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Subj: **SAS-2+: Add low power transceiver options**
Date: **Aug. 11, 2008**
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Overview

This proposal adds lower power transceiver modes to SAS. The intent is to add low power modes that are similar to or compatible with the low power modes available in SATA. This should allow an expander design that can work with either SATA or SAS devices in low power mode.

This proposal focuses on target initiating the power management requests, but initiator or expander may also initiate power management requests.

SATA uses 4 primitives for interface power management. SAS will also use 4 primitives but will use encodings chosen from the SAS encoding space. The primitives are:
   (a) PMREQ (PARTIAL) to request partial power mode (transceiver must recover within 10 us);
   (b) PMREQ (SLUMBER) to request slumber power mode (transceiver must recover within 10 msec);
   (c) PMACK to accept change into the requested power mode;
   (d) PMNAK to reject the power mode request.

When a power mode request is accepted, both ends of the link stop transmitting. Either end may revive the link by sending COMWAKE. Both ends are required to remember whether the link is SSP or STP protocol and previously negotiated settings (speed, SSC, multiplexing, etc.). The intent is that both ends can restart and obtain synchronization without needing to change receiver settings or redo training. Repeating training would increase the recovery time so much that partial power mode may not be feasible.

When an initiator requests an expander to open a link that is in partial power mode, recovery time should be fast enough so any delay can be covered by returning AIP (WAITING ON DEVICE) one time until the link is ready. When an initiator requests to open a link that is in slumber power mode, the expander should be allowed to use OPEN_REJECT (RETRY) (the recovery time will be several milliseconds and we don't want to tie up expander pathways for that long by using AIP). I think it is important to NOT pick new primitives for this to maintain compatibility with older initiators that wouldn't recognize the new primitive.

The partial mode has fast enough recovery so that it may be used by a target-expander link without explicit approval by an initiator. The slumber mode causes enough delay so that an initiator should explicitly allow/ disallow this option based on its performance requirements. There are several possibilities for this:
   (a) Use a SAS specific mode page. The initiator grants permission directly to a target without needing expander participation.
   (b) Only invoke slumber when idle, standby, or sleep is either commanded by initiator or initiated by timer expiration in the target.

There may be a desire to add information to SMP functions to indicate links that are in a low power mode, especially slumber mode. The DISCOVER function and the DISCOVER LIST function seem like obvious candidates to me. Are there others?

If a drive is removed while in partial or slumber and another drive is inserted, the drive will send a COMINIT at power up and alert the initiator/expander that something has changed since it did not

receive a COMWAKE. Similarly, if a drive is pulled and not replaced, it would become a loss of signal situation, so I think that both of these are covered.

Questions have also been raised about whether slumber mode actually saves a significant amount of power compared to partial mode. If the additional savings are not significant enough then perhaps this mode is not worth defining? Of course, if it is used in conjunction with idle or other longer recovery low power modes then perhaps it is still useful. This will be a discussion point. Anyone willing to provide comparative data on this is invited to do so.

SAS-2+ Changes (based on SAS-2 rev.14):

6.6 Out of band (OOB) signals
[clauses 6.6.1 through 6.6.4 are unchanged]

6.6.5 Idle bus condition
During power management states (Partial and Slumber), the transmitter device and receiver device are allowed to float. The maximum transmitter and receiver device transients specified in Table 54 and Table 56, respectively apply.

6.7 Phy reset sequences
[clauses 6.7.1 through 6.7.5 are unchanged]

6.7.6 SAS transceiver low power sequences

6.7.6.1 Transition from active to power management state

Figure new1 shows examples of the sequence to transition from active to power management state.

A. PMREQx sent, acknowledged, bus idle

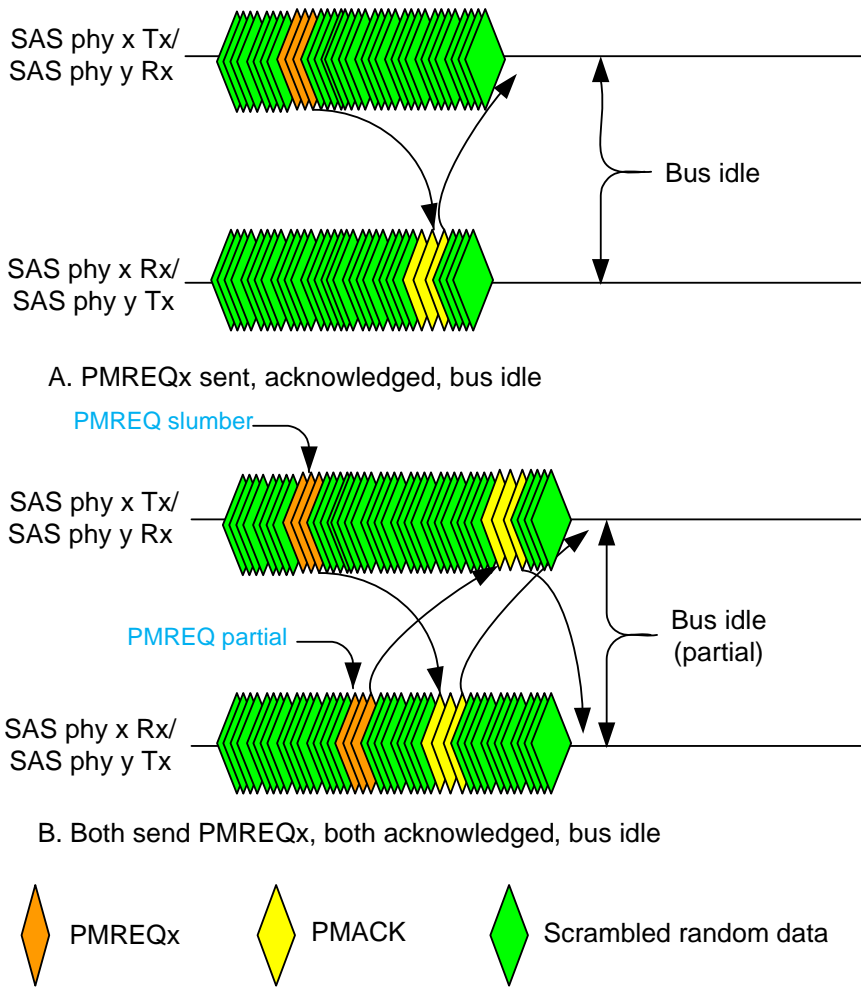B. Both send PMREQx, both acknowledged, bus idle

Figure new1 – SAS transition to power management

Figure new1-A shows a transition from both ends sending scrambled data to bus idle. The sequence proceeds as follows:
1) phy x sends PMREQ (x) primitive to phy y;
2) phy y sends PMACK primitive to phy x; and
3) both phys transition to the requested bus idle condition.

Figure new1-B shows a transition when both phy x and phy y send a PMREQ (x) primitive at the same time:
1) phy x sends PMREQ (x) primitive to phy y;
2) phy y sends PMREQ (x) primitive to phy x before it receives the primitive sent by phy x;
3) phy y sends PMACK to acknowledge receipt of phy x PMREQ (x) primitive but doesn't transition to bus idle yet;
4) pny x sends PMACK to acknowledge receipt of phy y PMREQ (x) primitive; and
5) both phys transition to the agreed upon bus idle condition.

The bus idle condition agreement is as follows:
a) if both phys sent request for slumber, then slumber bus condition agreement results;
b) if both phys sent request for partial, than partial bus condition results; or
c) if one phy sent request for slumber and the other phy sent request for partial, then partial bus condition results.

6.7.6.2 COMWAKE sequence to recover from power management state

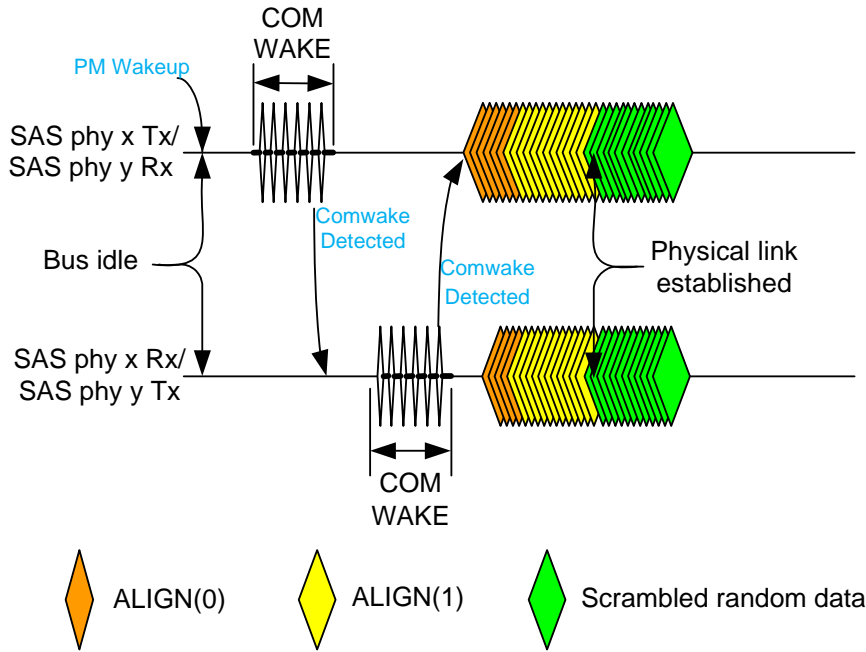The sequence to recover from either partial or slumber power management state is shown in figure new2.

Figure new2 – SAS COMWAKE wakeup sequence

The COMWAKE recovery sequence is as follows:
1) port x decides to wake up the link and initiates power management action to transition phy x to active state;
2) phy x transmits COMWAKE;
3) phy y detects COMWAKE, initiates power management action to transition phy y to active state, and transmits COMWAKE back to phy x;
4) both phys transmit ALIGN(0) primitives at previously negotiated settings;
5) when both receivers synchronize on ALIGN(0)s, the transmitters change to sending ALIGN(1)s; and
6) when both receivers synchronize on ALIGN(1)s, the transmitters change to idle dwords.

The link is now re-established with the same transfer rate and SNW3 settings (e.g., SSC mode and multiplexing mode) that were negotiated before the link was placed in power management mode.
[Note: should different ALIGN primitives be chosen instead of ALIGN(0) and ALIGN(1)?]

6.7.6.3 Recovery from hot plug events during power management

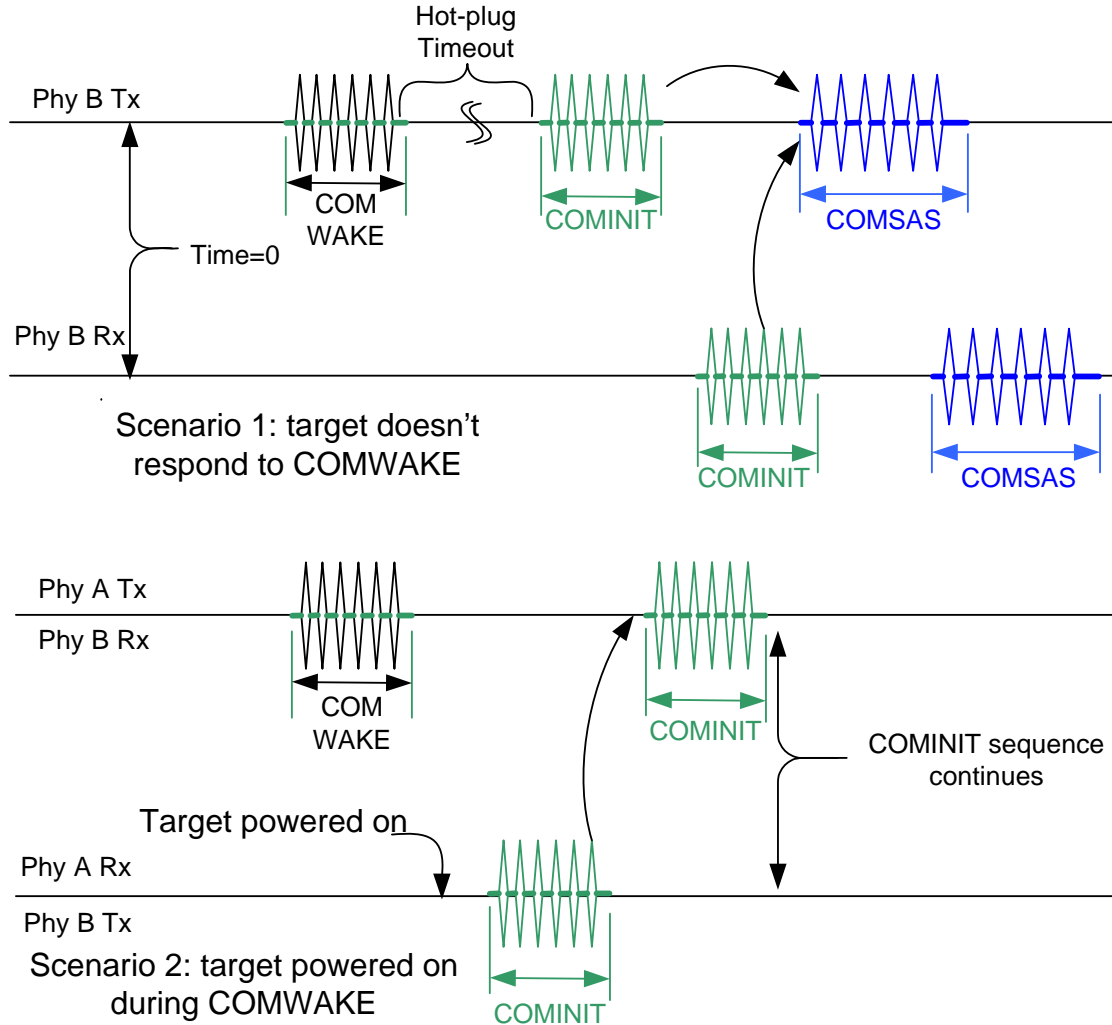Figure new3 shows examples of hot-plug scenarios that may occur during power management recovery.

Figure new3 – WAKEUP hot-plug examples

Scenario 1 depicts:
1) a SCSI initiator starting a power management wakeup sequence;
2) the SCSI target doesn't respond within timeout limit; and
3) the SCSI initiator recovers by changing to COMINIT sequence.

Scenario 2 depicts:
1) a SCSI initiator starting a power management sequence;
2) the SCSI target is powered on and begins COMINIT sequence within the timeout limit; and
3) the SCSI initiator proceeds by continuing the COMINIT sequence.

[Note: For scenario 1, is hot-plug timeout (500 ms) correct (this was suggested at last telecon), or should we define a new timeout that could be as small as 10 ms? Expander might be expecting

partial recovery (within 10 us) and already sent AIP (WAITING ON DEVICE) to initiator. Even if it was expecting slumber recovery (within 10 ms) and had sent OPEN REJECT (RETRY) there might be issues with a wait as long as 500 ms before the expander marks the port as "no device attached".]

6.8 SP (phy layer) state machine
6.8.1 SP state machine overview
The SP state machine controls the phy reset sequence. This state machine consists of ~~three~~ these sets of states:
- a) OOB sequence (OOB) states;
- b) SAS power management states;
- c) SAS speed negotiation (SAS) states; and
- d) SATA host emulation (SATA) states.

This state machine consists of the following states:
- a) SP0:OOB_COMINIT (see 6.8.3.2)(initial state);
- b) SP1:OOB_AwaitCOMX (see 6.8.3.3);
- c) SP2:OOB_NoCOMSASTimeout (see 6.8.3.4);
- d) SP3:OOB_AwaitCOMINIT_Sent (see 6.8.3.5);
- e) SP4:OOB_COMSAS (see 6.8.3.6);
- f) SP5:OOB_AwaitCOMSAS_Sent (see 6.8.3.7);
- g) SP6:OOB_AwaitNoCOMSAS (see 6.8.3.8);
- h) SP7:OOB_AwaitCOMSAS (see 6.8.3.9);
- i) SP8:SAS_Start (see 6.8.4.2);
- j) SP9:SAS_WindowNotSupported (see 6.8.4.3);
- k) SP10:SAS_AwaitALIGN (see 6.8.4.4);
- l) SP11:SAS_AwaitALIGN1 (see 6.8.4.5);
- m) SP12:SAS_AwaitSNW (see 6.8.4.6);
- n) SP13:SAS_Pass (see 6.8.4.7);
- o) SP14 SAS_Fail (see 6.8.4.8);
- p) SP15:SAS_PHY_Ready (see 6.8.4.9);
- q) SP16:SATA_COMWAKE (see 6.8.5.2);
- r) SP17:SATA_AwaitCOMWAKE (see 6.8.5.3);
- s) SP18:SATA_AwaitNoCOMWAKE (see 6.8.5.4);
- t) SP19:SATA_AwaitALIGN (see 6.8.5.5);
- u) SP20:SATA_AdjustSpeed (see 6.8.5.6);
- v) SP21:SATA_Transmit_ALIGN (see 6.8.5.7);
- w) SP22:SATA_PHY_Ready (see 6.8.5.8);
- x) SP23:SATA_PM_Partial (see 6.8.5.9);
- y) SP24:SATA_PM_Slumber (see 6.8.5.10);
- z) SP25:SATA_PortSel (see 6.8.6.2);
- aa) SP26:SATA_SpinupHold (see 6.8.7.2);
- bb) SP27:SAS_Settings (see 6.8.4.10);
- cc) SP28:SAS_TrainSetup (see 6.8.4.11);
- dd) SP29:SAS_Train (see 6.8.4.12); ~~and~~
- ee) SP30:SAS_TrainingDone (see 6.8.4.13);
- ff) SP31:SAS_PM_Partial (see 6.8.x.x);
- gg) SP32:SAS_PM_Slumber (see 6.8.x.x).
- hh) SP33:SAS_COMWAKE (see 6.8.x.x);
- ii) SP34:SAS_AwaitCOMWAKE_Sent (see 6.8.x.x);
- jj) SP35:SAS_AwaitNoCOMWAKE (see 6.8.x.x);
- kk) SP36:SAS_AwaitCOMWAKE (see 6.8.x.x);
- ll) SP37:SAS_PM_AwaitALIGN (see 6.8.x.x);
- m) SP38:SAS_ReceivedALIGN0 (see 6.8.x.x); and
- n) SP39:SAS_TransmitALIGN1 (see 6.8.x.x).

The SP state machine shall start in the SP0:OOB_COMINIT state after:
- a) a power on;
- b) a hard reset;

   c) receiving a Management Reset request from the management layer (e.g., from the SMP PHY CONTROL function requesting a phy operation of LINK RESET or HARD RESET in an expander device); or

   d) receiving a Disable Phy request from the management layer (e.g., from the SMP PHY CONTROL function requesting a phy operation of DISABLE in an expander device).

The SP state machine shall maintain a MgmtReset state machine variable to determine whether a
Management Reset request has been received. Any SP state that receives a Management Reset request shall set the MgmtReset state machine variable to one before making a transition to the SP0:OOB_COMINIT state (see 6.8.3.2). Any SP state that receives a power on, or a hard reset shall set the MgmtReset state machine variable to zero before making a transition to the SP0:OOB_COMINIT state.

The SP state machine shall maintain a Current SNW state machine variable to determine the current SNW (e.g., SNW-1, SNW-2, SNW-3, Final-SNW, Train-SNW, or Unsupported Phy Attached).

If the phy status is available through any of the following:
   a) the SMP DISCOVER response (see 10.4.3.10);
   b) the SMP DISCOVER LIST response (see 10.4.3.15);
   c) the Phy Control And Discover mode page (see 10.2.7.5); or
   d) the Protocol-Specific Port log page (see 10.2.8.1),

then the SP state machine shall maintain a ResetStatus state machine variable to determine the NEGOTIATED PHYSICAL LINK RATE field and/or the NEGOTIATED LOGICAL LINK RATE field.

If the phy supports SNW-3, then the SP state machine shall maintain a Commonly Supported Settings state machine variable that contains supported settings common between the phy and the attached phy.

If the phy supports SATA port selectors, the SP state machine shall maintain a COMWAKE_Received state machine variable to indicate whether a COMWAKE detected message was received in the SP0:OOB_COMINIT state or the SP1:OOB_AwaitCOMX state since the last time the SP0:OOB_COMINIT state was entered, and the SP state machine shall transition to the SP25:SATA_PortSel state whenever it receives a Transmit SATA Port Selection Signal request.

The SP state machine sends the following messages to the SP_DWS state machine (see 6.9):
   a) Start DWS; and
   b) Stop DWS.

The SP state machine receives the following messages from the SP_DWS state machine:
   a) DWS Lost; and
   b) DWS Reset.

The SP state machine shall maintain the timers listed in table 104.

Table 104 – SP state machine timers

Timer	Initial value
COMSAS Detect Timeout timer	COMSAS detect timeout (see table 87 in 6.6.1)
Await ALIGN Timeout time	Await ALIGN timeout (see table 94 in 6.7.2.2)
Hot-Plug Timeout timer	Hot plug timeout (see table 93 in 6.7.1)
RCDT timer	RCDT (see table 95 in 6.7.4.2)
SNLT timer	SNLT (see table 95 in 6.7.4.2)

SNTT timer	SNTT (see table 95 in 6.7.4.2)
TLT timer	TLT (see table 95 in 6.7.4.2)
MTT timer	MTT (see table 95 in 6.7.4.2)

6.8.2 SP transmitter and receiver

The SP transmitter transmits OOB signals and dwords on the physical link based on messages from the SP state machine (see 6.8).

The SP transmitter receives the following messages from the SP state machine:
   a) Transmit COMINIT;
   b) Transmit COMSAS;
   c) Transmit COMWAKE;
   d) Transmit SATA Port Selection Signal;
   e) Transmit D10.2;
   f) Set Rate with a Physical Link Rate argument, and an SSC On or an SSC Off argument;
   g) Transmit ALIGN with an argument indicating the specific type (e.g., Transmit ALIGN (0));
   h) Transmit Phy Capabilities Bits;
   i) Transmit TRAIN Pattern;
   j) Transmit TRAIN_DONE Pattern; and
   k) Transmit MUX Sequence.

When not otherwise instructed, the SP transmitter transmits D.C. idle.
Upon receiving a Transmit MUX Sequence message, the SP transmitter transmits:
   1) MUX (LOGICAL LINK 0);
   2) MUX (LOGICAL LINK 1);
   3) MUX (LOGICAL LINK 0);
   4) MUX (LOGICAL LINK 1);
   5) MUX (LOGICAL LINK 0); and
   6) MUX (LOGICAL LINK 1).

The SP transmitter shall complete any physical link rate change requested with the Set Rate message within RCDT (see table 95 in 6.7.4.2).

The SP transmitter sends the following messages to the SP state machine:
   a) COMINIT Transmitted;
   b) COMSAS Transmitted;
   c) COMWAKE Transmitted;
   d) SATA Port Selection Signal Transmitted;
   e) TRAIN_DONE Pattern Transmitted;
   f) Phy Capabilities Bits Transmitted; and
   g) MUX Sequence Transmitted.

The SP receiver receives OOB signals and dwords from the physical link and sends messages to the SP state machine indicating what it has received.

The SP receiver receives the following messages from the SP state machine:
   a) Set Rate with a Physical Link Rate argument, and an SSC On argument or an SSC Off argument;
   b) Start Training; and
   c) Abort Training.

The SP receiver sends the following messages to the SP state machine:
   a) COMINIT Detected;
   b) COMSAS Detected;
   c) COMWAKE Detected;

> d) COMSAS Completed;
> e) COMWAKE Completed;
> f) ALIGN Received with an argument indicating the specific type (e.g., ALIGN Received (0));
> g) Phy Capabilities Bits Received with arguments indicating the supported settings bits received;
> h) Training Completed;
> i) TRAIN_DONE Received; and
> j) Dword Received.

The ALIGN Received, Dword Received, and TRAIN_DONE Received messages are only sent when the SP_DWS state machine has achieved dword synchronization.

For SATA speed negotiation, the ALIGN Received (0) message includes an argument containing the physical link rate at which the ALIGN (0) primitives were detected. For SAS speed negotiation, only ALIGNs at the physical link rate specified by the last Set Rate message received by the SP transmitter cause ALIGN Received messages.

The SP transmitter relationship to other transmitters is defined in 4.3.2. The SP receiver relationship to other receivers is defined in 4.3.3.

6.8.3 OOB sequence states
6.8.3.1 OOB sequence states overview
Figure 154 shows the OOB sequence states. These states are indicated by state names with a prefix of OOB.

[figure 154 is unchanged]

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

If this state was entered because of a Disable Phy request, then upon entry into this state, this state shall:
> a) ignore COMINIT Detected messages until this state is re-entered due to a power on, hard reset, or Management Reset request; and
> b) set the ResetStatus state machine variable to DISABLED.

If this state was entered due to power on or hard reset, then upon entry into this state, this state shall set the ResetStatus state machine variable to UNKNOWN.

If this state was entered because of a Management Reset request, then upon entry into this state, this state shall:
> a) if the ResetStatus state machine variable is not set to RESET_IN_PROGRESS, SPINUP_HOLD, G1, G2, or G3, set the ResetStatus state machine variable to UNKNOWN; or

b) if the ResetStatus state machine variable is set to RESET_IN_PROGRESS, SPINUP_HOLD, G1, G2, or G3, set the ResetStatus state machine variable to RESET_IN_PROGRESS.

If this state was not entered due to a power on, hard reset, Disable Phy, or Management Reset request, then upon entry into this state, this state shall:
a) if the ResetStatus state machine variable is not set to PHY_RESET_PROBLEM, SPINUP_HOLD, or UNSUPPORTED_PHY_ATTACHED, set the ResetStatus state machine variable to UNKNOWN; or
b) if the ResetStatus state machine variable is set to PHY_RESET_PROBLEM, SPINUP_HOLD, or UNSUPPORTED_PHY_ATTACHED, not change the ResetStatus state machine variable.

If the phy supports SATA port selectors and this state receives a COMWAKE Detected message, this state shall:
a) if the ResetStatus state machine variable is not set to PHY_RESET_PROBLEM, SPINUP_HOLD, or UNSUPPORTED_PHY_ATTACHED, set the ResetStatus state machine variable to PORT_SELECTOR;
b) set the COMWAKE_Received state machine variable to one; and
c) if the ATTACHED SATA PORT SELECTOR bit is set to zero in the SMP DISCOVER response (see 10.4.3.10):
   A) set the ATTACHED SATA PORT SELECTOR bit to one in the SMP DISCOVER response; and
   B) send a SATA Port Selector Change confirmation to the link layer.

This state machine waits for receipt of a COMINIT Transmitted message and/or a COMINIT Detected message.

6.8.3.2.2 Transition SP0:OOB_COMINIT to SP1:OOB_AwaitCOMX
This transition shall occur if this state receives a COMINIT Transmitted message and has not received a COMINIT Detected message.

6.8.3.2.3 Transition SP0:OOB_COMINIT to SP3:OOB_AwaitCOMINIT_Sent
This transition shall occur if this state receives a COMINIT Detected message and has not received a COMINIT Transmitted message.

6.8.3.2.4 Transition SP0:OOB_COMINIT to SP4:OOB_COMSAS
This transition shall occur if this state receives both a COMINIT Transmitted message and a COMINIT Detected message.

6.8.3.3 SP1:OOB_AwaitCOMX state
6.8.3.3.1 State description
Upon entry into this state, the phy shall initialize and start the Hot-Plug Timeout timer if this phy is:
a) an expander phy; or
b) an initiator phy or target phy implementing the Hot-Plug Timeout timer.

If the phy supports SATA port selectors and this state receives a COMWAKE Detected message, this state shall:
a) if the ResetStatus state machine variable is not set to PHY_RESET_PROBLEM, SPINUP_HOLD, or UNSUPPORTED_PHY_ATTACHED, set the ResetStatus state machine variable to PORT_SELECTOR;
b) set the COMWAKE_Received state machine variable to one; and
c) if the ATTACHED SATA PORT SELECTOR bit is set to zero in the SMP DISCOVER response (see 10.4.3.10):

  A) set the ATTACHED SATA PORT SELECTOR bit to one in the SMP DISCOVER response; and
  B) send a SATA Port Selector Change confirmation to the link layer.

6.8.3.3.2 Transition SP1:OOB_AwaitCOMX to SP0:OOB_COMINIT
This transition shall occur if the Hot-Plug Timeout timer expires.

If the COMWAKE_Received state machine variable is set to zero and the ATTACHED SATA PORT SELECTOR bit is set to one in the SMP DISCOVER response (see 10.4.3.10), the state machine shall, before the transition:
 a) set the ATTACHED SATA PORT SELECTOR bit to zero in the SMP DISCOVER response; and
 b) send a SATA Port Selector Change confirmation to the link layer.

Before the transition, if this state was entered from SP0:OOB_COMINIT, this state shall set the ResetStatus state machine variable to UNKNOWN.

6.8.3.3.3 Transition SP1:OOB_AwaitCOMX to SP4:OOB_COMSAS
This transition shall occur after receiving either a COMINIT Detected message or a COMSAS Detected message. If COMSAS Detected was received, this transition shall include a COMSAS Detected argument.

If the ATTACHED SATA PORT SELECTOR bit is set to one in the SMP DISCOVER response (see 10.4.3.10), the state machine shall, before the transition:
 a) set the ATTACHED SATA PORT SELECTOR bit to zero in the SMP DISCOVER response; and
 b) send a SATA Port Selector Change confirmation to the link layer.

6.8.3.4 SP2:OOB_NoCOMSASTimeout state
6.8.3.4.1 State description
Upon entry into this state, the phy shall initialize and start the Hot-Plug Timeout timer if this phy is:
 a) this phy is an expander phy; or
 b) this phy is an initiator phy or target phy implementing the Hot-Plug Timeout timer.

6.8.3.4.2 Transition SP2:OOB_NoCOMSASTimeout to SP0:OOB_COMINIT
This transition shall occur if the Hot-Plug Timeout timer expires.

6.8.3.4.3 Transition SP2:OOB_NoCOMSASTimeout to SP4:OOB_COMSAS
This transition shall occur after receiving a COMINIT Detected message.

6.8.3.5 SP3:OOB_AwaitCOMINIT_Sent state
6.8.3.5.1 State description
This state waits for a COMINIT Transmitted message.

If the phy supports SATA port selectors and this state receives a COMWAKE Detected message, this state shall:
 a) if the ResetStatus state machine variable is not set to PHY_RESET_PROBLEM, SPINUP_HOLD, or UNSUPPORTED_PHY_ATTACHED, set the ResetStatus state machine variable to PORT_SELECTOR; and
 b) if the ATTACHED SATA PORT SELECTOR bit is set to zero in the SMP DISCOVER response (see 10.4.3.10):
  A) set the ATTACHED SATA PORT SELECTOR bit to one in the SMP DISCOVER response; and
  B) send a SATA Port Selector Change confirmation to the link layer.

6.8.3.5.2 Transition SP3:OOB_AwaitCOMINIT_Sent to SP4:OOB_COMSAS
This transition shall occur after receiving a COMINIT Transmitted message.

6.8.3.6 SP4:OOB_COMSAS state
6.8.3.6.1 State description
Upon entry into this state, the phy shall send a Transmit COMSAS message to the SP transmitter.

This state waits for receipt of a COMSAS Transmitted message and/or a COMSAS Detected message.

If the phy supports SATA port selectors and this state receives a COMWAKE Detected message, this state shall:
   a) if the ResetStatus state machine variable is not set to PHY_RESET_PROBLEM, SPINUP_HOLD, or UNSUPPORTED_PHY_ATTACHED, set the ResetStatus state machine variable to PORT_SELECTOR; and
   b) if the ATTACHED SATA PORT SELECTOR bit is set to zero in the SMP DISCOVER response (see 10.4.3.10):
      A) set the ATTACHED SATA PORT SELECTOR bit to one in the SMP DISCOVER response; and
      B) send a SATA Port Selector Change confirmation to the link layer.

6.8.3.6.2 Transition SP4:OOB_COMSAS to SP5:OOB_AwaitCOMSAS_Sent
This transition shall occur if this state receives a COMSAS Detected message or this state was entered with a COMSAS Detected argument, and this state has not received a COMSAS Transmitted message.

If the ATTACHED SATA PORT SELECTOR bit is set to one in the SMP DISCOVER response (see 10.4.3.10), the state machine shall set the ATTACHED SATA PORT SELECTOR bit to zero in the SMP DISCOVER response and send a SATA Port Selector Change confirmation to the link layer before the transition.

6.8.3.6.3 Transition SP4:OOB_COMSAS to SP6:OOB_AwaitNoCOMSAS
This transition shall occur if this state receives both a COMSAS Transmitted message and a COMSAS Detected message.

If the ATTACHED SATA PORT SELECTOR bit is set to one in the SMP DISCOVER response (see 10.4.3.10), the state machine shall set the ATTACHED SATA PORT SELECTOR bit to zero in the SMP DISCOVER response and send a SATA Port Selector Change confirmation to the link layer before the transition.

6.8.3.6.4 Transition SP4:OOB_COMSAS to SP7:OOB_AwaitCOMSAS
This transition shall occur if this state receives a COMSAS Transmitted message and has not received a COMSAS Detected message.

6.8.3.7 SP5:OOB_AwaitCOMSAS_Sent state
6.8.3.7.1 State description
This state waits for receipt of a COMSAS Transmitted message.

6.8.3.7.2 Transition SP5:OOB_AwaitCOMSAS_Sent to SP6:OOB_AwaitNoCOMSAS
This transition shall occur after receiving a COMSAS Transmitted message.

If this state received a COMSAS Completed message, it shall include a COMSAS Completed argument with the transition.

6.8.3.8 SP6:OOB_AwaitNoCOMSAS state
6.8.3.8.1 State description
This state machine waits for a COMSAS Completed message, which indicates that COMSAS has been completely received.

6.8.3.8.2 Transition SP6:OOB_AwaitNoCOMSAS to SP0:OOB_COMINIT
This transition shall occur after receiving a COMINIT Detected message.

Before the transition, this state shall set the ResetStatus state machine variable to UNKNOWN.

6.8.3.8.3 Transition SP6:OOB_AwaitNoCOMSAS to SP8:SAS_Start
This transition shall occur after receiving a COMSAS Completed message, or shall occur if a COMSAS Completed argument was received in the transition.

6.8.3.9 SP7:OOB_AwaitCOMSAS state
6.8.3.9.1 State description
Upon entry into this state, the phy shall initialize and start the COMSAS Detect Timeout timer.

6.8.3.9.2 Transition SP7:OOB_AwaitCOMSAS to SP2:OOB_NoCOMSASTimeout
This transition shall occur if the phy does not support SATA and the COMSAS Detect Timeout timer expires.

The state machine shall set the MgmtReset state machine variable to zero before the transition.

6.8.3.9.3 Transition SP7:OOB_AwaitCOMSAS to SP6:OOB_AwaitNoCOMSAS
This transition shall occur after receiving a COMSAS Detected message.

The state machine shall set the MgmtReset state machine variable to zero before the transition.

The state machine shall set the ATTACHED SATA PORT SELECTOR bit to zero in the SMP DISCOVER response (see 10.4.3.10). If the ATTACHED SATA PORT SELECTOR bit in the SMP DISCOVER response was set to one prior to this transition, the state machine shall send a SATA Port Selector Change confirmation to the link layer before the transition.

6.8.3.9.4 Transition SP7:OOB_AwaitCOMSAS to SP16:SATA_COMWAKE
This transition shall occur if:
   a) the phy supports SATA;
   b) the COMSAS Detect Timeout timer expires; and
       A) the MgmtReset state machine variable is set to one; or
       B) the phy does not implement SATA spinup hold.

The state machine shall set the MgmtReset state machine variable to zero before the transition.

The state machine shall set the ATTACHED SATA DEVICE bit to one in the SMP DISCOVER response (see 10.4.3.10) before the transition.

6.8.3.9.5 Transition SP7:OOB_AwaitCOMSAS to SP26:SATA _SpinupHold
This transition shall occur if:
   a) the phy supports SATA;
   b) the COMSAS Detect Timeout timer expires;
   c) the phy implements SATA spinup hold; and
   d) the MgmtReset state machine variable is set to zero.

The state machine shall set the ATTACHED SATA DEVICE bit to one in the SMP DISCOVER response (see 10.4.3.10) before the transition.

6.8.4 SAS speed negotiation states
6.8.4.1 SAS speed negotiation states overview

Figure 155 shows the SAS speed negotiation states, in which the phy has detected that it is attached to a SAS phy or expander phy rather than a SATA phy, and performs the SAS speed negotiation sequence. These states are indicated by state names with a prefix of SAS.

[figure 155 is unchanged.]

Figure 156 shows the SAS speed negotiation states related to SNW-3 and Train-SNW.
[figure 156 is unchanged.]

6.8.4.2 SP8:SAS_Start state
6.8.4.2.1 State description
This is the initial state for the SAS speed negotiation sequence.

Upon entry into this state, the phy shall initialize and start the RCDT timer.
If this state is entered from SP6:OOB_AwaitNoCOMSAS, then the Current SNW state machine variable shall be set to SNW-1. If this state is not entered from SP6:OOB_AwaitNoCOMSAS, then the Current SNW state machine variable shall be set to:
    a) SNW-2 if the Current SNW state machine variable is set to SNW-1;
    b) SNW-3 if the Current SNW state machine variable is set to SNW-2, and either SNW-1 is invalid or SNW-2 is valid;
    c) Final-SNW if the Current SNW state machine variable is set to SNW-2, SNW-1 is valid, and SNW-2 is invalid;
    d) Final-SNW if the Current SNW state machine variable is set to SNW-3, SNW-3 is invalid, and SNW-2 is valid; or
    e) Unsupported Phy Attached if the Current SNW state machine variable is set to SNW-3, SNW-3 is invalid, and SNW-2 is invalid.

After the Current SNW state machine variable is updated, if the Current SNW state machine variable is not set to Unsupported Phy Attached, then this state shall:
    a) initialize and start the RCDT timer; and
    b) if the SNW specified by the Current SNW state machine variable is supported, send a Set Rate message to the SP transmitter and SP receiver with:
        A) the Physical Link Rate argument set to 1.5 Gbps and an SSC Off argument, if the Current SNW state machine variable is set to SNW-1;
        B) the Physical Link Rate argument set to 3 Gbps and an SSC Off argument, if the Current SNW state machine variable is set to SNW-2;
        C) the Physical Link Rate argument set to 1.5 Gbps and an SSC Off argument, if the Current SNW state machine variable is set to Final-SNW, SNW-1 was valid and SNW-2 was invalid;
        D) the Physical Link Rate argument set to 3 Gbps and an SSC Off argument, if the Current SNW state machine variable is set to Final-SNW and SNW-2 was valid; or
        E) the Physical Link Rate argument set to 1.5 Gbps and either an SSC On argument or an SSC Off argument, if the Current SNW state machine variable is set to SNW-3.

During this state D.C. idle shall be transmitted.

6.8.4.2.2 Transition SP8:SAS_Start to SP0:OOB_COMINIT
This transition shall occur after receiving a COMINIT Detected message.

Before the transition, this state shall set the ResetStatus state machine variable to UNKNOWN.

6.8.4.2.3 Transition SP8:SAS_Start to SP1:OOB_AwaitCOMX
This transition shall occur if the Current SNW state machine variable is set to Unsupported Phy Attached.

Before the transition, this state shall set the ResetStatus state machine variable to UNSUPPORTED_PHY_ATTACHED.

6.8.4.2.4 Transition SP8:SAS_Start to SP9:SAS_WindowNotSupported
This transition shall occur after the RCDT timer expires if the SNW indicated by the Current SNW state machine variable is not supported.

6.8.4.2.5 Transition SP8:SAS_Start to SP10:SAS_AwaitALIGN
This transition shall occur after the RCDT timer expires if:
- a) the Current SNW state machine variable is not set to SNW-3; and
- b) the SNW indicated by the Current SNW state machine variable is supported.

6.8.4.2.6 Transition SP8:SAS_Start to SP27:SAS_Settings
This transition shall occur after the RCDT timer expires if:
- a) the Current SNW state machine variable is set to SNW-3; and
- b) SNW-3 is supported.

6.8.4.3 SP9:SAS_WindowNotSupported state
6.8.4.3.1 State description
Upon entry into this state, the phy shall initialize and start the SNTT timer.

During this state D.C. idle shall be transmitted.

6.8.4.3.2 Transition SP9:SAS_WindowNotSupported to SP14:SAS_Fail
This transition shall occur after the SNTT timer expires.

6.8.4.4 SP10:SAS_AwaitALIGN state
6.8.4.4.1 State description
Upon entry into this state, the phy shall:
- a) initialize and start the SNTT timer and SNLT timer;
- b) send a Start DWS message to the SP_DWS state machine; and
- c) repeatedly send Transmit ALIGN (0) messages to the SP transmitter.

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

6.8.4.4.2 Transition SP10:SAS_AwaitALIGN to SP0:OOB_COMINIT
This transition shall occur after receiving a DWS Lost message if this state does not send a Start DWS message, or after receiving a COMINIT Detected message.

Before the transition, this state shall set the ResetStatus state machine variable to UNKNOWN.

6.8.4.4.3 Transition SP10:SAS_AwaitALIGN to SP11:SAS_AwaitALIGN1
This transition shall occur if this state receives an ALIGN Received (0) message before the SNLT timer expires.

6.8.4.4.4 Transition SP10:SAS_AwaitALIGN to SP12:SAS_AwaitSNW
This transition shall occur if this state receives an ALIGN Received (1) message before the SNLT timer expires.

6.8.4.4.5 Transition SP10:SAS_AwaitALIGN to SP14:SAS_Fail
This transition shall occur if the SNTT timer expires.

6.8.4.5 SP11:SAS_AwaitALIGN1 state

6.8.4.5.1 State description
This state shall repeatedly send Transmit ALIGN (1) messages to the SP transmitter.

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

6.8.4.5.2 Transition SP11:SAS_AwaitALIGN1 to SP0:OOB_COMINIT
This transition shall occur after receiving a DWS Lost message if this state does not send a Start DWS message, or after receiving a COMINIT Detected message.

Before the transition, this state shall set the ResetStatus state machine variable to UNKNOWN.

6.8.4.5.3 Transition SP11:SAS_AwaitALIGN1 to SP12:SAS_AwaitSNW
This transition shall occur if this state receives an ALIGN Received (1) message before the SNLT timer expires. This indicates that the other phy has been able to achieve dword synchronization in the current SNW.

6.8.4.5.4 Transition SP11:SAS_AwaitALIGN1 to SP14:SAS_Fail
This transition shall occur if the SNTT timer expires. This indicates that the other phy has not been able to achieve dword synchronization in the current SNW.

6.8.4.6 SP12:SAS_AwaitSNW state
6.8.4.6.1 State description
This state shall repeatedly send Transmit ALIGN (1) messages to the SP transmitter.

If the Current SNW state machine variable is set to Final-SNW, this state shall send a Start SL_IR Receiver confirmation to the link layer.

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

This state waits for the SNTT timer to expire or for a Stop SNTT request.

6.8.4.6.2 Transition SP12:SAS_AwaitSNW to SP0:OOB_COMINIT
This transition shall occur after receiving a DWS Lost message if this state does not send a Start DWS message, or after receiving a COMINIT Detected message.

Before the transition, this state shall set the ResetStatus state machine variable to UNKNOWN.

6.8.4.6.3 Transition SP12:SAS_AwaitSNW to SP13:SAS_Pass
This transition shall occur after the SNTT timer expires or after receiving a Stop SNTT request.

6.8.4.7 SP13:SAS_Pass state
6.8.4.7.1 State description
This state determines if:
    a)   another SAS SNW is required; or
    b)   the SAS speed negotiation sequence is complete.

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

6.8.4.7.2 Transition SP13:SAS_Pass to SP0:OOB_COMINIT

This transition shall occur after receiving a DWS Lost message if this state does not send a Start DWS message, or after receiving a COMINIT Detected message.

Before the transition, this state shall set the ResetStatus state machine variable to UNKNOWN.

6.8.4.7.3 Transition SP13:SAS_Pass to SP8:SAS_Start
This transition shall occur if the Current SNW state machine variable is not set to Final-SNW.

6.8.4.7.4 Transition SP13:SAS_Pass to SP15:SAS_PHY_Ready
This transition shall occur if the Current SNW state machine variable is set to Final-SNW.

6.8.4.8 SP14:SAS_Fail state
6.8.4.8.1 State description
This state determines if:
  a) another SAS SNW is required; or
  b) the SAS speed negotiation sequence is complete.

6.8.4.8.2 Transition SP14:SAS_Fail to SP1:OOB_AwaitCOMX
This transition shall occur if the Current SNW state machine variable is set to Final-SNW.

Before the transition, this state shall set the ResetStatus state machine variable to PHY_RESET_PROBLEM.

6.8.4.8.3 Transition SP14:SAS_Fail to SP8:SAS_Start
This transition shall occur if the Current SNW state machine variable is not set to Final-SNW.

6.8.4.9 SP15:SAS_PHY_Ready state
6.8.4.9.1 State description
This state waits for a COMINIT Detected message, a DWS Lost message, a Power management (Partial) message, a Power management (Slumber) message, or a DWS Reset message.

Upon entry into this state, the phy shall:
  a) if multiplexing is enabled (see table 100 in 6.7.4.2.3.3):
      1) send a Transmit MUX Sequence message to the SP transmitter; and
      2) after receiving MUX Sequence Transmitted, send a Phy Layer Ready (SAS) confirmation to the link layer to indicate that the physical link has been brought up successfully in SAS mode;
  b) if multiplexing is not enabled, send a Phy Layer Ready (SAS) confirmation to the link layer to indicate that the physical link has been brought up successfully in SAS mode;
  c) if the SP transmitter is transmitting at 1.5 Gbps, set the ResetStatus state machine variable to G1;
  d) if the SP transmitter is transmitting at 3 Gbps, set the ResetStatus state machine variable to G2; and
  e) if the SP transmitter is transmitting at 6 Gbps, set the ResetStatus state machine variable to G3.

While in this state dwords from the link layer are transmitted at the negotiated physical link rate at the rate established in the previous SNW.

If multiplexing is disabled, each time this state receives a DWS Lost message, this state may send a Start DWS message to the SP_DWS state machine to re-acquire dword synchronization without running a new link reset sequence.

> NOTE 42 - If multiplexing is enabled and this state receives a DWS Lost message, this state does not send a Start DWS message and the state machine transitions to SP0:OOB_COMINIT.

6.8.4.9.2 Transition SP15:SAS_PHY_Ready to SP0:OOB_COMINIT
This transition shall occur after:
   a) receiving a DWS Lost message, if this state does not send a Start DWS message;
   b) receiving a DWS Lost message followed by a COMINIT Detected message, if this state
       does not send a Start DWS message; or
   c) receiving a DWS Reset message.

This transition may but should not occur after receiving a COMINIT Detected message before
receiving a DWS Lost message, or after receiving a COMINIT Detected message after sending a
Start DWS message (i.e., the SP state machine should ignore COMINIT Detected messages
unless the SP_DWS state machine has indicated loss of dword synchronization).

6.8.4.9.3 Transition SP15:SAS_PHY_Ready to SP31:SAS_PM_Partial
This transition shall occur after receiving a Power management (Partial) message.

6.8.4.9.3 Transition SP15:SAS_PHY_Ready to SP32:SAS_PM_Slumber
This transition shall occur after receiving a Power management (Slumber) message.

6.8.4.10 SP27:SAS_Settings state
6.8.4.11 SP28:SAS_TrainSetup
6.8.4.12 SP29:SAS_Train state
6.8.4.13 SP30:SAS_TrainingDone state
[Clauses 6.8.4.10 through 6.8.4.13 are unchanged.]

6.8.5 SATA host emulation states
6.8.5.1 SATA host emulation states overview
Figure 157 shows the SATA host emulation states, in which the phy has detected that it is
attached to a SATA phy and behaves as if it were a SATA host phy, initiating the SATA speed
negotiation sequence. These states are indicated by state names with a prefix of SATA.

*The power management states defined in this standard are for SAS initiator phys that support
SATA; expander devices that support SATA do not support power management in this standard.*
[no changes to this clause?]

6.8.6 SATA port selector state SP25:SATA_PortSel
6.8.7 SATA spinup hold state SP26:SATA_SpinupHold
 [no changes to the above clauses]

6.8.8 SAS phy power management states
6.8.8.1 SAS phy power management states overview
Figure xxx shows the SAS phy power management states. These states are for SAS initiator
phys, expander phys, and SAS target phys that support the phy power management option. Phys
compliant with previous versions of this standard do not support SAS power management.

[Need new state machine figure here for power management.]

6.8.8.2 SP31:SAS_PM_Partial state
6.8.8.2.1 State description
This state waits for a COMINIT Detected message, a COMWAKE Detected message, or a Power
Management (Exit) message.

Upon entry to this state, the phy shall be quiesced to match the partial low power mode
requirement (see x.x).

6.8.8.2.2 Transition SP31:SAS_PM_Partial to SP0:OOB_COMINIT

This transition shall occur after receiving a COMINIT Detected message.
Before the transition, this state shall set the ResetStatus state machine variable to UNKNOWN.

6.8.8.2.3 Transition SP31:SAS_PM_Partial to SP33:SAS_COMWAKE
This transition shall occur after receiving a COMWAKE Detected message or a Power management (Exit) message.

If this state received a COMWAKE Detected message, it shall include a COMWAKE Detected argument with the transition.

6.8.8.3 SP32:SAS_PM_Slumber state
6.8.8.3.1 State description
This state waits for a COMINIT Detected message, a COMWAKE Detected message, or a Power Management (Exit) message.

Upon entry to this state, the phy shall be quiesced to match the slumber low power mode requirement (see x.x).

6.8.8.3.2 Transition SP32:SAS_PM_Slumber to SP0:OOB_COMINIT
This transition shall occur after receiving a COMINIT Detected message.
Before the transition, this state shall set the ResetStatus state machine variable to UNKNOWN.

6.8.8.3.3 Transition SP32:SAS_PM_Slumber to SP33:SAS _COMWAKE
This transition shall occur after receiving a COMWAKE Detected message or a Power Management (Exit) message.

If this state received a COMWAKE Detected message, it shall include a COMWAKE Detected argument with the transition.

6.8.8.4 SP33:SAS_COMWAKE state
6.8.8.4.1 State description
Upon entry into this state, the phy shall send a Transmit COMWAKE message to the SP transmitter.

 This state waits for a COMWAKE Transmitted message and/or a COMWAKE Detected message.

6.8.8.4.2 Transition SP33:SAS_COMWAKE to SP34:SAS_AwaitCOMWAKE_Sent
This transition shall occur if this state receives a COMWAKE Detected message and this state has not received a COMWAKE Transmitted message, or shall occur if a COMWAKE Detected argument was received in the transition.

6.8.8.4.3 Transition SP33:SAS_COMWAKE to SP35:SAS_AwaitNoCOMWAKE
This transition shall occur if this state receives both a COMWAKE Transmitted message and a COMWAKE Detected message.

6.8.8.4.4 Transition SP33:SAS_PM_COMWAKE to SP36:SAS_AwaitCOMWAKE
This transition shall occur if this state receives a COMWAKE Transmitted message and has not received a COMWAKE Detected message.

6.8.8.5 SP34:SAS_AwaitCOMWAKE_Sent state
6.8.8.5.1 State description
This state waits for receipt of a COMWAKE Transmitted message.

6.8.8.5.2 Transition SP34:SAS_AwaitCOMWAKE_Sent to SP35:SAS_AwaitNoCOMWAKE
This transition shall occur after receiving a COMWAKE Transmitted message.

If this state received a COMWAKE Detected message, it shall include a COMWAKE Detected argument with the transition.

6.8.8.6 SP35:SAS_AwaitNoCOMWAKE state
6.8.8.6.1 State description
This state waits for a COMWAKE Detected message or a COMINIT Detected message.

6.8.8.6.2 Transition SP35:SAS_AwaitNoCOMWAKE to SP0:OOB_COMINIT
This transition shall occur after receiving a COMINIT Detected message.
Before the transition, this state shall set the ResetStatus state machine variable to UNKNOWN.

6.8.8.6.3 Transition SP35:SAS_AwaitNoCOMWAKE to SP37:SAS_PM_AwaitALIGN
This transition shall occur after receiving a COMWAKE Detected message, or shall occur if a COMWAKE Detected argument was received in the transition.

6.8.8.7 SP36:SAS_AwaitCOMWAKE state
6.8.8.7.1 State description
Upon entry into this state, the phy shall initialize and start the COMWAKE Detect Timeout timer [10 ms – new defined timer].

This state waits for a COMWAKE Detected message or a COMINIT Detected message.

6.8.8.7.2 Transition SP36:SAS_AwaitCOMWAKE to SP0:OOB_COMINIT
This transition shall occur if the COMWAKE Detect Timeout timer expires or a COMINIT Detected message is received.

Before the transition, this state shall set the ResetStatus state machine variable to UNKNOWN.

6.8.8.7.3 Transition SP36:SAS_AwaitCOMWAKE to SP37:SAS_PM_AwaitALIGN
This transition shall occur after receiving a COMWAKE Detected message.

6.8.8.8 SP37:SAS_PM_AwaitALIGN state
6.8.8.8.1 State description
Upon entry into this state, the phy shall:
    a) Send a Set Rate message to the SP transmitter and SP receiver with:
        A) the Physical Link Rate argument set to the last successfully negotiated link rate;
        B) the receiver training settings are restored;
        C) the SSC argument is restored; and
        D) the multiplexing argument is restored;
    b) initialize and start the SNTT timer and SNLT timer;
    c) send a Start DWS message to the SP_DWS state machine; and
    d) repeatedly send Transmit ALIGN (0) messages to the SP transmitter.

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

6.8.8.8.2 Transition SP37: SAS_PM_AwaitALIGN to SP0:OOB_COMINIT
This transition shall occur after receiving a DWS Lost message if this state does not send a Start DWS message (i.e., this happens after SNLT timer expires), or after receiving a COMINIT Detected message.

Before the transition, this state shall set the ResetStatus state machine variable to UNKNOWN.

6.8.8.8.3 Transition SP37: SAS_PM_AwaitALIGN to SP38:SAS_ReceivedALIGN0

This transition shall occur if this state receives an ALIGN Received (0) message before the SNLT timer expires.

6.8.8.8.4 Transition SP37: SAS_PM_AwaitALIGN to SP39:SAS_TransmitALIGN1

This transition shall occur if this state receives an ALIGN Received (1) message before the SNLT timer expires.

6.8.8.9 SP38:SAS_ReceivedALIGN0 state
6.8.8.9.1 State description
This state shall repeatedly send Transmit ALIGN (1) messages to the SP transmitter.

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

This state waits for the SNLT timer to expire.

6.8.8.9.2 Transition SP38:SAS_ReceivedALIGN0 to SP0:OOB_COMINIT

This transition shall occur after receiving a DWS Lost message if this state does not send a Start DWS message, or after receiving a COMINIT Detected message.

Before the transition, this state shall set the ResetStatus state machine variable to UNKNOWN.

6.8.8.9.3 Transition SP38:SAS_ReceivedALIGN0 to SP39:SAS_TransmitALIGN1

This transition shall occur if this state receives an ALIGN Received (1) message before the SNLT timer expires. This indicates that the other phy has been able to achieve dword synchronization.

6.8.8.10 SP39:SAS_TransmitALIGN1 state
6.8.8.10.1 State description
This state shall repeatedly send Transmit ALIGN (1) messages to the SP transmitter.

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

This state waits for the SNTT timer to expire or for a Stop SNTT request.

6.8.8.10.2 Transition SP39:SAS_TransmitALIGN1 to SP0:OOB_COMINIT

This transition shall occur after receiving a DWS Lost message if this state does not send a Start DWS message (i.e., this happens after SNTT timer expires), or after receiving a COMINIT Detected message.

Before the transition, this state shall set the ResetStatus state machine variable to UNKNOWN.

6.8.8.10.3 Transition SP39:SAS_TransmitALIGN1 to SP15:SAS_PHY_Ready

This transition shall occur after the SNTT timer expires or after receiving a Stop SNTT request.

6.9 SP_DWS (phy layer dword synchronization) state machine
6.10 Multiplexing
6.11 Spin-up
[No changes to the above clauses]

7 Link layer
7.1 Link layer overview

The link layer defines primitives, address frames, and connections. Link layer state machines interface to the port layer and the phy layer and perform the identification and hard reset sequences, connection management, and SSP, STP, and SMP specific frame transmission and reception.

7.2 Primitives
7.2.1 Primitives overview
[No changes to this clause.]

7.2.2 Primitive summary
Table 107 defines the deletable primitives.
[No changes to table 107.]

Table 108 defines the primitives not specific to the type of connection.
[Add these items to table 108.]

Primitive	Use	from			to			Primitive
		I	E	T	I	E	T	Sequence Type
PMACK	NoConn	I	E	T	I	E	T	Extended
PMNACK	NoConn	I	E	T	I	E	T	Extended
PMREQ (PARTIAL)	NoConn	I	E	T	I	E	T	Extended
PMREQ (SLUMBER)	NoConn	I	E	T	I	E	T	Extended

Table 109 defines the primitives used only inside SSP and SMP connections.
[No changes to table 109.]

Table 110 lists the primitives used only inside STP connections and on SATA physical links.
[No changes to table 110.]

7.2.3 Primitive encodings
Table 111 defines the primitive encoding for deletable primitives.
[No changes to table 111.]

Table 112 defines the primitive encoding for primitives not specific to type of connection.
[Add these items to table 112.]

Primitive	character				hexadecimal
	1st	2nd	3rd	4th	
PMACK	K28.5				
PMNACK	K28.5				
PMREQ (PARTIAL)	K28.5				
PMREQ (SLUMBER)	K28.5				

Table 113 defines the primitive encodings for primitives used only inside SSP and SMP connections.
[no changes to table 113.]

Table 114 lists the primitive encodings for primitives used only inside STP connections and on SATA physical links.
[no changes to table 114.]

7.2.4 Primitive sequences
7.2.5 Deletable primitives
[no changes to the above clauses]

7.2.6 Primitives not specific to type of connections
7.2.6.1 AIP (Arbitration in progress)
AIP is sent by an expander device after a connection request to specify that the connection request is being processed and specify the status of the connection request.

The versions of AIP representing different statuses are defined in table 119.

Table 119 — AIP primitives

Primitive	Description
AIP (NORMAL)	Expander device has accepted the connection request. This may be sent multiple times (see 7.12.4.3).
AIP (RESERVED 0)	Reserved. Processed the same as AIP (NORMAL).
AIP (RESERVED 1)	
AIP (RESERVED 2)	
AIP (WAITING ON CONNECTION)	Expander device has determined the routing for the connection request, but either the destination phys are all being used for connections or there are insufficient routing resources to complete the connection request. This may be sent multiple times (see 7.12.4.3).
AIP (WAITING ON DEVICE)	Expander device has determined the routing for the connection request and forwarded it to the output physical link. This is sent one time (see 7.12.4.3).
AIP (WAITING ON PARTIAL)	Expander device has determined the routing for the connection request, but the destination phys are all busy with other partial pathways. This may be sent multiple times (see 7.12.4.3).
AIP (RESERVED WAITING ON PARTIAL)	Reserved. Processed the same as AIP (WAITING ON PARTIAL).

See 7.12 for details on connections.

7.2.6.2 BREAK
7.2.6.3 BREAK_REPLY
7.2.6.4 BROADCAST
7.2.6.5 CLOSE
7.2.6.6 EOAF (End of address frame)
7.2.6.7 ERROR
7.2.6.8 HARD_RESET
7.2.6.9 OPEN_ACCEPT
[Clauses 7.2.6.2 through 7.2.6.9 are unchanged.]

7.2.6.10 OPEN_REJECT
OPEN_REJECT specifies that a connection request has been rejected and specifies the reason for the rejection. The result of some OPEN_REJECTs is to abandon (i.e., not retry) the connection request and the result of other OPEN_REJECTs is to retry the connection request.

All of the OPEN_REJECT versions defined in table 122 shall result in the originating port abandoning the connection request.

Table 122 — Abandon-class OPEN_REJECT primitives
[Table 122 is unchanged.]

All of the OPEN_REJECT versions defined in table 123 shall result in the originating port retrying the connection request.

Table 123 — Retry-class OPEN_REJECT primitives

Primitive	originator	Description
OPEN_REJECT (NO DESTINATION) a	Expander phy	An expander device in the pathway is not configuring and determines that: a) there is no such destination phy; b) the connection request routes to a destination expander phy in the same expander port as the source expander phy and the expander port is using the subtractive routing method; or c) the SAS address is valid for an STP target port in an STP/SATA bridge, but the initial Register - Device to Host FIS has not been successfully received (see 10.4.3.12).
OPEN_REJECT (PATHWAY BLOCKED) b	Expander phy	An expander device determined the pathway was blocked by higher priority connection requests.
OPEN_REJECT (RESERVED CONTINUE 0) c OPEN_REJECT (RESERVED CONTINUE 1) c	Unknown	Reserved. Process the same as OPEN_REJECT (RETRY).
OPEN_REJECT (RESERVED INITIALIZE 0) a OPEN_REJECT (RESERVED INITIALIZE 1) a	Unknown	Reserved. Process the same as OPEN_REJECT (NO DESTINATION).
OPEN_REJECT (RESERVED STOP 0) b OPEN_REJECT (RESERVED STOP 1) b	Unknown	Reserved. Process the same as OPEN_REJECT (PATHWAY BLOCKED).
OPEN_REJECT (RETRY)	Destination phy or zoning expander phy	Either: a) a phy with destination SAS address exists but is temporarily not able to accept connections (see 7.16.1, 7.17.5, and 7.18.3);[add power management reference here?] b) an expander device in the pathway is configuring and would otherwise have returned OPEN_REJECT (NO DESTINATION)(see 4.7.2 and 7.12.4.2.5); c) an expander device in the pathway is locked and would otherwise have returned OPEN_REJECT (ZONE VIOLATION)(see 4.9.3.5 and 7.12.4.2.5); or d) an expander device in the pathway has reduced functionality (see 4.6.8 and 7.12.4.2.5).

a If the I_T Nexus Loss timer is already running, it continues running; if it is not already running, it is initialized and started. Stop retrying the connection request if the I_T Nexus Loss timer expires.
b If the I_T Nexus Loss timer is already running, it continues running. Stop retrying the connection request if the I_T Nexus Loss timer expires.
c If the I_T Nexus Loss timer (see 8.2.2) is already running, it is stopped.

NOTE 49 - Some SAS logical phys compliant with earlier versions of this standard also transmit OPEN_REJECT (RETRY) if they receive an OPEN address frame while their SL_CC state machines are in the SL_CC5:BreakWait state (see 7.14.4.7).

7.2.6.11 SOAF (Start of address frame)
7.2.6.12 TRAIN
7.2.6.13 TRAIN_DONE
[Clauses 7.2.6.11 through 7.2.6.13 are unchanged.]

7.2.6.14 PMACK
PMACK specifies the positive acknowledgement of a power management request primitive.

See 7.10 for details of power management.

7.2.6.15 PMNACK
PMNACK specifies the negative acknowledgement of a power management request primitive.

See 7.10 for details of power management.

7.2.6.16 PMREQ (PARTIAL)
PMREQ (PARTIAL) specifies a request to transition to partial power management state.

See 7.10 for details of power management.

7.2.6.17 PMREQ (SLUMBER)
PMREQ (SLUMBER) specifies a request to transition to slumber power management state.

See7.10 for details of power management.

7.2.7 Primitives used only inside SSP and SMP connections
7.2.8 Primitives used only inside STP connections and on SATA physical links
[Clauses 7.2.7 and 7.2.8 are unchanged.]

7.3 Physical link rate tolerance management
7.4 Idle physical links
7.5 CRC
7.6 Scrambling
7.7 Bit order of CRC and scrambler
7.8 Address frames
[Clauses 7.3 through 7.8 are unchanged.]

7.9 Identification and hard reset sequence
7.9.1 Identification and hard reset sequence overview
After the phy reset sequence (see 6.7) has been completed indicating the physical link is using SAS rather than SATA, each logical phy either:
   a) performs an identification sequence by transmitting one or three IDENTIFY address frames (see 7.8.2); or
   b) performs a hard reset sequence by transmitting a HARD_RESET primitive sequence (see 7.2.6.8).

[Note: Is something needed here for power management recovery sequence?]

If multiplexing (see 6.10) is enabled (see table 100 in 6.7.4.2.3.3), the identification sequence and hard reset sequence begin with a multiplexing sequence (see 6.7.4.3).

Figure 176 shows two phys with multiplexing disabled performing the identification sequence. Only one IDENTIFY address frame is shown in this example.

[Figure 176 is unchanged.]

Figure 177 shows phy A performing the identification sequence and phy B performing the hard reset sequence. Multiplexing is disabled and only one IDENTIFY address frame is shown in this example.

[Figure 177 is unchanged.]

Each logical phy receives an IDENTIFY address frame or a HARD_RESET primitive sequence from the logical phy to which it is attached. The combination of a phy reset sequence, an optional hard reset sequence followed by another phy reset sequence, and an identification sequence is called a link reset sequence (see 4.4.1).

If a phy receives a valid IDENTIFY address frame within 1 ms of phy reset sequence completion, the SAS address in the outgoing IDENTIFY address frame(s) and the SAS address in the incoming IDENTIFY address frame determine the port to which a phy belongs (see 4.1.4). The phy ignores subsequent IDENTIFY address frames and HARD_RESET primitives until another phy reset sequence occurs.

If a phy receives a HARD_RESET primitive sequence within 1 ms of phy reset sequence completion, it shall be considered a reset event and cause a hard reset (see 4.4.2) of the port containing that phy. If a phy does not receive a HARD_RESET primitive sequence or a valid IDENTIFY address frame within 1 ms of phy reset sequence completion, it shall restart the phy reset sequence.

7.9.2 SAS initiator device rules
7.9.3 Expander device rules
7.9.4 SL_IR (link layer identification and hard reset) state machines
[Clauses 7.9.2 through 7.9.4 are unchanged.]
[Note: I suspect changes may be needed to SL_IR state machine for COMWAKE handling or power management.]

7.10 Power management
SAS interface power management may be supported in SSP when no connections are active.

 SSP target or initiator ports may generate PMREQ (PARTIAL) or PMREQ (SLUMBER). SSP initiator or target ports and expander ports may reply with PMNACK if power management is not permitted or PMACK if power management is supported and permitted.
[Note: Do we need more guidance on when partial or slumber modes should be invoked and what responses should result?]

SATA interface power management is not supported in STP.

STP initiator ports shall not generate SATA_PMREQ_P, SATA_PMREQ_S, or SATA_PMACK. If an STP initiator port receives SATA_PMREQ_P or SATA_PMREQ_S, it shall reply with SATA_PMNAK.

If an expander device receives SATA_PMREQ_P or SATA_PMREQ_S from a SATA device while an STP connection is not open, it shall not forward it to any STP initiator port and shall reply with SATA_PMNAK. If one of these primitives arrives while an STP connection is open, it may forward the primitive to the STP initiator port.

SCSI idle and standby power conditions, implemented with the START STOP UNIT command (see SBC-3) and the Power Condition mode page (see SPC-4), may be supported by SSP initiator ports and SSP target ports as described in 10.2.10.

ATA idle and standby power modes, implemented with the IDLE, IDLE IMMEDIATE, STANDBY, STANDBY IMMEDIATE, and CHECK POWER MODE commands (see ATA8-ACS), may be supported by STP initiator ports. The ATA sleep power mode, implemented with the SLEEP command, shall not be used.

7.11 SAS domain changes (Broadcast (Change) usage)
7.12 Connections
7.13 Rate matching
7.14 SL (link layer for SAS logical phys) state machines
7.15 XL (link layer for expander logical phys) state machine
7.16 SSP link layer
7.17 STP link layer
7.18 SMP link layer
[Clauses 7.11 through 7.18 are unchanged.]

10.2.7.4 Protocol-Specific Port mode page
The Protocol-Specific Port mode page (see SPC-4) contains parameters that affect SSP target port operation. If the mode page is implemented by one logical unit in a SCSI target device, it shall be implemented by all logical units in the SCSI target device that support the MODE SELECT or MODE SENSE commands.

The mode page policy (see SPC-4) for this mode page shall be either shared or per target port. If a SAS target device has multiple SSP target ports, the mode page policy should be per target port.

Parameters in this mode page:
a) shall affect all phys in the SSP target port if the mode page policy is per target port; or
b) shall affect all SSP target ports in the SAS target device if the mode page policy is shared.

Table 216 defines the format of the page for SAS SSP.

Table 216 — Protocol-Specific Port mode page for SAS SSP

Bit / Byte	7	6	5	4	3	2	1	0
0	PS	SPF	PAGE CODE (19h)					
1	PAGE LENGTH (0Dh)							
2	ALLOW SLUMBER	CONTINUE AWT	BRCAST ASYNCH EVENT	READY LED MEANING	PROTOCOL IDENTIFIER (6h)			
3	ALLOW PARTIAL							
4	(MSB)	I_T NEXUS LOSS TIME						
5								(LSB)
6	(MSB)	INITIATOR RESPONSE TIMEOUT						
7								(LSB)
8	(MSB)	REJECT TO OPEN LIMIT						
9								(LSB)
10	Reserved							

15

The PARAMETERS SAVEABLE (PS) bit is defined in SPC-4.

The SUBPAGE FORMAT (SPF) bit is defined in SPC-4 and shall be set to the value defined in table 216.

The PAGE CODE field is defined in SPC-4 and shall be set to the value defined in table 216.

The PAGE LENGTH field is defined in SPC-4 and shall be set to the value defined in table 216.

An ALLOW SLUMBER bit set to 1 specifies that the SAS port is allowed to initiate negotiation for slumber power management mode (see 7.10). An ALLOW SLUMBER bit set to 0 specifies that the SAS port shall not initiate negotiation for slumber power management mode.

A CONTINUE AWT bit set to one specifies that the SAS port shall not stop the Arbitration Wait Time timer and set the Arbitration Wait Time timer to zero when the SAS port receives an OPEN_REJECT (RETRY). A CONTINUE AWT bit set to zero specifies that the SAS port shall stop the Arbitration Wait Time timer and set the Arbitration Wait Time timer to zero when it receives an OPEN_REJECT (RETRY).

A BROADCAST ASYNCHRONOUS EVENT bit set to one specifies that the device server shall enable origination of Broadcast (Asynchronous Event) (see 4.1.13). A BROADCAST ASYNCHRONOUS EVENT bit set to zero specifies that the device server shall disable origination of Broadcast (Asynchronous Event).

The READY LED MEANING bit specifies the READY LED signal behavior (see 10.4.1). Regardless of the mode page policy (see SPC-4) for this mode page, the shared mode page policy shall be applied to the READY LED MEANING bit.

The PROTOCOL IDENTIFIER field is defined in SPC-4 and shall be set to the value defined in table 216 indicating that this is a SAS SSP specific mode page.

An ALLOW PARTIAL bit set to 1 specifies that the SAS port is allowed to initiate negotiation for partial power management mode (see 7.10). An ALLOW PARTIAL bit set to 0 specifies that the SAS port shall not initiate negotiation for partial power management mode.

10.4.3.10 DISCOVER function

[text and tables unchanged until table 269.]

Table 269 – DISCOVER response (1 of 3)

Bit / Byte	7	6	5	4	3	2	1	0
0	SMP FRAME TYPE (41h)							
1	FUNCTION (10h)							
2	FUNCTION RESULT							
3	RESPONSE LENGTH (00h or 1Ah)							
4	(MSB)	EXPANDER CHANGE COUNT						
5								(LSB)
6	Reserved							
7	Reserved							
8	Reserved							
9	PHY IDENTIFIER							
10	Reserved							
11	Reserved							
12	Resvd	ATTACHED DEVICE TYPE		ATTACHED REASON				
13	Reserved		PHY POWER STATE	NEGOTIATED LOGICAL LINK RATE				
14	Reserved				ATTACHED SSP INITIATOR	ATTACHED STP INITIATOR	ATTACHED SMP INITIATOR	ATTACHED SATA HOST
15	SATA PORT SELECTOR	Reserved			ATTACHED SSP TARGET	ATTACHED STP TARGET	ATTACHED SMP TARGET	ATTACHED SATA DEVICE
16	(MSB)	SAS ADDRESS						
23								(LSB)
24	(MSB)	ATTACHED SAS ADDRESS						
31								(LSB)
32								
33	Reserved					INSIDE ZPSDS PERSISTNT	REQUEST INSIDE ZPSDS	ATTACHED BRK_REPL CAPABLE
34	Reserved							
39								
12	PROG MIN PHYSICAL LINK RATE				HARDW MIN PHYSICAL LINK RATE			
13	PROG MAX PHYSICAL LINK RATE				HARDW MAX PHYSICAL LINK RATE			
42	PHY CHANGE COUNT							

[Existing text is unchanged until added text below.]

If the phy is a physical phy and a SAS phy or expander phy is attached, the ATTACHED REASON field indicates the value of the REASON field received in the IDENTIFY address frame (see 7.8.2) during the identification sequence. If the phy is a physical phy and a SATA phy is attached, the ATTACHED REASON field shall be set to 0h after the initial Register - Device to Host FIS has been received. If the phy is a virtual phy, the ATTACHED REASON field shall be set to 0h.

The PHY POWER STATE field indicates the power management state for the referenced phy and is described in table new2.

Table new2 — PHY POWER STATE field description

Value	Description
00b	Active power state
01b	Partial power state
10b	Slumber power state
11b	Reserved

The NEGOTIATED LOGICAL LINK RATE field is defined in table 271 and indicates the logical link rate being used by the phy. For physical phys, this is negotiated during the link reset sequence. For virtual phys, this field should be set to the maximum physical link rate supported by the expander device. This field may be different from the negotiated physical link rate when multiplexing is enabled.

[No other changes in this clause.]

10.4.3.15.4 DISCOVER LIST response SHORT FORMAT descriptor

Table 293 defines the SHORT FORMAT descriptor.

Table 293 – SHORT FORMAT descriptor

Byte \ Bit	7	6	5	4	3	2	1	0
0	PHY IDENTIFIER							
1	FUNCTION RESULT							
2	Restrct	ATTACHED DEVICE TYPE			ATTACHED REASON			
3	Restricted		PHY POWER STATE		NEGOTIATED LOGICAL LINK RATE			
4	Restricted				ATTACHED SSP INITIATOR	ATTACHED STP INITIATOR	ATTACHED SMP INITIATOR	ATTACHED SATA HOST
5	SATA PORT SELECTOR	Restricted			ATTACHED SSP TARGET	ATTACHED STP TARGET	ATTACHED SMP TARGET	ATTACHED SATA DEVICE
6	VIRTUAL PHY	Reserved			ROUTING ATTRIBUTE			
7	REASON				Reserved			
8	ZONE GROUP							
9	Restricted for DISCOVER response byte 60	INSIDE ZPSDS PERSISTNT	REQUEST INSIDE ZPSDS	Reserved	ZONE GROUP PERSISTNT	INSIDE ZPSDS	Reserved	
10	ATTACHED PHY IDENTIFIER							
11	PHY CHANGE COUNT							
12	(MSB)	ATTACHED SAS ADDRESS						
19								(LSB)
20	Reserved							
23								

The PHY IDENTIFIER field indicates the phy for which physical configuration link information is being returned.

The FUNCTION RESULT field indicates the value that is returned in the FUNCTION RESULT field in the SMP DISCOVER response for the specified phy (e.g., SMP FUNCTION ACCEPTED, PHY VACANT, or PHY DOES NOT EXIST). If the FUNCTION RESULT field is set to PHY VACANT or PHY DOES NOT EXIST, the rest of the fields in the SHORT FORMAT descriptor shall be ignored.

The fields in the SHORT FORMAT descriptor not defined in this subclause are defined in the SMP
DISCOVER response (see 10.4.3.10).

Annex K (informative)
Primitive encoding
[Update table K.1 to include coding of the PMREQ (PARTIAL), PMREQ (SLUMBER), PMACK, and PMNAK primitives.]