Maxtor Corporation
500 McCarthy Boulevard
Milpitas, CA 95035 USA

To: T10 Serial Attached SCSI PHY Working Group
From: Russ Brown
Email: russ_brown@maxtor.com
Contact: Mark Evans
Email: mark_evans@maxtor.com
408-894-5310
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Subject: Proposed changes for SAS driver and receiver electrical characteristics

Introduction

The following discusses some issues that have been identified with specifications for several items in subclause 5.7 Driver and receiver electrical characteristics, and proposes solutions for each. Revision 1 of this proposal has been updated based on the 6 June PHY WG meeting discussions. The changes from rev ~~0~~ 1 are identified with revision marks. Note that table, figure, and section numbers are referenced to sas-r00b. Revision 2 of this proposal has been updated to change the receiver excess input capacitance specification back to an impedance dip area specification as discussed in the 24 June conference call.

Table 14. Transmitted signal characteristics at Tx compliance points

Issues:

- The transmitted signal "rise/fall times" should be specified from "20% to 80%".
- The measurement bandwidth of 1.8x baud rate in note f is not sufficient to resolve the minimum rise/fall time limits:

  e.g.: @ 3 Gbps:
  - scope with BW = 1.8 x 3 Gbps -> 5.4 GHz would have
  - 10-90% trise ~ 0.35/5.4 G -> 65 ps or
  - 20-80% trise ~ 0.22/5.4 G -> 41 ps.
  - This bandwidth is not adequate to resolve a 67 ps min 20% – 80% trise/fall limit.

To resolve these issues we recommend that note f be changed to read, "Rise/fall times are measured from 20% to 80% of the "one" and "zero" amplitudes as defined in section 5.7.4.2, using a test load as in figure 30."
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Table 18. Impedance requirements

- The signal excursion for TDR Risetime should be specified as 20-80%, consistent with SATA 1.0.
- Is 85 ps fast enough for TDR risetime at 3 Gbps with 67 ps 20-80% Trise? Shouldn't this be 50 ps?

- The fastest allowed transmitter risetime is 0.2 UI. We propose that impedances be tested at a faster TDR risetime of 0.15 UI, or 100 ps at 1.5 Gbps and 50 ps at 3 Gbps.
- SATA 1.0 specifies 70 ps for cable & connectors to cover gen1 and gen2, and 100 ps for Tx / Rx impedances for gen1 only.
- The table should be expanded into separate sections for "media", "receiver termination", and "transmitter source termination".
- "Cable pair matching" should be changed to "Single ended impedance matching" and the spec for this should be included for "media", "receiver termination", and "transmitter source termination". The single ended impedance match is important to limit common-mode to differential signal conversion.
- "Through connection" should be replaced with a "Mated connector pairs" section, and specs for impedance should be included for differential, common mode and single-ended matching.
- Transmitter source impedance requirements:
  - SAS includes a transmitter source termination specification as in SATA.
  - This is NOT specified in FC. What is in XAUI ? Infiniband?
  - A tight transmitter Rsource requirement can significantly restrict driver circuitry design and is not that valuable.
  - A tight receiver termination impedance is more easily achieved.
  - The magnitude of receive end errors due to source mis-termination is proportional to the product of source and termination reflection coefficients.
  - Based on input from the 6 June meeting, we propose relaxing the transmitter source termination requirement for SAS to allow a lower source impedance value of 60 ohms min.

  e.g., with a 40 ohm min. transmitter, worst-case differential reflection coefficients are:
  - source RhoS = (40 – 110) / 150 = -0.467
  - load RhoL = (85 – 110) / 195 = -0.128
  - receive end reflection (settling) error (0.467 * 0.128) -> 6% (this is still small and is comparable to NEXT errors)

In note f:

- The "150 ps" allowed area for the receiver impedance dip corresponds to a 1 GHz pole (3 pf excess capacitance) in the receive path frequency response, and excessive high frequency attenuation for SAS (e.g., at 3 Gbps, -4.8 dB at Data rate / 2 = 1.5 GHz). ~~We propose specifying an excess differential input capacitance to correspond with an allowed 1 dB max frequency response roll-off at (data rate / 2), to be measured by TDR techniques as described in note f.~~
- The second to last sentence, "The product calculated by this method shall not be greater than 150 ps", should be ~~deleted and the calculation of excess input capacitance should be shown.~~ replaced with, "The area calculated by this method shall not be greater than the values shown in the above table".
- The reference to note a on "width" should be deleted because it does not apply.

All of the above results are in the following recommended replacement for Table 18 and the related note f:

Parameter	Units	1.5 Gbps	3 Gbps
TDR risetime 20% - 80% [a,b]	ps	100	50
Media (PCB or cable)			
Differential impedance [b,c,d]	ohms	100 +/- 10	100 +/- 10
Single-ended impedance match [b,c,d]	ohms	+/- 5	+/- 5
Common mode impedance [b,c,d]	ohms	32.5 +/- 7.5	32.5 +/- 7.5
Mated connectors			
Differential impedance [b,c,d]	ohms	100 +/- 15	100 +/- 15
Single-ended impedance match [b,c,d]	ohms	+/- 5	+/- 5
Common mode impedance [b,c,d]	ohms	32.5 +/- 7.5	32.5 +/- 7.5
Receiver termination			
Differential impedance [b,e,f]	ohms	100 +/- 15	100 +/- 15
Single-ended impedance match [b,e,f]	ohms	+/- 5	+/- 5
~~Excess differential input capacitance~~ Area of impedance dip [b,e,f]	~~pf~~ps	~~2~~ 150 max	~~1~~ 100 max
Common mode impedance [b,e]	ohms	20 min / 40 max	20 min / 40 max
Transmitter source termination			
Differential impedance [b]	ohms	60 min / 115 max	60 min / 115 max
Single-ended impedance match [b]	ohms	+/- 5	+/- 5
Common mode impedance [b]	ohms	15 min / 40 max	15 min / 40 max

Note f

At the time point corresponding to the connection of the receiver to the transmission line, the input capacitance of the receiver and its connection to the transmission line may cause the measured impedance to fall below the minimum impedances in this table. The area of the impedance dip (amplitude in units of the reflection coefficient rho, and duration in time) caused by this capacitance is ~~the time constant at this poin~~ directly proportional to the capacitance.~~t~~ ~~The value of this excess input capacitance is given by C = (area of impedance dip) / (R_0 \|\| R_R), where (R_0 \|\| R_R) is the parallel combination of the transmission line characteristic impedance and termination resistance at the receiver.~~ An approximate value for the area is given by the product of the amplitude of the dip (in units of rho, the reflection coefficient) and its width (in picoseconds) measured at the half-amplitude point. The area calculated by this method shall not be greater than the values shown in the above table. The amplitude is defined as being the difference in reflection coefficient ~~rho~~ between the reflection coefficient ~~rho~~ at the nominal impedance and the reflection coefficient ~~rho~~ at the minimum impedance point.

Figure 30. Test loads

- The Fig 29 comment is withdrawn. The 6 June PHY WG meeting has proposed reworking to incorporate a “worst case” compliance channel.