Exos AP 2U24

GEM 5 SES-3 Addenda

205135200-00-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 2U24 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 Specification [1] should be referenced.

This document applies to the following enclosure product IDs.

- EB-2425-AP-BV-1
- SP-3224-AP-BV-1
- SP-3224A-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.
Non-critical 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] T10 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	24
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

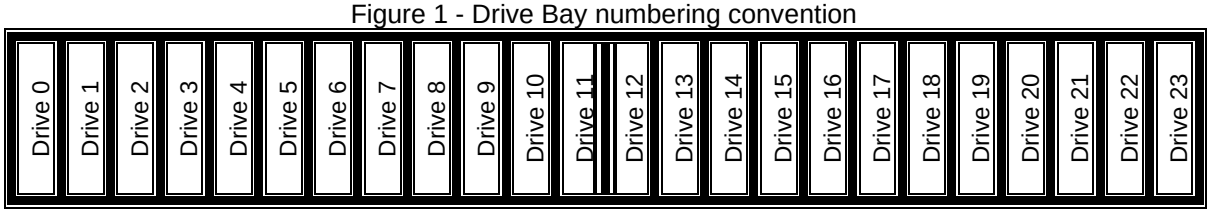
3 Element to Device Mapping

3.1 Enclosure FRU Layout

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

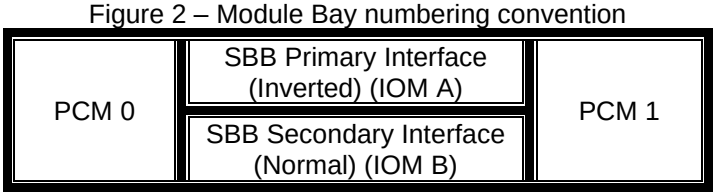
3.1.1 Enclosure Front View

Figure 1 - Drive Bay numbering convention



3.1.2 Enclosure Rear View

Figure 2 – Module Bay numbering convention



3.2 SES Element Mapping

For SES Pages 02h, 05h, 07h and 92h the element to physical device mapping is shown in Table 3.

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
…	…	…	…
23	23	Array Device element representing Disk Drive Bay 23	Enclosure
Enclosure Services Controller Electronics Elements			
24	0	Element associated with SEP device	SBB IOM A
25	1	Element associated with SEP device	SBB IOM B
Enclosure Elements			
26	0	Element representing the Enclosure	Enclosure
SAS Expander Elements			
27	0	SBB IOM SAS Expander	SBB IOM A
28	1	SBB IOM SAS Expander	SBB IOM B
SAS Connector Elements			
29	0	SAS Connector for IOM MiniSAS HD Port A	SBB IOM A
30	1	SAS Connector for IOM MiniSAS HD Port B	SBB IOM A
31	2	Internal IOC Port A	SBB IOM A
32	3	Internal IOC Port B	SBB IOM A
33	4	SAS Connector for IOM MiniSAS HD Port A	SBB IOM B
34	5	SAS Connector for IOM MiniSAS HD Port B	SBB IOM B
35	6	Internal IOC Port A	SBB IOM B
36	7	Internal IOC Port B	SBB IOM B
SBB Midplane Interconnect Elements			
37	0	SBB IOM to Midplane Interconnect Electronics	SBB IOM A
28	1	SBB IOM to Midplane Interconnect Electronics	SBB IOM B
Enclosure Electronics Power Elements			
39	0	SBB IOM Power Status and Control	SBB IOM A
40	1	SBB IOM Power Status and Control	SBB IOM B
Enclosure Electronics Diagnostics Elements			
41	0	SEP Diagnostics status and Control	SBB IOM A
42	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 (**2h**)		
9	SUBENCLOSURE IDENTIFIER (**00h**)							
10	NUMBER OF TYPE DESCRIPTOR HEADERS (**09h**)							
11	ENCLOSURE DESCRIPTOR LENGTH (**60**)							
12	ENCLOSURE LOGICAL IDENTIFIER (**Determined by Midplane VPD**)							
19								
20	ENCLOSURE VENDOR IDENTIFICATION (“**SEAGATE** ”)							
27								

Bit Byte	7	6	5	4	3	2	1	0
28	PRODUCT IDENTIFICATION (**"SP-3224-AP-BV-1 "** or "**SP-3224A-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 18 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								

[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 (**208**)						
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								
...	...							
104	Array Device Element 23 Descriptor							
107								
108	Enclosure Services Controller Electronics Overall Element Descriptor							
111								
112	Enclosure Services Controller Electronics Element 0 Descriptor							
115								
116	Enclosure Services Controller Electronics Element 1 Descriptor							
119								
120	Enclosure Overall Element Descriptor							
123								
124	Enclosure Element 0 Descriptor							
127								
128	SAS Expander Overall Element Descriptor							
131								
132	SAS Expander Element 0 Descriptor							
135								
136	SAS Expander Element 1 Descriptor							
139								
140	SAS Connector Overall Element Descriptor							
143								
144	SAS Connector Element 0 Descriptor							

Bit / Byte	7	6	5	4	3	2	1	0
147								
…	...							
172	SAS Connector Element 7 Descriptor							
175								
176	SBB Midplane Interconnect Overall Element Descriptor							
179								
180	SBB Midplane Interconnect Element 0 Descriptor							
183								
184	SBB Midplane Interconnect Element1 Descriptor							
187								
188	Enclosure Electronics Power Overall Element Descriptor							
191								
192	Enclosure Electronics Power Element 0 Descriptor							
195								
196	Enclosure Electronics Power Element1 Descriptor							
199								
200	Enclosure Electronics Diagnostics Overall Element Descriptor							
203								
204	Enclosure Electronics Diagnostics Element 0 Descriptor							
207								
208	Enclosure Electronics Diagnostics Element1 Descriptor							
211								

[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 [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 (**687**)				
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								
…	...							
104				Array Device Element 23 Descriptor (**00 00 00 00 h**)				
107								
108				Enclosure Services Controller Electronics Overall Element Descriptor (**00 00 00 00 h**)				
111								
112				Enclosure Services Controller Electronics Element 0 Descriptor (**00 00 00 7C h**) **124 bytes of descriptor data**[1]				
239								
240				Enclosure Services Controller Electronics Element 1 Descriptor (**00 00 00 7C h**) **124 bytes of descriptor data**[1]				
367								
368				Enclosure Overall Element Descriptor (**00 00 00 00 h**)				
371								
372				Enclosure Element 0 Descriptor (**00 00 00 47 h**) **71 bytes of descriptor data**[1]				
446								
447				SAS Expander Overall Element Descriptor (**00 00 00 00 h**)				
450								
451	SAS Expander Element 0 Descriptor							

Bit Byte	7	6	5	4	3	2	1	0
454	(**00 00 00 00 h**)							
455	SAS Expander Element 1 Descriptor (**00 00 00 00 h**)							
458								
459	SAS Connector Overall Element Descriptor (**00 00 00 00 h**)							
462								
463	SAS Connector Element 0 Descriptor (**00 00 00 14 h**)							
486	**20 bytes of descriptor data**[1]							
…	…							
631	SAS Connector Element 7 Descriptor (**00 00 00 14 h**)							
654	**20 bytes of descriptor data**[1]							
655	SBB Midplane Interconnect Overall Element Descriptor (**00 00 00 00 h**)							
658								
659	SBB Midplane Interconnect Element 0 Descriptor (**00 00 00 00 h**)							
662								
663	SBB Midplane Interconnect Element 1 Descriptor (**00 00 00 00 h**)							
666								
667	Enclosure Electronics Power Overall Element Descriptor (**00 00 00 00 h**)							
670								
671	Enclosure Electronics Power Element 0 Descriptor (**00 00 00 00 h**)							
674								
675	Enclosure Electronics Power Element 1 Descriptor (**00 00 00 00 h**)							
678								
679	Enclosure Electronics Diagnostics Overall Element Descriptor (**00 00 00 00 h**)							
682								
683	Enclosure Electronics Diagnostics Element 0 Descriptor (**00 00 00 00 h**)							
686								
687	Enclosure Electronics Diagnostics Element 1 Descriptor (**00 00 00 00 h**)							
690								

[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=XXXXXXXX;PN=XXXXXXXXXX;*
Temperature Sensor	*NM=XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX;LO=XXXXXXXXXXXXXXXX;*
Enclosure Services Controller Electronics	*TP=XX;SN=XXXXXXXXXXXXXXX;F1=XXXX;BL=XXXX;VR=XX;VC=XXXXXXXX;CR=XX;FR=XX;FC=XXXXXXXX;PN=XXXXXXXXXX;FF1=XXXXXXXX;PC=XXXXXXXX;*
Enclosure	*SN=XXXXXXXXXXXXXXX;VR=XX;VC=XXXXXXXX;CR=XX;PN=XXXXXXXXXX;CM=XX;TP=XX;*
Voltage Sensor	*NM=XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX;LO=XXXXXXXXXXXXXXXX;*
Current Sensor	*NM=XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX;LO=XXXXXXXXXXXXXXXX;*
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 (**1096**)						
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 23 Additional Status Descriptor								
836	INVALID	Reserved			EIP (**1**)	PROTOCOL IDENTIFIER (**6**)		
837	ADDITIONAL ELEMENT STATUS DESCRIPTOR LENGTH (**34**)							
838	Reserved							EIIOE (**0**)
839	ELEMENT INDEX (**23**)							
840	NUM OF DEVICE PHY DESCRIPTORS (**1**)							
841	DESC TYPE (**0**)		Reserved					NOT ALL PHYS (**1**)
842	Reserved							
843	DEVICE SLOT NUMBER (**23**)							
844	Phy Descriptor for Device 23 (SBB IOM A phy)							
871								

Bit Byte	7	6	5	4	3	2	1	0
Expander 0 Additional Status Descriptor								
872	INVALID	Reserved		EIP (**1**)	PROTOCOL IDENTIFIER (**6**)			
873	ADDITIONAL ELEMENT STATUS DESCRIPTOR LENGTH (**112**)							
874	Reserved							EIIOE (**0**)
875	ELEMENT INDEX (**37**)							
876	NUM OF EXPANDER PHY DESCRIPTORS (**49**)							
877	DESC TYPE (**1**)		Reserved					
878	Reserved							
879								
880	EXPANDER SAS ADDRESS							
887								
888	Phy Descriptor 0 for Expander 0 (SBB IOM A)							
889								
	…							
982	Phy Descriptor 48 for Expander 0 (SBB IOM A)							
985								
Expander 1 Additional Status Descriptor								
986	INVALID	Reserved		EIP (**1**)	PROTOCOL IDENTIFIER (**6**)			
987	ADDITIONAL ELEMENT STATUS DESCRIPTOR LENGTH (**112**)							
988	Reserved							EIIOE (**0**)
989	ELEMENT INDEX (**38**)							
990	NUM OF EXPANDER PHY DESCRIPTORS (**0**)							
991	DESC TYPE (**1**)		Reserved					
992	Reserved							
993								
994	EXPANDER SAS ADDRESS							
995								
888	Phy Descriptor 0 for Expander 1 (SBB IOM B)							
889								
	…							
1098	Phy Descriptor 48 for Expander 1 (SBB IOM B)							
1099								

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 (**1096**)						
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 23 Additional Status Descriptor								
836	INVALID	Reserved		EIP (**1**)	PROTOCOL IDENTIFIER (**6**)			
837	ADDITIONAL ELEMENT STATUS DESCRIPTOR LENGTH (**34**)							
838	Reserved							EIIOE (**0**)
839	ELEMENT INDEX (**23**)							
840	NUM OF DEVICE PHY DESCRIPTORS (**1**)							
841	DESC TYPE (**0**)		Reserved					NOT ALL PHYS (**1**)
842	Reserved							
843	DEVICE SLOT NUMBER (**23**)							
844	Phy Descriptor for Device 23 (SBB IOM B phy)							
871								
Expander 0 Additional Status Descriptor								
872	INVALID	Reserved		EIP (**1**)	PROTOCOL IDENTIFIER (**6**)			
873	ADDITIONAL ELEMENT STATUS DESCRIPTOR LENGTH (**112**)							
874	Reserved							EIIOE (**0**)
875	ELEMENT INDEX (**37**)							

Bit / Byte	7	6	5	4	3	2	1	0
876	NUM OF EXPANDER PHY DESCRIPTORS (**0**)							
877	DESC TYPE (**1**)		Reserved					
878	Reserved							
879								
880	EXPANDER SAS ADDRESS							
887								
888	Phy Descriptor 0 for Expander 0 (SBB IOM A)							
889								
	...							
982	Phy Descriptor 48 for Expander 0 (SBB IOM A)							
985								
Expander 1 Additional Status Descriptor								
986	INVALID	Reserved		EIP (**1**)	PROTOCOL IDENTIFIER (**6**)			
987	ADDITIONAL ELEMENT STATUS DESCRIPTOR LENGTH (**112**)							
988	Reserved							EIIOE (**0**)
989	ELEMENT INDEX (**38**)							
990	NUM OF EXPANDER PHY DESCRIPTORS (**37**)							
991	DESC TYPE (**1**)		Reserved					
992	Reserved							
993								
994	EXPANDER SAS ADDRESS							
995								
888	Phy Descriptor 0 for Expander 0 (SBB IOM B)							
889								
	...							
1098	Phy Descriptor 48 for Expander 0 (SBB IOM B)							
1099								

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)			PAGE LENGTH (2708)				
3								(LSB)
4	(MSB)			GENERATION CODE				
7								(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)			EXPANDER CHANGE COUNT				
14								(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)			EXPANDER CHANGE COUNT				
1366								(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 (**2256**)						
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								
…	…							
104	Array Device Element 23 Descriptor (**00 00 00 00 h**)							
107								
108	Enclosure Services Controller Electronics Overall Element Descriptor (**00 00 00 00 h**)							
111								
112	Enclosure Services Controller Electronics Element 0 Descriptor (**00 00 00 00 h**)							
115								
116	Enclosure Services Controller Electronics Element 1 Descriptor (**00 00 00 00 h**)							
119								
120	Enclosure Overall Element Descriptor (**00 00 00 00 h**)							
123								
124	Enclosure Element 0 Descriptor (**00 00 00 00 h**)							
127								
128	SAS Expander Overall Element Descriptor (**00 00 00 00 h**)							
131								
132	SAS Expander Element 0 Descriptor (**00 00 00 00 h**)							
135								
136	SAS Expander Element 1 Descriptor							

Bit / Byte	7	6	5	4	3	2	1	0
139	(**00 00 00 00 h**)							
140	SAS Connector Overall Element Descriptor (**00 00 00 00 h**)							
143								
144	SAS Connector Element 0 Descriptor (**01 00 02 00 h**) 512 bytes of descriptor data[1]							
659								
660	SAS Connector Element 1 Descriptor (**01 00 02 00 h**) 512 bytes of descriptor data[1]							
1175								
1176	SAS Connector Element 2 Descriptor (**01 00 00 00 h**)							
1179								
1180	SAS Connector Element 3 Descriptor (**01 00 00 00 h**)							
1183								
1184	SAS Connector Element 4 Descriptor (**01 00 02 00 h**) 512 bytes of descriptor data[1]							
1699								
1700	SAS Connector Element 5 Descriptor (**01 00 02 00 h**) 512 bytes of descriptor data[1]							
2215								
2216	SAS Connector Element 6 Descriptor (**01 00 00 00 h**)							
2219								
2220	SAS Connector Element 7 Descriptor (**01 00 00 00 h**)							
2223								
2224	SBB Midplane Interconnect Overall Element Descriptor (**00 00 00 00 h**)							
2227								
2228	SBB Midplane Interconnect Element 0 Descriptor (**00 00 00 00 h**)							
2231								
2232	SBB Midplane Interconnect Element1 Descriptor (**00 00 00 00 h**)							
2235								
2236	Enclosure Electronics Power Overall Element Descriptor (**00 00 00 00 h**)							
2239								
2240	Enclosure Electronics Power Element 0 Descriptor (**00 00 00 00 h**)							
2243								
2244	Enclosure Electronics Power Element1 Descriptor (**00 00 00 00 h**)							
2247								
2248	Enclosure Electronics Diagnostics Overall Element Descriptor (**00 00 00 00 h**)							
2251								
2252	Enclosure Electronics Diagnostics Element 0 Descriptor (**00 00 00 00 h**)							
2255								
2256	Enclosure Electronics Diagnostics Element1 Descriptor (**00 00 00 00 h**)							
2259								

[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 2U24 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 5.

5.2.1 Zone mode 1 - HA Performance Mode

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

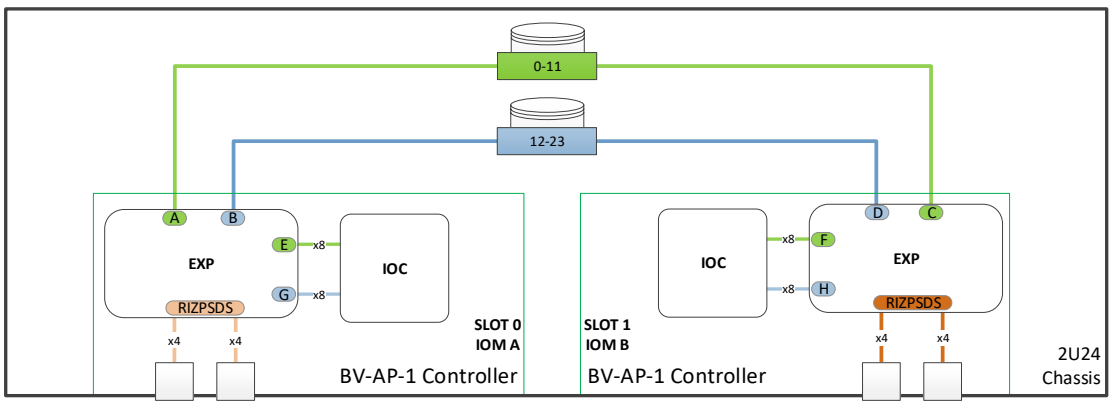
This zone mode segregates the disk drives into two even groups and assigns them to each of the embedded IOC x8 SAS ports, ensuring both ports are fully utilized for balanced I/O.

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.



Ⓐ = Zone Group

2U24 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	12	13	14	15	16	17	18	19	20	21	22	23

Figure 3 - Zone mode 1 configuration

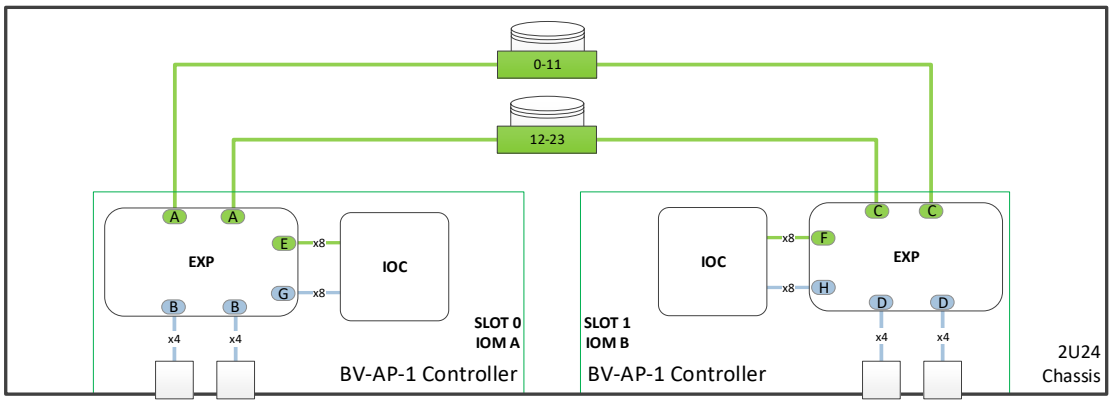
5.2.2 Zone mode 2 - HA Expansion Mode

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.



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

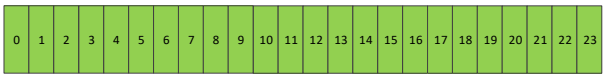


Figure 4 - Zone Mode 2 configuration

5.2.3 Zone Mode 3 - HA Hybrid

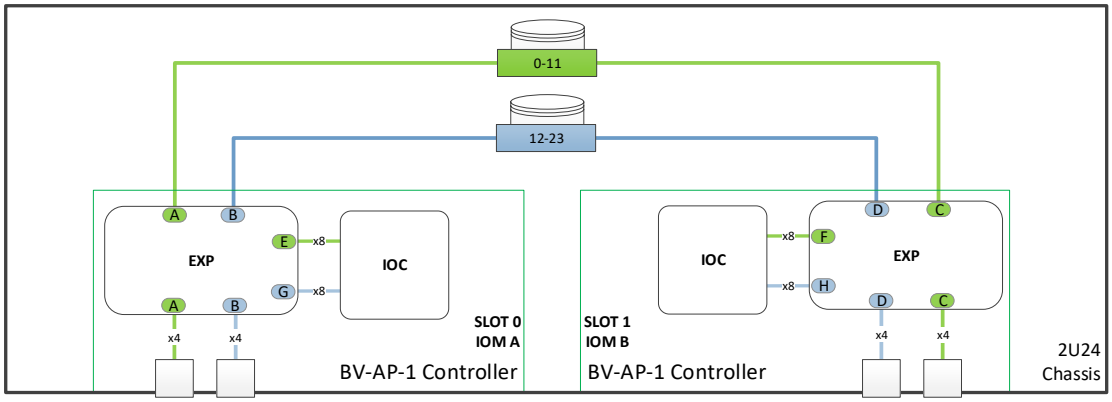
Zone mode 3 is optimized for high availability (HA) performance, along with support for expansion enclosures that should be excluded from the ZPSDS.

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

2U24 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

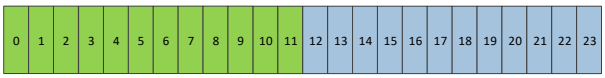


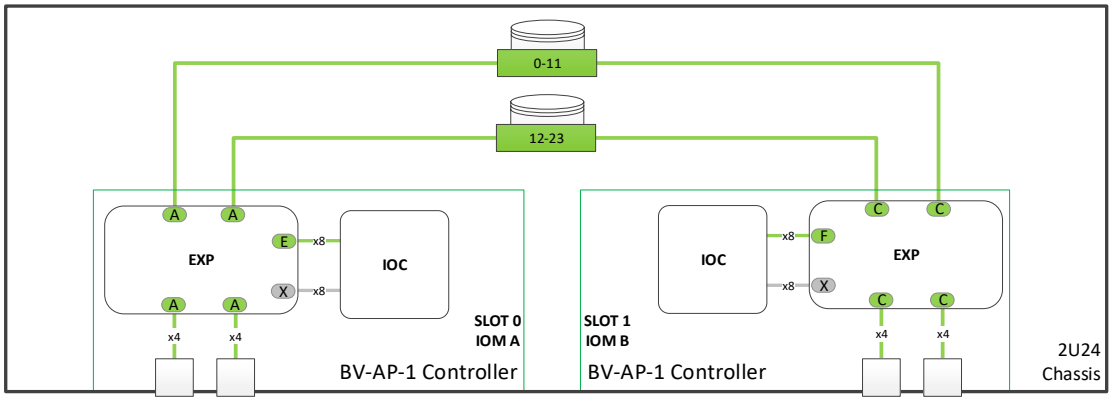
Figure 5 - Zone Mode 3 configuration

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

2U24 SAS ZM4

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

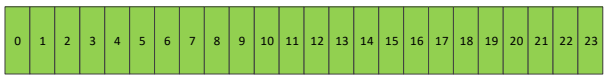


Figure 6 - Zone Mode 4 configuration

5.2.5 Zone Mode 5 - SCSN Performance Mode

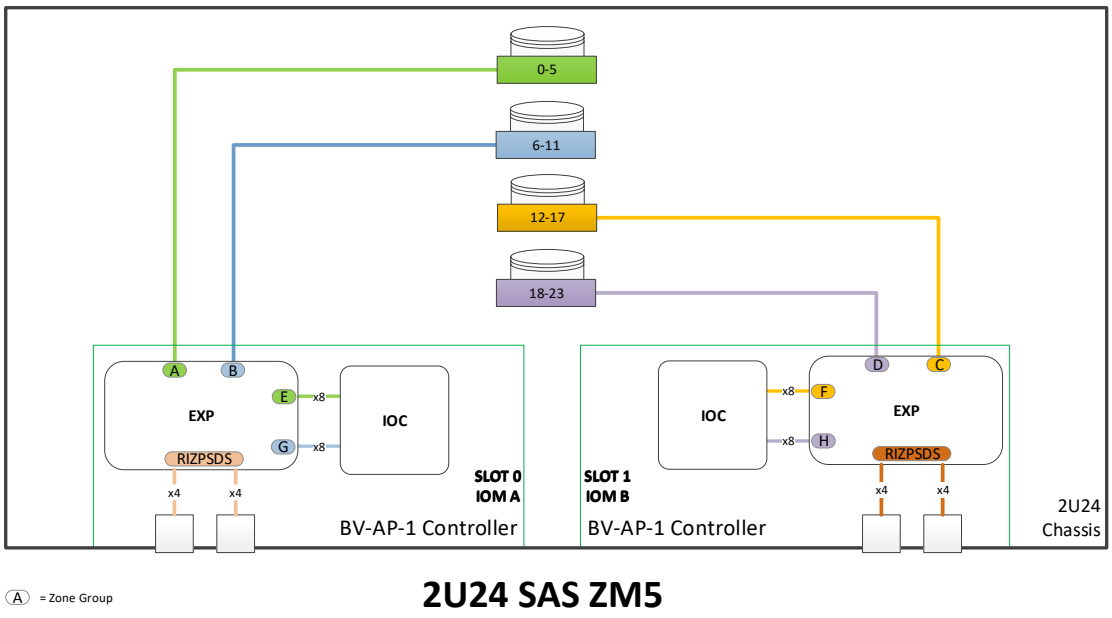
Zone mode 5 is optimized for single-enclosure performance where the drives are divided evenly between the two redundant enclosure data paths (known as Single Controller-Share Nothing),

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

2U24 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	12	13	14	15	16	17	18	19	20	21	22	23

Figure 7 - Zone Mode 5 configuration

5.2.6 Zone Mode 6 - SCSN expansion

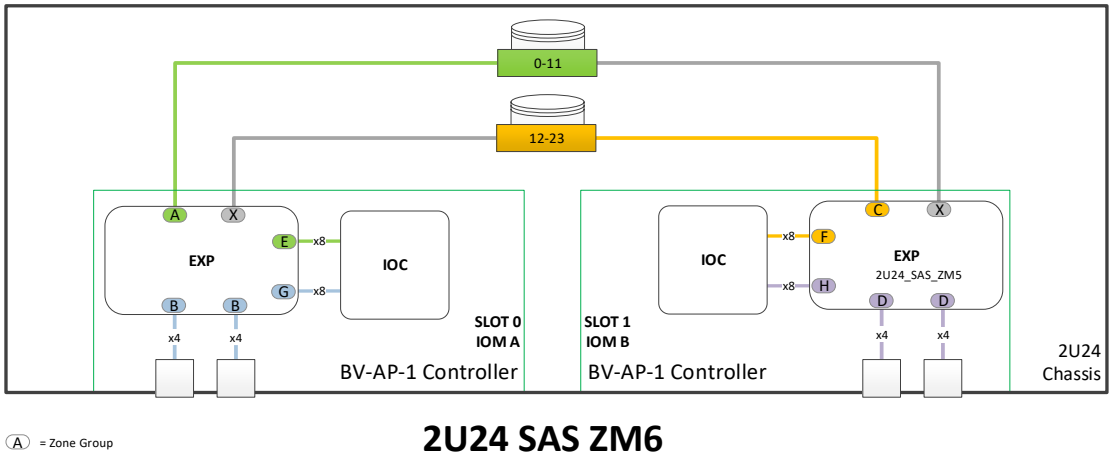
Zone mode 6 is optimized for expansion where the drives are divided between the two redundant enclosure data paths (known as Single Controller-Share Nothing),

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.



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	12	13	14	15	16	17	18	19	20	21	22	23

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	0	12	23	13	3h
	25	19h	1	12	22	13	3h
	26	1Ah	2	12	21	13	3h
	27	1Bh	3	12	16	13	3h
	28	1Ch	4	12	17	13	3h
	29	1Dh	5	12	18	13	3h
	30	1Eh	6	12	15	13	3h
	31	1Fh	7	12	12	13	3h
	32	20h	8	12	13	13	3h
	33	21h	9	12	14	13	3h
	34	22h	10	12	19	13	3h

Phy Type	Phy ID	Phy ID (hex)	IOM A		IOM B		RIZPSDS|IZP|ZGP
			Drive Bay	ZG	Drive Bay	ZG	
HDD	35	23h	11	12	20	13	3h
	36	24h	12	13	2	12	3h
	37	25h	13	13	11	12	3h
	38	26h	14	13	3	12	3h
	39	27h	15	13	4	12	3h
	40	28h	16	13	5	12	3h
	41	29h	17	13	6	12	3h
	42	2Ah	18	13	10	12	3h
	43	2Bh	19	13	7	12	3h
	44	2Ch	20	13	8	12	3h
	45	2Dh	21	13	9	12	3h
	46	2Eh	22	13	1	12	3h
	47	2Fh	23	13	0	12	3h

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	0	12	23	13	3h
	25	19h	1	12	22	13	3h
	26	1Ah	2	12	21	13	3h
	27	1Bh	3	12	16	13	3h
	28	1Ch	4	12	17	13	3h
	29	1Dh	5	12	18	13	3h
	30	1Eh	6	12	15	13	3h
	31	1Fh	7	12	12	13	3h
	32	20h	8	12	13	13	3h
	33	21h	9	12	14	13	3h
	34	22h	10	12	19	13	3h
	35	23h	11	12	20	13	3h
	36	24h	12	13	2	12	3h
	37	25h	13	13	11	12	3h

Phy Type	Phy ID	Phy ID (hex)	IOM A		IOM B		RIZPSDS|IZP|ZGP
			Drive Bay	ZG	Drive Bay	ZG	
HDD	38	26h	14	13	3	12	3h
	39	27h	15	13	4	12	3h
	40	28h	16	13	5	12	3h
	41	29h	17	13	6	12	3h
	42	2Ah	18	13	10	12	3h
	43	2Bh	19	13	7	12	3h
	44	2Ch	20	13	8	12	3h
	45	2Dh	21	13	9	12	3h
	46	2Eh	22	13	1	12	3h
	47	2Fh	23	13	0	12	3h

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	0	12	23	13	3h
	25	19h	1	12	22	13	3h
	26	1Ah	2	12	21	13	3h
	27	1Bh	3	12	16	13	3h
	28	1Ch	4	12	17	13	3h
	29	1Dh	5	12	18	13	3h
	30	1Eh	6	12	15	13	3h
	31	1Fh	7	12	12	13	3h
	32	20h	8	12	13	13	3h
	33	21h	9	12	14	13	3h
	34	22h	10	12	19	13	3h
	35	23h	11	12	20	13	3h
	36	24h	12	13	2	12	3h
	37	25h	13	13	11	12	3h

Phy Type	Phy ID	Phy ID (hex)	IOM A		IOM B		RIZPSDS|IZP|ZGP
			Drive Bay	ZG	Drive Bay	ZG	
HDD	38	26h	14	13	3	12	3h
	39	27h	15	13	4	12	3h
	40	28h	16	13	5	12	3h
	41	29h	17	13	6	12	3h
	42	2Ah	18	13	10	12	3h
	43	2Bh	19	13	7	12	3h
	44	2Ch	20	13	8	12	3h
	45	2Dh	21	13	9	12	3h
	46	2Eh	22	13	1	12	3h
	47	2Fh	23	13	0	12	3h

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	0	12	23	13	3h
	25	19h	1	12	22	13	3h
	26	1Ah	2	12	21	13	3h
	27	1Bh	3	12	16	13	3h
	28	1Ch	4	12	17	13	3h
	29	1Dh	5	12	18	13	3h
	30	1Eh	6	12	15	13	3h
	31	1Fh	7	12	12	13	3h
	32	20h	8	12	13	13	3h
	33	21h	9	12	14	13	3h
	34	22h	10	12	19	13	3h
	35	23h	11	12	20	13	3h
	36	24h	12	13	2	12	3h
	37	25h	13	13	11	12	3h

Phy Type	Phy ID	Phy ID (hex)	IOM A		IOM B		RIZPSDS|IZP|ZGP
			Drive Bay	ZG	Drive Bay	ZG	
HDD	38	26h	14	13	3	12	3h
	39	27h	15	13	4	12	3h
	40	28h	16	13	5	12	3h
	41	29h	17	13	6	12	3h
	42	2Ah	18	13	10	12	3h
	43	2Bh	19	13	7	12	3h
	44	2Ch	20	13	8	12	3h
	45	2Dh	21	13	9	12	3h
	46	2Eh	22	13	1	12	3h
	47	2Fh	23	13	0	12	3h

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	0	12	23	15	3h
	25	19h	1	12	22	15	3h
	26	1Ah	2	12	21	15	3h
	27	1Bh	3	12	16	14	3h
	28	1Ch	4	12	17	14	3h
	29	1Dh	5	12	18	15	3h
	30	1Eh	6	13	15	14	3h
	31	1Fh	7	13	12	14	3h
	32	20h	8	13	13	14	3h
	33	21h	9	13	14	14	3h
	34	22h	10	13	19	15	3h
	35	23h	11	13	20	15	3h
	36	24h	12	14	2	12	3h
	37	25h	13	14	11	13	3h

Phy Type	Phy ID	Phy ID (hex)	IOM A		IOM B		RIZPSDS|IZP|ZGP
			Drive Bay	ZG	Drive Bay	ZG	
HDD	38	26h	14	14	3	12	3h
	39	27h	15	14	4	12	3h
	40	28h	16	14	5	12	3h
	41	29h	17	14	6	13	3h
	42	2Ah	18	15	10	13	3h
	43	2Bh	19	15	7	13	3h
	44	2Ch	20	15	8	13	3h
	45	2Dh	21	15	9	13	3h
	46	2Eh	22	15	1	12	3h
	47	2Fh	23	15	0	12	3h

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	0	12	23	15	3h
	25	19h	1	12	22	15	3h
	26	1Ah	2	12	21	15	3h
	27	1Bh	3	12	16	14	3h
	28	1Ch	4	12	17	14	3h
	29	1Dh	5	12	18	15	3h
	30	1Eh	6	13	15	14	3h
	31	1Fh	7	13	12	14	3h
	32	20h	8	13	13	14	3h
	33	21h	9	13	14	14	3h
	34	22h	10	13	19	15	3h
	35	23h	11	13	20	15	3h
	36	24h	12	14	2	12	3h
	37	25h	13	14	11	13	3h

Phy Type	Phy ID	Phy ID (hex)	IOM A		IOM B		RIZPSDS|IZP|ZGP
			Drive Bay	ZG	Drive Bay	ZG	
Unmapped	38	26h	14	14	3	12	3h
	39	27h	15	14	4	12	3h
	40	28h	16	14	5	12	3h
	41	29h	17	14	6	13	3h
	42	2Ah	18	15	10	13	3h
	43	2Bh	19	15	7	13	3h
	44	2Ch	20	15	8	13	3h
	45	2Dh	21	15	9	13	3h
	46	2Eh	22	15	1	12	3h
	47	2Fh	23	15	0	12	3h

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