Application Note

METHOD OF IMPLEMENTATION (MOI) FOR DISPLAYPORT 8K COMPLIANCE TESTS

Products:

► R&S®ZNB

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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.

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 8k 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 (DP Standard Version 1.4a 19 April, 2018

VESA DisplayPort v1.4a PHY Layer Compliance Test Specification (PHY CTS) Revision 1.1 05 June, 2020

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	fsDP: Luxshare-ICT TFDP-V22RA or Wilder Technologies DP-TPA-R 640-0002-000 mDP: Luxshare-ICT TFDP-M21RA or Wilder Technologies mDP-TPA-R 640-0151-000 USB4 Type-C: Luxshare-ICT TF21-189G or Wilder Technologies DPC-TPA-R 640-0801-000	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 8k cable assemblies.

Compliance requirements are categorized into two measurement groups:

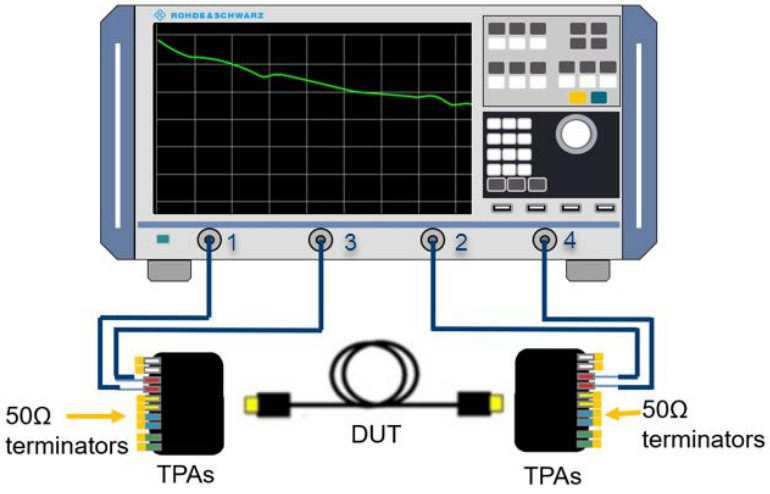
- Frequency Domain
  - ILFitAtNq Frequencies (Normative)
  - IRL (Normative)
  - Integrated Crosstalk- DP (Normative)
  - Differential-to-Common Mode Conversion (Normative)
  - Integrated Crosstalk between DP Lanes (Informative)
  - Integrated Multi-reflection (Informative)

- 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 IntePar

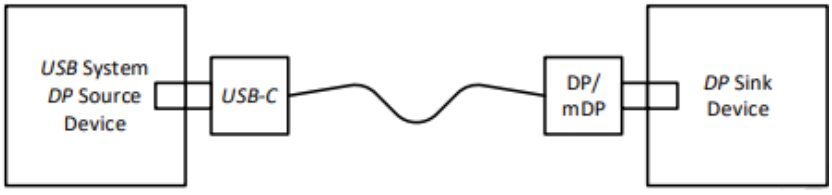
VESA provides the IntePar software tool to perform compliance verification for the DP8K specification.

1. Install MATLAB Runtime Library R2014b (8.4) at MATLAB Runtime - MATLAB Compiler - MATLAB (mathworks.com)
2. Download the IntePar files at VESA - IntePar_DP_R0p9.zip
3. Download the IntePar configuration files “DP2DP_input_rev0p9_RZ90_1p35-2p7-4p05GHz.mat” and “C2DP_input_rev0p9_RZ90_1p35-2p7-4p05GHz.mat” from VESA website here and here
4. Export the contents of the .zip file.
5. Review ‘Brief User Guides.pdf’
6. Run ‘IntePar_DP_R0p9.exe’

3.4 DisplayPort Alt Mode Explained

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

Source Device		Sink Device		Source Device		Sink Device	
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

3.5 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.
2. Press “FILE” > “Open Recall...”.
3. 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:

DP8k_Frequency.znxml

DP8k_Differential_Impedance_Profile.znxml

DP8k_Intra-pair_Skew.znxml

DP8k_Inter-pair_Skew.znxml

Overview about the setting in the different recall files:

Recall file	Start	Stop	Step size	IFBW	Power
DP8k_Frequency.znxml	10 MHz	20 GHz	10 MHz	1 kHz	0 dBm
DP8k_Differential_Impedance_Profile.znxml	10 MHz	20 GHz	10 MHz	1 kHz	0 dBm
DP8k_Intra-pair_Skew.znxml	10 MHz	20 GHz	10 MHz	1 kHz	0 dBm
DP8k_Inter-pair_Skew.znxml	10 MHz	20 GHz	10 MHz	1 kHz	0 dBm

3.6 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.

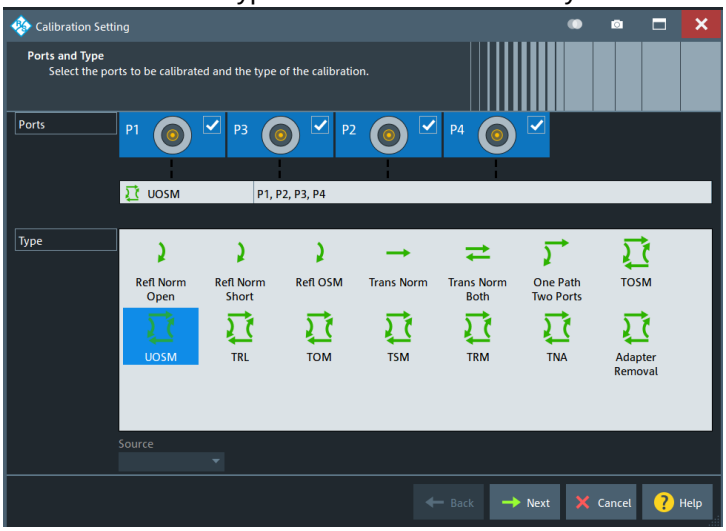
3.6.1 Coaxial calibration

3.6.1.1 Calibration with automated calibration unit

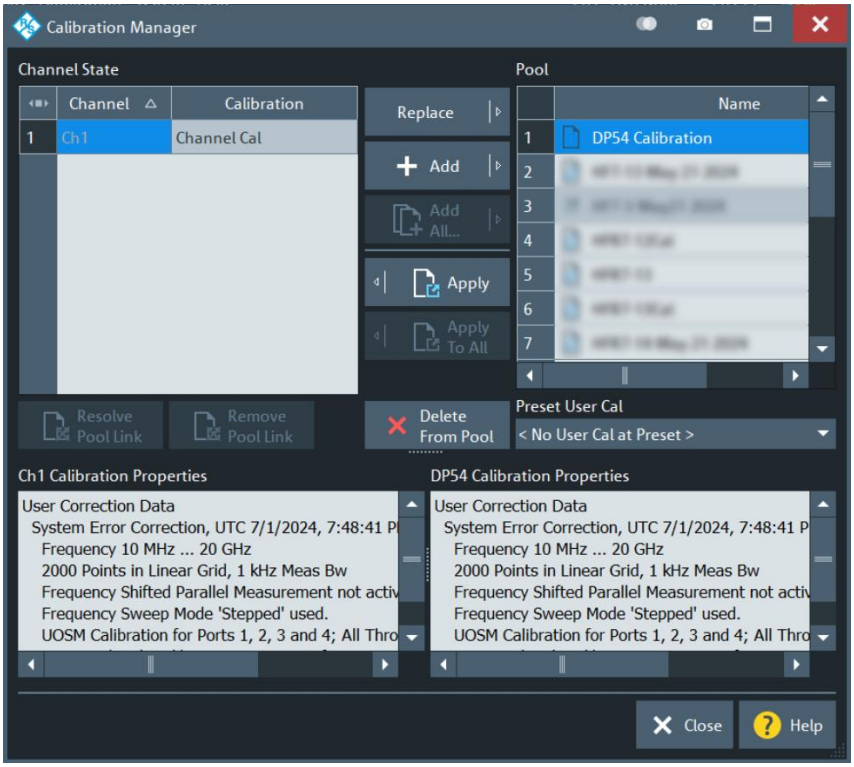
The most convenient method to perform coaxial calibration is to use an automated calibration unit. Doing so will complete calibration faster and more efficiently.

4. Make sure the active setup is the “Calibration” setup.
5. On the front panel, press “CAL”
6. Select “Start… (Cal Unit)”

7. Select Calibration Type UOSM for best accuracy.



8. Follow the calibration wizard during the whole process.
9. After the calibration is completed, select “Cal” > “Use Cal”.
10. Enter the “Cal Manager…”.
11. Add the calibration to the Pool and enter a meaningful name for the calibration.

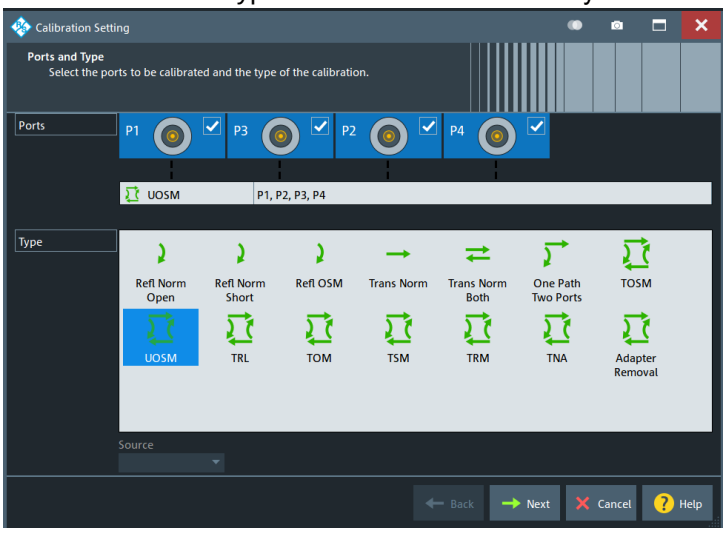


3.6.1.2 Manual calibration with calibration kit

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

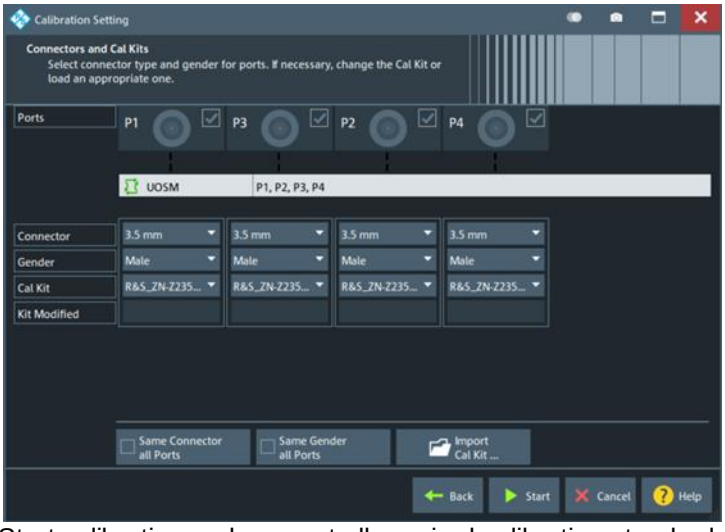
1. Make sure the active setup is the “Calibration” setup.

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.

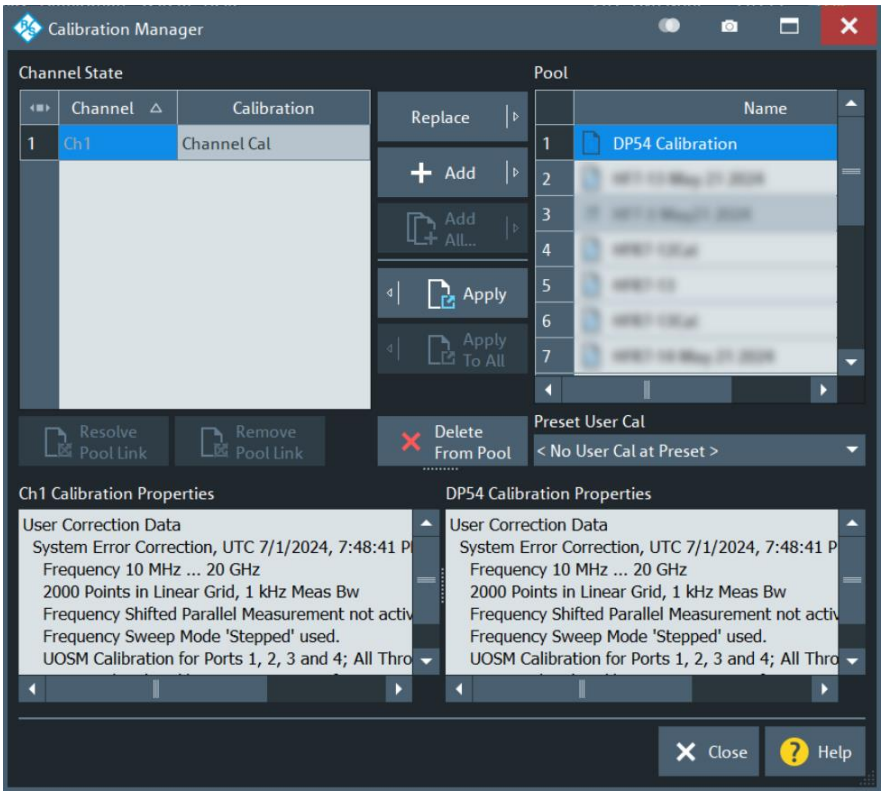
3.6.1.3 Recalling coaxial calibration

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. Locate the saved CAL in the CAL Pool and click on it
4. 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.*



3.6.2 De-embedding test fixtures

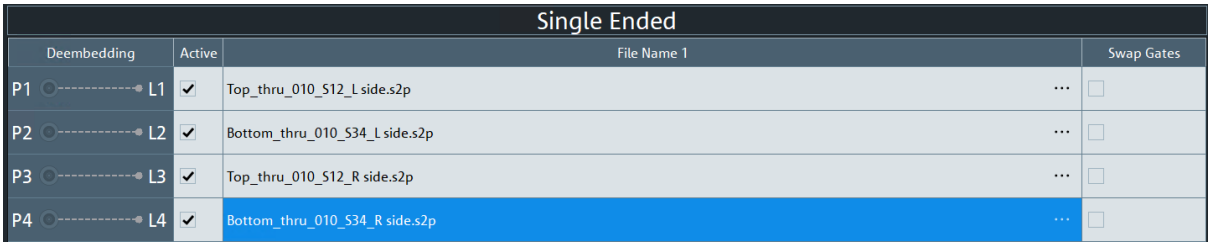
After coaxial calibration is completed, the next step is to remove the effect of the test fixtures that will be used during testing. This is accomplished by using files provided by the test fixture supplier or collecting de-embedding files from the fixtures manually. This section describes both methods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

3.6.2.1 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) which are delivered together with the test fixtures



3.6.2.2 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"

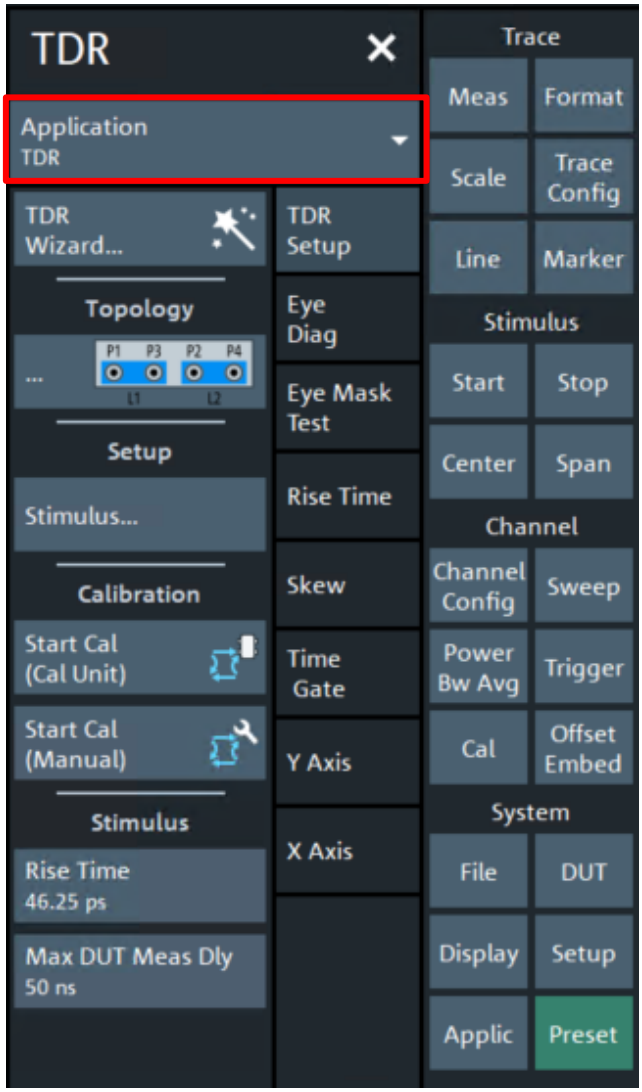
Fixture de-embedding is now properly applied.

3.7 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”.
2. In the “Application” dialog, select “TDR”.



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

3. 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)
- ► Differential-to-Common-Mode Conversion (Scd)

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

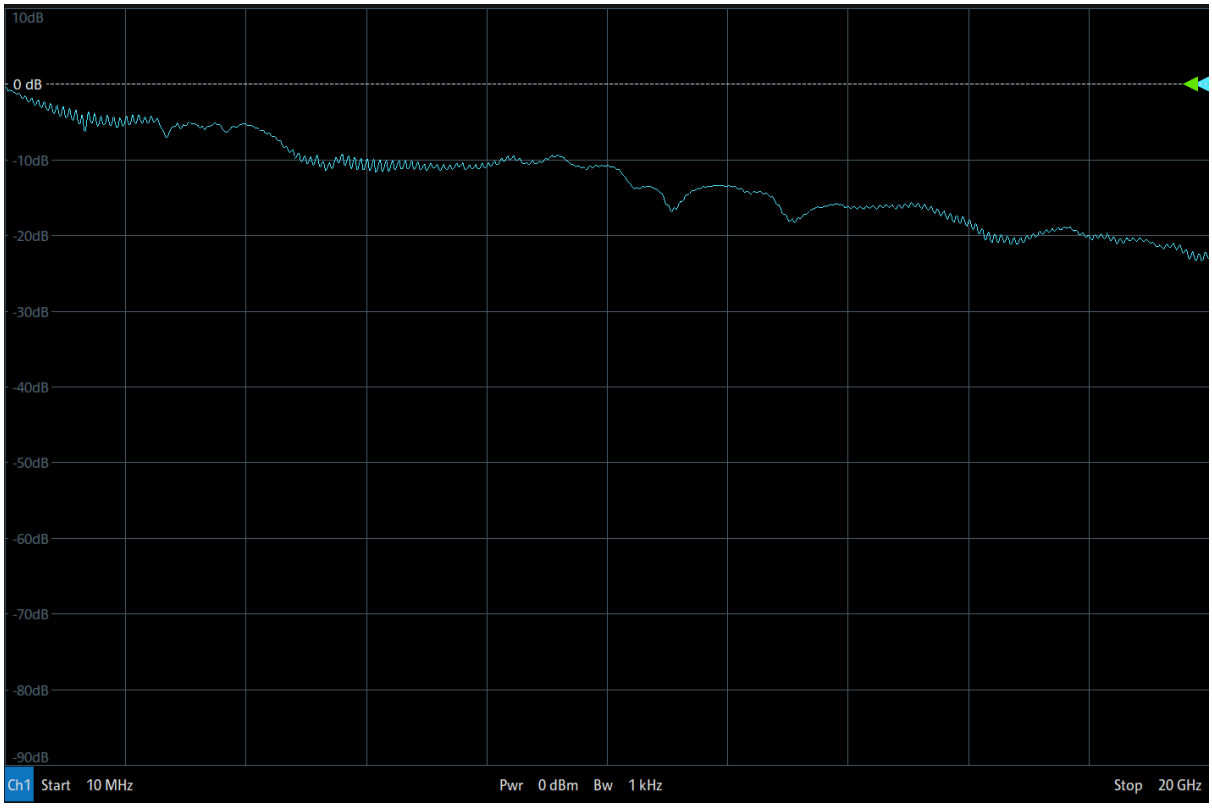
- ► Integrated Crosstalk between DP Lanes (INEXT/IFEXT)
- ► Integrated Multi-reflection (IMR)

4.1.1 Test Procedure

The tests above for DP8k utilize the IntePar. The compliance tool can be downloaded here: VESA - IntePar_DP_R0p9.zip

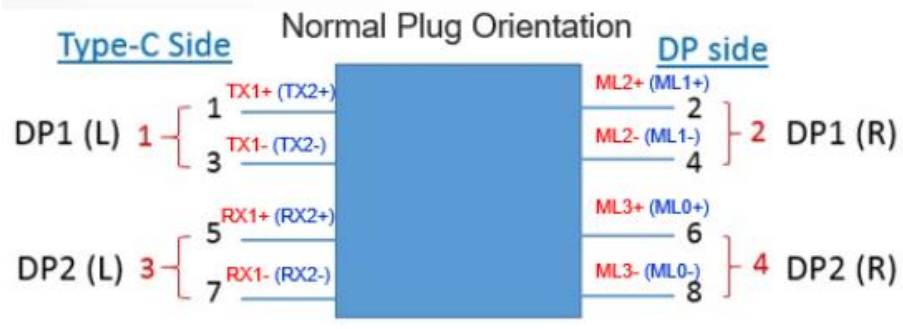
Note: Terminate all unused 3.5mm ports with 50Ω loads/matches.

6. Recall the setup file “DisplayPort8k.znxml”



Note: The normative parameters of interest (ILfitatNq, IMR, etc.) cannot be processed natively in the network analyzer firmware.

7. Verify that the calibration and de-embedding data is recalled and enabled
8. 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 4 to the respective test fixture ports.



Connections required for DP to DP, mDP to mDP, or DP to mDP:

ML0 and ML1 signals

#	Test Item	Port 1	Port 3	Port 2	Port 4	Filename
1	DP1(L) DP1(R) [1,2,3,4]	ML0+ (Left TF)	ML0- (Left TF)	ML0+ (Right TF)	ML0- (Right TF)	IL_ML0.s4p
2	DP2(L) DP2(R) [5,6,7,8]	ML1+ (Left TF)	ML1- (Left TF)	ML1+ (Right TF)	ML1- (Right TF)	IL_ML1.s4p

#	Test Item	Port 1	Port 3	Port 2	Port 4	Filename
3	DP1(L) DP2(L) [1,3,5,7]	ML0+ (Left TF)	ML0- (Left TF)	ML1+ (Left TF)	ML1- (Left TF)	NEXT_L_ML0_to_L_ML1.s4p
4	DP1(R) DP2(R) [2,4,6,8]	ML0+ (Right TF)	ML0- (Right TF)	ML1+ (Right TF)	ML1- (Right TF)	NEXT_R_ML0_to_R_ML1.s4p
5	DP1(L) DP2(R) [1,3,6,8]	ML0+ (Left TF)	ML0- (Left TF)	ML1+ (Right TF)	ML1- (Right TF)	FEXT_L_ML0_to_R_ML1.s4p
6	DP1(R) DP2(L) [2,4,5,7]	ML0+ (Right TF)	ML0- (Right TF)	ML1+ (Left TF)	ML1- (Left TF)	FEXT_R_ML0_to_L_ML1.s4p

ML2 and ML3 signals

#	Test Item	Port 1	Port 3	Port 2	Port 4	Filename
1	DP1(L) DP1(R) [1,2,3,4]	ML2+ (Left TF)	ML2- (Left TF)	ML2+ (Right TF)	ML2- (Right TF)	IL_ML2.s4p
2	DP2(L) DP2(R) [5,6,7,8]	ML3+ (Left TF)	ML3- (Left TF)	ML3+ (Right TF)	ML3- (Right TF)	IL_ML3.s4p
3	DP1(L) DP2(L)	ML2+ (Left TF)	ML2- (Left TF)	ML3+ (Left TF)	ML3- (Left TF)	NEXT_L_ML2_to_L_ML3.s4p
4	DP1(R) DP2(R) [2,4,6,8]	ML2+ (Right TF)	ML2- (Right TF)	ML3+ (Right TF)	ML3- (Right TF)	NEXT_R_ML2_to_R_ML3.s4p
5	DP1(L) DP2(R) [1,3,6,8]	ML2+ (Left TF)	ML2- (Left TF)	ML3+ (Right TF)	ML3- (Right TF)	FEXT_L_ML2_to_R_ML3.s4p
6	DP1(R) DP2(L) [2,4,5,7]	ML2+ (Right TF)	ML2- (Right TF)	ML3+ (Left TF)	ML3- (Left TF)	FEXT_R_ML2_to_L_ML3.s4p

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

TX1 and RX1 signals (normal plug orientation)

#	Test Item	Port 1	Port 3	Port 2	Port 4	Filename
1	DP1(L) DP1(R) [1,2,3,4]	TX1+ (Left TF)	TX1- (Left TF)	ML2+ (Right TF)	ML2- (Right TF)	IL_TX1.s4p
2	DP2(L) DP2(R) [5,6,7,8]	RX1+ (Left TF)	RX1- (Left TF)	ML3+ (Right TF)	ML3- (Right TF)	IL_RX1.s4p
3	DP1(L) DP2(L)	TX1+ (Left TF)	TX1- (Left TF)	RX1+ (Left TF)	RX1- (Left TF)	NEXT_L_TX1_to_L_RX1.s4p
4	DP1(R) DP2(R) [2,4,6,8]	ML2+ (Right TF)	ML2- (Right TF)	ML3+ (Right TF)	ML3- (Right TF)	NEXT_R_ML2_to_R_ML3.s4p
5	DP1(L) DP2(R) [1,3,6,8]	TX1+ (Left TF)	TX1- (Left TF)	ML3+ (Right TF)	ML3- (Right TF)	FEXT_L_TX1_to_R_ML3.s4p
6	DP1(R) DP2(L) [2,4,5,7]	ML2+ (Right TF)	ML2- (Right TF)	RX1+ (Left TF)	RX1- (Left TF)	FEXT_R_ML2_to_L_RX1.s4p

TX2 and RX2 (normal plug orientation)

#	Test Item	Port 1	Port 3	Port 2	Port 4	Filename
1	DP1(L) DP1(R) [1,2,3,4]	TX2+ (Left TF)	TX2- (Left TF)	ML1+ (Right TF)	ML1- (Right TF)	IL_TX2.s4p
2	DP2(L) DP2(R) [5,6,7,8]	RX2+ (Left TF)	RX2- (Left TF)	ML0+ (Right TF)	ML0- (Right TF)	IL_RX2.s4p
3	DP1(L) DP2(L)	TX2+ (Left TF)	TX2- (Left TF)	RX2+ (Left TF)	RX2- (Left TF)	NEXT_L_TX2_to_L_RX2.s4p
4	DP1(R) DP2(R) [2,4,6,8]	ML1+ (Right TF)	ML1- (Right TF)	ML0+ (Right TF)	ML0- (Right TF)	NEXT_R_ML1_to_R_ML0.s4p
5	DP1(L) DP2(R) [1,3,6,8]	TX2+ (Left TF)	TX2- (Left TF)	ML0+ (Right TF)	ML0- (Right TF)	FEXT_L_TX2_to_R_ML0.s4p
6	DP1(R) DP2(L) [2,4,5,7]	ML1+ (Right TF)	ML1- (Right TF)	RX2+ (Left TF)	RX2- (Left TF)	FEXT_R_ML1_to_L_RX2.s4p

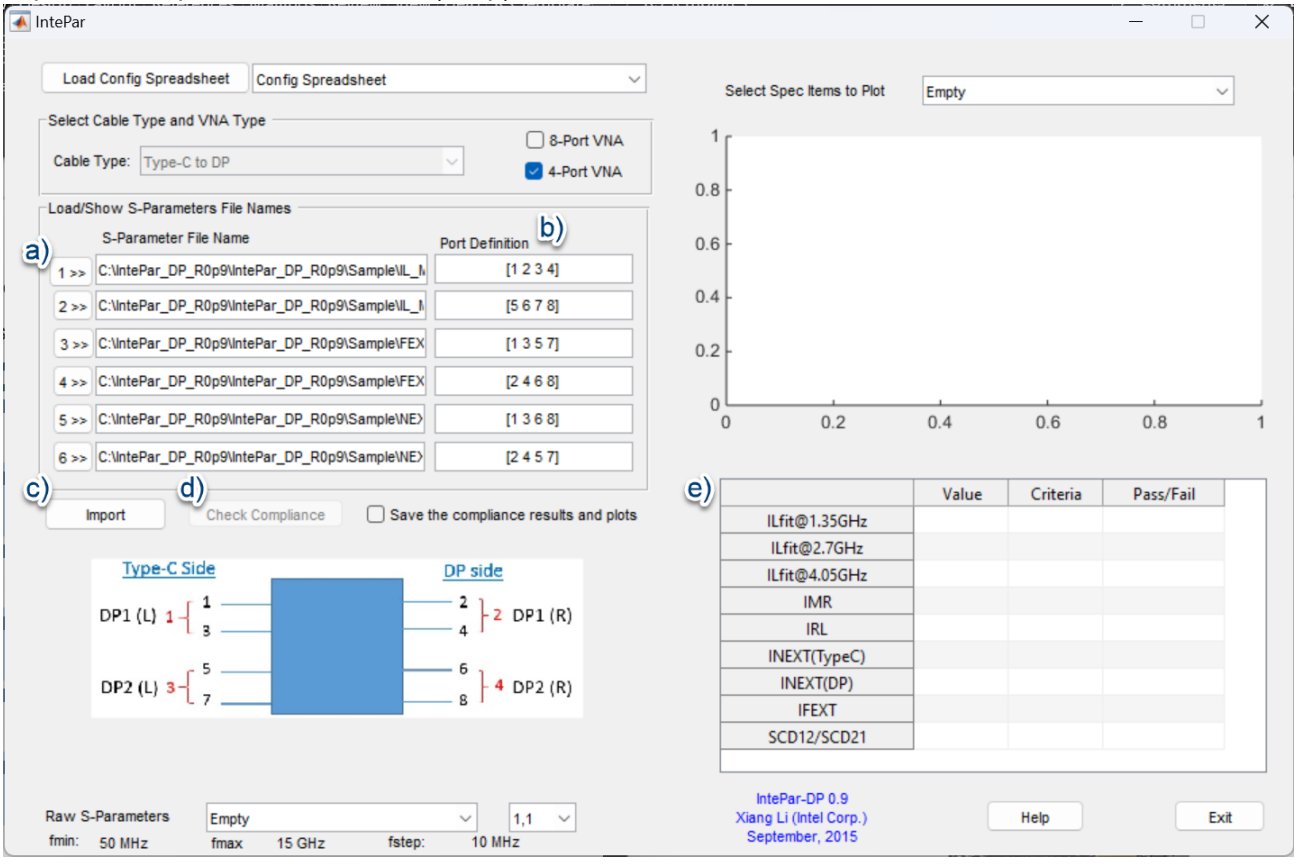
b) After an acquisition is complete, select “FILE” on the front panel then Select “Trace Data” > “s4p Port 1,2,3,4...”.

c) Use the name listed in the ‘Filename’ column in the above table for the file name of the exported Touchstone file.

4. Repeat step 3.a through 3.c for all 12 measurements per DUT.

5. Ensure that the correct file has been renamed to “C2DP_inputData.mat” for which DUT was tested, either the DP to DP .mat file (DP2DP_input_rev0p9_RZ90_1p35-2p7-4p05GHz.mat) or the C to DP .mat file (C2DP_input_rev0p9_RZ90_1p35-2p7-4p05GHz.mat)

6. Import the 6 4-port Touchstone files (*.s4p) to the “IntePar" software.



a) Load in S-parameter Files for DUT

b) Ensure port definition is correct, like in screenshot above

c) Press Import

d) Press Check Compliance, optionally save the compliance results and plots

e) Review results table in bottom right

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 group, the following normative tests will be performed:

- ► Differential Impedance Profile
- ► Intra-pair Skew

In this group, 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 “DP8k_DP_Differential_Impedance_Profile.znxml” or “DP8k_DP_Alt_Mode_Differential_Impedance_Profile.znxml”

2. Connect DUT to VNA

   DP 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)

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

DP Alt Mode (Type-C to DP or 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 (DP or 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

DP cable

Segment	Differential Impedance Value	Maximum Tolerance	Comment
Fixture	100 Ω	±10 Ω	Fixture should have trace lengths of no more than 50 mm (2 inches)
Connector		±10 Ω	Measurements to be made from 20% to 80% with a rise time of 50 ps
Wire Management		±10 Ω	
Cable		±5 Ω	

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

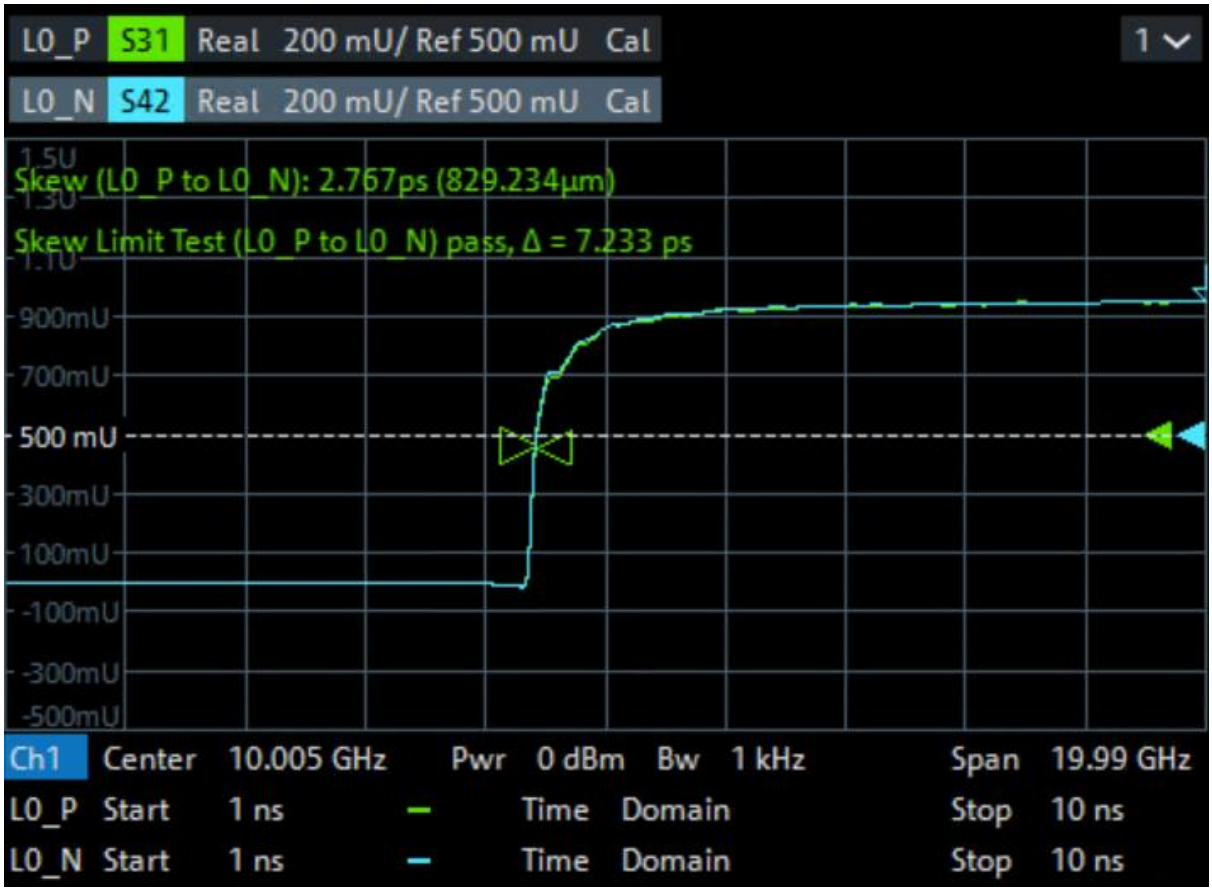
Segment	Differential Impedance Value	Maximum Tolerance	Comment
Fixture	100 Ω	±5 Ω	Fixture shall be de-embedded during measurement

Segment	Differential Impedance Value	Maximum Tolerance	Comment
USB Type-C Connector	85 Ω	±9 Ω	Measurements are to be made from 20% to 80% with a rise time of 50 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 “DP8k_Intra-pair_Skew.znxml”



2. Connect DUT to VNA

   DP 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)

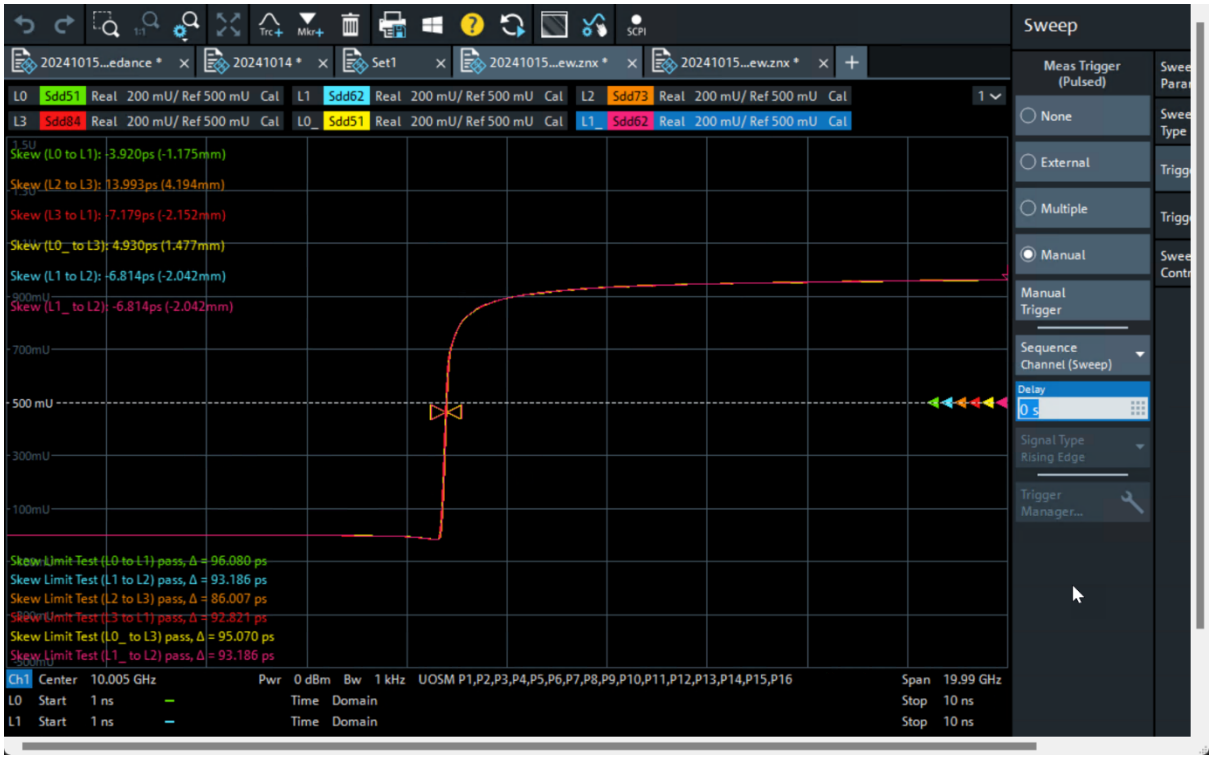
DP Alt Mode (Enhanced DP or Enhanced mDP to Type-C)

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) DP cable: Pass if time is ≤ 30 ps, otherwise fail. While using 50ps (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 “DP8k_Inter-pair_Skew.znxml”



2. Connect DUT to VNA

DP 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)

Port 1	Port 3	Port 2	Port 4
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 246.91ps)
   a) DP cable: Pass if time is < 246.91ps, otherwise fail. While using 50ps (20% to 80%) rise time
   b) DP Alt Mode: Pass if time is < 246.91ps, 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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1SLXXX | Version 1a | 08.2024
Application Note | Method of Implementation (MOI) for DisplayPort 8k Compliance Tests
Data without tolerance limits is not binding | Subject to change

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