200GAUI-4 and 400GAUI-8 host output eye requirements

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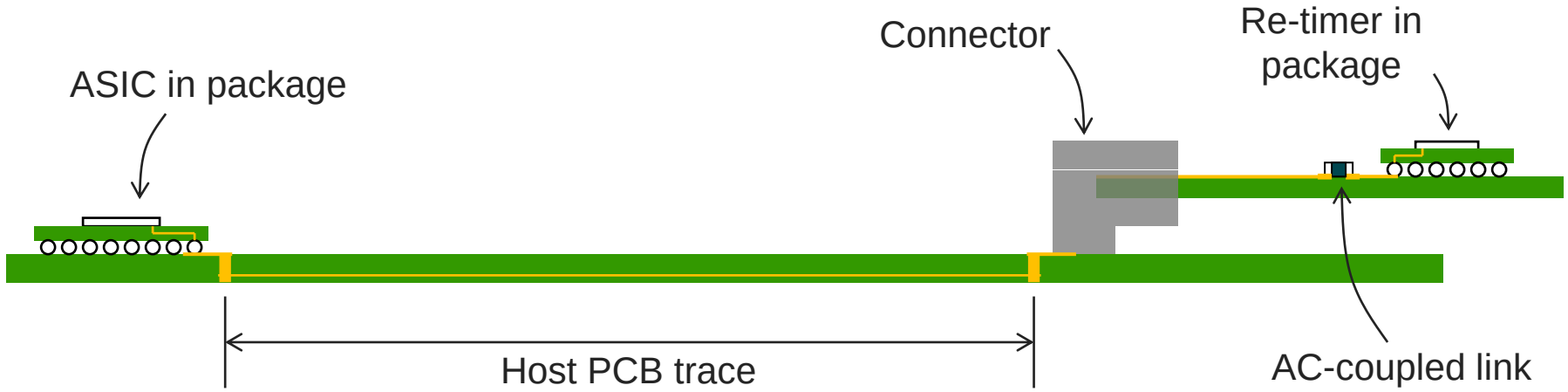
IEEE P802.3bs Task Force, September 2016

Introduction



- Comment #33 points out that the host output eye requirements at TP1a should be checked
- Recent scrutiny of the module output eye requirements lead to significant changes in those requirements (e.g., hegde_3bs_02_0516.pdf)
- This presentation explores the feasibility of the eye opening requirements at TP1a based on the latest assumptions for broadly achievable performance

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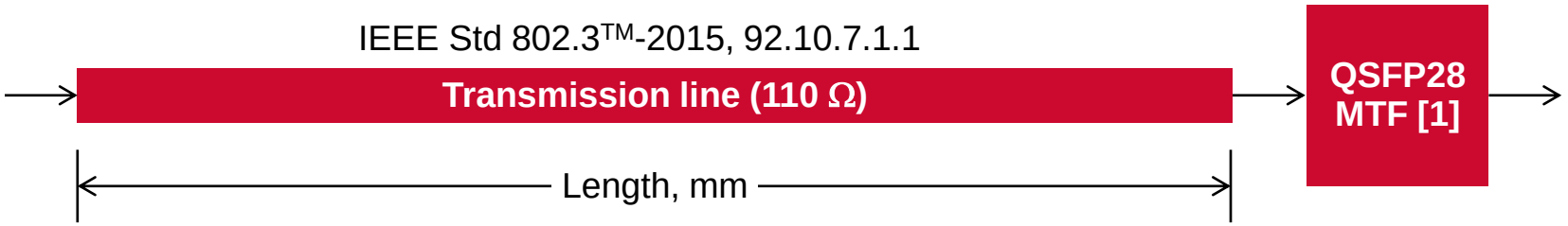
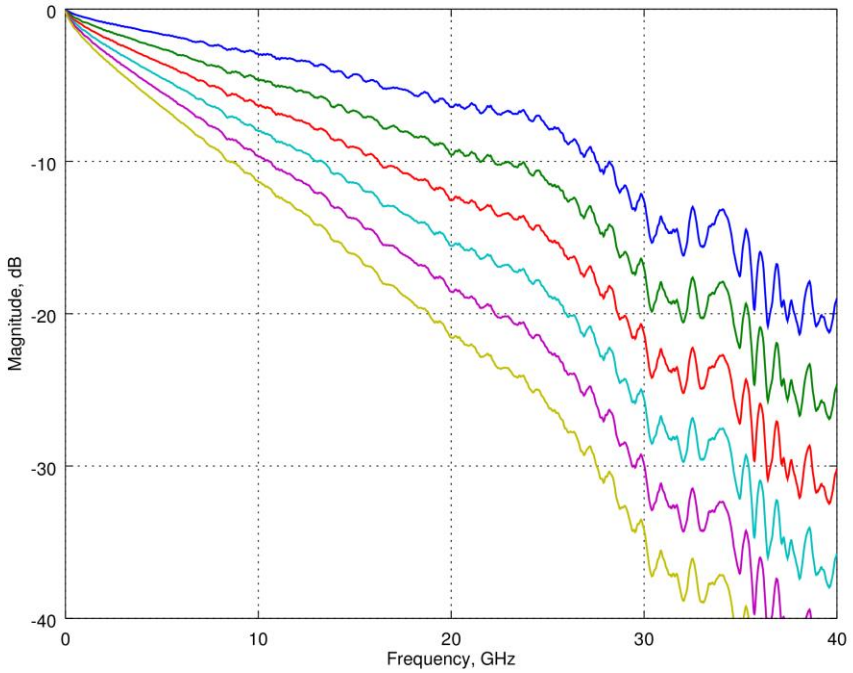
Presentation overview

- Chip-to-module channel model
- Method of analysis
- Results
- Summary and conclusions

Chip-to-module channel model





Insertion loss, dB

Length, mm	13.28 GHz
0	3.6
50	5.7
100	7.8
150	10
200	12.1
250	14.2

200GAUI-4 / 400GAUI-8 chip-to-module target

[1] DiMinico, Chris, "QSFP28 MTF", IEEE P802.3bs Task Force, May 2016.

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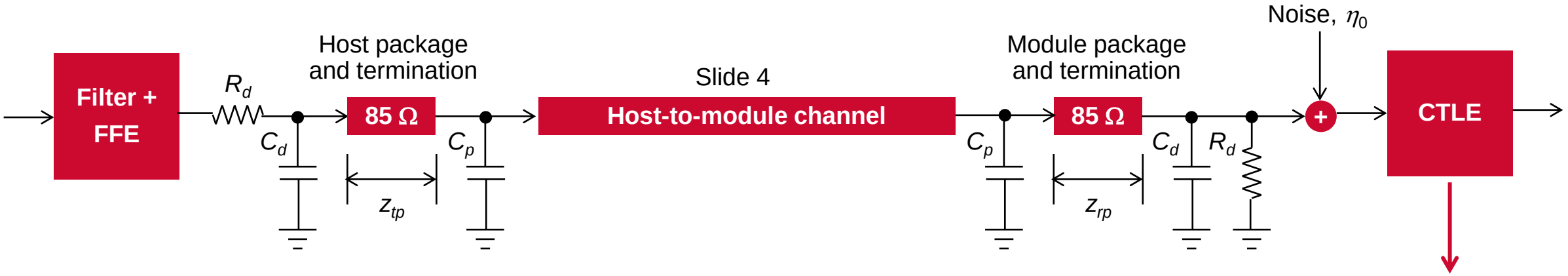
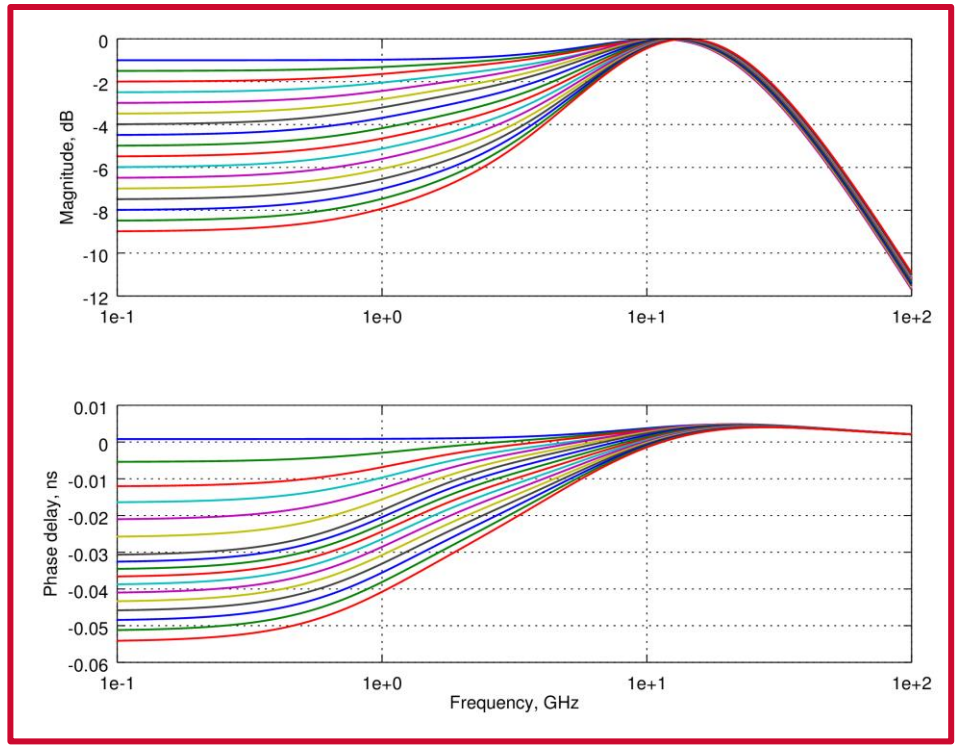
Method of analysis

- Calculate Channel Operating Margin (COM) per IEEE Std 802.3-2015 93A.1
- Begin with the parameter values from IEEE P802.3bs™/D2.0 Table 120D–7
- Replace the reference receiver with the continuous time linear equalizer (CTLE) defined in IEEE P802.3bs/D2.0 120E.3.1.7
- Similar to the analysis performed by Dallaire et al. to examine the feasibility of 400GAUI-8 module-to-chip links (e.g., dallaire_01_082415_elect.pdf)

System model



- Transmitter rise/fall times
- Transmitter level separation mismatch
- Transmitter output noise and distortion
- Transmitter uncorrelated jitter
- Receiver input referred noise
- Worst-case package and termination impedance mismatch



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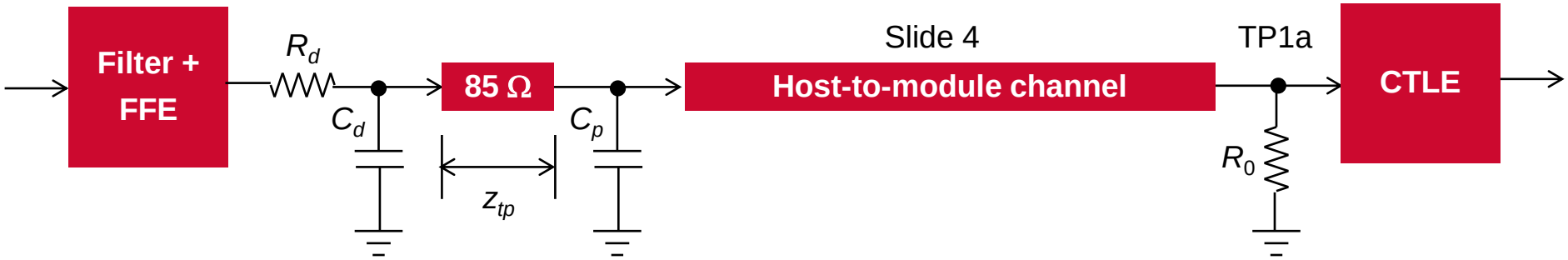
Far-end eye measurement



- Emulation of host output compliance test

Summary of COM results

Conditions	0 mm	50 mm	100 mm	150 mm	200 mm	250 mm
Baseline values	−0.98	−1.08	−0.79	−1.12	−1.55	−2.00
Change C_d to 180 fF and C_p to 90 fF	2.33	2.09	2.19	1.91	1.26	0.66
Add $c(-2)$ with step of 2.5% from 0 to 10%	2.78	2.85	3.14	2.68	2.32	1.54
Change z_{rp} to 6 mm	3.70	3.61	3.68	3.28	2.47	1.67

Far-end eye measurement conditions:

- **Replace receiver package and termination model with 50 Ω single-ended termination resistance**
- **Set receiver input-referred noise spectral density to 0**

Conditions	0 mm	50 mm	100 mm	150 mm	200 mm	250 mm
f_b = 26.5625 Gbaud	5.45	5.13	5.38	5.18	4.99	4.16

Green text corresponds to test cases where the system-level COM exceeds 3 dB

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Convert to vertical eye opening (VEO), V

$$VEO = 2A_s\left(1 - 10^{-COM/20}\right)$$

Conditions	0 mm	50 mm	100 mm	150 mm	200 mm	250 mm
Baseline values	0	0	0	0	0	0
Change C_d to 180 fF and C_p to 90 fF	0.031	0.022	0.019	0.013	0.007	0.003
Add $c(-2)$ with step of 2.5% from 0 to 10%	0.035	0.028	0.024	0.017	0.012	0.007
Change z_{rp} to 6 mm	0.046	0.036	0.029	0.021	0.013	0.008

Far-end eye measurement conditions:

- **Replace receiver package and termination model with 50 Ω single-ended termination resistance**
- **Set receiver input-referred noise spectral density to 0**

Conditions	0 mm	50 mm	100 mm	150 mm	200 mm	250 mm
f_b = 26.5625 Gbaud	0.071	0.050	0.041	0.032	0.025	0.018

Agrees well with analysis by Hegde et al. (hegde_3bs_02_0516.pdf)

Green corresponds to test cases where the system-level COM exceeds 3 dB

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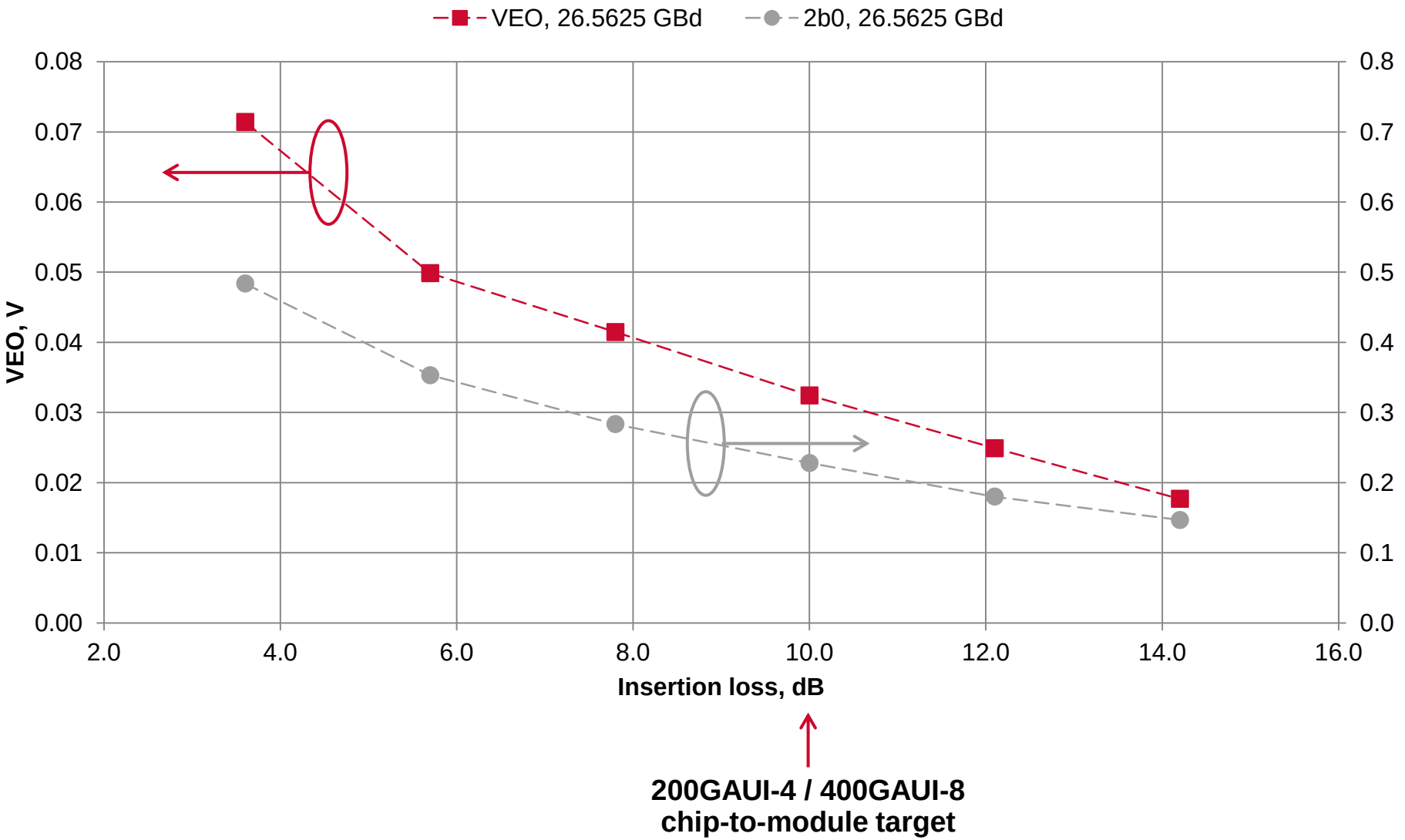
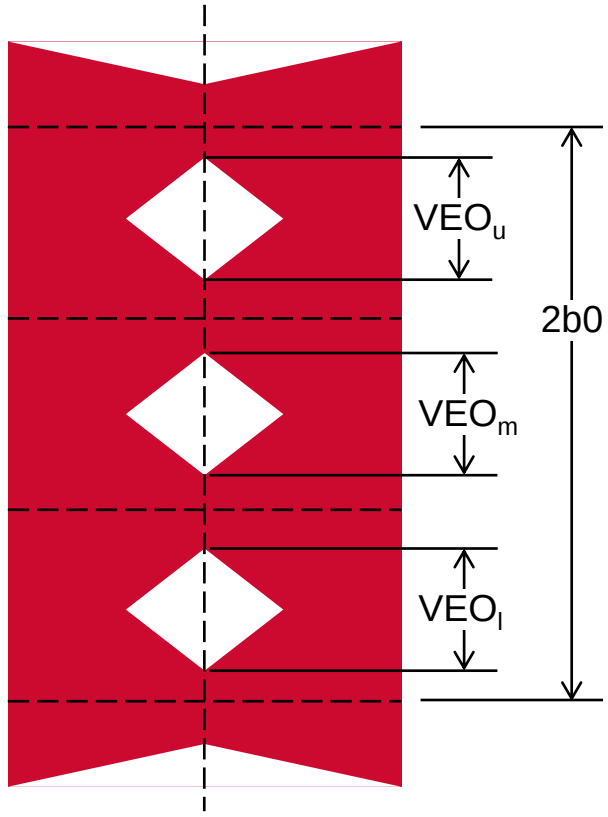
Far-end eye results summary



200GAUI-4 / 400GAUI-8 chip-to-module target



VEO = min(VEO$_l$, VEO$_m$, VEO$_u$)

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Summary and conclusions

- COM was used to analyze chip-to-module links and assess the achievable VEO at TP1a
- Horizontal eye opening is not measured by COM but needs to be evaluated
- Crosstalk was not included in this study and needs to be evaluated
- Agreement with the results presented in hegde_3bs_02_0516.pdf suggests that alignment between TP4 (far-end) and TP1a eye opening requirements is close to the correct answer

Backup slides

COM parameters and values

Parameter	Symbol	Baseline	Last iteration	Units
Signaling rate	f_b	26.5625	26.5625	GBd
Device package model				
Single-ended device capacitance	C_d	2.8E–4	1.8E–4	nF
Transmission line length, test 1	z_{tp}	12	12	mm
Transmission line length, test 2	z_{rp}	12	6	mm
Single-ended package capacitance	C_p	1.1E–4	0.9E–4	nF
Transmission line impedance	Z_c	85	85	Ω
Single-ended reference resistance	R_0	50	50	Ω
Single-ended termination resistance	R_d	55	55	Ω
Transmitter rise time	T_r	13	13	ps
Transmitter equalizer, minimum cursor coefficient	$c(0)$	0.6	0.6	—
Transmitter equalizer, second pre-cursor coefficient	$c(-2)$			
Minimum value		n/a	0	—
Maximum value		n/a	0.1	—
Step size		n/a	0.025	—
Transmitter equalizer, first pre-cursor coefficient	$c(-1)$			
Minimum value		−0.15	−0.15	—
Maximum value		0	0	—
Step size		0.05	0.05	—

COM parameters and values, continued

Parameter	Symbol	Baseline	Last iteration	Units
Transmitter equalizer, post-cursor coefficient Minimum value Maximum value Step size	$c(1)$	 −0.25 0 0.05	 −0.25 0 0.05	 — — —
Receiver equalizer	—	IEEE P802.3bs/D2.0 120E.3.1.7		—
Transmitter differential peak output voltage Victim Far-end aggressor Near-end aggressor	 A_v A_{fe} A_{ne}	 0.45 0.45 0.63	 0.45 0.45 0.63	 V V V
Number of signal levels	L	4	4	—
Level separation mismatch ratio	R_{LM}	0.95	0.95	—
Transmitter signal-to-noise ratio	SNR_{TX}	31	31	dB
Number of samples per unit interval	M	32	32	—
Random jitter, RMS	σ_{RJ}	0.01	0.01	UI
Dual-Dirac jitter, peak	A_{DD}	0.02	0.02	UI
One-sided noise spectral density	η_0	2.6E−8	2.6E−8	V^2/GHz
Target detector error ratio	DER_0	1E−5	1E−5	—