

# **Procedures Guide Version 1.1**

**Tektronix**

**MHL Cables Measurements**

# Measurement Procedures

## Equipment Required

Table 1 lists the equipment required to perform the differential impedance measurement.

**Table 1: Equipment required**

Item	Qty.	Recommended equipment
Sampling oscilloscope	1 ea.	Tektronix TDS8200 (or DSA8300/DSA8200/CSA8200)
TDR sampling module	2 ea.	Tektronix one 80E04 and one 80E03 (alternative is 2 80E04 )
50 $\Omega$ SMA terminator	4 ea.	Tektronix part number 01 5-1 021-00
50 $\Omega$ SMA cable	2 ea.	HUBER+SUHNER SUCOFLEX 104PEA
TPA (test fixture)	1 ea.	Wilder Technologies MHL-TPA-R-WOC and TPA-R-WOSI Also available as TF-MHL-TPA-R-WOC and TF-MHL-TPA-R-WOSI From Tektronix
80SPAR	1	I-connect Software

**NOTE.**

*To protect the sampling module from damage due to electro-overstress (EOS) and electrostatic discharge (ESD), power off a device under test (DUT) to discharge the static voltage completely from it before performing the procedures.*

*While performing the following procedures, be sure to wear a grounded antistatic wrist strap to discharge the static voltage from your body.*

## Front-Panel Buttons

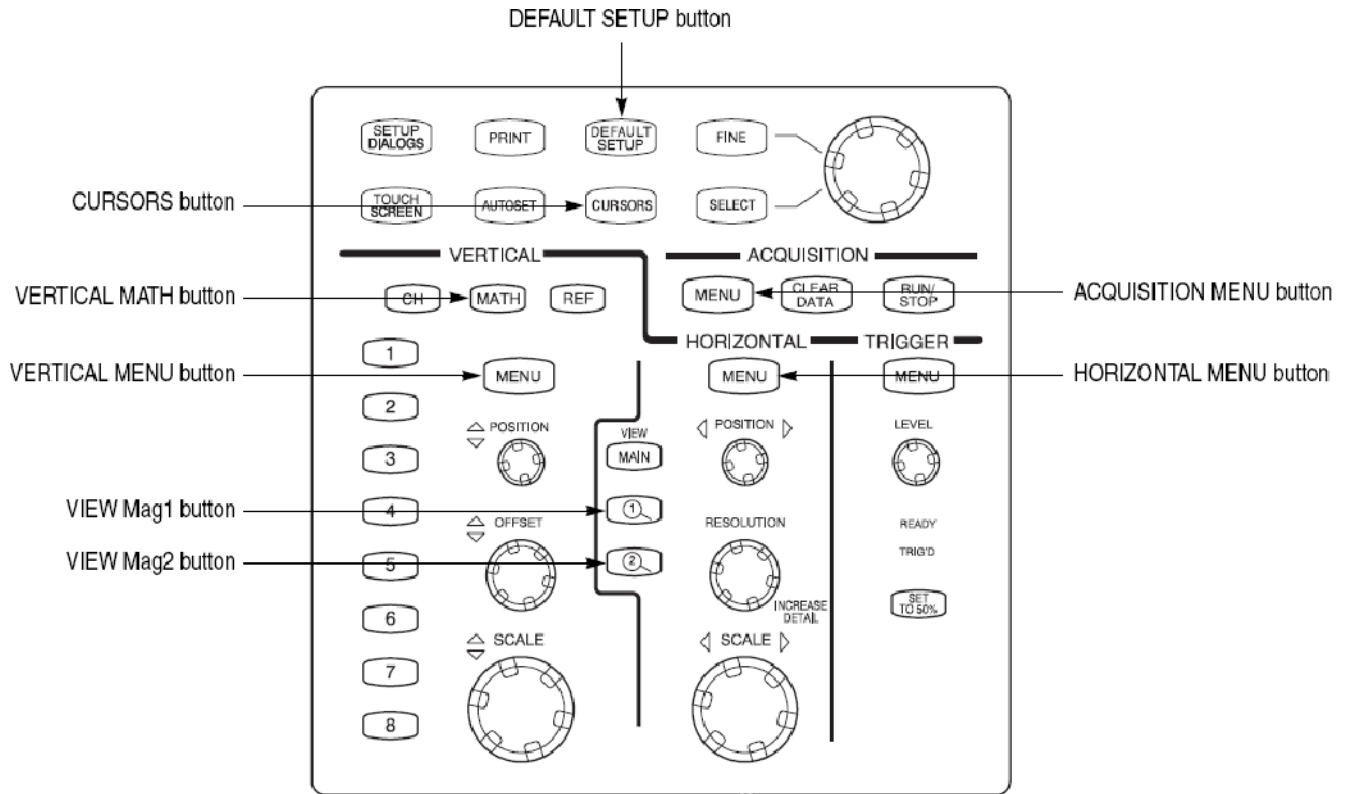


Figure 1: Front-panel buttons on the TDS8200

## Equipment Connections

1. Use DC block and 50Ohm SMA cable to connect the CH1 connector on the sampling module and the MHL + connector on the test fixture (see Figure 2).
2. Use DC block and 50 Ohm SMA cable to connect the CH2 connector on the sampling module and the MHL- connector on the test fixture (see Figure 2).
3. Use the similar configuration to connect the VBus and CBus.

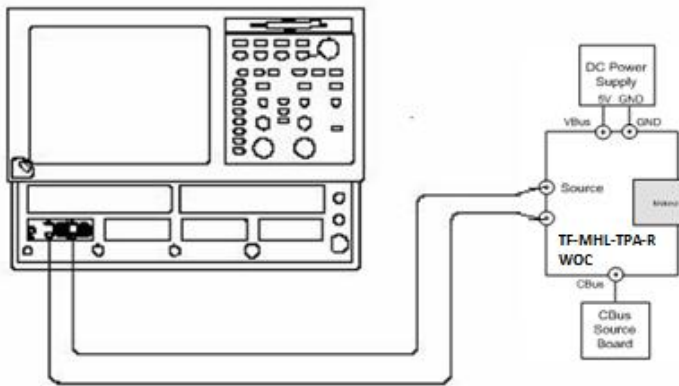


Figure 2: Initial equipment connections for the measurement using a TF-MHL-TPA-R-WOC

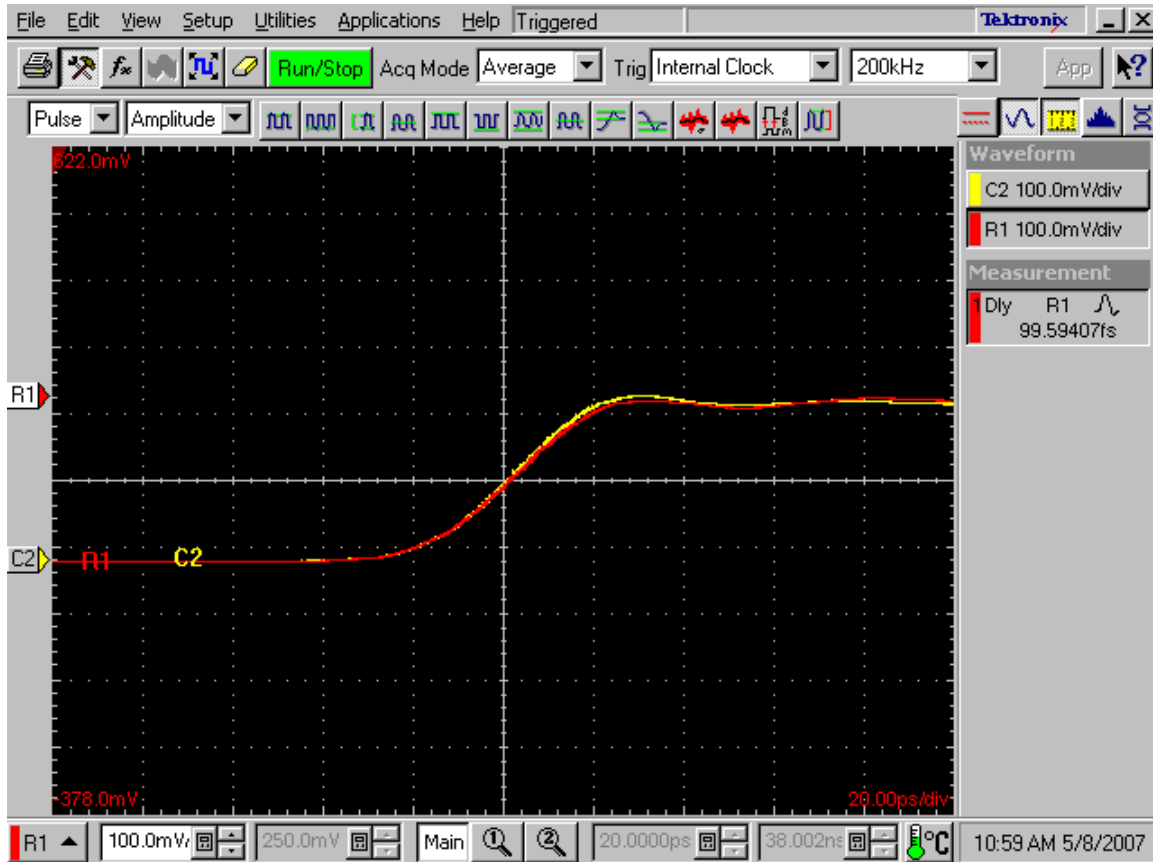
## Skew Calibration

### Match samplers to the ends of the cables

The purpose of this step is to set the samplers on each channel so that an input into the open end of each cable arrives at the sample gate at precisely the same time. This step compensates for cable and sampler differences. First stage is alignment of the channels 1-3 using the channel 2 as an independent TDR source, and then aligning acquisition of the channel 2 with respect to already aligned channel 1 using channel one as another independent source.<sup>1</sup> The de-skew procedure is to be performed in *rho* mode.

1. Connect SMA cables to the sampling modules of the oscilloscope. For the best results, it is desired that the SMA cables used in the measurements have approximately the same quality and length (matched within 20ps).
2. Connect channel 1 and channel 2 with SMA barrel, activate TDR step on channel 2 and acquisition on channel 1
3. Adjust the horizontal position and scale to get the rising edge on screen with good resolution (20ps/div). Record length should have the maximum number of 4000 points.
4. Save channel one (C1) waveform as a reference trace. Channel 3 and 4 will be aligned with respect to it.
5. Connect channel three (C3) to the channel two (C2) using SMA barrel, and display C3 on the screen.
6. Turn on the delay measurement to measure the time difference between the rising edge on the reference trace and the rising edge of C3 as shown in Figure 3.

<sup>1</sup> When only one TDR and one sampling modules are available another TDR channel can be used as an independent TDR source.



**Figure 3 Delay measurements between the reference (R1) acquired from the channel one and the channel two (C2). It has to be the minimum for the best deskew value.**

7. Adjust the channel deskew value in the *Vertical* menu of the *Setups* dialog until a delay value within 1ps is achieved as show
8. Repeat steps 5-7 for the C4.
9. Now, when the acquisition of C1 through C3 is aligned, the same approach can be used to align C4. For this purpose generate a new reference by using the step of C1 and acquiring it on C3. C3 has to be connected to C1 with the SMA barrel.
10. Repeat steps 5-7 for the C2 using acquired reference from C3.

Now, all four acquisition channels have been deskewed within 1ps.

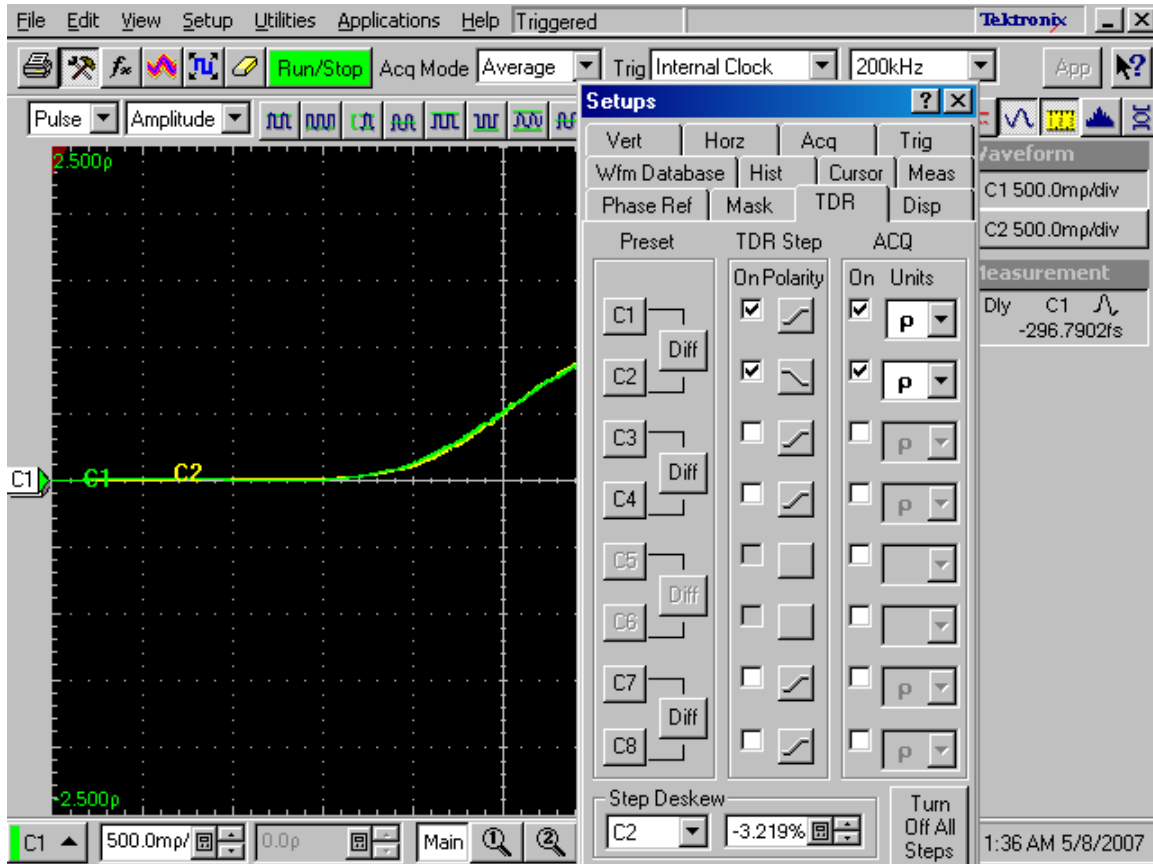
### Match the TDR pulses to the ends of the cables

The purpose of this step is to adjust the TDR pulses so they arrive at the ends of the cables at precisely the same time. The deskew has to be performed separately for odd and even TDR steps when 80E04 modules are used<sup>2</sup>. This section describes only odd mode TDR step deskew. The deskew procedure has to be performed in *rho* mode.

1. Disconnect the SMA barrel and turn on TDR pulses of the appropriate polarity for each channel (C1 and C2). Use the differential TDR preset selection to activate odd mode.
2. Adjust the horizontal position and scale so that the pulses as they arrive at the ends of the cables are visible on screen with good resolution. (Use *Average* mode and vectored display, a set time scale to 20ps/div).
3. Turn on the delay measurement to measure the time difference between the two pulse edges.
4. Adjust the *Step Deskew* in TDR menu to minimize the time difference between the C1 and C2 pulses. You might want to activate *Fine* button to reduce the increment of deskew as shown in Figure 4.

<sup>2</sup> Odd mode (differential) is generated when TDR steps set to opposite polarity, and even mode (common) is generated when both steps are of the same polarity.

## Measurement Procedures



**Figure 4 Differential TDR step deskew. The channels C1 and C2 are aligned within ~300fs.**

The instrument should now be set up to accurately make differential or common mode TDR measurements.

## Setting the Rise Time

1. Click the **TDR** tab, and then set **ACQ On Units** to **V**.
  - a. Differential mode: Opposite Polarity of CH1 & CH2
  - b. Common mode: Same Polarity of CH1 & CH2
2. Define a math waveform:
  - a. **Differential mode**: Press the **VERTICAL MATH** button, and then enter **Filter (CH1-CH2)** in the **Math Expression** field in the **Define Math** window.
  - b. **Common mode**: Press the **VERTICAL MATH** button, and then enter **Filter (CH1+CH2)/2** in the **Math Expression** field in the **Define Math** window.
  - c. Set **Filter Mode** to **Centered**.
  - d. Select the **Math Waveform On** check box, and then click **OK**.
  - e. Press the **VERTICAL MENU** button (if the Setups window is not displayed), and then click the **Vert** tab and select **M1**.
  - f. Set **Scale** to **100.0 mV/div** and **Position** to **-5.00 div**.
3. Use the **HORIZONTAL SCALE** knob to set the horizontal scale to **500 ps/div**.
4. Use the **HORIZONTAL POSITION** knob to display the math waveform at the center of the screen.
5. Set the sampling oscilloscope to measure the rise time of the waveform:
  - a. Press the **VERTICAL MENU** button (if the Setups window is not displayed), and then click the **Meas** tab.
  - b. Select **Meas3**, and then click the **Select Meas** button and select **Pulse-Timing > Rise Time**.
  - c. Click **Source1**, and then select **Main M1** on the **Source** tab.
  - d. Set **RefLevel** to **Relative** with **Reference Hi-Lo** to **80%-20%** respectively
6. Press the **VERTICAL MATH** button to display the **Define Math** window.

7. For **Differential mode**, adjust the rise time so that the reading of ⑤ in Figure 5 is 200 ps by changing the **Filter Risetime** value (see ⑥ in Figure 6). If you cannot adjust the value to 200 ps exactly, set it to the nearest value below 200 ps.

If a cable length  $\leq 300$  mm, adjust the rise time so that the reading of ⑤ in Figure 5 to 50 ps by changing the **Filter Risetime** value (see ⑥ in Figure 6). If you cannot adjust the value to 50 ps exactly, set it to the nearest value below 50 ps in addition to 200ps.

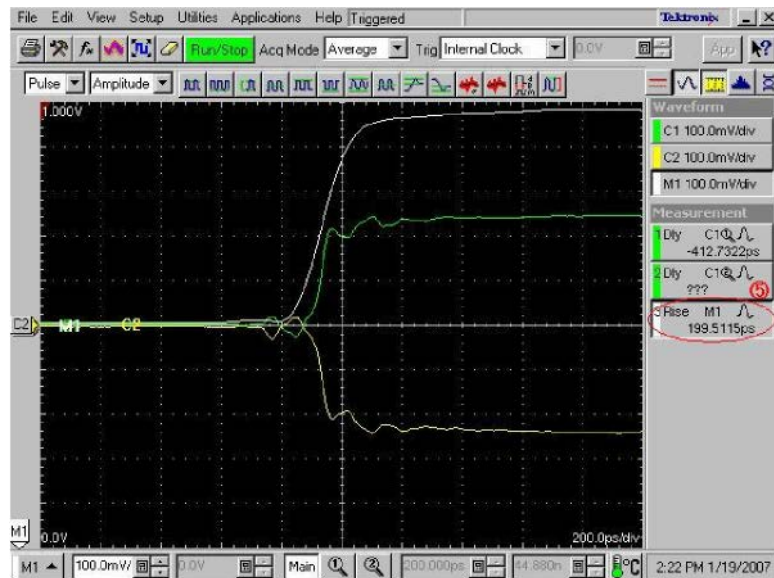


Figure 5: Adjusting the rise time

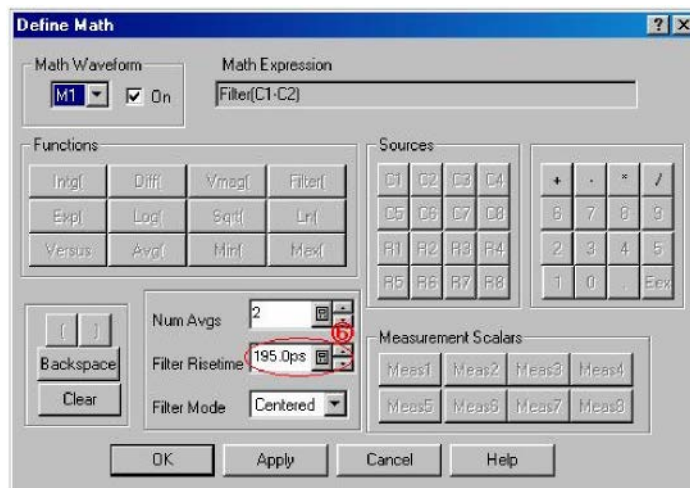


Figure 6: Changing the Filter Risetime value



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8. For **Common mode**, adjust the rise time so that the reading of ⑤ in Figure 5 is 600 ps by changing the **Filter Risetime** value (see ⑥ in Figure 6). If you cannot adjust the value to 600 ps exactly, set it to the nearest value below 600 ps.

If a cable length  $\leq 600$  mm, adjust the rise time so that the reading of ⑤ in Figure 5 to 50 ps by changing the **Filter Risetime** value (see ⑥ in Figure 6). If you cannot adjust the value to 50 ps exactly, set it to the nearest value below 50 ps in addition to 600ps

## Offset Calibration

1. Clear the C1 and C2 waveforms.
2. Press the **ACQUISITION MENU** button, and then click the **TDR** tab.
3. Set ACQ On Units to Ohm
4. Change the math waveform:
  - a. Press the **VERTICAL MATH** button to display the **Define Math** window, and then click **Clear**.
  - b. **Differential mode**: Enter **Filter (CH1 +CH2)** in the **Math Expression** field.
  - c. **Common mode**: Enter **Filter (CH1 +CH2)/4** in the **Math Expression** field.
5. Press the **VERTICAL MENU** button.
6. Click the **Vert** tab, and then set **M1 Scale** to **10.00 Ohms/div** and **M1 Position** to **-10.00 div**.
7. Set the **HORIZONTAL SCALE** to 500ps/div.
8. Adjust the **HORIZONTAL POSITION** knob so that the rise-time waveform is displayed at near 1 major division from the left side of the screen (see Figure 7).

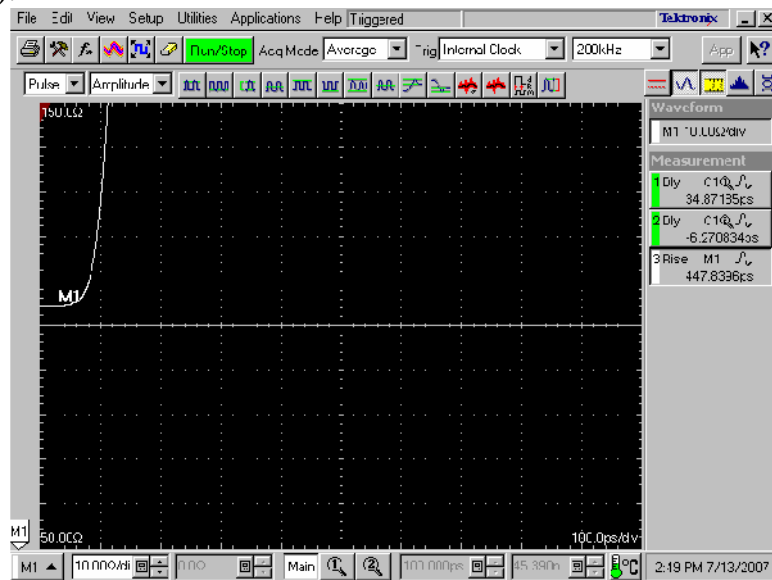


Figure 7: TDR rise-time waveform

9. Click **Horz** tab, and then Set **Horizontal reference** to **10.0%**.
10. Click the **Meas** tab.
11. Select **Meas1**, and then click the **Select Meas** button and select **Pulse-Amplitude > Mean**.
12. Click **Source1**, and then select **M1** in the **Source** tab.
13. Disconnect the test fixture from the 50ohm SMA cables.
14. Connect the 50ohm SMA terminators (female) or airlines to the end of the 50ohm SMA cables.

15. Measure the mean value of M1 (see Figure 8).

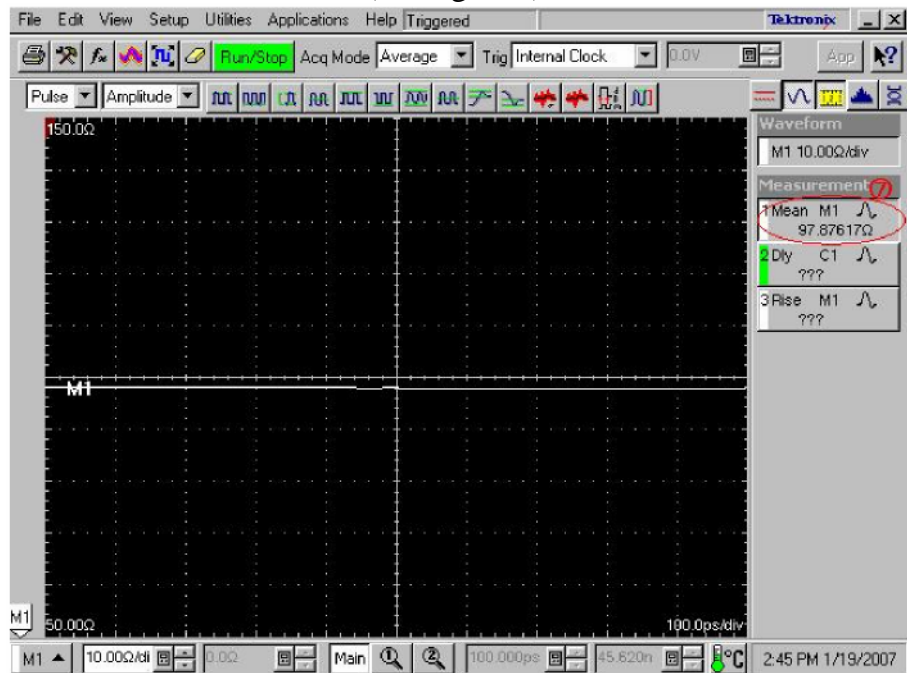


Figure 8: Measuring the M1 value

16. Press the **ACQUISITION MENU** button to display the **Math Expression** window.

17. Calculate the difference between 100 Ω and the value measured in step 16, and then enter the difference value in the **Math Expression** field. For instance, if the measured value is 97.8 ohm, enter  $\text{Filter}(C1+C2) + 2.2$  in the field. For common mode measurements repeat steps 11 through 17 only calculate the difference between 25 and the measured value.

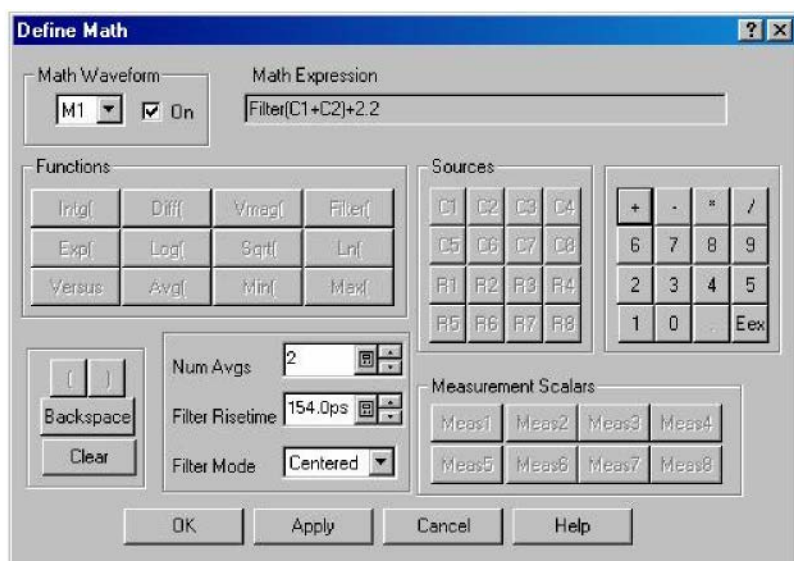


Figure 9: Entering the difference value

18. Press the **VERTICAL MENU** button (if the Setups window is not displayed), and click the **Vert** tab.
19. Set the **M1 Scale** to 10 ohm/div and **M1 Position** to -10 div.

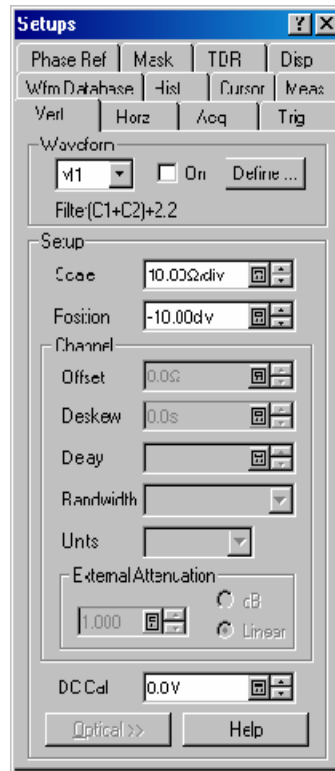
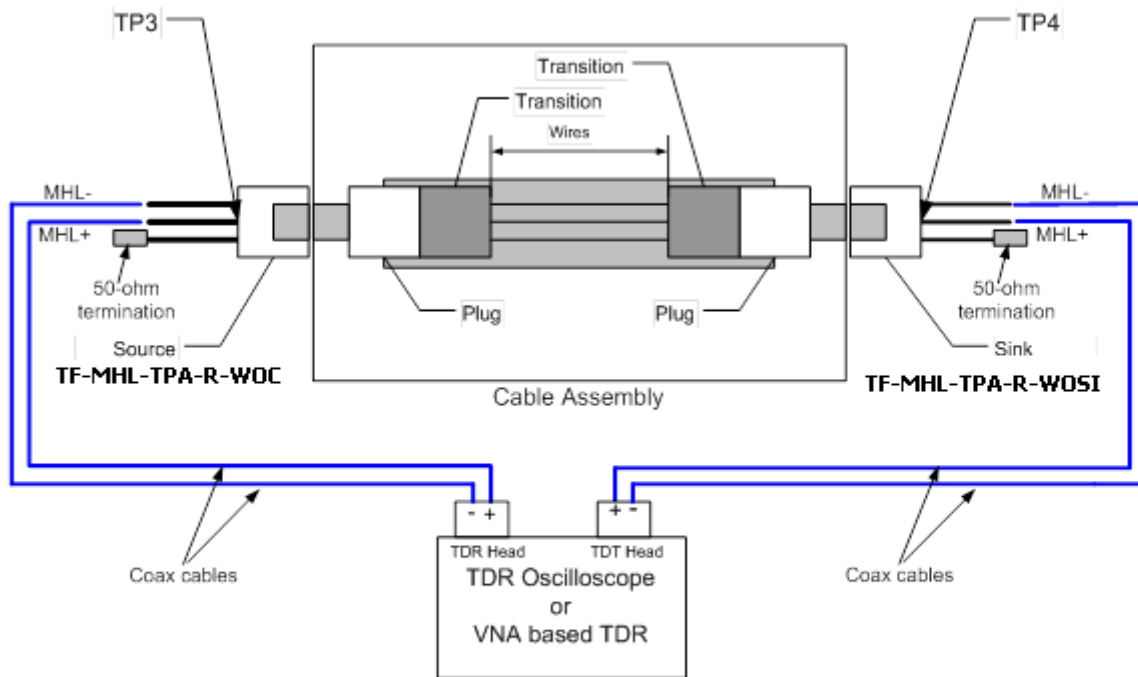


Figure 10: M1 Vertical Setup

## 7.2.1.2 Differential Intra Pair Skew



1. Using differential De-skew values obtained in procedure Skew calibration in page 4.
2. From the TDR menu, set the pulse in diff mode and the Acq Units to V
3. Connect SMA Cables to the TF-MHL-TPA-R-WOC (Ch1 to MHL+, Ch2 to MHL-) and TF-MHL-TPA-R-WOSI (Ch3 to MHL+, Ch4 to MHL-).
4. With the Horizontal position, place the Change point where the TDR reference and the connection of the DUT is on the first division from the left.
5. Place the Horizontal reference triangle at the top of the display to be at the first division from the left.
6. Using the Horizontal Scale knob, set the time base to be slightly greater than the length of the cable.
7. Turn off Channel 1 and 2 and turn on channel 3 and 4
8. From the setup menu, select the Measure tab
9. From the measure menu select timing and then select Delay
10. In the measure menu select Source 1 and set to Channel 3 and then Source 2 to Channel 4
11. The selected measurement should read less than or equal to 43 ps then Pass, if greater than 43 ps then fail.

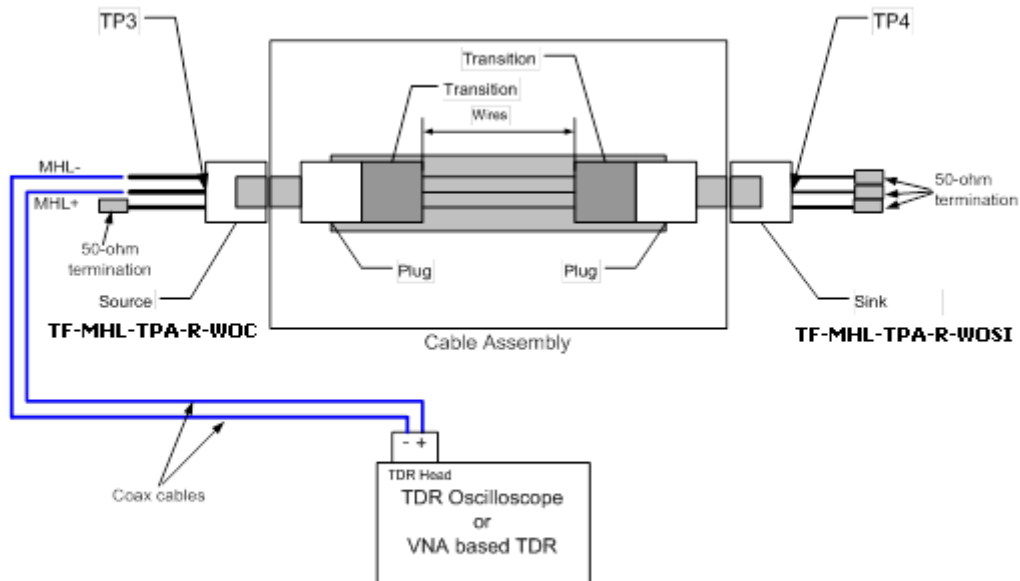
### 7.2.1.3 Common-mode Intra Pair Skew

1. Using Common De-skew values obtained in procedure Skew calibration in page 4.
2. From the TDR menu set the pulse in Common mode and the Acq units to V
3. Connect SMA Cables to the TF-MHL-TPA-R-WOC (Ch1 to MHL+, Ch2 to MHL-) and TF-MHL-TPA-R-WOSI (Ch3 to MHL+, Ch4 to MHL-).
4. With the Horizontal position, place the Change point where the TDR reference and the connection of the DUT is on the first division from the left.
5. Place the Horizontal reference triangle at the top of the display to be at the first division from the left
6. Using the Horizontal Scale knob, set the time base to be slightly greater than the length of the cable.
7. Turn off Channel 1 and 2 and turn on channel 3 and 4
8. From the setup menu Select the Measure tab
9. From the measure menu select timing and then select Delay
10. In the measure menu select Source 1 and set to Channel 3 and then Source 2 to Channel 4
11. The selected measurement should read less than or equal to 43 ps then Pass, if greater than 43 ps then fail.

### 7.2.1.4 Differential Characteristic Impedance

#### **If the Cable length > 300 mm**

1. Using Differential De-skew values
2. From the TDR menu set the pulse in diff mode and Acq units to Ohm
3. Connect SMA Cables to the TF-MHL-TPA-R-WOC and 50 Terminators to TF-MHL-TPA-R-WOSI.

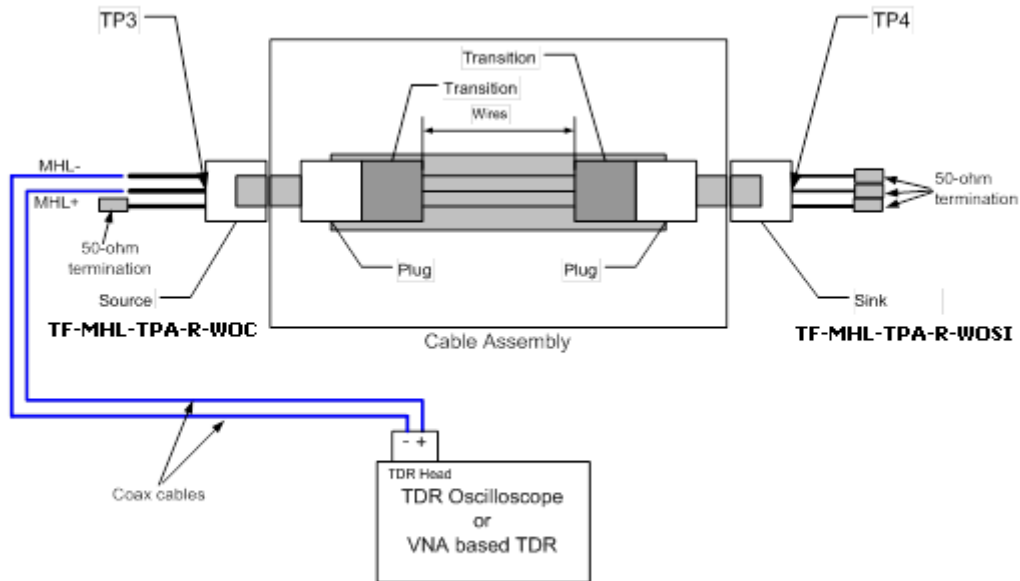


4. With the Horizontal position, place the Change point where the TDR reference and the connection of the DUT is on the first division from the left.
5. Place the Horizontal reference triangle at the top of the display to be at the first division from the left
6. Using the Horizontal Scale knob, set the time base to be slightly greater than  $T_{\text{conn}} + 2\text{ns}$
7. Turn off displayed Channel 1, 2, 3 and 4; Turn on Math1, follow rise time setup procedure of Differential mode.
8. Using the cursor measure impedance  $Z_{\text{od\_Transition}}$  from  $T_{\text{conn}}$  to  $T_{\text{conn}}+1\text{ns}$ . If measured  $Z_{\text{od\_Transition}}$  is  $(85 \text{ ohm} \leq Z_{\text{od\_Transition}} \leq 115 \text{ ohm})$  then it is Pass
9. Using the cursor measure impedance  $Z_{\text{od\_Cable}}$  from  $T_{\text{conn}}+1\text{ns}$  to  $T_{\text{conn}}+2\text{ns}$ . If measured  $Z_{\text{od\_Cable}}$  is  $(90 \text{ ohm} \leq Z_{\text{od\_Cable}} \leq 110 \text{ ohm})$  then it is Pass
10. If there is an excursion and the impedance  $Z_{\text{od\_Transition}}$  in the excursion range is  $(65 \text{ ohm} \leq Z_{\text{od\_Transition}} < 85 \text{ ohm})$  OR  $(115 \text{ ohm} < Z_{\text{od\_Transition}} \leq 125)$  and if the duration of excursion is less than 250 ps and if only one excursion exist in the range and the  $Z_{\text{od\_Cable}}$  is  $(90 \text{ ohm} \leq Z_{\text{od\_Cable}} \leq 110 \text{ ohm})$  then it is Pass.
11. All other conditions are fail.
12. Repeat steps 8 thru 11 for the Sink end of the cable.

**If the Cable length  $\leq 300$  mm**

1. Use Differential De-skew values.
2. From the TDR menu, set the pulse in diff mode and Acq units to Ohm
3. Connect SMA Cables to the TF-MHL-TPA-R-WOC and 50 Terminators to TF-MHL-TPA-R-WOSI.

## Measurement Procedures



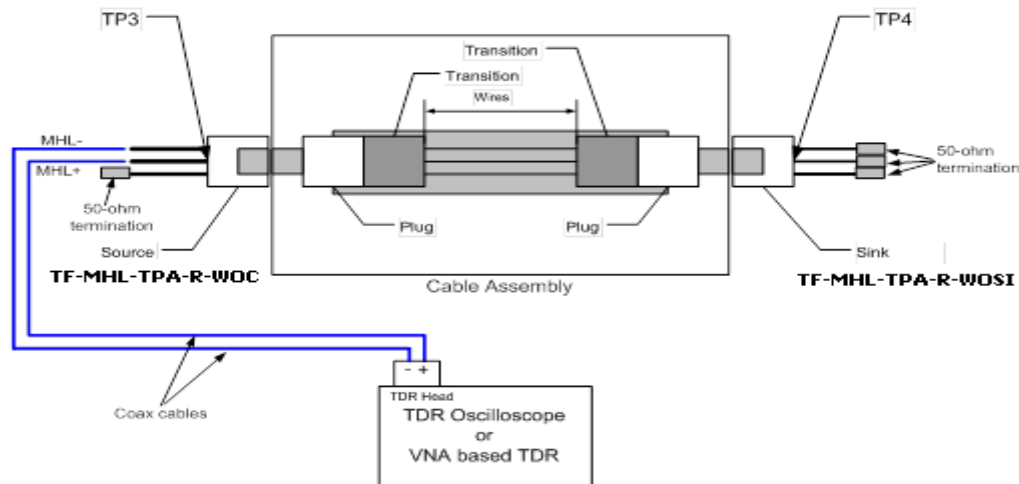
4. With the Horizontal position, place the Change point where the TDR reference and the connection of the DUT is on the first division from the left.
5. Place the Horizontal reference triangle at the top of the display to be at the first division from the left
6. Using the Horizontal Scale knob set the time base to be slightly greater than  $T_{\text{conn}200} + 1 \text{ ns}$
7. Turn off displayed Channel 1, 2, 3, and 4. Turn on Math1, follow the 200 psec rise time setup procedure in differential mode.
8. Using the cursor measure impedance  $Z_{\text{od\_Transition}}$  from  $T_{\text{conn}200}$  to  $T_{\text{conn}200} + 1\text{ns}$ .
9. Using the Horizontal Scale knob, set the time base to be slightly greater than  $T_{\text{conn}50} + 1.5 \text{ ns}$
10. Turn off displayed Channels 1, 2, 3 and 4; Turn on Math1, follow the 50 psec rise time setup procedure in differential mode.
11. Using the cursor measure impedance from  $T_{\text{conn}50} + 1\text{ns}$  to  $T_{\text{conn}50} + 1.5\text{ns}$  This is  $Z_{\text{OD\_CABLE\_SHORT}}$ .
12. The arithmetic mean of  $Z_{\text{OD\_CABLE\_SHORT}}$  is  $Z_{\text{OD\_CABLE\_AVE}}$
13. If the impedance  $(85 \text{ ohms} \leq Z_{\text{od\_Transition}} \leq 115 \text{ ohms})$  AND  $(85 \text{ ohms} \leq Z_{\text{OD\_CABLE\_SHORT}} \leq 115 \text{ ohms})$  AND  $(90 \text{ ohms} \leq Z_{\text{OD\_CABLE\_AVE}} \leq 110 \text{ ohms})$ , then it is Pass.
14. If there is an excursion and the impedance  $Z_{\text{od\_Transition}}$  in the excursion range is  $(65 \text{ ohms} \leq Z_{\text{od\_Transition}} < 85 \text{ ohms})$  OR  $(115 \text{ ohms} < Z_{\text{od\_Transition}} \leq 125 \text{ ohms})$ , and if the duration of excursion is less than 250ps and if only one excursion exist in the range, and if  $Z_{\text{OD\_CABLE\_SHORT}}$  is  $(85 \text{ ohms} \leq Z_{\text{OD\_CABLE\_SHORT}} \leq 115 \text{ ohms})$  as well as  $Z_{\text{OD\_CABLE\_AVE}}$  is  $(90 \text{ ohms} \leq Z_{\text{OD\_CABLE\_AVE}} \leq 110 \text{ ohms})$ , then it is Pass.
15. The test is pass if step 13, 14 is pass, all other conditions are fail.
16. Repeat the steps 1 through 15 for the Sink end of the cable.



## 7.2.1.5 Common-Mode Characteristic Impedance

### If the Cable length > 600 mm

1. Using the Common Mode De-skew values
2. From the TDR menu set the pulse in common mode and Acq units to Ohm
3. Connect SMA Cables to the TF-MHL-TPA-R-WOC (Ch1 to MHL+, Ch2 MHL-) and 50 Terminators to TF-MHL-TPA-R-WOSI.



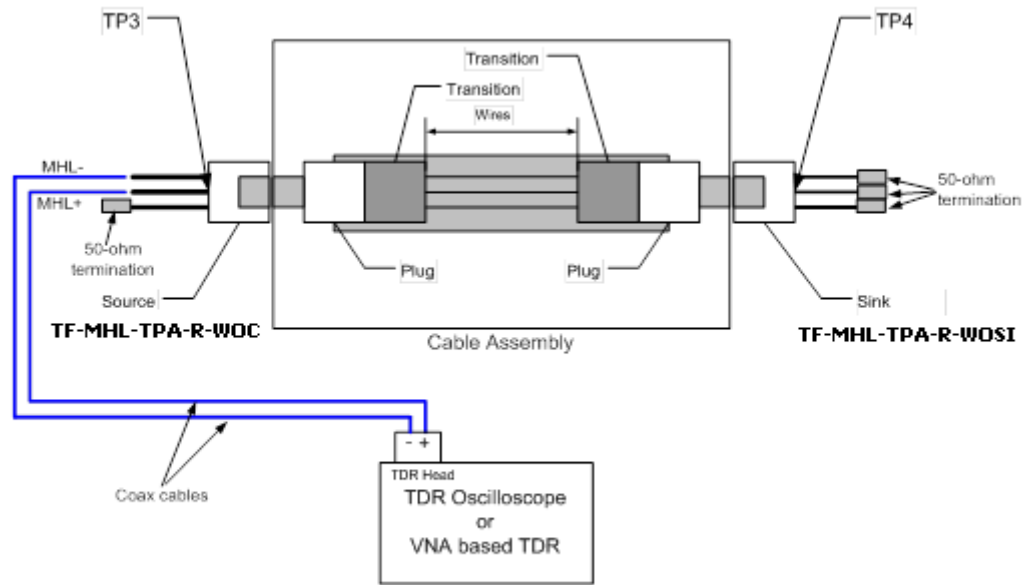
4. With the Horizontal position, place the Change point where the TDR reference and the connection of the DUT is on the first division from the left.
5. Place the Horizontal reference triangle at the top of the display to be at the first division from the left
6. Using the Horizontal Scale knob, set the time base to be slightly greater than  $T_{\text{conn}} + 4\text{ns}$
7. Turn off displayed Channel 1, 2, 3 and 4; turn on Math1 follow the rise time setup procedure for Common-mode.
8. Using the cursor measure impedance  $Z_{\text{oc\_Transition}}$  from  $T_{\text{conn}}$  to  $T_{\text{conn}}+3\text{ns}$ . If measured  $Z_{\text{oc\_Transition}}$  is ( $24 \text{ ohm} \leq Z_{\text{oc\_Transition}} \leq 36 \text{ ohm}$ ) then it is Pass.
9. Using the cursor measure impedance  $Z_{\text{oc\_Cable}}$  from  $T_{\text{conn}}+3\text{ns}$  to  $T_{\text{conn}}+4\text{ns}$ . If measured  $Z_{\text{oc\_Cable}}$  is ( $25 \text{ ohm} \leq Z_{\text{oc\_Cable}} \leq 35 \text{ ohm}$ ) then it is Pass.
10. If there is an excursion and the impedance  $Z_{\text{oc\_Transition}}$  in the excursion range ( $20 \text{ ohm} \leq Z_{\text{oc\_Transition}} < 24 \text{ ohm}$ ) OR ( $36 \text{ ohm} < Z_{\text{oc\_Transition}} \leq 40 \text{ ohm}$ ), and if the duration of excursion is less than 500 ps and if only one excursion exist in the range, and if ( $25 \text{ ohm} \leq Z_{\text{oc\_Cable}} \leq 35 \text{ ohm}$ ) then it is Pass.
11. The test is pass if step 8,9,10 is pass, all other conditions are fail.
12. Repeat steps 8 to 11 for the Sink end of the cable.

### If the Cable length $\leq 600$ mm

1. Using the Common Mode De-skew values

Measurement Procedures

2. From the TDR menu set the pulse in common mode and Acq units to Ohm
3. Connect SMA Cables to the TF-MHL-TPA-R-WOC (Ch1 to MHL+, Ch2 MHL-) and 50 Terminators to TF-MHL-TPA-R-WOSI.



4. With the Horizontal position, place the Change point where the TDR reference and the connection of the DUT is on the first division from the left.
5. Place the Horizontal reference triangle at the top of the display to be at the first division from the left
6. Using the Horizontal Scale knob set the time base to be slightly greater than  $T_{\text{conn}} + 4\text{ns}$
7. Turn off displayed Channel 1, 2, 3 and 4; turn on Math1, follow the rise time 600psec setup procedure in Common-mode.
8. Using the cursor measure impedance  $Z_{\text{oc\_Transition}}$  from  $T_{\text{conn}600}$  to  $T_{\text{conn}600} + 3\text{ns}$ . This is  $Z_{\text{oc\_Transition}}$ .
9. Using the Horizontal Scale knob set the time base to be slightly greater than  $T_{\text{conn}50} + 1.5 \text{ ns}$
10. Turn off displayed Channel 1, 2, 3 and 4; Turn on Math1, follow the rise time 50psec setup procedure in Common mode.
11. Using the cursor measure impedance  $Z_{\text{oc\_Cable\_Short}}$  from  $T_{\text{conn}50} + 1\text{ns}$  to  $T_{\text{conn}50} + 1.5\text{ns}$  This is  $Z_{\text{oc\_Cable\_Short}}$
12. The arithmetic mean of  $Z_{\text{oc\_Cable\_Short}}$  is  $Z_{\text{oc\_Cable\_ave}}$ .
13. If the measured ( $24 \text{ ohms} \leq Z_{\text{oc\_Transition}} \leq 36 \text{ ohms}$ ) AND ( $20 \text{ ohms} \leq Z_{\text{oc\_Cable\_Short}} \leq 40 \text{ ohms}$ ) AND ( $24 \text{ ohms} < Z_{\text{oc\_Cable\_ave}} \leq 36 \text{ ohms}$ ), then it is Pass.
14. If there is an excursion and the impedance  $Z_{\text{oc\_Transition}}$  in the excursion range ( $20 \text{ ohms} \leq Z_{\text{oc\_Transition}} < 24 \text{ ohms}$ ) OR ( $36 \text{ ohms} < Z_{\text{oc\_Transition}} \leq 40 \text{ ohms}$ ) and if the duration of excursion is less than 500ps and if only one excursion exist in the range and if ( $20 \text{ ohms} \leq Z_{\text{oc\_Cable\_Short}} \leq 40 \text{ ohms}$ ) AND ( $24 \text{ ohms} < Z_{\text{oc\_Cable\_ave}} \leq 36 \text{ ohms}$ ), then it is Pass.
15. The test is pass if step 13, 14 is pass, all other conditions are fail.
16. Repeat steps 11 through 15 for the Sink end of the cable.

## 7.2.1.6 CBUS Line Capacitance

1. From the TDR menu, set Ch1 TDR to Positive and Select the Ch1 Acq Units to V.
2. Set the Horizontal time base to a window that is .3 times longer than the electrical length of the cable. Typical setting 2ns/div.
  - a. Use horizontal position knob to move the waveform so the incident edge (first step) disappears to the left of the screen.(Make it off the screen towards left)
3. Connect the SMA cables to the MHL Cal fixture (MHL-TPA-C) using the open traces.
4. In the I-connect software from the acquisition window select Ch1 and then click the acquire button. Then double click on CH1 in the legend menu and rename as TDRcbus Ref Open.
5. Connect SMA Cable to the TF-MHL-TPA-R-WOC and 50 Terminators to MHL+/- and Vbus. Then connect the Cable
6. In the I-connect software from the acquisition window select Ch1 and then click the acquire button. Then double click on CH1 in the legend menu and rename as TDRcbus DUT.
7. From the Compute window select Z-line. For the DUT waveform, select TDRcbus DUT and for the step waveform, select TDRcbus Ref Open. Then click the compute button.
8. From the Legend window Right click on the TDRcbus DUT.
9. Right click on the Zline\_TDR\_Cbus waveform and select Cursor readout
10. Place one Cursor so that it lines up with the TDRcbus Ref Open and the second Cursor to line up with the open at the end of the Zline\_TDR\_Cbus waveform. Read the capacitance value, if the measured capacitance is  $30\text{pF} \leq C_{\text{CBUS}} \leq 350\text{pF}$ , then it is Pass, all other conditions fail.

## 7.2.1.7 CBUS Cable Delay

1. From the TDR menu, set Ch1 TDR to Positive and Select the Ch1 Acq box Units to V
2. Connect the SMA cables to the MHL Cal fixture (MHL-TPA-C) using the 2x Thru traces. Ch1 to one side as the source and Ch2 to the opposite side to capture the TDT waveform.
3. Set the Horizontal time base to a window that is .3 times longer than the electrical length of the cable. Typical setting 2ns/div.
  - a. Use horizontal position knob to move the waveform so the incident edge (first step) disappears to the left of the screen.(Make it off the screen towards left)
4. From the File pull down menu, select save waveform, Click on Ch2 and select R1 from the pull down reference box. Click Save and close.
5. Connect Ch1 to the TF-MHL-TPA-R-WOC Cbus terminal and Ch2 to the Cbus on TF-MHL-TPA-R-WOSI and 50 Terminators to MHL+/- and Vbus on both fixtures.
6. Select measurement tab from setup menu. From the measurement selection, select Pulse-timing and then delay. Select Source 1 and then from the pull down menu under

source selections select R1. Then select source 2 and then from the pull down menu under the selection select Ch1. If the delay readout is less than or equal to 35ns condition is passing, all other conditions fail.

## 7.2.1.8 Differential Insertion Loss

1. Using Differential De-skew values
2. From the Scope setup menu, select Channel 1 TDR slope to be Positive and Channel 2 TDR slope to be negative and the Acq units to V.
3. Define Math 1 as Channel 1 minus Channel 2 and Math2 as Channel 3 minus Channel 4
4. Set the Horizontal time base to a window that is .3 times longer than the electrical length of the cable. Typical setting 2ns/div.
  - a. Use horizontal position knob to move the waveform so the incident edge (first step) disappears to the left of the screen.(Make it off the screen towards left)
5. Connect the SMA cables to the MHL Cal fixture (MHL-TPA-C) using the Thru X2 traces. Channel 1 should connect to Channel 3 and Channel 2 should connect to Channel 4.
6. Turn on Math 2 and place the TDT waveform between .5 divisions and 1 division from the left side of the display.
7. Set the Horizontal reference triangle at the top of the display to one division from the left of the display.
8. In the I-connect software from the acquisition window select Math 2 and then click the acquire button. Then double click on Math2 in the legend menu and rename as TDT ref thru.
9. Disconnect the MHL Cal fixture and attach the MHL-TPA-R-WOC (ch1 to MHL+, Ch2 to MHL-) and MHL-TPA-R-WOSI (CH3 to MHL+, Ch4 to MHL-) fixtures, then connect the MHL Cable. Do not change any from scope settings.
10. In the I-connect software from the acquisition window select Math 2 and then click the acquire button. Then double click on Math2 in the legend menu and rename as TDTdds21.
11. From the Compute pull down, select the S-parameter. In the Waveforms, for DUT select TDTdds21, for Ref select TDT ref thru.
12. In the frequency content check set manually. Then set  $F_{max}$  to 6G
13. Click on Compute.
14. Verify that frequency response is better than Table 13-15. All intermediate frequencies must be less than the linear vector between the frequency points in table 1. If there is ripple on the curve, Enable the I connect View menu, Zoom in, move the cursor till the readout indicate the required frequency value on the table .

Frequency in MHz	Attenuation in dB
0	2.25
825	5.5
2475	12.0
4125	18.0
5100	21.5

Table 1 : MHL cable Differential Insertion loss for MHL Data Signal

15.If no frequencies violate the attenuation specification then it is Pass

### 7.2.1.9 Common-Mode Insertion Loss

1. Using Common mode de-skew values
2. From the Scope setup menu select Channel1 TDR slope to be Positive and Channel 2 TDR slope to be Positive and the Acq units to V.
3. Define Math 1 as Channel 1 Plus Channel 2 and Math2 as Channel 3 Plus Channel 4.
4. Set the Horizontal time base to a window that is .3 times longer than the electrical length of the cable. Typical setting 2ns/Div
  - a. Use horizontal position knob to move the waveform so the incident edge (first step) disappears to the left of the screen.(Make it off the screen towards left)
5. Connect the SMA cables to the MHL Cal fixture (MHL-TPA-C) using the Thru X2 traces. Channel 1 should connect to Channel 3 and Channel 2 should connect to Channel 4.
6. Turn on Math 2 and place the TDT waveform between .5 divisions and 1 division from the left side of the display.
7. Set the Horizontal reference triangle at the top of the display to one division from the left of the display.
8. In the I-connect software from the acquisition window select Math 2 and then click the acquire button. Then double click on Math2 in the legend menu and rename as TDTcc ref thru.
9. Disconnect the MHL Cal fixture and attach the MHL-TPA-R-WOC (ch1 to MHL+, Ch2 to MHL-) and MHL-TPA-R-WOSI (CH3 to MHL+, Ch4 to MHL-) fixtures, then connect the MHL Cable. Do not change any from scope settings.
10. In the I-connect software from the acquisition window select Math 2 and then click the

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acquire button. Then double click on Math2 in the legend menu and rename as TDTccs21.

11. From the Compute pull down select the S-parameter. In the Waveforms, for DUT select TDTccs21, for the Ref select TDTcc ref thru.
12. In the frequency content check set manually. Then set  $F_{\max}$  to 1.2G
13. Click on Compute.
16. Verify that frequency response is better then Table 13-16. All intermediate frequencies must be less than the linear vector between the main frequency points in table 2. If there is ripple on the curve, Enable the I connect View menu, Zoom in, move the cursor till the readout indicate the required frequency value on the table .

Frequency in MHz	Attenuation in dB
0	.5
25	1.5
125	3.0
375	5.5
1125	12.0

Table 2 : MHL cable Common mode Insertion loss for MHL Clock Signal

14. If no frequencies violate the attenuation specification then it is Pass

### 7.2.1.10 Differential and Common-Mode Conversion

1. When driving Differential use Differential de-skew values. When driving Common mode use Common mode De-skew values
2. From the Scope setup menu select Channel one TDR slope to be Positive and Channel 2 TDR slope to be negative and the Acq units to be Voltage.
3. Define Math 1 as Channel 1 minus Channel 2 and Math2 as Channel 3 minus Channel 4.
4. Set the Horizontal time base to a window that is .3 times longer than the electrical length of the cable. Typical setting 2ns/Div
  - a. Use horizontal position knob to move the waveform so the incident edge (first step) disappears to the left of the screen.(Make it off the screen towards left)
5. Connect the SMA cables to the MHL Cal fixture (MHL-TPA-C) using the Thru X2

traces. Channel 1 should connect to Channel 3 and Channel 2 should connect to Channel 4.

6. Turn on Math 2 and place the TDT waveform between .5 divisions and 1 division from the left side of the display.
7. Set the Horizontal reference triangle at the top of the display to one division from the left of the display.
8. In the I-connect software from the acquisition window select Math 2 and then click the acquire button. Then double click on Math2 in the legend menu and rename as TDTdd ref thru.
9. Disconnect the MHL Cal fixture and attach the MHL-TPA-R-WOC (Ch1 to MHL+, and Ch2to MHL-) and MHL-TPA-R-WOSI (Ch3 to MHL+ and Ch4 to MHL-) fixtures, then connect the MHL Cable. Do not change any scope settings.
10. Define Math2 as Channel 3 Plus Channel 4 and set math scale appropriately to the minimum value so that it wont clip the waveform.
11. In the I-connect software from the acquisition window select Math 2 and then click the acquire button. Then double click on Math2 in the legend menu and rename as TDTccs21.
12. From the Compute pull down menu select the S-parameter. In the Waveforms, for DUT select TDTccs21, for Ref select TDTdd ref thru.
13. In the frequency content check set manually. Then set  $F_{max}$  to 6G
14. Click on Compute.
17. Verify that frequency response is better then Table 3 . If there is ripple on the curve, Enable the I connect View menu, Zoom in, move the cursor till the readout indicate the required frequency value on the table .

Frequency in MHz	Attenuation in dB
0-300	-35
>300-675	-25
>675-1500	-20
>1500-5100	-15

Table3: MHL cable Mode conversion between Differential and Common mode signal

15. If no frequencies violate the attenuation specification then it is Pass

### 7.2.1.11 CBUS Insertion Loss

1. From the Scope setup menu select Channel one TDR slope to be Positive and the Acq units to be voltage.
2. Set the Horizontal time base to a window that is .3 times longer than the electrical

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length of the cable. Typical setting 2ns/div

- a. Use horizontal position knob to move the waveform so the incident edge (first step) disappears to the left of the screen.(Make it off the screen towards left)
3. Connect the SMA cables to the MHL Cal fixture (MHL-TPA-C) using the Thru X2 traces. Channel 1 should connect to Channel 3 .
4. Turn on Channel 3 and place the TDT waveform between .5 divisions and 1 division from the left side of the display.
5. Set the Horizontal reference triangle at the top of the display to one division from the left of the display.
6. In the I-connect software from the acquisition window select Channel 3 and then click the acquire button. Then double click on CH3 in the legend menu and rename as TDTcbus ref thru.
7. Disconnect the MHL Cal fixture and attach the MHL-TPA-R-WOC (C-Bus Connector) and MHL-TPA-R-WOSI fixtures (C-Bus Connector), then connect the MHL Cable. Do not change any from scope settings.
8. In the I-connect software from the acquisition window select Ch3 and then click the acquire button. Then double click on Math2 in the legend menu and rename as TDTcbuss21.
9. From the Compute pull down, select the S-parameter. In the Waveforms, for DUT select TDTcbuss21, for Ref select TDTcbus ref thru.
10. In the frequency content check set manually. Then set  $F_{max}$  to 400MHz
11. Click on Compute.
18. Verify that frequency response is better than Table 4. All intermediate frequencies must be less than the linear vector between the main frequency points in table 4. If there is ripple on the curve, Enable the I connect View menu, Zoom in, move the cursor till the readout indicate the required frequency value on the table .

Frequency in MHz	Attenuation in dB
0	0.5
1	0.5
10	0.8
100	2.8
300	7.0

Table 4 MHL CBUS Signal insertion loss

12. If no frequencies violate the attenuation specification then it is Pass



## 7.2.1.12 Far-End Crosstalk

1. From the Scope setup menu select Channel 1 TDR slope to be Positive
2. Set the Horizontal time base to a window that is .3 times longer than the electrical length of the cable. Typical setting 2ns/Div
  - a. Use horizontal position knob to move the waveform so the incident edge (first step) disappears to the left of the screen.(Make it off the screen towards left)
3. Connect the SMA cables to the MHL Cal fixture (MHL-TPA-C) using the Thru X2 traces. Channel 1 should connect to Channel 3
4. Turn on Channel 3 and place the TDT waveform between .5 divisions and 1 division from the left side of the display.
5. Set the Horizontal reference triangle at the top of the display to one division from the left of the display.
6. In the I-connect software from the acquisition window select Channel 3 and then click the acquire button. Then double click on CH3 in the legend menu and rename as TDTxtalk ref thru.
7. Disconnect the MHL Cal fixture and attach the MHL-TPA-R-WOC (MHL+ Connector) to ch1, and MHL-TPA-R-WOSI fixtures (C-Bus Connector) to ch3. Install 50 terminations on all reaming connections. Then connect the MHL Cable. Do not change any from scope settings.
8. In the I-connect software from the acquisition window select Ch3 and then click the acquire button. Then double click on Ch3 in the legend menu and rename as TDTxtkCbus+.
9. From the Compute pull down, select the S-parameter. In the Waveforms, for DUT select TDTxtkCbus+, for Ref select TDTxtalk ref thru.
10. In the frequency content check set manually. Then set  $F_{max}$  to 6GHz
11. Click on Compute.
19. Verify that frequency response is better than Table 5 for MHL and Cbus and table 6 for MHL and Vbus. If there is ripple on the curve, Enable the I connect View menu, Zoom in, move the cursor till the readout indicate the required frequency value on the table .

Frequency in MHz	Attenuation in dB
0-30Mhz	-30
>30 to 300Mhz	-20
>300Mhz to 5.1Ghz	-15

Table 5 MHL Cable assembly far-End Crosstalk between MHL and CBUS

12. Excursions of less than -11.5db is allowed from 825Mhz-5100 if the Insertion loss

meets the table 5-1 for MHL and Cbus.

Frequency in MHz	Attenuation in dB
0	2.
825	2
2475	8
4125	14.5
5100	18

Table 5-1 MHL Cable differential insertion Loss limit for Far- End Crosstalk

Frequency in MHz	Attenuation in dB
>0 to 300Mhz	-20
>300Mhz to 5.1Ghz	-15

Table 6 MHL Cable assembly Far-End Crosstalk between MHL and VBUS

13.Repeat Steps 1 through 13 for the following table combinations Table 7 Test pairs

Aggressor	Victim
Cbus	MHL-
MHL-	Cbus
MHL+	Cbus
Vbus	MHL+
Vbus	MHL-
MHL-	Vbus
MHL+	Vbus

Table 7 Test combination pairs

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14. Repeat steps 1 through 11 for the Cbus to Vbus and Vbus to Cbus

15. Verify that frequency response is better than Table 8

Frequency in MHz	Attenuation in dB
0 -225Mhz	-20
>225 – 375	-15
>375 – 1125	-10

Table 8 MHL cable assembly Far-End Crosstalk between the CBUS and VBUS

16. The Test is pass if step 12 to 16 is pass, all the other condition is fail.

— End of Procedures —