To: T10 Technical Committee
From: Rob Elliott, HP (elliott@hp.com)
Date: 27 May 2002
Subject: T10/02-198r1 SAS OOB timing

Revision History
Revision 0 (20 May 2002) first revision
Revision 1 (27 May 2002) incorporated feedback from the 21 May 2002 conference call.

Related Documents
sas-r00 - Serial Attached SCSI revision 0

Overview
The OOB timing requirements need to be more precise, listing the transmit burst time and specifying receiver tolerances.

Also, the May T10 SAS study group chose to make the COMSAS burst time match the other OOB signals, with its idle time increased to 3x the COMINIT idle time.

Suggested Changes
6.3 Out of band (OOB) signals

~~SATA defines "out of band" (OOB) signals used for phy resets. OOB signals are low-speed signal patterns detected by the phy that do not appear in normal data streams. They consist of 160 UI (106.7 ns) bursts of ALIGNs followed by defined amounts of idle time. The signals are differentiated by the length of idle time between the bursts of ALIGNs.~~

~~SATA defines two OOB signals: COMINIT/COMRESET and COMWAKE. SAS devices identify themselves with a SAS-specific OOB signal called COMSAS.~~

~~**[Editor's note: COMSAS timing is under debate again.]**~~

~~Table 21 describes the SATA OOB signals. Each signal shall be sent six times. Each signal shall be received four times to be detected.~~

~~**Table 21. OOB signal transmitter requirements**~~

~~Signal~~	~~Idle time minimum~~	~~Idle time nominal~~	~~Idle time maximum~~	~~Notes~~
~~COMWAKE~~	~~55 ns~~	~~106.7 ns (160 UIs)~~	~~175 ns~~	
~~COMINIT/COMRESET~~	~~175 ns~~	~~320 ns (480 UIs)~~	~~525 ns~~	~~Named COMRESET when sent by an initiator, and named COMINIT when sent by a target.~~

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SATA defines two OOB signals: COMINIT/COMRESET and COMWAKE. COMINIT and COMRESET are used in this standard interchangeably. SAS devices identify themselves with a SAS-specific OOB signal called COMSAS.

Table 1 defines the timing specifications for OOB signals.

Table 1. OOB signal timing specifications

Parameter	Nominal	Minimum	Maximum	Comments
~~COMSAS detector off threshold~~		~~175 ns~~	~~525 ns~~	~~Detector shall reject all bursts with spacings outside of this range.~~
~~COMSAS detector on threshold~~	~~320 ns~~	~~304 ns~~	~~336 ns~~	~~Detector shall detect all burst with spacings meeting this period.~~
~~COMSAS transmit spacing~~	~~320 ns~~	~~310,4 ns~~	~~329,6 ns~~	~~As measured from receiver thresholds of last and first differential crosspoints of the burst.~~
Unit interval during OOB (UI(OOB))	666,667 ps	666,600 ps	666,734 ps	Based on 1.5 Gbps clock tolerance.
Hot-Plug Timeout	100 ms	10 ms	500 ms	~~The hot plug retry timer.~~How often a device should resend COMINIT to detect if a device has been attached.
Rate change detect (RCD)		0 ns	320 ns	During speed negotiation, the t~~T~~ransmitter shall change speeds within this time.
~~Speed Negotiation Window~~Speed Negotiation Transmit Time (SNTT)	109,23~~2~~ µs	109,22~~0~~ µs	109,24 µs	~~The speed negotiation window is~~ The time allowed for speed negotiation of each rate is: UI(OOB) * 4096 * 40.
COMSAS detect timeout period	3,5 µs			Timer.
ALIGN Detect Timeout			880 µs	Allows over 32 768 G1 dwords.

[Editor's note: change all figures to use the (new) acronyms rather than absolute times. If numbers are used, they should be in parenthesis as examples.]

[Editor's note: SATA table 11 "transmit spacing" times correspond to COMWAKE and COMINIT minimum, nominal, and maximum idle times.]

Table 1 describes the OOB signal transmitter requirements. Each signal shall be sent six times. Each signal shall be received four times to be detected. When the link is synchronized, before sending an OOB signal, the transmitter shall transmit idle for 1 ms to ensure the receiver drops link synchronization and detects the OOB signal.

Table 2. OOB signal transmitter requirements

Signal	Burst time	Idle time
COMWAKE	160 UI(OOB)	160 UI(OOB)
COMINIT/RESET	160 UI(OOB)	480 UI(OOB)
COMSAS	160 UI(OOB)	1 440 UI(OOB)

[Editor's note: For burst times, just use units of UI(OOB) rather than multiply each entry by UI(OOB)(min/nom/max).]

Table 3 describes the OOB signal receiver requirements.

Table 3. OOB signal receiver requirements

Signal	Idle time		
	may detect	shall detect	shall not detect
COMWAKE	55 ns to 175 ns	101,3 ns to 112 ns	< 55 ns or > 175 ns
COMINIT/ COMRESET	175 ns to 525 ns	304 ns to 336 ns	< 175 ns or > 525 ns
COMSAS	525 ns to 1 575 ns	911,7 ns to 1008 ns	< 525 ns or > 1 575 ns

[Editor's note: Receiver burst times: SATA table 11 does not specify any receiver burst times. The sample circuit in SATA figure 31 might ignore bursts longer than 114,4 ns and definitely ignores bursts longer than 171,6 ns. Since the sample circuit is not normative, this behavior cannot be depended upon.]

[Editor's note: Receiver idle times: SATA "detector on threshold" corresponds to the "shall detect" region and "detector off threshold" corresponds to the "shall not detect" region. A "may detect region is assumed to sit between the two.]

[Editor's note: Systems must guarantee that the transmitters meeting the minimum transmit time and the maximum transmit time result in a signal at the receiver in the shall detect region.]

[Editor's note: The COMINIT numbers are all 3x the COMWAKE numbers, except 55*3=165 not 175 (58.3*3 is 175). Left the 55 as is since that's what SATA 1.0 specifies.]

Figure 1 illustrates the timing required for the generation and detection of all the SAS OOB signals. The signals labeled ComXxxDet and ComXxxSent (where Xxx is Wake, Init, or Sas)~~,~~ are inputs to the SAS phy ~~Initialization~~ layer state machine. ComXxxDet is an output from the OOB detection circuitry that indicates the detection of an incoming COMINIT, COMWAKE, or COMSAS ~~sequence~~signal. ComXxxSent is an output from the OOB generation circuitry that indicates that a burst of six COMWAKE, COMINIT, or COMSAS ~~sequences~~ signals has been output onto the link.

~~COMINIT as defined in the SATA specification is the same as COMRESET, and they are used in this standard interchangeably.~~

The ALIGNs used in OOB sequences are not required to be at generation 1 (G1) rates (1,5 Gbps), as this rate might not be supported in future generations of SAS devices. The ALIGNs are only required to generate an envelope for the detection circuitry, as required for any signaling that may be AC coupled. If G2 ALIGNs are used, the number of ALIGNs doubles compared with G1 ALIGNs. The time for these ~~bursts and spaces~~ idles is important, not the absolute number of ALIGNs in each burst.

A SAS transmitter should ~~send OOB sequences with~~ use ALIGNs at the G1 rate to create the burst portion of the OOB signal, but may ~~send them~~ use ALIGNs at its slowest supported rate if it does not support the G1 rate and shall not send them at a rate faster than its slowest supported rate~~s~~.

A SAS receiver shall detect OOB ~~sequences~~ signals comprised of ALIGNs transmitted at any rate up to its highest supported rate. This includes rates below its lowest supported rates.

[Editor's note: the last sentence drew flak in the 5/12 conference call. Without it, configurations are possible that cannot exchange OOB signals. Imagine a device supporting 1.5 and 3 Gbps talking to a device supporting 3 and 6 Gbps, and that the faster device (or the system) does not support 1.5 Gbps based OOB signals. Stepping through different rates on each HotPlugTimeout was proposed. However, if both sides step through, they may never synchronize.]

To send an OOB signal, a transmitter shall send the OOB signal at least six times. A receiver shall detect an OOB signal after receiving it at least four times. It shall not detect the same signal again until it has detected another OOB signal or an OOB signal negation time.

Table 3 shows the time a transmitter shall transmit idle after sending an OOB signal and after detecting an OOB signal before entering the speed negotiation section.

Table 3. OOB signal negation times

Parameter	Time
COMWAKE negation time	175 ns
COMINIT/COMRESET negation time	525 ns
COMSAS negation time	1 575 ns

[Editor's note: this time is used between the last OOB signal and the start of speed negotiation.]

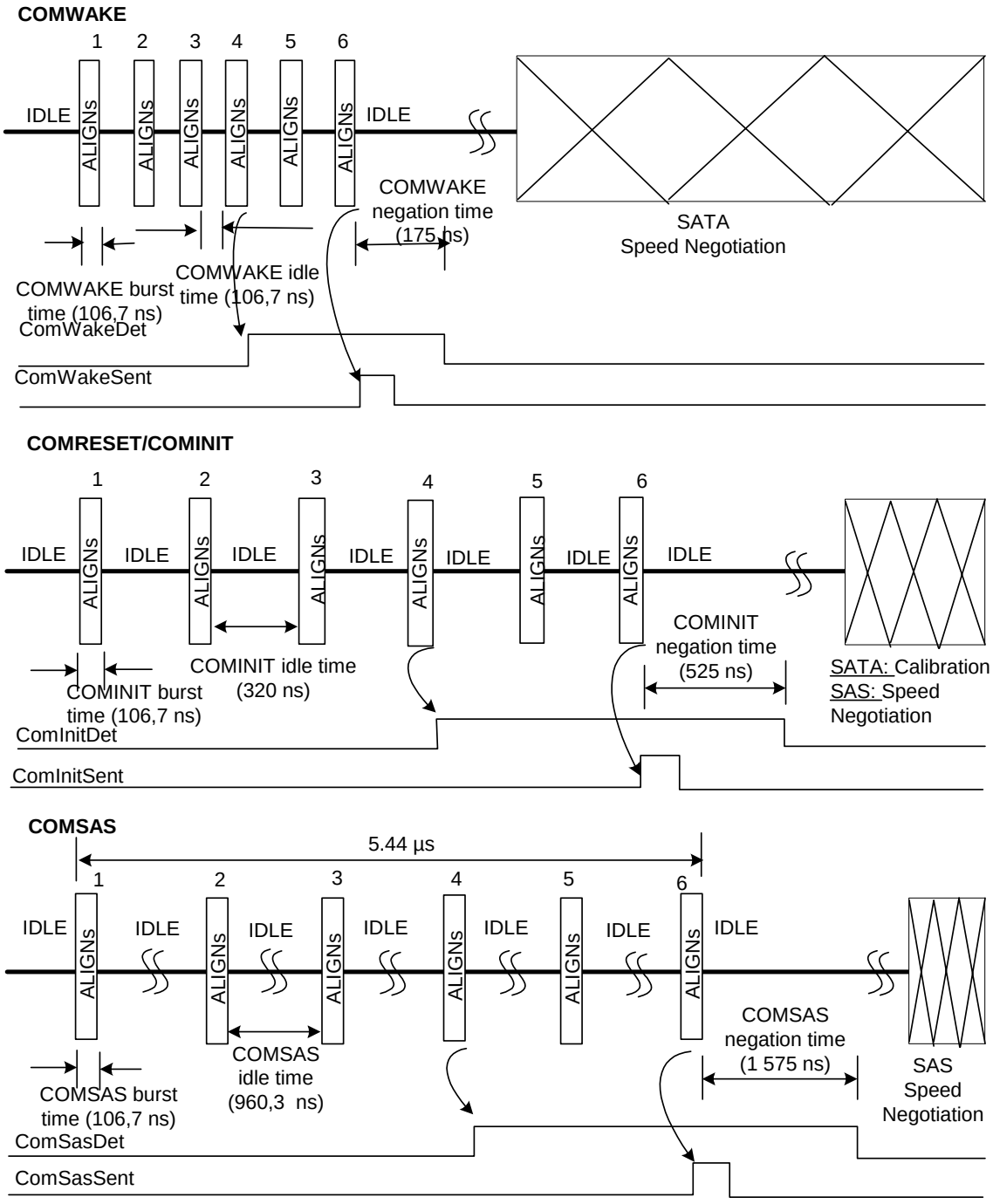

Figure 1. ~~Phy reset sequence~~OOB signal ~~generation~~ transmission and detection

Expanders shall not pass through OOB signals. An expander device shall run the link reset sequence independently on each physical link (initiator phy to expander phy, expander phy to expander phy, or expander phy to target phy).

The phy reset sequence shall only affect the phy, not the port or device containing the phy or other phys in the same port or device.