

COM Simulation and Analysis for 200Gbps/Lane CR

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IEEE P802.3df Task Force

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Outline

Overview

- □ Link Budget Analysis for 200G/L PAM4 CR
- **Channel Feasibility: Key Challenges**
- **Galaxies SerDes Feasibility: COM Sensitivity to Key Parameters**
- **D** Modulation Type for 200G/L CR: PAM4 vs PAM6
- **Conclusion**



Motivation and Methodology

- Explore feasibility of 200G/L PAM4 CR
 - Channel & SerDes requirements?
- Analyze channel requirements based on COM v3.70 simulation
 - All available 200G CR channels from IEEE, OIF, & OSFP (total 73x)
 - Based on baseline SerDes
- Assess SerDes feasibility starting from COM sensitivity check with sweeping key SerDes parameters
 - Provide the directions to make good trade-off between performance & power/cost of SerDes
 - Allow the interoperability between channel & SerDes improvements
- Investigate modulation format for 200G/L CR comparing PAM4 & PAM6 under the assumption of identical transceiver capability



Objectives

• Do

- Leverage published channel materials to represent potential 200Gbase channel characteristics and evaluate their corresponding performance
- Analyze 200G/L CR feasibility from the system's point of view
- Point out key challenges of channel: roll-off characterizing impairments, reflection, & crosstalk
- Provide direction of next generation SerDes: COM sensitivity of key parameters
- Provide the baseline performance for candidate modulation formats
- Don't
 - Offer the SerDes or channel solutions
 - Draw conclusions on modulation type for 200G/L CR



CR Channel Profile

- Channel variations mainly come from
 - Host PCB length
 - Cable length, impedance, & AWG
 - Verticals (connector & BGA breakout region)
 - Crosstalk
- Total of 73 channels



Source	Contributor	LR Channels			
	Amphenol	• 0.5/1m 27AWG CA			
1. OSFP 200GEL	Amphenol	 1"-7" PCB at each side (92 Ohm, 1.3dB/in @56GHz) BGA breakout: parallel/orthogonal (no skew)/orthogonal 			
	Keysight	Crosstalk mainly comes from connector via			
2. mellitz_3df_01_220502	Samtec	 0.5/1m/1.5 27AWG CA (100Ohm target) 2"/5"/7.45" PCB at each side (1.6dB/in @53.125GHz) Termination: T-line (ideal)/SMA 1.0mm/SMA 1.85mm/via 28mm No crosstalk 			
3. oif2022.194.00	Samtec	 1/1.5m 28AWG CA (92.5 Ohm) Cable backplane with connector direct to package: 100/250 mm 34 AWG (92.5 Ohm) Direct to package connector (Cp and Zp2 set to zero) Crosstalk mainly comes from connector via 			
BGA breakout inclu in channel group 1	TP0 ded & 2 Host	TP5			
253.125 GHz 5 4.5					

The objective is to explore diverse channels to assess LR technology feasibility Channel IL: 16~42 dB FOM_ILD: 0.93~4.23 dB

COM Simulation Consideration: 200G Baseline

	Table 93A-1 parameters		And Anna Anna Anna Anna Anna Anna Anna A	1
Parameter	Setting	Units	Information	
f þ	106.25	GBd		
f_min	0.05	GHz	3	
Delta_f	0.01	GHz		
C_d	[0.7e-4 0.7e-4]	nF	[TX RX]	
L_S	[0.12.0.12]	ŋН	[TX RX]	1
C_b	[0.3e-4 0.3e-4]	nF	[TX RX]	
z_p select	[12]		[test cases to run	
z_p (TX)	[12 31; 1.8 1.8]	mm	[test cases]	
z_p (NEXT)	[12 29 ; 1.8 1.8]	mm	[test cases]	
z_p(FEXT)	[12 31; 1.8 1.8]	mm	[test cases]	11
z_p (RX)	[12 29 ; 1.8 1.8]	mm	[test cases]	
C_p ·	[0.87e-4 0.87e-4]	nF	[TX RX]	
R_O	50	Ohm		
R_d	[50 50]	Ohm	[TX RX]	
A_v I	0.413	٧		
A_fe	0,413	V		
A ne	0,608	V		
L	4		1	
M	32	amp/U	- 1	
samples_for_C2M	32	amp/U		
T_0	0	mŲI		
AC_CM_RMS	0	V	[test cases]	0.0235 0.0256
	filter and Eq		-	1
f f	0.75	*fb		
c(0)	0.5		min	
c(-1)	[-0.4:0.02:0.04]		[min:step:max]	
c(-2)	[-0.1:0.02:0.2]		[min:step:max]	
c(-3)	[-0.1:0.02:0.1]		[min:step:max]	
c(1)	[-0.2:0.02:0.1]	1	[min:step:max]	
N_b	24	U		
b_max(1)	0.85		As/dffe1	
b_max(2N_b)	[0.5 0.3 0.3 0.2 "ones(1,20)]		As/dfe2,.N_b	
b_min(1)	0.3		As/dife1	
b min(2N b)	0.2 0.05 0.05 -0.03 ones(1.20)		As/dfe2N b	
g DC 🔳	[-20:1:-2]	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		
G Qual	[-2 -20; -2 -20; -2 -20; -2 -20]	dB	ranges	
G2 Qual	10-1-2-61	dB	ranges	

1	/O control	· · · · · ·	Table 93A-3 parameters				
DIAGNOSTICS	1	logical	Parameter	Setting	Units		
DISPLAY_WINDOW	0	logical	package_tl_gamma0_a1_a2	[0.0.000644085 0.00018018]			
CSV_REPORT	0	logical	package_tl_tau	5.700E-03	ns/mm		
RESULT_DIR	.)results\100GEL_	C2M_host_{da	package_Z_c	[87.5 87.5 ; 92.5 92.5]	Ohm		
SAVE_FIGURES	0	logical		ICN & FOM_ILD parameters			
Port Order	[1324]		f_v	0.594	*Fb		
RUNTAG	CR_eval		ff	0.594	<hz colum<="" f_r="" first="" in="" specified="" td=""></hz>		
COM_CONTRIBUTION	0	logical	f_n	0.594	GHz		
Local Search	2		f_2	80	GHz		
0	perational		A_ft	0,600	V		
VEC Pass threshold	12	db	A_nt	0.600	V		
EH_min	10	mV					
ERL Pass threshold	9.5	dB					
Min_VEO_Test	0	mV ·	Histogram_Window_Weight	gaussian	Seletions (rectangle, gaussia		
DER_0	0.0001		A STATE STATE AND				
U	0.0037496470588	ns					
FORCE_TR	1	logical	COM Pass threshold	3			
D1 (D)	CD.	and the second s	the real sector sector and the sector of the				

- **Die model** : keep the similar IL as 100G (parameters need further investigation) **PKG model**: 25% trace loss improvement from 100G, follows the values proposed in oif2021.596.01 (parameters need further investigation)
- **RXEQ length/rise time/jitter/RX noise PSD** scaled with 2x baud rate
- DER/TX swing/TX SNR/Nonlinearity/TXEQ length kept the same as 100G
- COM version: 3.70
- Test case (TC) 1 (short package): [z_p (TX) z_p (RX)] = [12 12] mm
- TC 2 (long package) : [z_p (TX) z_p (RX)] = [31 29] mm

Sigma BBN step	5.00E-03	V	
N	oise, jitter		
sigma_RJ	0.01	Ų	
A_DD	0.02	Ų	
eta_0	4.10E-09	V^2/GHz	
SNR TX	33	dB	
R_LM	0.95	-	

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Link Budget Analysis for 200G/L PAM4 CR

- Whole link budget analysis
 - To allow the interoperability among channel components & point out the design challenges
 - Currently the group don't have consensus in package model \rightarrow bump-to-bump IL target is evaluated instead of ball-to-ball IL target
 - Analyze performance from the system's point of view
- Whether 200G/L PAM4 CR works?
 - If keep the same IL target from 100G to 200G: bump-to-bump IL ~ 36.5 dB (28.5dB ball-to-ball + 8 dB PKG in 802.3ck)
 - If make SerDes capability aligned from 100G to 200G



Channel Feasibility: ILD

*wo crosstalk

- Resonances characterizing impairments in next generation have been discussed in <u>noujeim_3df_01_220224</u>
- Vertical transition
 - Connector footprint
 - BGA breakout region
 - ightarrow Can cause multiple reflections
 - \rightarrow Need more banks of floating taps
- Impedance mismatch
 - Connector-BGA breakout
 - Channel-package
 - → Reflection issue have been investigated in 802.3ck
- → Length of DFE/floating tab used to compensate reflections is twice of that for 100G/L CR



Noise Distribution (wo Crosstalk)

litter ΒN

ISI

- COM

*Channels with FOM_ILD_wi_PKG <= 2

- Basically, performance is limited by noise enhancement with increasing IL
- **Reflection-induced residual ISI can** further degrade COM





Channel Feasibility: Crosstalk

- Crosstalk Impact
 - Crosstalk can degrade COM up to ~2dB at IL of interest



 Insertion-loss-to-crosstalk ratio (ICR) of test channels: 10.5 dB ~ 22 dB • Link budget analysis (wo crosstalk)



• Crosstalk limit: ICR >= 25 dB?



Sensitivity to Transceiver Capability: A_v & SNR_TX

Sensitivity to A_v (TC2) Sensitivity to A_v (TC1) A v Scale Factor = 1.25 1.4 1.4 1.4 1.2 1.2 1.2 TC1 TC2 1 1 dCOM (dB) dCOM (dB) dcom (dB) 0.8 0.8 0.6 0.6 0.4 0.4 0.4 A v: 0.413 \rightarrow 0.51625 0.2 0.2 0.2 COM: ~0.65 dB gain 0 01 0 20 35 40 1.05 1.1 1.15 1.2 1.25 1.05 1.2 25 30 1.1 1.15 1.25 1 Bump-to-Bump IL (dB) A v Scale Factor A v Scale Factor

* Baseline: A v scale factor = 1 (A v = 0.413 V)

* Baseline: SNR TX = 33 dB





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Increased A v can help to enlarge signal margin

Concern: Linearity & power consumption

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Sensitivity to Transceiver Capability: Jitter



* Baseline: A DD = 0.02

* Baseline: Sigma_RJ = 0.01



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Sensitivity to Transceiver Capability: eta_0 & f_r



Sensitivity to Transceiver Capability: b_max (1)

*Baseline: b_max (1) = 0.85



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• More flexible DFE coefficient range

- Beneficial for longer channels due to less noise enhancement induced by CTLE
- Can help near-main cursor reflections (induced by roll-off)
- Concern: error propagation



Summary: Sensitivity to Transceiver Capability

• Average COM gain obtained by SerDes enhancement

• Based on TC2 & target bump-to-bump IL = 36.5 dB

	Changes from Baseline	Improvement	COM Gain
A_v	0.413 → 0.51625	25% increased	0.65 dB
SNR_TX	33 → 35	25% increased	0.18 dB
A_DD	0.02 → 0.016	20 % decreased	0.15 dB
Sigma_RJ	0.01 → 0.008	20 % decreased	0.04 dB
eta_0	4.1E-9 → 3.28E-9	20 % decreased	0.30 dB
f_r	0.75 → 0.5		0.00 dB
b_max (1)	0.85 → 1	17% increased	0.45 dB

- Potential ways to improve the reach of 200G/L CR
 - Increase $A_v \rightarrow$ Further investigation in linearity & power consumption required
 - Increase b_max (1) \rightarrow Advanced RX technology can help the problem of error propagation?
 - Enhance eta_0 \rightarrow It's very challenging to further improve RX noise



PAM4 vs PAM6 (wo Crosstalk)

- Assumptions: Identical transceiver capability for both PAM4 & PAM6
 - Identical impairments (absolute values of rise time, jitter, & RX noise)
 - Identical equalizer length

SNR penalty (PAM4 → PAM6)	1E-4	1E-5	1E-6
PAM4	18.23	19.46	20.42
PAM6	21.81	23.06	24.04
SNR Penalty (dB)	3.58	3.6	3.62



dCOM = COM(PAM6) - COM(PAM4)







PAM4 vs PAM6 (wo Crosstalk)

- PAM4 shows the better overall performance under
 - Bump-to-bump IL @ 53.125 GHz <= 36.5 dB</p>
 - Channel bandwidth is sufficient (FOM_ILD_wi_PKG <= 2)
- PAM6 outperform PAM4 when channel loss increases
- Channels with limit bandwidth enjoy higher performance gain when moving from PAM4 to PAM6



PAM4 vs PAM6 (wi Crosstalk)

- Crosstalk has a high-pass frequency response in general
- If signals can no longer maintain sufficient isolation, PAM6 gains a competitive advantage
- Required channel specifications as considering backward compatibility with 100G/L modulation format
 - BW/Reflection-related requirement: ILD <= 2dB?
 - Crosstalk requirement: ICR >= 25 dB?





Conclusions of 200G/L CR

- Feasibility of 200G/L PAM4 CR requires both channel and SerDes technology enablement
 - Based on potential reach: bump2bump IL ~36.5 dB
- Channel feasibility and the potential directions for channel design were explored
 - FOM_ILD_wi_PKG <= 2dB</p>
 - ICR >= 25 dB
- SerDes feasibility started with the sensitivity check of key parameters, and the potential solutions to achieve 200G/L PAM4 CR were observed
 - Increased TX swing under proper assessment of linearity & power consumption
 - More flexible DFE coefficient range with advanced RX technology
- Baseline performance of PAM4 & PAM6 was compared under the assumption of identical transceiver capability
 - PAM4 can outperform PAM6 under the well-qualified channel conditions



Further discussion

- Whether 36.5 dB bump-to-bump IL target can meet the 200G/L CR objective with 1 m cable reach?
- Potential approaches to extend bump-to-bump IL target
 - Further SerDes enhancement, e.g., increased A_v & b_max(1)
 - Advanced RX technology, e.g., MLSD
 - PAM6



APPENDIX



Sensitivity to Transceiver Capability

*Remove channels with ILD > 2

Bump-to-Bump IL (dB)

22

Minor changes in performance trend and the ulletresulting values when removing channels with FOM_ILD_wi_PKG > 2

	Changes from Baseline	Improvement	COM Gain
A_v	0.413 → 0.51625	25% increased	0.66 dB
SNR_TX	33 → 35	25% increased	0.22 dB
A_DD	0.02 → 0.016	20 % decreased	0.17 dB
Sigma_RJ	0.01 → 0.008	20 % decreased	0.04 dB
eta_0	4.1E-9 → 3.28E-9	20 % decreased	0.32 dB
f_r	0.75 → 0.5		0.04 dB
b_max (1)	0.85 → 1	17% increased	0.45 dB

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Bump-to-Bump IL (dB)

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COM Spreadsheet: PAM6

Parameter Setting Units Information DIAGNOSTICS 1 logical Parameter Setting Units 1 b <th></th> <th>Table 93A-1 parameters</th> <th></th> <th></th> <th></th> <th colspan="3">1/O control</th> <th></th> <th colspan="3">Table 93A-3 parameters</th>		Table 93A-1 parameters				1/O control				Table 93A-3 parameters		
I b B2.2062215373401 CBd DISPLAY_WINDOW 0 logical package_tig_amma0_a1_a2 (00.000644085 0.00018018) f_min 0.05 GHz CSV_REPORT 0 logical package_tig_amma0_a1_a2 (00.000644085 0.00018018) Defta_f 0.01 GHz CSV_REPORT 0 logical package_tisa 5.700E-03 ms/mm C_d (0.7e-40.7e-4) nE [TX RX] RESULT_DIR /vesuits\100GEL_C2M_host_(date) package_T_c (B7.5 87.5 ; 92.5 92.5) Ohm C_d (0.7e-40.7e-4) nE [TX RX] SAVE_FIGURES 0 logical package_T_c (B7.5 87.5 ; 92.5 92.5) Ohm C_d (0.7e-40.7e-4) nE [TX RX] SAVE_FIGURES 0 logical f.v 0.767 (B4.7 5 ; 92.5 92.5) Ohm C_s (0.120.12) ng6 [TX RX] PortOrder [13.24] f.v 0.767 GHz f_rspecified in first col c_s placed [12] (lest cases to run) COM_CONTRIBUTION 0 logical <th>Parameter</th> <th>Setting</th> <th>Units</th> <th>Information</th> <th></th> <th>DIAGNOSTICS</th> <th>1</th> <th>logical</th> <th>Parameter</th> <th>Setting</th> <th>Units</th>	Parameter	Setting	Units	Information		DIAGNOSTICS	1	logical	Parameter	Setting	Units	
f_min 0.05 GHz CSV_REPORT 0 logical package_fitau 5.700E-03 ms/mm Delta_f 0.01 GHz RESULT_DIR \vesults\100GEL_C2M_host_[date) package_f_c [87.5 87.5 ; 92.5 92.5] Ohm C_d [0.7e-40.7e-4] nf. [TX RX] SAVE_FIGURES 0 logical ICN & FOM_ID parameters L_s [0.12 0.12] nfd [TX RX] Port Order [1324] f_v 0.767 GHz rspecified in first col C_b [0.3e+40.3e-4] nf. [TX RX] Port Order [1324] f_f 0.767 GHz rspecified in first col z_p select [1.2] [testcases to run] COM_CONTRIBUTION 0 logical f_n 0.767 GHz rspecified in first col z_p (TX) [1231; 1.81.8] mm [testcases] Local Search 2 f_2 80 GHz z_p (NEXT) [1229; 1.81.8] mm [testcases] Operational A_ft 0.600 V z_p (FEXT) [1231; 1.81.8]	Lb 📕	82.2062215373401	CBd			DISPLAY_WINDOW	0	logical	package_tl_gamma0_a1_a2	[0.0.000644085 0.00018018]		
Detta_f 0.01 GHz RESULT_DIR \results\100GEL_C2M_host_[date) package_Z_c [87.5 87.5 ; 92.5] Ohm C_d [0.7e-40.7e-4] nF [TX RX] SAVE_FIGURES 0 logical IQN & FOM_ILD parameters L_s [0.120.12] nfd [TX RX] Port Order [13.24] f_v 0.767 GHz f_rspecified in first col C_b [0.3e-40.3e-4] nF [TX RX] RUNTAC CR eyal f_f 0.767 GHz f_rspecified in first col z_p select [12] [test cases to run] COM_CONTRIBUTION 0 logical f_n 0.767 GHz f_rspecified in first col z_p (TX) [1231; 1.81.8] mm [test cases] Local Search 2 f_2 80 GHz z_p (FEXT) [1229; 1.81.8] mm [test cases] Operational A_ft 0.600 V	f_min	0.05	GHz			CSV_REPORT	0	logical	package_tl_tau	5.700E-03	ng/mm	
C_d [0.7e-40.7e-4] nF [TX RX] SAVE_FIGURES 0 logical IQN & FOM_ILD parameters L_s [0.120.12] nfd [TX RX] Port Order [13.24] f_v 0.767 "Fip C_b [0.3e-40.3e-4] nF [TX RX] RUNTAC CR exal f_f 0.767 "Fip c_p select [12] [test cases to run] COM_CONTRIBUTION 0 logical f_n 0.767 GHz f_r specified in first col z_p select [12] [test cases to run] COM_CONTRIBUTION 0 logical f_n 0.767 GHz z_p (TX) [12.31; 1.8.1.8] mm [test cases] Local Search 2 f_2 80 GHz z_p (NEXT) [12.29; 1.8.1.8] mm [test cases] Operational A_ft 0.600 V z_p (FEXT) [12.31; 1.8.1.8] mm [test cases] VEC Pass threshold 12 db A_nt 0.600 V	Detta f	0.01	GHz			RESULT_DIR	.\results\100GEL_C2	M_host_{date}	package_Z_c	[87.5 87.5 ; 92.5 92.5]	Ohm	
Ls [0.12.0.12] ngl [TX RX] Port Order [1.3.2.4] f_V 0.767 "Fb C_b [0.3e-4.0.3e-4] nf. [TX RX] RUNTAG CR exal f_f 0.767 "Fb c_p select [1.2] [test cases to nun] COM_CONTRIBUTION 0 logical f_n 0.767 GHz f_r specified in first co z_p (TX) [12.31; 1.8.1.8] mm [test cases] Local Search 2 f_2 80 GHz z_p (NEXT) [12.29; 1.8.1.8] mm [test cases] Operational A_ft 0.600 V z_p (FEXT) [12.31; 1.8.1.8] mm [test cases] VEC Pass threshold 12 db A_nt 0.600 V	Cd	[0.7e-40.7e-4]	nF	[TX:RX]		SAVE_FIGURES	0	logical	1	ICN & FOM_ILD parameters		
C_b [0.3e+0.3e+1] nF [TX RX] RUNTAC CR eyal f_f 0.767 GHz f_r specified in first on z_p select [12] [test cases to run] COM_CONTRIBUTION 0 logical f_n 0.767 GHz f_r specified in first on z_p (TX) [1231; 1.81.8] mm [test cases] Local Search 2. f_2 80 GHz z_p (NEXT) [1229; 1.81.8] mm [test cases] Operational A_ft 0.600 V z_p (FEXT) [1231; 1.81.8] mm [test cases] VEC Pass threshold 12 db A_ft 0.600 V	Ls	[0.12 0.12]	nH	[TX RX]		Port Order	[1324]		f v	0.767	*Fb	
z_p select [12] [test cases to nun] COM_CONTRIBUTION 0 logical f_n 0.767 GHz z_p (TX) [1231; 1.81.8] mm [test cases] Local Search 2 f_2 80 GHz z_p (NEXT) [1229; 1.81.8] mm [test cases] Operational A_ft 0.600 V z_p (FEXT) [1231; 1.81.8] mm [test cases] VEC Pass threshold 12 db A_nt 0.600 V	C_b	[0.3e-4 0.3e-4]	nF	[TX RX]		RUNTAG	CR eyal		t f	0.767	GHz f_r specified in first column	
z_p (TX) [12 31; 1.8 1.8] mm [test cases] Local Search 2 f_2 80 GHz z_p (NEXT) [12 29; 1.8 1.8] mm [test cases] Operational A_ft 0.600 V z_p (FEXT) [12 31; 1.8 1.8] mm [test cases] VEC Pass threshold 12 db A_ft 0.600 V	z_p select	[12]		[test cases to run]		COM CONTRIBUTION	0	logical	t_n	0.767	GHz	
z_p (NEXT) [12 29; 1.8 1.8] mm (test cases) Operational A_ft 0.600 V z_p (FEXT) [12 31; 1.8 1.8] mm (test cases) VEC Pass threshold 12 db A_ft 0.600 V	z_p(TX)	[12 31; 1.8 1.8]	mm	[test cases]		Local Search	2		1_2	80	GHz	
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	z_p(FEXT)	[12 31; 1.8 1.8]	mm	[test cases]		VEC Pass thre shold	12	db	Ant	0.600	v	
z_p (RX) [12.29; 1.8 1.8] mm (test cases) EH_min 10 mV	z_p (RX)	[12 29; 1.8 1.8]	mm	[test cases]		EH_min	10	Vm				
C_p ■ [0.87e-40.87e-4] oF [TX/RX] BRLPass threshold 9.5 dB	C.p.	[0.87e-4 0.87e-4]	nF	[TX:RX]	14	ERL Pass threshold	9.5	dB			The second se	
R_0 50 Ohm Min_VEQ_Test 0 mV Histogram Window_Weight gaussian Selections (rectangle, gaussi	R_Q	50	Ohm			Min_VEO_Test	0	 Vm 	Histogram Window Weight	gaussian	Seletions (rectangle, gaussian, du:	
R_d [50 50] Ohm [TX RX] DER_0 0.0001	R_d	[50 50]	Ohm	[TX RX]		DERO	0.0001					
A_v 0.413 V 0.0037496470588 re	A.v.	0.413	V		1	T _i r	0.0037496470588	ne -				
A fg 0.413 V FORCE_TR 1 logical COM Pass threshold 3	A fe	0.413	-V			FORCE_TR	1	logical	COM Pass threshold	3		
A_ng 0.608 V PMD_fype CR	A_ne 📕	0.608	V			PMD type	CR					
BREAD_CRUMBS 0 logical	L L	Ó			1	BREAD_CRUMBS	0	logical	1			
M 32 Samp/U SAVE_CONFIG2MAT 1 logical Floating Tap Control	M	32	Samp/U		1.	SAVE CONFIG2MAT	1	logical		Floating Tap Control		
samples for C2M 32 Samp/U PLOT_CM 0 logical N_bg 3 012 or 3 groups	samples for C2M	32	Samp/U			PLOT CM	0	logica1	N_bg	3	012 or 3 groups	
T_O 0 mU TDR and ERL options N_bf ó taps per group	T O	0	mU			TDB	and ERL options		N_bf	á	taps per group	
AC_CM_RMS 0 V [test cases] [0.0235 0.0256] TDR 1 logical N_f 80 U[span for floating tap	AC CM RMS	0	V	[test cases]	[0.0235 0.0256]	TDR	1	logical	N_f	80	Ul span for floating taps	
filter and Eg ER 1. logical britans 0.2 max DFE value for ficialing		filter and Eq.	-			ERL	1	logical	bmaxg	0.2	maxDFE value for floating taps	
f_r 0.75 'fb EBL ONLY 0 logical	tr 📲	0.75	'fb			ERL ONLY	0	logical				
c(0) 0.5 min TR TDR 0.00645936511945 rg	e(0)	0.5	-	min		TR_TDR	0.00645936511945	TŞ.				
c[-1] [-0,4:0.02:0.04] [ministep:max] N 3500	c(-1)	[-0,4:0.02:0.04]		[min:step:max]		N	3500		1			
c[-2] [-0.1:0.02:0.2] [min:step:max] beta_x 0	c(-2)	[-0.1:0.02:0.2]		[min:step:max]		beta_x	0					
c[-3] [-0.1:0.02:0.1] [min:step:max] nho_x 0.618	c(-3)	[-0.1:0.02:0.1]	-	[min:step:max]		x_orh	0.618					
c(1) □ [-0.2:0.02:0.1] [min:step:max] fixture delay time □ [0:0] [port1 port2]	c(1)	[-0.2:0.02:0.1]		[min:step:max]		fixture delay time	[0 0]	[port1 port2]				
	N_b	24	U		1	TOR W_TXPKG	0		1			
b_max(1) 0,85 As/dffe1 N_bx 0 U	b_max(1)	0,85		As/dffe1		N_bx	0	UI .				
b_max(2N_b) (0.503.0.30.2" ones(1.20) As/dife2N_b Tukey_Window 1.	b_max(2N_b)	[0.503.0.30.2" ones(1,20)]		As/dfe2:.N_b		Tukey Window	1					
b min[1] As/dfiel Receiver testing	b min(1)	0.3		As/dffe1		Re	ceiver testing					
b mini2_N bi = 10 20 050 05-0 02 area(1 20) T As/die2_N b = RX CAUBRATION 0 korical	b mint2.N bl	10 20 050 05-0 031 ones[1 20] 1		As/dfe2N b		RX CALIBRATION	0	logical				
P DC	g DC	1-20:1:-21	dB	[min:step:max]		Sigma BBN step	5.00E-03	V				
1 z 22.882488614936 CWz Noise, jitter	12	37.882488614936	CHtz			- AC - I	Noise, litter					
01 22,862488614936 OW Cma R 0.00773705614469 U	[p1	32.882488614936	CHtz			sima Ri	0.00773705014409	U				
F p2 82,20622153/3401 OHz A DD 0.01547411228938 U	f p2	82.2062215373401	OHz			A DD	0.01547411228958	U	-			
g DC HP [-6(10) [min;step;max] ofa 0 5,00E-09 V^2/OH2	g DC HP	[-6:1:0]		[min:step:max]		eta 0	5.30E-DV	VA2/CH2				
1 HP P2 102767776921675 CHz SNR TX 33 dB	I HP PZ	1.02757776921075	CHtz			SNR TX	33	dB				
R. LM 0.95						R LM	0.95				1	

PAM4 vs PAM6 (wo Crosstalk)





PAM4 vs PAM6 (wi Crosstalk)





THANK YOU

