Draft Baseline Proposal for 100GAUI-1/200GAUI-2/400GAUI-4 C2M

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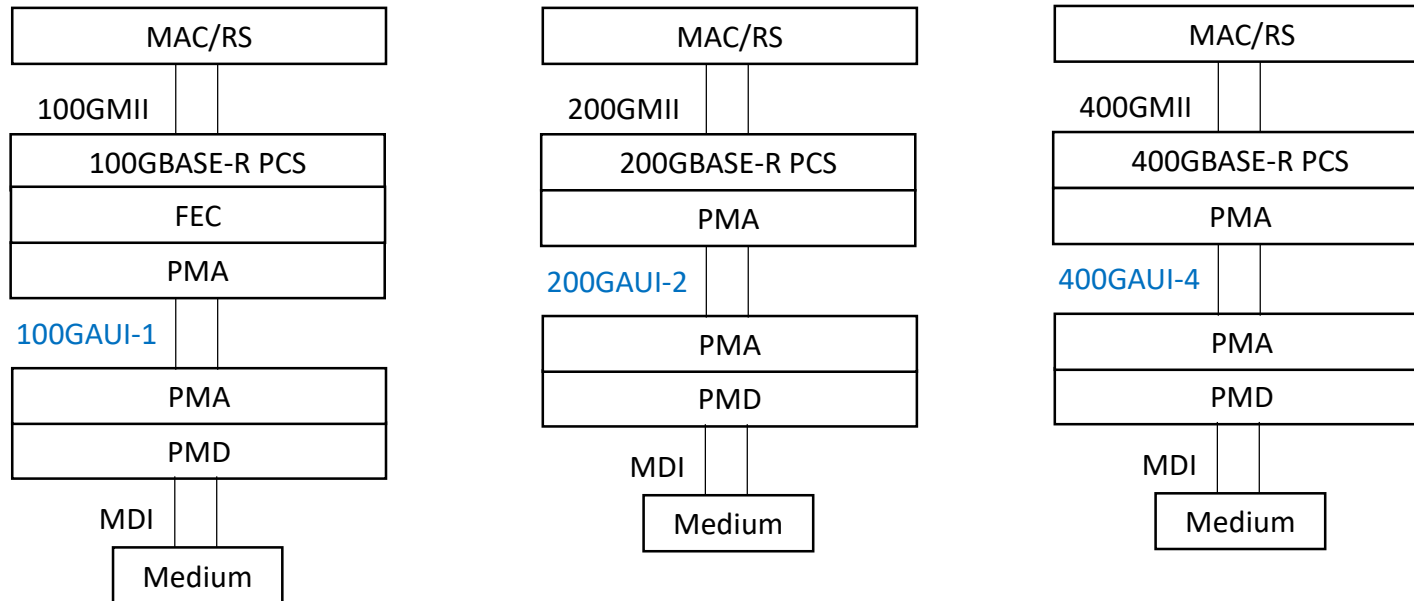
Rich Mellitz, Samtec

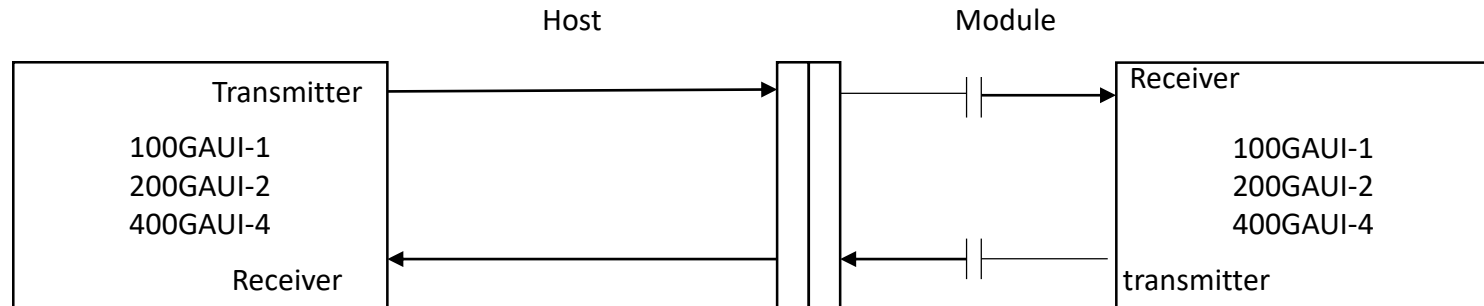Piers Dawe, Mellanox

Yasuo Hidaka, Credo Semiconductor

Supporters

- TBI

Overview

This is to propose a baseline for 100GAUI-1/200GAUI-2/400GAUI-4 C2M electrical interface.

C2M Link

❖ A typical C2M link includes host PCB trace, module PCB trace, AC-coupling capacitor and one connector.

Technical Choices

❖ Like 50GAUI-1/100GAUI-2/200GAUI-4/400GAUI-8 C2M (Annexes 120E and 135G), with enhancements.

❖ Signaling Rate: 53.125GBd.

❖ Modulation: PAM4.

❖ Gray-code specified same as 200GAUI-4 and 400GAUI-8.

❖ Precoding TBD.

❖ Channel insertion loss ≤ 16dB @ 26.5625GHz.

❖ Raw BER ≤ 1E-5. Link BER after FEC should be lower than 1e-12 for 100GE, and 1e-13 for 200GE and 400GE.

❖ Choose short reference equalizer to enable design tradeoff and low power module.

Specification Methodology

❖ Reuse 200GAUI-4 and 400GAUI-8 methodologies for electrical characteristics and corresponding tests.

  ❖ HCB/MCB method for host/module input/output compliance
  ❖ Test patterns
  ❖ Common to/from differential mode-conversion return loss and compliance point definitions
  ❖ Reuse clause 136 methodologies with ERL to replace differential return loss

❖ Leverage Annex 120E and OIF CEI-112G-VSR-PAM4 spec.

❖ Host output is specified at TP1a. Module output TP4 has near-end and far-end specs.
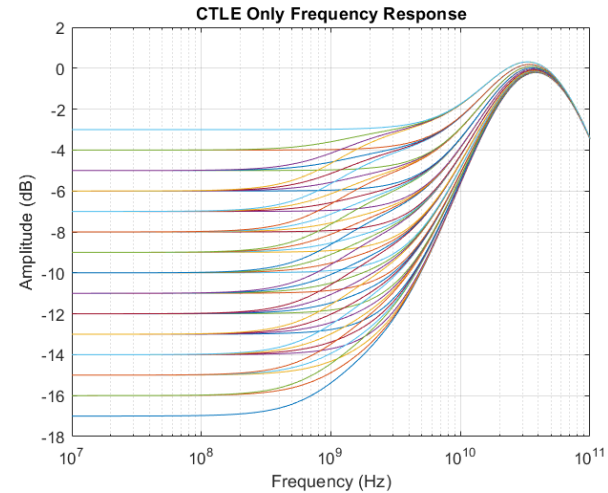
Reference Receiver

❖ No reference receiver is proposed to be chosen at this time. Reference receivers currently under consideration are CTLE + one of the following candidates:

- A: 4-tap DFE (DFE4post with b1max=0.5)
  - A2: b1max is reduced to 0.2
- B: 5-tap FFE with 1-tap DFE (FFE4post with DFE b1max=0.5)
- C: 5-tap FFE (FFE4post)
- D: 4-tap DFE (DFE4post with b1max = 0.0)

CTLE

CTLE Only Frequency Response
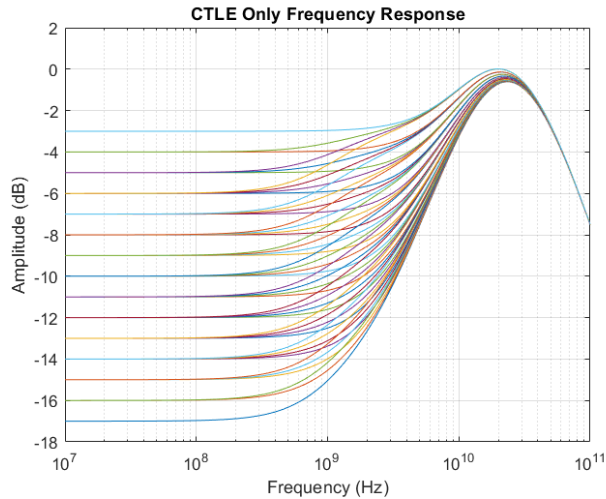
CTLE and Noise Filter for Receivers A, A2, and B

g_DC	[-14:1:-3]	dB
f_z	12.58	GHz
f_p1	20	GHz
f_p2	28	GHz
g_DC_HP	[-3:1:0]	dB
f_HP_PZ	1.328125	GHz

CTLE and Noise Filter for Receivers C and D

g_DC	[-14:1:-3]	dB
f_z	18.88	GHz
f_p1	28	GHz
f_p2	53.125	GHz
g_DC_HP	[-3:1:0]	dB
f_HP_PZ	1.328125	GHz

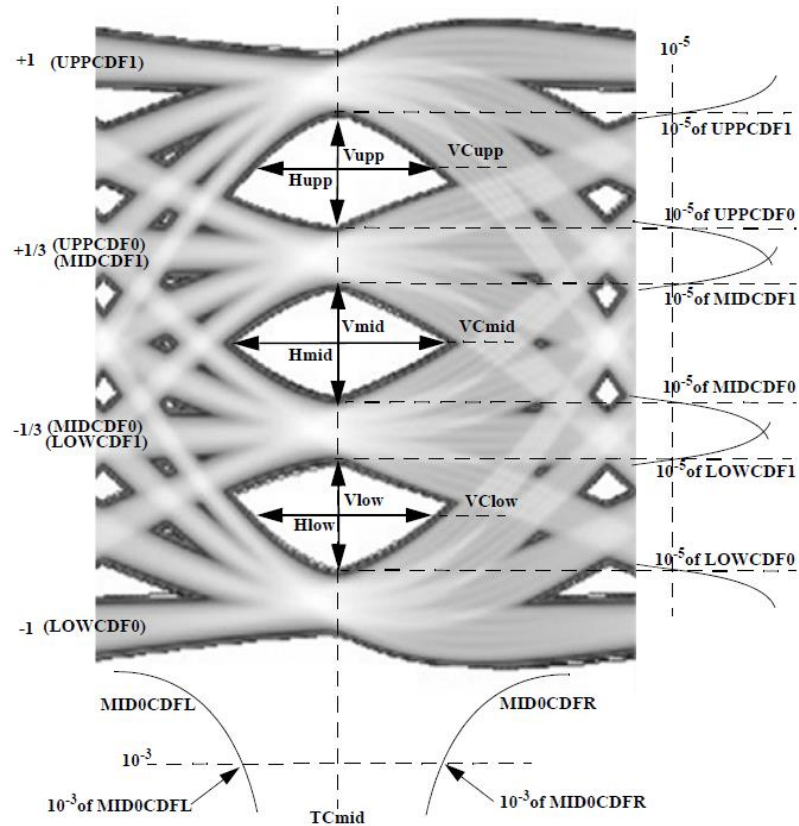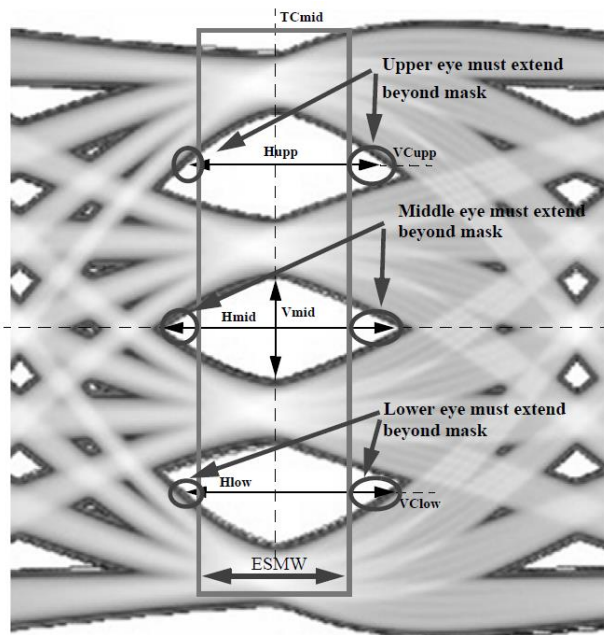CTLE for reference receivers A, A2, and B   CTLE for reference receivers C and D

- CTLE equation:

$$H(f) = \frac{GP_1P_2P_{LF}}{Z_1Z_{LF}} \times \frac{j2\pi f + Z_1}{(j2\pi f + P_1)(j2\pi f + P_2)} \times \frac{j2\pi f + Z_{LF}}{j2\pi f + P_{LF}}$$

- An additional noise filter is a fourth-order Bessel-Thomson filter same as in Annex 120E, with 3dB bandwidth TBD.

Eye width, eye height and VEC parameters

As in Annex 120E

Host Output Characteristics (at TP1a)

Parameter	400GAUI-8	100GAUI-1, 200GAUI-2, 400GAUI-4
Signaling Rate per lane	26.5625 GBd ± 100 ppm	53.125 GBd ± 100 ppm
DC common-mode output voltage (max)	2.8 V	2.8V
DC common-mode output voltage (min)	-0.3 V	-0.3 V
Single-ended output voltage (max)	3.3 V	3.3 V
Single-ended output voltage (min)	-0.4 V	-0.4 V
AC common-mode output voltage (max, RMS)	17.5 mV	20 mV

Differential peak-to-peak output voltage (max)
    Transmitter disabled
    Transmitter enabled
	
	35 mV
	880 mV
		
		35 mV
		870 mV

ESMW (Eye symmetry mask width)	0.22 UI	TBD
Eye height, differential (min)	32 mV	TBD
Vertical Eye Closure (max)	12 dB	10.5dB
Differential termination mismatch (max)	10%	10%
Transition time (min, 20% to 80%)	10 ps	TBD

❖   Parameters in magenta need to be confirmed.

Module Output Characteristics (at TP4)

Parameter	400GAUI-8	100GAUI-1, 200GAUI-2, 400GAUI-4
Signaling Rate per lane	26.5625 GBd ± 100 ppm	53.125 GBd ± 100 ppm
AC common-mode output voltage (max, RMS)	17.5 mV	20 mV
Differential peak-to-peak output voltage (max)	900 mV	900 mV
Near-end ESMW (Eye symmetry mask width)	0.265 UI	TBD
Near-end Eye height, differential (min)	70 mV	TBD
Far-end ESMW (Eye symmetry mask width)	0.2 UI	TBD
Far-end Eye height, differential (min)	30 mV	TBD
Far-end pre-cursor ISI Ratio	-4.5% to +2.5%	TBD
Differential termination mismatch (max)	10%	10%
Transition time (min, 20% to 80%)	9.5 ps	TBD
DC common mode voltage (min)	-350 mV	-350 mV
DC common mode voltage (max)	2850 mV	2850 mV

Host Input Characteristics

Parameter	400GAUI-8	100GAUI-1, 200GAUI-2, 400GAUI-4
Signaling Rate per lane	26.5625 GBd ± 100 ppm	53.125 GBd ± 100 ppm
Differential peak-to-peak input voltage tolerance (min)	900 mV at TP4	900 mV at TP4
Host stressed input test	120E.3.3.2	Reuse 120E.3.3.2 with updated parameters
Differential termination mismatch (max)	10% at TP4a	10% at TP4a
DC common mode voltage (min)	-0.3 V at TP4a	-0.3 V at TP4a
DC common mode voltage (max)	2.8 V at TP4a	2.8 V at TP4a

Module Input Characteristics

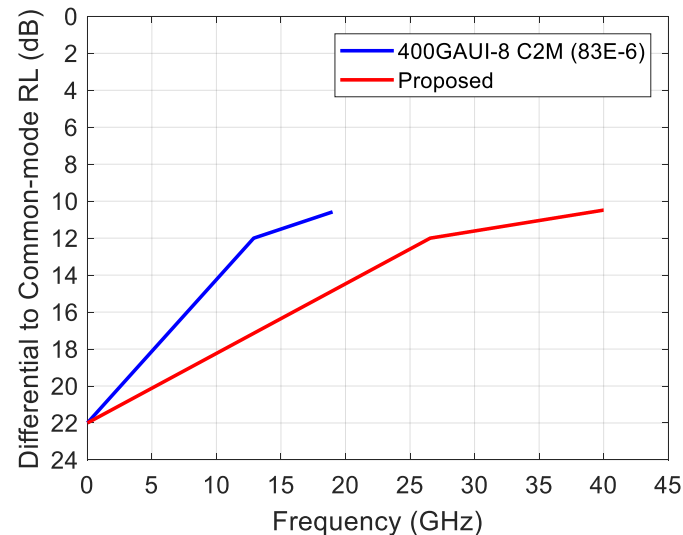| Parameter	400GAUI-8	100GAUI-1, 200GAUI-2, 400GAUI-4
Signaling Rate per lane	26.5625 GBd ± 100 ppm	53.125 GBd ± 100 ppm
Differential peak-to-peak input voltage tolerance (min)	900 mV at TP1a	900 mV at TP1a
Module stressed input test	120E.3.4.1	Reuse 120E.3.4.1 with updated parameters
Differential termination mismatch (max)	10% at TP1	10% at TP1
Single-ended voltage tolerance range (min)	-0.4 to 3.3 V at TP1a	-0.4 to 3.3 V at TP1a
DC common mode voltage (min)	-0.35 V at TP1	-0.35 V at TP1
DC common mode voltage (max)	2.85 V at TP1	2.85 V at TP1

Host/Module Input Differential to Common-mode Conversion Input Return Loss

❖ 400GAUI-8 (Equation (83E-6))

❖ $$RLcd(f) \geq \begin{cases} 22 - 20\left(\dfrac{f}{25.78}\right) & 0.01 \leq f < 12.89 \\ 15 - 6\left(\dfrac{f}{25.78}\right) & 12.89 \leq f < 19 \end{cases} \quad (dB)$$

❖ 100GAUI-1, 200GAUI-2, 400GAUI-4

❖ $$RLcd(f) \geq \begin{cases} 22 - 20\left(\dfrac{f}{53.125}\right) & 0.01 \leq f \leq 26.56 \\ 15 - 6\left(\dfrac{f}{53.125}\right) & 26.56 < f \leq 40 \end{cases} \quad (dB)$$
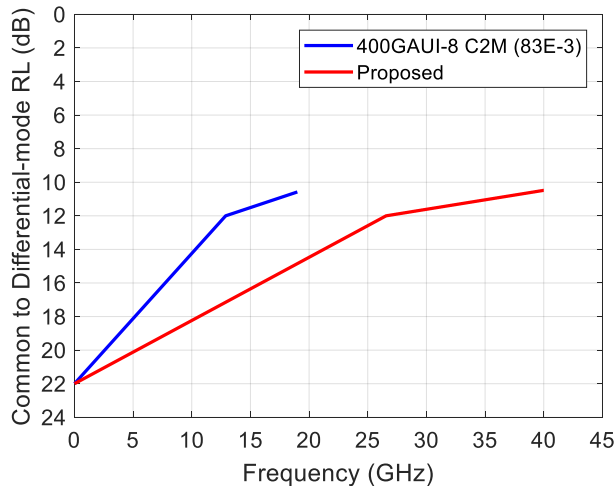
Host/Module Output Common to Differential-mode Conversion Return Loss

❖ 400GAUI-8 (Equation (83E-3))

❖ $$RLdc(f) \geq \begin{cases} 22 - 20\left(\dfrac{f}{25.78}\right) & 0.01 \leq f < 12.89 \\ 15 - 6\left(\dfrac{f}{25.78}\right) & 12.89 \leq f < 19 \end{cases} \quad (dB)$$

❖ 100GAUI-1, 200GAUI-2, 400GAUI-4

❖ $$RLdc(f) \geq \begin{cases} 22 - 20\left(\dfrac{f}{53.125}\right) & 0.01 \leq f \leq 26.56 \\ 15 - 6\left(\dfrac{f}{53.125}\right) & 26.56 < f \leq 40 \end{cases} \quad (dB)$$

Host/Module Input / Output Effective Return Loss

Parameter	50GBASE-CR, 100GBASE-CR2, 200GBASE-CR4	100GAUI-1, 200GAUI-2, 400GAUI-4
Transition time associated with a pulse	0.0189 ns	0.010 ns
Incremental available signal loss factor	1.7 GHz	1.7 GHz
Permitted reflection from a transmission line external to the device under test	0.3	0.3
Length of the reflection signal	300 UI	600 UI
Transmitter steady-state voltage, vf (min.) Transmitter steady-state voltage, vf (max.)	0.354 V 0.6 V	0.35 V 0.7 V
Linear fit pulse peak (min.)	0.49 x vf V	0.4 x vf V
Transmitter (Host/Module output) ERL	EQ 136-6 at TP2	EQ below at TP1a and TP4
Receiver (Host/Module input) ERL	≥ 10 dB at TP3	≥ 9 dB at TP1 and TP4a

❖ See 93A.5 for definition of parameters

❖ 50GBASE-CR, 100GBASE-CR2, 200GBASE-CR4 Transmitter ERL (Equation (136-6))

   ❖ $ERL \geq 40 \log_{10} \left(\dfrac{v_f}{\max\limits_{k}(p(k))} \right)$ (dB)

❖ 100GAUI-1, 200GAUI-2, 400GAUI-4 Host/Module output ERL

   ❖ $ERL \geq 40 \log_{10} \left(\dfrac{v_f}{\max\limits_{k}(p(k))} \right)$ (dB)
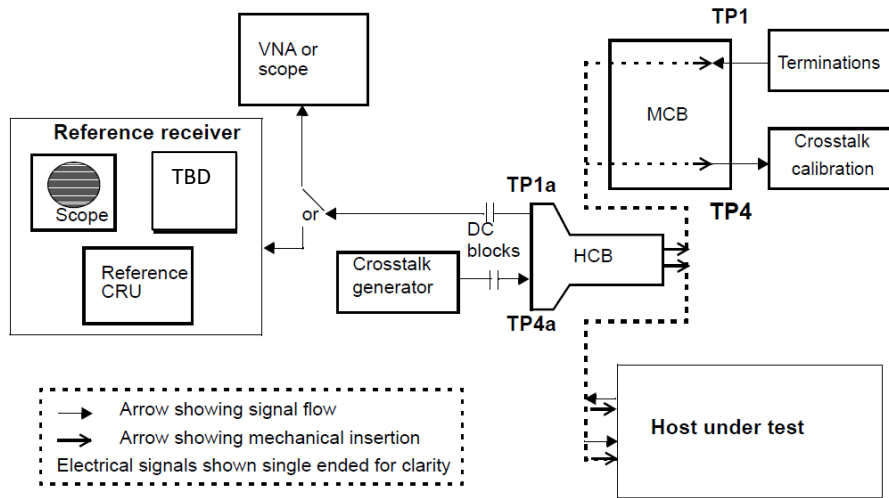
Host/Module Output Waveform Test

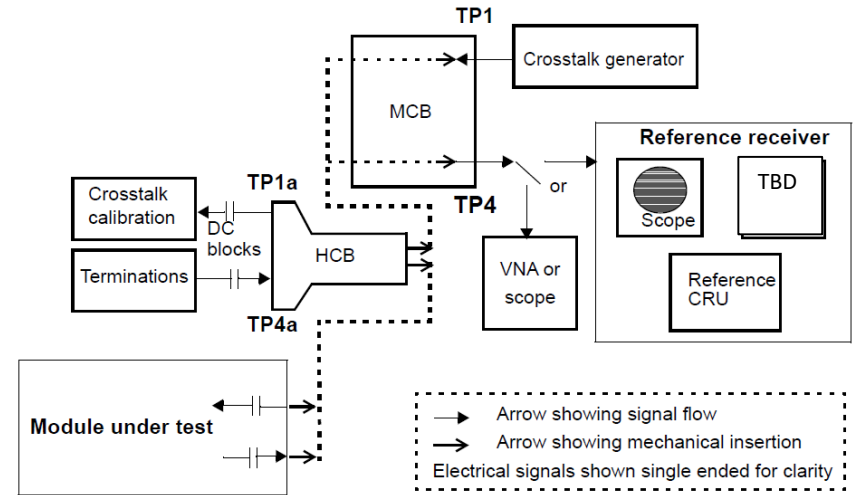Figure 120E–8—Example host output test configuration

Figure 120E–10—Example module output test configuration

- ❖ Test configuration is same as Annex 120E.
- ❖ Reference receiver TBD.

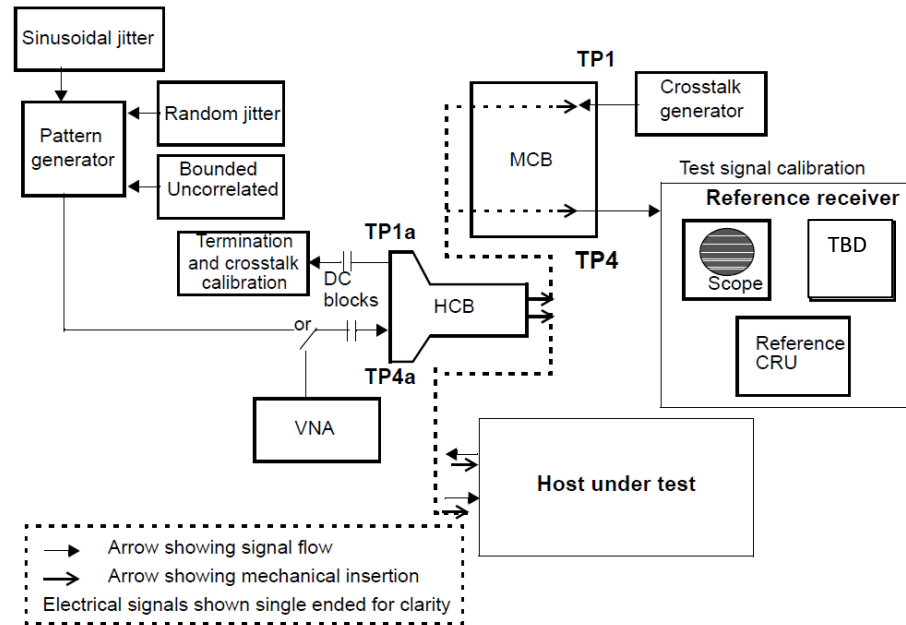# Host Stressed Receiver Test

Figure 120E–11—Example host stressed input test

- ❖ Test configuration is same as Annex 120E.
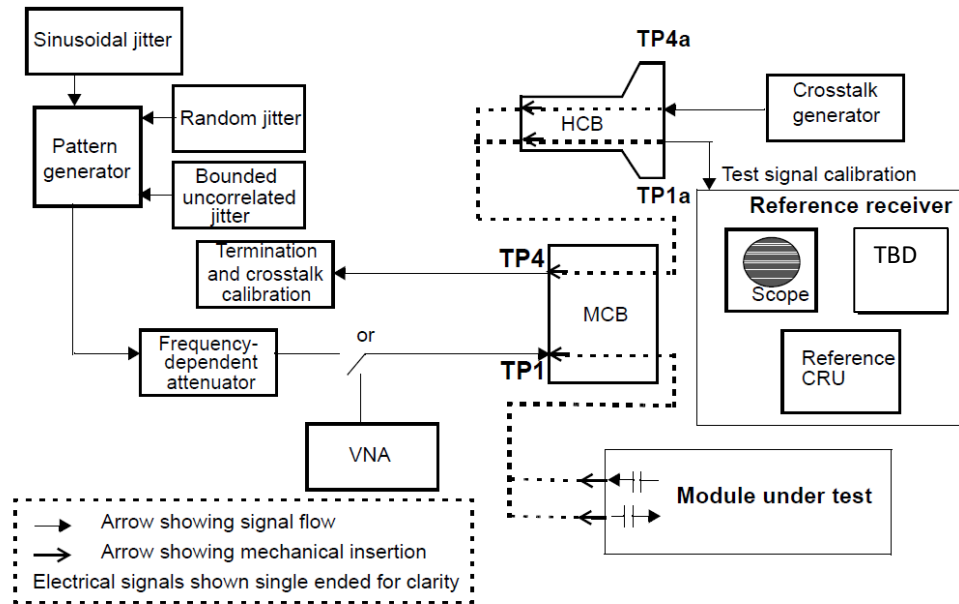- ❖ Reference receiver TBD.

Module Stressed Receiver Test

Figure 120E–12—Example module stressed input test

❖ Test configuration is same as Annex 120E.
❖ Reference receiver TBD.

Test Patterns

❖ Reuse PRBS13Q and PRBS31Q same as in Annex 120E.

Insertion Loss Budget

❖ Reuse recommended insertion loss mask similar as in Annex 120E.
  ❖ Alternatively use insertion loss target and replace insertion loss mask by COM.
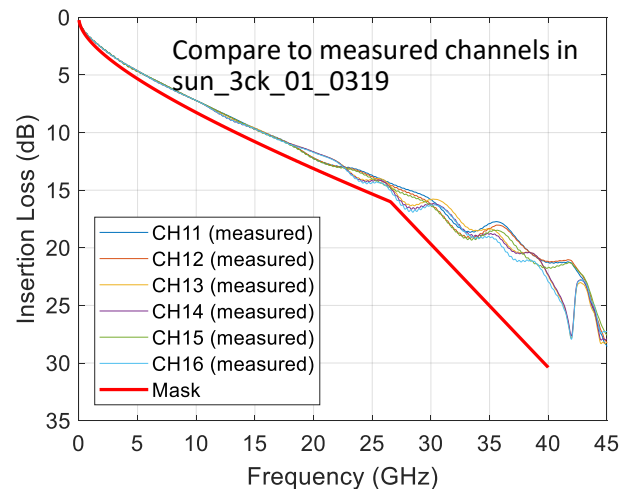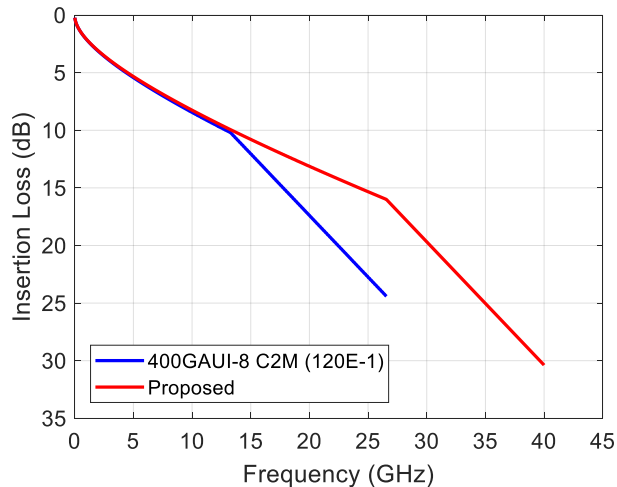
❖ 400GAUI-8 (Equation (120E-1))
  ❖ 10.2dB
  ❖ $Insertionloss(f) \leq \begin{cases} 0.05 + 1.8\sqrt{f} + 0.2705f & 0.01 \leq f \leq 13.28 \\ -4.0096 + 1.07f & 13.28 < f \leq 26.5625 \end{cases}$

❖ 100GAUI-1, 200GAUI-2, 400GAUI-4
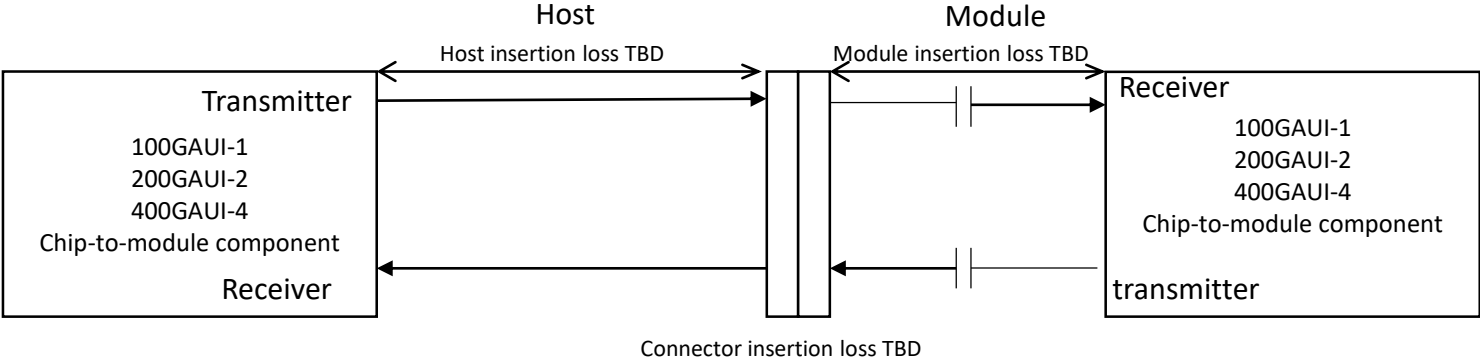 ❖ 16dB
  ❖ $Insertionloss(f) \leq \begin{cases} 0.05 + 1.8\sqrt{f} + 0.2513f & 0.01 \leq f \leq 26.56 \\ -12.4181 + 1.07f & 26.56 < f \leq 40 \end{cases}$

Insertion Loss Allocation

❖ Insertion loss allocation values are TBD.

Compliance Boards

❖ 400GAUI-8
- ❖ HCB like 92.11.1 where the HCB performs equivalent function as the TP2 or TP3 test fixture.
- ❖ MCB like 92.11.2 where the MCB performs equivalent function as the cable assembly test fixture.
- ❖ The mated compliance board like 92.11.3 where the MCB and HCB performs the equivalent function as the cable assembly test fixtures.
- ❖ There are specs for HCB and MCB reference trace insertion losses, mated HCB-MCB max, min and reference trace insertion losses, differential and common return losses, through and return mixed-mode losses, ICN, MDNEXT, MDFEXT.

❖ 100GAUI-1, 200GAUI-2, 400GAUI-4
- ❖ HCB characteristics are same as the TP2 or TP3 test fixture of 100GBASE-CR1, 200GBASE-CR2, 400GBASE-CR4 PMD.
- ❖ MCB characteristics are same as the cable assembly test fixture of 100GBASE-CR1, 200GBASE-CR2, 400GBASE-CR4 PMD.
- ❖ The mated compliance board characteristics are same as the cable assembly test fixtures of 100GBASE-CR1, 200GBASE-CR2, 400GBASE-CR4 PMD.

Summary

❖ Baseline proposal for 100GAUI-1, 200GAUI-2, 400GAUI-4 C2M.

❖ Reuse Annex 120E for test infrastructure and setup and reference receiver specification, where applicable.

❖ Reuse Annex 93A for reference receiver tuning algorithms and specifications, where applicable.

❖ Leverage Annex93A for ERL specification.

❖ Compliance board specifications common with 100GBASE-CR1, 200GBASE-CR2, 400GBASE-CR4.

❖ Propose short reference equalizer to allow design tradeoff and enable lower power module.

Thanks!

Backup Slides
Not Part Of the Draft Baseline Proposal

Package Assumption

❖ The following module package is used for whole link and TP4 analysis. Module package will not be part of the standard.

C_d	0.85e-4	nF
C_p	0.65e-4	nF
Package trace length Z_p	2-10	mm
Package PTH	0	mm
package_tl_gamma0_a1_a2	[0 0.0009909 0.0002772]	
package_tl_tau	6.1400E-03	ns/mm
package_Z_c	[87.5 87.5 ; 92.5 92.5]	Ohm

❖ Host package loss characteristics is the same as for KR/CR.

Straw poll #2
I would support using the following reference package model for the development of KR/CR/C2M-hostside COM baseline proposals:
- Slide 8 of benartsi_3ck_01_0119
- with Cd changed to TBD

Yes: 41   No: 0   Abstain: 13
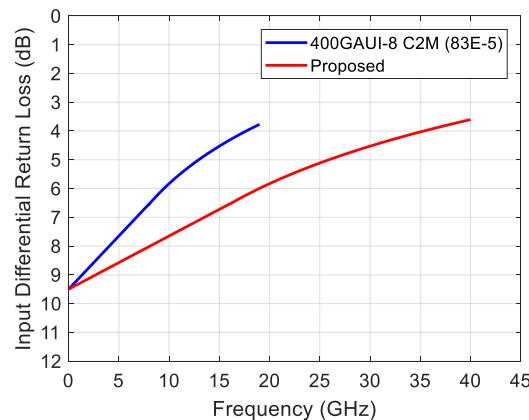
Host/Module Input Differential Return Loss

❖ Specify return loss mask as in 400GAUI-8, or adopt ERL with threshold pending.

❖ 400GAUI-8 (Equation (83E-5))

$$RLd(f) \geq \begin{cases} 9.5 - 0.37f & 0.01 \leq f < 8 \\ 4.75 - 7.4 \log_{10}\left(\frac{f}{14}\right) & 8 \leq f < 19 \end{cases}$$

❖ 100GAUI-1, 200GAUI-2, 400GAUI-4

$$RLd(f) \geq \begin{cases} 9.5 - 0.185f & 0.01 \leq f \leq 16 \\ 4.75 - 7.4 \log_{10}\left(\frac{f}{28}\right) & 16 < f \leq 40 \end{cases}$$

Host/Module Output Differential Return Loss

❖ Specify return loss mask as in 400GAUI-8, or adopt ERL with threshold pending.

❖ 400GAUI-8 (Equation (83E-2))

❖ $$RLd(f) \geq \begin{cases} 9.5 - 0.37f & 0.01 \leq f < 8 \\ 4.75 - 7.4 \log_{10}\left(\frac{f}{14}\right) & 8 \leq f < 19 \end{cases}$$

❖ 100GAUI-1, 200GAUI-2, 400GAUI-4

❖ $$RLd(f) \geq \begin{cases} 9.5 - 0.185f & 0.01 \leq f \leq 16 \\ 4.75 - 7.4 \log_{10}\left(\frac{f}{28}\right) & 16 < f \leq 40 \end{cases}$$