

Comparison of different options to account for

- ADC Quantization Noise and
- MLSE Implementation Penalty

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Overview

- Different options were presented so far in 802.3 dj in Electrical track to account for impact from ADC quantization noise and MLSE implementation penalty

ADC Quantization Noise consideration

- Adjust Input reference noise ETA_0 parameter in COM
- Include a separate parameter like ENOB in COM
- See presentation(s)
 - ❖ [Budgeting for receiver noise in Channel Operating Margin \(COM\)](#)
 - ❖ [Significance of including Quantization Noise in COM Evaluation](#)

MLSE Implementation Penalty Consideration

- Arbitrary limit on MLSE benefit like 1dB max
- MLSE sequence truncation as a way to account for Implementation penalty
- See presentation
 - ❖ [MLSE Sequence Truncation Implementation Penalty](#)

- Compare these options in CR/KR channel analysis

Compare ADC Quantization Noise Options

ADC Quantization Noise – Option1: Adjust ETA_0

Config: 5 from [kareti_3dj_01_2407](#) phase 2 settings

Package Combination: BB

Eta_0 is set to $1e-8 \text{ v}^2/\text{GHz}$

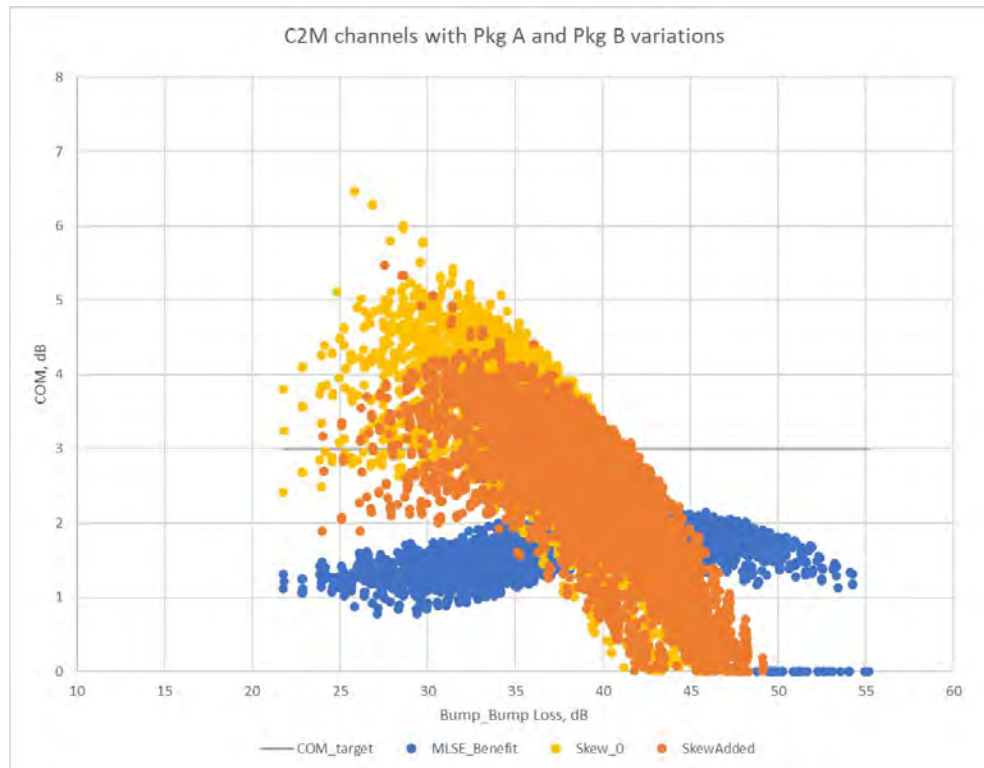
g_DC is set to 0.

COM version: 4.6 beta 4

Receiver

- Num of RX FFE pre-cursors : 6
- Num of RX FFE fixed post cursors : 8
- Number of banks of floating up to 100 UI: 3

**Max Tolerable Skew cases included but separated the stats.*



1 tap DFE (No MLSE)

Loss Range /number of COM failures -- Loss Range: 21.7672 : 55.1644

<=24	6	24-32	157	32-40	2651	>40	3887
Skew_Added	Skew_0	Skew_Added	Skew_0	Skew_Added	Skew_0	Skew_Added	Skew_0
1	5	108	49	1447	1204	2438	1449

MLSE - No Limit Placed

Loss Range /number of COM failures -- Loss Range: 21.7672 : 55.1644

<=24	0	24-32	0	32-40	66	>40	1753
Skew_Added	Skew_0	Skew_Added	Skew_0	Skew_Added	Skew_0	Skew_Added	Skew_0
0	0	0	0	32	34	1055	698

MLSE with max benefit limited to 1 dB

Loss Range /number of COM failures -- Loss Range: 21.7672 : 55.1644

<=24	1	24-32	2	32-40	428	>40	3056
Skew_Added	Skew_0	Skew_Added	Skew_0	Skew_Added	Skew_0	Skew_Added	Skew_0
1	0	2	0	247	181	1894	1162

Total#cases	10678	8832	1846	1630	9048
Cases <40 dB	6735	Cabled Host	PCB Host	CR	KR

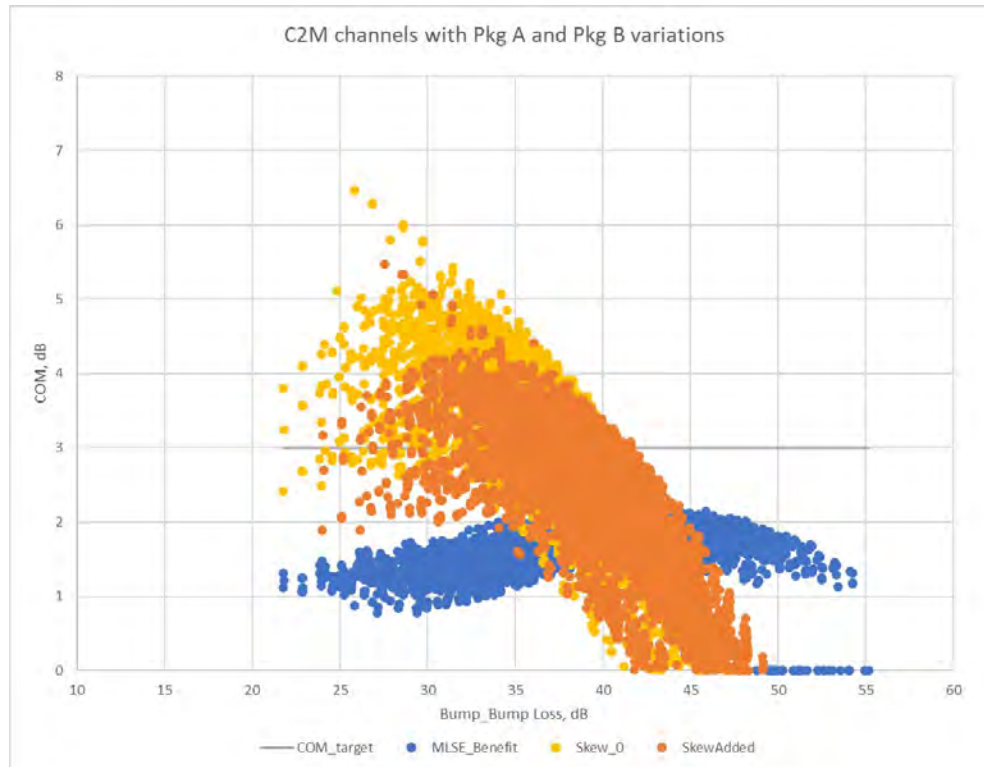
ADC Quantization Noise – Option2: Add a separate Parameter (ENOB)



Config: 5 from [kareti 3dj 01 2407](#) phase 2 settings
 Package Combination: **BB**
Eta_0 is set to $4.1e-9 \text{ v}^2/\text{GHz}$
g_DC is set to adapt (max limited to -20 dB).
COM version: 4.6 beta 4 with code update from Hossein Shakiba with a parameter ENOB added and set to 6
 Receiver

- Num of RX FFE pre-cursors : 6
- Num of RX FFE fixed post cursors : 8
- Number of banks of floating up to 100 UI: 3

**Max Tolerable Skew cases included but separated the stats.*



1 tap DFE (No MLSE)

Loss Range /number of COM failures -- Loss Range: 21.7672 : 55.1644

<=24	13	24-32	510	32-40	4098	>40	3936
Skew_Added	Skew_0	Skew_Added	Skew_0	Skew_Added	Skew_0	Skew_Added	Skew_0
1	12	240	270	2176	1922	2472	1464

MLSE - No Limit Placed

Loss Range /number of COM failures -- Loss Range: 21.7672 : 55.1644

<=24	1	24-32	23	32-40	186	>40	1886
Skew_Added	Skew_0	Skew_Added	Skew_0	Skew_Added	Skew_0	Skew_Added	Skew_0
1	0	23	0	112	74	1167	719

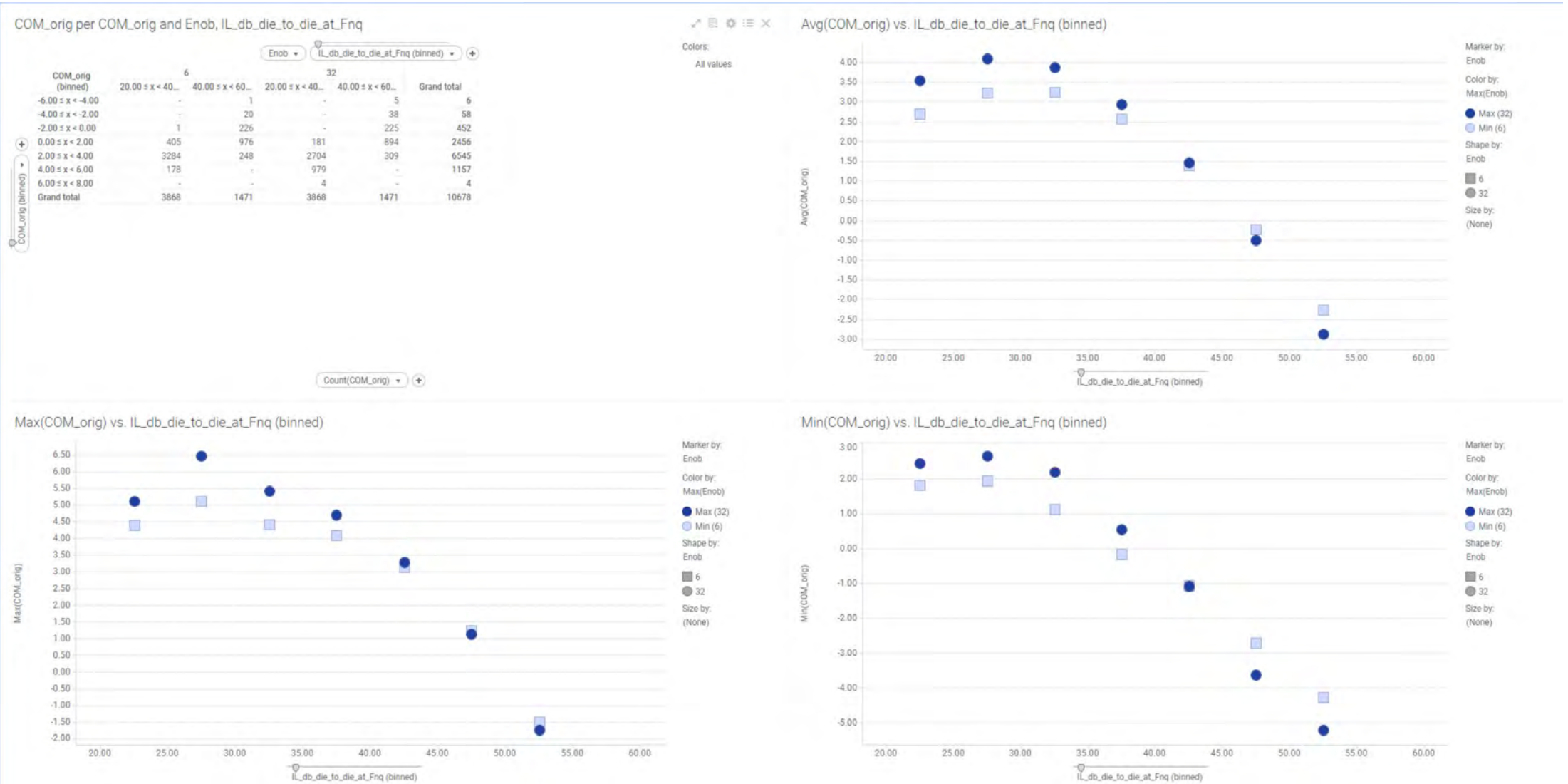
MLSE with max benefit limited to 1 dB

Loss Range /number of COM failures -- Loss Range: 21.7672 : 55.1644

<=24	5	24-32	80	32-40	1105	>40	3309
Skew_Added	Skew_0	Skew_Added	Skew_0	Skew_Added	Skew_0	Skew_Added	Skew_0
1	4	71	9	712	393	2086	1223

Total#cases	10678	8832	1846	1630	9048
Cases <40 dB	6735	Cabled Host	PCB Host	CR	KR

ADC Quantization Noise – Comparison of Option1 and Option2: COM_DFE (No MLSE)



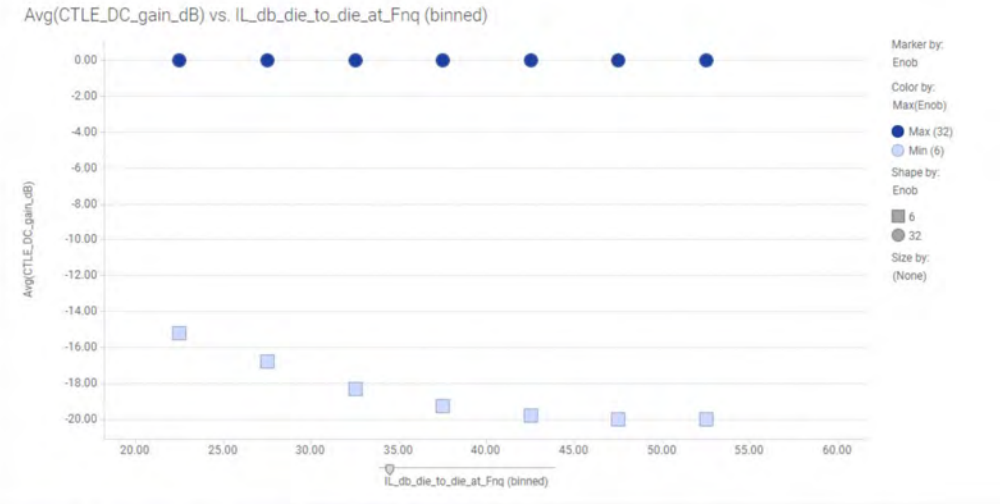
ADC Quantization Noise – Comparison of Option1 and Option2: g_DC



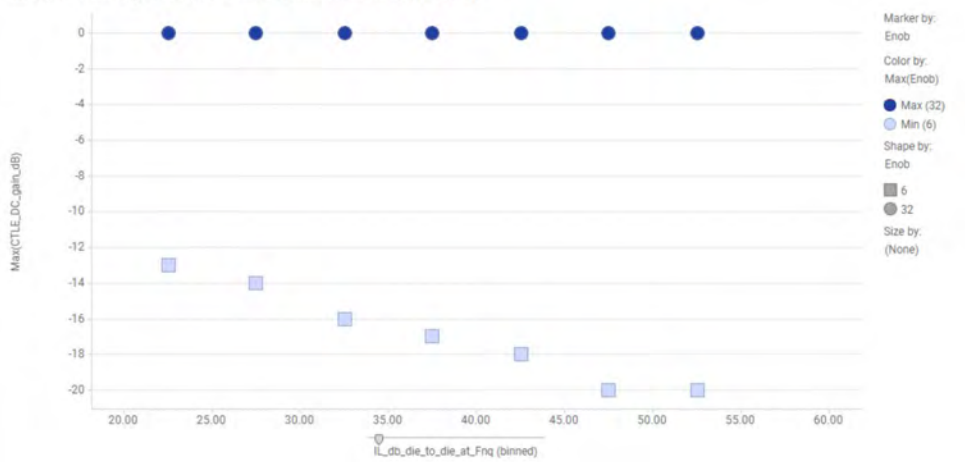
COM_orig per CTLE_DC_gain_dB and Enob, IL_db_die_to_die_at_Fnq

CTLE_DC_gain_dB	6		32		Grand total
	20.00 ≤ x < 40.00	40.00 ≤ x < 60.00	20.00 ≤ x < 40.00	40.00 ≤ x < 60.00	
-20	950	1204	-	-	2154
-19	1554	261	-	-	1815
-18	800	6	-	-	806
-17	384	-	-	-	384
-16	120	-	-	-	120
-15	51	-	-	-	51
-14	8	-	-	-	8
-13	1	-	-	-	1
0	-	-	3868	1471	5339
Grand total	3868	1471	3868	1471	10678

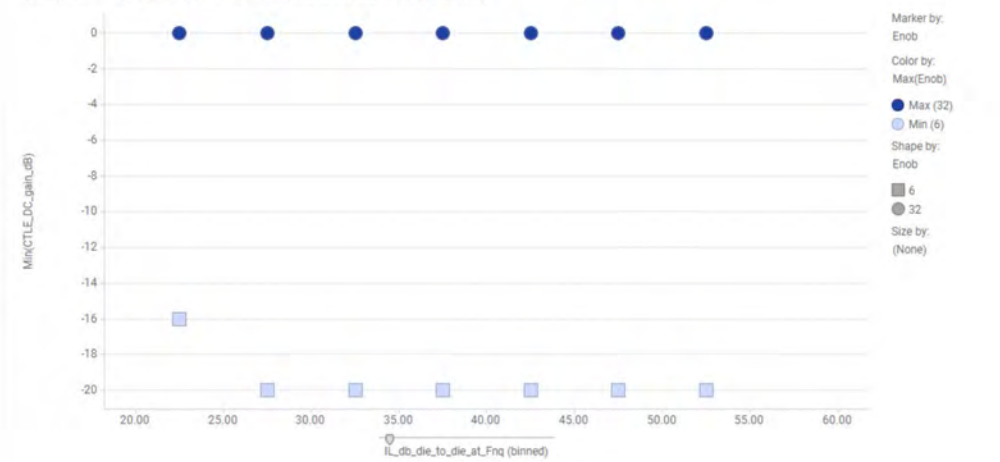
Avg(CTLE_DC_gain_dB) vs. IL_db_die_to_die_at_Fnq (binned)



Max(CTLE_DC_gain_dB) vs. IL_db_die_to_die_at_Fnq (binned)



Min(CTLE_DC_gain_dB) vs. IL_db_die_to_die_at_Fnq (binned)



ADC Quantization Noise Options Summary

- Comparison shows COM may have some deviation at low loss cases and aligns around 40 dB loss and slight deviation >40 dB loss cases
- While using g_DC max range is limited to -20 dB. Extending this range may close the gap a little.
- Simulation time : Option 2 takes about 20 times more time per channel compared to simulation time for Option 1
 - Option1 : 0.9 min – 38 min (average 20 min)
 - Option2 : 25 min – 17 hrs. (average 10 hours)
- **Option1: using ETA_0 is a reasonable compromise than using Option 2: introducing a separate parameter to account for ADC quantization noise**

Compare MLSE Implementation Penalty Options

MLSE Implementation Penalty- Options: Arbitrary limit vs Seq. truncation



MLSE - No Limit Placed ; trunc: 128

Loss Range /number of COM failures -- Loss Range: 21.7672 : 55.1644

<=24	0	24-32	0	32-40	66	>40	1753
Skew_Added	Skew_0	Skew_Added	Skew_0	Skew_Added	Skew_0	Skew_Added	Skew_0
0	0	0	0	32	34	1055	698

MLSE with max benefit limited to 1 dB; trunc: 128

Loss Range /number of COM failures -- Loss Range: 21.7672 : 55.1644

<=24	1	24-32	2	32-40	428	>40	3056
Skew_Added	Skew_0	Skew_Added	Skew_0	Skew_Added	Skew_0	Skew_Added	Skew_0
1	0	2	0	247	181	1894	1162

MLSE - No Limit Placed; trunc:15

Loss Range /number of COM failures -- Loss Range: 21.7672 : 54.244

<=24	0	24-32	0	32-40	91	>40	1995
Skew_Added	Skew_0	Skew_Added	Skew_0	Skew_Added	Skew_0	Skew_Added	Skew_0
0	0	0	0	51	40	1235	760

MLSE - No Limit Placed; trunc: 12

Loss Range /number of COM failures -- Loss Range: 21.7672 : 54.244

<=24	0	24-32	0	32-40	151	>40	2463
Skew_Added	Skew_0	Skew_Added	Skew_0	Skew_Added	Skew_0	Skew_Added	Skew_0
0	0	0	0	90	61	1557	906

MLSE - No Limit Placed; trunc:10

Loss Range /number of COM failures -- Loss Range: 21.7672 : 54.244

<=24	0	24-32	0	32-40	281	>40	2932
Skew_Added	Skew_0	Skew_Added	Skew_0	Skew_Added	Skew_0	Skew_Added	Skew_0
0	0	0	0	169	112	1846	1086

Config: 5 from [kareti 3dj 01 2407](#) phase 2 settings

Package Combination: BB

Eta_0 is set to 1e-8 v²/GHz

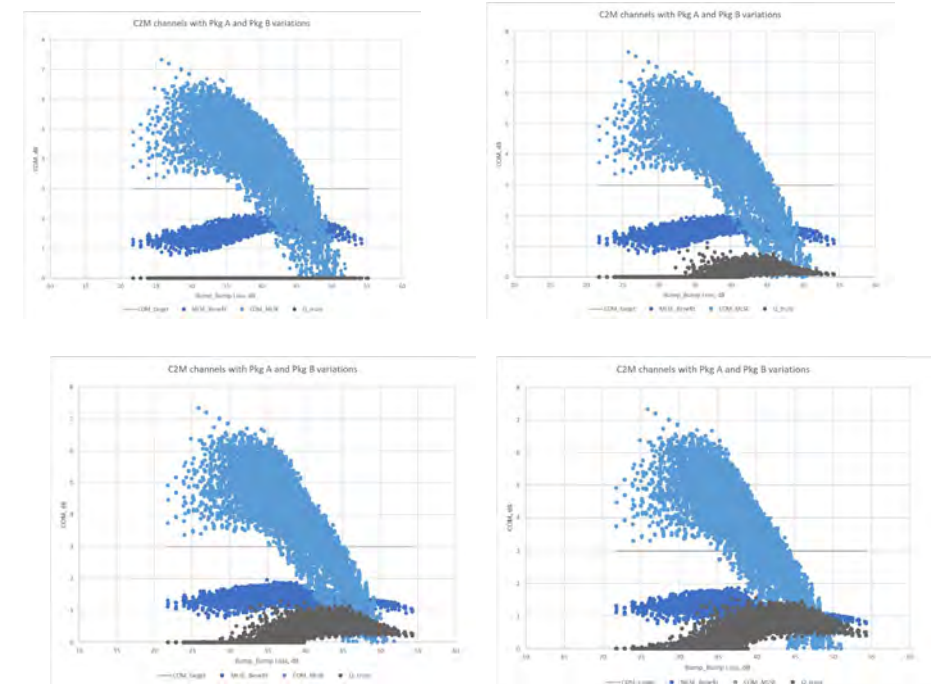
g_DC is set to 0.

COM version: 4.6 beta 4 with a code update from Hossein Shakiba with a parameter "trunc" added and is set a values 10,12 or 15 (a value of 128 represent no sequence truncation)

Receiver

- Num of RX FFE pre-cursors : 6
- Num of RX FFE fixed post cursors : 8
- Number of banks of floating up to 100 UI: 3

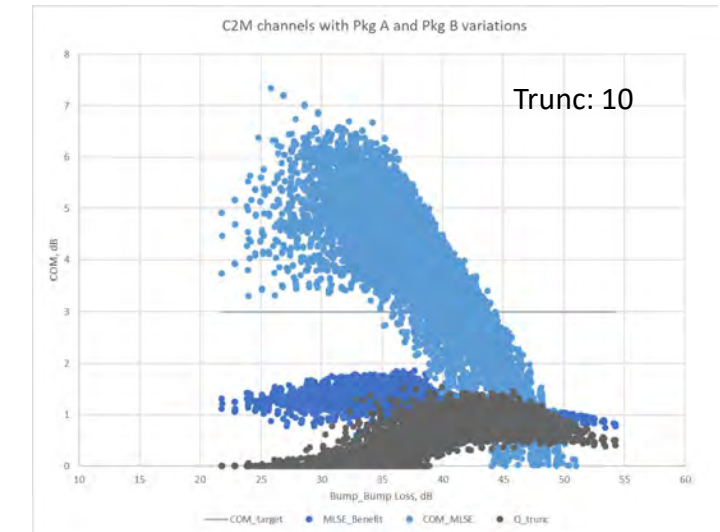
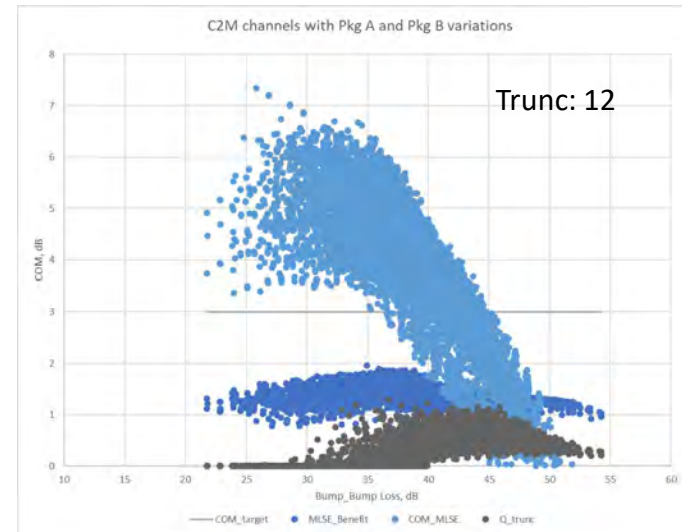
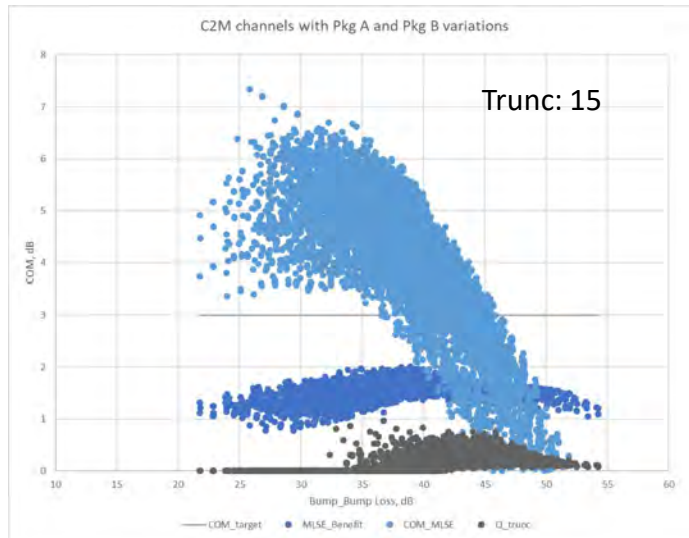
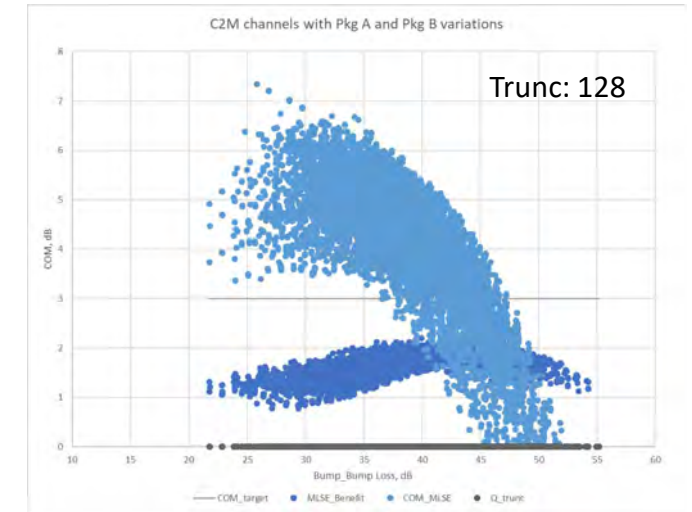
*Max Tolerable Skew cases included but separated the stats.



MLSE Implementation Penalty-Options: Arbitrary limit vs Seq. truncation



- Most implementations concerned about complexity and latency of MLSE implementation limit Sequence processing and trace back length to minimum of 15 symbols
- Using trunc = 15 for this analysis and compared with other trunc options 10 , 12 and limiting MLSE benefit to 1 dB
- Q_trunc in the plot shows the penalty compared to No implementation penalty case (trunc = 128)



MLSE Implementation Penalty Options Summary

- Arbitrary limit to MLSE benefit is not a reasonable option as shown in analysis
- Increase in COM computation time per case is almost negligible when Seq. truncation code is added to COM code.
- Using sequence truncation method and seq. truncation of 15 PAM4 symbols since most implementations concerned about complexity and latency use it as a minimum and **recommend this option to account for MLSE Implementation Penalty**