PMC
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T10/05-428r0

 SAS-2 channels analyses and suggestion for physical link requirements

To: T10 Technical Committee

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Subject: T10/05-428r0 SAS-2 channel compliance analyses and suggestion for electrical specification

Revision History
Revision 0 (06 November 2005) first revision

Related Documents

T10/05-357r0 SAS-2 External Cable Electrical Specification

T10/05-389r0 SAS-2 Channel Models (4-Connector, Board-to-Board)
T10/05-384r0 SAS-2 Channel Models (3-Connector, Board-to-Board)
T10/05-390r0 SAS-2 Channel Models (3-Connector, Board/Cable/Backplane/Drive)

T10/05-404r0 SAS-2 Multilane Cable Assembly Model, six meter
T10/05-401r0 SAS-2 Multilane Cable Assembly Model, half meter

T10/05-393r0 SAS-2 Channel Model (4 boards / 3 mated connectors)

OIF-CIE-02.0 Common Electrical I/O (CEI)- Electrical and Jitter Interoperability agreements for 6G+ bps and 11G+ bps I/O
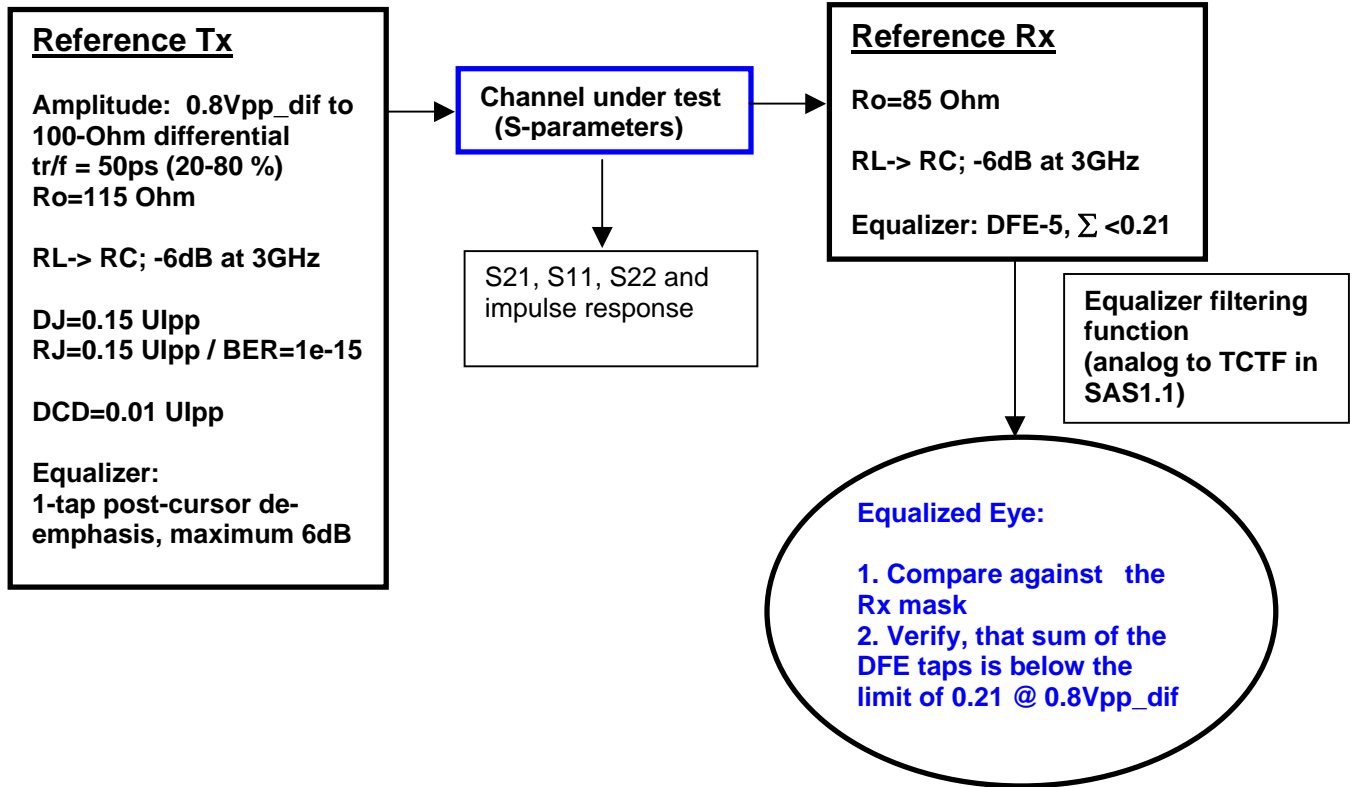

Overview

The SAS-2 channel performance analyzed for the models posted at T10 and listed above. The analyses method is similar to OIF-CEI-02.0 compliance method for 6G+ LR, but modified for SAS-2 environment.
Reference transmitter is a one-tap Tx with post-cursor de-emphasis, and reference receiver is a five-tap DFE equalizer. Our results do not necessary mandate DFE solution and are applicable to an FIR equalizer with similar performance. Since there was no crosstalk data posted for the backplanes, the crosstalk contribution could be factored in by analyzing amplitude and jitter margins.   PMC Sierra in-house statistical eye simulation tool (with method recommended by OIF-CEI-02.0) was employed. Because of the ambiguity in extrapolation of S-parameters data to DC, few results may require additional verifications.

# I. The SAS-2 6Gb/s Rx/ Tx requirements assumption (based on OIF-CEI-02.0 6G+ LR)

Characteristic	Units	6Gb/s
Tx		
Differential Amplitude	mV(p-p)	800 –1200
Return loss	dB	< **6**[a] at 3GHz
Recommened Rise/Fall time 20-80%	ps	> 30
Differential impedance	Ohm	100Ohm +/-15%
DJ	UI	< 0.15
RJ, CDF level 1e-15	UI	< 0.15
Tx- Equalizer		
1-tap post cursor de-emphasis with gain	dB	< 6dB
Adaptability	-	No, Preset Tap
Rx		
Return loss	dB	<**6**[a]
Differential impedance	Ohm	100 +/-**15%**[b]
Equalized eye amplitude	mV(p-p)	> 100
TJ, CDF level 1e-15	UI	< 0.6
Rx-Equalizer		
DFE with number of taps (or equivalent in performance FIR filter)	-	5
Adaptability		Yes
Limit for the sum of DFE taps for Tx =1Vpp, absolute value	Vpp	0.263
Rx-Training (Tx must repeatedly transmit training pattern on Rx request)		Yes
Definition for Training pattern		TBD
(In statistical eye simulation DFE taps are assumed to be equal to channel impulse response)		
Note: This assumptions are made for simulation purposes and is a subject for SAS-2 requirements discussion **a.** OIF-CEI-02.0 6G+ LR requirement - 8dB **b.** OIF-CEI-02.0 6G+ LR requirement +/-20%		

II. Reference Model for Channel Testing

Reference Tx

**Amplitude: 0.8Vpp_dif to 100-Ohm differential
tr/f = 50ps (20-80 %)
Ro=115 Ohm**

RL-> RC; -6dB at 3GHz

**DJ=0.15 UIpp
RJ=0.15 UIpp / BER=1e-15**

DCD=0.01 UIpp

**Equalizer:
1-tap post-cursor de-emphasis, maximum 6dB**

**Channel under test
(S-parameters)**

S21, S11, S22 and
impulse response

Reference Rx

Ro=85 Ohm

RL-> RC; -6dB at 3GHz

Equalizer: DFE-5, $\sum$ <0.21

**Equalizer filtering
function
(analog to TCTF in
SAS1.1)**

Equalized Eye:

**1. Compare against   the
Rx mask
2. Verify, that sum of the
DFE taps is below the
limit of 0.21 @ 0.8Vpp_dif**

Note: The amplitude, jitter, return loss, termination resistance in the reference model were selected to represent the worst-case attenuation in the link.

Compliance eye mask after equalizer

R_Y2

$TJ = 0.6UIpp$

R_Y1

0

-R_Y1

$2\,A = 100\,mV$

0.3UI

-R_Y2

0.0   R_X1   0.5   1-R_X1   1.0
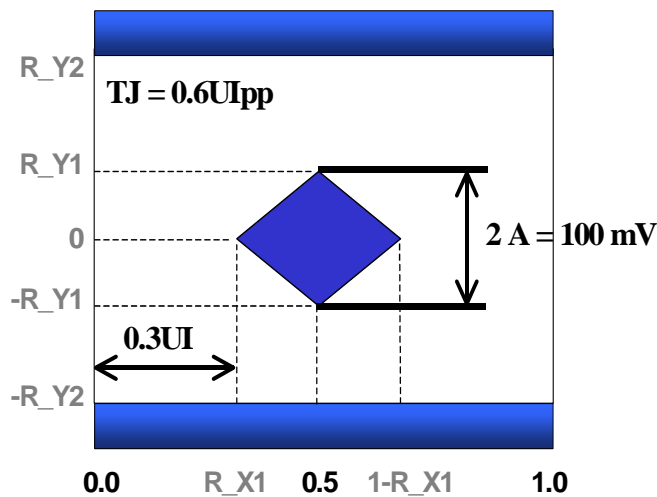
III. Channel Results Summary

| Channel	S21@ 3GHz dB	S11@ 3GHz dB	Equalized Eye at Rx				Note
			RL = -6dB 3 GHz		RL = -8dB 3 GHz		
			Tx ,6dB No DFE	Tx, 0dB DFE-5	Tx, 6dB No DFE	Tx, 0dB DFE-5	
HP01	-8.9	-13	0.56 / 0.1	0.48 / 0.2			For all channels:
HP02	-7.5	-10	0.58 / 0.1	0.48 / 0.22			Top: TJ in UIpp Bottom: 2x A Vpp
HP03	-6.4	-12	0.56 / 0.12	0.45 / 0.25			at BER=1-15. Failed mask is in
HP04	-6.6	-10	0.55 / 0.13	0.44 / 0.25			red
HP05	-6.8	-20	0.61 / 0.11	0.5 / 0.22			
HP06	-10.6	-12	0.52 / 0.09	0.45 / 0.18			
HP07	-8.0	-12	0.52 / 0.113	0.43 / 0.21			
HP08	-8.9	-13	0.54 / 0.11	0.44 / 0.19			
HP09	-12.1	-6 / -6 @ 2.5G	0.74 / 0.03	0.62 / 0.115	0.65 / 0.07	0.54 / 0.15	High reflections channels. ISI results were
HP10	-9.1	-14 / -3 @ 2.5G	closed eye	0.65 / 0.11	0.9 / 0.007	0.61 / 0.14	50% pessimistic versus Spectre. More data and
HP11	-8.7	-16 / -5 @ 2.25G	0.84 / 0.01	0.64 / 0.11	0.7 / 0.05	0.57 / 0.14	analyses is recommended
HP12	-7.5	-14	0.52 / 0.13	0.45 / 0.22	0.48 / 0.14	0.4 / 0.25	
HP13	-4.9	-14	0.57 / 0.12	0.45 / 0.24	0.53 / 0.15	0.40 / 0.29	
HP14	-2.8	-20	0.85 / 0.09	0.54 / 0.21	0.63 / 0.04	0.47 / 0.29	
miniSAS 4x 6m	-10.7	-9.5	0.55 / 0.09	0.44 / 0.18	0.52 / 0.127	0.42 / 0.199	With 4" (10cm) of PCB trace
miniSAS 4x 05m	-3	-10	0.59 / 0.1	0.46 / 0.33			
DELL 05-393r0	All channels have an open eye without equalization						Simulated S-parameters

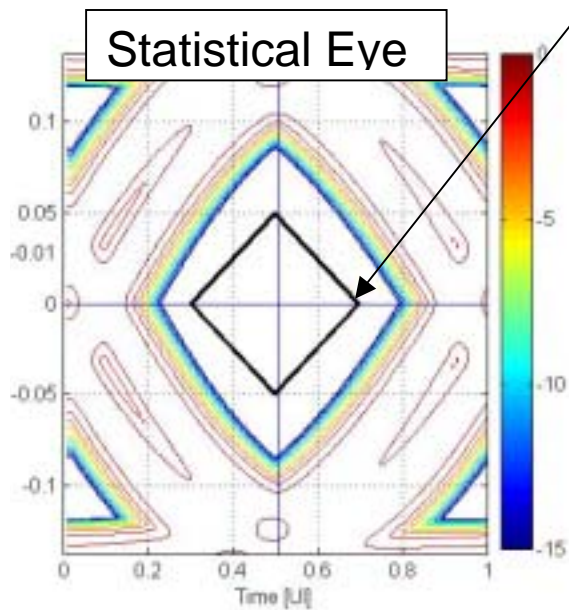## IV. Statistical Eye Examples

MiniSAS4x 6m with Tx/Rx RL= 20dB

Tx Eq 6dB
DFE OFF

2A= 0.195 V
TJ= 0.18 UIpp

PRBS-7 in Spectre:
2A= 0.15 V
TJ= 0.24 UIpp
(DC wander was
observed in sims due to
"Risky phase
interpolation to DC")

ISI ONLY

Compliance
mask

Statistical Eye
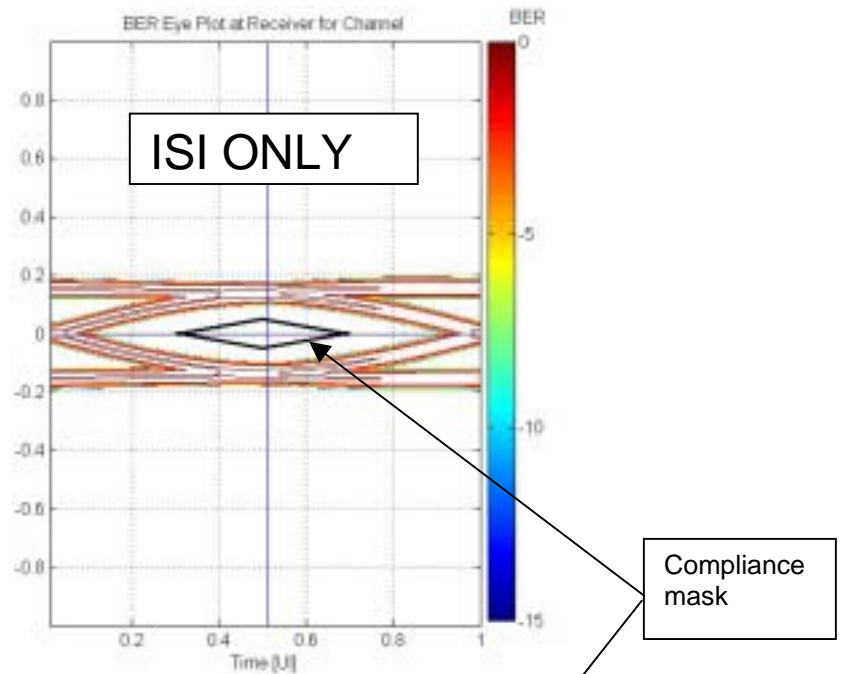
Tx Eq 6dB
DFE OFF
BER =1e-15

2A= 0.17 V
TJ= 0.43 UIpp

*MiniSAS4x 6m with **Tx/Rx RL= 6dB***

TX Eq 6dB
DFE OFF
BER =1e-15

2A= 0.097 V
TJ= 0.55 UIpp

Eye at the Receiver
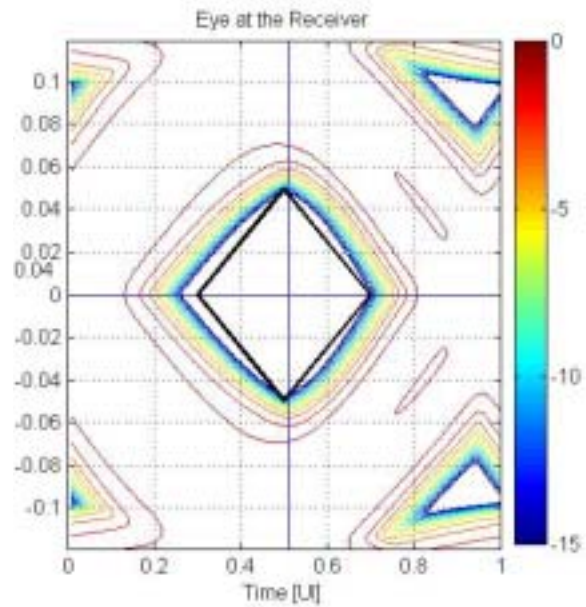
TX Eq 0dB
DFE ON
BER =1e-15

2A= 0.175 V
TJ= 0.44 UIpp

Eye at slicer assuming DFE Analysis
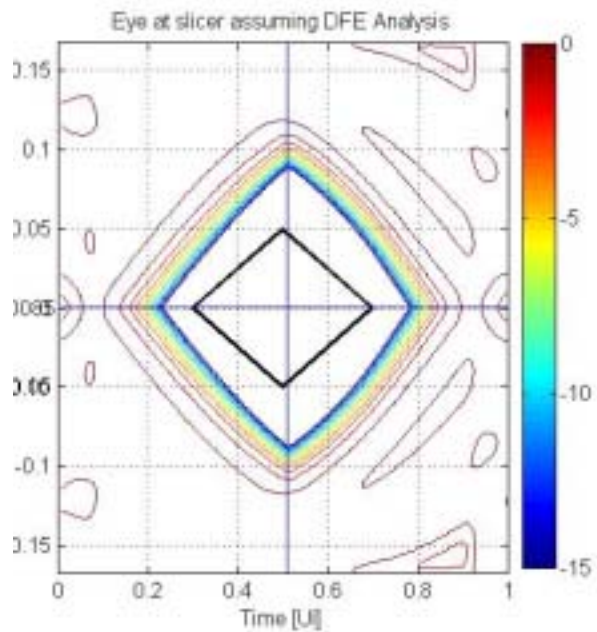
Channel HP10, RX/Tx RL =20dB

Tx Eq 6dB
DFE OFF
2A= 0.087 V
TJ= 0.45 UIpp

PRBS-7 in Spectre:
2A= 0.144 V
TJ= 0.27 UIpp

BER Eye Plot at Receiver for Channel

ISI ONLY
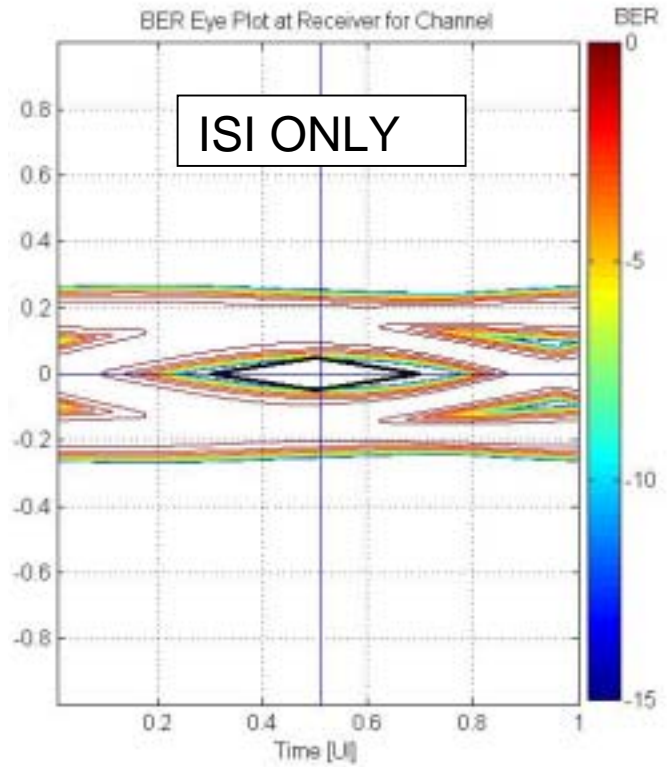
Channel HP10, RX/Tx RL =6dB

RL=6dB
Impulse
Response

Channel Impulse Response

Max @ 501
Lock @ 486

Tap #5
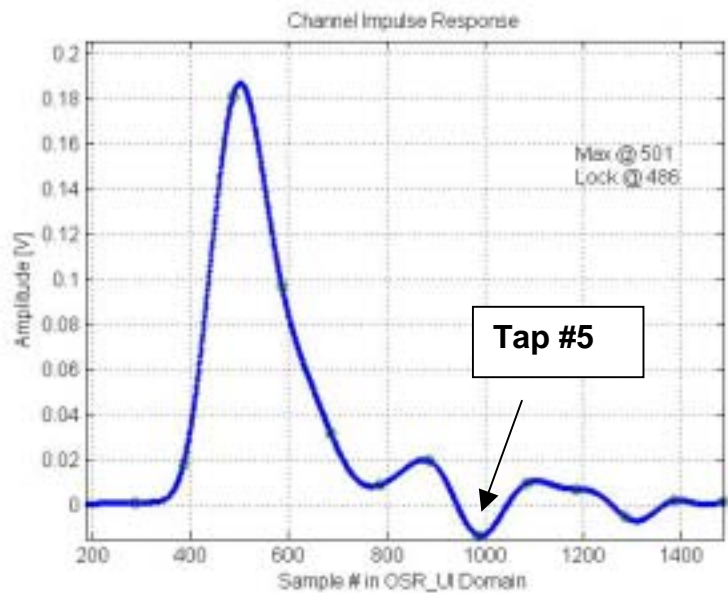
@ Rx Jitter added
TX Eq 0dB
DFE ON
BER =1e-15
2A= 0.11 V
TJ= 0.65 UIpp

Eye at slicer assuming DFE Analysis
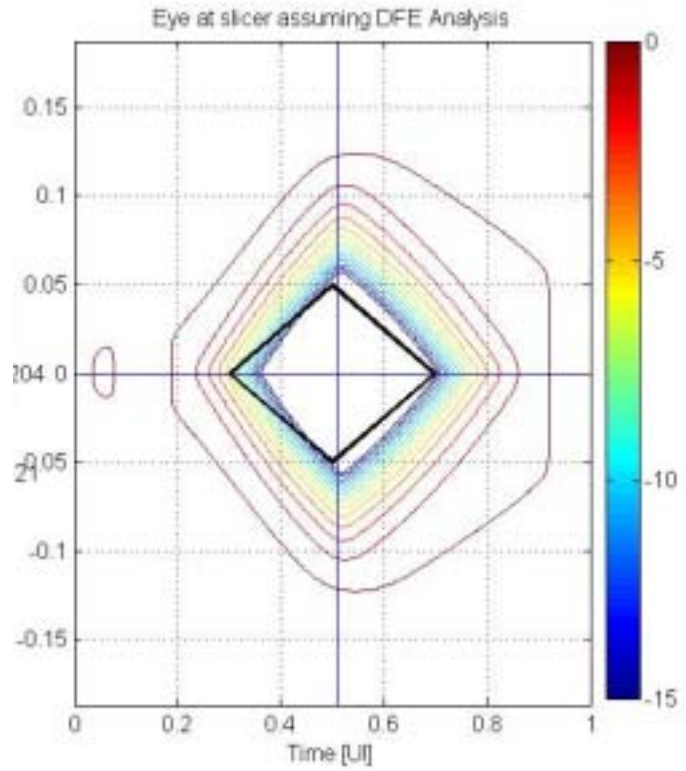
V. MiniSAS4x crosstalk with PRBS-7, Tx 1.2 Vpp_dif, two aggressors
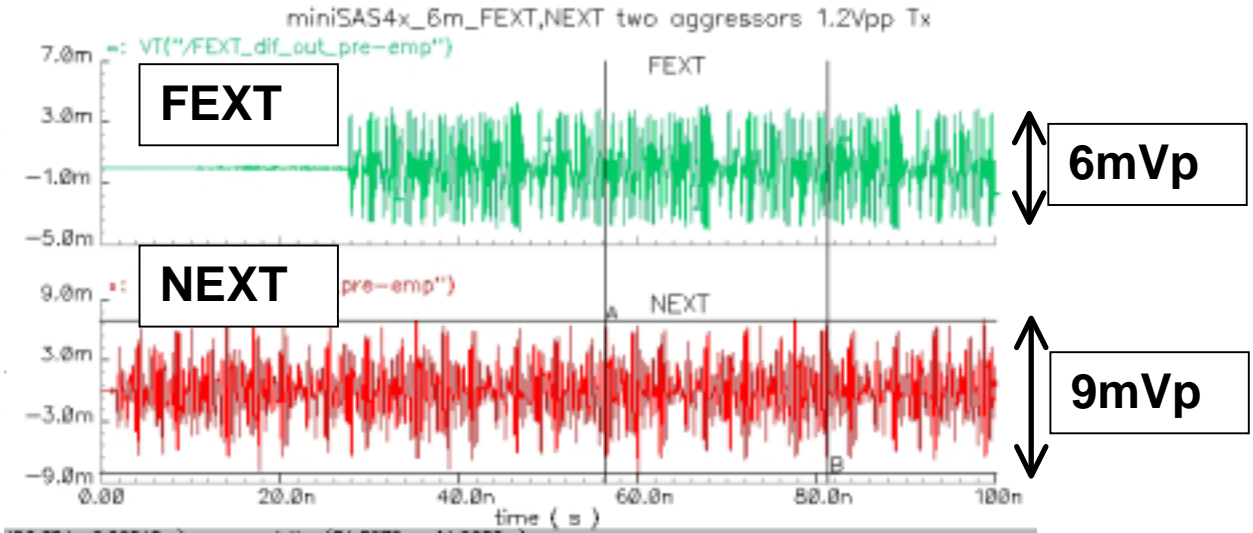
VI. Backplane crosstalk with PRBS-7, Tx 1.2 Vpp_dif four aggressors
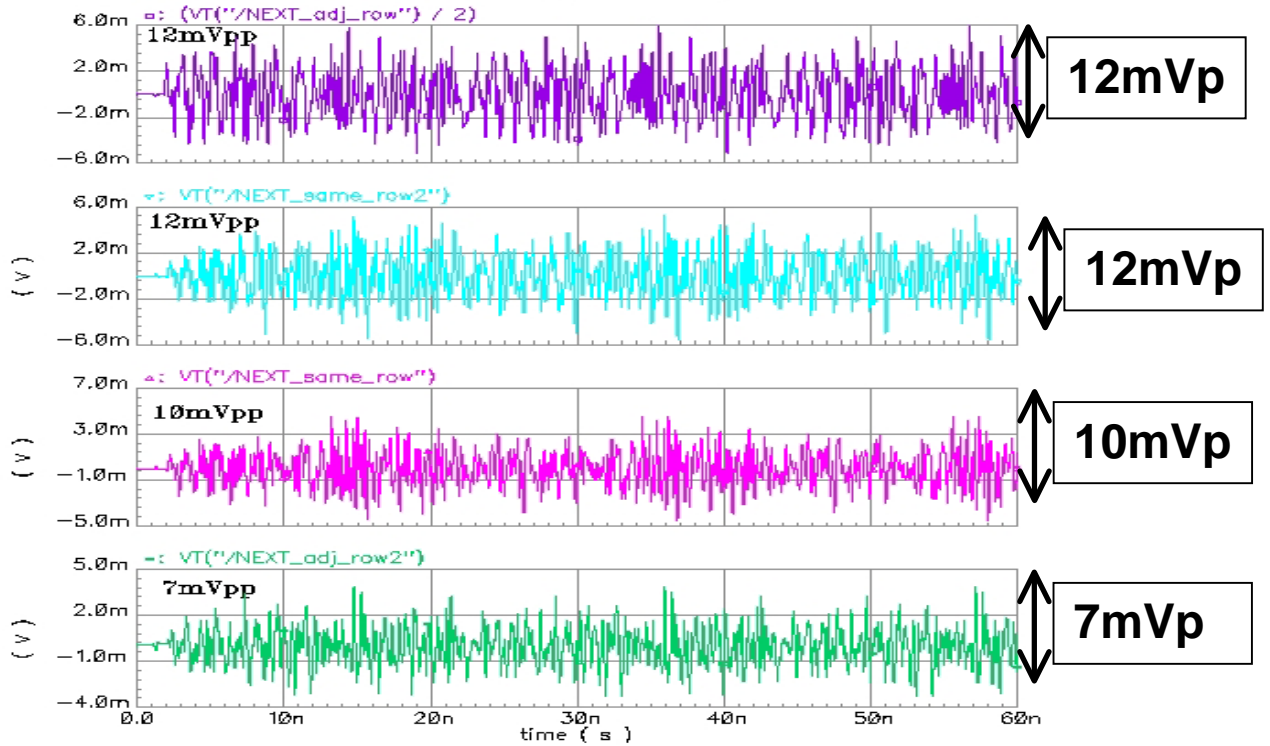
VII. Summary

- Requirements for the SAS-2 physical link where suggested. They are similar to OIF-CEI-6G+ LR with Rx/Tx return loss relaxed to 6dB at 3GHz.
- Analyses showed that all of the channels posted, except one, comply with the OIF-CEI-02.0 6G+ LR requirements for the return loss RL > 8dB. Margins against the eye mask believed to be sufficient for crosstalk noise impact of minimum 40mVpp
- Three channels do not comply with the suggested Rx/Tx return loss of 6dB at 3GHz. We recommend to continue their study with additional data and simulation tools