

# InfiniBand Trade Association

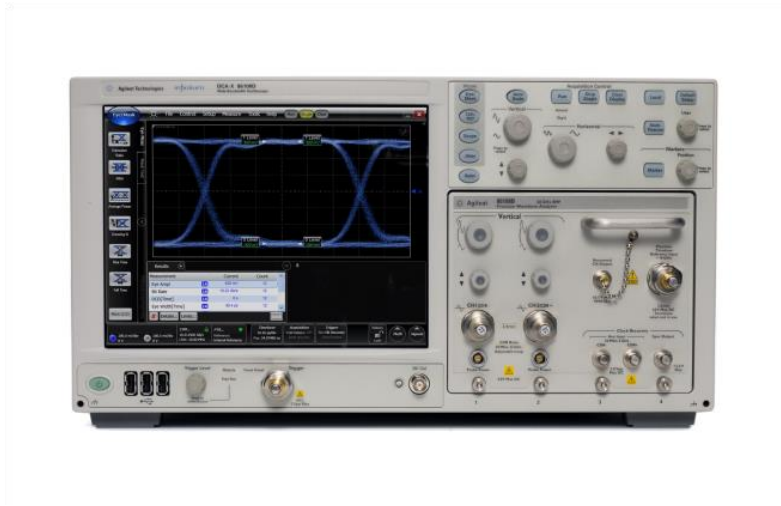
Revision 1.06

1/26/2014

---

## IBTA MOI for FDR Devices

### For Agilent 86100D DCA-X Oscilloscope Mainframe with 86108B Module



**This material is provided for reference only. The InfiniBand Trade Association does not endorse the vendor's equipment outlined in this document.**

**This document is provided "AS IS" and without any warranty of any kind, including, without limitation, any express or implied warranty of non-infringement, merchantability or fitness for a particular purpose. In no event shall IBTA or any member of IBTA be liable for any direct, indirect, special, exemplary, punitive, or consequential damages, including, without limitation, lost profits, even if advised of the possibility of such damages**

## Table of Contents

Introduction .....	4
Required Equipment .....	4
Equipment Configuration .....	4
General Setup .....	5
Test 1: Eye Mask test.....	6
Test 2: Rise and fall time tests .....	8
Test 3: Vcm – AC common mode output voltage .....	10
Test 4: Vdiffpp – Differential p-p output voltage.....	12
Test 5: DDPWS.....	14
Test 6: Normalized error “e”, “vf” and peak linear fit pulse response .....	15
Test 7: Calculating c-1, c0 and c+1 for other presets .....	17
Test 8: Jitter Measurements .....	18
Test 9: Far End Transmit Output Noise Measurements.....	20
Test 10: Signal to Noise Ratio ( $Q_{sq}$ ) Measurements .....	22

## Table of Figures

Figure 1 - Equipment configuration.....	4
Figure 2 - Eye Mask Test.....	7
Figure 3 - Rise/Fall time test.....	9
Figure 4 - verify signal pattern.....	10
Figure 5 - ACVrms Measurement.....	11
Figure 6 - Autoscale error message .....	12
Figure 7 - Vdiffpp measurement.....	13

## Table of Tables

Table 1- Modification Record.....	3
-----------------------------------	---

**Table 1- Modification Record**

Revision	Release Date	Author	Comments
1.01	11/2/2012	Rupert Dance	<ul style="list-style-type: none"><li>Initial version of the document developed during Plugfest 22 in October 2012 with the assistance of Daniel Fradkin and Vitaly Zavrajin from Mellanox.</li></ul>
1.02	11/11/2012	Rupert Dance	<ul style="list-style-type: none"><li>Added more images, tables of content, figures and tables</li><li>Updated document format</li><li>Added details about Agilent Equipment</li><li>Added test scripts</li></ul>
1.03	9/16/2013	Alexander Rysin	<ul style="list-style-type: none"><li>Updated the DDPWS measurement method (Test 5), including new Matlab script</li><li>Updated Normalized error “e”, “vf” and peak linear fit pulse response (Test 6), including new Matlab script.</li><li>Added transmit jitter measurements section (Test 7).</li><li>Added Far End Transmit Output Noise Measurements section (Test 8).</li><li>Added Signal to Noise Ratio (<math>Q_{sq}</math>) Measurements section (Test 9).</li></ul>
1.04	10/7/2013	Alexander Rysin & Rupert Dance	<ul style="list-style-type: none"><li>Corrected inaccuracies in some of the test descriptions</li></ul>
1.05	10/10/2013	Rob Sleight & John Dorigi	<ul style="list-style-type: none"><li>Updated MOI to use FlexDCA user interface. Added a list of required equipment.</li></ul>
1.06	1/26/14	Rob Sleight	<ul style="list-style-type: none"><li>Added Equipment Configuration section with equipment setup graphic.</li><li>Added optional N1027A-PT2 to equipment list.</li></ul>

## Introduction

This Method of Implementation (MOI) describes how to perform TX tests on an InfiniBand FDR device.

## Required Equipment

- Qty 1 Agilent 86100D DCA-X Wide-Bandwidth Oscilloscope with Options ETR/200/300/401
- Qty 1 Agilent 86108B Precision Waveform Analyzer with Options LBW/216 or HBW/232
- Qty 2 Agilent N1027A-PT2 (or Qty 1 86108B-PT2) 50 GHz Phase Shifters (optional)
- Qty 2 Agilent N9398C/ N9398F DC Blocks (or equivalent)
- Qty 2 Agilent 11901C 2.4mm (m) to 3.5mm (f) adapters (or equivalent) if using 86108B-HBW
- Qty 1 Wilder QSFP+ Plug Test Adapter Model QSFP+ (or equivalent)
- Qty 1 Device Under Test (DUT) – InfiniBand FDR

## Equipment Configuration

Setup the test equipment as shown below in Figure 1 - Equipment configuration. The N1027A-PT2 50 GHz phase shifters (optional) remove skew inherent in the system. The 11901C 2.4mm-3.5mm adapters interconnect the Wilder cable fixture to the 86108B via a 50 GHz (2.4mm) DC Block. If a 26 GHz (3.5mm) DC Block is used, swap the order of the DC block and 2.4mm-3.5mm adapters shown below.

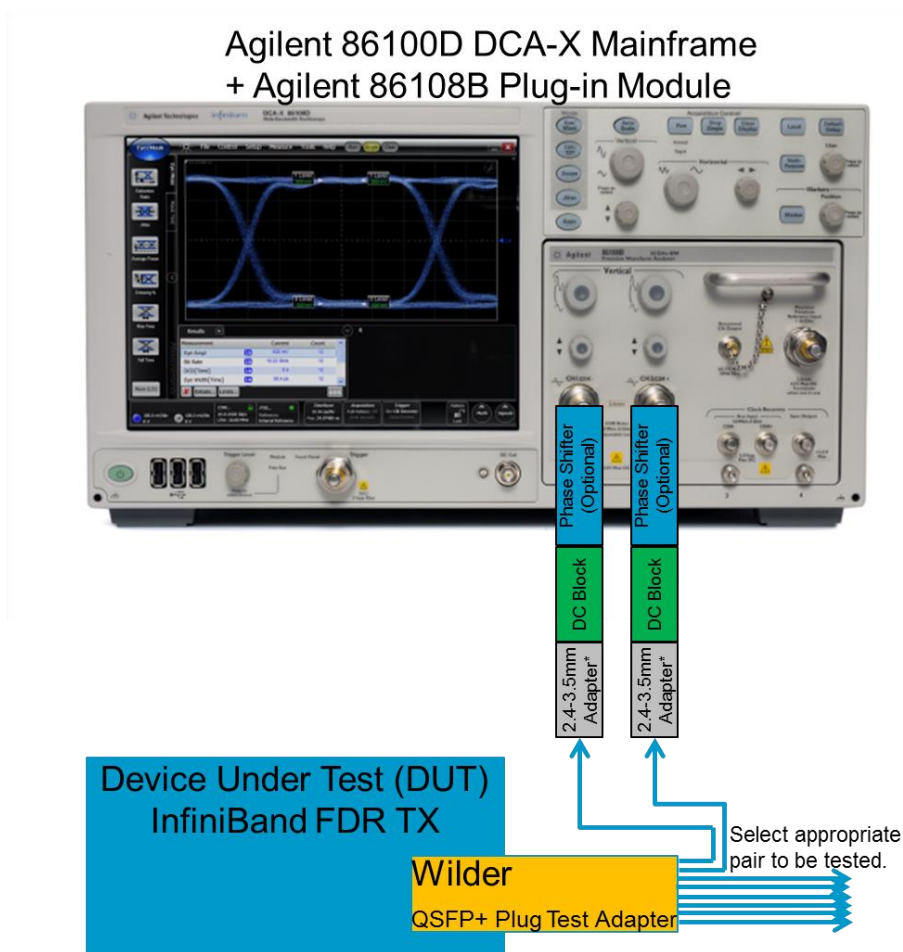


Figure 1 - Equipment configuration

## General Setup

1. Select Run prior to making any test measurement.
2. Clock recovery setup procedure
  - a. Click on CDR (Clock recovery) button
  - b. Make sure Nominal Data Rate is set to the rate you want (for example 14.0625 Gb/s)
  - c. Clock Recovery Loop Bandwidth (LBW) Setup
    - i. Target LBW: Rate Dependent
    - ii. Rate Divider: Data Rate/1667 (8.4 MHz)
    - iii. Click on “Advanced” and configure the peaking setting:
      1. Select Loop 1: 0dB (1<sup>st</sup> order PLL model)

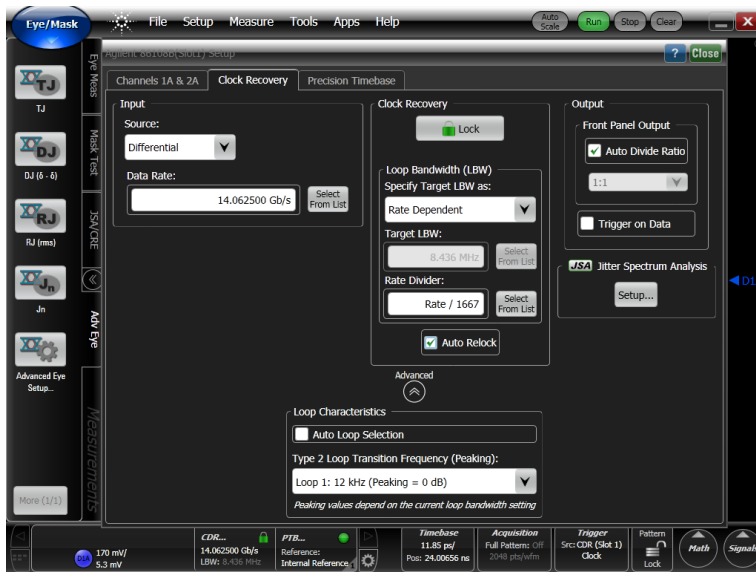
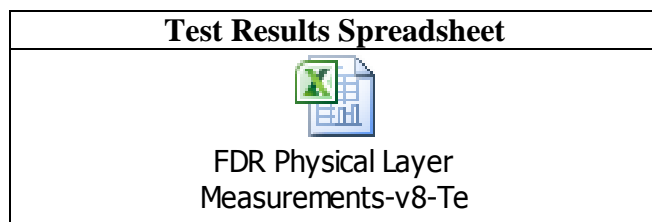


Figure 2 – Clock Recovery Setup

- d. Click on the Lock button – the indicator should turn **GREEN**; if the button is **RED**, then you are not in synch.
  - e. Turn Precision Timebase (PTB) on.
3. **Note:** In Oscilloscope Mode, turn Pattern Lock ON to see the waveform, turn OFF (unlock) to see the eye diagram.
4. Create a copy of the embedded spreadsheet for all ports you wish to test and select the appropriate tab for each lane you wish to test.
  - a. There is a Tab labeled test Spec which provides details of the specification to be tested.
  - b. There is a Tab labeled example which provides some sample data.
  - c. There are Tabs for all 4 lanes of a 4X IB device
  - d. There is a Summary tab which summarizes the results for the core tests of all 4 lanes.



## Test 1: Eye Mask test

**Purpose:** Measure the eye and determine the Mask Margin for Hit Ratio of 5E-5.

### Test Procedure

Note -To optimize measurement speed, it is best to acquire data first, and then turn on the mask test after the waveforms have been acquired.

- 1) Vendor should set to PRBS31 and preset 0
- 2) Select Setup | Mode | Eye Mask Mode
- 3) Press the Channel button and select Diff (configures D1A difference operator)
- 4) Execute CDR ([Clock recovery](#)) procedure
- 5) Make sure that the Pattern Lock button is **unlocked**
- 6) Setup |Acquisition Setup...| Samples/Waveform → 16200
- 7) Take at least 110 waveforms.  
Select Measure | Limit Tests | Acquisition Limits | Check Enable Limits | Set Waveforms to 110.
- 8) Set mask test margins for desired hit ratio.  
Select Measure | Eye/Mask | Mask Test Margins | Auto | Hit Ratio 5e-5 | Check Mask Test Margins On
- 9) Acquire the waveform data.  
Click Clear | Auto Scale | Run
- 10)
- 11) Open the FDR mask.  
Click the “Mask Test” tab. Select Load Mask File.... Navigate to the InfiniBand folder and open InfiniBand\_FDR.mskx



014.0625\_Infiniband\_FDR\_Host\_Tx.mskx

- 12)
- 13) The FlexDCA software will automatically grow the mask until it achieves a Hit Ratio of 5E-5. Record the mask margin.  
Note – refer to the FlexDCA Online HELP for more information on the Hit Ratio calculation.  
$$(\text{Total Margin Violations}) / (\text{Total Samples}) \leq \text{Hit Ratio}$$
where Total Samples is the # of samples in 1 UI; it is NOT the total samples acquired.

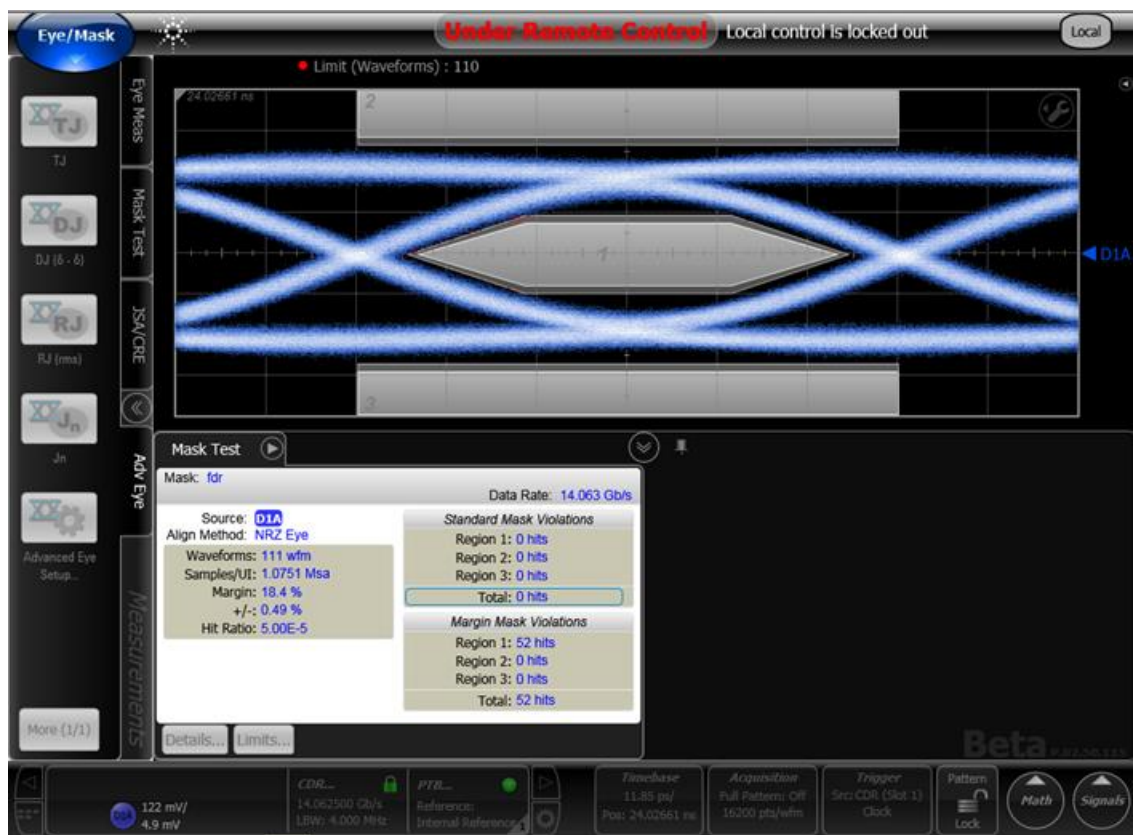


Figure 2 - Eye Mask Test

## Test 2: Rise and fall time tests

**Purpose:** Calculating the minimum rise and fall time for FDR Devices

### Test Procedure

Note -To optimize measurement speed, it is best to acquire data first, and then turn on measurements after the waveforms have been acquired.

- 1) Ask vendor to change to PRBS9 and Preset 0
- 2) Select Setup | Mode | Eye/Mask Mode
- 3) If the Diff (D1A) signal has not been configured...Press the Channel button and select Diff (configures D1A difference operator)
- 4) Execute CDR ([Clock recovery](#)) procedure
- 5)
- 6) Setup # of samples/waveform.  
Setup |Acquisition Setup...| Samples/Waveform ➔ 16200
- 7) Take at least 110 waveforms.  
Select Measure | Limit Tests | Acquisition Limits | Check Enable Limits | Set Waveforms to 110.
- 8) Acquire the waveform data.  
Click Clear | Auto Scale | Run
- 9) Configure 20%-80% rise/fall time  
Click Measure | Measure | Configure Base Measurements. On the “Thresholds” tab, select “20%, 50%, 80%”.
- 10) Enable Measurements  
On the “Eye Meas” tab, click:
  - a) Rise Time
  - b) Fall Time
  - c) Bit Rate (Optional). The displayed bit rate should be approximately the FDR bit rate.
- 11) Record the Values for both Tr and Tf



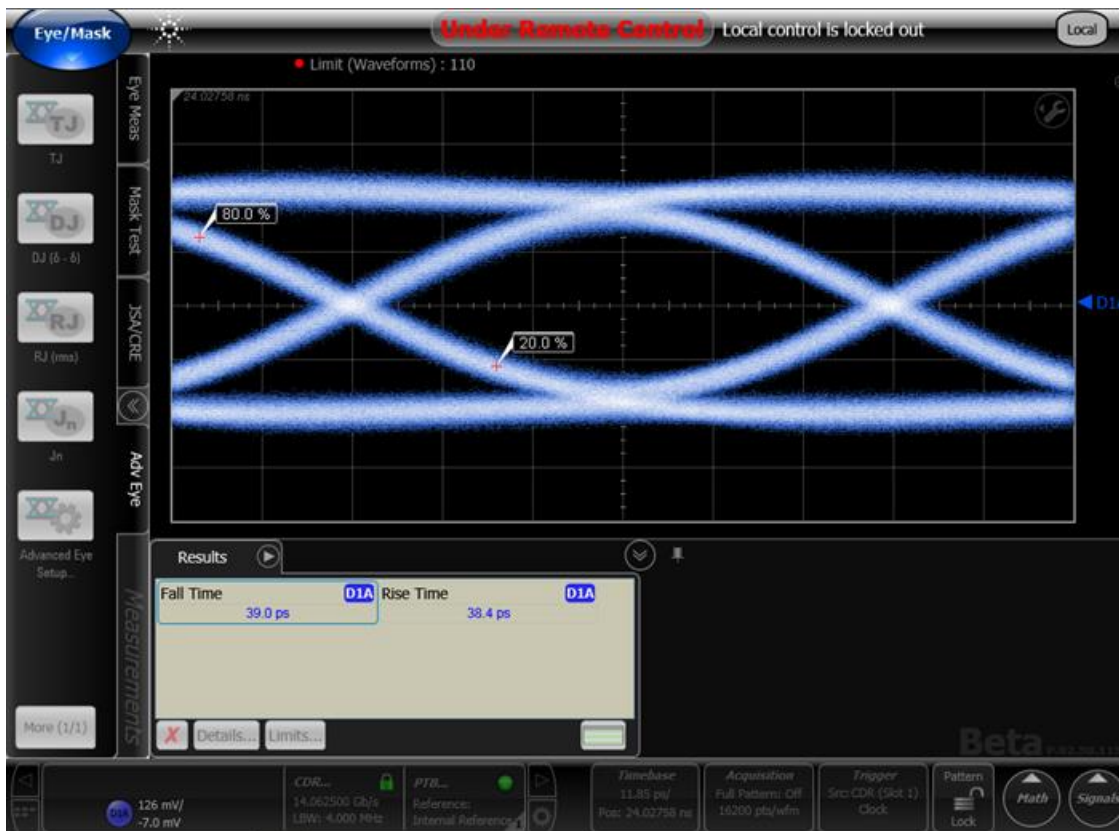


Figure 3 - Rise/Fall time test

### Test 3: Vcm – AC common mode output voltage

**Purpose:** This test is used to measure the AC common mode output voltage

#### Test Procedure

**Note:** The test should be run with the device set to preset 0 and two other presets chosen at random

- 1) Ask the device vendor to change the device transmit PRBS9 and to the preset being tested
- 2) Select Setup | Mode | Oscilloscope Mode
- 3) Verify that you have good signal
  - a) If the Diff (D1A) signal has not been configured...Press the Channel button and select Diff (configures D1A difference operator)
  - b) Execute CDR ([Clock recovery](#)) procedure
  - c) Enable Pattern Lock
  - d) Setup | Acquisition Setup... | Samples/Waveform → 16200
  - e) Auto Scale
  - f) Display 511 bits onscreen.

Setup | Timebase Setup... | Click “View Entire Pattern” button.

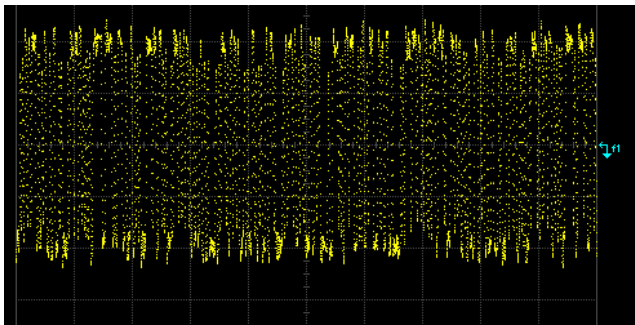
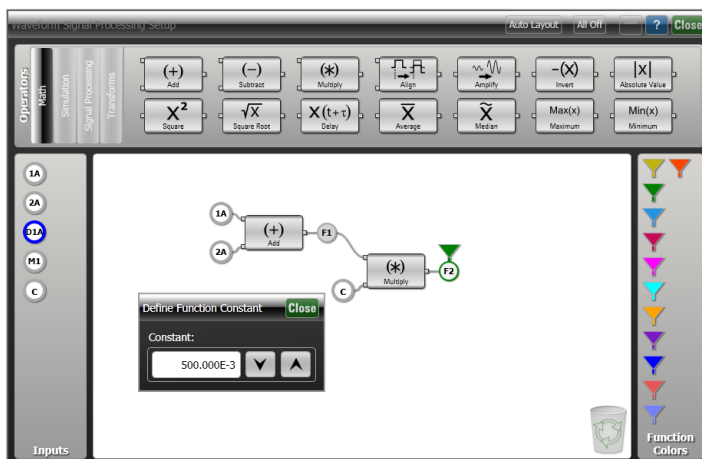


Figure 4 - verify signal pattern

- 4) Setup Common measurement.

Select Measure | Waveform Signal Processing | Math Operators and define common mode operator as shown below.



- 5)
  - a) Common  $(v+ \text{ plus } v-)/2$
  - b) Differential “D1” is  $v+ \text{ minus } v-$
- 6) Select the Amplitude Tab | Select RMS | Select entire display, AC and Function 2
- 7) Select Clear before recording the maximum value.
- 8) Record the value for ACVrms for Function F2.



Figure 5 - ACVrms Measurement

## Test 4: Vdiffpp – Differential p-p output voltage

**Purpose:** This test is used to measure the differential p-p output voltage with the driver disabled

### Test Procedure

- 1) Ask the vendor to disable his device
- 2) Select Setup | Mode | Oscilloscope Mode
- 3) Configure Diff (D1A) signal (if not already selected)  
Press the Channel button and select Diff (configures D1A difference operator)
- 4) Select the Amplitude Tab | Select RMS | select entire display AC and signal D1A
- 5) Select Autoscale
  - a) An error will occur because the signal is too small for the scope to synch on. Just click **close**.

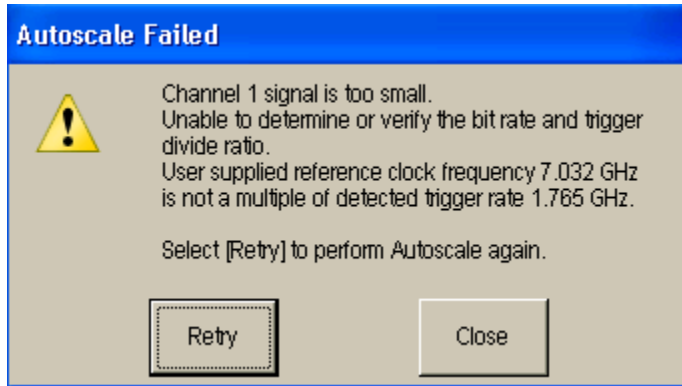


Figure 6 - Autoscale error message

- b) Record the value for ACVrms.
- c) Record maximum value which we expect to be in micro volts but could be in milli volts. The spreadsheet records mille volts so if the result is in micro volts, you need to convert. For example 428.46 uV is 0.42846 mV

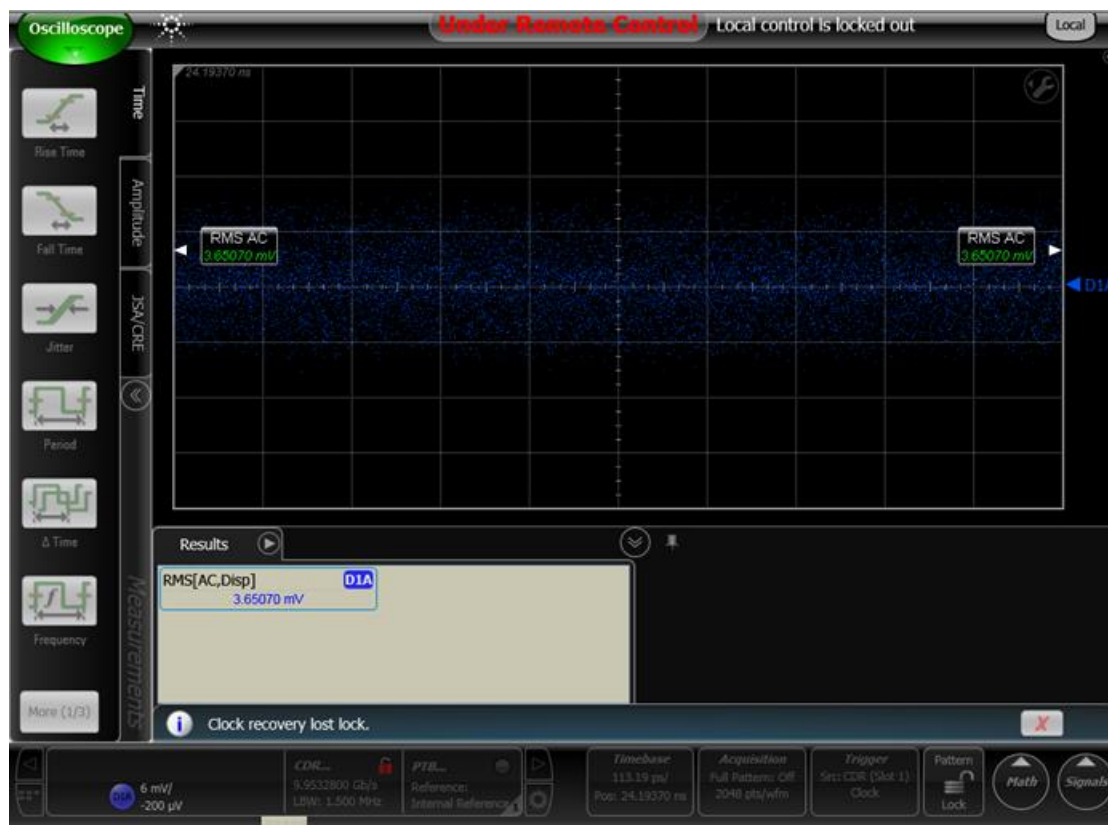


Figure 7 - Vdiffpp measurement

## Test 5: DDPWS

**Purpose:** This test is used to measure the Data Dependent Pulse Width Shrinkage

### Test Procedure

- 1) Ask the device vendor to change the device transmit PRBS9 and to the preset 0
- 2) Enter Jitter Mode (86100D Option 200)  
Setup | Mode | Jitter/Noise.
- 3) Configure Diff (D1A) signal (if not already selected)  
Press the Channel button and select Diff (configures D1A difference operator)
- 4) Execute CDR ([Clock recovery](#)) procedure
- 5) Configure results in Unit Interval (UI).  
Measure | Configure Jitter Mode Measurements...Select "Jitter Units" = Unit Interval
- 6) Select Meas Tab | DDPWS
- 7) Select Autoscale | Run
- 8) Record the DDPWS value into the spreadsheet.

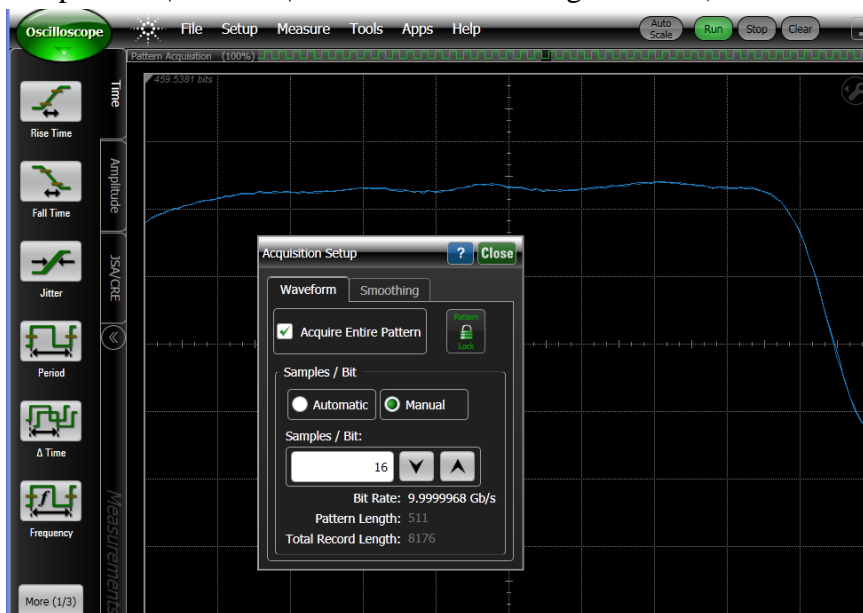


## Test 6: Normalized error “e”, “vf” and peak linear fit pulse response

**Purpose:** Test to calculate normalized error (linear fit) “e”, steady-state output voltage “vf” and peak linear fit pulse response for preset 1

### Test procedure:

- 1) Ask vendor to transmit PRBS9 using preset 1 and amplitude bit 1
- 2) Select Setup | Mode | Oscilloscope Mode
- 3) Configure Diff (D1A) signal (if not already selected)  
Press the Channel button and select Diff (configures D1A difference operator)
- 4) Execute CDR ([Clock recovery](#)) procedure
- 5) Enable Precision Timebase
- 6) Setup Averaging  
Setup | Acquisition Setup.... Select the “Smoothing” tab, select Average, # of Waveforms = 16.  
Note - the spec requires you to average does not specify the exact number.
- 7) Pattern Lock the signal to view waveform
- 8) Configure Acquisition Setup  
Select Setup | Acquisition setup...
  - a) Select Acquire Entire Pattern
  - b) Samples/Bit | Manual | 16 Total Record Length = 8176)



- 9)
- 10) Select File | Save | Waveform |
  - a) Under File Type, select: Pattern Waveform (\*.csv)
  - b) Under Waveform Source, check Differential 1A
  - c) Save the file with the name waveform1.txt
  - d) Open file, ‘waveform1.txt’, in note pad and strip header information from waveform file so only the Y values remain
  - e) Copy to a server and run the Matlab (Octave) script **tx\_equalizer\_performance-v2.m** with the **waveform1.txt** and **prbs9\_sequence.txt** in the same directory.

Matlab Script	PRBS9 Sequence	Sample Waveform data
---------------	----------------	----------------------

 tx_equalizer_performance_v3.m	 prbs9_sequence.txt	 waveform1.txt
--	---	--

- 11) The interesting output from the script is “vf”, linear pulse fit peak, “e” and “w”
- 12) **Note:** vf is also known as DC Amplitude. Preset 1 is the basis for all other presets. Preset 1 is defined by its amplitude (vf) and Linear Pulse Fit Peak - there is no pre-emphasis. Bigger the values indicate better signal and less distortion. If you see a small value for Linear Pulse Fit Peak, it means the signal is distorted. You don’t need to measure vf in other presets because spec does not demand it. This is because the value in the other presets can be calculated from the values obtained in preset 1.
- 13) Also critical is the “w” vector which is used in other calculations.
- Search for “w=” in the output and copy the numbers below into the script **tx\_equalizer\_performance-v3.m**. Go to the line w\_preset and horizontally put this into the script.
    - For example w\_preset= [0.18258;3.42125;1.50535;0.67913;0.27759;0.16897;-0.01429];
  - Run script again and the c-1 and c+1 should be effectively zero and c0 should be effectively 1
 

vf = 0.83825

linear\_fit\_pulse\_peak = 0.55555

rms\_normalized\_e = 2.9235e-004

c\_minus1 = -2.3351e-006 – *note this is effectively zero*

c0 = 1.0000

c\_plus1 = 2.0337e-007 - *note this is effectively zero*
  - This tells you everything is correct and w vector is correct.
- 14) Record the values for “**vf**”, **linear\_fit\_pulse\_peak** and **rms\_normalized\_e** into the spreadsheet.
- Note:** the script reports the values as Volts whereas the spreadsheet assumes mille volts. So for example 0.55555 should be entered as 555.55
- 15) **Note:** there is no reason to record the “c” values for preset 1 because they should always be 0, 1, 0 (this is the definition of preset 1).



## Test 7: Calculating c-1, c0 and c+1 for other presets

**Purpose:** Calculating the tap weights c-1, c0 and c+1

### Test Procedure

- 1) Ask vendor to transmit PRBS9 using another preset and amplitude bit 1
- 2) Select Setup | Mode | Oscilloscope Mode
- 3) Configure Diff (D1A) signal (if not already selected)  
Press the Channel button and select Diff (configures D1A difference operator)
- 4) Execute CDR ([Clock recovery](#)) procedure
  - a) Possible problem: if the signal does not look correct, select pattern lock (to unlock) and then lock it again.
- 5) Enable Precision Timebase
- 6) Pattern Lock the signal to view waveform
- 7) Configure the waveform Acquisition Setup  
Select Setup | Acquisition setup...
  - a) Select Acquire Entire Pattern
  - b) Samples/Bit | Manual | 16 (Total Record Length = 8176)
- 8) Select File | Save | Waveform | -
  - a) Under File Type, select: Pattern Waveform (\*.csv)
  - b) Under Waveform Source, check Differential 1A
  - c) Save the file with the name waveform1.txt
  - d) Open file, 'waveform1.txt', in note pad and strip header information from waveform file so only the Y values remain
  - e)
- 9) Copy to the server and run the Matlab (Octave) script with the [changed w vector](#).
- 10) Record the values from the output for rms\_normalized\_e, c-1, c0 and c+1 into the spreadsheet.
- 11) Record the values for Vcm for the other preset using the test procedure described in [Vcm test section](#).
- 12) **Important:** Go back to [step one of Calculating c-1](#), c0 and c+1 and ask the vendor to change to another preset and execute all these steps again.

**Important:** Go back to [Step one](#) of Calculating **normalized error** and ask the vendor to change the amplitude bit to zero (0) and execute all these steps again.

## Test 8: Jitter Measurements

**Purpose:** This test is used to measure the device transmitter jitter

### Test Procedure

**Note:** The test should be run with the device set to preset 0 and two other presets chosen at random.

1) Ask the vendor to configure the device to transmit a PRBS9 pattern with the preset being tested.

2) Enter Jitter Mode (86100D Option 200)

Setup | Mode | Jitter/Noise.

3) Configure Diff (D1A) signal (if not already selected)

Press the Channel button and select Diff (configures D1A difference operator)

4) Execute CDR ([Clock recovery](#)) procedure and check to make sure the precision timebase is active

5) Configure results in Unit Interval (UI).

Measure | Configure Jitter Mode Measurements...Select "Jitter Units" = Unit Interval

6) Press Auto Scale

7) Lock in the RJ value

Measure | Configure Jitter Mode Measurements | Advanced | Stabilization | RJ Stabilization

a) Select 'Get Measured RJ'

b) Select 'Fix RJ' checkbox



8) Select Setup | Mode | Eye/Mask Mode

9) Turn Off (i.e. Unlock) Pattern Lock

10) Change Device Pattern to PRBS31

11) Select Autoscale | Run

12) Select Advanced Eye Tab

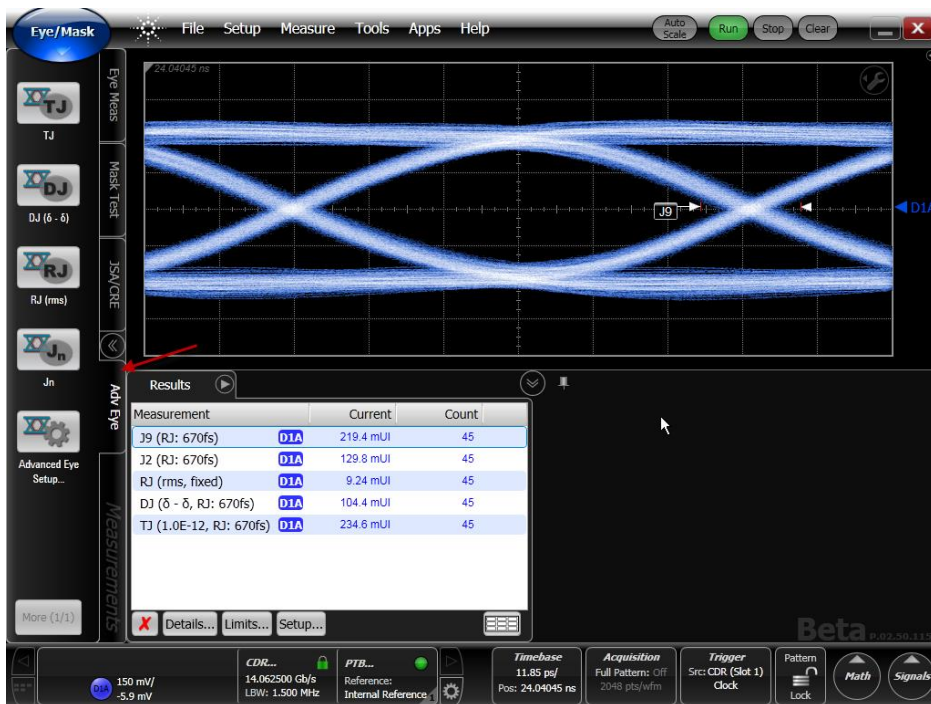
13) Select Advanced Eye Setup....

a) Change Jitter Units to 'Unit Interval'

b) Activate Jitter Measurements for TJ(1e-12), DJ(dd), RJ, J2 and J9

- c) Accumulate data and wait until the jitter result stabilizes (typically ~ 30 to 60 seconds)

Note: The RJ value measured in Jitter Mode for the PRBS9 pattern is fixed and used as part of the DJ and TJ measurement with Advanced Eye Analysis /401 for the PRBS31 pattern. The Advanced Eye Analysis requires N1010A revision greater than or equal to A.02.50.



- 14) For preset 0 only, go to the “Configure the TJ Probability” and set the Total Jitter P1 to “J2” and the Total Jitter P2 to “J9”. For any other preset set the Total Jitter P1 to **“TJ”**
- 15) For preset 0 – Record the J2, J9 and RJ values into the spreadsheet. Repeat the test with the “Total Jitter P1” set to **“TJ”**, subtract the DDJ value from the TJ value, and record the result to the spreadsheet.
- 16) For presets other than 0 - Record the RJ value into the spreadsheet. Subtract the DDJ value from the TJ value, and record the result to the spreadsheet.

## Test 9: Far End Transmit Output Noise Measurements

**Purpose:** This test is used to measure the far end transmit output noise

### Test Procedure

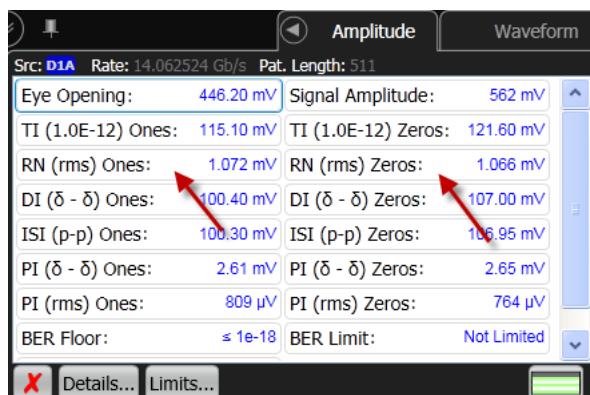
**Note:** The test should be run with the device set to preset 1 with amplitude bit set to 1. The test should be performed for two cables – a low loss cable, having an insertion loss of  $6 \text{ dB} \pm 1.5 \text{ dB}$  at 5.15625 GHz, and a high loss cable, having an insertion loss of  $15.7 \text{ dB} \pm 1.5 \text{ dB}$  at 5.15625 GHz. Prior to the measurements, the far end insertion loss of the cables should be measured using the following procedure:

- a. Measure the near end and far end crosstalk noise of the selected cables, using a vector network analyzer (VNA). The frequency range of the measurements should be 10 MHz – 15 GHz.
- b. For each lane, create a CSV worksheet arranged in the following manner:
  - The first column will contain the frequency points of the VNA measurements in GHz.
  - Columns B-E will contain the measured near end crosstalk values, in dB.
  - Columns F-H will contain the measured far-end crosstalk values, in dB.
- c. Save the attached Matlab (Octave) script **icn.m** in the directory of the created CSV worksheets.



icn.m

- d. Open the saved Matlab (Octave) script **icn.m**. Adjust the following parameters:
    - The filename of the CSV worksheet.
    - “Ant” value should be set to the output amplitude of the tested device’s transmitters in mV.
    - “Tnt” value should be set to the rise time of the tested device’s transmitters in ns.
    - “Tft” value should be set to the rise time of the signal source for the aggressor lines (crosstalk generator) in ns.
  - e. Run the Matlab (Octave) script. Record the calibrated far end crosstalk (denoted as sigma\_fx).
- 
- 1) Ask the vendor to configure the tested transmitter to transmit a low frequency square wave pattern (0xFF00) with the other transmitters of the same port set to transmit a PRBS31 pattern.
  - 2) Select Setup | Mode | Jitter Mode
  - 3) If the Diff (D1A) signal has not been configured...Press the Channel button and select Diff (configures D1A difference operator)
  - 4) Execute CDR ([Clock recovery](#)) procedure
  - 5) Control | Autoscale
  - 6) Turn on Amplitude Analysis in Jitter Mode
    - a. Select ‘Amplitude Tab’
    - b. Press ‘Amplitude Meas ON’
  - 7) Record the RN(rms) Ones and RN(rms) Zeros Value. This is the standard deviation of the noise on the one and zero level with deterministic amplitude interference contributions removed.



## Test 10: Signal to Noise Ratio (Q<sub>sq</sub>) Measurements

**Purpose:** This test is used to measure the transmit signal to noise ratio

### Test Procedure

**Note:** The test should be run with the device set to preset 0.

- 1) Ask the vendor to configure the tested transmitter to transmit a low frequency square wave pattern (0xFF00).
- 2) Select Setup | Mode | Jitter Mode
- 3) If the Diff (D1A) signal has not been configured...Press the Channel button and select Diff (configures D1A difference operator)
- 4) Execute CDR ([Clock recovery](#)) procedure
- 5) Control | Autoscale
- 6) Turn on Amplitude Analysis in Jitter Mode
  - a. Select 'Amplitude Tab'
  - b. Press 'Amplitude Meas ON'
- 7) Record the Q Value in the Amplitude Analysis Window. Q is the ratio of the signal level to random noise on the signal.  $Q = (V_{one} - V_{zero}) / (RN_{one} + RN_{zero})$

