Keysight Method of Implementation (MOI) for MIPI D-PHY Conformance Tests Using Keysight E5071C ENA Network Analyzer Option TDR
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1. Modification Record

<table>
<thead>
<tr>
<th>Revision</th>
<th>Comments</th>
<th>Issue Date</th>
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<tr>
<td>1.00</td>
<td>First Release</td>
<td>Dec 1, 2011</td>
</tr>
<tr>
<td>1.10</td>
<td>Updated procedures to Conformance Test Suite for D-PHY Physical Layer Version 1.1 Revision 03.</td>
<td>Oct 10, 2014</td>
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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 D-PHY. The instrument operations contained in this document are designed for Keysight E5071C ENA Network Analyzer Option TDR.

3. References

MIPI Alliance Conformance Test Suite for D-PHY Physical Layer Version 1.1 Revision 03
MIPI Alliance Specification for D-PHY Version 1.1

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: 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 (14/20 GHz models)

3. 3.5 mm cables of 4 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
     - HS-TX Single-Ended Output Impedance
     - HS-TX Single-Ended Output Impedance Mismatch
     - HS-RX DC Differential Input Impedance
   - Frequency Domain Measurements
     - HS-TX Differential Return Loss
     - HS-TX Common-Mode Return Loss
     - HS-TX Mode Conversion Limits
     - HS-RX Differential Return Loss
     - HS-RX Common-Mode Return Loss
     - HS-RX Mode Conversion Limits

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 D-PHY Tx/Rx Devices” from [www.keysight.com/find/ena-tdr_dphy-txrx](http://www.keysight.com/find/ena-tdr_dphy-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 tab (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.

<table>
<thead>
<tr>
<th>E5071C Test Set Option</th>
<th>State File Name</th>
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<tr>
<td>2D5/2K5/4D5/4K5</td>
<td>MIPI_D-PHYv1.1_TxRx_2D5-4K5.tdr</td>
</tr>
</tbody>
</table>
5.2.2. Running VBA macro program

1. Installing the VBA macro program

Obtain the VBA macro program from Keysight 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_D-PHYv1.1_TxRx” from the soft key menu and click on it.
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 Impedance (HS-TX)
  - Tr1: T11
  - Tr3: T22

- DC Differential Input Impedance (HS-RX)
  - Tr2: Tdd 11

**Channel 2  Frequency Domain**
- Differential Return Loss (HS-TX/HS-RX)
  - Tr1: Sdd 11

- Common-Mode Return Loss (HS-TX/HS-RX)
  - Tr2: Scc 11

- Mode Conversion Limits (HS-TX/HS-RX)
  - Tr3: Sdc 11
5.3. Calibration and Adjustment
   5.3.1. 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).
5.3.2. Frequency Domain Calibration

1. Input the parameters expected with the DUT (item1).\(^1\)
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).

---

\(^1\) Minimum rise and fall time (20-80%) of 100 ps is applicable for Max. HS bit rates > 1000 Mbps. For Max. HS bit rates ≤ 1000 Mbps, should not use values below 150 ps.
5.4. HS-TX S-Parameters

5.4.1. Differential Return Loss (SDD11)

5.4.1.1. Purpose
To verify that the Differential Return Loss of the DUT’s Clock and Data Lane HS transmitters exceeds the minimum conformance limits.

5.4.1.2. 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 maximum HS bit rates, minimum rise and fall times (20-80%), maximum toggle frequency for Low Power mode.
4. On the VBA macro, select “D-PHY Tx” from the drop down list and click Set Limit button.
5. Power on and configure the DUT to force its HS-TX into a fixed HS state, transmitting a continuous, repeating pattern on all Clock and Data Lanes.
6. Connect the DUT’s Data Lane 0 transmitter to the Test System.
7. Click Run button on the VBA macro.
   Note: If the trace data is not stable, it is recommended that adjusting the IF Bandwidth narrower than the default setting, and check if the trace becomes stable: \( \text{Avg} > \text{IF Bandwidth} > \text{(set a value)} \).
8. Read the pass/fail sign on the trace (item 1 in Figure 5-1).
9. Repeat the previous three steps for all other Data Lane, and the Clock Lane.

5.4.1.3. Observable Results
For all Clock and Data Lanes, verify that the SDD11 HS-TX Differential Return Loss meets or exceeds the limits shown in the figure below.
5.4.2. Common-Mode Return Loss (SCC11)

5.4.2.1. Purpose

To verify that the Common-Mode Return Loss of the DUT’s Clock and Data Lane HS transmitters exceeds the minimum conformance limits.

5.4.2.2. 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 maximum HS bit rates, minimum rise and fall times (20-80%), maximum toggle frequency for Low Power mode.
4. On the VBA macro, select “D-PHY Tx” from the drop down list and click Set Limit button.
5. Power on and configure the DUT to force its HS-TX into a fixed HS state, transmitting a continuous, repeating pattern on all Clock and Data Lanes.
6. Connect the DUT’s Data Lane 0 transmitter to the Test System.

7. Click Run button on the VBA macro.
   Note: If the trace data is not stable, it is recommended that adjusting the IF Bandwidth narrower than the default setting, and check if the trace becomes stable: \( \text{Avg} > \text{IF Bandwidth} \) > (set a value).

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

9. Repeat the previous three steps for all other Data Lanes, and the Clock Lane.

   5.4.2.3. Observable Results
   For all Clock and Data Lanes, verify that the SCC11 HS-TX Common-Mode Return Loss meets or exceeds the limits shown in the figure below.

5.4.3. Mode Conversion Limits (SDC11)

   5.4.3.1. Purpose
   To verify that the Mode Conversion S-parameters of the DUT’s Clock and Data Lane HS transmitters exceed the minimum conformance limits.

   5.4.3.2. 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 maximum HS bit rates, minimum rise and fall times (20-80%), maximum toggle frequency for Low Power mode.
   4. On the VBA macro, select “D-PHY Tx” from the drop down list and click Set Limit button.
   5. Power on and configure the DUT to force its HS-TX into a fixed HS state, transmitting a continuous, repeating pattern on all Clock and Data Lanes.
   6. Connect the DUT’s Data Lane 0 transmitter to the Test System.
   7. Click Run button on the VBA macro.
   Note: If the trace data is not stable, it is recommended that adjusting the IF Bandwidth narrower than the default setting, and check if the trace becomes stable: \( \text{Avg} > \text{IF} \)
Bandwidth > (set a value).

8. Read the pass/fail sign on the trace (item 3 in Figure 5-1).
9. Repeat the previous three steps for all other Data Lanes, and the Clock Lane.

5.4.3.3. Observable Results
For all Clock and Data Lanes, verify that the SDC11 HS-TX Mode Conversion Loss meets or exceeds the limits shown in the figure below.

5.4.4. Single-Ended Output Impedance ($Z_{OS}$)

5.4.4.1. Purpose
To verify that the Single-Ended Output Impedance ($Z_{OS}$) of the DUT’s HS transmitters is within the conformance limits.

5.4.4.2. 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 HS-TX into a fixed HS state, transmitting a continuous, repeating pattern on all Clock and Data Lanes.
4. Connect the DUT’s Data Lane 0 transmitter to the Test System.
   Note: If the trace data is not stable, it is recommended that adjusting the IF Bandwidth narrower than the default setting, and check if the trace becomes stable: Setup > Average > IF Bandwidth > (set a value).
5. Click Stop Single for Time Domain measurement.
6. Read the marker values$^2$ (item 1 in Figure 5-2) as $Z_{OS}$ for the Dp and Dn pins.
7. Repeat the previous three steps for all other Data Lanes, and Clock lane.

5.4.4.3. Observable Results
For all Clock and Data Lanes, verify that $Z_{OS}$ is between 40 and 62.5 ohms for both the Dp and Dn pins.

$^2$ 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.
5.4.5. Single-Ended Output Impedance Mismatch ($\Delta Z_{OS}$)

5.4.5.1. Purpose

To verify that the Single-Ended Output Impedance Mismatch ($\Delta Z_{OS}$) of the DUT’s HS transmitter is within the conformance limits.

5.4.5.2. Test Procedure

1. Obtain the $Z_{OS}$ values for each Clock and Data Lane from Single-Ended Output Impedance.

2. Compute the $\Delta Z_{OS}$ value, as described below.
   
   $\Delta Z_{OS} = 2(|Z_{OSDP} - Z_{OSDN}| / (Z_{OSDP} + Z_{OSDN}))$

3. For each lane, compute $\Delta Z_{OS}$ as described above.

5.4.5.3. Observable Results

For all Clock and Data Lanes, verify that $\Delta Z_{OS}$ is less than 10%.
5.5. HS-RX S-Parameters
   5.5.1. Differential Return Loss (SDD11)
       5.5.1.1. Purpose
To verify that the Differential Return Loss of the DUT’s Clock and Data Lane HS receivers 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 maximum HS bit rates, minimum rise and fall times (20-80%), maximum toggle frequency for Low Power mode, and minimum RF frequency.
4. On the VBA macro, select “D-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 Data Lane 0 receiver to the Test System.
7. Click Run button on the VBA macro.
   Note: If the trace data is not stable, it is recommended that adjusting the IF Bandwidth narrower than the default setting, and check if the trace becomes stable: Avg > IF Bandwidth > (set a value).
8. Read the pass/fail sign on the trace (item 1 in Figure 5-3).
9. Repeat the previous three steps for all other Data Lanes, and the Clock Lane.
5.5.1.3. Observable Results

For all Clock and Data Lanes, verify that the SDD11 HS-RX Differential Return Loss meets or exceeds the limits shown in the figure below.

![Differential Return Loss, Common-Mode Return Loss and Mode Conversion Limits](image)

Figure 5-3 Differential Return Loss, Common-Mode Return Loss and Mode Conversion Limits (HS-RX) Example

5.5.2. Common-Mode Return Loss (SCC11)

5.5.2.1. Purpose

To verify that the Common-Mode Return Loss of the DUT’s Clock and Data Lane HS receivers 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 maximum HS bit rates, minimum rise and fall times (20-80%), maximum toggle frequency for Low Power mode, and minimum RF
4. On the VBA macro, select “D-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 Data Lane 0 receiver to the Test System.

7. Click Run button on the VBA macro.
   
   Note: If the trace data is not stable, it is recommended that adjusting the IF Bandwidth narrower than the default setting, and check if the trace becomes stable: Avg > IF Bandwidth > (set a value).

8. Read the pass/fail sign on the trace (item 2 in Figure 5-3).

9. Repeat the previous three steps for all other Data Lanes, and the Clock Lane.

   5.5.2.3. Observable Results
   
   For all Clock and Data Lanes, verify that the SCC11 HS-RX Common-Mode Return Loss meets or exceeds the limits show in the figure below.

5.5.3. Mode Conversion Limit (SDC11)

5.5.3.1. Purpose
   
   To verify that the Mode Conversion S-parameters of the DUT’s Clock and Data Lane HS receivers exceed the minimum conformance limits.

   5.5.3.2. 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 maximum HS bit rates, minimum rise and fall times (20-80%), maximum toggle frequency for Low Power mode, and minimum RF frequency.
   4. On the VBA macro, select “D-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 Data Lane 0 receiver to the Test System.

7. Click **Run** button on the VBA macro.
   
   Note: If the trace data is not stable, it is recommended that adjusting the IF Bandwidth narrower than the default setting, and check if the trace becomes stable: **Avg > IF Bandwidth > (set a value).**

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

9. Repeat the previous three steps for all other Data Lanes, and the Clock Lane.

5.5.3.3. Observable Results

For all Clock and Data Lanes, verify that the SDC11 HS-RX Mode Conversion Loss meets or exceeds the limits shown in the figure below.

5.5.4. DC Differential Input Impedance (Z\text{ID})

5.5.4.1. Purpose

To verify that DC Differential Input Impedance (Z\text{ID}) of the TUT’s HS-RX line termination is within the conformance limits.

5.5.4.2. 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 Data Lane 0 receiver to the Test System.
   
   Note: If the trace data is not stable, it is recommended that adjusting the IF Bandwidth narrower than the default setting, and check if the trace becomes stable: **Setup > Average > IF Bandwidth > (set a value).**

5. Click **Stop Single** for Time Domain measurement.
6. Read the marker value\(^3\) (item 1 in Figure 5-4) as \(Z_{ID}\).

7. Repeat the previous three steps for all other Data Lanes, and Clock Lane.

5.5.4.3. Observable Results

For all Clock and Data Lanes, verify that \(Z_{ID}\) is between 80 and 125 Ohms.

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\(^3\) The marker is placed at 8 nsec by default. If the DUT response is not flat around the marker, adjust the marker position and horizontal scale.
6. Appendix


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 3.
13. Click Allocate Traces >.
6.1.2. HS-TX Single-Ended Output Impedance

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 100 ps (20-80%).
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 Trace3 in the To list.
22. Click **Copy**.
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23. Click Close.
24. Select Trace3.
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 Trace3.

6.1.3. HS-RX DC Differential Input Impedance
1. Open TDR/TDT tab.
2. Select Trace2.
3. Open Parameters tab.
4. Select the Topology (item1) of DUT to Differential.
5. Select Measure to Time Domain.
6. Select Format to Impedance.
7. Set Rise Time to 100 ps (20-80%).
8. Click Tdd11 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 10 Ohm/div with the Entry dialog box
15. Click the box below the right knob under Vertical.
16. Input 50 Ohm with the Entry dialog box.
17. Click **Marker** menu and select 1.
18. On Trace2, drag and drop the marker to 8 nsec.


6.2.1. Channel and Trace Settings
1. Press **Display**.
2. Click **Allocate Channels** >  
3. Press **Channel Next**.
4. Click **Num of Traces** > 3.
5. Click **Allocate Traces** >  

6.2.2. HS-TX/HS-RX 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 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**.

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6.2.3. HS-TX/HS-RX Common-Mode Return Loss
1. Press \textbf{Trace Next} to select Trace2.
2. Press \textbf{Meas \rightarrow Scc11}.
3. Press \textbf{Format \rightarrow Log Mag}.
4. Press \textbf{Scale}.
5. Set \textbf{Scale/Div} to 5 dB/div.
6. Set \textbf{Reference position} to 9 Div.

6.2.4. HS-TX/HS-RX Mode Conversion Limits
1. Press \textbf{Trace Next} to select Trace3.
2. Press \textbf{Meas \rightarrow Sdc11}.
3. Press \textbf{Format \rightarrow Log Mag}.
4. Press \textbf{Scale}.
5. Set \textbf{Scale/Div} to 5 dB/div.
6. Set \textbf{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 \textbf{Analysis \rightarrow Limit Test \rightarrow 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 > Beep > 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.
- HS-TX Differential Return Loss (Trace1 in Channel2)
- HS-TX Common-Mode Return Loss (Trace2 in Channel2)
- HS-TX Mode Conversion Limits (Trace3 in Channel2)
- HS-RX Differential Return Loss (Trace1 in Channel2)
- HS-RX Common-Mode Return Loss (Trace2 in Channel2)
- HS-RX Mode Conversion Limits (Trace3 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.
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.

### Differential Return Loss (HS-TX)

<table>
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<tr>
<th>Type</th>
<th>Begin Stimulus</th>
<th>End Stimulus</th>
<th>Begin Response</th>
<th>End Response</th>
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<tbody>
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<td>Max</td>
<td>$f_{LP,MAX}$</td>
<td>$f_h$</td>
<td>-18 dB</td>
<td>-9 dB</td>
</tr>
<tr>
<td>Max</td>
<td>$f_h$</td>
<td>$f_{MAX}$</td>
<td>-9 dB</td>
<td>-3 dB</td>
</tr>
</tbody>
</table>

### Differential Return Loss (HS-RX)

<table>
<thead>
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<th>Type</th>
<th>Begin Stimulus</th>
<th>End Stimulus</th>
<th>Begin Response</th>
<th>End Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max</td>
<td>0</td>
<td>$F_{LP,MAX}$</td>
<td>-18 dB</td>
<td>-18 dB</td>
</tr>
<tr>
<td>Max</td>
<td>$f_{LP,MAX}$</td>
<td>$f_h$</td>
<td>-18 dB</td>
<td>-9 dB</td>
</tr>
<tr>
<td>Max</td>
<td>$f_h$</td>
<td>$f_{MAX}$</td>
<td>-9 dB</td>
<td>-3 dB</td>
</tr>
</tbody>
</table>

$f_{LP,MAX}$: Toggle Frequency for Low Power mode

$f_h$: Maximum HS bit rates / 2

$f_{MAX}$: 1 / (Minimum Rise and Fall Time (20-80%) * 5)
### Keysight MOI for MIPI D-PHY Conformance Tests

#### Common-Mode Return Loss (HS-TX)

<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>Max</td>
<td>$f_{LP,MAX}$</td>
<td>$f_{MAX}$</td>
<td>-6 dB</td>
<td>-6 dB</td>
</tr>
</tbody>
</table>

#### Common-Mode Return Loss (HS-TX)

<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>Max</td>
<td>0</td>
<td>$f_{INT,MIN}/4$</td>
<td>0 dB</td>
<td>0 dB</td>
</tr>
<tr>
<td>Max</td>
<td>$f_{INT,MIN}/4$</td>
<td>$f_{INT,MIN}$</td>
<td>0 dB</td>
<td>-6 dB</td>
</tr>
<tr>
<td>Max</td>
<td>$f_{INT,MIN}$</td>
<td>$f_{MAX}$</td>
<td>-6 dB</td>
<td>-6 dB</td>
</tr>
</tbody>
</table>

$f_{INT,MIN}$: Minimum RF Frequency

$f_{LP,MAX}$: Toggle Frequency for Low Power mode

$f_{MAX}$: $1 / (\text{Minimum Rise and Fall Time (20-80\%) \times 5})$

#### Mode Conversion Limits (HS-TX)

<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>Max</td>
<td>0</td>
<td>$f_{MAX}$</td>
<td>-26 dB</td>
<td>-26 dB</td>
</tr>
</tbody>
</table>

#### Mode Conversion Limits (HS-RX)

<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>Max</td>
<td>0</td>
<td>$f_{MAX}$</td>
<td>-26 dB</td>
<td>-26 dB</td>
</tr>
</tbody>
</table>

$f_{MAX}$: $1 / (\text{Minimum Rise and Fall Time (20-80\%) \times 5})$