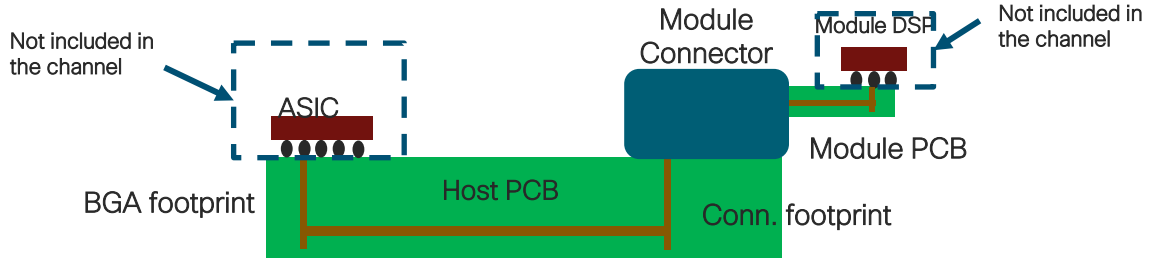
Update on 224G - C2M channel Analysis with COM 4.5 Beta 3

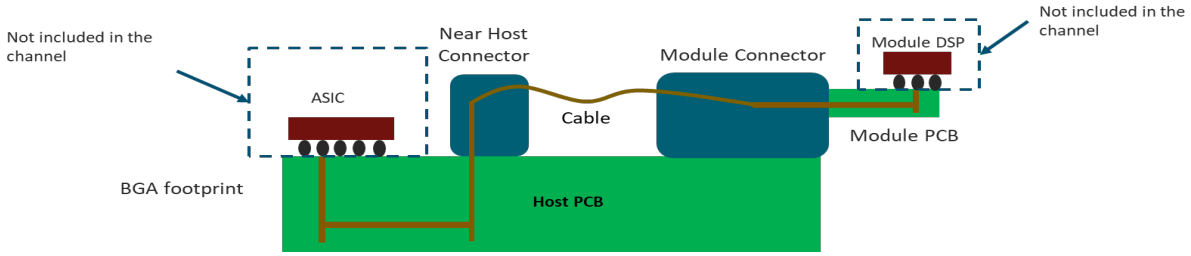
May 2024

Upen Reddy Kareti, Yi Tang, David Nozadze, Darja Padilla, Cisco

Channel Models

- No update to channel models – same as presented in - [kareti_3dj_01_2401.pdf]
- Review:
  - Corrected system PCB and module PCB channel component(s) that were improperly represented in the previous version(s) of the channels.
  - Improved ILD even for thicker PCB designs
  - Improved ICN – reduced Xtalk in Z-direction in PCB
  - Improved NEXT from Connector. Narrowed to one NEXT file representing connector improvements.
  - Reduced System channels Loss span
    - Ball_Ball Loss Limited to ~20 dB
    - Added shortest channels for cabled host and PCB host types
  - Included Module PCB Channel length/loss variations





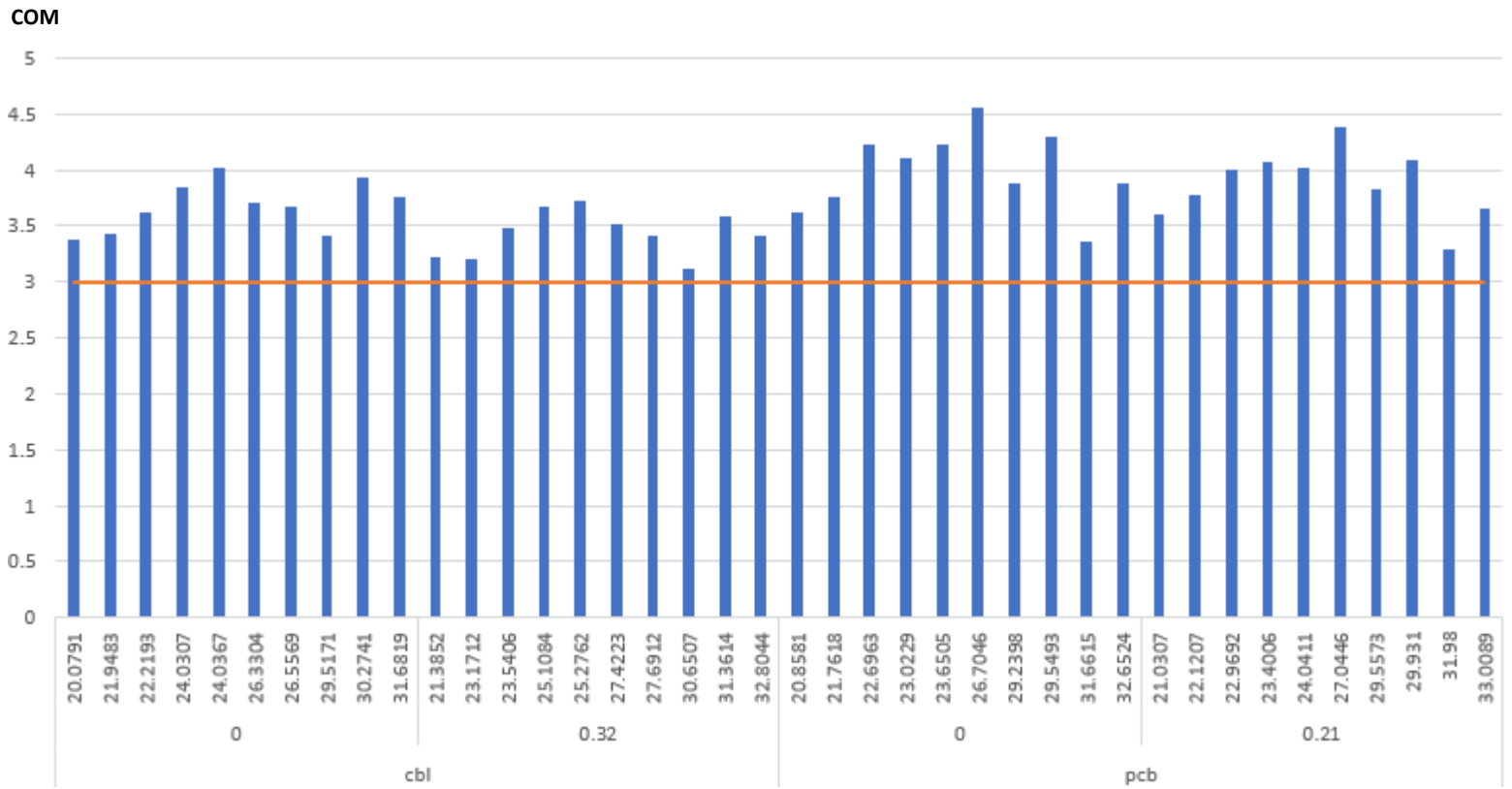
Skew	None*	Max Tolerable	Excessive*
PCB Host	0.0UI	0.21UI	0.43UI
Cabled Host	0.0UI	0.32UI	0.43UI

*Channels are for comparative study of skew impact, but not intended to be considered as a part of the current 64 port system design feasibility or 200Gbps/lane C2M deliberations

C2M Channel Analysis - Setup

- COM tool version: 4.5 Beta 3.
- Reference Receiver(s):
  - RX FFE with 6 fixed pre cursors and 8 fixed post cursors.
  - RX FFE with 6 fixed pre cursors and 4 fixed post cursors and 1 bank of 4 floating taps up to span of 24 UI
- Simulation setup and test cases Include:
  - Both types of packages (Type A and Type B)
  - Mixing of Package types for Package variations
    - Host Silicon package trace lengths – 8 mm to 45 mm
    - Module Silicon package trace lengths – 4 mm to 12 mm
  - Cover all Cabled_host and PCB_host channels
    - All skew variations
  - Receiver Input Reference Noise (ETA_0) levels (V^2/GHz)
    - 4.2e-9
    - 6e-9
    - 8e-9

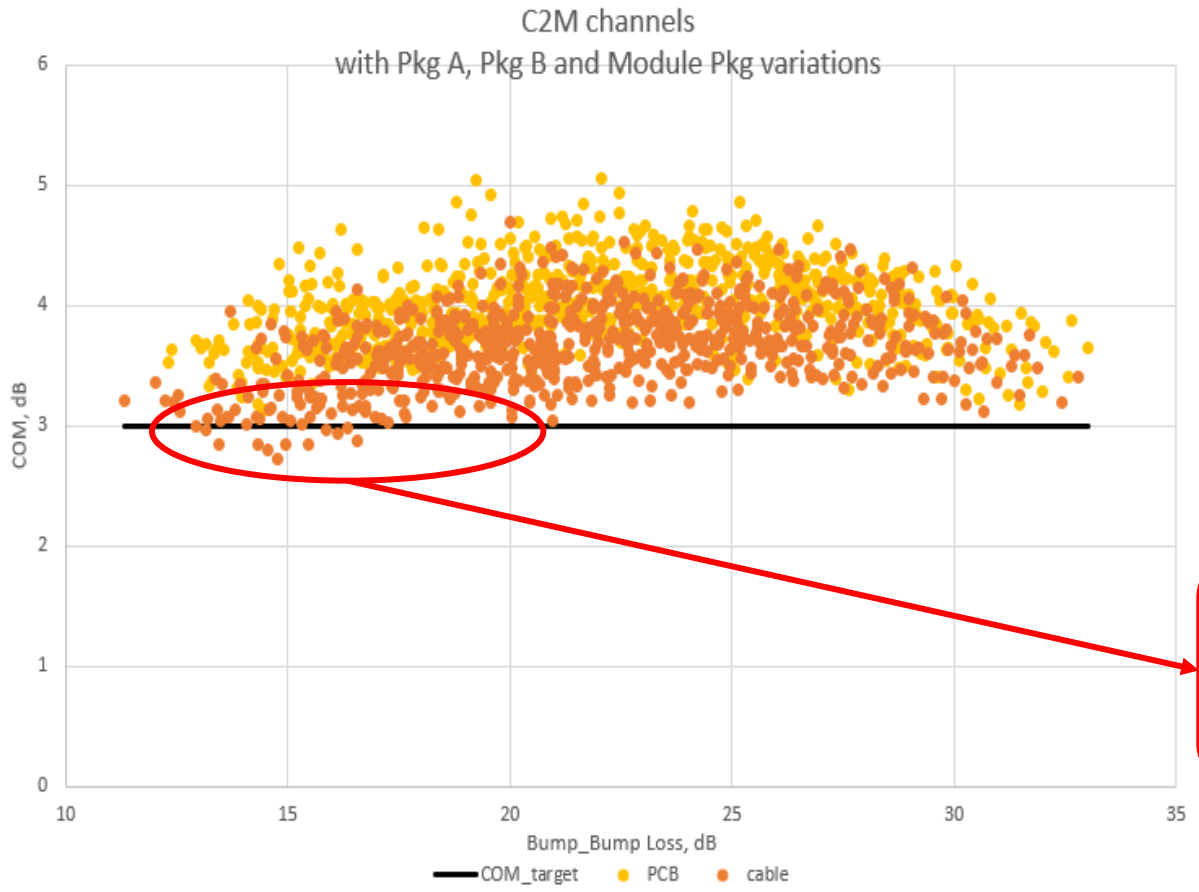
C2M Channel Analysis – Baseline



Includes:

Host package: type B, 45 mm
Module package: 12 mm
PCB-host: 0 & 0.21UI skew
Cabled-host: 0 & 0.32UI skew
ETA_0: 6.0E-09

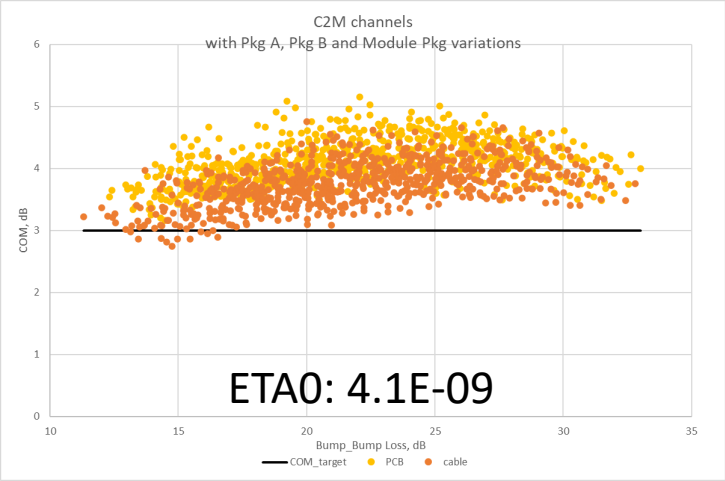
C2M Channel Analysis – All conditions

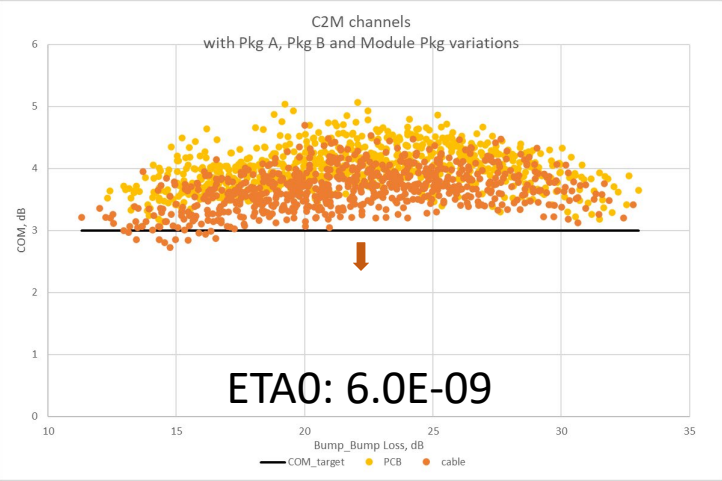


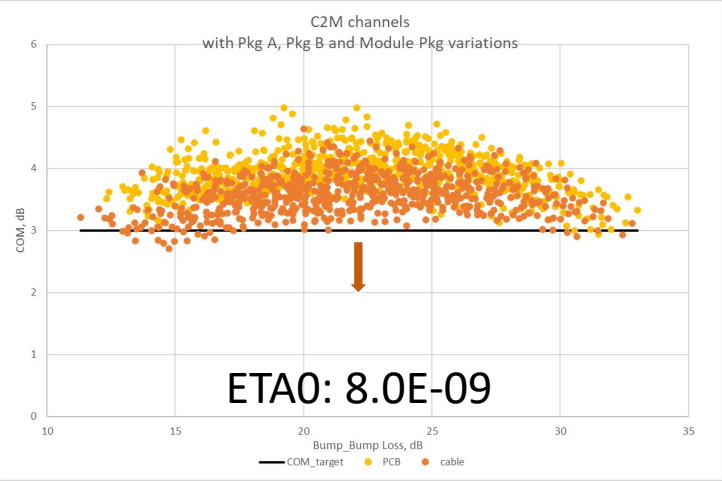
Includes:
Host package: type B, 45 mm
Module package: 12 mm
PCB-host: 0 & 0.21UI skew
Cabled-host: 0 & 0.32UI skew
ETA0: 6.0E-09

Some cabled host channels, with lower loss have reflections further away from the main cursor, pose challenges in meeting COM Compliance.

ETA0 Sensitivity Study



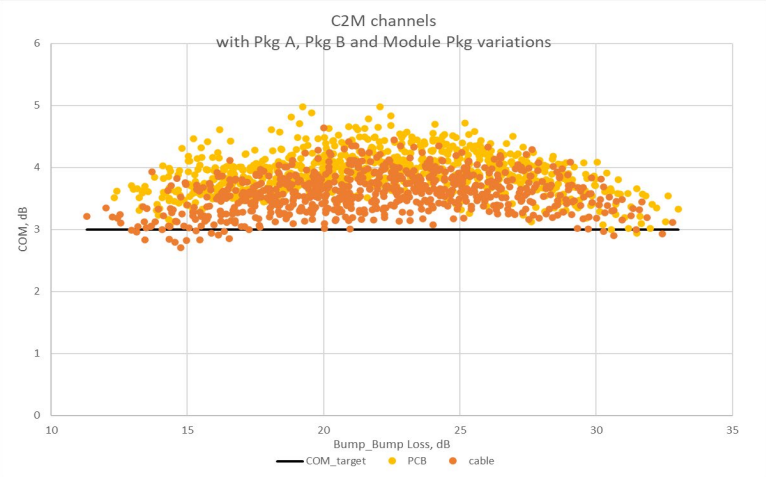


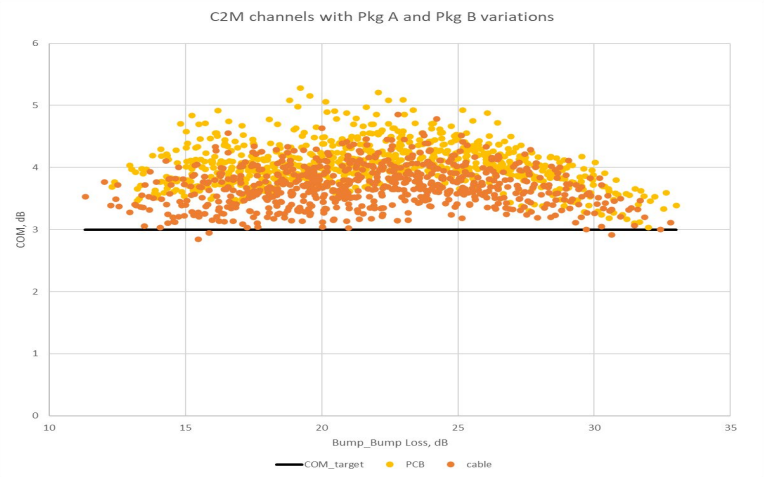


ETA0	IL <= 17 dB		17 dB < IL <= 26 dB		26 dB < IL <= 34 dB	
	Cbl	PCB	Cbl	PCB	Cbl	PCB
4.1E-09	10	0	0	0	0	0
6.0E-09	12	0	0	0	0	0
8.0E-09	14	0	1	0	4	2

Increasing ETA0 results in performance decline.

RX Capability With ETA0 8.0E-9





Type A: RX FFE with 6 fixed pre cursors and 8 fixed post cursors.

Type B: 4 fixed + 1 bank of 4 floating span upto 24 UI

Post Cursors	IL <= 17 dB		17 dB < IL <= 26 dB		26 dB < IL <= 34 dB	
	Cbl	PCB	Cbl	PCB	Cbl	PCB
Type A	14	0	1	0	4	2
Type B	2	0	0	0	2	0

Floating taps could help the low-loss cable channels pass COM

Key Findings from COM Rev 4.5 Beta 3 Analysis

- Loss is not the only factor affecting a reference receiver's equalization requirements.
- The reference receiver must effectively manage low-loss channels that exhibit high reflections, which may be more challenging than handling high-loss channels.
- Suitable receivers can support both cabled hosts (Insertion Loss < 32dB, skew < 0.32 UI) and PCB hosts (Insertion Loss < 34 dB, skew < 0.21 UI).
- Increasing ETA0 can result in performance decline, necessitating a more capable RX equalizer.

Backup

COM Table

Table 93A-1 parameters			
Parameter	**Setting**	**Units**	**Information**
f_b	106.25	GBd	
f_min	0.05	GHz	
Delta_f	0.01	GHz	
C_d	[0.4e-4 0.9e-4 1.1e-4 ;0.4e-4 0.9e-4 1.1e-4]	nF	[TX RX]
L_s	[0.13 0.15 0.14; 0.13 0.15 0.14]	nH	[TX RX]
C_b	[0.3e-4 0.3e-4]	nF	[TX RX]
R_0	5.00E+01	Ohm	
R_d	[50 50]	Ohm	[TX RX]
PKG_NAME	**PKG_HiR_CLASSB PKG_Module**		TX RX
A_v	0.413	V	
A_fe	0.413	V	
A_ne	0.45	V	
z_p select	[1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18]		
L	4		
M	32		
filter and Eq			
f_r	0.58	*fb	
c(0)	0.55		min
c(-1)	[-0.4:0.05:0]		[min:step:max]
c(-2)	[0:.05:0.1]		[min:step:max]
c(-3)	0		[min:step:max]
c(-4)	0		[min:step:max]
c(1)	0		[min:step:max]
N_b	1	UI	
b_max(1)	0.75		As/dffe1
b_max(2..N_b)	0.3		As/dfe2..N_b
b_min(1)	0		As/dffe1
b_min(2..N_b)	-0.15	S	As/dfe2..N_b
g_DC	[-10:1:-3]	dB	[min:step:max]
f_z	42.50	GHz	
f_p1	42.50	GHz	
f_p2	106.25	GHz	
g_DC_HP	[-5:1:0]		[min:step:max]
f_HP_PZ	1.328125	GHz	
Butterworth	1	logical	include in fr

I/O control		
DIAGNOSTICS	1	logical
DISPLAY_WINDOW	1	logical
CSV_REPORT	1	logical
RESULT_DIR	.\results\C2M_B_{date}\	
SAVE_FIGURES	0	logical
Port Order	[1 3 2 4]	
RUNTAG	C2M_B_eval_	
COM_CONTRIBUTION	1	logical
TDR and ERL options		
TDR	1	logical
ERL	1	logical
ERL_ONLY	0	ns
TR_TDR	0.01	
N	4000	logical
TDR_Butterworth	1	
beta_x	0	
rho_x	0.618	
TDR_W_TXPKG	0	UI
N_bx	20	
fixture delay time	[0 0]	
Tukey_Window	1	
Noise, jitter		UI
sigma_RJ	0.01	UI
A_DD	0.02	V^2/GHz
eta_0	6.00E-09	dB
SNR_TX	33	
R_LM	0.95	

Table 93A–3 parameters			
Parameter	**Setting**	**Units**	Information
package_tl_gamma0_a1_a2	[5e-4 0.00065 0.0003]		
package_tl_tau	0.006141	ns/mm	
package_Z_c	2 92 ; 70 70; 80 80; 100 10	Ohm	
z_p (TX)	; 1 1 11; 1 1 1 1; 0.5 0	mm	[test cases to run]
z_p (NEXT)	; 1 1 11; 1 1 1 1; 0.5 0	mm	[test cases]
z_p (FEXT)	; 1 1 11; 1 1 1 1; 0.5 0	mm	[test cases]
z_p (RX)	; 1 1 11; 1 1 1 1; 0.5 0	mm	[test cases]
C_p	[0.4e-4 0.4e-4]	nF	[test cases]
Operational			
ERL Pass threshold	10	dB	
COM Pass threshold	3	db	
DER_0	2.00E-05		
T_r	0.00400	ns	
FORCE_TR	1	logical	
PMD_type	C2Mcom		
EW	1		
MLSE	3	logical	
ts_anchor	1		
sample_adjustment	[-8 8]		
Local Search	2		
Filter: Rx FFE			
ffe_pre_tap_len	**6**	UI	
ffe_post_tap_len	8	UI	
ffe_pre_tap1_max	1	(normalized)	
ffe_post_tap1_max	1	(normalized)	
ffe_tapn_max	1	(normalized)	
FFE_OPT_METHOD	MMSE		FV-LMS or MMSE
num_ui_RXFF_noise	1024		
Floating Tap Control			
N_bg	**0**	0 1 2 or 3 groups	
N_bf	4	taps per group	
N_f	80	UI span for floating taps	
bmaxg	0.2	max DFE value for floating taps	
B_float_RSS_MAX	1	rss tail tap limit	
N_tail_start	25	(UI) start of tail taps limit	

SAVE_CONFIG2MAT	0	
Receiver testing		
RX_CALIBRATION	0	logical
Sigma BBN step	5.00E-03	V
ICN parameters		
f_v	0.278	Fb
f_f	0.278	Fb
f_n	0.278	Fb
f_2	61.625	GHz
A_ft	0.450	V
A_nt	0.450	V
Parameter	**Setting**	
board_tl_gamma0_a1_a2	*[0 6.44084e-4 3.6036e-05]*	1.4 db/in @ 53.12
board_tl_tau	*5.790E-03*	ns/mm
board_Z_c	100	Ohm
z_bp (TX)	*32*	mm
z_bp (NEXT)	*32*	mm
z_bp (FEXT)	*32*	mm
z_bp (RX)	*32*	mm
C_0	[0.2e-4 0]	nF
C_1	[0.2e-4 0]	nF
Include PCB	**0**	**logical**
Seletions (rectangle, gaussian,dual_rayleigh,triangle		
Histogram_Window_Weigh	gaussian	selection
Qr	*0.02*	UI

COM tool version: 4.5 Beta 3

Host & Module Package Test Cases

.START	PKG_LowR_CLASSA	[2.44 5.7] db	
Table 93A–3 parameters			
Parameter	**Setting**	**Units**	Information
package_tl_gamma0_a1_a2	[0.0005 0.00089 0.0002]		
package_tl_tau	0.006141	ns/mm	
package_Z_c	[87.5 87.5 ; 95 95 ; 100 100; 100 100]	Ohm	
R_d	[50 50]	Ohm	[TX RX]
z_p (TX)	3 1.8 1.8 1.8 1.8 1.8 1.8 1.8 1.8 1.8 1.8 1.8 1.8 1.8 1.8 1.8 1.8; 0 0	mm	[test cases]
z_p (NEXT)	3 1.8 1.8 1.8 1.8 1.8 1.8 1.8 1.8 1.8 1.8 1.8 1.8 1.8 1.8 1.8 1.8; 0 0	mm	[test cases]
z_p (FEXT)	3 1.8 1.8 1.8 1.8 1.8 1.8 1.8 1.8 1.8 1.8 1.8 1.8 1.8 1.8 1.8 1.8; 0 0	mm	[test cases]
z_p (RX)	3 1.8 1.8 1.8 1.8 1.8 1.8 1.8 1.8 1.8 1.8 1.8 1.8 1.8 1.8 1.8 1.8; 0 0	mm	[test cases]
C_p	[0.4e-4 0.4e-4]	nF	[TX RX]
A_v	3 0.4192 0.4049 0.4065 0.4114 0.4132 0.4173 0.4192 0.4049	V	Vf=0.400
A_fe	3 0.4192 0.4049 0.4065 0.4114 0.4132 0.4173 0.4192 0.4049	V	Vf=0.399
A_ne	3 0.4192 0.4049 0.4065 0.4114 0.4132 0.4173 0.4192 0.4049	V	Vf=0.400
.END			

.START	PKG_Module		
Table 93A–3 parameters			
Parameter	**Setting**	**Units**	Information
package_tl_gamma0_a1_a2	[0.0005 0.00089 0.0002]		
package_tl_tau	0.006141	ns/mm	
package_Z_c	[87.5 87.5 ; 95 95 ; 100 100; 100 100]	Ohm	
R_d	[50 50]	Ohm	[TX RX]
z_p (TX)	2; 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0; 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	mm	[test cases]
z_p (NEXT)	2; 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0; 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	mm	[test cases]
z_p (FEXT)	2; 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0; 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	mm	[test cases]
z_p (RX)	2; 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0; 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	mm	[test cases]
C_p	[0.4e-4 0.4e-4]	nF	[TX RX]
A_v	04 0.4049 0.4049 0.4049 0.4049 0.4049 0.4049 0.4049 0.4057 0.40	V	Vf=0.400
A_fe	04 0.4049 0.4049 0.4049 0.4049 0.4049 0.4049 0.4049 0.4057 0.40	V	Vf=0.399
A_ne	04 0.4049 0.4049 0.4049 0.4049 0.4049 0.4049 0.4049 0.4057 0.40	V	Vf=0.400
.END			

.START	PKG_HiR_CLASSB	[2.8 5.6 6.7 9.4] db	
Table 93A–3 parameters			
Parameter	**Setting**	**Units**	Information
package_tl_gamma0_a1_a2	[0.0005 0.00065 0.000293]		
package_tl_tau	0.006141	ns/mm	
package_Z_c	[87.5 87.5 ; 95 95 ; 100 100; 78 78]	Ohm	
R_d	[50 50]	Ohm	[TX RX]
z_p (TX)	2 2 ; 1.3 1.3 1.3 1.3 1.3 1.3 1.3 1.3 1.3 1.3 1.3 1.3 1.3 1.3 1.3 1.3 1	mm	[test cases]
z_p (NEXT)	2 2 ; 1.3 1.3 1.3 1.3 1.3 1.3 1.3 1.3 1.3 1.3 1.3 1.3 1.3 1.3 1.3 1.3 1	mm	[test cases]
z_p (FEXT)	2 2 ; 1.3 1.3 1.3 1.3 1.3 1.3 1.3 1.3 1.3 1.3 1.3 1.3 1.3 1.3 1.3 1.3 1	mm	[test cases]
z_p (RX)	2 2 ; 1.3 1.3 1.3 1.3 1.3 1.3 1.3 1.3 1.3 1.3 1.3 1.3 1.3 1.3 1.3 1.3 1	mm	[test cases]
C_p	[0.4e-4 0.4e-4]	nF	[TX RX]
A_v	3 0.4192 0.4049 0.4065 0.4114 0.4132 0.4173 0.4192 0.4049	V	Vf=0.400
A_fe	3 0.4192 0.4049 0.4065 0.4114 0.4132 0.4173 0.4192 0.4049	V	Vf=0.399
A_ne	3 0.4192 0.4049 0.4065 0.4114 0.4132 0.4173 0.4192 0.4049	V	Vf=0.400
.END			

Cabled host Channels – Key Characteristics

SL.NO	Intrapair Skew	0.0 UI			0.32UI	0.43 UI*
	Channel File Name	ICN, mv	FOM_ILD	Ball_Ball Insertion Loss, dB		
1	cbl_hst_S4_B2B_s0nl0_Ms1_9_t	4.32	0.20	9.09	10.17	11.11
2	cbl_hst_S4_B2B_s0nl0_Ms11_11_t	3.64	0.19	10.67	11.75	12.69
3	cbl_hst_S4_B2B_s0nl0_Ml2_11_t	3.59	0.19	10.83	11.91	12.85
4	cbl_hst_S4_B2B_s0nl0_Ms13_13_t	3.24	0.17	12.39	13.48	14.41
5	cbl_hst_S4_B2B_s0nl0_Ml12_13_t	3.01	0.19	12.41	13.50	14.43
6	cbl_hst_S4_B2B_s0nl0_Ms7_15_t	2.63	0.17	15.12	16.20	17.14
7	cbl_hst_S4_B2B_s0nl0_Ml6_15_t	2.41	0.17	15.38	16.46	17.39
8	cbl_hst_S4_B2B_s0nl0_Ml10_18_t	1.90	0.16	18.29	19.37	20.31
9	cbl_hst_S4_B2B_s0nl0_Ms18_18_t	2.10	0.16	18.51	19.59	20.53
10	cbl_hst_S4_B2B_s0nl0_Ml20_20_t	1.67	0.16	19.93	21.01	21.94

*The last column shows channel losses for excessive Skew

PCB host Channels – Key Characteristics

SL.NO	Intrapair Skew	0.0 UI			0.21UI	0.43 UI*
	Channel File Name	ICN, mv	FOM_ILD	Ball_Ball Insertion Loss, dB		
1	pcb_hst_S4_B2B_s0nl0_Ms21_9_t	4.45	0.20	9.07	9.53	11.09
2	pcb_hst_S4_B2B_s0nl0_Ms23_10_t	3.91	0.18	10.31	10.77	12.33
3	pcb_hst_S4_B2B_s0nl0_Ml22_10_t	3.70	0.20	10.83	11.29	12.85
4	pcb_hst_S4_B2B_s0nl0_Ms25_12_t	3.45	0.17	11.55	12.01	13.57
5	pcb_hst_S4_B2B_s0nl0_Ml24_12_t	3.24	0.18	12.06	12.52	14.09
6	pcb_hst_S4_B2B_s0nl0_Ml28_16_t	2.52	0.16	15.00	15.46	17.03
7	pcb_hst_S4_B2B_s0nl0_Ms33_18_t	2.28	0.16	17.67	18.13	19.70
8	pcb_hst_S4_B2B_s0nl0_Ml32_18_t	2.01	0.16	17.94	18.40	19.97
9	pcb_hst_S4_B2B_s0nl0_Ms19_20_t	2.01	0.17	20.46	20.92	22.48
10	pcb_hst_S4_B2B_s0nl0_Ml36_20_t	1.66	0.16	20.99	21.45	23.01

*The last column shows channel losses for excessive Skew