Giesecke & Devrient

StarSign Crypto USB Token powered by Sm@rtCafé Expert 6.0

FIPS 140-2 Non-proprietary Security Policy

Version 1.7

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Contents

1 Introduction

1.1 Purpose

This is a non-proprietary Security Policy for the Giesecke & Devrient (G&D) cryptographic module “StarSign Crypto USB Token powered by Sm@rtCafé Expert 6.0”. This Security Policy describes how the cryptographic module meets the security requirements applicable to Level 3 of FIPS 140-2 [FIPS 140-2] and accompanying cryptography-based standards and how to run it in FIPS-Approved mode.

The Federal Information Processing Standards Publication 140-2 — Security Requirements for Cryptographic Modules details the U.S. Government requirements for cryptographic modules. Information about the FIPS 140-2 standard and validation program is available on the NIST website http://csrc.nist.gov/groups/STM/cmvp/index.html.

1.2 References

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integrated circuit(s) cards – Proximity cards — Part 3: Initialization and anticollision

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[JCRE] Java Card™ Platform Classic Edition, Version 3.0.1, Runtime Environment Specification, Sun Microsystems, Inc., May 2009.

[JCVM] Java Card™ Platform Classic Edition, Version 3.0.1, Virtual Machine Specification, Sun Microsystems, Inc., May 2009.

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[FIPS 140-2 IG] Implementation Guidance for FIPS PUB 140-2 and the Cryptographic Module Validation Program, Initial Release: March 28, 2003, Last Update: March 03, 2011.

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[SP 800-38A] National Institute of Standards and Technology, Recommendation for Block Cipher Modes of Operation, Methods and Techniques, Special Publication 800-38A, May 2005.

[SP 800-38A, Appendix E] National Institute of Standards and Technology, Recommendation for Block Cipher Modes of Operation, Methods and Techniques, Special Publication 800-38A, May 2005. Appendix E references Modes of Triple-DES.

[SP 800-38B] National Institute of Standards and Technology, Recommendation for Block Cipher Modes of Operation: The CMAC Mode for Authentication, Special Publication 800-38B, May 2005.

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Overview information of Giesecke & Devrient products and services can be found at www.gi-de.com. For answers to technical or sales related questions, please refer to the contacts listed on the Giesecke & Devrient website.

1.3 Document Organization

This Security Policy is one document in a FIPS 140-2 submission package. In addition to this document, the submission package contains:

- The Vendor Evidence document
- The Finite State Machine Model
- The Sm@rtCafé Expert 6.0 Reference Manual, [SCE60 RefMan]
- Other supporting documentation

This Security Policy and the other validation submission documentation were produced by Giesecke & Devrient. With the exception of this non-proprietary Security Policy, the FIPS 140-2 validation submission documentation is proprietary to Giesecke & Devrient and is releasable only under appropriate non-disclosure agreements. For access to these documents, please contact Giesecke & Devrient.

2 Cryptographic Module Specification

2.1 Overview

The StarSign Crypto USB Token powered by Sm@rtCafé Expert 6.0 is a multi-chip standalone cryptographic module, which is an opaque, tamper-evident USB token that connects to an external general purpose computer device outside the cryptographic boundary.

Table 1 identifies the validated product configuration.

Table 1 Configuration

Product Model Name	FW Image Name	Tested Hardware Configuration
StarSign Crypto USB Token powered by Sm@rtCafé Expert 6.0	Sm@rtCafé Expert 6.0	NXP P5CC081, ISO 7816 contact only, SSOP20 (SMD) full USB Token package

The Sm@rtCafé Expert 6.0 firmware is implemented on the NXP smart card controller P5CC081 (see Section 2.3.2).

Hardware Versions: P5CC081 smart card controller and AU9540 USB smart card reader controller

Firmware Version: Sm@rtCafé Expert 6.0

Providing a complete set of International Organization for Standardization (ISO), Europay, MasterCard and Visa (EMV), and GlobalPlatform commands, the cryptographic module incorporates standards- and specifications-based functionality along with a proprietary command set.

The firmware is a Classic Edition Java Card 3 Platform ([JCAPI], [JCRE], [JCVM]) that implements the GlobalPlatform (GP) Card Specification Version 2.1.1 ([GPCS2.1.1]) and the Secure Channel Protocol 03 as per Amendment D to GlobalPlatform Card Specification Version 2.2, ([GP2.2, Amendment D]). The GP specifications define a secure infrastructure for post-issuance programmable smart cards and a life cycle for GP compliant products.

State transitions between states of the life cycle involve well-defined sequences of operations. Modules that have been issued are necessarily in the "SECURED" state. This means that the G&D Security Domain has been loaded onto the module plus a set of keys and a PIN through which the Crypto Officer can be authenticated.

The module can load applets post-validation, FIPS 140-2 validated or not. If a non-validated applet is loaded, the FIPS 140-2 validation of the module is no longer valid.

2.2 Cryptographic Algorithms

The cryptographic module implements the following cryptographic algorithms:

Name of the Algorithm	Approved	Allowed	Non-approved	Supported by the module (yes / no)*
AES with 128, 192, and 256 bits key lengths, ECB and CBC modes, Cert. #1755	x			yes
3-key Triple-DES and 2 key Triple-DES, ECB and CBC modes, Cert. #1136	x			yes
RSA with up to 2048 bits modulus length, Cert. #874	x			yes
RSA CRT with up to 2048 bits modulus length, Cert. #874	x			no
ECDSA in GF(p) with P=192, P=224 and P=256 curves, Cert. #232	x			no
SHA-1, Cert #1542	x			yes
SHA-224, SHA-256, SHA-384, and SHA-512 hash functions, Cert. #1542	x			no
CMAC	x			yes
Triple-DES MAC	x			no
DRBG (Deterministic Random Number Generator), Cert. #116	x			yes
ECDH Key Agreement		x		no
AES for key wrapping		x		yes
DES			x	no
DSA			x	no
RSA Encryption and Decryption			x	no
Korean SEED			x	no
RIPEMD-160			x	no
MD5			x	no
TRNG (non-deterministic hardware RNG, used for seeding the DRBG)		x		yes

***** “no” means that the module, as validated, does not support this algorithm. The algorithm can be used by post-validation loaded applets.

2.3 Physical Security with Well-Defined Interfaces

2.3.1 Security Level

The cryptographic module contains the NXP P5CC081 smart card chip (Section 2.3.2) and the Alcor Micro AU9540 USB smart card reader chip (Section 2.3.3). StarSign Crypto USB Token powered by Sm@rtCafé Expert 6.0 is developed to meet the FIPS 140-2 Level 3 requirements as indicated in Table 2.

Table 2 Module Security Level Specification

Security Requirements Section	Level
Cryptographic Module Specification	3
Module Ports and Interfaces	3
Finite State Model	3
Physical Security	3
Operational Environment	N/A

Security Requirements Section	Level
Roles, Services, and Authentication	3
Cryptographic Key Management	3
EMI/EMC	3
Self-tests	3
Design Assurance	3
Mitigation of Other Attacks	3

2.3.2 The NXP P5CC081 smart card controller

The functional diagram for the NXP P5CC081 controller is depicted in Figure 1. The controller contains the processor, Read Only Memory (264 KB), Random Access Memory (7680 Bytes), Electrically Erasable Programmable ROM (80 KB), co-processors, I/O, and timers. The power interface accepts voltages in the range of +5V +/-10% and +1.8V +/-10%.

The P5CC081 is a secure ISO/IEC 7816 contact interface PKI smart card controller providing the following security features:

- Low and high clock frequency sensor
- Low and high temperature sensor
- Low and high supply voltage sensor
- Single Fault Injection (SFI) attack detector
- Light sensors (including Integrated memory light sensor functionality)

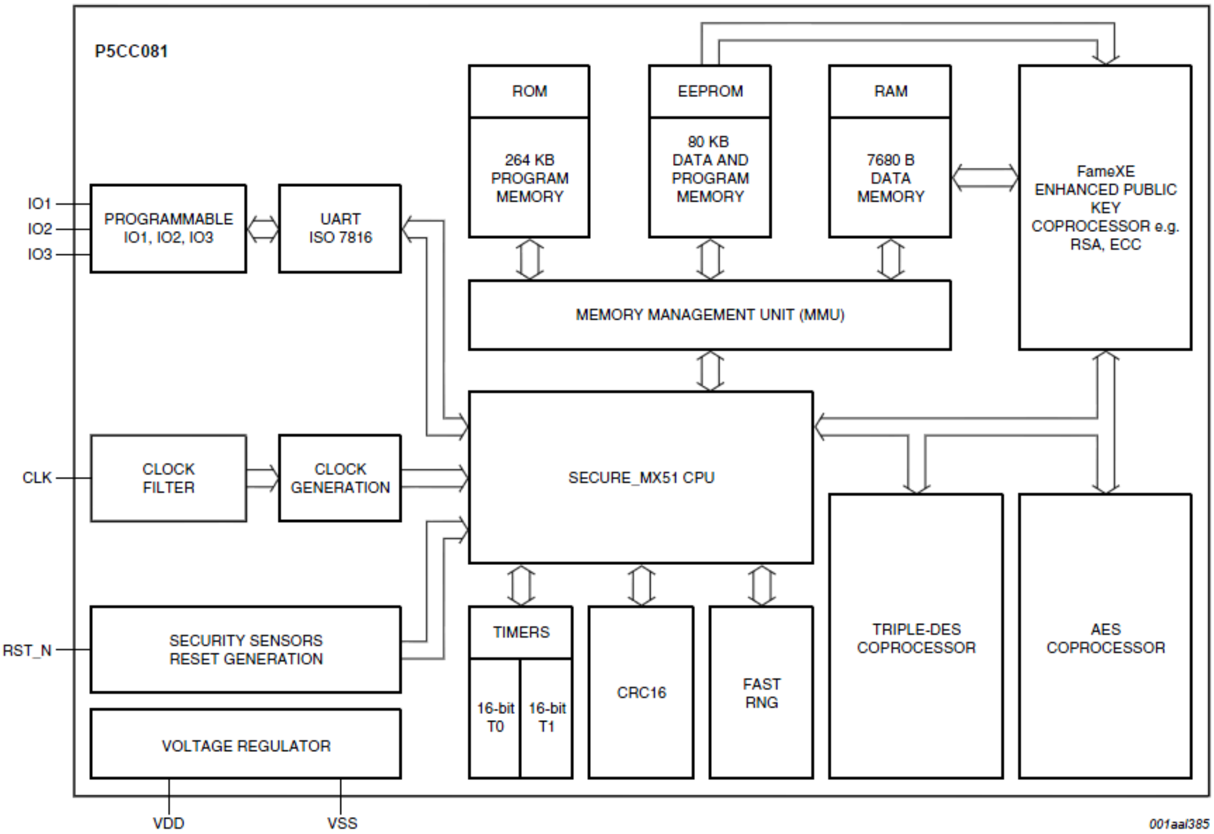


Figure 1 Block Diagram of the NXP P5CC081

The controller has been tested for and meets applicable Federal Communication Commission (FCC) Electromagnetic Interference (EMI) and Electromagnetic Compatibility (EMC) requirements for home use as defined in Subpart B of FCC Part 15.

The NXP P5CC081 controller itself is embedded in opaque tamper-evident SSOP20 SMD package that is placed in the USB token composite enclosure.

2.3.3 The USB AU9540 smart card reader controller

The AU9540 is a highly integrated single chip USB smart card reader controller, packed in 28-SSOP-form factor. AU9540 implements a hard-wired smart card interface providing all signals to interface directly with a smart card based on ISO/IEC 7816. It has a built-in DC-to-DC regulator that provides switched power supply of 1.8V, 3.0V or 5.0V card voltage to the smart card controller according to ISO 7816-3. The on-chip oscillator generates all necessary clock signals (USB bus, ASIC clock, smart card clock). The AU9549 connects to an external EERPOM via the I²C bus. The EEPROM is a 256 KB Holtek HT24L02.

The block diagram of the AU9540 is depicted in Figure 2.

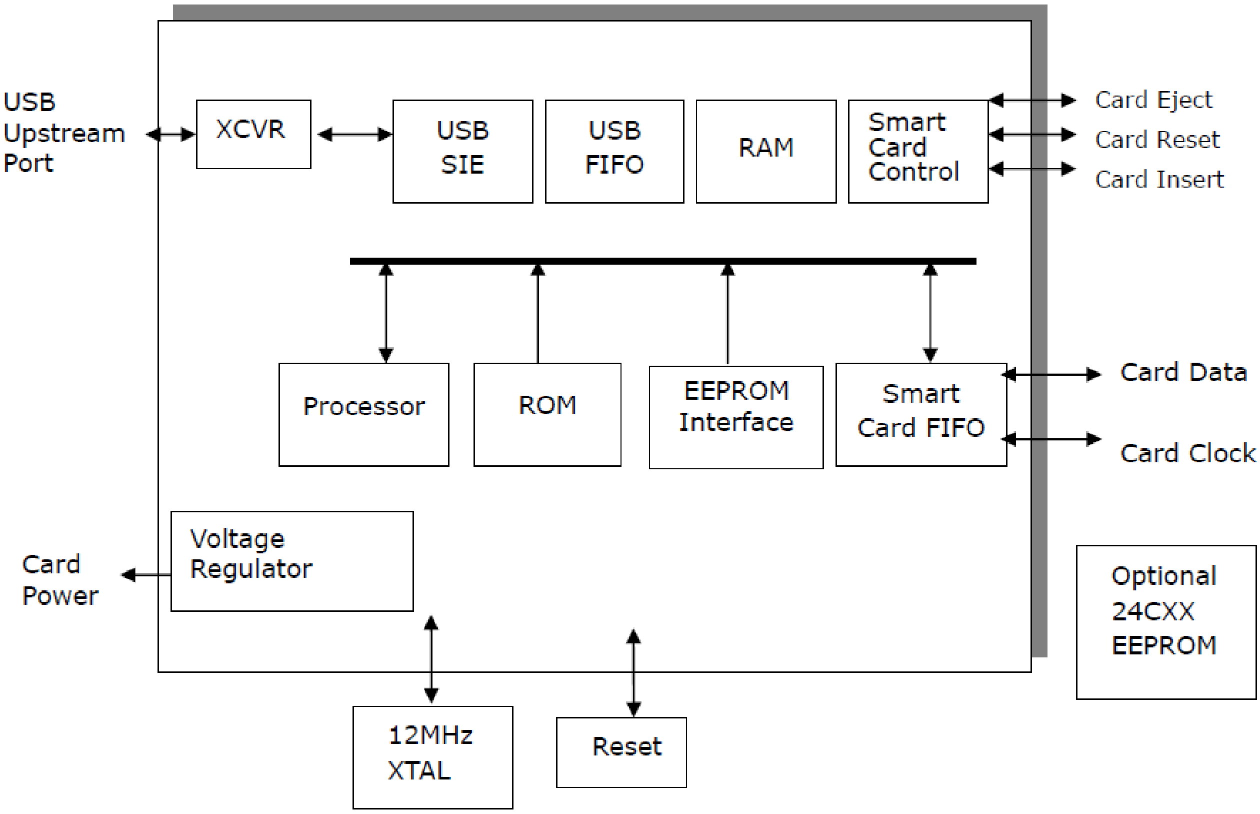


Figure 2 Block Diagram of the AU9540

2.3.4 The Physical Contact Interface

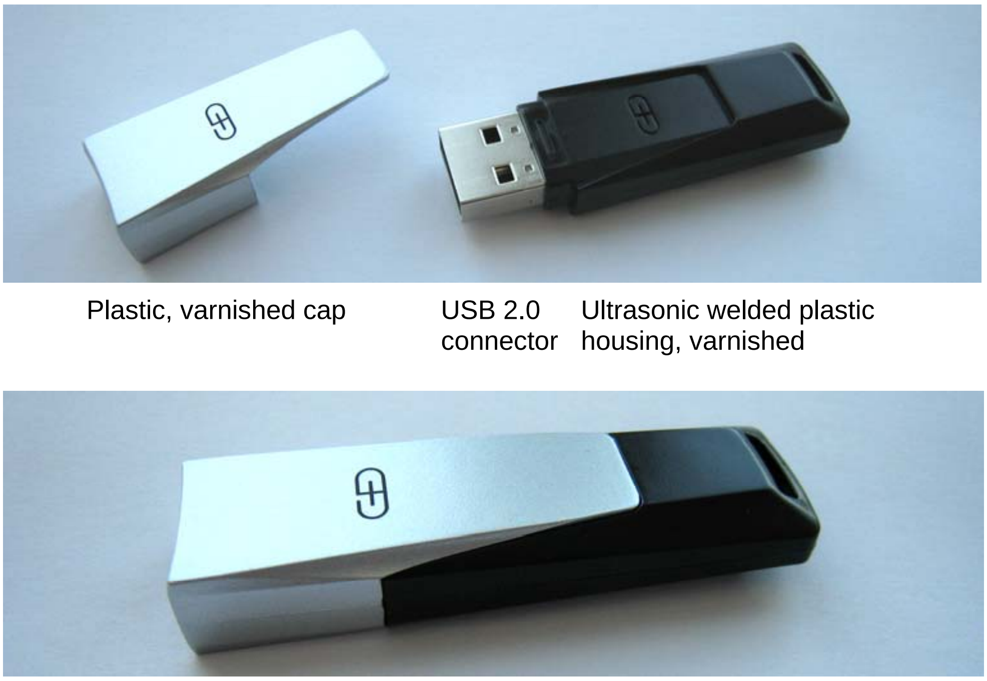
A single physical universal serial bus port (USB 2.0 full speed) is exposed on the top of the module that supports all logical interfaces (data input, data output, control input, status output, power).

Table 3 Specification of Cryptographic Module Physical Ports and Logical Interfaces

Physical Port	FIPS 140-2 Logical Interface
USB 2.0 port	Data Input Interface, Data Output Interface
USB 2.0 port	Control Input Interface
USB 2.0 port LED	Status Output
USB 2.0 port	Power

2.3.5 The Cryptographic Boundary

The cryptographic boundary of the cryptographic module is defined as being the outer perimeter of the metal and plastic with a plastic cap on the bottom. The cryptographic module does not contain any removable covers, doors, or openings. Figure 3 shows photographs of the cryptographic boundary.



Plastic, varnished cap

USB 2.0 connector

Ultrasonic welded plastic housing, varnished

Figure 3 Photographs of the USB Token

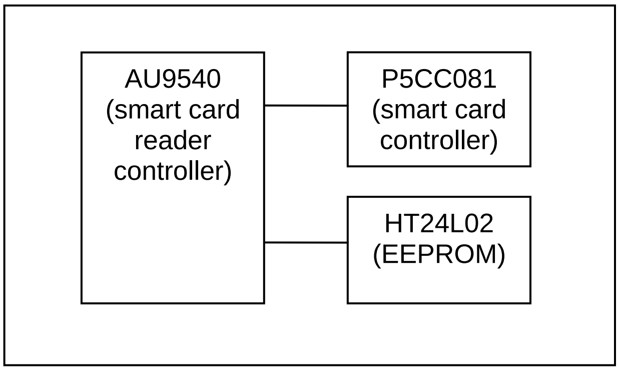

AU9540 (smart card reader controller)
P5CC081 (smart card controller)
HT24L02 (EEPROM)

Figure 4 Block Diagram of the cryptographic boundary

2.4 Finite State Model

The Sm@rtCafé Expert 6.0 firmware undergoes a set of well-defined state transitions. The Finite State Model for the Sm@rtCafé Expert 6.0 is provided as a separate document.

2.5 Firmware Security

The Sm@rtCafé Expert 6.0 firmware is protected from modification as it is stored in ROM of the NXP P5CC081 chip. This is system software written primarily using a high-level programming language and machine language that is specific to the underlying chip that allows for performance increase and enhancement of the module's security.

The Sm@rtCafé Expert 6.0 firmware is loaded onto the chip during manufacturing. An Error Detection Code (EDC) is calculated over the firmware during the installation process and checked each time the module is powered up. Attempts to modify the firmware require direct access to the IC and are prevented by the physical security mechanisms of the IC and the enclosure listed in Section 2.3.2.

The Sm@rtCafé Expert 6.0 firmware includes a Java Card virtual machine. Applets are isolated from each other due to the fact that each runs in a "Java sandbox" as defined in the Java Card virtual machine Specification [JCVM]. The Java Card programming language does not contain any constructs that allow cross-sandbox communication directly; any such communication must go by way of system software mechanisms, which allow for implementation of strict security measures.

Each applet is loaded on the card within a Secure Channel requiring at least MAC verification over each Load Block. CMAC as specified in NIST SP 800-38B [SP 800-38B] is used for MAC calculations. Sm@rtCafé Expert 6.0 provides the Data Authentication Pattern (DAP) acc. to [GPCS2.1.1] for secure content loading.

During the manufacturing process only trusted (i.e., validated against FIPS 140-2) applets are loaded onto the chip. These include the Card Manager applet and the G&D Security Domain.

After completion of the manufacturing process (including pre-personalization) when the chip has reached its Operating Life Cycle State (Card Manager SECURED State), only FIPS 140-2 validated applets shall be loaded and installed onto the module. At the time of loading, these applets must be identified as part of the cryptographic module. The FIPS 140-2 validation testing of the cryptographic module targeted this specific configuration. Changes to that configuration (such as loading an applet), would constitute a new module, and the new configuration would need to undergo FIPS 140-2 testing for FIPS 140-2 compliance.

2.6 Command Structure

The Sm@rtCafé Expert 6.0 firmware provides a well-defined, static set of commands. The details of these commands are defined in the Sm@rtCafé Expert 6.0 Reference Manual [SCE60 RefMan] included as a proprietary and private extension to this Security Policy.

Sm@rtCafé Expert 6.0 is only capable of operating in response to commands that are sent from the reader. The reader sends a command Application Protocol Data Unit (APDU) to the module and module responds with a response APDU, thus exchanging command-response pairs.

An APDU sent by the reader consists of a header and an optional body. The header contains a class byte differentiating between ISO defined commands and custom commands, an instruction byte containing the command code, and command-specific parameters. The command body contains data that is needed for command execution and, if necessary, followed by the length of expected response data.

The response APDU transmitted by the module consists of an optional body and a trailer. The body contains any data that is returned in response to the command. The trailer contains a status code.

The module provides a set of services through the Java Card API that is specified in [JCAPI] and the GlobalPlatform API [GPCS2.1.1]. The implemented Java Card package API classes are listed in Sm@rtCafé Expert 6.0 Reference Manual [SCE60 RefMan]. These services are only available internally to applets loaded and installed on the module. They cannot be accessed from outside the module.

3 Roles and Services

The module defines two distinct roles that are supported by the on-module cryptographic system, the Crypto Officer role and the User/Applet provider role.

3.1 Roles

The cryptographic module supports the following roles:

The Crypto Officer (CO). This role is responsible for managing the security configuration of the Card Manager and Security Domains. The CO role authenticates to the cryptographic module by demonstrating to the Card Manager application that he possesses the knowledge of a GP Secure Channel AES key set stored within the Card Manager. By successfully executing the GP mutual authentication protocol specified in [GP2.2, Amendment D], the CO role establishes a Secure Channel to the Card Manager and executes services allowed to the CO in a secure manner.

The User/Applet provider. The module supports a User role that has possession of the G&D Security Domain key set and can request services provided by the G&D Security Domain instantiated on the module. The CO is responsible for instantiating the G&D Security Domain and thereby defining User roles. Up to 127 G&D Security Domain instances can be created if memory resources permit.

After it has been manufactured, the cryptographic module is in possession of the Crypto Officer until it is ultimately issued to the User. From that point, the cryptographic module is in the physical possession of the User.

3.1.1 Identity-based Authentication

Identification. The operator identifies himself by selecting his application and the key set inside the application. The application of the Crypto Officer is the Card Manager. The application of the User/Applet provider is the G&D Security Domain.

An application is selected by issuing a SELECT command.

The selection of the key set is done by issuing the INITIALIZE UPDATE command, which is the first command of the two commands required to open a Secure Channel.

Authentication. The operator authenticates himself using a mutual authentication scheme comprising two commands INITIALIZE UPDATE and EXTERNAL AUTHENTICATE. During the mutual authentication, the operator has to encrypt a challenge sent by the cryptographic module and compute a MAC over the encrypted result, proving knowledge of the AES key set which was referenced during the identification process. AES keys with the following lengths are supported: 128, 192, 256 bits. The strength of authentication is assessed in Section 5.2.

The cryptographic module provides dedicated services for managing the Card Holder PIN (Global PIN) and for changing/unblocking the Global PIN. The cryptographic module does not use the Global PIN to provide authentication to its users. Any applet installed on the cryptographic module may use this PIN for authenticating Card Holders as end-users of the cryptographic module. In addition or alternatively to the Global PIN mechanism, applications can implement a private PIN identification mechanism.

3.2 Services

All commands (except the commands listed for unauthenticated services in Section 3.2.3) need a Secure Channel to be executed by either the CO or the User. During the Secure Channel opening, the command access condition is specified (‘NO SECURITY LEVEL, ’AUTHENTICATED’, ’C_MAC’, ‘C_DECRYPTION’) and access control is done on the received command APDUs.

3.2.1 Crypto Officer Administrative Services

The Crypto Officer uses a command set for the administration of the G&D Security Domains and to load applets onto the cryptographic module. The following commands may be sent to the Card Manager / Issuer Security Domain.

DELETE ALL is used to delete all packages and applet instances installed from those packages that have been loaded after completion of the module via LOAD commands.

CHANGE / UNBLOCK PIN replaces or unblocks the Global PIN (Card Holder PIN).

Applets loaded onto the module post-issuance must be FIPS 140-2 validated. If non-validated applets are loaded, the FIPS 140-2 validation of the module is no longer valid.

Applets are loaded through a Secure Channel established by the Crypto Officer (off-card entity) with the Card Manager (on-card entity) during the mutual authentication process. The applet is divided in a series of blocks that fit in a LOAD command. The loading is managed in a series of LOAD commands, each transmitting a block that is optionally encrypted and followed by a MAC across the header and the data field of the APDU command using the Secure Channel session keys generated during the mutual authentication process. CMAC as specified in [SP 800-38B] is used for MAC calculations. AES in CBC mode as specified in [SP 800-38A] is used for encryption / decryption.

Optionally a mechanism called “GP DAP” enables the applet provider to check that his applet has been correctly loaded independently of the Issuer. The following DAP verification modes are defined in [GPCS2.1.1]:

- Single-DES plus final Triple-DES MAC
- 2 key Triple-DES MAC (referred to as “full Triple-DES MAC”)
- 1024-bits RSA SSA-PKCS1-v1_5 signature as defined in PKCS#1 applied to a SHA-1 digest of the data being signed

The DES Load File Data Block Signature verification consists of a series of DES MAC verification, ended by Triple-DES MAC verification. All the DES and Triple-DES MAC operations use the ”GP DAP” Triple-DES key, loaded in the G&D Security Domain. DAP verification using this method shall not be used in FIPS approved mode, as DES is not an approved security function per [FIPS 140-2].

The “full Triple-DES MAC” is as defined in [ISO/IEC 9797-1] as MAC Algorithm 1 with output transformation 1, without truncation, and with Triple-DES taking the place of the block cipher. The full Triple-DES MAC DAP verification consists of a series of Triple-DES MAC verifications. All Triple-DES MAC operations use the ”GP DAP” Triple-DES key loaded in the G&D Security Domain. Full Triple-DES MAC DAP verification is allowed in the approved mode of operation.

The RSA Load File DAP is calculated using PKCS#1 signature with padding the SHA-1 digest is according to PKCS#1 V1.5 and encrypting it with the private RSA key with 1024 bits modulus length. DAP verification using RSA is allowed in the approved mode of operation.

3.2.2 Crypto Officer Services and User Services

The following commands are available to the Crypto Officer and to the User:

INSTALL instructs a Security Domain or the Card Manager which installation step it shall perform during an application installation process. It may only be executed within a Secure Channel. Its level of security depends on the security level defined in EXTERNAL AUTHENTICATE.

LOAD loads the byte-codes of the Load File (package) defined in the previously issued INSTALL command.

DELETE deletes a Load File (package) or an Application (applet instance).

EXTERNAL AUTHENTICATE is used by the module to authenticate the host, to establish the Secure Channel, and to determine the level of security required for all subsequent commands within the Secure Channel. A previous and successful execution of the INITIALIZE UPDATE command is required prior to processing this command.

PUT KEY is used to add or replace a single key or a set of keys.

GET STATUS is used to retrieve the life cycle data for Applications, Load Files (packages), or the Issuer Security Domain based on the search criteria defined in the APDU parameter and data fields. This command may only be executed within a Secure Channel. Its level of security depends on the security level defined in EXTERNAL AUTHENTICATE.

SET STATUS is used to modify the card life cycle state (by Crypto Officer only) and the life cycle state of an application (by Crypto Officer or User). If this command is used to set the Issuer Security Domain life cycle state to TERMINATED, all keys and the Global PIN are zeroized.

STORE DATA is used to store or to set the value of data elements utilized and managed by the Issuer Security Domain.

3.2.3 Unauthenticated Services

The following commands are available without prior role authentication:

MANAGE CHANNEL is used to open or to close a logical channel.

GET DATA is used to retrieve a single data object. It is available outside of a Secure Channel (no security condition). However, if issued within a Secure Channel, it must follow the same security level as defined in EXTERNAL AUTHENTICATE.

SELECT is used for selecting an application (Card Manager or G&D Security Domain).

GET FREE SPACE is used to display the largest free memory block for package loading or the complete available free EEPROM or the complete available Clear-On-Reset (COR) / Clear-On-Deselect (COD) space.

INITIALIZE UPDATE is used to initiate a Secure Channel with the Card Manager or a Security Domain. The session data are exchanged and session keys are generated by the module upon completion of this command. The Secure Channel is not considered open until completion of a successful EXTERNAL AUTHENTICATE command that must immediately follow the INITIALIZE UPDATE command.

3.2.4 Relationship between Roles and Services

Table 4 Services Authorized for Roles

Roles/Services	**Crypto Officer** (Issuer Security Domain)	**User/Applet Provider** (G&D Security Domain)	**Unauthenticated** (Any role)
INSTALL	X	X	
LOAD	X	X	
DELETE	X	X	
DELETE ALL	X		
EXTERNAL AUTHENTICATE	X	X	
GET DATA			X
GET FREE SPACE			X
GET STATUS	X	X	
INITIALIZE UPDATE			X
CHANGE/UNBLOCK PIN	X		
STORE DATA	X	X	
PUT KEY	X	X	
SELECT			X
MANAGE CHANNEL			X
SET STATUS	X	X	

3.2.5 Applet Services

User-developed Java Card applets that are downloaded onto the module shall use the Java Card API that is accessible by on-card applets only. The following cryptographic services are provided to the applets through the API:

Key Generation and Key Exchange:

- Generation of pairs of RSA keys.
- Generation of pairs of RSA CRT keys.
- The ECDH key agreement scheme.

Message Digest:

- API for the Message Digest algorithms SHA-1, SHA-224, SHA-256, SHA-384, and SHA-512.

Pseudorandom Bit Generator:

- An API that provides random number generation using output from the DRBG.

Signature and Verification:

- RSA with SHA-1 digest using the padding schemes ISO/IEC 9796, PKCS#1 and RFC 2409.
- RSA with the digests SHA-224, SHA-256, SHA-384, and SHA-512 using the PKCS#1 padding scheme.
- ECDSA in GF(p) 192 with SHA-1: An API to generate a 20-bytes SHA digest and perform signature generation or verification using ECDSA with the P-192 curve.
- ECDSA in GF(p) 224 with SHA-1: An API to generate a 20-bytes SHA digest and perform signature generation or verification using ECDSA with the P-224 curve.
- ECDSA in GF(p) 256 with SHA-1: An API to generate a 20-bytes SHA digest and perform signature generation or verification using ECDSA with the P-256 curve.
- ECDSA in GF(p) 224 with SHA-224: An API to generate a 28-byte SHA-224 digest and sign/verify the digest using ECDSA with the P-224 curve.
- ECDSA in GF(p) 256 with SHA-256: An API to generate a 32-byte SHA-256 digest and sign/verify the digest using ECDSA with the P-256 curve.

Bulk Encryption and Decryption:

- Triple-DES API that offers
  - 2-key and 3-key Triple-DES in ECB and CBC modes.
  - 3-key Triple-DES in outer CBC mode.
- AES encryption and decryption with block sizes 128, 192, and 256 bits in ECB and CBC modes.

The above stated algorithms are available for use in the FIPS approved mode of operation and undergo FIPS 140-2 validation testing.

The GP specification [GPCS2.1.1] defines various APIs that may be used by the applets and that provide the same services as the Card Manager commands (such as Secure Channel opening). In particular, the Global PIN verification may be implemented by the applets through the use of a dedicated API.

3.2.6 Cryptographic Functions

The cryptographic module provides the following cryptographic services:

Triple-DES (2-key and 3-key Triple-DES)

- A 2-key Triple-DES MAC is provided for DAP verification.
- Triple-DES encryption and decryption services are provided to applets through the Java Card API.

AES (128, 192 and 256 bits key sizes)

- AES encryption and decryption is provided as services to applets through Java Card API.
- AES for message data field decryption and response encryption is provided for Secure Channel confidentiality.

Message Digest

- The SHA-1, SHA-224, SHA-256, SHA-384, and SHA-512 Message Digest algorithms are provided as a service to applets through the Java Card API.

Message Authentication

- CMAC is provided for Secure Channel Protocol 03 message integrity and data origin authentication.
- Triple-DES MAC is provided for DAP verification services.

RSA (1024 to 2048 bits modulus length)

- RSA with 1024 bits modulus length is provided for signature verification services during DAP verification.
- RSA signature generation and signature verification functions are provided as services to applets through the Java Card API. The applet shall use the RSA algorithm only for key wrapping/unwrapping or signature generation/verification.

3.2.7 Random Bit Generator

The cryptographic module offers a NIST SP 800-90 Deterministic Random Bit Generator as approved security function that meets the requirements of FIPS 140-2 and SP 800-90.

DRBG implementation is a CTR_DRBG without prediction resistance based on 3-key Triple-DES. The output block length is 64 bits, the key length is 168 bits, seed length is 232 bits and the security strength for the Triple-DES block cipher algorithm with 3 keys is 112 bits.

A personalization string is not provided as an input value to the Instantiate function. There is no option for additional input to the Generate function. The Reseed function is not supported. Once the reseed counter has reached 2^{32} (the reseed interval), the Instantiate function is invoked that acquires fresh entropy input and combines it with a nonce to create a new seed with the help of the derivation function. The derivation function is implemented using a block cipher algorithm.

3.3 Critical Security Parameters (CSP)

Table 5 CSP Information

Key	Key type	Generation	Entry	Storage	Usage
Crypto Officer Initial keys (K_{INIT_ENC}, K_{INIT_MAC}, K_{INIT_DEK})	128 bits AES keys	External by manufacturing	Pre-configured	Veiled in the module's non-volatile memory	Authentication of Crypto Officer and Sensitive Data Decryption
Crypto Officer Static keys (K_{ENC}, K_{MAC}, K_{DEK})	AES keys of the supported sizes (128, 192, 256 bits)	External by Crypto Officer	Loaded in encrypted form with PUT KEY	Veiled in the module's non-volatile memory	Authentication of Crypto Officer Sensitive Data Decryption
Crypto Officer Session keys (S_{ENC}, S_{MAC})	AES keys of the supported lengths (128, 192, 256 bits)	Generated after authentication of Crypto Officer	Dynamically derived by the module during Secure Channel establishment	Temporarily, veiled in volatile memory	Secured communication (confidentiality- and/or integrity-protected) between terminal and module
Delegated Management Token Key (K_{Token})	1024 bits RSA key	External by Crypto Officer	Loaded in encrypted form with PUT KEY	Veiled in the module's non-volatile memory	Authorization of Delegated Management commands
Delegated Management Receipt Key ($K_{Receipt}$)	112 bits Triple-DES key	External by Crypto Officer	Loaded in encrypted form with PUT KEY	Veiled in the module's non-volatile memory	Confirmation of command execution
RSA DAP public key (PK_{DAP})	1024 bits RSA key	External by Crypto Officer	Loaded in encrypted form with PUT KEY	Protected with GHC checksum in module's non-volatile memory	Signature verification of Load File Data Block Hash
Triple-DES DAP key (K_{DAP})	112 bits Triple-DES key	External by Crypto Officer	Loaded in encrypted form with PUT KEY	Veiled in the module's non-volatile memory	Signature verification of Load File Data Block Hash
User Static keys (SDK_{ENC}, SDK_{MAC}, SDK_{DEK})	AES keys of the supported lengths (128, 192, 256 bits)	External by Crypto Officer	Loaded in encrypted form with PUT KEY or STORE DATA command	Veiled in the module's non-volatile memory	Secure Channel Authentication, Encryption and MAC Verification; Sensitive Data Decryption
User Session keys (KSC_{ENC}, KSC_{MAC})	AES keys of the supported lengths (128, 192, 256 bits)	Generated after User authentication	Dynamically derived on card during Secure Channel establishment	Temporarily, veiled in volatile memory	Secured communication (confidentiality- and/or integrity-protected) between terminal and module
Global PIN	PIN	External – entered by Crypto Officer	Loaded in encrypted form with CHANGE / UNBLOCK PIN	Veiled in the module's non-volatile memory	Card Holder verification

No secret keys and no private keys are output by the module.

If the Security Domain is personalized with Triple-DES keys and not with AES keys, FIPS validation is lost since the smart card operating system will automatically use the SCP 02 for securing communications instead of the FIPS approved AES-based SPC 03.

4 Security Rules

4.1 Identification and Authentication Security Rules

The cryptographic module implements Identity-based Access Control Rules for identifying and authenticating the Crypto Officer and the User/Applet provider role.

Crypto Officer Authentication. The Crypto Officer must prove possession of the Card Manager key set composed of three AES keys (K_{ENC}, K_{MAC} and K_{DEK}). K_{ENC}, K_{MAC} are used to derive the session keys that are used to encrypt, authenticate and check the integrity of the command data. K_{DEK} is used to decrypt sensitive data (e.g., secret keys) transported within an APDU command. This is the same process as the User authentication and follows the GP specifications [GPCS2.1.1] and [GP2.2, Amendment D].

User/Applet Provider Authentication. The User/Applet Provider must prove possession of the G&D Security Domain key set composed of three AES keys (SDK_{ENC}, SDK_{MAC}). SDK_{ENC}, SDK_{MAC} are used to derive the session keys that are used to encrypt, authenticate and check the integrity of the command data. This is the same process as the Crypto Officer authentication (via the INITIALIZE UPDATE and EXTERNAL AUTHENTICATE commands) but it uses the AES keys of the G&D Security Domain rather than the Issuer Security Domain keys.

Once it is manufactured, the cryptographic module belongs to the Crypto Officer until it is ultimately issued to the User.

4.2 Applet Loading Security Rules

Only applets validated according to FIPS 140-2 shall be loaded onto the cryptographic module. Applets can only be loaded through a secure channel thus requiring CMAC verification over each Load block. The applet is always loaded by the Issuer (Crypto Officer) or authorized by Issuer in case of Delegated Management.

4.2.1 GP Delegated Management

If Delegated Management is used, the Crypto Officer has to set Delegate Management Keys for Token verification (K_{Token}) and Receipt generation ($K_{Receipt}$), to install the G&D Security Domain with Delegated Management privilege and to set Secure Channel keys of this Security Domain.

The User of G&D Security Domain can load packages or install applications on the card only after Secure Channel initiation and presentation of a card with a Token during the INSTALL for LOAD command. The Token is an RSA signature generated by the Card Issuer using the Card Issuer’s private key that allows ensuring that the Card Issuer has authorized the load process and the loading of the content of the Load File Data Block and that the Card Issuer has authorized the installation process. If token verification was successful, the card processes the appropriate commands for delegated loading or installation and answers with a receipt, i.e., a Triple-DES MAC generated by the card acknowledging that the operation was performed successfully. For details see [GPCS2.1.1].

4.2.2 GP DAP

If the G&D Security Domain is instantiated with a DAP verification privilege, an applet may be loaded with an optional DAP. If the G&D Security Domain is instantiated with mandated DAP verification privilege, a DAP is always required.

The mechanism designated as “DAP” in [GPCS2.1.1] enables the applet provider to check, independently of the Issuer (Crypto Officer), that his applet has been correctly loaded. This check is done by MAC verification on the Load File. DAP may be generated either using Triple-DES or RSA.

As identified in Section 3.2.1, only DAP verification using full Triple-DES or RSA may be used in the approved mode of operation.

This process is described in the Sm@rtCafé Expert 6.0 Reference Manual [SCE60 RefMan].

4.3 Access Control Security Rules

Keys must be loaded through a Secure Channel and encrypted with the K_{DEK} or SDK_{DEK}. Therefore the keys are always loaded in encrypted form.

Global PIN might only be set or changed in the context of a Secure Channel and encrypted with the key used for sensitive data decryption. Therefore the PIN block is always encrypted with K_{DEK} when transferred in to the cryptographic module. It is double-encrypted (with K_{DEK} and S_{ENC}) if the Secure Channel security level requires command encryption.

4.4 Physical Security Rules

The physical security of the cryptographic module is designed to meet FIPS 140-2 level 3 requirements. The USB token is designed in opaque tamper-evident enclosure (ultrasonic welded) without any gaps or openings.

4.5 Key Management Security Policy

4.5.1 Cryptographic key generation

AES session key for Secure Channel derivation is conforming to [GP2.2, Amendment D]. The random data required for opening a Secure Channel is generated using the DRBG.

RSA and RSA CRT key pair generation is according to [ANSI X9.31] using the DRBG as the approved RNG.

4.5.2 Cryptographic key entry/output

Keys shall always be loaded after having been encrypted with the Sensitive Data Decryption key with the same or higher security strength. The PUT KEY command for adding or replacing keys or key sets may only be issued within a Secure Channel. During this process, the keys are double encrypted (using the session key S_{ENC} or KSC_{ENC} and the sensitive data encryption key K_{DEK} or SDK_{DEK}), provided that the Secure Channel security level is set to C_MAC and C_DECRYPTION.

The Security Domain key sets that were loaded onto the cryptographic module can be replaced after successful authentication by loading another key set for Crypto Officer or User using the PUT KEY command.

The PUT KEY command is used to replace the Crypto Officer’s initialization keys K_{INIT_ENC}, K_{INIT_MAC}, and K_{INIT_DEK} with the first new static key set composed of K_{ENC}, K_{MAC}, and K_{DEK}.

The module outputs public keys in non-encrypted form. Other than public keys, no secret keys and private keys or PINs can be output from the module.

4.5.3 Cryptographic key storage

Cryptographic keys stored with the cryptographic module have the following attributes:

- Key Identifier, which identifies each key within an on-card entity,
- An associated Key Version Number, which is used to differentiate between versions of the same key,
- Algorithm Identifier, which determines the associated cryptographic algorithm,
- Integrity Check Value for that key.

Symmetric keys are veiled by XOR calculation with card individual random number.

Exponent of RSA private key is veiled by multiplication with card individual random number.

DP and DQ of RSA CRT private key is veiled by multiplication with card individual random number.

P and Q of RSA CRT private key is veiled by modulo calculation with card individual random number.

PQ of RSA CRT private key is veiled by XOR calculation with card individual random number.

RSA public keys are stored in plaintext along with a generalised Hamming code (GHC) for each key.

ECC keys are veiled by multiplying them with card individual random number and dividing them (modulo the group order) by card individual random number and by XORing them with a card individual random byte string.

Veiled keys are considered plaintext for the purpose of FIPS 140-2 compliance.

4.5.4 Cryptographic key zeroization

The cryptographic module zeroizes cryptographic session keys S_{MAC}, S_{ENC} and KSC_{MAC}, KSC_{ENC} of the Security Domain (Issuer Security Domain and G&D Security Domain) when closing the Secure Channel or at card reset.

The keys for “GP DAP” $K_{DAP,}$ PK_{DAP} can only be updated. In order to delete DAP verification key(s) the Security Domain containing the key must be deleted. This operation deletes all keys contained in that Security Domain.

The keys loaded for Delegated Management K_{Token} and $K_{Receipt}$ can be zeroized by overwriting them with new values using the PUT KEY command.

The Global PIN can be zeroized by overwriting with a new value.

Key Management details can be found in Section 6.

All keys and the Global PIN can be zeroized by setting the card state to TERMINATED with the SET STATUS command.

4.6 Approved mode

The cryptographic module supports FIPS approved mode of operation at all times. However, the module provides certain non-approved functions as internal services to applets loaded on the module via the Java Card API. These services are not accessible to an external user. It is the responsibility of the applet to not use these functions in an approved mode. This will also be checked during the applet’s FIPS 140-2 validation. Please note that only FIPS 140-2 validated applets shall be loaded on the module.

The non-FIPS-approved functions provided by the cryptographic module are listed in Section 7.2. No non-allowed algorithms will be used by the validated module.

The cryptographic module is conforming to the ISO/IEC 7816-3 standard, which defines the Answer-to-Reset (ATR). The Answer-to-Reset is the value of the byte string (at most 32 bytes) returned by the module when it is reset by the interface device. A reset is triggered by an electrical signal to the RST pin. The coding conventions for the ATR are defined in ISO/IEC 7816-3. The transmission and protocol parameters and capabilities and the historical bytes are encoded in the ATR. The historical bytes describe operating characteristics of the cryptographic module. Their structure is as specified in ISO/IEC 7816-4, the content is proprietary.

The Answer-to-Reset (ATR) returned by the module serves as an approved mode indicator. The ATR returned by the Sm@rtCafé Expert 6.0 firmware for chip type P5CC081:

3B FD 18 00 00 80 31 FE 45 53 43 45 36 30 2D 43 43 30 38 31 2D 46 C3

Protocol parameters:	3B FD 18 00 00 80 31 FE 45
Historical bytes:	53 43 45 36 30 2D 43 43 30 38 31 2D 46
Checksum:	C3

The response to GET DATA in the approved mode returned by the Sm@rtCafé Expert 6.0 firmware is:

01 02 xx xx 02 04 xx xx xx xx 03 02 xx xx 04 08 xx xx xx xx xx xx xx xx 05 02 xx xx 07 04 **C0 8B 1F A2** 08 04 xx xx xx xx 09 03 xx xx xx 06 02 xx xx 0A 05 xx xx xx xx xx 0B 02 xx xx 0C 08 **00 00 8F 7D 00 00 00 00** 10 02 xx xx

The GET DATA response contains relevant information for ROM mask identification and self tests settings for FIPS.

The tag for ROM mask identification is ‘07’, the associated value with that tag is always ‘**C0 8B 1F A2**’.

The tag for FIPS-related settings is ‘0C’; it is followed by a variable value that depends on the underlying chip hardware, the enabled cryptographic algorithms and their associated self tests (see chapter 7.4).

The value following tag ‘0C’ has the following interpretation:

Bytes 1 and 2:	self tests during ATR
Bytes 3 and 4:	self tests after ATR before first command
Bytes 5 and 6:	self tests after ATS before first command
Bytes 7 and 8:	self tests during USB mode of operation (this is RFU, not relevant with this chip hardware)

Bytes 1, 3, 5 and 7 have identical format with the following assignment:

bit 7:	SHA-512
bit 6:	not set
bit 5:	RNG
bit 4:	Indicates the RSA modulus length used in self tests on RSA. If set to “0” modulus of 1024 bits is used, else if set to "1", modulus of 2048 bits is used.
bit 3:	ECDSA
bit 2:	ECDH
bit 1:	SHA-256
bit 0:	SHA-1

Bytes 2, 4, 6 and 8 have identical format with the following assignment:

bit 7:	DSA
bit 6:	AES
bit 5:	DES
bit 4:	RSA CRT Private
bit 3:	RSA Private
bit 2:	RSA Public
bit 1:	ROM Checksum
bit 0:	Package Checksum

5 Security Policy Check List Tables

5.1 Roles and Required Authentication

Role	Type of authentication	Authentication data
Crypto Officer	GP secure channel mutual authentication protocol	GP Secure Channel AES key set (Issuer Security Domain)
User / Applet Provider	GP secure channel mutual authentication protocol	GP secure channel AES key set (G&D Security Domain)

5.2 Algorithm Strengths

Algorithm	Bits of security
ECDH with ECDSA in GF(p) with P=192 curve ECDSA in GF(p) with P=224 curve ECDSA in GF(p) with P=256 curve	 80 bits 112 bits 128 bits

5.3 Strength of Authentication Mechanisms

Authentication Mechanism	Strength of Mechanism
Operator authentication based on AES	probability that a random attempt will succeed: > 1:2^{128} (for 128 bits key) > 1:2^{192} (for 192 bits key) > 1:2^{256} (for 256 bits key)

5.4 Services Authorized for Roles

Role	Authorized Services
Crypto Officer	The CO role services are listed in Sections 3.2.1, 3.2.2 and 3.2.3
User / Applet Provider	Services as listed in Sections 3.2.2 and 3.2.3

5.5 Mitigation of Other Attacks

Other Attacks	Mitigation Mechanism	Specific Limitations
Simple Power Analysis	Countermeasures against SPA	N/A
Differential Power Analysis	Countermeasures against DPA	N/A
Timing Analysis	Countermeasures against Timing Analysis	N/A
Differential Fault Analysis	Countermeasures against Differential Fault Analysis	N/A

5.6 Access Rights within Services

CSP	Service	Role	Type of Access
AES CO Static keys K_{ENC}, $K_{MAC,}$ K_{DEK}	PUT KEY	Crypto Officer	Write
AES CO Static keys: K_{ENC}, K_{MAC}	INITIALIZE UPDATE Generate session key for Encryption / Decryption and for Secure Channel Authentication and Secure Channel MAC Verification / Generation	Crypto Officer	Execute
AES CO key K_{DEK}	CHANGE/UNBLOCK PIN Sensitive data decryption	Crypto Officer	Execute
AES CO Session keys S_{ENC}, S_{MAC}	INITIALIZE UPDATE	Crypto Officer	Create
AES CO Session Encryption key S_{ENC}	Data confidentiality	Crypto Officer	Execute
AES CO Session MAC key S_{MAC}	Data and protocol integrity	Crypto Officer	Execute
AES User Static keys: SDK_{ENC}, $SDK_{MAC,}$ SDK_{DEK}, K_{DAP}	PUT KEY, STORE DATA	Crypto Officer and User	Write
AES User Static keys: SDK_{ENC}, SDK_{MAC}	INITIALIZE UPDATE Generate session key for Encryption/Decryption, Secure Channel Authentication and Secure Channel MAC Generation/ Verification	User	Execute
AES User Session Encryption key KSC_{ENC}	Data confidentiality	User	Execute
AES User Session MAC key KSC_{MAC}	Data and protocol integrity	User	Execute
AES User key SDK_{DEK}	Sensitive data decryption	User	Execute
“GP DAP” RSA public key PK_{DAP}, and “GP DAP” Triple-DES key K_{DAP}	PUT KEY	Crypto Officer	Write
“GP DAP” Triple-DES key K_{DAP}	LOAD (Signature verification of Load File Data Block Hash)	Crypto Officer and User	Execute
“GP DAP” RSA public key PK_{DAP}	LOAD (Signature verification of Load File Data Block Hash)	Crypto Officer and User	Execute
Delegated Management keys $K_{Receipt}$, K_{Token}	PUT KEY	Crypto Officer	Write
Delegated Management Triple-DES key $K_{Receipt}$	LOAD	Crypto Officer	Execute
Delegated Management RSA key K_{Token}	LOAD	Crypto Officer	Execute
Global PIN	CHANGE/UNBLOCK PIN	Crypto Officer	Write

6 Cryptographic Key Management

The cryptographic module with one G&D Security Domain includes the following keys:

- Initialization key set (K_{INIT_ENC}, K_{INIT_MAC}, K_{INIT_DEK}) that is used only for the first Card Manager key set loading.

- Security Domain (Issuer Security Domain and G&D Security Domain) key sets each containing three static AES keys stored in EEPROM. The key sets contain keys of one of the supported key sizes (128, 192, or 256 bits).

- K_{ENC}/SDK_{ENC} used for Crypto Officer/User authentication for Secure Channel initiation per GP Specification.

- K_{MAC}/SDK_{MAC} used for Crypto Officer/User authentication for Secure Channel initiation per GP Specification.

- K_{DEK} used by the Crypto Officer
  - as key wrapping key for encrypting keys input into the module using the PUT KEY command.
  - to change the Global PIN via the CHANGE / UBLOCK PIN command.

- SDK_{DEK} is the key wrapping key for encrypting keys input into the module by the User via the PUT KEY command.

- Security Domain Session Secure Channel keys are stored in RAM. These keys are derived from the Static Secure Channel keys. The supported AES key lengths for session keys are 128, 192, and 256 bits.
  - Secure Channel Session Encryption key S_{ENC} (derived from K_{ENC}) of Crypto Officer.
  - Secure Channel Session MAC Verification key S_{MAC} (derived from K_{MAC}) of Crypto Officer.
  - Secure Channel Session Encryption key KSC_{ENC} (derived from SDK_{ENC}) of User.
  - Secure Channel Session MAC Verification key KSC_{MAC} (derived from SDK_{MAC}) of User.

- “GP DAP” 112 bits Triple-DES key used for DAP verification using Triple-DES MAC.

- “GP DAP” 1024 bits RSA public key used for DAP verification using RSA signature verification.

- Delegated Management RSA key K_{Token} for Token verification that is used check if Delegated Management command is authorized by Crypto Officer.

- Delegated Management Triple-DES key $K_{Receipt}$ for Receipt generation that is used to prove successful execution of Delegated Management command.

All keys can be zeroized by setting the card state to TERMINATED.

7 Standards-Based Cryptography

7.1 FIPS approved algorithms

The cryptographic module implements strong, standards-based cryptography. It includes the following FIPS approved algorithms:

- AES with 128, 192, and 256 bits key lengths (ECB and CBC modes), Cert. #1755
- 2 key Triple-DES (ECB and CBC modes), Cert. #1136
- 3 key Triple-DES (ECB and CBC modes), Cert. #1136
- RSA with up to 2048 bits modulus length, Cert. #874
- RSA CRT with up to 2048 bits modulus length, Cert. #874. As validated, the module does not support this algorithm. Please refer to Section 2.1 for information on post-validated applets.
- ECDSA in GF(p) with P=192, P=224 and P=256 curves, Cert. #232. As validated, the module does not support this algorithm. Please refer to Section 2.1 for information on post-validated applets.
- SHA-1 hash functions, Cert. #1542
- SHA-224, SHA-256, SHA-384, and SHA-512, Cert. #1542. As validated, the module does not support this algorithm. Please refer to Section 2.1 for information on post-validated applets.
- CMAC, Cert. #1755
- Triple-DES MAC acc. to [ISO/IEC 9797-1]. As validated, the module does not support this algorithm. Please refer to Section 2.1 for information on post-validated applets.
- DRBG (Deterministic Random Number Generator), Cert. #116

7.2 The non-FIPS approved algorithms

The cryptographic module includes the following non-FIPS approved algorithms:

- DES
- DSA
- RSA Encryption and Decryption
- Korean SEED
- RIPEMD-160
- MD5

As validated, besides AES Key Wrapping, the module does not use the algorithms listed here for FIPS purposes. This validation considers these algorithms to be dead code without an applet. Please refer to Section 2.1 for information on post-validated applets.

7.3 Other algorithms allowed in FIPS mode

The cryptographic module includes the following algorithms that are non-FIPS approved but allowed to be used in FIPS approved mode:

- AES (Cert. #1755, key wrapping; key establishment methodology provides 128 to 256 bits of encryption strength)
- TRNG (nondeterministic hardware RNG)

- ECDH Key Agreement Scheme with cofactor multiplication, acc. to [IEEE P1363] . As validated, the module does not use support this algorithm. This validation considers these algorithms to be dead code without an applet. Please refer to Section 2.1 for information on post-validated applets.

7.4 Self-Tests

The cryptographic module runs start-up and conditional self tests to verify that it is functioning properly. The power-up self tests are performed when the module is powered up and before the module processes the first command it receives after reset. Conditional self-tests are be performed when an applicable security function or operation is invoked.

The operator can initiate module self-tests by issuing an APDU command after a card reset.

7.4.1 Power-Up Tests

Cryptographic algorithm test

A cryptographic algorithm test using a known answer test (KAT) is conducted when the module is powered up for the following cryptographic functions:

- AES
- Triple-DES
- RSA Signature Generation and Signature Verification
- RSA CRT Signature Generation
- ECDSA Signature Generation and Signature Verification
- SHA-1
- SHA-256
- SHA-512
- CMAC
- DRBG

Software/Firmware integrity test

A software/firmware integrity test using an error detection code is applied to all validated software and firmware components within the cryptographic module when the module is powered up. The module checks the integrity of the following components:

- Firmware in EEPROM: 32 bits Reed Solomon EDC
- Java Code in EEPROM: 16 bits hardware CRC

A known-answer test involves operating the cryptographic algorithm on input data for which the correct output is already known and comparing the calculated output with the previously generated output (the known answer). If the calculated output does not equal the known answer, the known-answer test fails.

7.4.2 Conditional Tests

Conditional pairwise consistency test

After generating an RSA or RSA CRT key pair the cryptographic module tests the consistency of the generated keys by calculating and verifying a digital signature with those keys.

Software/firmware load test

If Java Card applets are externally loaded into the cryptographic module, then the following software load test is performed.

Loading Java code to the module is only possible by the Crypto Officer after successful authentication that is achieved through the process of initiating a Secure Channel providing assurance to both the cryptographic module and the Crypto Officer that they are communicating with an authenticated entity. If any step in the mutual authentication process fails, the process shall be restarted, i.e. new challenges and Secure Channel session keys shall be generated.

Applets shall only be loaded via a Secure Channel requiring at least MAC verification over each Load block. All commands for loading shall be secured by a MAC and/or encrypted with session keys, depending on security level for the Secure Channel session.

Java code may be secured by data authentication pattern (DAP) that is specified in [GPCS2.1.1]. Data authentication pattern (DAP) verification provides a mechanism used by a Security Domain to verify that a Load File Data Block is authentic. The following verification modes for Load File DAP are allowed in FIPS approved mode:

- 2-key Triple-DES MAC (“full Triple-DES MAC” acc. to [GPCS2.1.1], B.1.2.1) using the K_{DAP} key.
- 1024-bits RSA SSA-PKCS1-v1_5 signature as defined in PKCS#1 is applied to a SHA-1 digest of the data being signed, i.e. the Load File Block ([GPCS2.1.1], B.2.1 and B.3) using the PK_{DAP}.

Continuous random number generator test

On every output generated by the DRBG the module performs a comparison with the previously generated random block. The first 8 bytes generated by the DRBG after power-up are saved for comparison with the next 8 bytes block to be generated and never used for any service like cryptographic key generation. The test fails if the two compared 8 bytes blocks are equal.

7.4.3 Module behaviour upon self-test failure

If the cryptographic module fails a self-test, the module enters an error state and outputs an error indicator via the status output interface. The cryptographic module will not perform any cryptographic operations while in an error state. All data output via the data output interface shall be inhibited when an error state exists.

While the module is in error state, no further communication is possible with the module. To exit the error state and to resume normal operation, the module is to be removed from the terminal and re-inserted or the terminal has to reset the module.

8 Mitigation of Attacks

The module implements countermeasures for the following attacks commonly used against smart cards: simple power analysis (SPA), differential power analysis (DPA), and timing analysis. These attacks work by monitoring the power consumption (SPA, DPA) or timing of operations during cryptographic processing in order to gain information about sensitive content, such as secret keys.

The module’s IC has a co-processor for performing AES, DES and Triple-DES operations. This co-processor was specifically designed by NXP to counter SPA, DPA, and timing analysis attacks. G&D has conducted testing of the module’s AES, DES and Triple-DES processing for resistance to these attacks and found that no information was leaked during this processing via these attacks.

The module’s RSA and ECDSA implementations have been hardened against SPA, DPA, fault and timing analysis using a variety of techniques. G&D has conducted testing of the module’s RSA and ECDSA processing for resistance to these attacks and found that no information was leaked during this processing via these attacks. For timing analysis, the timing of the implementation does not correlate to the inputs to the implementation. To counter SPA, data-dependent conditional jumps are avoided. Randomization of the RSA base and exponent is employed to counter DPA. ECDSA implementation includes SPA and DPA countermeasures in the point multiplication algorithm, in the modular inversion and in the computation of the ECDSA signature components.

9 Acronyms

APDU	Application Protocol Data Unit
ATR	Answer-To-Reset
CBC	Cipher-Block Chaining
CMAC	Cipher-based MAC
CSP	Critical Security Parameter
CO	Crypto Officer
CO	Clear-On-Deselect
COR	Clear-On-Reset
CRT	Chinese Remainder Theorem
CRC	Cyclic Redundancy Check
DAP	Data Authentication Pattern
DES	Data Encryption Standard
DPA	Differential Power Analysis
DRBG	Deterministic Random Bit Generator
DSA	Digital Signature Algorithm
EDC	Error Detection Code
EEPROM	Electrically Erasable Programmable ROM
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
FCC	Federal Communication Commission
GHC	Generalized Hamming Code
I/O	Input/Output
IC	Integrated Circuit
JCAPI	Java Card™ Application Programming Interface
JCRE	Java Card™ Runtime Environment
JCVM	Java Card™ Virtual Machine
KAT	Known Answer Test
MAC	Message Authentication Code
N/A	Not Applicable
GP	GlobalPlatform
PIN	Personal Identification Number
PKCS	Public Key Cryptography Standards
RAM	Random Access Memory
RNG	Random Number Generator
ROM	Read Only Memory
RSA	Rivest Shamir Adleman
RST	Reset
SCP	Secure Channel Protocol
SHA	Secure Hash Algorithm
SPA	Simple Power Analysis
TDEA	Triple Data Encryption Algorithm
TDES	Triple-DES
TRNG	True RNG