Revision 1.01
Feb-24, 2017

Universal Serial Bus Type-C™ Specification Revision 1.1

Keysight Method of Implementation (MOI) for USB Type-C™ Cables Assemblies Compliance Tests Using Keysight M937XA Multiport PXIe VNA

For Type-C to Type-C Passive Cable Assemblies (High Speed Signal), Type-C to Legacy Cable Assemblies, and Type-C to Legacy Adapter Assemblies

Table of Contents

1. Revision History

Revision	Date	Remarks
01.00	2016/04/14	• Initial release • Spec 1.1 and compliance document 1.0
01.01	2017/02/24	• Updated required equipment

2. Purpose

This test procedure is provided for USB Type-C cable testing using the Keysight M937XA PXIe VNA per USB Type-C Cable and Connector Specification Revision 1.1 and Connectors and Cable Assemblies Compliance Document 1.0.
The test procedure is applied for Type-C to Type-C passive cable assemblies (High Speed Signal), Type-C to legacy cable assemblies and Type-C to legacy adapter assemblies.

3. References

- Universal Serial Bus Type-C Cable and Connector Specification Revision 1.1 (April 3, 2015)
- Universal Serial Bus Type-C Connectors and Cable Assemblies Compliance Document 1.0 (October 6, 2015)

4. Required Equipment

Description	Test Equipment	QTY
Network Analyzer	Keysight M937XA PXIe Vector Network Analyzer ➢ Either M9374A (20 GHz) or M9375A (26.5 GHz) Note: The firmware of the M937XA with revision A.03.00 or later is required for operation.	6 ea.
Network Analyzer Software	➢ Option 010 (Time-domain Analysis) ➢ Option 551 (N-port Calibrated Measurements) Note: Only QTY 1 of these options needs to be ordered for one of the six M937xA modules when using a multiport configuration.	1 ea.
PXI Chassis	Keysight M9018A or M9019A PXIe 18-slot chassis	1 ea.
PXI Controller	Keysight M9037A High-performance embedded controller ➢ Option M04 (4 GB Memory)	1 ea.

	➢ Option WE3 or WE6 (Windows Embedded Standard 7 (32 bit) or (64 bit)	
Cable kits for multiport configuration	Keysight Y1242A Cable kits for multiport configuration	5 ea.
Accessory and tool kit	Keysight Y1281A accessory and tool kit for connector removal.	1 ea.
4-port ECal	Keysight N4433A (4-port, 20 GHz) ➢ Option 010 (3.5 mm female connectors on all ports)	1 ea.
Test Fixture	USB Type-C official test fixtures and calibration standards	1 ea.
RF cable	3.5 mm or SMA cables of 20 GHz bandwidth or more Note: Refer to Configuration Guide of Digital Interconnect Test System Reference Solution (5992-1447EN) for cable examples.	12 ea.
50 ohm Terminator	Termination for unused differential pairs (ex. Keysight 909D-301, 3.5 mm male termination)	8 ea.
Compliance Tool	USB Type-C cable assembly compliance tool provided by USB-IF	1 ea.

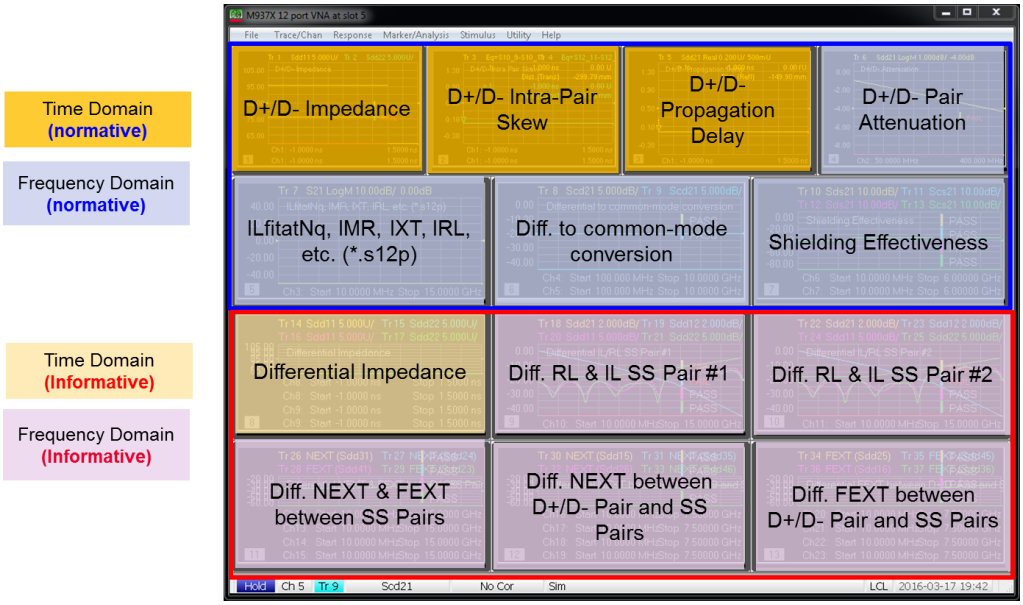
Note: Refer to the M937XA Configuration Guide (5991-4885EN) for more detail at: http://www.keysight.com/find/pxivna.

Note: Fixtures for testing USB 3.1/Type-C connectors and cable assemblies are available for purchase through Luxshare-ICT.
http://web.luxshare-ict.com/en/ProductList.php?id1=22&id2=92

5. Test Procedure

5.1. Outline of Test Procedure

1. **Test System Setup**
   - Launch a 12-port VNA
   - Automatic setup by recalling a state file
2. **Calibration**
   - ECal Calibration and De-embedding
   - Adjusting Effective Rise Time
3. **Measurements**
   1. **Time-domain Measurements**
      - D+/D- Impedance
      - D+/D- Intra-Pair Skew
      - D+/D- Propagation Delay
      - Differential Impedance (Informative)
   2. **Frequency-domain Measurements**
      - D+/D- Pair Attenuation
      - ILfitatNq, IMR, IXT, IRL, Differential to Common-Mode Conversion
      - Shielding Effectiveness
      - Differential Insertion Loss (Informative)
      - Differential Return Loss (Informative)
      - Differential NEXT & FEXT between SS Signal Pairs (Informative)
      - Differential NEXT & FEXT between D+/D- Pair and SS Signal Pairs (Informative)

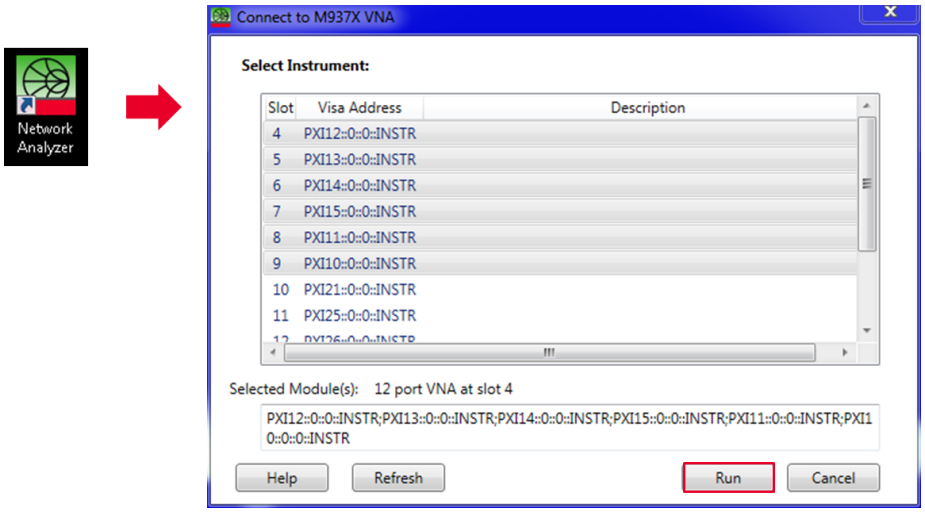


5.2. Test System Setup

This section describes how to set up parameters by recalling a state file of the 12-port M937XA that includes all the measurement settings necessary for USB Type-C cable assemblies (Type-C to Type-C cable assemblies, Type-C to legacy cable assemblies and Type-C to legacy adapter assemblies) compliance tests. The state file for the M937XA can be downloaded at: http:// www.keysight.com/find/pxivna_usbtype-c-cabcon

5.2.1. Launch a 12-port VNA

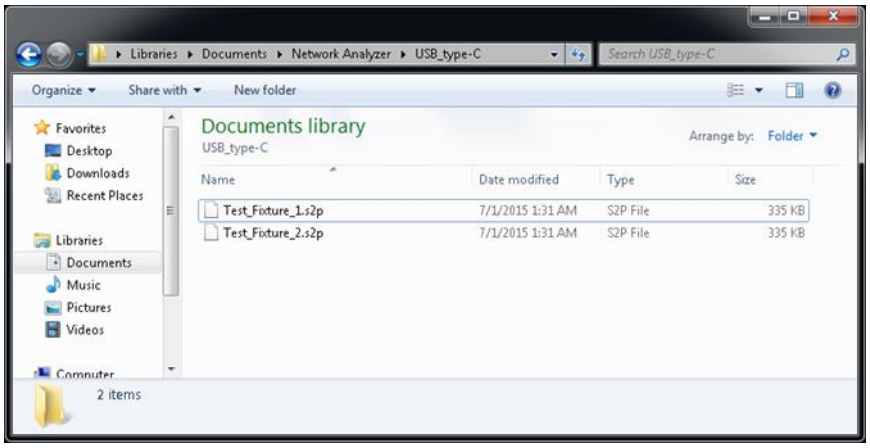
1. Double-click a shortcut icon "Network Analyzer" on desktop of the PXI controller
   For more details about installing the M937XA firmware, refer to the M937XA Startup Guide at: http://literature.cdn.keysight.com/litweb/pdf/M9370-90001.pdf
2. Select 6x PXI VNA modules to configure a 12-port VNA
3. Click "Run"



5.2.2. Save De-embedding Files

De-embedding Touchstone files of test fixtures (*.s2p) should be saved in the directory of the PXI controller in advance of recalling a state file. The file paths are pre-defined in the state file for all the measurements. The procedure of creating de-embedding files using the PLTS software is described in Appendix "Creating Fixture De-embedding Files using PLTS AFR".

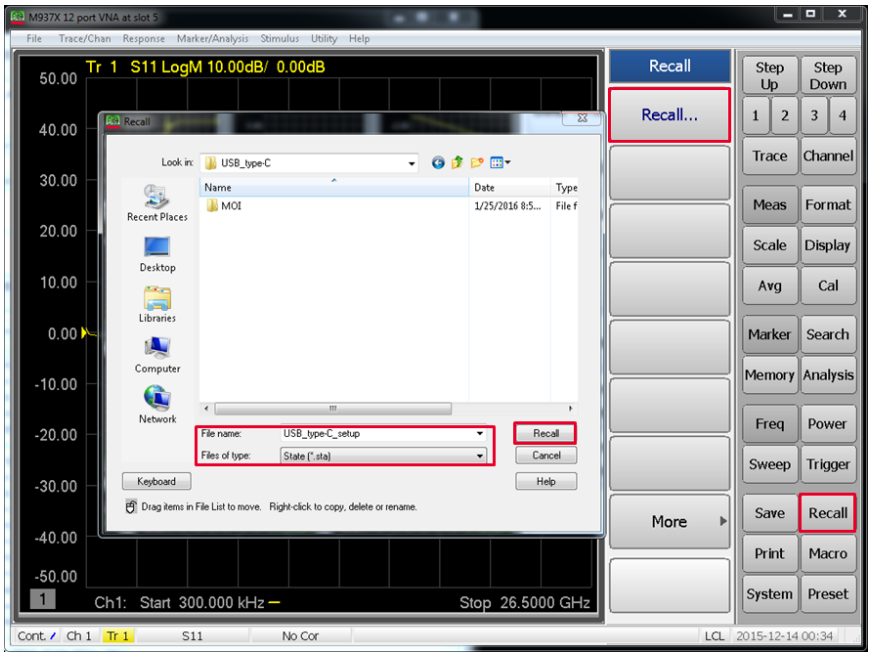
1. Rename 2-port Touchstone files of test fixtures (*.s2p) as:
   - "Test_Fixture_1.s2p" (Test Fixture - Side A)
   - "Test_Fixtures_2.s2p" (Test Fixture - Side B)
2. Save the two files under "C:/Users/Public/Documents/Network Analyzer/USB_Type-C/Test_Fixture_x.s2p" of the PXI controller



Note: In the following sections, steps using keys in Toolbar of the PXI firmware (on right screen) are highlighted in blue and **bold**, and softkeys are highlighted in **bold**.

5.2.3. Recall a State File

1. Click **Recall** > **Recall...**
2. Select "State (*.sta)" for Files of Type
3. Select a name of the state file ("USB_Type-C_Cable_HSS_ComplianceTest_for_12-port_M9474A_75A.sta")
4. Click "Recall"



Note: When the number of ports in a multiport VNA is smaller than 12, an error message is shown when recalling a state file for a 12-port VNA.

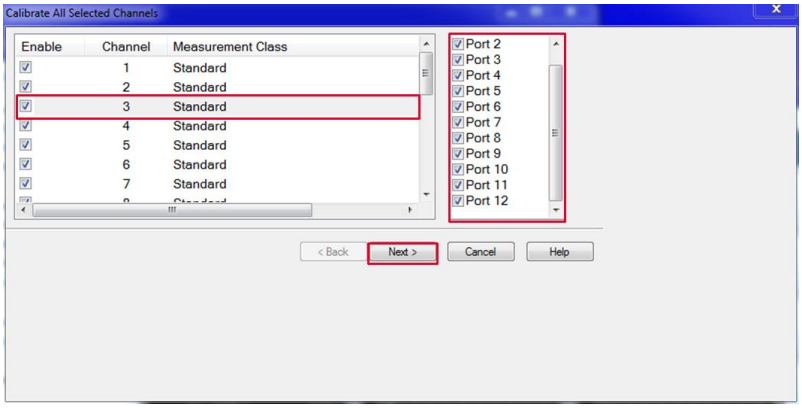
5.3. Calibration

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. The effect of test cables is removed by full multiport calibration using the ECal module. The effect of test fixture is removed by de-embedding 2-port S-parameter data (*.s2p) of each trace.

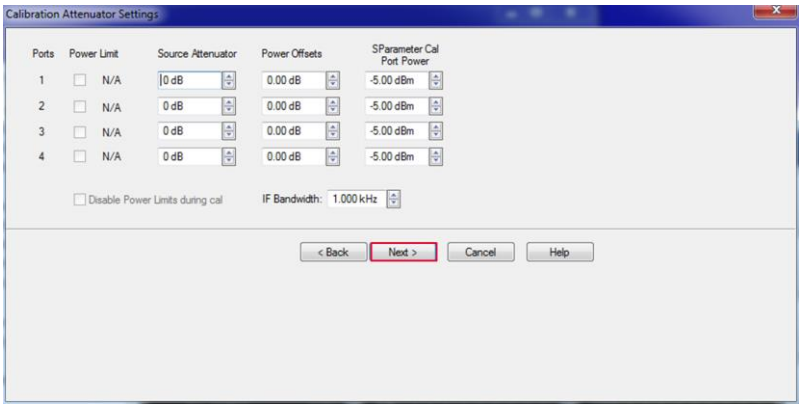
5.3.1. Perform Multiport Calibration using ECal

Full multiport calibration is performed by using the 4-port ECal Module (i.e. N4433A) at the end of RF cables connected to test ports of the M937XA multiport VNA.

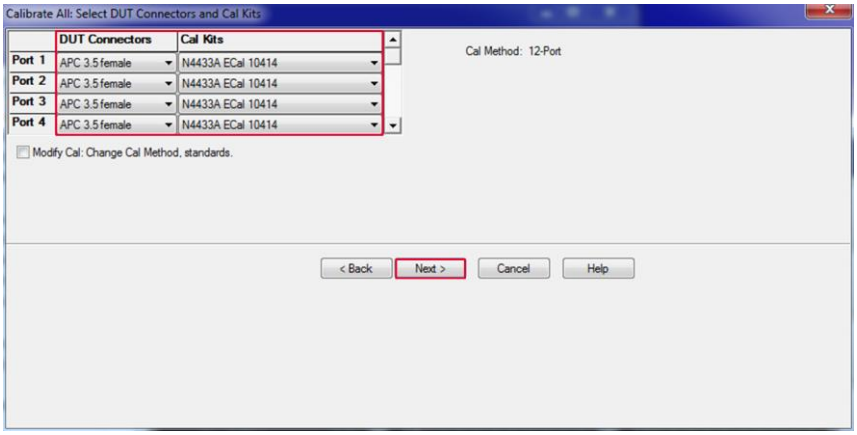
1. Click **Cal** > **Start Cal** > **Cal All Wizard…** to launch calibration wizard
2. Select Channel 3
3. Check all ports (Port 1 to Port 12) on right
4. Click “Next >”



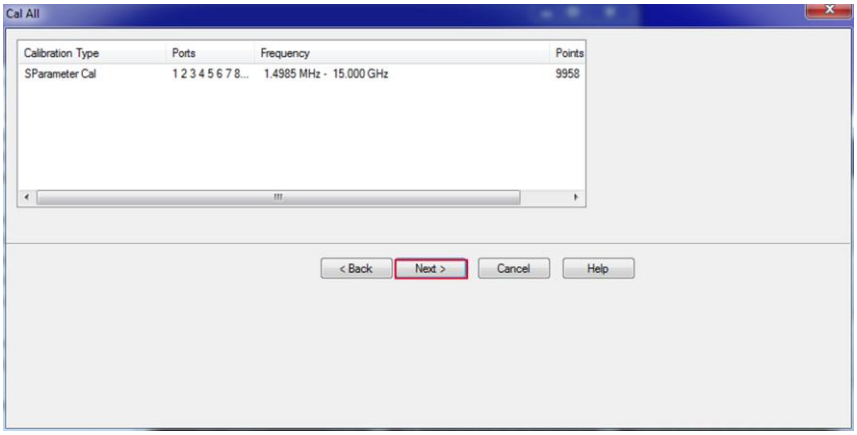
5. Click “Next >”



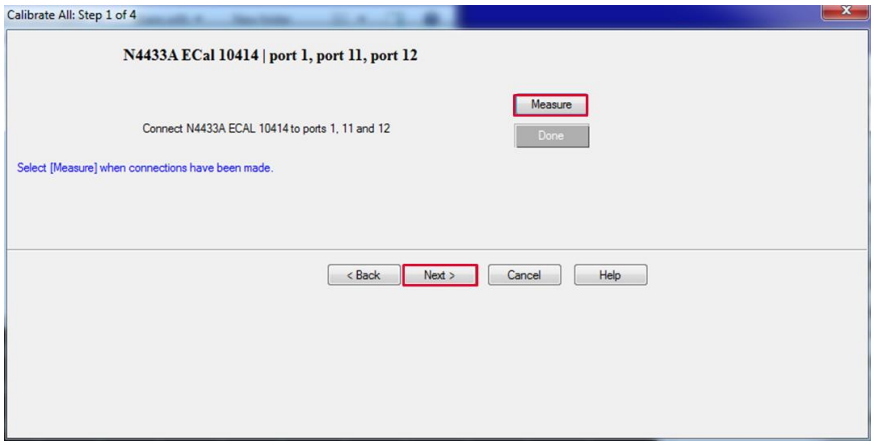
6. Select “APC 3.5 female” of DUT Connectors for all ports (Port 1 to Port 12)
7. Select “N4433A ECal xxx” of Cal Kits for all ports (Port 1 to Port 12)
8. Click “Next>”



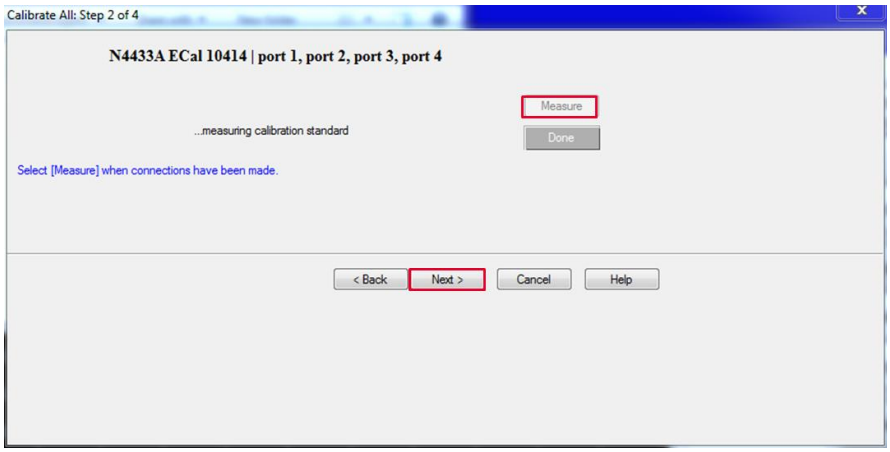
9. Click “Next>”



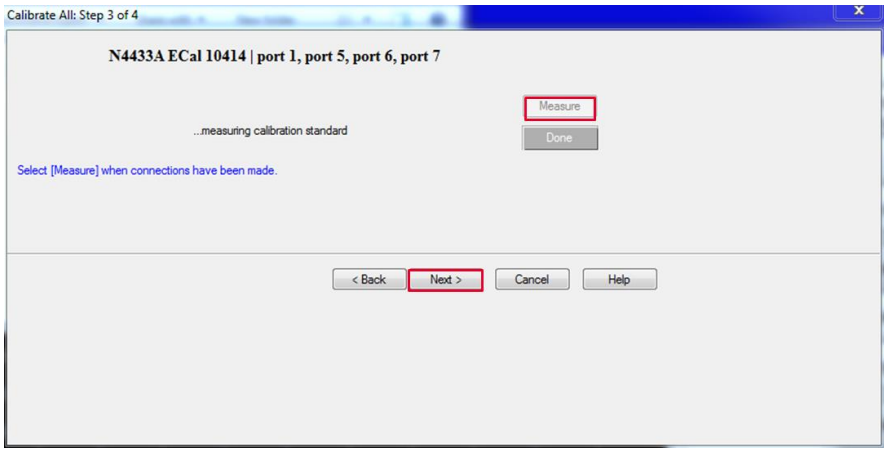
10. Connect port 1, port 11 and port 12 of the VNA to ECal ports.
11. Click “Measure” to start calibration measurements
12. Click “Next>” after the measurements are completed



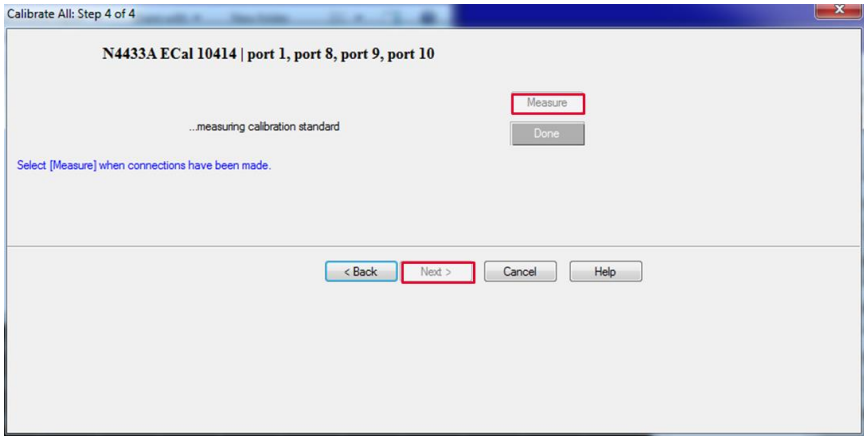
13. Connect port 1, port 2, port 3 and port 4 of the VNA to ECal ports.
14. Click “Measure” to start calibration measurements
15. Click “Next>” after the measurements are completed



16. Connect port 1, port 5, port 6 and port 7 of the VNA to ECal ports.
17. Click “Measure” to start calibration measurements
18. Click “Next>” after the measurements are completed

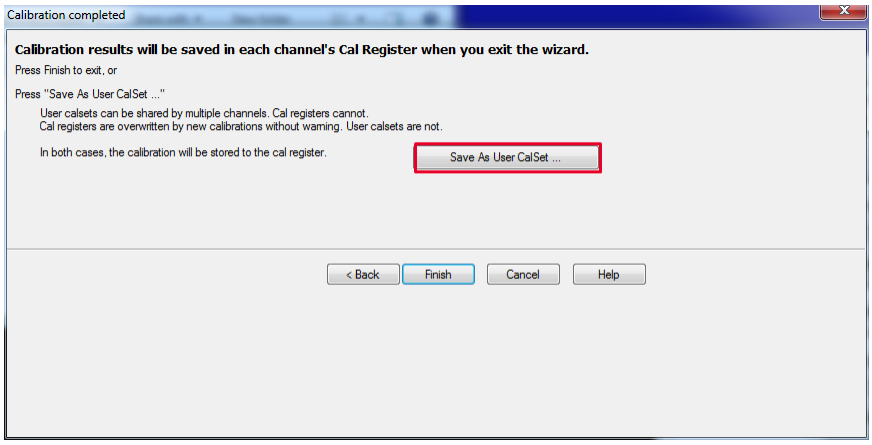


19. Connect port 1, port 8, port 9 and port 10 of the VNA to ECal ports.
20. Click “Measure” to start calibration measurements
21. Click “Next>” after the measurements are completed



22. Click “Save As User CalSet…”
23. Enter CalSet name

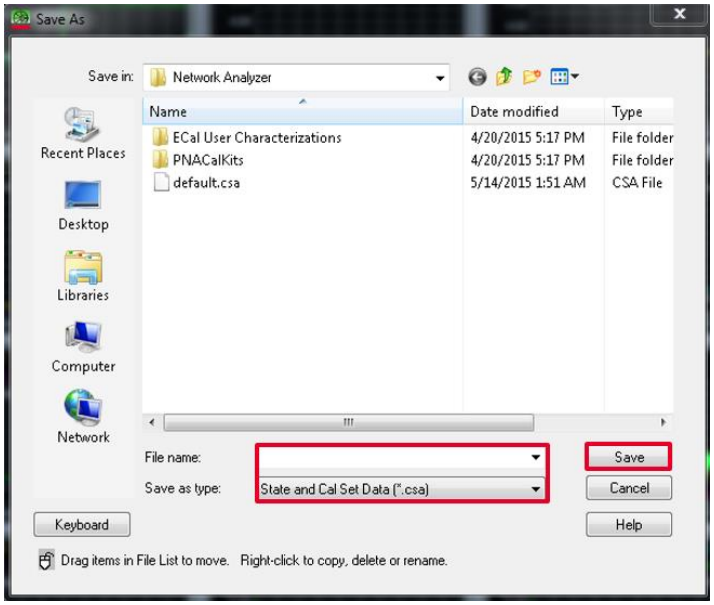
24. Click “Save”



Note: It will take 3-4 minutes to save cal set data for all measurement channels.

5.3.2. Save a State File including Cal Set Data

1. Click **Save** > **Save As...**
2. Select “State and Cal Set Data (*.csa)” of “Save as type”
3. Enter a file name
4. Click “Save”



5.3.3. Adjust Effective Rise Time

After performing multiport calibration, the effective rise time entering the USB Type-C connector pins is adjusted for the specification in time-domain measurements.

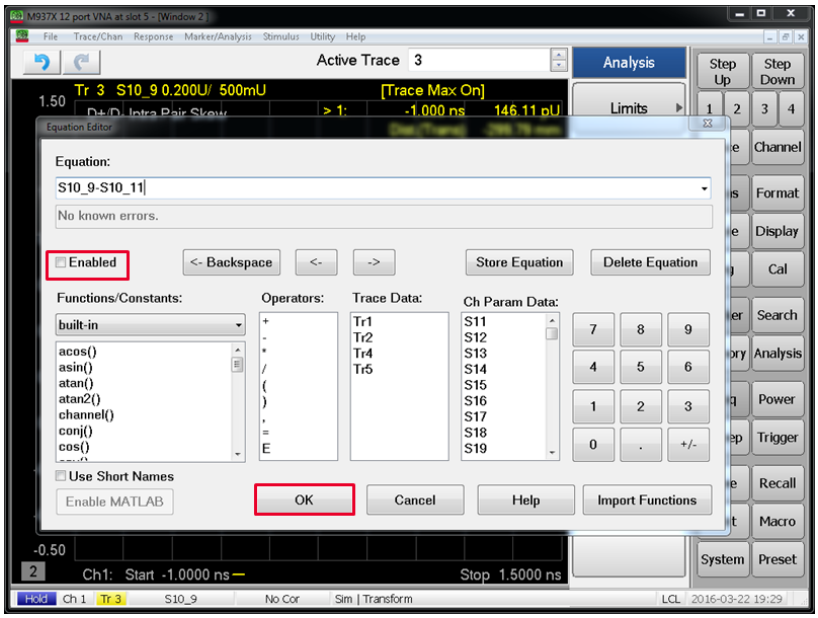
1x Thru standard is connected to the VNA’s port 1 (for SuperSpeed, SS Signal Pairs) and port 9 (for D+/D- Pair) with RF cables. Device under test (DUT) is disconnected

during the adjustment procedure.

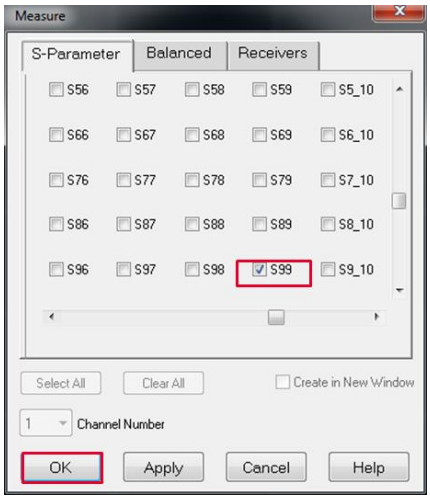
Trace #	Test Items	Rise Time %	Target Rise Time
Tr 1 & 2	D+/D- Impedance	20 – 80 %	400 ps
Tr 3 & 4	D+/D- Intra Pair Skew	20 – 80 %	400 ps
Tr 5	D+/D- Propagation Delay	20 – 80 %	400 ps
Tr 14 -17	Differential Impedance of SS Pairs (Type-C to Legacy Cable Assemblies only)	20 – 80 %	40 ps

For time-domain measurements of D+/D- Pair (Trace 1 to Trace 5), 1x Thru standard is connected to the VNA's port 9 with the RF cable.

1. Activate Trace 3
2. Click **Trace** > **Trace Max** and turn on to maximize trace
3. Click **Analysis** > **Equation Editor**
4. Uncheck "Enabled" to turn off equation editor
5. Click "OK"



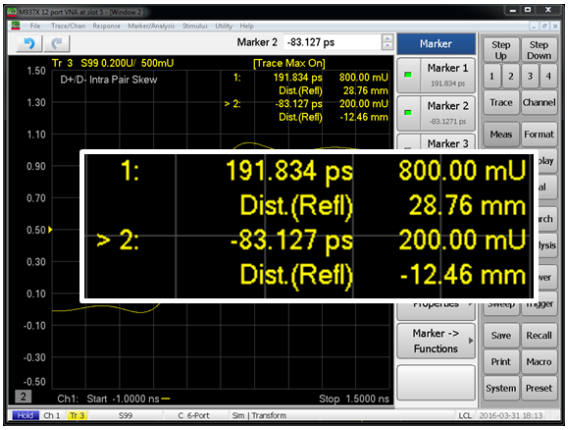
6. Click **Meas** > **S-Parameters…** and check S99
7. Click "OK"



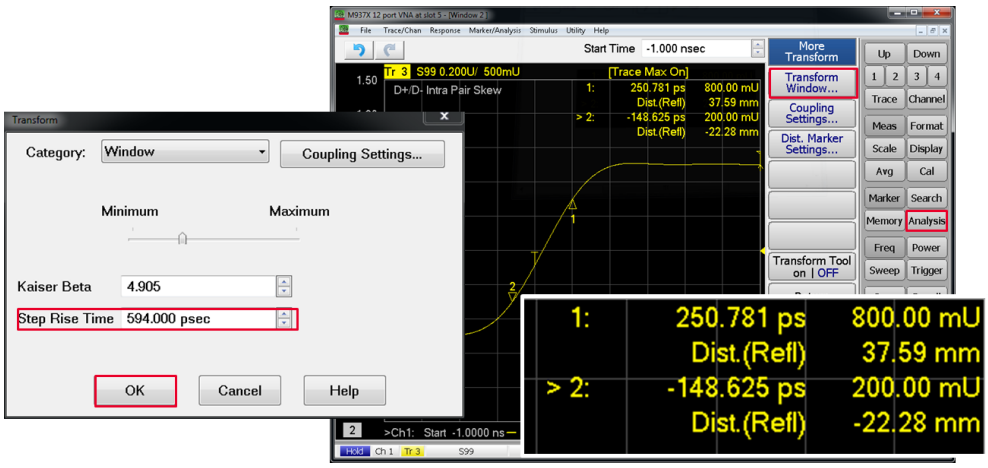
8. Click **Trigger** > **Continuous** to continue measurement sweeps

Markers should be enabled on the trace to calculate the effective rise time at 20 to 80%.

1. Click **Marker** to activate Marker 1
2. Click **Search** > **Target** and enter “0.8 U” as a target value
3. Click **Search** > **Target**
4. Click **Marker** > **Marker 2** to activate Marker 2
5. Click **Search** > **Target** and enter “0.2 U” as s target value
6. Click **Search** > **Tracking** and turn on tracking
7. Calculate delta of Marker 1 and Marker 2 in time domain (20 to 80 %, in psec)



8. Click **Analysis** > **Transform** > **More** > **Transform Window…**
9. Enter Step Rise Time until the measured delta in psec is close to the specified value (400 psec @ 20 to 80 %)



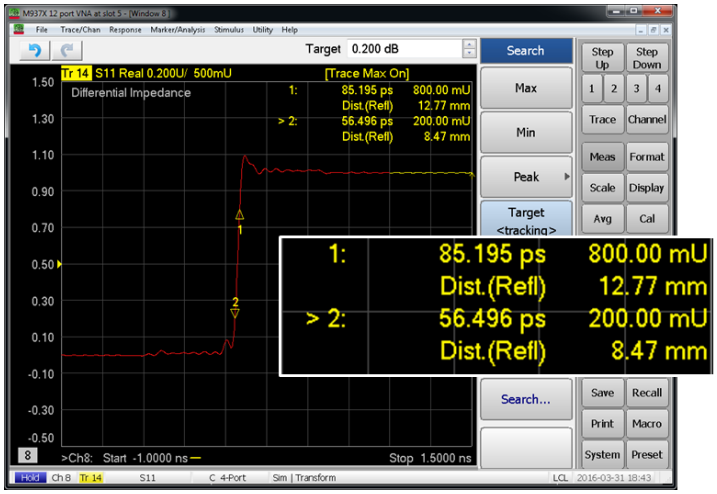
Note: Since step rise time with the PXI VNA firmware is defined as 10 to 90 % points, step rise time with the firmware should be larger than the targeted rise time specified at 20 to 80 % points (ex. 400 us).

10. Click “OK”
11. Click **Marker** and activate Marker 1
12. Click **Search** > **Target** and enter “0.5 U” as a target value
13. Click **Marker** and click the green button on left of **Marker 2** to turn off marker 2
14. Click **Analysis** > **Equation Editor**
15. Check “Enabled” to turn on equation editor
16. Click “OK”
17. Click **Trigger** > **Hold** to stop measurement sweeps
18. Activate Trace 1, 2, 4, and 5 of Channel 1 and apply obtained “Step Rise Time” of Step 10 for all traces

For differential impedance measurements of SS Pairs (Trace 14 to Trace 17), 1x Thru standard is connected to the VNA’s port 1 with the RF cable. The adjustment of rise time is done for USB Type-C to legacy cable assemblies only. For USB Type-C to Type-C cable assemblies or USB Type-C to legacy adapter assemblies, skip the following steps.

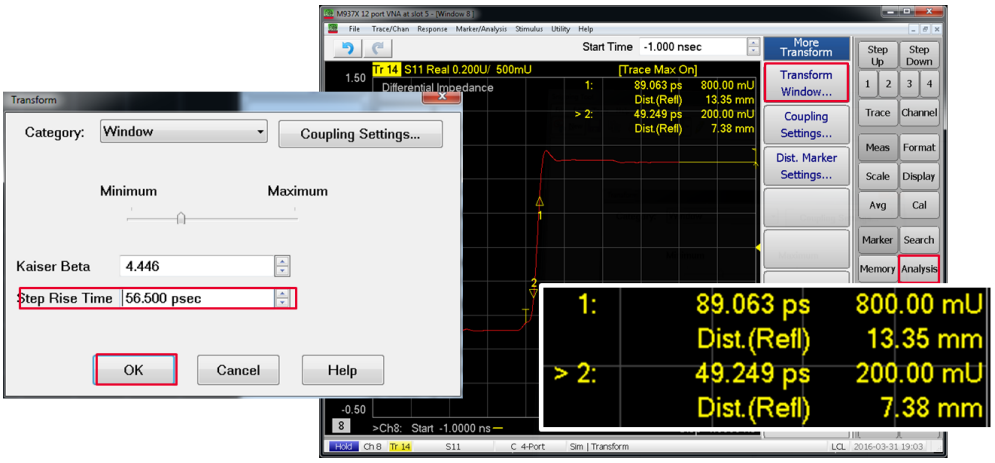
1. Activate Trace 14
2. Click **Trace** > **Trace Max** and turn on to maximize trace
3. Click **Meas** > **S11**
4. Click **Trigger** > **Continuous** to continue measurement sweeps
5. Click **Marker** to activate Marker 1
6. Click **Search** > **Target** and enter “0.8 U” as a target value
7. Click **Search** > **Tracking** and turn on tracking
8. Click **Marker** > **Marker 2** to activate Marker 2
9. Click **Search** > **Target** and enter “0.2 U” as s target value

10. Click **Search** > **Tracking** and turn on tracking
11. Calculate delta of marker1 and marker 2 in time domain (20 to 80 %, in psec)



12. Click **Analysis** > **Transform** > **More** > **Transform Window…**

13. Enter Step Rise Time until the measured delta is close to the specified value for impedance measurements (40 psec @ 20 to 80 %)
14. Click "OK"



15. Click Marker and click the green button on left of Marker 2 to turn off marker 2
16. Click **Meas** > **Balanced** > **Sdd11**
17. Click "OK"
18. Click **Trigger** > **Hold** to stop measurement sweeps
19. Activate Trace 15, 16, and 17 of Channel 8 and apply obtained "Step Rise Time" for all traces

5.4. Measurement

5.4.1. Select DUT

The setup macro is provided for selecting the USB Type-C DUT for compliance tests including USB Type-C to Type-C cable assemblies, USB Type-C to legacy cable assemblies and USB Type-C to legacy adapter assemblies. This macro automatically updates required test parameters such as limit values or port impedance depending on the specification of selected DUT.

Normative and informative test parameters for each DUT are listed below.

1. Normative

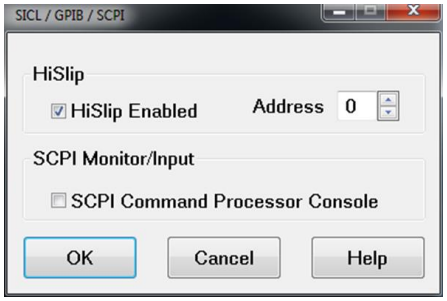
Test Parameters	Type-C to Type-C cable Assemblies	Type-C to Legacy cable Assemblies	Type-C to Legacy Adapter Assemblies
D+/D- Impedance	**Yes**	**Yes**	**Yes**
D+/D- Intra-Pair Skew	**Yes**	**Yes**	**Yes**
D+/D- Propagation Delay	**Yes**	**Yes**	**No**
D+/D- Pair Attenuation	**Yes**	**Yes**	**Yes**
ILfitatNq, IMR, IXT, IRL, Differential to Common-Mode Conversion	**Yes**	**Yes**	**Yes**
Differential to common-mode conversion	**Yes**	**Yes**	**Yes**
Shielding Effectiveness	**Yes**	**Yes**	**No**

2. Informative

Test Parameters	Type-C to Type-C cable Assemblies	Type-C to Legacy cable Assemblies	Type-C to Legacy Adapter Assemblies
Differential Impedance of SS Pairs	**No**	**Yes**	**No**
Differential Insertion Loss of SS Pairs	**Yes**	**Yes**	**Yes**
Differential Return Loss of SS Pairs	**Yes**	**No**	**Yes**
Differential NEXT & FEXT between SS Pairs	**Yes**	**Yes** (NEXT only)	**Yes** (NEXT only)
Differential NEXT & FEXT between D+/D- Pair and SS Pairs	**Yes**	**Yes**	**Yes**

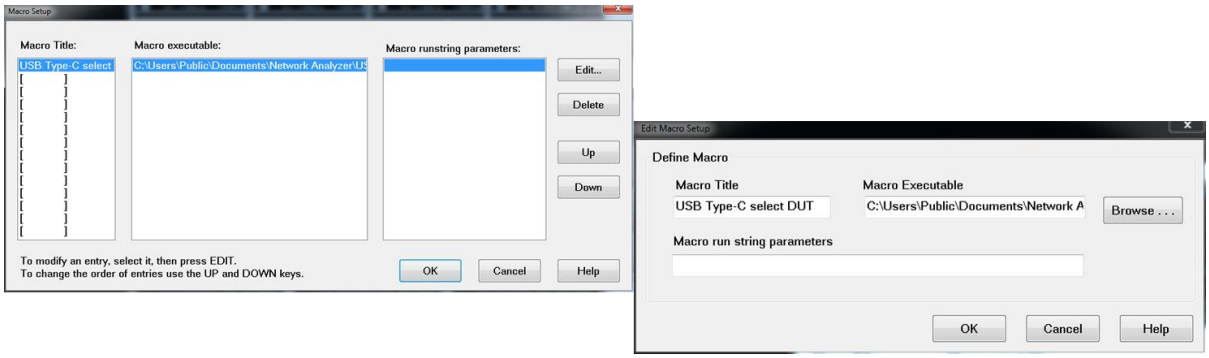
The macro requires communication with the VNA using the Hislip. For more information, refer to Keysight application note, “Programming with the M937XA PXIe Vector Network Analyzers” (product number 5992-0742EN).

1. Click **System** > **Configure** > **SICL / GPIB…**
2. Check “HiSlip Enabled”
3. Click “OK”

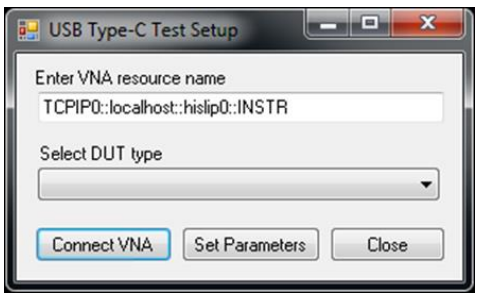


The setup macro should be saved in the directory of PXI controller. You can launch the macro by the PXI firmware by registering the file path.

1. Download macro "USB_Type-C_Select_DUT_xxxx.exe"
2. Save the file in the directory of PXI controller
3. Select **Macro** > **Macro Setup…**
4. Click "Edit…"
5. Enter "USB Type-C select DUT" as a Macro Title
6. Click "Browse…" and select file path
7. Click "Open"
8. Click "OK"
9. Click "OK"

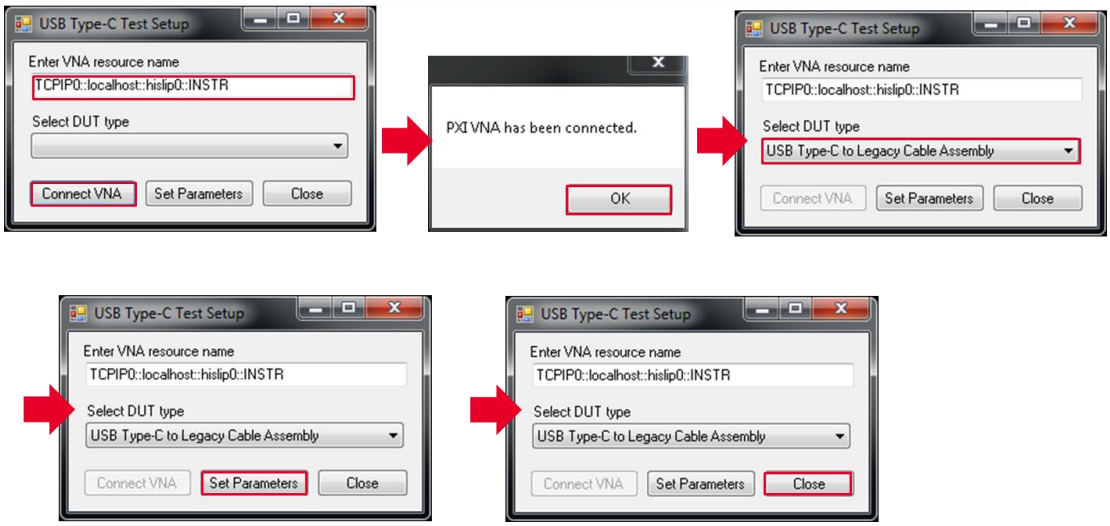


10. Activate Trace 37 of Channel 23
11. Select Macro > "USB_Type-C_Select_DUT_xxxx.exe" to launch the setup macro



12. Enter the resource name of multiport VNA (ex. TCPIP0::localhost::hislip0::INSTR)
13. Click "Connect VNA"

14. If the VNA is successfully connected by the macro, the message is shown. Then click “OK”
15. Select DUT type
    1. USB Type-C to Type-C Cable Assembly
    2. USB Type-C to Legacy Cable Assembly
    3. USB Type-C to Legacy Adapter Assembly
16. Click “Set Parameters”
17. Click “Close” after all the parameters are set up for the M937XA firmware



5.4.2. Connect VNA and test fixtures

All RF test cables from the 12-port VNA should be connected to the ports of test fixtures. Since multiport calibration is performed for all test items in the previous section, further connection & disconnection of test cables are not needed. Connection of the VNA’s ports and fixture ports are listed below. Note that unused ports of test fixtures should be terminated with 50-ohm terminations.

1. Type-C to Type-C Cable Assembly

   To cover all test items for USB Type-C to Type-C cable assemblies with five differential data lanes, it is necessary to perform two sets of 12-port measurements for: A) Tx1+/Tx1-, Rx1+/Rx1- and D+/D- differential pairs, and B) Tx2+/Tx2-, Rx2+/Rx2- and D+/D- differential pairs of cable under test.

   When the measurement for one set of pairs is completed, flip the DUT's connectors on both sides, connect to the test fixtures and perform measurements for the other set. Since the VNA's test cables remain connected to the test fixtures, re-calibration is not required.

A. Measurements of Tx1+/Tx1-, Rx1+/Rx1-, and D+/D- differential pairs

VNA Ports	Test Fixture A Side	Cable Assembly		Test Fixture B Side	VNA Ports
	Type-C (Receptacle)	Type-C (Plug)	Type-C (Plug)	Type-C (Receptacle)	
Port 1/3	Tx1+/Tx1-	Tx1+/Tx1-	Rx1+/Rx1-	Rx1+/Rx1-	Port 2/4
Port 5/7	Rx1+/Rx1-	Rx1+/Rx1-	Tx1+/Tx1-	Tx1+/Tx1-	Port 6/8
Port 9/11	D+/D-	D+/D-	D+/D-	D+/D-	Port 10/12
-	Tx2+/Tx2-	Tx2+/Tx2-	Rx2+/Rx2-	Rx2+/Rx2-	-
-	Rx2+/Rx2-	Rx2+/Rx2-	Tx2+/Tx2-	Tx2+/Tx2-	-

B. Measurements of Tx2+/Tx2-, Rx2+/Rx2-, and D+/D- differential pairs

VNA Ports	Test Fixture A Side	Cable Assembly		Test Fixture B Side	VNA Ports
	Type-C (Receptacle)	Type-C (Plug)	Type-C (Plug)	Type-C (Receptacle)	
Port 1/3	Tx1+/Tx1-	Tx2+/Tx2-	Rx2+/Rx2-	Rx1+/Rx1-	Port 2/4
Port 5/7	Rx1+/Rx1-	Rx2+/Rx2-	Tx2+/Tx2-	Tx1+/Tx1-	Port 6/8
Port 9/11	D+/D-	D+/D-	D+/D-	D+/D-	Port 10/12
-	Tx2+/Tx2-	Tx1+/Tx1-	Rx1+/Rx1-	Rx2+/Rx2-	-
-	Rx2+/Rx2-	Rx1+/Rx1-	Tx1+/Tx1-	Tx2+/Tx2-	-

2. Type-C to Legacy Cable Assembly

VNA Ports	Test Fixture A Side	Cable Assembly		Test Fixture B Side	VNA Ports
	Type-C (Receptacle)	Type-C (Plug)	Type-A/B/ Micro-B/ Mini-B (Plug)	Type-A/B/ Micro-B/ Mini-B (Receptacle)	
Port 1/3	Tx1+/Tx1-	⇔		Rx1+/Rx1-	Port 2/4
Port 5/7	Rx1+/Rx1-	⇔		Tx1+/Tx1-	Port 6/8
Port 9/11	D+/D-	⇔		D+/D-	Port 10/12
-	Tx2+/Tx2-	n/a		n/a	-
-	Rx2+/Rx2-	n/a		n/a	-

3. Type-C to Legacy Adapter Assembly

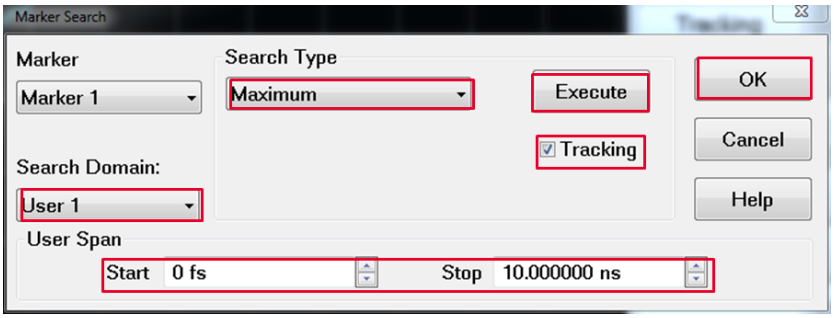
VNA Ports	Test Fixture A Side	Adapter Assembly	Test Fixture B Side	VNA Ports

	Type-C (Receptacle)	Type-C (Plug)	Type-A/B/ Micro-B/ Mini-B (Plug)	Type-A/ Micro-B (Receptacle)	
Port 1/3	Tx1+/Tx1-	⇔		Rx1+/Rx1-	Port 2/4
Port 5/7	Rx1+/Rx1-	⇔		Tx1+/Tx1-	Port 6/8
Port 9/11	D+/D-	⇔		D+/D-	Port 10/12
-	Tx2+/Tx2-	n/a		n/a	-
-	Rx2+/Rx2-	n/a		n/a	-

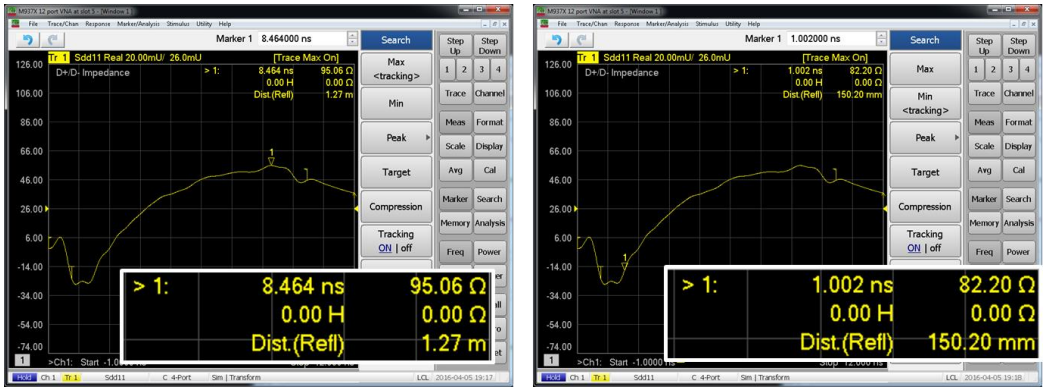
5.4.3. D+/D- Impedance

Multiple reflections from impedance mismatches cause noise at the receiver. Therefore, the impedance profile provides an indication of multiple reflection induced noise.

1. Select Trace 1 (Sdd11) of Channel 1 in Window 1
2. Click **Trace** > **Trace Max** and turn on to maximize the trace
3. Click **Trigger** > **Single** to trigger measurement sweep once
4. Click **Scale** > **Autoscale**
5. Click **Search** > **Search…**
6. Select “User 1” for Search Domain
7. Enter the span range in time domain depending on DUT’s cable length (ex. Start = 0 ns, Stop = 10 ns)
8. Select “Maximum”
9. Check “Tracking”
10. Click “Execute” to search for the max impedance value in the range
11. Click “OK”



12. Click **Search** > **Min** to search for the minimum impedance value
13. Confirm measured characteristic impedance is within 75 to 105 ohm



Note: Y-axis values on left of the screen do not represent impedance values in ohms.

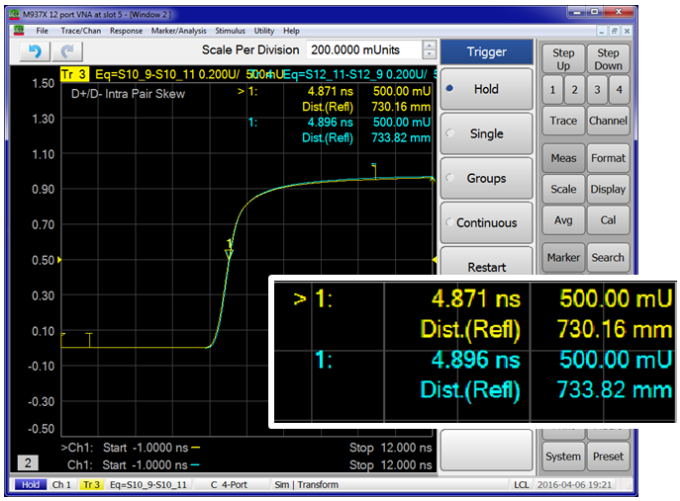
14. Repeat above steps for Trace 2 (Sdd22) of Channel 1 in Window 1

5.4.4. D+/D- Intra-Pair Skew

The intra-pair skew measurement ensures that the signal on both the D+ and D- lines of cable assembly arrive at the receiver at the same time.

1. Select Trace 3 (Eq=S10_9-S10_11) of Channel 1 in Window 2
2. Click **Display** > **Windows** > **More** > **Maximize** to maximize the window
3. Click **Trigger** > **Single** to trigger measurement sweep once
4. Calculate the delta between Trace 3 and Trace 4

   Ex.) 4.871 ns – 4.896 ns = -25 psec



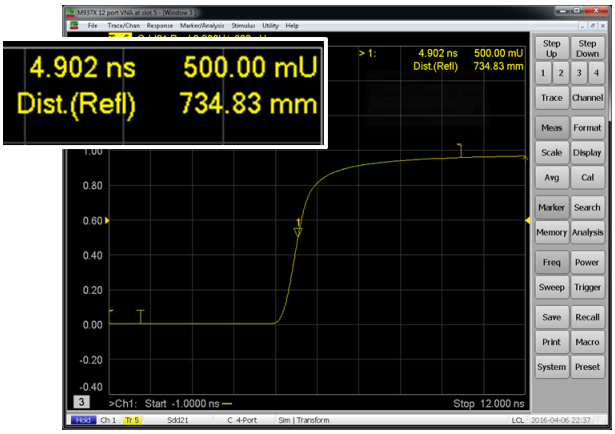
5. Confirm the measured skew of D+/D- pair is lower than 100 psec

5.4.5. D+/D- Propagation Delay

The propagation delay measurement is to verify the end-to-end propagation of the D+/D- lines of the cable/adapter assembly.

1. Select Trace 5 (Sdd21) of Channel 1 in Window 3

2. Click **Trace** > **Trace Max** and turn on to maximize the trace
3. Click **Trigger** > **Single** to trigger measurement sweep once
4. Confirm the measured delay is less than 20 nsec.



5.4.6. D+/D- Pair Attenuation

1. Select Trace 6 (Sdd21) of Channel 2 in Window 4
2. Click **Trace** > **Trace Max** and turn on to maximize the trace
3. Click **Trigger** > **Single** to trigger measurement sweep once
4. Confirm the measured Sdd21 (attenuation of D+/D- pair) is within the specification
    1. USB Type-C to Type-C cable assembly:
    2. USB Type-C to legacy cable assembly:

Start Frequency	Stop Frequency	Start Limit	Stop Limit
50 MHz	100 MHz	-1.02 dB	-1.43 dB
100 MHz	200 MHz	-1.43 dB	-2.40 dB
200 MHz	400 MHz	-2.40 dB	-4.35 dB

    3. USB Type-C to legacy adapter assembly:
    Greater or equal to -0.7 dB at 400 MHz

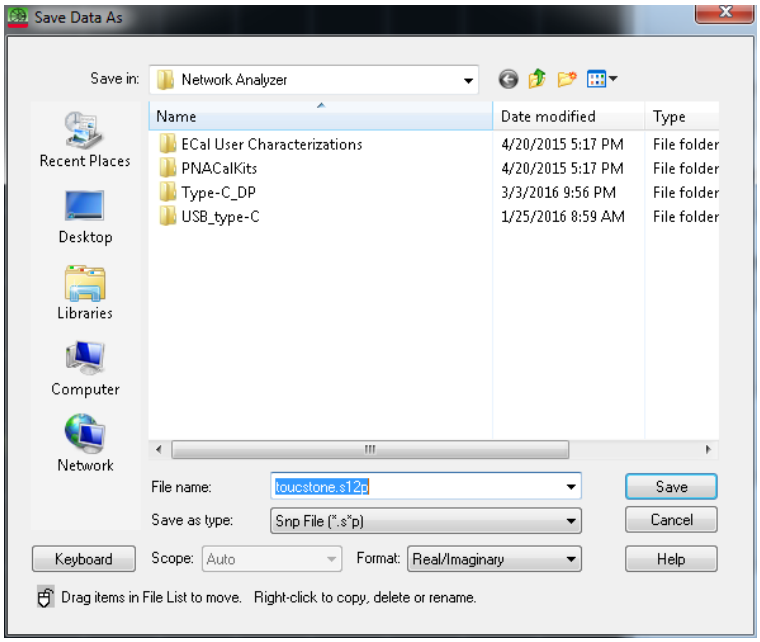
5.4.7. ILfitatNq, IMR, IXT, IRL, Differential to Common-Mode Conversion

ILfitatNq, IMR, IXT, IRL, Differential to Common-Mode Conversion performance are checked with the standard tool (*CableComp Tool*) provided by USB-IF. One 12-port Touchstone file (*.s12p) is created and saved with the PXI VNA firmware, and then imported to the compliance tool for pass/fail judgement.

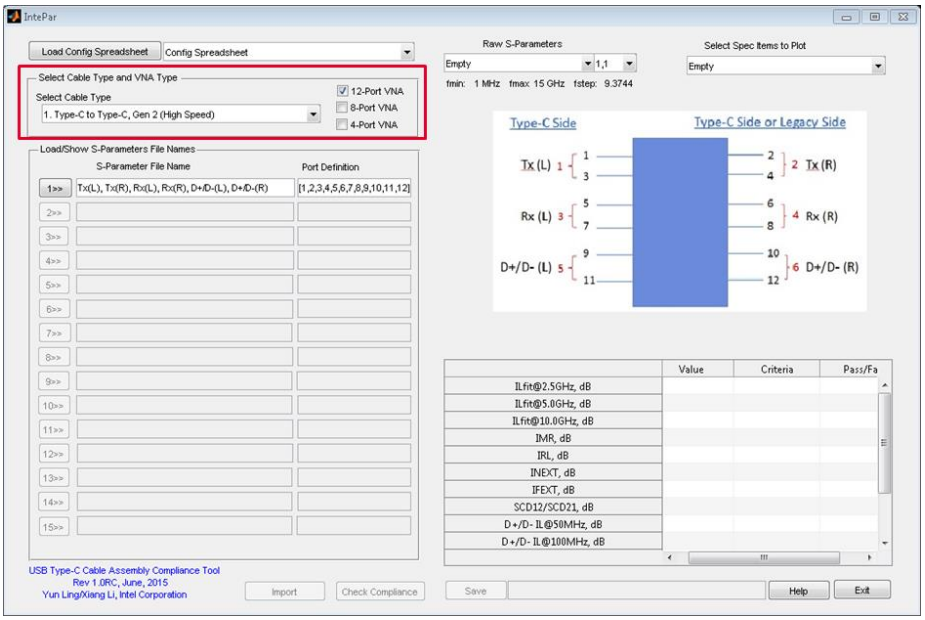
Note: The port Z conversion is turned off so the measurement is performed based on 50 ohm port impedance required by the standard tool.

1. Select Trace 7 of Channel 3 in Window 5

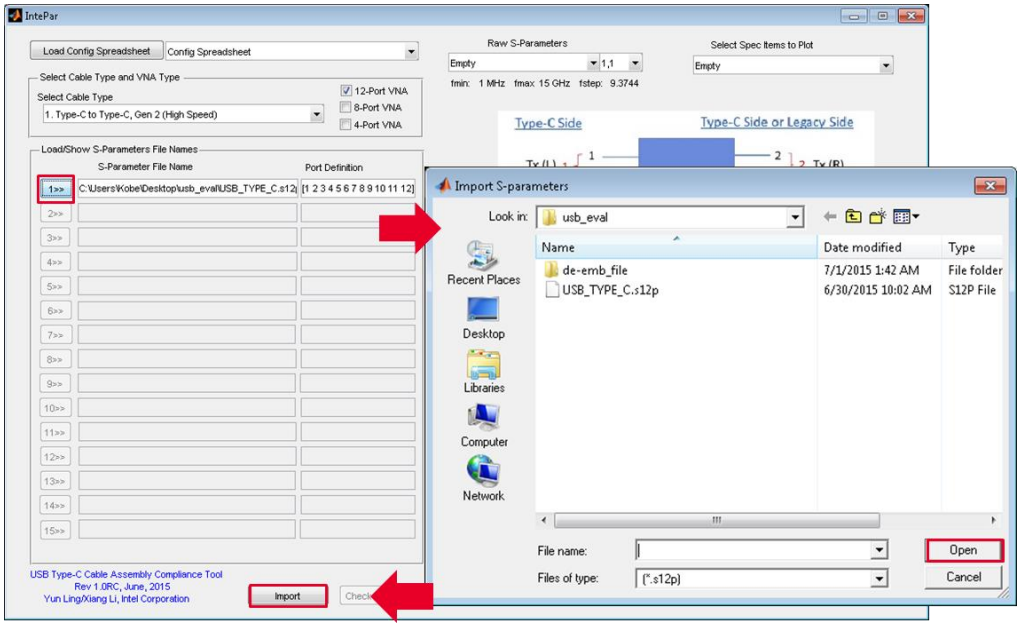
2. Click **Trigger** > **Single** to trigger measurement sweep once
3. Click **Save** > **Save Data As…**
4. Select “Snp File (*.s*p)” for “Save as type”
5. Enter File name with the file extension of “*.s12p” (ex. touchstone.s12p) to represent a 12-port Touchstone file.
6. Click “Save”



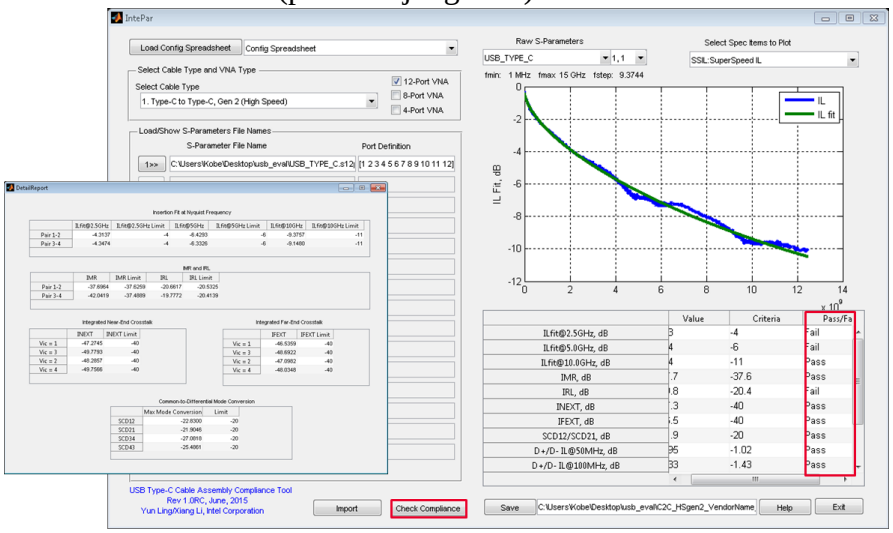
7. Launch USB Type-C Cable Assembly Compliance Tool
8. Select Cable Type (ex. “1. Type-C to Type-C, Gen 2 (High Speed)”)
9. Check “12-Port VNA”



10. Click “1>>” to load 12-port Touchstone file (*.s12p)
11. Select a file name of 12-port Touchstone file and click “Open”
12. Click “Import”



13. Click “Check Compliance”
14. Measurement results (pass/fail judgment) are shown.



5.4.8. Differential to Common-Mode Conversion

1. Select Trace 8 (Scd21) of Channel 4 in Window 6
2. Click **Trace** > **Trace Max** to maximize the trace
3. Click **Trigger** > **Single** to trigger measurement sweep once
4. Confirm measured differential to common-mode conversion (Scd21) is within the specification

1. USB Type-C to Type-C cable assembly:
2. USB Type-C to legacy cable assembly:

Start Frequency	Stop Frequency	Start Limit	Stop Limit
100 MHz	10 GHz	-20 dB	-20 dB

3. USB Type-C to legacy adapter assembly:

Start Frequency	Stop Frequency	Start Limit	Stop Limit
100 MHz	7.5 GHz	-15 dB	-15 dB

5. Repeat above steps for Trace 9 (Scd21) of Channel 5 in the same Window 6.

5.4.9. Shielding Effectiveness

Shielding effectiveness is checked with the standard tool (*CableComp Tool*) provided by USB-IF after make the measurement using the shielding effectiveness (RFI) test fixture. 4-port Touchstone files (*.s4p) are saved with the PXI VNA firmware, and then imported to the compliance tool for pass/fail judgement. Shielding effectiveness test is performed for cable assemblies such as USB Type-C to Type-C cable assemblies and USB Type-C to legacy cable assemblies.

Note: Port Z conversion is turned off so the measurement is performed based on 50 ohm port impedance setting required by the standard tool. De-embedding function to remove effect of test fixtures is also turned off.

1. Connect the VNA's port 10 to a single-ended port of RFI test fixture, port 1 & 3 to balanced ports of the test fixture.

Test Fixture	SE	Bal+	Bal-
VNA ports	Port 10 (SE)	Port 1 (Tx1+)	Port 3 (Tx1-)

2. Select Trace 10 (Sds21) of Channel 6 in Window 7
3. Click **Trace** > **Trace Max** to maximize the trace
4. Click **Trigger** > **Single** to trigger measurement sweep once
5. Confirm the measured differential model (Sds21) is within the specification
6. Repeat step 2 to step 3 for Trace 11 (Scs21) of Channel 6 in Window 7 and confirm the measured common model is within the specification
    1. USB Type-C to Type-C cable assembly:

Type	Start Frequency	Stop Frequency	Start Limit	Stop Limit
Differential Model	10 MHz	1.6 GHz	-55 dB	-55 dB
	1.6 GHz	4 GHz	-50 dB	-50 dB

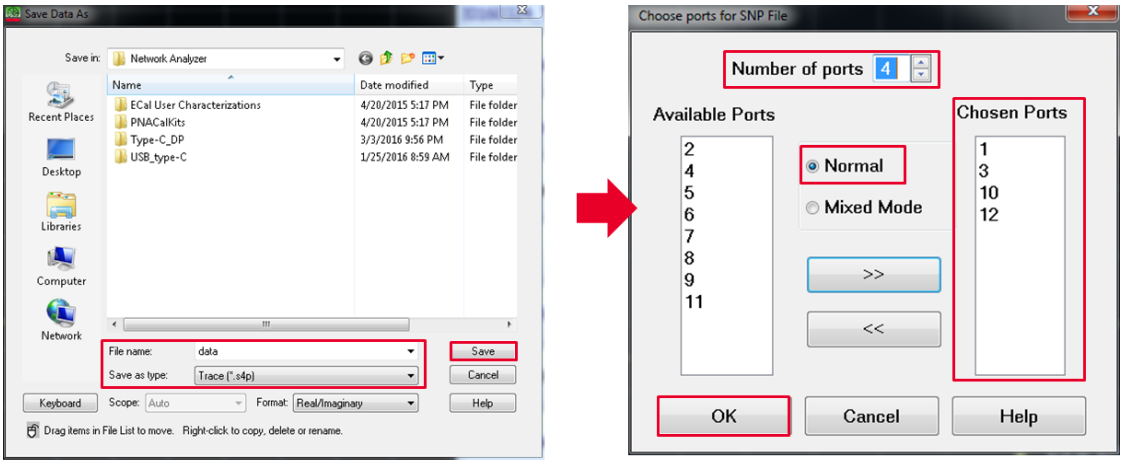
	5 GHz	6 GHz	-50 dB	-50 dB
Common Model	10 MHz	1.6 GHz	-40 dB	-40 dB
	1.6 GHz	4 GHz	-35 dB	-35 dB
	5 GHz	6 GHz	-35 dB	-35 dB

2. USB Type-C to legacy cable assembly:

Type	Start Frequency	Stop Frequency	Start Limit	Stop Limit
Differential Model	10 MHz	1.6 GHz	-49 dB	-49 dB
	1.6 GHz	4 GHz	-44 dB	-44 dB
	5 GHz	6 GHz	-44 dB	-44 dB
Common Model	10 MHz	1.6 GHz	-34 dB	-34 dB
	1.6 GHz	4 GHz	-29 dB	-29 dB
	5 GHz	6 GHz	-29 dB	-29 dB

3. USB Type-C to legacy adapter assembly: n/a

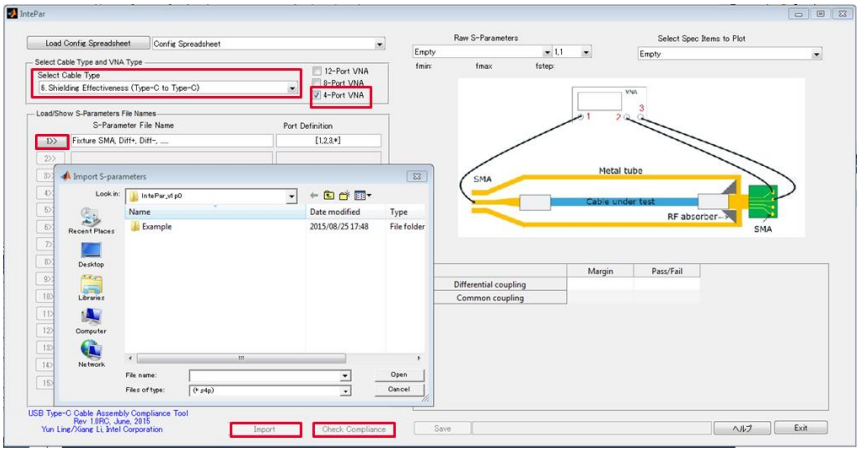
7. Click **Save** > **Save Data As…**
8. Select “Trace (*.s4p)” as data type
9. Enter File name (ex. data.s4p)
10. Click “Save”
11. Select Number of ports “4”
12. Check “Normal”
13. Chose VNA ports “1, 3, 10, 12”
14. Click “OK”



15. Launch the compliance tool
16. Select Cable Type (ex. “6. Shielding Effectiveness (Type-C to Type-C” or “7.

Shielding Effectiveness (Type-C to Legacy)")

17. Check "4-port VNA"
18. Click "1>>" and load the saved 4-port Touchstone file (*.s4p)
19. Click "Import"
20. Click "Check Compliance" for pass/fail judgement



21. Connect the VNA's ports to the RFI test fixture's ports and repeat the above steps for trace 12 and trace 13 (Scs21) of Channel 7 in Window 7.

Test Fixture	SE	Bal+	Bal-
VNA ports	Port 10 (SE)	Port 5 (Rx1+)	Port 7 (Rx1-)

Note: Select VNA's port 5, 7, 10, and 12 when saving a Touchstone file (*.s4p) at Step 13.

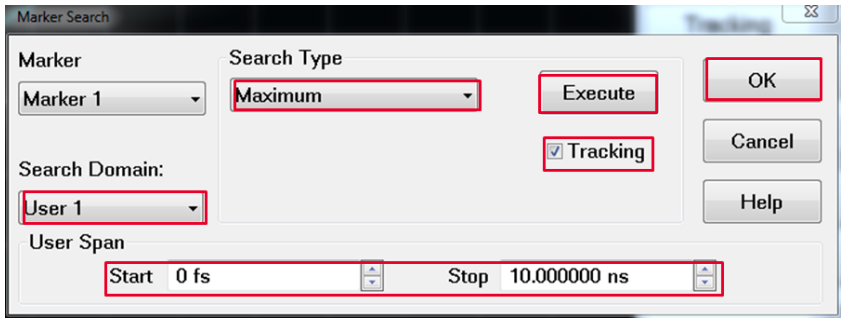
Note: Informative electrical performance targets are provided for each Type-C cable/adapter assembly. These targets are not part of the USB Type-C compliance requirements, but provided for the purpose of design guidelines and manufacturing control.

5.4.10. Differential Impedance (Informative)

Differential impedance is measured for SS Signal pairs of USB Type-C to legacy cable assembly only.

1. Select Trace 14 (Sdd11 of SS Pair #1) of Channel 8 in Window 8
2. Click **Trace** > **Trace Max** and turn on to maximize the trace
3. Click **Trigger** > **Single** to trigger measurement sweep once
4. Click **Scale** > **Autoscale**
5. Click **Search** > **Search…**
6. Select "User 1" for Search Domain
7. Enter the span range in time domain depending on DUT's cable length (ex. Start = 0 ns, Stop = 10 ns)

8. Select “Maximum”
9. Check “Tracking”
10. Click “Execute” to search for the max impedance value in the range
11. Click “OK”



12. Click **Search** > **Min** to search for the minimum impedance value
13. Confirm measured impedance is between 76 to 96 ohm
14. Repeat above steps for Trace 15 (Sdd22 of SS Pair #1) of Channel 8, Trace 16 (Sdd11 of SS Pair #2) and Tr17 (Sdd22 of SS Pair #2) of Channel 9 in Window 8

5.4.11. Differential Insertion Loss of SS Pairs (Informative)

1. Select Trace 18 (Sdd21 of SS Pair #1) of Channel 10 in Window 9
2. Click **Trace** > **Trace Max** to maximize the trace
3. Click **Trigger** > **Single** to trigger measurement sweep once
4. Confirm measured Sdd21 (differential insertion loss) is within the specification
   1. USB Type-C to Type-C cable assembly:

Start Frequency	Stop Frequency	Start Limit	Stop Limit
100 MHz	2.5 GHz	-2 dB	-4 dB
2.5 GHz	5 GHz	-4 dB	-6 dB
5 GHz	10 GHz	-6 dB	-11 dB
10 GHz	15 GHz	-11 dB	-20 dB

   2. USB Type-C to legacy cable assembly:

1) Except for USB Type-C to USB 3.1 Standard-A

Start Frequency	Stop Frequency	Start Limit	Stop Limit
100 MHz	2.5 GHz	-2 dB	-4 dB
2.5 GHz	5 GHz	-4 dB	-6 dB

2) USB Type-C to USB 3.1 Standard-A

Start Frequency	Stop Frequency	Start Limit	Stop Limit
100 MHz	2.5 GHz	-2 dB	-3.5 dB

2.5 GHz	5 GHz	-3.5 dB	-6 dB

Note: It is necessary to update the limit table for USB Type-C to USB 3.1 Standard-A. Click **Analysis** > **Limits** > **Limit Table** to show the limit table and update limit values.

3. USB Type-C to legacy adapter assembly:

Start Frequency	Stop Frequency	Start Limit	Stop Limit
10 MHz	2.5 GHz	-2.4 dB	-2.4 dB
2.5 GHz	5 GHz	-2.4 dB	-3.5 dB

5. Repeat above steps for Trace 19 (Sdd12 of SS Pair #1) of Channel 10 in Window 9, Trace 22 (Sdd21 of SS Pair #2) and Trace 23 (Sdd12 of SS Pair #2) of Channel 11 in Window 10

5.4.12. Differential Return Loss of SS Pairs (Informative)

Differential return loss is measured for SS Signal pairs of USB Type-C to Type-C cable assembly and USB Type-C to legacy adapter assembly only.

1. Select Trace 20 (Sdd11 of SS Pair #1) of Channel 10 in Window 9
2. Click **Trace** > **Trace Max** to maximize the trace
3. Click **Trigger** > **Single** to trigger measurement sweep once
4. Confirm measured Sdd11 (differential return loss) is within the specification
   1. USB Type-C to Type-C cable assembly:

Start Frequency	Stop Frequency	Start Limit	Stop Limit
100 MHz	5 GHz	-18 dB	-18 dB
5 GHz	10 GHz	-18 dB	-12 dB
10 GHz	15 GHz	-12 dB	-5 dB

   2. USB Type-C to legacy cable assembly: n/a

   3. USB Type-C to legacy adapter assembly:

Start Frequency	Stop Frequency	Start Limit	Stop Limit
10 MHz	5 GHz	-15 dB	-15 dB

5. Repeat above steps for Trace 21 (Sdd22 of SS Pair #1) of Channel 10, Trace 24 (Sdd11 of SS Pair #2) and Trace 25 (Sdd22 of SS Pair #2) of Channel 11 in Window 10

5.4.13. Differential NEXT between SS Signal Pairs (Informative)

1. Select Trace 26 (NEXT, Sdd31) of Channel 12 in Window 11
2. Click **Trace** > **Trace Max** to maximize the trace
3. Click **Trigger** > **Single** to trigger measurement sweep once
4. Confirm measured differential crosstalk (NEXT) is within the specification
    1. USB Type-C to Type-C cable assembly:

Start Frequency	Stop Frequency	Start Limit	Stop Limit
100 MHz	5 GHz	-37 dB	-37 dB
5 GHz	10 GHz	-37 dB	-32 dB
10 GHz	15 GHz	-32 dB	-25 dB

    2. USB Type-C to legacy cable assembly:

Start Frequency	Stop Frequency	Start Limit	Stop Limit
10 MHz	5 GHz	-34 dB	-34 dB

    3. USB Type-C to legacy adapter assembly:

Start Frequency	Stop Frequency	Start Limit	Stop Limit
10 MHz	2.5 GHz	-40 dB	-40 dB
2.5 MHz	5 GHz	-40 dB	-34 dB

5. Repeat above steps for Trace 27 (NEXT, Sdd24) of Channel 13 in Window 11

5.4.14. Differential FEXT between SS Signal Pairs (Informative)

Differential FEXT is measured for SS Signal pairs of USB Type-C to Type-C cable assembly only.

1. Select Trace 28 (FEXT, Sdd41) of Channel 12 in Window 11
2. Click **Trace** > **Trace Max** to maximize the trace
3. Click **Trigger** > **Single** to trigger measurement sweep once
4. Confirm measured differential crosstalk (FEXT) is within the specification
    1. USB Type-C to Type-C cable assembly:

Start Frequency	Stop Frequency	Start Limit	Stop Limit
100 MHz	5 GHz	-37 dB	-37 dB
5 GHz	10 GHz	-37 dB	-32 dB
10 GHz	15 GHz	-32 dB	-25 dB

    2. USB Type-C to legacy cable assembly: n/a

3. USB Type-C to legacy adapter assembly: n/a

5. Repeat above steps for Trace 29 (FEXT, Sdd23) of Channel 15 in Window11

5.4.15. Differential NEXT & FEXT between D+/D- Pair and SS Signal Pairs (Informative)

1. Select Trace 30 (NEXT, Sdd15) of Channel 16 in Window 12
2. Click **Trace** > **Trace Max** to maximize the trace
3. Click **Trigger** > **Single** to trigger measurement sweep once
4. Confirm measured differential crosstalk is within the specification
   1. USB Type-C to Type-C cable assembly:

Start Frequency	Stop Frequency	Start Limit	Stop Limit
100 MHz	5 GHz	-35 dB	-35 dB
5 GHz	7.5 GHz	-35 dB	-30 dB

   2. USB Type-C to legacy cable assembly:

Start Frequency	Stop Frequency	Start Limit	Stop Limit
10 MHz	5 GHz	-30 dB	-30 dB

   3. USB Type-C to legacy adapter assembly:

Start Frequency	Stop Frequency	Start Limit	Stop Limit
10 MHz	2.5 GHz	-30 dB	-30 dB

5. Repeat above steps for the following traces in Window 12 and 13.

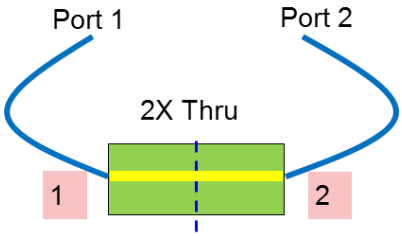
Window #	Channel #	Trace #	Trace Name
12	17	31	NEXT (Sdd35)
12	18	32	NEXT (Sdd26)
12	19	33	NEXT (Sdd46)
13	20	34	FEXT (Sdd25)
13	21	35	FEXT (Sdd35)
13	22	36	FEXT (Sdd16)
13	23	37	FEXT (Sdd36)

6. [Appendix] Creating Fixture De-embedding Files using PLTS AFR

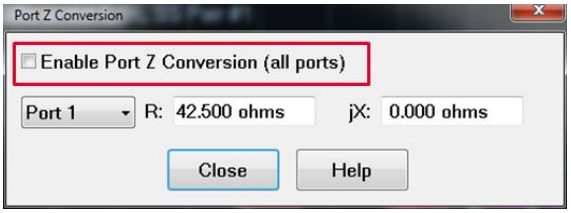
The procedure to create de-embedding Touchstone files (*.s2p) of test fixtures is introduced in the section using the Automatic Fixture Removal (AFR) function of Keysight Physical Layer Test System (PLTS).

6.1. 2x Thru Standard Measurement

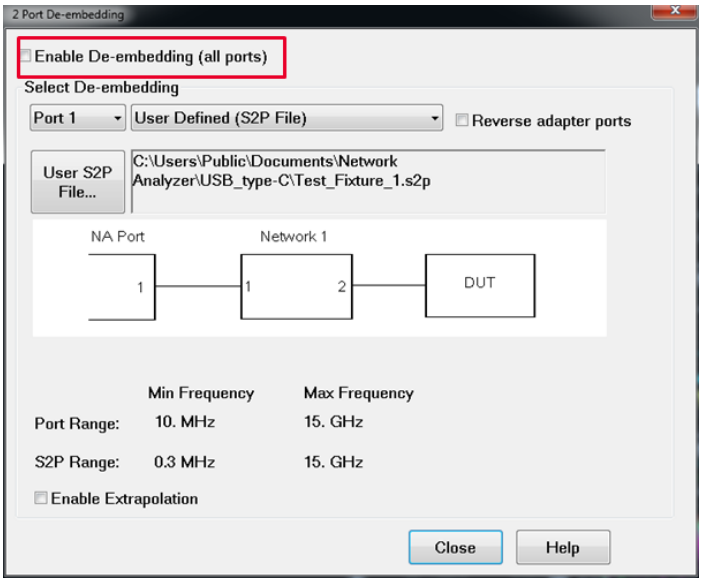
1. Recall the state file for the PXI VNA (*.sta) as described in Test System Setup section.
2. Perform multiport calibration using the ECal Module as described in Calibration section.
3. Select Channel 10 and maximize the Window 9.
4. Connect the PXI VNA's port (port 1 to 2) to 2x Thru standard with RF test cables.



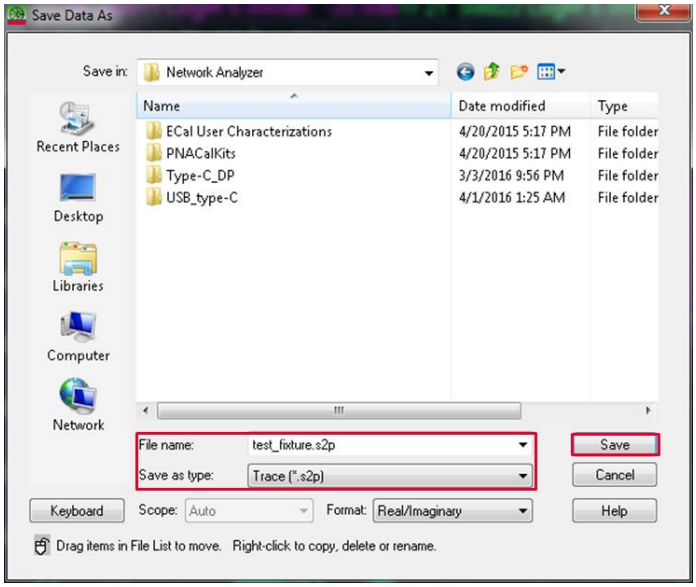
5. Click **Cal** > **Fixtures** > **More** > **Port Z Convers'n…** and uncheck "Enable Port Z Conversion (all ports)" to turn off port Z conversion



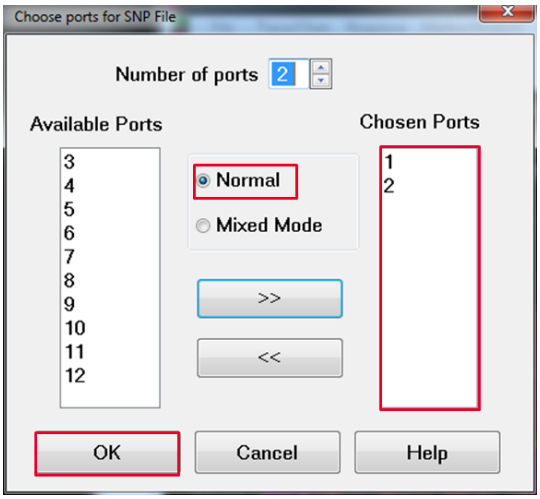
6. Click **Cal** > **Fixtures** > **2-Port Deembed…** and uncheck "Enable De-embedding (all ports)" to turn off de-embedding



7. Click **Trigger** > **Single**
8. Click **Save** > **Save Data As…**
9. Select “Trace (*.s2p)” for “Save as type”
10. Enter a file name
11. Click “Save”



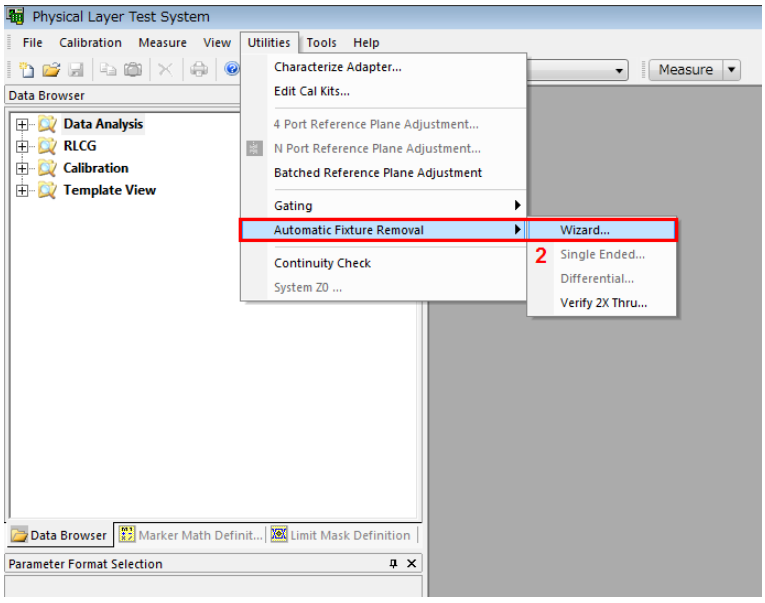
12. Check “Normal”
13. Chose port 1 and port 2 (Number of ports is “2”)
14. Click “OK”



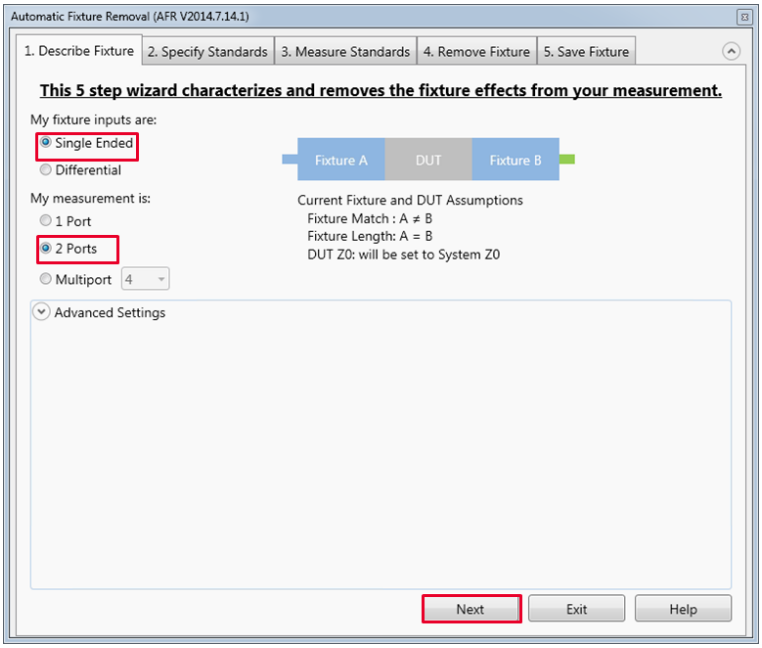
15. Click **Cal** > **Fixtures** > **More** > **Port Z Convers'n…** and check "Enable Port Z Conversion (all ports)" to turn on port Z conversion
16. Click **Cal** > **Fixtures** > **2-Port Deembed…** and check "Enable De-embedding (all ports)" to turn on de-embedding

6.2. Creating De-embedding files with AFR

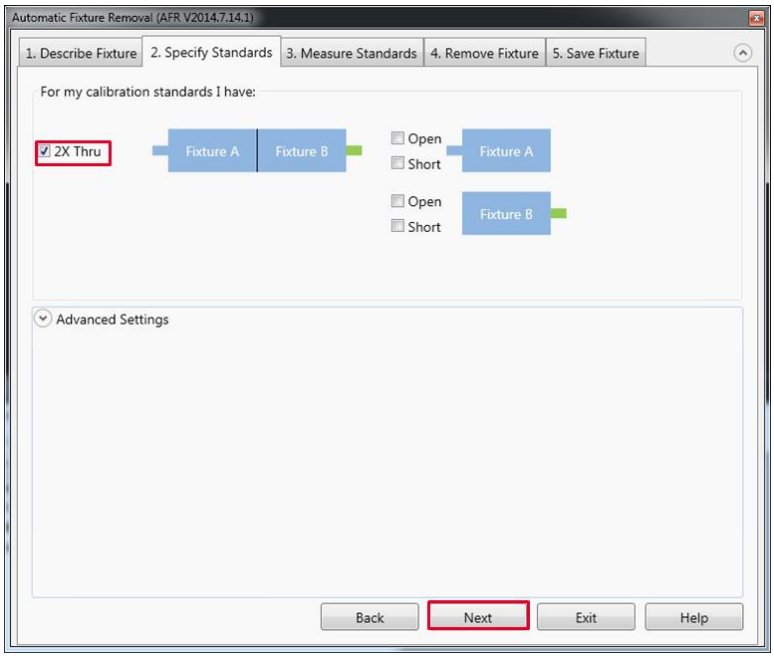
1. Launch Keysight PLTS Software
2. Click Utilities > Automatic Fixture Removal > Wizard



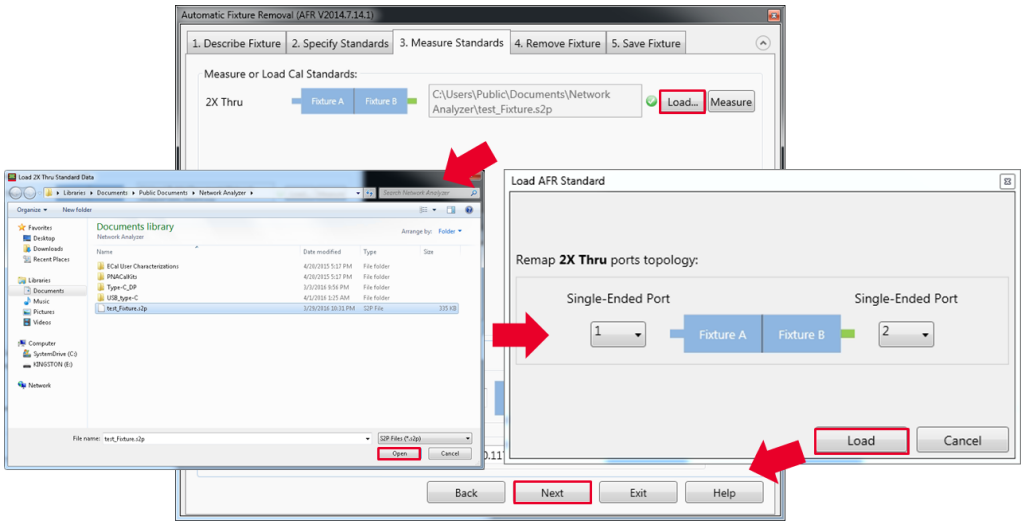
3. Select "Single Ended" and "2 Ports"
4. Click "Next"



5. Check “2X Thru”
6. Click “Next”



7. Click “Load…”
8. Select the measured Touchstone file (*.s2p) and click “Open”
9. Click “Load”
10. Click “Next



11. Select “5.Save Fixture” tab
12. Select “Touchstone” and “PNA Format”
13. Enter “Test_Fixture”
14. Click “Browse…” and enter directory (ex. “C:/Users/Public/Documents/Network Analyzer/USB_type-C”)
15. Enter a base file name, “Test_Fixture”
16. Click “Save Fixture Files” to save the two generated Touchstone files (*.s2p).
17. Click “Exit”