

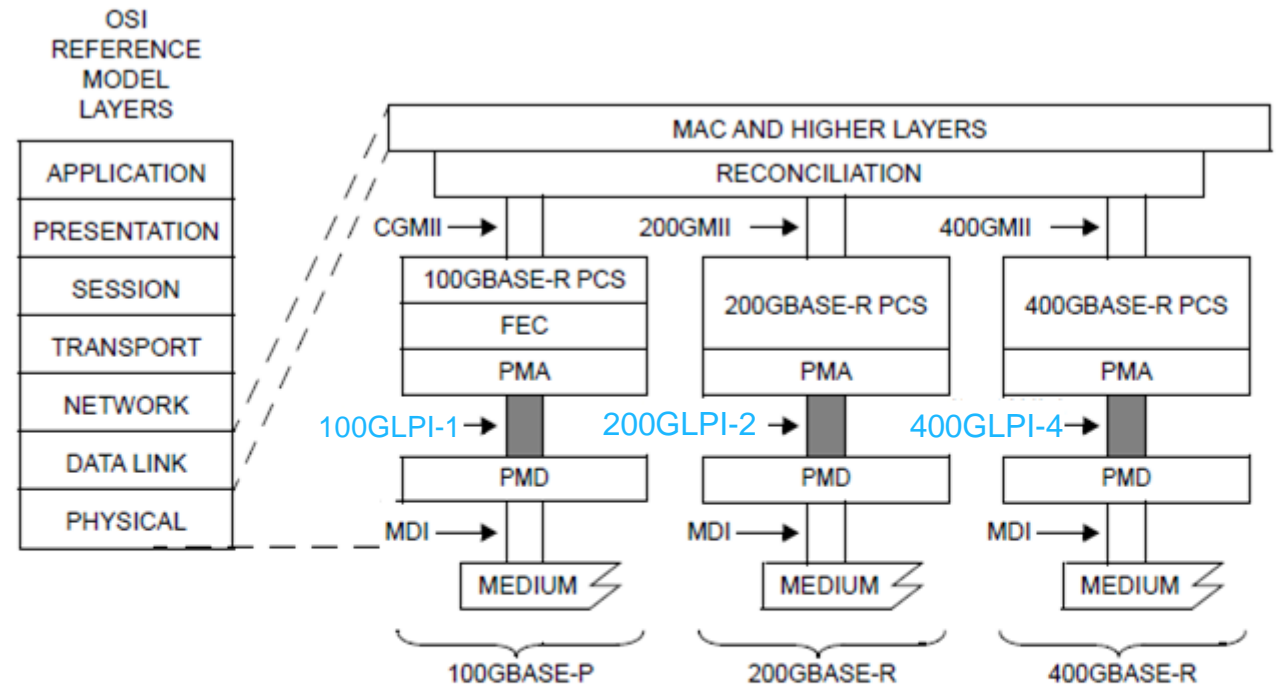
Baseline Linear Physical Interface Proposal

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LINEAR PHYSICAL INTERFACE (LPI)

- > LINEAR PHYSICAL INTERFACE (LPI) is an **optional PMD service interface for the PMDs in Clause 124, 140, 151, and TBD**. It allows the construction of compact optical transceiver modules for SMF and MMF applications with no clock and data recovery / DSP circuits inside....
- > Figure TBD shows the relationship of the LPI interface with other sublayers to the ISO/IEC Open System Interconnection (OSI) reference model ...

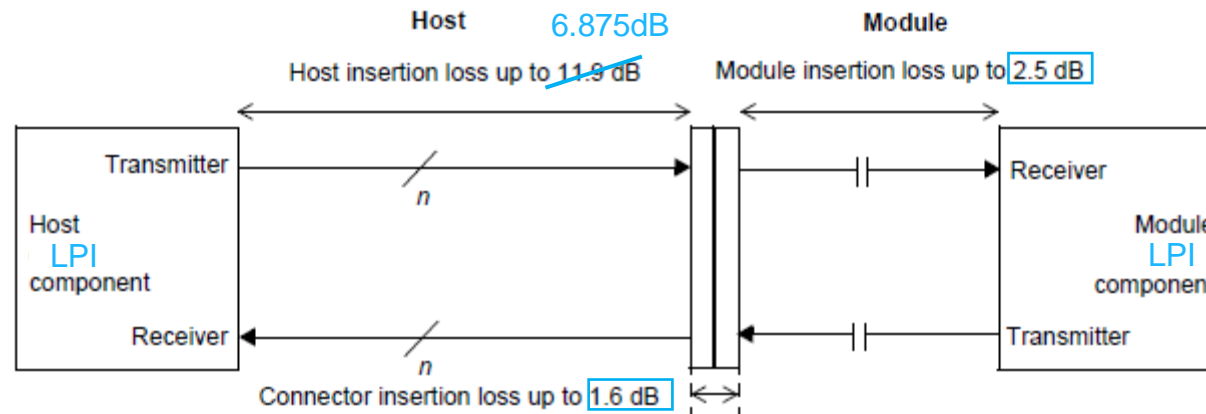


100GAUI-1 = 100 Gb/s ONE-LANE ATTACHMENT UNIT INTERFACE
 200GMII = 200 Gb/s MEDIA INDEPENDENT INTERFACE
 400GAUI-4 = 400 Gb/s FOUR-LANE ATTACHMENT UNIT INTERFACE
 400GMII = 400 Gb/s MEDIA INDEPENDENT INTERFACE
 MAC = MEDIA ACCESS CONTROL
 CGMII = 100 Gb/s MEDIA INDEPENDENT INTERFACE

200GAUI-2 = 200 Gb/s TWO-LANE ATTACHMENT UNIT INTERFACE
 FEC = FORWARD ERROR CORRECTION
 MDI = MEDIUM DEPENDENT INTERFACE
 PCS = PHYSICAL CODING SUBLAYER
 PMA = PHYSICAL MEDIUM ATTACHMENT
 PMD = PHYSICAL MEDIUM DEPENDENT

Channel Insertion Loss Budget & Host LPI

- Align host loss with 100GBASE-CRx



Note—The number of lanes n is equal to 1 for 100GAUI-1, 2 for 200GAUI-2, and 4 for 400GAUI-4.

Modified

Figure 120G-2—~~100GAUI-1, 200GAUI-2, and 400GAUI-4 C2M~~ insertion loss budget at 26.56 GHz

100GLPI-1

400GLPI-4

200GLPI-2

- > Modify to specify an electrical TDECQ with minimum swing from host

Modified Table 120G-1—Host output characteristics at TP1a

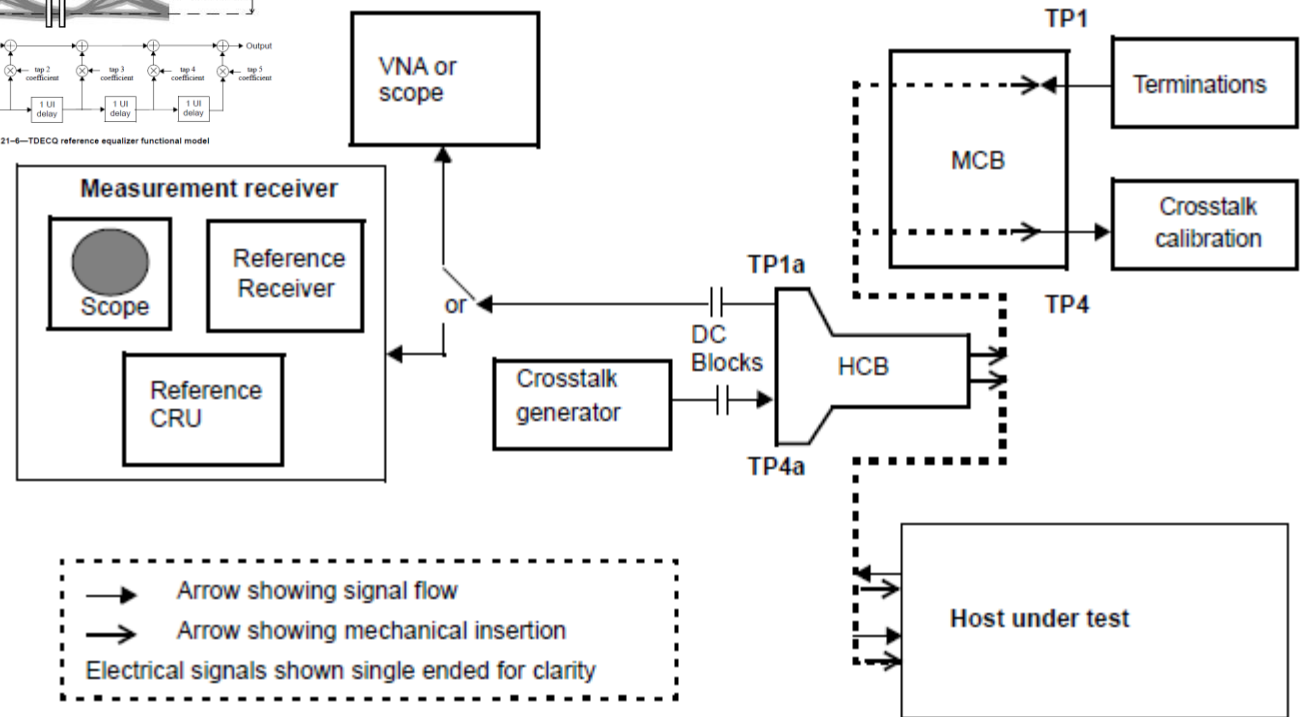
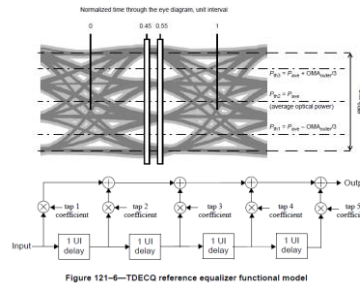
Parameter	Reference	Value	Units
Signaling rate per lane (range)	120G.3.1.1	53.125 ± 100 ppm	GBd
DC common-mode output voltage (max)	120G.5.1	2.8	V
DC common-mode output voltage (min)	120G.5.1	-0.3	V
Single-ended output voltage (max)	120G.5.1	3.3	V
Single-ended output voltage (min)	120G.5.1	-0.4	V
AC common-mode RMS output voltage (max)	120G.5.1	17.5	mV
Differential peak-to-peak output voltage (max) Transmitter disabled Transmitter enabled	120G.5.1	35 870	mV
ESMW (eye symmetry mask width)	120G.3.1.6	TBD	UI
Eye height, differential (min)	120G.3.1.6	15	mV
Vertical eye closure (max)	120G.3.1.6	9	dB
Common-mode to differential return loss (min)	120G.3.1.3	Equation (120G-1)	dB
Effective return loss (min)	120G.3.1.3	TBD	dB
Differential termination mismatch (max)	120G.3.1.4	10	%
Transition time (min, 20% to 80%)	120G.3.1.5	TBD	ps

Insert minimum output voltage pk-pk with value TBDmVppd

Electrical TDECQ: TBD

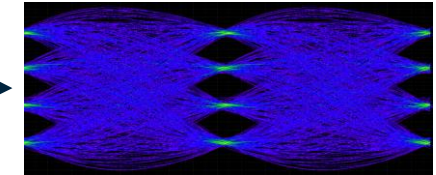
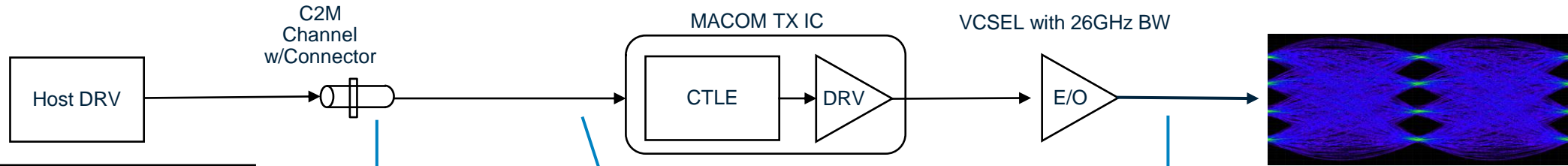
Example host output test configuration

- Modify to evaluate host using similar methodology as PMD
 - CTLE + 5-tap FFE to match SMF TDECQ equalizer



Modified Figure 120G-6—Example host output test configuration

LPI Simulations: Electrical TDECQ & Optical Output



BT Filter = 22GHz

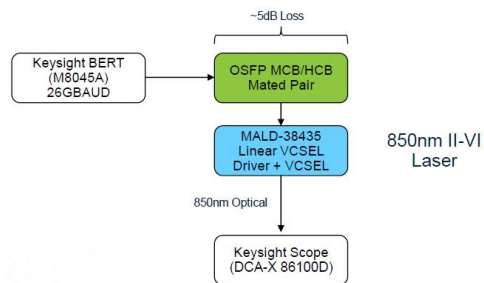
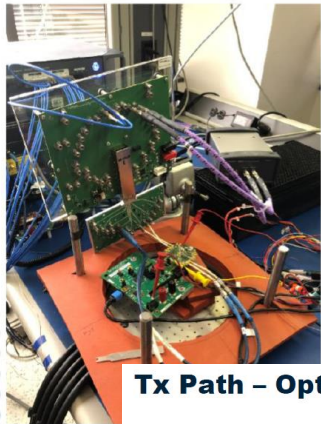
Parameter	Symbol	Value	Units
Device package model			
Single-ended device pad capacitance	C_d	1.2×10^{-4}	nF
Single-ended device series inductance	L_s	0.12	nH
Single-ended device bump capacitance	C_b	3×10^{-5}	nF
Transmission line length, Test 1	z_p	12	mm
Transmission line length, Tx Test 2	z_p	31	mm
Transmission line length, Rx Test 2	z_p	29	mm
Transmission line parameter, a_1	a_1	9.909×10^{-4}	ns ^{1/2} /mm
Transmission line parameter, a_2	a_2	2.772×10^{-4}	ns/mm
Single-ended package capacitance at package-to-board interface	C_p	8.7×10^{-5}	nF
Transmission line characteristic impedance	Z_c	87.5	nF
Transmission line 2 length	z_{p2}	1.8	mm
Transmission line 2 characteristic impedance	Z_{c2}	92.5	Ω

ID	Description	IL @ Nyq [dB]	5-tap TP1a Electrical TDECQ [dB]	9-Tap TDECQ At Fiber Output with 22GHz BT
1	mellitz_3ck_01_0518_C2M\9dB	9	1.36	2.03 dB
15C	Lim 15 with updated QSFP-DD connector	10	1.45	2.1 dB

Linear VCSEL Driver Demonstrations



Linear Tx Interface Demonstration – 26GBAUD VCSEL Result

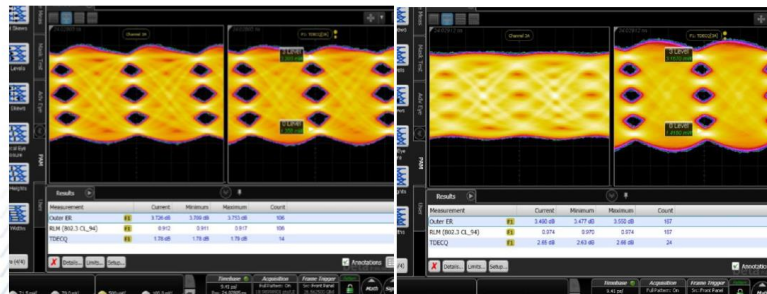


Tx Path – Optical Output Comparison



> TDECQ: FFE able to improve optical output from MACOM Optical Evaluation Board

- TDECQ 1.78dB (without MCB/HCB pair) vs 2.65dB (with MCB/HCB)
- MALD-38435 can be further optimized to interface directly to hosts

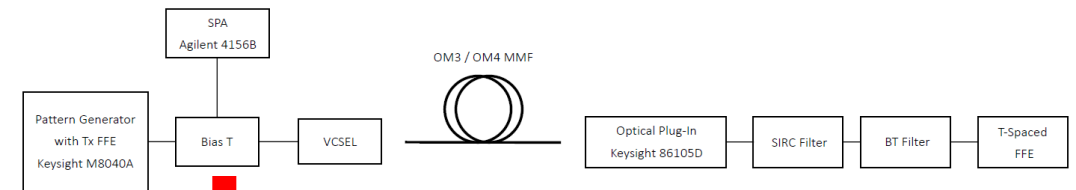


MALD-38435 optical output without MCB+HCB MALD-38435 optical output with MCB+HCB

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Experimental set-up

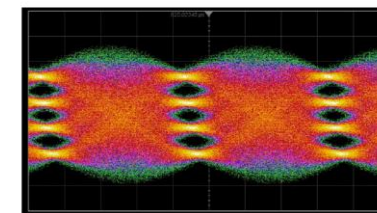


**Bias-T =
Linear Driver**

- OM3: EMB \approx 2000 MHz km @ 850 nm
- OM4: EMB \approx 4700 MHz km @ 850 nm

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Eye diagram after 100 m OM4



TDECQ: 3.5 dB

Modulation format	PAM4
Symbol rate	53.125 Gb/s
Pattern	PRBS15Q
Tx FFE	3-tap T-spaced
SER target for TDECQ	4.8×10^{-4}
DCA optical plug-in bandwidth	34 GHz
DCA SIRC bandwidth	38.3 GHz
DCA BT filter bandwidth	26.6 GHz
DCA FFE	9-tap T-spaced
Temperature	75 °C
Center wavelength	863 nm
RMS spectral width	0.42 nm
Outer ER	3 dB

- 100 m OM4 link: TDECQ within 4.5 dB with a 9-tap Rx FFE

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> Modify to specify an electrical TDECQ with minimum swing from module

Modified Table 120G-3—Module output characteristics (at TP4)

Parameter	Reference	Value	Units
Signaling rate per lane (range)	120G.3.1.1	53.125 ± 100 ppm	GBd
AC common-mode output voltage (max, RMS)	120G.5.1	17.5	mV
Differential peak-to-peak output voltage (max)	120G.5.1	900	mV
Near-end ESMW (Eye symmetry mask width)	120G.3.1.6	TBD	UI
Near-end eye height, differential (min)	120G.3.1.6	24	mV
Near-end vertical eye closure (max)	120G.3.1.6	7.5	dB
Far-end ESMW (eye symmetry mask width)	120G.3.1.6	TBD	UI
Far-end eye height, differential (min)	120G.3.1.6	24	mV
Far-end vertical eye closure (max)	120G.3.1.6	7.5	dB
Far-end pre-cursor ISI ratio	120G.5.3	TBD	—
Common-mode to differential return loss (min)	120G.3.1.3	Equation (120G-1)	dB
Effective return loss (min)	120G.3.2.3	TBD	dB
Differential termination mismatch (max)	120G.3.1.4	10	%
Transition time (min, 20% to 80%)	120G.3.1.5	TBD	ps
DC common-mode voltage (min) ^a	120G.5.1	-350	mV
DC common-mode voltage (max) ^a	120G.5.1	2850	mV

Insert minimum output voltage pk-pk with value TBDmVppd

Replace with:
Electrical TDECQ TBD

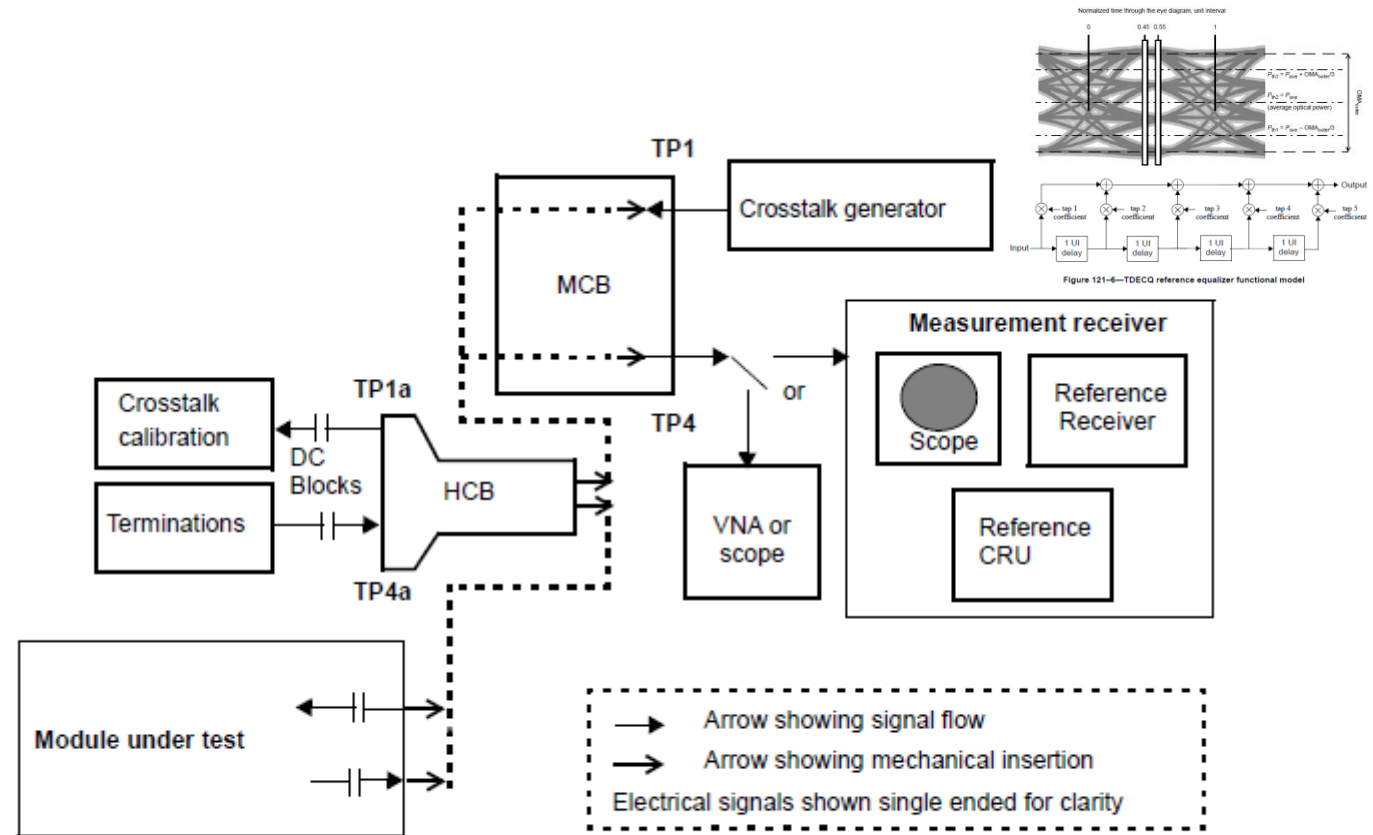
Remove – LPI has lower loss budget relative to C2M

TBD

^a DC common-mode voltage is generated by the host. Specification includes effects of ground offset voltage.

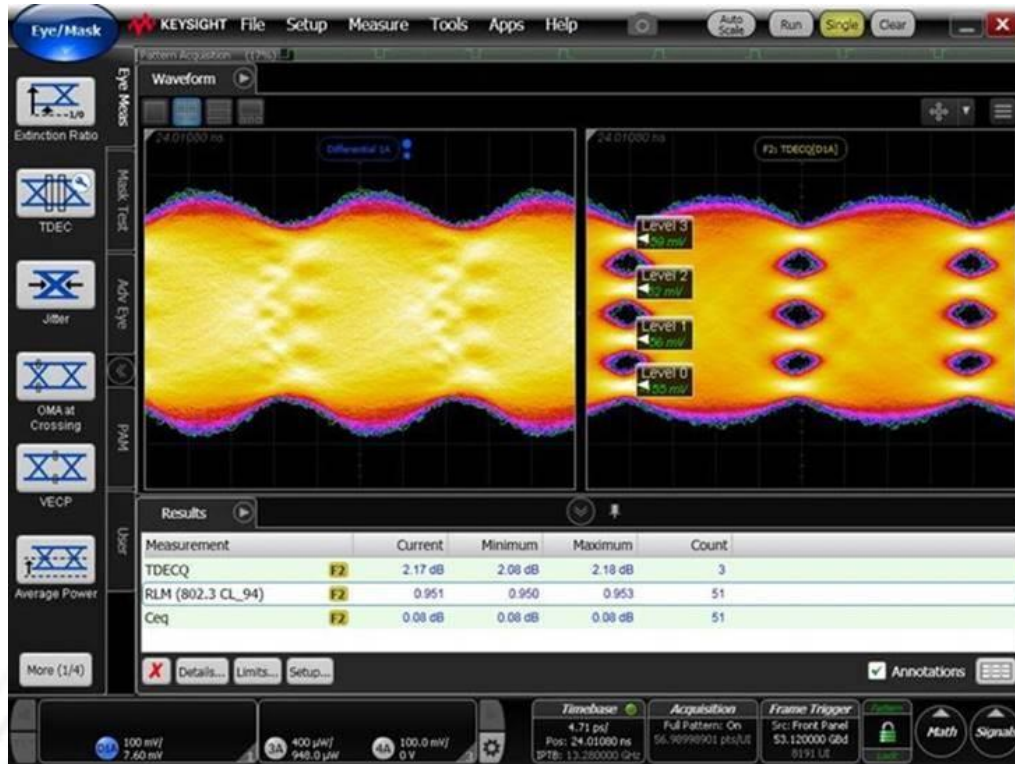
Example Module Output Text Configuration

- Evaluate module output in alignment with host capabilities
 - 9+ FFE Taps
 - DFE Taps



Modified Figure 120G-7—Example module output test configuration

Stressed Optical Source (3.5dB SMF TDECQ – 5Tap) --> MACOM PD/TIA --> Electrical TDECQ



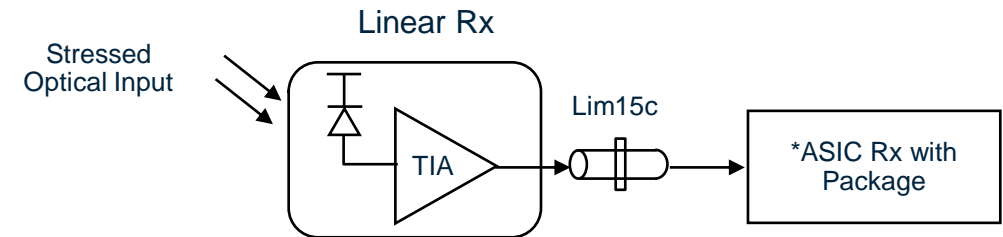
TDECQ FFE Taps=9
Electrical TDECQ = 2.17dB

	Performance after 10dB of trace loss & 16tap FFE
Stressed Sensitivity (BER 2.4E-4)*	Better than -8dBm OMA

*100GBASE-FR1 Spec = -2.5dBm OMA

Simulated Rx Path Performance

- > Stressed input
 - TDECQ = 3.4dB stressed
- > Rx MACOM TIA & PD modeled
- > Channel:
 - Lim15c leveraged in 802.3ck
 - 10dB at Nyquist for channel, 13dB total loss including ASIC package
- > ASIC Rx
 - IP* & Package (802.3ck) modeled
 - 16 tap FFE (selected to correlate with lab result)
 - Additional taps (FFE&DFE) expected to improve result



	Performance after Lim15c & 16tap FFE
Stressed Sensitivity (BER 2.4E-4)	Better than -8dBm OMA

100GBASE-FR1 Spec = -2.5dBm OMA

* With Support from Cadence IP

- > Modify to specify an electrical SECQ with minimum swing

Modified Table 120G-5—Host input characteristics

Parameter	Reference	Test point	Value	Units
Signaling rate, per lane (range)	120G.3.1.1	TP4a	53.125 ± 100 ppm	GBd
Differential peak-to-peak input voltage tolerance (min)	120G.5.1	TP4	900	mV
Common-mode to differential return loss (min)	120G.3.1.3	TP4a	Equation (120G-1)	dB
Effective return loss (min)	120G.3.3.1	TP4a	TBD	dB
Host stressed input test ^a	120G.3.3.2	TP4	See 120G.3.3.2	
Differential termination mismatch (max)	120G.3.1.4	TP4a	10	%
Common-mode voltage ^b	120G.5.1	TP4a		V
Min			-0.3	
Max			2.8	

→ Insert minimum output voltage pk-pk with value TBDmVppd

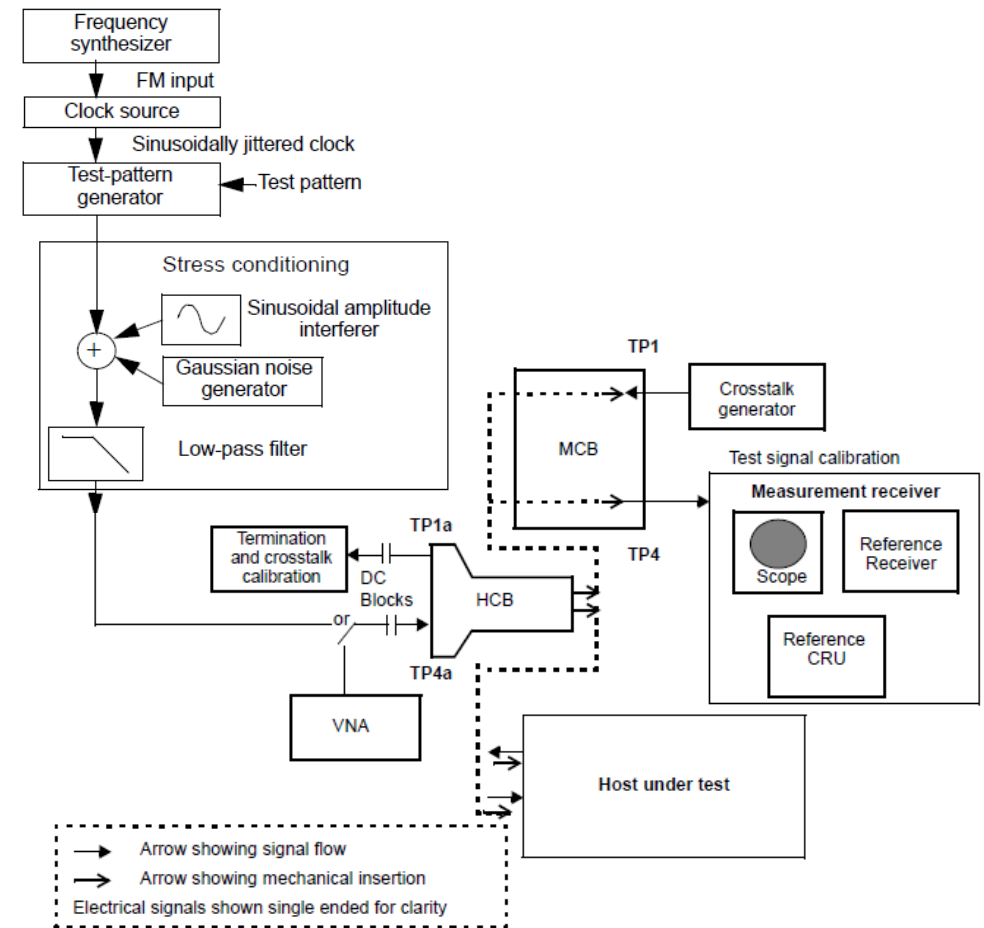
} Electrical SECQ TBD (Reference Section TBD)

^aMeets BER specified in 120G.1.1.

^bGenerated by host, referred to host ground.

Example Host Electrical SECQ Configuration

- Electrical version of the signal used to generate stressed receive sensitivity



Modified Figure 120G-8—Example host stressed input test

- > Specify an electrical SECQ with minimum swing

Modified Table 120G-8—Module input characteristics

Parameter	Reference	Test point	Value	Units
Signaling rate per lane (range)	120G.3.1.1	TP1	53.125 ± 100 ppm	GBd
Differential pk-pk input voltage tolerance (min)	120G.5.1	TP1a	900	mV
Common-mode to differential return loss (min)	120G.3.1.3	TP1	Equation (120G-1)	dB
Effective return loss (min)	120G.3.4.2	TP1	TBD	dB
Differential termination mismatch (max)	120G.3.1.4	TP1	10	%
Module stressed input test ^a	120G.3.4.1	TP1a	See 120G.3.4.1	
Single-ended voltage tolerance range (min)	120G.3.1.1	TP1a	-0.4 to 3.3	V
DC common-mode voltage (min) ^b	120G.3.1.1	TP1	-350	mV
DC common-mode voltage (max) ^b	120G.3.1.1	TP1	2850	mV

Insert minimum input voltage pk-pk with value TBDmVppd

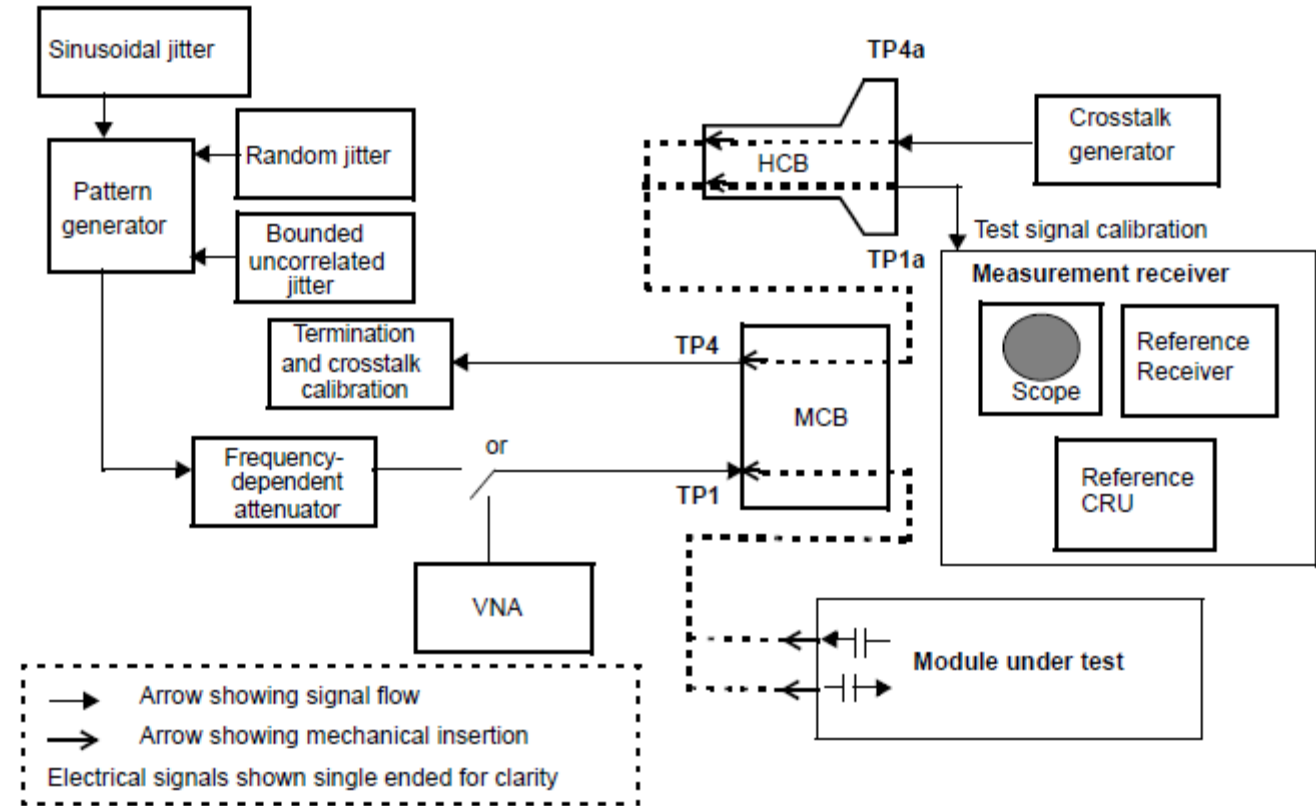
Electrical SECQ TBD

^a Meets BER specified in 120G.1.1.

^b DC common-mode voltage generated by the host. Specification includes effects of ground offset voltage.

Electrical SECQ into the module

- Electrical version of an expected host signal which meets electrical SECQ requirements



Modified Figure 120G-9—Example module stressed input test

> Proposed Baseline

- Leverages efforts in 802.3ck
- Aligns performance with optical interface methodology
- Enables the industry to leverage a PMD service interface, minimizing power and cost