InfiniBand NDR (400G) Active Time Domain Testing – MOI

NOVEMBER 2022 REV 1.1

I² NDC

Keysight Technologies

InfiniBand NDR ATD AOC Revision History

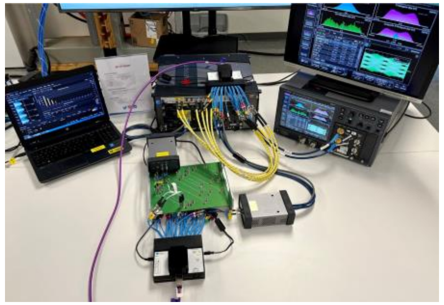
Initial posting of draft NDR ATD MOI

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

- Work in progress regarding NDR mask implementation << Future update.
- MTF Calibration/Test procedure

Infiniband NDR

OUTLINE

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/66b				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

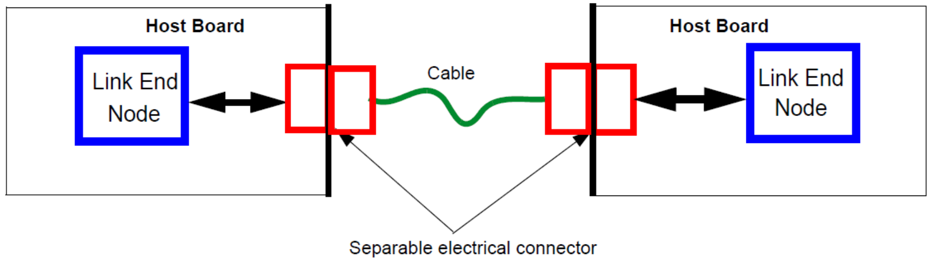


Figure 87 High-level topology block diagram

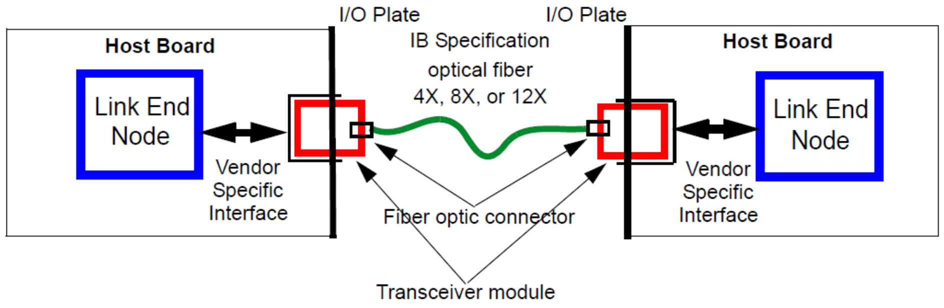


Figure 88 Optical Fiber Interconnect Topology

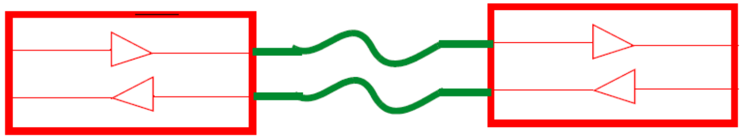


Figure 89 Full limiting active cable topology

Infiniband

NDR INTERFACE – LEVERAGING HDR & IEEE 802.3CK

Layer 1 specification not yet released for NDR
→ Leverage 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).

NDR Test Platform

TEST POINTS

NDR Cable Test References

LEVERAGING IEEE 802.3CK C2M

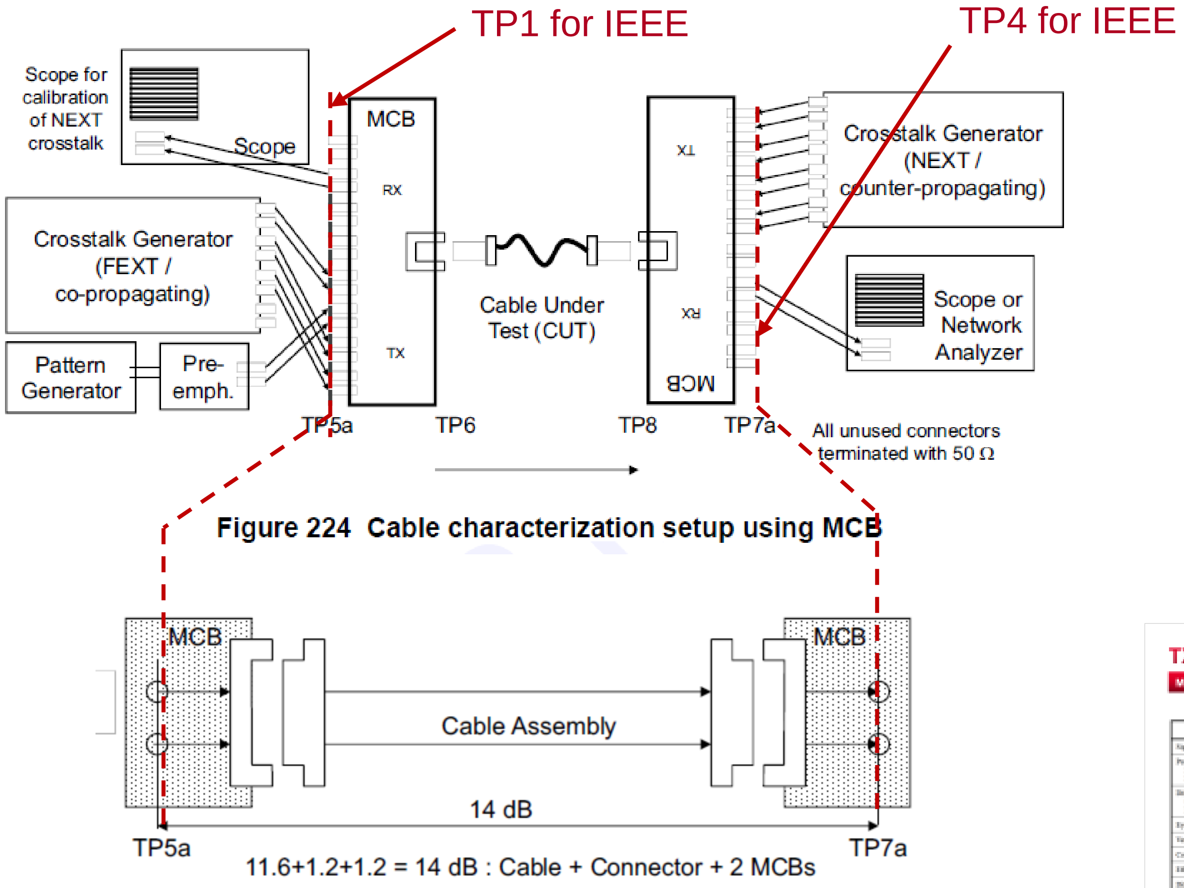


Figure 224 Cable characterization setup using MCB

Cable output and input test procedures follow

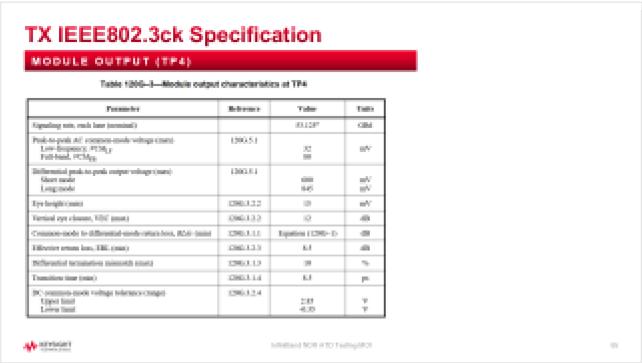
- IEEE Annex 120G 3.2 (Module output test at TP4)
- IEEE Annex 120G 3.4 (Module input test at TP1)
  - Long & short channels

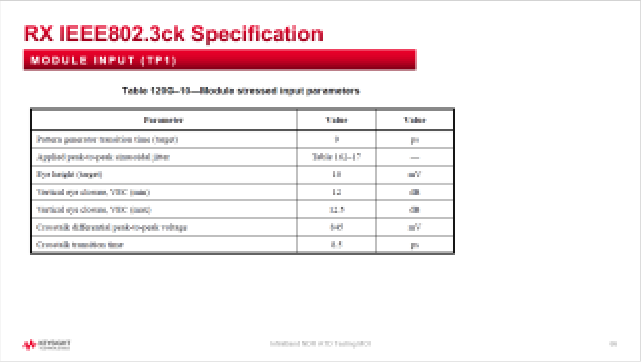
MCB characteristics follows

- IEEE Annex 162B (Test fixture for 100GBASE-CR1…400GAUI-4 C2M)

Notable differences

- crosstalk amplitude (see NEXT calibration slide)





Host Compliance Testing

IDENTICAL TO IEEE 802.3CK

The proposal is to make a separate document for host - Eye mask test (tbd by Nvidia) still open

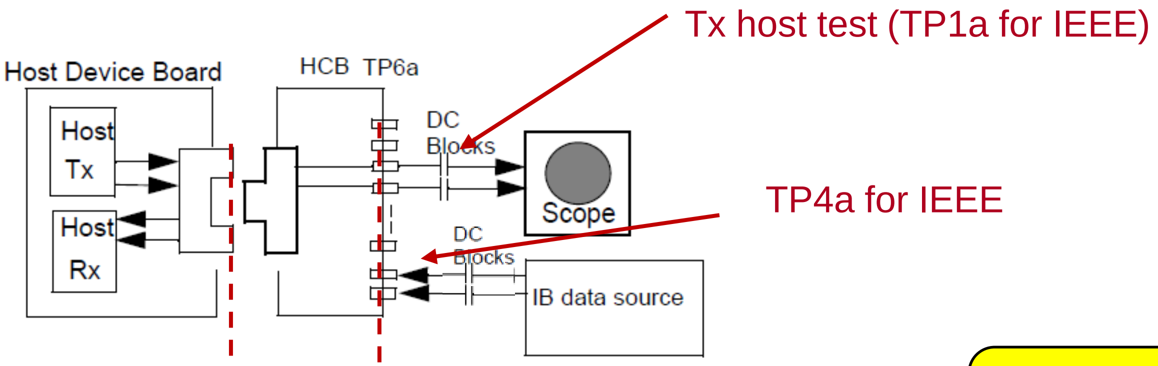


Figure 222 Host transmitter output characterization setup using HCB

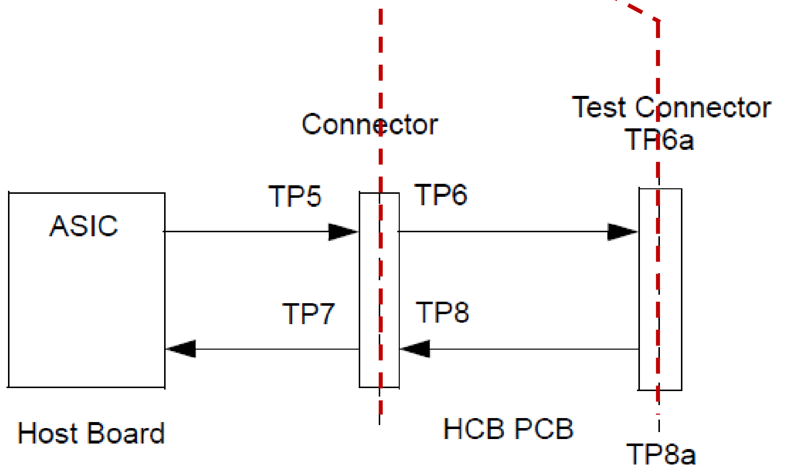


Figure 94 Host compliance board test points

For host compliance test procedures refer to a separate document

Host output and input test procedures follow

- IEEE Annex 120G 3.1 (Host output test at TP1a)
- IEEE Annex 120G 3.3 (Host input test at TP4a)

HCB characteristics follows

- IEEE Annex 162B (Test fixture for 100GBASE-CR1…400GAUI-4 C2M)

NDR Test Platform

EQUIPMENT

NDR Cable Test

EQUIPMENT OVERVIEW (OPTIONS ON NEXT PAGES)

M8040A system
- M8045A pattern generator for victim lane generation
- M8046A error detector
- M8194/96A arbitrary waveform generator for aggressor channels

N1000A+N1060A
- Reference Rx for
  - Tx test at TP4
  - victim lane calibration at TP1

Cables & RF adapters
- 1.85mm Matched cable pairs for M8045A
- 2.4mm Matched cable pair M8196A

2x Wilder Technologies MCB
- 2x **OSFP**-TPA1.85-MCB-R **or**
- 2 x QSFPDD-TPA1.85-MCB-R
  - OSFP, 1.85mm connector
  - CMIS control (on MCB or Aardvark)
  - 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

1x ISI board
- Compliant with IEEE 8023.ck
- MTF+Trace
  - ~18.2dB @Nyquist,
  - C2M COM>3dB

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	M8045A	Pattern generator and clock module 64GBaud	M8045A-G64/-0G2/-0G3/-0G4/-0P6/-801/-802/-803	1	Signal source for pattern generator and jitter impairment
	Keysight	M8057B	Remote head		2	
3	Keysight	M8046A	Analyzer module 64GBaud	M8046A-A64/-0A3/-0A4/-0A5/-0P3/-0P6/-801/-802	1	Error Detector
4	Keysight	M8196A	4 Channel 92 GSa/s Arbitrary Waveform Generator	M8196A-001	1	Aggressor lane generation
5	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
6	Multilane	ML4067	Channel emulation board or any other ISI trace compliant with IEEE 802.3ck.	-	1	For C2M long channel calibration and testing
7	Wilder	SP060x	SP0603A for OSFP or SP0607A for QSFP-DD 112G HCB Test Adapter	SP0603A/ SP0607A	1	For Crosstalk calibration (TX & RX Tests)
8	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
9	Keysight	M8196A-810	Matched Cable **Pair** for M8196A AWG, 2.4 mm	-	4	From AWG Output to MCB
10	Keysight	M8045A-801	Short Cable 1.85 mm (m) to 1.85 mm (m), 0.15 m, absolute matching 699 ps +- 1 ps	-	8	2 for BERT Remote Heads; 2 for MCB to ED; 2 from ISI Board to MCB
11	Total Phase	TP240141	Aardvark I2C/ SPI Host adapter	-	1	Require additional jumper cables.

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		Use Keysight demo laptop
12	Keysight	FlexDCA		06.92.13	Beta version used
13	Keysight	M8070B	System software for M8000 series of BER test solutions	9.0	
14	Keysight	M8070EDAB	Error Distribution Analysis Package for M8000 Series BER Test Solutions	1.8.160.2	for FLR estimation using M8046A error analyzer
15	Keysight	M8070ADVB	Advanced Measurement Package for M8000 Series BER Test Solutions	1.8.160.2	For automated jitter tolerance test
16	Keysight Technologies	N1091CKCA	DCA TX test application for IEEE802.3ck	1.19.9038	Automation TX test for C2M at TP4; Beta version used
17	Keysight Technologies	M8091CKPA	RX conformance test application for IEEE 802.3ck Rev. 2.50.8	2.50.8	Automation RX test for C2M Input at TP1

ALTERNATIVE EQUIPMENT

Item #	Vendor	Part Number	Description	Revision	Details
1	Any vendors	N.A	2x 100MHz Low Pass filter		For Low-frequency peak-to-peak AC common mode test Example: https://www.fairviewmicrowave.com/low-pass-filter-dc-100-mhz-sma-female-connectors-fmfl019-p.aspx
2	Any vendors		Matched Cable **Pair** for MCB loopback (see this slide)		from AWG Output to MCB. Can be skipped if the active cable offers local loopback capabilities (mandatory for IEEE 802.3ck)
3	Any vendors		50 ohm termination 1.85mm		For MCB

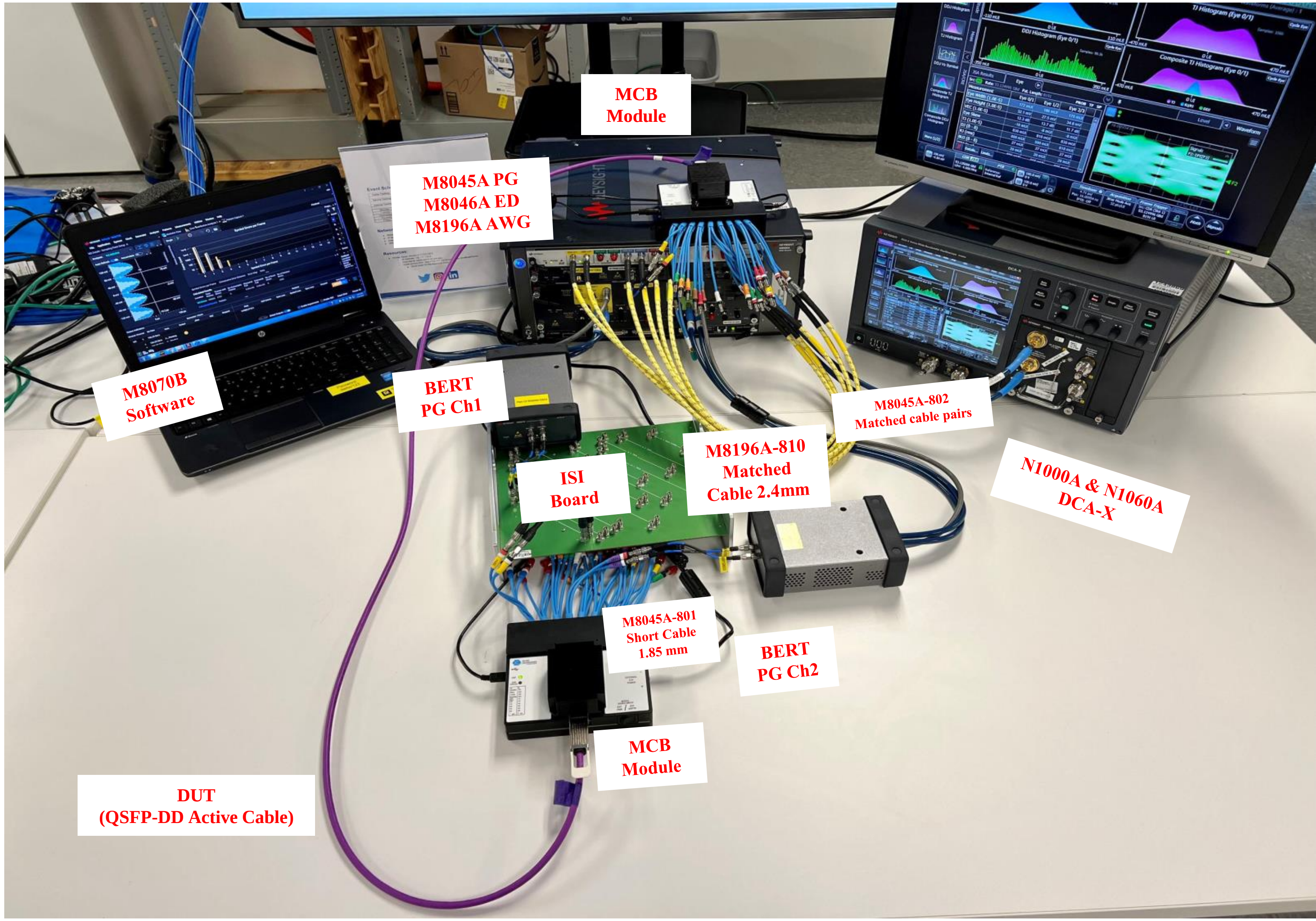
Setup Configuration

AEC Testing for TX and RX

- M8045A & M8196A as Reference Transmitters
- M8046A as Bit Error Detector
- N1000A + N1060A as Reference Receiver
- Wilder MCB as Mated Test Fixture*
  *Keysight part number SP0602A for OSFP or SP0606A for QSFP-DD 112G
- ISI Board as "host channel"
- AEC Cable or AOC Device Under Test
- M8045A-801 Short Cable 1.85mm
- M8045A-802 Matched Cable Pairs
- M8196A-810 Matched Cable Pair for M8196A AWG, 2.4 mm

Notes:

- Counter-propagating channels (leading to near-end crosstalk) come from the AWG and are connected directly to MCB#2
- The second PG is used as victim lane for Tx test



NDR Test Platform

DUT CONFIGURATION

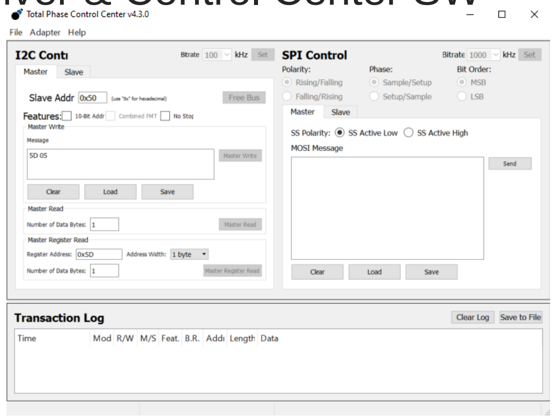
NDR Cable configuration

RECOMMENDED BUT OPTIONAL

Note: Following steps are recommended for DUTs that don't automatically turn on high power mode during testing; Programmed DUT may skip these steps; User are free to choose own I2C/SPI adapter from MCB supplier & its software for programming the DUT, to achieve the same goal; Below steps are done using Aardvark I2C/SPI adapter;

1. Tools needed for the DUT configuration:
   - Aardvark I2C/SPI Host adapter
   - Total Phase Installer exe file
   - Jumper cable
   - MCB

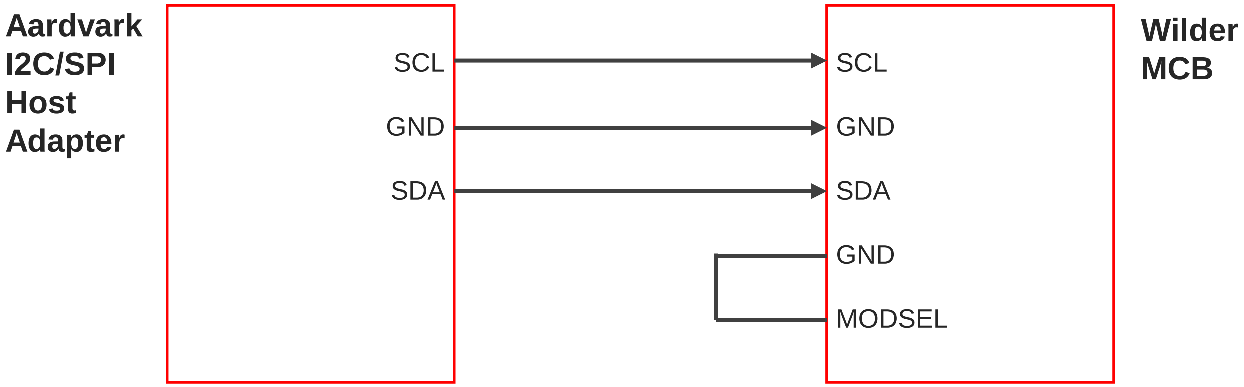
2. Preparation before config
   - Follow the quick start guide instructions to install the USB driver & Control Center SW
   - Once completed, launch the "Total Phase Control Center"

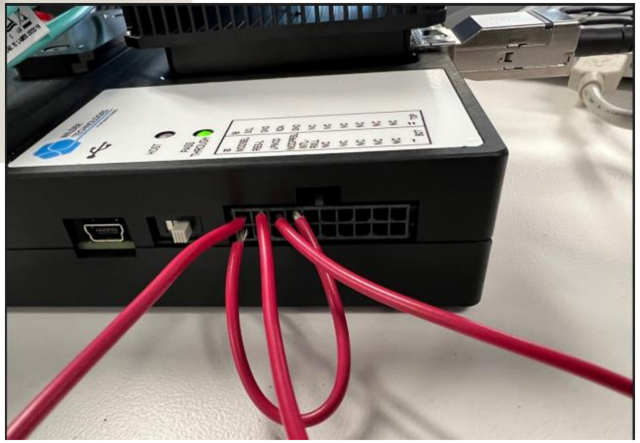


NDR Cable configuration

RECOMMENDED BUT OPTIONAL

3. Connect MCB (preferred vendor: Wilder Technologies) with Aardvark I2C/SPI Host adapter using Jumper cable
   - Connection diagram in below



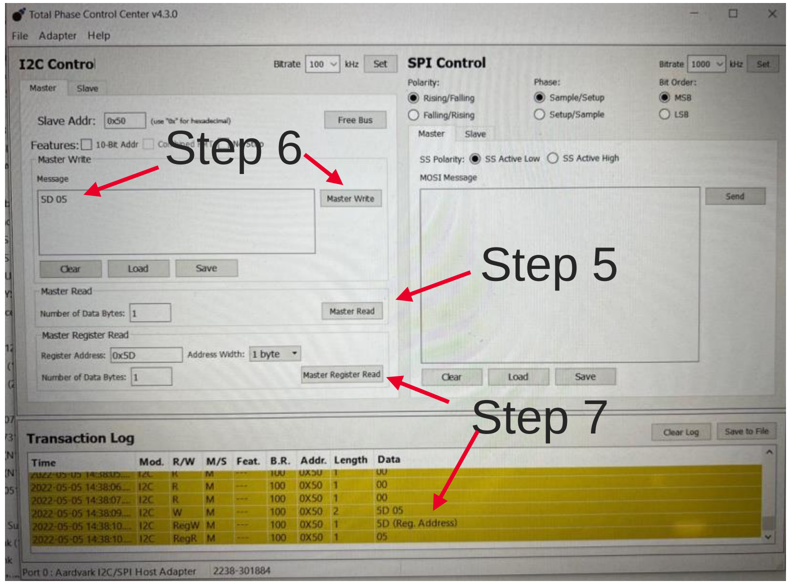


4. Insert the DUT into MCB and power on

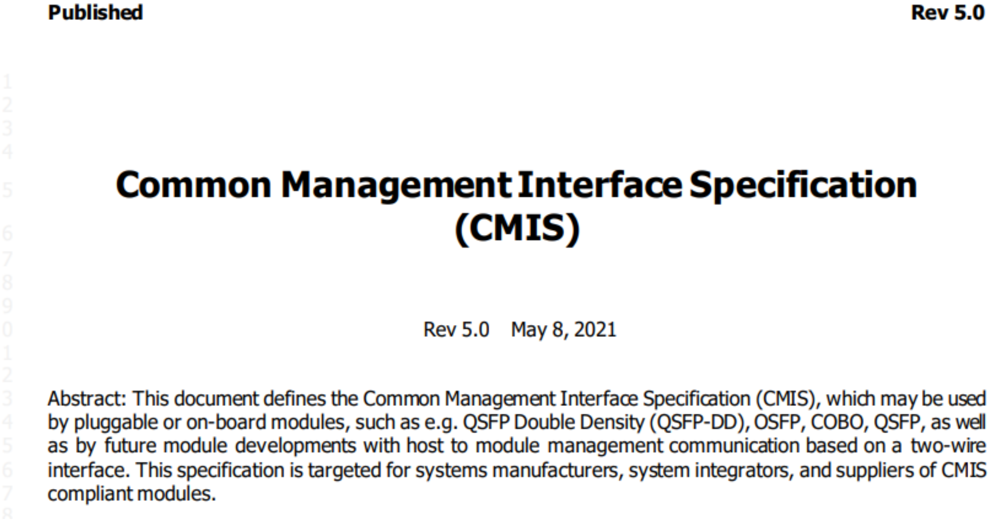
NDR Cable configuration

RECOMMENDED BUT OPTIONAL

5. On the Total Phase Launch Control, connect to DUT by pressing Master Read button
6. Insert “5D 05” (high power mode) into message and click Master Write button
7. Click Master Register Read button and read from transaction log to ensure this has been written into it
   - Note: configuration on the DUT need to done on each end of the cable



slave addr: 0x50
Message: 5D 05


Published **Rev 5.0**

Common Management Interface Specification (CMIS)

Rev 5.0 May 8, 2021

Abstract: This document defines the Common Management Interface Specification (CMIS), which may be used by pluggable or on-board modules, such as e.g. QSFP Double Density (QSFP-DD), OSFP, COBO, QSFP, as well as by future module developments with host to module management communication based on a two-wire interface. This specification is targeted for systems manufacturers, system integrators, and suppliers of CMIS compliant modules.

Cable Output Test Procedure

CONNECTION

Active Cable Test Configuration

VICTIM & AGGRESSOR LANES

1. Choose your test lane. E.g. TX1 to RX1

M8040A BERT

N1000A+N1060A DCA mainframe and module

MCB 2
RX1+ and RX1-
to
DCA channel 1A & 1B

M8057B
DATA OUT+
DATA OUT-
to
MCB TX1+ and TX1-

MCB 1

MCB 2

Active Cable Test Configuration

VICTIM & AGGRESSOR LANES

2. Connect Co-prop FEXT Aggressor from M8075B set #2 to MCB TX2 lane

FEXT Aggressor Lane
M8057B Set 2
DATA OUT+
DATA OUT-
to
MCB TX2+ and TX2-

MCB 2
RX1+ and RX1-
to
DCA channel 1A & 1B

Victim Lane
M8057B
DATA OUT+
DATA OUT-
to
MCB TX1+ and TX1-

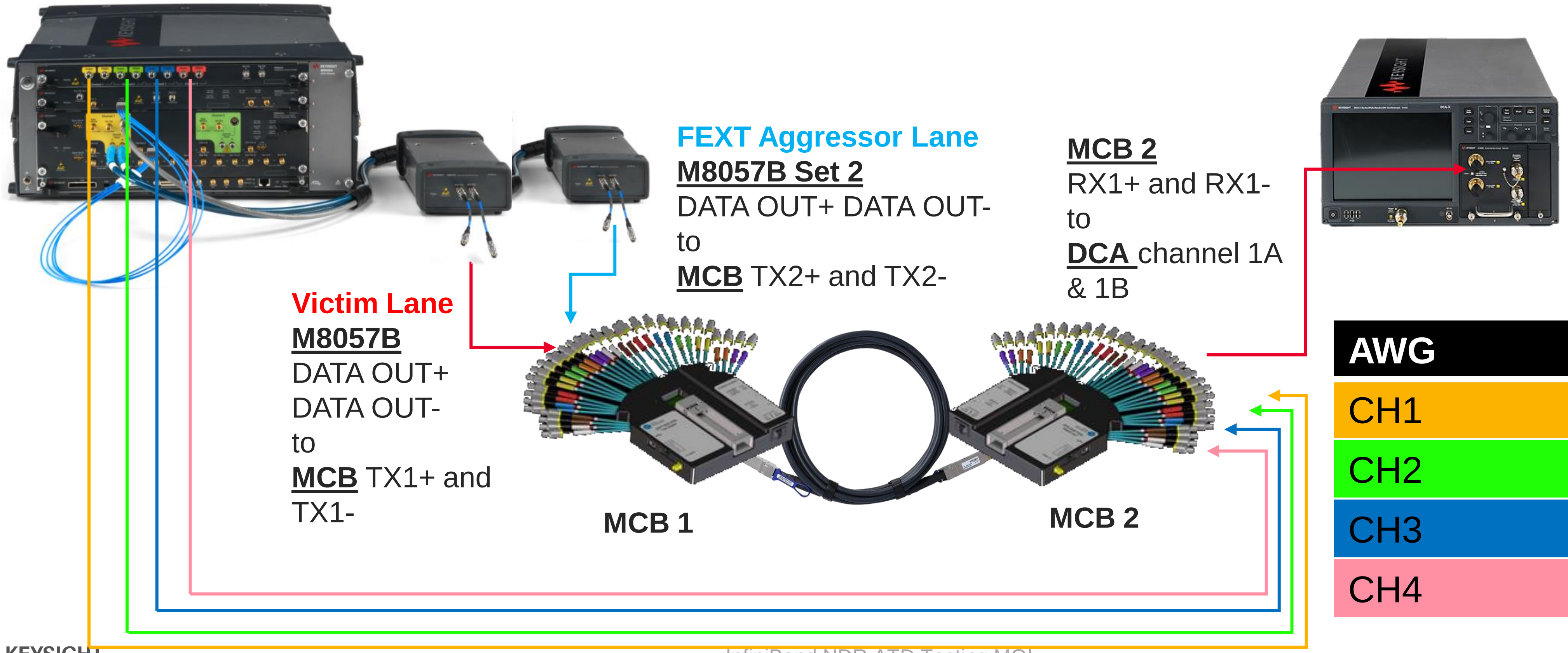
MCB 1

MCB 2

Active Cable Test Configuration

VICTIM & AGGRESSOR LANES

3. Connect Counter-prop FEXT Aggressor from AWG to MCB 2.
   - See near-end aggressor (NEXT) calibration slide for counter-propagating channel calibration
   - Note: Alternative method to use the loopback connection (see next slide), to fill up rest of the open ports of MCB 1 & MCB2



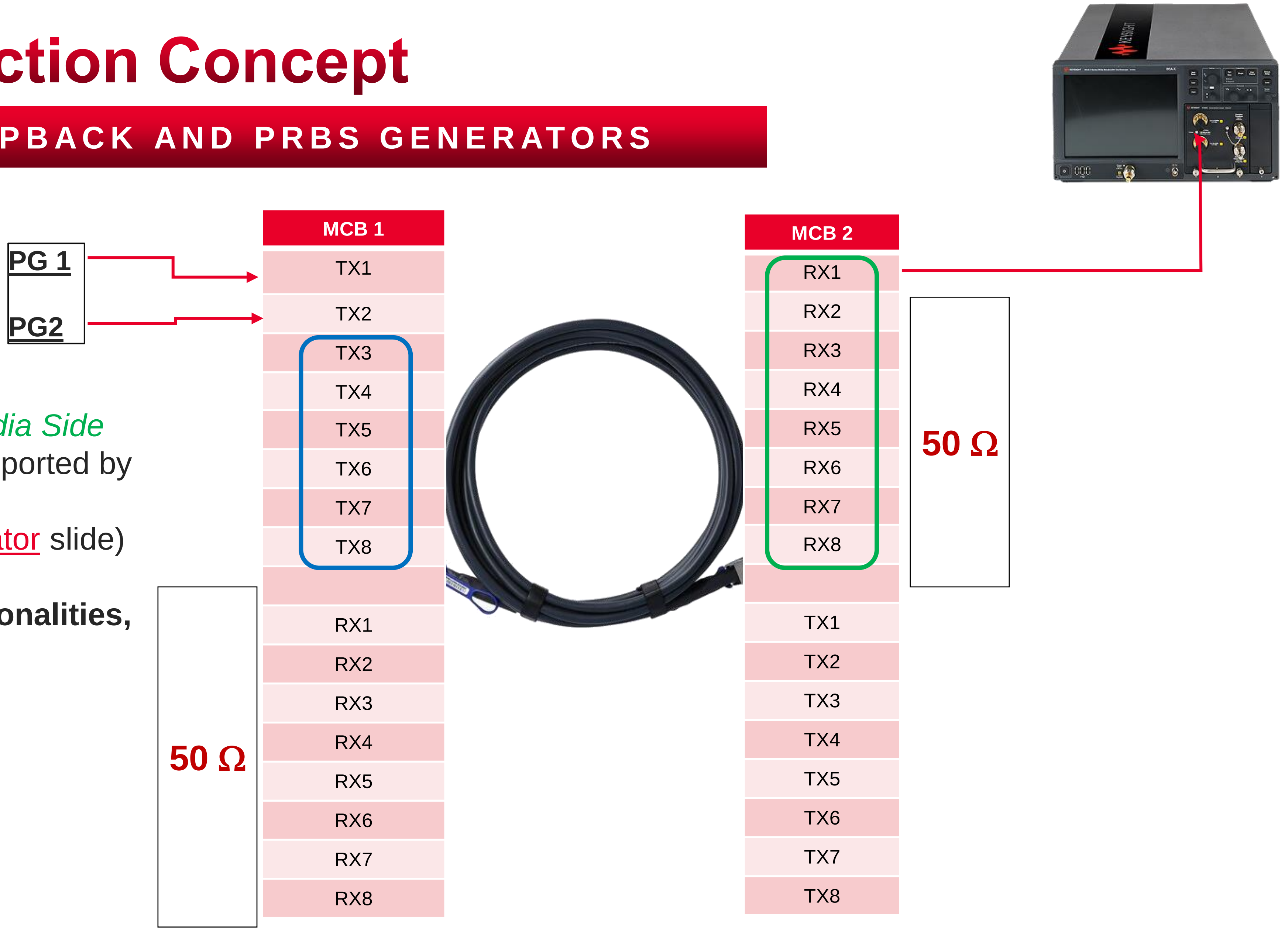
AWG	MCB 2
CH1	TX1+ & TX1-
CH2	TX2+ & TX2-
CH3	TX3+ & TX3-
CH4	TX4+ & TX4-

Loopback Connection Concept

USING CMIS LOCAL LOOPBACK AND PRBS GENERATORS

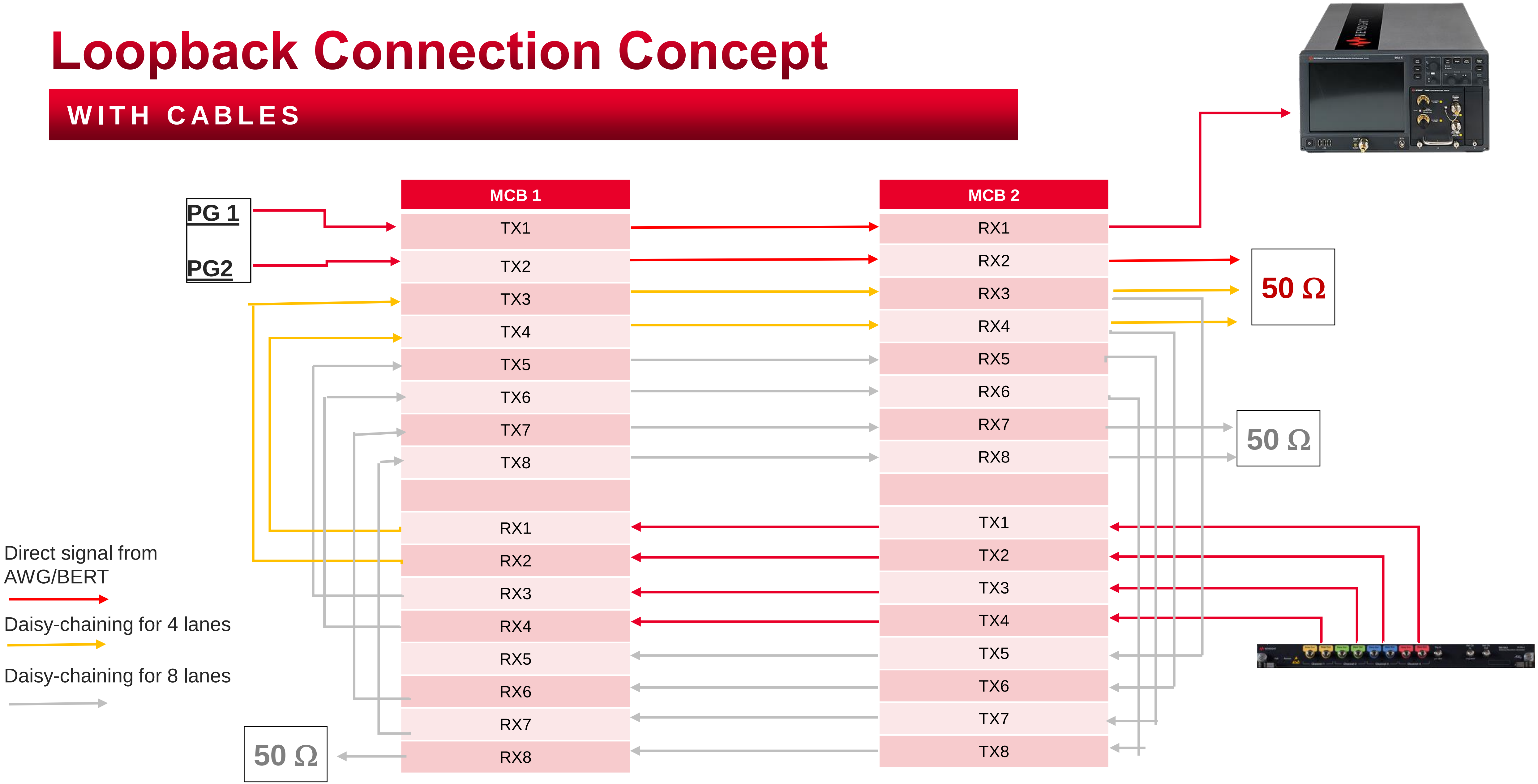
Check if the *PRBS generator* and *Media Side Input Loopback* functionalities are supported by the DUT
(see loopback slide and PRBS generator slide)

If DUT doesn't support these functionalities, go to the next slide



Loopback Connection Concept

WITH CABLES



Cable Output Test Procedure

ACTIVE CABLE TESTING

NDR Cable TX Test

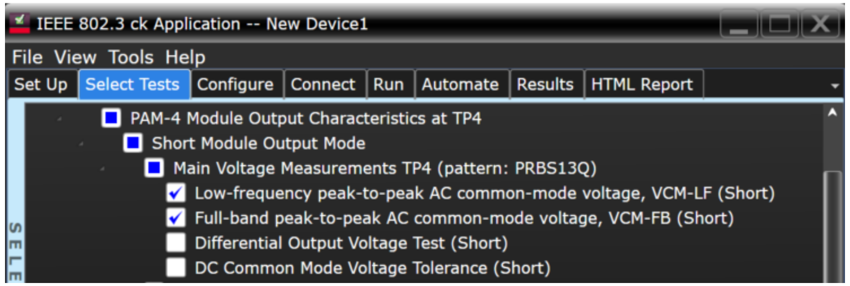
LEVERAGE TEST SPECS FROM IEEE802.3CK 120G3.2 C2M, MODULE OUTPUT TEST

Note: Below tests are conducted using N1091CKCA DCA TX Test application.

1. **Peak-to-peak AC common-mode voltage test** (VCMPP)
   - VCMPP-LF max limit at 32 mV
   - VCMPP-FB max limit at 80mV

Using N1091CKCA IEEE802.3ck TX test app

- In the app, select Peak-to-peak AC common-mode voltage (Low Frequency & Full-band) test to run.



- **Note:** Due Equivalent Time Sampling scope aliasing on the noise spectrum, DCA will provides the measurement on the full band with internal hardware filters (no additional filter is needed).
- **Note:** App will measure using 10E-5 of probability
- **Note:** For peak-to-peak AC common mode (Low Frequency), additional 2x of 100MHz LP filter will be needed.

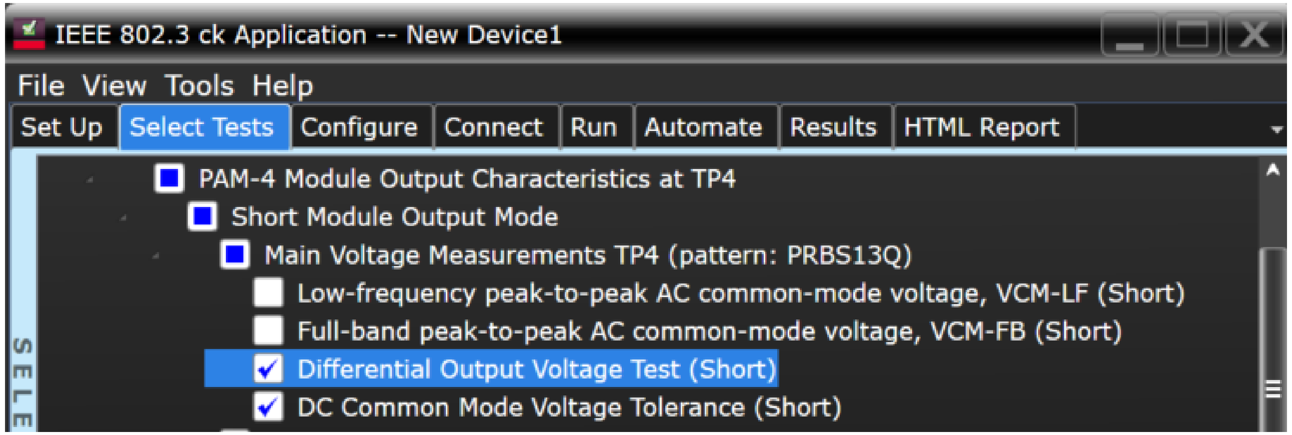
NDR Cable TX Test

LEVERAGE TEST SPECS FROM IEEE802.3CK 120G3.2 C2M, MODULE OUTPUT TEST

2. **Differential Output Voltage test** (short mode max limit: 600mV, long mode max limit: 845mV) **& DC common-mode voltage tolerance** (spec limit range: -0.35 to 2.85V)

Using N1091CKCA IEEE802.3ck TX test app

- In the app, select Differential output voltage test & DC common-mode voltage tolerance test to run.



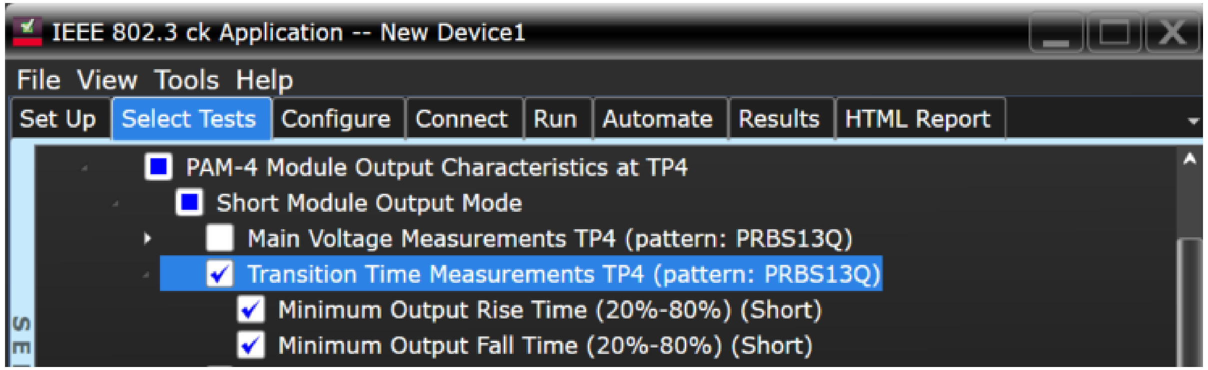
NDR Cable TX Test

LEVERAGE TEST SPECS FROM IEEE802.3CK 120G3.2 C2M, MODULE OUTPUT TEST

3. **Transition time measurement** (min spec limit: 8.5 ps)

Using N1091CKCA IEEE802.3ck TX test app

- Select transition test measurement test
  - Run rise-time and fall-time test
  - Note: Observed through a fourth-order Bessel-Thomson low-pass response with a 3dB bandwidth of 40GHz; Done internally using time-equivalent hardware filter

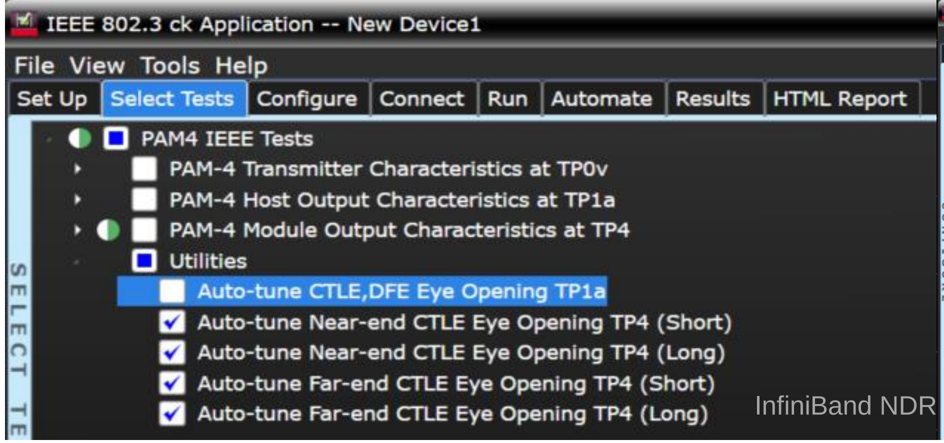


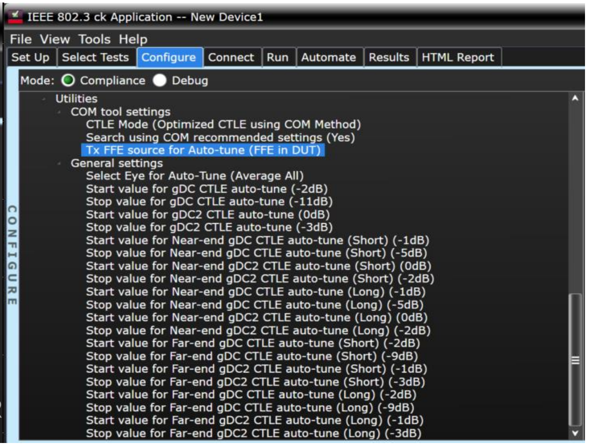
NDR Cable TX Test

LEVERAGE TEST SPECS FROM IEEE802.3CK 120G3.2 C2M, MODULE OUTPUT TEST

Before run EH and VEC test, **recommended** to find the optimal eye opening (gdc and gdc2 of CTLE) using Auto-tune utility tool by N1091CKCA.

- On the N1091CKCA IEEE802.3ck TX test app, run the auto-tune test for Near-end and Far-end (short and long mode)
  - **Recommended** to use default configuration settings to run Auto-tune and let app do the rest
  - **OR** select to run all the CTLE option. It takes approx. 40 mins for one auto-tune test, total 4 tests (Near-End short & long, Far-end short and long) will be approx. 160 mins. User can choose to reduce the searching range to minimize the time consume (**only use this** if you know what is the best range for your DUT, otherwise you could miss other option of CTLE combinations)
  - Note: During the auto-tune, app will add the respective insertion loss file for near-end and far end tests





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

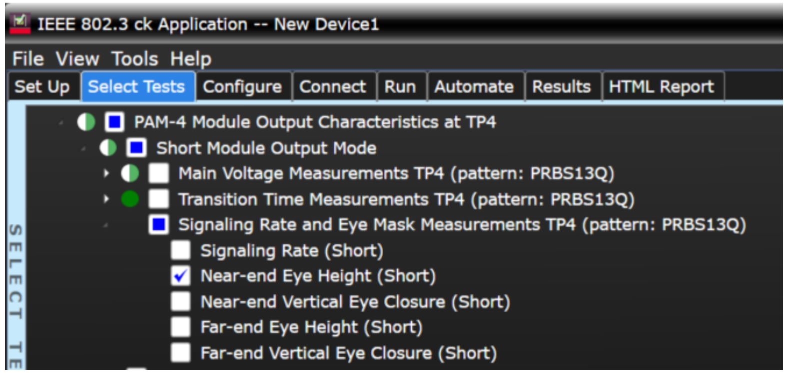
NDR Cable TX Test

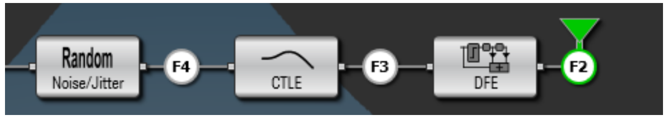
LEVERAGE TEST SPECS FROM IEEE802.3CK 120G3.2 C2M, MODULE OUTPUT TEST

4. **Near-end Eye Height** (min 15mV; short/long mode)

Using N1091CKCA IEEE802.3ck TX test app

- Select Near-end Eye Height test and run the test
  - For the short mode, app will include Zp=0 insertion loss file for measurement
  - For the long mode, app will include Zp=80 insertion loss file for measurement





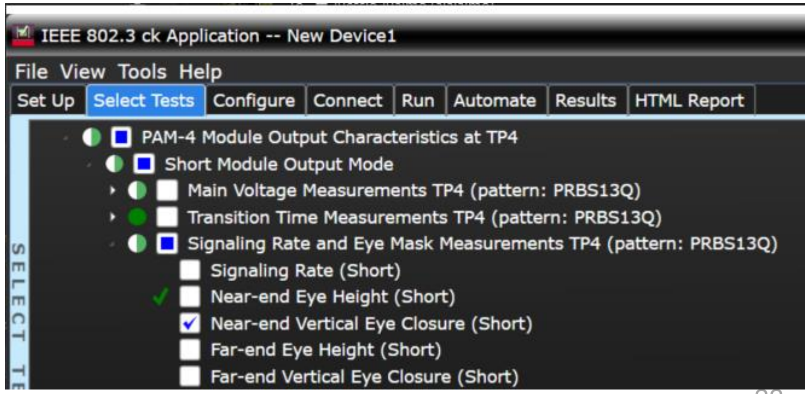
5. **Near-end VEC** (max 12dB; short/long mode)

Using N1091CKCA IEEE802.3ck TX test app

- Select Near-end Eye Height test and run the test
  - For the short mode, app will include Zp=0 insertion loss file for measurement
  - For the long mode, app will include 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



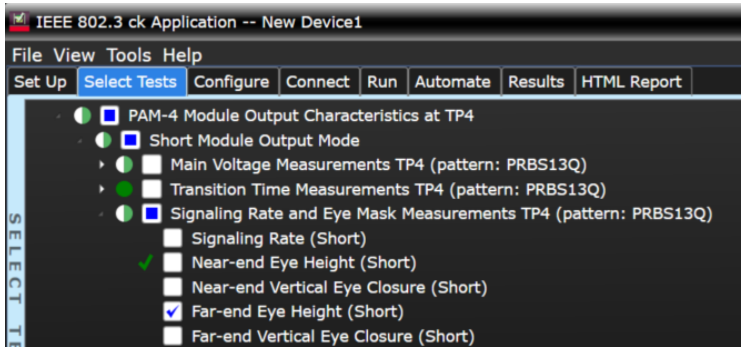
NDR Cable TX Test

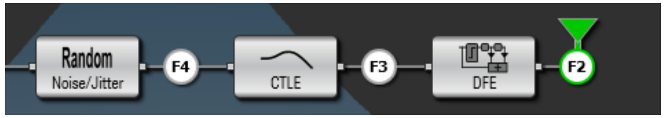
LEVERAGE TEST SPECS FROM IEEE802.3CK 120G3.2 C2M, MODULE OUTPUT TEST

6. **Far-end Eye Height** (min 15mV; short/long mode)

Using N1091CKCA IEEE802.3ck TX test app

- Select Far-end Eye Height test and run the test
  - For the short mode, app will include Zp=133 insertion loss file for measurement
  - For the long mode, app will include Zp=244.7 insertion loss file for measurement





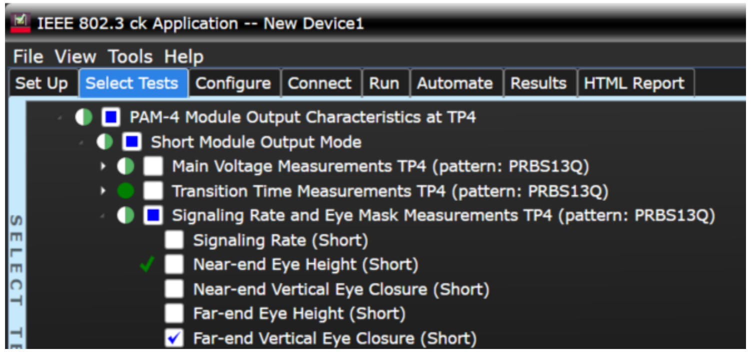
7. **Far-end VEC** (max 12dB; short/long mode)

Using N1091CKCA IEEE802.3ck TX test app

- Select Far-end Eye Height test and run the test
  - For the short mode, app will include Zp=133 insertion loss file for measurement
  - For the long mode, app will include 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



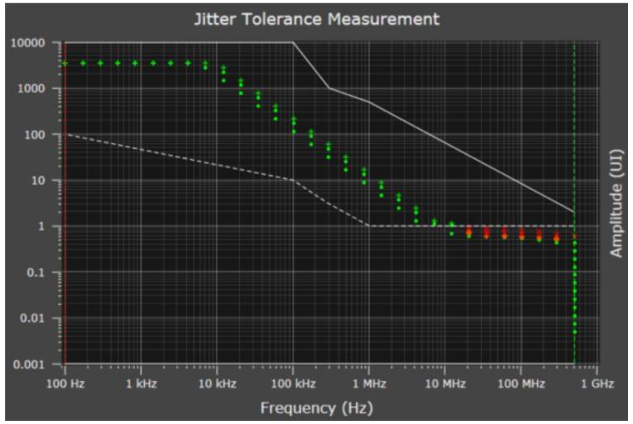
Cable Input test procedure

OVERVIEW

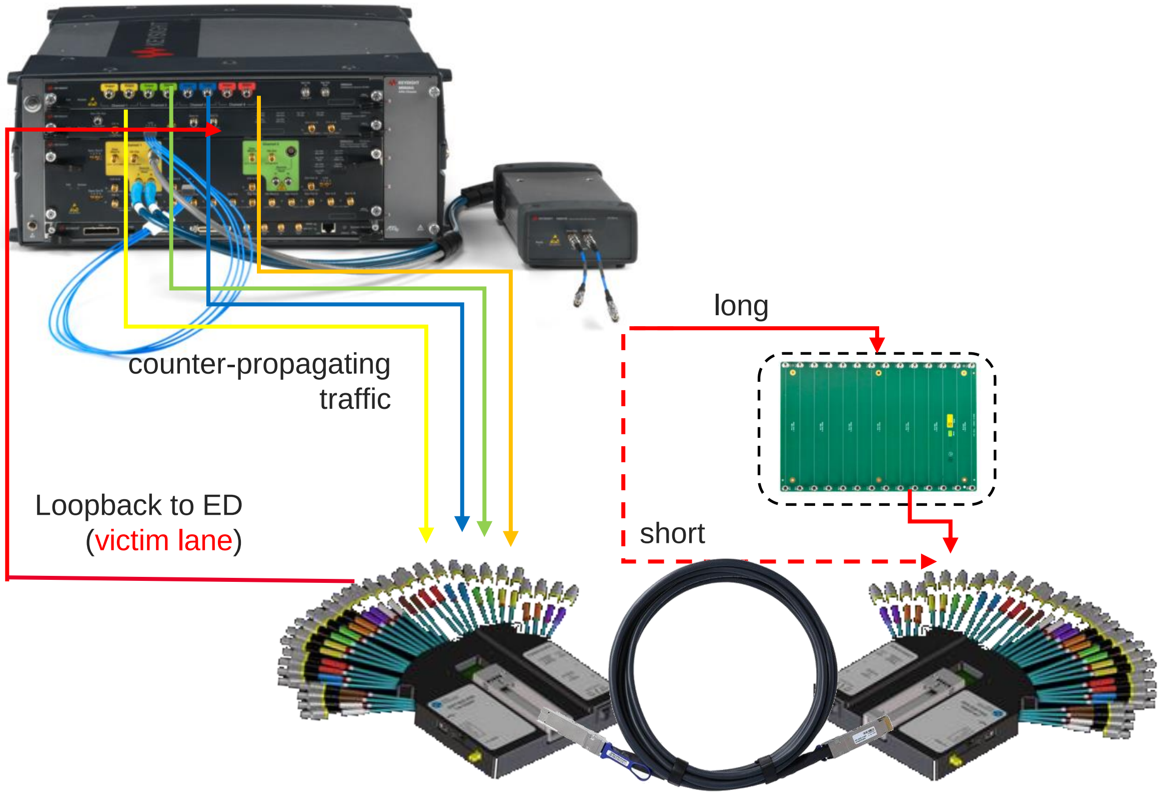
Cable Test- Rx test

PRINCIPLE

- Stress input test & Jitter tolerance test
  - **BER** & **FLR** (Frame Loss Ratio)
  - Calibrated **stress signal**
  - Sinusoidal **jitter** amplitude & frequency tested according to a test template



- Input voltage tolerance test
  - Vary Tx amplitude



Rx test overview

STRESSED SIGNAL CALIBRATION

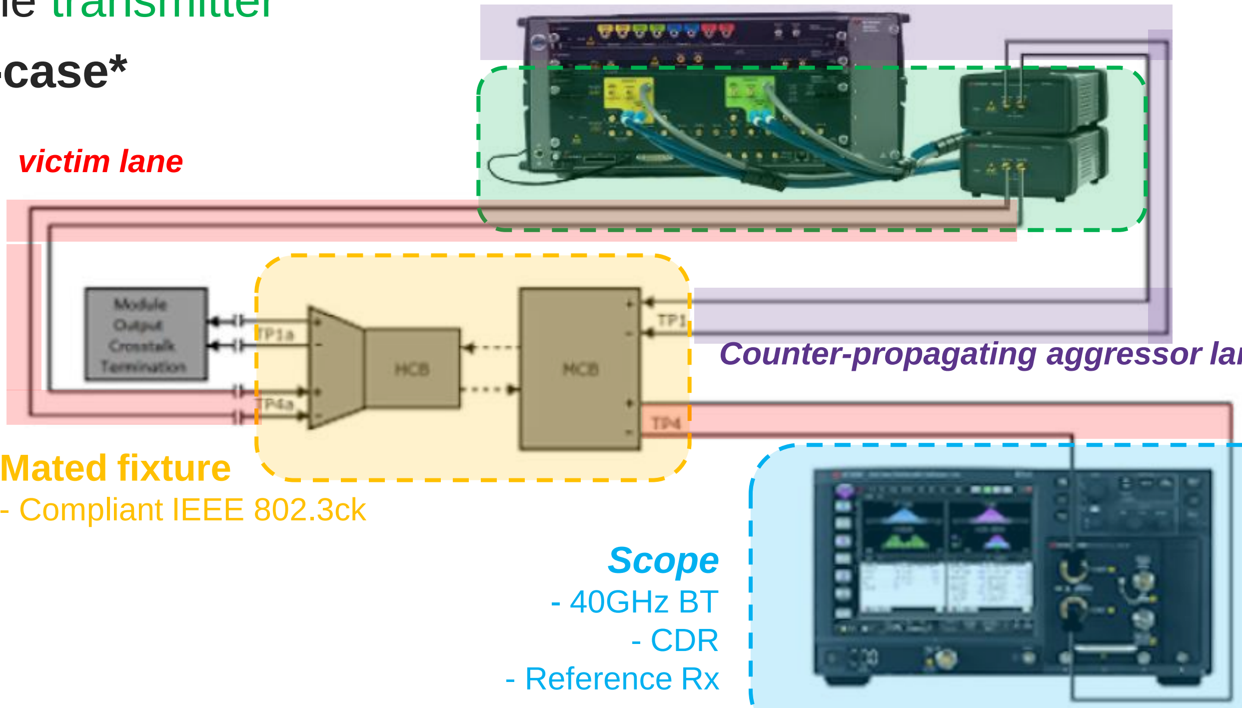
- Use a reference receiver
- To calibrate *victim lane*
- Through a test channel
- in presence of aggressors
- by adjusting the transmitter
- toward **worst-case***

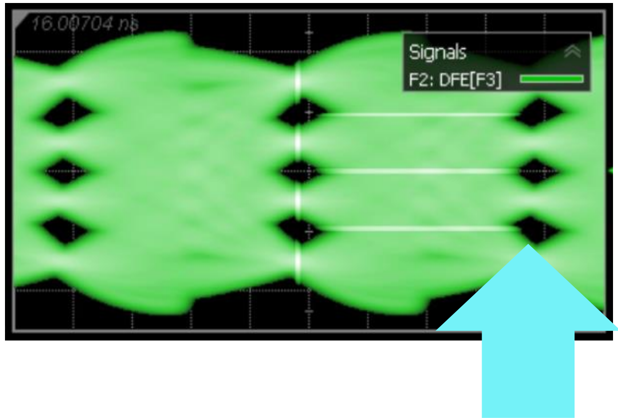
- **Step1**: optimize Tx de-emphasis and reference Rx equalizer for the current channel
- **Step2**: Adjust Tx RJ and amplitude toward target metrics

Transmitter
- 50mUI SJ, 5 taps FIR
- ***Adjustable** amplitude, RJ, BUJ

*12-12.5dB VEC & 15mV EH (1e-5) for IEEE 802.3ck module input test

victim lane





Counter-propagating aggressor lane(s)

Mated fixture
- Compliant IEEE 802.3ck

Scope
- 40GHz BT
- CDR
- Reference Rx

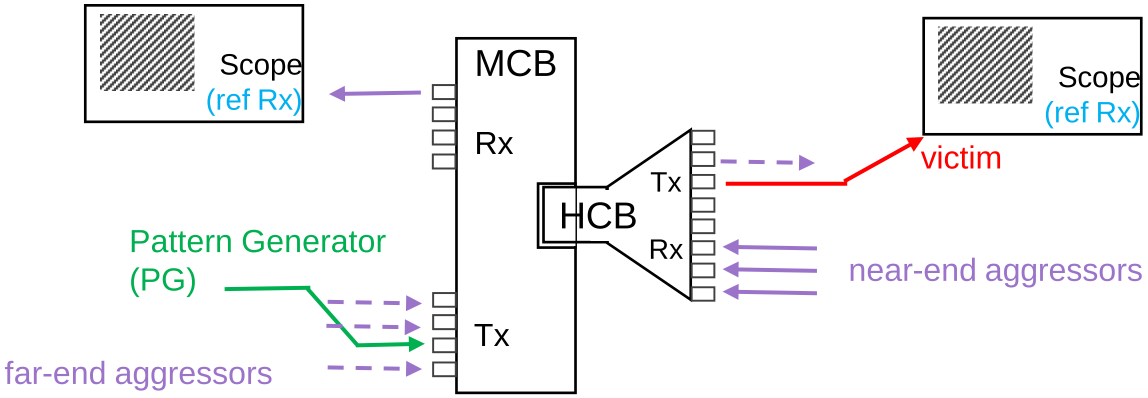
Rx referred noise

2-gain stage CTLE

4-TAP DFE

Cable Test Calibration

VICTIM & AGGRESSOR LANES



Far-end aggressors can be skipped for calibration & test. If used for the test, they must be present for calibration as well (injected Jrms in victim lane will be lower as without).

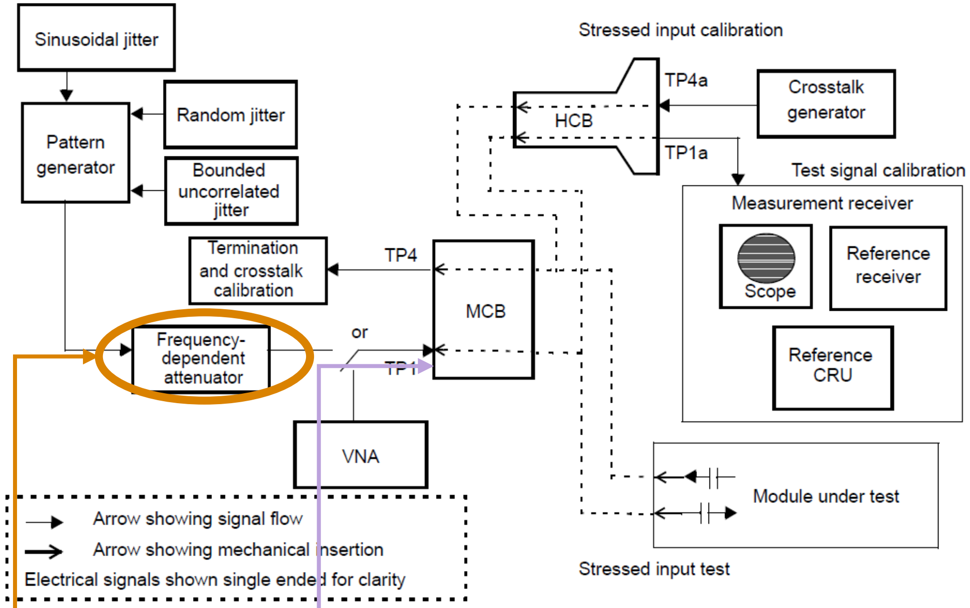


Figure 120G–10—Example module stressed input test

Only required for „high-loss“ case (Total IL=18.2dB)
Could be used with ISI trace

- **Ref. Rx following IEEE 802.3ck C2M**
- **Two calibrations necessary**
  - Low-loss (w/o host channel)
  - High-loss (w/ host channel)

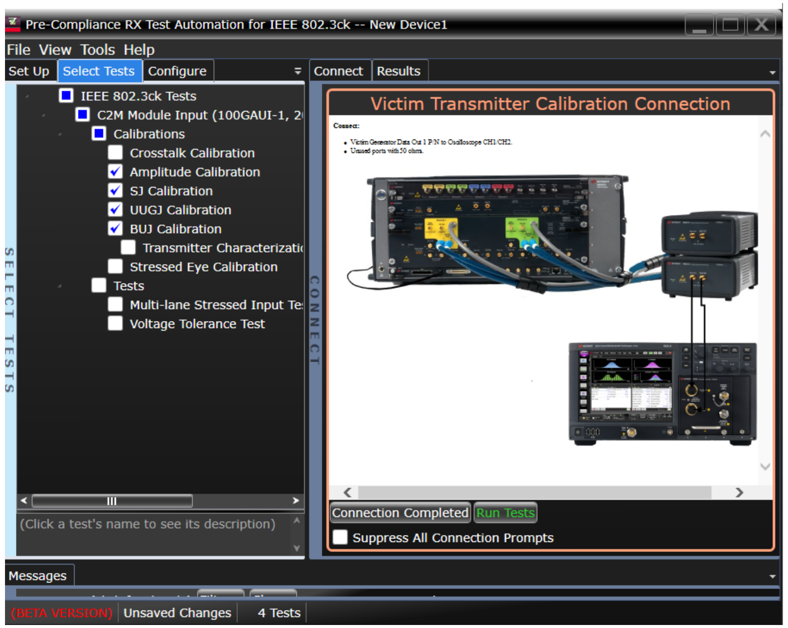
Cable Input test procedure

INSTRUMENT & AGGRESSOR LANE CALIBRATION

Instrument calibration

JITTER SOURCE AND AGGRESSOR CALIBRATION

1. Jitter source calibration
   - Connect the PG directly to the scope



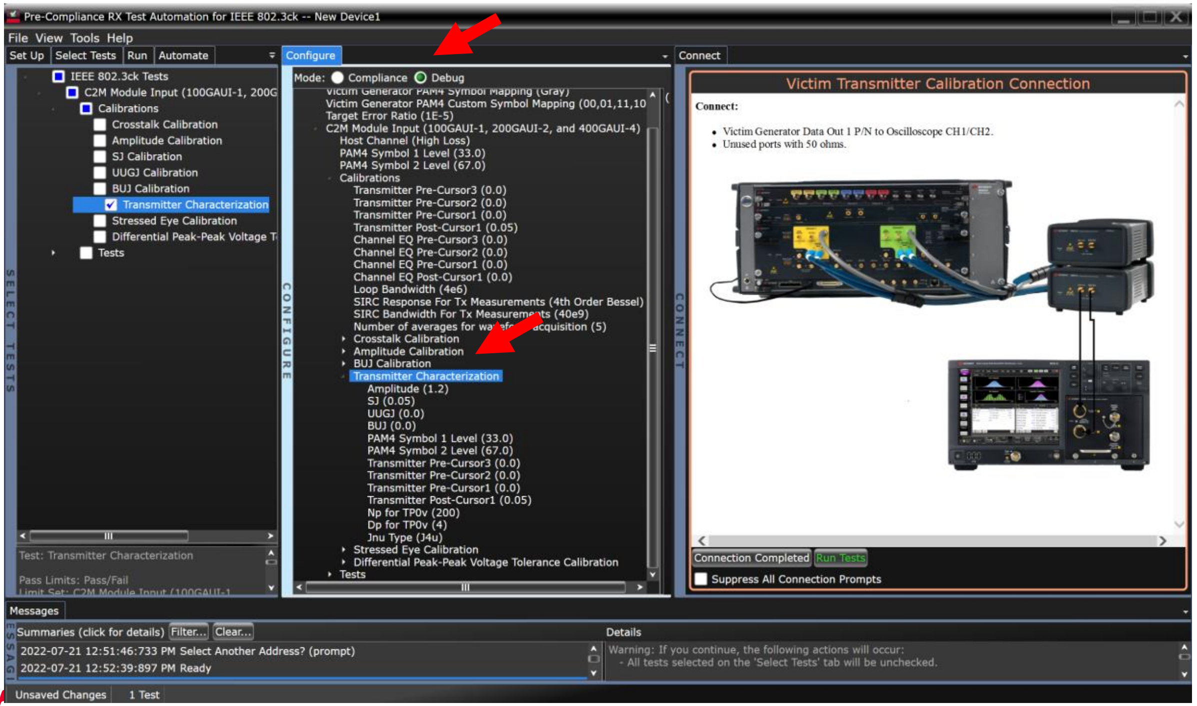
Note: A detailed step-by-step of using the M8091CKPA pre-compliance app for calibrations and tests are in the following section. Refer to slide "Co-propagating aggressors" onwards.

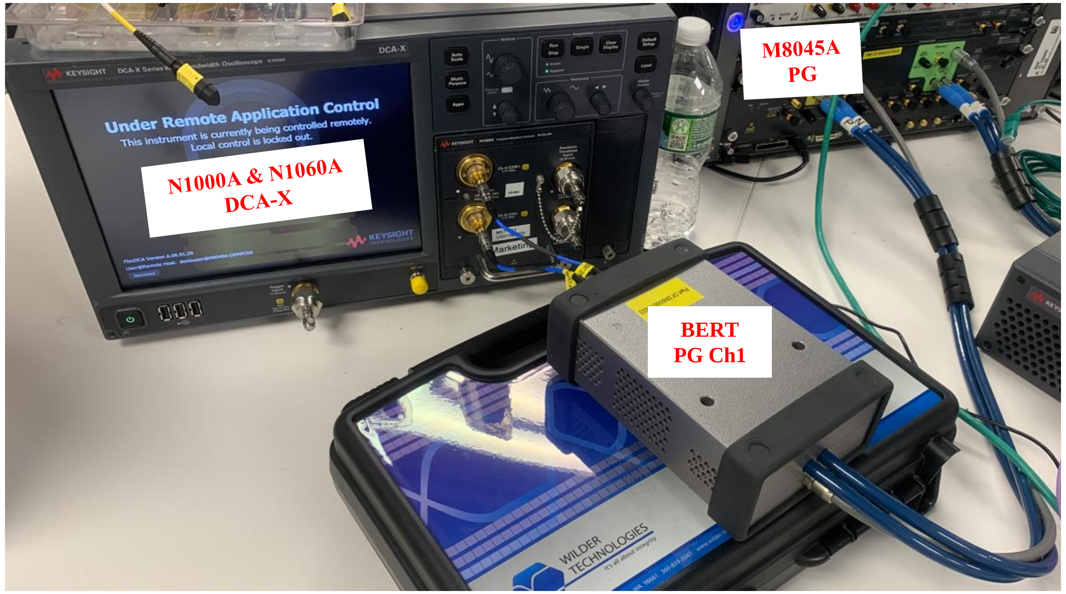
Instrument calibration

JITTER SOURCE AND AGGRESSOR CALIBRATION

2. Transmitter Characterization

- Remain the same setup as per Jitter source calibration and run the Tx Characterization
- You can run the app in **Compliance mode.** However, the **Debug mode** offers the flexibility to change the reference transmitter characteristics such as intrinsic jitter profile (SJ, BUJ) and rise-time (Transmitter Post-Cursor)





Transmitter characterization connections for C2M Host and C2M Module

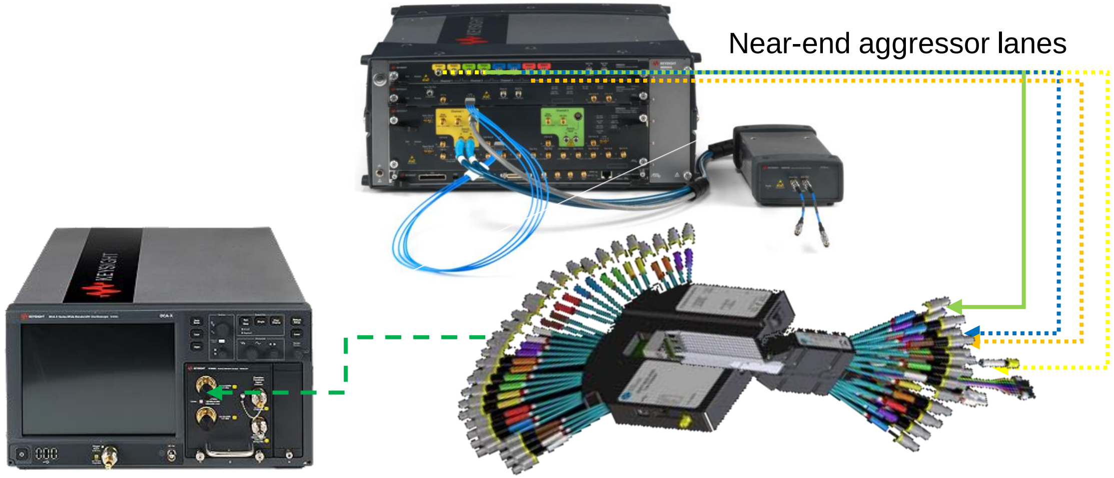
Parameter	Value	Status	Measured Value	Margin %	Pass Limits
Transmitter Measurements - IEEE 802.3ck PAM4 C2M Host TP0a	Pass				
---Additional Info---					
Transition Time	10 ps				
Transmitter Measurements	Measurement Name	Status	Measured Value	Margin %	Pass Limits
	Jrms	Pass	19.0 mUI	17.4 %	<= 23.0 mUI
	J4u	Pass	110.0 mUI	6.8 %	<= 118.0 mUI
	Level mismatch ratio RLM	Pass	0.96	1.1 %	>= 0.95
	Signal-to-noise-and-distortion ratio(Np=200)	Pass	33.69 dB	3.7 %	>= 32.50 dB
Output Jitter Measurement	(See image)				
Linear Fit Pulse Response(Np=200)	(See image)				

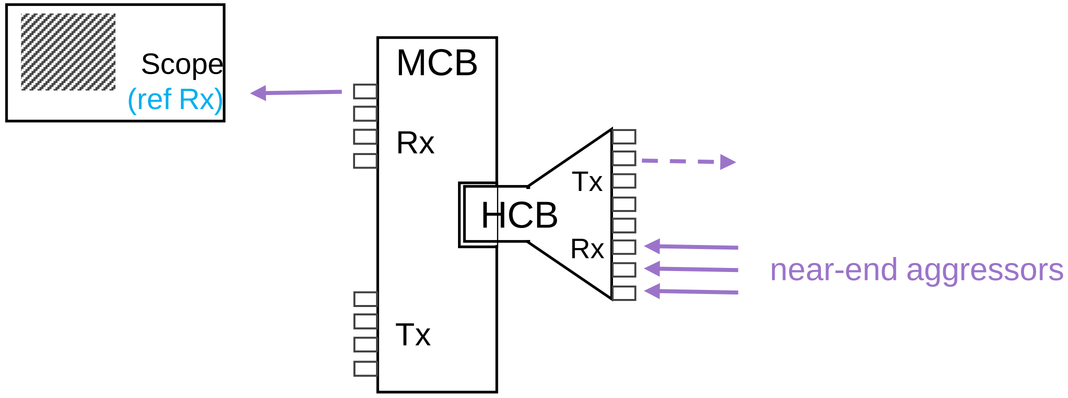
Example of Transmitter Characterization Results

Instrument calibration

NEAR END AGGRESSOR CALIBRATION

3. Near-end aggressor calibration (from AWG)





- Use IQ tools to perform in-situ de-emphasis (up to 30GHZ) – see details here
- Adjust the near-end aggressor @ the scope (TP7a) as follows* using PRBS13Q and scope response (SIRC) set to 4th order BT with 40GHz bandwidth
  - **9ps** 20-80% rise-time
  - **450mV** pk-pk amplitude - amplitude can be adjusted for each lane separately

* leveraging Table 103 HDR limiting active cable input electrical specifications. The corresponding IEEE 802.bs C2M foresees higher crosstalk amplitude (900mV)

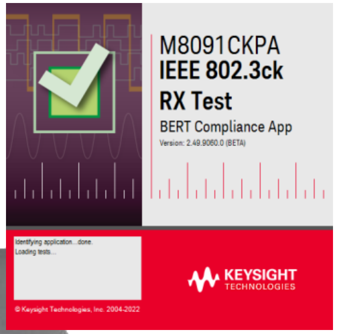
Cable Input test procedure

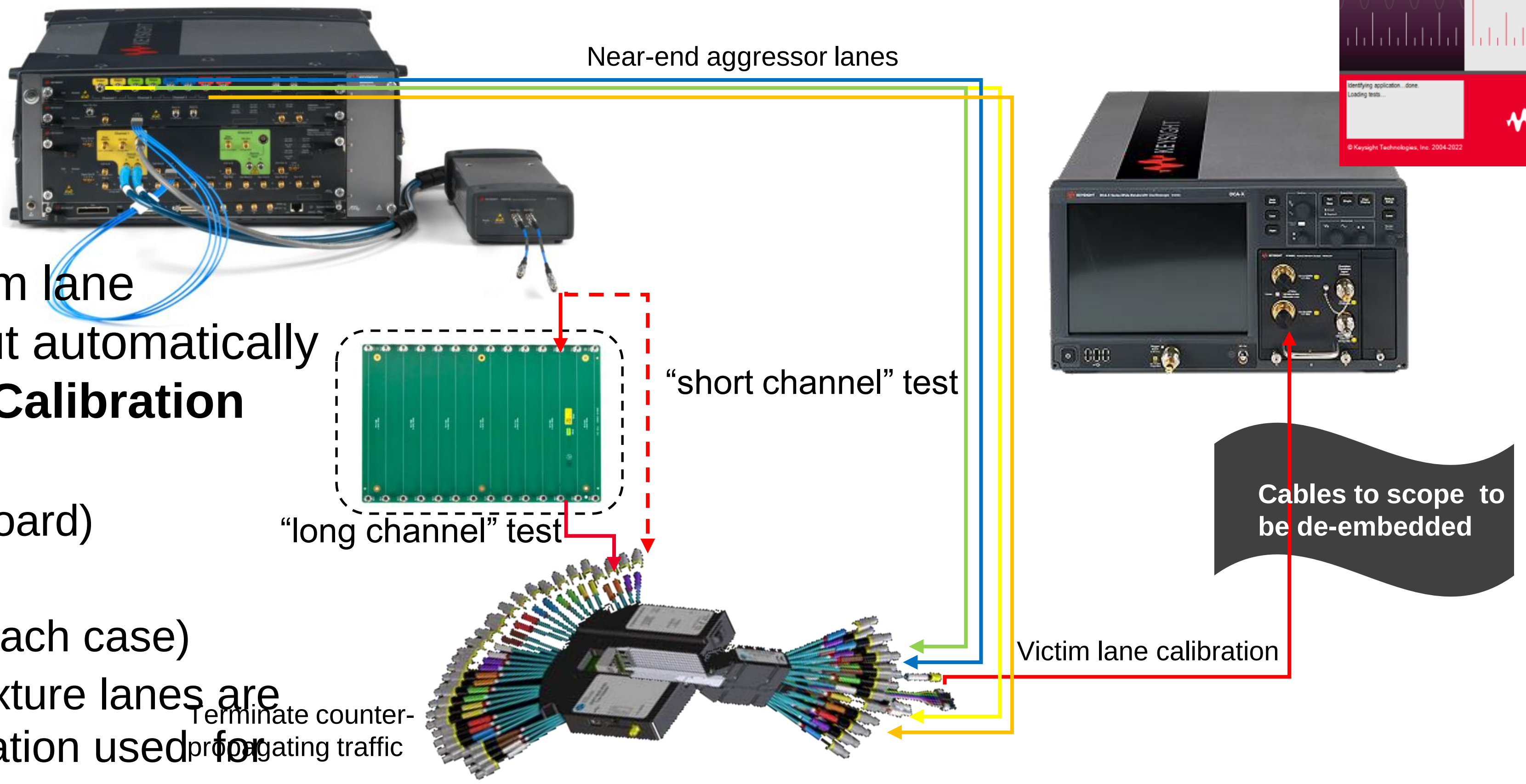
STRESS SIGNAL CALIBRATION

Cable Test – Victim lane calibration

STRESS SIGNAL CALIBRATIONS - TWO CASES

Use SW for automated calibration



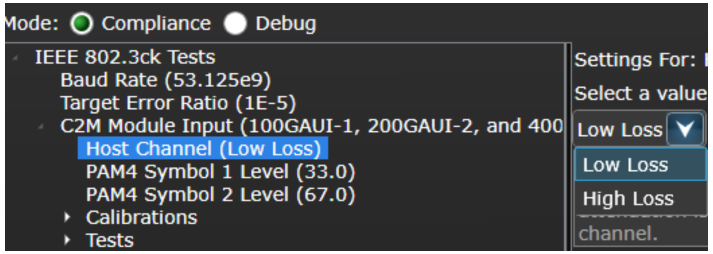


Tx Eq optimization & victim lane **Calibration** are carried out automatically by the M8091CKPA SW. **Calibration** required for both

4. Long channel (with ISI board)
5. Short-channel

- (save the calibration for each case)

Assumption: mated test fixture lanes are very similar → same calibration used for each lane

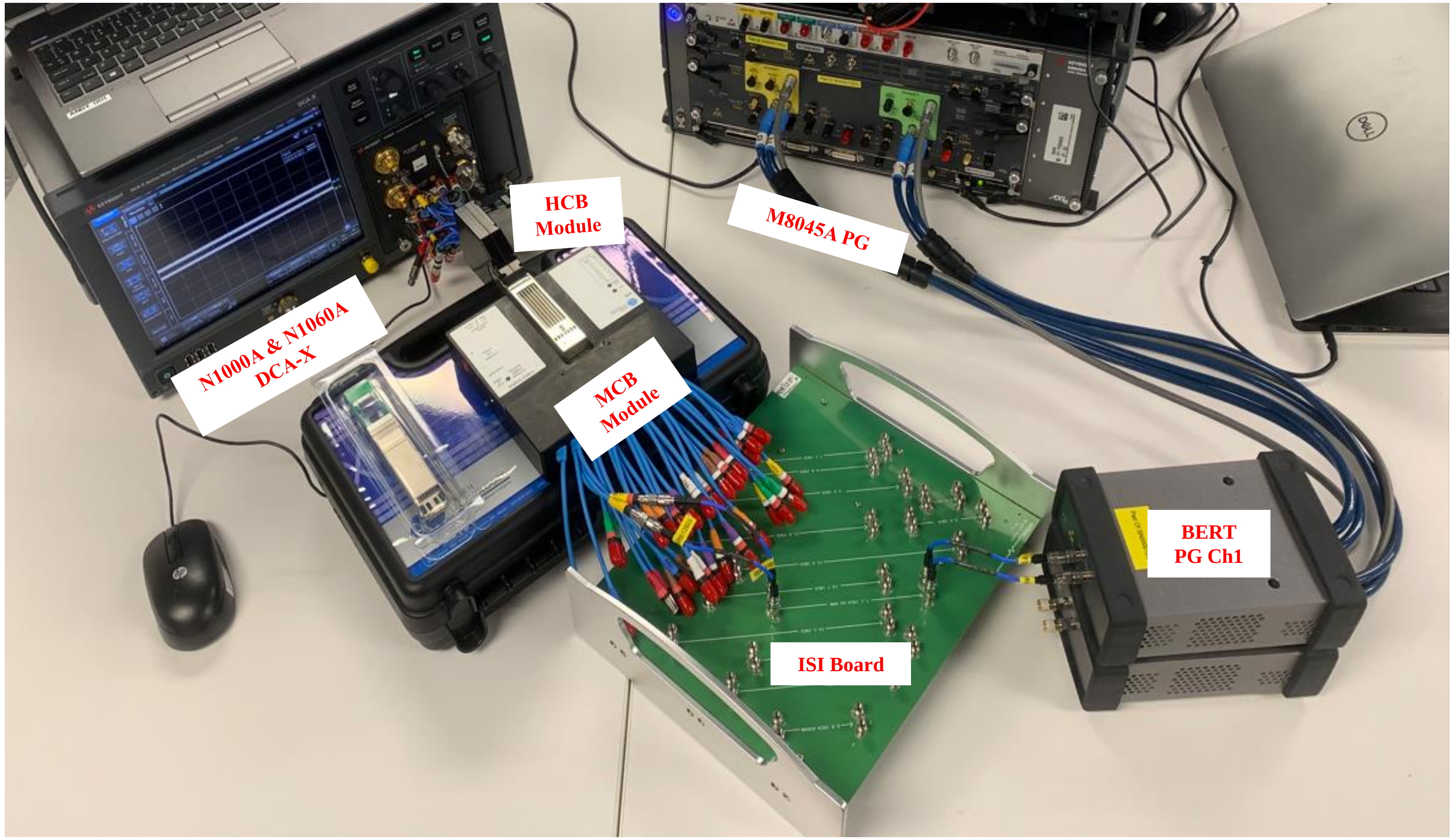


How many lanes? Should we take only lane #1?
Should we take the worst channel (COM?)?
OSFP → all lanes should be the same?
Guess the worse lane for OSFP?

Example Setup Configuration

VICTIM LANE - C2M MODULE INPUT CALIBRATION

- C2M Module Input (long channel) calibration for victim lane with ISI board
- For short channel calibration, pattern generator is directly connected to victim lane without the ISI board
- Counter-propagating aggressor lanes (near-end crosstalk) are generated by the AWG



Example for long channel test (with ISI baord)
Counter-propagating channels are not shown on this picture

Cable Input test procedure

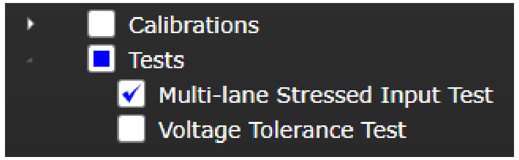
DUT TEST

Cable Test

DUT TEST (4 LANES)

6. Load the calibration project

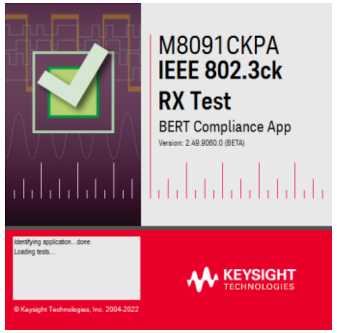
7. Run **stress input test** for each lane
   - Switch to PRBS31, sweep jitter & measure BER

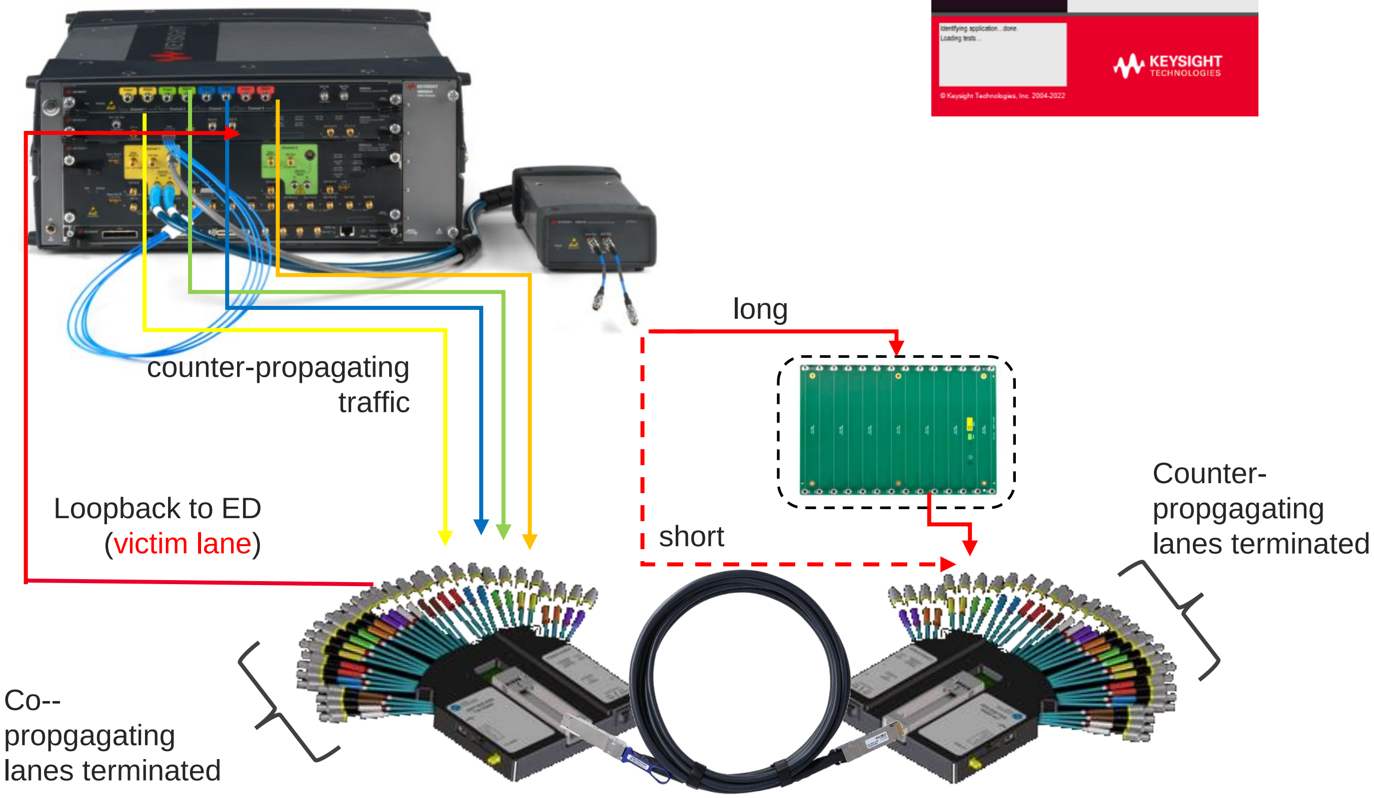


   - Verify FLR & FEC margin & characterize error bursts (if any)
   - Detailed procedure on **slide #63**

- **Repeat** the procedure for each lane in *long* and *short* channel scenario
  - Use **flags** (Run tab) to distinguish tests for each lane and long/short channels
- Generate **Test report**

Use SW for automated test





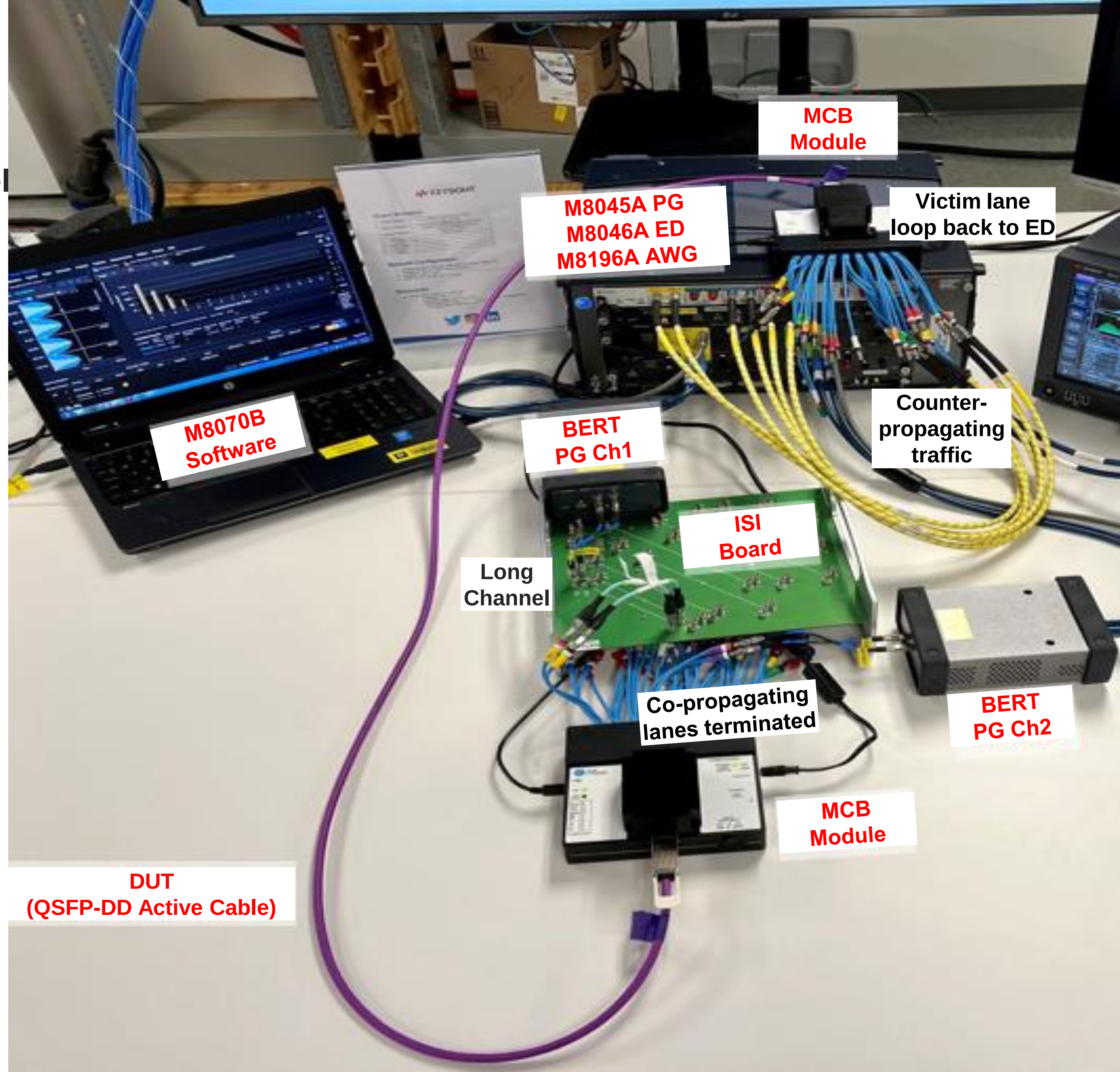
Note: A detailed step-by-step of using the M8091CKPA pre-compliance app for calibrations and tests are in the following section. Refer to "Using M8091CKPA for Cable Input Test" onwards.

Example Test Setup

Stress Input Test for the Calibrated Test Channel

- M8091CKPA conformance app for IEEE 802.3ck (112G) is required for automated test and calibration
- When testing an individual lane, other co-propagating and counter-propagating lanes should be terminated

Note: PG2 is used for Tx test



Example of Test Report

ACTIVE CABLE TESTING

KEYSIGHT TECHNOLOGIES

Test Report

Pass

Test Configuration Details	
Application	
Name	M8091CKPA IEEE 802.3ck RX Test
Version	2.50.0.0
Device Description	
Standard Option	C2M Module Input (100GAUI-1, 200GAUI-2, and 400GAUI-4)
Noise Channel S-Parameter Profile	C:\Program Files\Keysight\M8070B\Apps\M8091CKPA\app\SParameterProfiles\NoiseChannel.s4p
Excel Config File	C:\Program Files\Keysight\M8070B\Apps\M8091CKPA\app\ExcelConfigFiles\config_com_ieee8023_93a=3ck_d2p3_120F_C2C.xlsx
Test Session Details	
BERT SW Version	8.5.380.14
BERT Model Number	M8070B
BERT Serial Number	MY58C01063
Debug Mode Used	Yes
Compliance Limits	C2M Module Input (100GAUI-1, 200GAUI-2, and 400GAUI-4) Test Limit (official)
Last Test Date	2022-05-04 15:33:25 UTC -04:00

Summary of Results

Test Statistics	
Failed	0
Passed	5
Total	5

Margin Thresholds	
Warning	< 5 %
Critical	< 0 %

Pass	# Failed	# Trials	Test Name (click to jump)	Actual Value	Margin	Pass Limits
✓	0	1	Amplitude Calibration	Pass	100.000 %	Pass/Fail
✓	0	1	SJ Calibration	Pass	100.000 %	Pass/Fail
✓	0	1	Transmitter Characterization	Pass	100.000 %	Pass/Fail
✓	0	1	Stressed Eye Calibration	Pass	100.000 %	Pass/Fail
✓	0	1	Multi-lane Stressed Input Test	Pass	100.000 %	Pass/Fail

PDF

RX Stress Input Test Report

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.

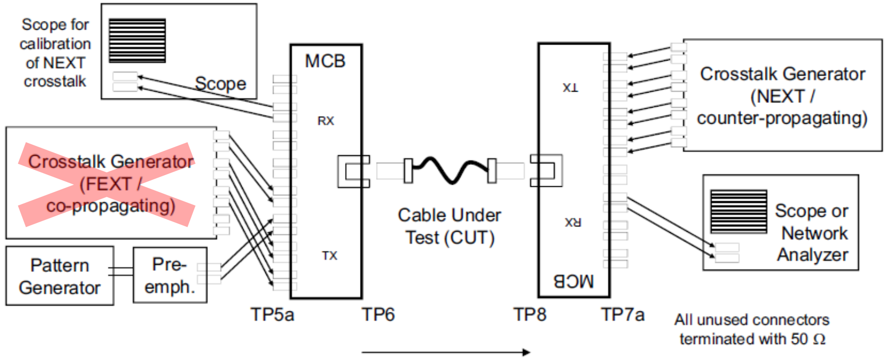


Figure 224 Cable characterization setup using MCB

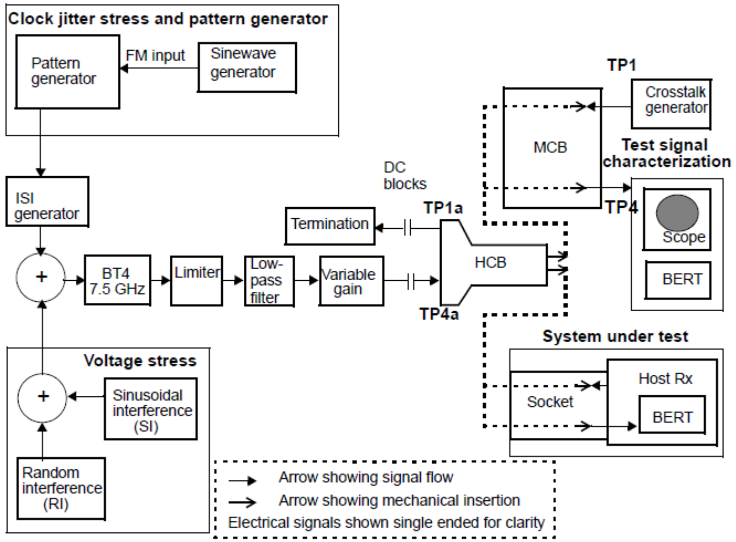


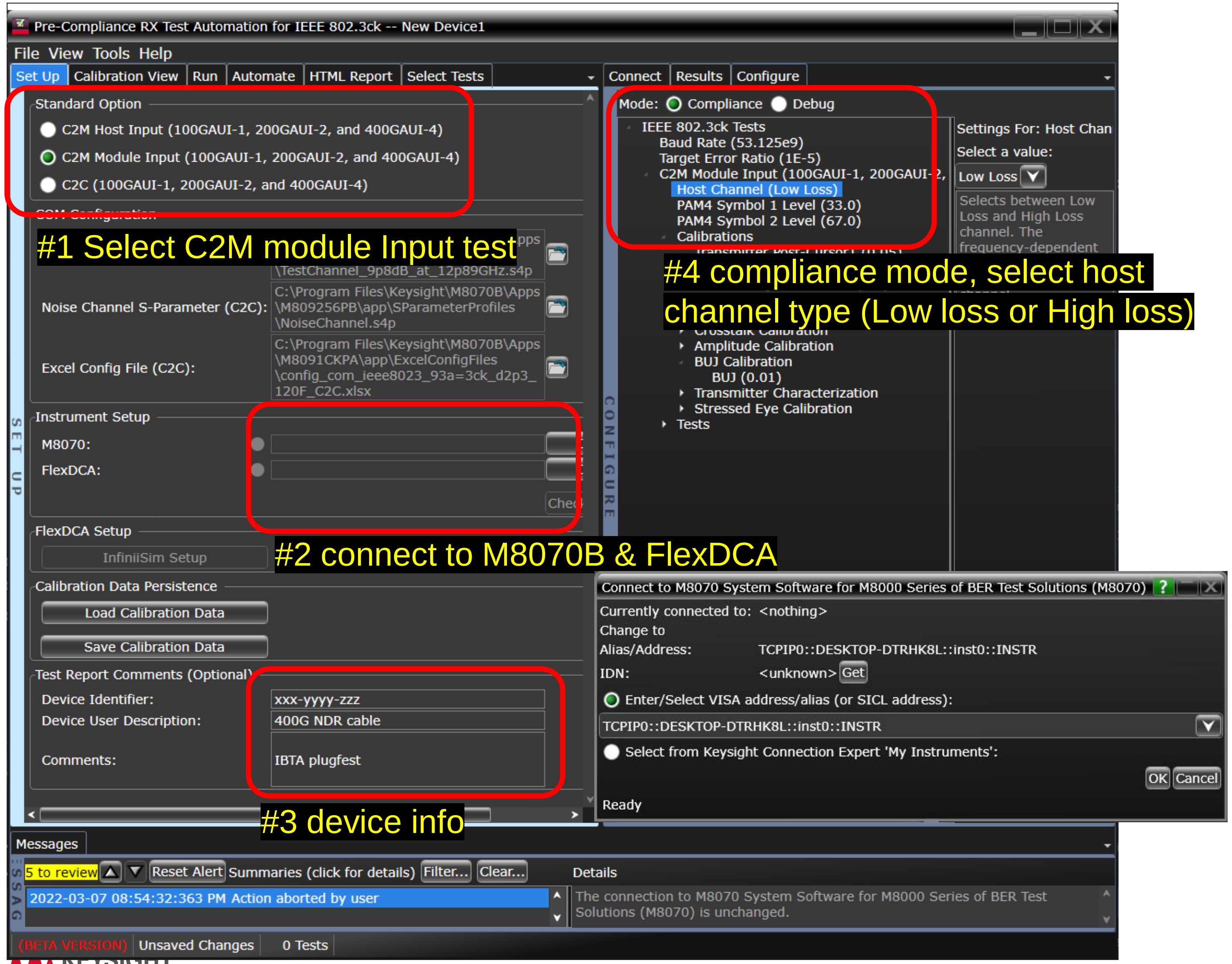
Figure 86A–8—Example jitter tolerance test configuration

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

Using M8091CKPA for Cable Input Test

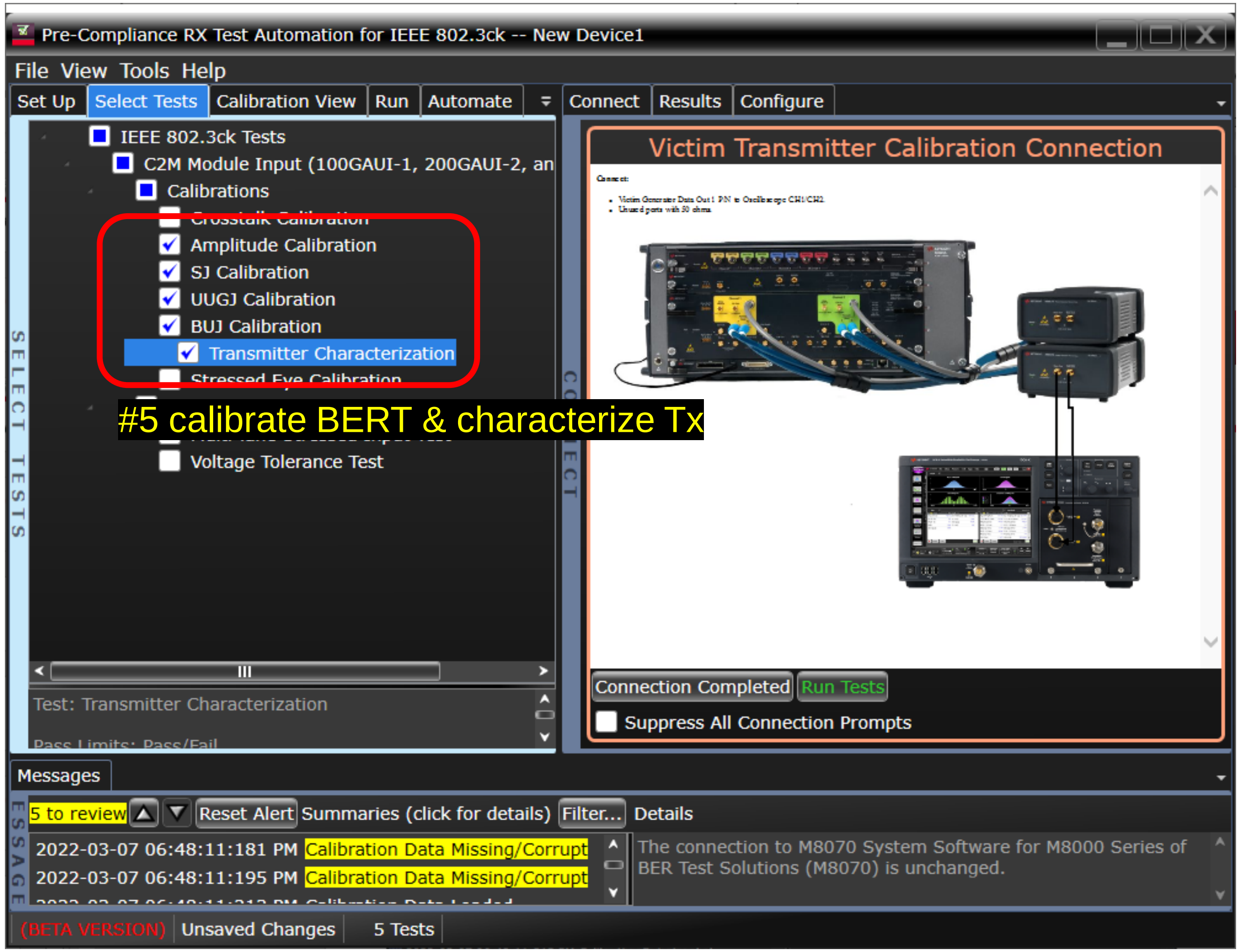
Using M8091CKPA

OVERVIEW #1 –C2M MODULE INPUT DEFAULT SETTINGS



Using M8091CKPA

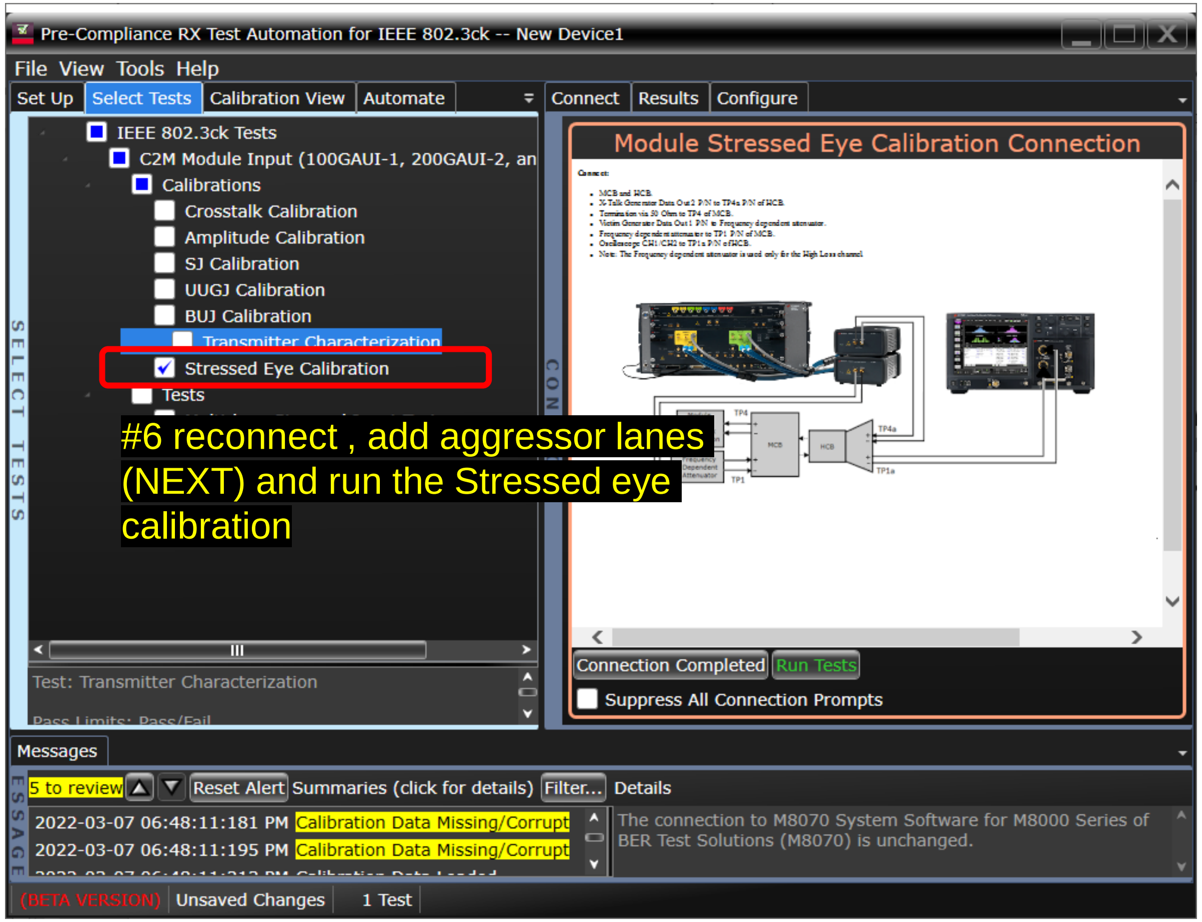
OVERVIEW #2 – EQUIPMENT CALIBRATION



- Do not run ***crosstalk calibration*** you're using an AWG / 3rd party source for the NEXT(near-end crosstalk)

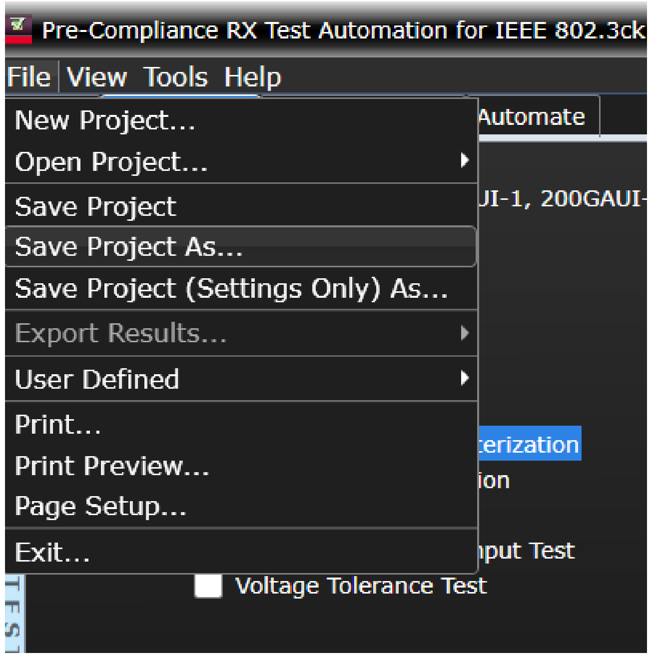
Using M8091CKPA

OVERVIEW #3 STRESSED CALIBRATION FOR "LOW LOSS" CHANNEL



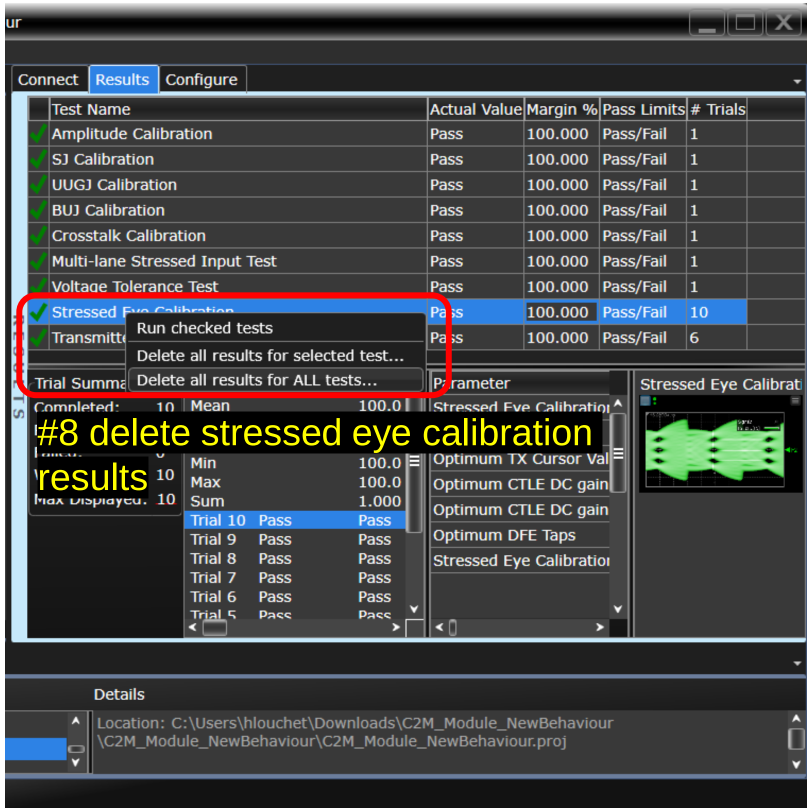
#6 reconnect , add aggressor lanes (NEXT) and run the Stressed eye calibration

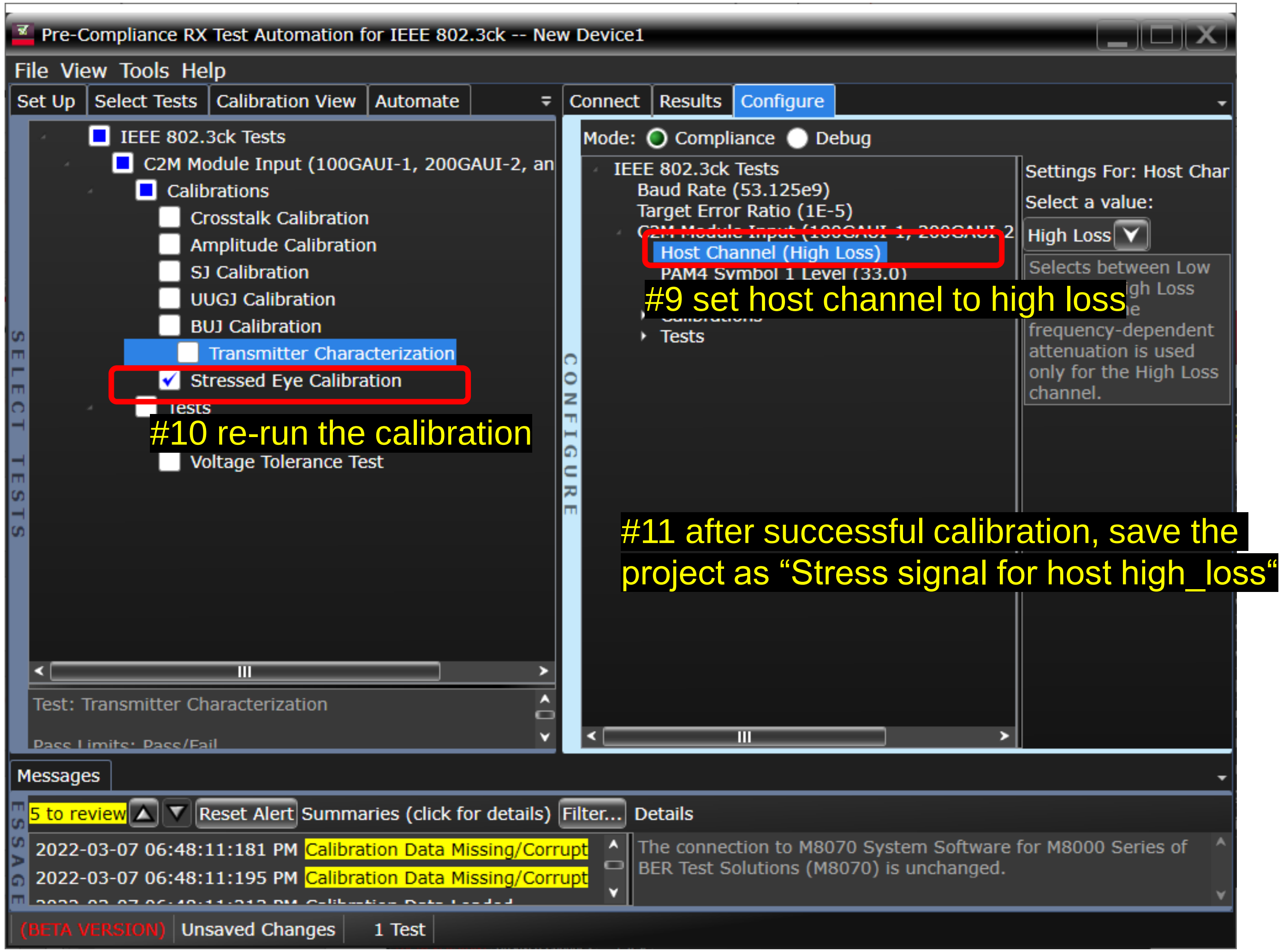
#7 after successful calibration, save the project as "Stress signal for host low_loss"



Using M8091CKPA

OVERVIEW #4 STRESS CALIBRATION FOR “HIGH-LOSS” CHANNEL





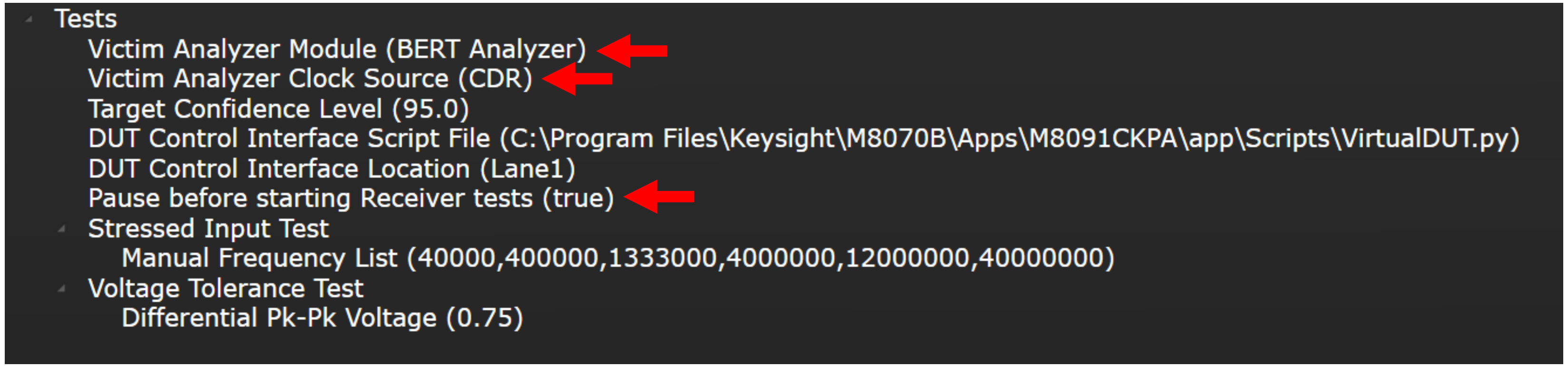
Using M8091CKPA

OVERVIEW #5 CONFIGURATION BEFORE THE RX TEST

#12 after successful calibrations, configure the analyzer settings before starting the tests.

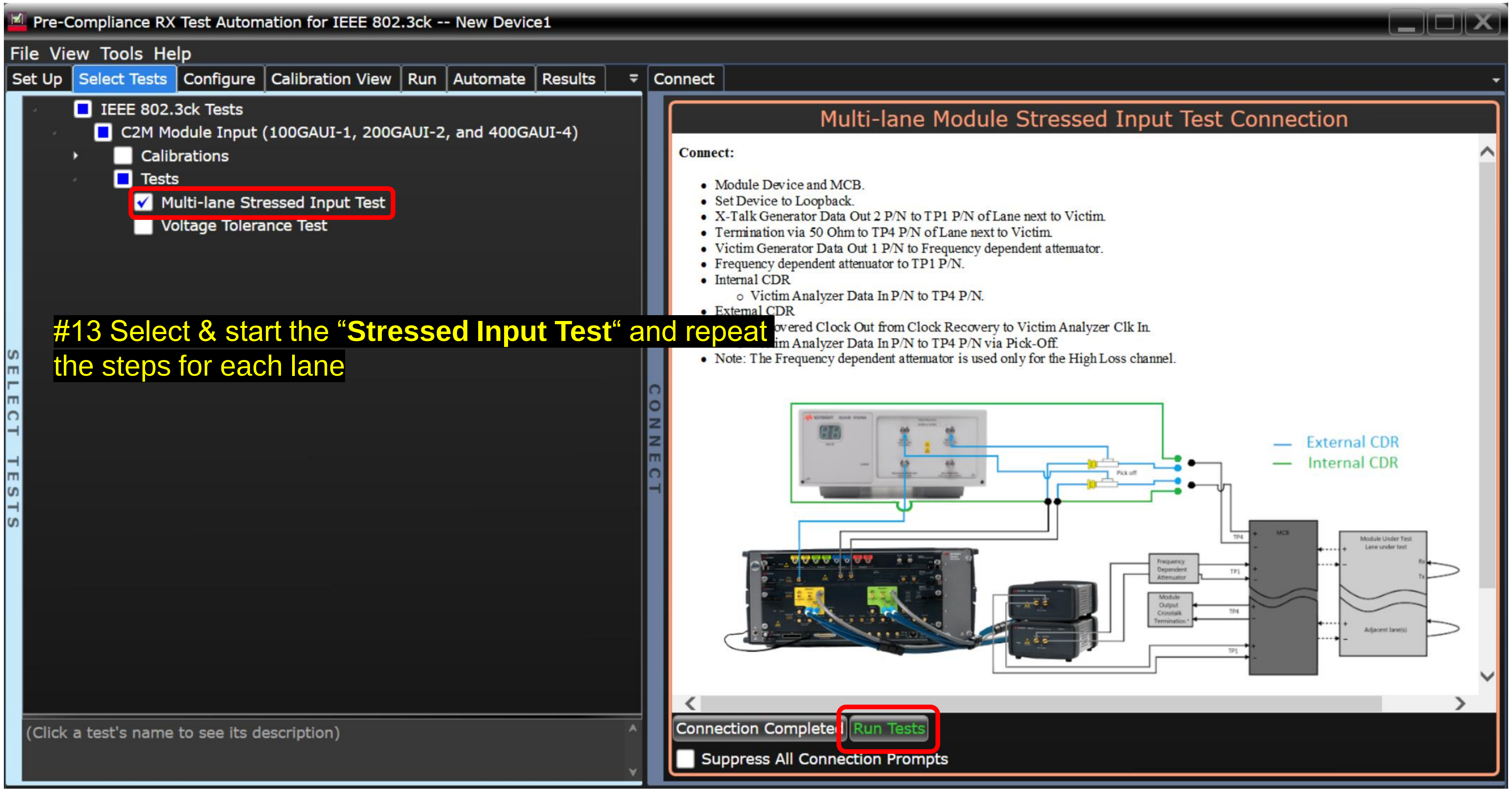
Set ‘**BERT Analyzer**‘ for Victim Analyzer Module and select ‘**CDR**‘ for Clock Source if M8046A is used.

Select ‘**True**‘ for ‘Pause before starting Receiver tests‘. This allows user to configure the Error Detector settings on M8070B before the test



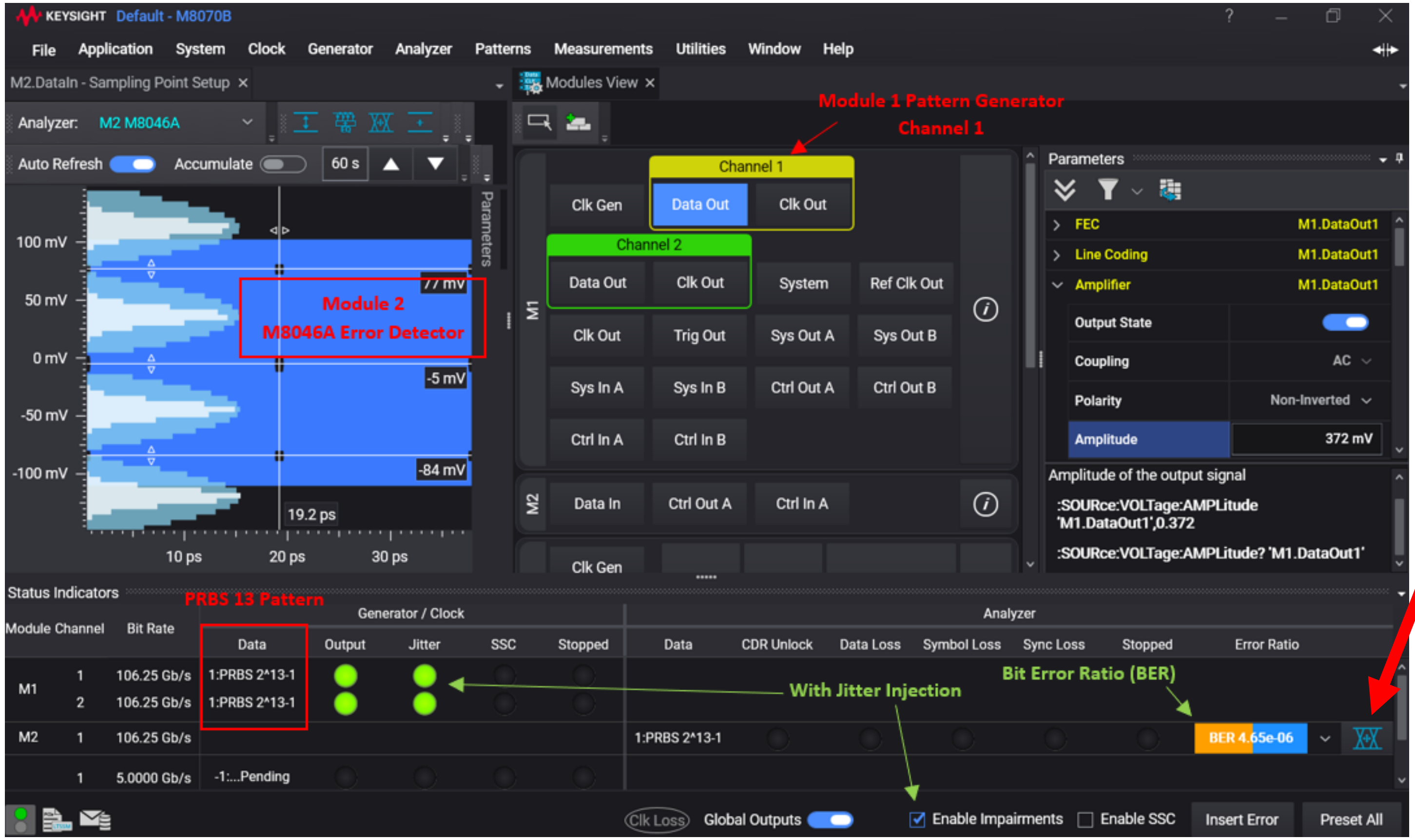
Using M8091CKPA

OVERVIEW #5 RUN TEST FOR EACH LANE



Using Error Detector on M8070B

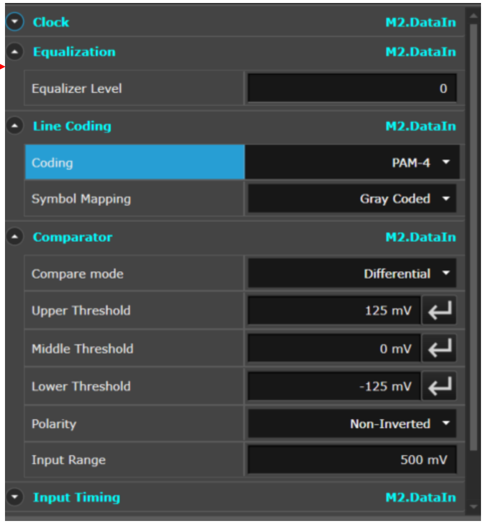
OVERVIEW #6 CONFIGURE ED ON M8070B



SW Requirements

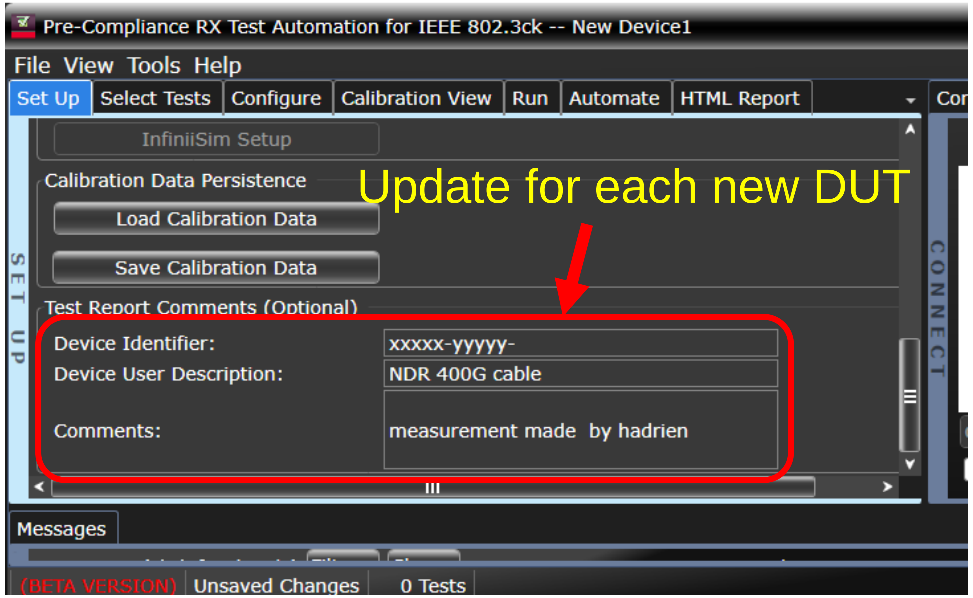
- M8070B, rev. 6.0 or higher
- M8070EDAB *error distribution analysis package*, rev. 1.0 or higher
- M8070ADVB advanced measurement package

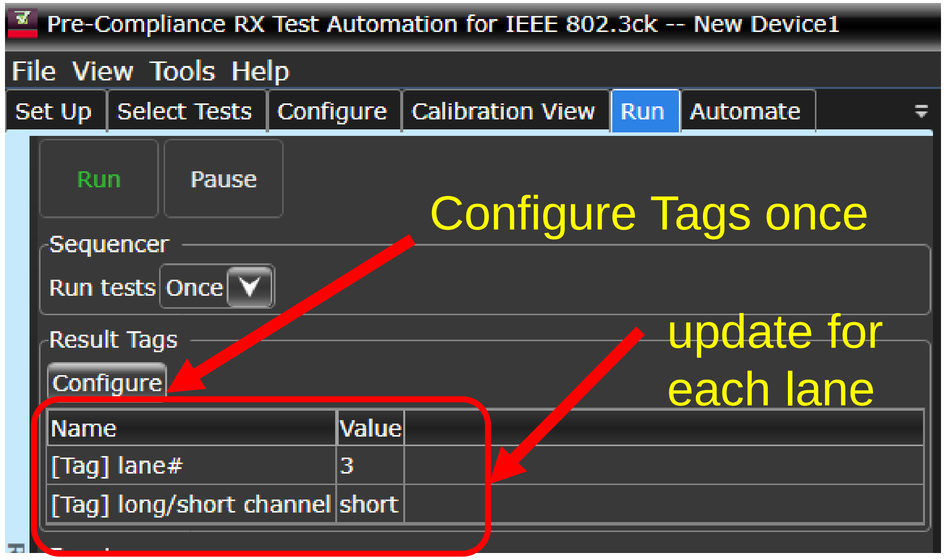
#14 Adjust ED Settings (coding, equalization) and "**Auto-align**" for BER measurement



Using M8091CKPA

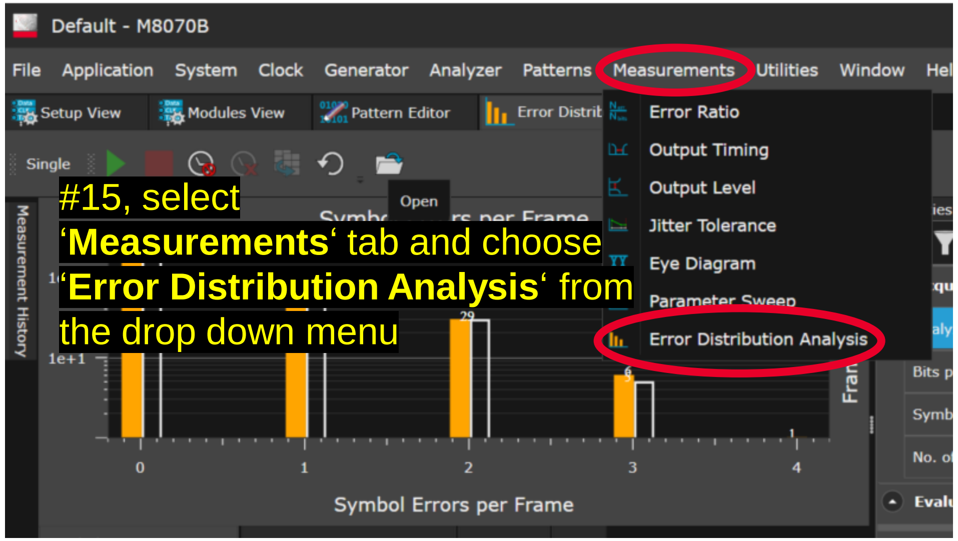
CREATING TEST REPORT





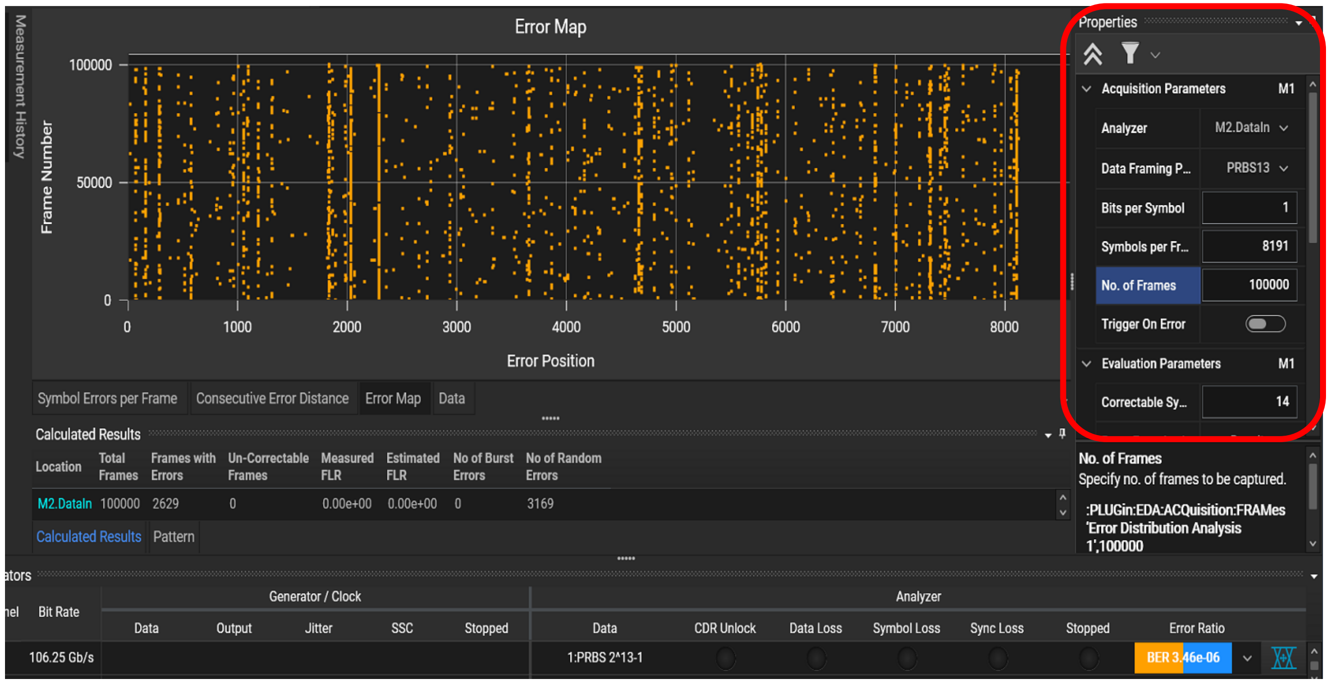
Using M8091CKPA

OPTIONAL - FLR MEASUREMENT



#15, select ‘**Measurements**‘ tab and choose ‘**Error Distribution Analysis**‘ from the drop down menu

#16 Run Error Analysis:
Configure “**Acquisition Parameters**“ to match the PRBS characteristics



Using M8091CKPA

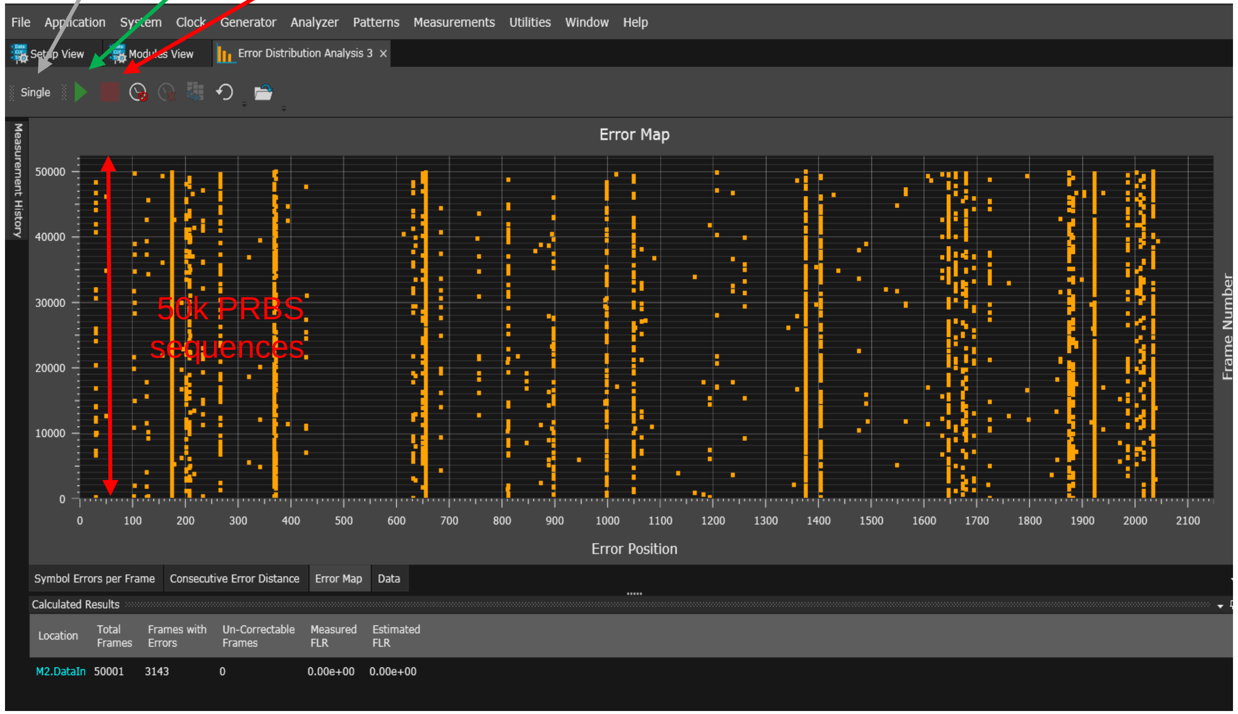
OPTIONAL - SWITCHING TO EDAB FOR FLR MEASUREMENT

#17 Select “Single“ or “Start“ button, captures will begin until “Stop“ button is selected

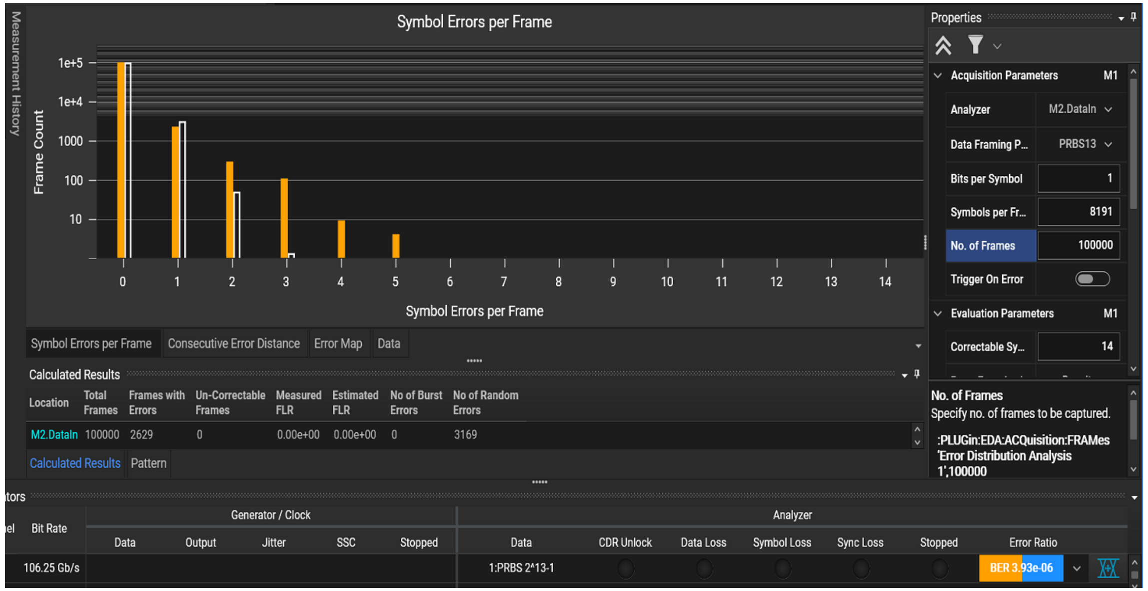
Single

Start

Stop



#18 Example of test result in Histogram



TX IEEE802.3ck Specification

MODULE OUTPUT (TP4)

Table 120G–3—Module output characteristics at TP4

Parameter	Reference	Value	Units
Signaling rate, each lane (nominal)		53.125[a]	GBd
Peak-to-peak AC common-mode voltage (max) Low-frequency, VCM_{LF} Full-band, VCM_{FB}	120G.5.1	 32 80	mV
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
Common-mode to differential-mode return loss, *RLdc* (min)	120G.3.1.1	Equation (120G–1)	dB
Effective return loss, ERL (min)	120G.3.2.3	8.5	dB
Differential termination mismatch (max)	120G.3.1.3	10	%
Transition time (min)	120G.3.1.4	8.5	ps
DC common-mode voltage tolerance (range) Upper limit Lower limit	120G.3.2.4	 2.85 -0.35	 V V

RX IEEE802.3ck Specification

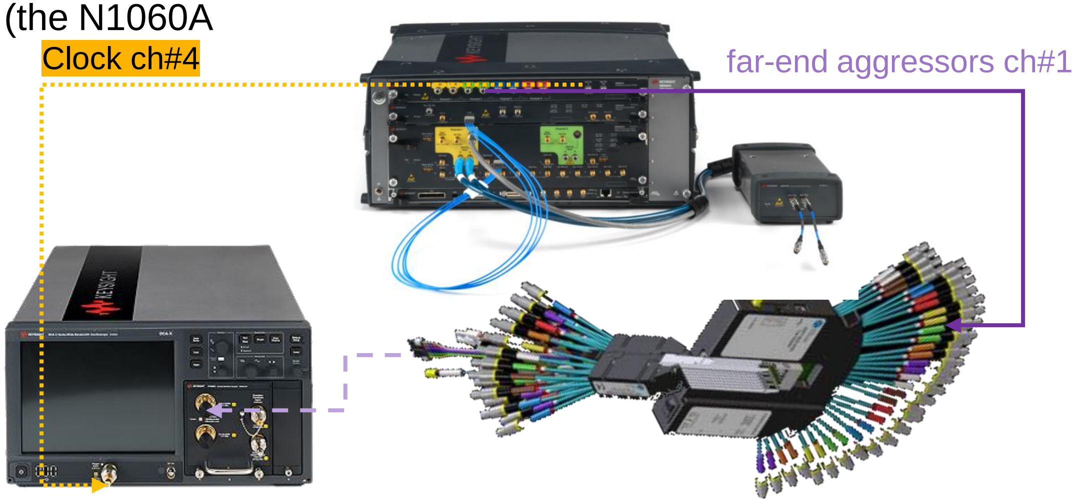
MODULE INPUT (TP1)

Table 120G–10—Module stressed input parameters

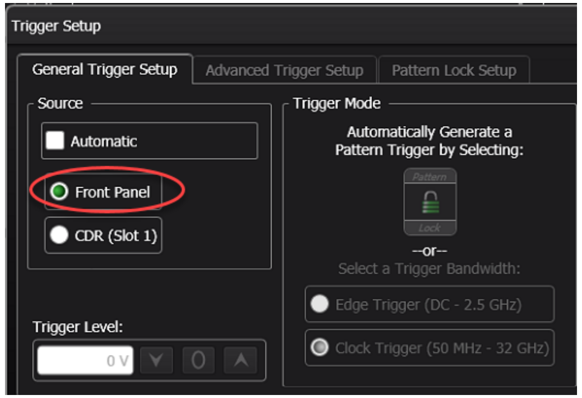
Parameter	Value	Value
Pattern generator transition time (target)	9	ps
Applied peak-to-peak sinusoidal jitter	Table 162–17	—
Eye height (target)	10	mV
Vertical eye closure, VEC (min)	12	dB
Vertical eye closure, VEC (max)	12.5	dB
Crosstalk differential peak-to-peak voltage	845	mV
Crosstalk transition time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

Near-end aggressor calibration using IQ tools

1. **Important:** In FlexDCA change *General Trigger Setup* from **CDR (Slot 1)** (the N1060A internal CDR) to ***Front Panel***
    - not doing this may result in **damaging** the N1060A CDR
2. Set up the connection as described
    - AWG channel 1 in N1060A input
    - AWG channel 4 in DCA trig (adapter required)
3. Start IQ tools on the PC
    - Connect to AWG and DCA
    - Perform an in-situ calibration (see attached pdf)
4. When in-situ cal. is done
    - Disconnect channel 4
    - change back the *FlexDCA Trigger Setup* to **CDR (Slot 1)**
    - In IQ tools t generate a 53.125 Gbaud PAM4 using the in-situ correction.
5. Verify rise-time and adjust amplitude



Adobe Acrobat Document



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[illegible]tern 7 supported	[illegible]rted	RO
	[illegible]	[illegible]	[illegible]	[illegible]
	0	[illegible]e Generator Pattern [illegible]		
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		

Annex A1

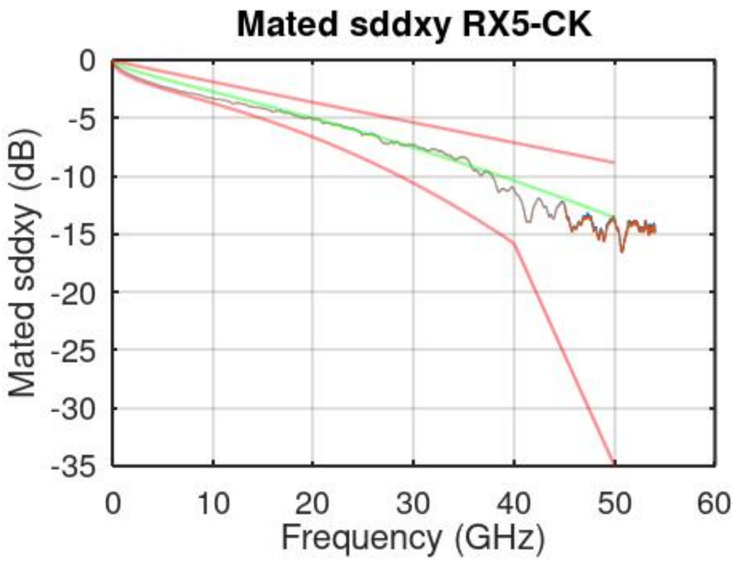
MTF CALIBRATION AND ELECTRICAL VERIFICATION

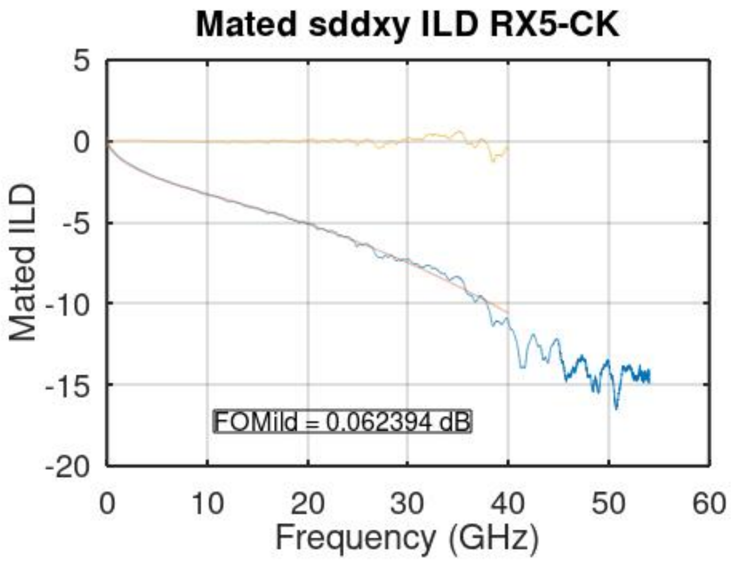
Wilder 800G QSFPDD MTF Response Example

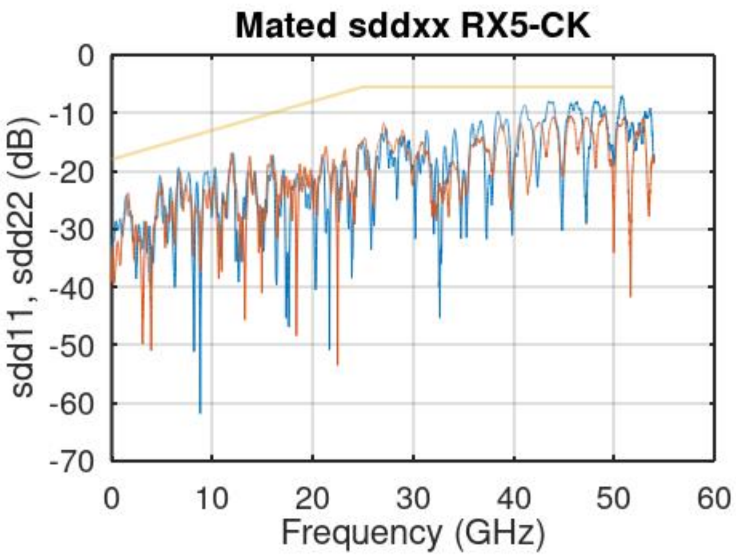
- A 4-port s-parameter set is measured for each channel of a mated pair test fixture (MTF).
- The mixed mode s-parameters are calculated from the single-ended s-parameters and plotted against the 802.3CK specification limit lines.
- The Figure of Merit (FOMild) is calculated based on the method outlined in the 802.3CK specification.
- ERL of MTF is calculated using the Channel Operating Margin tool with the proper input parameters for MTF.

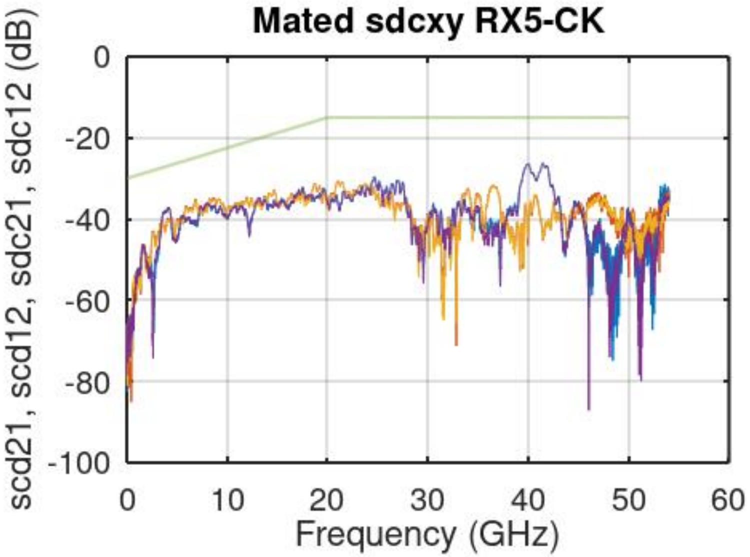
Wilder 800G QSFPDD MTF Response Example

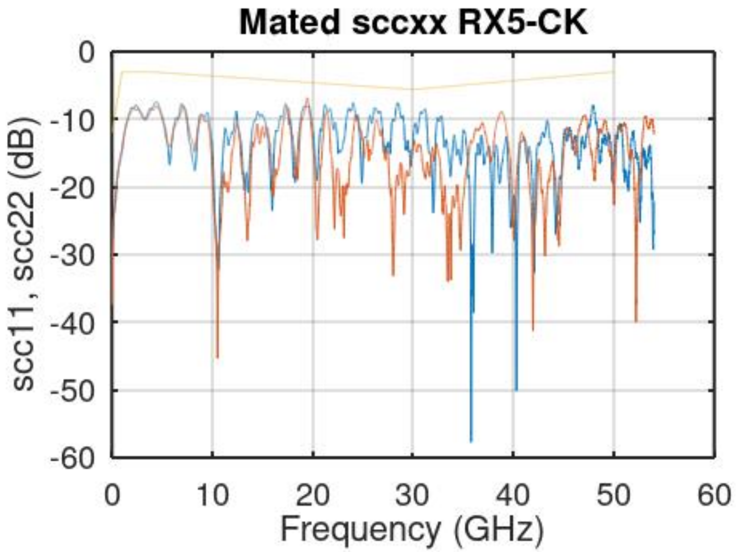
WILDER TECHNOLOGIES
It's all about integrity

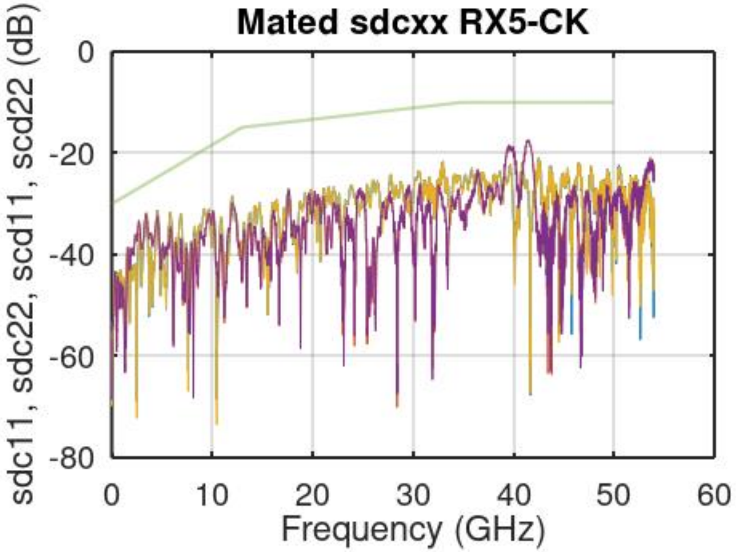










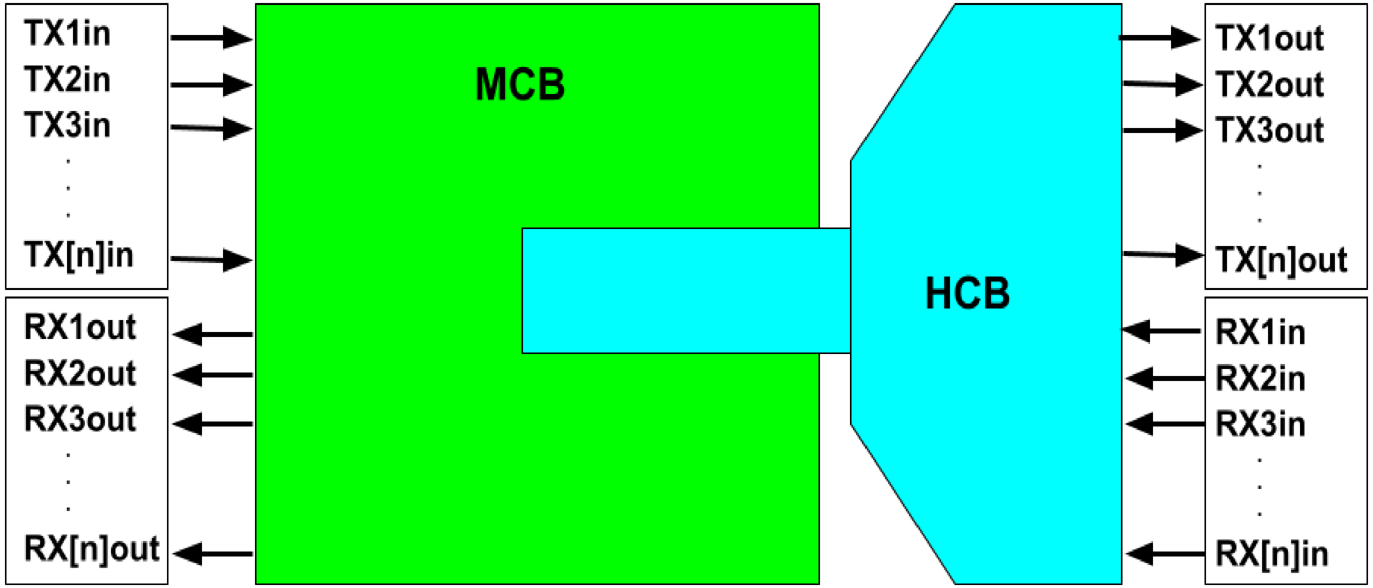


Wilder 800G QSFPDD ICN Example

TX victim is on HCB side and aggressors for TX victim are TX1in-TX[n]in on MCB (excluding thru channel) and TX1in-TX[n]in on MCB which make up the FEXT and NEXT responses, respectively.

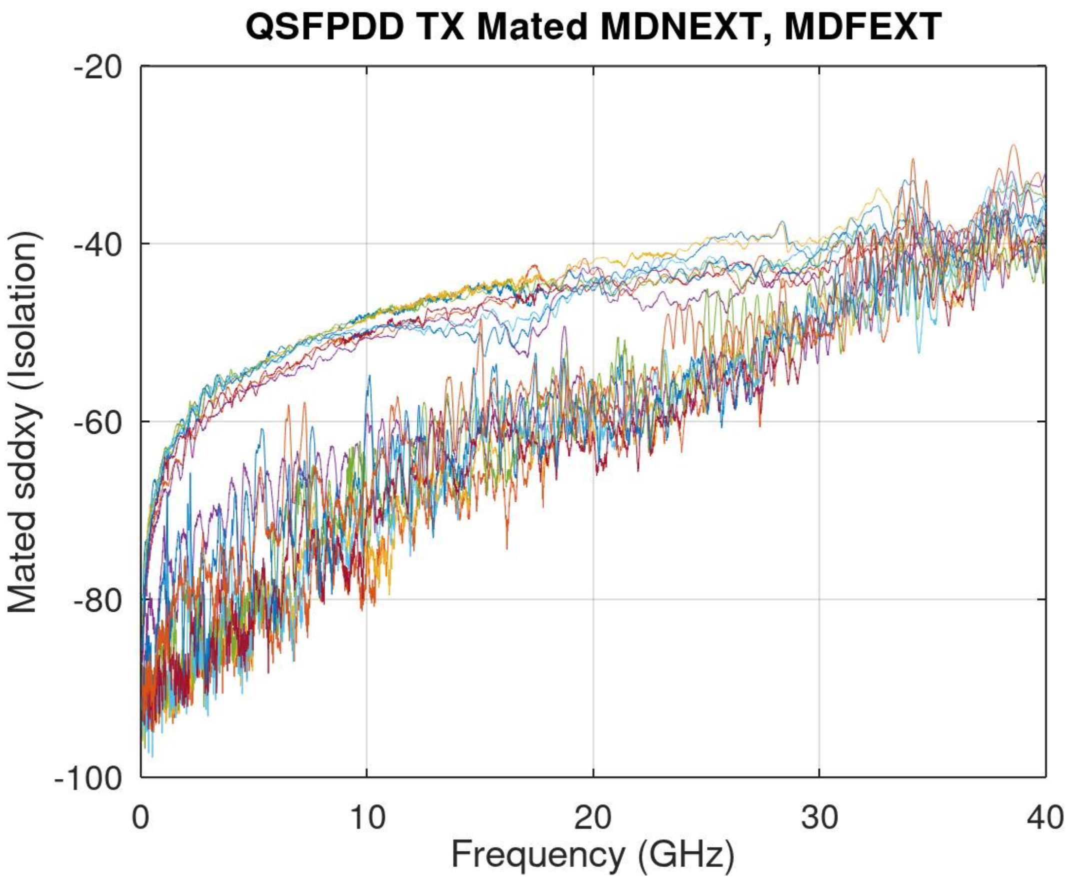
RX victim is on MCB side and aggressors for RX victim are RX1in-RX[n]in on HCB (excluding thru channel) and TX1in-TX[n]in on MCB which make up the FEXT and NEXT responses, respectively

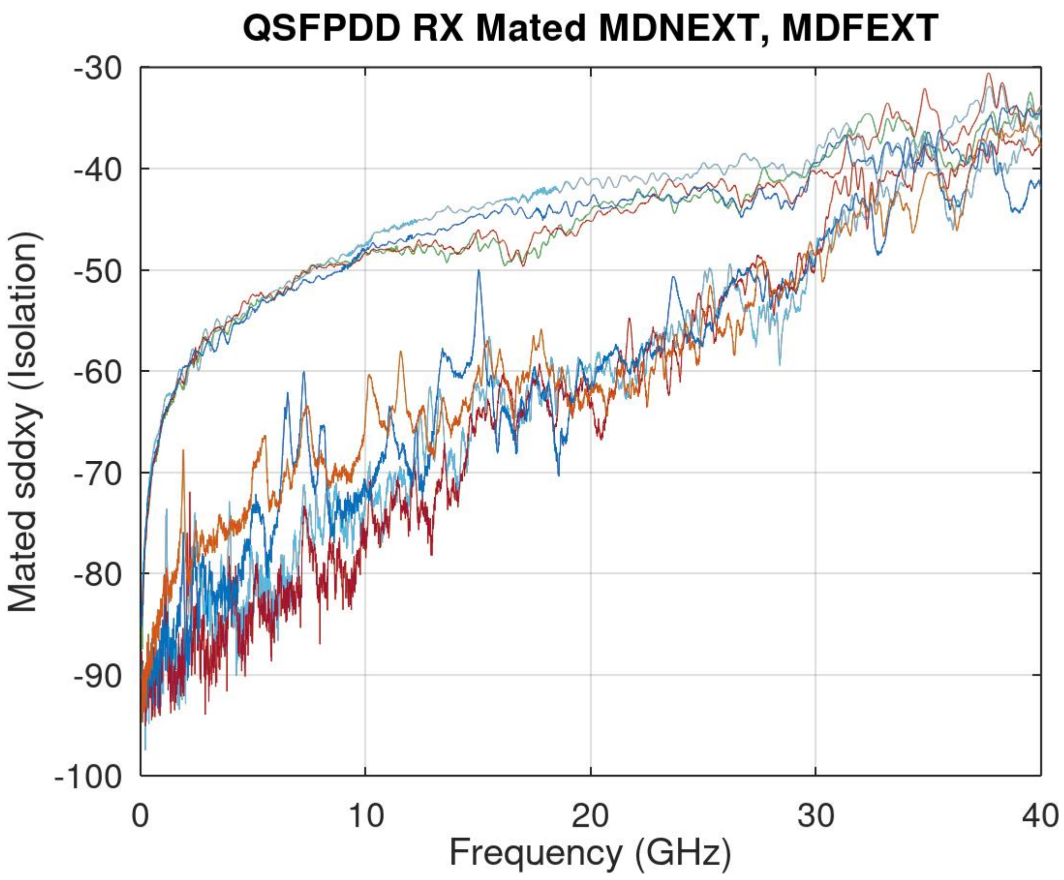
For each victim, all FEXT aggressors are power summed, and all NEXT aggressors are power summed then each are integrated as outlined in the CK and CEI specifications. Both single valued integrated noise levels are then added RSS to give the total ICN value.



Wilder 800G QSFPDD ICN Example

The two figures below are the multi-disturber responses (FEXT and NEXT) for TX victims and RX victims.





Wilder 800G QSFPDD ICN Example

WILDER TECHNOLOGIES
It's all about integrity

ICN (mV) from TX FEXT	Victim (HCB) p=port3, n=port4							
Aggressor (MCB) p=port1, n-port2	TX1 (mV)	TX2 (mV)	TX3 (mV)	TX4 (mV)	TX5 (mV)	TX6 (mV)	TX7 (mV)	TX8 (mV)
TX1	NA	0.18	2.75	0.16	1.02	0.19	0.22	0.16
TX2	0.20	NA	0.18	1.54	0.26	0.87	0.15	0.31
TX3	2.55	0.19	NA	0.17	0.31	0.19	0.15	0.15
TX4	0.17	1.98	0.15	NA	0.19	0.27	0.15	1.00
TX5	1.17	0.27	0.32	0.25	NA	0.97	2.02	0.46
TX6	0.23	1.23	0.21	0.32	1.10	NA	0.39	1.75
TX7	0.27	0.32	1.11	0.24	1.89	0.57	NA	0.86
TX8	0.12	0.33	0.17	1.12	0.39	1.81	0.93	NA
TX MDFEXT	2.85	2.41	3.01	1.98	2.49	2.33	2.28	2.27

ICN (mV) from TX NEXT	Victim (HCB) p=port3, n=port4							
Aggressor (HCB) p=port1, n=port2	TX1 (mV)	TX2 (mV)	TX3 (mV)	TX4 (mV)	TX5 (mV)	TX6 (mV)	TX7 (mV)	TX8 (mV)
RX1	0.24	0.39	0.28	0.42	0.22	0.28	0.18	0.38
RX2	0.35	0.25	0.36	0.23	0.18	0.17	0.23	0.19
RX3	0.16	0.36	0.17	0.47	0.19	0.23	0.18	0.41
RX4	0.34	0.21	0.46	0.19	0.19	0.16	0.26	0.14
RX5	0.16	0.22	0.21	0.28	0.33	0.39	0.35	0.45
RX6	0.19	0.18	0.26	0.24	0.37	0.30	0.25	0.29
RX7	0.14	0.21	0.17	0.29	0.30	0.37	0.42	0.70
RX8	0.21	0.21	0.34	0.20	0.28	0.32	0.40	0.52
TX MDFEXT	0.67	0.74	0.84	0.86	0.75	0.82	0.84	1.20

TX ICN total (mV)	2.92	2.52	3.12	2.16	2.60	2.47	2.43	2.57

The table to the left is ICN data calculated as outlined in 802.3CK for the TX victim responses.

Note that each row represents an ICN value as each aggressor is added to the power sum.

Wilder 800G QSFPDD ICN Example

WILDER TECHNOLOGIES
It's all about integrity

ICN (mV) for RX FEXT	Victim (MCB) p=port3, n=port4							
Aggressor (HCB) p=port1, n-port2	RX1 (mV)	RX2 (mV)	RX3 (mV)	RX4 (mV)	RX5 (mV)	RX6 (mV)	RX7 (mV)	RX8 (mV)
RX1	NA	0.21	2.75	0.16	1.20	0.33	0.33	0.31
RX2	0.21	NA	0.18	1.54	0.25	1.27	0.16	0.34
RX3	1.79	0.17	NA	0.17	0.32	0.30	1.18	0.28
RX4	0.15	2.77	0.15	NA	0.21	0.28	0.15	1.18
RX5	0.90	0.16	0.32	0.25	NA	0.99	1.97	0.58
RX6	0.26	1.09	0.21	0.32	1.28	NA	0.57	2.09
RX7	0.26	0.11	1.11	0.24	1.76	0.57	NA	0.84
RX8	0.18	0.26	0.17	1.12	0.44	2.72	1.06	NA
RX MDFEXT	2.06	3.00	3.01	1.98	2.56	3.25	2.63	2.67

ICN (mV) for RX NEXT	Victim (MCB) p=port3, n=port4							
Aggressor (MCB) p=port1, n=port2	RX1 (mV)	RX2 (mV)	RX3 (mV)	RX4 (mV)	RX5 (mV)	RX6 (mV)	RX7 (mV)	RX8 (mV)
TX1	0.16	0.32	0.28	0.42	0.16	0.20	0.15	0.20
TX2	0.43	0.25	0.36	0.23	0.22	0.25	0.17	0.18
TX3	0.15	0.26	0.17	0.47	0.17	0.27	0.17	0.29
TX4	0.21	0.12	0.46	0.19	0.19	0.24	0.18	0.19
TX5	0.22	0.19	0.21	0.28	0.39	0.43	0.35	0.40
TX6	0.24	0.23	0.26	0.24	0.45	0.50	0.33	0.25
TX7	0.18	0.16	0.17	0.29	0.30	0.31	0.37	0.37
TX8	0.25	0.14	0.34	0.20	0.36	0.35	0.52	0.34
RX MDFEXT	0.69	0.62	0.84	0.86	0.84	0.94	0.87	0.82

RX ICN total (mV)	2.18	3.06	3.12	2.16	2.70	3.38	2.77	2.79

The table to the left is ICN data calculated as outlined in 802.3CK for the RX victim responses.

Note that each row represents an ICN value as each aggressor is added to the power sum.