Application Note

METHOD OF IMPLEMENTATION (MOI) FOR DISPLAYPORT 54 COMPLIANCE TESTS

Products:

► R&S®ZNB

Patrick McKenzie | 1SLXXX | Version 1a | 06.2024

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This document is complemented by configuration files. The configuration files may be updated even if the version of the document remains unchanged.

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Contents

1 Introduction

The purpose of this document is to provide a step-by-step guidance on how to perform VESA compliance testing on DisplayPort 54 cable assembly.

Throughout this Method of Implementation (MOI), procedures will detail how to perform such VESA compliance testing using the R&S® ZNB lineup of Network Analyzers.

1.1 References

VESA DisplayPort (DP) Standard Version 2.1a 18 December, 2023

VESA DisplayPort v2.1 PHY Layer Compliance Test Specification (PHY CTS) Revision 1.0 12 June, 2023

VESA DisplayPort Alt Mode on USB Type-C Standard (DisplayPort Alt Mode) Version 2.1a 02 August, 2024

2 Required equipment

2.1 R&S®ZNB20 configuration

Description	Equipment	Quantity
Network analyzer	R&S®ZNB20 vector network analyzer, 4 ports, 100kHz - 20GHz, PC3.5 connectors with: – R&S®ZNB-K2, time domain (TDR) analysis (software license) – R&S®ZNB-K20, extended time domain (TDR) analysis (software license) – R&S®ZNB-K210, eazy de-embedding (EZD) (software license)	1
RF cable	R&S®ZV-Z193 var60, 50 Ohm, DC to 26.5GHz, 3.5mm(f)-3.5mm(m), flexible, phase stable, 60 inch (1520mm)	4
Calibration unit/kit	One of the following: – R&S®ZN-Z52 var30 calibration unit, 100kHz to 26.5 GHz, 4 ports, 3.5mm(f) – R&S®ZN-Z53 var32 calibration unit, 100 kHz to 26.5 GHz, 2 ports, 3.5mm(f) – R&S®ZN-Z135 var03 calibration kit, 50 Ohm, 0Hz to 26.5 GHz, 3.5mm(f)	1
Receptacle test fixture	Enhanced fsDP: Luxshare-ICT TFDP-V22RA Enhanced mDP: Luxshare-ICT TFDP-M21RA USB4 Type-C: Luxshare-ICT TF21-189G	A set of each based on cable type
50 Ohm terminator	One of the following: – Hirose HRM-601A(52) – XMA 2003-6110-00 – P1dB P1TR-SAM-26G2W	16

3 Test overview and preparation

3.1 Measurement scope

This document focusses on how to perform normative and informative compliance measurements for DisplayPort 54 cable assemblies.

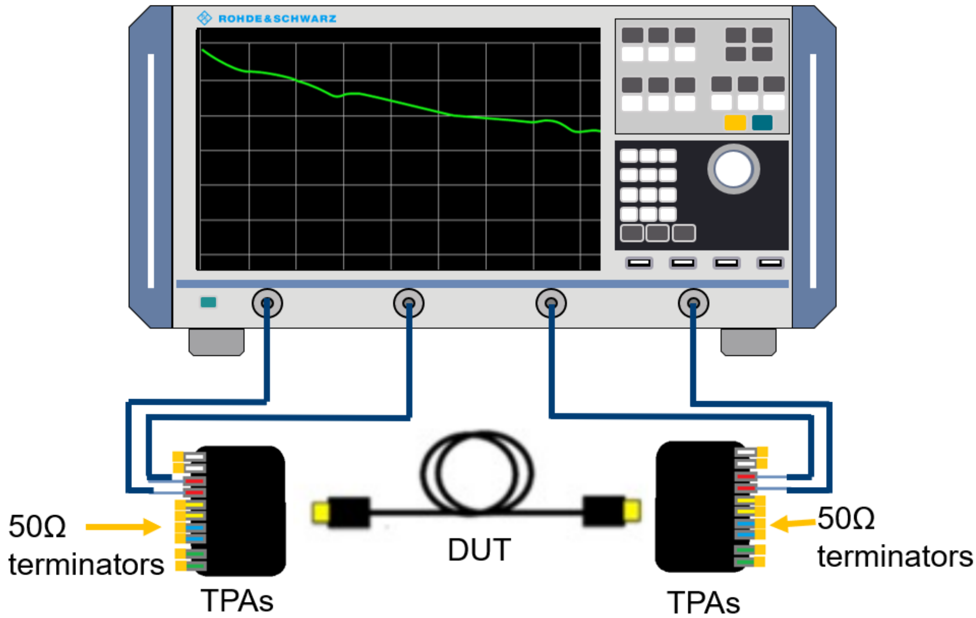
Compliance requirements are categorized into two measurement groups:

- ► Frequency Domain
  - – ILFitAtNq Frequencies (Normative)
  - – IRL (Normative)
  - – Integrated Crosstalk- DP (Normative)
  - – Differential-to-Common Mode Conversion (Normative)
  - – Integrated Crosstalk between DP Lanes (Informative)
  - – Integrated Multi-reflection (Informative)
- ► Time Domain
  - – Differential Impedance Profile (Normative)
  - – Intra-pair Skew (Normative)
  - – Inter-pair Skew (Informative)

3.2 Test setup

3.2.1 R&S®ZNB20 test setup

Equipment needed for testing is listed in R&S ZNB20 Configuration. Below is an example setup using the R&S®ZNB20.



To avoid confusion, throughout the document the test fixtures are referred to by their orientation in this diagram (left, right), or simply by an “L” or “R” subscript when appropriate.

3.3 Necessary software tools

3.3.1 Get_iPar

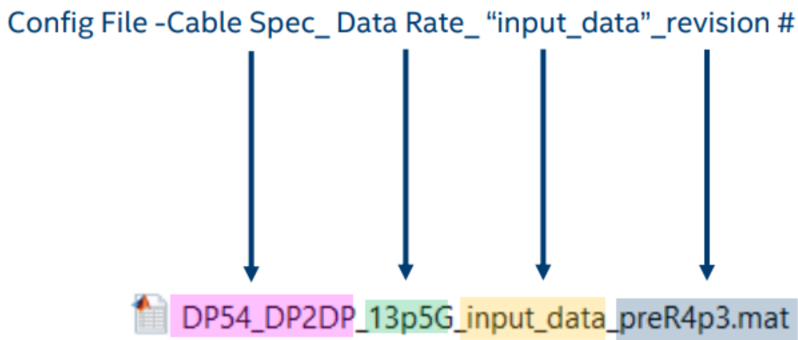
Several high-speed channel parameters are figures of merit that are calculated from S-parameter data but are not easily determined directly in the VNA firmware interface. The USB-IF provides the Get_iPar software tool to perform such calculations and provide values for compliance evaluation.

The Get_iPar tool is freely available at VESA - GET_IPAR Tool

1. Download the Get_iPar file related to DP54.
2. Export the contents of the .zip file.
3. Install MATLAB Runtime Library R2016a (9.0.1).

3.4 Touchstone file naming convention

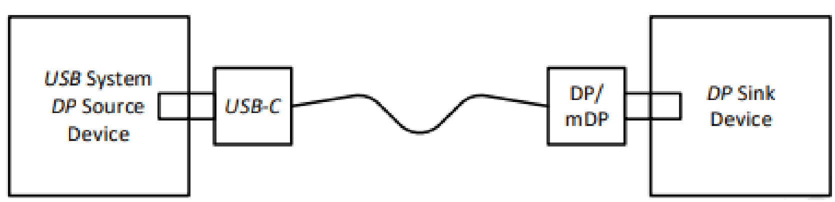
When saving touchstone files (*.s4p for R&S®ZNB20) to be used with the Get iPAR compliance tools, the following naming convention is recommended:



3.5 DisplayPort Alt Mode

DisplayPort Alt Mode is a feature that utilizes the USB Type-C connector on one end of the cable to transmit a DisplayPort signal between a source or sink. The first scenario is using the USB-C portion of the cable on the source side, this is called scenario 2a. The other scenario where the USB-C portion of the cable is connected to the sink side is called scenario 2b. These different scenarios require different cable wiring, more information is below.

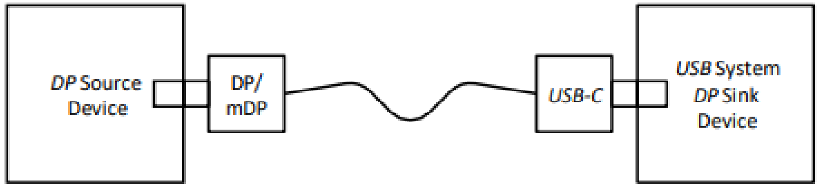
Scenario 2a Diagram



Scenario 2a Cable Wiring

Source Device		Sink Device		Source Device		Sink Device	
USB-C pin		Enhanced DP (normal plug)	Enhanced DP (flipped plug)	USB-C pin		Enhanced DP (normal plug)	Enhanced DP (flipped plug)
A1	GND	GND	GND	B12	GND	GND	GND
A2	Tx1+	ML2+	ML1+	B11	Rx1+	ML3+	ML0+
A3	Tx1-	ML2-	ML1-	B10	Rx1-	ML3-	ML0-
A4	VBUS	n/a	n/a	B9	VBUS	n/a	n/a
A5	CC1	n/a	n/a	B8	SBUS2	n/a	n/a
A6	D+	n/a	n/a	B7	D-	n/a	n/a
A7	D-	n/a	n/a	B6	D+	n/a	n/a
A8	SBUS1	AUX+	AUX-	B5	CC2	n/a	n/a
A9	VBUS	n/a	n/a	B4	VBUS	n/a	n/a
A10	Rx2-	ML0-	ML3-	B3	Tx2-	ML1-	ML2-
A11	Rx2+	ML0+	ML3+	B2	Tx2+	ML1+	ML2+
A12	GND	GND	GND	B1	GND	GND	GND

Scenario 2b Diagram



Scenario 2b Cable Wiring

Source Device		Sink Device		Source Device		Sink Device	
Enhanced DP (normal plug)	**Enhanced DP (flipped plug)**	**USB-C pin**		**Enhanced DP (normal plug)**	**Enhanced DP (flipped plug)**	**USB-C pin**	
GND	GND	A1	GND	GND	GND	B12	GND
ML1-	ML1-	A2	Tx1+	ML0-	ML0-	B11	Rx1+
ML1+	ML1+	A3	Tx1-	ML0+	ML0+	B10	Rx1-
n/a	n/a	A4	VBUS	n/a	n/a	B9	VBUS
n/a	n/a	A5	CC1	AUX-	AUX+	B8	SBUS2
n/a	n/a	A6	D+	n/a	n/a	B7	D-
n/a	n/a	A7	D-	n/a	n/a	B6	D+
AUX+	AUX-	A8	SBUS1	n/a	n/a	B5	CC2
n/a	n/a	A9	VBUS	n/a	n/a	B4	VBUS
ML3+	ML3+	A10	Rx2-	ML2+	ML2+	B3	Tx2-
ML3-	ML3-	A11	Rx2+	ML2-	ML2-	B2	Tx2+
GND	GND	A12	GND	GND	GND	B1	GND

3.6 Recall setup files

There are recall files delivered together with this document which makes it more convenient to perform the required measurements. There is one recall file for each group of measurements, one additional one for the calibration procedure, and three files for the shielding effectiveness test, e.g., 7 files.

Recalling the setup files

1. On the front panel of the instruments, click the green “PRESET” button.
4. Press “FILE” > “Open Recall...”.
5. Open the recall files (*.znxml) for the desired tests.

   In total there are 5 recall files for the different test groups and another one dedicated for the calibration procedure:

   – DP54_Frequency.znxml

   – DP54_Differential_Impedance_Profile.znxml

   – DP54_Intra-pair_Skew.znxml

   – DP54_Inter-pair_Skew.znxml

Overview about the setting in the different recall files:

Recall file	Start	Stop	Step size	IFBW	Power
DP54_Frequency.znxml	10 MHz	20 GHz	10 MHz	1 kHz	0 dBm
DP54_Differential_Impedance_Profile.znxml	10 MHz	20 GHz	10 MHz	1 kHz	0 dBm
DP54_Intra-pair_Skew.znxml	10 MHz	20 GHz	10 MHz	1 kHz	0 dBm
DP54_Inter-pair_Skew.znxml	10 MHz	20 GHz	10 MHz	1 kHz	0 dBm

3.7 Calibration and de-embedding

Calibration of the VNA and RF cables, as well as de-embedding of the test fixtures, is necessary to accurately measure the cable assembly characteristics at the proper test points.

This is accomplished by performing a coaxial calibration until the end of the RF cables, extract the test fixture S-parameter files using In-situ De-embedding (ISD) technique, and then import de-embedding files in the VNA which removes the effect of the test fixture.

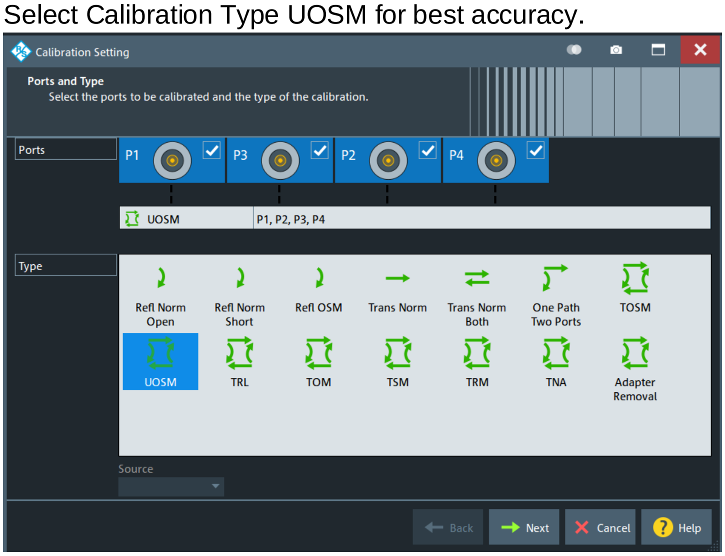
The four different test groups use different frequency ranges. The calibration recall file includes all the required frequency ranges needed for each test group. This allows for all required frequency ranges to be calibrated in a single step.

3.7.1 Coaxial calibration

3.7.1.1 Calibration with automated calibration unit

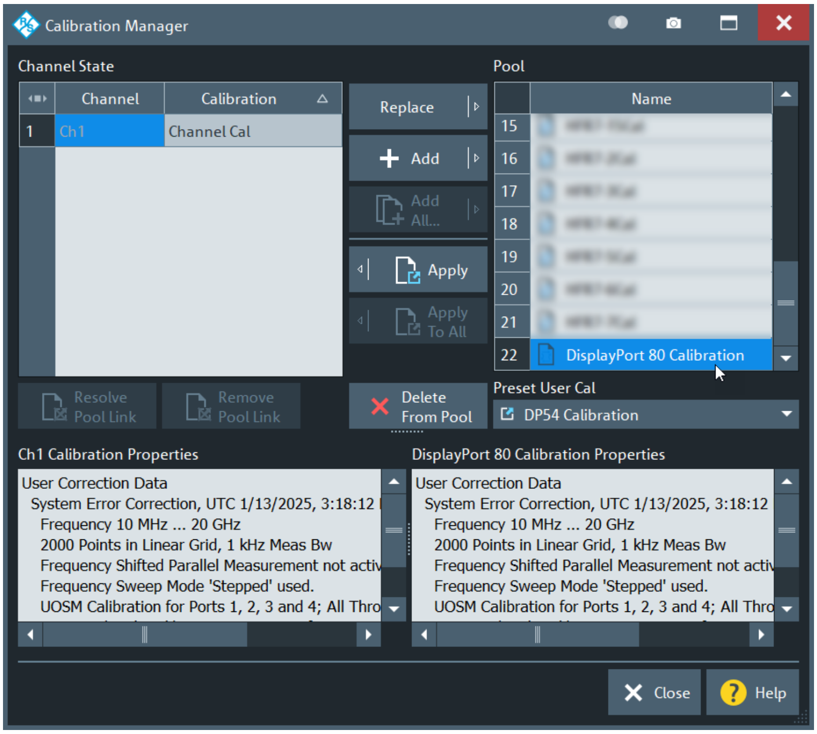
The most convenient method to perform coaxial calibration is to use an automated calibration unit. Doing so will complete calibration faster and more efficiently.

1. Make sure the active setup is the “Calibration” setup.
2. On the front panel, press “CAL”
3. Select “Start… (Cal Unit)”
4. Select Calibration Type UOSM for best accuracy.



5. Follow the calibration wizard during the whole process.

6. After the calibration is completed, select “Cal” > “Use Cal”.
7. Enter the “Cal Manager…”.
8. Add the calibration to the Pool and enter a meaningful name for the calibration.



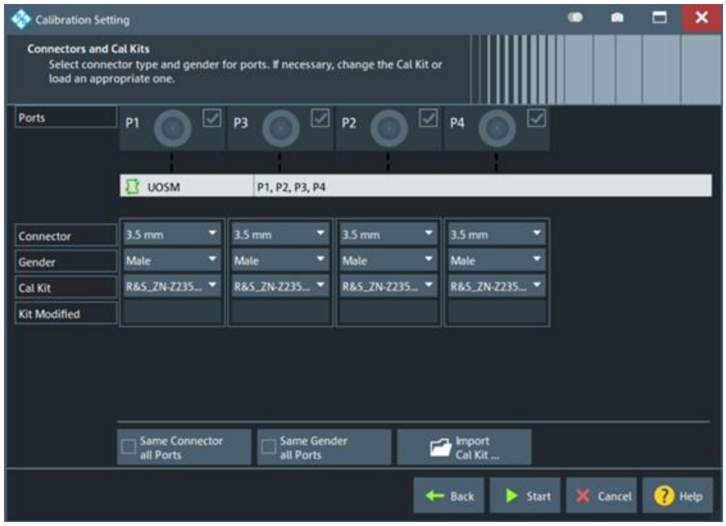
3.7.1.2 Manual calibration with calibration kit

Alternatively, if an automated calibration unit is not available, then a manual calibration kit can be used instead.

1. Make sure the active setup is the “Calibration” setup.
2. On the front panel, press “CAL” > “Start… (Manual)”
3. Select Calibration Type “UOSM” for best accuracy.

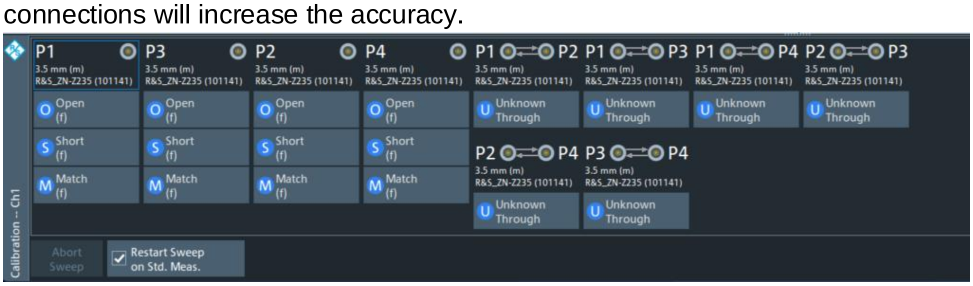
4. Open dialog “Calibration Setting”.

Check connector (e.g. 3.5 mm), gender (e.g. male) and used CalKit.



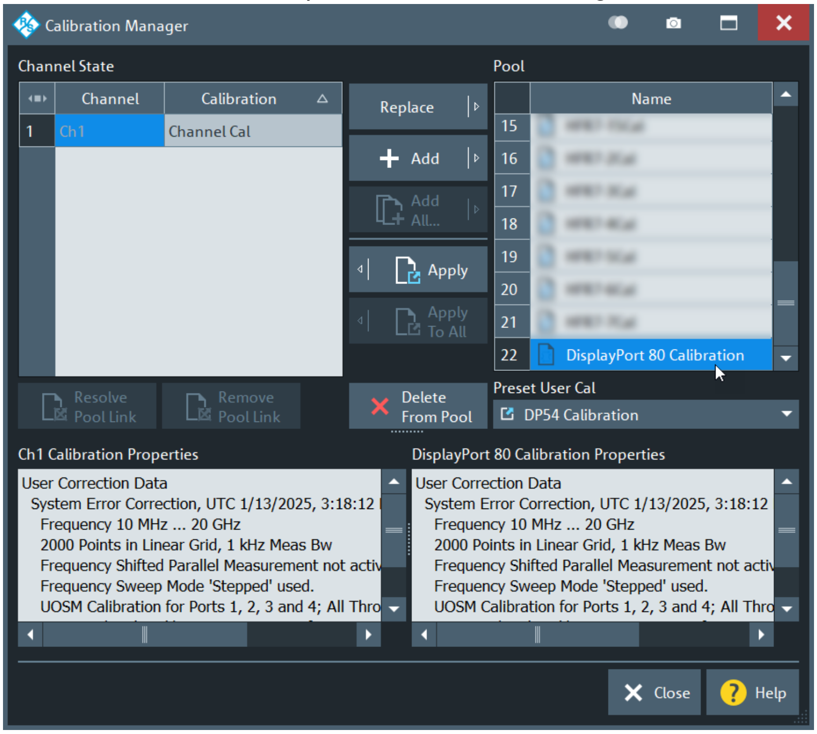
5. Start calibration and connect all required calibration standards (open, short, match and unknown through).

   It is required to measure at least 3 unknown through connections, however further measured connections will increase the accuracy.



6. After the calibration is completed, select “Cal” > “Use Cal”.
7. Enter the “Cal Manager…”.

8. Add the calibration to the pool and enter a meaningful name for the calibration.

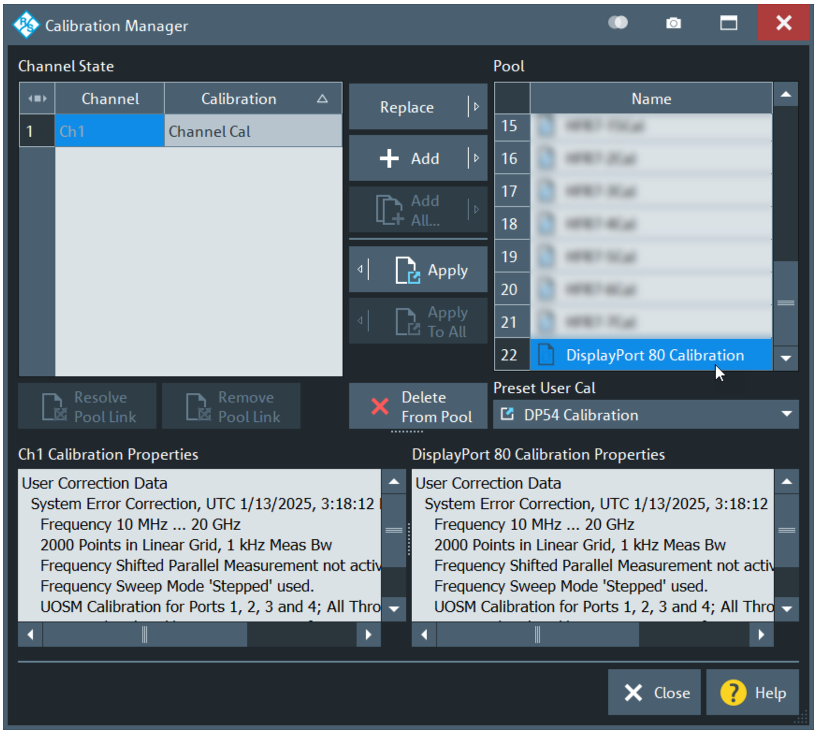


3.7.1.3 Recalling coaxial calibration

After calibrating to the end of the RF cables and storing the calibration data, select the measurement group preset where measurements should be performed. Then recall the calibration in the selected measurement group:

1. On the front panel, press “CAL” > “Use Cal”.
2. Open the “Cal manager …”.
3. Click “Apply” to make it active for the current measurement group.

Note: Recalling coaxial calibration procedure must be performed on each measurement group and channel after a firmware preset. Otherwise, measurements will be collected without proper calibration applied, resulting in inaccurate results.



3.7.2 De-embedding test fixtures

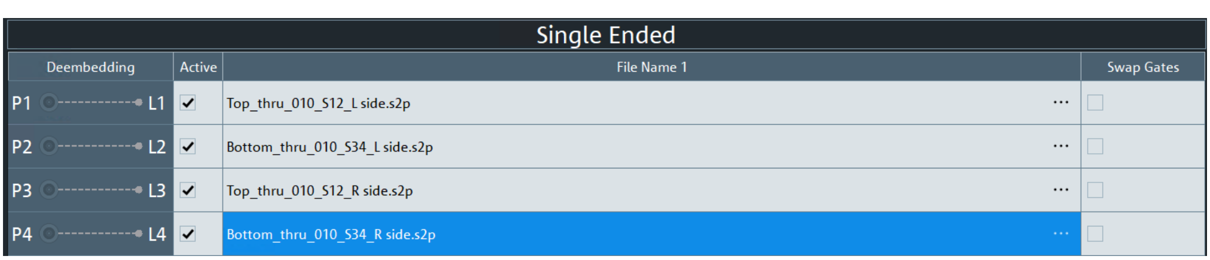
After coaxial calibration is completed, the next step is to remove the effect of the test fixtures that will be used during testing. This is accomplished by using files provided by the test fixture supplier or collecting de-embedding files from the fixtures manually. This section describes both methods of de-embedding.

The user should verify that the de-embedding files are applied before collecting DUT measurement data. This is especially true after a measurement group preset has been issued. Otherwise, measurements will be collected without proper de-embedding applied, resulting in inaccurate results.

3.7.2.1 Using de-embedding files provided by test fixture supplier

The most convenient de-embedding method is to use files provided by the test fixture vendor.

1. On the front panel, press “Offset Embed”.
2. Select “Single Ended”.
3. Import the 2-port Touchstone files (*.s2p) or the 4-port Touchstone files (*.s4p) which are delivered together with the test



3.7.2.2 Measuring and generating de-embedding files

In case the test fixture vendor could not supply the necessary files for de-embedding, or there is a concern regarding accuracy of such files (from fixture aging/use due to cable insertion over time), the user creates new de-embedding files by making measurements in the VNA firmware. This procedure will use the In-situ de-embedding (ISD) tool which requires the R&S®ZNB-K220 software option.

1. Go to Channel > Offset Embed
2. Go to Deembed Assistant
3. Connect port 1 to '+' on data lane that is under test and port 3 to '-' on data lane that is under test to the left fixture
4. Connect port 2 to '+' on data lane that is under test and port 4 to '-' on data lane that is under test to the right fixture
5. Select ISD as Fixture Tool
   a) Select "1 x 1 Balanced" for DUT
   b) Select "Balanced" for Left: Model A and Right: Model B
   c) Uncheck "Use same coupon Left and Right"
   d) Press Next
   e) On Coupon A select 1x Open
   f) For Port on Coupon A select "L1"
   g) Click "Measure" for Coupon A
   h) On Coupon B select 1x Open
   i) For Port on Coupon B select "L2"
   j) Click "Measure" for Coupon B
   k) On DUT + Fixture select for left side port "L1" and right side port "L2"
   l) Connect DUT to fixture left and fixture right.
   m) Click "Measure" DUT + Fixture
   n) Click "Apply"

Fixture de-embedding is now properly applied.

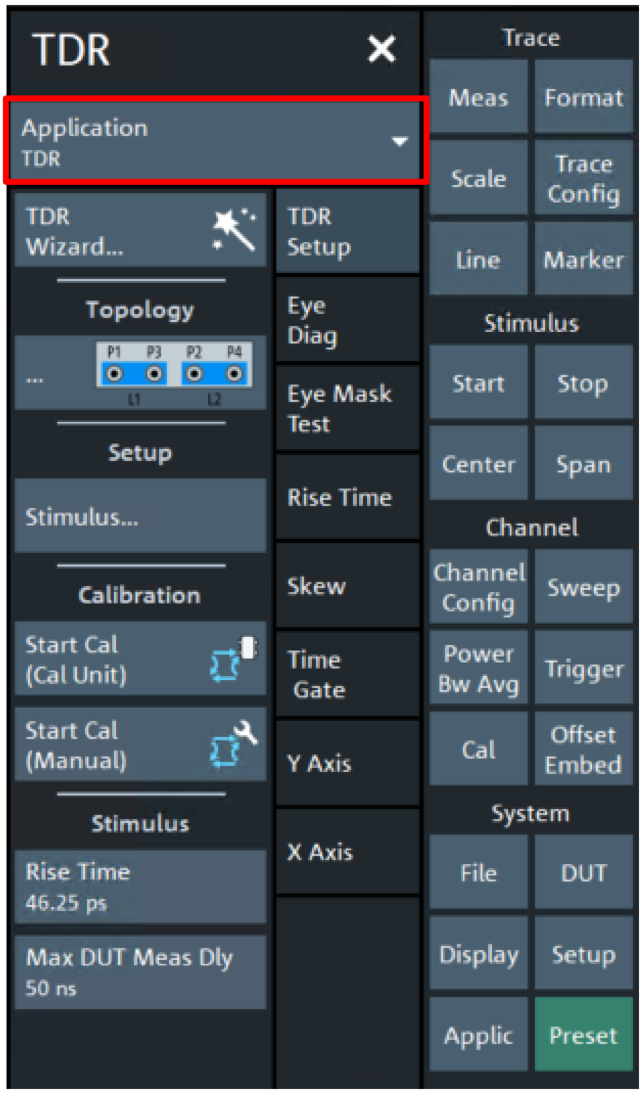
3.8 Stimulus rise time adjustment

This section demonstrates how the stimulus rise time of the R&S®ZNB is adjusted. This is necessary, when performing the time domain measurements (such as propagation delay), as the USB-IF requires different rise times be used in each of these scenarios.

Note: Licenses for the additional R&S®ZNB-K2 and R&S®ZNB-K20 options will be required for this functionality.

1. On the front panel, select "APPLIC".

6. In the "Application" dialog, select "TDR".



At the bottom of the "TDR" dialog, you find the "Rise Time" button.

7. Select "Rise Time" to adjust the rise time.

The rise time value can be defined to 10%/90% or 20%/80%.

4 Compliance measurements with R&S®ZNB20

This section describes how to perform the compliance measurements with the R&S®ZNB20 4-port vector network analyzer.

4.1 Frequency domain tests

In this group, the following normative tests will be performed:

► Insertion Loss Fit at Nyquist Frequencies (ILfitatNq)

► Integrated Return Loss (IRL)

► Integrated Crosstalk between (IXT_DP)

► Differential-to-Common-Mode Conversion (Scd)

In this group, the following informative tests will be performed:

► Integrated Crosstalk between DP Lanes (INEXT/IFEXT)

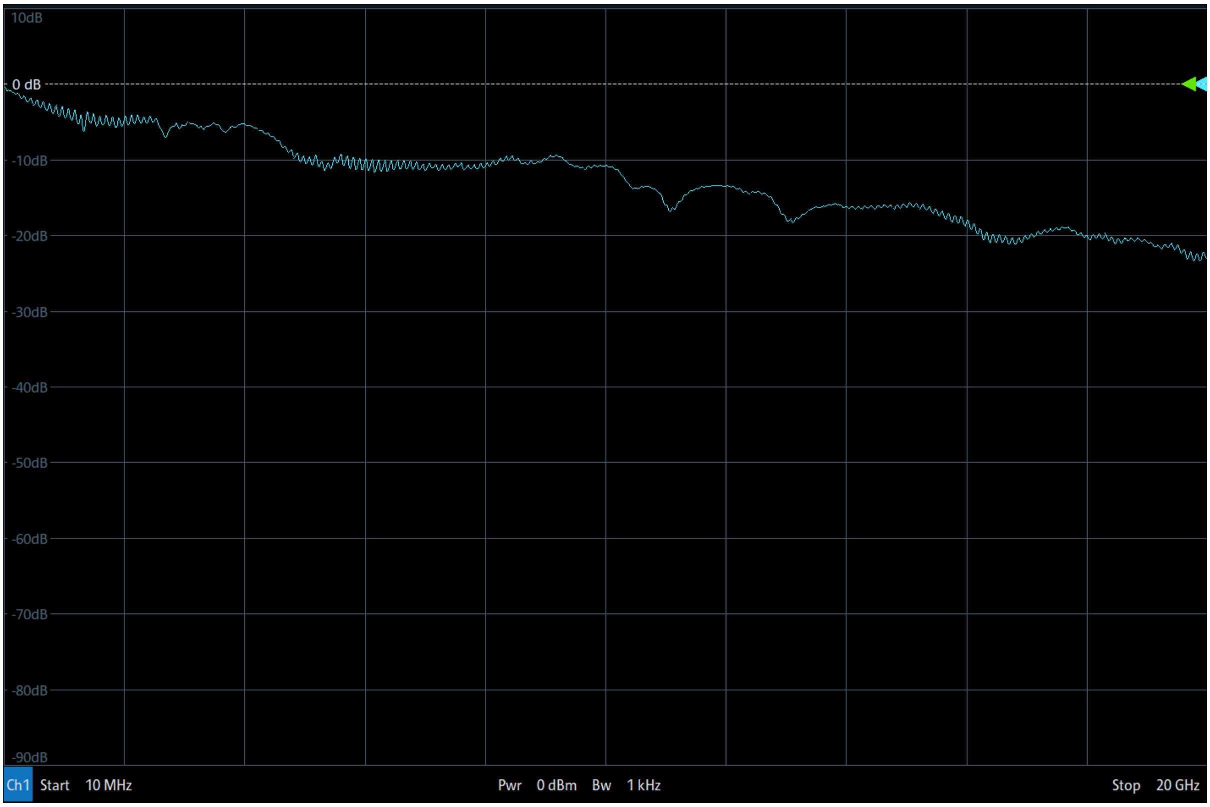
► Integrated Multi-reflection (IMR)

4.1.1 Test Procedure

The tests above for DP54 utilize the GetiPar tool provided by USB-IF. The compliance tool can be downloaded here: VESA - GET_IPAR Tool

Note: Terminate all unused 3.5mm ports with 50Ω loads/matches.

1. Recall the setup file “DP54_Frequency.znxml”



Note: The normative parameters of interest (ILfitatNq, IMR, etc.) cannot be processed natively in the network analyzer firmware. In addition to these normative requirements, the USB-IF also defines informative limits for several common frequency domain S-parameters and time domain impedance parameters. These informative limits are meant to be used as recommended guidelines for cable assembly design only, and not substitute the normative limits defined in GetiPar.

2. Verify that the calibration and de-embedding data is recalled and enabled
3. Perform the measurement and export the Touchstone file.
   a) Using the port mapping defined in the table below for your cable type, connect Port 1, Port 3, Port 2, and Port to the respective test fixture ports.

Connections required for Enhanced DP to Enhanded DP and Enhanced mDP to Enhanced mDP:

#	Test Item	Port 1	Port 3	Port 2	Port 4	Filename
1	IL, ML0	ML0+ (Left TF)	ML0- (Left TF)	ML0+ (Right TF)	ML0- (Right TF)	IL_ML0.s4p
2	FEXT, Left ML0 to Right ML1	ML0+ (Left TF)	ML0- (Left TF)	ML1+ (Right TF)	ML1- (Right TF)	FEXT__L_ML0_to_R_ML1.s4p
3	FEXT, Left ML0 to Right ML2	ML0+ (Left TF)	ML0- (Left TF)	ML2+ (Right TF)	ML2- (Right TF)	FEXT__L_ML0_to_R_ML2.s4p
4	FEXT, Left ML0 to Right ML3	ML0+ (Left TF)	ML0- (Left TF)	ML3+ (Right TF)	ML3- (Right TF)	FEXT__L_ML0_to_R_ML3.s4p

#	Test Item	Port 1	Port 3	Port 2	Port 4	Filename
5	NEXT, Left ML0 to Left ML1	ML0+ (Left TF)	ML0- (Left TF)	ML1+ (Left TF)	ML1- (Left TF)	NEXT__L_ML0_to_L_ML1.s4p
6	NEXT, Left ML0 to Left ML2	ML0+ (Left TF)	ML0- (Left TF)	ML2+ (Left TF)	ML2- (Left TF)	NEXT__L_ML0_to_L_ML2.s4p
7	NEXT, Left ML0 to Left ML3	ML0+ (Left TF)	ML0- (Left TF)	ML3+ (Left TF)	ML3- (Left TF)	NEXT__L_ML0_to_L_ML3.s4p
8	FEXT, Right ML0 to Left ML1	ML0+ (Right TF)	ML0- (Right TF)	ML1+ (Left TF)	ML1- (Left TF)	FEXT__R_ML0_to_L_ML1.s4p
9	FEXT, Right ML0 to Left ML2	ML0+ (Right TF)	ML0- (Right TF)	ML2+ (Left TF)	ML2- (Left TF)	FEXT__R_ML0_to_L_ML2.s4p
10	FEXT, Right ML0 to Left ML3	ML0+ (Right TF)	ML0- (Right TF)	ML3+ (Left TF)	ML3- (Left TF)	FEXT__R_ML0_to_L_ML3.s4p
11	NEXT, Right ML0 to Right ML1	ML0+ (Right TF)	ML0- (Right TF)	ML1+ (Right TF)	ML1- (Right TF)	NEXT_R_ML0_to__R_ML1.s4p
12	NEXT, Right ML0 to Right ML2	ML0+ (Right TF)	ML0- (Right TF)	ML2+ (Right TF)	ML2- (Right TF)	NEXT_R_ML0_to__R_ML2.s4p
13	NEXT, Right ML0 to Right ML3	ML0+ (Right TF)	ML0- (Right TF)	ML3+ (Right TF)	ML3- (Right TF)	NEXT_R_ML0_to__R_ML3.s4p
14	IL, ML1	ML1+ (Left TF)	ML1- (Left TF)	ML1+ (Right TF)	ML1- (Right TF)	IL_ML1.s4p
15	FEXT, Left ML1 to Right ML2	ML1+ (Left TF)	ML1- (Left TF)	ML2+ (Right TF)	ML2- (Right TF)	FEXT__L_ML1_to_R_ML2.s4p
16	FEXT, Left ML1 to Right ML3	ML1+ (Left TF)	ML1- (Left TF)	ML3+ (Right TF)	ML3- (Right TF)	FEXT__L_ML1_to_R_ML3.s4p
17	NEXT, Left ML1 to Left ML2	ML1+ (Left TF)	ML1- (Left TF)	ML2+ (Left TF)	ML2- (Left TF)	NEXT__L_ML1_to_L_ML2.s4p
18	NEXT, Left ML0 to Left ML2	ML1+ (Left TF)	ML1- (Left TF)	ML3+ (Left TF)	ML3- (Left TF)	NEXT__L_ML1_to_L_ML3.s4p
19	FEXT, Right ML1 to Left ML2	ML1+ (Right TF)	ML1- (Right TF)	ML2+ (Left TF)	ML2- (Left TF)	FEXT__R_ML1_to_L_ML2.s4p
20	FEXT, Right ML1 to Left ML3	ML1+ (Right TF)	ML1- (Right TF)	ML3+ (Left TF)	ML3- (Left TF)	FEXT__R_ML1_to_L_ML3.s4p
21	NEXT, Right ML1 to Right ML2	ML1+ (Right TF)	ML1- (Right TF)	ML2+ (Right TF)	ML2- (Right TF)	NEXT_R_ML1_to__R_ML2.s4p
22	NEXT, Right ML1 to Right ML3	ML1+ (Right TF)	ML1- (Right TF)	ML3+ (Right TF)	ML3- (Right TF)	NEXT_R_ML1_to__R_ML3.s4p
23	IL, ML2	ML2+ (Left TF)	ML2- (Left TF)	ML2+ (Right TF)	ML2- (Right TF)	IL_ML2.s4p
24	FEXT, Left ML2 to Right ML3	ML2+ (Left TF)	ML2- (Left TF)	ML3+ (Right TF)	ML3- (Right TF)	FEXT__L_ML2_to_R_ML3.s4p
25	NEXT, Left ML2 to Left ML3	ML2+ (Left TF)	ML2- (Left TF)	ML3+ (Left TF)	ML3- (Left TF)	NEXT__L_ML2_to_L_ML3.s4p

#	Test Item	Port 1	Port 3	Port 2	Port 4	Filename
26	FEXT, Right ML2 to Left ML3	ML2+ (Right TF)	ML2- (Right TF)	ML3+ (Left TF)	ML3- (Left TF)	FEXT__R_ML2_to_L_ML3.s4p
27	NEXT, Right ML2 to Right ML3	ML2+ (Right TF)	ML2- (Right TF)	ML3+ (Right TF)	ML3- (Right TF)	NEXT_R_ML2_to__R_ML3.s4p
28	IL, ML3	ML3+ (Left TF)	ML3- (Left TF)	ML3+ (Right TF)	ML3- (Right TF)	IL_ML3.s4p

Connections required for DP Alt Mode (USB Type-C to Enhanded DP or Enhanced mDP):

#	Test Item	Port 1	Port 3	Port 2	Port 4	Filename
1	IL, Tx1 to ML2	Tx1+ (Left TF)	Tx1- (Left TF)	ML2+ (Right TF)	ML2- (Right TF)	IL_Tx1_to_ML2.s4p
2	FEXT, Left Tx1 to Right ML3	Tx1+ (Left TF)	Tx1- (Left TF)	ML3+ (Right TF)	ML3- (Right TF)	FEXT__L_Tx1_to_R_ML3.s4p
3	FEXT, Left Tx1 to Right ML1	Tx1+ (Left TF)	Tx1- (Left TF)	ML1+ (Right TF)	ML1- (Right TF)	FEXT__L_Tx1_to_R_ML1.s4p
4	FEXT, Left Tx1 to Right ML0	Tx1+ (Left TF)	Tx1- (Left TF)	ML0+ (Right TF)	ML0- (Right TF)	FEXT__L_Tx1_to_R_ML0.s4p
5	NEXT, Left Tx1 to Left Rx1	Tx1+ (Left TF)	Tx1- (Left TF)	Rx1+ (Left TF)	Rx1- (Left TF)	NEXT__L_Tx1_to_L_Rx1.s4p
6	NEXT, Left Tx1 to Left Tx2	Tx1+ (Left TF)	Tx1- (Left TF)	Tx2+ (Left TF)	Tx2- (Left TF)	NEXT__L_Tx1_to_L_Tx2.s4p
7	NEXT, Left Tx1 to Left Rx1	Tx1+ (Left TF)	Tx1- (Left TF)	Rx1+ (Left TF)	Rx1- (Left TF)	NEXT__L_Tx1_to_L_Rx1.s4p
8	FEXT, Right ML0 to Left Rx1	ML2+ (Right TF)	ML2- (Right TF)	Rx1+ (Left TF)	Rx1- (Left TF)	FEXT__R_ML2_to_L_Rx1.s4p
9	FEXT, Right ML2 to Left Rx2	ML2+ (Right TF)	ML2- (Right TF)	Tx2+ (Left TF)	Tx2- (Left TF)	FEXT__R_ML2_to_L_Tx2.s4p
10	FEXT, Right ML2 to Left Rx2	ML2+ (Right TF)	ML2- (Right TF)	Rx2+ (Left TF)	Rx2- (Left TF)	FEXT__R_ML2_to_L_Rx2.s4p
11	NEXT, Right ML2 to Right ML3	ML2+ (Right TF)	ML2- (Right TF)	ML3+ (Right TF)	ML3- (Right TF)	NEXT_R_ML2_to__R_ML3.s4p
12	NEXT, Right ML2 to Right ML1	ML2+ (Right TF)	ML2- (Right TF)	ML1+ (Right TF)	ML1- (Right TF)	NEXT_R_ML2_to__R_ML1.s4p
13	NEXT, Right ML0 to Right ML3	ML2+ (Right TF)	ML2- (Right TF)	ML0+ (Right TF)	ML0- (Right TF)	NEXT_R_ML2_to__R_ML0.s4p
14	IL, Rx1 to ML3	Rx1+ (Left TF)	Rx1- (Left TF)	ML3+ (Right TF)	ML3- (Right TF)	IL_Rx1_to_ML3.s4p
15	FEXT, Left Rx1 to Right ML2	Rx1+ (Left TF)	Rx1- (Left TF)	ML1+ (Right TF)	ML1- (Right TF)	FEXT__L_Rx1_to_R_ML1.s4p
16	FEXT, Left ML1 to Right ML3	Rx1+ (Left TF)	Rx1- (Left TF)	ML0+ (Right TF)	ML0- (Right TF)	FEXT__L_Rx1_to_R_ML0.s4p

#	Test Item	Port 1	Port 3	Port 2	Port 4	Filename
17	NEXT, Left Rx1 to Left Tx2	Rx1+ (Left TF)	Rx1- (Left TF)	Tx2+ (Left TF)	Tx2- (Left TF)	NEXT__L_Rx1_to_L_Tx2.s4p
18	NEXT, Left Rx1 to Left Rx2	Rx1+ (Left TF)	Rx1- (Left TF)	Rx2+ (Left TF)	Rx2- (Left TF)	NEXT__L_Rx1_to_L_Rx2.s4p
19	FEXT, Right ML3 to Left Tx2	ML3+ (Right TF)	ML3- (Right TF)	Tx2+ (Left TF)	Tx2- (Left TF)	FEXT__R_ML3_to_L_Tx2.s4p
20	FEXT, Right ML3 to Left Rx2	ML3+ (Right TF)	ML3- (Right TF)	Rx2+ (Left TF)	Rx2- (Left TF)	FEXT__R_ML3_to_L_Rx2.s4p
21	NEXT, Right ML3 to Right ML1	ML3+ (Right TF)	ML3- (Right TF)	ML1+ (Right TF)	ML1- (Right TF)	NEXT_R_ML3_to__R_ML1.s4p
22	NEXT, Right ML3 to Right ML0	ML3+ (Right TF)	ML3- (Right TF)	ML0+ (Right TF)	ML0- (Right TF)	NEXT_R_ML3_to__R_ML0.s4p
23	IL, Tx2 to ML1	Tx2+ (Left TF)	Tx2- (Left TF)	ML1+ (Right TF)	ML1- (Right TF)	IL_Tx2_to_ML1.s4p
24	FEXT, Left Tx2 to Right ML0	Tx2+ (Left TF)	Tx2- (Left TF)	ML0+ (Right TF)	ML0- (Right TF)	FEXT__L_Tx2_to_R_ML0.s4p
25	NEXT, Left Tx2 to Left Rx2	Tx2+ (Left TF)	Tx2- (Left TF)	Rx2+ (Left TF)	Rx2- (Left TF)	NEXT__L_Tx2_to_L_Rx2.s4p
26	FEXT, Right ML1 to Left Rx2	ML1+ (Right TF)	ML1- (Right TF)	Rx2+ (Left TF)	Rx2- (Left TF)	FEXT__R_ML1_to_L_Rx2.s4p
27	NEXT, Right ML1 to Right ML0	ML1+ (Right TF)	ML1- (Right TF)	ML0+ (Right TF)	ML0- (Right TF)	NEXT_R_ML1_to__R_ML0.s4p
28	IL, Rx2 to ML0	Rx2+ (Left TF)	Rx2- (Left TF)	ML0+ (Right TF)	ML0- (Right TF)	IL_Rx2_to_ML0.s4p

b) After an acquisition is complete, select “FILE” on the front panel then Select “Trace Data” > “s4p Port 1,2,3,4...”.

c) Use the name listed in the ‘Filename’ column (based on the naming described in 3.4 Touchstone file naming convention) in the above table for the file name of the exported Touchstone file.

2. Repeat step 3.a through 3.c for all 28 measurements.

3. Import the 28 4-port Touchstone files (*.s4p) to the “Get_iPar" software.

The Get_iPar software can be used for the evaluation of several different compliance requirements. Due to its flexibility, there are configuration files (*.xlsx) used to automate the post-processing and evaluation of the cable assembly data. These files needed to be edited to properly perform the interested analysis.

a) After downloading the Get_iPar files, described in 3.3.1 Get_iPar, extract the content of the .zip file.

b) Within the ‘Templates’ folder there is a file called ‘USB4_Gen3_CableCom_Config_Example.xlsx’. This file will be used in the following steps, but must first be modified to reflect the settings necessary for VESA DP54 passive cable assembly testing. Modify the file as shown below:

USB4 Gen3 Cable Complaince Check Configuration File Example			
comp_check_type		1. 2	1=iPar+COM; 2=iPar only; 3=COM only; 4=Connector
result_folder	C:\Ger_iPar_v0p91a_release\DP80_results 2.		
cable_type		3. 0	0= passive cable; 1=active cable (only used for cable)
eta_0	[]		only use for active cable
save_assembled_cable_sp		1	
plot_cable_sp		1	
case_number	[1] 4.		
case_1	.\Templates\s4p_DP80_DUT_1_.xlsx 5.		
case_2	.\Templates\s8p_example_0p91a.xlsx		
case_3	.\Templates\s16p_example_0p91a.xlsx		
case_4	.\Templates\s20p_example_0p91a.xlsx		

1. select iPar only by typing ‘2’ into column b of the config excel sheet
2. Copy in the folder directory you would like the results to be put in after the compliance test has been completed
3. Select ‘0’ for passive cable in column b of the config excel sheet
4. Select the option that applies to your measurement data, in this example, we are showing data captured with a 4 port VNA, so we are selecting the s4p case. Note, the Get_iPar tool supports s4p, s8p, s16p, and s20p files.
5. Ensure that the case information in column b points to the excel file that contains a list of all s4p files that were measured for your DUT.

c) After editing ‘USB4_Gen3_CableCom_Config_Example.xlsx’ is completed. Open the file titled ‘s4p_example_0p91a.xlsx’ this excel sheet will contain the name of each of the 28 s4p files captured for the compliance test. Ensure all 28 s4p files are in the same file directory as the ‘s4p_example_0p91a.xlsx’ file.

folder	C:\Cable_Tools\measured_sp_examples\s4p\		
VNA_port	4		
sp_file_1	IL_ML0.s4p	sp_port_1	[1 2 3 4]
sp_file_2	FEXT__L_ML0_to_R_ML1.s4p	sp_port_2	[1 6 3 8]
sp_file_3	FEXT__L_ML0_to_R_ML2.s4p	sp_port_3	[1 10 3 12]
sp_file_4	FEXT__L_ML0_to_R_ML3.s4p	sp_port_4	[1 14 3 16]
sp_file_5	NEXT__L_ML0_to_L_ML1.s4p	sp_port_5	[1 5 3 7]
sp_file_6	NEXT__L_ML0_to_L_ML2.s4p	sp_port_6	[1 9 3 11]
sp_file_7	NEXT__L_ML0_to_L_ML3.s4p	sp_port_7	[1 13 3 15]
sp_file_8	FEXT__R_ML0_to_L_ML1.s4p	sp_port_8	[2 5 4 7]
sp_file_9	FEXT__R_ML0_to_L_ML2.s4p	sp_port_9	[2 9 4 11]
sp_file_10	FEXT__R_ML0_to_L_ML3.s4p	sp_port_10	[2 13 4 15]
sp_file_11	NEXT_R_ML0_to__R_ML1.s4p	sp_port_11	[2 6 4 8]
sp_file_12	NEXT_R_ML0_to__R_ML2.s4p	sp_port_12	[2 10 4 12]
sp_file_13	NEXT_R_ML0_to__R_ML3.s4p	sp_port_13	[2 14 4 16]
sp_file_14	IL_ML1.s4p	sp_port_14	[5 6 7 8]
sp_file_15	FEXT__L_ML1_to_R_ML2.s4p	sp_port_15	[5 10 7 12]
sp_file_16	FEXT__L_ML1_to_R_ML3.s4p	sp_port_16	[5 14 7 16]
sp_file_17	NEXT__L_ML1_to_L_ML2.s4p	sp_port_17	[5 9 7 11]
sp_file_18	NEXT__L_ML1_to_L_ML3.s4p	sp_port_18	[5 13 7 15]
sp_file_19	FEXT__R_ML1_to_L_ML2.s4p	sp_port_19	[6 9 8 11]
sp_file_20	FEXT__R_ML1_to_L_ML3.s4p	sp_port_20	[6 13 8 15]
sp_file_21	NEXT_R_ML1_to__R_ML2.s4p	sp_port_21	[6 10 8 12]
sp_file_22	NEXT_R_ML1_to__R_ML3.s4p	sp_port_22	[6 14 8 16]
sp_file_23	IL_ML2.s4p	sp_port_23	[9 10 11 12]
sp_file_24	FEXT__L_ML2_to_R_ML3.s4p	sp_port_24	[9 14 11 16]
sp_file_25	NEXT__L_ML2_to_L_ML3.s4p	sp_port_25	[9 13 11 15]
sp_file_26	FEXT__R_ML2_to_L_ML3.s4p	sp_port_26	[10 13 12 15]
sp_file_27	NEXT_R_ML2_to__R_ML3.s4p	sp_port_27	[10 14 12 16]
sp_file_28	IL_ML3.s4p	sp_port_28	[13 14 15 16]

After the 28 port names are listed in the excel file there will be an additional 16 USB2 files, these can be replaced with a closed square bracket like this: '[]' the closed square brackets indicate to the tool that this will not be tested, if the square brackets are not there then the get_iPar tool will not work.

usb2_file_1	[]	usb2_port_1	[17 1 19 3]
usb2_file_2	[]	usb2_port_2	[17 2 19 4]
usb2_file_3	[]	usb2_port_3	[17 5 19 7]
usb2_file_4	[]	usb2_port_4	[17 6 19 8]
usb2_file_5	[]	usb2_port_5	[17 9 19 11]
usb2_file_6	[]	usb2_port_6	[17 10 19 12]
usb2_file_7	[]	usb2_port_7	[17 13 19 15]
usb2_file_8	[]	usb2_port_8	[17 14 19 16]
usb2_file_9	[]	usb2_port_9	[18 1 20 3]
usb2_file_10	[]	usb2_port_10	[18 2 20 4]
usb2_file_11	[]	usb2_port_11	[18 5 20 7]
usb2_file_12	[]	usb2_port_12	[18 6 20 8]
usb2_file_13	[]	usb2_port_13	[18 9 20 11]
usb2_file_14	[]	usb2_port_14	[18 10 20 12]
usb2_file_15	[]	usb2_port_15	[18 13 20 15]
usb2_file_16	[]	usb2_port_16	[18 14 20 16]

d) Ensure that the correct limits for the Get_iPar tool are set, to do this go to the 'data' folder in the Get_iPar_v0p91a_release and put in the following files downloaded from VESA website:

DP80_DP2DP_20G_input_data_R3.mat		10/24/2021 9:29 PM	Microsoft Access Tabl...	31,041 KB
DP80_DP2TC_20G_input_data_R3.mat		10/24/2021 11:17 PM	Microsoft Access Tabl...	31,041 KB
input_data.mat		12/19/2019 1:27 PM	Microsoft Access Tabl...	31,041 KB

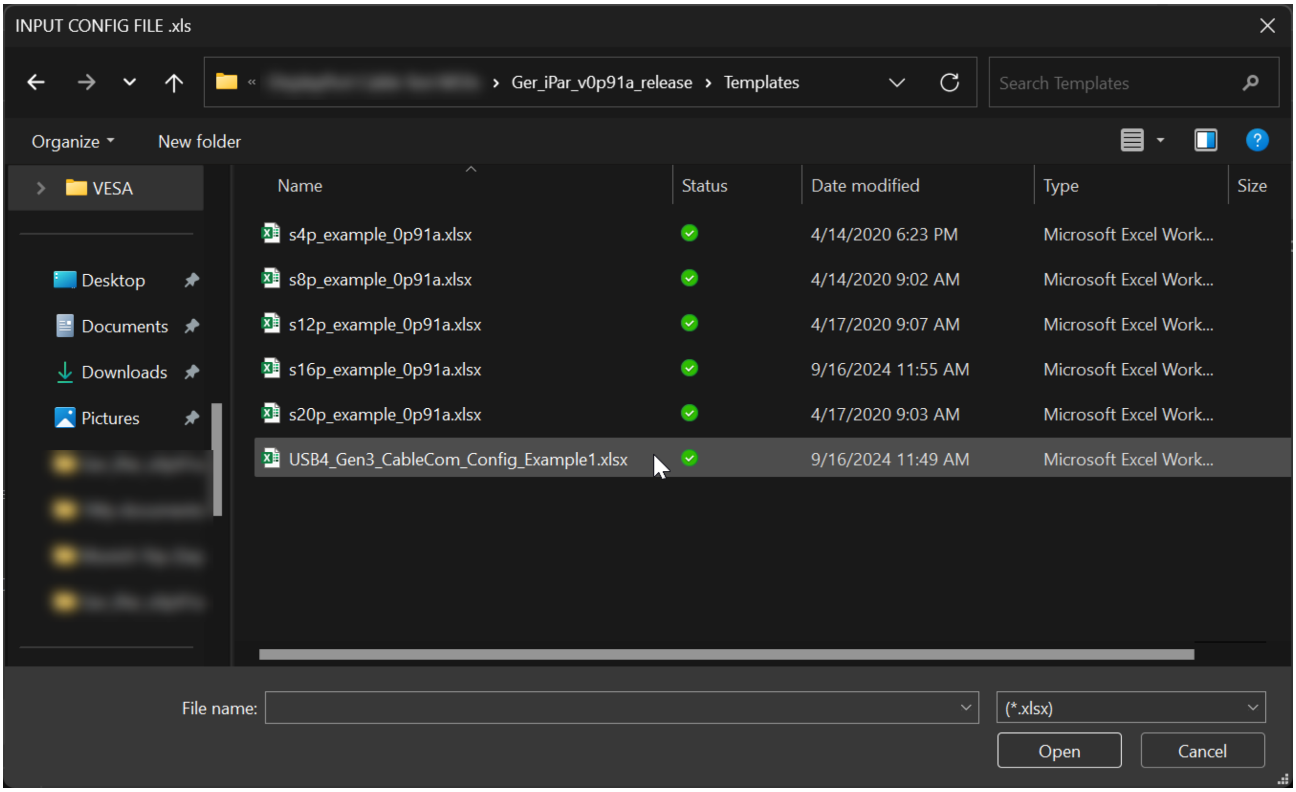
These files set the correct limits for the Get_iPar tool to determine the correct pass/fail criteria. These are downloadable on the VESA site here

To enable the DP2DP or DP2TC(Type-C) for Alt mode testing you need to rename the file to 'input_data.mat'

e) Navigate to the root directory of the extracted Get_iPar files, and run the *.exe

Name	Status	Date modified	Type	Size
data		9/13/2024 2:54 PM	File folder	
Templates		9/16/2024 11:55 AM	File folder	
Get_iPar_Instruction_Rev0.91a.pptx		12/1/2020 6:13 AM	Microsoft PowerPoint...	922 KB
Get_iPar_v0p91a.exe		12/7/2020 10:24 AM	Application	5,630 KB

f) Next, a pop-up window will appear, titled "INPUT CONFIG FILE". Select the 'USB4_Gen3_CableCom_Config_Example.xlsx" file in the 'Templates' folder.



g) The Get_iPar software will begin processing the 28 Touchstone files. This process may take several minutes. Plots will appear on the screen, but will automatically close. These can be viewed in the file location you specified the results would be placed in step b.

6. Retrieve the analysis results from the software.

Once the Get_iPar software has completed it's analysis, the compliance results will be stored in two spreadsheets within the folder outlined you designated in step b. The spreadsheets include numerical values as well as pass or fail judgement against the respective limit.

Passive cable	TX1(L)	TX1(R)	RX1(L)	RX1(R)	TX2(L)	TX2(R)	RX2(L)	RX2(R)	Limit	Pass/Fail
ILfit@0.1GHz, dB	-0.67	-0.67	-0.67	-0.67	-0.65	-0.65	-0.66	-0.66	-1	Pass
ILfit@2.7GHz, dB	-3.33	-3.33	-3.26	-3.26	-3.25	-3.25	-3.36	-3.36	-4	Pass
ILfit@5GHz, dB	-4.39	-4.39	-4.38	-4.38	-4.37	-4.37	-4.44	-4.44	-5.5	Pass
ILfit@6.75GHz, dB	-5.05	-5.05	-5.11	-5.11	-5.12	-5.12	-5.15	-5.15	-6.5	Pass
ILfit@10GHz, dB	-6.41	-6.41	-6.57	-6.57	-6.64	-6.64	-6.69	-6.69	-8.5	Pass
ILfit@15GHz, dB	-9.67	-9.67	-9.72	-9.72	-10	-10	-10.35	-10.35	-13	Pass
IMR, dB	-38.95	-38.95	-39.79	-39.79	-40.33	-40.33	-38	-38	-30.9	Pass
IRL, dB	-20.46	-20.46	-20.05	-20.05	-19.34	-19.34	-21.12	-21.12	-16.64	Pass
C2D, dB	-22.11	-27.9	-22.25	-24.5	-24.87	-23.22	-20.53	-21.29	-17	Pass
D2C, dB	-22.08	-28.04	-22.6	-24.21	-24.7	-23.27	-20.63	-21.26	-17	Pass
IXT_DP, dB	-41.01	-43.15	-41.6	-39.54	-39.9	-40.82	-41.56	-41.05	-34.9	Pass
IXT_USB, dB	-31.23	-32.18	-28.88	-29.44	-29.53	-29.12	-32.34	-31.55	-36	Fail

Detailed crosstalk between each pair in dB

Vic/Agg Port	TX1(L)	TX1(R)	RX1(L)	RX1(R)	TX2(L)	TX2(R)	RX2(L)	RX2(R)
TX1(L)			-31.49	-43.55	-47.12	-45.62	-47.76	-51.12
TX1(R)			-47	-32.34	-48.73	-46.35	-48.23	-50.79
RX1(L)	-31.49	-47			-32.49	-45.36	-45.62	-46.96
RX1(R)	-43.55	-32.34			-44.16	-32.79	-45.45	-46.88
TX2(L)	-47.12	-48.73	-32.49	-44.16			-32.69	-42.96
TX2(R)	-45.62	-46.35	-45.36	-32.79			-45.79	-31.73
RX2(L)	-47.76	-48.23	-45.62	-45.45	-32.69	-45.79		
RX2(R)	-51.12	-50.79	-46.96	-46.88	-42.96	-31.73		

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4.2 Time domain tests

Time domain measurements are directly performed on the R&S®ZNB20 vector network analyzer. Only for this section the R&S®ZNB-K2 time domain option is required:

In this section, the following normative tests will be performed:

- Differential Impedance Profile
- Intra-pair Skew

In this section, the following informative tests will be performed:

- Inter-pair Skew

4.2.1 Test Procedure

4.2.1.1 Differential Impedance Profile (Normative)

1. Recall the setup file “DP54_Differential_Impedance_Profile.znxml”

2. Connect DUT to VNA

   DP2.1 cable

Port 1	Port 3	Port 2	Port 4
ML0+ (Left TF)	ML0- (Left TF)	ML0+ (Right TF)	ML0- (Right TF)
ML1+ (Left TF)	ML1- (Left TF)	ML1+ (Right TF)	ML1- (Right TF)
ML2+ (Left TF)	ML2- (Left TF)	ML2+ (Right TF)	ML2- (Right TF)
ML3+ (Left TF)	ML3- (Left TF)	ML3+ (Right TF)	ML3- (Right TF)

DP Alt Mode (Type-C to Enhanced DP or Enhanced mDP)

Port 1	Port 3	Port 2	Port 4
Tx1+ (Left TF)	Tx1- (Left TF)	ML2+ (Right TF)	ML2- (Right TF)
Rx1+ (Left TF)	Rx1- (Left TF)	ML3+ (Right TF)	ML3- (Right TF)
Tx2+ (Left TF)	Tx2- (Left TF)	ML1+ (Right TF)	ML1- (Right TF)
Rx2+ (Left TF)	Rx2- (Left TF)	ML0+ (Right TF)	ML0- (Right TF)

DP Alt Mode (Enhanced DP or Enhanced mDP to Type-C)

Port 1	Port 3	Port 2	Port 4
ML0+ (Left TF)	ML0- (Left TF)	Rx1+ (Right TF)	Rx1- (Right TF)
ML1+ (Left TF)	ML1- (Left TF)	Tx1+ (Right TF)	Tx1- (Right TF)
ML2+ (Left TF)	ML2- (Left TF)	Tx2+ (Right TF)	Tx2- (Right TF)
ML3+ (Left TF)	ML3- (Left TF)	Rx2+ (Right TF)	Rx2- (Right TF)

3. Verify that the calibration and de-embedding data are recalled and enabled
4. Ensure correct limit lines are enabled for the DUT type
   a) DP2.1 cable limit lines

Segment	Differential Impedance Value	Maximum Tolerance	Comment
Fixture	100 Ω	±5 Ω	Fixture shall be de-embedded during measurement
Connector	85 Ω	±10 Ω	Measurements to be made from 20% to 80% with a rise time of 25 ps
Paddle Card and Wire Management	85 Ω	±10 Ω	
Cable	85 Ω	±5 Ω	

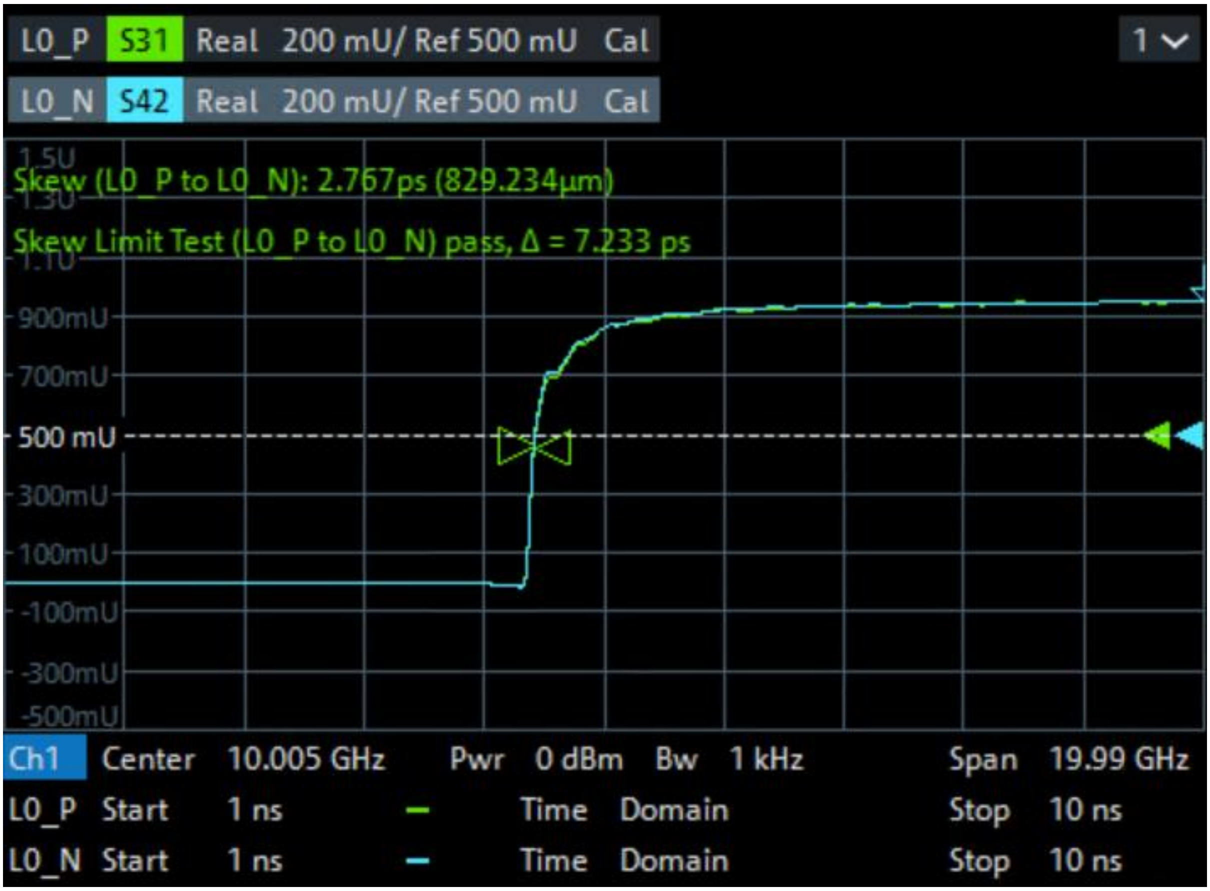
   b) DP Alt Mode (Type-C to Enhanced DP or Enhanced mDP)

Segment	Differential Impedance Value	Maximum Tolerance	Comment
Fixture	100 Ω	±5 Ω	Fixture shall be de-embedded during measurement
USB Type-C Connector	85 Ω	±9 Ω	Measurements are to be made from 20% to 80% with a rise time of 25 ps
USB Type-C Bulk Cable	85 Ω	±5 Ω	

5. If the trace falls out of the correct limit lines defined in the setup file for your DUT, then fail
6. Repeat steps 2 through 4 for each connection for the given DUT

4.2.1.2 Intra-pair Skew (Normative)

1. Recall the setup file “DP54_Intra-pair_Skew.znxml”



2. Connect DUT to VNA

DP2.1 cable

Port 1	Port 3	Port 2	Port 4
ML0+ (Left TF)	ML0- (Left TF)	ML0+ (Right TF)	ML0- (Right TF)
ML1+ (Left TF)	ML1- (Left TF)	ML1+ (Right TF)	ML1- (Right TF)
ML2+ (Left TF)	ML2- (Left TF)	ML2+ (Right TF)	ML2- (Right TF)
ML3+ (Left TF)	ML3- (Left TF)	ML3+ (Right TF)	ML3- (Right TF)

DP Alt Mode (Type-C to Enhanced DP or Enhanced mDP)

Port 1	Port 3	Port 2	Port 4
Tx1+ (Left TF)	Tx1- (Left TF)	ML2+ (Right TF)	ML2- (Right TF)
Rx1+ (Left TF)	Rx1- (Left TF)	ML3+ (Right TF)	ML3- (Right TF)
Tx2+ (Left TF)	Tx2- (Left TF)	ML1+ (Right TF)	ML1- (Right TF)
Rx2+ (Left TF)	Rx2- (Left TF)	ML0+ (Right TF)	ML0- (Right TF)

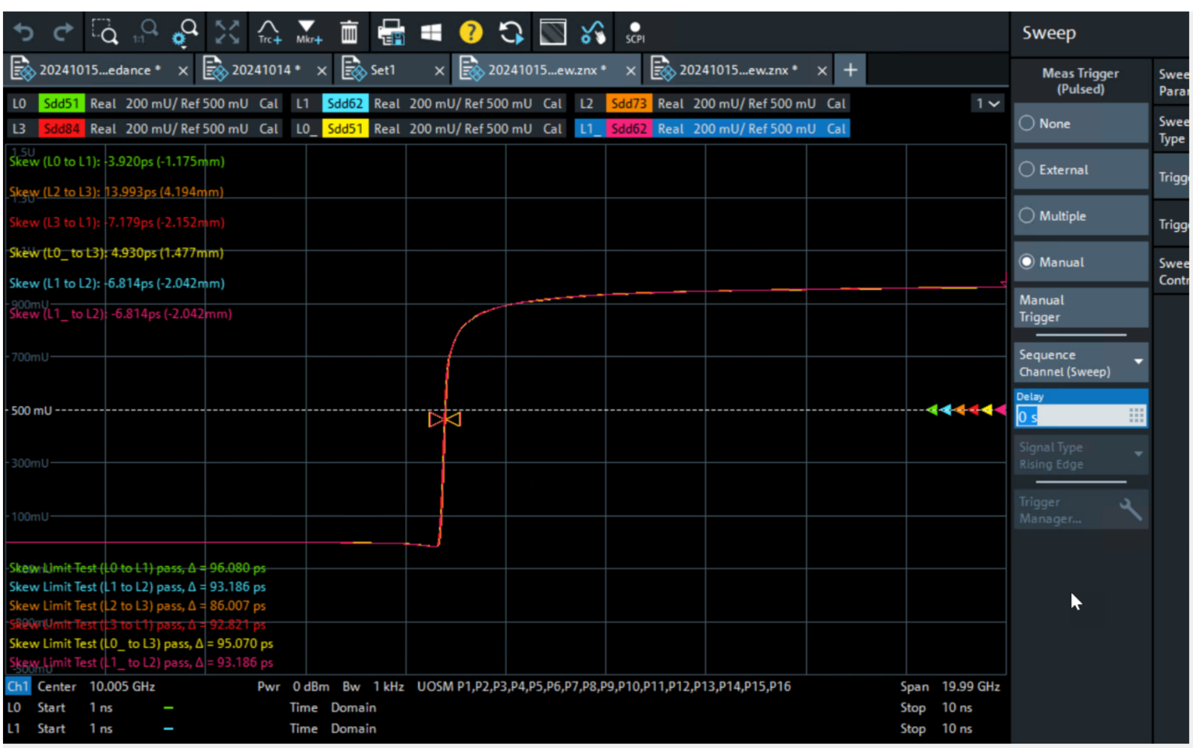
DP Alt Mode (Enhanced DP or Enhanced mDP to Type-C)

Port 1	Port 3	Port 2	Port 4
ML0+ (Left TF)	ML0- (Left TF)	Rx1+ (Right TF)	Rx1- (Right TF)
ML1+ (Left TF)	ML1- (Left TF)	Tx1+ (Right TF)	Tx1- (Right TF)
ML2+ (Left TF)	ML2- (Left TF)	Tx2+ (Right TF)	Tx2- (Right TF)
ML3+ (Left TF)	ML3- (Left TF)	Rx2+ (Right TF)	Rx2- (Right TF)

3. Verify that the calibration and de-embedding data are recalled and enabled
4. Evaluate the time delta
   a) DP2.1 cable: Pass if time is ≤ 10 ps, otherwise fail. While using 25ps (20% to 80%) rise time
   b) DP Alt Mode: Pass if time is < 30 ps, otherwise fail. While using 50ps (20% to 80%) rise time
5. Repeat steps 2 through 4 for each connection for the given DUT

4.2.1.3 Inter-pair Skew (Informative)

1. Recall the setup file "DP54_Inter-pair_Skew.znxml"



2. Connect DUT to VNA

   DP2.1 cable

Port 1	Port 3	Port 2	Port 4
ML0+ (Left TF)	ML0- (Left TF)	ML0+ (Right TF)	ML0- (Right TF)

Port 1	Port 3	Port 2	Port 4
ML1+ (Left TF)	ML1- (Left TF)	ML1+ (Right TF)	ML1- (Right TF)
ML2+ (Left TF)	ML2- (Left TF)	ML2+ (Right TF)	ML2- (Right TF)
ML3+ (Left TF)	ML3- (Left TF)	ML3+ (Right TF)	ML3- (Right TF)

DP Alt Mode (Type-C to Enhanced DP or Enhanced mDP)

Port 1	Port 3	Port 2	Port 4
Tx1+ (Left TF)	Tx1- (Left TF)	ML2+ (Right TF)	ML2- (Right TF)
Rx1+ (Left TF)	Rx1- (Left TF)	ML3+ (Right TF)	ML3- (Right TF)
Tx2+ (Left TF)	Tx2- (Left TF)	ML1+ (Right TF)	ML1- (Right TF)
Rx2+ (Left TF)	Rx2- (Left TF)	ML0+ (Right TF)	ML0- (Right TF)

DP Alt Mode (Enhanced DP or Enhanced mDP to Type-C)

Port 1	Port 3	Port 2	Port 4
ML0+ (Left TF)	ML0- (Left TF)	Rx1+ (Right TF)	Rx1- (Right TF)
ML1+ (Left TF)	ML1- (Left TF)	Tx1+ (Right TF)	Tx1- (Right TF)
ML2+ (Left TF)	ML2- (Left TF)	Tx2+ (Right TF)	Tx2- (Right TF)
ML3+ (Left TF)	ML3- (Left TF)	Rx2+ (Right TF)	Rx2- (Right TF)

3. Verify that the calibration and de-embedding data are recalled and enabled
4. Evaluate the time delta (limit is 2UI, which is equivalent to 100ps)
   a) DP2.1 cable: Pass if time is < 100 ps, otherwise fail. While using 25ps (20% to 80%) rise time
   b) DP Alt Mode: Pass if time is < 100 ps, otherwise fail. While using 50ps (20% to 80%) rise time
5. Repeat steps 2 through 4 for each connection for the given DUT

5 Literature

VESA DisplayPort (DP) Standard Version 2.1a 18 December, 2023

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The Rohde & Schwarz electronics group offers innovative solutions in the following business fields: test and measurement, broadcast and media, secure communications, cybersecurity, monitoring and network testing. Founded more than 80 years ago, the independent company which is headquartered in Munich, Germany, has an extensive sales and service network with locations in more than 70 countries.

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Application Note | Method of Implementation (MOI) for DisplayPort 54 Compliance Tests
Data without tolerance limits is not binding | Subject to change