



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

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 September Indianapolis meeting, lim_3ck_01_0919 analyzed worst case QSFPDD 2m cable model with realistic host, max. channel loss up to 28.5 dB
 - Data shows legacy pair can pass 3dB COM, new pair is short by 0.1dB
- This presentation further analyzed COM using the latest updated QSFPDD cable assembly model (see Palkert_3ck_01_1119)
- The mated cable model used in this analysis is simulation based, generated at worst case manufacturing condition
- Use latest COM scripts 2.75, with both KR & CR COM config to compare results

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



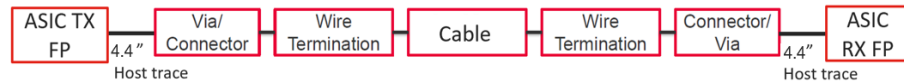
- Channels 4a (new pair) / 4b (legacy pair) – worst case condition: 28.5dB IL

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)

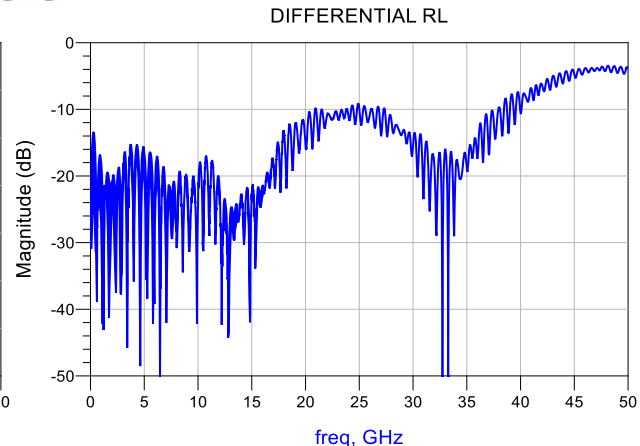
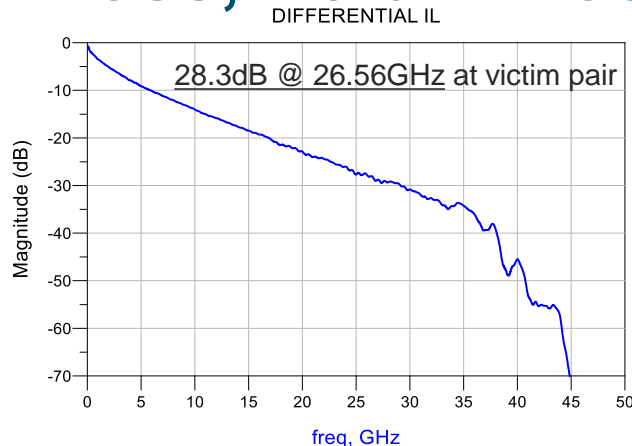
ASIC BGA footprint (long via) RX + host PCB trace 4.4" + [QSFP-DD footprint & connector (new/legacy pair) + wire termination + 2m 26AWG cable (mfg variation) + wire termination + QSFP-DD footprint & connector (new/legacy pair)] + termination (NEN channel description)

S-parameter files have been contributed as [lim_3ck_02_1119](#)

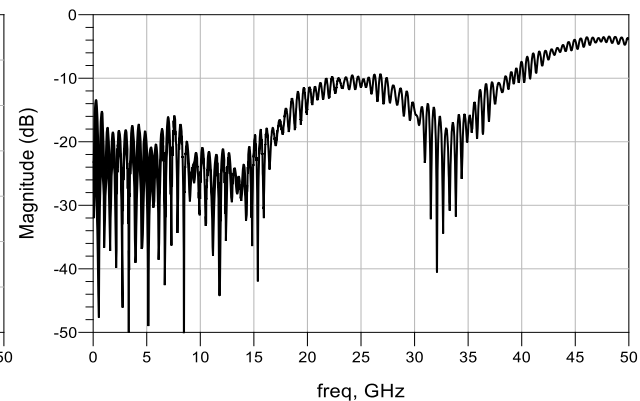
QSFP-DD Channel 4a/4b: Diff. Insertion Loss, Return Loss



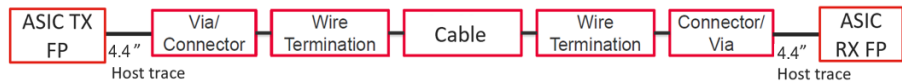
QSFP-DD
Channel 4a
(new pair)



QSFP-DD
Channel 4b
(legacy pair)

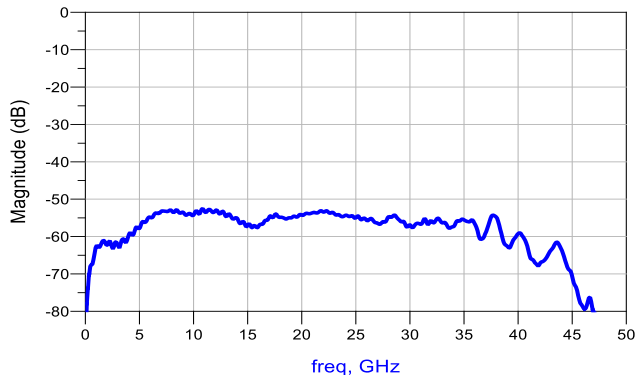


QSFP-DD Channel 4a/4b: Far-end and Near-end Crosstalk

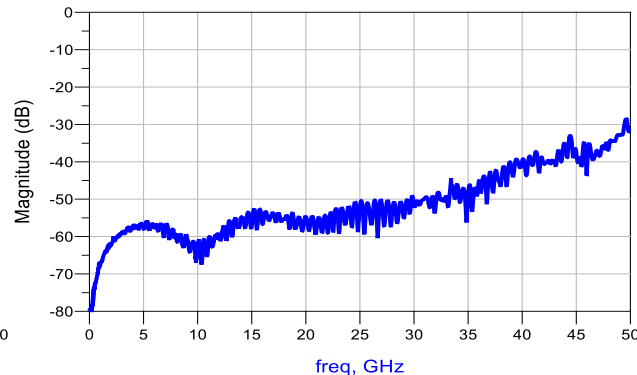


QSFP-DD Channel 4a (new pair)

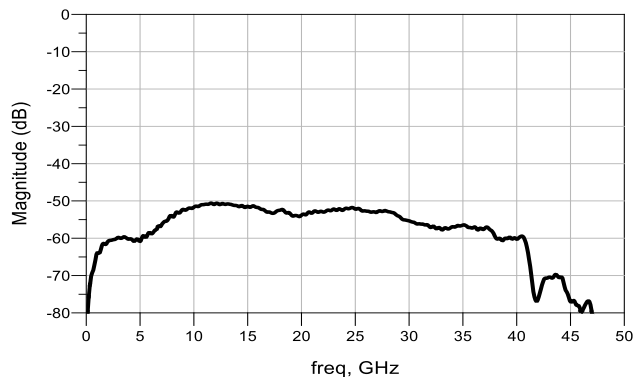
PSFEN



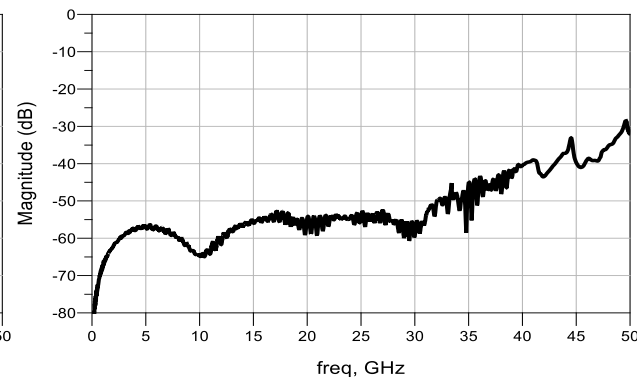
PSNEN



PSFEN



PSNEN



QSFP-DD Channel 4b (legacy pair)

106G PAM-4 COM Results - /w KR COM Config

DUT	COM case 1 (dB)	COM case 2 (dB)	ERL11 (dB)	ERL22 (dB)	FOM _{ILD} (dB _{Rms})	ICN (mV)	IL@26G b2b/d2d (dB), case 2
Channel 4a (QSFPDD, new pair)	4.15	3.24	17.58	16.89	0.37	1.38	28.3/41.0
Channel 4b (QSFPDD, legacy pair)	4.14	3.44	18.81	19.00	0.18	1.47	28.0/40.6

COM script version 2.75

Use KR COM config – see slide 12 for details

- Floating taps upto 40UI
- SNR_TX = 33dB; eta_0 = 8.2E-09
- **Except set b_max (2..N_b) = 0.3**

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

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

106G PAM-4 COM Results - /w CR COM Config

DUT	COM case 1 (dB)	COM case 2 (dB)	ERL11 (dB)	ERL22 (dB)	FOM _{ILD} (dBrms)	ICN (mV)	IL@26G b2b/d2d (dB), case2
TP1-TP4 CA (QSFPDD, new pair)	4.55	3.31	16.28	15.47	0.18	0.89	19.8/40.5
TP1-TP4 CA (QSFPDD, legacy pair)	4.85	3.60	15.50	15.26	0.22	0.78	19.5/39.6

TP1-TP4 CA model has 19.75dB loss at 26.56 GHz, the same 2m Cu cable as used in end-to-end channel (TP0-TP5).

COM script version 2.75

Use CR COM config – see slide 13 for details

- Floating taps upto 40UI
- Include PCB = 1
- **Except set b_max (2..N_b) = 0.3**
- **Set SNR_TX = 32 dB; eta_0 = 9.0E-9**

Summary

- Latest data shows QSFPDD 2m DAC channels with realistic host can pass 3dB COM
 - New pair has slightly worse IL & ERL than legacy pair, which impacts COM slightly → 3.24dB (new pair) vs 3.44dB (legacy pair)
- COM results agreement is pretty good when the same cable model is run with CR COM config using $SNR_{TX} = 32$ dB and $\eta_0 = 9.0E-9$
- Propose to adopt the CR baseline with the following:
 - TP1-TP4 IL = 19.75 dB (required)
 - TP0-TP5 IL = 28.5 dB (informative)
 - Ref receiver as in KR baseline

Backup Slides

COM 2.75 - KR Configuration used for TP0-TP5 analysis

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	[50 50]	Ohm	[TX RX]
A_v	0.415	V	vp/vf=.694
A_fe	0.415	V	vp/vf=.694
A_ne	0.608	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)	[0:0.02:0.12]		[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	12	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]
f_HP_PZ	0.6640625	GHz	

I/O control		
DIAGNOSTICS	1	logical
DISPLAY_WINDOW	1	logical
CSV_REPORT	1	logical
RESULT_DIR	.\results\100GEL_CR_{date}\	
SAVE_FIGURES	1	logical
Port Order	[1 3 2 4]	
RUNTAG	CR_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

TDR and ERL options		
TDR	1	logical
ERL	1	logical
ERL_ONLY	0	logical
TR_TDR	0.01	ns
N	3000	
beta_x	2.3407E+09	
rho_x	0.21	
fixture delay time	[0 0]	[port1 port2]
TDR_W_TXPKG	0	
N_bx	12	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	8.2E-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
benartsi_3ck_01_0119 & mellitz_3ck_01_0119		

Table 92-12 parameters		
Parameter	Setting	Units
board_tl_gamma0_a1_a2	[0 3.8206e-04 9.5909e-05]	1 dB / in
board_tl_tau	5.790E-03	ns/mm
board_Z_c	100	Ohm
z_bp (TX)	110.3	mm
z_bp (NEXT)	110.3	mm
z_bp (FEXT)	110.3	mm
z_bp (RX)	110.3	mm
C_0	[0.29e-4]	nF
C_1	[0.19e-4]	nF
Include PCB	0	logical

Floating Tap Control		
N_bg	3	0 1 2 or 3 groups
N_bf	3	taps per group
N_f	40	UI span for floating taps
bmaxg	0.05	max DFE value for floating taps

cable assemblies require this for each HCB

ICN parameters (v2.73)	
f_f	12.919
f_n	12.919
f_2	39.844
A_ft	0.600
A_nt	0.600
heck_3ck_03b_0319	Adopted Mar 2019
walker_3ck_01d_0719	Adopted July 2019
result of R_d=50	
benartsi_3ck_01a_0719	require COM 2.72 or later
mellitz_3ck_03_0919	
mellitz_3ck_02_0919	
under consideration	

COM 2.75 - CR Configuration used for TP0-TP5 analysis

Table 93A-1 parameters				I/O control			Table 93A-3 parameters		
Parameter	Setting	Units	Information	DIAGNOSTICS	1	logical	Parameter	Setting	Units
f_b	53.125	GBd		DISPLAY_WINDOW	1	logical	package_tl_gamma0_a1_a2	[0 0.0009909 0.0002772]	
f_min	0.05	GHz		CSV_REPORT	1	logical	package_tl_tau	6.141E-03	ns/mm
Delta_f	0.01	GHz		RESULT_DIR	.\results\100GEL_CR_{date}\		package_Z_c	[87.5 87.5 ; 92.5 92.5]	Ohm
C_d	[1.2e-4 1.2e-4]	nF	[TX RX]	SAVE_FIGURES	1	logical	benartsi_3ck_01_0119 & mellitz_3ck_01_0119		
L_s	[0.12, 0.12]	nH	[TX RX]	Port Order	[1 3 2 4]		Table 92-12 parameters		
C_b	[0.3e-4 0.3e-4]	nF	[TX RX]	RUNTAG	CR_eval_		Parameter	Setting	
z_p select	[1 2]		[test cases to run]	COM_CONTRIBUTION	0	logical	board_tl_gamma0_a1_a2	[0 3.8206e-04 9.5909e-05]	1 dB / in
z_p (TX)	[12 31; 1.8 1.8]	mm	[test cases]	Operational			board_tl_tau	5.790E-03	ns/mm
z_p (NEXT)	[12 29; 1.8 1.8]	mm	[test cases]	COM Pass threshold	3	dB	board_Z_c	100	Ohm
z_p (FEXT)	[12 31; 1.8 1.8]	mm	[test cases]	ERL Pass threshold	10	dB	z_bp (TX)	110.3	mm
z_p (RX)	[12 29; 1.8 1.8]	mm	[test cases]	DER_0	1.00E-04		z_bp (NEXT)	110.3	mm
C_p	[0.87e-4 0.87e-4]	nF	[TX RX]	T_r	6.16E-03	ns	z_bp (FEXT)	110.3	mm
R_d	50	Ohm		FORCE_TR	1	logical	z_bp (RX)	110.3	mm
R_d	[50 50]	Ohm	[TX RX]	TDR and ERL options			C_0	[0.29e-4]	nF
A_v	0.415	V	vp/vf=.694	TDR	1	logical	C_1	[0.19e-4]	nF
A_fe	0.415	V	vp/vf=.694	ERL	1	logical	Include PCB	1	logical
A_ne	0.608	V		ERL_ONLY	0	logical	Floating Tap Control		
L	4			TR_TDR	0.01	ns	N_bg	3	0 1 2 or 3 groups
M	32			N	3000		N_bf	3	taps per group
filter and Eq				beta_x	2.3407E+09		N_f	40	UI span for floating taps
f_r	0.75	*fb		rho_x	0.21		bmaxg	0.05	max DFE value for floating taps
c(0)	0.54		min	fixture delay time	[0 0]	[port1 port2]	cable assemblies require this for each HCB		
c(-1)	[-0.34:0.02:0]		[min:step:max]	TDR_W_TXPKG	0		ICN parameters (v2.73)		
c(-2)	[0:0.02:0.12]		[min:step:max]	N_bx	12	UI	f_f	12.919	
c(-3)	[-0.06:0.02: 0]		[min:step:max]	Receiver testing			f_n	12.919	
c(1)	[-0.2:0.05:0]		[min:step:max]	RX_CALIBRATION	0	logical	f_2	39.844	
N_b	12	UI		Sigma BBN step	5.00E-03	V	A_ft	0.600	
b_max(1)	0.85			Noise, jitter			A_nt	0.600	
b_max(2..N_b)	0.3			sigma_RJ	0.01	UI	heck_3ck_03b_0319	Adopted Mar 2019	
g_DC	[-20:1:0]	dB	[min:step:max]	A_DD	0.02	UI	walker_3ck_01d_0719	Adopted July 2019	
f_z	21.25	GHz		eta_0	9.00E-09	V^2/GHz	result of R_d=50		
f_p1	21.25	GHz		SNR_TX	32	dB	benartsi_3ck_01a_0719	require COM 2.72 or later	
f_p2	53.125	GHz		R_LM	0.95		mellitz_3ck_03_0919		
g_DC_HP	[-6:1:0]		[min:step:max]				mellitz_3ck_02_0919		
f_HP_PZ	0.6640625	GHz					under consideration		