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 Adapter Assemblies

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1. Revision History

<table>
<thead>
<tr>
<th>Revision</th>
<th>Date</th>
<th>Remarks</th>
</tr>
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<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</td>
</tr>
<tr>
<td></td>
<td></td>
<td>meas. on high speed signal tests</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Minor corrections</td>
</tr>
<tr>
<td>01.01</td>
<td>2016/01/21</td>
<td>• Minor corrections</td>
</tr>
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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 Adapter 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</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</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(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</td>
<td></td>
</tr>
<tr>
<td></td>
<td>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</td>
</tr>
</tbody>
</table>
**Keysight MOI for USB Type-C Connectors & Cable Assemblies Compliance Tests**  
* (Type-C to Legacy Adapter Assemblies)

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Fixture</td>
<td>USB Type-C official test fixtures and calibration standards</td>
<td>1 ea.</td>
</tr>
<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
   - [Raw Cable] Characteristic Impedance (Informative)
   - [Raw Cable] Intra-Pair Skew (Informative)
   - [Mated Connector] Differential Impedance (Informative)

   4-2. Frequency-domain Measurements
   - D+/D- Pair Attenuation
   - ILfitatNq, IMR, IXT, IRL, Differential to Common-Mode Conversion
   - [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 Return Loss (Informative)
   - Differential NEXT between SS Signal Pairs (Informative)
   - Differential NEXT & FEXT between D+/D- Pair and SS Signal Pairs (Informative)
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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/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.
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](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 >1-2-3-4**.

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 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

5.3.2. **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 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 5-1 Specification of Effective Rise Time**

<table>
<thead>
<tr>
<th>Trace</th>
<th>Test Items</th>
<th>Rise Time %</th>
<th>Target Rise Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tr 1 &amp; 5</td>
<td>D+/D- Impedance</td>
<td>20 – 80 %</td>
<td>400 ps</td>
</tr>
<tr>
<td>Tr 2 &amp; 6</td>
<td>D+/D- Intra-Pair Skew</td>
<td>20 – 80 %</td>
<td>400 ps</td>
</tr>
<tr>
<td>Tr 3 &amp; 7</td>
<td>[Raw Cable] Characteristic Impedance</td>
<td>10 – 90 %</td>
<td>200 ps</td>
</tr>
<tr>
<td>Tr 4 &amp; 8</td>
<td>[Mated Connector] Differential Impedance</td>
<td>20 – 80 %</td>
<td>40 ps</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.

• 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”.

• 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 adapter assembly, raw cable and mated connector are assumed as follows (Note: TF stands for Test Fixture). For adapter 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 adapter assembly using the ENA Option TDR are also supported with the limit lines.

[Type-C to Legacy Adapter Assembly]

<table>
<thead>
<tr>
<th>TF1</th>
<th>Adapter Assembly</th>
<th>TF2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type-C (Receptacle)</td>
<td>Type-C (Plug)</td>
<td>Type-A /Micro-B (Receptacle)</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>
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<td>Rx1+/Rx1-</td>
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</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>
</tr>
</thead>
<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>Mated Connector</td>
<td>Type-C (Plug)</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.
Keysight MOI for USB Type-C Connectors & Cable Assemblies Compliance Tests  
(Type-C to Legacy Adapter Assemblies)

<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>

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 (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 adapter 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.

<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 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 20 psec.
5.4.3. 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</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 greater or equal to -0.7 dB @400 MHz.

5.4.4. ILfitatNq, IMR, IXT, IRL, Differential to Common-Mode Conversion

ILfitatNq, 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 Tx+</td>
<td>TF2 Tx-</td>
</tr>
</tbody>
</table>

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 Rx+</td>
<td>TF2 Rx-</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(L) [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 Tx+</td>
<td>TF2 Tx-</td>
<td>TF2 Rx+</td>
<td>TF2 Rx-</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>


<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 Rx+</td>
<td>TF2 Rx-</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(L) [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 Tx+</td>
<td>TF2 Tx-</td>
<td>TF2 Rx+</td>
<td>TF2 Rx-</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 8: Differential NEXT between SS Signal Pairs.

Note: Limit line pass/fail judgment: Trace 16: Differential NEXT & FEXT between D+/D- Pair and SS Signal Pairs.
<table>
<thead>
<tr>
<th>Rx(L), D+/D-(L)</th>
<th>TF1 Rx1+</th>
<th>TF1 Rx1-</th>
<th>TF1 D+</th>
<th>TF1 D-</th>
</tr>
</thead>
<tbody>
<tr>
<td>[5,7,9,11]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Limit line pass/fail judgment: Trace 16: Differential NEXT & FEXT between D+/D- Pair and SS Signal Pairs.

<table>
<thead>
<tr>
<th>Tx(R), D+/D-(R)</th>
<th>TF2 Tx+</th>
<th>TF2 Tx-</th>
<th>TF2 D+</th>
<th>TF2 D-</th>
</tr>
</thead>
<tbody>
<tr>
<td>[2,4,10,12]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Limit line pass/fail judgment: Trace 16: Differential NEXT & FEXT between D+/D- Pair and SS Signal Pairs.

<table>
<thead>
<tr>
<th>Rx(R), D+/D-(R)</th>
<th>TF2 Rx+</th>
<th>TF2 Rx-</th>
<th>TF2 D+</th>
<th>TF2 D-</th>
</tr>
</thead>
<tbody>
<tr>
<td>[6,8,10,12]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Limit line pass/fail judgment: Trace 16: Differential NEXT & FEXT between D+/D- Pair and SS Signal Pairs.

<table>
<thead>
<tr>
<th>Tx(L), Rx(R) [1,3,6,8]</th>
<th>TF1 Tx1+</th>
<th>TF1 Tx1-</th>
<th>TF2 Rx+</th>
<th>TF2 Rx-</th>
</tr>
</thead>
</table>

Note: Limit line pass/fail judgment: n/a

<table>
<thead>
<tr>
<th>Tx(R), Rx(L) [2,4,5,7]</th>
<th>TF2 Tx+</th>
<th>TF2 Tx-</th>
<th>TF1 Rx1+</th>
<th>TF1 Rx1-</th>
</tr>
</thead>
</table>

Note: Limit line pass/fail judgment: n/a

<table>
<thead>
<tr>
<th>Tx(R), D+/D-(L)</th>
<th>TF2 Tx+</th>
<th>TF2 Tx-</th>
<th>TF1 D+</th>
<th>TF1 D-</th>
</tr>
</thead>
<tbody>
<tr>
<td>[2,4,9,11]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Limit line pass/fail judgment: Trace 16: Differential NEXT & FEXT between D+/D- Pair and SS Signal Pairs.

<table>
<thead>
<tr>
<th>Rx(R), D+/D-(L)</th>
<th>TF2 Rx+</th>
<th>TF2 Rx-</th>
<th>TF1 D+</th>
<th>TF1 D-</th>
</tr>
</thead>
<tbody>
<tr>
<td>[6,8,9,11]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Limit line pass/fail judgment: Trace 16: Differential NEXT & FEXT between D+/D- Pair and SS Signal Pairs.

<table>
<thead>
<tr>
<th>Tx(L), D+/D-(R)</th>
<th>TF1 Tx1+</th>
<th>TF1 Tx1-</th>
<th>TF2 D+</th>
<th>TF2 D-</th>
</tr>
</thead>
<tbody>
<tr>
<td>[1,3,10,12]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Limit line pass/fail judgment: Trace 16: Differential NEXT & FEXT between D+/D- Pair and SS Signal Pairs.

<table>
<thead>
<tr>
<th>Rx(L), D+/D-(R)</th>
<th>TF1 Rx1+</th>
<th>TF1 Rx1-</th>
<th>TF2 D+</th>
<th>TF2 D-</th>
</tr>
</thead>
<tbody>
<tr>
<td>[5,7,10,12]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Limit line pass/fail judgment: Trace 16: Differential NEXT & FEXT between D+/D- Pair and SS Signal Pairs.

7. Open the Excel spreadsheet [High_Speed]_Config_4ports_[1324].xlsx and modify “Cable Type” to 5 (Type-C to Legacy Adapter) 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”, 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.

5.4.5. 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 Tx+</td>
<td>TF2 Tx-</td>
</tr>
</tbody>
</table>

2. Press Trace Next to select Trace 10 (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>7.5 GHz</td>
<td>-15 dB</td>
<td>-15 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 Rx+</td>
<td>TF2 Rx-</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.

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 [Mated Connector]).

5.4.6. [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>
</table>
Keysight MOI for USB Type-C Connectors & Cable Assemblies Compliance Tests
(Type-C to Legacy Adapter Assemblies)

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

5.4.7. [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.

5.4.8. [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).
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.
5.4.9. [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 T1+</td>
<td>TF1 T1-</td>
<td>TF2 T1+</td>
<td>TF2 T1-</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 T2+</td>
<td>TF1 T2-</td>
<td>TF2 T2+</td>
<td>TF2 T2-</td>
</tr>
</tbody>
</table>

5.4.10. [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 T1+</td>
<td>TF1 T1-</td>
<td>TF2 T1+</td>
<td>TF2 T1-</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 T2+</td>
<td>TF1 T2-</td>
<td>TF2 T2+</td>
<td>TF2 T2-</td>
</tr>
</tbody>
</table>

5.4.11. [Mated Connector] Differential Return 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 Adapter Assemblies)

| Test Fixtures | TF1 Tx1+ | TF1 Tx1- | TF2 Tx1+ | TF2 Tx1- |

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 Port 1</th>
<th>Port 2</th>
<th>Port 3</th>
<th>Port 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>TF1 Rx1+</td>
<td>TF1 Rx1-</td>
<td>TF2 Rx1+</td>
<td>TF2 Rx1-</td>
</tr>
<tr>
<td>TF1 Tx2+</td>
<td>TF1 Tx2-</td>
<td>TF2 Tx2+</td>
<td>TF2 Tx2-</td>
</tr>
<tr>
<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 NEXT & FEXT 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 Port 1</th>
<th>Port 2</th>
<th>Port 3</th>
<th>Port 4</th>
</tr>
</thead>
<tbody>
<tr>
<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.

<table>
<thead>
<tr>
<th>E5071C Port 1</th>
<th>Port 2</th>
<th>Port 3</th>
<th>Port 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>TF1 Tx1+</td>
<td>TF1 Tx1-</td>
<td>TF2 Rx1+</td>
<td>TF2 Rx1-</td>
</tr>
<tr>
<td>TF2 Tx1+</td>
<td>TF2 Tx1-</td>
<td>TF2 Rx1+</td>
<td>TF2 Rx1-</td>
</tr>
<tr>
<td>TF2 Tx1+</td>
<td>TF2 Tx1-</td>
<td>TF1 Rx1+</td>
<td>TF1 Rx1-</td>
</tr>
<tr>
<td>TF1 Tx2+</td>
<td>TF1 Tx2-</td>
<td>TF1 Rx2+</td>
<td>TF1 Rx2-</td>
</tr>
<tr>
<td>TF1 Tx2+</td>
<td>TF1 Tx2-</td>
<td>TF2 Rx2+</td>
<td>TF2 Rx2-</td>
</tr>
<tr>
<td>TF2 Tx2+</td>
<td>TF2 Tx2-</td>
<td>TF2 Rx2+</td>
<td>TF2 Rx2-</td>
</tr>
<tr>
<td>TF1 Rx2+</td>
<td>TF1 Rx2-</td>
<td>TF1 Rx2+</td>
<td>TF1 Rx2-</td>
</tr>
</tbody>
</table>
5.4.13. [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.

<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 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.

<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 Tx1+</td>
<td>TF2 Tx1-</td>
</tr>
<tr>
<td>TF1 D+</td>
<td>TF1 D-</td>
<td>TF2 Tx1+</td>
<td>TF2 Tx1-</td>
<td></td>
</tr>
<tr>
<td>TF1 D+</td>
<td>TF1 D-</td>
<td>TF2 Rx1+</td>
<td>TF2 Rx1-</td>
<td></td>
</tr>
<tr>
<td>TF1 D+</td>
<td>TF1 D-</td>
<td>TF1 Tx2+</td>
<td>TF1 Tx2-</td>
<td></td>
</tr>
<tr>
<td>TF1 D+</td>
<td>TF1 D-</td>
<td>TF1 Rx2+</td>
<td>TF1 Rx2-</td>
<td></td>
</tr>
<tr>
<td>TF1 D-</td>
<td>TF1 D-</td>
<td>TF2 Tx1+</td>
<td>TF2 Tx1-</td>
<td></td>
</tr>
<tr>
<td>TF1 D-</td>
<td>TF1 D-</td>
<td>TF2 Rx1+</td>
<td>TF2 Rx1-</td>
<td></td>
</tr>
<tr>
<td>TF2 D+</td>
<td>TF2 D-</td>
<td>TF1 Tx1+</td>
<td>TF1 Tx1-</td>
<td></td>
</tr>
<tr>
<td>TF2 D+</td>
<td>TF2 D-</td>
<td>TF1 Rx1+</td>
<td>TF1 Rx1-</td>
<td></td>
</tr>
<tr>
<td>TF2 D+</td>
<td>TF2 D-</td>
<td>TF2 Tx2+</td>
<td>TF2 Tx2-</td>
<td></td>
</tr>
<tr>
<td>TF2 D+</td>
<td>TF2 D-</td>
<td>TF2 Rx2+</td>
<td>TF2 Rx2-</td>
<td></td>
</tr>
<tr>
<td>TF2 D+</td>
<td>TF2 D-</td>
<td>TF1 Tx2+</td>
<td>TF1 Tx2-</td>
<td></td>
</tr>
<tr>
<td>TF2 D+</td>
<td>TF2 D-</td>
<td>TF1 Rx2+</td>
<td>TF1 Rx2-</td>
<td></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>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.
Keysight MOI for USB Type-C Connectors & Cable Assemblies Compliance Tests (Type-C to Legacy Adapter Assemblies)

<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>Port 1</td>
<td>TF1 Rx1+</td>
<td>TF1Rx1-</td>
<td>TF2 Rx1+</td>
<td>TF2 Rx1-</td>
</tr>
<tr>
<td>Port 2</td>
<td>TF1 Tx2+</td>
<td>TF1 Tx2-</td>
<td>TF2 Tx2+</td>
<td>TF2 Tx2-</td>
</tr>
<tr>
<td>Port 3</td>
<td>TF1 Rx2+</td>
<td>TF1 Rx2-</td>
<td>TF2 Rx2+</td>
<td>TF2 Rx2-</td>
</tr>
</tbody>
</table>

5.4.15. 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>Port 1</td>
<td>TF1 Tx1+</td>
<td>TF1 Tx1-</td>
<td>TF2 Tx+</td>
<td>TF2 Tx-</td>
</tr>
</tbody>
</table>

2. Press Trace Next to select Trace 7 (Sdd21).


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>10 MHz</td>
<td>2.5 GHz</td>
<td>-2.4 dB</td>
<td>-2.4 dB</td>
</tr>
<tr>
<td>2.5 GHz</td>
<td>5 GHz</td>
<td>-2.4 dB</td>
<td>-3.5 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>Port 1</td>
<td>TF1 Rx1+</td>
<td>TF1 Rx1-</td>
<td>TF2 Rx+</td>
<td>TF2 Rx-</td>
</tr>
</tbody>
</table>

7. Repeat the same operation of step 3 to step 4 to confirm the measured insertion loss is within the specification.

5.4.16. 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>Port 1</td>
<td>TF1 Tx1+</td>
<td>TF1 Tx1-</td>
<td>TF2 Tx+</td>
<td>TF2 Tx-</td>
</tr>
</tbody>
</table>

2. Press Trace Next to select Trace 15 (Sdd11).


4. Confirm the measured differential return 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>10 MHz</td>
<td>5 GHz</td>
<td>-15 dB</td>
<td>-15 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>Port 1</td>
<td>TF1 Rx1+</td>
<td>TF1 Rx1-</td>
<td>TF2 Rx+</td>
<td>TF2 Rx-</td>
</tr>
</tbody>
</table>
7. Repeat the same operation of step 3 to step 4 to confirm the measured return loss is within the specification.

5.4.17. 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 **Analysis > Fixture Simulator > Port ZConversion > Port3 Z0 Real** and set the port impedance to “42.5 ohm”.
3. Press **Analysis > Fixture Simulator > Port ZConversion > Port4 Z0 Real** and set the port impedance to “42.5 ohm”.
4. Press **Trace Next** to select Trace 8 (Sdd21).
5. Press **Trigger > Single**.
6. 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>2.5 GHz</td>
<td>-40 dB</td>
<td>-40 dB</td>
</tr>
<tr>
<td>2.5 GHz</td>
<td>5 GHz</td>
<td>-40 dB</td>
<td>-34 dB</td>
</tr>
</tbody>
</table>

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>TF2 Tx+</td>
<td>TF2 Tx-</td>
<td>TF2 Rx+</td>
<td>TF2 Rx-</td>
</tr>
</tbody>
</table>

8. Press **Analysis > Fixture Simulator > Port ZConversion > Port1 Z0 Real** and set the port impedance to “45 ohm”.
9. Press **Analysis > Fixture Simulator > Port ZConversion > Port2 Z0 Real** and set the port impedance to “45 ohm”.
10. Press **Analysis > Fixture Simulator > Port ZConversion > Port3 Z0 Real** and set the port impedance to “45 ohm”.
11. Press **Analysis > Fixture Simulator > Port ZConversion > Port4 Z0 Real** and set the port impedance to “45 ohm”.
12. Repeat the same operation of step 5 to step 6 to confirm the measured crosstalk is within the specification.
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”.

5.4.18. 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.
Keysight MOI for USB Type-C Connectors & Cable Assemblies Compliance Tests
(Type-C to Legacy Adapter Assemblies)

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

2. Press **Analysis > Fixture Simulator > Port ZConversion > Port3 Z0 Real** and set the port impedance to “42.5 ohm”.

3. Press **Analysis > Fixture Simulator > Port ZConversion > Port4 Z0 Real** and set the port impedance to “42.5 ohm”.

4. Press **Trace Next** to select Trace 16 (Sdd21).

5. Press **Trigger > Single**.

6. 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>2.5 GHz</td>
<td>-30 dB</td>
<td>-30 dB</td>
</tr>
</tbody>
</table>

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

8. Repeat the same operation of step 5 to step 6 to confirm the measured crosstalk is within the specification.

9. 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 Rx1+</td>
<td>TF1 Rx1-</td>
</tr>
</tbody>
</table>

10. Press **Analysis > Fixture Simulator > Port ZConversion > Port3 Z0 Real** and set the port impedance to “45 ohm”.

11. Press **Analysis > Fixture Simulator > Port ZConversion > Port4 Z0 Real** and set the port impedance to “45 ohm”.

12. Repeat the same operation of step 5 to step 6 to confirm the measured crosstalk is within the specification.

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

14. Repeat the same operation of step 5 to step 6 to confirm the measured crosstalk is within the specification.

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

16. Press **Analysis > Fixture Simulator > Port ZConversion > Port1 Z0 Real** and set the port impedance to “45 ohm”.

17. Press **Analysis > Fixture Simulator > Port ZConversion > Port2 Z0 Real** and set the port impedance to “45 ohm”.

18. Repeat the same operation of step 5 to step 6 to confirm the measured crosstalk is within the specification.

19. Connect the E5071C ports (port 1 to 4) to the test fixture ports with RF cables.
20. Repeat the same operation of step 5 to step 6 to confirm the measured crosstalk is within the specification.

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

22. Press **Analysis > Fixture Simulator > Port ZConversion > Port3 Z0 Real** and set the port impedance to “42.5 ohm”.

23. Press **Analysis > Fixture Simulator > Port ZConversion > Port4 Z0 Real** and set the port impedance to “42.5 ohm”.

24. Repeat the same operation of step 5 to step 6 to confirm the measured crosstalk is within the specification.

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

26. Repeat the same operation of step 5 to step 6 to confirm the measured crosstalk is within the specification.

27. Press **Analysis > Fixture Simulator > Port ZConversion > Port1 Z0 Real** and set the port impedance to “42.5 ohm”.

28. Press **Analysis > Fixture Simulator > Port ZConversion > Port2 Z0 Real** and set the port impedance to “42.5 ohm”.

29. Press **Analysis > Fixture Simulator > Port ZConversion > Port3 Z0 Real** and set the port impedance to “45 ohm”.

30. Press **Analysis > Fixture Simulator > Port ZConversion > Port4 Z0 Real** and set the port impedance to “45 ohm”.

<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 D+</td>
<td>TF2 D-</td>
<td>TF2 Rx+</td>
<td>TF2 Rx-</td>
</tr>
</tbody>
</table>

<table>
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<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 D+</td>
<td>TF2 D-</td>
<td>TF1 Tx1+</td>
<td>TF1 Tx1-</td>
</tr>
</tbody>
</table>

<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 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 this 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).

![Image of D+/D- Impedance setup]

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

![Image of Trace Settings 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**.
14. Select **Trace 8**.
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**
10. Press **Display > Num of Traces > 16**.
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.
2. Press **Meas > Sdd21**.
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.
2. Press **Meas > Sdd21**.
3. Press **Scale > Scale/Div** to 10 dB/div.
4. Press **Scale > Reference Value** to -40 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 10.
2. Press **Meas > Scd21**.
3. Press **Scale > Scale/Div** to 5 dB/div.
4. Press **Scale > Reference Value** to -20 dB.

6.10. **[Raw Cable] Differential Insertion Loss (Informative)**
1. Press **Trace Next** to select Trace 4.
2. Press **Meas > Sdd21**.
3. Press **Scale > Scale/Div** to 5 dB/div.
4. Press **Scale > Reference Value** to -6 dB.

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

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.

6.16. 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.

6.17. Differential Return Loss (Informative)
1. Press **Trace Next** to select Trace 15.
2. Press **Meas > Sdd11**.
3. Press **Scale > Scale/Div** to 5 dB/div.
4. Press **Scale > Reference Value** to -20 dB.

6.18. Differential NEXT between SS 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 -40 dB.

1. Press **Trace Next** to select Trace 16.
2. Press **Meas** > **Sdd21**.
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 x</td>
<td>600 μs</td>
<td>10 μs</td>
<td>10 μs</td>
</tr>
<tr>
<td>2</td>
<td>0 ±</td>
<td>600 μs</td>
<td>75 μs</td>
<td>75 μs</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 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)

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)

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.
   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.

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).

![Diagram of 2x Thru Standard Measurement](image)

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.