Quantization Noise in COM – Direct Model or Proxy?

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Background

- In contribution *shakiba_3dj_02_2405.pdf* the impact of quantization noise on COM channel compliance verification was analyzed and a direct method for modeling it was proposed
- Contribution *healey_3dj_01b_2405.pdf* considered using existing means (e.g. scaling eta_0) as a proxy to represent quantization noise
- At the time, there was more support for using the simpler proxy method
  - Still considerable Y's and a lot of undecideds

May 2024

Straw Poll #1

I support adding a new noise term (such as 'eta_1' in healey_3dj_01a_2405, slide 6) to the COM reference receiver.

Results (all) Y: 13, , N: 37 , A: 31

- The "N" outcome was mostly motivated by the argument of "reference receiver trap"
- Eta_0 was elevated to 1E-8V^2/GHz to include the effect of quantization noise
- While the argument of proxy is generally understandable and in many cases applicable, quantization noise is too important to be ignored or represented by a simple proxy
- Also, it would have helped if the theoretical basis of the direct modeling approach and its calculation overhead were better understood, justified, and quantified

Facts to Consider

- A big part of the “reference receiver trap” was to avoid features that are implementation-specific and could cause unreasonable complication
- Vast majority to almost all receiver implementations nowadays use ADC, making this architecture generic and de-facto, and the natural baseline for the reference receiver
- Shift in paradigm to consider the non-ADC-based receiver implementation-specific
- Direct modeling of quantization noise stands on a solid theoretical foundation and can be simply embedded with reasonable overhead
- Quantization noise has some unique and specific attributes that makes it not a good candidate to be replaced by a proxy as simple as a fix scaled and uncorrelated eta_0 noise term
- Several other attributes of the current reference receiver and existing noise terms are likely less important and arguably more implementation-specific
- Uncertainty around TxFFE optimization in the absence of a realistic quantization noise

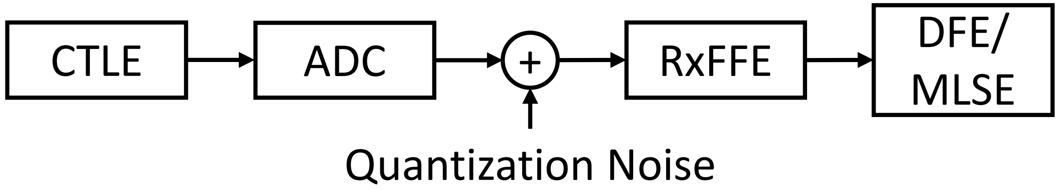
Motivation

- Some observations and developments since then:
  - There was a lack of enough data and clarity on the extend of the overhead of adding the quantization noise model to the COM flow
  - Noticeable ongoing interests and requests to further follow up on this topic
  - Several direct requests for having access to the COM Matlab function with the capability
  - More data have been generated and some presented by others since then
  - Recent changes in the COM code motivates an attempt to re-quantify the effect of quantization noise
  - The latest released version (480) of the COM Matlab function incorporates the feature
    - Demonstrates a reasonable run time overhead for the added value (also see shakiba_3dj_COM_03_2505.pdf)
    - Provides a wider access
    - There are few COM commit requests in recent COM ad hoc meetings that affect the COM results (bug fixes)
- Hopefully consensus will be built and a move in the right direction will be made:

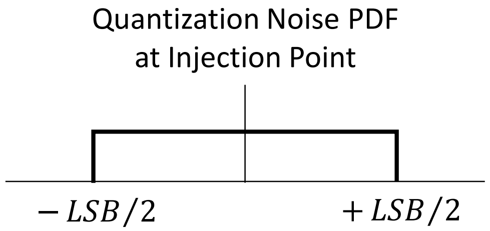
1) Enough support for adding quantization noise to the COM flow
2) … or use the presented material as a reference for people who wish to use the feature for further exploration

Quantization Noise Model

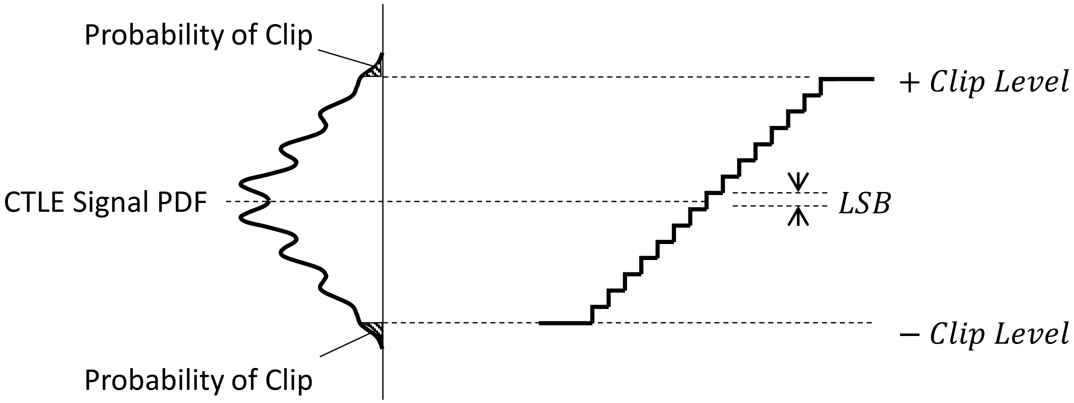
- Quantization noise is a new noise term added between CTLE and RxFFE



- It can be modeled by a white random noise with uniform distribution over –LSB/2 to +LSB/2 at the injection point



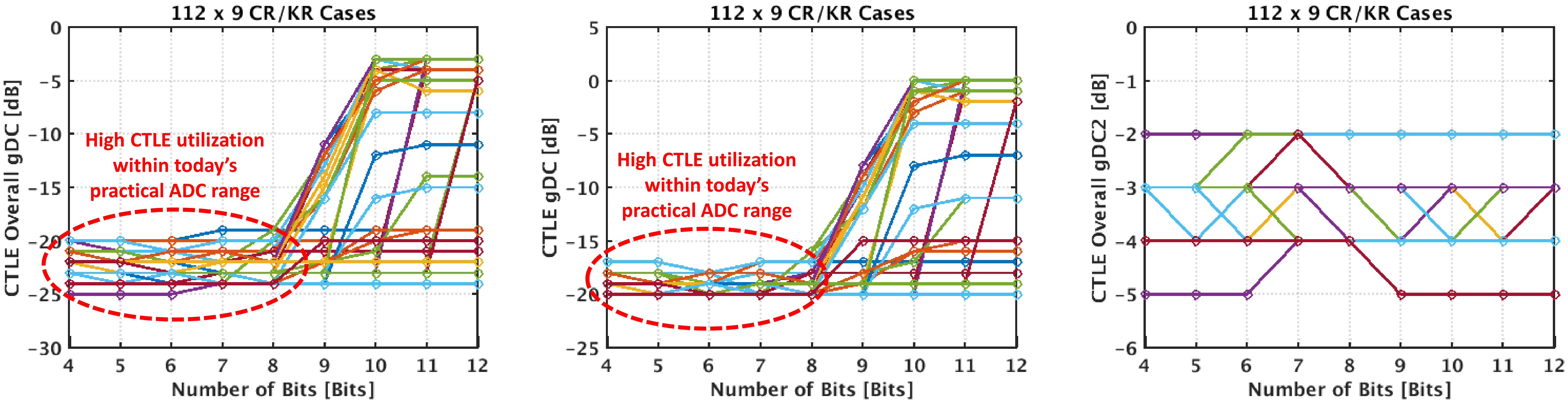
$$\sigma_{qn} = \frac{LSB}{\sqrt{12}}$$



- Quantization clip level can be calculated from the desired probability of signal clipping
- LSB, quantization step size, can be calculated from the desired number of bits and clip level
- Note that modeling quantization functionality is outside the scope, it is only its noise

Impact of Quantization Noise on CTLE Utilization

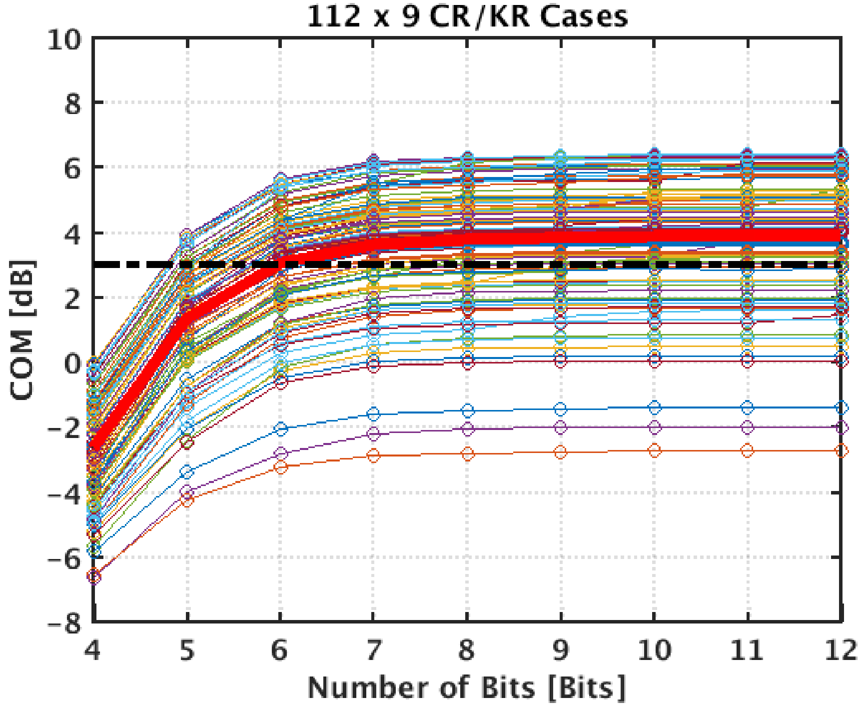
- Quantization noise has a prominent impact on the equalizer distribution and optimization

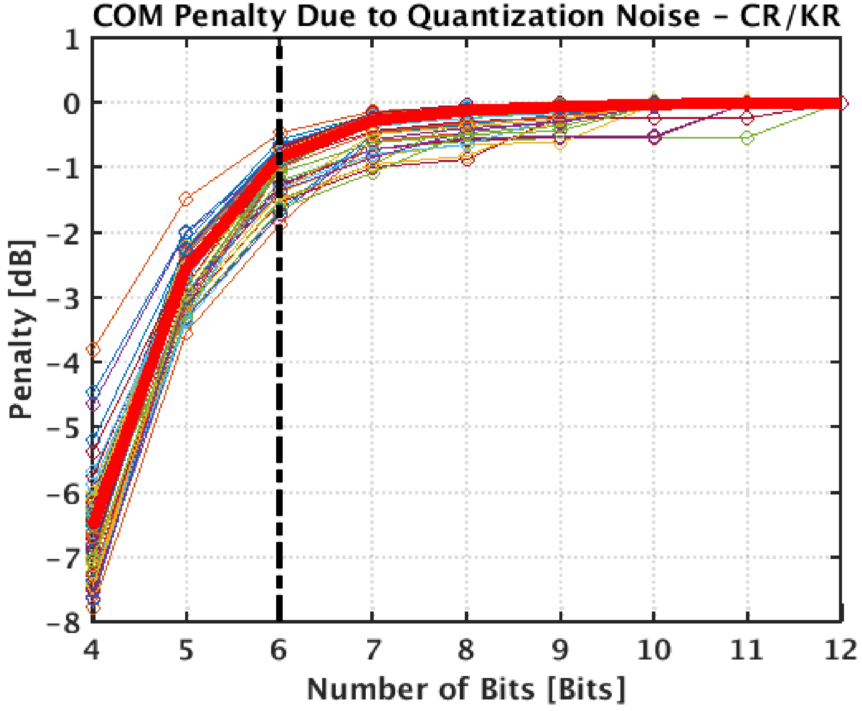


- CTLE high-frequency gain (gDC) utilization increases with increasing quantization noise
  - ❖ CTLE search range can not be generally reduced (fixing gDC to speed up optimization is not a choice)
- CTLE high-frequency utilization is unrealistically minimal when eta_0 is used as a proxy
- As expected, CTLE low-frequency boost (gDC2) utilization is not impacted

Impact of Quantization Noise on COM

- With direct modeling, the impact of quantization noise on COM can be quantified accurately, predictively, and realistically

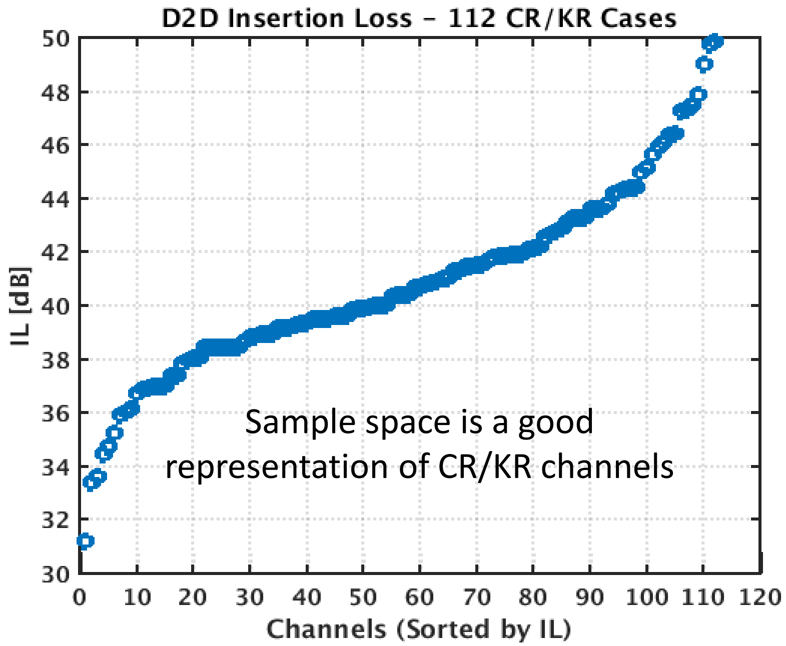


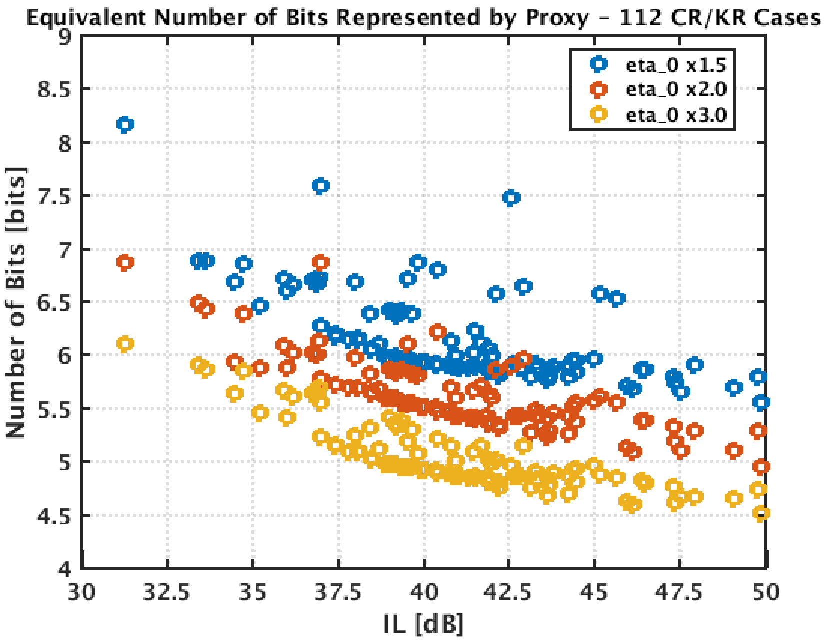


- For the test channels, at least 6 bits is needed to contain the quantization noise
- Even with 6 bits, the test channels suffer anywhere between 0.47dB to 1.86dB of COM penalty

The Concern with eta_0 Proxy Approach

- With eta_0 = 5E-9 and three scale values of 1.5, 2, and 3 COM was calculated for the test cases
- For each individual channel and using data from the plot on the previous slide, the calculated COM was mapped to an equivalent number of bits that would result in the same COM

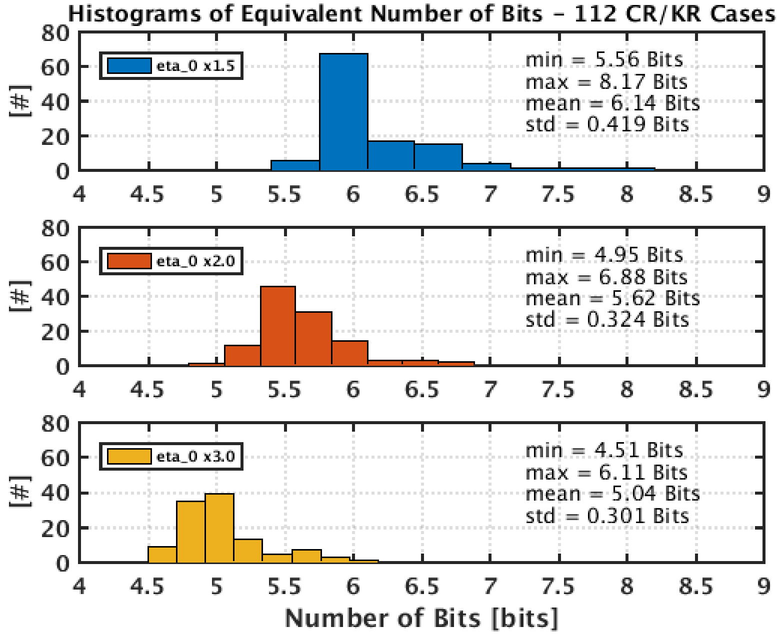


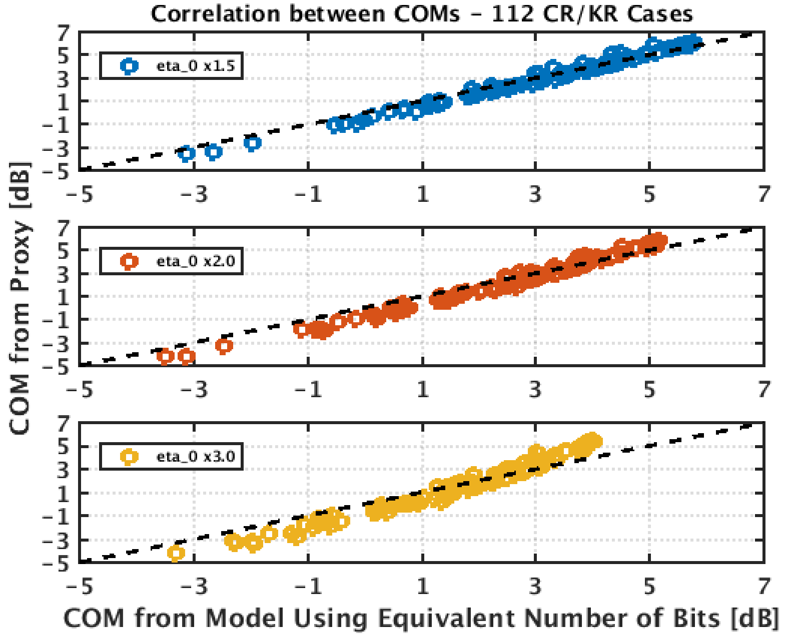


- Ideally, it is expected that the equivalent number of bits be independent of channel loss
- The variation and dependency/correlation to channel loss is evident

COM Results Comparison

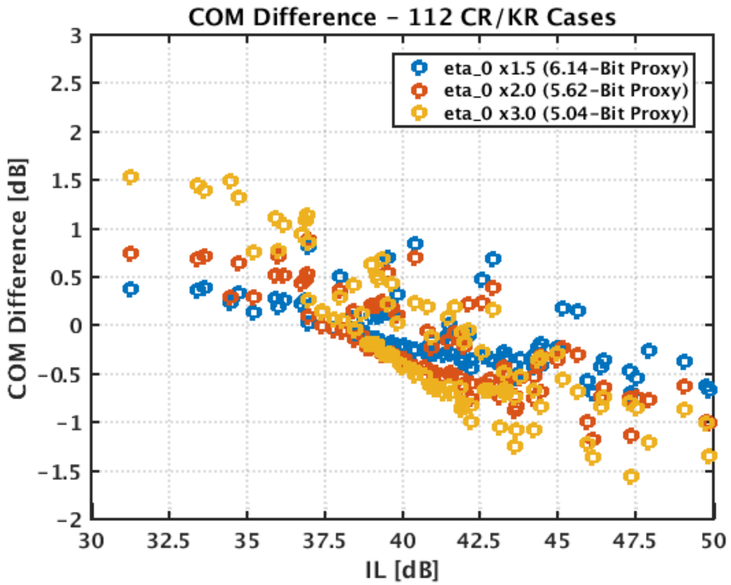
- As a result, the best estimate of the equivalent number of bits that each scale value reflects is its average over channels
- These averages are used to calculate COM that direct model of quantization noise yields
- COM values obtained from two methods (eta_0 proxy and direct model) now can be compared for the test channels

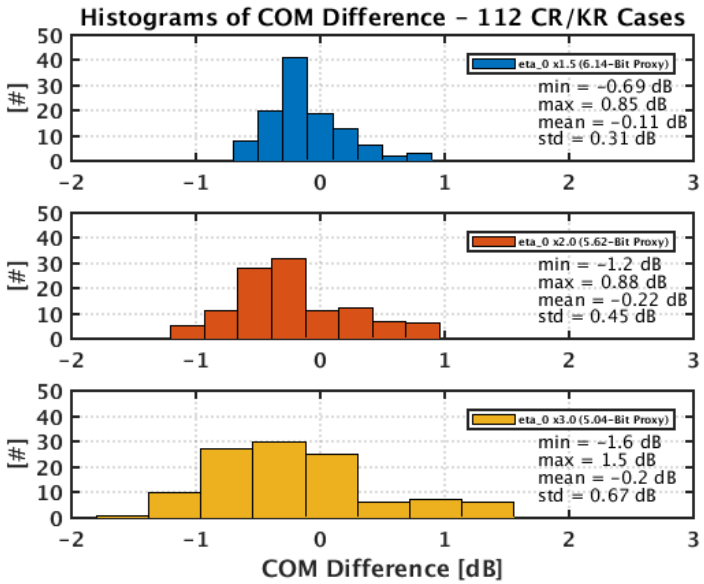




COM Difference

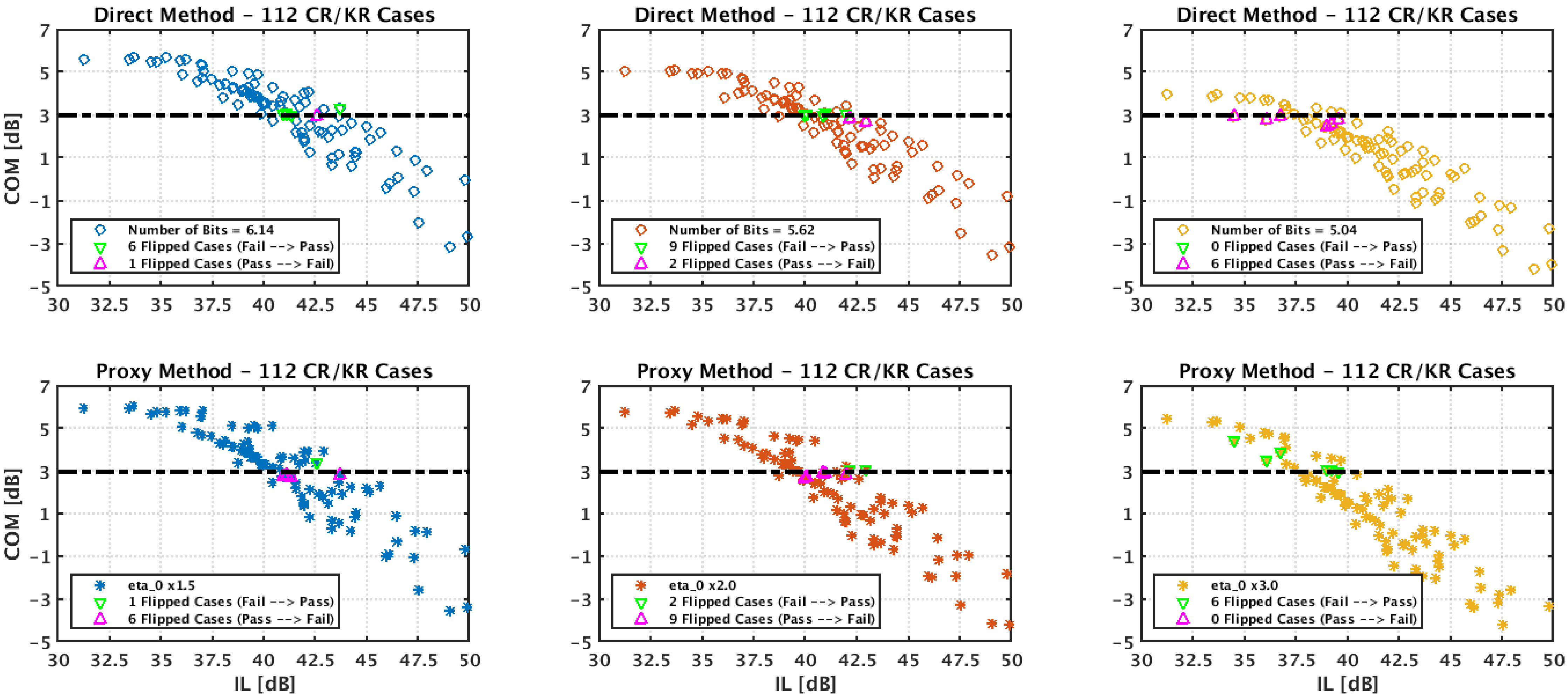
- Closer observations:
  - For channels with IL >~ 40dB the proxy method generally under-estimates COM
  - For channels with IL < ~40dB the proxy method generally over-estimates COM
  - Many channels with similar IL can exhibit large COM differences (even more than 1dB)
  - Correlation in general is not tight enough
  - Depending on the number of quantization bits (even in a practical range), channel, and insertion loss, the difference could be as much as ±1.5dB, which is unacceptable and could flip pass/fail cases





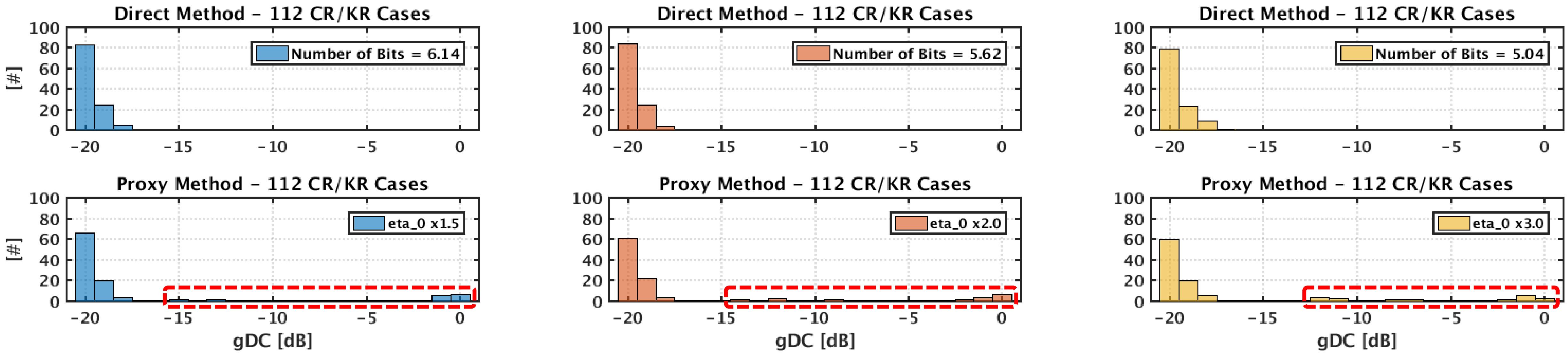
Pass/Fail and Flipping Cases

- The difference between COMs from two methods causes some cases to flip the pass/fail test

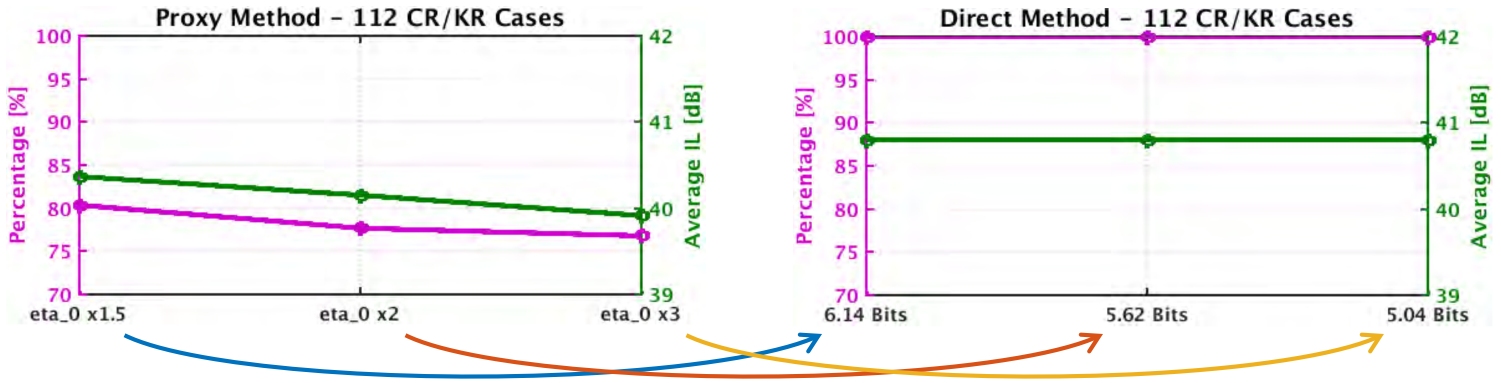


CTLE Utilization Comparison

- A noticeable population of cases do not properly utilize CTLE with the proxy method



- The trend of CTLE under-utilization as quantization noise increases is against expectation
  - Percentage of cases that utilize more than 16dB (out of 20dB or more than 80%) of CTLE:



On the COM Simulation Run Time

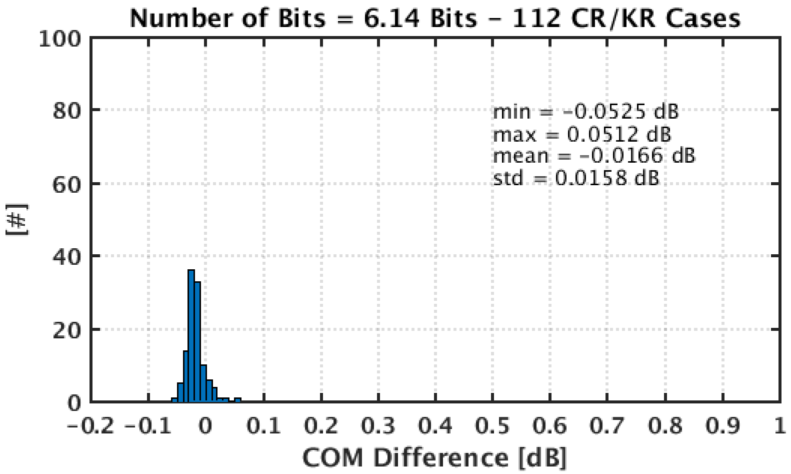
- A recent review of one of the changes in COM version 480 revealed that a part of one of the earlier commit requests was not properly implemented
- This change has to do with the method for calculating quantization noise during optimization iterations
  - ❖ Method 1 is less accurate, but runs faster (3% run time overhead)
  - ❖ Method 2 is more accurate but runs slower (106% run time overhead or 2X slower that method 1)
- Currently, due to a bug both methods are executed but ultimately method 1 overrides the new method
- Consequently, less accurate result of method 1 is yielded with slow run time of method 2 ☹
- A COM commit request will be presented in the COM ad hoc meeting this week to address this issue (shakiba_3dj_COM_03_2505.pdf)

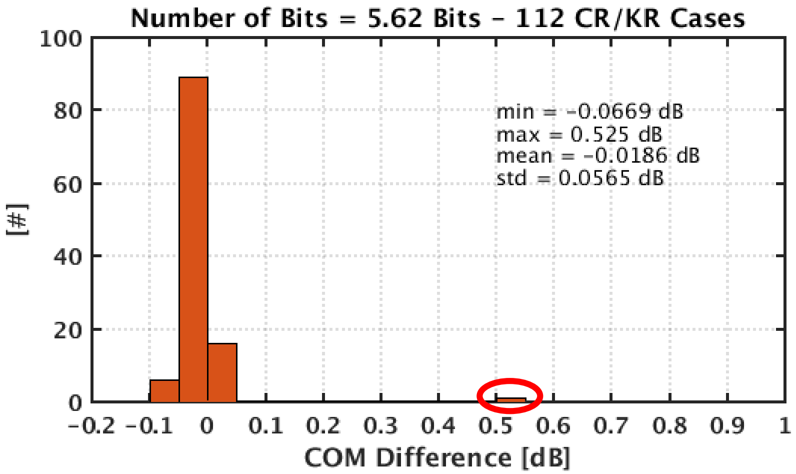
On the COM Simulation Run Time

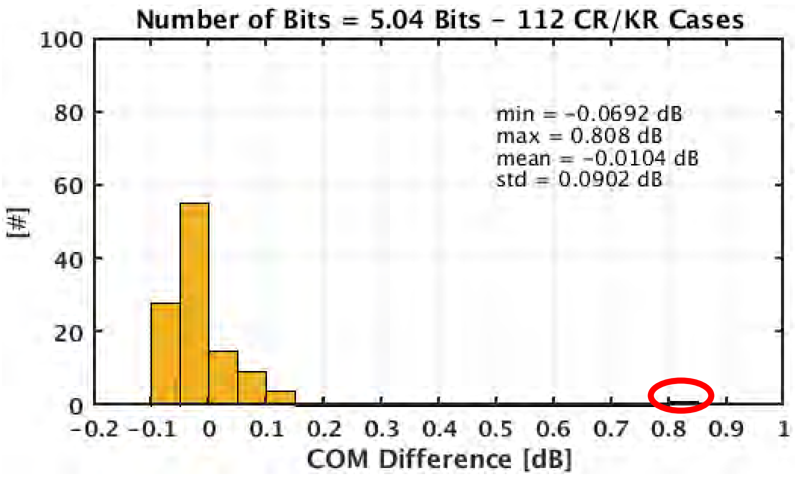
- Run time results without quantization noise and with quantization noise and for both methods across 112 test cases and 3 number of quantization bits:

Average Run Time [s] without Quantization Noise	Average Run Time [s] with Quantization Noise (Method 1)	Average Run Time [s] with Quantization Noise (Method 2)
195	201 (3% Overhead)	401 (106% Overhead)

- The penalty in COM for the above test cases is less than a fraction of a dB except for two cases







Summary and Conclusion

- Same study and data generation and analysis process was carried on a set of 110 C2C and a set of 208 C2M channels and similar results and trends were observed (see Appendix)
- To include the direct model of quantization noise in the COM flow, a candidate proposal could look like the following:
  - Scale back eta_0 from 1E-8V^2/GHz to 5E-9V^2/GHz
  - Add direct model of quantization noise based on this presentation
  - Set probability of clip, P_qc, to its default value of 2*DER0
  - Choose number of quantization bits, N_qb, to match the average COM obtained when eta_0 was 1E-8V^2/GHz

Channel	eta_0 [V^2/GHz]	P_qc (= 2*DER0)	N_qb
CR / KR	5E-9	2 x 2E-4	5.62
C2C	5E-9	2 x 0.67E-5	6.31
C2M	5E-9	2 x 2E-5	6.56

Thank You ☺

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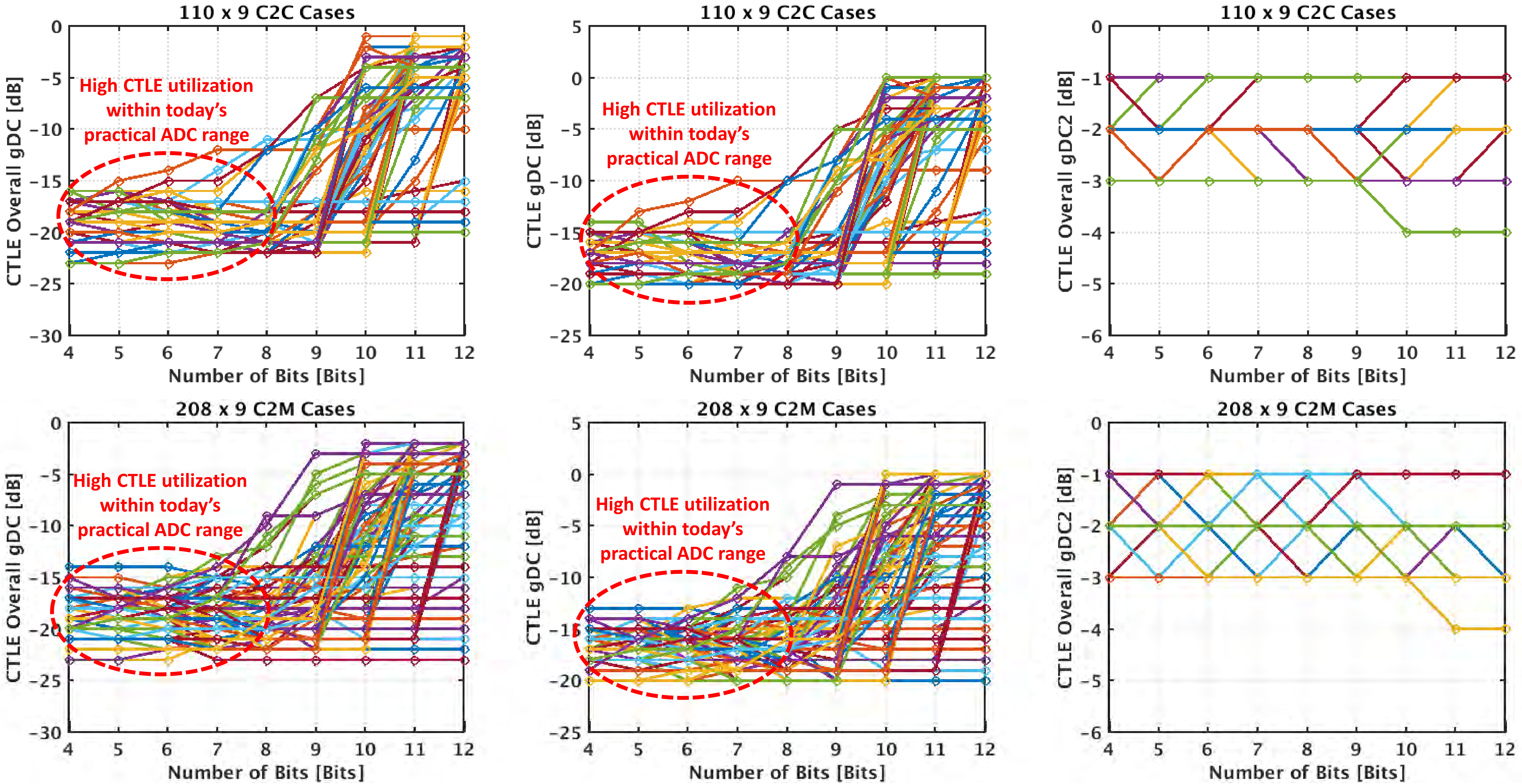
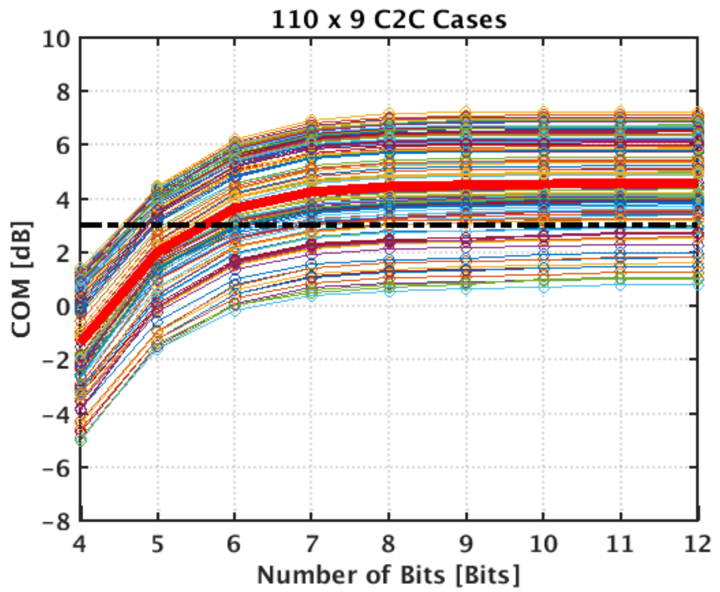
Appendix

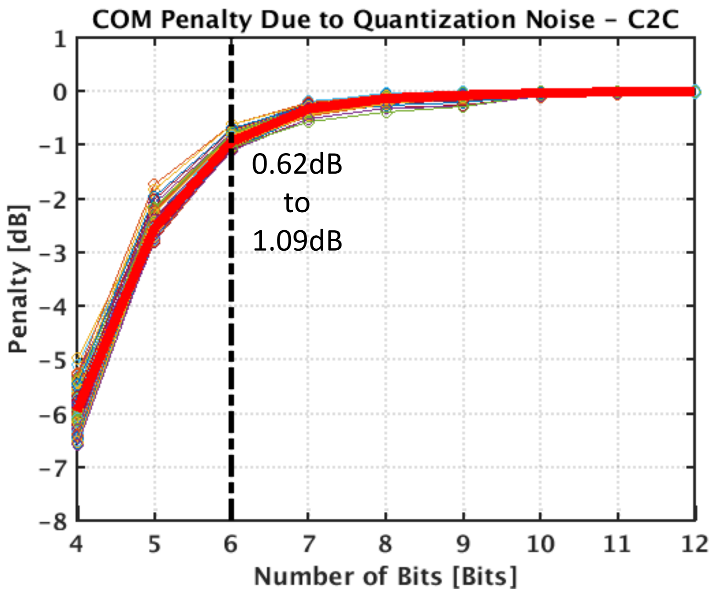
C2C and C2M Test Case Results

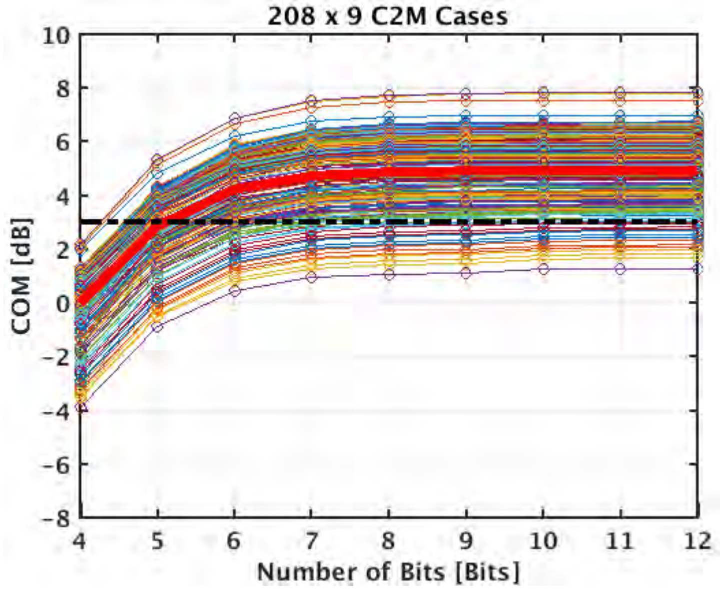
Impact of Quantization Noise on CTLE Utilization

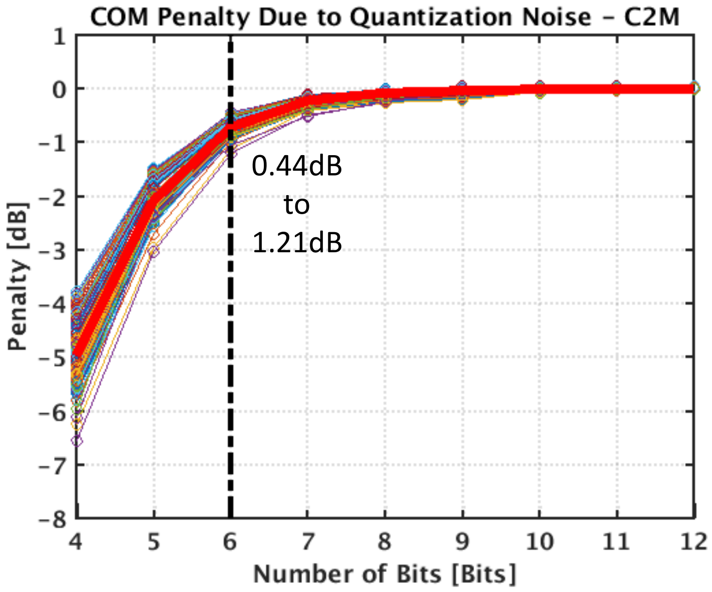


Impact of Quantization Noise on COM

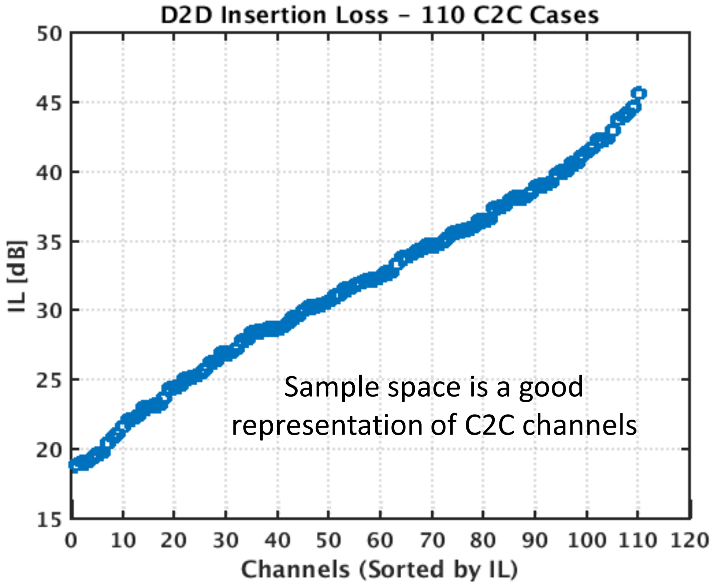


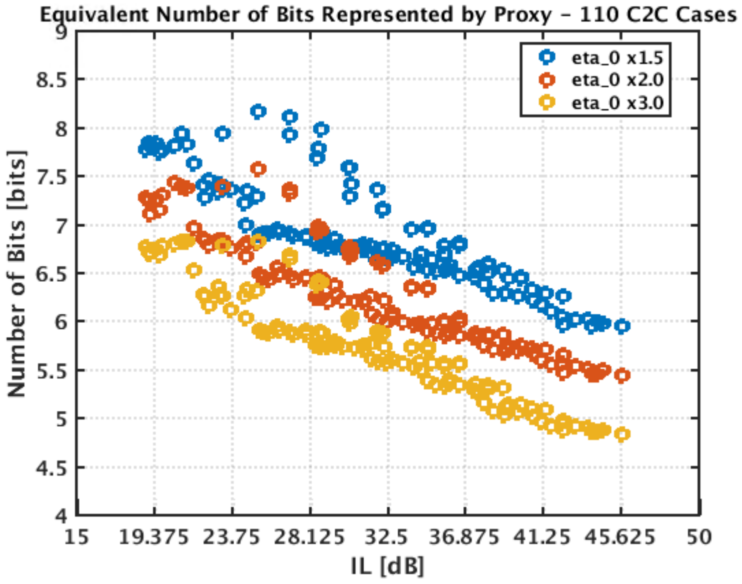


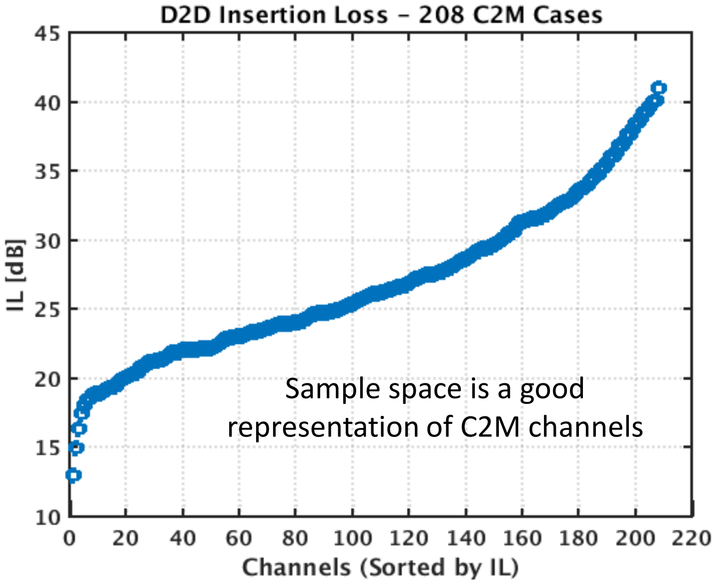


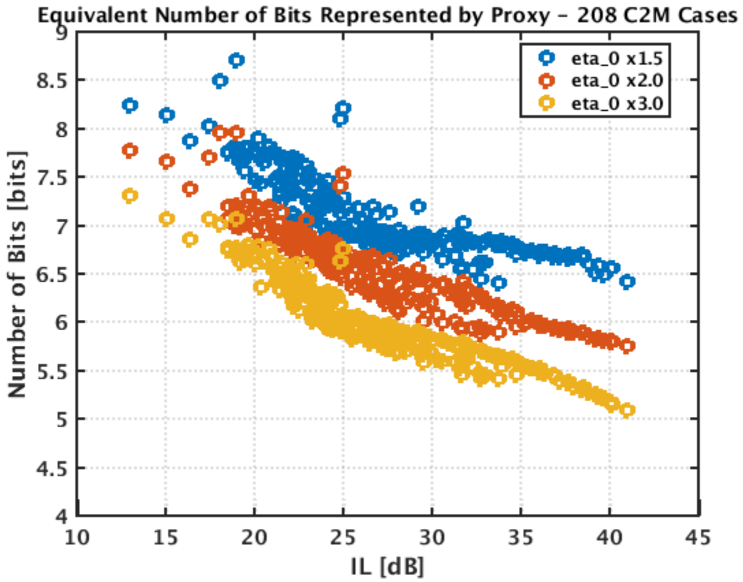


The Concern with eta_0 Proxy Approach

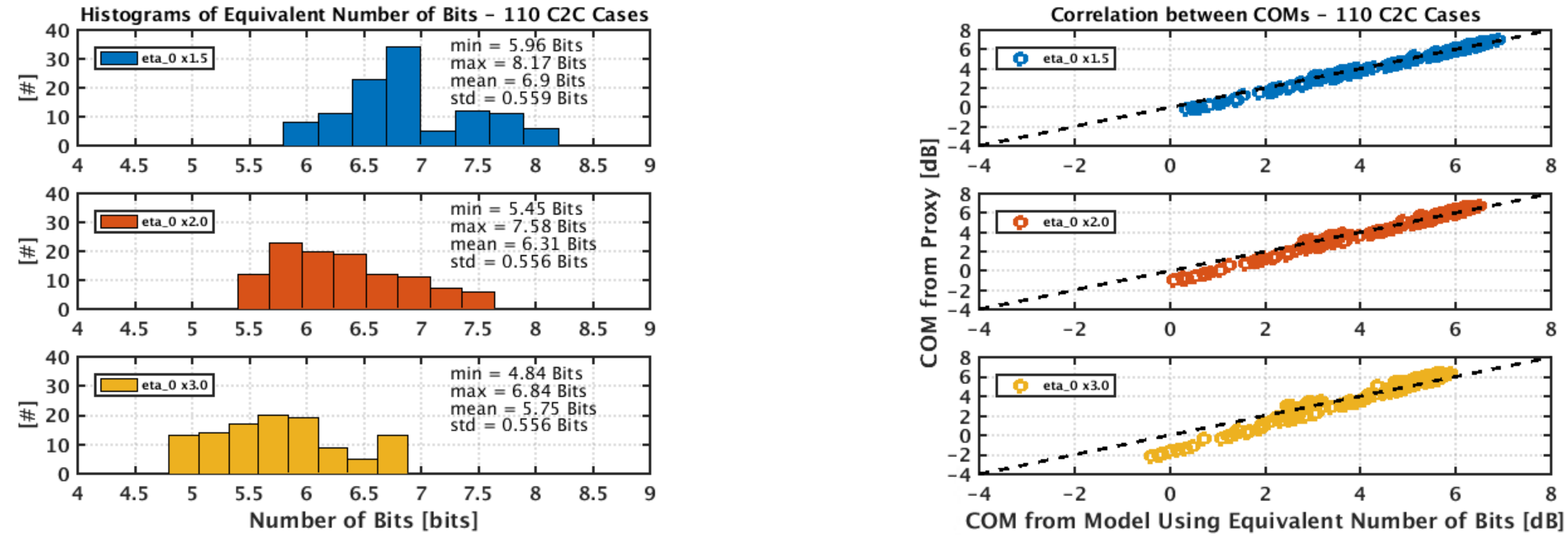


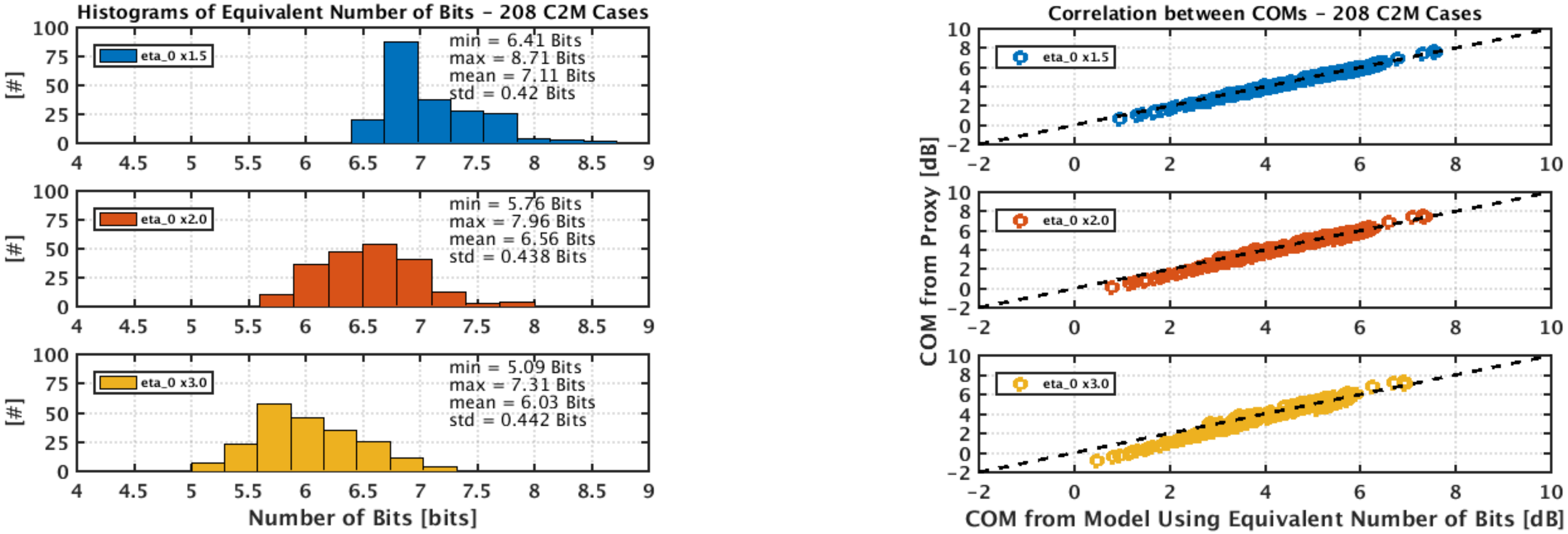




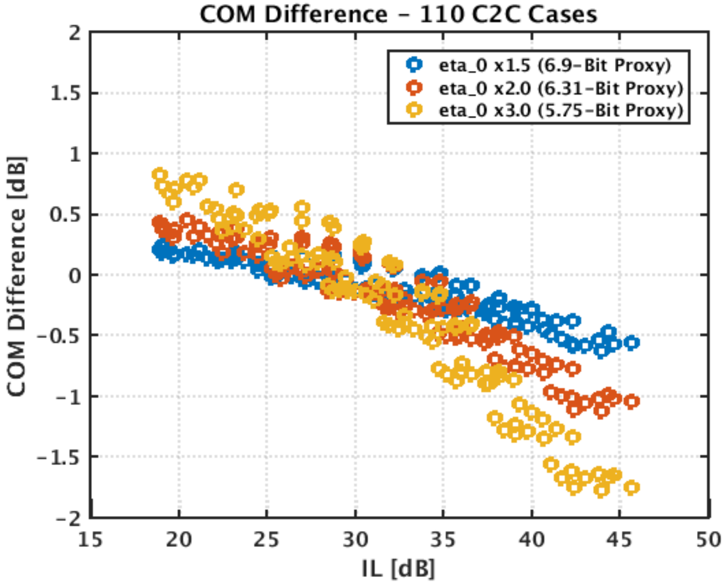


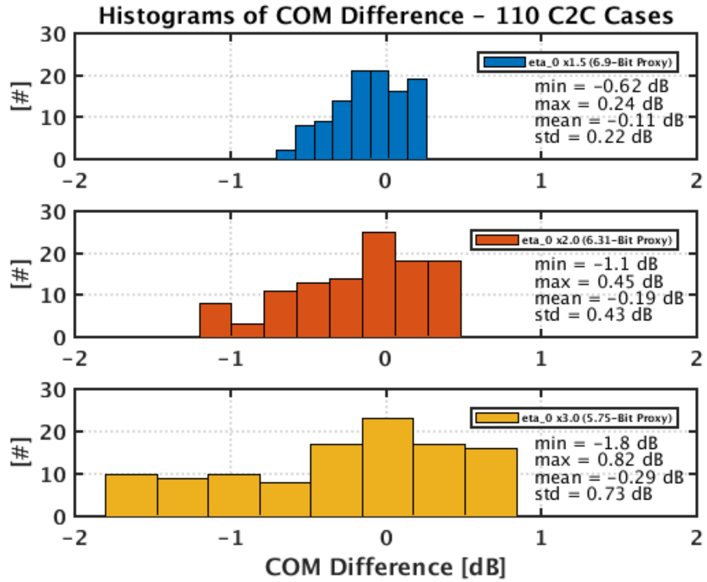
COM Results Comparison

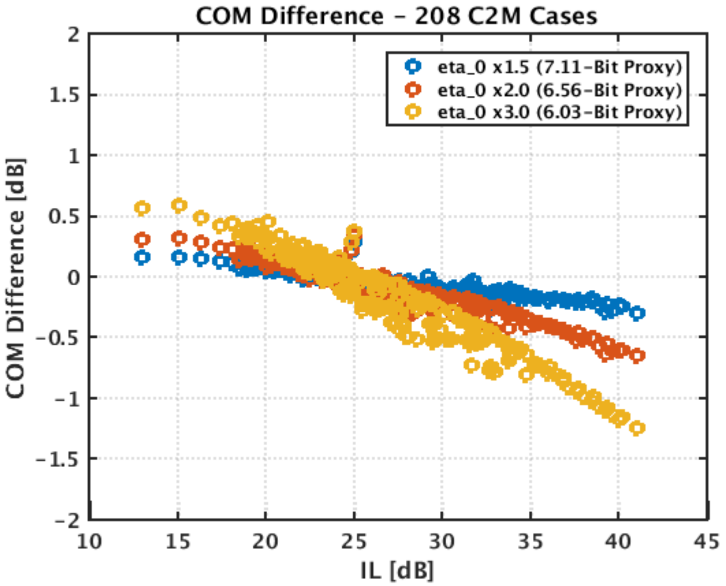


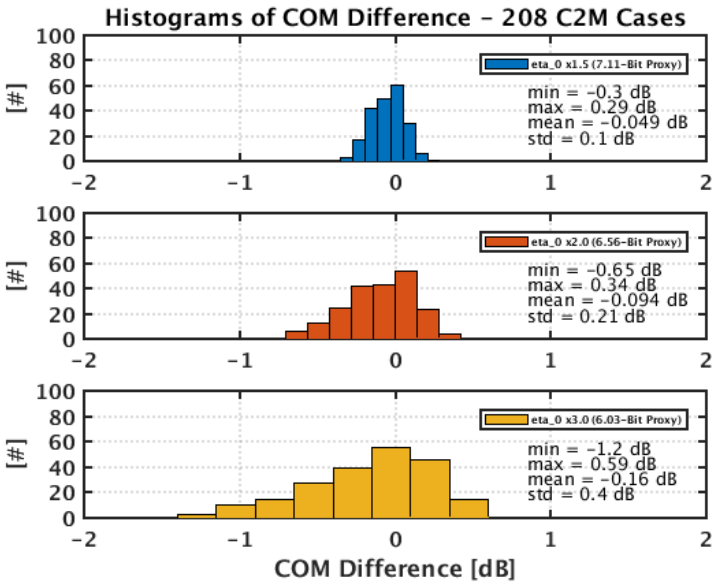


COM Difference

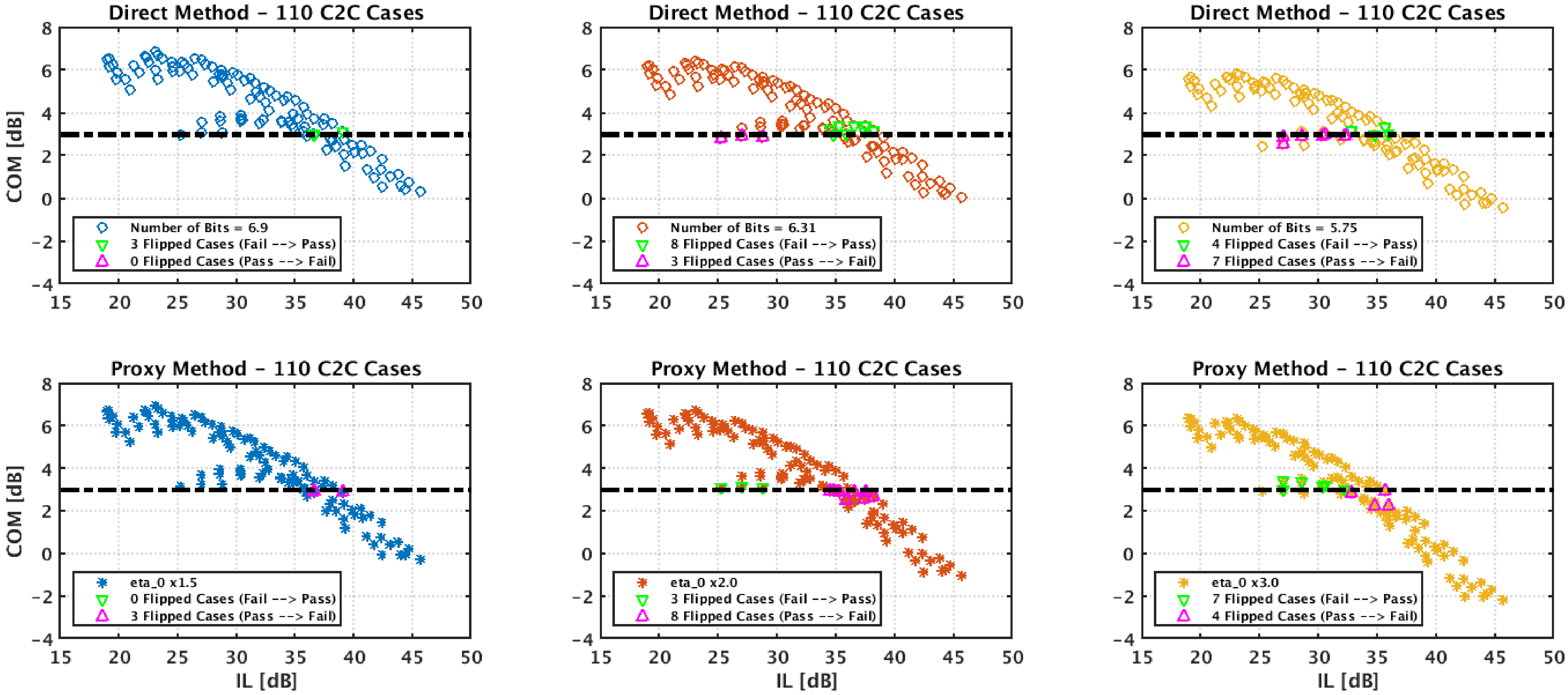




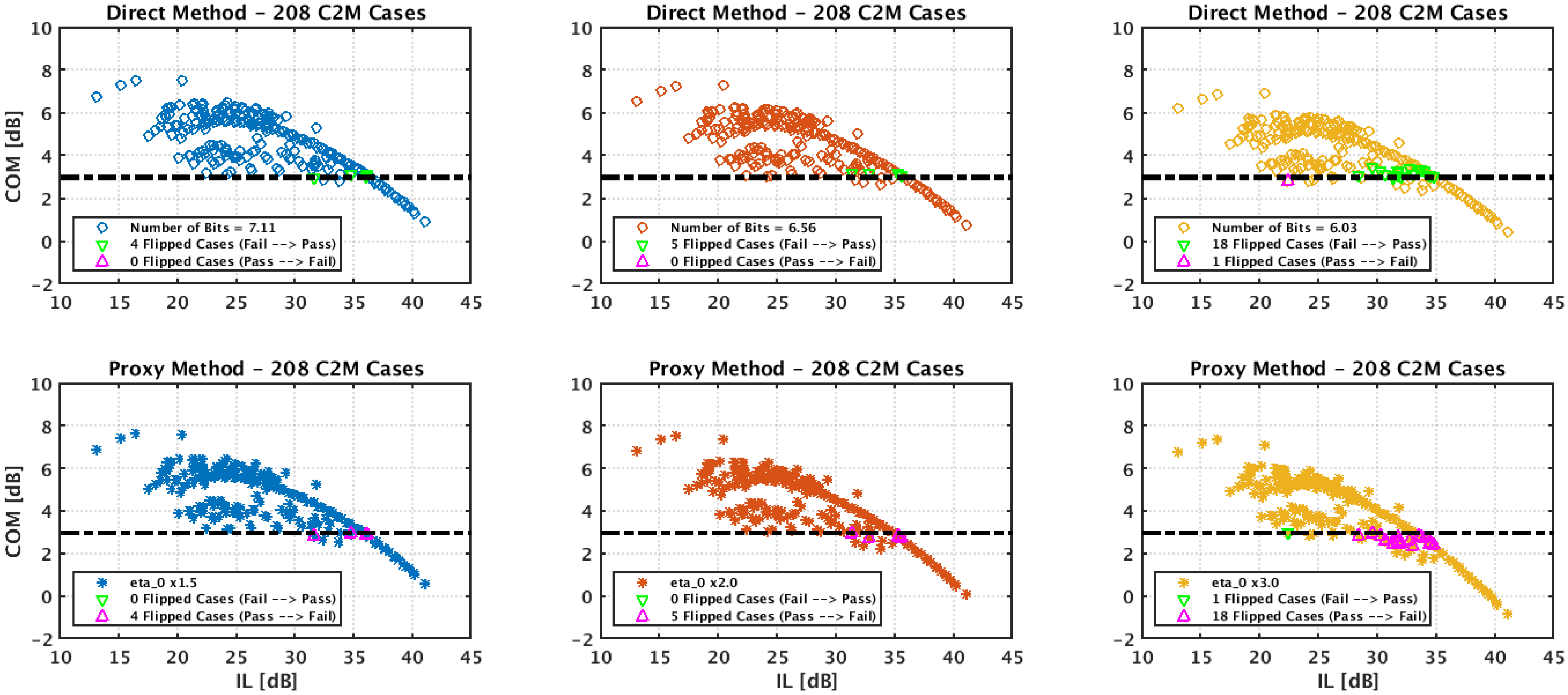




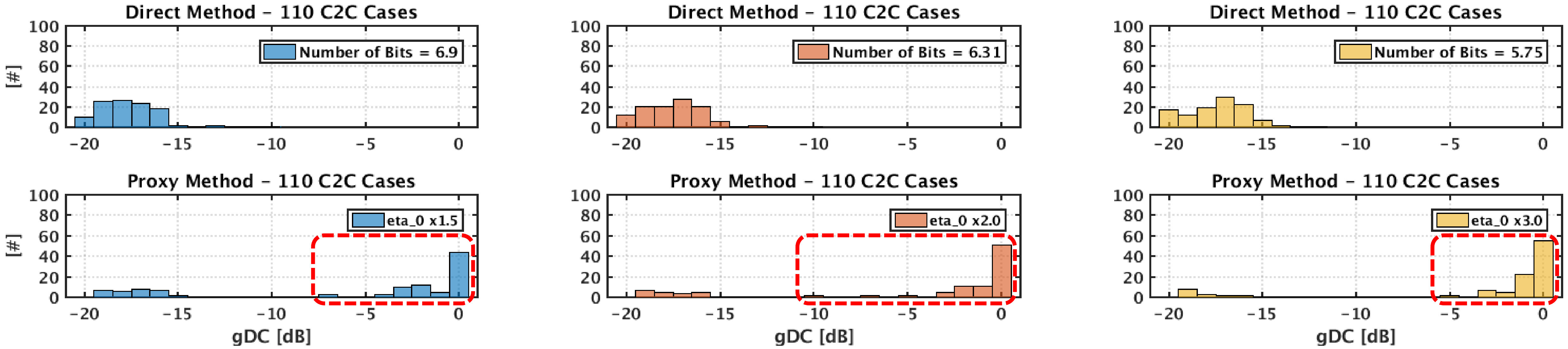
Pass/Fail and Flipping Cases



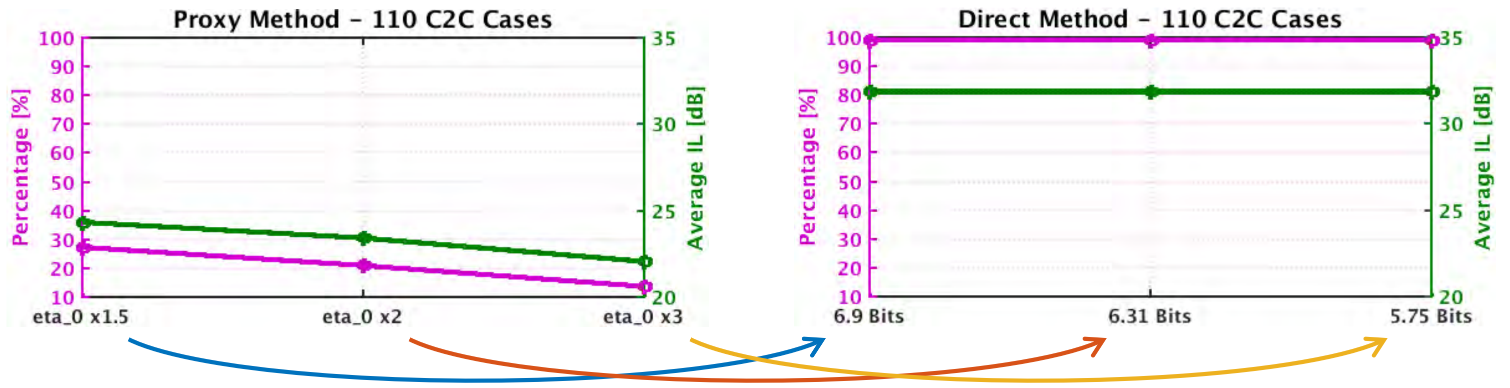
Pass/Fail and Flipping Cases



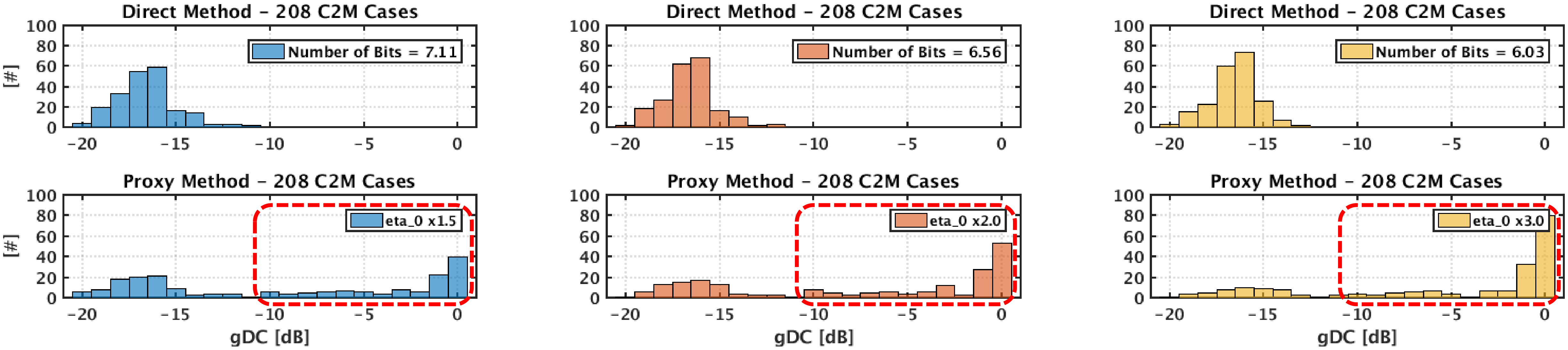
CTLE Utilization Comparison



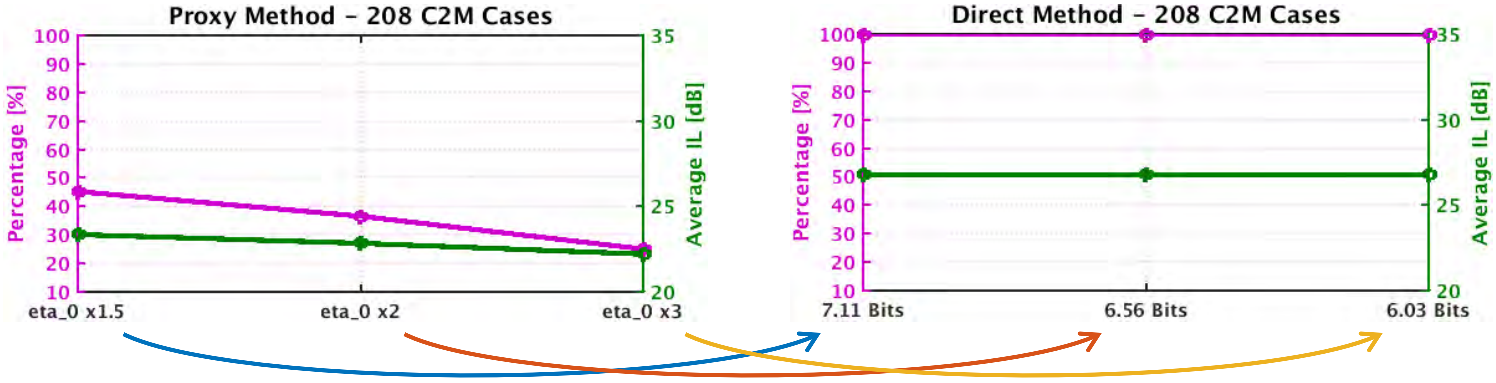
❖ Percentage of cases that utilize more than 12dB (out of 20dB or more than 60%) of CTLE:



CTLE Utilization Comparison



- Percentage of cases that utilize more than 10dB (out of 20dB or more than 50%) of CTLE:



Backup Slides

Channel and COM Info

CR/KR Test Channels

Channel #	Channel Source
1	https://www.ieee802.org/3/dj/public/tools/CR/lim_3dj_03_230629.zip
2	https://www.ieee802.org/3/dj/public/tools/CR/lim_3dj_04_230629.zip
3 – 7	https://www.ieee802.org/3/dj/public/tools/CR/kocsis_3dj_02_2305.zip
8 – 34	https://www.ieee802.org/3/dj/public/tools/KR/mellitz_3dj_02_elec_230504.zip
35 – 40	https://www.ieee802.org/3/dj/public/tools/CR/shanbhag_3dj_01_2305.zip
41 – 44	https://www.ieee802.org/3/dj/public/tools/KR/shanbhag_3dj_02_2305.zip
45 – 80	https://www.ieee802.org/3/dj/public/tools/KR/weaver_3dj_02_2305.zip
81 – 88	https://www.ieee802.org/3/dj/public/tools/KR/weaver_3dj_elec_01_230622.zip
89	https://www.ieee802.org/3/dj/public/tools/CR/lim_3dj_07_2309.zip
90 – 96	https://www.ieee802.org/3/dj/public/tools/KR/akinwale_3dj_01_2310.zip
97 – 100	https://www.ieee802.org/3/dj/public/tools/CR/akinwale_3dj_02_2311.zip
101 – 112	https://www.ieee802.org/3/dj/public/tools/CR/weaver_3dj_02_2311.zip

C2C Test Channels

Channel #	Channel Source
1 – 72	https://www.ieee802.org/3/dj/public/tools/c2c/heck_3dj_02_2405.zip
73 – 85	https://www.ieee802.org/3/dj/public/tools/c2c/heck_3dj_02_2403.zip
86 – 110	https://www.ieee802.org/3/dj/public/tools/c2c/mellitz_3dj_03_elec_230504.zip

C2M Test Channels

Channel #	Channel Source
1 – 4	https://www.ieee802.org/3/dj/public/tools/c2m/mellitz_3dj_02_2409.zip
5 – 64	https://www.ieee802.org/3/dj/public/tools/c2m/kareti_3dj_elec_02_240111.zip
65 – 82	https://www.ieee802.org/3/dj/public/tools/c2m/gore_3dj_elec_02_231026.zip
83 – 85	https://www.ieee802.org/3/dj/public/tools/c2m/lim_3dj_01_230629.zip https://www.ieee802.org/3/dj/public/tools/c2m/lim_3dj_02_230629.zip https://www.ieee802.org/3/dj/public/tools/c2m/lim_3dj_06_2309.zip
86 – 101 102 – 117	https://www.ieee802.org/3/dj/public/tools/c2m/weaver_3dj_elec_02_230831.zip
118 – 123	https://www.ieee802.org/3/dj/public/tools/c2m/shanbhag_3dj_03_2305.zip
124 – 206	https://www.ieee802.org/3/dj/public/tools/c2m/akinwale_3dj_02_2307.zip https://www.ieee802.org/3/dj/public/tools/c2m/akinwale_3dj_03_2307.zip https://www.ieee802.org/3/dj/public/tools/c2m/akinwale_3dj_04_2307.zip
207- 208	https://www.ieee802.org/3/dj/public/tools/c2m/rabinovich_3dj_02_230116.zip https://www.ieee802.org/3/dj/public/tools/c2m/rabinovich_3dj_03_230116.zip

CR/KR COM Config

- COM version 480_hs2p3 (customization _hs2p3 applies commit requests 4p8_1 to 4p8_5)

Parameter	Setting	Units	Information	stds ref.
Table 93A-1 parameters				
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]	d1.0
L_s	[0.13 0.15 0.14;0.13 0.15 0.14]	nH	[TX RX]	d1.0
C_b	[0.3e-4 0.3e-4]	nF	[TX RX]	d1.0
R_0	50	Ohm	[TX RX]	d1.0 cmt 396
R_d	[46.25 46.25]	Ohm	[TX RX]	
PKG_NAME	PKG_HIR_CLASSB PKG_LowR_CLASSA		TX RX	
A_v	0.387	V		
A_fe	0.387	V		
A_ne	0.482	V		
z_p select	[1]			
L	4			
M	32			
Filter and Eq				
f_r	0.550	*fb		d1.0 cmt 60 (60 GHz)
c(0)	0.54		min	d1.0 cmt 37
c(-1)	0	[-0.34:0.02:0]	[min:step:max]	d1.0 max value -0.34
c(-2)	0	[0:0.02:0.14]	[min:step:max]	d1.0 max value 0.14
c(-3)	0	0	[min:step:max]	
c(-4)	0	0	[min:step:max]	
c(1)	0	[-0.2:0.02:0]	[min:step:max]	d1.0 cmt 37
N_b	1	UI		d1.0
b_max(1)	0.85		As/dfe1	d1.0 cmt 279
b_max(2..N_b)	0		As/dfe2..N_b	
b_min(1)	0		As/dfe1	d1.0 cmt 279
b_min(2..N_b)	-0.15	UI	HA if NB=1	
g_DC	[-20:1:0]	dB	[min:step:max]	d1.0 (Max value -20)
f_z	42.50	GHz		d1.0
f_p1	42.50	GHz		d1.0
f_p2	106.25	GHz		d1.0
g_DC_HP	[-6:1:0]		[min:step:max]	d1.0
f_HP_PZ	1.328125	GHz		d1.0
Butterworth	1	logical	include in fr	

I/O control			stds ref.
DIAGNOSTICS	0	logical	
DISPLAY_WINDOW	0	logical	
CSV_REPORT	0	logical	
RESULT_DIR	.\results\C2M_{date}\		
SAVE_FIGURES	0	logical	
Port Order	[1 3 2 4]	input fi	
RUNTAG	C2M_		
COM_CONTRIBUTION	1	logical	
TDR and ERL options			
TDR	1	logical	
ERL	1	logical	
ERL_ONLY	0	logical	
TR_TDR	0.005	ns	
N	7000	UI	
TDR_Butterworth	1		
beta_x	0		
rho_x	0.618		
TDR_W_TXPKG	1	UI	ERL computed at TP 1a
N_bx	16	UI	
fixture delay time	[0 0]	s	
Tukey_Window	1		
Noise, jitter			
sigma_RJ	0.01	UI	
A_DD	0.02	UI	
eta_0	1.00E-08	V^2/GHz	
SNR_TX	33.5	dB	
R_LM	0.95		
[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]		
[illegible]	[illegible]		
[illegible]	[illegible]		
[illegible]	[illegible]		
[illegible]	[illegible]		
[illegible]	[illegible]		

Parameter	Setting	Units	Information	stds ref
Table 93A-3 parameters (Table Not Used with ClassA and B Packages)				
package_tl_gamma0_a1_a2	[5e-4 0.00065 0.0003]			
package_tl_tau	0.006141	ns/mm		
package_Z_c	[92 ; 70 70; 80 80; 100 ...	Ohm		
z_p (TX)	[1 1 1 1; 1 1 1 1 ; 0.5 ...	mm	[test cases to run]	
z_p (NEXT)	[1 1 1 1; 1 1 1 1 ; 0.5 ...	mm	[test cases]	
z_p (FEXT)	[1 1 1 1; 1 1 1 1 ; 0.5 ...	mm	[test cases]	
z_p (RX)	[1 1 1 1; 1 1 1 1 ; 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-04			
T_r	0.00400	ns		
FORCE_TR	1	logical	required for backward compatibility	
PMD_type	C2C			
samples_for_C2M	100			
T_O	50			
BW	1			
MLSE	1	logical		
ts_anchor	1			
sample_adjustment	[-16 16]			
Local Search	2		0=full grid search, 2=local search	
			MLSE trunction length 8-16 not adopted yet	
Filter: Rx FFE				
ffe_pre_tap_len	6	UI		
ffe_post_tap_len	8	UI		
ffe_pre_tap1_max	0.7	interpreted as +/-	COM to change to Wmax/min	
ffe_post_tap1_max	0.7	interpreted as +/-	COM to change to Wmax/min	
ffe_tapn_max	0.7	interpreted as +/-	COM to change to Wmax/min	
FFE_OPT_METHOD	MMSE		FV-LMS or MMSE	
num_ui_RXFF_noise	2048			
Floating Tap Control				
N_bg	2	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	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	0.278	Fb
f_f	0.278	Fb
f_n	0.278	Fb
f_2	58.438	GHz
A_ft	0.450	V
A_nt	0.450	V
Parameter	Setting	
board_tl_gamma0_a1_a2	[0 3.95e-4 2.6e-05]	1.4 db/in @ 53.125G
board_tl_tau	5.790E-03	ns/mm
board_Z_c	92.5	Ohm
z_bp (TX)	32	mm
z_bp (NEXT)	32	mm
z_bp (FEXT)	32	mm
z_bp (RX)	32	mm
C_0	[0.29e-4 0]	nF
C_1	[0.1e-4 0]	nF
Include PCB	0	logical
Selections (rectangle, gaussian,dual_rayleigh,triangle		
Histogram_Window_Weight	gaussian	selection
Qr	0.02	UI

.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]			d1.0
package_tl_tau	0.006141	ns/mm		d1.0
package_Z_c	[87.5 87.5 ; 92.5 92.5 ; 100 100; 100 100]	Ohm		d1.0
R_d	[46.25 46.25]	Ohm	[TX RX]	d1.0 cmt 396
z_p (TX)	[33 12 33 33 ; 1.8 1.8 1.8 1.8 ; 0 0 0 0 ; 0 0 0 0]	mm	[test cases]	d1.0
z_p (NEXT)	[33 12 33 33 ; 1.8 1.8 1.8 1.8 ; 0 0 0 0 ; 0 0 0 0]	mm	[test cases]	d1.0
z_p (FEXT)	[33 12 33 33 ; 1.8 1.8 1.8 1.8 ; 0 0 0 0 ; 0 0 0 0]	mm	[test cases]	d1.0
z_p (RX)	[33 12 33 33 ; 1.8 1.8 1.8 1.8 ; 0 0 0 0 ; 0 0 0 0]	mm	[test cases]	d1.0
C_p	[0.4e-4 0.4e-4]	nF	[TX RX]	d1.0
A_v	[0.385 0.385 0.385 0.385]	V	Vf=0.400	d1.2
A_fe	[0.385 0.385 0.385 0.385]	V	Vf=0.399	D1.2
A_ne	[0.481 0.481 0.481 0.481]	V	Vf=0.400	D1.2
.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]			d1.0
package_tl_tau	0.006141	ns/mm		d1.0
package_Z_c	[87.5 87.5 ; 95 95 ; 100 100; 78 78]	Ohm		d1.0
R_d	[46.25 46.25]	Ohm	[TX RX]	d1.0 cmt 396
z_p (TX)	[45 30 8 24 ; 2 2 2 2 ; 1.3 1.3 1.3 1.3 ; 1.5 1.5 1.5 1.5]	mm	[test cases]	d1.0
z_p (NEXT)	[44 29 8 24 ; 2 2 2 2 ; 1.3 1.3 1.3 1.3 ; 1.5 1.5 1.5 1.5]	mm	[test cases]	d1.0
z_p (FEXT)	[45 30 8 24 ; 2 2 2 2 ; 1.3 1.3 1.3 1.3 ; 1.5 1.5 1.5 1.5]	mm	[test cases]	d1.0
z_p (RX)	[44 29 8 24 ; 2 2 2 2 ; 1.3 1.3 1.3 1.3 ; 1.5 1.5 1.5 1.5]	mm	[test cases]	d1.0
C_p	[0.4e-4 0.4e-4]	nF	[TX RX]	d1.0
A_v	[0.385 0.385 0.385 0.385]	V	Vf=0.400	d1.0 cmt 434
A_fe	[0.385 0.385 0.385 0.385]	V	Vf=0.399	d1.0 cmt 434
A_ne	[0.481 0.481 0.481 0.481]	V	Vf=0.400	d1.0 cmt 434
.END				

C2C COM Config

- COM version 480_hs2p3 (customization _hs2p3 applies commit requests 4p8_1 to 4p8_5)

Table 93A-1 parameters

Parameter	Setting	Units	Information	stds ref.
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]	d1.0
L_s	[0.13 0.15 0.14; 0.13 0.15 0.14]	nH	[TX RX]	d1.0
C_b	[0.3e-4 0.3e-4]	nF	[TX RX]	d1.0
R_0	50	Ohm	[TX RX]	d1.0 cmt 396
R_d	[46.25 46.25]	Ohm	[TX RX]	
PKG_NAME	PKG_HIR_CLASSB PKG_LowR_CLASSA		TX RX	
A_v	0.387	V		
A_fe	0.387	V		
A_ne	0.482	V		
z_p select	[1]			
L	4			
M	32			
Filter and Eq				
f_r	0.550	*fb		d1.0 cmt 60 (60 GHz)
c(0)	0.54		min	d1.0 cmt 37
c(-1)	0	[-0.34:0.02:0]	[min:step:max]	d1.0 max value -0.34
c(-2)	0	[0:0.02:0.14]	[min:step:max]	d1.0 max value 0.14
c(-3)	0	0	[min:step:max]	
c(-4)	0	0	[min:step:max]	
c(1)	0	[-0.2:0.02:0]	[min:step:max]	d1.0 cmt 37
N_b	1	UI		d1.0
b_max(1)	0.85		As/dfe1	d1.0 cmt 279
b_max(2..N_b)	0		As/dfe2..N_b	
b_min(1)	0		As/dfe1	d1.0 cmt 279
b_min(2..N_b)	-0.15	UI	=A*1 NB=1	
g_DC	[-20:1:0]	dB	[min:step:max]	d1.0 [Max value -20]
f_z	42.50	GHz		d1.0
f_p1	42.50	GHz		d1.0
f_p2	106.25	GHz		d1.0
g_DC_HP	[-6:1:0]		[min:step:max]	d1.0
f_HP_PZ	1.328125	GHz		d1.0
Butterworth	1	logical	include in fr	

I/O control

Parameter	Setting	Units	stds ref.
DIAGNOSTICS	0	logical	
DISPLAY_WINDOW	0	logical	
CSV_REPORT	0	logical	
RESULT_DIR	.\results\C2M_{date}\		
SAVE_FIGURES	0	logical	
Port Order	[1 3 2 4]	input fi	
RUNTAG	C2M_		
COM_CONTRIBUTION	1	logical	
TDR and ERL options			
TDR	1	logical	
ERL	1	logical	
ERL_ONLY	0	logical	
TR_TDR	0.005	ns	
N	7000	UI	
TDR_Butterworth	1		
beta_x	0		
rho_x	0.618		
TDR_W_TXPKG	1	UI	ERL computed at TP 1a
N_bx	16	UI	
fixture delay time	[0 0]	s	
Tukey_Window	1		
Noise, Jitter			
sigma_RJ	0.01	UI	
A_DD	0.02	UI	
eta_0	1.00E-08	V^2/GHz	
SNR_TX	33.5	dB	
R_LM	0.95		
[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]		
[illegible]	[illegible]		
[illegible]	[illegible]		
[illegible]	[illegible]		
[illegible]	[illegible]		
[illegible]	[illegible]		

Table 93A-3 parameters (Table Not Used with ClassA and B Packages)

Parameter	Setting	Units	Information	stds ref
package_tl_gamma0_a1_a2	[5e-4 0.00065 0.0003]			
package_tl_tau	0.006141	ns/mm		
package_Z_c	[92 ; 70 70; 80 80; 100 1	Ohm		
z_p (TX)	[1 1 1 1; 1 1 1 1; 0.5	mm	[test cases to run]	
z_p (NEXT)	[1 1 1 1; 1 1 1 1; 0.5	mm	[test cases]	
z_p (FEXT)	[1 1 1 1; 1 1 1 1; 0.5	mm	[test cases]	
z_p (RX)	[1 1 1 1; 1 1 1 1; 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	6.70E-05			
T_r	0.00400	ns		
FORCE_TR	1	logical	required for backward compatibility	
PMD_type	C2C			
samples_for_C2M	100			
T_O	50			
BW	1			
MLSE	1	logical		
ts_anchor	1			
sample_adjustment	[-16 16]			
Local Search	2		0=full grid search, 2=local search	
			MLSE trunction length 8-16 not adopted yet	
Filter: Rx FFE				
ffe_pre_tap_len	5	UI		
ffe_post_tap_len	8	UI		
ffe_pre_tap1_max	0.7	interpreted as +/-	COM to change to Wmax/min	
ffe_post_tap1_max	0.7	interpreted as +/-	COM to change to Wmax/min	
ffe_tapn_max	0.7	interpreted as +/-	COM to change to Wmax/min	
FFE_OPT_METHOD	MMSE		FV-LMS or MMSE	
num_ui_RXFF_noise	2048			
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	7	(UI) start of tail taps limit		

Parameter	Setting	Units
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	58.438	GHz
A_ft	0.450	V
A_nt	0.450	V

Parameter	Setting	
board_tl_gamma0_a1_a2	[0 5.95e-4 2.6e-05]	1.4 db/in @ 53.125G
board_tl_tau	5.790E-03	ns/mm
board_Z_c	92.5	Ohm
z_bp (TX)	32	mm
z_bp (NEXT)	32	mm
z_bp (FEXT)	32	mm
z_bp (RX)	32	mm
C_0	[0.29e-4 0]	nF
C_1	[0.1e-4 0]	nF
Include PCB	0	logical
Selections (rectangle, gaussian, dual_rayleigh, triangle		
Histogram_Window_Weight	gaussian	selection
Qr	0.02	UI

.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]			d1.0
package_tl_tau	0.006141	ns/mm		d1.0
package_Z_c	[87.5 87.5 ; 92.5 92.5 ; 100 100; 100 100]	Ohm		d1.0
R_d	[46.25 46.25]	Ohm	[TX RX]	d1.0 cmt 396
z_p (TX)	[33 12 33 33 ; 1.8 1.8 1.8 1.8 ; 0 0 0 0 ; 0 0 0 0]	mm	[test cases]	d1.0
z_p (NEXT)	[33 12 33 33 ; 1.8 1.8 1.8 1.8 ; 0 0 0 0 ; 0 0 0 0]	mm	[test cases]	d1.0
z_p (FEXT)	[33 12 33 33 ; 1.8 1.8 1.8 1.8 ; 0 0 0 0 ; 0 0 0 0]	mm	[test cases]	d1.0
z_p (RX)	[33 12 33 33 ; 1.8 1.8 1.8 1.8 ; 0 0 0 0 ; 0 0 0 0]	mm	[test cases]	d1.0
C_p	[0.4e-4 0.4e-4]	nF	[TX RX]	d1.0
A_v	[0.385 0.385 0.385 0.385]	V	Vf=0.400	d1.2
A_fe	[0.385 0.385 0.385 0.385]	V	Vf=0.399	D1.2
A_ne	[0.481 0.481 0.481 0.481]	V	Vf=0.400	D1.2
.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]			d1.0
package_tl_tau	0.006141	ns/mm		d1.0
package_Z_c	[87.5 87.5 ; 95 95 ; 100 100; 78 78]	Ohm		d1.0
R_d	[46.25 46.25]	Ohm	[TX RX]	d1.0 cmt 396
z_p (TX)	[45 30 8 24 ; 2 2 2 2 ; 1.3 1.3 1.3 1.3 ; 1.5 1.5 1.5 1.5]	mm	[test cases]	d1.0
z_p (NEXT)	[44 29 8 24 ; 2 2 2 2 ; 1.3 1.3 1.3 1.3 ; 1.5 1.5 1.5 1.5]	mm	[test cases]	d1.0
z_p (FEXT)	[45 30 8 24 ; 2 2 2 2 ; 1.3 1.3 1.3 1.3 ; 1.5 1.5 1.5 1.5]	mm	[test cases]	d1.0
z_p (RX)	[44 29 8 24 ; 2 2 2 2 ; 1.3 1.3 1.3 1.3 ; 1.5 1.5 1.5 1.5]	mm	[test cases]	d1.0
C_p	[0.4e-4 0.4e-4]	nF	[TX RX]	d1.0
A_v	[0.385 0.385 0.385 0.385]	V	Vf=0.400	d1.0 cmt 434
A_fe	[0.385 0.385 0.385 0.385]	V	Vf=0.399	d1.0 cmt 434
A_ne	[0.481 0.481 0.481 0.481]	V	Vf=0.400	d1.0 cmt 434
.END				

C2M COM Config

- COM version 480_hs2p3 (customization _hs2p3 applies commit requests 4p8_1 to 4p8_5)

Parameter	Setting	Units	Information	stds ref.
Table 93A-1 parameters				
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]	d1.0
L_s	[0.13 0.15 0.14; 0.13 0.15 0.14]	nH	[TX RX]	d1.0
C_b	[0.3e-4 0.3e-4]	nF	[TX RX]	d1.0
R_0	50	Ohm	[TX RX]	d1.0 cmt 396
R_d	[46.25 46.25]	Ohm	[TX RX]	
PKG_NAME	PKG_HiR_CLASSB PKG_Module		TX RX	
A_v	0.387	V		
A_fe	0.387	V		
A_ne	0.482	V		
z_p select	[2]			
L	4			
M	32			
Filter and Eq				
f_r	0.550	*fb		d1.0 cmt 60 (60 GHz)
c(0)	0.54		min	d1.0 cmt 37
c(-1)	0	-0.34:0.02:	[min:step:max]	d1.0 max value -0.34
c(-2)	0	[0:0.02:0.14]	[min:step:max]	d1.0 max value 0.14
c(-3)	0	0	[min:step:max]	
c(-4)	0	0	[min:step:max]	
c(1)	0	[-0.2:0.02:0	[min:step:max]	d1.0 cmt 37
N_b	1	UI		d1.0
b_max(1)	0.85		As/dffe1	d1.0 cmt 279
b_max(2..N_b)	0		As/dfe2..N_b	
b_min(1)	0		As/dffe1	d1.0 cmt 279
b_min(2..N_b)	-0.15	UI	NA if Nb=1	
g_DC	[-20:1:0]	dB	[min:step:max]	d1.0 (Max value -20)
f_z	42.50	GHz		d1.0
f_p1	42.50	GHz		d1.0
f_p2	106.25	GHz		d1.0
g_DC_HP	[-6:1:0]		[min:step:max]	d1.0
f_HP_PZ	1.328125	GHz		d1.0
Butterworth	1	logical	include in fr	

I/O control	Setting	Units	stds ref.
DIAGNOSTICS	0	logical	
DISPLAY_WINDOW	0	logical	
CSV_REPORT	0	logical	
RESULT_DIR	.\results\C2M_{date}\		
SAVE_FIGURES	0	logical	
Port Order	[1 3 2 4]	input fi	
RUNTAG	C2M_		
COM_CONTRIBUTION	1	logical	
TDR and ERL options			
TDR	1	logical	
ERL	1	logical	
ERL_ONLY	0	logical	
TR_TDR	0.005	ns	
N	7000	UI	
TDR_Butterworth	1		
beta_x	0		
rho_x	0.618		
TDR_W_TXPKG	1	UI	ERL computed at TP 1a
N_bx	16	UI	
fixture delay time	[0 0]	s	
Tukey_Window	1		
Noise, Jitter			
sigma_RJ	0.01	UI	
A_DD	0.02	UI	
eta_0	1.00E-08	V^2/GHz	
SNR_TX	33.5	dB	
R_LM	0.95		
[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]		
[illegible]	[illegible]		
[illegible]	[illegible]		
[illegible]	[illegible]		
[illegible]	[illegible]		
[illegible]	[illegible]		

Parameter	Setting	Units	Information	stds ref
Table 93A-3 parameters (Table Not Used with ClassA and B Packages)				
package_tl_gamma0_a1_a2	[5e-4 0.00065 0.0003]			
package_tl_tau	0.006141	ns/mm		
package_Z_c	[92 ; 70 70; 80 80; 100 1	Ohm		
z_p (TX)	[1 1 1 1; 1 1 1 1 ; 0.5	mm	[test cases to run]	
z_p (NEXT)	[1 1 1 1; 1 1 1 1 ; 0.5	mm	[test cases]	
z_p (FEXT)	[1 1 1 1; 1 1 1 1 ; 0.5	mm	[test cases]	
z_p (RX)	[1 1 1 1; 1 1 1 1 ; 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	required for backward compatibility	
PMD_type	C2C			
samples_for_C2M	100			
T_O	50			
BW	1			
MLSE	1	logical		
ts_anchor	1			
sample_adjustment	[-16 16]			
Local Search	2		0=full grid search, 2=local search	
			MLSE trunction length 8-16 not adopted yet	
Filter: Rx FFE				
ffe_pre_tap_len	5	UI		
ffe_post_tap_len	8	UI		
ffe_pre_tap1_max	0.7	interpreted as +/-	COM to change to W max/min	
ffe_post_tap1_max	0.7	interpreted as +/-	COM to change to W max/min	
ffe_tapn_max	0.7	interpreted as +/-	COM to change to W max/min	
FFE_OPT_METHOD	MMSE		FV-LMS or MMSE	
num_ui_RXFF_noise	2048			
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		

Parameter	Setting	Units
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	58.438	GHz
A_ft	0.450	V
A_nt	0.450	V
Parameter	**Setting**	
board_tl_gamma0_a1_a2	[0 3.95e-4 2.6e-05]	1.4 db/in @ 53.125G
board_tl_tau	5.790E-03	ns/mm
board_Z_c	92.5	Ohm
z_bp (TX)	32	mm
z_bp (NEXT)	32	mm
z_bp (FEXT)	32	mm
z_bp (RX)	32	mm
C_0	[0.29e-4 0]	nF
C_1	[0.1e-4 0]	nF
Include PCB	**0**	**logical**
Selections (rectangle, gaussian,dual_rayleigh,triangle		
Histogram_Window_Weight	gaussian	selection
Qr	0.02	UI

.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]			d1.0
package_tl_tau	0.006141	ns/mm		d1.0
package_Z_c	[87.5 87.5 ; 92.5 92.5 ; 100 100; 100 100]	Ohm		d1.0
R_d	[46.25 46.25]	Ohm	[TX RX]	d1.0 cmt 396
z_p (TX)	[33 12 33 33 ; 1.8 1.8 1.8 1.8 ; 0 0 0 0 ; 0 0 0 0]	mm	[test cases]	d1.0
z_p (NEXT)	[33 12 33 33 ; 1.8 1.8 1.8 1.8 ; 0 0 0 0 ; 0 0 0 0]	mm	[test cases]	d1.0
z_p (FEXT)	[33 12 33 33 ; 1.8 1.8 1.8 1.8 ; 0 0 0 0 ; 0 0 0 0]	mm	[test cases]	d1.0
z_p (RX)	[33 12 33 33 ; 1.8 1.8 1.8 1.8 ; 0 0 0 0 ; 0 0 0 0]	mm	[test cases]	d1.0
C_p	[0.4e-4 0.4e-4]	nF	[TX RX]	d1.0
A_v	[0.385 0.385 0.385 0.385]	V	Vf=0.400	d1.2
A_fe	[0.385 0.385 0.385 0.385]	V	Vf=0.399	D1.2
A_ne	[0.481 0.481 0.481 0.481]	V	Vf=0.400	D1.2
.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]			d1.0
package_tl_tau	0.006141	ns/mm		d1.0
package_Z_c	[87.5 87.5 ; 95 95 ; 100 100; 78 78]	Ohm		d1.0
R_d	[46.25 46.25]	Ohm	[TX RX]	d1.0 cmt 396
z_p (TX)	[45 30 8 24 ; 2 2 2 2 ; 1.3 1.3 1.3 1.3 ; 1.5 1.5 1.5 1.5]	mm	[test cases]	d1.0
z_p (NEXT)	[44 29 8 24 ; 2 2 2 2 ; 1.3 1.3 1.3 1.3 ; 1.5 1.5 1.5 1.5]	mm	[test cases]	d1.0
z_p (FEXT)	[45 30 8 24 ; 2 2 2 2 ; 1.3 1.3 1.3 1.3 ; 1.5 1.5 1.5 1.5]	mm	[test cases]	d1.0
z_p (RX)	[44 29 8 24 ; 2 2 2 2 ; 1.3 1.3 1.3 1.3 ; 1.5 1.5 1.5 1.5]	mm	[test cases]	d1.0
C_p	[0.4e-4 0.4e-4]	nF	[TX RX]	d1.0
A_v	[0.385 0.385 0.385 0.385]	V	Vf=0.400	d1.0 cmt 434
A_fe	[0.385 0.385 0.385 0.385]	V	Vf=0.399	d1.0 cmt 434
A_ne	[0.481 0.481 0.481 0.481]	V	Vf=0.400	d1.0 cmt 434
.END				