200G AUI C2M Channel Analysis Updates

- A view into failed channel characteristics

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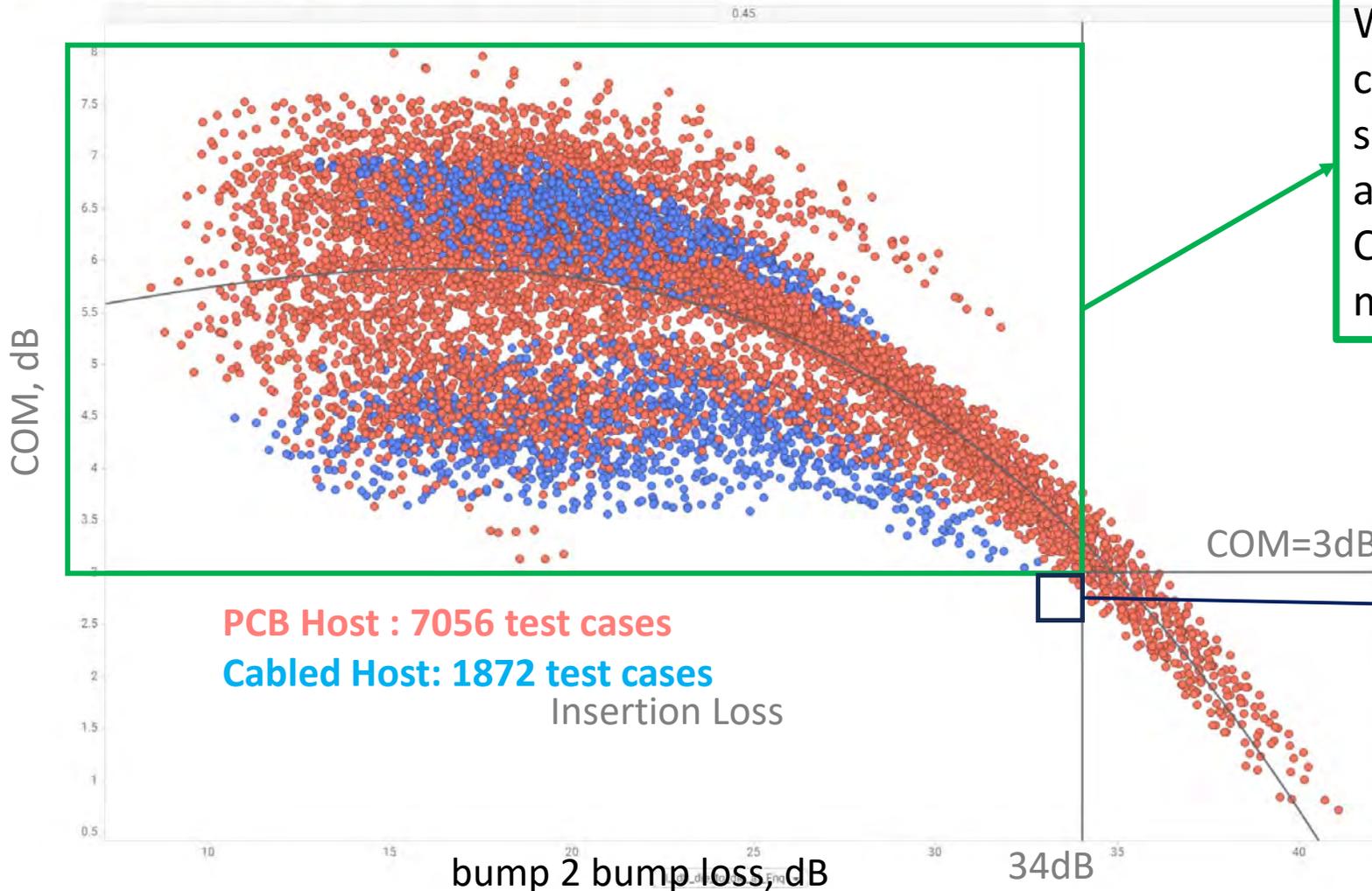IEEE 802.3dj Interim meetings, September 16th-19th, 2024

Outline

- Group adopted C2M Interface reference Receiver based on [lusted_3dj_01a_2406](#):
  - ✓ Number of fixed-position taps (N_fix) = 14 (d_w + 1 + 8 fixed-position post-cursor taps)
  - ✓ Number of floating tap groups (N_g) = 2
  - ✓ Number of taps per floating tap group (N_f) = 4
  - ✓ Highest allowed tap index (N_max) = 50

- [kareti_3dj_elec_01a_2408](#) provided updates to C2M channel analysis based on the reference receiver above and the key COM parameters in draft 1.1 specification:
  - ✓ RDr/RDt: 46.25 ohm
  - ✓ TX SNDR: 33.5 dB
  - ✓ F_r: 0.55 * fbaud
  - ✓ A_fe = A_v = 0.413, A_ne = 0.45V
  - ✓ Eta_0 = 1.0e-8 v^2/GHz
  - ❖ *The results shared were for 112.1 GBd, instead of 106.25 Gbd*

- This presentation
  - provides the results for 106.25 GBd analysis for all C2M channels contributed in 802.3dj project.
  - Propose Inspersion Loss Budget (ILdd) for C2M Interface and for its components.

Test Setup

- COM tool version: 4.6

- 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 in mm: 8, 15, 24, 30, 40, 45
  - Module package assumption:
    - Loss: Type A
    - Trace lengths in mm: 0,4, 8, 12 (0 for no Module Package is added – a sample COM table is included in Backup section of this presentation.

All Channel Results – Cabled host and PCB host channels

COM_orig vs. IL_db_die_to_die_at_Fnq

COM, dB

0.45

COM=3dB

PCB Host : 7056 test cases

Cabled Host: 1872 test cases

Insertion Loss

bump 2 bump loss, dB

34dB

With the adopted reference RX, most channels within the loss target successfully pass 3 dB COM, accommodating both PCB Host and Cabled Host implementations and manufacturing variations.

Failed Channel Test cases

All Channel Results – Failed Channels

Failed channels : Bump2bump loss <34 dB and COM < 3dB

(Excludes excessive skew
Cases)

Ref.RX Type	Test Cases					Channels					
	Total		PCB_Host		Cabled_Host		Total		PCB_Host		Cabled_Host	
	Count		Count	%	Count	%	Total		Count	%	Count	%
Pre:5;Post:8fixed2banks of 4_50UI	8928		7056	79.03%	1872	20.97%	186		147	79.03%	39	20.97%

Failed 3 dB COM_DFE with bump-bump Loss < 34 dB

Ref.RX Type	Test Cases					Channels failed at lease one test case					
	Total		PCB_Host		Cabled_Host		Total		PCB_Host		Cabled_Host	
	Count		Count	%	Count	%	Total		Count	%	Count	%
Pre:5;Post:8fixed2banks of 4_50UI	4	0.04%	4	0.06%	0	0.00%	3	1.61%	3	2.04%	0	0.00%

Total # of Channels	208
Without excessive Skew	188
COM covered channels	186

All Channel Results – Failed Channels and their characteristics

Failed channels : Bump2bump loss <34 dB and COM < 3dB

Channel Count	Channel Name	Ball2Ball Loss, dB	ERL,dB	ICN,mV	FOM_ILD	Host_Pkg_type	TX_pkg_len,mm	RX_pkg_len,mm	bump2bump Loss, dB	COM_DFE, dB
1	I_a_C2M_PCB_85ohms_13p0in_20230620_v3_t	27.9314	17.059	1.9545	0.069296	B	24	0	33.9501	2.9779
1	I_a_C2M_PCB_85ohms_13p0in_20230620_v3_t	27.9314	16.53	1.9545	0.069296	A	30	4	33.8803	2.947
2	I_a_C2M_PCB_85ohms_13p5in_20230620_v3_t	28.7556	16.53	1.9466	0.069637	A	24	4	33.7645	2.9316
3	I_a_C2M_PCB_85ohms_14p0in_20230620_v3_t	29.586	16.53	1.9378	0.070021	B	15	0	33.9383	2.8796
4	<=Total Failed Test Cases							*Min*	*33.7645*	*2.8796*
								Max	*33.9501*	*2.9779*

All Failed channels are pcb_host channels (no cabled _host channels contributed failed)

Excludes excessive skew Cases

Summary

- With the adopted reference RX, most channels within the loss budget (34 dB bump-to-bump) successfully pass 3 dB COM. There is no data shown otherwise.

- Loss alone doesn't define performance; other stress conditions play a significant role..

- There is no benefit to limit the reach (an informative target): the objective is to support a viable and robust ecosystem for various system integration of key applications.
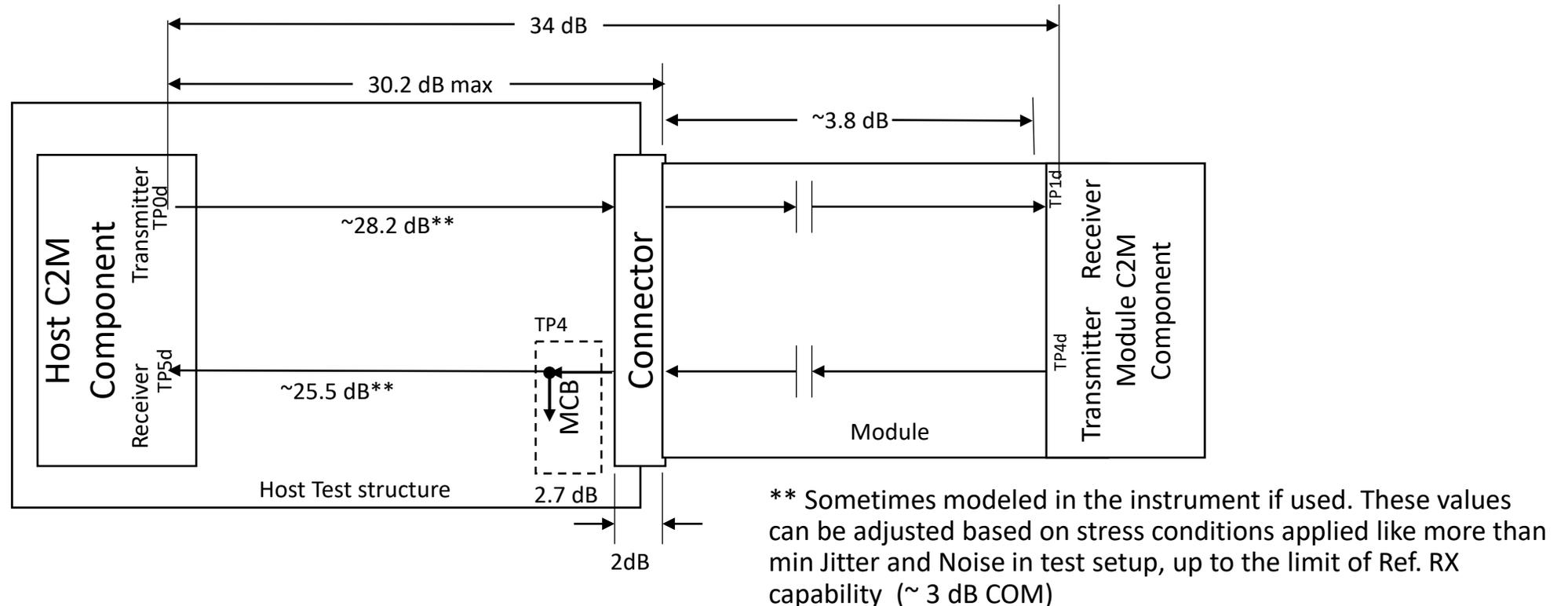
Proposal: C2M Loss Budget (ILdd)

Figure 176E–2—Components of a 200 Gb/s per lane AUI-C2M and insertion loss budget at 53.125 GHz

Backup

Sample COM table to use with COM 4.6 – part 1

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	[46.25 46.25]	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 19 20 21 22 23 24]		
L	4		
M	32		
filter and Eq			
f_r	0.55	*fb	
c(0)	0.55		min
c(-1)	0		[min:step:max]
c(-2)	0		[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)	0.85		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	[0]	dB	[min:step:max]
f_z	42.5	GHz	
f_p1	42.5	GHz	
f_p2	106.25	GHz	
g_DC_HP	[-6:1:0]		[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	1.00E-08	dB
SNR_TX	33.5	
R_LM	0.95	

Batch control options

BATCH_RUN	1	logical
CHANNEL_DIR	..\Channels\C2M_ieee_channels\IEEE_C2M_All_channels\	
ENOB	32	default 32
trunc	128	default 128

baseline
new

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	[92 92 ; 70 70; 80 80; 100 100]	Ohm	
z_p (TX)	[8 24 30 45 ; 1 1 1 1; 1 1 1 1 ; 0.5 0.5 0.5 0.5]	mm	[test cases to run]
z_p (NEXT)	[8 24 30 45 ; 1 1 1 1; 1 1 1 1 ; 0.5 0.5 0.5 0.5]	mm	[test cases]
z_p (FEXT)	[8 24 30 45 ; 1 1 1 1; 1 1 1 1 ; 0.5 0.5 0.5 0.5]	mm	[test cases]
z_p (RX)	[8 24 30 45 ; 1 1 1 1; 1 1 1 1 ; 0.5 0.5 0.5 0.5]	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	[-32 32]		
Local Search	0		0,1,2
Filter: Rx FFE			
ffe_pre_tap_len	5	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		
RXFFE FLOAT CTL	FOM		FOM o ISI
Floating Tap Control			
N_bg	2	0 1 2 or 3 groups	
N_bf	4	taps per group	
N_f	50	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	9	(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	0.264	Fb
f_f	0.264	Fb
f_n	0.264	Fb
f_2	61.655	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 @ 53.125G
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_Weight	gaussian	selection
Qr	0.02	UI

Sample COM table to use with COM 4.6 – part 2

Table 93A–3 parameters		Units	Information
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	[46.25 46.25]	Ohm	[TX RX]
z_p (TX)	[8 15 24 30 40 45 8 15 24 30 40 45 8 15 24 30 40 45 8 15 24 30 40 45;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 1.8 1.8 1.8 1.8 1.8 1.8 1.8 1.8;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 0 0 0 0 0 0 0 0]	mm	[test cases]
z_p (NEXT)	[8 8 8 8 15 15 15 15 24 24 24 24 30 30 30 30 40 40 40 40 45 45 45 45;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 1.8 1.8 1.8 1.8 1.8 1.8 1.8 1.8;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 0 0 0 0 0 0 0 0]	mm	[test cases]
z_p (FEXT)	[8 15 24 30 40 45 8 15 24 30 40 45 8 15 24 30 40 45 8 15 24 30 40 45;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 1.8 1.8 1.8 1.8 1.8 1.8 1.8 1.8;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 0 0 0 0 0 0 0 0]	mm	[test cases]
z_p (RX)	[8 8 8 8 15 15 15 15 24 24 24 24 30 30 30 30 40 40 40 40 45 45 45 45;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 1.8 1.8 1.8 1.8 1.8 1.8 1.8 1.8;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 0 0 0 0 0 0 0 0]	mm	[test cases]
C_p	[0.4e-4 0.4e-4]	nF	[TX RX]
A_v	[0.4049 0.4065 0.4114 0.4132 0.4173 0.4192 0.4049 0.4065 0.4114 0.4132 0.4173 0.4192 0.4049 0.4065 0.4114 0.4132 0.4173 0.4192 0.4049 0.4065 0.4114 0.4132 0.4173 0.4192]	V	Vf=0.400
A_fe	[0.4049 0.4065 0.4114 0.4132 0.4173 0.4192 0.4049 0.4065 0.4114 0.4132 0.4173 0.4192 0.4049 0.4065 0.4114 0.4132 0.4173 0.4192 0.4049 0.4065 0.4114 0.4132 0.4173 0.4192]	V	Vf=0.399
A_ne	[0.45 0.45 0.45 0.45 0.45 0.45 0.45 0.45 0.45 0.45 0.45 0.45 0.45 0.45 0.45 0.45 0.45 0.45 0.45 0.45 0.45 0.45 0.45 0.45]	V	Vf=0.400
.END			

.START	PKG_HiR_CLASSB	[2.8 5.6 6.7 9.4] db	
Table 93A–3 parameters		Units	Information
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	[46.25 46.25]	Ohm	[TX RX]
z_p (TX)	[8 15 24 30 40 45 8 15 24 30 40 45 8 15 24 30 40 45 8 15 24 30 40 45;2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 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 1.3 1.3 1.3 1.3 1.3 1.3 1.3 1.3;1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5]	mm	[test cases]
z_p (NEXT)	[8 8 8 8 15 15 15 15 24 24 24 24 30 30 30 30 40 40 40 40 45 45 45 45;2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 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 1.3 1.3 1.3 1.3 1.3 1.3 1.3 1.3;1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5]	mm	[test cases]
z_p (FEXT)	[8 15 24 30 40 45 8 15 24 30 40 45 8 15 24 30 40 45 8 15 24 30 40 45;2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 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 1.3 1.3 1.3 1.3 1.3 1.3 1.3 1.3;1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5]	mm	[test cases]
z_p (RX)	[8 8 8 8 15 15 15 15 24 24 24 24 30 30 30 30 40 40 40 40 45 45 45 45;2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 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 1.3 1.3 1.3 1.3 1.3 1.3 1.3 1.3;1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5]	mm	[test cases]
C_p	[0.4e-4 0.4e-4]	nF	[TX RX]
A_v	[0.4049 0.4065 0.4114 0.4132 0.4173 0.4192 0.4049 0.4065 0.4114 0.4132 0.4173 0.4192 0.4049 0.4065 0.4114 0.4132 0.4173 0.4192 0.4049 0.4065 0.4114 0.4132 0.4173 0.4192]	V	Vf=0.400
A_fe	[0.4049 0.4065 0.4114 0.4132 0.4173 0.4192 0.4049 0.4065 0.4114 0.4132 0.4173 0.4192 0.4049 0.4065 0.4114 0.4132 0.4173 0.4192 0.4049 0.4065 0.4114 0.4132 0.4173 0.4192]	V	Vf=0.399
A_ne	[0.45 0.45 0.45 0.45 0.45 0.45 0.45 0.45 0.45 0.45 0.45 0.45 0.45 0.45 0.45 0.45 0.45 0.45 0.45 0.45 0.45 0.45 0.45 0.45]	V	Vf=0.400
.END			

.START	PKG_Module		
Table 93A–3 parameters		Units	Information
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	[46.25 46.25]	Ohm	[TX RX]
z_p (TX)	[0 4 8 12 0 4 8 12 0 4 8 12 0 4 8 12 0 4 8 12 0 4 8 12;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 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)	[0 0 0 0 0 4 4 4 4 4 8 8 8 8 8 12 12 12 12 12;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 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)	[0 4 8 12 0 4 8 12 0 4 8 12 0 4 8 12 0 4 8 12 0 4 8 12;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 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)	[0 0 0 0 0 4 4 4 4 4 8 8 8 8 8 12 12 12 12 12;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 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	[0.4 0.4 0.4 0.4 0.4 0.4 0.404 0.404 0.404 0.404 0.404 0.404 0.4049 0.4049 0.4049 0.4049 0.4049 0.4049 0.4057 0.4057 0.4057 0.4057 0.4057 0.4057]	V	Vf=0.400
A_fe	[0.4 0.4 0.4 0.4 0.4 0.4 0.404 0.404 0.404 0.404 0.404 0.404 0.4049 0.4049 0.4049 0.4049 0.4049 0.4049 0.4057 0.4057 0.4057 0.4057 0.4057 0.4057]	V	Vf=0.399
A_ne	[0.45 0.45 0.45 0.45 0.45 0.45 0.45 0.45 0.45 0.45 0.45 0.45 0.45 0.45 0.45 0.45 0.45 0.45 0.45 0.45 0.45 0.45 0.45 0.45]	V	Vf=0.400
.END			