Update on Quantum’s Adjustable Active Filter for Ultra320

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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.
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.
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.
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.
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.
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).
  • 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.
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.
• 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).