100G CR End-to-End Channel Analysis Update (II)

Jane Lim, Arturo Pachon, Pirooz Tooyserkani

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Contributors

- Alex Haser, Molex

- Scott Sommers, Molex

- Tom Palkert, Molex

- CheeKit Chew, Molex

- Ayman Isaac, Molex

- Vivek Shah, Molex

- Xiang Fang, Cisco

- Rockwell Hsu, Cisco

- Wei Yao, Cisco

- Upen Reddy Kareti, Cisco

100G CR End-to-End Channel Model - Updated

- At July Vienna meeting, lim_3ck_01_0719 analyzed worst case 2m cable model with end-to-end loss upto 29 dB

  - Data shows fail to pass 3dB COM

- This presentation revisits the 2m cable channel with the following changes:

  - ASIC RX FP NEXT further improvement

  - Max cable model loss reduced from 20.0 dB to 19.75 dB (TP1 – TP4)

  - Host PCB loss is reduced from 7.0 dB to 6.875 dB at both ends

  - New target end-to-end channel loss - 28.5 dB

- The mated cable models used in the analysis is simulation based, generated at worst case manufacturing condition

- Use latest COM scripts 2.70, see backup slides for COM configs

End-to-End Channel Model Overview

- Host PCB stack-up is 30 layers, 150mil thick, with Meg7 material

- Host PCB via stub length is modelled as 7mil

- Diff pair trace width/spacing is 4.5mil/8.5mil

- ASIC package BGA footprint is extracted in HFSS using the same PCB stack-up

- 16 pairs (8 Tx, 8 Rx) QSFP-DD Connector and host PCB footprint and wire termination are solved in HFSS
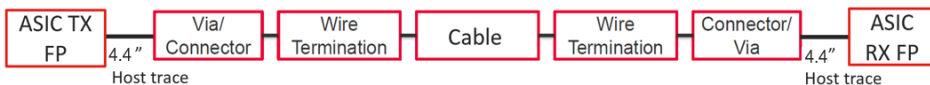
QSFP-DD Channel Buildup

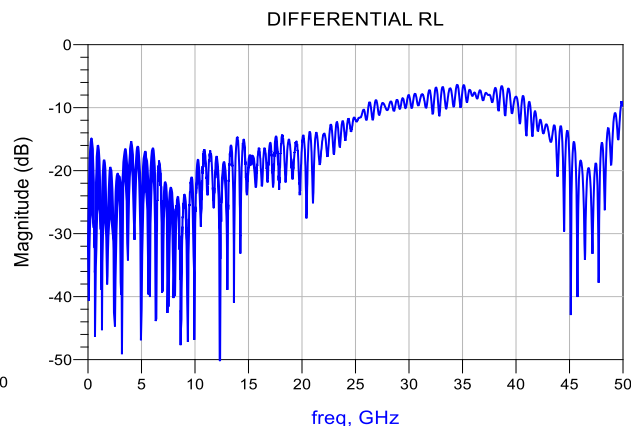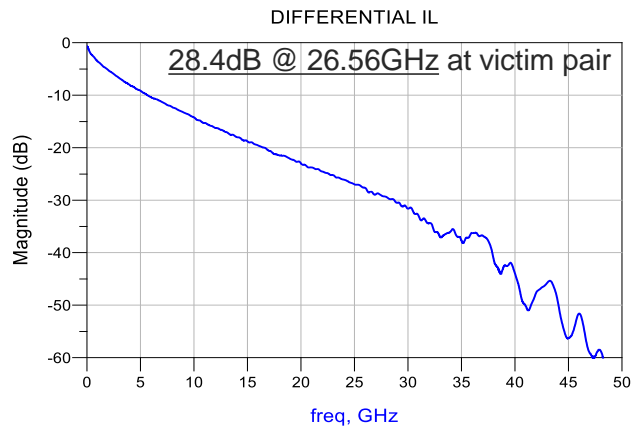- Channels 3a (new pair) / 3b (legacy pair) – worst case condition: 28.5dB IL

ASIC BGA footprint (mid length via) TX + host PCB trace 4.4" + [QSFP-DD footprint & connector (new/legacy pair) + wire termination + 2m 26AWG cable (mfg variation) + wire termination + QSFP-DD footprint & connector (new/legacy pair)] + host PCB trace 4.4" + improved ASIC BGA footprint (long via) RX (Thru and FEN channel description)

Improved ASIC BGA footprint (long via) RX + host PCB trace 4.4" + [QSFP-DD footprint & connector (new/legacy pair) + wire termination + 2m 26AWG cable (mfg variation) + wire termination + QSFP-DD footprint & connector (new/legacy pair)] + termination (NEN channel description)
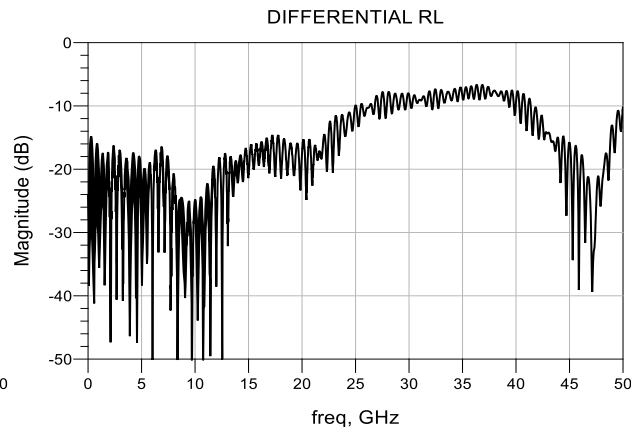
QSFP-DD Channel 3a/3b:
Diff. Insertion Loss, Return Loss

ASIC TX FP — 4.4" Host trace — Via/Connector — Wire Termination — Cable — Wire Termination — Connector/Via — 4.4" Host trace — ASIC RX FP

QSFP-DD Channel 3a (new pair)

DIFFERENTIAL IL

28.4dB @ 26.56GHz at victim pair

DIFFERENTIAL RL
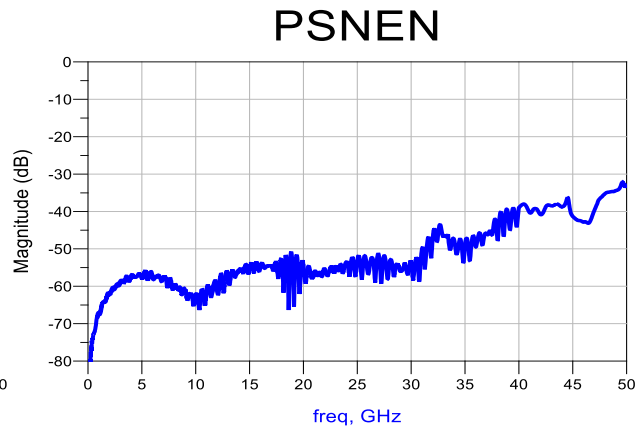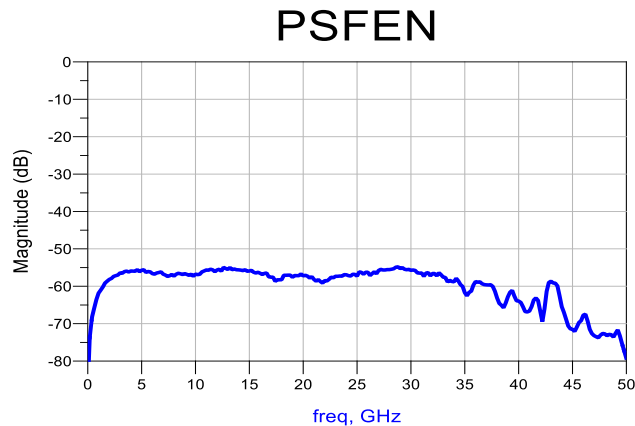
QSFP-DD Channel 3b (legacy pair)

DIFFERENTIAL IL

28.3dB @ 26.56GHz at victim pair

DIFFERENTIAL RL

QSFP-DD Channel 3a/3b: Far-end and Near-end Crosstalk
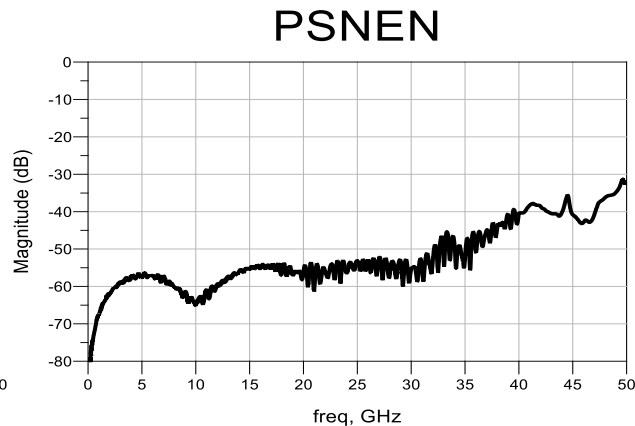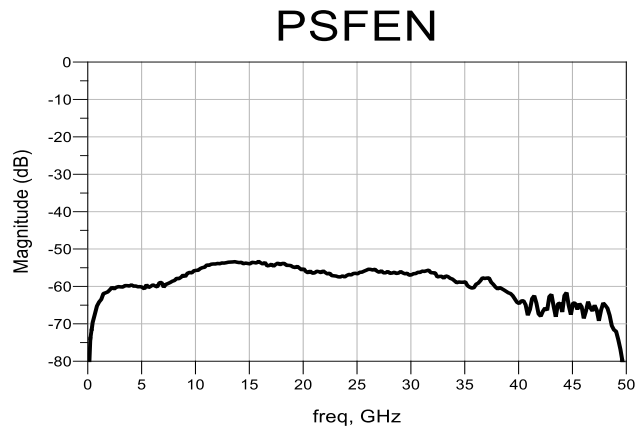
106G PAM-4 COM Results

DUT	COM case 1 (dB)	COM case 2 (dB)	ERL11 (dB)	ERL22 (dB)	FOM$_{ILD}$ (dBrms)	ICN (mV)	IL@26G b2b/d2d (dB)
Channel 3a (QSFPDD, new pair, worst case)	**3.80**	**2.90**	**16.82**	**17.57**	**0.48**	**1.16**	**28.4/40.9**
Channel 3b (QSFPDD, legacy pair, worst case)	**3.84**	**3.16**	**18.33**	**18.91**	**0.58**	**1.21**	**28.3/41.1**

COM script version 2.70
- **Die termination C: Cd 120fF / Ls 120pH/ Cb 30fF**
- **24 fixed DFE taps**

Case 1: z_p (TX) = 12 mm; z_p (RX) = 12 mm
Case 2: z_p (TX) = 31 mm; z_p (RX) = 29 mm

Summary

- The updated 2m CR channels with cable assemblies manufacturing variation have IL close to 28.5 dB
  - Data shows ~0.8 – 1.0 dB COM improvement compared to previously generated 29 dB channels
  - QSFP-DD legacy pair can now pass 3 dB COM target, the DD new pair is missing 0.1dB (under development by Molex)
  - ICN has been improved from ~1.5mV to ~1.2mV, mainly coming from ASIC RX footprint NEXT reduction

- 28.5dB loss budget (informative) looks promising for 2m Cu cable assembly baseline consideration

Backup Slides

Config_com_ieee8023_93a_3ck_KR_mellitz_06_12_2019 COM 2.70
Die termination C – Fixed 24 DFE taps

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	[1.2e-4 1.2e-4]	nF	[TX RX]
L_s	[0.12, 0.12]	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)	[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]
z_p (RX)	[12 29; 1.8 1.8]	mm	[test cases]
C_p	[0.87e-4 0.87e-4]	nF	[TX RX]
R_0	50	Ohm	
R_d	[45 45]	Ohm	[TX RX]
A_v	0.39	V	vp/vf=.694
A_fe	0.39	V	vp/vf=.694
A_ne	0.578	V	
L	4		
M	32		
filter and Eq			
f_r	0.75	*fb	
c(0)	0.5		min
c(-1)	[-0.3:0.02:0]		[min:step:max]
c(-2)	[0:0.02:0.12]		[min:step:max]
c(-3)	[-0.06:0.02: 0]		[min:step:max]
c(1)	[-0.2:0.05:0]		[min:step:max]
N_b	24	UI	
b_max(1)	0.85		
b_max(2..N_b)	0.3		
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]

I/O control		
DIAGNOSTICS	1	logical
DISPLAY_WINDOW	1	logical
CSV_REPORT	1	logical
RESULT_DIR	.\results\100GEL_KR_{date}\	
SAVE_FIGURES	1	logical
Port Order	[1 3 2 4]	
RUNTAG	KR_eval_	
COM_CONTRIBUTION	0	logical
Operational		
COM Pass threshold	3	dB
ERL Pass threshold	10	dB
DER_0	1.00E-04	
T_r	6.16E-03	ns
FORCE_TR	1	logical
Include PCB	0	logical
TDR and ERL options		
TDR	1	logical
ERL	1	logical
ERL_ONLY	0	logical
TR_TDR	0.01	ns
N	3000	
beta_x	2.53E+09	
rho_x	0.25	
fixture delay time	0	s
TDR_W_TXPKG	0	
N_bx	24	UI
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	33	dB
R_LM	0.95	

Table 93A–3 parameters		
Parameter	Setting	Units
package_tl_gamma0_a1_a2	[0 0.0009909 0.0002772]	
package_tl_tau	6.141E-03	ns/mm
package_Z_c	[87.5 87.5 ; 92.5 92.5]	Ohm

Table 92–12 parameters 5.2dB at 26.56GHz		
Parameter	Setting	
board_tl_gamma0_a1_a2	[0 0.000599 0.0001022]	1.286 dB/in or 0.0506 dB/mm at 100 ohms
board_tl_tau	6.200E-03	ns/mm
board_Z_c	90	Ohm
z_bp (TX)	102.7	mm
z_bp (NEXT)	102.7	mm
z_bp (FEXT)	102.7	mm
z_bp (RX)	102.7	mm

Floating Tap Control		
N_bg	0	0 1 2 or 3 groups
N_bf	0	taps per group
N_f	40	UI span for floating taps
bmaxg	0.1	max DFE value for floating taps

yellow indicates WIP

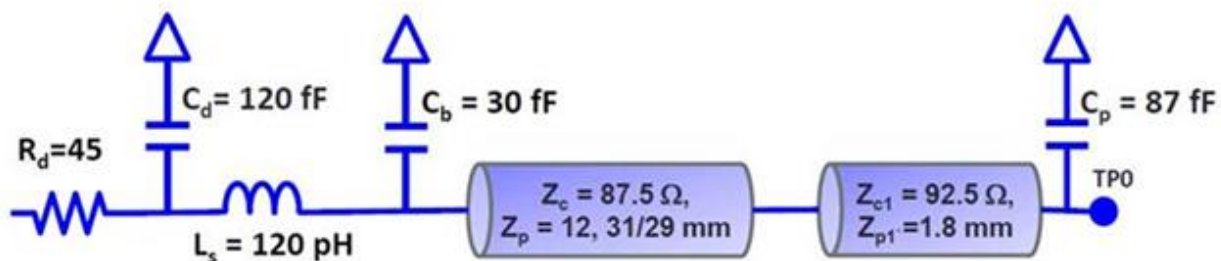# Package Proposal with LC Termination Compensation (single sided model)

Table 93A-1 parameters			
Parameter	Setting	Units	Information
C_d	[1.2e-4 1.2e-4]	nF	[TX RX]
L_s	[0.12, 0.12]	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)	[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]
z_p (RX)	[12 2990; 1.8 1.8]	mm	[test cases]
C_p	[0.87e-4 0.87e-4]	nF	[TX RX]
R_0	50	Ohm	
R_d	[45 45]	Ohm	[TX RX]
A_v	0.39	V	vp/vf=.694
A_fe	0.39	V	vp/vf=.694
A_ne	0.578	V	

Table 93A–3 parameters		
Parameter	Setting	Units
package_tl_gamma0_a1_a2	[0 0.0009909 0.0002772]	
package_tl_tau	6.141E-03	ns/mm
package_Z_c	[87.5 87.5 ; 92.5 92.5]	Ohm