

# PRIVORO

SafeCase Security Module

## FIPS 140-3 Non-Proprietary Security Policy

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## 1 General

This document defines the non-proprietary Security Policy for the SafeCase Security Module by Privoro, hereafter denoted the Module.

The Module:

- is a firmware-hybrid module with a single-chip embodiment, updated only by a complete image replacement by Privoro in the SafeCase environment;
- does not implement mitigations of attacks outside the [FIPS140-3] specification.

The Module is validated to FIPS 140-3 overall Level 2 requirements with security levels as follows:

*Table 1: Security Levels*

ISO/IEC 24759 Section 6. [Number Below]	FIPS 140-3 Section Title	Security Level
1	General	2
2	Cryptographic Module Specification	2
3	Cryptographic Module Interfaces	2
4	Roles, Services, and Authentication	2
5	Software / Firmware Security	2
6	Operational Environment	N/A
7	Physical Security	3
8	Non-Invasive Security	N/A
9	Sensitive Security Parameters Management	2
10	Self-tests	2
11	Life-cycle Assurance	2
12	Mitigation of Other Attacks	N/A

## 2 Cryptographic Module Specification

The Module is a firmware-hybrid Module as defined by [I19790], operated on a single-chip. The Module provides cryptographic services for use in SafeCase mobile device management systems. The tested Operational Environments are specified in Table 2 below.

*Table 2: Tested Operational Environments*

#	Operating System	Hardware Platform	Processor	PAA/Acceleration
1	Free-RTOS	NXP MK81FN256VDC15	NXP Kinetis K81FN256xxx15	PAA is enabled for the K81 <sup>1</sup>

The module comprises of the disjoint firmware component libpcrypt.a and the disjoint hardware component, the Memory-Mapped Cryptographic Acceleration Unit (MMCAU) within the NXP MK81FN256VDC15 single-chip which is the physical perimeter (TOEPP) of the module. The UID information returned by pcrypt\_status contains name ("SCSM"), hardware version (0x81001BD9) for the MMCAU disjoint hardware component and firmware version ("1.0.1"), consistent with the Module's CMVP listing information and tabularized below:

<sup>1</sup> K81= NXP MK81FN256VDC15

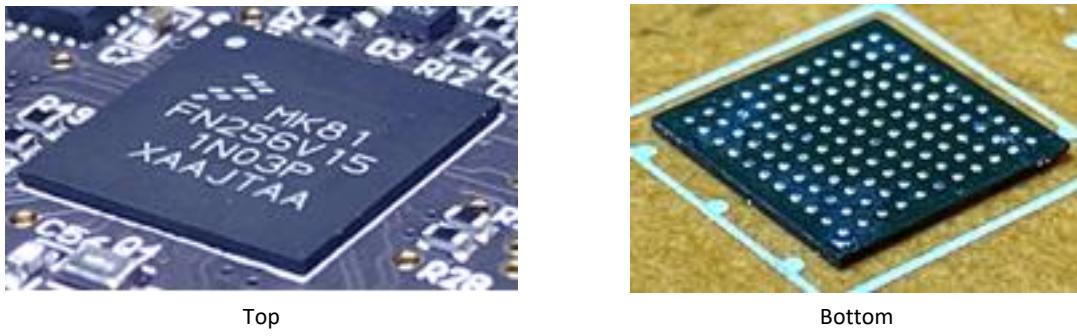
*Table 3: Tested Module Versioning Information/Identification*

#	Firmware Component	Firmware Version	Hardware Component	Hardware Version	Module Identifier
1	libpcrypt.a	1.0.1	Hardware accelerator (MMCAU) within the NXP MK81FN256VDC15 i.e. K81 chip	0x81001BD9	SCSM

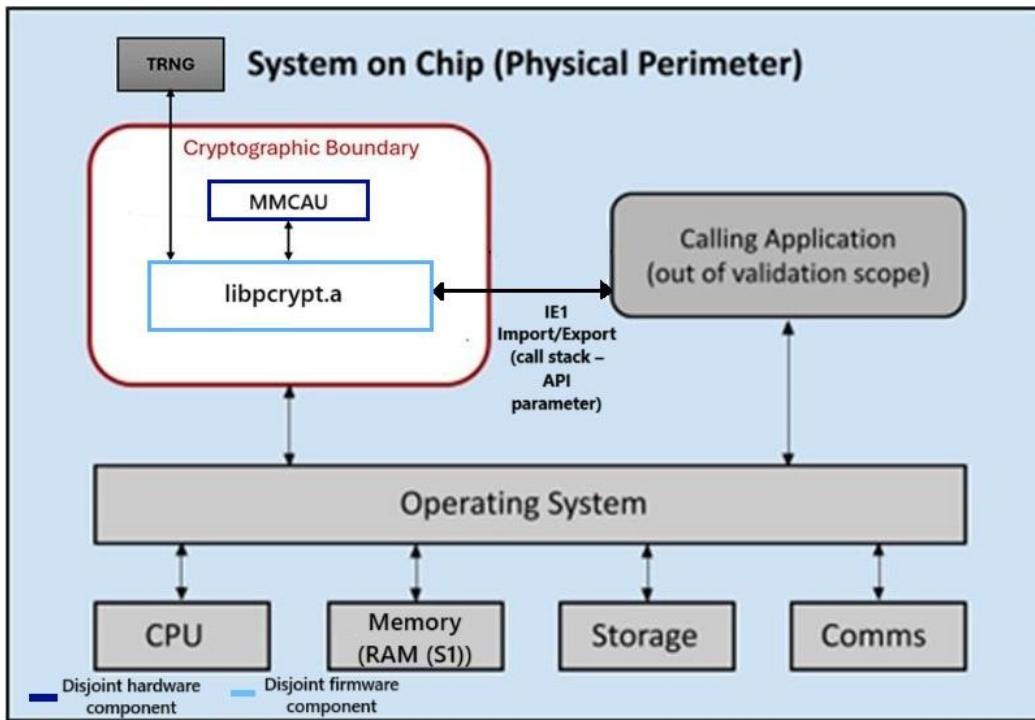
Please Note: The disjoint firmware component of the module is the libpcrypt.a statically linked library (version 1.0.1) and the disjoint hardware component of the module is the hardware accelerator (MMCAU) version 0x81001BD9. The module is identified by the identifier returned by the module, i.e. the 'SCSM' string as detailed in the table above.

## 2.1 Cryptographic Boundary

The physical form of the Module is depicted below. The physical perimeter (i.e. the Tested Operational Environment's Physical Perimeter (TOEPP)) consists of the surfaces, edges and solder connections of the NXP MK81FN256VDC15 integrated circuit shown in Figure 1.

*Figure 1: Module Physical Perimeter*

The module is a hybrid module with the disjoint firmware component, libpcrypt.a (executing on the ARM CPU core) and the disjoint hardware component (MMCAU) forming the cryptographic boundary as depicted in the Figure 2 (outlined in red). The libpcrypt.a uses AES hardware cryptographic acceleration from the MMCAU. Both the disjoint components reside within the NXP K81 SoC i.e. single chip.



*Figure 2: Module Block Diagram*

## 2.2 Modes of Operation, Security Rules and Guidance

The Module supports only an Approved mode of operation by default, and enforces the following security rules:

1. No additional interface or service is implemented by the Module which would provide access to SSPs.
2. Data output is inhibited during key generation, self-tests, zeroisation, and error states.
3. There are no restrictions on which keys or SSPs are zeroised by the zeroisation service.
4. The Module does not support manual key entry.
5. The Module does not output plaintext CSPs or intermediate key values.
6. Status information does not contain CSPs or sensitive data that if misused could lead to a compromise of the Module.

The Module design corresponds to the Module security rules. No specific installation requirements apply and the initialization process of the Module is as detailed in Section 11 of this document.

## 2.3 Degraded Operation

The Module does not support a degraded mode of operation.

## 2.4 Approved and Allowed Cryptographic Functionality

The Module implements the Approved cryptographic functions listed in Table 4. Equivalent strength in bits is given for each key or algorithm type (as some algorithms do not use or produce keys). The term  $s$  is used throughout to indicate security strength, following the notation used in the majority of the sources (refer to the notes below Table 4). This table is referenced by Table 13 (SSPs). All references to the algorithm standards cited throughout this document can be found in the References section.

Table 4: Approved Algorithms

CAVP Cert	Algorithm and Standard	Mode / Method	Description / Key Size(s) / Key Strength(s)	Use / Function
A2494	AES-ECB [FIPS197], [SP800-38A]	AES-ECB	AES-256 (s = 256)	Encryption (used only as a prerequisite for AES-CCM)
A2494	AES-CCM [SP800-38C]	AES-CCM	AES-256 (s = 256)	Authenticated encryption
Vendor Affirmed	CKG [SP800-133r2]	Direct The module supports the following sections per NIST [SP800-133r2]: 4, 5.1, 5.2, 5.3, 5.4, 6.1, 6.2.1, 6.4 and 6.5.	256-bit	Citation of [SP800-133r2] compliance required per [FIPS140-3_IG] D.H Scenario 2
A2494	ECDSA KeyGen [FIPS186-4]	Secret Generation Mode: Extra Bits	P-384 (s ≈ 192) See Note 2	Key generation
A2494	ECDSA SigGen [FIPS186-4]	SigGen (tested with SHA2-384)	P-384 (s ≈ 192) See Note 2	Signature generation
A2494	ECDSA SigVer [FIPS186-4]	SigVer (tested with SHA2-384)	P-384 (s ≈ 192) See Note 2	Signature verification
A2494	ENT [SP800-90B]	ENT (P)	1024-bit seed; 1024-bit nonce	DRBG seeding
A2494	Hash DRBG [SP800-90Ar1]	No prediction resistance	SHA2-256 (s = 256)	Random bit generation
A2494	HMAC-SHA2-384 [FIPS198-1]	Generate HMAC-SHA2-384 MAC	SHA2-384 (s = 384)	HMAC generation and verification
A2494	KAS [SP800-56Ar3]	Schemes: Ephemeral Unified Roles: Initiator, Responder KAS-ECC-SSC curves: P-384 KDA One-Step KDF	KAS-ECC per IG D.F Scenario 2 path (2) option 2  P-384 curve providing 192 bits of encryption strength	Key agreement with key derivation using [SP800-56Cr1] KDA
A2494	KAS-ECC-SSC [SP800-56Ar3]	Scheme: ephemeralUnified KAS Role: initiator, responder IG D.F Scenario 2 path 2 with an approved KDF per [SP800-56Ar3]	P-384 (s ≈ 192) See Note 2 and Note 3	Shared secret generation
A2494	KDA OneStep [SP800-56Cr1]	One-Step KDF Auxiliary function method: SHA2-384	SHA2-384 (112 ≤ s ≤ 384) See Note 6	Derivation of keying material from a KAS shared secret
A2494	RSA KeyGen [FIPS186-4]	Key generation mode: B.3.3 Primality tests per Table C.3	k=2048 (s ≈ 112) See Note 5	Key generation
A2494	RSA SigGen [FIPS186-4]	Signature type: PKCS 1.5 tested with k=2048 and SHA2-256	k=2048 (s ≈ 112) See Note 4 and Note 5	Signature generation
A2494	RSA Signature Primitive [FIPS186-4]	Private Key format: standard Public Exponent Mode: fixed	k=2048 (s ≈ 112) See Note 4 and Note 5	Signature primitive operation
A2494	RSA SigVer [FIPS186-4]	Signature type: PKCS 1.5 tested with k=2048 and SHA2-256	k=2048 (s ≈ 112) See Note 4 and Note 5	Signature verification
A2494	SHA2-256 [FIPS180-4]	SHA2-256	SHA2-256 (s = 256) See Note 1	Secure hash generation

CAVP Cert	Algorithm and Standard	Mode / Method	Description / Key Size(s) / Use / Function Key Strength(s)	
A2494	SHA2-384 [FIPS180-4]	SHA2-384	SHA2-384 (s = 384) See Note 1	Secure hash generation

**Note 1:** Preimage resistance strength applies to hash algorithms used in DRBG, KDFs. Described also in [SP800-57P1r5] Table 3.

**Note 2:** Elliptic curve strengths are annotated as approximate (i.e., s ~=) since [SP800-186] Table 1 provides approximate security strengths.

**Note 3:** Approved elliptic curves for ECC key agreement are given in [SP800-56Ar3] Table 24.

**Note 4:** In Digital Signature applications, security strength is primarily associated with the asymmetric key pair specification. The hash function used must have equivalent strength equal to or greater than the security strength of the associated key pair.

**Note 5:** Estimated security strengths of common RSA moduli are given in [SP800-56Br2] Table 4. IFC key types approved for Digital Signature Generation and Verification are given also in [SP800-57P1r5] Table 2. Equivalent strengths are annotated as approximate (i.e., s ~=) since [SP800-56Br2] Table 4 provides approximate security strengths.

**Note 6:** Security strengths for KDA One Step are given in [SP800-56Cr1] Table 1 (hash).

Reference sources for the strengths provided in Table 4 are as follows:

- AES (AES-256): [SP800-57P1r5] Table 2.
- ECC (P-384): [SP800-186] Table 1.
- IFC (k=2048): [SP800-56Br2] Table 4.
- SHA2 (SHA2-256, SHA2-384): [SP800-107r1] Table 1.

*Table 5: Non-Approved Algorithms Allowed in the Approved Mode of Operation with No Security Claimed*

Algorithm	Caveat	Use/Function
RSADP	No security claimed	Decryption of derived keying material, [FIPS 140-3_IG] 2.4.A Scenario 1

Please see the note below Table 9 pertaining to usage of RSADP.

The module does not implement the following:

- Non-Approved Algorithms Allowed in the Approved Mode of Operation
- Non-Approved Algorithms Not Allowed in the Approved Mode of Operation

### 3 Cryptographic Module Interfaces

The Module's logical interfaces are described in Table 6; the Module's physical ports are outside the cryptographic boundary.

*Table 6: Ports and Interfaces*

Physical port	Logical Interface	Data that passes over port/interface
N/A: Internal (call stack)	Control Input	API entry point: stack frame including non-sensitive parameters
	Data Input	API call parameters passed by reference or value for cryptographic service input
	Status Output	API return value: enumerated status resulting from call execution
	Data Output	API call parameters passed by reference for cryptographic service output

The Control Output interface is not applicable, as the module does not control other components.

## 4 Roles, Services and Authentication

The Module supports only the Cryptographic Officer (CO) role. It does not support multiple concurrent operators, a maintenance role or bypass capability. Operator authentication is described in Table 8.

*Table 7: Roles, Service Commands, Input and Output*

Role	Service	Input	Output
CO	pcrypt_aescm_decrypt	SC_EDK; ciphertext message	Plaintext message; status
CO	pcrypt_aescm_encrypt	SC_EDK; plaintext message	Ciphertext message; status
N/A	pcrypt_aes_free (Perform zeroisation)	AES struct (includes SC_EDK)	Status (AES struct zeroised, freed)
CO	pcrypt_aescm_init	SC_EDK	Initialized AES struct; status
CO	pcrypt_ecc_export_private	ECC struct inclusive of ECC_Private	ECC_Private; status
CO	pcrypt_ecc_export_public	ECC struct inclusive of ECC_Public	ECC_Public; status
CO	pcrypt_ecc_import_private	ECC_Private	Initialized ECC struct; status
CO	pcrypt_ecc_import_public	ECC_Public	Initialized ECC struct; status
CO	pcrypt_ecc_init_key	ECC_Private; ECC_Public	Initialized ECC struct; status
N/A	pcrypt_ecc_free (Perform zeroisation)	ECC struct (includes ECC_Private, ECC_Public, ECC_SGK, ECC_SVK)	Status
CO	pcrypt_ecc_gen_key	ECC key parameters	Initialized ECC struct; status
CO	pcrypt_ecc_sign	ECC_SGK; plaintext message	Signature; status
CO	pcrypt_ecc_verify_hash	ECC_SVK; plaintext message; signature	Status
CO	pcrypt_hmac_init	HMAC_MHK, uninitialized HMAC struct	Initialized HMAC struct, status
CO	pcrypt_hmac_update	HMAC struct, message	Status
CO	pcrypt_hmac_finalize	HMAC struct, output buffer pointer	Output buffer containing HMAC tag
N/A	pcrypt_hmac_free (Perform zeroisation)	HMAC struct (includes HMAC_HMK)	Status
CO	pcrypt_init	Password; memory management parameters	Status
CO	pcrypt_key_exchange	KAS_U_Private; KAS_V_Public; KAS_SS	KAS_DKM; status
CO	pcrypt_rng_generate_block	RBG_State	Random bit string; RBG_State; status
CO	pcrypt_rng_init	RBG_EI; RBG_State; parameters; flags	DRBG struct; status
CO	pcrypt_rsa_export_private	RSA struct inclusive of RSA_Private	RSA_Private; status
CO	pcrypt_rsa_export_public	RSA struct inclusive RSA_Public	RSA_Public; status
CO	pcrypt_rsa_import_private	RSA_Private	Initialized RSA struct; status
N/A	pcrypt_rsa_free (Perform zeroisation)	RSA struct (includes RSA_Private, RSA_Public, RSA_SGK, RSA_SVK)	Status
CO	pcrypt_rsa_gen_key	RSA parameters	Initialized RSA struct; status
CO	pcrypt_rsa_init	RSA_Private; RSA_Public	Initialized RSA struct; status
CO	pcrypt_rsa_sign	RSA_SGK; plaintext message	Signature; status
CO	pcrypt_rsa_verify	RSA_SVK; plaintext message; signature	Status
CO	pcrypt_sha256_hash	Plaintext message	Message digest; status
CO	pcrypt_sha384_hash	Plaintext message	Message digest; status
CO	pcrypt_selftest (Perform self-tests)	None	Status
N/A	pcrypt_status (Show status and Show module's versioning information)	Valid pointer to UID structure (optional)	Status: READY or ERROR UID: name, version; hardware version
CO	pcrypt_tamper_detected	None	Status

Role	Service	Input	Output
CO	pcrypt_uninit (Perform zeroisation)	None	Status
N/A	pcrypt_update_time	Time value	None

The pcrypt\_status service does not require authentication and provides information to address both AS04.13 (Show module's versioning information) and AS04.14 (output current status). The Module is similar to [FIPS140-3\_IG] 2.4.C Scenario 2, where pcrypt\_status provides a global dynamic indication of Module status and operation in the approved mode, augmented by a status value returned on each API call. The module supports role-based authentication.

*Table 8: Roles and Authentication*

Role	Authentication Method	Authentication Strength
CO	Authentication of a 256-bit memorized secret, in accordance with [SP800-140E] and [SP800-63B]; authentication attempts require at least 50 µs	$2^{256} = 1.16E+77$ 9.65E+71 in 1 minute

Table 9 describes all Approved services and service access to SSPs. The following annotations indicate the type of access by the Module service:

**G = Generate:** The Module generates or derives the SSP.

**R = Read:** The SSP is read from the Module (e.g., the SSP is output).

**W = Write:** The SSP is updated, imported, or written to the Module.

**E = Execute:** The Module uses the SSP in performing a cryptographic operation.

**Z = Zeroise:** The Module zeroises the SSP.

*Table 9: Approved Services*

Service	Description	Approved Security Functions	Keys and/or SSPs	Roles	Access rights to Keys and/or SSPs	Indicator
pcrypt_aescm_decrypt	Authenticated decrypt	AES-CCM #A2494 AES-ECB #A2494	SC_EDK	CO	WEZ	SW
pcrypt_aescm_encrypt	Authenticated encrypt	AES-CCM #A2494 AES-ECB #A2494	SC_EDK	CO	WEZ	SW
pcrypt_aescm_init	Initialize AES CCM struct	N/A	SC_EDK	CO	WRZ	SW
pcrypt_ecc_export_private, pcrypt_ecc_export_public, pcrypt_ecc_import_private, pcrypt_ecc_import_public	Extract ECC key (from struct) Initialize ECC struct	N/A	ECC_Private ECC_Public	CO	WRZ WRZ	SW
pcrypt_ecc_init_key	Initialize an ECC key struct	N/A	ECC_Private ECC_Public	CO	WRZ WRZ	SW
pcrypt_ecc_gen_key	Generate ECC key pair	ECDSA KeyGen #A2494 CKG	ECC_Private ECC_Public	CO	GRZ GRZ	SW
pcrypt_ecc_sign	Generate ECDSA signature	ECDSA SigGen #A2494	ECC_SGK	CO	EWZ	SW
pcrypt_ecc_verify_hash	Verify ECDSA signature	ECDSA SigVer #A2494	ECC_SVK	CO	EWZ	SW
pcrypt_hmac_init	Initialize HMAC	HMAC-SHA2-384 #A2494	HMAC_HMK	CO	WE	SW
pcrypt_hmac_update	Update HMAC	HMAC-SHA2-384 #A2494	HMAC_HMK	CO	E	SW
pcrypt_hmac_finalize	Generate HMAC tag	HMAC-SHA2-384 #A2494	HMAC_HMK	CO	EZ	SW
pcrypt_init	Initialize the Module; executes FW integrity test and all CASTs	SHA2-256 #A2494, SHA2-384 #A2494	PW_Entry PW_Ref	CO	E	SW
pcrypt_key_exchange	Key agreement and subsequent derivation of keying material from a shared secret	KAS-ECC-SSC #A2494, KDA OneStep #A2494	KAS_U_Private KAS_V_Public KAS_SS KAS_DKM	CO	EWZ EWZ GEZ GRZ	SW
pcrypt_rng_generate_block	Generate random bits	Hash DRBG #A2494	RBG_State	CO	WER	SW

Service	Description	Approved Security Functions	Keys and/or SSPs	Roles	Access rights to Keys and/or SSPs	Indicator
pcrypt_rng_init	Instantiate DRBG	Hash DRBG #A2494	RBG_EI RBG_State	CO	EZ EG	SW
pcrypt_rsa_export_private, pcrypt_rsa_export_public, pcrypt_rsa_import_private	Extract RSA key (from struct) Initialize RSA struct	N/A	RSA_Private RSA_Public	CO	WRZ	SW
pcrypt_rsa_gen_key	Generate RSA key pair	RSA KeyGen #A2494 CKG	RSA_Private RSA_Public	CO	GRZ	SW
pcrypt_rsa_init	Initialize RSA struct	N/A	RSA_Private RSA_Public	CO	WRZ	SW
pcrypt_rsa_sign	RSA sign a hashed message	RSA SigGen #A2494 RSA Signature Primitive #A2494	RSA_SGK	CO	WEZ	SW
pcrypt_rsa_verify	Verify RSA signature	RSA SigVer #A2494	RSA_SVK	CO	WEZ	SW
pcrypt_sha256_hash	Generate a message digest	SHA2-256 #A2494	N/A	CO	N/A	SW
pcrypt_sha384_hash	Generate a message digest	SHA2-384 #A2494	N/A	CO	N/A	SW
pcrypt_selftest (Perform self-tests)	On-demand invocation of self-tests	N/A	N/A	CO	N/A	SW
pcrypt_status (Show status and Show module's versioning information)	Provide Module status	N/A	N/A	N/A	N/A	SW
pcrypt_tamper_detected	Tamper detection	N/A	N/A	CO	N/A	SW
pcrypt_uninit pcrypt_aes_free pcrypt_ecc_free pcrypt_hmac_free pcrypt_rsa_free (Perform zeroisation)	Zeroise the DRBG and release struct memory, zeroising SSPs	N/A	RBG_EI RBG_State RBG_Seed SC_EDK ECC_Private ECC_Public ECC_SGK ECC_SVK HMAC_HMK RSA_Private RSA_Public RSA_SGK RSA_SVK KAS_DKM KAS_U_Private KAS_V_Public KAS_SS	N/A	Z	SW
pcrypt_update_time	Update module time	N/A	N/A	N/A	N/A	SW

SW refers to the enumerated status return value, encoded in two bytes.

The least significant byte gives status as one of the following:

PCRYPT\_STATUS\_READY: Module operation successful/normal

PCRYPT\_STATUS\_NOINIT: Module not initialized (Default startup state)

PCRYPT\_STATUS\_STFAIL: Module self-test failure

PCRYPT\_STATUS\_BADARG: Module passed invalid argument

PCRYPT\_STATUS\_DISABLED: Module is disabled (tamper detected)

PCRYPT\_STATUS\_ERROR: Module internal error

The most significant byte indicates the use of a non-Approved algorithm; at the time of validation, this only applies to RSA Decrypt (RSADP). PCRYPT\_STATUS\_FIPS\_NOALLOW: set to 1 if the service does not use an approved algorithm. Usage of RSADP is deemed non-Approved but allowed and conforms to [FIPS 140\_3\_IG] 2.4.A example scenario 1.

All functions zeroise SSPs within the function scope after use. Call stack cleanup is the responsibility of the application. The Module-provided methods to deallocate memory perform active zeroisation (overwriting with zeros) prior to deallocation. Zeroisation of *PW\_Ref* requires destruction of the firmware image via the SafeCase product Crypto Reset function (Table 13 “Z2”). As allowed by [SP800-140DTR] VE09.38.03, this mechanism is provided as a service of the SafeCase product. The indicator of zeroisation is a status word (SW) returned by the module as specified above.

## 5 Software/Firmware Security

The executable form of the disjoint firmware component of the Module is a firmware library statically linked in the SafeCase firmware. During initialization (without operator intervention and prior to operation), it performs an ECDSA P-384 with SHA2-384 signature verification over all files in the Module boundary. The operator can initiate the integrity test on demand by either power cycling the Module or by invoking the `pcrypt_init` service. The module does not support loading of firmware from an external source.

## 6 Operational Environment

The Module executes in a limited operational environment as defined by [I19790]. The module does not support loading firmware from an external source.

## 7 Physical Security

The Module is a single-chip embodiment as shown in Figure 1 with a tamper evident hard coating applied to it. The single-chip packaging is opaque in the visible spectrum.

No actions are required by the operator(s) to ensure that the physical security is maintained.

*Table 10: Physical Security Inspection Guidelines*

Physical Security Mechanism	Recommended Frequency of Inspection/Test	Inspection/Test Guidance Details
Single-chip packaging	The Module is intended to be mounted in additional packaging; physical inspection of the chip is not practical after packaging	N/A

*Table 11: EFP/EFT*

	Temperature or voltage measurement	Specify EFP or EFT	Specify if this condition results in a shutdown or zeroisation
Low Temperature	-40 C	EFP	Shutdown (inoperable state)
High Temperature	+105 C	EFP	Shutdown (inoperable state)
Low Voltage	1.54 V	EFP	Shutdown (inoperable state)
High Voltage	3.72 V	EFP	Shutdown (inoperable state)

*Table 12: Hardness testing temperature ranges*

	Hardness tested temperature measurement
Low Temperature	-40 C

High Temperature	+105 C
------------------	--------

## 8 Non-Invasive Security

[SP800-140F] currently does not define applicable metrics. The Module does not implement non-invasive security measures.

## 9 Sensitive Security Parameters Management

Table 13 summarizes the SSPs implemented by the Module.

*Table 13: SSPs*

Key/SSP Name/Type	Strength <sup>2</sup>	Security Function and Cert. Number	Generation	Import/Export		Establishment	Storage	Zeroisation	Use & related keys
				IE1 MD /EE	--				
ECC_Private_CSP	192	ECDSA KeyGen #A2494 CKG	G2	IE1 MD /EE	--	S1	Z1		Private component of ECC key pair generated on caller request (key pair purpose is unspecified); related to ECC_Public
ECC_Public_PSP	192	ECDSA KeyGen #A2494 CKG	G2	IE1 MD /EE	--	S1	Z1		Public component of ECC key pair generated on caller request (key pair purpose is unspecified); related to ECC_Private
ECC_SGK_CSP	192	ECDSA SigGen #A2494	--	IE1 MD /EE	--	S1	Z1		Private key for ECC signature generation; related to ECC_SVK
ECC_SVK_PSP	192	ECDSA SigVer #A2494	--	IE1 MD /EE	--	S1	Z1		Public key for ECC signature verification; related to ECC_SGK
HMAC_HMK_CSP	384	HMAC-SHA2-384 #A2494	--	IE1 MD /EE	--	S1	Z1		Key to generate and verify and HMAC
KAS_DKM_CSP	112 ≤ s ≤ 384	KDA OneStep #A2494	--	IE1 MD /EE	E2	S1	Z1		Key Derivation derived keying material <sup>3</sup>
KAS_U_Private_CSP	192	KAS-ECC-SSC #A2494	--	IE1 MD /EE	--	S1	Z1		Private key pair component provided by the local participant, used for Diffie-Hellman shared secret generation; related to KAS_V_Public
KAS_V_Public_PSP	192	KAS-ECC-SSC #A2494	--	IE1 MD /EE	--	S1	Z1		Public key pair component provided by the local participant, used for Diffie-Hellman shared secret generation; related to KAS_U_Private
KAS_SS_CSP	192	KAS-ECC-SSC #A2494	--	--	E1 E2	S1	Z1		Shared secret calculation; z output value is expected to be used by a KDF
PW_Entry_CSP	256	N/A	--	IE1 MD /EE	--	S1	Z1		Authentication input
PW_Ref_CSP	256	SHA2-256, SHA2-384	--	IE2	--	S2	Z2		Authentication reference (hashed)
RBG_EI_CSP	See Table 14	ENT (P)	G3	--	--	S1	Z1		Entropy input and nonce

<sup>2</sup> Strength is provided in bits. Please refer to Table 4 and the notes below it for the strength provenance (traceability to applicable standards and special publications).

<sup>3</sup> The separation into specific keys is done outside the scope of the module but must be conformant to [SP800-56Cr1].

Key/SSP Name/Type	Strength <sup>2</sup>	Security Function and Cert. Number	Generation	Import/Export	Establishment	Storage	Zeroisation	Use & related keys	
								S1	Z1
RBG_Seed CSP	440 bits	ENT (P), Counter DRBG	G3	--	--	S1	Z1	DRBG seed derived from the entropy input	
RBG_State CSP	256	Hash DRBG #A2494	--	--	E3	S1	Z1	Hash DRBG (SHA2-256) state: V (440 bits) and C (440 bits)	
RSA_Private CSP	112	RSA KeyGen #A2494 CKG	G1	IE1 MD /EE	--	S1	Z1	Private component of RSA key pair generated on caller request (key pair purpose is unspecified); related to RSA_Public	
RSA_Public PSP	112	RSA KeyGen #A2494 CKG	G1	IE1 MD /EE	--	S1	Z1	Public component of RSA key pair generated on caller request (key pair purpose is unspecified); related to RSA_Private	
RSA_SGK CSP	112	RSA SigGen #A2494 RSA Signature Primitive #A2494	--	IE1 MD /EE	--	S1	Z1	Private key for RSA signature generation; related to RSA_SVK	
RSA_SVK PSP	112	RSA SigVer #A2494	--	IE1 MD /EE	--	S1	Z1	Public key for RSA signature verification; related to RSA_SGK	
SC_EDK CSP	256	AES-CCM #A2494 AES-ECB #A2494	--	IE1 MD /EE	--	S1	Z1	AES key used for symmetric encryption (including AES authenticated encryption)	

### Legend

Generation	Establishment	Storage
G1: [FIPS186-4] RSA keypair generation	E1: [SP800-56Ar3] §5.7.1.2 ECC CDH	S1: RAM
G2: [FIPS186-4] ECDSA keypair generation	E2: [SP800-56Cr1] KDA OneStep	
G3: [SP800-90B] DRBG seed material	E3: [SP800-90Ar1] Hash_df; Instantiate; Generate; Reseed	
Import/Export		Zeroisation
IE1: Call stack (API) parameters		Z1: Cleared after use, module initiated
IE2: Entered in manufacturing		Z2: Cleared by Crypto Reset, operator initiated

Table 14: Non-Deterministic Random Number Generation Specification

Entropy sources	Minimum number of bits of entropy	Details
K81 <sup>4</sup> ENT (P)	[SP800-90Ar1] <i>min_length</i> : 256 bits [SP800-90Ar1] <i>seedlen</i> : 440 bits	[FIPS140-3_IG] 9.3.A: The Module generates entropy within the Module's physical perimeter: option 1(b) using a [SP800-90B] compliant ENT present on the SoC component Per [SP800-90Ar1] Table 2, the SHA2-256 Hash DRBG requires 256 bits of entropy (equivalent to security strength) within the 440-bit <i>DRBG_Seed</i> value As input to the [SP800-90Ar1] Hash_df, the Module collects 1024 bits of data from the ENT to use as entropy and nonce input. The [SP800-90B] compliant assessment supports at least

<sup>4</sup> K81= NXP MK81FN256VDC15

Entropy sources	Minimum number of bits of entropy	Details
		0.99 bits of entropy per bit of ENT output; as such the DRBG seeding material contains at least 1013 bits of entropy, well in excess of the requirement

## 10 Self-tests

Each time the Module is powered on, it tests that the cryptographic algorithms still operate correctly, and that sensitive data has not been damaged. CASTs are available on demand and can be tested periodically using the pcrypt\_selftest command. The integrity test can be run on demand by either power cycling the Module or by invoking the pcrypt\_init service. The disjoint firmware component of the module, i.e., the libpcrypt.a, performs an ECDSA P-384 with SHA2-384 signature verification over all files in the Module boundary during module initialization i.e. on every boot.

On power-on or reset, the Module performs the self-tests described below. All cryptographic algorithm self-tests (CASTs) must complete successfully prior to any other use of cryptography by the Module. The ECDSA CASTs are performed prior to the firmware integrity test. All CASTs are implemented as known answer tests.

If one of the CASTs or the firmware integrity test fails, the Module enters the STFAIL error state. The error state is persistent, and no services are available. All attempts to use the Module's services result in the return of a non-zero error code, PCRYPT\_STATUS\_STFAIL. A power-cycle or reset of the Module is required to recover from an error state, causing it to retry all self-tests.

### Pre-Operational Self-Tests

- FW integrity test: ECDSA #A2494 (P-384/SHA2-384) signature verification over all firmware in the Module boundary.

### Conditional Cryptographic Algorithm Self-Tests (CASTs)

- AES-CCM #A2494: Encrypt CAST performed using reference inputs (256-bit AES key size). Covers self-test requirement for AES-ECB encrypt.
- AES-CCM #A2494: Decrypt CAST performed using reference inputs (256-bit AES key size).
- ECDSA SigGen #A2494: Signature generation CAST using reference inputs (P-384, SHA2-384).
- ECDSA SigVer #A2494: Signature verification CAST using reference inputs (P-384, SHA2-384).
- ENT: [SP800-90B] Startup and conditional tests; executes a suite of self-tests prior to raising a “valid” flag.
- ENT(P) developer defined health tests.
- Hash DRBG #A2494: Instantiate, Generate and Reseed CASTs using reference inputs on the SHA2-256 Hash DRBG.
- HMAC-SHA2-384 #A2494: HMAC CAST using SHA2-384 and reference inputs (192-bit HMAC key).
- KAS-ECC-SSC #A2494: KAS-ECC-SSC CASTs using reference inputs (P-384 curve).
- KDA OneStep #A2494: One-Step KDF CAST using a known shared secret reference input (256-bit z).
- RSA SigGen #A2494: Signature generation CAST using reference inputs (k = 2048).
- RSA SigVer #A2494: Signature verification CAST using reference inputs (k = 2048).
- SHA2-256 #A2494: Message digest generation CAST using SHA2-256.
- SHA2-384 #A2494: Message digest generation CAST using SHA2-384.

### Conditional Pairwise Consistency Tests (PCTs)

- ECDSA KeyGen #A2494: Pairwise consistency test of generated key pair.
- RSA KeyGen #A2494: Pairwise consistency test of generated key pair.

## 11 Life-cycle Assurance

The Privoro SafeCase Security Module FIPS 140-3 Guidance [GD] describes all procedures for secure installation, initialization, configuration, provisioning, decommissioning and sanitization of the Module. The Module is a component of the SafeCase product, integrated in the Privoro manufacturing setting and thus no further installation procedures are required of the Crypto Officer. The initialization process for the module involves loading the module and successfully authenticating to it as the Crypto Officer using the pcrypt\_init service. There are no maintenance requirements for the Module.

## 12 Mitigation of Other Attacks

The Module does not implement mitigations of other attacks outside the scope of [FIPS140-3].

## References

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## Acronyms and Definitions

- CAVP: Cryptographic Algorithm Validation Program
- ACVTS: Automated Cryptographic Validation Testing System
- AES: Advanced Encryption Standard, see [FIPS197]
- API: Application Programming Interface
- CAST: Cryptographic Algorithm Self-Test
- CCM: Counter with CBC-MAC
- CKG: Cryptographic Key Generation
- CMVP: Cryptographic Module Validation Program
- CO: Cryptographic Officer
- CSP: Critical Security Parameter, see [FIPS140-3]
- CPU: Central Processing Unit
- CCCS: Canadian Centre for Cybersecurity
- DRAM: Dynamic Random-Access Memory
- DRBG: Deterministic Random Number Generator, see [SP800-90Ar1]
- DTR: Derived Test Requirements
- ECB: Electronic Code Book

- ECC: Elliptic Curve Cryptography
- ECDSA: Elliptic Curve Digital Signature Algorithm, see [FIPS186-4]
- FIPS: Federal Information Processing Standard
- HMAC: Keyed-Hash Message Authentication Code, see [FIPS198-1]
- IG: Implementation Guidance, see [FIPS140-3\_IG]
- KAS: Key Agreement Scheme
- KDF: Key Derivation Function
- MAC: Message Authentication Code
- NIST: National Institute of Standards and Technology
- OE: Operating Environment
- PCT: Pairwise Consistency Test
- PSP: Public Security Parameter
- RSADP: RSA Decryption Primitive
- SHA/SHS: Secure Hash Algorithm/Standard, see [FIPS180-4]
- SP: NIST Special Publication
- SSC: Shared Secret Calculation
- SSP: Sensitive Security Parameter