

# 100GEL C2M Channel Analysis Update

Jane Lim, Cisco

Pirooz Tooyserkani, Cisco

Upen Reddy Kareti, Cisco

Joel Goergen, Cisco

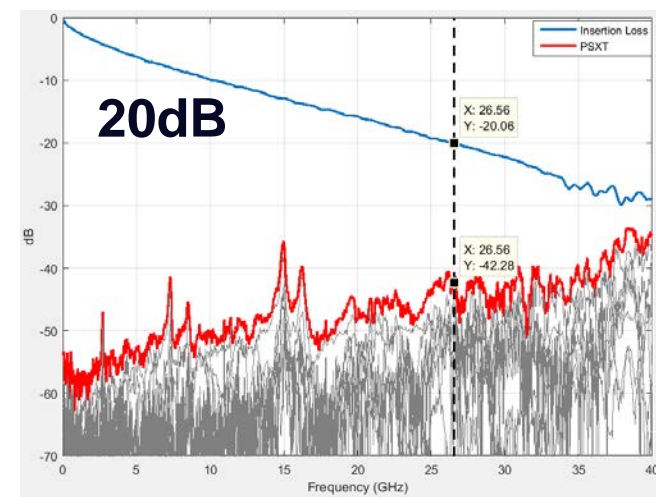
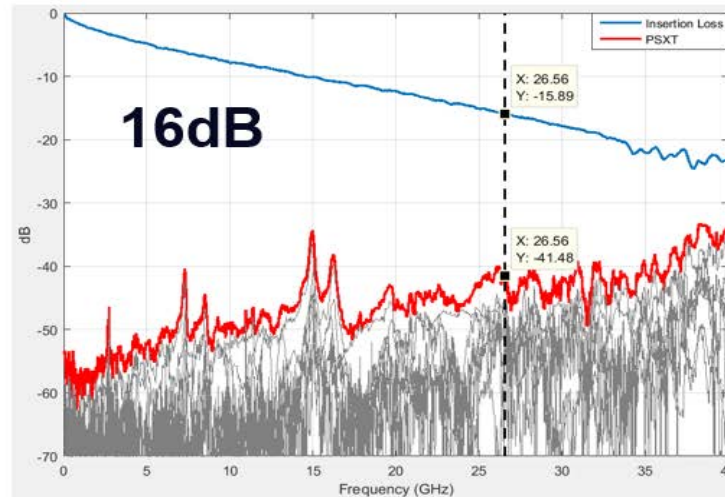
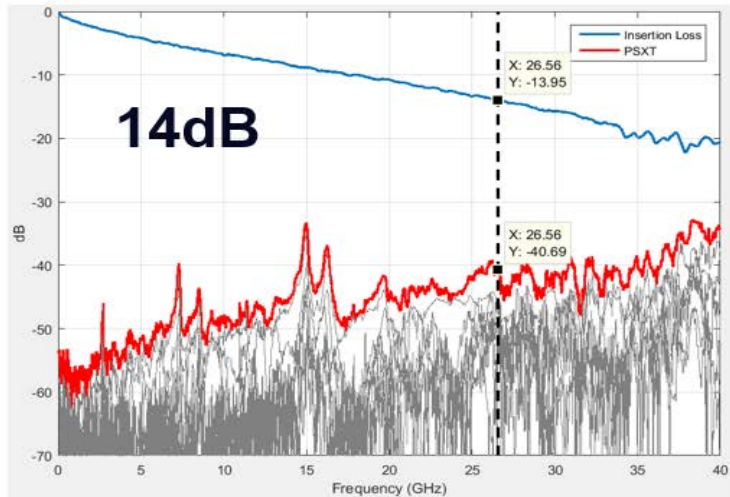
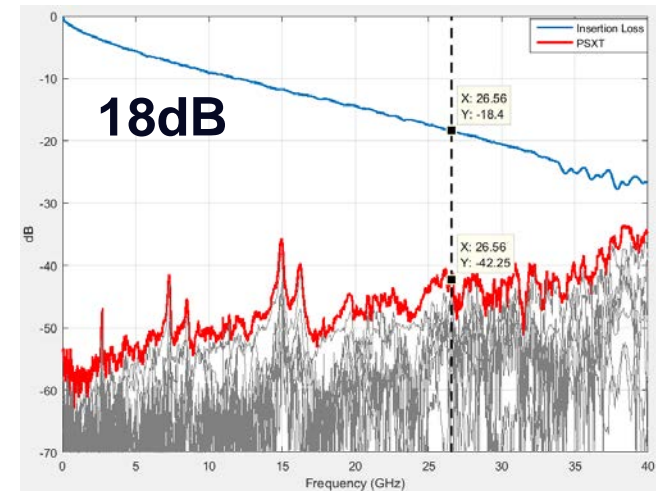
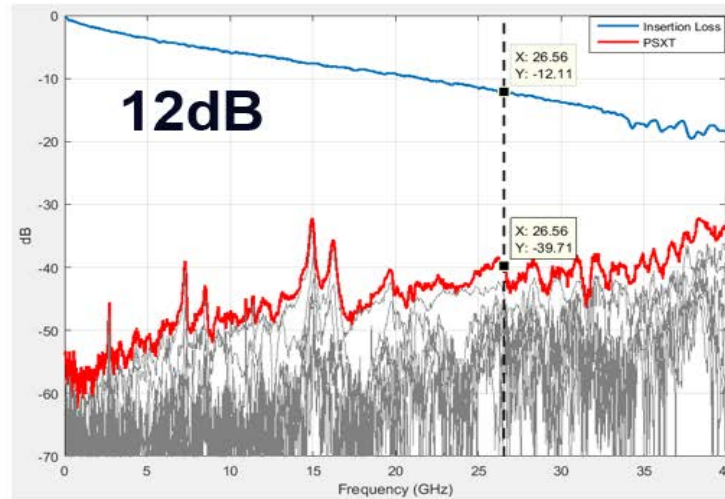
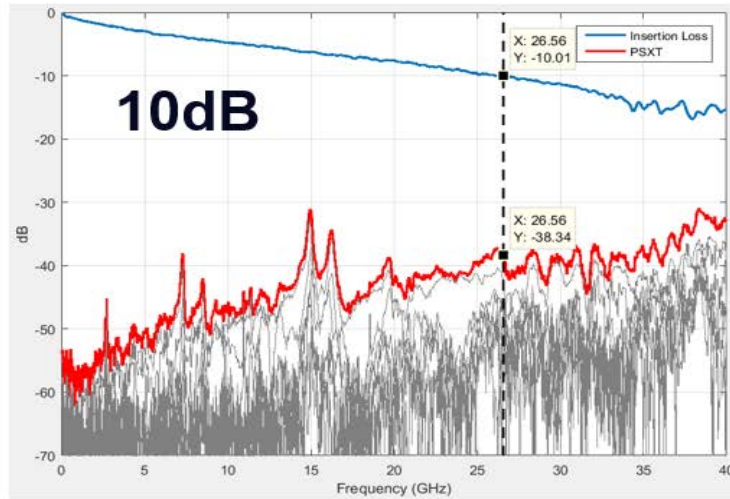
Marco Mazzini, Cisco

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# C2M Channel Analysis Update

- In July San Diego meeting, we submitted 10/12/14/16 dB C2M channels using QSFP connector for Serdes system design and simulation
- QSFP-DD is one of the MDIs under consideration for 802.3ck, there is an interest to analyze 100GEL C2M Serdes performance including system channels using QSFP-DD connector
- We have worked with connector supplier to build channels (12/14/16 dB) which includes host PCB and connector effects (ILD & crosstalk)
- The contributed channels with different MDIs are to be considered for Port type 2 with 14-16 dB (TP0 – TP1a) for optics/AOC/ACC ([http://www.ieee802.org/3/ck/public/18\\_07/lim\\_3ck\\_01b\\_0718.pdf](http://www.ieee802.org/3/ck/public/18_07/lim_3ck_01b_0718.pdf)), with low module power design in mind
- Further channel analysis was performed to study:
  - How many Rx/Tx FFE taps are required?
  - Does Rx DFE required?
  - Can Serdes achieve < 400mW per channel?

# C2M Ball-to-Ball Channels using QSFP



Remark: Package footprint, Host PCB trace and QSFP Test Fixture included.

S-parameter files with 3 different trace lengths can be found at :

[http://www.ieee802.org/3/ck/public/tools/c2m/lim\\_3ck\\_01\\_0718.zip](http://www.ieee802.org/3/ck/public/tools/c2m/lim_3ck_01_0718.zip)

# Channel Analysis using QSFP – Update

- Simulation Setup:

- Supplier A Serdes IBIS-AMI model, run in ADS tool, 1M simulated Bits
- Data rate: 106.25Gbps PAM4; PRBS23 pattern and Gray-coded
- TX swing = 900mVpdd, 4-tap TX FIR (2-pre, 1-main, 1-pst); TX setting grossly tuned, but may not be optimal
- TX jitter added (TX\_Dj = 0.05 p-p; TX\_Rj = 0.008 UI-rms; TX\_DCD = 0.02 p-p)
- RX EQ/CDR/calibrations are all adaptive; RX noise and jitter are included
- RX FFE taps (0-pre, 3 pst taps settings: 16, 8 and 4 taps are swept), no DFE on the RX
- Small Package: ~3dB TX and ~2dB RX

- Simulation Results:

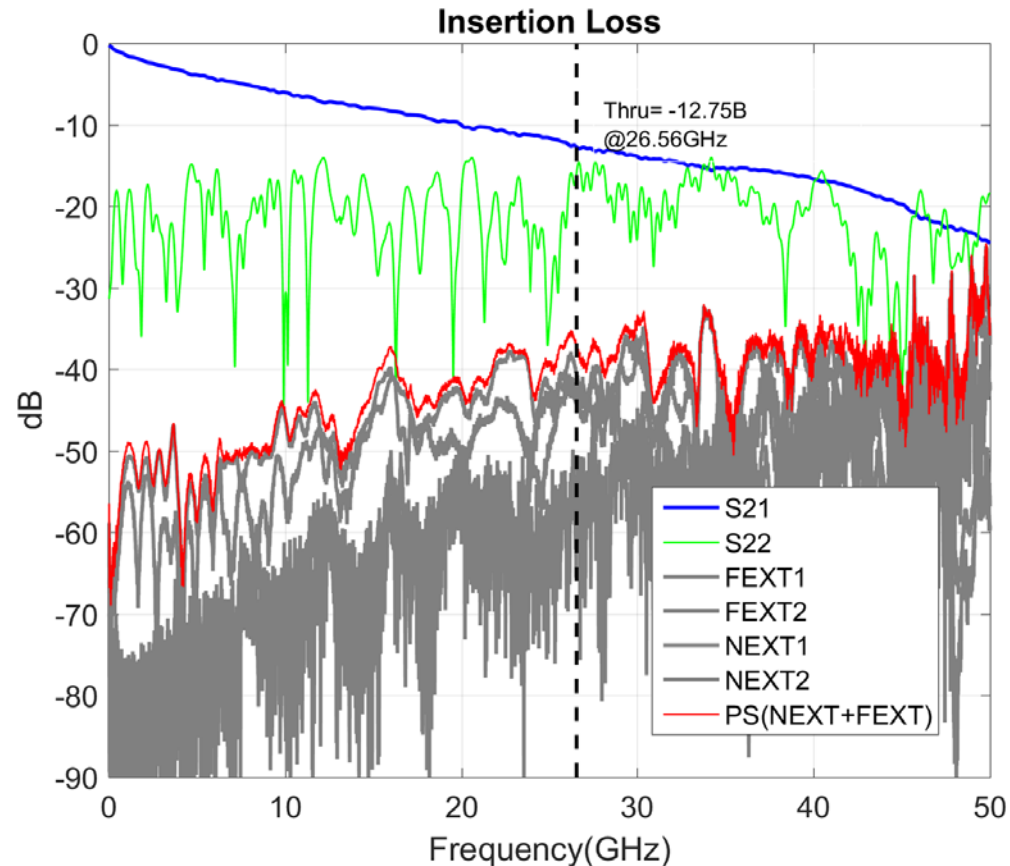
- To achieve better than 1e-6 BER requires 8-pst FFE or higher for upto 16dB ball-ball channel
- Extending channel loss beyond 16dB can't achieve reasonable BER without adding DFE

Channel	20dB	18dB	16dB	14dB	12dB	10dB
0-pre/16-pst FFE	7.78e-5	4.78e-6	1.12e-7	3.46e-8	9.69e-8	3.04e-9
0-pre/8-pst FFE	2.34e-4	1.55e-5	7.87e-7	2.71e-7	5.04e-7	3.54e-8
0-pre/4-pst FFE	3.16e-4	8.83e-5	4.75e-6	2.13e-6	4.15e-6	2.59e-6

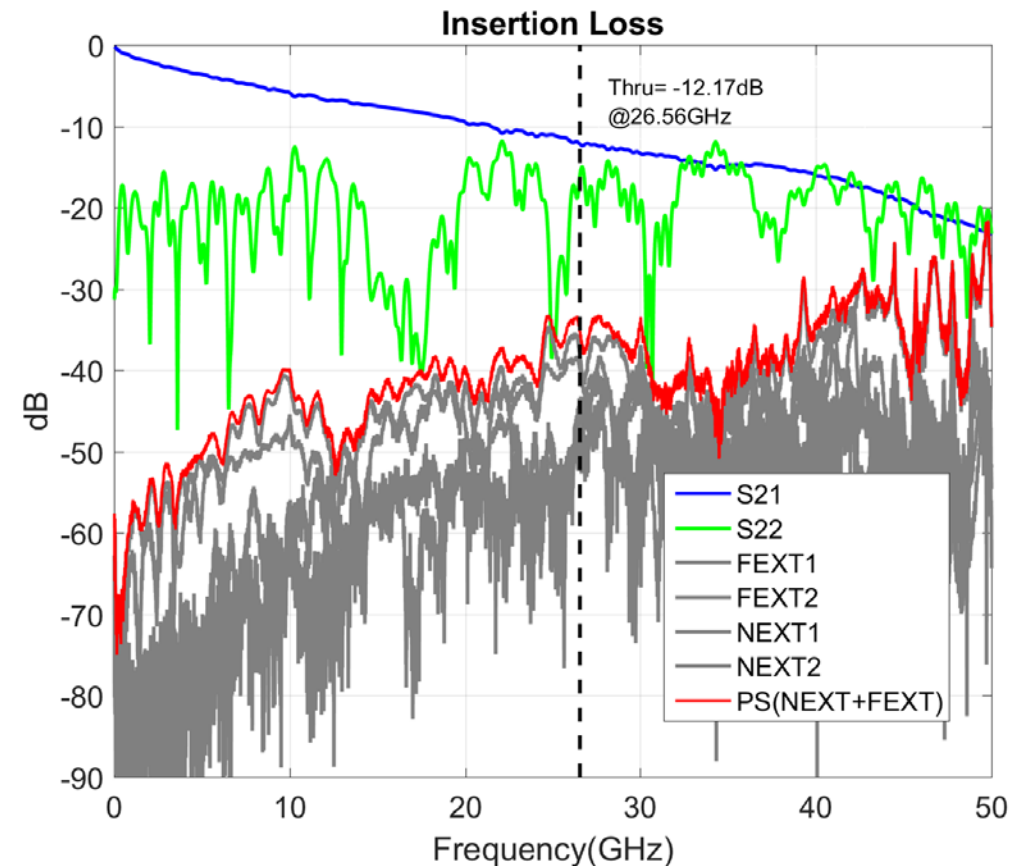
# C2M 12dB Channel using QSFP-DD

- Package footprint, Meg7 host PCB trace, QSFP-DD & module PCB included

Legacy Pair (outer row)



New Pair (inner row)

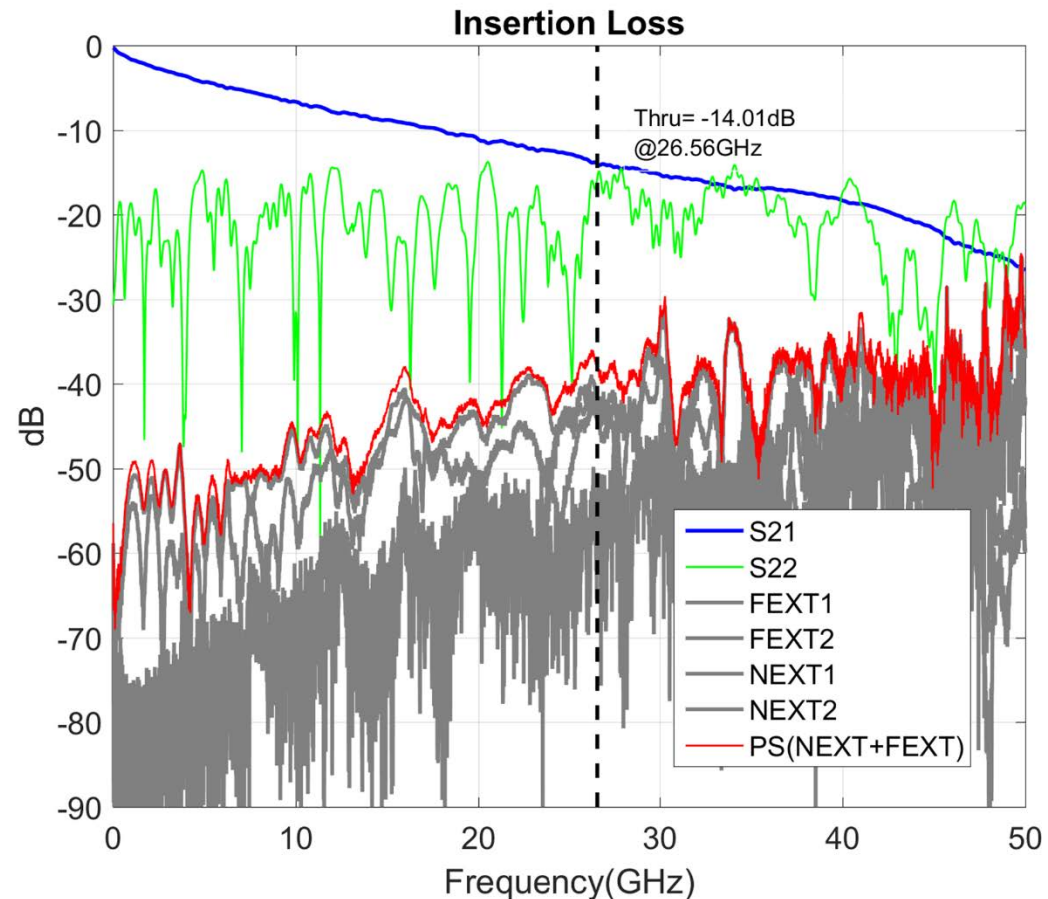




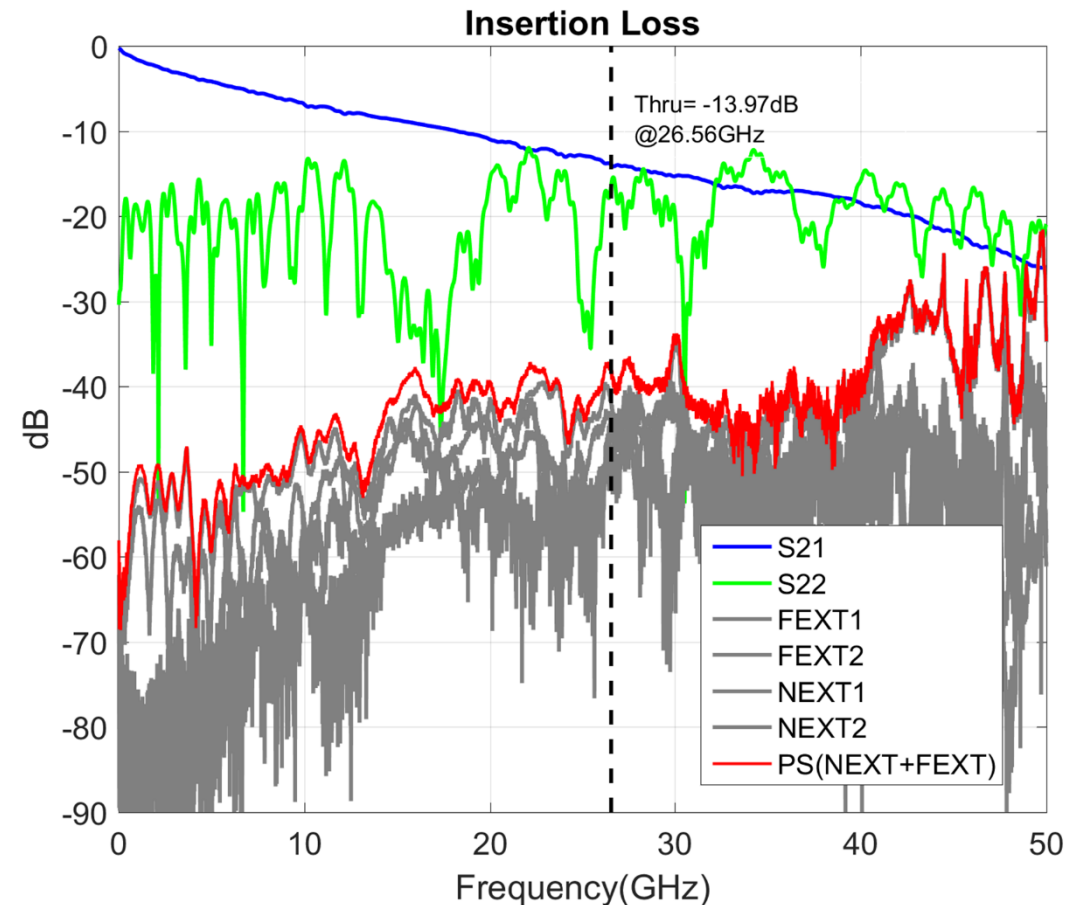
# C2M 14dB Channel using QSFP-DD

- Package footprint, Meg7 host PCB trace, QSFP-DD & module PCB included

Legacy Pair (outer row)



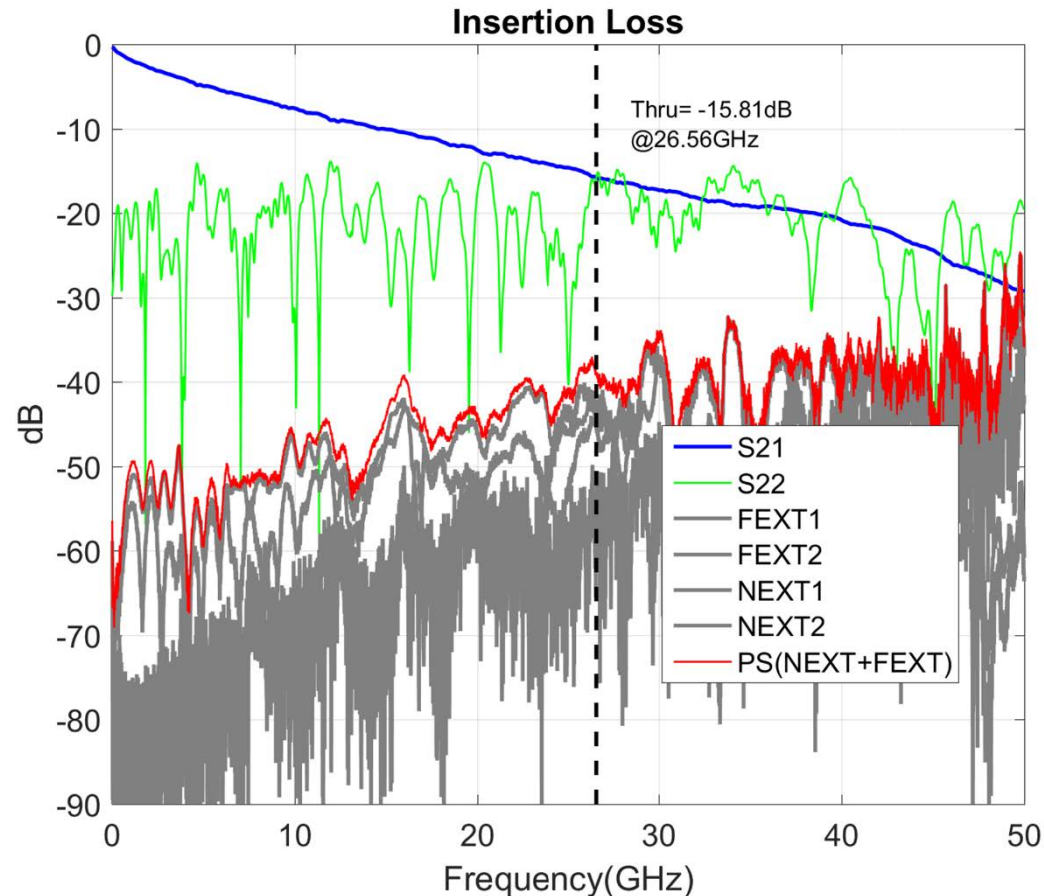
New Pair (inner row)



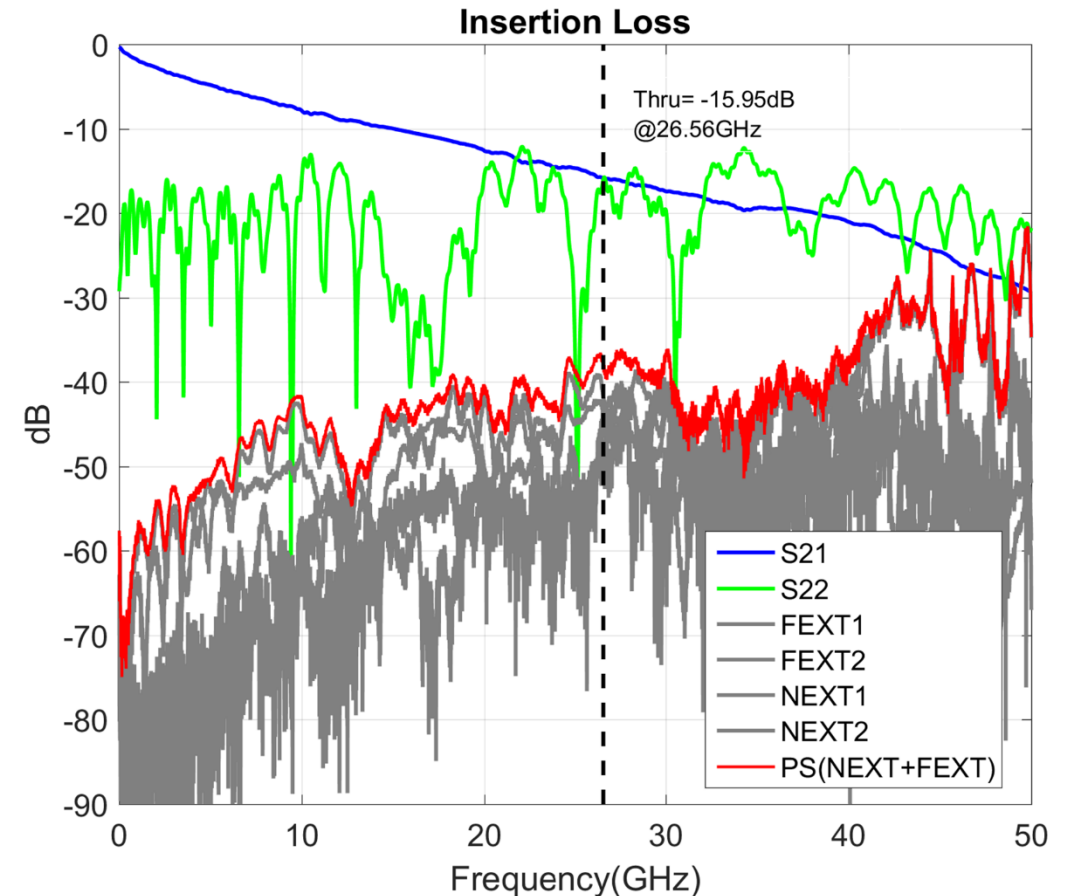
# C2M 16dB Channel using QSFP-DD

- Package footprint, Meg7 host PCB trace, QSFP-DD & module PCB included

Legacy Pair (outer row)

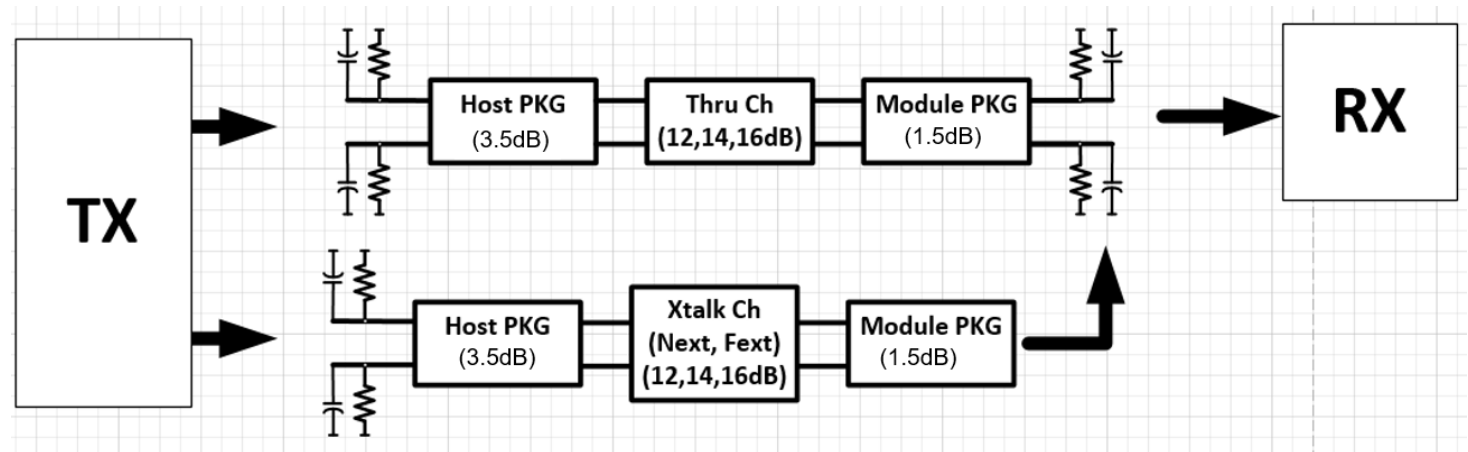


New Pair (inner row)



# Channel Analysis using QSFP-DD

- Simulation Setup:
  - Supplier B Serdes time-domain MATLAB simulator incorporating circuit data
  - Data rate: 106.25Gbps PAM4
  - TX swing = 800mVpdd, TX FIR (2-pre, 1-main, 1-pst)
  - TX jitter added (TX\_Dj = 400 fs p-p; TX\_Rj = 175 fs rms)
  - RX EQ/CDR/calibrations are all adaptive; RX noise (4 mV rms) and jitters are included
  - The RX can be configured as 10-tap FFE or 6-tap FFE, # of pre-cursor taps were programmed to be 0,1,2,3 (for 10 tap) and 0,1,2 (for 6 tap); DFE starts roughly where the FFE leaves off, minimal power hit on DFE to equalize the channel with far away cursors
  - Package: ~3.5dB TX and ~1.5dB RX
  - Die cap: 130 fF





# 12dB Channel Results

- PRBS Pattern: PRBS13 (MSB) & PRBS17 (LSB)
- LMS adaptation and clock recovery: active
- TX FIR sweep and CTLE sweep for each data set

		12dB							
with Xtalk		SNR	BER	SNR	BER	SNR	BER	SNR	BER
#Rx FFE, #Pre		10,3		10,2		10,1		10,0	
#DFE	0	23.59	1.02E-11	23.40	2.81E-11	22.35	3.49E-09	20.41	2.05E-06
#DFE	8	24.10	5.72E-13	23.66	7.20E-12	22.58	1.33E-09	20.58	1.29E-06
#DFE	16	24.58	2.73E-14	24.11	5.37E-13	22.85	4.04E-10	20.80	6.99E-07
#Rx FFE, #Pre				6,2		6,1		6,0	
#DFE	0			17.51	5.90E-04	20.98	4.14E-07	19.69	1.18E-05
#DFE	8			23.53	1.38E-11	22.46	2.14E-09	20.49	1.68E-06
#DFE	16			23.86	2.33E-12	22.82	4.66E-10	20.76	7.82E-07

# 14dB Channel Results

- PRBS Pattern: PRBS13 (MSB) & PRBS17 (LSB)
- LMS adaptation and clock recovery: active
- TX FIR sweep and CTLE sweep for each data set

		14dB							
with Xtalk		SNR	BER	SNR	BER	SNR	BER	SNR	BER
#Rx FFE, #Pre		10,3		10,2		10,1		10,0	
#DFE	0	22.55	1.47E-09	22.83	4.50E-10	21.14	2.59E-07	19.97	6.30E-06
#DFE	8	23.58	1.09E-11	23.20	7.60E-11	21.46	9.04E-08	20.11	4.47E-06
#DFE	16	24.11	5.43E-13	23.72	5.16E-12	21.71	3.87E-08	20.30	2.78E-06
#Rx FFE, #Pre				6,2		6,1		6,0	
#DFE	0			18.05	2.60E-04	20.05	5.15E-06	19.05	4.61E-05
#DFE	8			23.21	7.35E-11	21.29	1.60E-07	20.00	5.77E-06
#DFE	16			23.66	6.89E-12	21.64	4.93E-08	20.24	3.20E-06

# 16dB Channel Results

- PRBS Pattern: PRBS13 (MSB) & PRBS17 (LSB)
- LMS adaptation and clock recovery: active
- TX FIR sweep and CTLE sweep for each data set

		16dB							
with Xtalk		SNR	BER	SNR	BER	SNR	BER	SNR	BER
#Rx FFE, #Pre		10,3		10,2		10,1		10,0	
#DFE	0	22.08	1.00E-08	22.54	1.55E-09	21.67	4.54E-08	20.52	1.64E-06
#DFE	8	23.39	2.94E-11	22.98	2.17E-10	22.04	1.15E-08	20.69	9.75E-07
#DFE	16	23.73	4.78E-12	23.37	3.31E-11	22.55	1.53E-09	21.17	2.63E-07
#Rx FFE, #Pre				6,2		6,1		6,0	
#DFE	0			17.30	7.88E-04	21.01	3.75E-07	19.90	7.35E-06
#DFE	8			22.88	3.41E-10	21.94	1.71E-08	20.46	1.80E-06
#DFE	16			23.25	5.86E-11	22.00	1.36E-08	20.52	1.53E-06

# SNR Improvement Summary and Power Impact

- Delta in performance to 6 tap FFE with 0 Pre

Total power saving w.r.t different modes

Base SNR (6,0,0) = 19.05dB					Base SNR (6,0,0) = 19.9dB				
14dB Channel,6 Tap FFE					16dB Channel,6 Tap FFE				
RxFFEPre	3				RxFFEPre	3			
	2	-0.99	4.16	4.62		2	-2.60	2.98	3.35
	1	1.00	2.24	2.60		1	1.11	2.04	2.10
	0	0.00	0.96	1.19		0	0.00	0.56	0.62
DFE Taps		0	8	16	DFE Taps		0	8	16
14dB Channel,10 Tap FFE					16dB Channel,10 Tap FFE				
RxFFEPre	3	3.51	4.53	5.06	RxFFEPre	3	2.18	3.49	3.83
	2	3.78	4.16	4.67		2	2.64	3.08	3.47
	1	2.09	2.42	2.66		1	1.76	2.14	2.64
	0	0.92	1.06	1.25		0	0.62	0.79	1.27
DFE Taps		0	8	16	DFE Taps		0	8	16

FFE #taps	DFE #taps	Power impact
10	16	23%
10	8	20%
10	0	17%
6	16	5%
6	8	3%
6	0	0%

# Summary

- C2M ball-to-ball channels including QSFP and QSFPDD connector effects are constructed for Serdes channel analysis
- 2 vendor Serdes are used to analyze the raw BER, reasonable BER can be achieved for upto 16dB channel with 4 taps Tx FIR and 6-10 taps Rx FFE
- Based on initial feedback from Serdes suppliers, ~400mW/ch is a reasonable target for the C2M channels currently in consideration



# Thank You !