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

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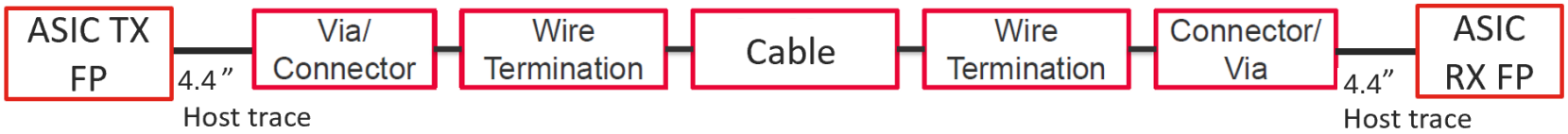
100G CR End-to-End Channel Model - Updated

- 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



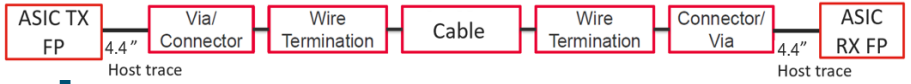
- Channels 4a (new pair) / 4b (legacy pair) – worst case condition: 28.5dB IL

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)

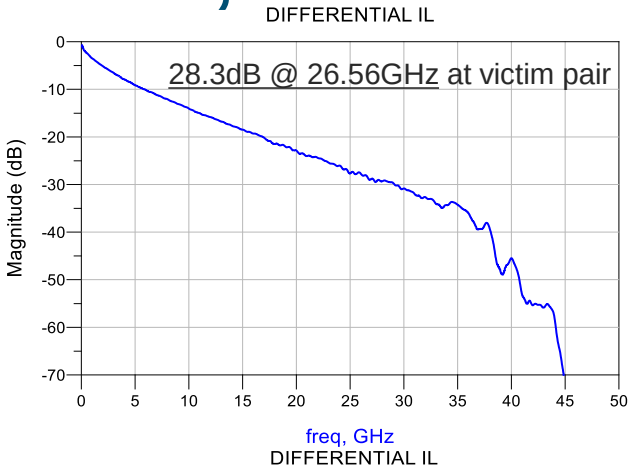
ASIC BGA footprint (long via) RX + host PCB trace 4.4” + [QSFP-DD footprint & connector (new/legacy pair) + wire termination + 2m 26AWG cable (mfg variation) + wire termination + QSFP-DD footprint & connector (new/legacy pair)] + termination (NEN channel description)

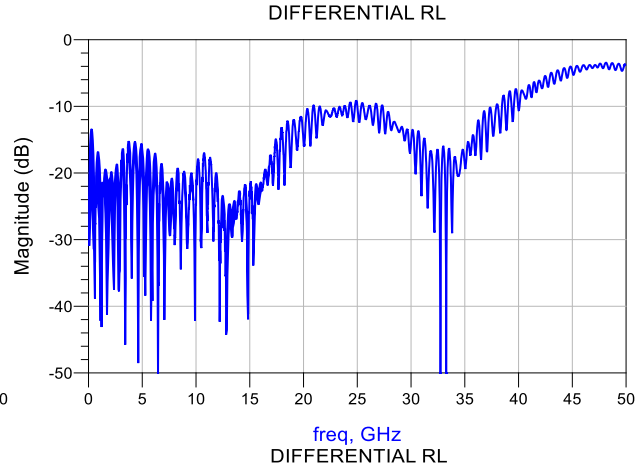
S-parameter files have been contributed as lim_3ck_02_1119

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

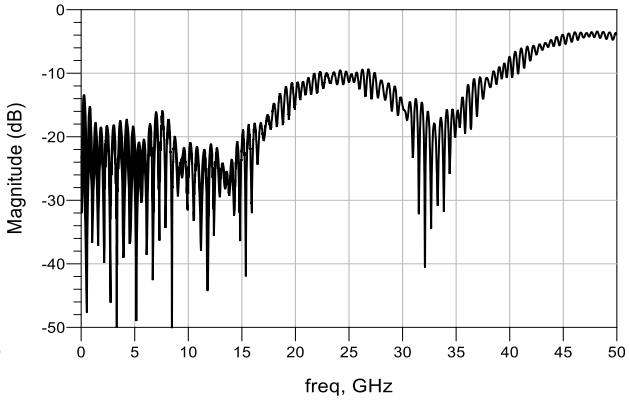


QSFP-DD Channel 4a (new pair)

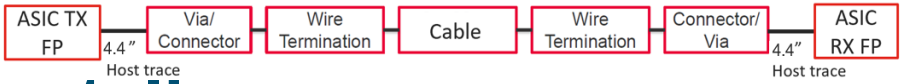




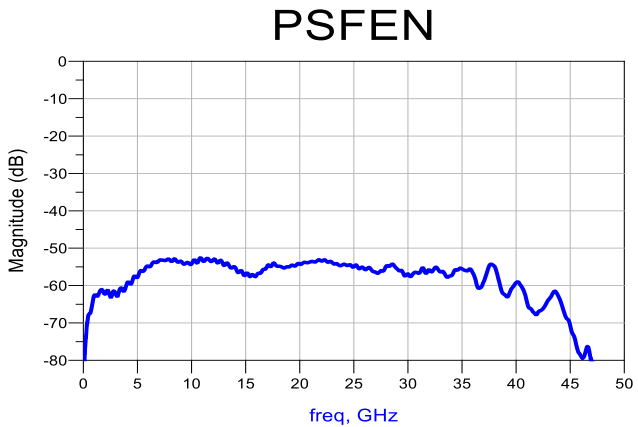
QSFP-DD Channel 4b (legacy pair)

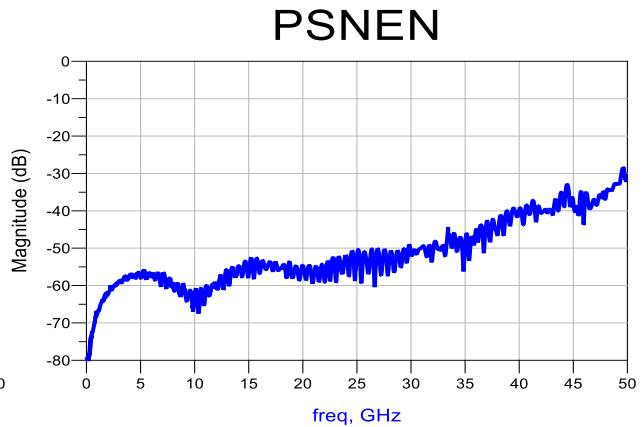


QSFP-DD Channel 4a/4b: Far-end and Near-end Crosstalk

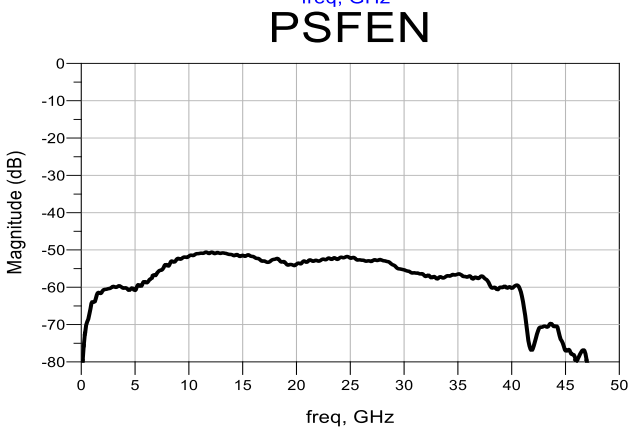


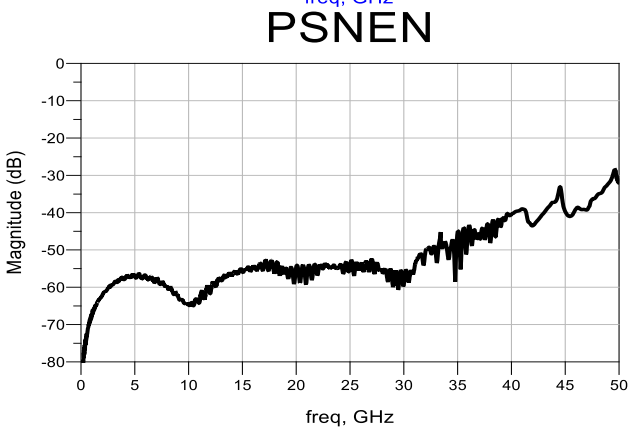
QSFP-DD Channel 4a (new pair)





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} (dBrms)	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**	
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			
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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	
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A_v	0.415	V	vp/vf=.694
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A_ne	0.608	V	
L	4		
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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]	
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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	9.00E-09	V^2/GHz
SNR_TX	32	dB
R_LM	0.95	

Table 93A–3 parameters		
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package_Z_c	[87.5 87.5 ; 92.5 92.5]	Ohm
benartsi_3ck_01_0119 & mellitz_3ck_01_0119		
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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	**1**	**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		