

IBTA VNA MOI for FDR and EDR Cable Tests

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Table 1: Modification Record

Revision	Release Date	Author	Comments
1.00	02/27/2014	Rupert Dance	<ul style="list-style-type: none"> • First draft of the VNA MOI for InfiniBand FDR and EDR Cables
1.01	03/03/2014	Rupert Dance	<ul style="list-style-type: none"> • After review and updates by Curtis Donahue and Llolsten Kaonga • Added FDR and EDR Specs • Added example plots
1.02	3/4/2014	Rupert Dance	<ul style="list-style-type: none"> • Updates based on review by Jim Vana 3M
1.03	3/21/2014	Rupert Dance	<ul style="list-style-type: none"> • Updated Initial Setup section on page 6 an fourth paragraph as per comments from Jay Diepenbrock made in Comment 9154 • Made updates as per OJ Danzy from Keysight after review by Jeff Lapak • Changed sweep parameters from 3999 → 4000 • Added the fact that N5222A, N5242A, N5224A, N5244A, N5225A, N5245A, N5227A, and N5247A network analyzers can be used to perform this test. • Added a note that Keysight recommends using a lower IFBW (10 kHz)
1.04	9/22/2014	O.J. Danzy	<ul style="list-style-type: none"> • Modified frequency collection settings to be more in-line with frequencies needed for data processing • Added Keysight Physical Layer Test System with Matlab integration for processing of data to determine pass/fail criteria • In many places changed N5244A to PNA and changed PNA-X to PNA.
1.05	4/14/2015	O.J. Danzy	<ul style="list-style-type: none"> • Added verbiage to discuss the number of points/point spacing when higher frequency measurement systems are used. See page 7 section 4.b
1.06	4/11/2017	Mike Bogochow	<ul style="list-style-type: none"> • Updated specification reference • RSD: changed Agilent to Keysight

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Software Forge

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University of New Hampshire InterOperability Laboratory (UNH-IOL)

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Jeff Lapak

ELECTRICAL SIGNALING CHARACTERISTICS

Overview:

This test procedure was written to explain how to use the Keysight PNA Network Analyzer (4 port models) to make the measurements required per the InfiniBand Architecture Specification Volume 2 Release 1.3.1 FDR and EDR cables and connectors.

References

InfiniBand Architecture Specification Volume 2 Version 1.3.1 2014-09-03-Draft

General Resources Requirements

See [Appendix A](#) for IBTA Specifications

See [Appendix B](#) for FDR measurement specifications.

See [Appendix C](#) for EDR measurement specifications.

Initial Setup for Keysight PNA Network Analyzer

This section contains notes regarding the setup for testing InfiniBand FDR and EDR cables using the Keysight PNA Network Analyzer. Based on their settings and frequency ranges, the N5222A, N5242A, N5224A, N5244A, N5225A, N5245A, N5227A, and N5247A network analyzers can also be used. These notes include calibration and other general notes pertaining to the tests outlined in this document which use the VNA.

Passive Cables - A “Passive cable” is one that is either: unequalized, equalized in connector or equalized in wire.

Limiting Active Cables – A “Limiting Active” cable is one that has active electrical components that act as nonlinear limiting devices in both connectors and may utilize either a Copper interconnect or an optical fiber. A special case of a "Half Active" cable is one that utilizes a Copper interconnect and has active electrical components that act as nonlinear limiting devices in only one of the connectors.

The following procedures are valid for both passive and active FDR and EDR cable testing except that Insertion Loss, NEXT, and FEXT measurements are not performed on Active Limiting cables.

Perform an instrument warm-up and compensation according to the user manual of the network analyzer before connecting the 3.5mm cables and Module Compliance Boards (MCB).

The **high-level description** for testing passive cables is explained below.

- 1) Compensate for temperature changes
- 2) Connect 3.5mm cables
- 3) Set PNA parameters
- 4) Calibrate the VNA
- 5) Run the test
- 6) Post process the s4p files using Matlab scripts
- 7) Post process the s4p files using Keysight Physical Layer Test System ([PLTS](#)) software

Detailed Description

- 1) Compensate for any temperature changes by connecting 50 ohm terminators on all ports and running the temperature compensation algorithm on the PNA.
- 2) Connect 4 3.5mm cables to the PNA front end.
- 3) Adjust the frequency parameters
 - Push the Freq button on the Chassis
 - Set the Start Frequency to 10 MHz
 - Set the Stop Frequency to 26.5 GHz (or higher)



Figure 1: Frequency Parameters

- 4) Set the Sweep parameters
 - a) Push the Sweep button on the Chassis
 - b) Set the Number of points to 2650 (if frequency is higher than 26.5 GHz, then use 10 MHz point spacing. For example, this would correspond to 4000 points if the stop frequency is set to 40 GHz.)

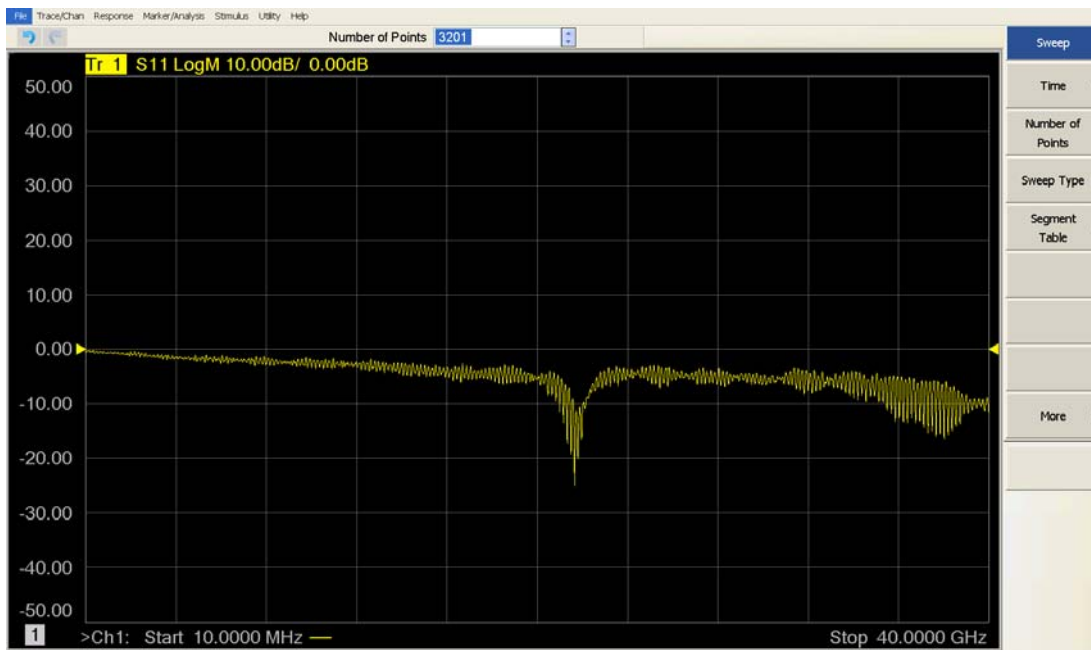


Figure 2: Sweep Parameters

- 5) Set the Average Parameters
 - a) Push the Avg button on the Chassis
 - b) Set IF Bandwidth (IFBW) to 70 kHz or less (select a number that is compatible with the scope – use up/down arrows). Keysight recommends using a lower IFBW (1-3 kHz) with stepped sweep enabled. These are close to the PLTS defaults

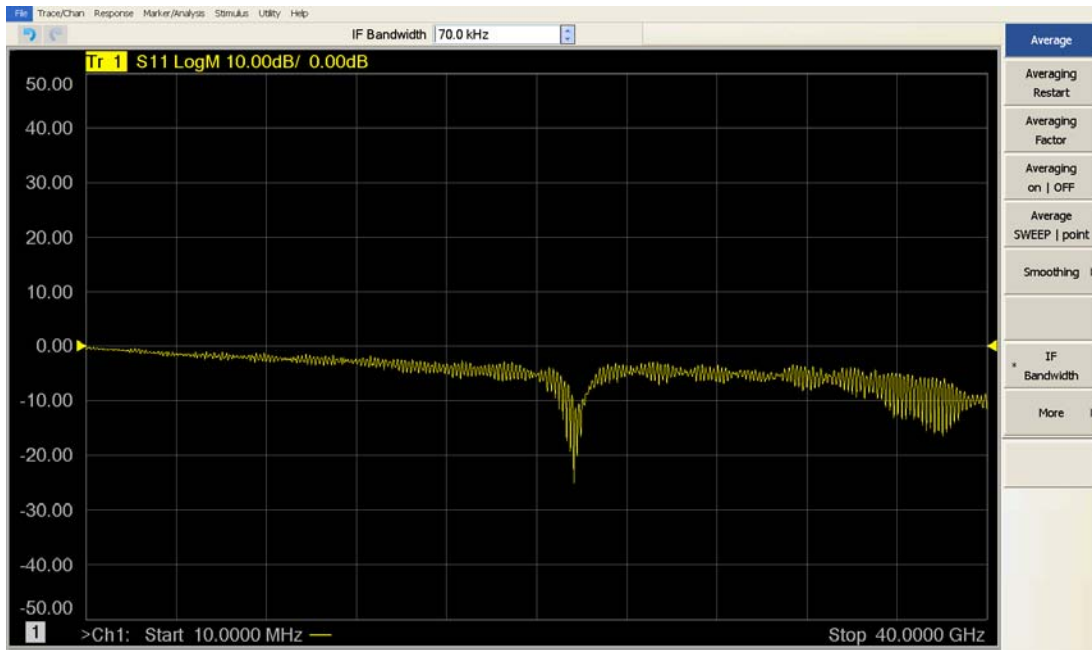


Figure 3: Average Parameters

- 6) Use the Keysight Electronic Calibration Module (ECal) Model N4691B or N4692A to perform the calibration. Calibration must be performed after every power cycle or as needed. After plugging the ECal into a USB port on the PNA, please wait until the WAIT light goes out and the green READY light appears.
 - a) Push the Cal button on the Chassis
 - b) Select Start Cal from the software menu on the right
 - c) Select Cal Wizard from the software menu on the right

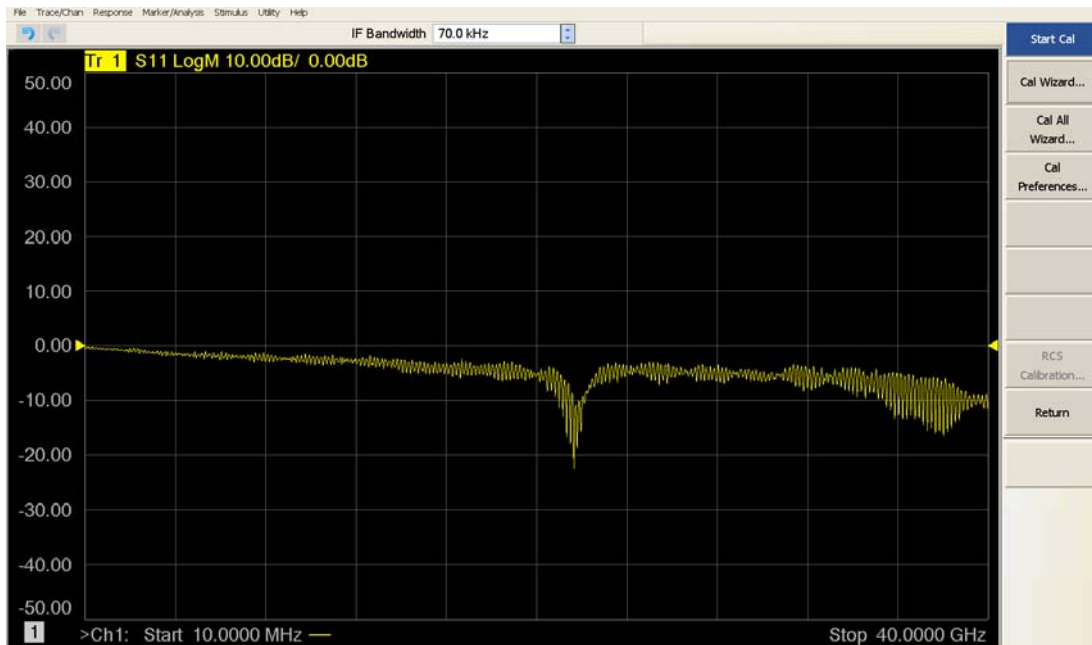


Figure 4: Start Calibration

d) Select SmartCal (mechanical or electronic calibration) or Use Electronic Calibration (ECal) from the menu and then hit next

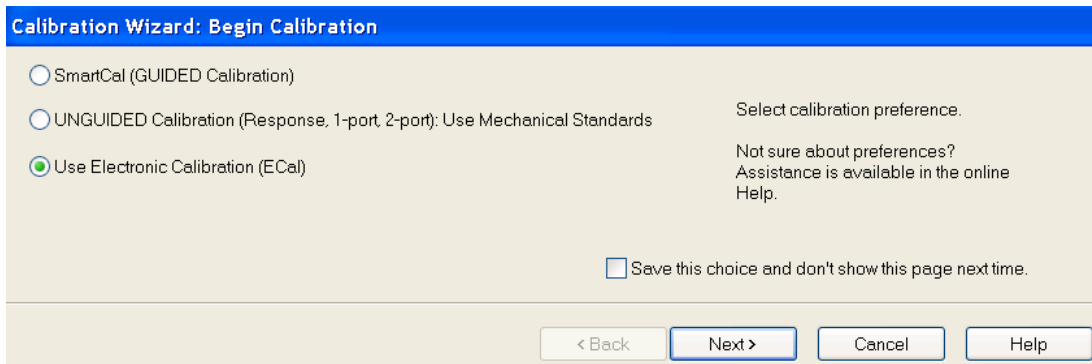


Figure 5: Use ECal

7) Accept the defaults on the next screen and hit Next

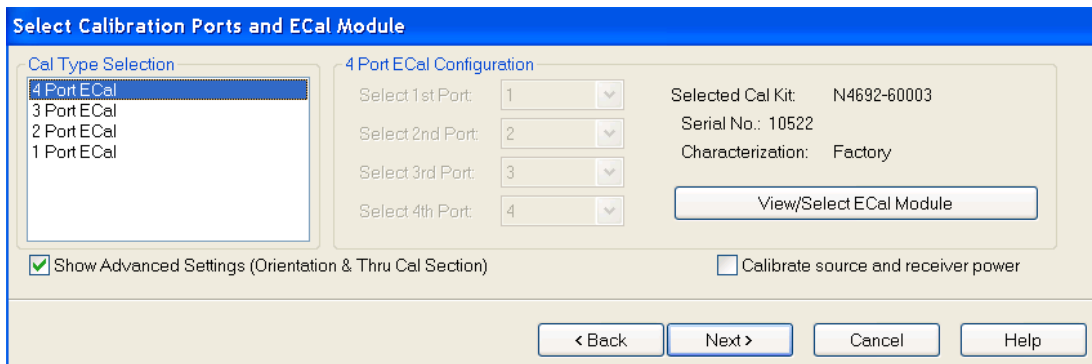


Figure 6: Select Calibration Ports

8) Accept the defaults on the next screen and hit Next
 The Keysight recommendation is to add a 4th thru and make sure the main thru pair are both calibrated. That is paths 1-2 and 3-4.

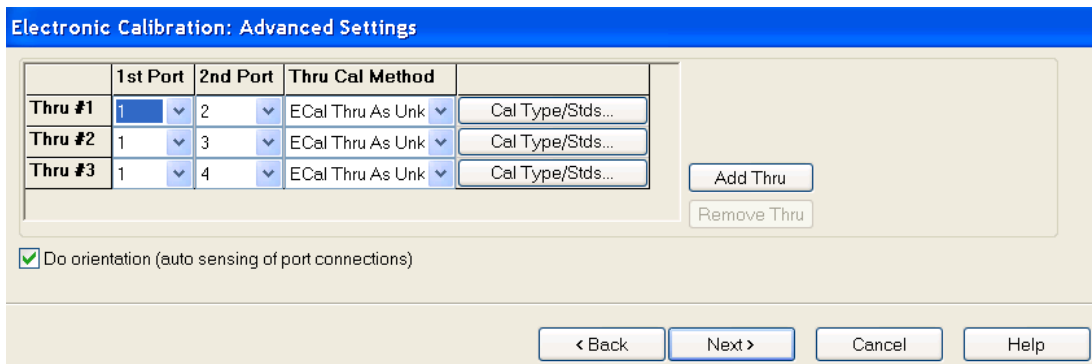


Figure 7: ECal Advanced Settings

- 9) Follow the on-screen prompts to complete the calibration process. The representative screens following screens show the use of a 2 port ecal module.

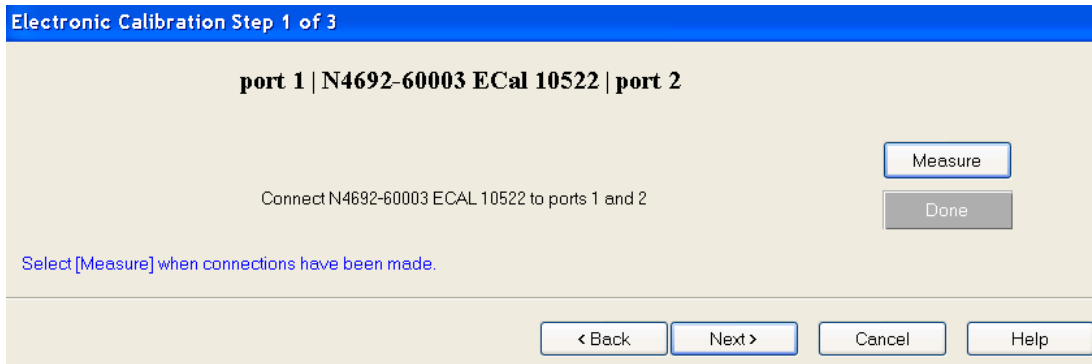


Figure 8: Calibrating Ports 1 and 2

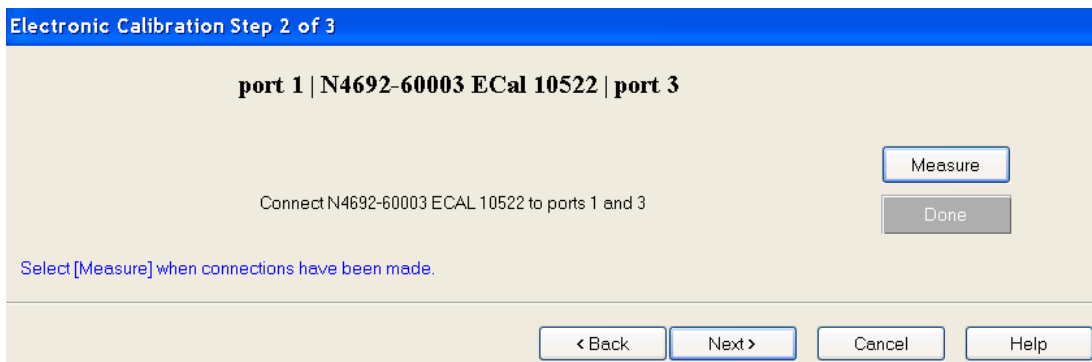


Figure 9: Calibrating Ports 2 and 3

- 10) Leave Port 1 of the PNA connected to Port A of the ECal and attach Port 4 of the PNA to Port B of the ECal and hit measure. When this measurement is complete, the calibration is complete and you should select finish.

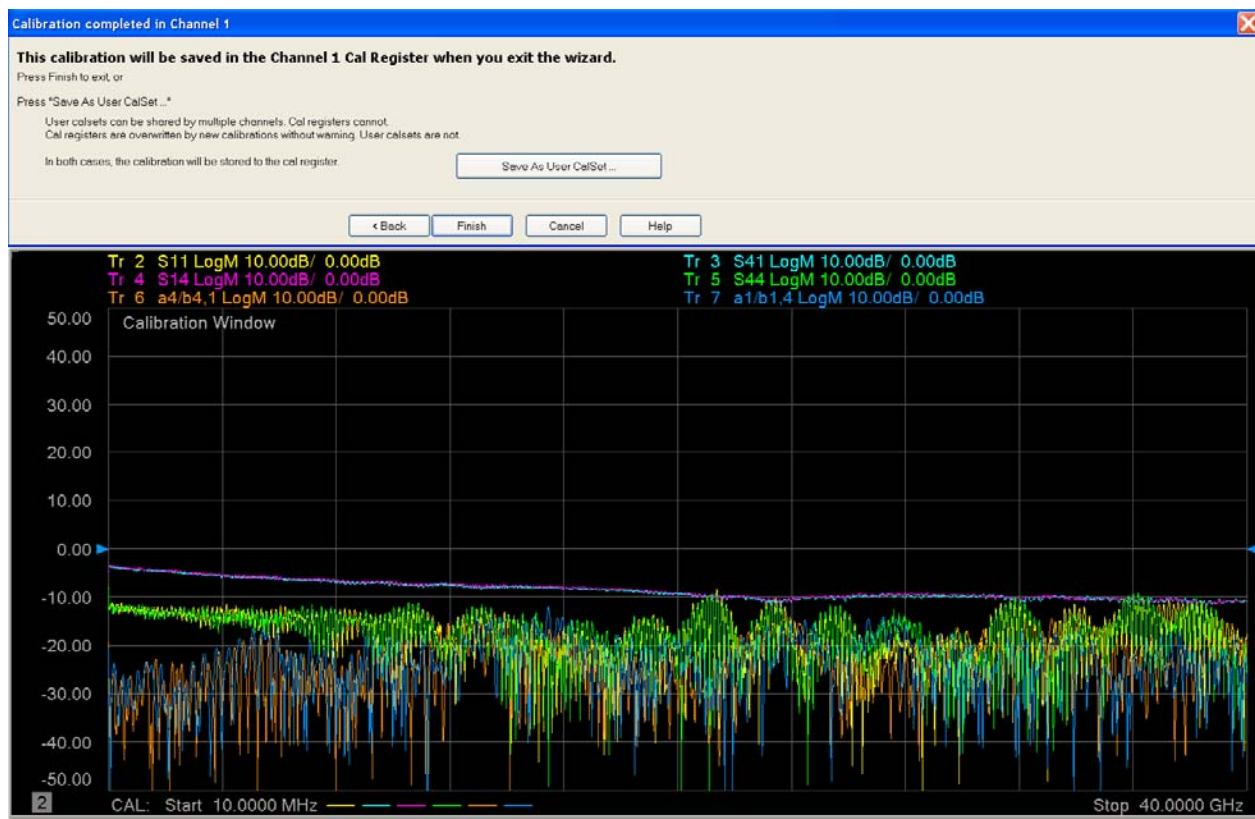


Figure 10: ECal Results

Test Procedures for FDR and EDR InfiniBand cables

1) **For Insertion Loss and Return Loss tests:**

- a) Ports 1 and Port 3 of the PNA are connected to the inputs of one differential pair on MCB-A while Port 2 and Port 4 are connected to the outputs of the same pair on MCB-B.

2) **For Integrated Crosstalk Noise (ICN) test:**

- a) The near-end and far-end crosstalk sources need to be measured to perform these tests. To do this Port 2 and Port 4 on MCB-B (the RX of the lane under test) remain connected to the outputs of the differential pair but Ports 1 and Port 3 are connected to the 7 other TX pairs between the two MCBs. If the lane under test is TX4, then the crosstalk sources would be:

FEXT Source	NEXT Source
MCB-A: TX1	MCB-B: TX1
MCB-A: TX2	MCB-B: TX2
MCB-A: TX3	MCB-B: TX3
-	MCB-B: TX4

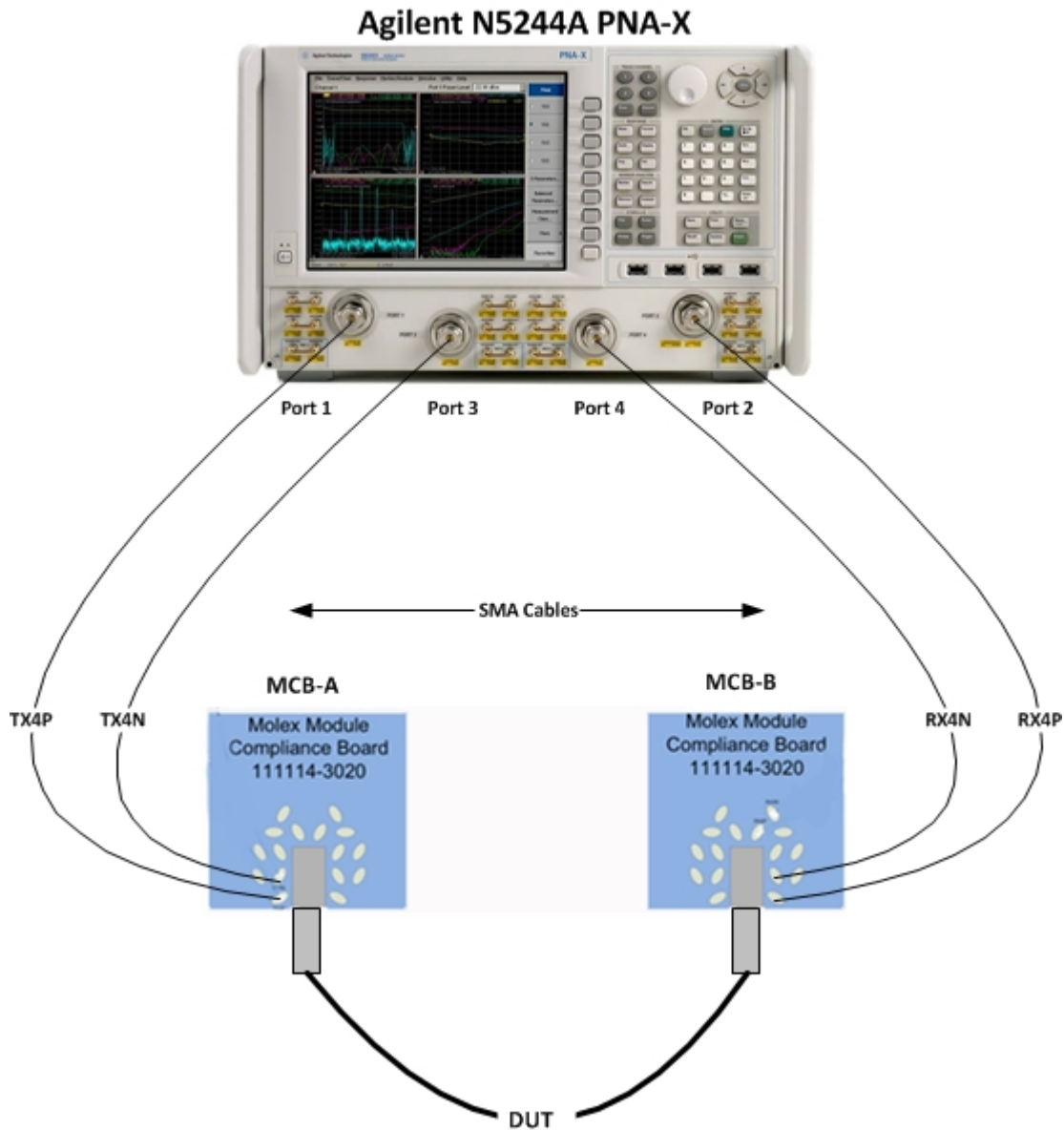


Figure 11: Test Configuration

- 3) The CIWG test procedures tests the worst case lane of the cables submitted for testing. The worst case lane is determined by using the Mellanox Eye Opening test procedure which is described in a separate Method of Implementation (MOI) which is available on the IBTA website. In this VNA MOI, we will assume that the worst case lane is Lane 4
- 4) Connect the 3.5mm Cable from Port 1 of the PNA to the TX4P SMA connector on the Molex Module Compliance Board A (MCB-A). Attach Port 3 to TX4N on MCB-A. Attach the 3.5MM Cable from Port 2 of the PNA to RX4P and Port 4 to RX4N on MCB-B as shown above.
- 5) All other **RX** SMA connectors on both MCBs must be terminated with 50 OHM terminations. This eliminates cross talk reflection from the other lanes when measuring victim lane.
- 6) Insert the zQSFP+ connector which has the worst lane into MCB-B. Connect the other end of the DUT into MCB-A. This is done so that the results are consistent for all the cables tested at the Plugfest.
- 7) If the DUT is a passive cable, the MCBs should **not** be powered on. If the DUT is an Active Cable, power must be available for both boards.
 - a) **Note:** during IBTA PlugFest testing, it has been found that some DUTs are sensitive to whether both boards are powered and others are sensitive to whether MCB-A or MCB-B is powered. Therefore we run this test in all three combinations and take the best results.
- 8) **Running the tests:**
 - a) Push the Trigger button on the chassis
 - b) Select Single from the menu on the right

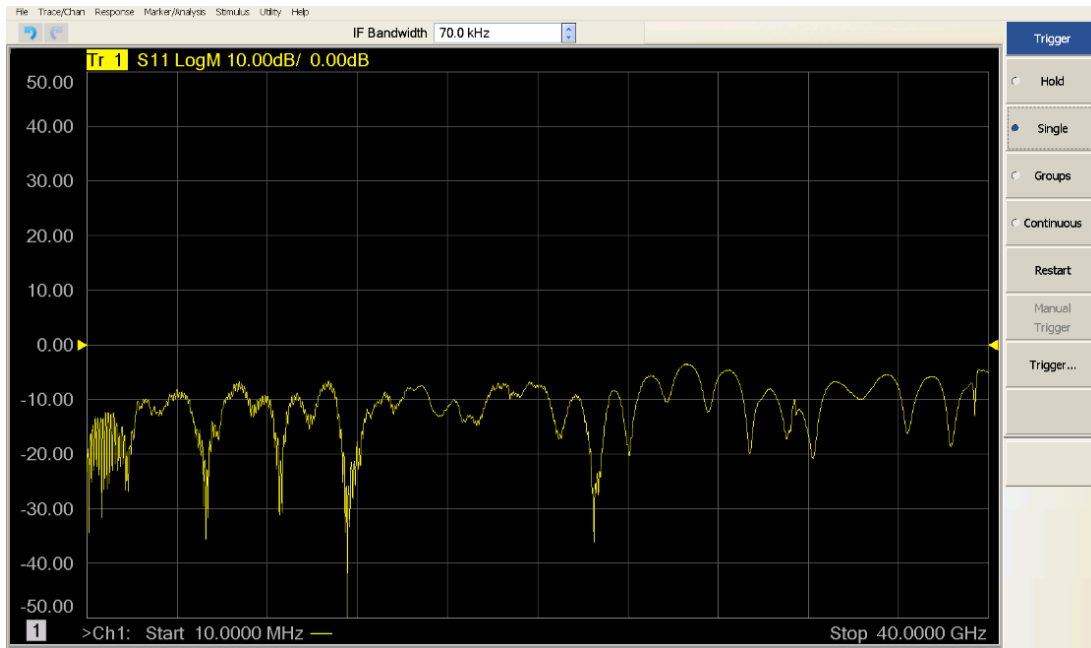


Figure 12: Running the tests

- 9) Saving the results
 - a) Select File | Save As and create a directory to store the data. For example DUT-99-002
 - b) Select the file type (s4p) and create a file name – convention is that we call this file victim.s4p

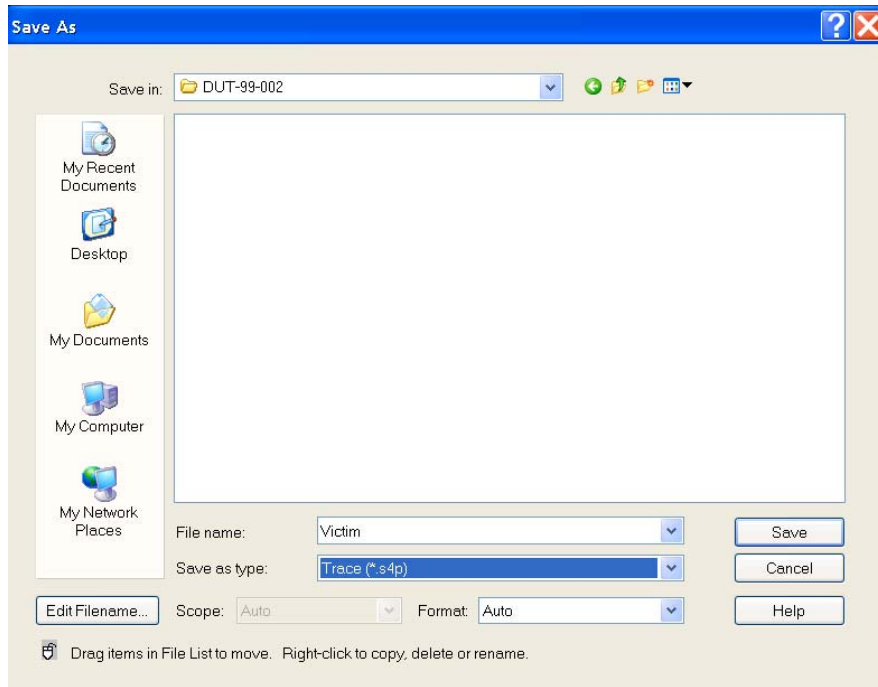


Figure 13: Saving Results

- 10) For a Passive cable, the victim.s4p file will provide the data for the following measurements and calculated specifications:
- IL, Fitted IL, ILD, ILDrms, SDD11, SDD22, SCC11, SCC22, SDC11, SDC22, ICMCN = [f (SCD21)]
 - These are single ended measurements and so the results on the screen cannot be interpreted.
- 11) Additional steps are required when testing Passive Cables in order to measure ICN. Seven measurements are required so that we stimulate all channels, one at a time, while still measuring the victim lane. The following steps illustrate the procedure when the victim lane is TX4 on MCB-A. In general the 3 MCB-A lanes must include all lanes other than the victim.
- The 3.5MM Cables from Ports 2 and 4 remain attached to the victim lane on MCB-B and do not change.
 - Attach the 3.5MM Cables from Ports 1 and 3 to TX1 of **MCB-A** and measure and then save the results as FX1.s4p
 - Attach the 3.5MM Cables from Ports 1 and 3 to TX2 of **MCB-A** and measure and then save the results as FX2.s4p
 - Attach the 3.5MM Cables from Ports 1 and 3 to TX3 of **MCB-A** and measure and then save the results as FX3.s4p
 - Attach the 3.5MM Cables from Ports 1 and 3 to TX1 of **MCB-B** and measure and then save the results as NX1.s4p
 - Attach the 3.5MM Cables from Ports 1 and 3 to TX2 of **MCB-B** and measure and then save the results as NX2.s4p
 - Attach the 3.5MM Cables from Ports 1 and 3 to TX3 of **MCB-B** and measure and then save the results as NX3.s4p
 - Attach the 3.5MM Cables from Ports 1 and 3 to TX4 of **MCB-B** and measure and then save the results as NX4.s4p

Post Processing the S4P Results

- 1) UNH-IOL has a Matlab test suite to process the s4p files and obtain results. This test suite is part of a larger test environment and therefore it is not possible to provide a complete working solution for vendors to use in their labs. Automated post processing is performed by UNH-IOL using their Matlab test environment and the end results are provided to the CIWG for determining compliance with the IBTA Specifications.

The test scripts calculate the following from the S4P files from the device under test (DUT).

- a) Insertion Loss (Sdd21), Fitted Insertion Loss (FIL), Insertion Loss Deviation (ILD) and ILDrms.
 - b) Return Loss measurements
 - i) Sdd11, Sdd22, Scc11, Scc22
 - c) Common Mode to Differential Reflection
 - i) Sdc11, Sdc22
 - d) Integrated Common Mode Conversion Noise (ICMCN)
 - i) SCD21
-
- 2) Keysight Physical Layer Test System (PLTS) software in combination with internal Matlab collaboration can process the data files to determine pass/fail for:
 - a) Insertion Loss (Sdd21), Fitted Insertion Loss (FIL), Insertion Loss Deviation (ILD) and ILDrms.
 - b) Return Loss measurements
 - i. Sdd11, Sdd22, Scc11, Scc22
 - c) Common Mode to Differential Reflection
 - i. Sdc11, Sdc22
 - d) Integrated Common Mode Conversion Noise (ICMCN)
 - i. SCD21

Sample FDR Plots

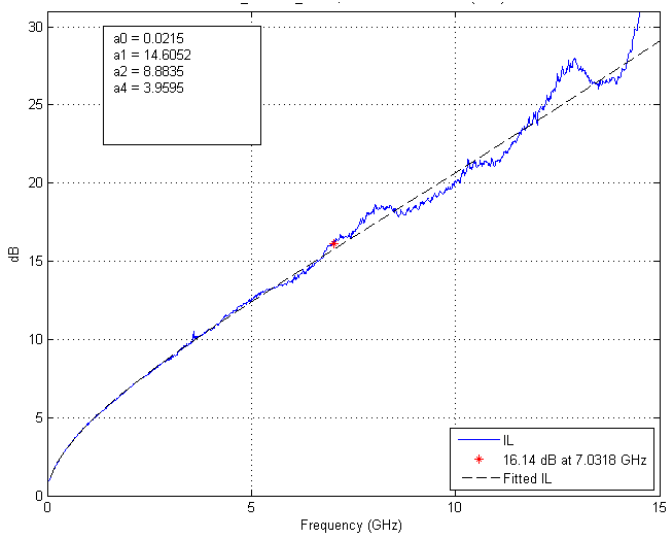


Figure 14: IL and Fitted Insertion Loss

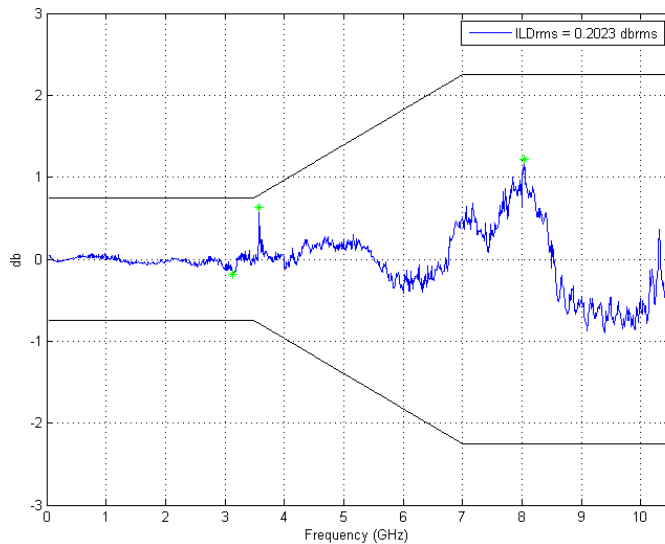


Figure 15: Insertion Loss Deviation

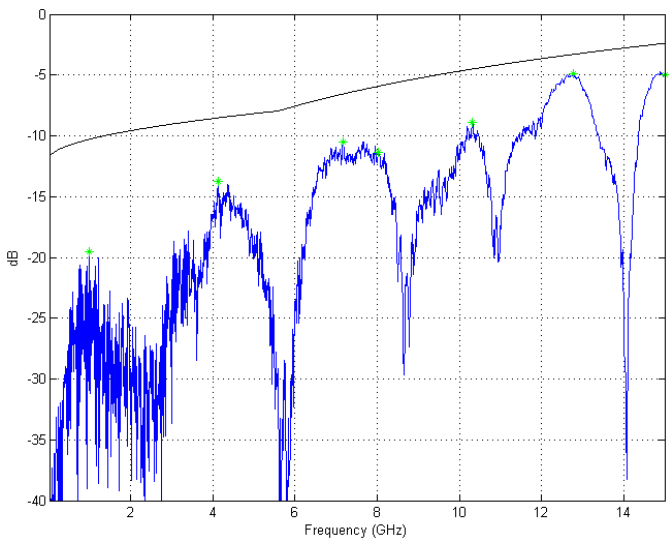


Figure 16: SDD11

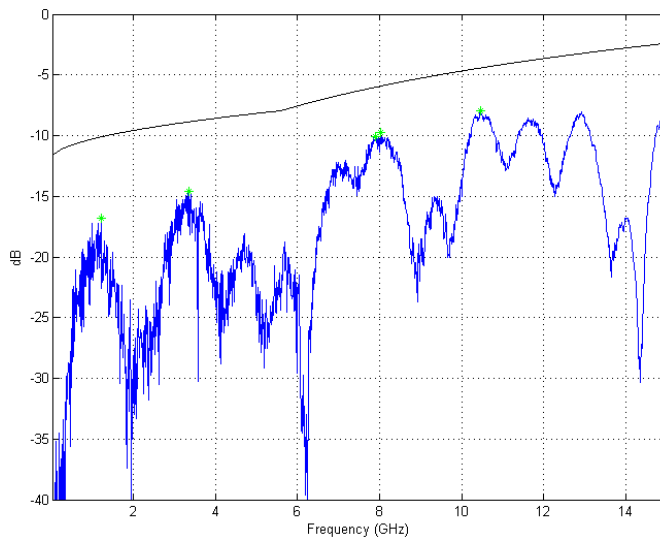


Figure 17: SDD22

Sample FDR Plots

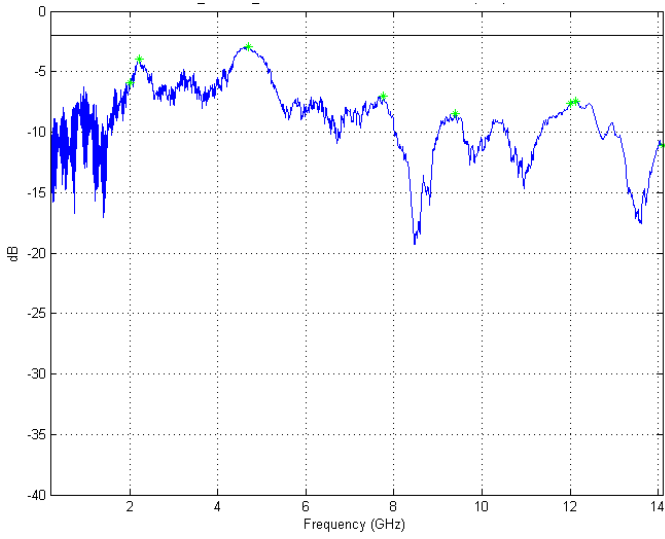


Figure 18: SCC11

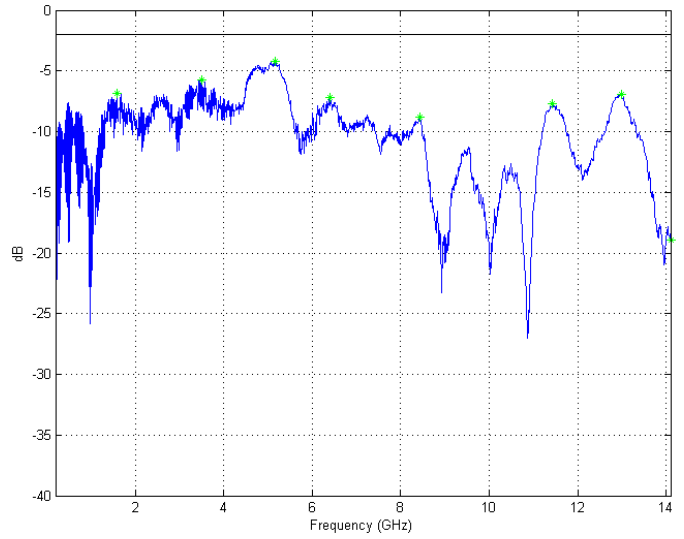


Figure 19: SCC22

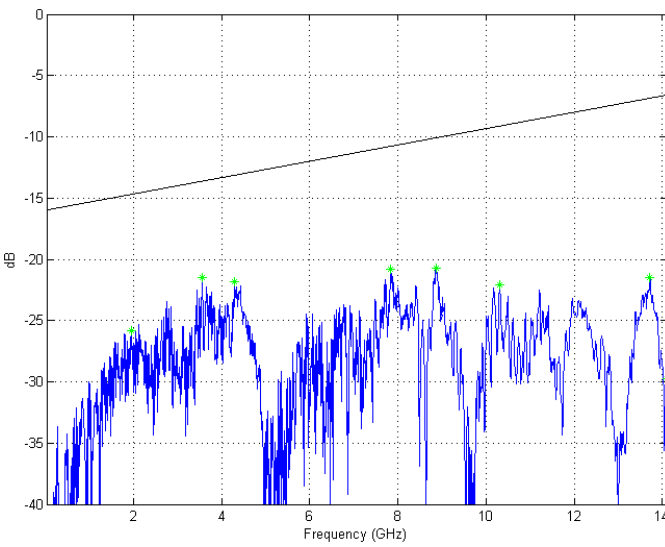


Figure 20: SDC11

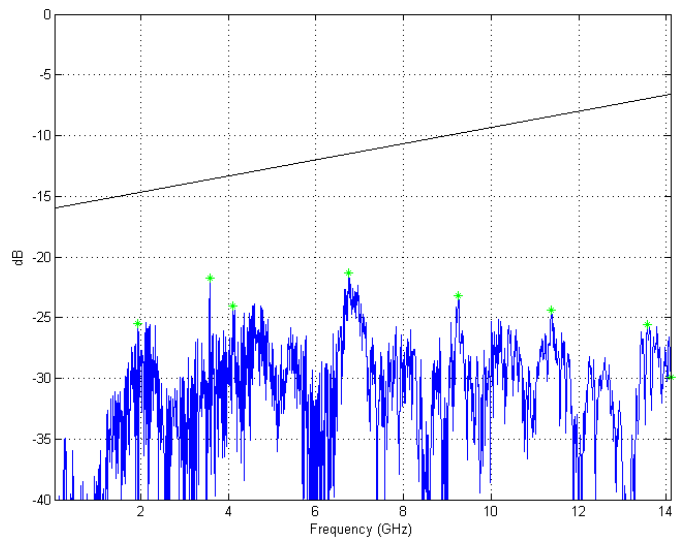


Figure 21: SDC22

Post Processing with Keysight PLTS

Prerequisites:

- Keysight PLTS 2014 Update 1 or newer
 - N1930B with options 1xP for Victim Only or 1xP and 7xP for Full Templates
- Mathworks Matlab 2012b or newer
 - Base with Signal Processing Toolbox

1. Installing the FDR and EDR templates and Matlab scripts for use with PLTS

- a. Extract the Infiniband_FDR_EDR_PLTS_Templates.zip file to the directory C:\
- b. The system should then have a folder structure of C:\Infiniband with multiple xml and Matlab m files for both FDR and EDR
- c. Open PLTS (*e.g. Start->Programs->Keysight Technologies->PLTS 2014 Update 1->PLTS 2014 Update 1*)
- d. In the Data Browser window on the left side of the screen, right click on Template View and select Import Template
- e. Navigate the C:\Infiniband and import each of the FDR an EDR templates

2. Using the FDR and EDR Victim Only Templates

- a. These are templates that test all parameters except for ICN based off the victim.s4p file
- b. Open PLTS (*e.g. Start->Programs->Keysight Technologies->PLTS 2014 Update 1->PLTS 2014 Update 1*)
- c. Select File->Import->Single File
- d. Browse to the desired victim.s4p file and Select OK to open
- e. Select the desired xDR Victim Only template
- f. The display will update with 8 plots with Pass/Fail Criteria from the standard
- g. Review Results to determine Pass/Fail

3. Using the FDR and EDR Full Templates

- a. These are templates that use a s20p file that is built inside of PLTS using the victim.s4p, FXn.s4p, and NXn.s4p files. They complete all tests including the ICN test
- b. Open PLTS (*e.g. Start->Programs->Keysight Technologies->PLTS 2014 Update 1->PLTS 2014 Update 1*)
- c. Select File->Import->Build File
- d. In item 2, press the Change button to change the configuration of the data to import
- e. In item 1, change the number of ports to 20 and then select OK to close the window and return to the Import Multiple Files Window
- f. In item 4, select Browse to navigate to the directory with all 8 measurement files and select to open the victim.s4p file
- g. In item 5, set the parameter mapping to Port
- h. In item 6, the port mapping should be 1-1, 2-2, 3-3, 4-4 and then use the >> arrow to push that data into the grid
- i. In item 4, select Browse and go back to the directory with all measurements and follow step h with the following file and port mappings as continued in table 2.

Note: You will receive a warning after each import regarding the S22, S24, S42, and S44 data, select No for each warning.

File Name	Port 1	Port 2	Port 3	Port 4
Victim.s4p	1	2	3	4
FX1.s4p	6	2	8	4
FX2.s4p	10	2	12	4
FX3.s4p	14	2	16	4
NX1.s4p	5	2	7	4
NX2.s4p	9	2	11	4
NX3.s4p	13	2	15	4
NX4.s4p	17	2	19	4

Table 2: PLTS port mapping for Full Template usage

- j. In item 5, change the parameter mapping to individual
- k. In item 6, select Ideal Crosstalk for File Parameters, and use Shift and the mouse to select all remaining parameters in the DUT parameter selection, then press >> to push all data over to the grid.
- l. The grid should now be full
- m. On the bottom of the window select Export and save the *.s20p file that corresponds with this data
- n. In item 7, make sure that All is selected and that Interpolate is NOT checked

- o. Select OK to continue
- p. Select the desired FDR or EDR Full Template to view the data

Appendix A – Resource Requirements

- InfiniBand Architecture Specification Volume 2 Version 1.4.2017-04-06

Appendix B – FDR S parameter requirements

Table 3: FDR Insertion Loss

Description	Min Value	Max Value	Unit
Maximum insertion loss at 7.03125 GHz	-	15	dB
Maximum fitted insertion loss coefficient a_0	-0.75	0.5	dB
Maximum fitted insertion loss coefficient a_1	0	17.96	dB
Maximum fitted insertion loss coefficient a_2	0	10.25	dB
Maximum fitted insertion loss coefficient a_4	0	7.91	dB

Table 4: FDR Insertion Loss Deviation (ILD)

Frequency (GHz)	Min Value	Max Value	Unit
$0.05 \leq f < 3.50$	-0.75	0.75	dB
$3.50 \leq f < 7.00$	$0.75 - 0.4286 * f$	$0.4286 * f - 0.75$	dB
$7.00 \leq f \leq 10.5$	-2.25	2.25	dB

Table 5: FDR SDD11 and SDD22

Range (GHz)	Max Value (dB)
$0.05 \leq f < 8$	$-9.5 + 0.37 * (f)$
$8 \leq f < 14.1$	$-4.75 + 7.4 * \log_{10}(f/14)$

Table 6: FDR SCC11 and SCC22

Range (GHz)	Max Value (dB)
$.200 \leq f < 14.1$	-2

Table 7: FDR SDC11 and SDC22

Range (GHz)	Max Value (dB)
$0.01 \leq f < 12.89$	$-22 + 20 * (f/25.78)$
$12.89 \leq f < 14.1$	$-15 + 6 * (f/25.78)$

Table 8: FDR ICN

Range (GHz)	Max Value (mV)
$3 \leq IL \leq 7.65$	9
$7.65 < IL \leq 15.0$	$12.75 - 0.49 * IL$

Table 9: FDR ILD_{rms} and ICMCN

Measurement	Max Value
ILD_{rms}	0.41 dB _{rms}
ICMCN	40 mV

Appendix C – EDR S parameter requirements

Table 10: EDR Insertion Loss

Description	Min Value	Max Value	Unit
Maximum insertion loss at 12.89 GHz	-	16.74	dB
Maximum fitted insertion loss coefficient a_0	-0.75	0.5	dB
Maximum fitted insertion loss coefficient a_1	0	17.96	dB
Maximum fitted insertion loss coefficient a_2	0	10.25	dB
Maximum fitted insertion loss coefficient a_4	0	7.91	dB

Table 11: EDR Insertion Loss Deviation (ILD)

Frequency (GHz)	Min Value	Max Value	Unit
$0.05 \leq f < 5.0$	-0.75	0.75	dB
$5.0 \leq f < 15.5$	$-0.26*(f-5.0)-0.75$	$0.26*(f-5.0)+0.75$	dB
$15.5 \leq f \leq 19.5$	-3.5	3.5	dB

Table 12: EDR SDD11 and SDD22

Range (GHz)	Max Value (dB)
$0.05 \leq f < 8$	$-9.5 + 0.37 * (f)$
$8 \leq f \leq 26$	$-4.75 + 7.4 * \log_{10}(f/14)$

Table 13: EDR SCC11 and SCC22

Range (GHz)	Max Value (dB)
$0.05 \leq f < 26$	-2

Table 14: EDR SDC11 and SDC22

Range (GHz)	Max Value (dB)
$0.01 \leq f < 12.89$	$-22 + 20 * (f/25.78)$
$12.89 \leq f < 26$	$-15 + 6 * (f/25.78)$

Table 15: EDR ICN

Range (GHz)	Max Value (mV)
$3 \leq IL \leq 7.65$	9
$7.65 < IL \leq 26.0$	$12.75 - 0.49 * IL$

Table 16: EDR ILD_{rms} and ICMCN

Measurement	Max Value
ILD_{rms}	0.41 dB _{rms}
ICMCN	60 mV

