Initial C2M Analysis on Select Channels with COM 4.3

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Overview

- **COM settings and configurations**
- **Highlights of Kareti and Weaver channels**
- **COM results at DER0=2E-5 with Eta0=1E-8 and 6E-9**
  - Some results with DER0=2E-4
- **COM results with increasing PCB loss**
- **Summary**

Note of cautions: results provided here are based on just released COM 4.3 and C2M configuration is work in progress.

COM Key Settings

- **Analysis is preliminary based on recently released COM 4.3**
  - COM configuration is preliminary
  - After constraining the CTLE range the MMSE results are practically identical to LV-LMS, prior to constraining CTLE gDC MMSE had convergence issue and local search results were much worse than LV-LMS
  - MMSE local search compute time ~3-4/min per case, full search ~50 min per case
- **Key COM parameters**
  - TX FFE configuration: 2 pre taps with one post, for configuration investigated pre/post taps were all 0
  - ASIC is 30 or 45 mm Package B (high loss)
  - CDR package 8 mm
  - Eta0=1E-8 and 6E-9 (considering CK Eta0=4.1E-8, dj C2M Eta0 shouldn't be tighter than 1E-8)
  - DER0=2E-5, some results with 2E-4
  - gDC≤6 dB with g_DC_HP≤5 dB, total CTLE gain was ~ 6 dB
  - DFE max tap =0.75 (did not reach max except in case > 32 dB bump-bump loss after adding PCB loss)
  - RX FFE configuration: 5 pre taps and with total of (25, 30, 35, 40, 45, 50, 55, and 60) FFE taps.

COM Config File

Table 93A-1 parameters			
Parameter	**Setting**	**Units**	**Information**
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]
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_d	[50 50]	Ohm	[TX RX]
R_0	50	Ohm	
PKG_NAME	PKG_HiR_CLASSB PKG_Module		TX RX
A_v	0.413	V	rqd syntx
A_fe	0.413	V	rqd syntx
A_ne	0.608	V	rqd syntx
L	4		
M	32		
filter and Eq			
f_r	0.55	*fb	
c(0)	0.55		min
c(-1)	[-0.4:0.02:0]		[min:step:max]
c(-2)	[0::02:0.1]		[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)	0.75		As/dffe1
b_max(2..N_b)	1		As/dfe2..N_b
b_min(1)	0		As/dffe1
b_min(2..N_b)	-0.15	S	As/dfe2..N_b
g_DC	[-6:1:0]	dB	[min:step:max]
f_z	42.50	GHz	
f_p1	42.50	GHz	
f_p2	106.25	GHz	
g_DC_HP	[-5:1:0]		[min:step:max]
f_HP_PZ	1.328125	GHz	
Butterworth	1	logical	include in fr

I/O control		
DIAGNOSTICS	1	logical
DISPLAY_WINDOW	1	logical
CSV_REPORT	0	logical
RESULT_DIR	.\results\C2M_{date}\	
SAVE_FIGURES	0	logical
Port Order	[1 3 2 4]	
RUNTAG	C2M TP1a_COM_model	
COM_CONTRIBUTION	0	logical
Operational		
ERL Pass threshold	10	dB
COM Pass threshold	3	db
VEC Pass threshold	10.69073041	
DER_0	2.00E-05	
T_r	4.00E-03	ns
FORCE_TR	1	logical
Min_VEO_Test	0	mV
PMD_type	C2M	
T_O	50	mUI
samples_for_C2M	100	samples/UI
EW	0	
MLSE	0	
ts_anchor	1	
sample_adjustment	[-12 12]	
Local Search	2	
FFE_OPT_METHOD	MMSE	FV-LMS or MMSE
num_ui_RXFF_noise	1024	

Noise, jitter		UI
sigma_RJ	0.01	UI
A_DD	0.02	V^2/GHz
eta_0	1.00E-08	dB
SNR_TX	33	
R_LM	0.95	

Table 93A–3 parameters			
Parameter	Setting	Units	Information
package_tl_gamma0_a1_a2	[5e-4 0.00065 0.0003]		rqd syntx
package_tl_tau	0.006141	ns/mm	rqd syntx
package_Z_c	[92 92 ; 70 70; 80 80; 100 100]	Ohm	rqd syntx
z_p select	[4]		rqd syntx
z_p (TX)	[8 24 30 45 ; 1 1 1 1; 1 1 1 1 ; 0.5 0.5 0.5 0.5]	mm	rqd syntx
z_p (NEXT)	[8 8 8 8; 0 0 0 0 ;0 0 0 0 ;0 0 0 0]	mm	rqd syntx
z_p (FEXT)	[8 24 30 45 ; 1 1 1 1; 1 1 1 1 ; 0.5 0.5 0.5 0.5]	mm	rqd syntx
z_p (RX)	[8 8 8 8; 0 0 0 0 ;0 0 0 0 ;0 0 0 0]	mm	rqd syntx
C_p	[0.4e-4 0.4e-4]	nF	rqd syntx
Floating Tap Control			
N_bg	0	0 1 2 or 3 groups	
N_bf	4	taps per group	
N_f	120	UI span for floating taps	
bmaxg	0.2	max DFE value for floating taps	
B_float_RSS_MAX	0.1	rss tail tap limit	
N_tail_start	35	(UI) start of tail taps limit	
Filter: Rx FFE			
ffe_pre_tap_len	5	UI	
ffe_post_tap_len	34	UI	
ffe_pre_tap1_max	1	(normalized)	
ffe_post_tap1_max	1	(normalized)	
ffe_tapn_max	1	(normalized)	
TDR and ERL options			
TDR	1	logical	
ERL	1	logical	
ERL_ONLY	0	ns	
TR_TDR	0.01		
N	1000	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		

SAVE_CONFIG2MAT	0	
Receiver testing		
RX_CAUBRATION	0	logical
Sigma BBN step	5.00E-03	V
ICN parameters		
f_v	0.588	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 6.44084e-4 3.6036e-05]*	1.4 db/in @ 53.125G
board_tl_tau	*5.790E-03*	ns/mm
board_Z_c	95	Ohm
z_bp (TX)	*125*	mm
z_bp (NEXT)	*125*	mm
z_bp (FEXT)	*125*	mm
z_bp (RX)	*0*	mm
C_0	[0 0]	nF
C_1	[0 0]	nF
Include PCB	**0**	**logical**
Seletions (rectangle, gaussian,dual_rayleigh,triangle		
Histogram_Window_Weight	gaussian	selection
Qr	*0.02*	UI

baseline
new
relevant for RxFFE
adjusted in experiment

59.03
59.03
106.25

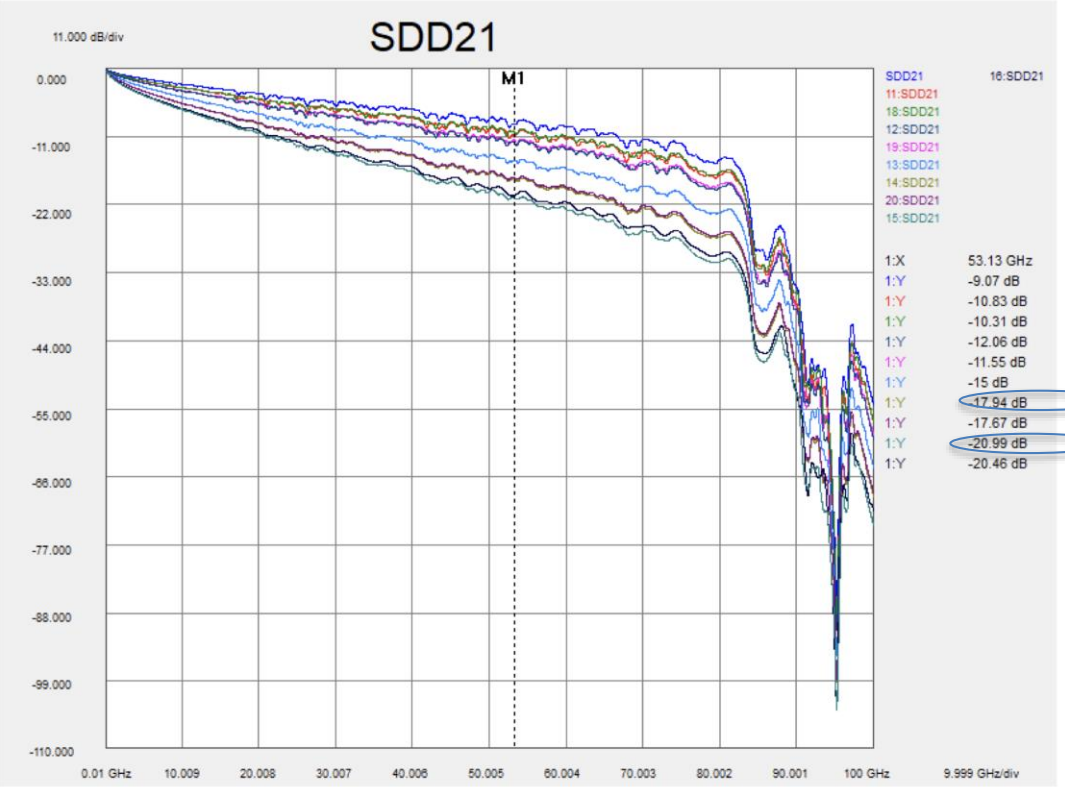
.START	PKG_LowR_CLASSA	[2.44 5.7] db	
Table 93A–3 parameters			
Parameter	Setting	Units	Information
ckage_tl_gamma0_a1	[0.0005 0.00089 0.0002]		
package_tl_tau	0.006141	ns/mm	
package_Z_c	[87.5 87.5 ; 92.5 92.5 ; 100 100; 100 100]	Ohm	
R_d	[50 50]	Ohm	[TX RX]
z_p (TX)	[12 24 30 45 ; 1.8 1.8 1.8 1.8 ; 0 0 0 0 ; 0 0 0 0]	mm	[test cases]
z_p (NEXT)	[8 8 8 8 ; 0 0 0 0; 0 0 0 0 ; 0 0 0 0]	mm	[test cases]
z_p (FEXT)	[12 24 30 45 ; 1.8 1.8 1.8 1.8 ; 0 0 0 0 ; 0 0 0 0]	mm	[test cases]
z_p (RX)	[8 8 8 8 ; 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	[0.4057 0.4143 0.4143 0.4143]	V	Vf=0.400
A_fe	[0.4057 0.4143 0.4143 0.4143]	V	Vf=0.399
A_ne	[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
ckage_tl_gamma0_a1	[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	[50 50]	Ohm	[TX RX]
z_p (TX)	[12 24 30 45 ; 2 2 2 2; 1.3 1.3 1.3 1.3 ; 1.5 1.5 1.5 1.5]	mm	[test cases]
z_p (NEXT)	[8 8 8 8 ; 0 0 0 0; 0 0 0 0 ; 0 0 0 0]	mm	[test cases]
z_p (FEXT)	[12 24 30 45 ; 2 2 2 2; 1.3 1.3 1.3 1.3 ; 1.5 1.5 1.5 1.5]	mm	[test cases]
z_p (RX)	[8 8 8 8 ; 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 0.4114 0.4132 0.4173]	V	Vf=0.400
A_fe	[0.4049 0.4114 0.4132 0.4173]	V	Vf=0.399
A_ne	[0.45 0.45 0.45 0.45]	V	Vf=0.400
.END			

.START	PKG_Module		
Table 93A–3 parameters			
Parameter	Setting	Units	Information
ckage_tl_gamma0_a1	[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	[50 50]	Ohm	[TX RX]
z_p (TX)	[8 8 8 8 ; 0 0 0 0 ; 0 0 0 0 ; 0 0 0 0]	mm	[test cases]
z_p (NEXT)	[8 8 8 8 ; 0 0 0 0 ; 0 0 0 0 ; 0 0 0 0]	mm	[test cases]
z_p (FEXT)	[8 8 8 8 ; 0 0 0 0 ; 0 0 0 0 ; 0 0 0 0]	mm	[test cases]
z_p (RX)	[8 8 8 8 ; 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	[0.4057 0.4057 0.4057 0.4057]	V	Vf=0.400
A_fe	[0.4057 0.4057 0.4057 0.4057]	V	Vf=0.399
A_ne	[0.45 0.45 0.45 0.45]	V	Vf=0.400
.END			

Channels for This Study

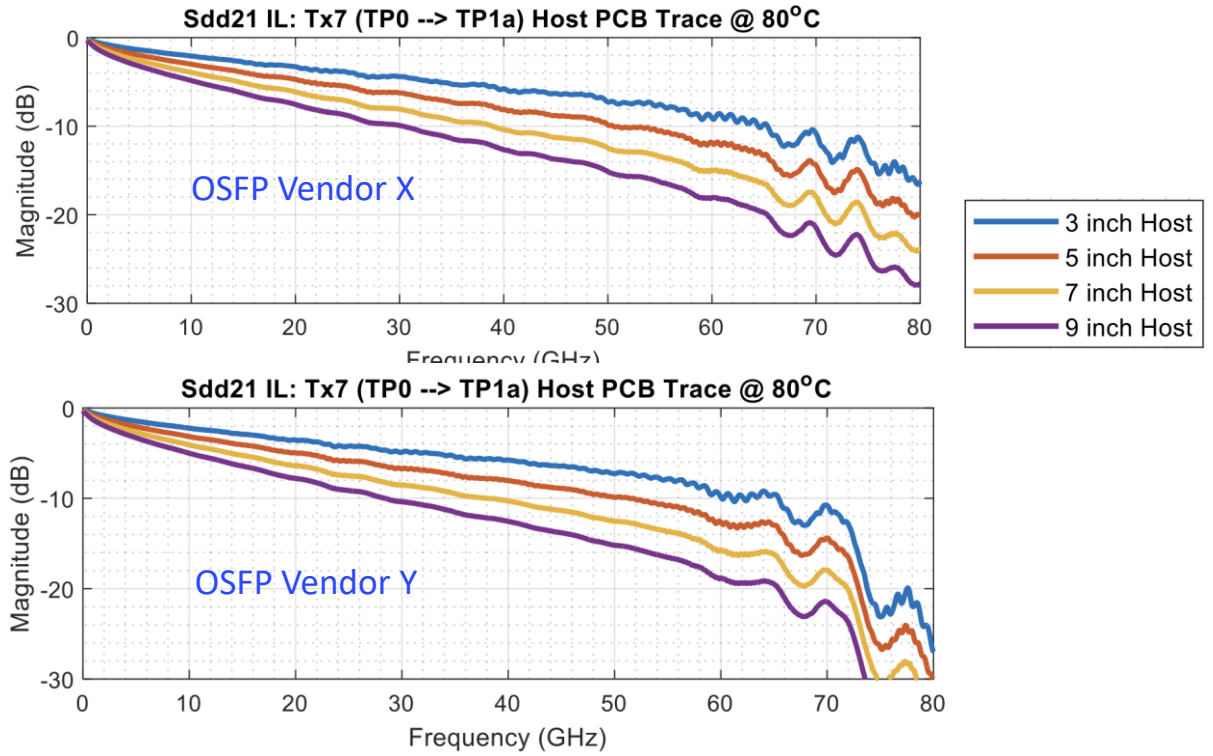
- **Kareti SL. No 8 and 10 channels**



SL. No 8

SL. No 10

- **Weaver 9” OSFP channels vendor X and Y**



Highlighted Channel Parameters for This Study

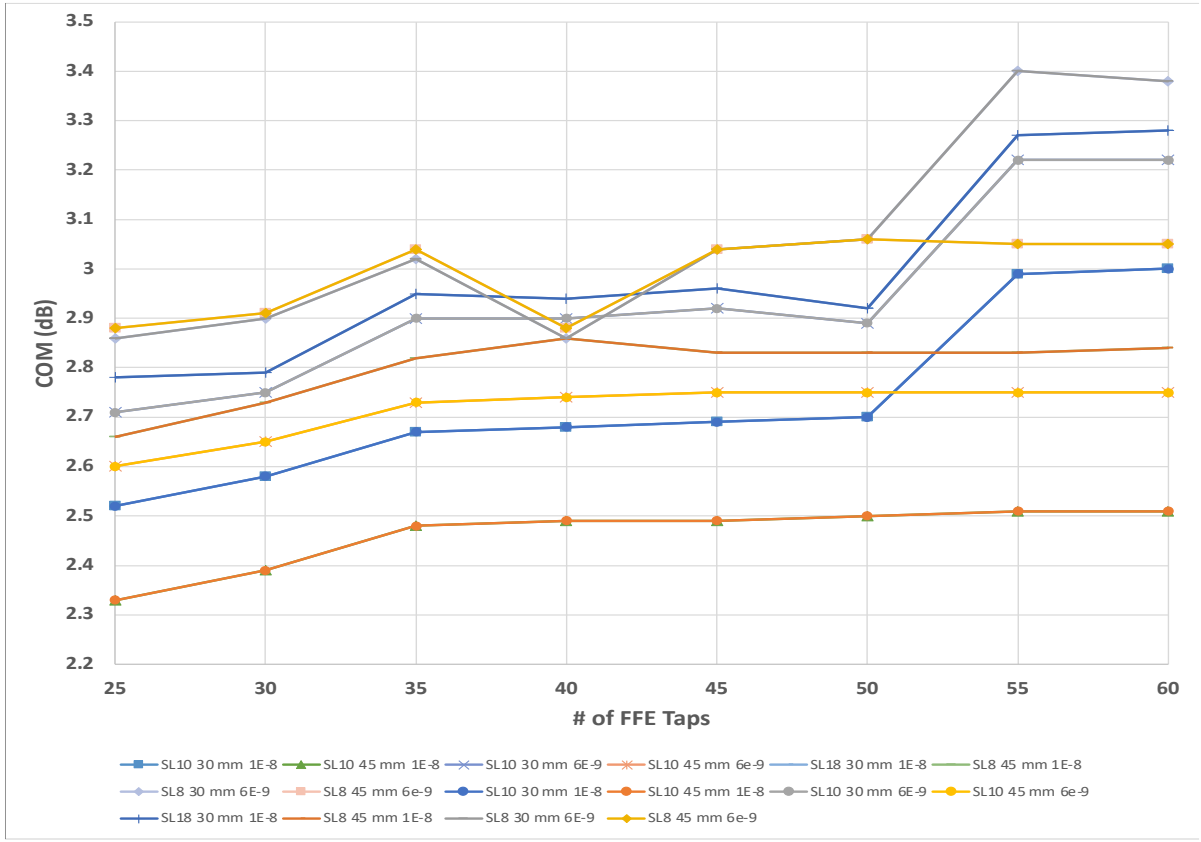
- **Key difference between Kareti and Weaver channels are:**
  - FOM ILD is much higher on Kareti channels
  - ICN is much higher on the Weaver OSFP vendor X channel.

Channel	Trace Length (in)	Channel IL (dB)	ICN (mV)	FOM ILD	ERL11	ERL22	IL b-b with PKG B 30 mm+8mm CDR (dB)	IL b-b with PKG B 45 mm+8mm CDR (dB)
Kareti SL No 8	Unknown	17.9	1.37	0.147	16.8	15.9	26.4	29.1
Kareti SL No 10	Unknown	21.2	1.12	0.147	17.2	16.1	29.5	32.2
Weaver Vendor "X" OSFP Tx7	9	15.7	1.83	0.080	21.5	15.3	24.5	27.1
Weaver Vendor "Y" OSFP Tx7	9	16.1	1.03	0.074	21.8	15.8	24.6	27.2

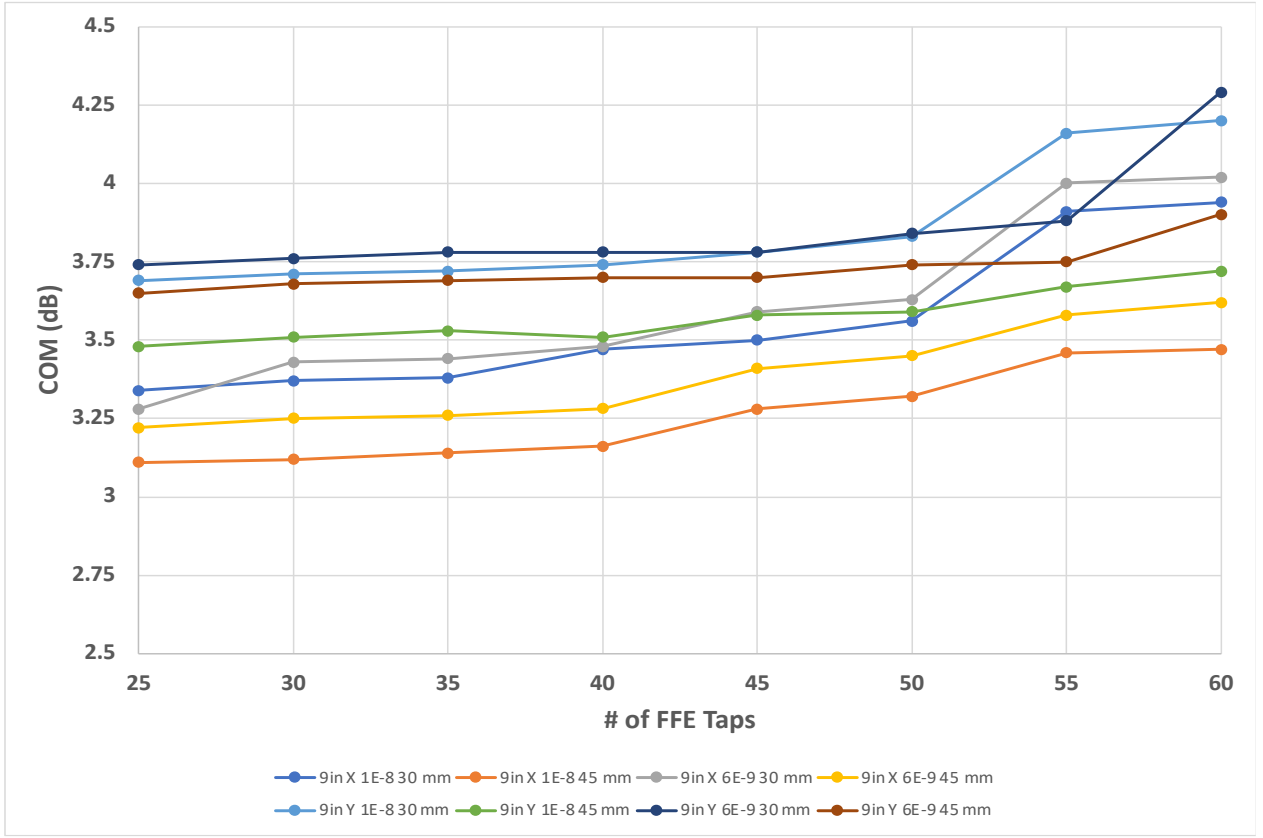
COM Results

- **Reducing Eta0 from 1E-8 to 6E-9 improves the COM by ~0.2 dB**
- **Kareti SL No 8 with 45 mm package passes 3 dB COM for ≥ 45 taps, Kareti No 10 with 45 mm package doesn't pass 3 dB COM even with 60 tap FFE**
  - Considering diminishing return increasing FFE taps, the higher loss Kareti channels require MLSE or terminating the FEC.

Kareti SL No. 8 and 10 Channels



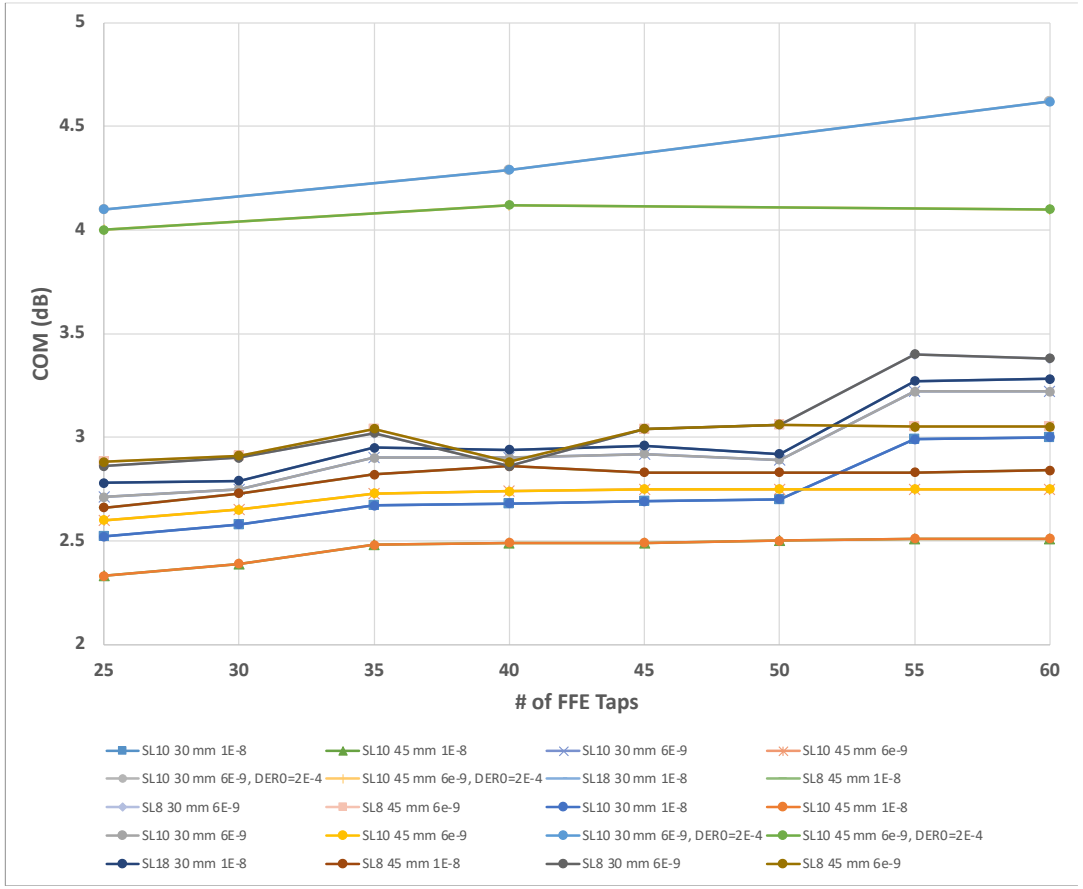
Weaver 9" OSFP Channels



COM Results

- **Kareti channel COM results with addition of results for Kareti SL No 10 channel at DER0=2E-4**
  - The more challenging Kareti channel SL No 10 now has COM > 4 dB even with 25 taps FFE!

Kareti SL No. 8 and 10 Channels

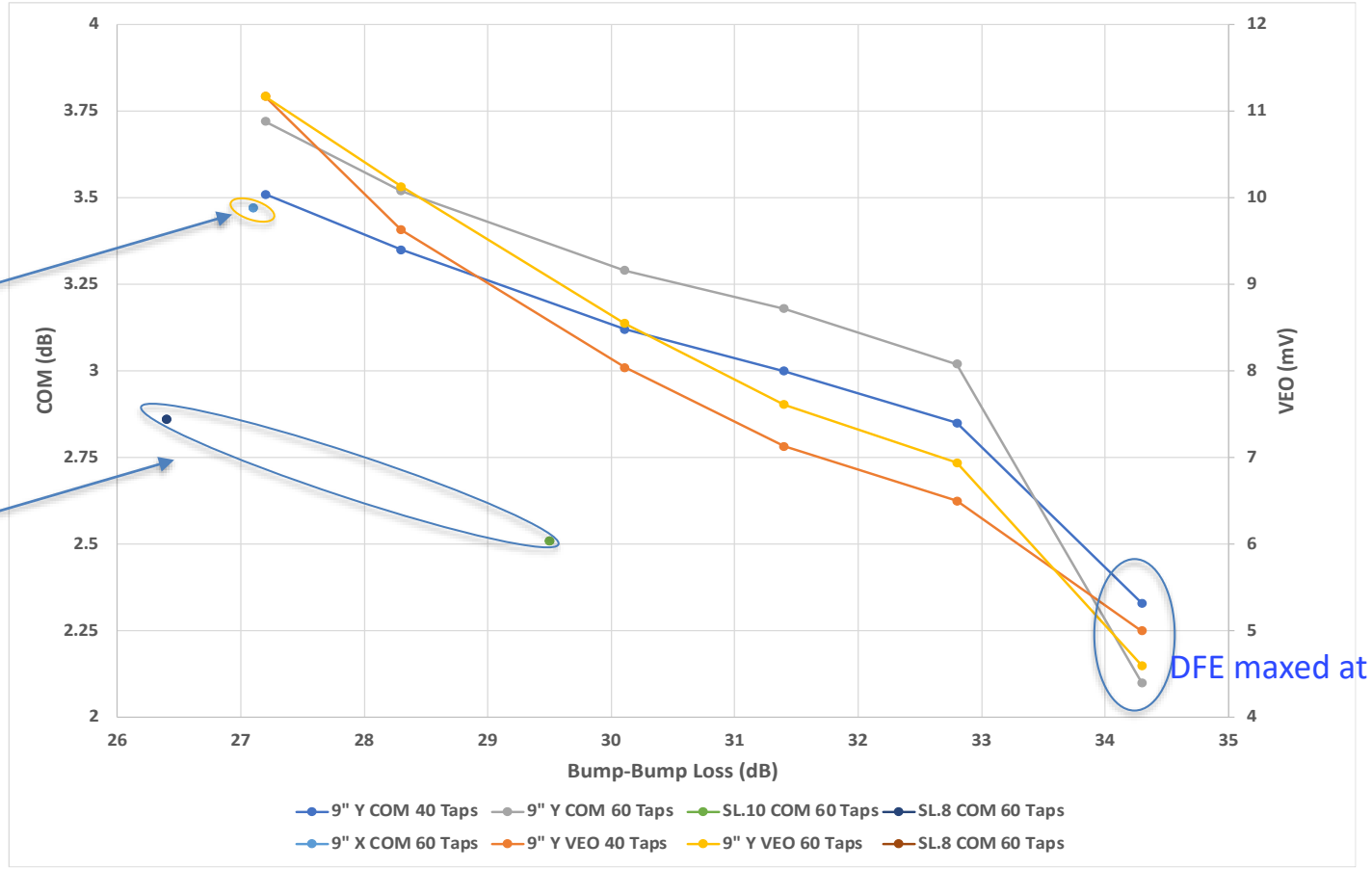


Impact of Increasing Channel Loss on COM

- **Use one of the best channel the Weaver 9” with vendor Y OSFP (lower ICN) to study loss impact on COM by adding (25, 50, 75, 100, and 125 mm) PCB loss to the channel**
  - Results are for Eta0=1E-8 (with Eta0=6E-9 results will be better by ~0.15 dB).

Weaver 9” vendor X OSFP
Without any added PCB

Kareti SL No. 8 and 10 Channels
Without any added PCB loss



DFE maxed at 0.75 for these case

Summary

- **Some preliminary results from COM 4.3 with MMSE evaluating two sets of dj submitted C2M channels targeting 102.4T switches**
  - Some results maybe slightly pessimistic (~0.1 dB) compared to be released COM 4.4
  - For the above channels TX FFE taps were all zero for nFFE+1TDFE receiver
- **C2M operating at DER0 of 2E-5 compared to KR at DER0 of 2E-4 adds about 2 dB of COM penalty**
  - As the loss increases > 30 dB there is just not enough signal at the more strengthen C2M BER
  - Increasing FFE taps beyond 40 taps adds cost with diminishing return for C2M
- **Solution space for practical FFE/DFE equalizers that operates at C2M DER0 of 2E-5 with > 30 dB of loss are limited**
  - Even Weaver OSFP vendor Y OSFP (ILD=0.074, ICN=1.03 mV) with added PCB loss starting failing ~32 dB
  - Weaver 9” channels with Package B (9.5 dB) has bump-bump loss of 27.2 dB, so is there a reason to go beyond 30 dB loss considering option of not connecting longest package trace to longest PCB trace
- **Segmented FEC at DER0=2E-4 can offer 2+ dB of COM gain and will support 36+ dB bump-bump loss**
- **It was brought up channel with skew may benefit increasing receiver pre-cursors from 5 to 6 taps**
  - Brief analysis of Weaver channels with 6 pre-cursors show negligible improvement <~0.02 dB
  - Brief analysis of Kareti channels with 6 pre-cursors show ~0.25 dB COM improvement for 25 tap FFE and ~0.35 dB for 60 taps FFE receiver.