Considerations for 50 Gbps Backplane and Direct attached Cable Channels

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Outline

- Measured data from Backplane and Direct Attached Cables (DAC) using test Serdes EVBs
- Backplane Channels
- Noise contributors based on COM
- Exploration of COM parameters
- Conclusions/Proposals

Background

- In order to get some quantitative insights into 50G serdes capabilities, early test samples from 3 different suppliers were tested on a common test setup for cable and backplane channels
- The test samples were not all based on the same design architecture
- Cisco has already presented that a target channel IL of ~32 dB would be in line with our system design requirements

  Goal was to confirm the feasibility of such a target

- Thank you to the companies who supplied the test silicon. Individual details will not be shared in this presentation

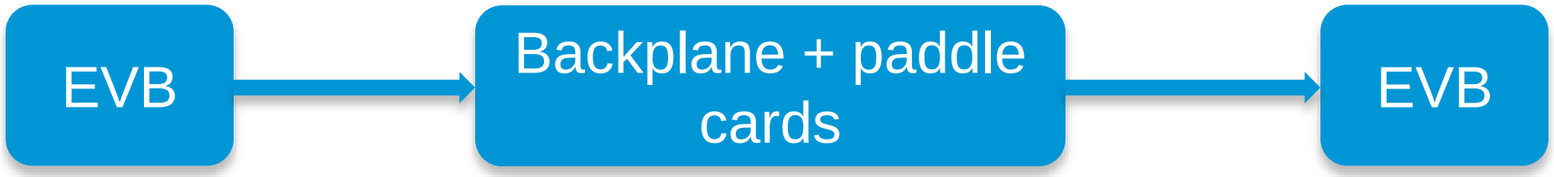
  It is recognized that this is early silicon and further development, improvements and refinement will happen before going to production

Test Set Up

- Direct Attached Cable

End to End connection included traces in EVB + cables to Host card+ Host card trace+ DAC + Host card trace + cables to EVB+ EVB trace + All connectors

- Back Plane



End to End connection included traces in EVB + cables to paddle card+ Paddle card trace+ Backplane Trace + Paddle card trace + cables to EVB + EVB trace + All connectors

Results for DAC measurements

Serdes List	Channel Description	End to End Loss@14 GHz (dB)	Pre-FEC BER	Comments
Serdes A	CableD1_30AWG_1M + 2" host card Trace	21.5	5.58E-08	For 56.25 Gbps data rate
Serdes A	CableB1_26AWG_3M + 2" host card Trace	29	8.38E-08	For 56.25 Gbps data rate
Serdes A	CableA1_26AWG_5M + 4" host card Trace	34.5	9.37E-06	For 56.25 Gbps data rate
Serdes A	CableA2_26AWG_5M + 4" host card Trace	36.5	4.38E-05	For 56.25 Gbps data rate
Serdes B	CableB1_26AWG_3M + 4" host card Trace	33.61	1.00E-09	For 53.125 Gbps data rate
Serdes B	CableA1_26AWG_5M + 3" host card Trace	35.54	2.00E-07	For 53.125 Gbps data rate
Serdes C	CableB1_26AWG_3M + 4" host card Trace	30	2.50E-07	For 56.25 Gbps data rate
Serdes C	CableB1_26AWG_3M + 5" host card Trace	32	1.05E-06	For 56.25 Gbps data rate
Serdes C	CableA1_26AWG_3M + 4" host card Trace	34	5.55E-05	For 56.25 Gbps data rate
Serdes C	CableC1_26AWG_5M + 2" host card Trace	34	2.52E-05	For 56.25 Gbps data rate

- End to End Loss is from bga to bga of the test chip – Package loss excluded
- Xtalk Aggressor channel(s) included if available in EVB
- Results are sought by increasing through channel loss with available combinations of the channel sub components, till then the link fails or pre-FEC BER > 1e-4

Results for Backplane measurements

Serdes List	Channel Description	End to End Loss@14 GHz (dB)	Pre-FEC BER	Comments
Serdes A	Backplane + paddle cards	37	2.49E-06	For 56.25 Gbps data rate
Serdes A	Backplane + paddle cards	38	4.64E-05	For 56.25 Gbps data rate
Serdes B	Backplane + paddle cards	34	1.45E-09	For 53.125 Gbps data rate
Serdes B	Backplane + paddle cards	34.5	2.53E-08	For 53.125 Gbps data rate
Serdes B	Backplane + paddle cards	35.5	1.80E-07	For 53.125 Gbps data rate
Serdes C	Backplane + paddle cards	24.2	9.81E-09	For 56.25 Gbps data rate
Serdes C	Backplane + paddle cards	27.2	1.56E-07	For 56.25 Gbps data rate
Serdes C	Backplane + paddle cards	28.7	1.69E-06	For 56.25 Gbps data rate
Serdes C	Backplane + paddle cards	29.3	1.53E-05	For 56.25 Gbps data rate
Serdes C	Backplane + paddle cards	31.3	2.90E-05	For 56.25 Gbps data rate
Serdes C	Backplane + paddle cards	32.7	1.32E-05	For 56.25 Gbps data rate
Serdes C	Backplane + paddle cards	34.2	4.48E-04	For 56.25 Gbps data rate

- End to End Loss is from bga ball to bga ball of the test chip – Package loss excluded
- Xtalk Aggressor channel(s) included if available in EVB
- Results are sought by increasing through channel loss with available combinations of the channel sub components, till then the link fails or pre-FEC BER > 1e-4

Back Plane Channels : COM

Channel number	Insertion Loss @ Nyquist	FOM_ILD	ICN mV			COM		
			Thru	8FEXT	5 FEXT + 3 NEXT	Thru	8FEXT	5FEXT + 3NEXT
Ch1	10.7876	0.31042	0	1.4182	1.2534	4.8251	4.7816	4.7856
Ch2	12.4579	0.30047	0	1.2597	1.1147	4.5919	4.5513	4.5463
Ch3	17.3145	0.28196	0	0.81332	0.81725	4.6597	4.6219	4.5937
Ch4	20.874	0.31335	0	0.65098	0.72664	4.3937	4.3432	4.259
Ch5	22.3474	0.28224	0	0.58646	0.69128	3.9172	3.8764	3.7685
Ch6	25.3573	0.3028	0	0.5156	0.64907	3.5045	3.4655	3.3116
Ch7	27.6685	0.31005	0	0.42342	0.60807	2.8654	2.8413	2.6154
Ch8	30.1441	0.30382	0	0.34888	0.57276	2.3723	2.3495	2.0145
Ch9	32.859	0.31247	0	0.31019	0.55667	1.1103	1.0906	0.63969
Ch10	34.9828	0.34579	0	0.27666	0.54711	0.20211	0.18435	-0.32395
Data Rate 53.125 Gbps Baud Rate 28.5625 GBd Nyquist Frequency 13.28125 GHz								

System of backplane channels are characterized and evaluated in COM; Different Xtalk conditions included (Thru; 8 FEXT; 5 FEXT+ 3 NEXT)

These Channels were also used in the test serdes measurements

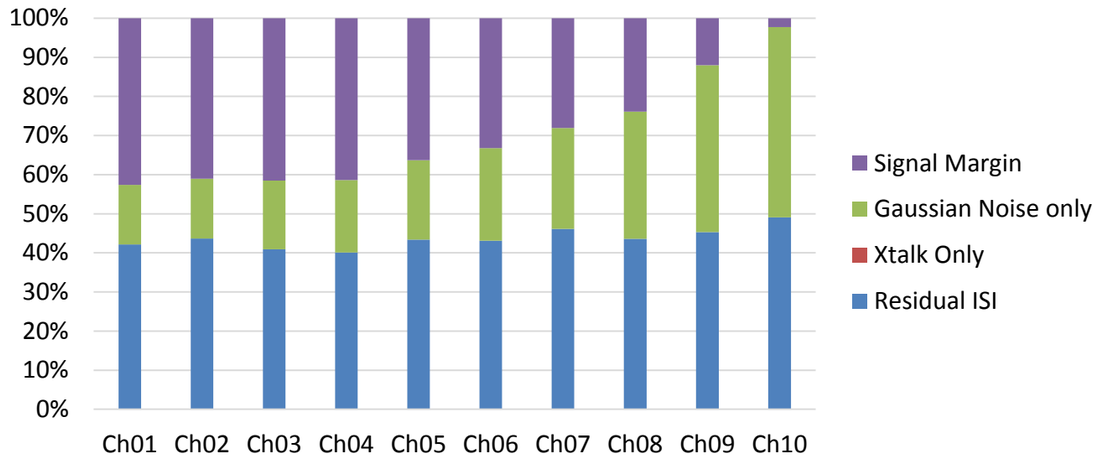
COM parameters used are based on mellitz_021716_50GE_NGOATH with minor changes – g_DC_HP allowed to go to -7 dB; COM parameter table is included in the supporting slides at the end.

Only Long package is used

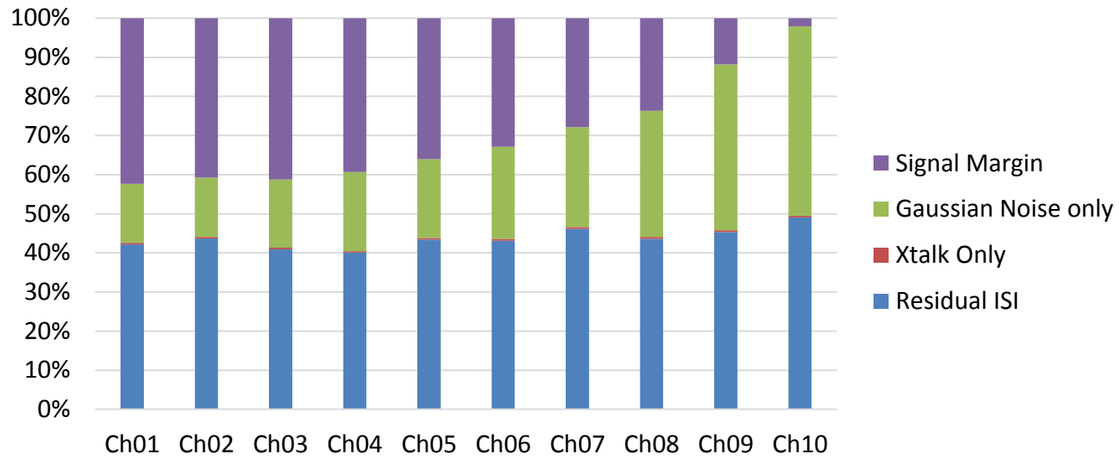
Back Plane Channels : A look into Noise contributors

Channel Number	Signal (mv)	Total Noise (mv)	% of Signal	Residual ISI (mv)	% of Noise	% of Signal	ISI + Xtalk (mv)	Xtalk Only (mv)	% of Noise	% of Signal	Gaussian Noise only (mv)	% of Noise	% of Signal
Thru Channels only													
Ch1	38.255	21.95	57.38%	16.12	73.44%	42.14%	16.12	0	0.00%	0.00%	5.83	26.56%	15.24%
Ch2	29.0127	17.1	58.94%	12.67	74.09%	43.67%	12.67	0	0.00%	0.00%	4.43	25.91%	15.27%
Ch3	15.6974	9.18	58.48%	6.42	69.93%	40.90%	6.42	0	0.00%	0.00%	2.76	30.07%	17.58%
Ch4	10.1564	5.951	58.59%	4.07	68.39%	40.07%	4.07	0	0.00%	0.00%	1.881	31.61%	18.52%
Ch5	8.5288	5.4328	63.70%	3.7015	68.13%	43.40%	3.7015	0	0.00%	0.00%	1.7313	31.87%	20.30%
Ch6	6.5544	4.3784	66.80%	2.825	64.52%	43.10%	2.825	0	0.00%	0.00%	1.5534	35.48%	23.70%
Ch7	5.1286	3.6875	71.90%	2.3643	64.12%	46.10%	2.3643	0	0.00%	0.00%	1.3232	35.88%	25.80%
Ch8	4.0236	3.0619	76.10%	1.7543	57.29%	43.60%	1.7543	0	0.00%	0.00%	1.3076	42.71%	32.50%
Ch9	2.9744	2.6175	88.00%	1.3474	51.48%	45.30%	1.3474	0	0.00%	0.00%	1.2701	48.52%	42.70%
Ch10	2.5109	2.4532	97.70%	1.2329	50.26%	49.10%	1.2329	0	0.00%	0.00%	1.2203	49.74%	48.60%
Channels with Xtalk --- 8FEXT													
Ch1	38.255	22.06	57.67%	16.12	73.07%	42.14%	16.27	0.15	0.68%	0.39%	5.79	26.25%	15.14%
Ch2	29.0127	17.18	59.22%	12.67	73.75%	43.67%	12.79	0.12	0.70%	0.41%	4.39	25.55%	15.13%
Ch3	15.6974	9.22	58.74%	6.42	69.63%	40.90%	6.49	0.07	0.76%	0.45%	2.73	29.61%	17.39%
Ch4	10.1564	6.16	60.65%	4.07	66.07%	40.07%	4.11	0.04	0.65%	0.39%	2.05	33.28%	20.18%
Ch5	8.5288	5.4584	64.00%	3.7015	67.81%	43.40%	3.7356	0.0341	0.62%	0.40%	1.7228	31.56%	20.20%
Ch6	6.5544	4.398	67.10%	2.825	64.23%	43.10%	2.8577	0.0327	0.74%	0.50%	1.5403	35.02%	23.50%
Ch7	5.1286	3.6978	72.10%	2.3643	63.94%	46.10%	2.3899	0.0256	0.69%	0.50%	1.3079	35.37%	25.50%
Ch8	4.0236	3.07	76.30%	1.7543	57.14%	43.60%	1.7744	0.0201	0.65%	0.50%	1.2956	42.20%	32.20%
Ch9	2.9744	2.6234	88.20%	1.3474	51.36%	45.30%	1.3623	0.0149	0.57%	0.50%	1.2611	48.07%	42.40%
Ch10	2.5109	2.4582	97.90%	1.2329	50.15%	49.10%	1.2429	0.01	0.41%	0.40%	1.2153	49.44%	48.40%
Channels with Xtalk --- 5FEXT + 3 NEXT													
Ch1	38.255	22.05	57.64%	16.12	73.11%	42.14%	16.27	0.15	0.68%	0.39%	5.78	26.21%	15.11%
Ch2	29.0127	17.19	59.25%	12.67	73.71%	43.67%	12.79	0.12	0.70%	0.41%	4.4	25.60%	15.17%
Ch3	15.6974	9.25	58.93%	6.42	69.41%	40.90%	6.54	0.12	1.30%	0.76%	2.71	29.30%	17.26%
Ch4	10.1564	6.22	61.24%	4.07	65.43%	40.07%	4.2	0.13	2.09%	1.28%	2.02	32.48%	19.89%
Ch5	8.5288	5.5267	64.80%	3.7015	66.97%	43.40%	3.8465	0.145	2.62%	1.70%	1.6802	30.40%	19.70%
Ch6	6.5544	4.4767	68.30%	2.825	63.10%	43.10%	2.9823	0.1573	3.51%	2.40%	1.4944	33.38%	22.80%
Ch7	5.1286	3.7952	74.00%	2.3643	62.30%	46.10%	2.5438	0.1795	4.73%	3.50%	1.2514	32.97%	24.40%
Ch8	4.0236	3.1907	79.30%	1.7543	54.98%	43.60%	1.9836	0.2293	7.19%	5.70%	1.2071	37.83%	30.00%
Ch9	2.9744	2.7632	92.90%	1.3474	48.76%	45.30%	1.627	0.2796	10.12%	9.40%	1.1362	41.12%	38.20%
Ch10	2.5109	2.6063	103.80%	1.2329	47.30%	49.10%	1.5266	0.2937	11.27%	11.70%	1.0797	41.43%	43.00%

Back Plane Channels : A look into Noise contributors

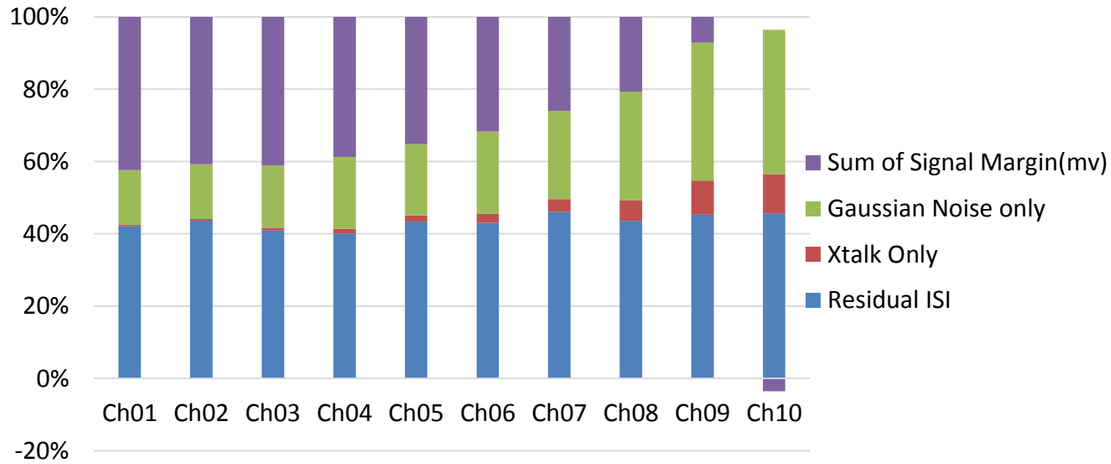


THRU only



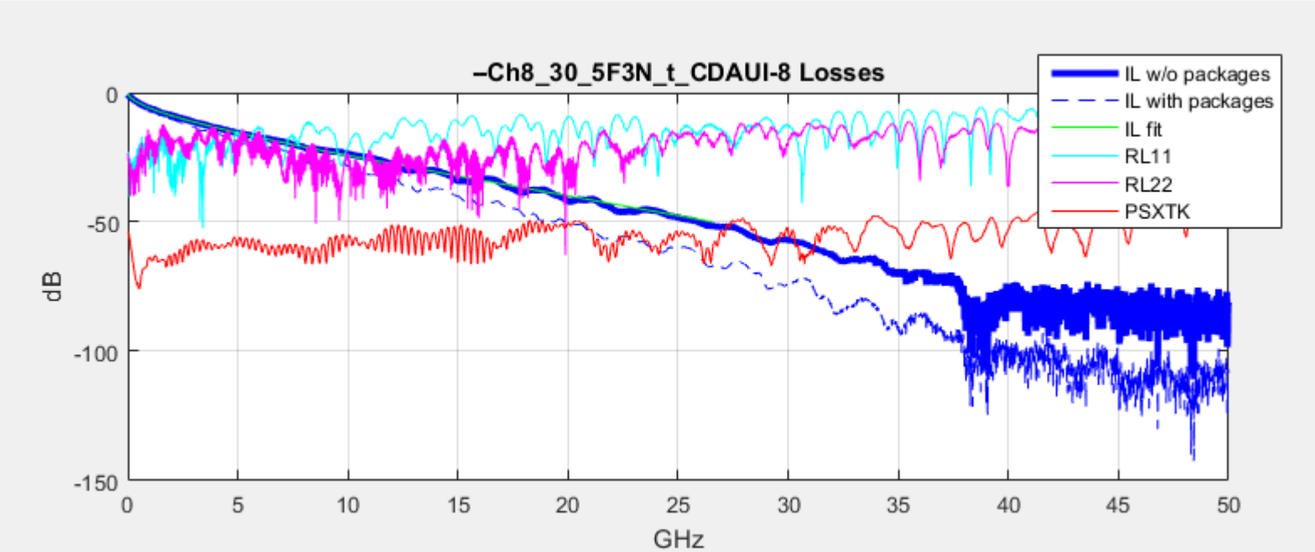
8FEXT

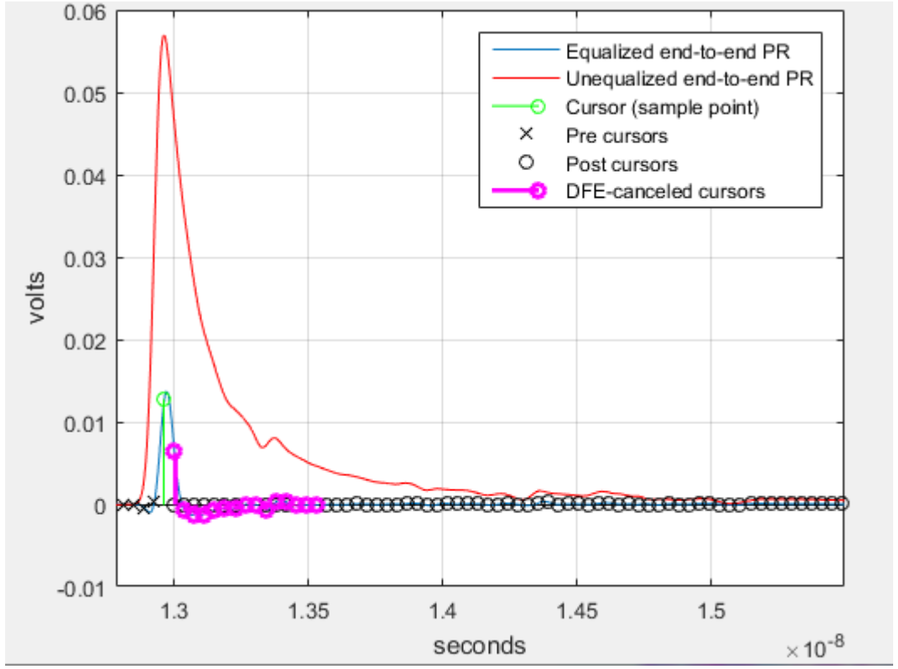
- Consistent high contribution from Residual ISI; COM reference equalizers are not sufficient ; They need to represent/align more closely to real implementations
- A finer look into factors that can reduce Gaussian noise contributors is needed, like .. SNR_TX etc..
- Needs a second look into Signal eroding factors, like reference CDR used in COM

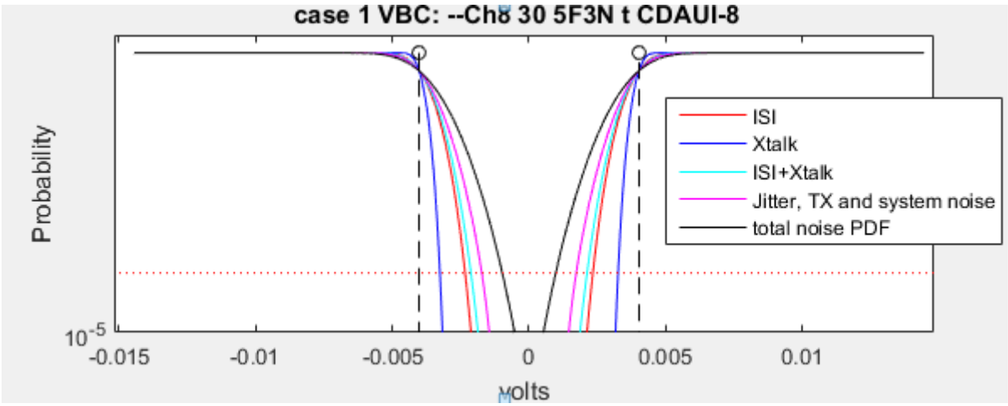


5FEXT+3NEXT

COM exploration for 30 dB channel







- Improvements needed to control package and overall reflection
- 15 tap DFE is not good enough- noise well beyond 40 taps
- Need to explore ways to limit TX introduced noise and RX equalization capabilities
- Improve LFEQ + CTLE combined gain, but may need VGA to gain the signal or limit the COM margin to 2 dB.

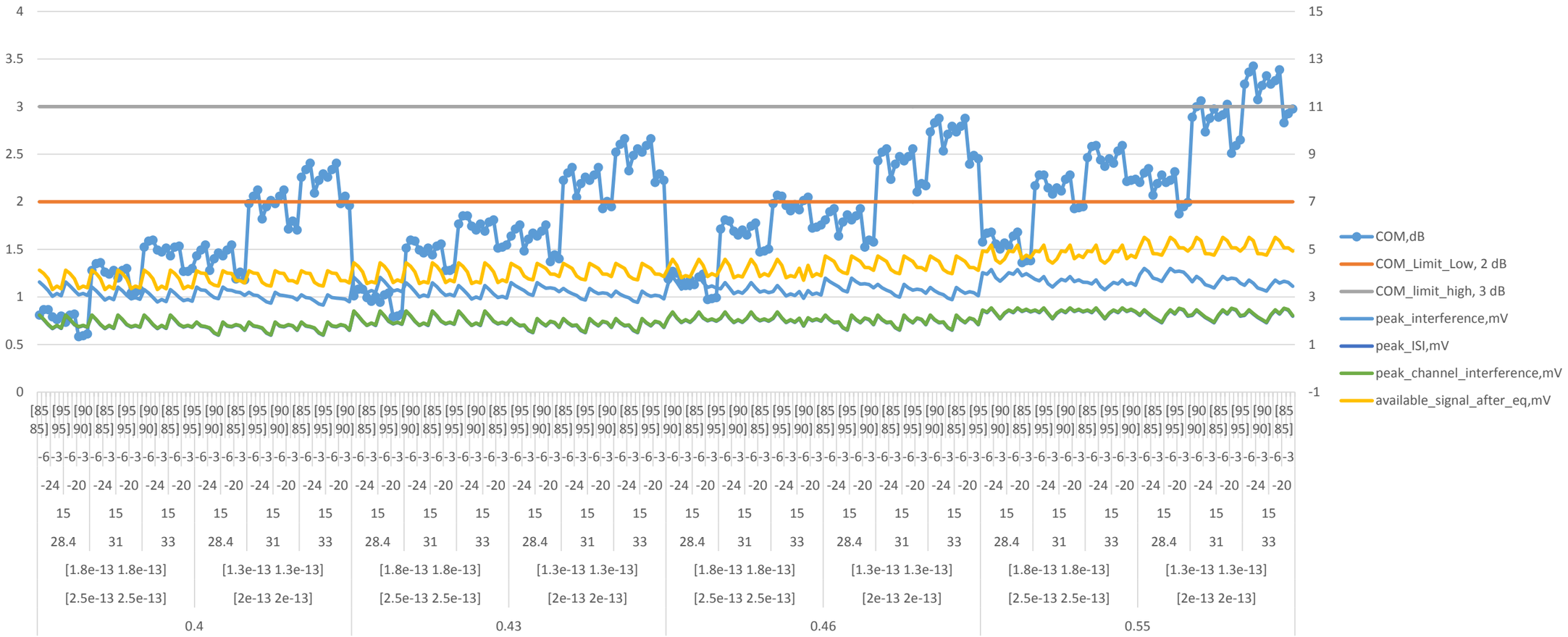
COM exploration for 30 dB channel : Parameters

Starting with present values as median the following parameters are varied to explore the Solution space.

- g_DC
- g_DC_HP
- C_d
- C_p
- Package_Z_c
- SNR_TX
- A_v;A_fe;A_ne
- N_b
- bmax(1)
- bmax(2 .. N_b)

COM parameter(s)	Range of values
g_DC	{[-20:1:0];[-24:1:0]}
g_DC_HP	{[-3:1:0];[-6:1:0]}
C_d;C_p	{[2.5e-4 2.5e-4],[1.8e-4 1.8e-4];[2.0e-4 2.0e-4],[1.3e-4 1.3e-4];[1.8e-4 1.8e-4],[1.1e-4 1.1e-4]}
Package_Z_c	[85 90 95]
SNR_TX	[28.4 31 33]
A_v;A_fe;A_ne	{[0.4 0.4 0.6];[0.43 0.43 0.645];[0.46 0.46 0.69];[0.55 0.55 0.825]}
N_b	[15 25 40 64]
Bmax(1); bmax(2 … N-b)	{[1 1];[0.5 0.2]}

COM exploration for 30 dB channel : Solution Space



This is a snapshot of solution space for 15 tap DFE; Can demo/include a full solution space to understand impact of each parameter

Conclusions

- The presented measured data shows range of vendor’s serdes with more than one type of architecture can support > 30 dB of channels for both backplane and DAC channels
- The test silicon we have had in the lab are all expected to have scheduled update to further improve the performance in the near future. Also new vendors are being added to this test schedule.
- Class of backplane channels are evaluated with COM to understand factors for noise contribution
- A solution space was generated for a 30 dB backplane channel that provided a detailed look into impact of each parameters under consideration
- Based on this analysis of early test silicon, we are satisfied that a 30 dB channel is technically feasible

Considerations for modifying backplane and twinax Objectives

We have gained some good confidence in our understanding of the technology capabilities possible and would like to propose some refinements to the objectives.

We considered two approaches to propose changes (assuming KP4 FEC or other types of FEC being discussed):

Approach 1:

3m reach twinax for objective

Dual objectives for the backplane application to satisfy different applications

- *KR-S : 25 dB loss budget for backplane @ 53.125 Gbps*
- *KR-L : 30-32 dB loss budget for backplane @ 53.125 Gbps*

Approach 2:

3m reach twinax for objective

30 dB loss budget for backplane @53.125 Gbps

Consistent feedback that Approach 2 was preferred

Proposal

Modify the currently adopted objectives for copper twinax and backplane PHYs as below:

- Define single-lane 50 Gb/s PHYs for operation over

  Copper twinaxial cables with lengths up to at least 3m

  Printed circuit board backplane with a total channel insertion loss of <= 30dB at 13.28125 GHz.
- Define four-lane 200 Gb/s PHYs for operation over:

  Copper twinaxial cables with lengths up to at least 3m.

  Printed circuit board backplane with a total channel insertion loss of <= 30dB at 13.28125 GHz .
- Define a two-lane 100 Gb/s PHY for operation over copper twin-axial cables with lengths up to at least 3m.
- Define a two-lane 100 Gb/s PHY for operation over a printed circuit board backplane with a total channel insertion loss of <= 30dB at 13.28125 GHz

Supporting Information

COM Parameters used

Table 93A-1 parameters			
Parameter	**Setting**	**Units**	**Information**
f_b	26.5625	GBd	
f_min	0.05	GHz	
Delta_f	0.01	GHz	
C_d	[2.3e-4 2.3e-4]	nF	[TX RX]
z_p select	[1]		[test cases to run]
z_p (TX)	[30]	mm	[test cases]
z_p (NEXT)	[12]	mm	[test cases]
z_p (FEXT)	[30]	mm	[test cases]
z_p (RX)	[30]	mm	[test cases]
C_p	[1.1e-4 1.1e-4]	nF	[TX RX]
R_0	50	Ohm	
R_d	[55 55]	Ohm	[TX RX]
f_r	0.75	*fb	
c(0)	0.6		min
c(-1)	[-0.15:0.05:0]		[min:step:max]
c(-2)	[-0.15:0.05:0]		[min:step:max]
c(1)	[-0.35:0.05:0]		[min:step:max]
g_DC	[-20:1:0]	dB	[min:step:max]
f_z	10.625	GHz	
f_p1	10.625	GHz	
f_p2	1.00E+99	GHz	
A_v	0.45	V	
A_fe	0.45	V	
A_ne	0.65	V	
L	4		
M	32		
N_b	15	UI	
b_max(1)	0.5		
b_max(2..N_b)	0.2		
sigma_RJ	0.01	UI	
A_DD	0.02	UI	
eta_0	2.60E-08	V^2/GHz	
SNR_TX	31.1	dB	
R_LM	0.95		
DER_0	1.00E-04		
Operational control			
COM Pass threshold	3	dB	
Include PCB	0	Value	0, 1, 2

g_DC_HP	[-7:1:0]		[min:step:max]
f_HP_PZ	0.6640625	GHz	

I/O control		
DIAGNOSTICS	1	logical
DISPLAY_WINDOW	1	logical
Display frequency domain	1	logical
CSV_REPORT	1	logical
RESULT_DIR	.\results\COM50_{date}\	
SAVE_FIGURES	0	logical
Port Order	[1 2 3 4]	
RUNTAG	_CDAUI-8	
Receiver testing		
RX_CALIBRATION	0	logical
Sigma BBN step	5.00E-03	V
IDEAL_TX_TERM	0	logical
T_r	8.00E-03	ns
T_r_filter_type	0	logical
T_r_meas_point	0	logical

Non standard control options		
INC_PACKAGE	1	logical
IDEAL_RX_TERM	0	logical
INCLUDE_CTLE	1	logical
INCLUDE_TX_RX_FILTER	1	logical
COM_CONTRIBUTION	0	logical
CDR_OVERSAMPLED	0	logical

Table 93A–3 parameters		
Parameter	**Setting**	**Units**
package_tl_gamma0_a1_a2	[0 1.734e-3 1.455e-4]	
package_tl_tau	6.141E-03	ns/mm
package_Z_c	90	Ohm

Table 92–12 parameters		
Parameter	**Setting**	
board_tl_gamma0_a1_a2	[0 4.114e-4 2.547e-4]	
board_tl_tau	6.191E-03	ns/mm
board_Z_c	110	Ohm
z_bp (TX)	151	mm
z_bp (NEXT)	72	mm
z_bp (FEXT)	72	mm
z_bp (RX)	151	mm

Thank you.