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## **1 Introduction**

The goal of this proposal is to provide a method for SATA devices capable of both SATA and SAS transmission amplitudes to handshake with a SATA-capable SAS initiator or expander device such that the OOB sequence results in both devices operating at the optimum amplitude for the system. Also, a potential issue is identified where SAS expanders may not complete an OOB sequence with SAS end devices, and a new OOB sequence is described to resolve the issue. This proposal is based on SAS-1.1 revision 0.

## **2 Overview**

The following tables present several OOB sequences that describe issues or how to resolve issues. Details of what needs to be added or changed in the SAS 1.1 draft standard to achieve the goal will be described in a subsequent version of this proposal.

When used in this proposal, “i” level means the transmission amplitude defined in the ATA-7 standard (approximately 500 mv), and “x” level means the transmission amplitude defined in the SAS standard (approximately 1500 mv). By definition in the SAS standard, a SAS and SATA capable initiator or expander device can transmit at both levels.

It should also be noted that the OOB signals COMRESET and COMINIT have exactly the same timing and are used in the SAS standard interchangeably. Most of the time this signal is referenced as COMINIT in the SAS standard.

### 3 OOB sequences

#### 3.1 SAS/SATA initiator/expander and SATA “i” only device

Table 1 shows the OOB sequence for a SAS and SATA capable initiator or expander device connected to a SATA device that is only capable of transmitting at the “i” level, where the “i” level is sufficient for system operation. This sequence is described in the current SAS standard.

**Table 1 — SAS/SATA initiator/expander and SATA “i” only device**

Step	SAS/SATA initiator/expander	Direction	SATA “i” only device
1	Transmits COMINIT @ “i” level	--->	Detects COMINIT
2	Detects COMINIT	<---	Transmits COMINIT @ “i” level
3	Transmits COMSAS @ “i” level	--->	Does not detect a signal
4	COMSAS timeout		
5	Transmits COMWAKE @ “i” level	--->	Detects COMWAKE
6	Detects COMWAKE	<---	Transmits COMWAKE @ “i” level
7	Devices begin SATA speed negotiation at “i” level		

The above sequence may not work if the “i” level is not sufficient for system operation. There is no solution to this problem. Also, if a SAS initiator or expander device transmits a COMWAKE signal after a COMSAS timeout, then the device waits to receive a COMWAKE signal or the port must be reset (see 6.7.5.3 SP17:SATA\_AwaitCOMWAKE state in SAS1r00).

#### 3.2 SAS/SATA initiator/expander and SATA “i/x” device, OOB detected at “i” level

Table 2 shows the proposed OOB sequence for a SAS and SATA capable initiator or expander device connected to a SATA device capable of transmitting at both the “i” level and the “x” level where the “i” level is sufficient for OOB sequences but may or may not be sufficient for system operation.

**Table 2 — SAS/SATA initiator/expander and SATA “i/x” device, OOB detected at “i” level**

Step	SAS/SATA initiator/expander	Direction	SATA “i/x” device
1	Transmits COMINIT @ “i” level	--->	Detects COMINIT
2	Detects COMINIT	<---	Transmits COMINIT @ “i” level
3	Transmits COMSAS @ “i” level	--->	Detects COMSAS
4	Detects COMWAKE	<---	Transmits COMWAKE @ “x” level
5	Transmits COMWAKE @ “x” level	--->	Detects COMWAKE
6	Detects COMWAKE	<---	Transmits COMWAKE @ “x” level
7	Devices begin SATA speed negotiation at “x” level		

In the above sequence, the SATA device sends all signals at the “x” level after it detects the COMSAS signal, and the SAS device sends all signals at the “x” level after it detects the first COMWAKE signal. Detecting COMSAS is a new requirement for a SATA device complying with this proposal. Detecting COMWAKE after COMSAS is new requirement for a SAS and SATA capable initiator or expander device. Though the “x” level of signalling may not be needed for all configurations, operating at that level provides better signal integrity than operation at the “i” level.

### 3.3 SAS/SATA initiator/expander and SATA “i/x” device, OOB detected at “x” level

Table 3 shows the proposed OOB sequence for a SAS and SATA capable initiator or expander device connected to a SATA device capable of transmitting at both the “i” level and the “x” level where the “i” level is insufficient for OOB sequences.

**Table 3 — SAS/SATA initiator/expander and SATA “i/x” device, OOB detected at “x” level**

Step	SAS/SATA initiator/expander	Direction	SATA “i/x” device
1	Transmits COMINIT @ “i” level	--->	Does not detect a signal
2	Hot-plug timeout		
3	Transmits COMINIT @ “x” level	--->	Detects COMINIT
4	Does not detect a signal	<---	Transmits COMINIT @ “i” level
5	Hot-plug timeout		
6	Transmits COMINIT @ “i” level	--->	Does not detect a signal
7	Hot-plug timeout		
8	Transmits COMINIT @ “x” level	--->	Detects COMINIT
9	Does not detect a signal	<---	Transmits COMINIT @ “i” level
10	Hot-plug timeout		
11	Transmits COMINIT @ “i” level	--->	Does not detect a signal
12	Hot-plug timeout		
13	Transmits COMINIT @ “x” level	--->	Detects COMINIT
14	Detects COMINIT	<---	Transmits COMINIT @ “x” level
			see note a see note b
15	Transmits COMSAS @ “x” level	--->	Detects COMSAS
16	Detects COMWAKE	<---	Transmits COMWAKE @ “x” level
17	Transmits COMWAKE @ “x” level	--->	Detects COMWAKE
18	Detects COMWAKE	<---	Transmits COMWAKE @ “x” level
19	Devices begin SATA speed negotiation at “x” level		
Notes			
<sup>a</sup> if a SATA “i/x” device receives a COMWAKE before receiving a COMSAS, then the device has to assume it's connected to a non-"x"-level aware host in a less than optimum system, and the device should drop back to transmitting at the "i" level to avoid damage to the host.			
<sup>b</sup> if a SATA “i/x” device has not received a COMSAS or a COMWAKE after transmitting COMINIT twice at the “x” level, then the device should go back to step 3 (i.e., drop back to transmitting at the "i" level).			

In the above sequence, the SATA device changes to transmit at the “x” level after detecting the third COMINIT signal. The SAS initiator or expander device changes to transmit at the “x” level after receiving a COMINIT signal after having transmitted three COMINIT signals at the “x” level. Steps 15 through 18 aren't absolutely required in this sequence, but requiring these steps makes this sequence consistent with the sequence described in table 2.

### 3.4 SAS/SATA initiator/expander and SAS device

Table 4 shows the OOB sequence for a SAS and SATA capable initiator or expander device connected to a SAS device only capable of transmitting at the “x” level, where the “i” level is insufficient for OOB sequences. This sequence is described in the current SAS standard.

**Table 4 — SAS/SATA initiator/expander and SAS “x” only device (as is)**

Step	SAS/SATA initiator/expander	Direction	SAS “x” only device
1	Transmits COMINIT @ “i” level	--->	Does not detect a signal
2	Detects COMINIT	<---	Transmits COMINIT @ “x” 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 @ “x” level
8	Not defined		

In the above sequence, the standard is not clear about what happens if a device transmits a COMWAKE signal and does not receive a COMWAKE signal. The proposed solution is shown in table 5.

**Table 5 — SAS/SATA initiator/expander and SAS “x” only device (proposed)**

Step	SAS/SATA initiator/expander	Direction	SAS “x” only device
1	Transmits COMINIT @ “i” level	--->	Does not detect a signal
2	Detects COMINIT	<---	Transmits COMINIT @ “x” 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 @ “x” level
8	Transmits COMSAS @ “x” level	--->	Detects COMSAS
9	Detects COMSAS	<---	Transmits COMSAS @ “x” level
10	Devices begin SAS speed negotiation at “x” level		

In the above sequence, it is proposed that a SAS and SATA capable initiator or expander device change to the “x” level after receiving a COMINIT signal after transmitting a COMWAKE signal. This will work because only a SAS device will send a COMINIT signal under those conditions. A SATA device may only send a COMINIT signal when a connection is established.

The OOB sequence for a SAS and SATA capable initiator or expander device connected to another SAS and SATA capable initiator or expander device is implied in the SAS standard but needs some clarification. Table 6 shows the proposed sequence that the wording should describe

**Table 6 — SAS/SATA initiator/expander and SAS/SATA initiator/expander (proposed)**

Step	SAS/SATA initiator/expander	Direction	SAS/SATA initiator/expander
1	Transmits COMINIT @ "i" level	--->	Does not detect a signal
2	Does not detect a signal	<---	Transmits COMINIT @ "i" level
3	Hot-plug timeout		Hot-plug timeout
4	Transmits COMINIT @ "x" level	--->	Detects COMINIT
5	Detects COMINIT	<---	Transmits COMINIT @ "x" level
8	Transmits COMSAS @ "x" level	--->	Detects COMSAS
9	Detects COMSAS	<---	Transmits COMSAS @ "x" level
10	Devices begin SAS speed negotiation at "x" level		

It is proposed that, as shown in the above sequence, if a SAS and SATA capable initiator or expander device transmits a COMINIT at the "i" level, does not detect a signal, transmits a COMINIT at the "x" level and DOES detect a signal, then it transmits COMSAS at the "x" level. Also, if a SAS and SATA capable initiator or expander device receives a COMSAS after transmitting a COMINIT at the "x" level, it transmits COMSAS at the "x" level.

### 3.5 SATA “i/x” host and SATA “i/x” device (informative)

Based on the above (particularly 3.3 SAS/SATA initiator/expander and SATA “i/x” device, OOB at “x” level), the OOB sequence described in table 7 could be used by a SATA host capable of transmitting at the “x” level connected to a SATA device capable of transmitting at the “x” level where the “i” level is insufficient for OOB sequences.

**Table 7 — SATA “i/x” host and SATA “i/x” device**

Step	SATA “i/x” host	Direction	SATA “i/x” device
1	Transmits COMRESET @ “i” level	--->	Does not detect a signal
2	timeout		
3	Transmits COMRESET @ “x” level	--->	Detects COMRESET
4	Does not detect a signal	<---	Transmits COMINIT @ “i” level
5	timeout		
6	Transmits COMRESET @ “i” level	--->	Does not detect a signal
7	timeout		
8	Transmits COMRESET @ “x” level	--->	Detects COMRESET
9	Does not detect a signal	<---	Transmits COMINIT @ “i” level
10	timeout		
11	Transmits COMRESET @ “i” level	--->	Does not detect a signal
12	timeout		
13	Transmits COMRESET @ “x” level	--->	Detects COMRESET
14	Detects COMINIT	<---	Transmits COMINIT @ “x” level
15	Transmits COMWAKE @ “x” level	--->	Detects COMWAKE @ “x” level
16	Detects COMWAKE	<---	Transmits COMWAKE @ “x” level
18	Devices begin SATA speed negotiation at “x” level		

In the above sequence, the SATA device changes to transmit at the “x” level after detecting the third COMRESET signal. The SATA host changes to transmit at the “x” level after receiving a COMINIT signal after having transmitted three COMRESET signals at the “x” level.

As an alternative, if a SATA host capable of transmitting at the “x” level was configured in a system that would only operate at “x” levels, the process could be shortened by having the host only transmit COMRESETs at the “x” level.