112Gbps LR COM Updates

Mike Li, Hsinho Wu, Masashi Shimanouchi, Adee Ran, Itamar Levin

For IEEE 802.3ck

Nov, 2018

Intel

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Rethinking 112Gbps LR Baseline COM

- Previously proposed LR COM with FFE-heavy/DFE(1-tap) (Config 0) ref. RX configuration
  - Based on 802.3cd with the following changes:
    - TX:
      - Scale rise/fall time (T_r), jitter (A_DD, sigma_RJ)
      - Extended pre-tap 1 and post-tap 1 range to -0.3
    - RX:
      - eta_0 (8.2e-9 V^2/GHz),
      - CTLE: f_z, f_p1 (both scaled), f_p2 (56GHz), f_HP_PZ (0.7GHz)
      - Added FFE (3 pre-taps + 12 post-taps)
      - 1-tap DFE
    - Package:
      - Added 20mm option, Cd: 130fF

Rethinking 112Gbps LR Baseline COM: Latest 802.3ck Straw Poll

Straw Poll #9:

Do you support a reference receiver for copper cable and backplane COM to be…

(A) DFE as is in past COM (i.e. Annex 93A)

(B) ZF/MMSE FFE + DFE

(C) ZF/MMSE FFE + DFE ADC/DSP model

(D) Something else

(E) Need more information

(pick 1)

A: 18 B: 13 C: 4 D: 0 E: 14

Rethinking 112Gbps LR Baseline COM: Path Forward

- Considerations
  - Using FFE is a common design for ADC-based 112Gbps RX which is emerging as main-stream, however
    - Adapting FFE coefficients are design-specific yet well-known analytical solutions exist
      - e.g. Zero-forcing, MMSE
    - Questions raised about FFE and DFE co-optimization with the overlapping post-taps
      - Highly design specific
  - Do we really need to include FFE in the baseline ref. RX model?
    - Both DFE and FFE (post-tap part) served to compensate impairment in the post-cursor locations
    - TX FFE has been used to compensate impairment in the pre-cursor locations
  - How is a DFE-only (1) or FFE-lite/DFE-heavy (2) baseline ref. RX options compared to the previously proposed FFE-heavy/DFE(1-tap) (0) option?
    - **DFE-only (1): RX has no FFE** $\Rightarrow$ *no FFE optimization methodology is needed in COM*
    - **FFE-lite/DFE-heavy (2): RX has FFE, pre-tap only, and long DFE** $\Rightarrow$ *No FFE/DFE co-optimization methodology is needed in COM, yet ADC-based RX has this capabilities*
  - *Goal is to develop simple COM method yet provide reasonable performance*

112Gbps LR COM with DFE-only (1) and FFE-lite/DFE-heavy (2) options

- Baseline
  - 802.3cd COM
    - http://www.ieee802.org/3/cd/public/adhoc/archive/mellitz_080217_3cd_01_adhoc.pdf
    - http://www.ieee802.org/3/cd/public/adhoc/archive/mellitz_3cd_0817_COM.zip
- Change Summary
  - TX
    - Scale: TX rise/fall time (T_r), jitter (A_DD, sigma_RJ)
    - Same: TX EQ (2 pre- + 1 post-taps), RLM, noise (SNR_TX)
      - Pre-tap1 and post-tap1 min. = -0.3
  - RX
    - RX input referred noise (eta_0): 8.2e-9 V^2/GHz
    - Equalization
      - CTLE
        - » Scale f_z, f_p1, f_p2
      - f_p2 = 56 GHz (= baud rate)*
        - » F_HP_PZ: 0.7 GHz (=f_b / 80)
  - Config 1: DFE-only
    - DFE Configuration
      - 12~28 post-taps
      - DFE tap coef. Tap 1 ≤ 0.7, others ≤ 0.2
  - Config 2: FFE-lite/DFE-heavy
    - DFE Configuration
      - 12~28 post-taps
      - DFE tap coef. Tap 1 ≤ 0.7, others ≤ 0.2
    - FFE Configuration
      - 3 pre-taps
      - FFE tap coef: Main cursor: 1, Pre-tap 1: ≤0.5, other taps: ≤0.125
- Package / TX/RX Capacitance and Termination
  - Length: max 20 or 30mm
  - TL: Z_c = 92.5 Ohms
  - Cd: 130fF
  - Cp: 110fF
  - Rd: 50 Ohms

**: In 802.3cd COM, f_p2 is 2x baud rate (112GHz) which We believe it might be too high for today's CMOS technology. Further, f_r (RX noise filter) is set at 0.75x baud rate which will reduce the effectiveness of higher f_p2.*

Proposed 112Gbps LR COM Spreadsheet

Config 1: DFE-only

Table 93A-1 parameters			
Parameter	**Setting**	**Units**	**Information**
f_b	56	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	[1 2 3 4 5]		[test cases to run]
z_p (TX)	[12 20 30 20 30]	mm	[test cases]
z_p (NEXT)	[12 12 12 12 12]	mm	[test cases]
z_p (FEXT)	[12 20 20 30 30]	mm	[test cases]
z_p (RX)	[12 20 20 30 30]	mm	[test cases]
C_p	[1.1e-4 1.1e-4]	nF	[TX RX]
R_0	50	Ohm	
R_d	[50 50]	Ohm	[TX RX] or selected
f_r	0.75	*fb	
c(0)	0.6		min
c(-1)	[-0.3:0.025:0]		[min:step:max]
c(-2)	[0:0.025:0.1]		[min:step:max]
c(1)	[-0.3:0.025:0]		[min:step:max]
g_DC	[-20:1:0]	dB	[min:step:max]
g_DC_HP	[-6:1:0]		[min:step:max]
f_HP_PZ	0.7	GHz	
f_z	22.4	GHz	
f_p1	22.4	GHz	
f_p2	56	GHz	
A_v	0.41	V	tdr selected
A_fe	0.41	V	tdr selected
A_ne	0.6	V	tdr selected
L	4		
M	32		
N_b	16	UI	
b_max(1)	0.7		
b_max(2..N_b)	0.2		
sigma_RJ	0.01	UI	
A_DD	0.02	UI	
eta_0	8.20E-09	V^2/GHz	
SNR_TX	32.5	dB	tdr selected
R_LM	0.95		
DER_0	1.00E-04		
Operational control			
COM Pass threshold	3	dB	
Include PCB	0	Value	0, 1, 2

I/O control		
DIAGNOSTICS	0	logical
DISPLAY_WINDOW	0	logical
Display frequency domain	0	logical
CSV_REPORT	1	logical
RESULT_DIR	.\results\D1p2_{date}\	
SAVE_FIGURES	0	logical
Port Order	[1 3 2 4]	
RUNTAG	v165_d1p0a	
Receiver testing		
RX_CALIBRATION	0	logical
Sigma BBN step	5.00E-03	V
IDEAL_TX_TERM	0	logical
T_r	0.006160714	ns
FORCE_TR	1	logical

RX FFE		
ffe_enable	0	logical
ffe_pre_tap_len	3	UI
ffe_tap_step_size	0.01	UI
ffe_main_cursor	1	
ffe_pre_tap1_max	0.5	
ffe_tapn_max	0.125	

Table 93A–3 parameters		
Parameter	**Setting**	**Units**
package_tl_gamma0_a1_a2	[0 1.734e-3 1.455e-4]	
package_tl_tau	6.141E-03	ns/mm
package_Z_c	92.5	Ohm (tdr sel)

Table 92–12 parameters		
Parameter	**Setting**	
board_tl_gamma0_a1_a2	[0 4.114e-4 2.547e-4]	
board_tl_tau	6.191E-03	ns/mm
board_Z_c	110	Ohm
z_bp (TX)	151	mm
z_bp (NEXT)	72	mm
z_bp (FEXT)	72	mm
z_bp (RX)	151	mm

Proposed 112Gbps LR COM Spreadsheet

Config 2: FFE-lite/DFE-heavy

Table 93A-1 parameters			
Parameter	**Setting**	**Units**	**Information**
f_b	56	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	[1 2 3 4 5]		[test cases to run]
z_p (TX)	[12 20 30 20 30]	Mm	[test cases]
z_p (NEXT)	[12 12 12 12 12]	Mm	[test cases]
z_p (FEXT)	[12 20 20 30 30]	mm	[test cases]
z_p (RX)	[12 20 20 30 30]	mm	[test cases]
C_p	[1.1e-4 1.1e-4]	nF	[TX RX]
R_0	50	Ohm	
R_d	[50 50]	Ohm	[TX RX] or selected
f_r	0.75	*fb	
c(0)	0.6		min
c(-1)	[-0.3:0.025:0]		[min:step:max]
c(-2)	[0:0.025:0.1]		[min:step:max]
c(1)	[-0.3:0.025:0]		[min:step:max]
g_DC	[-20:1:0]	dB	[min:step:max]
g_DC_HP	[-6:1:0]		[min:step:max]
f_HP_PZ	0.7	GHz	
f_z	22.4	GHz	
f_p1	22.4	GHz	
f_p2	56	GHz	
A_v	0.41	V	tdr selected
A_fe	0.41	V	tdr selected
A_ne	0.6	V	tdr selected
L	4		
M	32		
N_b	16	UI	
b_max(1)	0.7		
b_max(2..N_b)	0.2		
sigma_RJ	0.01	UI	
A_DD	0.02	UI	
eta_0	8.20E-09	V^2/GHz	
SNR_TX	32.5	dB	tdr selected
R_LM	0.95		
DER_0	1.00E-04		
Operational control			
COM Pass threshold	3	dB	
Include PCB	0	Value	0, 1, 2

I/O control		
DIAGNOSTICS	0	logical
DISPLAY_WINDOW	0	logical
Display frequency domain	0	logical
CSV_REPORT	1	logical
RESULT_DIR	.\results\D1p2_{date}\	
SAVE_FIGURES	0	logical
Port Order	[1 3 2 4]	
RUNTAG	v165_d1p0a	
Receiver testing		
RX_CALIBRATION	0	logical
Sigma BBN step	5.00E-03	V
IDEAL_TX_TERM	0	logical
T_r	0.006160714	ns
FORCE_TR	1	logical

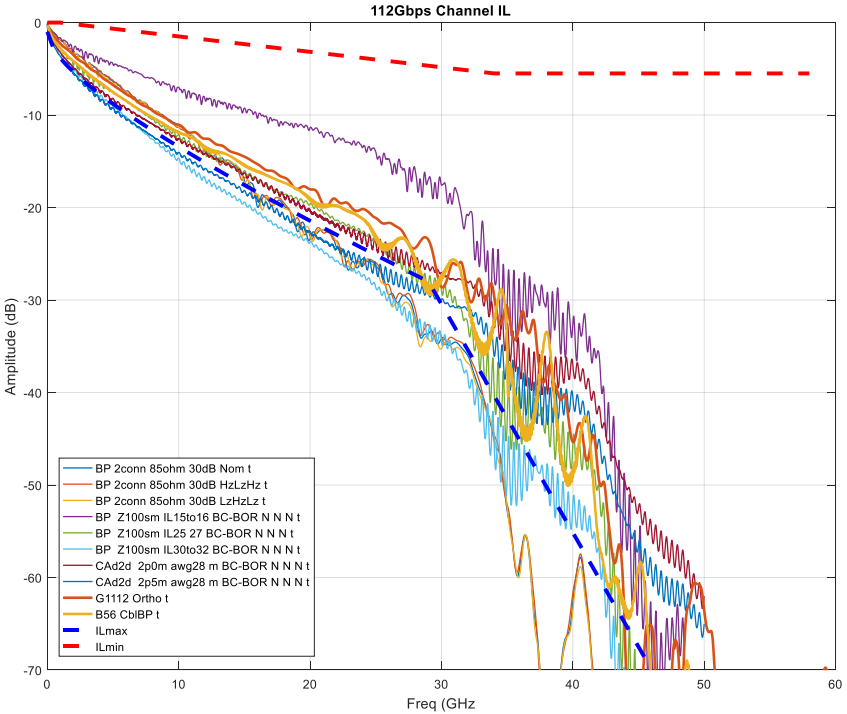
RX FFE		
ffe_enable	1	logical
ffe_pre_tap_len	3	UI
ffe_tap_step_size	0.01	UI
ffe_main_cursor	1	
ffe_pre_tap1_max	0.5	
ffe_tapn_max	0.125	

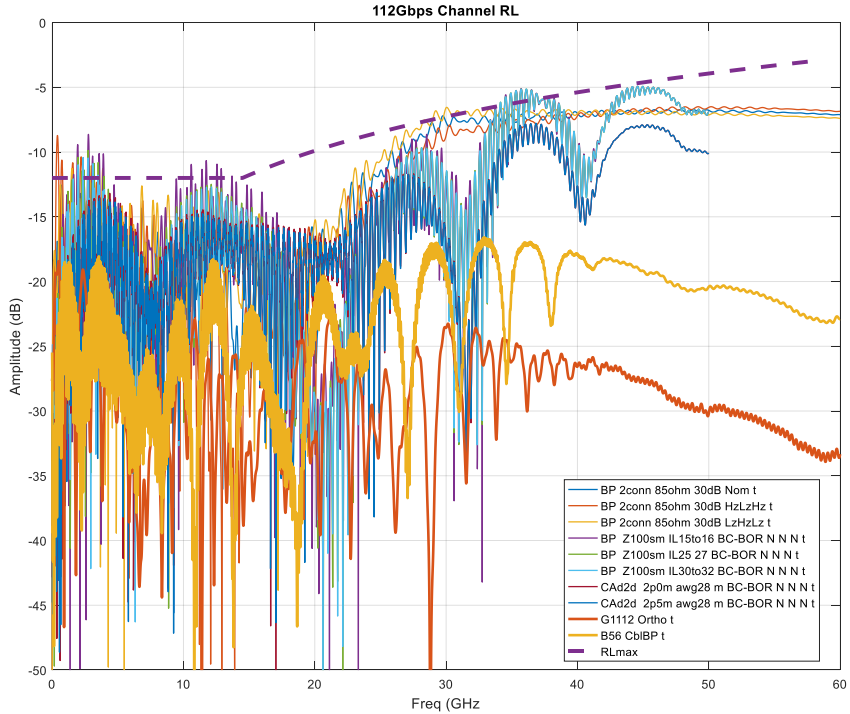
Table 93A–3 parameters		
Parameter	**Setting**	**Units**
package_tl_gamma0_a1_a2	[0 1.734e-3 1.455e-4]	
package_tl_tau	6.141E-03	ns/mm
package_Z_c	92.5	Ohm (tdr sel)

Table 92–12 parameters		
Parameter	**Setting**	
board_tl_gamma0_a1_a2	[0 4.114e-4 2.547e-4]	
board_tl_tau	6.191E-03	ns/mm
board_Z_c	110	Ohm
z_bp (TX)	151	mm
z_bp (NEXT)	72	mm
z_bp (FEXT)	72	mm
z_bp (RX)	151	mm

Channel Characteristics

w/ informative IL and RL Masks





112Gbps Test Channel COM Results

w/ 20mm Packages w/o Crosstalk: FFE-heavy(3-pre/n-post)/DFE(1-tap) (Config 0, previously proposed)

Source	Channel w/o XTLK	FFE Tap Length (Post-tap Length)							
		16 (12)	17 (13)	18 (14)	19 (15)	20 (16)	24 (20)	28 (24)	32 (28)
Heck	BP_2conn_85ohm_30dB_Nom_t	-1.93	-1.88	-0.64	0.44	0.62	1.72	1.94	1.99
Heck	BP_2conn_85ohm_30dB_HzLzHz_t	-2.29	-2.22	-1.15	0.1	0.45	2.11	2.38	2.43
Heck	BP_2conn_85ohm_30dB_LzHzLz_t	-1.53	-1.46	0.16	0.98	0.99	2.33	2.63	2.69
Mellitz	BP__Z100sm_IL15to16_BC-BOR_N_N_N_t	-0.58	-0.53	0.6	1.82	1.88	2.45	3.01	3.07
Sametc	BP__Z100sm_IL25_27_BC-BOR_N_N_N_t	-0.56	-0.47	0.22	1.51	1.57	2.05	2.55	2.79
Mellitz	BP__Z100sm_IL30to32_BC-BOR_N_N_N_t	-1.09	-0.93	-0.64	0.55	0.56	0.96	1.39	1.56
Mellitz	CAd2d__2p0m_awg28_m_BC-BOR_N_N_N_t	-0.06	-0.06	0.84	2.17	2.17	2.19	2.2	2.21
Mellitz	CAd2d__2p5m_awg28_m_BC-BOR_N_N_N_t	-0.32	-0.21	0.41	1.65	1.65	1.69	1.69	1.69
Tracy	G1112_Ortho_t	1.65	1.57	3.05	5.42	5.42	5.43	5.61	5.75
Tracy	B56_CblBP_t	0.29	0.21	1.78	4.29	4.29	4.36	4.45	4.47

– FFE/DFE coefficients were found using proprietary methods

112Gbps Test Channel COM Results

w/ 20mm Packages w/ Crosstalk: FFE-heavy(3-pre/n-post)/DFE(1-tap) (Config 0, previously proposed)

Source	Channel w/o XTLK	FFE Tap Length (Post-tap Length)							
		16 (12)	17 (13)	18 (14)	19 (15)	20 (16)	24 (20)	28 (24)	32 (28)
Heck	BP_2conn_85ohm_30dB_Nom_t	-3.48	-3.38	-2.41	-1.9	-1.7	-1.09	-0.99	-0.98
Heck	BP_2conn_85ohm_30dB_HzLzHz_t	-3.8	-3.79	-2.98	-2.27	-1.92	-0.9	-0.83	-0.75
Heck	BP_2conn_85ohm_30dB_LzHzLz_t	-3.14	-3	-1.95	-1.46	-1.36	-0.65	-0.48	-0.47
Mellitz	BP__Z100sm_IL15to16_BC-BOR_N_N_N_t	-1.24	-1.2	-0.28	0.71	0.77	1.22	1.62	1.65
Sametc	BP__Z100sm_IL25_27_BC-BOR_N_N_N_t	-2.12	-2.09	-1.58	-0.62	-0.62	-0.32	0.03	0.13
Mellitz	BP__Z100sm_IL30to32_BC-BOR_N_N_N_t	-3.74	-3.56	-3.56	-2.9	-3.02	-2.77	-2.59	-2.63
Mellitz	CAd2d__2p0m_awg28_m_BC-BOR_N_N_N_t	-1.28	-1.38	-0.27	0.33	0.46	0.47	0.48	0.48
Mellitz	CAd2d__2p5m_awg28_m_BC-BOR_N_N_N_t	-1.58	-1.51	-0.91	-0.35	-0.27	-0.24	-0.24	-0.23
Tracy	G1112_Ortho_t	1.57	1.45	2.91	5.18	5.19	5.21	5.38	5.5
Tracy	B56_CblBP_t	0.19	0.11	1.66	4.11	4.11	4.17	4.25	4.26

– FFE/DFE coefficients were found using proprietary methods

112Gbps Test Channel COM Results

w/ 20mm Packages w/o Crosstalk: DFE-Only (Config 1)

Source	Channel w/o XTLK	DFE Tap Length (Post-tap Length)							
		12	13	14	15	16	20	24	28
Heck	BP_2conn_85ohm_30dB_Nom_t	-2.66	-1.95	-1.3	-0.87	0.23	0.71	0.73	0.75
Heck	BP_2conn_85ohm_30dB_HzLzHz_t	-2.92	-2.23	-1.5	-1.18	0.11	0.96	1	1.01
Heck	BP_2conn_85ohm_30dB_LzHzLz_t	-2.33	-1.55	-0.93	-0.26	0.63	1.05	1.1	1.14
Mellitz	BP__Z100sm_IL15to16_BC-BOR_N_N_N_t	-0.7	-0.26	0.86	0.86	1.23	2.06	2.63	2.72
Sametc	BP__Z100sm_IL25_27_BC-BOR_N_N_N_t	-1.12	-0.71	0.18	0.18	0.7	1.39	1.92	1.96
Mellitz	BP__Z100sm_IL30to32_BC-BOR_N_N_N_t	-1.98	-1.68	-0.85	-0.83	-0.51	0	0.36	0.39
Mellitz	CAd2d__2p0m_awg28_m_BC-BOR_N_N_N_t	-0.13	0.39	1.66	1.66	1.87	1.95	1.95	1.99
Mellitz	CAd2d__2p5m_awg28_m_BC-BOR_N_N_N_t	-0.53	-0.1	1.07	1.07	1.31	1.36	1.37	1.41
Tracy	G1112_Ortho_t	1.19	1.63	3.31	3.31	3.76	3.94	4.08	4.28
Tracy	B56_CblBP_t	-0.16	0.63	2.73	2.77	3.12	3.21	3.29	3.41

– DFE coefficients were found with zero-forcing method

112Gbps Test Channel COM Results

w/ 20mm Packages w/o Crosstalk: FFE-lite (3-pre/0-post)/DFE-heavy (n taps) (Config 2)

Source	Channel w/o XTLK	DFE Tap Length							
		12	13	14	15	16	20	24	28
Heck	BP_2conn_85ohm_30dB_Nom_t	-1.88	-0.99	-0.2	0.38	1.54	2.11	2.15	2.17
Heck	BP_2conn_85ohm_30dB_HzLzHz_t	-2.16	-1.16	-0.5	-0.09	1.31	2.34	2.38	2.42
Heck	BP_2conn_85ohm_30dB_LzHzLz_t	-1.55	-0.64	0.1	0.97	1.93	2.45	2.51	2.53
Mellitz	BP__Z100sm_IL15to16_BC-BOR_N_N_N_t	-0.4	0.16	1.79	1.96	2.05	2.81	3.58	3.82
Sametc	BP__Z100sm_IL25_27_BC-BOR_N_N_N_t	-0.43	0.14	1.37	1.38	1.69	2.46	3.1	3.21
Mellitz	BP__Z100sm_IL30to32_BC-BOR_N_N_N_t	-1.34	-0.9	0.1	0.1	0.42	1.01	1.5	1.57
Mellitz	CAd2d__2p0m_awg28_m_BC-BOR_N_N_N_t	0.22	0.81	2.3	2.3	2.48	2.57	2.57	2.65
Mellitz	CAd2d__2p5m_awg28_m_BC-BOR_N_N_N_t	-0.14	0.48	1.77	1.79	1.97	2.07	2.08	2.14
Tracy	G1112_Ortho_t	2.01	2.73	5.04	5.19	5.37	5.55	5.83	6.02
Tracy	B56_CblBP_t	0.55	1.56	4.07	4.17	4.51	4.57	4.66	4.82

Note: FFE is with 3 pre-taps 0 post-tap. DFE tap length is 12~28.

- FFE coefficient were found using MMSE method
- DFE coefficients were found using zero-forcing method

112Gbps Test Channel COM Results

w/ 20mm Packages w/ Crosstalk: FFE-lite (3-pre/0-post)/DFE-heavy (n taps) (Config 2)

Source	Channel w/o XTLK	DFE Tap Length							
		12	13	14	15	16	20	24	28
Heck	BP_2conn_85ohm_30dB_Nom_t	-3.46	-2.85	-2.29	-1.9	-1.21	-0.89	-0.88	-0.87
Heck	BP_2conn_85ohm_30dB_HzLzHz_t	-3.72	-3.02	-2.54	-2.29	-1.42	-0.91	-0.86	-0.81
Heck	BP_2conn_85ohm_30dB_LzHzLz_t	-3.2	-2.52	-2.05	-1.48	-0.98	-0.65	-0.63	-0.58
Mellitz	BP__Z100sm_IL15to16_BC-BOR_N_N_N_t	-1.02	-0.57	0.72	0.85	0.93	1.51	2.07	2.25
Sametc	BP__Z100sm_IL25_27_BC-BOR_N_N_N_t	-2.06	-1.66	-0.86	-0.86	-0.62	-0.17	0.18	0.24
Mellitz	BP__Z100sm_IL30to32_BC-BOR_N_N_N_t	-4.03	-3.8	-3.27	-3.27	-3.15	-2.9	-2.7	-2.66
Mellitz	CAd2d__2p0m_awg28_m_BC-BOR_N_N_N_t	-0.95	-0.48	0.65	0.65	0.76	0.8	0.83	0.88
Mellitz	CAd2d__2p5m_awg28_m_BC-BOR_N_N_N_t	-1.62	-1.1	-0.26	-0.25	-0.09	0.01	0.01	0.04
Tracy	G1112_Ortho_t	1.89	2.58	4.81	4.96	5.13	5.3	5.56	5.73
Tracy	B56_CblBP_t	0.45	1.43	3.88	3.97	4.31	4.36	4.45	4.61

Note: FFE is with 3 pre-taps 0 post-tap. DFE tap length is 12~28.

- FFE coefficient were found using MMSE method
- DFE coefficients were found using zero-forcing method

112Gbps Test Channel COM Results

w/ TX 30mm Package + RX 20mm Packages w/o Crosstalk: FFE-lite (3-pre/0-post)/DFE-heavy (n taps) (Config 2)

Source	Channel w/o XTLK	DFE Tap Length							
		12	13	14	15	16	20	24	28
Heck	BP_2conn_85ohm_30dB_Nom_t	-1.36	-0.92	-0.72	-0.27	0.26	1.35	1.82	1.84
Heck	BP_2conn_85ohm_30dB_HzLzHz_t	-1.5	-1.05	-0.76	-0.49	0.26	1.54	1.98	2.03
Heck	BP_2conn_85ohm_30dB_LzHzLz_t	-1.22	-0.76	-0.64	0.03	0.45	1.54	2.03	2.11
Mellitz	BP__Z100sm_IL15to16_BC-BOR_N_N_N_t	1.05	1.24	1.78	1.8	1.84	2.87	4.25	4.41
Sametc	BP__Z100sm_IL25_27_BC-BOR_N_N_N_t	0.85	1.09	1.41	1.43	1.62	2.55	3.44	3.49
Mellitz	BP__Z100sm_IL30to32_BC-BOR_N_N_N_t	-0.36	-0.23	0.09	0.1	0.23	0.92	1.43	1.45
Mellitz	CAd2d__2p0m_awg28_m_BC-BOR_N_N_N_t	1.51	1.78	2.24	2.24	2.28	2.44	2.96	2.99
Mellitz	CAd2d__2p5m_awg28_m_BC-BOR_N_N_N_t	0.99	1.23	1.6	1.6	1.66	1.76	2.26	2.27
Tracy	G1112_Ortho_t	2.99	3.05	3.88	3.86	3.93	4.24	5.78	5.83
Tracy	B56_CblBP_t	2.11	2.7	3.86	3.94	4.07	4.34	4.85	4.9

Note: FFE is with 3 pre-taps 0 post-tap. DFE tap length is 12~28.

– FFE coefficient is found using MMSE method

112Gbps Test Channel COM Results

w/ TX 30mm Package + RX 20mm Packages w/ Crosstalk: FFE-lite (3-pre/0-post)/DFE-heavy (n taps) (Config 2)

Source	Channel w/o XTLK	DFE Tap Length							
		12	13	14	15	16	20	24	28
Heck	BP_2conn_85ohm_30dB_Nom_t	-2.45	-2.09	-1.88	-1.62	-1.18	-1.04	-0.8	-0.47
Heck	BP_2conn_85ohm_30dB_HzLzHz_t	-2.66	-2.28	-2.1	-1.86	-1.32	-1.14	-0.79	-0.39
Heck	BP_2conn_85ohm_30dB_LzHzLz_t	-2.33	-1.97	-1.76	-1.53	-1.13	-0.9	-0.68	-0.38
Mellitz	BP__Z100sm_IL15to16_BC-BOR_N_N_N_t	0.37	0.51	0.95	0.96	1.02	1.89	2.91	3.01
Sametc	BP__Z100sm_IL25_27_BC-BOR_N_N_N_t	-0.84	-0.65	-0.43	-0.42	-0.32	0.31	0.79	0.82
Mellitz	BP__Z100sm_IL30to32_BC-BOR_N_N_N_t	-2.92	-2.84	-2.68	-2.68	-2.63	-2.36	-2.06	-2.05
Mellitz	CAd2d__2p0m_awg28_m_BC-BOR_N_N_N_t	0.43	0.65	0.98	0.98	1.01	1.15	1.52	1.55
Mellitz	CAd2d__2p5m_awg28_m_BC-BOR_N_N_N_t	-0.32	-0.15	0.13	0.13	0.18	0.24	0.58	0.59
Tracy	G1112_Ortho_t	2.88	2.93	3.74	3.72	3.78	4.08	5.58	5.63
Tracy	B56_CblBP_t	2.03	2.59	3.73	3.81	3.93	4.19	4.69	4.73

Note: FFE is with 3 pre-taps 0 post-tap. DFE tap length is 12~28.

– FFE coefficient is found using MMSE method

112Gbps Test Channel COM Results

w/ TX 20mm Package + RX 30mm Packages w/o Crosstalk: FFE-lite (3-pre/0-post)/DFE-heavy (n taps) (Config 2)

Source	Channel w/o XTLK	DFE Tap Length							
		12	13	14	15	16	20	24	28
Heck	BP_2conn_85ohm_30dB_Nom_t	-0.94	-0.42	-0.15	0.23	0.85	1.1	1.48	2.03
Heck	BP_2conn_85ohm_30dB_HzLzHz_t	-1.18	-0.6	-0.33	-0.03	0.79	1.08	1.65	2.32
Heck	BP_2conn_85ohm_30dB_LzHzLz_t	-0.8	-0.33	-0.02	0.35	0.93	1.34	1.73	2.25
Mellitz	BP__Z100sm_IL15to16_BC-BOR_N_N_N_t	1.04	1.24	1.78	1.79	1.84	2.87	4.25	4.39
Sametc	BP__Z100sm_IL25_27_BC-BOR_N_N_N_t	0.86	1.08	1.4	1.42	1.62	2.55	3.44	3.49
Mellitz	BP__Z100sm_IL30to32_BC-BOR_N_N_N_t	-0.37	-0.23	0.09	0.1	0.23	0.91	1.43	1.45
Mellitz	CAd2d__2p0m_awg28_m_BC-BOR_N_N_N_t	1.51	1.78	2.24	2.24	2.28	2.44	2.96	2.99
Mellitz	CAd2d__2p5m_awg28_m_BC-BOR_N_N_N_t	0.99	1.23	1.61	1.61	1.66	1.76	2.26	2.27
Tracy	G1112_Ortho_t	2.97	3.04	3.86	3.85	3.92	4.22	5.76	5.81
Tracy	B56_CblBP_t	2.11	2.7	3.86	3.94	4.07	4.34	4.85	4.9

Note: FFE is with 3 pre-taps 0 post-tap. DFE tap length is 12~28.

– FFE coefficient is found using MMSE method

112Gbps Test Channel COM Results

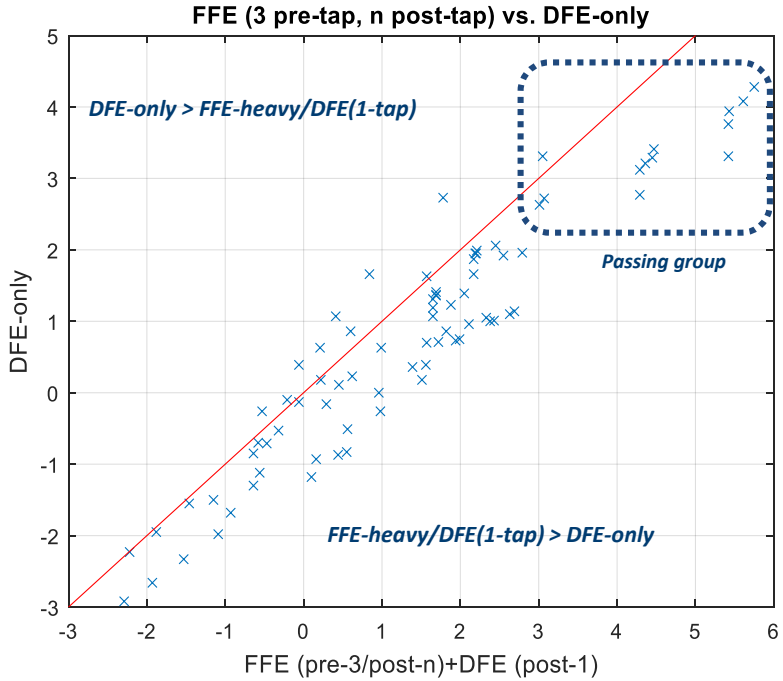
w/ TX 20mm Package + RX 30mm Packages w/ Crosstalk: FFE-lite (3-pre/0-post)/DFE-heavy (n taps) (Config 2)

Source	Channel w/o XTLK	DFE Tap Length							
		12	13	14	15	16	20	24	28
Heck	BP_2conn_85ohm_30dB_Nom_t	-3.35	-3.08	-2.93	-2.66	-2.33	-1.71	-1.47	-1.46
Heck	BP_2conn_85ohm_30dB_HzLzHz_t	-3.52	-3.29	-3.08	-2.89	-2.45	-1.75	-1.51	-1.54
Heck	BP_2conn_85ohm_30dB_LzHzLz_t	-3.22	-2.9	-2.84	-2.42	-2.21	-1.62	-1.35	-1.32
Mellitz	BP__Z100sm_IL15to16_BC-BOR_N_N_N_t	-0.09	0.12	0.51	0.52	0.57	1.33	2.25	2.33
Sametc	BP__Z100sm_IL25_27_BC-BOR_N_N_N_t	-1.56	-1.41	-1.22	-1.21	-1.12	-0.59	-0.21	-0.17
Mellitz	BP__Z100sm_IL30to32_BC-BOR_N_N_N_t	-3.94	-3.87	-3.74	-3.74	-3.71	-3.49	-3.26	-3.25
Mellitz	CAd2d__2p0m_awg28_m_BC-BOR_N_N_N_t	-0.22	-0.03	0.26	0.26	0.28	0.4	0.71	0.73
Mellitz	CAd2d__2p5m_awg28_m_BC-BOR_N_N_N_t	-1.07	-0.91	-0.68	-0.68	-0.65	-0.6	-0.31	-0.3
Tracy	G1112_Ortho_t	2.82	3.02	3.68	3.65	3.72	4.01	5.48	5.53
Tracy	B56_CblBP_t	1.96	2.52	3.64	3.72	3.84	4.08	4.57	4.61

Note: FFE is with 3 pre-taps 0 post-tap. DFE tap length is 12~28.

– FFE coefficient is found using MMSE method

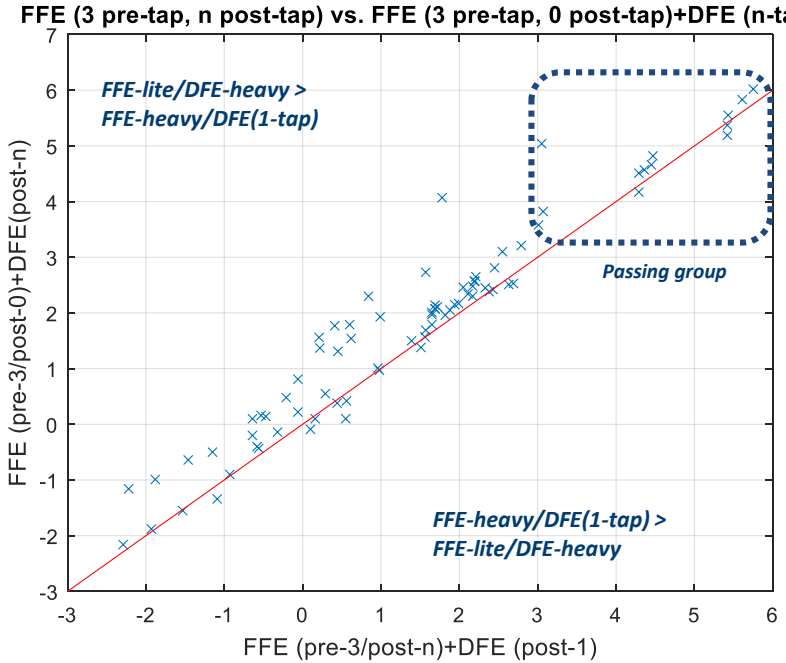
FFE-heavy(3-pre, n-post)/DFE(1-tap) (Config 0) vs DFE-only (Config 1)



Mean Diff = 0.64dB (1.14dB for passing group)
FFE-heavy/DFE (1-tap) (Config 0) outperforms

Config 1 underperforms Config 0

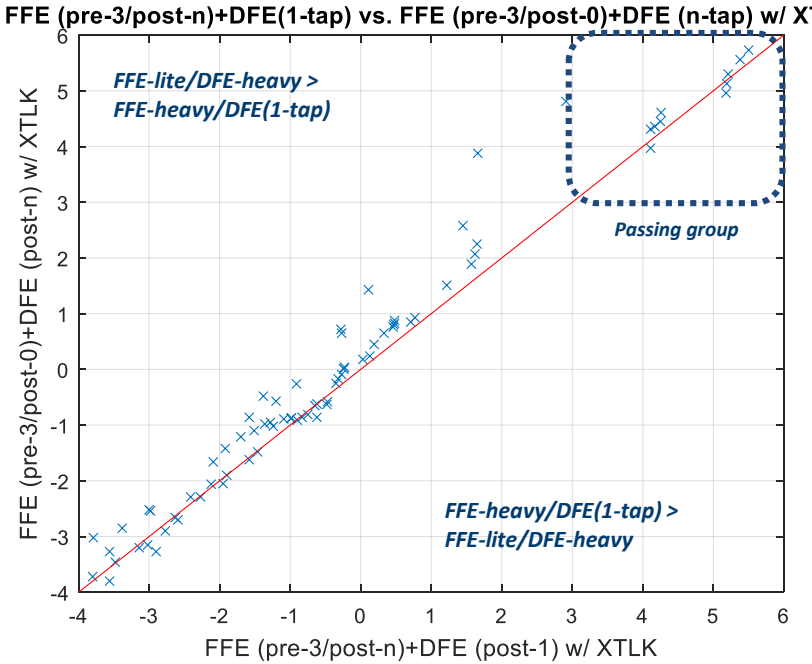
FFE-heavy(3-pre, n-post)/DFE(1-tap) (Config 0) vs FFE-lite(3-pre/0-post)/DFE-heavy (n taps) (Config 2) w/o Crosstalk



Mean Diff = -0.39dB (-0.35dB for passing group)
FFE-lite (3-pre/0-post)/DFE (n taps) (Config 2) slightly outperforms

Config 2 is comparable to Config 0

FFE-heavy(3-pre, n-post)/DFE(1-tap) (Config 0) vs FFE-lite(3-pre/0-post)/DFE-heavy (n taps) (Config 2) w/ Crosstalk



Mean Diff = -0.27dB (-0.10dB for passing group)
FFE-lite (3-pre/0-post)/DFE (n taps) (Config 2) slightly outperforms

Config 2 is comparable to Config 0

New Findings

- Config 1 (DFE-only) underperforms Config 0 (FFE-heavy/DFE(1-tap))
  - COM is ~1dB worse
- Config 2 (FFE-lite/DFE-heavy) is comparable to Config 0 (FFE-heavy/DFE(1-tap))

New Findings (cont.)

– Comparisons among baseline ref. RX models

Config #	Baseline Ref. RX	Performance (w.r.t. *Config 0*)	Complexity	Notes
0	FFE-heavy (3-pre/n-post)/DFE (1-tap)	**High**	**High** 	• Good performance • Complex COM model and standardization
1	DFE-only	**Low** 	**Low**	• Low performance • Uses existing COM methodology
2	FFE-lite (3-pre/0-post)/DFE-heavy (n-taps)	**High** 	**Low/Medium**	• Good Performance • Use existing 802.3/OIF-CEI and COM methodology

Recommendations

- Use Config 2 (FFE-lite/DFE-heavy) as 112Gbps LR COM baseline ref. RX
  - 3 FFE pre-taps and 16 DFE taps
  - Use existing methods (in 802.3 and OIF CEI) to calculate FFE/DFE coefficients
    - FFE coefficients (pre-taps): MMSE (used in SBR fitting)
    - DFE coefficients: Zero-Forcing (used in existing COM)

Thank You