Ultrastar® DC HC310 TCG Enterprise HDD
Ultrastar® DC HC320 TCG Enterprise HDD
Ultrastar® DC HC330 TCG Enterprise HDD
FIPS 140-2 Cryptographic Module
Non-Proprietary Security Policy

Protection of Data at Rest

Version: 1.9
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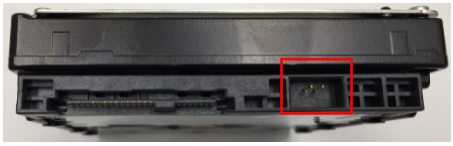
1. Cryptographic Module Overview

The self-encrypting Ultrastar® DC HC310 TCG Enterprise HDD hereafter referred to as "Ultrastar DC HC310" or "Cryptographic Module" is a multi-chip embedded module that complies with FIPS 140-2 Level 2 security. The self-encrypting Ultrastar® DC HC320 TCG Enterprise HDD hereafter referred to as "Ultrastar DC HC320" or "Cryptographic Module" is a multi-chip embedded module that complies with FIPS 140-2 Level 2 security. The self-encrypting Ultrastar® DC HC330 TCG Enterprise HDD, hereafter referred to, respectively, as "Ultrastar DC HC330" or "Cryptographic Module" is a multi-chip embedded module that complies with FIPS 140-2 *Level 2* security. All Cryptographic Modules comply with the *Trusted Computing Group (TCG) SSC: Enterprise Specification*. The drive enclosure defines the cryptographic boundary. See Figure 1, Figure 2, and Figure 3 for additional information. The SIO port pins to the right of the SAS connector are disabled in FIPS Approved Mode. Except for the four-conductor motor control cable, all components within the cryptographic boundary tested are compliant with FIPS 140-2 requirements. The control cable is not security relevant and therefore excluded from FIPS 140-2 requirements.

Figure 1: Cryptographic Boundary for Ultrastar DC HC310

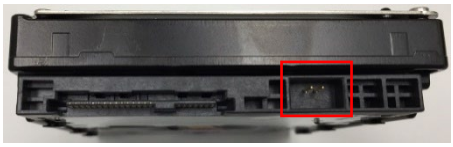
Top View



SAS Port View

Figure 2: Cryptographic Boundary for Ultrastar DC HC320

Top View



SAS Port View

Figure 3: Cryptographic Boundary for Ultrastar DC HC330

Top View

SAS Port View

1.1 Models

Table 1 defines the characteristics and firmware version associated with each validated Ultrastar DC HC310 model. Table 2 defines the characteristics and firmware version associated with the validated Ultrastar DC HC320 model. Table 3 defines the characteristics and firmware version associated with the validated Ultrastar DC HC330 model. The formatting of an Ultrastar DC HC310, Ultrastar DC HC320, and Ultrastar DC HC330 can be converted from 512e to 4Kn and vice versa.

Table 1 - Ultrastar DC HC310 TCG Enterprise 3.5-inch HDD Model

Model Number	Firmware	Description
HUS726T4TAL5205	R984, R9G0, R9U0	4TB, 512e, 7200 RPM, 12 Gb/s, SAS
HUS726T4TALS205	R984, R9G0, R9U0	4TB, 512n, 7200 RPM, 12 Gb/s, SAS
HUS726T6TAL5205	R984, R9G0, R9U0	6TB, 512e, 7200 RPM, 12 Gb/s, SAS

Table 2 - Ultrastar DC HC320 TCG Enterprise 3.5-inch HDD Model

Model Number	Firmware	Description
HUS728T8TAL5205	R980, R9G0, R9U0	8TB, 512e, 7200 RPM, 12 Gb/s, SAS

Table 3 - Ultrastar DC HC330 TCG Enterprise 3.5-inch HDD Model

Model Number	Firmware	Description
WUS721010AL5205	R920, R942, R944, R980, R9G0, R9L2, R9U0, LE01, LE02, NA00, NA01, NA02, NE00, NE01, NE02	10 TB, 512e, 7200 RPM, 12 Gb/s, SAS

1.2 Security Level

The Cryptographic Module meets all requirements applicable to FIPS 140-2 *Level 2* Security.

Table 4 - Module Security Level Specification

FIPS 140-2 Security Requirements Section	FIPS 140-2 Security Level Achieved
Cryptographic Module Specification	2
Module Ports and Interfaces	2
Roles, Services and Authentication	2
Finite State Model	2
Physical Security	2
Operational Environment	N/A
Cryptographic Key Management	2
EMI/EMC	3
Self-Tests	2
Design Assurance	2
Mitigation of Other Attacks	N/A

2. Modes of Operation

2.1 FIPS Approved Mode of Operation

The Cryptographic Module has a single FIPS Approved mode of operation. Configuration and policy determine the Cryptographic Module's mode of operation. The Cryptographic Module enters FIPS Approved Mode after successfully completing the Initialize Cryptographic service instructions referenced in Section 7.2. The operator can determine if the Cryptographic Module is operating in a FIPS Approved mode by invoking the Get FIPS mode service. A return value of 1 indicates that the Cryptographic Module is operating in FIPS Approved mode. The Crypto Officer shall not enable the Makers Authority after a Cryptographic Module enters FIPS Approved mode. The Cryptographic Module is in FIPS non-Approved mode whenever the Makers Authority or the Maintenance mode is enabled. If the Crypto Officer enables the Makers Authority after the Cryptographic Module enters FIPS Approved mode, the Crypto Officer must also execute the TCG Revert Method to zeroize the Cryptographic Module. If the Crypto Officer subsequently executes the Initialize Cryptographic service instructions provided in Section 7.2 with the intent of placing the Cryptographic Module in FIPS Approved mode, the Crypto Officer must first execute the TCG Revert Method to zeroize the Cryptographic Module.

For the respective models, the Ultrastar DC HC310 Product Specification, Ultrastar DC HC320 Product Specification, and Ultrastar DC HC330 Product Specification provide information on how to execute the Initialize Cryptographic service as well as the TCG Revert Method.

2.2 Approved Algorithms

The Cryptographic Module supports the following FIPS Approved algorithms. All algorithms and key lengths comply with NIST SP 800-131A rev2. All algorithms are supported in FIPS Approved and non-Approved mode.

Table 5 - FIPS Approved Algorithms

Algorithm	Description	Cert #
AES Firmware	[FIPS 197, SP800 38A, SP 800 38F] Functions: Encryption, decryption, and key wrapping to protect an associated MEK in data storage applications Modes: ECB, KW Key Sizes: 256	AES 3880
AES Hardware[1]	[FIPS 197, SP800 38A] Functions: Encryption and decryption Modes: ECB Key Sizes: 128, 256	AES 3881
AES XTS Hardware[2]	[FIPS 197, SP800 38A, SP800 38E] Functions: Encryption and decryption in storage applications Modes: XTS • XTS-AES Key_1 does not equal XTS-AES Key_2 • The length of the XTS-AES data unit does not exceed 2^{20} blocks. Key Sizes: 128, 256	AES 3881

[1] AES ECB-128 was tested but is not utilized by the Cryptographic Module
[2] AES XTS-128 was tested but is not utilized by the Cryptographic Module.

Algorithm	Description	Cert #
DRBG Firmware	[SP800 90A] Functions: Deterministic random number generator that uses an AES-256 block cipher derivation function. Modes: CTR Security Strength: 256 bits	DRBG 1108
HMAC Firmware	[FIPS 198-1] Functions: Key encrypting key (KEK) derivation used within the PBKDF SHA sizes: SHA-256	HMAC 2522
RSA Firmware	[FIPS 186-4, PSS] Functions: Digital signature verification with SHA-256[3] Key sizes: 2048	RSA 1978
SHA Firmware	[FIPS 180-4] Functions: AUTH Digest and KEK generation SHA sizes: SHA-256	SHS 3203
SHA Hardware/Firmware	[FIPS 180-4] Functions: Digital Signature verification SHA sizes: SHA-256	SHS 3204

Table 6 - Approved Cryptographic Functions Tested with Vendor Affirmation

Algorithm	Description	Rationale
CKG	[SP800 133] Cryptographic Key Generation Functions: Generated from the DRBG without further modification or post processing	Vendor Affirmed [FIPS140] IG D.12 [SP800-133] Sections 4, 6.1, and 6.2.3.
PBKDF	[SP800 132] Password Based Key Derivation Function Functions: Key Encrypting Key Modes: HMAC-SHA-256 Key Sizes: 256 bits	Vendor Affirmed [FIPS140] IG D.6 [SP800 132] Section 5.4

The Cryptographic Module supports the following non-Approved but allowed algorithm:

- A hardware NDRNG seeds the Approved [SP800 90A] CTR_DRBG. Available entropy does not modify the bit strength of cryptographic keys generated by the CTR_DRBG. Each 2-bit NDRNG sample contains at least 1.00167 bits of min entropy. Each time the CTR_DRBG is instantiated or reseeded, one thousand twenty-four (1024) 2-bit samples seed the CTR_DRBG. This equates to 2048 bits of entropy data and translates to 1025 bits of min-entropy. A min-entropy of 1025 bits is sufficient to assert that the CTR_DRBG has a bit security of 256 bits. A security strength of 256 bits exceeds the minimum requirement of 112 bits of security strength established by NIST.

3. Ports and Interfaces

The Cryptographic Module uses a standard 29-pin Serial Attached SCSI (SAS) connector that conforms to the mechanical requirements of SFF 8680. Table 7 below identifies the Cryptographic Module's ports and interfaces. The Cryptographic Module does not provide a separate maintenance access interface.

[3] SHA-256 Cert. #3204

Table 7 - FIPS 140-2 Ports and Interfaces

FIPS 140-2 Interface	Cryptographic Module Ports
Power	Power connector [SAS]
Control Input	SAS connector [SAS], SIO Port (disabled)
Status Output	SAS connector [SAS], SIO Port (disabled)
Data Input	SAS connector [SAS], SIO Port (disabled)
Data Output	SAS connector [SAS], SIO Port (disabled)

4. Identification and Authentication Policy

The Cryptographic Module enforces role separation by requiring a role identifier and an authentication credential (Personal Identification Number or PIN). The Cryptographic Module enforces the following FIPS140-2 operator roles.

4.1 Crypto Officer

4.1.1 Secure ID (SID) Authority

This TCG authority initializes the Cryptographic Module. Section 11.3.1 of the TCG Storage Security Subsystem Class: Enterprise Specification defines this role.

4.1.2 EraseMaster Authority

This TCG authority can selectively zeroize bands within the Cryptographic Module. Section 11.4.1 of the TCG Storage Security Subsystem Class: Enterprise Specification defines this role. The TCG EraseMaster authority can disable Users and erase LBA bands (user data regions).

4.2 BandMaster Authority (User)

User roles correspond to Bandmaster Authorities. Section 11.4.1 of the TCG Storage Security Subsystem Class: Enterprise Specification provides a definition. Users have the authority to lock, unlock, and configure LBA bands (user data regions) and to issue read and write commands to the SED. The TCG EraseMaster authority can disable a Bandmaster.

4.3 Anybody

Services are provided that do not require authentication. With one exception, these do not disclose, modify, or substitute Critical Security Parameters, use an Approved security function, or otherwise affect the security of the Cryptographic Module. The excepted service is the Generate Random service, which provides output from an instance of the [SP800 90A] DRBG.

4.4 Makers

For failure analysis purposes, the vendor can enable a logical diagnostic port to perform diagnostics and gather data on the failure. A power cycle automatically disables the logical diagnostic port. An operator must authenticate to the SID authority and the Makers authority to enable the logical diagnostic port. The Cryptographic Module is in FIPS non-Approved mode whenever the Crypto Officer enables the Makers authority. The vendor performs failure analysis within the vendor's facility. Makers authentication data shall not leave the vendor's facilities. During normal operation, the Crypto Officer disables the Makers authority when invoking the Initialize Cryptographic Module service.

4.5 Maintenance

For failure analysis purposes, the vendor can enable a privilege mode to perform diagnostics and gather drive health and failure data. Power cycling the module automatically negates the Maintenance role authentication. After

authentication, Vendor Unique Commands (VUC) support diagnostic functions for testing the drive media and the SCSI bus integrity. The operational environment cannot be modified while authenticated to the maintenance role.

The following table maps TCG authorities to FIPS 140-2 roles.

Table 8 - Roles and Required Identification and Authentication

Authority	Description	Authentication Type	Authentication Data
SID Authority	The SID Authority is a Crypto Officer role that initializes the Cryptographic Module and authorizes Firmware downloads.	Role-based	CO Identity (TCG SID Authority) and PIN (TCG SID Authority PIN)
EraseMaster Authority	The EraseMaster Authority is a Crypto Officer role that zeroizes Media Encryption keys and disables Users.	Role-based	CO Identity (TCG EraseMaster Authority) and PIN (TCG EraseMaster PIN)
BandMaster N (N = 0 to 15)	BandMaster is a User role that controls read/write access to LBA Bands.	Role-based	User Identity (TCG BandMaster Authority) and PIN (TCG BandMaster PIN)
Anybody	Anybody is a role that does not require authentication.	Unauthenticated	N/A
Makers (Disabled)	Completion of the Initialize Cryptographic Module service disables the Makers Authority	Role-based	CO Identity (TCG SID Authority) and PIN (Makers PIN)
Maintenance	Maintenance role for Diagnostics commands	Role-based	32-bit EDC

Table 9 - Authentication Mechanism Strengths

Authentication Mechanism	Mechanism Strength
TCG Credential (PIN)	TCG Credentials are 256 bits, which provides 2^{256} possible values. The probability that a random attempt succeeds is 1 chance in 2^{256} (approximately (8.64×10^{-78}) which is significantly less than 1/1,000,000 ($1x\ 10^{-6}$). Multiple, successive authentication attempts can only occur sequentially (one at a time) and only when the failed authentication *Tries* count value does not exceed the associated *TriesLimit* value. Each authentication attempt consumes 1.28 milliseconds. Therefore, at most, 46875 authentication attempts are possible within a one-minute interval. Thus, the probability that a false acceptance occurs within a one-minute interval is 4.05×10^{-73}, which is significantly less than 1 chance in 100,000 (1×10^{-5}).
Maintenance Role Credential	The maintenance role credential embedded within the VUC that enables the maintenance role is a 32-bit EDC, which provides 2^{32} possible values. The probability that a random attempt will succeed or a false acceptance will occur is at least 1 chance in 2^{32} (2.33×10^{-10}), which is significantly less than 1/1,000,000 ($1x\ 10^{-6}$). Authentication attempts consume approximately 7.9 milliseconds. Therefore, at most, 7559 authentication attempts are possible within a one-minute interval. Thus, the probability that a false acceptance occurs within a one-minute interval is 1.76×10^{-6}, which is less than 1 chance in 100,000 (1×10^{-5}).

5. Access Control Policy

5.1 Roles and Services

Table 10 - Authenticated CM Services (Approved and Non-Approved Mode)

Service	Description	Role(s)	Approved Mode	Non-Approved Mode
Initialize Cryptographic Module[4]	Crypto Officer provisions the Cryptographic Module from organizational policies	CO (SID Authority)	X	X
Authenticate	Input a TCG Credential for authentication	CO (SID Authority, EraseMaster), Users, (BandMasters)	X	X
Lock/Unlock Firmware Download Control	Deny/Permit access to Firmware Download service	CO (SID Authority)	X	X
Firmware Download	Load and utilize RSA2048 PSS and SHA-256 to verify the entire firmware image. If the new self-tests complete successfully, the SED executes the new code. Unlocking the Firmware Download Control enables the downloading of firmware.	CO (SID Authority)	X	
Zeroize (TCG Revert)	The TCG Revert method zeroizes a drive and return the Cryptographic Module to its original manufactured state.	CO (SID Authority, EraseMaster), Users, (BandMasters)	X	X
Set	Write data structures; access control enforcement occurs per data structure field. This service can change PINs.	CO (SID Authority, EraseMaster), Users, (BandMasters)	X	X
Set LBA Band	Set the starting location, size, and attributes of a set of contiguous Logical Blocks	Users (BandMasters)	X	X
Lock/Unlock LBA Band	Deny/Permit access to a LBA Band	Users (BandMasters)	X	X
Write Data	Transform plaintext user data to ciphertext and write in a LBA band	Users (BandMasters)	X	X

[4] See Cryptographic Module Acceptance and Provisioning within the Ultrastar DC HC330 Product Specification

Service	Description	Role(s)	Approved Mode	Non-Approved Mode
Read Data	Read ciphertext from a LBA band and output user plaintext data	Users (BandMasters)	X	X
Set Data Store	Write a stream of bytes to unstructured storage	Users (BandMasters)	X	X
Erase LBA Band	Band is cryptographically erased by changing LBA band encryption keys to new values. Erasing an LBA band with EraseMaster sets the TCG Credential to the default value.	CO (EraseMaster)	X	X
Set Vendor Data (Diagnostics)	A Non-Approved service that is unavailable after the Initialize Cryptographic Module service completes. For failure analysis purposes, the vendor can enable a logical diagnostic port to perform diagnostics and gather data on the failure.	Makers		X
Diagnostics	For failure analysis purposes, the vendor can enable a maintenance role to perform diagnostics and gather failure and drive health data. Vendor Unique Commands (VUC) support diagnostic functions for testing the drive media and the SCSI bus integrity.	Maintenance		X

5.2 Unauthenticated Services

Table 11 - Unauthenticated Services lists the unauthenticated services the *C*ryptographic Module provides.

Table 11 - Unauthenticated Services

Service	Description
Reset Module	Power on Reset
Self-Test	The Cryptographic Module performs self-tests when it powers up
Status Output	TCG (IF-RECV) protocol
Get FIPS Mode	TCG 'Level 0 Discovery' method outputs the FIPS mode of the Cryptographic Module.
Start Session	Start TCG session
End Session	End a TCG session by clearing all session state
Generate Random	TCG Random method generates a random number from the [SP800 90A] DRBG

Service	Description
Get	Reads data structure; access control enforcement occurs per data structure field
Get Data Store	Read a stream of bytes from unstructured storage
Zeroize (TCG Revert)	The TCG Revert method returns the Cryptographic Module to its original manufactured state; authentication data (PSID) is printed on the external label
SCSI	[SCSI Core] and [SCSI Block] commands to function as a standardized storage device. See Table 15 - SCSI Commands
FIPS 140 Compliance Descriptor[5]	This service reports the FIPS 140 revision as well as the cryptographic module's overall security level, hardware revision, firmware revision and module name.

5.3 Definition of Critical Security Parameters (CSPs)

The Cryptographic Module contains the CSPs listed in Table 12 - CSPs and Private Keys. Zeroization of CSPs complies with the purge requirements for SCSI hard disk drives within [SP800 88], Guidelines for Media Sanitization.

Table 12 - CSPs and Private Keys

Name	Type	Description
AUTH Digest	256-bit authentication data	SHA-256 digest of a PIN and a PIN salt
Crypto Officer PIN - TCG Credential (2 total)	256-bit authentication data	The PBKDF uses this PIN to authenticate a Crypto Officer's credentials.
DRBG Seed	256-byte Entropy input	Internal state associated with the [SP800-90A] CTR_DRBG using AES-256 Sourced from NDRNG
DRBG State: Key	256-bit value	Internal state associated with the [SP800-90A] CTR_DRBG using AES-256
DRBG State: V	128-bit value	Internal state associated with the [SP800-90A] CTR_DRBG using AES-256.
KEK – Key Encrypting Key (16 total)	SP 800-132 PBKDF (256 bits)	Ephemeral keys derived from BandMaster PINs and 256-bit KDF salts that wrap the MEKs using an SP 800-38F AES-256 Key Wrap. Note: Keys protected by this SP 800-132 PBKDF derived key shall not leave the module.
Maintenance Role Credential	32-bit authentication	A 32-bit EDC authenticates the credentials of the VUC that enables the maintenance role.
MEK - Media Encryption Key[6] (16 total - 1 per LBA band)	XTS-AES-256 (512 bits)	Encrypts and decrypts LBA Bands. Each key is only associated with one LBA band. The Cryptographic Module's DRBG generates MEKs without modification.
NDRNG	256-byte Entropy output	Entropy source for DRBG
User PIN –TCG Credential (16 total)	256-bit authentication data	The PBKDF uses this PIN to authenticate a User's credentials.

[5] See FIPS140 Compliance Descriptor Overview within the[SFSC] Security Features for SCSI Commands

[6] A concatenation of XTS-AES Key_1 (256 bits) and XTS-AES Key_2 (256 bits)

5.4 Definition of Public Security Parameters

The Cryptographic Module utilizes several public security parameters (PSP). Table 13 - Public Security Parameters lists the PSPs. The Cryptographic Module uses a public key to verify the digital signature of a firmware download image. If the digital signature verification process fails when utilizing the primary public key, the Cryptographic Module attempts to use the secondary public key to verify the digital signature. The Cryptographic Module rejects the downloaded firmware image if both attempts to verify the digital signature fail.

Table 13 - Public Security Parameters

Key Name	Type	Description
KDF Salt - Key Derivation Function Salt (16 total)	256-bit key	The Cryptographic Module's DRBG generates KDF salts without modification.
PIN Salt (16 total)	256-bit key	The Cryptographic Module's DRBG generates PIN salts without modification.
PSID	Twenty-character alpha-numeric string	A unique value generated in the factory and printed on the Cryptographic Module's label. The PSID provides authentication data and proof of physical presence for the Zeroize service.
RSAPublicKey[0]	RSA 2048 public key	Primary public key used to verify the digital signature of a firmware image.
RSAPublicKey[1]	RSA 2048 public key	Secondary public key used to verify the digital signature of a firmware image.
MSID	32-character alphanumeric string	The MSID is derived by concatenating the Cryptographic Module's serial number four times. For example, if the serial number were KF7B98G3 then the MSID would be KF7B98G3KF7B98G3KF7B98G3KF7B98G3.

5.5 SP800-132 Key Derivation Function Affirmations

- The Cryptographic Module utilizes a [SP800 132] Password Based Key Derivation Function (PBKDF).
- The Cryptographic Module complies with Option 2a within [SP800 132].
- The Cryptographic Module tracks TCG Credentials (PINs) by hashing the concatenation of a 256-bit PIN salt and the TCG Credential PIN. The Cryptographic Module stores the SHA-256 AUTH Digest and associated PIN salt in the Reserved Area.
- Security policy rules set the minimum TCG Credential PIN length at 32 bytes. The Cryptographic Module allows values from 0x00 to 0xFF for each byte of a PIN
- The upper bound for the probability of guessing a TCG Credential PIN is 2^{-256}. The difficulty of guessing the PIN is equivalent to a brute force attack.
- KEKs ([SP800 132] Master Keys) derive from passing a TCG Credential PIN ([SP800 132] Password) and a 256-bit KDF salt though an [SP800 132] PBKDF. The Cryptographic Module creates a unique KEK for each LBA Band. The KEK generation process utilizes the HMAC-SHA-256 algorithm. Each KEK has a security strength of 128-bits against a collision attack.
- Each 256-bit salt is a random number generated using the [SP800 90A] DRBG.
- The sole use of a KEK is to wrap and unwrap its associated Media Encryption Key (MEK), which is used in storage applications.

5.6 Definition of CSP Modes of Access

Table 14 – CSP and PSP Access Rights within Services defines the relationship between access to Critical Security Parameters (CSPs) and the different Cryptographic Module services. The definitions provided below define the access modes listed in Table 14.

- **G** = Generate: The Cryptographic Module generates a CSP from the [SP800-90A] DRBG, derives a CSP with the Key Derivation Function or hashes authentication data with SHA-256.
- **I** = Input**:** The Cryptographic Module imports a CSP or PSP from outside the cryptographic boundary.
- **O** = Output: The Cryptographic Module does not support the output of CSPs outside the cryptographic boundary. The Cryptographic module outputs the value of selective PSPs.
- **E** = Execute: The module executes a service that uses the CSP or PSP.
- **S** = Store: The Cryptographic Module stores a CSP or PSP persistently on media within the cryptographic module.
- **Z** = Zeroize: The Cryptographic Module zeroizes a CSP or PSP that is stored in volatile or non-volatile memory.

Table 14 – CSP and PSP Access Rights within Services

Service	CSP								PSP				
	AUTH Digest	CO PIN	DRBG	NDRNG	KEK	MEK	User PIN	Maintenance Role Credential	RSAPublicKey[0.1]	MSID	PSID	PIN salt	KDF Salt
Initialize Cryptographic Module	GS	IE	GE	GE	G	GS	IE			OIE		GS	GS
Authenticate	E	IE			GE	E	IE					E	E
Lock/Unlock Firmware Download Control													
Firmware Download									IE				
Set													
Set LBA Band													
Lock/Unlock LBA Band													
Write Data						E							
Read Data						E							
Set Data Store													
Set Vendor Data (Diagnostics)													
Diagnostics								E					
Erase LBA Band						GSZ							
Self-Test (KATs)													

Service	CSP								PSP				
	AUTH Digest	CO PIN	DRBG	NDRNG	KEK	MEK	User PIN	Maintenance Role Credential	RSAPublicKey[0.1]	MSID	PSID	PIN salt	KDF Salt
Reset Module (Power on Reset)			GE	GE									
Status Output													
Get FIPS mode													
Start Session													
End Session													
Generate Random			GE	E									
Get Data Store													
Get													
Zeroize (TCG Revert)	Z	Z	GE	Z	G	GSZ	Z			E	I	GSZ	GSZ
SCSI													
FIPS 140 Compliance Descriptor													

6. Operational Environment

The Cryptographic Module operating environment is non-modifiable. Therefore, the FIPS 140-2 operational environment requirements are not applicable to this module. While operational, the code working set cannot be added, deleted, or modified. For firmware upgrades, the Cryptographic Module uses an authenticated download service to upgrade its firmware in its entirety. If the download operation is successful, authorized and verified, the Cryptographic Module will begin operating with the new code working set. Firmware loaded into the Cryptographic Module that is not on the FIPS 140-2 certificate is out of the scope of this validation and requires a separate FIPS 140-2 validation.

7. Security Rules

The Cryptographic Module enforces applicable FIPS 140-2 Level 2 security requirements. This section documents the security rules that the Cryptographic Module enforces.

7.1 Invariant Rules

1. The Cryptographic Module supports four distinct types of operator roles: Crypto Officer, User, Maintenance, and Makers. Initialization disables the Makers role.
2. Power cycling a Cryptographic Module clears all existing authentications.
3. After the Cryptographic Module has successfully completed all self-tests and initialized according to the instructions provided in Section 7.2, it is in FIPS Approved mode. The Crypto Officer shall not enable the Makers Authority after the Cryptographic Module enters FIPS Approved mode.
4. When the Cryptographic Module is unable to authenticate TCG Credentials, operators do not have access to any cryptographic service other than the unauthenticated Generate Random service.

5. The Cryptographic Module performs the following tests. Upon failure of any test, the Cryptographic Module enters a soft error state. A failing Cryptographic Module reports the error condition by transmitting an UEC via the [SCSI] protocol. After entering the soft error state, a failing Cryptographic Module does not process functional commands unless a power cycle occurs, and the error state clears.
   A. Power up Self-Tests
      1) Firmware Integrity 32-bit EDC
      2) Firmware AES Encrypt KAT, Cert AES 3880
      3) Firmware AES Decrypt KAT, Cert AES 3880
      4) RSA 2048 PSS Verify KAT, Cert RSA 1978
      5) DRBG KAT[7], Cert DRBG 1108
      6) Firmware SHA-256 KAT, Cert SHS 3203
      7) HMAC-SHA-256 KAT, Cert HMAC 2522
      8) Hardware AES Encrypt KAT, Cert AES 3881
      9) Hardware AES Decrypt KAT, Cert AES 3881
      10) HW/FW SHA-256 KAT, Cert SHS 3204
      11) Key Wrap KAT, KW-AE, Cert. AES 3880
      12) Key Wrap KAT, KW-AD, Cert. AES 3880
   B. Conditional Tests
      1) The Cryptographic Module performs a Continuous Random Number Generator test on the DRBG.
      2) The Cryptographic Module performs a Continuous Random Number Generator test on the hardware NDRNG entropy source.
      3) The Cryptographic Module performs an Adaptive Proportion test and a Repetition Count test on the hardware NDRNG entropy source.
      4) The Cryptographic Module performs a key comparison test on XTS-AES Key_1 and XTS-AES Key_2 that satisfies IG A.9 XTS-AES Key Generation Requirements.
      5) Firmware Download Test, RSA 2048 PSS (Cert#1978), SHA-256 (Cert#3204)
6. An operator can command the Cryptographic Module to perform the power-up self-test by power cycling the device.
7. Power-up self-tests do not require operator action.
8. Data output is inhibited during key generation, self-tests, zeroization, and error states.
9. Status information does not contain CSPs or sensitive data that if misused, could compromise the Cryptographic Module.
10. The zeroization service deletes all plaintext keys and CSPs.
11. The Cryptographic Module supports a maintenance role. The operator must execute the TCG Revert Method to zeroize the Cryptographic Module before entering and exiting the maintenance role. The operator must also execute the TCG Revert Method to zeroize the Cryptographic Module after exiting the maintenance role.
12. The Cryptographic Module does not support manual key entry.
13. The Cryptographic Module does not have any external input/output devices used for entry/output of data.
14. The Cryptographic Module does not output plaintext CSPs.
15. The Cryptographic Module does not output intermediate key values.
16. The Cryptographic Module does not support concurrent operators.

[7] The DRBG KAT is inclusive of the instantiate, generate and reseed function health tests required in SP 800-90A rev 1

17. The End Session service deletes the current operator authentication. The Cryptographic Module requires operators to re-authenticate upon execution of the End Session service.
18. The host shall authenticate to LBA Bands after a power cycle.
19. The Crypto Officer shall assure that all host issued PINs are 32-bytes in length.
20. After a Firmware Download, the CO must execute "Set 'Firmware_Dload_Port.PortLocked = True' ".

7.2 Initialization Rules

The Crypto Officer shall follow the instructions provided in the FIPS 140 Crypto Officer Instructions section of the Ultrastar DC HC310 Product Specification, Ultrastar DC HC320 Product Specification or Ultrastar DC HC330 Product Specification and the Delivery & Operation (Crypto Officer's) Manual for acceptance and end of life procedures.

The Crypto Officer shall initialize the modules cryptographic services by executing the TCG methods listed below.

1. StartSession and SyncSession using the 'Admin SP'
    a. Get MSID
    b. Use the MSID to authenticate to the SID
        i. An authentication failure indicates that a tamper event has occurred for the Cryptographic Module
    c. Set 'SID PIN' to an organizational value
    d. Set 'Makers.Enabled = FALSE'
    e. Set 'Firmware_Dload_Port.PortLocked = True
    f. Set 'Firmware_Dload_Port.LockOnReset = PowerCycle'
    g. EndSession
2. StartSession and SyncSession using the 'Locking SP'
    a. Use the MSID to authenticate to the EraseMaster
        i. An authentication failure indicates that a tamper event has occurred for the Cryptographic Module
    b. Set 'EraseMaster PIN' to a new value
    c. Erase Band0
    d. Use the MSID to authenticate to the BandMaster[0]
        i. An authentication failure indicates that a tamper event has occurred for the Cryptographic Module.
    e. Set 'BandMaster[0] PIN' to a new value
    f. As required by organizational policy, repeat steps 2.d to 2.e for each LBA band
    g. EndSession
3. Power cycle or reset the Cryptographic Module.

The instructions provided above accomplish the following:

- Establish authentication data for the TCG Authorities by replacing the MSID (default PIN value).
- Erase the LBA Bands. When the Cryptographic Module erases LBA bands it also cryptographically erases the Media Encryption Keys associate with each LBA band.
- Establish the LBA Bands. When the Cryptographic Module establishes LBA bands it also generates a unique Media Encryption Key for each LBA band.
- Disable the Makers Authority
- Lock the Firmware Download service and set the Firmware Download service to lock automatically after a power cycle.

At the end of the initialization process, the Cryptographic Module will be in FIPS Approved mode. While in FIPS Approved mode, only an authenticated Crypto Officer can change the state of the firmware download service.

7.3 Zeroization Rules

The Crypto Officer shall use the TCG Revert Method to perform the zeroization function. After successfully executing TCG Revert the Crypto Officer shall power cycle the module. Power cycling a Cryptographic Module assures the erasure of all CSPs stored in volatile memory. Reverting and power cycling the cryptographic module zeroizes all Critical Security Parameters.

8. Physical Security Policy

8.1 Mechanisms

The Cryptographic Module does not make claims in the Physical Security area beyond FIPS 140-2 Security Level 2.

- All components are production-grade materials with standard passivation.
- The enclosure is opaque.
- Engineering design supports opacity requirements.
- Western Digital applies four (4) tamper-evident security seal during manufacturing. Seal number 1 covers the PCBA on the bottom of the Cryptographic Module. Seal numbers 2, 3, and 4 wrap from the top cover of the Cryptographic Module to the side of the Cryptographic Module.
- Figure 2 and Figure 3 illustrate where Western Digital factory personnel apply the tamper seals.
- The tamper-evident security seal cannot be penetrated or removed and reapplied without evidence of tampering. In addition, the tamper-evident security seals are difficult to replicate.

Figure 4: Tamper-Evident Seal over PCBA

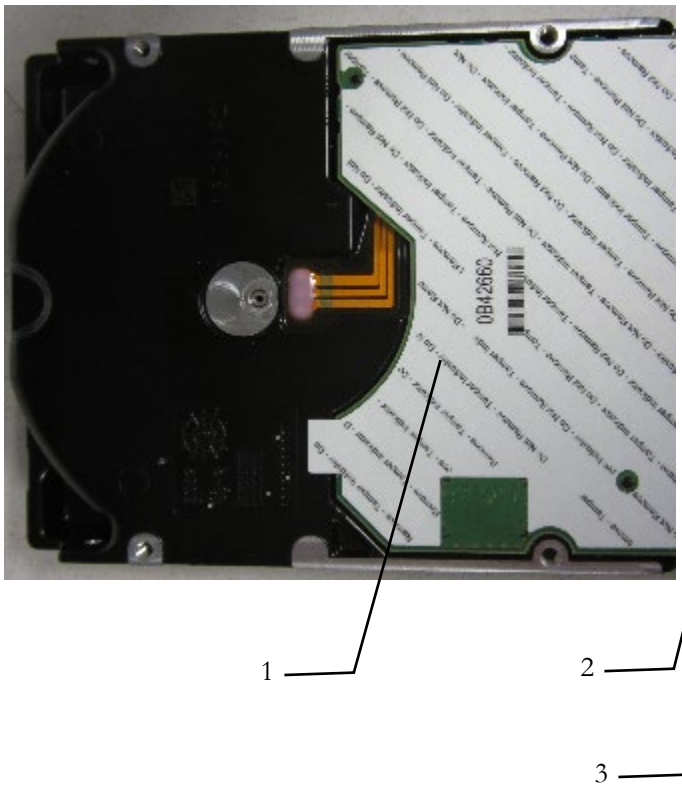


Figure 5: Wrapping Tamper-Evident Seals

8.2 Operator Responsibility

The Crypto Officer shall inspect the Cryptographic Module enclosure for evidence of tampering at least once a year. If the inspection reveals evidence of tampering, the Crypto Officer should return the module to Western Digital.

Figure 6: Tamper Evidence on Tamper Seals

9. Mitigation of Other Attacks Policy

The Cryptographic Module is not designed to mitigate any specific attacks beyond the scope of the requirements within FIPS 140-2.

10. Definitions

- **Allowed**: NIST approved, i.e., recommended in a NIST Special Publication, or acceptable, i.e., no known security risk as opposed to deprecated, restricted and legacy-use. [SP800 131A] for terms
- **Anybody**: A formal TCG term for an unauthenticated role. [TCG Core]
- **Approved**: [FIPS140] approved or recommended in a NIST Special Publication.
- **Approved mode of operation**: A mode of the Cryptographic Module that employs only approved security functions. [FIPS140]
- **Authenticate**: Prove the identity of an Operator or the integrity of an object.
- **Authorize**: Grant an authenticated Operator access to a service or an object.
- **Ciphertext**: Encrypted data transformed by an Approved security function.
- **Confidentiality**: A cryptographic property that sensitive information is not disclosed to unauthorized parties.
- **Credential**: A formal TCG term for data used to authenticate an Operator. [TCG Core]
- **Critical Security Parameter (CSP):** Security-related information (e.g., secret and private cryptographic keys, and authentication data such as credentials and PINs) whose disclosure or modification can compromise the security of a cryptographic module. [FIPS140]
- **Cryptographic Boundary**: An explicitly defined continuous perimeter that establishes the physical bounds of a Cryptographic Module and contains all the hardware, software, and/or firmware components of a cryptographic module. [FIPS140]
- **Cryptographic key (Key)**: An input parameter to an Approved cryptographic algorithm
- **Cryptographic Module**: The set of hardware, software, and/or firmware used to implement approved security functions contained within the cryptographic boundary. [FIPS140]
- **Crypto Officer**: An Operator performing cryptographic initialization and management functions. [FIPS140]
- **Data at Rest**: User data residing on the storage device media when the storage device is powered off.
- **Discovery**: A TCG method that provides the properties of the TCG device. [TCG Enterprise]
- **Integrity**: A cryptographic property that sensitive data has not been modified or deleted in an unauthorized and undetected manner.

- **Interface**: A logical entry or exit point of a Cryptographic Module that provides access to the Cryptographic Module for logical information flows. [FIPS140]
- **Key Derivation Function (KDF)**: An Approved cryptographic algorithm by which one or more keys are derived from a shared secret and other information.
- **Key Encrypting Key (KEK)**: A cryptographic key that is used to encrypt or decrypt other keys.
- **Key management**: The activities involving the handling of cryptographic keys and other related security parameters (e.g., authentication data) during the entire life cycle of the Cryptographic Module.
- **Key Wrap**: An Approved cryptographic algorithm that uses a KEK to provide Confidentiality and Integrity.
- **LBA Band**: A formal [TCG Core] term that defines a contiguous logical block range (sequential LBAs) to store encrypted User Data; bands do not overlap, and each has its own unique encryption key and other settable properties.
- **Manufactured SID (MSID)**: A unique default value that vendors assign to each SED during manufacturing. An externally visible MSID value is not required if the user can derive the MSID from other information printed on the drive. The MSID is readable with the TCG protocol. It is the initial and default value for all TCG credentials. [TCG Core]
- **Method**: A TCG command or message. [TCG Core]
- **Operator**: A consumer, either human or automation, of cryptographic services that is external to the Cryptographic Module. [FIPS140]
- **Personal Identification Number (PIN)**: A formal TCG term designating a string of octets used to authenticate an identity. [TCG Core]
- **Plaintext**: Unencrypted data.
- **Port**: A physical entry or exit point of a Cryptographic Module that provides access to the Cryptographic Module for physical signals. [FIPS140]
- **PSID (Physical Security Identifier)**: A SED unique value printed on the Cryptographic Module's label used as authentication data and proof of physical presence for the Zeroize service.
- **Public Security Parameters (PSP)**: Public information whose modification can compromise the security of the Cryptographic Module (e.g., a public key).
- **Read Data**: An external request to transfer User Data from the SED. [SCSI Block]
- **Reserved Area**: Private data on the Storage Medium that is not accessible outside the Cryptographic Boundary.
- **Security Identifier (SID)**: A TCG authority used by the Crypto Officer. [TCG Core]
- **Self-Encrypting Drive (SED)**: A storage device that provides data storage services, which automatically encrypts all user data written to the device and automatically decrypts all user data read from the device.
- **Session**: A formal TCG term that envelops the lifetime of an Operator's authentication. [TCG Core]
- **Storage Medium**: The non-volatile, persistent storage location of a SED; it is partitioned into two disjoint sets, a User Data area and a Reserved Area.
- **User**: An Operator that consumes cryptographic services. [FIPS140]
- **User Data**: Data transferred from/to a SED using the Read Data and Write Data commands. [SCSI Block]
- **Vendor Unique Command**: An SCSI command that is available at the discretion of an implementer.
- **Write Data**: An external request to transfer User Data to a SED. [SCSI Block]
- **Zeroize**: Invalidate a Critical Security Parameter. [FIPS140]

11. Acronyms

- **CO**: Crypto Officer [FIPS140]

- **CRC**: Cyclic Redundancy Check
- **CSP**: Critical Security Parameter [FIPS140]
- **DRAM**: Dynamic Random Access Memory
- **DRBG**: Deterministic Random Bit Generator
- **EDC**: Error Detection Code
- **EMI**: Electromagnetic Interference
- **FIPS**: Federal Information Processing Standard
- **HDD**: Hard Disk Drive
- **KAT**: Known Answer Test
- **KDF**: Key Derivation Function
- **LBA**: Logical Block Address
- **MEK**: Media Encryption Key
- **MSID**: Manufactured Security Identifier
- **NDRNG**: Non-deterministic Random Number Generator
- **NIST**: National Institute of Standards and Technology
- **PIN**: Personal Identification Number
- **PSID**: Physical Security Identifier
- **PSP**: Public Security Parameter
- **SAS**: Serial Attached SCSI
- **SCSI**: Small Computer System Interface
- **SED**: Self-encrypting Drive
- **SID**: TCG Security Identifier, the authority representing the Cryptographic Module owner
- **SSD**: Solid-state Drive
- **TCG**: Trusted Computing Group
- **VUC**: Vendor Unique Command
- **UEC**: Universal Error Code
- **XTS**: A mode of AES that utilizes "Tweakable" block ciphers

12. References

12.1 NIST Specifications

- [AES] Advanced Encryption Standard, FIPS PUB 197, NIST, November 2001
- [DSS] Digital Signature Standard, FIPS PUB 186-4, NIST, July 2013
- [FIPS140] Security Requirements for Cryptographic Modules, FIPS PUB 140-2, NIST, December 2002
- [HMAC] The Keyed-Hash Message Authentication Code, FIPS PUB 198-1, July 2008
- [SHA] Secure Hash Standard (SHS), FIPS PUB 180-4, NIST, August 2015
- [SP800 38A] Recommendation for Block Cipher Modes of Operation: Methods and Techniques, NIST, December 2001
- [SP800 38E] Recommendation for Block Cipher Modes of Operation: The XTS-AES Mode for Confidentiality on Storage Devices, NIST, January 2010
- [SP800 38F] Recommendation for Block Cipher Modes of Operation: Methods for Key Wrapping, NIST, December 2012
- [SP800 57] Recommendation for Key Management – Part I General (Revision 4), NIST, January 2016
- [SP800 88] Guidelines for Media Sanitization, NIST, December 2014

- [SP800 90A] Recommendation for Random Number Generation Using Deterministic Random Bit Generators (Revision 1), NIST, June 2015
- [SP800 90B] Recommendation for Entropy Sources Used for Random Bit Generation, NIST, January 2018
- [SP800 131A] Transitions: Recommendation for Transitioning the Use of Cryptographic Algorithms and Key Lengths (Revision 2), NIST, March 2019
- [SP800 132] Recommendation for Password-Based Key Derivation, NIST, December 2010
- [SP800 133] Recommendation for Cryptographic Key Generation, NIST (Revision 2), June 2020

12.2 Trusted Computing Group Specifications

- [TCG Core] *TCG Storage Architecture Core Specification,* Version 2.0 Revision 1.0 (April 20, 2009)
- [Enterprise] TCG Storage Security Subsystem Class: Enterprise Specification, Version 1.00 Revision 3.00 (January 10, 2011)
- [TCG App Note] TCG Storage Application Note: Encrypting Storage Devices Compliant with SSC: Enterprise, Version 1.00 Revision 1.00 Final
- [TCG Opal] *TCG Storage Security Subsystem Class: Opal Specification,* Version 2.00 Final Revision 1.00 (February 24, 2012)
- TCG Storage Interface Interactions Specification (SIIS), Version 1.02, (2011)

12.3 International Committee on Information Technology Standards T10 Technical Committee Standards

- [SCSI Core] SCSI Primary Commands (SPC-4)
- [SCSI Block] SCSI Block Commands (SBC-3)
- [SAS] Serial Attached SCSI (SAS-3)
- [SFSC] Security Features for SCSI Commands

12.4 Documents

- [Product Specification] Hard Disk Drive Specification Ultrastar™ DC HC310 3.5 inch Serial Attached SCSI Hard Disk Drive, August 2018, https://www.westerndigital.com/products/data-center-drives/ultrastar-dc-hc300-series-hdd
- [Product Specification] Hard Disk Drive Specification Ultrastar™ DC HC320 3.5 inch Serial Attached SCSI Hard Disk Drive , August 2018, https://www.westerndigital.com/products/data-center-drives/ultrastar-dc-hc300-series-hdd
- [Product Manual] Ultrastar® DC HC330 3.5 inch Serial Attached SCSI Hard Disk Drive Product Manual , October 2019, 2679-810033-A01, https://www.westerndigital.com/products/data-center-drives/ultrastar-dc-hc300-series-hdd
- [Datasheet] Ultrastar® DC HC310 Datasheet, (July 2018), https://www.westerndigital.com/products/data-center-drives/ultrastar-dc-hc300-series-hdd
- [Datasheet] Ultrastar® DC HC320 Datasheet, (June 2018), https://www.westerndigital.com/products/data-center-drives/ultrastar-dc-hc300-series-hdd
- [Datasheet] Ultrastar® DC HC330 Datasheet, (August 2019), https://www.westerndigital.com/products/data-center-drives/ultrastar-dc-hc300-series-hdd
- [D&O] Delivery & Operation (Crypto Officer) Manual, Version: 0.12 (January 7, 2017)

12.5 SCSI Commands

Table 15 - SCSI Commands

Description	Code		Description	Code
FORMAT UNIT	04h		RESERVE	16h
INQUIRY	12h		RESERVE	56h
LOG SELECT	4Ch		REZERO UNIT	01h
LOG SENSE	4Dh		SANITIZE	48h
MODE SELECT	15h		SEEK (6)	0Bh
MODE SELECT	55h		SEEK (10)	2Bh
MODE SENSE	1Ah		SEND DIAGNOSTIC	1Dh
MODE SENSE	5Ah		SET DEVICE IDENTIFIER	A4h/06h
PERSISTENT RESERVE IN	5Eh		START STOP UNIT	1Bh
PERSISTENT RESERVE OUT	5Fh		SYNCHRONIZE CACHE (10)	35h
PRE-FETCH (16)	90h		SYNCHRONIZE CACHE (16)	91h
PRE-FETCH (10)	34h		TEST UNIT READY	00h
READ (6)	08h		UNMAP	42h
READ (10)	28h		VERIFY (10)	2Fh
READ (12)	A8h		VERIFY (12)	AFh
READ (16)	88h		VERIFY (16)	8Fh
READ (32)	7Fh/09h		VERIFY (32)	7Fh/0Ah
READ BUFFER	3Ch		WRITE (6)	0Ah
READ CAPACITY (10)	25h		WRITE (10)	2Ah
READ CAPACITY (16)	9Eh/10h		WRITE (12)	AAh
READ DEFECT DATA	37h		WRITE (16)	8Ah
READ DEFECT DATA	B7h		WRITE (32)	7Fh/0Bh
READ LONG (16)	9Eh/11h		WRITE AND VERIFY (10)	2Eh
READ LONG	3Eh		WRITE AND VERIFY (12)	AEh
REASSIGN BLOCKS	07h		WRITE AND VERIFY (16)	8Eh
RECEIVE DIAGNOSTICS RESULTS	1Ch		WRITE AND VERIFY (32)	7Fh/0Ch
RELEASE	17h		WRITE BUFFER	3Bh
RELEASE	57h		WRITE LONG (10)	3Fh
REPORT DEVICE IDENTIFIER	A3h/05h		WRITE LONG (16)	9Fh/11h
REPORT LUNS	A0h		WRITE SAME (10)	41h
REPORT SUPPORTED OPERATION CODES	A3h/0Ch		WRITE SAME (16)	93h
REPORT SUPPORTED TASK MANAGEMENT FUNCTIONS	A3h/0Dh		WRITE SAME (32)	7Fh/0Dh
REQUEST SENSE	03h			