To: T10 Technical Committee
From: Rob Elliott, HP (elliott@hp.com)
Date: 27 August 2005
Subject: 05-306r0 SAS-2 STP connection time limits and STP/SMP I_T nexus loss

Revision history
Revision 0 (27 August 2005) First revision

Related documents
sas1r09e - Serial Attached SCSI revision 9e
05-305 - SAS-2 Maximum SMP connection time

Overview
SAS-1.1 provides several tools to help keep SSP target ports (and, indirectly, SSP initiator ports) from keeping connections open too long and causing congestion in the fabric:

   a) the MAXIMUM CONNECT TIME LIMIT field in the Disconnect-Reconnect mode page - limits the time of a connection (even if it is transferring frames)
   b) the BUS INACTIVITY TIME LIMIT field in the Disconnect-Reconnect mode page - limits the time of a connection that is not transferring frames
   c) the I_T NEXUS LOSS TIME field in the Disconnect-Reconnect mode page - limits the number of OPEN retries in response to OPEN_REJECT (NO DESTINATION)
   d) numerous 1 ms timeouts in the link layer - ACK/NAK timeout, Credit timeout, DONE Response timeout, etc.

SAS-1.1 does not define any such tools for STP target ports (and, indirectly, STP initiator ports and SMP initiator ports), however.

One approach is for the STP target port to close the connection between every frame. This may not be the best for all situations - if the STP initiator port or the SATA device can send data frames back-to-back, this adds a lot of overhead. Another approach is to let the STP initiator port always initiate closing the connection. There is no rule guaranteeing it must do so, however; if both sides wait on the other, the connection will never be closed.

Adding fields such as those defined for SSP will let STP target ports, STP initiator ports, and SMP initiator ports make better decisions about connection management and behave more consistently with the SSP target ports in the fabric.

Proposal:

   a) define an STP MAXIMUM CONNECT TIME LIMIT field (in the SMP REPORT PHY SATA/PHY CONTROL functions) to instruct the associated STP target port how long before it must try to close a connection (regardless of activity)
   b) define an STP BUS INACTIVITY TIME LIMIT field (in the SMP REPORT PHY SATA/PHY CONTROL functions) to instruct the associated STP target port how long it may keep a connection open while not sending a frame (e.g. waiting for the SATA device to send another frame)
   c) define an STP I_T NEXUS LOSS TIME field (in the SMP REPORT PHY SATA/PHY CONTROL functions) to instruct the associated STP target port how long to keep trying to open an STP initiator port in the face of OPEN_REJECT (NO DESTINATION) connection responses.
   d) Define a fixed 2 second I_T nexus loss time for an SMP initiator port in a self-configuring expander. This could be a programmable value like SSP and STP, but since it doesn't affect SMP target ports, just SMP initiator ports, there is no obvious place to define it.

The timers enforcing these values are implemented by the port layer the same as their SSP counterparts. An STP/SATA bridge and an SMP initiator port in an expander device conceptually include a port layer.

   Editor's Note 1: it's not really a goal that an expander allow different values be programmed for each phy. The fields could be placed in new SMP functions that are expander-wide if this is a problem.

4.5 I_T nexus loss

When a SAS port receives OPEN_REJECT (NO DESTINATION), OPEN_REJECT (PATHWAY BLOCKED), or an open connection timeout occurs in response to a connection request, it shall retry the connection request until:

    a)   the connection is established;
    ~~b)   for SSP target ports, the time indicated by the I_T NEXUS LOSS field in the Protocol-Specific Port mode page (see 10.2.7.2) expires; or~~
    ~~c)   for STP ports, SMP ports, or SSP initiator ports, a vendor-specific I_T nexus loss time expires;~~
    d)   the I_T nexus loss timer, if any, expires (see 8.2.2.1, 10.2.7.2, and 10.4.3.7);

~~An SSP initiator port should retry the connection request for the time indicated by the I_T NEXUS LOSS field in the Protocol-Specific Port mode page (see 10.2.7.2) for the SSP target port to which it is trying to establish a connection.~~

I_T nexus loss is handled by the port layer state machines (see 8.2.2.3).

If the I_T nexus loss timer expires in an SSP port, then the port shall send a Nexus Loss event notification to the SCSI application layer (see 10.2.5) and the SCSI device shall perform the actions defined for I_T nexus loss in SAM-3.

    Editor's Note 2: reordered the preceding two paragraphs (not shown as changes)

If the I_T nexus loss timer expires in an STP target port, then the port shall abort any commands for the lost STP initiator port and clear the affiliation, if any (see 7.17.5). If the STP target port is in an STP/SATA bridge, the STP/SATA bridge shall originate a link reset sequence to the SATA device.

If the I_T nexus loss timer expires in an STP initiator port, then the port shall abort any commands for the lost STP target port.

If the I_T nexus loss timer expires in an SMP initiator port, then the port shall stop attempting to establish connections to the lost SMP target port.

If the I_T nexus loss timer expires in an initiator port, then a management application client should cause a link reset sequence on the phy(s) attached to the lost target port (e.g, if directly attached, the phys in the initiator port; if attached via expander device(s), the phys in the expander device closest to and attached to the target port).

7.17.5 Affiliations

Coherent access to the SATA task file registers shall be provided for each STP initiator port. STP target ports that do not track all commands by the STP initiator ports' SAS addresses shall implement affiliations to provide coherency. STP target ports that track all commands by the STP initiator ports' SAS addresses shall not implement affiliations.

An affiliation is a state entered by an STP target port where it refuses to accept connection requests from STP initiator ports other than the one that has established an affiliation.

An STP target port that supports affiliations shall establish an affiliation whenever it accepts a connection request. When an affiliation is established, the STP target port shall reject all subsequent connection requests from other STP initiator ports with OPEN_REJECT (STP RESOURCES BUSY).

An STP target port shall maintain an affiliation until any of the following occurs:

    a)   power on;
    b)   the SAS target device receives an SMP PHY CONTROL request specifying the phy with the affiliation and specifying a phy operation of HARD RESET (see 10.4.3.10) from any SMP initiator port;

   c) the SAS target device receives an SMP PHY CONTROL request specifying the phy with the affiliation and specifying a phy operation of TRANSMIT SATA PORT SELECTION SIGNAL (see 10.4.3.10) from any SMP initiator port;

   d) the SAS target device receives an SMP PHY CONTROL request specifying the phy with the affiliation and specifying a phy operation of CLEAR AFFILIATION (see 10.4.3.10) from the same SAS initiator port that has the affiliation.

     If a connection is already established to the STP target port on one phy while an SMP PHY CONTROL request specifying a phy operation of CLEAR AFFILIATION is processed by an SMP target port on another phy, the affiliation shall be cleared and the STP target port shall respond to new connection attempts with:

     A) AIP (WAITING ON CONNECTION) and/or OPEN_REJECT (RETRY), if the STP target port is in an expander device; or

     B) OPEN_REJECT (RETRY), if the STP target port is in a SAS device;

     rather than OPEN_REJECT (STP RESOURCES BUSY);

   e) a connection to the phy with the affiliation is closed with CLOSE (CLEAR AFFILIATION); ~~or~~

   f) the STP target port is part of a STP/SATA bridge and a link reset sequence is begun on the SATA physical link that was not requested by an SMP PHY CONTROL request specifying the phy and specifying a phy operation of LINK RESET (see 10.4.3.10); or

   g) an I_T nexus loss occurs (see 4.5, 8.2.2.1, and 10.4.3.7).

An affiliation established when a command is transmitted shall be maintained until all frames for the command have been delivered. An STP initiator port implementing command queuing (see SATAII-EXT) shall maintain an affiliation while any commands are outstanding to avoid confusing SATA devices, which only understand one SATA host. STP initiator ports may keep affiliations for longer tenures, but this is discouraged.

An STP target port that implements affiliations shall implement one affiliation per STP target port. Multiple phys on the same STP target port shall use the same affiliation. Support for affiliations is indicated in the SMP REPORT PHY SATA function response (see 10.4.3.7).

8.2.2 PL_OC (port layer overall control) state machine

8.2.2.1 PL_OC state machine overview

A PL_OC state machine:

   a) receives requests from the SSP, SMP, and STP transport layers;
   b) sends messages to the PL_PM state machine;
   c) receives messages from the PL_PM state machine;
   d) selects frames to transmit;
   e) selects phys on which to transmit frames;
   f) receives confirmations from the link layer;
   g) sends confirmations to the transport layer;
   h) has Arbitration Wait Time timers; and
   i) has I_T Nexus Loss timers.

This state machine consists of the following states:

   a) PL_OC1:Idle (see 8.2.2.2) (initial state); and
   b) PL_OC2:Overall_Control (see 8.2.2.3).

After power on this state machine shall start in the PL_OC1:Idle state.

The PL_OC state machine shall maintain:

   a) a pool of pending Tx Frame messages for each destination SAS address; and
   b) as many pending Tx Open message slots as there are phys in the port.

The PL_OC state machine shall maintain the timers listed in table 1.

Table 1 — PL_OC state machine timers

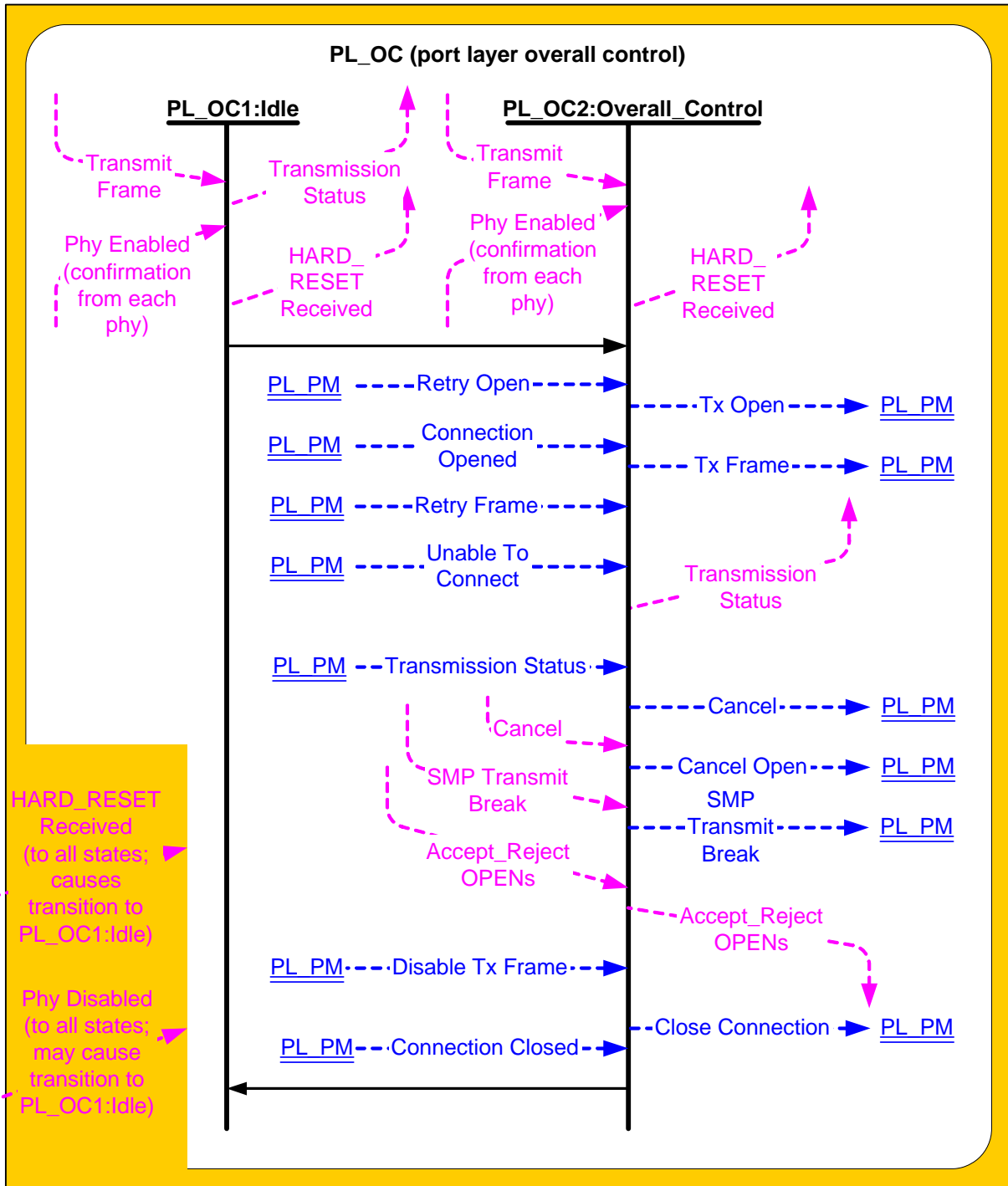| Timer	Maximum number of timers	Initial value
I_T Nexus Loss timer	One per destination SAS address	Depending on the protocol used by the port: a) for SSP target ports, the value in the I_T NEXUS LOSS TIME field in the Protocol-Specific Port mode page (see 10.2.7.2); b) for SSP initiator ports, the value in the I_T NEXUS LOSS TIME field in the Protocol-Specific Port mode page for the SSP target port with that destination SAS address (see 10.2.7.2); c) for STP target ports, the value in the STP I_T NEXUS LOSS TIME field in the SMP REPORT PHY SATA function (see 10.4.3.7); d) for STP initiator ports, the value in the STP I_T NEXUS LOSS TIME field in the SMP REPORT PHY SATA function for the STP target port with that destination SAS address; or e) for SMP initiator ports, 2 000 ms.
Arbitration Wait Time timer	One per pending Tx Open message	0000h, a vendor specific value less than 8000h (see 7.12.3), or the value received with a Retry Open message.

Figure 1 shows the PL_OC state machine.

Figure 1 — PL_OC (port layer overall control) state machine

8.2.2.2 PL_OC1:Idle state

8.2.2.2.1 PL_OC1:Idle state description

This state is the initial state of the PL_OC state machine.

If this state receives a HARD_RESET Received confirmation, then this state shall send a HARD_RESET Received confirmation to the transport layer.

If this state receives a Transmit Frame request, then this state shall send a Transmission Status (No Phys In Port) confirmation to the transport layer.

If an I_T Nexus Loss timer expires for a destination SAS address, this state shall perform the following:

a) delete the I_T Nexus Loss timer for the SAS address;
b) send a Transmission Status (I_T Nexus Loss) confirmation for each pending Tx Frame message for the SAS address; and
c) discard each pending Tx Frame message for the SAS address and any corresponding pending Tx Open messages.

If the port is an STP target port or an STP initiator port, the port shall abort all commands as described in 4.5.

8.2.2.2.2 Transition PL_OC1:Idle to PL_OC2:Overall_Control

This transition shall occur after a Phy Enabled confirmation is received for at least one phy assigned to the port.

8.2.2.3 PL_OC2:Overall_Control state

8.2.2.3.1 PL_OC2:Overall_Control state overview

This state may receive Transmit Frame requests from the transport layers (i.e., SSP and SMP) and Retry frame messages from PL_PM state machines. This state shall create a pending Tx Frame message for each received Transmit Frame request and Retry Frame message. There may be more than one pending Tx Frame message at a time for each SSP transport layer. There shall be only one pending Tx Frame message at a time for each SMP transport layer.

This state selects PL_PM state machines through which connections are established. This state shall only attempt to establish connections through PL_PM state machines whose phys are enabled. In a vendor-specific manner, this state selects PL_PM state machines on which connections are established to transmit frames. This state shall receive a response to a message from a PL_PM state machine before sending another message to that PL_PM state machine.

This state also:

a) receives connection management requests from the transport layers;
b) sends connection management messages to PL_PM state machines;
c) receives connection management messages from PL_PM state machines; and
d) sends connection management confirmations to the transport layers.

After receiving a Transmit Frame request for a destination SAS address for which there is no connection established and for which no I_T Nexus Loss timer has been created, this state shall create an I_T Nexus Loss timer for that SAS address if:

a) the protocol is SSP;
b) this state machine is in an SSP target port;
c) the Protocol-Specific Port mode page is implemented by the SSP target port; and
d) the I_T nexus loss time is not 0000h.
a) the protocol is SSP, the port is an SSP target port, the Protocol-Specific Port mode page is implemented, and the I_T NEXUS LOSS TIME field in the Disconnect-Reconnect mode page (see 10.2.7.1) is not set to 0000h;
b) the protocol is STP, the port is an STP target port, and the STP I_T NEXUS LOSS TIME field in the SMP REPORT PHY SATA function is not set to 0000h; or
c) the protocol is SMP, and the port is an SMP initiator port.

This state may create an I_T Nexus Loss timer for that SAS address if:

a) the protocol is SSP and the port is this state machine is in an SSP initiator port; or then this state may create an I_T Nexus Loss timer for the SAS address. If a state machine in an SSP initiator port and creates an I_T Nexus Loss timer, then the state machine should use the value in the I_T NEXUS LOSS TIME field in the Protocol-Specific Port mode page for the SSP target port (see 10.2.7.2) as the initial value for its I_T Nexus Loss timer.

6

    b)   the protocol is STP and the port is an STP initiator port.

~~Other SAS ports may detect an I_T nexus loss in a vendor-specific manner.~~

When this state creates an I_T Nexus Loss timer it shall:

    a)   initialize the I_T Nexus Loss timer as specificied in table 1 (see 8.2.2.1); and
    b)   not start the I_T Nexus Loss timer.

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    Editor's Note 3: moved the When... paragraph down a few paragraphs from its current location

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If there are no pending Tx Frame messages for a destination SAS address and an I_T Nexus Loss timer has been created for that destination SAS address, then this state shall delete the I_T Nexus Loss timer for that destination SAS address.

If this state receives a HARD_RESET Received confirmation, then this state shall discard all pending Tx Frame messages and delete all I_T Nexus Loss timers and send a HARD_RESET Received confirmation to the transport layer.

8.2.2.3.2 PL_OC2:Overall_Control state establishing connections

This state receives Phy Enabled confirmations indicating when a phy is available.

This state receives Retry Open messages from a PL_PM state machine.

This state creates pending Tx Open messages based on pending Tx Frame messages and Retry Open messages. Pending Tx Open messages are sent to a PL_PM state machine as Tx Open messages.

If this state receives a Retry Open (Retry) message, then this state shall process the Retry Open message.

If this state receives a Retry Open (No Destination) or a Retry Open (Open Timeout Occurred) message and an I_T Nexus Loss timer has not been created for the destination SAS address (e.g., an SSP target port does not support the I_T NEXUS LOSS TIME field in the Protocol-Specific Port mode page or the field is set to 0000h), then this state shall process the Retry Open message as either a Retry Open message or an Unable To Connect message. This selection is vendor-specific.

If this state receives a Retry Open (Pathway Blocked) message and an I_T Nexus Loss timer has not been created for the destination SAS address, then this state shall process the Retry Open message.

If this state receives a Retry Open (No Destination), Retry Open (Open Timeout Occurred), or Retry Open (Pathway Blocked) message, and an I_T Nexus Loss timer has been created for the destination SAS address with an initial value of FFFFh, then this state shall process the Retry Open message (i.e., the Retry Open message is never processed as an Unable to Connect message).

If this state receives a Retry Open (No Destination) or a Retry Open (Open Timeout Occurred) message, an I_T Nexus Loss timer has been created for the destination SAS address, and there is no connection established with the destination SAS address, then this state shall check the I_T Nexus Loss timer, and:

    a)   if the I_T Nexus Loss timer is not running and the I_T nexus loss time is not set to FFFFh, then this state shall start the timer;
    b)   if the I_T Nexus Loss timer is running, then this state shall not stop the timer; and
    c)   if the I_T Nexus Loss timer has expired, then this state shall process the Retry Open message as if it were an Unable To Connect message (see 8.2.2.3.4).

If this state receives a Retry Open (Pathway Blocked) message, an I_T Nexus Loss timer has been created for the destination SAS address, and there is no connection established with the destination SAS address, then this state shall check the I_T Nexus Loss timer, and:

    a)   if the I_T Nexus Loss timer is running, then this state shall not stop the timer; and
    b)   if the I_T Nexus Loss timer has expired, then this state shall process the Retry Open message as if it were an Unable To Connect message (see 8.2.2.3.4).

If this state receives a Retry Open (Retry) and an I_T Nexus Loss timer is running for the destination SAS address, then this state shall:

 a) stop the I_T Nexus Loss timer (if the timer has been running); and
 b) initialize the I_T Nexus Loss timer.

This state shall create a pending Tx Open message if:

 a) this state has a pending Tx Frame message or has received a Retry Open message;
 b) this state has fewer pending Tx Open messages than the number of PL_PM state machines (i.e., the number of phys in the port);
 c) there is no pending Tx Open message for the destination SAS address; and
 d) there is no connection established with the destination SAS address.

This state may create a pending Tx Open message if:

 a) this state has a pending Tx Frame message, or this state has received a Retry Open message and has not processed the message by sending a confirmation; and
 b) this state has fewer pending Tx Open messages than the number of PL_PM state machines.

This state shall have no more pending Tx Open messages than the number of PL_PM state machines.

If this state receives a Retry Open message and there are pending Tx Frame messages for which pending Tx Open messages have not been created, then this state should create a pending Tx Open message from the Retry Open message.

If this state does not create a pending Tx Open message from a Retry Open message (e.g., the current number of pending Tx Open messages equals the number of phys), then this state shall discard the Retry Open message. This state may create a new pending Tx Open message at a later time for the pending Tx Frame message that resulted in the Retry Open message.

If this state receives a Retry Open (Opened By Destination) message and the initiator port bit and protocol arguments match those in the Tx Open messages that resulted in the Retry Open message, then this state may discard the Retry Open message and use the established connection to send pending Tx Frame messages as Tx Frame messages to the destination SAS address. If this state receives a Retry Open (Opened By Destination) message, then, if this state has a pending Tx Open slot available, this state may create a pending Tx Open message from the Retry Open message.

> NOTE 1 - If a connection is established by another port as indicated by a Retry Open (Opened By Destination) message, credit may not be granted for frame transmission. In this case this state may create a pending Tx Open message from a Retry Open message in order to establish a connection where credit is granted.

This state shall send a pending Tx Open message as a Tx Open message to a PL_PM state machine that has an enabled phy and does not have a connection established. If there is more than one pending Tx Open message, this state should send a Tx Open message for the pending Tx Open message that has been pending for the longest time first.

If this state creates a pending Tx Open message from one of the following messages:

 a) a Retry Open (Opened By Destination);
 b) a Retry Open (Opened By Other);
 c) a Retry Open (Collided); or
 d) a Retry Open (Pathway Blocked),

then this state shall:

 a) create an Arbitration Wait Time timer for the pending Tx Open message;
 b) set the Arbitration Wait Time timer for the pending Tx Open message to the arbitration wait time argument from the Retry Open message; and
 c) start the Arbitration Wait Time timer for the pending Tx Open message.

When a pending Tx Open message is sent to a PL_PM state machine as a Tx Open message, the Tx Open message shall contain the following arguments to be used in an OPEN address frame:

  a) initiator port bit from the Transmit Frame request;
  b) protocol from the Transmit Frame request;
  c) connection rate from the Transmit Frame request;
  d) initiator connection tag from the Transmit Frame request;
  e) destination SAS address from the Transmit Frame request;
  f) source SAS address from the Transmit Frame request;
  g) pathway blocked count; and
  h) arbitration wait time.

If this state creates a pending Tx Open message from one of the following:

  a) a Transmit Frame request;
  b) a Retry Open (No Destination) message;
  c) a Retry Open (Open Timeout Occurred) message; or
  d) a Retry Open (Retry) message,

then this state shall:

  a) set the pathway blocked count argument in the Tx Open message to zero; and
  b) set the arbitration wait time argument in the Tx Open message to zero or a vendor-specific value less than 8000h (see 7.12.3).

If a pending Tx Open message was created as the result this state receiving a Retry Open (Pathway Blocked) message, then this state shall set the pathway blocked count argument in the Tx Open message to the value of the pathway blocked count argument received with the message plus one, unless the pathway blocked count received with the argument is FFh.

If a pending Tx Open message was created as the result of this state receiving one of the following:

  a) a Retry Open (Opened By Destination) message;
  b) a Retry Open (Opened By Other) message;
  c) a Retry Open (Collided) message; or
  d) a Retry Open (Pathway Blocked) message;

then this state shall set the arbitration wait time argument in the Tx Open message to be the value from the Arbitration Wait Time timer created as a result of the Retry Open message.

After this state sends a Tx Open message, this state shall discard the pending Tx Open message from which the Tx Open messages was created. After this state discards a pending Tx Open message, this state may create a new pending Tx Open message.

If this state receives a Connection Opened message and the initiator port bit and protocol arguments match those in any pending Tx Frame messages, then this state may use the established connection to send pending Tx Frame messages as Tx Frame messages to the destination SAS address.

8.2.2.3.3 PL_OC2:Overall_Control state connection established

If this state receives a Connection Opened message or a Retry Open (Opened By Destination) message for a SAS address, and an I_T Nexus Loss timer has been created for the SAS address, then this state shall:

  a) stop the I_T Nexus Loss timer for the SAS address, if the timer has been running; and
  b) initialize the I_T Nexus Loss timer.

8.2.2.3.4 PL_OC2:Overall_Control state unable to establish a connection

If this state receives a Retry Open (No Destination), Retry Open (Open Timeout Occurred), or Retry Open (Pathway Blocked) message and the I_T Nexus Loss timer for the SAS address has expired, then this state shall perform the following:

  a) delete the I_T Nexus Loss timer for the SAS address;
  b) discard the Retry Open message;

   c) send a Transmission Status (I_T Nexus Loss) confirmation for the pending Tx Frame message from which the Retry Open message resulted;

   d) discard the pending Tx Frame message from which the Retry Open message resulted;

   e) if this state has any pending Tx Frame messages with the same destination SAS address and protocol as the Retry Open message, and this state has not sent a Tx Open message to a PL_PM state machine for the messages, then this state shall send a Transmission Status (I_T Nexus Loss) confirmation for each pending Tx Frame message and discard the pending Tx Frame messages and any corresponding pending Tx Open messages; and

   f) if this state has any pending Tx Frame messages with the same destination SAS address and protocol as the Retry Open message, and this state has sent a Tx Open message to a PL_PM state machine for a message, then this state shall send a Cancel Open message to each PL_PM state machine to which it has sent a Tx Open message. After receiving an Unable To Connect (Cancel Acknowledge) message from a PL_PM state machine in response to the Cancel Open message, then this state shall send a Transmission Status (I_T Nexus Loss) confirmation for each pending Tx Frame message and discard the pending Tx Frame messages and any corresponding pending Tx Open messages.

If this state receives a Retry Open (No Destination), Retry Open (Open Timeout Occurred), or Retry Open (Pathway Blocked) message and processes it as an Unable To Connect message, or this state receives an Unable To Connect message, then this state shall send a Transmission Status confirmation as defined in table 2.

Table 2 — Confirmations from Unable To Connect or Retry Open messages

Message received	Confirmation to be sent to transport layer
Retry Open (No Destination)	Transmission Status (I_T Nexus Loss) if the I_T Nexus Loss timer for the SAS address has expired, or Transmission Status (No Destination) if it has not
Retry Open (Open Timeout Occurred)	Transmission Status (I_T Nexus Loss) if the I_T Nexus Loss timer for the SAS address has expired, or Transmission Status (Open Timeout Occurred) if it has not
Retry Open (Pathway Blocked)	Transmission Status (I_T Nexus Loss) if the I_T Nexus Loss timer for the SAS address has expired
Unable to Connect (Bad Destination)	Transmission Status (Bad Destination)
Unable To Connect (Break Received)	Transmission Status (Break Received)
Unable To Connect (Connection Rate Not Supported)	Transmission Status (Connection Rate Not Supported)
Unable To Connect (Port Layer Request)	Transmission Status (Cancel Acknowledge)
Unable To Connect (Protocol Not Supported)	Transmission Status (Protocol Not Supported)
Unable To Connect (STP Resources Busy)	Transmission Status (STP Resources Busy)
Unable To Connect (Wrong Destination)	Transmission Status (Wrong Destination)

If this state receives an Unable To Connect (Connection Rate Not Supported), Unable To Connect (Protocol Not Supported), or Unable To Connect (STP Resources Busy) message and an I_T Nexus Loss timer is running for the SAS address, then this state shall:

   a) stop the I_T Nexus Loss timer, if the timer has been running; and

   b) initialize the I_T Nexus Loss timer.

This state shall discard the pending Tx Frame message for which the Transmission Status confirmation was sent.

8.2.2.3.5 PL_OC2:Overall_Control state connection management

If this state receives an Accept_Reject Opens request, then this state shall send an Accept_Reject Opens message to all phys in the port.

If this state receives an SMP Transmit Break request, then this state shall send an SMP Transmit Break message to the PL_PM state machine associated with the corresponding SMP transport state machine. If there is no PL_PM state machine associated with the request, the PM_OC state shall ignore the request.

If this state receives one of the following:

  a) a Connection Closed (Close Timeout) message;
  b) a Connection Closed (Break Requested) message; or
  c) a Connection Closed (Break Received) message,

then this state shall not send a Tx Open or Tx Frame message to the PL_PM state machine that sent the message until this state receives a Connection Closed (Transition to Idle) message from that PL_PM state machine.

If this state receives a Connection Closed (Normal) message or a Connection Closed (Transition to Idle) message indicating that a connection with a destination SAS address is no longer open and this state has pending Tx Open messages, then this state may send a Tx Open message to the PL_PM state machine that sent the Connection Closed message.

If this state is in a wide SSP port, then this state shall not reject an incoming connection request on one phy because it has an outgoing connection request on another phy.

If this state is in an SSP port, there are no pending Tx Frame messages for a destination SAS address with which a PL_PM state machine has established a connection, and the connection was established by a message from this state, then this state should send a Close Connection message to the PL_PM state machine.

If this state is in an SSP port, has no pending Tx Frame messages for a destination SAS address with which a PL_PM state machine has established a connection, and the connection was established by the destination, then this state may wait a vendor-specific time and then shall send a Close Connection message to the PL_PM state machine.

If this state has received a Disable Tx Frame message from a PL_PM state machine, then this state should send a Close Connection message to the PL_PM state machine.

> NOTE 2 - The PL_PM state machine sends a Close Connection request to the link layer upon receipt of a Close Connection message or on expiration of the Bus Inactivity Time Limit timer (see 8.2.3.4.1).

8.2.2.3.6 PL_OC2:Overall_Control state frame transmission

In order to prevent livelocks, If this state is in a wide SSP port, has multiple connections established, and has a pending Tx Frame message, then this state shall send at least one Tx Frame message to a PL_PM state machine before sending a Close Connection message to the PL_PM state machine.

After this state receives a Connection Opened message from a PL_PM state machine, this state selects pending Tx Frame messages for the destination SAS address with the same initiator port bit and protocol arguments, and, as an option, the same connection rate argument, and sends the messages to the PL_PM state machine as Tx Frame messages.

This state may send a Tx Frame message to any PL_PM state machine that has established a connection with the destination SAS address when the initiator port bit and protocol arguments match those in the Tx Frame message.

After this state sends a Tx Frame message to a PL_PM state machine, it shall not send another Tx Frame message to that PL_PM state machine until it receives a Transmission Status (Frame Transmitted) message.

This state may send a Tx Frame message containing a COMMAND frame for a destination SAS address to a PL_PM state machine while waiting for one of the following messages for Tx Frame messages containing COMMAND frames for the same destination SAS address from different PL_PM state machines:

   a) Transmission Status (ACK Received);
   b) Transmission Status (NAK Received);
   c) Transmission Status (ACK/NAK Timeout); or
   d) Transmission Status (Connection Lost Without ACK/NAK).

This state shall not send a Tx Frame message containing a TASK frame for a task that only affects an I_T_L_Q nexus (e.g., an ABORT TASK or QUERY TASK task management function (see SAM-3)) until this state has received one of the following messages for each Tx Frame message with the same I_T_L_Q nexus:

   a) Transmission Status (ACK Received);
   b) Transmission Status (NAK Received);
   c) Transmission Status (ACK/NAK Timeout); or
   d) Transmission Status (Connection Lost Without ACK/NAK).

This state shall not send a Tx Frame message containing a TASK frame for a task that only affects an I_T_L nexus (e.g., an ABORT TASK SET, CLEAR TASK SET, CLEAR ACA, or LOGICAL UNIT RESET task management function (see SAM-3)) until this state has received one of the following messages for each Tx Frame message with the same I_T_L nexus:

   a) Transmission Status (ACK Received);
   b) Transmission Status (NAK Received);
   c) Transmission Status (ACK/NAK Timeout); or
   d) Transmission Status (Connection Lost Without ACK/NAK).

This state shall not send a Tx Frame message containing a TASK frame for a task that only affects an I_T nexus until this state has received one of the following messages for each Tx Frame message with the same I_T nexus:

   a) Transmission Status (ACK Received);
   b) Transmission Status (NAK Received);
   c) Transmission Status (ACK/NAK Timeout); or
   d) Transmission Status (Connection Lost Without ACK/NAK).

Once this state has sent a Tx Frame message containing a DATA frame to a PL_PM state machine, this state shall not send a Tx Frame message containing a DATA frame with the same I_T_L_Q to another PL_PM state machine until this state has received one of the following messages for each Tx Frame message containing a DATA frame for the same I_T_L_Q nexus:

   a) Transmission Status (ACK Received);
   b) Transmission Status (NAK Received);
   c) Transmission Status (ACK/NAK Timeout); or
   d) Transmission Status (Connection Lost Without ACK/NAK).

Read DATA frames and write DATA frames for the same I_T_L_Q nexus may be transmitted and received simultaneously on the same or different phys.

If this state is in an SMP initiator port, then this state shall send the Tx Frame message containing the SMP REQUEST frame to the PL_PM state machine on which the connection was established for the Tx Open message. If this state is in an SMP target port, then this state shall send the Tx Frame message containing the SMP RESPONSE frame to the PL_PM state machine on which the connection was established for the Tx Open message. See 7.18 for additional information about SMP connections.

Characteristics of STP connections are defined by SATA (also see 7.17).

The following arguments shall be included with the Tx Frame message:

   a) the frame to be transmitted; and
   b) Balance Required or Balance Not Required.

A Balance Not Required argument shall only be included if:

a) the request was a Transmit Frame (Non-Interlocked) request (i.e., the request included a DATA frame); and
b) the last Tx Frame message sent to this PL_PM state machine while this connection has been established was for a DATA frame having the same logical unit number and tag value as the DATA frame in this Tx Frame message.

If a Balance Not Required argument is not included in the Tx Frame message, then a Balance Required argument shall be included.

If this state receives a Disable Tx Frames message from a PL_PM state machine, then this state should send no more Tx Frame messages to that state machine until a new connection is established.

8.2.2.3.7 PL_OC2:Overall_Control state frame transmission cancellations

Cancel requests cause this state to cancel previous Transmit Frame requests. A Cancel request includes the following arguments:

a) destination SAS address; and
b) tag.

If this state receives a Cancel request and has not already sent a Tx Frame message for the Transmit Frame request to a PL_PM state machine for the Transmit Frame request specified by the Cancel request, then this state shall:

a) discard all Transmit Frame requests for the specified destination SAS address and tag; and
b) send a Transmission Status (Cancel Acknowledge) confirmation to the transport layer.

If this state receives a Cancel request and has already sent a Tx Frame message to a PL_PM state machine for the Transmit Frame request specified by the Cancel request, then this state shall send a Cancel message to the PL_PM state machine to which the Tx Frame message was sent. The Cancel message shall include the tag.

8.2.2.3.8 Transition PL_OC2:Overall_Control to PL_OC1:Idle

This transition shall occur after:

a) sending a HARD_RESET Received confirmation to the transport layer; or
b) a Phy Disabled confirmation is received from all of the link layers in the port;

8.2.3 PL_PM (port layer phy manager) state machine

8.2.3.1 PL_PM state machine overview

A PL_PM state machine:

a) receives messages from the PL_OC state machine;
b) sends requests to the link layer;
c) receives confirmations from the link layer;
d) sends confirmations to the transport layer;
e) sends messages to PL_OC state machine;
f) has an Arbitration Wait Time timer;
g) may have a Bus Inactivity Time Limit timer; and
h) may have Maximum Connect Time Limit timer.

This state machine consist of the following states:

a) PL_PM1:Idle (see 8.2.3.2) (initial state);
b) PL_PM2:Req_Wait (see 8.2.3.3);
c) PL_PM3:Connected (see 8.2.3.4); and
d) PL_PM4:Wait_For_Close (see 8.2.3.5).

After power on this state machine shall start in the PL_PM1:Idle state.

The PL_PM state machine shall maintain the timers listed in table 3.

Table 3 — PL_PM state machine timers

| Timer	Initial value
Arbitration Wait Time timer	The arbitration wait time argument from a Retry Open message (see 8.2.2.3.1).
Bus Inactivity Time Limit timer	Depending on the protocol used by the port: a) for SSP target ports, the value in the BUS INACTIVITY TIME LIMIT field in the Disconnect-Reconnect mode page; or b) for STP target ports, the value in the STP BUS INACTIVITY TIME LIMIT field in the SMP REPORT PHY SATA function.
Maximum Connect Time Limit timer	Depending on the protocol used by the port: a) for SSP target ports, the value in the MAXIMUM CONNECT TIME LIMIT field in the Disconnect-Reconnect mode page (see 10.2.7.1); or b) for STP target ports, the value in the STP MAXIMUM CONNECT TIME LIMIT field in the SMP REPORT PHY SATA function.

Figure 2 shows part 1 of the PL_PM state machine.
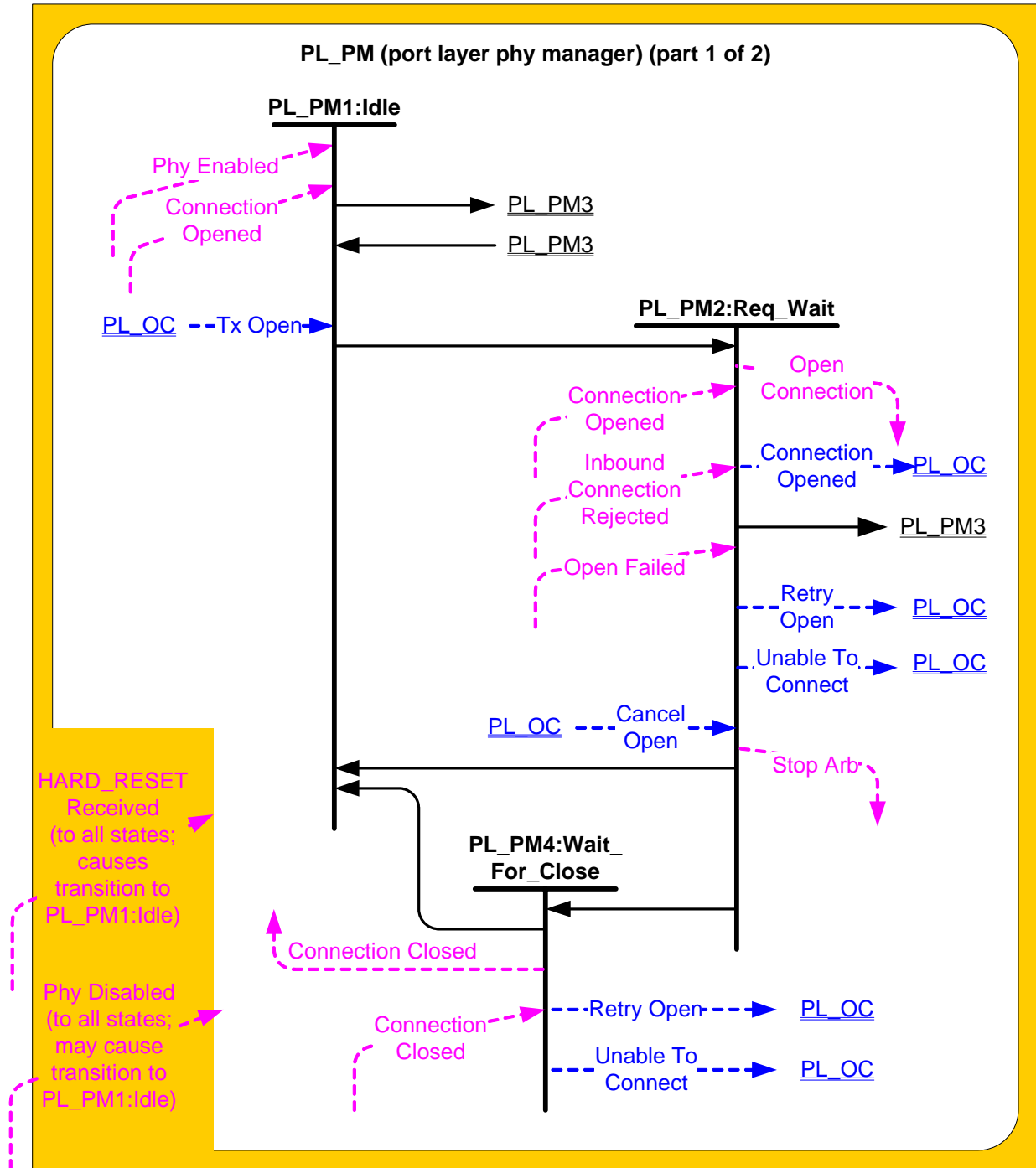
Figure 2 — PL_PM (port layer phy manager) state machine (part 1)

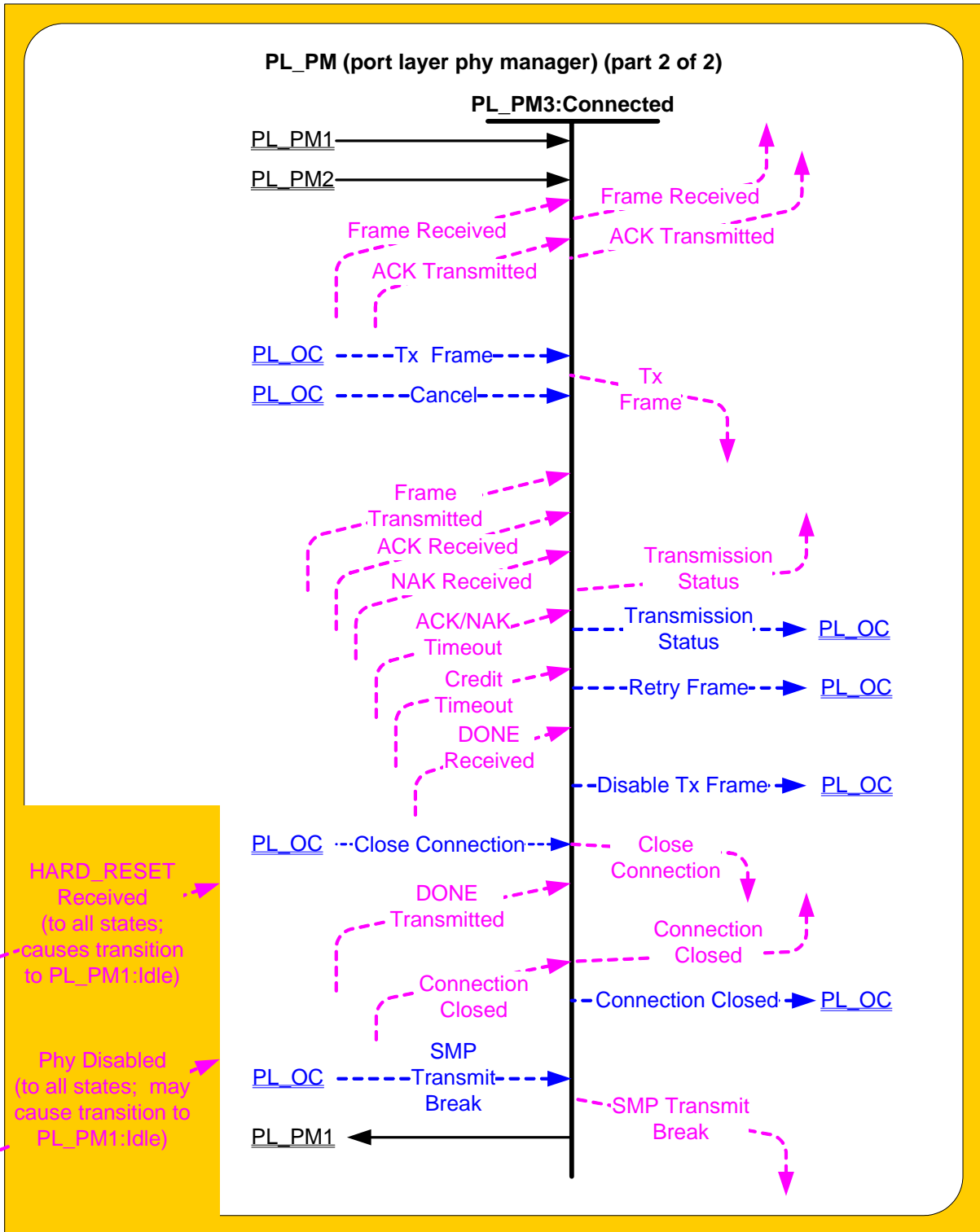Figure 3 shows part 2 of the PL_PM state machine.

Figure 3 — PL_PM (port layer phy manager) state machine (part 2)

8.2.3.2 PL_PM1:Idle state

8.2.3.2.1 PL_PM1:Idle state description

This is the initial state of the PL_PM state machine.

8.2.3.2.2 Transition PL_PM1:Idle to PL_PM2:Req_Wait

This transition shall occur after:

    a) a Phy Enabled confirmation is received; and
    b) a Tx Open message is received.

8.2.3.2.3 Transition PL_PM1:Idle to PL_PM3:Connected

This transition shall occur after a Connection Opened confirmation is received.

8.2.3.3 PL_PM2:Req_Wait state

8.2.3.3.1 PL_PM2:Req_Wait state overview

This state sends an Open Connection request to the link layer and waits for a confirmation. This state sends and receives connection management messages to and from the PL_OC state machine.

If this state receives a HARD_RESET Received confirmation, then this state shall terminate all operations.

8.2.3.3.2 PL_PM2:Req_Wait establishing a connection

Upon entry into this state, this state shall:

    a) create an Arbitration Wait Time timer;
    b) initialize the Arbitration Wait Time timer to the arbitration wait time argument received with the Tx
        Open message;
    c) start the Arbitration Wait Time timer; and
    d) send an Open Connection request to the link layer.

The Open Connection request shall contain the following arguments from the Tx Open message to be used in an OPEN address frame:

    a) initiator port bit;
    b) protocol;
    c) connection rate;
    d) initiator connection tag;
    e) destination SAS address;
    f) source SAS address;
    g) pathway blocked count; and
    h) arbitration wait time.

8.2.3.3.3 PL_PM2:Req_Wait connection established

If this state receives a Connection Opened confirmation, then this state shall send a Connection Opened message to the PL_OC state machine.

If this state receives a Connection Opened confirmation and the confirmation was not in response to an Open Connection request from this state (i.e., the connection was established in response to an OPEN address frame from another device), then this state shall discard any Open Connection request and send a Retry Open message to the PL_OC state machine. If the Connection Opened confirmation was from the destination of the Open Connection request, then this state shall send a Retry Open (Opened By Destination) message. If the Connection Opened confirmation was from a destination other than the destination of the Open Connection request, then this state shall send a Retry Open (Opened By Other) message.

A Retry Open (Opened By Destination) or Retry Open (Opened By Other) message shall contain the following arguments:

    a) initiator port bit set to the value received with the Tx Open message;
    b) protocol set to the value received with the Tx Open message;
    c) connection rate set to the value received with the Tx Open message;
    d) initiator connection tag set to the value received with the Tx Open message;
    e) destination SAS address set to the value received with the Tx Open message;

   f)   source SAS address set to the value received with the Tx Open message;
   g)   pathway blocked count set to the value received with the Tx Open message; and
   h)   arbitration wait time set to the value of the Arbitration Wait Time timer.

8.2.3.3.4 PL_PM2:Req_Wait unable to establish a connection

If this state receives one of the Open Failed confirmations listed in table 4, then this state shall send either a Retry Open message or an Unable To Connect message to the PL_OC state machine.

Table 4 defines the message to be sent for each Open Failed confirmation.

Table 4 — Messages from Open Failed confirmations

Confirmation received	Message to be sent to PL_OC
Open Failed (Pathway Blocked)	Retry Open (Pathway Blocked)
Open Failed (Retry)	Retry Open (Retry)
Open Failed (No Destination)	Retry Open (No Destination)
Open Failed (Bad Destination)	Unable To Connect (Bad Destination)
Open Failed (Connection Rate Not Supported)	Unable To Connect (Connection Rate Not Supported)
Open Failed (Protocol Not Supported)	Unable To Connect (Protocol Not Supported)
Open Failed (STP Resources Busy)	Unable To Connect (STP Resources Busy)
Open Failed (Wrong Destination)	Unable To Connect (Wrong Destination)

If this state receives an Inbound Connection Rejected confirmation after sending an Open Connection request, then this state shall discard the Open Connection request and send a Retry Open (Collided) message to the PL_OC state machine.

A Retry Open message shall include the following arguments:

   a)   initiator port bit set to the value received with the Tx Open message;
   b)   protocol set to the value received with the Tx Open message;
   c)   connection rate set to the value received with the Tx Open message;
   d)   initiator connection tag set to the value received with the Tx Open message;
   e)   destination SAS address set to the value received with the Tx Open message;
   f)   source SAS address set to the value received with the Tx Open message;
   g)   pathway blocked count argument set to the value received with the Tx Open message; and
   h)   arbitration wait time set to the value of the Arbitration Wait Time timer.

An Unable To Connect message shall include the following arguments:

   a)   initiator connection tag set to the value received with the Tx Open message;
   b)   destination SAS address set to the value received with the Tx Open message; and
   c)   source SAS address set to the value received with the Tx Open message.

8.2.3.3.5 PL_PM2:Req_Wait connection management

If this state receives a Cancel Open message and a Connection Opened confirmation has not been received, then this state shall send a Stop Arb request to the link layer.

8.2.3.3.6 Transition PL_PM2:Req_Wait to PL_PM1:Idle

This transition shall occur after:

   a)   a Retry Open message is sent to the PL_OC state machine;
   b)   an Unable To Connect message is sent to the PL_OC state machine;

18

    c)   all operations have been terminated after a HARD_RESET Received confirmation is received; or

    d)   a Phy Disabled confirmation is received.

8.2.3.3.7 Transition PL_PM2:Req_Wait to PL_PM3:Connected

This transition shall occur after a Connection Opened confirmation is received.

8.2.3.3.8 Transition PL_PM2:Req_Wait to PL_PM4:Wait_For_Close

This transition shall occur after one of the following confirmations is received:

    a)   an Open Failed (Open Timeout Occurred);

    b)   an Open Failed (Break Received); or

    c)   an Open Failed (Port Layer Request).

8.2.3.4 PL_PM3:Connected state

8.2.3.4.1 PL_PM3:Connected state description

If:

    a)   the protocol for the connection is SSP, ~~and this state is in~~ the port is an SSP target port, and the MAXIMUM CONNECT TIME LIMIT field in the Disconnect-Reconnect mode page (see 10.2.7.1) is not set to zero; or

    b)   the protocol for the connection is STP, the port is an STP target port, and the STP MAXIMUM CONNECT TIME LIMIT field in the SMP REPORT PHY SATA function is not set to zero,

then, upon entry into this state, this state shall:

    a)   create a Maximum Connect Time Limit timer;

    b)   initialize the Maximum Connect Time Limit timer as specified in table xx (see 8.2.3.1); and

    c)   start the Maximum Connect Time Limit timer.

If:

    a)   the protocol for the connection is SSP, the port is an SSP initiator port, and the MAXIMUM CONNECT TIME LIMIT field in the Disconnect-Reconnect mode page (see 10.2.7.1) for the destination SSP target port is not set to zero; or

    b)   the protocol for the connection is STP, the port is an STP initiator port, and the STP MAXIMUM CONNECT TIME LIMIT field in the SMP REPORT PHY SATA function for the destination STP target port is not set to zero,

then, upon entry into this state, this state may:

    a)   create a Maximum Connect Time Limit timer;

    b)   initialize the Maximum Connect Time Limit timer as specified in table xx (see 8.2.3.1); and

    c)   start the Maximum Connect Time Limit timer.

~~If the protocol for the connection is SSP, and this state is in an SSP target port, and the MAXIMUM CONNECT TIME LIMIT field in the Disconnect-Reconnect mode page (see 10.2.7.1) is set to zero, then this state shall not create a Maximum Connect Time Limit timer (i.e., there is no maximum connect time limit).~~

Editor's Note 4: the "shall not" rule is unnecessary

~~Other SAS ports may implement a Maximum Connect Time Limit timer in a vendor-specific manner.~~

Editor's Note 5: Specifics are provided in the new "may" section above

If:

   a) the protocol for the connection is SSP, ~~and this state is in~~ the port is an SSP target port, and the BUS INACTIVITY TIME LIMIT field in the Disconnect-Reconnect mode page (see 10.2.7.1) is set to a non-zero value; or
   b) the protocol for the connection is STP, the port is an STP target port, and the STP BUS INACTIVITY TIME LIMIT field in the SMP REPORT PHY SATA function is set to a non-zero value,

then, upon entry into this state, this state shall:

   a) create a Bus Inactivity Time Limit timer;
   b) initialize the Bus Inactivity Time Limit timer as specified in table xx (see 8.2.3.1); and
   c) not start the Bus Inactivity Time Limit timer.

If:

   a) the protocol for the connection is SSP, the port is an SSP initiator port, and the BUS INACTIVITY TIME LIMIT field in the Disconnect-Reconnect mode page (see 10.2.7.1) for the destination SSP target port is set to a non-zero value; or
   b) the protocol for the connection is STP, the port is an STP initiator port, and the STP BUS INACTIVITY TIME LIMIT field in the SMP REPORT PHY SATA function for the destination STP target port is set to a non-zero value,

then, upon entry into this state, this state may:

   a) create a Bus Inactivity Time Limit timer;
   b) initialize the Bus Inactivity Time Limit timer as specified in table xx (see 8.2.3.1); and
   c) not start the Bus Inactivity Time Limit timer.

~~If the protocol for the connection is SSP, and this state is in an SSP target port, and the BUS INACTIVITY TIME LIMIT field in the Disconnect-Reconnect mode page (see 10.2.7.1) is set to zero, then this state shall not create a Bus Inactivity Time Limit timer (i.e., there is no maximum bus inactivity time limit).~~

Editor's Note 6: the "shall not create" rule is unnecessary

~~Other SAS ports may implement a Bus Inactivity Time Limit timer in a vendor-specific manner.~~

Editor's Note 7: Specifics are provided in the new "may" section above

If a Bus Inactivity Time Limit timer has been created and:

   a) if the connection is SSP or SMP and this state receives a Tx Frame message; or
   b) if the connection is STP and the phy is not both transmitting and receiving SATA_SYNC,

then this state shall:

   a) stop the Bus Inactivity Time Limit timer, if it is running; and
   b) initialize the Bus Inactivity Time Limit timer as specified in table xx (see 8.2.3.1).

Editor's Note 8: This timer is not intended to clean up errors - it is just to prevent bus hogging from compliant devices. Thus, for STP, waiting for SYNC/SYNC should suffice. The Maximum Connect Time Limit would normally kick in next.

If this state receives a Tx Frame message, this state shall send a Tx Frame request to the link layer. The following arguments from the Tx Frame message shall be included with the Tx Frame request:

   a) the frame to be transmitted; and

b)   if this state is in an SSP port, Balance Required or Balance Not Required.

For STP connections, this state connects the STP transport layer to the STP link layer.

If a Bus Inactivity Time Limit timer ~~has been created and this state receives an ACK Received or NAK Received confirmation, then this state shall start the Bus Inactivity Time Limit timer. If the Bus Inactivity Time Limit timer~~ expires ~~before this state receives a Tx Frame message,~~ then ~~this state shall send a Close Connection request to the link layer~~:

a)   if the connection is SSP and there is no Tx Frame request outstanding (i.e., this state is not waiting for an ACK Received or NAK Received confirmation), then this state shall send a Close Connection request to the link layer; and

b)   if the connection is SSP and there is a Tx Frame request outstanding (i.e., this state is waiting for an ACK Received or NAK Received confirmation), then this state shall send a Close Connection request to the link layer after receiving an ACK Received or NAK Received confirmation;

c)   if the connection is STP, then this state shall send a Close Connection request to the link layer.

> Editor's Note 9: changes copied from 05-305 for the SSP items. Per earlier text, the timer is stopped when there is no SYNC/SYNC, so the wait is not mentioned in c).

If a Maximum Connect Time Limit timer ~~has been created and this state receives an ACK Received or NAK Received confirmation, then this state shall check the Maximum Connect Time Limit timer. If the Maximum Connect Time Limit timer has expired~~ expires:

a)   if the connection is SSP and there is no Tx Frame request outstanding (i.e., this state is not waiting for an ACK Received or NAK Received confirmation), then this state shall send a Close Connection request to the link layer; ~~and~~

b)   if the connection is SSP and there is a Tx Frame request outstanding (i.e., this state is waiting for an ACK Received or NAK Received confirmation), then this state shall send a Close Connection request to the link layer after receiving an ACK Received or NAK Received confirmation;

c)   if the connection is STP, then this state shall send a Close Connection request to the link layer after the phy is both transmitting and receiving SATA_SYNC;

d)   if the connection is SMP, then this state shall send an SMP Transmit Break request to the link layer.

> Editor's Note 10: changes copied from 05-305 for the SSP and SMP items.

> Editor's Note 11: This timer is not intended to clean up errors - it is just to prevent bus hogging from compliant devices. Thus, for STP, waiting for SYNC/SYNC should suffice. Another timer may be appropriate to clean up connections that are not reaching SYNC/SYNC (started after this timer expires?). It would have to use BREAKs and link resets to clean up.

If this state receives a Tx Frame message after sending a Close Connection request but before receiving a Connection Closed confirmation, then this state shall send a Retry Frame message to the PL_OC state machine.

If this state receives a Frame Received confirmation, then this state shall send a Frame Received confirmation to the transport layer. The confirmation shall include the arguments received with the confirmation (e.g., the frame).

If this state receives an ACK Transmitted confirmation, then this state shall send an ACK Transmitted confirmation to the transport layer including the tag of the frame that was ACKed.

If this state receives a Frame Transmitted confirmation, then this state shall send a Transmission Status (Frame Transmitted) confirmation to the transport layer.

If this state receives an ACK Received confirmation, then this state shall send a Transmission Status (ACK Received) confirmation to the transport layer.

If this state receives a NAK Received confirmation, then this state shall send a Transmission Status (NAK Received) confirmation to the transport layer.

If this state receives an ACK/NAK Timeout confirmation, then this state shall send a Transmission Status (ACK/NAK Timeout) confirmation to the transport layer.

If this state receives a Cancel message, then this state shall:

  a) discard all Tx Frame requests for the specified tag;
  b) send a Transmission Status (Cancel Acknowledge) confirmation to the transport layer including the destination SAS address and the tag as arguments; and
  c) discard any subsequent confirmations for previous Tx Frame requests sent for the tag.

If this state receives a Close Connection message from the PL_OC state machine, then this state shall send a Close Connection request to the link layer.

If this state receives one of the following:

  a) a Connection Closed (Normal) confirmation;
  b) a Connection Closed (Close Timeout) confirmation;
  c) a Connection Closed (Break Requested) confirmation;
  d) a Connection Closed (Break Received) confirmation; or
  e) a Connection Closed (Transition to Idle) confirmation,

then this state shall send a Connection Closed message to the PL_OC state machine including the argument received with the confirmation.

If this state receives a Connection Closed (Transition to Idle) confirmation after receiving:

  a) a Connection Closed (Break Received) confirmation; or
  b) a Connection Closed (Break Requested) confirmation,

then this state shall send a Transmission Status (Break Received) confirmation to the transport layer.

If this state receives a Connection Closed (Normal) confirmation, a Connection Closed (Transition to Idle) confirmation, or a Phy Disabled confirmation after sending a Transmission Status (Frame Transmitted) confirmation, but before this state receives an ACK Received or NAK Received confirmation, then this state shall send a Transmission Status (Connection Lost Without ACK/NAK) confirmation to the transport layer.

If this state receives a Connection Closed (Normal) confirmation, a Connection Closed (Transition to Idle) confirmation, or a Phy Disabled confirmation after sending a Tx Frame request but before receiving a Frame Transmitted confirmation, then this state shall send a Retry Frame message to the PL_OC state machine.

If this state receives a Connection Closed confirmation during an SMP connection, this state shall send a Connection Closed confirmation to the transport layer.

If this state receives a Credit Timeout confirmation, then this state shall send a Retry Frame message to the PL_OC state machine.

A Retry Frame message shall include the following arguments from the Tx Frame message:

  a) initiator port bit;
  b) protocol;
  c) connection rate;
  d) initiator connection tag;
  e) destination SAS address;
  f) source SAS address; and
  g) frame.

After this state receives a DONE Received (Normal) or DONE Received (Credit Blocked) confirmation, if it does not receive a Tx Frame message within 1 ms, then this state shall send a Disable Tx Frames message to the PL_OC state machine.

If this state receives a DONE Received (ACK/NAK Timeout) or DONE Transmitted confirmation, then this state shall send a Disable Tx Frames message to the PL_OC state machine.

If this state receives an SMP Transmit Break message, then this state shall send an SMP Transmit Break request to the link layer.

Editor's Note 12: SMP Transmit Break is in the figure but not in the text

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If this state receives a HARD_RESET Received confirmation, then this state machine shall terminate all operations.

8.2.3.4.2 Transition PL_PM3:Connected to PL_PM1:Idle

This transition shall occur after:

a) a Connection Closed (Transition to Idle) message is sent to the PL_OC state machine; or
b) all operations are terminated after a HARD_RESET Received confirmation is received.

8.2.3.5 PL_PM4:Wait_For_Close state

8.2.3.5.1 PL_PM4:Wait_For_Close state description

After receiving a Connection Closed (Transition to Idle) confirmation, if this state was entered as the result of the PL_PM2:Req_Wait state receiving an Open Failed (Open Timeout Occurred) confirmation, then this state shall send a Retry Open (Open Timeout Occurred) message to the PL_OC state machine. The Retry Open message shall include the following arguments:

a) initiator port bit set to the value received with the Tx Open message;
b) protocol set to the value received with the Tx Open message;
c) connection rate set to the value received with the Tx Open message;
d) initiator connection tag set to the value received with the Tx Open message;
e) destination SAS address set to the value received with the Tx Open message;
f) source SAS address set to the value received with the Tx Open message;
g) pathway blocked count argument set to the value received with the Tx Open message; and
h) arbitration wait time set to the value of the Arbitration Wait Time timer.

If this state receives a Connection Closed confirmation and the connection request was for an SMP connection, this state shall send a Connection Closed confirmation to the transport layer.

After receiving a Connection Closed (Transition to Idle) confirmation, if this state was entered after the PL_PM2:Req_Wait state received an Open Failed (Port Layer Request) confirmation (i.e., as the result of the PL_PM2:Req_Wait state sending a Stop Arb request), then this state shall send an Unable to Connect (Port Layer Request) message to the PL_OC state machine.

After receiving a Connection Closed (Transition to Idle) confirmation, if this state was entered as the result of the PL_PM2:Req_Wait state receiving an Open Failed (Break Received) confirmation, then this state shall send an Unable to Connect (Break Received) message to the PL_OC state machine.

The Unable To Connect message shall include the following arguments:

a) initiator connection tag set to the value received with the Tx Open message;
b) destination SAS address set to the value received with the Tx Open message; and
c) source SAS address set to the value received with the Tx Open message.

If this state receives a HARD_RESET Received confirmation, then this state shall terminate all operations.

8.2.3.5.2 Transition PL_PM4:Wait_For_Close to PL_PM1:Idle

This transition shall occur after:

a) a Retry Open or Unable To Connect message is sent to the PL_OC state machine; or

    b)   all operations are terminated after a HARD_RESET Received confirmation is received.

10.4.3.5 DISCOVER function

...

The PROGRAMMED MINIMUM PHYSICAL LINK RATE field indicates the minimum physical link rate set by the PHY CONTROL function (see 10.4.3.10). The values are defined in table 198. The default value shall be the value of the HARDWARE MINIMUM PHYSICAL LINK RATE field.

...

The PROGRAMMED MAXIMUM PHYSICAL LINK RATE field indicates the maximum physical link rate set by the PHY CONTROL function (see 10.4.3.10). The values are defined in table 198. The default value shall be the value of the HARDWARE MAXIMUM PHYSICAL LINK RATE field.

...

The PARTIAL PATHWAY TIMEOUT VALUE field indicates the partial pathway timeout value in microseconds (see 7.12.4.5) set by the PHY CONTROL function (see 10.4.3.10).

> NOTE 3 - The recommended default value for PARTIAL PATHWAY TIMEOUT VALUE is 7 μs. ~~The partial pathway timeout value may be set by the PHY CONTROL function (see 10.4.3.10).~~

> Editor's Note 13: above change makes the wording more consistent with other fields

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10.4.3.7 REPORT PHY SATA function

The REPORT PHY SATA function returns information about the SATA state for a specified phy. This SMP function shall be implemented by SMP target ports that share SAS addresses with STP target ports and by SMP target ports in expander devices with STP/SATA bridges. This SMP function shall not be implemented by any other type of SMP target port.

Table 5 defines the request format.

Table 5 — REPORT PHY SATA request

Byte\Bit	7	6	5	4	3	2	1	0
0				SMP FRAME TYPE (40h)				
1				FUNCTION (12h)				
2				Reserved				
8								
9				PHY IDENTIFIER				
10				Reserved				
11								
12	(MSB)			CRC				
15								(LSB)

The SMP FRAME TYPE field shall be set to 40h.

The FUNCTION field shall be set to 12h.

The PHY IDENTIFIER field specifies the phy (see 4.2.7) for which information shall be reported.

The CRC field is defined in 10.4.3.1.

Table 6 defines the response format.

Table 6 — REPORT PHY SATA response

Byte\Bit	7	6	5	4	3	2	1	0
0	SMP FRAME TYPE (41h)							
1	FUNCTION (12h)							
2	FUNCTION RESULT							
3	Reserved							
8								
9	PHY IDENTIFIER							
10	Reserved							
11	Reserved					STP I_T NEXUS LOSS OCCURRED	AFFILIATIONS SUPPORTED	AFFILIATION VALID
12	Reserved							
15								
16	STP SAS ADDRESS							
23								
24	REGISTER DEVICE TO HOST FIS							
43								
44	(MSB)							
45	~~Reserved~~STP BUS INACTIVITY TIME LIMIT							(LSB)
46	(MSB)							
47	STP MAXIMUM CONNECT TIME LIMIT							(LSB)
48	AFFILIATED STP INITIATOR SAS ADDRESS							
55								
56	(MSB)							
57	STP I_T NEXUS LOSS TIME							(LSB)
58	Reserved							
59								
~~56~~60	(MSB)							
~~59~~63	CRC							(LSB)

The SMP FRAME TYPE field shall be set to 41h.

The FUNCTION field shall be set to 12h.

The FUNCTION RESULT field is defined in 10.4.3.2.

The PHY IDENTIFIER field indicates the phy (see 4.2.7) for which information is being reported.

An STP I_T NEXUS LOSS OCCURRED bit set to one indicates that the STP target port encountered an I_T nexus loss. An STP I_T NEXUS LOSS OCCURRED bit set to zero indicates that an I_T nexus loss has not occurred.

An AFFILIATIONS SUPPORTED bit set to one indicates that affiliations are supported by the STP target port containing the specified phy. An AFFILIATIONS SUPPORTED bit set to zero indicates that affiliations are not supported by the STP target port containing the specified phy.

The AFFILIATION VALID bit shall be set to one when the AFFILIATED STP INITIATOR SAS ADDRESS field is valid and the STP target port containing the specified phy is maintaining an affiliation (see 7.17.5). The AFFILIATION VALID bit shall be set to zero when no affiliation is being maintained.

The STP SAS ADDRESS field contains the SAS address (see 4.2.2) of the STP target port that contains the specified phy.

The REGISTER DEVICE TO HOST FIS field contains the contents of the initial Register - Device to Host FIS. For an STP/SATA bridge, this is delivered by the attached SATA device after a link reset sequence (see ATA/ATAPI-7 V3 and SATAII-EXT). For a native STP target port in an end device, this is directly provided.

The FIS contents shall be stored with little-endian byte ordering (i.e., the first byte, byte 24, contains the FIS Type).

For an STP/SATA bridge, the first byte of the field (i.e., the FIS Type) shall be initialized to zero on power on and whenever the phy has restarted the link reset sequence after losing dword synchronization (see 6.9)(i.e., the SP state machine transitioned from SP15:SAS_PHY_Ready or SP22:SATA_PHY_Ready to SP0:OOB_COMINIT (see 6.8)) to indicate the field is invalid and the attached SATA device has not delivered a Register – Device to Host FIS. The first byte of the field shall be set to 34h when the attached SATA device has delivered the initial Register – Device to Host FIS. The remaining contents of the REGISTER DEVICE TO HOST FIS field shall remain constant until a link reset sequence causes the attached SATA device to deliver another initial Register – Device to Host FIS.

An STP/SATA bridge that receives a connection request for a SATA device that has not successfully delivered the initial Register – Device to Host FIS shall return an OPEN_REJECT (NO DESTINATION).

NOTE 4 - If there is a problem receiving the expected initial Register - Device to Host FIS, the STP/SATA bridge should use SATA_R_ERR to retry until it succeeds. In the DISCOVER response, the ATTACHED SATA DEVICE bit is set to one and the ATTACHED SAS ADDRESS field is valid, but the ATTACHED DEVICE TYPE field is set to 000b (i.e., no device attached) during this time.

The STP BUS INACTIVITY TIME LIMIT field contains the bus inactivity time limit for STP connections set by the PHY CONTROL function (see 10.4.3.10).

The STP MAXIMUM CONNECT TIME LIMIT field contains the maximum connect time limit for STP connections set by the PHY CONTROL function (see 10.4.3.10).

The AFFILIATED STP INITIATOR SAS ADDRESS field contains the SAS address (see 4.2.2) of the STP initiator port that currently has an affiliation with the STP target port that contains the specified phy.

The STP I_T NEXUS LOSS TIME field contains the time that an STP target port retries certain connection requests set by the PHY CONTROL function (see 10.4.3.10).

The CRC field is defined in 10.4.3.2.

10.4.3.10 PHY CONTROL function

The PHY CONTROL function requests actions by the specified phy. This SMP function may be implemented by any SMP target port.

Table 7 defines the request format.

Table 7 — PHY CONTROL request

Byte\Bit	7	6	5	4	3	2	1	0
0	SMP FRAME TYPE (40h)							
1	FUNCTION (91h)							
2	Reserved							
8								
9	PHY IDENTIFIER							
10	PHY OPERATION							
11	Reserved				UPDATE STP I_T NEXUS LOSS TIME	UPDATE STP MAXIMUM CONNECT TIME LIMIT	UPDATE STP BUS INACTIVITY TIME LIMIT	UPDATE PARTIAL PATHWAY TIMEOUT VALUE
12	Reserved							
15								
16	(MSB) STP BUS INACTIVITY TIME LIMIT							
17								(LSB)
18	(MSB) STP MAXIMUM CONNECT TIME LIMIT							
19								(LSB)
20	(MSB) STP I_T NEXUS LOSS TIME							
21								(LSB)
22	Reserved							
31								
32	PROGRAMMED MINIMUM PHYSICAL LINK RATE				Reserved			
33	PROGRAMMED MAXIMUM PHYSICAL LINK RATE				Reserved			
34	Reserved							
35								
36	Reserved				PARTIAL PATHWAY TIMEOUT VALUE			
37	Reserved							
39								
40	(MSB) CRC							
43								(LSB)

> Editor's Note 16: There are enough reserved fields in this function to avoid expanding the size. However, they may not be best as per-phy fields.

The SMP FRAME TYPE field shall be set to 40h.

The FUNCTION field shall be set to 91h.

The PHY IDENTIFIER field specifies the phy (see 4.2.7) to which the PHY CONTROL request applies.

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An UPDATE PARTIAL PATHWAY TIMEOUT VALUE bit set to one specifies that the PARTIAL PATHWAY TIMEOUT VALUE field shall be honored. An UPDATE PARTIAL PATHWAY TIMEOUT VALUE bit set to zero specifies that the PARTIAL PATHWAY TIMEOUT VALUE field shall be ignored.

An UPDATE STP BUS INACTIVITY TIME LIMIT bit set to one specifies that the STP BUS INACTIVITY TIME LIMIT field shall be honored. An UPDATE STP BUS INACTIVITY TIME LIMIT bit set to zero specifies that the STP BUS INACTIVITY TIME LIMIT field shall be ignored.

An UPDATE STP MAXIMUM CONNECT TIME LIMIT bit set to one specifies that the STP MAXIMUM CONNECT TIME LIMIT field shall be honored. An UPDATE STP MAXIMUM CONNECT TIME LIMIT bit set to zero specifies that the STP MAXIMUM CONNECT TIME LIMIT field shall be ignored.

An UPDATE STP I_T NEXUS LOSS TIME bit set to one specifies that the STP I_T NEXUS LOSS TIME field shall be honored. An UPDATE STP I_T NEXUS LOSS TIME bit set to zero specifies that the STP I_T NEXUS LOSS TIME field shall be ignored.

The STP BUS INACTIVITY TIME LIMIT field contains the maximum period that an STP target port is permitted to maintain a connection (see 4.1.10) without transferring a frame to the STP initiator port. This value shall be the number of 100 μs increments between frames that the STP target port transmits during a connection. When this number is exceeded, the STP target port shall close the connection. A value of zero in this field specifies that there is no bus inactivity time limit. This value is reported in the REPORT PHY SATA function (see 10.4.3.7). The bus inactivity time limit is enforced by the port layer (see 8.2.3).

The STP MAXIMUM CONNECT TIME LIMIT field contains the maximum duration of a connection (see 4.1.10). This value shall be the number of 100 μs increments that an STP target port transmits during a connection after which the STP target port shall connection at the next opportunity (e.g., a value of one in this field means that the time is less than or equal to 100 μs and a value of two in this field means that the time is less than or equal to 200 μs). If an STP target port is transferring a frame when the maximum connection time limit is exceeded, the STP target port shall complete transfer of the frame before closing the connection. A value of zero in this field specifies that there is no maximum connection time limit. This value is reported in the REPORT PHY SATA function (see 10.4.3.7). The maximum connection time limit is enforced by the port layer (see 8.2.3).

The STP I_T NEXUS LOSS TIME field contains the time that an STP target port shall retry connection requests to an STP initiator port that are rejected with responses indicating the STP initiator port may no longer be present (see 8.2.2) before recognizing an I_T nexus loss (see 4.5). Table 8 defines the values of the STP I_T NEXUS LOSS TIME field. If this mode page is not implemented, the I_T nexus loss time is vendor specific. This value is enforced by the port layer (see 8.2.2).

Table 8 — STP I_T NEXUS LOSS TIME **field**

Code	Description
0000h	Vendor-specific amount of time.
0001h to FFFEh	Time in milliseconds.
FFFFh	The STP target port shall never recognize an I_T nexus loss (i.e., it shall retry the connection requests forever).

NOTE 5 - The default value of the STP I_T NEXUS LOSS TIME field should be non-zero. It is recommended that this value be 2 000 ms.

NOTE 6 - An STP initiator port should retry connection requests for the time indicated by the I_T NEXUS LOSS field in the SMP TBD function for the STP target port to which it is trying to establish a connection (see 4.5). SSP initiator ports and target ports use the value in the I_T NEXUS LOSS TIME field in the Disconnect-Reconnect mode page (see 10.2.7.2.2). SMP initiator ports use a fixed value (see 8.2.2).

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The PROGRAMMED MINIMUM PHYSICAL LINK RATE field specifies the minimum physical link rate the phy shall support during a link reset sequence (see 4.4.1). Table 9 defines the values for this field. If this field is changed along with a phy operation of LINK RESET or HARD RESET, that phy operation shall utilize the new value for this field. This value is reported in the DISCOVER function (see 10.4.3.5).

The PROGRAMMED MAXIMUM PHYSICAL LINK RATE field specifies the maximum physical link rates the phy shall support during a link reset sequence (see 4.4.1).Table 9 defines the values for this field. If this field is changed along with a phy operation of LINK RESET or HARD RESET, that phy operation shall utilize the new value for this field. This value is reported in the DISCOVER function (see 10.4.3.5).

Table 9 — PROGRAMMED MINIMUM PHYSICAL LINK RATE **and** PROGRAMMED MAXIMUM PHYSICAL LINK RATE **fields**

Code	Description
0h	Do not change current value
8h	1,5 Gbps
9h	3,0 Gbps
All others	Reserved

If the PROGRAMMED MINIMUM PHYSICAL LINK RATE field or the PROGRAMMED MAXIMUM PHYSICAL LINK RATE field is set to an unsupported or reserved value, or the PROGRAMMED MINIMUM PHYSICAL LINK RATE field and PROGRAMMED MAXIMUM PHYSICAL LINK RATE field are set to an invalid combination of values (e.g., the minimum is greater than the maximum), the SMP target port shall not change either of their values and may return a function result of SMP FUNCTION FAILED in the response frame. If it returns a function result of SMP FUNCTION FAILED, it shall not perform the requested phy operation.

The PARTIAL PATHWAY TIMEOUT VALUE field specifies the amount of time in microseconds the expander phy shall wait after receiving an Arbitrating (Blocked On Partial) confirmation from the ECM before requesting that the ECM resolve pathway blockage (see 7.12.4.6). A PARTIAL PATHWAY TIMEOUT VALUE field value of zero (i.e., 0 μs) specifies that partial pathway resolution shall be requested by the expander phy immediately upon reception of an Arbitrating (Blocked On Partial) confirmation from the ECM. The PARTIAL PATHWAY TIMEOUT VALUE field is only honored when the UPDATE PARTIAL PATHWAY TIMEOUT VALUE bit is set to one. This value is reported in the DISCOVER function (see 10.4.3.5).