

To: T10 Technical Committee  
From: Rob Elliott, HP (elliott@hp.com)  
Date: 13 January 2005  
Subject: 04-374r2 SES-2 Define a SAS Expander element

### **Revision history**

Revision 0 (7 November 2004) First revision

Revision 1 (8 December 2004) Incorporated comments from November SAS and CAP WGs.

Revision 2 (13 January 2005) Incorporated comments from Kevin Marks, Dell - added support for SATA drives being represented by Device/Array Device elements (possibly with SATA port selectors).

### **Related documents**

ses2r09 - SCSI Enclosure Services - 2 revision 9

sas1r06 - Serial Attached SCSI - 1.1 revision 6

### **Overview**

SAS expanders are not SCSI devices (although some might contain an embedded SCSI target port to provide access to an SES logical unit). This means that Device elements or Array Device elements are not really appropriate ways to represent them in SES. Without representation, though, software is unable to determine the enclosure in which each expander device (discovered with the SMP protocol) is located. If it determines that all the devices attached to an expander are in a certain enclosure, then it might assume that expander is also in that enclosure; however, that is not guaranteed (the expander could be outside in a separate box). The expander's embedded SES logical unit could be listed as a Device element (leading to its enclosure's identification) but not all expanders include SES logical units.

To determine which expanders are located in which enclosures, a new **SAS Expander** element is proposed. The Device Element Status diagnostic page is renamed the Additional Element Status diagnostic page and expanded to return information about SAS Expander elements in addition to returning that information about Device and Array Device elements.

In a dual-domain enclosure, the enclosure services process may or may not have access to information about expanders in the other domain, so elements for them may or may not be included. The RELATIVE ENCLOSURE SERVICE PROCESS IDENTIFIER and NUMBER OF ENCLOSURE SERVICE PROCESSES fields in the Configuration diagnostic page are the clues to decipher this and map the topology discovered via SMP to the information returned by the enclosure services process.

Additionally, a **SAS Connector** element is proposed to represent each connector (or specifically, which physically link in each connector) in the enclosure. The Additional Element Status diagnostic page descriptor for each SAS Expander element indicates the SAS Connector to which each phy is attached (if any), and the Device, Array Device, or SAS Expander element (if any) to which each phy is attached.

The following figure is an example of how the Configuration, Enclosure Status (elements), and Additional Element Status pages interact.

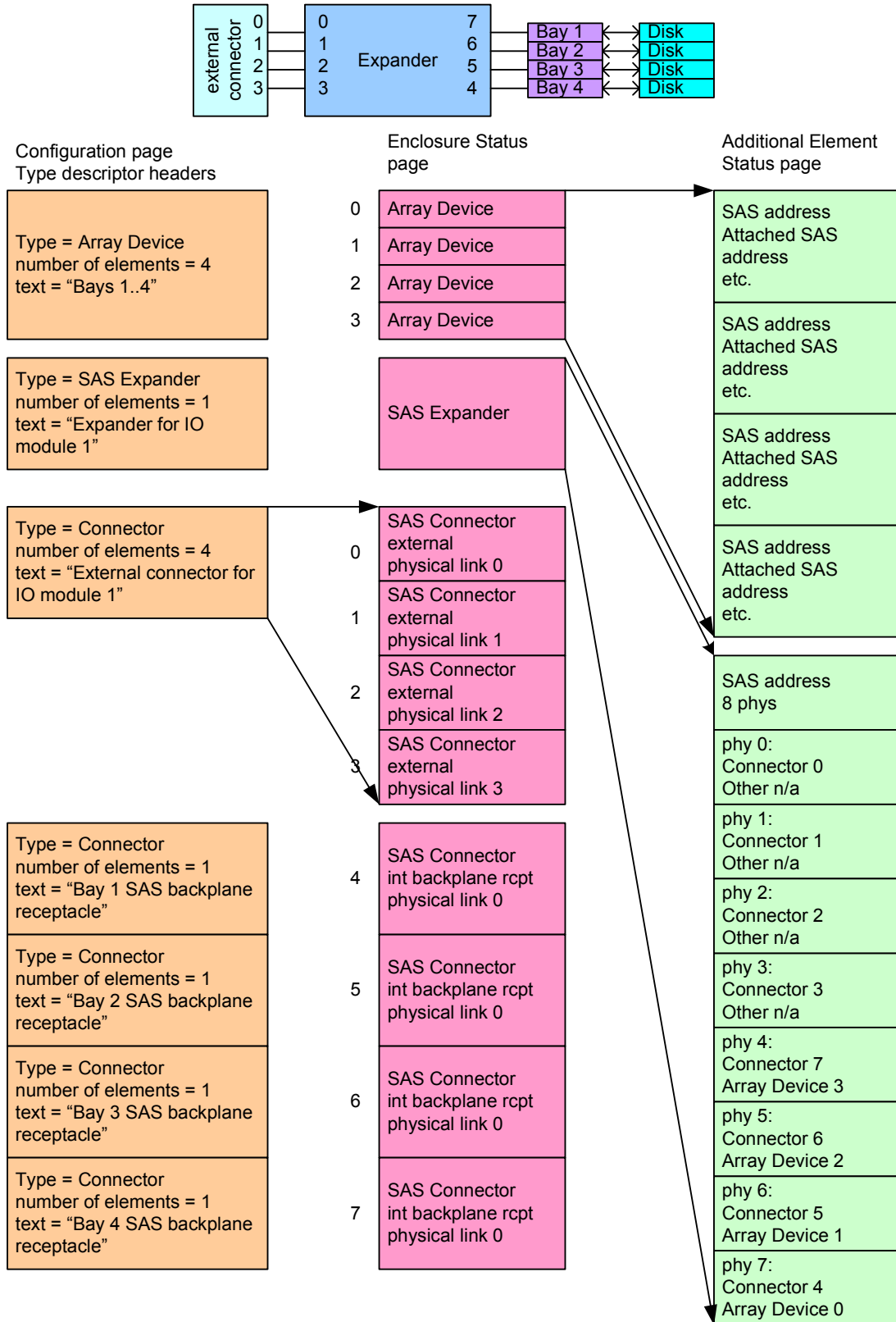


Figure 1 — Examples of diagnostic page contents

**Suggested changes**

### 6.1.13 Device [Additional Element Status diagnostic page](#)

#### 6.1.13.1 Device [Additional Element Status diagnostic page overview](#)

The optional [Device Additional Element Status diagnostic page](#) provides additional information about Device elements [and](#), Array Device elements, [and SAS Expander elements](#).

The [Device Additional Element Status diagnostic page](#) returns a device information descriptor for each of the Device elements [and](#), Array Device elements, [and SAS Expander elements](#) that have been allowed for by the NUMBER OF POSSIBLE ELEMENTS field [in the corresponding type descriptor header](#) in the Configuration diagnostic page. The device information descriptors shall be in the same order as the ELEMENT STATUS fields in the Enclosure Status diagnostic page.

The [Device Additional Element Status diagnostic page](#) is read by the RECEIVE DIAGNOSTIC RESULTS command with a PCV bit set to one and a PAGE CODE field set to 0Ah. If the parameter list for a SEND DIAGNOSTIC command contains a PAGE CODE field set to 0Ah, the command shall be treated as having an invalid field error (see 4.5).

Table 1 describes the [Device Additional Element Status diagnostic page](#).

**Table 1 — Additional Element Status diagnostic page**

Byte\Bit	7	6	5	4	3	2	1	0	
0	PAGE CODE (0Ah)								
1	Reserved								
2	(MSB)	PAGE LENGTH (n - 3)						(LSB)	
3									
4	(MSB)	GENERATION CODE						(LSB)	
7									
<a href="#">Device Additional Element Status descriptor list</a>									
8	Zero or more <a href="#">Device Additional Element Status descriptors</a> (see table 2)								
n									

The PAGE LENGTH field indicates the length in bytes of the diagnostic parameters that follow.

The format of the [Device Additional Element Status descriptor](#) is shown in table 2.

**Table 2 — Additional Element Status descriptor**

Byte\Bit	7	6	5	4	3	2	1	0
0	Reserved				PROTOCOL IDENTIFIER			
1	<a href="#">DEVICE ADDITIONAL ELEMENT STATUS DESCRIPTOR LENGTH</a> (n - 1)							
2	Protocol-specific information							
n								

The PROTOCOL IDENTIFIER field is defined in SPC-3 and identifies the protocol of the device being described by the [Device Additional Element Status descriptor](#).

The [DEVICE ADDITIONAL ELEMENT STATUS DESCRIPTOR LENGTH](#) field indicates the length in bytes of the protocol-specific information.

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[Editor's Note 1: the length field limits each descriptor to 256 bytes](#)

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### 6.1.13.2 ~~Fibre Channel Device~~ Additional Element Status descriptor for Fibre Channel

Table 3 describes the ~~Device~~ Additional Element Status descriptor for Fibre Channel devices.

**Table 3 — ~~Fibre Channel Device~~ Additional Element Status descriptor for Fibre Channel**

Byte\Bit	7	6	5	4	3	2	1	0
0	Reserved				PROTOCOL IDENTIFIER (0h)			
1	<del>DEVICE</del> <u>ADDITIONAL</u> ELEMENT STATUS DESCRIPTOR LENGTH (n - 1)							
2	NUMBER OF PORTS							
3	Reserved							
4	(MSB)	NODE NAME						(LSB)
11								
One port descriptor for each port								
12	PORT LOOP POSITION							
13	Reserved							
14	Reserved							
15	Reserved							
16	PORT REQUESTED HARD ADDRESS							
17	(MSB)	N_PORT IDENTIFIER						(LSB)
19								
20	(MSB)	N_PORT_NAME						(LSB)
27								
28 to n	...							

The PROTOCOL IDENTIFIER field of 0h indicates the descriptor is describing [a Device Element or an Array Device element that can contain a Fibre Channel SCSI ports device](#).

The ~~DEVICE~~ ADDITIONAL ELEMENT STATUS DESCRIPTOR LENGTH field indicates the length of the ~~Device~~ Additional Element Status descriptor.

The NUMBER OF PORTS field indicates how many ~~SCSI~~Fibre Channel ports are being described. There is one port descriptor for each port.

The NODE\_NAME field contains the node Name\_Identifier of the corresponding Fibre Channel node.

The PORT LOOP POSITION field indicates the position of the corresponding Fibre Channel port on a Fibre Channel Arbitrated Loop.

The PORT REQUESTED HARD ADDRESS field contains the Fibre Channel Arbitrated Loop requested hard address of the corresponding Fibre Channel port.

The N\_PORT IDENTIFIER field contains the address identifier of the corresponding Fibre Channel port. Applications may compare the lower 8 bits of this field with the PORT REQUESTED HARD ADDRESS field to determine whether the port was assigned its requested address.

The N\_PORT\_NAME field contains the Name\_Identifier of the corresponding Fibre Channel port.

### 6.1.13.3 Serial Attached SCSI ~~Device~~ Additional Element Status descriptor

#### [6.1.13.3.1 Serial Attached SCSI Additional Element Status descriptor overview](#)

[Table 4 describes the Additional Element Status descriptor for Serial Attached SCSI devices and expander devices.](#)

**Table 4 — SAS Additional Element Status descriptor [for SAS](#)**

Byte\Bit	7	6	5	4	3	2	1	0
0	Reserved				PROTOCOL IDENTIFIER (6h)			
1	ADDITIONAL ELEMENT STATUS DESCRIPTOR LENGTH (n - 1)							
2	Descriptor-type specific							
3	DESCRIPTOR TYPE		Descriptor-type specific					
25	Descriptor-type specific							
n	Descriptor-type specific							

The PROTOCOL IDENTIFIER field set to 6h indicates the descriptor is describing [a Device element or an Array Device Element that can contain a SAS device or a SATA device, or is describing a SAS Expander element.](#)

A DESCRIPTOR TYPE field set to 00b indicates the descriptor describes a Device element or an Array Device element (see 6.1.13.3.2). A DESCRIPTOR TYPE field set to 01b indicates the descriptor describes a SAS Expander element (see 6.1.13.3.3). A DESCRIPTOR TYPE field set to 10b or 11b is reserved.

#### **6.1.13.3.2 Additional Element Status descriptor for Device and Array Device elements for SAS**

Table 4 describes the [Device Additional Element Status descriptor](#) for ~~Serial Attached SCSI devices~~ Device elements and Array Device elements [that can contain SAS devices or SATA devices.](#)

**Table 5 — SAS Additional Element Status descriptor for Device and Array Device elements [for SAS](#)**

Byte\Bit	7	6	5	4	3	2	1	0
0	Reserved				PROTOCOL IDENTIFIER (6h)			
1	<del>DEVICE</del> <a href="#">ADDITIONAL</a> ELEMENT STATUS DESCRIPTOR LENGTH (n - 1)							
2	NUMBER OF PHY DESCRIPTORS							
3	<a href="#">DESCRIPTOR TYPE (00b)</a>		Reserved					NOT ALL PHYS
Phy descriptor list								
4	Phy descriptor (see table 6) (first)							
31	...							
n - 27	Phy descriptor (see table 6) (last)							
n	Phy descriptor (see table 6) (last)							

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[Editor's Note 2: there is room for 9 phy descriptors \(28x9=252\)](#)

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The PROTOCOL IDENTIFIER field set to 6h [and DESCRIPTOR TYPE field set to 00b](#) indicate the descriptor is describing [a Device element or an Array Device Element that can contain a SAS device or a SATA device](#)~~Serial Attached SCSI (SAS) ports.~~

The ~~DEVICE~~ [ADDITIONAL](#) ELEMENT STATUS DESCRIPTOR LENGTH field indicates the length in bytes of the rest of the [Device Additional Element Status descriptor](#).

The NUMBER OF PHY DESCRIPTORS field indicates how many phy descriptors ~~follow~~[are in the phy descriptor list.](#)

A NOT ALL PHYS bit set to one indicates that all phys in the SAS device or SATA device ~~are~~ may or may not be described. A NOT ALL PHYS bit set to zero indicates that all phys in the SAS device or SATA device are described.

NOTE 1 The NOT ALL PHYS bit may be set to one for SAS devices with multiple ports, where the enclosure services process only has access to information about the phys in one of the ports (e.g., in the same SAS domain as the enclosure services process).

Table 6 describes the phy descriptor.

**Table 6 — Phy descriptor**

Byte\Bit	7	6	5	4	3	2	1	0
0	Reserved	DEVICE TYPE			Reserved			
1	Reserved							
2	Reserved				SSP INITIATOR PORT	STP INITIATOR PORT	SMP INITIATOR PORT	Reserved
3	<del>Reserved</del> <u>SATA PORT SELECTOR</u>	Reserved			SSP TARGET PORT	STP TARGET PORT	SMP TARGET PORT	<del>Reserved</del> <u>SATA DEVICE</u>
4	ATTACHED SAS ADDRESS							
11	SAS ADDRESS							
12	SAS ADDRESS							
19	SAS ADDRESS							
20	PHY IDENTIFIER							
21	Reserved							
27	Reserved							

If the device currently associated with the Device element or Array Device element is a SAS device:

- a) ~~the~~ **The** DEVICE TYPE field, SSP INITIATOR PORT bit, STP INITIATOR PORT bit, SMP INITIATOR PORT bit, SSP TARGET PORT bit, STP TARGET PORT bit, SMP TARGET PORT bit, SAS ADDRESS field, and PHY IDENTIFIER field contain the values of the fields in the IDENTIFY address frame transmitted by the phy (see SAS);
- b) the SATA PORT SELECTOR bit shall be set to zero; and
- c) the SATA DEVICE bit shall be set to zero.

NOTE 2 - The phy transmits these fields in the IDENTIFY address frame to the attached phy (usually an expander phy in an expander device). The enclosure services process may retrieve the values from the attached phy (e.g., an enclosure process built into an expander device has direct access to the values received by the expander phy).

If the device currently associated with the Device element or Array Device element is a SATA device:

- a) the DEVICE TYPE field shall be set to 000b;
- b) the SSP INITIATOR PORT bit shall be set to zero;
- c) the STP INITIATOR PORT bit shall be set to zero;
- d) the SMP INITIATOR PORT bit shall be set to zero;
- e) the SSP TARGET PORT bit shall be set to zero;
- f) the STP TARGET PORT bit shall be set to zero;
- g) the SMP TARGET PORT bit shall be set to zero;
- h) the SATA PORT SELECTOR bit shall be set to one if the SATA device is attached to a SATA port selector and the SATA PORT SELECTOR bit shall be set to zero if it is not;

- i) [the SATA DEVICE bit shall be set to one:](#)
- j) [the SAS ADDRESS field shall be set to the SAS address of the STP target port of the STP/SATA bridge, and](#)
- k) [the PHY IDENTIFIER field shall be set to 00h.](#)

The ATTACHED SAS ADDRESS field contains the SAS address of the attached phy (e.g., [the SAS address of the expander phy to which the SAS device is attached](#))(see SAS).

NOTE 3 - All the fields are from the perspective of the SAS device [or SATA device](#) associated with the Device element [or Array Device element](#) (e.g., the disk drive), not the device (e.g., the expander device) which receives the IDENTIFY address frame. The ATTACHED SAS ADDRESS fields [for multiple phys in the same SAS device or SATA device differ](#) **indicate** if ~~a SAS device~~ [it](#) is attached to more than one SAS domain.

[NOTE 4 - A SATA device may be attached to more than one SAS domain using a SATA port selector.](#)

**[6.1.13.3 Additional Element Status descriptor for SAS Expander elements \[all new\]](#)**

[Table 7 describes the Additional Element Status descriptor for SAS Expander elements.](#)

**Table 7 — Additional Element Status descriptor for SAS Expander elements**

Byte\Bit	7	6	5	4	3	2	1	0
0	Reserved				PROTOCOL IDENTIFIER (6h)			
1	ADDITIONAL ELEMENT STATUS DESCRIPTOR LENGTH (n - 1)							
2	NUMBER OF EXPANDER PHY DESCRIPTORS							
3	<a href="#">DESCRIPTOR TYPE (01b)</a>		Reserved					
4	SAS ADDRESS							
11								
Expander phy descriptor list								
12	Expander phy descriptor (see table 8) (first)							
	...							
n	Expander phy descriptor (see table 8) (last)							

[The PROTOCOL IDENTIFIER field set to 6h and DESCRIPTOR TYPE field set to 01b indicate the descriptor is describing a SAS Expander element.](#)

[The ADDITIONAL ELEMENT STATUS DESCRIPTOR LENGTH field indicates the length in bytes of the rest of the Additional Element Status descriptor.](#)

[The NUMBER OF EXPANDER PHY DESCRIPTORS field indicates how many expander phy descriptors are in the phy descriptor list.](#)

[The SAS ADDRESS field indicates the SAS address of the expander device \(see SAS\).](#)

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Editor’s Note 3: there is room for 122 expander phy descriptors

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[Table 8 describes the expander phy descriptor.](#)

**Table 8 — Expander phy descriptor**

Byte\Bit	7	6	5	4	3	2	1	0
0	CONNECTOR ELEMENT INDEX							
1	OTHER ELEMENT INDEX							

[The CONNECTOR ELEMENT INDEX field indicates the index of a Connector element to which the expander phy is attached. If the expander phy is not attached to a connector represented by a Connector element, this field shall be set to FFh.](#)

[The OTHER ELEMENT INDEX field indicates the index of a Device element, Array Device element, or SAS Expander element to which the expander phy is attached. If the expander phy is not attached to one of those elements, this field shall be set to FFh.](#)

### 7.1 Element definitions overview

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Table 9 lists the elements and their ELEMENT TYPE codes, and indicates which elements accept the DISABLE bit (see 7.2.2) in their control field, and which elements contain a value subject to comparison with a threshold.



Table 9 — Element type codes

Type code	Type of element	DISABLE bit reference	Threshold	Reference
00h	Unspecified	not defined	none	7.3.1
01h	Device	not defined	none	7.3.2
02h	Power Supply	not defined	none	7.3.4
03h	Cooling	not defined	none	7.3.5
04h	Temperature Sensor	7.3.6	temperature	7.3.6
05h	Door Lock	not defined	none	7.3.7
06h	Audible Alarm	not defined	none	7.3.8
07h	Enclosure Services Controller Electronics	not defined	none	7.3.9
08h	SCC Controller Electronics	not defined	none	0.0.1
09h	Nonvolatile Cache	not defined	none	7.3.11
0Ah	Invalid Operation Reason	not defined	none	7.3.12
0Bh	Uninterruptible Power Supply	not defined	battery status	7.3.13
0Ch	Display	not defined	none	7.3.14
0Dh	Key Pad Entry	not defined	none	7.3.15
0Eh	Enclosure	not defined	none	7.3.16
0Fh	SCSI Port/Transceiver	not defined	none	7.3.17
10h	Language	not defined	none	7.3.18
11h	Communication Port	not defined	none	7.3.19
12h	Voltage Sensor	7.3.20	% voltage	7.3.20
13h	Current Sensor	7.3.21	% current	7.3.21
14h	SCSI Target Port	not defined	none	7.3.22
15h	SCSI Initiator Port	not defined	none	7.3.23
16h	Simple Subenclosure	not defined	none	7.3.24
17h	Array Device	not defined	none	7.3.3
<a href="#">18h</a>	<a href="#">SAS Expander</a>	<a href="#">not defined</a>	<a href="#">none</a>	<a href="#">7.3.xx</a>
<del>18h</del> <a href="#">19h</a> -7Fh	Reserved	reserved	reserved	
80h-FFh	Vendor-specific	vendor specific	vendor specific	

### 0.0.1 SAS Expander element [\[new\]](#)

The SAS Expander element represents a SAS expander device.

The format of the control field for a SAS Expander element is defined in table 10.

**Table 10 — SAS Expander element for control type diagnostic pages**

Byte\Bit	7	6	5	4	3	2	1	0
0	COMMON CONTROL							
1	RQST IDENT	Reserved						
2	Reserved							
3	Reserved							

The COMMON CONTROL field is specified in 7.2.2.

~~The RQST IDENT (request identify) bit is set to request that the element be identified by a visual indication. When the RQST IDENT bit is set to zero, the visual indication is not present.~~

[A RQST IDENT \(request identify\) bit set to one specifies that the enclosure services process identify the element by a visual indication. A RQST IDENT bit set to zero specifies that the enclosure services process not identify the element by a visual indication.](#)

[\[globally change the RQST IDENT paragraph in each control element to match\]](#)

The format of the status field for a SAS Expander element is defined in table 11.

**Table 11 — SAS Expander element for status type diagnostic pages**

Byte\Bit	7	6	5	4	3	2	1	0
0	COMMON STATUS							
1	IDENT	Reserved						
2	Reserved							
3	Reserved							

The COMMON STATUS field is specified in 7.2.3.

~~The IDENT (identify) bit is set to one to indicate that the RQST IDENT control bit has been set and that the element is providing a visual indication of its location. The IDENT bit is set to zero when the RQST IDENT control bit is set to zero or not implemented.~~

[An IDENT \(identify\) bit set to one indicates that the enclosure services process is currently identifying the element by a visual indication because the RQST IDENT bit was set to one in the control field. An IDENT bit set to zero indicates that the enclosure services process is not currently identifying the element by a visual indication based on the RQST IDENT bit in the control field, or a visual indication is not implemented.](#)

[\[globally change the IDENT paragraph in each status element to match\]](#)

### 0.0.2 SAS Connector element [\[new\]](#)

The SAS Connector element represents a SAS connector or a portion of a SAS connector.

The format of the control field for a SAS Connector element is defined in table 12.

**Table 12 — SAS Connector element for control type diagnostic pages**

Byte\Bit	7	6	5	4	3	2	1	0
0	COMMON CONTROL							
1	RQST IDENT	Reserved						
2	Reserved							
3	Reserved							

The COMMON CONTROL field is specified in 7.2.2.

The RQST IDENT (request identify) bit is set to request that the element be identified by a visual indication. When the RQST IDENT bit is set to zero, the visual indication is not present.

The format of the status field for a SAS Connector element is defined in table 13.

**Table 13 — SAS Connector element for status type diagnostic pages**

Byte\Bit	7	6	5	4	3	2	1	0
0	COMMON STATUS							
1	IDENT	CONNECTOR TYPE						
2	CONNECTOR PHYSICAL LINK							
3	Reserved							

The COMMON STATUS field is specified in 7.2.3.

The IDENT (identify) bit is set to one to indicate that the RQST IDENT control bit has been set and that the element is providing a visual indication of its location. The IDENT bit is set to zero when the RQST IDENT control bit is set to zero or not implemented.

The CONNECTOR TYPE field indicates the type of connector and is defined in table 14.

**Table 14 — CONNECTOR TYPE field**

Code	Description	Maximum number of physical links (informative)
00h	No information	unknown
01h	SAS external receptacle (i.e., SFF-8470)	4
02h to 0Fh	Reserved for external connectors	
10h	SAS internal wide plug (i.e., SFF-8484)	4
11h to 1Fh	Reserved for internal wide connectors	
20h	SAS backplane receptacle (i.e., SFF-8482)	2
21h	SATA-style host plug (i.e., ATA/ATAPI-7 V3)	1
22h	SAS plug (i.e., SFF-8482)	2
23h	SATA device plug (i.e., ATA/ATAPI-7 V3)	1
24h to 2Fh	Reserved for internal connectors to end devices	
30h to EFh	Reserved	
F0h to FFh	Vendor specific	

The CONNECTOR PHYSICAL LINK field indicates the physical link in the connector represented by this element. A CONNECTOR PHYSICAL LINK field set to FFh indicates that the element represents the entire connector, not just one physical link in the connector. If a connector has only one physical link, the CONNECTOR PHYSICAL LINK field should be set to 01h rather than FFh.