200G AUI C2M Channel Analysis Updates

- C2M Loss Target

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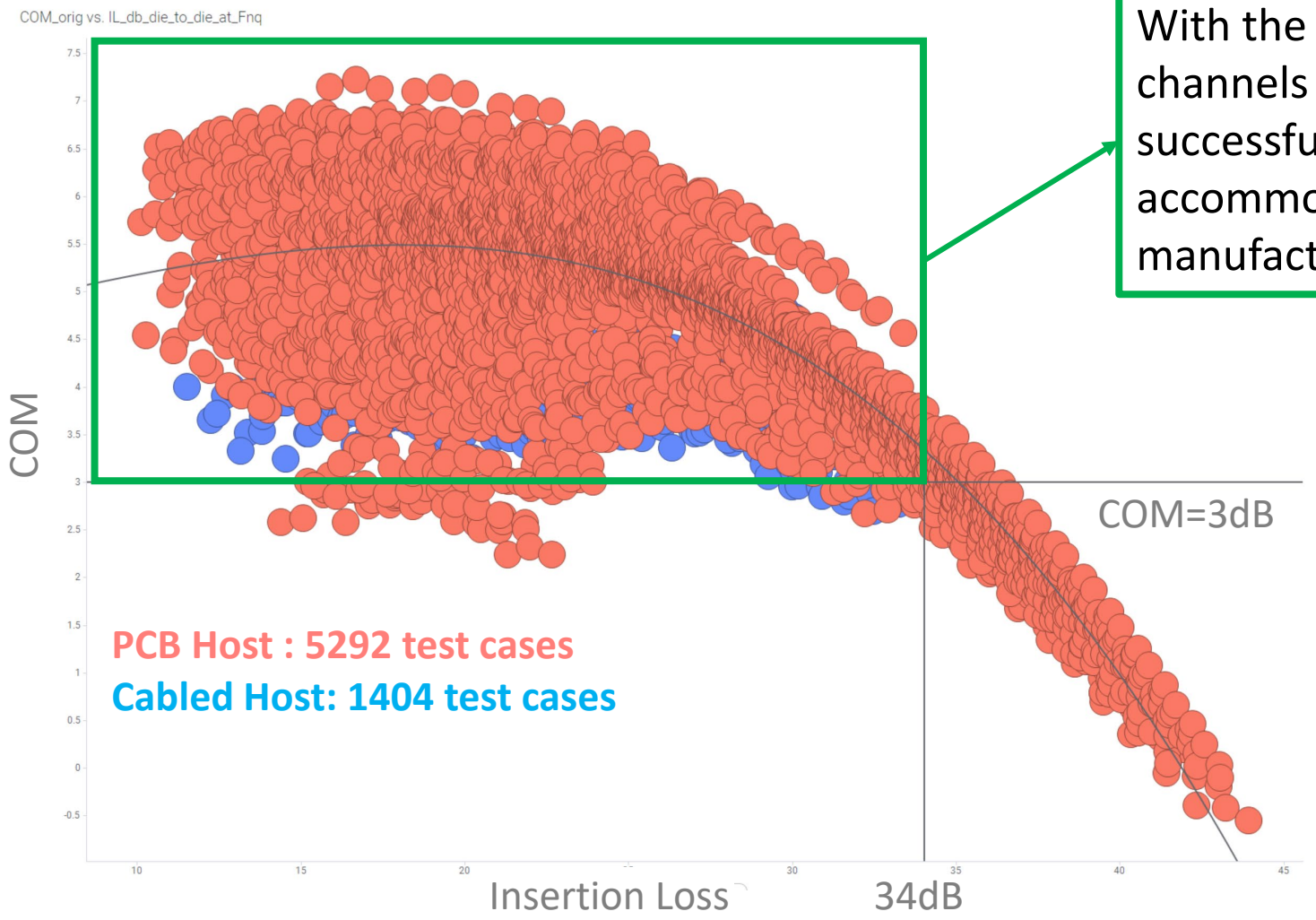
Test Cases

- Channel models used: all C2M channels contributed to 802.3dj https://www.ieee802.org/3/dj/public/tools/index.html
  - Cisco channels are based on a fully routed 512-radix system with both PCB host and cabled host implementations, including stress conditions such as max tolerable skews, via locations, discontinuities in the channels, etc.
  - Excessive skew cases for both PCB and cabled hosts are excluded from the study.
- 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: 4, 8, 12 (no Module Package cases were simulated but excluded from results , to keep the same scope of analysis done earlier cycles) – a sample COM table is included in Backup section of this presentation.

Test Setup

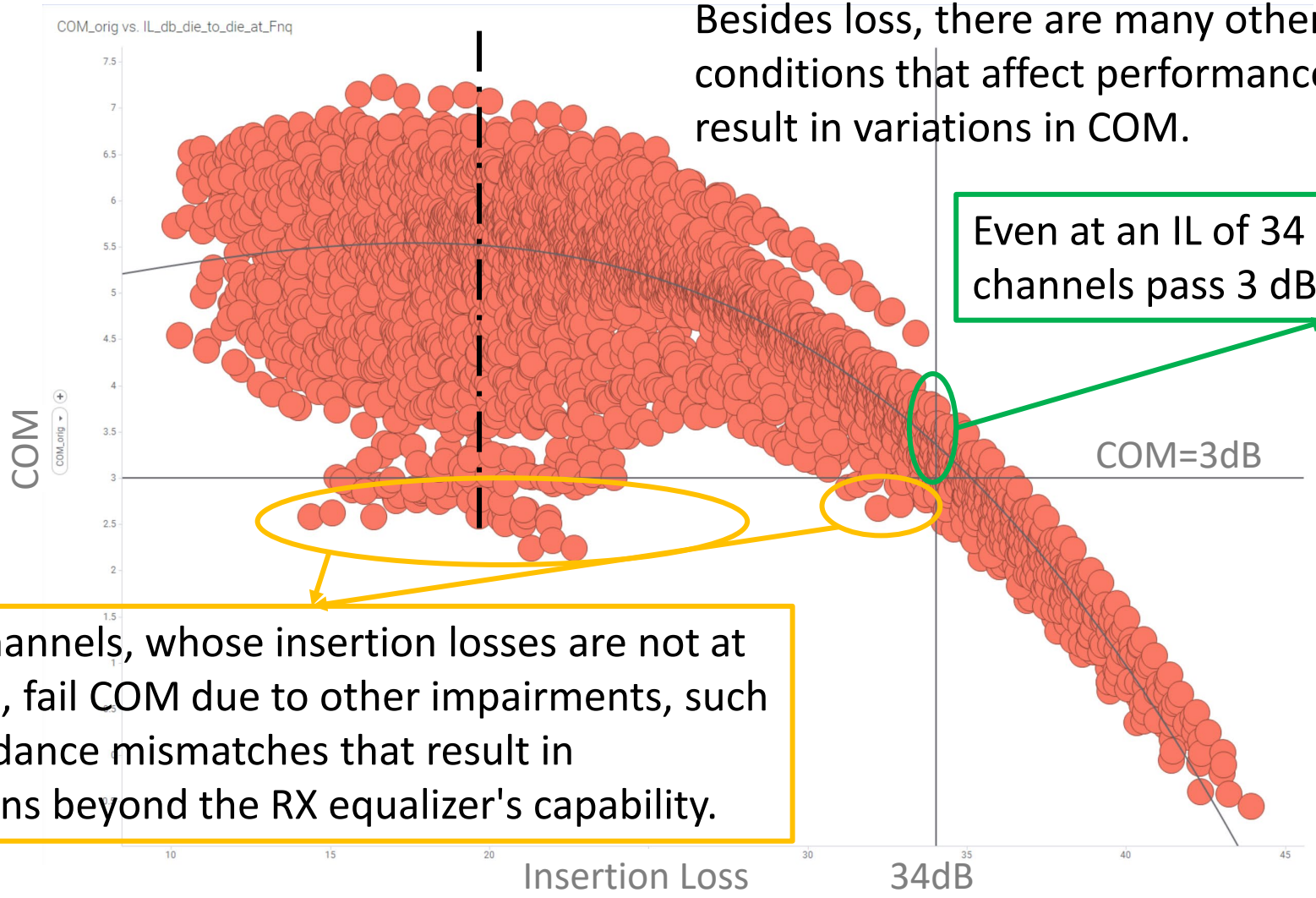
- COM tool version: 4.6 Beta 4.
- COM Parameters based on draft 1.1 (The complete COM table is attached in the back up)
  - RDr/RDt: 46.25 ohm
  - TX SNDR: 33.5 dB
  - F_r: 0.55 * fbaud
  - A_fe = A_v, A_ne = 0.45V
  - Eta_0 = 1.0e-8 v^2/GHz
- Reference Receiver:
  - Number of RX FEE pre-cursors: 5
  - Number of RX FFE fixed post-cursors: 8
  - Number of banks of floating up to 50 UI: 2 banks of 4 taps

All Channel Results – Cabled host and PCB host channels



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

PCB Host Channel Results

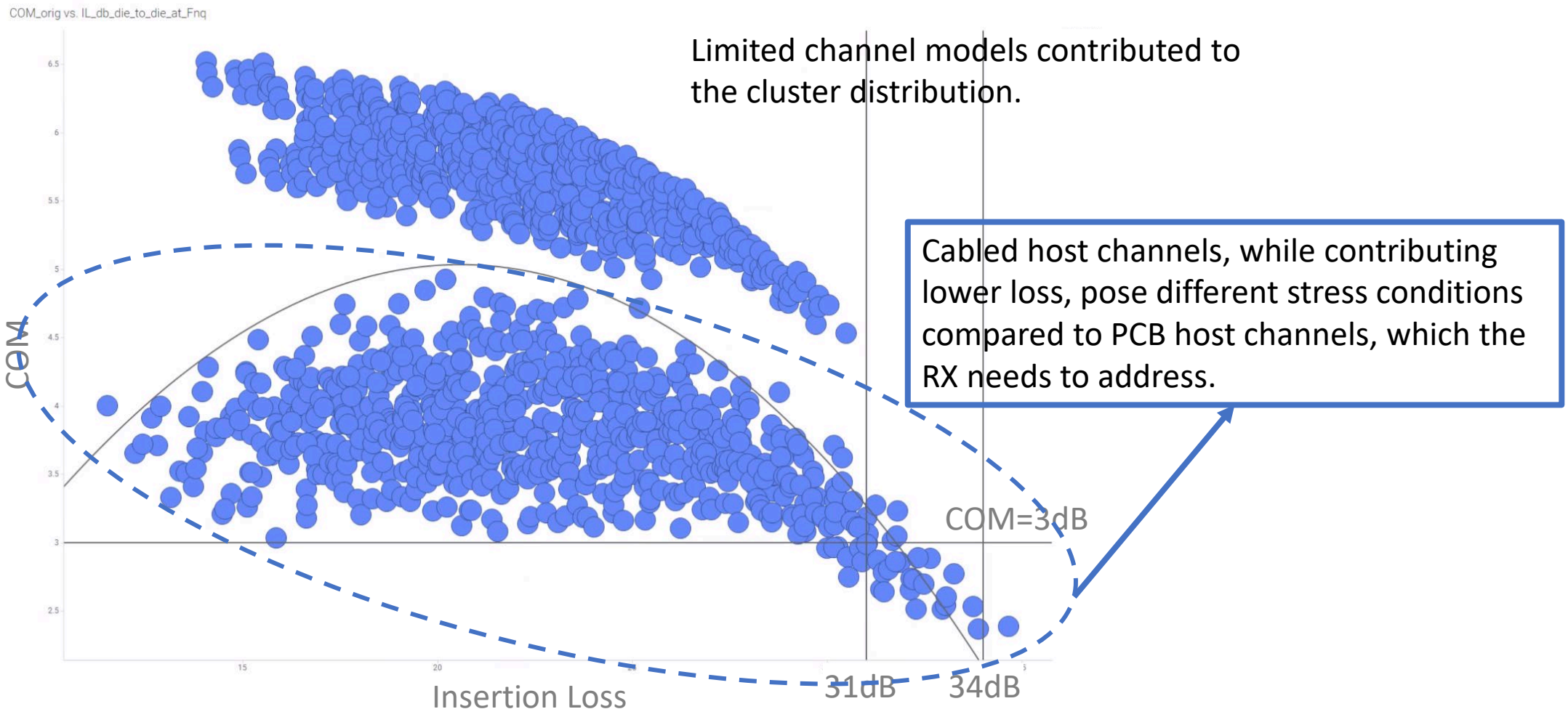


Besides loss, there are many other stress conditions that affect performance and result in variations in COM.

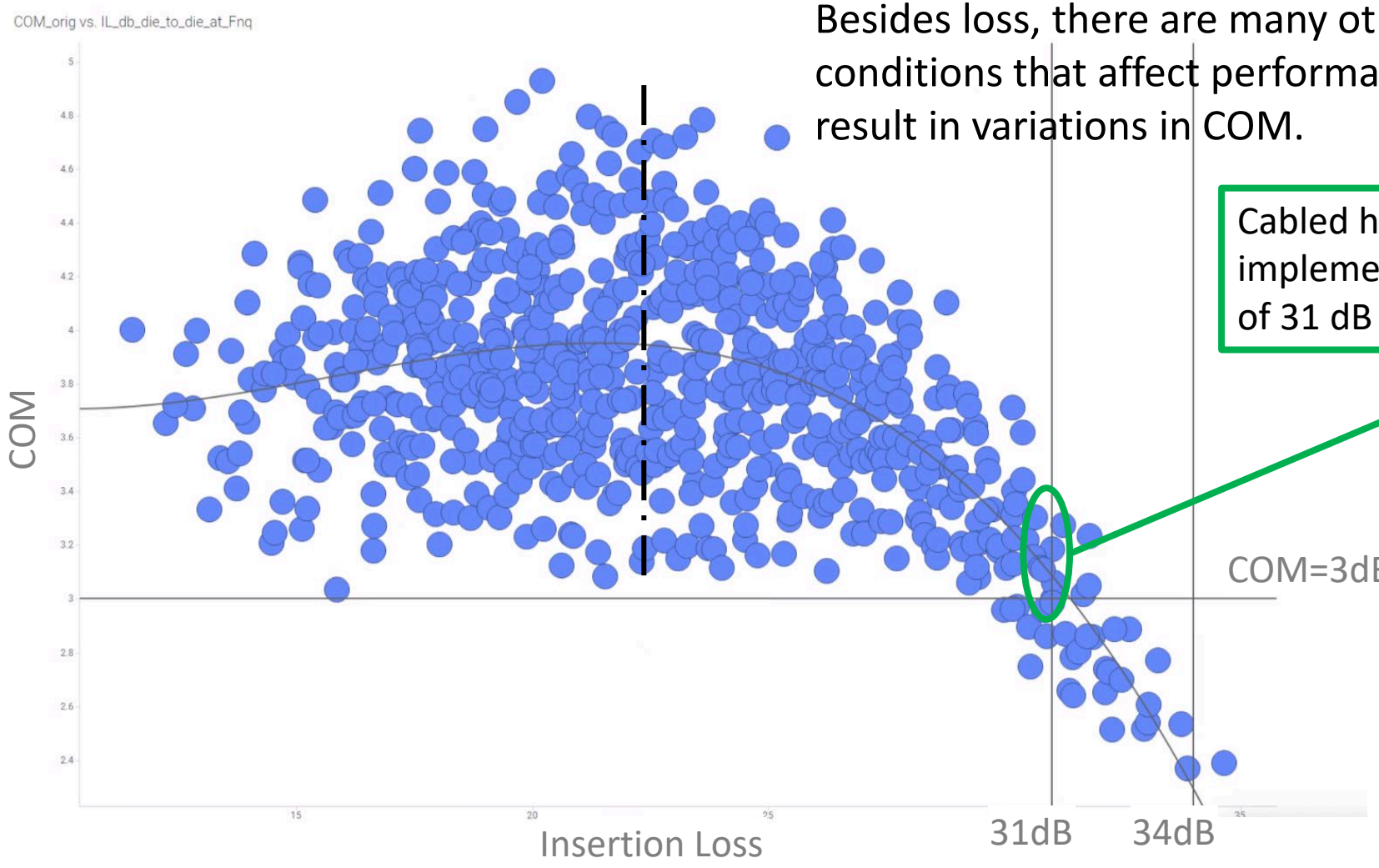
Even at an IL of 34 dB, many PCB host channels pass 3 dB COM.

Some channels, whose insertion losses are not at the limit, fail COM due to other impairments, such as impedance mismatches that result in reflections beyond the RX equalizer's capability.

Cabled Host Channel Results



Cabled Host Channel Results



Besides loss, there are many other stress conditions that affect performance and result in variations in COM.

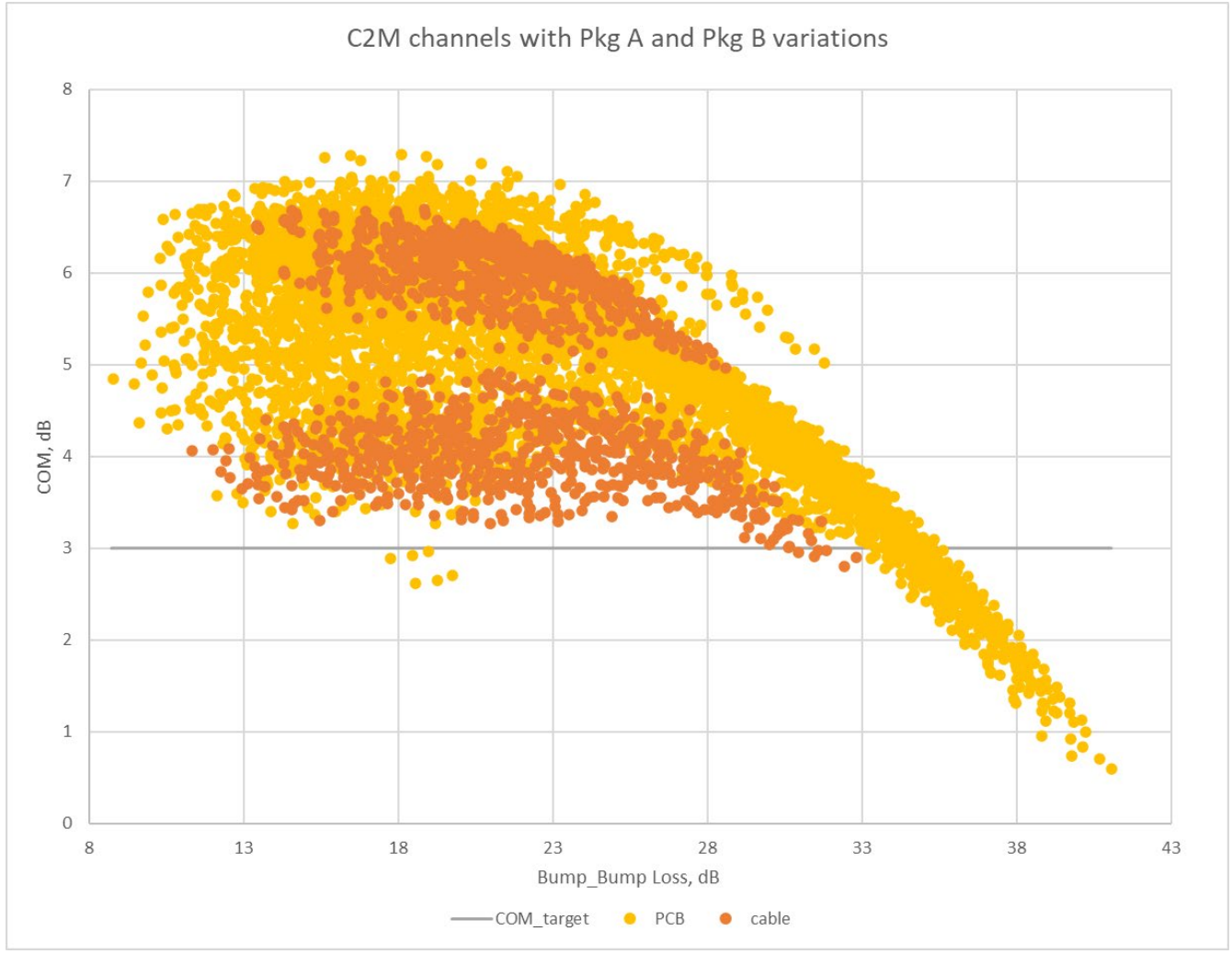
Cabled host channels with various implementations and an insertion loss of 31 dB can pass 3 dB COM.

Conclusion

- With the adopted reference RX, most channels within the loss budget below successfully pass 3 dB COM:
  - PCB Host bump to bump IL: 34 dB
  - Cabled host bump to bump IL: 31 dB
- Loss alone doesn't define performance; other stress conditions play a significant role..
- Extrapolations from a limited data set (ghiasi_3dj_01_2407.pdf) are difficult to make
  - Sensitivity to stress conditions needs to be understood better
- The compliance methodology needs to consider all the stress conditions and requires further study.

Backup

C2M Channel Analysis – Phase 1: as of May 2024



COM version: 4.6 beta 2

Receiver

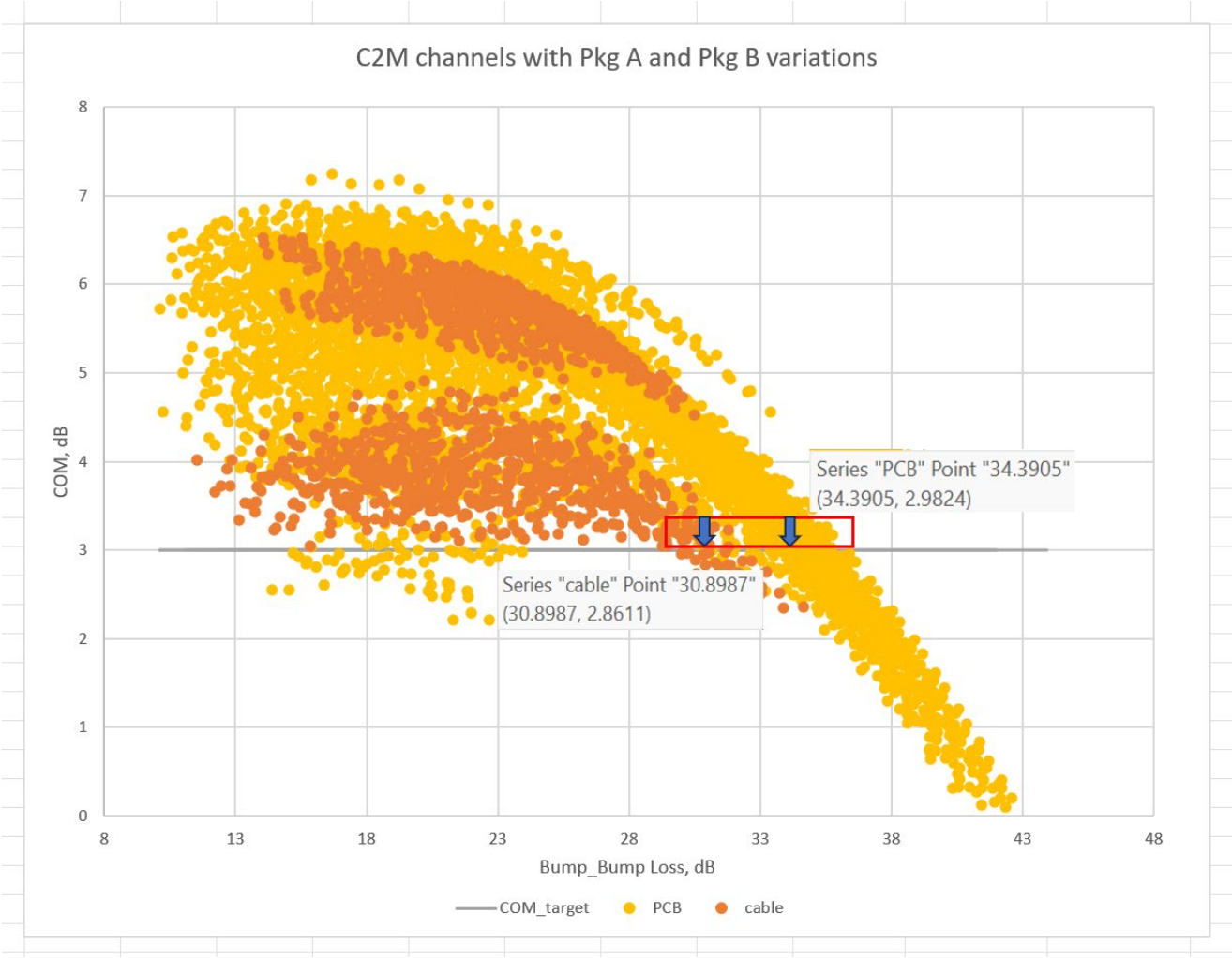
- Num of RX FFE pre-cursors : 5
- Num of RX FFE fixed post cursors : 8
- Number of banks of floating up to 50 UI: 2

NEXT Voltage levels

- A_Ne = A_V

**Excessive Skew cases removed*

C2M Channel Analysis – Phase 2: as of July 2024



COM version: 4.6 beta 4

Receiver

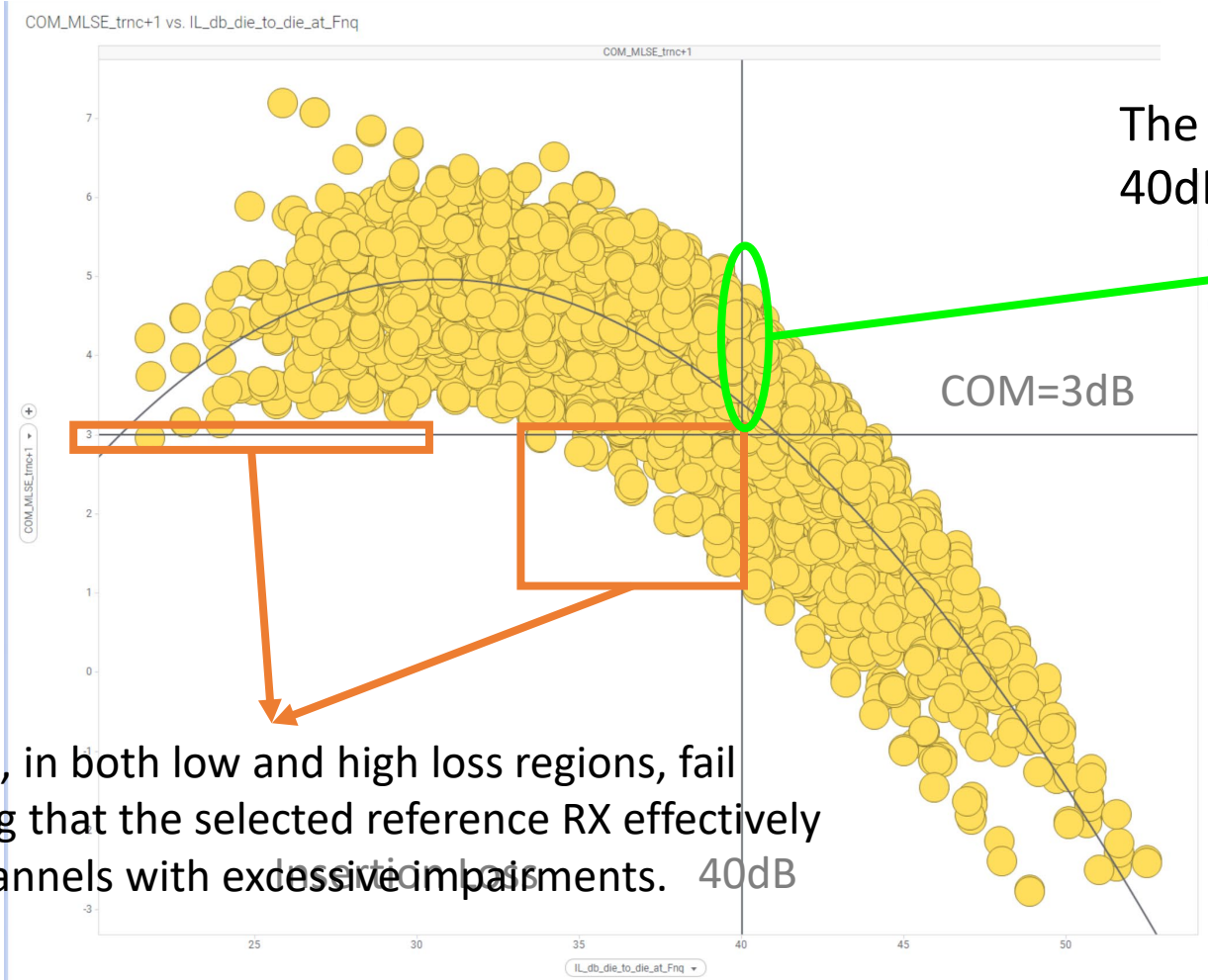
- Num of RX FFE pre-cursors : 5
- Num of RX FFE fixed post cursors : 8
- Number of banks of floating up to 50 UI: 2

NEXT Voltage levels

- A_Ne = 0.45
- RDt = RDr = 46.25 Ohm
- F_r = 0.55*fbaud
- SNR_TX = 33.5 dB

**Excessive Skew cases removed*

CR/KR channels- Target Loss with Ref. RX as of Jul 2024



COM

The majority of the channels with an IL of 40dB pass COM.

Some channels, in both low and high loss regions, fail COM, indicating that the selected reference RX effectively screens out channels with excessive impairments.

TX and RX: Package Type Combination: **BB**

Receiver

- Num of RX FFE pre-cursors : 6
- Num of RX FFE fixed post cursors : 8
- Number of banks of floating up to 80 UI: 2 banks of 4 taps

**Cases with No Skew added*

Sample COM table to use with COM 4.6 Beta 4 – part 1

Table 93A-1 parameters			
Parameter	**Setting**	**Units**	**Information**
f_b	112.1	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	44.84	GHz	
f_p1	44.84	GHz	
f_p2	112.10	GHz	
g_DC_HP	[-6:1:0]		[min:step:max]
f_HP_PZ	1.40125	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 Beta 4 – part 2

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	[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			
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			
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 0 4 4 4 4 4 4 8 8 8 8 8 8 12 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 0 4 4 4 4 4 4 8 8 8 8 8 8 12 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			