

TCG Storage Interface Interactions Specification (SIIS)

**Specification Version 1.04
Revision 1.00
August 18 2015**

Contact: admin@trustedcomputinggroup.org

TCG

PUBLISHED

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Table of Contents

1	Introduction	1
1.1	Document Purpose	1
1.2	Scope	1
1.3	Intended Audience	1
1.4	References to Other Documents.....	1
1.4.1	Approved References.....	1
1.4.2	References under development	2
1.5	Definition of Terms.....	2
2	Overview	2
3	SCSI Interface.....	3
3.1	Mapping of Resets	3
3.2	Mapping of IF-SEND and IF-RECV	8
3.2.1	IF_SEND	8
3.2.2	IF_RECV	8
3.3	Handling Common TPer Errors.....	9
3.4	Discovery of Security Capabilities.....	10
3.4.1	Security Protocol 0x00	10
3.5	Miscellaneous Issues.....	10
3.5.1	Queued Commands	10
3.5.2	MBR Interactions.....	11
3.5.3	LUN usage	11
3.5.4	Current Maximum LBA	11
3.5.5	Interaction of Opal SSC with the SANITIZE command.....	11
3.5.6	Interaction of Enterprise SSC with the SANITIZE command.....	12
3.5.7	Special Locking SP command interactions	12
4	ATA Interface.....	13
4.1	Mapping of Resets	13
4.2	Mapping of IF-SEND and IF-RECV	14

4.2.1	IF_SEND	14
4.2.2	IF_RECV	14
4.3	Handling Common TPer Errors.....	15
4.4	Discovery of Security Capabilities.....	16
4.4.1	IDENTIFY DEVICE.....	16
4.4.2	Security Protocol 0x00	16
4.5	Miscellaneous Issues.....	16
4.5.1	Feature set interactions.....	16
4.5.1.1	Trusted Computing feature set	16
4.5.1.2	Sense Data Reporting feature set	17
4.5.1.3	Locking Template interactions with the ATA Security feature set.....	17
4.5.1.4	Interaction of Opal SSC with the ATA Sanitize Device feature set.....	17
4.5.1.5	Interaction of Enterprise SSC with the ATA Sanitize Device feature set ..	18
4.5.1.6	Interaction of the Opal SSC Activate method with the ATA Security feature set	18
4.5.2	Current Maximum LBA	19
4.5.3	Special Locking SP command interactions	19
5	NVM Express Interface	20
5.1	Mapping of Resets	20
5.2	Mapping of IF-SEND and IF-RECV	21
5.2.1	IF_SEND	21
5.2.2	IF_RECV	21
5.3	Handling Common TPer Errors.....	22
5.4	Discovery of Security Capabilities.....	22
5.4.1	Identify Controller Data Structure	22
5.4.2	Security Protocol 0x00	22
5.5	Miscellaneous Issues.....	23
5.5.1	Security Commands	23
5.5.2	Namespace	23
5.5.3	Locking Template interactions with the Format NVM Command.....	23
5.5.3.1	Overview	23
5.5.3.2	Interaction with Opal SSC	23
5.5.3.3	Interaction with Enterprise SSC.....	24
5.5.4	Current Maximum LBA	24
6	eMMC Interface	25
6.1	Mapping of Resets	25

6.2 Mapping of IF-SEND and IF-RECV	25
6.2.1 IF_SEND	25
6.2.2 IF_RECV	26
6.2.3 eMMC Command Structure for TCG IF_SEND and IF_RECV.....	26
6.2.3.1 eMMC Block Allocation Overview	26
6.2.3.2 eMMC CMD23 SET_BLOCK_COUNT	26
6.2.3.3 eMMC CMD54 PROTOCOL_WR and CMD53 PROTOCOL_RD commands.....	27
6.3 Handling Common TPer Errors.....	28
6.4 Discovery of Security Capabilities.....	28
6.4.1 Discovery of Security Capabilities	28
6.4.1.1 Security Protocol Information	28
6.5 Miscellaneous Issues.....	29
6.5.1 Partition Management	29

1 Introduction

1.1 Document Purpose

The TCG Storage specifications are intended to provide a comprehensive command architecture for putting Storage Devices under policy control as determined by the trusted platform host, the capabilities of the storage device to conform with the policies of the trusted platform, and the lifecycle state of the Storage Device as a trusted peripheral (TPer). This document also serves as a specification for TPer if that is deemed appropriate.

This document provides the essential mapping between concepts and features of the TCG Storage Architecture Core Specification, and several host/device interfaces.

1.2 Scope

The scope of this document is the interaction between the TPer and interface commands and transports. The command interfaces described are ATA and SCSI. SCSI transports described are SAS, FC, and ATAPI. This document is written from the perspective of the Storage Device, not the host.

1.3 Intended Audience

The intended audience for this document is Storage Device and peripheral device manufacturers and developers that wish to tie Storage Devices and peripherals into trusted platforms.

1.4 References to Other Documents

1.4.1 Approved References

- [1]. IETF RFC 2119, 1997, "Key words for use in RFCs to Indicate Requirement Levels"
- [2]. INCITS 447-2008, "Information technology - SCSI Architecture Model - 4 (SAM-4)". Available from <http://webstore.ansi.org/>
- [3]. INCITS 482-2012, "Information technology - ATA/ATAPI Command Set - 2 (ACS-2)". Available from <http://webstore.ansi.org/>
- [4]. INCITS 451-2008, "Information technology - AT Attachment – 8 ATA/ATAPI Architecture Model (ATA8-AAM)". Available from <http://webstore.ansi.org/>
- [5]. INCITS 481-2011, "Information technology - Fibre Channel Protocol for SCSI, Fourth Version (FCP-4)". Available from <http://webstore.ansi.org/>
- [6]. INCITS 417-2006, "Information technology - Serial Attached SCSI - 1.1 (SAS-1.1). Available from <http://webstore.ansi.org/>
- [7]. INCITS 471-2010, Information technology - USB Attached SCSI (UAS), March 9, 2010. Available from <http://webstore.ansi.org/>
- [8]. Universal Serial Bus Mass Storage Class USB Attached SCSI Protocol (UASP), Revision 1.0, June 24, 2009. Available from <http://www.usb.org>.
- [9]. Universal Serial Bus Mass Storage Class Bulk-Only Transport (USBOT), Revision 1.0, September 31, 1999. Available from <http://www.usb.org>.
- [10]. NVM Express Specification version 1.2. Available from <http://www.nvmexpress.org/>

- [11]. JESD84-B50 eMMC Specification version 5.0. Available from <http://www.jedec.org/>
- [12]. JESD220B UFS Specification version 2.0. Available from <http://www.jedec.org/>
- [13]. PCI Express® Base Specification Revision 3.0. Available from <http://www.pcisig.com/>

1.4.2 References under development

- [14]. [INCITS T10/1731-D], "Information technology - SCSI Primary Commands - 4 (SPC-4)". Available from <http://t10.org/>
- [15]. [INCITS T10/1799-D], "Information technology - SCSI Block Commands - 3 (SBC-3)". Available from <http://t10.org/>
- [16]. eMMC Security Extension version 1.0 Available from <http://www.jedec.org/>
- [17]. UFS Security Extension version 1.0 Available from <http://www.jedec.org/>

1.5 Definition of Terms

Term	Definition
IF-RECV	An interface command used to retrieve security protocol data from the TPer.
IF-SEND	An interface command used to transmit security protocol data to the TPer.
Locking SP	A security provider that incorporates the Locking Template as described in the Core Spec.
SSC	Security Subsystem Class. SSC specifications describe profiled sets of TCG functionality
TCG Reset	A high-level reset type defined in the Core Spec.
TPer	The TCG security subsystem within a Storage Device.
Trusted Peripheral	A TPer.

2 Overview

This document defines for each interface:

- Mapping of interface events to TCG resets
- Mapping of IF-SEND, IF-RECV
- Handling of common TPer errors
- Discovery of security capabilities
- Miscellaneous issues

3 SCSI Interface

See [2], [14], [15], [5] and [6] for details on SCSI architecture, commands and transports.

See [3] for details on ATAPI commands.

See [7], [8] and [9] for details on UAS and USB.

See [12] and [17] for details on UFS.

3.1 Mapping of Resets

Table 1 - SAS Resets Mapped to TCG reset_type

SAS Event	Maps to TCG reset_type
Power on reset	Power cycle
I-T Nexus Loss	(none)
Task Management-Abort Task	(none)
Task Management-Abort Task Set	(none)
Task Management-Clear Task Set	(none)
Task Management-Clear ACA	(none)
Task Management-I-T Nexus reset	(none)
Task Management-LUN Reset	Hardware Reset
Link Reset Sequence	(none)
Link reset sequence with hard reset	Hardware Reset

Table 2 - Fibre Channel Resets Mapped to TCG reset_type

FC Event	Maps to TCG reset_type	Other Comments
Power on reset	Power cycle	
I-T Nexus Loss	(none)	
Task Management-Abort Task	(none)	
Task Management-Abort Task Set	(none)	
Task Management-Clear Task Set	(none)	
Task Management-Clear ACA	(none)	
Task Management-I-T Nexus reset	(none)	
Task Management-LUN Reset	Hardware Reset	
Task Management-Target reset	Hardware Reset	
LIP(AL_PD,AL_PS)	Hardware Reset	LIP directed reset
LIP(FF,AL_PS)	Hardware Reset	LIP Global reset
Port Login	(none)	
Process Login	(none)	

Table 3 - ATAPI Resets Mapped to TCG reset_type

ATAPI Event	Maps to TCG reset_type
Power on reset	Power cycle
Hardware reset	PATA: Hardware Reset SATA: If Software Settings Preservation is enabled, then COMRESET is not a TCG Hardware Reset. If Software Settings Preservation is disabled, then COMRESET is a TCG Hardware Reset.
Software reset	(none)
DEVICE RESET command	(none)

Table 4 - UAS Events Mapped to TCG reset_type

Event	Maps to TCG reset_type	Reference
Device Power Cycle	Power cycle	[9]
Task Management-Abort Task	(none)	[14]
Task Management-Abort Task Set	(none)	[14]
Task Management-Clear Task Set	(none)	[14]
Task Management-Clear ACA	(none)	[14]
Task Management-I-T Nexus reset	Hardware Reset	[14]
Task Management-LUN Reset	(none)	[14]
USB VBus Power Cycle	Power cycle	[9]
USB Port Reset	(none)	[9]
USB Set Configuration with wValue set to zero	(none)	[9]
USB Set Configuration with wValue set to non-zero value that is not equal to the current value of bConfiguration.	(none)	[9]
USB Set Configuration with wValue set to non-zero value that is equal to the current value of bConfiguration.	(none)	[9]
USB Bulk-Out Endpoint Reset (Also known as Clear Feature, Endpoint Halt of the first Bulk-Out pipe of the Mass Storage Interface)	(none)	[9]
USB Bulk-In Endpoint Reset (Also known as Clear Feature, Endpoint Halt of the first Bulk-In pipe of the Mass Storage Interface)	(none)	[9]
USB Suspend	Hardware Reset	[9]
USB Resume	Hardware Reset	[9]

Table 5 - USB Events Mapped to TCG reset_type

Event	Maps to TCG reset_type	Reference
Device Power Cycle	Power cycle	[9]
USB VBus Power Cycle	Power cycle	[9]
USB Port Reset	(none)	[9]
USB Set Configuration with wValue set to zero	(none)	[9]
USB Set Configuration with wValue set to non-zero value that is not equal to the current value of bConfiguration.	(none)	[9]
USB Set Configuration with wValue set to non-zero value that is equal to the current value of bConfiguration.	(none)	[9]
USB Bulk-Out Endpoint Reset (Also known as Clear Feature, Endpoint Halt of the first Bulk-Out pipe of the Mass Storage Interface)	(none)	[9]
USB Bulk-In Endpoint Reset (Also known as Clear Feature, Endpoint Halt of the first Bulk-In pipe of the Mass Storage Interface)	(none)	[9]
USB Interface Reset (Also known as the BBB Bulk Only Mass Storage Reset Request x 21 FF with wIndex addressing the bInterfaceNumber of the Mass Storage Interface)	(none)	[9]
USB Suspend	Hardware Reset	[9]
USB Resume	Hardware Reset	[9]

Table 6 - UFS Events Mapped to TCG reset_type

UFS Event	Maps to TCG reset_type	Reference
Power-on	Power cycle	[12]
HW Pin Reset	Hardware Reset	[12]
EndPoint Reset	Hardware Reset	[12]
Task Management-Abort Task	(none)	[14]
Task Management-AbortTask Set	(none)	[14]
Task Management-Clear Task Set	(none)	[14]
Task Management-LUN Reset	(none)	[14]
Host System UniPro Reset	Hardware Reset	[12]

3.2 Mapping of IF-SEND and IF-RECV

3.2.1 IF_SEND

IF_SEND SHALL be implemented with the SECURITY PROTOCOL OUT [14] command, with additional requirements on the CDB as specified in Table 7.

Table 7 - IF-SEND CDB field contents (SCSI)

SECURITY PROTOCOL	SECURITY PROTOCOL SPECIFIC	INC_512	TRANSFER LENGTH
0x00	Security Protocol 0x00 is not defined for IF-SEND		
0x01	a ComID	1 ^a	Non-zero ^b number of 512-byte data units.
0x02	a ComID	1 ^a	Non-zero ^b number of 512-byte data units.
0x06	a ComID	0	Number of bytes of data.
^a If the INC_512 parameter in the CDB is zero, then the TPer SHALL report Other Invalid Command Parameter (see 3.3). ^b If the TRANSFER LENGTH parameter in the CDB is zero, then the TPer SHALL report Other Invalid Command Parameter (see 3.3).			

3.2.2 IF_RECV

IF_RECV SHALL be implemented with the SECURITY PROTOCOL IN [14] command, with additional requirements on the CDB as described in Table 8.

Table 8 - IF-RECV CDB field contents (SCSI)

SECURITY PROTOCOL	SECURITY PROTOCOL SPECIFIC	INC_512	ALLOCATION LENGTH
0x00	(See [14] for details)	0 or 1	INC_512=0: Number of bytes of data. INC_512=1: Number of 512-byte data units.
0x01	a ComID	1 ^a	Non-zero ^b number of 512-byte data units.
0x02	a ComID	1 ^a	Non-zero ^b number of 512-byte data units.
0x06	a ComID	0	Number of bytes of data.
^a If the INC_512 parameter in the CDB is zero, then the TPer SHALL report Other Invalid Command Parameter (see 3.3). ^b If the ALLOCATION LENGTH parameter in the CDB is zero, then the TPer SHALL report Other Invalid Command Parameter (see 3.3), even though SPC-4 allows ALLOCATION LENGTH to be zero.			

3.3 Handling Common TPer Errors

There are some common errors detected by the TPer. This section describes how they are reported via the SCSI interface.

Table 9 - TPer Errors (SCSI)

TPer Error ID	Status	Sense Key	ASC/ASCQ	Comments
Good	GOOD	NO SENSE	NO ADDITIONAL SENSE INFORMATION	Normal command completion
Invalid Security Protocol ID parameter	CHECK CONDITION	ILLEGAL REQUEST	INVALID FIELD IN CDB	No data SHALL be transferred
Invalid Transfer Length parameter on IF-SEND	CHECK CONDITION	ILLEGAL REQUEST	INVALID FIELD IN CDB	No data SHALL be transferred.
Other Invalid Command Parameter	CHECK CONDITION	ILLEGAL REQUEST	INVALID FIELD IN CDB	No data SHALL be transferred.
Synchronous Protocol Violation	CHECK CONDITION	ILLEGAL REQUEST	COMMAND SEQUENCE ERROR	No data SHALL be transferred.
Data Protection Error	CHECK CONDITION	DATA PROTECT	ACCESS DENIED–NO ACCESS RIGHTS	No data SHALL be transferred.

3.4 Discovery of Security Capabilities

3.4.1 Security Protocol 0x00

See the description of SECURITY PROTOCOL IN [14] for information on Security Protocol 0x00.

3.5 Miscellaneous Issues

3.5.1 Queued Commands

The TPer requires that for a given ComID the order of the IF-SEND and IF-RECV command completion be the same as the order that the host application sent the commands.

Some transport protocols MAY NOT guarantee ordering of delivery or ordering of IF-SEND and IF-RECV command completion. Therefore, the host application communicating with the TPer SHOULD ensure that a prior IF-SEND or IF-RECV has completed prior to issuing another, or use mechanisms in the interface protocol to ensure ordering (e.g. ORDERED Task Attribute for SCSI Transport protocols).

Begin Informative Content

The following definition of synchronous behavior does not affect the queuing behavior (if any) of the device interface. On queuing devices, synchronicity is enforced at the time IF-SEND/RECV commands are dequeued for processing by the drive. For non-queuing devices, synchronicity is enforced at the time the IF-SEND/RECV is initially received by the device. If queuing behavior is supported, the host should use Ordered Queuing for IF-SEND/RECV commands or indeterminate behavior may result.

It is assumed that the drive can only process one IF-SEND/RECV interface command at a time.

End Informative Content

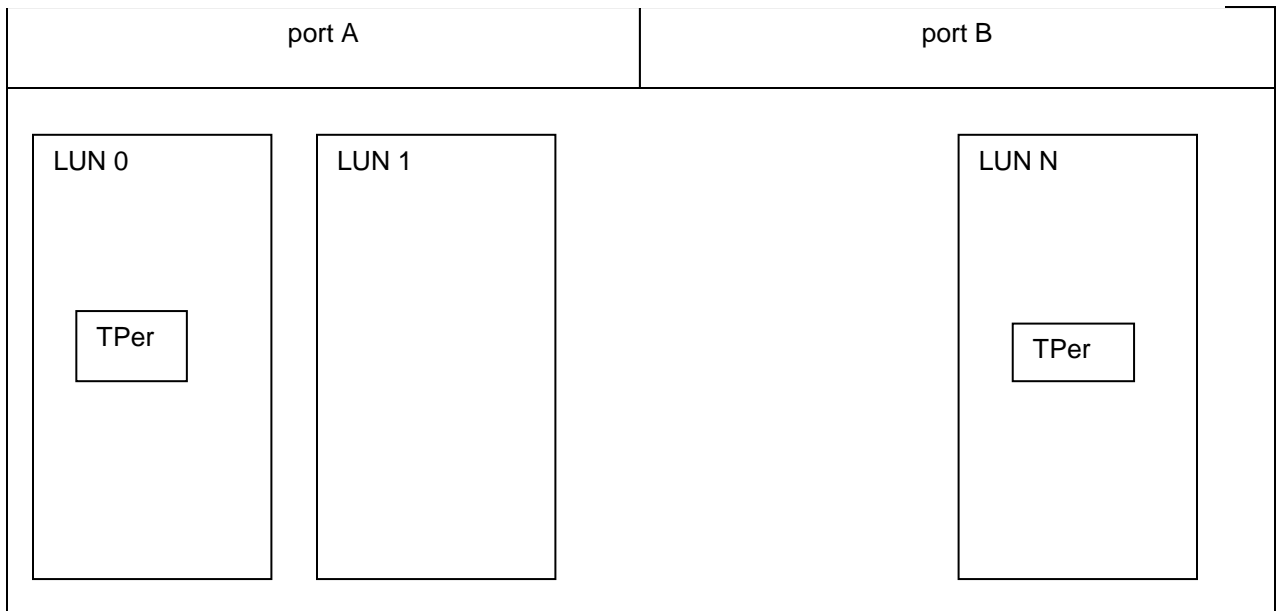
3.5.2 MBR Interactions

The LUN associated with the MBR is the boot LUN.

3.5.3 LUN usage

A target that has multiple LUNs MAY have multiple TPer. Each TPer SHALL be associated with a different LUN. Every LUN on a device is not required to have a TPer, but LUNs that support the TCG Core specification commands and functionality SHALL have a TPer. A TPer SHALL only be associated with exactly one LUN. A LUN MAY have no TPer.

Figure 1 - SCSI target: port, LUN and TPer relationships



The Current Maximum LBA is the maximum LBA that is permitted at the current time by a normal read or write command.

Table 10 specifies the definition of Current Maximum LBA. Current Maximum LBA is undefined if it is not specified in Table 10.

Table 10 - Current Maximum LBA (SCSI)

READ CAPACITY(10)¹	READ CAPACITY(16)¹	Current Maximum LBA
RETURNED LOGICAL BLOCK ADDRESS < FFFF_FFFFh	CDB not supported	READ CAPACITY(10) RETURNED LOGICAL BLOCK ADDRESS parameter
RETURNED LOGICAL BLOCK ADDRESS <= FFFF_FFFFh	CDB supported and RETURNED LOGICAL BLOCK ADDRESS <= FFFF_FFFF_FFFF_FFEh	READ CAPACITY(16) RETURNED LOGICAL BLOCK ADDRESS parameter
¹ For this determination, PMI SHALL be set to zero in the CDB.		

3.5.5 Interaction of Opal SSC with the SANITIZE command

The Storage Device MAY support (i.e., REPORT SUPPORTED OPERATION CODES command) SANITIZE commands when no SP exists that incorporates the Locking Template or when an SP that incorporates the Locking Template is in the Manufactured-Inactive state.

In all other cases, the Storage Device SHALL:

- a) report that SANITIZE commands are not supported (e.g., response to REPORT SUPPORTED OPERATION CODES command, and terminate SANITIZE commands); or
- b) perform the following:
 - a. report that SANITIZE commands are supported; and
 - b. terminate SANITIZE commands with a Data Protection Error (see 3.3).

3.5.6 Interaction of Enterprise SSC with the SANITIZE command

If:

- a) the EraseMaster C_PIN credential is not equal to MSID;
- b) any Bandmaster C_PIN credential is not equal to MSID; or
- c) for any Locking table object:
 - a. the WriteLockEnabled column is TRUE;
 - b. the ReadLockedEnabled column is TRUE;
 - c. the RangeStart column is not equal to zero; or
 - d. the RangeLength column is not equal to zero,

then the Storage Device SHALL terminate a SANITIZE command with a Data Protection Error (see 3.3).

A successful SANITIZE command SHALL eradicate all Locking SP media encryption keys and generate new media encryption keys.

3.5.7 Special Locking SP command interactions

For an SD implementing the Opal SSC or the Enterprise SSC, the SD SHALL terminate the following commands with a Status of CHECK CONDITION, sense key set to ILLEGAL REQUEST and additional sense code set to INVALID COMMAND OPERATION CODE:

- a) READ LONG(10);
- b) READ LONG(16);
- c) WRITE LONG(10), (WR_UNCOR = 0); and
- d) WRITE LONG(16), (WR_UNCOR = 0).

4 ATA Interface

See [3] and [4] for details on ATA architecture, commands and transports.

4.1 Mapping of Resets

Table 11 - ATA Resets Mapped to TCG reset_type

ATA Event	Maps to TCG reset_type
Power on reset	Power Cycle
Software reset	(none)
Hardware reset	PATA: Hardware Reset SATA: If Software Settings Preservation is enabled, then COMRESET is not a TCG Hardware Reset. If Software Settings Preservation is disabled, then COMRESET is a TCG Hardware Reset.

4.2 Mapping of IF-SEND and IF-RECV

4.2.1 IF_SEND

IF_SEND SHALL be implemented with either the TRUSTED SEND or TRUSTED SEND DMA commands, with additional requirements on the inputs as described in Table 12:

Table 12 - IF-SEND command parameters (ATA)

Security Protocol	SP_Specific	Transfer Length
0x00	Security Protocol 0x00 is not defined for IF-SEND	
0x01	a ComID	Non-zero ^a number of 512-byte data units.
0x02	a ComID	Non-zero ^a number of 512-byte data units.
0x06	Protocol 0x06 is defined for SCSI only.	
^a If the Transfer Length parameter is zero, then the TPer SHALL report Other Invalid Command Parameter (see 4.3).		

4.2.2 IF_RECV

IF_RECV SHALL be implemented with either the TRUSTED RECEIVE or TRUSTED RECEIVE DMA commands, with additional requirements on the inputs as described in Table 13:

Table 13 - IF-RECV command parameters (ATA)

Security Protocol	SP_Specific	Transfer Length
0x00	(See [3])	Non-zero number of 512-byte data units.
0x01	a ComID	Non-zero ^a number of 512-byte data units.
0x02	a ComID	Non-zero ^a number of 512-byte data units.
0x06	Protocol 0x06 is defined for SCSI only.	
^a If the Transfer Length parameter is zero, then the TPer SHALL report Other Invalid Command Parameter (see 4.3).		

4.3 Handling Common TPer Errors

There are some common errors detected by the TPer. This section describes how they are reported via the ATA interface.

See [3] for information about the Sense Data Reporting (SDR) feature set and the SENSE DATA AVAILABLE (SDA) (i.e., ATA STATUS field bit 1) bit.

Table 14 describes common TPer errors if:

- a) SDR is not supported;
- a) SDR is supported and SDR is disabled; or
- b) SDR is supported and SDR is enabled and SENSE DATA AVAILABLE is cleared to zero.

Table 15 describes common TPer errors if:

- a) SDR is supported and SDR is enabled and SENSE DATA AVAILABLE is set to one.

Table 14 - TPer Errors (ATA) – Without Sense Data Reporting (SDA=0)

TPer Error ID	ATA Status Field	ATA Error Field	Comments
Good	0x50	0x00	Normal command completion
Invalid Security Protocol ID parameter	0x51	0x04	No data SHALL be transferred
Invalid Transfer Length parameter on IF-SEND	0x51	0x04	No data SHALL be transferred.
Other Invalid Command Parameter	0x51	0x04	No data SHALL be transferred.
Synchronous Protocol Violation	0x51	0x04	No data SHALL be transferred.
Data Protection Error	0x51	0x04	No data SHALL be transferred.

Table 15 - TPer Errors (ATA) – With Sense Data Reporting (SDA=1)

TPer Error ID	ATA Status Field Bit 1	Sense Key	ASC/ASCQ	Comments
Good	1	NO SENSE	NO ADDITIONAL SENSE	Normal command completion
Invalid Security Protocol ID parameter	1	ILLEGAL REQUEST	INVALID FIELD IN CDB	No data SHALL be transferred
Invalid Transfer Length parameter on IF-SEND	1	ILLEGAL REQUEST	INVALID FIELD IN CDB	No data SHALL be transferred.
Other Invalid Command Parameter	1	ILLEGAL REQUEST	INVALID FIELD IN CDB	No data SHALL be transferred.
Synchronous Protocol Violation	1	ILLEGAL REQUEST	COMMAND SEQUENCE ERROR	No data SHALL be transferred.
Data Protection Error	1	DATA PROTECT	ACCESS DENIED– NO ACCESS RIGHTS	No data SHALL be transferred.

4.4 Discovery of Security Capabilities

4.4.1 IDENTIFY DEVICE

The IDENTIFY DEVICE command (see [3]) indicates whether the device has support for the ATA Security feature set or the Trusted Computing feature set. See IDENTIFY DEVICE data words 48, 82, and 128 for further information.

4.4.2 Security Protocol 0x00

The TRUSTED RECEIVE command (see [3]) describes Security Protocol 0x00.

4.5 Miscellaneous Issues

4.5.1 Feature set interactions

4.5.1.1 Trusted Computing feature set

The Trusted Computing feature set SHALL be supported by the device.

4.5.1.2 Sense Data Reporting feature set

If the Sense Data Reporting (SDR) feature set is supported and enabled, then common TPer errors are reported as Sense Codes instead of as regular ATA errors. (See [3] and 4.3).

4.5.1.3 Locking Template interactions with the ATA Security feature set

If the lifecycle state of the Locking SP changes from the Manufactured-Inactive state to the Manufactured state, then:

- 1) the TPer SHALL save the current value of:
 - a. IDENTIFY DEVICE, word 82, bit 1;
 - b. IDENTIFY DEVICE, word 85, bit 1; and
 - c. IDENTIFY DEVICE, word 128;and
- 2) the TPer SHALL change the value of IDENTIFY DEVICE, word 82, bit 1 to zero.

If the lifecycle state of the Locking SP is in the Manufactured state, then IDENTIFY DEVICE commands processed by the device SHALL indicate that the ATA Security feature set is not supported.

If the lifecycle state of the Locking SP changes from the Manufactured state to the Manufactured-Inactive state, then the TPer SHALL restore the value of the IDENTIFY DEVICE data to the values that were saved when the TPer changed the state from Manufactured-Inactive to Manufactured:

- a) IDENTIFY DEVICE, word 82, bit 1;
- b) IDENTIFY DEVICE, word 85, bit 1; and
- c) IDENTIFY DEVICE, word 128.

If there is no Locking SP or the lifecycle state of the Locking SP is in the Manufactured-Inactive state, IDENTIFY DEVICE commands processed by the device MAY indicate that the ATA Security feature set is supported.

When ATA Security is Enabled (a User Password is set), the TPer SHALL prohibit issuance of an SP that incorporates the Locking Template, and SHALL prohibit a SP that incorporates the Locking Template from transitioning out of the Manufactured-Inactive state.

4.5.1.4 Interaction of Opal SSC with the ATA Sanitize Device feature set

The Storage Device MAY support (i.e., IDENTIFY DEVICE, word 59, bit 12 = 1) the ATA Sanitize Device feature set when no SP exists that incorporates the Locking Template or when an SP that incorporates the Locking Template is in the Manufactured-Inactive state.

In all other cases, the Storage Device SHALL:

- a) report that the ATA Sanitize Device feature set is not supported (i.e., IDENTIFY DEVICE, word 59, bit 12 = 0); or
- b) perform the following:
 - a. report that the ATA Sanitize Device feature set is supported (i.e., IDENTIFY DEVICE word 59, bit 12 = 1); and
 - b. terminate the following commands with a Data Protection Error (see 4.3):
 - i. CRYPTO SCRAMBLE EXT command;
 - ii. OVERWRITE EXT command;
 - iii. BLOCK ERASE EXT command;
 - iv. SANITIZE ANTIFREEZE LOCK EXT command; and
 - v. SANITIZE FREEZE LOCK EXT command.

4.5.1.5 Interaction of Enterprise SSC with the ATA Sanitize Device feature set

If:

- a) the EraseMaster C_PIN credential is not equal to MSID;
- b) any Bandmaster C_PIN credential is not equal to MSID; or
- c) for any Locking table object:
 - a. the WriteLockEnabled column is TRUE;
 - b. the ReadLockedEnabled column is TRUE;
 - c. the RangeStart column is not equal to zero; or
 - d. the RangeLength column is not equal to zero,

then the Storage Device SHALL terminate the following commands with a Data Protection Error (see 4.3):

- a) CRYPTO SCRAMBLE EXT command;
- b) OVERWRITE EXT command;
- c) BLOCK ERASE EXT command;
- d) SANITIZE ANTIFREEZE LOCK EXT command; and
- e) SANITIZE FREEZE LOCK EXT command,

A successful SANITIZE command SHALL eradicate all Locking SP media encryption keys and generate new media encryption keys.

4.5.1.6 Interaction of the Opal SSC Activate method with the ATA Security feature set

If the Activate method is invoked on the Locking SP while ATA Security is Enabled (i.e., a User Password is set), the method invocation SHALL fail with a status of ACTIVATE FAILED.

4.5.2 Current Maximum LBA

The Current Maximum LBA is the maximum LBA that is permitted at the current time by a normal read or write command. Table 16 specifies the definition of Current Maximum LBA.

Table 16 - Current Maximum LBA (ATA)

IDENTIFY DEVICE word 83 bit 10	IDENTIFY DEVICE word 69 bit 3	Current Maximum LBA
0	N/A	(IDENTIFY DEVICE words 60 to 61) minus 1
1	0	(IDENTIFY DEVICE words 100 to 103) minus 1
1	1	(IDENTIFY DEVICE words 230 to 233) minus 1

4.5.3 Special Locking SP command interactions

If:

- a) an SD implements the Opal SSC or the Enterprise SSC; and
- b) the Sense Data Reporting feature is supported and is enabled,

then the SD SHALL terminate the following ATA commands with the Sense Key set to ILLEGAL REQUEST and the additional sense set to INVALID COMMAND OPERATION CODE:

- a) READ LONG;
- b) WRITE LONG;
- c) SCT READ LONG; and
- d) SCT WRITE LONG.

If:

- a) an SD implements the Opal SSC or the Enterprise SSC; and
- b) the Sense Data Reporting feature is not supported or is not enabled,

then the SD SHALL return command aborted for the following ATA commands:

- a) READ LONG;
- b) WRITE LONG;
- c) SCT READ LONG; and
- d) SCT WRITE LONG.

5 NVM Express Interface

See [10] for details on NVM Express architecture, commands and transports.

5.1 Mapping of Resets

Table 17 – NVM Express Resets Mapped to TCG reset_type

NVM Express Event	Maps to TCG reset_type	Reference
Power (power-up)	Power Cycle	[10]
PCIe hot reset	None	[13]
PCIe warm reset	None	[13]
PCIe cold reset	None	[13]
PCIe transaction layer Data Link Down status	None	[13]
NVMe subsystem reset	None	[10]
NVMe Controller reset (CC.EN transitions from 1 to 0)	None	[10]
NVMe Function level (PCI) reset	None	[10]
NVMe Queue level reset	None	[10]

5.2 Mapping of IF-SEND and IF-RECV

5.2.1 IF_SEND

IF_SEND SHALL be implemented with the Security Send command [10], with additional requirements on the inputs as described in Table 18:

Table 18 - IF-SEND command parameters (NVM Express)

Security Protocol	SP_Specific	Transfer Length
0x00	Security Protocol 0x00 is not defined for IF-SEND	
0x01	a ComID	Number of bytes to transfer.
0x02	a ComID	Number of bytes to transfer.
0x06	Protocol 0x06 is defined for SCSI only.	

5.2.2 IF_RECV

IF_RECV SHALL be implemented with the Security Receive command [10], with additional requirements on the inputs as described in Table 19:

Table 19 - IF-RECV command parameters (NVM Express)

Security Protocol	SP_Specific	Allocation Length
0x00	(See [10])	Number of bytes to transfer.
0x01	a ComID	Number of bytes to transfer.
0x02	a ComID	Number of bytes to transfer.
0x06	Protocol 0x06 is defined for SCSI only.	

5.3 Handling Common TPer Errors

There are some common errors detected by the TPer. This section describes how they are reported via the NVM Express interface.

Common Tper errors are reported in the NVM Express Admin Completion Queue, Status Field (see [10]). The Status Code Type (SCT) field and the Status Code (SC) field SHALL indicate and map the TPer error as in Table 20.

Table 20 - TPer Errors (NVM Express)

TPer Error ID	Status Code Type	Status Code	Comments
Good	Generic Command Status	Successful Completion	Normal command completion
Invalid Security Protocol ID parameter	Generic Command Status	Invalid Field in Command	No data SHALL be transferred.
Invalid Transfer Length parameter on IF-SEND	Generic Command Status	Invalid Field in Command	No data SHALL be transferred.
Other Invalid Command Parameter	Generic Command Status	Invalid Field in Command	No data SHALL be transferred.
Synchronous Protocol Violation	Generic Command Status	Command Sequence Error	No data SHALL be transferred.
Data Protection Error	Media and Data Integrity Errors	Access Denied	No data SHALL be transferred.

5.4 Discovery of Security Capabilities

5.4.1 Identify Controller Data Structure

The Optional Admin Command Support (OACS) of the Identify Controller Data Structure (see [10]) indicates whether the device has support for the Security Send and Security Receive commands.

5.4.2 Security Protocol 0x00

The Security Receive command (see [10]) describes Security Protocol 0x00.

5.5 Miscellaneous Issues

5.5.1 Security Commands

The optional Security Send and Security Receive commands SHALL be implemented by the device.

5.5.2 Namespace

A target that has multiple Namespaces MAY have multiple TPer. Each TPer SHALL be associated with a different Namespace. Every Namespace on a device is not required to have a TPer, but Namespaces that support the TCG Core specification commands and functionality SHALL have a TPer. A TPer SHALL only be associated with exactly one Namespace. A Namespace MAY have no TPer.

5.5.3 Locking Template interactions with the Format NVM Command

5.5.3.1 Overview

If no Namespace contains a TPer that contains an SP that incorporates the Locking Template, then the Identify Controller Data Structure NVM Command Set Attributes Field, Format NVM Attributes (FNA) bit 2 MAY be set to one to indicate cryptographic erase is supported. Otherwise, the Identify Controller Data Structure NVM Command Set Attributes Field, Format NVM Attributes (FNA) bit 2 SHALL be cleared to zero to indicate cryptographic erase is not supported.

5.5.3.2 Interaction with Opal SSC

If:

- a) the Namespace is not `0xFFFFFFFF`;
- b) an SP exists in that Namespace's TPer that incorporates the Locking Template; and
- c) the lifecycle state of that SP is not "Manufactured-Inactive",

then the Format NVM command SHALL fail with an Invalid Security State condition returned in the Admin Completion Queue, Command Specific Error.

If:

- a) the Namespace is `0xFFFFFFFF`;
- b) any Namespace's TPer contains an SP that incorporates the Locking Template;
- c) the lifecycle state of any of those SPs is not "Manufactured-Inactive",

then the Format NVM command SHALL fail with an Invalid Security State condition returned in the Admin Completion Queue, Command Specific Error.

If all SPs that incorporate the Locking Template are in the "Manufactured-Inactive" lifecycle state, then the Identify Controller Data Structure NVM Command Set Attributes Field, Format NVM Attributes (FNA) bit 2 MAY be set to one to indicate cryptographic erase is supported. Otherwise, the Identify Controller Data Structure NVM Command Set Attributes Field, Format NVM Attributes (FNA) bit 2 SHALL be cleared to zero to indicate cryptographic erase is not supported.

5.5.3.3 Interaction with Enterprise SSC

If:

- a) the Namespace is not 0xFFFFFFFF;
- b) the namespace contains a TPer that contains an SP that incorporates the Locking Template;
- c) and:
 - d) the EraseMaster C_PIN credential is not equal to MSID;
 - e) any Bandmaster C_PIN credential is not equal to MSID; or
 - f) for any Locking table object:
 - a. the WriteLockEnabled column is TRUE;
 - b. the ReadLockedEnabled column is TRUE;
 - c. the RangeStart column is not equal to zero; or
 - d. the RangeLength column is not equal to zero,

then the Storage Device SHALL terminate a Format NVM command with an Invalid Security State condition returned in the Admin Completion Queue, Command Specific Error.

If:

- d) the Namespace is 0xFFFFFFFF;
- e) any namespace contains a TPer; and;
- f) for all TPer that incorporate the Locking Template:
 - g) the EraseMaster C_PIN credential is not equal to MSID;
 - h) any Bandmaster C_PIN credential is not equal to MSID; or
 - i) for any Locking table object:
 - a. the WriteLockEnabled column is TRUE;
 - b. the ReadLockedEnabled column is TRUE;
 - c. the RangeStart column is not equal to zero; or
 - d. the RangeLength column is not equal to zero,

then the Storage Device SHALL terminate a Format NVM command with an Invalid Security State condition returned in the Admin Completion Queue, Command Specific Error.

5.5.4 Current Maximum LBA

The Current Maximum LBA is the maximum LBA that is permitted at the current time by a normal read or write command. The Current Maximum LBA is the value of the Namespace Size (NSZE) field minus one.

6 eMMC Interface

See [11] for details on eMMC architecture, commands and transports. In addition further details relating to the mapping provided below are found in [16].

6.1 Mapping of Resets

Table 21 specifies the eMMC events that are mapped to TCG resets.

Table 21 - eMMC Events Mapped to TCG reset_type

eMMC Event	Maps to TCG reset_type	Reference
Power On	Power cycle	[11]
H/W Reset (Pin, Reset Signal)	Hardware Reset	[11]
GO_IDLE_STATE (CMD0)	Hardware Reset	[11]
GO_PRE_IDLE_STATE (CMD0)	Hardware Reset	[11]
GO_INACTIVE_STATE (CMD15)	Power cycle	[11]
HPI (High Priority Interrupt)	None	[11]

6.2 Mapping of IF-SEND and IF-RECV

6.2.1 IF_SEND

IF_SEND is implemented with the combination of a CMD23 (i.e., SET_BLOCK_COUNT), followed by a CMD54 (PROTOCOL_WR), with additional requirements on the inputs as described in Table 22. CMD23 command is used to set the transfer block count for the CMD54. See [11] for details about CMD23 and CMD54.

Table 22 - IF-SEND command parameters (eMMC)

Security Protocol	SP_Specific	Transfer Length
0x00	Security Protocol 0x00 is not defined for IF-SEND	
0x01	a ComID	Non-zero ¹ number of 512 byte data units as defined in CMD23
0x02	a ComID	Non-zero ¹ number of 512 byte data units as defined in CMD23
0x06	Protocol 0x06 is defined for SCSI only.	
¹ If the Transfer Length parameter (“number of blocks”) in CMD23 is zero or if CMD23 was not successfully received, then the eMMC device SHALL report SEC_INVALID_COMMAND_PARAMETER (see 6.4).		

6.2.2 IF_RECV

IF_RECV is implemented with the combination of a CMD23 (SET_BLOCK_COUNT), followed by a CMD53 (PROTOCOL_RD), with additional requirements on the inputs as described in Table 23. CMD23 command is used to set the transfer block count for the CMD53. See [11] for details about CMD23 and CMD53.

Table 23 - IF-RECV command parameters (eMMC)

Security Protocol	SP_Specific	Allocation Length
0x00	See [11] ²	Non-zero ¹ number of 512 byte data units as defined in CMD23
0x01	a ComID	Non-zero ¹ number of 512 byte data units as defined in CMD23
0x02	a ComID	Non-zero ¹ number of 512 byte data units as defined in CMD23
0x06	Protocol 0x06 is defined for SCSI only.	
¹ If the Transfer Length parameter (“number of blocks”) in CMD23 is zero or if CMD23 was not successfully received, then the eMMC device SHALL report SEC_INVALID_COMMAND_PARAMETER (see 6.4). ² When receiving CMD53 (PROTOCOL_RD) with Security Protocol value equal to 00h the device SHALL return the list of supported protocols.		

6.2.3 eMMC Command Structure for TCG IF_SEND and IF_RECV

6.2.3.1 eMMC Block Allocation Overview

The eMMC protocol uses the CMD23 SET_BLOCK_COUNT command (see 6.2.3.2) to set the block count for the CMD54 command or the CMD53 command (see 6.2.3.3) that immediately follows it. The block count of the CMD54 command or the CMD53 command is specified in 512-byte blocks (i.e., Allocation Length maps to the number of blocks in the payload multiplied by 512). Payload padding to the specified number of 512 byte blocks SHALL consist of zeros.

For TCG on the eMMC transport, the IF_SEND command consists of the combination of a CMD23, followed by a CMD54.

In TCG on the eMMC transport, the IF_RECV command consists of the combination of a CMD23, followed by a CMD53.

6.2.3.2 eMMC CMD23 SET_BLOCK_COUNT command

CMD23 SET_BLOCK_COUNT is sent before CMD54 or CMD53 to set a transfer length of one or more 512-byte block. See Table 24.

Table 24 - eMMC CMD23 Command Block

Bit Byte	7	6	5	4	3	2	1	0
0	[47] Start Bit	[46] Transition Bit	[45:40] Command Index					

1	[39] Reliable Write Request	[38] '0' non-packed	[37] tag request	[36:33] context ID	[32]: forced programming
2	[31:24] set to 0				
3	[23:16] Number of Blocks (15:8)				
4	[15:8]: Number of Blocks (7:0)				
5	[7:1] CRC7				[0] Stop Bit

The value of Command Index is defined as 23 for this command. See [11] for more information.

The value in the Number of Blocks field specifies how many blocks are to be transferred in the next command. See [11] for more information.

All other fields are defined in [11].

6.2.3.3 eMMC CMD54 PROTOCOL_WR and CMD53 PROTOCOL_RD commands

CMD54 PROTOCOL_WR and CMD53_PROTOCOL_RD commands are used to send the Security Protocol and the Security Protocol Specific parameters of the TCG IF_SEND and IF_RECV commands. See Table 25.

Table 25 - eMMC CMD54 and CMD53 Structure

Bit Byte	7	6	5	4	3	2	1	0
0	[47] Start Bit	[46] Transition Bit	[45:40] Command Index					
1	[39:32] Security Protocol Specific (15:8)							
2	[31:24] Security Protocol Specific (7:0)							
3	[23:16] Security Protocol							
4	[15:8] Reserved							
5	[7:1] CRC7							[0] Stop Bit

See Table 22 and Table 23 for usage of Bytes 1 and 2, the Security Protocol Specific fields in addition with the Security Protocol field.

All other fields are defined in [11].

6.3 Handling Common TPer Errors

Security related errors are detected by the eMMC interface or by the TPer. This section describes how they are reported by the eMMC interface.

See [11] for details.

Table 26 - TPer Errors (eMMC)

TPer Error ID	eMMC Device Status	EXCEPTION EVENTS STATUS ¹	EXT SECURITY ERR ²	Comments
Good	No error	No error	No error	Normal command completion
Invalid Security Protocol ID parameter	EXCEPTION EVENT=1	EXTENDED SECURITY FAILURE =1	SEC INVALID COMMAND PARAMETERS =1	No data SHALL be transferred.
Invalid Transfer Length parameter on IF-SEND	EXCEPTION EVENT=1	EXTENDED SECURITY FAILURE =1	SEC INVALID COMMAND PARAMETERS =1	No data SHALL be transferred.
Other Invalid Command Parameter	EXCEPTION EVENT=1	EXTENDED SECURITY FAILURE =1	SEC INVALID COMMAND PARAMETERS =1	No data SHALL be transferred.
Synchronous Protocol Violation	EXCEPTION EVENT=1	EXTENDED SECURITY FAILURE =1	SEC INVALID COMMAND PARAMETERS =1	No data SHALL be transferred.
Data Protection Error	EXCEPTION EVENT=1	EXTENDED SECURITY FAILURE =1	ACCESS DENIED=1	No data SHALL be transferred.
¹ EXCEPTION_EVENTS_STATUS field of the EXT_CSD register ² EXT_SECURITY_ERR field of the EXT_CSD register				

6.4 Discovery of Security Capabilities

6.4.1 Discovery of Security Capabilities

6.4.1.1 Security Protocol Information

In order to discover whether the extended protocol pass through commands are supported the host SHOULD verify that Command Class 10 is supported by the device (in CCC field in CSD Register).

In order to receive and send extended protocol information CMD53 and CMD54 SHALL be used.

Refer to Security Protocol Information (see [11]) for the discovery of which security feature set is supported.

When receiving PROTOCOL_RD (CMD53) with Security Protocol value equal to 00h the device SHALL return the list of supported protocols.

6.5 Miscellaneous Issues

6.5.1 Partition Management

The Locking Template SHALL be associated with and manage only the User Data Area partition (see [11]).