Revision 1.10

20 Mar 2014

Agilent Method of Implementation (MOI) for MIPI M-PHY Conformance Tests Using Agilent E5071C ENA Network Analyzer Option TDR

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Agilent MOI for MIPI M-PHY Conformance Tests

1. Modification Record

Revision	Comments	Issue Date
1.00	First Release	Dec 1, 2011
1.10	Updated procedures to spec version 3.0.	Mar 20, 2014

2. Purpose

This document is intended to provide the measurement procedures for the interface S-parameter and impedance tests defined in the MIPI Alliance Specification for M-PHY. The instrument operations contained in this document are designed for Agilent E5071C ENA Network Analyzer Option TDR.

3. References

MIPI Alliance Specification for M-PHY v3.0

MIPI Alliance Conformance Test Suite for M-PHY Physical Layer v1.0

4. Resource Requirements

1. ENA Series Network Analyzer with Enhanced Time Domain Option

   Note: Use the test set option of 4.5 GHz or above, and either of 2-port and 4-port.

   Note: Ensure that E5071C firmware revision A.11.31 or above is installed.

   Note: E5071C-TDR application software revision A.01.56 or above is installed.

2. Electronic Calibration Module N4431B (for 4.5/6.5/8.5 GHz models) or N4433A (for 14/20 GHz models)

3. 3.5 mm cables of 4.5 GHz bandwidth or above x2

5. Test Procedure

5.1. Outline of Test Procedure

1. Instrument Setup

2. Calibration and Adjustment

Time Domain Calibration with the setup wizard in the TDR application software

Frequency Domain Calibration with the VBA macro program

3. Measurements and Data Analysis

Time Domain Measurements

- Single-Ended Output Resistance

- HS-TX Single-Ended Output Resistance Mismatch

- Single-Ended Output Resistance, STALL or SLEEP State

- M-RX Differential Termination Resistance

Frequency Domain Measurements

- M-TX Differential Return Loss

- M-TX Common-Mode Return Loss

- M-RX Differential Return Loss

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

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

*Note: Buttons (in the TDR or VBA) are displayed in Green color and **Bold**. (Example: **Trace**, **Rise Time**)*

*Note: Tabs (in the TDR) are displayed in Brown color and **Bold**. (Example: **Setup**, **Trace Control**)*

5.2. Instrument Setup

This section describes the procedures for recalling the state file and VBA macro that support the instrument setup. Download "E5071C-TDR Test Package for MIPI M-PHY Tx/Rx Devices" from www.agilent.com/find/ena-tdr_mphy-txrx.

Extract the zip file and transfer the extracted files to the instrument with a USB flash memory. For manual measurement settings, refer to 6 Appendix.

5.2.1. Recalling State File

1. If TDR setup wizard appears, click **Close** button on the wizard.

2. Open **Setup** tab (item1).

3. Click **Advanced Mode** (item2).
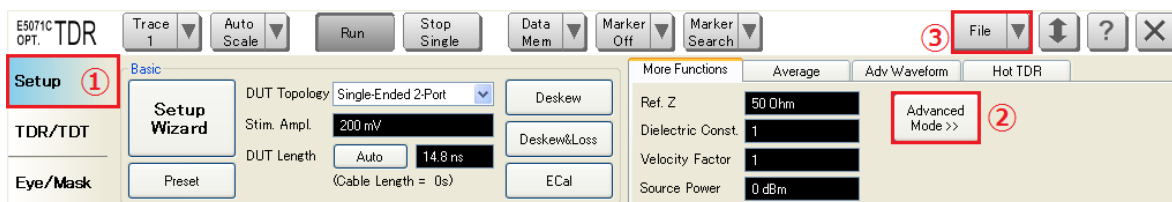
4. A dialog box appears requesting for confirmation. Then click **Yes**. (Clear the check box for "Use Advanced Calibration Methods")
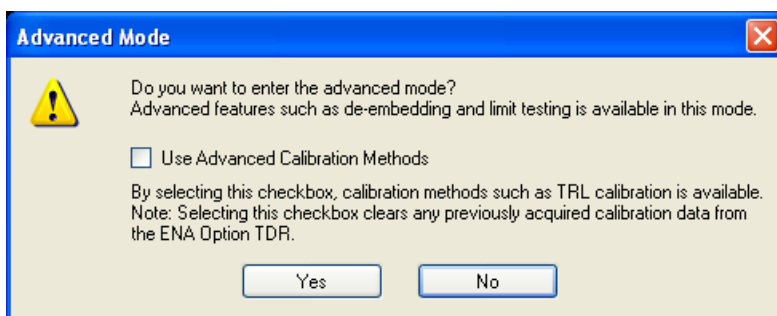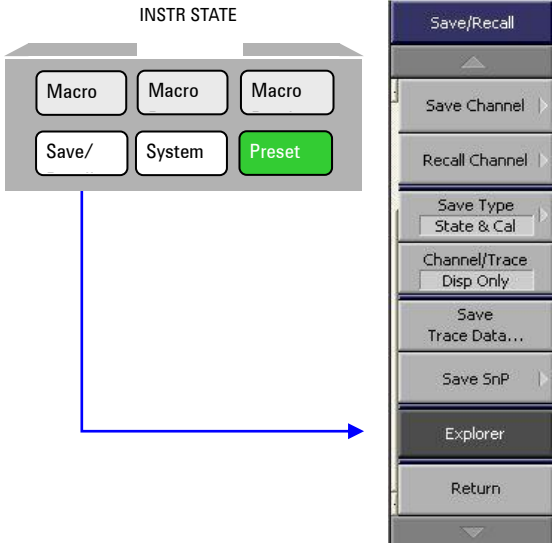
5. Click **File** (item3) and select **Recall State** to open the Recall State dialog box.

6. Specify the folder and appropriate state file name, and click **Open**.

E5071C Test Set Option	State File Name
240/245/260/265/280/285/440/445/460/465/480/485	MIPI_M-PHYv3_TxRx_24x-48x.tdr
2D5/2K5/4D5/4K5	MIPI_M-PHYv3_TxRx_2D5-4K5.tdr

5.2.2. Running VBA macro program

1. Installing the VBA macro program

Obtain the VBA macro program from Agilent and install it on the E5071C.

● Press **Save/Recall** on the front panel, then press the **Explorer** soft key.

● Using **Explorer**, copy the file to the "D:¥VBA" folder.

2. Running the VBA macro program

- Press **Macro Setup** button from the front panel, then click the **Load & Run** soft key.
- Select "MIPI_M-PHYv3_TxRx" from the soft key menu and click on it.
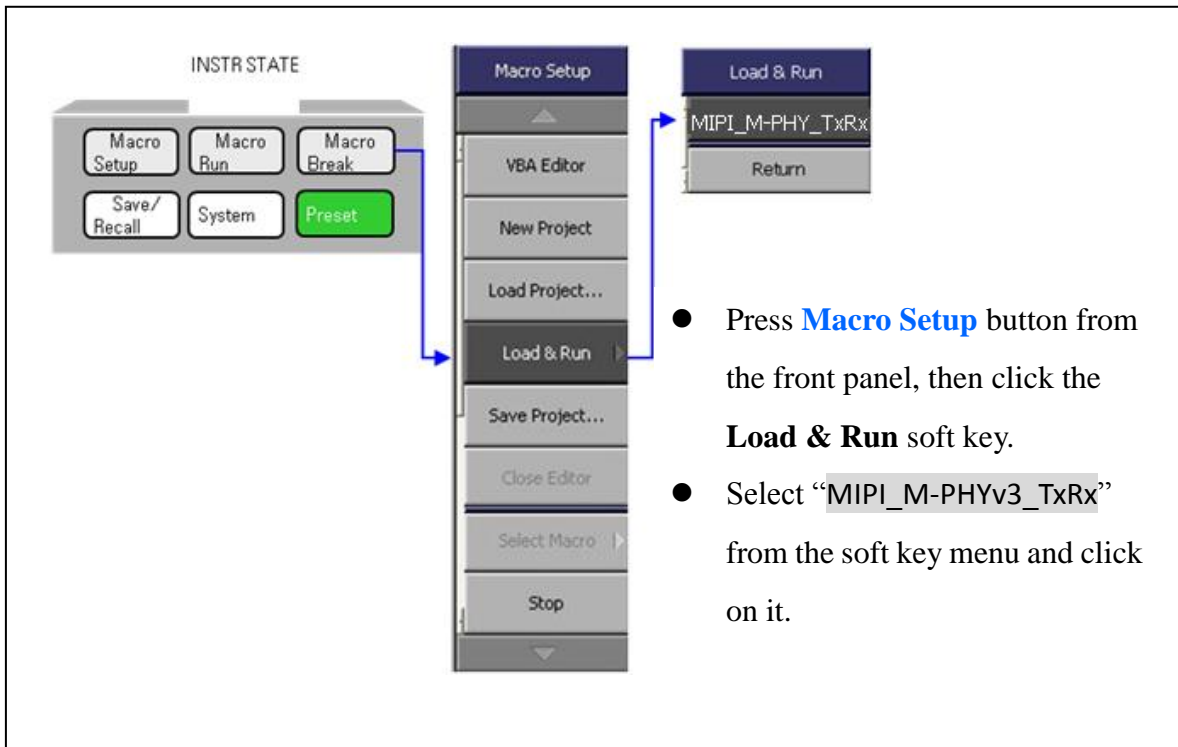
5.3. Screen Configuration

This section describes the screen configuration of ENA Option TDR.
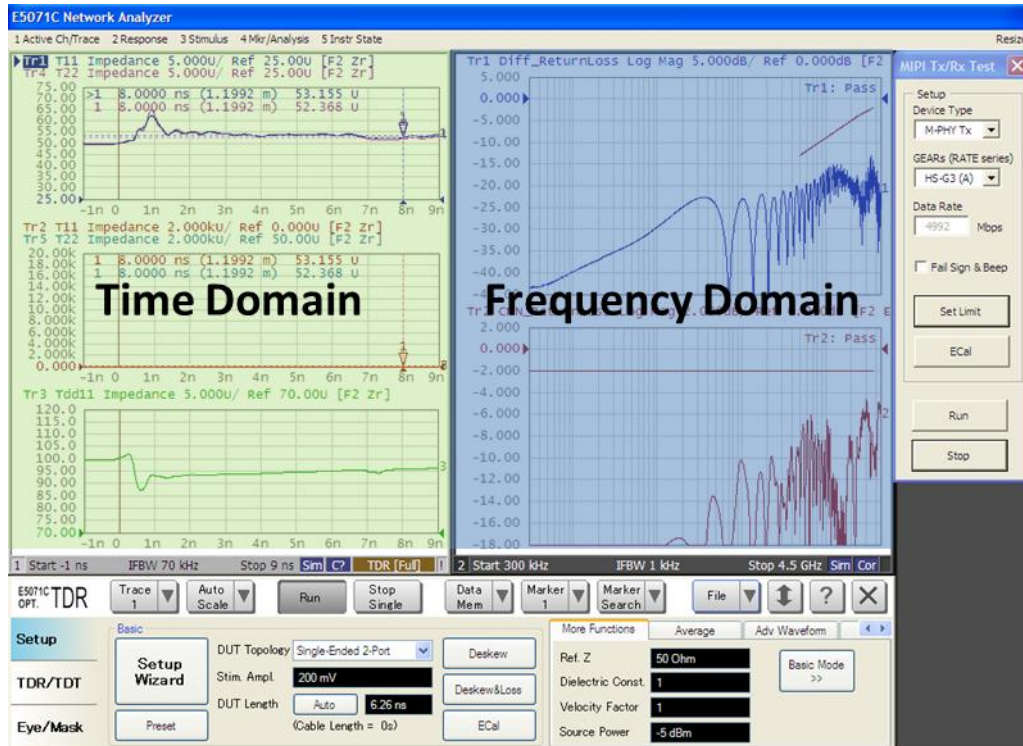
Channel1 dedicated to time domain measurements is controlled by the TDR application software located at the bottom of the screen and Channel2 dedicated to frequency domain measurements is controlled by the VBA macro program located at the upper right of the screen.

Description of Measurement Window

Channel 1   Time Domain

Single-Ended Output Resistance (M-TX)
 Tr1: T11
 Tr4: T22

Single-Ended Output Resistance, STALL or SLEEP State (M-TX)
 Tr2: T11
 Tr5: T22

Differential Termination Resistance (M-RX)
 Tr3: Tdd11

Channel 2   Frequency Domain

Differential Return Loss (M-TX/M-RX)
 Tr1: Sdd11

Common-Mode Return Loss (M-TX)
 Tr2: Scc11

5.4. Calibration and Adjustment

5.4.1. Time Domain Calibration

1. Connect the test cables to the port 1 and port 2 on the E5071C.

2. Press **Channel Next** key to select Channel1.

3. Open **Setup** tab (item1).

4. Click **ECal** (item2) to launch the Full Calibration (ECal) and Fixture Compensation wizard.
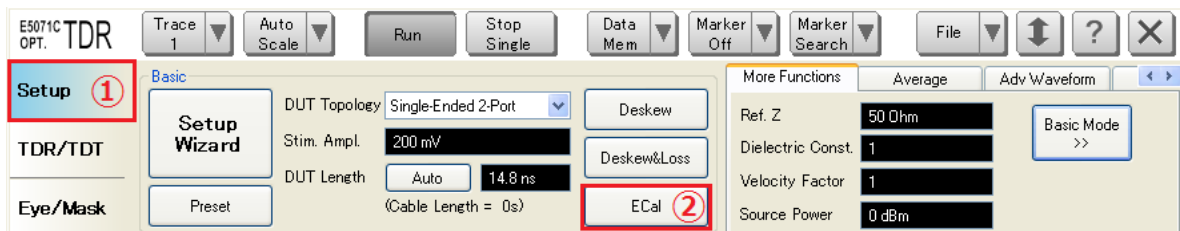
5. Connect the test cables to the ECal module.

6. Click **Calibrate** (item3), then it will start the full calibration. Wait until the check-mark appears on the right of Calibrate button.

7. Click **Next** (item4).
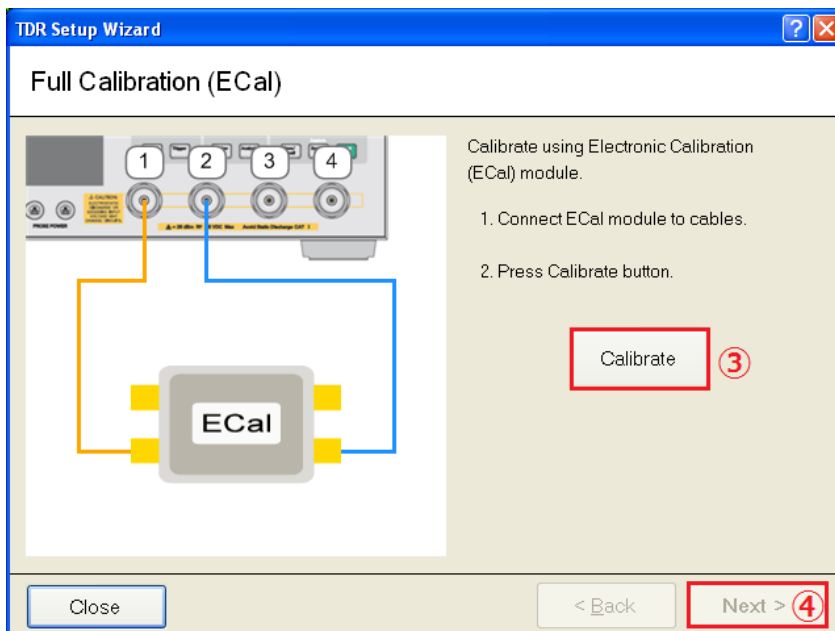
8. Connect port 1 and port 2 cables to the test fixtures and make the fixture end open.

9. Click **Fixture Comp** (item5), then it will start the fixture compensation. Wait until the check-mark appears on the right of Fixture Comp button.

10. Click **Finish** (item6).
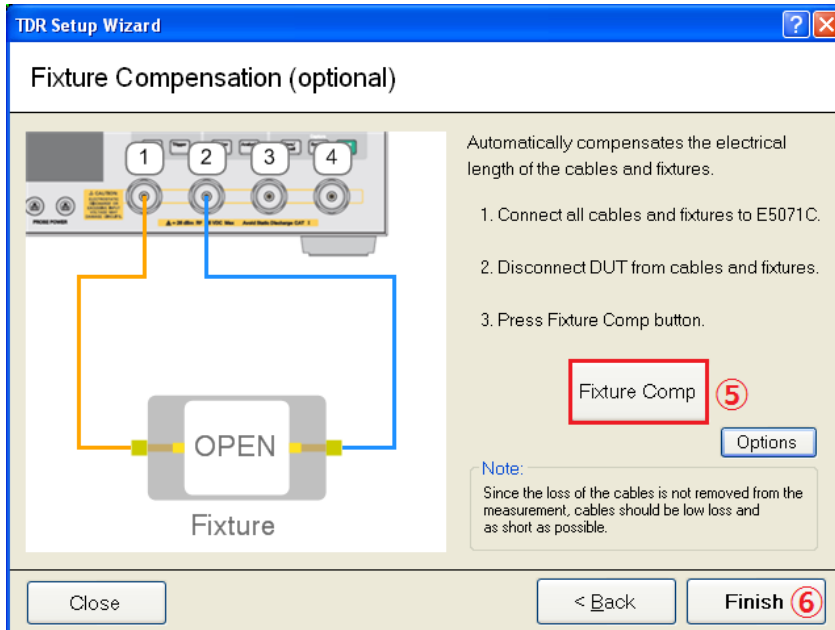
5.4.2. Frequency Domain Calibration

1. Select the GEARs (RATE series), then VBA sets the initial value to the data rate defined in the spec, and input the data rate according to the DUT if needed (item1).

2. Click **Set Limit** (item2).

3. Connect port 1 and port 2 cables to the ECal module.

4. Click **ECal** (item3) to perform the Full Calibration (ECal).

5.5.   M-TX S-Parameter and Impedance

5.5.1.   Differential Return Loss (SDD$_{TX}$)

5.5.1.1.   Purpose

To verify that the Differential Return Loss (SDD$_{TX}$) of the DUT's M-TX exceeds the minimum conformance limits.

5.5.1.2.   Test Procedure

1. Press **Channel Next** key to select Channel2.

2. Press **Channel Max** key to enlarge Channel2.

3. Ensure the VBA shows the desired bit rate.

4. On the VBA macro, select "M-PHY Tx" from the drop down list and click Set Limit button.

5. Power on and configure the DUT to force its M-TX into a continuously transmitting HS state, transmitting a continuous CRPAT repeating pattern, using the Large Amplitude.

6. Connect the DUT's M-TX to the Test System.

7. Click **Run** button on the VBA macro.

8. Read the pass/fail sign on the trace (item 1 in Figure 5-1).

9. Repeat the previous three steps for the Small Amplitude case (if the DUT supports Small Amplitude).

10. Repeat the previous four steps for all other LANEs (if the DUT implements multiple LANEs).

5.5.1.3.   Observable Results

For all LANEs, verify that the SDD$_{TX}$ Differential Return Loss meets or exceeds the limit shown in the figure below, for all supported Amplitude cases (e.g., Large/Small).
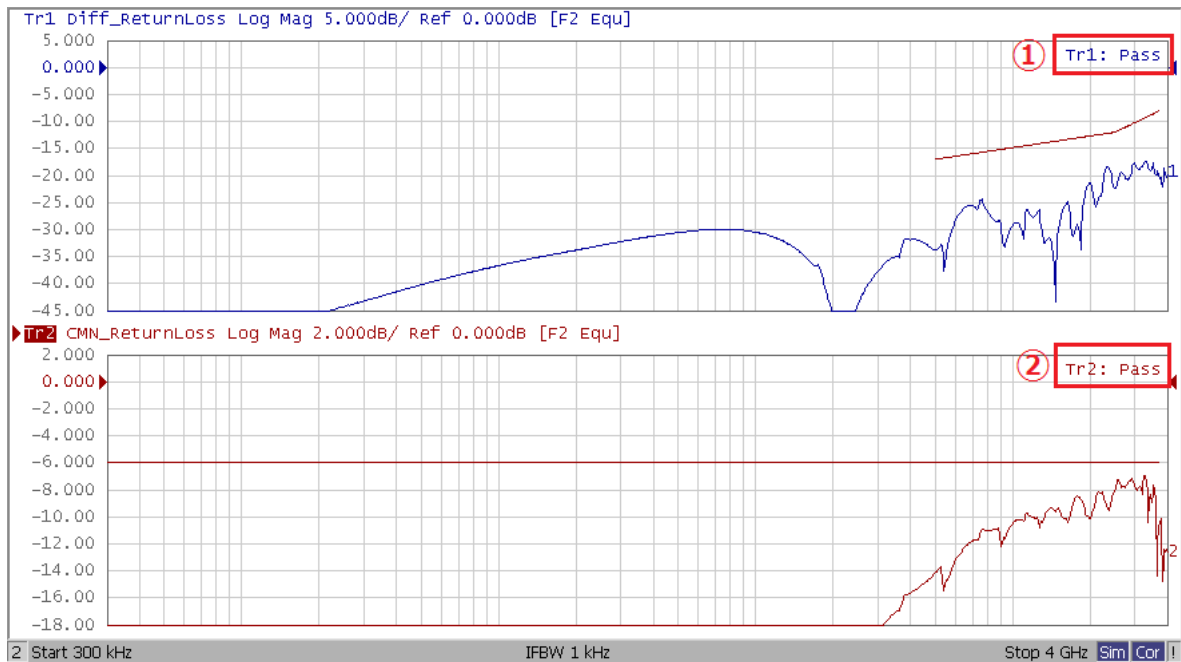
Figure 5-1 Differential Return Loss (SDD$_{TX}$) and Common-Mode Return Loss (SCC$_{TX}$) Example

5.5.2. Common-Mode Return Loss (SCC$_{TX}$)

5.5.2.1. Purpose

To verify that the Common-Mode Return Loss (SCC$_{TX}$) of the DUT's M-TX exceeds the minimum conformance limits.

5.5.2.2. Test Procedure

1. Press **Channel Next** key to select Channel2.

2. Press **Channel Max** key to enlarge Channel2.

3. Ensure the VBA shows the desired bit rate.

4. On the VBA macro, select "M-PHY Tx" from the drop down list and click Set Limit button.

5. Power on and configure the DUT to force its M-TX into a continuously transmitting HS state, transmitting a continuous CRPAT repeating pattern, using the Large Amplitude.

6. Connect the DUT's M-TX to the Test System.

7. Click **Run** button on the VBA macro.

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8. Read the pass/fail sign on the trace (item 2 in Figure 5-1).

9. Repeat the previous three steps for the Small Amplitude case (if the DUT supports Small Amplitude).

10. Repeat the previous four steps for all other LANEs (if the DUT implements multiple LANEs).

5.5.2.3.   Observable Results

For all LANEs, verify that the SCC_{TX} Common-Mode Return Loss meets or exceeds the limits shown in the figure below, for all supported Amplitude cases (e.g., Large/Small).

5.5.3.   Single-Ended Output Resistance (R_{SE-TX})

5.5.3.1.   Purpose

To verify that the Single-Ended Output Resistance (R_{SE-TX}) of the DUT's M-TX is within the conformance limits.

5.5.3.2.   Test Procedure

1. Press **Channel Next** key to select Channel1.

2. Press **Channel Max** key to enlarge Channel1.

3. Power on and configure the DUT to force its M-TX into a fixed HS state, transmitting a continuous, DIF-P state.

4. Connect the DUT's M-TX LANE transmitter to the Test System.

5. Click **Stop Single** for Time Domain measurement.

6. Read the marker values[1] (item 1 in Figure 5-2) as R_{SE-TX} for the TXDP and TXDN pins.

7. Repeat the previous three steps for the DIF-N state.

8. Repeat the previous four steps for all other LANEs.

5.5.3.3.   Observable Results

For all LANEs, verify that R_{SE-TX} is between 40 and 60 ohms for both the TXDP and TXDN pins, for both the DIF-P and DIF-N state.

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[1] The markers are placed at 8 nsec by default. If the DUT response is not flat around the marker, adjust the marker position and horizontal scale.
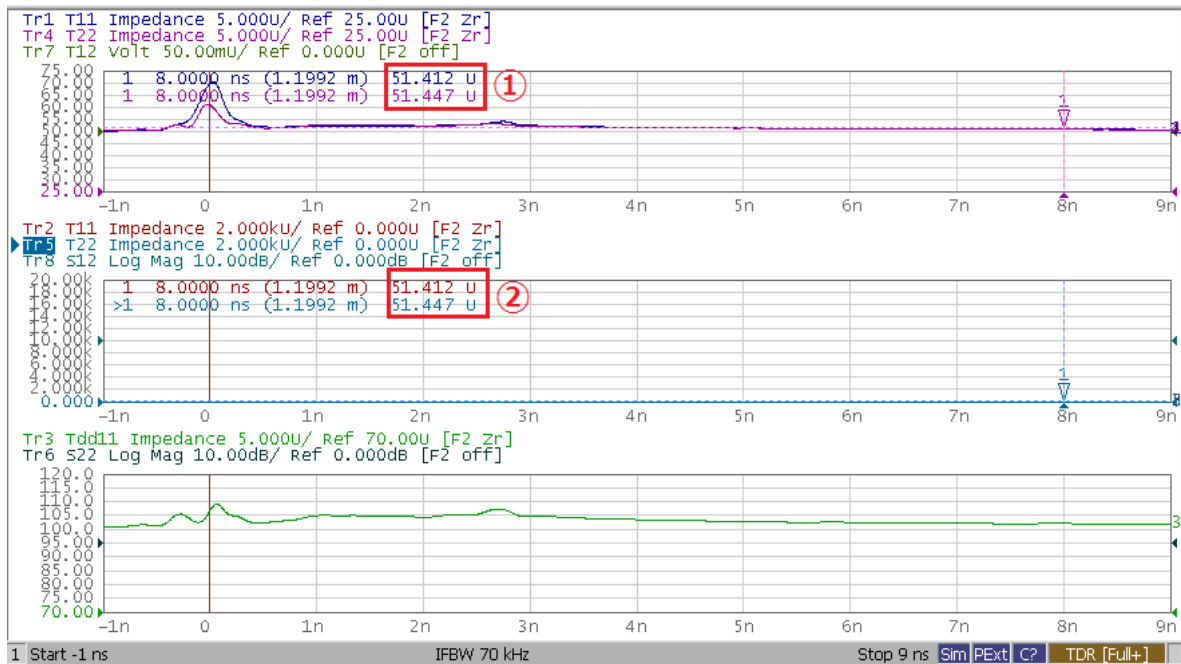
Figure 5-2 Single Ended Output Resistance (R$_{SE-TX}$) Example

5.5.4. HS-TX Single-Ended Output Resistance Mismatch (ΔR$_{SE-TX}$)

5.5.4.1. Purpose

To verify that the Single-Ended Output Resistance Mismatch (ΔR$_{SE-TX}$) of the DUT's HS-TX is within the conformance limits.

5.5.4.2. Test Procedure

1. Obtain the four LAN 0 R$_{SE-TX}$ results from Single-Ended Output Resistance.

2. Compute the four ΔR$_{SE-TX}$ values, as described below.

   - ΔR$_{SE-TX}$(1) = R$_{SE-TX}$(TXDP$_{(DIF-P)}$) − R$_{SE-TX}$(TXDN$_{(DIF-P)}$)

   - ΔR$_{SE-TX}$(2) = R$_{SE-TX}$(TXDP$_{(DIF-P)}$) − R$_{SE-TX}$(TXDN$_{(DIF-N)}$)

   - ΔR$_{SE-TX}$(3) = R$_{SE-TX}$(TXDP$_{(DIF-N)}$) − R$_{SE-TX}$(TXDN$_{(DIF-P)}$)

   - ΔR$_{SE-TX}$(4) = R$_{SE-TX}$(TXDP$_{(DIF-N)}$) − R$_{SE-TX}$(TXDN$_{(DIF-N)}$)

3. Repeat the previous two steps for all other LANEs.

5.5.4.3. Observable Results

Verify that all four ΔR$_{SE-TX}$ values are less than +/- 6 ohms.

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5.5.5. Single-Ended Output Resistance, STALL or SLEEP ($R_{SE-PO-TX}$)

5.5.5.1. Purpose

To verify that the Single-Ended Output Resistance during the STALL or SLEEP state ($R_{SE-PO-TX}$) of the DUT's M-TX is within the conformance limits.

5.5.5.2. Test Procedure

1. Press **Channel Next** key to select Channel1.

2. Press **Channel Max** key to enlarge Channel1.

3. Power on and configure the DUT to force its M-TX into a SLEEP state.

4. Connect the DUT's M-TX LANE transmitter to the Test System.

5. Click **Stop Single** for Time Domain measurement.

6. Read the marker values[2] (item 2 in Figure 5-2) as R_{SE-TX} for the TXDP and TXDN pins.

7. Repeat the previous three steps for the STALL state.

8. Repeat the previous four steps for all other LANEs.

5.5.5.3. Observable Results

For all LANEs, verify that $R_{SE-PO-TX}$ is less than 500 ohms for both the TXDP and TXDN pins, for both the SLEEP and STALL states.

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[2] The markers are placed at 8 nsec by default. If the DUT response is not flat around the marker, adjust the marker position and horizontal scale.

5.6.   M-RX S-Parameters and Impedance

5.6.1.   Differential Return Loss (SDD$_{RX}$)

5.6.1.1.   Purpose

To verify that the Differential Return Loss (SDD$_{RX}$) of the DUT's M-RX exceeds the minimum conformance limits.

5.6.1.2.   Test Procedure

1. Press **Channel Next** key to select Channel2.

2. Press **Channel Max** key to enlarge Channel2.

3. Ensure the VBA shows the desired bit rate.

4. On the VBA macro, select "M-PHY Rx" from the drop down list and click Set Limit button.

5. Power on and configure the DUT to force its RX into fixed state where the HS-RX termination is enabled.

6. Connect the DUT's M-RX LANE to the Test System.

7. Click **Run** button on the VBA macro.

8. Read the pass/fail sign on the trace (item 1 in Figure 5-3).

9. Repeat the previous three steps for all other LANEs.

5.6.1.3.   Observable Results

For all LANEs, verify that the SDD$_{RX}$ Differential Return Loss meets or exceeds the limits shown in the figure below.
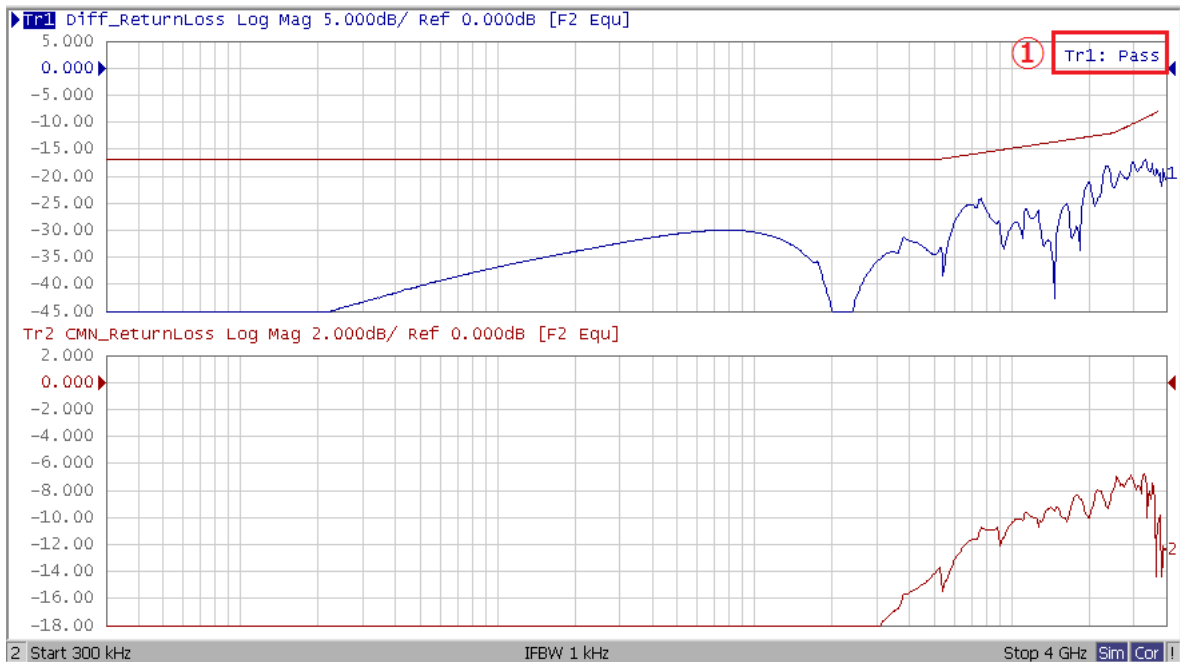
Figure 5-3 Differential Return Loss (SDD$_{RX}$) Example

5.6.2. Differential Termination Resistance (R$_{DEF-RX}$)

5.6.2.1. Purpose

To verify that the Differential Termination Resistance of the DUT's M-RX is within the conformance limits.

5.6.2.2. Test Procedure

1. Press **Channel Next** key to select Channel1.

2. Press **Channel Max** key to enlarge Channel1.

3. Power on and configure the DUT to force its RX into fixed state where the HS-RX termination is enabled.

4. Connect the DUT's M-RX LANE to the Test System.

5. Click **Stop Single** for Time Domain measurement.

6. Read the marker value[3] (item 1 in Figure 5-4) as R$_{DIF-RX}$ for the RXDP and RXDN

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[3] The markers are placed at 8 nsec by default. If the DUT response is not flat around the marker, adjust the marker position and horizontal scale.

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pins.

7. Repeat the previous three steps for all other LANEs.

5.6.2.3.   Observable Results

For all LANEs, verify that R_{DIF-RX} is between 80 and 110 ohms for both the TXDP and

TXDN pins.
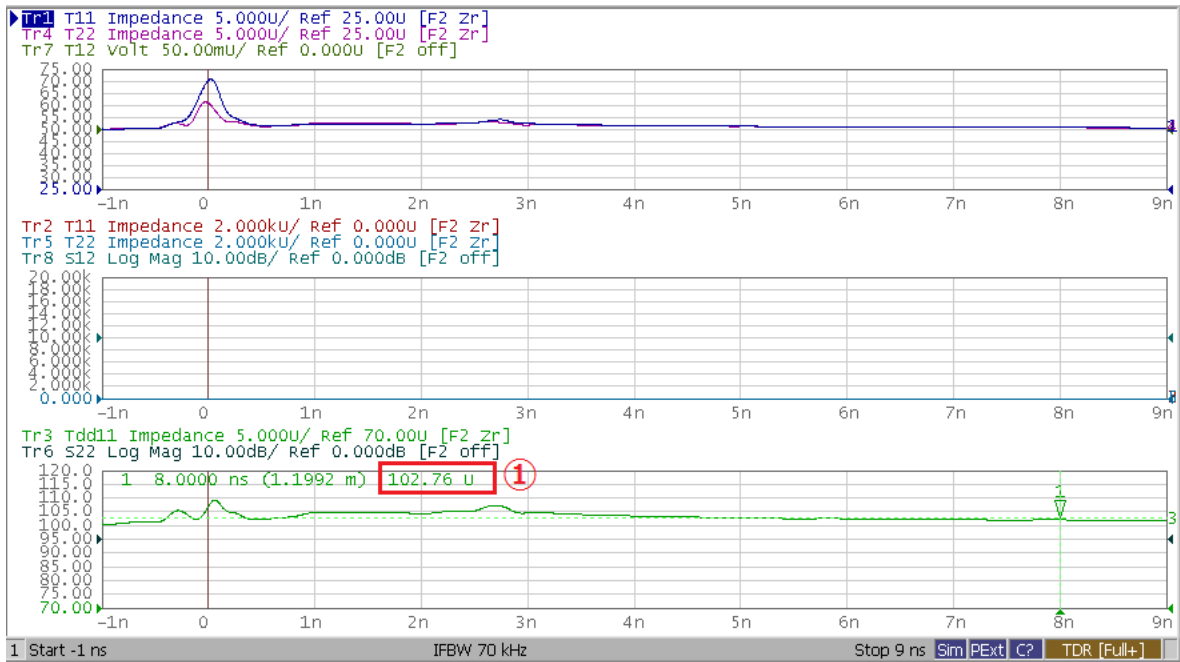
Figure 5-4 Differential Termination Resistance (R_{DEF-RX}) Example

6. Appendix

6.1. Manual Setup for Time Domain Measurement

6.1.1. Starting Setup

1. If TDR setup wizard was appeared, click **Close** button in the TDR setup wizard.

2. Open **Setup** tab (item1).

3. Click **Preset** (item2).

4. A dialog box appears requesting for confirmation. Then click **OK**.

5. Set **DUT Topology** (item3) to "Single-Ended 2-port".

6. Set **Source Power** to -20 dBm. (in More Function Tab)

7. Set **IF Bandwidth** to 1 kHz. (in Average Tab)

8. Click **Advanced Mode** (item4).
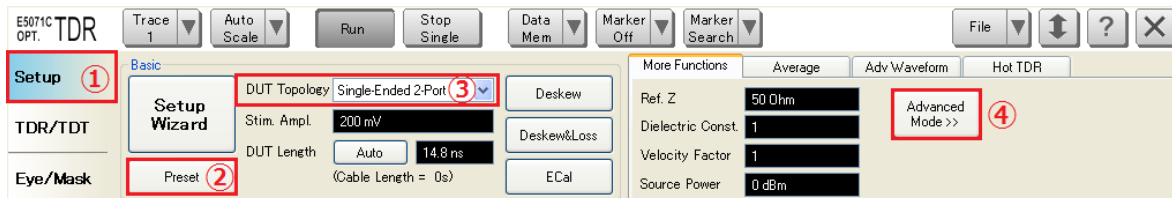
9. A dialog box appears requesting for confirmation. Then click **Yes** (Clear the check box for "Use Advanced Calibration Methods").
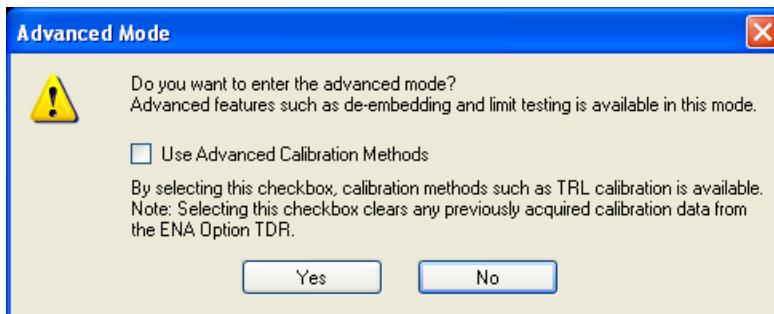
10. Click **Stop Single**.

11. Press **Display**.

12. Set **Num of Traces** to 5.

13. Click **Allocate Traces** > .

6.1.2. Impedance Single-Ended Output Resistance

6.1.2.1. Measurement Setup

1. Open **TDR/TDT** tab.

2. Select **Trace1**.

3. Open **Parameters** tab.

4. Select the **Topology** (item1) of DUT to Single-Ended.
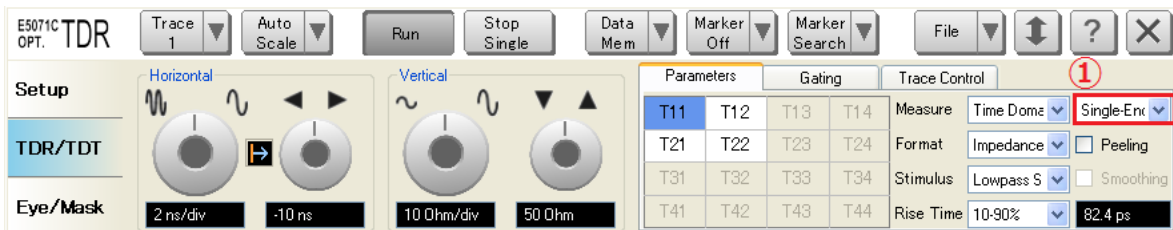
5. Set **Measure** to Time Domain.

6. Select **Format** to Impedance.

7. Set **Rise Time** to 200 ps (10-90%).

8. Click **T11** in the table.

9. Click the box below the left knob under Horizontal.

10. Input 1 nsec/div with the Entry dialog box.

11. Click the box below the right knob under Horizontal.

12. Input -1 nsec with the Entry dialog box.

13. Click the box below the left knob under Vertical.

14. Input 5 Ohm/div with the Entry dialog box.

15. Click the box below the right knob under Vertical.

16. Input 25 Ohm with the Entry dialog box.

17. Open **Trace Control** tab.

18. Clear Marker check box under Coupling.

19. Click **Trace Settings Copy** button. Then Trace Settings Copy dialog box appears.

20. Select **Trace1** in the From list.

21. Select **Trace4** in the To list.

22. Click **Copy**.

23. Click **Close**.

24. Select **Trace4**.

25. Open **Parameters** tab.

26. Click **T22** in the table.

27. Select **Trace1**.

28. Click **Maker** menu and select 1.

29. On Trace1, drag and drop the marker to 8 nsec.

30. Repeat the previous three steps for Trace4.

6.1.3. Impedance Single-Ended Output Resistance, STALL or SLEEP State

1. Open **TDR/TDT** tab.

2. Select **Trace2**.

3. Open **Parameters** tab.

4. Select **Measure** to Time Domain.

5. Select **Format** to Impedance.

6. Set **Rise Time** to 200 ps (10-90%).

7. Click **T11** in the table.

8. Click the box below the left knob under Horizontal.

9. Input 1 nsec/div with the Entry dialog box.

10. Click the box below the right knob under Horizontal.

11. Input -1 nsec with the Entry dialog box.

12. Click the box below the left knob under Vertical.

13. Input 2 kOhm/div with the Entry dialog box

14. Click the box below the right knob under Vertical.

15. Input 0 Ohm with the Entry dialog box.

16. Open **Trace Control** tab.

17. Click **Trace Settings Copy** button. Then Trace Settings Copy dialog box appears.

18. Select **Trace2** in the From list.

19. Select **Trace5** in the To list.

20. Click **Copy**.

21. Click **Close**.

22. Open **Parameters** tab.

23. Select **Trace5**.

24. Click **T22** in the table.

25. Select **Trace2**.

26. Click **Marker** menu and select 1.

27. On Trace2, drag and drop the marker to 8 nsec.

28. Repeat the previous three steps for trace5.

6.1.4.   M-RX Differential Termination Resistance

1.   Open **TDR/TDT** tab.

2.   Select **Trace3**.

3.   Open **Parameters** tab.

4.   Select the **Topology** (item1) of DUT to Differential.
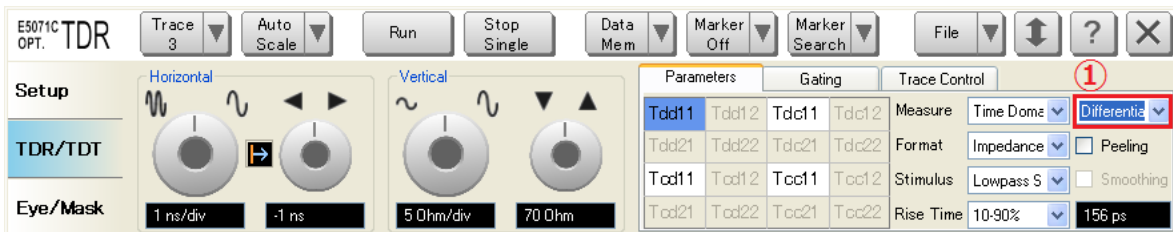
5.   Select **Format** to Impedance.

6.   Set **Rise Time** to 200 ps (10-90%).

7.   Click **Tdd11** in the table.

8.   Click the box below the left knob under Horizontal.

9.   Input 1 nsec/div with the Entry dialog box.

10. Click the box below the right knob under Horizontal.

11. Input -1 nsec with the Entry dialog box.

12. Click the box below the left knob under Vertical.

13. Input 5 Ohm/div with the Entry dialog box.

14. Click the box below the right knob under Vertical.

15. Input 75 Ohm with the Entry dialog box.

6.2. Manual Setup for Frequency Domain Measurement

6.2.1. Channel and Trace Settings

1. Press **Display**.

2. Click **Allocate Channels** > ⊡ .

3. Press **Channel Next**.

4. Click **Num of Traces** > **2**.

5. Click **Allocate Traces** > ⊟ .

6.2.2. Differential Return Loss

1. Press **Trace Next** to select Trace1.

2. Press **Sweep Setup** > **Power >** Set **Power** to -20 dBm.

3. Click **Return**.

4. Set **Points** to 1001.

5. Set **Sweep Type** to Log Freq.

6. Press **Start** > Set start value to 300 kHz.

7. Press **Stop** > Set stop value to 4.5 GHz.

8. Press **Avg** > Set **IF Bandwidth** to 1 kHz.

9. Press **Analysis** > **Fixture Simulator** > **Fixture Simulator** to turn it **ON**.

10. Click **Topology** > **Device** > **Bal**.

11. Click **Port1 (bal)** > **1-2**.

12. Click **Return**.

13. Click **BalUn ON All Traces**.

14. Click **Measurement** > **Sdd11**.

15. Press **Format** > **Log Mag**.

16. Press **Scale**.

17. Set **Scale/Div** to 5 dB/div.

18. Set **Reference position** to 9 Div.

6.2.3. Common-Mode Return Loss

1. Press **Trace Next** to select Trace2.

2. Press **Meas** > **Scc11**.

3. Press **Format** > **Log Mag**.

4. Press **Scale**.

5. Set **Scale/Div** to 2 dB/div.

6. Set **Reference position** to 9 Div.

6.3. Limit Test Settings

The E5071C-TDR provides a capability of setting limit lines to perform pass/fail test on each measurement.

6.3.1. Turning On/Off Fail Sign

If this option is turned on, a fail sign appears when one or more measurement items violate the limit lines. It is useful to check overall test result.

1. Press **Analysis** > **Limit Test** > **Fail Sign** to switch the fail sign ON/OFF.

6.3.2. Setting the Warning Beeper

If this option is turned on, a beep is generated when one or more measurement items violate the limit lines.

1. Press **System** > **Misc Setup** > **Beeper** > **Beep Warning** to switch the warning beeper ON/OFF.

6.3.3.   Defining the Limit Line

Set limit lines to perform pass/fail tests on the following measurement items.

- M-TX Differential Return Loss (Trace1 in Channel2)

- M-TX Common-Mode Return Loss (Trace2 in Channel2)

- M-RX Differential Return Loss (Trace1 in Channel2)

Note: If using the VBA, appropriate limit lines are automatically selected for Attenuation and Phase in accordance with the DUT cable type.

1. Press **Channel Next** key and **Trace Next** key to activate the trace on which limit lines should be set.
2. Press **Analysis** > **Limit Test** > **Edit Limit Line** to display the limit table shown below (Initially, no segments are entered in the limit table). Using the limit table, create/edit a segment.

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

3. Enter the limit line data following the tables below.
4. Click **Return**.
5. Click **Limit Line** and turn it **ON**.
6. Click **Limit Test** and turn it **ON**.
7. Repeat 1 to 6 for each Measurement items.

- **HS-G1**

Differential Return Loss (M-TX)

Type	Begin Stimulus	End Stimulus	Begin Response	End Response
Max	F_{HS_MIN}	F_{HS}	-17 dB	-10 dB
Max	F_{HS}	F_{HS_MAX}	-10 dB	-7 dB

Differential Return Loss (M-RX)

Type	Begin Stimulus	End Stimulus	Begin Response	End Response
Max	0	F_{HS_MIN}	-17 dB	-17 dB
Max	F_{HS_MIN}	F_{HS}	-17 dB	-10 dB
Max	F_{HS}	F_{HS_MAX}	-10 dB	-7 dB

Common-Mode Return Loss (M-TX)

Type	Begin Stimulus	End Stimulus	Begin Response	End Response
Max	0	F_{HS_MAX}	-6 dB	-6 dB

F_{HS_MIN}: Data Rate * 0.1

F_{HS}: Data Rate * 0.5

F_{HS_MAX}: Data Rate * 0.75

- **HS-G2**

Differential Return Loss (M-TX)

Type	Begin Stimulus	End Stimulus	Begin Response	End Response
Max	F_{HS_MIN}	F_{HS}	-17 dB	-4.8 dB
Max	F_{HS}	F_{HS_MAX}	-4.8 dB	-3 dB

Differential Return Loss (M-RX)

Type	Begin Stimulus	End Stimulus	Begin Response	End Response
Max	0	F_{HS_MIN}	-17 dB	-17 dB
Max	F_{HS_MIN}	F_{HS}	-17 dB	-4.8 dB
Max	F_{HS}	F_{HS_MAX}	-4.8 dB	-3 dB

Common-Mode Return Loss (M-TX)

Type	Begin Stimulus	End Stimulus	Begin Response	End Response
Max	0	F_{HS_MAX}	-4 dB	-4 dB

F_{HS_MIN}: Data Rate * 0.1

F_{HS}: Data Rate * 0.5

F_{HS_MAX}: Data Rate * 0.75

- **HS-G3**

Differential Return Loss (M-TX)

Type	Begin Stimulus	End Stimulus	Begin Response	End Response
Max	F_{HS_MIN}	F_{HS}	-13 dB	-3.8 dB
Max	F_{HS}	F_{HS_MAX}	-3.8 dB	-2 dB

Differential Return Loss (M-RX)

Type	Begin Stimulus	End Stimulus	Begin Response	End Response
Max	0	F_{HS_MIN}	-13 dB	-13 dB
Max	F_{HS_MIN}	F_{HS}	-13 dB	-3.8 dB
Max	F_{HS}	F_{HS_MAX}	-3.8 dB	-2 dB

Common-Mode Return Loss (M-TX)

Type	Begin Stimulus	End Stimulus	Begin Response	End Response
Max	0	F_{HS_MAX}	-2 dB	-2 dB

F_{HS_MIN}: Data Rate * 0.1

F_{HS}: Data Rate * 0.5

F_{HS_MAX}: Data Rate * 0.75