InfiniBand Trade Association

Revision 1.08
9/25/2014

Tektronix TDR MOI for SDR-QDR Cables Tests For Tektronix (DSA8300 based sampling instrument with IConnect and 80SJNB)

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Table 1: Modification Record

Revision	Release Date	Author	Comments
0.1	4/19/2007	Jon Beckwith	• Initial Template Release
0.2	5/31/2007	Jon Beckwith	• Changed averaging factor to 250 • Moved compensation to the beginning of the procedure (before deskew) • Updated deskew procedure • Specified eye mask file settings/location
0.3	10/5/2007	Jeff Lapak:	• Changed procedure of test 7.2.01 • Modified Initial Measurement Setups for Active and Passive cables • Updated pictures to correct errors • Made changes to accommodate for new test procedure
0.31	12/7/2007	Rupert Dance	• Updates to 7.1.02
0.4	1/15/2008	Rupert Dance	• Updated TOC to correct undefined bookmark • Add DDR and QDR specifications to 7.1.02 • Update reference to the IB Spec • Fixed reference to Mellanox Eye Opener Software • Fixed reference to CJTPAT • Added Appendix E – S parameter requirements
0.41	1/18/2008	Rupert Dance	• Corrected the description of the IB Specification
0.5	8/25/2008	Jon Beckwith	• Fixed Active cable setup • Fixed figure 2 and 3 • Added Matlab version (PF13) • Changed all affected reference and waveform files • Added section to the passive cable setup about positioning and other notes about the importance of proper setup • Fixed calibration table. • Removed any references to Z wfm files, as these are not needed • Added test Mellanox Eye Opening Test • Added 80E10 characteristics to Appendix B. • Added Appendix E reference to RL tests.
0.51	8/28/2008	Rupert Dance	• Review new test document and updated test Mellanox Eye Opening Test with table • Updated Appendix A • Added Bookmarks and Links
0.52	8/28/2008	Rupert Dance	• Updates based on CIWG Meeting feedback
0.53	9/10/2008	Jon Beckwith	• Added text and figure on page 12 to clarify TX/RX signals relative to port
0.54	9/16/2008	Jon Beckwith	• Fixed labeling on figure 5 (Efficiere fixture)
0.55	10/3/2008	Jon Beckwith	• Updated to clarify PF14 procedures for Active cables
0.60	3/25/2009	Jon Beckwith	• Added QDR active cable requirements • Added fixture notes and table • Changed procedure to use min amplitude with nominal pre-emphasis and max amplitude with nominal pre-emphasis • Updated RL formulas in 7.2.01 • Updated active cable jitter test, added table 7.2.04-1
0.61	3/30/2009	Jon Beckwith Rupert Dance	• Added hyperlinks to Mellanox Eye Opening Test in the all discussion sections • Added test 7.2.05 which reminds vendors that Active Cables must pass Mellanox Eye Opening tests • Added test fixture part numbers
0.62	3/31/2009	Rupert Dance	• Change figure reference in 7.1.06 and 7.2.03 and Added Hyperlinks • Updated Observable results in 7.1.05
0.63	6/12/2009	Rupert Dance	• Updated the Mellanox Eye Opening Table of Results
0.64	9/17/2009	Jon Beckwith Rupert Dance	• Added updated RL limits and Appendix E • Added definition for Passive Cables which include Linear Active • Updated Mellanox Eye Opening Procedure
0.65	9/25/2009	Rupert Dance	• Final Updates for the October 2009 Plugfest • Updated RL Observable Results • Updated Molex Test Fixture Notes
0.66	4/3/2010	Rupert Dance	• Updates for the April 2010 Plugfest • Updated Insertions Loss values for QDR • Added Tables of Figures and Tables
0.67	4/13/2010	Rupert Dance	• Updates version of Matlab Code on page 31
0.68	4/20/2010	Rupert Dance	• Updated Tables in Appendix E
0.69	2/25/2011	Rupert Dance	• Updated Table11 in Appendix E for the approved Insertion Loss values for QDR
0.70	9/22/2011	Rupert Dance	• Moved Mellanox Eye Opening Test from 7.1.07 to the start of the Electrical

			Validation tests • Eliminated 7.2.05 which was only a reference to 7.1.0.7 • Added new section for FDR Passive Copper Cables • Added new section for FDR Active Cables • Added FDR ICN, IL RL tests
0.71	9/28/2011	Rupert Dance	• Updated titles on FDR tests to indicate whether they are Passive, Linear active or apply to all. • Added Common Mode Generation MOI from Jason Ellison (FCI)
0.72	2/16/2012	Rupert Dance	• First draft for PF21 • Updated 7.3.02 FDR RL Equation to go up to 14 GHz
1.0	02/05/2014	Llolsten Kaonga	• Removed the Mellanox Eye Opening procedure to a separate MOI • Updated references to the IBTA volume 2 specification
1.01	2/13/2014	Rupert Dance	• Removed FDR tests – now being done wit VNA • Removed reference to Mellanox Eye Opening Equipment needs • Removed FDR Spec Tables
1.03	06/24/2014	Jeffrey Lapak	• Updated Instrumentation information • Removed Active Cable Eye and Jitter measurements as these have been integrated into Tektronix ATD MOI for FDR Active Cables_Rev1_6a and later revisions.
1.04	8/14/2014	Curtis Donahue	• Update Tektronix Images • Updated Correct acquisition window settings on page 31
1.05	8/24/2014	Rupert Dance	• Editorial updates • Change CX4 to MicroGiGaCN • Added QDR specs where missing • Updated test fixture diagrams and hyperlinks • Reviewed Appendix E – some changes still pending
1.06	8/26/2014	Rupert Dance	• Updated after review with Jeff Lapak • Removed section for Active Cable Test Equipment setup • Updated observable results for Cross Talk • Removed eye width opening observable results for DDR. This test only applies to SDR • Updated Table 7 to match the Volume 2 1.3.1 spec on page 324 • Updated Table 10 to include the points as well as the formula.
1.07	8/28/2014	Rupert Dance	• Updated Table 8 on page 36 to match with the new proposed chances to the Volume 2 Spec. • See: https://cw.infinibandta.org/wg/CIWG/mail/thread/21668
1.08	9/25/2014	Rupert Dance	• Made editorial changes based on review in CIWG meeting • Updated a few Hyperlinks and validated all of them

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FCI
Jason Ellison

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Software Forge
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John Calvin
Mike Martin
Kees Propstra
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Curtis Donahue
Jon Beckwith
Jeff Lapak
Andy Baldman
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INTRODUCTION

The tests contained in this document are organized in order to simplify the identification of information related to a test, and to facilitate in the actual testing process. Tests are separated into groups, primarily in order to reduce setup time in the lab environment, however the different groups typically also tend to focus on specific aspects of device functionality.

The test definitions themselves are intended to provide a high-level description of the motivation, resources, procedures, and methodologies specific to each test. Formally, each test description contains the following sections:

Purpose

This document outlines precise and specific procedures required to conduct IB PHY MOI tests. This document covers the following tests which are all implemented using a Tektronix DSA8300 Sampling Oscilloscope.

ELECTRICAL SIGNALING CHARACTERISTICS

Overview:

This test procedure was written to explain how to use the Tektronix CSA/DSA8xxx series oscilloscope and IConnect software to make the measurements required per the InfiniBand Architecture Specification Volume 2 Release 1.3.1 Chapter 6 for SDR-QDR.

This procedure is formatted in such a way as to make each test "stand alone" and capable of being performed manually. Note that test throughput can be improved by grouping tests with the same set-up together and automating the process using a command line interface of the IConnect software.

References

InfiniBand Architecture Specification Volume 2 Release 1.3.1 Chapter 6
Tektronix CSA/TDS8xxx oscilloscope user manual
Tektronix IConnect software (full version)

General Resources Requirements

See Appendix A
See Appendix C for measurement accuracy specifications.

Initial Measurement Setup

This section contains notes regarding the setup for testing InfiniBand cables. They include setup file generation, calibration, and other general notes pertaining to all (or most) of the tests outlined in this document. Note that the setup is much different for an active or a passive cable.

Be sure to read this section thoroughly! Setup is 95% of the time required for the testing of one cable, and if it is done incorrectly, it will drastically increase the testing time!

Passive Cables - A "Passive cable" is one that is either: unequalized, equalized in connector, equalized in wire, or a linear active cable.

Before connecting the measurement cables and adaptors perform instrument's warm-up and compensation according the user manual of the sampling oscilloscope.

The high-level description for testing passive cables is explained below. Steps 1-4 are expanded in this section.

1. Compensate for temperature changes
2. Connect SMA cables
3. Deskew the sampler heads
4. Generate the setup files
5. Generate the reference files (calibrate)
6. Run the test
7. Run the Matlab scripts
8. Generate the eye diagram

1. Compensate for any temperature changes by connecting 50 ohm terminators on all ports and running the temperature compensation algorithm on the DSO. This is indicated by the green (or red) thermometer gauge on the bottom of the screen.

2. Connect 10 SMA cables to the 80E04 sampling modules as shown in figure 1.

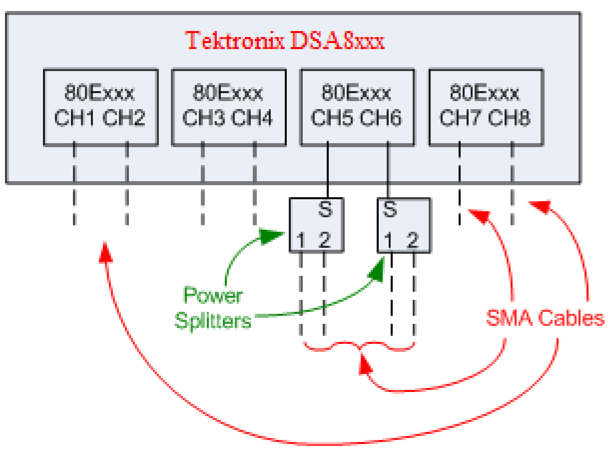


Figure 1: SMAs connected to 80Exx modules

3. Deskewing the sampler heads:
   - Follow the procedure in Appendix B to align the TDR sampling heads

After the transmitters and receivers have been properly aligned, the setup files must be created for every one of the tests.

4. Setup generation procedure

- Set the horizontal scale to the longest length cable using the 1ft/1ns rule
    i. Example: 12m = 39 feet, 40 ns*4 = 160 ns (16 ns/div)
- Set the Horiz record length to 4000
- Move the starting position to hide the first step. **Also make sure to position it in between the end of the SMA cable and the QSFP or MicroGiGaCN connector at the beginning of the InfiniBand cable. Put the position in the "middle" of the fixture. See the proper windowing procedure in Appendix B for more information.** Note: If this step is not performed, the Return Loss results are significantly worse due to the resonance created between the SMA connector and the cable connector.
- Set Average Condition to 250 (or 128) in the Acq screen
- Make sure the TDRs are set up as differential
- Save the setup according to the filenames in Table 2. Note that one setup can be used for multiple tests, but a different calibration will be needed.

Table 2: Setup and calibration information

Test #	Setup	Calibration	Filename
7.1.01 – Differential Impedance (Side A)	RLILZ_A	Open 1,2	RL_A_ref.wfm
7.1.01 – Differential Impedance (Side B)	RL_B	Open 7,8	RL_B_ref.wfm
7.1.02 – Insertion Loss	RLILZ_A	2x thru 1,2-7,8	A_ref_dut.wfm
7.1.03 – Return Loss (Side A)	RLILZ_A	Open 1,2	RL_A_ref.wfm
7.1.03 – Return Loss (Side B)	RL_B	Open 7,8	RL_B_ref.wfm
7.1.04 – Crosstalk (part 1)	XTALK1	2x thru 3,4-7,8	A_ref_xt_1.wfm
7.1.04 – Crosstalk (part 2)	XTALK2	2x thru 5,6-7,8 (with other SMA's terminated)	A_ref_xt_2.wfm

Now a calibration must be performed. These are the "reference files" that ensures the effects of the test setup are removed. This is also known as "generating the reference files."

4. Reference file generation procedure:
    - Load the RLILZ_A setup file on the DSO
    - Connect the Open reference on the fixture to CH1 and CH2 on the DSO
    - Download the reference data into IConnect using long captures. (Note: it is very wise to save backups, into a <fixturename> directory (like Efficere 4x) as these may be overwritten very easily)
    - In IConnect, select "Waveform Math" and create the CH1-CH2 waveform. Note, for the Xtalk2 reference file, you must multiply it by 2 because of the power splitters
    - Right click on "CH1-CH2" and Save As "RL_A_ref.wfm"
    - Repeat for the rest of the waveforms (RL_B_ref.wfm, A_ref_dut.wfm, etc.)

Table 3: Calibration procedures

Open calibration	2x calibration
Use the "Open" calibration on the test fixture.	Connect the source and receiver to the THRU or 2X SMA on the fixture

Now that the reference files have been generated, connect the SMA cables to the fixtures as shown in figure 2.

Connect appropriate fixtures and the cable under test according to the Figure 2. Ch1 and Ch2 are connected to the inputs of one diff pair (the RX of the lane under test), while Ch7 and Ch8 are connected to the outputs of the same pair. The three adjacent lanes are connected to Ch3, Ch4, and power splitters on Ch5 and Ch6. Cross-talk sources should be connected to far end (nearest the TX of the lane under test) of the device and on the appropriate channels.

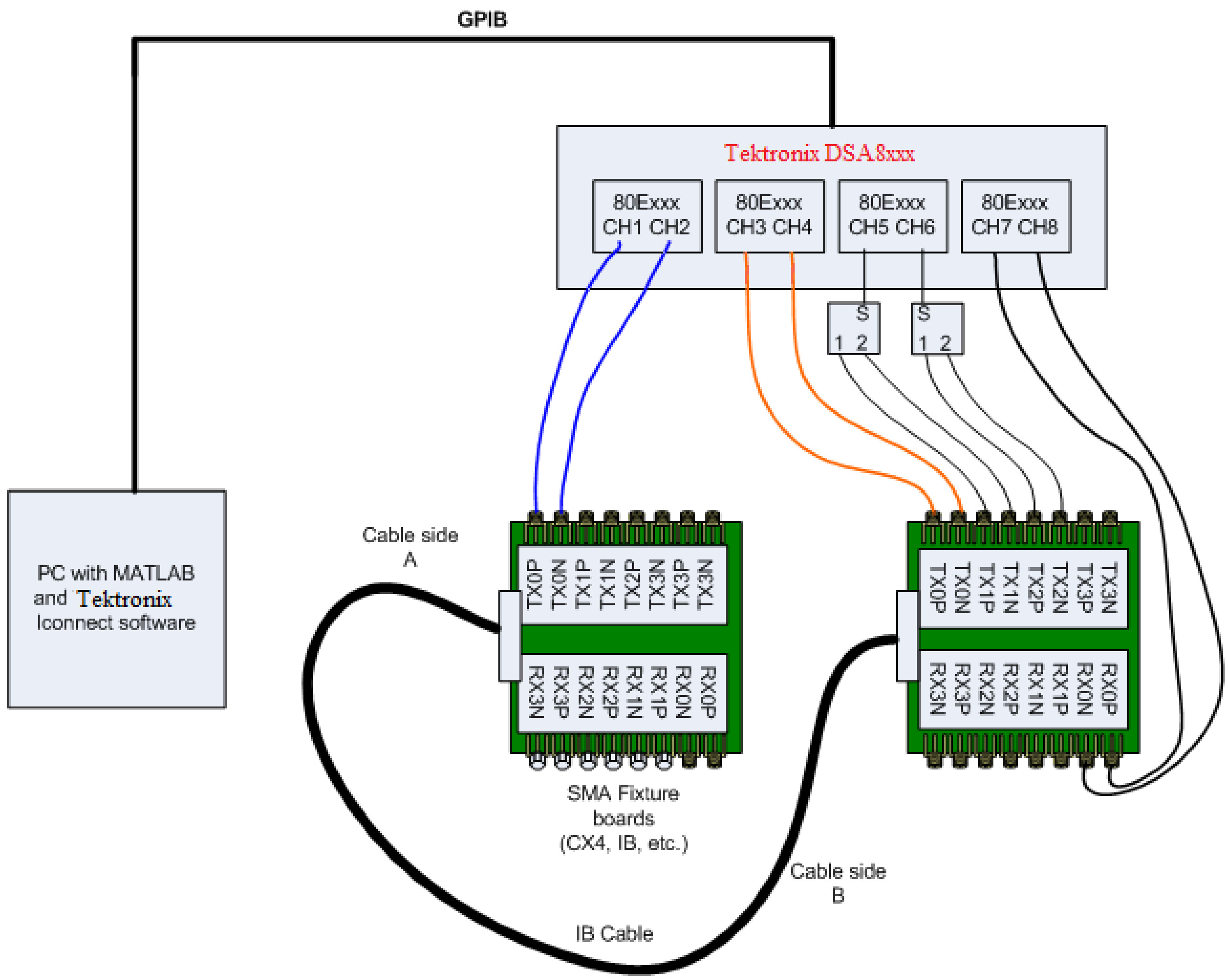


Figure 2: IB cable measurement setup

The disturbers need to be terminated with 50Ω terminations

Test Fixture Notes
There are several fixtures used as part of testing. Below is a brief description of each one, and which test(s) it is used for.

Table 4: Fixtures used during testing

Connector	Passive/Active	Fixture
MicroGiGaCN	Passive	Efficere 4x
MicroGiGaCN	Active	Fujitsu 4x
12X	Passive/Active	Fujitsu 12x
QSFP	All	Amphenol QSFP/ Molex QSFP
CXP	All	Molex CXP

- Efficere 4x (4X-SMA-25R)
    - The SMAs are labeled as shown in figure 4 and figure 5

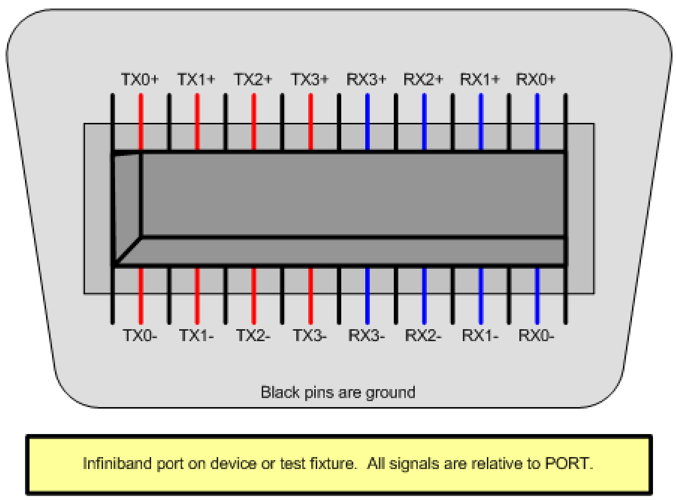


Figure 3: Pin out of female 4x connector on device or test fixture relative to device port

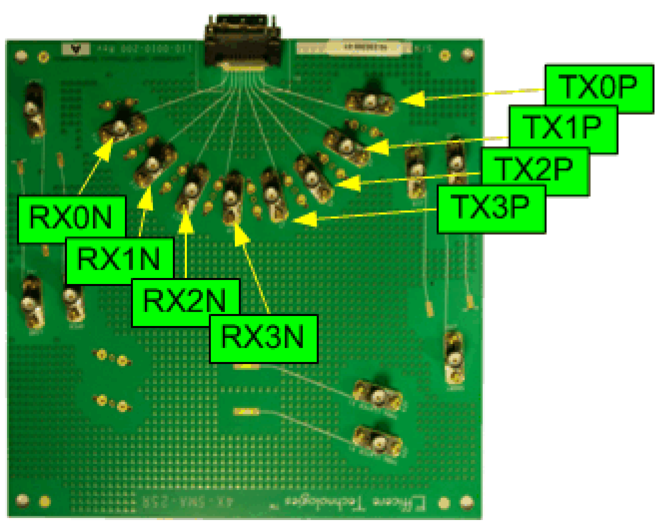


Figure 4: Front view of Efficere board

- With the MicroGiGaCN connector on the top and the side of the board labeled "Efficere" facing you, the right half of the board is positive TX, the left half is negative RX (relative to device's port).
- The other side of the board (facing away from you) has negative RX on the right half, and positive TX on the left half.

- Fujitsu 4x (FCN-268Z008-XG)
    - With the MicroGiGaCN on the bottom, the right half is TX, the left half is RX relative to device's port.
    - For the TX side, the odd numbered SMA connectors are positive, and even are negative
    - For the RX side, the even numbered SMA connectors are positive, and odd are negative
    - Supply 3.3V to the VCC and GND pins on the lower right side of the board

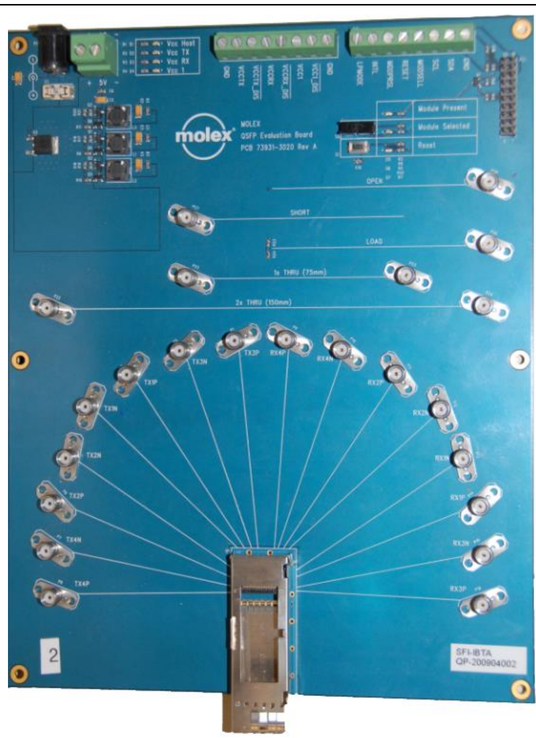
- Fujitsu 12x (FCN-268Z024-XG)
    - Same numbering rules as the 4x card

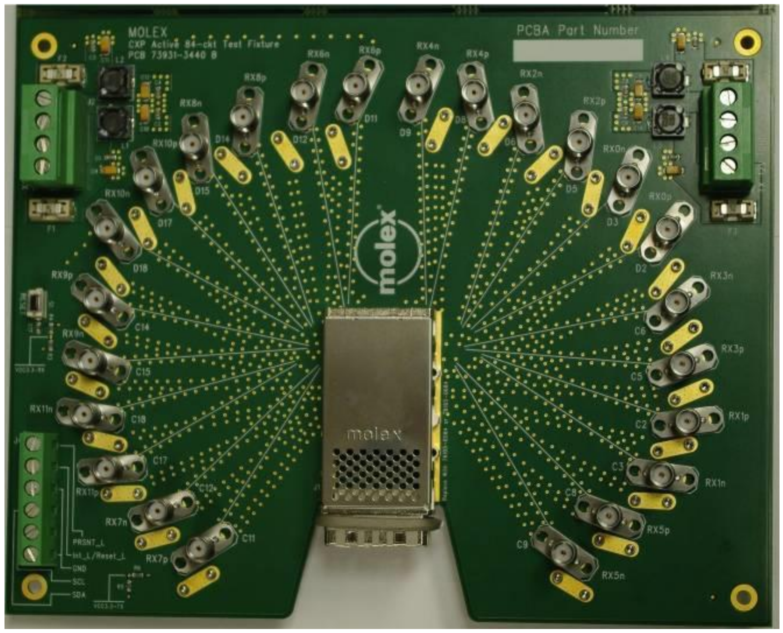
- Amphenol QSFP (563490002 rev. C)
    - SMAs labeled TX are the RX of the cable
    - The board needs 3.3V on VCC1, VCCRX, and VCCTX in order to work

- Molex QSFP (0739313022) – SDR-QDR
    - These are the boards approved by the EWG for QSFP testing at IBTA Plugfests since April 2009

- Molex CXP (73931-3440) – SDR-QDR
    - These are the boards approved by the EWG for CXP testing at IBTA Plugfests since October 2009

- Molex zQSFP+ (1111143022) - FDR & EDR
    - Molex zQSFP+ MCB for FDR & EDR testing

	
Molex QSFP	**Molex zQSFP+**



Molex CXP

Figure 5: Molex Test Fixtures

PASSIVE CABLES – SDR-QDR

The tests contained in this section comprise those performed using a TDR along with a PC running IConnect along with Matlab. As of the latest revision of the MOI, the testing is performed on a Tektronix DSA8xxx Digitizing Signal Analyzer with 4 80Exx modules.

All of the tests contained in this section begin with the initial measurement setup and continue with the downloading of data into IConnect. In each test, the written procedure stops there, but in reality the next step is to open MATLAB and run several scripts.

The Matlab code is updated at every Plugfest. Please refer to the CIWG download site for the latest code:

- https://cw.infinibandta.org/wg/CIWG/document/index
- Then navigate to the folder Matlab Scripts

After all data for tests 7.1.01-7.1.06 has been gathered, copy the data into the '\IConnectData' folder, open MATLAB and type the following:

- IB_Initialize;
- IB_Test('DUT_Name');

After the MATLAB script generates the figures, it will pause for a user input regarding the eye height and jitter. These values are measured from the eye diagram in IConnect, which is generated by hand. Refer to Appendix D for a detailed procedure.

After a complete test has been performed and all files have been generated, a summary of the tests can be found in the IB_DUT_Report.txt file.

A "Passive cable" is one that is either: unequalized, equalized in connector, equalized in wire, or a linear active cable.

Test 7.1.01 – Cable Differential Impedance

Purpose: To verify that the differential impedance of the passive cable assembly is within the conformance limits.

References:

[1] InfiniBand Architecture Specification – Volume 2, Physical Specifications, Rel. 1.3.1, Chapter 6.8.2, Linear Cable Electrical Requirements
[2] Appendix A, Resource Requirements
[3] CIWG Conference Call Notes

Resource Requirements:

See Appendix A.

Discussion:

Reference [1] defines the electrical characteristics that shall be exhibited by a copper InfiniBand cable. These electrical requirements are specified for cables with width 1x (4 conductors), 4x (16 conductors), 8x (32 conductors), and 12x (48 conductors). The frequency range of this test is determined by the technology being tested. SDR is specified up to 1.25GHz, DDR is specified up to 2.5 GHz, and QDR is specified up to 5 GHz. This test is designed to measure the differential impedance of the cable conductors, which is nominally 100Ω, however due to stray capacitance and inductance and other factors, this value is specified to be between 89 and 114 Ω.

The test shall be performed on the "worst" differential pair, or lane in the InfiniBand port assembly. This lane is determined in the Mellanox Eye Opening MOI. The lane that has the lowest initial eye opening measurement is used.

Test Setup:

1. Use the general test setup described in the Initial Measurement Setup section.

Test Procedure:

1. Load the setup file to the DSO (**RLILZ_A**).
2. Press the Run/Stop button on the DSO.
3. Download the data to IConnect
   a. Press "Detect" in IConnect
   b. Select the channels that are to be downloaded
   c. If enhanced resolution is needed, be sure to turn on long record captures.
   d. Press download
   e. After the download has completed, on the pull-down menus on the right side of the TDA software, select the channels to perform the math on, and operator as well.
   f. Subtract the channels from one another
   g. A new waveform appears in the window. Right-click and choose save as…
   h. Save as **RL_A_dd.wfm**
4. Repeat for the other end of the InfiniBand Cable using **RLZ_B** as the reference and **RL_B_dd.wfm** as the filename.

Observable Results:

The differential impedance of the cable shall be between 90 and 110 Ω. This test is for SDR cables only.

Possible Problems:

None.

Test 7.1.02 – Cable Insertion Loss

Purpose: To verify that the insertion loss of the passive cable assembly is within the conformance limits.

References:

[1] InfiniBand Architecture Specification – Volume 2, Physical Specifications, Rel. 1.3.1, Chapter 6.8.2, Linear Cable Electrical Requirements
[2] Appendix A, Resource Requirements

Resource Requirements:

See Appendix A.

Discussion:

Reference [1] defines the electrical characteristics that shall be exhibited by a copper InfiniBand cable. These electrical requirements are specified for cables with width 1x (4 conductors), 4x (16 conductors), 8x (32 conductors), and 12x (48 conductors) as well as different rates of operation. The frequency range of this test is determined by the technology being tested. SDR is specified up to 1.25GHz, DDR is specified up to 2.5 GHz, and QDR is specified up to 5 GHz. This test is designed to measure the insertion loss of the cable assembly.

The test shall be performed on the "worst" differential pair, or lane in the InfiniBand port assembly. This lane is determined in the Mellanox Eye Opening MOI. The lane that has the lowest initial eye opening measurement is used.

Test Setup:

1. Use the general test setup described in the Initial Measurement Setup section.

Test Procedure:

1. Load the setup file to the DSO (**RLILZ_A**).
2. Press the Run/Stop button on the DSO.
3. Download the data to IConnect
   a. Press "Detect" in IConnect
   a. Select the channels that are to be downloaded
   b. If enhanced resolution is needed, be sure to turn on long record captures.
   c. Press download
   d. After the download has completed, on the pull-down menus on the right side of the TDA software, select the channels to perform the math on, and operator as well.
   e. Subtract the channels from one another
   f. A new waveform appears in the window. Right-click and choose save as…
   g. Save as **A_tdt.wfm**

Observable Results:

The insertion loss for an SDR cable shall be less than 10dB for frequencies up to 1.25 GHz for SDR. See Appendix E for insertion loss for DDR & QDR.

Possible Problems:

None.

Test 7.1.03 – Cable Assembly Return Loss

Purpose: To verify that the return loss of the passive cable assembly is within the conformance limits.

References:

[1] InfiniBand Architecture Specification – Volume 2, Physical Specifications, Rel. 1.3.1, Chapter 6.8.2, Linear Cable Electrical Requirements
[2] Appendix A, Resource Requirements

Resource Requirements:

See Appendix A.

Discussion:

Reference [1] defines the electrical characteristics that shall be exhibited by a copper InfiniBand cable. These electrical requirements are specified for cables with width 1x (4 conductors), 4x (16 conductors), 8x (32 conductors), and 12x (48 conductors) as well as different rates of operation. The frequency range of this test is determined by the technology being tested. SDR is specified up to 1.25GHz, DDR is specified up to 2.5 GHz, and QDR is specified up to 5 GHz. This test is designed to measure the return loss of the cable assembly.

The test shall be performed on the "worst" differential pair, or lane in the InfiniBand port assembly. This lane is determined in the Mellanox Eye Opening MOI. The lane that has the lowest initial eye opening measurement is used. The Return Loss at TP6 and TP7 shall satisfy the equations shown in Appendix E.

Test Setup:

1. Use the general test setup described in the Initial Measurement Setup section.

Test Procedure:

1. **Note: The waveforms required for this test have already been gathered in 7.1.01.**
2. Load the setup file to the DSO (**RLILZ_A**).
3. Press the Run/Stop button on the DSO.
4. Download the data to IConnect
   a. Press "Detect" in IConnect
   b. Select the channels that are to be downloaded
   c. If enhanced resolution is needed, be sure to turn on long record captures.
   d. Press download
   e. After the download has completed, on the pull-down menus on the right side of the TDA software, select the channels to perform the math on, and operator as well.
   f. Subtract the channels from one another
   g. A new waveform appears in the window. Right-click and choose save as…
   a. Save as **RL_A_dd.wfm**
5. Repeat for the other end of the InfiniBand Cable using **RLZ_B** as the reference and **RL_B_dd.wfm** as the filename.

Observable Results:

- The Return Loss for an SDR cable is not specified. See Appendix E for return loss for DDR & QDR.
- RL on the cable input of the worst lane is required for all cables. In the case of hybrid cables (those with a different connector on one end than that on the other), the worst lane in each direction will be tested.
- Return Loss on the cable output of the worst lane is informative for linear active cables and for passive cables that are equalized in the connector. It is normative (required) for unequalized cables and those cables that are passively equalized in the wire.

Possible Problems:

None.

Test 7.1.04 – Cable Assembly Near End Crosstalk

Purpose: To verify that the near end crosstalk within the cable assembly is within the conformance limits.

References:

[1] InfiniBand Architecture Specification – Volume 2, Physical Specifications, Rel. 1.3.1, Chapter 6.8.2, Linear Cable Electrical Requirements

[2] Appendix A, Resource Requirements

Resource Requirements:

See Appendix A.

Discussion:

Reference [1] defines the electrical characteristics that shall be exhibited by a copper InfiniBand cable. These electrical requirements are specified for cables with width 1x (4 conductors), 4x (16 conductors), 8x (32 conductors), and 12x (48 conductors) as well as different rates of operation. The frequency range of this test is determined by the technology being tested. SDR is specified up to 1.25GHz, DDR is specified up to 2.5 GHz, and QDR is specified up to 5 GHz. This test is designed to measure how susceptible the cable assembly is to crosstalk.

The test shall be performed on the "worst" differential pair, or lane in the InfiniBand port assembly. This lane is determined in the Mellanox Eye Opening MOI. The lane that has the lowest initial eye opening measurement is used.

Test Setup:

1. Use the general test setup described in the Initial Measurement Setup section.

Test Procedure:

1. Load the setup file to the DSO (**Xtalk1**).
2. Press the Run/Stop button on the DSO.
3. Download the data to IConnect
   b. Press "Detect" in IConnect
   c. Select the channels that are to be downloaded
   d. If enhanced resolution is needed, be sure to turn on long record captures.
   e. Press download
   f. After the download has completed, on the pull-down menus on the right side of the TDA software, select the channels to perform the math on, and operator as well.
   g. Subtract the channels from one another
   h. A new waveform appears in the window. Right-click and choose save as…
   i. Save as **A_xt_1.wfm**
4. Repeat for the other disturbers using **Xtalk2** as the reference and **A_xt_2.wfm** as the filename.

Observable Results:

The cable assembly crosstalk shall be less than 4% for MicroGiGaCN connectors and 2% for QSFP connectors.

Possible Problems:

None.

Test 7.1.05 – Eye Height

Purpose: To verify that the minimum eye opening of the passive cable assembly is greater than the conformance limit.

References:

[1] InfiniBand Architecture Specification – Volume 2, Physical Specifications, Rel. 1.3.1, Chapter 6.8.2, Linear Cable Electrical Requirements
[2] Appendix A, Resource Requirements

Resource Requirements:

See Appendix A.

Discussion:

Reference [1] defines the electrical characteristics that shall be exhibited by a copper InfiniBand cable. These electrical requirements are specified for cables with width 1x (4 conductors), 4x (16 conductors), 8x (32 conductors), and 12x (48 conductors) as well as different rates of operation. The frequency range of this test is determined by the technology being tested. SDR is specified up to 1.25GHz, DDR is specified up to 2.5 GHz, and QDR is specified up to 5 GHz. This test is designed to measure the vertical eye opening of the cable assembly.

The test shall be performed on the "worst" differential pair, or lane in the InfiniBand port assembly. This lane is determined in the Mellanox Eye Opening MOI. The lane that has the lowest initial eye opening measurement is used.

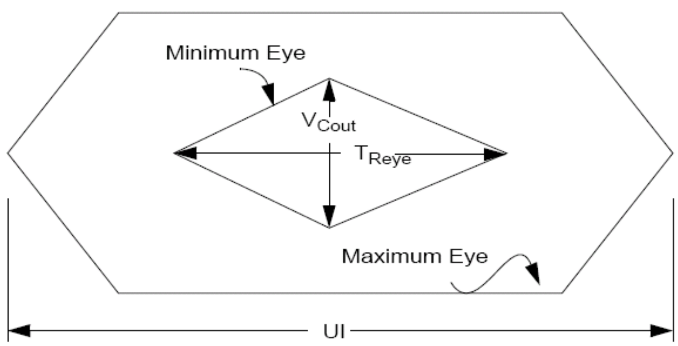


Figure 6: Eye diagram specifications

Test Setup:

1. No test setup is required for generating the eye diagrams. This step is done entirely in IConnect and MATLAB.

Test Procedure:

1. Note: Data must be gathered from Insertion Loss and Crosstalk before building the eye.
2. Compile the waveforms by running ('IB_Initialize' and 'IB_Test') in MATLAB
3. Use the procedure outlined in Appendix D to create the eye diagram
4. Record the eye height opening
5. Enter the value into MATLAB.
6. Save the image in the "images" folder of the DUT

Observable Results:

The minimum eye opening, Vc_{out} shall be greater than 196 mV for SDR cables. Test 7.1.05 (Eye Height) is not required for DDR and QDR cables

Possible Problems:

Occasionally the crosstalk observed within one cable can be so great that the eye opening is not able to be calculated automatically by the software. In these cases, cursors should be used for a manual measurement.

Test 7.1.06 – Eye Width

Purpose: To verify that the eye width opening of the passive cable assembly is greater than the conformance limit.

References:

[1] InfiniBand Architecture Specification – Volume 2, Physical Specifications, Rel. 1.3.1, Chapter 6.8.2, Cable Assembly Electrical Requirements
[2] Appendix A, Resource Requirements

Resource Requirements:

See Appendix A.

Discussion:

Reference [1] defines the electrical characteristics that shall be exhibited by a copper InfiniBand cable. These electrical requirements are specified for cables with width 1x (4 conductors), 4x (16 conductors), 8x (32 conductors), and 12x (48 conductors) as well as different rates of operation. The frequency range of this test is determined by the technology being tested. SDR is specified up to 1.25GHz, DDR is specified up to 2.5 GHz, and QDR is specified up to 5 GHz. This test is designed to measure the horizontal eye width opening of the cable assembly.

The test shall be performed on the "worst" differential pair, or lane in the InfiniBand port assembly. This lane is determined in Mellanox Eye Opening Test. The lane that has the lowest initial eye opening measurement is used.

Test Setup:

1. No test setup is required for generating the eye diagrams. This step is done entirely in IConnect and MATLAB.

Test Procedure:

1. Note: Data must be gathered from Insertion Loss and Crosstalk before building the eye.
2. Compile the waveforms by running ('IB_Initialize' and 'IB_Test') in MATLAB
3. Use the procedure outlined in Appendix D to create the eye diagram
4. Record the eye width
5. Save the image in the "images" folder of the DUT

Observable Results:

The eye width opening, T_{Reye} (see Figure 6), shall be greater than 0.75 UI. The peak-to-peak jitter value shall be less than 0.25 UI; 100 ps for SDR.

Possible Problems:

Occasionally the crosstalk observed within one cable can be so great that the eye opening is not able to be calculated automatically by the software. In these cases, cursors should be used for a manual measurement.

ACTIVE CABLES – SDR-QDR (Return Loss Only)

The tests contained in this section comprise those performed using a Tektronix DSA8xxx chassis with a TDR sampling head and running 80SJNB software

The tests in this section are specified for Active InfiniBand Cables. These cables require power as well as active fixtures prior to being tested.

An "active" cable is one that is either active copper or fiber or a limiting active copper cable.

Test 7.2.01 – Cable Assembly Return Loss

Purpose: To verify that the return loss of the active cable assembly is within the conformance limits.

References:

[1] InfiniBand Architecture Specification – Volume 2, Physical Specifications, Rel. 1.3.1, Chapter 6.8.2, Linear Cable Electrical Requirements
[2] Appendix A, Resource Requirements
[3] IBTA EWG – Proposed Active Cable Interface Specification 090305.ppt (to be included in InfiniBand Architecture Specification)

Resource Requirements:

See Appendix A.

Discussion:

Reference [1] defines the electrical characteristics that shall be exhibited by an active InfiniBand cable. These electrical requirements are specified for cables with width 1x (4 conductors), 4x (16 conductors), 8x (32 conductors), and 12x (48 conductors) as well as different rates of operation. The frequency range of this test is determined by the technology being tested. SDR is specified up to 1.25GHz, DDR is specified up to 2.5 GHz, and QDR is specified up to 5 GHz. This test is designed to measure the return loss of the cable assembly.

The test shall be performed on the "worst" differential pair, or lane in the InfiniBand port assembly. This lane is determined in test Mellanox Eye Opening Test. The lane that has the lowest initial eye opening measurement is used. The Return Loss at TP6 shall satisfy the equations shown in Appendix E.

Test Setup:

1. Use the general test setup described in the Initial Measurement Setup section.

Test Procedure:

1. Load the setup to the DSO (**RLILZ_A**).
2. Press the Run/Stop button on the DSO.
3. Download the data to IConnect
   a. Press "Detect" in IConnect
   b. Select the channels that are to be downloaded
   c. If enhanced resolution is needed, be sure to turn on long record captures.
   d. Press download
   e. After the download has completed, on the pull-down menus on the right side of the TDA software, select the channels to perform the math on, and operator as well.
   f. Subtract the channels from one another
   g. A new waveform appears in the window. Right-click and choose save as…
   j. Save as **RL_A_dd.wfm**
4. Repeat for the other end of the InfiniBand Cable using **RLZ_B** as the reference and **RL_B_dd.wfm** as the filename.

Observable Results:

- The Return Loss for an SDR active cable is not specified. See Appendix E for return loss for DDR & QDR.
- Return Loss on the cable output (side B) is informative for active cables

Possible Problems: None.

Appendix A – Resource Requirements

The resource requirements include two separate sets of equipment. The equipment required for Passive Cable tests is shown in section A.1.

A.1 Equipment for Passive Cable tests

1. TDR Sampling Heads
    a. (4) Tektronix 80E04 modules (or a higher model number)

2. Test Fixture – see Test Fixtures Section

3. Oscilloscope chassis
    a. Tektronix DSA8300 Chassis

4. (10) Matched SMA Cables

5. Software
    a. Matlab R2006A or later
    b. Matlab-Code - PF25 or later
    c. Tektronix IConnect

6. Terminators
    a. (8) 50 Ohm terminations

A.2 Equipment for Active Cable tests

1. TDR Sampling Heads
    a. (1) Tektronix 80EXX module

2. Test Fixture - see Test Fixtures Section

3. Oscilloscope chassis
    a. Tektronix DSA8300 Chassis with 80SJNB Jitter Noise and BER Analysis software

4. SMA cables
    a. (10) matched SMA cables
    b. (1) additional SMA cable (for scope trigger input)

Appendix B – TDR Alignment and Acquisition Setup

Mixed Mode TDR Channel Alignment with Independent TDR Source

Introduction

This deskew procedure utilizes an independent acquisition source and assumes availability of two TDR sampling modules (80E04, 80E08, or 80E10). It can also be used with one TDR (80E04, 80E08, or 80E10), and one dual sampling module (80E03 or 80E09). It aligns both samplers and TDR steps allowing measuring mixed mode S-parameters. The procedure starts with the alignment of the samplers and concludes with alignment of the acquisition channels.

Required Equipment

1. One sampling oscilloscope mainframe (DSA8300).
2. Two TDR sampling modules (80E04, 80E08, or 80E10);
3. Four matched SMA cables
4. One SMA barrel (female-to-female) adaptor.

Figure 7: Equipment required to perform mixed mode deskew procedure.

The wrist strap is important for ESD protection and a calibrated torque wrench is recommended to protect the connectors and to get good repeatability.

Match samplers to the ends of the cables

The purpose of this step is to set the samplers on each channel so that an input into the open end of each cable arrives at the sample gate at precisely the same time. This step compensates for cable and sampler differences. First stage is alignment of the channels 1-3 using the channel 4 as an independent TDR source, and then aligning acquisition of the channel 4 with respect to already aligned channel 3 using channel one as another independent source.[1] The deskew procedure is to be performed in *rho* mode.

1. Connect SMA cables to the sampling modules of the oscilloscope. For the best results, it is desired that the SMA cables used in the measurements have approximately the same quality and length (matched within 20ps).

[1] When only one TDR and one sampling modules are available another TDR channel can be used as an independent TDR source.

2. Connect channel 1 and channel 4 with SMA barrel, activate TDR step on channel 4 and acquisition on channel 1 (see Figure 2).

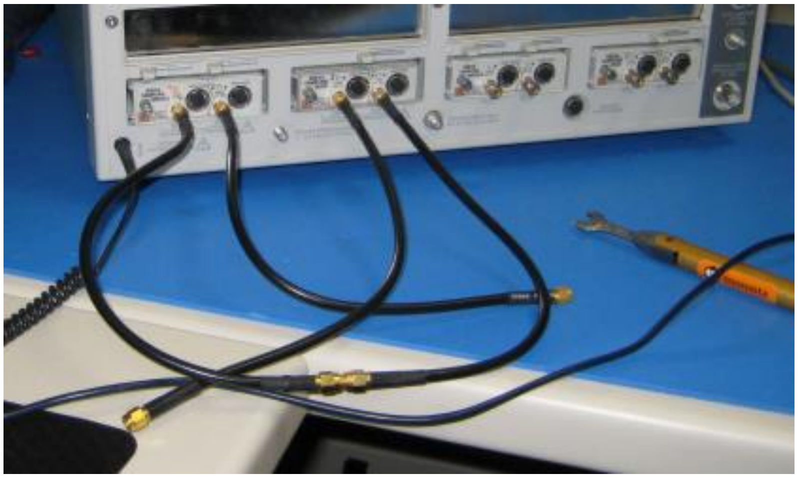


Figure 8: C1 is connected to C4 with SMA barrel.

The TDR step is generated on C4 and acquired using C1.

3. Adjust the horizontal position and scale to get the rising edge on screen with good resolution (20ps/div). Record length should have the maximum number of 4000 points.
4. Save channel one (C1) waveform as a reference trace. Channel 2 and 3 will be aligned with respect to it.
5. Connect channel two (C2) to the channel four (C4) using SMA barrel, and display C2 on the screen.
6. Turn on the delay measurement to measure the time difference between the rising edge on the reference trace and the rising edge of C2 as shown in Figure 3.

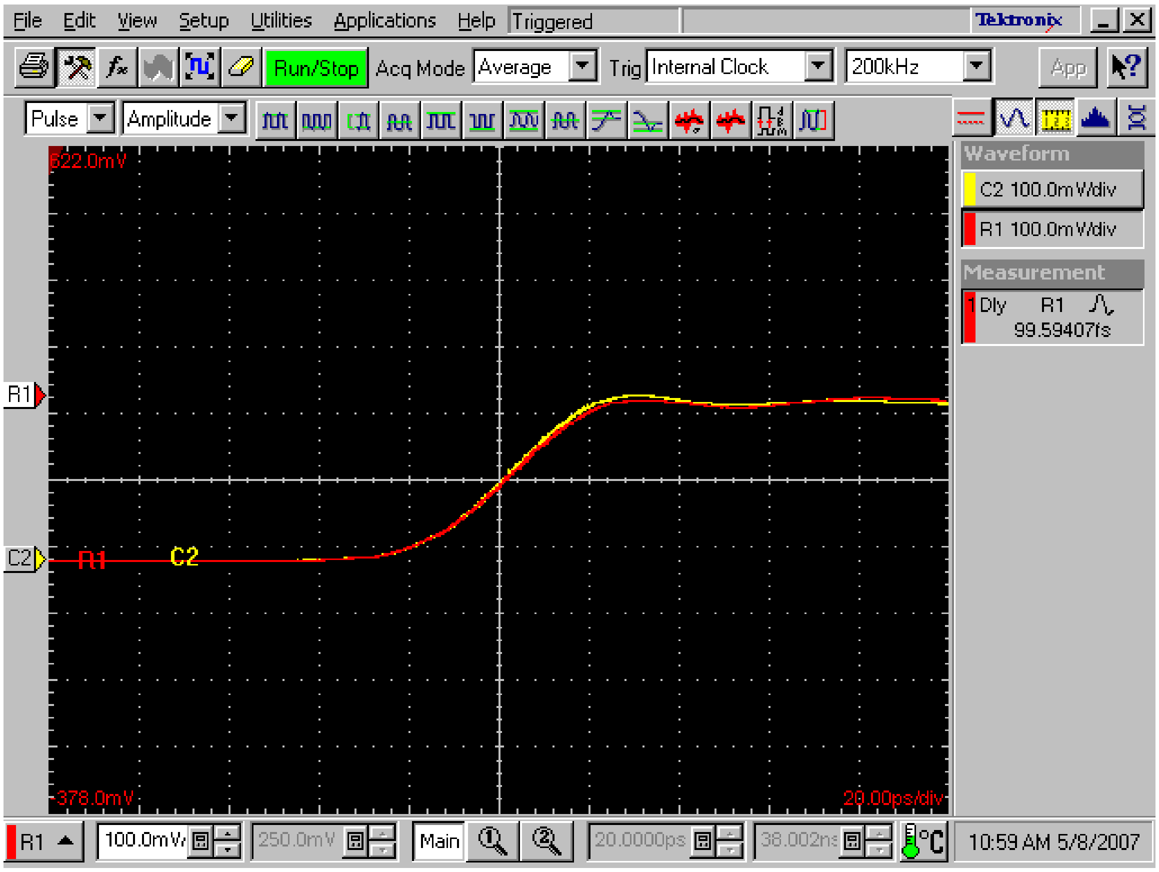


Figure 9: Delay measurements between reference (R1) acquired from channel one and channel two (C2). It has to be the minimum for the best deskew value.

7. Adjust the channel deskew value in the *Vertical* menu of the *Setups* dialog until a delay value within 1ps is achieved as show
8. Repeat steps 5-7 for the C3.
9. Now, when the acquisition of C1 through C3 is aligned, the same approach can be used to align C4. For this purpose generate a new reference by using the step of C1 and acquiring it on C3. C3 has to be connected to C1 with the SMA barrel.
10. Repeat steps 5-7 for the C4 using acquired reference from C3.

Now, all four acquisition channels have been deskewed within 1ps.

Match the TDR pulses to the ends of the cables

The purpose of this step is to adjust the TDR pulses so they arrive at the ends of the cables at precisely the same time. The deskew has to be performed separately for odd and even TDR steps when 80E04 modules are used[2]. This section describes only odd mode TDR step deskew. The deskew procedure has to be performed in *rho* mode.

1. Disconnect the SMA barrel and turn on TDR pulses of the appropriate polarity for each channel (C1 and C2). Use the differential TDR preset selection to activate odd mode.
2. Adjust the horizontal position and scale so that the pulses as they arrive at the ends of the cables are visible on screen with good resolution. (Use *Average* mode and vectored display, a set time scale to 20ps/div).

[2] Odd mode (differential) is generated when TDR steps set to opposite polarity and even mode (common) is generated when both steps are of the same polarity.

3. Turn on the delay measurement to measure the time difference between the two pulse edges.
4. Adjust the *Step Deskew* in TDR menu to minimize the time difference between the C1 and C2 pulses. You might want to activate *Fine* button to reduce the increment of deskew as shown in Figure 4.

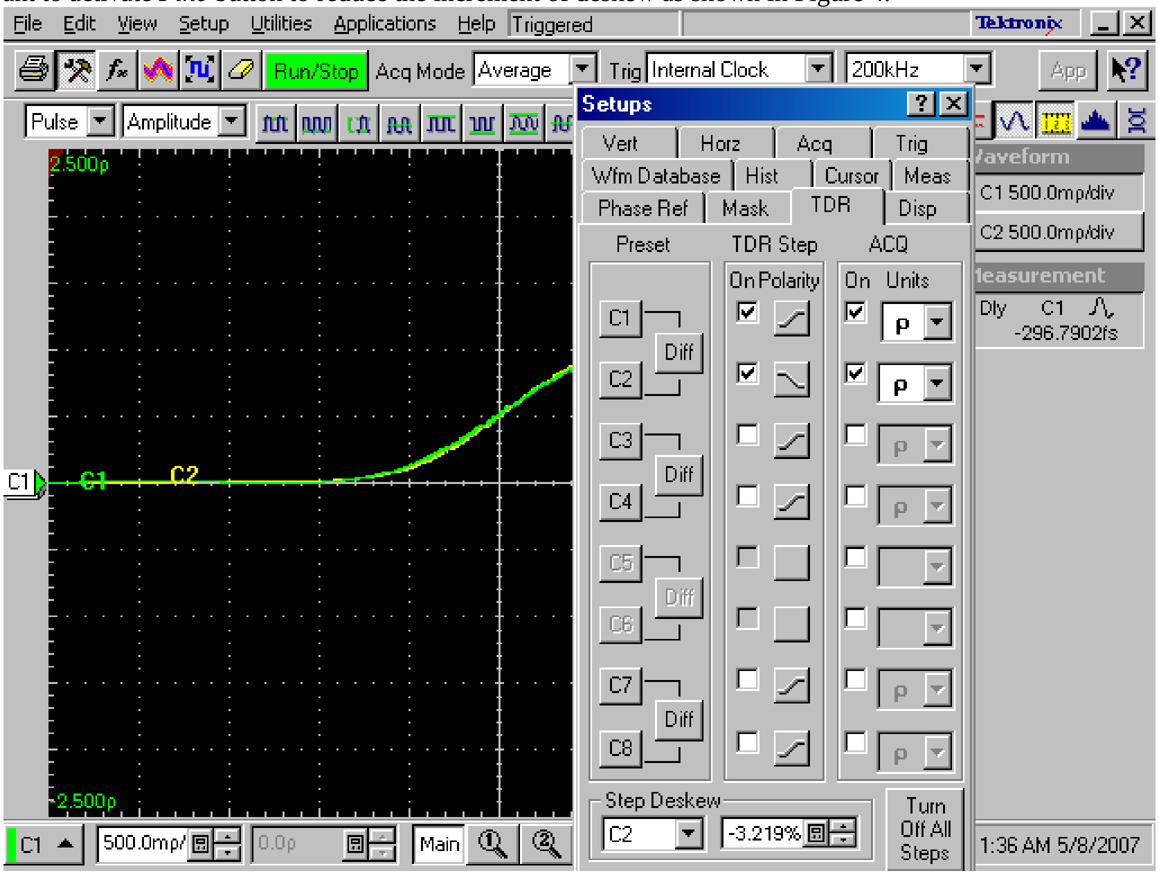


Figure 10: Differential TDR step deskew. The channels C1 and C2 are aligned within ~300fs.

5. Repeat steps 1-4 for C3 and C4, and save the instrument setup.
6. Repeat steps 1-5 in even mode if desired.

The instrument should now be set up to accurately make differential or common mode TDR measurements.

Correct Acquisition Window Settings for S-parameters Calculations with IConnect

The acquisition of S-parameters with TDR/T instrument requires that the DUT's reflections settle to their steady DC level. The approximate rule of thumb for the acquisition window width is four or five times time delay of the DUT. This is shown in the Figure B.2.1.

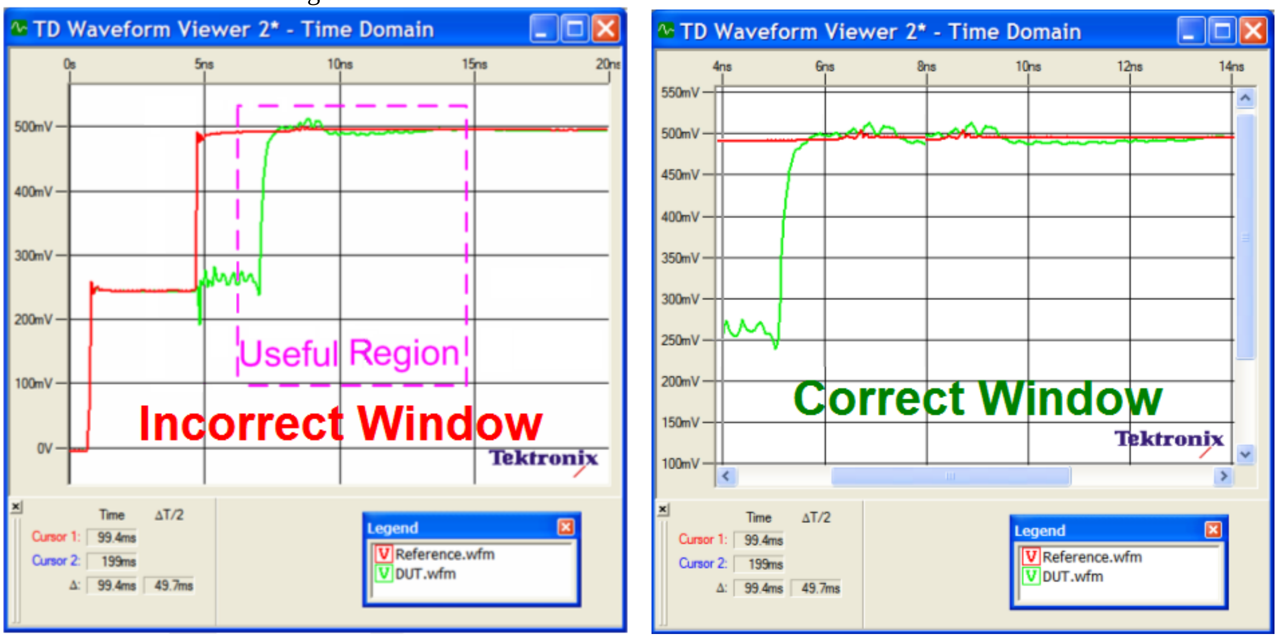


Figure 11: B.2.1. Correct acquisition window settings used in IConnect software to compute S-parameters.

First incident step is windowed out, and all reflections settled to a steady DC level.

Also be sure to position the window AFTER the end of the SMA cable but BEFORE the MicroGiGaCN (or QSFP) connector on the test fixture.

Appendix C - TDNA Measurement System Accuracy

Table C.1 summarizes characteristics of the TDNA system used for RX/TX and SI test. The system is based on a standard 80E04 module that allows to perform both return and insertion loss measurements from time domain data.

Table 5: C.1 TDR System Characteristics with a standard 80E04 module

Characteristics	Value
Input Impedance	50 ±0.5Ω
TDR Step Amplitude	250 mV
TDR System Reflected Rise Time (10% to 90%)	≤35 ps
TDR System Incident Rise Time (10% to 90%)	≤28 ps (typical)
TDR Step Maximum Repetition Rate	200 kHz
DC Vertical Range Accuracy within 2°C of Compensated Temperature	±[2 mV + 0.007 (Offset) + 0.02 (Vertical Value-Offset)]
RMS Noise (typical/maximum)	600 µV/≤1.2 mV
Bandwidth	20GHz
Dynamic Range	50-60dB

Table 6: C.2 TDR System Characteristics with a standard 80E10 module

Characteristics	Value
Input Impedance	50 ±0.5Ω
TDR Step Amplitude	250 mV
TDR System Reflected Rise Time (10% to 90%)	≤15 ps
TDR System Incident Rise Time (10% to 90%)	≤15 ps (typical)
TDR Step Maximum Repetition Rate	200 kHz
DC Vertical Range Accuracy within 2°C of Compensated Temperature	±[2 mV + 0.007 (Offset) + 0.02 (Vertical Value-Offset)]
RMS Noise (typical/maximum)	600 µV/≤700 µV
Bandwidth	50GHz
Dynamic Range	50-60dB

Appendix D – Generating Eye Diagrams using IConnect

This appendix shows the user how to generate an eye diagram using Tektronix IConnect software. This procedure is used for the Eye Height and Eye Width Tests listed in the Passive Cable section.

Steps:

1. Go to eye window (from the "Window" menu)

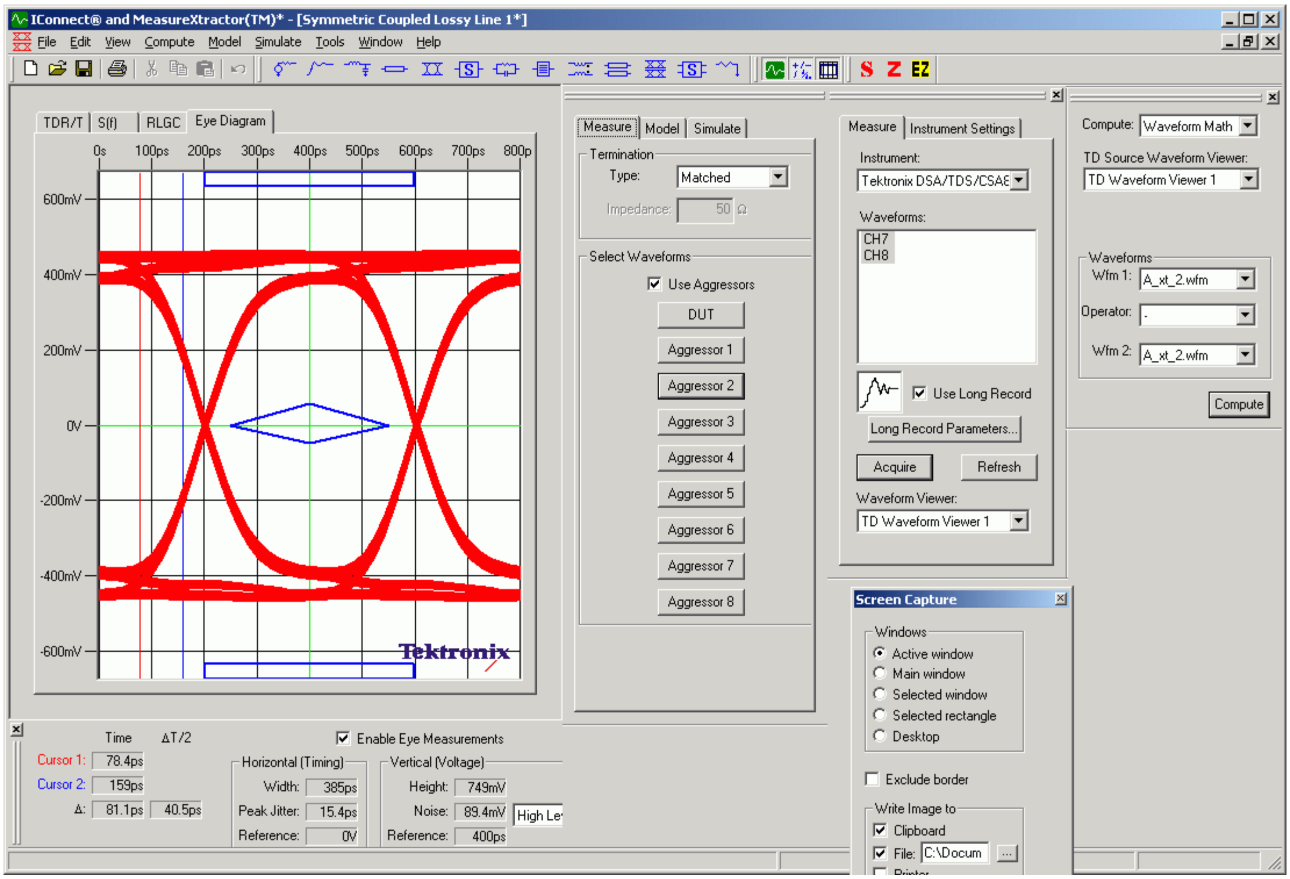


Figure 12: Generating Eye Diagrams using IConnect

2. Click the Measure tab, make sure "User Aggressors" is checked
3. Click DUT

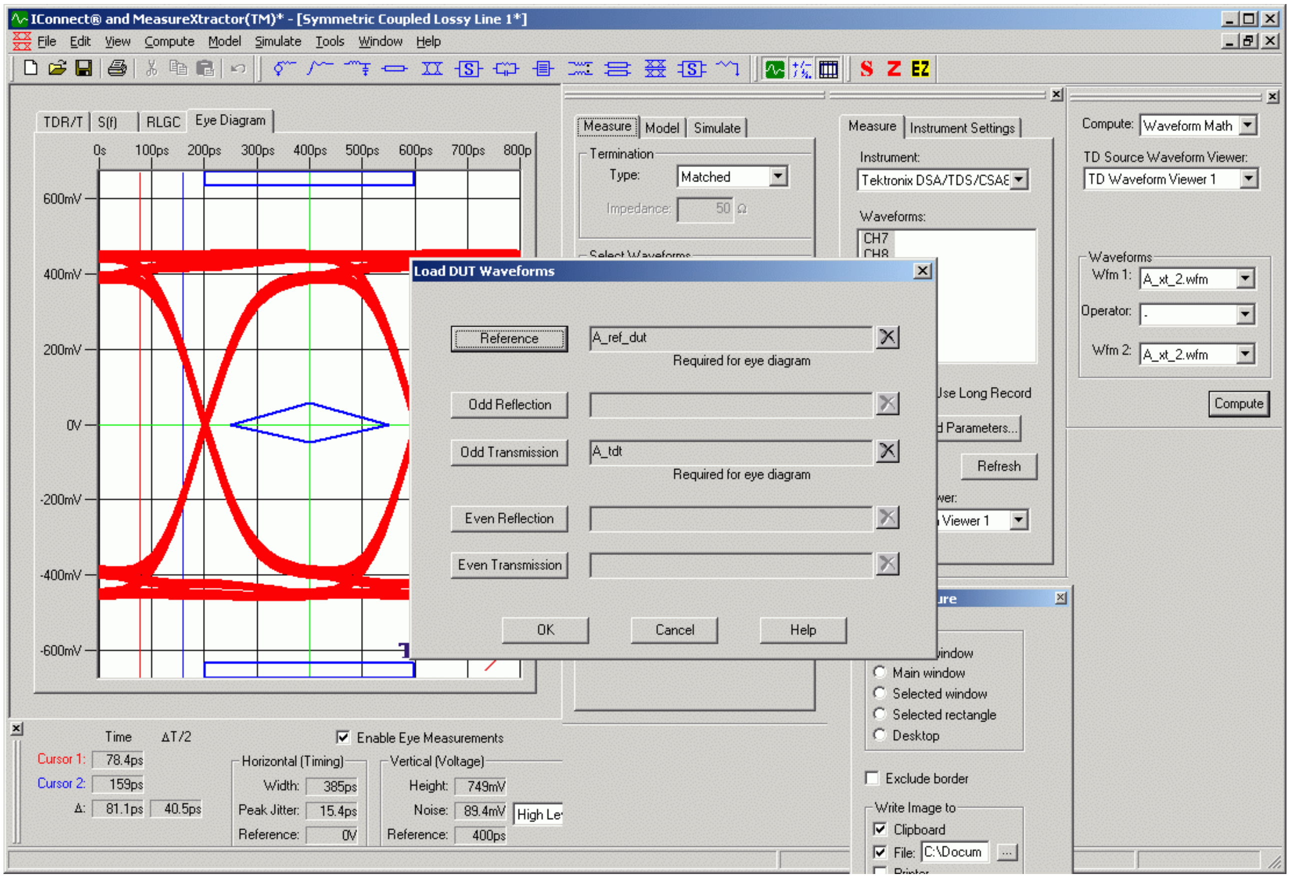


Figure 13: Generating Eye Diagrams using IConnect – Use Aggressors

4. Click Reference and select A_ref_dut.wfm.
5. This is the data that was saved in the IConnectData folder, but is also stored in the 'raw_data' folder of the DUT's directory

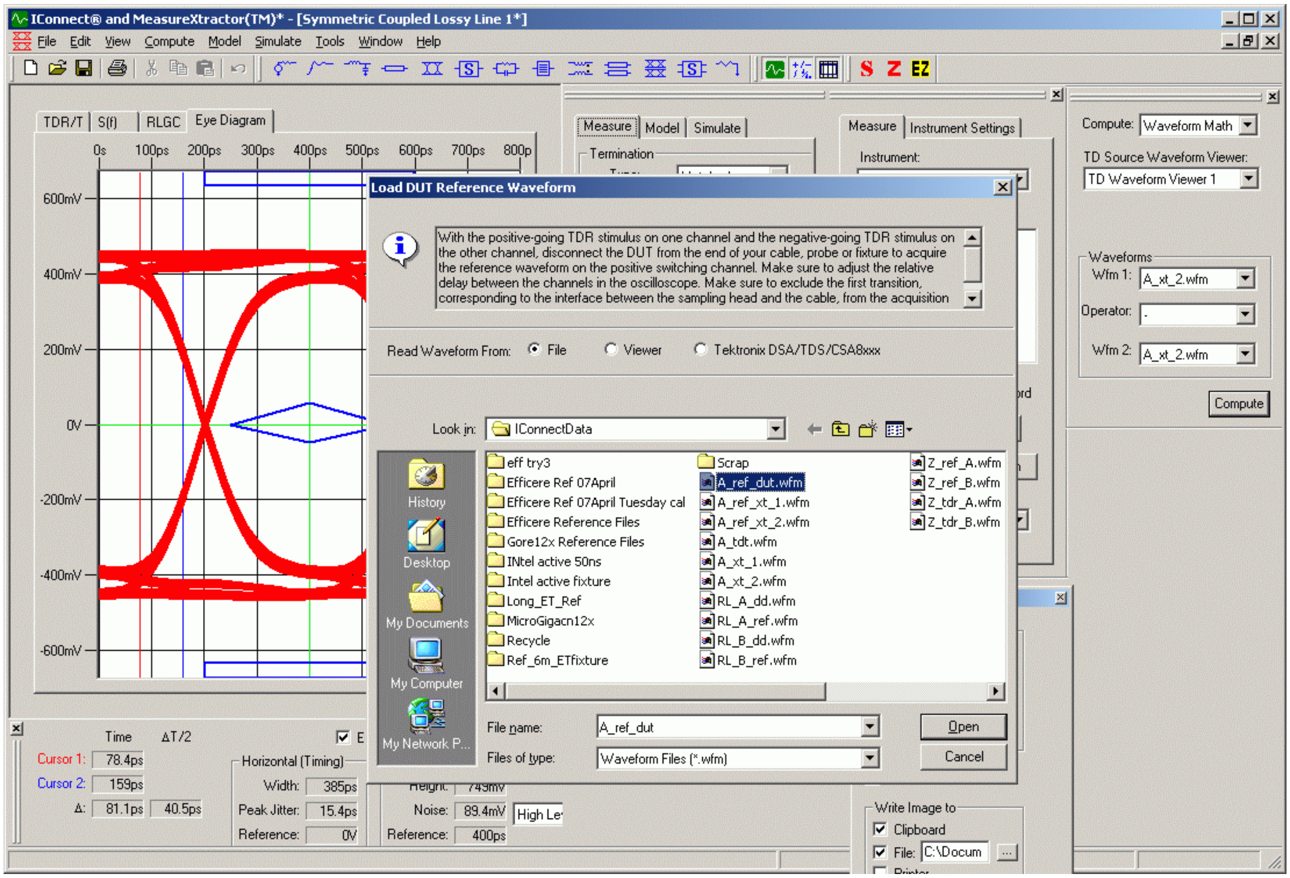


Figure 14: Generating Eye Diagrams using IConnect – Click Reference and select A_ref_dut.wfm

6. Click Odd transmission, and select A_tdt.wfm
7. Click OK
8. Click Aggressor 1
9. Select A_ref_xt_1.wfm and A_xt_1.wfm
10. Click Aggressor 2
11. Select A_ref_xt_2.wfm and A_xt_2.wfm
12. Click the simulate tab
13. Click display, with “show” and “use” checked for DUT, Aggressor 1, and Aggressor 2

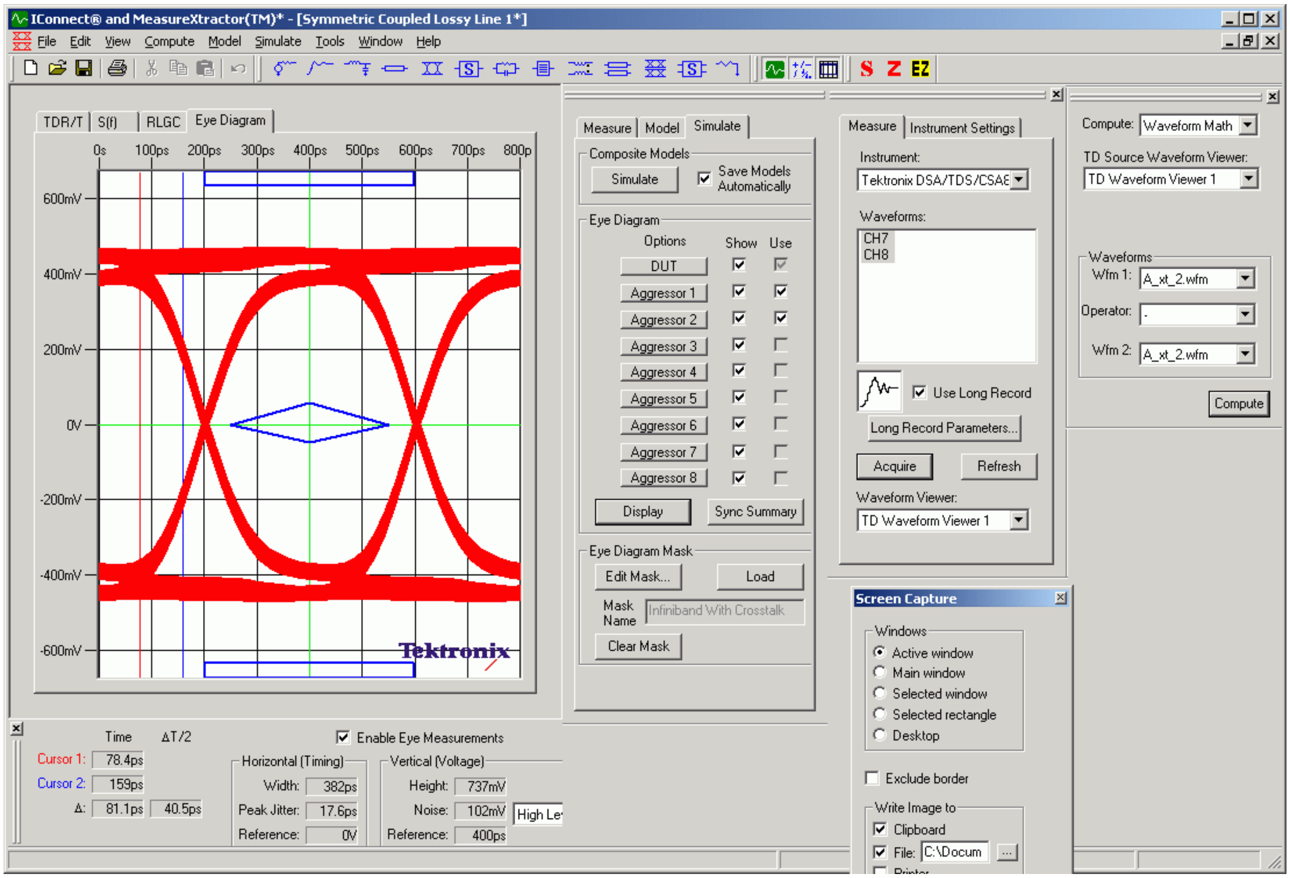


Figure 15: Generating Eye Diagrams using IConnect – load eye diagram mask

14. Click “load” under “eye diagram mask”
15. For SDR, browse to select “InfiniBand with crosstalk” in the “Results” directory
16. For DDR, browse to select “InfiniBand with crosstalk [DDR]” in the “Results” directory
17. Record eye height and pk-pk jitter

To save the eye diagram, make sure the “screen capture” toolbar is displayed.

1. Make sure write image to “file” checkbox is checked
2. Browse to the save location
3. Click Save
4. In the “screen capture” toolbar, click “Capture”

Appendix E – S parameter requirements

- SDD11 and SDD21 requirements are taken from the InfiniBand Architecture Specification Volume 2 Release 1.3.1.

Table 7: Insertion Loss for Passive Cables at 5.0 Gb/s (DDR)[a]

Frequency	SDD21 (min.) [c]
100 MHz	-8
200 MHz	-8
625 MHz	-8
1250 MHz	-8
1875 MHz	-9.5
2500 MHz	-11

Table 8 - Return Loss for Active and Passive Cables at 5.0 Gb/s (DDR)[a]

Frequency (GHz)	SDD11 (max)
0.1 – 1.0	-10
1.0 – 4.1	$-\left(12-2*\sqrt{f}\right)$
4.1 – 5.0	$-\left(6.3-13*\log_{10}\left(f/5.5\right)\right)$

Table 9 - Insertion Loss for Passive Cables at 10.0 Gb/s (QDR)[a]

Frequency (MHz)	SDD21 (min.) [c]
100	-8
200	-8
625	-8
1250	-8
1875	-8.5
2500	-9.3
3750	-11.2
5000	-13
7500	-18 (Informative)
8500	-20 (Informative)
9000	-21 (Informative)
10000	-23 (Informative)

Table 10 – Return Loss for Active and Passive Cables at 10.0 Gb/s (QDR)[a]

Frequency (GHz)	SDD11 (max)
0.1 – 1.0	-10
1.0 – 2.5	$-\left(12-2*\sqrt{f}\right)$
2.5 – 4.1	$-\left(12-2*\sqrt{f}\right)$
4.1 – 10	$-\left(6.3-13*\log_{10}\left(f/5.5\right)\right)$

Frequency (MHz)	SDD11 (min.) [c]
100	-10
200	-10
625	-10
1250	-9.8
1875	-9.3
2500	-8.8
3750	-8.1
5000	-6.8
10000	-2.9

a) All values are measured in dB
b) Return loss measurements are not required on passive equalized cables on the signal pins at the cable end containing the equalizer components.
c) sdd21 must decrease smoothly as frequency increases, with no notch-like behavior at frequencies