SAS-2 External Link Crosstalk
Budget Suggestion and Analyses

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With contribution of Galen Fromm, Molex

T10/06-104r1
Changes in Rev 1

- Statistical eye simulations for 3Gb/s 10m miniSAS4x external link are added in the end
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

Launch Signal

SAS-2 Device

PCB-A

CT

CR

SAS-2 Device

PCB-A

CT

CR

Crosstalk Budget

10m miniSAS4x

S-parameters data for 10m miniSAS4x
(assumption based on Molex test coverage)
Suggestion for miniSAS4x Crosstalk (after Galen Fromm, Molex)

Note: PMC-Sierra measured total level of crosstalk is below \(-40\)dB
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

-15

BER

40mVpp
0.24UI

6dB Tx, 5 tap DFE

120 mVpp
0.49UI

0

-15

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

6dB Tx 1Vpp, no DFE

-15
BER

40mVpp
0.24UI

CH 1
33mVpp
0.24UI

CH 2
40mVpp
0.24UI

CH 3
35mVpp
0.23UI

CH 4
39mVpp
0.21UI

6dB Tx 1Vpp, no DFE, PRBS7
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)

<table>
<thead>
<tr>
<th>X-Talk</th>
<th>-36.0 dB</th>
</tr>
</thead>
<tbody>
<tr>
<td>X-Talk/Insertion Loss (channel)</td>
<td>20.0 dB</td>
</tr>
<tr>
<td>X-Talk/Insertion Loss (actual)</td>
<td>14.0 dB</td>
</tr>
</tbody>
</table>

**Vertical 6Gb/s Eye Opening at the Rx**

<table>
<thead>
<tr>
<th>Launch Voltage mVpp</th>
<th>X-talk mVpp</th>
<th>Ideal Equalizer mVpp</th>
<th>6dB Tx 5-tapDFE DJ=0.15UIpp RJ=0.15UIpp BER=1e-15</th>
<th>With 25mVpp crosstalk added</th>
</tr>
</thead>
<tbody>
<tr>
<td>1600</td>
<td>25.4</td>
<td>254</td>
<td>[Colors and annotations indicating changes]</td>
<td></td>
</tr>
<tr>
<td>1200</td>
<td>19.0</td>
<td>190</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1000</td>
<td>15.8</td>
<td>158</td>
<td>[Colors and annotations indicating changes]</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0pF load: 120mVpp 0.49UI</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1pF load: 100mVpp 0.44UI</td>
<td></td>
</tr>
<tr>
<td>800</td>
<td>12.7</td>
<td>127</td>
<td>[Colors and annotations indicating changes]</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0pF load: 95mVpp 0.39UI</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1pF load: 80mVpp 0.35UI</td>
<td></td>
</tr>
</tbody>
</table>

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
3Gb/s simulations with 10m miniSAS4x model

S21(f)

-10dB at 1.5GHz

SAS1.1 CT TCTF
-7dB at 1.5GHz

1.5 GHz

Frequency
3Gb/s statistical eye with 10m minSAS4x model, $Tx = 1.6$ Vpp, 0 dB pre-emphasis, $DJ = 0.15UI$, $RJ = 0.15UI$, BER = $1e^{-12}$

- Tx output eye violates SAS1.1 requirement:
  - $2z1 \geq 275mV; 2x1 \leq 0.55UI$
  - A result of extra 3dB loss and ISI vs. SAS1.1 TCTF
- Tx pre-emphasis is required to become compliant
  - Not mandatory in SAS1.1
3Gb/s statistical with 10m minSAS4x model, Tx =1.2 Vpp, 6 dB pre-emphasis
DJ=0.15UI, RJ=0.15UI, BER=1e-12

- A 1.2Vpp amplitude and 6dB Tx pre-emphasis yield compliant eye, but with very low margin on amplitude
- A 1.5Vpp Tx amplitude and a 6dB pre-emphasis yield compliant eye with margins: 2Z1 = 345mV; 2X1=0.41UI
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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