FIPS 140 - 2 Security Policy for:

KIOXIA TCG Enterprise SSC Self-Encrypting Solid State Drive

(PX model NA02, NA04, NA05)

KIOXIA CORPORATION

Rev 3.0.0

Overview

The KIOXIA TCG Enterprise SSC Self-Encrypting Solid State Drive (listed in Section1.1 Product Version) is used for solid state drive data security. This Cryptographic Module (CM) provides various cryptographic services using FIPS approved algorithms. Services include hardware-based data encryption, cryptographic erase, and FW download.

This CM is multiple-chip embedded, and the physical boundary of the CM is the entire SSD. The logical boundary is SAS interface (same as the physical boundary). The physical interface for power-supply and for communication is one SAS connector. The CM is connected with host system by SAS cable. The logical interface is the SAS, TCG SWG, and Enterprise SSC.

The CM has the non-volatile storage area for not only user data but also the keys, CSPs, and FW. The latter storage area is called the “system area”, which is not logically accessible / addressable by the host application.

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Overall Level	2

Table 1 - Security Level Detail

Interface	Ports
Data Input	SAS connector
Control Input	SAS connector
Data Output	SAS connector
Status Output	SAS connector
Power Input	SAS connector

Table 1-1 - Physical/Logical Port Mapping

Acronyms

AES	Advanced Encryption Standard
CM	Cryptographic Module
CSP	Critical Security Parameter
DRBG	Deterministic Random Bit Generator
EDC	Error Detection Code

FW	Firmware
HMAC	Keyed-Hashing for Message Authentication code
KAT	Known Answer Test
LBA	Logical Block Address
MSID	Manufactured SID
NDRNG	Non-Deterministic Random Number Generator
PCB	Printed Circuit Board
POST	Power on Self-Test
PSID	Printed SID
SED	Self-Encrypting Drive
SHA	Secure Hash Algorithm
SID	Security ID

Section 1 – Module Specification

The CM has one FIPS 140 approved mode of operation and CM is always in approved mode of operation. The CM provides services defined in Section 2.1 and other non-security related services.

Section 1.1 – Product Version

The KIOXIA Enterprise SSC Self-Encrypting Solid State Drive has been validated:

HW version: A0 with PX02SMU020, PX02SMU040, PX02SMU080, or PX02SMQ160
FW version: NA02, NA04, NA05

The PX02SMU080 with NA02, NA04 and NA05 varies “Product ID” value of INQUIRY command according to customer requirements. These “Product ID” values are X440_PHM2800MCTO and X577_PHM2800MCTO.

Section 2 – Roles Services and Authentication

This section describes roles, authentication method, and strength of authentication.

Role Name	Role Type	Type of Authentication	Authentication	Authentication Strength	Multi Attempt strength
EraseMaster	Crypto Officer	Role	PIN	$1/2^{48} < 1/1{,}000{,}000$	$15{,}000 / 2^{48} < 1 / 100{,}000$
SID	Crypto Officer	Role	PIN	$1/2^{48} < 1/1{,}000{,}000$	$15{,}000 / 2^{48} < 1 / 100{,}000$
BandMaster0	User	Role	PIN	$1/2^{48} < 1/1{,}000{,}000$	$15{,}000 / 2^{48} < 1 / 100{,}000$
BandMaster1	User	Role	PIN	$1/2^{48} < 1/1{,}000{,}000$	$15{,}000 / 2^{48} < 1 / 100{,}000$
…	…	…	…	…	…
BandMaster8	User	Role	PIN	$1/2^{48} < 1/1{,}000{,}000$	$15{,}000 / 2^{48} < 1 / 100{,}000$

Table 2 - Identification and Authentication Policy

Per the security policy rules, the minimum PIN length is 6 bytes. Therefore the probability that a random attempt will succeed is $1/2^{48} < 1{,}000{,}000$ (the CM accepts any value (0x00-0xFF) as each byte of PIN). The CM waits 4msec when authentication attempt fails, so the maximum number of authentication attempts is 15,000 times in 1 min. Therefore the probability that random attempts in 1min will succeed is $15{,}000 / 2^{48} < 1 / 100{,}000$.

Section 2.1 – Services

This section describes services which the CM provides.

Service	Description	Role(s)	Keys & CSPs	RWX(Read,Write,eXecute)	Algorithm(CAVP Certification Number)	Method
Band Lock/Unlock	Block or allow read (decrypt) / write (encrypt) of user data in a band. Locking also requires read/write locking to be enabled	BandMaster0 … BandMaster8	Table MAC Key	X	HMAC-SHA256 (#1611)	SECURITY PROTOCOL IN(TCG Set Method Result)
Cryptographic Erase	Erase user data (in cryptographic means) by changing the data encryption key	EraseMaster	MEK(s) RKey Table MAC Key	W X X	Hash_DRBG(#397) AES256CBC(#2598) HMAC-SHA256 (#1611)	SECURITY PROTOCOL IN(TCG Erase Method Result)
Data read/write(decrypt/encrypt)	Encryption / decryption of unlocked user data to/from band	None	MEKs	X	XTS-AES256(#2598)	SCSI READ/WRITE Commands
Download Port Lock/Unlock	Enable / Disable Firmware Download service	SID	Table MAC Key	X	HMAC-SHA256 (#1611)	SECURITY PROTOCOL IN(TCG Set Method Result)
Firmware Download	Load complete firmware image. The device is reset and will run with the new code	None	PubKey	X	RSASSA-PKCS-v1_5(#1331)	SCSI WRITE BUFFER
RandomNumber generation	Provide a random number generated by the CM	None	Seed	R	Hash_DRBG(#397)	SECURITY PROTOCOL IN(TCG Random Method Result)
Reset(run POSTs)	Runs POSTs and delete CSPs in RAM	None	N/A	N/A	N/A	Power on reset
Set band position and size	Set the location and size of the LBA range	BandMaster0 … BandMaster8	Table MAC Key	X	HMAC-SHA256 (#1611)	SECURITY PROTOCOL IN(TCG Set Method Result)
Set PIN	Setting PIN (authentication data)	All for their PIN	RKey Table MAC Key	X X	AES256CBC(#2598) HMAC-SHA256 (#1611) SHA256(#2183)	SECURITY PROTOCOL IN(TCG Set Method Result)
Show Status	Report status of the CM	None	N/A	N/A	N/A	SCSI REQUEST SENSE
Zeroization	Erase user data in all bands by changing the data encryption key, initialize range settings, and reset PINs for TCG	AdminSP.PSID(using PSID[1])	RKey Table MAC KEY MEKs PIN	X,W X W W	AES256CBC(#2598) HMAC-SHA256 (#1611) Hash_DRBG(#397)	SECURITY PROTOCOL IN(TCG RevertSP Method Result)

Table 3 - FIPS Approved services

Algorithm	CAVP Certification Number
AES256CBC	#2598
XTS-AES256	#2598

[1] PSID (Printed SID) is public drive-unique value which is used for the TCG Revert AdminSP method.

SHA256	#2183
HMAC-SHA256	#1611
RSASSA-PKCS-v1_5	#1331
Hash_DRBG	#397

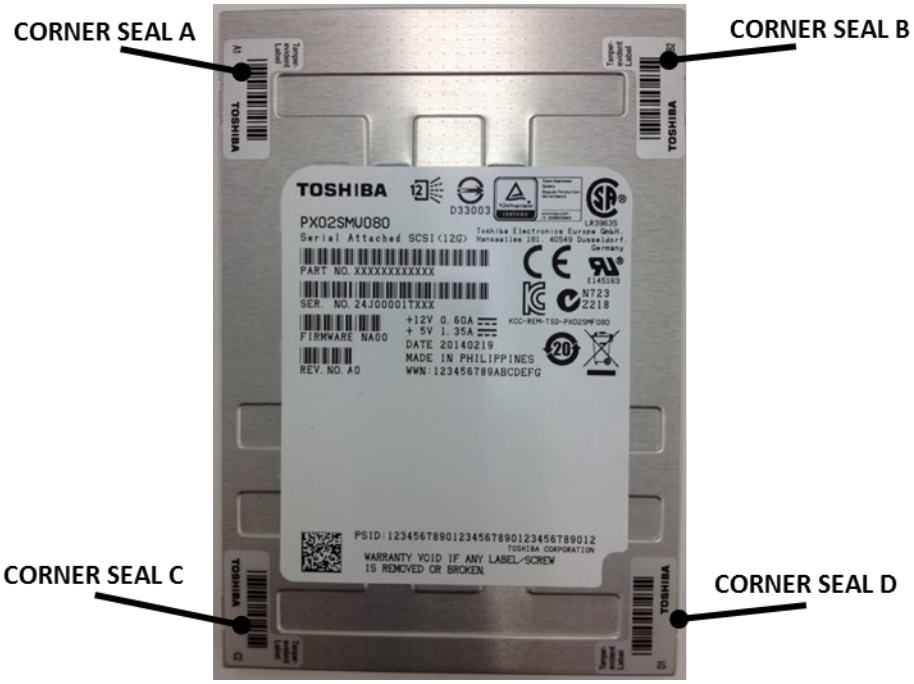
Table 4 - FIPS Approved Algorithms

Section 3 – Physical Security

The CM has the following physical security:

- Production-grade components with standard passivation
- Exterior of the drive is opaque
- In PX02SMU020/040/080 : Four tamper-evident security seals (CORNER SEAL A, CORNER SEAL B, CORNER SEAL C, and CORNER SEAL D) are applied to the CM in factory. These opaque and tamper-evident security seals are applied to top cover of the CM. These seals prevent top cover removal
- In PX02SMQ160: Three tamper-evident security seals are applied to the CM in factory
  - One opaque and tamper-evident security seal (BASE SEAL) is applied to base of the CM. This seal prevents an attacker to access the PCB
  - Two opaque and tamper-evident security seals (SIDE SEAL A and SIDE SEAL B) is applied to side of the CM. These seals prevent cover removal
- The tamper-evident security seals cannot be penetrated or removed and reapplied without tamper-evidence

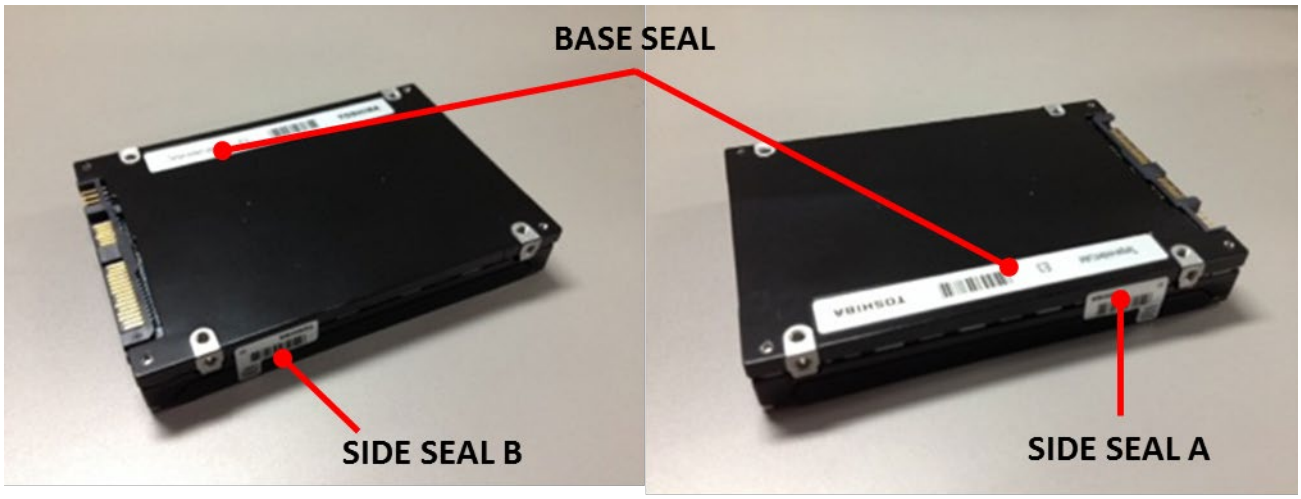
CORNER SEAL A CORNER SEAL B CORNER SEAL C CORNER SEAL D
(PX02SMU020/040/080)



OVERVIEW OF TOP COVER
(PX02SMU020/040/080)

BASE SEAL(PX02SMQ160)

SIDE SEAL A SIDE SEAL B
(PX02SMQ160)



OVERVIEW OF BASE
(PX02SMQ160)

The operator is required to inspect the CM periodically for one or more of the following tamper evidence. If the operator discovers tamper evidence, the CM should be removed.

- Message "VOID" on security seal or enclosure
- Text on security seals does not match original
- A scratch on security seals covered screws
- Security seal cutouts do not match original

Section 4 – Operational Environment

Operational Environment requirements are not applicable because the CM operates in a "non-modifiable", that is the CM cannot be modified and no code can be added or deleted.

Section 5 – Key Management

The CM uses keys and CSPs in the following table.

Key/CSP	Length	Type	Zeroize Method	Establishment	Output	Persistence/Storage
BandMaster/Erase Master/SID PINs	256	PIN	Zeroization service	Electronic input	No	SHA digest/System Area
MEKs	512	Symmetric	Zeroization service	DRBG	No	Encrypted by RKey / System Area
MSID	256	Public	N/A(Public)	Manufacturing	Output: Host can retrieve	Plain / System Area
PubKey	2048	Public	N/A(Public)	Manufacturing	No	Plain / System Area
RKey	256	Symmetric	Zeroization service	DRBG	No	Obfuscated(Plain in FIPS means) / System Area
Seed	440	DRBG seed	Power-Off	Entropy collected from NDRNG at instantiation	No	Plain/RAM
Table MAC Key	256	HMAC Key	Zeroization service	DRBG	No	Encrypted by RKey / System Area

Note that there is no security-relevant audit feature and audit data.

Section 6 – Self Tests

The CM runs self-tests in the following table.

Function	Self-Test Type	Abstract
Firmware Integrity Check	Power-On	EDC 32-bit
SHA256	Power-On	Digest KAT
FW HMAC SHA256	Power-On	Digest KAT
AES(AES CBC)	Power-On	Encrypt and Decrypt KAT
AES(AES XTS)	Power-On	Encrypt and Decrypt KAT
FW Hash_DRBG	Power-On	DRBG KAT
FW RSASSA-PKCS-v1_5	Power-On	Signature verification KAT
FW Hash_DRBG	Conditional	Verify newly generated random number not equal to previous one
NDRNG	Conditional	Verify newly generated random number not equal to previous one

When the CM continuously enters in error state in spite of several trials of reboot, the CM may be sent back to factory to recover from error state.

Section 7 – Design Assurance

Initial operations to setup this module are following:

1. Get MSID from SAS interface.
2. Set range configurations with BandMaster authority by using MSID as PIN.
3. Change BandMaster(s)/EraseMaster PINs.

To get more details, refer to the guidance document provided with the CM.

Section 8 – Mitigation of Other Attacks

The CM does not mitigate other attacks beyond the scope of FIPS 140-2 requirements.