Achievable IL under Different 802.3dj C2M Candidates

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IEEE P802.3dj Task Force

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Outline

- Background and Proposal Recap
- Achievable IL of 802.3dj candidates
- Proposed straw poll

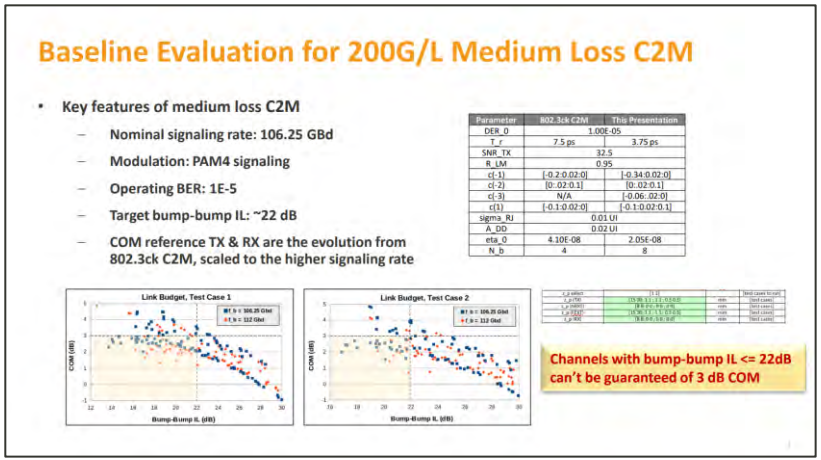
Contributor

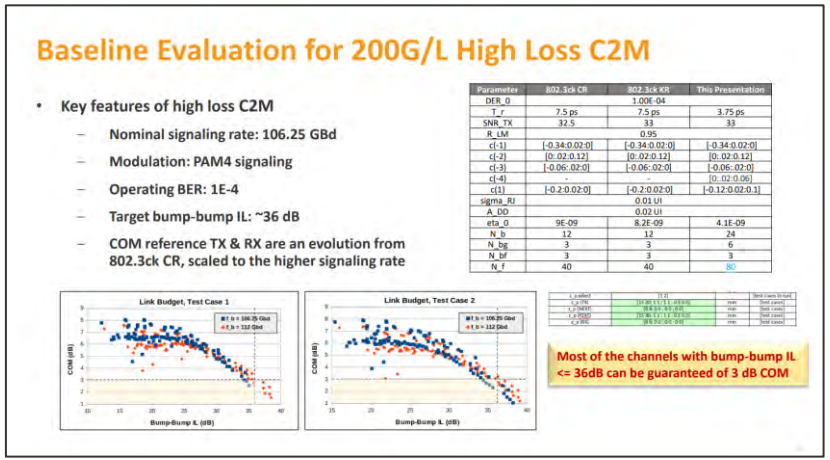
- **Kent Lusted, Intel**

Background

AUI C2M Spec	Target Loss	AUI BER	Ref TX/RX
Medium Loss	~22 dB	1E-5	802.3ck C2M-like + FLT
High Loss	~36 dB	1E-4	802.3ck CR-like

- Recap of lit_3dj_01a_230116 and lit_3dj_02a_230116





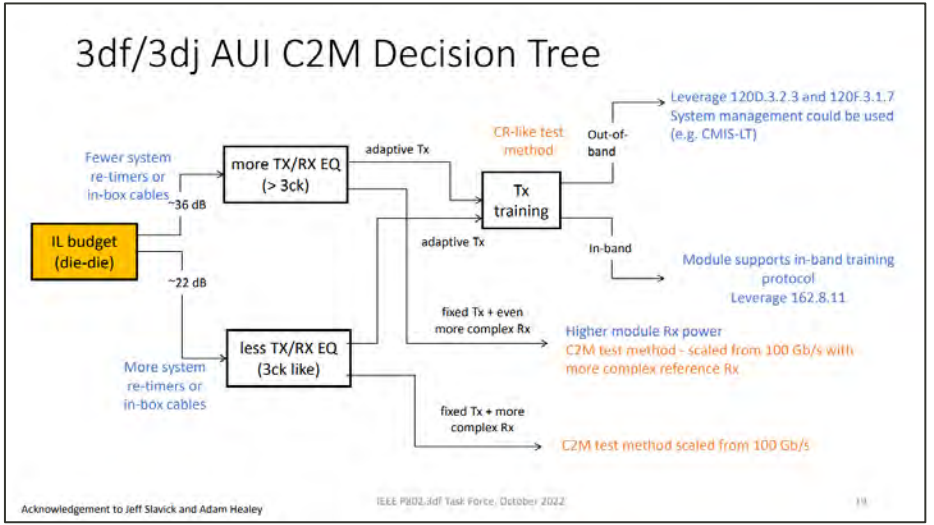
- Updates in response to the feedback, especially
  - AUI BER target: 1E-5/5E-5/1E-4?
  - Serdes capability: Evolution from 802.3ck C2M/CR? Float-tap (FLT) DFE? MLSE?
- This presentation aim to provide the achievable IL for different 802.3dj C2M candidates

3dj AUI C2M Directions

- FEC architecture
  - AUI interaction with optical PMDs development, as in brown_3dj_optx_adhoc_01a_230222 and he_3df_01_2211

FEC Type	AUI BER	Optical PMD BER
Type 1: End-to-end	1E-5	2.4E-4
Type 2: Concatenated	1E-5	3.0E-3
	5E-5	2.4E-3
Type 3: Segmented	1E-4	1.0E-4

Source: lusted_3df_01_220927



- Test methodology
  - CMIS-LT introduced in ghiasi_3dj_01_230116
  - 802.3ck C2M-like without link training
  - <This presentation> 802.3ck CR/KR-like with link training
- Reference transmitter and receiver
  - Medium loss C2M: 802.3ck C2M-like TX/RX
  - High loss C2M: 802.3ck CR-like TX/RX
  - shakiba_3dj_01_230116 proposed a method for incorporating MLSE effect and have been integrated into COM 4.0

COM Simulation Setting

- COM 4.0 used, COM spreadsheet in appendix
- 112 test channels, details in appendix
- Reference COM parameters: host-to-module
  - Host package length: [15, 30, 45] mm

Updates to lit_3dj_01a_230116 and lit_3dj_02a_230116 are highlighted in pink

Exploratory of 802.3dj Medium Loss C2M

Exploratory of 802.3dj High Loss C2M

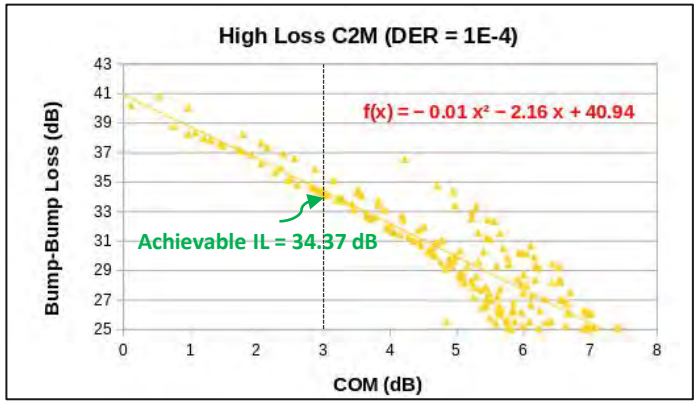
Parameter	802.3ck C2M	802.3ck CR	802.3ck KR	802.3ck C2M-like	802.3ck C2M-like + FLT	802.3ck CR-like	802.3ck CR-like + MLSE
DER_0	1E-5	1E-4	1E-4	1E-5/5E-5/1E-4	1E-5/5E-5/1E-4	1E-5/5E-5/1E-4	1E-5/5E-5/1E-4
SNR_TX	32.5	32.5	33	32.5	32.5	33	33
R_LM	0.95	0.95	0.95	0.95	0.95	0.95	0.95
TxFIR Length	4 (2 pre)	5 (3 pre)	5 (3 pre)	5 (3 pre)	5 (3 pre)	6 (4 pre)	6 (4 pre)
eta_0	4.10E-08	9E-09	8.2E-09	2.05E-08	2.05E-08	4.1E-09	4.1E-09
N_b	4	12	12	8	8	24	24
N_bg	0	3	3	0	3	6	6
N_bf	-	3	3	3	3	3	3
N_f	-	40	40	80	80	80	80
MLSE	0	0	0	0	0	0	1

- Compliance methodology in this presentation: 802.3ck CR-like test methodology
  - Die-die evaluation under the assumption of link training
  - We don't have a clear image of pass criterion at TP1a yet

Methodology Clarification

- **Achievable IL shown in this presentation**
  - Joint consideration of 3 host package lengths: z_p(TX) = [15, 30, 45] mm
  - COM target >= 3 dB
  - Medium loss C2M: 2nd order polynomial fitted to data with bump-bump IL <= 25 dB
  - High loss C2M: 2nd order polynomial fitted to data with bump-bump IL >= 25 dB

Example of High Loss C2M



As shown in lit_3dj_01a_230116 and lit_3dj_02a_230116, different impedance corners have been included in most of the test channels

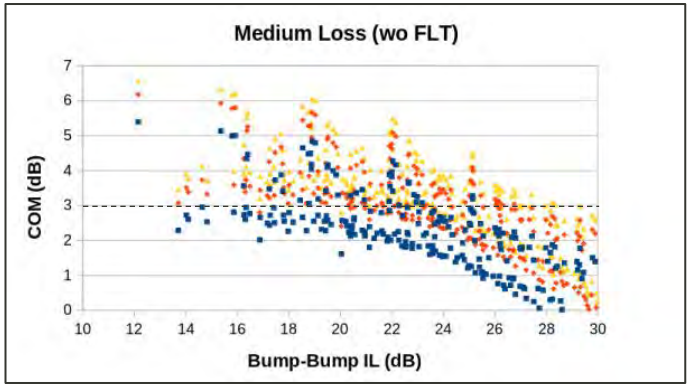
→ **Result in a conservative estimate of achievable IL due to severe reflection issue**

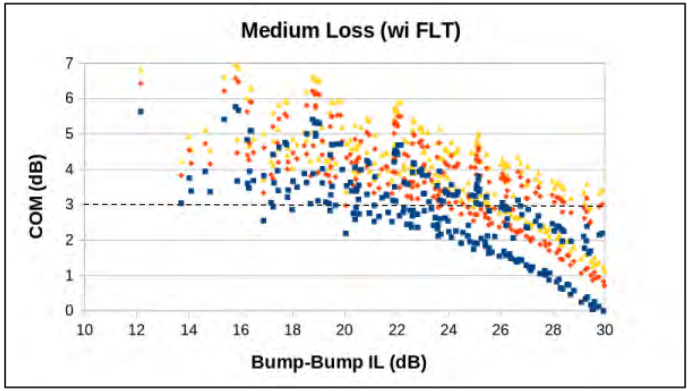
→ Further channel specifications required

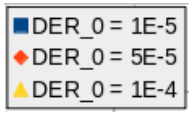
Achievable IL of Medium Loss C2M

DER_0	Reference TX & RX	Achievable IL
1E-5	802.3ck C2M-like	19.97
1E-5	802.3ck C2M-like + FLT	21.37
5E-5	802.3ck C2M-like	21.44
5E-5	802.3ck C2M-like + FLT	22.88
1E-4	802.3ck C2M-like	22.27
1E-4	802.3ck C2M-like + FLT	23.67

Evolution from 802.3ck C2M







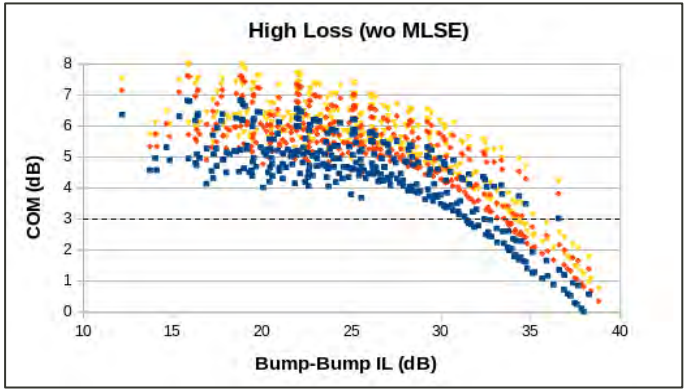
- **Concatenated FEC with AUI DER_0 = 5E-5 and float-tap DFE (FLT) can provide comparable loss tolerance for medium loss C2M**

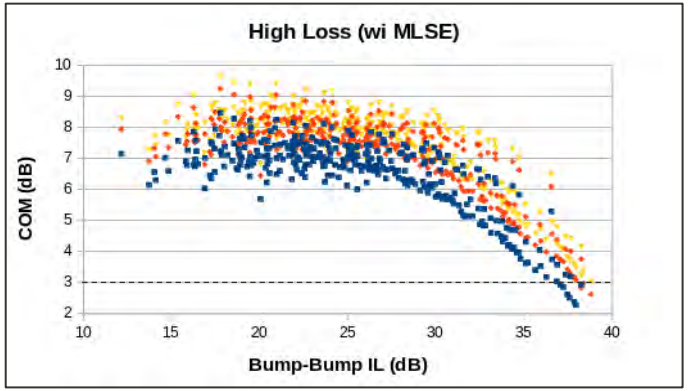
Achievable IL of High Loss C2M

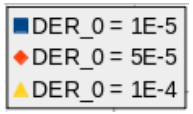
DER_0	Reference TX & RX	Achievable IL
1E-5	3ck CR/KR-like	31.75
1E-5	3ck CR/KR-like + MLSE	36.5
5E-5	3ck CR/KR-like	33.5
5E-5	3ck CR/KR-like + MLSE	38.13
1E-4	3ck CR/KR-like	34.37
1E-4	3ck CR/KR-like + MLSE	38.82

Evolution from 802.3ck CR

- Further relax DER_0 from 5E-5 to 1E-4 doesn't seem to help much
- MLSE can provide ~4.5 dB IL margin under 3dB COM
  - b_max (1) = 0.85

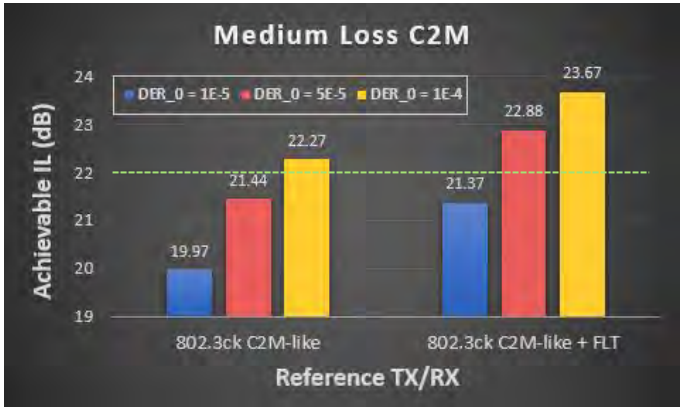


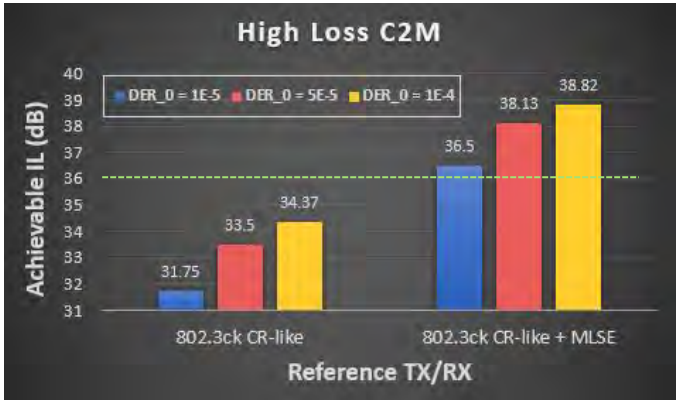




802.3dj C2M Candidates vs Achievable IL

- This presentation address C2M technical considerations from the perspective of achievable loss
  - Again, please be aware this is a **conservative estimate of achievable IL** due to the lack of channel compliance





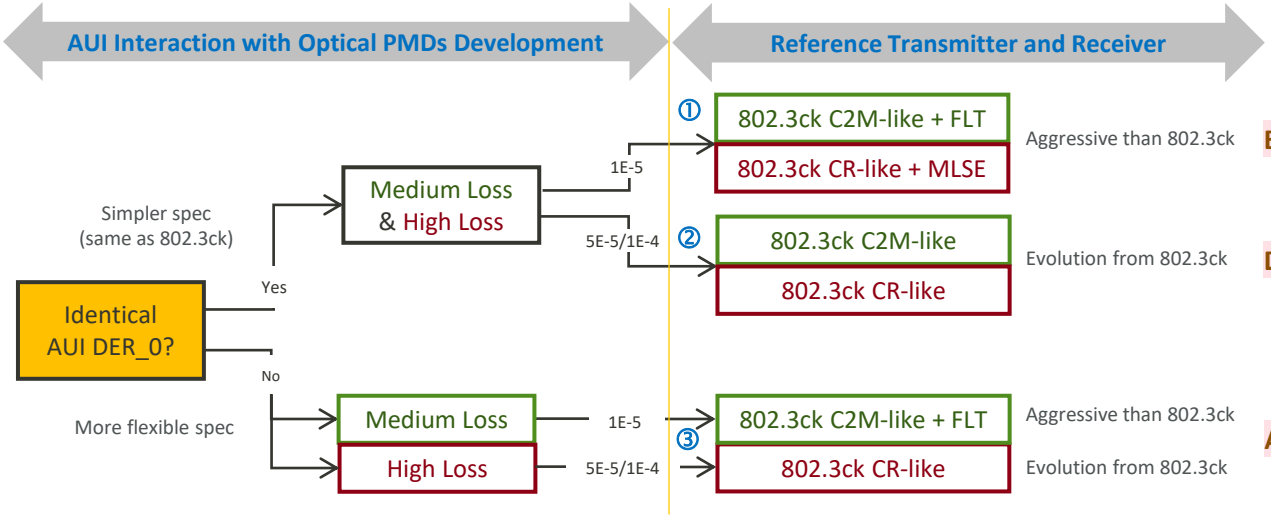
AUI interaction with optical PMDs development

Ref TX & RX

SerDes/AUI DER_0	1E-5	5E-5	1E-4
802.3ck C2M-like	19.97	21.44	22.27
802.3ck C2M-like + FLT	21.37	22.88	23.67
802.3ck CR-like	31.75	33.5	34.37
802.3ck CR-like + MLSE	36.5	38.13	38.82

Acknowledgements: Jeff Slavick (Broadcom), Adam Healey (Broadcom), and Kent Lusted (Intel)

3dj AUI C2M DER_0 Decision Tree



BER of 1E-5 for high loss C2M reasonable?

Decision of Type 2 concatenated FEC?

Any benefits from option 3?

Relax DER_0 target or more capable ref RX?

**Abbreviations*
High loss (HL) C2M
Medium loss (ML) C2M

Option	AUI DER_0 Target		Reference TX/RX		Pros	Cons
	Medium	High	Medium	High		
1	1E-5	1E-5	802.3ck C2M-like + FLT	802.3ck CR-like + MLSE	• More flexible for PMDs & FECs • Same configurations of PMDs & FECs for HL & ML C2M	• More power in AUI
2	5E-5	5E-5	802.3ck C2M-like	802.3ck CR-like	• Same configurations of PMDs & FECs for HL & ML C2M • Less power in AUI	• Stronger FECs and/or tighter PMD BER required
3	1E-5	5E-5	802.3ck C2M-like + FLT	802.3ck CR-like	• Relax FEC & PMD requirements for ML C2M	• Different configurations of PMDs & FECs for HL & ML C2M

Proposed Straw Poll

- To meet the high loss AUI C2M target of ~36 dB, I would prefer the approach of:
  - A) relax the DER_0 target (e.g., 1E-4)
  - B) more capable reference receiver (e.g., MLSE)
- A:, B:
- Pick one

Appendix

COM Spreadsheet for 200G/L Medium Loss C2M

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 2 3]		[test cases to run]
z_p (TX)	[15 30 45; 1 1 1 ; 1 1 1 ; 0.5 0.5 0.5]	mm	[test cases]
z_p (NEXT)	[8 8 8; 0 0 0; 0 0 0; 0 0 0]	mm	[test cases]
z_p (FEXT)	[15 30 45; 1 1 1 ; 1 1 1 ; 0.5 0.5 0.5]	mm	[test cases]
z_p (RX)	[8 8 8; 0 0 0; 0 0 0; 0 0 0]	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	[50 50]	Ohm	[TX RX]
A_v	0.413	V	vp/vf=
A_fg	0.413	V	vp/vf=
A_ne	0.45	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: .02:0.1]		[min:step:max]
c(-3)	[-0.06: .02:0]		[min:step:max]
c(1)	[-0.1:0.02:0.1]		[min:step:max]
N_b	8	UI	
b_max(1)	0.85		As/dffe1
b_max(2..N_b)	[0.3 0.3 0.2*ones(1,5)]		As/dfe2..N_b
b_min(1)	0.3		As/dffe1
b_min(2..N_b)	[0.05 0.05 -0.05*ones(1,5)]		As/dfe2..N_b
g_DC	[-13:1:0]	dB	[min:step:max]
f_z	42.5	GHz	
f_p1	42.5	GHz	
f_p2	106.25	GHz	
g_DC_HP	[-3:0.5:0]		[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

I/O control		
DIAGNOSTICS	0	logical
DISPLAY_WINDOW	0	logical
CSV_REPORT	0	logical
RESULT_DIR	.\results\CAKB_{date}\	
SAVE_FIGURES	0	logical
Port Order	[1 3 2 4]	
RUNTAG	CAKB_RCos_eval	
COM_CONTRIBUTION	0	logical
Operational		
ERL Pass threshold	10	dB
COM Pass threshold	3	db
DER_0	1.00E-05	
T_r	3.75E-03	ns
FORCE_TR	1	logical
PMD_type	C2C	
FW	1	
TDR and ERL options		logical
TDR	1	logical
ERL	1	logical
ERL_ONLY	0	ns
TR_TDR	0.01	
N	800	logical
TDR_Butterworth	1	
beta_x	0	
rho_x	0.618	
TDR_W_TXPKG	0	UI
N_bx	8	
fixture delay time	[0 0]	
Tukey Window	1	
Noise, jitter		UI
sigma_RJ	0.01	UI
A_DD	0.02	V^2/GHz
eta_0	2.05E-08	dB
SNR_TX	32.5	
R_LM	0.95	
Enforce Causality	1	
S-parameter magnitude extra	trend_to_DC	

Table 93A-3 parameters		
Parameter	**Setting**	**Units**
package_tl_gamma0_a1_a2	[0 0.0008455 0.000340225]	
package_tl_tau	0.006644805	ns/mm
package_Z_c	92 92 92; 70 70 70; 80 80 80; 100 100 100	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**
Selections (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	0	0 1 2 or 3 groups
N_bf	3	taps per group
N_f	80	UI span for floating tap
bmaxg	0.2	max DFE value for floa
Receiver testing		
RX_CALIBRATION	0	logical
Sigma_BBN step	5.00E-03	V

COM Spreadsheet for 200G/L High Loss C2M

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 2 3]		[test cases to run]
z_p (TX)	[15 30 45; 1 1 1; 1 1 1; 0.5 0.5 0.5]	mm	[test cases]
z_p (NEXT)	[8 8 8; 0 0 0; 0 0 0; 0 0 0]	mm	[test cases]
z_p (FEXT)	[15 30 45; 1 1 1; 1 1 1; 0.5 0.5 0.5]	mm	[test cases]
z_p (RX)	[8 8 8; 0 0 0; 0 0 0; 0 0 0]	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	[50 50]	Ohm	[TX RX]
A_v	0.413	V	vp/vf=
A_fe	0.413	V	vp/vf=
A_ne	0.45	V	
L	4		
M	32		
filter and En			
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:.02:0]		[min:step:max]
c(-4)	[0:.02:0.04]		[min:step:max]
c(1)	[-0.12:0.02:0.1]		[min:step:max]
N_b	24	UI	
b_max(1)	0.85		As/dffe1
b_max(2..N_b)	[0.5 0.3 0.3 0.2*ones(1,20)]		As/dfe2..N_b
b_min(1)	0.3		As/dffe1
b_min(2..N_b)	[0.2 0.05 0.05 -0.05*ones(1,20)]		As/dfe2..N_b
g_DC	[-20:1:0]	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

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	10	dB
COM Pass threshold	3	db
DER_0	1.00E-04	
T_r	3.75E-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	800	logical
TDR_Butterworth	1	
beta_x	0	
rho_x	0.618	
TDR_W_TXPKG	0	UI
N_bx	8	
fixture delay time	[0 0]	
Tukey_Window	1	
Noise, jitter		UI
sigma_RJ	0.01	UI
A_DD	0.02	V^2/GHz
eta_0	4.10E-09	dB
SNR_TX	32.5	
R_LM	0.95	
Enforce Causality	1	
S-parameter magnitude extrap	trend_to_DC	

Table 93A-3 parameters		
Parameter	**Setting**	**Units**
package_tl_gamma0_a1_a2	[0 0.0008455 0.000340225]	
package_tl_tau	0.00644805	ns/mm
package_Z_c	[92 92 92; 70 70 70; 80 80 80; 100 100 100]	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**
Selections (rectangle, gaussian,dual_rayleigh,triangle		
Histogram_Window_Weight	gaussian	selection
Qr	0.02	UI
CTLE 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	6	0 1 2 or 3 groups
N_bf	3	taps per group
N_f	80	UI span for floating taps
bmaxg	0.2	max DFE value for floati
Receiver testing		
RX_CALIBRATION	0	logical
Sigma_BBN step	5.00E-03	V

Channel List

- **Total of 112 test channels**

CH #	Source	Supporting Presentation
36	OSFP MSA	
21	akinwale_3df_01_2209	akinwale_3df_elec_01_220921
21	akinwale_3df_02_2209	
21	akinwale_3df_03_2209	
3	rabinovich_3df_01_2209	rabinovich_3df_elec_01b_220921
3	rabinovich_3df_02_2209	
5	tracy_3df_02_2211	tracy_3df_02_2211
1	rabinovich_3dj_02_230116	rabinovich_3dj_01_230116
1	rabinovich_3dj_03_230116	

Thank you

Questions and Discussions