COM Simulation for 200G/L CR and KR with Floating FFE Taps

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Overview

- Background and Objective
- COM Analysis with Post Tap Dimension
- Benefits from Floating Taps
- Discussion and Summary

Background and Objective

- **Discussion on floating FFE since August 2023**
  - **Floating-tap DFE and FFE have been compared in lit_3dj_elec_01a_230817, which shows impact on channel pass/fail**
  - **lit_3dj_01a_2309 and lim_3dj_05_2309 addressed the floating FFE methodology for COM**
- **mellitz_3dj_elec_02_231026 investigated the effect on RX FFE length**
  - **Without MLSE, 120+ post taps required to meet 40dB loss target and 3dB COM**
  - **Floating taps are not used for this set of experiments**
- **This presentation provides results from COM 4.2beta2 with floating FFE implementation to help progress CR & KR baseline equalizer**
  - **Key feature of COM 4.2beta2: floating DFE → floating FFE**
  - **Change from COM 4.2beta (This presentation): floating bank searched based on pulse response (ISI), instead of FFE coefficients**

COM Configuration for KR & CR

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]
z_p select	1		[test cases to run]
z_p (TX)	[12 31; 1 1 ; 1 1 ; 0.5 0.5]	mm	[test cases]
z_p (NEXT)	[12 29; 1 1 ; 1 1 ; 0.5 0.5]	mm	[test cases]
z_p (FEXT)	[12 31; 1 1 ; 1 1 ; 0.5 0.5]	mm	[test cases]
z_p (RX)	[12 29; 1 1 ; 1 1 ; 0.5 0.5]	mm	[test cases]
PKG_Tx_FFE_preset	0		
C_p	[0.5e-4 0.5e-4]	nF	[TX RX]
R_0	50	Ohm	
R_d	[45 45]	Ohm	[TX RX]
A_v	0.39235	V	vp/vf=
A_fe	0.39235	V	vp/vf=
A_ne	0.45	V	
L	4		
M	32		
filter and Eq			
f_r	0.6	*fb	
c(0)	0.54		min
c(-1)	[-0.4:0.02:0]		[min:step:max]
c(-2)	[0:.02:0.12]		[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)	[0.3 0.2*ones(1,22)]		As/dfe2..N_b
b_min(1)	0		As/dffe1
b_min(2..N_b)	[-0.2 -0.2*ones(1,22)]		As/dfe2..N_b
g_DC	[-12:1:0]	dB	[min:step:max]
f_z	42.5	GHz	
f_p1	42.5	GHz	
f_p2	106.25	GHz	
g_DC_HP	[-6:1:0]		[min:step:max]
f_HP_PZ	1.328125	GHz	
Butterworth	1	logical	include in fr
Raised_Cosine	0	logical	include in fr
RC_Start	6.70E+10	Hz	start freq for RCos
RC_end	7.97E+10	Hz	end freq for RCos
CDR			
sample_adjustment	[-16 8]	phase	
ts_anchor	1		

I/O control		
DIAGNOSTICS	0	logical
DISPLAY_WINDOW	0	logical
CSV_REPORT	0	logical
RESULT_DIR	.\results\CAKR_[date]\	
SAVE_FIGURES	0	logical
Port Order	[1 3 2 4]	
RUNTAG	CAKR_RCos_eval_	
COM_CONTRIBUTION	0	logical
Operational		
ERL Pass threshold	9.7	dB
COM Pass threshold	3	db
DER_0	1.00E-04	
T_r	4.00E-03	ns
FORCE_TR	1	logical
PMD_type	C2C	
EW	1	
TDR and ERL options		logical
TDR	1	logical
ERL	1	logical
ERL_ONLY	0	ns
TR_TDR	0.01	
N	3500	logical
TDR_Butterworth	1	
beta_x	0	
rho_x	0.618	
TDR_W_TXPKG	0	UI
N_bx	0	
fixture delay time	[0 0]	
Tukey_Window	1	
Noise, jitter		
sigma_RJ	0.01	UI
A_DD	0.02	UI
eta_0	6.00E-09	V^2/GHz
SNR_TX	33	dB
R_LM	0.95	

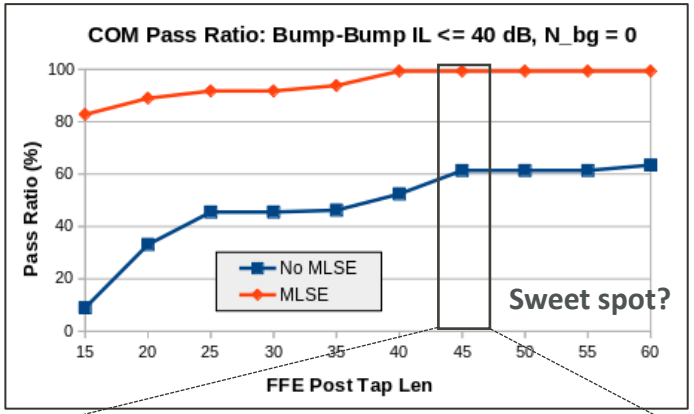
Enforce Causality	0
S-parameter magnitude extrapolation policy	trend_to_DC

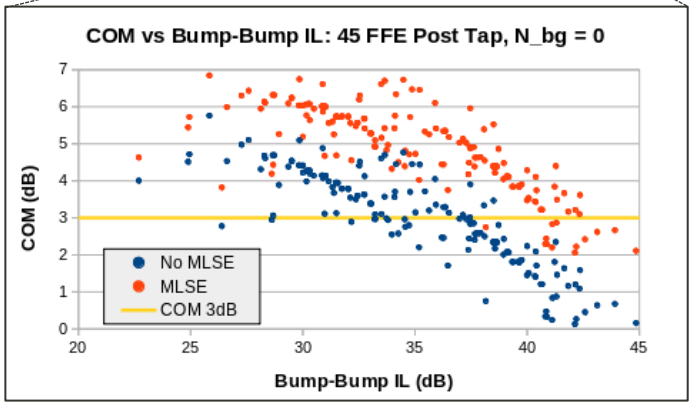
Filter: RxFFE		
ffe_pre_tap_len	6	UI
ffe_post_tap_len	xx	UI
ffe_tap_step_size	0	
ffe_main_cursor_min	1	
ffe_pre_tap1_max	1	
ffe_post_tap1_max	1	
ffe_tapn_max	1	
ffe_backoff	0	

Table 93A-3 parameters		
Parameter	**Setting**	**Units**
package_tl_gamma0_a1_a2	[0 8.455e-4 3.40225e-4]	
package_tl_tau	0.00644805	ns/mm
package_Z_c	[92 92; 70 70; 80 80; 100 100]	Ohm
Parameter	**Setting**	
board_tl_gamma0_a1_a2	*[0 6.44084e-4 3.6036e-05]*	1.5 db/in @ 56G
board_tl_tau	*5.790E-03*	ns/mm
board_Z_c	100	Ohm
z_bp (TX)	*125*	mm
z_bp (NEXT)	0	mm
z_bp (FEXT)	*125*	mm
z_bp (RX)	0	mm
C_0	[0.2e-4 0]	nF
C_1	[0.2e-4 0]	nF
Include PCB	**0**	**logical**
Seletions (rectangle, gaussian,dual_rayleigh,triangle		
Histogram_Window_Weight	gaussian	selection
Qr	*0.02*	UI
ICN parameters		
f_v	0.594	Fb
f_f	0.594	Fb
f_n	0.594	Fb
f_2	79.688	GHz
A_ft	0.450	V
A_nt	0.450	V
Floating Tap Control		
N_bg	xx	0 1 2 or 3 groups
N_bf	5	taps per group
N_f	60	UI span for floating taps
bmaxg	0.2	max DFE value for floating taps
N_tail_start	xx	(UI) start of tail taps limit
MLSE	0	logical
Receiver testing		
RX_CALIBRATION	0	logical
Sigma BBN step	5.00E-03	V
mli_3df_02_220316		
benartsi_3df_01a_2211		

First look at the CR/KR Channels: Fixed FFE Tap Only

- Total of 145 test cases varies with
  - All CR & KR channels posted in 802.3dj Tools & Channels
  - 2 package test cases: short/long
  - Bump-bump IL <= 40dB
- With MLSE, 40 taps are good enough?
  - COM gets consistent 2 dB gain as IL > 35dB
  - In practical, MLSE gain is a little over 1 dB at most
  - More work required here
- Power efficiency: 60+ taps vs MLSE?
  - > 45-tap seems less helpful?

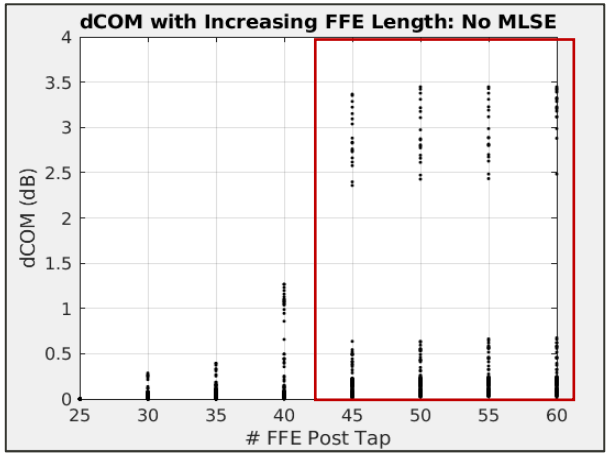


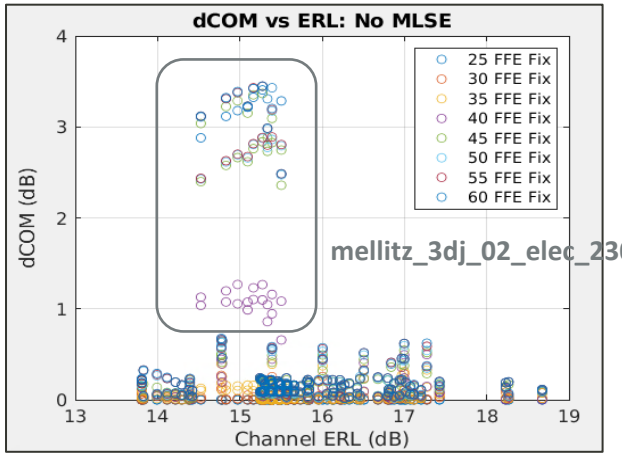


Benefits from Increasing Taps: Fixed FFE Tap Only

- FFE taps span within some ranges, e.g., 45th-60th UIs, contribute negligible COM gain
  - Benefits from floating taps?
- mellitz_3dj_02_elec_230504 channel seems to benefit more with increasing FFE taps
  - Reflections majorly located at increasing tap range?
  - Relative low ERL?
  - Need more study

Baseline: 25 fixed taps

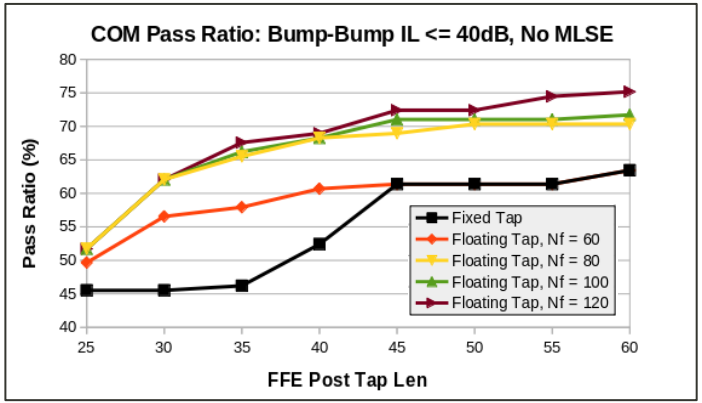




Benefits from Floating Tap

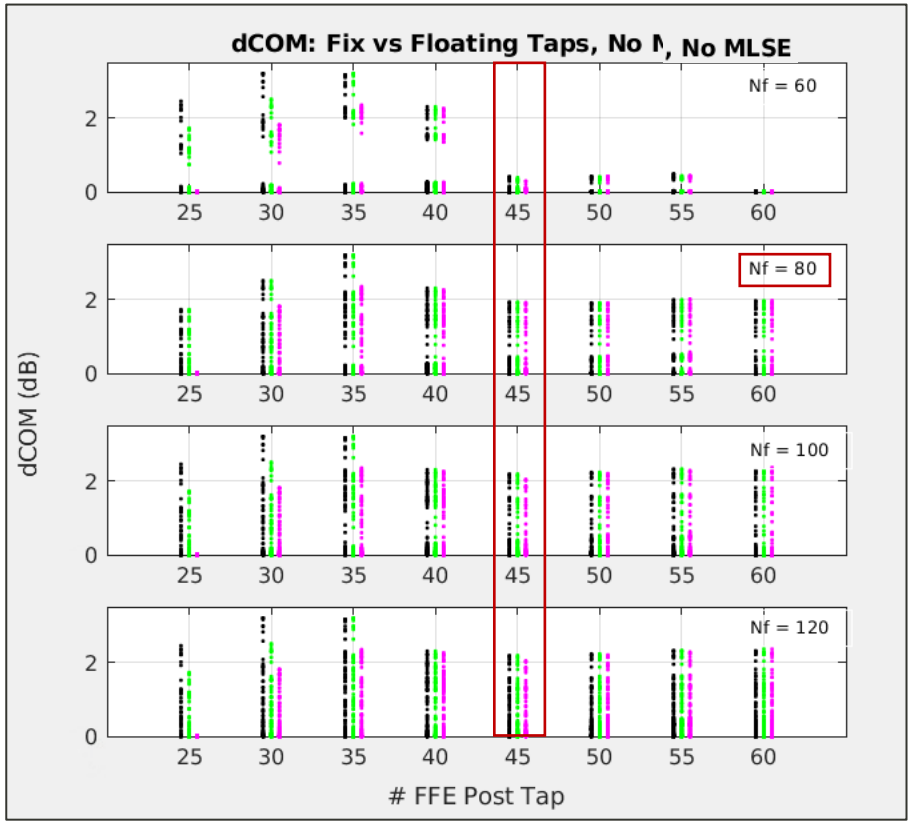
- Floating tap enjoys higher flexibility under the identical FFE length
  - Short fixed taps + floating taps
- Sweet spots of post tap dimension
  - Floating taps with total of >= 45 taps
  - Nf = 80

** 20 FFE fixed taps + floating taps*



dCOM = COM (Floating Tap)-COM (Fixed Tap Only)

** Set total taps identical for comparison*



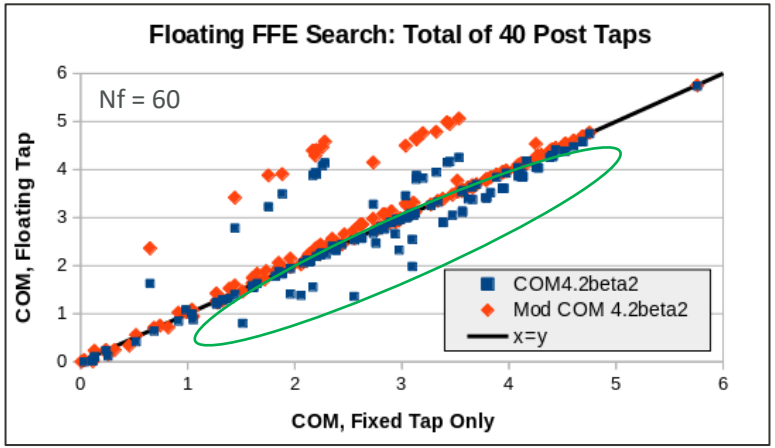
Discussion and Summary

- Suggested to revise floating FFE functionality with proposed methodology for COM
- Provided CR and KR channel analysis suggesting reference parameters path forward
  - <= 45 FFE taps in total
  - Floating FFE with Nf <= 80
- Recommended baseline equalizer for 802.3dj CR and KR: MLSE with floating FFE taps
  - Floating taps yield benefit of less taps
  - Need more study on MLSE behavior in COM

Appendix

Sensitivity of Floating Bank Search Criteria

- COM 4.2beta2: Floating bank search methodology
  - Step 1: Compute FFE coefficients for all taps within floating tap range Nf
  - Step 2: Search floating bank location based on resulting FFE coefficient in Step 1
- [This Presentation] Modified COM 4.2beta2
  - Step 1: Search floating bank location based on FFE input SBR (ISI), see lit_3dj_01a_2309



- With the same tap number, fixed tap outperforms floating tap frequently
  - [Major] Current methodology of floating bank search cannot guarantee the optimal bank location
    - FFE coefficients are hard to determine ISI strength directly due to inherent behavior of convolution
    - *Suggestion: Search bank location based on ISI, instead of FFE coefficients*
  - [Minor] Even we allocate floating taps to the identical location that fixed taps used, the resulting FFE coefficients are different
    - COM 4.2beta2 simply set all resulting FFE coefficients at non-selected floating taps to 0
    - *Suggestion: Calculate FFE coefficients with selected taps only (and their corresponding delay)*

Thank you

Questions and Discussions