Baseline Proposal for 200G/L High Loss C2M

Tobey P.-R. Li, Mau-Lin Wu

MediaTek

IEEE P802.3dj Task Force

2023/01/17

Outline

- Background and Introduction
- COM Link Budget Analysis for 200G/L High Loss C2M
- Main Challenges Facing 200G/L High Loss C2M
- Summary and Proposal

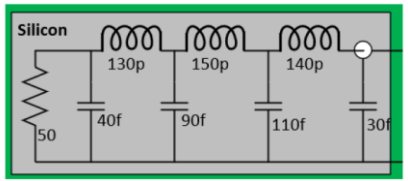
Background and Introduction

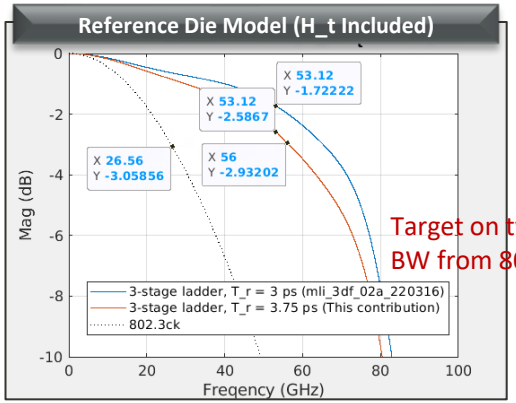
- Update to tli_3df_01b_220316 "COM Simulation and Analysis for 200Gbps/Lane Chip-to-Module " with
  - Updated device model based on mli_3df_02a_220316 & artsi_3df_01a_2211
  - More posted channels from 802.3df and OIF
  - Target on 200Gbps/L high loss C2M
  - Updated COM reference TX & RX, which are the evolution from 802.3ck CR
- This presentation provide the direction for high loss C2M specification
  - Based extensively on ran_3df_elec_01b_220921 and lusted_3df_02_2211 with more COM simulations to construct a complete baseline proposal
  - Analyze feasibility of target loss and operating DER
  - Analyze equalization solutions to pass COM
- The intention of this presentation is NOT to
  - Address specific type of chip-to-module interface
  - Address specific ASIC implementation
  - Address specific compliance methodology

COM Simulation Setting

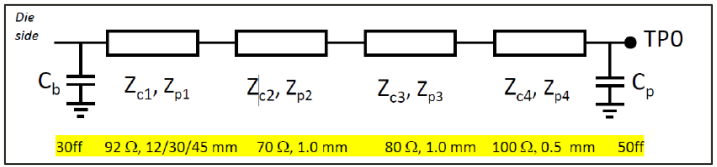
- Test methodology in this presentation: die-die evaluation for link budget analysis
- 112 test channels, details in appendix
- COM v3.90 adopted, COM spreadsheet in appendix
- Reference device model
  - Die model: mli_3df_02a_220316 except T_r = 3.75ps
  - Package model: artsi_3df_01a_2211

Parameter	Setting
C_d	[0.4e-4 0.9e-4 1.1e-4 ;0.4e-4 0.9e-4 1.1e-4]
L_s	[0.13 0.15 0.14; 0.13 0.15 0.14]
C_b	[0.3e-4 0.3e-4]
T_r	3.75E-03
z_p (TX)	[15 30; 1 1 ; 1 1 ; 0.5 0.5]
z_p (NEXT)	[8 8; 0 0 ; 0 0 ; 0 0]
z_p (FEXT)	[15 30; 1 1 ; 1 1 ; 0.5 0.5]
z_p (RX)	[8 8; 0 0 ; 0 0 ; 0 0]
C_p	[0.5e-4 0.5e-4]
package_tl_gamma0_a1_a2	[0 0.0008455 0.000340225]
package_tl_tau	0.00644805
package_Z_c	[92 92 ; 70 70; 80 80; 100 100]





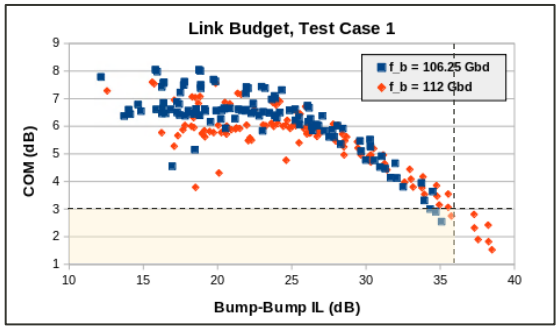
Target on twice of BW from 802.3ck

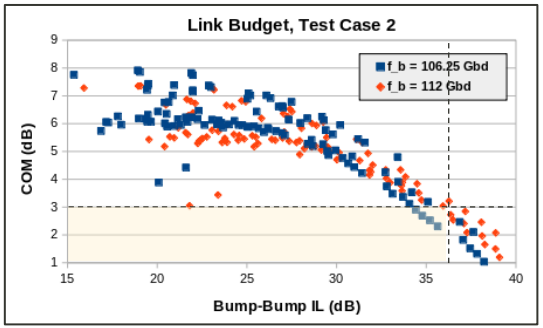


Baseline Evaluation for 200G/L High Loss C2M

- Key features of high loss C2M
  - Nominal signaling rate: 106.25 GBd
  - Modulation: PAM4 signaling
  - Operating BER: 1E-4
  - Target bump-bump IL: ~36 dB
  - COM reference TX & RX are an evolution from 802.3ck CR, scaled to the higher signaling rate

Parameter	802.3ck CR	802.3ck KR	This Presentation
DER_0	1.00E-04		
T_r	7.5 ps	7.5 ps	3.75 ps
SNR_TX	32.5	33	33
R_LM	0.95		
c(-1)	[-0.34:0.02:0]	[-0.34:0.02:0]	[-0.34:0.02:0]
c(-2)	[0:.02:0.12]	[0:.02:0.12]	[0:.02:0.12]
c(-3)	[-0.06:.02:0]	[-0.06:.02:0]	[-0.06:.02:0]
c(-4)	-	-	[0:.02:0.06]
c(1)	[-0.2:0.02:0]	[-0.2:0.02:0]	[-0.12:0.02:0.1]
sigma_RJ	0.01 UI		
A_DD	0.02 UI		
eta_0	9E-09	8.2E-09	4.1E-09
N_b	12	12	24
N_bg	3	3	6
N_bf	3	3	3
N_f	40	40	80



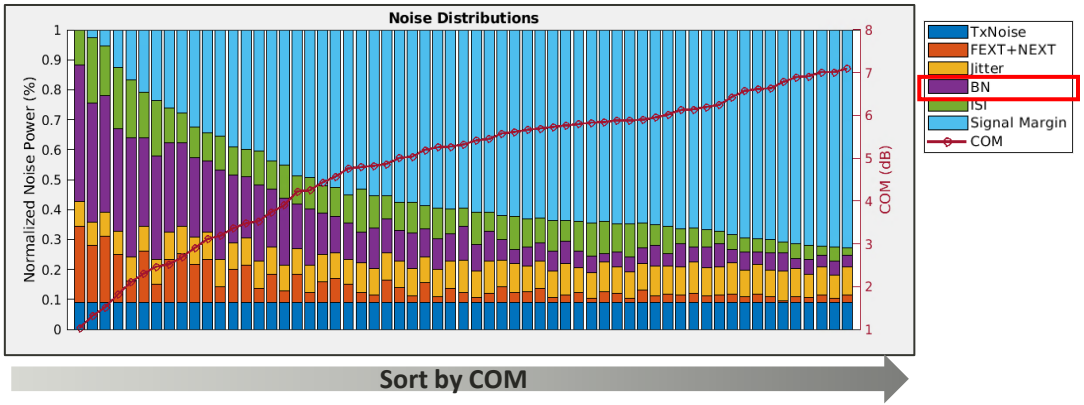


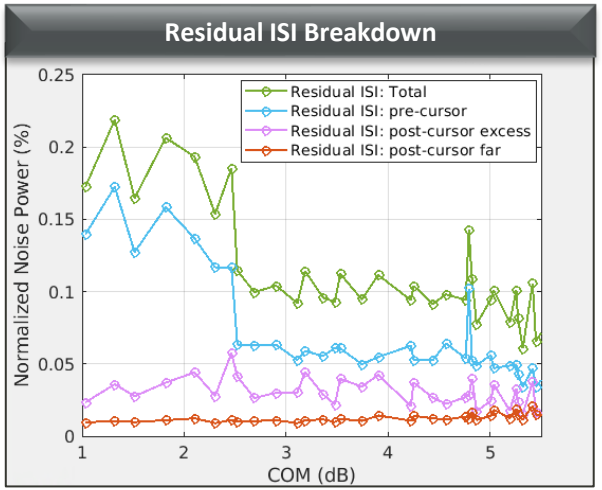
z_p select	[1 2]		[test cases to run]
z_p (TX)	[15 30; 1 1 ; 1 1 ; 0.5 0.5]	mm	[test cases]
z_p (NEXT)	[8 8; 0 0 ; 0 0 ; 0 0]	mm	[test cases]
z_p (FEXT)	[15 30; 1 1 ; 1 1 ; 0.5 0.5]	mm	[test cases]
z_p (RX)	[8 8; 0 0 ; 0 0 ; 0 0]	mm	[test cases]

Most of the channels with bump-bump IL <= 36dB can be guaranteed of 3 dB COM

Main Challenge of 200G/L High Loss C2M: Noise Enhancement

- **Noise distribution defined in 93A.1.6**





**Take test case 2 under baud-rate of 106.25GBd as example*
** Choose channels with bump-bump IL >= 25 dB*

- **Noise enhancement majorly impacts the link performance**
- **TxFIR is reluctant to mitigate pre-cursor due to signal swing reduction, especially for higher loss channels**

Summary and Proposal

- **Main challenge affect the feasibility of 200G/L high loss C2M**
  - **Noise enhancement**
  - **Residual pre-cursor ISI**
- **Baseline proposal for 200G/L high loss C2M**
  - **Operating BER: 1E-4**
  - **Target bump-bump IL: ~36 dB**
  - **COM reference TX & RX are an evolution from 802.3ck CR**

Parameter	802.3ck CR	802.3ck KR	Proposed Value for 200G/L High Loss C2M
DER_0	1.00E-04	1.00E-04	1.00E-04
SNR_TX	32.5	33	33
R_LM	0.95	0.95	0.95
TxFIR Length	5 (3 pre)	5 (3 pre)	6 (4 pre)
eta_0	9E-09	8.2E-09	4.1E-09
N_b	12	12	24
N_bg	3	3	6
N_bf	3	3	3
N_f	40	40	80

Appendix

COM Spreadsheet for 200G/L High Loss C2M

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]		[test cases to run]
z_p (TX)	[15 30; 1 1 ; 1 1 ; 0.5 0.5]	mm	[test cases]
z_p (NEXT)	[8 8; 0 0 ; 0 0 ; 0 0]	mm	[test cases]
z_p (FEXT)	[15 30; 1 1 ; 1 1 ; 0.5 0.5]	mm	[test cases]
z_p (RX)	[8 8; 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 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:.02:0]		[min:step:max]
C(-4)	[0:.02:0.06]		[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

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	33	
R_LM	0.95	
Enforce Causality	1	
S-parameter magnitude extrap	trend_to_DC	

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 ; 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	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

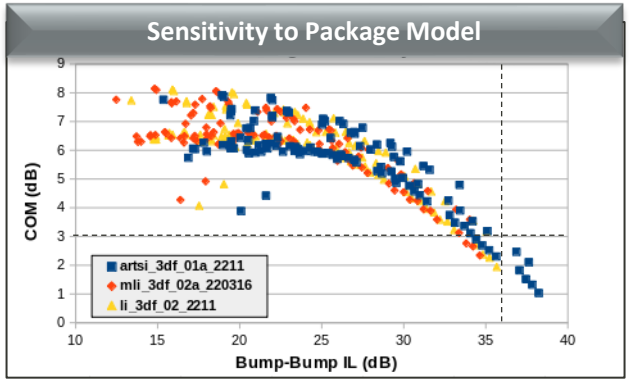
Channel List

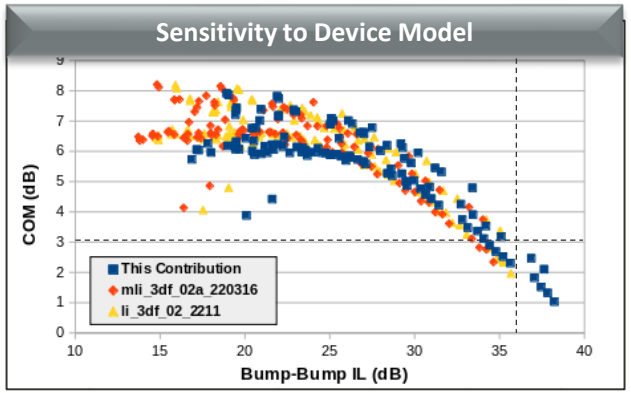
CH #	Source	Supporting Presentation	Contributor
36	OSFP MSA	OSFP 200GEL	Amphenol and Keysight
2	rabinovich_3df_022422	rabinovich_3df_01a_220224	Rick Rabinovich, Keysight
21	akinwale_3df_01_2209	akinwale_3df_elec_01_220921	Femi Akinwale, Intel
21	akinwale_3df_02_2209		
21	akinwale_3df_03_2209		
3	rabinovich_3df_01_2209	rabinovich_3df_elec_01b_220921	Rick Rabinovich, Keysight
3	rabinovich_3df_02_2209		
5	tracy_3df_02_2211	tracy_3df_02_2211	Nathan Tracy, TE Connectivity

Sensitivity to Device Model

- **Basically, device model makes less significant impact on bump-bump loss budget analysis**
- **ASIC capability will affect host reach and cause different levels of reflection**
  - **Further study needed**

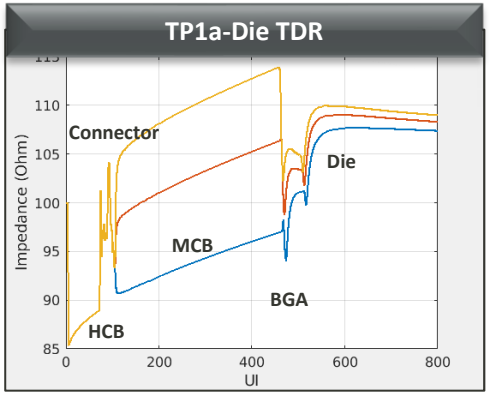
Parameter	This Presentation	mli_3df_02a_220316	li_3df_02_2211
C_d	[0.4e-4 0.9e-4 1.1e-4 ;0.4e-4 0.9e-4 1.1e-4]		
L_s	[0.13 0.15 0.14; 0.13 0.15 0.14]		
C_b	[0.3e-4 0.3e-4]		
T_r	3.75E-03	3E-03	3E-03
z_p (TX)	[15 30; 1 1 ; 1 1 ; 0.5 0.5]	[15 30; 1.8 1.8]	[15 30; 2.1 2.1]
z_p (NEXT)	[8 8; 0 0 ; 0 0 ; 0 0]	[8 8 ; 0 0]	[8 8 ; 0 0]
z_p (FEXT)	[15 30; 1 1 ; 1 1 ; 0.5 0.5]	[15 30; 1.8 1.8]	[15 30; 2.1 2.1]
z_p (RX)	[8 8; 0 0 ; 0 0 ; 0 0]	[8 8 ; 0 0]	[8 8 ; 0 0]
C_p	[0.5e-4 0.5e-4]	[0.4e-4 0.4e-4]	[0.6e-4 0.6e-4]
package_tl_gamma0_a1_a2	[0 0.0008455 0.000340225]	[0 0.00089 0.000155]	[0.0005 0.00089 0.0002]
package_tl_tau	0.00644805	0.006141	0.006141
package_Z_c	[92 92 ; 70 70; 80 80; 100 100]	[92 92 ; 70 70; 80 80; 100 100]	[92 92 ; 70 70; 80 80; 100 100]

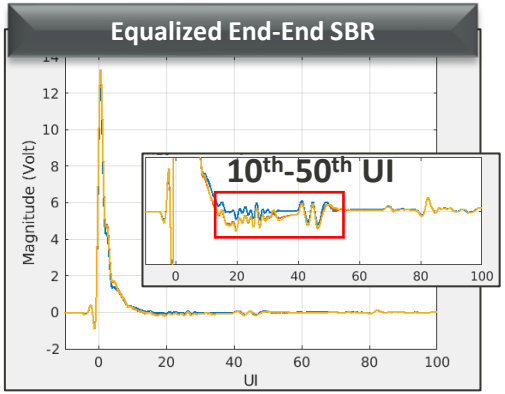


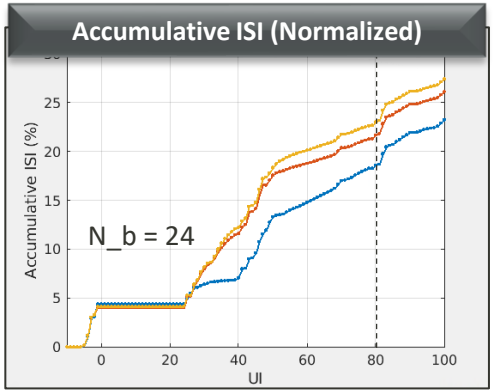


UI Span for Floating Tap: N_f

Channel	COM	Bump-Bump IL
85 Ohm	3.48 dB	33.13 dB
93 Ohm	3.74 dB	32.81 dB
100 Ohm	4.25 dB	32.73 dB







akinwale_3df_01_2209/85ohms/C2M_PCB_85ohms_25dB_202208016_v2
akinwale_3df_02_2209/93ohms/C2M_PCB_93ohms_25dB_202208016_v2/
akinwale_3df_03_2209/100ohms/C2M_PCB_100ohms_25dB_202208016_v2/

** Take test case 2 as example*
** 3 representative channels are selected*

- **Reflections due to inevitable mechanical transitions in channels, especially the transition to connector and package, are mainly located at 10th-50th UI for 30mm package**
- **Severe reflection region is up to 80th UI → N_f = 80**

Thank you

Questions and Discussions