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To: **T10 SAS Protocol Working Group**
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Subject: **SAS-2.1 / SPL, Low power transceiver options, phy states**

1 Related documents

SAS-2r14h - Serial Attached SCSI - 2, revision 14h
T10/08-015r5, SAS: Add low power transceiver options
T10/08-249r3, SAS 2.1 / SPL+: Link Layer Power Management

2 Introduction

This proposal is a first pass at adding what is required in proposal 08-015 for the phy layer state diagrams to include the low power transceiver options of partial and slumber conditions for SAS.

Revision 1 of this proposal removes all link layer state elements, as those are now described in 08-249. These deletions are not shown in this revision.

Revision 2 of this proposal includes resolution to the comments received since revision 1 was posted.

Revision 3 of this proposal includes input from the SAS Protocol working group on 3 November 08 and all clause, figure, and table numbers were updated to be consistent with SAS-2r15.

3 Proposal

The following are the proposed changes based on the heading numbers in SAS-2r15:

6.7.1 Phy reset sequences overview

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A phy shall originate a phy reset sequence after:

a) power on;
b) hard reset (i.e., receiving a HARD_RESET primitive sequence before an IDENTIFY address frame) (see 4.4.2);
c) management application layer request (see 6.8.1);
d) losing dword synchronization and not attempting to re-acquire dword synchronization (see 6.8.4.9 and 6.8.5.8);
e) Receive Identify Timeout timer expires (see 7.10); ~~or~~
f) ~~for expander phys, after~~ a hot-plug timeout occurs for an expander phy (see 6.7.5);
g) a hot-plug timeout occurs while in a SAS phy power management state (see 6.8.5); or
h) the SNLT timer expires while in a SAS phy power management state (see 6.8.5).

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Change Table 96 — Phy reset sequence timing specifications as follows:

Parameter	Minimum	Maximum	Comments
Hot-plug timeout	10 ms	500 ms	The time after which: a) an expander phy shall retry an unsuccessful phy reset sequence; b) a SAS initiator phy should retry an unsuccessful phy reset sequence (see 6.7.5); or c) a phy shall initiate a phy reset sequence if the phy does not receive a COMWAKE Completed message while in a SAS phy power management state (see 6.8.5).

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6.7.4.2.2 SAS speed negotiation sequence timing specifications

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In Table 98 — SAS speed negotiation sequence timing specifications, change the wording in the "Speed negotiation lock time" row to be as follows:

Parameter	Acronym	Time [a]	Comments
.....	.....	.....	.....
Speed negotiation lock time	10 ms	500 ms	a) The maximum time for a phy to reply with ALIGN (1) during SNW-1, SNW-2, and Final-SNW; or b) The maximum time for a phy to reply with an ALIGN (0) or ALIGN (1) while in a SAS phy power management state (see 6.8.5).
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6.8.1 SP state machine overview

The SP state machine controls the phy reset sequence. This state machine consists of ~~three~~ four sets of states:

c) OOB sequence (OOB) states;
d) SAS speed negotiation (SAS) states~~.~~;
e) SAS phy power management (PS) states; and
f) SATA host emulation (SATA) states~~; and~~.

This state machine consists of the following states

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ad) SP29:SAS_Train (see 6.8.4.12);~~ and~~
ae) SP30:SAS_TrainingDone (see 6.8.4.13)~~.~~;
af) SP31:SAS_PS_Phy_Low_Power state (see 6.8.5.2);
ag) SP32:SAS_PS_ALIGN0 state (see 6.8.5.3); and
ah) SP33:SAS_PS_ALIGN1 state (see 6.8.5.4).

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If the phy supports SAS phy power management, then this state machine shall maintain a SASPhyPwrMgmt state machine variable to determine the current power condition of the phy.

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6.8.2 SP transmitter and receiver

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The SP transmitter receives the following messages from the SP state machine:

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k) Transmit TRAIN_DONE Pattern; ~~and~~
l) Transmit MUX Sequence;
m) Enter Partial Power Condition; and
n) Enter Slumber Power Condition.

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The SP receiver receives the following messages from the SP state machine:

a) Set Physical Link Rate with an argument specifying the physical link rate (e.g., 1.5 Gbps, 3 Gbps, or 6 Gbps);
b) Receive Phy Capabilities Bits;
c) Start Training; ~~and~~
d) Abort Training;
e) Enter Partial Power Condition; and
f) Enter Slumber Power Condition.

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6.8.3.1 OOB sequence states overview

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In figure 166 – SP (phy layer) state machine - OOB sequences states, add a transition arrow from all SAS phy power management states to the SP0:OOB_COMINIT state.

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6.8.3.2 SP0:OOB_COMINIT state

6.8.3.2.1 State description

This state is the initial state for this state machine.

Upon entry into this state, the phy shall:

a) set the COMWAKE_Received state machine variable to zero;
b) set the SASPhyPwrMgmt state machine variable to Active;
c) send a Stop DWS message to the SP_DWS state machine;
d) send a Phy Layer Not Ready confirmation to the link layer;
e) set the ATTACHED SATA DEVICE bit to zero in the SMP DISCOVER response (see 10.4.3.10);
f) if this state was entered due to power on, then set the ATTACHED SATA PORT SELECTOR bit to zero in the SMP DISCOVER response (see 10.4.3.10); and
g) if this state was not entered because of a Disable Phy request, then send a Transmit COMINIT message to the SP transmitter.

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6.8.4.1 SAS speed negotiation states overview

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In figure 167 – SP (phy layer) state machine - SAS speed negotiation states, add:

a) a Phy Power Management request to the SP15:SAS_PHY_Ready state;
b) a transition arrow from the SP15:SAS_PHY_Ready state to the SP31:SAS_PS_Phy_Low_Power state; and
c) a transition arrow from the SP33:SAS_PS_ALIGN1 state to the SP15:SAS_PHY_Ready state.

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6.8.4.2 SP8:SAS_Start state

6.8.4.2.1 State description

This is the ~~initial~~ state ~~for~~ in which the SAS speed negotiation sequence begins.

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6.8.4.9 SP15:SAS_Phy_Ready state

6.8.4.9.1 State description

This state waits for:

a) a COMINIT Detected message;
b) a DWS Lost message;~~, or~~
c) a DWS Reset message; or
d) a Phy Power Management request.

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6.8.4.9.3 Transition SP15:SAS_Phy_Ready to SP31:SAS_PS_Phy_Low_Power

This transition shall occur after this state receives a Phy Power Management (Partial) request or a Phy Power Management (Slumber) request.

If this transition is the result of this state receiving a Phy Power Management (Partial) request, then the transition shall include a Partial argument.

If this transition is the result of this state receiving a Phy Power Management (Slumber) request, then the transition shall include a Slumber argument.

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6.8.5 SAS phy power management states

[Editor's note: this is a new clause with a new figure. The numbers of the clauses regarding SATA that follow increment by one (e.g., 6.8.5 becomes 6.8.6), and the numbers of all subsequent figures increment by one.]

6.8.5.1 SAS phy power management states overview

Figure a shows the SAS phy power management states. These states are entered when a phy is requested to enter a low power condition (i.e., the SAS partial low power condition or the SAS slumber low power condition) and process the actions that return a phy from a low power condition to participating in an operational logical link.

These states are indicated by state names with a prefix of SAS_PS.

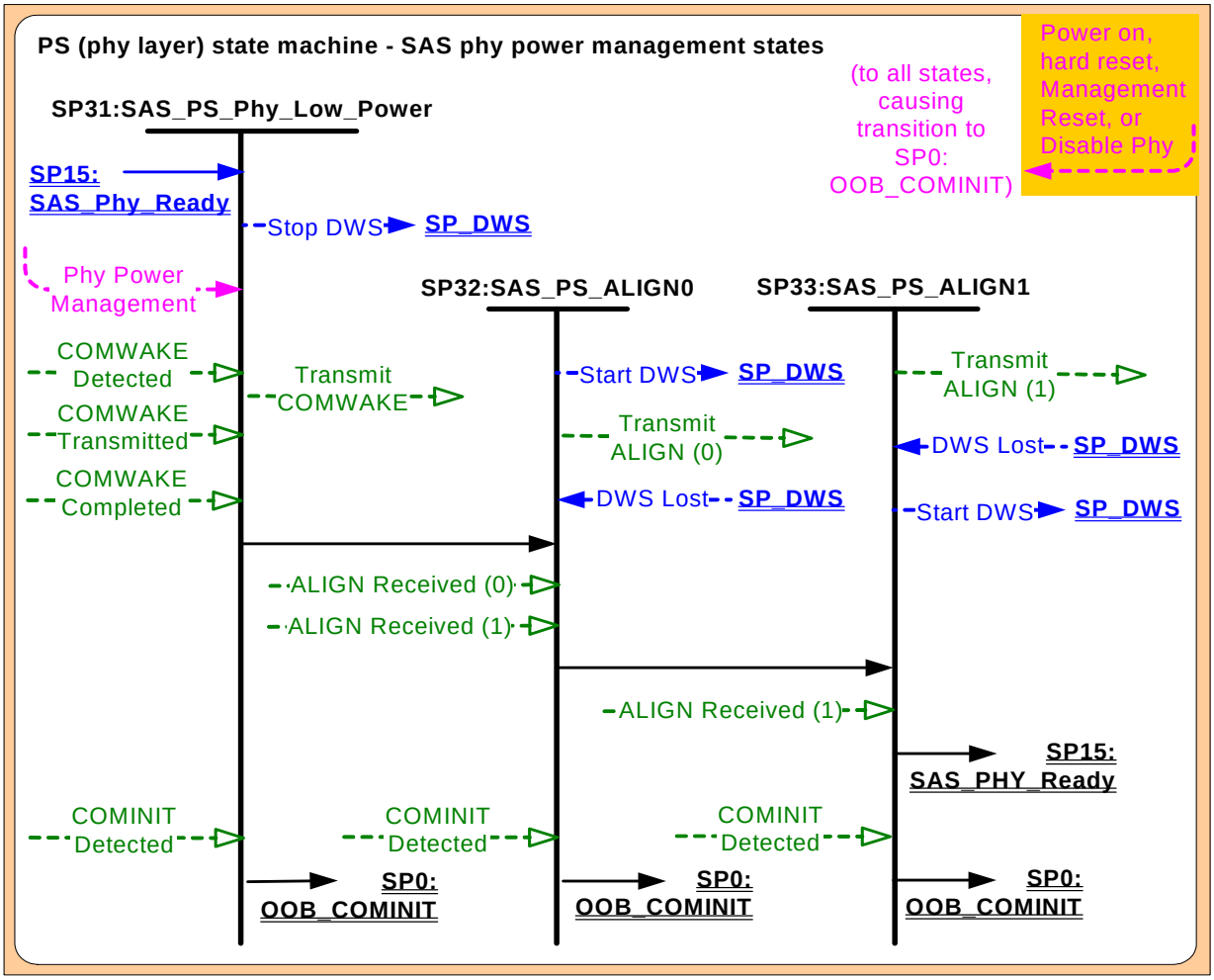

Figure a — PS (phy layer) state machine - SAS phy power management states

6.8.5.2 SP31:SAS_PS_Phy_Low_Power state

6.8.5.2.1 State description

Upon entry into this state, this state shall send a Stop DWS message.

If this state is entered with a Partial argument, then:

a) this state shall send an Enter Partial Power Condition message to the SP transmitter and receiver;
b) the phy shall enter the Partial power condition (see [add a cross reference to a clause where this is defined in 08-015]); and
c) the state shall set the SASPhyPwrMgmt state machine variable to Partial.

If this state is entered with a Slumber argument, then:

a) this state shall send an Enter Slumber Power Condition message to the SP transmitter and receiver;
b) the phy shall enter the Slumber power condition (see [add a cross reference to a clause where this is defined in 08-015]); and
c) the state shall set the SASPhyPwrMgmt state machine variable to Slumber.

[editor's note: I think these should be called "phy power conditions" in this and all related proposals as opposed to "power states" to minimize confusion in the state diagrams and descriptions.]

If this state receives a Phy Power Management (Exit) request or a COMWAKE Detected message, then this state shall send a Transmit COMWAKE message.

6.8.5.2.2 Transition SP31:SAS_PS_Phy_Low_Power to SP0:OOB_COMINIT

This transition shall occur if:

a) this state:
   A) receives a COMWAKE Transmitted message; and
   B) does not receive a COMWAKE Completed message within a hot-plug timeout (see table 96 in 6.7.1);
   or
b) this state receives a COMINIT Detected message.

6.8.5.2.3 Transition SP31:SAS_PS_Phy_Low_Power to SP32:SAS_PS_ALIGN0

This transition shall occur after this state:

a) receives a COMWAKE Transmitted message; and
b) receives a COMWAKE Completed message.

6.8.5.3 SP32:SAS_PS_ALIGN0 state

6.8.5.3.1 State description

Upon entry into this state, the phy shall:

1) initialize and start the SNLT timer;
2) send a Set Physical Link Rate message to the SP transmitter and to the SP receiver and send a Set SSC message to the SP transmitter with the arguments set to those determined from the last speed negotiation window;
3) if applicable, restore any vendor-unique information for the SP receiver (e.g., determined from the previous Train-SNW speed negotiation window with the arguments set to the same values as those for the previous entry into the SP28:SAS_TrainSetup state (see 6.8.4.11));
4) send a Start DWS message; and
5) repeatedly send Transmit ALIGN (0) messages.

Each time this state receives a DWS Lost message, this state may send a Start DWS message to re-acquire dword synchronization without running a new link reset sequence.

6.8.5.3.2 Transition SP32:SAS_PS_ALIGN0 state to SP0:OOB_COMINIT

This transition shall occur after this state:

a) receives a DWS Lost message, if this state does not send a Start DWS message;
b) receives a COMINIT Detected message; or
c) does not receive an ALIGN Received (0) message or an ALIGN Received (1) message before the SNLT timer expires.

6.8.5.3.3 Transition SP32:SAS_PS_ALIGN0 to SP33:SAS_PS_ALIGN1

This transition shall occur:

a) if this state receives an ALIGN Received (0) message or an ALIGN Received (1) message before the SNLT timer expires; and
b) after this state has sent at least three Transmit ALIGN (0) messages.

6.8.5.4 SP33:SAS_PS_ALIGN1 state

6.8.5.4.1 State description

Upon entry into this state, the phy shall:

1) initialize and start the SNLT timer; and
2) repeatedly send Transmit ALIGN (1) messages.

Each time this state receives a DWS Lost message, this state may send a Start DWS message to re-acquire dword synchronization without running a new link reset sequence.

6.8.5.4.2 Transition SP33:SAS_PS_ALIGN1 state to SP0:OOB_COMINIT

This transition shall occur after this state:

a) receives a DWS Lost message, if this state does not send a Start DWS message;
b) receives a COMINIT Detected message; or
c) does not receive an ALIGN Received (1) message before the SNLT timer expires.

6.8.5.4.3 Transition SP33:SAS_PS_ALIGN1 state to SP15:SAS_PHY_Ready

This transition shall occur:

a) if this state receives an ALIGN Received (1) message before the SNLT timer expires;
b) after this state has sent at least three Transmit ALIGN (1) messages; and
c) after this state sets the SASPhyPwrMgmt state machine variable to Active.

NOTE 1 - Receipt of the ALIGN Receive (1) message indicates that the connected phy has been able to achieve dword synchronization with the previously negotiated settings.

NOTE 2 - After the transition, the SP15:SAS_PHY_Ready state sends a Phy Layer Ready (SAS) confirmation after establishing multiplexing, if multiplexing is enabled.

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