SAS-2 External Link Crosstalk Budget Suggestion and Analyses

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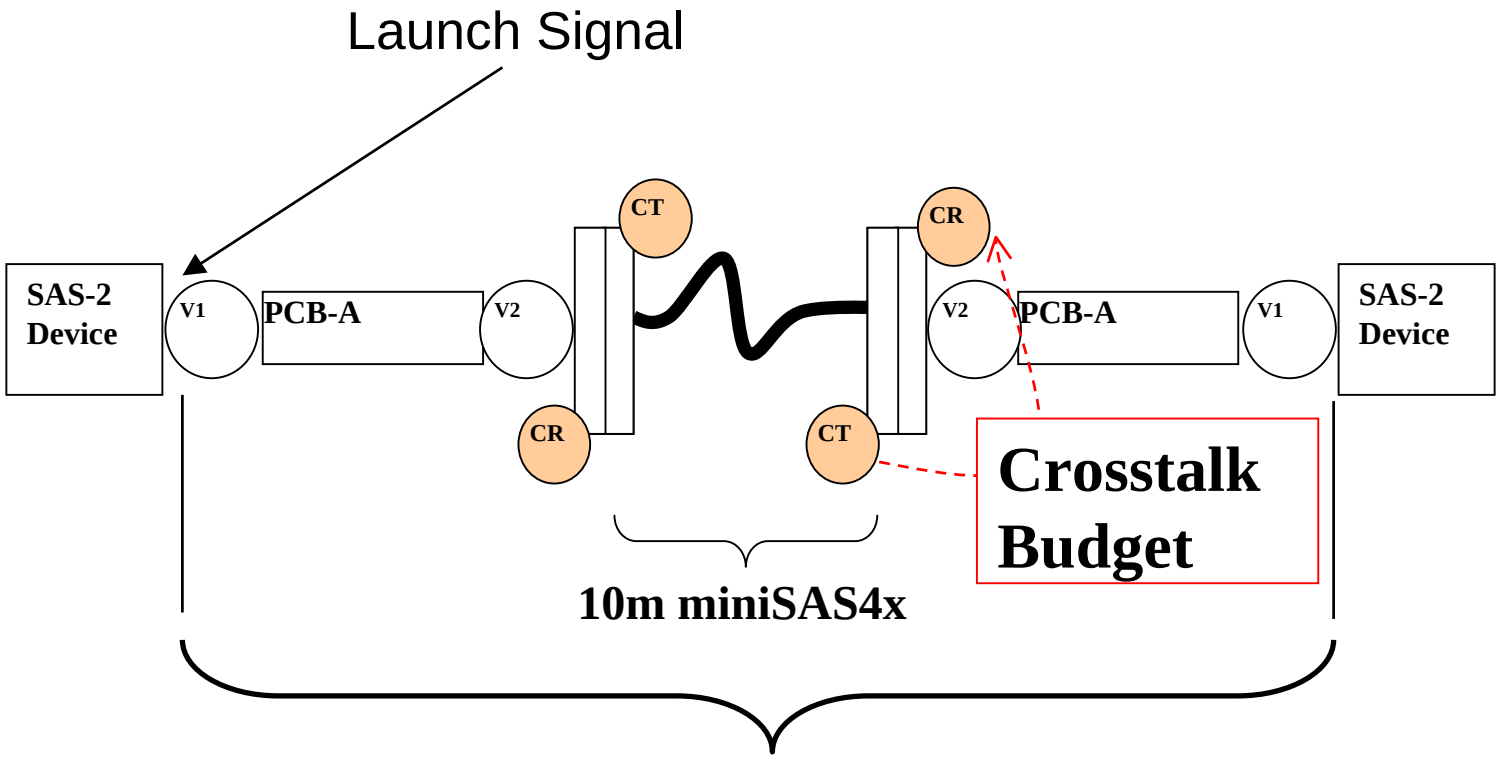
With contribution of Galen Fromm, Molex

T10/06-104r0

Background

- SAS-2 does not provision link crosstalk cancellation
  - It is costly and requires one more step of adaptation
- Link budget analyses presented in **T10/05-352r0** showed that new improved crosstalk number is required to accommodate for 10m external cable
  - An action item of SAS-2 WG conference call of 26-Jan-06
- New crosstalk requirement of –36dB up to 4.5GHz is suggested (contribution from Molex, Galen Fromm)
- We used statistical eye simulations (same as in **T10/05-352r0) to** estimate new channel budget and crosstalk impact on 10m miniSAS4x channel

External Cable Link



S-parameters data for 10m miniSAS4x
(assumption based on Molex test coverage)

Suggestion for miniSAS4x Crosstalk (after Galen Fromm, Molex)

Table 41 — ~~Additiona~~R~~equirements for external cable assemblies using Mini SAS 4x~~

All data rates

Requirement [a, b, c, d]	Units	~~1,5 Gbps~~	~~3,0 Gbps~~
Maximum near-end crosstalk for each receive pair	dB	~~-26~~	-36dB

[a] All measurements are made through mated connector pairs.

[b] Determine all valid aggressor/victim near-end crosstalk transfer modes. Over the complete frequency range of this measurement, determine the sum of the crosstalk transfer ratios, measured in the frequency domain, of all crosstalk transfer modes. To remove unwanted bias due to test fixture noise, magnitudes less than -50 dB (e.g., -60 dB) at all frequencies may be ignored. The following equation details the summation process of the four valid near-end crosstalk sources. All NEXT values expressed in dB format in a passive transfer network shall have negative dB magnitude.

$$\text{TotalNEXT}(f) = 10 \times \log \sum_{1}^{4} 10^{\langle \text{NEXT}(f)/10 \rangle}$$

[c] The range for this frequency domain measurement is 10 MHz to 4 500 MHz.

[d] The far end of the mated cable assembly shall be terminated in its characteristic impedance. Insertion loss variations (i.e., cable length) may change the measurement result.

Working Draft Serial Attached SCSI - 2 (SAS-2) **139**

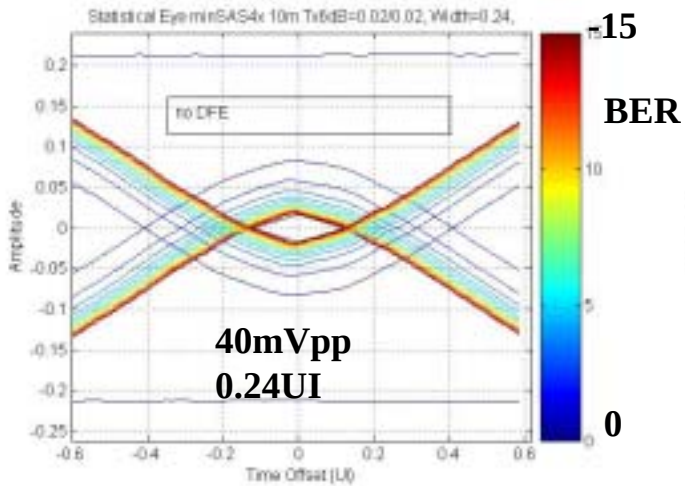
Note: PMC-Sierra measured total level of crosstalk is below –40dB

Evaluation of Crosstalk Impact

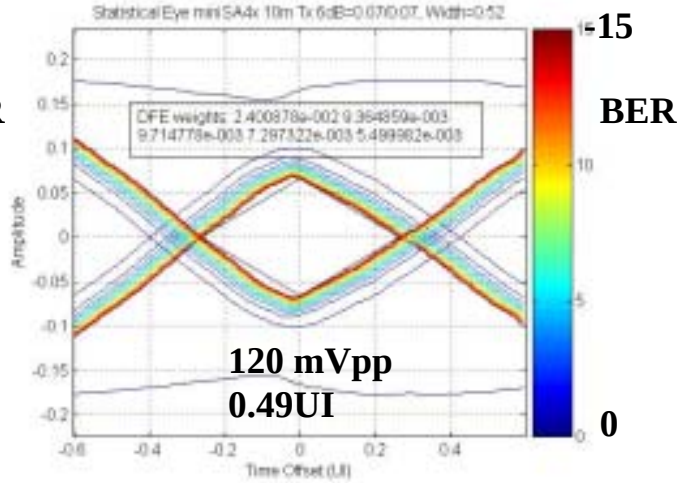
- Statistical or deterministic crosstalk ?
  - “Deterministic” crosstalk from synchronous data source is most harmful
    - Amplitude summation rather than power terms
    - Excludes statistical methods from crosstalk simulation
    - Rx eye closer can be accounted as a result of vertical eye shift on the maximum amount of crosstalk amplitude
- Maximum crosstalk amplitude is simply derived as Tx launch peak-to-peak divided by crosstalk attenuation (-36dB)
  - Quite accurate assumption at 6Gb/s
  - At 3Gb/s is a subject to rise/fall time minimum number

Statistical Eye simulated for 10m miniSAS4x S-parameters, Tx =1Vpp No crosstalk, BER=1e-15

6dB Tx , no DFE

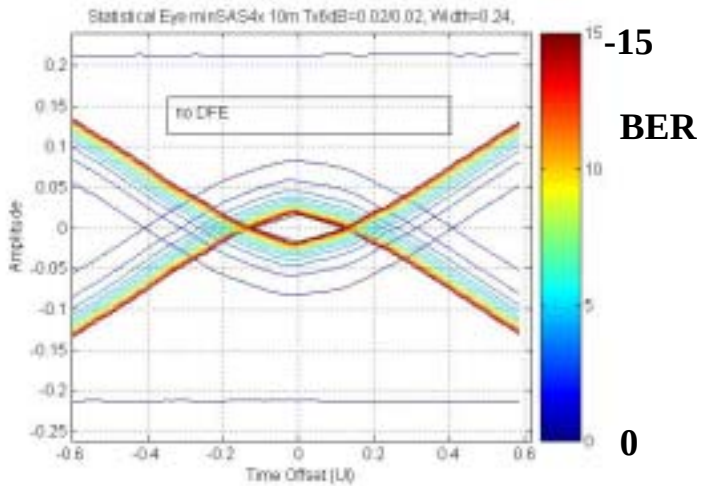


6dB Tx , 5 tap DFE



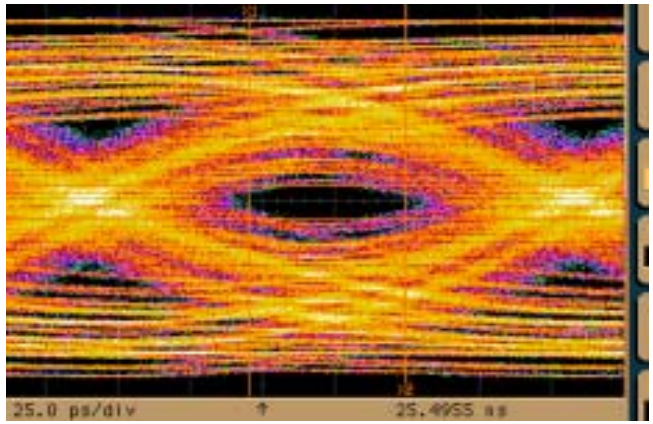
6Gb/s Statistical Eye vs. Measured Eye 10m miniSAS4x

6dB Tx 1Vpp , no DFE



40mVpp
0.24UI

6dB Tx 1Vpp , no DFE, PRBS7

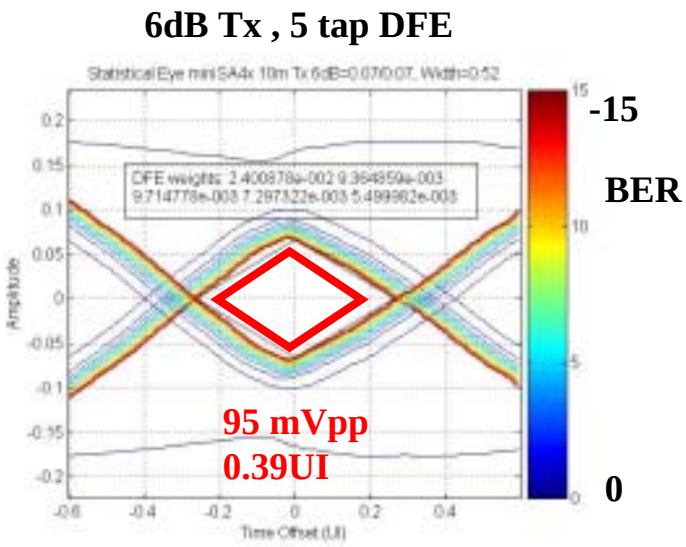


CH 1	CH2	CH3	CH4
33mVpp	40mVpp	35mVpp	39mVpp
0.24UI	0.24UI	0.23UI	0.21UI

Statistical Eye Simulated for 10m miniSAS4x S-parameters, Tx =1Vpp with 25mVpp of crosstalk added

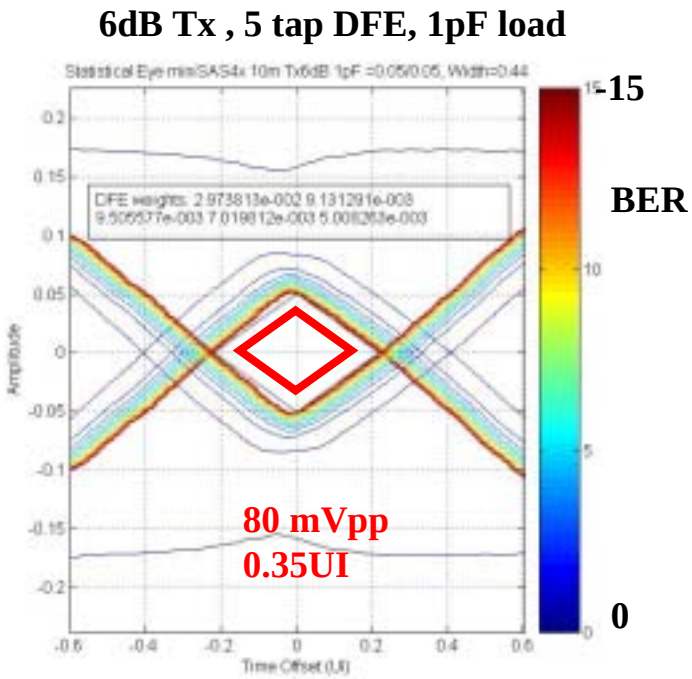
- 25mVpp crosstalk reduces Rx eye opening below 100mVpp/0.4UI

- Return loss impact is on the next page



Statistical Eye Simulated for 10m miniSAS4x S-parameters, Tx =1Vpp 25mVpp of crosstalk and 1pF load

- 1pF load (~7dB at 3GHz) attenuates both the signal and crosstalk
- Eye opening drops below 80mV/0.35UI



Crosstalk in 10m miniSAS4x external channel (assumed loss 16dB at 3GHz)

X-Talk			**-36.0**	**dB**
X-Talk/Insertion Loss (channel)			**20.0**	**dB**
X-Talk/Insertion Loss (actual)			**14.0**	**dB**
Vertical 6Gb/s Eye Openning at the Rx				
Launch Voltage mVpp	X-talk mVpp	Ideal Equalizer mVpp	6dB Tx 5-tapDFE DJ=0.15UIpp RJ=0.15UIpp BER=1e-15	With 25mVpp crosstalk added
1600	25.4	254		
1200	19.0	190		
1000	15.8	158	0pF load: 120mVpp 0.49UI 1pF load: 100mVpp 0.44UI	0pF load: 95mVpp 0.39UI 1pF load: 80mVpp 0.35UI
800	12.7	127		

Note: with an assumption of 1.6V aggressor

Summary

- Statistical eye analyses for 10m miniSAS4x S-params showed that suggested crosstalk requirement of -36dB (as opposed to –26dB in SAS1.1) makes 10m SAS-2 external channel feasible
- Assumption was made that the internal level of crosstalk in the packaged device does not degrade this result significantly
- Need to discuss areas for further budget improvement
  - SAS1.1 1.6V launch conditions on SAS-2 link
  - Return loss, minimum Tx amplitude
  - Other ?

To Discuss Further

- The analyses showed that SAS-2 channel loss budget is dictated by the amount of crosstalk at the RX, but not by the link loss at 3GHz itself
  - Setting external link crosstalk level at –36dB at 3GHz creates a complimentary requirement for the channel *insertion loss to crosstalk ratio* to be better than 20dB
- Applying same analyses to internal links will require *insertion loss to crosstalk ratio* to be same 20dB (or close to that) for an internal channel
  - Should we accept 20 dB as a new requirement ?
    - This will demand crosstalk to be less than –35 … -38 dB for some internal channels posted at T10
    - Note, SAS1.1 *insertion loss to crosstalk ratio* is around 20dB at 1.5GHz

Related T10 contributions

- 05-352R0
  External Link Amplitude Budget (SAS-2)
  Author:Yuriy Greshishchev, PMC-Sierra, Inc.
  Date posted: 2005/09/12

- 06-027R0
  SAS-2 10-Meter Multilane Cable Assembly Models
  Author: Galen Fromm, Molex
  Date posted: 2005/12/16

Thinking You Can Build On

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