InfiniBand HDR (200G) Method of Implementation

Active Time Domain (ATD) Testing

Anritsu MP1900A Signal Quality Analyzer
Keysight DCA-X Wideband Sampling Scope

Anritsu
envision : ensure

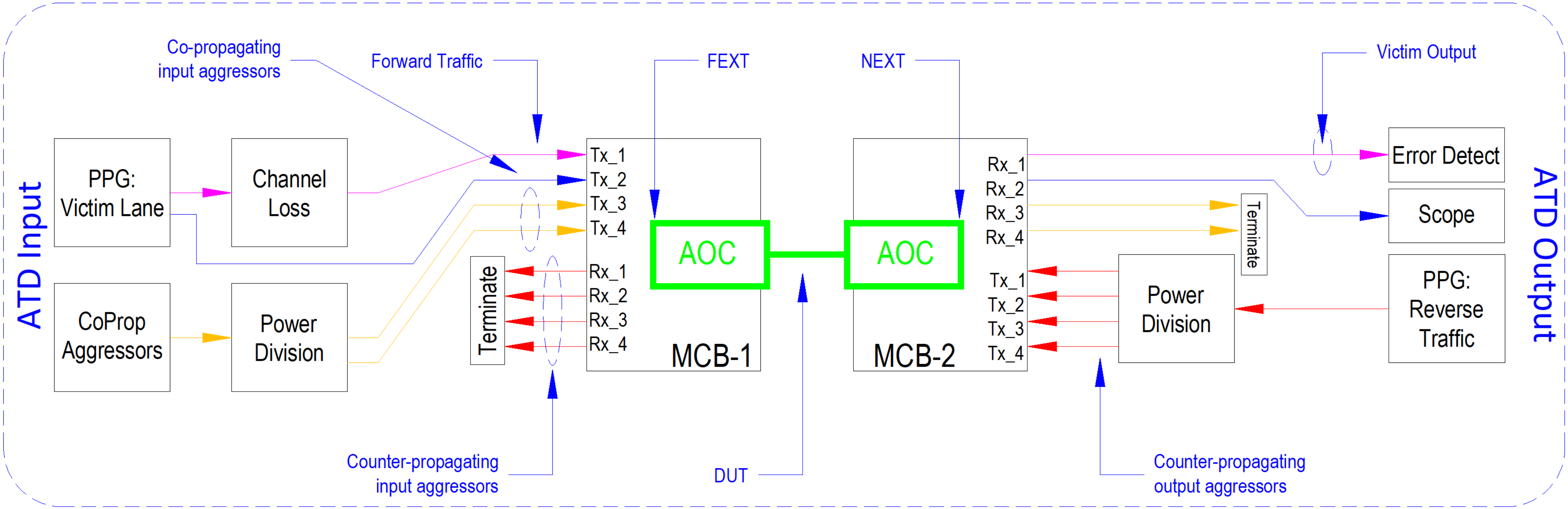
Test Equipment Images

MP1900A Signal Quality Analyzer

Keysight DCA-X Wideband Sampling Scope

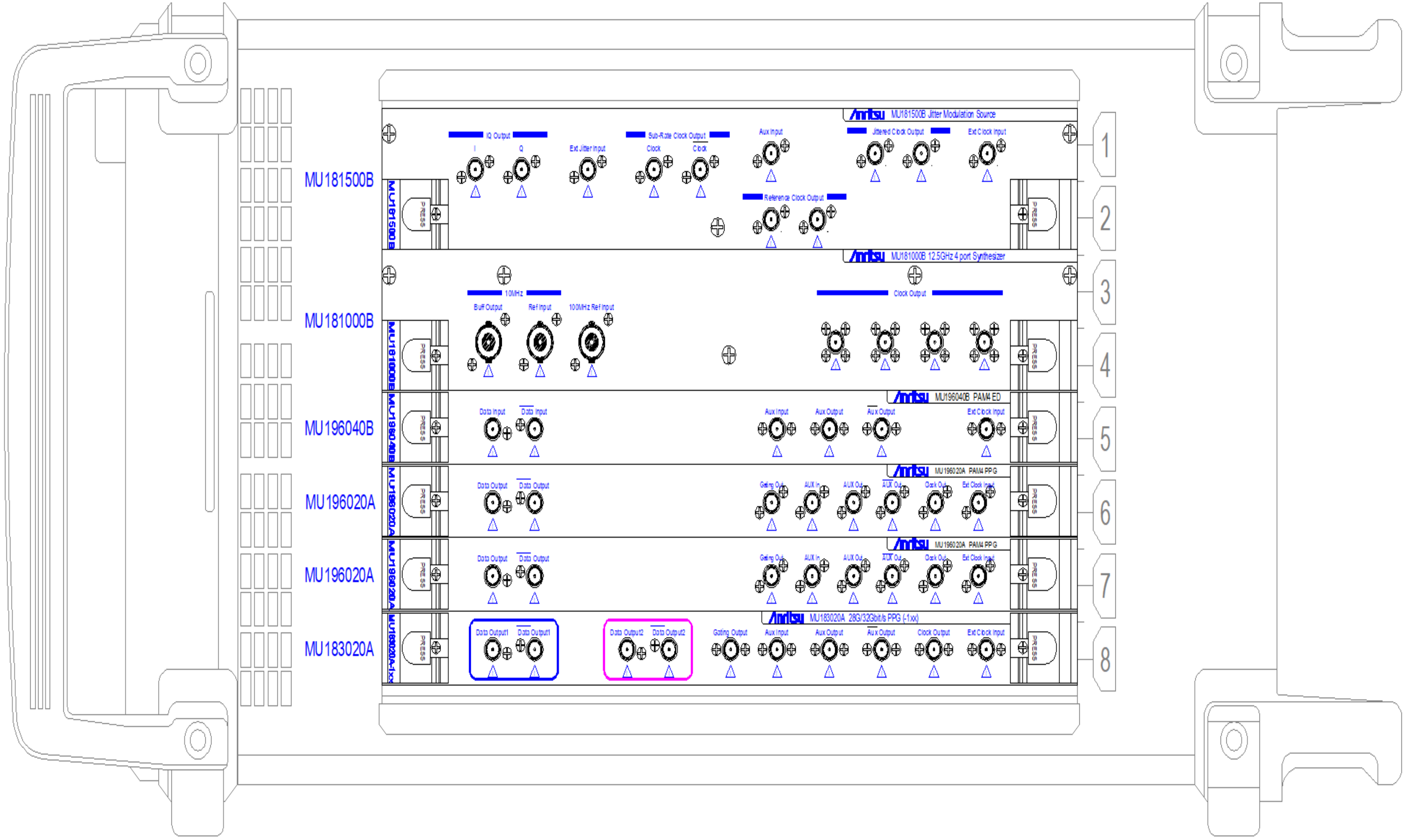
Target Test Platform (Block Diagram)

Calibrate test equipment to create the following environment for testing Active Optical Cables. Victim signal to be calibrated with jitter and channel loss stressors in the presence of co-propagating and counter-propagating aggressor signals.



Anritsu MP1900A Configuration

Slot	Part #	Description
-	MP1900A	SIGNAL QUALITY ANALYZER-R
1, 2	MU181000B	12.5 GHz 4port Synthesizer.
3, 4	MU181500B	Jitter Modulation Source.
5	MU196040B	PAM4 ED
	MU196040B-001	32G baud
	MU196040B-011	Equalizer
	MU196040B-021	29G baud Clock Recovery
	MU196040B-041	SER Measurement
	MU196040B-042	FEC Analysis
6	MU196020A	PAM4 PPG
	MU196020A-001	32G baud
	MU196020A-011	4Tap Emphasis
	MU196020A-030	Data Delay
	MU196020A-040	Adjustable ISI
	J1758A	ISI Board K
	MU196020A-042	FEC Pattern Generation
7	MU196020A	PAM4 PPG
	MU196020A-001	32G baud
	MU196020A-011	4Tap Emphasis
	MU196020A-030	Data Delay
	MU196020A-040	Adjustable ISI
	MU196020A-042	FEC Pattern Generation
8	MU183020A	28G/32G bit/s PPG.
	MU183020A-001	32G bit/s Extension.
	MU183020A-023	2ch 3.5V Data Out.
	MU183020A-031	2ch Data Delay.

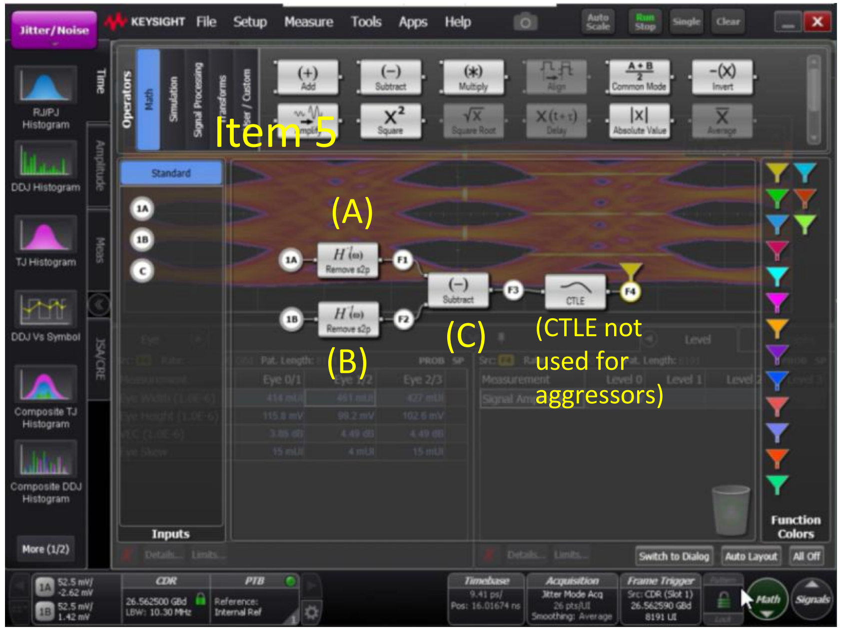


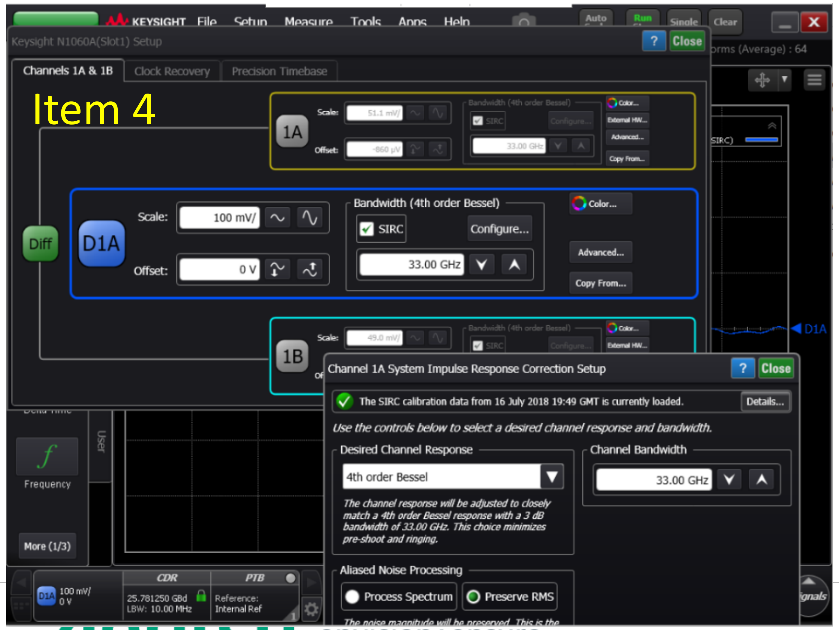
Scope Setting Overview

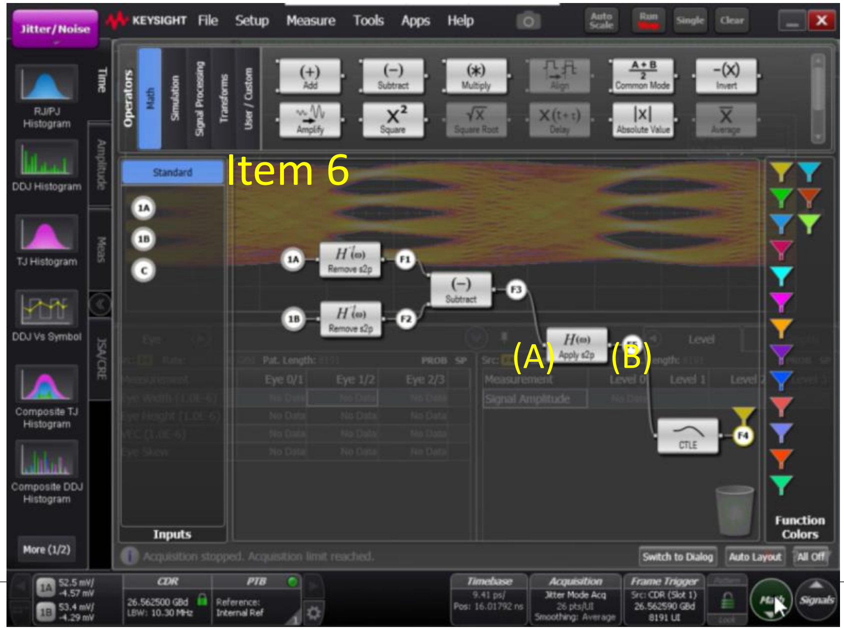
Not detailed in this document, the DCA-X must be pre-configured as follows before any calibration measurements are made.

1. Perform mainframe / module / time-base calibration.
2. Attach proper V (1.85mm) skew matched cable assemblies to scope channels. S-parameter data to 70GHz minimum must exist for each cable. This data used to compensate measurement channel.
3. Perform DCA-X channel de-skew procedure using pre-attached V measurement cables. Must use external trigger for this step. Scope CR cannot be used. Use manual hardware de-skew to fine-tune if necessary.
4. Adjust scope BW to 33GHz 4-th order Bessel response.
5. Configure scope math function to de-embed cables from the channel 1 (A) and channel 2 (B) measurement paths (remove s-parameters function). Use scope math function to create a differential signal (C) from the resulting cable de-embedded signals.
6. Configure Emulated Loss Channel (A) and CTLE block (B) when measuring DUT output parameters through far-end emulated channel.
7. AC-Common-Mode Voltage measurement must also be configured using scope math function.
8. After performing above steps, determine scope attenuation factors by measuring the difference between power meter and scope measurement of 6.445GHz CW signal. These differences are entered as external attenuation in the External HW section. See MOI worksheet tab for additional information.

Scope Figures Referenced in Previous Slide







Target Test Platform (Diagram Implementation)

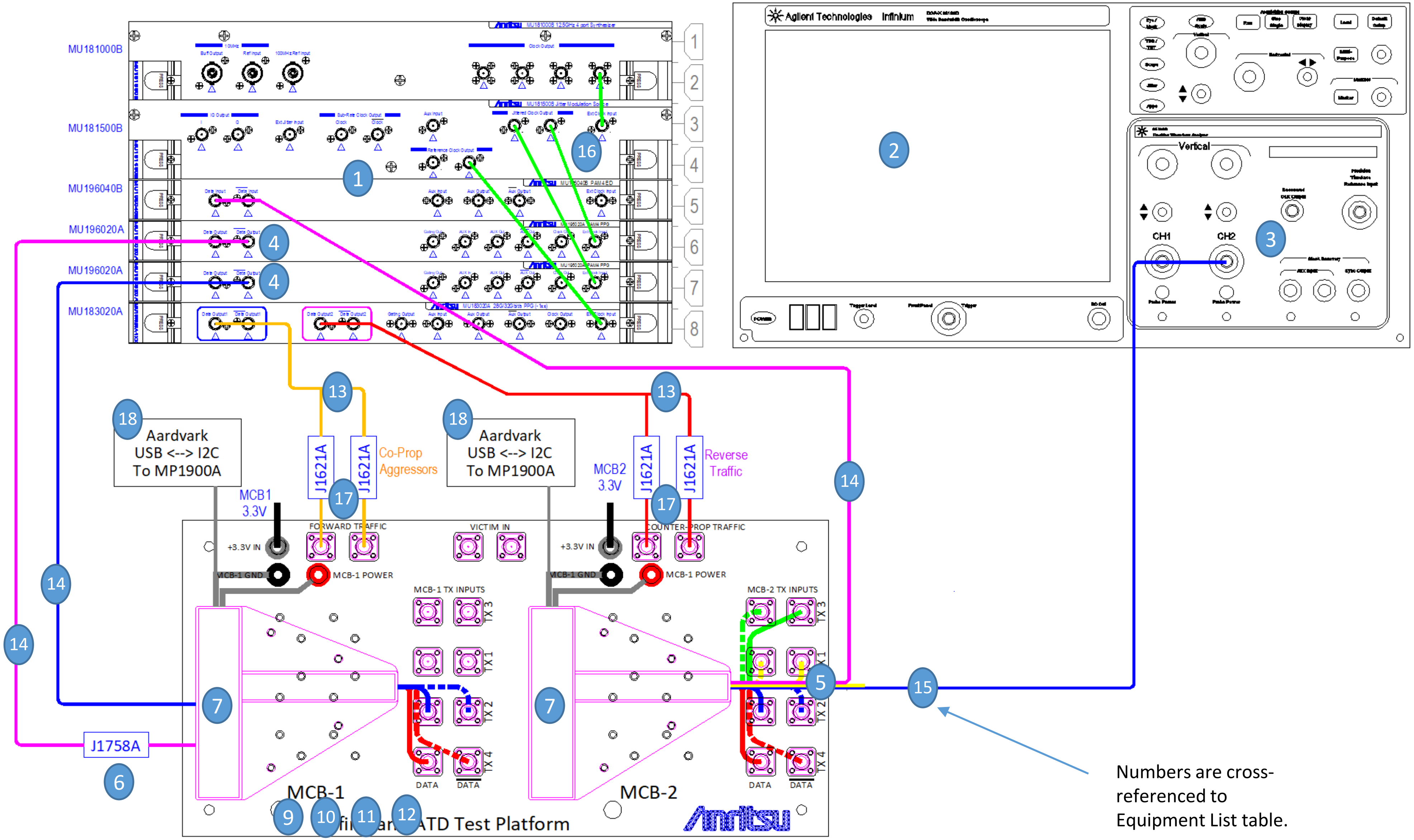
Final test platform as shown.

Single MP1900A mainframe provides all victim & aggressor signals to test fixtures and Cable Under Test.

Error Detector measures BER at DUT Rx1 output

DCA measures quality of signal at DUT RX2 output.

DUT I2C interfaces controlled by Aardvarks.

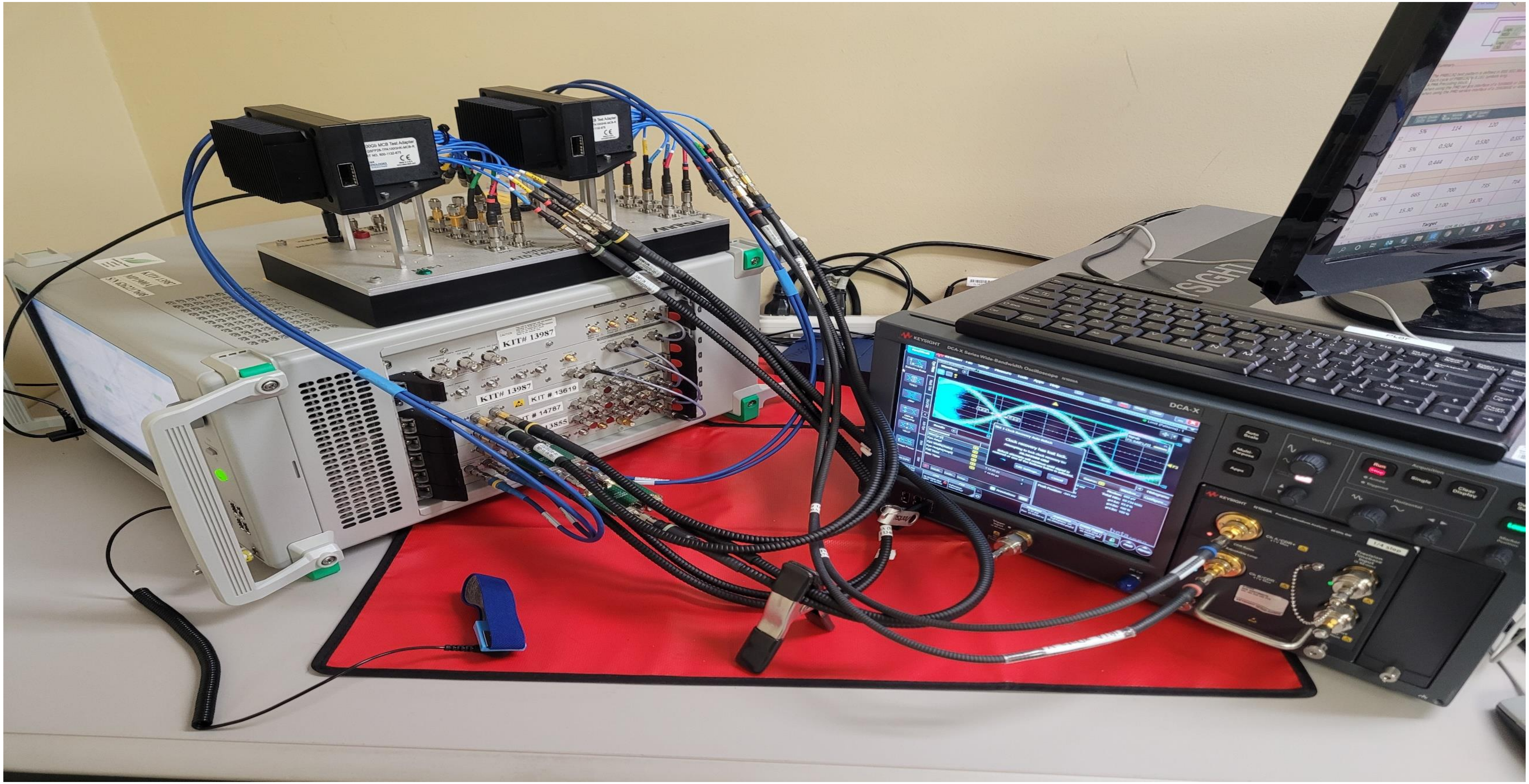


Numbers are cross-referenced to Equipment List table.

Equipment List

Item #	Description	Vendor	Part #	Qty	Function / Details
1	Signal Quality Analyzer	Anritsu	MP1900A	1	Signal Source for traffic and jitter impairments
2	Sampling Scope Mainframe	Keysight	DCA-X 86100	1	Scope Mainframe
3	Sampling Scope Module	Keysight	N1060A	1	Sampling module for all time domain measurements.
4	V Male - K Female Adaptors	Anritsu	34VKF50	4	Conversion from PPG1, PPG2 V to J1741A K
5	V Female - K Male Adaptors	Anritsu	34VFK50A	2	Conversion from MCB K to J1790A V
6	ISI Channel	Anritsu	J1758A	1	Fixed ISI Channel
7	MCB	Wilder Technologies	QSFP28-TPA100G-MCB-R	2	Module Compliance Board for AOC testing.
8	HCB	Wilder Technologies	QSFP28-TAP100G-HCB-P	1	Host Compliance Board (module) used for ATD calibration.
9	ATD Test Platform	Anritsu	AER-1004	1	Test platform to support for equipment / MCB / DUT connections
10	Power Divider	Anritsu	K240A	4	PPG signal division for driving all AOC lanes. Embedded inside AER-1004
11	Power Splitter	Anritsu	K241A	8	PPG signal division for driving all AOC lanes. Embedded inside AER-1004
12	K Cables, 0.24m	CW Swift	EP7024R-6	21	Interconnect cables for driving AOC lanes. Embedded inside AER-1004
13	K Cables, 0.8m	Anritsu	J1551A	2	Interconnect cables for aggressor signals. Skew matched pairs.
14	K Cables, 0.8m	Anritsu	J1741A	6	Interconnect cables for victim input & output signals. Length specific cables.
15	V Cables, 0.8m	Anritsu	J1790A	2	Scope measurement cables. Length specific cables.
16	SMA Cables, 0.3m	Anritsu	J1349A	4	Interconnect cables for MP1800A Clocking and Scope Triggering
17	3dB Passive Equalizer	Anritsu	J1621A	4	Equalization for aggressor signals
18	I2C/SPI Host Adapter	Aardvark	TP240141	2	AOC Programming
19	Clip Lead Set	Aardvark	TP240411	2	Interfaces between DB9 and MCB terminal block for programming
20	3.3V/ 10W Supply	Phihong	PSAA20R-033	2	AOC Power Supplies
21	50 Ohm Terminations	-	-	-	Terminate unused ports during test and calibration
22	Synthesizer	Anritsu	MG3692C	1	Signal source for scope calibration
23	Power Meter	Anritsu	ML2437A	1	Power Meter Control Unit
24	Power Sensor	Anritsu	MA2482D	1	Power Sensor, 10MHz - 18GHz

Target Test Platform (Photo Implementation)



Loss Channel

Final loss channel selection to be made upon completion of all s-parameter measurements.

Final Loss Channel includes Wilder Tech QSFP28 MCB + HCB + Anritsu J1758A channel + J1741A cables.

PPG ISI function will be used to fine-tune tune to 10dB Insertion Loss. *(Setting of -1.73dB to compensate for excess physical loss)*

From IBTA Specification

$$Insertion\_loss(f) \le \begin{cases} 0.05 + 1.8\sqrt{f} + 0.2705f & 0.01 \le f \le 13.28 \\ -4.0096 + 1.07f & 13.28 < f \le 26.5625 \end{cases} (\mathrm{dB}) \quad (120E\text{–}1)$$

where

f is the frequency in GHz

Insertion_loss(f) is the 200GAUI-4 or 400GAUI-8 chip-to-module insertion loss

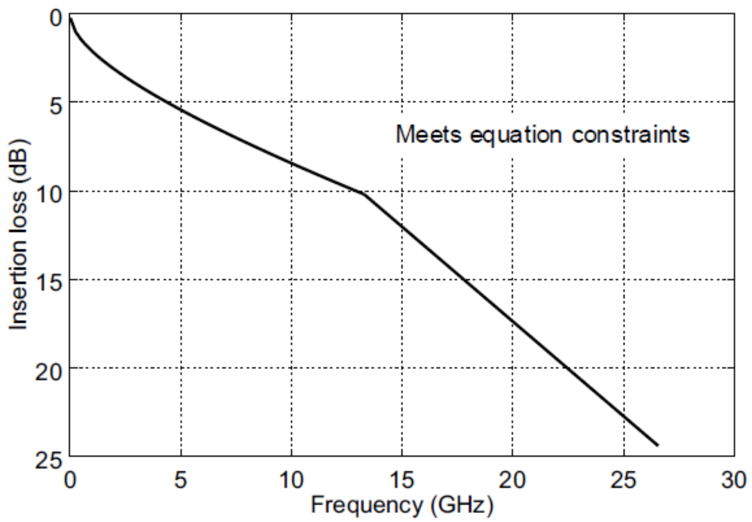
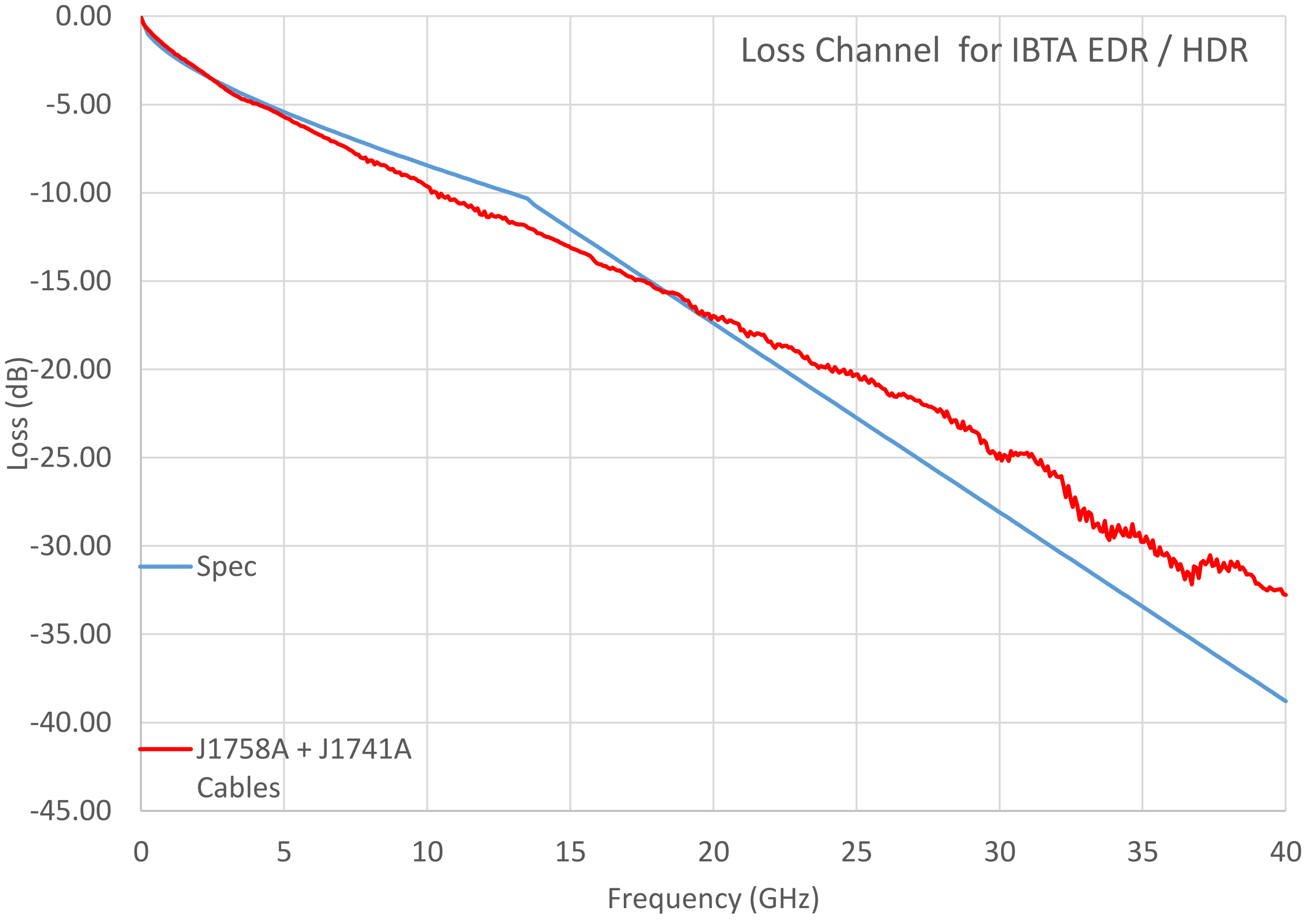
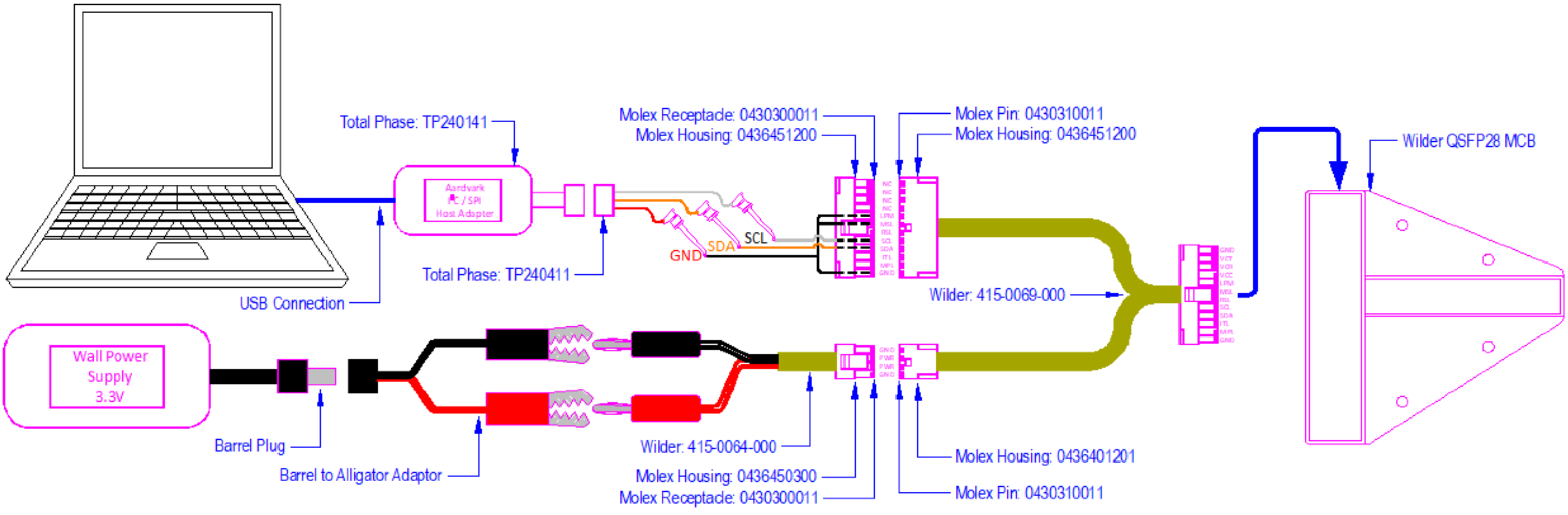


Figure 120E–4—Recommended 200GAUI-4 or 400GAUI-8 chip-to-module channel insertion loss

Actual Test Data



I2C Interface



Notes:

- Discrete connection shown above using banana and clip lead cable assemblies.
- Custom cable assembly typically used at Plugfests which directly connects I2C signals & power across Aardvark, ATD test fixture and MCB.

Measurement Targets

Calibration (DUT Input)

HDR Calibration Parameter	Unit	Tol. (+/-)	Min	Nominal	Max	Window Size	Source
Forward Data Rate	Gbaud	0.01%	-	26.56250	-	-	v2r1_4.171005.pdf
Counter FEXT Aggressors Vp-p	mV	5%	428	450	473	45	Table 103 v2r1_5.200930.pdf
Counter FEXT Aggressors Transition Speed	ps	18%	13.94	17.00	20.06	6.12	Table 103 v2r1_5.200930.pdf
PPG Cal: Eye Sym Mask Width	UI p-p	20%	0.176	0.220	0.264	0.088	Table 120E-8
	ps p-p	20%	6.83	8.53	10.24	3.41	802.3bm, Annex 120E
PPG Cal: Even Odd Jitter	UI p-p	20%	0.015	0.019	0.023	0.008	Table 120E-8
	ps p-p	20%	0.59	0.74	0.88	0.29	802.3bm, Annex 120E
PPG Cal: J4u	UI rms	10%	0.106	0.118	0.130	0.024	Table 120E-8
	ps rms	10%	4.12	4.58	5.03	0.92	802.3bm, Annex 120E
PPG Cal: Jrms	UI rms	10%	0.021	0.023	0.025	0.005	Table 120E-8
	ps rms	10%	0.80	0.89	0.98	0.18	802.3bm, Annex 120E
PPG Cal: Eye Width	UI p-p	10%	0.198	0.220	0.242	0.044	Table 120E-8
	ps p-p	10%	7.68	8.53	9.39	1.71	802.3bm, Annex 120E
PPG Cal: SJ Injection	UI p-p	10%	0.045	0.050	0.055	0.010	Table 120E-8
	ps p-p	10%	1.75	1.94	2.13	0.39	802.3bm, Annex 120E
Forward Traffic Eye Height	mV	5%	30	32	34	3	Table 103 v2r1_5.200930.pdf
Forward Traffic Eye Width	UI p-p	5%	0.209	0.220	0.231	0.022	Table 103 v2r1_5.200930.pdf
Forward Traffic Total Jitter	UI p-p	5%	0.769	0.780	0.791	0.02	Calculated
Counter NEXT Aggressors Vp-p	mV	5%	836	880	924	88	Table 104 v2r1_5.200930.pdf
Counter NEXT Aggressors Transition Speed	ps	10%	15.30	17.00	18.70	3.40	Table 104 v2r1_5.200930.pdf

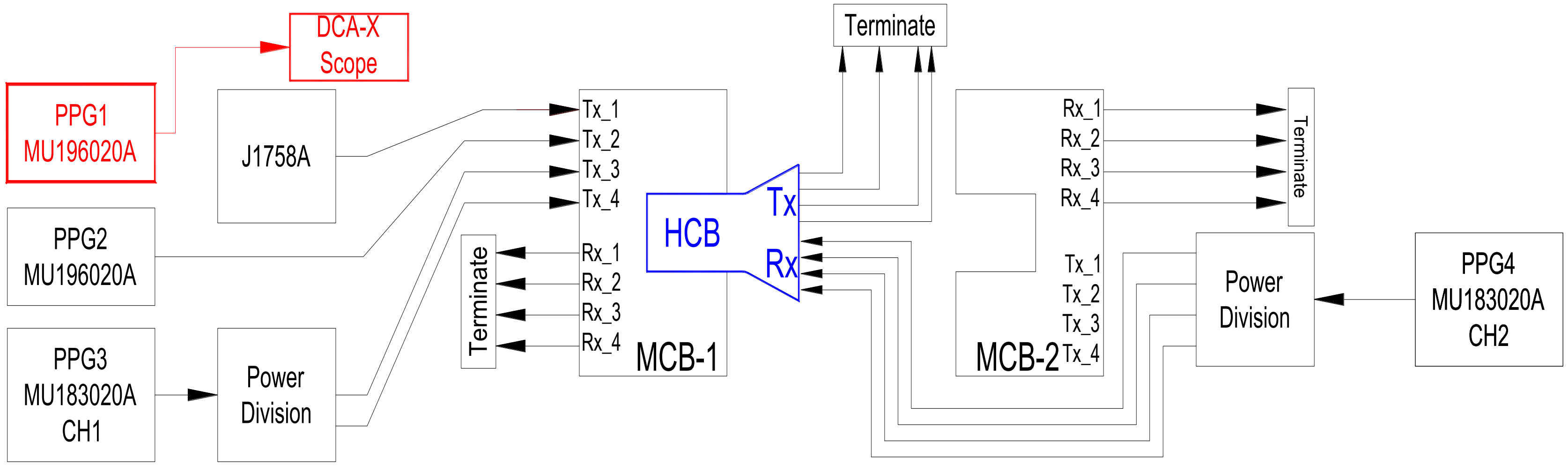
Compliance (DUT Output)

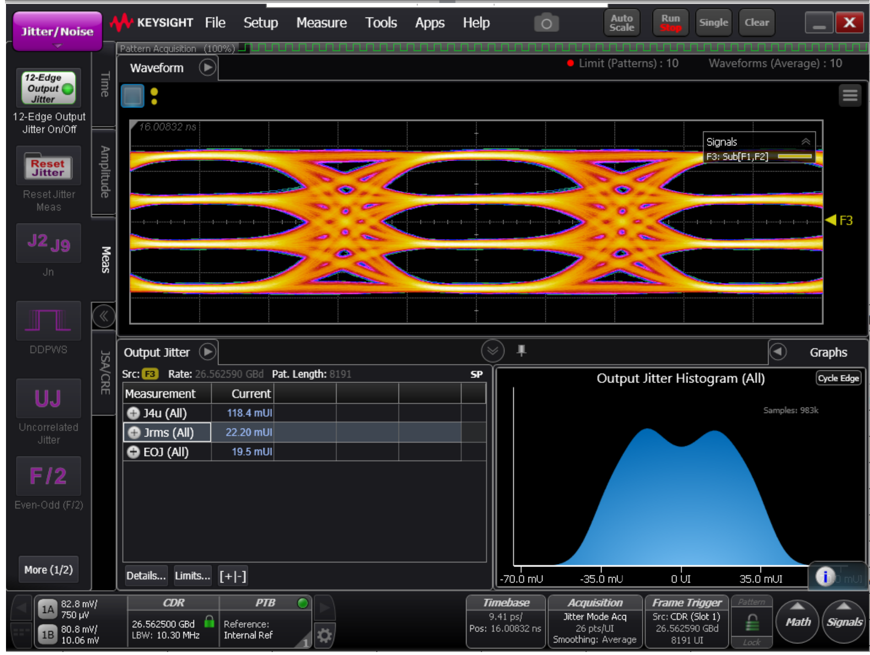
HDR DUT Parameter	Unit	Min	Max	Source
Near-End Eye Symmetry Mask Width	UI p-p	0.265	-	Table 104 v2r1_5.200930.pdf
Far-End Eye Symmetry Mask Width	UI p-p	0.200	-	Table 104 v2r1_5.200930.pdf
Near-End Eye Height	mV	70.00	-	Table 104 v2r1_5.200930.pdf
Far-End Eye Height	mV	30.00	-	Table 104 v2r1_5.200930.pdf
Differential Unsigned Voltage	mV	450.00	-	Table 104 v2r1_5.200930.pdf
Far-end precursor ISI ratio	%	-7.00	4.00	Table 104 v2r1_5.200930.pdf
BER 2 minute Gate	-	-	1.00E-05	Error Free. Lane 0. Working Group Discussions
AC common mode output voltage	mV	-	20	Table 104 v2r1_5.200930.pdf

Calibration Step 1: Set Baseline PPG Jitter

Intrinsic jitter characteristics targets for Random Jitter, Bounded Uncorrelated Jitter (BUJ), Odd/Even Jitter and Sinusoidal Jitter (SJ) are adjusted and verified in this calibration step.
Signal measured directly at the output of the pattern generator.
Red elements indicate the relevant signal sources, paths and measurement equipment.

Instruments to Adjust	Setting Notes
MU196020A PPG1, Channel 1 **MU181500B Jitter Module**	MU196020A: Set amplitude, level balance, HPJ, QPRBS13 pattern MU181500B BUJ: Bit Rate 2.65625 Gb/s, 200MHz, PRBS7 (for baseline J4u) MU181500B SJ1: Frequency = 91MHz (50mUI per tolerance chart) MU181500B SJ2: Frequency = 87MHz (for baseline Jrms) MU181500B RJ: Unfiltered (baseline) Objective: Determine jitter set points to achieve calibration targets as measured by DCA-X Sample measurements shown in scope images (RLM, Eye Width, DJ, J4u, Jrms, EOJ)

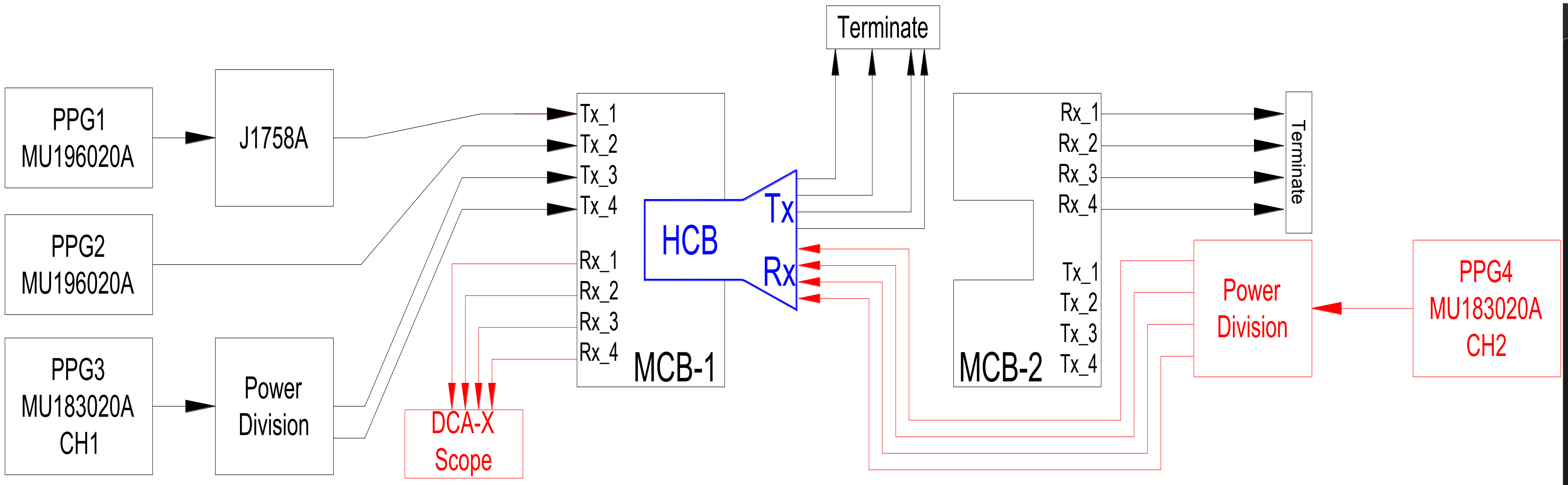


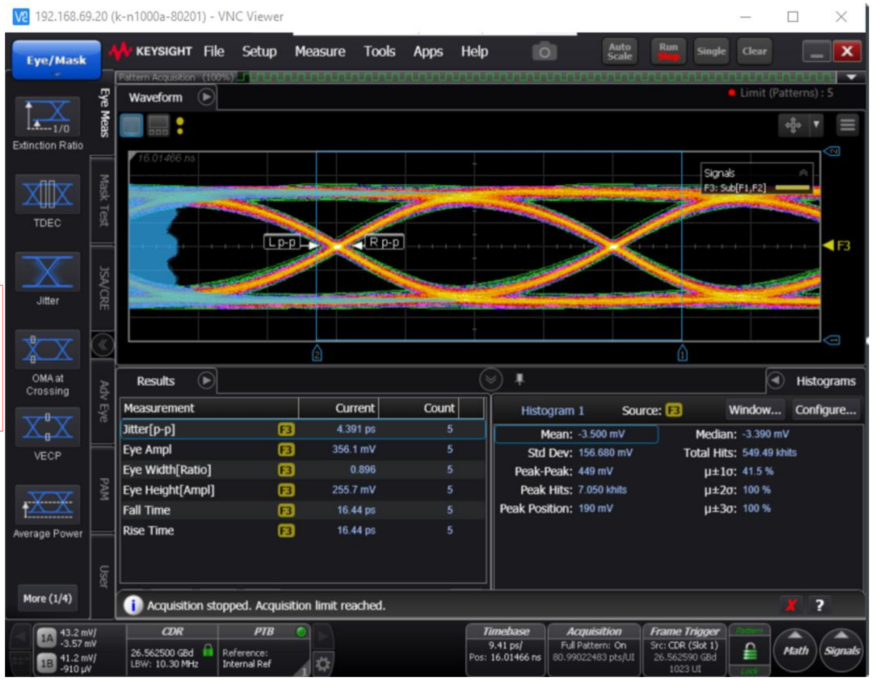


Calibration Step 2: Counter-Prop FEXT Aggressors

Set counter-propagating aggressor crosstalk for the victim calibration in later steps.
Counter-propagating aggressor signals are applied into the HCB and measured at corresponding points on MCB-1 using the scope.
Red elements indicate the relevant signal sources, paths and measurement equipment.

Instruments to Adjust	Setting Notes
MU183020A, PPG4, Channel 2	MU183020A: Calibrate using PRBS10. Final Test using PRBS31 pattern. Objective: Determine amplitude set point to achieve calibration targets as measured by DCA-X Sample measurements shown in scope images (Histogram Peak-Peak, Rise Time, Fall Time)

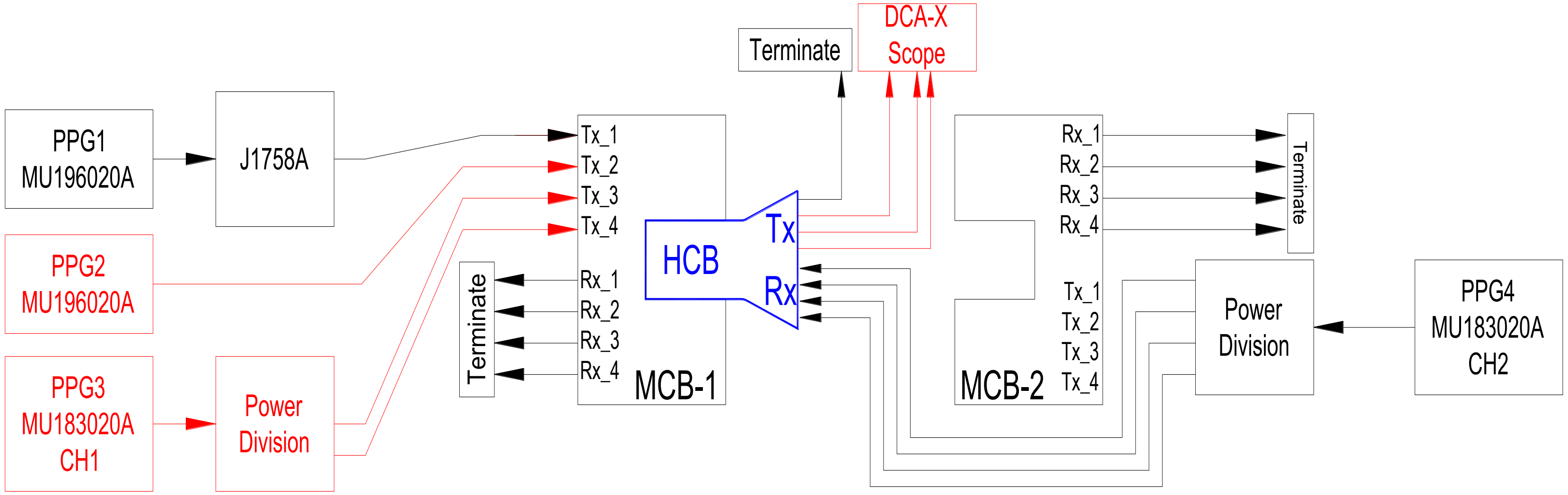


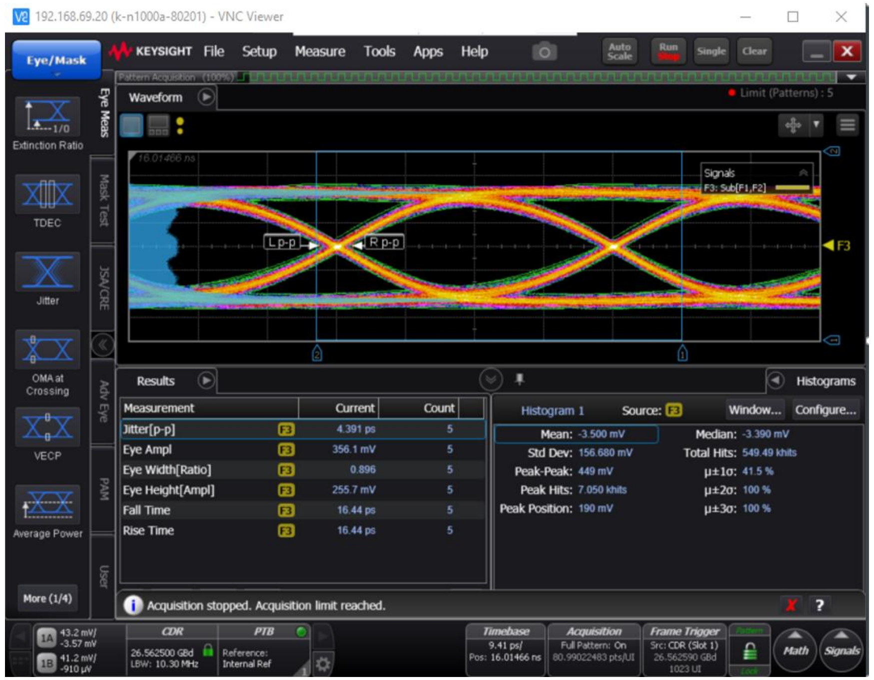


Calibration Step 3: Co-Prop FEXT Aggressors

Set co-propagating aggressor crosstalk for the victim calibration in later steps. Co-propagating aggressor. signals are applied into the MCB and measured at corresponding points on HCB using the scope.
Red elements indicate the relevant signal sources, paths and measurement equipment.

Instrument to Adjust	Setting Notes
MU196020A, PPG1 MU183020A, PPG2, Channel 1	MU18x020A: Calibrate using PRBS10. Final Test using PRBS31 pattern. Objective: Determine amplitude set point to achieve calibration targets as measured by DCA-X Sample measurements shown in scope images (Histogram Peak-Peak, Rise Time, Fall Time)

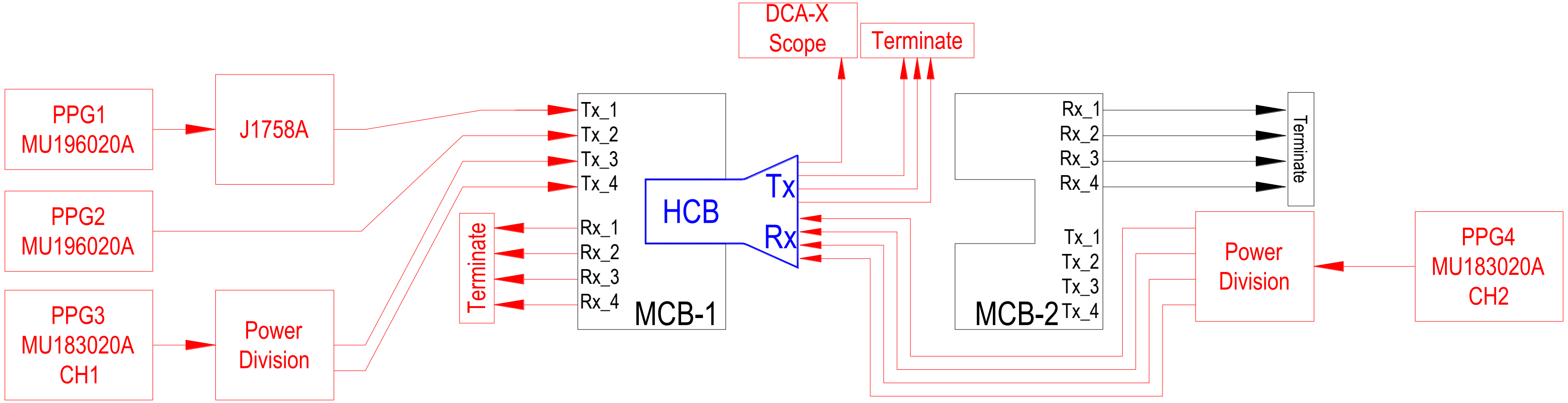




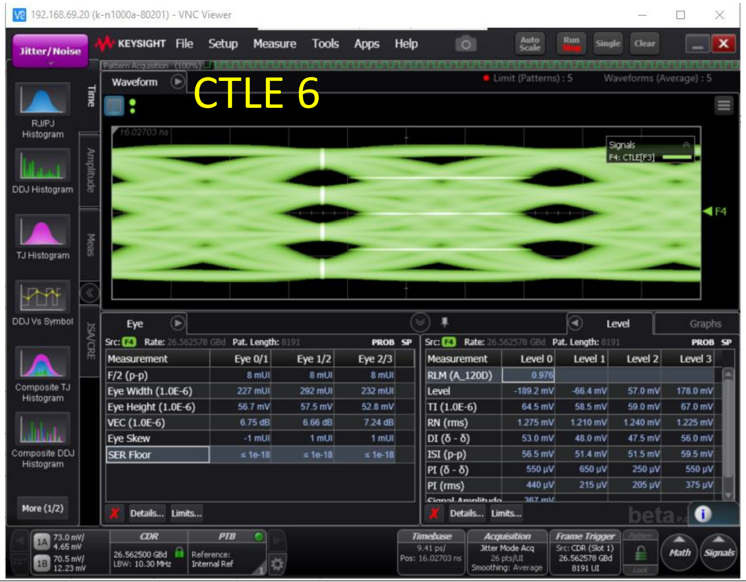
Calibration Step 4: Scope CTLE Setting

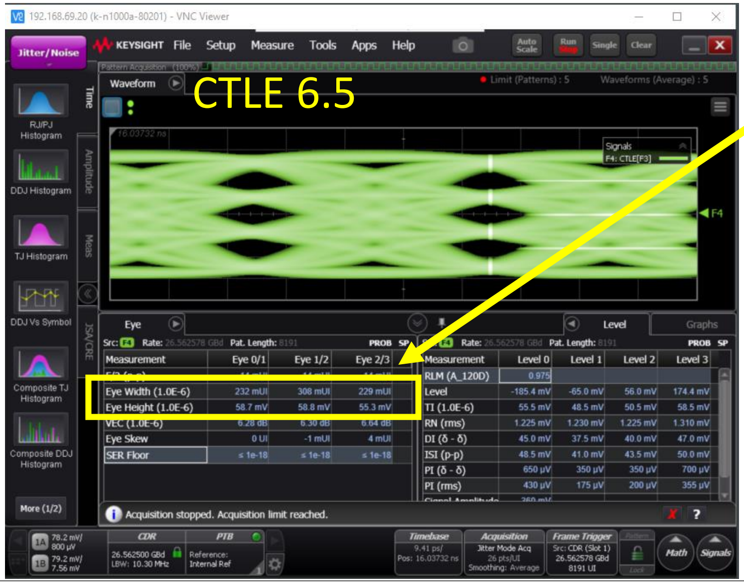
The DCA-X CTLE function simulates the DUT CTLE. Find DCA-X CTLE setting to produce maximum Eye Width x Eye Height product at specified BER.
That CTLE Setting must be used for Final Victim Eye Width / Height Calibration

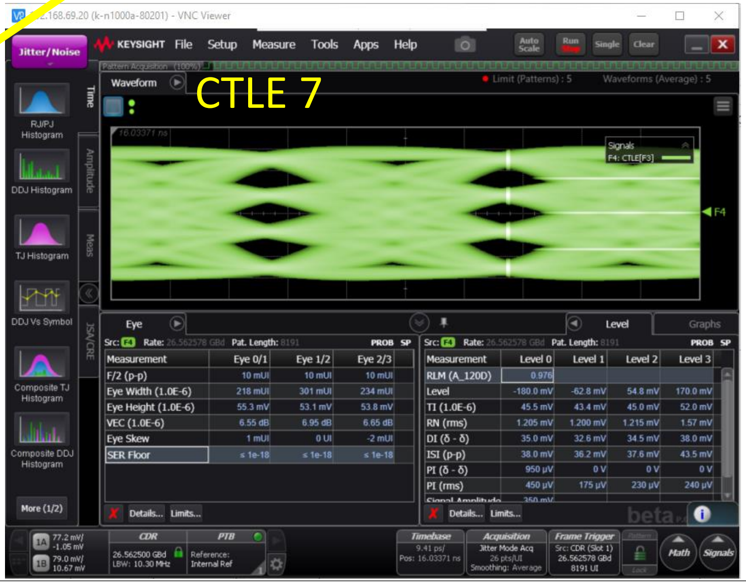
Instrument to Adjust	Setting Notes
No PPG set points adjusted here. Apply ALL previous calibrated signals shown in red.	Advance through all scope CTLE Settings to find the maximum Eye Width x Eye Height product. Select ONLY IEEE 802.3bs CDAUI-8 Presets in 0.5dB steps (when needed).



CTLE	EW	EH	Product
0	-	-	-
1	-	-	-
2	-	-	-
3	-	-	-
4	70	6	420
5	184	33	6072
5.5	209	45.8	9572.2
6	227	56.7	12870.9
6.5	232	58.7	13618.4
7	218	55.3	12055.4
8	204	45	9180
9	176	30.8	5420.8

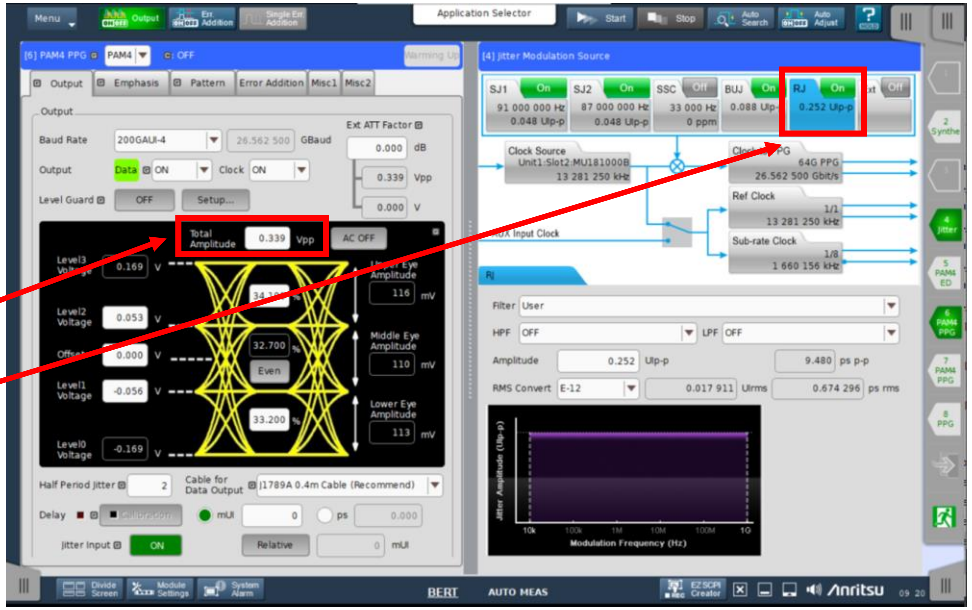




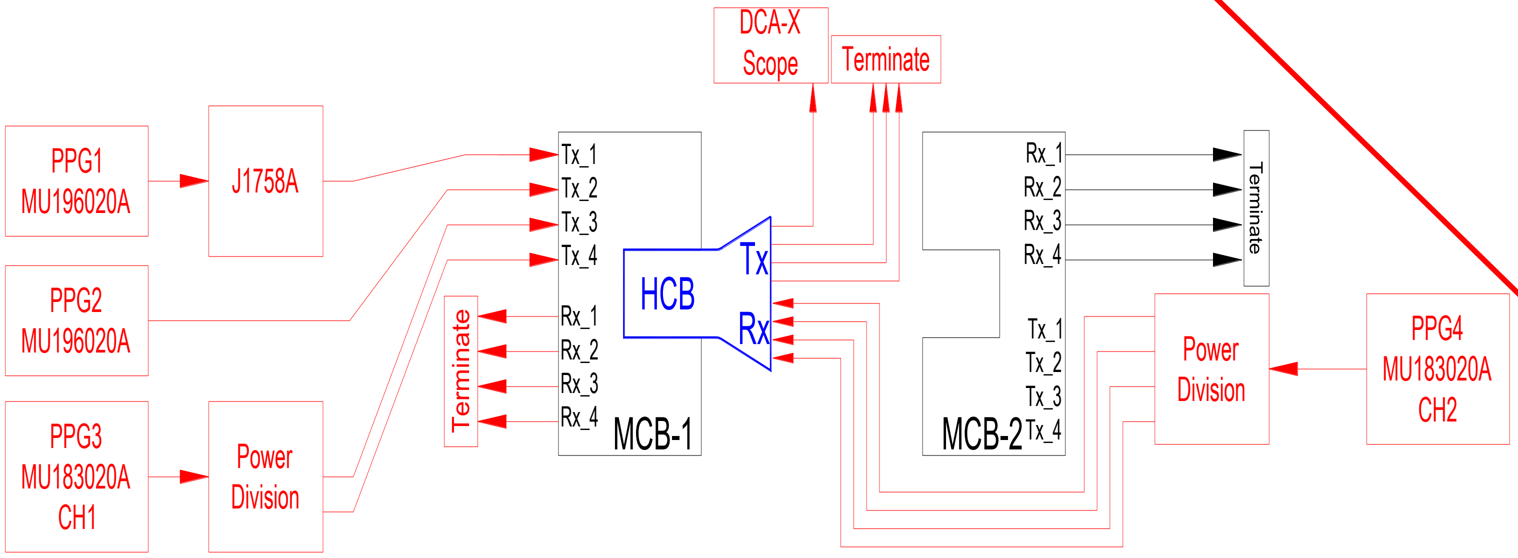


Calibration Step 5: Final Eye Width/Height

Achieve eye width and height calibration targets with all stressors and aggressor traffic enabled.
All measurements to be performed at previously determined scope CTLE setting.



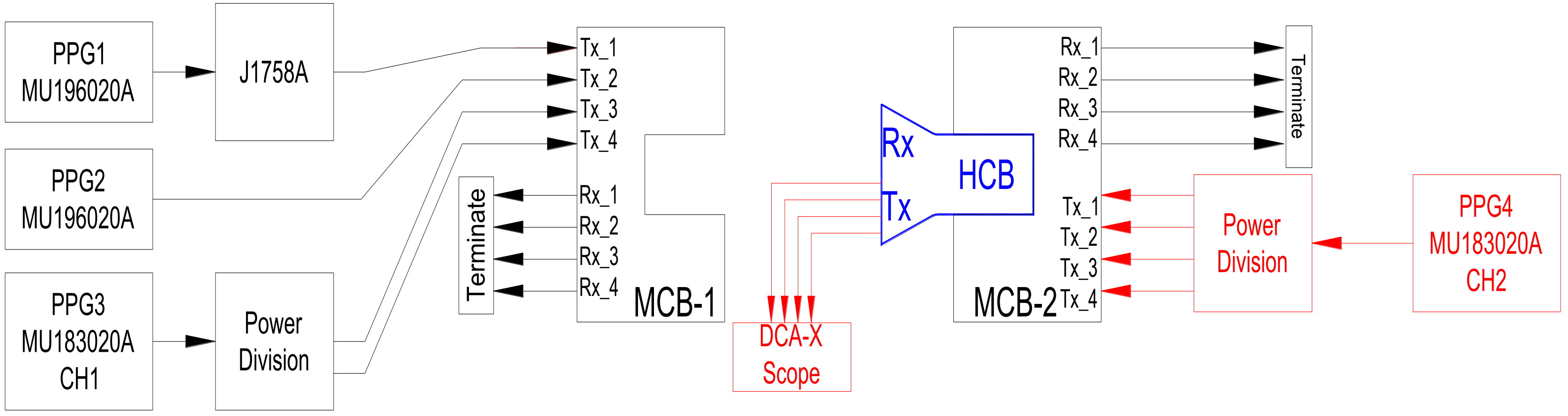
Instrument to Adjust	Setting Notes
MU196020A PPG1, Channel 1 **MU181500B Jitter Module**	MU196020A: Set amplitude to achieve final Eye Height MU181500B RJ: Set amplitude to achieve final Eye Width Sample measurements shown in scope images (Eye Width, Eye Height)

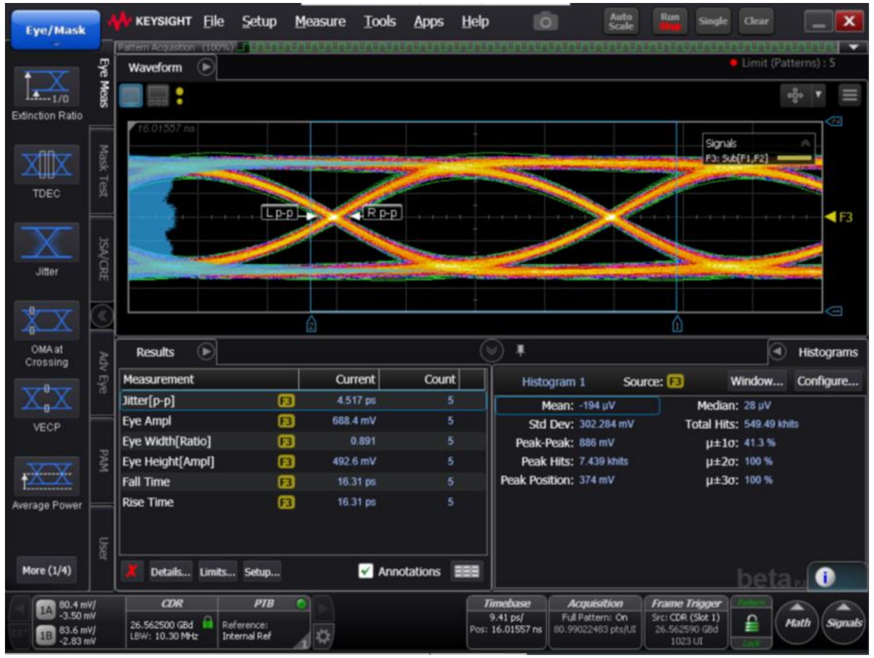


Calibration Step 6: Counter-Prop NEXT Aggressors

Set counter-propagating aggressor crosstalk for the victim calibration in later steps.
Counter-propagating aggressor signals are applied into the HCB and measured at corresponding points on MCB-2 using the scope.
Red elements indicate the relevant signal sources, paths and measurement equipment.

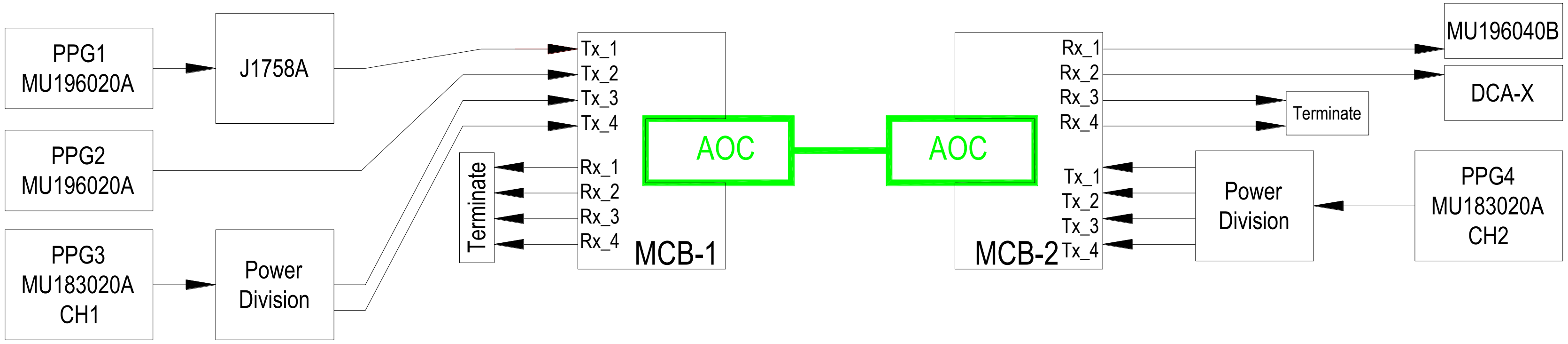
Instruments to Adjust	Setting Notes
MU183020A, PPG4, Channel 2	MU183020A: Calibrate using PRBS10. Final Test using PRBS31 pattern. Objective: Determine amplitude set point to achieve calibration targets as measured by DCA-X Sample measurements shown in scope images (Histogram Peak-Peak, Rise Time, Fall Time)

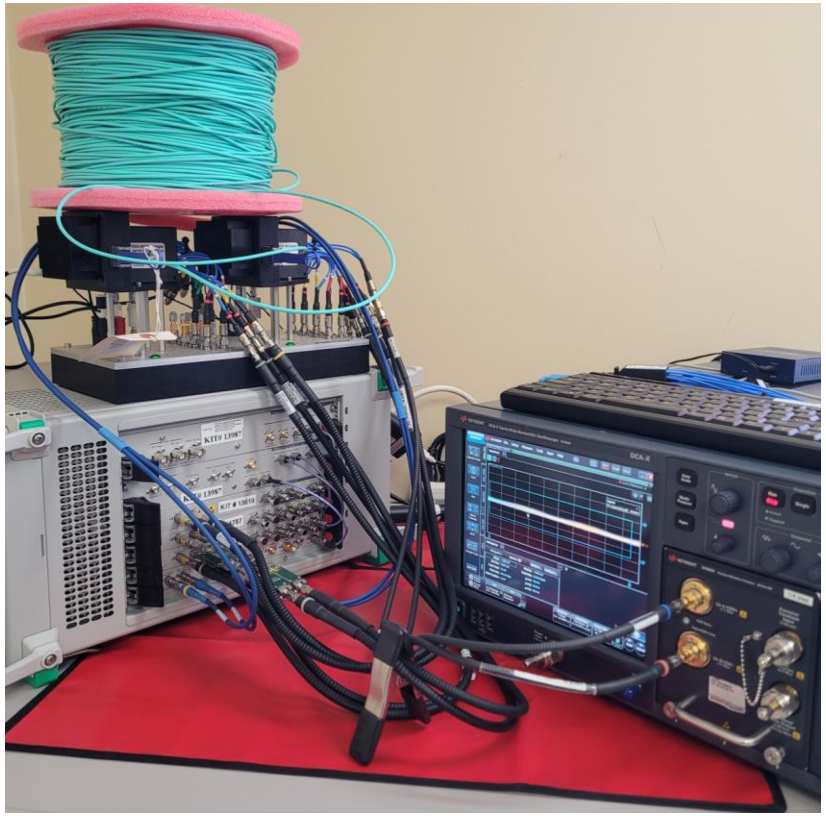


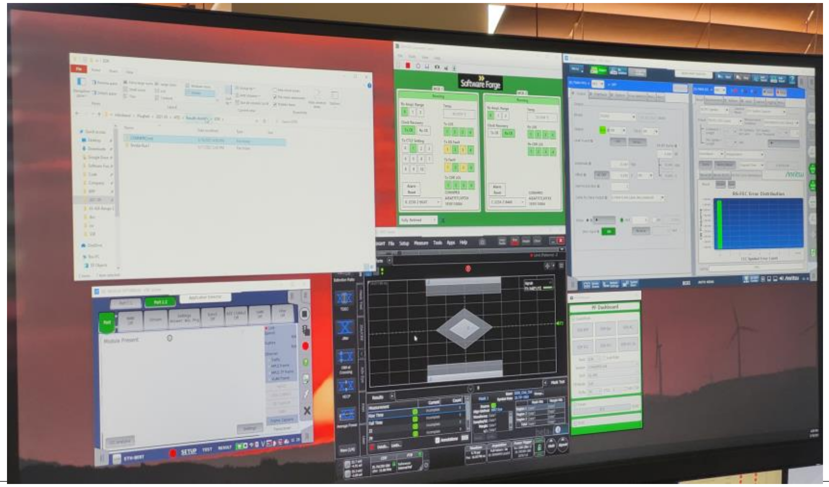


Compliance Test

Test DUT as shown, applying all stressors and aggressor traffic as previously calibrated.







Final Test Notes:

1. Software Forge EEPROM Command Center (ECC) used to configure DUT for proper ranges, CTLE, and clock recovery settings.

2. Final DUT parameters include:
   - BER
   - Near & Far end Eye Width Mask Symmetry (Far-end is emulated in scope using channel model)
   - Near & Far end Eye Height (Far-end is emulated in scope using channel model)
   - Transition Speed per specification
   - AC Common-Mode Output Voltage

HDR Compliance Specifications

Scope auto-measurements to determine parameters:

- ESMEn, ESMEf
- EHn, EHf
- Far-end pre-cursor ISI ratio

MP1900A to determine parameters:

- Bit Error Rate
- PAM4 Symbol Error Rate
- FEC Symbol Error Rate
- FEC Uncorrectable Error Rate

6.9.2.4.2 HDR LIMITING ACTIVE CABLE OUTPUT REQUIREMENTS

Each electrical output lane and signal of the HDR active cable when measured at TP7a shall meet the specifications of Table 104 while the signals on all input lanes at the other end of the cable comply with the specifications of Table 103 on page 386 and the specified crosstalk signals are applied to all lanes of the active cable's electrical input at the output end of the cable. The active cable electrical output shall be AC coupled; i.e. it shall present a high DC common-mode impedance at TP7a. There may be various methods for AC coupling in actual implementations.

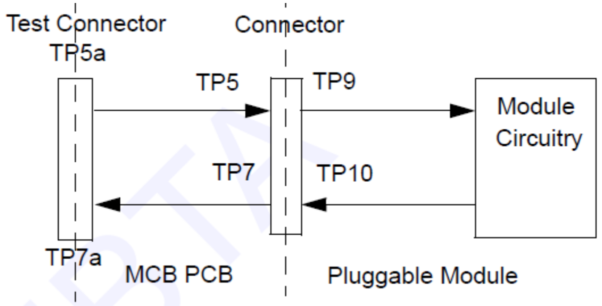


Figure 96 Module compliance board test points, pluggable module

Table 104 HDR limiting active cable output electrical specifications

Symbol	Parameter	Specification value(s)	Unit	Conditions/Comments
	Crosstalk signal V pk-pk, each aggressor	880 +/- 10%	mV	At TP6a. Counter-propagating aggressors.[a] Transition time measured at PRBS13Q positions given in 802.3 120E 3.1.5
	Crosstalk signal transition time, 20%-80%	17 +/- 3	ps	

Symbol	Parameter	Max	Min	Unit	Conditions/Comments
	Bit Error Rate	9E-6			Stressed input signal to cable
Vout	Single-ended output voltage	2.85	-0.35	V	Referred to Signal Ground; measured at TP7a
V_{CM}	AC common mode output voltage	20		mV	(RMS); at TP7a
	Differential termination mismatch	5		%	1 MHz; at TP7a
S_{DD22}	Differential output return loss	Equation 27 on page 377		dB	At TP7a, 50 MHz to 26 GHz
S_{CC22}	Common mode output return loss	-2		dB	At TP7a, 200 MHz to 26 GHz
S_{DC22}	Common mode to differential reflection	Eq. 28 on page 378		dB	At TP7a, 50 MHz to 26 GHz
t_r, t_f	Output transition time, 20-80%		9.5	ps	PRBS13Q, see 120E.3.1.5 for positions in the pattern
ESMWn	Near-end eye symmetry mask width		0.265	UI	At TP7a Ref: 802.3 120E.4.2
Y2	Differential unsigned output voltage		450	mV	At TP7a. Hit Ratio=5E-5 with 100 Ω load.
EHn	Near-end eye height (differential)		70	mV	
ESMWf	Far-end eye symmetry mask width		0.2	UI	
EHf	Far-end eye height (differential)		30	mV	
	Far-end pre-cursor ISI ratio		-7 to +4	%	At TP7a

a. Please refer to CIWG Method of Implementation (MOI) document Active Time Domain Testing for detailed specification of testing methodology and parameters.

Anritsu
envision : ensure