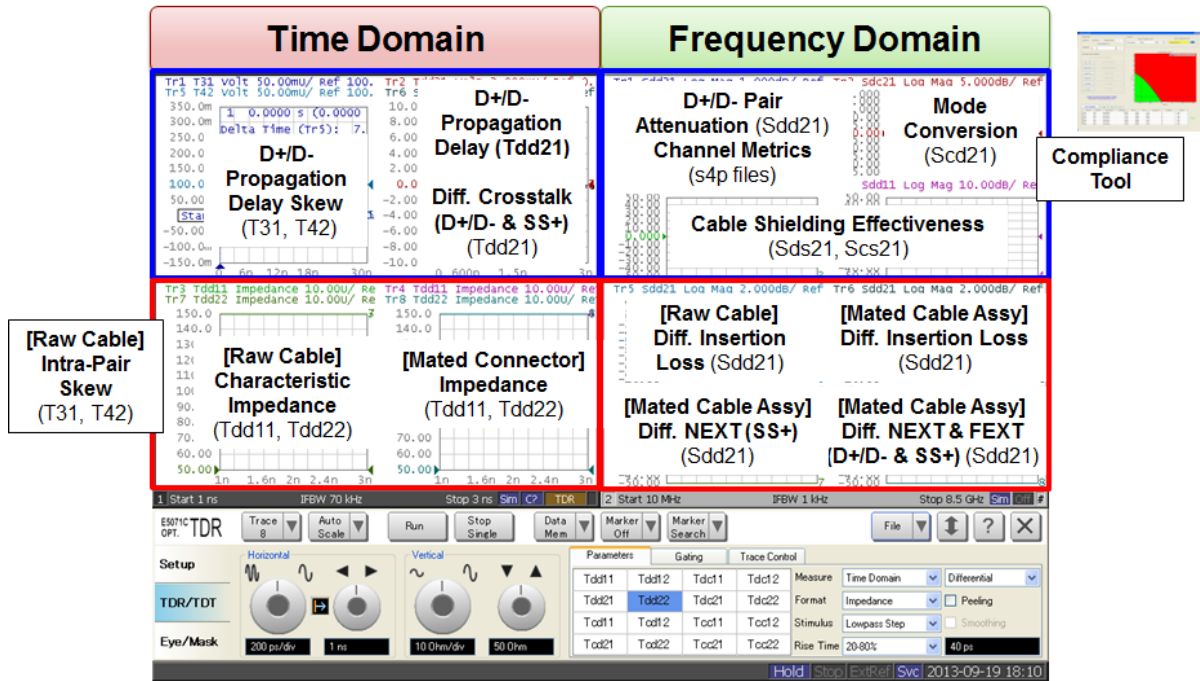
4-1. Time-domain Measurements

- D+/D- Pair Propagation Delay
- D+/D- Pair Propagation Delay Skew
- Differential Crosstalk between D+/D- and SuperSpeed Gen 2 Signal Pairs
- [Raw Cable] Characteristic Impedance (Informative)
- [Raw Cable] Intra-Pair Skew (Informative)
- [Mated Connector] Impedance (Informative)

4-2. Frequency-domain Measurements

- D+/D- Pair Attenuation
- 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 Near-end Crosstalk (NEXT) between SuperSpeed Gen 2 Signal Pairs (Informative)
- [Mated Cable Assembly] Differential Near-end and Far-end Crosstalk (NEXT and FEXT) between D+/D- Pair and SuperSpeed Gen 2 Signal Pairs (Informative)

Keysight MOI for USB 3.1 Connectors & Cable Assemblies Compliance Tests



Normative & Informative Measurement Parameters

Note: Hard keys (Keys on the E5071C's front panel) are displayed in **Blue color** and **Bold**.

(Example: **Avg**, **Analysis**)

Note: Soft keys (Keys on the E5071C's screen) are displayed in **Bold**.

(Example: **S11**, **Real**, **Transform**)

Note: Buttons of the TDR software are displayed in **Green color** and **Bold**.

(Example: **Trace**, **Rise Time**)

Note: Tabs of the TDR software are displayed in **Brown color** and **Bold**.

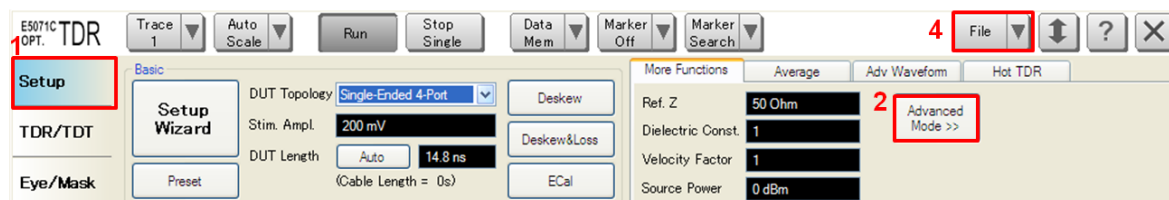
(Example: **Setup**, **Trace Control**)

5.2. Setup

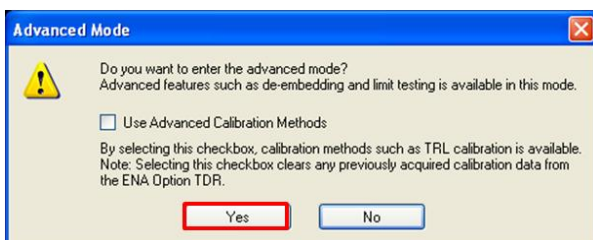
5.2.1. Recalling a State File

This section describes how to recall a state file of the E5071C that includes all the measurement settings for USB3.1 connectors and cable assemblies compliance tests. The state file can be downloaded at: http://www.keysight.com/find/ena-tdr_compliance Copy the state file into the E5071C's directory via USB mass storage device and recall the state file using the TDR software. Necessary parameters for testing are automatically set up in the E5071C. Refer to Appendix for the details about manual setup. If TDR setup wizard is shown, click **Close** button in the TDR setup wizard main window.

1. Open **Setup** tab.
2. Click **Advanced Mode** to show the dialog box.



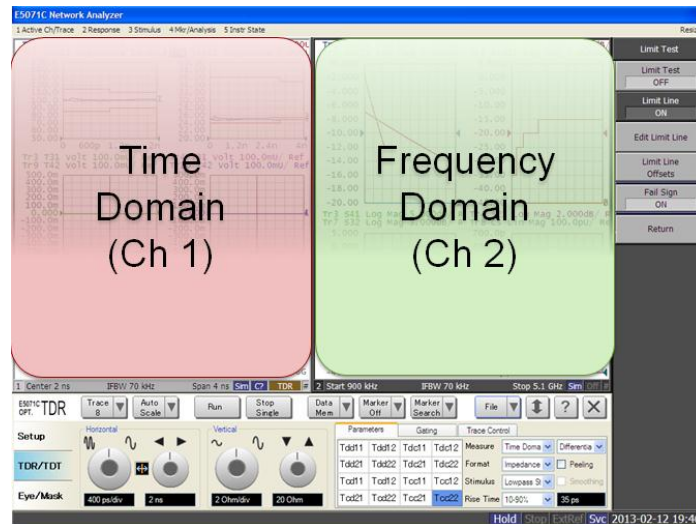
3. A dialog box appears requesting for confirmation. Then click **Yes**. (Uncheck “Use Advanced Calibration Methods”)



4. Click **File** and select **Recall State**.
5. Specify a folder and a file name, and click **Open**.

The E5071C's channel 1 is used for time-domain measurements by using the TDR software displayed at the bottom of the E5071C's screen. The channel 2 is used for frequency-domain measurements by using the hard keys on the front panel and the soft keys on the right side of the screen.

Keysight MOI for USB 3.1 Connectors & Cable Assemblies Compliance Tests



5.2.2. Saving a State File

All the measurement settings including calibration information can be saved in a state file (*.tdr). After performing calibration, all necessary calibration coefficients are saved in a state file and can be recalled for the next measurements.

1. Press **Save/Recall** > **Save Type** and select **State & Cal** as a state file type.
2. Click **File** of the TDR software and select **Save State**.



3. Enter file name and save the state file with calibration information.

5.3. Calibration

The purpose of this step is to calibrate the RF effects such as delay, loss or mismatch of RF cables and test fixture traces before measurements. In order to remove the fixture trace effect, two calibration methods (ECal calibration & de-embedding or TRL calibration) are available with the E5071C firmware for the USB3.1 connectors and cable assemblies compliance tests.

5.3.1. ECal Calibration and De-embedding

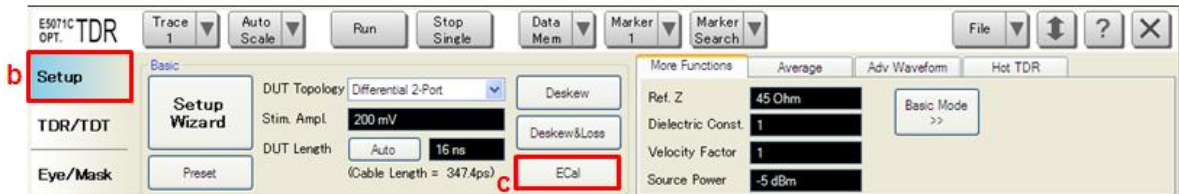
Full calibration is performed by using the 4-port ECal Module (i.e. N4433A) at the end of RF cables connected to the E5071C's test ports. The effect of the fixture is removed by de-embedding the fixture traces with S-parameter Touchstone files.

5.3.1.1. Time-Domain Measurements

ECal calibration and de-embedding for time-domain measurements are performed by the TDR software.

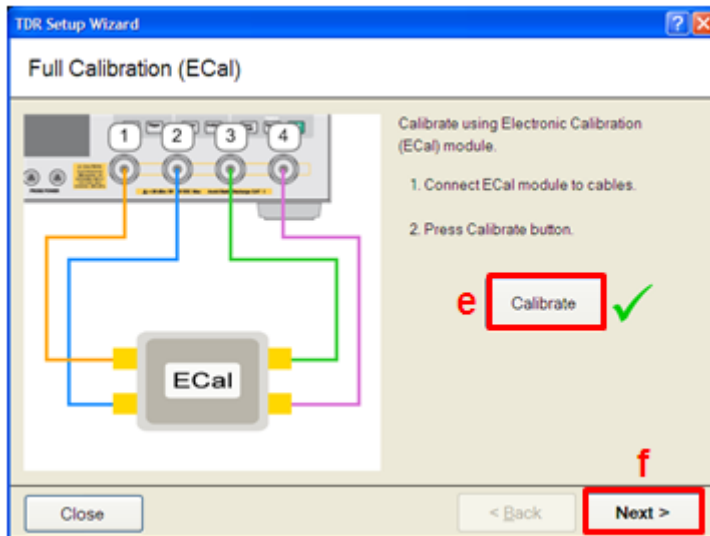
1. ECal Calibration

- a) Press **Channel Next** to select Channel 1.
- b) Click **Setup** tab.
- c) Click **ECal** to launch the TDR Setup Wizard.

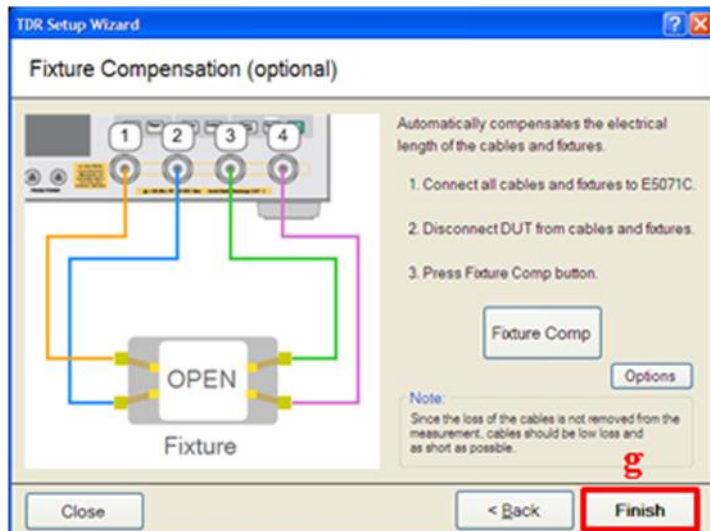


- d) Connect the E5071C ports (port 1 to 4) to the ECal module with RF cables.
- e) Click **Calibrate** to perform ECal Calibration.
- f) Click **Next >**.

Keysight MOI for USB 3.1 Connectors & Cable Assemblies Compliance Tests



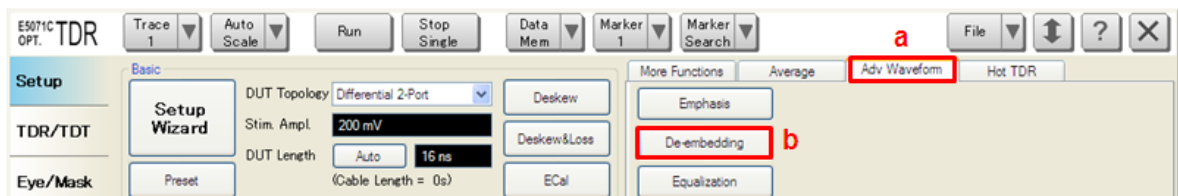
g) Click **Finish** to complete ECal calibration.



2. De-embedding

a) Click **Adv Waveform** tab

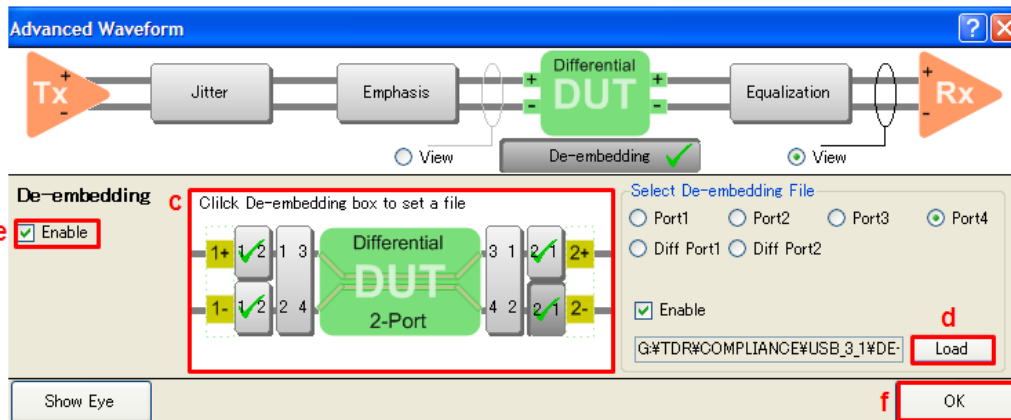
b) Click **De-embedding** to launch Advanced Waveform wizard.



c) Click De-embedding box to set the Touchstone file. 2-port files (*.s2p) for single-ended lines or 4-port files (*.s4p) for differential lines can be selected for the de-embedding function.

d) Load the Touchstone file.

- e) Enable the de-embedding function.
- f) Click **OK**.



Note: For more details about the de-embedding function, refer to the E5071C ENA help below.

http://ena.support.keysight.com/e5071c/manuals/webhelp/eng/measurement/fixture_simulator/obtaining_characteristics_after_embedding_de_embedding_4_port.htm

5.3.1.2. Frequency-Domain Measurements

Ecal calibration and de-embedding for frequency-domain measurements are performed by the E5071C firmware.

1. Ecal Calibration
 - a) Press **Channel Next** to select Channel 2.
 - b) Connect the E5071C ports (port 1 to 4) to the ECal module with RF cables.
 - c) Press **Cal > ECal > 4-Port Cal**.
2. De-embedding (In case of 2-port file)
 - a) Press **Analysis > Fixture Simulator > De-Embedding > Select Port >** and select E5071C's Port (1 to 4) to de-embed fixture trace.
 - b) Press **Analysis > Fixture Simulator > De-Embedding > User File** and specify a 2-port de-embedding file (*.s2p).
 - c) Press **Analysis > Fixture Simulator > De-Embedding > Select Type** to set to **User**.
 - d) Continue the same for the other ports of the E5071C.
 - e) Press **Analysis > Fixture Simulator > De-Embedding** to turn on De-Embedding.
3. De-embedding (In case of 4-port file)

- a) Press **Analysis** > **Fixture Simulator** > **De-Embedding SnP** > **Topology** > **Select Topology** > **C**.
- b) Press **Analysis** > **Fixture Simulator** > **De-Embedding SnP** > **Topology** > **Ports** > **1-3-2-4**.
- c) Press **Analysis** > **Fixture Simulator** > **De-Embedding SnP** > **Topology** > **User File (nwk1)**... and specify a 4-port de-embedding file (*.s4p).
- d) Press **Analysis** > **Fixture Simulator** > **De-Embedding SnP** > **Topology** > **Type (nwk1)** > **De-Embed**.
- e) Press **Analysis** > **Fixture Simulator** > **De-Embedding SnP** > **Topology** > **User File (nwk2)**... and specify a 4-port de-embedding file (*.s4p).
- f) Press **Analysis** > **Fixture Simulator** > **De-Embedding SnP** > **Topology** > **Type (nwk2)** > **De-Embed**.
- g) Press **Analysis** > **Fixture Simulator** > **De-Embedding SnP** > **De-Embedding SnP** to turn on.

Note: For more details about the de-embedding function, refer to the E5071C ENA help below.

http://ena.support.keysight.com/e5071c/manuals/webhelp/eng/measurement/fixture_simulator/obtaining_characteristics_after_embedding_de_embedding_4_port.htm

5.3.2. TRL Calibration

TRL calibration is performed to remove the RF effects (i.e. mismatch, loss or delay) of RF cables and test fixtures. The definition file of TRL calibration standards is imported to the E5071C, and TRL calibration is performed with the E5071C firmware by measuring the TRL calibration standards such as Thru, Short, Lines or Load.

The calibration can be applied for the both channels, channel 1 for time domain measurements and channel 2 for frequency-domain measurements.

5.3.2.1. Selecting TRL Cal Kit

1. Press **Channel Next** to select Channel 1 or Channel 2
2. Press **Cal** > **Cal Kit** and select **User**.
3. Press **Cal** > **Modify Cal Kit** > **Import Cal Kit** and select the cal kit definition file (*.ckx) and click **Open**.
4. Confirm that the imported cal kit is set for the selected channel by pressing **Cal** > **Cal Kit**.

5.3.2.2. Performing TRL Calibration

1. Thru measurement
 - a) Connect Thru standard of USB 3.1 TRL calibration kit to the E5071C port 1 and port 2 with the RF cable.
 - b) Press **Cal** > **Calibrate** > **4-port TRL Cal** > **Thru/Line** > **1-2 Thru/Line**.

Keysight MOI for USB 3.1 Connectors & Cable Assemblies Compliance Tests

- c) Connect Thru standard of USB 3.1 TRL calibration kit to the E5071C port 1 and port 3 with the RF cable.
 - d) Press **Cal > Calibrate > 4-port TRL Cal > Thru/Line > 1-3 Thru/Line**.
 - e) Connect Thru standard of USB 3.1 TRL calibration kit to the E5071C port 3 and port 4 with the RF cable.
 - f) Press **Cal > Calibrate > 4-port TRL Cal > Thru/Line > 3-4 Thru/Line**.
2. Reflect measurement
- a) Connect Short standard of USB 3.1 TRL calibration kit to the E5071C port 1 with the RF cable.
 - b) Press **Cal > Calibrate > 4-port TRL Cal > Reflect > Port1 Reflect**.
 - c) Connect Short standard of USB 3.1 TRL calibration kit to the E5071C port 2 with the RF cable.
 - d) Press **Cal > Calibrate > 4-port TRL Cal > Reflect > Port2 Reflect**.
 - e) Connect Short standard of USB 3.1 TRL calibration kit to the E5071C port 3 with the RF cable.
 - f) Press **Cal > Calibrate > 4-port TRL Cal > Reflect > Port3 Reflect**.
 - g) Connect Short standard of USB 3.1 TRL calibration kit to the E5071C port 4 with the RF cable.
 - h) Press **Cal > Calibrate > 4-port TRL Cal > Reflect > Port4 Reflect**.
3. Line/Match measurement
- a) Connect Line 1 standard of USB 3.1 TRL calibration kit to the E5071C port 1 and port 2 with the RF cable.
 - b) Press **Cal > Calibrate > 4-port TRL Cal > Line/Match > 1-2 Line/Match > Line/Match 1 (Line1)**.
 - c) Connect Line 2 standard of USB 3.1 TRL calibration kit to the E5071C port 1 and port 2 with the RF cable.
 - d) Press **Cal > Calibrate > 4-port TRL Cal > Line/Match > 1-2 Line/Match > Line/Match 2 (Line2)**.
 - e) Connect Line 3 standard of USB 3.1 TRL calibration kit to the E5071C port 1 and port 2 with the RF cable.
 - f) Press **Cal > Calibrate > 4-port TRL Cal > Line/Match > 1-2 Line/Match > Line/Match 3 (Line3)**.
 - g) Connect Line 4 standard of USB 3.1 TRL calibration kit to the E5071C port 1 and port 2 with the RF cable.
 - h) Press **Cal > Calibrate > 4-port TRL Cal > Line/Match > 1-2 Line/Match > Line/Match 4 (Line4)**.
 - i) Connect Load standard of USB 3.1 TRL calibration kit to the E5071C port 1 and port 2 with the RF cable.

- j) Press **Cal > Calibrate > 4-port TRL Cal > Line/Match > 1-2 Line/Match > Line/Match 5 (Load)**.
 - k) Press **Cal > Calibrate > 4-port TRL Cal > Line/Match > 1-3 Line/Match** and repeat step a) to step j) by connecting line and load standards to the E5071C port 1 and port 3 with the RF cable.
 - l) Press **Cal > Calibrate > 4-port TRL Cal > Line/Match > 3-4 Line/Match** and repeat step a) to step j) by connecting line and load standards to the E5071C port 3 and port 4 with the RF cable.
4. Press **Cal > Calibrate > 4-port TRL Cal > Done** to complete calibration. The calibration coefficients are calculated and the error correction is automatically turned on.
 5. Repeat the above TRL calibration for another channel after confirming that the imported cal kit is set for the channel by pressing **Cal > Cal Kit**.

5.3.3. Adjustment of Effective Rise Time

After performing the calibration, the effective rise time entering the USB 3.1 connector pins is adjusted for the specification in time-domain measurements (Table 5-1).

1X Thru standard is connected to the E5071C port with RF cables. DUT is disconnected during the adjustment procedure.

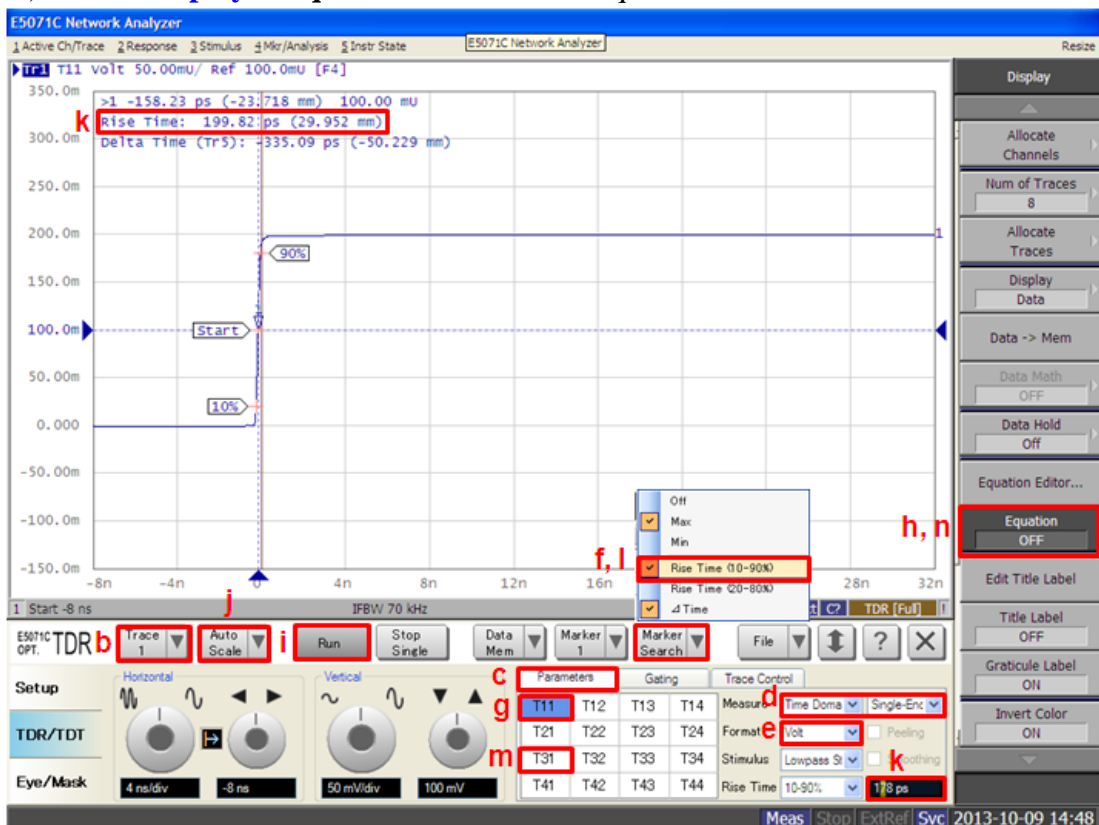
Table 5-1 Specification of Effective Rise Time

Trace	Test Items	Rise Time %	Target Rise Time
Tr 1 & 5	D+/D- Pair Propagation Delay Skew	10 – 90 %	200 ps
Tr 2	D+/D- Pair Propagation Delay	10 – 90 %	200 ps
Tr 6	Differential Crosstalk between D+/D- and SuperSpeed Gen 2 Signal Pairs	10 – 90 %	500 ps
Tr 3 & 7	[Raw Cable] Characteristic Impedance	10 – 90 %	200 ps
Tr 4 & 8	[Mated Connector] Impedance	20 – 80 %	40 ps

1. Press **Channel Next** to select Channel 1.
2. Press **Trace Max** to maximize the selected trace in the screen.
3. Open **TDR/TDT** tab.
4. Adjust effective rise time for each trace with the following procedure.
 - Trace 1 (Trace 5) (Adjust effective rise time for Trace 1 then Trace 5)
 - a) Connect 1X Thru standard to the E5071C port 1 (port 2) with the RF cable.
 - b) Click **Trace 1 (Trace 5)**.
 - c) Click **Parameter** tab.
 - d) Select Measure to “Time Domain” and “Single-Ended”.
 - e) Select Format to “Volt”.
 - f) Click **Marker Search** and select “Rise Time (10–90%)”.

Keysight MOI for USB 3.1 Connectors & Cable Assemblies Compliance Tests

- g) Click **T11 (T22)**.
- h) Press **Display > Equation** to turn off the equation editor.
- i) Click **Run** to measure the rise time on the screen.
- j) Click **Auto Scale** and select “X&Y”.
- k) Enter rise time until the measured rise time is close to the specified value (200 ps).
- l) Click **Marker Search** and select “Rise Time (10–90%)” to turn off the marker.
- m) Click **T31 (T42)**.
- n) Press **Display > Equation** to turn on the equation editor.



- Trace 2
 - a) Connect 1X Thru standard to the E5071C port 1 with the RF cable.
 - b) Click **Trace 2**.
 - c) Click **Parameter** tab.
 - d) Select Measure to “Time Domain” and “Single-Ended”.
 - e) Select Format to “Volt”.
 - f) Click **Marker Search** and select “Rise Time (10–90%)”.
 - g) Click **T11**.
 - h) Click **Run** to measure the rise time on the screen.
 - i) Click **Auto Scale** and select “X&Y”.
 - j) Enter rise time until the measured rise time is close to the specified value (200

- ps).
 - k) Click **Marker Search** and select “Rise Time (10–90%)” to turn off the marker.
 - l) Select Measure to “Time Domain” and “Differential”.
 - m) Click **Tdd21**.
- Trace 6
 - a) Connect 1X Thru standard to the E5071C port 1 with the RF cable.
 - b) Click **Trace 6**.
 - c) Click **Parameter** tab.
 - d) Select Measure to “Time Domain” and “Single-Ended”.
 - e) Select Format to “Volt”.
 - f) Click **Marker Search** and select “Rise Time (10–90%)”.
 - g) Click **T11**.
 - h) Click **Run** to measure the rise time on the screen.
 - i) Click **Auto Scale** and select “X&Y”.
 - j) Enter rise time until the measured rise time is close to the specified value (500 ps).
 - k) Click **Marker Search** and select “Rise Time (10–90%)” to turn off the marker.
 - l) Select Measure to “Time Domain” and “Differential”.
 - m) Click **Tdd21**.
 - Trace 3 (Trace 7) (Adjust effective rise time for Trace 3 then Trace 7)
 - a) Connect 1X Thru standard to the E5071C port 1 (port 3) with the RF cable.
 - b) Click **Trace 3 (Trace 7)**.
 - c) Click **Parameter** tab.
 - d) Select Measure to “Time Domain” and “Single-Ended”.
 - e) Select Format to “Volt”.
 - f) Click **Marker Search** and select “Rise Time (10–90%)”.
 - g) Click **T11 (T33)**.
 - h) Click **Run** to measure the rise time on the screen.
 - i) Click **Auto Scale** and select “X&Y”.
 - j) Enter rise time until the measured rise time is close to the specified value (200 ps).
 - k) Click **Marker Search** and select “Rise Time (10–90%)” to turn off the marker.
 - l) Select Measure to “Time Domain” and “Differential”.
 - m) Select Format to “Impedance”.
 - n) Click **Tdd11 (Tdd22)**.
 - Trace 4 (Trace 8) (Adjust effective rise time for Trace 4 then Trace 8)
 - a) Connect 1X Thru standard to the E5071C port 1 (port 3) with the RF cable.

Keysight MOI for USB 3.1 Connectors & Cable Assemblies Compliance Tests

- b) Click **Trace 4 (Trace 8)**.
- c) Click **Parameter** tab.
- d) Select Measure to “Time Domain” and “Single-Ended”.
- e) Select Format to “Volt”.
- f) Click **Marker Search** and select “Rise Time” (20–80 %).
- g) Click **T11 (T33)**.
- h) Click **Run** to measure the rise time on the screen.
- i) Click **Auto Scale** and select “X&Y”.
- j) Enter rise time until the measured rise time is close to the specified value (40 ps).
- k) Click **Marker Search** and select “Rise Time” (20–80 %) to turn off the marker.
- l) Select Measure to “Time Domain” and “Differential”.
- m) Select Format to “Impedance”.
- n) Click **Tdd11 (Tdd22)**.

5.4. Measurement

The connections for cable assembly, raw cable and mated connector are assumed as follows (Note: TF stands for Test Fixture).

[Cable Assembly]

TF1	Cable Assembly		TF2
Std-A (Receptacle)	Std-A (Plug)	Micro-B (Plug)	Micro-B (Receptacle)
D+/D-	⇔		D+/D-
Tx+/Tx-	⇔		Rx+/Rx-
Rx+/Rx-	⇔		Tx+/Tx-

[Raw Cable]

A Side	Raw Cable	B Side
D+/D-	⇔	D+/D-
Tx+/Tx-	⇔	Tx+/Tx-
Rx+/Rx-	⇔	Rx+/Rx-

[Mated Connector]

TF1	Mated Connector	TF2
Std-A (Receptacle)		Micro-B (Receptacle)
D+/D-	⇔	D+/D-
Tx+/Tx-	⇔	Tx+/Tx-
Rx+/Rx-	⇔	Rx+/Rx-

5.4.1. D+/D- Pair Propagation Delay Skew

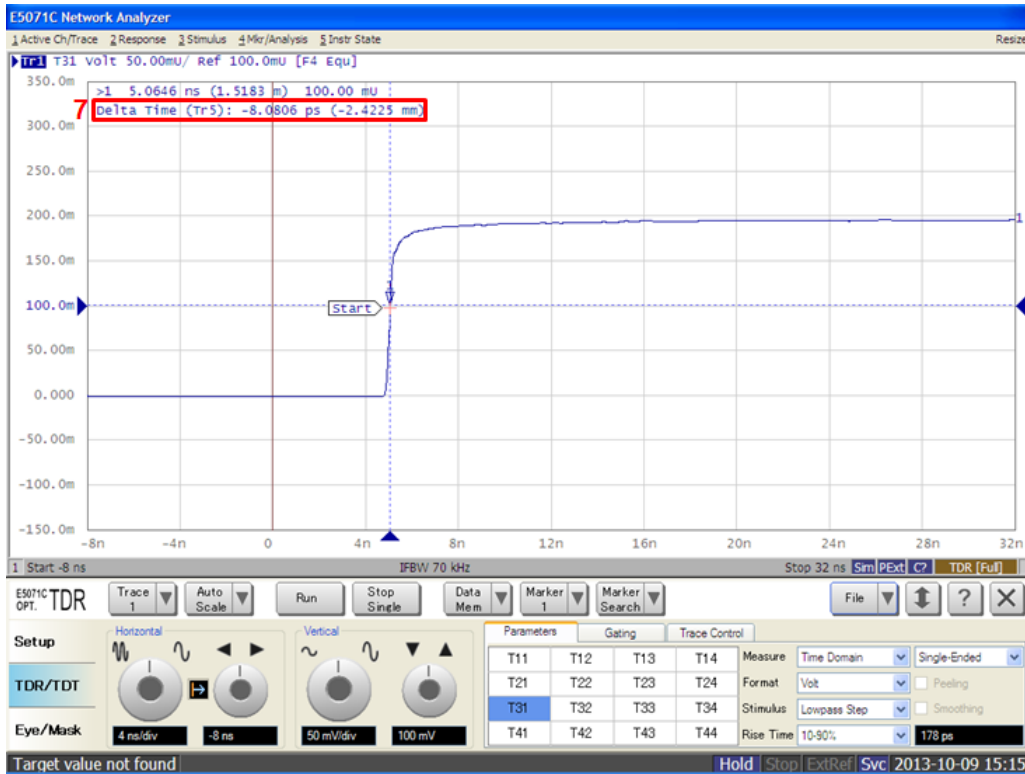
The propagation delay skew measurement ensures that the signal on both the D+ and D- lines of cable assembly arrive at the receiver at the same time.

1. Connect the E5071C ports (port 1 to port 4) to the test fixture ports with RF cables.

E5071C	Port 1	Port 2	Port 3	Port 4
Test Fixtures	TF1 D+	TF1 D-	TF2 D+	TF2 D-

Note: Unused fixture pots should be terminated with 50 ohm terminators.

2. Press **Channel Next** to select Channel 1.
3. Press **Channel Max** to maximize Channel 1 on the screen.
4. Press **Trace Max** to maximize the selected trace on the screen.
5. Select **Trace 1 (T31)**.
6. Click **Stop Single**.



7. Read Delta Time (Tr5) on the E5071C screen.
8. Confirm the measured intra-pair skew of D+/D- pair is lower than 100 psec.

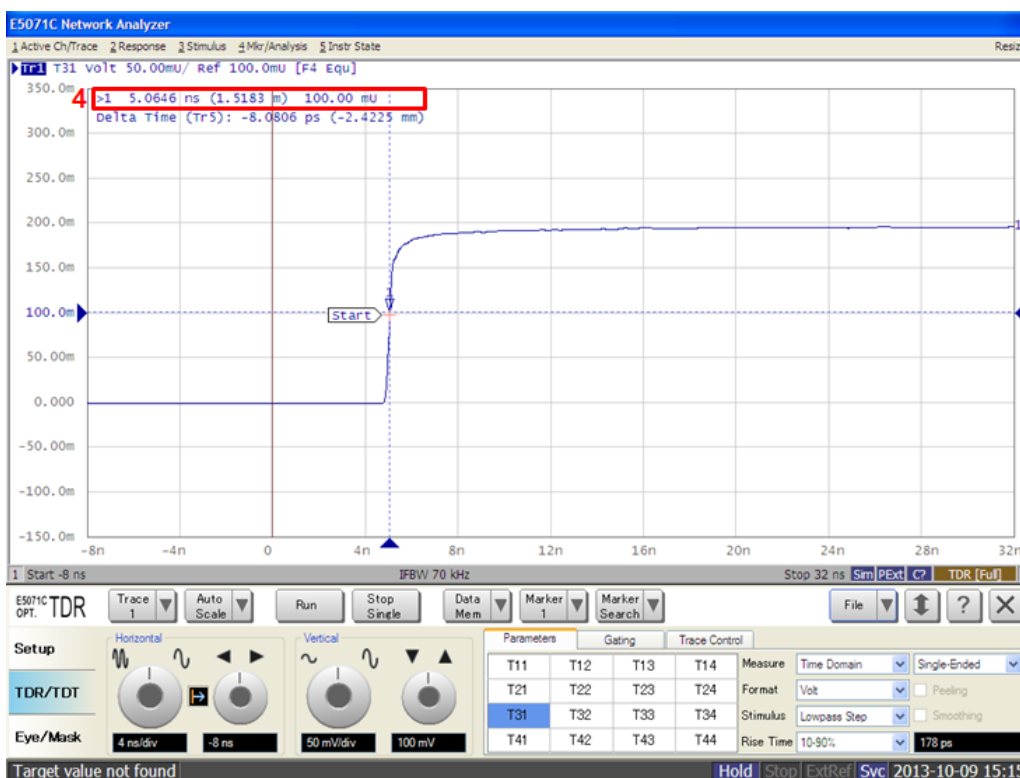
5.4.2. D+/D- Pair Propagation Delay

The propagation delay measurement is to verify the end-to-end propagation of the D+/D- lines of the cable assembly.

1. Connect the E5071C ports (port 1 to port 4) to the test fixture ports with RF cables.

E5071C	Port 1	Port 2	Port 3	Port 4
Test Fixtures	TF1 D+	TF1 D-	TF2 D+	TF2 D-

2. Select **Trace 2 (Tdd21)**.
3. Click **Stop Single**.



4. Read marker value of Trace 2 on the screen.
5. Confirm the measured propagation delay is within the limit shown below.

Connector Type	Limit
Standard-A to Standard-B Standard-A to Standard-A	<26 nsec
Standard-A to Micro-AB Micro-AB to Micro-AB Micro-AB to Standard-B	<10 nsec

5.4.3. Differential Crosstalk between D+/D- and SuperSpeed Gen 2 Signal Pairs

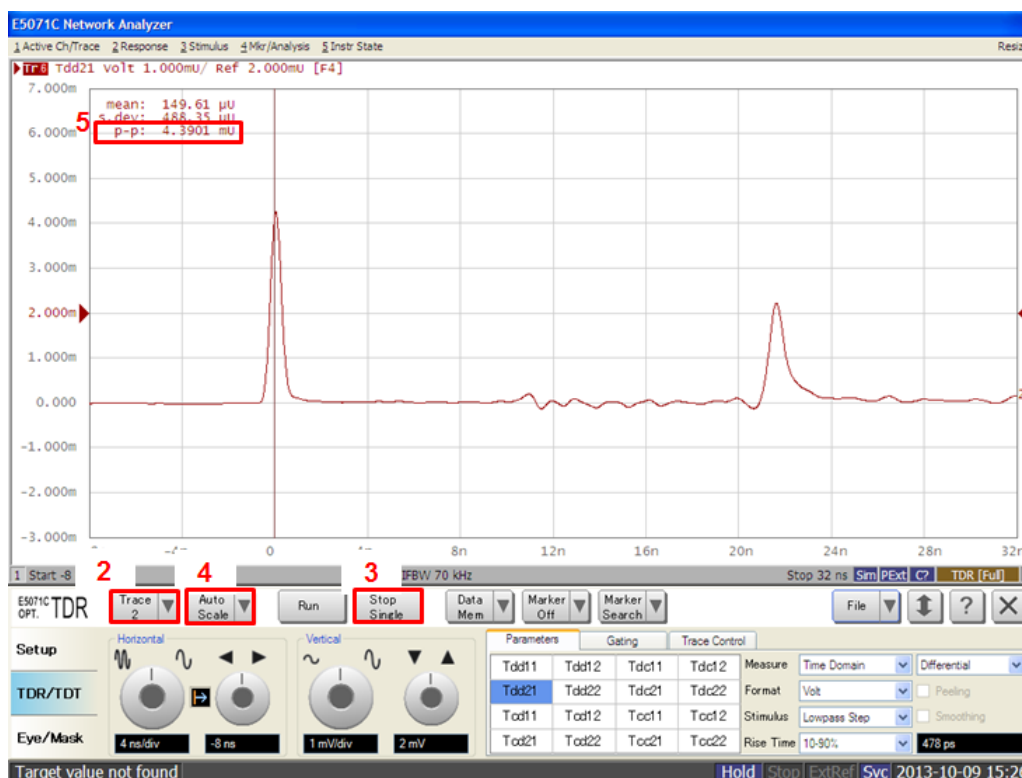
The differential near-end crosstalk (DDNEXT) and far-end crosstalk (DDFEXT) between the D+/D- pair and the SuperSpeed Gen 2 signal pairs shall be measured in time domain for the mated cable assembly.

1. Connect the E5071C ports (port 1 to port 4) to the test fixture ports with RF cables.

E5071C	Port 1	Port 2	Port 3	Port 4
Test Fixtures	TF1 D+	TF1 D-	TF1 Tx+	TF1 Tx-

2. Select **Trace 6 (Tdd21)**.
3. Click **Stop Single**.
4. Click **Auto Scale** and select "X&Y".
5. Read the peak-to-peak (p-p) value on the screen.

Keysight MOI for USB 3.1 Connectors & Cable Assemblies Compliance Tests



6. Confirm the measured crosstalk in percentage does not exceed the limits below.
 - USB 3.1 Standard-A connector: 2 % (p-p \leq 8 mV)
 - USB 3.1 Standard-B connector: 2 % (p-p \leq 8 mV)
 - USB 3.1 Micro connector family: 2 % (p-p \leq 8 mV)
7. Connect the E5071C ports to the test fixture ports, and repeat step 3 to step 6 to confirm the measured crosstalk for all the following combinations is within the specification.

E5071C	Port 1	Port 2	Port 3	Port 4
Test Fixtures	TF1 D+	TF1 D-	TF1 Rx+	TF1 Rx-
	TF1 D+	TF1 D-	TF2 Tx+	TF2 Tx-
	TF1 D+	TF1 D-	TF2 Rx+	TF2 Rx-
	TF2 D+	TF2 D-	TF2 Tx+	TF2 Tx-
	TF2 D+	TF2 D-	TF2 Rx+	TF2 Rx-
	TF2 D+	TF2 D-	TF1 Tx+	TF1 Tx-
	TF2 D+	TF2 D-	TF1 Rx+	TF1 Rx-

5.4.4. D+/D- Pair Attenuation

1. Connect the E5071C ports (port 1 to 4) to the test fixture ports with RF cables.

E5071C	Port 1	Port 2	Port 3	Port 4
Test Fixtures	TF1 D+	TF2 D+	TF1 D-	TF2 D-

2. Press **Channel Next** to select Channel 2.
3. Press **Trace Next** to select Trace 1 (Sdd21).

4. Press **Trace Max** to maximize the selected trace on the screen.
5. Press **Trigger > Single**.
6. Confirm the measured attenuation of D+/D- pair is within the limit shown below.

Start Frequency	Stop Frequency	Start Limit	Stop Limit
12 MHz	24 MHz	-670 mdB	-950 mdB
24 MHz	48 MHz	-950 mdB	-1.35 dB
48 MHz	96 MHz	-1.35 dB	-1.9 dB
96 MHz	200 MHz	-1.9 dB	-3.2 dB
200 MHz	400 MHz	-3.2 dB	-5.8 dB

5.4.5. Channel Metrics (eH, eW, ILfitatNq, IMR and IXT)

The test results of channel metrics are checked with a standard tool (*CableComp Tool*) provided by USB-IF. Six 4-port Touchstone files (*.s4p) are measured and saved by the E5071C firmware, and then imported by the compliance tool to conduct cable assembly compliance test of the channel metrics.

1. Connect the E5071C ports (port 1 to 4) to the test fixture ports with RF cables.

Test path name	Port 1	Port 2	Port 3	Port 4
host_tx_pair_thru	TF1 Tx+	TF2 Rx+	TF1 Tx-	TF2 Rx-

2. Press **Trace Next** to select Trace 1 (Sdd21).
3. Press **Trigger > Single**.
4. Press **Save/Recall > Save SnP > S4P > [1-2-3-4]...** to save the measured Touchstone file.
5. Connect the E5071C ports with test fixture ports shown below and repeat step 3 to step 4 to save all necessary Touchstone files (*.s4p) in the E5071C.

Test path name	Port 1	Port 2	Port 3	Port 4
host_rx_pair_thru	TF1 Rx+	TF2 Tx+	TF1 Rx-	TF2 Tx-
a-side_next	TF1 Rx+	TF1 Tx+	TF1 Rx-	TF1 Tx-
a-b_fext	TF1 Rx+	TF2 Rx+	TF1 Rx-	TF2 Rx-
b-side_next	TF2 Tx+	TF2 Rx+	TF2 Tx-	TF2 Rx-
b-a_fext	TF2 Tx+	TF1 Tx+	TF2 Tx-	TF1 Tx-

6. Launch compliance test tool and import six 4-port Touchstone files (*.s4P) for pass/fail judgement.

5.4.6. Differential to Common-Mode Conversion

1. Connect the E5071C ports (port 1 to 4) to the test fixture ports with RF cables.

E5071C	Port 1	Port 2	Port 3	Port 4
Test Fixtures	TF1 Tx+	TF2 Rx+	TF1 Tx-	TF2 Rx-

2. Press **Trace Next** to select Trace 2 (Scd21).
3. Press **Trigger > Single**.

- Confirm the measured differential to common-mode conversion is less than or equal to -20 dB across the frequency range from 100 MHz to 10 GHz.

Note: The conversion does not require embedding the reference host and the reference device with the mated cable assembly; it is for the mated cable assembly only.

- Connect the E5071C ports to the test fixture ports.

E5071C	Port 1	Port 2	Port 3	Port 4
Test Fixtures	TF1 Rx+	TF2 Tx+	TF1 Rx-	TF2 Tx-

- Repeat the same operation of step 3 to step 4 to confirm the measured differential to common-mode conversion is within the specification.

5.4.7. Cable Shielding Effectiveness

- Connect the E5071C ports (port 1 to 3) to the test fixture ports with RF cables.

E5071C	Port 1 (SE)	Port 2 (Bal+)	Port 3 (Bal-)
Test Fixtures	SE	Tx+	Tx-

- Press **Analysis** > **Fixture Simulator** > **Topology** > **Device** > **SE-Bal**.
- Press **Analysis** > **Fixture Simulator** > **Topology** > **Port1(se)** > **1**.
- Press **Analysis** > **Fixture Simulator** > **Topology** > **Port2(bal)** > **2-3**.
- Press **Analysis** > **Fixture Simulator** > **De-Embedding** to turn off De-Embedding.
- Press **Trace Next** to select Trace 3.
- Press **Meas** > **Sds21**.
- Press **Trace Next** to select Trace 4.
- Press **Meas** > **Scs21**.
- Press **Trigger** > **Single**.
- Confirm the measured Sds21/Scs21 is less than or equal to -40 dB in the frequency range from 100 MHz to 10 GHz.
- Repeat the same operation of step 10 to step 11 for all the following combinations to confirm the measured Sds21/Scs21 is within the specification.

E5071C	Port 1 (SE)	Port 2 (Bal+)	Port 3 (Bal-)
Test Fixtures	SE	Rx+	Rx-
	SE	D+	D-

- Press **Analysis** > **Fixture Simulator** > **Topology** > **Device** > **Bal-Bal**.
- Press **Analysis** > **Fixture Simulator** > **Topology** > **Port1(bal)** > **1-3**.
- Press **Analysis** > **Fixture Simulator** > **Topology** > **Port2(bal)** > **2-4**.
- Press **Analysis** > **Fixture Simulator** > **De-Embedding** to turn on De-Embedding.

Informative electrical performance targets are provided for raw cables, mated connectors, and mated cable assemblies. These targets are not part of the USB 3.1 compliance requirements, but provided for the purpose of design guidelines and manufacturing control.

5.4.8. [Raw Cable] Characteristic Impedance (Informative)

1. Connect the E5071C ports (port 1 to 4) to the test fixture ports with RF cables.

E5071C	Port 1	Port 2	Port 3	Port 4
RF Connection	A Side Tx+	A Side Tx-	B Side Tx+	B Side Tx-

2. Press **Channel Next** to select Channel 1.
3. Select **Trace 3 (Tdd11)**.
4. Click **Stop Single**.
5. Confirm the measured characteristic impedance is within the limit shown below.

	Min	Max	Unit	Note
Differential characteristic impedance	85	95	Ohm	*1
Single-ended characteristic impedance	42	48	Ohm	

- *1. For the Shielded Differential Pair (SDP)
6. Select **Trace 7 (Tdd22)** and repeat step 5 for the impedance measurement at the device-end of DUT.
7. Connect the E5071C ports (port 1 to 4) to the test fixture ports with RF cables.

E5071C	Port 1	Port 2	Port 3	Port 4
RF Connection	A Side Rx+	A Side Rx-	B Side Rx+	B Side Rx-

8. Repeat the same operation of step 3 to step 6 to confirm the measured impedance is within the specification.

5.4.9. [Raw Cable] Intra-Pair Skew (Informative)

1. Connect the E5071C ports (port 1 to 4) to the test fixture ports with RF cables.

E5071C	Port 1	Port 2	Port 3	Port 4
RF Connection	A Side Tx+	A Side Tx-	B Side Tx+	B Side Tx-

2. Select **Trace 1 (T31)**.
3. Click **Stop Single**.
4. Confirm the measured intra-pair skew is less than 15 ps/m.
5. Connect the E5071C ports (port 1 to 4) to the test fixture ports with RF cables.

E5071C	Port 1	Port 2	Port 3	Port 4
RF Connection	A Side Rx+	A Side Rx-	B Side Rx+	B Side Rx-

6. Repeat the same operation of step 3 to step 5 to confirm the measured skew for Rx pair is within the specification.

5.4.10. [Raw Cable] Differential Insertion Loss (Informative)

1. Connect the E5071C ports (port 1 to 4) to the test fixture ports with RF cables.

E5071C	Port 1	Port 2	Port 3	Port 4
RF Connection	A Side Tx+	B Side Tx+	A Side Tx-	B Side Tx-

2. Press **Channel Next** to select Channel 2.
 3. Press **Trace Next** to select Trace 5 (Sdd21).
 4. Press **Trigger > Single**.
 5. Confirm the measured differential insertion loss is xx.
 6. Connect the E5071C ports (port 1 to 4) to the test fixture ports with RF cables.
- | E5071C | Port 1 | Port 2 | Port 3 | Port 4 |
|---------------|------------|------------|------------|------------|
| RF Connection | A Side Rx+ | B Side Rx+ | A Side Rx- | B Side Rx- |
7. Repeat the same operation of step 4 to step 5 to confirm the measured insertion loss is within the specification.

5.4.11. [Mated Connector] Impedance (Informative)

1. Connect the E5071C ports (port 1 to 4) to the test fixture ports with RF cables.
- | E5071C | Port 1 | Port 2 | Port 3 | Port 4 |
|---------------|---------|---------|---------|---------|
| Test Fixtures | TF1 Tx+ | TF1 Tx- | TF2 Tx+ | TF2 Tx- |
2. Press **Channel Next** to select Channel 1.
 3. Select **Trace 4 (Tdd11)**.
 4. Click **Stop Single**.
 5. Confirm the measured characteristic impedance is within the limit, 90 +- 10 ohm.
 6. Select **Trace 8 (Tdd22)** and repeat step 5 for the far end of DUT.
 7. Connect the E5071C ports (port 1 to 4) to the test fixture ports with RF cables.
- | E5071C | Port 1 | Port 2 | Port 3 | Port 4 |
|---------------|---------|---------|---------|---------|
| Test Fixtures | TF1 Rx+ | TF1 Rx- | TF2 Rx+ | TF2 Rx- |
8. Repeat the same operation of step 3 to step 6 to confirm the measured impedance for Rx pair is within the specification.

5.4.12. [Mated Cable Assembly] Differential Insertion Loss (Informative)

1. Connect the E5071C ports (port 1 to 4) to the test fixture ports with RF cables.
- | E5071C | Port 1 | Port 2 | Port 3 | Port 4 |
|---------------|---------|---------|---------|---------|
| Test Fixtures | TF1 Tx+ | TF2 Tx+ | TF1 Tx- | TF2 Tx- |
2. Press **Channel Next** to select Channel 2.
 3. Press **Trace Next** to select Trace 6 (Sdd21).
 4. Press **Trigger > Single**.
 5. Confirm the measured differential insertion loss is less than or equal to -6 dB from DC to 5 GHz and no strong resonance within DC to 5 GHz.
 6. Connect the E5071C ports (port 1 to 4) to the test fixture ports with RF cables.
- | E5071C | Port 1 | Port 2 | Port 3 | Port 4 |
|---------------|---------|---------|---------|---------|
| Test Fixtures | TF1 Rx+ | TF2 Rx+ | TF1 Rx- | TF2 Rx- |
7. Repeat the same operation of step 4 to step 5 to confirm the measured insertion loss for Rx pair is within the specification.

5.4.13. [Mated Cable Assembly] Differential Near-end Crosstalk (NEXT) between SuperSpeed Gen 2 Signal Pairs (Informative)

1. Connect the E5071C ports (port 1 to 4) to the test fixture ports with RF cables.

E5071C	Port 1	Port 2	Port 3	Port 4
Test Fixtures	TF1 Tx+	TF1 Rx+	TF1 Tx-	TF1 Rx-

2. Press **Trace Next** to select Trace 7 (Sdd21).
3. Press **Trigger > Single**.
4. Confirm the measured differential crosstalk is less than or equal to -34 dB up to 5 GHz.
5. Connect the E5071C ports (port 1 to 4) to the test fixture ports with RF cables.

E5071C	Port 1	Port 2	Port 3	Port 4
Test Fixtures	TF2 Tx+	TF2 Rx+	TF2 Tx-	TF2 Rx-

6. Repeat the same operation of step 3 to step 4 to confirm the measured NEXT for the far end is within the specification.

5.4.14. [Mated Cable Assembly] Differential Near-end and Far-end Crosstalk (NEXT and FEEXT) between D+/D- Pair and SuperSpeed Gen 2 Signal Pairs (Informative)

1. Connect the E5071C ports (port 1 to 4) to the test fixture ports with RF cables.

E5071C	Port 1	Port 2	Port 3	Port 4
Test Fixtures	TF1 D+	TF1 Tx+	TF1 D-	TF1 Tx-

2. Press **Trace Next** to select Trace 8 (Sdd21).
3. Press **Trigger > Single**.
4. Confirm the measured differential crosstalk is less than or equal to -30 dB up to 5 GHz.
5. Repeat the same operation of step 3 to step 4 for all the following combinations to confirm the measured crosstalk is within the specification.

E5071C	Port 1	Port 2	Port 3	Port 4
Test Fixtures	TF1 D+	TF1 Rx+	TF1 D-	TF1 Rx-
	TF1 D+	TF2 Tx+	TF1 D-	TF2 Tx-
	TF1 D+	TF2 Rx+	TF1 D-	TF2 Rx-
	TF2 D+	TF2 Tx+	TF2 D-	TF2 Tx-
	TF2 D+	TF2 Rx+	TF2 D-	TF2 Rx-
	TF2 D+	TF1 Tx+	TF2 D-	TF1 Tx-
	TF2 D+	TF1 Rx+	TF2 D-	TF1 Rx-

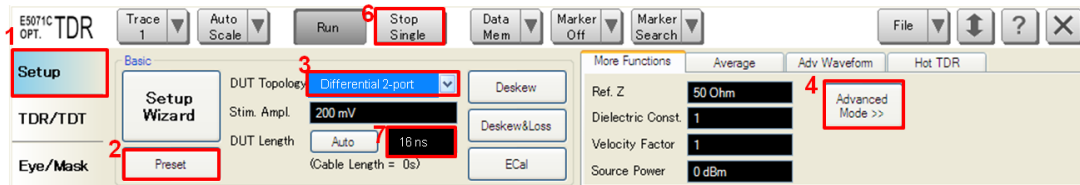
6. [Appendix] Manual Setup

The procedures of manual setup for time-domain and frequency-domain measurements are introduced in the section. All the following parameters are saved in the E5071C's state file, which is available at: http://www.keysight.com/find/ena-tdr_usb3_1-cabcon

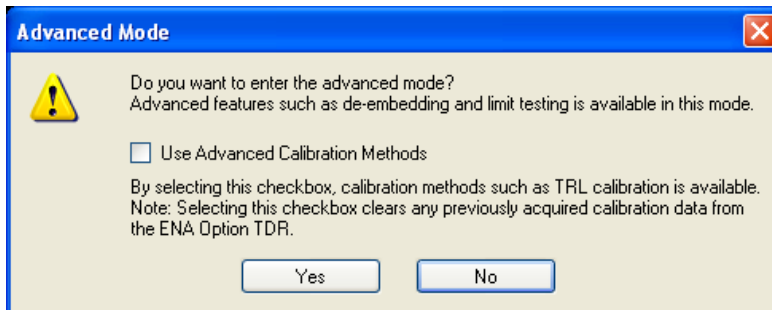
6.1. Channel & Trace Setup

If TDR setup wizard is shown when launching the TDR software, click **Close** button in the TDR setup wizard main window.

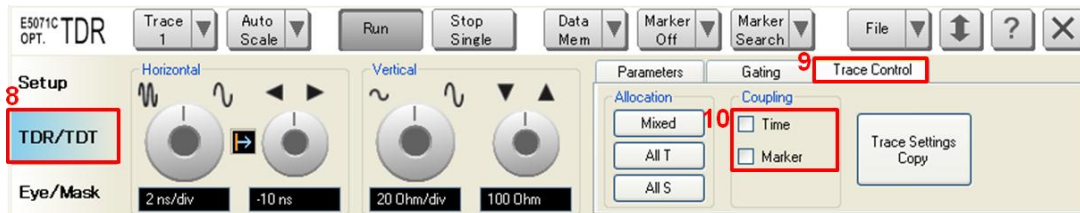
1. Open **Setup** tab in the TDR software.
2. Click **Preset** to preset the instrument. Click **OK** in a dialog box to continue.
3. Set **DUT Topology** to “Differential 2-Port”. Click **OK** in a dialog box.
4. Click **Advanced Mode**>>.



5. A dialog box appears requesting for confirmation. Then click **Yes**. (Clear the check box for “Use Advanced Calibration Methods”)



6. Click **Stop Single**.
7. Set DUT Length to “16 ns”.
8. Open **TDR/TDT** tab.
9. Click **Trace Control** tab.
10. Clear **Time** and **Marker** check box under Coupling.



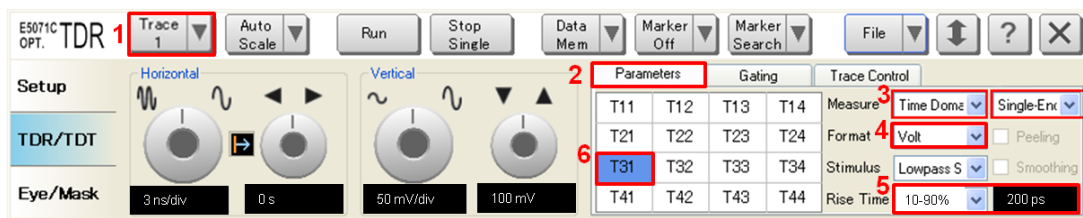
11. Press **Display** > **Allocate Channels** > .

12. Press **Channel Max** to maximize the screen of channel 1.

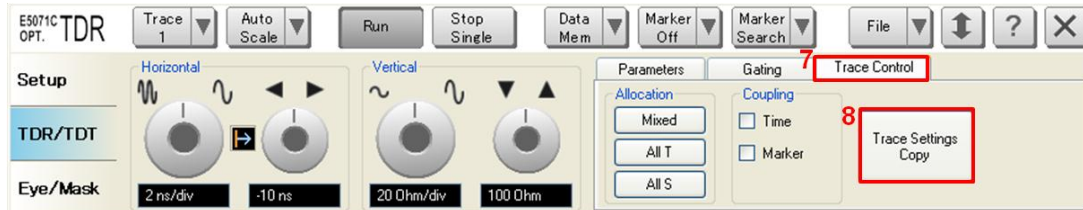
6.2. D+/D- Pair Propagation Delay Skew

6.2.1. Parameter Setup

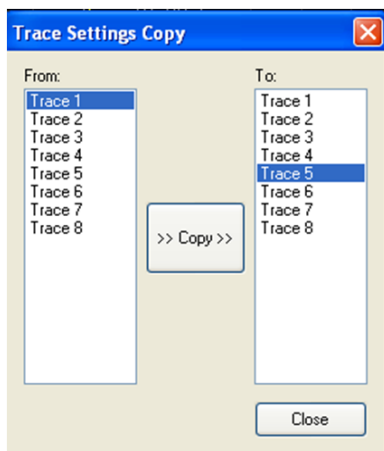
1. Select **Trace 1**.
2. Open **Parameters** tab.
3. Select “Time Domain” and “Single-Ended” for Measure.
4. Select Formant to “Volt”.
5. Select **Rise Time** to 10-90% and input value (200 ps).
6. Click **T31**.



7. Open **Trace Control** tab.
8. Click **Trace Settings Copy** to launch trace copy dialog box.

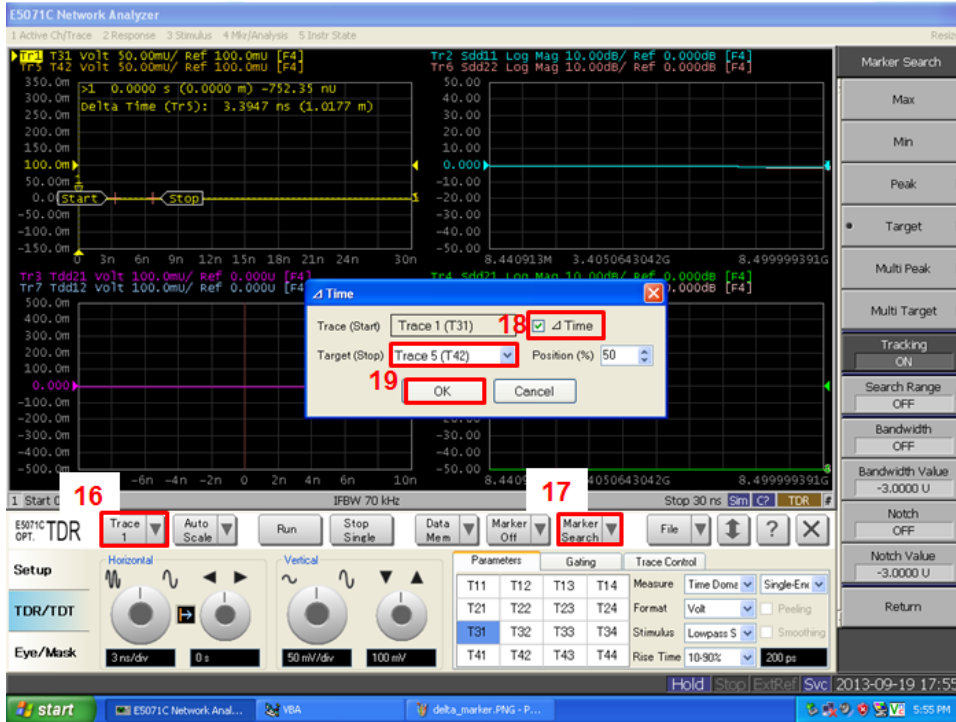


9. Select Trace 1 in the From list.
10. Select Trace 5 in the To list.
11. Click **Copy**.
12. Click **Close**.



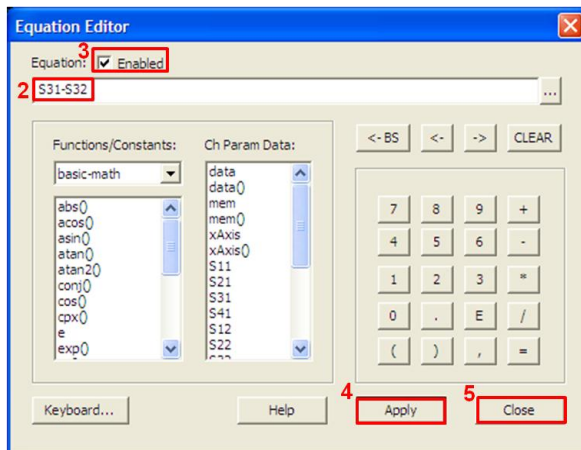
13. Select **Trace 5**.
14. Open **Parameters** tab.

15. Click **T42**.
16. Select **Trace 1** (T31) .
17. Click **Marker Search** and select **Δ Time**.
18. Check **Δ Time**.
19. Select **Target (Stop)** to Trace 5 and click **OK**.



6.2.2. Crosstalk Compensation

1. Select **Trace 1**.
2. Press **Display** > **Equation Editor...** > Enter an equation “**S31-S32**”.
3. Check **Enabled** to enable the equation on trace.
4. Click **Apply**.
5. Click **Close**.



6. Select **Trace 5**.
7. Press **Display** > **Equation Editor...** > Enter an equation “**S42-S41**”.
8. Check **Enabled** to enable the equation on trace.
9. Click **Apply**.
10. Click **Close**.

6.3. D+/D- Pair Propagation Delay

1. Select **Trace 2**.
2. Open **Parameters** tab.
3. Select “Time Domain” and “Differential” for Measure.
4. Select Formant to “Volt”.
5. Select **Rise Time** to 10-90% and input value (200 ps).
6. Click **Tdd21**.
7. Input vertical scale (100 mV/div) and vertical position (200 mV).
8. Press **Marker Search** > **Target** > **Target Value** and enter 200 mU.
9. Press **Marker Search** and turn on **Tracking**.

6.4. Differential Crosstalk between D+/D- and SuperSpeed Gen 2 Signal Pairs

1. Select **Trace 6**.
2. Open **Parameters** tab.
3. Select “Time Domain” and “Differential” for Measure.
4. Select Formant to “Volt”.
5. Select **Rise Time** to 10-90% and input value (500 ps).
6. Click **Tdd21**.
7. Press **Marker Fctn** > **Statistics** > and turn it **ON**.

6.5. [Raw Cable] Characteristic Impedance (Informative)

1. Select **Trace 3**.
2. Open **Parameters** tab.
3. Select “Time Domain” and “Differential” for Measure.
4. Select Format to “Impedance”
5. Select **Rise Time** to 10-90% and input value (200 ps).
6. Click **Tdd11**.
7. Input vertical scale (10 Ohm/div) and vertical position (50 Ohm).
8. Open **Trace Control** tab.
9. Click **Trace Settings Copy** to launch trace copy dialog box.
10. Select the Trace 3 in the From list.
11. Select the Trace 7 in the To list.
12. Click **Copy**.

13. Click **Close**.
14. Select **Trace 7**.
15. Open **Parameter** tab.
16. Click **Tdd22**.

6.6. [Mated Connector] Impedance (Informative)

1. Select **Trace 4**.
2. Open **Parameters** tab.
3. Select “Time Domain” and “Differential” for Measure.
4. Select Format to “Impedance”
5. Select **Rise Time** to 20-80% and input value (40 ps).
6. Click **Tdd11**.
7. Input vertical scale (10 Ohm/div) and vertical position (50 Ohm).
8. Open **Trace Control** tab.
9. Click **Trace Settings Copy** to launch trace copy dialog box.
10. Select the Trace 4 in the From list.
11. Select the Trace 8 in the To list.
12. Click **Copy**.
13. Click **Close**.
14. Select **Trace 8**.
15. Open **Parameters** tab.
16. Click **Tdd22**.

6.7. Common Parameters Setup for Frequency-domain Measurements

1. Press **Channel Next** to select Channel 2.
2. Press **Sweep Setup** > **Points** and set to “1,601”.
3. Press **Start** > Set start value to “10 MHz”.
4. Press **Stop** > Set stop value to “12 GHz”.
5. Press **Avg** > Set **IF Bandwidth** to “1 kHz”.
6. Press **Analysis** > **Fixture Simulator** and turn it **ON**.
7. Press **Analysis** > **Fixture Simulator** > **Topology** > **Device** > **Bal-Bal**
8. Press **Analysis** > **Fixture Simulator** > **Topology** > **Port1 (bal)** > **1-3**
9. Press **Analysis** > **Fixture Simulator** > **Topology** > **Port2 (bal)** > **2-4**
10. Press **Display** > **Num of Traces** > 8.
11. Press **Display** > **Allocate Traces** > x8 (2 columns by 4 rows).
12. Press **Analysis** > **Fixture Simulator** > **BalUn ON All Traces** to enable mixed-mode S-parameters (i.e. Sdd21) measurements on all traces.
13. Press **Analysis** > **Fixture Simulator** > **Port ZConversion** > **Port1 Z0 Real** and set the port impedance to “45 ohm”.
14. Press **Analysis** > **Fixture Simulator** > **Port ZConversion** > **Port2 Z0 Real** and set

the port impedance to “45 ohm”.

15. Press **Analysis** > **Fixture Simulator** > **Port ZConversion** > **Port3 Z0 Real** and set the port impedance to “45 ohm”.
16. Press **Analysis** > **Fixture Simulator** > **Port ZConversion** > **Port4 Z0 Real** and set the port impedance to “45 ohm”.
17. Press **Analysis** > **Fixture Simulator** > **Port ZConversion** > **Port ZConversion** and turn ON.

6.8. D+/D- Pair Attenuation

1. Press **Trace Next** to select Trace 1.
2. Press **Meas** > **Sdd21**.
3. Press **Scale** > **Scale/Div** to 1 dB/div.
4. Press **Scale** > **Reference Value** to -4 dB.
5. Press **Save/Recall** > **Save SnP** > **SnP Format** > **Real/Imaginary**.

6.9. Differential to Common-mode Conversion

1. Press **Trace Next** to select Trace 2.
2. Press **Meas** > **Scd21**.
3. Press **Scale** > **Scale/Div** to 5 dB/div.
4. Press **Scale** > **Reference Value** to -20 dB.

6.10. Cable Shielding Effectiveness

1. Press **Trace Next** to select Trace 3.
2. Press **Scale** > **Scale/Div** to 10 dB/div.
3. Press **Scale** > **Reference Value** to -40 dB.
4. Press **Trace Next** to select Trace 4.
5. Press **Scale** > **Scale/Div** to 10 dB/div.
6. Press **Scale** > **Reference Value** to -40 dB.

6.11. [Raw Cable] Differential Insertion Loss (Informative)

1. Press **Trace Next** to select Trace 5.
2. Press **Meas** > **Sdd21**.
3. Press **Scale** > **Scale/Div** to 5 dB/div.
4. Press **Scale** > **Reference Value** to -6 dB.

6.12. [Mated Cable Assembly] Differential Insertion Loss (Informative)

1. Press **Trace Next** to select Trace 6.
2. Press **Meas** > **Sdd21**.
3. Press **Scale** > **Scale/Div** to 2 dB/div.
4. Press **Scale** > **Reference Value** to -6 dB.

6.13. [Mated Cable Assembly] Differential Near-end Crosstalk (NEXT) between SuperSpeed Gen 2 Signal Pairs (Informative)

1. Press **Trace Next** to select Trace 7.
2. Press **Meas** > **Sdd21**.
3. Press **Scale** > **Scale/Div** to 5 dB/div.
4. Press **Scale** > **Reference Value** to -25 dB.

6.14. [Mated Cable Assembly] Differential Near-end and Far-end Crosstalk (NEXT and FEXT) between D+/D- Pair and SuperSpeed Gen 2 Signal Pairs (Informative)

1. Press **Trace Next** to select Trace 8.
2. Press **Meas** > **Sdd21**.
3. Press **Scale** > **Scale/Div** to 5 dB/div.
4. Press **Scale** > **Reference Value** to -20 dB.

6.15. Defining Limit Line Tables

1. Press **Trace Next** to select trace to set the limit line table.
2. Press **Analysis** > **Limit Test** > **Limit Line** and turn it **ON** to display limit lines.
3. Press **Analysis** > **Limit Test** > **Edit Limit Line** to edit the limit line table.

	Type	Begin Stimulus	End Stimulus	Begin Response	End Response
1	MAX	0 s	600 ps	105 u	105 u
2	MIN	0 s	600 ps	75 u	75 u
3					

4. Press **Analysis** > **Limit Test** > **Limit Test** and turn it **ON**.
5. Press **Analysis** > **Limit Test** > **Fail Sign** to switch the fail sign ON/OFF. When turned on, the Fail sign is displayed on the E5071C's screen, if one or more failed traces are within the channel.
6. Press **System** > **Misc Setup** > **Beeper** > **Beep Warning** to turn ON/OFF the warning beeper.

7. [Appendix] Defining TRL Calibration Kit

The TRL calibration kit file is defined with the E5071C before TRL calibration. Refer to the values defined by the fixture.

1. Create a new cal kit file.
 - A) Press **Cal** > **Cal Kit** and select **User** to setup a cal kit definition file.
 - B) Press **Cal** > **Modify Cal Kit** > **Label Kit (User)** and enter name of new cal kit file. (i.e. USB3.1 TRL).
2. Define thru standard.
 - A) Press **Cal** > **Modify Cal Kit** > **Define STDs** > **1.No Name** > **Label** and enter "Thru".
 - B) Press **Cal** > **Modify Cal Kit** > **Define STDs** > **1.Thru** > **STD Type** and select **Delay/Thru**.
 - C) Press **Cal** > **Modify Cal Kit** > **Define STDs** > **1.Thru** > **Offset Delay** and enter the value of thru standard. (i.e. 0.0000 s)
 - D) Press **Cal** > **Modify Cal Kit** > **Define STDs** > **1.Thru** > **Offset Z0** and enter the value of the thru standard. (i.e. 50.000 ohm)
 - E) Press **Cal** > **Modify Cal Kit** > **Define STDs** > **1.Thru** > **Offset Loss** and enter the value of the thru standard. (i.e. 0.0000 ohm/s)
 - F) Press **Cal** > **Modify Cal Kit** > **Define STDs** > **1.Thru** > **Min. Frequency** and enter the value of the thru standard. (i.e. 0.0000 Hz)
 - G) Press **Cal** > **Modify Cal Kit** > **Define STDs** > **1.Thru** > **Max. Frequency** and enter the value of the thru standard. (i.e. 20.000 GHz)
 - H) Press **Cal** > **Modify Cal Kit** > **Define STDs** > **1.Thru** > **Media** and select **Coaxial**.
3. Define short standard.
 - A) Press **Cal** > **Modify Cal Kit** > **Define STDs** > **2.No Name** > **Label** and enter "Short".
 - B) Press **Cal** > **Modify Cal Kit** > **Define STDs** > **2.Short** > **STD Type** and select **Short**.
 - C) Press **Cal** > **Modify Cal Kit** > **Define STDs** > **2.Short** > **Offset Delay** and enter the value of short standard. (i.e. 0.0000 s)
 - D) Press **Cal** > **Modify Cal Kit** > **Define STDs** > **2.Short** > **Offset Z0** and enter the value of the short standard. (i.e. 50.000 ohm)
 - E) Press **Cal** > **Modify Cal Kit** > **Define STDs** > **2.Short** > **Offset Loss** and enter the value of the short standard. (i.e. 0.0000 ohm/s)
 - F) Press **Cal** > **Modify Cal Kit** > **Define STDs** > **2.Short** > **Min. Frequency** and enter the value of the short standard. (i.e. 0.0000 Hz)
 - G) Press **Cal** > **Modify Cal Kit** > **Define STDs** > **2.Short** > **Max. Frequency** and

- enter the value of the short standard. (i.e. 20.000 GHz)
- H) Press **Cal** > **Modify Cal Kit** > **Define STDs** > **2.Short** > **Media** and select **Coaxial**.
4. Define open standard.
- A) Press **Cal** > **Modify Cal Kit** > **Define STDs** > **3.No Name** > **Label** and enter “Open”.
- B) Press **Cal** > **Modify Cal Kit** > **Define STDs** > **3.Open** > **STD Type** and select **Open**.
- C) Press **Cal** > **Modify Cal Kit** > **Define STDs** > **3.Open** > **Offset Delay** and enter the value of open standard. (i.e. 0.0000 s)
- D) Press **Cal** > **Modify Cal Kit** > **Define STDs** > **3.Open** > **Offset Z0** and enter the value of the open standard. (i.e. 50.000 ohm)
- E) Press **Cal** > **Modify Cal Kit** > **Define STDs** > **3.Open** > **Offset Loss** and enter the value of the open standard. (i.e. 0.0000 ohm/s)
- F) Press **Cal** > **Modify Cal Kit** > **Define STDs** > **3.Open** > **Min. Frequency** and enter the value of the open standard. (i.e. 0.0000 Hz)
- G) Press **Cal** > **Modify Cal Kit** > **Define STDs** > **3.Open** > **Max. Frequency** and enter the value of the open standard. (i.e. 20.000 GHz)
- H) Press **Cal** > **Modify Cal Kit** > **Define STDs** > **3.Open** > **Media** and select **Coaxial**.
5. Define load standard.
- A) Press **Cal** > **Modify Cal Kit** > **Define STDs** > **4.No Name** > **Label** and enter “Load”.
- B) Press **Cal** > **Modify Cal Kit** > **Define STDs** > **4.Load** > **STD Type** and select **Load**.
- C) Press **Cal** > **Modify Cal Kit** > **Define STDs** > **4.Load** > **Offset Delay** and enter the value of load standard. (i.e. 0.0000 s)
- D) Press **Cal** > **Modify Cal Kit** > **Define STDs** > **4.Load** > **Offset Z0** and enter the value of the load standard. (i.e. 50.000 ohm)
- E) Press **Cal** > **Modify Cal Kit** > **Define STDs** > **4.Load** > **Offset Loss** and enter the value of the load standard. (i.e. 0.0000 ohm/s)
- F) Press **Cal** > **Modify Cal Kit** > **Define STDs** > **4.Load** > **Min. Frequency** and enter the value of the load standard. (i.e. 0.0000 Hz)
- G) Press **Cal** > **Modify Cal Kit** > **Define STDs** > **4.Load** > **Max. Frequency** and enter the value of the load standard. (i.e. 100.00 MHz)
- H) Press **Cal** > **Modify Cal Kit** > **Define STDs** > **4.Load** > **Media** and select **Coaxial**.
- I) Press **Cal** > **Modify Cal Kit** > **Define STDs** > **4.Load** > **Length Type** and select **Fixed**.
6. Define line 1 standard.

- A) Press **Cal** > **Modify Cal Kit** > **Define STDs** > **5.No Name** > **Label** and enter “Line1”.
 - B) Press **Cal** > **Modify Cal Kit** > **Define STDs** > **5.Line1** > **STD Type** and select **Delay/Thru**.
 - C) Press **Cal** > **Modify Cal Kit** > **Define STDs** > **5.Line1** > **Offset Delay** and enter the value of line1 standard. (i.e. 938.21 ps)
 - D) Press **Cal** > **Modify Cal Kit** > **Define STDs** > **5.Line1** > **Offset Z0** and enter the value of the line1 standard. (i.e. 50.000 ohm)
 - E) Press **Cal** > **Modify Cal Kit** > **Define STDs** > **5.Line1** > **Offset Loss** and enter the value of the line1 standard. (i.e. 0.0000 ohm/s)
 - F) Press **Cal** > **Modify Cal Kit** > **Define STDs** > **5.Line1** > **Min. Frequency** and enter the value of the line1 standard. (i.e. 100.00 MHz)
 - G) Press **Cal** > **Modify Cal Kit** > **Define STDs** > **5.Line1** > **Max. Frequency** and enter the value of the line1 standard. (i.e. 376.00 MHz)
 - H) Press **Cal** > **Modify Cal Kit** > **Define STDs** > **5.Line1** > **Media** and select **Coaxial**.
7. Define line 2 standard.
- A) Press **Cal** > **Modify Cal Kit** > **Define STDs** > **6.No Name** > **Label** and enter “Line2”.
 - B) Press **Cal** > **Modify Cal Kit** > **Define STDs** > **6.Line2** > **STD Type** and select **Delay/Thru**.
 - C) Press **Cal** > **Modify Cal Kit** > **Define STDs** > **6.Line2** > **Offset Delay** and enter the value of line2 standard. (i.e. 250.43 ps)
 - D) Press **Cal** > **Modify Cal Kit** > **Define STDs** > **6.Line2** > **Offset Z0** and enter the value of the line2 standard. (i.e. 50.000 ohm)
 - E) Press **Cal** > **Modify Cal Kit** > **Define STDs** > **6.Line2** > **Offset Loss** and enter the value of the line2 standard. (i.e. 0.0000 ohm/s)
 - F) Press **Cal** > **Modify Cal Kit** > **Define STDs** > **6.Line2** > **Min. Frequency** and enter the value of the line2 standard. (i.e. 376.00 MHz)
 - G) Press **Cal** > **Modify Cal Kit** > **Define STDs** > **6.Line2** > **Max. Frequency** and enter the value of the line2 standard. (i.e. 1.414 GHz)
 - H) Press **Cal** > **Modify Cal Kit** > **Define STDs** > **6.Line2** > **Media** and select **Coaxial**.
8. Define line 3 standard.
- A) Press **Cal** > **Modify Cal Kit** > **Define STDs** > **7.No Name** > **Label** and enter “Line3”.
 - B) Press **Cal** > **Modify Cal Kit** > **Define STDs** > **7.Line3** > **STD Type** and select **Delay/Thru**.
 - C) Press **Cal** > **Modify Cal Kit** > **Define STDs** > **7.Line3** > **Offset Delay** and enter the value of line3 standard. (i.e. 66.34 ps)

- D) Press **Cal** > **Modify Cal Kit** > **Define STDs** > **7.Line3** > **Offset Z0** and enter the value of the line3 standard. (i.e. 50.000 ohm)
 - E) Press **Cal** > **Modify Cal Kit** > **Define STDs** > **7.Line3** > **Offset Loss** and enter the value of the line3 standard. (i.e. 0.0000 ohm/s)
 - F) Press **Cal** > **Modify Cal Kit** > **Define STDs** > **7.Line3** > **Min. Frequency** and enter the value of the line3 standard. (i.e. 1.414 GHz)
 - G) Press **Cal** > **Modify Cal Kit** > **Define STDs** > **7.Line3** > **Max. Frequency** and enter the value of the line3 standard. (i.e. 5.318 GHz)
 - H) Press **Cal** > **Modify Cal Kit** > **Define STDs** > **7.Line3** > **Media** and select **Coaxial**.
9. Define line 4 standard.
- I) Press **Cal** > **Modify Cal Kit** > **Define STDs** > **8.No Name** > **Label** and enter “Line4”.
 - J) Press **Cal** > **Modify Cal Kit** > **Define STDs** > **8.Line4** > **STD Type** and select **Delay/Thru**.
 - K) Press **Cal** > **Modify Cal Kit** > **Define STDs** > **8.Line4** > **Offset Delay** and enter the value of line4 standard. (i.e. 17.06 ps)
 - L) Press **Cal** > **Modify Cal Kit** > **Define STDs** > **8.Line4** > **Offset Z0** and enter the value of the line4 standard. (i.e. 50.000 ohm)
 - M) Press **Cal** > **Modify Cal Kit** > **Define STDs** > **8.Line4** > **Offset Loss** and enter the value of the line4 standard. (i.e. 0.0000 ohm/s)
 - N) Press **Cal** > **Modify Cal Kit** > **Define STDs** > **8.Line4** > **Min. Frequency** and enter the value of the line4 standard. (i.e. 5.318 GHz)
 - O) Press **Cal** > **Modify Cal Kit** > **Define STDs** > **8.Line4** > **Max. Frequency** and enter the value of the line4 standard. (i.e. 20.000 GHz)
 - P) Press **Cal** > **Modify Cal Kit** > **Define STDs** > **8.Line4** > **Media** and select **Coaxial**.
10. Specify sub class of cal kit.
- A) Press **Cal** > **Modify Cal Kit** > **Specify CLSs** > **Sub Class** > **Sub Class 1**.
 - B) Press **Cal** > **Modify Cal Kit** > **Specify CLSs** > **TRL Thru** > **Set All** > **1.Thru**.
 - C) Press **Cal** > **Modify Cal Kit** > **Specify CLSs** > **TRL Reflect** > **2.Short**.
 - D) Press **Cal** > **Modify Cal Kit** > **Specify CLSs** > **TRL Line/Match** > **Set All** > **5.Line1**.
 - E) Press **Cal** > **Modify Cal Kit** > **Specify CLSs** > **Sub Class** > **Sub Class 2**.
 - F) Press **Cal** > **Modify Cal Kit** > **Specify CLSs** > **TRL Line/Match** > **Set All** > **6.Line2**.
 - G) Press **Cal** > **Modify Cal Kit** > **Specify CLSs** > **Sub Class** > **Sub Class 3**.
 - H) Press **Cal** > **Modify Cal Kit** > **Specify CLSs** > **TRL Line/Match** > **Set All** > **7.Line3**.
 - I) Press **Cal** > **Modify Cal Kit** > **Specify CLSs** > **Sub Class** > **Sub Class 4**.

Keysight MOI for USB 3.1 Connectors & Cable Assemblies Compliance Tests

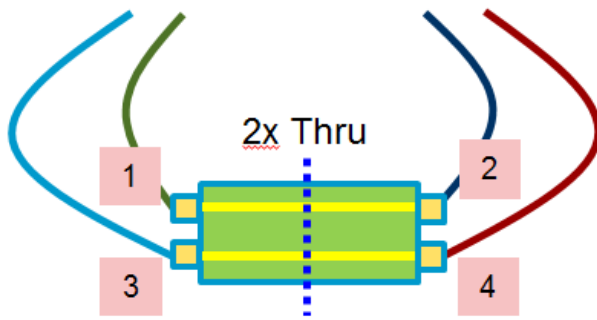
- J) Press **Cal** > **Modify Cal Kit** > **Specify CLSs** > **TRL Line/Match** > **Set All** > **8.Line4**.
 - K) Press **Cal** > **Modify Cal Kit** > **Specify CLSs** > **Sub Class** > **Sub Class 5**.
 - L) Press **Cal** > **Modify Cal Kit** > **Specify CLSs** > **TRL Line/Match** > **Set All** > **4.Load**.
11. Press **Cal** > **Modify Cal Kit** and select **Export Cal Kit...** to Save Cal Kit File (*.ckx).

8. [Appendix] De-embedding File Creation using PLTS AFR

The procedure to create the de-embedding files using the Keysight Physical Layer Test System (PLTS) Automatic Fixture Removal (AFR) function and 2x Thru standard is introduced in the section.

8.1. 2x Thru Standard Measurement

1. Recall the state file as described in 5.2.1. Recalling a State File.
2. Perform the calibration using ECal as described in 5.3.1.2 Frequency-Domain Measurements > 1. ECal Calibration.
3. Connect the E5071C ports (port 1 to 4) to 2x Thru standard with RF cables as shown below (1, 2, 3, 4 are E5071C port numbers).

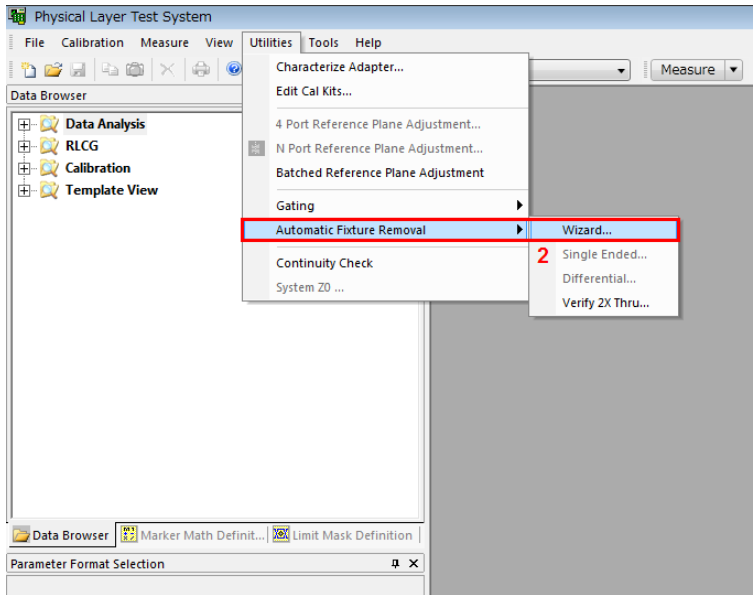


3. Press **Channel Max** to maximize Channel 2 on the screen.
4. Press **Trace Next** to select Trace 6 (Sdd21).
5. Press **Trace Max** to maximize the selected trace on the screen.
6. Press **Analysis > Fixture Simulator > Port ZConversion > Port ZConversion** and turn OFF.
7. Press **Trigger > Single**.
8. Press **Save/Recall > Save SnP > S4P > [1-2-3-4]...**
9. Enter file name and save the 4-port Touchstone file (*.s4P).
10. Press **Analysis > Fixture Simulator > Port ZConversion > Port ZConversion** and turn ON.

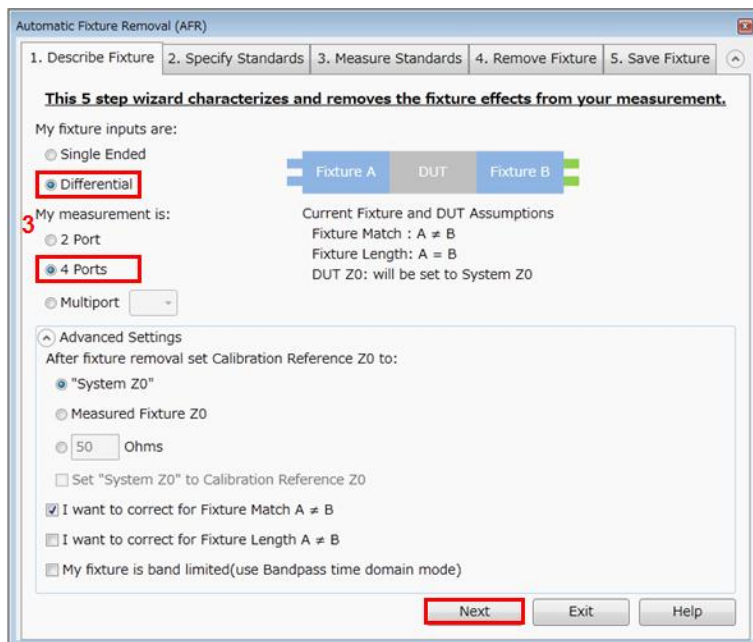
8.2. De-embedding File Creation

1. Launch PLTS software.
2. Click **Utilities > Automatic Fixture Removal > Wizard**.

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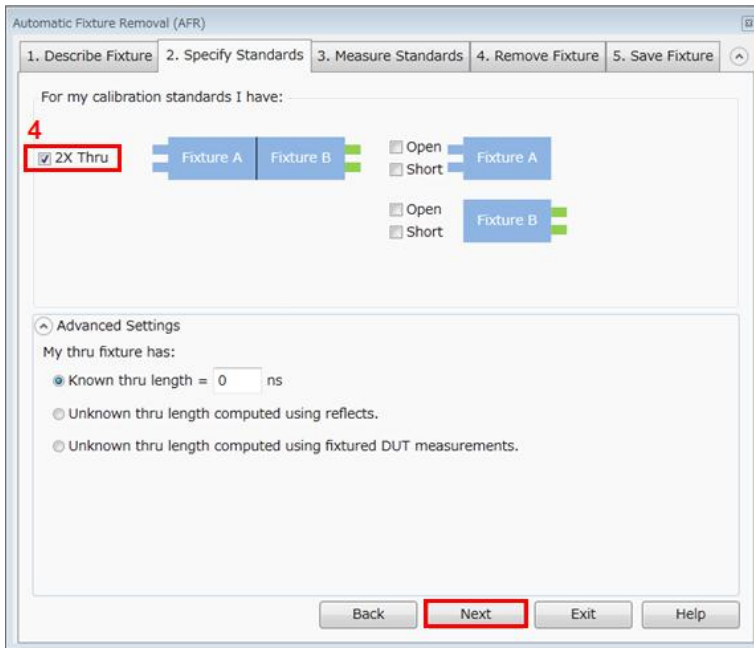


3. Select **Differential/4-Ports** > **Next**.

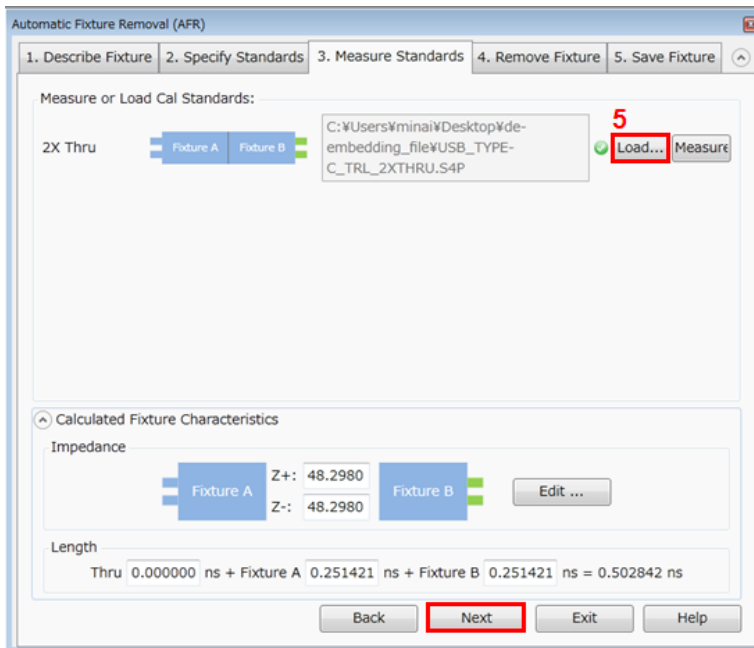


4. Check **2X Thru** > **Next**.

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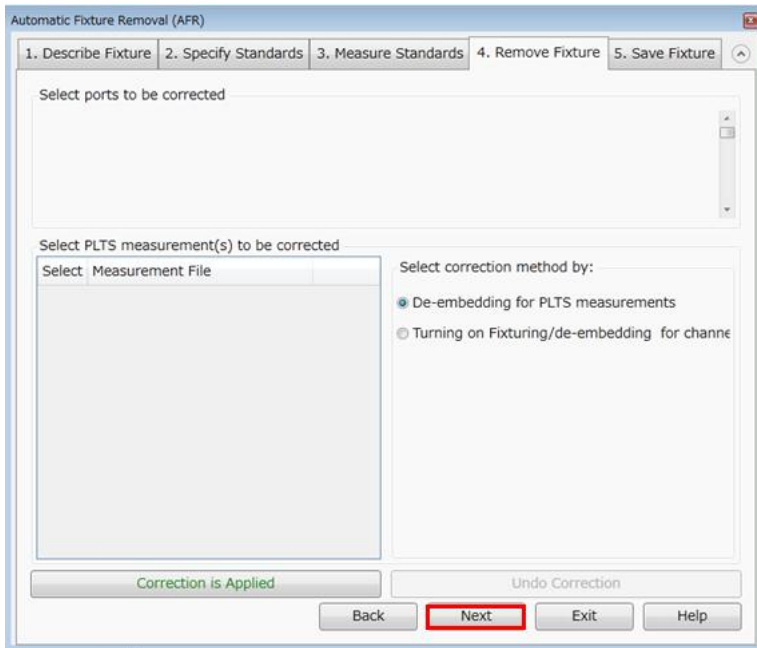


5. Load the Touchstone file for 2x Thru > **Next**.



6. Click **Next**.

Keysight MOI for USB 3.1 Connectors & Cable Assemblies Compliance Tests



7. Select **PNA Format** > enter file name > Click **Save Fixture Files** to create two fixture files > Exit.

