Active Time Domain Testing for InfiniBand NDR Cables – MOI

MARCH 21, 2025 : REV 1.9

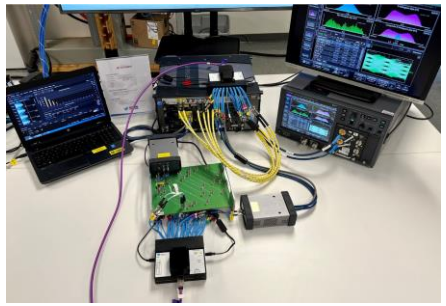
I² NDC

Keysight Technologies

InfiniBand NDR ATD AOC Revision History

Initial posting of draft NDR ATD MOI

ID	Title	Modified Date	Modified By	Company
8779	Draft Keysight NDR ATD MOI.pdf Download (3.19 MB) Preview	Mar 25, 2022 Revision .75 (1 total)	John Calvin Keysight Technologies	Keysight Technologies



Configured and tested at IBTA

39th InfiniBand™ and

RoCE Plugfest #39, May 2, 2022

Posted revised (workshop feedback) NDR ATD MOI, release candidate 1.0, September 2, 2022

Posted revised (October 5, 2022 review feedback) NDR ATD MOI, release candidate 1.1; November 30, 2022

- MTF Calibration/Test procedure

Posted revised (March 21, 2025 review feedback) , Version 1.9

- G800 Setup for signal generation (victim & co-propagating lanes)

Infiniband NDR

OUTLINE

The InfiniBand NDR Interface

NDR Test Platform

Preparing measurements

- Cross-talk calibration
- Victim lame calibration

Cable Test

- Cable Output Test (Tx)
- Cable Input Test (Rx)

Appendix

- DUT control – pattern Generation
- DUT control – long and short mode

InfiniBand NDR interface

OVERVIEW

Infiniband

SPEED & CABLE TYPES

Characteristics		SDR	DDR	QDR	FDR10	FDR	EDR	HDR	NDR	XDR	GDR
Signaling rate (Gbit/s)		2.5	5	10	10.3125	14.0625[18]	25.78125	50	100	200	400
Theoretical effective throughput (Gb/s)[19]	for 1 link	2	4	8	10	13.64	25	50	100	200	400
	for 4 links	8	16	32	40	54.54	100	200	400	800	1600
	for 8 links	16	32	64	80	109.08	200	400	800	1600	3200
	for 12 links	24	48	96	120	163.64	300	600	1200	2400	4800
Encoding (bits)		8b/10b[20]				64b/66				t.b.d	
Modulation		NRZ						PAM4		t.b.d	
Adapter latency (µs)[21]		5	2.5	1.3	0.7	0.7	0.5	<0.6[22]		t.b.d.	
Year[23]		2001, 2003	2005	2007	2011	2011	2014[24]	2018[24]	2022[24]	t.b.d.	

This MoI is focusing on **full limiting active cable**

- Far-end & near-end limiting not relevant at this speed
- Host Tx & Rx responsible for equalization

Cable type	Tx card	Connector	Cable	Connector	Rx card
Full limiting active copper or fiber (Active Optical)	Tx responsible for equalizing	Redriver		Redriver	Rx responsible for equalizing

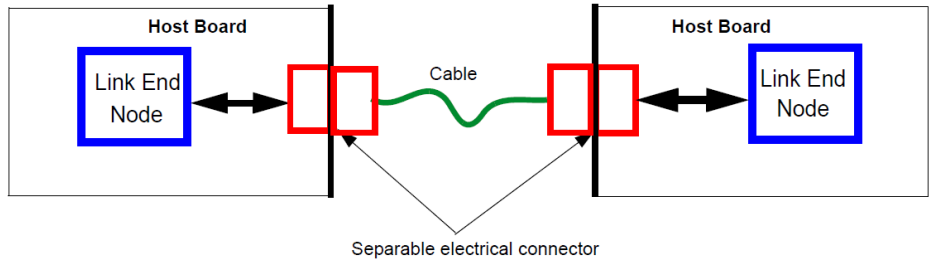


Figure 87 High-level topology block diagram

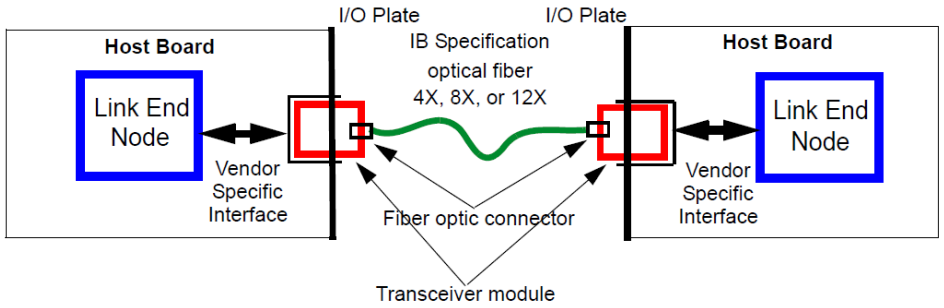


Figure 88 Optical Fiber Interconnect Topology

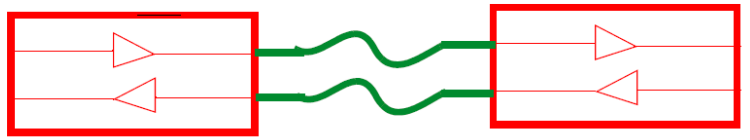


Figure 89 Full limiting active cable topology

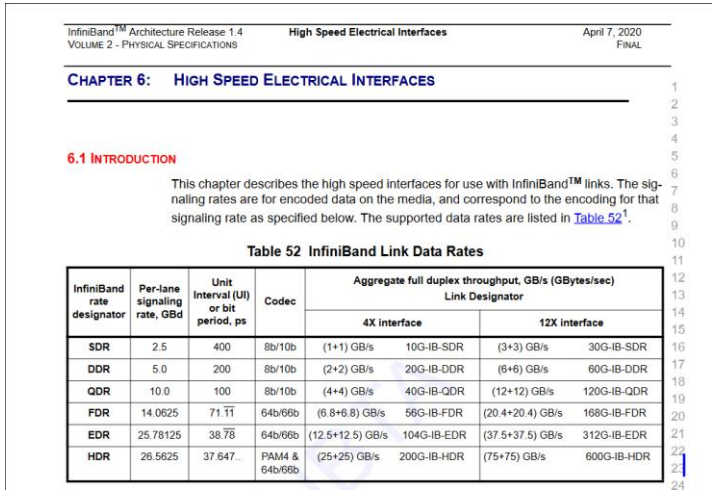
Infiniband

NDR INTERFACE – LEVERAGING HDR & IEEE 802.3CK

Layer 1 test procedures for validating NDR limiting active cable described in section **6.10.2.4** of the ***InfiniBandTM Architecture Specification Volume 2 Release*** **.** The document leverages HDR test strategy & IEEE 802.3ck C2M specifications.

IBTA Active Time Domain (ATD) Testing for Active Cables

- Anritsu ATD MOI for Active **FDR** Cables
- Anritsu Keysight ATD MOI for Active **EDR** Cables
- Anritsu Keysight ATD MOI for Active **HDR** Cables



InfiniBand™ Architecture Release 1.4 — High Speed Electrical Interfaces — April 7, 2020
VOLUME 2 - PHYSICAL SPECIFICATIONS — FINAL

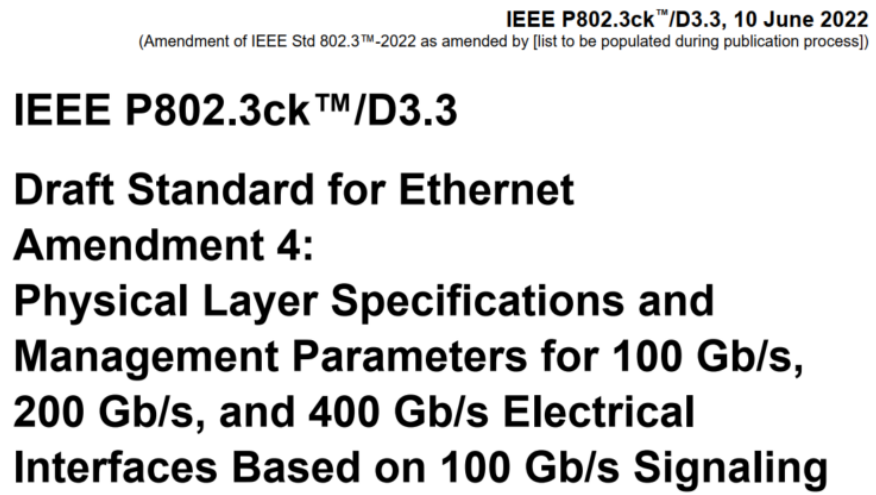
CHAPTER 6: HIGH SPEED ELECTRICAL INTERFACES

6.1 INTRODUCTION

This chapter describes the high speed interfaces for use with InfiniBand™ links. The signaling rates are for encoded data on the media, and correspond to the encoding for that signaling rate as specified below. The supported data rates are listed in Table 52[1].

Table 52 InfiniBand Link Data Rates

InfiniBand rate designator	Per-lane signaling rate, GBd	Unit Interval (UI) or bit period, ps	Codec	Aggregate full duplex throughput, GB/s (GBytes/sec) Link Designator			
				4X interface		12X interface	
SDR	2.5	400	8b/10b	(1+1) GB/s	10G-IB-SDR	(3+3) GB/s	30G-IB-SDR
DDR	5.0	200	8b/10b	(2+2) GB/s	20G-IB-DDR	(6+6) GB/s	60G-IB-DDR
QDR	10.0	100	8b/10b	(4+4) GB/s	40G-IB-QDR	(12+12) GB/s	120G-IB-QDR
FDR	14.0625	71.$\overline{11}$	64b/66b	(6.8+6.8) GB/s	56G-IB-FDR	(20.4+20.4) GB/s	168G-IB-FDR
EDR	25.78125	38.$\overline{78}$	64b/66b	(12.5+12.5) GB/s	104G-IB-EDR	(37.5+37.5) GB/s	312G-IB-EDR
HDR	26.5625	37.647..	PAM4 & 64b/66b	(25+25) GB/s	200G-IB-HDR	(75+75) GB/s	600G-IB-HDR



IEEE P802.3ck™/D3.3, 10 June 2022
(Amendment of IEEE Std 802.3™-2022 as amended by [list to be populated during publication process])

IEEE P802.3ck™/D3.3

Draft Standard for Ethernet Amendment 4: Physical Layer Specifications and Management Parameters for 100 Gb/s, 200 Gb/s, and 400 Gb/s Electrical Interfaces Based on 100 Gb/s Signaling

Note: While current specifications are limited to four lanes (400Gbps), some devices and interfaces can accommodate up to eight lanes. In this document, we assume OSFP112G interface but the procedure is identical for QSFP-DD800 interface (8 lanes), and QSFP112 interface (4 lanes).

InfiniBand NDR interface

TEST POINTS

NDR Cable Test References

SECTION 6.10.2.4 NDR-PAM4

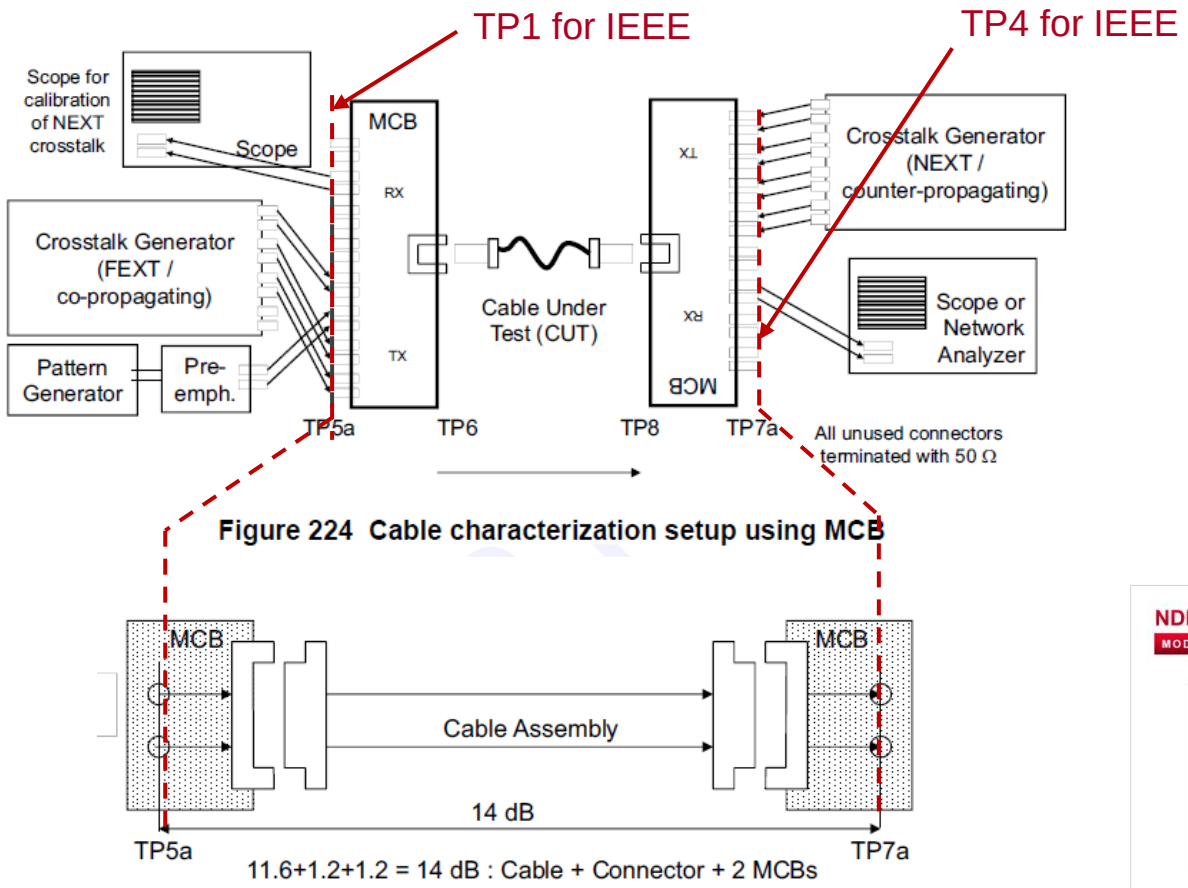


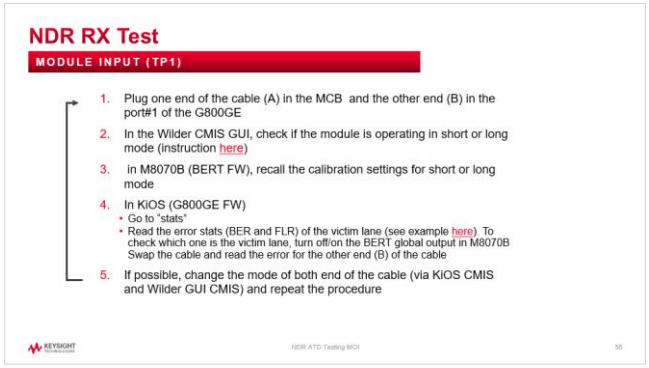
Figure 224 Cable characterization setup using MCB

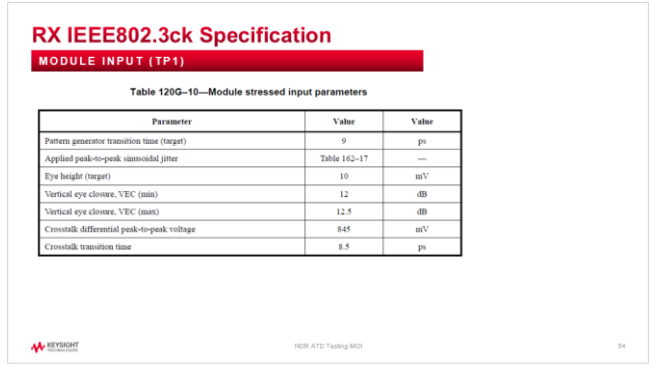
Main reference: ***InfiniBandTM Architecture Specification Volume 2 Release 1.6***

- Full limiting active cables - ***section 6.10.2.4***
- MCB characteristics - ***ANNEX A1***

Notable differences with IEEE 802.3ck

- Optional eye width (eye mask) test at TP7a
- crosstalk amplitude (see NEXT calibration slide)





Host Compliance Testing

SECTION 6.10.2.3 NDR-PAM4

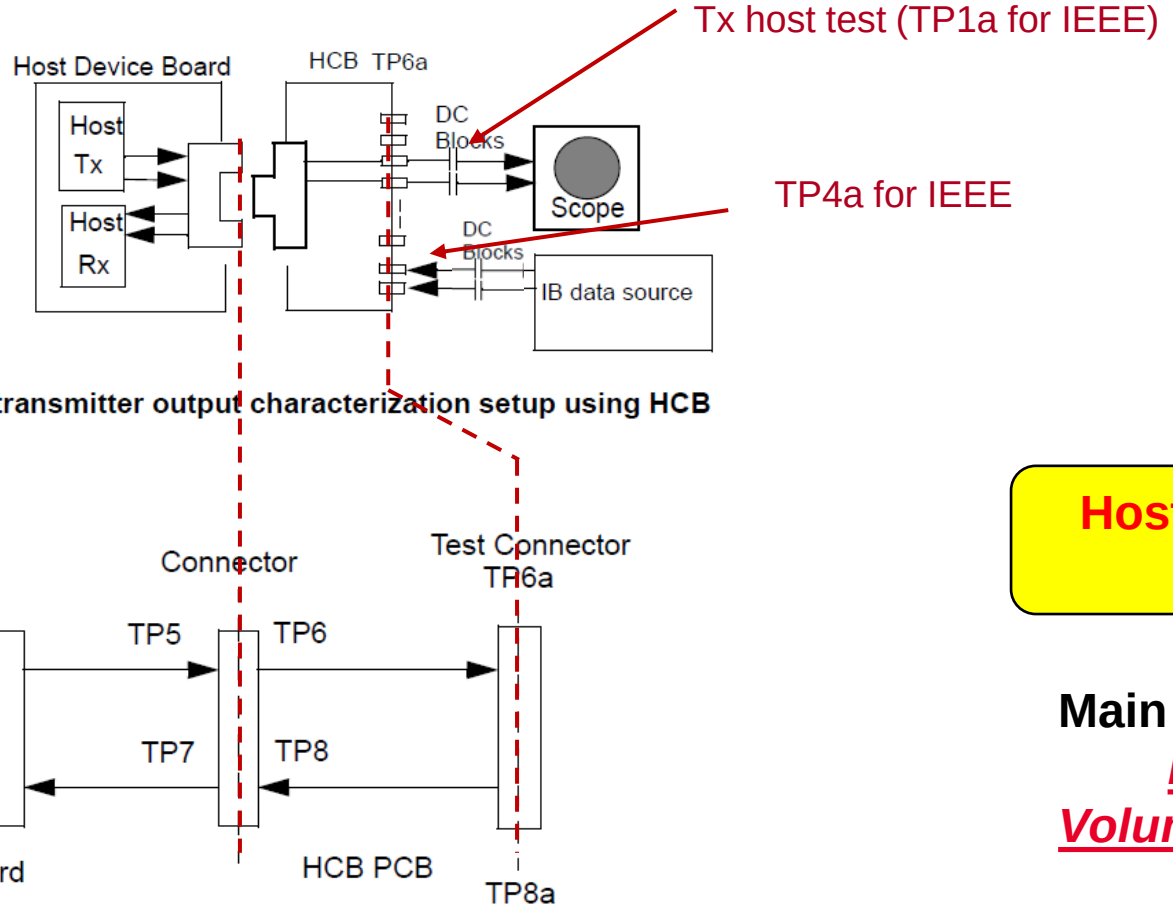


Figure 222 Host transmitter output characterization setup using HCB

Figure 94 Host compliance board test points

Host compliance test procedures are not covered in this document

Main reference

***InfiniBandTM Architecture Specification Volume 2 Release 1.6* section 6.10.2.3**

NDR Active Cable Test Platform

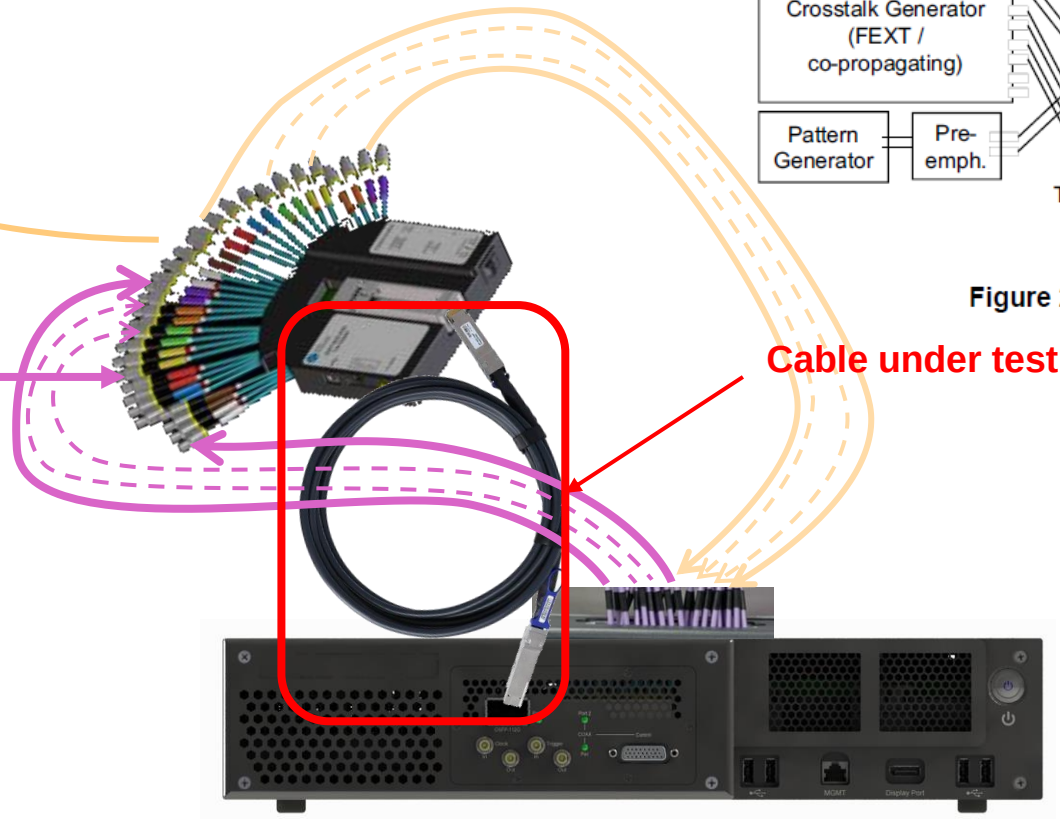
OVERVIEW

NDR Active Cable Test Platform

HW CONFIGURATION OVERVIEW

Sampling scope
- N1000A mainframe
- N1060A module

M8042A BERT
- M8042A pattern generator
- M8058A remote head
- M8009A clock



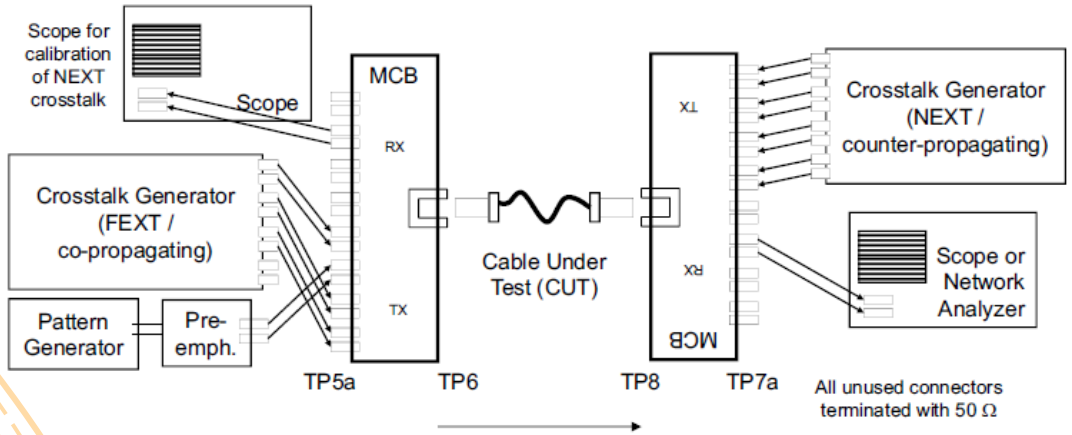
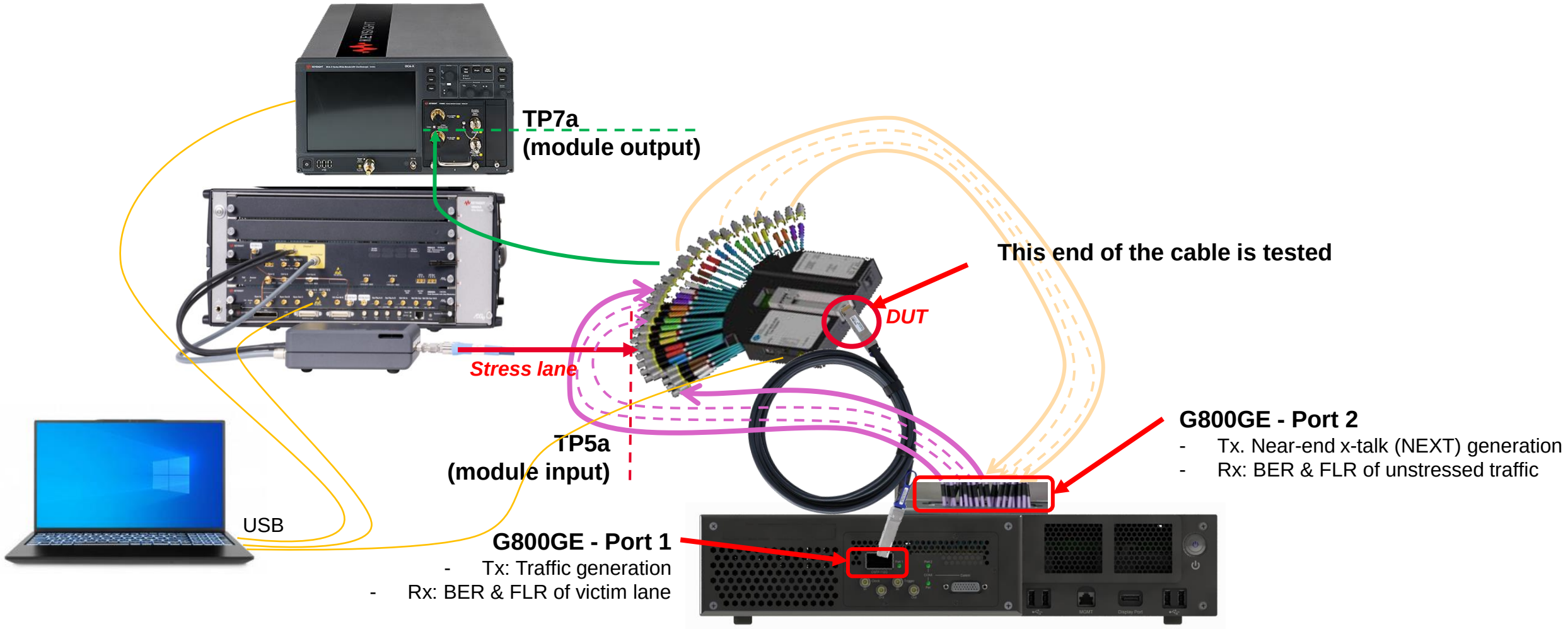


Figure 224 Cable characterization setup using MCB

G800GE-02
- Port1: QSFP-DD or OSFP port
- Port2: Coax
- Samtec bullseye coax interface

NDR Active Cable Test Platform

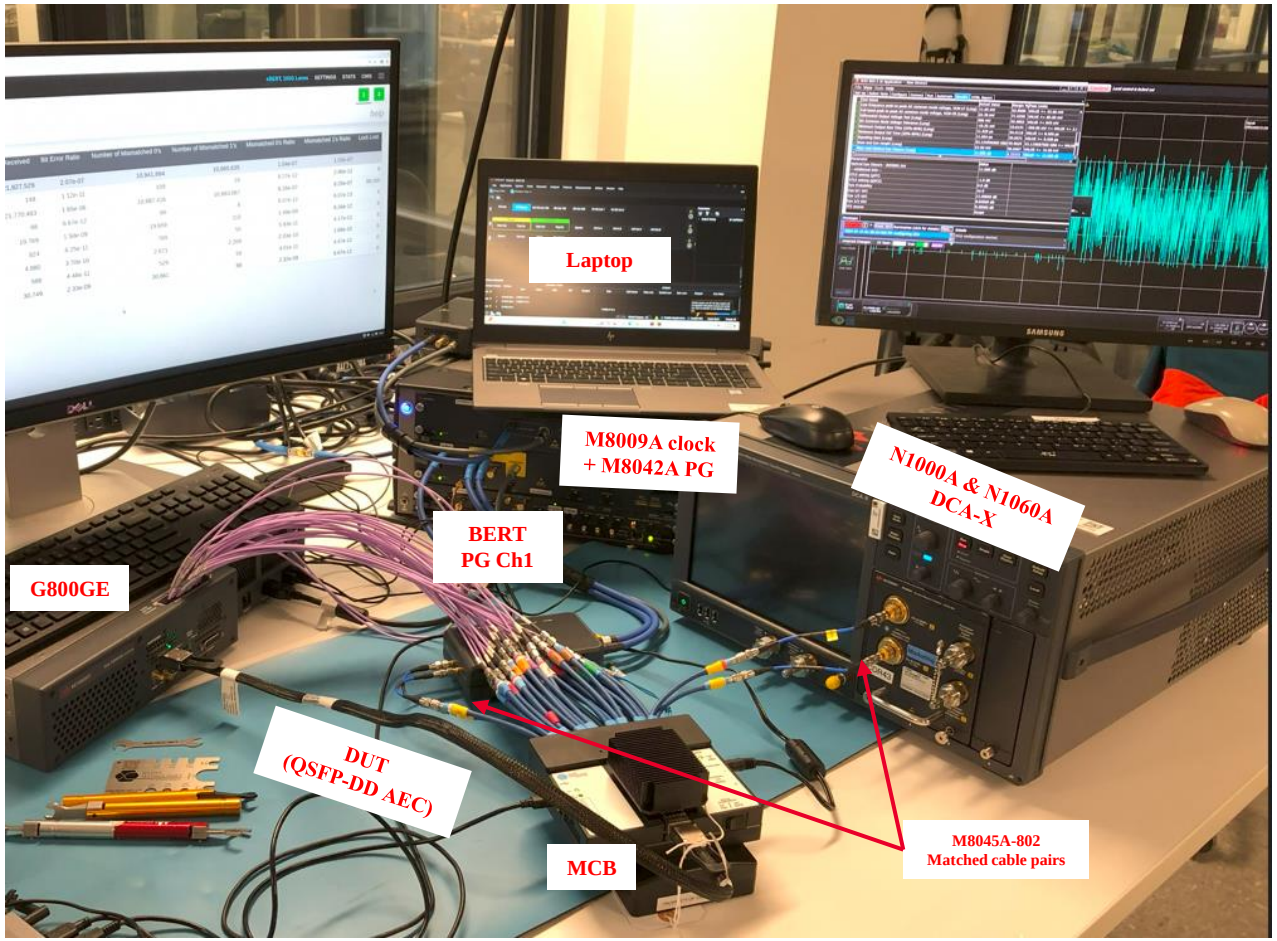
SAME CONFIGURATION FOR CABLE INPUT AND OUTPUT TESTS



Setup Configuration

AEC Testing for TX and RX

- M8042A for victim lane generation
- G800GE-02 as a reference host
  - Port 1 (QSFP-DD or OSFP): generate counter-propagating traffic
  - Port 1 BER/FLR measurement of all lanes (incl. victim lane)
  - Port 2 (coax) – generates co-propagating aggressor lanes
- N1000A + N1060A as reference Receiver
  - Runs FlexDCA (firmware) and N1091CKCA app
- Wilder MCB as Mated Test Fixture*
  *Keysight part number SP0602A for OSFP or SP0606A for QSFP-DD 112G
- AEC Cable or AOC - Device Under Test
- M8045A-801 Short Cable 1.85mm
- M8045A-802 Matched Cable Pairs
- : Laptop
  - M8070B (BERT firmware), Wilder CMIS, M8091CKA Rx app
  - , FlexDCA (scope firmware) and N1091CKCA app (optional, can run on N100A)
  - 5 USB ports for BERT, DCA, MCB, Mouse & keyboard



NDR Active Cable Test Platform

EQUIPMENT LIST

NDR Active Cable Test Platform

EQUIPMENT OVERVIEW (OPTIONS ON NEXT PAGES)

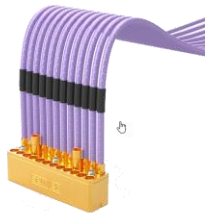
M8050A system
- M8042A pattern generator for victim lane generation

G800GE-02 system
- QSFP-DD + COAX interface **or**
- OSFP + COAX interface

N1000A+N1060A
- Reference receiver for
  - Module output test
  - victim lane calibration
  - Near-end aggressor calibration

1x Wilder Technologies MCB
- 1x OSFP-TPA1.85-MCB-R **or**
- 1x QSFPDD-TPA1.85-MCB-R
  - OSFP, 1.85mm connector
  - CMIS control
  - Incl. power supply (16Watt)
  - Incl. FAN

1x Wilder Technologies HCB
- 1x OSFP-TPA1.85-HCB-P **or**
- 1x QSFPDD-TPA1.85-HCB-P
  - 1.85mm connector



Samtec “Bullseye” coaxial cable interface
- BE40A-S-24SP-2-2-160500

Cables & RF adapters
- 3 x 1.85mm Matched cable **pairs**

Equipment List

RECOMMENDED HW

Item #	Vendor	Part Number	Description	Options	Qty	Details
1	Keysight	M8040A	5 slot AXIe chassis	M8040A-BU2	1	Chassis
2	Keysight	M8042A	Pattern generator and clock module 64GBaud	M8042A-0G1/-G64/-0G1/-0G4 M8009A-061/ -0G3	1	Signal source for pattern generator and jitter impairment
3	Keysight	M8058A	Remote head (1.85mm)		2	
4	Keysight	G800GE-02	941-0087 (OSFP+coax), 941-0089 (QDD+coax)	905-1102	1	Aggressor lane generation and BER/FLE measurement
5	Samtec	BE40A	50 GHz, Bulls Eye® High-Performance Test Assembly	BE40A-S-24SP-2-2-160500	1	Coax cable interface for port 2 of G800GE
6	Keysight	N1000A + N1060A	DCA-X Wide-Bandwidth Oscilloscope Mainframe + N1060A Precision Waveform Analyzer	N1000A-PLK/-STB N1060A-050/-EVA/-264/-PTB/-JSA	1 1	For TX test and stressed signal calibration
7	Wilder	DCOM-ISI-112G-9CH	Channel emulation board or any other ISI trace compliant with IEEE 802.3ck.	-	1	For C2M long channel calibration and testing – **optional** M8070ISIB SW can be used instead
8	Wilder	SP060x	SP0603A for OSFP or SP0607A for QSFP-DD 112G HCB Test Adapter	SP0603A/ SP0607A	1	For Crosstalk calibration (TX & RX Tests)
9	Wilder	SP060x	SP0602A for OSFP or SP0606A for QSFP-DD 112G MCB Test Adapter incl. fan to cool down the device	SP0602A/ SP0606A	2	Module Compliance Board for active cable testing
10	Keysight	M8045A-801	Short Cable 1.85 mm (m) to 1.85 mm (m), 0.15 m, absolute matching 699 ps +- 1 ps	-	4	2 for BERT Remote Heads; 2 for MTF to scope (2 from ISI Board to MCB)

Equipment List

LAPTOP & SW

Item #	Vendor	Part Number	Description	Revision	Details
			Laptop with at least 3 UBS ports (USB hub possible) , Windows 10, 64bits and valid license for the SW products listed below. **Microsfot Excel** required for stressed input calibration		
12	Keysight	FlexDCA		A.07.41.27	or higher
13	Keysight	M8070B	System software for M8000 series of BER test solutions	10.0.160.6	or hgher
14	Keysight	M8070ISIB	Adjustable ISI Channel Emulation Package for M8000 Series BER Test Solutions	1.8.160.2	or higher, For emulating long host channel. ISI board can be used instead.
15	Keysight	M8070ADVB	Advanced Measurement Package for M8000 Series BER Test Solutions	1.6.180.2	Or higher
16	Keysight Technologies	N1091CKCA	DCA TX test application for IEEE802.3ck	1.23.0.0	Automation TX test for C2M at TP4; Beta version used
17	Keysight Technologies	M8091CKCA	RX conformance test application for IEEE 802.3ck	1-2-3-0	Automation RX test for C2M Input at TP1
	Wilder Technologies		CMIS GUI Sofware Version 2.27	2.27	Or higher. To control the DUT (turn on/off)

Preparing measurements

EQUIPMENT AND SIGNAL CALIBRATION

Preparing Measurements

N1060A DCA – OVERVIEW

N1060A

- Guide for making RF connections (including applying torque, connectors and adapters: https://helpfiles.keysight.com/scopes/FlexDCA-UG/Content/Topics/Modules/N1060A.htm?Highlight=N1060A%20Precision%20Waveform%20Analyzer%20Module

FlexDCA Module Calibration

- Perform the module calibration on N1060A before making any physical connections to the DUT
- https://helpfiles.keysight.com/scopes/FlexDCA-UG/Content/Topics/Calibration/b_cal_module.htm?tocpath=Tools%7CCalibrations%7C_____0

Preparing Measurements

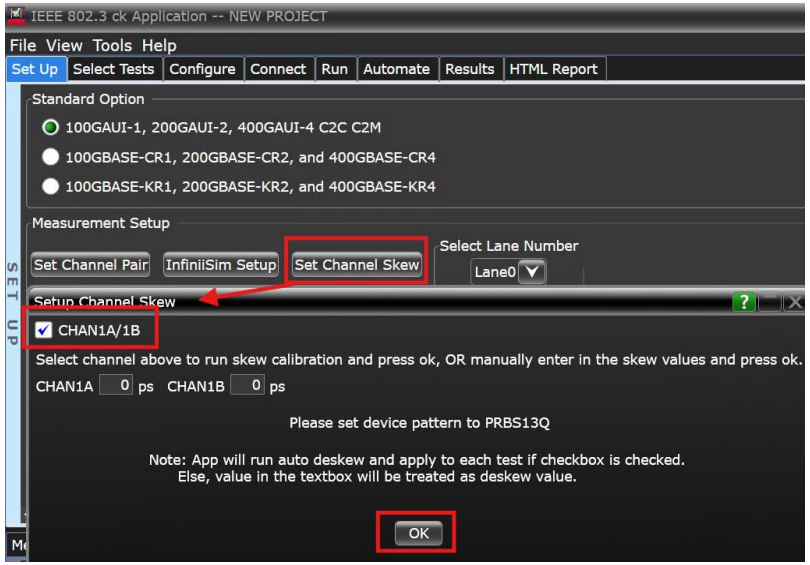
N1060A & 1091CKCA – OVERVIEW

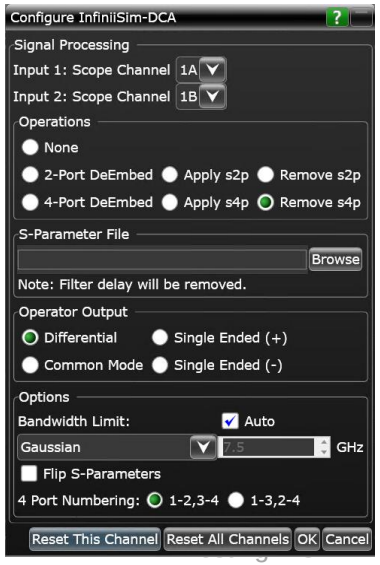
Channel Deskew

- Execute the 'auto differential deskew' on FlexDCA after establishing the measurement connection and before initiating the measurement
- Link: https://helpfiles.keysight.com/scopes/FlexDCA-UG/Content/Topics/Channels/advanced-elect-diff-setup.htm
- It is recommended to perform the channel deskew on the N1091CKCA app. Navigate to Set Up tab, select Set Channel Skew, enable the Channel 1A & 1B and then hit 'OK' run the deskew process

De-embed

- Use InfiniiSIM setup to remove cable loss
- Navigate to the Set Up tab, configure the infiniiSIM setup, choose to remove s2p/s4p using s-parameter file

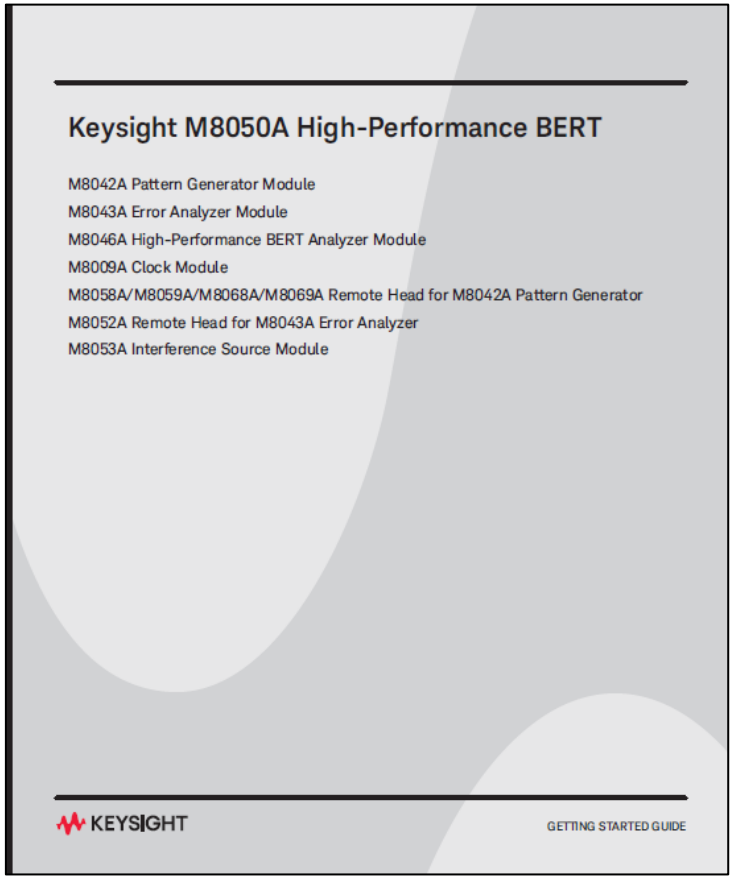




Preparing Measurements

M8050A BERT - OVERVIEW

Keysight.com



With demo unit

Preparing Measurements

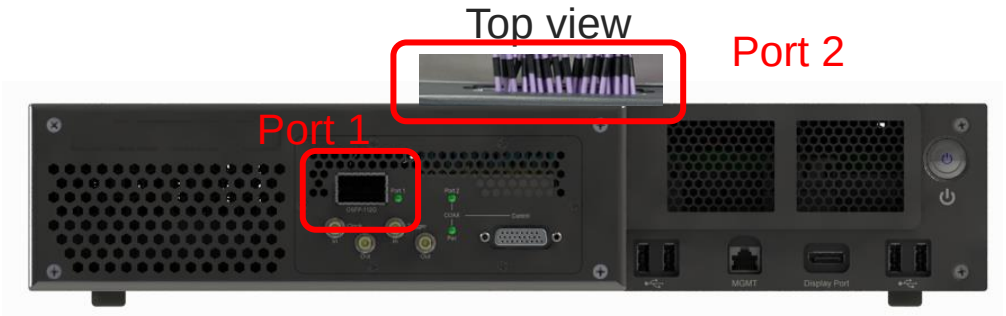
G800GE – OVERVIEW

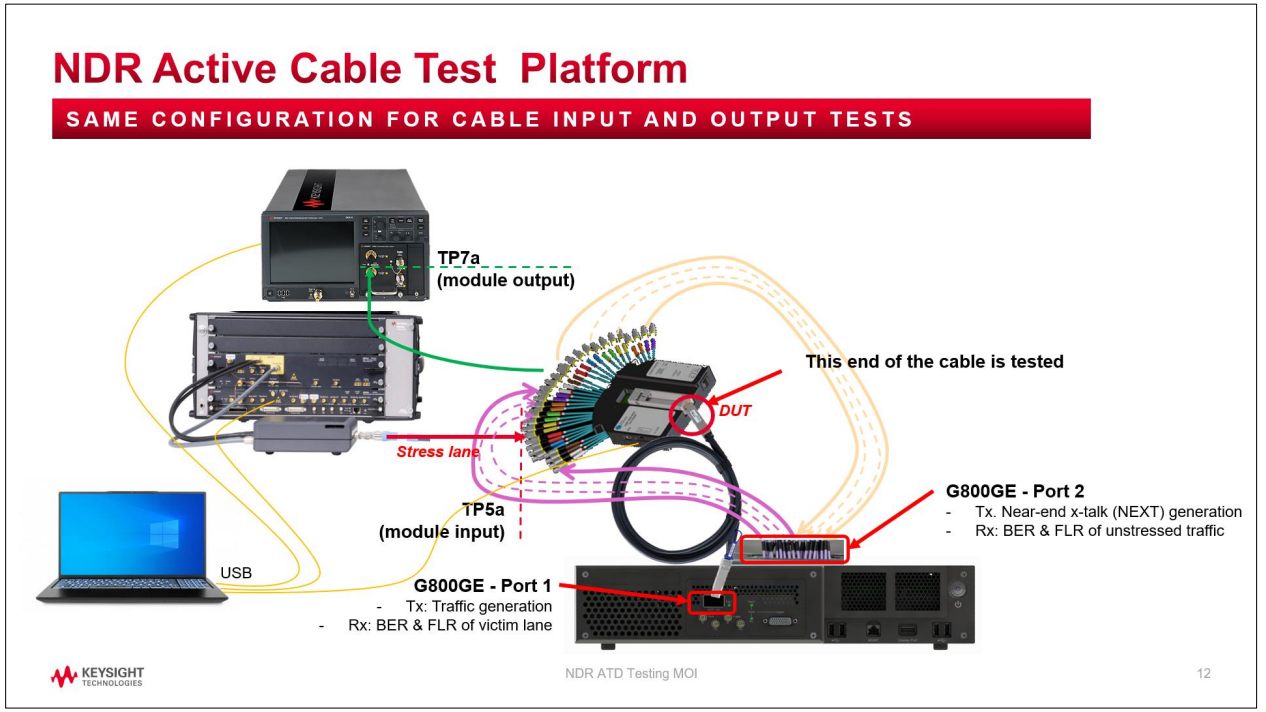
The G800GE platform supports 50G (26.125Gbd PAM4) and 100G (53.125Gbd PAM4) lane rates required for HDR and NDR cable testing.

The G800GE platform is used for both input and output test

- **Input test (Tx test)**
  - Port 1 – signal generation (victim & co-propagating lanes)
  - Port 2 – counter-propagating aggressors

- **Output test (Rx test)**
  - Port 1 – Error detector (BER & LFR)
  - Port 2 – counter-propagating aggressors (calibration only)
  - Port 2 – co-propagating aggressors lanes (optional)





Preparing Measurements

G800GE – CONNECTING PORT 2 COAX INTERFACE

The G800GE Port 2 (Coax)

- “Transmit” on odd lanes
- “Receive” on even lanes
- “A” and “B” are the differential pairs

Top view

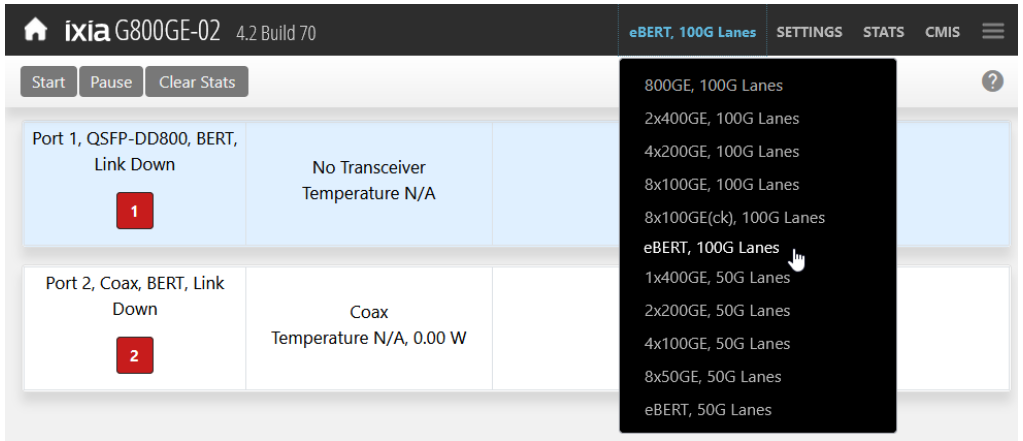
Refer to this document for detailed procedure

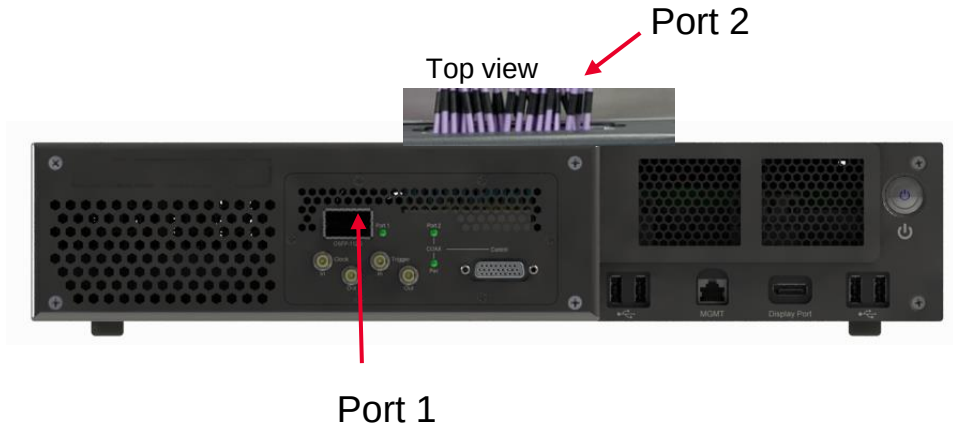
Adobe Acrobat Document

Preparing Measurements

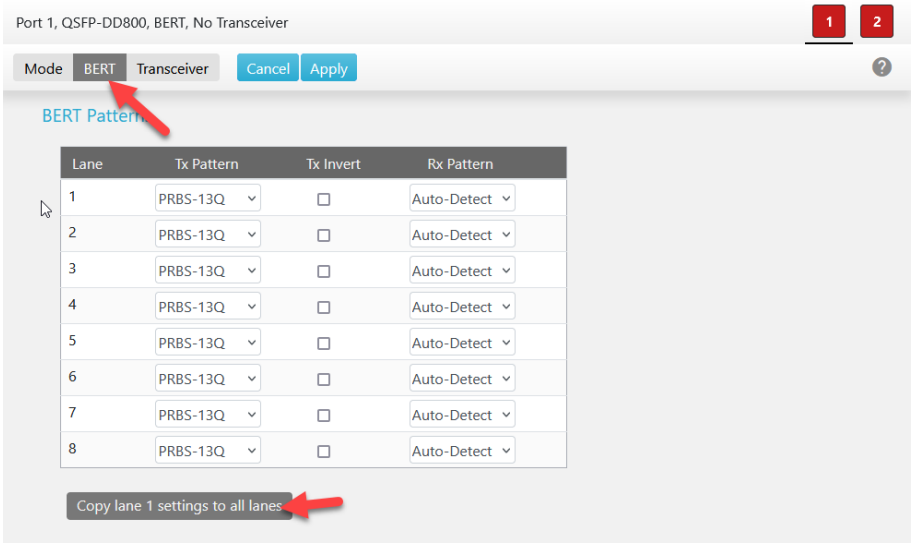
G800GE - GENERAL SETTINGS

1. Open G800GE KiOS
2. Change Line Speed to eBERT, 100G Lanes





3. Set port 1 BERT Pattern to PRBS13Q
   PRBS31Q required for TP7a (IEEE TP4) measurements



4. Set **Port 2** BERT Pattern to PRBS13Q
   For NEXT calibration only. After that change back to PRBS31Q

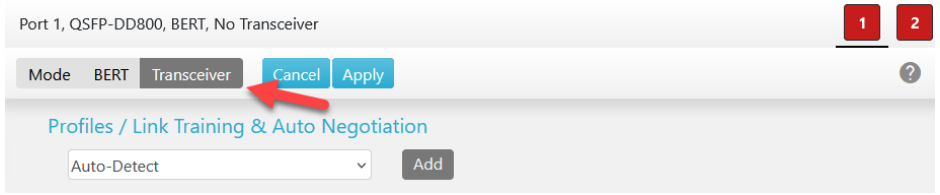
Preparing measurements

AGGRESSOR LANES CALIBRATION

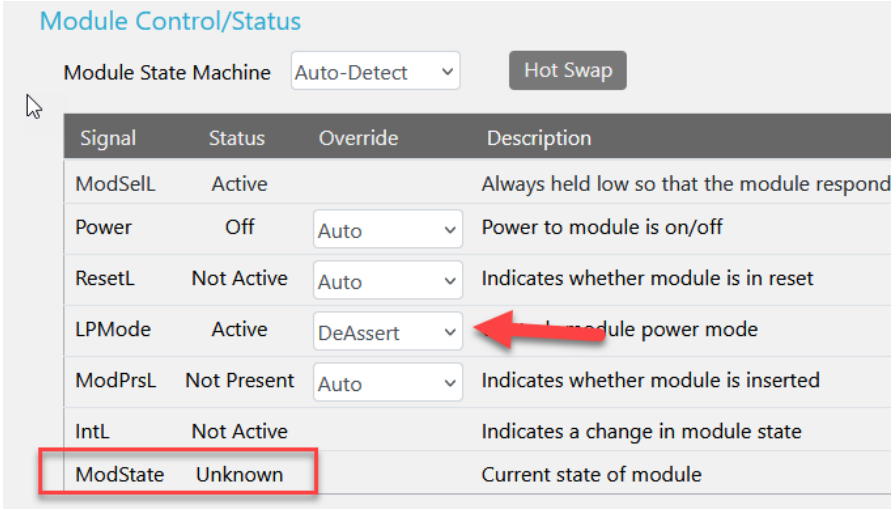
Cable Output Test Procedure

G800GE SETTINGS #2

4. Turn on the transceiver on **Port 1**
   - Tx host settings can be set to Auto-detect



   - If the device remains in low-power mode, force to exit it



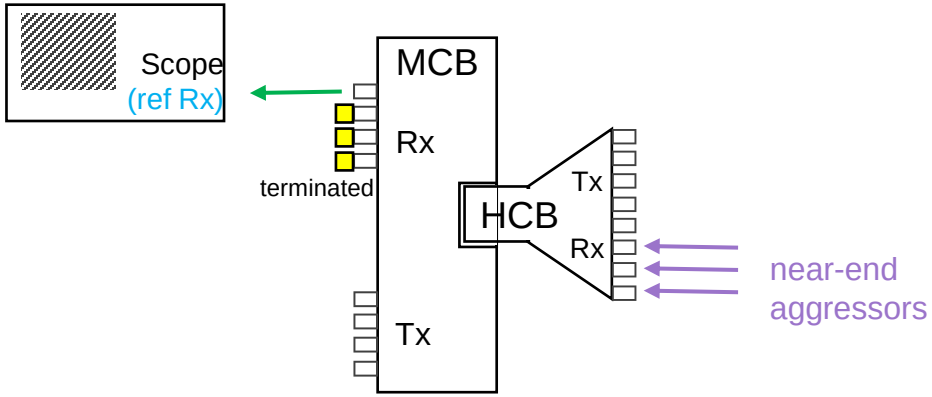
5. verify that the module state is “active” and that it is drawing current

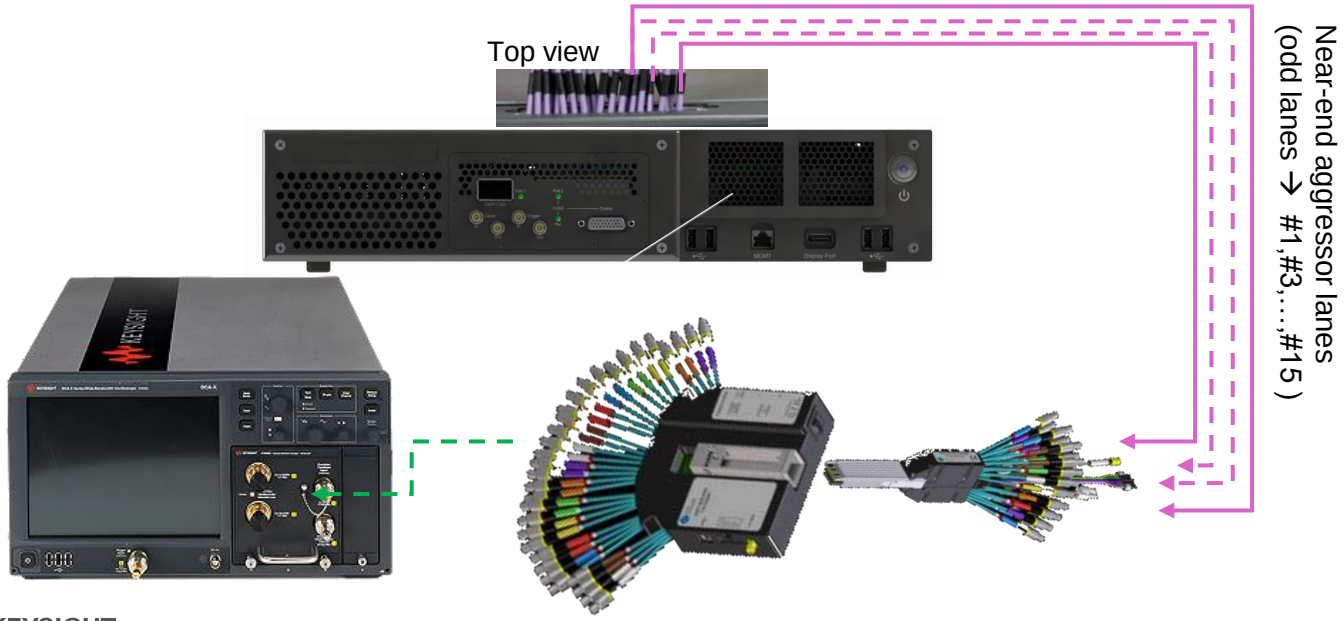
6. Set host Tx settings on **Port 2**
   - See near-end aggressor (NEXT) calibration slide for counter-propagating channel calibration

Preparing Measurements

NEAR END CROSSTALK (NEXT) CALIBRATION

1. Connect Port2 Tx lanes as follows: HCB_Rx_n → MCB_Rx_n
2. Connect the NEXT lane to be calibrated on the scope
3. Terminate other lanes





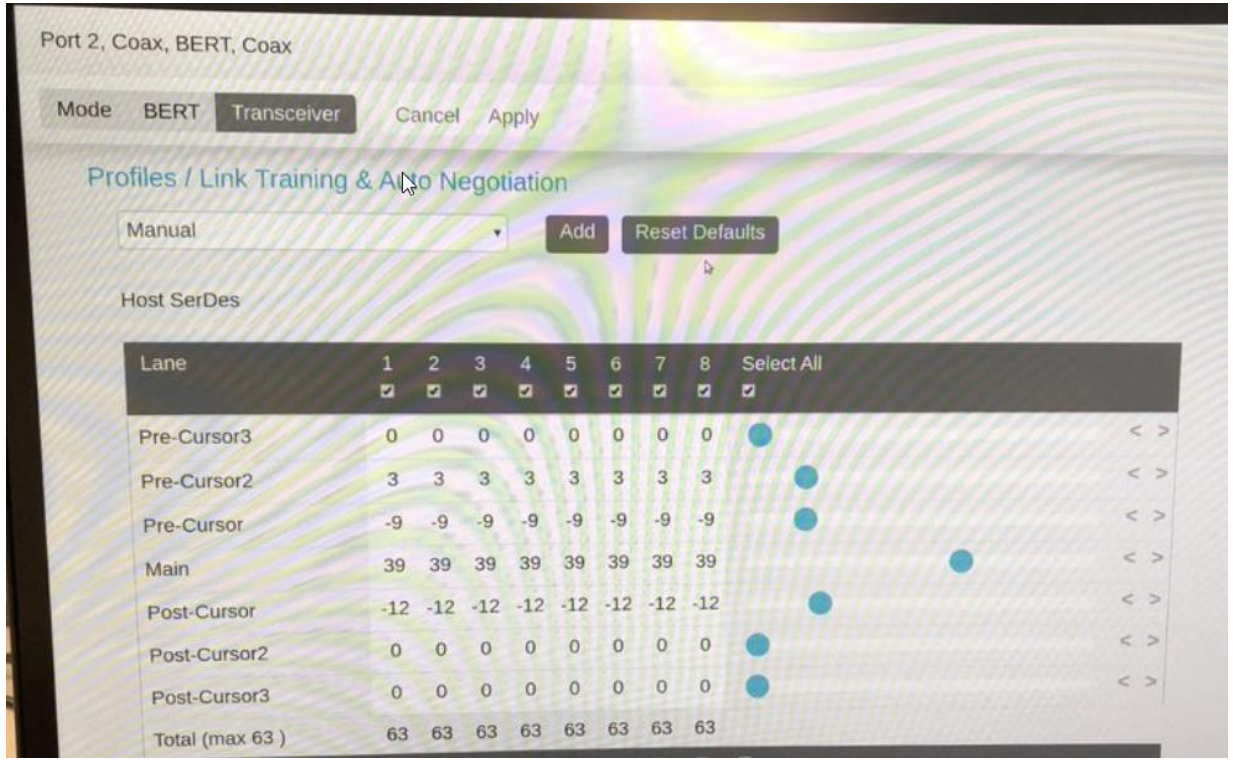
Preparing Measurements

NEAR END CROSSTALK (NEXT) CALIBRATION

4. Tune G800GE Port 2 Host Settings

- Observe the near-end aggressor @ TP7a on the scope using PRBS13Q and set scope response (SIRC) to 4th order BT with 40GHz bandwidth
- Adjust the host settings on the G800GE port2 (coax) to get as close as possible to
  - 17ps 20-80% rise-time , 450mV pk-pk amplitude
  - Recommended Tx host settings are:

    Pre3 / Pre2 / Pre / Main / Post / Post2 / Post 3
    0 / 3 / -8 / 41 / -11 / 0 / 0



Preparing measurements

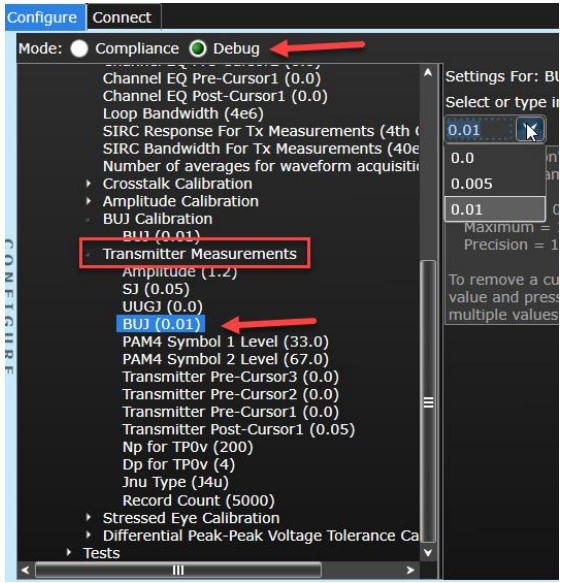
VICTIM LANE CALIBRATION

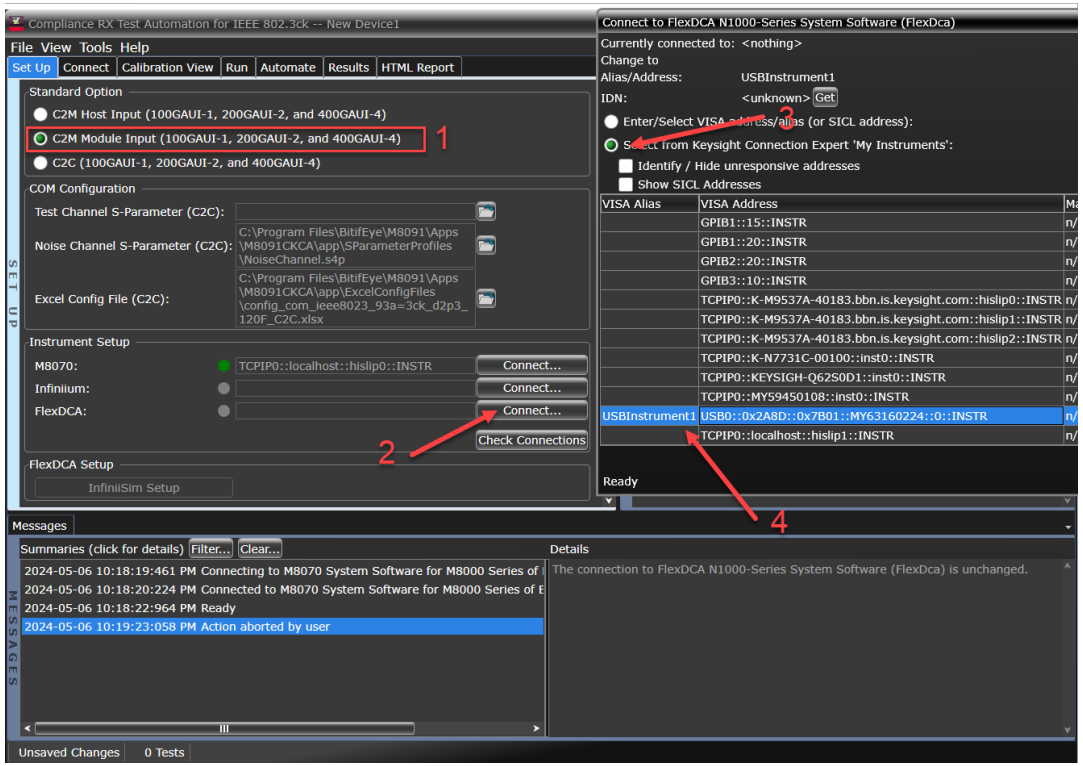
Victim Lane Calibration

REFERENCE TRANSMITTER MEASUREMENTS

1. Start M8070B BERT Firmware
2. Start M8091CKCA application
   - Select C2M Module input Test
   - Connect the to the Instruments Firmware
3. Go to the configure Tab and select the *Debug* Mode
   - In transmitter Measurements set *BUJ* to **0.01UI**

(this ensures that the transmitter has a realistic jitter profile and prevent too much random jitter to be added during victim lane calibration)

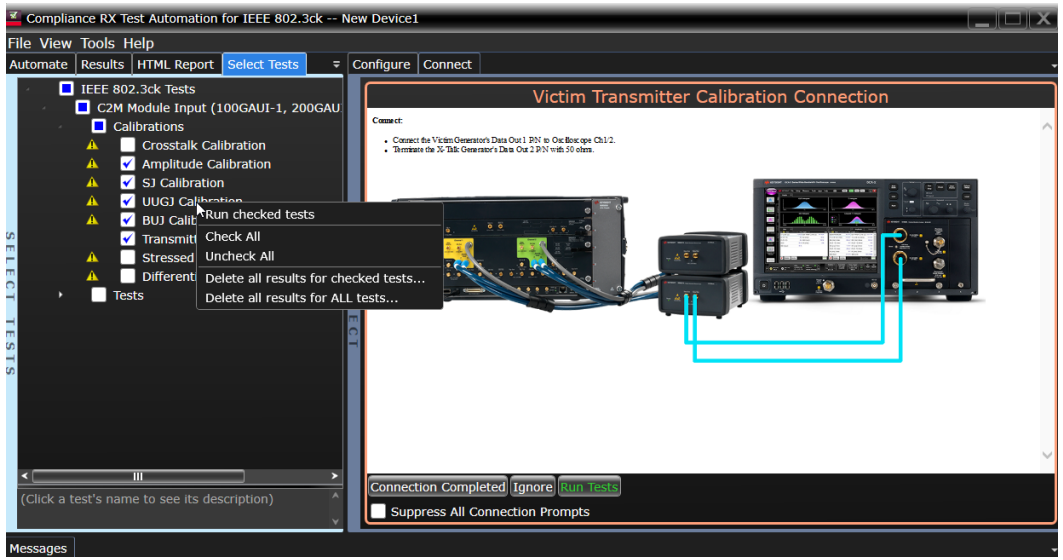




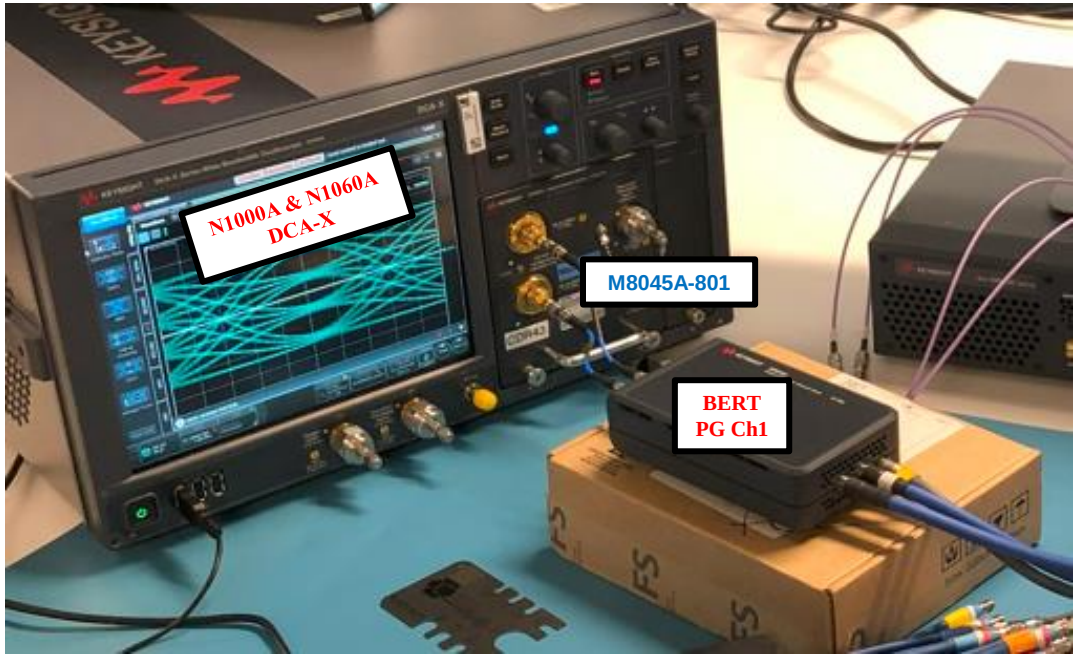
Victim Lane Calibration

REFERENCE TRANSMITTER MEASUREMENTS

4. Jitter source and transmitter calibrations
   - Connect the PG directly to the scope
   - In the *Select Test* Tab select
     - *Amplitude, SJ and UUGJ Calibration*
     - *Transmitter Measurements*
   - *Right-click to start the calibrations or go to the s tab to create some tags for your calibration (date, parameters etc.)*



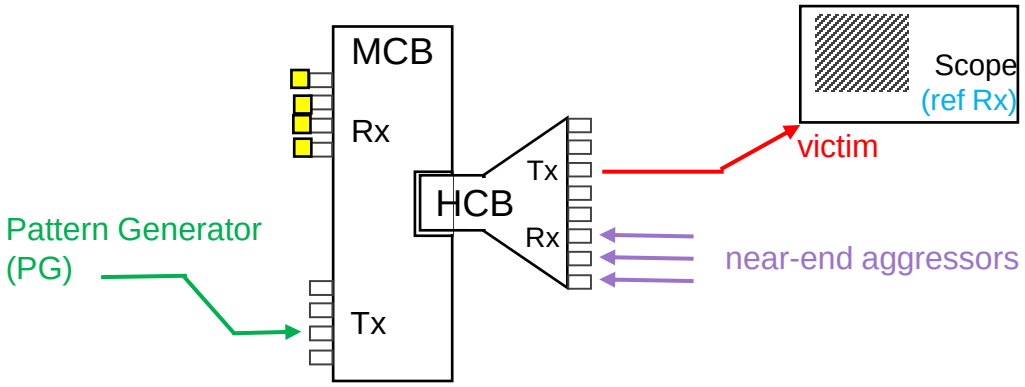
Transmitter characterization connections for C2M Module Input Test

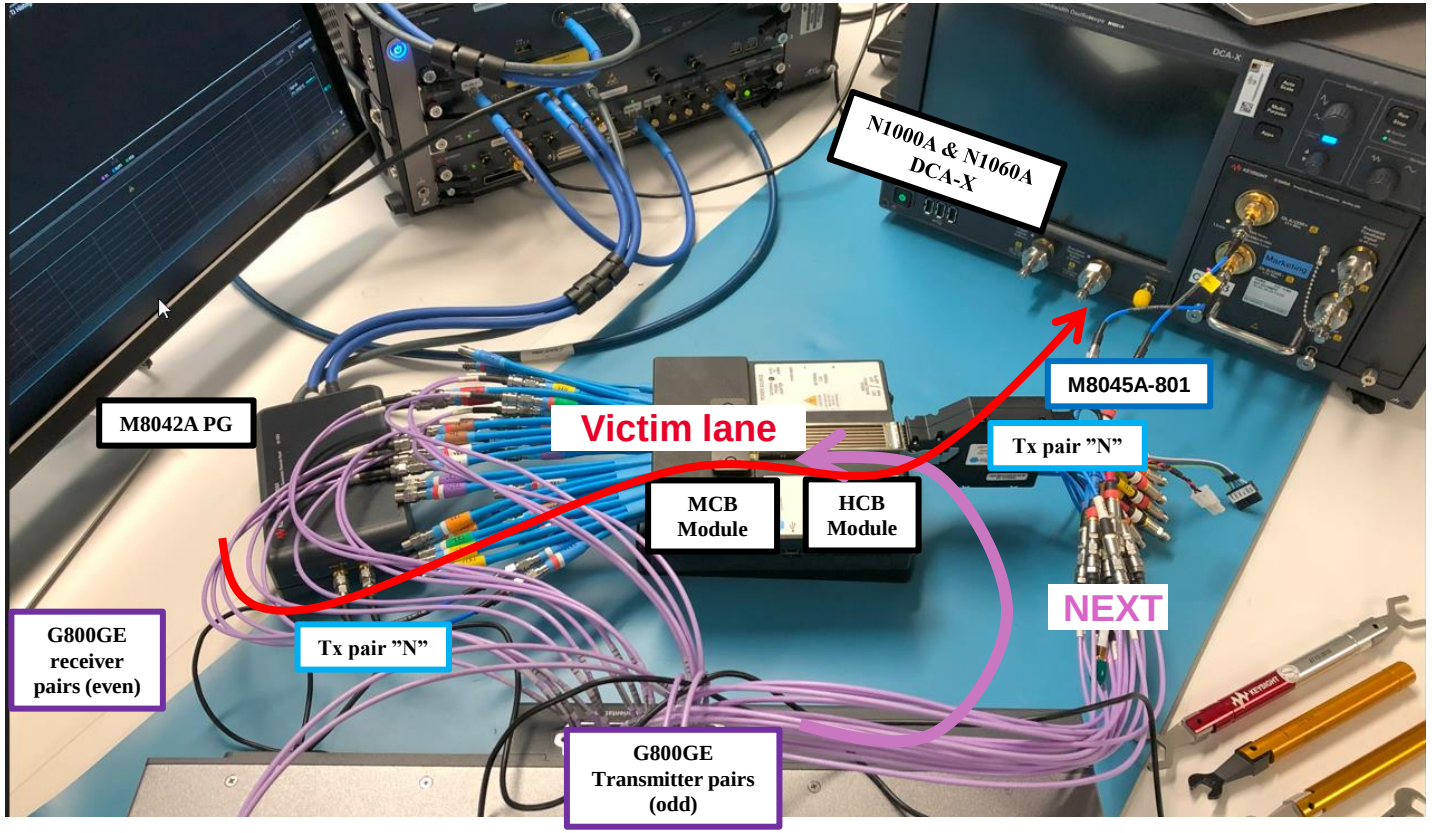


Note: before running the calibration, verify that the skew between the scope differential port must be less than 2ps. If this is not the case, the scope skew must be re-calibrated.

Example Setup Configuration

VICTIM LANE - C2M MODULE INPUT CALIBRATION



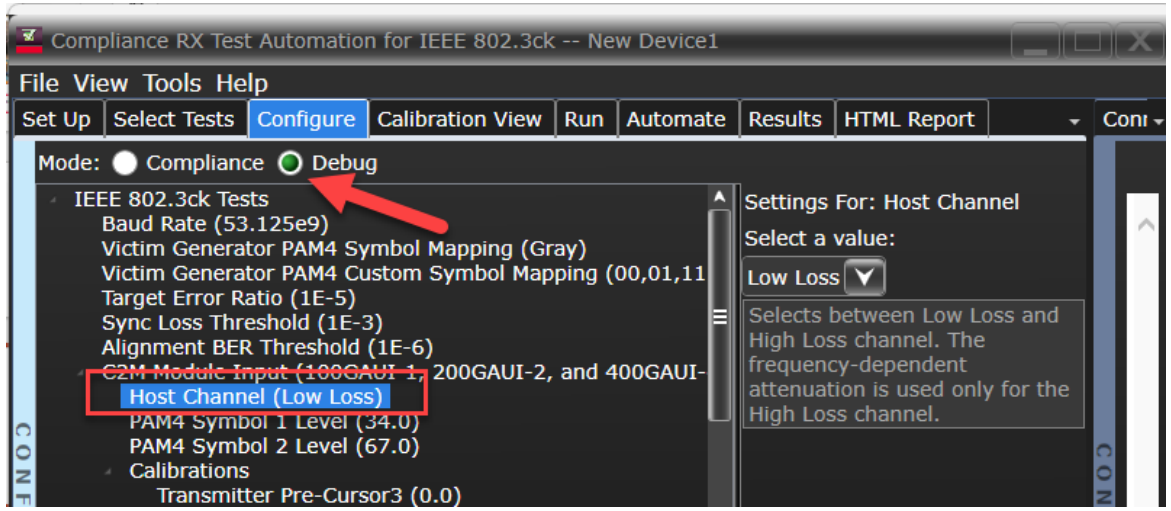


- Connect as shown above
- Victim lane is always "lane 1"

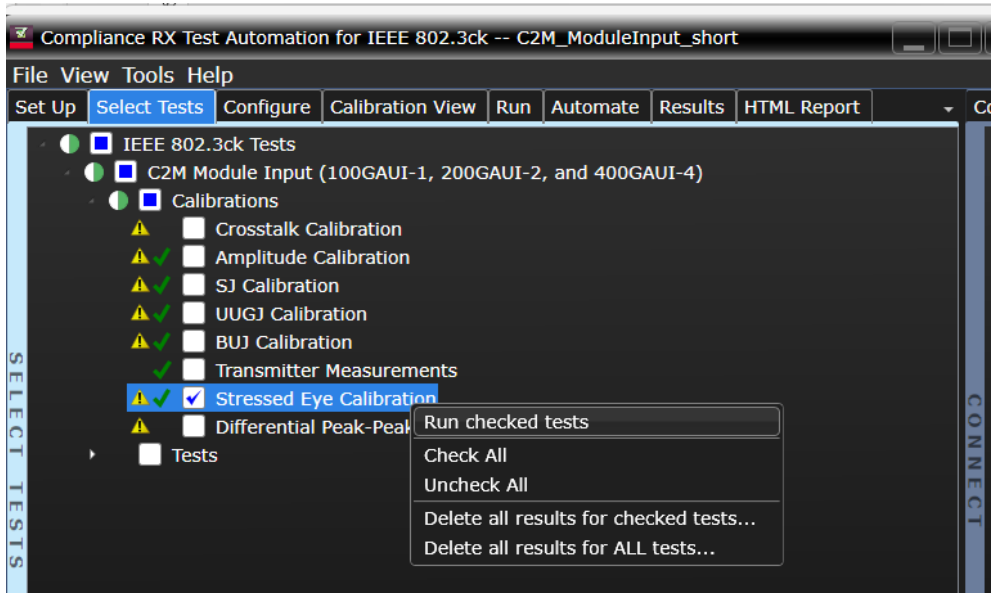
Cable Test – Victim lane calibration

SHORT HOST CASE

1. “Configure Tab”
   - Host Channel = Low Loss



2. “Select Tests” Tab
   - Unselect previous calibration tests
   - Select “Stressed Eye Calibration”, right-click→ “run checked tests”

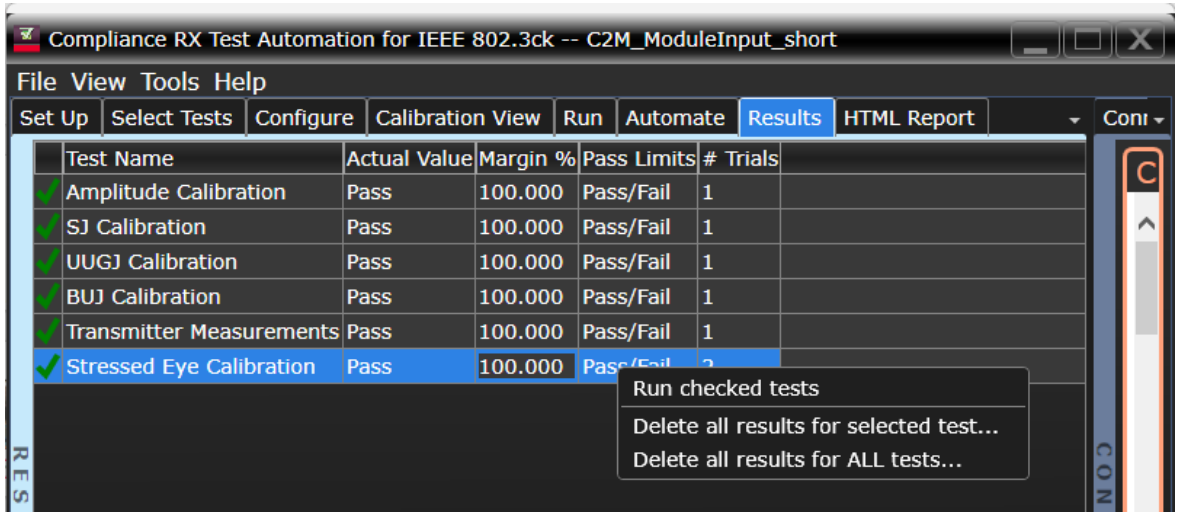


3. After calibration
   - Save M8091CKCA project as “low-loss”
   - Save M8070B settings as “low-loss”

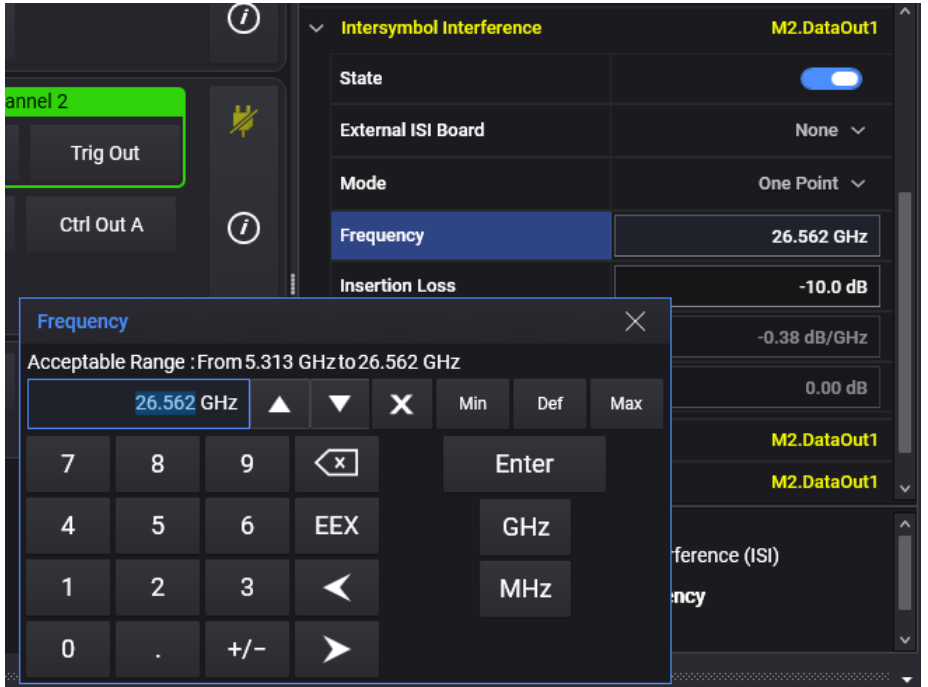
Cable Test – Victim lane calibration

LONG HOST CASE

1. Save the “Short host” project as “Long host”
2. “Results” tab
   - Delete the previous stress eye calibration result (short host)



3. “Configure” Tab
   - Host Channel = High Loss
4. “Select Test” Tab
   - Select “Stressed Eye Calibration”, right-click→ “run checked tests”
5. !**Manual Step! -** After BERT has been initialized
   - Go to M8070B – M2-DataOut1. ISI
   - Add -10dB ISI at Nyquist (max Freq)



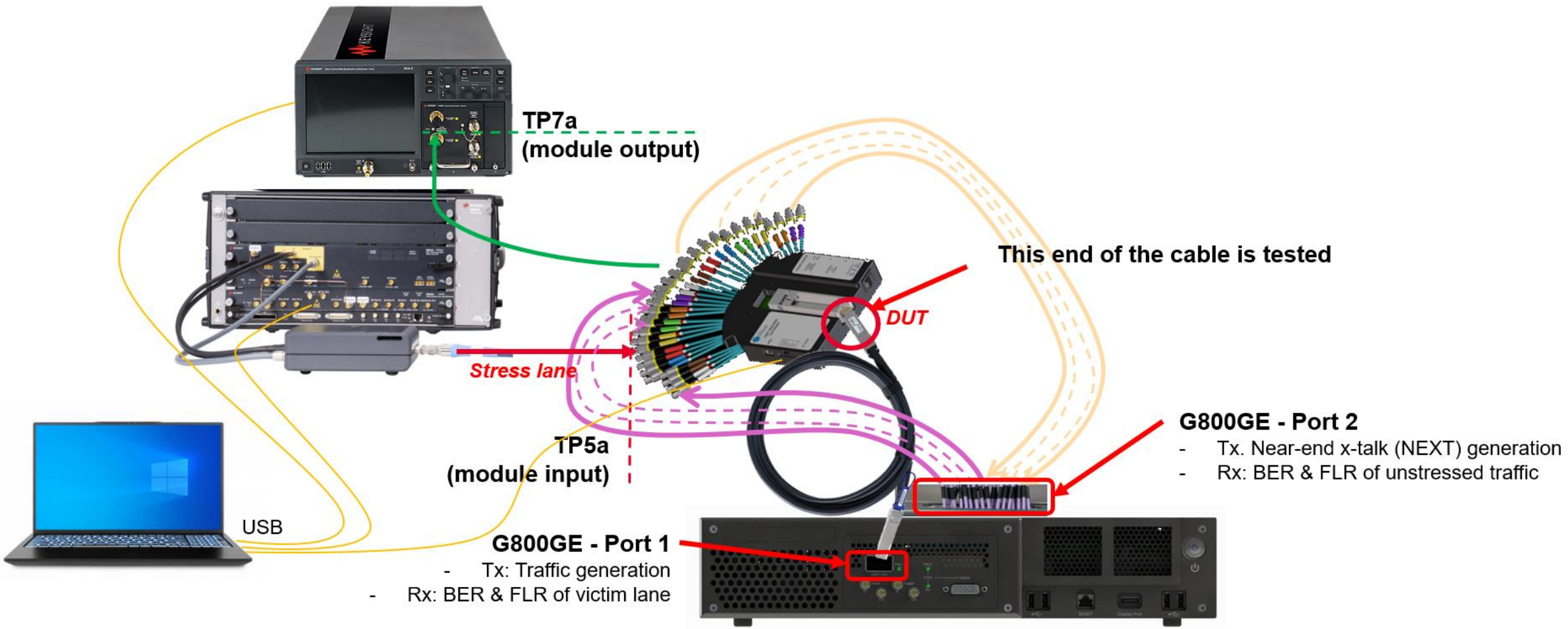
6. After calibration
   Save M8091CKCA project as “high-loss”
   Save M8070B settings as “high-loss”

Cable Test

TEST OVERVIEW

NDR Active Cable Test Platform

SAME CONFIGURATION FOR CABLE INPUT AND OUTPUT TESTS



Combined Cable Input and Output Test

TEST OVERVIEW

The cable performance should be verified for two different host-channel scenarios with low and high insertion loss referred to as **near-end (low loss)** and **far-end (high loss)**. In addition, the module can support both **short** and **long** mode.

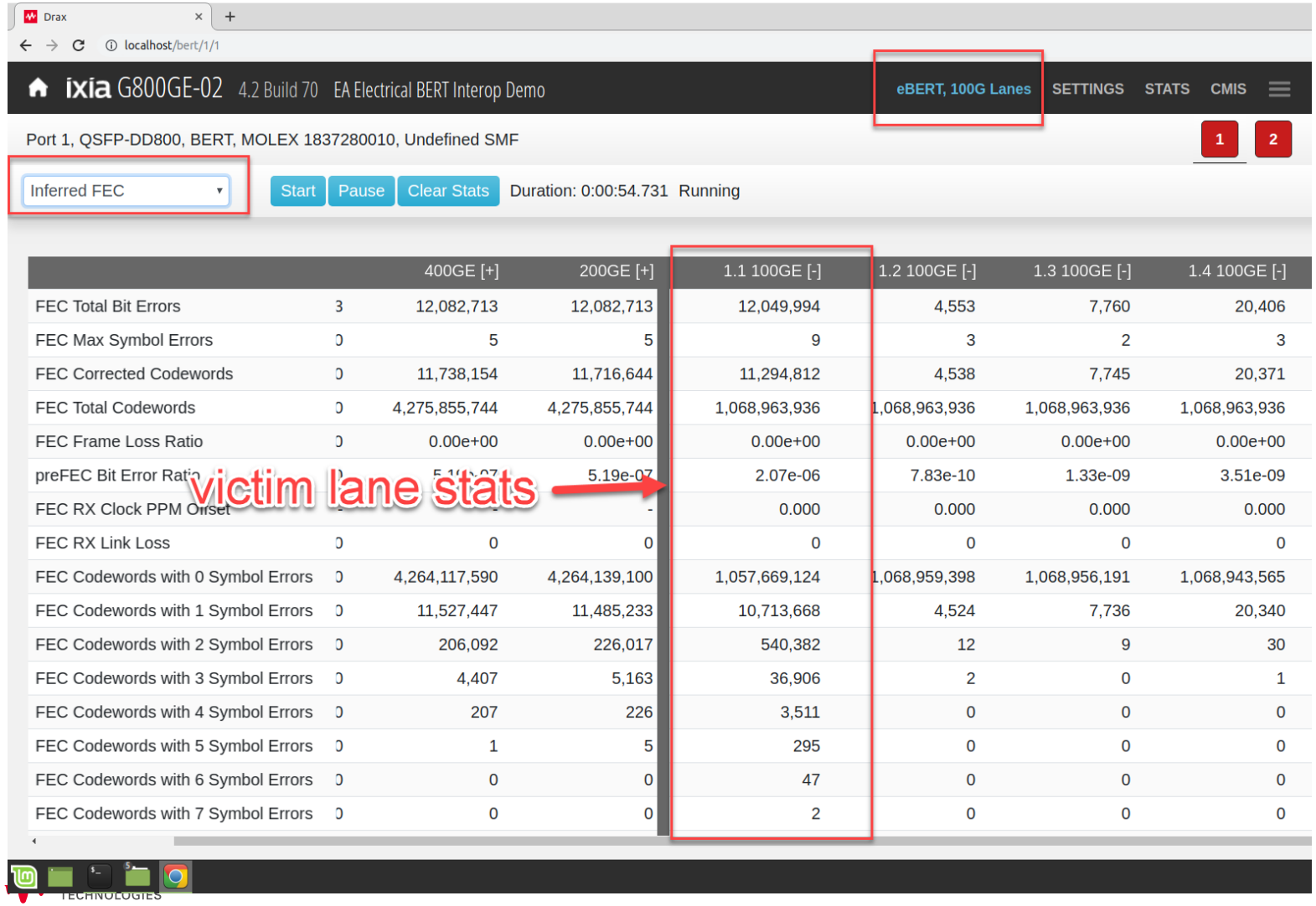
	Output test		Input test	
	Host Near-end	**Host Far-end**	**Host Near-end**	**Host Far-end**
Module "Short"	mandatory	Optional	mandatory	mandatory
Module "Long"	Optional	mandatory	mandatory	mandatory

Notes:

- The module is set in "Short" or "Long" mode via the CMIS interface.
- These tests should be carried out for both ends of the cable (A & B)
- The victim lane is set in "near-end" or "far-end" configuration by loading the "low-loss" or "high-loss" M8070B settings saved during victim lane calibration
- BER and FEC stats are read on the other end of the cable plugged into the G800GE module

Input Test

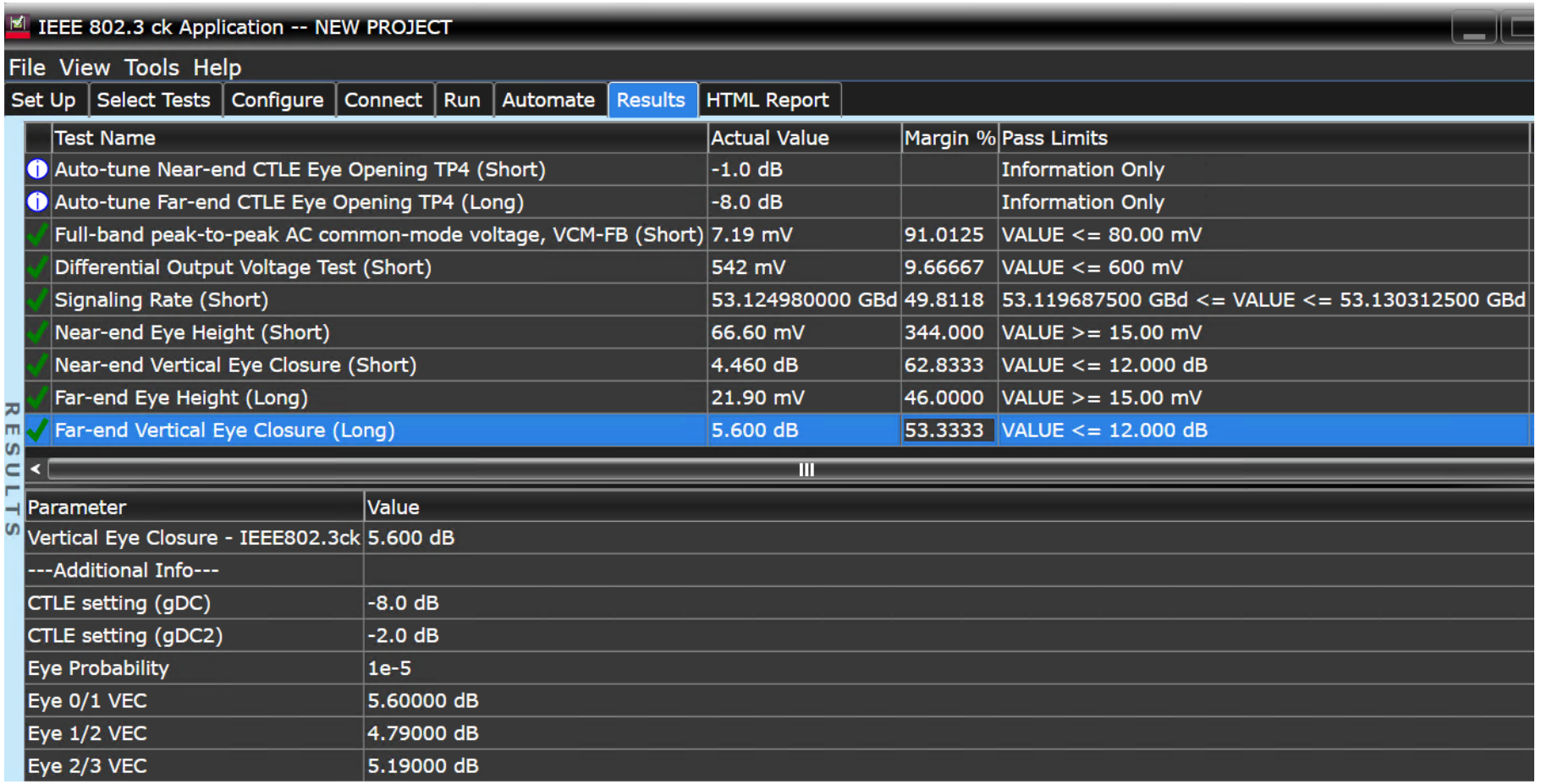
EXAMPLE RESULTS



		400GE [+]	200GE [+]	1.1 100GE [-]	1.2 100GE [-]	1.3 100GE [-]	1.4 100GE [-]
FEC Total Bit Errors	3	12,082,713	12,082,713	12,049,994	4,553	7,760	20,406
FEC Max Symbol Errors	0	5	5	9	3	2	3
FEC Corrected Codewords	0	11,738,154	11,716,644	11,294,812	4,538	7,745	20,371
FEC Total Codewords	0	4,275,855,744	4,275,855,744	1,068,963,936	1,068,963,936	1,068,963,936	1,068,963,936
FEC Frame Loss Ratio	0	0.00e+00	0.00e+00	0.00e+00	0.00e+00	0.00e+00	0.00e+00
preFEC Bit Error Ratio	0	[illegible]	5.19e-07	2.07e-06	7.83e-10	1.33e-09	3.51e-09
FEC RX Clock PPM Offset	[illegible]	[illegible]	-	0.000	0.000	0.000	0.000
FEC RX Link Loss	0	0	0	0	0	0	0
FEC Codewords with 0 Symbol Errors	0	4,264,117,590	4,264,139,100	1,057,669,124	1,068,959,398	1,068,956,191	1,068,943,565
FEC Codewords with 1 Symbol Errors	0	11,527,447	11,485,233	10,713,668	4,524	7,736	20,340
FEC Codewords with 2 Symbol Errors	0	206,092	226,017	540,382	12	9	30
FEC Codewords with 3 Symbol Errors	0	4,407	5,163	36,906	2	0	1
FEC Codewords with 4 Symbol Errors	0	207	226	3,511	0	0	0
FEC Codewords with 5 Symbol Errors	0	1	5	295	0	0	0
FEC Codewords with 6 Symbol Errors	0	0	0	47	0	0	0
FEC Codewords with 7 Symbol Errors	0	0	0	2	0	0	0

Output Test

EXAMPLE RESULTS


IEEE 802.3 ck Application -- NEW PROJECT

File View Tools Help

Set Up | Select Tests | Configure | Connect | Run | Automate | Results | HTML Report

RESULTS

Test Name	Actual Value	Margin %	Pass Limits
Auto-tune Near-end CTLE Eye Opening TP4 (Short)	-1.0 dB		Information Only
Auto-tune Far-end CTLE Eye Opening TP4 (Long)	-8.0 dB		Information Only
Full-band peak-to-peak AC common-mode voltage, VCM-FB (Short)	7.19 mV	91.0125	VALUE <= 80.00 mV
Differential Output Voltage Test (Short)	542 mV	9.66667	VALUE <= 600 mV
Signaling Rate (Short)	53.124980000 GBd	49.8118	53.119687500 GBd <= VALUE <= 53.130312500 GBd
Near-end Eye Height (Short)	66.60 mV	344.000	VALUE >= 15.00 mV
Near-end Vertical Eye Closure (Short)	4.460 dB	62.8333	VALUE <= 12.000 dB
Far-end Eye Height (Long)	21.90 mV	46.0000	VALUE >= 15.00 mV
Far-end Vertical Eye Closure (Long)	5.600 dB	53.3333	VALUE <= 12.000 dB

Parameter	Value
Vertical Eye Closure - IEEE802.3ck	5.600 dB
---Additional Info---	
CTLE setting (gDC)	-8.0 dB
CTLE setting (gDC2)	-2.0 dB
Eye Probability	1e-5
Eye 0/1 VEC	5.60000 dB
Eye 1/2 VEC	4.79000 dB
Eye 2/3 VEC	5.19000 dB

Cable Test

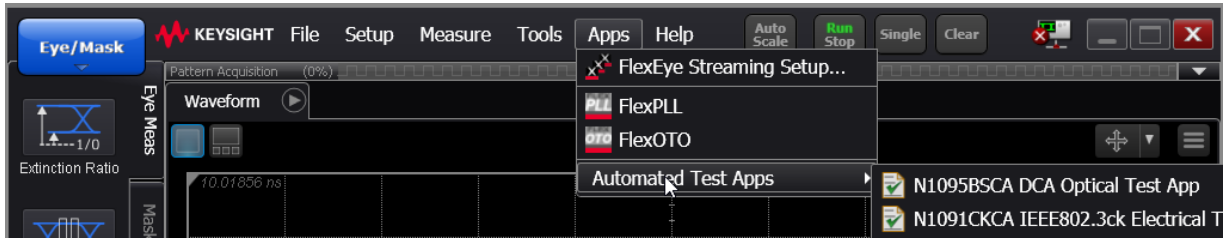
CABLE OUTPUT TEST PROCEDURE

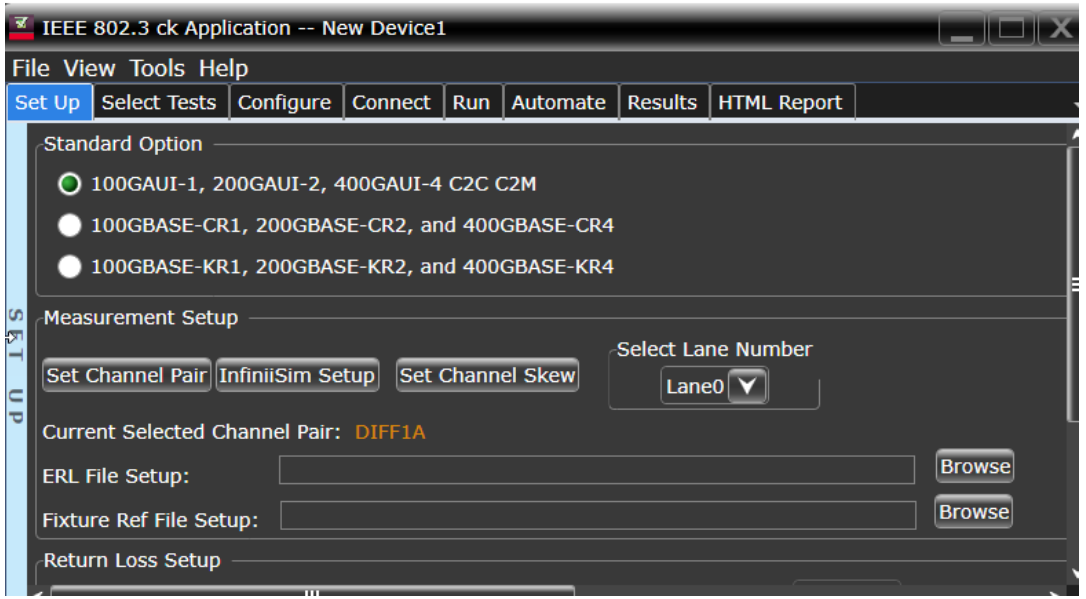
Cable Output Test Procedure

NDR USING N1091CKCA FOR IEEE 802.3CK

Note: The following tests are conducted using the N1091CKCA DCA TX Test Application

1. Open the N1091CKCA application through the FlexDCA interface.
   - Navigate to Apps > Automated Test App > N1091CKCA.
2. Choose the C2M interface.
   - For instructions on de-embedding cables and adjusting scope skew, please see slides #18 and #19.





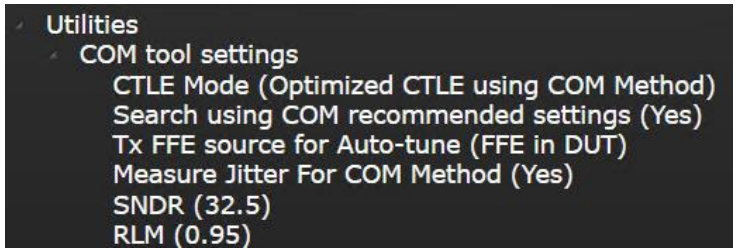
Cable Output Test Procedure

NDR USING N1091CKCA FOR IEEE 802.3CK

3. It is recommended to perform the "auto-tune eye opening test" for optimal CTLE settings related to eye opening.
   - This option can be accessed under the Utilities test.

Auto-tune Eye Opening Test Settings

- By default, the application selects “Optimized CTLE using COM method” as the CTLE mode. In this setting, the app will capture the signal and transform it into Pulse response, subsequently recommending TX FFE tap settings to enhance the output signal.
- Alternatively, users can opt for the ‘brute force method’ to evaluate all CTLE combinations, although this results in a longer measurement duration.
  - To switch to the brute force method, navigate to the configure tab under Utilities and change the CTLE mode from “optimized CTLE using COM method” to “Auto-tune.”
  - Brute force method may take approx. 40 mins for one auto-tune test, 160 mins for all 4 auto-tune utility test.



Parameter	Limits to meet, for Autotune utility test to report optimal eye opening
Eye Height	15mV (min)
VEC	12dB (max)

*App will not report result if failed to meet the above limit, even it is opened eyes signal

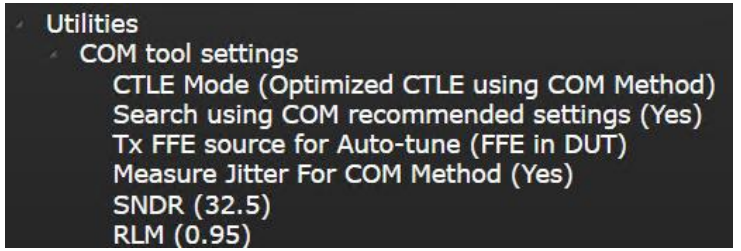
Cable Output Test Procedure

NDR USING N1091CKCA FOR IEEE 802.3CK

Auto-tune Eye Opening Test Settings (cont.)

TX FFE source for Auto-tune

- The default setting is “FFE in scope,” which utilizes FlexDCA’s math block to apply the FFE settings suggested by the COM tool. It serves as a “preview” of the recommended TX FFE setting.
- If TX tap settings (equalizer) can be adjusted, it is advisable to change the setting to “FFE in DUT.” This will prompt the app to guide you in modifying the tap settings after calculating the necessary values.



Jitter Measurement for COM

- To determine COM, it is necessary to have Add and Sigma RJ, which can be assessed using the jitter mode of FlexDCA.
- If the signal experiences degradation, FlexDCA might have difficulty in accurately characterizing it while in jitter mode.
- This mode is enabled by default; if characterization issues arise, consider disabling it.
- When turned off, two additional parameters become visible: Jrms and J3u, which have specification limits of 0.023 and 0.115, respectively.
- The utility test will bypass the 12-edge jitter mode to evaluate Jrms and J3u, utilizing 0.023 and 0.115 as the input values.

Cable Output Test Procedure

NDR USING N1091CKCA FOR IEEE 802.3CK

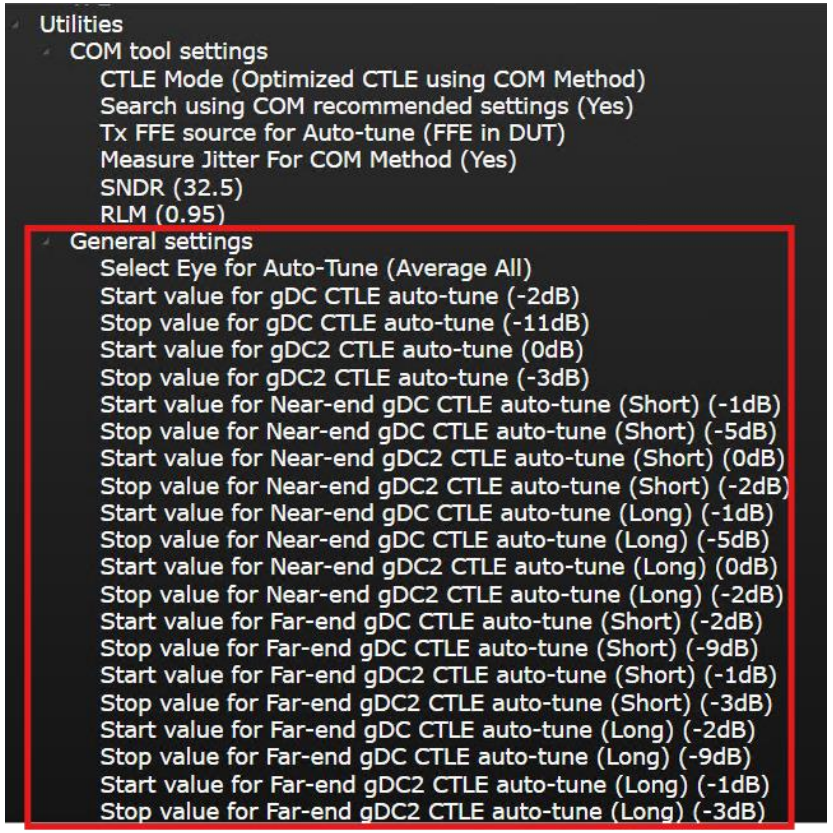
Settings for Auto-tune Eye Opening Test (cont.)

SNDR and RLM values

- These represent the specification limit values. Users may adjust the SNDR and RLM values if their measured results fall below these limits.

General Settings

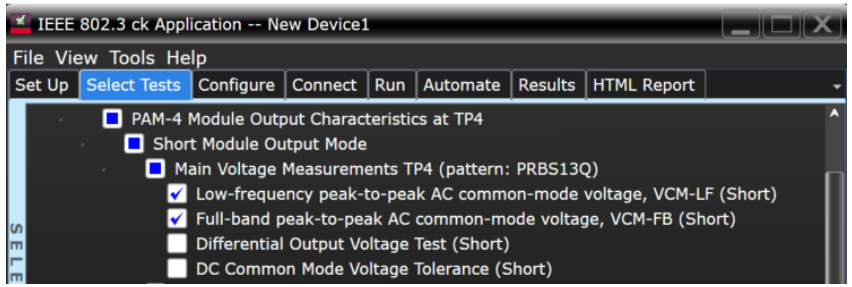
- This indicates the starting and stopping values (range) for the TP1a & TP4 CTLE auto tune, which is advised to stay at the default setting.
- Users have the option to modify this range if desired.



Cable Output Test Procedure

NDR USING N1091CKCA FOR IEEE 802.3CK

4. Peak-to-Peak AC Common-Mode Voltage Test (VCMPP)
   - The maximum limit for VCMPP-LF is set at 32 mV.
   - The maximum limit for VCMPP-FB is established at 80 mV.



In the application, choose the Peak-to-Peak AC Common-Mode Voltage (Low Frequency & Full-Band) test to conduct.

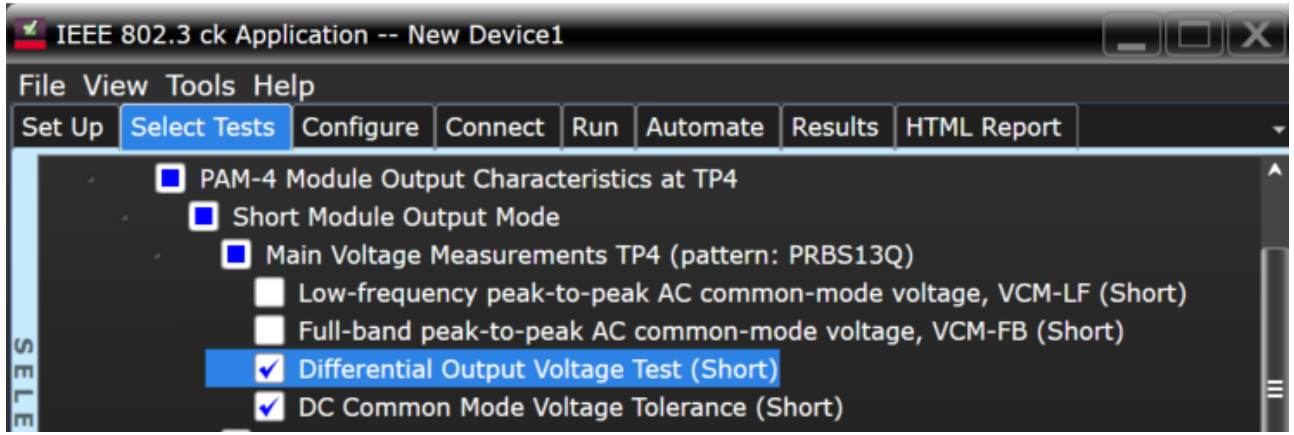
- **Note:** Due to Equivalent Time Sampling scope aliasing affecting the noise spectrum, the DCA will provide measurements across the full band utilizing internal hardware filters (no extra filtering is required).
- **Note:** The application will perform measurements with a probability of 10E-5.
- **Note:** For the Peak-to-Peak AC Common Mode (Low Frequency), an additional 2x 100 MHz low-pass filter will be necessary.

NDR Cable TX Test

NDR USING N1091CKCA FOR IEEE 802.3CK

5. **Differential Output Voltage Test** (maximum limit for short mode: 600mV, maximum limit for long mode: 845mV) **and DC Common-Mode Voltage Tolerance** (specified limit range: -0.35 to 2.85V)

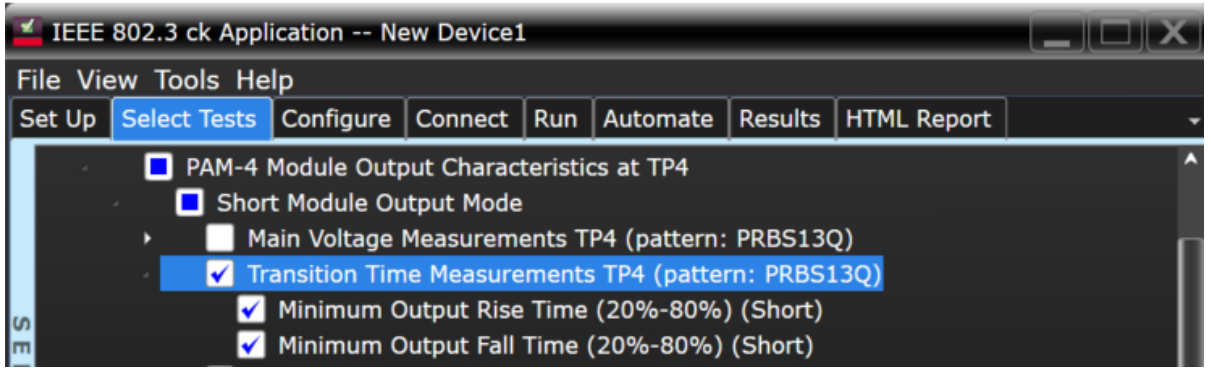
   - Within the application, choose the Differential Output Voltage Test and the DC Common-Mode Voltage Tolerance Test to execute.



NDR Cable TX Test

NDR USING N1091CKCA FOR IEEE 802.3CK

6. **Measurement of Transition Time** (minimum specification limit: 8.5 ps)
   - Choose the transition test measurement option
   - Conduct rise-time and fall-time evaluations
     - **Note:** This is monitored through a fourth-order Bessel-Thomson low-pass filter with a 3dB bandwidth of 40GHz; performed internally using a time-equivalent hardware filter

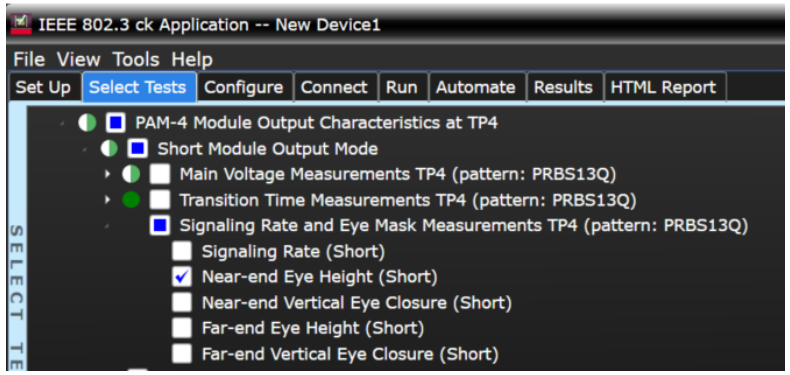


NDR Cable TX Test

NDR USING N1091CKCA FOR IEEE 802.3CK

7. Near-end Eye Height (minimum 15mV; short/long mode)

- Choose the Near-end Eye Height test and initiate the process.
  - In short mode, the application will use the Zp=0 insertion loss file for the measurement.
  - In long mode, the application will utilize the Zp=80 insertion loss file for the measurement.



8. Near-end VEC (maximum 12dB; short/long mode)

- Select the Near-end VEC test and commence the evaluation.
  - The short mode will incorporate the Zp=0 insertion loss file for measurement.
  - The long mode will employ the Zp=80 insertion loss file for measurement.

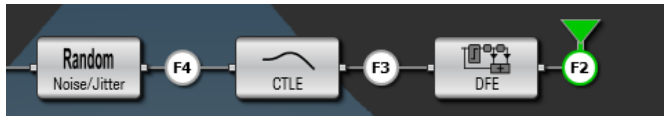
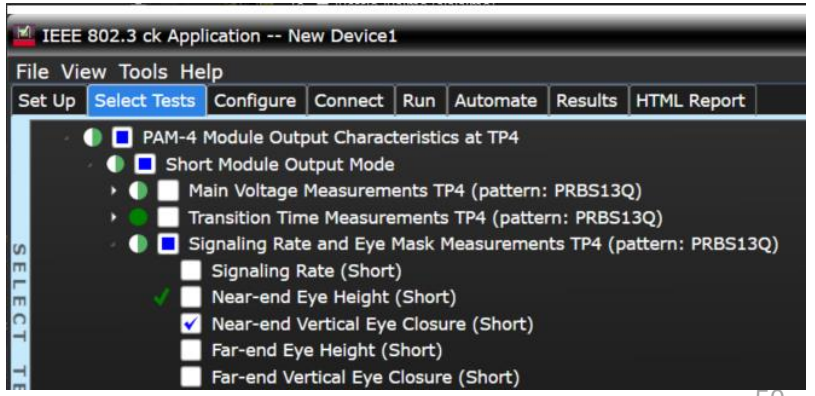


Table 120G–5—PCB length for module output measurements

Module output mode	Host channel type	PCB length, z_p (mm)
Short	near-end	0
Short	far-end	133
Long	near-end	80
Long	far-end	244.7

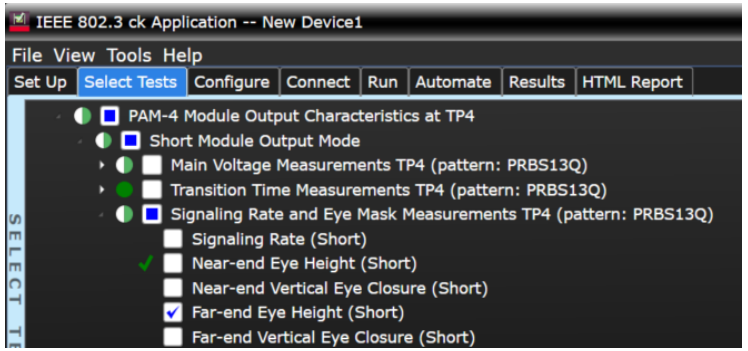


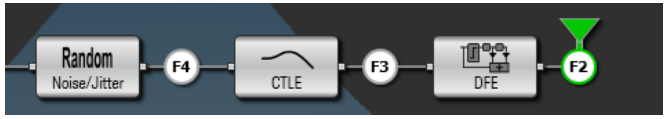
NDR Cable TX Test

NDR USING N1091CKCA FOR IEEE 802.3CK

9. Far-end Eye Height (minimum 15mV; short/long mode)

- Choose the Far-end Eye Height test and initiate it
  - In short mode, the application will incorporate the Zp=133 insertion loss file for measurement
  - In long mode, the application will incorporate the Zp=244.7 insertion loss file for measurement



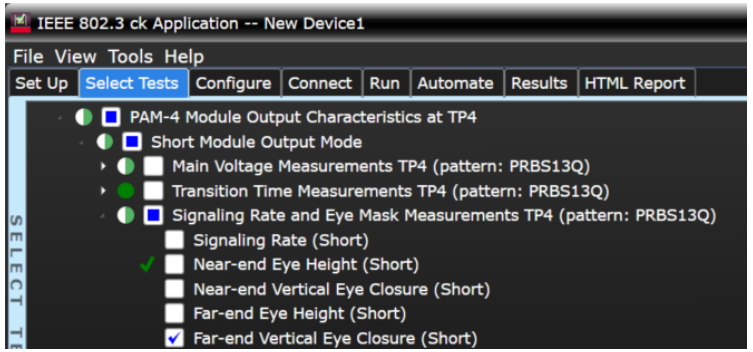


10. Far-end VEC (maximum 12dB; short/long mode)

- Choose the Far-end VEC test and initiate it
  - In short mode, the application will incorporate the Zp=133 insertion loss file for measurement
  - In long mode, the application will incorporate the Zp=244.7 insertion loss file for measurement

Table 120G–5—PCB length for module output measurements

Module output mode	Host channel type	PCB length, z_p (mm)
Short	near-end	0
Short	far-end	133
Long	near-end	80
Long	far-end	244.7

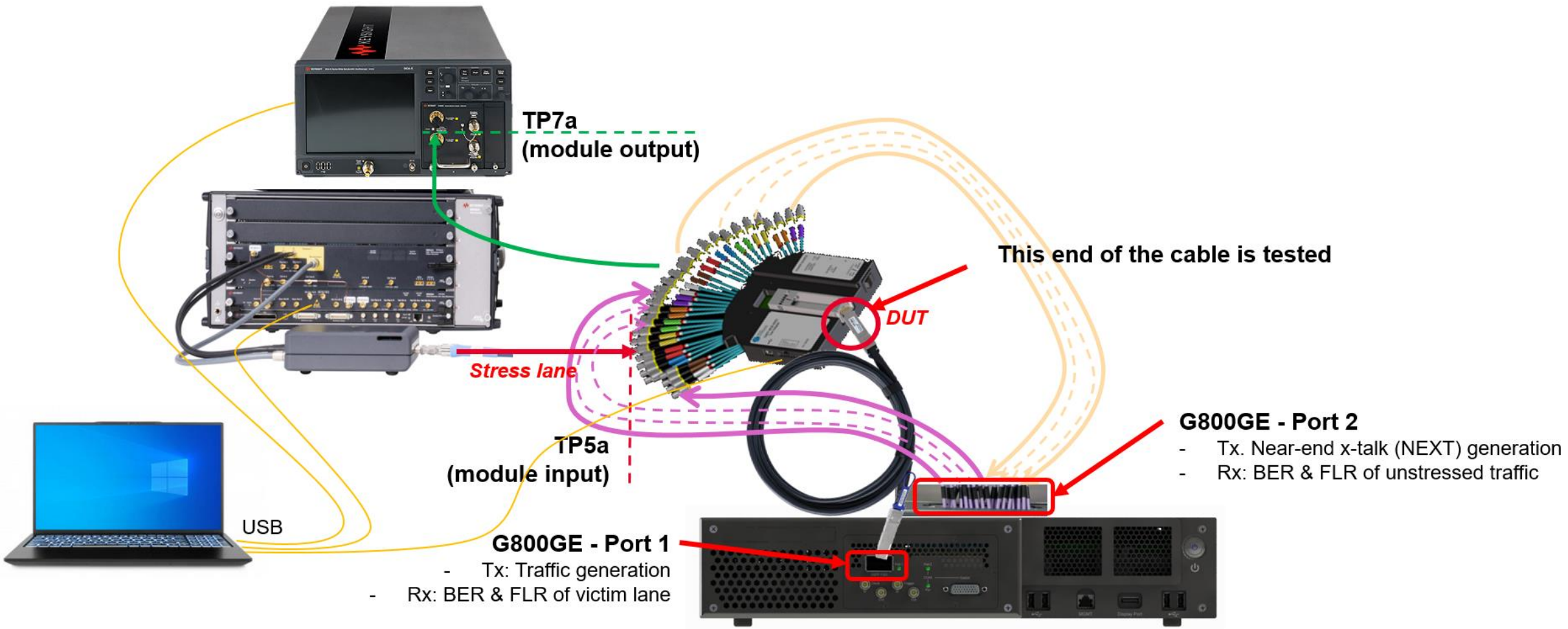


Cable test

CABLE INPUT TEST PROCEDURE

NDR Active Cable Test Platform

SAME CONFIGURATION FOR CABLE INPUT AND OUTPUT TESTS



RX IEEE802.3ck Specification

MODULE INPUT (TP1)

Table 120G–10—Module stressed input parameters

Parameter	Value	Value
Pattern generator transition time (target)	9	ps
Applied peak-to-peak sinusoidal jitter	Table 162–17	—
Eye height (target)	10	mV
Vertical eye closure, VEC (min)	12	dB
Vertical eye closure, VEC (max)	12.5	dB
Crosstalk differential peak-to-peak voltage	845	mV
Crosstalk transition time	8.5	ps

NDR RX Test

MODULE INPUT (TP1)

1. Plug one end of the cable (A) in the MCB and the other end (B) in the port#1 of the G800GE
2. In the Wilder CMIS GUI, check if the module is operating in short or long mode (instruction here)
3. in M8070B (BERT FW), recall the calibration settings for short or long mode
4. In KiOS (G800GE FW)
   - Go to “stats”
   - Read the error stats (BER and FLR) of the victim lane (see example here). To check which one is the victim lane, turn off/on the BERT global output in M8070B Swap the cable and read the error for the other end (B) of the cable
5. If possible, change the mode of both end of the cable (via KiOS CMIS and Wilder GUI CMIS) and repeat the procedure

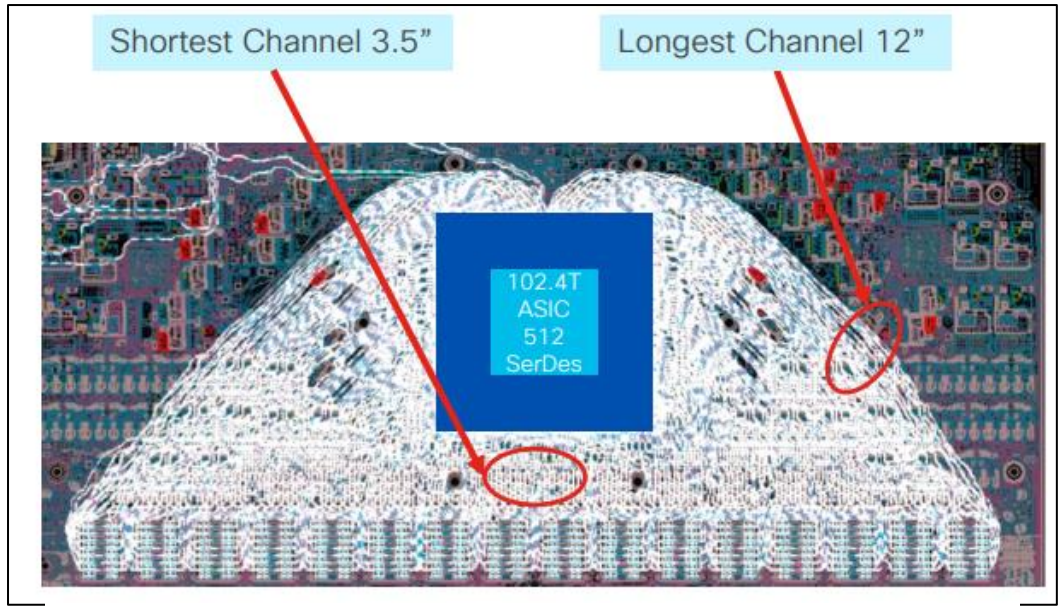
Controlling the DUT mode

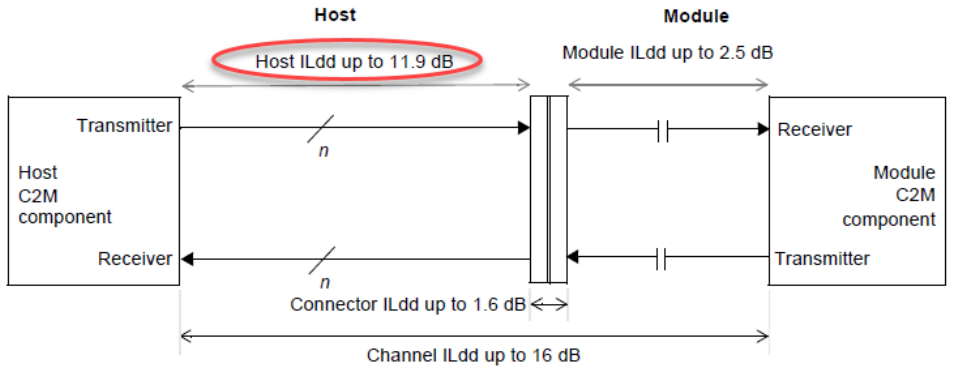
MODULE SHORT AND LONG MODE

Module *short* and *long* modes

THE NEED TO ACCOMMODATE DIFFERENT HOST CHANNELS

102.4T Implementation Study, Cisco





- The Host dd IL can range from 2.3dB to 11.9dB (realistically from ~5dB to ~11dB)
- To ensure a successful link with the module, the host chip, which knows the run length of the soldering, can
  - Adjust its Tx FIR and Rx CTLE
  - Request the module to operate in the *short* or the *long* mode

Table 120G–3—Module output characteristics at TP4

Parameter	Reference	Value	Units
Signaling rate, each lane (nominal)		53.125[a]	GBd
Differential peak-to-peak output voltage (max) Short mode Long mode	120G.5.1	 600 845	 mV mV
Eye height (min)	120G.3.2.2	15	mV
Vertical eye closure, VEC (max)	120G.3.2.2	12	dB

Module *short* and *long* modes

THE NEED TO ACCOMMODATE DIFFERENT HOST CHANNELS

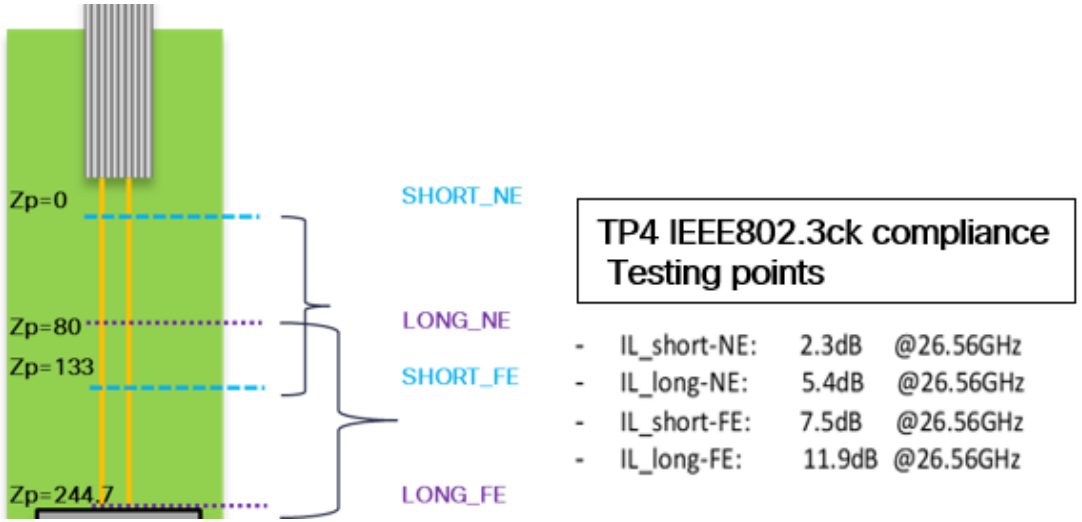
Table 120G–4—Module output mode mapping

IEEE 802.3 interface type	Module output mode	Host electrical interface
100GAUI-1 C2M	short	100GAUI-1-S C2M
100GAUI-1 C2M	long	100GAUI-1-L C2M
200GAUI-2 C2M	short	200GAUI-2-S C2M
200GAUI-2 C2M	long	200GAUI-2-L C2M
400GAUI-4 C2M	short	400GAUI-4-S C2M
400GAUI-4 C2M	long	400GAUI-4-L C2M

→ Modules are usually per default in "*short* " mode
→ The host will "tweak" module CMIS (Tx settings) to make it operate in long mode.

- The **module output** supports two equalization states: *short* and *long*. In the short state, the module shall meet for near-end requirement (low loss channel). In the long state, the module shall meet for far-end requirement (high loss channel).

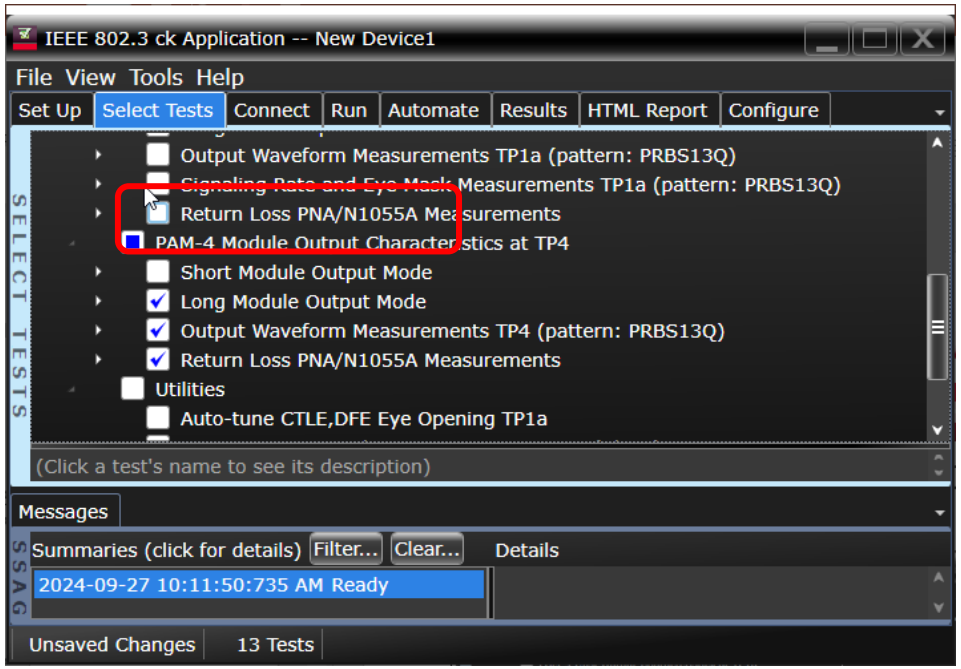
- Four Host / Module modes combinations are possible:



Module short and long mode

OUTPUT TEST MUST BE CARRIED OUT FOR BOTH MODES

Module output test using **N1091CKCA**



→ The host channel (FE/NE) is emulated in the scope

- FE & NE channel cases will result in different CTLE range for the host reference receiver in the scope

Continuous time filter, DC gain for TP4 near-end Range Step size	g_{DC}	 −5 to −1 1.0	 dB
Continuous time filter, DC gain for TP4 far-end Range Step size	g_{DC}	 −9 to −2 1.0	 dB

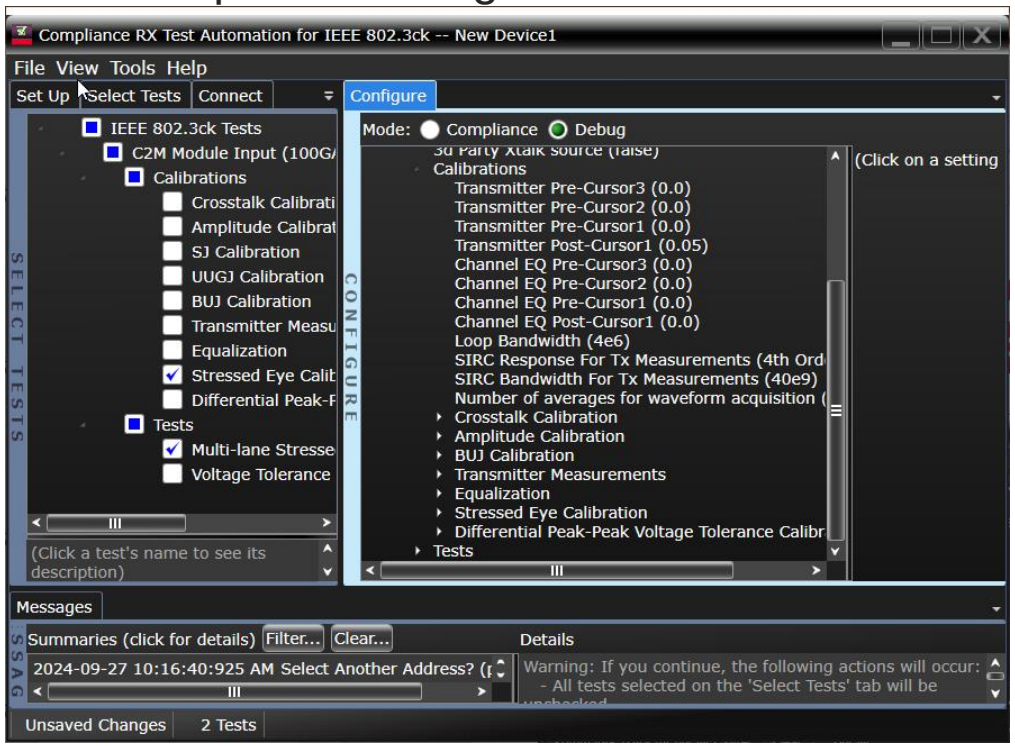
- Depending on the module mode (short or long) different S-parameters are used → The module mode must be known for the test

→ Make sure the module is in the correct mode before testing!

Module short and long mode

INPUT TEST INDEPENDENT OF THE MODULE MODE

Module input test using **M8091CKCA**

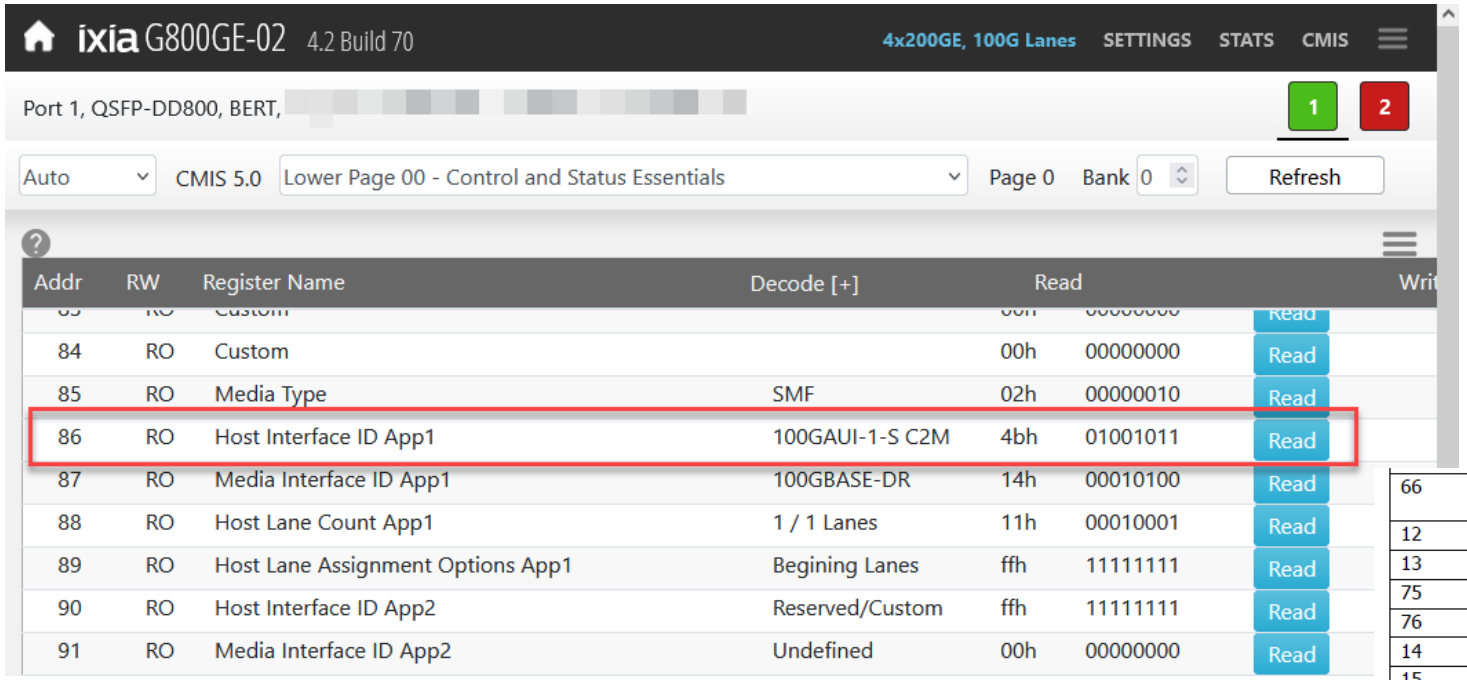


The module receiver is expected to behave independently of the mode (TX only). However, some vendors may adjust the initial settings of the adaptive receiver equalizer depending on the module mode.

→ It is recommended to repeat the input test for both module modes

Checking the module mode

USING CMIS INTERFACE



Addr	RW	Register Name	Decode [+]	Read		Writ
84	RO	Custom		00h	00000000	Read
85	RO	Media Type	SMF	02h	00000010	Read
86	RO	Host Interface ID App1	100GAUI-1-S C2M	4bh	01001011	Read
87	RO	Media Interface ID App1	100GBASE-DR	14h	00010100	Read
88	RO	Host Lane Count App1	1 / 1 Lanes	11h	00010001	Read
89	RO	Host Lane Assignment Options App1	Begining Lanes	ffh	11111111	Read
90	RO	Host Interface ID App2	Reserved/Custom	ffh	11111111	Read
91	RO	Media Interface ID App2	Undefined	00h	00000000	Read

66	42	CAUI-4 C2M (Annex 83E) with RS (528,514) FEC	103.13	4	25.78125	NRZ	1
12	C	100GAUI-4 C2M (Annex 135E)	106.25	4	26.5625	NRZ	1
13	D	100GAUI-2 C2M (Annex 135G)	106.25	2	26.5625	PAM4	2
75	4B	100GAUI-1-S C2M (Annex 120G)	106.25	1	53.125	PAM4	2
76	4C	100GAUI-1-L C2M (Annex 120G)	106.25	1	53.125	PAM4	2
14	E	200GAUI-8 C2M (Annex 120C)	212.50	8	26.5625	NRZ	1
15	F	200GAUI-4 C2M (Annex 120E)	212.50	4	26.5625	PAM4	2
77	4D	200GAUI-2-S C2M (Annex 120G)	212.50	2	53.125	PAM4	2
78	4E	200GAUI-2-L C2M (Annex 120G)	212.50	2	53.125	PAM4	2
128	80	200GAUI-1 (Annex176E)	212.50	1	106.25	PAM4	2
16	10	400GAUI-16 C2M (Annex 120C)	425.00	16	26.5625	NRZ	1
17	11	400GAUI-8 C2M (Annex 120E)	425.00	8	26.5625	PAM4	2
79	4F	400GAUI-4-S C2M (Annex 120G)	425.00	4	53.125	PAM4	2
80	50	400GAUI-4-L C2M (Annex 120G)	425.00	4	53.125	PAM4	2
129	81	400GAUI-2 (Annex176E)	425.00	2	106.25	PAM4	2
81	51	800GAUI-8 S C2M (Annex 120G)	850.00	8	53.125	PAM4	2
82	52	800GAUI-8 L C2M (Annex 120G)	850.00	8	53.125	PAM4	2
130	82	800GAUI-4 (Annex176E)	850.00	4	106.25	PAM4	2
85	55	1.6TAUI-16-S C2M (Annex 120G)	1700.00	16	53.125	PAM4	2

CMIS 4.0 control

LOOPBACK

Table 8-69 Loopback Capabilities (Page 13h)

Byte	Bits	Name	Description	Type
128	7	Reserved		RO
	6	Simultaneous Host and Media Side Loopback supported	0b=Simultaneous host and media side loopback not supported 1b=Simultaneous host/media side loopback supported	RQD
	5	Per-lane Media Side Loopback supported	0b=Individual lane media side loopback not supported 1b=Individual lane media side loopback supported	
	4	Per-lane Host Side Loopback supported	0b=Individual lane host side loopback not supported 1b=Individual lane host side loopback supported	
	3	Host Side Input Loopback supported	0b=Host side input loopback not supported 1b=Host side input loopback supported	
	2	Host Side Output Loopback supported	0b=Host side output loopback not supported 1b=Host side output loopback supported	
	1	Media Side Input Loopback supported	0b=Media side input loopback not supported 1b=Media side input loopback supported	
	0	Media Side output Loopback supported	0b=Media side output loopback not supported 1b=Media side output loopback supported	

Table 8-88 Loopback Controls (Page 13h)

Byte	Bits	Name	Description	Type
180	7	Media side output loopback lane 8 enable	0b=normal non-loopback operation 1b=loopback operation enabled. If the Per-lane Media Side Loopback Supported field=1, loopback control is per lane. Otherwise, if any loopback enable bit is set to 1, all Media side lanes are in output loopback.	RW Opt.
	6	Media side output loopback lane 7 enable		
	5	Media side output loopback lane 6 enable		
	4	Media side output loopback lane 5 enable		
	3	Media side output loopback lane 4 enable		
	2	Media side output loopback lane 3 enable		
	1	Media side output loopback lane 2 enable		
	0	Media side output loopback lane 1 enable		
181	7	Media side input loopback lane 8 enable	0b=normal non-loopback operation 1b=loopback operation enabled. If the Per-lane Media Side Loopback Supported field=1, loopback control is per lane. Otherwise, if any loopback enable bit is set to 1, all media side lanes are in input loopback.	RW Opt.
	6	Media side input loopback lane 7 enable		
	5	Media side input loopback lane 6 enable		
	4	Media side input loopback lane 5 enable		
	3	Media side input loopback lane 4 enable		
	2	Media side input loopback lane 3 enable		
	1	Media side input loopback lane 2 enable		
	0	Media side input loopback lane 1 enable		

See CMIS 4.0 - **page 13h**

1. Check capabilities (13h – Byte 128)
2. Activate Media Side input loopback (13h – Byte 181)
   e.g. for ch 1-8: 11111111

CMIS 4.0 control

PRBS GENERATOR

Table 8-73 PRBS Pattern Generation Capabilities (Page 13h)

Byte	Bits	Name	Description	Type
	7	Host Side G…tern 7 supported	…rted	RO
		…e Generator Patter…		
134	7	Media Side Generator Pattern 7 supported	1b=Supported 0b=Not supported	RO RQD
	6	Media Side Generator Pattern 6 supported		
	5	Media Side Generator Pattern 5 supported		
	4	Media Side Generator Pattern 4 supported		
	3	Media Side Generator Pattern 3 supported		
	2	Media Side Generator Pattern 2 supported		
	1	Media Side Generator Pattern 1 supported		
	0	Media Side Generator Pattern 0 supported		
135	7	Media Side Generator Pattern 15 supported	1b=Supported 0b=Not supported	RO RQD
	6	Media Side Generator Pattern 14 supported		
	5	Media Side Generator Pattern 13 supported		
	4	Media Side Generator Pattern 12 supported		
	3	Media Side Generator Pattern 11 supported		
	2	Media Side Generator Pattern 10 supported		
	1	Media Side Generator Pattern 9 supported		
	0	Media Side Generator Pattern 8 supported		

The pattern checking capabilities of the module are advertised in Table 8-74. The pattern number corresponds to the pattern coding in Table 8-72.

Table 8-72 Pattern coding

PRBS Pattern code	Name	Description
0	PRBS-31Q	As defined in 802.3-2018 clause 120.5.11.2.2
1	PRBS-31	
2	PRBS-23Q	ITU-T Recommendation O.172, 2005
3	PRBS-23	
4	PRBS-15Q	x^15 + x^14 + 1
5	PRBS-15	
6	PRBS-13Q	As defined in 802.3-2018 clause 120.5.11.2.1
7	PRBS-13	
8	PRBS-9Q	As defined in 802.3-2018 clause 120.5.11
9	PRBS-9	
10	PRBS-7Q	x^7 + x^6 + 1
11	PRBS-7	
12	SSPRQ	As defined in 802.3-2018 clause 120.5.11.2.3
13	Reserved	
14	Custom	Vendor Pattern
15	User Pattern	Pattern provided in bytes 224-255

[See CMIS 4.0](#) - **page 13h**

1. Check capabilities (13h – Byte 134-135)
2. Active Media side Generator
   e.g. for ch3-8: 11111100

Table 8-78 Media Side Pattern Generator Controls (Page 13h)

Byte	Bits	Name	Description	Type
152	7	Media Side Generator Lane 8 enable	1b=Enable generator, using the configuration defined in bytes 153-159 0b=Disable pattern generator	RW Opt.
	6	Media Side Generator Lane 7 enable		
	5	Media Side Generator Lane 6 enable		
	4	Media Side Generator Lane 5 enable		
	3	Media Side Generator Lane 4 enable		
	2	Media Side Generator Lane 3 enable		
	1	Media Side Generator Lane 2 enable		
	0	Media Side Generator Lane 1 enable		

Discussion

Co-propagating aggressors

CO-PROPAGATING AGGRESSOR LANES

Why do we skip FEXT for Rx test?

- Stress lane is calibrated as worst-case eye that includes the impact of co-propagating crosstalk
- FLR (post-FEC) can be estimated from single lane error statistics
- Use the same signal for all lanes

A1.2.3 CABLE CHARACTERIZATION

Cables are characterized using two Module Compliance Boards, one on each end of the cable under test (CUT) as shown in Figure 224 on page 667, using the method described in IEEE 802.3-2015 Annex 86A. Note that the MCBs supply power to the connected cables and provide access to the Management Interface. Passive cable testing requires only the use of the vector network analyzer.

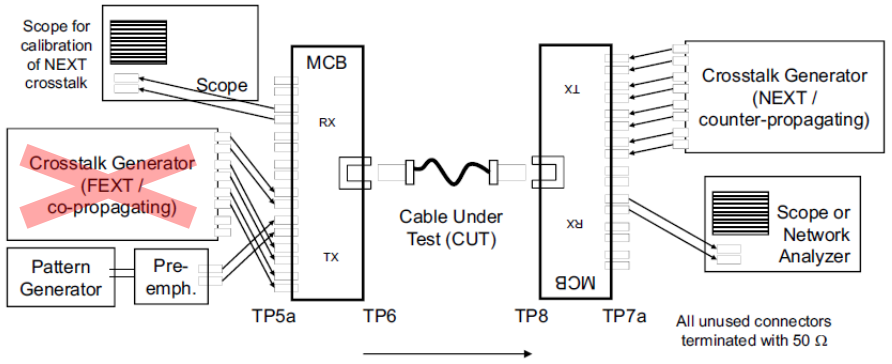


Figure 224 Cable characterization setup using MCB

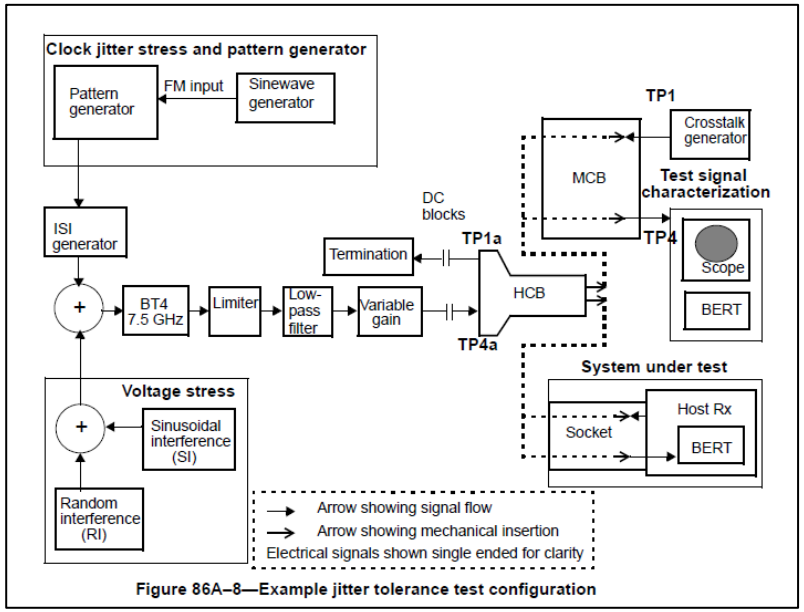


Figure 86A–8—Example jitter tolerance test configuration

→ **FEXT can be omitted if the stress lane is calibrated without FEXT**