Universal Serial Bus Type-C™ Specification Revision 1.1

Keysight Method of Implementation (MOI) for USB Type-C™ Connectors and Cables Assemblies Compliance Tests Using Keysight E5071C ENA Option TDR

For Type-C to Legacy Cable Assemblies

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# Table of Contents

1. Revision History ................................................................................................................. 4  
2. Purpose ................................................................................................................................. 4  
3. References ............................................................................................................................. 4  
4. Required Equipment .............................................................................................................. 4  
5. Test Procedure ....................................................................................................................... 6  
  5.1. Outline of Test Procedure ................................................................................................. 6  
  5.2. Setup ................................................................................................................................. 8  
    5.2.1. Recalling a State File .................................................................................................. 8  
    5.2.2. Saving a State File .................................................................................................... 9  
  5.3. Calibration ....................................................................................................................... 10  
    5.3.1. ECal Calibration and De-embedding .......................................................................... 10  
    5.3.2. TRL Calibration ......................................................................................................... 13  
    5.3.3. Adjustment of Effective Rise Time ............................................................................. 15  
  5.4. Measurement .................................................................................................................... 18  
    5.4.1. D+/D- Impedance ...................................................................................................... 18  
    5.4.2. D+/D- Intra-Pair Skew .............................................................................................. 19  
    5.4.3. D+/D- Propagation Delay ......................................................................................... 20  
    5.4.4. D+/D- Pair Attenuation ........................................................................................... 21  
    5.4.5. ILfitatNq, IMR, IXT, IRL, Differential to Common-Mode Conversion .......... 21  
    5.4.6. Differential to Common-Mode Conversion ................................................................. 24  
    5.4.7. Shielding Effectiveness ............................................................................................. 24  
    5.4.8. [Raw Cable] Characteristic Impedance (Informative) ........................................... 26  
    5.4.9. [Raw Cable] Intra-Pair Skew (Informative) .............................................................. 26  
    5.4.10. [Raw Cable] Differential Insertion Loss (Informative) ............................................ 26  
    5.4.11. [Mated Connector] Differential Impedance (Informative) ...................................... 27  
    5.4.12. [Mated Connector] Differential Insertion Loss (Informative) .............................. 27  
    5.4.13. [Mated Connector] Differential Return Loss (Informative) ..................................... 28  
    5.4.15. [Mated Connector] Differential NEXT & FEXT between D+/D- Pair and SS Signal Pairs (Informative) ......................................................................................................................................................................................... 29  
    5.4.16. [Mated Connector] Differential to Common-Mode Conversion (Informative) ......................................................................................................................................................................................... 30  
    5.4.17. Differential Impedance (Informative) ...................................................................... 30  
    5.4.18. Differential Insertion Loss (Informative) ................................................................. 30  
    5.4.19. Differential NEXT between SS Signal Pairs (Informative) ........................................ 31  
    5.4.20. Differential NEXT & FEXT between D+/D- Pair and SS Signal Pairs (Informative) ......................................................................................................................................................................................... 32
   6.1. Channel & Trace Setup ........................................................................................................... 33
   6.2. D+/D- Impedance ..................................................................................................................... 34
   6.3. D+/D- Intra-Pair Skew ............................................................................................................ 35
       6.3.1. Parameter Setup ............................................................................................................. 35
       6.3.2. Crosstalk Compensation ............................................................................................... 36
   6.4. [Raw Cable] Characteristic Impedance (Informative) .......................................................... 36
   6.5. [Mated Connector] Differential Impedance (Informative) ...................................................... 37
   6.6. Common Parameters Setup for Frequency-domain Measurements ........................................... 37
   6.7. D+/D- Pair Attenuation .......................................................................................................... 38
   6.8. ILfitatNq, IMR, IXT, IRL, Differential to Common-Mode Conversion .................................... 38
   6.9. Differential to Common-Mode Conversion ........................................................................... 38
   6.10. Shielding Effectiveness ....................................................................................................... 38
   6.11. [Raw Cable] Differential Insertion Loss (Informative) ........................................................ 38
   6.15. [Mated Connector] Differential NEXT & FEXT between SS Signal Pairs (Informative) ...... 39
       (Informative) .......................................................................................................................... 39
   6.17. Differential Insertion Loss (Informative) ............................................................................. 39
   6.18. Differential NEXT between SS Signal Pairs (Informative) .................................................. 40
   6.20. Defining Limit Line Tables ................................................................................................. 40
7. [Appendix] Defining TRL Calibration Kit .................................................................................... 41
8. [Appendix] De-embedding File Creation using PLTS AFR ........................................................ 45
   8.1. 2x Thru Standard Measurement .......................................................................................... 45
   8.2. De-embedding File Creation ............................................................................................... 45
1. Revision History

<table>
<thead>
<tr>
<th>Revision</th>
<th>Date</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>00.90</td>
<td>2015/02/06</td>
<td>• Initial release</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Spec 1.0 and compliance document draft</td>
</tr>
<tr>
<td>01.00</td>
<td>2015/11/24</td>
<td>• Spec 1.1 and compliance document 1.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Changed port configuration for Ch2 freq. domain meas. on high speed signal tests</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Minor corrections</td>
</tr>
</tbody>
</table>

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 Type-C Cable and Connector Specification Revision 1.1 and Connectors and Cable Assemblies Compliance Document 1.0. This test procedure is for Type-C to Legacy Cable Assemblies.

3. References

- Universal Serial Bus Type-C Cable and Connector Specification Revision 1.1 (April 3, 2015)
- Universal Serial Bus Type-C Connectors and Cable Assemblies Compliance Document 1.0 (October 6, 2015)

4. Required Equipment

<table>
<thead>
<tr>
<th>Description</th>
<th>Test Equipment</th>
<th>QTY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Network Analyzer</td>
<td>Keysight E5071C ENA Series Network Analyzer</td>
<td>1 ea.</td>
</tr>
<tr>
<td></td>
<td>• Option 4K5 (20 GHz)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Option TDR (Enhanced time domain analysis)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Note: Ensure that</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- E5071C firmware revision A.11.31 or above (Windows XP), or B.13.01 or above (Windows 7) is installed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- E5071C-TDR application software revision A.01.57 or above (Windows XP), or B.02.02.00.00 or above (Windows 7) is installed</td>
<td></td>
</tr>
<tr>
<td>4-port ECAl</td>
<td>Keysight N4433A (4-port, 20 GHz)</td>
<td>1 ea.</td>
</tr>
</tbody>
</table>

4
### Keysight MOI for USB Type-C Connectors & Cable Assemblies Compliance Tests
(Type-C to Legacy Cable Assemblies)

<table>
<thead>
<tr>
<th>Test Fixture</th>
<th>Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adapter</td>
<td>83059B coaxial adapter for E5071C ports</td>
<td>4 ea.</td>
</tr>
<tr>
<td>RF cable</td>
<td>3.5 mm or SMA cables of 20 GHz bandwidth or more</td>
<td>4 ea.</td>
</tr>
<tr>
<td>Compliance Tool</td>
<td>USB Type-C cable assembly compliance tool provided by USB-IF</td>
<td>1 ea.</td>
</tr>
</tbody>
</table>

Note: Fixtures for testing USB 3.1/Type-C connectors and cable assemblies are available for purchase through Luxshare-ICT.

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- Impedance
   - D+/D- Intra-Pair Skew
   - D+/D- Propagation Delay
   - [Raw Cable] Characteristic Impedance (Informative)
   - [Raw Cable] Intra-Pair Skew (Informative)
   - [Mated Connector] Differential Impedance (Informative)
   - Differential Impedance (Informative)

4-2. **Frequency-domain Measurements**
   - D+/D- Pair Attenuation
   - ILfitatNq, IMR, IXT, IRL, Differential to Common-Mode Conversion
   - Shielding Effectiveness
   - [Raw Cable] Differential Insertion Loss (Informative)
   - [Mated Connector] Differential Insertion Loss (Informative)
   - [Mated Connector] Differential Return Loss (Informative)
   - [Mated Connector] Differential NEXT & FEXT between SS Signal Pairs (Informative)
   - [Mated Connector] Differential NEXT & FEXT between D+/D- Pair and SS Signal Pairs (Informative)
   - [Mated Connector] Differential to Common-Mode Conversion (Informative)
   - Differential Insertion Loss (Informative)
   - Differential NEXT between SS Signal Pairs (Informative)
   - Differential NEXT & FEXT between D+/D- Pair and SS Signal Pairs (Informative)
Keysight MOI for USB Type-C Connectors & Cable Assemblies Compliance Tests
(Type-C to Legacy Cable Assemblies)

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 USB Type-C connectors and cable assemblies compliance tests. The state file can be downloaded at:
http://www.keysight.com/find/enaxtdr_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.
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.

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. Refer to Appendix for the details about de-embedding file creation.

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 >.
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 detail 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.
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 Type-C 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**.
   c) Connect Thru standard of USB Type-C 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 Type-C 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 Type-C 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 Type-C 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 Type-C 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 Type-C 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 Type-C 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 Type-C 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 Type-C 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 Load standard of USB Type-C 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 (Load).**

i) Press **Cal > Calibrate > 4-port TRL Cal > Line/Match > 1-3 Line/Match and repeat step a) to step h) by connecting line and load standards to the E5071C port 1 and port 3 with the RF cable.

j) Press **Cal > Calibrate > 4-port TRL Cal > Line/Match > 3-4 Line/Match**
and repeat step a) to step h) 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 Type-C 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>
<thead>
<tr>
<th>Table 5-1 Specification of Effective Rise Time</th>
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<tbody>
<tr>
<td>Trace</td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td>Tr 1 &amp; 5</td>
</tr>
<tr>
<td>Tr 1</td>
</tr>
<tr>
<td>Tr 2 &amp; 6</td>
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<tr>
<td>Tr 3 &amp; 7</td>
</tr>
<tr>
<td>Tr 4 &amp; 8</td>
</tr>
<tr>
<td>Tr 4 &amp; 8</td>
</tr>
</tbody>
</table>

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 for Trace 1 with port 1 then Trace 5 with port 3)
  a) Connect 1x Thru standard to the E5071C port 1 (port 3) 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 (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 (400 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).

- Trace 2 (Trace 6) (Adjust for Trace 2 with port 1 then Trace 6 with port 2)
  a) Connect 1x Thru standard to the E5071C port 1 (port 2) with the RF cable.
b) Click Trace 2 (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 (20–80%)”.
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 (400 ps).
l) Click Marker Search and select “Rise Time (20–80%)” to turn off the marker.
m) Click T31 (T42).
n) Press Display > Equation to turn on the equation editor.
Keysight MOI for USB Type-C Connectors & Cable Assemblies Compliance Tests
(Type-C to Legacy Cable Assemblies)

- Trace 3 (Trace 7) (Adjust for Trace 3 with port 1 then Trace 7 with port 3)
  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 for Trace 4 with port 1 then Trace 8 with port 3)
  a) Connect 1x Thru standard to the E5071C port 1 (port 3) with the RF cable.
  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 Type-C to legacy cable assembly, raw cable and mated connector are assumed as follows (Note: TF stands for Test Fixture). For cable assembly frequency domain measurements, the standard compliance tool is used for the pass/fail judgment. The manual measurement procedures for raw cable, mated connector, and several test items of cable assembly using the ENA Option TDR are also supported with the limit lines.

[Type-C to Legacy Cable Assembly]

<table>
<thead>
<tr>
<th>TF1</th>
<th>Cable Assembly</th>
<th>TF2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type-C (Receptacle)</td>
<td>Type-C (Plug)</td>
<td>Type-A/B /Micro-B/Mini-B (Plug)</td>
</tr>
<tr>
<td>D+/D-</td>
<td>⇐</td>
<td>D+/D-</td>
</tr>
<tr>
<td>Tx1+/Tx1-</td>
<td>⇐</td>
<td>Rx+/Rx-</td>
</tr>
<tr>
<td>Rx1+/Rx1-</td>
<td>⇐</td>
<td>Tx+/Tx-</td>
</tr>
<tr>
<td>Tx2+/Tx2-</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Rx2+/Rx2-</td>
<td>n/a</td>
<td>n/a</td>
</tr>
</tbody>
</table>

Note: Associate the USB logo on the Type-C cable connector with the test fixture’s “Top SIDE” printed on it for the orientation.

[Raw Cable]

<table>
<thead>
<tr>
<th>A Side</th>
<th>Raw Cable</th>
<th>B Side</th>
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<tbody>
<tr>
<td>D+/D-</td>
<td>⇐</td>
<td>D+/D-</td>
</tr>
<tr>
<td>Tx1+/Tx1-</td>
<td>⇐</td>
<td>Tx1+/Tx1-</td>
</tr>
<tr>
<td>Rx1+/Rx1-</td>
<td>⇐</td>
<td>Rx1+/Rx1-</td>
</tr>
<tr>
<td>Tx2+/Tx2-</td>
<td>n/a</td>
<td>Tx2+/Tx2-</td>
</tr>
<tr>
<td>Rx2+/Rx2-</td>
<td>n/a</td>
<td>Rx2+/Rx2-</td>
</tr>
</tbody>
</table>

[Mated Connector]

<table>
<thead>
<tr>
<th>TF1</th>
<th>Mated Connector</th>
<th>TF2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type-C (Receptacle)</td>
<td>Type-C (Plug)</td>
<td></td>
</tr>
<tr>
<td>D+/D-</td>
<td>⇐</td>
<td>D+/D-</td>
</tr>
<tr>
<td>Tx1+/Tx1-</td>
<td>⇐</td>
<td>Tx1+/Tx1-</td>
</tr>
<tr>
<td>Rx1+/Rx1-</td>
<td>⇐</td>
<td>Rx1+/Rx1-</td>
</tr>
<tr>
<td>Tx2+/Tx2-</td>
<td>⇐</td>
<td>Tx2+/Tx2-</td>
</tr>
<tr>
<td>Rx2+/Rx2-</td>
<td>⇐</td>
<td>Rx2+/Rx2-</td>
</tr>
</tbody>
</table>

5.4.1. D+/D- Impedance
Multiple reflections from impedance mismatches cause noise at the receiver. Therefore, the impedance profile provides an indication of multiple reflection induced noise.
1. Connect the E5071C ports (port 1 to 4) to the test fixture ports with RF cables.
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 (Tdd11).
6. Click **Stop Single**.
7. Confirm the measured characteristic impedance is within 75 ohm min and 105 ohm max.
8. Select Trace 5 (Tdd22) and repeat step 7 for the far end of DUT.

5.4.2. D+/D- Intra-Pair Skew

The intra-pair 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.

2. Select Trace 2 (T31).
3. Click **Stop Single**.
4. Read Delta Time (Tr6) on the E5071C screen.
5. Confirm the measured intra-pair skew of D+/D- pair is lower than 100 psec.
5.4.3. D+/D- 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.

<table>
<thead>
<tr>
<th>E5071C</th>
<th>Port 1</th>
<th>Port 2</th>
<th>Port 3</th>
<th>Port 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Fixtures</td>
<td>TF1 D+</td>
<td>TF1 D-</td>
<td>TF2 D+</td>
<td>TF2 D-</td>
</tr>
</tbody>
</table>

2. Select Trace 1 (Tdd11).
3. Open TDR/TDT tab.
4. Open Parameters tab.
5. Select Formant to “Volt”.
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.
10. Click Stop Single.

11. Read marker value of Trace 1 on the screen.
12. Confirm the measured propagation delay at the rising edge is less than 20 nsec or less than 10 nsec (Type-C to Micro-B cable assembly).
13. Press Marker Search and turn off Tracking.
14. Click Marker and select “1” to turn off the marker.
15. Open Parameters tab.
16. Select Formant to “Impedance”.
17. Click **Tdd11**.

5.4.4. D+/D- Pair Attenuation

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

<table>
<thead>
<tr>
<th>E5071C Port</th>
<th>Port 1</th>
<th>Port 2</th>
<th>Port 3</th>
<th>Port 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Fixtures</td>
<td>TF1 D+</td>
<td>TF1 D-</td>
<td>TF2 D+</td>
<td>TF2 D-</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Start Frequency</th>
<th>Stop Frequency</th>
<th>Start Limit</th>
<th>Stop Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 MHz</td>
<td>100 MHz</td>
<td>-1.02 dB</td>
<td>-1.43 dB</td>
</tr>
<tr>
<td>100 MHz</td>
<td>200 MHz</td>
<td>-1.43 dB</td>
<td>-2.40 dB</td>
</tr>
<tr>
<td>200 MHz</td>
<td>400 MHz</td>
<td>-2.40 dB</td>
<td>-4.35 dB</td>
</tr>
</tbody>
</table>

5.4.5. ILfitaNq, IMR, IXT, IRL, Differential to Common-Mode Conversion

ILfitaNq, IMR, IXT, IRL, Differential to Common-Mode Conversion are checked with a standard tool (**CableComp Tool**) provided by USB-IF. Fifteen 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 tests.

**Note:** Trace 2 is allocated for the measurements though, other traces can be used to check the measurement results with the limit line and the pass/fail judgment as described in **Note** below.

**Note:** The port Z conversion is turned off so the measurements are performed based on 50 ohm port impedance setting required by the standard tool.

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

<table>
<thead>
<tr>
<th>Test path name</th>
<th>Port 1</th>
<th>Port 2</th>
<th>Port 3</th>
<th>Port 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tx(L), Tx(R) [1,2,3,4]</td>
<td>TF1 Tx1+</td>
<td>TF1 Tx1-</td>
<td>TF2 Rx+</td>
<td>TF2 Rx-</td>
</tr>
</tbody>
</table>

**Note:** Limit line pass/fail judgment: **Trace 7:** Differential Insertion Loss (Except for USB Type-C to USB 3.1 Standard-A), **Trace 15:** Differential Insertion Loss (USB Type-C to USB 3.1 Standard-A), **Trace 10:** Differential to Common-Mode Conversion.
2. Press **Analysis** > **Fixture Simulator** > **Port ZConversion** > **Port ZConversion** and turn OFF.

3. Press **Trigger** > **Single**.

4. Press **Trace Next** to select desired trace as described in **Note** to check the limit line and the pass/fail judgment.

5. Press **Save/Recall** > **Save SnP** > **S4P** > [1-2-3-4... ]... to save the measured Touchstone file.

6. Connect the E5071C ports with test fixture ports shown below and repeat step 3 to step 5 to save all necessary Touchstone files (*.s4p) in the E5071C.

<table>
<thead>
<tr>
<th>Test path name</th>
<th>Port 1</th>
<th>Port 2</th>
<th>Port 3</th>
<th>Port 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rx(L), Rx(R) [5,7,6,8]</td>
<td>TF1 Rx1+</td>
<td>TF1 Rx1-</td>
<td>TF2 Tx+</td>
<td>TF2 Tx-</td>
</tr>
<tr>
<td>D+/D-(L), D+/D-(R) [9,10,11,12]</td>
<td>TF1 D+</td>
<td>TF1 D-</td>
<td>TF2 D+</td>
<td>TF2 D-</td>
</tr>
<tr>
<td>Tx(L), Rx(R) [1,3,5,7]</td>
<td>TF1 Tx1+</td>
<td>TF1 Tx1-</td>
<td>TF1 Rx1+</td>
<td>TF1 Rx1-</td>
</tr>
<tr>
<td>Tx(R), Rx(R) [2,4,6,8]</td>
<td>TF2 Rx+</td>
<td>TF2 Rx-</td>
<td>TF2 Tx+</td>
<td>TF2 Tx-</td>
</tr>
<tr>
<td>Tx(L), D+/D-(L) [1,3,9,11]</td>
<td>TF1 Tx1+</td>
<td>TF1 Tx1-</td>
<td>TF1 D+</td>
<td>TF1 D-</td>
</tr>
</tbody>
</table>

**Note**: Limit line pass/fail judgment:
- **Trace 7**: Differential Insertion Loss (Except for USB Type-C to USB 3.1 Standard-A).
- **Trace 15**: Differential Insertion Loss (USB Type-C to USB 3.1 Standard-A).
- **Trace 10**: Differential to Common-Mode Conversion.
- **Trace 1**: D+/D- Pair Attenuation.
- **Trace 9**: Return Loss.
- **Trace 8**: Differential NEXT between SS Signal Pairs.
- **Trace 8**: Differential NEXT between SS Signal Pairs.
- **Trace 16**: Differential NEXT & FEXT between D+/D- Pair and SS.
<table>
<thead>
<tr>
<th>Signal Pairs</th>
<th>TF1 Rx1+</th>
<th>TF1 Rx1-</th>
<th>TF1 D+</th>
<th>TF1 D-</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rx(L), D+/D- (L) [5,7,9,11]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Note: Limit line pass/fail judgment: Trace 16:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Differential NEXT &amp; FEXT between D+/D- Pair and SS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Signal Pairs.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tx(R), D+/D- (R) [2,4,10,12]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Note: Limit line pass/fail judgment: Trace 16:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Differential NEXT &amp; FEXT between D+/D- Pair and SS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Signal Pairs.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rx(R), D+/D- (R) [6,8,10,12]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Note: Limit line pass/fail judgment: Trace 16:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Differential NEXT &amp; FEXT between D+/D- Pair and SS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Signal Pairs.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tx(L), Rx(R) [1,3,6,8]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Note: Limit line pass/fail judgment: n/a</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Signal Pairs.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tx(R), Rx(L) [2,4,5,7]</td>
<td>TF2 Rx+</td>
<td>TF2 Rx-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Note: Limit line pass/fail judgment: n/a</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Signal Pairs.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tx(R), D+/D- (L) [2,4,9,11]</td>
<td>TF2 Rx+</td>
<td>TF2 Rx-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Note: Limit line pass/fail judgment: Trace 16:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Differential NEXT &amp; FEXT between D+/D- Pair and SS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Signal Pairs.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rx(R), D+/D- (L) [6,8,9,11]</td>
<td>TF2 Tx+</td>
<td>TF2 Tx-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Note: Limit line pass/fail judgment: n/a</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Signal Pairs.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tx(L), D+/D- (R) [1,3,10,12]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Note: Limit line pass/fail judgment: Trace 16:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Differential NEXT &amp; FEXT between D+/D- Pair and SS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Signal Pairs.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rx(L), D+/D- (R) [5,7,10,12]</td>
<td>TF1 Rx1+</td>
<td>TF1 Rx1-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Note: Limit line pass/fail judgment: Trace 16:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Differential NEXT &amp; FEXT between D+/D- Pair and SS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

7. Open the Excel spreadsheet [High_Speed]_config_4ports_[1324].xlsx and modify “Cable Type” to 4 (Type-C to Legacy) and “S-parameter Path and Name” to match them with fifteen 4-port Touchstone files (*.s4p) you measured. Do not change “Number of VNA Ports” and “Port Arrangement”.

8. Launch compliance tool, load Excel spreadsheet [High_Speed]_config_4ports_[1324].xlsx by clicking “Load Config Spreadsheet”,

23
click “Import” to import fifteen 4-port Touchstone files (*.s4p), then click “Check Compliance” for pass/fail judgment.

9. Press **Analysis > Fixture Simulator > Port ZConversion > Port ZConversion** and turn ON.

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.

<table>
<thead>
<tr>
<th>E5071C</th>
<th>Port 1</th>
<th>Port 2</th>
<th>Port 3</th>
<th>Port 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Fixtures</td>
<td>TF1 Tx1+</td>
<td>TF1 Tx1-</td>
<td>TF2 Rx+</td>
<td>TF2 Rx-</td>
</tr>
</tbody>
</table>

2. Press **Trace Next** to select Trace 10 (Scd21).
3. Press **Trigger > Single**.
4. Confirm the measured differential to common-mode conversion is within the limit shown below.

<table>
<thead>
<tr>
<th>Start Frequency</th>
<th>Stop Frequency</th>
<th>Start Limit</th>
<th>Stop Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 MHz</td>
<td>10 GHz</td>
<td>-20 dB</td>
<td>-20 dB</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>E5071C</th>
<th>Port 1</th>
<th>Port 2</th>
<th>Port 3</th>
<th>Port 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Fixtures</td>
<td>TF1 Rx1+</td>
<td>TF1 Rx1-</td>
<td>TF2 Tx+</td>
<td>TF2 Tx-</td>
</tr>
</tbody>
</table>

6. 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. Shielding Effectiveness

Shielding Effectiveness is checked with a standard tool (**CableComp Tool**) provided by USB-IF after making the measurement using a shielding effectiveness test fixture. 4-port Touchstone file (*.s4p) is measured and saved by the E5071C firmware, and then imported by the compliance tool to conduct cable assembly compliance tests. The manual measurement procedure using the ENA Option TDR is also supported with the limit lines. Note: The port Z conversion is turned off so the measurements are performed based on 50 ohm port impedance setting required by the standard tool.

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

<table>
<thead>
<tr>
<th>E5071C</th>
<th>Port 1 (SE)</th>
<th>Port 2 (Bal+)</th>
<th>Port 3 (Bal-)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Fixtures</td>
<td>SE</td>
<td>Tx1+</td>
<td>Tx1-</td>
</tr>
</tbody>
</table>

2. Press **Analysis > Fixture Simulator > Topology > Device > SE-Bal**.
3. Press **Analysis > Fixture Simulator > Topology > Port1(se) > 1**.
4. Press **Analysis > Fixture Simulator > Topology > Port2(bal) > 2-3**.
5. Press **Analysis > Fixture Simulator > Port ZConversion > Port ZConversion** and turn OFF.
6. Press **Analysis > Fixture Simulator > De-Embedding** to turn off De-Embedding if it is turned on.
7. Press **Trace Next** to select Trace 3.
8. Press **Meas > Sds21**.
9. Press **Trace Next** to select Trace 11.
10. Press **Meas > Scs21**.
11. Press **Trigger > Single**.
12. Confirm the measured Sds21/Scs21 is within the limit shown below.

<table>
<thead>
<tr>
<th>Type</th>
<th>Start Frequency</th>
<th>Stop Frequency</th>
<th>Start Limit</th>
<th>Stop Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Differential Model</td>
<td>10 MHz</td>
<td>1.6 GHz</td>
<td>-49 dB</td>
<td>-49 dB</td>
</tr>
<tr>
<td></td>
<td>1.6 GHz</td>
<td>4 GHz</td>
<td>-44 dB</td>
<td>-44 dB</td>
</tr>
<tr>
<td></td>
<td>5 GHz</td>
<td>6 GHz</td>
<td>-44 dB</td>
<td>-44 dB</td>
</tr>
<tr>
<td>Common Model</td>
<td>10 MHz</td>
<td>1.6 GHz</td>
<td>-34 dB</td>
<td>-34 dB</td>
</tr>
<tr>
<td></td>
<td>1.6 GHz</td>
<td>4 GHz</td>
<td>-29 dB</td>
<td>-29 dB</td>
</tr>
<tr>
<td></td>
<td>5 GHz</td>
<td>6 GHz</td>
<td>-29 dB</td>
<td>-29 dB</td>
</tr>
</tbody>
</table>

13. Press **Save/Recall > Save SnP > S4P > [1-2-3-4]**... to save the measured Touchstone file.
14. Repeat the same operation of step 11 to step 13 for all the following combinations to confirm the measured Sds21/Scs21 is within the specification.

<table>
<thead>
<tr>
<th>Test Fixtures</th>
<th>Port 1 (SE)</th>
<th>Port 2 (Bal+)</th>
<th>Port 3 (Bal-)</th>
</tr>
</thead>
<tbody>
<tr>
<td>E5071C</td>
<td>SE</td>
<td>Rx1+</td>
<td>Rx1-</td>
</tr>
</tbody>
</table>

15. Launch compliance tool, select “7. Shielding Effectiveness (Type-C to Legacy)” for “Select Cable Type”, check “4-Port VNA”. Load 4-port Touchstone file (*.s4p) by clicking “1>>”, click “Import” to import 4-port Touchstone file (*.s4p), then click “Check Compliance” for pass/fail judgment.
16. Press **Analysis > Fixture Simulator > Topology > Device > Bal-Bal**.
17. Press **Analysis > Fixture Simulator > Topology > Port1(bal) > 1-2**.
18. Press **Analysis > Fixture Simulator > Topology > Port2(bal) > 3-4**.
19. Press **Analysis > Fixture Simulator > Port ZConversion > Port ZConversion** and turn ON.
20. Press **Analysis > Fixture Simulator > De-Embedding** to turn on De-Embedding if it was turned off at step 5.

Informative electrical performance targets are provided for raw cables, mated connectors, and mated cable assemblies. These targets are not part of the USB Type-C compliance requirements, but provided for the purpose of design guidelines and manufacturing control. For [Raw Cable] and [Mated Connector] measurements, apply the appropriate calibration depending on the test fixture and also set the appropriate port Z conversion by pressing **Channel Next** to select Channel 2 frequency domain measurements, then **Analysis > Fixture Simulator > Port ZConversion** (45 ohm for all Port1/2/3/4 Z0 Real for [Raw Cable] and 42.5 ohm for all Port1/2/3/4 Z0 Real for
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.

<table>
<thead>
<tr>
<th>E5071C</th>
<th>Port 1</th>
<th>Port 2</th>
<th>Port 3</th>
<th>Port 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>RF Connection</td>
<td>A Side Tx1+</td>
<td>A Side Tx1-</td>
<td>B Side Tx1+</td>
<td>B Side Tx1-</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Type</th>
<th>Limit</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shielded Differential Pair (SDP)</td>
<td>90 +/- 5</td>
<td>Ohm</td>
</tr>
<tr>
<td>Single-ended coaxial SS+ signal wires</td>
<td>45 +/- 3</td>
<td>Ohm</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>E5071C</th>
<th>Port 1</th>
<th>Port 2</th>
<th>Port 3</th>
<th>Port 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>RF Connection</td>
<td>A Side Rx1+</td>
<td>A Side Rx1-</td>
<td>B Side Rx1+</td>
<td>B Side Rx1-</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>E5071C</th>
<th>Port 1</th>
<th>Port 2</th>
<th>Port 3</th>
<th>Port 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>RF Connection</td>
<td>A Side Tx1+</td>
<td>A Side Tx1-</td>
<td>B Side Tx1+</td>
<td>B Side Tx1-</td>
</tr>
</tbody>
</table>

2. Select **Trace 2 (T31)**.
3. Click **Stop Single**.
4. Confirm the measured intra-pair skew is less than 10 ps/m.
5. Connect the E5071C ports (port 1 to 4) to the test fixture ports with RF cables.

<table>
<thead>
<tr>
<th>E5071C</th>
<th>Port 1</th>
<th>Port 2</th>
<th>Port 3</th>
<th>Port 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>RF Connection</td>
<td>A Side Rx1+</td>
<td>A Side Rx1-</td>
<td>B Side Rx1+</td>
<td>B Side Rx1-</td>
</tr>
</tbody>
</table>

6. Repeat the same operation of step 3 to step 4 to confirm the measured skew 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.

<table>
<thead>
<tr>
<th>E5071C</th>
<th>Port 1</th>
<th>Port 2</th>
<th>Port 3</th>
<th>Port 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>RF Connection</td>
<td>A Side Tx1+</td>
<td>A Side Tx1-</td>
<td>B Side Tx1+</td>
<td>B Side Tx1-</td>
</tr>
</tbody>
</table>
2. Press **Channel Next** to select Channel 2.
3. Press **Trace Next** to select Trace 4 (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.

<table>
<thead>
<tr>
<th>E5071C</th>
<th>Port 1</th>
<th>Port 2</th>
<th>Port 3</th>
<th>Port 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>RF Connection</td>
<td>A Side Rx1+</td>
<td>A Side Rx1-</td>
<td>B Side Rx1+</td>
<td>B Side Rx1-</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>E5071C</th>
<th>Port 1</th>
<th>Port 2</th>
<th>Port 3</th>
<th>Port 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Fixtures</td>
<td>TF1 Tx1+</td>
<td>TF1 Tx1-</td>
<td>TF2 Tx1+</td>
<td>TF2 Tx1-</td>
</tr>
</tbody>
</table>

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, 85 +- 9 ohm.
6. Select **Trace 8 (Tdd22)** and repeat step 5 for the far end of DUT.
7. Repeat the same operation of step 3 to step 6 for all the following combinations to confirm the measured impedance is within the specification.

<table>
<thead>
<tr>
<th>E5071C</th>
<th>Port 1</th>
<th>Port 2</th>
<th>Port 3</th>
<th>Port 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Fixtures</td>
<td>TF1 Rx1+</td>
<td>TF1 Rx1-</td>
<td>TF2 Rx1+</td>
<td>TF2 Rx1-</td>
</tr>
<tr>
<td></td>
<td>TF1 Tx2+</td>
<td>TF1 TX2-</td>
<td>TF2 Tx2+</td>
<td>TF2 Tx2-</td>
</tr>
<tr>
<td></td>
<td>TF1 Rx2+</td>
<td>TF1 Rx2-</td>
<td>TF2 Rx2+</td>
<td>TF2 Rx2-</td>
</tr>
</tbody>
</table>

5.4.12. [Mated Connector] Differential Insertion Loss (Informative)
1. Connect the E5071C ports (port 1 to 4) to the test fixture ports with RF cables.

<table>
<thead>
<tr>
<th>E5071C</th>
<th>Port 1</th>
<th>Port 2</th>
<th>Port 3</th>
<th>Port 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Fixtures</td>
<td>TF1 Tx1+</td>
<td>TF1 Tx1-</td>
<td>TF2 Tx1+</td>
<td>TF2 Tx1-</td>
</tr>
</tbody>
</table>

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 within the limit shown below.

<table>
<thead>
<tr>
<th>Start Frequency</th>
<th>Stop Frequency</th>
<th>Start Limit</th>
<th>Stop Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 MHz</td>
<td>2.5 GHz</td>
<td>-0.25 dB</td>
<td>-0.35 dB</td>
</tr>
<tr>
<td>2.5 GHz</td>
<td>5 GHz</td>
<td>-0.35 dB</td>
<td>-0.45 dB</td>
</tr>
<tr>
<td>5 GHz</td>
<td>10 GHz</td>
<td>-0.45 dB</td>
<td>-0.75 dB</td>
</tr>
<tr>
<td>10 GHz</td>
<td>15 GHz</td>
<td>-0.75 dB</td>
<td>-1.85 dB</td>
</tr>
</tbody>
</table>
6. Repeat the same operation of step 4 to step 5 for all the following combinations to confirm the measured insertion loss is within the specification.

<table>
<thead>
<tr>
<th>E5071C</th>
<th>Port 1</th>
<th>Port 2</th>
<th>Port 3</th>
<th>Port 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Fixtures</td>
<td>TF1 Rx1+</td>
<td>TF1 Rx1-</td>
<td>TF2 Rx1+</td>
<td>TF2 Rx1-</td>
</tr>
<tr>
<td></td>
<td>TF1 Tx2+</td>
<td>TF1 TX2-</td>
<td>TF2 Tx2+</td>
<td>TF2 Tx2-</td>
</tr>
<tr>
<td></td>
<td>TF1 Rx2+</td>
<td>TF1 Rx2-</td>
<td>TF2 Rx2+</td>
<td>TF2 Rx2-</td>
</tr>
</tbody>
</table>

5.4.13. [Mated Connector] Differential Return Loss (Informative)

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

<table>
<thead>
<tr>
<th>E5071C</th>
<th>Port 1</th>
<th>Port 2</th>
<th>Port 3</th>
<th>Port 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Fixtures</td>
<td>TF1 Tx1+</td>
<td>TF1 Tx1-</td>
<td>TF2 Tx1+</td>
<td>TF2 Tx1-</td>
</tr>
</tbody>
</table>

2. Press **Trace Next** to select Trace 13 (Sdd11).
3. Press **Trigger > Single**.
4. Confirm the measured differential insertion loss is within the limit shown below.

<table>
<thead>
<tr>
<th>Start Frequency</th>
<th>Stop Frequency</th>
<th>Start Limit</th>
<th>Stop Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 MHz</td>
<td>5 GHz</td>
<td>-20 dB</td>
<td>-20 dB</td>
</tr>
<tr>
<td>5 GHz</td>
<td>10 GHz</td>
<td>-20 dB</td>
<td>-13 dB</td>
</tr>
<tr>
<td>10 GHz</td>
<td>15 GHz</td>
<td>-13 dB</td>
<td>-6 dB</td>
</tr>
</tbody>
</table>

5. Repeat the same operation of step 3 to step 4 for all the following combinations to confirm the measured return loss is within the specification.

<table>
<thead>
<tr>
<th>E5071C</th>
<th>Port 1</th>
<th>Port 2</th>
<th>Port 3</th>
<th>Port 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Fixtures</td>
<td>TF1 Rx1+</td>
<td>TF1 Rx1-</td>
<td>TF2 Rx1+</td>
<td>TF2 Rx1-</td>
</tr>
<tr>
<td></td>
<td>TF1 Tx2+</td>
<td>TF1 TX2-</td>
<td>TF2 Tx2+</td>
<td>TF2 Tx2-</td>
</tr>
<tr>
<td></td>
<td>TF1 Rx2+</td>
<td>TF1 Rx2-</td>
<td>TF2 Rx2+</td>
<td>TF2 Rx2-</td>
</tr>
</tbody>
</table>


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

<table>
<thead>
<tr>
<th>E5071C</th>
<th>Port 1</th>
<th>Port 2</th>
<th>Port 3</th>
<th>Port 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Fixtures</td>
<td>TF1 Tx1+</td>
<td>TF1 Tx1-</td>
<td>TF1 Rx1+</td>
<td>TF1 Rx1-</td>
</tr>
</tbody>
</table>

2. Press **Trace Next** to select Trace 6 (Sdd21).
3. Press **Trigger > Single**.
4. Confirm the measured differential crosstalk is within the limit shown below.

<table>
<thead>
<tr>
<th>Start Frequency</th>
<th>Stop Frequency</th>
<th>Start Limit</th>
<th>Stop Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 MHz</td>
<td>5 GHz</td>
<td>-40 dB</td>
<td>-40 dB</td>
</tr>
<tr>
<td>5 GHz</td>
<td>10 GHz</td>
<td>-40 dB</td>
<td>-36 dB</td>
</tr>
<tr>
<td>10 GHz</td>
<td>15 GHz</td>
<td>-36 dB</td>
<td>-30 dB</td>
</tr>
</tbody>
</table>

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.
5.4.15. [Mated Connector] Differential NEXT & FEXT between D+/D- Pair and SS Signal Pairs (Informative)

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

2. Press Trace Next to select Trace 14 (Sdd21).


4. Confirm the measured differential crosstalk is within the limit shown below.

<table>
<thead>
<tr>
<th>Start Frequency</th>
<th>Stop Frequency</th>
<th>Start Limit</th>
<th>Stop Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 MHz</td>
<td>5 GHz</td>
<td>-40 dB</td>
<td>-40 dB</td>
</tr>
<tr>
<td>5 GHz</td>
<td>7.5 GHz</td>
<td>-40 dB</td>
<td>-36 dB</td>
</tr>
</tbody>
</table>

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.
5.4.16. [Mated Connector] Differential to Common-Mode Conversion (Informative)

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

<table>
<thead>
<tr>
<th>E5071C</th>
<th>Port 1</th>
<th>Port 2</th>
<th>Port 3</th>
<th>Port 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Fixtures</td>
<td>TF1 Tx1+</td>
<td>TF1 Tx1-</td>
<td>TF2 Tx1+</td>
<td>TF2 Tx1-</td>
</tr>
</tbody>
</table>

2. Press Trace Next to select Trace 12 (Scd21).
4. Confirm the measured differential to common-mode conversion is within the limit shown below.

<table>
<thead>
<tr>
<th>Start Frequency</th>
<th>Stop Frequency</th>
<th>Start Limit</th>
<th>Stop Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 MHz</td>
<td>6 GHz</td>
<td>-30 dB</td>
<td>-30 dB</td>
</tr>
<tr>
<td>6 GHz</td>
<td>10 GHz</td>
<td>-30 dB</td>
<td>-25 dB</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>E5071C</th>
<th>Port 1</th>
<th>Port 2</th>
<th>Port 3</th>
<th>Port 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Fixtures</td>
<td>TF1 Rx1+</td>
<td>TF1 Rx1-</td>
<td>TF2 Rx1+</td>
<td>TF2 Rx1-</td>
</tr>
<tr>
<td></td>
<td>TF1 Tx2+</td>
<td>TF1 Tx2-</td>
<td>TF2 Tx2+</td>
<td>TF2 Tx2-</td>
</tr>
<tr>
<td></td>
<td>TF1 Rx2+</td>
<td>TF1 Rx2-</td>
<td>TF2 Rx2+</td>
<td>TF2 Rx2-</td>
</tr>
</tbody>
</table>

5.4.17. Differential Impedance (Informative)

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

<table>
<thead>
<tr>
<th>E5071C</th>
<th>Port 1</th>
<th>Port 2</th>
<th>Port 3</th>
<th>Port 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Fixtures</td>
<td>TF1 Tx1+</td>
<td>TF1 Tx1-</td>
<td>TF2 Rx+</td>
<td>TF2 Rx-</td>
</tr>
</tbody>
</table>

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 76 ohm min and 96 ohm max.
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.

<table>
<thead>
<tr>
<th>E5071C</th>
<th>Port 1</th>
<th>Port 2</th>
<th>Port 3</th>
<th>Port 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Fixtures</td>
<td>TF1 Rx1+</td>
<td>TF1 Rx1-</td>
<td>TF2 Tx+</td>
<td>TF2 Tx-</td>
</tr>
</tbody>
</table>

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

5.4.18. Differential Insertion Loss (Informative)

1. Connect the E5071C ports (port 1 to 4) to the test fixture ports with RF cables.
Keysight MOI for USB Type-C Connectors & Cable Assemblies Compliance Tests
(Type-C to Legacy Cable Assemblies)

<table>
<thead>
<tr>
<th>Test Fixtures</th>
<th>TF1 Tx1+</th>
<th>TF1 Tx1-</th>
<th>TF2 Rx+</th>
<th>TF2 Rx-</th>
</tr>
</thead>
</table>

2. Press **Channel Next** to select Channel 2.

3. Press **Trace Next** to select Trace 7 (Sdd21) (Except for USB Type-C to USB 3.1 Standard-A) or Trace 15 (Sdd21) (USB Type-C to USB 3.1 Standard-A).

4. Press **Trigger > Single**.

5. Confirm the measured differential insertion loss is within the limit shown below.

<table>
<thead>
<tr>
<th>Start Frequency</th>
<th>Stop Frequency</th>
<th>Start Limit</th>
<th>Stop Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 MHz</td>
<td>2.5 GHz</td>
<td>-2 dB</td>
<td>-4 dB</td>
</tr>
<tr>
<td>2.5 GHz</td>
<td>5 GHz</td>
<td>-4 dB</td>
<td>-6 dB</td>
</tr>
</tbody>
</table>

Except for USB Type-C to USB 3.1 Standard-A (Trace 7)

USB Type-C to USB 3.1 Standard-A (Trace 15)

<table>
<thead>
<tr>
<th>Start Frequency</th>
<th>Stop Frequency</th>
<th>Start Limit</th>
<th>Stop Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 MHz</td>
<td>2.5 GHz</td>
<td>-2 dB</td>
<td>-3.5 dB</td>
</tr>
<tr>
<td>2.5 GHz</td>
<td>5 GHz</td>
<td>-3.5 dB</td>
<td>-6 dB</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>E5071C</th>
<th>Port 1</th>
<th>Port 2</th>
<th>Port 3</th>
<th>Port 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Fixtures</td>
<td>TF1 Rx1+</td>
<td>TF1 Rx1-</td>
<td>TF2 Tx+</td>
<td>TF2 Tx-</td>
</tr>
</tbody>
</table>

7. Repeat the same operation of step 4 to step 5 to confirm the measured insertion loss is within the specification.

For the NEXT/FEXT measurements, turn the port Z conversion off by pressing **Channel Next** to select Channel 2, then **Analysis > Fixture Simulator > Port ZConversion > Port ZConversion** so the measurements are performed based on 50 ohm port impedance setting for all the connections. Or the appropriate port Z conversion can be set for each connection reflecting the actual connector impedance (i.e. Type-C side or legacy side).

5.4.19. Differential NEXT between SS Signal Pairs (Informative)

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

<table>
<thead>
<tr>
<th>E5071C</th>
<th>Port 1</th>
<th>Port 2</th>
<th>Port 3</th>
<th>Port 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Fixtures</td>
<td>TF1 Tx1+</td>
<td>TF1 Tx1-</td>
<td>TF1 Rx1+</td>
<td>TF1 Rx1-</td>
</tr>
</tbody>
</table>

2. Press **Trace Next** to select Trace 8 (Sdd21).

3. Press **Trigger > Single**.

4. Confirm the measured differential crosstalk is within the limit shown below.

<table>
<thead>
<tr>
<th>Start Frequency</th>
<th>Stop Frequency</th>
<th>Start Limit</th>
<th>Stop Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 MHz</td>
<td>5 GHz</td>
<td>-34 dB</td>
<td>-34 dB</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>E5071C</th>
<th>Port 1</th>
<th>Port 2</th>
<th>Port 3</th>
<th>Port 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Fixtures</td>
<td>TF2 Tx+</td>
<td>TF2 Tx-</td>
<td>TF2 Rx+</td>
<td>TF2 Rx-</td>
</tr>
</tbody>
</table>
6. Repeat the same operation of step 3 to step 4 to confirm the measured crosstalk is within the specification.

5.4.20. Differential NEXT & FEXT between D+/D- Pair and SS Signal Pairs (Informative)
1. Connect the E5071C ports (port 1 to 4) to the test fixture ports with RF cables.

<table>
<thead>
<tr>
<th>E5071C</th>
<th>Port 1</th>
<th>Port 2</th>
<th>Port 3</th>
<th>Port 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Fixtures</td>
<td>TF1 D+</td>
<td>TF1 D-</td>
<td>TF1 Tx1+</td>
<td>TF1 Tx1-</td>
</tr>
</tbody>
</table>

2. Press **Trace Next** to select Trace 16 (Sdd21).
3. Press **Trigger > Single**.
4. Confirm the measured differential crosstalk is within the limit shown below.

<table>
<thead>
<tr>
<th>Start Frequency</th>
<th>Stop Frequency</th>
<th>Start Limit</th>
<th>Stop Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 MHz</td>
<td>5 GHz</td>
<td>-30 dB</td>
<td>-30 dB</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>E5071C</th>
<th>Port 1</th>
<th>Port 2</th>
<th>Port 3</th>
<th>Port 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Fixtures</td>
<td>TF1 D+</td>
<td>TF1 D-</td>
<td>TF1 Tx1+</td>
<td>TF1 Rx1-</td>
</tr>
<tr>
<td></td>
<td>TF1 D+</td>
<td>TF1 D-</td>
<td>TF2 Tx+</td>
<td>TF2 Tx-</td>
</tr>
<tr>
<td></td>
<td>TF1 D+</td>
<td>TF1 D-</td>
<td>TF2 Rx+</td>
<td>TF2 Rx-</td>
</tr>
<tr>
<td></td>
<td>TF2 D+</td>
<td>TF2 D-</td>
<td>TF2 Tx+</td>
<td>TF2 Tx-</td>
</tr>
<tr>
<td></td>
<td>TF2 D+</td>
<td>TF2 D-</td>
<td>TF2 Rx+</td>
<td>TF2 Rx-</td>
</tr>
<tr>
<td></td>
<td>TF2 D+</td>
<td>TF2 D-</td>
<td>TF1 Tx1+</td>
<td>TF1 Tx1-</td>
</tr>
<tr>
<td></td>
<td>TF2 D+</td>
<td>TF2 D-</td>
<td>TF1 Rx1+</td>
<td>TF1 Rx1-</td>
</tr>
</tbody>
</table>

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

6.2. **D+/D- Impedance**
1. Select **Trace 1**.
2. Open **Parameters** tab.
4. Select Format to “Impedance”
5. Select **Rise Time** to 20-80% and input value (400 ps).
6. Click **Tdd11**.
7. Input vertical scale (10 Ohm/div) and vertical position (40 Ohm).

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

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

14. Select **Trace 5**.
15. Open **Parameter** tab.
16. Click **Tdd22**.
6.3. D+/D- Intra-Pair Skew

6.3.1. Parameter Setup
1. Select Trace 2.
2. Open Parameters tab.
4. Select Formant to “Volt”.
5. Select Rise Time to 20-80% and input value (400 ps).
6. Click T31.
7. Input vertical scale (50 mV/div) and vertical position (100 mV).
8. Open Trace Control tab.
9. Click Trace Settings Copy to launch trace copy dialog box.
10. Select Trace 2 in the From list.
11. Select Trace 6 in the To list.
12. Click Copy.
13. Click Close.
15. Open Parameters tab.
16. Click T42.
17. Select Trace 2 (T31).
18. Click Marker Search and select Δ Time.
19. Check Δ Time.
20. Select Target (Stop) to Trace 6 and click OK.
6.3.2. Crosstalk Compensation

1. Select Trace 2.
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.

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.

6.4. [Raw Cable] Characteristic Impedance (Informative)

1. Select Trace 3.
2. Open Parameters tab.
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 (40 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.
15. Open Parameter tab.
16. Click Tdd22.
6.5. [Mated Connector] Differential Impedance (Informative)
1. Select Trace 4.
2. Open Parameters tab.
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 (35 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.
15. Open Parameters tab.
16. Click Tdd22.

6.6. Common Parameters Setup for Frequency-domain Measurements
1. Press Channel Next to select Channel 2.
2. Press Sweep Setup > Points and set to “1,500”.
3. Press Start > Set start value to “10 MHz”.
4. Press Stop > Set stop value to “15 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) > 1-2
9. Press Analysis > Fixture Simulator > Topology > Port2 (bal) > 3-4
11. Press Display > Allocate Traces >
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 “42.5 ohm”.
14. Press Analysis > Fixture Simulator > Port ZConversion > Port2 Z0 Real and set the port impedance to “42.5 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.

6.7. D+/D- Pair Attenuation
1. Press Trace Next to select Trace 1.
3. Press Scale > Scale/Div to 1 dB/div.
4. Press Scale > Reference Value to -4 dB.

6.8. ILfitatNq, IMR, IXT, IRL, Differential to Common-Mode Conversion
1. Press Trace Next to select Trace 2.
3. Press Scale > Scale/Div to 10 dB/div.
4. Press Scale > Reference Value to -40 dB.

6.9. Differential to Common-Mode Conversion
1. Press Trace Next to select Trace 10.
3. Press Scale > Scale/Div to 5 dB/div.
4. Press Scale > Reference Value to -20 dB.

6.10. 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 11.
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 4.
3. Press Scale > Scale/Div to 5 dB/div.
4. Press Scale > Reference Value to -6 dB.

Keysight MOI for USB Type-C Connectors & Cable Assemblies Compliance Tests
(Type-C to Legacy Cable Assemblies)

1. Press **Trace Next** to select Trace 12.
2. Press **Meas > Scd21**.
3. Press **Scale > Scale/Div** to 5 dB/div.
4. Press **Scale > Reference Value** to -30 dB.

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

1. Press **Trace Next** to select Trace 13.
2. Press **Meas > Sdd11**.
3. Press **Scale > Scale/Div** to 5 dB/div.
4. Press **Scale > Reference Value** to -20 dB.

6.15. [Mated Connector] Differential NEXT & FEXT between SS Signal Pairs (Informative)
1. Press **Trace Next** to select Trace 6.
2. Press **Meas > Sdd21**.
3. Press **Scale > Scale/Div** to 5 dB/div.
4. Press **Scale > Reference Value** to -40 dB.

1. Press **Trace Next** to select Trace 14.
2. Press **Meas > Sdd21**.
3. Press **Scale > Scale/Div** to 5 dB/div.
4. Press **Scale > Reference Value** to -40 dB.

6.17. Differential Insertion Loss (Informative)
1. Press **Trace Next** to select Trace 7.
2. Press **Meas > Sdd21**.
3. Press **Scale > Scale/Div** to 2 dB/div.
4. Press **Scale > Reference Value** to -10 dB.
5. Press **Trace Next** to select Trace 15.
6. Press **Meas > Sdd21**.
7. Press **Scale > Scale/Div** to 2 dB/div.
8. Press **Scale > Reference Value** to -10 dB.
6.18. Differential NEXT between SS Signal Pairs (Informative)
1. Press Trace Next to select Trace 8.
3. Press Scale > Scale/Div to 5 dB/div.
4. Press Scale > Reference Value to -40 dB.

1. Press Trace Next to select Trace 16.
3. Press Scale > Scale/Div to 5 dB/div.
4. Press Scale > Reference Value to -40 dB.

6.20. 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.

<table>
<thead>
<tr>
<th>Type</th>
<th>Begin Stimulus</th>
<th>End Stimulus</th>
<th>Begin Response</th>
<th>End Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0 s</td>
<td>600 μs</td>
<td>100 μs</td>
<td>200 μs</td>
</tr>
<tr>
<td>2</td>
<td>Min</td>
<td>0 s</td>
<td>600 μs</td>
<td>100 μs</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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. USB Type-C 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.

   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 the 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 the 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. 200.00 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. 383.96 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. 200 MHz)

G) Press **Cal** > **Modify Cal Kit** > **Define STDs** > 5.**Line1** > **Max. Frequency** and enter the value of the line1 standard. (i.e. 1 GHz)

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. 84.782 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. 850 MHz)

   G) Press **Cal** > **Modify Cal Kit** > **Define STDs** > 6.**Line2** > **Max. Frequency** and enter the value of the line2 standard. (i.e. 4.25 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. 59.449 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. 4 GHz)

G) Press **Cal > Modify Cal Kit > Define STDs > 7.Line3 > Max. Frequency** and enter the value of the line3 standard. (i.e. 20 GHz)

H) Press **Cal > Modify Cal Kit > Define STDs > 7.Line3 > Media** and select **Coaxial**.

9. 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**.

   J) Press **Cal > Modify Cal Kit > Specify CLSs > TRL Line/Match > Set All > 4.Load**.

10. 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 for high speed signal tests as described in 5.2.1. Recalling a State File.
2. Press Channel Next to select Channel 2.
3. Press Channel Max to maximize Channel 2 on the screen.
4. Perform the calibration using ECaL as described in 5.3.1.2 Frequency-Domain Measurements > 1. ECaL Calibration.
5. 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).

6. Press Analysis > Fixture Simulator > Topology > Port1 (bal) > 1-3
7. Press Analysis > Fixture Simulator > Topology > Port2 (bal) > 2-4
8. Press Analysis > Fixture Simulator > Port ZConversion > Port ZConversion and turn OFF.
9. Press Trace Next to select Trace 7 (Sdd21).
10. Press Trace Max to maximize the selected trace on the screen.
12. Press Save/Recall > Save SnP > S4P > [1-2-3-4]...
13. Enter file name and save the 4-port Touchstone file (*.s4P).
14. Press Analysis > Fixture Simulator > Port ZConversion > Port ZConversion and turn ON.
15. Press Analysis > Fixture Simulator > Topology > Port1 (bal) > 1-2
16. Press Analysis > Fixture Simulator > Topology > Port2 (bal) > 3-4

8.2. De-embedding File Creation
1. Launch PLTS software.
2. Click Utilities > Automatic Fixture Removal > Wizard.
3. Select Differential/4-Ports > Next.

4. Check 2X Thru > Next.
5. Load the Touchstone file for 2x Thru > Next.

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