NVM Express: SCSI Translation Reference

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Revision 1.2

March 17, 2014

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Introduction

1.1 Scope and Theory of Operation

This document defines an NVM Express translation reference for SCSI. NVM Express defines a host controller interface and command set for use with non-volatile memory (NVM) devices, such as PCI Express solid state drives (SSDs). There are existing applications and software infrastructure built upon the SCSI architectural model defined by T10. The purpose of this document is to define a mapping between SCSI and NVM Express specifications to enable a seamless transition to NVM Express by preserving existing software infrastructure investments.

Host software implementing the mapping of SCSI commands into NVM Express commands may be logically viewed as a layer within the operating system stack. Figure 1 depicts the translation layer pictorially. The NVM Express Driver may implement the translation as an upper layer within the driver.

Figure 1: NVM Express SCSI Translation Driver Model
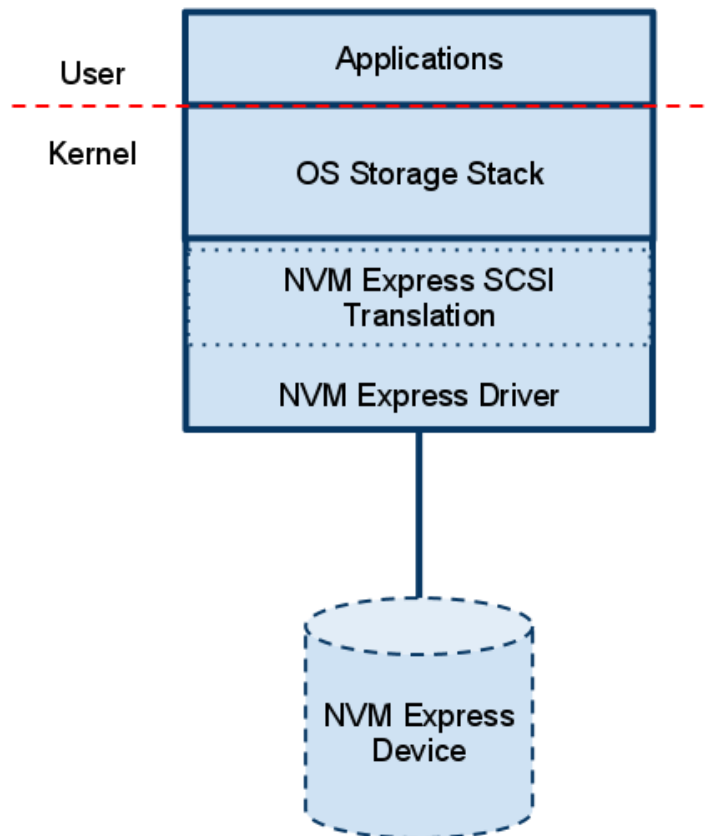
The translation layer exists logically below the operating system storage stack built upon SCSI and logically above the NVM Express driver implementing the NVM Express host interface. Translation requires the mapping of:

- SCSI commands to NVM Express Commands. Refer to Sections 2, 3, 4, 5.
- NVM Express Status to SCSI Status. Refer to Section 7.

1.2 Normative References

The following standards are referenced within this document:

- ISO/IEC 14776-454, SCSI Primary Commands – 4 (SPC-4) [T10/1731-D]

- ISO/IEC 14776-323, SCSI Block Commands – 3 (SBC-3) [T10/1799-D]

- SCSI Architecture Model – 4 (SAM-4) [T10/1683-D]

- SCSI / ATA Translation – 3 (SAT-3)

- NVM Express 1.0b or later

2 Overview of Command Mappings

SCSI defines commands for an assortment of devices, some of which are not pertinent to NVM subsystems. Figure 2 provides a summary of the SCSI commands that this reference document shall provide a translation for. Translation of all other commands not listed in Figure 2 is unspecified.

Figure 2: NVM Express SCSI Command Mappings

SCSI Command	NVM Express Command(s)	Reference
COMPARE AND WRITE	Compare and Write	5.1
FORMAT UNIT	Format NVM	5.2
INQUIRY	Identify	4.1
LOG SENSE	Get Features, Get Log Page	4.2
MODE SELECT(6)	See Note 1	4.3
MODE SELECT(10)	See Note 1	
MODE SENSE(6)	Identify, Get Features	4.4
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UNMAP	Dataset Management	5.6
VERIFY(10)	VERIFY	5.7
VERIFY(12)		
VERIFY(16)		
WRITE LONG (10)	Write Uncorrectable	5.9
WRITE LONG (16)		
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WRITE(10)		
WRITE(12)		
WRITE(16)		
WRITE BUFFER	Firmware Image Download, Firmware Image Activate	4.11

Notes:
1. MODE SELECT(6), MODE SELECT(10), REQUEST SENSE and TEST UNIT READY commands do not map 1-to-1 to NVM Express commands; a device driver should translate as specified in the referenced sections.

3 Common SCSI Field Translations

This section specifies the translation of common fields shared by multiple SCSI commands.

3.1 ALLOCATION LENGTH

ALLOCATION LENGTH is specified (SPC-4) as indicating number of bytes allocated by the application client in Data-in buffer for parameter data. Support for this field requires ensuring accesses to Data-in buffer are within the range defined by the ALLOCATION LENGTH.

3.2 BYTCHK

Support requires translation to FUA field of the NVM Express command.

3.3 CONTROL

Support unspecified.

3.4 DPO

Support unspecified. Disable page out (DPO) specifies retention characteristics which are not supported in NVM Express.

3.5 GROUP NUMBER

Support unspecified.

3.6 FUA

Support requires translation to FUA field of NVM Express command.

3.7 FUA_NV

Support unspecified. FUA_NV requests that data to be read from non volatile cache.

3.8 LOGICAL BLOCK ADDRESS

Support requires translation to Starting LBA field of NVM Express command.

3.9 PARAMETER LIST LENGTH

PARAMETER LIST LENGTH is specified (SPC-4) as indicating number of bytes allocated by the application client in data-out buffer for MODE SELECT parameter data, which shall include header, block descriptor(s) and mode pages. Support for this field requires ensuring accesses to Data-out buffer are within the range defined by the PARAMETER LIST LENGTH.

3.10   PRODUCT IDENTIFICATION

Shall be set to the first 16 bytes of the Model Number (MN) field within the Identify Controller Data Structure.

3.11   PRODUCT REVISION LEVEL

Shall be set to the first 4 bytes of the Firmware Revision (FR) field within the Identify Controller Data Structure.

3.12   IMMED

CODE	Notes
0b	Shall be supported by returning status after command is complete.
1b	Command may be terminated with CHECK CONDITION status, ILLEGAL REQUEST sense key, and ILLEGAL FIELD IN CDB additional sense code.

3.13   T10 VENDOR IDENTIFICATION

Shall be set to "NVMe" followed by 4 spaces: "NVMe   ".

3.14   TRANSFER LENGTH

Support requires translation to Number of Logical Blocks (NLB) field of NVM Express command. Note that for SCSI commands with values of TRANSFER LENGTH greater than 2^16, multiple NVM Express commands may need to be issued to satisfy the request.

3.15   VENDOR SPECIFIC IDENTIFIER

This field has a size of 36 bits.

3.16   VERIFICATION LENGTH

Support requires translation to Number of Logical Blocks (NLB) field of the NVM Express command.

3.17   VRPROTECT

Support for VRPROTECT requires setting PRACT and PRCHK fields of the NVM Express command:

If BYTCHK set to zero:

VRPROTECT CODE	PRACT	PRCHK

000b, 001b, 101b	1	111b
010b	1	011b
011b	1	000b
100b	1	100b

If BYTCHK set to one:

VRPROTECT CODE	PRACT	PRCHK
000b	1	111b
001b, 010b, 011b, 100b, 101b	1	000b

3.18   **WRPROTECT**

Support for WRPROTECT requires setting PRACT and PRCHK fields of the NVM Express command:

WRPROTECT CODE	PRACT	PRCHK
000b	1	000b
001b, 101b	0	111b
010b	0	011b
011b	0	000b
100b	0	100b
All other codes shall result in command termination with CHECK CONDITION status, ILLEGAL REQUEST sense key, and ILLEGAL FIELD IN CDB additional sense code.		

4 SCSI Primary Command Mappings

This section defines the translation of SCSI commands applicable to all SCSI devices into NVM Express commands and structures.

4.1 INQUIRY (SPC-4)

A SCSI INQUIRY command shall be translated into an NVM Express Identify command. The INQUIRY command requests information regarding the device. The type of information to return is indicated in the EVPD and PAGE CODE fields of the INQUIRY command. Table 4-1 specifies the translation of INQUIRY fields.

Table 4-1: INQUIRY CDB Field Translation

INQUIRY Field	Notes and References	
OPERATION CODE	Specified as 12h (SBC-3).	
EVPD (Enable vital product data)	**CODE**	**Notes**
	0b	Shall be supported by returning Standard INQUIRY Data to application client, refer to 6.1.1.
	1b	Shall be supported by returning Vital Product Data to application client, refer to PAGE CODE field.
PAGE CODE	**CODE**	**Notes**
	00h	Shall be supported by returning Supported VPD Pages data page to application client, refer to 6.1.2.
	80h	Shall be supported by returning Unit Serial Number data page to application client. Refer to 6.1.3.
	83h	Shall be supported by returning Device Identification data page to application client, refer to 6.1.4.
	86h	May optionally be supported by returning Extended INQUIRY data page to application client, refer to 6.1.5.
	B1h	Shall be supported by returning Block Device Characteristics VPD Page to application client, refer to 6.1.7.
	All Others	Command may be terminated with CHECK CONDITION status, ILLEGAL REQUEST sense key, and ILLEGAL FIELD IN CDB additional sense code.
ALLOCATION LENGTH	Refer to 3.1.	
CONTROL	Refer to 3.3.	

4.2 **LOG SENSE (SPC-4)**

LOG SENSE is used by application clients to retrieve statistical and operational information.

Table 4-2: Translation of LOG SENSE

LOG SENSE Field	Notes and References
OPERATION CODE	Specified as 4Dh (SPC-4).
SP	<table><tr><td>**Code**</td><td>**Notes**</td></tr><tr><td>0b</td><td>Shall be supported by performing LOG SENSE command. Log parameters shall not be saved.</td></tr><tr><td>1b</td><td>Command may be terminated with CHECK CONDITION status, ILLEGAL REQUEST sense key, and ILLEGAL FIELD IN CDB additional sense code.</td></tr></table>
PC	<table><tr><td>**Code**</td><td>**Notes**</td></tr><tr><td>01b</td><td>Cumulative values shall be returned to application client.</td></tr><tr><td>All Others</td><td>Command may be terminated with CHECK CONDITION status, ILLEGAL REQUEST sense key, and ILLEGAL FIELD IN CDB additional sense code.</td></tr></table>
PAGE CODE	<table><tr><td>**Code**</td><td>**Notes**</td></tr><tr><td>00h</td><td>Shall be supported by returning Supported Log Pages log page to application client. Refer to 6.2.1.</td></tr><tr><td>2Fh</td><td>Shall be supported by returning Informational Exceptions log page to application client. Refer to 6.2.2.</td></tr><tr><td>0Dh</td><td>Shall be supported by returning Temperature log page to application client. Refer to 6.2.3.</td></tr><tr><td>All Others</td><td>Command may be terminated with CHECK CONDITION status, ILLEGAL REQUEST sense key, and ILLEGAL FIELD IN CDB additional sense code.</td></tr></table>
SUBPAGE CODE	Unspecified.
PARAMETER POINTER	Unspecified.
ALLOCATION LENGTH	Refer to 3.1.
CONTROL	Refer to 3.3.

4.3 MODE SELECT(6), MODE SELECT(10) (SPC-4)

MODE SELECT is used by application clients to specify mode parameters. The MODE SELECT command fields should be translated per Table 4-3. Support for MODE SELECT(6) and MODE SELECT(10) also requires a device driver to translate mode parameter data as specified in 6.3.

Table 4-3: MODE SELECT Field Translations

MODE SELECT Field	Notes and References		
OPERATION CODE	Specified as (SPC-4):		
	SCSI Command		**OPERATION CODE**
	MODE SELECT(6)		15h
	MODE SELECT(10)		55h
SP	**CODE**	**Notes**	
	1b	Any saveable mode pages should be saved. If the pages are not saved, then there is no distinction between current and saved pages	
	0b	Shall be supported. There shall be no distinction between current and saved pages.	
PF	**CODE**	**Notes**	
	1b	Indicates that the MODE SELECT parameters following the header and block descriptor(s) are structured as pages of related parameters and are defined in the SPC-4 standard.	
	0b	May result in command termination with CHECK CONDITION status, ILLEGAL REQUEST sense key, and ILLEGAL FIELD IN CDB additional sense code.	
PARAMETER LIST LENGTH	Refer to 3.9.		
CONTROL	Refer to 3.3.		

4.4 **MODE SENSE(6), MODE SENSE(10) (SPC-4)**

MODE SENSE requests that mode parameters be returned to the application client.

Table 4-4: MODE SENSE CDB Field Translations

MODE SENSE Field	Notes and References		
OPERATION CODE	SPC-4 specifies this field as:		
	SCSI Command		OPERATION CODE
	MODE SENSE(6)		1Ah
	MODE SENSE(10)		5Ah
DBD	CODE	Notes	
	0b	Shall be supported by returning zero or more block descriptors in the returned MODE SENSE data.	
	1b	Shall be supported by not returning any block descriptors in the returned MODE SENSE data.	
LLBAA*	Indicates if LONGLBA field in the parameter data shall be set to 1 or 0. If LLBAA is set to 1 then LONGLBA shall be set to 1, if LLBAA is set to 0 then LONGLBA shall be set to 0.		
PC	CODE	Notes	
	00b	Shall be supported by returning current values in mode pages to application client.	
	01b	Shall be supported by returning changeable values in modes pages to application client.	
	10b	Shall be supported by returning default values in modes pages to application client.	
	11b	Command may be terminated with CHECK CONDITION status, ILLEGAL REQUEST sense key, and ILLEGAL FIELD IN CDB additional sense code.	
PAGE CODE	CODE	Notes	
	08h	Shall be supported by returning Caching mode page, refer to 6.3.2.	
	0Ah	Shall be supported by returning Control mode page to application client, refer to 6.3.2	
	1Ah	Shall be supported by returning Power Condition mode page to application client, refer to 6.3.3.3.	
	3Fh	Shall be supported by returning all supported mode pages as defined in section6.3.	
	All Others	Command may be terminated with CHECK CONDITION status, ILLEGAL REQUEST sense key, and ILLEGAL FIELD IN CDB additional sense code.	
SUBPAGE CODE	Unspecified.		
ALLOCATION LENGTH	Refer to 3.1.		
CONTROL	Refer to 3.3.		
* MODE SENSE (10) only.			

4.5 **REPORT LUNS (SPC-4)**

REPORT LUNS (SPC-4) returns a list of logical units to the application client. The 4 least significant bytes shall be set to 0h. Support for REPORT LUNS requires the Identify command and returning to the application client REPORT LUNS Parameter Data as specified in 6.6.

Table 4-5: REPORT LUNS CDB Field Notes

REPORT LUNS Field	Notes and References
OPERATION CODE	Specified as A0h (SPC-4).
SELECT REPORT	Shall be supported by returning all namespaces accessible to host software as individual LUNs.
ALLOCATION LENGTH	Refer to 3.1.
CONTROL	Refer to 3.3.

4.6 **REQUEST SENSE (SPC-4)**

REQUEST SENSE requests that sense data be returned to application client. Support requires returning sense data as defined in 6.5.

Table 4-6: REQUEST SENSE CDB Field Translations

REQUEST SENSE Field	Notes and References	
OPERATION CODE	Specified as 03h (SPC-4).	
DESC	**CODE**	**Notes**
	1b	Shall be supported by returning descriptor format sense data to application client. Refer to6.5.2
	0b	Shall be supported by returning fixed format sense data to application client. Refer to 6.5.1.
ALLOCATION LENGTH	Refer to 3.1.	
CONTROL	Refer to 3.3.	

4.7 **SECURITY PROTOCOL IN (SPC-4)**

The SCSI SECURITY PROTOCOL IN command is used to retrieve information regarding security protocols and previous SECURITY PROTOCOL OUT commands. SECURITY PROTOCOL IN shall translate to an NVM Express Security Receive command.

Table 4-7: SECURITY PROTOCOL IN CDB Field Translations

SECURITY PROTOCOL IN Field	Notes and References
OPERATION CODE	Specified as A2h (SBC-3).
SECURITY PROTOCOL	Shall translate to Security Protocol field of NVM Express Security Receive command.
SECURITY PROTOCOL SPECIFIC	Shall translate to SP Specific field of NVM Express Security Receive command.
INC_512	<table><tr><th>CODE</th><th>Notes</th></tr><tr><td>0b</td><td>Shall be supported. Indicates ALLOCATION LENGTH field specifies number of bytes to transfer.</td></tr><tr><td>1b</td><td>Shall result in command termination with CHECK CONDITION status, ILLEGAL REQUEST sense key, and ILLEGAL FIELD IN CDB additional sense code.</td></tr></table>
ALLOCATION LENGTH	Shall translate to Transfer Length field of NVM Express Security Receive command.
CONTROL	Refer to 3.3.

4.8 SECURITY PROTOCOL OUT (SPC-4)

The SCSI SECURITY PROTOCOL OUT command is used to send data specifying operations to be performed. SECURITY PROTOCOL OUT command shall translate to an NVM Express Security Send command.

Table 4-8: SECURITY PROTOCOL OUT CDB Field Translations

SECURITY PROTOCOL OUT Field	Notes and References
OPERATION CODE	Specified as B5h (SBC-3).
SECURITY PROTOCOL	Shall translate to Security Protocol field of NVM Express Security Send command.
SECURITY PROTOCOL SPECIFIC	Shall translate to SP Specific field of NVM Express Security Send command.
INC_512	<table><tr><th>CODE</th><th>Notes</th></tr><tr><td>0b</td><td>Shall be supported. Indicates TRANSFER LENGTH field specifies number of bytes to transfer.</td></tr><tr><td>1b</td><td>Shall result in command termination with CHECK CONDITION status, ILLEGAL REQUEST sense key, and ILLEGAL FIELD IN CDB additional sense code.</td></tr></table>
TRANSFER LENGTH	Shall translate to Transfer Length field of NVM Express Security Receive command.
CONTROL	Refer to 3.3.

4.9 START STOP UNIT (SPC-4)

START STOP UNIT requests that power states of the device transition to states specified by the command. Support for START STOP UNIT requires Set Features, Get Features and power state transitioning. Get Features and Set Features shall be used with namespace FFFFFFFFh.

Table 4-9: START STOP UNIT CDB Field Translations

START STOP UNIT Field	Notes and References
OPERATION CODE	Specified as 1Bh (SBC-3).
IMMED	Refer to 3.12.
POWER CONDITION MODIFIER	Refer to Table 4-10.
POWER CONDITION	Refer to Table 4-10.
NO_FLUSH	If set to 0b a Flush command shall precede any command that may result from a START STOP UNIT translation.
LOEJ	Unspecified. Indicates actions regarding loading or ejecting medium.
START	Refer to Table 4-10.
CONTROL	Refer to 3.3.

Table 4-10: Translation of Power States

POWER CONDITION	Name	POWER CONDITION MODIFIER	Notes		
00h	START_VALID	0h		START Code	Notes
				01h	A Set Features command shall be issued specifying power state 0
				00h	A Set Features command shall be issued specifying the lowest power state supported as indicated in the Get Features command.
01h	ACTIVE	0h	A Set Features command shall be issued specifying power state 0.		
02h	IDLE	0h	A Set Features command shall be issued specifying power state 1.		
		1h	A Set Features command shall be issued specifying power state 2.		
		2h	A Set Features command shall be issued specifying power state 3.		
03h	STANDBY	0h	A Set Features command shall be issued specifying power state N-2, where N is the last power state supported.		
		1h	A Set Features command shall be issued specifying power state N-1, where N is the last power state supported.		
07h	LU_CONTROL	0h	Unspecified.		

4.10   TEST UNIT READY (SPC-4)

TEST UNIT READY support requires a status to be returned to application client indicating the status of the logical unit. If the NVM Express device is in power state 0 and ready to accept commands a status of GOOD shall be returned, otherwise a status of CHECK CONDITION and a sense key of NOT READY shall be returned.

Table 4-11: TEST UNIT READY CDB Field Translations

TEST UNIT READY Field	Notes and References
OPERATION CODE	Specified as 00h (SPC-4).
CONTROL	Refer to 3.3.

4.11 WRITE BUFFER (SPC-4)

The SCSI WRITE BUFFER command is used for testing and downloading of microcode and errors. Support for downloading of microcode requires the NVM Express Firmware Image Download and Firmware Activate commands.

Table 4-12: WRITE BUFFER CDB Field Translations

WRITE BUFFER Field	Notes and References
OPERATION CODE	Specified as 3Bh (SPC-4).
MODE	<table><tr><td>CODE</td><td>Notes</td></tr><tr><td>05h</td><td>Download microcode, save, and activate mode. This mode shall be supported by issuing a Firmware Image Download command, followed by a Firmware Activate command.</td></tr><tr><td>07h</td><td>Download microcode with offsets, save, and activate mode. If there is no knowledge of the total length of the image to be downloaded, the command may be terminated with CHECK CONDITION status, ILLEGAL REQUEST sense key, and ILLEGAL FIELD IN CDB additional sense code. If the total length of the image to be downloaded in multiple pieces is understood/determinable, this mode shall be supported by issuing a Firmware Image Download command and, after the entire image has been downloaded, a subsequent Firmware Activate command.</td></tr><tr><td>0Eh</td><td>Download microcode with offsets, save, and defer activate mode. This mode shall be supported by issuing a Firmware Image Download command.</td></tr><tr><td>0Fh</td><td>Activate deferred microcode mode. This mode shall be supported by issuing a Firmware Activate command.</td></tr><tr><td>All others</td><td>Command may be terminated with CHECK CONDITION status, ILLEGAL REQUEST sense key, and ILLEGAL FIELD IN CDB additional sense code.</td></tr></table>
BUFFER ID	Shall translate to Firmware Slot (FS) field of Firmware Activate command.

BUFFER OFFSET	Shall translate to Offset (OFST) field of Firmware Image Download command.
PARAMETER LIST LENGTH	Shall translate to Number of Dwords (NUMD) field of Firmware Image Download command. Refer to 3.9.
CONTROL	Refer to 3.6.

5 SCSI Block Command Mappings

This section defines the translation of SCSI command set extensions for direct-access block devices into NVM Express commands and structures.

5.1 COMPARE AND WRITE (SBC-3)

Support for COMPARE AND WRITE requires support for the NVM Express Compare and Write fused operation and is indicated in bit 0 of the Fused Operation Support field of the Identify Controller data structure.

Table 5-1: COMPARE AND WRITE CDB Field Translations

COMPARE AND WRITE Field	Notes and References
OPERATION CODE	Specified as 89h (SPC-4).
FUA_NV	Refer to 3.7.
FUA	Refer to 3.6.
DPO	Refer to 3.4.
WRPROTECT	Refer to 3.15.
LOGICAL BLOCK ADDRESS	Refer to 3.8.
GROUP NUMBER	Refer to 3.5.
NUMBER OF LOGICAL BLOCKS	Shall be translated to Number of Logical Blocks field of the NVM Express Compare command.
CONTROL	Refer to 3.3.

5.2 FORMAT UNIT (SBC-3)

Support for FORMAT UNIT requires the NVM Express Format NVM command and retention of NUMBER OF LOGICAL BLOCKS and LOGICAL BLOCK LENGTH mode parameter block descriptor fields as defined in 6.3.2.

Table 5-2: FORMAT UNIT CDB Field Translations

FORMAT UNIT Field	Notes and References
OPERATION CODE	Specified as 04h (SPC-4).
FMTPINFO	<table><tr><th>CODE</th><th>Notes</th></tr><tr><td>0b</td><td>Shall be supported by formatting unit without protection.</td></tr><tr><td>1b</td><td>May be supported if protection information is supported by formatting unit with protection information, refer to 5.2.1. Otherwise command may be terminated with CHECK CONDITION status, ILLEGAL REQUEST sense key, and ILLEGAL FIELD IN CDB additional sense code.</td></tr></table>
LONGLIST	LONGLIST shall be ignored if FMTDATA field is set to zero. Otherwise: <table><tr><th>CODE</th><th>Notes</th></tr><tr><td>0b</td><td>Indicates a short parameter list header.</td></tr><tr><td>1b</td><td>Indicates a long parameter list header.</td></tr></table>
FMTDATA	Unspecified. When set to 1b DEFECT LIST FORMAT is used.
CPMLST	Unspecified. Indicates the type of defect list (complete list). Ignored when FMTDATA is set to 1.
DEFECT LIST FORMAT	Unspecified. If FMTDATA is 1, specifies format of address descriptors in defect list.
CONTROL	Refer to 3.3.

5.2.1 **FORMAT UNIT Parameter list**

FORMAT UNIT Parameter list contains a header, an optional initialization pattern descriptor, and an optional defect list.

Table 5-3: FORMAT UNIT Parameter List Header (long and short) Translations

FORMAT UNIT Parameter List Header Field	Notes and References
PROTECTION FIELD USAGE	Refer to 5.2.1.
FOV	Unspecified
DPRY	Unspecified
DCRT	Unspecified
STPF	Unspecified
IP	Unspecified
IMMED	Refer to 3.12.
P_I_INFORMATION	SBC-3 specifies this as being set to zero.
PROTECTION INTERVAL EXPONENT	<table><tr><td>Code</td><td>Notes</td></tr><tr><td>0</td><td>Protection information interval shall equal the logical block length.</td></tr><tr><td>All others</td><td>Command may be terminated with CHECK CONDITION status, ILLEGAL REQUEST sense key, and ILLEGAL FIELD IN CDB additional sense code.</td></tr></table>
DEFECT LIST LENGTH	Unspecified

5.2.1 **Formatting with Protection Information**

The type of protection to format a logical unit with is dependent upon the FTMPINFO field of FORMAT UNIT and the PROTECTION FIELD USAGE field of the FORMAT UNIT Parameter list.

Table 5-4: PROTECTION FIELD USAGE and FMTPINFO Translations

PROTECTION FIELD USAGE Code	FMTPINFO Code	Notes and References
000b	00b	Logical unit shall be formatted with type 0 protection. Protection Information field of Format NVM shall be set to 000b.
000b	10b	Logical unit shall be formatted with type 1 protection. Protection Information field of Format NVM shall be set to 001b.
000b	11b	Logical unit shall be formatted with type 2 protection. Protection Information field of Format NVM shall be set to 010b.
001b	11b	Logical unit shall be formatted with type 3 protection. Protection Information field of Format NVM shall be set to 011b.

| **All other values are unspecified.** |

5.3 **READ(6), READ(10), READ(12), READ(16) (SBC-3)**

Support for READ(6), READ(10), READ(12) or READ(16) requires an NVM Express Read command.

READ Field	Notes and References
OPERATION CODE	Specified as (SBC-3): | SCSI Command	OPERATION CODE | |---|---| | READ(6) | 08h | | READ(10) | 28h | | READ(12) | A8h | | READ(16) | 88h |
FUA_NV[*]	Refer to 3.7.
FUA[*]	Refer to 3.6.
DPO[*]	Refer to 3.4.
RDPROTECT[*]	Support for field requires setting PRACT and PRCHK of NVM Express read command: | RDPROTECT	PRACT	PRCHK | |---|---|---| | 000b | 1 | 111b | | 001b, 101b | 0 | 111b | | 010b | 0 | 011b | | 011b | 0 | 000b | | 100b | 0 | 100b | All other codes shall result in command termination with CHECK CONDITION status, ILLEGAL REQUEST sense key, and ILLEGAL FIELD IN CDB additional sense code.
LOGICAL BLOCK ADDRESS	Refer to 3.8.
GROUP NUMBER[*]	Refer to 3.5.
TRANSFER LENGTH	Refer to 3.14.
CONTROL	Refer to 3.3.
[*] READ(10), READ(12), and READ(16) only	

5.4 READ CAPACITY(10), READ CAPACITY(16) (SBC-3)

READ CAPACITY(10) and READ CAPACITY(16) requests that information regarding capacity and medium format be returned to application client. Support for READ CAPACITY(10) and READ CAPACITY(16) requires an Identify command and returning READ CAPACITY Parameter Data as specified in 6.4.

Table 5-6: READ CAPACITY CDB Field Translations

READ CAPACITY Field	Notes and References
OPERATION CODE	Specified as (SBC-3): <table><tr><td>**SCSI Command**</td><td>**OPERATION CODE**</td></tr><tr><td>READ CAPACITY(10)</td><td>25h</td></tr><tr><td>READ CAPACITY(16)</td><td>9Eh</td></tr></table>
SERVICE ACTION[*]	Set to 10h as specified in SPC-4.
LOGICAL BLOCK ADDRESS	Shall be set to zero when PMI bit is not obsolete and set to 0b, otherwise command may be terminated with CHECK CONDITION status, ILLEGAL REQUEST sense key, and ILLEGAL FIELD IN CDB additional sense code.
ALLOCATION LENGTH[*]	Refer to 3.1.
PMI	This field is obsolete in some versions of SBC-3. If not obsolete, this field shall be translated: <table><tr><td>CODE</td><td>Notes</td></tr><tr><td>0b</td><td>Shall be supported by returning information on the last logical block.</td></tr><tr><td>1b</td><td>Command may be terminated with CHECK CONDITION status, ILLEGAL REQUEST sense key, and ILLEGAL FIELD IN CDB additional sense code.</td></tr></table>
CONTROL	Refer to 3.3.
[*] READ CAPACITY (16) only	

5.5 SYNCHRONIZE CACHE(10), SYNCHRONIZE CACHE(16) (SBC-3)

Support SYNCHRONIZE CACHE(10) and SYNCHRONIZE CACHE(16) requires an NVM Express Flush Command. All command specific fields are unspecified.

5.6 **UNMAP (SBC-3)**

Support for UNMAP requires NVM Express Dataset Management command.

UNMAP Field	Notes and References	
OPERATION CODE	Specified as 42h (SBC-3).	
ANCHOR	**CODE**	**Notes**
	0b	Shall be supported by setting Attribute – Deallocate (AD) bit to 1b in NVM Express Dataset Management command
	1b	Command permissible for resource-provisioned devices.
GROUP NUMBER	Refer to 3.5.	
PARAMETER LIST LENGTH	Refer to 3.9.	
CONTROL	Refer to 3.3.	

5.6.1 **UNMAP Parameter List**

The parameter list specifies information regarding the block descriptors in Data-out buffer.

UNMAP Parameter List Field	Notes and References
UNMAP DATA LENGTH	Specifies number of bytes in Data-out buffer.
UNMAP BLOCK DESCRIPTOR DATA LENGTH	Specifies number of bytes of UNMAP block descriptors in Data-out buffer.

5.6.2 **UNMAP Block Descriptor**

The UNMAP Block Descriptor shall be translated into the Dataset Management Range Definition. NOTE: In SCSI, LBAs are stored in big endian, whereas NVMe are stored little endian.

UNMAP Block Descriptor Field	Notes and References
UNMAP LOGICAL BLOCK ADDRESS	Shall translate to Starting LBA field
NUMBER OF LOGICAL BLOCKS	Shall translate to Length in Logical Blocks field.

5.7 **VERIFY(10), VERIFY(12), VERIFY(16)(SBC-3)**

Support for VERIFY(10), VERIFY(12) and VERIFY(16) requires a translation to the NVM Express Compare command.

Table 5-10: VERIFY CDB Field Translations

VERIFY	Notes and References		
OPERATION CODE	Specified as (SBC-3):		
	SCSI Command	**OPERATION CODE**	
	VERIFY(10)	2Fh	
	VERIFY (12)	AFh	
	VERIFY (16)	8Fh	
VRPROTECT	Refer to 3.17.		
DPO	Refer to 3.4.		
BYTCHK	Refer to3.2 .		
LOGICAL BLOCK ADDRESS	Refer to 3.8.		
GROUP NUMBER	Refer to 3.5.		
VERIFICATION LENGTH	Refer to 3.16.		
CONTROL	Refer to 3.3.		

5.8 **WRITE(6), WRITE(10), WRITE(12), WRITE(16) (SBC-3)**

Support for WRITE(6), WRITE(10), WRITE(12), and WRITE(16) requires a translation to the NVM Express Write command.

Table 5-11: WRITE CDB Field Translations

WRITE	Notes and References		
OPERATION CODE	Specified as (SBC-3):		
	SCSI Command	**OPERATION CODE**	
	WRITE(6)	0Ah	
	WRITE(10)	2Ah	
	WRITE(12)	AAh	
	WRITE(16)	8Ah	
FUA_NV[*]	Refer to 3.7.		
FUA[*]	Refer to 3.6.		
DPO[*]	Refer to 3.4.		
WRPROTECT[*]	Refer to 3.18.		
LOGICAL BLOCK ADDRESS	Refer to 3.8.		
GROUP NUMBER[*]	Refer to 3.5.		
TRANSFER LENGTH	Refer to 3.14.		
CONTROL	Refer to 3.3.		
[*] WRITE(10), WRITE(12), and WRITE(16) only			

5.9 **WRITE LONG(10), WRITE LONG(16) (SBC-3)**

WRITE LONG requests that a logical/physical block be marked as containing an error, or transfer data to the medium. Support requires the Write Uncorrectable command.

Table 5-12: WRITE LONG CDB Field Translations

WRITE LONG Field	Notes and References
OPERATION CODE	Specified as (SBC-3): <table><tr><td>**SCSI Command**</td><td>**OPERATION CODE**</td></tr><tr><td>WRITE LONG(10)</td><td>3Fh</td></tr><tr><td>WRITE LONG(16)</td><td>9Fh</td></tr></table>
SERVICE ACTION[*]	Shall be set to 11h as specified in SBC-3.
COR_DIS	<table><tr><td>**CODE**</td><td>**Notes**</td></tr><tr><td>1b</td><td>Shall be supported by issuing Write Uncorrectable command.</td></tr><tr><td>0b</td><td>Command may be terminated with CHECK CONDITION status, ILLEGAL REQUEST sense key, and ILLEGAL FIELD IN CDB additional sense code.</td></tr></table>
WR_UNCOR	<table><tr><td>**CODE**</td><td>**Notes**</td></tr><tr><td>0b</td><td>Shall be supported by issuing Write Uncorrectable command.</td></tr><tr><td>1b</td><td>Command may be terminated with CHECK CONDITION status, ILLEGAL REQUEST sense key, and ILLEGAL FIELD IN CDB additional sense code.</td></tr></table>
PBLOCK	<table><tr><td>**CODE**</td><td>**Notes**</td></tr><tr><td>0b</td><td>Shall be supported by issuing Write Uncorrectable command.</td></tr><tr><td>1b</td><td>Command may be terminated with CHECK CONDITION status, ILLEGAL REQUEST sense key, and ILLEGAL FIELD IN CDB additional sense code.</td></tr></table>
LOGICAL BLOCK ADDRESS	Refer to3.8.
BYTE TRANSFER LENGTH	Unspecified.
CONTROL	Refer to 3.3.
[*] WRITE LONG(16) only	

6 SCSI Data

Some SCSI commands use Data-in and Data-out buffers to return information to the application client, or to specify additional command parameters. The content of Data-in and Data-out buffers when used in this manner is defined by SPC-4 and SBC-3. This section describes support for SCSI data.

6.1 INQUIRY Data

6.1.1 Standard INQUIRY Data Page

Table 6-1: Translation of Standard INQUIRY data

Standard INQUIRY data Field	Notes and References
PERIPHERAL QUALIFIER	Shall be set to 000b indicating support for PERIPHERAL DEVICE TYPE.
PERIPHERAL DEVICE TYPE	Shall be set to 00h indicating direct access block device.
RMB	Shall be set to 0b indicating media cannot be removed.
VERSION	Shall be set to 06h indicating implementation of SPC-4.
NORMACA	Shall be set to 0b indicating ACA task attribute and CONTROL bytes are unsupported
HISUP	Shall be set to 1b indicating hierarchal addressing.
RESPONSE DATA FORMAT	Shall be set to 0010b indicating response data in SPC-4 format.
ADDITIONAL LENGTH	Shall be set to 1Fh indicating size of structure with no additional bytes.
SCCS	Shall be set to 0b indicating embedded storage arrays are unsupported.
ACC	Shall be set to 0b indicating access controls coordinator is unsupported.
TPGS	Shall be set to 0b indicating asymmetric LUN access is unsupported.
3PC	Shall be set to 0b indicating third party copy commands are unsupported.
PROTECT	Shall use Identify Namespace Data Structure End to End Data Protection Type Settings (DPS) field to determine value:

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	Identify DPS Value	PROTECT Value	
	000b	0b	
	All others	1b	
ENCSEV	Shall be set to 0b indicating embedded enclosure services are unsupported.		
MULTIP	Shall be set using bit 0 of Multi-Interface Capabilities field of the Identify Controller Data Structure.		
ADDR16	Shall be set to 0b indicating 16-bit wide SCSI addresses (SCSI Parallel Interface Specific INQUIRY data) are unsupported.		
WBUS16	Shall be set to 0b indicating 16-bit wide data transfers (SCSI Parallel Interface Specific INQUIRY data) are unsupported.		
SYNC	Shall be set to 0b indicating synchronous data transfers (SCSI Parallel Interface Specific INQUIRY data) are unsupported.		
CMDQUE	Shall be set to 1b indicating support for Command Management Model.		
T10 VENDOR IDENTIFICATION	Refer to 3.12.		
PRODUCT IDENTIFICATION	Refer to 3.10.		
PRODUCT REVISION LEVEL	Refer to 3.11.		

6.1.2 Supported VPD Pages Data Page

Table 6-2: Translation of Supported VPD Pages VPD Page

Supported VPD Pages Field	Notes and References
PERIPHERAL QUALIFIER	Shall be set to 000b indicating support for PERIPHERAL DEVICE TYPE connected to logical unit.
PERIPHERAL DEVICE TYPE	Shall be set to 00h indicating direct access block device.
PAGE LENGTH	Shall be set to 5 indicating number of items supported VPD pages list requires.
Supported VPD Page list	<table><tr><th>Byte</th><th>Supported VPD Page</th><th>Code</th></tr><tr><td>4</td><td>Supported VPD Pages</td><td>00h</td></tr><tr><td>5</td><td>Unit Serial Number</td><td>80h</td></tr><tr><td>6</td><td>Device Identification</td><td>83h</td></tr><tr><td>7</td><td>Extended INQUIRY Data</td><td>86h</td></tr><tr><td>8</td><td>Block Limits</td><td>B0h</td></tr><tr><td>9</td><td>Block Device Characteristics VPD Page</td><td>B1h</td></tr><tr><td>10</td><td>Logical Block Provisioning VPD page</td><td>B2h</td></tr></table>

6.1.3 Unit Serial Number VPD Page

The Unit Serial Number VPD page returns product serial number information to the application client. Support requires Identify Namespace Data Structure.

Table 6-3: Translation of Unit Serial Number VPD Page

Unit Serial Number VPD Page Field	Notes and References
PERIPHERAL QUALIFIER	Shall be set to 000b indicating support for PERIPHERAL DEVICE TYPE connected to logical unit.
PERIPHERAL DEVICE TYPE	Shall be set to 00h indicating direct access block device.
PAGE CODE	Set to 80h as defined in SPC-4.
PAGE LENGTH	Shall be set to 20 indicating the page length.
PRODUCT SERIAL NUMBER	Shall be set to a 20 byte value by translating the IEEE Extended Unique Identifier (EUI64) field of the Identify Namespace Data Structure (Note: EUI64 is in the process of being added and is not present in the NVM Express 1.0c specification). The EUI64 field shall be translated by converting each nibble into an ASCII equivalent representation, right aligning, and inserting a "_" after the 4th, 8th, 12th position, and a "." after the 16th position in the string. For example, "0x0123456789ABCDEF" would be converted to "0123_4567_89AB_CDEF."

6.1.4 Device Identification Data Page

Table 6-4: Translation of Device Identification VPD Page

Device Identification VPD Field	Notes and References
PERIPHERAL QUALIFIER	Shall be set to 000b indicating device for PERIPHERAL DEVICE TYPE connected to logical unit
PERIPHERAL DEVICE TYPE	Shall be set to 00h indicating direct access block device
PAGE CODE	Shall be set to 83h indicating Device Identification VPD Page
PAGE LENGTH	Shall be set to the size of the remaining bytes of Device Identification VPD Page.
Designation Descriptor List	The designation descriptor list shall contain designators in either NAA IEEE Registered Extended designator format (refer to 6.1.4.1) or T10 Vendor ID based designator format (refer to 6.1.4.3).

6.1.4.1 NAA IEEE Registered Extended designator format

Table 6-5: NAA Designation Descriptor

NAA IEEE Registered Extended Designator Format Fields	Notes and References
PROTOCOL IDENTIFIER	Shall be set to 0h. PIV field shall indicate this field is reserved as no specific protocol to be identified.
CODE SET	Shall be set to 1h indicating associated fields are in binary format.
PIV	Shall be set to 0b indicating PROTOCOL IDENTIFIER field is reserved.
ASSOCIATION	Shall be set to 00b indicating DESIGNATOR field is associated with logical unit.
DESIGNATOR TYPE	Shall be set to 3h indicating NAA format and assignment authority.
DESIGNATOR LENGTH	Shall be set to the number of bytes of the DESIGNATOR field.
NAA	Shall be set to 6h indicating IEEE Registered NAA Extended.
IEEE COMPANY_ID	Shall be set using IEEE OUI Identifier field of the Identify Controller Data Structure (Note: refer to ECN 008).
VENDOR SPECIFIC IDENTIFIER VENDOR SPECIFIC IDENTIFIER EXTENSION	VENDOR SPECIFIC IDENTIFIER and VENDOR SPECIFIC IDENTIFIER EXTENSION shall logically be combined to form a single 100-bit field. NVMe devices compliant with revision 1.1 or later support an IEEE Extended Unique Identifier (EUI64). To form the 100-bit field, EUI64 (64 bits) shall be concatenated with "0x000000000" (36 bits). For example, "0x0123456789ABCDEF" would be converted to "0x0123456789ABCDEF000000000". NVMe devices compliant with revision 1.0 that do not support the EUI64 field form the 100-bit field as: • Bits 99:84: 16 bit PCI Vendor ID (bytes 01:00 of Identify Controller data structure) • Bits 83:32: Lower 52 bits of Serial Number (bytes 10:04 of Identify Controller data structure) • Bits 31:00: Namespace Identifier

6.1.4.2   NAA Locally Assigned Designator Format

Table 6-6: Translation of NAA Locally Assigned Designator

NAA Locally Assigned Designator Format Fields	Notes and References
PROTOCOL IDENTIFIER	Shall be set to 0h. PIV field shall indicate this field is reserved as no specific protocol to be identified.
CODE SET	Shall be set to 1h indicating associated fields are in binary format.
PIV	Shall be set to 0b indicating PROTOCOL IDENTIFIER field is reserved.
ASSOCIATION	Shall be set to 00b indicating DESIGNATOR field is associated with logical unit.
DESIGNATOR TYPE	Shall be set to 3h indicating NAA format and assignment authority.
DESIGNATOR LENGTH	Shall be set to 08h indicating length of designator.
NAA	Shall be set to 3h indicating Locally Assigned Designator.
LOCALLY ADMINISTERED VALUE	For NVMe devices compliant with revision 1.1 or later, shall be set to the first 60 bits of the IEEE Extended Unique Identifier (EUI64) field of the Identify Namespace Data Structure. For NVMe devices compliant with revision 1.0, shall be set to the concatenation of the translation of PRODUCT IDENTIFICATION field from standard INQUIRY data as specified in 3.10, and the following 60-bit field: • Bits 59:44: 16 bit PCI Vendor ID (bytes 01:00 of Identify Controller data structure) • Bits 43:08: Lower 36 bits of Serial Number (bytes 08:04 of Identify Controller data structure) • Bits 07:00: Lower 8 bits of Namespace Identifier

6.1.4.3 T10 Vendor ID Based Descriptor

T10 Vendor ID Based Descriptor Field	Notes and References
PROTOCOL IDENTIFIER	Shall be set to 0h. PIV field shall indicate this field is reserved as no specific protocol to be identified.
CODE SET	Shall be set to 2h indicating associated fields are in ASCII format.
PIV	Shall be set to 0b indicating PROTOCOL IDENTIFIER field is reserved.
ASSOCIATION	Shall be set to 00b indicating DESIGNATOR field is associated with logical unit.
DESIGNATOR TYPE	Shall be set to 8h indicating SCSI name string format and assignment authority.
DESIGNATOR LENGTH	Shall be set to size of T10 VENDOR IDENTIFICATION and VENDOR SPECIFIC IDENTIFIER fields.
T10 VENDOR IDENTIFICATION	Refer to 3.13.
VENDOR SPECIFIC IDENTIFIER	For NVMe devices compliant with revision 1.1 or later, shall be set to the concatenation of the translation of PRODUCT IDENTIFICATION field from standard INQUIRY data as specified in 3.10, and the IEEE Extended Unique Identifier (EUI64) field of the Identify Namespace Data Structure. For NVMe devices compliant with revision 1.0, shall be set to the concatenation of the translation of PRODUCT IDENTIFICATION field from standard INQUIRY data as specified in 3.10, and the following 100-bit field: • Bits 99:84: 16 bit PCI Vendor ID (bytes 01:00 of Identify Controller data structure) • Bits 83:32: Lower 52 bits of Serial Number (bytes 10:04 of Identify Controller data structure) • Bits 31:00: Namespace Identifier

6.1.5 Extended INQUIRY Data VPD Page

This page is optional.

Table 6-8: Translation of Extended INQUIRY Data VPD Page

Extended INQUIRY Data Field	Notes and References
PERIPHERAL QUALIFIER	Shall be set to 000b indicating device for PERIPHERAL DEVICE TYPE connected to logical unit
PERIPHERAL DEVICE TYPE	Shall be set to 00h indicating direct access block device
PAGE CODE	Shall be set to 86h indicating Extending INQUIRY Data VPD
PAGE LENGTH	Set to 3Ch
ACTIVATE MICROCODE	Shall be set to 10b indicating microcode will be activated after a hard reset.
SPT	SPT shall be translated using the DPC field of the Identify Namespace Data Structure: <table><tr><th>DPC Value (bits 0-2)</th><th>SPT Value</th></tr><tr><td>000b</td><td>Undefined</td></tr><tr><td>001b</td><td>000b</td></tr><tr><td>010b</td><td>010b</td></tr><tr><td>011b</td><td>001b</td></tr><tr><td>100b</td><td>100b</td></tr><tr><td>101b</td><td>011b</td></tr><tr><td>110b</td><td>101b</td></tr><tr><td>111b</td><td>111b</td></tr></table>
GRD_CHK	If DPS field of Identify Namespace Data Structure is 000b, this field shall be set to 0b, otherwise set to 1b.
APP_CHK	If DPS field of Identify Namespace Data Structure is 000b, this field shall be set to 0b, otherwise set to 1b.
REF_CHK	If DPS field of Identify Namespace Data Structure is 000b, this field shall be set to 0b, otherwise set to 1b.
UASK_SUP	Shall be set to 1b indicating sense key specific data is returned for UNIT ATTENTION sense key.
GROUP_SUP	Shall be set to 0b indicating grouping function is unsupported.
PRIOR_SUP	Shall be set to 0b indicating command priority is unsupported.
HEADSUP	Shall be set to 0b indicating HEAD OF QUEUE task attribute is unsupported.

ORDSUP	Shall be set to 0b indicating ORDERED task attribute is unsupported.
SIMPSUP	Shall be set to 0b indicating SIMPLE task attribute is unsupported.
WU_SUP	Shall be set to 0b indicating WR_UNCOR field of WRITE LONG is unsupported, i.e. WRITE LONG is unsupported.
CRD_SUP	Shall be set to 0b indicating COR_DIS field of WRITE LONG is unsupported, i.e. WRITE LONG is unsupported.
NV_SUP	Shall be set to 0b indicating a non-volatile cache is unsupported, i.e. FUA_NV is unsupported.
V_SUP	Shall be set using the Volatile Write Cache (VMC) field of the Identify Controller Data Structure.
P_I_I_SUP	Shall be set to 0b indicating protection information intervals are unsupported.
LUICLR	Shall be set to 1b indicating unit attentions are cleared according to SPC-4.
R_SUP	Shall be set to 0b indicating referrals are unsupported.
CBCS	Shall be set to 0b indicating capability-based command security is unsupported.
MULTI I_T NEXUS MICROCODE DOWNLOAD	Shall be set to 0h indicating handling of microcode downloads is vendor specific.

6.1.6 Block Limits VPD Page

Table 6-9: Translation of Block Limits VPD Page

Block Limits VPD Field	Notes and References
PERIPHERAL QUALIFIER	Shall be set to 000b indicating device for PERIPHERAL DEVICE TYPE connected to logical unit
PERIPHERAL DEVICE TYPE	Shall be set to 00h indicating direct access block device
PAGE CODE	Shall be set to B0h indicating Block Limits VPD Page
PAGE LENGTH	Shall be set to 003Ch.
WSNZ	Unspecified
MAXIMUM COMPARE AND WRITE LENGTH	Shall be set to 00h if Fused Operation is not supported; May be set to a non-zero value that is less than or equal to the value in MAXIMUM TRANSFER LENGTH field if Fused Operation is supported.
OPTIMAL TRANSFER LENGTH GRANULARITY	Unspecified
MAXIMUM TRANSFER LENGTH	Shall be set to value calculated according to method described in NVMe v1.1 Identify Controller Data Structure: Maximum Data Transfer Size (MDTS)
OPTIMAL TRANSFER LENGTH	Unspecified
MAXIMUM PREFETCH LENGTH	Unspecified
MAXIMUM UNMAP LBA COUNT	Shall be set to 0000_0000h if Dataset Management command – Deallocate (AD) attribute is not supported. Shall be set to non-zero value if Dataset Management command – Deallocate (AD) attribute is supported.
MAXIMUM UNMAP BLOCK DESCRIPTOR COUNT	Shall be set to 0000_0000h if Dataset Management command – Deallocate (AD) attribute is not supported. Shall be set to 0000_0100h if Dataset Management command – Deallocate (AD) attribute is supported.
OPTIMAL UNMAP GRANULARITY	Unspecified
UNMAP GRANULARITY ALIGNMENT	Unspecified
UGAVALID	Unspecified

MAXIMUM WRITE SAME LENGTH	Unspecified

6.1.7 Block Device Characteristics VPD Page

Table 6-10: Translation of Block Device Characteristics VPD Page

Block Device Characteristics VPD Field	Notes and References
PERIPHERAL QUALIFIER	Shall be set to 000b indicating device for PERIPHERAL DEVICE TYPE connected to logical unit
PERIPHERAL DEVICE TYPE	Shall be set to 00h indicating direct access block device
PAGE CODE	Shall be set to B1h indicating Device Identification VPD Page
PAGE LENGTH	Shall be set to 3Ch.
MEDIUM ROTATION RATE	Shall be set to 0001h indicating a non-rotating device (SSD).
NOMINAL FORM FACTOR	Shall be set to 0h indicating form factor not reported.

6.1.8 Logical Block Provisioning VPD Page

Table 6-11: Translation of Block Device Characteristics VPD Page

Block Limits VPD Field	Notes and References
PERIPHERAL QUALIFIER	Shall be set to 000b indicating device for PERIPHERAL DEVICE TYPE connected to logical unit
PERIPHERAL DEVICE TYPE	Shall be set to 00h indicating direct access block device
PAGE CODE	Shall be set to B2h indicating Block Limits VPD Page
PAGE LENGTH	Shall be set to 04h.
THRESHOLD EXPONENT	Shall be set to 00h to indicate that there are no thin provisioning thresholds This would require modification if thin-provisioning is supported
LBPU	Shall be set to 0 if Dataset Management command – Deallocate (AD) attribute is not supported. Shall be set to 1 if Dataset Management command – Deallocate (AD) attribute is supported. This is reporting whether use of UNMAP to unmap LBAs is supported.
LBPWS	Shall be set to 0, to indicate that use of WRITE SAME(16) to unmap LBAs is not supported.
LBPWS10	Shall be set to 0, to indicate that use of WRITE SAME(10) to unmap LBAs is not supported.
LBPRZ	Shall be set to 1 if Dataset Management command – Deallocate (AD) attribute is supported and the device returns all zeros for reads of deallocated LBAs, otherwise set to 0.
ANC_SUP	Shall be set to 0, to indicate that setting the ANC bit in UNMAP is not supported.
DP	Shall be set to 0, to indicate that no Provisioning Group Descriptors follow. This would require modification if thin-provisioning is supported

PROVISIONING TYPE	Shall be set to 0 if Dataset Management command – Deallocate (AD) attribute is not supported < and Namespace Identify Data = NSFEAT bit 0 is reported "0" indicating that the namespace is not thin-provisioned.
	Shall be set to 1 if Dataset Management command – Deallocate (AD) attribute is supported, indicating that the device is resource-provisioned.
	Shall be set to 2 if Namespace Identify Data – NSFEAT bit 0 is reported "1", indicating that the namespace is thin-provisioned.

6.2 **Log Pages**

6.2.1 **Supported Log Pages**

Table 6-12: Translation of Supported Log Pages

Supported Log Pages Log Page Field	Notes and References
PAGE CODE	Set to 00h as specified in SPC-4.
SPF	Set to 0b as specified in SPC-4.
DS	Set to 0b as specified in SPC-4.
SUBPAGE CODE	Set to 00h as specified in SPC-4.
PAGE LENGTH	Shall be set to 3h indicating the length of Supported Pages List.
Supported Pages List	<table><tr><th>Byte</th><th>PAGE CODE</th><th>Notes</th></tr><tr><td>4</td><td>00h</td><td>Indicates support for Supported Log Pages log page.</td></tr><tr><td>5</td><td>0Dh</td><td>Indicates support for Temperature Log Page log page.</td></tr><tr><td>6</td><td>2Fh</td><td>Indicates support for Informational Exceptions log page.</td></tr></table>

6.2.2 Information Exceptions Log Page

Informational Exceptions Log Page Field	Notes and References
PAGE CODE	Set to 2Fh as specified in SPC-4.
SPF	Set to 0b as specified in SPC-4.
DS	Set to 0b as specified in SPC-4.
SUBPAGE CODE	Set to 00h as specified in SPC-4.
PAGE LENGTH	Shall be set to 8h indicating the length of remaining log page.
PARAMETER CODE	Set to 0000h as specified by SPC-4.
FORMAT AND LINKING	Shall be set to 11b indicating parameter is a binary format list parameter.
TMC	Set to 00b as specified in SPC-4.
ETC	Set to 0b as specified in SPC-4.
TSD	Set to 1b indicating log parameter disabled.
DU	Set to 0b as specified in SPC-4.
PARAMETER LENGTH	Shall be set to 04h indicating 4 parameters.
INFORMATIONAL EXCEPTION ADDITIONAL SENSE CODE	Shall be set to 0h.
INFORMATIONAL EXCEPTION ADDITIONAL SENSE CODE QUALIFIER	Shall be set to 0h.
MOST RECENT TEMPERATURE READING	Shall be supported using Temperature field of Get Log Page SMART / Health Information Log. A conversion to Celsius from Kelvin must occur.

6.2.3 Temperature Log Page

Table 6-14: Translation of Temperature Log Page

Temperature Log Page Field	Notes and References
DS	Unspecified.
SPF	Shall be set to 0b as specified in SPC-4.
PAGE CODE	Shall be set to 0Dh as specified in SPC-4.
SUBPAGE CODE	Shall be set to 00h as specified by SPC-4.
PAGE LENGTH	Shall be set to 0Ch as specified by SPC-4.
PARAMETER CODE	Shall be set to 0000h as specified in SPC-4.
FORMAT AND LINKING	Shall be set to 01b indicating parameter is in binary format.
TMC	Shall be set to 00b for LOG SENSE as specified by SPC-4 or ignored.
ETC	Shall be set to 0 for LOG SENSE as specified by SPC-4 or ignored.
TSD	Shall be set to 0 for LOG SENSE as specified by SPC-4 or ignored.
DU	Shall be set to 0 for LOG SENSE as specified by SPC-4 or ignored.
PARAMETER LENGTH	Shall be set to 02h as specified in SPC-4.
TEMPERATURE	Shall be set to Temperature field of Get Log Page – SMART / Health Information Log. This shall require a conversion from Kelvin to Celsius.
PARAMETER CODE	Shall be set to 0001h as specified in SPC-4.
FORMAT AND LINKING	Shall be set to 01b indicating parameter is in binary format.
TMC	Shall be set to 0 for LOG SENSE as specified by SPC-4 or ignored.
ETC	Shall be set to 0 for LOG SENSE as specified by SPC-4 or ignored.
TSD	Shall be set to 0 for LOG SENSE as specified by SPC-4 or ignored.
DU	Shall be set to 0 for LOG SENSE as specified by SPC-4 or ignored.
PARAMETER LENGTH	Shall be set to 02h as specified in SPC-4.
REFERENCE TEMPERATURE	Shall be set using Temperature Threshold Feature of Get Features command. This shall require a conversion from Kelvin to Celsius

6.3 Mode Parameters

Mode Parameters specify information regarding a logical unit. MODE SELECT is used by application clients to set parameter values. MODE SENSE is used to return current values of parameter data to application client. An NVM Express driver may support a mode parameter by mapping the value to an NVM Express data structure if possible or by storing the parameter value internally within the driver. There is no distinction between current and saved mode pages. The mode parameter list contains a mode parameter header, zero or more block descriptors, followed by zero or more variable-length mode pages.

6.3.1 Mode Parameter Headers

Mode Parameter Header(6) is used by MODE SELECT(6) and MODE SENSE(6) commands. Mode Parameter Header(10) is used by MODE SELECT(10) and MODE SENSE(10). Mode Parameter Header(6) and Mode Parameter Header(10) have similar fields and are translated in Table 6-15. When not specified in the description, each field is applicable to both MODE SENSE and MODE SELECT commands.

Table 6-15: Mode Parameter Header Field Translations

Mode Parameter Header Field	Notes and References
MODE DATA LENGTH	Shall indicate number of bytes of data to transfer. The mode data length does not include the number of bytes in the MODE DATA LENGTH field. When translating MODE SELECT commands, this field is reserved.
MEDIUM TYPE	Shall be set to 00h indicating a direct access block device.
WP	Shall be set to 1b if bit 3 of the Critical Warning field of the SMART / Health Information Log page is set to 1b (i.e. media has been placed in read only mode.). Otherwise shall be set to 0b.
DPOFUA	When used with MODE SELECT this field is reserved. Shall be set to 1b indicating DPO and FUA are supported.
LONGLBA*	This field shall be ignored for MODE SELECT 10. The value of this field is determined by LLBAA field of the MODE SENSE 10 command: | LLBAA	Notes
0b	Shall be set to 0b indicating mode parameter block descriptors are 8 bytes long should there be any.
1b	Shall be set to 1b indicating mode parameter block descriptor(s) are 16 bytes long should there be any.	
BLOCK DESCRIPTOR LENGTH	The value of this field is determined by the LONGLBA field and shall indicate the number of bytes of all block descriptors: | LONGLBA	Notes
0b	Shall indicate the number if block descriptors multiplied by 8.
1b	Shall indicate the number if block descriptors multiplied by 16. | Note that this length does not include mode pages that may follow the last block descriptor should there be any.
* Mode Parameter Header 10 only.	

6.3.2 **Mode Parameter Block Descriptor**

Mode Parameter Block Descriptors may be optionally supported and are used to specify the size and number of blocks of a logical unit Table 6-16 describes how to determine the initial values of the parameters.   Support for this parameter when used along with a FORMAT UNIT command requires retention of the fields within the driver during a MODE SELECT command.

Table 6-16: Mode Parameter Block Descriptor Field Translations

Long LBA Mode Parameter Block Descriptor Field	Notes and References
NUMBER OF LOGICAL BLOCKS	Shall be determined through translation of Namespace Capacity of Identify Namespace Data Structure.
LOGICAL BLOCK LENGTH	Shall be determined through translation of Formatted LBA Size (FLBAS) field of Identify Namespace Data Structure.

6.3.3 **Mode Page Formats**

The following sections define the translation for the supported mode pages.

6.3.3.1 **Caching Mode Page**

Caching Mode Page Field	Notes and References	
Write Back Cache Enable (WCE)	The value of this field is dependent on the command:	
	MODE SENSE	Shall be set to the value of Volatile Write Cache Enable field of the NVM Express Get Features command with Volatile Write Cache Feature Identifier.
	MODE SELECT	Shall be set to the value of Volatile Write Cache Enable field of the NVM Express Set Features command with the Volatile Write Cache Feature Identifier to be sent to the NVMe device.
All other fields shall be unspecified.		

6.3.3.2 Control Mode Page

Table 6-17: Control Mode Page Field Translations

Control Mode Page Field	Notes and References
PS	Shall be set to 0b indicating device server is unable to save parameters.
SPF	Shall be set to 0b indicating page_0 mode page format is being used.
PAGE CODE	Shall be set to 0Ah indicating Control Mode Page.
PAGE LENGTH	Shall be set to 0Ah indicating number of bytes of mode parameters.
TST	Shall be set to 000b indicating one task set for all I_T nexuses.
TMF_ONLY	Shall be set to 0b. Note that ACA is not supported.
DPICZ	Shall be set to 0b if application client reserves this field otherwise shall be set to 1b indicating protection information disabled when RDPROTECT field is zero.
D_SENSE	Shall be set to 1b indicating that sense data is returned in descriptor format.
GLTSD	Shall be set to 1b indicating that the logical unit does not implicitly save log parameters.
RLEC	Shall be set to zero indicating log exception conditions are not reported.
QUEUE ALGORITHM MODIFIER	Shall be set to one indicating commands may be reordered.
NUAR	Shall be set to 0b. Note that reservations are not supported.
QERR	Shall be set to 01b.
RAC	Shall be set to 0b indicating the device server may return BUSY status for any length of time while BUSY condition persists.
UA_INTLCK_CTRL	Shall be set to 00b indicating that unit attention condition is cleared in the same transaction as a CHECK CONDITION status.
SWP	Shall be set to 0b indicating no support for software write protect.
ATO	Shall be set to 0b indicating LOGICAL BLOCK APPLICATION TAG and LOGICAL BLOCK REFERENCE TAG may be modified depending on protection type.
TAS	Shall be set to one indicating that aborted commands shall be completed with TASK ABORTED status.
AUTOLOAD MODE	Shall be set to 000b indicating medium is loaded for full access when inserted.
BUSY TIMEOUT PERIOD	Shall be set to FFFFh indicating unlimited busy timeout.
EXTENDED SELF-TEST COMPLETION TIME	Shall be set to 0000h, SMART self-tests are unsupported.

6.3.3.3 Power Condition Control Mode Page

Table 6-18: Translation of Power Condition Control Mode Page

Power Condition Control Mode Page Field	Notes and References
PS	Shall be set to 0h indicating page not savable.
SPF	Shall be set to 0h indicating page_0 page format is used.
PAGE CODE	Set to 1Ah as specified by SPC-4.
PAGE LENGTH	Set to 26h as specified by SPC-4. Indicates length of page.
PM_BG_PRECENDENCE	Shall be set to 00H, indicating vender specific power management and background interactions.
STANDBY_Y	Timers are not supported in NVM Express. When processing a MODE SENSE command, these fields shall be returned as zero. When processing a MODE SELECT command, the command may be terminated with CHECK CONDITION status, sense key set to ILLEGAL REQUEST and additional sense code set to INVALID FIELD IN PARAMETER LIST.
IDLE_C	
IDLE_B	
IDLE_A	
STANDBY_Z	
IDLE_A CONDITION TIMER	
STANDBY_Z CONDITION TIMER	
IDLE_B CONDITION TIMER	
IDLE_C CONDITION TIMER	
STANDBY_Y CONDITION TIMER	

6.3.3.4 Return all pages Mode Page

6-19: Mode pages returned

Mode Pages (returned in ascending numerical order)
0x08
0x0A
0x1A

6.3.3.5 Return all pages and subpages Mode Page

6-20: Mode pages returned

Mode Pages (returned in ascending numerical order)
0x08
0x0A
0x1A

6.3.3.6 Informational Exceptions Control Mode Page

Table 6-21: Translation of Informational Exceptions Control Mode Page

Informational Exceptions Control Mode Page Field	Notes and References
PS	Shall be set to 0b indicating page not savable.
SPF	Shall be set to 0b indicating page_0 mode page format is used.
PAGE CODE	Set to 1Ch as specified by SPC-4.
PAGE LENGTH	Shall be set to 0Ah indicating length of page.
LOGERR	Shall be set to 0b indicating device server may log informational exception conditions in the Informational Exceptions log page.
EBACKERR	Shall be set to 0b indicating reporting of informational exception conditions occurring during processing of background self tests is disabled.
TEST	
DEXPT	<table><tr><td>Field</td><td>Value</td><td>Comments</td></tr><tr><td>TEST</td><td>0</td><td rowspan="3">Failure prediction processing and warning processing shall be disabled.</td></tr><tr><td>DEXCPT</td><td>1</td></tr><tr><td>EWASC</td><td>0</td></tr></table>
EWASC	
EBF	Shall be set to 0b indicating device specific background functions are disabled.
PERF	Shall be set to 1b indicating processing of informational exception conditions that cause delays are disabled.
MRIE	Shall be set to 0h indicating device server shall not report informational exception conditions.
INTERVAL TIMER	Shall be set to zero indicating reporting informational exception conditions are vendor specific.
REPORT COUNT	Shall be set to zero indicating no limit on number of times a device server may report informational exception conditions.

6.4 READ CAPACITY Parameter Data

READ CAPACITY Parameter Data is returned to application client in response to a READ CAPACITY(10) or READ CAPACITY(16) command (refer to 5.4).

Table 6-22: Translation of READ CAPACITY Parameter Data

READ CAPACITY Parameter Data Field	Notes and References	
RETURNED LOGICAL BLOCK ADDRESS	Shall be set to:	
	READ CAPACITY (10)	Shall be set to Namespace Size NSZE field of the Identify Namespace Data Structure, or FFFF_FFFFh if NSZE exceeds the maximum value this field is able to contain. Note that if this field is set to FFFF_FFFFh then SBC-3 specifies that the application client issue a READ CAPACITY (16).
	READ CAPACITY(16)	Shall be set to Namespace Size NSZE field of the Identify Namespace Data Structure, or FFFF_FFFF_FFFF_FFFFh if NSZE exceeds the maximum value this field is able to contain.
LOGICAL BLOCK LENGTH	Shall be set to the LBA Data Size (LBADS) field of the LBA Format Data Structure currently indicated by the Formatted LBA Size (FLBAS) field within the Identify Namespace Data Structure.	
PROT_EN*	Shall be set to 0b if protection information is not enabled as indicated in the End-to-end Protection Type Settings (DPS) field within Identify Namespace Data Structure. Otherwise shall be set to 1b.	
P_TYPE*	Shall be set using End to End Data Protection Type Settings field of Identify Namespace Data Structure:	

DPS Code	P_TYPE Code
000b	Unspecified
001b	000b
010b	001b
011b	010b

LOGICAL BLOCKS PER PHYSICAL EXPONENT*	Shall be set to 0 indicating one or more physical blocks per logical block.	
P_I_EXPONENT*	Unspecified. Indicates number of protection information intervals within each logical block.	
TPE*	Unspecified. Indicates thin provisioning is implemented.	
TPRZ*	Unspecified. Indicates how unmapped LBA bits should be set.	
LOWEST ALIGNED LOGICAL BLOCK ADDRESS*	Shall be set to zero indicating LBA 0 is the first logical blocks located at the beginning of a physical block.	
*READ CAPACITY (16) parameter data only		

6.5 Sense Data

Sense data is requested by the application client with a REQUEST SENSE command. Since autosense is supported, sense information is returned along with the completion of a command to the application client.

6.5.1   Fixed Format Sense Data

Fixed Format Sense Data Field	Notes and References
RESPONSE CODE	Shall be set to 70h indicating current errors are returned.
VALID	Shall be set to 0b indicating INFORMATION field is not defined.
SENSE KEY	Shall be set to NO SENSE.
ILI	Shall be set to 0b, field is undefined.
EOM	Shall be set to 0b, field is undefined.
FILEMARK	Shall be set to 0b, field is undefined.
INFORMATION	Shall be set to 0b, field is undefined.
ADDITIONAL SENSE LENGTH	Shall indicate the number of bytes of additional sense data.
COMMAND-SPECIFIC INFORMATION	Shall contain information depending on command where the exception condition occurred.
ADDITIONAL SENSE CODE	Shall be set to NO ADDITIONAL SENSE INFORMATION if device is in power state 00h, otherwise shall be set to LOW POWER CONDITION ON.
ADDITIONAL SENSE CODE QUALIFIER	Shall be set to zero indicating detailed information is not available.
FIELD REPLACEABLE UNIT CODE	Shall be set to zero indicating no additional sense code.
SENSE KEY SPECIFIC	Shall be set to zero, field is undefined.
SKSV	Shall be set to zero indicating SENSE KEY SPECIFIC field is undefined.

6.5.2   Descriptor Format Sense Data

Table 6-23: Descriptor Format Sense Data Field Translations

Fixed Format Sense Data Field	Notes and References
RESPONSE CODE	Shall be set to 72h indicating current errors are returned.
SENSE KEY	Shall be set to NO SENSE.
ADDITIONAL SENSE CODE	Shall be set to NO ADDITIONAL SENSE INFORMATION if device is in power state 00h, otherwise shall be set to LOW POWER CONDITION ON.
ADDITIONAL SENSE CODE QUALIFIER	Shall be set to zero indicating detailed information is not available.
ADDITIONAL SENSE CODE LENGTH	Shall be set to zero indicating no additional sense code.

6.6 REPORT LUNS Parameter Data

REPORT LUNS Parameter data is requested by the application client with a REPORT LUNS command (refer to 4.5). Support for REPORT LUNS requires the Identify command.

Table 6-24: REPORT LUNS Parameter Data Field Translations

REPORT LUNS Parameter Data Field	Notes and References
LUN LIST LENGTH	Shall indicate the length of the LUN LIST as specified in SPC-4. The LUN LIST LENGTH depends on the translation of the LUN LIST field.
LUN LIST	The list shall contain logical unit numbers corresponding to namespaces present on the device with a Namespace Capacity (NCAP) field of the Identify Namespace Structure set to greater than 0h. Logical unit numbers shall begin with 0 and have a maximum value of NN-1, where NN is the Number of Namespaces field within Identify Controller Data Structure.

7 Status Mappings

Command statuses shall require translation from a NVM Express Status Code to a SCSI Status Code, Sense Key, and an Additional Sense Code where applicable.

7.1 Generic Command Status

Table 7-1: Generic Command Status Mappings

NVM Express	SCSI		
Status Code	Status Code	Sense Key	Additional Sense Code
Success Completion	GOOD	NO SENSE	
Invalid Command Opcode	CHECK CONDITION	ILLEGAL REQUEST	INVALID COMMAND OPERATION CODE
Invalid Field in Command	CHECK CONDITION	ILLEGAL REQUEST	INVALID FIELD IN CDB
Data Transfer Error	CHECK CONDITION	MEDIUM ERROR	
Commands Aborted due to Power Loss Notification	TASK ABORTED	ABORTED COMMAND	WARNING – POWER LOSS EXPECTED
Internal Device Error	CHECK CONDITION	HARDWARE ERROR	INTERNAL TARGET FAILURE
Command Abort Requested	TASK ABORTED	ABORTED COMMAND	
Command Aborted due to SQ Deletion	TASK ABORTED	ABORTED COMMAND	
Command Aborted due to Failed Fused Command	TASK ABORTED	ABORTED COMMAND	
Command Aborted due to Missing Fused Command	TASK ABORTED	ABORTED COMMAND	
Invalid Namespace or Format	CHECK CONDITION	ILLEGAL REQUEST	ACCESS DENIED – INVALID LU IDENTIFIER
LBA Out of Range	CHECK CONDITION	ILLEGAL REQUEST	LOGICAL BLOCK ADDRESS OUT OF RANGE
Capacity Exceeded	CHECK CONDITION	MEDIUM ERROR	
Namespace Not Ready	CHECK CONDITION	NOT READY	LOGICAL UNIT NOT READY, CAUSE NOT REPORTABLE

7.2 Command Specific Status

Table 7-2: Command Specific Status Mappings

NVM Express	SCSI		
Status Code	Status Code	Sense Key	Additional Sense Code
Completion Queue Invalid	CHECK CONDITION	ILLEGAL REQUEST	
Invalid Queue Identifier	Unspecified	Unspecified	Unspecified
Maximum Queue Size Exceeded	Unspecified	Unspecified	Unspecified
Abort Command Limit Exceeded	CHECK CONDITION	ILLEGAL REQUEST	
Asynchronous Event Request Limit Exceeded	Unspecified	Unspecified	Unspecified
Invalid Firmware Slot	Unspecified	Unspecified	Unspecified
Invalid Firmware Image	Unspecified	Unspecified	Unspecified
Invalid Interrupt Vector	Unspecified	Unspecified	Unspecified
Invalid Log Page	Unspecified	Unspecified	Unspecified
Invalid Format	CHECK CONDITION	ILLEGAL REQUEST	FORMAT COMMAND FAILED
Conflicting Attributes	CHECK CONDITION	ILLEGAL REQUEST	INVALID FIELD IN CDB

7.3 Media Errors

Table 7-3: Media Errors Mappings

NVM Express	SCSI		
Status Code	Status Code	Sense Key	Additional Sense Code
Write Fault	CHECK CONDITION	MEDIUM ERROR	PERIPHERAL DEVICE WRITE FAULT
Unrecovered Read Error	CHECK CONDITION	MEDIUM ERROR	UNRECOVERED READ ERROR
End-to-end Guard Check Error	CHECK CONDITION	MEDIUM ERROR	LOGICAL BLOCK GUARD CHECK FAILED
End-to-end Application Tag Check Error	CHECK CONDITION	MEDIUM ERROR	LOGICAL BLOCK APPLICATION TAG CHECK FAILED
End-to-end Reference Tag Check Error	CHECK CONDITION	MEDIUM ERROR	LOGICAL BLOCK REFERENCE TAG CHECK FAILED
Compare Failure	CHECK CONDITION	MISCOMPARE	MISCOMPARE DURING VERIFY OPERATION
Access Denied	CHECK CONDITION	ILLEGAL REQUEST	ACCESS DENIED – INVALID LU IDENTIFIER

8 Task Management Functions

Task Management Functions are requests by application clients affecting the processing of a SCSI commands. Support for Task Management Functions requires maintaining a mapping between the SCSI command issued by the application client and one or more NVM Express commands resulting from translation into NVM Express.

Table -8-1: Translation of Task Management Functions

Function	Notes
ABORT TASK	May be supported by issuing an Abort command.
ABORT TASK SET	May be supported by issuing an Abort command on all outstanding commands.
CLEAR ACA	Unspecified
CLEAR TASK SET	May be supported by issuing an Abort command on all outstanding commands.
I_T NEXUS RESET	Shall be supported by returning FUNCTION SUCCEEDED if there are outstanding commands in the submission queue, otherwise by returning FUNCTION COMPLETE.
LOGICAL UNIT RESET	Shall be supported by writing a 0 to Enable (EN) field of Controller Configuration register.
QUERY TASK	May be supported. If specified command has one or more NVM Express commands queued resulting from translation than FUNCTION SUCEEDED shall be returned. Otherwise, FUNCTION COMPLETE shall be returned.
QUERY TASK SET	Unspecified
QUERY ASYNCHRONOUS EVENT	Unspecified