AN12543

SE05x IoT applet APDU Specification

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Application note

Document information

Information	Content
Keywords	SE05x IoT Applet, Internet of Things, Secure Element
Abstract	This document provides the API description of the EdgeLock SE05x Plug & Trust secure element family.

1 Introduction

1.1 Context

SE05x is designed to be used as a part of an IoT system. It works as an auxiliary security device attached to a host controller. The host controller communicates with SE05x through an I^2C interface (with the host controller being the I^2C controller and the SE05x being the target). Besides the mandatory connection to the host controller, the SE05x device can optionally be connected to a sensor node or similar element through a separate I^2C interface. In this case, the SE05x device is the I^2C controller and the sensor node the target. Lastly, SE05x has a connection for a native contactless antenna, providing a wireless interface to an external device such as a smartphone.

Note: *With regards to the SE050 product family, this document is meant for the SE050E variant. For SE050F, please see AN12413.*

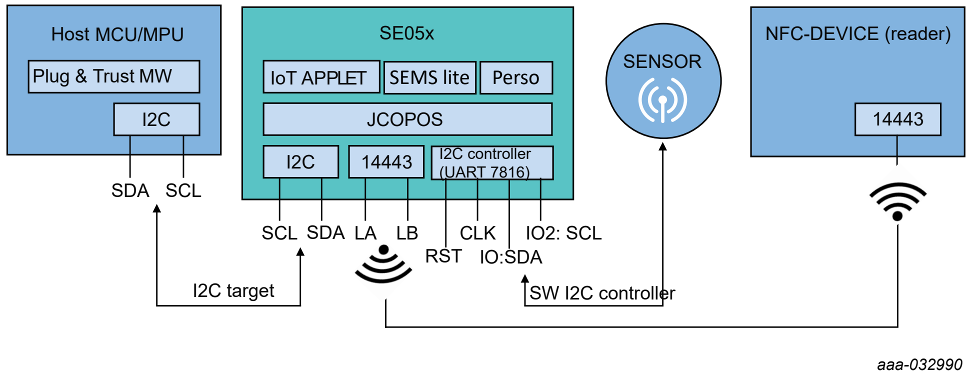


Figure 1. SE05x solution block diagram

The SE05x provides a wide range of (cryptographic) possibilities. Note that users need to be aware of the cryptographic principles when using the functionality of SE05x for the intended use cases.

Additional guidance is available in [UserGuidelines], each variant comes with a dedicated UGM.

2 SE05x architecture

2.1 Security Domain layout

NXP is in control of the Supplementary Security Domain (SSD) which holds the SE05x IoT applet.

The AID of the NXP IoT SSD is D276000085304A434F9003.

2.2 SE05x applet

The instance AID for SE05x IoT applet - pre-provisioned by NXP - is A00000039654530000000103000000000.

The applet version used in a SE05x configuration is described in the product’s configuration sheet.

The APDU buffer size is 270 bytes.

Internally, the SE05x IoT applet is using a command and response buffer of 1024 bytes. Any command that does not specify specific limitations on input and output is restricted by this buffer size of 1024 bytes.

3 SE05x IoT applet functionality overview

This section provides an overview of the functionalities of the SE05x IoT applet.

Not all functionalities are available on each product type; for the supported functionalities for a specific product variant, refer to the SE050, SE051 or SE052 configuration datasheet respectively.

3.1 Supported functionality

The SE05x IoT applet supports:

- Generic module management
  - Lifecycle management
  - Session management
  - Timer functionality
  - Access control
  - Secure import/export of keys or files
- applet Secure Channel management
  - AESKey sessions (previously called SCP03)
  - ECKey sessions (previously called FastSCP)
- Random number generation
- Key management (ECC, RSA, AES, 3DES, etc.): write, read, lock, delete
- Elliptic curve cryptographic operations
- RSA cryptographic operations
- AES modes: ECB, CBC, CTR, GCM, CCM
- Random Initialization Vector generation for AES mode CTR, GCM and CCM.
- Binary file creation and management
- UserID creation and management
- Monotonic counter creation and management
- PCR creation and management
- Hash operations
- Message authentication code generation
  - CMAC
  - HMAC
  - GMAC
- Key derivation functionality
  - HKDF
  - PBKDF2
- Specific use case support
  - TLS PSK master secret calculation
  - MIFARE DESFire protocol support
  - I^2C Controller support

3.2 SE05x Secure Objects

3.2.1 Classes

The SE05x has one base object type called *Secure Object*. A Secure Object can be derived to classes depicted in Figure 2:

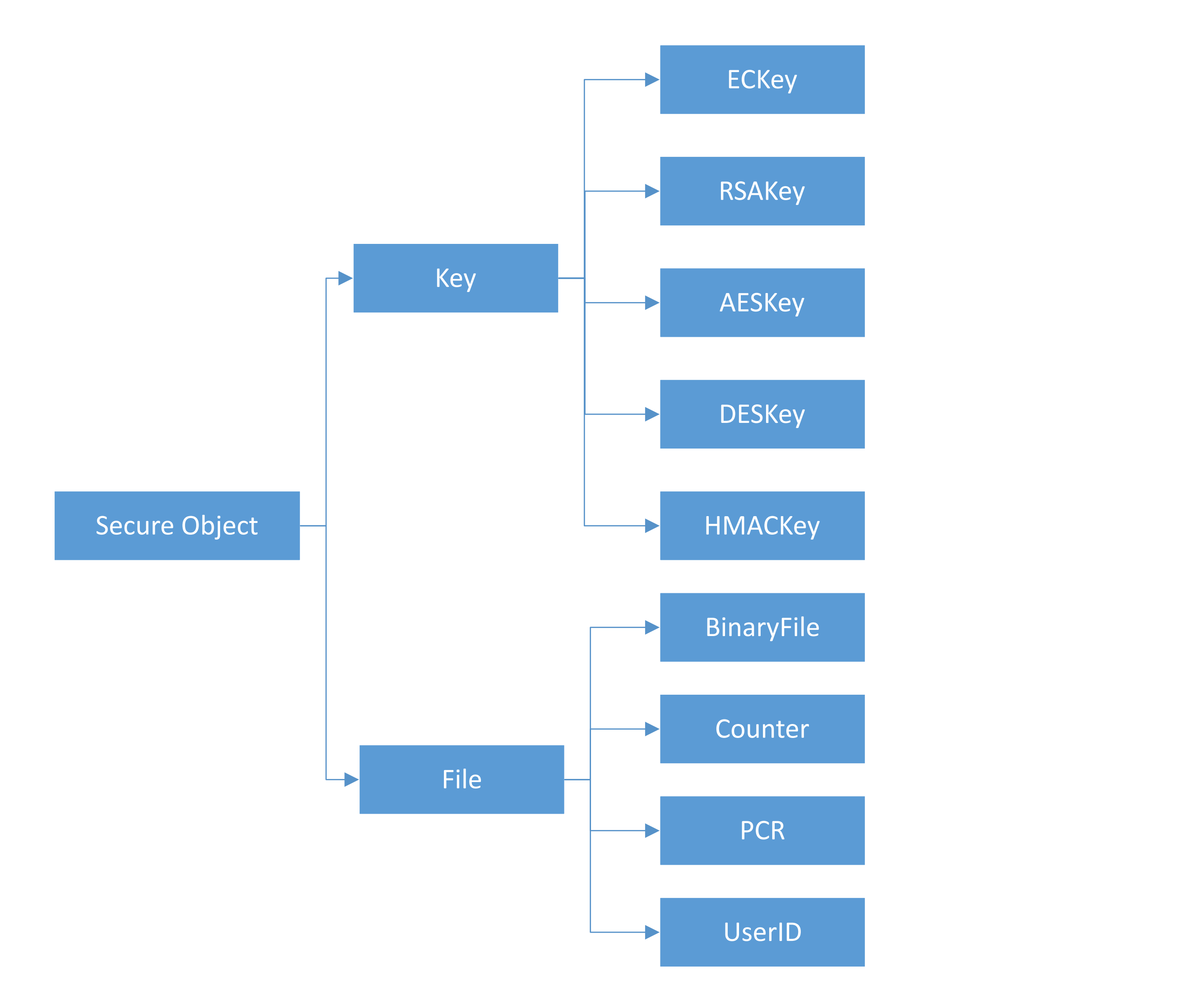


Figure 2. SE05x Secure Object structure

3.2.1.1 ECKey

An ECKey object is any elliptic curve key type (key pair/private key/public key), either transient (Cleared on Deselect (CoD)) or persistent. ECKey objects are linked to one of the supported EC curves (listed in Section 4.3.20).

EC private keys are always stored in a ECPrivateKey object which size is exactly equal to EC curve bit size.

EC public keys are represented in uncompressed form for all curves in Weierstrass form; i.e., a byte array starting with 0x04 followed by the X and Y coordinates concatenated. Both X and Y are again exactly equal to the EC curve bit size.

For the Edwards curve 25519 (ECC_ED_25519), public and private keys to be used for signature operations (sign/verify).

For the Montgomery curve 25519 (ECC_MONT_DH_25519), public and private keys are to be used for key agreement operations.

For the Montgomery curve 448 (ECC_MONT_DH_448), public and private keys are to be used for key agreement operations.

When the rules for the length of the keys are not strictly applied, using the stored key can lead to a system reset of the device.

Table 1. Supported EC curves

Name	Weierstras	Private key byte length	Public key byte length	Remarks
UNUSED	-			
NIST_P192	Y	24	49	
NIST_P224	Y	28	57	
NIST_P256	Y	32	65	
NIST_P384	Y	48	97	
NIST_P521	Y	66	133	
Brainpool160	Y	20	41	
Brainpool192	Y	24	49	
Brainpool224	Y	28	57	
Brainpool256	Y	32	65	
Brainpool320	Y	40	81	
Brainpool384	Y	48	97	
Brainpool512	Y	64	129	
Secp160k1	Y	20	41	
Secp192k1	Y	24	49	
Secp224k1	Y	28	57	
Secp256k1	Y	32	65	
ID_ECC_ED_25519	N	32	32	Edwards curve 25519 to be used for EdDSA sign/verify operations. See Section 7 for correct byte order..
ID_ECC_ED_448	-	-	-	Edwards curve 448 (to be used for EdDSA sign/verify operations): Not Available for use.
ID_ECC_MONT_DH_25519	N	32	32	Montgomery curve 25519 to be used for shared secret generation. See Section 7 for correct byte order.
ID_ECC_MONT_DH_448	N	56	56	Montgomery curve 448 to be used for shared secret generation. See Section 7 for correct byte order.

3.2.1.2 RSAKey

An RSAKey object is any RSA key type (key pair/private key/public key), either transient (Cleared on Deselect) or persistent. The private key can be in CRT or in raw format.

In CRT format, the key components must match the size of the key type, e.g. for RSA2048, each component must be 2048 bit (256 bytes). In raw format, keys must match the key type.

3.2.1.3 AESKey

An AESKey object is any AES key of size 128 bit, 192 bit, or 256 bit, either transient (Cleared on Deselect) or persistent.

3.2.1.4 DESKey

A DESKey object is any DES key, either transient (Cleared on Deselect) or persistent.

DESKey objects store the keys including parity bits, so the length is either 8 bytes, 16 bytes, or 24 bytes respectively for DES, 2-key 3DES and 3-key 3DES. The value of the parity bits is not checked inside the SE05x.

3.2.1.5 HMACKey

An HMACKey object is a secret of any length, 1 byte up to 256 bytes. Typically, it is used as input for message authentication codes or key derivation functions when the key material is not 16 bytes or 32 bytes in length. It can be either transient or persistent.

3.2.1.6 BinaryFile

A BinaryFile object is a file containing a byte array of a specific length (minimum 1 byte). Files are initialized by default with all 0x00. It can be either transient (Cleared on Deselect) or persistent.

The transient binary files are reset to zero on deselection or actual reset. The maximum file size is 0x7FFF bytes.

3.2.1.7 Counter

A counter object is a monotonic counter, either transient (Cleared on Deselect) or persistent. A monotonic counter can only be incremented and not be decremented to a lower value. Note that transient counters are an exception as the value is reset to all zeroes on a deselect. Its length is 1 byte up to 8 bytes.

3.2.1.8 PCR

A Platform Configuration Register (PCR) object is a 32-byte array that holds the value of a SHA256. PCRs can be either persistent or transient. Transient PCRs are reset on deselect of the applet (ClearOnDeselect); the initial value is restored once the applet is selected.

Persistent PCRs are reset using the WritePCR APDU.

PCRs are created with any initial value and can be updated by sending data to the PCR; i.e., extend the PCR. PCRs can be reset or deleted, but this is typically protected and not possible for users who create and extend PCRs.

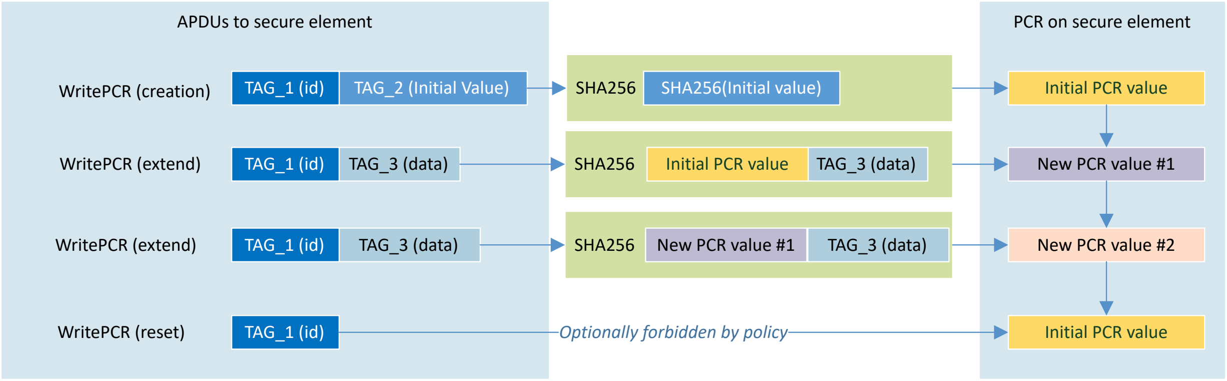


Figure 3. Example PCR sequence

PCRs can be used in object policies to enforce actions, being available only when a PCR value matches the expected value. This can be used, for instance, to enforce an integrity check on a chain of boot loaders.

3.2.1.9 UserID

A User ID object is a value which is used to logically group secure objects. UserID objects can only be created as Authentication objects (see Section 3.2.3). They cannot be updated once created (i.e. the value of an existing UserID can not be changed). A session that is opened by a UserID Authentication Object is not applying secure messaging (so no encrypted or MACed communication).

By default, the maximum number of allowed authentication attempts is set to infinite. Its length is 4 bytes up to 16 bytes. It is intended for use cases where a trusted operating system on a host MCU/MPU is isolating applications based e.g. on application ID.

3.2.2 Object types

3.2.2.1 Persistent objects

A persistent Secure Object is fully stored in non-volatile memory, so the content and all the Secure Object attributes are stored persistently.

3.2.2.2 Transient objects

A transient object exists in non-volatile memory, but the transient object content exists in transient memory until the applet is deselected. Therefore, the objects survive a deselect, but the object contents will not survive. Keys will become invalid until they are set again, Files will have content being reset to all zero, except for PCRs, these will restore the initial value.

The Secure Object attributes are stored persistently, these remain unchanged after reselect.

A Secure Object can be constructed to be a transient object by setting the INS_TRANSIENT flag in the INS byte of a C-APDU when creating a Secure Object.

Transient objects can only be used in sessions owned by the user (see Users) who created the object. For example, if user ‘00000001’ creates a transient object, this object can only be accessed in sessions opened by this user. The same concept applies to the default session. Transient objects created within the default session can only be accessed in the context of the default session.

If a user tries to access a transient object created by another user, the applet rejects the command with SW ‘6985’.

Note that transient Secure Objects can be deleted by any user to which the policy POLICY_OBJ_ALLOW_DELETE is assigned, so deletion is not restricted to the session owner.

importExternalObject cannot be used for transient objects.

3.2.3 Authentication object

An Authentication Object is a Secure Object that can only be used to open a session. Sessions cannot be opened by objects that are not Authentication Objects. Authentication Objects are always persistent, transient Authentication Objects are not supported.

Strictly speaking, UserIDs are not Authentication Objects as they do not feature security properties of authentication credentials, but as they also use the session concept (described in UserID session).

A Secure Object can be constructed to be an Authentication Object by setting a flag in the INS byte of a C-APDU. Authentication objects can only be of class ECKey, AESKey (only 128 bit) or UserID.

For Authentication Objects of type ECKey, the public key component will be used on the secure element (so either ECPublicKey or ECKeyPair objects) and only Weierstrass curves can be used for Authentication Objects, using others curves will lead to authentication failure.

Note that available policies for Authentication Objects are restricted (see Section 3.7.4 for more details).

Table 2 describes the supported Secure Object types

Table 2. Valid Authentication Object types

Secure Object type	Max. authentication attempt range	Default max. authentication attempts
UserID	[0-255]	Unlimited (= 0)
AESKey (128 bit only)	[0-0x7FFF]	Unlimited (= 0)
ECKey (public key on Weierstrass curve)	[0-0x7FFF]	Unlimited (= 0)

3.2.3.1 Users

A user is the entity that opens a session on the secure element.

For the default session, anyone can be the user (as that session is not protected by authentication).

For an authenticated session, the user is defined by the authentication object that is used to authenticate to the SE05x. Thus, anyone who knows the content of the authentication object can use it to perform a successful session setup and in that way become a user. There is no distinction on whoever is using the authentication object; the authentication object that is used becomes the reference to the user.

3.2.4 Object attributes

Each Secure Object has a number of attributes assigned to it. These attributes are listed in Table 3 for Authentication Objects and in Table 4 for non-Authentication Objects.

Table 3. Authentication Object attributes

Attribute	Size (bytes)	Description
Object identifier	4	See Object identifiers
Object class	1	See Object class

Table 3. Authentication Object attributes*...continued*

Attribute	Size (bytes)	Description
Authentication indicator	1	See Authentication indicator
Authentication attempts counter	2	See Authentication attempts counter
Session Owner identifier	4	See Session Owner identifier
Maximum authentication attempts	2	See Maximum authentication attempts
Policy	Variable	See Policy
Origin	1	See Origin
Version	4	See Version

Table 4. non-Authentication Objects

Attribute	Size (bytes)	Description
Object identifier	4	See Object identifiers
Object type	1	See Object type
Authentication indicator	1	See Authentication indicator
Minimum tag length for AEAD operations	2	See Minimum tag length for AEAD operations
Session Owner identifier	4	See Session Owner identifier
Minimum output length	2	See Minimum output length
Policy	Variable	See Policy
Origin	1	See Origin
Version	4	See Version

3.2.4.1 Object identifier

Each Secure Object is addressed using a 4-byte unique identifier. A Secure Object identifier is in the range of [0x00000001-0xFFFFFFFF], range of [0x7FFF0000-0x7FFFFFFF] is reserved for NXP. The identifier 0x00000000 is invalid and shall not be used. An object identifier is assigned when a new object is created.

The Table 5 below lists all the object identifiers which are reserved for specific purposes, such as applet configuration and management.

Table 5. Reserved file identifiers

Identifier	Description
0x00000000	Invalid object identifier
0x7FFF0200	RESERVED_ID_TRANSPORT
0x7FFF0201	RESERVED_ID_ECKEY_SESSION
0x7FFF0202	RESERVED_ID_EXTERNAL_IMPORT
0x7FFF0204	RESERVED_ID_FEATURE

Table 5. Reserved file identifiers*...continued*

Identifier	Description
0x7FFF0205	RESERVED_ID_FACTORY_RESET
0x7FFF0206	RESERVED_ID_UNIQUE_ID
0x7FFF0207	RESERVED_ID_PLATFORM_SCP
0x7FFF0208	RESERVED_ID_I2CM_ACCESS
0x7FFF0209	RFU
0x7FFF020A	RESERVED_ID_RESTRICT
0x7FFF020B	RESERVED_ID_DESFIRE_CRC_TABLE
0x7FFF020C	RESERVED_ID_SELFTEST_INFO
0x7FFF0210	RESERVED_ID_SPAKE2+_M_P256_UNCOMPRESSED
0x7FFF0211	RESERVED_ID_SPAKE2+_N_P256_UNCOMPRESSED
0x7FFF0212	RESERVED_ID_SPAKE2+_M_P384_UNCOMPRESSED
0x7FFF0213	RESERVED_ID_SPAKE2+_N_P384_UNCOMPRESSED
0x7FFF0214	RESERVED_ID_SPAKE2+_M_P521_UNCOMPRESSED
0x7FFF0215	RESERVED_ID_SPAKE2+_N_P521_UNCOMPRESSED
0x7FFF1000	RESERVED_ID_SELFTEST_GCM_ENC_CMD
0x7FFF1001	RESERVED_ID_SELFTEST_GCM_ENC_RESP
0x7FFF1002	RESERVED_ID_SELFTEST_GCM_DEC_CMD
0x7FFF1003	RESERVED_ID_SELFTEST_GCM_DEC_RESP
0x7FFF1004	RESERVED_ID_SELFTEST_TLS_KDF_CMD
0x7FFF1005	RESERVED_ID_SELFTEST_TLS_KDF_RESP
0x7FFF1006	RESERVED_ID_SELFTEST_SP80056C_KDF_CMD
0x7FFF1007	RESERVED_ID_SELFTEST_SP80056C_KDF_RESP
0x7FFF1008	RESERVED_ID_SELFTEST_PBKDF2_CMD
0x7FFF1009	RESERVED_ID_SELFTEST_PBKDF2_RESP
0x7FFF100A	RESERVED_ID_SELFTEST_GCM_KEY
0x7FFF100B	RESERVED_ID_SELFTEST_TLS_KDF_KEY
0x7FFF100C	RESERVED_ID_SELFTEST_PBKDF2_KEY
0x7FFF2000	RESERVED_ID_SPAKE2+_PINCODES_SALTS
0x7FFF2011..0x7FFF202F	See ReservedIDs for SPAKE2+ verifiers
0x7FFF2030	RESERVED_ID_ECKEY_INTERNAL_SIGN
0x7FFF2031	RESERVED_ID_INTERNAL_SIGN_TBS_LIST

3.2.4.1.1 Default configuration

By default, each device will be initialized with the following base configuration:

- EC NIST P-256 curve created and set

Note that the reserved identifiers might have a credential associated (during NXP Trust Provisioning) or not. If no associated credential is present (i.e., the identifier is reserved, but no credential is set), users can create a credential for that particular identifier.

The reserved identifiers are detailed in the next sections.

3.2.4.1.1.1 RESERVED_ID_TRANSPORT

An authentication object which allows the user to switch SetLockState of the applet. The LockState defines whether the applet is transport locked or not.

3.2.4.1.1.2 RESERVED_ID_ECKEY_SESSION

A device unique key pair which contains the SE05x Key Agreement key pair in ECKey session context. See ECKey session.

3.2.4.1.1.3 RESERVED_ID_EXTERNAL_IMPORT

A device unique key pair which contains SE05x Key Agreement key pair in ECKey session context; A constant card challenge (all zeroes) is used in order to be able to pre-calculate the encrypted session commands. See Secure Object external import.

3.2.4.1.1.4 RESERVED_ID_FEATURE

An authentication object which allows to change the applet variant. This object is created and owned by NXP to define the supported feature set.

3.2.4.1.1.5 RESERVED_ID_FACTORY_RESET

An authentication object which allows the user to execute the DeleteAll command which deleted all Secure Objects except objects with Origin set to "ORIGIN_PROVISIONED".

3.2.4.1.1.6 RESERVED_ID_UNIQUE_ID

A BinaryFile Secure Object which holds the device unique ID. This file cannot be overwritten or deleted.

3.2.4.1.1.7 RESERVED_ID_PLATFORM_SCP

An authentication object which allows the user to change the platform SCP requirements, i.e. make platform SCP mandatory or not, using SetPlatformSCPRequest. Mandatory means full security, i.e. command & response MAC and encryption. Only platform SCP03 will be sufficient, not applet session SCP.

3.2.4.1.1.8 RESERVED_ID_I2CM_ACCESS

An authentication object which grants access to the I2C master feature. If the credential is not present, access to I2C master is allowed in general. Otherwise, a session using this credential shall be established and I2CM commands shall be sent within this session.

3.2.4.1.1.9 RESERVED_ID_RESTRICT

An authentication object which grants access to the DisableObjectCreation command.

3.2.4.1.1.10 RESERVED_ID_DESFIRE_CRC_TABLE

A BinaryFile object - pre-provisioned by NXP - that holds the Mifare CRC32 table. This is only required when using DESFire APDUs. The policy that is applied does not allow file deletion or modification, except sessions opened by RESERVED_ID_FEATURE.

3.2.4.1.1.11 RESERVED_ID_SELFTEST_INFO

A BinaryFile object - pre-provisioned by NXP - that holds the information for applet self tests if the product supports FIPS 140-3. The content is read-only and internally interpreted by the applet for self test purpose.

3.2.4.1.1.12 RESERVED_ID_SPAKE2+_M_P256_UNCOMPRESSED

An ECKey pair object that has ALLOW_READ policy for all users and contains the value of M for SPAKE2+ for P-256 in uncompressed format.

3.2.4.1.1.13 RESERVED_ID_SPAKE2+_N_P256_UNCOMPRESSED

An ECKey pair object that has ALLOW_READ policy for all users and contains the value of N for SPAKE2+ for P-256 in uncompressed format.

3.2.4.1.1.14 RESERVED_ID_SPAKE2+_M_P384_UNCOMPRESSED

An ECKey pair object that has ALLOW_READ policy for all users and contains the value of M for SPAKE2+ for P-384 in uncompressed format.

3.2.4.1.1.15 RESERVED_ID_SPAKE2+_N_P384_UNCOMPRESSED

An ECKey pair object that has ALLOW_READ policy for all users and contains the value of N for SPAKE2+ for P-384 in uncompressed format.

3.2.4.1.1.16 RESERVED_ID_SPAKE2+_M_P521_UNCOMPRESSED

An ECKey pair object that has ALLOW_READ policy for all users and contains the value of M for SPAKE2+ for P-521 in uncompressed format.

3.2.4.1.1.17 RESERVED_ID_SPAKE2+_N_P521_UNCOMPRESSED

An ECKey pair object that has ALLOW_READ policy for all users and contains the value of N for SPAKE2+ for P-521 in uncompressed format.

3.2.4.1.1.18 RESERVED_ID_SELFTEST_GCM_ENC_CMD

A BinaryFile object that has ALLOW_READ policy for all users, containing a self-test Command APDU for AES128 GCM encryption.

3.2.4.1.1.19 RESERVED_ID_SELFTEST_GCM_ENC_RESP

A BinaryFile object that has ALLOW_READ policy for all users, containing a self-test Response APDU for AES128 GCM encryption.

3.2.4.1.1.20 RESERVED_ID_SELFTEST_GCM_DEC_CMD

A BinaryFile object that has ALLOW_READ policy for all users, containing a self-test Command APDU for AES128 GCM decryption.

3.2.4.1.1.21 RESERVED_ID_SELFTEST_GCM_DEC_RESP

A BinaryFile object that has ALLOW_READ policy for all users, containing a self-test Response APDU for AES128 GCM decryption.

3.2.4.1.1.22 RESERVED_ID_SELFTEST_TLS_KDF_CMD

A BinaryFile object that has ALLOW_READ policy for all users, containing a self-test Command APDU for TLS KDF.

3.2.4.1.1.23 RESERVED_ID_SELFTEST_TLS_KDF_RESP

A BinaryFile object that has ALLOW_READ policy for all users, containing a self-test Response APDU for TLS KDF.

3.2.4.1.1.24 RESERVED_ID_SELFTEST_SP80056C_KDF_CMD

A BinaryFile object that has ALLOW_READ policy for all users, containing a self-test Command APDU for SP800-56C one step KDF.

3.2.4.1.1.25 RESERVED_ID_SELFTEST_SP80056C_KDF_RESP

A BinaryFile object that has ALLOW_READ policy for all users, containing a self-test Response APDU for SP800-56C one step KDF.

3.2.4.1.1.26 RESERVED_ID_SELFTEST_PBKDF2_CMD

A BinaryFile object that has ALLOW_READ policy for all users, containing a self-test Command APDU for PBKDF2.

3.2.4.1.1.27 RESERVED_ID_SELFTEST_PBKDF2_RESP

A BinaryFile object that has ALLOW_READ policy for all users, containing a self-test Response APDU for PBKDF2.

3.2.4.1.1.28 RESERVED_ID_SELFTEST_KEY_GCM

An AESKey object that has ALLOW_ENC, ALLOW_DEC and ALLOW_READ policy for all users, containing a key for AES GCM self testing.

3.2.4.1.1.29 RESERVED_ID_SELFTEST_KEY_TLS_KDF

An AESKey object that has ALLOW_TLS_KDF, ALLOW_TLS_KDF_EXT_RANDOM and ALLOW_READ policy for all users, containing a key for TLS KDF self testing.

3.2.4.1.1.30 RESERVED_ID_SELFTEST_KEY_PBKDF2

An AESKey object that has ALLOW_PBKDF and ALLOW_READ policy for all users, containing a key for PBKDF2 self testing.

3.2.4.1.1.31 RESERVED_ID_SPAKE2+_PINCODES_SALTS

A BinaryFile Secure Object with default policy that contains the pin codes and salts for the precomputed SPAKE2+ verifiers as depicted in RESERVED_IDs for SPAKE2+ verifiers. Offset 0 contains pin code #1 (4 bytes BCD encoded).

Offset 4 contains salt #1 (32 bytes).

Offset 36 contains pin code #2 (4 bytes BCD encoded).

Offset 40 contains salt #2 (32 bytes).

Offset 72 contains pin code #3 (4 bytes BCD encoded).

Offset 76 contains salt #3 (32 bytes).

3.2.4.1.1.32 RESERVED_IDs for SPAKE2+ verifiers

Identifiers in the range of 0x7FFF2010 until 0x7FFF202F can contain precomputed SPAKE2+ verifiers for cipher suite P-256/SHA256/HKDF-SHA256/HMAC-SHA256. They are all stored in HMACKey objects with policy ALLOW_KA for all users.

When provisioned, pin codes and salt will be stored in RESERVED_ID_SPAKE2+_PINCODES_SALTS.

Table 6. Reserved file identifiers for SPAKE2+ verifiers

Identifier	Description
0x7FFF2011	w0 for iteration count 1000, pin code #1 and salt #1.
0x7FFF2012	w0 for iteration count 5000, pin code #1 and salt #1.
0x7FFF2013	w0 for iteration count 10000, pin code #1 and salt #1.
0x7FFF2014	w0 for iteration count 50000, pin code #1 and salt #1.
0x7FFF2015	w0 for iteration count 100000, pin code #1 and salt #1.
0x7FFF2016	w0 for iteration count 1000, pin code #2 and salt #2.
0x7FFF2017	w0 for iteration count 5000, pin code #2 and salt #2.
0x7FFF2018	w0 for iteration count 10000, pin code #2 and salt #2.
0x7FFF2019	w0 for iteration count 50000, pin code #2 and salt #2.
0x7FFF201A	w0 for iteration count 100000, pin code #2 and salt #2.
0x7FFF201B	w0 for iteration count 1000, pin code #3 and salt #3.
0x7FFF201C	w0 for iteration count 5000, pin code #3 and salt #3.
0x7FFF201D	w0 for iteration count 10000, pin code #3 and salt #3.
0x7FFF201E	w0 for iteration count 50000, pin code #3 and salt #3.
0x7FFF201F	w0 for iteration count 100000, pin code #3 and salt #3.
0x7FFF2021	L for iteration count 1000, pin code #1 and salt #1.
0x7FFF2022	L for iteration count 5000, pin code #1 and salt #1.
0x7FFF2023	L for iteration count 10000, pin code #1 and salt #1.

Table 6. Reserved file identifiers for SPAKE2+ verifiers...*continued*

Identifier	Description
0x7FFF2024	L for iteration count 50000, pin code #1 and salt #1.
0x7FFF2025	L for iteration count 100000, pin code #1 and salt #1.
0x7FFF2026	L for iteration count 1000, pin code #2 and salt #2.
0x7FFF2027	L for iteration count 5000, pin code #2 and salt #2.
0x7FFF2028	L for iteration count 10000, pin code #2 and salt #2.
0x7FFF2029	L for iteration count 50000, pin code #2 and salt #2.
0x7FFF202A	L for iteration count 100000, pin code #2 and salt #2.
0x7FFF202B	L for iteration count 1000, pin code #3 and salt #3.
0x7FFF202C	L for iteration count 5000, pin code #3 and salt #3.
0x7FFF202D	L for iteration count 10000, pin code #3 and salt #3.
0x7FFF202E	L for iteration count 50000, pin code #3 and salt #3.
0x7FFF202F	L for iteration count 100000, pin code #3 and salt #3.

3.2.4.1.1.33 RESERVED_ID_ECKEY_INTERNAL_SIGN

An ECKey key pair that contains the policy ALLOW_SIGN | ALLOW_READ | FORBID_EXTERNAL_INPUT_SIGN for all users. The policy FORBID_EXTERNAL_INPUT_SIGN contains the identifier 0x7FFF2031 (= RESERVED_ID_INTERNAL_SIGN_TBS_LIST).

3.2.4.1.1.34 RESERVED_ID_INTERNAL_SIGN_TBS_LIST

The Secure Object with identifier RESERVED_ID_INTERNAL_SIGN_TBS_LIST is used in the policy of the object with identifier RESERVED_ID_ECKEY_INTERNAL_SIGN. Users need to create this object as BinaryFile object to contain the list of identifiers of the Secure Objects that need to be concatenated as input to the internal signature generation of the key pair with identifier RESERVED_ID_ECKEY_INTERNAL_SIGN.

3.2.4.2 Object class

The Object type attribute indicates the class of the Secure Object. See SecureObjectType for the list of supported object types and each associated value.

Note that for ECKey objects, the returned type will always contain the curve ID in the returned value (so SecureObjectType will be > 0x20).

3.2.4.3 Authentication indicator

The Authentication indicator indicates whether the Secure Object is created as an Authentication Object or not.

The value is one of SetIndicator where SET means the Secure Object is created as Authentication Object and NOT_SET means the Secure Object not created as Authentication Object.

3.2.4.4 Authentication attempts counter

The Authentication attempts counter is a 2-byte value that counts the number of failed authentication attempts.

The counter has an initial value of 0 and will only increase if both:

- the Secure Object is an Authentication Object.

- the Maximum Authentication Attempts has been set to a non-zero value.

Resets to 0 when a successful authentication is performed.

If the Authentication Objects is of type UserID, the authentication attempts are not reported (i.e. the attribute value remains 0).

3.2.4.5 Minimum tag length for AEAD operations

The minimum AEAD tag length is a 2-byte value that defines the minimum tag length that is to be used in AEAD (encrypt and decrypt) operations when executing one of the commands:

- AEADInit
- AEADOneShot

This only applies to non Authentication Objects of type SymmKey.

Valid minimum tag lengths must be at least 4 bytes and at most 16 bytes, other values will not be accepted.

3.2.4.6 Session Owner identifier

“Owner” of the secure object; i.e., the 4-byte identifier of the session authentication object when the object has been created. Transient Secure Objects are bound to the Session Owner. They can only be accessed and used when the Session Owner attribute matches the Secure Object used to authenticate the current session.

Persistent Secure Objects are not bound to the Session Owner, these are fully controlled by policy management.

3.2.4.7 Minimum output length

The minimum output length of an HMACKey object that is required when executing one of the commands:

- HKDFExtractAndExpand:
- HKDFExpandOnly
- PBKDF2DeriveKey
- TLSCalculatePreMasterSecret

The minimum output length will only be enforced when the output is stored into a target object, the minimum does not apply when output to host is requested.

The minimum length can be defined in the WriteSymmKey command when creating a new HMACKey.

If the requested length is smaller than the minimum output length, an error will be returned and no data are stored in the target object.

3.2.4.8 Maximum authentication attempts

Maximum number of authentication attempts.

This value can be set when creating a new Secure Object as specified inTable 2.

The default value is 0, which means unlimited.

When this attribute is set (to a non-zero value), the Authentication Object cannot be used for authenticating anymore once the maximum number of authentication attempts is reached.

3.2.4.9 Policy

Variable length attribute that holds the policy of the Secure Object. See Policies for details.

3.2.4.10 Origin

The Origin attribute is a 1-byte field that indicates the Origin of the Secure Object: either externally set (ORIGIN_EXTERNAL), internally generated (ORIGIN_INTERNAL) or trust provisioned by NXP (ORIGIN_PROVISIONED). See Table 32.

This attribute is updated during applet runtime for Secure Objects of type AESKey, DESKey, HMACKey, ECKey, RSAKey, Counter and BinaryFile.

Only Secure Objects of type ECKey and RSAKey can have ORIGIN_INTERNAL.

For Secure Objects of type File, the value is always set to ORIGIN_EXTERNAL or ORIGIN_PROVISIONED.

3.2.4.11 Version

Attribute that holds the version of the Secure Object. Default = 0. See Section 3.10 for details about versioning of Secure Objects.

3.2.5 Secure Object size

The Secure Object size will be reported in bytes:

- For EC keys: the size of the curve is returned, see ECKey for the exact size per curve.
- For RSA keys: the key size is returned (i.e. bit strength of the key in bytes, e.g. 0x80 for RSA1024 keys).
- For AES/DES/HMAC keys, the key size is returned.
- For binary files: the total file size is returned, even when just a part of the object is read.
- For userIDs: the userID can be of any supported length, but 0 will be returned in all cases.
- For counters: the counter length is returned.
- For PCR: the PCR length is returned.

3.2.6 Writing Secure Objects

The 4-byte object identifier is used to write the target object. If an object does not yet exist, it will be created. If an object already exists, the value of the object will be updated.

The attributes of an existing object cannot be modified, except the Authentication attempt counter and the Origin (see Table 7). Also the size or other characteristics (e.g. EC curve or RSA format) of the Secure Object cannot be modified on an existing object.

For any Secure Object op type Key (ECKey, RSAKey, AESKey, DESKey and HMACKey), when the key value is externally generated, the byte size must match exactly the size the expected input size: see Classes for the exact size expected per key type.

When Secure Objects are used as target object to store the output of a C-APDU directly, the target Secure Object byte size must match exactly same size as the expected output size, else the APDU will fail to execute. This is applicable for the APDUs:

- ECDHGenerateSharedSecret: the target Secure Object must equal the length of the shared secret.
- ECPointMultiply: the target Secure Object must equal the length of an uncompressed EC point.
- HKDFExtractAndExpand: the target Secure Object must equal the length of the requested output length (see also minimum output length).
- HKDFExpandOnly: the target Secure Object must equal the length of the requested output length (see also minimum output length).
- PBKDF2DeriveKey: the target Secure Object must equal the length of the requested output length (see also minimum output length).

- TLSCalculatePreMasterSecret: the target Secure Object must equal the length of the TLS pre master secret (see also minimum output length).
- DFDiversifyKey: the target Secure Object must equal the length of an AES128 key.

Table 7. Secure Object Attribute updatability

Attribute	Updatable after object creation
Object identifier	N
Object type	N
Authentication attribute	N
Authentication attempt counter/tag length	Y (only the authentication attempt counter can reset when succesfully authenticating an ECKey session)
Session Owner identifier	N
Maximum authentication attempts/ minimum output length	N
Policy	N
Origin	Y (only applies to Secure Objects of types ECKey, RSAKey, AESKey, DESKey, HMACKey, Counter and BinaryFile, see Object attributes)

3.2.7 Reading Secure Objects

3.2.7.1 Common read operation

Secure Objects can be read by calling ReadSecureObject function, but only non-secret parts can be returned:

- Reading asymmetric keys will only return the public key.
- Reading symmetric keys will return an error as this is not allowed.

3.2.7.2 Reading with attestation

The user can request attestation for the requested Secure Object when calling ReadObject by adding the applicable flag (e.g. INS_ATTEST) into the INS byte of the C-APDU. Next to setting the attestation flag, the user must pass the attestating Secure Object identifier, the attestating algorithm and a 16-byte freshness value as part of the APDU payload. The freshness needs to give the opportunity to avoid replays, so preferably it's (pseudo-)randomized for each attestation request.

If attestation is requested, the R-APDU will contain:

- a TLV containing the value of the Secure Object (if non-secret).
- a TLV containing the chip unique identifier (see RESERVED_ID_UNIQUE_ID).
- a TLV containing the attributes of the Secure Object.
- a TLV containing the Secure Object size.
- a TLV containing a timestamp value.
- a TLV containing the attestation signature.

The signature can only be applied by Secure Objects that have the policy POLICY_OBJ_ALLOW_ATTESTATION. If attestation has been requested and the attestation object identifier does not have the policy attached, a SW_SECURITY_STATUS_NOT_SATISFIED will be returned.

The signature input is a concatenation of:

- the (plain) C-APDU header + payload (i.e. the complete APDU except the Le bytes) hashed with a digest that matches the bit strength of the requested attestation algorithm (e.g. SHA384 for SIG_ECDSA_SHA_384).
- the TLV in the R-APDU containing the value of the Secure Object.
- the TLV in the R-APDU containing the chip unique identifier.
- the TLV in the R-APDU containing the attributes of the Secure Object.
- the TLV in the R-APDU containing the Secure Object size.
- the TLV in the R-APDU containing the timestamp value.

Next to ReadObject, also I2CM response can be read with attestation (see I2CMExecuteCommandSet for details) as well as TriggerSelfTest.

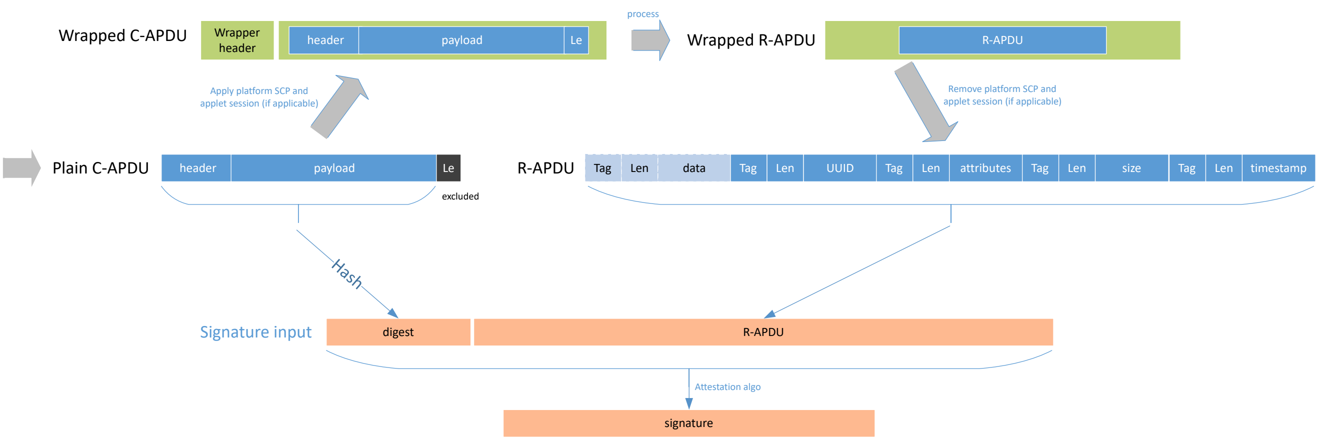


Figure 4. SE05x attestation signature components

3.2.8 Secure Object import/export

Transient Secure Objects of type AESKey, DESKey, RSAKey or ECCKey can be serialized so the Secure Object can be represented as a byte array. The byte array contains all attributes of the Secure Object, as well as the value (including the secret part) of the object.

Exported credentials are always device individually encrypted and MAC'ed, so the import needs to be done on the same device as the export was triggered.

An object may only be imported if the SecureObject ID and type are the same as the exported object. Therefore, it is not possible to import if the corresponding Secure Object in the applet has been deleted.

Notes:

- The exported Secure Object key value is not deleted automatically.

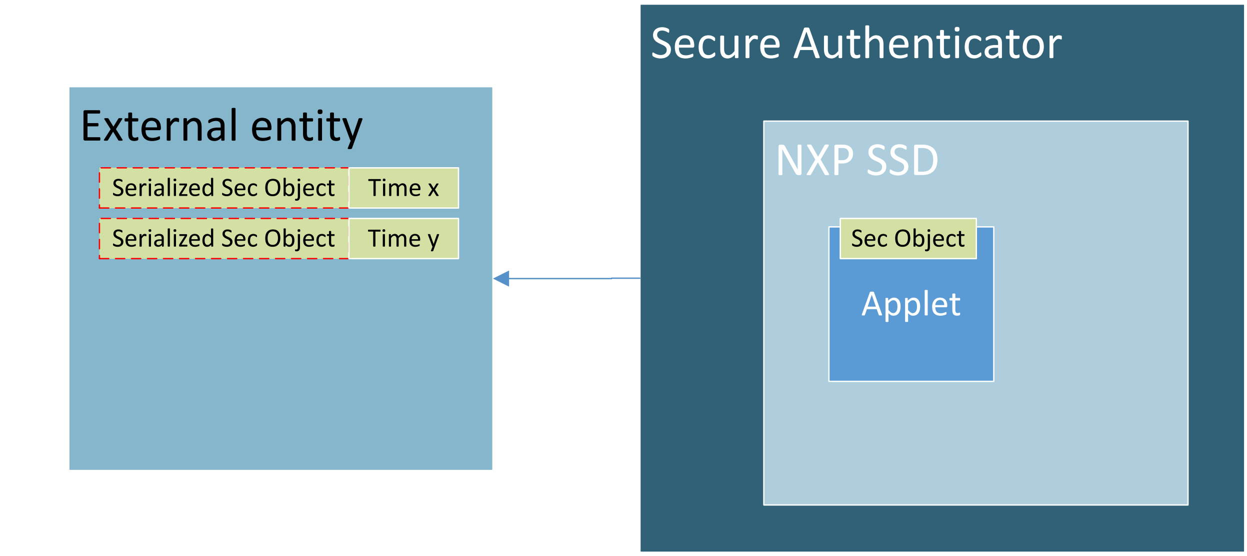


Figure 5. Secure Object import/export

3.2.9 Secure Object external import

Secure Objects can be imported into the SE05x through a secure channel which does not require the establishment of a session. This feature is also referred to single side import and can only be used to create or update objects.

The mechanism is based on ECKey session to protect the Secure Object content and is summarized in the following figure.

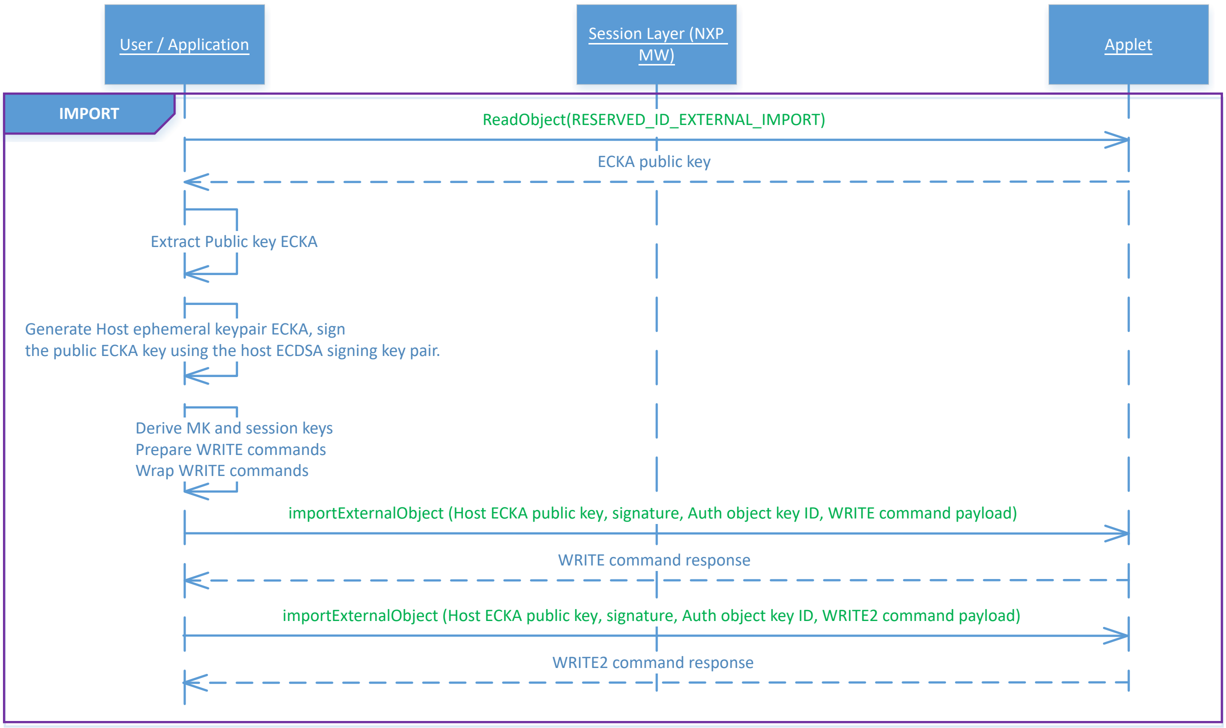

User / Application
Session Layer (NXP MW)
Applet
IMPORT
ReadObject(RESERVED_ID_EXTERNAL_IMPORT)
ECKA public key
Extract Public key ECKA
Generate Host ephemeral keypair ECKA, sign the public ECKA key using the host ECDSA signing key pair.
Derive MK and session keys
Prepare WRITE commands
Wrap WRITE commands
importExternalObject (Host ECKA public key, signature, Auth object key ID, WRITE command payload)
WRITE command response
importExternalObject (Host ECKA public key, signature, Auth object key ID, WRITE2 command payload)
WRITE2 command response

Figure 6. External import flow

The flow above can be summarized in the following steps:

1. The user obtains the SE public key for import via an attested ReadObject command, passing identifier RESERVED_ID_EXTERNAL_IMPORT to get the public key from the device’s key pair. The attestation result needs to be checked for validity.
2. The user calls Section 4.7.2 with input:
   - the applet AID (e.g.A00000039654530000000103000000000)
   - the SCPparameters
     - 1-byte SCP identifier, must equal 0xAB
     - 2-byte SCP parameter, must equal 0x01 followed by 1-byte security level (which follows the GlobalPlatform security level definition, see: Table 10).
   - key type, must be 0x88 (AES key type)
   - key length, must be 0x10 (AES128 key)
   - host public key (65-byte NIST P-256 public key)
   - host public key curve identifier (must be 0x03 (= NIST_P256))
   - ASN.1 signature over the TLV with tags 0xA6 and 0x7F49.

The applet will then calculate the master key by performing SHA256 over a byte array containing (in order):

- 4-byte counter value being 0x00000001
- shared secret (ECDH) calculation according to [IEEE-P1363] using the private key from RESERVED_ID_ECKEY_SESSION and the public key provided as input to ECKeySessionInternalAuthenticate. The length depends on the curve used (e.g. 32 byte for NIST P-256 curve).
- 16 bytes 00000000000000000000000000000000.

- 2-byte SCP parameter, must equal 0x01 followed by 1-byte security level (which follows the GlobalPlatform security level definition, see: Table 10.
- 1-byte key type
- 1-byte key length

The master key will then be the 16 MSB's of the hash output.

Using the master key, the 3 session keys are derived by following the GlobalPlatform SCP03 specification to derive session keys, e.g. derivation input:

- ENC session key = CMAC(MK, 00000000000000000000000400008001)
- CMAC session key = CMAC(MK, 00000000000000000000000600008001)
- RMAC session key = CMAC(MK, 00000000000000000000000700008001)

The Authentication Object ID needs to be passed using TAG_IMPORT_AUTH_KEY_ID, followed by the WriteSecureObject APDU command (using tag TAG_1).

The WriteSecureObject APDU command needs to be constructed as follows:

- Encrypt the command encryption counter (starting with 0x00000000000000000000000000000001) using the ENC session key. This becomes the IV for the encrypted APDU.
- Get the APDU command payload and pad it (ISO9797 M2 padding).
- Encrypt the payload in AES CBC mode using the S_ENC key.
- Set the Secure Messaging bit in the CLA (0x04).
- Concatenate the MAC chaining value with the full APDU.
- Then calculate the MAC on this byte array and append the 8-byte MAC value to the APDU.
- Finally increment the encryption counter for the next command.

A receipt will be generated by doing a CMAC operation on the concatenation of the MAC chaining value, the response APDU (which is empty) and the status word, using the RMAC session key,

Receipt = CMAC(RMAC session key, MCV | R-APDU | SW)

The ImportExternalObject commands can only be sent in the default session.

The ImportExternalObject commands can be replayed.

See ImportExternalObject for details.

3.3 Crypto Objects

3.3.1 Object types

A Crypto Object is an instance of a Cipher, Digest, Signature or AEAD that allows users to process data in multiple steps (init/update/final).

The state is lost when the session is closed or expires.

3.3.2 Object identifiers

Crypto Object identifiers are 2 bytes long in the range [0x0000-0xFFFF].

3.3.3 Using Crypto Objects

When a Crypto Object gets created, the Crypto Object type as well as the Crypto Object sub-type (e.g., Type = Cipher, sub-type = AES_CBC_NOPAD) needs to be specified by the user to create a Crypto Object.

The Crypto Object identifier remains available for the user until DeleteCryptoObject APDU command is called.

A Crypto Object can only be used (i.e. any crypto operation as well as managing the Crypto Object itself) by the creator of the Crypto Object. So a Crypto Object is bound to the Session Owner identifier attribute.

Note: *The object is created in non-volatile memory and the content remains in transient memory. Also, the creation of a Crypto Context has impact on the available memory, as shown in Crypto Objects.*

The following figure shows a flow diagram with an example creation, use and deletion of two Crypto Objects, one used for encrypting a longer data stream and one used for hashing a longer data stream.

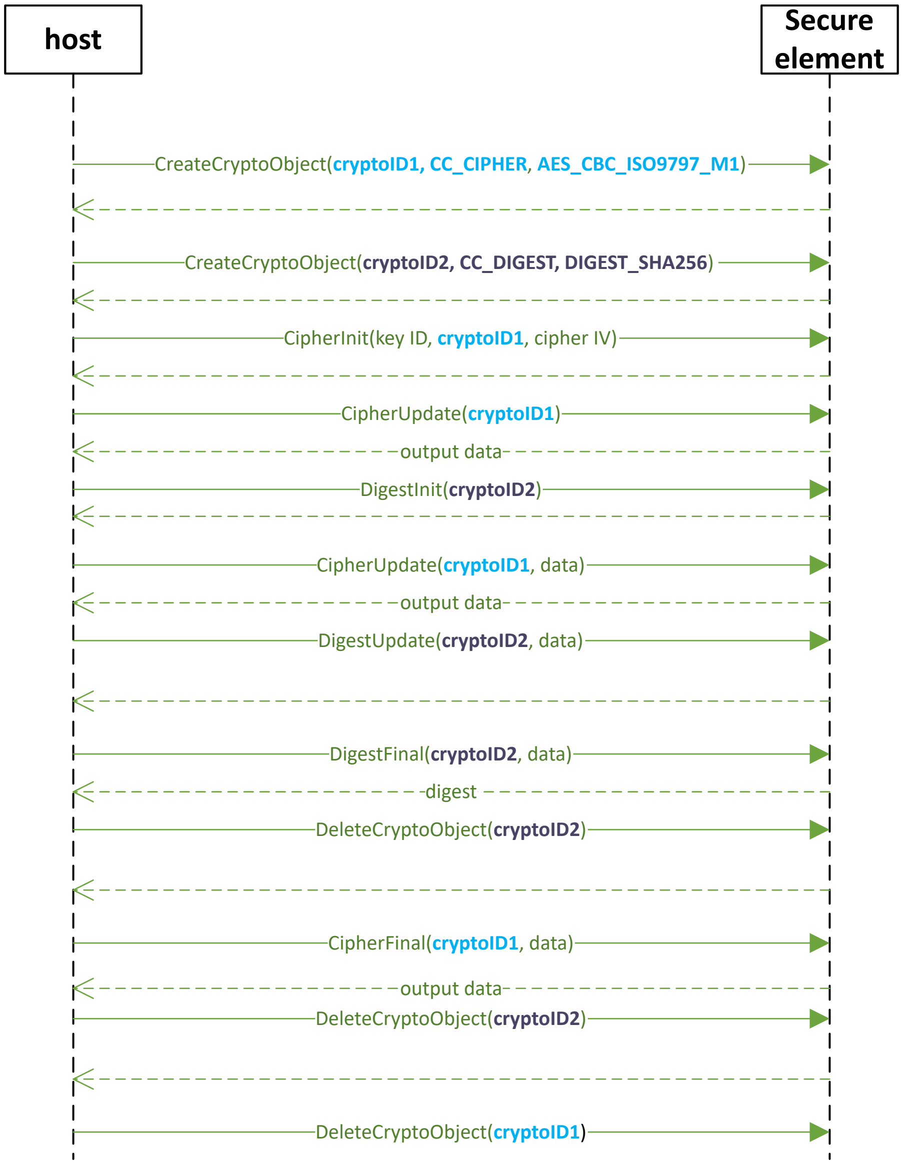

host
Secure element
CreateCryptoObject(cryptoID1, CC_CIPHER, AES_CBC_ISO9797_M1)
CreateCryptoObject(cryptoID2, CC_DIGEST, DIGEST_SHA256)
CipherInit(key ID, cryptoID1, cipher IV)
CipherUpdate(cryptoID1)
output data
DigestInit(cryptoID2)
CipherUpdate(cryptoID1, data)
output data
DigestUpdate(cryptoID2, data)
DigestFinal(cryptoID2, data)
digest
DeleteCryptoObject(cryptoID2)
CipherFinal(cryptoID1, data)
output data
DeleteCryptoObject(cryptoID2)
DeleteCryptoObject(cryptoID1)

Figure 7. Example Crypto Object usage

3.4 Supported applet features

An instance of the SE05x IoT applet can be tuned to support specific functional blocks or features.

There are two bitmaps that defines applet features (appletConfig) and feature bits (= extended feature bitmap), which can be set using SetappletFeatures. Note that these only reflect the applet functionality, depending on the operating system additional limitations might apply (especially for FIPS compliance).

Note that users need to ensure both the features and extended features are filled properly.

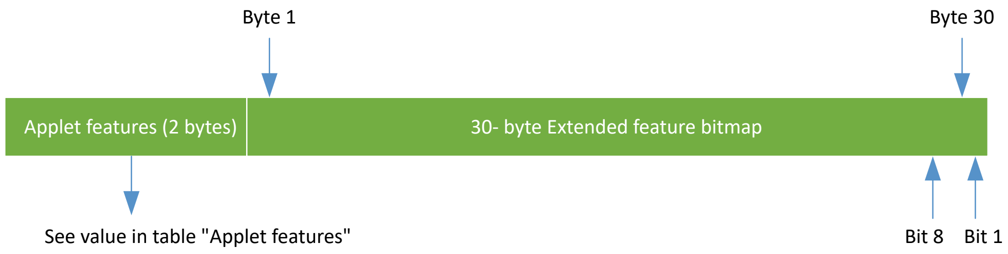

Byte 1
Byte 30
Applet features (2 bytes)
30- byte Extended feature bitmap
See value in table "Applet features"
Bit 8
Bit 1

Figure 8. Setting applet features and extended features bitmap

Table 8. applet features

Feature	Value	Description
CONFIG_RESERVED	0x0001	No functionality impact (reserved)
CONFIG_ECDSA_ECDH_ECDHE	0x0002	ECDSA and DH support (new key creation & key update)
CONFIG_EDDSA	0x0004	Use of curve ID_ECC_ED_25519 (new key creation & key update)
CONFIG_DH_MONT	0x0008	Use of curve ID_ECC_MONT_DH_ 25519 or ID_ECC_MONT_DH_448 (new key creation & key update).
CONFIG_HMAC	0x0010	Writing HMACKey objects (new key creation & key update)
CONFIG_RSA_PLAIN	0x0020	Writing RSAKey objects (new RSA raw key creation)
CONFIG_RSA_CRT	0x0040	Writing RSAKey objects (new RSA CRT key creation)
CONFIG_AES	0x0080	Writing AESKey objects (new key creation & key update)
CONFIG_DES	0x0100	Writing DESKey objects (new key creation & key update)
CONFIG_PBKDF	0x0200	PBKDF2 (crypto operation)
CONFIG_TLS	0x0400	TLS Handshake support commands (crypto operations, see TLS handshake support)
CONFIG_MIFARE	0x0800	MIFARE DESFire support (crypto operations, see MIFARE DESFire support)
CONFIG_RESERVED	0x1000	No functionality impact (reserved)
CONFIG_I2CM	0x2000	I^{2}C Controller support (crypto operations, see I2C controller support)
CONFIG_RESERVED	0x4000	No functionality impact (reserved)

Table 9. Extended feature bitmap

Feature	Byte mask	Description
EXTCFG_RESERVED	B1b8-B2b3	No functionality impact (reserved)
EXTCFG_CRYPTO_EC_FORBID_ECDH	B2b2	Forbid ECDHSharedSecretGeneration (crypto operation)
EXTCFG_RESERVED	B2b1-B3b4	No functionality impact (reserved)
EXTCFG_CRYPTO_RSA_FORBID_ENC_DEC	B3b3	Forbid RSAEncrypt and RSADecrypt
EXTCFG_CRYPTO_RSA_FORBID_SHA1	B3b2	Forbid SHA-1 in any RSA crypto operations
EXTCFG_CRYPTO_RSA	B3b1	Enable RSA crypto operations
EXTCFG_RESERVED	B3b2-B4b6	No functionality impact (reserved)
EXTCFG_CRYPTO_AEAD_GCM_FORBID_EXT_IV	B4b5	Forbid external IV generation for AEAD GCM operations.
EXTCFG_CRYPTO_AEAD	B4b4	Enable AEAD crypto operations
EXTCFG_CRYPTO_HMAC	B4b3	Enable HMAC crypto operations
EXTCFG_CRYPTO_DES	B4b2	Enable DES crypto operations
EXTCFG_CRYPTO_AES	B4b1	Enable AES crypto operations
EXTCFG_CRYPTO_HKDF_FORBID_IN_OUT_LT_112BIT	B5b8	Forbid input or output of less than 112 bits for HKDF. Applies to both key as well as salt parameters.
EXTCFG_RESERVED	B5b7-B5b2	No functionality impact (reserved)
EXTCFG_CRYPTO_HKDF	B5b1	Enable HKDF crypto operations.
EXTCFG_CRYPTO_PBKDF_FORBID_SALT_LT_128BIT	B6b8	Forbid salt of less than 128 bits in PBKDF2.
EXTCFG_CRYPTO_PBKDF_FORBID_IN_OUT_LT_112BIT	B6b7	Forbid key output of less than 112 bits for PBKDF2.
EXTCFG_RESERVED	B6b6-B6b2	No functionality impact (reserved)
EXTCFG_CRYPTO_PBKDF	B6b1	Enable PBKDF2 crypto operation.
EXTCFG_CRYPTO_TLS_KDF_FORBID_LT_HMAC_SHA256	B7b8	Forbid HMAC with digests that have less than 256 bit security strength for TLS Handshake support operations.
EXTCFG_CRYPTO_TLS_KDF_FORBID_IN_OUT_LT_112BIT	B7b7	Forbid key input or output of less than 112 bits for TLS Handshake support operations.
EXTCFG_CRYPTO_TLS_KDF_ALLOW_EXT_RANDOM_POLICY	B7b6	Allow to set POLICY_OBJ_TLS_KDF_ALLOW_EXT_RANDOM
EXTCFG_RESERVED	B7b5-B7b2	No functionality impact (reserved)
EXTCFG_CRYPTO_TLS_KDF	B7b1	Enable TLS Handshake support operations.
EXTCFG_RESERVED	B8b8-B8b2	No functionality impact (reserved)

Table 9. Extended feature bitmap*...continued*

Feature	Byte mask	Description
EXTCFG_CRYPTO_DIGEST	B8b1	Enable digest operations
EXTCFG_RESERVED	B9b8-B9b2	No functionality impact (reserved)
EXTCFG_CRYPTO_DESFIRE	B9b1	Enable DESFire support operations
EXTCFG_RESERVED	B10b8	No functionality impact (reserved)
EXTCFG_CRYPTO_PAKE_SPAKE2PLUS_P256_SHA256_HKDF_HMAC	B10b8	Enable PAKE for SPAKE2PLUS_P256_SHA256_HKDF_HMAC (see [SPAKE2+])
EXTCFG_CRYPTO_PAKE_SPAKE2PLUS_P256_SHA512_HKDF_CMAC	B10b7	Enable PAKE for SPAKE2PLUS_P256_SHA512_HKDF_CMAC (see [SPAKE2+])
EXTCFG_CRYPTO_PAKE_SPAKE2PLUS_P256_SHA256_HKDF_CMAC	B10b6	Enable PAKE for SPAKE2PLUS_P256_SHA256_HKDF_CMAC (see [SPAKE2+])
EXTCFG_CRYPTO_PAKE_SPAKE2PLUS_P521_SHA512_HKDF_HMAC	B10b5	Enable PAKE for SPAKE2PLUS_P521_SHA512_HKDF_HMAC (see [SPAKE2+])
EXTCFG_CRYPTO_PAKE_SPAKE2PLUS_P384_SHA512_HKDF_HMAC	B10b4	Enable PAKE for SPAKE2PLUS_P384_SHA512_HKDF_HMAC (see [SPAKE2+])
EXTCFG_CRYPTO_PAKE_SPAKE2PLUS_P384_SHA256_HKDF_HMAC	B10b3	Enable PAKE for SPAKE2PLUS_P384_SHA256_HKDF_HMAC (see [SPAKE2+])
EXTCFG_CRYPTO_PAKE_SPAKE2PLUS_P256_SHA512_HKDF_HMAC	B10b2	Enable PAKE for SPAKE2PLUS_P256_SHA512_HKDF_HMAC (see [SPAKE2+])
EXTCFG_CRYPTO_PAKE_SPAKE2PLUS_P256_SHA256_HKDF_HMAC_v02	B10b1	Enable PAKE for SPAKE2PLUS_P256_SHA256_HKDF_HMAC (for SPAKE2+ version 02; see [SPAKE2+v02])
EXTCFG_CRYPTO_ALLOW_INTERNAL_SIGN	B11b8	Enable Internal Signature Generation
EXTCFG_RESERVED	B11b7-B13b2	No functionality impact (reserved)
EXTCFG_ALLOW_LC1	B13b1	Allow APDUs over Logical Channel 1
EXTCFG_RESERVED	B14b8-B30b1	No functionality impact (reserved)

3.5 Secure Channel Protocols

3.5.1 Multi-level SCP

The SE05x IoT applet allows the user to set up a secure channel on different levels (i.e., both types are fully independent and can be enabled in parallel):

- **Platform SCP**: for local attack protection. This secure channel needs to be set up via the card manager of the OS using the standard ISO7816-4 secure channel APDUs, see [2].
- **applet level SCP**: for end-to-end secure channel protection. The commands to set up a secure channel on applet level are present in the APDU specification.
  - Users can choose to authenticate with either an AESKey or ECKey to open an AESKey or ECKey session respectively, resulting in session keys that are used for secure messaging on the session.

3.5.2 Security Level

The SE05x IoT applet uses the Security Level definitions as defined in GlobalPlatform, (see Table 10-1 in [SCP03]) and as depicted in Table 10.

Table 10. Security Level

B8	B7	B6	B5	B4	B3	B2	B1	Meaning
-	-	-	-	-	-	1	-	C_DECRYPTION
-	-	-	-	-	-	-	1	C_MAC
-	-	1	-	-	-	-	-	R_ENCRYPTION
-	-	-	1	-	-	-	-	R_MAC
-	-	-	-	X	X	-	-	RFU
0	0	0	0	0	0	0	0	NO_SECURITY_LEVEL

3.6 Sessions

The SE05x IoT applet allows to set up **applet sessions**. An applet session is an authenticated communication channel between the owner of an Authentication Object and the SE05x IoT applet.

Commands can be sent to the SE05x IoT applet either:

- Without creating an applet session (= session-less access).
- Inside an applet session.

Each session needs to have a different authentication object; i.e. one Authentication Object cannot be used to open multiple sessions in parallel.

applet sessions can only be set up via session-less access, so a new applet session cannot be opened from within an existing applet session.

3.6.1 Session-less access

By default, the applet does not require authentication: any command can be sent without creating a session and session-less access is always available (i.e. not closed).

Note that the session-less access does not protect the SE05x use against multi-threaded behavior (as any user or thread can interfere at any moment).

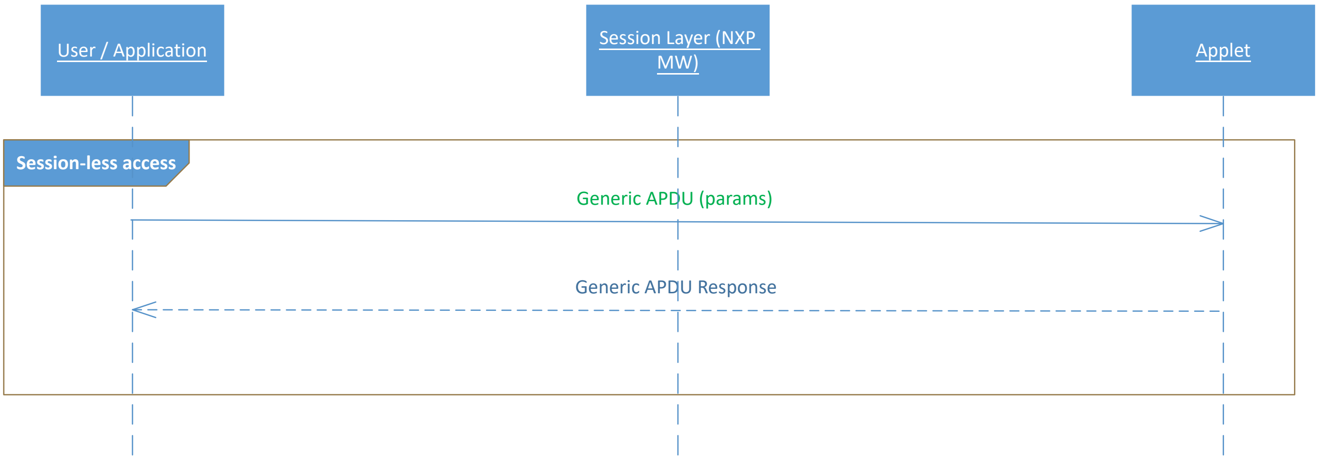


Figure 9. Session-less access

Note:

Without opening an applet session, the APDU prepared by the User / Application are sent directly to the applet

3.6.2 applet sessions

The following applet session types exist:

- **userID session**: using a userID to open a session
- **AESKey session**: using an AESKey as Authentication Object
- **ECKey session**: using an ECKey as Authentication Object.

To open an (authenticated) applet session, a user must do the following:

1. Call CreateSession, passing an Authentication Object identifier as input and getting an 8-byte unique **session identifier** as response. At this point the session is not yet opened and commands should not be wrapped yet until authentication succeeded.
2. Depending on the type of Authentication Object, authentication needs to occur.
3. Once successfully authenticated, the session is opened. Commands sent within a session are wrapped in a ProcessSessionCmd APDU where the 1st argument is the session identifier and the 2nd argument is the APDU to be handled.

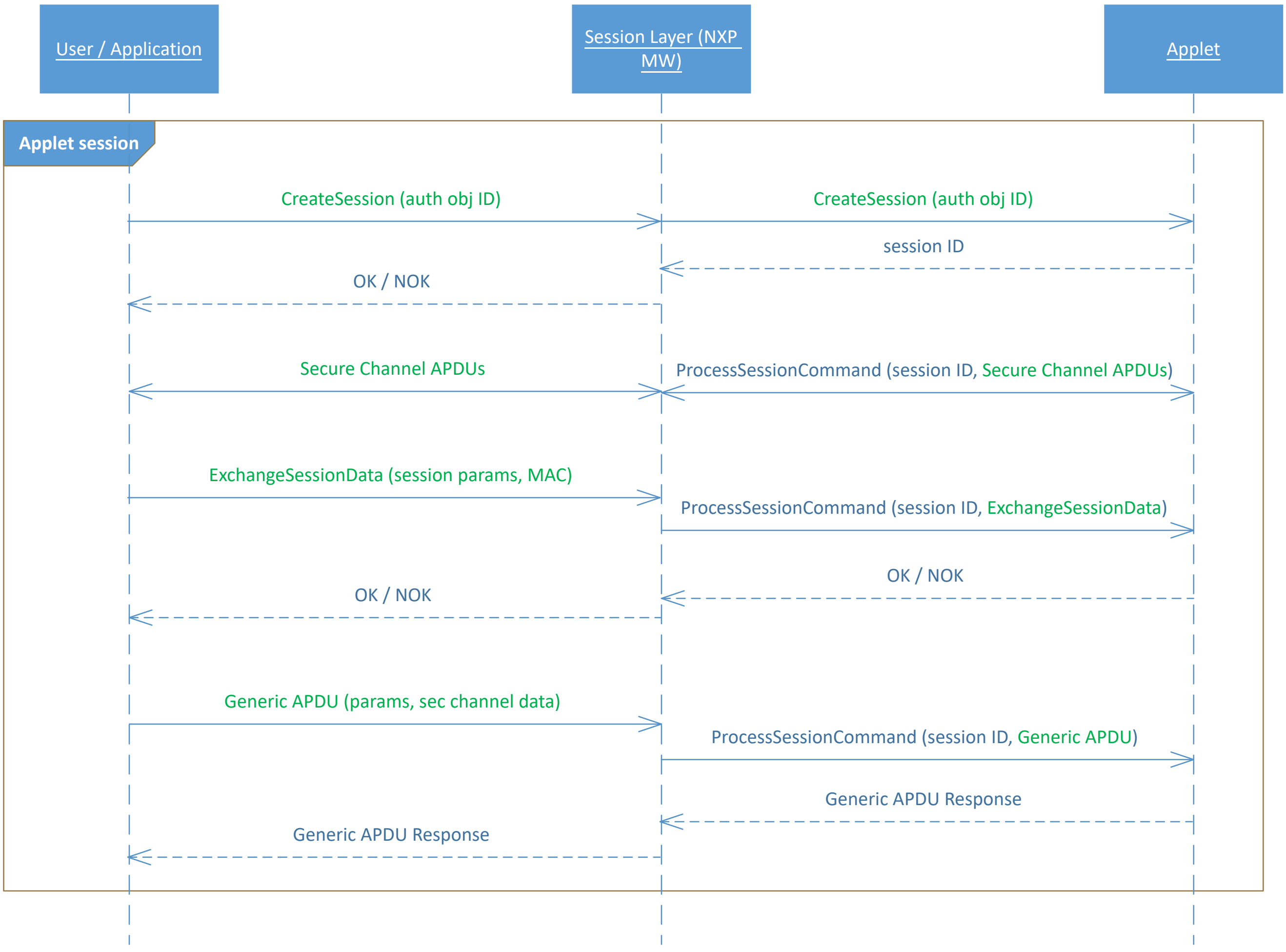

User / Application
Session Layer (NXP MW)
Applet
Applet session
CreateSession (auth obj ID)
CreateSession (auth obj ID)
session ID
OK / NOK
Secure Channel APDUs
ProcessSessionCommand (session ID, Secure Channel APDUs)
ExchangeSessionData (session params, MAC)
ProcessSessionCommand (session ID, ExchangeSessionData)
OK / NOK
OK / NOK
Generic APDU (params, sec channel data)
ProcessSessionCommand (session ID, Generic APDU)
Generic APDU Response
Generic APDU Response

Figure 10. applet session (overview)

Optionally, the host may provide an ExchangeSessionData command as the first command within a session (see ExchangeSessionData). This command is used to set the policies for the given session. This command shall not be accepted after other commands have been sent within the session.

For example, it is not possible to encrypt data and then set the session policies. In other words, if the user needs to restrict session usage, the first thing to do is to set the policies.

If the ExchangeSessionData command is not provided, the default session policy applies (see Section 3.7.3).

3.6.3 Session creation

As mentioned, the first step is to get a session identifier by calling CreateSession. The Authentication Object identifier will determine the type of session that will be opened, and each session type has different authentication methods associated.

By default MAX NR OF SESSIONS applet sessions can be opened in parallel.

3.6.3.1 UserID session

The session opening is done by providing a previously registered userID:

- VerifySessionUserID passes the value of the userID as argument. If the userID matches the stored value, the session is opened. UserID sessions can only be used or closed once the VerifySessionUserID has returned SW_NO_ERROR.

UserID sessions are only set up once VerifySessionUserID has returned SW_NO_ERROR.

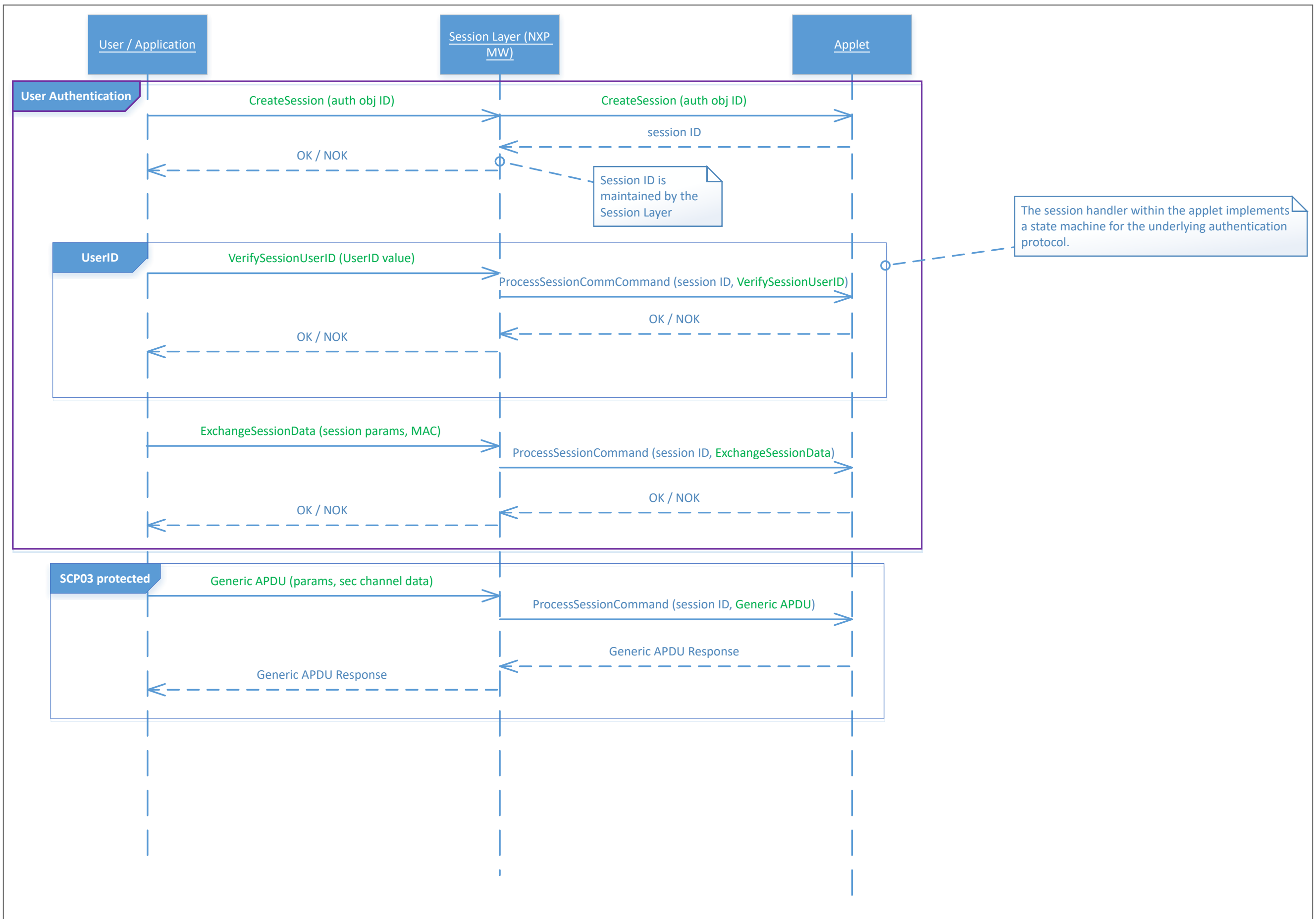

User / Application
Session Layer (NXP MW)
Applet
User Authentication
CreateSession (auth obj ID)
CreateSession (auth obj ID)
session ID
OK / NOK
Session ID is maintained by the Session Layer
The session handler within the applet implements a state machine for the underlying authentication protocol.
UserID
VerifySessionUserID (UserID value)
ProcessSessionCommCommand (session ID, VerifySessionUserID)
OK / NOK
OK / NOK
ExchangeSessionData (session params, MAC)
ProcessSessionCommand (session ID, ExchangeSessionData)
OK / NOK
OK / NOK
SCP03 protected
Generic APDU (params, sec channel data)
ProcessSessionCommand (session ID, Generic APDU)
Generic APDU Response
Generic APDU Response

Figure 11. Session creation using UserID

3.6.3.2 AESKey session

Authentication follows the GlobalPlatform authentication steps, namely

1. SCPInitializeUpdate is called to perform an INITIALIZE UPDATE command.
2. SCPExternalAuthenticate is called to perform an EXTERNAL AUTHENTICATE command.

Note that only 1 AESKey object is used as master key for all three session keys (S-ENC/S-MAC/S-RMAC); for the derivation input, this master key is used three times.

AESKey sessions are only set up once SCPExternalAuthenticate has returned SW_NO_ERROR.

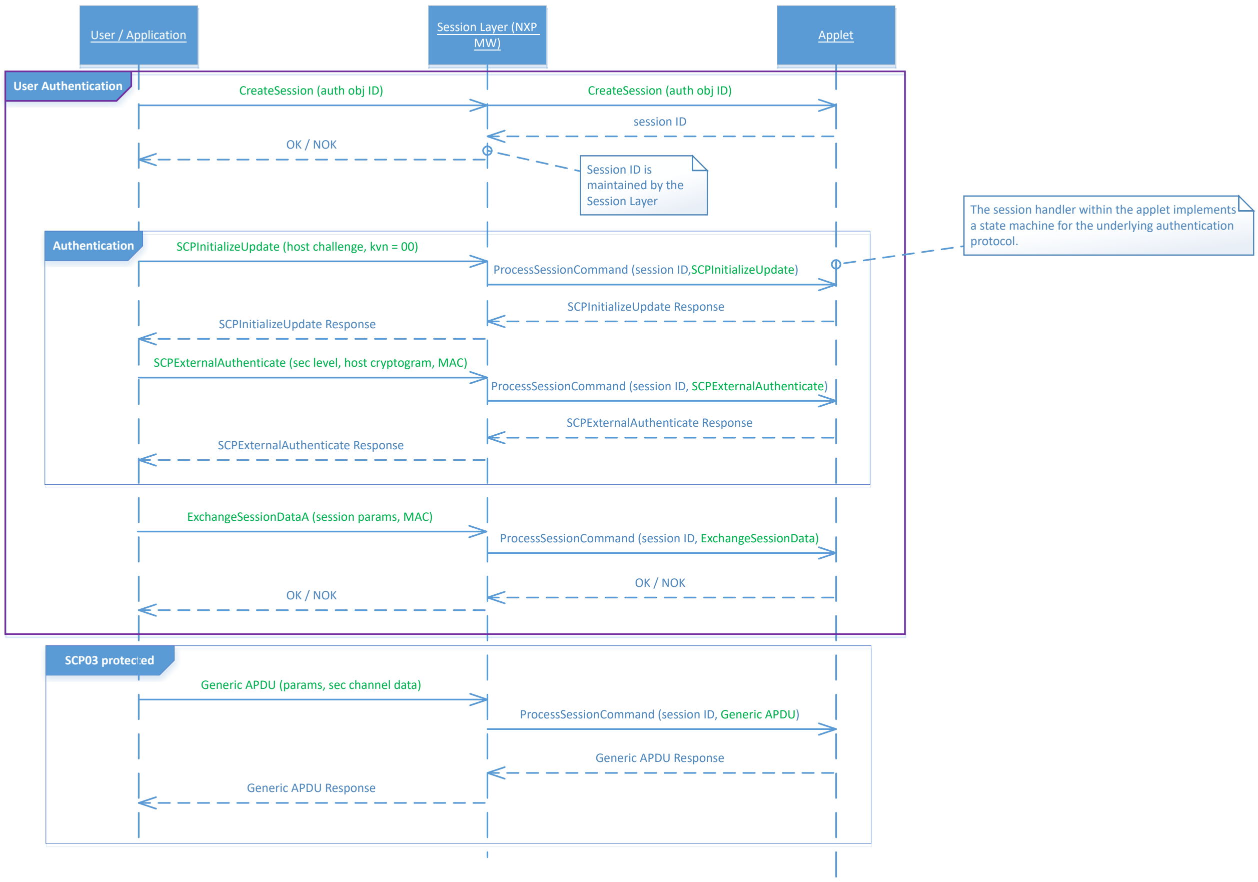

User / Application
Session Layer (NXP MW)
Applet
User Authentication
CreateSession (auth obj ID)
CreateSession (auth obj ID)
session ID
OK / NOK
Session ID is maintained by the Session Layer
The session handler within the applet implements a state machine for the underlying authentication protocol.
Authentication
SCPInitializeUpdate (host challenge, kvn = 00)
ProcessSessionCommand (session ID,SCPInitializeUpdate)
SCPInitializeUpdate Response
SCPInitializeUpdate Response
SCPExternalAuthenticate (sec level, host cryptogram, MAC)
ProcessSessionCommand (session ID, SCPExternalAuthenticate)
SCPExternalAuthenticate Response
SCPExternalAuthenticate Response
ExchangeSessionDataA (session params, MAC)
ProcessSessionCommand (session ID, ExchangeSessionData)
OK / NOK
OK / NOK
SCP03 protected
Generic APDU (params, sec channel data)
ProcessSessionCommand (session ID, Generic APDU)
Generic APDU Response
Generic APDU Response

Figure 12. Session creation using an AES key as authentication object

3.6.3.3 ECKey session

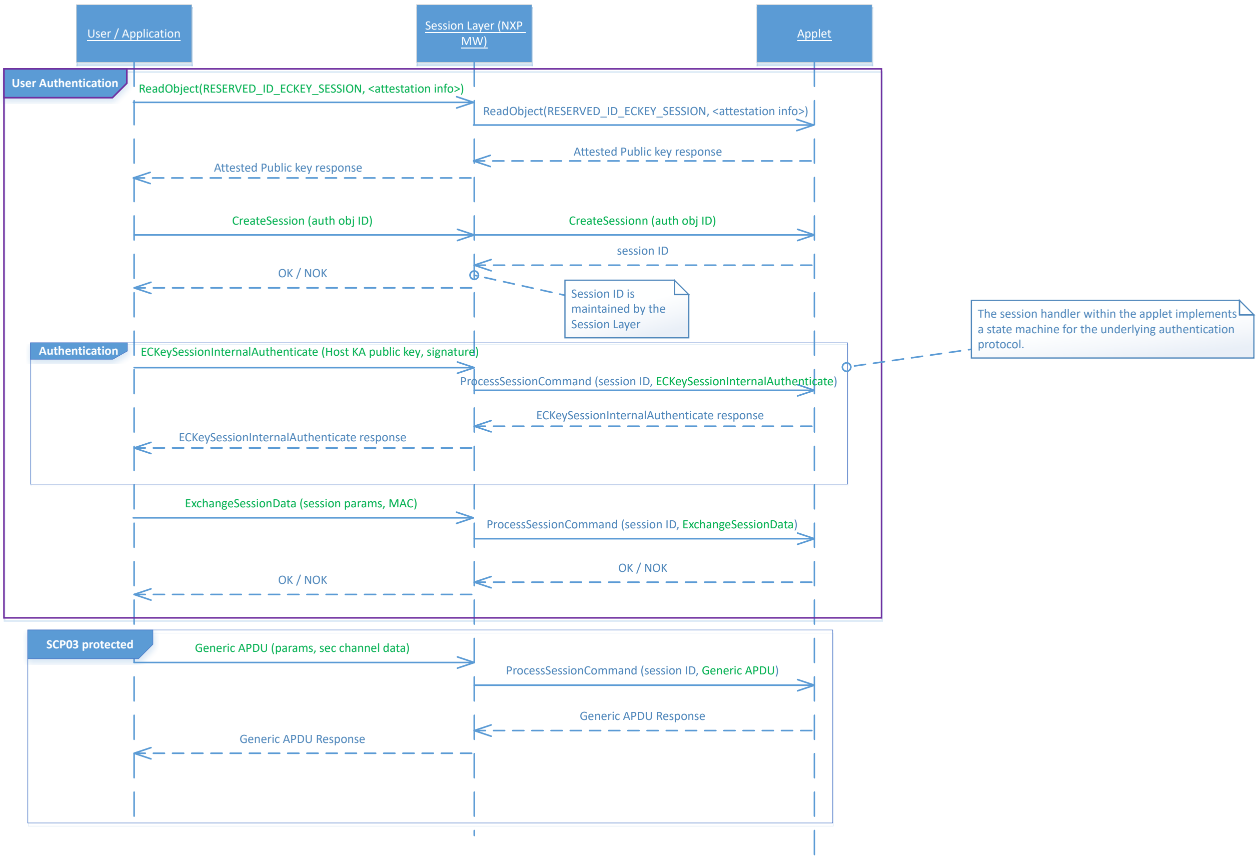

User / Application
Session Layer (NXP MW)
Applet
User Authentication
ReadObject(RESERVED_ID_ECKEY_SESSION, <attestation info>)
ReadObject(RESERVED_ID_ECKEY_SESSION, <attestation info>)
Attested Public key response
Attested Public key response
CreateSession (auth obj ID)
CreateSessionn (auth obj ID)
session ID
OK / NOK
Session ID is maintained by the Session Layer
The session handler within the applet implements a state machine for the underlying authentication protocol.
Authentication
ECKeySessionInternalAuthenticate (Host KA public key, signature)
ProcessSessionCommand (session ID, ECKeySessionInternalAuthenticate)
ECKeySessionInternalAuthenticate response
ECKeySessionInternalAuthenticate response
ExchangeSessionData (session params, MAC)
ProcessSessionCommand (session ID, ExchangeSessionData)
OK / NOK
OK / NOK
SCP03 protected
Generic APDU (params, sec channel data)
ProcessSessionCommand (session ID, Generic APDU)
Generic APDU Response
Generic APDU Response

Figure 13. Session creation using ECKey session as authentication mechanism.

An ECKey Session is established as follows:

1. The user obtains the SE public key for import via an attested ReadObject command, passing identifier RESERVED_ID_ECKEY_SESSION to get the public key from the device’s key pair. The attestation result needs to be checked for validity. This step only needs to be done for the first ECKey session setup. Any successive ECKey session setup can reuse the key requested initially.
2. The user calls CreateSession with the desired authentication object ID (EC public key or EC Keypair) and receives a session ID.
3. To prof the knowledge of the authentication object secret, the user calls ECKeySessionInternalAuthenticate with input:
   - the applet AID (e.g. A0000003965453000000010300000000)
   - the SCP parameters
     - 1-byte SCP identifier, must equal 0xAB
     - 2-byte SCP parameter, must equal 0x01 followed by 1-byte security level (which follows the GlobalPlatform security level definition, see: Table 10). Note that security level NO_SECURITY_LEVEL is not supported for ECKey sessions.
   - key type, must be 0x88 (AES key type)
   - key length, must be 0x10 (AES128 key)
   - host public key (65-byte NIST P-256 public key); for each ECKey session setup, this key must be a unique key, so this should be the public key of an ephemeral key pair.

- host public key curve identifier (must be 0x03 (= NIST_P256))
- ASN.1 signature over the TLV with tags 0xA6 and 0x7F49 (using the Host Private key).

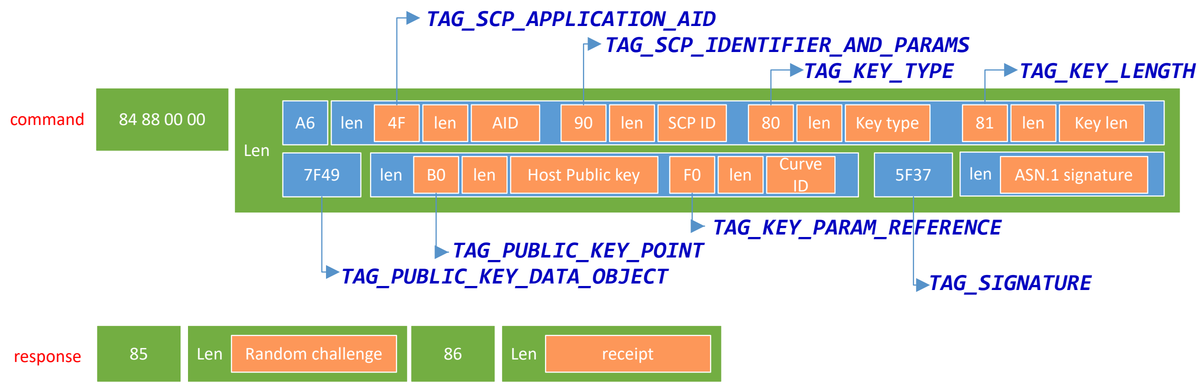


Figure 14. ECKeySessionInternalAuthenticate

The applet will then calculate the master key by performing SHA256 over a byte array containing (in order):

- 4-byte counter value being 0x00000001
- shared secret (ECDH calculation according to [IEEE-P1363] using the private key from RESERVED_ID_ECKEY_SESSION and the public key provided as input to ECKeySessionInternalAuthenticate. The length depends on the curve used (see Supported EC Curves).
- 16-byte random generated by the SE05x as returned in the response of the ECKeySessionInternalAuthenticate command.
- 2-byte SCP parameters, parameter, must equal 0x01 followed by 1-byte security level (which follows the GlobalPlatform security level definition, see: security level).
- 1-byte key type
- 1-byte key length

The master key will then be the 16 MSB’s of the hash output.

Using the master key, the 3 session keys are derived by following the GlobalPlatform specification to derive session keys, e.g. derivation input:

- ENC session key = CMAC(MK, 00000000000000000000000400008001)
- CMAC session key = CMAC(MK, 00000000000000000000000600008001)
- RMAC session key = CMAC(MK, 00000000000000000000000700008001)

A receipt will be generated by doing a CMAC operation on the input from tag 0xA6 and 0x7F49 using the RMAC session key,

Receipt = CMAC(RMAC session key, <input from TLV 0xA6 and TLV 0x7F49>)

ECKey sessions are only set up once ECKeySessionInternalAuthenticate has returned SW_NO_ERROR.

4. Commands can be exchanged in the protected session.
   When secure objects have a policy specified for the authentication object ID (as passed via CreateSession) the respective Access Rules are active within this session.

3.6.4 Session runtime

Sessions can be renewed (by calling RefreshSession from within an existing session).

A refresh means that the session policy is updated with the new policy passed in RefreshSession while the session context remains the same (e.g., state).

When the Authentication Object that is used to open a session is deleted from within that session, the session will be closed automatically immediately after the response APDU has been sent.

When the Authentication Object that is used to open a session is altered, the session remains active.

3.6.5 Session closure

Sessions can be closed in multiple ways:

- explicitly by calling CloseSession
- implicitly due to an applied session policy, i.e. expiry of the session lifetime or reaching the maximum number of allowed APDUs.
- implicitly due to deselect or power cycle.
- implicitly due to deletion of the Authentication Object used to open the session. If the Authentication Object is updated, the session is not closed. If a session is open and the Authentication Object used to open this session is deleted from within another session (using a different Authentication Object), the session remains open until closed in another way.

Sessions are fully transient. If a session expires, its state information is lost.

Note that sessions can only be closed if the session is fully set up; i.e., authentication must be finished successfully.

3.7 Policies

All restrictions that can be applied to Secure Objects or to sessions are constructed as policy sets. A policy set is a combination of different policies on the same item:

- Object policy: defines the restrictions and working conditions of a Secure Object.
- Session policy: defines the restrictions and working conditions of a session.

3.7.1 Object policies

The concepts defined in this section are listed in Table 11

Table 11. Policy notation

Term	Meaning
Policy set	A collection of policies that restrict usage of a specific object; i.e., each object may contain one policy set. An object may also not contain a specific policy set, in which case the default policy set applies.
Policy	A collection of access rules that are applicable to a specific user or a group of users.
Access Rule	Defines the capability to access a resource in a certain manner. For example, an access rule defined within this specification is the capability to use an object for encryption.

3.7.1.1 Policy set

A policy set can be specified when creating an object and it is not modifiable. Policy sets are structured as defined in Table 12.

Table 12. Policy set

Field	Length	Description
Policy	9-53	First policy
Policy	9-53	Second policy
…	…	…

3.7.1.2 Policy

Each policy is structured according to Table 13 and Table 14.

Table 13. Policy

Field	Length	Description	M / O / C
Length of policy	1	Number of bytes of the following fields	M
Authentication Object ID	4	The authentication object to which the following access rules apply.	M
Access rules (AR)	4, 8, 12, 40, 44 or 48 bytes	See Section 3.7.1.3	M

Table 14. Access Rule structure

Field	Length	Description	M / O/ C
AR Header	4	Access rules header of fixed size	M
AR Extension	0, 4, 8, 36, 40 or 44	Optional access rules extension	C

Notes:

- The Authentication Object ID defines the Authentication Object to which the access rules apply. When the value is 0x00000000, the access rules apply to the default session, which can be opened by anybody. E.g.: 08**00000000**0014000008**11111111**18000000 assigns the Access Rule 00140000 to the default session. However, these access rules are not inherited by sessions with the Authentication Object with identifier 0x11111111.
- Transient objects are bound to the creating session, to prevent interference by other sessions. Access rules set for transient objects which are not related to the current session do not have an effect, as the transient object will not be accessible from those other sessions.
- For a single policy set, the policies need to contain unique Authentication Object IDs: a certain Authentication Object ID cannot be present multiple times in the same policy set. E.g. 08**00000000**00140000008**00000000**18000000 will not work and should be constructed as 08**00000000**18140000.
- If users do not set a specific Policy Set, the default policies apply to the object. The Default Policy applies to any session.

3.7.1.3 Access Rule

An access rule defines which operations are allowed on an object. As defined in Table 13 and Table 14 , an access rule contains a mandatory 4-byte header and an optional extension of up to 44 bytes.

The coding of the header and extensions is defined in section Policy Constants.

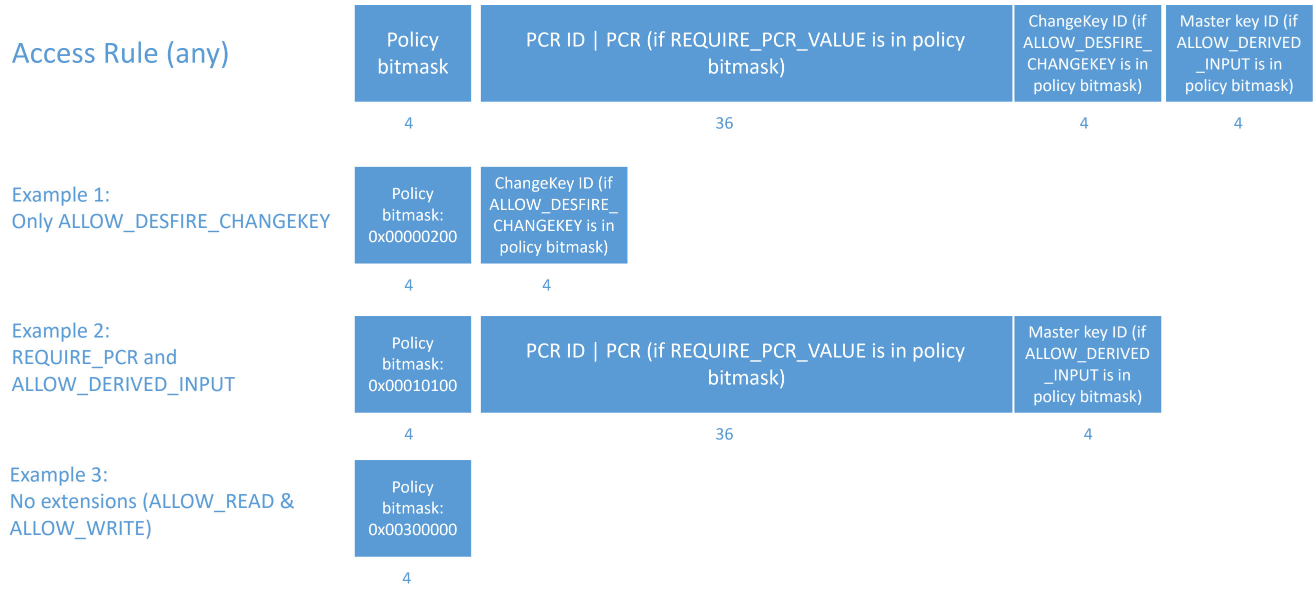

Access Rule (any)
Policy bitmask
PCR ID | PCR (if REQUIRE_PCR_VALUE is in policy bitmask)
ChangeKey ID (if ALLOW_DESFIRE_CHANGEKEY is in policy bitmask)
Master key ID (if ALLOW_DERIVED_INPUT is in policy bitmask)
4
36
4
4
Example 1:
Only ALLOW_DESFIRE_CHANGEKEY
Policy bitmask: 0x00000200
ChangeKey ID (if ALLOW_DESFIRE_CHANGEKEY is in policy bitmask)
4
4
Example 2:
REQUIRE_PCR and ALLOW_DERIVED_INPUT
Policy bitmask: 0x00010100
PCR ID | PCR (if REQUIRE_PCR_VALUE is in policy bitmask)
Master key ID (if ALLOW_DERIVED_INPUT is in policy bitmask)
4
36
4
Example 3:
No extensions (ALLOW_READ & ALLOW_WRITE)
Policy bitmask: 0x00300000
4

Figure 15. Access Rule construction & examples

Access rule extensions are conditional to the presence of specific access rules. If an access rules requires extension, then the extension shall be present; otherwise the access rule shall be deemed invalid. Extensions are added from left to right in the same order in which the access rules are defined. As an example, consider that a specific object defines a policy for an Authentication Object ID (e.g., identifier = ‘7FFF0000’) as follows:

- Read access is granted (POLICY_OBJ_ALLOW_READ)
- A PCR object with ID ‘4FFFF000’ shall have value ‘00112233445566778899AABBCCDDEEFF00112233445566778899AABBCCDDEEFF’ (POLICY_OBJ_REQUIRE_PCR_VALUE)

The above example policy would be coded as follows:

- Policy length: ‘2C’ (44 bytes total)
- Access rule header: ‘00210000’ (POLICY_OBJ_ALLOW_READ | POLICY_OBJ_REQUIRE_PCR_VALUE)
- Access rule extension: ‘4FFFF00000112233445566778899AABBCCDDEEFF00112233445566778899AABBCCDDEEFF’

3.7.1.4 Policy validation

Policies are validated during the object creation. An object is only created if the attached policy is valid and, if the policy validation fails, the error code 0x6A80 is returned as response to the object creation command.

Besides checking the policy structure and length, the following rules are checked:

- If no policy is attached, the default policies are applied, and no more checks are performed.
- Each access rule is checked against the object type.

Table 15 defines which access rules are allowed for each object class, as defined in Classes.

Table 15. Policy validation per object type

Object class	Applicable access rules
Policies applicable to all Secure Objects: • Symmetric Key Objects • Asymmetric Key Objects	POLICY_OBJ_FORBID_ALL POLICY_OBJ_ALLOW_READ POLICY_OBJ_ALLOW_WRITE

Table 15. Policy validation per object type*...continued*

Object class	Applicable access rules
- BinaryFile, Counter, PCR or UserID Secure Objects	POLICY_OBJ_ALLOW_DELETE POLICY_OBJ_REQUIRE_SM POLICY_OBJ_REQUIRE_PCR_VALUE
Additional policies applicable to Symmetric Key Objects (policies specific to Symmetric Key Objects are put in *italic*)	POLICY_OBJ_ALLOW_SIGN POLICY_OBJ_ALLOW_VERIFY POLICY_OBJ_ALLOW_ENC POLICY_OBJ_ALLOW_DEC POLICY_OBJ_ALLOW_IMPORT_EXPORT POLICY_OBJ_ALLOW_DERIVED_INPUT POLICY_OBJ_FORBID_DERIVED_OUTPUT *POLICY_OBJ_ALLOW_TLS_KDF* *POLICY_OBJ_ALLOW_TLS_KDF_EXT_RANDOM* *POLICY_OBJ_ALLOW_TLS_PMS* *POLICY_OBJ_ALLOW_KDF* *POLICY_OBJ_ALLOW_PBKDF* *POLICY_OBJ_ALLOW_RFC3394_UNWRAP* *POLICY_OBJ_ALLOW_DESFIRE_AUTHENTICATION (only applies to AESKey Secure Objects)* *POLICY_OBJ_ALLOW_DESFIRE_DUMP_SESSION_KEYS (only applies to AESKey Secure Objects)* *POLICY_OBJ_ALLOW_DESFIRE_CHANGEKEY (only applies to AESKey Secure Objects)* *POLICY_OBJ_ALLOW_DESFIRE_KDF (only applies to AESKey Secure Objects)* *POLICY_OBJ_FORBID_EXTERNAL_IV* *POLICY_OBJ_ALLOW_USAGE_AS_HMAC_PEPPER*
Additional policies applicable to Asymmetric Key Objects (policies specific to Asymmetric Key Objects are put in *italic*)	POLICY_OBJ_ALLOW_SIGN POLICY_OBJ_ALLOW_VERIFY POLICY_OBJ_ALLOW_ENC POLICY_OBJ_ALLOW_DEC POLICY_OBJ_ALLOW_IMPORT_EXPORT POLICY_OBJ_ALLOW_DERIVED_INPUT POLICY_OBJ_FORBID_DERIVED_OUTPUT *POLICY_OBJ_ALLOW_GEN* *POLICY_OBJ_ALLOW_KA* *POLICY_OBJ_ALLOW_ATTESTATION* *POLICY_OBJ_FORBID_EXTERNAL_INPUT_SIGN*

3.7.2 Session policies

A policy may be associated to a session while opening a session. A policy controls certain aspects of session lifecycle.

Session policies are structured as per Table 16.

Table 16. Session policy

Field	Length	Description
Length of policy	1	The number of bytes of the policy (a value between 2 and 6)

Table 16. Session policy*...continued*

Field	Length	Description
Header	2	Bitmap encoding access rules for a session
Extension	0-4	Optional extension

The extension bytes are optional and follow the same rules as defined for object policies. The policies applicable to sessions are detailed in section Session policy.

3.7.3 Default policies

This section defines the default policy rules per object type. Default policies are enabled only for ease of use; users must define a (non-default) policy for each Secure Object based on the security requirements for the product.

Table 17. Default object policies

Object type	Default policy
Authentication Object	Maximum attempts: unlimited. Applied policies: POLICY_OBJ_ALLOW_READ
Non-Authentication Object all classes (policies applicable to all classes defined below, regardless of their type) [any Secure Object type]	POLICY_OBJ_ALLOW_READ POLICY_OBJ_ALLOW_WRITE POLICY_OBJ_ALLOW_DELETE
Non-Authentication Object Symmetric key [AES, DES, HMAC]	POLICY_OBJ_ALLOW_SIGN POLICY_OBJ_ALLOW_VERIFY POLICY_OBJ_ALLOW_ENC POLICY_OBJ_ALLOW_DEC POLICY_OBJ_ALLOW_IMPORT_EXPORT *POLICY_OBJ_ALLOW_KDF*
Non-Authentication Object Asymmetric key [RSA, EC]	POLICY_OBJ_ALLOW_SIGN POLICY_OBJ_ALLOW_VERIFY POLICY_OBJ_ALLOW_ENC POLICY_OBJ_ALLOW_DEC POLICY_OBJ_ALLOW_IMPORT_EXPORT *POLICY_OBJ_ALLOW_GEN* *POLICY_OBJ_ALLOW_KA*

Table 18. Default session policies

Object type	Default policy
Session	No maximum number of APDU or command limitations Session refresh is not allowed

3.7.4 Authentication Object policies

Authentication objects policies are limited to the following policies or a subset thereof:

- POLICY_OBJ_ALLOW_READ
- POLICY_OBJ_ALLOW_WRITE
- POLICY_OBJ_ALLOW_DELETE

Some policies can be set, but do not have effect on Authentication Objects, e.g.:

- POLICY_OBJ_REQUIRE_SM
- POLICY_OBJ_REQUIRE_PCR_VALUE
- POLICY_OBJ_FORBID_ALL

3.7.5 Policy check

When a Secure Object exists and a new Write command is sent to update the value of the object, the user can insert the policy of the object into the C-APDU to ensure that the object is only written when the given policy equals the existing policy. The policy given in the TLV[TAG_POLICY_CHECK] must match exactly with the policy that is present on that Secure Object, else the C-APDU will be rejected.

This only applies when the value of the object is given as input for the C-APDU, it is ignored when there is no input argument (e.g. when using a Write command to generate a key inside the SE05x).

3.7.6 Policy usage

This chapter will give more detailed information on certain policies.

3.7.6.1 POLICY_OBJ_FORBID_ALL

POLICY_OBJ_FORBID_ALL can be applied to prevent a particular session owner to have access to a Secure Object.

3.7.6.2 POLICY_OBJ_FORBID_DERIVED_OUTPUT

When a function allows optionally output to be stored into a target object instead of returning via the R-APDU, the POLICY_OBJ_FORBID_DERIVED_OUTPUT can be applied on the source object to prevent output being returned to the host and as such mandate the use of a target object. Functions that do not store output in a target object would also block output to host in case this policy is set.

Applicable functions:

- ECDSASign
- EdDSASign
- ECDHGenerateSharedSecret
- ECPointMultiply
- PAKEComputeSessionKeys - note that this only blocks the output of the shared secret Ke and not the key confirmation message.
- CipherInit
- CipherOneShot
- AEADInit
- AEADOneShot
- MACInit (only when generating a MAC value)
- MACOneShot (only when generating a MAC value)
- HKDFExtractThenExpand
- HKDFExpandOnly
- PBKDF2DeriveKey
- RSASign
- RSAEncrypt
- RSADecrypt
- DFDumpSessionKeys

- DFChangeKey
- TLSPerformPRF

Note that target objects are not implicitely created, so these must be created upfront by calling WriteSecureObject.

3.7.6.3 POLICY_OBJ_ALLOW_DERIVED_INPUT

When a target object is derived from a source object, the POLICY_OBJ_ALLOW_DERIVED_INPUT restricts the target object to be derived from a single source object.

The policy takes a 4-byte extension pointing to the source object that needs to be used in the key derivation. For any other source object, an error would be returned.

Applicable functions:

- ECDHGenerateSharedSecret
- ECPointMultiply
- HKDFExtractThenExpand
- HKDFExpandOnly
- DFDiversifyKey
- PBKDF2DeriveKey
- TLSCalculatePreMasterSecret
- CreateCryptoObject

This policy is overruled by the POLICY_OBJ_ALLOW_WRITE: When POLICY_OBJ_ALLOW_WRITE is applied to the target object, any source object would be allowed to derive into that target object (in case the user is allowed by that policy), even if POLICY_OBJ_ALLOW_DERIVED_INPUT is applied on the object.

3.7.6.4 POLICY_OBJ_FORBID_EXTERNAL_IV

POLICY_OBJ_FORBID_EXTERNAL_IV can be applied to enforce internal IV generation for specific commands. This policy, together with POLICY_OBJ_ALLOW_ENC, denies input of an external IV and limits the use of the Secure Object to the following algorithms:

- AES CTR
- AES CCM
- AES GCM/GMAC

Applicable functions:

- CipherInit
- CipherOneShot
- AEADInit
- AEADOneShot

If the policy is applied to a Secure Object, it will only allow encryption, decryption is blocked -regardless of whether POLICY_OBJ_ALLOW_DEC is applied as well or not-.

3.7.6.5 POLICY_OBJ_FORBID_EXTERNAL_INPUT_SIGN

POLICY_OBJ_FORBID_EXTERNAL_INPUT_SIGN can be applied to enforce internal signature generation. When this policy is applied, the Secure Object cannot be used to sign external data. Only internally stored data can be signed.

Applicable functions:

- ECDSASign
- EdDSASign
- RSASign

The policy takes a 4-byte extension pointing to the BinaryFile object that contains the list of input files. The file containing the list of input files as well as all of the input files must allow read access to the user applying the signature.

3.8 Lifecycle management

The applet has 2 different lifecycle states:

- Active – all commands are allowed (as long as they do not violate policies)
- Inactive – only a subset of commands is allowed.

Commands that are allowed in Inactive state are defined in Table 19.

Table 19. Commands allowed in Inactive state

Command	Remark
GetVersion	
ReadState	
ReadObject	Only object with identifier RESERVED_ID_UNIQUE_ID can be read.
GetRandom	
CreateSession	

The applet can be set to Inactive state calling SetLockState.

Unlocking the applet can only be done by a successful authentication using the reserved authentication object with identifier RESERVED_ID_TRANSPORT.

3.9 Timestamp functionality

The system provides timestamps during attestation. A timestamp is a relative counter value of 12 bytes of which the most significant 4 bytes are persistent and the least significant 8 bytes are transient.

The transient part is strongly monotonic, i.e. any read will return an increased value (excl. wrap around).

The persistent part is updated on each first call to get an attested read or the first call to GetTimestamp.

3.10 Secure Object versioning

For the following Secure Objects, a *version* can be passed as input parameter:

- RSAKey objects
- ECKey objects
- SymmKey objects
- BinaryFile objects

By default, the version of an object is 0.

If versioning is required, the user can pass a non-zero value as version of the object.

In that case, any further write attempt to the object must include a version number that is equal to or higher than the stored version, else the command will be rejected. Note that a write attempt means either key generation (on chip), key insertion or importing an external object.

For Secure Objects written in multiple APDUs (e.g. RSA keys), each APDU must contain the same version -in case a version is present-.

If the version is 0, no additional NVM writes are done besides the Secure Object value update itself.

The maximum version is 0x7FFFFFFF. When the maximum is reached, no further write attempt is possible.

3.11 Disable Secure Object creation

It is possible to prevent creation or creation + update of Secure Objects on SE05x, either persistent or transient, by calling DisableSecureObjectCreation.

The user can choose to permanently disable the creation which is irreversible, or transiently disable creation which remains valid until next deselect.

The user can choose to prevent creation of additional objects (= least restrictive) or to prevent creation of additional objects and update of existing objects (= most restrictive).

The feature is protected by the RESERVED_ID_RESTRICT.

3.12 Internal signature generation

The SE05x IoT applet supports internal signature generation when the extended config bit EXTCFG_CRYPTO_ALLOW_INTERNAL_SIGN is set. Users must set up the configuration for the internal signature generation with at least:

- a BinaryFile Secure Object called *tbsItemList* that has as content 1 or more concatenated Secure Object identifiers of other BinaryFiles. When applying a signature operation, the signature will apply over the content of all the objects indicated in the tbsItemList, starting with the file identifier at offset 0, then offset 4, etc.. This file must be a persistent Secure Object, else an error will be returned when calling the signature generation function (ECDSASign, EdDSASign or RSASign). Maximum size of the file should be 128 bytes, so maximum 32 BinaryFile objects can be concatenated as input for the signature generation. This Secure Object must allow read access to the user generating the signature.
- an asymmetric key Secure Object containing a private key, e.g. an ECKeyPair, with at least policy POLICY_OBJ_ALLOW_SIGN and POLICY_OBJ_FORBID_EXTERNAL_INPUT_SIGN. This policy requires a 4-byte extension containing the identifier of the tbsItemList Secure Object. The policy will deny signing any other content than the files indicated in the tbsItemList.
- all BinaryFile objects indicated in the tbsItemList must allow read access to the user generating the signature. If a BinaryFile is not present, this will be ignored and the next file in the list is processed. These files can be persistent or transient and can have different associated policies.

When the user requests to sign, the appropriate signature generation function should be called without user input data. The function will then return the hash over the concatenated data in TLV[TAG_2] and the signature over the concatenated data in TLV[TAG_1].

The total size of the data to be signed depends on the APDU:

- for ECDSASign: up to 1024 bytes.
- for EdDSASign: up to 960 bytes
- for RSASign: depends on the algortihm and key size

Table 20. Maximum number of content bytes for RSA internal signature generation

	512 bits	1024 bits	1152 bits	2048 bits	3072 bits	4096 bits
RSA_SHA1_PKCS1	895	830	814	701	573	445
RSA_SHA224_PKCS1	887	822	806	693	565	437
RSA_SHA256_PKCS1	883	818	802	689	561	433

Table 20. Maximum number of content bytes for RSA internal signature generation*...continued*

	512 bits	1024 bits	1152 bits	2048 bits	3072 bits	4096 bits
RSA_SHA384_PKCS1	Not supported	802	786	673	545	417
RSA_SHA512_PKCS1	Not supported	786	770	657	529	401
RSA_SHA1_PKCS1_PSS	895	830	814	701	573	445
RSA_SHA224_PKCS1_PSS	887	822	806	693	565	437
RSA_SHA256_PKCS1_PSS	Not supported	818	802	689	561	433
RSA_SHA384_PKCS1_PSS	Not supported	802	786	673	545	417
RSA_SHA512_PKCS1_PSS	Not supported	Not supported	770	657	529	401

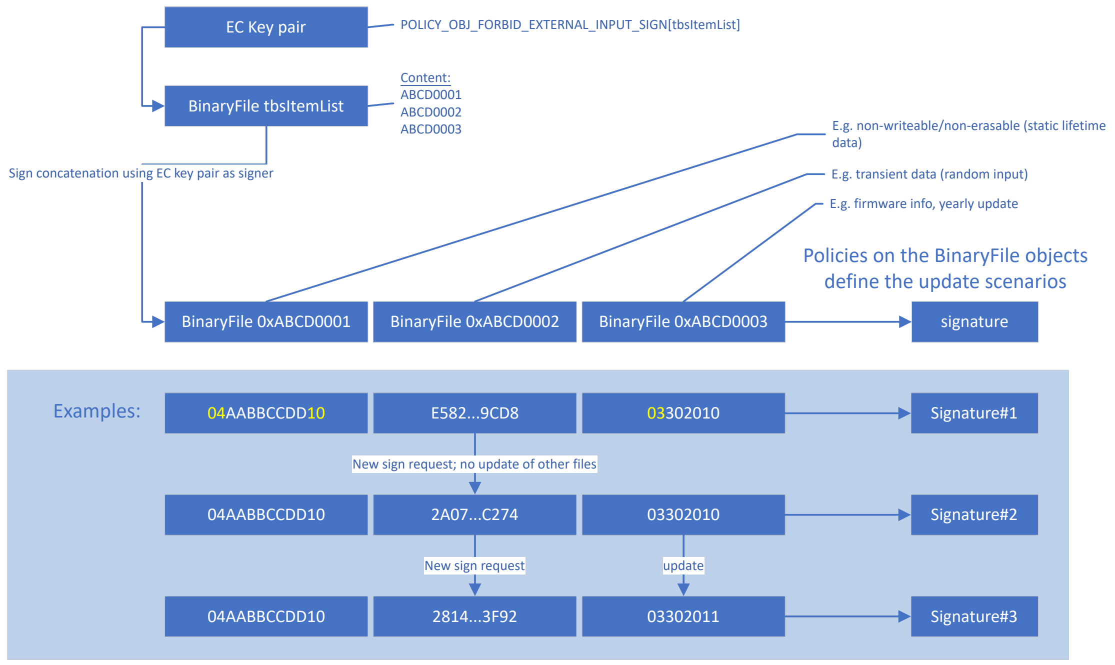

EC Key pair
POLICY_OBJ_FORBID_EXTERNAL_INPUT_SIGN[tbsItemList]
BinaryFile tbsItemList
Content:
ABCD0001
ABCD0002
ABCD0003
Sign concatenation using EC key pair as signer
E.g. non-writeable/non-erasable (static lifetime data)
E.g. transient data (random input)
E.g. firmware info, yearly update
Policies on the BinaryFile objects define the update scenarios
BinaryFile 0xABCD0001
BinaryFile 0xABCD0002
BinaryFile 0xABCD0003
signature
Examples:
04AABBCCDD10
E582...9CD8
03302010
Signature#1
New sign request; no update of other files
04AABBCCDD10
2A07...C274
03302010
Signature#2
New sign request
update
04AABBCCDD10
2814...3F92
03302011
Signature#3

Figure 16. Internal signature example

3.13 FIPS compliance

3.13.1 FIPS 140-2

The SE05x runs in FIPS 140-2, Level 3 (Physical security at Level 4) “approved mode of operation” only if:

- the applet version is equal to 7.2.0.
- the applet feature set is restricted to the following features being set to 1:
  - CONFIG_ECDSA_ECDH_ECDHE
  - CONFIG_HMAC
  - CONFIG_DES
  - CONFIG_AES
  - CONFIG_I2CM
  - CONFIG_RSA_PLAIN

  - CONFIG_RSA_CRT
  - CONFIG_PBKDF
  - CONFIG_TLS
  - CONFIG_RESERVED (these can be set or unset => no influence to FIPS approved mode of operation)
- the applet extended feature set is restricted to the following features being set to 1:
  - EXTCFG_CRYPTO_RSA
  - EXTCFG_CRYPTO_AEAD_GCM_FORBID_EXT_IV
  - EXTCFG_CRYPTO_AEAD
  - EXTCFG_CRYPTO_HMAC
  - EXTCFG_CRYPTO_DES
  - EXTCFG_CRYPTO_AES
  - EXTCFG_CRYPTO_HKDF
  - EXTCFG_CRYPTO_HKDF_FORBID_IN_OUT_LT_112BIT
  - EXTCFG_CRYPTO_PBKDF
  - EXTCFG_CRYPTO_PBKDF_FORBID_SALT_LT_128BIT
  - EXTCFG_CRYPTO_PBKDF_FORBID_IN_OUT_LT_112BIT
  - EXTCFG_CRYPTO_TLS_KDF
  - EXTCFG_CRYPTO_TLS_KDF_FORBID_LT_HMAC_SHA256
  - EXTCFG_CRYPTO_TLS_KDF_ALLOW_EXT_RANDOM_POLICY
  - EXTCFG_CRYPTO_TLS_KDF_FORBID_IN_OUT_LT_112BIT
  - EXTCFG_CRYPTO_DIGEST
  - EXTCFG_CRYPTO_PAKE_SPAKE2PLUS_P256_SHA256_HKDF_HMAC

All other applet features and extended features as mentioned in Supported Applet Features must be set to 0.

When the module runs in FIPS approved mode of operation, at least the following Secure Objects are trust provisioned:

- RESERVED_ID_ECKEY_SESSION
- RESERVED_ID_EXTERNAL_IMPORT
- RESERVED_ID_FEATURE
- RESERVED_ID_PLATFORM_SCP

Note that the product type needs to be running on a platform that is configured properly for FIPS 140-2 compliance. Refer to the SE050F or SE051F configuration datasheet for further details.

3.13.2 FIPS 140-3

The SE05x runs in FIPS 140-3, Level 3 (Physical security at Level 4) “approved mode of operation” only if:

- the applet version is equal to 7.2.22.
- the applet feature set is restricted to the following features being set to 1:
  - CONFIG_ECDSA_ECDH_ECDHE
  - CONFIG_HMAC
  - CONFIG_RSA_PLAIN
  - CONFIG_RSA_CRT
  - CONFIG_AES
  - CONFIG_PBKDF
  - CONFIG_TLS

  - CONFIG_I2CM
- the applet extended feature set is restricted to the following features being set to 1:
  - EXTCFG_CRYPTO_RSA
  - EXTCFG_CRYPTO_AEAD_GCM_FORBID_EXT_IV
  - EXTCFG_CRYPTO_AEAD
  - EXTCFG_CRYPTO_HMAC
  - EXTCFG_CRYPTO_AES
  - EXTCFG_CRYPTO_HKDF
  - EXTCFG_CRYPTO_HKDF_FORBID_IN_OUT_LT_112BIT
  - EXTCFG_CRYPTO_PBKDF
  - EXTCFG_CRYPTO_PBKDF_FORBID_SALT_LT_128BIT
  - EXTCFG_CRYPTO_PBKDF_FORBID_IN_OUT_LT_112BIT
  - EXTCFG_CRYPTO_TLS_KDF
  - EXTCFG_CRYPTO_TLS_KDF_FORBID_LT_HMAC_SHA256
  - EXTCFG_CRYPTO_TLS_KDF_ALLOW_EXT_RANDOM_POLICY
  - EXTCFG_CRYPTO_TLS_KDF_FORBID_IN_OUT_LT_112BIT
  - EXTCFG_CRYPTO_DIGEST
  - EXTCFG_ CRYPTO_PAKE_ SPAKE2PLUS_P384_ SHA512_HKDF_ HMAC
  - EXTCFG_ CRYPTO_PAKE_ SPAKE2PLUS_P384_ SHA256_HKDF_ HMAC
  - EXTCFG_ CRYPTO_PAKE_ SPAKE2PLUS_P256_ SHA512_HKDF_ HMAC

All other applet features and extended features as mentioned in Supported Applet Features are set to 0.

When the module runs in FIPS approved mode of operation, at least the following Secure Objects are trust provisioned:

- RESERVED_ID_ECKEY_SESSION
- RESERVED_ID_EXTERNAL_IMPORT
- RESERVED_ID_FEATURE
- RESERVED_ID_PLATFORM_SCP
- RESERVED_ID_SELFTEST_GCM_ENC_CMD
- RESERVED_ID_SELFTEST_GCM_ENC_RESP
- RESERVED_ID_SELFTEST_GCM_DEC_CMD
- RESERVED_ID_SELFTEST_GCM_DEC_RESP
- RESERVED_ID_SELFTEST_TLS_KDF_CMD
- RESERVED_ID_SELFTEST_TLS_KDF_RESP
- RESERVED_ID_SELFTEST_SP80056C_KDF_CMD
- RESERVED_ID_SELFTEST_SP80056C_KDF_RESP
- RESERVED_ID_SELFTEST_PBKDF2_CMD
- RESERVED_ID_SELFTEST_PBKDF2_RESP
- RESERVED_ID_SELFTEST_KEY_GCM
- RESERVED_ID_SELFTEST_KEY_TLS_KDF
- RESERVED_ID_SELFTEST_KEY_PBKDF2

Before using one of the following functionalities from a user session, users must first use the algorithm from the default session to enable the use of the algorithm from a user session.

- AEAD with AEADMode equal to AES_GCM.
- PBKDF2
- TLS KDF

The product type needs to be running on a platform that is configured properly for FIPS 140-3 compliance. Refer to the SE052F configuration datasheet for further details.

The creation of secure objects which are not supported or partially supported in FIPS 140-3 mode may consume memory regardless the result of object creation.

Garbage collection needs to be triggered manually in order to recover the memory consumed by failed object creation. Any object delection will trigger garbage collection as well.

Features not available when running in FIPS 140-3 mode:

- WriteSymmKey with P1 equal to P1_DES.
- PAKE support
- Mifare DESFire support

3.14 Mandate of platform SCP channel

The SE05x allows to mandate the use of platform SCP by calling SetPlatformSCPRequest. When enabled, users must be authenticated to the platform with highest security level (i.e. C_DECRYPTION/C_MAC and R_ENCRYPTION/R_MAC), else the command will be rejected by the IoT applet.

Exceptions that will not be rejected are:

- Select
- GetVersion
- ReadState

3.15 Garbage collection

The SE05x supports garbage collection to clean up memory.

Garbage collection is triggered when either of these items is deleted:

- Secure Object -only the Secure Object that is deleted is cleaned up, no linked object etc.-
- Crypto Object
- EC curve

When garbage collection is triggered, it will be executed in the delete command itself.

4 SE05x APDU interface

4.1 APDU Format

SE05x IoT applet defines APDUs according to [ISO7816-4] APDU message format. Both standard as well as extended length APDUs are supported. APDUs described in the document use standard length APDU format notation, but extended length APDUs are supported as well.

When the response would contain more than 256 bytes, the C-APDU must be an extended length APDU, i.e. the Le field must be 3 bytes long, else the applet would respond SW_CONDITIONS_NOT_SATISFIED.

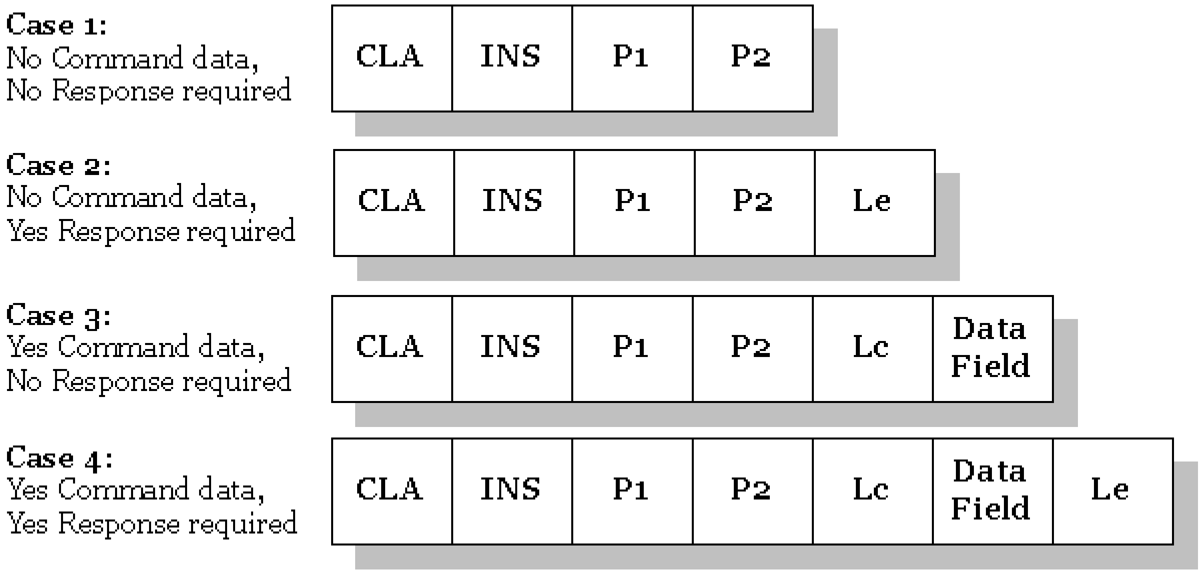


Figure 17. APDU format

4.1.1 APDU header

4.1.1.1 CLA byte

The CLA byte is fixed for each command to 0x80 (= no secure messaging) or 0x84 (= proprietary secure messaging). Any other CLA byte will be rejected.

If APDUs are wrapped (as payload to ProcessSessionCmd), the CLA byte of the wrapper is checked, but the CLA byte of the APDU command in the payload is not checked.

4.1.2 Le field

No explicit checks are done on the Le field validity by the applet. Le field must in any case be smaller than 0x8000.

4.1.3 TLV based payloads

All APDU’s have TLV based payload according to [ISO7816-4] Annex D with some exceptions, as mentioned below.

4.1.3.1 TLV Tag encoding

The specification allows 1-byte Tags only; any value 0x00 up to 0xFF is possible, so this does not comply to [ISO7816-4] Annex D.2: Tag field

4.1.3.2 TLV Length encoding

According [ISO7816-4] Annex E.2: Length field

The length field is limited to 3 bytes maximum (in that case 0x82 followed by 2 bytes indicating the length).

R-APDUs might use a 3-byte L field, even if the length is less than 128 bytes.

4.1.3.3 TLV Value encoding

According [ISO7816-4] Annex E.3: Value field

4.1.4 TLV description

Each TLV will be described with one of the following descriptions:

- *[Optional]* means that the TLV can be used or not; up to the user to decide.
- *[Conditional: <condition>; <error code>]* will indicate that the TLV is conditional where <condition> specifies the condition which is applicable and <error code> specifies the expected error code in case the condition is not fulfilled; e.g.:
  - [Conditional: object does not yet exist; SW_WRONG_DATA] would mean that the TLV is needed when the object does not yet exist. If the TLV is absent in that case, the returned error code would be SW_WRONG_DATA.
  - Note that the error code is not always present. In that case any error code should be assumed.
- If neither [Optional] nor [Conditional] are mentioned, then the TLV is [Mandatory].

A TLV can be Optional and Conditional at the same time. Then the Condition must apply and it is then up to the user to use the TLV or not.

Note that for some APDUs, certain TLVs might be skipped, so it could be an APDU uses e.g., TLV[TAG_1], TLV[TAG_2], TLV[TAG_4], but not TLV[TAG_3].

4.1.5 TLV order

TLVs described for C-APDU must always come in the order as described for an APDU, so users cannot mix the order of TLVs in the C-APDU payload.

4.2 Error codes

Each APDU will list a number of error codes. Note that the listed error codes on each APDU are not limiting; i.e., if another error code is returned, it means the APDU has failed processing and users should take care of appropriate error handling.

4.3 Constants

4.3.1 Error codes

Table 21. Error codes

Name	Value	Description
SW_NO_ERROR	0x9000	No Error
SW_WRONG_LENGTH	0x6700	Wrong length (e.g. C-APDU does not fit into APDU buffer)
SW_CONDITIONS_NOT_SATISFIED	0x6985	Conditions not satisfied
SW_SECURITY_STATUS	0x6982	Security status not satisfied.
SW_WRONG_DATA	0x6A80	Wrong data provided.
SW_DATA_INVALID	0x6984	Data invalid – policy set invalid for the given object
SW_COMMAND_NOT_ALLOWED	0x6986	Command not allowed – access denied based on object policy
SW_FILE_FULL	0x6A84	Not enough memory space available (either transient or persistent memory).

4.3.2 General

Table 22. General constants

Name	Value	Description
MAX_NUMBER_OF_SESSIONS	2	Maximum number of simultaneous applet sessions (excl. session-less access)
MAX_I2CM_COMMAND_LENGTH	255	

4.3.3 Instruction

Table 23. Instruction mask constants

Name	Value	Description
INS_MASK_INS_CHAR	0xF0	4 MSBit for instruction characteristics.
INS_MASK_INSTRUCTION	0x0F	4 LSBit for instruction

Table 24. Instruction characteristics constants

Name	Value	Description
INS_TRANSIENT	0x80	Mask for transient object creation, can only be combined with INS_WRITE. This bit is ignored when the Secure Object already exists.
INS_AUTH_OBJECT	0x40	Mask for authentication object creation, can only be combined with INS_WRITE. This bit is ignored when the Secure Object already exists.
INS_ATTEST	0x20	Mask for getting attestation data

Table 25. Instruction constants

Name	Value	Description
INS_WRITE	0x01	Write or create a persistent object.
INS_READ	0x02	Read the object
INS_CRYPTO	0x03	Perform Security Operation
INS_MGMT	0x04	General operation
INS_PROCESS	0x05	Process session command
INS_IMPORT_EXTERNAL	0x06	Import external object

4.3.4 P1 parameter

Table 26. P1Mask constants

Name	Value	Description
P1_UNUSED	0x80	Highest bit not used
P1_MASK_KEY_TYPE	0x60	2 MSBit for key type
P1_MASK_CRED_TYPE	0x1F	5 LSBit for credential type

Table 27. P1KeyType constants

Name	Value	Description
P1_KEY_PAIR	0x60	Key pair (private key + public key)
P1_PRIVATE	0x40	Private key
P1_PUBLIC	0x20	Public key

Table 28. P1Cred constants

Name	Value
P1_DEFAULT	0x00
P1_EC	0x01
P1_RSA	0x02
P1_AES	0x03
P1_DES	0x04
P1_HMAC	0x05
P1_BINARY	0x06
P1_USERID	0x07
P1_COUNTER	0x08
P1_PCR	0x09
P1_CURVE	0x0B
P1_SIGNATURE	0x0C
P1_MAC	0x0D

Table 28. P1Cred constants*...continued*

Name	Value
P1_CIPHER	0x0E
P1_TLS	0x0F
P1_CRYPTO_OBJ	0x10
P1_AEAD	0x11
P1_PAKE	0x12

4.3.5 P2 parameter

Table 29. P2 constants

Name	Value
P2_DEFAULT	0x00
P2_GENERATE	0x03
P2_CREATE	0x04
P2_SIZE	0x07
P2_SIGN	0x09
P2_VERIFY	0x0A
P2_INIT	0x0B
P2_UPDATE	0x0C
P2_FINAL	0x0D
P2_ONESHOT	0x0E
P2_DH	0x0F
P2_DIVERSIFY	0x10
P2_AUTH_FIRST_PART2	0x12
P2_AUTH_NONFIRST_PART2	0x13
P2_DUMP_KEY	0x14
P2_CHANGE_KEY_PART1	0x15
P2_CHANGE_KEY_PART2	0x16
P2_KILL_AUTH	0x17
P2_IMPORT	0x18
P2_EXPORT	0x19
P2_SESSION_CREATE	0x1B
P2_SESSION_CLOSE	0x1C
P2_SESSION_REFRESH	0x1E
P2_SESSION_POLICY	0x1F
P2_VERSION	0x20
P2_VERSION_EXT	0x21
P2_MEMORY	0x22

Table 29. P2 constants*...continued*

Name	Value
P2_LIST	0x25
P2_TYPE	0x26
P2_EXIST	0x27
P2_DELETE_OBJECT	0x28
P2_DELETE_ALL	0x2A
P2_SESSION_USERID	0x2C
P2_HKDF	0x2D
P2_PBKDF	0x2E
P2_HKDF_EXPAND_ONLY	0x2F
P2_I2CM	0x30
P2_I2CM_ATTESTED	0x31
P2_MAC	0x32
P2_UNLOCK_CHALLENGE	0x33
P2_CURVE_LIST	0x34
P2_ID	0x36
P2_ENCRYPT_ONESHOT	0x37
P2_DECRYPT_ONESHOT	0x38
P2_ATTEST	0x3A
P2_ATTRIBUTES	0x3B
P2_CPLC	0x3C
P2_TIME	0x3D
P2_TRANSPORT	0x3E
P2_VARIANT	0x3F
P2_PARAM	0x40
P2_DELETE_CURVE	0x41
P2_ENCRYPT	0x42
P2_DECRYPT	0x43
P2_VALIDATE	0x44
P2_GENERATE_ONESHOT	0x45
P2_VALIDATE_ONESHOT	0x46
P2_CRYPTO_LIST	0x47
P2_RANDOM	0x49
P2_TLS_PMS	0x4A
P2_TLS_PRF_CLI_HELLO	0x4B
P2_TLS_PRF_SRV_HELLO	0x4C
P2_TLS_PRF_CLI_RND	0x4D

Table 29. P2 constants*...continued*

Name	Value
P2_TLS_PRF_SRV_RND	0x4E
P2_RAW	0x4F
P2_IMPORT_EXT	0x51
P2_SCP	0x52
P2_AUTH_FIRST_PART1	0x53
P2_AUTH_NONFIRST_PART1	0x54
P2_CM_COMMAND	0x55
P2_RESTRICT	0x57
P2_SANITY	0x58
P2_DH_REVERSE	0x59
P2_PRF_BOTH	0x5A
P2_STATE	0x5B
P2_ECPM	0x62

4.3.6 SecureObject type

Table 30. SecureObjectType constants

Name	Value
TYPE_EC_KEY_PAIR	0x01
TYPE_EC_PRIV_KEY	0x02
TYPE_EC_PUB_KEY	0x03
TYPE_RSA_KEY_PAIR	0x04
TYPE_RSA_KEY_PAIR_CRT	0x05
TYPE_RSA_PRIV_KEY	0x06
TYPE_RSA_PRIV_KEY_CRT	0x07
TYPE_RSA_PUB_KEY	0x08
TYPE_AES_KEY	0x09
TYPE_DES_KEY	0x0A
TYPE_BINARY_FILE	0x0B
TYPE_USERID	0x0C
TYPE_COUNTER	0x0D
TYPE_PCR	0x0F
TYPE_HMAC_KEY	0x11
TYPE_EC_KEY_PAIR_NIST_P192	0x21
TYPE_EC_PRIV_KEY_NIST_P192	0x22
TYPE_EC_PUB_KEY_NIST_P192	0x23
TYPE_EC_KEY_PAIR_NIST_P224	0x25

Table 30. SecureObjectType constants*...continued*

Name	Value
TYPE_EC_PRIV_KEY_NIST_P224	0x26
TYPE_EC_PUB_KEY_NIST_P224	0x27
TYPE_EC_KEY_PAIR_NIST_P256	0x29
TYPE_EC_PRIV_KEY_NIST_P256	0x2A
TYPE_EC_PUB_KEY_NIST_P256	0x2B
TYPE_EC_KEY_PAIR_NIST_P384	0x2D
TYPE_EC_PRIV_KEY_NIST_P384	0x2E
TYPE_EC_PUB_KEY_NIST_P384	0x2F
TYPE_EC_KEY_PAIR_NIST_P521	0x31
TYPE_EC_PRIV_KEY_NIST_P521	0x32
TYPE_EC_PUB_KEY_NIST_P521	0x33
TYPE_EC_KEY_PAIR_Brainpool160	0x35
TYPE_EC_PRIV_KEY_Brainpool160	0x36
TYPE_EC_PUB_KEY_Brainpool160	0x37
TYPE_EC_KEY_PAIR_Brainpool192	0x39
TYPE_EC_PRIV_KEY_Brainpool192	0x3A
TYPE_EC_PUB_KEY_Brainpool192	0x3B
TYPE_EC_KEY_PAIR_Brainpool224	0x3D
TYPE_EC_PRIV_KEY_Brainpool224	0x3E
TYPE_EC_PUB_KEY_Brainpool224	0x3F
TYPE_EC_KEY_PAIR_Brainpool256	0x41
TYPE_EC_PRIV_KEY_Brainpool256	0x42
TYPE_EC_PUB_KEY_Brainpool256	0x43
TYPE_EC_KEY_PAIR_Brainpool320	0x45
TYPE_EC_PRIV_KEY_Brainpool320	0x46
TYPE_EC_PUB_KEY_Brainpool320	0x47
TYPE_EC_KEY_PAIR_Brainpool384	0x49
TYPE_EC_PRIV_KEY_Brainpool384	0x4A
TYPE_EC_PUB_KEY_Brainpool384	0x4B
TYPE_EC_KEY_PAIR_Brainpool512	0x4D
TYPE_EC_PRIV_KEY_Brainpool512	0x4E
TYPE_EC_PUB_KEY_Brainpool512	0x4F
TYPE_EC_KEY_PAIR_Secp160k1	0x51
TYPE_EC_PRIV_KEY_Secp160k1	0x52
TYPE_EC_PUB_KEY_Secp160k1	0x53
TYPE_EC_KEY_PAIR_Secp192k1	0x55

Table 30. SecureObjectType constants*...continued*

Name	Value
TYPE_EC_PRIV_KEY_Secp192k1	0x56
TYPE_EC_PUB_KEY_Secp192k1	0x57
TYPE_EC_KEY_PAIR_Secp224k1	0x59
TYPE_EC_PRIV_KEY_Secp224k1	0x5A
TYPE_EC_PUB_KEY_Secp224k1	0x5B
TYPE_EC_KEY_PAIR_Secp256k1	0x5D
TYPE_EC_PRIV_KEY_Secp256k1	0x5E
TYPE_EC_PUB_KEY_Secp256k1	0x5F
TYPE_EC_KEY_PAIR_ED25519	0x65
TYPE_EC_PRIV_KEY_ED25519	0x66
TYPE_EC_PUB_KEY_ED25519	0x67
TYPE_EC_KEY_PAIR_MONT_DH_25519	0x69
TYPE_EC_PRIV_KEY_MONT_DH_25519	0x6A
TYPE_EC_PUB_KEY_MONT_DH_25519	0x6B
TYPE_EC_KEY_PAIR_MONT_DH_448	0x71
TYPE_EC_PRIV_KEY_MONT_DH_448	0x72
TYPE_EC_PUB_KEY_MONT_DH_448	0x73

Note: *TYPE_EC_KEY_PAIR, TYPE_EC_PRIV_KEY and TYPE_EC_PUB_KEY are not returned, the curve will always be included for respectively EC key pairs, EC private keys or EC public keys.*

4.3.7 Memory

Table 31. Memory constants

Name	Value	Description
MEM_PERSISTENT	0x01	Persistent memory
MEM_TRANSIENT_RESET	0x02	Transient memory, clear on reset
MEM_TRANSIENT_DESELECT	0x03	Transient memory, clear on deselect

4.3.8 Origin

Table 32. Origin constants

Name	Value	Description
ORIGIN_EXTERNAL	0x01	Generated outside the module.
ORIGIN_INTERNAL	0x02	Generated inside the module.
ORIGIN_PROVISIONED	0x03	Trust provisioned by NXP

4.3.9 TLV tags

Table 33. Tags

Name	Value
TAG_SESSION_ID	0x10
TAG_POLICY	0x11
TAG_MAX_ATTEMPTS	0x12
TAG_IMPORT_AUTH_DATA	0x13
TAG_IMPORT_AUTH_KEY_ID	0x14
TAG_POLICY_CHECK	0x15
TAG_1	0x41
TAG_2	0x42
TAG_3	0x43
TAG_4	0x44
TAG_5	0x45
TAG_6	0x46
TAG_7	0x47
TAG_8	0x48
TAG_9	0x49
TAG_10	0x4A
TAG_11	0x4B
TAG_TS	0x4F
TAG_ATT_SIG	0x52

4.3.10 ECSignatureAlgo

Table 34. ECSignatureAlgo

Name	Value	Description
SIG_ECDSA_PLAIN	0x09	NOT SUPPORTED
SIG_ECDSA_SHA	0x11	ECDSA with a SHA-1 digest as input.
SIG_ECDSA_SHA_224	0x25	ECDSA with a SHA224 digest as input.
SIG_ECDSA_SHA_256	0x21	ECDSA with a SHA256 digest as input.
SIG_ECDSA_SHA_384	0x22	ECDSA with a SHA384 digest as input.
SIG_ECDSA_SHA_512	0x26	ECDSA with a SHA512 digest as input.

4.3.11 EDSignatureAlgo

Table 35. EDSignatureAlgo

Name	Value	Description
SIG_ED25519PURE	0xA3	EDDSA Pure (using SHA512 as digest)

4.3.12 ECDHAlgo

Table 36. ECDHAlgo

Name	Value	Description
EC_SVDP_DH	0x01	Generates the SHA1 of the X coordinate.
EC_SVDP_DH_PLAIN	0x03	Generates the X coordinate

4.3.13 ECPMAlgo

Table 37. ECPMAlgo

Name	Value	Description
EC_PACE_GM	0x05	Generates the uncompressed EC point (s * G + H)
EC_SVDP_DH_PLAIN_XY	0x06	Generates the uncompressed EC point XY.

4.3.14 RSASignatureAlgo

Table 38. RSASignatureAlgo

Name	Value	Description
RSA_SHA1_PKCS1_PSS	0x15	RFC8017: RSASSA-PSS
RSA_SHA224_PKCS1_PSS	0x2B	RFC8017: RSASSA-PSS
RSA_SHA256_PKCS1_PSS	0x2C	RFC8017: RSASSA-PSS
RSA_SHA384_PKCS1_PSS	0x2D	RFC8017: RSASSA-PSS
RSA_SHA512_PKCS1_PSS	0x2E	RFC8017: RSASSA-PSS; RSA512 not supported for this algorithm.
RSA_SHA1_PKCS1	0x0A	RFC8017: RSASSA-PKCS1-v1_5
RSA_SHA_224_PKCS1	0x27	RFC8017: RSASSA-PKCS1-v1_5
RSA_SHA_256_PKCS1	0x28	RFC8017: RSASSA-PKCS1-v1_5
RSA_SHA_384_PKCS1	0x29	RFC8017: RSASSA-PKCS1-v1_5
RSA_SHA_512_PKCS1	0x2A	RFC8017: RSASSA-PKCS1-v1_5

4.3.15 RSAEncryptionAlgo

Table 39. RSAEncryptionAlgo

Name	Value	Description
RSA_NO_PAD	0x0C	Plain RSA, padding required on host.
RSA_PKCS1	0x0A	RFC8017: RSAES-PKCS1-v1_5
RSA_PKCS1_OAEP	0x0F	RFC8017: RSAES-OAEP (using SHA1 as digest)

4.3.16 RSABitLength

Table 40. RSABitLength

Name	Value
RSA_512	512
RSA_1024	1024

Table 40. RSABitLength*...continued*

Name	Value
RSA_1152	1152
RSA_2048	2048
RSA_3072	3072
RSA_4096	4096

4.3.17 RSAKeyComponent

Table 41. RSAKeyComponent

Name	Value	Description
RSA_COMP_MOD	0x00	Modulus
RSA_COMP_PUB_EXP	0x01	Public key exponent
RSA_COMP_PRIV_EXP	0x02	Private key exponent
RSA_COMP_P	0x03	CRT component p
RSA_COMP_Q	0x04	CRT component q
RSA_COMP_DP	0x05	CRT component dp
RSA_COMP_DQ	0x06	CRT component dq
RSA_COMP_INVQ	0x07	CRT component q_inv

4.3.18 DigestMode

Table 42. DigestMode constants

Name	Value
DIGEST_NO_HASH	0x00
DIGEST_SHA	0x01
DIGEST_SHA224	0x07
DIGEST_SHA256	0x04
DIGEST_SHA384	0x05
DIGEST_SHA512	0x06

4.3.19 MACAlgo

Table 43. MACAlgo constants

Name	Value	Description
HMAC_SHA1	0x18	
HMAC_SHA256	0x19	
HMAC_SHA384	0x1A	
HMAC_SHA512	0x1B	
CMAC128	0x31	
DES_CMAC8	0x7A	Only available in DigestOneShot.

4.3.20 ECCurve

Table 44. ECCurve constants

Name	Curve ID	Weierstrass
UNUSED	0x00	-
NIST_P192	0x01	Y
NIST_P224	0x02	Y
NIST_P256	0x03	Y
NIST_P384	0x04	Y
NIST_P521	0x05	Y
Brainpool160	0x06	Y
Brainpool192	0x07	Y
Brainpool224	0x08	Y
Brainpool256	0x09	Y
Brainpool320	0x0A	Y
Brainpool384	0x0B	Y
Brainpool512	0x0C	Y
Secp160k1	0x0D	Y
Secp192k1	0x0E	Y
Secp224k1	0x0F	Y
Secp256k1	0x10	Y
RFU	0x11	-
ID_ECC_ED_25519	0x40	N
ID_ECC_MONT_DH_25519	0x41	N
ID_ECC_MONT_DH_448	0x43	N

Note: *Curve ID's ECC_MONT_DH_25519 and ECC_MONT_DH_448 only need to be created using CreateECCurve and deleted using DeleteECCurve, no need to call SetECCurveParameters for these curves. Curve ID ECC_ED_25519 does not need to be created using CreateECCurve (this would return an error), does not need SetECCurveParameters and can not be deleted using DeleteECCurve.*

4.3.21 ECCurveParam

Table 45. ECCurveParam constants

Name	Value
CURVE_PARAM_A	0x01
CURVE_PARAM_B	0x02
CURVE_PARAM_G	0x04
CURVE_PARAM_N	0x08
CURVE_PARAM_PRIME	0x10

4.3.22 CipherMode

Table 46. CipherMode constants

Name	Value	Description
DES_CBC_NOPAD	0x01	Using DESKey Secure Objects
DES_CBC_ISO9797_M1	0x02	Using DESKey Secure Objects
DES_CBC_ISO9797_M2	0x03	Using DESKey Secure Objects
DES_CBC_PKCS5	0x04	NOT SUPPORTED
DES_ECB_NOPAD	0x05	Using DESKey Secure Objects
DES_ECB_ISO9797_M1	0x06	NOT SUPPORTED
DES_ECB_ISO9797_M2	0x07	NOT SUPPORTED
DES_ECB_PKCS5	0x08	NOT SUPPORTED
AES_ECB_NOPAD	0x0E	Using AESKey Secure Objects
AES_CBC_NOPAD	0x0D	Using AESKey Secure Objects
AES_CBC_ISO9797_M1	0x16	Using AESKey Secure Objects
AES_CBC_ISO9797_M2	0x17	Using AESKey Secure Objects
AES_CBC_PKCS5	0x18	NOT SUPPORTED
AES_CTR	0xF0	Using AESKey Secure Objects

4.3.23 AEADMode

Table 47. AEADMode

Name	Value	Description
AES_GCM	0xB0	AES GCM/GMAC operations
AES_CCM	0xF4	AES CCM operations

4.3.24 AttestationAlgo

AttestationAlgo is either ECSignatureAlgo or RSASignatureAlgo.

4.3.25 AppletConfig

Table 48. Applet configurations

Name	Value
CONFIG_RESERVED	0x0001
CONFIG_ECDSA_ECDH_ECDHE	0x0002
CONFIG_EDDSA	0x0004
CONFIG_DH_MONT	0x0008
CONFIG_HMAC	0x0010
CONFIG_RSA_PLAIN	0x0020
CONFIG_RSA_CRT	0x0040
CONFIG_AES	0x0080

Table 48. Applet configurations*...continued*

Name	Value
CONFIG_DES	0x0100
CONFIG_PBKDF	0x0200
CONFIG_TLS	0x0400
CONFIG_MIFARE	0x0800
CONFIG_I2CM	0x2000
CONFIG_ECC_ALL	0x000F
CONFIG_RSA_ALL	0x0060
CONFIG_ALL	0x3FFF

4.3.26 LockIndicator

Table 49. LockIndicator constants

Name	Value
TRANSIENT_LOCK	0x01
PERSISTENT_LOCK	0x02

4.3.27 LockState

Table 50. LockState constants

Name	Value
LOCKED	0x01
UNLOCKED	Any except 0x01

4.3.28 RestrictMode

Table 51. RestrictMode constants

Name	Value
RESTRICT_NEW	0x01
RESTRICT_ALL	0x02

4.3.29 CryptoContext

Table 52. CryptoContext constants

Name	Value	Description
CC_DIGEST	0x01	For DigestInit/DigestUpdate/DigestFinal
CC_CIPHER	0x02	For CipherInit/CipherUpdate/CipherFinal
CC_SIGNATURE	0x03	For MACInit/MACUpdate/MACFinal
CC_AEAD	0x04	For AEADInit/AEADUpdate/AEADFinal
CC_PAKE	0x05	For PAKE support

4.3.30 Result

Table 53. Result constants

Name	Value
RESULT_SUCCESS	0x01
RESULT_FAILURE	0x02

4.3.31 TransientIndicator

Table 54. TransientIndicator constants

Name	Value
PERSISTENT	0x01
TRANSIENT	0x02

4.3.32 SetIndicator

Table 55. SetIndicator constants

Name	Value
NOT_SET	0x01
SET	0x02

4.3.33 MoreIndicator

Table 56. MoreIndicator constants

Name	Value	Description
NO_MORE	0x01	No more data available
MORE	0x02	More data available

4.3.34 HealthCheckMode

Table 57. HealthCheckMode constants

Name	Value	Description
HCM_FIPS	0xF906	Triggers all on-demand self-tests. Can only be done when the module is in FIPS mode. When the test fails, the chip goes into TERMINATED state.
HCM_ CODE_SIGNATURE	0xFE01	Performs ROM integrity checks. When the test fails, the chip triggers the attack counter and the chip will reset.
HCM_DYNAMIC_FLASH_INTEGRITY	0xFD02	Performs flash integrity tests. When the test fails, the chip triggers the attack counter and the chip will reset.
HCM_SHIELDING	0xFC03	Performs tests on the active shield protection of the hardware. When the test fails, the chip triggers the attack counter and the chip will reset.

Table 57. HealthCheckMode constants*...continued*

Name	Value	Description
HCM_SENSOR	0xFB04	Performs self-tests on hardware sensors and reports the status.
HCM_SFR_CHECK	0xFA05	Performs self-tests on the hardware registers. When the test fails, the chip triggers the attack counter and the chip will reset.

4.3.35 PlatformSCPRequest

Table 58. PlatformSCPRequest constants

Name	Value	Description
SCP_REQUIRED	0x01	Platform SCP is required (full enc & MAC)
SCP_NOT_REQUIRED	0x02	No platform SCP required.

4.3.36 SPAKE2PlusDeviceType

Table 59. SPAKE2PlusDeviceType

Name	Value	Description
SPAKE2PLUS_DEVICE_TYPE_UNKNOWN	0x00	The device type is not set.
SPAKE2PLUS_DEVICE_TYPE_A	0x01	w0 and w1 required.
SPAKE2PLUS_DEVICE_TYPE_B	0x02	w0 and L required.

4.3.37 PAKEMode

Table 60. PAKEMode

Name	Value	Description
SPAKE2PLUS_P256_SHA256_HKDF_HMAC_v02	0x01	see [SPAKE2+v02] for details
SPAKE2PLUS_P256_SHA512_HKDF_HMAC	0x02	see [SPAKE2+] for details
SPAKE2PLUS_P384_SHA256_HKDF_HMAC	0x03	see [SPAKE2+] for details
SPAKE2PLUS_P384_SHA512_HKDF_HMAC	0x04	see [SPAKE2+] for details
SPAKE2PLUS_P521_SHA512_HKDF_HMAC	0x05	see [SPAKE2+] for details
SPAKE2PLUS_ED25519_SHA256_HKDF_HMAC	0x06	Not supported
SPAKE2PLUS_ED448_SHA512_HKDF_HMAC	0x07	Not supported
SPAKE2PLUS_P256_SHA256_HKDF_CMAC	0x08	see [SPAKE2+] for details
SPAKE2PLUS_P256_SHA512_HKDF_CMAC	0x09	see [SPAKE2+] for details
SPAKE2PLUS_P256_SHA256_HKDF_HMAC	0x0A	see [SPAKE2+] for details

4.3.38 PAKEState

Table 61. PAKEState

Name	Value	Description
PAKE_STATE_SETUP	0x00	
PAKE_STATE_KEY_SHARE_GENERATED	0xA5	
PAKE_STATE_SESSION_KEYS_GENERATED	0x5A	

4.3.39 CryptoObject

A CryptoObject is a 2-byte value consisting of a CryptoContext in MSB and one of the following in LSB:

- DigestMode in case CryptoContext = CC_DIGEST
- CipherMode in case CryptoContext = CC_CIPHER
- MACAlgo in case CryptoContext = CC_SIGNATURE
- AEADMode in case CryptoContext = CC_AEAD
- PAKEMode in case CryptoContext = CC_PAKE

4.3.40 VersionInfo

VersionInfo is a 7-byte value consisting of:

- 1-byte Major applet version
- 1-byte Minor applet version
- 1-byte patch applet version
- 2-byte appletConfig, indicating the supported applet features
- 2-byte Secure Box version: major version (MSB) concatenated with minor version (LSB).

4.3.41 Policy constants

A notation will be used to identify specific bits: the most significant Byte is 1 and the most significant bit is 8; so if B2b7 is set, this would be coded as 0x00 0x40.

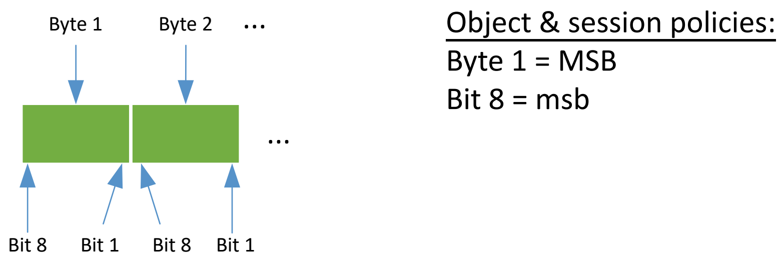


Figure 18. Policy notation

4.3.41.1 Session policy

The session policy header is coded as follows:

Table 62. Session policies

Policy name	Description	Position in Header	Extension required?	Extension length
POLICY_SESSION_MAX_APDU	Defines the maximum number of APDUs allowed within the session. Note that the ExchangeSessionData command itself is also counted as APDU within the session.	0x8000	Y	2
POLICY_SESSION_MAX_TIMEOUT	Defines the time (in seconds) that a session remains opened. When the timeout expires, the session is closed.	0x4000	Y	2
POLICY_SESSION_ALLOW_REFRESH	Defines whether this session can be refreshed without losing context.	0x2000	N	
RFU	Other values reserved for future use	0x1FFF	n/a	

Setting a session policy is optional. If not set, there is no maximum number of APDU allowed, neither a session timeout. The session cannot be refreshed by default. In short, the default session policy is coded as: ‘02 0000’

4.3.41.2 Object policy

This section lists all object policies and indicates which policies are applicable for which type of object. Attempting to set policies not allowed for a certain object type leads to failure on object creation.

Table 63. Access rules

Access rule	Description	Bit in AR Header	Extension required?	Extension length
POLICY_OBJ_ALLOW_TLS_KDF	Allow TLS KDF (TLSPerform PRF).	0x80000000	N	
POLICY_OBJ_ALLOW_TLS_PMS	Allow TLS pre master secret calculation	0x40000000	N	
POLICY_OBJ_FORBID_ALL	Explicitly forbid all operations	0x20000000	N	
POLICY_OBJ_ALLOW_SIGN	Allow signature or MAC generation	0x10000000	N	
POLICY_OBJ_ALLOW_VERIFY	Allow signature or MAC verification	0x08000000	N	
POLICY_OBJ_ALLOW_KA	Allow key agreement	0x04000000	N	
POLICY_OBJ_ALLOW_ENC	Allow encryption	0x02000000	N	
POLICY_OBJ_ALLOW_DEC	Allow decryption	0x01000000	N	
POLICY_OBJ_ALLOW_KDF	Allow KDF	0x00800000	N	
POLICY_OBJ_ALLOW_RFC3394_UNWRAP	Allow key wrapping (master key)	0x00400000	N	
POLICY_OBJ_ALLOW_READ	Allow to read the object	0x00200000	N	
POLICY_OBJ_ALLOW_WRITE	Allow to write the object	0x00100000	N	
POLICY_OBJ_ALLOW_GEN	Allow to (re)generate the object (only internally)	0x00080000	N	
POLICY_OBJ_ALLOW_DELETE	Allow to delete the object	0x00040000	N	

Table 63. Access rules*...continued*

Access rule	Description	Bit in AR Header	Extension required?	Extension length
POLICY_OBJ_REQUIRE_SM	Require SCP03 or ECKey session secure messaging where secure messaging requires C_MAC and C_DECRYPTION set.	0x00020000	N	
POLICY_OBJ_REQUIRE_PCR_VALUE	Indicates that access to the object is allowed only if the given PCR object contains a certain value	0x00010000	Y	4 bytes PCR object ID 32 bytes PCR value
POLICY_OBJ_ALLOW_ATTESTATION	Indicates that this object may be used to create attestation statements (i.e. perform attestation of other objects)	0x00008000	N	
POLICY_OBJ_ALLOW_DESFIRE_AUTHENTICATION	Indicates that this object may be used to perform DESFire authentication	0x00004000	N	
POLICY_OBJ_ALLOW_DESFIRE_DUMP_SESSION_KEYS	Indicates that the DESFire session keys may be dumped to host	0x00002000	N	
POLICY_OBJ_ALLOW_IMPORT_EXPORT	Indicates that this object can be imported or exported	0x00001000	N	
POLICY_OBJ_FORBID_DERIVED_OUTPUT	Indicates if the object allows to output derived data	0x00000800	N	
POLICY_OBJ_ALLOW_TLS_KDF_EXT_RANDOM	Indicates that client randoms can be inserted as argument for TLSPerformPRF.	0x00000400	N	
POLICY_OBJ_ALLOW_DESFIRE_CHANGEKEY	Indicates that the key can be used to overwrite a DESFire card key.	0x00000200	Y	4 bytes DESFire authentication key identifier.
POLICY_OBJ_ALLOW_DERIVED_INPUT	Indicates that a key object uses derived output as key value.	0x00000100	Y	4 bytes master key for derivation.
POLICY_OBJ_ALLOW_PBKDF	Allow PBKDF	0x00000080	N	
POLICY_OBJ_ALLOW_DESFIRE_KDF	Allow DESFire key diversification	0x00000040	N	
POLICY_OBJ_FORBID_EXTERNAL_IV	Enforce internal IV generation	0x00000020	N	
POLICY_OBJ_ALLOW_USAGE_AS_HMAC_PEPPER	Allow usage as secret salt	0x00000010	N	
POLICY_OBJ_FORBID_EXTERNAL_INPUT_SIGN	Forbid signature generation with external input	0x00000008	Y	4 bytes Binary File identifier containing the list of objects to sign.
RFU	Other values reserved for future use	0x00000007	n/a	

4.4 Applet selection

The applet can be selected by sending a GP SELECT command. This command interacts with the JCOP Card Manager and will result in the selection of the SE05x IoT applet.

Table 64. AppletSelect C-APDU

Field	Value	Description
CLA	0x00	
INS	0xA4	
P1	0x04	
P2	0x00	
Lc	0x10	
Payload	0xA0000003965453000000010300000000	Applet AID
Le	0x00	

Table 65. AppletSelect R-APDU Body

Value	Description
Applet version	7-byte VersionInfo

Table 66. AppletSelect R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

4.5 Session management

See Sessions for general information on sessions.

4.5.1 Generic session commands

4.5.1.1 CreateSession

Creates a session on SE05x.

Depending on the authentication object being referenced, a specific method of authentication applies. The response needs to adhere to this authentication method.

Table 67. CreateSession C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_MGMT	See Instruction
P1	P1_DEFAULT	See P1
P2	P2_SESSION_CREATE	See P2
Lc	#(Payload)	Payload length.

Table 67. CreateSession C-APDU...*continued*

Field	Value	Description
Payload	TLV[TAG_1]	4-byte authentication object identifier.
Le	0x0C	Expecting TLV with 8-byte session ID.

Table 68. CreateSession R-APDU Body

Value	Description
TLV[TAG_1]	8-byte session identifier.

Table 69. CreateSession R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.
SW_CONDITIONS_NOT_SATISFIED	• The authenticator does not exist • The provided input data are incorrect. • The session is invalid.

4.5.1.2 ExchangeSessionData

Sets session policies for the current session.

Table 70. ExchangeSessionData C-APDU

Field	Value	Description
CLA	0x80 or 0x84	-
INS	INS_MGMT	See Instruction
P1	P1_DEFAULT	See P1
P2	P2_SESSION_POLICY	See P2
Lc	#(Payload)	Payload length.
Payload	TLV[TAG_1]	Session policies
	C-MAC	If applicable
Le	0x00	-

Table 71. ExchangeSessionData R-APDU Body

Value	Description
R-MAC	Optional, depending on established security level

Table 72. ExchangeSessionData R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.
SW_CONDITIONS_NOT_SATISFIED	Invalid policies

4.5.1.3 ProcessSessionCmd

Requests a command to be processed within a specific session. Note that the applet does not check the validity of the CLA byte of the TLV[TAG_1] payload.

If the command returns an error, the actual APDU command (in TLV[TAG_1]) is not executed.

Table 73. ProcessSessionCmd C-APDU

Field	Value	Description
CLA	0x80 or 0x84	-
INS	INS_PROCESS	See Instruction
P1	P1_DEFAULT	See P1
P2	P2_DEFAULT	See P2
Lc	#(Payload)	Payload length.
Payload	TLV[TAG_SESSION_ID]	Session ID
	TLV[TAG_1]	Actual APDU command to be processed. The full command is to be added, including APDU Header and Payload.
Le	0x00	

Table 74. ProcessSessionCmd R-APDU Body

Value	Description
variable	as defined in the specific command section

Table 75. ProcessSessionCmd R-APDU Trailer

SW	Description
variable	as defined in the specific command section

4.5.1.4 RefreshSession

Refreshes a session on SE05x, the policy of the running session can be updated; the rest of the session state remains.

Table 76. RefreshSession C-APDU

Field	Value	Description
CLA	0x80	-
INS	INS_MGMT	See Instruction
P1	P1_DEFAULT	See P1
P2	P2_SESSION_REFRESH	See P2
Lc	#(Payload)	Payload length.
	TLV[TAG_POLICY]	Byte array containing the policy to attach to the session. *[Optional]*
Le	-	

Table 77. RefreshSession R-APDU Body

Value	Description
-	

Table 78. RefreshSession R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

4.5.1.5 CloseSession

Closes a running session.

When a session is closed, it cannot be reopened.

All session parameters are transient.

If CloseSession returns a Status Word different from SW_NO_ERROR, the applet immediately needs to be reselected as further APDUs would not be handled successfully.

Table 79. CloseSession

Field	Value	Description
CLA	0x80	
INS	INS_MGMT	See Instruction
P1	P1_DEFAULT	See P1
P2	P2_SESSION_CLOSE	See P2

Table 80. CloseSession R-APDU Body

Value	Description
None	

Table 81. CloseSession R-APDU Trailer

SW	Description
SW_NO_ERROR	The session is closed successfully.
SW_CONDITIONS_NOT_SATISFIED	The session is not closed successfully.

4.5.2 UserID session operations

4.5.2.1 VerifySessionUserID

Verifies the session user identifier (UserID) in order to allow setting up a session. If the UserID is correct, the session establishment is successful; otherwise the session cannot be opened (SW_CONDITIONS_NOT_SATISFIED is returned).

Table 82. VerifySessionUserID C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_MGMT	See Instruction
P1	P1_DEFAULT	See P1
P2	P2_SESSION_USERID	See P2
Lc	#(Payload)	Payload length.
	TLV[TAG_1]	UserID value.
Le	-	No data to be returned.

Table 83. VerifySessionUserID R-APDU Body

Value	Description
-	No data returned.

Table 84. VerifySessionUserID R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.
SW_CONDITIONS_NOT_SATISFIED	Wrong userID value.

4.5.3 AESKey session operations

4.5.3.1 SCPInitializeUpdate

[SCP03] Section 7.1.1 shall be applied.

The user shall always set the P1 parameter to ‘00’ (KVN = ‘00’).

4.5.3.2 SCPExternalAuthenticate

[SCP03] Section 7.1.2 shall be applied.

4.5.4 ECKey session operations

4.5.4.1 ECKeySessionInternalAuthenticate

Initiates an authentication based on an ECKey Authentication Object. See Section 3.6.3.3 for more information.

The user shall always use key version number = ‘00’ and key identifier = ‘00’.

Table 85. ECKeySessionInternalAuthenticate C-APDU

Field	Value	Description
CLA	0x84	
INS	0x88	

Table 85. ECKeySessionInternalAuthenticate C-APDU*...continued*

Field	Value	Description
P1	P1_DEFAULT	Key version number
P2	P2_DEFAULT	Key identifier
Lc	#(Payload)	
Payload	TLV[TAG_1]	Input data (see Table 86)
Le	0x00	

Table 86. ECKeySessionInternalAuthenticate C-APDU payload

TAG	SubTag	Length	Value
0xA6		Var	Control Reference Template
	0x4F	5-16	applet Instance AID
	0x90	3	SCP identifier and parameters: • SCP identifier must equal 0xAB • 2 byte parameters: 0x01 followed by a 1-byte GlobalPlatform security level
	0x80	1	Key type
	0x81	1	Key length; only 16 bytes are supported (AES128)
0x7F49			
	0xB0	Var	Host key pair public key.
	0xF0	Var	1-byte ECCurve identifier.
0x5F37		Var	ASN.1 signature generated using the host key pair's private key.

Table 87. ECKeySessionInternalAuthenticate R-APDU Body

Value	Description
0x85	16-byte secure element challenge
0x86	16-byte receipt

Table 88. ECKeySessionInternalAuthenticate R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

4.6 Module management

4.6.1 SetLockState

Sets the applet transport lock (locked or unlocked). There is a Persistent lock and a Transient Lock. If the Persistent lock is UNLOCKED, the device is unlocked (regardless of the Transient lock). If the Persistent lock is LOCKED, the device is only unlocked when the Transient lock is UNLOCKED and the device will be locked again after deselect of the applet.

Note that regardless of the lock state, the credential RESERVED_ID_TRANSPORT allows access to all features. For example, it is possible to write/update objects within the session opened by RESERVED_ID_TRANSPORT, even if the applet is locked.

The default TRANSIENT_LOCK state is LOCKED; there is no default PERSISTENT_LOCK state (depends on product configuration).

Table 89. Lock behavior

PERSISTENT_LOCK	TRANSIENT_LOCK	Behavior
UNLOCKED	UNLOCKED	Unlocked until PERSISTENT_LOCK set to LOCKED.
UNLOCKED	LOCKED	Unlocked until PERSISTENT_LOCK set to LOCKED.
LOCKED	UNLOCKED	Unlocked until deselect or TRANSIENT_LOCK set to LOCKED.
LOCKED	LOCKED	Locked until PERSISTENT_LOCK set to UNLOCKED.

This command can only be used in a session that used the credential with identifier RESERVED_ID_TRANSPORT as authentication object.

Table 90. SetLockState C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_MGMT	See Instruction
P1	P1_DEFAULT	See P1
P2	P2_TRANSPORT	See P2
Lc	#(Payload)	
Payload	TLV[TAG_1]	1-byte LockIndicator
	TLV[TAG_2]	1-byte LockState
Le	-	No data to be returned.

Table 91. SetLockState R-APDU Body

Value	Description
None	No data returned.

Table 92. SetLockState R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

4.6.2 DisableObjectCreation

Disables object creation, either permanent or temporary and either only for new objects or also for existing objects.

Users need to decide if the switch is permanent or temporary:

- To permanently disable: LockIndicator = LOCK_PERSISTENT
- To temporary disable: LockIndicator = LOCK_TRANSIENT

Persistent locks remain over the lifetime of the product, transient locks are unlocked when deselecting the applet.

Users need to decide the level of restriction:

- To disable creation of new Secure Objects: RestrictMode = RESTRICT_NEW
- To disable creation of new Secure Objects and disable update of existing objects: RestrictMode = RESTRICT_ALL.

The following scenarios are applicable:

- When applying RESTRICT_ALL to LOCK_PERSISTENT, no object creation, modification or deletion is possible any more (permanently).
- When applying RESTRICT_NEW to LOCK_PERSISTENT, no new object creation or deletion is possible any more (permanently), but existing objects can still be modified.
- When applying RESTRICT_ALL to LOCK_TRANSIENT, no new object creation, modification or deletion is possible any more until applet deselect.
- When applying RESTRICT_NEW to LOCK_TRANSIENT, no new object creation or deletion is possible any more until applet deselect, but modification is possible except if RESTRICT_ALL is set on LOCK_PERSISTENT.

This command can only be used in a session that used the credential with identifier RESERVED_ID_RESTRICT as authentication object.

Table 93. DisableObjectCreation C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_MGMT	See Instruction
P1	P1_DEFAULT	See P1
P2	P2_RESTRICT	See P2
Lc	#(Payload)	
Payload	TLV[TAG_1]	1-byte LockIndicator
	TLV[TAG_2]	1-byte RestrictMode
Le	-	No data to be returned.

Table 94. DisableObjectCreation R-APDU Body

Value	Description
None	No data returned.

Table 95. DisableObjectCreation R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

4.6.3 SetPlatformSCPRequest

Sets the required state for platform SCP (required or not required). This is a persistent state.

If platform SCP is set to SCP_REQUIRED, any applet APDU command will be refused by the applet when platform SCP is not enabled. Enabled means full encryption and MAC, both on C-APDU and R-APDU. Any other level is not sufficient and will not be accepted. SCP02 will not be accepted (as there is no response MAC and encryption).

If platform SCP is set to “not required,” any applet APDU command will be accepted by the applet.

This command can only be used in a session that used the credential with identifier RESERVED_ID_PLATFORM_SCP as authentication object.

Note that the default state is SCP_NOT_REQUIRED.

Table 96. SetPlatformSCPRequest C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_MGMT	See Instruction
P1	P1_DEFAULT	See P1
P2	P2_SCP	See P2
Lc	#(Payload)	
Payload	TLV[TAG_1]	1-byte PlatformSCPRequest
Le	-	No data to be returned.

Table 97. SetPlatformSCPRequest R-APDU Body

Value	Description
None	No data returned.

Table 98. SetPlatformSCPRequest R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

4.6.4 SetAppletFeatures

Sets the applet features that are supported. To successfully execute this command, the session must be authenticated using the RESERVED_ID_FEATURE.

The 2-byte input value is a pre-defined AppletConfig value.

Table 99. SetAppletFeatures C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_MGMT	See Instruction
P1	P1_DEFAULT	See P1
P2	P2_VARIANT	See P2
Lc	#(Payload)	Payload length.
Payload	TLV[TAG_1]	2-byte Variant from AppletConfig or a 32-byte array starting with a 2-byte Variant from AppletConfig followed by 30 bytes ExtendedFeatureBits.

Table 100. SetAppletFeatures R-APDU Body

Value	Description
None	No data returned.

Table 101. SetAppletFeatures R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

4.6.5 SendCardManagerCommand

Sends a command to the Card Manager.

This function allows to send Card Manager commands from an external entity without the need to select the Card Manager explicitly, using the applet mechanisms to ensure a secure end-to-end channel for these commands to be communicated, e.g. using an ECKey session.

Note that the use of the command does not bypass any security mechanism from the Card Manager, i.e. users still must authenticate before performing a command that requires authentication.

Table 102. SendCardManagerCommand C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_MGMT	See Instruction
P1	P1_DEFAULT	See P1
P2	P2_CM_COMMAND	See P2
Lc	#(Payload)	Payload length
Payload	TLV[TAG_1]	APDU to be sent to the Card Manager.
Le	0x00	Expected response length

Table 103. SendCardManagerCommand R-APDU Body

Value	Description
TLV[TAG_1]	Byte array containing the Card Manager response.

Table 104. SendCardManagerCommand R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

4.6.6 TriggerSelfTest

Trigger a system health check for the system. When calling this command, a self-test is triggered in the operating system. When the test fails, the device might not respond with a R-APDU as the chip is reset.

If HealthCheckMode is set to HCM_FIPS, the test will only work if the device is running in FIPS approved mode of operation. See FIPS compliance.

Table 105. TriggerSelfTest C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_MGMT	See Instruction. In addition to INS_MGMT, users can set a flag to request an attested response.
P1	P1_DEFAULT	See P1
P2	P2_SANITY	See P2
Lc	#(Payload)	Payload length
Payload	TLV[TAG_1]	2-byte value from HealthCheckMode
	TLV[TAG_5]	4-byte attestation object identifier. Minimum policy: POLICY_OBJ_ALLOW_ATTESTATION *[Optional]* *[Conditional: only when attestation is requested.]*
	TLV[TAG_6]	1-byte AttestationAlgo *[Optional]* *[Conditional: only when attestation is requested.]*
	TLV[TAG_7]	16-byte freshness random *[Optional]* *[Conditional: only when attestation is requested.]*
Le	0x00	2-byte response + attested data (if an attestation flag is set).

Table 106. TriggerSelfTest R-APDU Body

Value	Description
TLV[TAG_1]	TLV containing 1-byte Result.
TLV[TAG_2]	TLV containing 18-byte chip unique ID *[Conditional: only when attestation is requested.]*
TLV[TAG_4]	TLV containing 0x0000. *[Conditional: only when attestation is requested.]*
TLV[TAG_TS]	TLV containing 12-byte timestamp *[Conditional: only when attestation is requested.]*
TLV[TAG_ATT_SIG]	TLV containing signature over the hashed plain C-APDU concatenated with tag, length and value of TLV[TAG_1], TLV[TAG_2], TLV[TAG_4] and TLV[TAG_TS] as returned by the applet. *[Conditional: only when attestation is requested.]*

Table 107. TriggerSelfTest R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

4.6.7 ReadState

Read the LockState, RestrictMode and PlatformSCPRequest status of the device. This command will return the current state of the device, regardless of transient or persistent lock state.

This command can be sent without applying platform SCP -even if PlatformSCPRequest is SCP_REQUIRED- and will also return a valid response when the LockState is LOCKED.

Table 108. ReadState C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_READ	See Instruction.
P1	P1_DEFAULT	See P1
P2	P2_STATE	See P2
Le	0x07	3-byte response.

Table 109. ReadState R-APDU Body

Value	Description
TLV[TAG_1]	TLV containing 3-byte result: LockState, RestrictMode and PlatformSCPRequest. If RestrictMode equals 0x00, no restrictions are applied.

Table 110. ReadState R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

4.7 Secure Object management

4.7.1 WriteSecureObject

Creates or writes to a Secure Object to the SE05x.

Table 111. WriteSecureObject C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_WRITE	See Instruction, possibly containing INS_TRANSIENT and INS_AUTH_OBJ in addition to INS_WRITE.
P1		See P1
P2		See P2
Lc	#(Payload)	Payload Length.
Payload		See WriteSecureObject variants

Table 112. WriteSecureObject R-APDU Body

Value	Description
-	No data returned.

Table 113. WriteSecureObject R-APDU Trailer

SW	Description
SW_NO_ERROR	The file is created or updated successfully.

Table 114. WriteSecureObject variants

APDU	Reference	Description
WriteECKey	WriteECKey	Write an EC key pair, private key or public key.
WriteRSAKey	WriteRSAKey	Write a raw RSA key pair, private key or public key.
WriteSymmKey	WriteSymmKey	Write an AES, DES or HMAC key.
WriteBinary	WriteBinary	Write to a binary file.
WriteUserID	WriteUserID	Write a userID value.
WriteCounter	WriteCounter	Write or increment a monotonic counter.
WritePCR	WritePCR	Write a PCR value.
ImportObject	ImportObject	Import an encrypted serialized Secure Object (previously exported)
ImportExternalObject	ImportExternal Object	Import an encrypted serialized Secure Object (externally created)

4.7.1.1 WriteECKey

Write or update an EC key object.

P1KeyType indicates the key type to be created (if the object does not yet exist).

If P1KeyType = P1_KEY_PAIR, Private Key Value (TLV[TAG_3]) and Public Key Value (TLV[TAG_4) must both be present, or both be absent. If absent, the key pair is generated in the SE05x.

If the object already exists, P1KeyType is ignored.

Warning: writing transient ECKey Secure Objects causes NVM write accesses.

Note: *For keys using curve ID equal to ID_ECC_ED_25519, ID_ECC_MONT_DH_25519 or ID_ECC_MONT_DH_448, check the description about endianness in Edwards curve byte order.*

Table 115. WriteECKey C-APDU

Field	Value	Description
P1	P1KeyType | P1_EC	See P1, P1KeyType should only be set for new objects. P1Key Type equal to P1_PRIVATE_KEY or P1_PUBLIC_KEY must only be used for external key insertion; for on-chip key generation, P1 KeyType must always be equal to P1_KEY_PAIR.
P2	P2_DEFAULT	See P2
Payload	TLV[TAG_POLICY]	Byte array containing the object policy. *[Optional: default policy applies]*

Table 115. WriteECKey C-APDU*...continued*

Field	Value	Description
		[Conditional – only when the object identifier is not in use yet; else an error is returned and the object's value is not updated.]
	TLV[TAG_POLICY_CHECK]	Byte array containing the object policy.to be compared against. *[Optional: if present, the existing policy must match this policy for the command to be executed.]* *[Conditional: only enforced when the key is passed as input, not checked for key generation]*
	TLV[TAG_MAX_ATTEMPTS]	2-byte maximum number of attempts. If 0 is given, this means unlimited. *[Optional: default unlimited]* *[Conditional: only when the object identifier is not in use yet and INS includes INS_AUTH_OBJECT; see AuthenticationObject Policies]*
	TLV[TAG_1]	4-byte object identifier Minimum policy:POLICY_OBJ_ALLOW_WRITE if the key allows to be updated by providing external data or POLICY_OBJ_ALLOW_GEN if the key allows to be regenerated on-chip.
	TLV[TAG_2]	1-byte curve identifier, see ECCurve *[Conditional: only when the object identifier is not in use yet;]*
	TLV[TAG_3]	Private key value (see ECKey) *[Conditional: only when the private key is externally generated and P1KeyType is either P1_KEY_PAIR or P1_PRIVATE]*
	TLV[TAG_4]	Public key value (see ECKey) *[Conditional: only when the public key is externally generated and P1KeyType is either P1_KEY_PAIR or P1_PUBLIC]*
	TLV[TAG_11]	4-byte version, maximum is 134217727 (or 0x7FFFFFFF).. *[Optional]*

4.7.1.2 WriteRSAKey

Creates or writes an RSA key or a key component.

Supported key sizes are listed in RSABitLength. Other values are not supported.

Once an RSAKey object has been created, its format remains fixed and cannot be updated (so CRT or raw mode, no switch possible).

If the object already exists, P1KeyType is ignored.

When generating an RSA key inside the SE05x, only one APDU is required:

- if the object does not yet exist, this APDU must contain the key type (in P1), optionally the object policy (in TLV[TAG_POLICY]), the object identifier, the key size and optionally a version.
- if the object already exists, this APDU must contain the object identifier and optionally a version (version is mandatory when the existing object already has a version associated).

When inserting an RSA key (externally generated), mutliple APDUs are required:

- if the object does not yet exist, the first APDU must contain the key type (in P1), optionally the object policy (in TLV[TAG_POLICY]), the object identifier, the key size, one of the components and optionally a version. Each next APDU must contain the object identifier, one of the remaining key components and the same version -if any- as used in the first APDU.

- if the object already exists, the first APDU must contain the object identifier, one of the key components and optionally a version (version is mandatory when the existing object already has a version associated). Each next APDU must contain the object identifier, one of the remaining key components and the same version -if any- as used in the first APDU.

Each key component must be entered by the same user, where same user means:

- the authentication object used to open an applet session (UserID, AESKey or ECKey).
- the Session Owner identifier of the importExternalObject command (if the writeRSAKey is wrapped inside a importExternalObject command).
- the default user

The policy applies only once all key components are set. During key creation, only writing the key (components) is allowed, regardless of the policy.

For update of existing keys, the user can pass the original policy in TLV[TAG_POLICY_CHECK]. In that case, the key update is only done when the policy in this TLV equals exactly to the policy of the existing object. This only applies to key insertion, not to key generation. For key generation, this TLV is ignored.

Warning: writing transient RSAkey Secure Objects in CRT mode causes NVM write accesses.

Table 116. WriteRSAKey C-APDU

Field	Value	Description
P1	P1KeyType | P1_RSA	See P1
P2	P2_DEFAULT or P2_RAW	See P2; P2_RAW only in case P1KeyType = P1_KEY_PAIR and TLV[TAG_3] until TLV[TAG_10] is empty and the SE05x must generate a raw RSA key pair; all other cases: P2_DEFAULT.
Payload	TLV[TAG_POLICY]	Byte array containing the object policy. *[Optional: default policy applies]* *[Conditional: only when the object identifier is not in use yet, else an error is returned and the object's value is not updated.]*
	TLV[TAG_POLICY_CHECK]	Byte array containing the object policy.to be compared against. *[Optional: if present, the existing policy must match this policy for the command to be executed.]* *[Conditional: only enforced when the key is passed as input, not checked for key generation]*
	TLV[TAG_1]	4-byte object identifier Minimum policy:POLICY_OBJ_ALLOW_WRITE if the key allows to be updated by providing external data or POLICY_OBJ_ALLOW_GEN if the key allows to be regenerated on-chip. The policy applies when the key is fully initialized.
	TLV[TAG_2]	2-byte key size in bits (RSABitLength) *[Conditional: only when the object identifier is not in use yet]*
	TLV[TAG_3]	P component *[Conditional: only when the object identifier is in CRT mode and the key is generated externally and P1KeyType is either P1_KEY_PAIR or P1_PRIVATE]*
	TLV[TAG_4]	Q component *[Conditional: only when the object identifier is in CRT mode and the key is generated externally and P1KeyType is either P1_KEY_PAIR or P1_PRIVATE]*

Table 116. WriteRSAKey C-APDU...*continued*

Field	Value	Description
	TLV[TAG_5]	DP component *[Conditional: only when the object identifier is in CRT mode and the key is generated externally and P1KeyType is either P1_KEY_PAIR or P1_PRIVATE]*
	TLV[TAG_6]	DQ component *[Conditional: only when the object identifier is in CRT mode and the key is generated externally and P1KeyType is either P1_KEY_PAIR or P1_PRIVATE]*
	TLV[TAG_7]	INV_Q component *[Conditional: only when the object identifier is in CRT mode and the key is generated externally and P1KeyType is either P1_KEY_PAIR or P1_PRIVATE]*
	TLV[TAG_8]	Public exponent
	TLV[TAG_9]	Private Key (non-CRT mode only)
	TLV[TAG_10]	Public Key (Modulus)
	TLV[TAG_11]	4-byte version, maximum is 134217727 (or 0x7FFFFFFF). *[Optional]*

Keys can only be used for cryptographic operations when all the required key components for the Secure Object have been set succesfully.

Applicable key components:

Table 117. Applicable key components

Key type	TAG_3	TAG_4	TAG_5	TAG_6	TAG_7	TAG_8	TAG_9	TAG_10
P1KeyType equals P1_KEY_PAIR, P2 equals P2_DEFAULT	Required	Required	Required	Required	Required	Required	NA	Required
P1KeyType equals P1_KEY_PAIR, P2 equals P2_RAW	NA	NA	NA	NA	NA	Required	Required	Required
P1KeyType equals P1_PRIVATE_KEY, P2 equals P2_DEFAULT	Required	Required	Required	Required	Required	NA	NA	NA
P1KeyType equals P1_PRIVATE_KEY, P2 equals P2_RAW	NA	NA	NA	NA	NA	NA	Required	Required
P1KeyType equals P1_PUBLIC_KEY, P2 equals P2_DEFAULT	NA	NA	NA	NA	NA	Required	NA	Required
P1KeyType equals P1_PUBLIC_KEY, P2 equals P2_RAW	NA	NA	NA	NA	NA	Required	NA	Required

4.7.1.3 WriteSymmKey

Creates or writes an AES key, DES key or HMAC key, indicated by P1:

- P1_AES
- P1_DES
- P1_HMAC

Users can pass [RFC3394] wrapped keys by indicating the KEK in TLV[TAG_2]. Note that RFC3394 requires 8-byte aligned input, so this can only be used when the key has an 8-byte aligned length.

Table 118. WriteSymmKey C-APDU

Field	Value	Description
P1	See above	See P1
P2	P2_DEFAULT	See P2
Payload	TLV[TAG_POLICY]	Byte array containing the object policy. *[Optional: default policy applies]* *[Conditional: only when the object identifier is not in use yet, else an error is returned and the object's value is not updated.]*
	TLV[TAG_POLICY_CHECK]	Byte array containing the object policy.to be compared against. *[Optional: if present, the existing policy must match this policy for the command to be executed.]*
	TLV[TAG_MAX_ATTEMPTS]	2-byte maximum number of attempts. If 0 is given, this means unlimited. *[Optional: default unlimited]* *[Conditional: only when the object identifier is not in use yet and INS includes INS_AUTH_OBJECT; see AuthenticationObject Policies]*
	TLV[TAG_1]	4-byte object identifier Minimum policy:POLICY_OBJ_ALLOW_WRITE if the key allows to be updated.
	TLV[TAG_2]	4-byte KEK identifier, must be an AESKey identifier. *[Conditional: only when the key value is RFC3394 wrapped]*
	TLV[TAG_3]	Key value, either plain or RFC3394 wrapped. Minimum policy:POLICY_OBJ_ALLOW_RFC3394_UNWRAP
	TLV[TAG_4]	2-byte minimum tag length for AEAD operations, minimum is 4 and maximum is 16. *[Optional: default value = 16 bytes]* *[Conditional: only allowed for P1 = P1_AES]*
	TLV[TAG_5]	2-byte minimum output length for KDF or TLS premaster secret calculation.. *[Conditional: only allowed for P1 = P1_HMAC]* *[Optional: Default value = 16 bytes for HMACKey; set to 0 and unused for other SymmKeys]*
	TLV[TAG_11]	4-byte version, maximum is 134217727 (or 0x7FFFFFFF). *[Optional: default value = 0 (= no versioning)]*

4.7.1.4 WriteBinary

Creates or writes to a binary file object. Data are written to either the start of the file or (if specified) to the offset passed to the function.

Note: the policy will be applied immediately after the first WriteBinary APDU command. This means that for large Binary files -which require multiple WriteBinary APDUs due to limitation of the APDU buffer size- the subsequent WriteBinary commands need to fulfill the policy that is set in the first WriteBinary command.

Table 119. WriteBinary C-APDU

Field	Value	Description
P1	P1_BINARY	See P1

Table 119. WriteBinary C-APDU...*continued*

Field	Value	Description
P2	P2_DEFAULT	See P2
Payload	TLV[TAG_POLICY]	Byte array containing the object policy. *[Optional: default policy applies]* *[Conditional: only when the object identifier is not in use yet, else an error is returned and the object's value is not updated.]*
	TLV[TAG_POLICY_CHECK]	Byte array containing the object policy.to be compared against. *[Optional: if present, the existing policy must match this policy for the command to be executed.]*
	TLV[TAG_1]	4-byte object identifier Minimum policy:POLICY_OBJ_ALLOW_WRITE if the file allows to be updated. The policy will be applied immediately after the first C-APDU.
	TLV[TAG_2]	2-byte file offset *[Optional: default = 0]*
	TLV[TAG_3]	2-byte file length (up to 0x7FFF). *[Conditional: only when the object identifier is not in use yet]*
	TLV[TAG_4]	Data to be written *[Optional: if not given, TAG_3 must be filled and the data will be initialized to zeroes; mandatory when the object exists]*
	TLV[TAG_11]	4-byte version, maximum is 134217727 (or 0x7FFFFFFF). *[Optional]*

4.7.1.5 WriteUserID

Creates a UserID object, setting the user identifier value.

UserIDs must be created as Authentication Object, userIDs as non-Authentication Objects are not supported.

Table 120. WriteUserID C-APDU

Field	Value	Description
P1	P1_USERID	See P1
P2	P2_DEFAULT	See P2
	TLV[TAG_POLICY]	Byte array containing the object policy. *[Optional: default policy applies]* *[Conditional: only when the object identifier is not in use yet, else an error is returned and the object's value is not updated.]*
	TLV[TAG_MAX_ATTEMPTS]	2-byte maximum number of attempts. If 0 is given, this means unlimited. The maximum number of attempts must be smaller than 256. *[Optional: default = 0]* *[Conditional: only when the object identifier is not in use yet]*
	TLV[TAG_1]	4-byte object identifier.
	TLV[TAG_2]	Byte array containing 4 to 16 bytes user ID value.

4.7.1.6 WriteCounter

Creates or writes to a counter object.

Counters can only be incremented, not decremented.

When a counter reaches its maximum value (e.g., 0xFFFFFFFF for a 4-byte counter), it cannot be incremented again.

An input value (TAG_3) must always have the same length as the existing counter (if it exists); otherwise the command will return an error.

Table 121. WriteCounter C-APDU

Field	Value	Description
P1	P1_COUNTER	See P1
P2	P2_DEFAULT	See P2
Payload	TLV[TAG_POLICY]	Byte array containing the object policy. *[Optional: default policy applies]* *[Conditional: only when the object identifier is not in use yet, else an error is returned and the object's value is not updated.]*
	TLV[TAG_POLICY_CHECK]	Byte array containing the object policy.to be compared against. *[Optional: if present, the existing policy must match this policy for the command to be executed.]*
	TLV[TAG_1]	4-byte counter identifier. Minimum policy:POLICY_OBJ_ALLOW_WRITE if the counter allows to be updated.
	TLV[TAG_2]	2-byte counter size (1 up to 8 bytes). *[Conditional: only if object doesn't exist yet and TAG_3 is not given]*
	TLV[TAG_3]	Counter value *[Optional: - if object doesn't exist: must be present if TAG_2 is not given. - if object exists: if not present, increment by 1. if present, set counter to value.]*

4.7.1.7 WritePCR

Creates or writes to a PCR object.

A PCR is a hash to which data can be appended; i.e., writing data to a PCR will update the value of the PCR to be the hash of all previously inserted data concatenated with the new input data.

A PCR will always use DigestMode = DIGEST_SHA256; no other configuration possible.

If TAG_2 and TAG_3 are not passed, the PCR is reset to the hash of its initial value (i.e., the hash of the value given when the PCR was created).

This reset is controlled under the POLICY_OBJ_ALLOW_DELETE policy, so users that can delete the PCR can also reset the PCR to initial value.

Table 122. WritePCR C-APDU

Field	Value	Description
P1	P1_PCR	See P1
P2	P2_DEFAULT	See P2
Payload	TLV[TAG_POLICY]	Byte array containing the object policy.

Table 122. WritePCR C-APDU*...continued*

Field	Value	Description
		[Optional: default policy applies] *[Conditional: only when the object identifier is not in use yet, else an error is returned and the object's value is not updated.]*
	TLV[TAG_POLICY_CHECK]	Byte array containing the object policy.to be compared against. *[Optional: if present, the existing policy must match this policy for the command to be executed.]*
	TLV[TAG_1]	4-byte PCR identifier. Minimum policy:POLICY_OBJ_ALLOW_WRITE if the PCR allows to be extended Optional policy:POLICY_OBJ_ALLOW_DELETE if the PCR allows to be reset to its initial value (next to regular Secure Object deletion).
	TLV[TAG_2]	Initial value. *[Conditional: only when the object identifier is not in use yet]*
	TLV[TAG_3]	Data to be extended to the existing PCR. *[Conditional: only when the object identifier is already in use]* *[Optional: not present if a Reset is requested]*

4.7.1.8 ImportObject

Writes a serialized Secure Object to the SE05x (i.e., “import”). See SecureObjectImportExport for details on the import/export mechanism.

Table 123. ImportObject C-APDU

Field	Value	Description
P1	P1_DEFAULT	See P1
P2	P2_IMPORT	See P2
Payload	TLV[TAG_1]	4-byte identifier. Minimum policy:POLICY_OBJ_ALLOW_IMPORT_EXPORT
	TLV[TAG_2]	1-byte RSAKeyComponent *[Conditional: only when the identifier refers to an RSAKey object]* The first imported component for RSA keys needs to be: • RSA CRT Private keys: RSA_COMP_P • All other RSA keys and keypairs: RSA_COMP_MOD
	TLV[TAG_3]	Serialized object (encrypted).

4.7.2 ImportExternalObject

Note: *The APDU “ImportExternalObject” must not be used without first contacting NXP to avoid potential problems. If you have used or plan to use the APDU “ImportExternalObject,” please make sure you contact your NXP representative.*

Combined with the INS_IMPORT_EXTERNAL mask, enables users to send a WriteSecureObject APDU (WriteECKey until WritePCR) protected by the same security mechanisms as an ECKey session. See Secure Object external import for details on the flow of the external import mechanism. Only persistent Secure Objects can be created using this C-APDU, transient Secure Objects cannot be created using ImportExternalObject.

Table 124. ImportExternalObject C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_IMPORT_EXTERNAL	See Instruction
P1	P1_DEFAULT	See P1
P2	P2_DEFAULT	See P2
Lc	#(Payload)	
Payload	TLV[TAG_IMPORT_AUTH_DATA]	Authentication data
	TLV[TAG_IMPORT_AUTH_KEY_ID]	Host public key Identifier
	TLV[TAG_1]…	Wraps a complete WriteSecureObject command, protected by ECKey session secure messaging
Le	0x08	8 byte Response MAC

The authentication data field includes the same data as defined for the ECKey session Internal Authenticate command; i.e., the host public key and corresponding signature.

The host public key Identifier is the 4-byte identifier of the public part of the key pair used to sign the ephemeral key.

TAG_1 contains a full WriteSecureObject command, including header and payload. This command is wrapped by the session keys derived from the authentication data present in the previous tags. For example, to import an AES Key, the command defined in WriteSymmKey would be passed.

In summary, the ImportExternalObject can be fully pre-computed offcard. The steps to pre-compute a command are the following:

1. Generate the payload for an INTERNAL AUTHENTICATE command as defined by ECKeySessionInternalAuthenticate. This payload is added to tag TAG_IMPORT_AUTH_DATA as is.
2. Add to tag TAG_IMPORT_AUTH_ID the identifier of the host Key Agreement public key.
3. Perform ECDH using the stored private key and the host Key Agreement public key.
4. Assuming a DR.SE equals to 16 bytes of zeroes, derive the master key and the corresponding session keys defined in ECKeySession.
5. Prepare the complete WriteSecureObject command
6. Using the session keys from step 4, wrap the WriteSecureObject command with C-DEC + C-MAC, as defined in ECKey session
7. Add to tag TAG_1 the complete wrapped APDU from the previous step

Note: each ImportExternalObject command executes in its own implicit one-shot session. This means that for each command, all counters and MAC chaining values are assumed to be the initial values as defined in ECKey session.

Table 125. ImportExternalObject R-APDU Body

Value	Description
CMAC	8-byte CMAC over the MAC chaining value + the status word.

Table 126. ImportExternalObject R-APDU Trailer

SW	Description
SW_NO_ERROR	The importExternalObject has finished succesfully.

4.7.3 ReadSecureObject

4.7.3.1 ReadObject

Reads the content of a Secure Object.

- If the object is a key pair, the command will return the key pair’s public key.
- If the object is a public key, the command will return the public key.
- If the object is a private key or a symmetric key or a userID, the command will return an error, except if attestation is requested. In that case the object attributes will be returned, but not the key value.
- If the object is a binary file, the file content is read, giving the offset in TLV[TAG_2] and the length to read in TLV[TAG_3]. Both TLV[TAG_2] and TLV[TAG_3] are bound together; i.e.. either both tags are present, or both are absent. If both are absent, the whole file content is returned.
- If the object is a monotonic counter, the counter value is returned.
- If the object is a PCR, the PCR value is returned.
- If TLV[TAG_4] is filled, only the modulus or public exponent of an RSA key pair or RSA public key is read. It does not apply to other Secure Object types.

When attestation is requested, the secure object is read with attestation.

When the response length would exceed 256 bytes, the ReadObject command must be send as extended length APDU in order for the R-APDU to be in extended length format as well, else the command would return SW_CONDITIONS_NOT_SATISFIED.

Note: *For keys using curve ID = ID_ECC_ED_25519, ID_ECC_MONT_DH_25519 or ID_ECC_MONT_DH_448, check the explanation in Section 7.*

Table 127. ReadObject C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_READ	See Instruction, in addition to INS_READ, users can set a flag to request reading with attestation.
P1	P1_DEFAULT	See P1
P2	P2_DEFAULT	See P2
Lc	#(Payload)	Payload Length.
	TLV[TAG_1]	4-byte object identifier Minimum policy: POLICY_OBJ_ALLOW_READ
	TLV[TAG_2]	2-byte offset *[Optional: default 0]* *[Conditional: only when the object is a BinaryFile object]*
	TLV[TAG_3]	2-byte length *[Optional: default is the complete object content's length]* *[Conditional: only when the object is a BinaryFile object]*
	TLV[TAG_4]	1-byte RSAKeyComponent: either RSA_COMP_MOD or RSA_COMP_PUB_EXP. *[Optional]* *[Conditional: only for RSA key components]*
	TLV[TAG_5]	4-byte attestation object identifier. *[Optional]* *[Conditional: only when attestation is requestedt]*

Table 127. ReadObject C-APDU*...continued*

Field	Value	Description
	TLV[TAG_6]	1-byte AttestationAlgo *[Optional]* *[Conditional: only when attestation is requested]*
	TLV[TAG_7]	16-byte freshness random *[Optional]* *[Conditional: only when attestation is requested]*
Le	0x00	

Table 128. ReadObject R-APDU Body

Value	Description
TLV[TAG_1]	Data read from the Secure Object.
TLV[TAG_2]	18-byte Chip unique ID. *[Conditional: only when attestation is requested.]*
TLV[TAG_3]	Byte array containing the Secure Object attributes. *[Conditional: only when attestation is requested.]*
TLV[TAG_4]	2-byte Secure Object size.

Table 128. ReadObject R-APDU Body*...continued*

Value	Description
TLV[TAG_TS]	12-byte timestamp. *[Conditional: only when attestation is requested.]*
TLV[TAG_ATT_SIG]	Signature applied over the hashed plain C-APDU concatenated with tag, length and value of TLV[TAG_1], TLV[TAG_2], TLV[TAG_3], TLV[TAG_4] and TLV[TAG_TS] as returned by the applet. *[Conditional: only when attestation is requested.]*

Table 129. ReadObject R-APDU Trailer

SW	Description
SW_NO_ERROR	The value is read successfully.
SW_CONDITIONS_NOT_SATISFIED	The value cannot be read.

4.7.3.2 ReadAttributes

Reads the Object Attributes of a Secure Object (without the value of the Secure Object).

The response will contain a TLV[TAG_3] containing the object attributes.

When attestation is requested by putting an attestation flag into the INS byte, the secure object is read with attestation.

Table 130. ReadAttributes C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_READ	See Instruction, in addition to INS_READ, users can set a flag to request reading with attestation.
P1	P1_DEFAULT	See P1
P2	P2_ATTRIBUTES	See P2
Lc	#(Payload)	Payload Length.
	TLV[TAG_1]	4-byte object identifier Minimum policy: POLICY_OBJ_ALLOW_READ
	TLV[TAG_5]	4-byte attestation object identifier. *[Optional]* *[Conditional: only when attestation is requestedt]*
	TLV[TAG_6]	1-byte AttestationAlgo *[Optional]* *[Conditional: only when attestation is requestedt]*
	TLV[TAG_7]	16-byte freshness random *[Optional]* *[Conditional: only when attestation is requestedt]*

Table 130. ReadAttributes C-APDU*...continued*

Field	Value	Description
Le	0x00	

Table 131. ReadAttributes R-APDU Body

Value	Description
TLV[TAG_2]	18-byte Chip unique ID. *[Conditional: only when attestation is requested.]*
TLV[TAG_3]	Byte array containing the Secure Object attributes.
TLV[TAG_4]	2-byte Secure Object size. *[Conditional: only when attestation is requested.]*
TLV[TAG_TS]	12-byte timestamp. *[Conditional: only when attestation is requested.]*
TLV[TAG_ATT_SIG]	Signature applied over the hashed plain C-APDU concatenated with tag, length and value of TLV[TAG_2], TLV[TAG_3], TLV[TAG_4] and TLV[TAG_TS] as returned by the applet. *[Conditional: only when attestation is requested.]*

Table 132. ReadAttributes R-APDU Trailer

SW	Description
SW_NO_ERROR	The read is done successfully.

4.7.3.3 ExportObject

Reads a transient Secure Object from SE05x. See SecureObjectImportExport for details on the import/export mechanism.

Table 133. ExportObject C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_READ	See Instruction.
P1	P1_DEFAULT	See P1
P2	P2_EXPORT	See P2
Lc	#(Payload)	Payload Length.
	TLV[TAG_1]	4-byte object identifier Minimum policy:POLICY_OBJ_ALLOW_IMPORT_EXPORT
	TLV[TAG_2]	1-byte RSAKeyComponent *[Conditional: only when the identifier refers to an RSAKey object]* The first exported component for RSA keys needs to be: • RSA CRT Private keys: RSA_COMP_P • All other RSA keys and keypairs: RSA_COMP_MOD
Le	0x00	

Table 134. ExportObject R-APDU Body

Value	Description
TLV[TAG_1]	Length of the exported Secure Object data(2 bytes) + Exported Secure Object data + Length of the MAC(2 bytes) + MAC

Table 135. ExportObject R-APDU Trailer

SW	Description
SW_NO_ERROR	The file is created or updated successfully.

4.7.4 ManageSecureObject

4.7.4.1 ReadType

Get the type of a Secure Object.

Table 136. ReadType C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_READ	See Instruction
P1	P1_DEFAULT	See P1
P2	P2_TYPE	See P2
Lc	#(Payload)	
	TLV[TAG_1]	4-byte object identifier. Minimum policy: POLICY_OBJ_ALLOW_READ
Le	0x00	

Table 137. ReadType R-APDU Body

Value	Description
TLV[TAG_1]	Type of the Secure Object: one of SecureObjectType
TLV[TAG_2]	TransientIndicator

Table 138. ReadType R-APDU Trailer

SW	Description
SW_NO_ERROR	Data is returned successfully.

4.7.4.2 ReadSize

Get the Secure Object size for the specified Secure Object.

Table 139. ReadSize C-APDU

Field	Value	Description
CLA	0x80	

Table 139. ReadSize C-APDU*...continued*

Field	Value	Description
INS	INS_READ	See Instruction
P1	P1_DEFAULT	See P1
P2	P2_SIZE	See P2
Lc	#(Payload)	
	TLV[TAG_1]	4-byte object identifier. Minimum policy: POLICY_OBJ_ALLOW_READ
Le	0x00	

Table 140. ReadSize R-APDU Body

Value	Description
TLV[TAG_1]	Byte array containing Secure Object size.

Table 141. ReadSize R-APDU Trailer

SW	Description
SW_NO_ERROR	Data are returned successfully.
SW_CONDITIONS_ NOT_SATISFIED	Data are not returned.

4.7.4.3 ReadIDList

Get a list of present Secure Object identifiers.

The offset in TAG_1 is an 0-based offset in the list of object. As the user does not know how many objects would be returned, the offset needs to be based on the return values from the previous ReadIDList. If the applet only returns a part of the result, it will indicate that more identifiers are available (by setting TLV[TAG_1] in the response to 0x01). The user can then retrieve the next chunk of identifiers by calling ReadIDList with an offset that equals the amount of identifiers listed in the previous response.

Example 1: first ReadIDList command TAG_1=0, response TAG_1=0, TAG_2=complete list

Example 2: first ReadIDList command TAG_1=0, response TAG_1=1, TAG_2=first chunk (m entries) second ReadIDList command TAG_1=m, response TAG_1=1, TAG_2=second chunk (n entries) thirst ReadIDList command TAG_1=(m+n), response TAG_1=0, TAG_2=third last chunk

Table 142. ReadIDList C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_READ	See Instruction
P1	P1_DEFAULT	See P1
P2	P2_LIST	See P2
Lc	#(Payload)	

Table 142. ReadIDList C-APDU*...continued*

Field	Value	Description
	TLV[TAG_1]	2-byte offset
	TLV[TAG_2]	1-byte type filter: 1 byte from SecureObjectType or 0xFF for all types.
Le	0x00	

Table 143. ReadIDList R-APDU Body

Value	Description
TLV[TAG_1]	1-byte MoreIndicator
TLV[TAG_2]	Byte array containing 4-byte identifiers.

Table 144. ReadIDList R-APDU Trailer

SW	Description
SW_NO_ERROR	Data is returned successfully.

4.7.4.4 CheckObjectExists

Check if a Secure Object with a certain identifier exists or not.

Table 145. CheckObjectExists C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_MGMT	See Instruction
P1	P1_DEFAULT	See P1
P2	P2_EXIST	See P2
Lc	#(Payload)	
	TLV[TAG_1]	4-byte existing Secure Object identifier.
Le	0x00	

Table 146. CheckObjectExists R-APDU Body

Value	Description
TLV[TAG_1]	1-byte Result

Table 147. CheckObjectExists R-APDU Trailer

SW	Description
SW_NO_ERROR	Data is returned successfully.

4.7.4.5 DeleteSecureObject

Triggers the deletion of a Secure Object. Garbage collection is triggered.

If the object origin = ORIGIN_PROVISIONED, an error will be returned and the object is not deleted, even if the policy allows deletion.

Table 148. DeleteSecureObject C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_MGMT	See Instruction
P1	P1_DEFAULT	See P1
P2	P2_DELETE_OBJECT	See P2
Lc	#(Payload)	
	TLV[TAG_1]	4-byte existing Secure Object identifier. Minimum policy:POLICY_OBJ_ALLOW_DELETE
Le	-	No data to be returned.

Table 149. DeleteSecureObject R-APDU Body

Value	Description
-	No data returned.

Table 150. DeleteSecureObject R-APDU Trailer

SW	Description
SW_NO_ERROR	The APDU command is handled successfully.

4.8 EC curve management

APDUs listed in this section manage operations related to EC curves.

4.8.1 CreateECCurve

Create an EC curve listed in ECCurve.

This function must be called for all supported curves in ECCurve when the curve is to be used, except curve identifier equal to ID_ECC_ED_25519 (see Note in ECCurve).

If the curve is already fully initilized, SW_CONDTIONS_NOT_SATISFIED will be returned; users have to call DeleteECCurve if the curve needs to be recreated.

When using the curve with identifier ID_ECC_MONT_DH_25519 or ID_ECC_MONT_DH_448, this function must only be called when using ECDHGenerateSharedSecret with an external public key as input, not when the external public key is passed via a Secure Object identifier.

Table 151. CreateECCurve C-APDU

Field	Value	Description
CLA	0x80	

Table 151. CreateECCurve C-APDU*...continued*

Field	Value	Description
INS	INS_WRITE	See Instruction
P1	P1_CURVE	See P1
P2	P2_CREATE	See P2
Lc	#(Payload)	
	TLV[TAG_1]	1-byte curve identifier (from ECCurve).
Le	-	No data to be returned.

Table 152. CreateECCurve R-APDU Body

Value	Description
-	No data returned.

Table 153. CreateECCurve R-APDU Trailer

SW	Description
SW_NO_ERROR	The APDU command is handled successfully.

4.8.2 SetECCurveParam

Set a curve parameter. The curve must have been created first by CreateEcCurve.

All parameters must match the expected value for the listed curves. If the curve parameters are not correct, the curve cannot be used.

Users have to set all 5 curve parameters for the curve to be usable. Once all curve parameters are given, the secure element will check if all parameters are correct and return SW_NO_ERROR. If the values of the parameters do not match the expected curve parameters, an error will be returned.

If the curve is already fully initilized, SW_CONDTIONS_NOT_SATISFIED will be returned; users have to call DeleteECCurve if the parameters need to be reset.

This function must be called for all supported curves in ECCurve when the curve is to be used, except curve identifiers equal to ID_ECC_ED_25519, ID_ECC_MONT_DH_25519 or IC_ECC_MONT_DH_448 (see Note in ECCurve).

Table 154. SetECCurveParam C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_WRITE	See Instruction
P1	P1_CURVE	See P1
P2	P2_PARAM	See P2
Lc	#(Payload)	
	TLV[TAG_1]	1-byte curve identifier, from ECCurve
	TLV[TAG_2]	1-byte ECCurveParam
	TLV[TAG_3]	Bytestring containing curve parameter value.

Table 155. SetECCurveParam R-APDU Body

Value	Description
-	No data returned.

Table 156. SetECCurveParam R-APDU Trailer

SW	Description
SW_NO_ERROR	The APDU command is handled successfully.

4.8.3 GetECCurveID

Get the curve associated with an EC key.

Table 157. GetECCurveID C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_READ	See Instruction
P1	P1_CURVE	See P1
P2	P2_ID	See P2
Lc	#(Payload)	
Payload	TLV[TAG_1]	4-byte identifier
Le	0x00	

Table 158. GetECCurveID R-APDU Body

Value	Description
TLV[TAG_1]	1-byte curve identifier (from ECCurve)

Table 159. GetECCurveID R-APDU Trailer

SW	Description
SW_NO_ERROR	Data is returned successfully.

4.8.4 ReadECCurveList

Get a list of (Weierstrass) EC curves that are instantiated.

Table 160. ReadECCurveList C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_READ	See Instruction
P1	P1_CURVE	See P1
P2	P2_LIST	See P2
Le	0x00	

Table 161. ReadECCurveList R-APDU Body

Value	Description
TLV[TAG_1]	Byte array listing all curve identifiers in ECCurve (excluding UNUSED) where the curve identifier < 0x40; for each curve, a 1-byte SetIndicator is returned.

Table 162. ReadECCurveList R-APDU Trailer

SW	Description
SW_NO_ERROR	Data is returned successfully.

4.8.5 DeleteECCurve

Deletes an EC curve. Garbage collection is triggered.

This function is not required for curve identifier ID_ECC_ED_25519.

Table 163. DeleteECCurve C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_MGMT	See Instruction
P1	P1_CURVE	See P1
P2	P2_DELETE_OBJECT	See P2
Lc	#(Payload)	
	TLV[TAG_1]	1-byte curve identifier (from ECCurve)

Table 164. DeleteECCurve R-APDU Body

Value	Description
-	No data returned.

Table 165. DeleteECCurve R-APDU Trailer

SW	Description
SW_NO_ERROR	The APDU command is handled successfully.

4.9 Crypto Object management

4.9.1 CreateCryptoObject

Creates a Crypto Object on the SE05x. Once the Crypto Object is created, it is bound to the user who created the Crypto Object, no other user can use the Crypto Object.

For valid combinations of CryptoObject and the CryptoObject subtype, see CryptoObject.

If the CryptoContext equals CC_PAKE, the created object will be in PAKEState equal to PAKE_STATE_SETUP. Depending on the PAKEMode, M and N need to be present in the corresponding reserved object identifiers (see Default configuration).

Note: *The creation of a Crypto Object causes flash writes.*

Table 166. CreateCryptoObject C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_WRITE	See Instruction
P1	P1_CRYPTO_OBJ	See P1
P2	P2_DEFAULT	See P2
Lc	#(Payload)	Payload length
Payload	TLV[TAG_1]	2-byte Crypto Object identifier
	TLV[TAG_2]	1-byte CryptoContext
	TLV[TAG_3]	1-byte Crypto Object subtype, either from DigestMode, CipherMode, MACAlgo (depending on TAG_2), AEADMode or PAKEMode.
	TLV[TAG_4]	4-byte identifier of the target Secure Object; this needs to be an HMACKey of the expected length to store the result. Minimum policy: POLICY_OBJ_ALLOW_WRITE or POLICY_OBJ_ALLOW_DERIVED_INPUT with the 4-byte identifier of w0 as extension. *[Optional]* *[Conditional] Only used when TLV[TAG_2] equals CC_PAKE.*

Table 167. CreateCryptoObject R-APDU Body

Value	Description
-	No data returned.

Table 168. CreateCryptoObject R-APDU Trailer

SW	Description
SW_NO_ERROR	The Crypto Object is created successfully.

4.9.2 ReadCryptoObjectList

Get the list of allocated Crypto Objects indicating the identifier, the CryptoContext and the sub type of the CryptoContext.

Table 169. ReadCryptoObjectList C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_READ	See Instruction
P1	P1_CRYPTO_OBJ	See P1
P2	P2_LIST	See P2
Le	0x00	

Table 170. ReadCryptoObjectList R-APDU Body

Value	Description
TLV[TAG_1]	Byte array containing a list of 2-byte Crypto Object identifiers, followed by 1-byte CryptoContext and 1-byte subtype for each Crypto Object (so 4 bytes for each Crypto Object).

Table 171. ReadCryptoObjectList R-APDU Trailer

SW	Description
SW_NO_ERROR	Data is returned successfully.

4.9.3 DeleteCryptoObject

Deletes a Crypto Object on the SE05x. Garbage collection is triggered.

Note: when a Crypto Object is deleted, the memory (as mentioned in Crypto Objects) is de-allocated and will be freed up on the next incoming APDU.

Note: *The deletion of a Crypto Object causes flash writes.*

Table 172. DeleteCryptoObject C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_MGMT	See Instruction
P1	P1_CRYPTO_OBJ	See P1
P2	P2_DELETE_OBJECT	See P2
Lc	#(Payload)	Payload length
Payload	TLV[TAG_1]	2-byte Crypto Object identifier

Table 173. DeleteCryptoObject R-APDU Body

Value	Description
-	No data returned.

Table 174. DeleteCryptoObject R-APDU Trailer

SW	Description
SW_NO_ERROR	The APDU command is handled successfully.

4.10 Crypto operations EC

Elliptic Curve Crypto operations are supported and tested for all curves listed in ECCurve.

4.10.1 Signature generation

4.10.1.1 ECDSASign

The ECDSASign command signs external data using the indicated key pair or private key.

The ECSignatureAlgo indicates the ECDSA algorithm that is used, but the hashing of data always must be done on the host. E.g., if ECSignatureAlgo = SIG_ ECDSA_SHA256, the user must have applied SHA256 on the input data already.

The user must take care of providing the correct input length; i.e., the data input length (TLV[TAG_3]) must match the digest indicated in the signature algorithm (TLV[TAG_2]).

This is performed according to the ECDSA algorithm as specified in [ANSI X9.62]. The signature (a sequence of two integers ‘r’ and ‘s’) as returned in the response adheres to the ASN.1 DER encoded formatting rules for integers.

Table 175. ECDSASign C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	Instruction
P1	P1_SIGNATURE	See P1
P2	P2_SIGN	See P2
Lc	#(Payload)	
	TLV[TAG_1]	4-byte identifier of EC key pair or private key. Minimum policy:POLICY_OBJ_ALLOW_SIGN Optional policy: POLICY_OBJ_FORBID_DERIVED_OUTPUT to prevent output to host. Optional policy: POLICY_OBJ_FORBID_EXTERNAL_INPUT_SIGN to forbid signature generation with external input.
	TLV[TAG_2]	1-byte ECSignatureAlgo.
	TLV[TAG_3]	Byte array containing hashed input data; the hash algorithm must match the ECSignatureAlgo in TLV[TAG_2]. *[Conditional: Only when internal signature generation is not used]*
Le	0x00	Expecting ASN.1 signature

Table 176. ECDSASign R-APDU Body

Value	Description
TLV[TAG_1]	ECDSA Signature in ASN.1 format.
TLV[TAG_2]	Hash over the data that are input for the signature generation. The digest used matches the ECSignatureAlgo from the C-APDU. *[Conditional: only when internal signature generation is used.]*

Table 177. ECDSASign R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

4.10.1.2 EdDSASign

The EdDSASign command signs external data using the indicated key pair or private key (using a Twisted Edwards curve). This is performed according to the EdDSA algorithm as specified in [RFC8032].

The input data for TLV[TAG_3] need to be the plain data (i.e. not hashed), maximum length is:

- 940 bytes for use in the default session, an AESKey or an ECKey session.
- 919 bytes for use in a UserID session.

These limits on input data length are not affected by platform SCP.

The signature as returned in the response is a 64-byte array, being the concatenation of the signature r and s component (without leading zeroes for sign indication).

Note: *See Section 7 for correct byte order.*

Table 178. EdDSASign C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	Instruction
P1	P1_SIGNATURE	See P1
P2	P2_SIGN	See P2
Lc	#(Payload)	
	TLV[TAG_1]	4-byte identifier of EC key pair or private key. Minimum policy: POLICY_OBJ_ALLOW_SIGN Optional policy: POLICY_OBJ_FORBID_DERIVED_OUTPUT to prevent output to host. Optional policy: POLICY_OBJ_FORBID_EXTERNAL_INPUT_SIGN to forbid signature generation with external input.
	TLV[TAG_2]	1-byte EDSignatureAlgo
	TLV[TAG_3]	Byte array containing plain input data. *[Conditional: Only when internal signature generation is not used]*
Le	0x00	Expecting signature

Table 179. EdDSASign R-APDU Body

Value	Description
TLV[TAG_1]	EdDSA Signature (r concatenated with s).

Table 180. EdDSASign R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

4.10.2 Signature verification

4.10.2.1 ECDSAVerify

The ECDSAVerify command verifies whether the signature is correct for a given (hashed) data input using an EC public key or EC key pair’s public key.

The ECSignatureAlgo indicates the ECDSA algorithm that is used, but the hashing of data must always be done on the host. E.g., if ECSignatureAlgo = SIG_ ECDSA_SHA256, the user must have applied SHA256 on the input data already.

The key cannot be passed externally to the command directly. In case users want to use the command to verify signatures using different public keys or the public key value regularly changes, the user should create a transient key object to which the key value is written and then the identifier of that transient secure object can be used by this ECDSAVerify command.

Table 181. ECDSAVerify C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	Instruction
P1	P1_SIGNATURE	See P1
P2	P2_VERIFY	See P2
Lc	#(Payload)	
	TLV[TAG_1]	4-byte identifier of the key pair or public key. Minimum policy:POLICY_OBJ_ALLOW_VERIFY
	TLV[TAG_2]	1-byte ECSignatureAlgo.
	TLV[TAG_3]	Byte array containing hashed data to compare.
	TLV[TAG_5]	Byte array containing ASN.1 signature
Le	0x03	Expecting TLV with Result

Table 182. ECDSAVerify R-APDU Body

Value	Description
TLV[TAG_1]	Result of the signature verification (Result).

Table 183. ECDSAVerify R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.
SW_CONDITIONS_NOT_SATISFIED	Incorrect data

4.10.2.2 EdDSAVerify

The EdDSAVerify command verifies whether the signature is correct for a given data input (hashed using SHA512) using an EC public key or EC key pair’s public key. The signature needs to be given as concatenation of r and s.

The data needs to be compared with the plain message without being hashed.

The input data for TLV[TAG_3] need to be the plain data (i.e. not hashed), maximum length is:

- 940 bytes for use in the default session, an AESKey or an ECKey session.
- 919 bytes for use in a UserID session.

These limits on input data length are not affected by platform SCP.

Note: *See chapter Edwards curve byte order for correct byte order as both r and s need to be reversed (converting endianness).*

This is performed according to the EdDSA algorithm as specified in [RFC8032].

The key cannot be passed externally to the command directly. In case users want to use the command to verify signatures using different public keys or the public key value regularly changes, the user should create a transient key object to which the key value is written and then the identifier of that transient secure object can be used by this EdDSAVerify command.

Table 184. EdDSAVerify C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	Instruction
P1	P1_SIGNATURE	See P1
P2	P2_VERIFY	See P2
Lc	#(Payload)	
	TLV[TAG_1]	4-byte identifier of the key pair or public key. Minimum policy:POLICY_OBJ_ALLOW_VERIFY
	TLV[TAG_2]	1-byte EDSignatureAlgo.
	TLV[TAG_3]	Byte array containing plain data to compare.
	TLV[TAG_5]	64-byte array containing the signature (concatenation of r and s).
Le	0x03	Expecting TLV with Result

Table 185. EdDSAVerify R-APDU Body

Value	Description
TLV[TAG_1]	Result of the signature verification (Result).

Table 186. EdDSAVerify R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.
SW_CONDITIONS_NOT_SATISFIED	Incorrect data

4.10.3 Shared secret generation

4.10.3.1 ECDHGenerateSharedSecret

The ECDHGenerateSharedSecret command computes a shared secret using an EC private key on SE05x and an external public key provided by the caller. The external public key can either be passed as byte array (using TLV[TAG_2]) or via a Secure Object identifier to an ECPublicKey object (using TLV[TAG_3]).

The output shared secret is returned to the caller (if TLV[TAG_7] is not used) or stored inside an AESKey or HMACKey (using TLV[TAG_7]).

Using P2 equal to P2_DH will return or store output in big endian format. Using P2 equal to P2_DH_REVERSE will return or store output in little endian format. Note that -when storing the public key into a Secure Object- the byte order must also be reversed for correct shared secret generation.

All curves from ECCurve are supported, except ECC_ED_25519.

Note that ECDHGenerateSharedSecret commands with EC keys using curve ID_ECC_MONT_DH_25519 or ID_ECC_MONT_DH_448 cause NVM write operations for each call if the public key is passed as a byte array. This is not the case for the other curves and also not when the external public key is passed via a transient Secure Object identifier.

Table 187. ECDHGenerateSharedSecret C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	Instruction
P1	P1_EC	See P1
P2	P2_DH or P2_DH_REVERSE	See P2
Lc	#(Payload)	
Payload	TLV[TAG_1]	4-byte identifier of the key pair or private key. Minimum policy: POLICY_OBJ_ALLOW_KA Optional policy: POLICY_OBJ_FORBID_DERIVED_OUTPUT to prevent output to host (i.e. mandate use of TLV[TAG_7]).
	TLV[TAG_2]	Byte array containing external public key (see ECKey). *[Conditional: only when TAG_3 is absent]*
	TLV[TAG_3]	4-byte identifier of the external EC public key. Minimal policy: POLICY_OBJ_ALLOW_KA *[Conditional: only when TAG_2 is absent]*
	TLV[TAG_4]	1-byte ECDHAlgo *[Optional: default is EC_SVDP_DH_PLAIN]*
	TLV[TAG_7]	4-byte identifier of the target Secure Object, either of type AESKey or HMACKey. Minimum policy: POLICY_OBJ_ALLOW_WRITE or POLICY_OBJ_ALLOW_DERIVED_INPUT with the 4-byte identifier of TLV[TAG_1] as extension to restrict key derivation. *[Optional]*
Le	0x00	Expected shared secret length.

Table 188. ECDHGenerateSharedSecret R-APDU Body

Value	Description
TLV[TAG_1]	The returned shared secret. *[Conditional: only when the input does not contain TLV[TAG_7].}*

Table 189. ECDHGenerateSharedSecret R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

4.10.4 EC Point Multiplication

4.10.4.1 ECPointMultiply

The ECPointMultiply command computes an ECC point on the curve using an EC private key on SE05x and an external public key provided by the caller. The external public key can either be passed as byte array (using TLV[TAG_2]) or via a Secure Object identifier to an ECPublicKey object (using TLV[TAG_3]).

The output is returned to the caller (if TLV[TAG_7] is not used) or stored inside an ECPublicKey object (using TLV[TAG_7]).

All curves from ECCurve are supported, except ECC_ED_25519.

Note:

ECPointMutliply commands with EC keys using curve ID_ECC_MONT_DH_25519 or ID_ECC_MONT_DH_448 cause NVM write operations for each call if the public key is passed as a byte array. This is not the case for the other curves and also not when the external public key is passed via a transient Secure Object identifier.

ECPointMultiply commands with EC keys using curve ID_ECC_MONT_DH_25519 or ID_ECC_MONT_DH_448 and ECPMAlgo equal to EC_PACE_GM are resulting in regular point multiplication (with ECPMAlgo equal to EC_SVDP_DH_PLAIN_XY).

Table 190. ECPointMultiply C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	Instruction
P1	P1_EC	See P1
P2	P2_ECPM	See P2
Lc	#(Payload)	
Payload	TLV[TAG_1]	4-byte identifier of the key pair or private key. Minimum policy: POLICY_OBJ_ALLOW_KA Optional policy: POLICY_OBJ_FORBID_DERIVED_OUTPUT would prevent to execute this command succesfully.
	TLV[TAG_2]	Byte array containing external public key (see ECKey). *[Conditional: only when TAG_3 is absent]*
	TLV[TAG_3]	4-byte identifier of the external EC public key. Minimal policy: POLICY_OBJ_ALLOW_KA *[Conditional: only when TAG_2 is absent]*
	TLV[TAG_4]	1-byte ECPMAlgo
	TLV[TAG_7]	4-byte identifier of the target Secure Object; this needs to be an ECPublicKey of the expected length to store the result. Minimum policy: POLICY_OBJ_ALLOW_WRITE or POLICY_OBJ_ALLOW_DERIVED_INPUT with the 4-byte identifier of TLV[TAG_1] as extension to restrict key derivation. *[Optional]*
Le	0x00	Expected EC point length.

Table 191. ECPointMultiply R-APDU Body

Value	Description
TLV[TAG_1]	The returned EC point. Format depends on the ECPMAlgo. *[Conditional: only when the input does not contain TLV[TAG_7].}*

Table 192. ECPointMultiply R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

4.10.5 PAKE support

PAKE functionality is provided by using Crypto Objects using CryptoContext CC_PAKE.

Once a CryptoObject is available, the Crypto Object must be initialized before generating a key share by calling all of the following functions:

- PAKEConfigDevice
- PAKEInitDevice
- PAKEInitCredentials

When the CryptoObject is fully initialized, a key share can be generated by calling PAKEComputeKeyShare. This will move the PAKEState of the CryptoObject from PAKE_STATE_SETUP to PAKE_STATE_KEY_SHARE_GENERATED.

When the CryptoObject is in PAKEState PAKE_STATE_KEY_SHARE_GENERATED, the session keys can be generated by calling PAKEComputeSessionKeys. This will move the PAKEState of the CryptoObject from PAKE_STATE_KEY_SHARE_GENERATED to PAKE_STATE_SESSION_KEYS_GENERATED.

When the CryptoObject is in PAKEState PAKE_STATE_SESSION_KEYS_GENERATED, the session keys can be verified by calling PAKEVerifySessionKeys. This will move the PAKEState of the CryptoObject from PAKE_STATE_SESSION_KEYS_GENERATED to PAKE_STATE_SETUP.

Other functions can be interleaved between each step, e.g. PAKEGetState or any other command can be called.

Ongoing sessions can be canceled by calling one of the initialization functions again.

4.10.5.1 PAKEConfigDevice

Configure a CryptoObject by providing the device type for the Crypto Object.

If the PAKEState does not equal PAKE_STATE_SETUP, any ongoing key share or session key generation will be cleared.

This command will set the PAKEState of the Crypto Object to PAKE_STATE_SETUP.

Note: *This APDU will cause NVM write accesses.*

Table 193. PAKEConfigDevice C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	Instruction
P1	P1_PAKE	See P1

Table 193. PAKEConfigDevice C-APDU*...continued*

Field	Value	Description
P2	P2_TYPE	See P2
Lc	#(Payload)	
Payload	TLV[TAG_2]	2-byte Crypto Object identifier
	TLV[TAG_3]	1-byte SPAKE2PlusDeviceType
Le	-	

Table 194. PAKEConfigDevice R-APDU Body

Value	Description
-	

Table 195. PAKEConfigDevice R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

4.10.5.2 PAKEInitDevice

Configure a CryptoObject by providing the Context, idProver and idProvider.

If the 3 parameters do not fit into the APDU buffer, this function can be called multiple times with each time different TLVs, but this must be done in the correct order . In case of multiple APDUs, the user must take care that the proper order is followed: Context not later than idProver and idProver not later than idVerifier. So for example sending the Context in the first APDU and idProver and idVerifier in the second APDU is fine. The same TLV should not be sent twice.

If the PAKEState does not equal PAKE_STATE_SETUP, any ongoing key share or session key generation will be cleared.

This command will set the PAKEState of the Crypto Object to PAKE_STATE_SETUP.

Note: *This APDU will cause NVM write accesses on the first occurence after selecting the applet.*

Table 196. PAKEInitDevice C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	Instruction
P1	P1_PAKE	See P1
P2	P2_ID	See P2
Lc	#(Payload)	
Payload	TLV[TAG_2]	2-byte Crypto Object identifier
	TLV[TAG_3]	ByteString of 0 up to 768 bytes containing the Context. *[Optional]*
	TLV[TAG_4]	ByteString of 0 up to 768 bytes containing idProver. *[Optional]*

Table 196. PAKEInitDevice C-APDU...*continued*

Field	Value	Description
	TLV[TAG_5]	ByteString of 0 up to 768 containing id Verifier. *[Optional]*
Le	-	

Table 197. PAKEInitDevice R-APDU Body

Value	Description
-	

Table 198. PAKEInitDevice R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

4.10.5.3 PAKEInitCredentials

Initialize the PAKE credentials for a Crypto Object.

Note: For a type A device, it is adviced to store w0 and w1 in transient Secure Objects as the value will change often (on every new secure pairing).

For a type B device, it is adviced to store w0 and L into persistent Secure Objects as the value is fixed for the device (until updated).

The Secure Objects storing w0, w1 and L must not contain the POLICY_OBJ_ALLOW_READ: the values remain securely stored and cannot be read. If these are readable, SW_CONDITIONS_NOT_SATISFIED will be returned.

If the PAKEState does not equal PAKE_STATE_SETUP, any ongoing key share or session key generation will be cleared.

This command will set the PAKEState of the Crypto Object to PAKE_STATE_SETUP.

Note: *This APDU will cause NVM write accesses.*

Table 199. PAKEInitCredentials C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	Instruction
P1	P1_PAKE	See P1
P2	P2_PARAM	See P2
Lc	#(Payload)	
Payload	TLV[TAG_2]	2-byte Crypto Object identifier
	TLV[TAG_3]	4-byte AESKey or HMACKey identifier containing w0. Must be non-readable. Minimum policy:POLICY_OBJ_ALLOW_KA Optional policy: POLICY_OBJ_FORBID_DERIVED_OUTPUT to prevent output to host.

Table 199. PAKEInitCredentials C-APDU*...continued*

Field	Value	Description
	TLV[TAG_4]	4-byte AESKey or HMACKey identifier containing w1. Must be non-readable. Minimum policy:POLICY_OBJ_ALLOW_KA Optional policy: POLICY_OBJ_FORBID_DERIVED_OUTPUT to prevent output to host. *[Conditional: only needed if the device type is of type SPAKE2PLUS_DEVICE_TYPE_A]; mutually exclusive with TLV[TAG_5].*
	TLV[TAG_5]	4-byte HMACKey identifier containing L. Minimum policy:POLICY_OBJ_ALLOW_KA Optional policy: POLICY_OBJ_FORBID_DERIVED_OUTPUT to prevent output to host. *[Conditional: only needed if the device type is of type SPAKE2PLUS_DEVICE_TYPE_B]; mutually exclusive with TLV[TAG_4].*
Le	-	

Table 200. PAKEInitCredentials R-APDU Body

Value	Description
-	

Table 201. PAKEInitCredentials R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

4.10.5.4 PAKEComputeKeyShare

Computes the key share pA (for SPAKE_DEVICE_TYPE_A) or pB (for SPAKE_DEVICE_TYPE_B).

If the PAKEState does not equal PAKE_STATE_SETUP, any ongoing key share or session key generation will be cleared.

This command will set the PAKEState of the Crypto Object to PAKE_STATE_KEY_SHARE_GENERATED.

Table 202. PAKEComputeKeyShare C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	Instruction
P1	P1_SPAKE	See P1
P2	P2_UPDATE	See P2
Lc	#(Payload)	
Payload	TLV[TAG_2]	2-byte Crypto Object identifier
	TLV[TAG_3]	Byte array containing pA. *[Conditional: only for SPAKE2PLUS_DEVICE_TYPE_B]*

Table 202. PAKEComputeKeyShare C-APDU...*continued*

Field	Value	Description
Le	0x00	

Table 203. PAKEComputeKeyShare R-APDU Body

Value	Description
TLV[TAG_1]	TLV containing the key share pA for SPAKE2PLUS_DEVICE_TYPE_A or pB for SPAKE2PLUS_DEVICE_TYPE_B as byte array.

Table 204. PAKEComputeKeyShare R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

4.10.5.5 PAKEComputeSessionKeys

Computes the session keys.

If the PAKEState does not equal PAKE_STATE_KEY_SHARE_GENERATED, any ongoing key share or session key generation will be cleared.

This command will set the PAKEState of the Crypto Object to PAKE_STATE_SESSION_KEYS_GENERATED.

Note: *This APDU will cause NVM write accesses.*

Table 205. PAKEComputeSessionKeys C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	Instruction
P1	P1_SPAKE	See P1
P2	P2_GENERATE	See P2
Lc	#(Payload)	
Payload	TLV[TAG_2]	2-byte Crypto Object identifier
	TLV[TAG_3]	Byte array containing pB. *[Conditional: only for device type A]*
Le	0x00	

Table 206. PAKEComputeSessionKeys R-APDU Body

Value	Description
TLV[TAG_1]	TLV containing the shared secret Ke as byte array. *[Conditional: only when the Crypto Object allows output to host.}*
TLV[TAG_2]	TLV containing the key confirmation message cA (for device type SPAKE2PLUS_DEVICE_TYPE_A) or cB (for device type SPAKE2PLUS_DEVICE_TYPE_B).

Table 207. PAKEComputeSessionKeys R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

4.10.5.6 PAKEVerifySessionKeys

Verifies the session keys and returns RESULT_SUCCESS if verified succesfully or RESULT_FAILURE if not verified successfully.

The CryptoObject must be in PAKEState PAKE_STATE_SESSION_KEYS_GENERATED, else an error will be returned.

Executing this command will bring the CryptoObject into PAKEState PAKE_STATE_SETUP.

Table 208. PAKEVerifySessionKeys C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	Instruction
P1	P1_PAKE	See P1
P2	P2_VERIFY	See P2
Lc	#(Payload)	
Payload	TLV[TAG_2]	2-byte Crypto Object identifier
	TLV[TAG_3]	Byte array containing the key confirmation message cB for SPAKE2 PLUS_DEVICE_TYPE_A or cA for SPAKE2PLUS_DEVICE_TYPE_B.
Le	-	

Table 209. PAKEVerifySessionKeys R-APDU Body

Value	Description
TLV[TAG_1]	TLV containing a 1-byte Result.

Table 210. PAKEVerifySessionKeys R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

4.10.5.7 PAKEReadDeviceType

Reads the device type from a CryptoObject with CryptoContext equal to CC_PAKE.

If the CryptoContext of the CryptoObject is not equal to CC_PAKE, an error will be returned.

Table 211. PAKEReadDeviceType C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_READ	Instruction
P1	P1_PAKE	See P1

Table 211. PAKEReadDeviceType C-APDU*...continued*

Field	Value	Description
P2	P2_DEFAULT	See P2
Lc	#(Payload)	
Payload	TLV[TAG_2]	TLV containing a 2-byte Crypto Object identifier
Le	-	

Table 212. PAKEReadDeviceType R-APDU Body

Value	Description
TLV[TAG_1]	TLV containing a 1-byte SPAKE2PlusDeviceType

Table 213. PAKEReadDeviceType R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

4.10.5.8 PAKEReadState

Reads the PAKEState from a CryptoObject with CryptoContext equal to CC_PAKE.

If the CryptoContext of the CryptoObject is not equal to CC_PAKE, an error will be returned.

Table 214. PAKEReadState C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_READ	Instruction
P1	P1_PAKE	See P1
P2	P2_STATE	See P2
Lc	#(Payload)	
Payload	TLV[TAG_2]	TLV containing a 2-byte Crypto Object identifier
Le	-	

Table 215. PAKEReadState R-APDU Body

Value	Description
TLV[TAG_1]	TLV containing a 1-byte PAKEState

Table 216. PAKEReadState R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

4.11 Crypto operations RSA

RSA crypto operations will be available for certain bit lengths, defined in RSABitLength.

For detailed information, see RFC8017 on PKCS#1 RSA Cryptography Specification.

Note: *Some combinations of RSABitLength with RSASignatureAlgo are not supported and will result in SW_CONDITIONS_NOT_SATISFIED: a key size of 512 bits is not valid for RSA_SHA384_PKCS1, RSA_SHA512_PKCS1 and RSA_SHA512_PKCS1_PSS. Other combinations are supported, but the result will only be valid if key size and algoriothm fulfill the cryptographic requirements of the RSA specification.*

4.11.1 Signature Generation

4.11.1.1 RSASign

The RSASign command signs the input message using an RSA private key.

Padding schemes supported: see RSASignatureAlgo.

Table 217. RSASign C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	Instruction
P1	P1_SIGNATURE	See P1
P2	P2_SIGN	See P2
Lc	#(Payload)	
	TLV[TAG_1]	4-byte identifier of the key pair or private key. Minimum policy:POLICY_OBJ_ALLOW_SIGN Optional policy: POLICY_OBJ_FORBID_DERIVED_OUTPUT would prevent to execute this command succesfully. Optional policy: POLICY_OBJ_FORBID_EXTERNAL_INPUT_SIGN to forbid signature generation with external input.
	TLV[TAG_2]	1-byte RSASignatureAlgo
	TLV[TAG_3]	Byte array containing input data. *[Conditional: Only when internal signature generation is not used]*
	TLV[TAG_4]	Byte array containing 2 bytes for salt length. Maximum salt lengh allowed = RSA key size - 2(Padding bytes) - Default hash length. Default hash length is also allowed as salt length. *[Optional; default salt length = digest length from RSASignatureAlgo]* *[Conditional; only for signature algorithms with suffix _PSS]*
Le	0x00	Expecting ASN.1 signature.

Table 218. RSASign R-APDU Body

Value	Description
TLV[TAG_1]	RSA signature in ASN.1 format.
TLV[TAG_2]	Hash over the data that are input for the signature generation. The digest used matches the RSASignatureAlgo from the C-APDU.. *[Conditional: only when internal signature generation is used.]*

Table 219. RSASign R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

4.11.2 Signature Verification

4.11.2.1 RSAVerify

The RSAVerify command verifies the given signature and returns the result.

The key cannot be passed externally to the command directly. In case users want to use the command to verify signatures using different public keys or the public key value regularly changes, the user should create a transient key object to which the key value is written and then the identifier of that transient secure object can be used by this RSAVerify command.

Table 220. RSAVerify C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	Instruction
P1	P1_SIGNATURE	See P1
P2	P2_VERIFY	See P2
Lc	#(Payload)	
Payload	TLV[TAG_1]	4-byte identifier of the key pair or public key. Minimum policy:POLICY_OBJ_ALLOW_VERIFY
	TLV[TAG_2]	1-byte RSASignatureAlgo
	TLV[TAG_3]	Byte array containing data to be verified.
	TLV[TAG_4]	Byte array containing 2 byte salt length. Maximum salt lengh allowed = RSA key size - 2(Padding bytes) - Default hash length. Default hash length is also allowed as salt length. *[Optional: default salt length = digest length of RSASignatureAlgo]* *[Conditional; only for signature algorithms with suffix _PSS]*
	TLV[TAG_5]	Byte array containing ASN.1 signature.
Le	0x03	Expecting Result in TLV

Table 221. RSAVerify R-APDU Body

Value	Description
TLV[TAG_1]	Result: Verification result

Table 222. RSAVerify R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

4.11.3 Encryption

4.11.3.1 RSAEncrypt

The RSAEncrypt command encrypts data.

Table 223. RSAEncrypt C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	Instruction
P1	P1_RSA	See P1
P2	P2_ENCRYPT_ONESHOT	See P2
Lc	#(Payload)	
Payload	TLV[TAG_1]	4-byte identifier of the key pair or public key. Minimum policy:POLICY_OBJ_ALLOW_ENC Optional policy: POLICY_OBJ_FORBID_DERIVED_OUTPUT would prevent to execute this command succesfully.
	TLV[TAG_2]	1-byte RSAEncryptionAlgo
	TLV[TAG_3]	Byte array containing data to be encrypted.
Le	0x00	Expected TLV with encrypted data.

Table 224. RSAEncrypt R-APDU Body

Value	Description
TLV[TAG_1]	Encrypted data

Table 225. RSAEncrypt R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

4.11.3.2 RSADecrypt

The RSADecrypt command performs an RSA private key operation. This can be used to either decrypt data or to sign a hashed message.

Table 226. RSADecrypt C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	Instruction
P1	P1_RSA	See P1
P2	P2_DECRYPT_ONESHOT	See P2
Lc	#(Payload)	
Payload	TLV[TAG_1]	4-byte identifier of the key pair or private key. Minimum policy:POLICY_OBJ_ALLOW_DEC Optional policy: POLICY_OBJ_FORBID_DERIVED_OUTPUT would prevent to execute this command succesfully.
	TLV[TAG_2]	1-byte RSAEncryptionAlgo
	TLV[TAG_3]	Byte array containing input data.
Le	0x00	Expected TLV with response data.

Table 227. RSADecrypt R-APDU Body

Value	Description
TLV[TAG_1]	Processed data

Table 228. RSADecrypt R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

4.12 Crypto operations AES/DES

Cipher operations can be done either using Secure Object of type AESKey or DESKey.

CipherMode indicates the algorithm to be applied.

Cipher operations can be done in one shot mode or in multiple steps. Users are recommended to opt for one shot mode as much as possible as there is no NVM write access in that case, while an AES operation in multiple steps involves NVM write access.

There are 2 options to use AES crypto modes:

- in multiple steps: init/update/final – multiple calls to process data.
- in one shot mode – 1 call to process data

Note: If the Crypto Object is using AES in CTR mode, input data for CipherUpdate need to be block aligned (16-byte blocks).

4.12.1 CipherInit

Initialize a symmetric encryption or decryption. The Crypto Object keeps the state of the cipher operation until it’s finalized or deleted. Once the CipherFinal function is executed successfully, the Crypto Object state returns to the state immediately after the previous CipherInit function.

Table 229. CipherInit C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	Instruction
P1	P1_CIPHER	See P1
P2	P2_ENCRYPT or P2_DECRYPT	See P2
Lc	#(Payload)	
Payload	TLV[TAG_1]	4-byte identifier of the key object. Minimum policy:POLICY_OBJ_ALLOW_ENC or POLICY_OBJ_ALLOW_DEC depending on P2. Optional policy: POLICY_OBJ_FORBID_EXTERNAL_IV Optional policy: POLICY_OBJ_FORBID_DERIVED_OUTPUT would prevent to execute this command succesfully.
	TLV[TAG_2]	2-byte Crypto Object identifier
	TLV[TAG_4]	Byte array containing the initialization vector for AES [16 bytes] for DES [8 bytes] or a 2-byte value containing the length of the initialization vector to be generated (only when P2 = P2_ENCRYPT and the CyptoObject type equals CC_CIPHER with subtype equal to AES_CTR.. *[Optional]* *[Conditional: only when the Crypto Object type equals CC_CIPHER, subtype is not including ECB]*
Le	-	

Table 230. CipherInit R-APDU Body

Value	Description
TLV[TAG_3]	Byte array containing the initialization vector. *[Conditional: only when P2 equals P2_ENCRYPT_ONESHOT and TLV[TAG_4] in the C-APDU contains 2 bytes Value.]*

Table 231. CipherInit R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

4.12.2 CipherUpdate

Update a cipher context.

Table 232. CipherUpdate C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	Instruction
P1	P1_CIPHER	See P1

Table 232. CipherUpdate C-APDU*...continued*

Field	Value	Description
P2	P2_UPDATE	See P2
Lc	#(Payload)	
Payload	TLV[TAG_2]	2-byte Crypto Object identifier
	TLV[TAG_3]	Byte array containing input data
Le	0x00	Expecting returned data.

Table 233. CipherUpdate R-APDU Body

Value	Description
TLV[TAG_1]	Output data

Table 234. CipherUpdate R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

4.12.3 CipherFinal

Finish a sequence of cipher operations.

Table 235. CipherFinal C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	Instruction
P1	P1_CIPHER	See P1
P2	P2_FINAL	See P2
Lc	#(Payload)	
Payload	TLV[TAG_2]	2-byte Crypto Object identifier
	TLV[TAG_3]	Input data
Le	0x00	Expected returned data.

Table 236. CipherFinal R-APDU Body

Value	Description
TLV[TAG_1]	Output data

Table 237. CipherFinal R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

4.12.4 CipherOneShot

Encrypt or decrypt data in one shot mode.

The key object must be either an AES key or a DES key.

Table 238. CipherOneShot C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	Instruction
P1	P1_CIPHER	See P1
P2	P2_ENCRYPT_ONESHOT or P2_DECRYPT_ONESHOT	See P2
Lc	#(Payload)	
Payload	TLV[TAG_1]	4-byte identifier of the key object. Minimum policy:POLICY_OBJ_ALLOW_ENC or POLICY_OBJ_ALLOW_DEC depending on P2. Optional policy: POLICY_OBJ_FORBID_EXTERNAL_IV Optional policy: POLICY_OBJ_FORBID_DERIVED_OUTPUT would prevent to execute this command succesfully.
	TLV[TAG_2]	1-byte CipherMode
	TLV[TAG_3]	Byte array containing input data.
	TLV[TAG_4]	Byte array containing the initialization vector for AES [16 bytes] for DES [8 bytes] (if more bytes are passed for DES they are ignored) or a 2-byte value containing the length of the initialization vector to be generated (only when P2 = P2_ENCRYPT_ONESHOT and the CipherMode equals AES_CTR). *[Optional]* *[Conditional: when the CipherMode requires an initialization vector, this is a mandatory input]*
Le	0x00	Expecting return data.

Table 239. CipherOneShot R-APDU Body

Value	Description
TLV[TAG_1]	Output data
TLV[TAG_3]	Byte array containing the initialization vector . *[Conditional: only when P2 equals P2_ENCRYPT_ONESHOT TLV[TAG_4] in the C-APDU contains 2 bytes Value.]*

Table 240. CipherOneShot R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

4.13 Authenticated Encryption with Associated Data (AEAD)

AEAD operations can be done using a Secure Object of type AESKey.

AEADMode indicates the algorithm to be applied.

There are 2 options to use AEAD crypto modes:

- in one shot mode – 1 call to process data
- in multi shot mode – multiple calls to process data (init/update/final sequence).

Users are recommended to opt for one shot mode as much as possible as there is no NVM write access in that case, while an AEAD operation in multiple steps involves NVM write access.

Notes on using AEAD crypto operations:

- AEADMode equal to AES_GCM supports IV lengths of 12 up to 60 bytes. Any other input will return an error.
- AEADMode equal to AES_GCM can be used for GMAC operations by omitting the data input and only send Additional Authenticated Data (AAD) input.
- AEADMode equal to AES_CCM supports tag lengths of 4, 6, 8, 10, 12, 14 and 16 bytes only. Any other input will return an error.
- AEADMode equal to AES_CCM supports nonce length of 7,8,9, 10, 11, 12 or 13 bytes only. Any other input will return an error.
- AEADMode equal to AES_CCM is only available in multi shot mode.
- It is up to the user to send AAD and (plain or encrypted) input data 16-byte aligned, both for AAD and data to encrypt or decrypt (except for the last block of the AAD and the last block of the data to encrypt or decrypt). AAD must always be sent before (plain or encrypted) input data. For AEADOneShot, these can be passed together as input.

4.13.1 AEADInit

Initialize an authentication encryption or decryption with associated data. The Crypto Object keeps the state of the AEAD operation until it's finalized or deleted. Once the AEADFinal function is executed successfully, the Crypto Object state returns to the state immediately after the previous AEADInit function.

When TLV[TAG_5] contains a 2-byte Value, the initialization vector will be randomly generated (matching the requested length) and will be returned in the response command; else the TLV[TAG_5] must contain the IV to be used.

Table 241. AEADInit C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	Instruction
P1	P1_AEAD	See P1
P2	P2_ENCRYPT or P2_DECRYPT	See P2
Lc	#(Payload)	
Payload	TLV[TAG_1]	4-byte identifier of the AESKey Secure object. Minimum policy:POLICY_OBJ_ALLOW_ENC or POLICY_OBJ_ALLOW_DEC depending on P2. Optional policy: POLICY_OBJ_FORBID_EXTERNAL_IV Optional policy: POLICY_OBJ_FORBID_DERIVED_OUTPUT would prevent to execute this command succesfully.

Table 241. AEADInit C-APDU...continued

Field	Value	Description
	TLV[TAG_2]	2-byte Crypto Object identifier
	TLV[TAG_5]	Byte array containing the initialization vector [12 bytes until 60 bytes for Cypto Object type equals CC_CIPHER with subtype equal to AES_GCM; 7 up to 13 bytes for CyptoObject type equals CC_CIPHER with subtype equal to AES_CCM] or a 2-byte value containing the initialization vector length when P2 equals P2_ENCRYPT and the CyptoObject type equals CC_CIPHER with subtype equal to AES_GCM or AES_CCM.
	TLV[TAG_6]	Byte array containing 2-byte AAD length. *[Conditional: needed if AEADMode equals AES_CCM]*
	TLV[TAG_7]	Byte array containing 2-byte message length. *[Conditional: needed if AEADMode equals AES_CCM]*
	TLV[TAG_8]	Byte array containing 2-byte mac size. This must be equal to or higher than the minimum tag length attribute of the key identified in TLV[TAG_1]. *[Conditional: needed if AEADMode equals AES_CCM].*
Le	0x00	Expecting returned data. *[Conditional: Only when P2 equals P2_ENCRYPT and TLV[TAG_5] in the C-APDU contains 2 bytes Value.]*

Table 242. AEADInit R-APDU Body

Value	Description
TLV[TAG_3]	Byte array containing the used initialization vector. It remains valid until deselect, AEADInit, AEADFinal or AEADOneShot is called. *[Conditional: Only when P2 equals P2_ENCRYPT and TLV[TAG_5] in the C-APDU contains 2 bytes Value.]*

Table 243. AEADInit R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

4.13.2 AEADUpdate

Update a Crypto Object of type CC_AEAD.

The user either needs to send input data or Additional Authenticated Data (AAD), but not both at once.

Note that the R-APDU does not always contain output data, even if input data are passed to the C-APDU. These might only be returned when calling AEADFinal.

Table 244. AEADUpdate C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	Instruction
P1	P1_AEAD	See P1
P2	P2_UPDATE	See P2

Table 244. AEADUpdate C-APDU...*continued*

Field	Value	Description
Lc	#(Payload)	
Payload	TLV[TAG_2]	2-byte Crypto Object identifier
	TLV[TAG_3]	Byte array containing input data *[Conditional: only when TLV[TAG_4] is not present]* *[Optional]*
	TLV[TAG_4]	Byte array containing Additional Authenticated Data. *[Conditional: only when TLV[TAG_3] is not present]* *[Optional]*
Le	0x00	Expecting returned data.

Table 245. AEADUpdate R-APDU Body

Value	Description
TLV[TAG_1]	Output data *[Conditional: only when output data is available]*

Table 246. AEADUpdate R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

4.13.3 AEADFinal

Finish a sequence of AEAD operations. The AEADFinal command provides the computed GMAC or indicates whether the GMAC is correct depending on the P2 parameters passed during AEADInit. The length of the GMAC is always 16 bytes when P2 equals P2_ENCRYPT. When P2 equals P2_DECRYPT, the minimum tag length to pass is 4 bytes.

Table 247. AEADFinal C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	Instruction
P1	P1_AEAD	See P1
P2	P2_FINAL	See P2
Lc	#(Payload)	
Payload	TLV[TAG_2]	2-byte Crypto Object identifier
	TLV[TAG_6]	Byte array containing tag to verify. The tag length must be equal to or higher than the minimum tag lengthattribute of the key identified in TLV[TAG_1] ot the AEADInit command.

Table 247. AEADFinal C-APDU...*continued*

Field	Value	Description
		[Conditional] When the mode is decrypt and verify (i.e. AEADInit has been called with P2 = P2_DECRYPT).
Le	0x00	Expected returned data.

Table 248. AEADFinal R-APDU Body

Value	Description
TLV[TAG_1]	Output data *[Conditional: only when output data is available]*
TLV[TAG_2]	Byte array containing tag (if P2 = P2_ENCRYPT) or byte array containing Result (if P2 = P2_DECRYPT)

Table 249. AEADFinal R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

4.13.4 AEADOneShot

Authenticated encryption or decryption with associated data in one shot mode.

The key object must be an AES key.

When the AEADMode equals AES_GCM, the length of AAD + length of data should be limited to 888 bytes - the total C-APDU buffer length, where length of AAD and length of data are both rounded up to a multiple of 16, e.g. a C-APDU where data length = 397 bytes, AAD length = 20 bytes and IV length = 12 bytes is normally 456 bytes long (= 7 bytes extended C-APDU header + 6 bytes for TLV[TAG_1] + 3 bytes for TLV[TAG_2] + 401 bytes for TLV[TAG_3] + 22 bytes for TLV[TAG_4] + 14 bytes for bytes for TLV[TAG_5] + 3 bytes Le) would be fine as 888 - 456 >= (400 + 32).

When P2 equals P2_ENCRYPT_ONE_SHOT, the AEADOneShot command returns the encrypted data and computed authentication tag. When passed to the command, the authentication tag length must be at least the size that is defined during key creation (default 16 bytes). See Section 4.7.1.3 for details.

The length of the authentication tag is always 16 bytes when P2 equals P2_ENCRYPT_ONESHOT.

When P2 equals P2_DECRYPT_ONESHOT:

- the minimum authentication tag length to pass is defined during key creation (default 16 bytes). See Section 4.7.1.3 for details.
- when the authentication tag is not correct, only the result will be returned, no output data will be present.

Table 250. AEADOneShot C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	Instruction
P1	P1_AEAD	See P1
P2	P2_ENCRYPT_ONESHOT or P2_DECRYPT_ONESHOT	See P2

Table 250. AEADOneShot C-APDU*...continued*

Field	Value	Description
Lc	#(Payload)	
Payload	TLV[TAG_1]	4-byte identifier of the AESKey Secure object. Minimum policy:POLICY_OBJ_ALLOW_ENC or POLICY_OBJ_ALLOW_DEC depending on P2. Optional policy: POLICY_OBJ_FORBID_EXTERNAL_IV. Optional policy: POLICY_OBJ_FORBID_DERIVED_OUTPUT would prevent to execute this command succesfully.
	TLV[TAG_2]	1-byte AEADMode except AEAD_CCM.
	TLV[TAG_3]	Byte array containing input data. *[Optional]*
	TLV[TAG_4]	Byte array containing Additional Authenticated Data. *[Optional]*
	TLV[TAG_5]	If AEADMode = AES_GCM: Byte array containing an initialization vector (IV length = 12 up to 60 bytes) or 2-byte value containing the requested initialization vector length.
	TLV[TAG_6]	2-byte value containing the requested tag length (if P2 equals P2_ENCRYPT_ONESHOT) or a 4 up to 16-byte array containing the authentication tag to verify (if P2 equals P2_DECRYPT_ONESHOT). The tag length must be equal to or higher than the minimum tag lengthattribute of the key identified in TLV[TAG_1].
Le	0x00	Expecting return data.

Table 251. AEADOneShot R-APDU Body

Value	Description
TLV[TAG_1]	Byte array containing output data.
TLV[TAG_2]	Byte array containing tag (if P2 = P2_ENCRYPT_ONESHOT) or byte array containing Result (if P2 = P2_DECRYPT_ONESHOT)
TLV[TAG_3]	Byte array containing the initialization vector *[Conditional: Only when P2 equals P2_ENCRYPT_ONESHOT and TLV[TAG_5] in the C-APDU contains 2 bytes Value]*

Table 252. AEADOneShot R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

4.14 Message Authentication Codes

There are 2 options to use Message Authentication Codes on SE05x:

- in multiple steps: init/update/final – multiple calls to process data.
- in one shot mode – 1 call to process data

Users are recommended to opt for one shot mode as much as possible as there is no NVM write access in that case, while a MAC operation in multiple steps involves NVM write access.

4.14.1 MACInit

Initiate a MAC operation. The state of the MAC operation is kept in the Crypto Object until it’s finalized or deleted.

The 4-byte identifier of the key must refer to an AESKey, DESKey or HMACKey.

Table 253. MACInit C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	Instruction
P1	P1_MAC	See P1
P2	P2_GENERATE or P2_VALIDATE	See P2
Lc	#(Payload)	
Payload	TLV[TAG_1]	4-byte identifier of the MAC key. Minimum policy:POLICY_OBJ_ALLOW_SIGN or POLICY_OBJ_ALLOW_VERIFY depending on P2. Optional policy: POLICY_OBJ_FORBID_DERIVED_OUTPUT would prevent to execute this command succesfully (only when P2 equals P2_GENERATE).
	TLV[TAG_2]	2-byte Crypto Object identifier
Le	-	No data to be returned.

Table 254. MACInit R-APDU Body

Value	Description
-	No data returned.

Table 255. MACInit R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

4.14.2 MACUpdate

Update a MAC operation.

Table 256. MACUpdate C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	Instruction
P1	P1_MAC	See P1
P2	P2_UPDATE	See P2
Lc	#(Payload)	
Payload	TLV[TAG_1]	Byte array containing data to be taken as input to MAC.

Table 256. MACUpdate C-APDU...*continued*

Field	Value	Description
	TLV[TAG_2]	2-byte Crypto Object identifier
Le	-	No data to be returned.

Table 257. MACUpdate R-APDU Body

Value	Description
-	No data returned.

Table 258. MACUpdate R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

4.14.3 MACFinal

Finalize a MAC operation.

Table 259. MACFinal C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	Instruction
P1	P1_MAC	See P1
P2	P2_FINAL	See P2
Payload	TLV[TAG_1]	Byte array containing data to be taken as input to MAC.
	TLV[TAG_2]	2-byte Crypto Object identifier
	TLV[TAG_3]	Byte array containing MAC to validate. *[Conditional: only applicable if the crypto object is set for validating (MACInit P2 = P2_VALIDATE)]*
Le	0x00	Expecting MAC or result.

Table 260. MACFinal R-APDU Body

Value	Description
TLV[TAG_1]	MAC value (when MACInit had P2 = P2_GENERATE) or Result (when MACInit had P2 = P2_VERIFY).

Table 261. MACFinal R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

4.14.4 MACOneShot

Performs a MAC operation in one shot (without keeping state).

The 4-byte identifier of the key must refer to an AESKey, DESKey or HMACKey.

Table 262. MACOneShot C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	Instruction
P1	P1_MAC	See P1
P2	P2_GENERATE_ONESHOT or P2_VALIDATE_ONESHOT	See P2
Lc	#(Payload)	
Payload	TLV[TAG_1]	4-byte identifier of the key object. Minimum policy:POLICY_OBJ_ALLOW_SIGN or POLICY_OBJ_ALLOW_VERIFY depending on P2. Optional policy: POLICY_OBJ_FORBID_DERIVED_OUTPUT to prevent output to host (only when P2 equals P2_GENERATE_ONESHOT).
	TLV[TAG_2]	1-byte MACAlgo
	TLV[TAG_3]	Byte array containing data to be taken as input to MAC.
	TLV[TAG_5]	MAC to verify (when P2=P2_VALIDATE_ONESHOT)
Le	0x00	Expecting MAC or Result.

Table 263. MACOneShot R-APDU Body

Value	Description
TLV[TAG_1]	MAC value (P2=P2_GENERATE_ONESHOT) or Result (when p2=P2_VALIDATE_ONESHOT).

Table 264. MACOneShot R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

4.15 Key Derivation Functions

4.15.1 HKDF

Perform HMAC Key Derivation Function according to [RFC5869]. There are 2 options:

- Perform the full algorithm, i.e. Extract-and-Expand => see HKDFExtractAndExpand
- Perform only the Expand step, i.e. skip Extract => see HKDFExpandOnly

The output of the HKDF functions can be either:

- sent back to the caller => precondition: none of the input Secure Objects -if present- shall have a policy POLICY_OBJ_FORBID_DERIVED_OUTPUT set.

- be stored in a Secure Object => precondition: the Secure Object must be created upfront and the size must exactly match the expected length.

4.15.1.1 HKDFExtractAndExpand

The full HKDF algorithm is executed, i.e. Extract-And-Expand.

If salt length equals 0 or salt is not provided as input, the default salt will be used.

Applet versions prior to 7.2.46 have a maximum salt length input of 64 bytes.

If the output is stored into an object, the object indicated in TLV[TAG_7] must be created before calling this function.

Note: *This APDU will cause NVM write accesses on the first occurence after selecting the applet.*

Table 265. HKDFExtractAndExpand C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	See Instruction
P1	P1_DEFAULT	See P1
P2	P2_HKDF	See P2
Lc	#(Payload)	
Payload	TLV[TAG_1]	4-byte HMACKey identifier (= IKM). Minimum policy: POLICY_OBJ_ALLOW_KDF Optional policy: POLICY_OBJ_FORBID_DERIVED_OUTPUT to prevent output to host.
	TLV[TAG_2]	1-byte DigestMode (except DIGEST_NO_HASH and DIGEST_SHA224)
	TLV[TAG_3]	Byte array containing salt. If EXTCFG_CRYPTO_HKDF_FORBID_IN_OUT_LT_112BIT is set, the minimum is 14 bytes. Applet versions prior to 7.2.46 have a salt length limit up of 64 bytes. *[Optional]* *[Conditional: only when TLV[TAG_6] is absent.]*
	TLV[TAG_4]	Info: The context and information to apply. *[Optional]*
	TLV[TAG_5]	2-byte requested length (L): 1 up to 768 bytes. If EXTCFG_CRYPTO_HKDF_FORBID_IN_OUT_LT_112BIT is set, the minimum is 14 bytes. If a minimum output length is set on the key from TLV[TAG_1], the requested length must be equal or bigger than the minimum output length.
	TLV[TAG_6]	4-byte HMACKey identifier containing salt. If EXTCFG_CRYPTO_HKDF_FORBID_IN_OUT_LT_112BIT is set, this TLV cannot be used and salt needs to be passed via TLV[TAG_3]. Minimum policy: POLICY_OBJ_ALLOW_USAGE_AS_HMAC_PEPPER Optional policy: POLICY_OBJ_FORIBD_DERIVED_OUTPUT to prevent output to host. *[Optional]* *[Conditional: only when TLV[TAG_3] is absent]*
	TLV[TAG_7]	4-byte identifier of the target Secure Object; this must be an HMACKey or AESKey. For HMACKey, minimum output length applies.

Table 265. HKDFExtractAndExpand C-APDU*...continued*

Field	Value	Description
		Minimum policy:POLICY_OBJ_ALLOW_WRITE or POLICY_OBJ_ALLOW_DERIVED_INPUT with the 4-byte HMACKey identifier from TLV[TAG_1] as extension to restrict key derivation. *[Optional]*
Le	0x00	Expecting returned data.

Table 266. HKDFExtractAndExpand R-APDU Body

Value	Description
TLV[TAG_1]	HKDF output. *[Conditional: only when the input does not contain TLV[TAG-7]]*

Table 267. HKDFExtractAndExpand R-APDU Trailer

SW	Description
SW_NO_ERROR	The HKDF is executed successfully.

4.15.1.2 HKDFExpandOnly

Only step 2 of the algorithm is executed, i.e. Expand only.

Salt length is limited to 64 bytes.

Using an IV as input parameter results in a FIPS compliant NIST SP800-108 KDF in Feedback Mode where K[0] is the provided IV. This KDF is using a 8-bit counter, AFTER_FIXED counter location.

If the output is stored into an object, the object indicated in TLV[TAG_7] must be created before calling this function.

Note: *This APDU will cause NVM write accesses on the first occurence after selecting the applet.*

Table 268. HKDFExpandOnly C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	See Instruction
P1	P1_DEFAULT	See P1
P2	P2_HKDF_EXPAND_ONLY	See P2
Lc	#(Payload)	
Payload	TLV[TAG_1]	4-byte HMACKey identifier (= PRK). Minimum policy: POLICY_OBJ_ALLOW_KDF Optional policy: POLICY_OBJ_FORBID_DERIVED_OUTPUT to prevent output to host.
	TLV[TAG_2]	1-byte DigestMode (except DIGEST_NO_HASH and DIGEST_SHA224)
	TLV[TAG_3]	Byte array (0-64 bytes) containing IV. *[Optional]* *[Conditional: only when TLV[TAG_6] is absent.]*

Table 268. HKDFExpandOnly C-APDU*...continued*

Field	Value	Description
	TLV[TAG_4]	Info: The context and information to apply (1 to 80 bytes). *[Optional]*
	TLV[TAG_5]	2-byte requested length (L): 1 up to 768 bytes. If EXTCFG_CRYPTO_HKDF_FORBID_IN_OUT_LT_112BIT is set, the minimum is 14 bytes. If a minimum output length is set on the key from TLV[TAG_1], the requested length must be equal or bigger than the minimum output length.
	TLV[TAG_6]	4-byte HMACKey identifier containing IV. Minimum policy: POLICY_OBJ_ALLOW_USAGE_AS_HMAC_PEPPER Optional policy: POLICY_OBJ_FORIBD_DERIVED_OUTPUT to prevent output to host. *[Optional]* *[Conditional: only when TLV[TAG_3] is absent]*
	TLV[TAG_7]	4-byte identifier of the target Secure Object; this must be an HMACKey or AESKey. For HMACKey, minimum output length applies. Minimum policy:POLICY_OBJ_ALLOW_WRITE or POLICY_OBJ_ALLOW_DERIVED_INPUT with the 4-byte HMACKey identifier from TLV[TAG_1] as extension to restrict key derivation. *[Optional]*
Le	0x00	Expecting returned data.

Table 269. HKDFExpandOnly R-APDU Body

Value	Description
TLV[TAG_1]	HKDF output. *[Conditional: only when the input does not contain TLV[TAG-7]]*

Table 270. HKDFExpandOnly R-APDU Trailer

SW	Description
SW_NO_ERROR	The HKDF is executed successfully.

4.15.2 PBKDF2

4.15.2.1 PBKDF2DeriveKey

Password Based Key Derivation Function 2 (PBKDF2) according to [RFC8018]. The default HMAC algorithm is HMAC SHA1.

The password is an input to the KDF and must be stored inside the SE05x.

If the output is stored into an object, the object indicated in TLV[TAG_7] must be created before calling this function.

Table 271. PBKDF2DeriveKeyC-APDU

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	Instruction
P1	P1_DEFAULT	See P1
P2	P2_PBKDF	See P2
Lc	#(Payload)	
Payload	TLV[TAG_1]	4-byte password identifier (object type must be HMACKey) Minimum policy: POLICY_OBJ_ALLOW_PBKDF Optional policy:POLICY_OBJ_FORBID_DERIVED_OUTPUT to prevent output to host
	TLV[TAG_2]	Salt (0 to 64 bytes; if EXTCFG_CRYPTO_PBKDF_FORBID_SALT_LT_128BIT is set, the minimum length is 16 bytes). *[Optional: if both TLV[TAG_2] and TLV[TAG_6] are absent, no salt is used]* *[Conditional: only when TLV[TAG_6] is absent]*
	TLV[TAG_3]	2-byte Iteration count: 1 up to 0x7FFF.
	TLV[TAG_4]	2-byte Requested length: 1 up to 512 bytes. If EXTCFG_CRYPTO_PBKDF_FORBID_IN_OUT_LT_112BIT is set, the minimum length is 14 bytes. If a minimum output length is set on the key from TLV[TAG_1], the requested length must be equal or bigger than the minimum output length.
	TLV[TAG_5]	1-byte MACAlgo (one of the HMAC algorithms only). Passing 0 as value equals to HMAC_SHA1. *[Optional; default is HMAC_SHA1]*
	TLV[TAG_6]	4-byte HMACKey identifier containing salt. Minimum policy: POLICY_OBJ_ALLOW_USAGE_AS_HMAC_PEPPER Optional policy: POLICY_OBJ_FORIBD_DERIVED_OUTPUT to prevent output to host. *[Optional: if both TLV[TAG_2] and TLV[TAG_6] are absent, no salt is used]* *[Conditional: only when TLV[TAG_2] is absent]*
	TLV[TAG_7]	4-byte identifier of the target Secure Object; this must be an HMACKey or AESKey. For HMACKey, minimum output length applies. Minimum policy: POLICY_OBJ_ALLOW_WRITE or POLICY_OBJ_ALLOW_DERIVED_INPUT with the 4-byte HMACKey identifier from TLV[TAG_1] as extension to restrict key derivation. *[Optional]*
Le	0x00	Expecting derived key material.

Table 272. PBKDF2DeriveKey R-APDU Body

Value	Description
TLV[TAG_1]	Derived key material (session key). *[Conditional: only when the input does not contain TLV[TAG-7]]*

Table 273. PBKDF2DeriveKey R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

4.16 MIFARE DESFire support

MIFARE DESFire EV2 Key derivation (S-mode). This is limited to AES128 keys only.

The SE05x can be used by a card reader to setup a session where the SE05x stores the master key(s) and the session keys are generated and passed to the host.

The SE05x keeps an internal state of MIFARE DESFire authentication data during authentication setup. This state is fully transient, so it is lost on deselect of the applet.

The MIFARE DESFire state is owned by 1 user at a time; i.e., the user who calls DFAuthenticateFirstPart1 owns the MIFARE DESFire context until DFAuthenticateFirstPart1 is called again or until DFKillAuthentication is called.

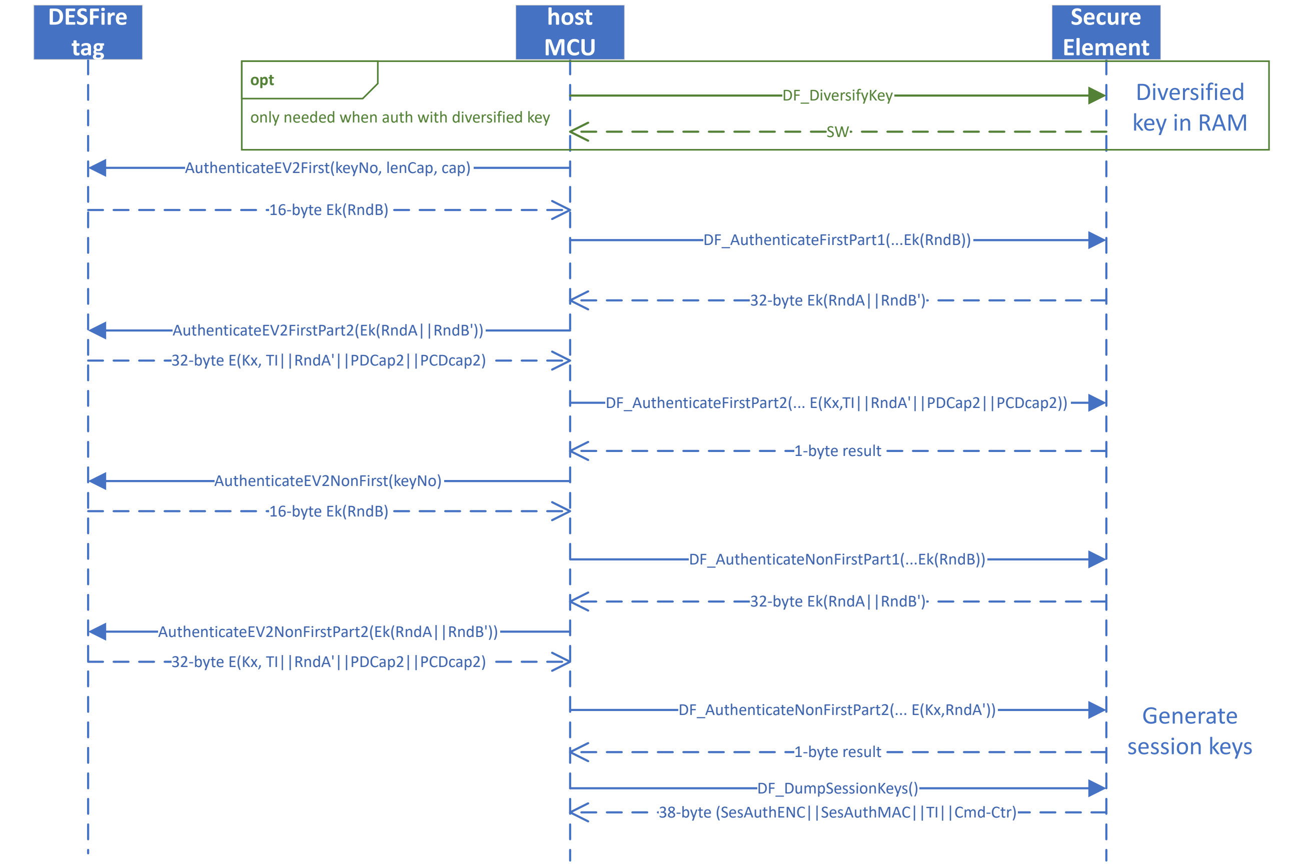

DESFire tag
host MCU
Secure Element
opt
only needed when auth with diversified key
DF_DiversifyKey
SW
Diversified key in RAM
AuthenticateEV2First(keyNo, lenCap, cap)
16-byte Ek(RndB)
DF_AuthenticateFirstPart1(...Ek(RndB))
32-byte Ek(RndA||RndB')
AuthenticateEV2FirstPart2(Ek(RndA||RndB'))
32-byte E(Kx, TI||RndA'||PDCap2||PCDcap2)
DF_AuthenticateFirstPart2(... E(Kx,TI||RndA'||PDCap2||PCDcap2))
1-byte result
AuthenticateEV2NonFirst(keyNo)
16-byte Ek(RndB)
DF_AuthenticateNonFirstPart1(...Ek(RndB))
32-byte Ek(RndA||RndB')
AuthenticateEV2NonFirstPart2(Ek(RndA||RndB'))
32-byte E(Kx, TI||RndA'||PDCap2||PCDcap2)
DF_AuthenticateNonFirstPart2(... E(Kx,RndA'))
Generate session keys
1-byte result
DF_DumpSessionKeys()
38-byte (SesAuthENC||SesAuthMAC||TI||Cmd-Ctr)

Figure 19. Example DESFire authentication using SE05x

The SE05x can also be used to support a ChangeKey command, either supporting ChangeKey or ChangeKeyEV2. To establish a correct use case, policies need to be applied to the keys to indicate keys can be used for ChangeKey or not, etc..

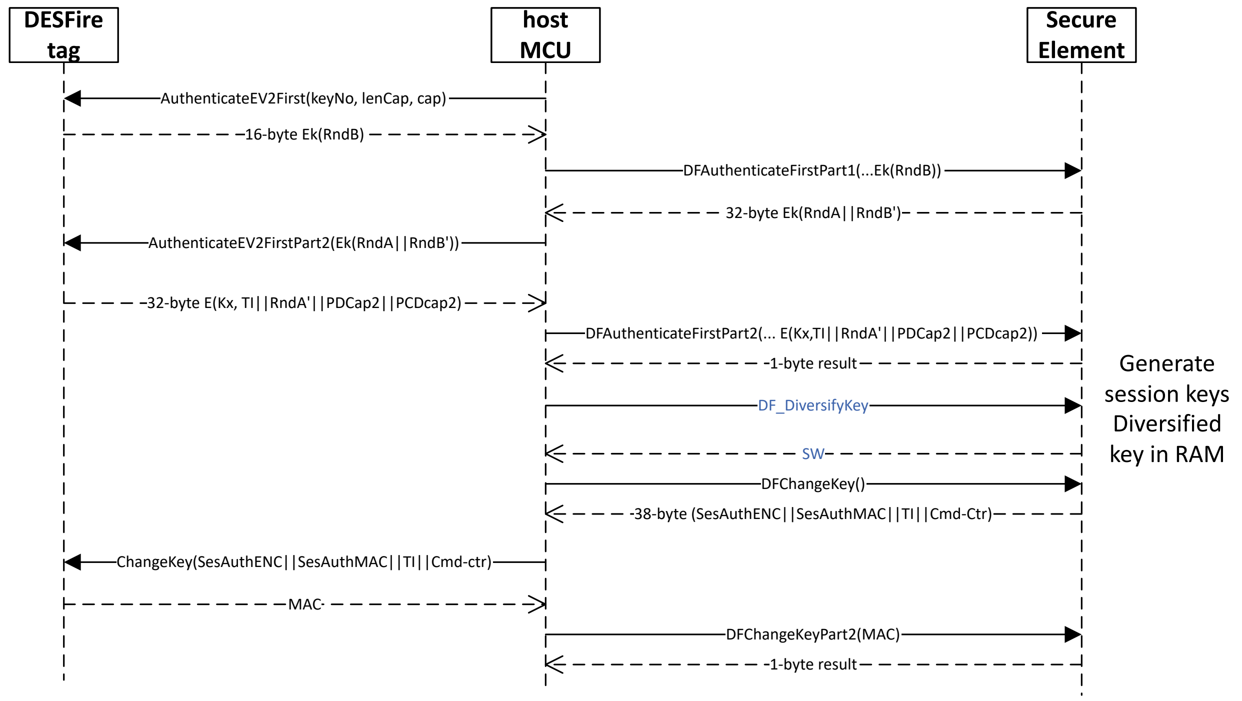

DESFire tag
host MCU
Secure Element
AuthenticateEV2First(keyNo, lenCap, cap)
16-byte Ek(RndB)
DFAuthenticateFirstPart1(...Ek(RndB))
32-byte Ek(RndA||RndB')
AuthenticateEV2FirstPart2(Ek(RndA||RndB'))
32-byte E(Kx, TI||RndA'||PDCap2||PCDcap2)
DFAuthenticateFirstPart2(... E(Kx,TI||RndA'||PDCap2||PCDcap2))
1-byte result
Generate session keys Diversified key in RAM
DF_DiversifyKey
SW
DFChangeKey()
38-byte (SesAuthENC||SesAuthMAC||TI||Cmd-Ctr)
ChangeKey(SesAuthENC||SesAuthMAC||TI||Cmd-ctr)
MAC
DFChangeKeyPart2(MAC)
1-byte result

Figure 20. DESFire ChangeKey example

4.16.1 DFDiversifyKey

Create a Diversified Key according [AN10922]. Input is *divInput* of 1 up to 31 bytes.

Note that users need to create the diversified key object before calling this function.

Table 274. DFDiversifyKey C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	Instruction
P1	P1_DEFAULT	See P1
P2	P2_DIVERSIFY	See P2
Lc	#(Payload)	
	TLV[TAG_1]	4-byte master key identifier. Minimum policy: POLICY_OBJ_ALLOW_DESFIRE_KDF
	TLV[TAG_2]	4-byte identifier of the target Secure Object; this must be a 128-bit AESKey. Minimum policy:POLICY_OBJ_ALLOW_WRITE or POLICY_OBJ_ALLOW_DERIVED_INPUT with the 4-byte identifier of TLV[TAG_1] as extension to restrict key derivation.
	TLV[TAG_3]	Byte array containing divInput (up to 31 bytes).
Le	-	No data to be returned.

Table 275. DFDiversifyKey R-APDU Body

Value	Description
-	No data returned.

Table 276. DFDiversifyKey R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.
SW_CONDITIONS_NOT_SATISFIED	No master key found.
SW_CONDITIONS_NOT_SATISFIED	Wrong length for divInput.

4.16.2 DFAuthenticateFirst

Mutual authentication between the reader and the card, part 1.

4.16.2.1 DFAuthenticateFirstPart1

Table 277. DFAuthenticateFirstPart1 C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	Instruction
P1	P1_DEFAULT	See P1
P2	P2_AUTH_FIRST_PART1	See P2
Lc	#(Payload)	
	TLV[TAG_1]	4-byte key identifier. Minimum policy:POLICY_OBJ_ALLOW_DESFIRE_ AUTHENTICATION
	TLV[TAG_2]	16-byte encrypted card challenge: E(Kx,RndB)
Le	0x00	

Table 278. DFAuthenticateFirstPart1 R-APDU Body

Value	Description
TLV[TAG_1]	32-byte output data: E(Kx, RandA || RandB')

Table 279. DFAuthenticateFirstPart1 R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

4.16.2.2 DFAuthenticateFirstPart2

For First part 2, the key identifier is implicitly set to the identifier used for the First authentication. DFAuthenticateFirstPart1 needs to be called before; otherwise an error is returned.

This command needs to be called by the same user who initiated the DESFire authentication, else it will return an error.

Table 280. DFAuthenticateFirstPart2 C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	Instruction
P1	P1_DEFAULT	See P1
P2	P2_AUTH_FIRST_PART2	See P2
Lc	#(Payload)	
	TLV[TAG_1]	32 byte input: E(Kx,TI||RndA'||PDcap2||PCDcap2)
Le	0x00	

Table 281. DFAuthenticateFirstPart2 R-APDU Body

Value	Description
TLV[TAG_1]	12-byte array returning PDcap2||PCDcap2.

Table 282. DFAuthenticateFirstPart2 R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

4.16.3 DFAuthenticateNonFirst

Mutual authentication between the reader and the card, non-first authentication.

4.16.3.1 DFAuthenticateNonFirstPart1

Table 283. DFAuthenticateNonFirstPart1 C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	Instruction
P1	P1_DEFAULT	See P1
P2	P2_AUTH_NONFIRST_PART1	See P2
Lc	#(Payload)	
	TLV[TAG_1]	4-byte key identifier. Minimum policy: POLICY_OBJ_ALLOW_DESFIRE_AUTHENTICATION
	TLV[TAG_2]	16-byte encrypted card challenge: E(Kx,RndB)
Le	0x00	

Table 284. DFAuthenticateNonFirstPart1 R-APDU Body

Value	Description
TLV[TAG_1]	32-byte output data: E(Kx, RandA || RandB')

Table 285. DFAuthenticateNonFirstPart1 R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

4.16.3.2 DFAuthenticateNonFirstPart2

For NonFirst part 2, the key identifier is implicitly set to the identifier used for the NonFirst part 1 authentication. DFAuthenticateNonFirstPart1 needs to be called before; otherwise an error is returned.

This command needs to be called by the same user who initiated the DESFire authentication, else it will return an error.

If authentication fails, SW_WRONG_DATA will be returned.

Table 286. DFAuthenticateNonFirstPart2 C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	Instruction
P1	P1_DEFAULT	See P1
P2	P2_AUTH_NONFIRST_PART2	See P2
Lc	#(Payload)	
	TLV[TAG_1]	16-byte E(Kx, RndA’)
Le	-	No data to be returned.

Table 287. DFAuthenticateNonFirstPart2 R-APDU Body

Value	Description
-	No data returned.

Table 288. DFAuthenticateNonFirstPart2 R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.
SW_WRONG_DATA	Authentication failed.

4.16.4 DFDumpSessionKeys

Dump the Transaction Identifier and the session keys to the host.

This command needs to be called by the same user who initiated the DESFire authentication, else it will return an error.

To allow the command to execute succesfully, the key that is used to authenticate must have POLICY_OBJ_ALLOW_DESFIRE_DUMP_SESSION_KEY enabled and not have the policy POLICY_OBJ_FORBID_DERIVED_OUTPUT set.

Table 289. DFDumpSessionKeys C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	Instruction
P1	P1_DEFAULT	See P1
P2	P2_DUMP_KEY	See P2
Lc	#(Payload)	
Le	0x2A	Expecting TLV with 38 bytes data.

Table 290. DFDumpSessionKeys R-APDU Body

Value	Description
TLV[TAG_1]	38 bytes: KeyID.SesAuthENCKey || KeyID.SesAuthMACKey || TI || Cmd-Ctr

Table 291. DFDumpSessionKeys R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

4.16.5 DFChangeKey

4.16.5.1 DFChangeKeyPart1

The DFChangeKeyPart1 command is supporting the function to change keys on the DESFire PICC. The command generates the cryptogram required to perform such operation.

This command needs to be called by the same user who initiated the DESFire authentication, else it will return an error.

The new key and, if used, the current (or old) key must be stored in the SE05x. This means the new PICC key must be present in the SE05x prior to issuing this command.

The 1-byte key set number indicates whether DESFire ChangeKey or DESFire ChangeKeyEV2 is used. When key set equals 0xFF, ChangeKey is used.

Table 292. DFChangeKeyPart1 C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	Instruction
P1	P1_DEFAULT	See P1
P2	P2_CHANGE_KEY_PART1	See P2
Lc	#(Payload)	

Table 292. DFChangeKeyPart1 C-APDU*...continued*

Field	Value	Description
	TLV[TAG_1]	4-byte identifier of the old key. Minimum policy: POLICY_OBJ_ALLOW_DESFIRE_CHANGEKEY Optional policy: POLICY_OBJ_FORBID_DERIVED_OUTPUT would prevent to execute this command succesfully. *[Optional: if the authentication key is the same as the key to be replaced, this TAG should not be present].*
	TLV[TAG_2]	4-byte identifier of the new key. Minimum policy: POLICY_OBJ_ALLOW_DESFIRE_CHANGEKEY Optional policy: POLICY_OBJ_FORBID_DERIVED_OUTPUT would prevent to execute this command succesfully.
	TLV[TAG_3]	1-byte key set number *[Optional: when set to 0xFF, a ChangeKey command will be created without key set number.]*
	TLV[TAG_4]	1-byte DESFire key number to be targeted.
	TLV[TAG_5]	1-byte key version
Le	0x00	

Table 293. DFChangeKeyPart1 R-APDU Body

Value	Description
TLV[TAG_1]	Cryptogram holding key data

Table 294. DFChangeKeyPart1 R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

4.16.5.2 DFChangeKeyPart2

The DFChangeKeyPart2 command verifies the MAC returned by ChangeKey or ChangeKeyEV2. Note that this function only needs to be called if a MAC is returned (which is not the case if the currently authenticated key is changed on the DESFire card).

This command needs to be called by the same user who initiated the DESFire authentication, else it will return an error.

Table 295. DFChangeKeyPart2 C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	See Instruction
P1	P1_DEFAULT	See P1
P2	P2_CHANGE_KEY_PART2	See P2
Lc	#(Payload)	
	TLV[TAG_1]	MAC

Table 295. DFChangeKeyPart2 C-APDU*...continued*

Field	Value	Description
Le	0x00	

Table 296. DFChangeKeyPart2 R-APDU Body

Value	Description
TLV[TAG_1]	1-byte Result

Table 297. DFChangeKeyPart2 R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

4.16.6 DFKillAuthentication

DFKillAuthentication invalidates any authentication and clears the internal DESFire state. Keys used as input (master keys or diversified keys) are not touched.

This command needs to be called by the same user who initiated the DESFire authentication, else it will return an error.

Table 298. DFKillAuthentication C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	Instruction
P1	P1_DEFAULT	See P1
P2	P2_KILL_AUTH	See P2
Lc	#(Payload)	

Table 299. DFKillAuthentication R-APDU Body

Value	Description
-	No data returned.

Table 300. DFKillAuthentication R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

4.17 TLS handshake support

4.17.1 TLSGenerateRandom

Generates a random that is stored in the SE05x and used by TLSPerformPRF.

Table 301. TLSGenerateRandom C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	See Instruction
P1	P1_TLS	See P1
P2	P2_RANDOM	See P2
Lc	#(Payload)	
Le	0x24	Expecting TLV with 32 bytes data.

Table 302. TLSGenerateRandom R-APDU Body

Value	Description
TLV[TAG_1]	32-byte random value

Table 303. TLSGenerateRandom R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

4.17.2 TLSCalculatePreMasterSecret

The command TLSCalculatePreMasterSecret will compute the pre-master secret for TLS according to [RFC5246]. The pre-master secret will always be stored in an HMACKey object (TLV[TAG_3]). The HMACKey object must be created before with the expected length of the pre master secret; otherwise the calculation of the pre-master secret will fail.

Supported algorithms and related input data are listed in following table:

Table 304. Supported TLS 1.2 configurations

Config	RFC reference	PSK (TLV[TAG_1])	ECKey key pair (TLV{TAG_2])	RSAKey key pair (TLV{TAG_2])	Input data (TLV[TAG_4])
PSK Key Exchange	[RFC4279]	v			none
RSA_PSK Key Exchange	[RFC4279]	v		v	RSA encrypted secret
ECDHE_PSK Key Exchange	[RFC5489]	v	v		external EC public key
RSA Key Exchange	[RFC5246]			v	RSA encrypted secret
EC Key Exchange	[RFC4492]		v		external EC public key

When POLICY_OBJ_ALLOW_DERIVED_INPUT is applied to prevent write access to the target object, this policy must have either the ECKey key pair or RSA key pair as extension. If no key pair is present, the extension must contain the identifier of the PSK.

Table 305. TLSCalculatePreMasterSecret C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	See Instruction
P1	P1_TLS	See P1
P2	P2_TLS_PMS	See P2
Lc	#(Payload)	
	TLV[TAG_1]	4-byte HMACKey identifier referring to a 16, 32, 48 or 64-byte PSK. Minimum policy:POLICY_OBJ_ALLOW_TLS_PMS [*Optional*]
	TLV[TAG_2]	4-byte key pair identifier. Minimum policy: POLICY_OBJ_ALLOW_KA Optional policy: POLICY_OBJ_FORBID_DERIVED_OUTPUT must be set in case of EC keys to prevent output to host via other APDUs. *[Optional]*
	TLV[TAG_3]	4-byte identifier of the target Secure Object; this must be an HMACKey (see also minimum output length). Minimum policy:POLICY_OBJ_ALLOW_WRITE or POLICY_OBJ_ALLOW_DERIVED_INPUT with the 4-byte identifier of TLV[TAG_2] if present, else with the 4-byte identifier of TLV[TAG_1] as extension to restrict key derivation.
	TLV[TAG_4]	Byte array containing input data.
	TLV[TAG_6]	2-byte client version *[Optional]* *[Conditional: required for RSA_PSK or RSA Key Exchange algorithm]*
Le	-	No data to be returned.

Table 306. TLSCalculatePreMasterSecret R-APDU Body

Value	Description
-	No data returned.

Table 307. TLSCalculatePreMasterSecret R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

4.17.3 TLSPerformPRF

The command TLSPerformPRF will compute either:

- the master secret for TLS according to [RFC5246], section 8.1
- key expansion data from a master secret for TLS according to [RFC5246], section 6.3. Note that the use of TLSPerformPRF for key expansion requires to have P2 equal to P2_PRF_BOTH as the user must be able to insert both random values.

Each time before calling this function, TLSGenerateRandom must be called. Executing this function will clear the random that is stored in the SE05x.

The function can be called as client or as server and either using the pre-master secret or master secret as input, stored in an HMACKey.

This results in P2 having these possibilities:

- P2_TLS_PRF_CLI_HELLO: pass the clientHelloRandom to calculate a master secret, the serverHelloRandom is in SE05x, generated by TLSGenerateRandom.
- P2_TLS_PRF_SRV_HELLO: pass the serverHelloRandom to calculate a master secret, the clientHelloRandom is in SE05x, generated by TLSGenerateRandom.
- P2_TLS_PRF_CLI_RANDOM: pass the clientRandom to generate key expansion data, the serverRandom is in SE05x, generated by TLSGenerateRandom.
- P2_TLS_PRF_SRV_RANDOM: pass the serverRandom to generate key expansion data, the clientRandom is in SE05x
- P2_PRF_BOTH: pass the clientRandom and serverRandom (in the order that the user defines) to calculate a master secret or key expansion data. In this case, the input HMAC key must have the policy POLICY_OBJ_ALLOW_TLS_KDF_EXT_RANDOM set. Also note that the policy should in general be allowed: if extended feature bit EXTCFG_CRYPTO_TLS_KDF_ALLOW_EXT_RANDOM_POLICY is not set, this policy cannot be applied to any object, hence P2_PRF_BOTH can not be used succesfully.

Table 308. TLSPerformPRF C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	See Instruction
P1	P1_TLS	See P1
P2	See description above.	See P2
Lc	#(Payload)	
	TLV[TAG_1]	4-byte HMACKey identifier. Minimum policy:POLICY_OBJ_ALLOW_TLS_KDF Optional policy: POLICY_OBJ_ALLOW_TLS_KDF_EXT_RANDOM (see description above). Optional policy: POLICY_OBJ_FORBID_DERIVED_OUTPUT would prevent to execute this command succesfully.
	TLV[TAG_2]	1-byte DigestMode, except DIGEST_NO_HASH and DIGEST_SHA224
	TLV[TAG_3]	Label (1 to 64 bytes)
	TLV[TAG_4]	32-byte or 64-byte random value (any P2 except P2_PRF_BOTH requires 32 bytes; P2_PRF_BOTH requires 64 bytes).
	TLV[TAG_5]	2-byte requested length (1 up to 512 bytes)
Le	0x00	

Table 309. TLSPerformPRF R-APDU Body

Value	Description
TLV[TAG_1]	Byte array containing requested output data.

Table 310. TLSPerformPRF R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

4.18 I2C controller support

The I2C controller support is provided to SE05x users to enable the SE05x as I2C controller. A set of commands can be sent via an APDU to the SE05x after which the SE05x will execute the commands and respond via R-APDU.

When the INS byte contains an attestation flag, the R-APDU will be attested.

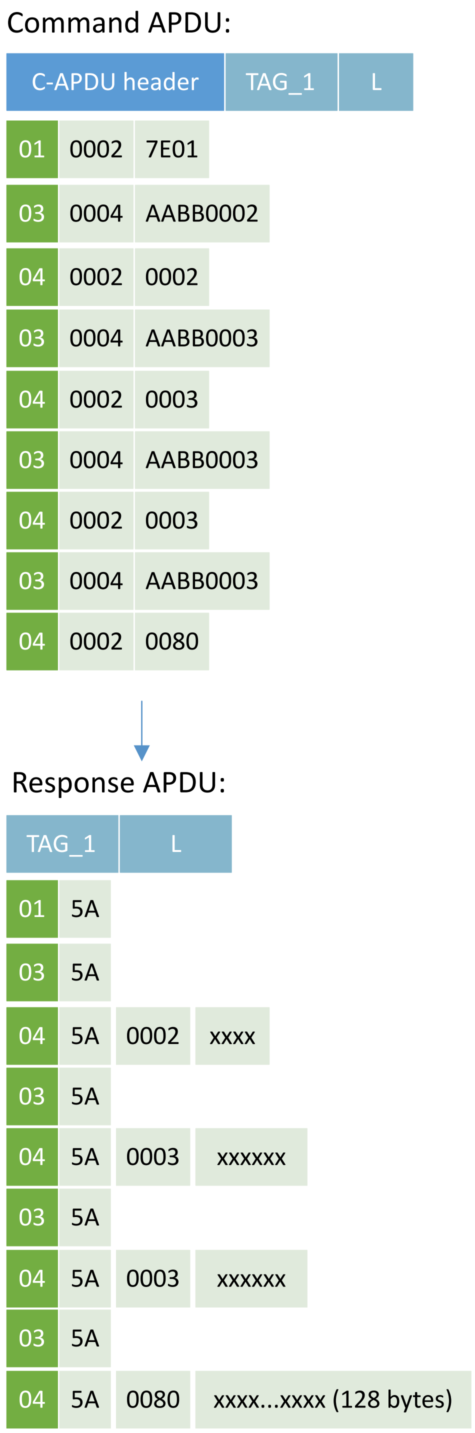
The command set that can be put as part of the TLV[TAG_1] payload of the C-APDU is a byte array consisting out of a concatenation of TLV elements from Table 311.

Only 1 READ command is allowed at the end of the TLV.

Table 311. I2C controller command set TLVs

Instruction	Value	Description
CONFIGURE	0x01	configures the I2C controller; followed by 0x0002 and 2 bytes config. Byte 1: target address Byte 2: clock; 0x00 = 100 kHz, 0x01: 400 kHz
WRITE	0x03	Bytes to be written by the I2C controller; followed by 2-byte length indicator + length number of bytes to write.
READ	0x04	Number of bytes to be read by the I2C controller; followed by 0x0002 and 2 bytes read length.

- A CONFIGURE command stays valid (i.e., stored in the native library) until the next CONFIGURE is sent, so the configuration of a target is saved.
- The CONFIGURE tag must be the first tag in a command sequence.
- The length of a command sequence is limited to MAX_I2CM_COMMAND_LENGTH. If the command is longer, the applet will return SW_CONDITIONS_NOT_SATISFIED.



Command APDU:

C-APDU header	TAG_1	L

01	0002	7E01
03	0004	AABB0002
04	0002	0002
03	0004	AABB0003
04	0002	0003
03	0004	AABB0003
04	0002	0003
03	0004	AABB0003
04	0002	0080

Response APDU:

TAG_1	L

01	5A		
03	5A		
04	5A	0002	xxxx
03	5A		
04	5A	0003	xxxxxx
03	5A		
04	5A	0003	xxxxxx
03	5A		
04	5A	0080	xxxx...xxxx (128 bytes)

Figure 21. Example ExecuteI2CCommandSet

4.18.1 I2CMExecuteCommandSet

Execute one or multiple I2C commands in controller mode. Execution is conditional to the presence of the authentication object identified by RESERVED_ID_I2CM_ACCESS. If the credential is not present in the eSE, access is allowed in general. Otherwise, a session shall be established before executing this command. In this case, the I2CMExecuteCommandSet command shall be sent within the mentioned session.

The I^2C command set is constructed as a sequence of instructions described in Table 311 with the following rules:

- The length should be limited to MAX_I2CM_COMMAND_LENGTH.
- The data to be read cannot exceed MAX_I2CM_COMMAND_LENGTH, including protocol overhead.

Table 312. I2CMExecuteCommandSet C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	See Instruction, in addition to INS_CRYPTO, users can set a flag to request an attested response.
.P1	P1_DEFAULT	See P1
P2	P2_I2CM	See P2
Lc	#(Payload)	
	TLV[TAG_1]	Byte array containing I2C Command set as TLV array.
	TLV[TAG_2]	4-byte attestation object identifier. Minimum policy:POLICY_OBJ_ALLOW_ATTESTATION *[Optional]* *[Conditional: only when attestation is requested.]*
	TLV[TAG_3]	1-byte AttestationAlgo *[Optional]* *[Conditional: only when attestation is requested.]*
	TLV[TAG_7]	16-byte freshness random *[Optional]* *[Conditional: only when attestation is requested.]*
Le	0x00	Expecting TLV with return data.

Table 313. I2CMExecuteCommandSet R-APDU Body

Value	Description
TLV[TAG_1]	Read response, a bytestring containing a sequence of: • CONFIGURE (0x01), followed by 1 byte of return code (0x5A = SUCCESS). • WRITE (0x03), followed by 1 byte of return code • READ (0x04), followed by – Length: 2 bytes in big endian encoded without TLV length encoding – Read bytes • 0xFF followed by the error return code in case of a structural error of the incoming buffer (too long, for example)
TLV[TAG_2]	TLV containing 18-byte chip unique ID *[Conditional: only when attestation is requested.]*
TLV[TAG_4]	TLV containing 2-byte 0x0000. *[Conditional: only when attestation is requested.]*
TLV[TAG_TS]	TLV containing 12-byte timestamp *[Conditional: only when attestation is requested.]*

Table 313. I2CMExecuteCommandSet R-APDU Body*...continued*

Value	Description
TLV[TAG_ATT_SIG]	TLV containing signature over the hashed plain C-APDU concatentated with tag, length and value of TLV[TAG_1], TLV[TAG_2], TLV[TAG_4] and TLV[TAG_TS] as returned by the applet. *[Conditional: only when attestation is requested.]*

Table 314. I2CMExecuteCommandSet R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

4.19 Digest operations

There are 2 options to use Digest operations on SE05x:

- in multiple steps: init/update/final – multiple calls to process data.
- in one shot mode – 1 call to process data

Users are recommended to opt for one shot mode as much as possible.

4.19.1 DigestInit

Open a digest operation. The state of the digest operation is kept in the Crypto Object until the Crypto Object is finalized or deleted.

Table 315. DigestInit C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	See Instruction
P1	P1_DEFAULT	See P1
P2	P2_INIT	See P2
Lc	#(Payload)	
	TLV[TAG_2]	2-byte Crypto Object identifier

Table 316. DigestInit R-APDU Body

Value	Description
-	No data returned.

Table 317. DigestInit R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

4.19.2 DigestUpdate

Update a digest operation.

Table 318. DigestUpdate C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	See Instruction
P1	P1_DEFAULT	See P1
P2	P2_UPDATE	See P2
Lc	#(Payload)	
	TLV[TAG_2]	2-byte Crypto Object identifier
	TLV[TAG_3]	Data to be hashed.
Le	-	No data to be returned.

Table 319. DigestUpdate R-APDU Body

Value	Description
-	No data returned.

Table 320. DigestUpdate R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

4.19.3 DigestFinal

Finalize a digest operation.

Table 321. DigestFinal C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	See Instruction
P1	P1_DEFAULT	See P1
P2	P2_FINAL	See P2
Lc	#(Payload)	
	TLV[TAG_2]	2-byte Crypto Object identifier
	TLV[TAG_3]	Data to be hashed.
Le	0x00	Expecting TLV with hash value.

Table 322. DigestFinal R-APDU Body

Value	Description
TLV[TAG_1]	hash value

Table 323. DigestFinal R-APDU Trailer

SW	Description
SW_NO_ERROR	The hash is created successfully.

4.19.4 DigestOneShot

Performs a hash operation in one shot (without context).

Table 324. DigestOneShot C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	See Instruction
P1	P1_DEFAULT	See P1
P2	P2_ONESHOT	See P2
Lc	#(Payload)	
	TLV[TAG_1]	1-byte DigestMode (except DIGEST_NO_HASH)
	TLV[TAG_2]	Data to hash.
Le	0x00	TLV expecting hash value

Table 325. DigestOneShot R-APDU Body

Value	Description
TLV[TAG_1]	Hash value.

Table 326. DigestOneShot R-APDU Trailer

SW	Description
SW_NO_ERROR	The hash is created successfully.

4.20 Generic management commands

4.20.1 GetVersion

Gets the applet version information.

This will return 7-byte or 37-byte VersionInfo (including major, minor and patch version of the applet, supported applet features and secure box version).

Table 327. GetVersion C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_MGMT	See Instruction
P1	P1_DEFAULT	See P1
P2	P2_VERSION or P2_VERSION_EXT	See P2
Lc	#(Payload)	
Le	0x00	Expecting TLV with 7-byte data (when P2 = P2_VERSION) or a TLV with 37 byte data (when P2= P2_VERSION_EXT).

Table 328. GetVersion R-APDU Body

Value	Description
TLV[TAG_1]	7-byte VersionInfo (if P2 = P2_VERSION) or 7-byte VersionInfo followed by 30 bytes extendedFeature Bits (if P2 = P2_VERSION_EXT)

Table 329. GetVersion R-APDU Trailer

SW	Description
SW_NO_ERROR	Data is returned successfully.

4.20.2 GetTimestamp

Gets a monotonic counter value (time stamp) from the operating system of the device (both persistent and transient part). See TimestampFunctionality for details on the timestamps.

Table 330. GetTimestamp C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_MGMT	See Instruction
P1	P1_DEFAULT	See P1
P2	P2_TIME	See P2
Lc	#(Payload)	
Le	0x14	Expecting TLV with timestamp.

Table 331. GetTimestamp R-APDU Body

Value	Description
TLV[TAG_1]	TLV containing a 12-byte operating system timestamp.

Table 332. GetTimestamp R-APDU Trailer

SW	Description
SW_NO_ERROR	Data is returned successfully.

4.20.3 GetFreeMemory

Gets the amount of free memory. MemoryType indicates the type of memory.

The result indicates the amount of free memory. Note that behavior of the function might not be fully linear and can have a granularity of 16 bytes since the applet will typically report the “worst case” amount. For example, when allocating 2 bytes at a time, the first report will show 16 bytes being allocated, which remains the same for the next 7 allocations of 2 bytes.

Table 333. GetFreeMemory C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_MGMT	See Instruction
P1	P1_DEFAULT	See P1
P2	P2_MEMORY	See P2
Lc	#(Payload)	
	TLV[TAG_1]	Memory
Le	0x06	Expecting TLV with 2-byte data.

Table 334. GetFreeMemory R-APDU Body

Value	Description
TLV[TAG_1]	2 or 4 bytes indicating the amount of free memory of the requested memory type. The number of returned bytes will be fixed per product type: SE050 and SE051 products return 2 bytes, SE052 products return 4 bytes. If 2 bytes are returned and 32768 bytes or more bytes are available, 0x7FFF is given as response.

Table 335. GetFreeMemory R-APDU Trailer

SW	Description
SW_NO_ERROR	Data is returned successfully.

4.20.4 GetRandom

Gets random data from the SE05x.

Table 336. GetRandom C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_MGMT	See Instruction
P1	P1_DEFAULT	See P1
P2	P2_RANDOM	See P2

Table 336. GetRandom C-APDU*...continued*

Field	Value	Description
Lc	#(Payload)	
	TLV[TAG_1]	2-byte requested size.
Le	0x00	Expecting random data

Table 337. GetRandom R-APDU Body

Value	Description
TLV[TAG_1]	Random data.

Table 338. GetRandom R-APDU Trailer

SW	Description
SW_NO_ERROR	Data is returned successfully.

4.20.5 DeleteAll

Delete all Secure Objects, delete all curves and Crypto Objects. Secure Objects that are trust provisioned by NXP are not deleted (i.e., all objects that have Origin set to ORIGIN_PROVISIONED, including the objects with reserved object identifiers listed in Object attributes).

This command can only be used from sessions that are authenticated using the credential with index RESERVED_ID_FACTORY_RESET.

Important: if a secure messaging session is up & running (e.g., AESKey or ECKey session) and the command is sent within this session, the response of the DeleteAll command will not be wrapped (i.e., not encrypted and no R-MAC), so this will also break down the secure channel protocol (as the session is closed by the DeleteAll command itself).

Table 339. DeleteAll C-APDU

Field	Value	Description
CLA	0x80	
INS	INS_MGMT	See Instruction
P1	P1_DEFAULT	See P1
P2	P2_DELETE_ALL	See P2
Lc	0x00	

Table 340. DeleteAll R-APDU Body

Value	Description
-	No data returned.

Table 341. DeleteAll R-APDU Trailer

SW	Description
SW_NO_ERROR	The APDU command is handled successfully.

5 APDU list summary

This section contains a list of all C-APDUs.

Table 342. APDU list

Name	CLA	INS	P1	P2	Remarks
CreateSession	0x80	0x04	0x00	0x1B	
ExchangeSessionData	0x80	0x04	0x00	0x1F	
ProcessSessionCmd	0x80	0x05	0x00	0x00	
RefreshSession	0x80	0x04	0x00	0x1E	
CloseSession	0x80	0x04	0x00	0x1C	
VerifySessionUserID	0x80	0x04	0x00	0x2C	
SCPInitializeUpdate	0x80	0x50			
SCPExternalAuthenticate	0x80	0x82			
ECKeySessionInternalAuthenticate	0x84	0x88	0x00	0x00	
SetLockState	0x80	0x04	0x00	0x3E	Protected by RESERVED_ID_TRANSPORT (if present).
DisableObjectCreation	0x80	0x04	0x00	0x57	Protected by RESERVED_ID_RESTRICT (if present).
SetPlatformSCPRequest	0x80	0x04	0x00	0x52	Protected by RESERVED_ID_PLATFORM_SCP (if present).
SetAppletFeatures	0x80	0x04	0x00	0x3F	Protected by RESERVED_ID_FEATURE (if present).
SendCardManagerCommand	0x80	0x04	0x00	0x55	
TriggerSelfTest	0x80	0x04	0x00	0x58	
ReadState	0x80	0x02	0x00	0x5B	
WriteECKey	0x80	0x01*	key type | 0x01	0x00	* can be in addition: INS_TRANSIENT (0x80), INS_AUTH_OBJECT (0x40) and INS_ATTEST (0x20).
WriteRSAKey	0x80	0x01*	key type | 0x02	0x00 (CRT) or 0x4F (raw)	* can be in addition: INS_TRANSIENT (0x80) and INS_ATTEST (0x20).
WriteSymmKey	0x80	0x01*	Type	0x00	* can be in addition: INS_TRANSIENT (0x80), INS_AUTH_OBJECT (0x40) and INS_ATTEST (0x20).
WriteBinary	0x80	0x01*	0x06	0x00	* can be in addition: INS_TRANSIENT (0x80) and INS_ATTEST (0x20).
WriteUserID	0x80	0x01*	0x07	0x00	* can be in addition: INS_TRANSIENT (0x80), INS_AUTH_OBJECT (0x40) and INS_ATTEST (0x20).

Table 342. APDU list*...continued*

Name	CLA	INS	P1	P2	Remarks
WriteCounter	0x80	0x01*	0x08	0x00	* can be in addition: INS_ TRANSIENT (0x80) and INS_ ATTEST (0x20).
WritePCR	0x80	0x01	0x09	0x00	
ImportObject	0x80	0x01	0x00	0x18	
ImportExternalObject	0x80	0x06	0x00	0x00	
ReadObject	0x80	0x02	0x00	0x00	
ReadAttributes	0x80	0x02	0x00	0x3B	
ExportObject	0x80	0x02	0x00	0x19	
ReadType	0x80	0x02	0x00	0x26	
ReadSize	0x80	0x02	0x00	0x07	
ReadIDList	0x80	0x02	0x00	0x25	
CheckObjectExists	0x80	0x04	0x00	0x27	
DeleteSecureObject	0x80	0x04	0x00	0x28	
CreateECCurve	0x80	0x01	0x0B	0x04	
SetECCurveParam	0x80	0x01	0x0B	0x40	
GetECCurveId	0x80	0x02	0x0B	0x36	
ReadECCurveList	0x80	0x02	0x0B	0x25	
DeleteECCurve	0x80	0x04	0x0B	0x28	
CreateCryptoObject	0x80	0x01	0x10	0x00	
ReadCryptoObjectList	0x80	0x02	0x10	0x25	
DeleteCryptoObject	0x80	0x04	0x10	0x28	
ECDSASign	0x80	0x03	0x0C	0x09	
EdDSASign	0x80	0x03	0x0C	0x09	
ECDSAVerify	0x80	0x03	0x0C	0x0A	
EdDSAVerify	0x80	0x03	0x0C	0x0A	
ECDHGenerateSharedSecret	0x80	0x03	0x01	0x0F or 0x59	
ECPointMultiply	0x80	0x03	0x01	0x62	
PAKEConfigDevice	0x80	0x03	0x12	0x26	
PAKEInitDevice	0x80	0x03	0x12	0x36	
PAKEInitCredentials	0x80	0x03	0x12	0x40	
PAKEComputeKeyShare	0x80	0x03	0x12	0x0C	
PAKEComputeSessionKeys	0x80	0x03	0x12	0x03	
PAKEVerifySessionKeys	0x80	0x03	0x12	0x0A	
PAKEReadDeviceType	0x80	0x02	0x12	0x00	
PAKEReadState	0x80	0x02	0x12	0x5B	

Table 342. APDU list*...continued*

Name	CLA	INS	P1	P2	Remarks
RSASign	0x80	0x03	0x0C	0x09	
RSAVerify	0x80	0x03	0x0C	0x0A	
RSAEncrypt	0x80	0x03	0x02	0x37	
RSADecrypt	0x80	0x03	0x02	0x38	
CipherInit	0x80	0x03	0x0E	0x42 or 0x43	
CipherUpdate	0x80	0x03	0x0E	0x0C	
CipherFinal	0x80	0x03	0x0E	0x0D	
CipherOneShot	0x80	0x03	0x0E	0x37 or 0x38	
AEADInit	0x80	0x03	0x11	0x42 or 0x43	
AEADUpdate	0x80	0x03	0x11	0x0C	
AEADFinal	0x80	0x03	0x11	0x0D	
AEADOneShot	0x80	0x03	0x11	0x37 or 0x38	
MACInit	0x80	0x03	0x0D	0x03	
MACUpdate	0x80	0x03	0x0D	0x0C	
MACFinal	0x80	0x03	0x0D	0x0D	
MACOneShot	0x80	0x03	0x0D	0x45/0x46	
HKDFExtractAndExpand	0x80	0x03	0x00	0x2D	
HKDFExpandOnly	0x80	0x03	0x00	0x2F	
PBKDF2	0x80	0x03	0x00	0x2E	
DFDiversifyKey	0x80	0x03	0x00	0x10	
DFAuthenticateFirstPart1	0x80	0x03	0x00	0x53	
DFAuthenticateFirstPart2	0x80	0x03	0x00	0x54	
DFAuthenticateNonFirstPart1	0x80	0x03	0x00	0x12	
DFAuthenticateNonFirstPart2	0x80	0x03	0x00	0x13	
DFDumpSessionKeys	0x80	0x03	0x00	0x14	
DFChangeKeyPart1	0x80	0x03	0x00	0x15	
DFChangeKeyPart2	0x80	0x03	0x00	0x16	
DFKillAuthentication	0x80	0x03	0x00	0x17	
TLSGenerateRandom	0x80	0x03	0x0F	0x49	
TLSCalculatePreMasterSecret	0x80	0x03	0x0F	0x4A	
TLSPerformPRF	0x80	0x03	0x0F	0x4B-0x4E or 0x5A	
I2CMExecuteCommandSet	0x80	0x03	0x00	0x30	

Table 342. APDU list*...continued*

Name	CLA	INS	P1	P2	Remarks
DigestInit	0x80	0x03	0x00	0x0B	
DigestUpdate	0x80	0x03	0x00	0x0C	
DigestFinal	0x80	0x03	0x00	0x0D	
DigestOneShot	0x80	0x03	0x00	0x0E	
GetVersion	0x80	0x04	0x00	0x20 or 0x21	
GetTimestamp	0x80	0x04	0x00	0x3D	
GetFreeMemory	0x80	0x04	0x00	0x22	
GetRandom	0x80	0x04	0x00	0x49	
DeleteAll	0x80	0x04	0x00	0x2A	

6 Policy mapping

6.1 Policy mapping tables

6.1.1 Policy mapping to symmetric key Secure Objects

The table below uses the following syntax: "v" means supported, empty cells mean not supported; A = Authentication Object; NA= Non-Authentication Object

Table 343. Policy mapping SymmKey Secure Objects

policy (starting with "POLICY_OBJ_")	Function	AESKey	DESKey	HMACKey	TLV	Description	A	NA
ALLOW_TLS_KDF	TLSPerformPRF			v	TAG_1	input key		v
ALLOW_TLS_PMS	TLSCalculatePreMasterSecret			v	TAG_1	PSK (unless ALLOW_WRITE is set).		v
ALLOW_SIGN	MACInit	v		v	TAG_1	input key		v
	MACOneShot	v	v	v	TAG_1	input key		v
ALLOW_VERIFY	MACInit	v		v	TAG_1	input key		v
	MACOneShot	v	v	v	TAG_1	input key		v
ALLOW_KA	PAKEInitCredentials	v		v	TAG_3	w0		v
		v		v	TAG_4	w1		v
ALLOW_ENC	CipherInit	v	v		TAG_1	input key		v
	CipherOneShot	v	v		TAG_1	input key		v
	AEADInit	v			TAG_1	input key		v
	AEADOneShot	v			TAG_1	input key		v
ALLOW_DEC	CipherInit	v	v		TAG_1	input key		v
	CipherOneShot	v	v		TAG_1	input key		v
	AEADInit	v			TAG_1	input key		v
	AEADOneShot	v			TAG_1	input key		v

Table 343. Policy mapping SymmKey Secure Objects...*continued*

policy (starting with "POLICY_OBJ_")	Function	AESKey	DESKey	HMACKey	TLV	Description	A	NA
ALLOW_KDF	HKDFExtractAndExpand			v	TAG_1	IKM		v
				v	TAG_6	salt (if present)		v
	HKDFExpandOnly			v	TAG_1	PRK		v
				v	TAG_6	IV (if present)		v
ALLOW_RFC3394_UNWRAP	WriteSymmKey	v			TAG_3	Key Encryption Key		v
ALLOW_READ	ReadObject	v	v	v	TAG_1	Object to read (for SymmKeys, this only works when attestation is requested and this will not return the key value)	v	v
	ReadAttributes	v	v	v	TAG_1	Object to read the attributes from	v	v
	ReadType	v	v	v	TAG_1	Object to read the type from	v	v
	ReadSize	v	v	v	TAG_1	Object to read the size from	v	v
ALLOW_WRITE	WriteSymmKey	v	v	v	TAG_1	Object to write (policy only applies when the object already exists)	v	v
	DFDiversifyKey	v			TAG_3	Key to derive into (policy only applies when the object already exists)		v
ALLOW_DELETE	DeleteSecureObject	v	v	v	TAG_1	Object to delete (only when the Secure Object does not have ORIGIN_PROVISIONED).	v	v
REQUIRE_SM	(any)	v	v	v	N.A.	Any access to the object requires secure messaging, at least C-MAC.	v	v
REQUIRE_PCR_VALUE	(any)	v	v	v	N.A.	Any access to the object requires a matching PCR value.	v	v
ALLOW_DESFIRE_AUTHENTICATION	DFAuthenticateFirstPart1	v			TAG_1	key to authenticate with		v
	DFAuthenticateNonFirstPart1	v			TAG_1	key to authenticate with		v
	DFChangeKeyPart1	v			TAG_1	old key		v
ALLOW_DESFIRE_DUMP_SESSION_KEY	DFDumpSessionKeys	v			N.A,	On the DESFire key used during authentication.		v

Table 343. Policy mapping SymmKey Secure Objects*...continued*

policy (starting with "POLICY_OBJ_")	Function	AESKey	DESKey	HMACKey	TLV	Description	A	NA
ALLOW_IMPORT_EXPORT	ExportObject	v	v	v	TAG_1	transient object to export from		v
	ImportObject	v	v	v	TAG_1	transient object to import to		v
FORBID_DERIVED_OUTPUT	PAKEInitCredentials	v		v	TAG_3	w0 object identifier		v
	PAKEInitCredentials	v		v	TAG_4	w1 object identifier		v
	PAKEInitCredentials			v	TAG_5	L object identifier		v
	CipherInit	v	v		TAG_1	input key		v
	CipherOneShot	v	v		TAG_1	input key		v
	AEADInit	v			TAG_1	input key		v
	AEADOneShot	v			TAG_1	input key		v
	MACInit	v		v	TAG_1	input key		v
	MACOneShot	v	v	v	TAG_1	input key		v
	HKDFExtractAndExpand			v	TAG_1	IKM		v
				v	TAG_6	salt		v
	HKDFExpandOnly			v	TAG_1	PRK		v
				v	TAG_6	salt		v
	PBKDF2DeriveKey			v	TAG_1	input key		v
				v	TAG_6	salt		v
	DFChangeKeyPart1	v			TAG_1	old key		v
		v			TAG_2	new key		v
	DFDumpSessionKeys	v			N.A,	On the DESFire key used during authentication.		v
	TLSPerformPRF			v	TAG_1	input key		v
ALLOW_TLS_KDF_EXT_RANDOM	TLSPerformPRF			v	TAG_1	input key		v
ALLOW_DESFIRE_CHANGEKEY	DFChangeKeyPart1	v			TAG_1	old key		v
	DFChangeKeyPart1	v			TAG_2	new key		v

Table 343. Policy mapping SymmKey Secure Objects*...continued*

policy (starting with "POLICY_OBJ_")	Function	AESKey	DESKey	HMACKe	TLV	Description	A	NA
ALLOW_DERIVED_INPUT	CreateCryptoObject			v	TAG_4	target output object		v
	ECDHGenerateSharedSecret	v		v	TAG_7	target output object		v
	DFDiversifyKey	v			TAG_2	diversified key		v
	HKDFExtractAndExpand	v		v	TAG_7	input key		v
	HKDFExpandOnly	v		v	TAG_7	input key		v
	PBKDF2DeriveKey	v		v	TAG_7	target output object		v
	TLSCalculatePreMasterSecret			v	TAG_3	target output object		v
ALLOW_PBKDF	PBKDF2DeriveKey			v	TAG_1	input key		v
ALLOW_DESFIRE_KDF	DFDiversifyKey	v			TAG_1	input key		v
FORBID_EXTERNAL_IV	CipherInit	v	v		TAG_1	input key		v
	CipherOneShot	v	v		TAG_1	input key		v
	AEADInit	v	v		TAG_1	input key		v
	AEADOneShot	v	v		TAG_1	input key		v
ALLOW_USAGE_AS_ HMAC_PEPPER	HKDFExtractAndExpand			v	TAG_6	salt (if present) and no target output object given.		v
	HKDFExpandOnly			v	TAG_6	salt (if present) and no target output object given.		v
	PBKDF2DeriveKey			v	TAG_6	salt		v

6.1.2 Policy mapping to RSAKey Secure Objects

The table below uses the following syntax: "v" means supported, empty cells mean not supported; A = Authentication Object; NA= Non-Authentication Object

Table 344. Policy mapping RSAKey Secure Objects

policy (starting with "POLICY_OBJ_")	Function	key pair	public	private	TLV	Description	A	NA
ALLOW_SIGN	RSASign	v		v	TAG_1	key to sign		v
ALLOW_VERIFY	RSAVerify	v	v		TAG_1	key to verify		v
ALLOW_KA	TLSCalculatePreMasterSecret	v			TAG_2	key pair to be used.		v

Table 344. Policy mapping RSAKey Secure Objects*...continued*

policy (starting with "POLICY_OBJ_")	Function	key pair	public	private	TLV	Description	A	NA
ALLOW_ENC	RSAEncrypt	v	v		TAG_1	key to encrypt		v
ALLOW_DEC	RSADecrypt	v		v	TAG_1	key to decrypt		v
ALLOW_READ	ReadObject	v	v	v	TAG_1	key to read (will only return public key)	v	v
	ReadAttributes	v	v	v	TAG_1	Object to read the attributes from	v	v
	ReadType	v	v	v	TAG_1	Object to read the type from	v	v
	ReadSize	v	v	v	TAG_1	Object to read the size from	v	v
ALLOW_WRITE	WriteRSAKey	v	v	v	TAG_1	key to write	v	v
ALLOW_GEN	WriteRSAKey	v			TAG_1	key pair to generate		v
ALLOW_DELETE	DeleteSecureObject	v	v	v	TAG_1	Object to delete (only when the Secure Object does not have ORIGIN_PROVISIONED).	v	v
REQUIRE_SM	(any)	v	v	v	N.A.	Any access to the object requires secure messaging, at least C-MAC.	v	v
REQUIRE_PCR_VALUE	(any)	v	v	v	N.A.	Any access to the object requires a matching PCR value.	v	v
ALLOW_ATTESTATION	ReadObject	v		v	TAG_5	attestating key		v
	I2CMExecuteCommandSet	v		v	TAG_3	attestating key		v
	TriggerSelfTest	v		v	TAG_6	attestating key		v
ALLOW_IMPORT_EXPORT	ExportObject	v	v	v	TAG_1	transient object to export from		v
	ImportObject	v	v	v	TAG_1	transient object to import to		v
FORBID_DERIVED_OUTPUT	RSASign	v		v	TAG_1	key to sign		v
	RSAEncrypt	v	v		TAG_1	key to encrypt		v
	RSADecrypt	v		v	TAG_1	key to decrypt		v
ALLOW_DERIVED_INPUT	-							
FORBID_EXTERNAL_INPUT_SIGN	RSASign	v		v	TAG_1	key to sign		v

6.1.3 Policy mapping to ECKey Secure Objects

The table below uses the following syntax: "v" means supported, empty cells mean not supported; A = Authentication Object; NA= Non-Authentication Object

Table 345. Policy mapping ECKey Secure Objects

policy (starting with "POLICY_OBJ_")	Function	EC Keypair	EC public key	EC private key	TLV	Description	A	NA
ALLOW_SIGN	ECDSASign	v		v	TAG_1	private key		v
	EdDSASign	v		v	TAG_1	private key		v
ALLOW_VERIFY	ECDSAVerify	v	v		TAG_1	public key		v
	EdDSAVerify	v	v		TAG_1	public key		v
ALLOW_KA	ECDHGenerateSharedSecret	v		v	TAG_1	input key object		v
	ECPointMultiply	v		v	TAG_1	input key object		v
	TLSCalculatePreMasterSecret	v			TAG_2	key pair in PSK_ECDHE or ECDHE.		v
	PAKEInitCredentials		v		TAG_5	L		v
ALLOW_ENC	-							
ALLOW_DEC	-							
ALLOW_READ	ReadObject	v	v	v	TAG_1	key to read (this will only return the public key value).	v	v
	ReadAttributes	v	v	v	TAG_1	Object to read the attributes from	v	v
	ReadType	v	v	v	TAG_1	Object to read the type from	v	v
	ReadSize	v	v	v	TAG_1	Object to read the size from	v	v
ALLOW_WRITE	WriteECKey	v	v	v	TAG_1	key to write	v	v
ALLOW_GEN	WriteECKey	v		v	TAG_1	key pair or private key to generate		v
ALLOW_DELETE	DeleteSecureObject	v	v	v	TAG_1	Object to delete (only when the Secure Object does not have ORIGIN_ PROVISIONED).	v	v
REQUIRE_SM	(any)	v	v	v	N.A.	Any access to the object requires secure messaging, at least C-MAC.	v	v
REQUIRE_PCR_VALUE	(any)	v	v	v	N.A.	Any access to the object requires a matching PCR value.	v	v

Table 345. Policy mapping ECKey Secure Objects*...continued*

policy (starting with "POLICY_OBJ_")	Function	EC Keypair	EC public key	EC private key	TLV	Description	A	NA
ALLOW_ATTESTATION	ReadObject	v		v	TAG_5	attestating key		v
	I2CMExecuteCommandSet	v		v	TAG_3	attestating key		v
	TriggerSelfTest	v		v	TAG_6	attestating key		v
ALLOW_IMPORT_EXPORT	ExportObject	v	v	v	TAG_1	transient object to export from		v
	ImportObject	v	v	v	TAG_1	transient object to import to		v
FORBID_DERIVED_OUTPUT	ECDSASign	v		v	TAG_1	input key object		v
	EdDSASign	v		v	TAG_1	input key object		v
	ECDHGenerateSharedSecret	v		v	TAG_1	input key object		v
	ECPointMultiply	v		v	TAG_1	input key object		v
ALLOW_DERIVED_INPUT	ECPointMultiply		v		TAG_7	target output object		v
FORBID_EXTERNAL_INPUT_SIGN	ECDSASign	v		v	TAG_1	key to sign		v

6.1.4 Policy mapping to File Secure Objects

The table below uses the following syntax: "v" means supported, empty cells mean not supported; A = Authentication Object; NA= Non-Authentication Object

Table 346. Policy mapping

policy (starting with "POLICY_OBJ_")	Function	Binary file	UserID	Counter	PCR	TLV	Description	A	NA
ALLOW_SIGN	-								
ALLOW_VERIFY	-								
ALLOW_KA	-								
ALLOW_ENC	-								
ALLOW_DEC	-								
ALLOW_RFC3394_UNWRAP	-								

Table 346. Policy mapping*...continued*

policy (starting with "POLICY_OBJ_")	Function	Binary file	UserID	Counter	PCR	TLV	Description	A	NA
ALLOW_READ	ReadObject	v	v	v	v	TAG_1	Object to read.	v	v
	ReadAttributes	v	v	v	v	TAG_1	Object to read the attributes from	v	v
	ReadType	v	v	v	v	TAG_1	Object to read the type from	v	v
	ReadSize	v	v	v	v	TAG_1	Object to read the size from	v	v
ALLOW_WRITE	WriteBinary	v				TAG_1	BinaryFile to be updated		v
	WriteCounter			v		TAG_1	Counter to be updated.		v
	WritePCR				v	TAG_1	PCR to be updated.		v
ALLOW_DELETE	DeleteSecureObject	v	v	v	v	TAG_1	Object to be deleted.	v	v
	WritePCR				v	TAG_1	PCR to be reset		v
REQUIRE_SM	(any)	v	v	v	v	N.A.	Any access to the object requires secure messaging, at least C-MAC.	v	v
REQUIRE_PCR_VALUE	(any)	v		v	v	N.A.	Any access to the object requires a matching PCR value.	v	v
ALLOW_ATTESTATION	-								
ALLOW_DESFIRE_AUTHENTICATION	-								
ALLOW_DESFIRE_DUMP_SESSION_KEY	-								
ALLOW_IMPORT_EXPORT	-						transient object to export from		v
	-						transient object to import to		v
FORBID_DERIVED_OUTPUT	-								
ALLOW_DESFIRE_CHANGEKEY	-								
ALLOW_DERIVED_INPUT	-								

7 Edwards curve byte order

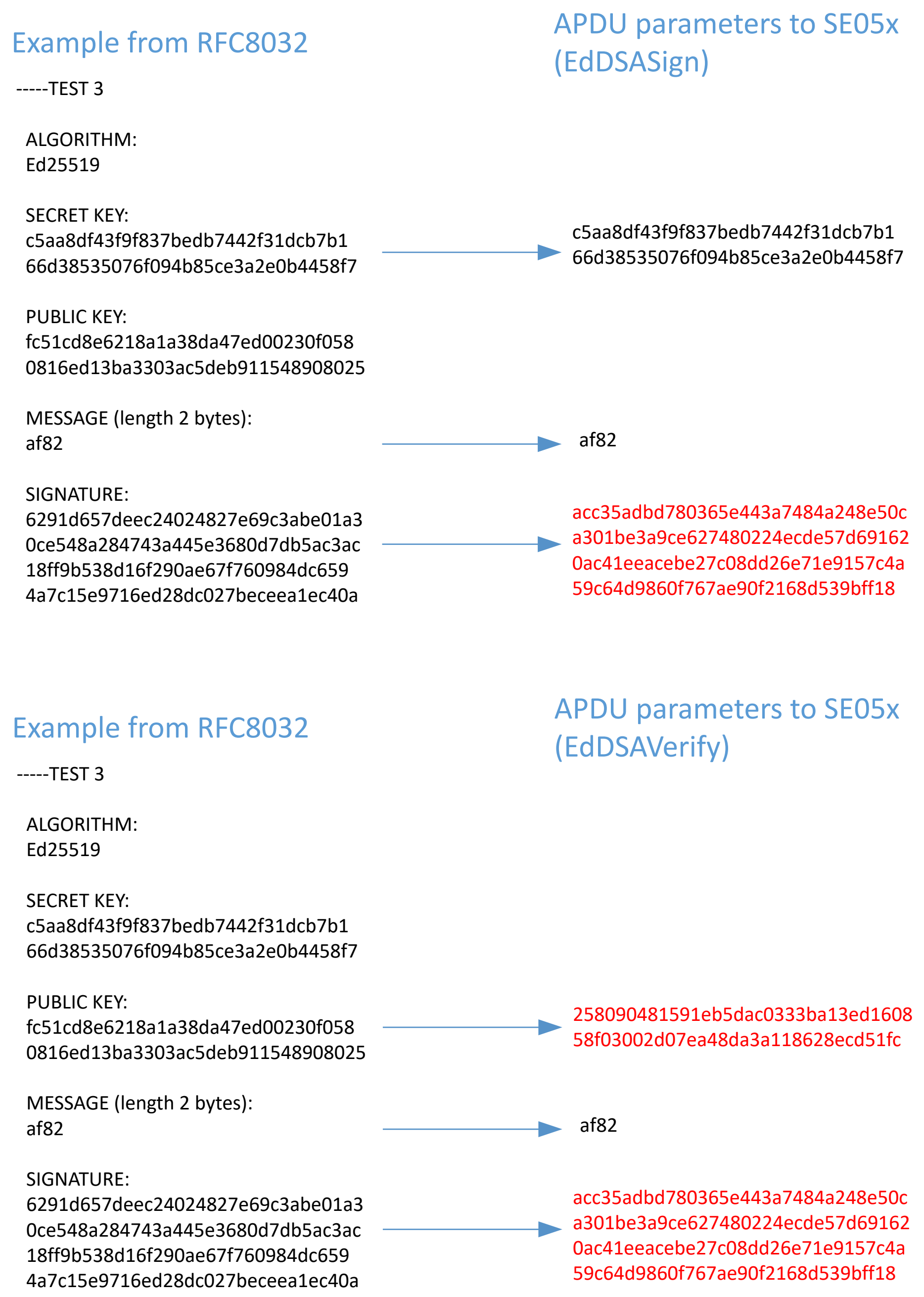
For keys and key operations using Edwards curve Curve25519 or Curve448, the byte order needs attention as the SE05x uses big endian byte order for most of the parameters on these curves while the standards (RFC8032 and RFC7748) use little endian notation for all parameters.

This applies to WriteECKey (using curve ID_ECC_ED_25519) and will impact:

- EdDSASign/EdDSAVerify (using curve ID_ECC_ED_25519)
- ECDHGenerateSharedSecret (using curve ID_ECC_MONT_DH_25519 or ID_ECC_MONT_DH_448)

7.1 EdDSA

See Figure 22 for the correct byte order: for the public key and the signature components r and s, the byte order needs to be reversed.



Example from RFC8032

-----TEST 3

ALGORITHM:
Ed25519

SECRET KEY:
c5aa8df43f9f837bedb7442f31dcb7b1
66d38535076f094b85ce3a2e0b4458f7

PUBLIC KEY:
fc51cd8e6218a1a38da47ed00230f058
0816ed13ba3303ac5deb911548908025

MESSAGE (length 2 bytes):
af82

SIGNATURE:
6291d657deec24024827e69c3abe01a3
0ce548a284743a445e3680d7db5ac3ac
18ff9b538d16f290ae67f760984dc659
4a7c15e9716ed28dc027beceea1ec40a

APDU parameters to SE05x (EdDSASign)

c5aa8df43f9f837bedb7442f31dcb7b1
66d38535076f094b85ce3a2e0b4458f7

af82

acc35adbd780365e443a7484a248e50c
a301be3a9ce627480224ecde57d69162
0ac41eeacebe27c08dd26e71e9157c4a
59c64d9860f767ae90f2168d539bff18

Example from RFC8032

-----TEST 3

ALGORITHM:
Ed25519

SECRET KEY:
c5aa8df43f9f837bedb7442f31dcb7b1
66d38535076f094b85ce3a2e0b4458f7

PUBLIC KEY:
fc51cd8e6218a1a38da47ed00230f058
0816ed13ba3303ac5deb911548908025

MESSAGE (length 2 bytes):
af82

SIGNATURE:
6291d657deec24024827e69c3abe01a3
0ce548a284743a445e3680d7db5ac3ac
18ff9b538d16f290ae67f760984dc659
4a7c15e9716ed28dc027beceea1ec40a

APDU parameters to SE05x (EdDSAVerify)

258090481591eb5dac0333ba13ed1608
58f03002d07ea48da3a118628ecd51fc

af82

acc35adbd780365e443a7484a248e50c
a301be3a9ce627480224ecde57d69162
0ac41eeacebe27c08dd26e71e9157c4a
59c64d9860f767ae90f2168d539bff18

Figure 22. Byte order for Edwards curve sign and verify operation

7.2 ECDHGenerateSharedSecret

See Figure 23 for the correct byte order: for the private key and the shared secret, the byte order needs to be reversed.

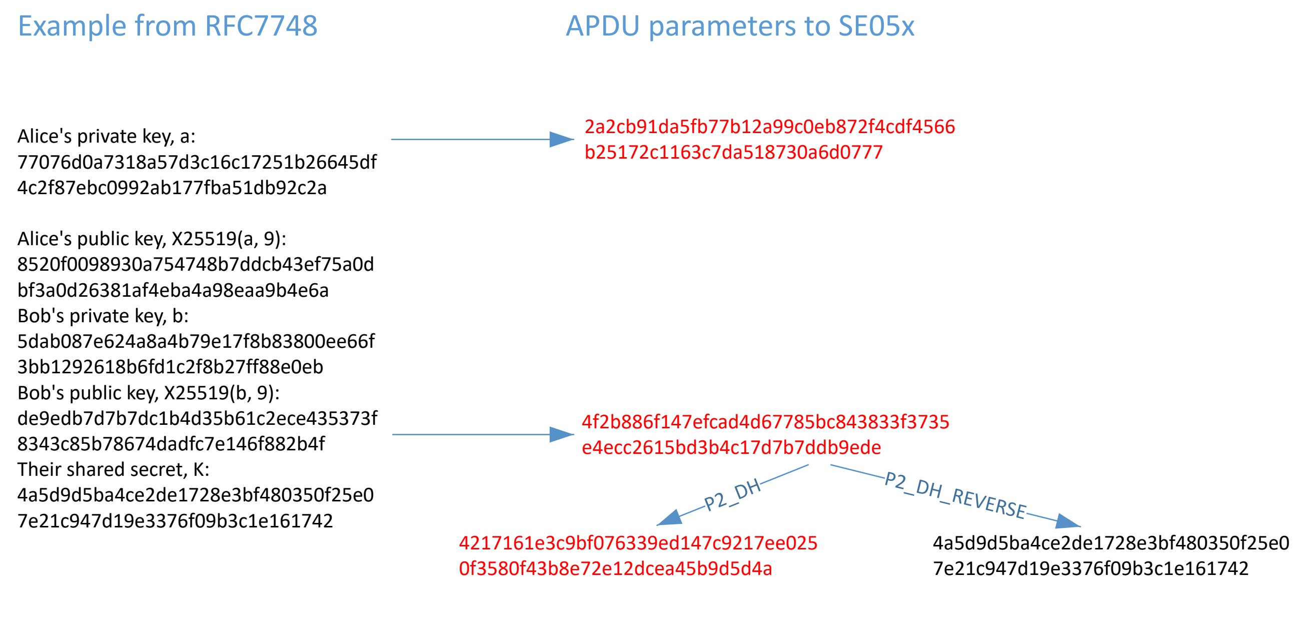

Example from RFC7748
APDU parameters to SE05x
Alice's private key, a:
77076d0a7318a57d3c16c17251b26645df
4c2f87ebc0992ab177fba51db92c2a
2a2cb91da5fb77b12a99c0eb872f4cdf4566
b25172c1163c7da518730a6d0777
Alice's public key, X25519(a, 9):
8520f0098930a754748b7ddcb43ef75a0d
bf3a0d26381af4eba4a98eaa9b4e6a
Bob's private key, b:
5dab087e624a8a4b79e17f8b83800ee66f
3bb1292618b6fd1c2f8b27ff88e0eb
Bob's public key, X25519(b, 9):
de9edb7d7b7dc1b4d35b61c2ece435373f
8343c85b78674dadfc7e146f882b4f
4f2b886f147efcad4d67785bc843833f3735
e4ecc2615bd3b4c17d7b7ddb9ede
Their shared secret, K:
4a5d9d5ba4ce2de1728e3bf480350f25e0
7e21c947d19e3376f09b3c1e161742
P2_DH
P2_DH_REVERSE
4217161e3c9bf076339ed147c9217ee025
0f3580f43b8e72e12dcea45b9d5d4a
4a5d9d5ba4ce2de1728e3bf480350f25e0
7e21c947d19e3376f09b3c1e161742

Figure 23. Byte order for Edwards Montgomery curve shared secret operation

8 Applet upgrade support

The SE05x IoT applet supports GlobalPlatform Amendment H.

Applet upgrades can be triggered using Amendment H API. The original applet will save its state (all persistently stored data: any applet state, Secure Objects, Crypto objects and ECCurves + the import/export keys) when a MANAGE_ELF_UPGRADE(start) command is sent and the new applet will restore the state when a MANAGE_ELF_UPGRADE(restore) command is sent.

There are no specific APDUs involved in the upgrade process itself while a certain applet revision will be described by a matching APDU specification (as the APDU interface might change during an upgrade).

9 Example sequences

9.1 AES GCM/GMAC

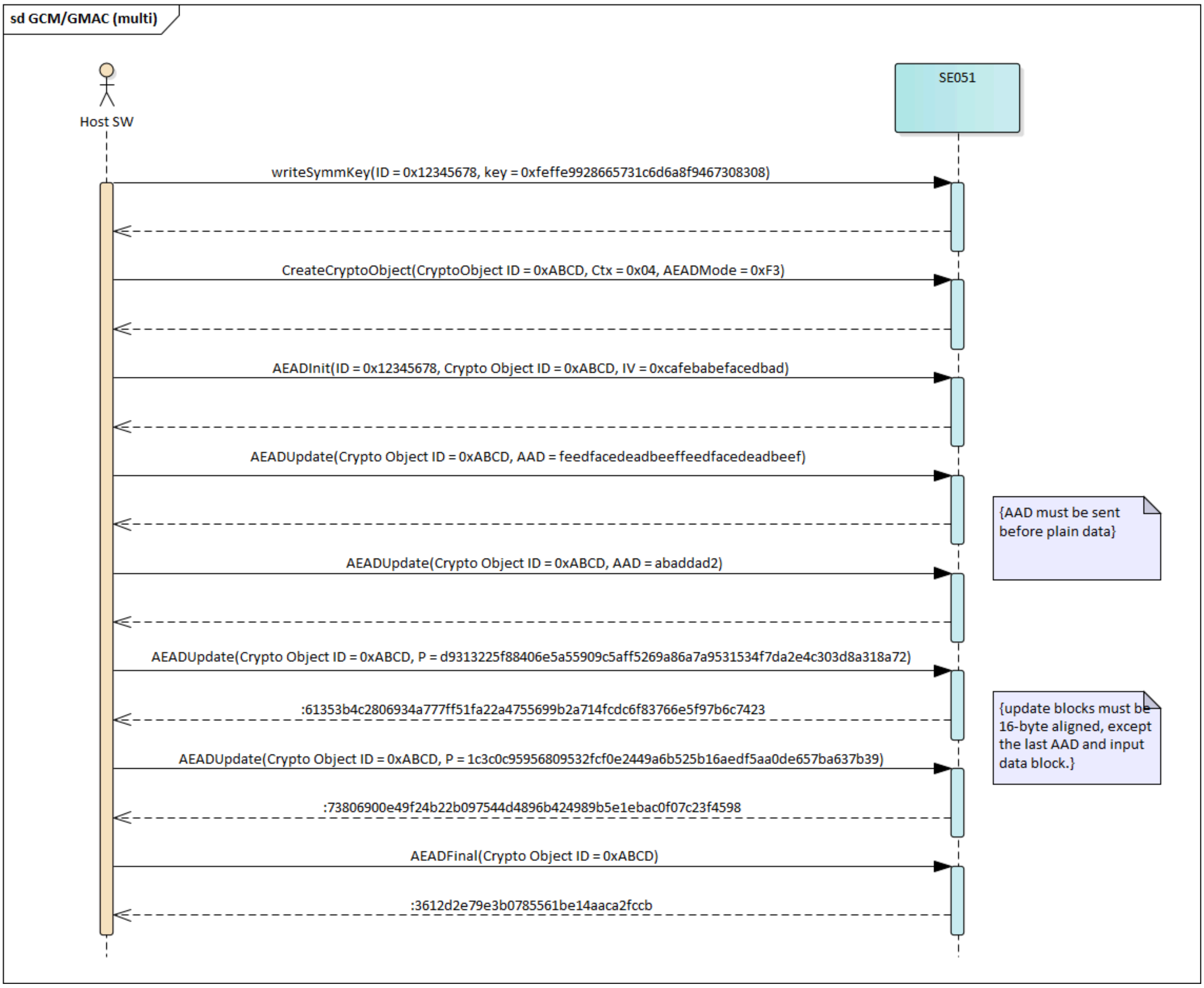

sd GCM/GMAC (multi)
Host SW
SE051
writeSymmKey(ID = 0x12345678, key = 0xfeffe9928665731c6d6a8f9467308308)
CreateCryptoObject(CryptoObject ID = 0xABCD, Ctx = 0x04, AEADMode = 0xF3)
AEADInit(ID = 0x12345678, Crypto Object ID = 0xABCD, IV = 0xcafebabefacedbad)
AEADUpdate(Crypto Object ID = 0xABCD, AAD = feedfacedeadbeeffeedfacedeadbeef)
{AAD must be sent before plain data}
AEADUpdate(Crypto Object ID = 0xABCD, AAD = abaddad2)
AEADUpdate(Crypto Object ID = 0xABCD, P = d9313225f88406e5a55909c5aff5269a86a7a9531534f7da2e4c303d8a318a72)
:61353b4c2806934a777ff51fa22a4755699b2a714fcdc6f83766e5f97b6c7423
{update blocks must be 16-byte aligned, except the last AAD and input data block.}
AEADUpdate(Crypto Object ID = 0xABCD, P = 1c3c0c95956809532fcf0e2449a6b525b16aedf5aa0de657ba637b39)
:73806900e49f24b22b097544d4896b424989b5e1ebac0f07c23f4598
AEADFinal(Crypto Object ID = 0xABCD)
:3612d2e79e3b0785561be14aaca2fccb

Figure 24. Example GCM operation in multiple steps (P2_ENCRYPT)

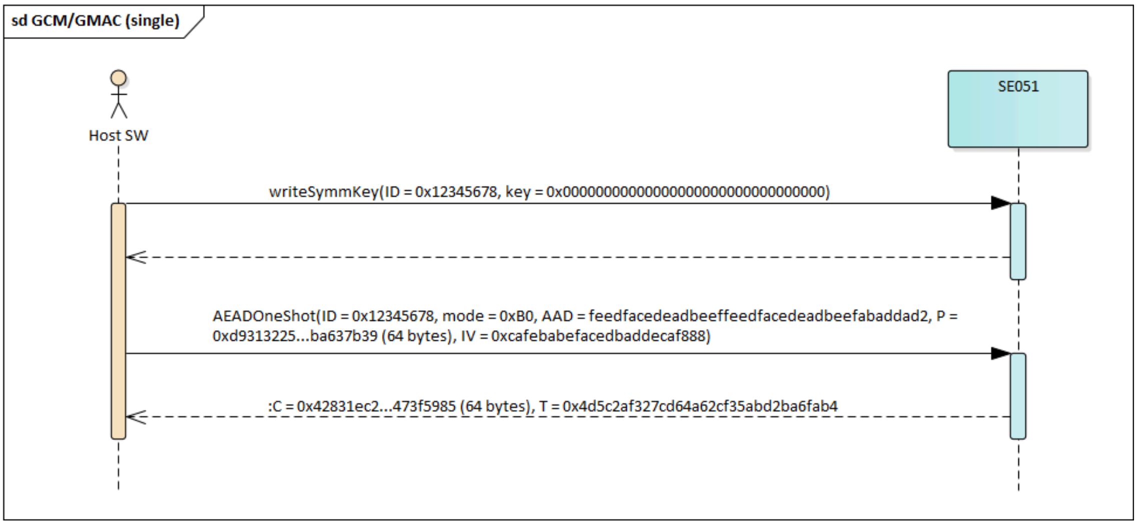

sd GCM/GMAC (single)
Host SW
SE051
writeSymmKey(ID = 0x12345678, key = 0x00000000000000000000000000000000)
AEADOneShot(ID = 0x12345678, mode = 0xB0, AAD = feedfacedeadbeeffeedfacedeadbeefabaddad2, P = 0xd9313225...ba637b39 (64 bytes), IV = 0xcafebabefacedbaddecaf888)
:C = 0x42831ec2...473f5985 (64 bytes), T = 0x4d5c2af327cd64a62cf35abd2ba6fab4

Figure 25. Example GCM operation in one shot mode (P2_ENCRYPT)

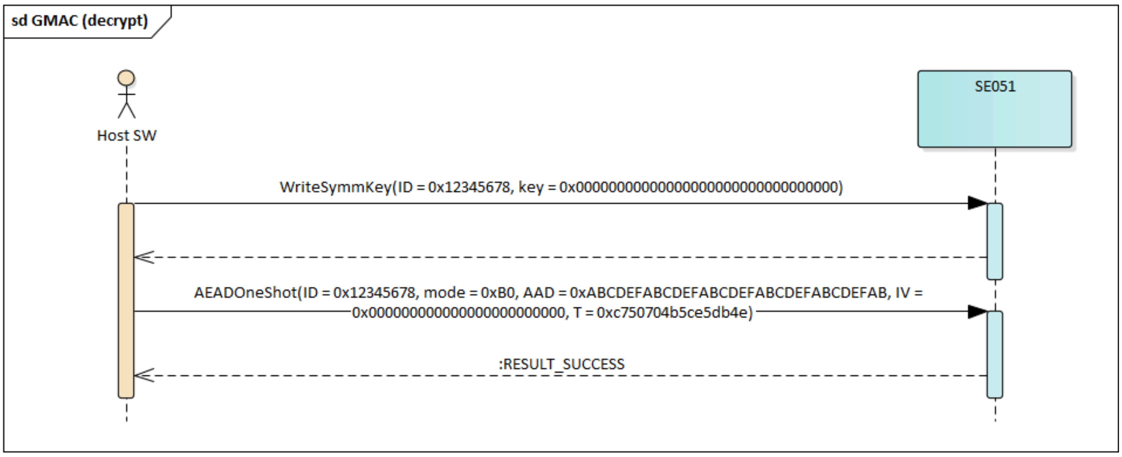

sd GMAC (decrypt)
Host SW
SE051
WriteSymmKey(ID = 0x12345678, key = 0x00000000000000000000000000000000)
AEADOneShot(ID = 0x12345678, mode = 0xB0, AAD = 0xABCDEFABCDEFABCDEFABCDEFABCDEFAB, IV = 0x000000000000000000000000, T = 0xc750704b5ce5db4e)
:RESULT_SUCCESS

Figure 26. Example GMAC operation in multiple steps (P2_DECRYPT)

10 Memory consumption

10.1 Secure Objects

Note that the values listed in the table are indicative only: they apply to regular Secure Objects (not authentication objects) with a default policy. For EC key objects, the memory for creating the curve needs to be incorporated once (when the curve is created).

Table 347. Secure Object memory ECKey

Object Type (#bytes NVM/RAM)	Persistent key pair [bytes]	Transient key pair [bytes]	Persistent private key [bytes]	Transient private key [bytes]	Persistent public key [bytes]	Transient public key [bytes]
EC NIST P192 [curve: 252/0]	320/0	208/96	320/0	208/96	204/0	140/64
EC NIST P224 [curve: 276/0]	328/0	208/112	328/0	208/112	212/0	140/80
EC NIST P256 [curve: 260/0]	352/0	208/128	352/0	208/128	220/0	140/80
EC NIST P384 [curve: 396/0]	400/0	208/176	400/0	208/176	252/0	140/112
EC NIST P521 [curve: 504/0]	452/0	208/240	452/0	208/240	288/0	140/144
EC Brainpool160_R1 [curve: 228/0]	312/0	208/96	312/0	208/96	196/0	140/64
EC Brainpool192_R1 [curve: 252/0]	320/0	208/96	320/0	208/96	204/0	140/64
EC Brainpool224_R1 [curve: 276/0]	328/0	208/112	328/0	208/112	212/0	140/80
EC Brainpool256_R1 [curve: 300/0]	352/0	208/128	352/0	208/128	220/0	140/80
EC Brainpool320_R1 [curve: 348/0]	368/0	208/144	368/0	208/144	236/0	140/96
EC Brainpool384_R1 [curve: 396/0]	400/0	208/176	400/0	208/176	252/0	140/112
EC Brainpool512_R1 [curve: 492/0]	448/0	208/224	448/0	208/224	284/0	140/144
EC SEC_P160_K1 [curve: 228/0]	312/0	208/96	312/0	208/96	196/0	140/64
EC SEC_P192_K1 [curve: 252/0]	320/0	208/96	320/0	208/96	204/0	140/64
EC SEC_P224_K1 [curve: 276/0]	328/0	208//112	328/0	208/112	212/0	140/80
EC SEC_P256_K1 [curve: 300/0]	352/0	208/128	352/0	208/128	220/0	140/80
ED_25519 [curve: 0/0]	308/0	184/112	308/0	184/112	308/0	184/112
MONT_DH_25519 [curve: 0/0]	276/0	184/80	276/0	184/80	276/0	184/96

Table 347. Secure Object memory ECKey*...continued*

Object Type (#bytes NVM/RAM)	Persistent key pair [bytes]	Transient key pair [bytes]	Persistent private key [bytes]	Transient private key [bytes]	Persistent public key [bytes]	Transient public key [bytes]
MONT_DH_448 [curve: 0/0]	300/0	184/104	300/0	184/104	300/0	184/120

Table 348. Secure Object memory RSAKey

Object Type (#bytes NVM/RAM)	Persistent key pair [bytes]	Transient key pair [bytes]	Persistent private key [bytes]	Transient private key [bytes]	Persistent public key [bytes]	Transient public key [bytes]
RSA512 raw	412/0	196/240	264/0	132/160	204/0	132/96
RSA512 CRT	536/0	200/368	388/0	136/272	204/0	132/96
RSA1024 raw	604/0	196/432	400/0	140/288	276/0	140/176
RSA1024 CRT	760/0	212/592	556/0	144/448	Not applicable	Not applicable
RSA1152 raw	664/0	208/496	432/0	140/320	292/0	140/192
RSA1152 CRT	788/0	212/608	556/0	144/448	Not applicable	Not applicable
RSA2048 raw	1000/0	208/832	656/0	140/544	404/0	140/304
RSA2048 CRT	1220/0	212/1040	876/0	144/768	Not applicable	Not applicable
RSA3072 raw	1384/0	Not applicable	912/0	Not applicable	532/0	140/432
RSA3072 CRT	1668/0	Not applicable	1196/0	Not applicable	Not applicable	Not applicable
RSA4096 raw	1768/0	Not applicable	1186/0	Not applicable	660/0	Not applicable
RSA4096 CRT	2116/0	Not applicable	1516/0	Not applicable	Not applciable	Not applicable

Table 349. Secure Object memory SymmKey

Object Type	Persistent key [bytes]	Transient key [bytes]
AESKey	NVM: 136 + key size in bytes RAM: 0	NVM: 116 RAM: 16 + key size in bytes
DESKey	NVM: 160 + key size in bytes RAM: 0	NVM: 136 RAM: 32 + key size in bytes
HMACKey	NVM: 140 + key size in bytes RAM: 0	NVM: 120 RAM: 16 + key size in bytes

Table 350. Secure Object memory File objects

Object Type	Persistent object [bytes]	Transient object [bytes]
BinaryFile	NVM: 96 + file size in bytes RAM: 0	NVM: 92 RAM: file size in bytes
Counter	NVM: 96 + counter size in bytes RAM: 0	NVM: 92 RAM: 16
PCR	NVM: 180 RAM: 0	NVM: 144 RAM: 32
UserID	NVM: 112 RAM: 0	Not Applicable

10.2 Crypto Objects

Table 351. Crypto Object memory

Object Type	Object sub-type	NVM memory [bytes]	transient memory [bytes]
Digest	DIGEST_SHA	108	112
Digest	DIGEST_SHA224	108	112
Digest	DIGEST_SHA256	108	128
Digest	DIGEST_SHA384	108	224
Digest	DIGEST_SHA512	108	224
Cipher	DES_CBC_NOPAD	116	32
Cipher	DES_CBC_ISO9797_M1	116	32
Cipher	DES_CBC_ISO9797_M2	116	32
Cipher	DES_CBC_PKCS5	116	16
Cipher	DES_ECB_NOPAD	116	16
Cipher	DES_ECB_ISO9797_M1	116	16
Cipher	DES_ECB_ISO9797_M2	116	16
Cipher	DES_ECB_PKCS5	116	0
Cipher	AES_ECB_NOPAD	116	32
Cipher	AES_CBC_NOPAD	116	48
Cipher	AES_CBC_ISO9797_M1	116	48
Cipher	AES_CBC_ISO9797_M2	116	48
Cipher	AES_CBC_PKCS5	116	32
Cipher	AES_CTR	116	48
Signature	HMAC_SHA1	112	240
Signature	HMAC_SHA256	112	288
Signature	HMAC_SHA384	112	560
Signature	HMAC_SHA512	112	560
Signature	CMAC_128	116	48
AEAD	AES_GCM	124	96

Table 351. Crypto Object memory*...continued*

Object Type	Object sub-type	NVM memory [bytes]	transient memory [bytes]
AEAD	AES_CCM	280	160
PAKE	SPAKE2PLUS_P256_SHA256_HKDF_HMAC_v02	420*	848*
PAKE	SPAKE2PLUS_P256_SHA256_HKDF_HMAC	420*	896*
PAKE	SPAKE2PLUS_P256_SHA512_HKDF_HMAC	420*	1104*
PAKE	SPAKE2PLUS_P384_SHA256_HKDF_HMAC	420*	1184*
PAKE	SPAKE2PLUS_P384_SHA512_HKDF_HMAC	452*	1392*
PAKE	SPAKE2PLUS_P521_SHA512_HKDF_HMAC	488*	1712*
PAKE	SPAKE2PLUS_P256_SHA256_HKDF_CMAC	416*	848*
PAKE	SPAKE2PLUS_P256_SHA512_HKDF_CMAC	416*	960*

Note: ** The values for the PAKE Crypto Objects can differ from the specified values. Users are advised to check the memory consumption figures on the product variant in use.*

11 Abbreviations

AEAD	Authenticated Encryption with Associated Data
AES	Advanced Encryption Standard
API	Application Programming Interface
APDU	Application Protocol Data Unit
CCM	Counter with CBC-MAC
CLA	Class
DES	Data Encryption Standard
EC	Elliptic Curve
ECC	Elliptic Curve Cryptography
ECDH	Elliptic Curve Diffie Hellman
ECKA	Elliptic Curve Key Agreement
FIPS	Federal Information Processing Standard
GCM	Galois Counter Mode
GMAC	Galois Counter Mode Message Authentication Code
HKDF	HMAC-based Key Derivation Function
I2C	Inter-Integrated Circuit
INS	Instruction
IoT	Internet of Things
KDF	Key Derivation Function
KDH	Symmetric Key Based On A Diffe-Hellman Operation
MAC	Message Authentication Code
PAKE	Password Authenticated Key Exchange
PBKDF	Password Based Key Derivation Function
PCR	Platform Configuration Register
PICC	Proximity IntegratedCircuit Card
PRF	Pseudo Random Function
PSK	Pre Shared Key
Rev	Revision
RSA	Rivest Shamir Adleman
SCP	Secure Channel Protocol
SSD	Supplementary Security Domain
TLS	Transport Layer Security
TLV	Tag Length Value
UGM	User Guidance Manual

12 References

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[2] **[SCP03]** — GlobalPlatform Card Technology
Secure Channel Protocol 03
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[3] **[IEEE-P1363]** — 1363-2000 - IEEE Standard Specification for Public-Key Cryptography
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29 Aug. 2000
https://ieeexplore.ieee.org/document/891000

[4] **[RFC3394]** — Advanced Encryption Standard (AES) Key Wrap Algorithm
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September 2002
https://tools.ietf.org/html/rfc3394

[5] **[AN10922]** — Symmetric Key Diversifications
NXP Semiconductors
https://www.nxp.com/docs/en/application-note/AN10922.pdf

[6] **[SPAKE2+v02]** — SPAKE2+, an Augmented PAKE
Network Working Group
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[8] **[SE050F]** — SE050 - APDU specification
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[9] **[UserGuidelines]** *Reference depends on the used variant.*

— SE051 - User Guidelines
NXP Semiconductors
Document number: AN12730
https://www.docstore.nxp.com

— SE051W - User Guidelines
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Document number: AN13484
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NXP Semiconductors
Document number: AN13483
https://www.docstore.nxp.com

— SE050F - User Guidelines
NXP Semiconductors
Document number: AN13482

https://www.docstore.nxp.com

— SE052F - User Guidelines
NXP Semiconductors
Document number: AN13904
https://www.docstore.nxp.com

Revision history

Revision history

Rev	Date	Description
AN12543 v.4.5	27 March 2024	• Renamed ALLOW_HKDF policy to ALLOW_KDF. • Modified GetFreeMemory R-APDU description to cover platforms with 4 bytes response data. • Updated FIPS 140-3 section indicating unsupported features. • Updated Le values and descriptions where missing. • Updated the description of ExportObject R-APDU Body table. • Updated the description of TLV[TAG4] in RSASign C-APDU and RSAVerify C-APDU. • Added note to FIPS 140-3 section on memory consumption and triggering manual garbage collection for non-supported secure object creation.
4.4	29 November 2023	• Added FIPS 140-3 section and additional RESERVED_ID secure objects. • Added note to FIPS 140-3 section on enabling specific algorithms in FIPS 140-3 mode of operation. • Updated description of B5b8 in the extended feature bits. • Updated and corrected APDU list summary. • Added RESERVED_ID_SELFTEST_INFO. • Added note for TLV[TAG_6] in HKDFExtractAndExpand.
4.3	2023-01-02	• Removed applet version from SE05x architecture section. • Modified description for salt length in HKDFExtractAndExpand and HKDFExpand Only. • Added note for unsupported combinations in Crypto Operations RSA. • Added size limits for internal signature generation input. • Added Condition for PAKEComputeSessionKeys output. • Renamed POLICY_OBJ_ALLOW_INTERNAL_SIGNATURE to POLICY_OBJ_FORBID_EXTERNAL_INPUT_SIGN and added more information. • Allow files to be absent as input to internal signature generation. • Added note on validation of results for ECPointMultiply using Montgomery curves and EC_PACE_GM as algorithm. • Added note on flash writes for CreateCryptoObject and DeleteCryptoObject. • Updated description of TLV[TAG_5] for AEADInit to reflect also the nonce length for AES_CCM.
4.2	2022-08-22	• Target object for CreateCryptoObject added. • Added policies for PAKEInitCredentials. • Updated memory tables for PAKE Crypto Objects. • Updated SPAKE state machine. • Added extended feature bits for PAKE cipher suites. • Add 0 as valid MACAlgo for PBKDFDeriveKey (defaulting to HMAC_SHA1). • Removed ECDAA functionality. • Added notes on NVM access for HKDF and PAKE commands.
4.1	2022-03-28	• Updated PAKE APDU descriptions. • Updated internal signature generation description. • Added reference to SPAKE2+; updated UGM references
4.0	2022-02-15	• Made specification product agnostic. • Fixed typos. • Removed TYPE_EC_CURVE from SecureObjectType. • Added note on deletion of transient Secure Objects in Users.

Revision history*...continued*

Rev	Date	Description
		• Added additional functions to policy mapping tables that use POLICY_OBJ_ALLOW_READ. • Removed EXTCFG_CRYPTO_AEAD_GCM_SELF_TEST from extended feature bitmap. • Added CC_PAKE to CryptoContext and to CreateCryptoObject. • Added Internal signature generation and POLICY_OBJ_INTERNAL_SIGN. • Added P1_PAKE to P1 constants. • Enabled additional PAKEMode constants and updated Crypto Object memory table • Added minimum policy for PAKE operations.
3.0	2021-10-29	Updated for applet 7.2.0
2.1	2021-03-24	Clarifications and minor fixes to version 2.0
2.0	2020-10-26	Prepared for release: corrected command & feature descriptions for applet version 6.0.0.
1.0	2019-12-18	Initial version

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