Backplane COM Analysis for Reference Rx Baseline

Howard Heck, Subas Bastola, Jingbo Li, Femi Akinwale, Cesar Mendez-Ruiz – Intel Corporation

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IEEE 802.3ck 100 Gb/s, 200 Gb/s and 400 Gb/s Electrical Interfaces Task Force

Contents

Summary & Recommendations

- Objective: Develop reference equalizer recommendations for KR.
- Criteria: Choose equalizer to
  - maximize the percentage of contributed channels with ≥3dB COM.
  - get all of the 'highlighted' (a.k.a. 'must work') channels to ≥3dB COM.
- Proposed reference equalizer:
  - 80%-83% of sub-29dB channels meet 3dB COM (C_d dependent).
  - All but 3 of the 'highlighted' channels meet 3dB COM. None of the options analyzed achieved 3dB.
  - We also analyzed the impact of C_d, as part of the analysis to help the TF select the C_d baseline.
- To address the COM deficit for the failing channels we analyzed package trace loss & length mismatch.
  - Results were negative. They are included in backup.

Parameter	Recommendation
TxFFE $c(-3)$	[-0.06: 0.02: 0.00]
# Fixed DFE taps	16
# Floating DFE banks	2
# taps per bank	4
max bank span	40UI from cursor
$b_{max}(1)$	0.85

Channels

Channels – Full Set

#	Main File	Folder	Files	Documentation
1	cable_CKP_16dB.zip	Cable_BKP_16dB_0p575m.zip	Cable_BKP_16dB_0p575m_*.s4p	heck_3ck_02_0119.pdf
2		Cable_BKP_16dB_0p575m_more_isi.zip	Cable_BKP_16dB_0p575m_more_isi_*.s4p	
3		Cable_BKP_16dB_0p995m_updated.zip	Cable_BKP_16dB_0p995m_updated_*.s4p	
4		Cable_BKP_16dB_0p0p995m_more_isi_updated.zip	Cable_BKP_16dB_0p0p995m_more_isi_updated_*.s4p	
5	cable_CKP_20dB.zip	Cable_BKP_20dB_0p575m.zip	Cable_BKP_20dB_0p575m_*.s4p	
6		Cable_BKP_20dB_0p575m_more_isi.zip	Cable_BKP_20dB_0p575m_more_isi_*.s4p	
7		Cable_BKP_20dB_0p995m_updated.zip	Cable_BKP_20dB_0p995m_updated_*.s4p	
8		Cable_BKP_20dB_0p0p995m_more_isi_updated.zip	Cable_BKP_20dB_0p0p995m_more_isi_updated_*.s4p	
9	cable_CKP_24dB.zip	Cable_BKP_24dB_0p575m.zip	Cable_BKP_24dB_0p575m_*.s4p	
10		Cable_BKP_24dB_0p575m_more_isi.zip	Cable_BKP_24dB_0p575m_more_isi_*.s4p	
11		Cable_BKP_24dB_0p995m_updated.zip	Cable_BKP_24dB_0p995m_updated_*.s4p	
12		Cable_BKP_24dB_0p0p995m_more_isi_updated.zip	Cable_BKP_24dB_0p0p995m_more_isi_updated_*.s4p	
13	cable_CKP_28dB.zip	Cable_BKP_28dB_0p575m.zip	Cable_BKP_28dB_0p575m_*.s4p	
14		Cable_BKP_28dB_0p575m_more_isi.zip	Cable_BKP_28dB_0p575m_more_isi_*.s4p	
15		Cable_BKP_28dB_0p995m_updated.zip	Cable_BKP_28dB_0p995m_updated_*.s4p	
16		Cable_BKP_28dB_0p0p995m_more_isi_updated.zip	Cable_BKP_28dB_0p0p995m_more_isi_updated_*.s4p	
17	tracy_3ck_02_0119_orthoBP.zip	DPO_IL_12dB	DPO_4in_Meg7_*.s4p	tracy_3ck_01b_0119.pdf
18		DPO_IL_24dB	DPO_10in_Meg7_*.s4p	
19		DPO_IL_28dB	DPO_12in_Meg7_*.s4p	
20		DPO_IL_32dB	DPO_14in_Meg7_*.s4p	
21	tracy_3ck_03_0119_tradBP.zip	-	Std_BP_12inch_Meg7_*.s4p	
22	zambell_3ck_01_1118_links01to09.zip	Link_1	See the folder	zambell_3ck_01_1118.pdf
23		Link_2		
24		Link_3		
25		Link_4		
26		Link_5		
27		Link_6		
28		Link_7		
29		Link_8		
30		Link_9		
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32		Link_11		
33		Link_12		
34		Link_13		
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37		Link_16		
38		Link_17		
39		Link_18		
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41		Link_20		
42		Link_21		
43		Link_22		
44		Link_23		
45		Link_24		
46		Link_25		
47		Link_26		
48		Link_27		
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51		CaBP_BGAVia_Opt1_32dB.zip	CaBP_BGAVia_Opt1_32dB_*.s4p	
52		CaBP_BGAVia_Opt2_24dB.zip	CaBP_BGAVia_Opt2_24dB_*.s4p	
53		CaBP_BGAVia_Opt2_28dB.zip	CaBP_BGAVia_Opt2_28dB_*.s4p	
54		CaBP_BGAVia_Opt2_32dB.zip	CaBP_BGAVia_Opt2_32dB_*.s4p	
55	kareti_3ck_01_1118_backplane.zip	-	Bch1_3p5	kareti_3ck_01a_1118.pdf
56			Bch2_7	
57			Bch2_a0_7	
58			Bch2_a10_7	
59			Bch2_a12p5_7	
60			Bch2_a15_7	
61			Bch2_a2p5_7	
62			Bch2_a5_7	
63			Bch2_a7p5_7	
64			Bch2_b10_7	
65			Bch2_b15_7	
66			Bch2_b2p5_7	
67			Bch2_b2_7	
68			Bch2_b4_7	
69			Bch2_b6_7	
70			Bch2_b7p5_7	
71			Bch2_b8_7	
72			Bch3_14	
73			Bch4_30	
74	kareti_3ck_01_1118_cabledBP.zip	-	CAch1_b2	
75			CAch1	
76			CAch2_a0	
77			CAch2_a10	
78			CAch2_a2p5	
79			CAch2_a5	
80			CAch2_a7p5	
81			CAch2_b10	
82			CAch2_b2p5	
83			CAch2_b2	
84			CAch2_b4	
85			CAch2_b6	
86			CAch2_b7p5	
87			CAch2_b8	
88			CAch2	
89			CAch3_b2	
90			CAch3	
91			CAch4_b2	
92			CAch4	
93	kareti_3ck_01_1118_orthoBP.zip	-	OAch1	
94			OAch2	
95			OAch3	
96			OAch4	
97			OAch5	
98			OAch6	
99			OAch7	
100			Och1	
101			Och2	
102			Och3	
103			Och4	
104			Och5	
105			Och6	
106			Och7	
107			Och8	

107 channels pulled from the p802.3ck repository.

COM spreadsheet is included in backup slides.

P802.3ck Highlighted Channel Subset

Contribution	Channel
heck_3ck_01_1118	28dB Cabled Backplane/Cable_BKP_28dB_0p575m_more_isi
	16dB Cabled Backplane/Cable_BKP_16dB_0p575m_more_isi
mellitz_3ck_adhoc_02_081518	24,28,30dB including BGA Via/CaBP_BGAVia_Opt2_28dB
tracy_3ck_01_0119	Traditional Backplane Channels/Std_BP_12inch_Meg7
	Orthogonal Backplane Channels/DPO_IL_12dB
kareti_3ck_01a_1118	Measured Orthogonal Backplane Channels/OAch4
	~~Measured Orthogonal Backplane Channels/Och4~~
	Measured Cabled Backplane Channels/CAch3_b2
	~~Measured Traditional Backplane Channels/Bch2_a7p5_7~~
	Measured_Traditional_Backplane_Channels/Bch2_b7p5_7

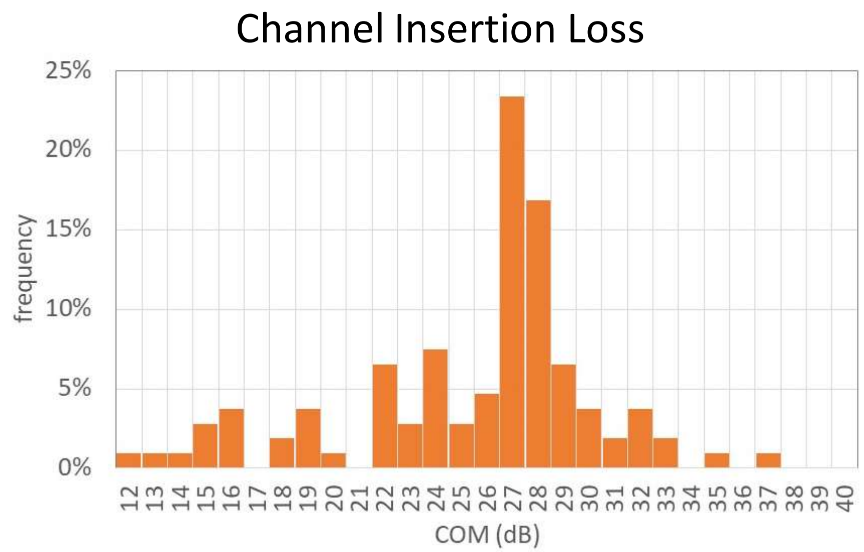
#	Name	IL (dB)
14	Heck1	28.8
2	Heck2	15.2
53	Mellitz1	26.3
21	Tracy1	15.7
17	Tracy2	12.2
96	Kareti1	27.7
~~103~~	~~Kareti2~~	~~28.1~~
89	Kareti3	28.5
~~63~~	~~Kareti4~~	~~28.4~~
70	Kareti5	28.9

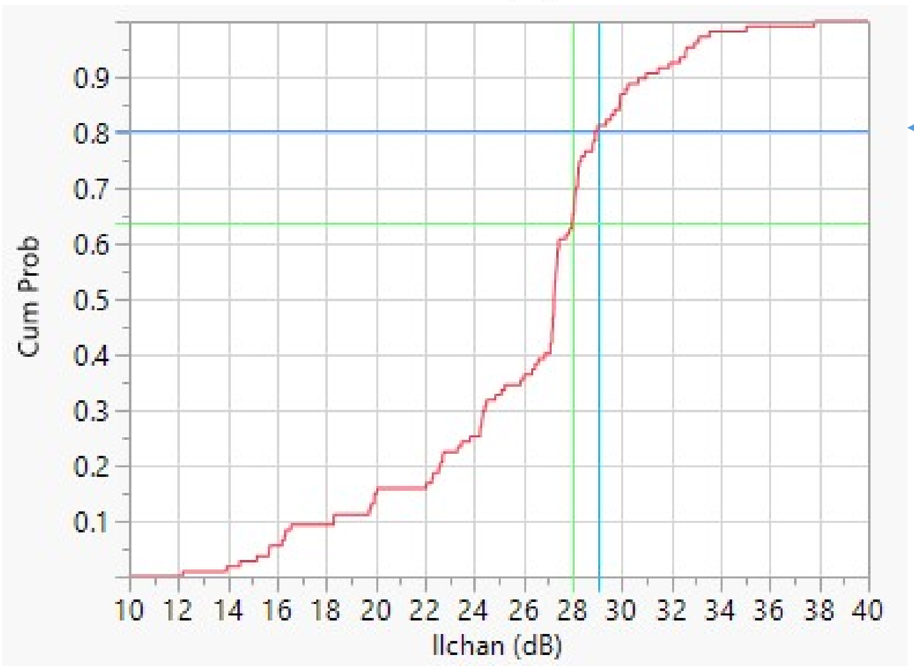
Source: kochuparambil_3ck_01a_0119.pdf.

Channel Selection

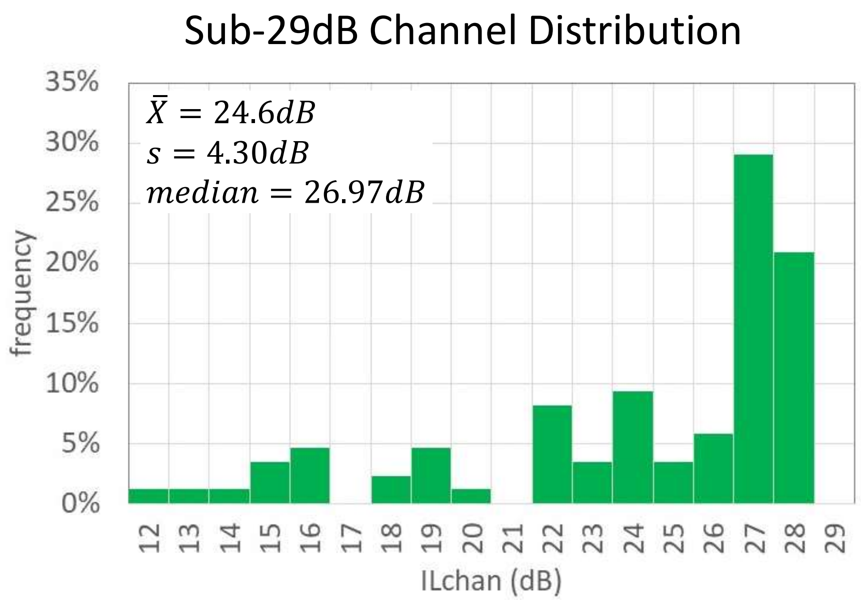
- Approach: Restrict analysis to sub-29dB channels.
- Reasoning:
  - Our 28dB objective doesn't require that all channels with 28dB insertion loss meet COM≥3.0dB.
  - Nor does it mean that some channels with more than 28dB insertion loss won't meet COM≥3.0dB.
  - All of our highlighted channels have less than 29dB insertion loss. Three of them fall between 28dB & 29dB.

Channel Insertion Loss Statistics





All 'highlighted' channels fit within 29dB.



Floating Tap Algorithm

1) Get the ISI waveform vector, $X = [x_1 \quad x_2 \quad x_3 \quad \ldots \quad x_n]$.
2) Compute the norm, $\bar{X}$,of the ISI vector.
3) Apply a bank (e.g. 3 taps) to each successive ISI sample set: $[x_1 \quad x_2 \quad x_3]$, $[x_2 \quad x_3 \quad x_4]$,…, $[x_{n-2} \quad x_{n-1} \quad x_n]$
4) Compute the norm for each location from step 3): $\bar{X}_1$, $\bar{X}_2$,… ,$\bar{X}_{n-2}$
5) Select the location that gives max difference in the norm: $\max_i(\bar{X} - \bar{X}_i)$.
6) Repeat steps 1-5 for each bank.

Sub-29dB Contributed Channel Analysis

Experiment Definition

Case	$b1_{max}$	N_{tpb}	UI_{mf}	C_d (fF)	c(-3)	L_{pkg} (mm)
1	0.85	3	40	110	0	12,32
2	0.85	3	80	110	0	12,32
3	0.85	3	40	110	1	12,32
4	0.85	3	80	110	1	12,32
5	0.85	3	40	120	0	12,32
6	0.85	3	80	120	0	12,32
7	0.85	3	40	120	1	12,32
8	0.85	3	80	120	1	12,32
9	0.85	3	40	130	0	12,32
10	0.85	3	80	130	0	12,32
11	0.85	3	40	130	1	12,32
12	0.85	3	80	130	1	12,32
13	0.85	4	40	110	0	12,32
14	0.85	4	80	110	0	12,32
15	0.85	4	40	110	1	12,32
16	0.85	4	80	110	1	12,32
17	0.85	4	40	120	0	12,32
18	0.85	4	80	120	0	12,32
19	0.85	4	40	120	1	12,32
20	0.85	4	80	120	1	12,32
21	**0.85**	**4**	**40**	**130**	**0**	**12,32**
22	0.85	4	80	130	0	12,32
23	0.85	4	40	130	1	12,32
24	0.85	4	80	130	1	12,32

Case	$b1_{max}$	N_{tpb}	UI_{mf}	C_d (fF)	c(-3)	L_{pkg} (mm)
25	0.7	3	40	110	0	12,32
26	0.7	3	80	110	0	12,32
27	0.7	3	40	110	1	12,32
28	0.7	3	80	110	1	12,32
29	0.7	3	40	120	0	12,32
30	0.7	3	80	120	0	12,32
31	0.7	3	40	120	1	12,32
32	0.7	3	80	120	1	12,32
33	0.7	3	40	130	0	12,32
34	0.7	3	80	130	0	12,32
35	0.7	3	40	130	1	12,32
36	0.7	3	80	130	1	12,32
37	0.7	4	40	110	0	12,32
38	0.7	4	80	110	0	12,32
39	0.7	4	40	110	1	12,32
40	0.7	4	80	110	1	12,32
41	0.7	4	40	120	0	12,32
42	0.7	4	80	120	0	12,32
43	0.7	4	40	120	1	12,32
44	0.7	4	80	120	1	12,32
45	0.7	4	40	130	0	12,32
46	0.7	4	80	130	0	12,32
47	0.7	4	40	130	1	12,32
48	0.7	4	80	130	1	12,32

Symbol	Description	Min	Mid	Max
$b_{max}(1)$	Max coefficient value for DFE 1st postcursor	0.7		0.85
N_{tpb}	# of taps per floating bank	3		4
UI_{mf}	Max distance of floating bank from cursor	40		80
C_d	Device capacitance	110 fF	120 fF	130 fF
$c(-3)$	3rd precursor for TxFFE5	-0.06		None
L_{pkg}	Package main route length	12 mm		32 mm

All cases use 16 fixed taps and 2 banks of floating taps.

$b_{max}(n) = 0.3$ for $n > 1$.

The 3rd precursor tap range is from -0.06 to 0 w/ 0.02 step size.

# of COM runs =10,292

'Baseline' Case

Variable	Value	Units
$b_{max}(1)$	0.85	
N_{tpb}	4	# taps
UI_{mf}	40	UI
C_d	130	fF
$TxFFE$	4	# taps

Notes: Each case is run with both package lengths and with 107 contributed backplane channels (see the "channels" worksheet).
Case 21 is treated as the baseline: $b_{max}(1)$=0.85, N_{tpb}=4, UI_{mf}=40, C_d=130fF, no 3rd TxEQ precursor.

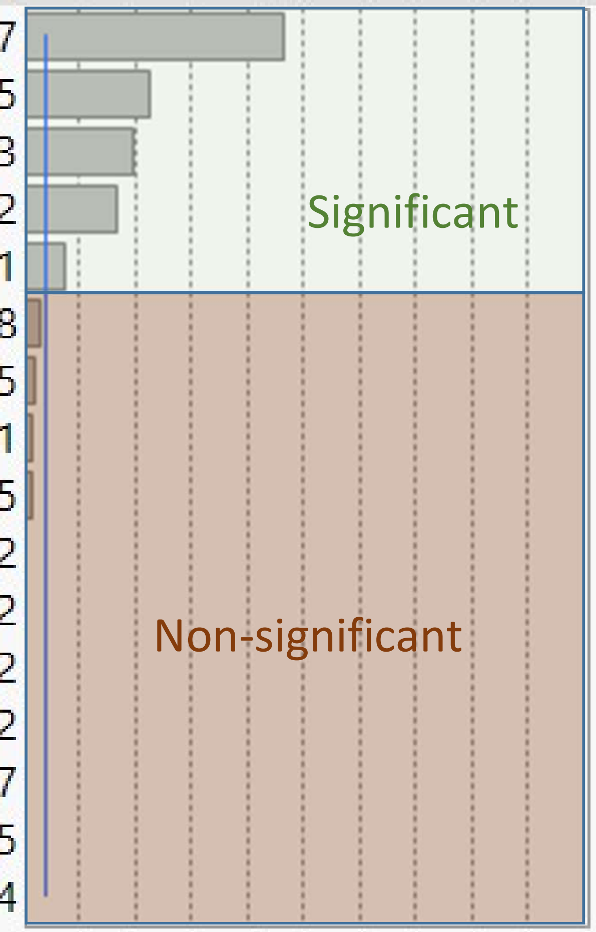
Parameter Significance

- Statistical model fitted to raw data.
  - Identify significant effects & use them to select cases of interest.
- % meeting 3dB COM primarily depends on 1st order terms:

TxFFE	# of Tx taps
Ulmax	max bank span from cursor
Cd	device capacitance
b1max	max coefficient, 1^{st} Rx postcursor
Ntpb	# of taps per bank

Effect Summary

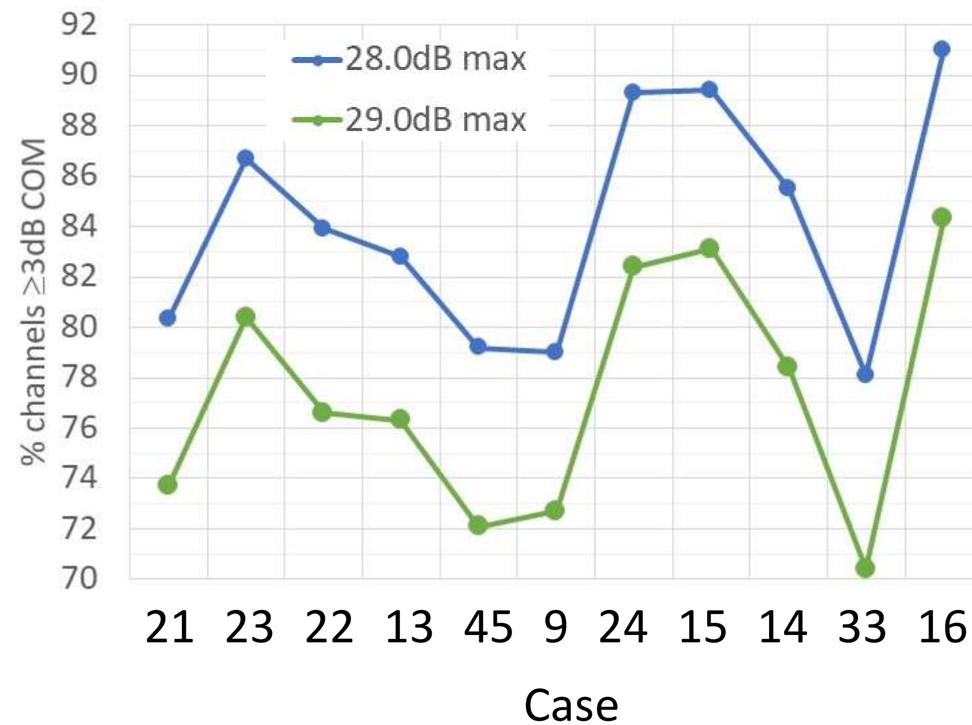
Source	LogWorth	PValue
TxFFE	23.277	0.00000
Ulmax	11.335	0.00000
Cd	9.993	0.00000
b1max	8.422	0.00000
Ntpb	3.771	0.00017
Ulmax*TxFFE	1.528	0.02966
Cd*Cd	1.125	0.07501
Ulmax*Cd	0.801	0.15823
b1max*TxFFE	0.785	0.16419
Ntpb*TxFFE	0.222	0.60041
Ntpb*Ulmax	0.202	0.62862
b1max*Ulmax	0.202	0.62862
b1max*Ntpb	0.182	0.65740
Cd*TxFFE	0.137	0.72944
b1max*Cd	0.115	0.76682
Ntpb*Cd	0.094	0.80478



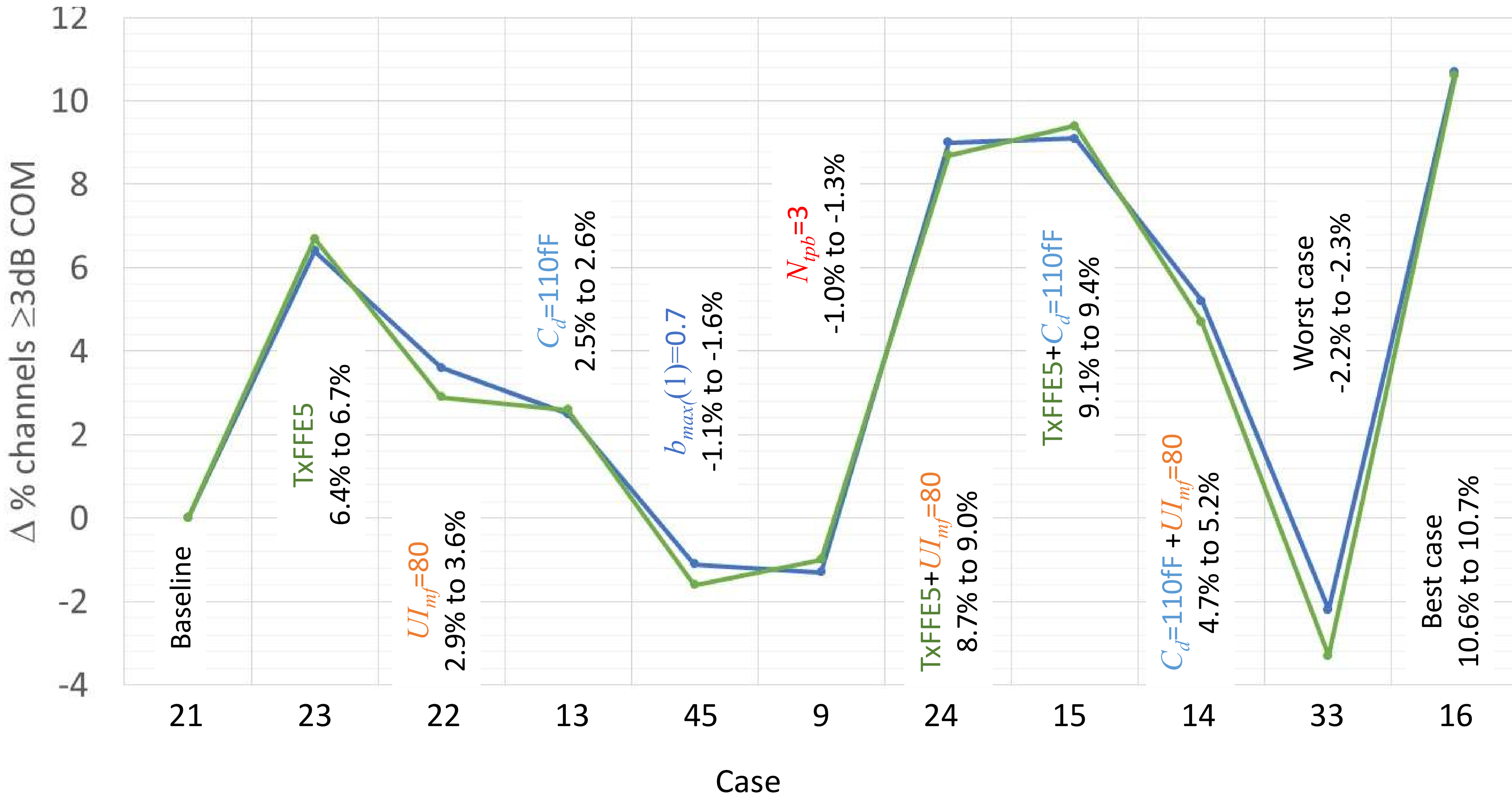
Summarized Results for Select Cases

% Channels Meeting 3.0dB Com for Selected Cases

Case			Baseline	+TxFFE5	$+UI_{mf}$	$+C_d$	$-b1_{max}$	$-N_{tpb}$	+TxFFE5 $+UI_{mf}$	+TxFFE5 $+C_d$	$+C_d$ $+Ui_{mf}$	Worst Case	Best Case
Sim Case			21	23	22	13	45	9	24	15	14	33	16
$b1_{max}$			0.85	0.85	0.85	0.85	**0.7**	0.85	0.85	0.85	0.85	**0.7**	0.85
N_{tpb} (# taps)			4	4	4	4	4	**3**	4	4	4	**3**	4
UI_{mf} (#UI)			40	40	**80**	40	40	40	**80**	40	**80**	40	**80**
C_d (fF)			130	130	130	**110**	130	130	130	**110**	**110**	130	**110**
TxFFE (# taps)			4	**5**	4	4	4	4	**5**	**5**	4	4	**5**
% Pass	ILchan (dB)	28.0	80.3	86.7	83.9	82.8	79.2	79.0	89.3	89.4	85.5	78.1	91.0
		29.0	73.7	80.4	76.6	76.3	72.1	72.7	82.4	83.1	78.4	70.4	84.3
Δ	ILchan (dB)	28.0	0.0	6.4	3.6	2.5	-1.1	-1.3	9.0	9.1	5.2	-2.2	10.7
		29.0	0.0	6.7	2.9	2.6	-1.6	-1.0	8.7	9.4	4.7	-3.3	10.6
			Baseline	TxFFE5	UI_{mf}=80	C_d=110fF	$b1_{max}$=0.7	N_{tpb}=3	TxFFE5+UI_{mf}=80	TxFFE5+C_d=110fF	C_d=110fF +UI_{mf}=80	Worst case	Best case

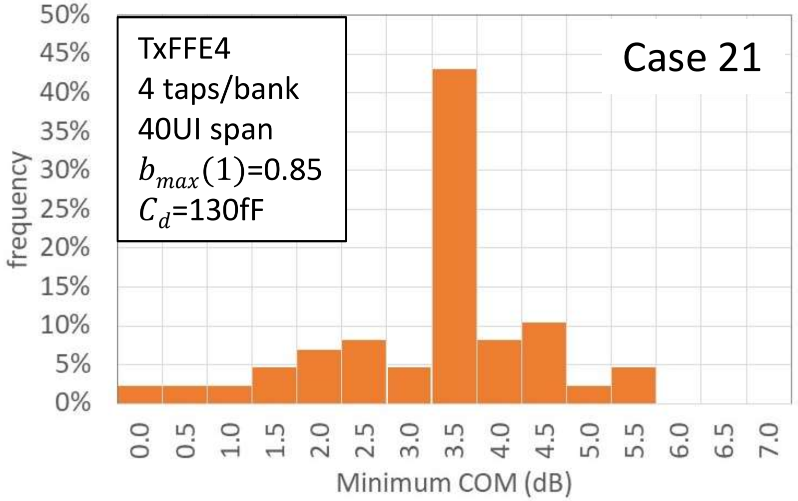


Selected Case Impact

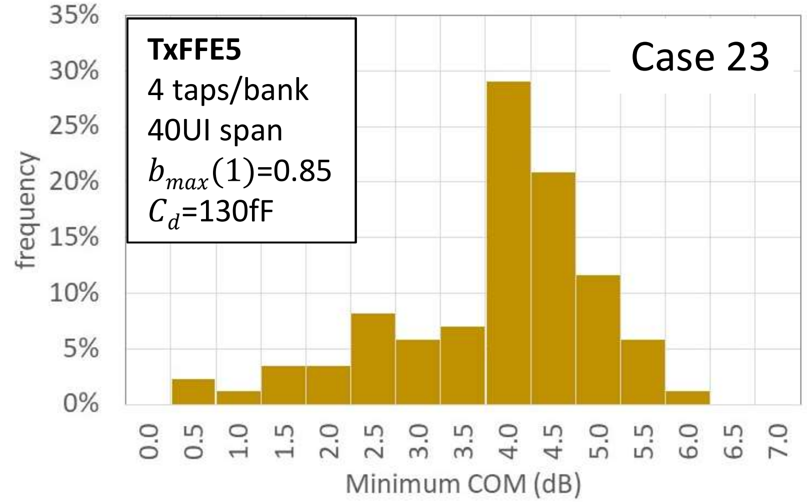


Statistics for Select Cases

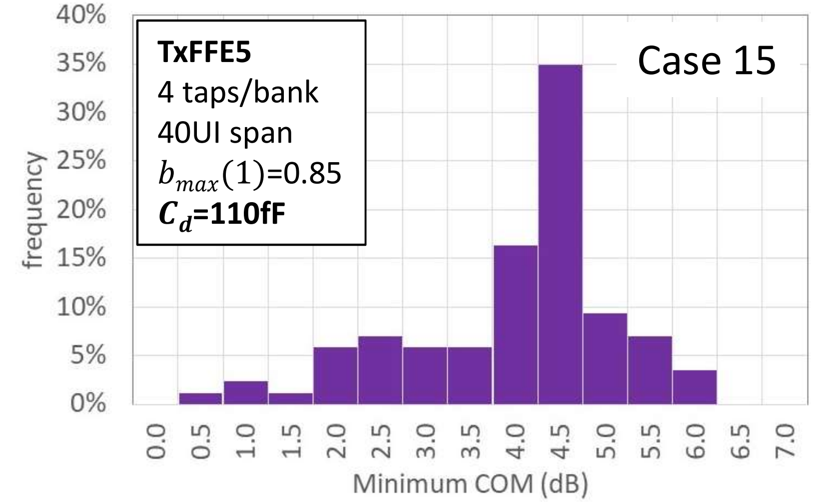
Baseline

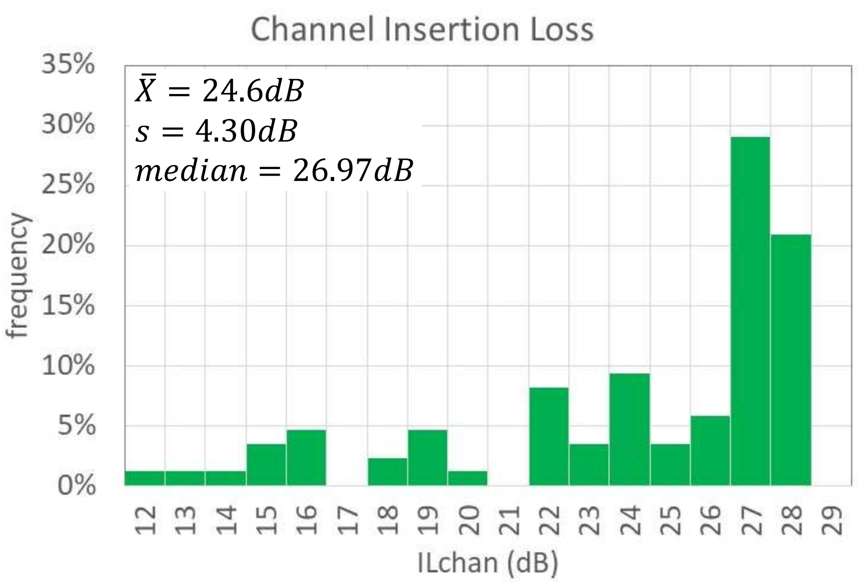


+TxFFE5



+TxFFE5+C_d(min)

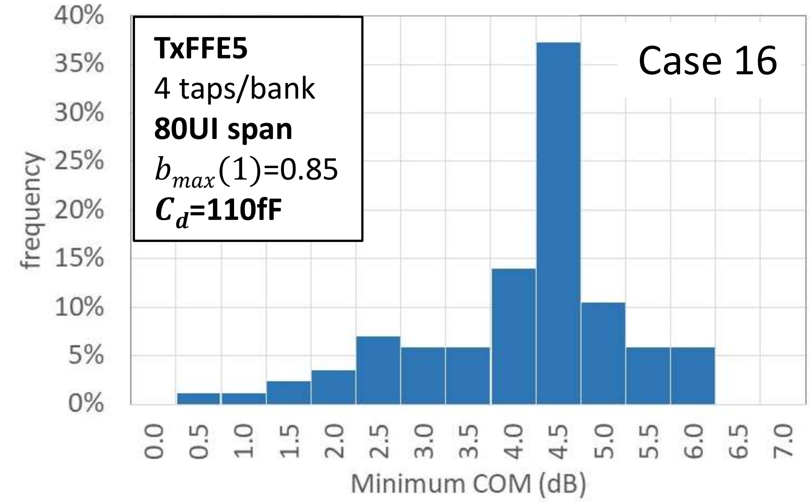




COM Summary

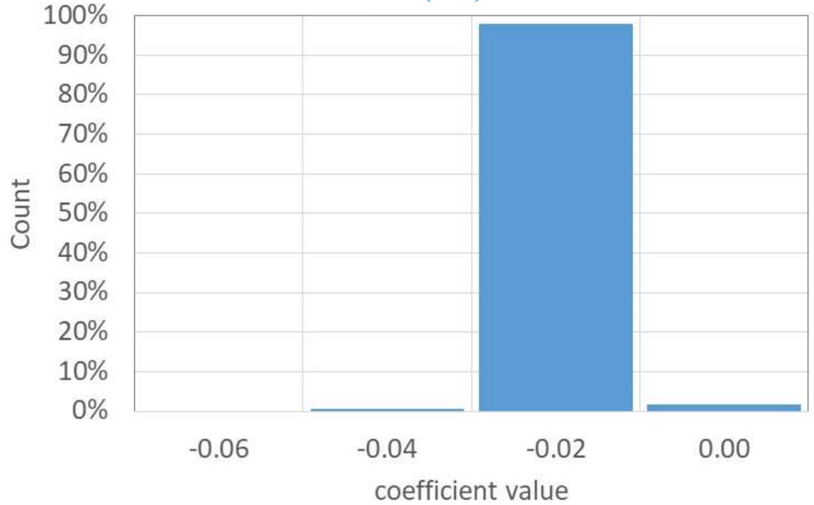
	21	23	15	16
$\bar{X}$	3.55	4.07	4.24	4.35
s	1.16	1.16	1.16	1.14
$mode$	3.70	4.31	4.54	4.54
$median$	3.75	4.35	4.54	4.62

Best Case

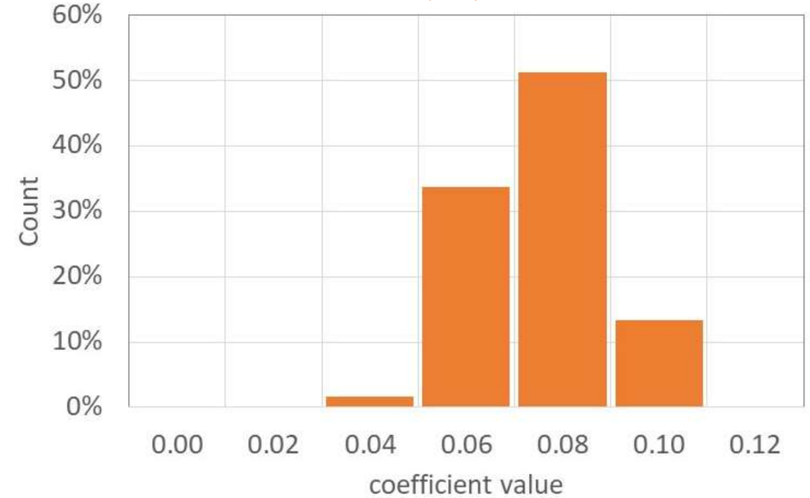


TxFFE5 Coefficient Statistics for sub-29dB Channels

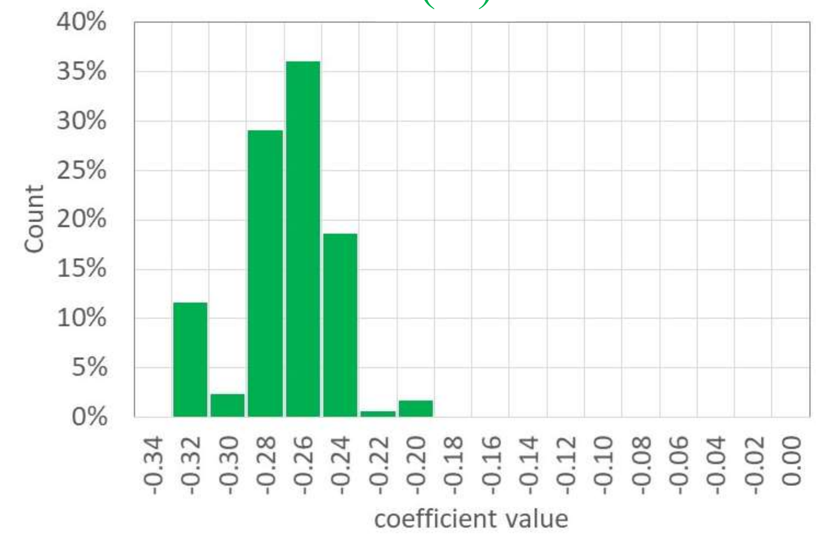
$c(-3)$



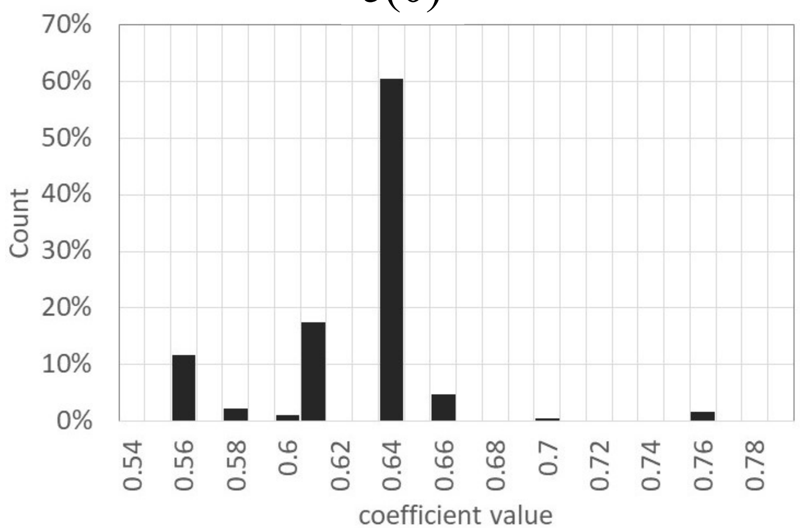
$c(-2)$



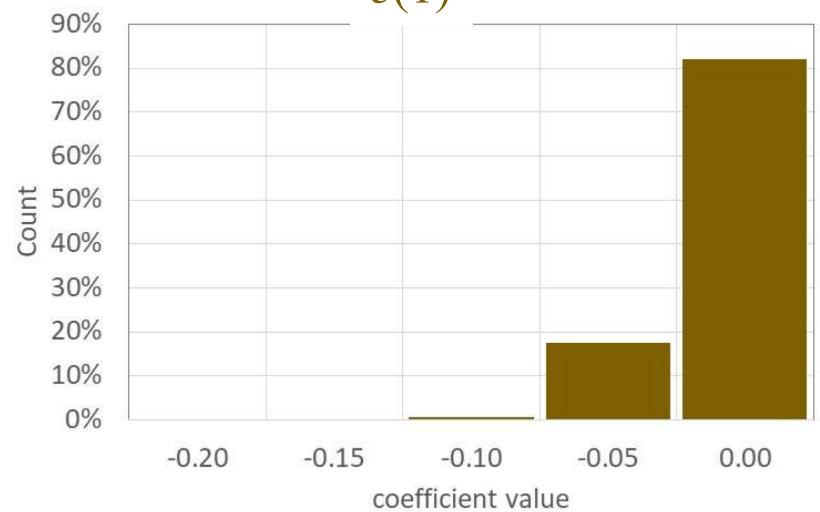
$c(-1)$



$c(0)$



$c(1)$



Tap	**Mode**	$\bar{X}$	S
$c(-3)$	-0.02	-0.02	0.003
$c(-2)$	0.08	0.08	0.014
$c(-1)$	-0.26	-0.27	0.0254
$c(0)$	0.64	0.63	0.034
$c(1)$	0.00	-0.01	0.0202

‘Highlighted’ Channel Analysis

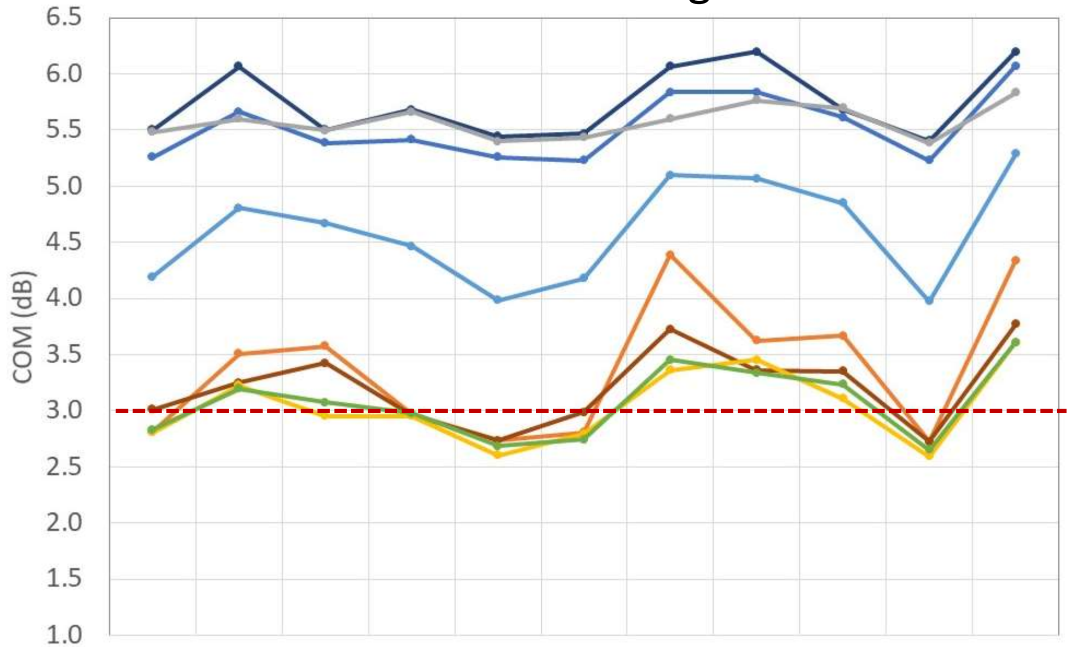
P802.3ck Highlighted Channel Subset

Contribution	Channel	#	Name	IL (dB)
heck_3ck_01_1118	28dB Cabled Backplane/Cable_BKP_28dB_0p575m_more_isi	14	Heck1	28.8
	16dB Cabled Backplane/Cable_BKP_16dB_0p575m_more_isi	2	Heck2	15.2
mellitz_3ck_adhoc_02_081518	24,28,30dB including BGA Via/CaBP_BGAVia_Opt2_28dB	53	Mellitz1	26.3
tracy_3ck_01_0119	Traditional Backplane Channels/Std_BP_12inch_Meg7	21	Tracy1	15.7
	Orthogonal Backplane Channels/DPO_IL_12dB	17	Tracy2	12.2
kareti_3ck_01a_1118	Measured Orthogonal Backplane Channels/OAch4	96	Kareti1	27.7
	~~Measured Orthogonal Backplane Channels/Och4~~	~~103~~	~~Kareti2~~	~~28.1~~
	Measured Cabled Backplane Channels/CAch3_b2	89	Kareti3	28.5
	~~Measured Traditional Backplane Channels/Bch2_a7p5_7~~	~~63~~	~~Kareti4~~	~~28.4~~
	Measured_Traditional_Backplane_Channels/Bch2_b7p5_7	70	Kareti5	28.9

Source: kochuparambil_3ck_01a_0119.pdf.

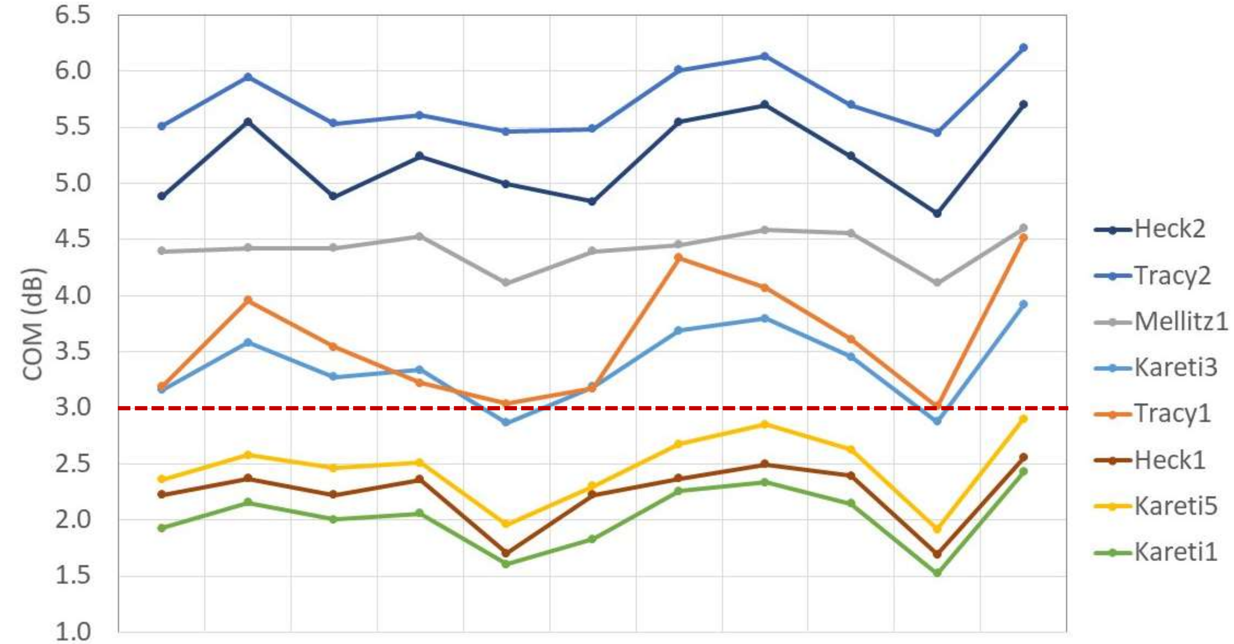
Highlighted Channel Experiment Results

12mm Package



Case	Baseline	+TxFFE5	$+UI_{mf}$	$+C_d$	$-b1_{max}$	$-N_{tpb}$	+TxFFE5 $+UI_{mf}$	+TxFFE5 $+C_d$	$+C_d$ $+Ui_{mf}$	Worst Case	Best Case
Sim Case	21	23	22	13	45	9	24	15	14	33	16
$b1_{max}$	0.85	0.85	0.85	0.85	**0.7**	0.85	0.85	0.85	0.85	**0.7**	0.85
N_{tpb} (# taps)	4	4	4	4	4	**3**	4	4	4	**3**	4
UI_{mf} (#UI)	40	40	**80**	40	40	40	**80**	40	**80**	40	**80**
C_d (fF)	130	130	130	**110**	130	130	130	**110**	**110**	130	**110**
TxFFE (# taps)	4	**5**	4	4	4	4	**5**	**5**	4	4	**5**

32mm Package



	Baseline	+TxFFE5	$+UI_{mf}$	$+C_d$	$-b1_{max}$	$-N_{tpb}$	+TxFFE5 $+UI_{mf}$	+TxFFE5 $+C_d$	$+C_d$ $+Ui_{mf}$	Worst Case	Best Case
	21	23	22	13	45	9	24	15	14	33	16
	0.85	0.85	0.85	0.85	**0.7**	0.85	0.85	0.85	0.85	**0.7**	0.85
	4	4	4	4	4	**3**	4	4	4	**3**	4
	40	40	**80**	40	40	40	**80**	40	**80**	40	**80**
	130	130	130	**110**	130	130	130	**110**	**110**	130	**110**
	4	**5**	4	4	4	4	**5**	**5**	4	4	**5**

Summary & Recommendations

- Objective: Develop reference equalizer recommendations for KR.
- Criteria: Choose equalizer to
  - maximize the percentage of contributed channels with ≥3dB COM.
  - get all of the 'highlighted' (a.k.a. 'must work') channels to ≥3dB COM.
- Proposed reference equalizer: →
  - 80%-83% of sub-29dB channels meet 3dB COM (C_d dependent).
  - All but 3 of the 'highlighted' channels meet 3dB COM. None of the options analyzed achieved 3dB.
  - We also analyzed the impact of C_d, as part of the analysis to help the TF select the C_d baseline.

Parameter	Recommendation
TxFFE $c(-3)$	[-0.06: 0.02: 0.00]
# Fixed DFE taps	16
# Floating DFE banks	2
# taps per bank	4
max bank span	40UI from cursor
$b_{max}(1)$	0.85

- To address the COM deficit for the failing channels we analyzed package trace loss & length mismatch.
  - Results were negative. They are included in backup.

Thank you!

Additional data

COM Template w/ 2 Floating Banks

Table 93A-1 parameters			
Parameter	**Setting**	**Units**	**Information**
f_b	53.125	GBd	
f_min	0.05	GHz	
Delta_f	0.01	GHz	
C_d	[1.3e-4 1.3e-4]	nF	[TX RX]
z_p select	[1 2]		[test cases to run]
z_p (TX)	[12 32; 1.8 1.8]	mm	[test cases]
z_p (NEXT)	[12 32; 1.8 1.8]	mm	[test cases]
z_p (FEXT)	[12 32; 1.8 1.8]	mm	[test cases]
z_p (RX)	[12 32; 1.8 1.8]	mm	[test cases]
C_p	[0.87e-4 0.87e-4]	nF	[TX RX]
R_0	50	Ohm	
R_d	[50 50]	Ohm	[TX RX]
A_v	0.413	V	vp/vf=.694
A_fe	0.413	V	vp/vf=.694
A_ne	0.608	V	
L	4		
M	32		
filter and Eq			
f_r	0.75	*fb	
c(0)	0.54		min
c(-1)	[-0.34:0.02:0]		[min:step:max]
c(-2)	[0:0.02:0.12]		[min:step:max]
c(-3)	[-0.06:0.02:0]		[min:step:max]
c(1)	[-0.1:0.05:0]		[min:step:max]
N_b	20	UI	
b_max(1)	0.85		
b_max(2..N_b)	0.3		
g_DC	[-20:1:0]	dB	[min:step:max]
f_z	21.25	GHz	
f_p1	21.25	GHz	
f_p2	53.125	GHz	
g_DC_HP	[-6:1:0]		[min:step:max]
f_HP_PZ	0.6640625	GHz	
ffe_pre_tap_len	**0**	UI	
ffe_post_tap_len	0	UI	
ffe_tap_step_size	0.02		
ffe_main_cursor_min	0.7		
ffe_pre_tap1_max	0.3		
ffe_post_tap1_max	0.3		
ffe_tapn_max	0.125		
ffe_backoff	0		
Nb_floatingbank	2		
Nb_tapperbank	3		
Floating_maxUI	100	UI	>N_b+Nb_floating
Floating_maxBound	0.3		

I/O control		
DIAGNOSTICS	0	logical
DISPLAY_WINDOW	0	logical
CSV_REPORT	1	logical
RESULT_DIR	.\TestCaseFloatingBank\	
SAVE_FIGURES	0	logical
Port Order	[1 3 2 4]	
RUNTAG	testBank	
COM_CONTRIBUTION	0	logical
Operational		
COM Pass threshold	3	dB
ERL Pass threshold	10.5	dB
DER_0	1.00E-04	
T_r	6.16E-03	ns
FORCE_TR	1	logical
Include PCB	0	logical
TDR and ERL options		
TDR	1	logical
ERL	0	logical
ERL_ONLY	0	logical
TR_TDR	0.01	ns
N	1000	
TDR_Butterworth	1	logical
beta_x	1.70E+09	
rho_x	**0.18**	
fixture delay time	0	enter sec
Receiver testing		
RX_CALIBRATION	0	logical
Sigma BBN step	5.00E-03	V
Noise, jitter		
sigma_RJ	0.01	UI
A_DD	0.02	UI
eta_0	8.20E-09	V^2/GHz
SNR_TX	33	dB
R_LM	0.95	

Table 93A–3 parameters		
Parameter	**Setting**	**Units**
package_tl_gamma0_a1_a2	[0 0.0009909 0.0002772]	
package_tl_tau	6.141E-03	ns/mm
package_Z_c	[87.5 87.5 ; 92.5 92.5]	Ohm

Table 92–12 parameters		
Parameter	**Setting**	
board_tl_gamma0_a1_a2	*[0 3.8206e-04 9.5909e-05]*	
board_tl_tau	*5.790E-03*	ns/mm
board_Z_c	*90*	Ohm
z_bp (TX)	*119*	mm
z_bp (NEXT)	*119*	mm
z_bp (FEXT)	*119*	mm
z_bp (RX)	*119*	mm

Used with version 2.58 of the tool

COM Template – 24 Fixed Taps

Table 93A-1 parameters			
Parameter	Setting	Units	Information
f_b	53.125	GBd	
f_min	0.05	GHz	
Delta_f	0.01	GHz	
C_d	[1.3e-4 1.3e-4]	nF	[TX RX]
z_p select	[1 2]		[test cases to run]
z_p (TX)	[12 32; 1.8 1.8]	mm	[test cases]
z_p (NEXT)	[12 32; 1.8 1.8]	mm	[test cases]
z_p (FEXT)	[12 32; 1.8 1.8]	mm	[test cases]
z_p (RX)	[12 32; 1.8 1.8]	mm	[test cases]
C_p	[0.87e-4 0.87e-4]	nF	[TX RX]
R_0	50	Ohm	
R_d	[50 50]	Ohm	[TX RX]
A_v	0.413	V	vp/vf=.694
A_fe	0.413	V	vp/vf=.694
A_ne	0.608	V	
L	4		
M	32		
filter and Eq			
f_r	0.75	*fb	
c(0)	0.54		min
c(-1)	[-0.34:0.02:0]		[min:step:max]
c(-2)	[0:0.02:0.12]		[min:step:max]
c(-3)	[-0.06:0.02:0]		[min:step:max]
c(1)	[-0.1:0.05:0]		[min:step:max]
N_b	20	UI	
b_max(1)	0.85		
b_max(2..N_b)	0.3		
g_DC	[-20:1:0]	dB	[min:step:max]
f_z	21.25	GHz	
f_p1	21.25	GHz	
f_p2	53.125	GHz	
g_DC_HP	[-6:1:0]		[min:step:max]
f_HP_PZ	0.6640625	GHz	
ffe_pre_tap_len	**0**	UI	
ffe_post_tap_len	0	UI	

I/O control		
DIAGNOSTICS	0	logical
DISPLAY_WINDOW	0	logical
CSV_REPORT	1	logical
RESULT_DIR	.\TestCaseFloatingBank\	
SAVE_FIGURES	0	logical
Port Order	[1 3 2 4]	
RUNTAG	testBank	
COM_CONTRIBUTION	0	logical
Operational		
COM Pass threshold	3	dB
ERL Pass threshold	10.5	dB
DER_0	1.00E-04	
T_r	6.16E-03	ns
FORCE_TR	1	logical
Include PCB	0	logical
TDR and ERL options		
TDR	1	logical
ERL	0	logical
ERL_ONLY	0	logical
TR_TDR	0.01	ns
N	1000	
TDR_Butterworth	1	logical
beta_x	1.70E+09	
rho_x	**0.18**	
fixture delay time	0	enter sec
Receiver testing		
RX_CALIBRATION	0	logical
Sigma BBN step	5.00E-03	V
Noise, jitter		
sigma_RJ	0.01	UI
A_DD	0.02	UI
eta_0	8.20E-09	V^2/GHz
SNR_TX	33	dB
R_LM	0.95	

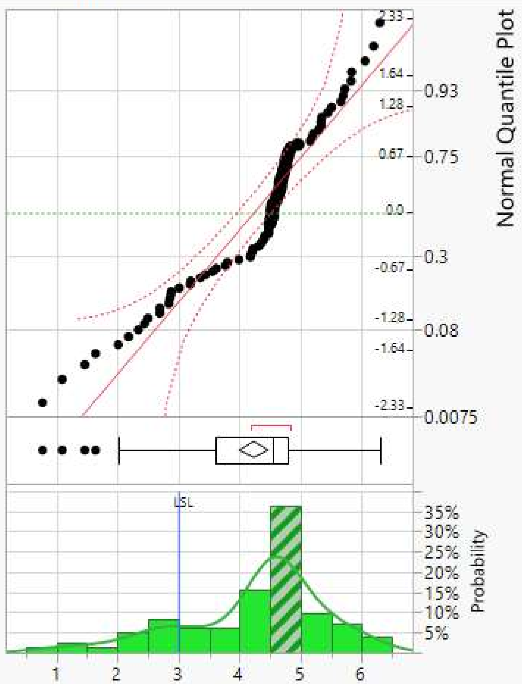
Table 93A–3 parameters		
Parameter	Setting	Units
package_tl_gamma0_a1_a2	[0 0.0009909 0.0002772]	
package_tl_tau	6.141E-03	ns/mm
package_Z_c	[87.5 87.5 ; 92.5 92.5]	Ohm

Table 92–12 parameters		
Parameter	Setting	
board_tl_gamma0_a1_a2	*[0 3.8206e-04 9.5909e-05]*	
board_tl_tau	*5.790E-03*	ns/mm
board_Z_c	90	Ohm
z_bp (TX)	*119*	mm
z_bp (NEXT)	*119*	mm
z_bp (FEXT)	*119*	mm
z_bp (RX)	*119*	mm

Used with version 2.58 of the tool

Distribution for Case 15 w/ Sub-29dB Channels

COM min (dB)



Smooth Curve

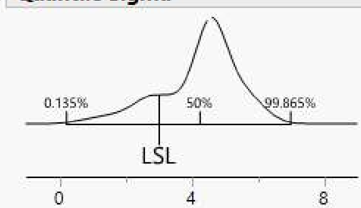
Nonparametric Density

Kernel Std
0.427804

Capability Analysis

Specification	Value	Portion	% Actual
Lower Spec Limit	3	Below LSL	17.4419
Spec Target	.	Above USL	.
Upper Spec Limit	.	Total Outside	17.4419

Quantile Sigma



Capability	Index
CP	.
CPK	0.345
CPM	.
CPL	0.345
CPU	.

Portion	Percent	PPM	Sigma Quality
Below LSL	16.8388	168387.90	2.461
Above USL	.	.	.
Total Outside	16.8388	168387.90	2.461

Quantiles

100.0%	maximum	6.3
99.5%		6.3
97.5%		6.1755
90.0%		5.555
75.0%	quartile	4.79
50.0%	median	4.54
25.0%	quartile	3.605
10.0%		2.482
2.5%		1.15475
0.5%		0.77
0.0%	minimum	0.77

Summary Statistics

Mean	4.2384884
Std Dev	1.1585148
Std Err Mean	0.1249259
Upper 95% Mean	4.4868745
Lower 95% Mean	3.9901023
N	86
Minimum	0.77
Maximum	6.3
Median	4.54
Mode	4.48

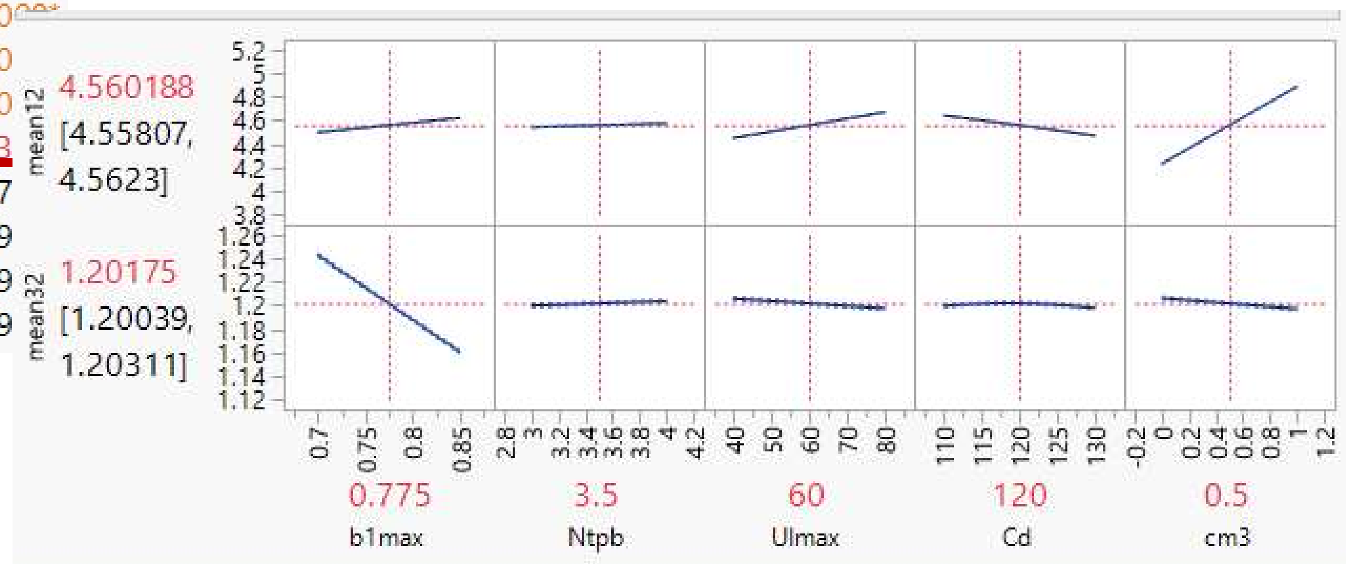
Note: The mode shown is the smallest of 2 modes with a count of 4.

Parameter Significance 2

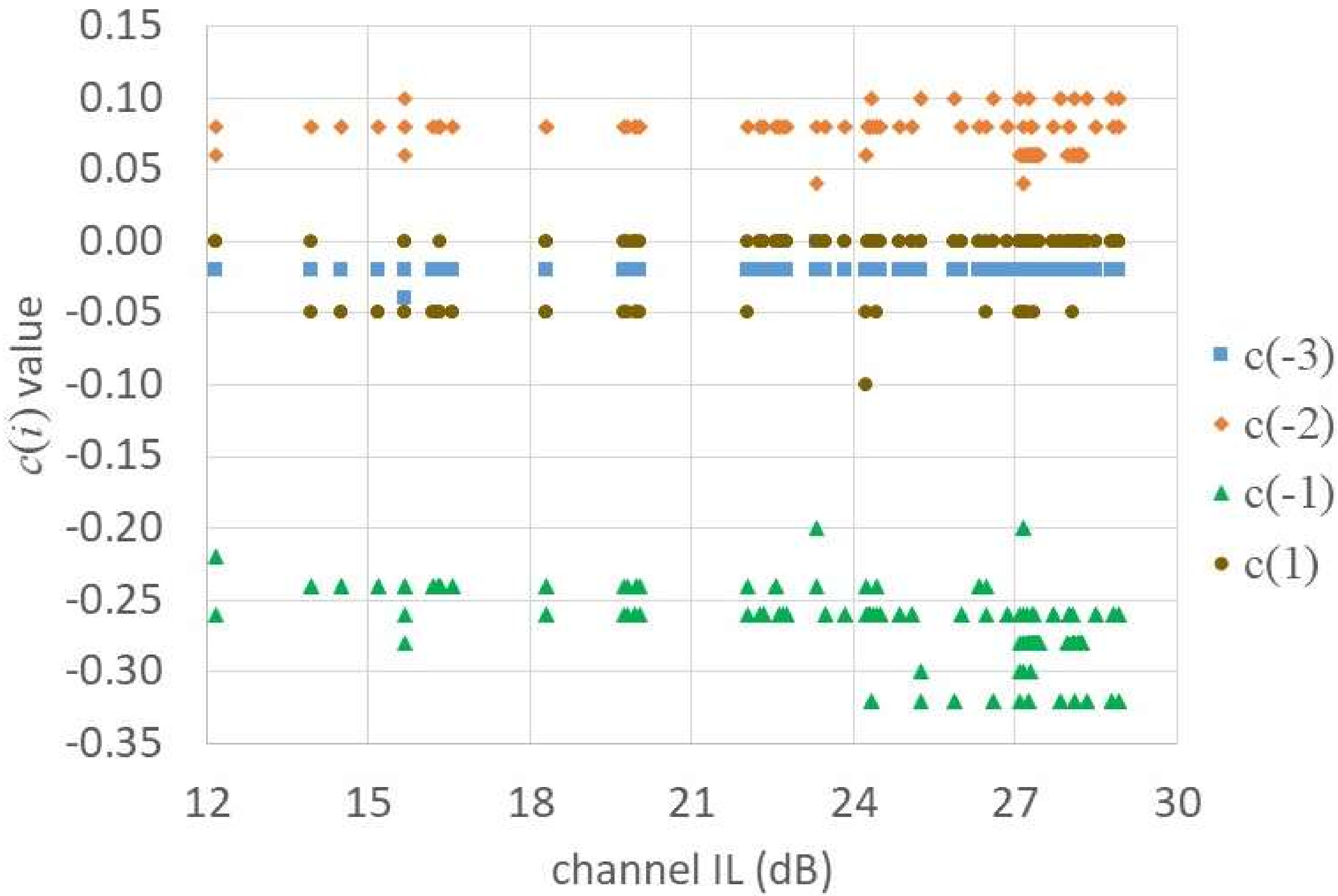
From fit of mean COM to the 5 variables

Term	Estimate	Std Error	t Ratio	Prob>|t|
b1max	-0.55	0.005148	-106.8	<.0001*
(Ulmax-60)*(cm3-0.5)	-0.000504	3.861e-5	-13.06	<.0001*
cm3	-0.009083	0.000772	-11.76	<.0001*
Ulmax	-0.00021	1.931e-5	-10.90	<.0001*
(Ntpb-3.5)*(Ulmax-60)	0.00035	3.861e-5	9.06	<.0001*
(Cd-120)*(cm3-0.5)	0.0005125	9.458e-5	5.42	<.0001*
(b1max-0.775)*(cm3-0.5)	-0.048889	0.010296	-4.75	<.0001*
Ntpb	0.0036667	0.000772	4.75	<.0001*
(Cd-120)*(Cd-120)	-3.063e-5	8.191e-6	-3.74	0.00
(b1max-0.775)*(Ntpb-3.5)	-0.032222	0.010296	-3.13	0.00
(Ntpb-3.5)*(cm3-0.5)	0.0046667	0.001544	3.02	0.00
(Ntpb-3.5)*(Cd-120)	-0.000212	9.458e-5	-2.25	0.03
Cd	-8.75e-5	4.729e-5	-1.85	0.07
(Ulmax-60)*(Cd-120)	-3.125e-6	2.364e-6	-1.32	0.19
(b1max-0.775)*(Ulmax-60)	0.0002222	0.000257	0.86	0.39
(b1max-0.775)*(Cd-120)	8.3333e-5	0.000631	0.13	0.89

b1max is main effect with 32mm pkg
c(-3) is main effect with 12mm pkg



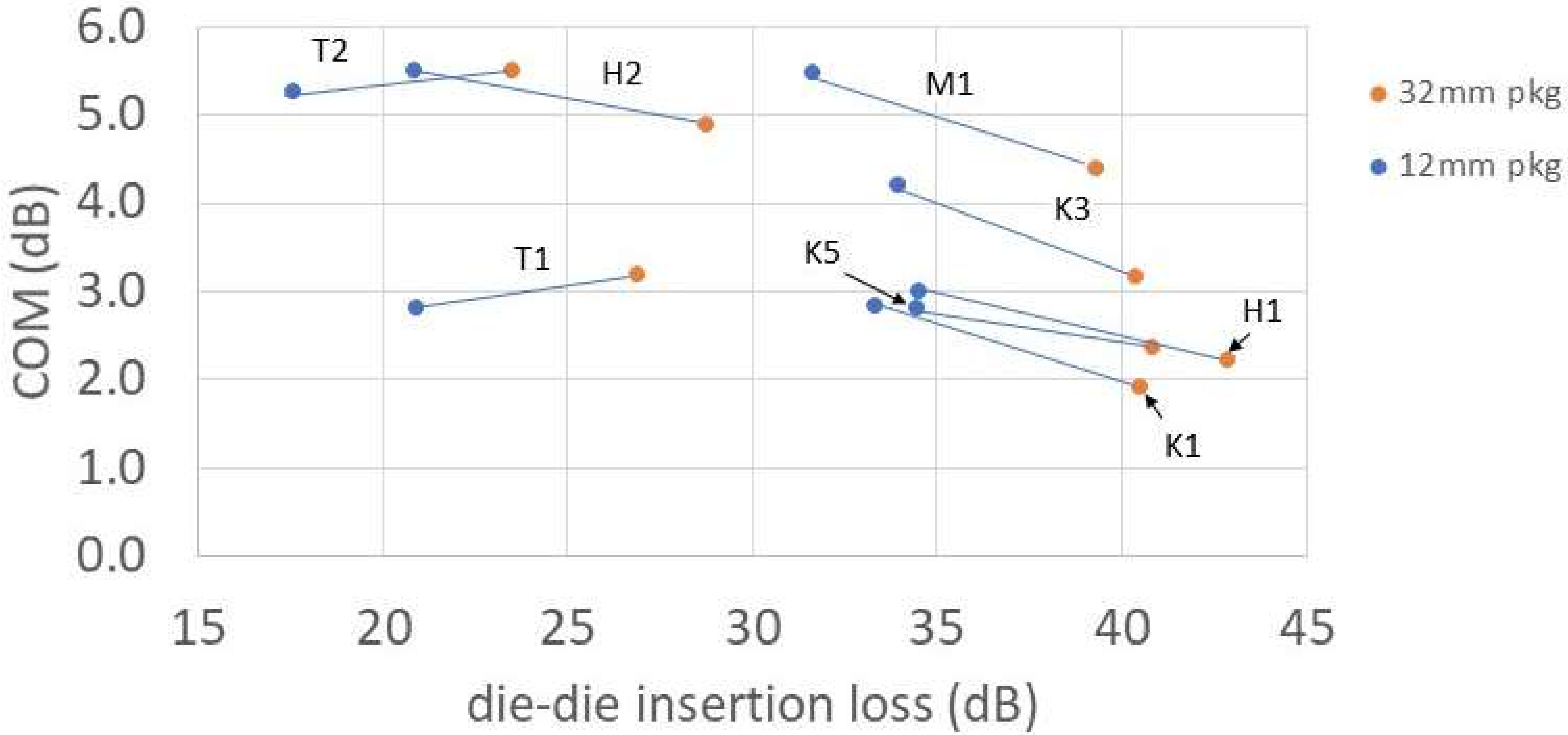
TxFFE5 Coefficients for sub-29dB Channels



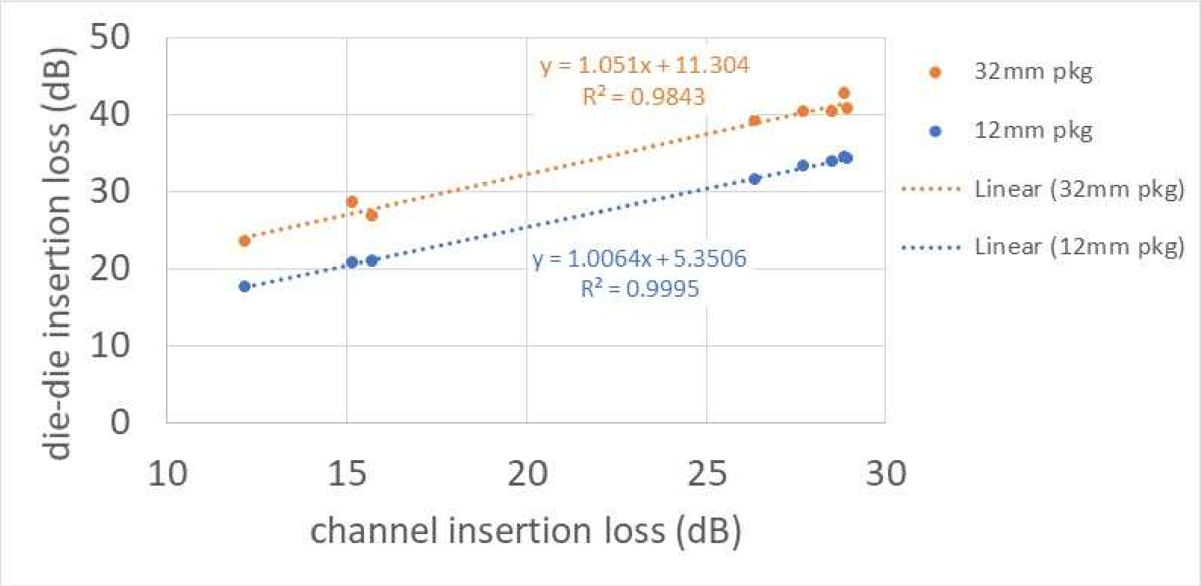
Includes coefficients obtained with 12 mm & 32 mm package routes.

Package ‘Improvement’ Analysis

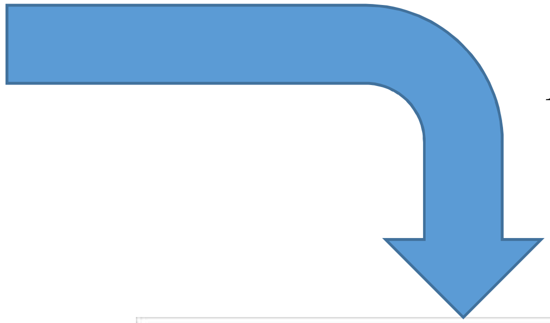
Highlighted Channel COM vs. Die-Die IL



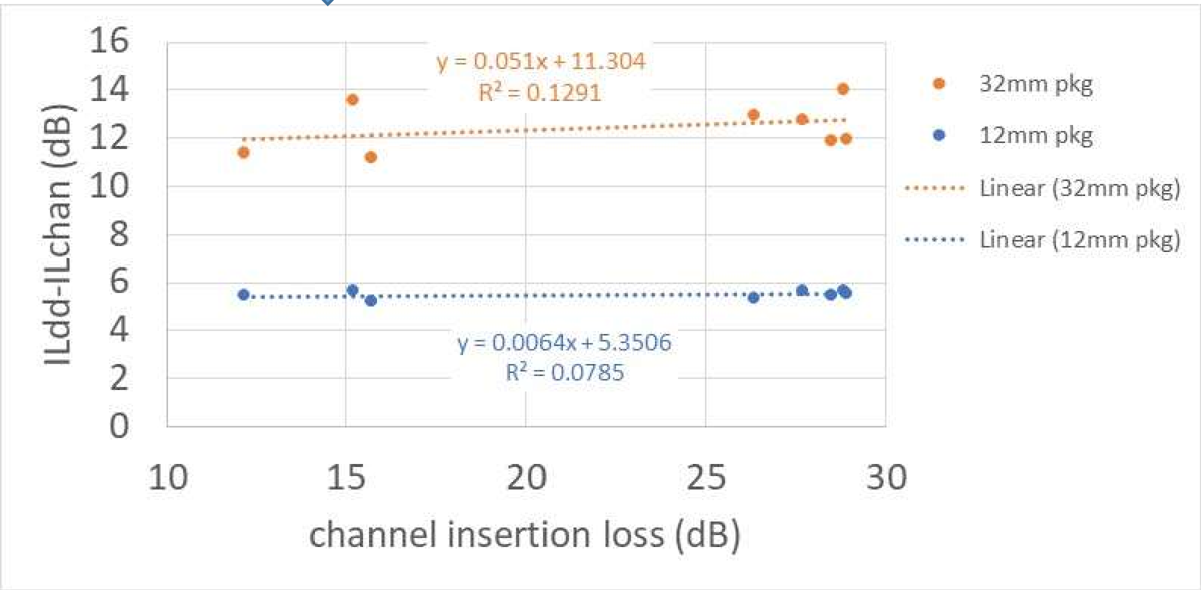
Highlighted Channel Die-Die Insertion Loss



Two 32mm packages contribute ~11.3dB.



IL(chan)-*IL*(die-die)



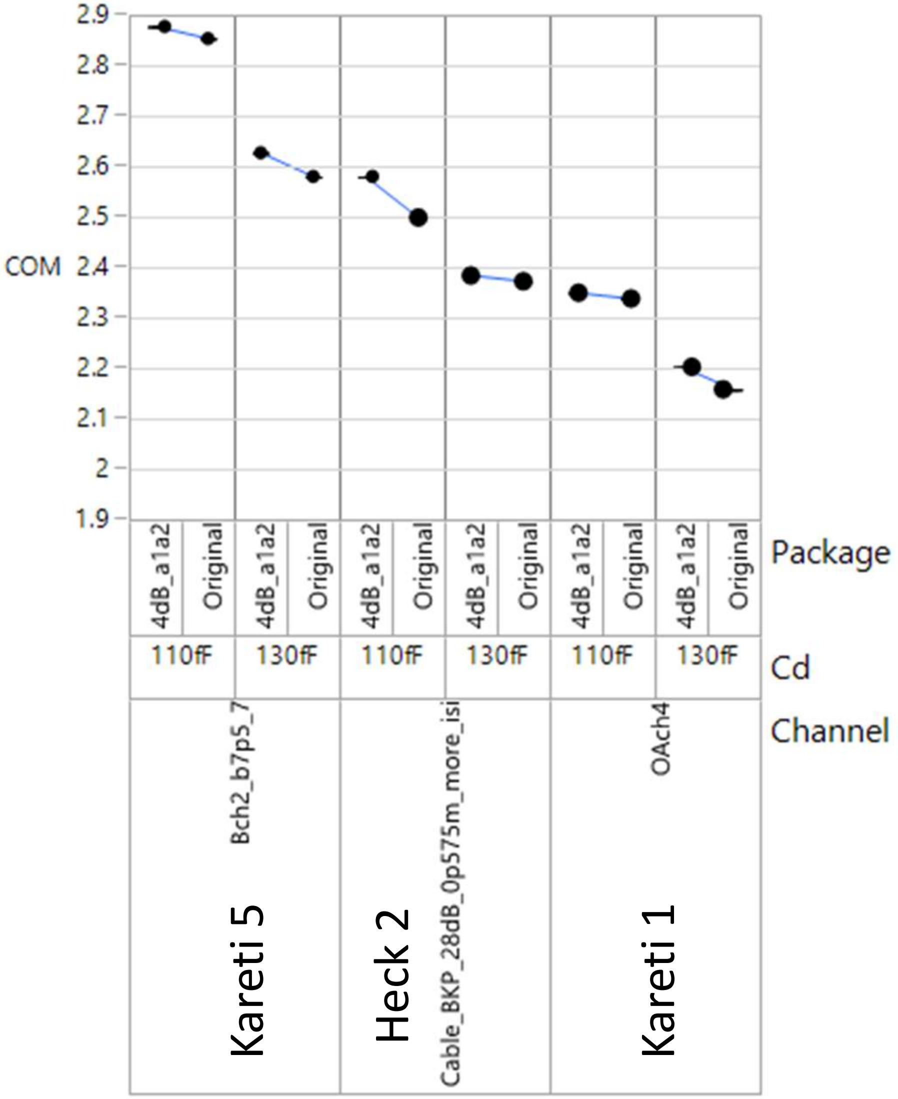
Estimated package contribution to insertion loss:

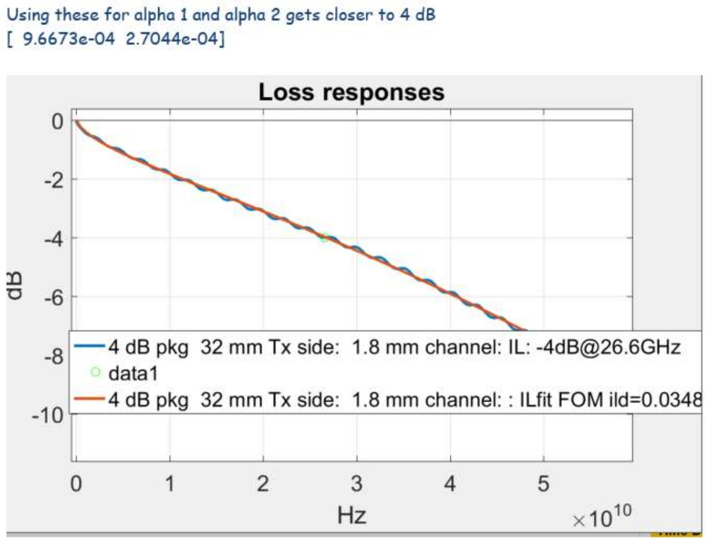
- 12mm pkg: 5.35dB/2 = 2.68dB
- 32mm pkg: 11.30dB/2 = 5.65dB

Estimated package trace loss ~0.15dB/mm

Reduced Reference Package Loss

16 fixed+2 banks of 4floating to 40UI





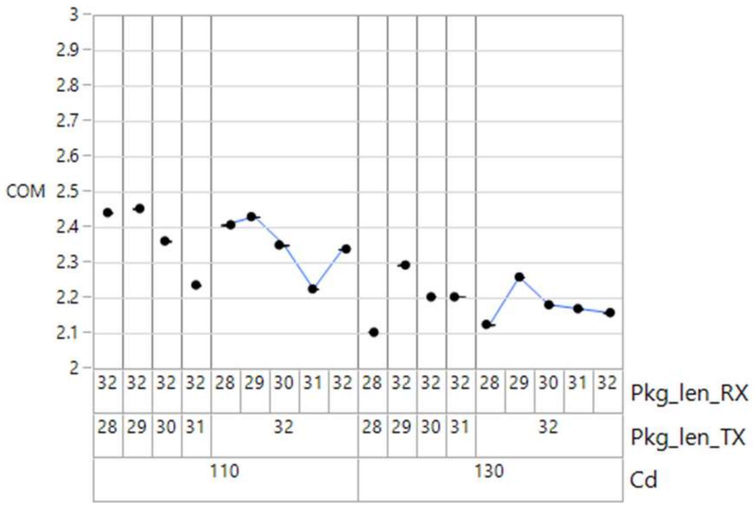
Package T-line models courtesy of Rich Mellitz.

Original = existing ref pkg model
4dB_a1a2 = modified model (above)

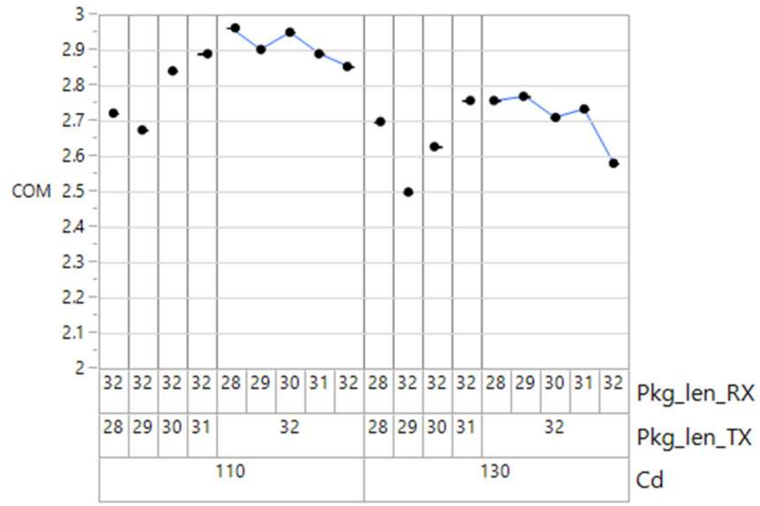
- RxEQ = 16 fixed + 2 banks of 4 taps with 40UI span.
- Reducing package loss to 4dB gives <0.1dB COM benefit; not enough to close gap to 3dB COM.

Package Length Mismatch

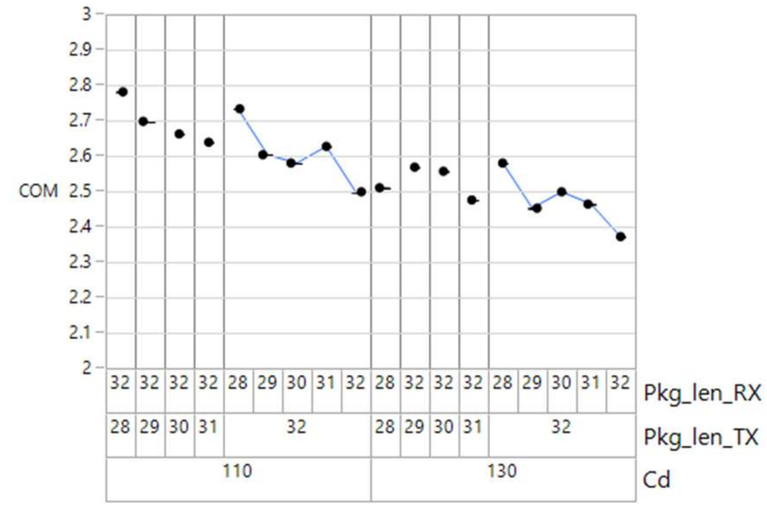
Kareti 1



Kareti 5



Heck 2



- RxEQ: 16 fixed taps + 2 banks of 4 floating taps with 40UI span.
- Tx/Rx package length mismatch can give COM improvement, but not enough to close the gap to 3dB.