Revision 1.1

15-Dec 2009

Universal Serial Bus 3.0 Specification Version 1.0 Agilent Method of Implementation (MOI) for USB 3.0 Connectors and Cable Assemblies Compliance Tests Using Agilent E5071C ENA Network Analyzer

Table of Contents

1. Modification Record

Revision	Comments	Issue Date
1.0	Draft.	Jun 16, 2009
1.1	- Added the Near End Crosstalk for Time Domain. - Added the 4-Port ECal and De-Embedding. - Modified the test limit for the Near End Crosstalk and the Far End Crosstalk.	Dec 15, 2009

2. Instrumentation Requirements

1. E5071C Network Analyzer (Must include option 010 and one of the following options 480/485/4D5/4K5)
2. A set of USB 3.0 test fixtures which includes TRL/M calibration boards from 4 MHz to 8.5 GHz

   List of test fixtures
   - Short
   - Thru
   - Load
   - Line1
   - Line2

   Note: For more information, refer to Define Calkit in 4.1.1.1.
3. Four 3.5mm(f)-Type N(m) adapters (Agilent 1250-1744)

   (Not required if E5071C includes option 4D5 or 4K5)
4. Four 3.5 mm cables 10GHz bandwidth or equivalent
5. 50 ohm terminations to terminate unused channels (ex. Agilent 909D-301)
6. N4431B Electronic Calibration Module (ECal module).

   (If E5071C includes option 4D5 or 4K5, select N4433A ECal module)

Reference Documents

1. Universal Serial Bus 3.0 Specification.
2. Universal Serial Bus 3.0 Connectors and Cable Assemblies Compliance Document.

3. Outline of the testing

Set measurement conditions.

Connect matched 3.5 mm cables to the test ports of the instruments.

Perform TRL/M or ECal & De-Embedding calibration at the 3.5 mm cables for all ports.

Time Domain Measurements

-Mated Connector Impedance measurements (Normative).

-Raw Cable Impedance measurements (Informative).

-Intra-Pair Skew measurements (Informative).

-Near End Crosstalk measurements (Normative).

Frequency Domain Measurements

-Insertion Loss measurements (Normative).

-Near End Crosstalk measurements (Normative).

-Far End Crosstalk measurements (Informative).

-Crosstalk between D+/D- and Super Speed measurements (Normative).

-Common-Mode Conversion measurements (Normative).

*Note: Hard Keys (Keys located on the Front panel of E5071C) are displayed in Blue color and **Bold**. (Example:* **Display**, **Marker**, **Analysis***)*

*Note: Soft keys (Keys on the screen) are displayed as **Bold**. (Example:* **S11**, **Real**, **Transform***)*

4. Calibration Methods

Perform TRL/M Calibration for Time Domain Measurements and Frequency Domain Measurements.

Calibration for Time Domain Measurements

Please select from the following.

1. TRL/M Calibration (Refer to 4.1.1 TRL/M Calibration)

Note: TRL/M calibration from 4 MHz to 8.5 GHz is required in this MOI. Make sure the TRL/M calibration board satisfies the condition.

2. ECal & De-Embedding (Refer to 4.1.2 4-Port ECal (Full 4-port calibration) and De-Embedding.

Calibration for Frequency Domain Measurements

Please select from the following.

1. TRL/M Calibration (Refer to 4.1.1 TRL/M Calibration)

Note: TRL/M calibration from 4 MHz to 8.5 GHz is required in this MOI. Make sure the TRL/M calibration board satisfies the condition.

2. ECal & De-Embedding (Refer to 4.1.2 4-Port ECal (Full 4-port calibration) and De-Embedding.

4.1. Calibration for Time Domain and Frequency Domain Measurements

4.1.1. TRL/M Calibration

TRL/M calibration requires defining calibration kit before performing measurement setup.

4.1.1.1. Define Calkit

1. Press **Cal** key.
2. Click **Cal Kit** > **User**
3. Click **Modify Kit** > **Label Kit [User]**, then type in a name you want.
4. Click **Define STDs** >
   a) **1.No Name** >
      1. **Label** : ”Thru”
      2. **STD Type** : Delay/Thru
      3. **Offset Delay** : Value defined by the fixture
      4. **Offset Z0** : Value defined by the fixture
      5. **Offset Loss** : Value defined by the fixture
      6. **Min. Frequency** : Value defined by the fixture
      7. **Max. Frequency** : Value defined by the fixture
      8. **Return**
   b) **2.No Name** >
      1. **Label** : ”Short”
      2. **STD Type** : Short
      3. **Offset Delay** : Value defined by the fixture
      4. **Offset Z0** : Value defined by the fixture
      5. **Offset Loss** : Value defined by the fixture
      6. **Min. Frequency** : Value defined by the fixture
      7. **Max. Frequency** : Value defined by the fixture

8. **Return**

c) **3.No Name** >

1. **Label** : ”Open”
2. **STD Type** : Open
3. **Offset Delay** : Value defined by the fixture
4. **Offset Z0** : Value defined by the fixture
5. **Offset Loss** : Value defined by the fixture
6. **Min. Frequency** : Value defined by the fixture
7. **Max. Frequency** : Value defined by the fixture
8. **Return**

d) **4.No Name** >

1. **Label** : ”Load”
2. **STD Type** : Load
3. **Offset Delay** : Value defined by the fixture
4. **Offset Z0** : Value defined by the fixture
5. **Offset Loss** : Value defined by the fixture
6. **Min. Frequency** : Value defined by the fixture
7. **Max. Frequency** : Value defined by the fixture
8. **Return**

e) **5.No Name** >

1. **Label** : ”Line1”
2. **STD Type** : Delay/Thru
3. **Offset Delay** : Value defined by the fixture
4. **Offset Z0** : Value defined by the fixture
5. **Offset Loss** : Value defined by the fixture
6. **Min. Frequency** : Value defined by the fixture
7. **Max. Frequency** : Value defined by the fixture
8. **Return**

f) Repeat step e) for the remaining Lines and enter definitions according to the fixture.

Example:

6.No Name >

1. **Label** : ”Line2”
2. **STD Type** : Delay/Thru
3. **Offset Delay** : Value defined by the fixture
4. **Offset Z0** : Value defined by the fixture
5. **Offset Loss** : Value defined by the fixture
6. **Min. Frequency** : Value defined by the fixture
7. **Max. Frequency** : Value defined by the fixture
8. **Return**

5. Click **Return**.
6. Click **Specify CLSs** >

a) **Sub class1** >

1. **TRL Thru** > **Set All** > **Thru** > **Return**
2. **TRL Reflect** > **Short** or **Open**
3. **TRL Line/Match** > **Set All** > **Load** > **Return**

b) **Sub class2** >

1. **TRL Line/Match** > **Set All** > **Line1** > **Return**

c) Select next Sub classes for the remaining Lines according to step b).

Example:

Sub class3 >

1. **TRL Line/Match** > **Set All** > **Line2** > **Return**

7. Click **Return**
8. Click **Export Calkit…** to open the dialog box and Save user Calkit.
9. Specify a folder, enter a file name, and click **Save**.

Note: Refer to “Modifying Calibration Kit Definition” in ENA online help for the detail.

4.1.1.2. Calibrate

1. Refer to Chapter 5 USB 3.0 Cable Measurements and perform measurement setup.
2. Press **Cal** key.
3. Click **Calkit** and select Calkit which you previously defined.
4. Click **Calibrate** > **4-Port TRL Cal**.
5. Click **Thru/Line**.
   a) Connect “Thru” standard between Port1 and Port2.
   b) Click **1-2 Thru/Line** > **Thru/Line 1**.
   c) Click **Return**.
   d) Connect “Thru” standard between Port1 and Port3.
   e) Click **1-3 Thru/Line** > **Thru/Line 1**.
   f) Click **Return**.
   g) Connect “Thru” standard between Port3 and Port4.
   h) Click **3-4 Thru/Line** > **Thru/Line 1**.
   i) Click **Return**.
   j) Click **Return**.
6. Click **Reflect**.
   a) Connect “Short” or “Open” standard defined at subclass setting to Port1.
   b) Click **Port1 Reflect** > **Reflect 1**.
   c) Click **Return**.
   d) Connect “Short” or “Open” standard defined at subclass setting to Port2.
   e) Click **Port2 Reflect** > **Reflect 1**.
   f) Click **Return**.
   g) Connect “Short” or “Open” standard defined at subclass setting to Port3.
   h) Click **Port3 Reflect** > **Reflect 1**.
   i) Click **Return**.
   j) Connect “Short” or “Open” standard defined at subclass setting to Port4.

k) Click **Port4 Reflect** > **Reflect 1**.

l) Click **Return**.

m) Click **Return**.

7. Click **Line/Match**

a) Click **1-2 Line/Match**.

b) Connect “Load” standard between Port1 and Port2.

c) Click **Line/Match 1[Load]**.

d) Connect “Line1” standard between Port1 and Port2.

e) Click **Line/Match 2[Line1]**.

f) Repeat step b) to e) for the remaining defined Lines.

Example: Connect “Line2” standard between Port1 and Port2.

Click **Line/Match 3[Line2]**.

g) Click **Return**.

h) Click **1-3 Line/Match** and repeat step b) to f).

i) Click **3-4 Line/Match** and repeat step b) to f).

j) Click **Return**.

8. Click **Done** to finish TRL/M 4-port calibration. At this point, the calibration coefficient is calculated and saved. The error correction function is automatically turned on.

9. Press **Save/Recall** > **Save Channel** > **State A**.

Note: Refer to “4-port TRL Calibration” in ENA online help for the detail.

4.1.2. 4-Port ECal (Full 4-port calibration) and De-Embedding

De-Embedding function allows arbitrary networks, such as fixtures, in Touchstone data format to be removed from the total network.

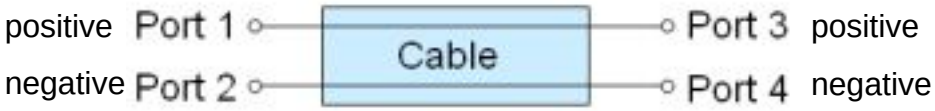
1. Prepare two-port Touchstone data files (.s2p format) corresponding to the network to be de-embedded.
2. Connect ECal to test port cables.
3. Press **Cal** > **ECal** > **4-Port Cal**.
4. Press **Analysis** > **Fixture Simulator** > **De-Embedding**.
5. Click **Select Port**.
6. Click **1**, **2**, **3** or **4** to select the test port for which the network de-embedding is applied.
7. Click **User File**.
8. Using the dialog box that appears, select the Touchstone data file defining the characteristics of the network to be de-embedded. Once the file is selected, the selection of **Select Type** automatically changes to **User**. To cancel a user-defined file that has been set up, click **Select Type** > **None**.
9. Repeat the procedure to set up the Touchstone data file for each port from which a network is to be de-embedded.
10. Click **De-Embedding** to turn the network de-embedding function **ON**.
11. Click **Return**.

Note: Refer to "Extending the Calibration Plane Using Network De-embedding" in ENA online help for the detail.

5. USB 3.0 Cable Measurements

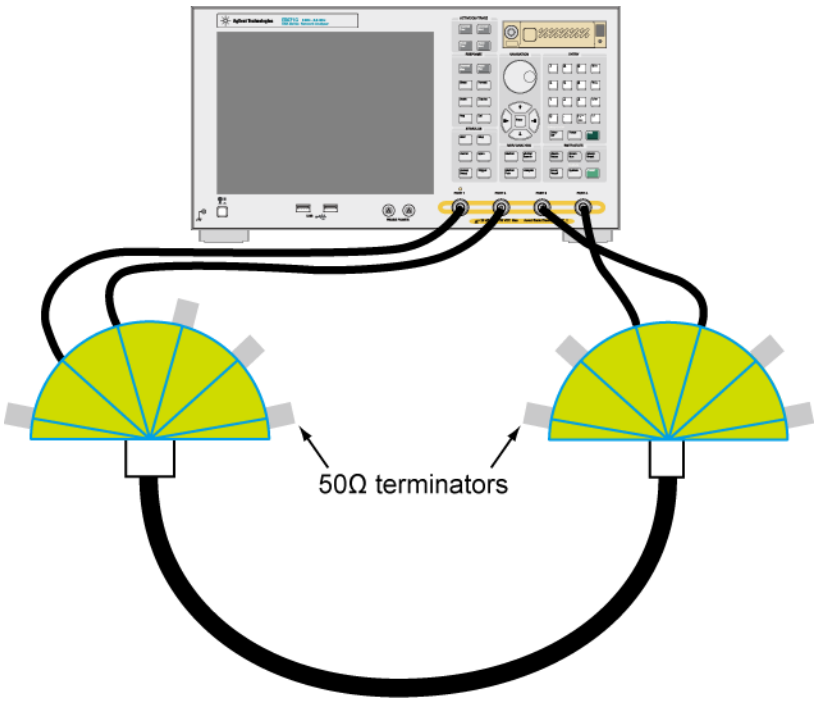
5.1. Test Port Cable and Fixture Connection

Cable under test will be tested in the following manner



Note: DUT is connected with port1 and port2 of the E5071C.

Example: Testing Insertion Loss.



5.2. Mated Connector Impedance Measurement (Normative)

5.2.1. Impedance Profile

The impedance profile of the mated connector is defined from the receptacle through the plug cable mated area.

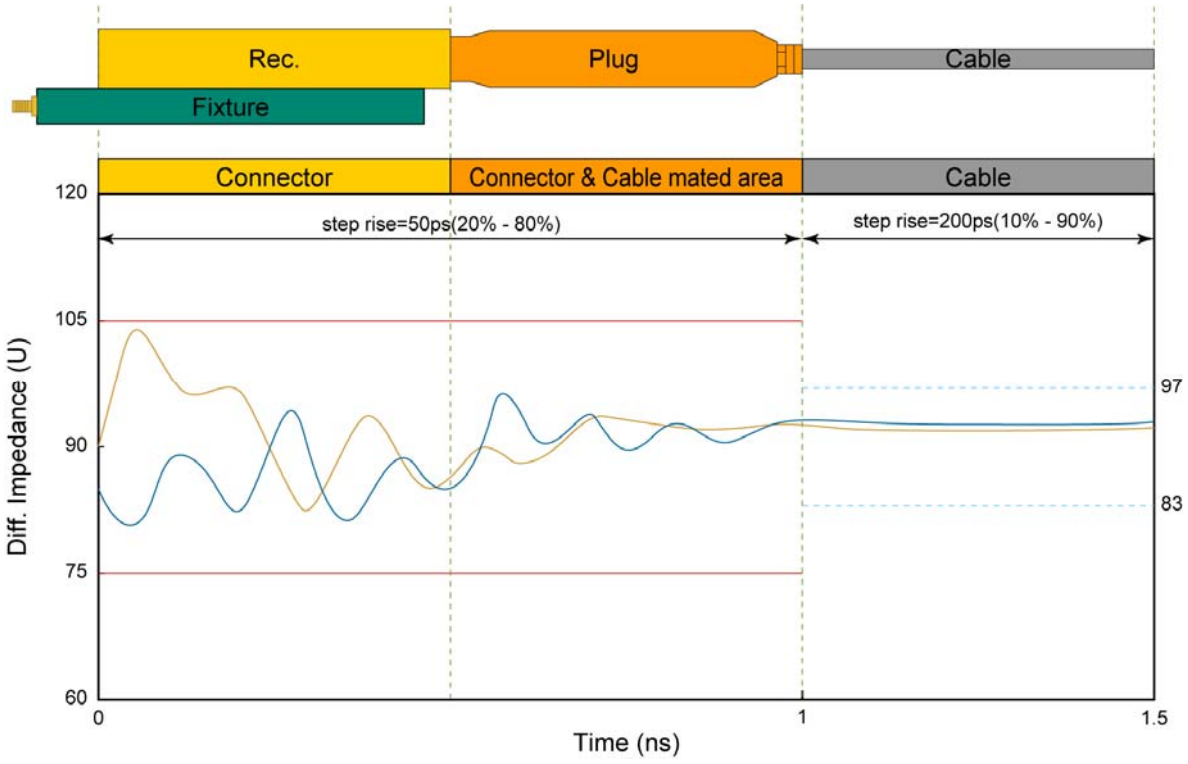


Figure 5-1 Impedance Profile and Impedance Limits

5.2.2. Measurement Setup

1. Press **Preset** > **OK**.
2. Press **Display** > Set **Num of Traces** > **2**.
3. Press **Sweep Setup** > **Sweep Type** > **Lin Freq**.
4. Set **Points** to 1601.
5. Press **Start** > Set start value to 100 MHz.
6. Press **Stop** > Set stop value to 7 GHz.
7. Press **Avg** > Set **IF Bandwidth** to 10 kHz.
8. Press **Analysis** > **Fixture Simulator** > **Fixture Simulator** and turn it **ON**.

9. Click **Port ZConversion** and turn it **ON**.
10. Set **Port1 Z0 Real**, **Port2 Z0 Real**, **Port3 Z0 Real** and **Port4 Z0 Real** to 45 ohm.
11. Click **Return**.
12. Click **Topology** > **Device** > **Bal-Bal**.
13. Click **Port1 (bal)** > **1-2**.
14. Click **Port2 (bal)** > **3-4**.
15. Click **Return**.
16. Click **BalUn** and turn it **ON**.
17. Click **Measurement** > **Sdd11**.
18. Press **Format** > **Real**.
19. Press **Analysis** > **Transform** > **Transform** and turn it **ON**.
20. Click **Type** > **Lowpass Step**.
21. Click **Set Freq Low pass** if trace 1 selected.
22. Set **Start** to 0 sec.
23. Set **Stop** to 1.5 nsec.
24. Click **Window** > Set **Step Rise** to 66.7 psec. (Refer to Method for Determining the Step Rise in 6 Appendix)
25. Press **Analysis** > **Conversion** > **Conversion** and turn it **ON**.
26. Click **Function** > **Z:Reflection**.
27. Press **Scale** > Set **Divisions** to 12.
28. Set **Scale/Div** to 5 U/div.
29. Set **Reference position** to 6 Div.
30. Set **Reference Value** to 90 U.
31. Press **Trace Next**.
32. Press **Analysis** > **Fixture Simulator** > **BalUn** and turn it **ON**.
33. Click **Measurement** > **Sdd22**.
34. Repeat step 18 to 30 for trace 2.

5.2.3. Calibration

Refer to 4.1.1 TRL/M Calibration or 4.1.2 4-Port ECal (Full 4-port calibration) and De-Embedding.

5.2.4. Measurement

1. Connect the test fixture to the test port cables according to the Figure 5-2 Connection Example for Connector Impedance Measurement. Unused terminals should be terminated.
2. Connect a USB 3.0 cable to the test fixtures.
3. Press **Trigger** > **Single**.
4. Measurement result is displayed. Refer to Table 5-1 Mated Connector Impedance Limits for Pass/Fail criteria.
5. Using the same manner above, measure other pairs.

5.2.5. Data Analysis

For Pass/Fail refer to below Mated Connector Impedance Limits. (Refer to Figure 5-1 Impedance Profile and Impedance Limits)

Table 5-1 Mated Connector Impedance Limits

Limit	Start Time	End Time	Start Limit	End Limit
Upper	0 s	1 ns	105 U	105 U
Lower	0 s	1 ns	75 U	75 U

"U": impedance unit.

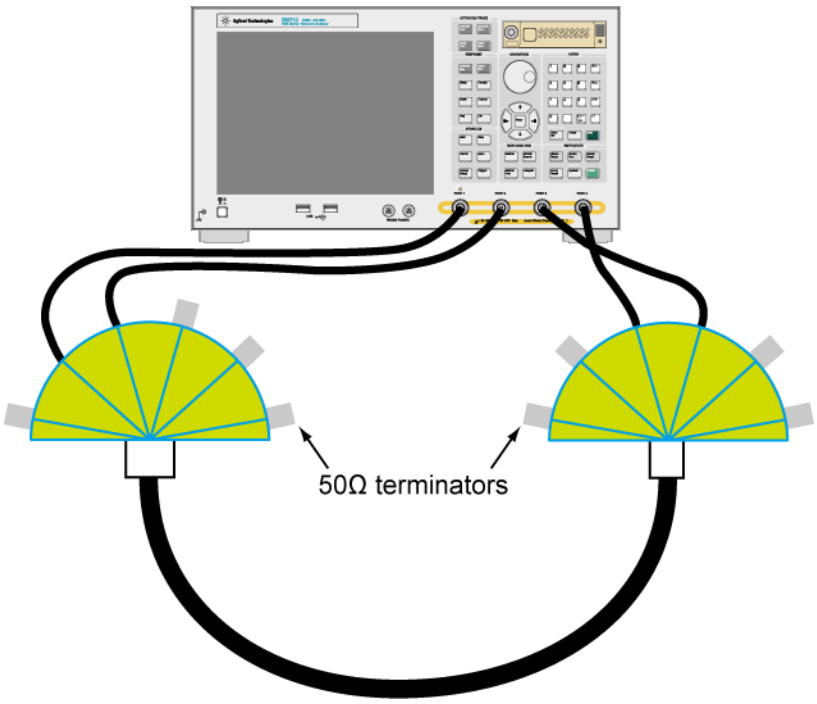


Figure 5-2 Connection Example for Connector Impedance Measurement

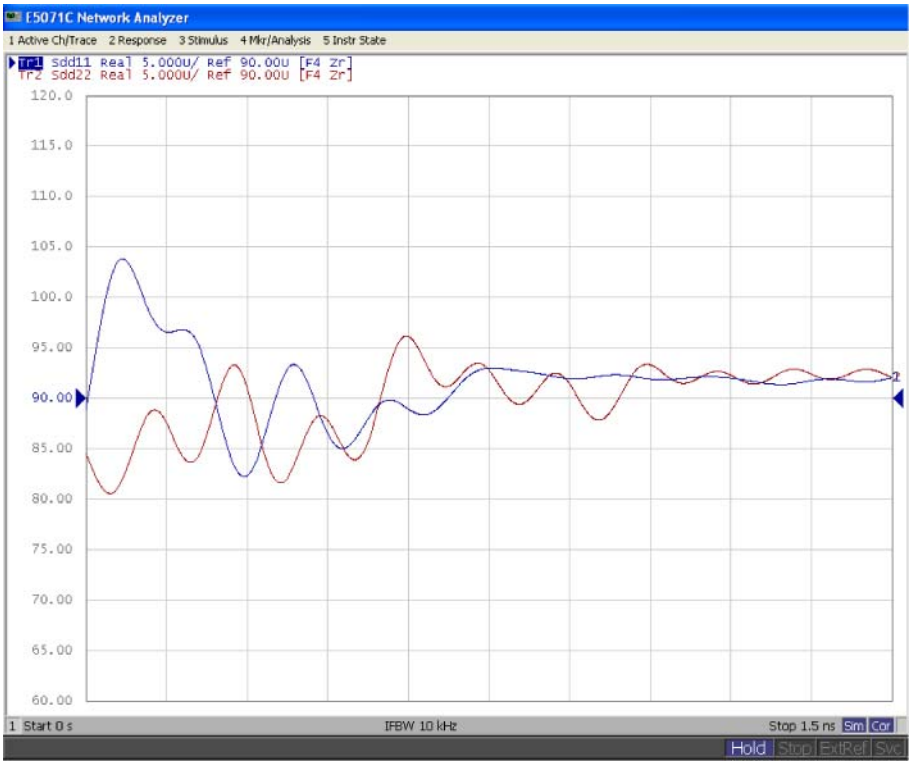


Figure 5-3 Connector Impedance Measurement Result Example

5.3. Raw Cable Impedance Measurement (Informative)

5.3.1. Impedance Profile

Refer to Figure 5-1 Impedance Profile and Impedance Limits.

5.3.2. Measurement Setup

1. Press **Preset** > **OK**.
2. Press **Display** > Set **Num of Traces** > **2**.
3. Press **Sweep Setup** > **Sweep Type** > **Lin Freq**.
4. Set **Points** to 1601.
5. Press **Start** > Set start value to 100 MHz.
6. Press **Stop** > Set stop value to 7.0 GHz.
7. Press **Avg** > Set **IF Bandwidth** to 10 kHz.
8. Press **Analysis** > **Fixture Simulator** > **Fixture Simulator** and turn it **ON**.
9. Click **Port ZConversion** and turn it **ON**.
10. Set **Port1 Z0 Real**, **Port2 Z0 Real**, **Port3 Z0 Real** and **Port4 Z0 Real** to 45 ohm.
11. Click **Return**.
12. Click **Topology** > **Device** > **Bal-Bal**.
13. Click **Port1 (bal)** > **1-2**.
14. Click **Port2 (bal)** > **3-4**.
15. Click **Return**.
16. Click **BalUn** and turn it **ON**.
17. Click **Measurement** > **Sdd11**.
18. Press **Format** > **Real**.
19. Press **Analysis** > **Transform** > **Transform** and turn it **ON**.
20. Click **Type** > **Lowpass Step** if trace 1 selected.
21. Click **Set Freq Low pass**.
22. Set **Start** to 0 sec.

23. Set **Stop** to 1.5 nsec.
24. Click **Window** > Set **Step Rise** to 200 psec. (Refer to Method for Determining the Step Rise in 6 Appendix)
25. Press **Analysis** > **Conversion** > **Conversion** and turn it **ON**.
26. Click **Function** > **Z:Reflection**.
27. Press **Scale** > Set **Divisions** to 12.
28. Set **Scale/Div** to 5 U/div.
29. Set **Reference position** to 6 Div.
30. Set **Reference Value** to 90 U.
31. Press **Trace Next**.
32. Press **Analysis** > **Fixture Simulator** > **BalUn** and turn it **ON**.
33. Click **Measurement** > **Sdd22**.
34. Repeat step 18 to step 30 for trace 2.

5.3.3. Calibration

Refer to 4.1.1 TRL/M Calibration or 4.1.2 4-Port ECal (Full 4-port calibration) and De-Embedding.

5.3.4. Measurement

1. Connect the test fixture to the test port cables according to the Figure 5-4 Connection Example for Cable Impedance measurement. Unused terminals should be terminated.
2. Connect a USB 3.0 cable to the test fixtures.
3. Press **Trigger** > **Single**.
4. Measurement result is displayed. Refer to Table 5-2 Raw Cable Impedance Limits for Pass/Fail criteria.

5. Using the same manner above, measure other pairs.

5.3.5. Data Analysis

For Pass/Fail refer to below Raw Cable Impedance Limits. (Refer to Figure 5-1 Impedance Profile and Impedance Limits)

Table 5-2 Raw Cable Impedance Limits

Limit	Start Time	End Time	Start Limit	End Limit
Upper	1 ns	1.5 ns	97 U	97 U
Lower	1 ns	1.5 ns	83 U	83 U

"U": Impedance unit

Note: Recommended start time is 0.6 ns.

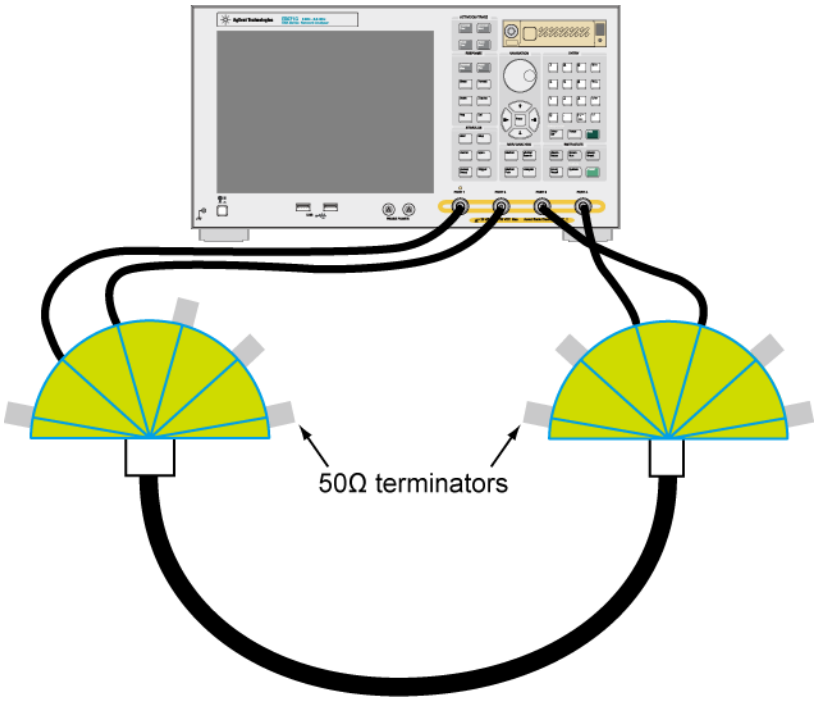


Figure 5-4 Connection Example for Cable Impedance measurement

Figure 5-5 Impedance Measurement Result Example

5.4. Intra-Pair Skew Measurement (Informative)

5.4.1. Measurement Setup

1. Press **Preset** > **OK**.
2. Press **Display** > Set **Num of Traces** > **2**.
3. Press **Sweep Setup** > **Sweep Type** > **Lin Freq**.
4. Set **Points** to 1601.
5. Press **Start** > Set start value to 100 MHz.
6. Press **Stop** > Set stop value to 7.0 GHz.
7. Press **Avg** > Set **IF Bandwidth** to 10 kHz.
8. Press **Analysis** > **Fixture Simulator** > **Port ZConversion** and turn it **ON**.
9. Set **Port1 Z0 Real**, **Port2 Z0 Real**, **Port3 Z0 Real** and **Port4 Z0 Real** to 45 ohm.
10. Click **Return**.
11. Click **Measurement** > **S11**.
12. Press **Format** > **Real**.
13. Press **Analysis** > **Transform** > **Transform** and turn it **ON**.
14. Click **Type** > **Lowpass Step**.
15. Click **Set Freq Low pass** if trace 1 selected.
16. Set **Center** to 0 sec.
17. Set **Span** to 20 nsec.
18. Click **Window** > Set **Step Rise** to 200 psec. (Refer to Method for Determining the Step Rise in 6 Appendix)
19. Press **Scale** > Set **Divisions** to 12.
20. Set **Scale/Div** to 200 mU/div.
21. Set **Reference position** to 5 Div.
22. Set **Reference Value** to 500 mU.
23. Press **Trace Next**.
24. Repeat step 11 to step 22 for trace 2.

5.4.2. Calibration

Refer to 4.1.1 TRL/M Calibration or 4.1.2 4-Port ECal (Full 4-port calibration) and De-Embedding.

5.4.3. Fixture DeSkew

1. Press **Display** > Set **Num of Traces** > **6**.
2. Press **Trace Next**/**Trace Prev** keys to select the trace 3.
3. If **Equation** is **ON**, click the key to turn it **OFF**.
4. Press **Meas** > **S11**.
5. Press **Format** > **Real**.
6. Press **Analysis** > **Transform** > **Transform** and turn it **ON**.
7. Click **Type** > **Lowpass Step**.
8. Click **Window** > Set **Step Rise** to 200 psec. (Refer to Method for Determining the Step Rise in 6 Appendix)
9. Press **Trace Next**/**Trace Prev** keys to select the trace 4.
10. Press **Meas** > **S22**.
11. Press **Format** > **Real**.
12. Press **Analysis** > **Transform** > **Transform** and turn it **ON**.
13. Click **Type** > **Lowpass Step**.
14. Click **Window** > Set **Step Rise** to 200 psec. (Refer to Method for Determining the Step Rise in 6 Appendix)
15. Press **Trace Next**/**Trace Prev** keys to select the trace 5.
16. Press **Meas** > **S33**.
17. Press **Format** > **Real**.
18. Press **Analysis** > **Transform** > **Transform** and turn it **ON**.
19. Click **Type** > **Lowpass Step**.

20. Click **Window** > Set **Step Rise** to 200 psec. (Refer to Method for Determining the Step Rise in 6 Appendix)
21. Press **Trace Next**/**Trace Prev** keys to select the trace 6.
22. Press **Meas** > **S44**.
23. Press **Format** > **Real**.
24. Press **Analysis** > **Transform** > **Transform** and turn it **ON**.
25. Click **Type** > **Lowpass Step**.
26. Click **Window** > Set **Step Rise** to 200 psec. (Refer to Method for Determining the Step Rise in 6 Appendix)
27. Press **Trace Next**/**Trace Prev** keys to select the trace 3.
28. Connect the test fixture to the test port cables according to the Figure 5-9 Connection Example for Intra-Pair Skew measurement. Unused terminals should be terminated.
29. With no USB 3.0 cable assemblies connected to the fixture (open condition), press **Trigger** > **Single**.
30. Press **Marker Fctn** > **Couple** > **ON**.
31. Press **Marker** key.
32. Press **Marker Fctn** > **Couple** > **OFF**.
33. Press **Trace Next**/**Trace Prev** keys to select the trace 3.
34. Press **Marker Search** > **Target** > Set **Target Value** to 500 mU.
35. Click **Search Target**.
36. Press **Cal** > **Port Extensions** > **Extension Port 1** > Set **Coax. Extension** to Marker Value divided by two. (Refer to Figure 5-6 Marker Value for Port Extensions)

Note: Here Port extension is measured with reflection method. It is required to divide the Marker Value by two because the electrical length of the fixture is half the length measured by reflection method.

Figure 5-6 Marker Value for Port Extensions

Extension Port 1 = Trace3 Marker Value divided by two
Extension Port 2 = Trace4 Marker Value divided by two
Extension Port 3 = Trace5 Marker Value divided by two
Extension Port 4 = Trace6 Marker Value divided by two

37. Repeat step 34 to step 37 for trace 4, 5, 6 and input Marker Value divided by two into extension port number accordingly.
38. Click **Return**.
39. Click **Extensions** and turn it **ON**.
40. Press **Trace Next**/**Trace Prev** keys to select the trace 3.
41. Press **Marker** > Set **Marker 1** to 0 sec.
42. Repeat step 41 to step 42 for trace 4, 5, 6.

5.4.4. Crosstalk compensation

1. Press **Trace Next**/**Trace Prev** keys to select the trace 1.
2. Press **Display** > **Equation Editor…** > Enter an equation **“Intra+= S31-S32”**.
3. Check **Equation Enabled** check box.
4. Click **Apply**.
5. Click **Close**.
6. Press **Trace Next**/**Trace Prev** keys to select the trace 2.
7. Press **Display** > **Equation Editor…** > Enter an equation **“Intra-= S42-S41”**.
8. Check **Equation Enabled** check box.
9. Click **Apply**.
10. Click **Close**.

5.4.5. Measurement

1. Connect a USB 3.0 cable to the test fixtures.
2. Press **Trace Next**/**Trace Prev** keys to select the trace 1.
3. Press **Analysis** > **Transform**.
4. Set **Start** to 0 sec.
5. Set **Stop** to 200 nsec.
6. Press **Trigger** > **Single**.
7. Press **Marker Search** > **Target** > Set **Target Value** to 500 mU.
8. Click **Search Target**.
9. Press **Analysis** > **Transform** > Set **Center** to Marker Value. (Refer to Figure 5-7 Marker Value to set Center)

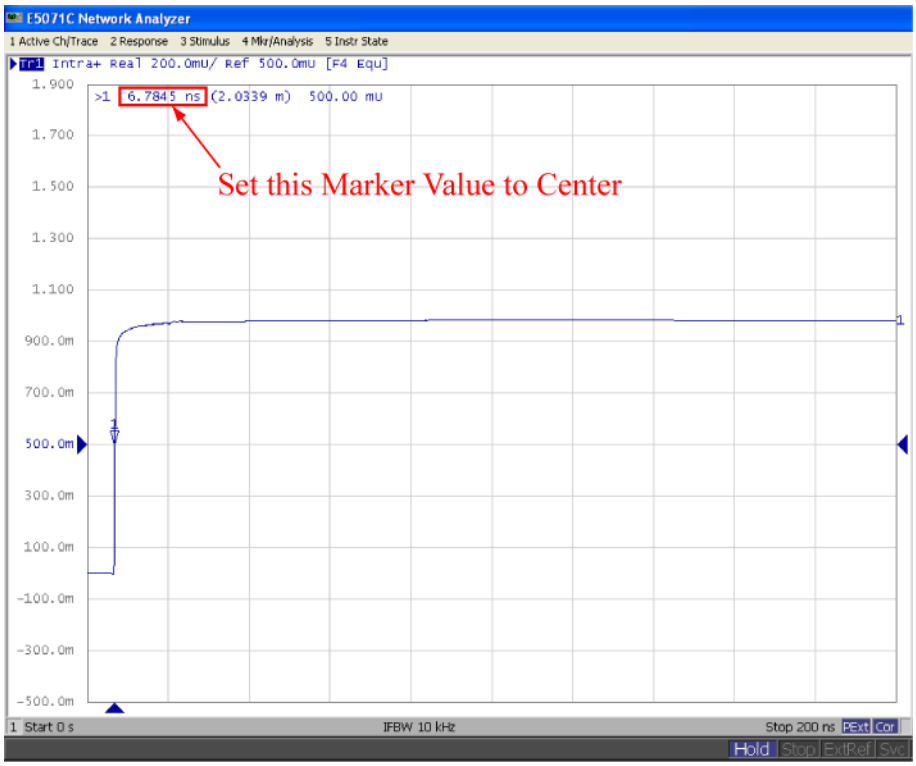


Figure 5-7 Marker Value to set Center

10. Set **Span** to 200 psec.

Note: This procedure allows higher resolution.

11. Press **Trigger** > **Single**.
12. Press **Marker Search** > **Target** > **Search Target**.
13. Write down the Marker Value for Intra-Pair Skew calculation. (Refer to Figure 5-1 Impedance Profile and Impedance Limits)

Figure 5-8 Marker Value for Intra-Pair Skew

14. Repeat step 2 to step 13 for trace 2.
15. Refer to 5.4.6 Data Analysis for Pass/Fail criteria.
16. Using the same manner above, measure other channels.

5.4.6. Data Analysis

1. Intra-Pair Skew = Absolute(Trace 1 Marker Value - Trace 2 Marker Value)
2. If (Intra-Pair Skew) < 15 psec/m: Pass, else: Fail.

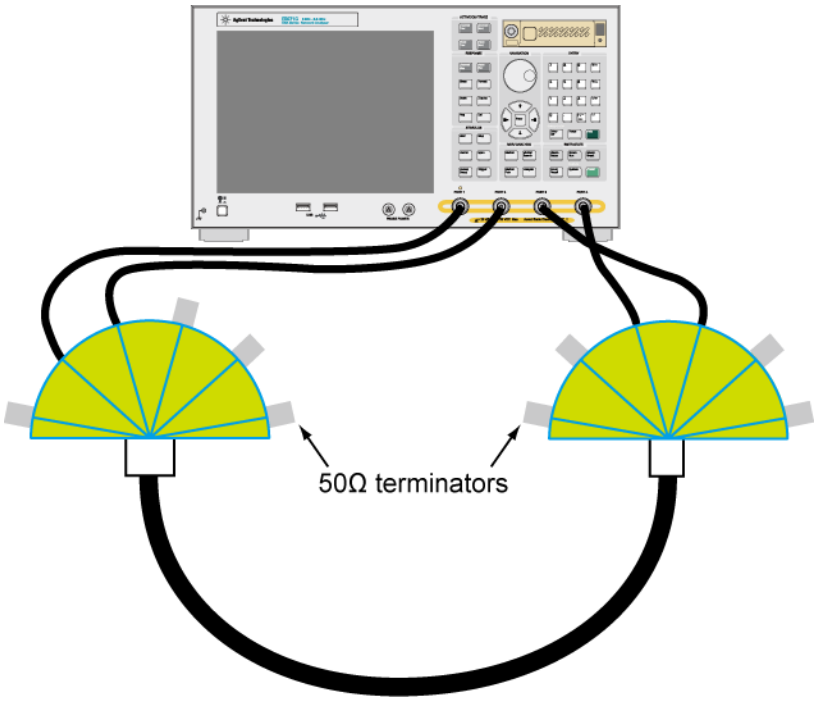


Figure 5-9 Connection Example for Intra-Pair Skew measurement

Figure 5-10 Intra-Pair Skew Measurement Result Example

5.5. Insertion Loss (Sdd21) Measurement (Normative)

5.5.1. Measurement Setup

1. Press **Preset** > **OK**.
2. Press **Sweep Setup** > **Sweep Type** > **Lin Freq**.
3. Set **Points** to 201.
4. Press **Start** > Set start value to 100 MHz.
5. Press **Stop** > Set stop value to 8.5 GHz.
6. Press **Avg** > Set **IF Bandwidth** to 10 kHz.
7. Press **Format** > **Log Mag**.
8. Press **Analysis** > **Fixture Simulator** > **Fixture Simulator** and turn it **ON**.
9. Click **Port ZConversion** and turn it **ON**.
10. Set **Port1 Z0 Real**, **Port2 Z0 Real**, **Port3 Z0 Real** and **Port4 Z0 Real** to 45 ohm.
11. Click **Return**.
12. Click **Topology** > **Device** > **Bal-Bal**.
13. Click **Port1 (bal)** > **1-2**.
14. Click **Port2 (bal)** > **3-4**.
15. Click **Return**.
16. Click **BalUn** and turn it **ON**.
17. Click **Measurement** > **Sdd21**.
18. Press **Scale** > Set **Divisions** to 12.
19. Set **Scale/Div** to 5 dB/div.
20. Set **Reference position** to 10 Div.
21. Set **Reference Value** to 0 dB.

5.5.2. Calibration

Refer to 4.1.1 TRL/M Calibration or 4.1.2 4-Port ECal (Full 4-port calibration) and De-Embedding.

5.5.3. Measurement

1. Connect the test fixture to the test port cables according to the Figure 5-11 Connection Example for Insertion Loss measurement. Unused terminals should be terminated.
2. Connect a USB 3.0 cable to the test fixtures
3. Press **Trigger** > **Single**.
4. Measurement result is displayed. Refer to Table 5-3 Insertion Loss - Lower Limit for Pass/Fail criteria.
5. Using the same manner above, measure other pairs.

5.5.4. Data Analysis

For Pass/Fail refer to below Insertion Loss Lower Limit.

If the lower limit indicated by the limit line is exceeded, the judgment result is pass. If it is not exceeded, the judgment result is fail for all measurement points on the trace.

Table 5-3 Insertion Loss - Lower Limit

Start Frequency	End Frequency	Start Limit	End Limit
100 MHz	1.25 GHz	-1.5 dB	-5 dB
1.25 GHz	2.5 GHz	-5 dB	-7.5 dB
2.5 GHz	7.5 GHz	-7.5 dB	-25 dB

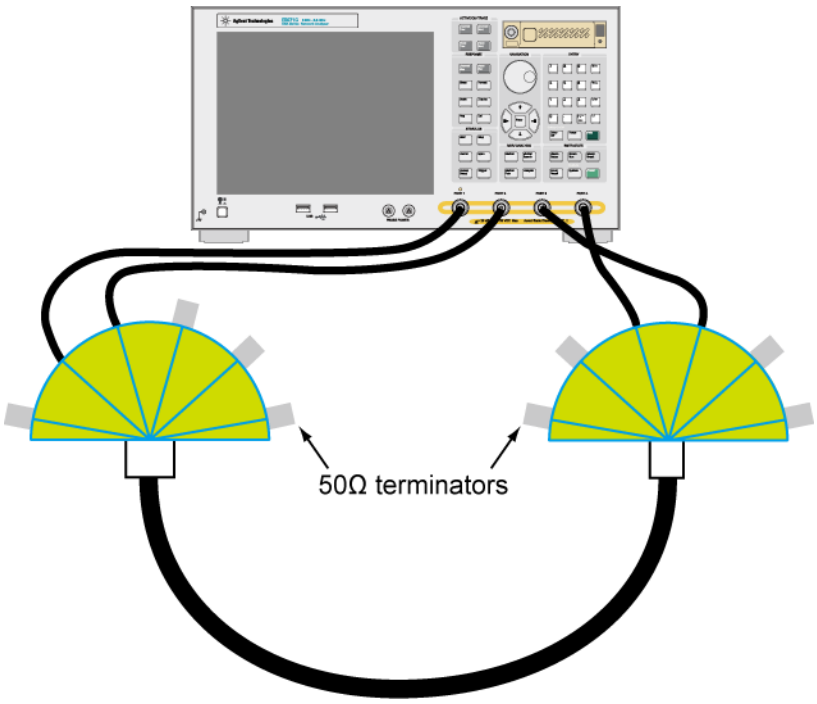


Figure 5-11 Connection Example for Insertion Loss measurement

Figure 5-12 Insertion Loss Measurement Result Example

5.6. Near End Crosstalk (Sdd21) Measurement (Normative)

5.6.1. Measurement Setup for Frequency Domain

1. Press **Preset** > **OK**.
2. Press **Sweep Setup** > **Sweep Type** > **Lin Freq**.
3. Set **Points** to 201.
4. Press **Start** > Set start value to 100 MHz.
5. Press **Stop** > Set stop value to 8.5 GHz.
6. Press **Avg** > Set **IF Bandwidth** to 10 kHz.
7. Press **Format** > **Log Mag**.
8. Press **Analysis** > **Fixture Simulator** > **Fixture Simulator** and turn it **ON**.
9. Click **Port ZConversion** and turn it **ON**.
10. Set **Port1 Z0 Real**, **Port2 Z0 Real**, **Port3 Z0 Real** and **Port4 Z0 Real** to 45 ohm.
11. Click **Return**.
12. Click **Topology** > **Device** > **Bal-Bal**.
13. Click **Port1 (bal)** > **1-2**.
14. Click **Port2 (bal)** > **3-4**.
15. Click **Return**.
16. Click **BalUn** and turn it **ON**.
17. Click **Measurement** > **Sdd21**.
18. Press **Scale** > Set **Divisions** to 12.
19. Set **Scale/Div** to 5 dB/div.
20. Set **Reference position** to 8 Div.
21. Set **Reference Value** to -20 dB.

5.6.2. Calibration

Refer to 4.1.1 TRL/M Calibration or 4.1.2 4-Port ECal (Full 4-port calibration) and De-Embedding.

5.6.3. Measurement

1. Connect the test fixture to the test port cables according to the Figure 5-14 Connection Example for Near End Crosstalk measurement. Unused terminals should be terminated.
2. Connect a USB 3.0 cable to the test fixtures.
3. Press **Trigger** > **Single**.
4. Measurement result is displayed. Refer to Table 5-4 Frequency Domain Near End Crosstalk - Upper Limit for Pass/Fail criteria.
5. Using the same manner above, measure other pairs.

5.6.4. Data Analysis

As for this test, the limits vary depending on the connector type of the USB cable.

For Pass/Fail refer to below Near End Crosstalk - Upper Limit.

If the upper limit indicated by the limit line is not exceeded, the judgment result is pass. If it is exceeded, the judgment result is fail for all measurement points on the trace.

Note: For the standard B-type, if the results are greater than or equal to -32 dB of limits and less than -27 dB of limits, you should perform the Near End Crosstalk of the time domain. (Refer to Figure 5-13)

Table 5-4 Frequency Domain Near End Crosstalk - Upper Limit

Frequency Range	Standard B-Type	Micro B-Type	Other Type
100 MHz to 2.5 GHz	-32 dB to -32 dB (-27 dB to -27 dB)	-27 dB to -27 dB	-32 dB to -32 dB
2.5 GHz to 3 GHz	-32 dB to -23 dB (-27 dB to -23 dB)	-27 dB to -23 dB	-32 dB to -23 dB
3 GHz to 7.5 GHz	-23 dB to -23 dB	-23 dB to -23 dB	-23 dB to -23 dB

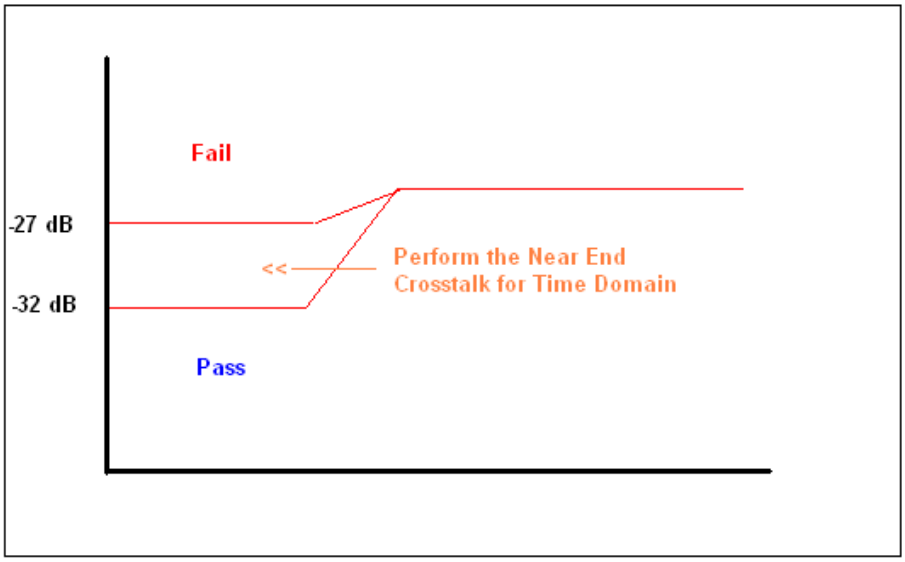


Figure 5-13 Frequency Domain Near End Crosstalk Pass/Fail Criteria for the Standard B-Type

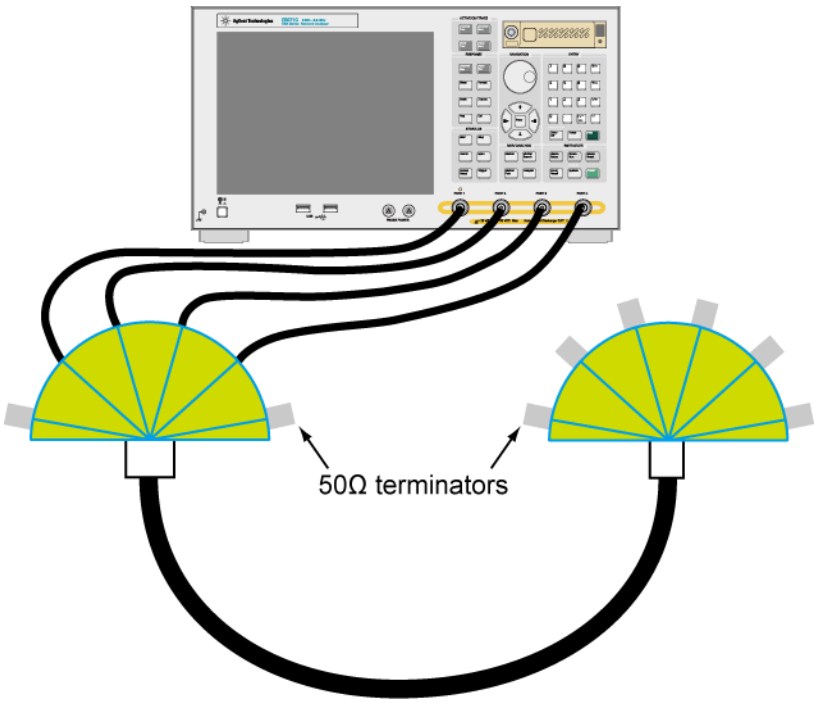


Figure 5-14 Connection Example for Near End Crosstalk measurement

Figure 5-15 Frequency Domain Near End Crosstalk Measurement Result Example

5.6.5. Measurement Setup for Time Domain

For the standard B-type, if the frequency domain Near End Crosstalk results are greater than or equal to -32 dB of limits and less than -27 dB of limits, you should perform the Near End Crosstalk of the time domain.

1. Press **Preset** > **OK**.
2. Press **Sweep Setup** > **Sweep Type** > **Lin Freq**.
3. Set **Points** to 1601.
4. Press **Start** > Set start value to 100 MHz.
5. Press **Stop** > Set stop value to 7 GHz.
6. Press **Avg** > Set **IF Bandwidth** to 10 kHz.
7. Press **Analysis** > **Fixture Simulator** > **Fixture Simulator** and turn it **ON**.
8. Click **Port ZConversion** and turn it **ON**.
9. Set **Port1 Z0 Real**, **Port2 Z0 Real**, **Port3 Z0 Real** and **Port4 Z0 Real** to 45 ohm.
10. Click **Return**.
11. Click **Topology** > **Device** > **Bal-Bal**.
12. Click **Port1 (bal)** > **1-2**.
13. Click **Port2 (bal)** > **3-4**.
14. Click **Return**.
15. Click **BalUn** and turn it **ON**.
16. Click **Measurement** > **Sdd21**.
17. Press **Format** > **Real**
18. Press **Analysis** > **Transform** > **Transform** and turn it **ON**.
19. Click **Type** > **Lowpass Step**.
20. Click **Set Freq Low pass**
21. Set **Start** to 0 sec.
22. Set **Stop** to 3 nsec.

23. Click **Window** > Set **Step Rise** to 66.7 psec. (Refer to Method for Determining the Step Rise in 6 Appendix)
24. Press **Analysis** > **Conversion** > **Conversion** and turn it **OFF**.

5.6.6. Calibration

Refer to 4.1.1 TRL/M Calibration or 4.1.2 4-Port ECal (Full 4-port calibration) and De-Embedding.

5.6.7. Measurement

1. Connect the test fixture to the test port cables according to the Figure 5-14 Connection Example for Near End Crosstalk measurement. Unused terminals should be terminated.
2. Connect a USB 3.0 cable to the test fixtures.
3. Press **Marker Function** > **Statistics** and turn it **ON**.
4. Press **Trigger** > **Single**.
5. Press **Scale** > **Auto Scale**.
6. Read the peak-to-peak (p-p) value.
7. Using the same manner above, measure the other pair.

5.6.8. Data Analysis

If p-p < 15 mU: Pass, else: Fail.

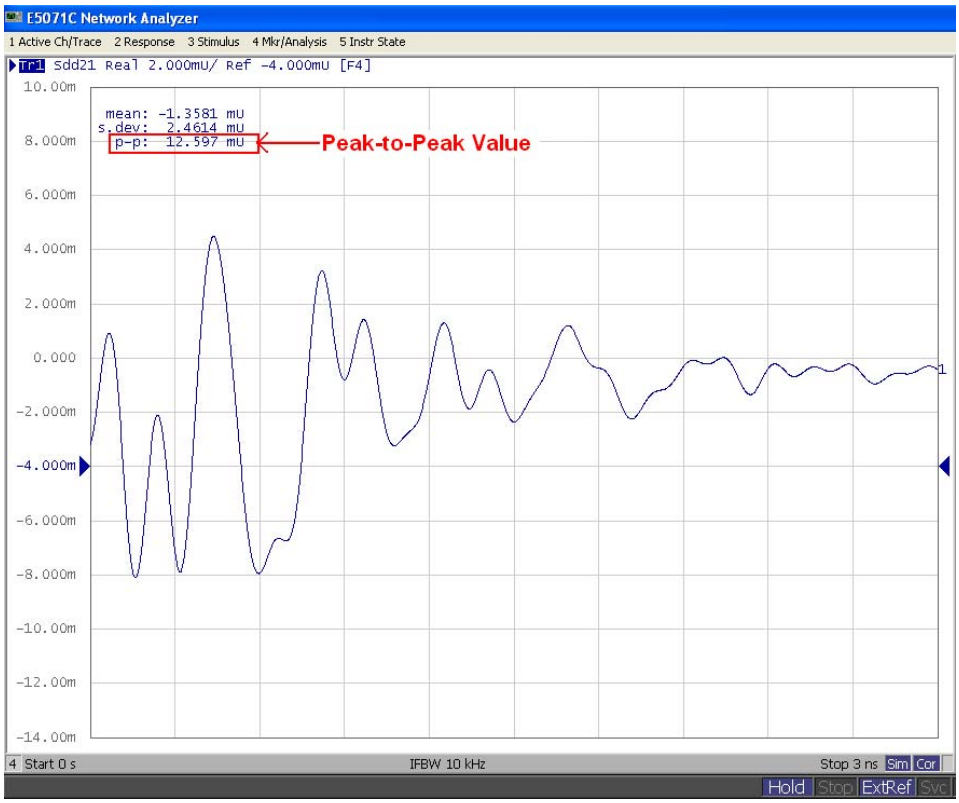


Figure 5-16 Time Domain Near End Crosstalk Measurement Result Example

5.7. Far End Crosstalk (Sdd21) Measurement (Informative)

5.7.1. Measurement Setup

25. Press **Preset** > **OK**.
26. Press **Sweep Setup** > **Sweep Type** > **Lin Freq**.
27. Set **Points** to 201.
28. Press **Start** > Set start value to 100 MHz.
29. Press **Stop** > Set stop value to 8.5 GHz.
30. Press **Avg** > Set **IF Bandwidth** to 10 kHz.
31. Press **Format** > **Log Mag**.
32. Press **Analysis** > **Fixture Simulator** > **Fixture Simulator** and turn it **ON**.
33. Click **Port ZConversion** and turn it **ON**.
34. Set **Port1 Z0 Real**, **Port2 Z0 Real**, **Port3 Z0 Real** and **Port4 Z0 Real** to 45 ohm.
35. Click **Return**.
36. Click **Topology** > **Device** > **Bal-Bal**.
37. Click **Port1 (bal)** > **1-2**.
38. Click **Port2 (bal)** > **3-4**.
39. Click **Return**.
40. Click **BalUn** and turn it **ON**.
41. Click **Measurement** > **Sdd21**.
42. Press **Scale** > Set **Divisions** to 12.
43. Set **Scale/Div** to 5 dB/div.
44. Set **Reference position** to 8 Div.
45. Set **Reference Value** to -20 dB.

5.7.2. Calibration

Refer to 4.1.1 TRL/M Calibration or 4.1.2 4-Port ECal (Full 4-port calibration) and De-Embedding.

5.7.3. Measurement

1. Connect the test fixture to the test port cables according to the Figure 5-17 Connection Example for Frequency Domain Far End Crosstalk measurement. Unused terminals should be terminated.
2. Connect a USB 3.0 cable to the test fixtures.
3. Press **Trigger** > **Single**.
4. Measurement result is displayed. Refer to Table 5-5 Frequency Domain Far End Crosstalk - Upper Limit for Pass/Fail criteria.
5. Using the same manner above, measure other pairs.

5.7.4. Data Analysis

For Pass/Fail refer to below Near End Crosstalk - Upper Limit.

If the upper limit indicated by the limit line is not exceeded, the judgment result is pass. If it is exceeded, the judgment result is fail for all measurement points on the trace.

Table 5-5 Frequency Domain Far End Crosstalk - Upper Limit

Frequency Range	Standard B-Type	Micro B-Type	Other Type
100 MHz to 2.5 GHz	-32 dB to -32 dB	-27 dB to -27 dB	-32 dB to -32 dB
2.5 GHz to 3 GHz	-32 dB to -23 dB	-27 dB to -23 dB	-32 dB to -23 dB
3 GHz to 7.5 GHz	-23 dB to -23 dB	-23 dB to -23 dB	-23 dB to -23 dB

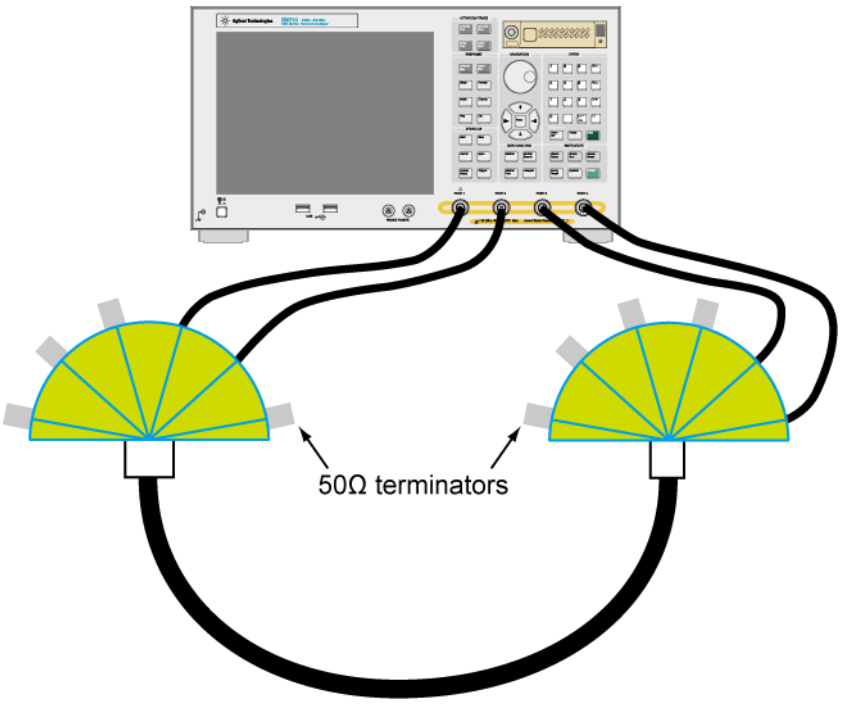


Figure 5-17 Connection Example for Frequency Domain Far End Crosstalk measurement

Figure 5-18 Frequency Domain Far End Crosstalk Measurement Result Example

5.8. Crosstalk between D+/D- and Super Speed (Sdd21) Measurement (Normative)

5.8.1. Measurement Setup

1. Press **Preset** > **OK**.
2. Press **Sweep Setup** > **Sweep Type** > **Lin Freq**.
3. Set **Points** to 201.
4. Press **Start** > Set start value to 100 MHz.
5. Press **Stop** > Set stop value to 8.5 GHz.
6. Press **Avg** > Set **IF Bandwidth** to 10 kHz.
7. Press **Format** > **Log Mag**.
8. Press **Analysis** > **Fixture Simulator** > **Fixture Simulator** and turn it **ON**.
9. Click **Port ZConversion** and turn it **ON**.
10. Set **Port1 Z0 Real**, **Port2 Z0 Real**, **Port3 Z0 Real** and **Port4 Z0 Real** to 45 ohm.
11. Click **Return**.
12. Click **Topology** > **Device** > **Bal-Bal**.
13. Click **Port1 (bal)** > **1-2**.
14. Click **Port2 (bal)** > **3-4**.
15. Click **Return**.
16. Click **BalUn** and turn it **ON**.
17. Click **Measurement** > **Sdd21**.
18. Press **Scale** > Set **Divisions** to 12.
19. Set **Scale/Div** to 5 dB/div.
20. Set **Reference position** to 8 Div.
21. Set **Reference Value** to -20 dB.

5.8.2. Calibration

Refer to 4.1.1 TRL/M Calibration or 4.1.2 4-Port ECal (Full 4-port calibration) and De-Embedding.

5.8.3. Measurement

1. Press **Display** > if **Equation** is **ON**, click the key to turn it **OFF**.
2. Connect the test fixture to the test port cables according to the Figure 5-19 Connection Example for Near End Crosstalk measurement and Figure 5-20 Connection Example for Far End Crosstalk measurement. Unused terminals should be terminated.
3. Connect a USB 3.0 cable to the test fixtures.
4. Press **Trigger** > **Single**.
5. Measurement result is displayed. Refer to Table 5-6 For Pass/Fail refer to bellow Crosstalk between D+/D- and Super Speed – Upper Limit for Pass/Fail criteria.
6. Using the same manner above, measure other pairs.

5.8.4. Data Analysis

For Pass/Fail refer to below Crosstalk between D+/D- and Super Speed - Upper Limit.
If the upper limit indicated by the limit line is not exceeded, the judgment result is pass. If it is exceeded, the judgment result is fail for all measurement points on the trace.

Table 5-6 For Pass/Fail refer to bellow Crosstalk between D+/D- and Super Speed – Upper Limit

Start Frequency	End Frequency	Start Limit	End Limit
100 MHz	2.5 GHz	-21 dB	-21 dB
2.5 GHz	3.0 GHz	-21 dB	-15 dB
3.0 GHz	7.5 GHz	-15 dB	-15 dB

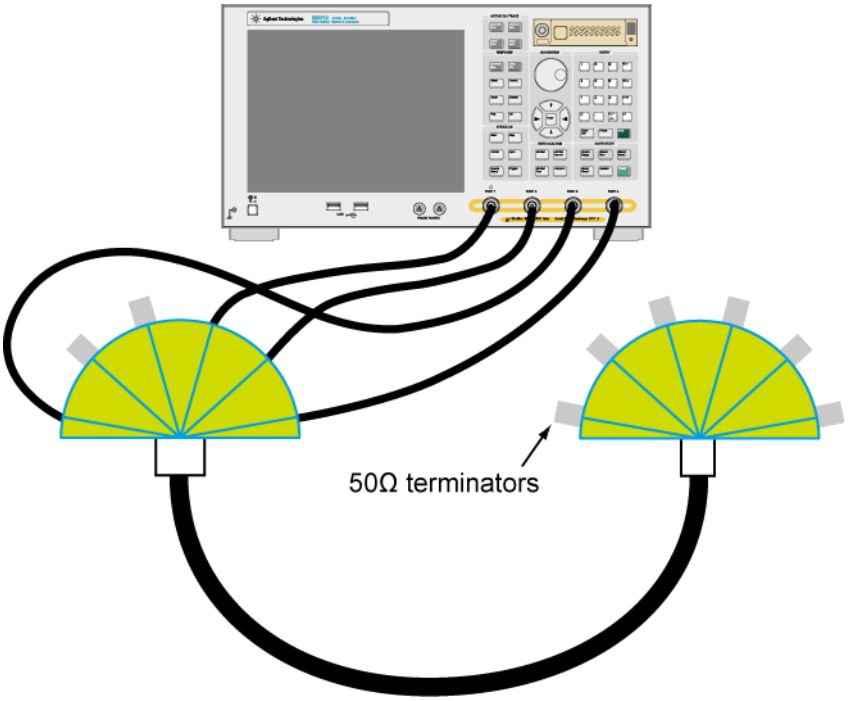


Figure 5-19 Connection Example for Near End Crosstalk measurement

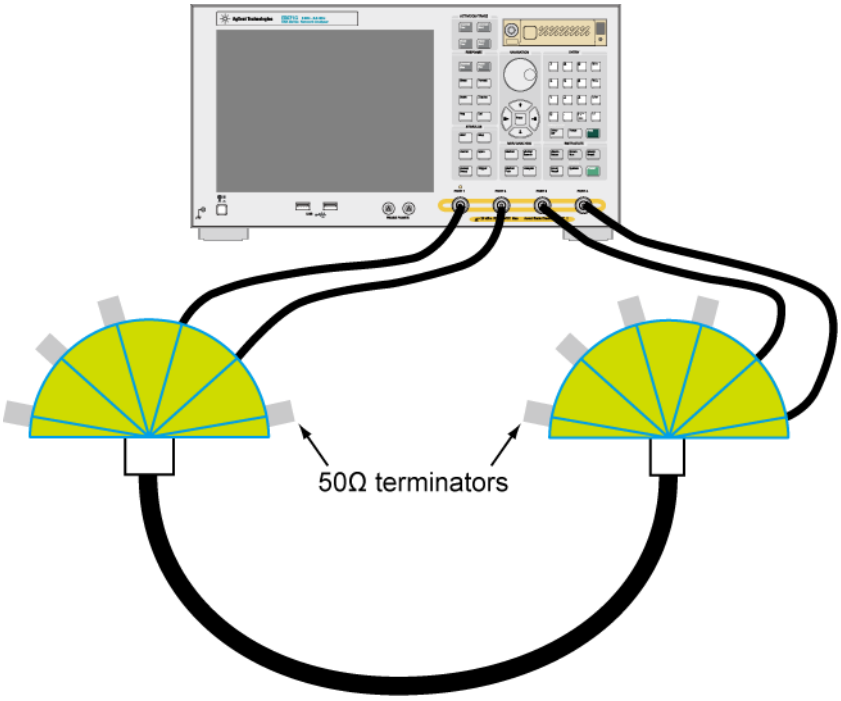


Figure 5-20 Connection Example for Far End Crosstalk measurement

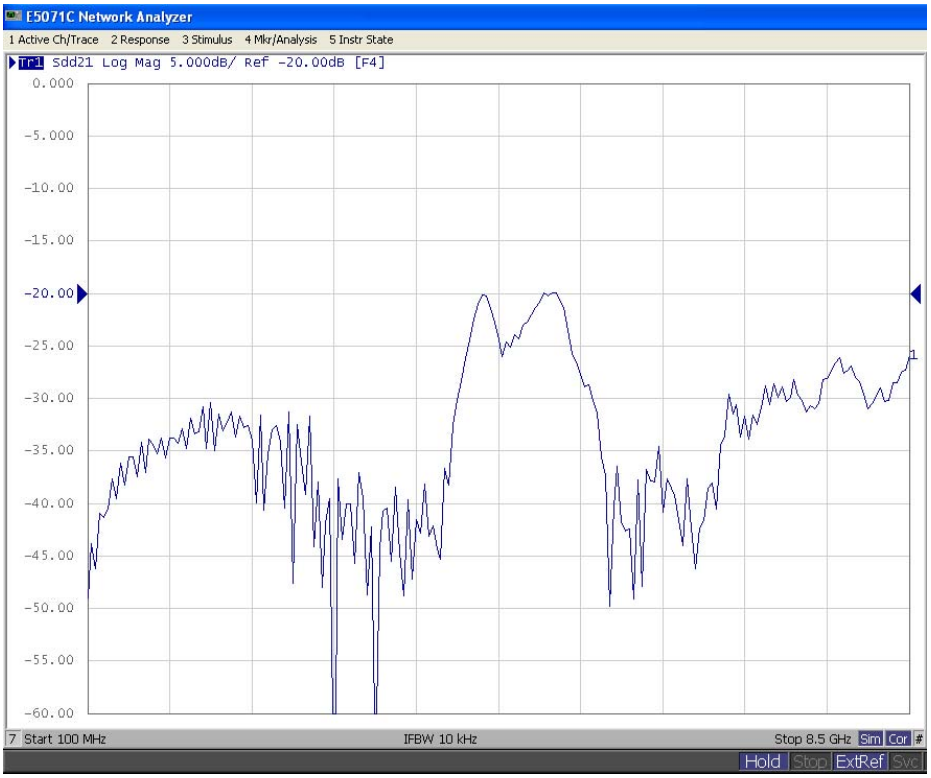


Figure 5-21 Crosstalk between D+/D- and Super Speed Measurement Result Example

5.9. Common-Mode Conversion (Scd21) Measurement

5.9.1. Measurement Setup

1. Press **Preset** > **OK**.
2. Press **Sweep Setup** > **Sweep Type** > **Lin Freq**.
3. Set **Points** to 201.
4. Press **Start** > Set start value to 100 MHz.
5. Press **Stop** > Set stop value to 8.5 GHz.
6. Press **Avg** > Set **IF Bandwidth** to 10 kHz.
7. Press **Format** > **Log Mag**.
8. Press **Analysis** > **Fixture Simulator** > **Fixture Simulator** and turn it **ON**.
9. Click **Port ZConversion** and turn it **ON**.
10. Set **Port1 Z0 Real**, **Port2 Z0 Real**, **Port3 Z0 Real** and **Port4 Z0 Real** to 45 ohm.
11. Click **Return**.
12. Click **Topology** > **Device** > **Bal-Bal**.
13. Click **Port1 (bal)** > **1-2**.
14. Click **Port2 (bal)** > **3-4**.
15. Click **Return**.
16. Click **BalUn** and turn it **ON**.
17. Click **Measurement** > **Scd21**.
18. Press **Scale** > Set **Divisions** to 12.
19. Set **Scale/Div** to 5 dB/div.
20. Set **Reference position** to 8 Div.
21. Set **Reference Value** to -20 dB.

5.9.2. Calibration

Refer to 4.1.1 TRL/M Calibration or 4.1.2 4-Port ECal (Full 4-port calibration) and De-Embedding.

5.9.3. Measurement

1. Connect the test fixture to the test port cables according to the Figure 5-22 Connection Example for Common-Mode conversion measurement. Unused terminals should be terminated.
2. Connect a USB 3.0 cable to the test fixtures.
3. Press **Trigger** > **Single**.
4. Measurement result is displayed. Refer to Data Analysis for Pass/Fail criteria.
5. Using the same manner above, measure other channels.

5.9.4. Data Analysis

IF (All measurement points from 100 MHz to 7.5 GHz) <= -20 dB: Pass, else: Fail.

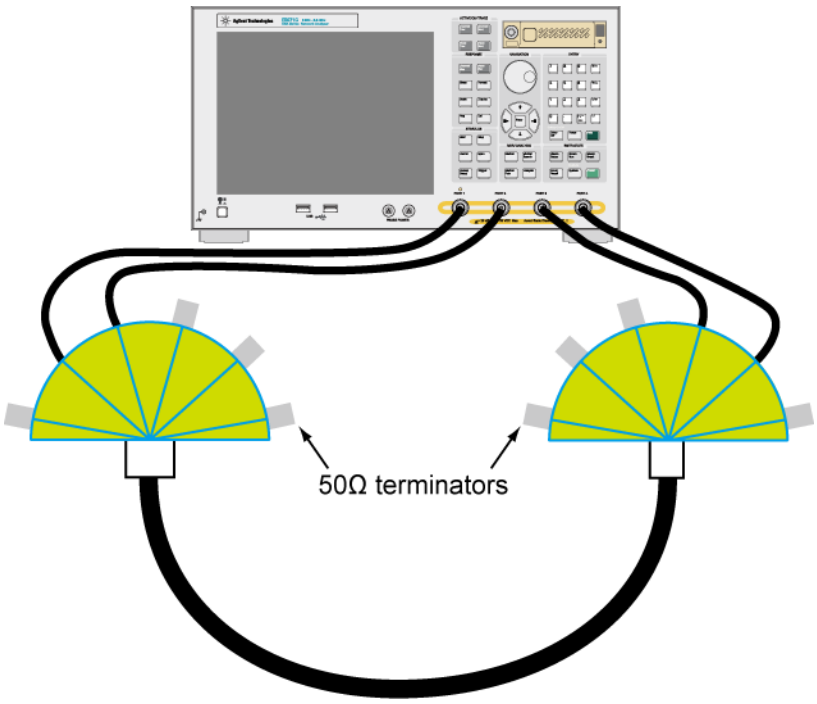


Figure 5-22 Connection Example for Common-Mode conversion measurement

Figure 5-23 Common-Mode Conversion Measurement Result Example

6. Appendix

6.1. Method for Determining the Step Rise

6.1.1. Settings

1. Press **Preset** > **OK**
2. Press **Sweep Setup** > Set **Points** to 1601.
3. Press **Avg** > Set **IF Bandwidth** to 10 kHz.
4. Click **Measurement** > **S21**.
5. Press **Format** > **Real**
6. Press **Analysis** > **Transform** > **Transform** and turn it **ON**.
7. Click **Type** > **Lowpass Step**.
8. Click **Set Freq Low pass**
9. Set **Start** to 0 sec.
10. Set **Stop** to 3 nsec.
11. Click **Window** > Set **Step Rise** to 66.7 psec.

    Note: Refer to Table 6-1 Settings for Step Rise.

6.1.2. Calibration

Follow the procedure below to perform a 2-port Calibration using the ECal module.

1. Connect the 3.5 mm cables from port1 and port2 to ECal module.
2. Press **Cal** > **ECal** > **2-Port Cal** > **Port 1-2**.

6.1.3. Thru Standard Measurement

1. Connect ports on the Thru standard of TRL/M calibration to the test ports to be measured.

6.1.4. Step Rise Adjustment

1. Press **Scale** > **Auto Scale**.
2. Press **Marker Fctn** > **Discrete** and turn it **ON**.
3. Press **Marker**.
4. Press **Marker Search** > **Target** > Set **Target Value** to 200 mU or 100 mU.

   Note: Refer to Table 6-1 Settings for Step Rise.
5. Press **Marker** > **Marker 2**.
6. Press **Marker Search** > **Target** > Set **Target Value** to 800 mU or 900 mU.

   Note: Refer to Table 6-1 Settings for Step Rise.

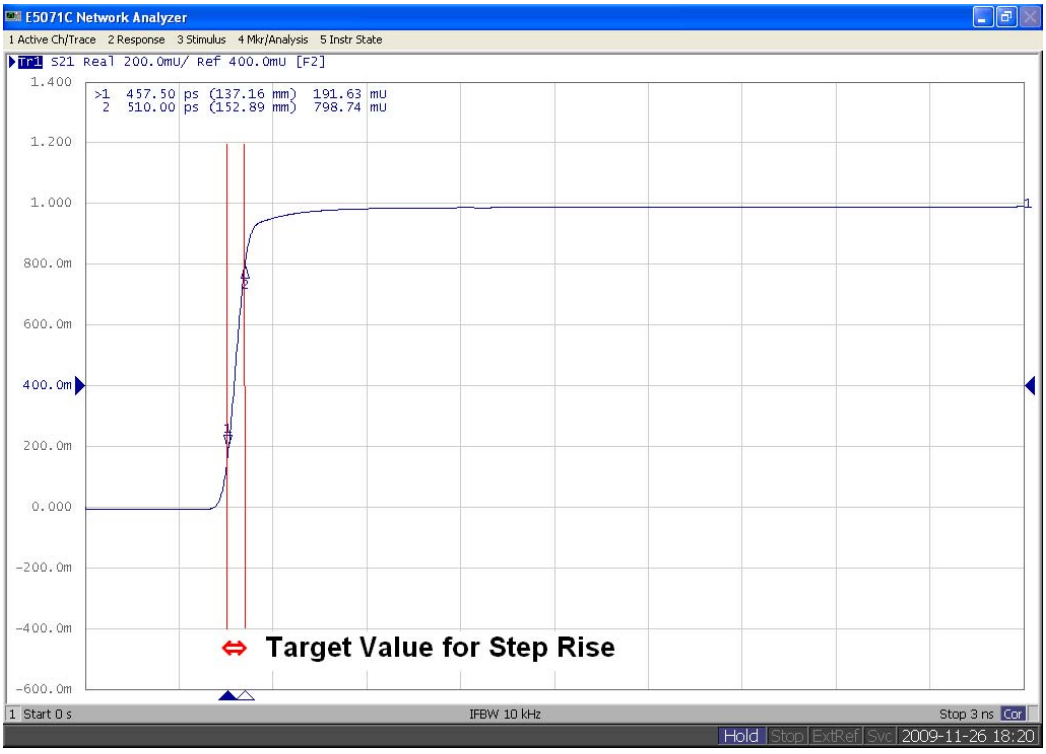


Figure 6-1 Step Rise Adjustment in Rough Scale

7. Change Start/Stop to increase the resolution of the target value.

A) Press **Analysis** > **Transform** > **Start**, then input target value.

B) Press **Analysis** > **Transform** > **Stop**, then input target value.

C) Press **Marker** > **Marker 1**.

D) Press **Marker Search** > **Target** > **Search Target**.

E) Press **Marker** > **Marker 2**.

F) Press **Marker Search** > **Target** > **Search Target**.

G) Repeat from A) to F).

8. Adjust the step rise close to the target step rise as Figure 6-2 Step Rise Adjustment in higher resolution.

   A) Press **Analysis** > **Transform** > **Window > Step Rise**.

   B) Press **Marker** > **Marker 1**.

   C) Press **Marker Search** > **Target** > **Search Target**, then input target value.

   D) Press **Marker** > **Marker 2**.

   E) Press **Marker Search** > **Target** > **Search Target**, then input target value.

   F) Repeat from A) to F) until target step rise.

9. This value is applied to the **Step Rise**.

Table 6-1 Settings for Step Rise

Test	Initial for Input Value	Target Value Step Rise	Target Value Marker 1	Target Value Marker 2
Imp. Connector	66.7 psec	50 psec (20 % - 80 %)	200 mU	800 mU
Imp. Cable	200 psec	200 psec (10 % - 90 %)	100 mU	900 mU
Intra-Pair Skew	200 psec	200 psec (10 % - 90 %)	100 mU	900 mU
Near End Crosstalk for Time Domain	66.7 psec	50 psec (20 % - 80 %)	200 mU	800 mU

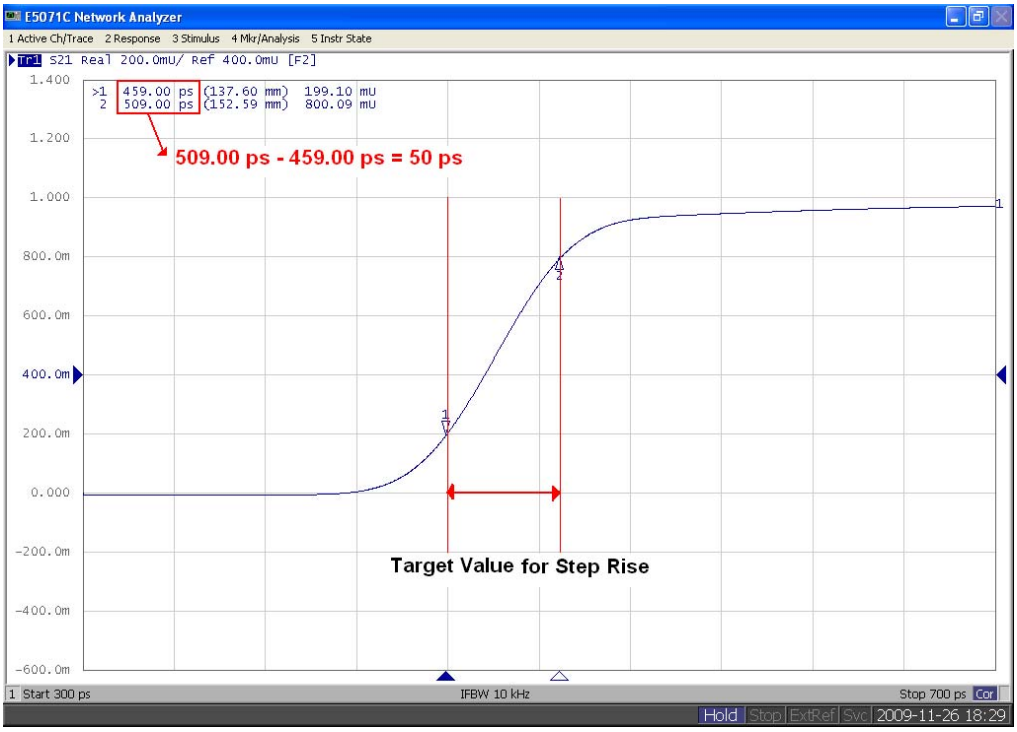


Figure 6-2 Step Rise Adjustment in higher resolution