Quantum™

T10/00-409r0

Update on Quantum's Adjustable Active Filter for Ultra320

Mark Evans
Quantum Corporation

SPI-4 Working Group Meeting
31 October 2000
Seaside, CA

Introduction

- Over the last year Quantum has presented much data about many facets of AAF and transmitter pre-comp with cutback.
- Much of this data was gathered using real backplanes and hard disk drives (though with optimistic test set-ups).
- However, some of what we presented for AAF were our estimations based on significant design experience.
- As our AAF design nears completion, we thought it would be beneficial to provide an update on some of the actual data that we now have about our design parameters.
- To frame this, we thought it would be appropriate to briefly recap some of the material that we had previously presented for the many who have not participated in every SPI-4 meeting.

Transmitter Pre-compensation

- We began investigating transmitter pre-comp as we thought it would be an adequate solution for Ultra320 SCSI.
- Dr. Andrew Bishop of Quantum made a comprehensive presentation to T10 examining transmitter pre-comp (see T10/99-335r0) with the following conclusions:
  - Timing pre-comp is insufficient to compensate for ISI at 320 MB/s.
  - Amplitude pre-comp with cutback between ≈ 33% and 45% is adequate for some systems with long cables and closely-spaced loads.
  - Amp pre-comp does not improve margin for short cable systems.
  - The extra signal amplitude required for pre-comp contributes to ringing and overshoot, decreasing available hold time.
  - Amplitude pre-comp would not work for Ultra640.
  - There were unresolved issues with amplitude pre-comp.
  - We would collect more data including crosstalk.

More Pre-comp Data

- The next month Andy came to the SPI-4 working group with more test data (see T10/00-104r0) and the following conclusions:
  - For short cable configurations pre-comp is not necessary.
  - When crosstalk is included, transmitter pre-comp is insufficient for configurations with long cables due to lack of set-up and amplitude margin.
  - Our test data were optimistic:
    - We were using test equipment to generate ideal signals;
    - The increase in power, reflections, and crosstalk weren't considered.
- Therefore, we did not believe pre-comp would be sufficient for Ultra320 SCSI and had begun investigating a receiver alternative.

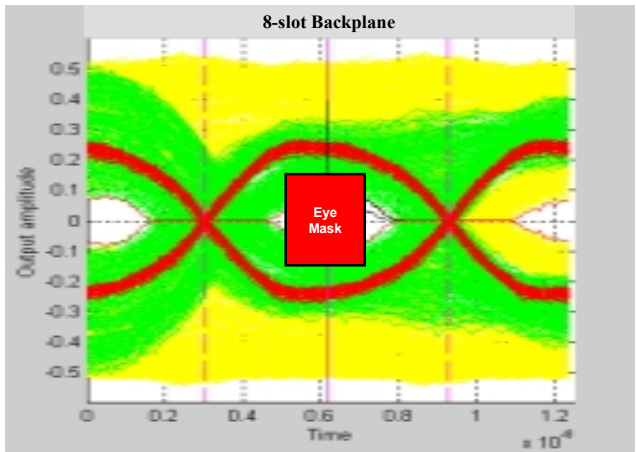
Issues with Amplitude Pre-comp

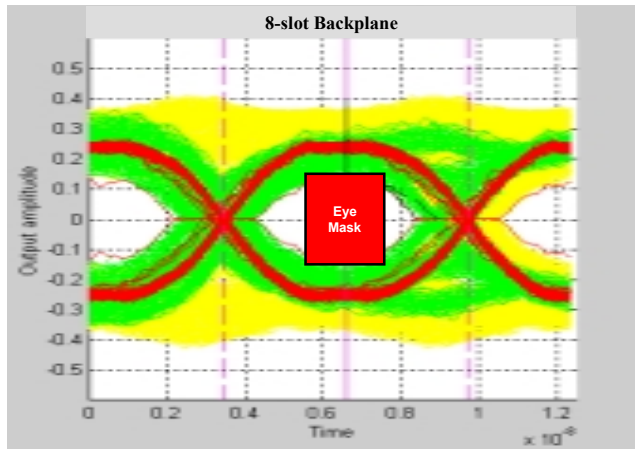
- At this point we stopped our investigation into the issues we had identified with transmitter pre-comp.
- However, the following are issues with pre-comp that have not been addressed in T10 (also see T10/00-103r2) :
  - One level of cutback is not best for all systems.
  - Pre-comp causes increased crosstalk and reflections and should actually be disabled in some systems.
  - Pre-comp is open loop, and nothing has been proposed as to how the cutback could be adjusted.
  - Pre-comp is inefficient: a significant portion of the power added at a transmitter is dissipated in the system before it gets to the receiver.
  - Pre-comp drivers have increased capacitance.
  - Pre-comp requires more power than AAF with the corresponding thermal dissipation and reliability issues.
  - Pre-comp could have EM radiation issues.
  - Common mode effects are not yet quantified.
  - Transmitter pre-comp certainly won't be sufficient for Ultra640.

Introducing the Receiver Equalizer

- In Part II of this presentation, Andy introduced the concept of receiver equalization and showed the first of hundreds of eye diagrams from our testing and our AAF design.

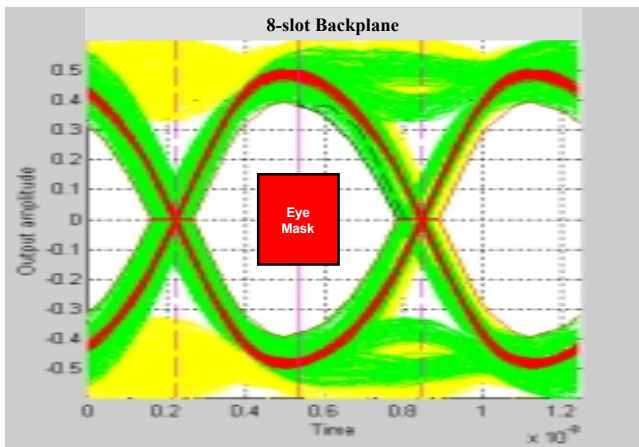
NOTHING





PRE-COMP

AAF

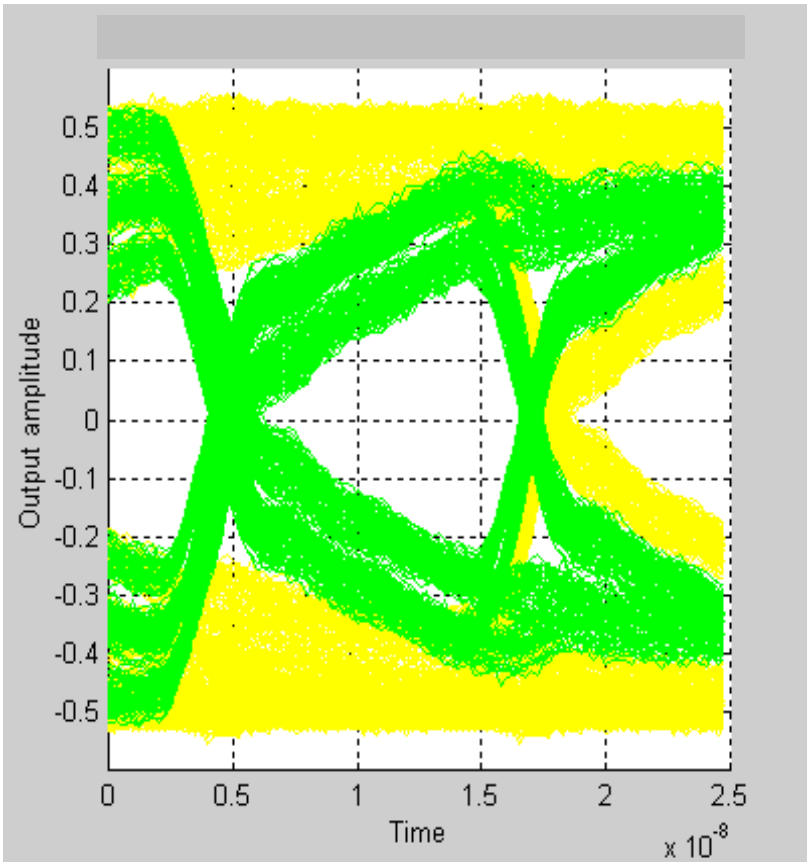


Quantum's Test Set-up

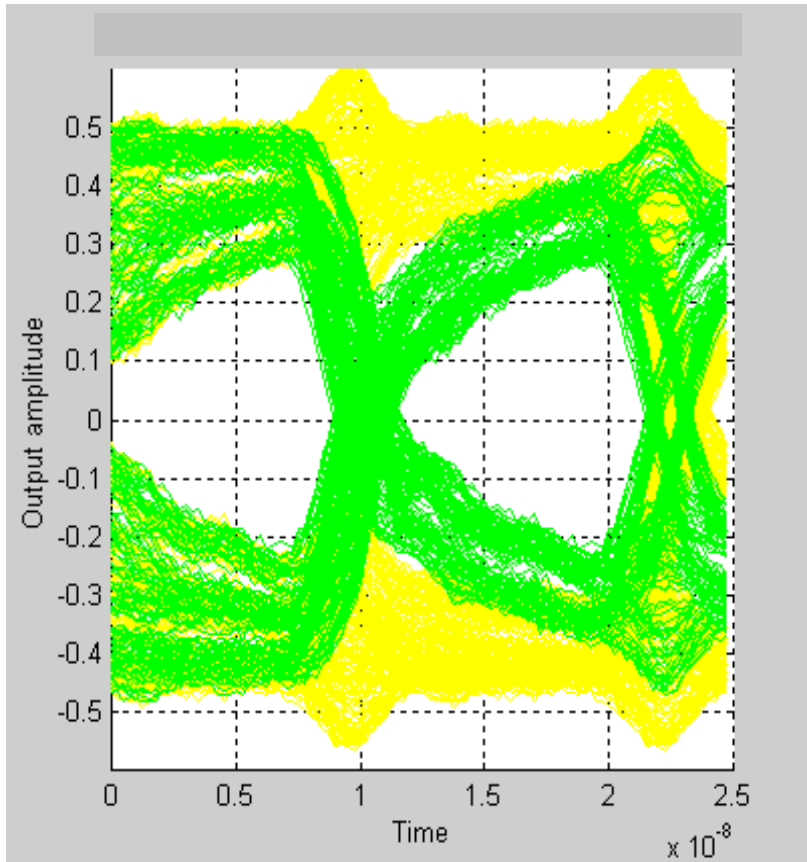
- Several questions have been asked about the Quantum test set-up. The following is a brief review of what we've presented at T10 to qualify our testing:
- We presented detailed descriptions of our test configurations in T10/00-215R0.
- We presented detailed descriptions of our test procedures in T10/00-214R0.
- Since we were using test equipment for signal generation we demonstrated the validity of our set-up by:
  - Performing testing with our set-up at Ultra160 rates as presented in T10/00-147r1,
  - Comparing our test set-up running at Ultra160 rates to actual HBAs in systems running at Ultra160 rates as presented in T10/00-224R0.

Quantum Test Set-up vs Vendor A

Test Set-up



Vendor A HBA



- The opening of the eyes in the center of the diagrams is virtually identical, thus
- The Quantum test set-up yields the same results as an HBA.

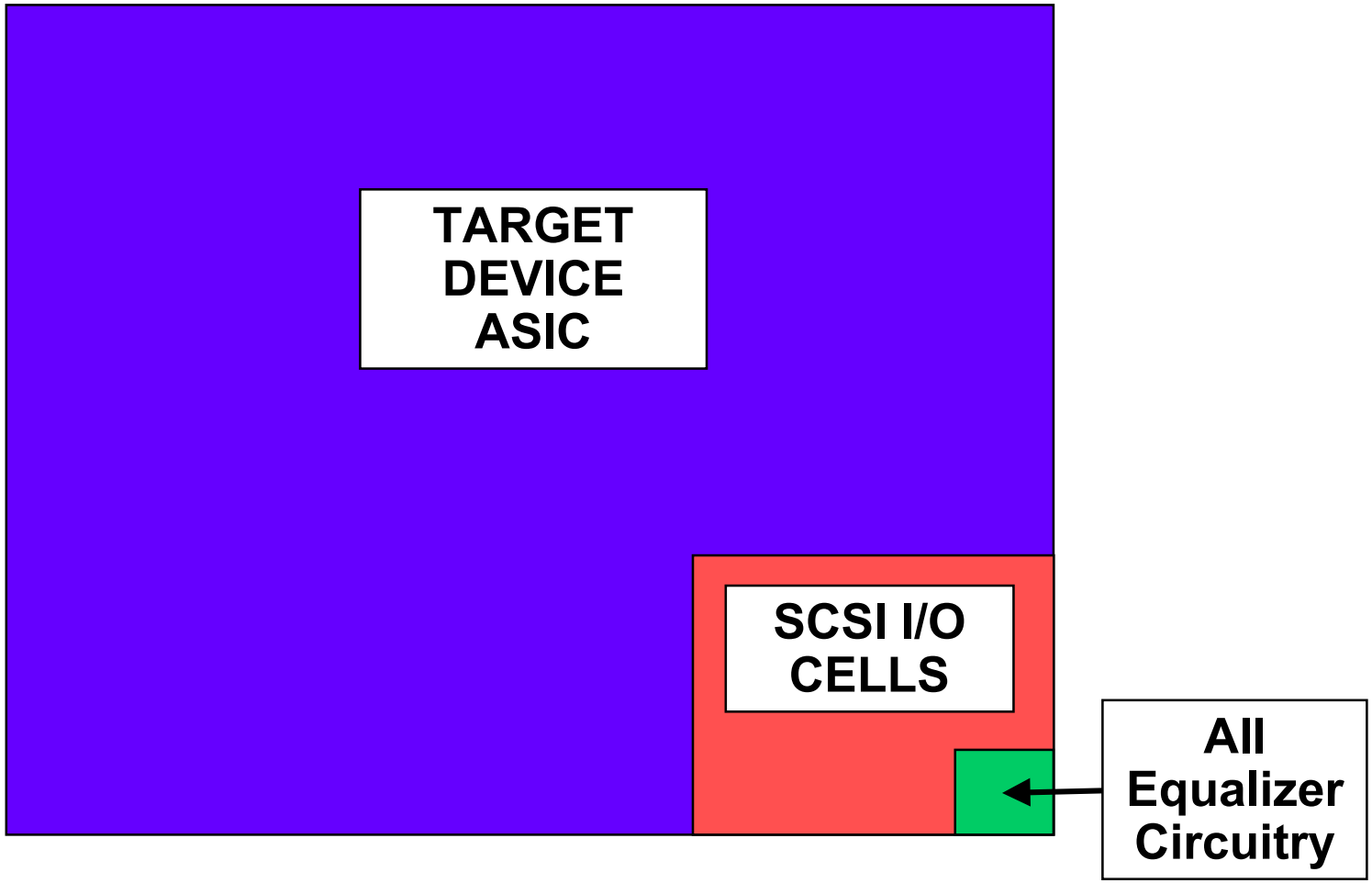
Other Ultra320 SCSI Data

- Quantum has presented much supplemental data regarding Ultra320 SCSI including:
  - AAF works in some systems exceeding the specification: data was presented where AAF worked in a system with a 25-meter cable into a backplane with six loads in T10/00-153r0 (pre-comp failed to provide adequate margin in this system),
  - In a very preliminary first blush AAF appears to be extensible to 640: data was presented for the same system with a 25-meter cable into a backplane with six loads running at 160 MHz in T10/00-154r0.
  - The overall effect of noise is worse on a system using a transmitter pre-comp scheme and better on a system using an AAF scheme (see T10/00-273r0).
- Other testing justifying pre-comp is based on testing a small number of nominal systems – not legal corner cases.

Quantum's AAF Design

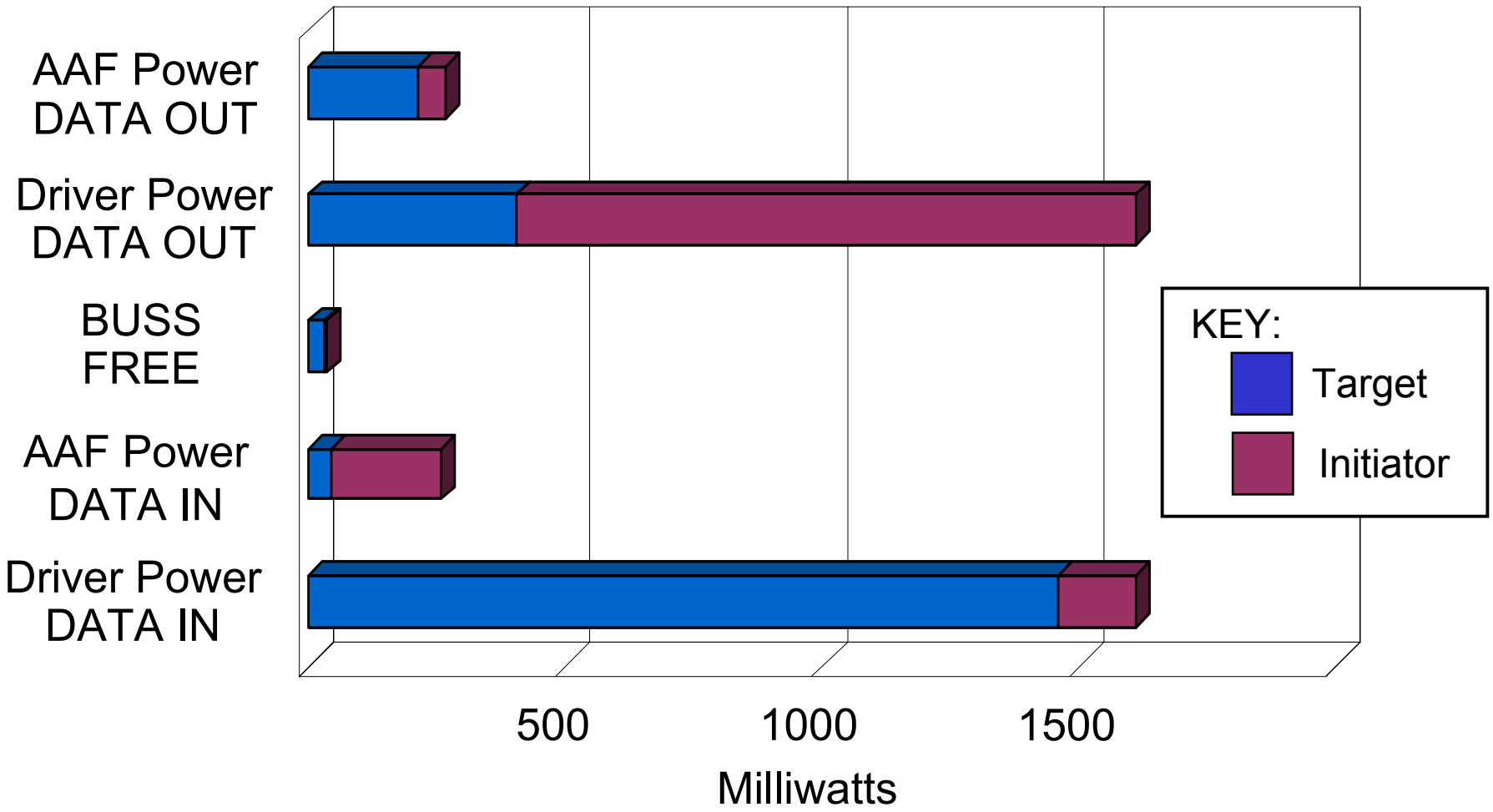
- Several people not familiar with AAF design have made speculations about the characteristics of our AAF.
- Our hardware design is complete, and these are the facts:
  - This is not a read channel; it's just designed by read channel experts.
  - The cost of our design is pennies not dollars.
  - The total size of our equalizer is about 15% of our I/O cell.
  - The total power consumed by all of our AAF circuitry when receiving in DT DATA OUT phase is 207 mW (or 277 microhorsepower).
  - The total power consumed by all of our AAF circuitry when not receiving data is 4.3 mW (or 5.8 μhp).
  - Our design adds no noise or phase distortion to the received signal; even at 1x boost our AAF provides filtering of high-frequency noise.
  - Our design compensates for variations in temperature, voltage, and process.

Relative Size of Quantum's AAF



The equalizer circuitry uses less than 1% of the area of Quantum's target ASIC.

Relative Power of Quantum's AAF



AAF when in receiving mode consumes about 15% of the power consumed by the drivers at 500 mV.

Summary

- Quantum knows a lot about pre-comp. This was the first solution we explored for Ultra320.
- Pre-comp will not be sufficient for all slots in all systems.
- No protocol has been proposed that will provide a method for determining and setting the correct pre-comp value over the range of systems where it may be sufficient.
- There are other outstanding issues with pre-comp that have not been addressed.
- Quantum's test set-up is valid; there are systems out there with characteristics worse than those we've presented.
- We developed a receiver solution now known as AAF.
- We proposed and developed all of the protocol required for AAF in T10 and that protocol is now included in SPI-4.
- There are no outstanding issues with Quantum's AAF design.

Conclusions

- Transmitter pre-comp will not work for all legal Ultra320 SCSI configurations (the only outstanding question is: what is the actual percentage of systems that won't work with pre-comp – and this could take years to determine).

- AAF works for all legal Ultra320 SCSI configurations that we've tested (and even for many configurations that are out of spec).