Date: November 4, 2007

To: T10 Committee

From Brad Besmer, LSI

Subject: SAS-2 PHY CHANGE COUNT increment due to zoning changes

## Overview

## Background

The DISCOVER process needs to know that phy specific zoning changes have occurred. The SAS-2 specification already indicates that a Broadcast (Change) is sent upon completion of the Unlock step, but there is no indication on a per-phy basis which phy(s) may have changed.

# **SAS-2** Changes

# 7.11 SAS domain changes (Broadcast (Change) usage)

After power on or receiving Broadcast (Change) via an SMP initiator port, the management application client should scan the SAS domain using the discover process (see 4.7) to search for SAS initiator devices, SAS target devices, and expander devices.

The expander device shall originate Broadcast (Change) from at least one phy in each expander port other than the expander port that is the cause for originating Broadcast (Change).

Expander devices shall originate Broadcast (Change) for the following expander phy-related reasons:

a) after an expander phy's SP state machine transitions from the SP15:SAS\_PHY\_Ready or SP22:SATA\_PHY\_Ready state to the SP0:OOB\_COMINIT state (see 6.8);

NOTE 1 - This occurs when the expander phy is reset or disabled with the SMP PHY CONTROL function DISABLE, LINK RESET, HARD RESET, or TRANSMIT SATA PORT SELECTION SIGNAL phy operations (see 10.4.3.28) as well as when dword synchronization is unexpectedly lost;

- b) after a virtual phy has been disabled with the SMP PHY CONTROL function DISABLE phy operation or started processing a reset requested by the LINK RESET or HARD RESET phy operations (see 10.4.3.28);
- c) after an expander phy's SP state machine reaches the SP26:SATA\_SpinupHold state and sends a SATA Spinup Hold confirmation as defined in 6.8.7and 6.11;
- d) after an expander phy's SP state machine receives a COMWAKE Detected message in states SP0:OOB\_COMINIT, SP1:OOB\_AwaitCOMX, SP3:OOB\_AwaitCOMINIT\_Sent, or SP4:OOB\_COMSAS if the ATTACHED SATA PORT SELECTOR bit is set to zero in the SMP DISCOVER response (see 10.4.3.9) prior to receiving the COMWAKE detected message (see 6.8.3 and table 342 in 10.4.3.9);
- e) after an expander phy's SP state machine transitions from the SP1:OOB\_AwaitCOMX state to the SP0:OOB\_COMINIT state if the ATTACHED SATA PORT SELECTOR bit was set to one in the SMP DISCOVER response upon entry to SP1:OOB\_AwaitCOMX, and if no COMWAKE detected message was received while in SP1:OOB\_AwaitCOMX before the transition to SP0:OOB\_COMINIT (see 6.8.3.3.2);
- f) after an expander phy completes the link reset sequence (see 7.9);
- g) after a virtual phy has been enabled or completed processing a reset requested by the SMP PHY CONTROL function LINK RESET or HARD RESET phy operations (see 10.4.3.28); and
- h) after an STP/SATA bridge receives an initial Register Device to host FIS (see 9.3.1).

In zoning expander devices with zoning enabled, forwarding Broadcasts is subject to restrictions defined in 4.9.5.

In zoning expander devices with zoning enabled, a Broadcast (Change) for an expander phy-related reason shall be originated from the source zone group of the expander phy causing the Broadcast (Change) or from zone group 1.

Expander devices shall originate Broadcast (Change) for the following expander device-related reasons:

- after a self-configuring expander device has changed its CONFIGURING bit from one to zero in the SMP REPORT GENERAL response (see 10.4.3.3) as described in 4.7.2. In zoning expander devices with zoning enabled, the source zone group shall be 01h;
- b) after a locked expander device is unlocked (see 4.9.6.5 and 10.4.3.23), with the source zone group as specified in 4.9.6.5 and 10.4.3.23.

Expander devices shall forward Broadcast (Change) for the following reasons:

a) after an expander phy receives Broadcast (Change).

For a virtual phy, if there is any time after a reset is originated during which connection requests to the attached SAS address result in connection responses of OPEN\_REJECT (NO DESTINATION), the expander device shall originate the Broadcast (Change) twice, once at the start of the reset (i.e., when the SAS address becomes unavailable) and once at its completion (i.e., when the SAS address becomes available). If there is no such time window, the expander device shall originate the Broadcast (Change) twice at the Broadcast (Change) once.

SAS initiator ports may originate Broadcast (Change) to force other SAS initiator ports and expander ports to re-run the discover process, but should not be sent by SAS target ports.

A SAS initiator port that receives Broadcast (Change) shall follow the SAS initiator device rules (see 7.9.2) to discover and configure the topology.

An expander device that receives Broadcast (Change) shall follow the expander device rules (see 7.9.3) to discover and configure the topology.

See 10.4.3.3 for details on counting Broadcast (Change) origination in an expander device.

#### 10.4.3.9 DISCOVER function

The DISCOVER function returns information about the specified phy. This SMP function provides information from the IDENTIFY address frame received by the phy and additional phy-specific information. This SMP function shall be implemented by all management device servers.

NOTE 2 - The DISCOVER LIST function (see 10.4.3.15) returns information about one or more phys.

Table 1 defines the request format.

Byte\Bit	7	6	5	4	3	2	1	0
0		SMP FRAME TYPE (40h)						
1		FUNCTION (10h)						
2		Reserved						
3		REQUEST LENGTH (02h)						
4				Poso	nved			
7								
8				Reserved				IGNORE ZONE GROUP
9				PHY IDE	NTIFIER			
10				Poso	nved			
11				TC3C	iveu			
12	(MSB)				C			
15				Cr	0			(LSB)

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

The FUNCTION field shall be set to 10h.

The REQUEST LENGTH field shall be set to 02h. For compatibility with previous versions of this standard, a REQUEST LENGTH field set to 00h specifies that there are 2 dwords before the CRC field.

An IGNORE ZONE GROUP bit set to one specifies that the management device server shall return information about the specified phy (i.e., the phy specified by the PHY IDENTIFIER field) regardless of the zone permission table.

An IGNORE ZONE GROUP bit set to zero specifies that the management device server shall:

- a) if the SMP initiator port has access to the specified phy based on the zone permission table, return the requested information; and
- b) if the SMP initiator port does not have access to the specified phy, return a function result of PHY VACANT in the response frame (see table 315 in 10.4.3.2).

If the management device server is not in a zoning expander device with zoning enabled, it shall ignore the IGNORE ZONE GROUP bit.

The PHY IDENTIFIER field specifies the phy (see 4.2.8) for which the information is being requested.

The CRC field is defined in 10.4.3.1.

Table 2 defines the response format.

Table 2 — DISCOVER response (part 1 01 3)	Table 2 —	DISCOVER	response	(part 1	of 3)
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Byte\Bit	7	6	5	4	3	2	1	0		
0		SMP FRAME TYPE (41h)								
1				FUNCT	on (10h)					
2				FUNCTIO	ON RESULT					
3				RESPONSE	LENGTH (1A	h)				
4	(MSB)					т				
5		(LSB)								
6		Reserved								
8										
9				PHY ID	ENTIFIER					
10				Rese	rved					
11										
12	Reserved	ATTA	ACHED DEVICE	TYPE						
13		Res	erved		N	EGOTIATED LO	OGICAL LINK F	RATE		
14	Reserved			ATTACHED SSP INITIATOR	ATTACHED STP INITIATOR	ATTACHED SMP INITIATOR	ATTACHED SATA HOST			
15	ATTACHED SATA Reserved PORT SELECTOR				ATTACHED SSP TARGET	ATTACHED STP TARGET	ATTACHED SMP TARGET	ATTACHED SATA DEVICE		
16										
23	SAS ADDRESS									
24	ATTACHED SAS ADDRESS									
31										
32			/	ATTACHED PH	Y IDENTIFIEF	۶				
33			Reserved			ATTACHED INSIDE ZPSDS PERSISTENT	ATTACHED REQUESTED INSIDE ZPSDS	ATTACHED BREAK_REPLY CAPABLE		
34				Poco	nved		•			
39				Rese						
40	PROGRA		JM PHYSICAL	LINK RATE	HARD	VARE MINIMUN	M PHYSICAL L	INK RATE		
41	PROGRA	MMED MAXIM	UM PHYSICAL	LINK RATE	HARDV	VARE MAXIMUI	M PHYSICAL L	INK RATE		
42				PHY CHA						
43	VIRTUAL PHY		Reserved		PA	RTIAL PATHWA	AY TIMEOUT \	/ALUE		
44		Res	served			ROUTING	ATTRIBUTE			
45	Reserved	Reserved CONNECTOR TYPE								

Byte\Bit	7	6	5	4	3	2	1	0
46		CONNECTOR ELEMENT INDEX						
47				CONNECTOR	PHYSICAL LI	NK		
48		_		Rese	rved			
49								
50		Vendor specific						
51								
52		<u>.</u>		ATTACHED D	EVICE NAME			
59		1		1				
60	Reserved	REQUESTED INSIDE ZPSDS CHANGED BY EXPANDER	INSIDE ZPSDS PERSISTENT	REQUESTED INSIDE ZPSDS	Reserved	ZONE GROUP PERSISTENT	INSIDE ZPSDS	ZONING ENABLED
61		I	I	Deee	m vo d		I	I
62		-		Kese	iveu			
63				ZONE	GROUP			
64		SELF-CONFIGURATION STATUS						
65		SELF-CONFIGURATION LEVELS COMPLETED						
66				5				
67								
68								
75	SELF-CONFIGURATION SAS ADDRESS							
76								
79		PROGRAMMED PHY CAPABILITIES						
80								
83		-	Ĺ	URRENT PHY	CAPABILITIE	5		
84			۵.			.e		
87		-	~	TROILD FIT	CAPABILITIL	-0		
88				Rese	rved			
93		-		Rese				
94		REA	ASON		NE	GOTIATED PH	IYSICAL LINK	RATE
95			Res	erved			NEGOTIATED SSC	HARDWARE MUXING SUPPORTED

# Table 2 — DISCOVER response (part 2 of 3)

Byte\Bit	7	6	5	4	3	2	1	0
96	Reserved		DEFAULT INSIDE ZPSDS PERSISTENT	DEFAULT REQUESTED INSIDE ZPSDS	Reserved	DEFAULT ZONE GROUP PERSISTENT	Reserved	DEFAULT ZONING ENABLED
97		Reserved						
98				Res	erved			
99				DEFAULT 2	ZONE GROUF	)		
100	Res	served	SAVED INSIDE ZPSDS PERSISTENT	SAVED REQUESTED INSIDE ZPSDS	Reserved	SAVED ZONE GROUP PERSISTENT	Reserved	SAVED ZONING ENABLED
101		Reserved						
102		Reserved						
103		SAVED ZONE GROUP						
104	SHADOWSHADOWSHADOWINSIDEREQUESTEDZONEZPSDSINSIDEGROUPPERSISTENTZPSDSPERSISTENT				served			
105	Reserved							
106		Reserved						
107		SHADOW ZONE GROUP						
108	(MSB)	_		CR	C			
111								(LSB)

#### Table 2 — DISCOVER response (part 3 of 3)

Editor's Note 1: add an optional field indicating drive presence (if known)

Editor's Note 2: add a BAY NUMBER field next to CONNECTOR ELEMENT INDEX to continue moving key SES information about drive bays (slots) directly into SMP

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

The FUNCTION field shall be set to 10h.

The FUNCTION RESULT field is defined in 10.4.3.2.

The RESPONSE LENGTH field shall be set to 1Ah. For compatibility with previous versions of this standard, a RESPONSE LENGTH field set to 00h indicates that there are 12 dwords before the CRC field.

The EXPANDER CHANGE COUNT field is defined in the SMP REPORT GENERAL response (see 10.4.3.3).

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

The ATTACHED DEVICE TYPE field indicates the device type attached to this phy and is defined in table 3.

Code	Description
000b	No device attached
001b	SAS device or SATA device
010b	Expander device
011b	Expander device compliant with a previous version of this standard
All others	Reserved

Table	3 —	ATTACHED	DEVICE	TYPE	field
10010	•		DEVICE		

If the phy is a physical phy, the ATTACHED DEVICE TYPE field shall only be set to a value other than 000b after:

- a) if a SAS device or expander device is attached, after the identification sequence is complete;
- b) if a SATA phy is attached and the STP/SATA bridge does not retrieve IDENTIFY (PACKET) DEVICE data, after the STP/SATA bridge receives the initial Register Device to Host FIS; and
- c) if a SATA phy is attached and the STP/SATA bridge retrieves IDENTIFY (PACKET) DEVICE data, after the STP/SATA bridge receives IDENTIFY (PACKET) DEVICE data or it encounters a failure retrieving that data.

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 NEGOTIATED LOGICAL LINK RATE field is defined in table 4 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.

NEGOTIATED PHYSICAL LINK RATE field	Multiplexing	NEGOTIATED LOGICAL LINK RATE field
9b (i.e. G2)	Disabled	9h (i.e., 3 Gbps)
	Enabled	8h (i.e., 1,5 Gbps)
Ab (i.e. G3)	Disabled	Ah (i.e., 6 Gbps)
An (i.e., CC)	Enabled	9h (i.e., 3 Gbps)
All others	Any	Same as the NEGOTIATED LOGICAL LINK RATE field

 Table 4 — NEGOTIATED LOGICAL LINK RATE field

NOTE 3 - In previous versions of this standard that did not define multiplexing, the NEGOTIATED LOGICAL LINK RATE field was called the NEGOTIATED PHYSICAL LINK RATE field and the NEGOTIATED PHYSICAL LINK RATE field in byte 94 did not exist.

Editor's Note 3: There is interest in getting rid of G1, G2, and G3 and using 1,5 Gbps, 3 Gbps, and 6 Gbps throughout. That would affect the names of some of the above code values.

Table 5 defines the ATTACHED SATA PORT SELECTOR bit and the ATTACHED SATA DEVICE bit.

ATTACHED SATA PORT SELECTOR <b>bit</b> <b>value</b> <sup>a b d</sup>	ATTACHED SATA DEVICE <b>bit</b> <b>value</b> <sup>c d</sup>	Description
0	0	<ul> <li>Either:</li> <li>a) the phy is a virtual phy; or</li> <li>b) the phy is a physical phy, and neither a SATA port selector nor a SATA device is attached and ready on the selected phy.</li> </ul>
0	1	The phy is a physical phy and the attached phy is a SATA device phy. No SATA port selector is present (i.e., the SP state machine did not detect COMWAKE in response to the initial COMINIT, but sequenced through the normal (non-SATA port selector) SATA device OOB sequence).
1	0	<ul> <li>The phy is a physical phy, the attached phy is a SATA port selector host phy, and either:</li> <li>a) the attached phy is the inactive host phy, or</li> <li>b) the attached phy is the active host phy and a SATA device is either not present or not ready behind the SATA port selector</li> <li>(i.e., the SP state machine detected COMWAKE while waiting for COMINIT).</li> </ul>
1	1	The phy is a physical phy, the attached phy is a SATA port selector's active host phy and a SATA device is present behind the SATA port selector (i.e., the SP state machine detected COMWAKE while waiting for COMINIT, timed out waiting for COMSAS, and exchanged COMWAKE with an attached SATA device).
<ul> <li>The ATTAC UNKNOW</li> <li>Whenever (Change)(</li> <li>For the pu device.</li> <li>The ATTAC SP state m</li> </ul>	HED SATA PO N (i.e., 0h), I the ATTACHE see 7.11). rposes of the HED SATA PO nachine (see	RT SELECTOR bit is invalid if the NEGOTIATED LOGICAL LINK RATE field is set to DISABLED (i.e., 1h), or RESET_IN_PROGRESS (i.e., 5h). ED SATA PORT SELECTOR bit changes, the phy shall originate a Broadcast e ATTACHED SATA DEVICE bit, a SATA port selector is not considered a SATA RT SELECTOR bit and the ATTACHED SATA DEVICE bit are updated as specified in the 6.8).

 Table 5 — ATTACHED SATA PORT SELECTOR and ATTACHED SATA DEVICE bits

An ATTACHED SATA HOST bit set to one indicates a SATA host port is attached. An ATTACHED SATA HOST bit set to zero indicates a SATA host port is not attached.

NOTE 4 - Support for SATA hosts is outside the scope of this standard.

If a SAS phy reset sequence occurs (see 6.7.4)(i.e., one or more of the ATTACHED SSP INITIATOR PORT bit, ATTACHED STP INITIATOR PORT bit, the ATTACHED SMP INITIATOR PORT bit, the ATTACHED SSP TARGET PORT bit, the ATTACHED SMP INITIATOR PORT bit, the ATTACHED SSP TARGET PORT bit, and/or the ATTACHED SMP TARGET PORT bit is set to one), then the ATTACHED SATA PORT SELECTOR bit, the ATTACHED SATA DEVICE bit, and the ATTACHED SATA HOST bit shall each be set to zero.

An ATTACHED SSP INITIATOR PORT bit set to one indicates the attached phy supports an SSP initiator port. An ATTACHED SSP INITIATOR PORT bit set to zero indicates the attached phy does not support an SSP initiator port. If the phy is a physical phy, the ATTACHED SSP INITIATOR PORT bit indicates the value of the SSP INITIATOR PORT bit received in the IDENTIFY address frame (see 7.8.2) during the identification sequence.

An ATTACHED STP INITIATOR PORT bit set to one indicates the attached phy supports an STP initiator port. An ATTACHED STP INITIATOR PORT bit set to zero indicates the attached phy does not support an STP initiator port.

If the phy is a physical phy, the ATTACHED STP INITIATOR PORT bit indicates the value of the STP INITIATOR PORT bit received in the IDENTIFY address frame (see 7.8.2) during the identification sequence.

An ATTACHED SMP INITIATOR PORT bit set to one indicates the attached phy supports an SMP initiator port. An ATTACHED SMP INITIATOR PORT bit set to zero indicates the attached phy does not support an SMP initiator port. If the phy is a physical phy, the ATTACHED SMP INITIATOR PORT bit indicates the value of the SMP INITIATOR PORT bit received in the IDENTIFY address frame (see 7.8.2) during the identification sequence.

An ATTACHED SSP TARGET PORT bit set to one indicates the attached phy supports an SSP target port. An ATTACHED SSP TARGET PORT bit set to zero indicates the attached phy does not support an SSP target port. If the phy is a physical phy, the ATTACHED SSP TARGET PORT bit indicates the value of the SSP TARGET PORT bit received in the IDENTIFY address frame (see 7.8.2) during the identification sequence.

An ATTACHED STP TARGET PORT bit set to one indicates the attached phy supports an STP target port. An ATTACHED STP TARGET PORT bit set to zero indicates the attached phy does not support an STP target port. If the phy is a physical phy, the ATTACHED STP TARGET PORT bit indicates the value of the STP TARGET PORT bit received in the IDENTIFY address frame (see 7.8.2) during the identification sequence.

An ATTACHED SMP TARGET PORT bit set to one indicates the attached phy supports an SMP target port. An ATTACHED SMP TARGET PORT bit set to zero indicates the attached phy does not support an SMP target port. If the phy is a physical phy, the ATTACHED SMP TARGET PORT bit indicates the value of the SMP TARGET PORT bit received in the IDENTIFY address frame (see 7.8.2) during the identification sequence.

If the phy is a physical phy, the ATTACHED SSP INITIATOR PORT bit, ATTACHED STP INITIATOR PORT bit, ATTACHED SMP INITIATOR PORT bit, ATTACHED SSP TARGET PORT bit, ATTACHED SMP TARGET PORT bit, and ATTACHED SMP TARGET PORT bit shall be updated at the end of the identification sequence.

If a SATA phy reset sequence occurs (see 6.7.3)(i.e., the ATTACHED SATA PORT SELECTOR bit is set to one, the ATTACHED SATA DEVICE bit is set to one, or the ATTACHED SATA HOST bit is set to one), then the ATTACHED SSP INITIATOR PORT bit, ATTACHED STP INITIATOR PORT bit, ATTACHED STP TARGET PORT bit, ATTACHED SMP INITIATOR PORT bit, ATTACHED SSP TARGET PORT bit, ATTACHED STP TARGET PORT bit, and ATTACHED SMP TARGET PORT bit shall each be set to zero.

If the phy is an expander phy, the SAS ADDRESS field contains the SAS address of the expander device (see 4.2.4). If the phy is a SAS phy, the SAS ADDRESS field contains the SAS address of the SAS port (see 4.2.7). If the phy is a physical phy, the SAS ADDRESS field contains the value of the SAS ADDRESS field transmitted in the IDENTIFY address frame (see 7.8.2) during the identification sequence.

The ATTACHED SAS ADDRESS field is defined as follows:

- a) if the attached port is an expander port, the ATTACHED SAS ADDRESS field contains the SAS address of the attached expander device (see 4.2.4);
- b) if the attached port is a SAS port, the ATTACHED SAS ADDRESS field contains SAS address of the attached SAS port (see 4.2.7); and
- c) if the attached port is a SATA device port, the ATTACHED SAS ADDRESS field contains the SAS address of the STP/SATA bridge (see 4.6.2).

For a physical phy, the ATTACHED SAS ADDRESS field contains the value of the SAS ADDRESS field received in the IDENTIFY address frame (see 7.8.2) during the identification sequence, and shall be updated:

- a) after the identification sequence completes, if a SAS phy or expander phy is attached; or
- b) after the COMSAS Detect Timeout timer expires (see 6.8.3.9), if a SATA phy is attached.

An STP initiator port should not make a connection request to the attached SAS address until the ATTACHED DEVICE TYPE field is set to a value other than 000b (see table 3).

The ATTACHED PHY IDENTIFIER field is defined as follows:

- a) if the attached phy is a SAS phy, the ATTACHED PHY IDENTIFIER field contains the phy identifier of the attached SAS phy in the attached SAS device;
- b) if the attached phy is an expander phy, the ATTACHED PHY IDENTIFIER field contains the phy identifier (see 4.2.8) of the attached expander phy in the attached expander device; and
- c) if the attached phy is a SATA device phy, the ATTACHED PHY IDENTIFIER field contains 00h;

- d) if the attached phy is a SATA port selector phy and the expander device is able to determine the port of the SATA port selector to which it is attached, the ATTACHED PHY IDENTIFIER field contains 00h or 01h; and
- e) if the attached phy is a SATA port selector phy and the expander device is not able to determine the port of the SATA port selector to which it is attached, the ATTACHED PHY IDENTIFIER field contains 00h.

If the phy is a physical phy and the attached phy is a SAS phy or an expander phy, the ATTACHED PHY IDENTIFIER field contains the value of the PHY IDENTIFIER field received in the IDENTIFY address frame (see 7.8.2) during the identification sequence.

For a physical phy, the ATTACHED PHY IDENTIFIER field shall be updated:

- a) after the identification sequence completes, if a SAS phy or expander phy is attached; or
- b) after the COMSAS Detect Timeout timer expires (see 6.8.3.9), if a SATA phy is attached.

If the phy is a physical phy, the ATTACHED INSIDE ZPSDS PERSISTENT bit indicates the value of the INSIDE ZPSDS PERSISTENT bit received in the IDENTIFY address frame (see 7.8.2) from the attached phy during the identification sequence. If the phy is a virtual phy, the ATTACHED INSIDE ZPSDS PERSISTENT bit shall be set to zero.

If the phy is a physical phy, the ATTACHED REQUESTED INSIDE ZPSDS bit indicates the value of the REQUESTED INSIDE ZPSDS bit received in the IDENTIFY address frame (see 7.8.2) from the attached phy during the identification sequence. If the phy is a virtual phy, the ATTACHED REQUESTED INSIDE ZPSDS bit shall be set to zero.

If the phy is a physical phy, the ATTACHED BREAK\_REPLY CAPABLE bit indicates the value of the BREAK\_REPLY CAPABLE bit received in the IDENTIFY address frame (see 7.8.2) during the identification sequence. If a phy reset sequence occurs (see 6.7) then the ATTACHED BREAK\_REPLY CAPABLE bit shall be set to zero. If the phy is a virtual phy, the ATTACHED BREAK\_REPLY CAPABLE bit shall be set to zero.

The PROGRAMMED MINIMUM PHYSICAL LINK RATE field indicates the minimum physical link rate set by the PHY CONTROL function (see 10.4.3.28). The values are defined in table 6. The default value shall be the value of the HARDWARE MINIMUM PHYSICAL LINK RATE field.

The HARDWARE MINIMUM PHYSICAL LINK RATE field indicates the minimum physical link rate supported by the phy. The values are defined in table 7.

The PROGRAMMED MAXIMUM PHYSICAL LINK RATE field indicates the maximum physical link rate set by the PHY CONTROL function (see 10.4.3.28). The values are defined in table 6. The default value shall be the value of the HARDWARE MAXIMUM PHYSICAL LINK RATE field.

Code	Description
0h	Not programmable
1h - 7h	Reserved
8h	1,5 Gbps
9h	3 Gbps
Ah	6 Gbps
Bh - Fh	Reserved for future physical link rates

Table 6 — PROGRAMMED MINIMUM PHYSICAL LINK RATE and PROGRAMMED MAXIMUM PHYSICAL LINK rate fields

The HARDWARE MAXIMUM PHYSICAL LINK RATE field indicates the maximum physical link rate supported by the phy. The values are defined in table 7. If the phy is a virtual phy, this field should be set to the maximum physical link rate supported by the expander device.

Table 7 — HARDWARE MINIMUM PHYSICAL LINK RATE and HARDWARE MAXIMUM PHYSICAL LINK RATE fields

Code	Description
0h - 7h	Reserved
8h	1,5 Gbps
9h	3 Gbps
Ah	6 Gbps
Bh - Fh	Reserved for future physical link rates

The PHY CHANGE COUNT field counts the number of Broadcast (Change)s originated by an expander phy. Expander devices shall support this field. Other device types shall not support this field. This field shall be set to zero at power on. The expander device shall increment this field at least once when it originates a Broadcast (Change) for any reason described in 7.11 from the specified expander phy and shall not increment this field when forwarding a Broadcast (Change). The expander device shall increment this field at least once when it originates a broadcast (Change).

- a) it originates a Broadcast (Change) for any expander phy related reason described in 7.11 from the specified expander phy; or
- b) the zone phy information has changed for the specified expander phy after a locked expander device is unlocked,

and shall not increment this field when forwarding a Broadcast (Change).

After incrementing the PHY CHANGE COUNT field, the expander device is not required to increment the PHY CHANGE COUNT field again unless a DISCOVER response is transmitted. The PHY CHANGE COUNT field shall wrap to zero after the maximum value (i.e., FFh) has been reached.

NOTE 5 - Application clients that use the PHY CHANGE COUNT field should read it often enough to ensure that it does not increment a multiple of 256 times between reading the field.

A VIRTUAL PHY bit set to one indicates the phy is a virtual phy and is part of an internal port and the attached device is contained within the expander device. A VIRTUAL PHY bit set to zero indicates the phy is a physical phy and the attached device is not contained within the expander device.

The PARTIAL PATHWAY TIMEOUT VALUE field indicates the partial pathway timeout value in microseconds (see 7.12.4.4) set by the PHY CONTROL function (see 10.4.3.28).

NOTE 6 - The recommended default value for PARTIAL PATHWAY TIMEOUT VALUE is 7 µs.

The ROUTING ATTRIBUTE field indicates the routing attribute supported by the phy (see 4.6.7.1) and is defined in table 8.

Code	Name	Description
Oh	Direct routing attribute	Direct routing method for attached end devices. Attached expander devices are not supported on this phy.
1h	Subtractive routing attribute	Either: a) subtractive routing method for attached expander devices; or b) direct routing method for attached end devices.
2h	Table routing attribute	Either: a) table routing method for attached expander devices; or b) direct routing method for attached end devices.
All others	Reserved	

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The ROUTING ATTRIBUTE field shall not change based on the attached device type.

The CONNECTOR TYPE field indicates the type of connector used to access the phy, as reported by the enclosure services process for the enclosure (see the SAS Connector element in SES-2). A CONNECTOR TYPE field set to 00h indicates no connector information is available and that the CONNECTOR ELEMENT INDEX field and the CONNECTOR PHYSICAL LINK fields are invalid and shall be ignored.

The CONNECTOR ELEMENT INDEX indicates the element index of the SAS Connector element representing the connector used to access the phy, as reported by the enclosure services process for the enclosure (see the SAS Connector element in SES-2).

The CONNECTOR PHYSICAL LINK field indicates the physical link in the connector used to access the phy, as reported by the enclosure services process for the enclosure (see the SAS Connector element in SES-2).

The ATTACHED DEVICE NAME field is defined as follows:

- a) if the attached phy is an expander phy, the ATTACHED DEVICE NAME field contains the device name of the attached expander device (see 4.2.4);
- b) if the attached phy is a SAS phy, the ATTACHED DEVICE NAME field contains the device name of the attached SAS device (see 4.2.7); and
- c) if the attached phy is a SATA device phy, the ATTACHED DEVICE NAME field contains the world wide name of the SATA device (see 4.6.2) or 00000000 00000000h.

For physical phys, table 9 defines how the ATTACHED DEVICE NAME field is updated.

Condition	Update time	Value	
A SAS phy or expander phy is attached	Completion of the identification sequence	The management device server shall set this field to the DEVICE NAME field in the incoming IDENTIFY address frame (i.e., the attached expander device name or attached SAS device name (see 4.2.4))	
	Expiration of the COMSAS Detect Timeout timer (see 6.6.3)	The management device server shall set this field to 00000000 00000000h	
A SATA phy is attached	Reception of IDENTIFY (PACKET) DEVICE data from the SATA device <sup>a</sup>	<ul> <li>Either:</li> <li>a) if IDENTIFY (PACKET) DEVICE data word 255 (i.e., the Integrity word) is correct and words 108-111 (i.e., the World Wide Name field) are not set to zero, the management device server shall set this field to the world wide name indicated by words 108-111 according to table 12 in 4.2.5;</li> <li>b) if IDENTIFY (PACKET) DEVICE data word 255 (i.e., the Integrity word) is correct and words 108-111 (i.e., the World Wide Name) are set to zero, the management device server shall set this field to 0000000 00000000h; or</li> <li>c) if IDENTIFY (PACKET) DEVICE data word 255 (i.e., the Integrity word) is not correct, the management device server shall set this field to 0000000 0000000h;</li> </ul>	
	Processing a PHY CONTROL function SET ATTACHED DEVICE NAME phy operation	The management device server shall set this field to the value specified in the ATTACHED DEVICE NAME field in the PHY CONTROL request (see 10.4.3.28).	
<sup>a</sup> This row only applies if the expander device originates the IDENTIFY (PACKET) DEVICE command.			

 Table 9 — ATTACHED DEVICE NAME field

A REQUESTED INSIDE ZPSDS CHANGED BY EXPANDER bit set to one indicates that the zoning expander device set the REQUESTED INSIDE ZPSDS bit to zero in the zone phy information at the completion of the last link reset sequence. A REQUESTED INSIDE ZPSDS CHANGED BY EXPANDER bit set to zero indicates that the zoning expander device did not set the REQUESTED INSIDE ZPSDS bit to zero in the zone phy information at the completion of the last link reset sequence.

NOTE 7 - The zone manager may use the REQUESTED INSIDE ZPSDS CHANGED BY EXPANDER bit to determine why the REQUESTED INSIDE ZPSDS bit has changed in the DISCOVER response from the value to which it last set the bit.

The INSIDE ZPSDS PERSISTENT bit indicates the value of the INSIDE ZPSDS PERSISTENT bit in the zone phy information (see 4.9.3.1).

The REQUESTED INSIDE ZPSDS bit indicates the value of the REQUESTED INSIDE ZPSDS bit in the zone phy information (see 4.9.3.1).

The ZONE GROUP PERSISTENT bit indicates the value of the ZONE GROUP PERSISTENT bit in the zone phy information (see 4.9.3.1).

The INSIDE ZPSDS bit indicates the value of the INSIDE ZPSDS bit in the zone phy information (see 4.9.3.1).

A ZONING ENABLED bit set to one indicates that zoning is enabled in the expander device. A ZONING ENABLED bit set to zero indicates that zoning is disabled in the expander device.

The ZONE GROUP field indicates the value of the ZONE GROUP field in the zone phy information (see 4.9.3.1).

The SELF-CONFIGURATION STATUS field indicates the status of a self-configuring expander device pertaining to the specified phy and is defined in table 10.

Code	Description
00h	No status available
01h - FFh	As defined for the STATUS TYPE field in the self-configuration status descriptor in the REPORT SELF-CONFIGURATION STATUS response (see table 323 in 10.4.3.5)

Table 10 — SELF-CONFIGURATION S	STATUS	field
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The SELF-CONFIGURATION LEVELS COMPLETED field indicates the number of levels of expander devices beyond the expander port containing the specified phy for which the self-configuring expander device's management application client has completed the discover process and is defined in table 11.

Code	Description
00h	<ul> <li>The management application client:</li> <li>a) has not begun the discover process through the expander port containing the specified phy; or</li> <li>b) has not completed the discover process through the expander port containing the specified phy.</li> </ul>
01h	The management application client has completed discovery of the expander device attached to the expander port containing the specified phy (i.e., level 1).
02h	The management application client has completed discovery of the expander devices attached to the expander device attached to the expander port containing the specified phy (i.e., level 2).
FFh	The management application client has completed discovery of the expander devices attached at level 255.

Table 11 — SELF-CONFIGURATION LEVELS COMPLETED find	eld
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NOTE 8 - The self-configuration levels completed field does not reflect the level of externally configurable expander devices that the configuration subprocess updates to enable the discover process to proceed to higher levels.

The SELF-CONFIGURATION SAS ADDRESS field indicates the SAS address of the SMP target port to which the self-configuring expander device established a connection or attempted to establish a connection using the specified phy and resulted in the status indicated by the SELF-CONFIGURATION STATUS field.

The PROGRAMMED PHY CAPABILITIES field indicates the SNW-3 phy capabilities bits that are going to be transmitted in the next link reset sequence containing SNW-3 as defined in table 90 in 6.7.4.2.3.3.

The CURRENT PHY CAPABILITIES field indicates the outgoing SNW-3 phy capabilities bits transmitted in the last link reset sequence as defined in table 90 in 6.7.4.2.3.3. If the last link reset sequence did not include SNW-3 or was a SATA link reset sequence, the current phy capabilities field shall be set to zero.

The ATTACHED PHY CAPABILITIES field indicates the incoming SNW-3 phy capabilities bits received in the last SNW-3 as defined in table 90 in 6.7.4.2.3.3. If the last link reset sequence did not include SNW-3 or was a SATA link reset sequence, the attached phy capabilities field shall be set to zero.

The REASON field indicates the reason for the last reset of the phy. If the phy is a physical phy, the REASON field indicates the value of the REASON field transmitted 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 REASON field indicates the reason for the link reset sequence (see 7.8.2).

A NEGOTIATED SSC field set to one indicates that SSC is enabled (see 5.3.8). A NEGOTIATED SSC field set to zero indicates that SSC is disabled. The NEGOTIATED SSC field is only valid when the NEGOTIATED PHYSICAL LINK RATE field is greater than or equal to 8h.

The NEGOTIATED PHYSICAL LINK RATE field is defined in table 12. If the phy is a physical phy, this field indicates the physical link rate negotiated during the link reset sequence. If the phy is a virtual phy, this field should be set to the maximum physical link rate supported by the expander device. The negotiated physical link rate may be less than the programmed minimum physical link rate or greater than the programmed maximum physical link rates have been changed since the last link reset sequence.

SP state machine ResetStatus state machine variable	Code	Description	
UNKNOWN	0h	Phy is enabled; unknown physical link rate. <sup>a</sup>	
DISABLED	1h	Phy is disabled.	
PHY_RESET_ PROBLEM	2h	Phy is enabled; a phy reset problem occurred (see 6.7.4.2.4).	
SPINUP_HOLD	3h	Phy is enabled; detected a SATA device and entered the SATA spinup hold state. The SMP PHY CONTROL function (see 10.4.3.28) phy operations of LINK RESET and HARD RESET may be used to release the phy.	
PORT_ SELECTOR	4h	Phy is enabled; detected a SATA port selector. The physical link rate has not been negotiated since the last time the phy's SP state machine entered the SP0:OOB_COMINIT state. The SATA spinup hold state has not been entered since the last time the phy's SP state machine entered the SP0:OOB_COMINIT state. The value in this field may change to 3h, 8h, 9h, or Ah if attached to the active phy of the SATA port selector. Presence of a SATA port selector is indicated by the ATTACHED SATA PORT SELECTOR bit (see table 5).	
RESET_ IN_ PROGRESS	5h	Phy is enabled; the expander phy is performing an SMP PHY CONTROL function (see 10.4.3.28) phy operation of LINK RESET or HARD RESET. This value is returned if the specified phy contained a value of 8h, 9h, or Ah in this field when an SMP PHY CONTROL function phy operation of LINK RESET or HARD RESET phy operation is processed.	
UNSUPPORTED_ PHY_ ATTACHED	6h	Phy is enabled; a phy is attached without any commonly supported settings.	
Reserved 7h Reserved		Reserved	
G1 8h Phy is er		Phy is enabled; 1,5 Gbps physical link rate.	
G2	9h	Phy is enabled; 3 Gbps physical link rate.	
G3	Ah	Phy is enabled; 6 Gbps physical link rate.	
Reserved	Bh - Fh	Phy is enabled; reserved for future logical or physical link rates.	
<sup>a</sup> This code may be used by an application client in its local data structures to indicate an unknown negotiated logical or physical link rate (e.g., before the discover process has queried the phy).			

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A HARDWARE MUXING SUPPORTED bit set to one indicates the phy supports multiplexing (see 6.10). A HARDWARE MUXING SUPPORTED bit set to zero indicates the phy does not support multiplexing. This value is not adjusted based on the negotiated physical link rate.

The DEFAULT INSIDE ZPSDS PERSISTENT bit contains the default value of the INSIDE ZPSDS PERSISTENT bit in the zone phy information (see 4.9.3.1).

The DEFAULT REQUESTED INSIDE ZPSDS bit contains the default value of the REQUESTED INSIDE ZPSDS bit in the zone phy information (see 4.9.3.1).

The DEFAULT ZONE GROUP PERSISTENT bit contains the default value of the ZONE GROUP PERSISTENT bit in the zone phy information (see 4.9.3.1).

The DEFAULT ZONING ENABLED bit contains the default value of the ZONING ENABLED bit (see 4.9.3.1).

The DEFAULT ZONE GROUP field contains the default value of the ZONE GROUP field in the zone phy information (see 4.9.3.1).

The SAVED INSIDE ZPSDS PERSISTENT bit contains the default value of the INSIDE ZPSDS PERSISTENT bit in the zone phy information (see 4.9.3.1).

The SAVED REQUESTED INSIDE ZPSDS bit contains the default value of the REQUESTED INSIDE ZPSDS bit in the zone phy information (see 4.9.3.1).

The SAVED ZONE GROUP PERSISTENT bit contains the default value of the ZONE GROUP PERSISTENT bit in the zone phy information (see 4.9.3.1).

The SAVED ZONING ENABLED bit contains the default value of the ZONING ENABLED bit (see 4.9.3.1).

The SAVED ZONE GROUP field contains the default value of the ZONE GROUP field in the zone phy information (see 4.9.3.1).

The SHADOW INSIDE ZPSDS PERSISTENT bit contains the default value of the INSIDE ZPSDS PERSISTENT bit in the zone phy information (see 4.9.3.1).

The SHADOW REQUESTED INSIDE ZPSDS bit contains the default value of the REQUESTED INSIDE ZPSDS bit in the zone phy information (see 4.9.3.1).

The SHADOW ZONE GROUP PERSISTENT bit contains the default value of the ZONE GROUP PERSISTENT bit in the zone phy information (see 4.9.3.1).

The SHADOW ZONING ENABLED bit contains the default value of the ZONING ENABLED bit (see 4.9.3.1).

The SHADOW ZONE GROUP field contains the default value of the ZONE GROUP field in the zone phy information (see 4.9.3.1).

The CRC field is defined in 10.4.3.2.