106Gbps LR COM Investigation (IV)

Mike Li, Hsinho Wu, Masashi Shimanouchi

For IEEE 802.3ck

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Intel

Recap of the Basics Assumptions Used In Previous Investigations

- Investigation (I):http://www.ieee802.org/3/ck/public/18_09/li_3ck_02_0918.pdf
- Investigation (II): http://www.ieee802.org/3/ck/public/18_11/li_3ck_02a_1118.pdf
- Investigation (III): http://www.ieee802.org/3/ck/public/19_01/li_3ck_01_0119.pdf

Observations

- Most of 802.3ck LR receivers will be ADC-based designs which contains long FFE and short DFE
- Straw polls and trends indicated that 802.3ck is to adapt DFE-only baseline RX with increased bmax1 range
- COM evaluations on available 802.3ck channels indicated 20~24 post-taps are needed for adequate link performance
  - Requirement of 24 post-taps will push up device power consumption
  - Many channels do not need 24-taps to achieve 3dB COM

Investigation in this study

- Reduce total DFE tap length with floating-taps

106Gbps LR COM with Floating Tap DFE

- TX
  - Scale: TX rise/fall time (T_r), jitter (A_DD, sigma_RJ)
  - TX EQ
    - 3 pre-taps + 1 post-tap
  - Same RLM, SNR_{TX}
- RX
  - RX input referred noise (eta_0): 8.2e-9 V^2/GHz
  - Equalization
    - CTLE
      - Scale f_z, f_p1, f_p2
      - f_p2 = 53.125 GHz (= baud rate)*
      - f_HP_PZ: 0.7 GHz (=f_b / 80)
  - DFE Configuration
    - 12~28 fixed post-taps plus 4 grouped floating taps to up 64th tap
    - DFE tap coef.: Tap 1 ≤ 0.85, others ≤ 0.2
- Package / TX/RX Capacitance and Termination
  - Length: 12mm, 20mm and 32mm T-line + 1.8mm PTH
    - T-line/PTH parameters: a1=0.0009909, a2= 0.0002772, tau=6.14e-3 ns/mm, $Zc_{T\text{-}line}$=87.5Ω, Zc_{PTH}=92.5Ω
  - Cd: 130fF
  - Cp: 87fF
  - Rd: 50 Ohms

Proposed 106Gbps LR COM Spreadsheet

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	[1.3e-4 1.3e-4]	nF	[TX RX]
z_p select	[2, 3]		[test cases to run]
z_p (TX)	[12 20 32; 1.8 1.8 1.8]	mm	[test cases]
z_p (NEXT)	[12 12 12; 1.8 1.8 1.8]	mm	[test cases]
z_p (FEXT)	[12 20 32; 1.8 1.8 1.8]	mm	[test cases]
z_p (RX)	[12 20 32; 1.8 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	
A_fe	0.413	V	
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:.02:0.12]		[min:step:max]
c(-3)	[-0.06:0.02:0.0]		[min:step:max]
c(1)	[-0.1:0.05:0]		[min:step:max]
N_b	[12:4:28]	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	
Include PCB	0	logical	

I/O control		
DIAGNOSTICS	0	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	CK_LR_0410	
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

TDR and ERL options		
TDR	0	logical
ERL	0	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	
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	32.5	dB
R_LM	0.95	

Floating tap DFE		
ndfe_float	4	
dfe_float_max	64	

Table 93A–3 parameters		
Parameter	**Setting**	**Units**
package_tl_gamma0_a1_a2	[0 0.0009909 0.0002772]	
package_tl_tau	6.1400E-03	ns/mm
package_Z_c	[87.5 87.5 ; 92.5 92.5]	Ohm

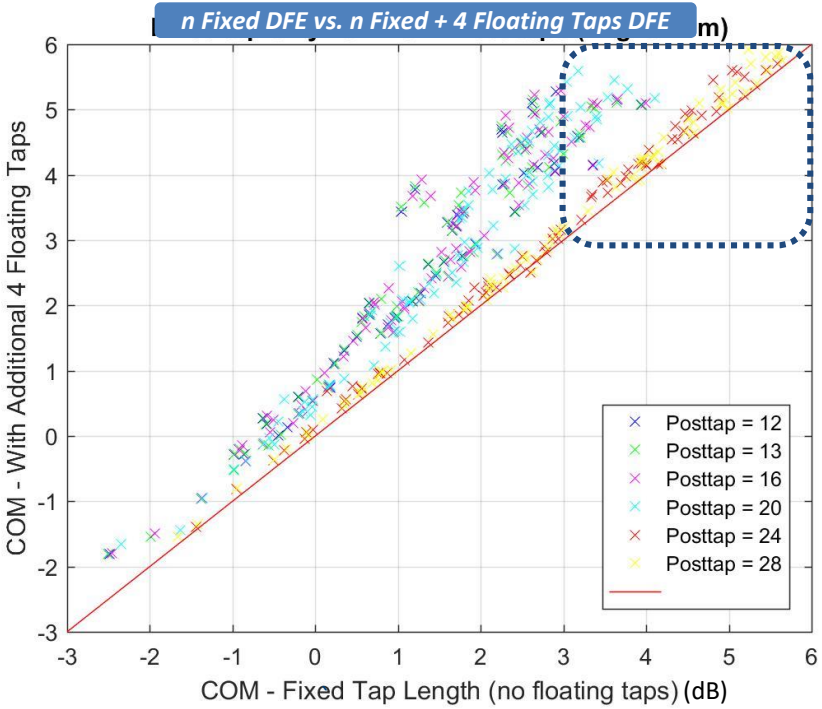
Table 92–12 parameters		
Parameter	**Setting**	
board_tl_gamma0_a1_a2	*[0 3.8206e-04 9.5909e-05]*	
board_tl_tau	*5.790E-03*	ns/mm
board_Z_c	90	Ohm
z_bp (TX)	*50*	mm
z_bp (NEXT)	*50*	mm
z_bp (FEXT)	*50*	mm
z_bp (RX)	*50*	mm

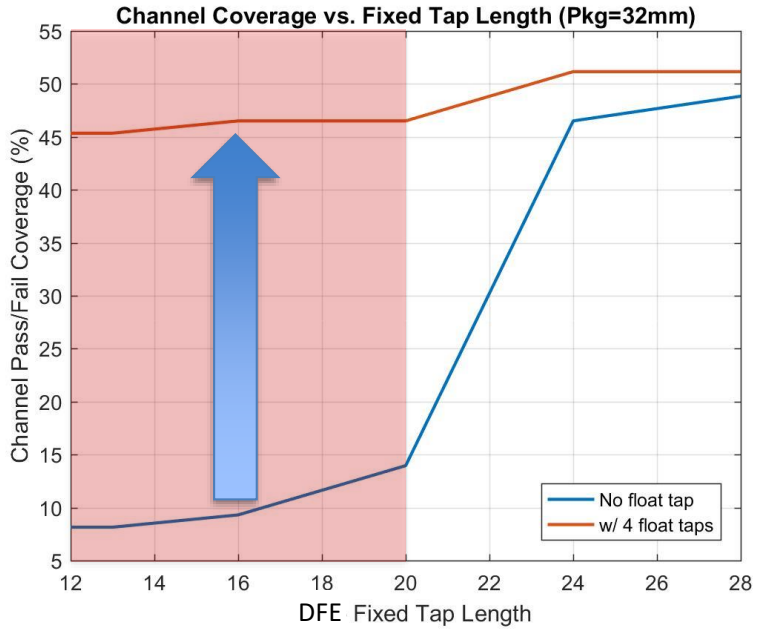
Channel Data

CH #	Description	Reference Document	Notes
1-2	Cable_BKP_28dB\Cable_BKP_28dB_0p575m_more_isi Cable_BKP_28dB\Cable_BKP_16dB_0p575m_more_isi	heck_3ck_01_1118.pdf	
3	CaBP_BGAVia_Opt2_28dB\CaBP_BGAVia_Opt2_28dB	mellitz_3ck_adhoc_02_081518.pdf	
4-5	tracy_3ck_03_0119_tradBP\Std_BP_12inch_Meg7 tracy_3ck_02_0119_orthoBP\DPO_IL_12dB	Tracy_3ck_01_0119	
6-9	kareti_3ck_01_1118_ortho\OAch4_t kareti_3ck_01_1118_ortho\Och4_t kareti_3ck_01_1118_cabledBP\CAch3_b2_t kareti_3ck_01_1118_backplane_2\Bch2_a2p5_7_t	kareti_3ck_01a_1118.pdf	
10-12	Initial Host 30dB Backplane Channel Models	heck_100GEL_01_0118.pdf	
13-15	Best Case 3”, 13”, 18” Tachyon Backplane	mellitz_100GEL_adhoc_01_010318.pdf	
16-17	Synthesized CR Channels (2.0m and 2.5m 28AWG Cable)	mellitz_100GEL_adhoc_01_021218.pdf	
17-18	Orthogonal or Cabled Backplane Channels	tracy_100GEL_03_0118.pdf	
20-33	16/20/24/28dB Cabled Backplane Channels	heck_3ck_01_1118.pdf	
27-32	24/28/32dB Cabled Backplane Channels including Via	mellitz_3ck_adhoc_02_081518.pdf	
39-55	Measured Traditional Backplane Channels	kareti_3ck_01a_1118.pdf	
56-73	Measured Cabled Backplane Channels		
75-86	Measured Orthogonal Backplane Channels		

All channel data are from IEEE 802.3ck Task Force Tools & Channels page: http://www.ieee802.org/3/ck/public/tools/index.html

106Gbps Test Channel COM Results
w/32mm Packages

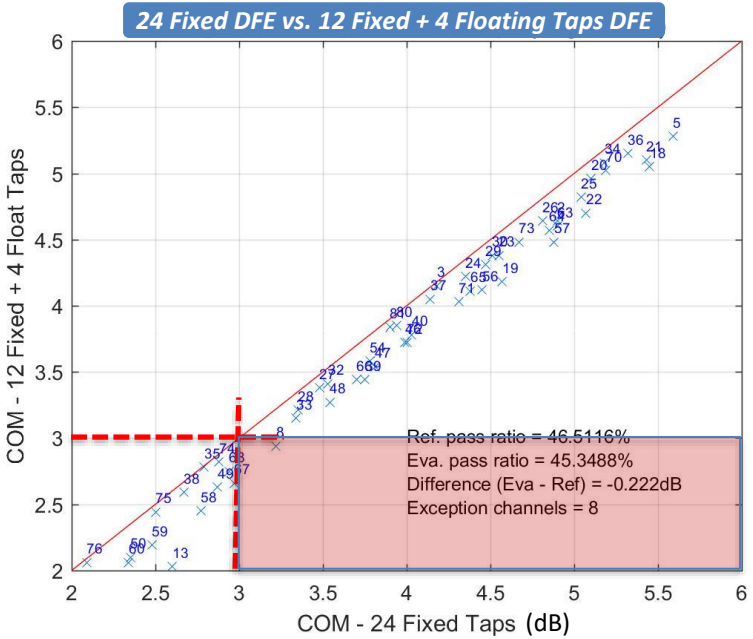


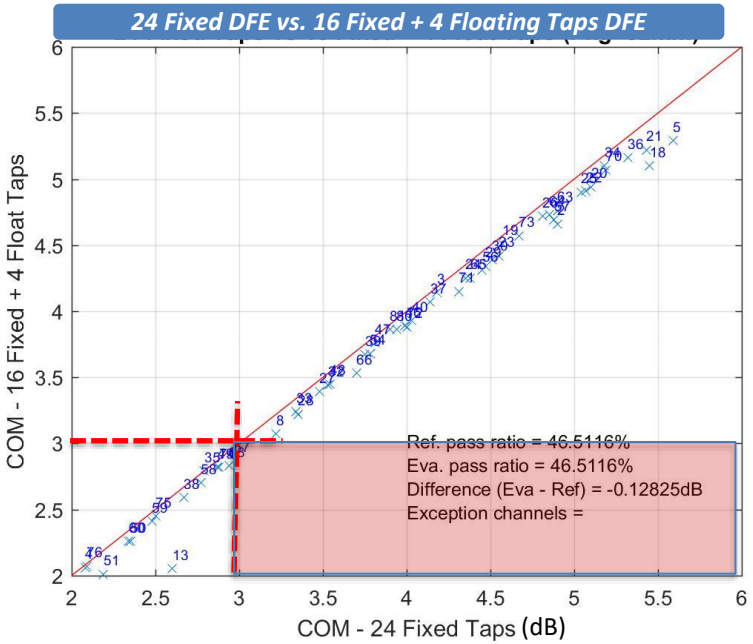


DFE fixed tap lengths where floating taps improve solution space effectively

- Floating tap DFE improves COM when fixed tap length ≤ 20

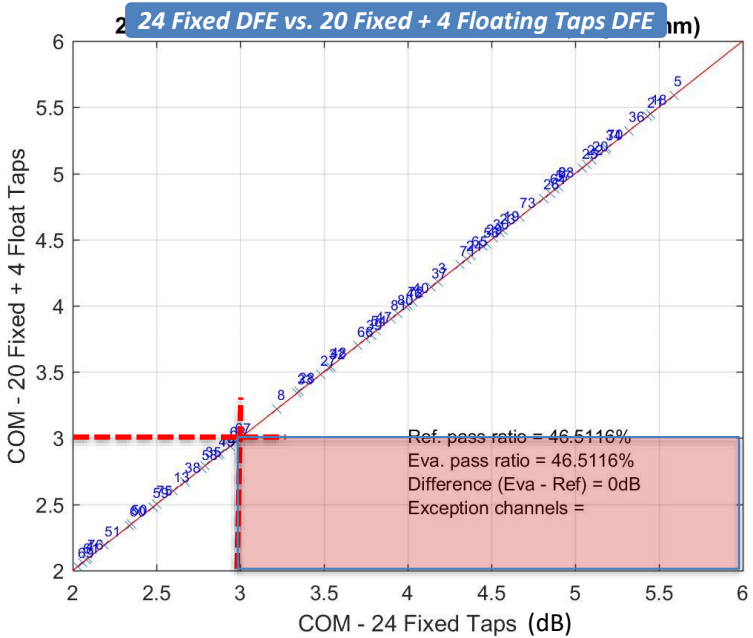
106Gbps Test Channel COM Results
w/32mm Packages





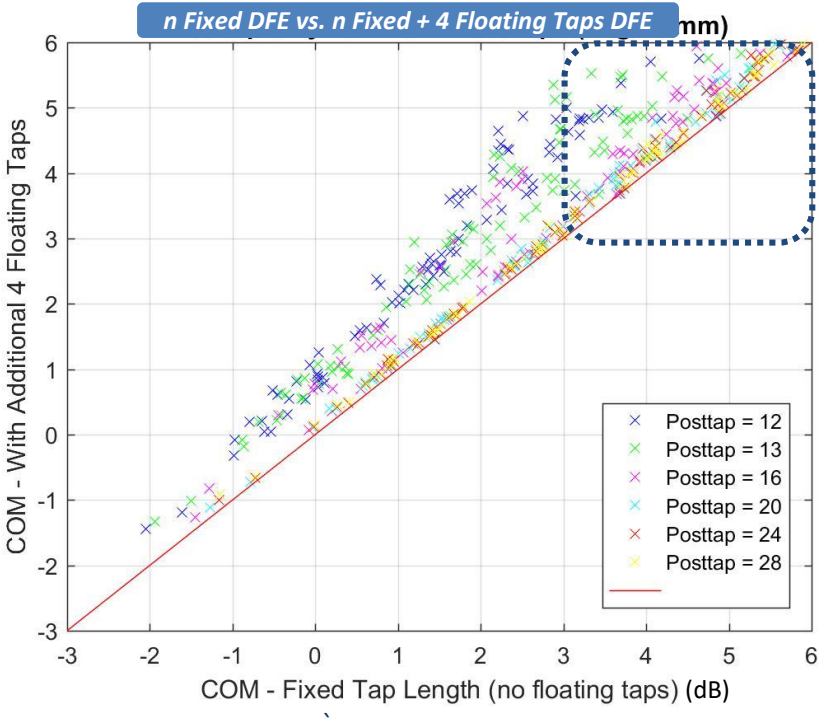
- 12-fixed + 4-floating DFE can achieve almost the same COM pass/fail coverage
  - Only 1 channel is exception
- 16-fixed + 4-floating DFE achieves the same COM pass/fail coverage

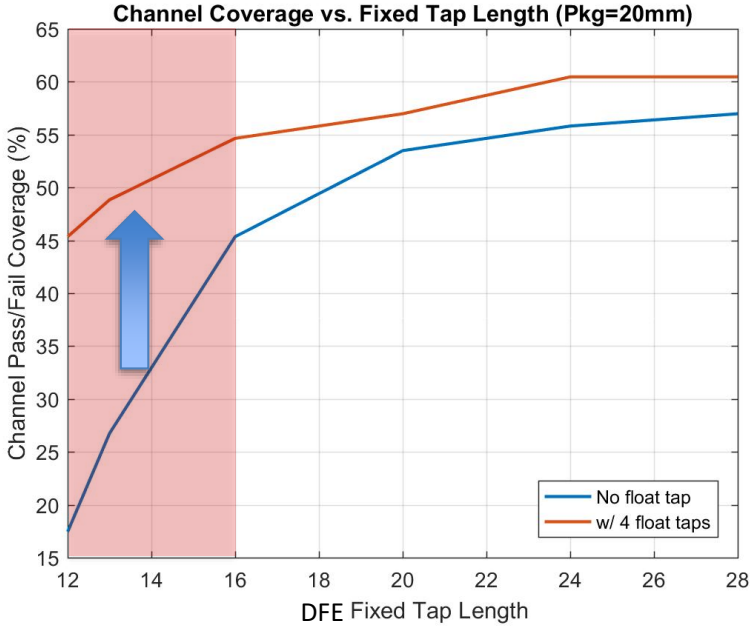
106Gbps Test Channel COM Results
w/32mm Packages



- 20-fixed + 4-floating DFE achieves the same COM pass/fail coverage

106Gbps Test Channel COM Results
w/20mm Packages

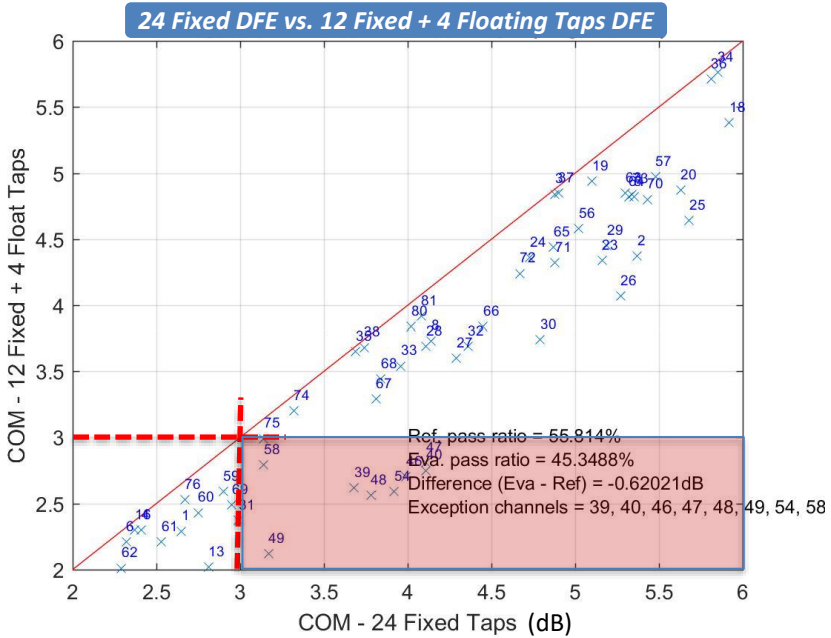


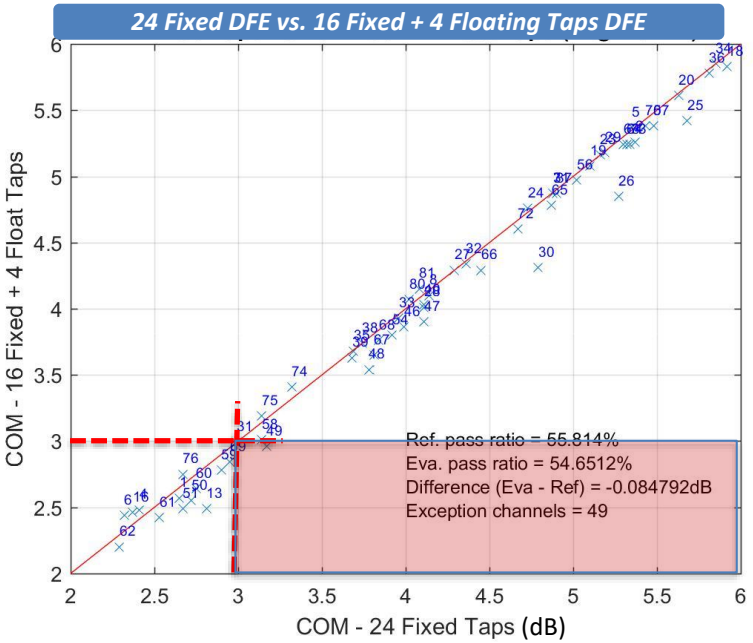


DFE fixed tap lengths where floating taps improve solution space effectively

- Floating tap DFE improves COM when fixed tap length ≤ 16

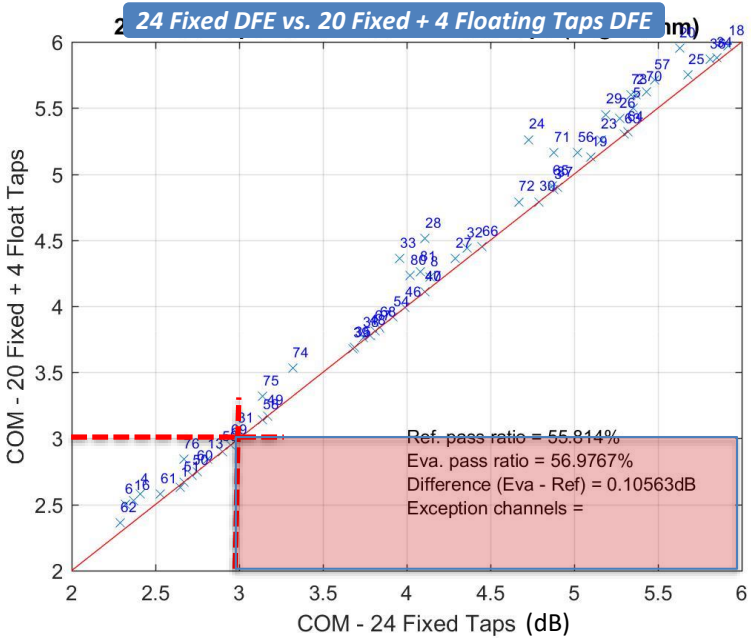
106Gbps Test Channel COM Results
w/20mm Packages





- 12-fixed + 4-floating DFE can achieve similar COM pass/fail coverage
  - 8 exceptions
  - Coverage is ~10% less than 24-fixed case
- 16-fixed + 4-floating DFE achieves almost the same COM pass/fail coverage
  - 1 channel exception

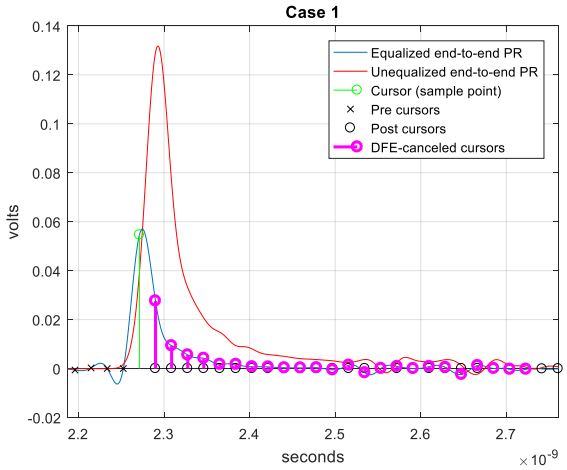
106Gbps Test Channel COM Results
w/20mm Packages



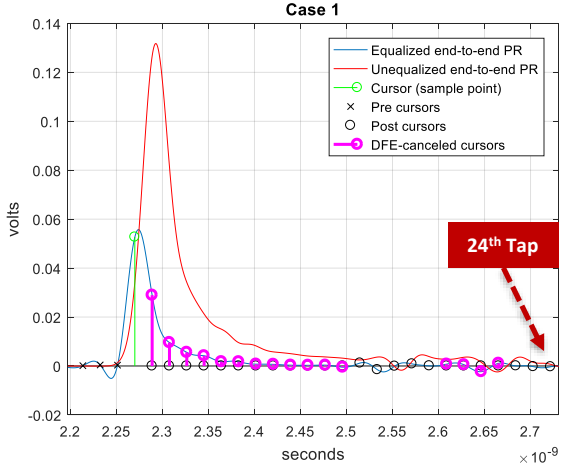
- 20-fixed + 4-floating DFE achieves the same COM pass/fail coverage

Channel 39: with 20mm Package (kareti_3ck_01_1118_backplane_2\Bch1_3p5)

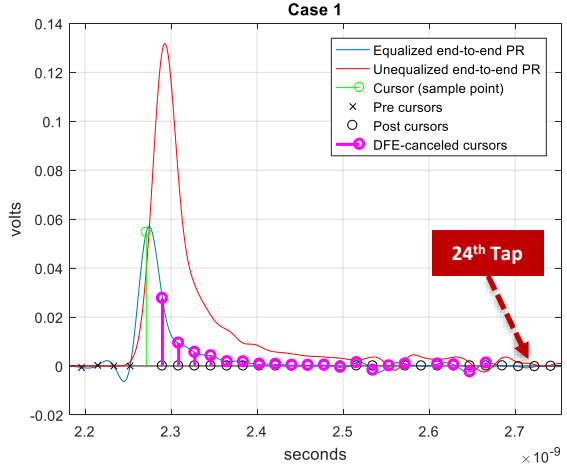
802.3ck LR Trending RX: 24 Fixed (COM=3.68dB)



12 Fixed + 4 Floating (COM=2.62dB)

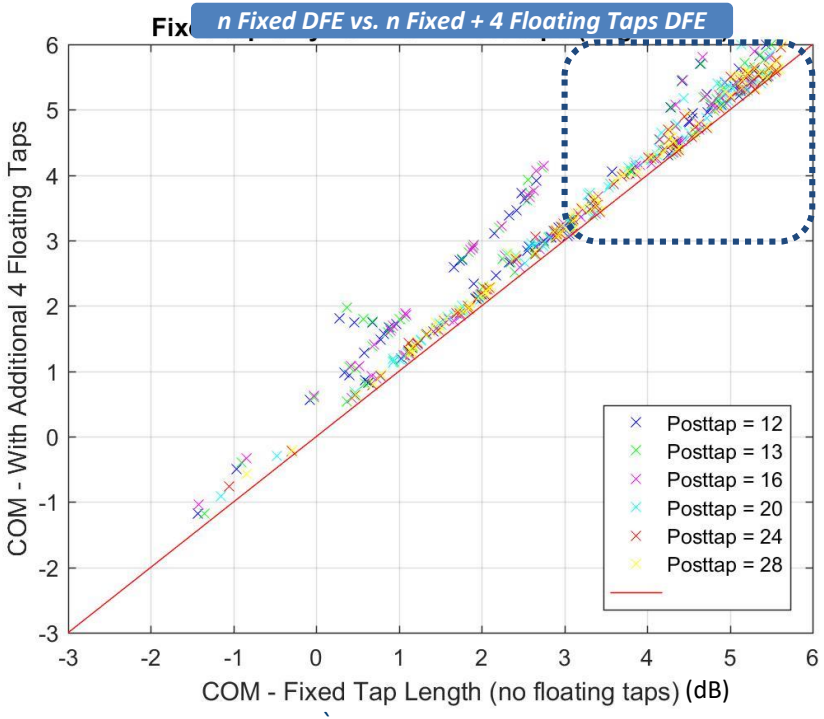


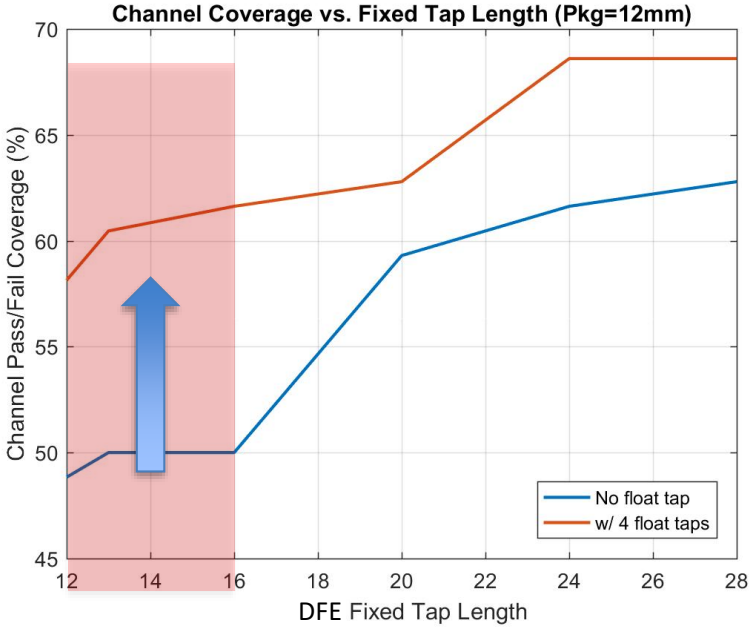
16 Fixed + 4 Floating (COM=3.63dB)



- Kareti channel 39 has reflection/discontinuities at 13~16 and 18~21 taps
- Extend Fixed tap length to 16 will resolve this issue (mostly)

106Gbps Test Channel COM Results
w/12mm Packages

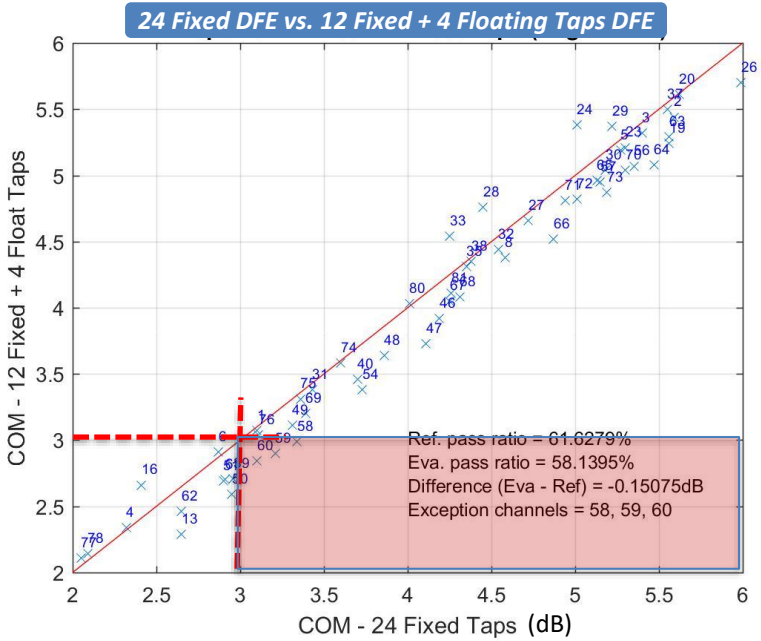


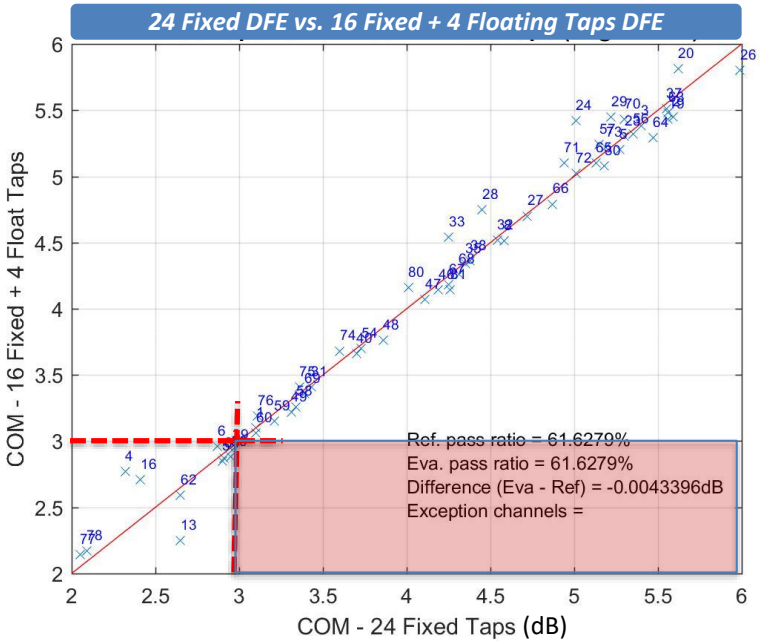


DFE fixed tap lengths where floating taps improve solution space effectively

- Floating tap DFE improves COM when fixed tap length ≤ 16

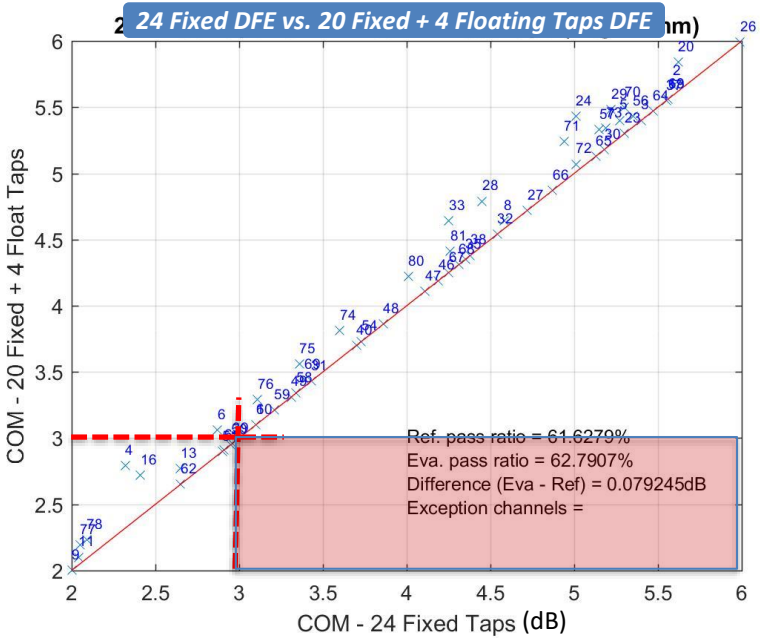
106Gbps Test Channel COM Results
w/12mm Packages





- 12-fixed + 4-floating DFE can achieve similar COM pass/fail coverage
  - 3 exceptions
  - Coverage is ~3% less than 24-fixed case
- 16-fixed + 4-floating DFE achieves almost the same COM pass/fail coverage
  - 0 channel exception

106Gbps Test Channel COM Results
w/12mm Packages



- 20-fixed + 4-floating DFE achieves better COM pass/fail coverage

Summary and Conclusions

- Floating DFE taps greatly improve solution space
  - With 4 grouped floating taps and 12~16 fixed taps

- When using 24 fixed DFE taps as benchmark, 16 fixed + 4 floating taps has shown to be the most effective configuration
  - 16+4 provides almost the same channel coverage as 24 fixed
    - With 32mm package: 16+4 provides same channel coverage
    - With 20mm package: 16+4 provides almost same channel coverage (1 exception)
    - With 12mm package: 16+4 provides same channel coverage

Thank You