COM Sensitivity Analysis of Key Parameters

Mau-Lin Wu, Pei-Rong Li
MediaTek
IEEE 802.3ck Task Force

Outline

- Background and Motivation
- Selected 9 KR Channels Analysis
- COM Sensitivity Analysis
  - N_b
  - b_max(0)
  - b_max(2..N_b)
  - C_d
- Proposal and Summary

Background and Motivation

- During 2019 Long Beach interim meeting,
  - Baseline package model was adopted [minutes_3ck_0119_unapproved.pdf, Straw poll #2]
    - However, 'C_d' is TBD
  - 9 KR channels were selected as baseline [kochuparambil_3ck_01c_0119.pdf]
    - Action: include 9 KR baseline channels for analysis
  - COM 2.58 released [mellitz_3ck_01_0119.pdf]
    - Action: adopt COM 2.58 for following analysis
  - The majority prefers DFE as referenced RX in COM [minutes_3ck_0119_unapproved.pdf, Straw poll #5]
- Motivations
  - COM values for 9 KR baseline channels
  - COM sensitivity to 'N_b', 'b_max(1)', 'b_max(2..N_b)', 'C_d'
- Conclusions
  - Only 28dB IL KR channels with small enough ICN & ILD can pass 3 dB COM threshold by >= 22-tap DFE
  - COM is sensitive to 'N_b' in the range of 20 to 24
  - COM is not sensitive to 'b_max(1)' in the range of >= 0.75
  - COM is not sensitive to 'b_max(2..N_b) in the range of >= 0.30
  - COM is sensitive to 'C_d' if N_b <= 20

Baseline COM Parameters

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	[1.1e-4 1.1e-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	24	UI	
b_max(1)	0.85		
b_max(2..N_b)	0.2		
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		
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		

I/O control		
DIAGNOSTICS	1	logical
DISPLAY_WINDOW	0	logical
CSV_REPORT	1	logical
RESULT_DIR	\results\100GEL_WG_[date]\	
SAVE_FIGURES	0	logical
Port Order	[1 3 2 4]	
RUNTAG	CR_eval_	
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	1	logical
ERL_ONLY	0	logical
TR_TDR	0.01	ns
N	1000	
TDR_Butterworth	1	logical
beta_x	1.70E+09	
rho_x	**0.25**	
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

Selected 9 KR Channels

- 9 KR channels were selected as baseline in ‘kochuparambil_3ck_01c_0119.pdf’

Contribution	Channel	CH ID
heck_3ck_01_1118	28dB Cabled Backplane/Cable_BKP_28dB_0p575m_more_isi	1
	16dB Cabled Backplane/Cable_BKP_16dB_0p575m_more_isi	2
mellitz_3ck_adhoc_02_081518	24,28,30dB including BGA Via/CaBP_BGAVia_Opt2_28dB	3
tracy_3ck_01_0119	Traditional Backplane Channels/Std_BP_12inch_Meg7	4
	Orthogonal Backplane Channels/DPO_IL_12dB	5
kareti_3ck_01a_1118	Measured Orthogonal Backplane Channels/OAch4	6
	Measured Orthogonal Backplane Channels/Och4	7
	Measured Cabled Backplane Channels/CAch3_b2	8
	Measured Traditional Backplane Channels/Bch2_a7p5_7	9

Selected 9 KR Channels – Small IL

- N_b = 16/20/24/28 for DFE ref. RX
- 802.3ck KR objective : IL up to 28dB [CH 2, 3, 4, 5, 8, 9 meets]
  - CH 2, 3, 5 pass 3dB COM easily – small IL, ICN, or ILD
  - CH 4, 8 pass 3dB COM only when **N_b >= 22** – to cover 'double-reflection' due to package
  - CH 9 can't pass 3dB COM even N_b=32 – too large ICN

CH ID	IL (wo PKG, dB)	ICN (mV)	FOM_ILD (dB)	COM (dB)				Min. N_b for 3dB COM
				N_b=16	N_b=20	N_b=24	N_b=28	
1	29.42	1.571	1.074	1.25	1.27	2.34	2.52	>32
2	16.39	2.151	0.864	3.38	3.68	5.32	5.68	6
3	26.72	0.659	0.514	3.80	3.85	4.54	4.55	2
4	16.49	8.317	0.876	2.11	2.12	3.17	3.21	22
5	13.10	1.750	1.036	3.58	3.76	5.88	5.98	6
6	28.72	0.700	0.899	1.32	1.33	1.87	1.89	>32
7	28.92	0.700	1.122	0.28	0.30	0.79	0.80	>32
8	27.81	0.475	0.274	2.64	2.75	3.70	3.77	22
9	27.09	1.783	0.678	0.66	1.20	1.63	1.67	>32

Selected 9 KR Channels – Large IL

- For those IL > 28 dB [CH 1, 6, 7]
  - Impossible to have 3dB COM unless ICN & ILD is small enough

CH ID	IL (wo PKG, dB)	ICN (mV)	FOM_ILD (dB)	COM (dB)				Min. N_b for 3dB COM
				N_b=16	N_b=20	N_b=24	N_b=28	
1	*29.42*	*1.571*	*1.074*	*1.25*	*1.27*	*2.34*	*2.52*	*>32*
2	16.39	2.151	0.864	3.38	3.68	5.32	5.68	6
3	26.72	0.659	0.514	3.80	3.85	4.54	4.55	2
4	16.49	8.317	0.876	2.11	2.12	3.17	3.21	22
5	13.10	1.750	1.036	3.58	3.76	5.88	5.98	6
6	*28.72*	*0.700*	*0.899*	*1.32*	*1.33*	*1.87*	*1.89*	*>32*
7	*28.92*	*0.700*	*1.122*	*0.28*	*0.30*	*0.79*	*0.80*	*>32*
8	27.81	0.475	0.274	2.64	2.75	3.70	3.77	22
9	27.09	1.783	0.678	0.66	1.20	1.63	1.67	>32

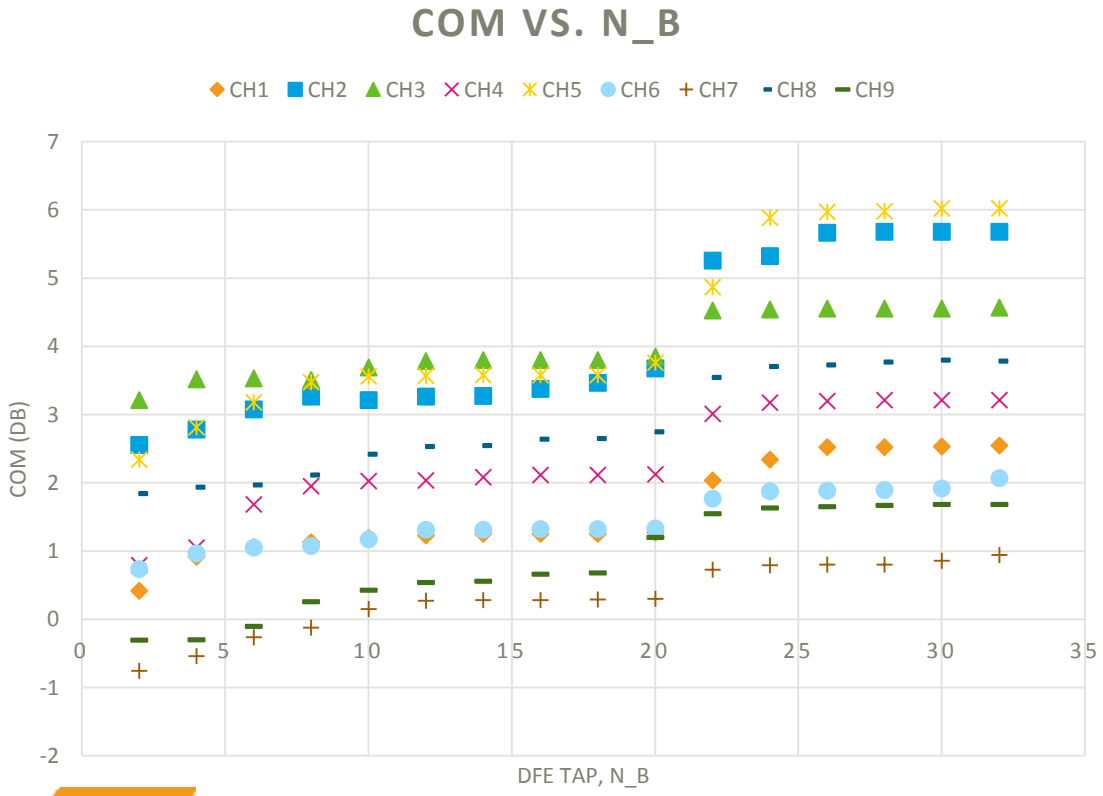
Selected 9 KR Channels – IL ~= 28 dB

- Correlation to backplane types?
  - Ca = Cabled, Or = Orthogonal, Tra = Traditional
- CH 1 vs. CH 6 [2.34 dB vs. 1.87 dB]
  - CH 1 with larger IL, ICN, & ILD, but larger COM as well
  - Q: Other factors than IL, ICN, & ILD to impact COM?

CH ID	IL (wo PKG, dB)	ICN (mV)	FOM_ILD (dB)	COM (dB)				Min. N_b for 3dB COM	Back plane Type
				N_b=16	N_b=20	N_b=24	N_b=28		
1	29.42	1.571	1.074	1.25	1.27	2.34	2.52	>32	Ca
3	26.72	0.659	0.514	3.80	3.85	4.54	4.55	2	Ca
6	28.72	0.700	0.899	1.32	1.33	1.87	1.89	>32	Or
7	28.92	0.700	1.122	0.28	0.30	0.79	0.80	>32	Or
8	27.81	0.475	0.274	2.64	2.75	3.70	3.77	22	Ca
9	27.09	1.783	0.678	0.66	1.20	1.63	1.67	>32	Tra

COM Values by Varying 'N_b'

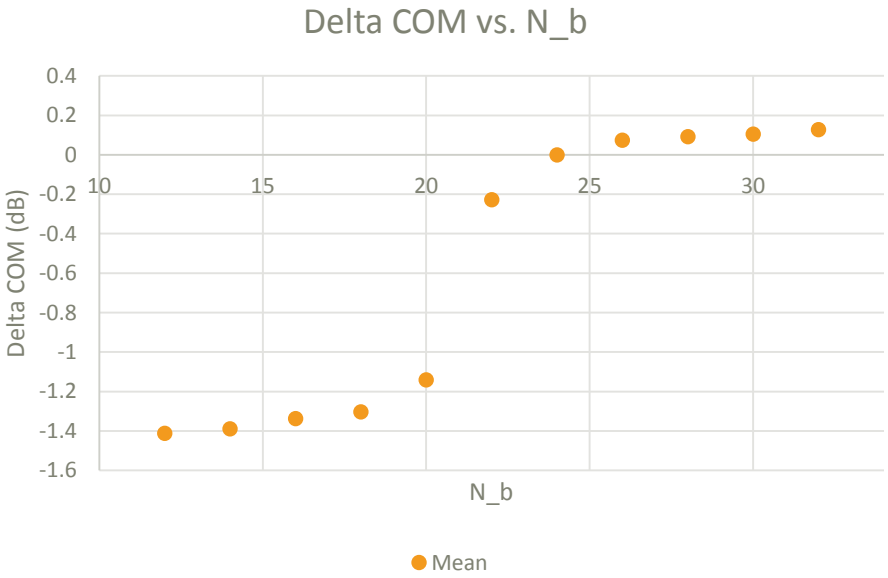
- Settings – COM2.58
  - Baseline PKG model
  - C_d = 110 fF
- DFE



- Obvious gain when N_b = 20 → 24
  - To cover 'double-reflection' due to package model (z_p = 32 mm)
  - 1dB (mean)

COM Sensitivity – ‘N_b’

- Including IEEE 42 channels for analysis [Selected 9 KR channels inc.]
- COM 2.58 with baseline package (C_d = 110 fF)
- DFE with varying ‘N_b’

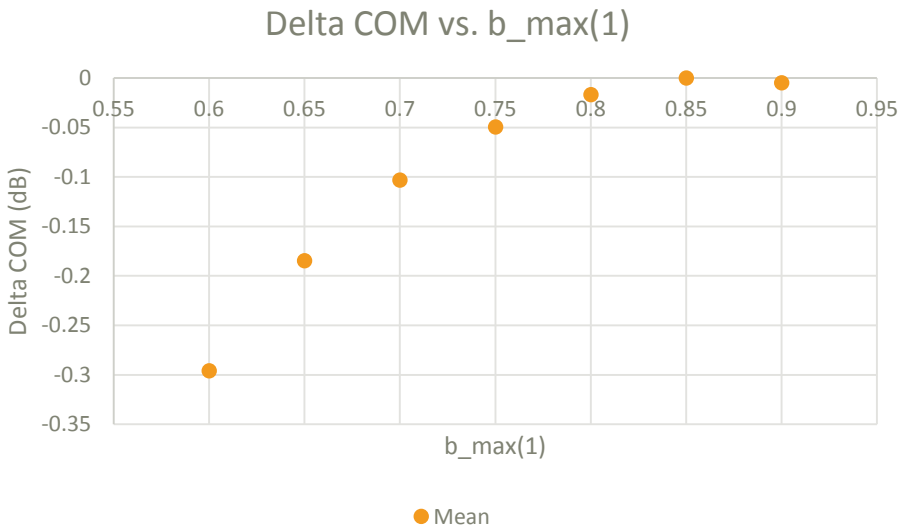


- Obvious gain when N_b = 20 → 22
  - To cover ‘double-reflection’ due to package model (z_p = 32 mm)
  - 0.9 dB (mean)
- Proposal
  - Adopt N_b = 24

		COM Sensitivity (dB, mean)		
N_b	N_b Range	20~22	18~20, 22~24	Others
	Sen. (COM/tap)	0.46 dB/tap	0.10 dB/tap	0.02 dB/tap

COM Sensitivity – 'b_max(1)'

- Including IEEE 42 channels for analysis [Selected 9 KR channels inc.]
- COM 2.58 with baseline package (C_d = 110 fF)
- DFE
  - N_b = 24
  - With varying 'b_max(1)'

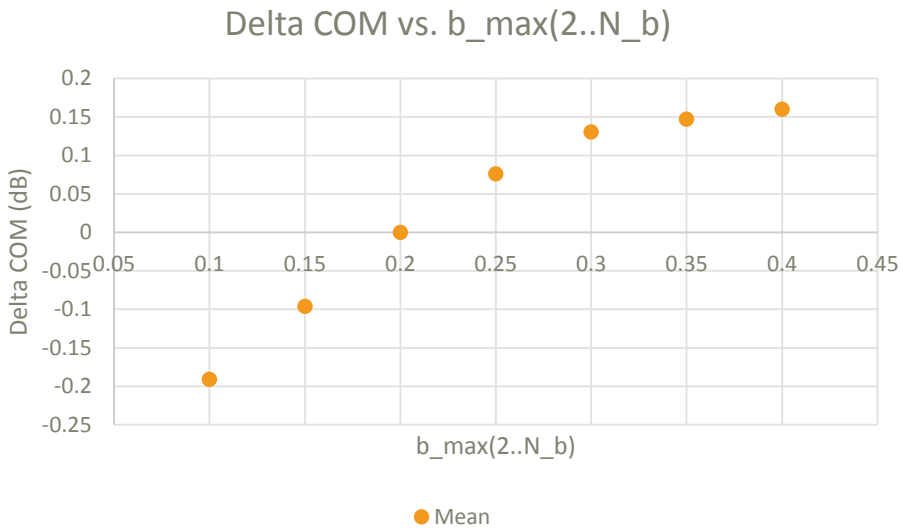


- COM is NOT sensitive in the range of 0.75 to 0.9
  - Within 0.05 dB mean difference
  - Larger b_max(1) raises concerns of error propagation, which is NOT considered in COM model
- Proposal
  - Adopt b_max(1) = 0.75

		COM Sensitivity (dB, mean)	
b_max(1)	b_max(1) Range	0.6~0.75	0.75~0.9
	Sen. (COM/val)	0.13 dB/0.1	0.03 dB/0.1

COM Sensitivity – 'b_max(2..N_b)'

- Including IEEE 42 channels for analysis [Selected 9 KR channels inc.]
- COM 2.58 with baseline package (C_d = 110 fF)
- DFE
  - N_b = 24
  - With varying 'b_max(2..N_b)'

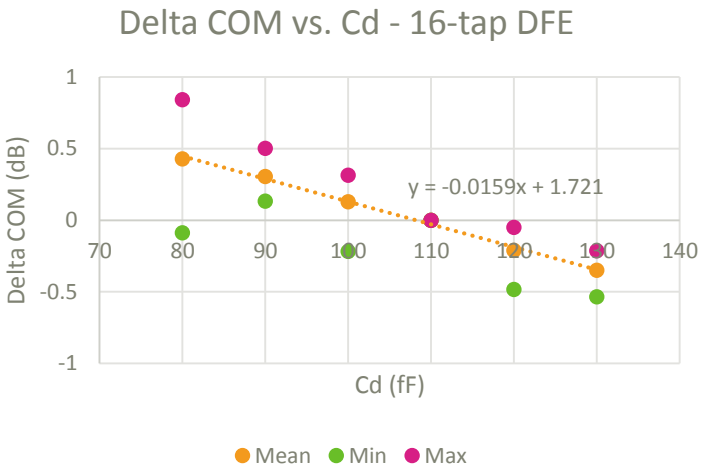


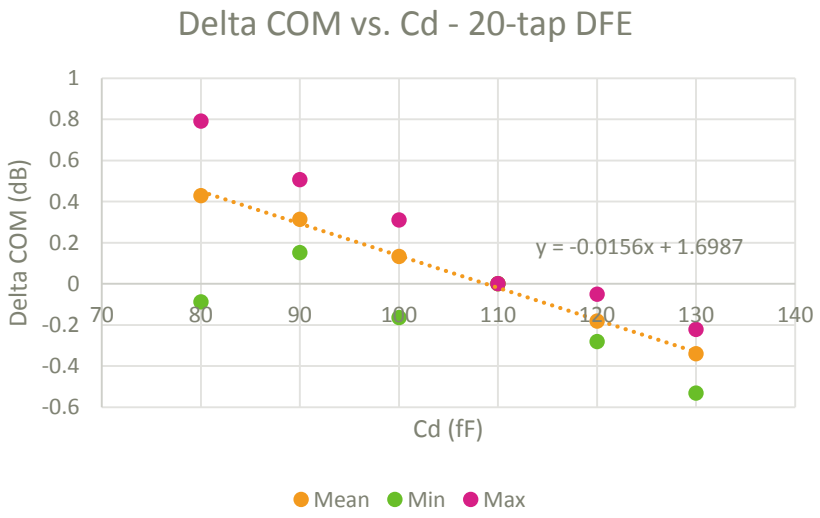
- COM is NOT sensitive in the range of 0.3 to 0.4
  - Close to 0.15 dB mean gain from 0.2 to 0.3
  - Larger b_max(2..N_b) raises concerns of error propagation, which is NOT considered in COM model
- Proposal
  - Adopt b_max(2..N_b) = 0.3, if error propagation analysis shows adequate

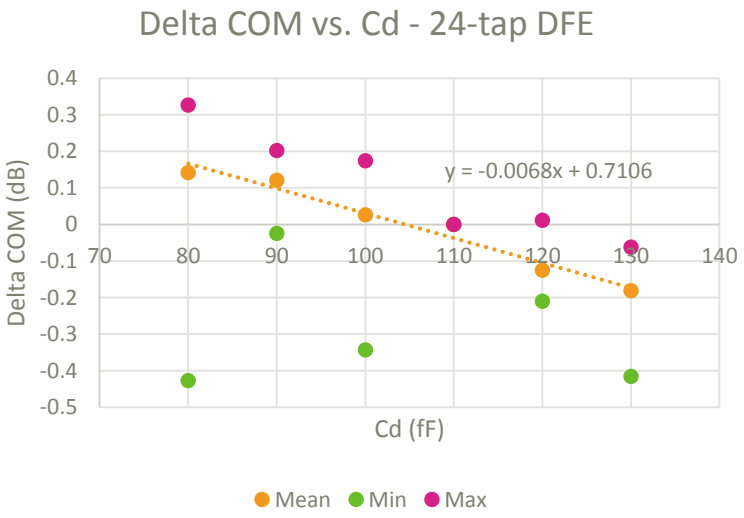
		COM Sensitivity (dB, mean)	
b_max(2..N_b)	b_max(2..N_b) Range	0.1~0.3	0.3~0.4
	Sen. (COM/val)	0.16 dB/0.1	0.03 dB/0.1

COM Sensitivity – 'C_d'

- COM 2p58 – baseline package model (C_d = 110 fF)
- Selected 9 KR channels
- 16 & 20-tap DFEs
  - Double reflection of package NOT covered by DFE
  - COM sensitivity ~= 0.16 dB / 10fF
- 24-tap DFE
  - COM sensitivity ~= 0.07 dB / 10fF
- COM is sensitive to 'C_d' if N_b <= 20







COM Sensitivity – Summary

		COM Sensitivity (dB, mean)		
N_b	N_b Range	20~22	18~20, 22~24	Others
	Sen. (COM/tap)	0.46 dB/tap	0.10 dB/tap	0.02 dB/tap
b_max(1)	b_max(1) Range	0.6~0.75	0.75~0.9	
	Sen. (COM/val)	0.13 dB/0.1	0.03 dB/0.1	
b_max(2..N_b)	b_max(2..N_b) Range	0.1~0.3	0.3~0.4	
	Sen. (COM/val)	0.16 dB/0.1	0.03 dB/0.1	
C_d	N_b Range	16 & 20	24	
	Sen. (COM/10fF)	0.16 dB/10fF	0.07 dB/10fF	

- It requires N_b >= 22 to get extra 1dB COM
- By considering COM sensitivity, propose b_max as
  - b_max(1) = 0.75 & b_max(2..N_b) = 0.3
  - Need to check error propagation impact to FEC
- COM is not sensitive to 'C_d' if N_b = 24

Proposal & Summary

- Selected 9 KR channels analysis – to achieve 28 dB IL target, it requires
  - N_b >= 22 by DFE ref. RX
  - Small enough ICN & ILD
- Proposals based on COM sensitivity analysis
  - N_b = 24
  - b_max(1) = 0.75
  - b_max(2..N_b) = 0.3

everyday genius