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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 are identified with revision marks. Note that table, figure, and section numbers are referenced to sas-r00b.

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% ~~settled~~of the "one" and "zero" amplitudes as defined in section 5.7.4.2, using a test load as in ~~figure 29. Measured values are to be corrected for measurement instrument bandwidth and loading."~~figure 30."

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Table 18. Impedance requirements

- The ~~TDR rise time for 3 Gbps~~signal excursion for TDR Risetime should be specified ~~from "10% to 90%".~~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?
- ~~Is a specification for "Through connection" needed, since other parameters are defined as measured through mated connector pairs? If it is needed, it should be defined as "Mated~~

connector pairs".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.
- We think it would be more clear if the table were divided intoThe 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.
  - WeBased on input from the 6 June meeting, we propose relaxing the transmitter source termination requirement for SAS to allow mucha lower source impedance values.value of 60 ohms min.

  e.g., with the above,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, -4.8dB 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.
- 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 ~~10~~20% - ~~90~~80% [a,b]	ps	~~85~~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
~~Differential impedance match [b,e,f]~~	~~ohms~~	~~+/- 5~~	~~+/- 5~~
Single-ended impedance match [b,e,f]	ohms	+/- 5	+/- 5
Excess differential input capacitance [b,e,f]	pf	2 max	1 max
Common mode impedance [b,e]	ohms	20 min / 40 max	20 min / 40 max
Transmitter source termination			
Differential impedance [b]	ohms	~~40~~ 60 min / 115 max	~~40~~ 60 min / 115 max
Single-ended impedance match [b]	ohms	+/- 5	+/- 5
Common mode impedance [b]	ohms	~~10~~ 15 min / 40 max	~~10~~ 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 point. 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 amplitude is defined as being the difference in rho between the rho at the nominal impedance and the rho at the minimum impedance point.

Figure 30. Test loads

- ~~Probe points are shown only at the receiver. These are fine for the receiver, but should also be shown for the transmitter at the compliance point connector. A max loading due to measurement probe capacitance of ?? 0.5 pf ?? (50 ohms x 0.5 pf -> 25 ps) should also be specified.~~The Fig 29 comment is withdrawn. The 6 June PHY WG meeting has proposed reworking to incorporate a “worst case” compliance channel.