T10/01-224r0

Ultra640 SCSI Measured Data from Cables & Backplanes

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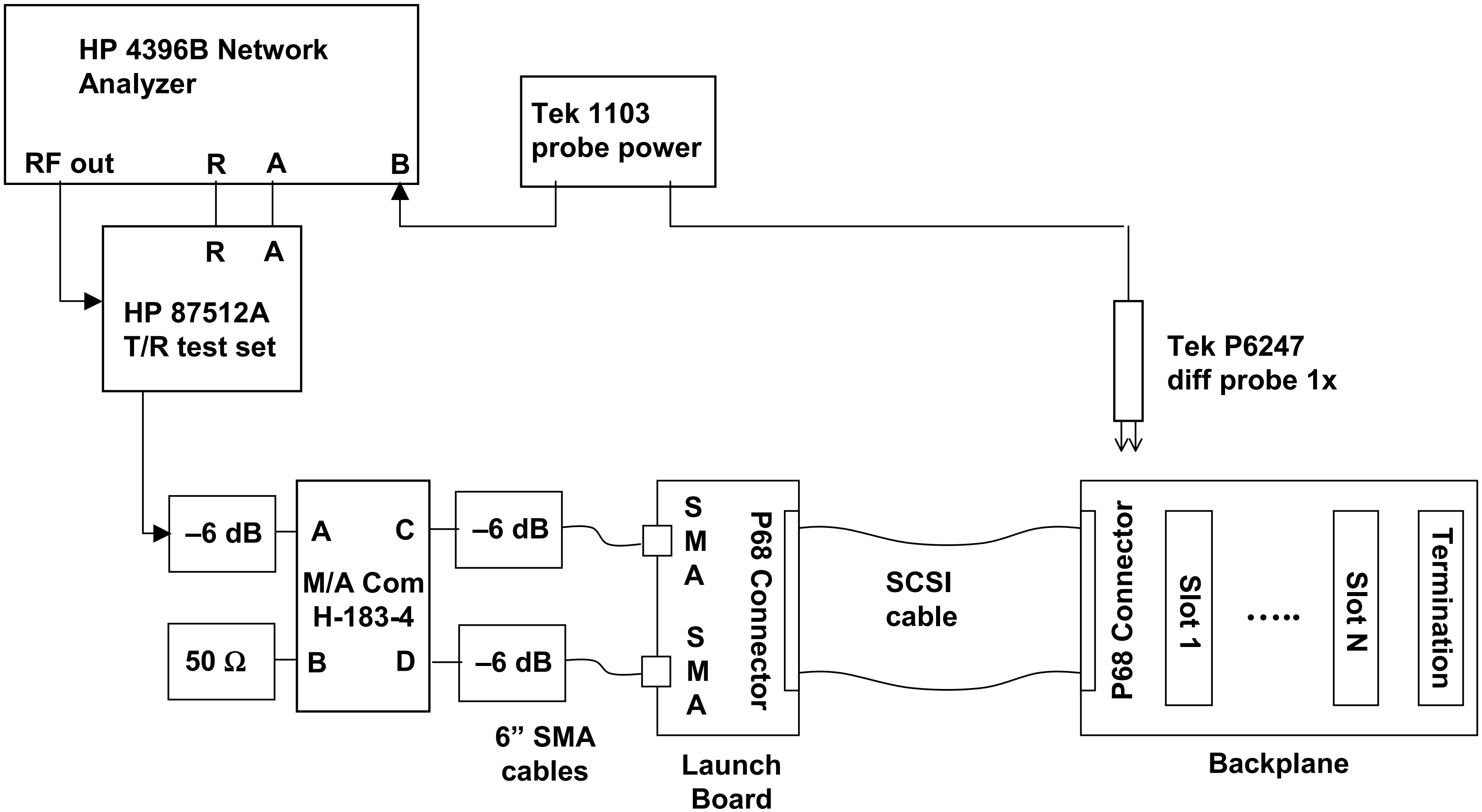
Introduction

- 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

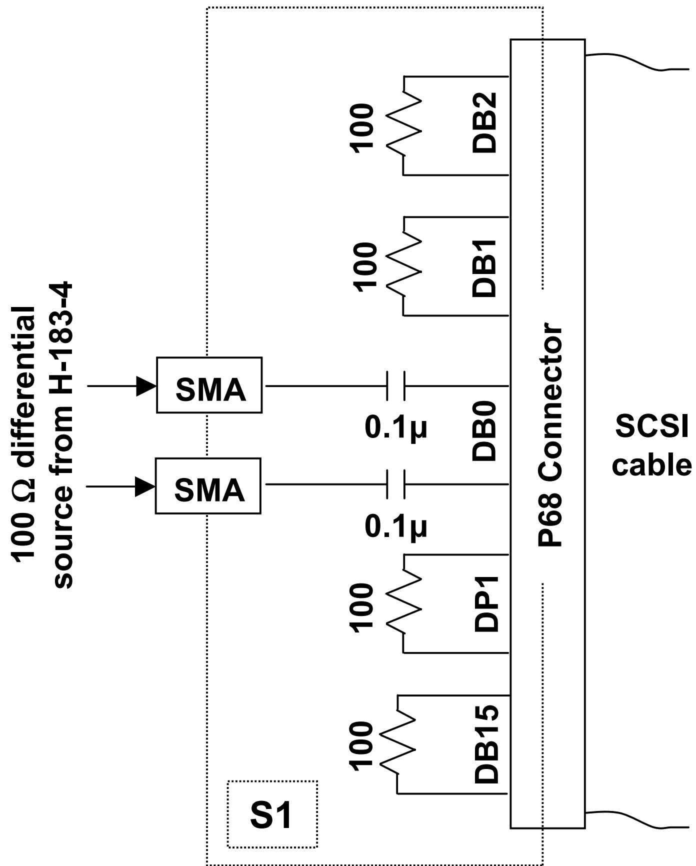


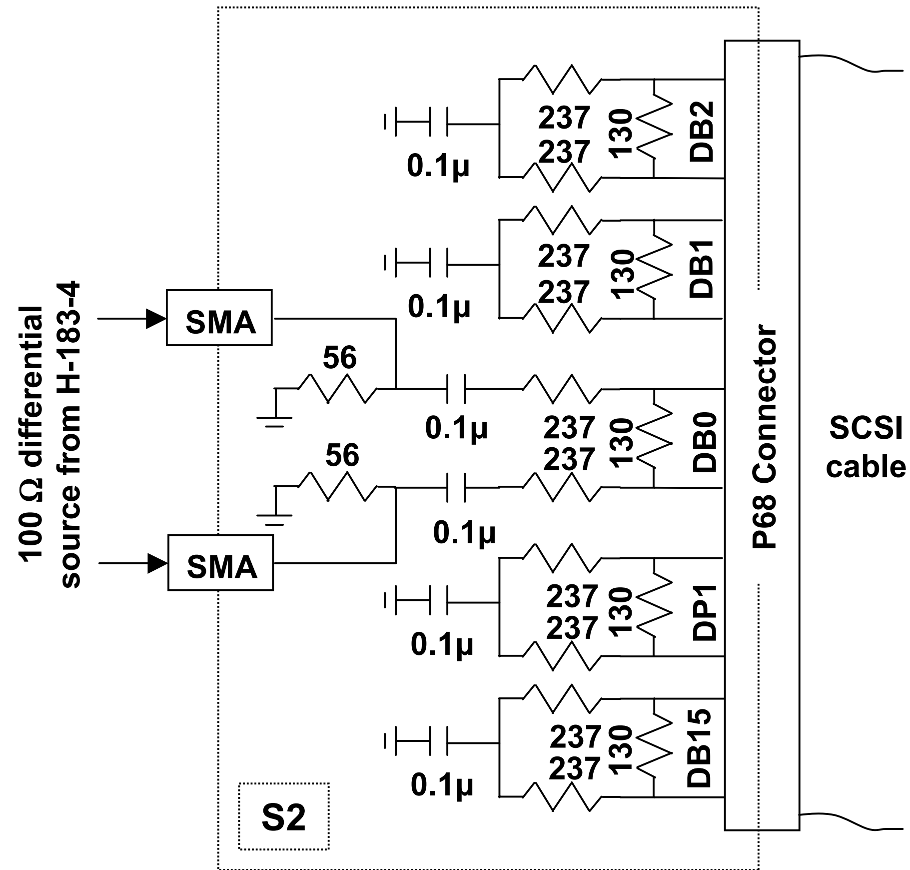
For cable-only measurements active terminator or resistive loads were used in place of backplane

Cable / Backplane Frequency Response Test Setup Notes

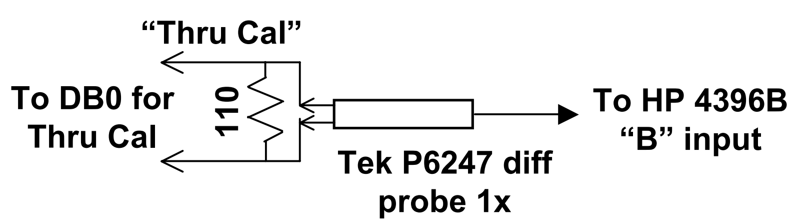
- Measurement set-up is similar to that in SCSI T10 PIP document 01-076r0
  - HP4396B Network Analyzer with 87512A T/R test set and M/A Com Hybrid
  - TEK P6247 1 GHz diff probe (x1) voltage sense to HP4396B "B" input allows measurements at various connectors along an actively terminated SCSI bus
  - 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



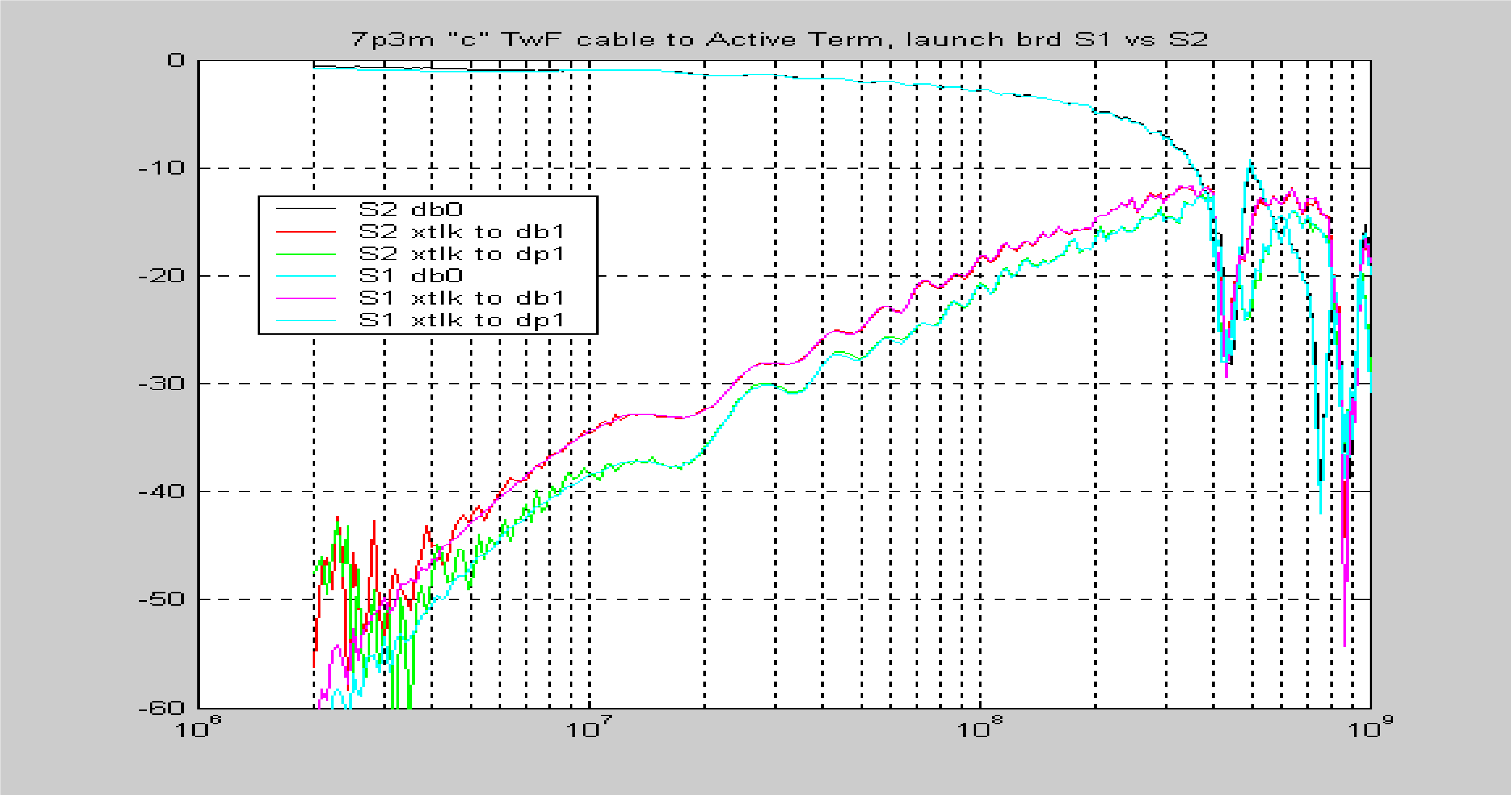


S1:
Rsource(diff) = 100 Ω
Rsource(cm, DB0) = 25 Ω
Rsource(cm, others) = inf



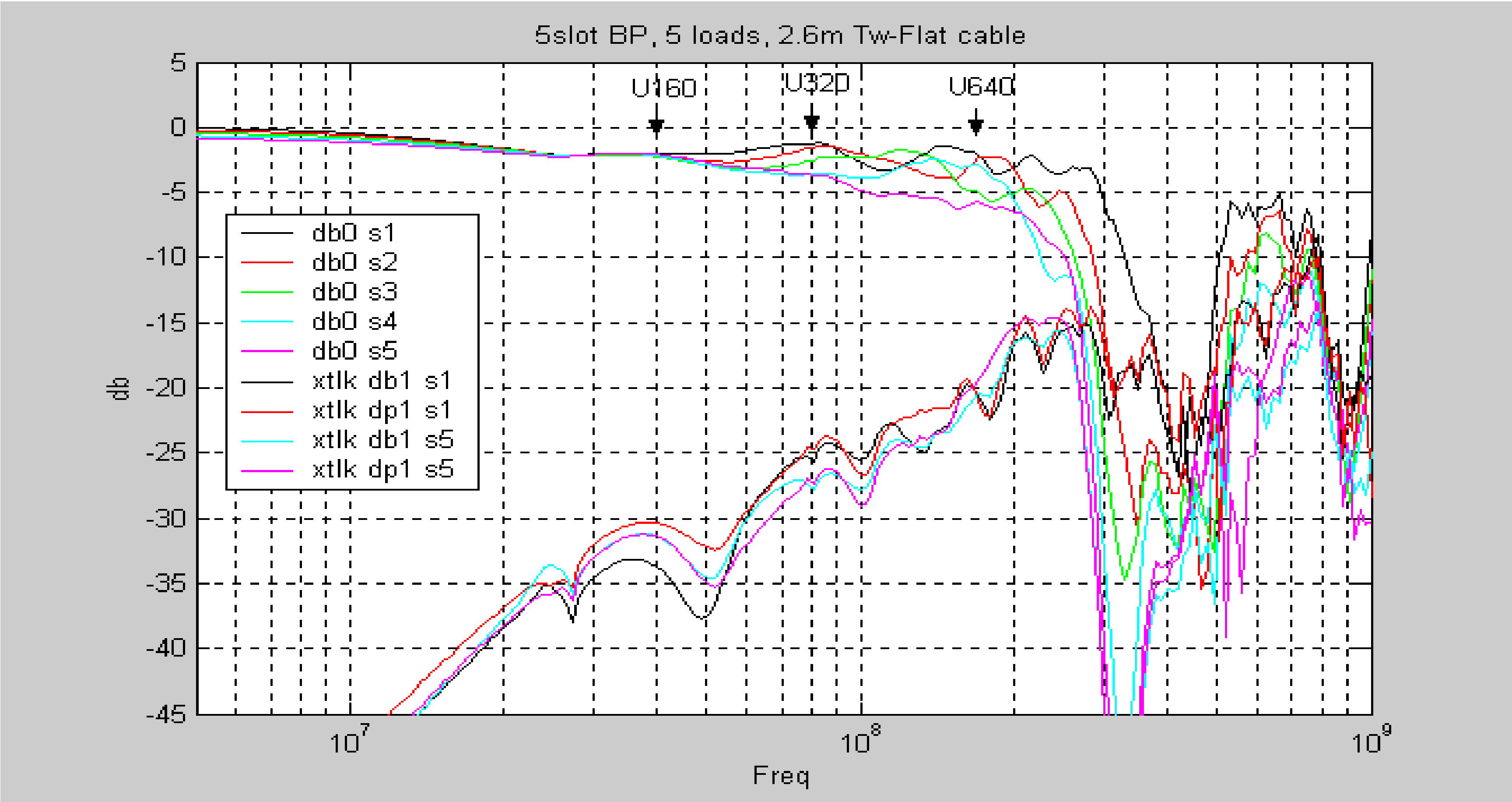
S2:
Rsource(diff) = 105 Ω
Rsource(cm) = 120 Ω

Effect of Common Mode Rsource:
Launch Boards S1 versus S2 into Active Terminator Load



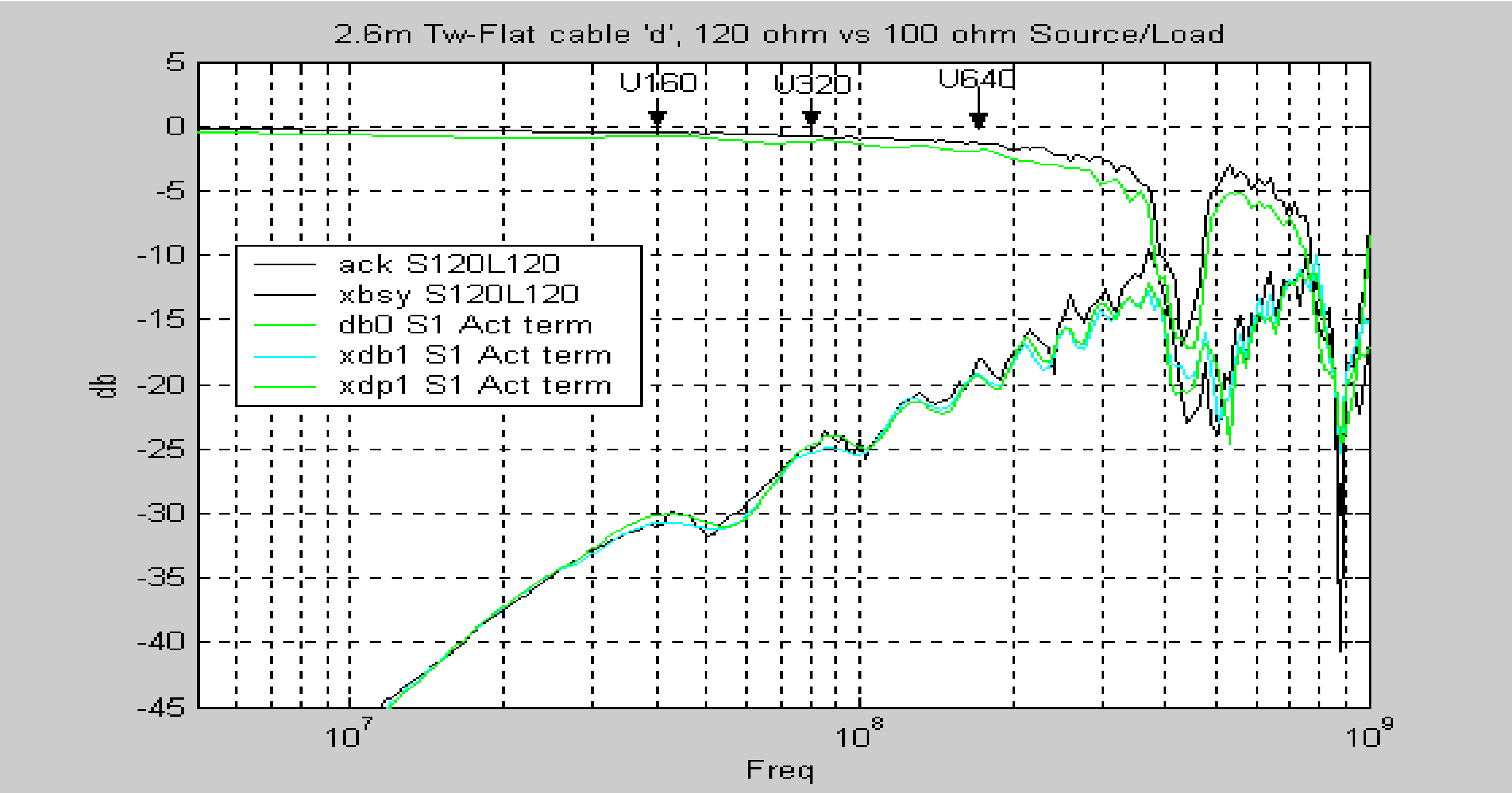
- **7.3 m Twisted-Flat cable: Amphenol 125-3096-996X 30AWG, 1" Flats, 9.85" Pitch**
- **Common mode source resistance does not significantly affect these frequency response or crosstalk results.**

5-slot Backplane / 2.6 m Twisted-Flat Cable: Amplitude Response at all Slots, Plus Crosstalk at Slots 1 and 5



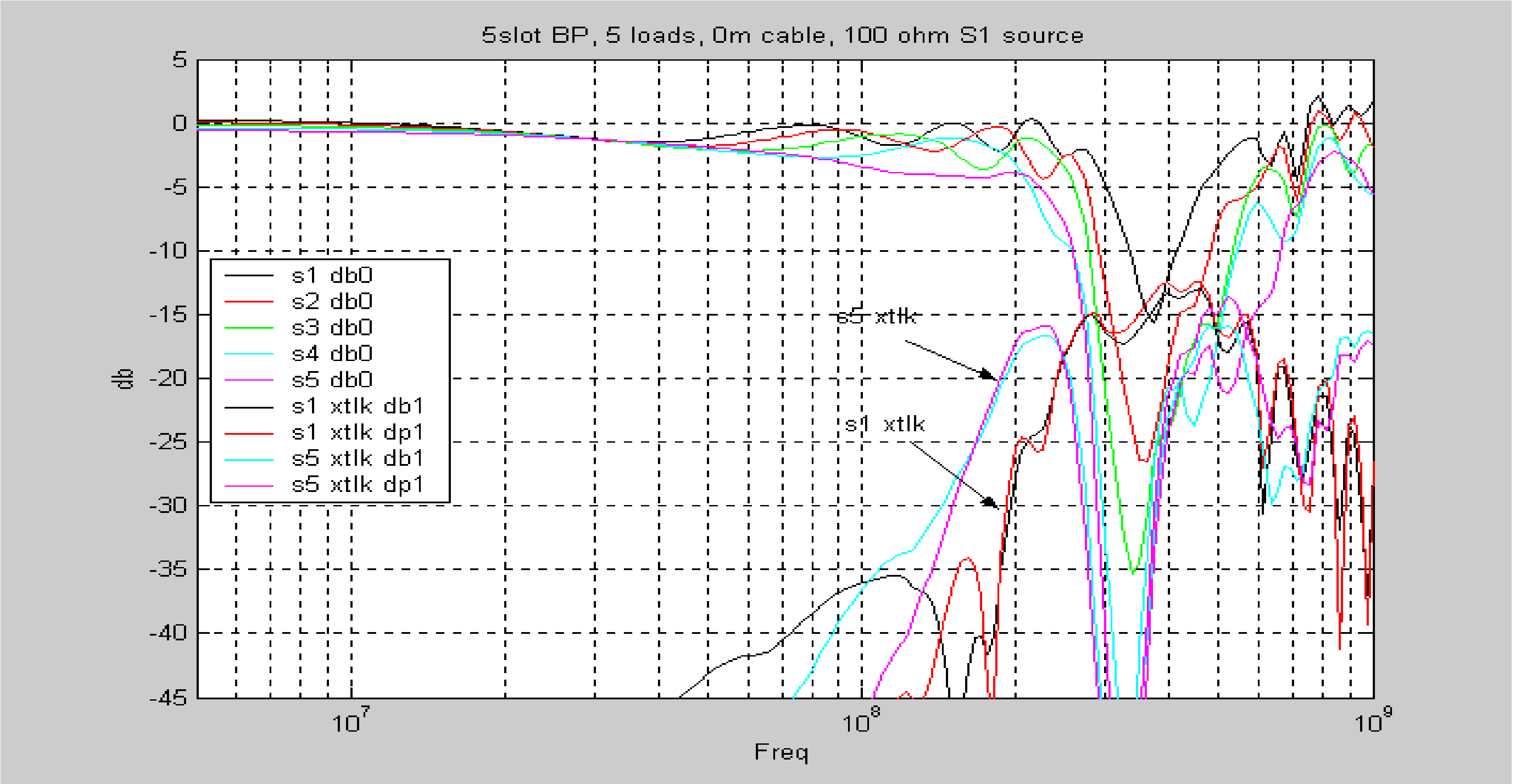
- **Response of complete 2.6 m cable plus loaded 5-slot backplane system**
- **Cable: Amphenol 125-3096-996 30AWG 1.75" Flats, 9.85" Pitch**

2.6 m Twisted-Flat Cable Amplitude Response: 120 Ω Source / Load versus 100 Ω Source / Active Termination



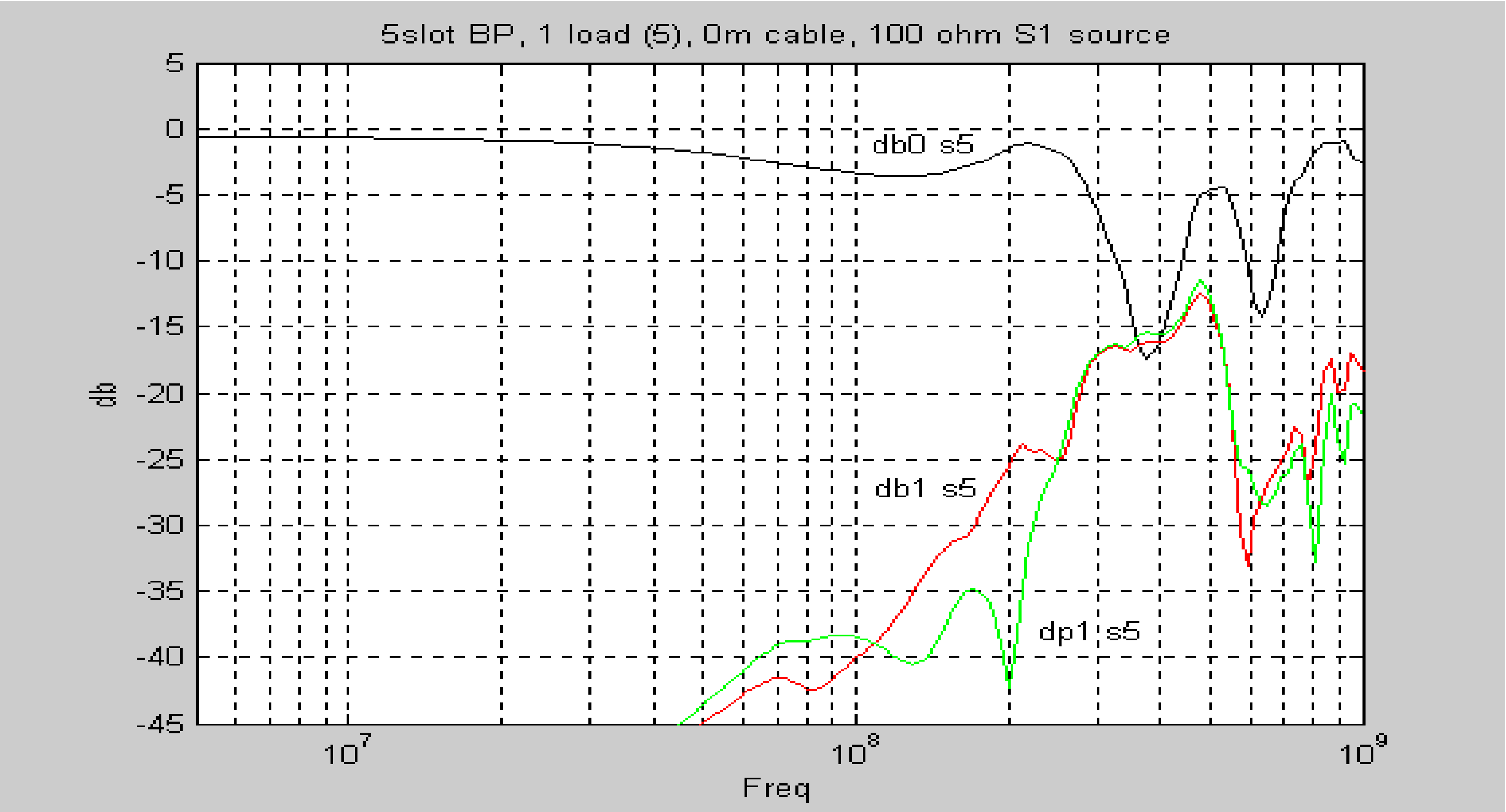
- **Response of the 2.6 m cable only**
- **Cable: Amphenol 125-3096-996 30AWG, 1.75" Flats, 9.85" Pitch**
- **Major frequency response characteristics are the same when measured with 100 Ω or 120 Ω source / load resistances.**

5-slot Backplane with no Cable: Amplitude Response at Slots 1 through 5, Plus Crosstalk at Slots 1 and 5,



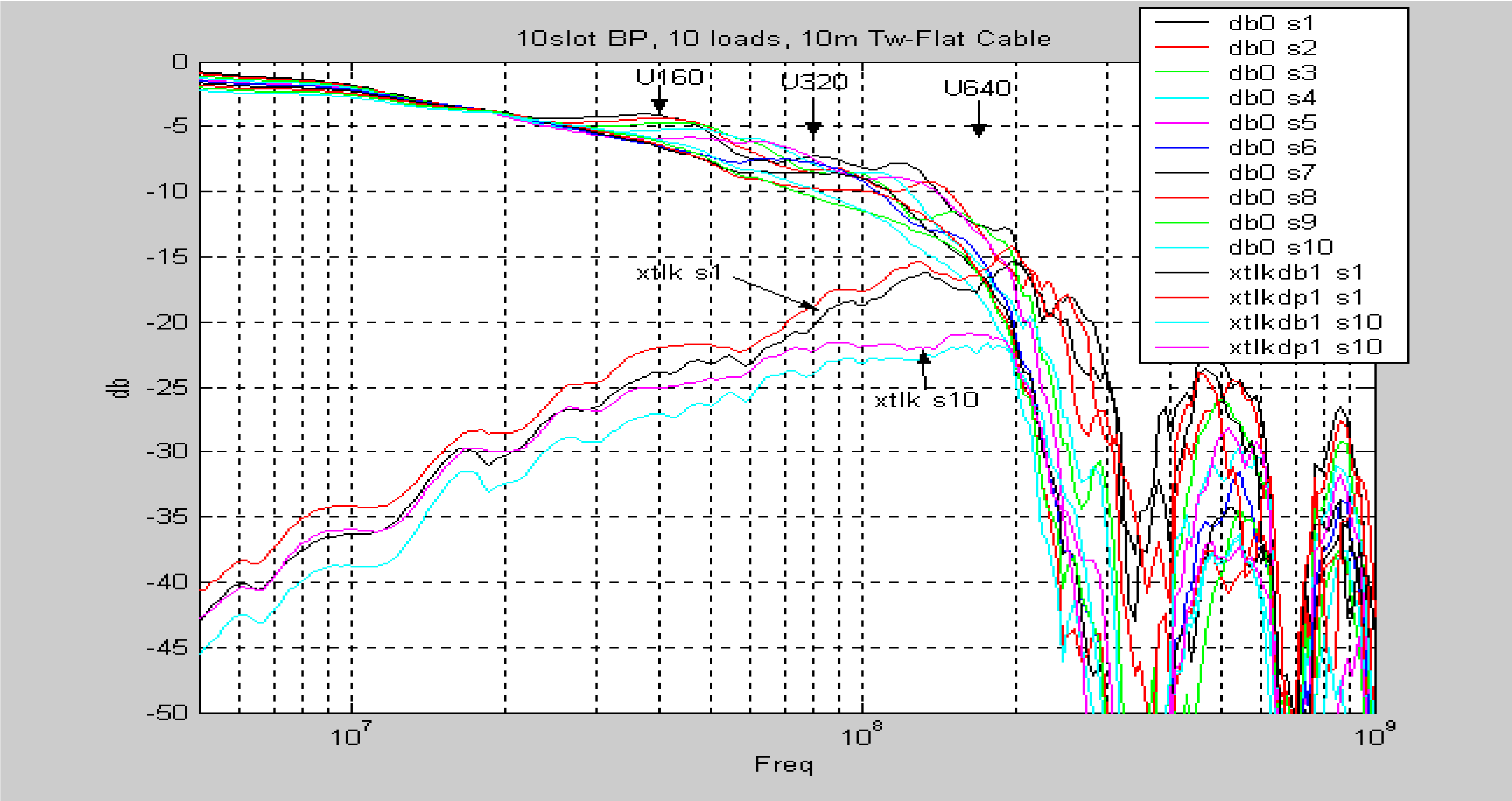
- Response of fully-loaded, 5-slot backplane without cable
- The backplane alone shows a deep notch at 300 to 400 MHz and significant ripple at 160 MHz
- Crosstalk is more complex on backplanes than on twisted-flat cables

5-slot Backplane with no Cable: Amplitude Response at Slot 5, Load at Slot 5 Only



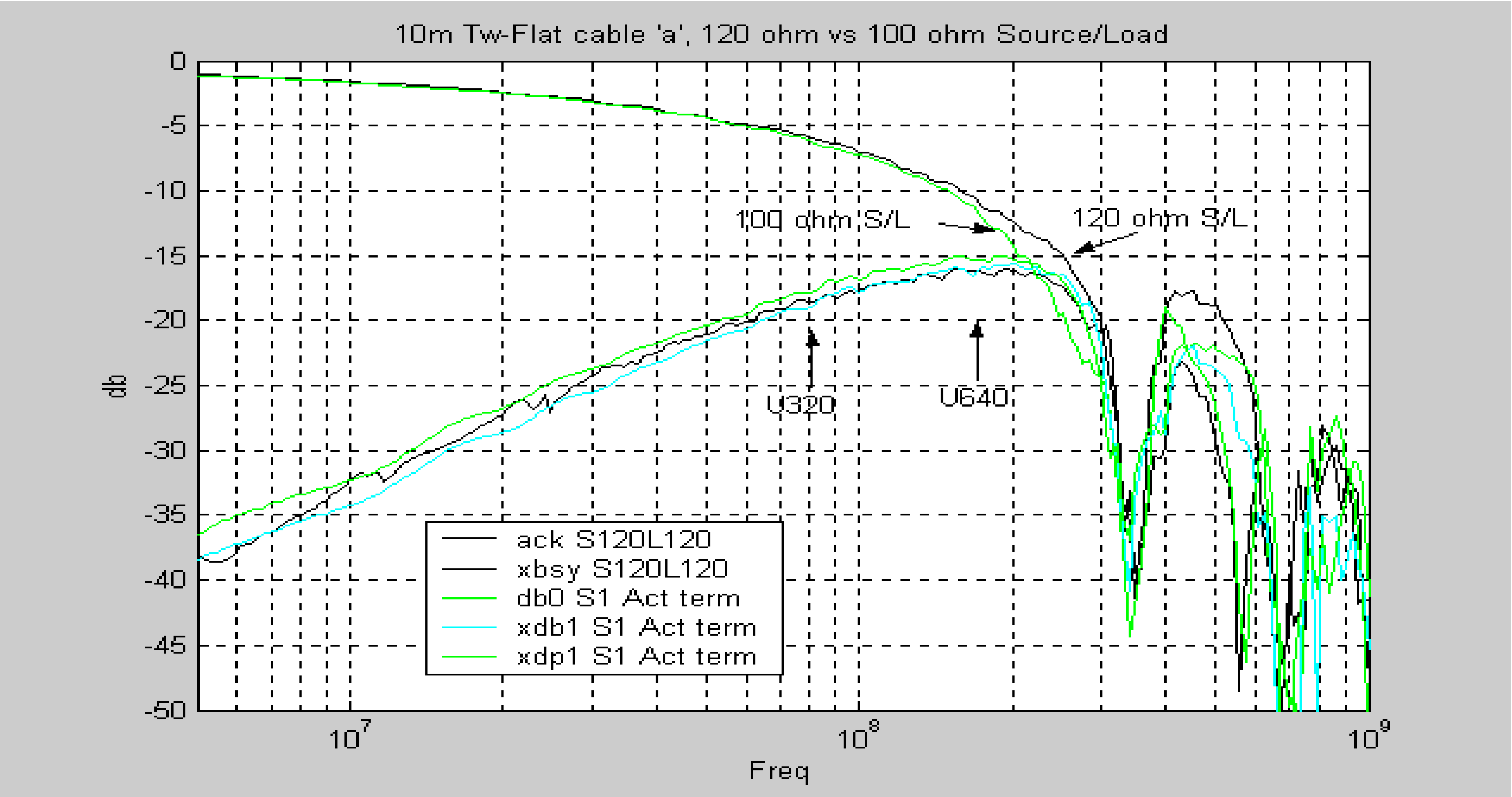
- **The backplane response notch varies with backplane loading**

10-slot Backplane / 10 m Tw-Flat cable: Amplitude Response at all Slots, Plus Crosstalk at Slots 1 and 10



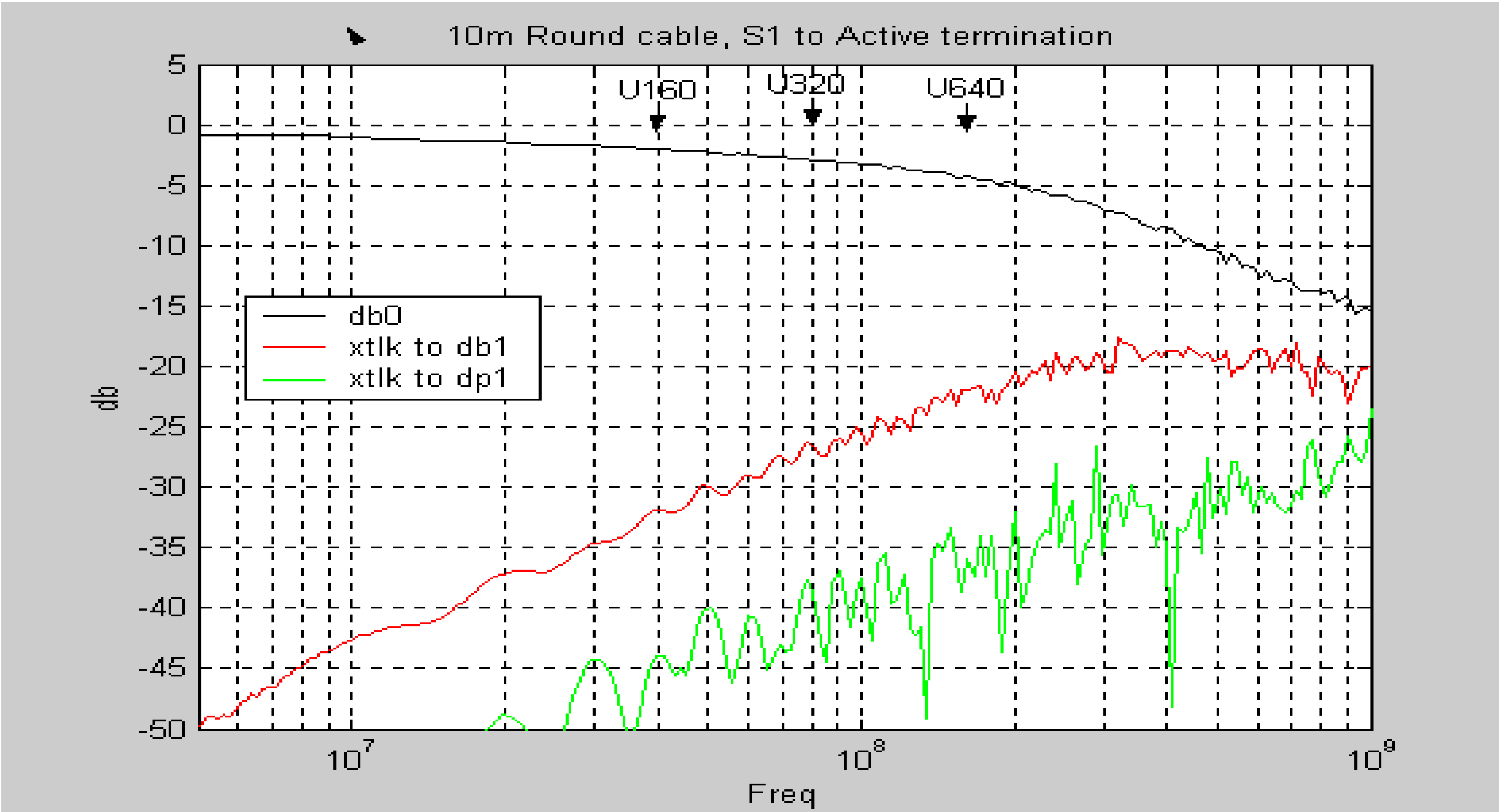
- Response of complete 10 m cable plus loaded 10-slot backplane system
- Twisted-Flat Cable Amphenol 125-3099-995 30AWG, 1.75” Flats, 11.75” Pitch
- Crosstalk is about equal to the signal at Ultra640 1010 frequency (160 MHz)

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**

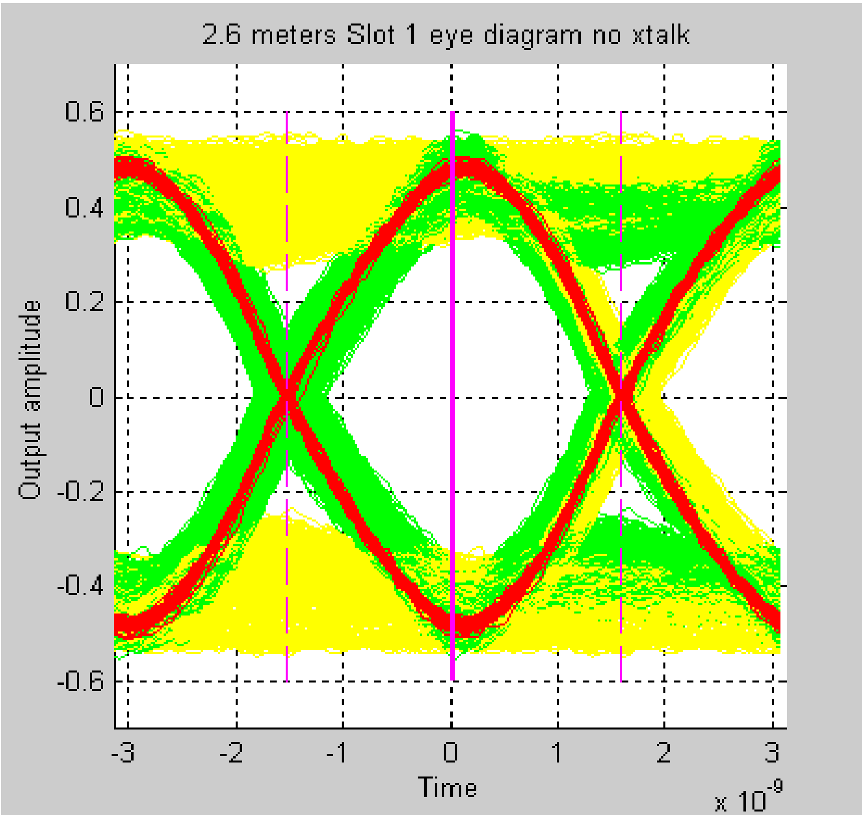
10 m Round Cable
100 Ω Source / Active Terminator Load



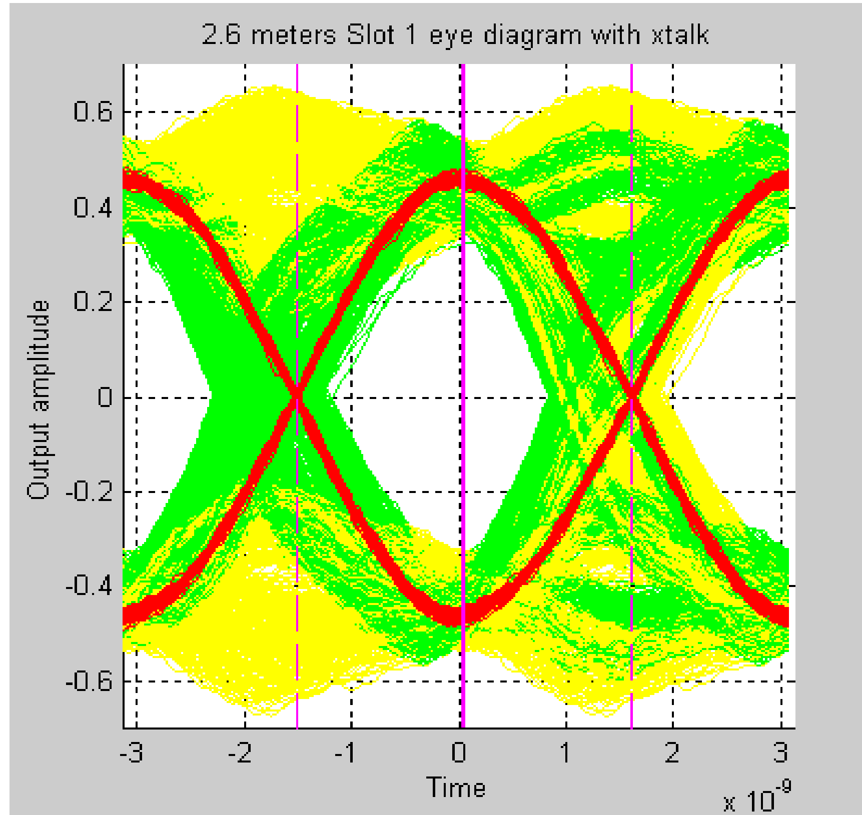
- **10 m round shielded cable: Madison 28 AWG**
- **Round cable does not show the notches seen in the twisted-flat cable response**
- **Different "adjacent pairs" should be considered for round cable crosstalk**

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

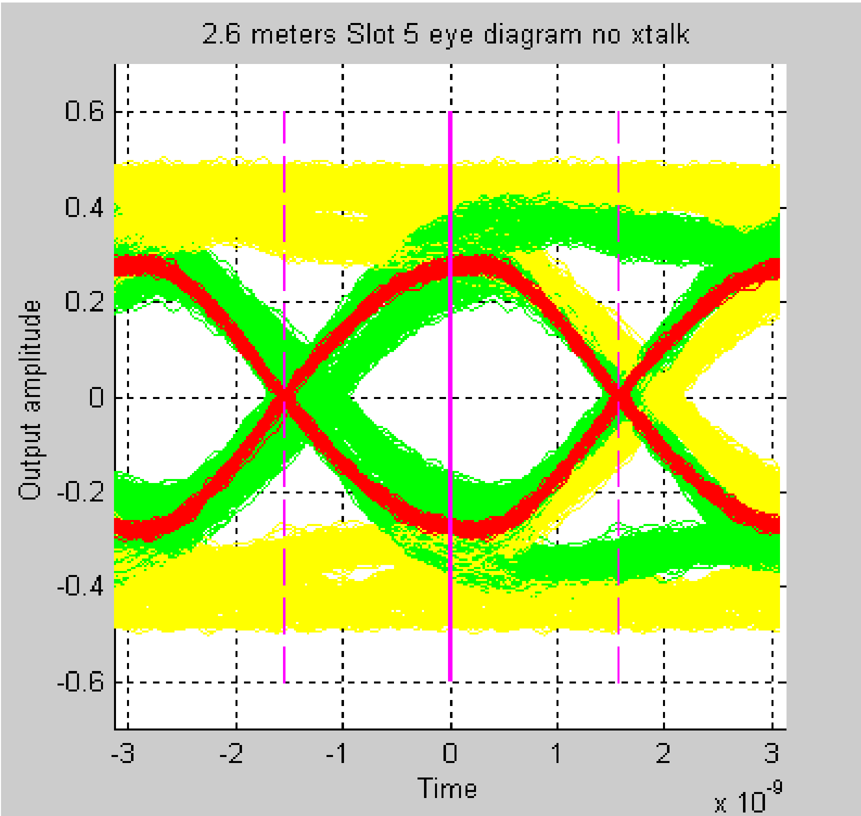


- Drive Signal: 500 mV peak differential on DB0
- Crosstalk: 500 mV peak 1010 on DB1 and DBP1

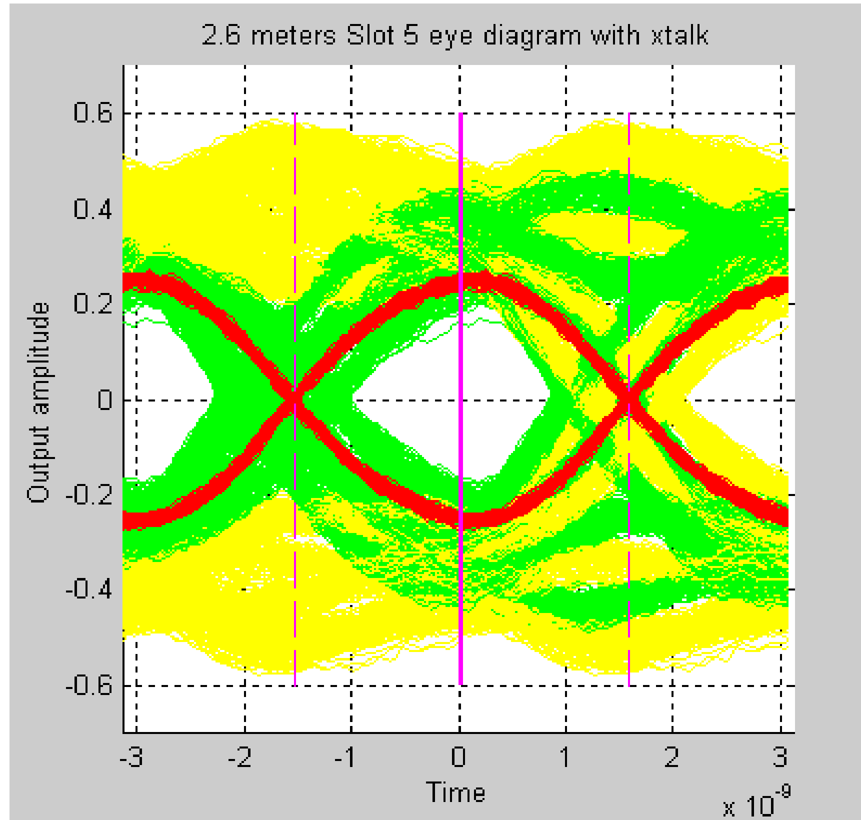
- ISI+reflections ~ 0.7ns, 1010 pattern (no Xtlk) ~ 0.5V pk, ISI+reflections + Xtlk ~ 1.2 ns
- Cable: Twisted-Flat, Amphenol p/n 125-3096-995, 30 AWG, 1.75" Flats, 9.85" Pitch

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

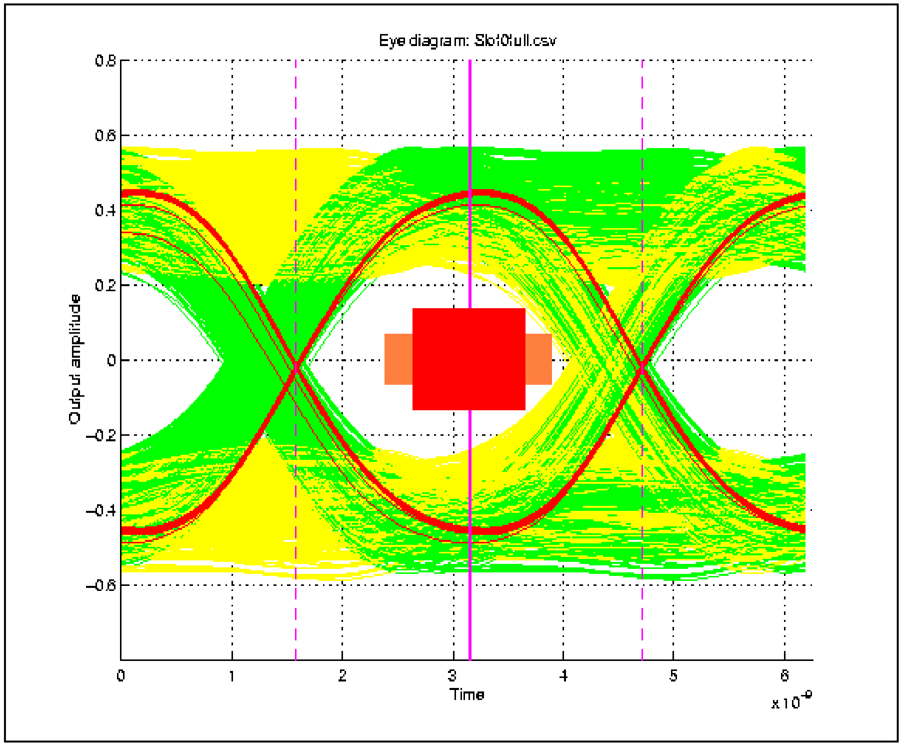


- Drive Signal: 500 mV peak differential on DB0
- Crosstalk: 500 mV peak 1010 on DB1 and DBP1

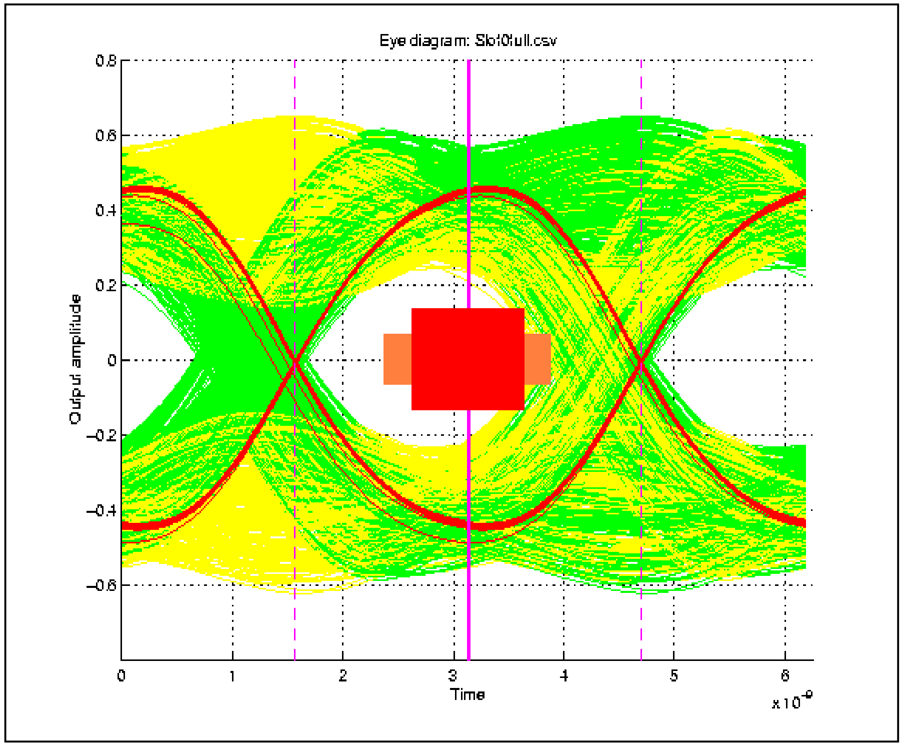
- **ISI+reflections ~ 0.8 ns, 1010 pattern (no Xtlk) ~ 0.25 Vpk, ISI+reflections+Xtlk ~ 1.4 ns**
- **Cable: Twisted-Flat, Amphenol p/n 125-3096-995, 30 AWG, 1.75” Flats, 9.85” Pitch**

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

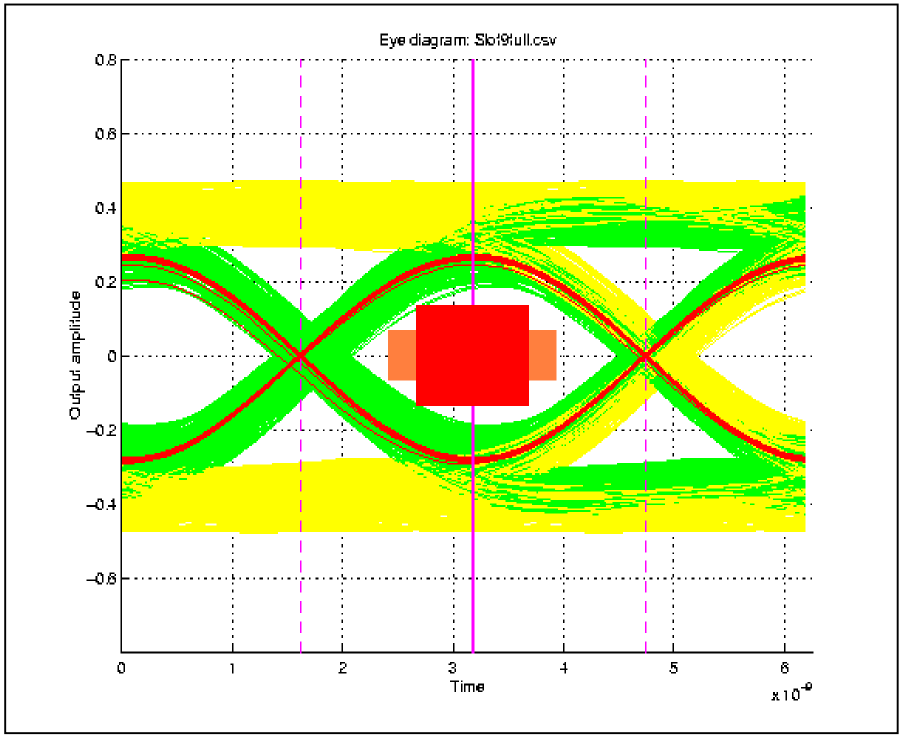


- Drive Signal: 500 mV peak differential on DB0
- Crosstalk: 500 mV peak 1010 on DB1 and DBP1

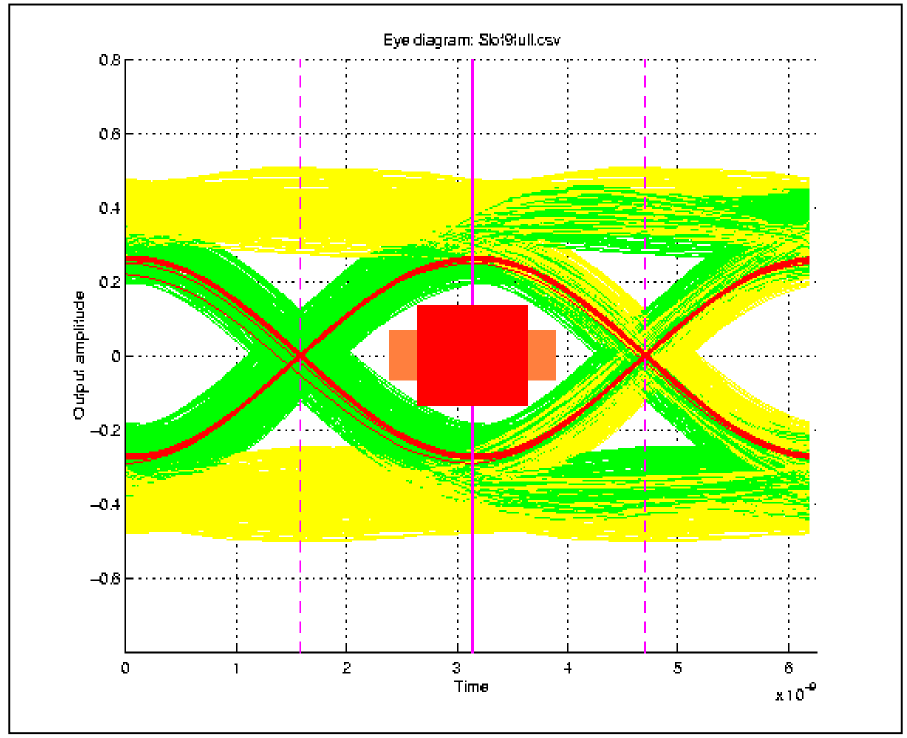
- ISI+reflections ~ 0.8 ns, 1010 pattern (no Xtlk) ~ 0.45 Vpk, ISI+reflections +Xtlk ~ 1.1 ns
- Cable: Twisted-Flat, Amphenol p/n 125-3099-995, 30 AWG, 1.75" Flats, 11.75" Pitch
- Masks: Red: +/- 130 mV, +/- 0.5 ns   Orange: +/- 65 mV +/- 0.75 ns

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

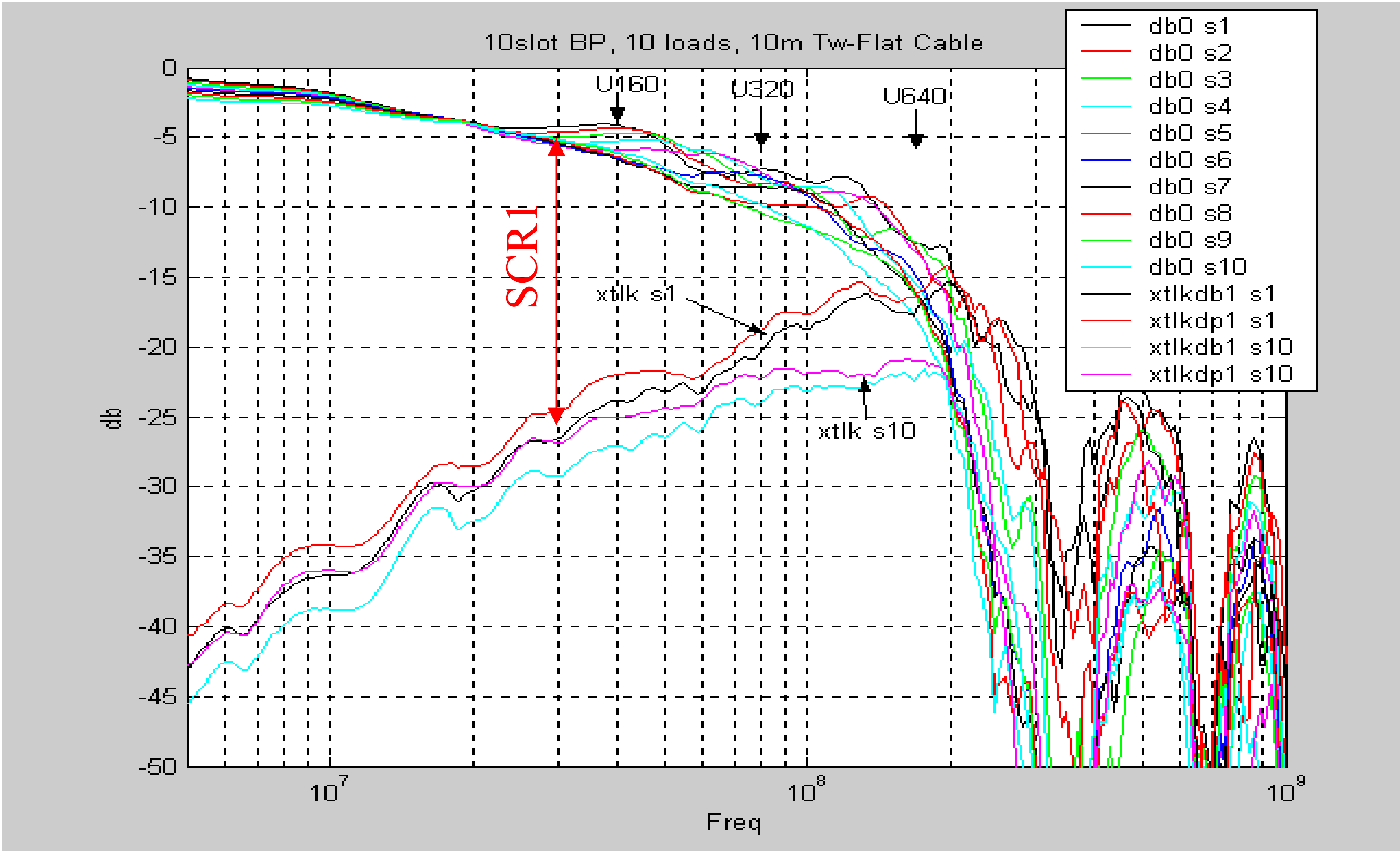


- Drive Signal: 500 mV peak differential on DB0
- Crosstalk: 500 mV peak 1010 on DB1 and DBP1

- 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

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 a 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