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To: T10 SAS Protocol Working Group
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Subject: SAS-1.1, protocol for changing driver amplitude

Introduction

This proposal provides a method for SATA-capable SAS initiator or expander devices to handshake with SATA devices capable of both SATA and SAS transmission amplitudes such that the OOB sequence results in both devices operating at the optimum amplitude on an operation physical link. Also, this proposal addresses two additional issues. The first could occur when a SAS/SATA initiator/expander is performing an OOB sequence with a SAS device where the SATA amplitude is insufficient (see the following) to complete the sequence. The second could occur if there is no response to COMWAKE, as this case is not described in the draft standard. This proposal is based on SAS-1.1 revision 1.

Issue with a SAS/SATA initiator/expander performing OOB with a SAS device in a system requiring SAS amplitude

The following table shows the OOB sequence for a SAS and SATA capable initiator or expander device connected to a SAS device, where the SATA "i" level is insufficient to complete the OOB sequences. This sequence is described in the current SAS standard.

Table 1 — SAS/SATA initiator/expander and SAS device

Step	SAS/SATA initiator/expander	Direction	SAS device
1	Transmits COMINIT @ "i" level	--->	Does not detect a signal
2	Detects COMINIT	<---	Transmits COMINIT @ SAS level
3	Transmits COMSAS @ "i" level	--->	Does not detect a signal
4	COMSAS detect timeout		
5	Transmits COMWAKE @ "i" level	--->	Does not detect a signal
6			Hot-plug timeout
7	Detects COMINIT	<---	Transmits COMINIT @ SAS level
8	Go to SP0:OOB_COMINIT, but transmission level for next COMINIT not clearly defined		

As shown in the above sequence, the standard is not clear about what happens if a SAS initiator or expander device detects a COMINIT after transmitting a COMWAKE.

1) Change clause 5.3.4 Signal characteristics at IT, CT, and XT to be as follows:

5.3.4 Signal characteristics at IT, CT, and XT

This subclause defines the inter-operability requirements of the signal at the transmitter end of a TxRx connection as measured into the zero-length test load specified in figure 52. All specifications are based on differential measurements.

~~The OOB sequence shall be performed at signal voltage levels corresponding to the lowest supported transfer rate. Expander phys supporting being attached to SATA devices shall use SATA 1.0 signal levels (see ATA/ATAPI-7 V3) during the first OOB sequence after a power on or hard reset if the 1,5 Gbps transfer rate is supported. As soon as COMSAS has been exchanged, the expander phy shall increase its transmit levels to the SAS voltage levels specified in table 26. If a COMINIT is not received within a hot-plug timeout at SATA 1.0 signal levels, the expander phy shall increase its transmit levels to the SAS voltage levels and perform the OOB sequence again. If no COMINIT is received within a hot-plug timeout of the second OOB sequence the expander phy shall initiate another OOB sequence using SATA 1.0 signal levels. The expander phy shall continue alternating between sending COMINIT at SATA 1.0 signal levels and SAS signal levels until a COMINIT is received.~~

~~If the OOB sequence is completed at the SAS voltage level and a SATA device is detected rather than a SAS target device, the expander phy shall switch to SATA 1.0 voltage levels and repeat the OOB sequence.~~

~~NOTE 9 – SAS initiator phys supporting being attached to SATA devices may use the same algorithm as expander phys.~~

~~SAS initiator phys and SAS target phys shall transmit OOB signals at the lowest supported transfer rate using SAS signal levels.~~

Table 25 specifies the signal characteristics at IT, XT, and XT.

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2) Change clause 6.6.3 SAS to SATA phy reset sequence to be as follows:

6.6.3 SAS to SATA phy reset sequences

[Replace the text before Figure 61 - SAS to SATA OOB sequence with the following:]

SAS initiator devices and expander devices may be directly attached to SATA devices.

If an expander device supports the 1,5 Gbps transfer rate and being attached to SATA devices, but the expander device does not support SATA device amplitude adjustment, then the expander device shall perform the following as the first phy reset sequence after a power on or hard reset:

- a) the phy shall transmit a COMINIT at the SATA 1.0 voltage levels (see ATA/ATAPI-7 V3);
- b) if a COMINIT is not received by the phy within a hot-plug timeout after the phy has transmitted a COMINIT at the SATA 1.0 voltage levels, then the phy shall transmit a COMINIT at the SAS voltage levels;
- c) if a COMINIT is not received by the phy within a hot-plug timeout after the phy has transmitted a COMINIT at the SAS voltage levels, then the phy shall transmit a COMINIT at the SATA 1.0 voltage levels;
- d) the phy shall alternate between (b) and (c) until a COMINIT or COMSAS is received;
- e) if a COMINIT is received by the phy, then the phy shall transmit a COMSAS at the voltage levels at which the last COMINIT was transmitted;
- f) if a COMSAS is received by the phy, then the phy shall set its transmit levels to SAS voltage levels as specified in table 26 and begin SAS speed negotiation (see 6.6.4.2);

- g) if a COMWAKE is received by an expander phy before the phy has transmitted a COMAKE (i.e., the phy is connected to the active phy in a port selector), then the expander shall set the ATTACHED SATA PORT SELECTOR bit in the DISCOVER response to one (see 6.7.3.2.1);
- h) if a COMSAS is not received by the phy within a COMSAS timeout after the phy has transmitted a COMSAS, then the phy shall transmit a COMWAKE at the SATA 1.0 voltage levels;
- i) if a COMWAKE is received by the phy after the phy has transmitted a COMWAKE, then the phy shall begin the SATA speed negotiation sequence;
- j) if a COMINIT is received by a phy within a hot-plug timeout after the phy has transmitted a COMWAKE, then the phy shall transmit a COMINIT at the SATA 1.0 voltage levels and go to (d); and
- k) if a COMWAKE or COMINIT is not received by the phy within a hot-plug timeout after the phy has transmitted a COMWAKE, then the phy shall transmit a COMINIT at the SATA 1.0 voltage levels and go to (d).

If an expander device supports the 1,5 Gbps transfer rate, being attached to SATA devices, and SATA device amplitude adjustment, then the expander device shall perform the following as the first phy reset sequence after a power on or hard reset:

- a) the phy shall transmit a COMINIT at the SATA 1.0 voltage levels (see ATA/ATAPI-7 V3);
- b) if a COMINIT is not received by the phy within a hot-plug timeout after the phy has transmitted a COMINIT at the SATA 1.0 voltage levels, then the phy shall transmit a COMINIT at the SAS voltage levels;
- c) if a COMINIT is not received by the phy within a hot-plug timeout after the phy has transmitted a COMINIT at the SAS voltage levels, then the phy shall transmit a COMINIT at the SATA 1.0 voltage levels;
- d) the phy shall alternate between (b) and (c) until a COMINIT or COMSAS is received;
- e) if a COMINIT is received by the phy, then the phy shall transmit a COMSAS at the voltage levels at which the last COMINIT was transmitted;
- f) if a COMWAKE is received by the phy before the phy has transmitted a COMSAS, and the phy is an expander phy (i.e., the phy is connected to the active phy in a port selector), then the expander shall set the ATTACHED SATA PORT SELECTOR bit in the DISCOVER response to one (see 6.7.3.2.1);
- g) if a COMWAKE is received by the phy before the phy has transmitted a COMSAS, then the phy shall transmit a COMINIT at the SATA 1.0 voltage levels and go to (d)
- h) if a COMSAS is received by the phy, then the phy shall set its transmit levels to SAS voltage levels as specified in table 26 and begin SAS speed negotiation (see 6.6.4.2);
- i) if a COMWAKE is received by the phy after the phy has transmitted a COMSAS but before the phy has transmitted a COMWAKE, then the phy shall begin the SATA speed negotiation sequence at the SAS voltage levels;
- j) if a COMSAS or COMWAKE is not received by the phy within a COMSAS timeout after the phy has transmitted a COMSAS, then the phy shall transmit a COMWAKE at the SATA 1.0 voltage levels;
- k) if a COMWAKE is received by the phy after the phy has transmitted a COMWAKE, then the phy shall begin the SATA speed negotiation sequence;
- l) if a COMINIT is received by a phy within a hot-plug timeout after the phy has transmitted a COMWAKE, then the phy shall transmit a COMINIT at the SATA 1.0 voltage levels and go to (d); and
- m) if a COMWAKE or COMINIT is not received by the phy within a hot-plug timeout after the phy has transmitted a COMWAKE, then the phy shall transmit a COMINIT at the SATA 1.0 voltage levels and go to (d).

Note x - An initiator device may implement one of the above phy reset sequences.

The COMSAS identifies the phy as a SAS phy or expander phy instead of a SATA phy.

If a SATA phy that does not support amplitude adjustment is attached to the physical link, then the SATA phy either:

- a) misinterprets the COMSAS to be a COMRESET and responds with a COMINIT; or
- b) ignores the COMSAS and provides no response within a COMSAS detect timeout.

Either response indicates to the SAS device that a SATA phy is attached. As a result the SAS device shall initiate transmit COMWAKE and enter the SATA speed negotiation sequence.

Figure 61 shows a reset sequence between a SAS phy or expander phy (i.e., a phy compliant with this standard) and a SATA phy (i.e., a phy in a SATA device, defined by SATA). The two possible cases are presented. The first case is that the SATA phy ignores the COMSAS and provides no response within a COMSAS detect timeout. The second case is that the SATA phy misinterprets the COMSAS to be a COMRESET and responds with a COMINIT. The SP state machine treats these two cases the same, and determines that a SATA phy is attached after a COMSAS detect timeout. The SATA speed negotiation sequence shall be entered after COMWAKE.

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3) Add a new informative annex as follows:

Annex x (informative) SATA device amplitude adjustment during the phy reset sequence

A SATA device phy could be implemented such that it is capable of transmitting at both the SATA 1.0 and the SAS voltage levels. The following is a sequence that could be used by such a device when connected to a SAS expander or initiator device that supports being attached to SATA devices and supports SATA device amplitude adjustment such that the OOB sequence would result in both devices operating at the optimum amplitude when on an operation physical link:

- a) if the phy receives a COMRESET/COMINIT, then the phy transmits a COMINIT at the SATA 1.0 voltage levels;
- b) if the phy receives a COMWAKE, then the phy transmits a COMWAKE and begins SATA speed negotiation;
- c) if the phy receives a second COMRESET/COMINIT before receiving a COMWAKE, then the phy transmits a COMINIT at the SAS voltage levels; and
- d) if the phy receives a COMWAKE or COMSAS, then the phy transmits a COMWAKE at the SAS voltage levels and begins SATA speed negotiation.

A SATA host phy could be implemented such that it is capable of transmitting at both the SATA 1.0 and the SAS voltage levels. The following is a sequence that could be used by such a host when connected to a SATA implementing device amplitude adjustment such that the OOB sequence would result in both devices operating at the optimum amplitude when on an operation physical link.

- a) the phy transmits a COMRESET at the SATA 1.0 voltage levels;
- b) if a COMINIT is not received within a hot-plug timeout, then the phy transmits a COMRESET at the SAS voltage levels;
- c) if a COMINIT is not received within a hot-plug timeout, then the phy transmits a COMRESET at the SATA 1.0 voltage levels;
- d) the phy alternates between (b) and (c) until a COMINIT is received;
- e) if a COMINIT is received, then the phy transmits a COMSAS at the voltage levels at which the last COMINIT was transmitted;
- f) if a COMWAKE is received, then the phy transmits a COMWAKE at SAS voltage levels, and the SATA speed negotiation sequence shall begin;
- g) if a COMWAKE is not received within a COMSAS timeout, then the phy transmits a COMWAKE at the voltage levels at which the last COMINIT was transmitted;
- h) if a COMWAKE is received, then the SATA speed negotiation sequence begins; and
- i) if a COMWAKE is not received within a hot-plug timeout, then the phy shall go to (a).