Ultra640 SCSI
Measured Data from Cables & Backplanes

Russ Brown
Maxtor Corporation
Parallel SCSI Working Group
17 July 2001
Colorado Springs, CO

T10/01-224r0
Introduction

• The following presents some of Maxtor’s initial cable / backplane testing results for Ultra640 SCSI including:
  – Frequency domain attenuation and crosstalk
  – Sample eye diagrams at Ultra640 speeds

• Our focus here is on the full cable / backplane system
  – To understand the main design issues for a Ultra640 SCSI interface
  – To help establish system requirements for Ultra640

• We have been following the PIP committee activities, and have used an extension of the test set-up in T10/01-076r0 for our frequency domain tests.
Cable / Backplane Frequency Response Test Setup

For cable-only measurements, active terminator or resistive loads were used in place of backplane.
Cable / Backplane Frequency Response Test Setup Notes

- Measurement set-up is similar to that in SCSI T10 PIP document 01-076r0
  - HP4396B Network Analyzer with 87512A T/R test set and M/A Com Hybrid
  - TEK P6247 1 GHz diff probe (x1) voltage sense to HP4396B “B” input allows measurements at various connectors along an actively terminated SCSI bus
  - Network Analyzer set-up: Sweep = 5 MHz to 1 GHz, B/W = 1 KHz, sweep time = 1 sec
  - Maxtor Custom PCB Launch board, labeled “S1”:
    - SMAs through 0.1 µF to DB0 on SCSI wide (68-pin) female-to-PCB (angle) connector, giving a 100 Ω AC coupled differential source
    - 100 Ω differential terminations on adjacent DB1, DB2, DBP1, DB15
    - Other source configurations also tried to check dependence on differential and common mode source resistances
  - Active termination: Amphenol #503380001
  - R100 termination: 68-pin, female-to-PCB angle connector with 100 Ω chip resistor differential terminations on DB15, DBP1, DB0, DB1, & DB2
- Data is acquired with the network analyzer and plots constructed in MatLab
- Eye diagrams constructed as before, with AWGs driving a training plus data pattern on the measured channel, and a “…101010…” pattern on the two adjacent channels
Cable / Backplane Test Setup: Launch Boards

**S1:**
- Rsource(diff) = 100 Ω
- Rsource(cm, DB0) = 25 Ω
- Rsource(cm, others) = inf

**S2:**
- Rsource(diff) = 105 Ω
- Rsource(cm) = 120 Ω

---

**Diagram Details:**
- **S1**: SMA to P68 Connector
- **S2**: SMA to P68 Connector
- **“Thru Cal”**: Tek P6247 diff probe 1x
- **To DB0 for Thru Cal**: 10 Ω
- **To HP 4396B “B” input**: 0.1 µF
- **56**: 0.1 µF
- **237**: 0.1 µF
- **130**: 0.1 µF
- **DP1**: DB15
- **DB0**: DB1
- **DB2**: DB0
- **SCSI cable**
- **100 Ω differential source from H-183-4**
Effect of Common Mode Resource:
Launch Boards S1 versus S2 into Active Terminator Load

- 7.3 m Twisted-Flat cable: Amphenol 125-3096-996X 30AWG, 1” Flats, 9.85” Pitch
- Common mode source resistance does not significantly affect these frequency response or crosstalk results.
5-slot Backplane / 2.6 m Twisted-Flat Cable: Amplitude Response at all Slots, Plus Crosstalk at Slots 1 and 5

- Response of complete 2.6 m cable plus loaded 5-slot backplane system
- Cable: Amphenol 125-3096-996 30AWG 1.75” Flats, 9.85” Pitch
2.6 m Twisted-Flat Cable Amplitude Response: 120 Ω Source / Load versus 100 Ω Source / Active Termination

- Response of the 2.6 m cable only
- Cable: Amphenol 125-3096-996 30AWG, 1.75” Flats, 9.85” Pitch
- Major frequency response characteristics are the same when measured with 100 Ω or 120 Ω source / load resistances.
5-slot Backplane with no Cable: Amplitude Response at Slots 1 through 5, Plus Crosstalk at Slots 1 and 5,

- Response of fully-loaded, 5-slot backplane without cable
- The backplane alone shows a deep notch at 300 to 400 MHz and significant ripple at 160 MHz
- Crosstalk is more complex on backplanes than on twisted-flat cables
5-slot Backplane with no Cable: Amplitude Response at Slot 5, Load at Slot 5 Only

- The backplane response notch varies with backplane loading
10-slot Backplane / 10 m Tw-Flat cable: Amplitude Response at all Slots, Plus Crosstalk at Slots 1 and 10

- Response of complete 10 m cable plus loaded 10-slot backplane system
- Twisted-Flat Cable Amphenol 125-3099-995 30AWG, 1.75” Flats, 11.75” Pitch
- Crosstalk is about equal to the signal at Ultra640 1010 frequency (160 MHz)
10 m T-F Cable Amplitude Response and Crosstalk, 120 Ω Source / Load, 100 Ω Source / Active Terminator Load

- Response of the 10 m cable only
- Cable: Twisted-Flat, Amphenol p/n 125-3099-995, 30 AWG, 1.75” Flats, 11.75” Pitch
- Similar responses obtained with 100 Ω and 120 Ω source / load impedances
10 m Round Cable
100 Ω Source / Active Terminator Load

- 10 m round shielded cable: Madison 28 AWG
- Round cable does not show the notches seen in the twisted-flat cable response
- Different “adjacent pairs” should be considered for round cable crosstalk
Ultra640 Eye Diagrams:
5-slot Backplane, 5 loads, 2.6 m Twisted-Flat Cable
Eye Diagrams at Slot 1, without and with Crosstalk

• Drive Signal: 500 mV peak differential on DB0
• Crosstalk: 0 mV

• Drive Signal: 500 mV peak differential on DB0
• Crosstalk: 500 mV peak 1010 on DB1 and DBP1

• ISI+reflections ~ 0.7ns, 1010 pattern (no Xtlk) ~ 0.5V pk, ISI+reflections + Xtlk ~ 1.2 ns
• Cable: Twisted-Flat, Amphenol p/n 125-3096-995, 30 AWG, 1.75” Flats, 9.85” Pitch
Ultra640 Eye Diagrams:
5-slot Backplane, 5 loads, 2.6 m Twisted-Flat Cable
Eye Diagrams at Slot 5, without and with Crosstalk

- Drive Signal: 500 mV peak differential on DB0
- Crosstalk: 0 mV

- ISI+reflections ~ 0.8 ns, 1010 pattern (no Xtlk) ~ 0.25 Vpk, ISI+reflections+Xtlk ~ 1.4 ns
- Cable: Twisted-Flat, Amphenol p/n 125-3096-995, 30 AWG, 1.75” Flats, 9.85” Pitch
Ultra640 Eye Diagrams:  
8-slot Backplane, 8 loads, 1.25 m Twisted-Flat cable  
Eye Diagrams at Slot 1, without and with Crosstalk

- Drive Signal: 500 mV peak differential on DB0  
- Crosstalk: 0 mV

- ISI+reflections ~ 0.8 ns, 1010 pattern (no Xtlk) ~ 0.45 Vpk, ISI+reflections +Xtlk ~ 1.1 ns  
- Cable: Twisted-Flat, Amphenol p/n 125-3099-995, 30 AWG, 1.75” Flats, 11.75” Pitch  
- Masks: Red: +/- 130 mV, +/- 0.5 ns  Orange: +/- 65 mV +/- 0.75 ns
Ultra640 Eye Diagrams:
8-slot Backplane, 8 loads, 1.25 m Twisted-Flat cable
Eye Diagrams at Slot 8, without and with Crosstalk

- Drive Signal: 500 mV peak differential on DB0
- Crosstalk: 0 mV

- ISI+reflections ~ 0.8 ns, 1010 pattern (no Xtlk) ~ 0.28 Vpk, ISI+reflections +Xtlk ~ 1.1 ns
- Cable: Twisted-Flat, Amphenol p/n 125-3099-995, 30 AWG, 1.75” Flats, 11.75” Pitch
- Masks: Red: +/- 130 mV, +/- 0.5 ns  Orange: +/- 65 mV +/- 0.75 ns

- Drive Signal: 500 mV peak differential on DB0
- Crosstalk: 500 mV peak 1010 on DB1 and DBP1
Signal to Crosstalk Ratio
10-slot Backplane, 10 Loads, 10 m Twisted-Flat Cable

- SCR1 = 1-sided Signal / Crosstalk ratio
- Twisted-Flat Cable: Amphenol 125-3099-995 30AWG, 1.75” Flats, 11.75” Pitch
“SCR” = Signal-to-Crosstalk Ratio

• Crosstalk is an important issues and must be specified somehow.
• As measured with the network analyzer setup of slide #3 and as shown in the previous slide, “SCR1” is the ratio of signal amplitude on a driven pair (DB0) to crosstalk amplitude on one adjacent pair (e.g., DB1) with only one pair (DB0) driven, measured as a function of frequency.
• In an operating SCSI bus, crosstalk interference would be from all adjacent pairs to the pair under test, and hence at least 6 dB worse than SCR1 (i.e., operating SCR = SCR1 – 6 dB).
• This SCR measurement may be a useful way of measuring and specifying crosstalk.
• From the above 10 m cable / 10-slot backplane data:
  • SCR(80 MHz) = 12 – 6 = 6 dB (our earlier data shows a good compensated eye at Ultra320 for this case).
  • SCR(160 MHz) = 3 – 6 = -3 dB (not much hope at Ultra640).
Observations:

- Existing twisted-flat cables and backplanes show serious frequency response notches above 300 MHz due to periodic mis-terminations
  - Ultra640: max fundamental at 160 MHz … OK
  - Ultra1280: max fundamental at 320 MHz … OOPS!

- Frequency responses show significant ripple up to 160 MHz
  - Indicates a rapidly changing phase response -> difficult to compensate

- Crosstalk rises with Freq (approx 6 dB / oct), amplitude response falls
  - Signal / crosstalk ratio degrades rapidly at higher data rates

- A 10-slot backplane / 10 m twisted-flat cable that can be compensated with margin at Ultra320 speeds has no signal / crosstalk margin at Ultra640 speeds
Observations (cont’d):

- Eye diagrams on existing backplanes with short (1.25 m and 2.6 m) cables show wide variation slot-to-slot

- SCSI Ultra640 will require improved backplanes and improved or shorter twisted flat cables over those used at slower speeds

- For Ultra1280, major backplane and cable changes will be needed

- Is the 120 Ω cable / 105 Ω terminator a good impedance point for high speed LVD? Should we consider lower impedance cable for better match to backplanes and terminators?

- Response of a non-shielded cable is very dependent on it’s environment. Above some frequency (Fmax = ??) non-shielded cables won’t make sense