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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, an OOB sequence is described to provide a solution to SAS expanders not completing an OOB sequence with SAS end devices. This proposal is based on SAS-1.1 revision 1.

1) Remove the description of the OOB sequence from clause 5.3.4 Signal characteristics at IT, CT, and XT 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

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

~~To initiate a phy reset sequence a phy shall:~~

If an expander device supports being attached to SATA devices but does not support SATA device amplitude adjustment, then it shall perform the following as the first phy reset sequence after a power on or hard reset if the 1.5 Gbps transfer rate is supported:

- a) the phy shall transmit a COMINIT at the SATA 1.0 voltage levels (see ATA/ATAPI-7 V3); ~~and~~
- b) if a COMINIT is not received within a hot-plug timeout, then the phy shall transmit a COMINIT at the SAS voltage levels;
- c) if a COMINIT is not received within a hot-plug timeout, 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 is received;
- e) if ~~in response to receiving~~ a COMINIT is received, then the phy shall transmit a COMSAS at the voltage levels at which the last COMINIT was transmitted;
- f) if a COMSAS is received, 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 COMSAS is not received within a COMSAS timeout, then the phy shall transmit a COMWAKE at the SATA 1.0 voltage levels;
- h) if a COMWAKE is received, then the SATA speed negotiation sequence shall begin;
- i) if a COMINIT is received after a COMWAKE has been transmitted, then the phy shall transmit a COMSAS at the SAS voltage levels and go to (f); and
- j) if a COMWAKE or COMINIT is not received within a hot-plug timeout, then the phy shall go to (a).

If an expander device supports being attached to SATA devices and supports SATA device amplitude adjustment, then it shall perform the following as the first phy reset sequence after a power on or hard reset if the 1.5 Gbps transfer rate is supported:

- a) the phy shall transmit a COMINIT at SATA 1.0 voltage levels;
- b) if a COMINIT is not received within a hot-plug timeout, then the phy shall transmit a COMINIT at the SAS voltage levels;
- c) if a COMINIT is not received within a hot-plug timeout, 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 is received;
- e) if a COMINIT is received, then the phy shall transmit a COMSAS at the voltage levels at which the last COMINIT was transmitted;
- f) if a COMSAS is received, then the phy shall increase 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, then the phy shall transmit a COMWAKE at SAS voltage levels, and the SATA speed negotiation sequence shall begin;
- h) if a COMSAS or a COMWAKE is not received within a COMSAS timeout, then the phy shall transmit a COMWAKE at the voltage levels at which the last COMINIT was transmitted;
- i) if a COMWAKE is received, then the SATA speed negotiation sequence shall begin;
- j) if a COMINIT is received after a COMWAKE has been transmitted, then the phy shall transmit a COMSAS at the SAS voltage levels and go to (f); and
- k) if a COMWAKE or COMINIT is not received within a hot-plug timeout, then the phy shall go to (a).

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 is attached to the physical link it 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 phy that a SATA phy is attached. As a result the phy 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 device implementing 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).