Exos AP 2U12

GEM 5 SES-3 Addenda

205135100-00-A
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Revision History

Revision	Date	Change Description
00-A	2023-03-30	Initial release

Table of Contents

1 Introduction

1.1 Scope

This document is provided as an extension to the GEM 5 SES-3 Specification to detail exact SES page layouts and specification deviations implemented by the Exos AP 2U12 12G SAS storage server product. It is a guide to inform both customers and product testers of the intended SES page structure a product variant provides.

This document is not intended to cover all specifics of SES implementation for the Seagate storage enclosure platform. For details on element/descriptor formats and behavior, the GEM 5 SES-3 Specification [3] and ANSI T-10 SES [1] should be referenced.

This document applies to the following enclosure product IDs.

- HB-1235-AP-BV-1
- SP-3212-AP-BV-1
- SP-3212A-AP-BV-1

1.2 Terms and Abbreviations

ANSI	American National Standards Institute
CDB	Command Descriptor Block
CLI	Command Line Interface
EEPROM	Electrically Erasable Programmable Read-Only Memory
EIIOE	Element Index Includes Overall Element
EIP	Element Index Present
EM	Enclosure Management
ESI	Enclosure Services Interface Processor
ESP	Enclosure Services Process
FRU	Field Replaceable Unit
GEM	Generic Enclosure Management
IOC	I/O Controller
IOM	I/O Module
LED	Light-Emitting Diode
LSB	Least Significant Bit
MSB	Most Significant Bit
NAA	Network Address Authority
PCM	Power Cooling Module
PSU	Power Supply Unit
RQST	Request
RSVD	Reserved
SAS	Serial Attached SCSI
SBB	Storage Bridge Bay
SBBMI	SBB Midplane Interconnect
SCSI	Small Computer System Interface
SCSN	Single Controller Shared Nothing
SEP	Storage Enclosure Processor
SES	SCSI Enclosure Services
SGPIO	Serial General Purpose I/O
TWI	Two Wire Interface
VPD	Vital Product Data
ZG	Zone Group
ZPSDS	Zoned Portion of the Service Delivery Subsystem
ZPT	Zone Permissions Table

Application client	An object that is the source of SCSI commands.
Attached ESP	An ESP that is attached to another device server.
Critical condition	An enclosure condition established when one or more elements inside the enclosure have failed or are operating outside of their specification. The failure of the element makes continued normal operation of at least some elements in the enclosure impossible. Some elements within the enclosure may be able to continue normal operation.
Information condition	An enclosure condition that should be made known to the application client. The condition is not an error and does not reduce the capabilities of the devices in the enclosure.
Noncritical condition	An enclosure condition established when one or more elements inside the enclosure have failed or are operating outside of their specifications. The failure of the elements does not affect continued normal operation of the enclosure. All SCSI devices in the enclosure continue to operate according to their specifications. The ability of the devices to operate correctly if additional failures occur may be reduced by a noncritical condition.
Standalone ESP	An ESP that is also the device server.
Subenclosure	An enclosure accessed through a primary subenclosure's ESP.
Unrecoverable condition	An enclosure condition established when one or more elements inside the enclosure have failed and have disabled some functions of the enclosure. The enclosure may be incapable of recovering or bypassing the failure and requires repairs to correct the condition.

1.3 Notation Conventions

<value>h	Indicates a hexadecimal number, e.g., *23h*
<value>	A value without leading zeroes and no suffix indicates a decimal number, e.g., *34.*
[option0, option1]	Indicates possible options for this field.
[valueX..valueY]	Indicates options range from valueX to valueY.
[defaultX: valueX..valueY]	Indicates the default value "defaultX", with possible alternatives.
[XX]	Indicates variable values.

1.4 References

[1] T-10 SES-3 Revision 6
[2] SCSI Primary Commands - 4 (SPC-4) Revision 36n
[3] GEM 5 ANSI SES-3 Specification
[4] SAS Protocol Layer - 3 (SPL-3) Revision 7

2 Supported ANSI SES-3 Pages and Elements

Table 1 lists the ANSI SES pages and Vendor Unique SES pages supported by the enclosure. Table 2 lists the ANSI and Vendor Specific SES elements supported by the enclosure.

Table 1 - Supported SES Pages

Page Code	Description	Control/Status
ANSI SES Pages		
00h	Supported Diagnostics Pages Diagnostic Page	Status
01h	Configuration Diagnostic Page	Status
02h	Enclosure Diagnostic Page	Control and Status
05h	Threshold Out Diagnostic Page	Control and Status
07h	Element Descriptor Diagnostic Page	Status
0Ah	Additional Element Status Diagnostic Page	Status
0Eh	Download Microcode Control Diagnostic Page	Control and Status
Vendor Specific Pages		
84h/85h	In-band CLI Control Page	Control and Status
90h	Customer VPD Control Page	Control and Status
91h	Statistics Page	Status
92h	Extended Status Page	Status

Table 2 - Supported SES Elements

Element Code	Description	Element count
ANSI SES Elements		
17h	Array Device	12
04h	Temperature Sensor	6
07h	Enclosure Services Controller Electronics	2
0Eh	Enclosure	1
18h	SAS Expander	2
19h	SAS Connector	8
Vendor Specific SES Elements		
86h	SBB Midplane Interconnect	2
89h	Enclosure Electronics Power	2
8Bh	Enclosure Electronics Diagnostics	2

3 Element to Device Mapping

3.1 Enclosure FRU Layout

The layout of the enclosure with respect to physical FRU location is as follows.

3.1.1 Enclosure Front View

Figure 1 - Drive Bay numbering convention

Drive 0	Drive 1	Drive 2	Drive 3
Drive 4	Drive 5	Drive 6	Drive 7
Drive 8	Drive 9	Drive 10	Drive 11

3.1.2 Enclosure Rear View

Figure 2 – Module Bay numbering convention

PCM 0	SBB Primary Interface (Inverted) (IOM A)	PCM 1
	SBB Secondary Interface (Normal) (IOM B)	

3.2 SES Element Mapping

For SES Pages 02h, 05h, 07h and 92h the element to physical device mappings are as follows.

Table 3 - SES Element Descriptions

Global Element Index	Relative Element Index	Description	Associated FRU
Array Device Elements			
0	0	Array Device element representing Disk Drive Bay 0	Enclosure
…	…	…	…
11	11	Array Device element representing Disk Drive Bay 11	Enclosure
Enclosure Services Controller Electronics Elements			
12	0	Element associated with SEP device	SBB IOM A
13	1	Element associated with SEP device	SBB IOM B
Enclosure Elements			
14	0	Element representing the Enclosure	Enclosure
SAS Expander Elements			
15	0	SBB IOM SAS Expander	SBB IOM A
16	1	SBB IOM SAS Expander	SBB IOM B
SAS Connector Elements			
17	0	SAS Connector for IOM MiniSAS HD Port A	SBB IOM A
18	1	SAS Connector for IOM MiniSAS HD Port B	SBB IOM A
19	2	Internal IOC Port A	SBB IOM A
20	3	Internal IOC Port B	SBB IOM A
21	4	SAS Connector for IOM MiniSAS HD Port A	SBB IOM B
22	5	SAS Connector for IOM MiniSAS HD Port B	SBB IOM B
23	6	Internal IOC Port A	SBB IOM B
24	7	Internal IOC Port B	SBB IOM B
SBB Midplane Interconnect Elements			
25	0	SBB IOM to Midplane Interconnect Electronics	SBB IOM A
26	1	SBB IOM to Midplane Interconnect Electronics	SBB IOM B
Enclosure Electronics Power Elements			
27	0	SBB IOM Power Status and Control	SBB IOM A
28	1	SBB IOM Power Status and Control	SBB IOM B
Enclosure Electronics Diagnostics Elements			
29	0	SEP Diagnostics status and Control	SBB IOM A
30	1	SEP Diagnostics status and Control	SBB IOM B

4 Diagnostic Page Layouts

4.1 Diagnostic Page 00h

Diagnostics Page 00h lists all SES pages supported by the SEP. The page 00h response reported by the documented product is shown in Table 4.

Table 4 - Diagnostic Page 00h Layout

Bit / Byte	7	6	5	4	3	2	1	0
0	PAGE CODE (**00h**)							
1	Reserved							
2	(MSB)	PAGE LENGTH (**12**)						
3								(LSB)
4		SUPPORTED PAGE LIST (**00 01 02 05 07 0A 0E 84 85 90 91 92 h**)						
15								

4.2 SES Page 01h

SES Page 01h provides information on enclosure identification and element layout in SES pages 02h, 05h, 07h and 92h. Table 5 covers the layout of Page 01h for the enclosure documented within this addendum.

Table 5 - SES Page 01h Layout

Bit / Byte	7	6	5	4	3	2	1	0
0	PAGE CODE (**01h**)							
1	NUMBER OF SECONDARY SUBENCLOSURES (**00h**)							
2	(MSB)	PAGE LENGTH (**185**)						
3								(LSB)
4	(MSB)	GENERATION CODE						
7								(LSB)
Enclosure Descriptor List[1]								
8	RSVD	RELATIVE ENCLOSURE SERVICES PROCESS ID (**1h**)			RSVD	NUMBER OF ENCLOSURE SERVICES PROCESSES (2**h**)		
9	SUBENCLOSURE IDENTIFIER (**00h**)							
10	NUMBER OF TYPE DESCRIPTOR HEADERS (**08h**)							
11	ENCLOSURE DESCRIPTOR LENGTH (**60**)							
12	ENCLOSURE LOGICAL IDENTIFIER (**Determined by Midplane VPD**)							
19								
20	ENCLOSURE VENDOR IDENTIFICATION (“**SEAGATE** ”)							

Bit Byte	7	6	5	4	3	2	1	0
27								
28	PRODUCT IDENTIFICATION (“**SP-3212-AP-BV-1** ” or “**SP-3212A-AP-BV-1**”)							
43								
44	PRODUCT REVISION LEVEL (**Determined by GEM firmware version**)							
47								
48	ENCLOSURE SERIAL NUMBER (**Determined by Midplane VPD**)							
62								
63	ENCLOSURE CONFIGURATION SETTINGS (**00h**)							
64	ENCLOSURE ID (**Determined by value of enclosure shelf ID**)							
66								
67	Reserved							
70								
71	ENCLOSURE OPTIONAL SETTINGS (**02h**)							
	Type Descriptor Header List[2]							
72	Array Device Descriptor (**17 0C 00 00 h**)							
75								
76	Enclosure Services Controller Electronics Descriptor (**07 02 00 00 h**)							
79								
80	Enclosure Descriptor (**0E 01 00 00 h**)							
83								
84	SAS Expander Descriptor (**18 02 00 00 h**)							
87								
88	SAS Connector Descriptor (**19 08 00 00 h**)							
91								
92	SBB Midplane Interconnect Descriptor (**86 02 00 19 h**)							
95								
96	Enclosure Electronics Power Descriptor (**89 02 00 1B h**)							
99								
100	Enclosure Electronics Diagnostics Descriptor (**8B 02 00 21 h**)							
103								
	Type Descriptor Text List[3]							
104	SBB Midplane Interconnect Text Descriptor (“**SBB Midplane Interconnect**”)							
128								
129	Enclosure Electronics Power Text Descriptor (“**Enclosure Electronics Power**”)							
155								
156	Enclosure Electronics Diagnostics Text Descriptor (“**Enclosure Electronics Diagnostics**”)							
188								

Bit Byte	7	6	5	4	3	2	1	0

[1] See sections 6.2.1 – 6.2.3 in [3] for further details
[2] See section 6.2.4 in [3] for further details on the element descriptor format
[3] See section 6.2.5 in [3] for further details

4.3 SES Page 02h and Page 05h Layout

SES Page 02h and SES Page 05h both conform to the same overall page layout, with 4-byte elements listed in the same order as defined by SES Page 01h. As such, both page structures are defined in Table 6.

Table 6 - SES Page 02h and SES Page 05h Layout

Bit Byte	7	6	5	4	3	2	1	0
0	PAGE CODE (**02h/05h**)							
1	SHORT STATUS[1] (Page 02h) / Reserved (Page 05h)							
2	(MSB)	PAGE LENGTH (**160**)						
3								(LSB)
4	(MSB)	GENERATION CODE						
7								(LSB)
Status Descriptor List[2] (Page 02h) / Threshold Descriptor List[3] (Page 05h)								
8	Array Device Overall Element Descriptor							
11								
12	Array Device Element 0 Descriptor							
15								
	...							
56	Array Device Element 11 Descriptor							
59								
60	Enclosure Services Controller Electronics Overall Element Descriptor							
63								
64	Enclosure Services Controller Electronics Element 0 Descriptor							
67								
68	Enclosure Services Controller Electronics Element 1 Descriptor							
71								
72	Enclosure Overall Element Descriptor							
75								
76	Enclosure Element 0 Descriptor							
79								
80	SAS Expander Overall Element Descriptor							
83								

Bit Byte	7	6	5	4	3	2	1	0
84	SAS Expander Element 0 Descriptor							
87								
88	SAS Expander Element 1 Descriptor							
91								
92	SAS Connector Overall Element Descriptor							
95								
96	SAS Connector Element 0 Descriptor							
99								
…	...							
124	SAS Connector Element 7 Descriptor							
127								
128	SBB Midplane Interconnect Overall Element Descriptor							
131								
132	SBB Midplane Interconnect Element 0 Descriptor							
135								
136	SBB Midplane Interconnect Element 1 Descriptor							
139								
140	Enclosure Electronics Power Overall Element Descriptor							
143								
144	Enclosure Electronics Power Element 0 Descriptor							
147								
148	Enclosure Electronics Power Element 1 Descriptor							
151								
152	Enclosure Electronics Diagnostics Overall Element Descriptor							
155								
156	Enclosure Electronics Diagnostics Element 0 Descriptor							
159								
160	Enclosure Electronics Diagnostics Element 1 Descriptor							
163								

[1] See section 6.3.2.1 in [3] for details on the SHORT STATUS format
[2] See section 7 of [3] for status descriptor format details for each element type
[3] See section 6.5 of [3] for threshold descriptor format details

4.3.1 SES Page 05h Threshold Support

Not all SES element types support SES Page 05h threshold status or control descriptors. Where an element does not support a threshold descriptor, it shall set its status descriptor to all zeros, i.e., [00 00 00 00 h]. Table 7 shows which element types are expected to support a threshold.

Table 7 - Threshold Descriptor Support

Element Type	Threshold Descriptor Support
Array Device	No
Temperature Sensor	Yes
Enclosure Services Controller Electronics	No
Enclosure	No
SAS Expander	No
SAS Connector	No
SBB Midplane Interconnect	No
Enclosure Electronics Power	No
Enclosure Electronics Diagnostics	No
All Overall Elements	No

4.4 SES Page 07h Layout

Table 8 shows the page 07h layout implemented by the documented product.

GEM uses SES Page 07h to report version and serialization information for each of the enclosure FRUs. It may also provide supplemental information with regards to physical element location within the enclosure. Not all elements provide a descriptor string. Where this is the case, 00h will be reported for the descriptor length.

Please note the example below provides a typical representation of the page output. To allow for variation in output, it is recommended that any client should fully parse the page content and not rely on fixed offsets. For example, the temperature sensor element descriptors will only be reported if the associated FRU is present. The descriptor headers will always be present and report a non-zero value if there is data available to read and parse

Table 8 - SES Page 07h Layout

Bit **Byte**	7	6	5	4	3	2	1	0
0	PAGE CODE (**07h**)							
1	Reserved							
2	(MSB)	PAGE LENGTH (**435**)						
3								(LSB)
4	(MSB)	GENERATION CODE						
7								(LSB)
Element Descriptor List								
8	Array Device Overall Element Descriptor (**00 00 00 00 h**)							
11								
12	Array Device Element 0 Descriptor (**00 00 00 00 h**)							
15								
…	…							
56	Array Device Element 11 Descriptor (**00 00 00 00 h**)							
59								
60	Enclosure Services Controller Electronics Overall Element Descriptor (**00 00 00 00 h**)							
63								
64	Enclosure Services Controller Electronics Element 0 Descriptor (**00 00 00 7C h**) **124 bytes of descriptor data**[1]							
191								
192	Enclosure Services Controller Electronics Element 1 Descriptor (**00 00 00 00 h**)							
195								
196	Enclosure Overall Element Descriptor (**00 00 00 00 h**)							
199								
200	Enclosure Element 0 Descriptor (**00 00 00 47 h**) **71 bytes of descriptor data**[1]							
274								
275	SAS Expander Overall Element Descriptor (**00 00 00 00 h**)							
278								

Bit Byte	7	6	5	4	3	2	1	0
279	SAS Expander Element 0 Descriptor (**00 00 00 00 h**)							
282								
283	SAS Expander Element 1 Descriptor (**00 00 00 00 h**)							
286								
287	SAS Connector Overall Element Descriptor (**00 00 00 00 h**)							
290								
291	SAS Connector Element 0 Descriptor (**00 00 00 14 h**)							
314	**20 bytes of descriptor data**[1]							
…	…							
399	SAS Connector Element 7 Descriptor (**00 00 00 00 h**)							
402	**20 bytes of descriptor data**[1]							
403	SBB Midplane Interconnect Overall Element Descriptor (**00 00 00 00 h**)							
406								
407	SBB Midplane Interconnect Element 0 Descriptor (**00 00 00 00 h**)							
410								
411	SBB Midplane Interconnect Element1 Descriptor (**00 00 00 00 h**)							
414								
415	Enclosure Electronics Power Overall Element Descriptor (**00 00 00 00 h**)							
418								
419	Enclosure Electronics Power Element 0 Descriptor (**00 00 00 00 h**)							
422								
423	Enclosure Electronics Power Element1 Descriptor (**00 00 00 00 h**)							
426								
427	Enclosure Electronics Diagnostics Overall Element Descriptor (**00 00 00 00 h**)							
430								
431	Enclosure Electronics Diagnostics Element 0 Descriptor (**00 00 00 00 h**)							
434								
435	Enclosure Electronics Diagnostics Element1 Descriptor (**00 00 00 00 h**)							
438								

[1] See section 4.4.1 for descriptor string format

4.4.1 Page 07h Descriptor Strings

The descriptor string formats used by each element that supports them are shown in Table 9. Note that the string formats may be subject to change over time as new FRUs are supported by the enclosure or additional information becomes available. Refer to [3] for full details on descriptor string decoding.

Table 9 - FRU Descriptor string formats

Element Type	Descriptor String
Power Supply	*TP=XX;SN=XXXXXXXXXXXXXXX;F1=XXXX;F2=XXXX;VR=XX;VC=XXXX XXXX;PN=XXXXXXXXXX;*
Temperature Sensor	*NM=XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX;LO=XXXXXXXXXXXX XXXX;*
Enclosure Services Controller Electronics	*TP=XX;SN=XXXXXXXXXXXXXXX;F1=XXXX;BL=XXXX;VR=XX;VC=XXXX XXXX;CR=XX;FR=XX;FC=XXXXXXXX;PN=XXXXXXXXXX;FF1=XXXXXXX X;PC=XXXXXXXX;*
Enclosure	*SN=XXXXXXXXXXXXXXX;VR=XX;VC=XXXXXXXX;CR=XX;PN=XXXXXXX XXX;CM=XX;TP=XX;*
Voltage Sensor	*NM=XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX;LO=XXXXXXXXXXXX XXXX;*
Current Sensor	*NM=XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX;LO=XXXXXXXXXXXX XXXX;*
SAS Connector	*WN=XXXXXXXXXXXXXXXX;*

4.5 SES Page 0Ah Layout

SES Page 0Ah only reports phy descriptor data for elements that belong to the directly queried IOM. As such the page layout differs when queried from IOM A or IOM B. Both page formats are shown in the sections below.

4.5.1 SES Page 0Ah Layout for SBB IOM A

Table 10 - SES Page 0Ah Layout for SBB IOM A

Bit / Byte	7	6	5	4	3	2	1	0
0	PAGE CODE (**0Ah**)							
1	Reserved							
2	(MSB)	PAGE LENGTH (**664**)						
3								(LSB)
4	(MSB)	GENERATION CODE						
7								(LSB)
Device Slot 0 Additional Status Descriptor								
8	INVALID	Reserved		EIP (**1**)	PROTOCOL IDENTIFIER (**6**)			
9	ADDITIONAL ELEMENT STATUS DESCRIPTOR LENGTH (**34**)							
10	Reserved							EIIOE (**0**)
11	ELEMENT INDEX (**0**)							
12	NUM OF DEVICE PHY DESCRIPTORS (**1**)							
13	DESC TYPE (**0**)		Reserved					NOT ALL PHYS (**1**)
14	Reserved							
15	DEVICE SLOT NUMBER (**0**)							
16	Phy Descriptor for Device 0 (SBB IOM A phy)							
43								
	...							
Device Slot 11 Additional Status Descriptor								
404	INVALID	Reserved		EIP (**1**)	PROTOCOL IDENTIFIER (**6**)			
405	ADDITIONAL ELEMENT STATUS DESCRIPTOR LENGTH (**34**)							
406	Reserved							EIIOE (**0**)
407	ELEMENT INDEX (**11**)							
408	NUM OF DEVICE PHY DESCRIPTORS (**1**)							
409	DESC TYPE (**0**)		Reserved					NOT ALL PHYS (**1**)
410	Reserved							
411	DEVICE SLOT NUMBER (**11**)							
412	Phy Descriptor for Device 11 (SBB IOM A phy)							
439								

Bit Byte	7	6	5	4	3	2	1	0
Expander 0 Additional Status Descriptor								
440	INVALID	Reserved		EIP (**1**)	PROTOCOL IDENTIFIER (**6**)			
441	ADDITIONAL ELEMENT STATUS DESCRIPTOR LENGTH (**112**)							
442	Reserved							EIIOE (**0**)
443	ELEMENT INDEX (**15**)							
444	NUM OF EXPANDER PHY DESCRIPTORS (**49**)							
445	DESC TYPE (**1**)		Reserved					
446	Reserved							
447								
448	EXPANDER SAS ADDRESS							
455								
456	Phy Descriptor 0 for Expander 0 (SBB IOM A)							
457								
	…							
550	Phy Descriptor 48 for Expander 0 (SBB IOM A)							
553								
Expander 1 Additional Status Descriptor								
554	INVALID	Reserved		EIP (**1**)	PROTOCOL IDENTIFIER (**6**)			
555	ADDITIONAL ELEMENT STATUS DESCRIPTOR LENGTH (**112**)							
556	Reserved							EIIOE (**0**)
557	ELEMENT INDEX (**16**)							
558	NUM OF EXPANDER PHY DESCRIPTORS (**0**)							
559	DESC TYPE (**1**)		Reserved					
560	Reserved							
561								
562	EXPANDER SAS ADDRESS							
563								
564	Reserved							
667								

4.5.2 SES Page 0Ah Layout for SBB IOM B

Table 11 - SES Page 0Ah Layout for SBB IOM B

Bit / Byte	7	6	5	4	3	2	1	0
0	PAGE CODE (**0Ah**)							
1	Reserved							
2	(MSB)	PAGE LENGTH (**664**)						
3								(LSB)
4	(MSB)	GENERATION CODE						
7								(LSB)
Device Slot 0 Additional Status Descriptor								
8	INVALID	Reserved			EIP (**1**)	PROTOCOL IDENTIFIER (**6**)		
9	ADDITIONAL ELEMENT STATUS DESCRIPTOR LENGTH (**34**)							
10	Reserved							EIIOE (**0**)
11	ELEMENT INDEX (**0**)							
12	NUM OF DEVICE PHY DESCRIPTORS (**1**)							
13	DESC TYPE (**0**)		Reserved					NOT ALL PHYS (**1**)
14	Reserved							
15	DEVICE SLOT NUMBER (**0**)							
16	Phy Descriptor for Device 0 (SBB IOM B phy)							
43								
	…							
Device Slot 11 Additional Status Descriptor								
404	INVALID	Reserved			EIP (**1**)	PROTOCOL IDENTIFIER (**6**)		
405	ADDITIONAL ELEMENT STATUS DESCRIPTOR LENGTH (**34**)							
406	Reserved							EIIOE (**0**)
407	ELEMENT INDEX (**11**)							
408	NUM OF DEVICE PHY DESCRIPTORS (**1**)							
409	DESC TYPE (**0**)		Reserved					NOT ALL PHYS (**1**)
410	Reserved							
411	DEVICE SLOT NUMBER (**11**)							
412	Phy Descriptor for Device 11 (SBB IOM B phy)							
439								
Expander 0 Additional Status Descriptor								
440	INVALID	Reserved			EIP (**1**)	PROTOCOL IDENTIFIER (**6**)		
441	ADDITIONAL ELEMENT STATUS DESCRIPTOR LENGTH (**112**)							
442	Reserved							EIIOE (**0**)
443	ELEMENT INDEX (**15**)							

Bit / Byte	7	6	5	4	3	2	1	0
444	NUM OF EXPANDER PHY DESCRIPTORS (**0**)							
445	DESC TYPE (**1**)		Reserved					
446	Reserved							
447								
448	EXPANDER SAS ADDRESS							
449								
450	Reserved							
455								
Expander 1 Additional Status Descriptor								
456	INVALID	Reserved			EIP (**1**)	PROTOCOL IDENTIFIER (**6**)		
457	ADDITIONAL ELEMENT STATUS DESCRIPTOR LENGTH (**112**)							
458	Reserved							EIIOE (**0**)
459	ELEMENT INDEX (**16**)							
460	NUM OF EXPANDER PHY DESCRIPTORS (**49**)							
461	DESC TYPE (**1**)		Reserved					
462	Reserved							
463								
464	EXPANDER SAS ADDRESS							
465								
466	Phy Descriptor 0 for Expander 0 (SBB IOM B)							
467								
	...							
664	Phy Descriptor 48 for Expander 0 (SBB IOM B)							
667								

4.6 Vendor Unique Page 91h Layout

Vendor unique Page 91h is used to report enclosure statistics counters. The layouts of the control and status pages are identical, however, the bit definitions within the descriptors vary (see [3] for details). Table 12 covers the basic layout of page 91h for the documented product.

Table 12 - SES Page 91h Layout

Bit / Byte	7	6	5	4	3	2	1	0
0	PAGE CODE (**91h**)							
1	Reserved							
2	(MSB)							
3	PAGE LENGTH (2036)							(LSB)
4	(MSB)							
7	GENERATION CODE							(LSB)
	Expander 0 Phy Statistics Descriptor							
8	ELEMENT TYPE CODE (**18h**)							
9	TYPE RELATIVE INDEX (**0**)							
10	DESCRIPTOR FORMAT REVISION (**01h**)							
11	NUMBER OF PHY STATISTICS DESCRIPTORS (**48**)							
12	PHY STATISTICS DESCRIPTOR LENGTH (**28**)							
13	(MSB)							
14	EXPANDER CHANGE COUNT							(LSB)
15	Reserved							
16	Phy 0 Statistics Descriptor[1]							
43								
…	…							
1332	Phy 47 Statistics Descriptor[1]							
1359								
	Expander 1 Phy Statistics Descriptor							
1360	ELEMENT TYPE CODE (**18h**)							
1361	TYPE RELATIVE INDEX (**1**)							
1362	DESCRIPTOR FORMAT REVISION (**01h**)							
1363	NUMBER OF PHY STATISTICS DESCRIPTORS (**48**)							
1364	PHY STATISTICS DESCRIPTOR LENGTH (**28**)							
1365	(MSB)							
1366	EXPANDER CHANGE COUNT							(LSB)
1367	Reserved							
1368	Phy 0 Statistics Descriptor[1]							
1396								

Bit Byte	7	6	5	4	3	2	1	0
…	...							
2684	Phy 47 Statistics Descriptor[1]							
2711								

[1] See [3] for full details on the format of the Phy Statistics status/control descriptor

4.7 Vendor Unique Page 92h Layout

Vendor unique Page 92h extends the status that can be represented in page 02h for each element. The page structure itself represents that of page 07h with descriptor headers used to advertise the size of additional data available for each element. Not all elements provide page 92h descriptors and where this is the case the descriptor length will be set to 0.

As with Page 07h, the example Page 92h output provided below is subject to change based on FRUs and cables that may or may not be present at the time of capture. The descriptor header will indicate if there is any data to be read.

Table 13 - SES Page 92h Layout

Bit / Byte	7	6	5	4	3	2	1	0
0	PAGE CODE (**92h**)							
1	Reserved							
2	(MSB)	PAGE LENGTH (**2208**)						
3								(LSB)
4	(MSB)	GENERATION CODE						
7								(LSB)
Extended Status Descriptor List								
8	Array Device Overall Element Descriptor (**00 00 00 00 h**)							
11								
12	Array Device Element 0 Descriptor (**00 00 00 00 h**)							
15								
	...							
56	Array Device Element 11 Descriptor (**00 00 00 00 h**)							
59								
60	Enclosure Services Controller Electronics Overall Element Descriptor (**00 00 00 00 h**)							
63								
64	Enclosure Services Controller Electronics Element 0 Descriptor (**00 00 00 00 h**)							
67								
68	Enclosure Services Controller Electronics Element 1 Descriptor (**00 00 00 00 h**)							
71								
72	Enclosure Overall Element Descriptor (**00 00 00 00 h**)							
75								
76	Enclosure Element 0 Descriptor (**00 00 00 00 h**)							
79								
80	SAS Expander Overall Element Descriptor (**00 00 00 00 h**)							
83								
84	SAS Expander Element 0 Descriptor (**00 00 00 00 h**)							
87								

Bit Byte	7	6	5	4	3	2	1	0
88	SAS Expander Element 1 Descriptor (**00 00 00 00 h**)							
91								
92	SAS Connector Overall Element Descriptor (**00 00 00 00 h**)							
95								
96	SAS Connector Element 0 Descriptor (**01 00 02 00 h**) 512 bytes of descriptor data[1]							
611								
612	SAS Connector Element 1 Descriptor (**01 00 02 00 h**) 512 bytes of descriptor data[1]							
1127								
1128	SAS Connector Element 2 Descriptor (**01 00 00 00 h**)							
1131								
1132	SAS Connector Element 3 Descriptor (**01 00 00 00 h**)							
1135								
1136	SAS Connector Element 4 Descriptor (**01 00 02 00 h**) 512 bytes of descriptor data[1]							
1651								
1652	SAS Connector Element 5 Descriptor (**01 00 02 00 h**) 512 bytes of descriptor data[1]							
2167								
2168	SAS Connector Element 6 Descriptor (**01 00 00 00 h**)							
2171								
2172	SAS Connector Element 7 Descriptor (**01 00 00 00 h**)							
2175								
2176	SBB Midplane Interconnect Overall Element Descriptor (**00 00 00 00 h**)							
2179								
2180	SBB Midplane Interconnect Element 0 Descriptor (**00 00 00 00 h**)							
2183								
2184	SBB Midplane Interconnect Element 1 Descriptor (**00 00 00 00 h**)							
2187								
2188	Enclosure Electronics Power Overall Element Descriptor (**00 00 00 00 h**)							
2191								
2192	Enclosure Electronics Power Element 0 Descriptor (**00 00 00 00 h**)							
2195								
2196	Enclosure Electronics Power Element 1 Descriptor (**00 00 00 00 h**)							
2199								
2200	Enclosure Electronics Diagnostics Overall Element Descriptor (**00 00 00 00 h**)							
2203								
2204	Enclosure Electronics Diagnostics Element 0 Descriptor (**00 00 00 00 h**)							
2207								
2208	Enclosure Electronics Diagnostics Element 1 Descriptor (**00 00 00 00 h**)							
2211								

Bit Byte	7	6	5	4	3	2	1	0
[1] See [3] for extended status descriptor format for SAS connectors								

5 Zone Modes

The AP-BV-1 controller incorporates an embedded SAS IOC for the purpose of accessing the disk drives. The IOC supports 16 Phys but can only form wide ports with a maximum width of 8 phys. When both ports are attached to the same SAS expander, as is the case for the AP-BV-1, I/O may become unbalanced between the two ports.

To account for this, the AP-BV-1 controller implements several zoning schemes that can be used to deterministically control how traffic from the two IOC wide-ports is shared amongst internal and expansion drives.

5.1 Zone Mode Configurations

This section details the zone configurations that can be applied to the AP-BV-1 controllers in the Exos E 2U12 enclosure, using the zone modes feature. The supported zone mode configurations are described in Table 14. Refer to [3] for further details of the zone mode feature.

Table 14 - Zone Mode Configurations

Zone mode	Zone Configuration	Description
1	HA Performance Mode	Default zone mode optimized for dual-path high-availability (HA), single-enclosure performance. See 5.2.1
2	HA Expansion Mode	Zone mode optimized for dual-path high-availability (HA), multi-enclosure topologies. See 5.2.2
3	HA Hybrid Mode	Zone mode optimized for high availability (HA) performance, with support for expansion enclosures that are to be excluded from the ZPSDS. See 5.2.3
4	Single Core Mode	Zone mode emulating previous generations of AP with single-core SAS IOCs. See 5.2.4
5	SCSN Performance Mode	Zone mode optimized for single-enclosure performance with drives evenly divided between the two redundant enclosure data paths. See 5.2.5
6	SCSN Expansion Mode	Zone mode optimized for expansion with drives divided between the two redundant enclosure data paths. See 5.2.6

5.2 Zone Configuration Layouts

For simplicity, this section provides a generalized view of the zone group assignments implemented by each of the zone modes. In this view, each zone group is represented as a letter, rather than the numerical identified implemented within SAS. Full details of the actual phy zone group assignments and permissions tables are included in Appendix A.

5.2.1 Zone mode 1 - HA Performance Mode

Zone mode 1 is optimized for dual-path high-availability (HA), single-enclosure performance.

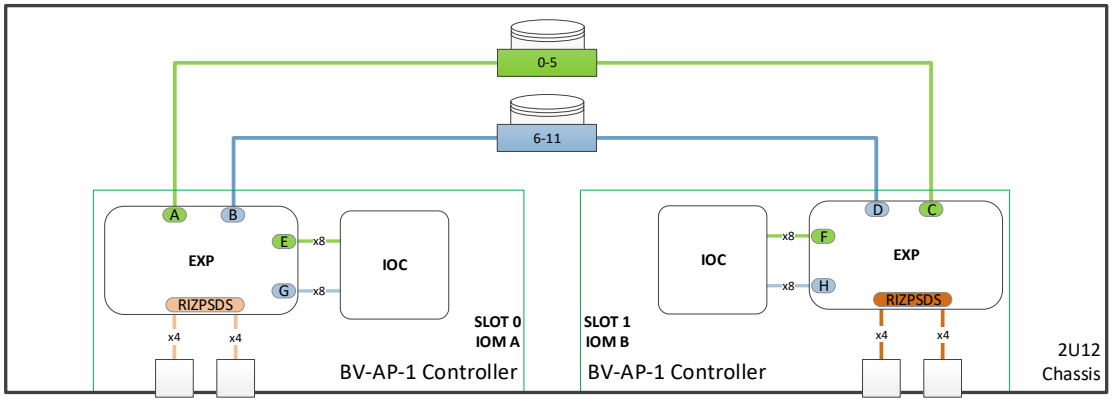
This zone mode segregates the disk drives into two even groups and assigns them to each of the embedded IOC x8 SAS ports, ensuring both ports are fully utilized for balanced I/O.

The expansion ports are configured with the Requested Inside ZPSDS bit set to '1', permitting the ZPSDS to be extended to downstream enclosures, if expansion is desired. However, it should be noted that downstream enclosures must implement a compatible zone group assignment and permissions table.

If the ZPSDS is not extended beyond the expansion port, bandwidth for downstream drives may not evenly distribute across the on-board IOC ports.

Zone mode 1 is the default zone mode enabled by the AP-BV-1 controller if no alternative zone mode is configured.

Figure 3 shows the generalized zoning scheme implemented by zone mode 1.



A = Zone Group

2U12 SAS ZM1

Src/Dest	A	B	C	D	E	F	G	H
A	Y				Y			
B		Y					Y	
C			Y			Y		
D				Y				Y
E	Y				Y			
F			Y			Y		
G		Y					Y	
H				Y				Y

0	1	2	3
4	5	6	7
8	9	10	11

Figure 3 - Zone mode 1 configuration

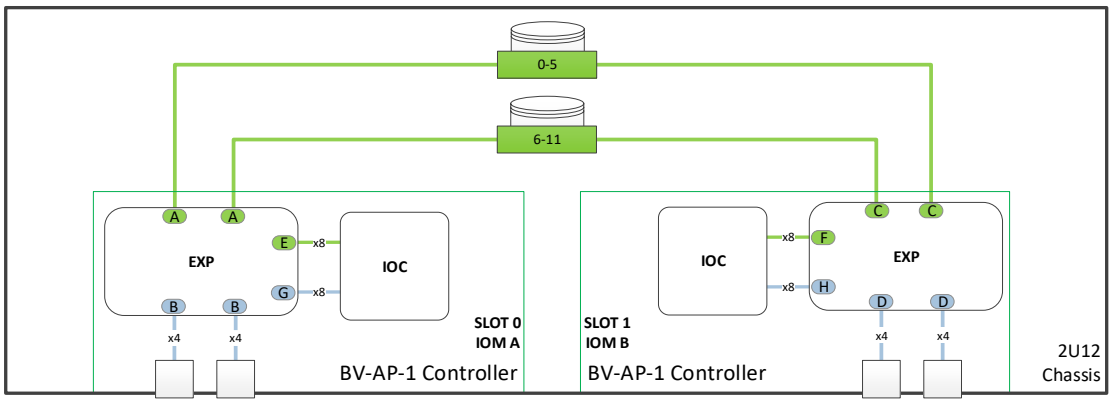
5.2.2 Zone mode 2 - HA Expansion Mode

Zone mode 2 is optimized for dual-path high-availability (HA), multi-enclosure topologies.

The zone mode assigns the enclosure's internal drives to a single IOC port and the drives of all expansion enclosures to the remaining IOC port.

The expansion ports are configured with the Requested Inside ZPSDS bit set to '0', and therefore no requirement is placed on the expansion enclosures to implement zoning.

Figure 4 shows the generalized zoning scheme implemented by zone mode 2.



Ⓐ = Zone Group

2U12 SAS ZM2

Src/Dest	A	B	C	D	E	F	G	H
A	Y				Y			
B		Y					Y	
C			Y			Y		
D				Y				Y
E	Y				Y			
F			Y			Y		
G		Y					Y	
H				Y				Y

0	1	2	3
4	5	6	7
8	9	10	11

Figure 4 - Zone Mode 2 configuration

5.2.3 Zone Mode 3 - HA Hybrid

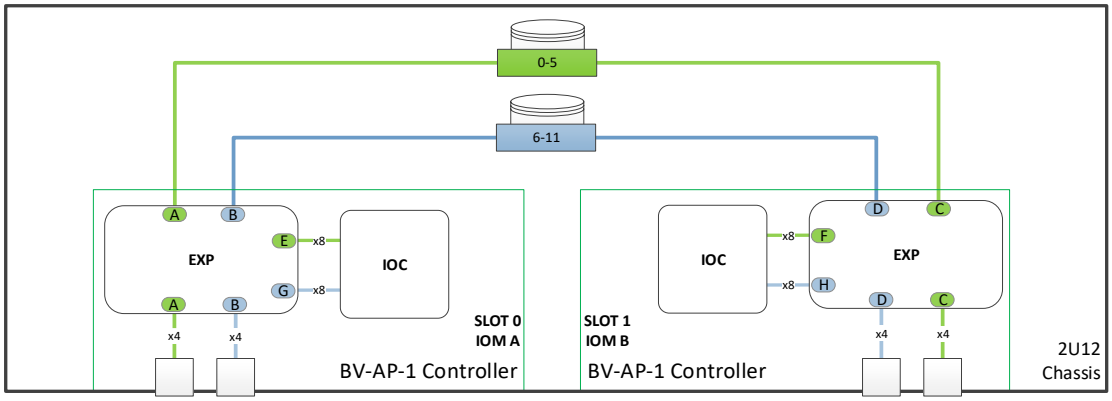
Zone mode 3 is optimized for high availability (HA) performance, along with support for expansion enclosures that should be excluded from the ZPSDS.

The zone mode splits the internal disk drives into two even groups and assigns them to each of the embedded IOC x8 SAS ports, ensuring both ports are fully utilized for balanced I/O.

The expansion ports are also divided between the two zones, ensuring that expansion enclosures attached to expansion port 0 are visible to IOC port 0 and expansion enclosures attached to expansion port 1 are visible to IOC 1.

The expansion enclosures are not required to implement zoning or extend the ZPSDS, however, as the expansion ports belong to separate zone groups, it is not permitted to chain to a single enclosure using a x8 wide port.

Figure 5 shows the generalized zoning scheme implemented by zone mode 3.



A = Zone Group

2U12 SAS ZM3

Src/Dest	A	B	C	D	E	F	G	H
A	Y				Y			
B		Y					Y	
C			Y			Y		
D				Y				Y
E	Y				Y			
F			Y			Y		
G		Y					Y	
H				Y				Y

0	1	2	3
4	5	6	7
8	9	10	11

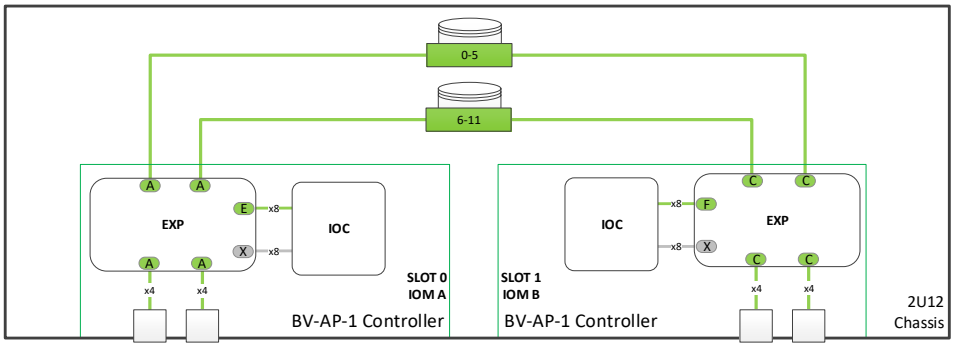
Figure 5 - Zone Mode 3 configuration

5.2.4 Zone Mode 4 - HA Single Core Mode

Zone mode 4 emulates previous generations of AP controllers that utilized IOCs with a single SAS core. This is useful when an I/O stack is not configured to handle multi-pathed access to the enclosure SES targets.

In this mode, only one of the IOC ports has access to both internal and external SAS devices, with the second IOC port having no access to any part of the SAS topology.

Figure 6 shows the generalized zoning scheme implemented by zone mode 4.



A = Zone Group

2U12 SAS ZM4

Src/Dest	A	...	C	...	E	F
A	Y	...		...	Y	
...	...	...	...	...	...	...
C		...	Y	...		Y
...	...	...	...	...	...	...
E	Y	...		...	Y	
F		...	Y	...		Y

0	1	2	3
4	5	6	7
8	9	10	11

Figure 6 - Zone Mode 4 configuration

5.2.5 Zone Mode 5 - SCSN Performance Mode

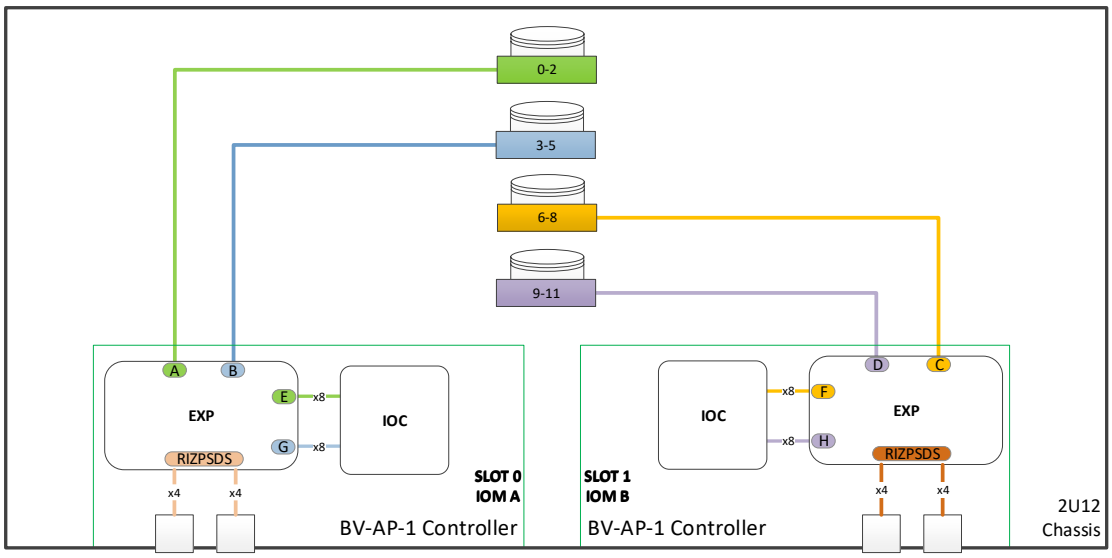
Zone mode 5 is optimized for single-enclosure performance where the drives are divided evenly between the two redundant enclosure data paths (known as Single Controller-Share Nothing),

The share nothing configs are mostly used with host I/O stacks that are not multi-path or HA-aware but there is still a desire to the use the full enclosure bandwidth. In such cases each enclosure controller can be viewed as a separate storage node with access to half of the total enclosure drive population. If the controller fails, the partner controller will not have access to its drives.

On each controller, this zone mode splits the disk drives into four even groups and assigns two of the groups to each of embedded IOC x8 SAS ports, ensuring both ports are fully utilized for balanced I/O. The drive groups that are not assigned locally are assigned evenly to the IOC ports on the partner controller, ensuring that only half the drives are visible on each path.

The expansion ports are configured with the Requested Inside ZPSDS bit set to '1', allowing the ZPSDS to be extended to downstream enclosures, if expansion is desired. However, it should be noted that downstream enclosures must implement a compatible zone group assignment and permissions table

Figure 7 shows the generalized zoning scheme implemented by zone mode 5



Ⓐ = Zone Group

2U12 SAS ZM5

Src/Dest	A	B	C	D	E	F	G	H
A	Y				Y			
B		Y					Y	
C			Y			Y		
D				Y				Y
E	Y				Y			
F			Y			Y		
G		Y					Y	
H				Y				Y

0	1	2	3
4	5	6	7
8	9	10	11

Figure 7 - Zone Mode 5 configuration

5.2.6 Zone Mode 6 - SCSN expansion

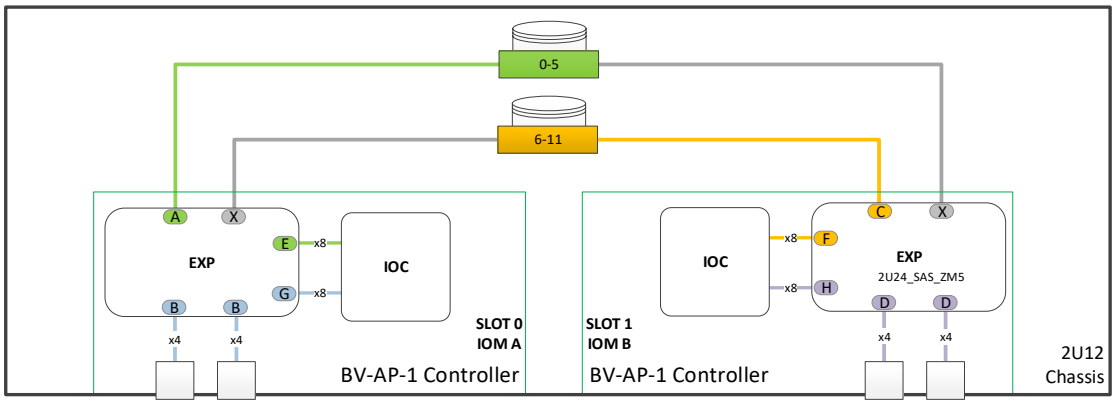
Zone mode 6 is optimized for expansion where the drives are divided between the two redundant enclosure data paths (known as Single Controller-Share Nothing),

The share nothing configs are mostly used with host I/O stacks that are not multi-path or HA-aware but there is still a desire to the use the full enclosure bandwidth. In such cases each enclosure controller can be viewed as a separate storage node with access to half of the total drive population. If the controller fails, the partner controller will not have access to its drives.

On each controller, this zone mode splits the disk drives into 2 even groups and assigns one of the groups to a single port on the IOC. The other group is assigned to single port on the IOC of the partner controller, ensuring that only half the drives are visible on each path. The second IOC port of each controller is assigned to their respective expansion ports.

The expansion ports are configured with the Requested Inside ZPSDS bit set to '0', and therefore no requirement is placed on the expansion enclosures to implement zoning.

Figure 8 shows the generalized zoning scheme implemented by zone mode 6.



A = Zone Group

2U12 SAS ZM6

Src/Dest	A	B	C	D	E	F	G	H
A	Y				Y			
B		Y					Y	
C			Y			Y		
D				Y				Y
E	Y				Y			
F			Y			Y		
G		Y					Y	
H				Y				Y

0	1	2	3
4	5	6	7
8	9	10	11

Figure 8 - Zone Mode 6 configuration

Appendix A Detailed Zone Configuration

A-1 Zone mode 1 configuration

A-1.1 Zone mode 1 phy settings

Table 15 - Phy Zone Settings for Zone Mode 1

Phy Type	Phy ID	Phy ID (hex)	IOM A		IOM B		RIZPSDS|IZP|ZGP
			Drive Bay	ZG	Drive Bay	ZG	
MiniSAS 0	0	0h	N/A	1	N/A	1	7h
	1	1h	N/A	1	N/A	1	7h
	2	2h	N/A	1	N/A	1	7h
	3	3h	N/A	1	N/A	1	7h
MiniSAS 1	4	4h	N/A	1	N/A	1	7h
	5	5h	N/A	1	N/A	1	7h
	6	6h	N/A	1	N/A	1	7h
	7	7h	N/A	1	N/A	1	7h
IOC 0	8	8h	N/A	10	N/A	10	3h
	9	9h	N/A	10	N/A	10	3h
	10	Ah	N/A	10	N/A	10	3h
	11	Bh	N/A	10	N/A	10	3h
	12	Ch	N/A	10	N/A	10	3h
	13	Dh	N/A	10	N/A	10	3h
	14	Eh	N/A	10	N/A	10	3h
	15	Fh	N/A	10	N/A	10	3h
IOC 1	16	10h	N/A	11	N/A	11	3h
	17	11h	N/A	11	N/A	11	3h
	18	12h	N/A	11	N/A	11	3h
	19	13h	N/A	11	N/A	11	3h
	20	14h	N/A	11	N/A	11	3h
	21	15h	N/A	11	N/A	11	3h
	22	16h	N/A	11	N/A	11	3h
	23	17h	N/A	11	N/A	11	3h
HDD	24	18h	8	13	3	12	3h
	25	19h	4	12	7	13	3h
	26	1Ah	0	12	11	13	3h
	27	1Bh	1	12	2	12	3h
	28	1Ch	5	12	10	13	3h
	29	1Dh	9	13	6	13	3h
	30	1Eh	2	12	9	13	3h
	31	1Fh	6	13	5	12	3h
	32	20h	3	12	8	13	3h
	33	21h	7	13	4	12	3h

Phy Type	Phy ID	Phy ID (hex)	IOM A		IOM B		RIZPSDS|IZP|ZGP
			Drive Bay	ZG	Drive Bay	ZG	
	34	22h	10	13	1	12	3h
	35	23h	11	13	0	12	3h
Unmapped	36	24h	N/A	N/A	N/A	N/A	N/A
	37	25h	N/A	N/A	N/A	N/A	N/A
	38	26h	N/A	N/A	N/A	N/A	N/A
	39	27h	N/A	N/A	N/A	N/A	N/A
	40	28h	N/A	N/A	N/A	N/A	N/A
	41	29h	N/A	N/A	N/A	N/A	N/A
	42	2Ah	N/A	N/A	N/A	N/A	N/A
	43	2Bh	N/A	N/A	N/A	N/A	N/A
	44	2Ch	N/A	N/A	N/A	N/A	N/A
	45	2Dh	N/A	N/A	N/A	N/A	N/A
	46	2Eh	N/A	N/A	N/A	N/A	N/A
	47	2Fh	N/A	N/A	N/A	N/A	N/A

A-1.2 Zone mode 1 permissions table

Note that all source and destination permissions not documented in the ZPT below should be assumed to be set to ‘0’, except when stipulated otherwise in SPL [4].

Table 16 - Zone Permissions Table for Zone Mode 1

Dst ZG Src ZG	0	1	2	…	10	11	12	13
0	1	1	0	…	0	0	0	0
1	1	1	1	…	1	1	1	1
2	0	1	1	…	0	0	0	0
…	…	…	…	…	…	…	…	…
10	0	1	0	…	1	0	1	0
11	0	1	0	…	0	1	0	1
12	0	1	0	…	1	0	1	0
13	0	1	0	…	0	1	0	1

A-2 Zone mode 2 configuration

A-2.1 Zone mode 2 phy settings

Table 17 - Phy Zone Settings for Zone Mode 2

Phy Type	Phy ID	Phy ID (hex)	IOM A		IOM B		RIZPSDS|IZP|ZGP
			Drive Bay	ZG	Drive Bay	ZG	
MiniSAS 0	0	0h	N/A	8	N/A	8	3h
	1	1h	N/A	8	N/A	8	3h
	2	2h	N/A	8	N/A	8	3h
	3	3h	N/A	8	N/A	8	3h
MiniSAS 1	4	4h	N/A	8	N/A	8	3h
	5	5h	N/A	8	N/A	8	3h
	6	6h	N/A	8	N/A	8	3h
	7	7h	N/A	8	N/A	8	3h
IOC 0	8	8h	N/A	10	N/A	10	3h
	9	9h	N/A	10	N/A	10	3h
	10	Ah	N/A	10	N/A	10	3h
	11	Bh	N/A	10	N/A	10	3h
	12	Ch	N/A	10	N/A	10	3h
	13	Dh	N/A	10	N/A	10	3h
	14	Eh	N/A	10	N/A	10	3h
	15	Fh	N/A	10	N/A	10	3h
IOC 1	16	10h	N/A	11	N/A	11	3h
	17	11h	N/A	11	N/A	11	3h
	18	12h	N/A	11	N/A	11	3h
	19	13h	N/A	11	N/A	11	3h
	20	14h	N/A	11	N/A	11	3h
	21	15h	N/A	11	N/A	11	3h
	22	16h	N/A	11	N/A	11	3h
	23	17h	N/A	11	N/A	11	3h
HDD	24	18h	8	13	3	12	3h
	25	19h	4	12	7	13	3h
	26	1Ah	0	12	11	13	3h
	27	1Bh	1	12	2	12	3h
	28	1Ch	5	12	10	13	3h
	29	1Dh	9	13	6	13	3h
	30	1Eh	2	12	9	13	3h
	31	1Fh	6	13	5	12	3h
	32	20h	3	12	8	13	3h
	33	21h	7	13	4	12	3h
	34	22h	10	13	1	12	3h
	35	23h	11	13	0	12	3h
	36	24h	N/A	N/A	N/A	N/A	N/A

Phy Type	Phy ID	Phy ID (hex)	IOM A		IOM B		RIZPSDS|IZP|ZGP
			Drive Bay	ZG	Drive Bay	ZG	
Unmapped	37	25h	N/A	N/A	N/A	N/A	N/A
	38	26h	N/A	N/A	N/A	N/A	N/A
	39	27h	N/A	N/A	N/A	N/A	N/A
	40	28h	N/A	N/A	N/A	N/A	N/A
	41	29h	N/A	N/A	N/A	N/A	N/A
	42	2Ah	N/A	N/A	N/A	N/A	N/A
	43	2Bh	N/A	N/A	N/A	N/A	N/A
	44	2Ch	N/A	N/A	N/A	N/A	N/A
	45	2Dh	N/A	N/A	N/A	N/A	N/A
	46	2Eh	N/A	N/A	N/A	N/A	N/A
	47	2Fh	N/A	N/A	N/A	N/A	N/A

A-2.2 Zone mode 2 permissions table

Note that all source and destination permissions not documented in the ZPT below should be assumed to be set to '0', except when stipulated otherwise in SPL [4].

Table 18 - Zone Permissions Table for Zone Mode 2

DST ZG / SRC ZG	0	1	2	…	8	…	10	11	12	13
0	1	1	0	…	0	…	0	0	0	0
1	1	1	1	…	1	…	1	1	1	1
2	0	1	1	…	0	…	0	0	0	0
…	…	…	…	…	…	…	…	…	…	…
8	0	1	0	…	1	…	0	1	0	0
…	…	…	…	…	…	…	…	…	…	…
10	0	1	0	…	0	…	1	0	1	1
11	0	1	0	…	1	…	0	1	0	0
12	0	1	0	…	0	…	1	0	1	0
13	0	1	0	…	0	…	1	0	0	1

A-3 Zone mode 3 configuration

A-3.1 Zone mode 3 phy settings

Table 19 - Phy Zone Settings for Zone Mode 3

Phy Type	Phy ID	Phy ID (hex)	IOM A		IOM B		RIZPSDS|IZP|ZGP
			Drive Bay	ZG	Drive Bay	ZG	
MiniSAS 0	0	0h	N/A	8	N/A	8	3h
	1	1h	N/A	8	N/A	8	3h
	2	2h	N/A	8	N/A	8	3h
	3	3h	N/A	8	N/A	8	3h
MiniSAS 1	4	4h	N/A	9	N/A	9	3h
	5	5h	N/A	9	N/A	9	3h
	6	6h	N/A	9	N/A	9	3h
	7	7h	N/A	9	N/A	9	3h
IOC 0	8	8h	N/A	10	N/A	10	3h
	9	9h	N/A	10	N/A	10	3h
	10	Ah	N/A	10	N/A	10	3h
	11	Bh	N/A	10	N/A	10	3h
	12	Ch	N/A	10	N/A	10	3h
	13	Dh	N/A	10	N/A	10	3h
	14	Eh	N/A	10	N/A	10	3h
	15	Fh	N/A	10	N/A	10	3h
IOC 1	16	10h	N/A	11	N/A	11	3h
	17	11h	N/A	11	N/A	11	3h
	18	12h	N/A	11	N/A	11	3h
	19	13h	N/A	11	N/A	11	3h
	20	14h	N/A	11	N/A	11	3h
	21	15h	N/A	11	N/A	11	3h
	22	16h	N/A	11	N/A	11	3h
	23	17h	N/A	11	N/A	11	3h
HDD	24	18h	8	13	3	12	3h
	25	19h	4	12	7	13	3h
	26	1Ah	0	12	11	13	3h
	27	1Bh	1	12	2	12	3h
	28	1Ch	5	12	10	13	3h
	29	1Dh	9	13	6	13	3h
	30	1Eh	2	12	9	13	3h
	31	1Fh	6	13	5	12	3h
	32	20h	3	12	8	13	3h
	33	21h	7	13	4	12	3h
	34	22h	10	13	1	12	3h
	35	23h	11	13	0	12	3h
	36	24h	N/A	N/A	N/A	N/A	N/A

Phy Type	Phy ID	Phy ID (hex)	IOM A		IOM B		RIZPSDS|IZP|ZGP
			Drive Bay	ZG	Drive Bay	ZG	
Unmapped	37	25h	N/A	N/A	N/A	N/A	N/A
	38	26h	N/A	N/A	N/A	N/A	N/A
	39	27h	N/A	N/A	N/A	N/A	N/A
	40	28h	N/A	N/A	N/A	N/A	N/A
	41	29h	N/A	N/A	N/A	N/A	N/A
	42	2Ah	N/A	N/A	N/A	N/A	N/A
	43	2Bh	N/A	N/A	N/A	N/A	N/A
	44	2Ch	N/A	N/A	N/A	N/A	N/A
	45	2Dh	N/A	N/A	N/A	N/A	N/A
	46	2Eh	N/A	N/A	N/A	N/A	N/A
	47	2Fh	N/A	N/A	N/A	N/A	N/A

A-3.2 Zone mode 3 permissions table

Note that all source and destination permissions not documented in the ZPT below should be assumed to be set to '0', except when stipulated otherwise in SPL [4].

Table 20 - Zone Permissions Table for Zone Mode 3

DST ZG / SRC ZG	0	1	2	…	8	9	10	11	12	13
0	1	1	0	…	0	0	0	0	0	0
1	1	1	1	…	1	1	1	1	1	1
2	0	1	1	…	0	0	0	0	0	0
…	…	…	…	…	…	…	…	…	…	…
8	0	1	0	…	1	0	0	1	0	0
9	0	1	0	…	0	1	0	1	0	0
10	0	1	0	…	0	0	1	0	1	1
11	0	1	0	…	1	1	0	1	0	0
12	0	1	0	…	0	0	1	0	1	0
13	0	1	0	…	0	0	1	0	0	1

A-4 Zone mode 4 configuration

A-4.1 Zone mode 4 phy settings

Table 21 - Phy Zone Settings for Zone Mode 4

Phy Type	Phy ID	Phy ID (hex)	IOM A		IOM B		RIZPSDS|IZP|ZGP
			Drive Bay	ZG	Drive Bay	ZG	
MiniSAS 0	0	0h	N/A	8	N/A	8	3h
	1	1h	N/A	8	N/A	8	3h
	2	2h	N/A	8	N/A	8	3h
	3	3h	N/A	8	N/A	8	3h
MiniSAS 1	4	4h	N/A	8	N/A	8	3h
	5	5h	N/A	8	N/A	8	3h
	6	6h	N/A	8	N/A	8	3h
	7	7h	N/A	8	N/A	8	3h
IOC 0	8	8h	N/A	10	N/A	10	3h
	9	9h	N/A	10	N/A	10	3h
	10	Ah	N/A	10	N/A	10	3h
	11	Bh	N/A	10	N/A	10	3h
	12	Ch	N/A	10	N/A	10	3h
	13	Dh	N/A	10	N/A	10	3h
	14	Eh	N/A	10	N/A	10	3h
	15	Fh	N/A	10	N/A	10	3h
IOC 1	16	10h	N/A	11	N/A	11	3h
	17	11h	N/A	11	N/A	11	3h
	18	12h	N/A	11	N/A	11	3h
	19	13h	N/A	11	N/A	11	3h
	20	14h	N/A	11	N/A	11	3h
	21	15h	N/A	11	N/A	11	3h
	22	16h	N/A	11	N/A	11	3h
	23	17h	N/A	11	N/A	11	3h
HDD	24	18h	8	13	3	12	3h
	25	19h	4	12	7	13	3h
	26	1Ah	0	12	11	13	3h
	27	1Bh	1	12	2	12	3h
	28	1Ch	5	12	10	13	3h
	29	1Dh	9	13	6	13	3h
	30	1Eh	2	12	9	13	3h
	31	1Fh	6	13	5	12	3h
	32	20h	3	12	8	13	3h
	33	21h	7	13	4	12	3h
	34	22h	10	13	1	12	3h
	35	23h	11	13	0	12	3h
	36	24h	N/A	N/A	N/A	N/A	N/A

Phy Type	Phy ID	Phy ID (hex)	IOM A		IOM B		RIZPSDS|IZP|ZGP
			Drive Bay	ZG	Drive Bay	ZG	
Unmapped	37	25h	N/A	N/A	N/A	N/A	N/A
	38	26h	N/A	N/A	N/A	N/A	N/A
	39	27h	N/A	N/A	N/A	N/A	N/A
	40	28h	N/A	N/A	N/A	N/A	N/A
	41	29h	N/A	N/A	N/A	N/A	N/A
	42	2Ah	N/A	N/A	N/A	N/A	N/A
	43	2Bh	N/A	N/A	N/A	N/A	N/A
	44	2Ch	N/A	N/A	N/A	N/A	N/A
	45	2Dh	N/A	N/A	N/A	N/A	N/A
	46	2Eh	N/A	N/A	N/A	N/A	N/A
	47	2Fh	N/A	N/A	N/A	N/A	N/A

A-4.2 Zone mode 4 permissions table

Note that all source and destination permissions not documented in the ZPT below should be assumed to be set to '0', except when stipulated otherwise in SPL [4].

Table 22 - Zone Permissions Table for Zone Mode 4

DST ZG / SRC ZG	0	1	2	…	8	…	10	11	12	13
0	1	1	0	…	0	…	0	0	0	0
1	1	1	1	…	1	…	1	0[a]	1	1
2	0	1	1	…	0	…	0	0	0	0
…	…	…	…	…	…	…	…	…	…	…
8	0	1	0	…	1	…	1	0	0	0
…	…	…	…	…	…	…	…	…	…	…
10	0	1	0	…	1	…	1	0	1	1
11	0	0[a]	0	…	0	…	0	1	0	0
12	0	1	0	…	0	…	1	0	1	0
13	0	1	0	…	0	…	1	0	0	1

[a] ZG1 access is intentionally disallowed to suppress SEP access from second IOC port

A-5 Zone mode 5 configuration

A-5.1 Zone mode 5 phy settings

Table 23 - Phy Zone Settings for Zone Mode 5

Phy Type	Phy ID	Phy ID (hex)	IOM A		IOM B		RIZPSDS|IZP|ZGP
			Drive Bay	ZG	Drive Bay	ZG	
MiniSAS 0	0	0h	N/A	1	N/A	1	7h
	1	1h	N/A	1	N/A	1	7h
	2	2h	N/A	1	N/A	1	7h
	3	3h	N/A	1	N/A	1	7h
MiniSAS 1	4	4h	N/A	1	N/A	1	7h
	5	5h	N/A	1	N/A	1	7h
	6	6h	N/A	1	N/A	1	7h
	7	7h	N/A	1	N/A	1	7h
IOC 0	8	8h	N/A	10	N/A	16	3h
	9	9h	N/A	10	N/A	16	3h
	10	Ah	N/A	10	N/A	16	3h
	11	Bh	N/A	10	N/A	16	3h
	12	Ch	N/A	10	N/A	16	3h
	13	Dh	N/A	10	N/A	16	3h
	14	Eh	N/A	10	N/A	16	3h
	15	Fh	N/A	10	N/A	16	3h
IOC 1	16	10h	N/A	11	N/A	17	3h
	17	11h	N/A	11	N/A	17	3h
	18	12h	N/A	11	N/A	17	3h
	19	13h	N/A	11	N/A	17	3h
	20	14h	N/A	11	N/A	17	3h
	21	15h	N/A	11	N/A	17	3h
	22	16h	N/A	11	N/A	17	3h
	23	17h	N/A	11	N/A	17	3h
HDD	24	18h	8	14	3	13	3h
	25	19h	4	13	7	14	3h
	26	1Ah	0	12	11	15	3h
	27	1Bh	1	12	2	12	3h
	28	1Ch	5	13	10	15	3h
	29	1Dh	9	15	6	14	3h
	30	1Eh	2	12	9	15	3h
	31	1Fh	6	14	5	13	3h
	32	20h	3	13	8	14	3h
	33	21h	7	14	4	13	3h
	34	22h	10	15	1	12	3h
	35	23h	11	15	0	12	3h
	36	24h	N/A	N/A	N/A	N/A	N/A

Phy Type	Phy ID	Phy ID (hex)	IOM A		IOM B		RIZPSDS|IZP|ZGP
			Drive Bay	ZG	Drive Bay	ZG	
Unmapped	37	25h	N/A	N/A	N/A	N/A	N/A
	38	26h	N/A	N/A	N/A	N/A	N/A
	39	27h	N/A	N/A	N/A	N/A	N/A
	40	28h	N/A	N/A	N/A	N/A	N/A
	41	29h	N/A	N/A	N/A	N/A	N/A
	42	2Ah	N/A	N/A	N/A	N/A	N/A
	43	2Bh	N/A	N/A	N/A	N/A	N/A
	44	2Ch	N/A	N/A	N/A	N/A	N/A
	45	2Dh	N/A	N/A	N/A	N/A	N/A
	46	2Eh	N/A	N/A	N/A	N/A	N/A
	47	2Fh	N/A	N/A	N/A	N/A	N/A

A-5.2 Zone mode 5 permissions table

Note that all source and destination permissions not documented in the ZPT below should be assumed to be set to '0', except when stipulated otherwise in SPL [4].

Table 24 - Zone Permissions Table for Zone Mode 5

DST ZG / SRC ZG	0	1	2	…	10	11	12	13	14	15	16	17
0	1	1	0	…	0	0	0	0	0	0	0	0
1	1	1	1	…	1	1	1	1	1	1	1	1
2	0	1	1	…	0	0	0	0	0	0	0	0
…	…	…	…	…	…	…	…	…	…	…	…	…
10	0	1	0	…	1	0	1	0	0	0	0	0
11	0	1	0	…	0	1	0	1	0	0	0	0
12	0	1	0	…	1	0	1	0	0	0	0	0
13	0	1	0	…	0	1	0	1	0	0	0	0
14	0	1	0	…	0	0	0	0	1	0	1	0
15	0	1	0	…	0	0	0	0	0	1	0	1
16	0	1	0	…	0	0	0	0	1	0	1	0
17	0	1	0	…	0	0	0	0	0	1	0	1

A-6 Zone mode 6 configuration

A-6.1 Zone mode 6 phy settings

Table 25 - Phy Zone Settings for Zone Mode 6

Phy Type	Phy ID	Phy ID (hex)	IOM A		IOM B		RIZPSDS|IZP|ZGP
			Drive Bay	ZG	Drive Bay	ZG	
MiniSAS 0	0	0h	N/A	8	N/A	9	3h
	1	1h	N/A	8	N/A	9	3h
	2	2h	N/A	8	N/A	9	3h
	3	3h	N/A	8	N/A	9	3h
MiniSAS 1	4	4h	N/A	8	N/A	9	3h
	5	5h	N/A	8	N/A	9	3h
	6	6h	N/A	8	N/A	9	3h
	7	7h	N/A	8	N/A	9	3h
IOC 0	8	8h	N/A	10	N/A	16	3h
	9	9h	N/A	10	N/A	16	3h
	10	Ah	N/A	10	N/A	16	3h
	11	Bh	N/A	10	N/A	16	3h
	12	Ch	N/A	10	N/A	16	3h
	13	Dh	N/A	10	N/A	16	3h
	14	Eh	N/A	10	N/A	16	3h
	15	Fh	N/A	10	N/A	16	3h
IOC 1	16	10h	N/A	11	N/A	17	3h
	17	11h	N/A	11	N/A	17	3h
	18	12h	N/A	11	N/A	17	3h
	19	13h	N/A	11	N/A	17	3h
	20	14h	N/A	11	N/A	17	3h
	21	15h	N/A	11	N/A	17	3h
	22	16h	N/A	11	N/A	17	3h
	23	17h	N/A	11	N/A	17	3h
HDD	24	18h	8	14	3	13	3h
	25	19h	4	13	7	14	3h
	26	1Ah	0	12	11	15	3h
	27	1Bh	1	12	2	12	3h
	28	1Ch	5	13	10	15	3h
	29	1Dh	9	15	6	14	3h
	30	1Eh	2	12	9	15	3h
	31	1Fh	6	14	5	13	3h
	32	20h	3	13	8	14	3h
	33	21h	7	14	4	13	3h
	34	22h	10	15	1	12	3h
	35	23h	11	15	0	12	3h
	36	24h	N/A	N/A	N/A	N/A	N/A

Phy Type	Phy ID	Phy ID (hex)	IOM A		IOM B		RIZPSDS|IZP|ZGP
			Drive Bay	ZG	Drive Bay	ZG	
Unmapped	37	25h	N/A	N/A	N/A	N/A	N/A
	38	26h	N/A	N/A	N/A	N/A	N/A
	39	27h	N/A	N/A	N/A	N/A	N/A
	40	28h	N/A	N/A	N/A	N/A	N/A
	41	29h	N/A	N/A	N/A	N/A	N/A
	42	2Ah	N/A	N/A	N/A	N/A	N/A
	43	2Bh	N/A	N/A	N/A	N/A	N/A
	44	2Ch	N/A	N/A	N/A	N/A	N/A
	45	2Dh	N/A	N/A	N/A	N/A	N/A
	46	2Eh	N/A	N/A	N/A	N/A	N/A
	47	2Fh	N/A	N/A	N/A	N/A	N/A

A-6.2 Zone mode 6 permissions table

Note that all source and destination permissions not documented in the ZPT below should be assumed to be set to ‘0’, except when stipulated otherwise in SPL [4].

Table 26 - Zone Permissions Table for Zone Mode 6

DST ZG / SRC ZG	0	1	2	…	8	9	10	11	12	13	14	15	16	17
0	1	1	0	…	0	0	0	0	0	0	0	0	0	0
1	1	1	1	…	1	1	1	1	1	1	1	1	1	1
2	0	1	1	…	0	0	0	0	0	0	0	0	0	0
…	…	…	…	…	…	…	…	…	…	…	…	…	…	…
8	0	1	0	…	1	0	0	1	0	0	0	0	0	0
9	0	1	0	…	0	1	0	0	0	0	0	0	0	1
10	0	1	0	…	0	0	1	0	1	1	0	0	0	0
11	0	1	0	…	1	0	0	1	0	0	0	0	0	0
12	0	1	0	…	0	0	1	0	1	0	0	0	0	0
13	0	1	0	…	0	0	1	0	0	1	0	0	0	0
14	0	1	0	…	0	0	0	0	0	0	1	0	1	0
15	0	1	0	…	0	0	0	0	0	0	0	1	1	0
16	0	1	0	…	0	0	0	0	0	0	1	1	1	0
17	0	1	0	…	0	1	0	0	0	0	0	0	0	1