SOLUTION BRIEF

DisplayPort 2.1b Source & Sink Return Loss Test MOI

DP Source and Sink Return Loss Test using Keysight Vector Network Analyzer with Enhanced TDR App

KEYSIGHT

Table of Contents

Revision History

Revision	Comments	Date
1.0	First draft for E5080B series	26-Oct-2022
1.1	Updated Unigraf software and firmware setup steps.	21-Feb-2022
1.2	Updated gating setup procedure	20-June-2025
1.3	Updated VNA sweep setting to 0 dBm and removed gating procedure – based on Apr 2026 VESA spec.	8-April-2026

Reference Documents

1. DP2.1 PHY Electrical CTS, Revision 1.1draft (Mar 2026).
2. VESA DisplayPort (DP) Standard Specification, Revision 2.1b (Dec 2025).
3. VESA DisplayPort Alt Mode Specification, Revision 2.1 (Nov 2022).

Configuration Requirements

Description	Test Equipment	Qty
Network analyzer	Keysight Vector Network Analyzer: (20 GHz or higher is recommended as DP2.x/USB4/Type-C requires measurements up to 20 GHz) **4-Ports, 20GHz VNA:** • E5080B-4K0: 4-port test set, 9 kHz to 20 GHz or • P5024A-400 Streamline USB Series VNA or • M9804A-400 PXI Multiport VNA or • N522xB PNA Note: Ensure that VNA firmware revision is at least version A.15.60.xx or above (Windows 10).	1 ea.
Software (Recommended if TDR is needed)	S9x011A/B Enhanced time-domain analysis with TDR * Selection is based on the VNA platforms. x=6 for ENA, x=7 for Streamline USB, x=5 for PXI, x=3 for PNA family	1 ea.
Test controller and software tool	• Unigraf UCD-323 Gen 2 Ref Source/Sink AUX CH Controller • Unigraf Extended TSI API / **UCD Console v2 Software Bundle v2.4.24 published 25-Oct-2022 onwards.** https://www.unigraf.fi/downloads/ • Request the execution batch file from Unigraf support or download the execution batch file from K.com	1 ea.
Test fixture	**For DP/mDP mode** • Enhanced DP plug TPA fixture • Enhanced mDP plug TPA fixture • DisplayPort plug TPA fixture • Mini DisplayPort plug TPA fixture • DP AUX breakout board **For USB-C DP Alt mode** • DisplayPort Type-C test fixture	1 ea.
ECal module	Min. 2-Port / 4-Port Electronic Calibration (ECal) Module EG: N4433D-010/0DC 4-Ports	1 ea.
RF cable	3.5 mm or SMA cables of 4 GHz bandwidth or more * Y1740A-100 (3.5-mm m-m, 36 inch) cable is recommended for USB and PXI VNA	2 ea.
Adapter (For E5080B only)	Coaxial straight Female-SMA Female-SMA 50-Ohm adapters (Keysight 1250-1666).	4 ea.
Terminator	50-ohm terminations to terminate unused channels (EG: Keysight 909D-301)	6 ea.

Test Procedure

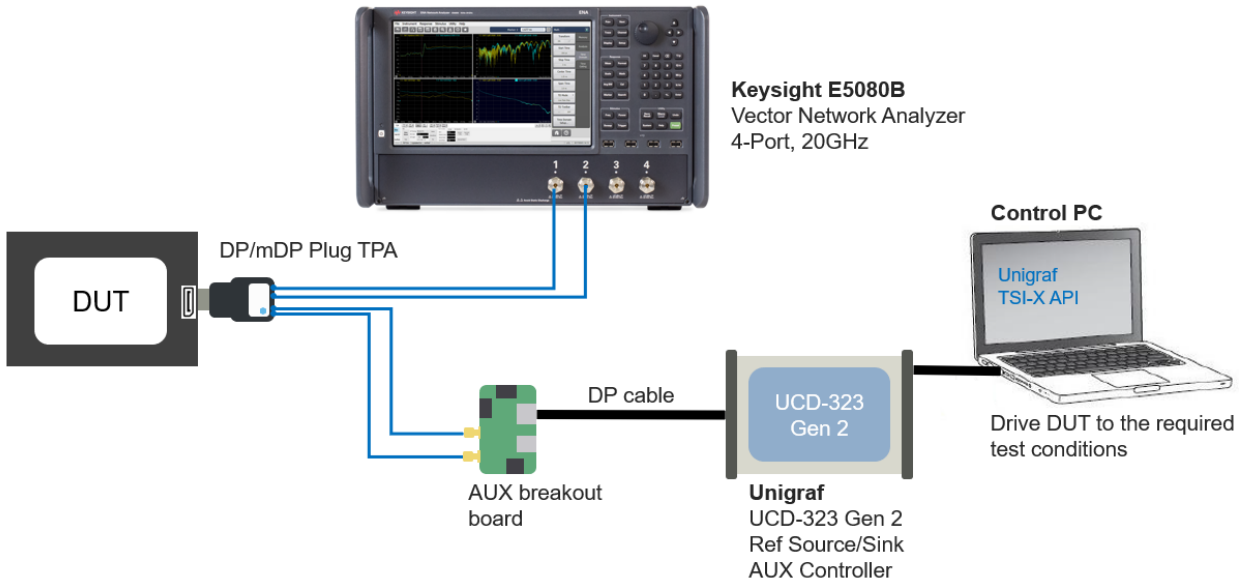
Test Flow Chart

Steps	Procedure
Step 1	The VNA should be powered on and allowed to warm up - recommendation is for 24 hours prior to measurement.
Step 2	Set measurement conditions by recalling a state file or manual setup.
Step 3	Setup test equipment and test fixture connections based on the connection diagrams. • Setup DP/mDP mode/DP USB Type-C Alt Mode. • Setup Unigraf's AUX channel controller and install Unigraf TSI-X API. • Connect test fixture to AUX channel controller, DP DUT and VNA port.
Step 4	Perform 2-Port/4-Port Electronic Calibration (ECal) for time-domain and frequency-domain.
Step 5	Run Unigraf TSI-X API to control AUX channel settings from the connected PC. • In the TSI-X API folder, run the **DP20 TXRX Return Loss test.bat** batch file to setup DP bitrates and test pattern.
Step 6	Perform frequency domain measurements for DP TX and RX return loss from VNA traces.

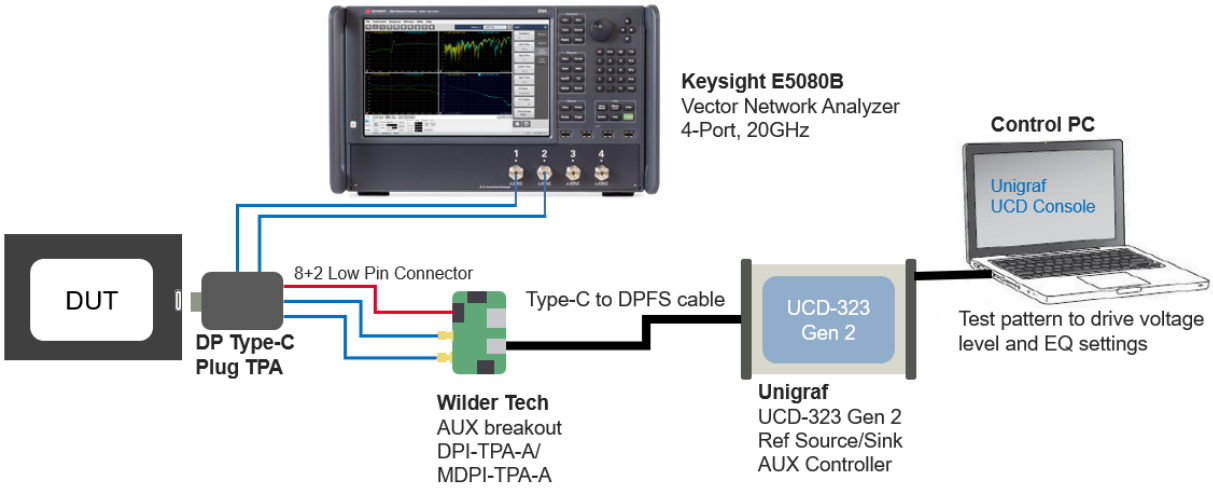
Test Setup

DP lane under test will setup in the following manner.

For full size DP and mini DP setup



For DP USB Type-C Alt Mode setup



Note: User may use a USB Type-C to DP cable with a USB PD 3.0/3.1 chipset, which puts the DUT into DP Alt mode.

Measurement Setups

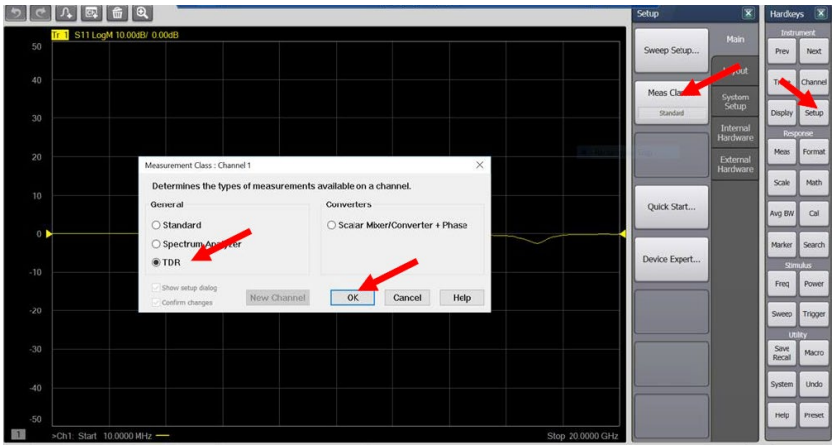
Recalling a State File

This section describes how to recall a state file for Time Domain and Frequency Domain settings.
If you have a state file, copy over the state file to a USB mass storage device and load it to the VNA unit.
Connect the USB mass storage device into the front USB port of the VNA unit.

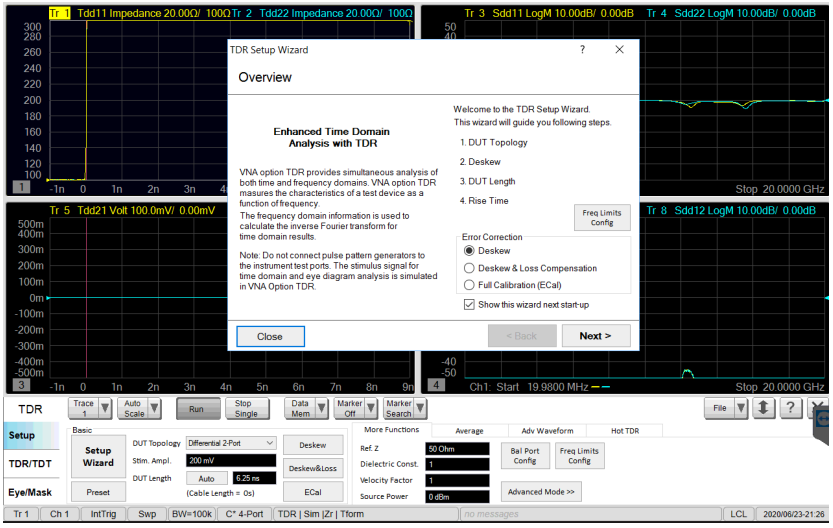
For manual measurement settings, refer to Chapter 6.0 Appendix for the manual setup procedure.

1. Click **Setup** **> Main > Meas Class**… to launch measurement class setup dialog box

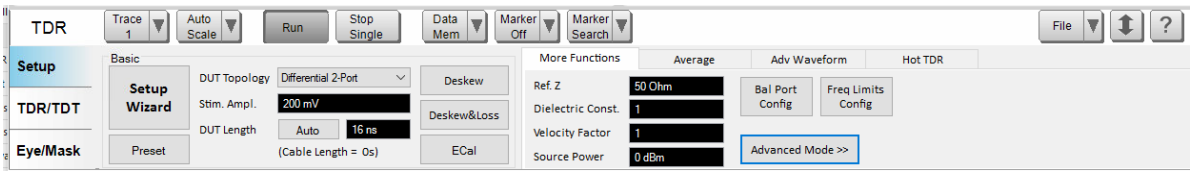
2. Select **TDR** and click OK.



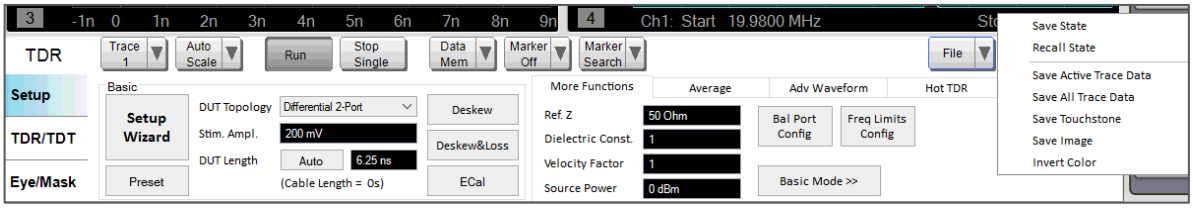
3. Select Close and confirm with Yes to close the setup wizard.



4. Select Click **Advanced Mode** of TDR software and Click Yes to enter the advanced mode.



5. Click **File > Recall State**. Select the state file (*.tdr) and click Open to recall.



6. The windows will launch pre-define state file configuration for compliance testing.

7. All the measurement settings including calibration information can be saved.
   Select **File > Save State As…** > State and Cal Set Date (*.csa) to save the settings.

Common Parameters Setup for Frequency Domain Measurements

1. Press **Channel Next** to select Channel 2.

2. Select **Sweep** > Sweep Setup and key-in sweep properties as below:

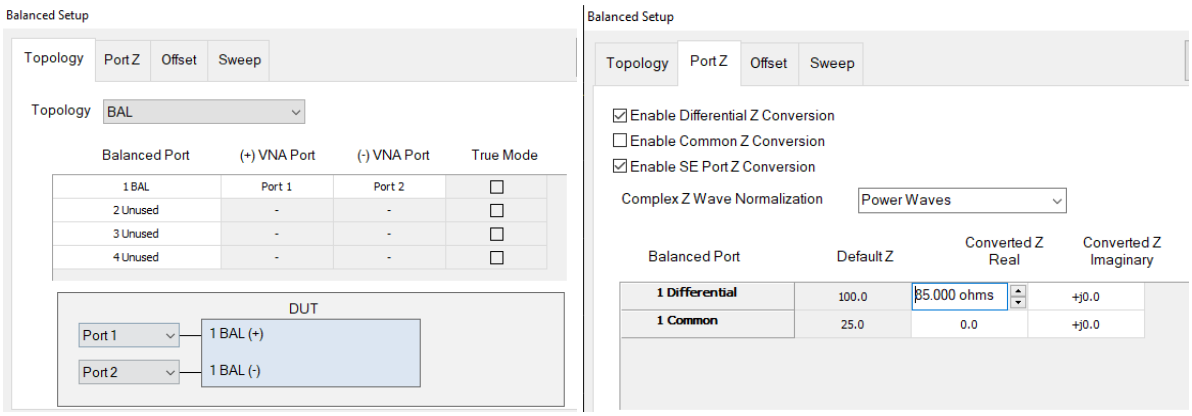
   - Set **Start** value to “50 MHz”.
   - Set **Stop** value to “12 GHz”.
   - Set **Power** value to “0 dBm”.
   - Set **Points** and set to “1600”.
   - Set **IF Bandwidth** to “1 kHz”.

3. Select **Cal > Fixtures > Fixture Setup > Port Z**… Select and check “**Enable Port Z Conversion (all ports)**” to turn ON Port Z conversion for 85-Ohm system impedance.

4. Select **Meas > Balanced > Topology… > BAL**

5. Select **Balanced Port > 1 BAL > Port 1- Port 2**

   Note 1: You can set one BAL mode for one measurement at a time. Optional to set BAL-BAL mode if you want to setup 2 pairs of lanes measurements.



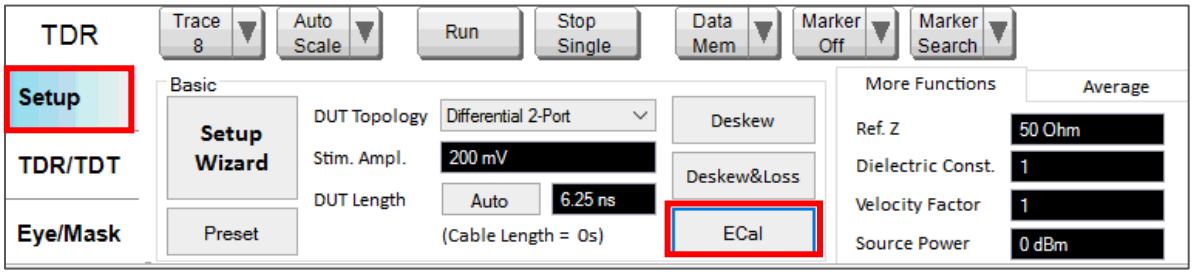
Calibration Setup

The purpose of this step is to calibrate the RF effects such as delay, loss or mismatch of RF cables and test fixture traces before measurements.

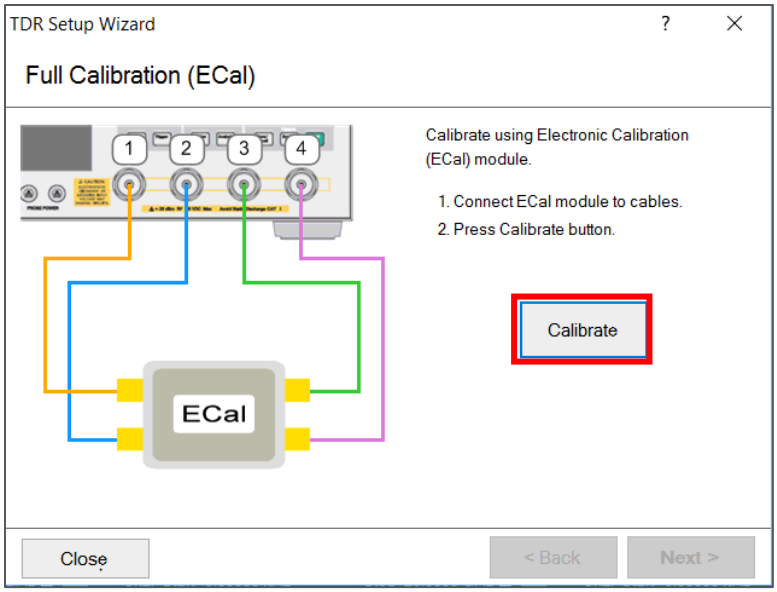
ECal Calibration on Time Domain

ECal calibration for time-domain measurements is performed by the TDR software. Optional if no time-domain measurement is needed.

1. Press **Channel Next** to select Channel 1.
2. Click **Setup** tab.
3. Click **ECal** to launch the TDR Setup Wizard.



4. Connect the VNA ports (Port 1 - Port 2) to the ECal module with RF cables. Terminate unused ports with 50-Ohm terminators.
5. Click **Calibrate** button to perform 2-Port ECal Calibration.

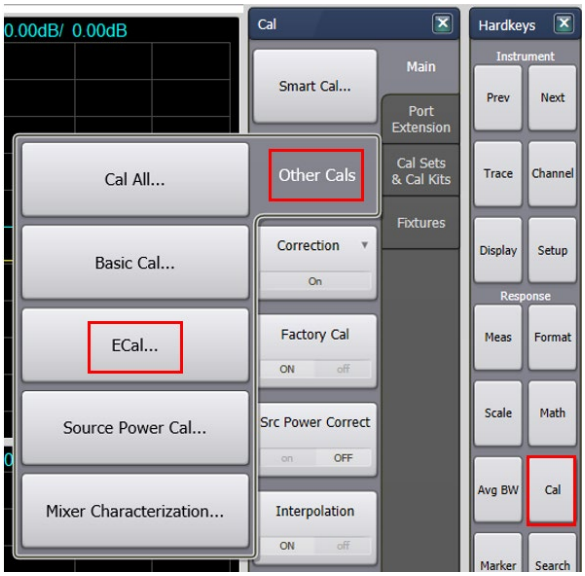


6. Click **Next >** to proceed. Completed calibration will show Green √ sign
7. Click **Finish** to complete the ECal.

ECal Calibration on Frequency Domain

ECal calibration for frequency-domain measurements are performed by the VNA firmware.

1. Press **Channel Next** to select Channel 2.
2. Connect the VNA ports (Port 1 - Port 2) to the ECal module with RF cables.
3. Press **Cal** > **Main** > **Other ECal** > **Ecal…** > select **2-Port ECal** and click **Next** to proceed.
4. Click **Finish** when the ECal is completed.



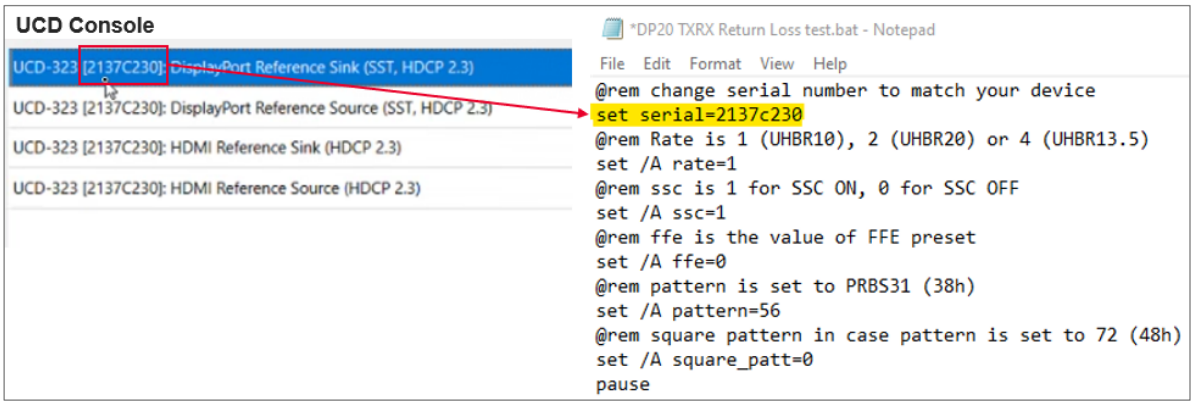
Setup Unigraf Controller and Configuration Batch File

1. Go to Unigraf download page, scroll down to 4th section for - UCD-340, 323 Gen2, 323, 301 Software & Firmware. https://www.unigraf.fi/downloads/
   a. Download and install Console v2 Software Bundle v2.4.29* (or any newer version).
   b. Download and install Console v2 Firmware package v2.3.40* (v2.3.38 is works too).

2. After installing Console v2 Bundle Software and Firmware package, run UCDConfig.exe utility. Select your Utility and click Next to proceed to firmware update.
   a. You can also use UCD Console to check your UCD device operation - Link tab shows the status info and control items for the DisplayPort link.
   b. More information please refer to Unigraf UCD-3XX Console User Manual

3. After Installation, you will find your machine directory --> C:\Program Files\Unigraf\Unigraf UCD Tools\sdk\c\examples\DP2.0 AUX controller\DP2.0 AUX Controller demo package 1.0.x.zip
   - Unzip the DP2.0 AUX Controller demo package to your current folder, and copy file **DP20 TXRX Return Loss test.bat** (which downloaded from K.com) to that folder.

4. Open to Edit **DP20 TXRX Return Loss test.bat** by setting the serial ID according to your UCD-323 unit. Save and close the batch file.



5. Execute the **DP20 TXRX Return Loss test.bat** batch file to configure DP AUX channel into return loss mode before the measurement.

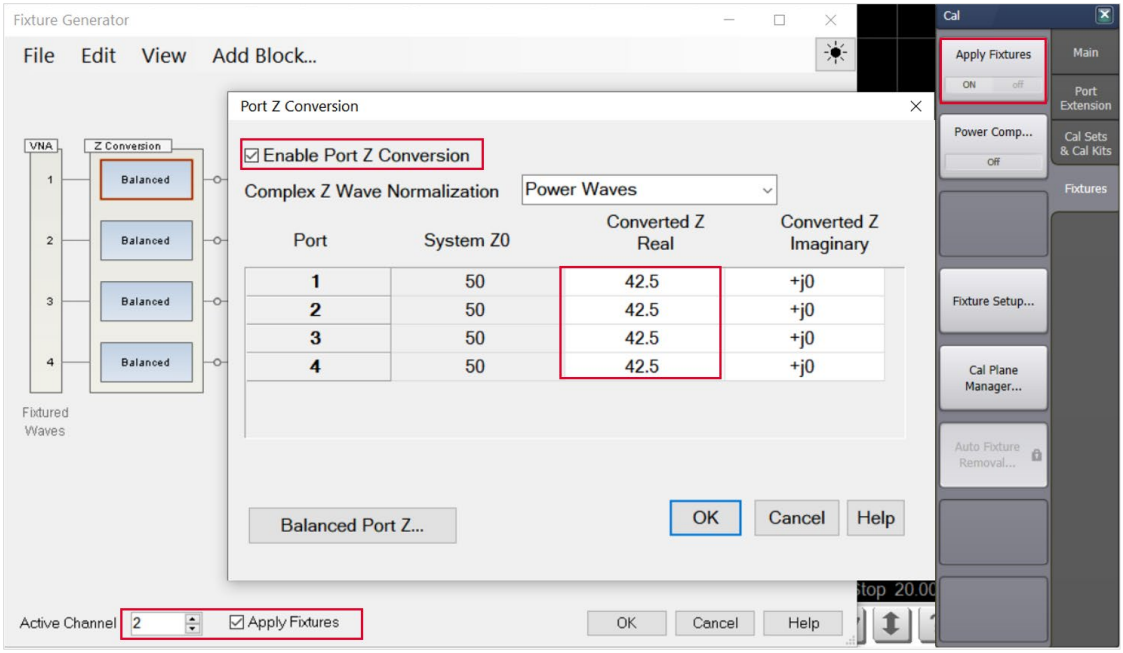
Test Parameter	Condition
Test Point	TP2
Bit Rate	UHBR10, UHBR13.5, or UHBR20
Spread Spectrum Clocking	SSC Enabled
Preset Number	Any preset number optimized for TP2
Test Pattern	PRBS31
Lane Setting	All test lanes are supported

Measurement and Data Analysis

DUT Mode	Full-size DP / Mini DP		USB-C DP Alt Mode	
DUT Lanes	Port 1	Port 2	Port 1	Port 2
1	ML_Lanes_2 +	ML_Lanes_2 -	TX1 +	TX1 -
2	ML_Lanes_1 +	ML_Lanes_1 -	TX2 +	TX2 -
3	ML_Lanes_3 +	ML_Lanes_3 -	RX1 +	RX1 -
4	ML_Lanes_0 +	ML_Lanes_0 -	RX2 +	RX2 -

Run Return Loss from VNA Trace

1. Connect the VNA ports (Port 1 and Port 2) to DP/mDP/USB-C test fixture ports with RF cables according to the Table above. Unused DP lanes should be terminated with 50-ohm terminators.
2. Press Channel Next to select Channel 2 (Frequency Domain).
3. Setup frequency range based on DP2.1 spec. Refer to 6.2 for Frequency Range Setup.
4. Select **Cal** > **Fixtures** > **Fixture Setup** > right click **Port Z Conversion…** check "**Enable Port Z Conversion (all ports)**" to turn ON Port Z Conversion. Make sure the **System Z0** is set to "**42.5**" which equal to 85Ω differential that is required by DP CTS.



5. Execute Unigraf TSI-X API batch files – "**DP20 TXRX Return Loss test.bat**" from your machine that connected with UCD-323 to control the DUT transmitter/receiver to output PRBS31 pattern for Return Loss measurement.
6. Select **Trace 2 (Sdd11) / Trace 3 (Scc11)** for differential return loss or common-mode return loss.
7. Press **Double-click** on the instrument front panel to enlarge the trace.
8. Press **Trigger** > Single.
9. Run and confirm the measured values are within the limit shown below. Otherwise, it will show Fail.
10. Repeat the test for all remaining DP/mDP/USB-C lanes and all supported UHBR rates.

RL limit for DPTXs and DPRXs with a USB Type-C Connector (Normative)

Differential RL

$$SDD11\ (f)\begin{cases} -8.5 & 0.05 < f_{GHz} \leq 3 \\ -3.5 + 8.3 \times \log_{10}\left(\frac{f_{GHz}}{12}\right) & 3 < f_{GHz} \leq 12 \end{cases}$$

DP source/sink's differential return loss limit, Sdd11

Frequency	Stop Frequency	Start Limit	Stop Limit
0.05 GHz	3.00 GHz	-8.50 dB	-8.50 dB
3.00 GHz	4.00 GHz	-8.50 dB	-7.50 dB
4.00 GHz	6.00 GHz	-7.50 dB	-6.00 dB
6.00 GHz	8.00 GHz	-6.00 dB	-5.00 dB
8.00 GHz	10.00 GHz	-5.00 dB	-4.15 dB
10.00 GHz	12.00 GHz	-4.15 dB	-3.50 dB

Common Mode RL

$$SCC11\ (f)\begin{cases} -6 & 0.05 < f_{GHz} \leq 2.5 \\ -3 & 2.5 < f_{GHz} \leq 12 \end{cases}$$

DP source/sink's common-mode return loss limit, SCC11

Frequency	Stop Frequency	Start Limit	Stop Limit
0.05 GHz	2.50 GHz	-6.0 dB	-6.0 dB
2.50 GHz	12 GHz	-3.0 dB	-3.0 dB

RL for DPTXs and DPRXs with a DP Connector (Normative)

Differential RL

$$SDD11\,(f)\begin{cases} -10 & 0.05 < f_{GHz} \leq 3 \\ -4.5 + 8.3 \times \log_{10}\left(\frac{f_{GHz}}{12}\right) & 3 < f_{GHz} \leq 12 \end{cases}$$

DP source/sink's differential return loss limit, Sdd11

Frequency	Stop Frequency	Start Limit	Stop Limit
0.05 GHz	3.00 GHz	-10 dB	-10 dB
3.00 GHz	4.00 GHz	-10 dB	-8.5 dB
4.00 GHz	6.00 GHz	-8.5 dB	-7.0 dB
6.00 GHz	8.00 GHz	-7.00 dB	-6.00 dB
8.00 GHz	10.00 GHz	-6.00 dB	-5.15 dB
10.00 GHz	12.00 GHz	-5.15 dB	-4.50 dB

Common Mode RL

$$SCC11\,(f)\begin{cases} -3 & 0.05 < f_{GHz} \leq 2.5 \\ -1 & 2.5 < f_{GHz} \leq 12 \end{cases}$$

DP source/sink's common-mode return loss limit, SCC11

Frequency	Stop Frequency	Start Limit	Stop Limit
0.05 GHz	2.50 GHz	-3.0 dB	-3.0 dB
2.50 GHz	12 GHz	-1.0 dB	-1.0 dB

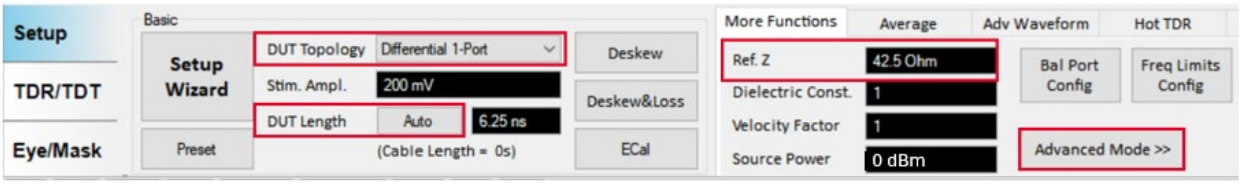
Manual Setup

The procedures of manual setup for time domain and frequency domain measurements are introduced in this section for reference. All the required testing parameters have been properly set and saved in the respective standards testing state file (*.tdr).

Channel and Trace Setup

If TDR setup wizard is shown when launching the TDR software, click **Close** button in the TDR setup wizard main window.

1. Open **Setup** tab in the TDR software.
2. Click **Preset** to preset the instrument Click OK in a dialog box to continue.
3. Set **DUT Topology** to "***Differential 1 Port***" Click OK in a dialog box.
4. Click **Advanced Mode>>** and click Yes to enter to Advanced mode.
5. Set DUT Length to "Auto".
6. Ref. Z = "42.5 Ohm"
7. Source Power = 0 dBm
8. Under **Average** tab, set the IF Bandwidth = 1kHz.

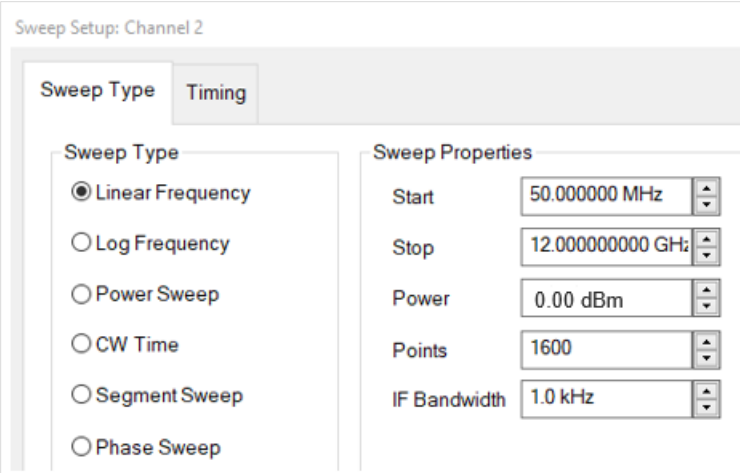


Differential Impedance

1. Select Trace Tdd11 from the ETDR default window.
2. Open **TDR/TDT** > **Parameters** tab.
3. Select "**Time Domain**" and "**Differential**" for Measure.
4. Select Formant to "**Impedance**".
5. Input vertical scale (10 Ohm/div) and vertical position (50 Ohm).

Frequency Range Setup

1. Based on the latest DP 2.1 CTS, setup the required testing requirements.
2. Select Sweep > Sweep Setup and key-in sweep properties as below:

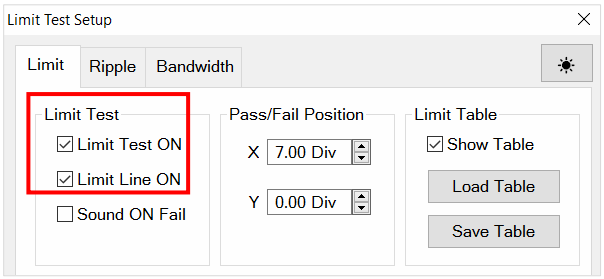


Defining Limit Line Tables

1. Press **Trace Next** to select trace to set the limit line table.
2. Press **Math**> Analysis > Limit Table > Limit > to edit the limit table.

	Type	Begin Stimulus	End Stimulus	Begin Response	End Response
1	Max	50.0000 MHz	2.50000 GHz	-3.00000 dB	-3.00000 dB
2	Max	2.50000 GHz	12.0000 GHz	-1.00000 dB	-1.00000 dB
3	Off	0.000000 Hz	0.000000 Hz	0.000000 dB	0.000000 dB

3. Press **Math**> Analysis > Limit… > to launch Limit Test Setup window.
4. Select to turn on “Limit Test ON” and “Limit Line ON”, optional to turn on “Sound ON Fail”.



Web Resources

www.keysight.com/find/D9042DPPC

www.keysight.com/find/D9040DPPC

www.keysight.com/find/S94USBCB

www.keysight.com/find/S94DPPCB

www.keysight.com/find/ena-tdr_compliance

www.keysight.com/find/usb-vna

www.keysight.com/find/na

www.keysight.com/find/vnasoftware

www.keysight.com/find/ecal

For more information on Keysight Technologies' products, applications, or services, please visit: www.keysight.com