Ultra320 SCSI vs Ultra160 SCSI
Eye Diagram Data

Russ Brown
Quantum Corporation

SCSI Physical Working Group Meeting
09 Feb 2000
Huntington Beach, CA
Objectives

- Evaluate Ultra160 margins with the same techniques as used for our Ultra320 data
  - Ultra160 transmitter drive level used for evaluation was 400mV peak differential
  - Ultra320 data was taken from presentation (00-104r0)
    - 400mV peak differential for No Comp and Rx Equalized
    - 400mV / 720mV peak differential for Tx Precomp

- Measure the signal degradations to find eye opening with ISI, reflections and crosstalk for typical configurations, including:
  - Amplitude errors;
  - Timing shift errors;
  - Miscellaneous noise.
## Estimated Ultra320/160 Error Sources

<table>
<thead>
<tr>
<th>Source</th>
<th>U-320</th>
<th>U-160</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Random amplitude (0-to-pk)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Terminator voltage mismatch</td>
<td>13mV</td>
<td>13mV</td>
</tr>
<tr>
<td>Terminator resistance mismatch</td>
<td>5mV</td>
<td>5mV</td>
</tr>
<tr>
<td>Driver error</td>
<td>40mV</td>
<td>40mV</td>
</tr>
<tr>
<td>Receiver comparator</td>
<td>30mV</td>
<td>30mV</td>
</tr>
<tr>
<td>Root sum squares of random amplitude</td>
<td>52mV</td>
<td>52mV</td>
</tr>
<tr>
<td><strong>Deterministic Amplitude: (0-to-pk)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cable + back-plane resistance</td>
<td>28mV</td>
<td>28mV</td>
</tr>
<tr>
<td>Comparator overdrive requirement</td>
<td>70mV</td>
<td>70mV</td>
</tr>
<tr>
<td>Total amplitude 0-to-pk factors:</td>
<td>150mV</td>
<td>150mV</td>
</tr>
<tr>
<td><strong>Timing factors (0-to-pk)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low Vt vs substrate noise</td>
<td>100ps</td>
<td>50ps</td>
</tr>
<tr>
<td>Receiver clock jitter</td>
<td>125ps</td>
<td>250ps</td>
</tr>
<tr>
<td>Residual de-skew</td>
<td>125ps</td>
<td>3.3ns</td>
</tr>
<tr>
<td>De-skew stability</td>
<td>100ps</td>
<td>N/A</td>
</tr>
<tr>
<td>Input slew rate dependent skew</td>
<td>100ps</td>
<td>100ps</td>
</tr>
<tr>
<td>Receiver amp dependent delay</td>
<td>150ps</td>
<td>150ps</td>
</tr>
<tr>
<td>Receiver FF rise/fall prop delay difference</td>
<td>300ps</td>
<td>300ps</td>
</tr>
<tr>
<td>Total 0-to-pk timing factors:</td>
<td>1.0ns</td>
<td>4.15ns</td>
</tr>
</tbody>
</table>

These are the error sources that are not accounted for by our test setup as well as those in the SPI-3 budget. 0-to-peak values converted from peak-to-peak numbers by a factor of 1/2.
Error Sources

- Error sources are used to define the range over which a receiver characteristic may typically vary from the ideal sample point, i.e., the actual sample point may lie anywhere within a box defined by 2 times 0-to-peak height and 2 times 0-to-peak width of the errors.

- Amplitude error sources define height, and timing error sources define width, e.g., set-up time margin is measured as the distance from the eye diagram waveform to the box.
10 meter Madison 28AWG† round shielded cable plus 6-slot backplane.

Waveforms captured @ 4Gs/s:
- no pre-comp: $\Delta A = 0.0$ (refer to 99-335r0)
- amplitude pre-comp: $\Delta A = 0.8$

† Supplied by Amphenol
• 2.25 meter Hitachi 32AWG twisted-flat cable† plus 6-slot backplane.

• Waveforms captured @ 4Gs/s:
  • no pre-comp: $\Delta A = 0.0$ (refer to 99-335R0)
  • amplitude pre-comp: $\Delta A = 0.8$

†supplied by Hitachi & Circuit Assembly
**Config 3: Loaded Long Cable + BP**

- Hitachi 10 meter 32AWG twisted-flat ribbon cable† with 25cm load spacing plus 6-slot backplane.

- Waveforms captured @ 4Gs/s:
  - no pre-comp: \( \Delta A = 0.0 \) (refer to 99-335R0)
  - amplitude pre-comp: \( \Delta A = 0.8 \)

† supplied by Hitachi & Circuit Assembly
Ultra-320 SCSI vs Ultra-160 SCSI E

Test Schematic

50 Ω aggressor XTALK source 1†

DB(P1)

50 Ω random data source*

DB(0)

DB(1)

50 Ω aggressor XTALK source 2†

DB1+

DB1−

DB0+

DB0−

DbP1+

DbP1−

Cable + backplane configuration 1 or 2

Termination 100Ω, located at end of back-plane

Differential probe on victim

Perfect terminators

receiver board identification:
- XT8bd1 to XT8bd9 are on ribbon cable,
- XT8bp1 to XT8bp6 or XT8bp10 to XT8bp15 are on the back-plane

* TEK 2041       † HP81130A
Config 1*, Ultra320, No comp

*10m round cable + loaded 6-slot backplane @ bp1

Conclusion: Failing Margin
(Increasing amplitude would still fail)
Config 1*, Ultra320, Tx Precomp

*10m round cable + loaded 6-slot backplane @ bp1

Conclusion: Failing Margin
(Can't increase amplitude to improve margin)
Config 1*, Ultra320, Rx Equalized

*10m round cable + loaded 6-slot backplane @ bp1

Conclusion: Excellent Margin
**Config 1**, Ultra160

*10m round cable + loaded 6-slot backplane @ bp1

**Conclusion:** Failing Margin*

(*Increasing amplitude would make margin adequate)
Config 2*, Ultra320, No comp

*2.25m twisted-flat cable + loaded 6-slot backplane @ bp1

Conclusion: Adequate Margin
Config 2*, Ultra320, Tx Precomp

*2.25m twisted-flat cable + loaded 6-slot backplane @ bp1

Conclusion: Adequate Margin
Config 2*, Ultra320, Rx Equalized

*2.25m twisted-flat cable + loaded 6-slot backplane @ bp1

Conclusion: Excellent Margin
Ultra-320 SCSI vs Ultra-160 SCSI

Config 2*, Ultra160

*2.25m twisted-flat cable + loaded 6-slot backplane @ bp1

Conclusion: Excellent Margin
Config 3*, Ultra320, No comp

*10m twisted-flat cable w/9 loads + loaded 6-slot backplane @ cp9

Conclusion: Failing Margin
Config 3*, Ultra320, Tx Precomp

Conclusion: **Insufficient Margin**
(Can't increase amplitude to improve margin)
Config 3*, Ultra320, Rx Equalized

*10m twisted-flat cable w/9 loads + loaded 6-slot backplane @ cp9

Conclusion: Excellent Set-up Margin*
(*Increased amplitude would make Hold margin adequate)
Config 3*, Ultra160

*10m twisted-flat cable w/9 loads + loaded 6-slot backplane @ cp9

Amplitude (mV)

Time (ns)

Conclusion: Failing Margin*

(*Increasing amplitude would make margin adequate)
## Summary of Results

<table>
<thead>
<tr>
<th>Configuration (description)</th>
<th>Ultra320</th>
<th>Ultra160</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No Comp</td>
<td>w/Tx Pre-comp</td>
</tr>
<tr>
<td>1  (10m round cable + loaded 6-slot backplane @ bp1)</td>
<td>Failing margin</td>
<td>Failing margin</td>
</tr>
<tr>
<td>2  (2.25m flat cable + loaded 6-slot backplane @ bp1)</td>
<td>Adequate margin</td>
<td>Adequate margin</td>
</tr>
<tr>
<td>3  (10m twisted-flat cable w/9 loads + loaded 6-slot backplane @ cp9)</td>
<td>Failing margin</td>
<td>Insufficient margin</td>
</tr>
</tbody>
</table>

* Increasing amplitude would make margin adequate.
Conclusions

1. U160 eye diagrams show adequate margin with all configurations (though getting close with 10m cable with 16 loads)
2. U320 provides adequate margin without precomp or equalization with a short cable (2.5m) configuration
3. U320 using transmitter precomp provides insufficient margin with typical configurations
4. U320 using receiver equalization provides excellent margins with all configurations