



Cryptnox Hardware Wallet — API Reference

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Contents

1	Introduction	2
1.1	Security model	2
1.2	Supported algorithms and curves	3
2	Technical specifications	5
2.1	Cryptographic capabilities	5
2.2	Communication protocols	6
2.3	Secure element features	7
2.4	Hardware and JavaCard platform	9
3	Lifecycle management	10
3.1	Card startup	10
3.2	Initialization	10
3.3	Pairing	11
3.4	Reset	11
4	Secure channel	13
4.1	Opening a secure channel	13
4.2	Mutual authentication	13
4.3	Encrypted APDUs	14
5	Authentication	16
5.1	PIN authentication	16
5.2	User key authentication	16
5.3	Disabling PIN auth	18
6	Seed management	19
6.1	Generation	19
6.2	Recovery	20
6.3	Key hierarchies	20
6.4	Key source types	21
7	Key derivation	22
7.1	Triple curve support	22
7.2	Derivation sources	22
7.3	Parent key caching	23
7.4	Performance considerations	23
8	EC signature	24
8.1	Signature types	24
8.2	Key selection	24
8.3	Ephemeral nonce	25
8.4	ECDSA output format	25
8.5	BIP340 Schnorr output format	25
8.6	EdDSA output format	25
8.7	Pinless signing	26
8.8	PIN and auth reset after signing	26

9	Command overview	27
9.1	Application & info	27
9.2	Initialization	27
9.3	User authentication	28
9.4	Key management	28
9.5	Signing & decryption	29
9.6	MuSig2 (BIP-327)	29
9.7	Data & history	29
9.8	Administration	30
10	Setup & channel commands	31
10.1	SELECT	31
10.2	GET CARD PUBKEY	32
10.3	GET MANUFACTURER CERTIFICATE	33
10.4	GET CARD CERTIFICATE	34
10.5	INIT	35
10.6	OPEN SECURE CHANNEL	36
10.7	MUTUALLY AUTHENTICATE	38
10.8	CHANGE PAIRING KEY	39
11	Cryptographic commands	40
11.1	VERIFY PIN	40
11.2	CHANGE PIN	41
11.3	UNBLOCK PIN	42
11.4	LOAD KEY	43
11.5	DERIVE KEY	45
11.6	GENERATE TRNG RANDOM	46
11.7	GENERATE KEY	47
11.8	SIGN	47
11.9	DECRYPT	51
11.10	GENERATE RSA SEED WRAP KEY	52
11.11	SIGN PUBLIC	53
11.12	RESET	54
12	Data commands	56
12.1	GET CARD INFO / READ DATA	56
12.2	GET HISTORY	57
12.3	WRITE DATA	58
12.4	GET PUBKEY	59
13	User key & configuration commands	63
13.1	ADD USER KEY	63
13.2	CHECK USER KEY	65
13.3	DELETE USER KEY	69
13.4	SET PINLESS PATH	70
13.5	SET PIN AUTH	71
13.6	SET PUB EXPORT	72
14	MuSig2 commands (BIP-327)	74
14.1	NONCE GEN	75
14.2	LOAD COSIGNER KEY	76
14.3	PARTIAL SIGN	76

14.4	References	78
15	Status codes reference	79
15.1	Standard status words	79
15.2	Secure channel status words	79
15.3	PIN retry behavior	80
15.4	PUK retry behavior	80
16	Cryptographic assets	81
16.1	Factory Dual Basic Group Secret	81
16.2	Card long-term attestation key	81
16.3	Session ephemeral private key	81
16.4	Pairing key	82
16.5	Secure Channel session keys (AES / MAC)	82
16.6	PIN	82
16.7	PUK	82
16.8	PUK-derived pairing fallback	83
16.9	User private keys (off-card)	83
16.10	FIDO credential (slot 3)	83
16.11	Pinless path derivation settings	83
16.12	Dual-generation partial secrets	84
16.13	Master seed	84
17	License	85

Cryptnox Hardware Wallet v2.0 with user auth by ECDSA 256r1, EdDSA, RSA2048 and FIDO auth.

This JavaCard Open Platform 3 applet provides basic HSM-like “cryptoki” capabilities for managing crypto-currencies private key secure storage and signature for any blockchain using SECP256k1 or SECP256r1 for ECDSA, and Ed25519 for EdDSA of the transactions. This applet acts like a hierarchical key tree hardware wallet.

The main purposes are key generation, key derivation, authentication and signing.

Communication with the card happens through a simple APDU interface, together with a Secure Channel guaranteeing confidentiality, authentication and integrity of all commands. Many parts of the card comply with ISO/IEC 7816 (1/2/3/...) and Global Platform standards. T=1 mode used.

The secure channel is quite similar to GP SCP03. The applet uses Extended APDU to stick on T=1 single query, single answer.

The applet hosts a “Dual Basic Group Secret” EC secret key, which is a secret designed to be shared within a pair of Cryptnox Hardware Wallet cards. This is loaded at factory with a one-shot encryption. This secures the dual generation process.

1 Introduction

The Cryptnox Hardware Wallet v2.0 is a JavaCard-based secure hardware wallet that provides hardware security module (HSM)-grade protection for blockchain operations. It is engineered to manage cryptographic keys, perform key derivation, and sign transactions directly within the card's secure environment, ensuring that private keys never leave the Secure Element.

The card supports secure storage of seeds and private keys and offers compatibility with secp256k1, secp256r1, and Ed25519 elliptic curves. It is capable of generating ECDSA signatures, Bitcoin Schnorr signatures (BIP340), and EdDSA signatures (RFC 8032) depending on the selected curve. User authentication mechanisms include PIN, PUK, pairing key, and optional external authentication through a user key or FIDO2 authenticator. These multiple layers of access control ensure both flexibility and robust security.

1.1 Security model

The Cryptnox Hardware Wallet v2.0 is built on a Common Criteria EAL6+ certified Secure Element, providing resistance to both physical and logical attacks. All sensitive data exchanges are protected by a Secure Channel protocol, based on principles similar to GlobalPlatform SCP03, which ensures mutual authentication, confidentiality, and integrity through AES-256 encryption and CMAC-based message authentication codes.

Access to card functions is enforced through PIN and PUK-based control, with retry limits and delay mechanisms to prevent brute-force attacks. In addition to local authentication, users can optionally employ an external key, such as a TPM, Secure Enclave, or FIDO2 device, to authorize sensitive operations.

The design also supports a dual-card backup generation mode, allowing two cards to share identical seeds securely. This redundancy mechanism guarantees recoverability without ever exporting or revealing the private seed material outside the Secure Element.

Important

Private keys and seeds are generated and stored exclusively within the Secure Element. There is no command or mechanism to extract raw key material from the card.

See also

- [Secure channel](#) — detailed Secure Channel protocol and session key derivation
- [Authentication](#) — PIN, PUK, user key, and FIDO2 authentication mechanisms
- [Seed management](#) — seed generation, dual generation mode, and key source types

1.2 Supported algorithms and curves

The Cryptnox Hardware Wallet v2.0 supports a comprehensive suite of asymmetric, symmetric, and hashing algorithms that align with current blockchain and authentication standards.

1.2.1 Elliptic curves

Curve	Usage	Signature types
secp256k1	Bitcoin, Ethereum, and other blockchain ecosystems	ECDSA, Schnorr (BIP340)
secp256r1 (NIST P-256)	Enterprise security, TLS, FIDO2/WebAuthn	ECDSA
Ed25519	Solana, Cardano, Polkadot, and other EdDSA-based ecosystems	EdDSA (RFC 8032)

1.2.2 Signature algorithms

Scheme	Curve	Notes
ECDSA (canonical low-S)	secp256k1, secp256r1	DER-encoded, default mode
ECDSA (EOSIO)	secp256k1, secp256r1	Filtered to fit EOSIO standard
Schnorr (BIP340)	secp256k1 only	64-byte raw signature
EdDSA (RFC 8032)	Ed25519 only	64-byte raw signature

See also

[EC signature](#) — signature types, output formats, and pinless signing

1.2.3 Symmetric cryptography

All secure messaging operations use AES-256 CBC for encryption and AES-256 CMAC for message integrity and authentication within the Secure Channel.

1.2.4 Key derivation

Hierarchical deterministic key derivation is implemented following:

Standard	Curve	Description
BIP32	secp256k1	Bitcoin HD wallet standard
SLIP-0010	secp256r1, Ed25519	Alternative derivation for non-k1 curves

Child keys are derived using HMAC-SHA512 as per standard definitions. The card also supports pinless path derivation, compatible with EIP-1581, allowing selective derivation paths to operate without requiring PIN entry.

See also

[Key derivation](#) — dual curve support, derivation sources, and parent key caching

1.2.5 Randomness

The Secure Element integrates a hardware True Random Number Generator (TRNG) compliant with AIS-20 Class DRG.3, used for generating seeds, keypairs, and session nonces.

1.2.6 Hash functions

Algorithm	Usage
SHA-256	Message digests, PIN/PUK verification, fingerprint computation
SHA-512	Session key derivation, HMAC-SHA512 for BIP32/SLIP10

1.2.7 Standards compliance

Standard	Scope
ISO/IEC 7816 (Parts 1–4)	Smartcard electrical, transmission, and APDU communication
ISO/IEC 14443 (Parts 2–4) Type A	NFC contactless communication standard
GlobalPlatform SCP03	Secure, authenticated communication between host and card
BIP32, BIP39, BIP44	Hierarchical deterministic wallet structures and derivation
SLIP10	Key derivation for non-k1 curves
BIP340	Schnorr signature scheme for Bitcoin / secp256k1
RFC 8032	EdDSA signature scheme for Ed25519
EIP-1581	Pinless derivation path standard

This compliance ensures compatibility across blockchain environments, enterprise identity frameworks, and security infrastructures.

2 Technical specifications

The Cryptnox Hardware Wallet card integrates advanced hardware and cryptographic capabilities to deliver a secure, high-performance environment for blockchain operations and key management. It is implemented on a certified Secure Element platform and adheres to international smartcard and cryptographic standards.

2.1 Cryptographic capabilities

The Cryptnox Hardware Wallet card supports a broad range of cryptographic functions for blockchain signing, enterprise authentication, and key derivation.

It operates on `secp256k1`, `secp256r1`, and `Ed25519` (EdDSA) elliptic curves, maintaining independent key derivation trees for each. The hierarchical deterministic wallet structure supports up to eight levels of derivation depth as defined in BIP32 (for `secp256k1`), SLIP10 (for `secp256r1`), and SLIP10 (for `Ed25519`).

The card supports multiple signature schemes, including ECDSA (DER-encoded with canonical low-S enforcement), EOSIO-compatible ECDSA, BIP340 Schnorr signatures for Bitcoin use cases, and EdDSA (`Ed25519`) for modern blockchain and authentication protocols.

For symmetric cryptography, the card uses AES-256 CBC for data encryption and AES-256 CMAC for message integrity. Key derivation follows the HMAC-SHA512 standard used in BIP32 and SLIP10.

Table 1: Cryptographic summary

Category	Algorithm	Details
Asymmetric (signing)	ECDSA, Schnorr (BIP340), EdDSA	<code>secp256k1</code> , <code>secp256r1</code> , <code>Ed25519</code>
Symmetric (encryption)	AES-256 CBC	Secure Channel data encryption
Symmetric (integrity)	AES-256 CMAC	Message authentication codes
Key derivation	HMAC-SHA512	BIP32 / SLIP10 child key derivation
Hashing	SHA-256, SHA-512	Digests, verification, session keys
Random generation	TRNG (AIS-20 DRG.3)	Seeds, keypairs, session nonces

➔ See also

- [EC signature](#) — signature types and output formats
- [Key derivation](#) — derivation depth, triple curve support, and caching
- [Seed management](#) — seed generation and dual generation mode

2.2 Communication protocols

The Cryptnox Hardware Wallet card communicates using ISO 7816 APDUs over the T=1 protocol, with full support for extended APDUs to handle larger payloads. In addition, the card supports ISO 14443 NFC contactless communication, enabling wireless interaction with NFC-capable devices. All sensitive operations are performed through an authenticated Secure Channel, established via ECDH and protected by AES-256 encryption.

2.2.1 APDU model

The card follows a standard command/response exchange structure:

CLA		INS		P1		P2		Lc		Data		Le
-----	--	-----	--	----	--	----	--	----	--	------	--	----

Extended APDUs (>255 bytes) are supported for operations that require large data exchanges.

See also

[Setup & channel commands](#), [Cryptographic commands](#), [Data commands](#), [User key & configuration commands](#) — full APDU command reference

2.2.2 T=1 protocol

A block-oriented communication model with built-in error detection and message chaining, ensuring reliable data transfer even during extended or chained APDUs.

2.2.3 NFC contactless (ISO 14443)

The card supports ISO 14443 NFC contactless communication, allowing interaction with NFC-enabled smartphones, terminals, and other contactless readers. The same APDU command set is available over both the contact (ISO 7816) and contactless (ISO 14443) interfaces.

2.2.4 Secure channel

The Secure Channel is derived through an ECDH exchange combined with the pairing key, producing session keys via SHA-512 derivation. These keys protect the session using AES-256 CBC (encryption) and AES-256 CMAC (integrity), with replay protection managed by nonces and counters.

See also

[Secure channel](#) — full protocol description, mutual authentication, and error conditions

2.2.5 Authentication

Access control relies on a multi-tiered authentication framework:

Method	Credential	Description
PIN	4–9 digits	Required before sensitive operations. Three failed attempts trigger a lockout, recoverable via the PUK.
PUK	12 characters	Used for PIN recovery and card reset, with unlimited attempts but enforced delay mechanisms.
Pairing key	32 bytes	Required to open a Secure Channel; recoverable from PUK if lost.
User keys	ECDSA / RSA / FIDO2	External authentication keys uploaded to authorize transactions.
FIDO2	Challenge-response	External authenticator such as a YubiKey, TPM, or Secure Enclave.

See also

[Authentication](#) — PIN retry behavior, user key slots, and FIDO authentication details

2.2.6 Query/response model

Communication is strictly one command per response, ensuring predictable and deterministic interactions without concurrency.

2.3 Secure element features

The Secure Element serves as the foundation of the card's security model, designed to protect cryptographic materials and enforce all access control mechanisms within a tamper-resistant environment.

2.3.1 Security certifications

Certification	Scope
Common Criteria EAL6+	Hardware and embedded software assurance
FIPS 140-2/3	Cryptographic primitives (AES, SHA, RNG)

The architecture is hardened against side-channel attacks (DPA/SPA) and fault injection attempts, safeguarding against both passive and active threats.

2.3.2 Memory and isolation

Persistent data is stored in secure EEPROM, which is physically and logically isolated from the JavaCard operating system.

Hardware-level protections prevent unauthorized reads, and all write and erase operations include integrity verification routines. This isolation also enforces non-exportability of private keys and seeds. The hierarchical key derivation engine supports up to eight levels of depth, consistent with BIP32 and SLIP10 standards.

2.3.3 Key management

Private keys and seeds never leave the Secure Element. The card supports a dual-seed generation protocol, allowing two cards to securely generate and share identical seeds without ever exposing key material.

Three independent key derivation trees exist for secp256k1, secp256r1, and Ed25519 (EdDSA) curves, enabling simultaneous use across blockchain, enterprise, and modern authentication contexts.

All cryptographic operations are gated by PIN-based authentication, with optional pinless paths available for predefined derivation slots where repeated authentication is not required.

Important

There is no APDU command or mechanism to export private keys or seeds from the card. Key material is strictly non-extractable by design.

2.3.4 Communication security

Card communication is based on ISO 7816 APDU exchanges using the T=1 protocol, with full support for extended-length APDUs. ISO 14443 NFC contactless communication is also supported, providing the same command set over a wireless interface.

A Secure Channel protocol, built on ECDH key exchange and AES-256 encryption, ensures the confidentiality and integrity of all exchanges.

Each session is mutually authenticated, protected with AES-256 CBC for encryption and AES-256 CMAC for integrity, and reinforced with nonce-based replay protection.

2.3.5 Hardware random number generator

The integrated TRNG, compliant with AIS-20 Class DRG.3, provides entropy for all critical security operations including seed creation, keypair generation, and cryptographic session nonces.

This guarantees randomness at the hardware level, essential for maintaining cryptographic unpredictability.

2.4 Hardware and JavaCard platform

The Cryptnox Hardware Wallet card is built on the NXP JCOP 4.x Secure Element platform, a JavaCard-based architecture recognized for its robust security and versatility.

It provides dedicated memory partitions for cryptographic key storage and hierarchical key derivation trees, ensuring strict separation between the secure and application layers.

The integrated True Random Number Generator (TRNG) complies with AIS-20 Class DRG.3 certification, providing high-entropy randomness for seed generation, keypair creation, and session nonces.

Note

For a complete overview of the card's lifecycle, from SELECT through initialization, pairing, and reset, see [Lifecycle management](#).

3 Lifecycle management

3.1 Card startup

After receiving the ATR from the card, one must select the applet to use it. The applet AID is 0xA00000010000112. This command provides some basic info about the card applet and status flags. The card can be accessed over the contact interface (ISO 7816) or the NFC contact-less interface (ISO 14443).

See also

SELECT and *GET MANUFACTURER CERTIFICATE* commands for full details on the startup sequence and response fields.

3.2 Initialization

Right after the installation, the applet is not initialized and the user needs to send some parameters to use the card. The INIT command can only be executed on a fresh card; a reset is required if the card was already initialized. Many base parameters changes require a card reset (except PIN/PUK change).

The parameters are sent using “one shot encryption”: the AES key is directly the ECDH of the 2 keys (card and computer). In addition to the personal code number, one needs to generate a random common shared key for the card pairing, used later for a fully authenticated and secured channel.

Table 1: Initialization parameters

Parameter	Size	Description
Owner Name	1 + 20B max	Length byte + up to 20 characters
Owner Email	1 + 60B max	Length byte + up to 60 characters
PIN	9B	4–9 digit number, padded with 0x00 to 9 bytes
PUK	12B	12 digits/letters/bytes
Pairing key	32B	Secure Channel first pairing key

The PIN must be 4 to 9 figure number characters ('0'–'9'). If the PIN is less than 9 bytes, it must be filled with 0x00 until 9 characters long.

The parameters sent are encrypted and the command payload is:

PubKey IV EncryptedParams

During initialization, three independent key derivation trees are prepared for secp256k1, secp256r1, and Ed25519 (EdDSA). Each tree maintains its own seed and derivation hierarchy, following BIP32 (for secp256k1), SLIP10 (for secp256r1), and SLIP10 (for Ed25519).

 See also

INIT command for the full APDU specification.

3.3 Pairing

After the initialization, the card and the host must share a common secret to be used as an authenticated secure channel. This secret is required any time further to communicate with the card (using a secure channel). The registration of the first common secret (pairing key) is done during the init phase. There is 1 pairing key slot.

The user can use a common public pairing key and only use PIN for authentication. Otherwise, the user host needs to store its pairing key in a safe place. In the case the client would communicate with several cards, the user needs to associate the pairing key with the instance serial number of the card.

 Note

If the user loses their pairing info, a stretched hash of the PUK (SHA256 applied 32 times) can be used as the pairing key (slot 0xFF).

 See also

- *CHANGE PAIRING KEY* command for pairing key management
- *Secure channel* for the full Secure Channel protocol description

3.4 Reset

When the PUK code is sent into the RESET command, the card is reset. The reset PUK code is chosen during the initialization stage. The PUK reset code is a 12 characters long string, which allows a full reset of the card.

On top of this 12 characters secret, the reset is also secured by the user pairing key mechanism (if secret). That means that resetting a card requires, on top of the PUK, to know the pairing key to send the command encrypted. Still, the PUK can act as a pairing key on its own.

The reset command erases everything in the card, including all three key derivation trees (secp256k1, secp256r1, and Ed25519), and makes the card as it was before the initialization.

 Important

The PUK tries are unlimited, but there is an internal loop hash that takes time inside the card for each try. Every 12 tries, a power cycle is required to perform new tries.

 See also

- `cmd-reset` for the full APDU specification
- [Status codes reference](#) for PUK retry behavior details

4 Secure channel

4.1 Opening a secure channel

In a standard use of the applet, just after selecting the applet, the client opens a secure channel using their pairing key for this card.

Just after SELECT, the user queries the card certificate and asks the card for its session public key. The session key of the card is provided in a minimalist certificate, which holds a salt provided by the user.

The user generates an EC key pair (SessionUserPrivateKey / SessionUserPublicKey) for the session and provides the public key part when querying to open the secure channel.

The card responds with a session salt. All parameters of the secure channel are computed using:

```
ECDHXsecret = SessionCardPrivateKey . SessionUserPublicKey (x)    [Card side]
              = SessionUserPrivateKey . SessionCardPublicKey (x)   [Client side]

SessionCardPublicKey - received in the SELECT command card answer
SessionUserPublicKey - transmitted to the card in the OPEN SECURE CHANNEL command

AESkey | MACkey = SHA512( ECDHXsecret | PairingKey | SessionSalt )
```

When P1=0xFF, the pairing key used is $\text{SHA256}^{32}(\text{PUKcode})$. That way, the PUK can be used as a pairing key, and a user losing their pairing key can still use the PUK to access the card.

See also

GET CARD CERTIFICATE, *OPEN SECURE CHANNEL*, and *MUTUALLY AUTHENTICATE* commands for full APDU specifications.

4.2 Mutual authentication

Right after the secure channel is opened, the user shall test it using the *MUTUALLY AUTHENTICATE* command. A successful encryption-decryption full loop means the device and the client have the same pairing key, authenticating each other.

If the authentication fails the card responds with 0x6982. In this case the *OPEN SECURE CHANNEL* command must be repeated to generate new keys.

See also

Authentication for PIN and user key authentication that occurs after the Secure Channel is established.

4.3 Encrypted APDUs

After a successful `OPEN SECURE CHANNEL` command, all communications between card and client are encrypted.

Note

Only the data fields of C-APDUs are encrypted. CLA, INS, P1, P2 for C-APDUs are plaintext. This means no sensitive data should be sent in these parameters. Additionally a MAC is calculated for the entire APDU, including the unencrypted fields.

Because R-APDUs can only contain data if their SW is a success or warning status word (0x9000, 0x62XX, 0x63XX), when the secure channel is open all responses will have SW 0x9000. The actual SW is always appended at the end of the response data before encryption, which means the client must interpret the last two bytes of the plaintext response as the SW.

An exception to this is SW 0x6982, which indicates that the Secure Channel has been aborted and as such is returned without any MAC.

4.3.1 Encryption process

To encrypt the data both the card and the client do the following:

1. The data is padded using the ISO/IEC 9797-1 Method 2 algorithm.
2. The data is encrypted using AES in CBC mode using the session key.
3. An AES CBC-MAC is calculated over the entire APDU data.
4. The data field of the APDU is set to the MAC followed by the encrypted data.

4.3.2 Decryption process

To decrypt the data both the card and the client do the following:

1. The first 16 bytes of the APDU data are the MAC to be verified.
2. The remaining data is decrypted using AES in CBC mode using the session key.
3. The padding is removed.

The IV used for the encryption is the last seen MAC from the counterpart. This optimizes the number of transmitted bytes and guarantees protection from replay attacks. For the MAC generation, a zero IV is always used.

4.3.3 MAC generation for C-APDUs

Calculated on the concatenation of:

```
CLA INS P1 P2 LC1 LC2 LC3 00 00 00 00 00 00 00 00 | encrypted data field
```

The 9-byte long padding does not become part of the data field and does not affect LCx.

- LCx = (Len 00 00) if len < 256 bytes
- LCx = (00 LenMSB LenLSB) if len ≥ 256 bytes (big endian short)

4.3.4 MAC generation for R-APDUs

Calculated on the concatenation of:

```
LR1 LR2 LR3 00 00 00 00 00 00 00 00 00 00 00 00 | encrypted data field
```

The 13-byte long padding does not become part of the response field. LRx is the length of the encrypted response data field and is not transmitted.

- LRx = (Len 00 00) if len < 256 bytes
- LRx = (00 LenMSB LenLSB) if len ≥ 256 bytes (big endian short)

4.3.5 Error conditions

1. If a sensitive command is received without an active Secure Channel, the card shall respond with SW 0x6985 (SW_CONDITIONS_NOT_SATISFIED).
2. If a MAC cannot be verified the card shall respond 0x6982 and the Secure Channel must be closed.

Warning

When sending very large data commands in the secure channel (much larger than expected), the reply can be illegible and cannot be decrypted. If the command is too large, the MAC-IV chain is broken, since the auth data for the received command data will not be properly read by the card, and any further message will use outdated MAC data.

See also

[Status codes reference](#) for a complete reference of all status words, including Secure Channel specific error codes.

5 Authentication

5.1 PIN authentication

The PIN chosen during the initialization needs to be provided after each EC signature, because a signature resets the PIN validity.

The PIN verification is done in a standard way through the secure channel. The PIN must be between 4 and 9 figures long.

5.1.1 Retry behavior

Event	Behavior
Per-session tries	The PIN can be tested 3 times before a lockout is triggered.
After lockout	Three failed attempts trigger a lockout requiring a power cycle of the card.
After power cycle	3 more tries are available. Another three incorrect attempts cause a permanent lock until the PUK is used.
PIN locked	Requires unlocking with the PUK via the <code>UNBLOCK PIN</code> command.
<code>0x63C0</code> response	Returned when tries need a power cycle, even if the PIN is correct.
Persistent <code>0x63C0</code>	After power cycle, if the card still throws <code>0x63C0</code> , the PIN is blocked.

After a successful signature command, the PIN verification is reset. A PIN verification is valid until the card powers off or a signature is performed.

See also

- [VERIFY PIN](#) command for the full APDU specification
- [Status codes reference](#) for PIN and PUK retry counter details

5.2 User key authentication

Another way to authenticate the user is with an EC256r1, RSA, or EdDSA key pair. There is a random challenge to be signed for PIN-like behavior. The public key is registered in the card, and the “blockchain” EC signature can be allowed with a signature from this user key: hash to be signed with the card must be signed with the user key.

The goal of this function is to use the Cryptnox Hardware Wallet card (to make transactions) in conjunction with a key storage such as iOS Secure Enclave Touch ID or a PC TPM, instead of using the PIN.

The PIN check and user authentication is reset after any EC signature (of all the authorized hashes).

This user auth by ECDSA can also be performed by an external FIDO authenticator.

A user key can be uploaded in a slot only once, and requires the `DELETE USER KEY` command if there is already a key in the slot.

5.2.1 Key slots

Slot	Key type	Format
1	EC 256r1	X9.62 uncompressed (65 bytes: 04 X Y)
2	RSA 2048	256 bytes modulus, exponent must be 65537
3	FIDO	CredIDLength(1B) CredID(up to 64B) ECpubkey(65B)
4	EC 256r1	X9.62 uncompressed (65 bytes: 04 X Y)
5	EC 256r1	X9.62 uncompressed (65 bytes: 04 X Y)

5.2.2 Authentication modes

There are 2 kinds of user auth:

Mode	P1	Description
Challenge-response	0x01 / 0x02	Auth for all commands except <code>SIGN</code> . The card provides a random challenge, the user signs it.
Auth for sign	0x00 / 0x10	Auth the transaction hash. The challenge is one or a set of hashes to be “blockchain” signed. When P1 is OR'd with 0x10, the data message is a hash list (1 to 4 hashes).

5.2.3 FIDO authentication

When the slot index is 3, this is a special case for a FIDO signature. The data must include the counter, making the data input:

```
hash(33-97B) | counter(4B) | ECsignature(EC256r1 ASN1)
```

The card checks the signature as a WebAuthn “user verified” message:

```
sha256hash(rp_id) | [0x05] | counter_word | sha256hash(clientData)
```

Where:

- `rp_id` = "cryptnox.ch"
- `clientData` = `'{"type": "webauthn.get", "origin": "https://cryptnox.ch", "challenge": "", "clientExtensions": {}}'`

Note

The restriction for FIDO2 user-auth-for-sign is a maximum of 3 hashes can be authorized at once (instead of 4).

5.3 Disabling PIN auth

With the `SET PIN AUTH` command, one can disable the PIN auth and only let the auth performed by user authentication (public keys registered).

Important

When PIN auth is disabled, only user key authentication (slots 1–5) can authorize operations. Make sure at least one user key is registered before disabling PIN auth.

See also

- [ADD USER KEY](#), [CHECK USER KEY](#), and [SET PIN AUTH](#) commands for full APDU specifications
- [EC signature](#) for details on how signing resets authentication state

6 Seed management

The applet manages a 256-bit master secret called the “seed”. This is the BIP32 master seed, and can be externally computed from a mnemonic to a binary seed using BIP39. The key pairs used for ECDSA and EdDSA are then computationally derived from this seed using SLIP10/BIP32 derivation scheme.

Once the card has a seed or a master key, it is not possible to erase or change it, except by performing a reset with the PUK.

Important

The seed is strictly non-extractable. There is no command to read or export the raw seed from the card. The only way to remove it is a full card reset via the PUK.

6.1 Generation

The master seed can be generated in the card using the random number generator in the chip system (AIS-20 class DRG.3). With the use of the `GENERATE KEY` command, the seed secret never escapes the card protection. If performed the simple way, there is no way to get a backup of this seed.

6.1.1 Dual generation mode

The dual generation mode allows a cross generation between 2 cards which then share a common seed. One card is a backup of the other. The secret seed cannot be output in any way.

The 2 cards generate each a part of the secret, which is mixed with the other. This is secure because it is not possible to read the seed, and it provides a backup, as the 2 cards are identical after a dual generation initialization. Still in this mode, there is no way to extract the seed and put it in another blockchain wallet.

The common seed is `SHA256(ECDH)`. Even the computer doing the transfer exchange cannot compute the seed, protected by ECDH. Similarly, the computer cannot be part of the key exchange, as this requires a signature shared with a secret key, only located within the cards pair.

Dual generation protocol:

card 1 : 80D00400	-> PublicKeySigned of the 1st card
card 2 : 80D00400	-> PublicKeySigned of the 2nd card
card 1 : 80D00500 PK2	-> PublicKeySigned of the 2nd card sent
card 2 : 80D00500 PK1	-> PublicKeySigned of the 1st card sent

After this, the 2 cards have a common seed. One card is a backup of the other.

 See also

[LOAD KEY](#) command for the full APDU specification of seed loading and dual generation.

6.1.2 External random entropy

The card can output random data. The query answer is only output data and is not used internally by the card. It is the user's responsibility to compute a mnemonic using the `GENERATE RANDOM` command and then compute the corresponding seed, which can be uploaded in the card using the `LOAD KEY` command.

6.2 Recovery

The JavaCard applet can load a binary seed (or eventually just an EC key pair). Once this seed is loaded in the card, this card now behaves like the one it was backed up from.

 Note

Key derivation paths are not backed up and must be identical to retrieve the same key pairs. After loading a seed, use the `DERIVE KEY` command to navigate to the desired path.

 See also

- [LOAD KEY](#) command for the recovery APDU specification
- [Key derivation](#) for derivation path management after recovery

6.3 Key hierarchies

From a single seed, the card derives three independent key hierarchies:

- **secp256k1** – Bitcoin, Ethereum, and other blockchain ecosystems
- **secp256r1** – Enterprise security, TLS, FIDO2/WebAuthn
- **EdDSA (Ed25519)** – Modern cryptographic signatures (Solana, nacl, etc.)

All three hierarchies are rooted in the same master seed but are otherwise fully independent.

6.4 Key source types

After loading or generating, the key source info byte (returned by [READ DATA](#) with P1=0, P2=0) indicates the origin:

Code	Description
0x00	No key (not seeded)
'K'	A single secp256k1 EC pair was loaded
'X'	An extended secp256k1 key was loaded (a BIP32 node)
'L'	An external seed was loaded
'S'	Internal seed generated
'D'	Seed generated using dual generation mode

7 Key derivation

The card applet is fully compliant with BIP32 (secp256k1 curve) and SLIP10 (secp256r1 and Ed25519 curves), except the maximum depth of derivation from the master key is **8 levels**.

The card stores the present key pair (and its parent), used for signature. This can be changed using the `DERIVE KEY` command, giving a relative path (from the present or parent key pair), or an absolute path (from the master key pair).

See also

[Seed management](#) for how the master seed is generated or loaded before derivation can be used.

7.1 Triple curve support

The card can derive with:

Curve	Standard	Usage
secp256k1	BIP32	Bitcoin, Ethereum, and other blockchain ecosystems
secp256r1	SLIP10	Enterprise security, TLS, FIDO2/WebAuthn
Ed25519	SLIP10	Modern cryptographic signatures (Solana, nacl, etc.)

A flag in `DERIVE KEY`, `GET PUBKEY`, or `SIGN` is used to select one of the three curves. There are 3 separate key trees in the card, one for secp256k1, one for secp256r1, and one for Ed25519. They are separated, only linked from the same seed.

7.2 Derivation sources

P1 bits 7-6	Source
00	Derive from master keys (absolute path)
01	Derive from parent keys
10	Derive from current keys (relative path)
11	Reserved

7.3 Parent key caching

The ability to start derivation from the parent keys allows to more efficiently switch between children of the same key. Note however that only the immediate parent of the current key is cached so one cannot use this to go back in the keys hierarchy.

If no valid parent key is available (e.g., when the current key pair is the master root), the status code 0x6B00 is returned.

Note

Parent key caching is particularly useful for wallet software that needs to iterate over multiple child addresses (e.g., `m/44'/60'/0'/0/0` through `m/44'/60'/0'/0/n`) without re-deriving from the master each time.

7.4 Performance considerations

For ease of use, the user can derive from the root master node key pair (absolute path) at each card startup, or even before each signature. This takes some time. It is better to store intermediate public keys hash and check the status to observe the current key pair in use.

This off-card complex key management is not needed if the signature volume is below one thousand per day.

See also

- [DERIVE KEY](#) and [GET PUBKEY](#) commands for the full APDU specifications
- [EC signature](#) for on-the-fly derivation during signature operations

8 EC signature

The card applet can sign any 256-bit hash provided, using ECDSA with secp256k1 or secp256r1 EC parameters. Most blockchain systems use SHA2-256 to hash the message, but this card applet is agnostic: the signature is performed on a hash provided by the user.

The card also supports EdDSA signatures using Ed25519 curve parameters. Unlike ECDSA, the EdDSA input is the data itself (not a hash), prepended with 2 bytes of length in big endian. The data length is limited to 1200 bytes (1202 bytes with the length header).

The derivation of the key pair node can also be done using the signature command (relative or absolute). The card derives just before signing; this cannot be used to sign with a different key, and this cannot change the current stored key.

See also

[Key derivation](#) for standalone derivation and path management.

8.1 Signature types

P2	Signature type	Description
0x00	ECDSA (canonical low-S)	Default mode, DER-encoded r and s values
0x01	ECDSA (EOSIO)	Filtered to fit EOSIO standard
0x02	Schnorr (BIP340)	Bitcoin Schnorr, secp256k1 only, 64-byte output
0x03	EdDSA (Ed25519)	EdDSA signature, Ed25519 only, 64-byte output as per RFC 8032

8.2 Key selection

P1	Description
0x00	Current ECDSA key
0x01	Derive and sign (ECDSA, with derive flag)
0x02	Derive and sign (ECDSA, absolute path)
0x03	Pinless path (ECDSA)
0x20	Current EdDSA key
0x21	Derive and sign (EdDSA, with derive flag)

8.3 Ephemeral nonce

The ephemeral k used in the ECDSA and Schnorr is random and different for each signature. For ECDSA, this is automatically performed by the Signature function of the underlying JCOP4 platform, which internally provides a source of high-quality randomness during the signature.

Important

This applet does **not** use RFC 6979 deterministic digital signature generation. The nonce is always sourced from the hardware TRNG.

8.4 ECDSA output format

The signature is encoded as an X9.62 ASN1 DER sequence of two INTEGER values, r and s , in that order:

```
SEQUENCE ::= { r INTEGER, s INTEGER }
```

Additionally, to be compatible with blockchain specific signatures, the s part of the signature is always output as “canonical”, changed for s to be on the “lower” side (s lower than $n/2$).

8.5 BIP340 Schnorr output format

Returns 64 bytes $R|S = 2 \times 256$ bits MSB first, as per BIP340 standard.

The 32-byte nonce $rand$ value is directly provided by a random source in the JCOP4 platform. Works only with secp256k1 keys (current, derive, or pinless).

8.6 EdDSA output format

Returns 64 bytes $R|S = 2 \times 32$ bytes, as per RFC 8032 standard.

The input data is the raw message (not a hash), prepended with 2 bytes indicating the data length in big endian format. The maximum data length is 1200 bytes (1202 bytes including the 2-byte length header).

Works only with Ed25519 keys (current or derive).

8.7 Pinless signing

P1=0x03 is specifically designed for payment transactions. It can be executed without Secure Channel (since no sensitive info is transmitted) and does not require PIN authentication.

The current derivation path on the card remains unchanged, but the signing process is performed using the pinless derivation path previously defined using the `SET PINLESS PATH` command.

The pinless path is restricted to the EIP-1581 prefix (`m/43'/60'/1581'/...`).

Note

Pinless signing is designed for point-of-sale NFC tap scenarios where the card signs a transaction without requiring user interaction beyond the physical tap.

See also

[*SET PINLESS PATH*](#) for configuring the pinless derivation path.

8.8 PIN and auth reset after signing

An EC signature resets the PIN or user key auth. A PIN verification (or user sign auth) must be performed afterwards and before calling any commands which require user auth (or PIN) checked.

If several hashes are granted by user-auth-for-sign, the card expects the signatures to be done in the exact same order as the authentication. The reset of the auth occurs when all signatures are done (up to 4).

After a successful signature session, the user auth is left opened: if a PIN was provided, the PIN stays verified for other commands. If a user key auth was used, the EC auth is opened for other commands.

In case of bad PIN provided, the PIN auth is disengaged.

See also

- [*SIGN*](#) command for the full APDU specification
- [*Authentication*](#) for PIN and user key authentication details

9 Command overview

The following table provides a summary of all APDU commands supported by the Cryptnox Hardware Wallet card, along with their authentication and security requirements.

9.1 Application & info

Command	Description	Secure Channel	PIN / User Key	PUK
SELECT	Selects the Cryptnox applet.	✗	✗	✗
Get Card Public Key	Retrieves the card factory EC public key.	✗	✗	✗
Get Manufacturer Certificate	Reads Cryptnox X509 manufacturer certificate (paged).	✗	✗	✗
Get Card Certificate	Retrieves ephemeral session certificate (for secure channel setup).	✗	✗	✗

9.2 Initialization

Command	Description	Secure Channel	PIN / User Key	PUK
INIT	Initializes card with PIN, PUK, and pairing key.	✓ One-shot	✗	✓ Set initial
Open Secure Channel	Establishes Secure Channel with pairing key.	✗	✗	0xFF fall-back
Mutually Authenticate	Confirms Secure Channel integrity with challenge/response.	✗	✗	✗
Change Pairing Key	Updates Secure Channel pairing key.	✓	✗	✗

9.3 User authentication

Command	Description	Secure Channel	PIN / User Key	PUK
Verify PIN	Verifies user PIN, unlocks card for session.	✓	✓ PIN	✗
Change PIN / PUK	Changes PIN or PUK.	✓	✓ PIN or PUK	✓ To change PUK
Unblock PIN	Unblocks PIN with PUK and new PIN.	✓	✗	✓
Add User Key	Stores external user public key (ECDSA, RSA, FIDO).	✓	✓ PIN / User Key	✓ If PIN disabled
Check User Key	Performs challenge-response authentication using user key.	✓	✓ User Key sig	✗
Delete User Key	Deletes a registered user key slot.	✓	✗	✓
Set Pin Auth	Enables/disables PIN auth (forces User Key only).	✓	✗	✓

9.4 Key management

Command	Description	Secure Channel	PIN / User Key	PUK
Load Key	Loads seed, keypair, or performs dual seed generation.	✓	✓	✗
Generate Key	Generates new seed internally.	✓	✓	✗
Generate RSA Seed Wrap Key	Generates RSA keypair for seed wrapping.	✓	✗	✗
Set Pinless Path	Configures EIP-1581 pinless derivation path.	✓	✗	✓
Set Pub Export	Enables xpub or clear pubkey output.	✓	✗	✓
Get Public Key	Reads current or derived public key, xpub.	✓ Except pinless	✓ Except pinless	✗
Derive Key	Derives new key pair from seed (BIP32 / SLIP-0010).	✓	✓	✗
Generate TRNG Random	Outputs random data (16–64 bytes).	✓	✗	✗

9.5 Signing & decryption

Command	Description	Secure Channel	PIN / User Key	PUK
Sign Public	Certifies the current blockchain public key.	✓	✓	✗
Sign	Signs hash (ECDSA / Schnorr) or data (EdDSA).	✓ Except pinless	✓ Except pinless	✗
Decrypt	ECIES-like decryption / symmetric key output.	✓	✓	✗

9.6 MuSig2 (BIP-327)

Command	Description	Secure Channel	PIN / User Key	PUK
Nonce Gen	Generates MuSig2 secret nonce pair, returns (R1, R2).	✓	✓ Except pinless	✗
Load Cosigner Key	Feeds one cosigner pubkey into the KeyAgg list hash.	✓	✓ Except pinless	✗
Partial Sign	Returns the card's BIP-327 partial signature <code>s_i</code> .	✓	✓ Except pinless	✗

9.7 Data & history

Command	Description	Secure Channel	PIN / User Key	PUK
Get Card Info / Read Data	Reads owner info, key source, counters, user slot info.	✓	✓ Protected slots	✗
Get History	Reads signing history slots.	✓	✓	✗
Write Data	Writes user data slot or custom bytes.	✓	✓	✗

9.8 Administration

Command	Description	Secure Channel	PIN / User Key	PUK
Reset	Full factory reset of the card.	✓	✗	✓
Disable Reset	Permanently disables reset capability.	✓	✗	✓

Note

For detailed APDU specifications, parameters, and response codes of each command, refer to the dedicated command pages: [Setup & channel commands](#), [Cryptographic commands](#), [Data commands](#), [User key & configuration commands](#), and [MuSig2 commands \(BIP-327\)](#).

10 Setup & channel commands

10.1 SELECT

Request APDU

CLA	INS	P1	P2	LC	Data
0x00	0xA4	0x04	0x00	0x07	AID

Request Data

Field	Size	Description
AID	7B	Application identifier: 0xA00000010000112

The SELECT command is documented in the ISO 7816-4 specifications and is used to select the application on the card, making it the active one. The data field is the AID of the application.

After receiving the ATR from the card, this must be the first command sent. It provides basic information about the card applet status and flags, which the client should use to determine the card's current state and capabilities before proceeding with further operations.

Response Data — 24 bytes

Field	Size	Description
Applet type	1B	'B' = Basic
Applet version	3B	Major.Middle.Minor (e.g. 0x02 0x00 0x00 = v2.0.0)
Status flags	2B	Big-endian short, see below
PubKey flags	2B	Big-endian short, see below
Custom bytes	16B	User-defined, written by WRITE DATA (0xFC P1=1). Default: 0x00

Status flag bits (bit 15 = MSB, bit 0 = LSB):

Bit	Meaning
7	Reset is disabled
6	Initialized
5	Seed (master seed or EC pair loaded)
4	Pin Auth possible
3	Pinless enabled
2	xpub output enabled
1	Clear read of current public key enabled

PubKey flag bits:

Bit	Meaning
0	User Public Key #1 (ECDSA 256r1) active
1	User Public Key #2 (RSA 2048) active
2	User Public Key #3 (FIDO2) active
4	User Public Key #4 (ECDSA 256r1) active
5	User Public Key #5 (ECDSA 256r1) active

The custom bytes can be used to provide personal hints about how to authenticate with the card, or what's stored inside the card. Note that whoever has the card can freely and easily read this data.

The card serial ID can be read with the GET MANUFACTURER CERTIFICATE command which provides the card certificate signed by the manufacturer. The card serial is the serial of the provided X509 certificate.

Status Words

SW	Description
0x9000	Success

10.2 GET CARD PUBKEY

Request APDU

CLA	INS	P1	P2	LC	Data
0x80	0xF4	0x00	0x00	—	None

Response Data — 65 bytes

Field	Size	Description
Card public key	65B	EC R1 uncompressed point (04 X Y)

This command reads the card's static EC R1 public key. During the installation of the applet, the card initializes its own EC R1 key pair. This command is only useful for the manufacturer at factory to send the Cryptnox certificate in the card, which contains this card public key, thus authenticating the genuineness of the card.

10.3 GET MANUFACTURER CERTIFICATE

Request APDU

CLA	INS	P1	P2	LC	Data
0x80	0xF7	0x00	Page	—	None

P2 values

P2	Description
0x00	First 253 bytes of certificate + 2 bytes length prefix
0x01+	Remaining pages, 255 bytes each

Response Data

Field	Size	Description
Certificate length	2B	Big-endian short (P2=0 only)
Certificate data	up to 253B/255B	X509 certificate fragment

This command reads the Cryptnox card X509 certificate. This command should be used after each SELECT and before the OPEN_SECURE_CHANNEL command in order to:

- Read the Card Serial Number. This is useful to get the right pairing key associated with the card, especially when the user client communicates with several cards and needs to associate the PairingKey with the instance SN.
- Read the card public key, to further check the ECDH card public key authenticity during the secure channel setup.
- Check if the card is genuine by verifying the certificate against the Cryptnox public key.

The answer is limited to 255 bytes per page. P2=0 returns the first 253 bytes of the certificate prepended with 2 bytes of its total length. P2>0 returns the remaining parts, paginated by 255 bytes.

Status Words

SW	Description
0x9000	Success

10.4 GET CARD CERTIFICATE

Request APDU

CLA	INS	P1	P2	LC	Data
0x80	0xF8	0x00	0x00	0x08	Nonce

Request Data

Field	Size	Description
Nonce	8B	Random nonce for certificate freshness

This command generates and provides the card basic certificate. It should be used after each GET MANUFACTURER CERTIFICATE and before the OPEN SECURE CHANNEL command in order to securely get the card ephemeral public key for the channel encryption key exchange.

The nonce is provided by the command query, so the certificate can only be refreshed and live generated by the card. This ensures that the session public key is fresh and has not been replayed from a previous session.

Response Data — variable (~138-140 bytes)

The basic card certificate is a special compact format:

Field	Size	Description
Tag	1B	'c' (0x43)
Nonce	8B	Echo of the provided nonce
Session public key	65B	Ephemeral EC 256r1 card key for ECDH
Signature	70-72B	ASN1-DER ECDSA signature over the above fields, signed with the card private key

The session public key is the ephemeral EC 256r1 card key for the ECDH secure channel establishment. The signature is made from the concatenation of the tag, nonce and session public key, signed with the card's static private key (whose public key is in the Cryptnox certificate). This allows the client to verify the session key authenticity.

Status Words

SW	Description
0x9000	Success
0x6984	Nonce length is not 8 bytes

10.5 INIT

Request APDU

CLA	INS	P1	P2	LC	Data
0x80	0xFE	0x00	0x00	var	PubKey(LV) IV Encrypted payload

Preconditions: Card must be in pre-initialized state.

This command is only available when the applet is in pre-initialized state and successful execution brings the applet into the initialized state. This command is needed to allow securely storing secrets on the applet. Currently these are the PIN, PUK and pairing password. The user can also enter personal info (name and email).

The client must take the public key received after the GET CARD CERTIFICATE command, generate a random keypair and perform R1 EC-DH to generate an AES key. It must then generate a random IV and encrypt the payload using AES-CBC with ISO/IEC 9797-1 Method 2 padding.

This scheme guarantees protection against passive MITM attacks. Since the applet has no “owner” before the execution of this command, protection against active MITM cannot be provided at this stage. However since the communication happens locally (either through NFC or contacted interface) the realization of such an attack at this point is unrealistic.

Request Data (wire format)

Field	Size	Description
PubKey length	1B	Length of the EC public key (65)
PubKey	65B	Client ephemeral EC R1 uncompressed point for ECDH
IV	16B	AES-CBC initialization vector
Encrypted payload	var	AES-CBC encrypted parameters (ISO 9797-1 M2 padded)

Decrypted payload content

The payload is the concatenation of the User data, PIN, PUK and the Secure Channel first pairing secret. The User data consists of the User Name and the User Email, each prepended with a byte indicating their length. For example: 0x07 | 'Cryptnox' | 0x14 | 'contact@cryptnox.com'.

These user fields can carry whatever information the user wants to input in the card: their name, an ID number, a key identifier, etc.

Field	Size	Description
Name length	1B	Length of owner name (0-20)
Name	0-20B	Owner name
Email length	1B	Length of owner email (0-60)
Email	0-60B	Owner email
PIN	9B	4-9 digit PIN, right-padded with 0x00
PUK	12B	PUK code
Pairing secret	32B	First secure channel pairing key

The PIN must be 4 to 9 figure number characters ('0'-'9'). If the PIN is less than 9 bytes, it must be filled with 0x00 until 9 chars long.

After successful execution, this command cannot be executed anymore (except after a full reset with PUK). The regular SecureChannel (with pairing) is active and PIN and PUK are initialized and validated.

Status Words

SW	Description
0x9000	Success
0x6D00	Applet already initialized
0x6A80	Invalid data (bad pubkey, non-digits in PIN, wrong decrypted length)
0x6984	Decryption invalid (wrong encryption key or bad padding)

10.6 OPEN SECURE CHANNEL

Request APDU

CLA	INS	P1	P2	LC	Data
0x80	0x10	Key idx	0x00	0x41	Client session public key

This APDU command is the first step to establish a Secure Channel session. A session is aborted when the application is deselected, either directly or because of a card power off or tear away.

In a standard use of the applet, just after selecting the applet, the client opens a secure channel using their PairingKey for this card. The user generates an EC key pair for the session and provides the public key part in this command.

P1 values

P1	Description
0x00	Pairing key slot 0
0xFF	Use SHA256 ³² (PUK) as pairing key

When $P1=0xFF$, the PUK can be used as a pairing key. This is useful when the user has lost their pairing info: the PUK hashed 32 times with SHA256 can always be used as a pairing key.

Request Data

Field	Size	Description
Client session public key	65B	EC 256r1 uncompressed point (04 X Y)

Response Data — 32 bytes

The card generates a random 256-bit salt which is sent to the client.

Field	Size	Description
Session salt	32B	Random salt for key derivation

Key derivation — performed identically by both card and client:

```
ECDHsecret = PrivateKey . CounterpartPublicKey (x-coordinate)

For the card: ECDHsecret = SessionCardPrivateKey . SessionUserPublicKey (x)
For the user: ECDHsecret = SessionUserPrivateKey . SessionCardPublicKey (x)

AESkey | MACkey = SHA512( ECDHsecret | PairingKey | Salt )
[0..31] = AESkey (256-bit encryption key)
[32..63] = MACkey (256-bit MAC key)
```

The SessionCardPublicKey is received in the GET CARD CERTIFICATE response. The SessionUserPublicKey is transmitted to the card in this command.

For the mutual authentication, any IV can be used for the first encrypted message. Then the IV to use is the latest MAC field received from the counterpart.

Status Words

SW	Description
0x9000	Success
0x6A86	Invalid P1 (unknown pairing key index)
0x6A80	Data is not a valid public key

10.7 MUTUALLY AUTHENTICATE

Request APDU (encrypted)

CLA	INS	P1	P2	LC	Data
0x80	0x11	0x00	0x00	var	MAC Encrypted random

This APDU command allows both parties to verify that the keys generated in the `OPEN SECURE CHANNEL` step are matching and thus guarantee authentication of the counterpart.

The data sent by both parties is a 256-bit random number. The APDU data is sent encrypted with the keys generated in the `OPEN SECURE CHANNEL` step. Each party must verify the MAC of the received APDU. If the MAC and padding can be verified, it means that both parties are using the same keys.

Only after this step has been executed can the secure channel be considered to be opened and other commands sent.

Request Data (plaintext before encryption)

Field	Size	Description
Random	32B	256-bit random number

Response Data (plaintext after decryption) — 32 bytes

Field	Size	Description
Random	32B	256-bit random number from the card

If the authentication fails the card responds with 0x6982. In this case the `OPEN SECURE CHANNEL` command must be repeated to generate new keys.

Note

Once the secure channel is opened, for commands requiring a secure channel, the status error codes are sent back as encrypted data through the tunnel. The last 2 bytes of the decoded data are the command status word, and the “outer plain” data are always 0x9000. The real status word is the one being encrypted in the secure channel inner data payload.

Status Words

SW	Description
0x9000	Success
0x6985	Previous APDU was not <code>OPEN SECURE CHANNEL</code>
0x6982	Authentication failed or data is not 256-bit

10.8 CHANGE PAIRING KEY

Request APDU (encrypted)

CLA	INS	P1	P2	LC	Data
0x80	0xDA	0x00	0x00	var	MAC Encrypted data

Preconditions: Secure Channel must be opened.

Update the SecureChannel PairingKey for a new one. The PUK is required for authorization.

In case the current pairing key was lost, preventing the opening of any secure channel (needed to change it), one has to use the PUK derived key as the pairing key (key index 0xFF in OPEN_SECURE_CHANNEL). The PUK pairing slot can't be changed this way, but it is automatically updated when the PUK is changed.

Request Data (plaintext)

Field	Size	Description
New PairingKey	32B	New pairing secret
PUK	12B	Current PUK for authorization

Total plaintext: 44 bytes.

Status Words

SW	Description
0x9000	Success
0x6700	Data is not 44 bytes
0x63Cx	Wrong PUK (x = remaining tries before power cycle)
0x6A86	P1 is not 0

11 Cryptographic commands

11.1 VERIFY PIN

Request APDU (encrypted)

CLA	INS	P1	P2	LC	Data
0x80	0x20	0x00	0x00	var	MAC Encrypted PIN (or empty)

Preconditions: Secure Channel must be opened.

The PIN verification is done in a standard way through the secure channel. The PIN chosen during the initialization needs to be provided after each EC signature, because a signature resets the PIN validity.

If the PIN entry is correct, the card returns 0x9000 and the PIN is marked as authenticated for the entire session (until the application is deselected, the card is reset/teared, or a signature is performed).

When there is no data in the command, the card returns 1 byte indicating the number of PIN retries left. This allows the client to check the PIN status without attempting a verification.

The PIN must be between 4 and 9 figures long.

Request Data — Verify mode (plaintext)

Field	Size	Description
PIN	4-9B	Digit characters '0' - '9'

Request Data — Query mode: Send with empty data.

Response Data (query mode) — 1 byte

Field	Size	Description
Retries remaining	1B	Number of PIN attempts left

Retry behavior: The PIN can be tested 3 times before a disconnection of the card is required. Then it can be tested 3 more times before the PIN state is locked, requiring unlocking with PUK. When the number of tries reaches 3 (per session), the card needs a power cycle before accepting new PIN verification, and it returns 0x63C0. After a power cycle, if the card still throws 0x63C0, that means the PIN is blocked and the UNBLOCK PIN command must be used.

Status Words

SW	Description
0x9000	PIN correct (verified for session)
0x63Cx	Wrong PIN. x = remaining attempts
0x63C0	Session tries exhausted (power cycle required) or PIN blocked
0x6700	Incorrect data length
0x6986	Card not initialized or PIN auth disabled

11.2 CHANGE PIN

Request APDU (encrypted)

CLA	INS	P1	P2	LC	Data
0x80	0x21	Selector	0x00	var	MAC Encrypted data

Preconditions: Secure Channel must be opened. To change the PIN: user PIN must be verified (else PUK must be provided in data).

Change the PIN or PUK. In case of invalid format, the code 0x6A80 is returned. If the conditions match, the PIN or PUK is updated and 0x9000 is returned.

The new PIN must be 9 chars long, must start with at least 4 figure characters ('0'-'9'). If the PIN is less than 9 numbers, it must be filled with 0x00 until 9 chars long. The PUK must be 12 bytes long.

P1=0x00 — Change PIN (PIN already verified):

Field	Size	Description
New PIN	9B	4-9 digits, right-padded with 0x00

The current PUK added for auth in data is mandatory if PinAuth is disabled, as the PIN can't be verified. The new PIN is verified for the session (until card power cycle or EC signature), except if PinAuth is disabled.

P1=0x00 — Change PIN (PIN not verified, use PUK instead):

Field	Size	Description
New PIN	9B	4-9 digits, right-padded with 0x00
PUK	12B	Current PUK for authorization

P1=0x01 — Change PUK:

Field	Size	Description
New PUK	12B	New PUK code
Current PUK	12B	Current PUK for authorization

Total plaintext: 24 bytes.

P1=other — Returns remaining PIN tries with 0x63Cx. Resets any user auth.

Status Words

SW	Description
0x9000	Success
0x6A80	Invalid PIN/PUK format
0x6985	PIN not validated or card not initialized. Also returned when bad PUK provided to change PIN (this is considered as PIN not validated).
0x9840	PUK given is invalid (when P1=0x01)
0x63Cx	Remaining PIN tries (when P1=other)

11.3 UNBLOCK PIN

Request APDU (encrypted)

CLA	INS	P1	P2	LC	Data
0x80	0x22	0x00	0x00	var	MAC Encrypted data

Preconditions: Secure Channel opened, PIN must be blocked, PinAuth enabled.

Unblock the user PIN. The data field must contain exactly 21 chars, otherwise SW 0x6A80 is returned. The first 12 bytes are the PUK and the last 9 digits are the new PIN. If the PUK is correct the PIN is changed to the given one, PIN is unblocked and authenticated for the rest of the session. The status code 0x9000 is returned.

The PIN must be 9 chars long, must start with 4 figure characters ('0'-'9'). If the PIN is less than 9 numbers, it must be filled with 0x00 until 9 chars long.

Request Data (plaintext) — 21 bytes

Field	Size	Description
PUK	12B	PUK code
New PIN	9B	4-9 digits, right-padded with 0x00

If the PUK is wrong, the SW 0x63Cx is sent back; x is the remaining tries left before a power cycle is required. PUK tries are unlimited, but only 12 tries can be performed on each power cycle. The card needs to be powered off (and then on) before sending new PUK. Else it throws 0x63C0 without checking the PUK.

Status Words

SW	Description
0x9000	Success (PIN unblocked and authenticated)
0x6A80	Format invalid (not 21 bytes or non-digit PIN)
0x6985	PIN is not blocked or PinAuth disabled
0x63Cx	Wrong PUK. x = remaining tries before power cycle

11.4 LOAD KEY

Request APDU (encrypted)

CLA	INS	P1	P2	LC	Data
0x80	0xD0	Key type	0x00	var	MAC Encrypted data

Preconditions: Secure Channel opened, PIN or challenge-response validated.

Load a seed or a key pair. Can also be used for dual generation of the seed (shared with 2 cards paired beforehand). Once a seed is loaded in the card, this card now behaves like the one it was backup from. Be aware that key derivation paths are not backed up and must be identical to retrieve the same key pairs.

The PIN must be at the end of the data, unless a user key auth was performed. PIN when provided is always right-filled with 0x00 up to 9 bytes. Load key checks the last 9 bytes as the PIN in case no user auth by key is valid.

P1 values

P1	Description
0x01	ECC SECP256k1 keypair (k1 only). Key source set to 'K'.
0x02	ECC SECP256k1 extended keypair with chain code (k1 only). Key source set to 'X'.
0x03	Binary seed (BIP39, 16-64 bytes). Master key nodes computed following SLIP10, compatible with BIP32. One master key for k1, one for r1. Key source set to 'L'.
0x04	Dual Gen part 1: initializes the dual generation seed mode and sends back a public key signed with the Basic Group key. Nothing is done about any key or seed loading at this stage.
0x05	Dual Gen part 2: receives the public key from the other card (plus signature). After this, both cards have a common seed. Key source set to 'D'.

P1=0x01 — EC keypair (plaintext)

Field	Size	Description
Tag 0xA1	1B	Keypair template tag
Template length	1-2B	BER-TLV length
Tag 0x80	1B	Public key tag (optional, can be omitted)
Public key length	1-2B	BER-TLV length
Public key	65B	EC uncompressed point (optional)
Tag 0x81	1B	Private key tag
Private key length	1-2B	BER-TLV length
Private key	32B	EC private key scalar
PIN	9B	Right-padded with 0x00 (omit if user auth done)

P1=0x02 — Extended keypair: Same as P1=0x01 with additional Tag 0x82 = chain code (32B).

P1=0x03 — Binary seed (plaintext)

Field	Size	Description
Seed	16-64B	BIP39 binary seed
PIN	9B	Right-padded with 0x00 (omit if user auth done)

Dual generation protocol (P1=0x04 and P1=0x05):

```
card 1 : 80D00400      -> PublicKeySigned of the 1st card
card 2 : 80D00400      -> PublicKeySigned of the 2nd card
card 1 : 80D00500 PK2   -> Send 2nd card's signed key to 1st card
card 2 : 80D00500 PK1   -> Send 1st card's signed key to 2nd card
```

After this, the 2 cards have a common seed SHA256(ECDH). One card is a backup of the other, even if no secrets were leaked externally. Even the computer doing the transfer exchange can't compute the seed (protected by ECDH). The computer can't be part of the key exchange, as this requires a signature with a secret key only located within the cards.

The common seed can be checked by making a derivation path and reading the blockchain public keys of the cards, which should match.

Status Words

SW	Description
0x9000	Success. PIN is validated for the session.
0x63Cx	Wrong PIN
0x6A80	Invalid format, invalid dual signature, or PIN expected (data len < 9B)
0x6A86	Invalid P1
0x6986	Key/seed already loaded (requires reset)

Note

This command can only be performed once. There's no way to erase the seed except with a full reset using the PUK. After successful loading with PIN, the PIN is validated for the

session. The PIN-less path is reset. Unless a `DERIVE KEY` is sent, a subsequent `SIGN` command will use the master keypair for signature.

11.5 DERIVE KEY

Request APDU (encrypted)

CLA	INS	P1	P2	LC	Data
0x80	0xD1	Options	0x00	var	MAC Encrypted path

Preconditions: Secure Channel opened, PIN or challenge-response validated, seed loaded.

This command is used before a signing session to generate a private key according to the BIP32 and SLIP10 specifications. The generated key is used for all subsequent `SIGN` sessions. The maximum depth of derivation from the master key is 8. Any attempt to get deeper results in 0x6A80 being returned.

The BIP32 specifications define a few checks which must be performed on the derived keys. If these fail (mostly using r1 curve), there is a looping mechanism described by the SLIP10 proposal, enforced by the card.

The ability to start derivation from the parent keys allows to more efficiently switch between children of the same key. Note however that only the immediate parent of the current key is cached so you cannot use this to go back in the hierarchy. If no valid parent key is available (e.g. when the current key is the master root), the status code 0x6B00 is returned.

P1 bit fields

Bits	Description
bit 4	0 = secp256k1; 1 = secp256r1
bit 5	0 = ECDSA curve; 1 = EdDSA (Ed25519)
bits 7-6	00 = from master; 01 = from parent; 10 = from current

Request Data (plaintext)

Field	Size	Description
Path elements	n × 4B	Sequence of 32-bit big-endian integers (0 to 8 levels). Empty = set master key as current.

Each path element is 4 bytes. For hardened derivation, set bit 31 (OR with 0x80000000).

A client can perform a `GET PUBKEY` command to get the actual current key path and resume derivation using a different path.

Status Words

SW	Description
0x9000	Success
0x6A80	Invalid format or depth > 8
0x6B00	Derivation from parent but no valid parent cached (e.g. master is current)
0x6985	No seed loaded or PIN not verified

11.6 GENERATE TRNG RANDOM

Request APDU (encrypted)

CLA	INS	P1	P2	LC	Data
0x80	0xD3	Size	0x00	—	None

Preconditions: Secure Channel must be opened.

Used to generate some random data from the chip internal TRNG (AIS 20 class DRG.3). The given size with P1 shall be between 16 and 64 bytes and must be a multiple of 4 (16, 20, 24, ..., 64).

This command is only an output, to use the chip secure random number generator. For example to generate a mnemonic in the host machine from a confident random source. It doesn't change any state in the card.

Response Data

Field	Size	Description
Random data	P1 bytes	Raw TRNG output from the chip

Status Words

SW	Description
0x9000	Success
0x6A86	Invalid P1 (not 16-64 or not multiple of 4)

11.7 GENERATE KEY

Request APDU (encrypted)

CLA	INS	P1	P2	LC	Data
0x80	0xD4	0x00	0x00	var	MAC Encrypted PIN

Preconditions: Secure Channel opened.

Generates a new seed and stores keys completely on card. The state of the card after execution is the same as if a `LOAD KEY` command had been performed. With the use of this command, the seed secret never escapes the card protection. If performed the simple way, there's no way to get a backup of this seed.

The key source is set to 'S'.

Request Data (plaintext)

Field	Size	Description
PIN	9B	Right-padded with 0x00 (omit if user auth done)

Status Words

SW	Description
0x9000	Success. PIN is validated for the session.
0x63Cx	Wrong PIN
0x6986	Seed/key already loaded (requires reset)
0x6A80	PIN expected or bad data

Note

This command can be performed only once after a card reset, as there's no way to erase nor change the current wallet seed key, except with a reset with the PUK. After successful generation with PIN, the PIN is validated for the session.

11.8 SIGN

Request APDU (encrypted, except pinless mode)

CLA	INS	P1	P2	LC	Data
0x80	0xC0	Key/derive	Sig type	var	MAC Encrypted data (or plaintext for pinless)

Preconditions: Secure Channel opened (except pinless), PIN or user auth or pinless, key loaded.

The card applet can sign any 256-bit hash provided, using ECDSA with 256k1 or 256r1 EC parameters. It also supports EdDSA (Ed25519) signatures on raw data, and BIP340 Schnorr signatures. Most blockchain systems use SHA2-256 to hash the message, but this card applet is agnostic from this for ECDSA, since the signature is performed on a hash provided by the user. For EdDSA, the card signs raw data directly (the EdDSA algorithm performs its own internal hashing per RFC 8032).

The ephemeral k used in the ECDSA and Schnorr is random and different for each signature. For ECDSA, this is automatically performed by the Signature function of the underlying JCOP4 platform. This applet does not use RFC6979 deterministic digital signature generation.

The derivation of the key pair node can also be done using the signature command (relative or absolute). The card derives just before signing. This can't be used to sign with a different key, and this cannot change the current stored key.

Additionally, to be compatible with blockchain specific signatures, the S part of the signature is always output as “canonical”, changed for S to be on the “lower” side (S lower than $n/2$).

P1 values

P1	Description
0x00	Current key (k1)
0x10	Current key (r1)
0x20	Current key (Ed25519)
0x01	Derive + sign with k1 (OR with bits 7-6 for source)
0x11	Derive + sign with r1 (OR with bits 7-6 for source)
0x21	Derive + sign with Ed25519 (OR with bits 7-6 for source)
0x03	Pinless path (k1 only, no SC required)

P1=0x03 is specifically thought for payment transactions. It can be executed without Secure Channel (since no sensitive info is transmitted) and does not require PIN authentication. The current derivation path on the card remains unchanged, but the signing process is performed using the PIN-less derivation path previously defined using the SET PINLESS PATH command.

P2 values

P2	Description
0x00	ECDSA with canonical low S
0x01	ECDSA with EOSIO canonical filter
0x02	Bitcoin Schnorr BIP340 (k1 only)
0x03	EdDSA (Ed25519, RFC 8032)

Request Data — P1=0x00/0x10 (current key, plaintext)

Field	Size	Description
Hash	32B	256-bit hash to sign
PIN	9B	Right-padded with 0x00 (omit if user auth or pinless)

Request Data — P1=0x01/0x11 (derive + sign, plaintext)

Field	Size	Description
Hash	32B	256-bit hash to sign
Path elements	n × 4B	Derivation path (32-bit big-endian integers)
PIN	9B	Right-padded with 0x00 (omit if user auth)

Request Data — P1=0x20 (current Ed key, plaintext)

Field	Size	Description
Data length	2B	Big-endian length of the raw data to sign
Data	1-1200B	Raw data to sign (max 1200 bytes, not a hash)
PIN	9B	Right-padded with 0x00 (omit if user auth)

Request Data — P1=0x21 (derive + sign Ed, plaintext)

Field	Size	Description
Data length	2B	Big-endian length of the raw data to sign
Data	1-1200B	Raw data to sign (max 1200 bytes, not a hash)
Path elements	n × 4B	Derivation path (32-bit big-endian integers)
PIN	9B	Right-padded with 0x00 (omit if user auth)

Request Data — P1=0x03 (pinless, plaintext, no SC)

Field	Size	Description
Hash	32B	256-bit hash to sign

Response Data — ECDSA (P2=0x00 or 0x01)

The signature is encoded as an X9.62 ASN1 DER sequence: SEQUENCE { r INTEGER, s INTEGER }. For usage on some blockchains, one needs to calculate the recovery ID in addition to the signature. To calculate the recovery ID, apply the same algorithm used for public key recovery from a transaction starting with a recovery ID of 0. If the public key matches, you have found the recovery ID, otherwise increment and try again.

Field	Size	Description
Signature	70-72B	ASN.1 DER X9.62 format

Response Data — BIP340 Schnorr (P2=0x02)

Returns 64 bytes R|S = 2x256 bits MSB first, as per BIP340 standard. The 32-byte nonce is provided by a random source in the JCOP4 platform. Works only with k1 keys.

Field	Size	Description
R	32B	Schnorr R component (MSB first)
S	32B	Schnorr S component (MSB first)

Response Data — EdDSA (P2=0x03)

Returns 64 bytes R|S as per RFC 8032 (Ed25519). The signature is computed over the raw data provided in the request (not a hash). The EdDSA algorithm performs its own internal SHA-512 hashing as specified by the standard.

Field	Size	Description
R	32B	EdDSA R component per RFC 8032
S	32B	EdDSA S component per RFC 8032

PIN behavior: The PIN must be with a 9 numbers fixed length, right-filled with 0x00. If there was no valid user auth or not in pinless mode, the data length expected is counted with the PIN included. A PIN try is always counted when calling this command with a path data longer than a 9 bytes PIN.

An EC signature resets the PIN or user key auth. That means that a PIN verification (or user sign auth) must be performed afterwards and before calling any commands which require a user auth. If several hashes are granted by user-auth-for-sign, the card expects the signatures to be done in the exact same order as the authentication. The reset of the auth occurs when all signatures are done (up to 4).

After a successful signature session, the user auth is left opened: if a PIN was provided, the PIN stays verified for other commands. If a user key auth was used, the EC auth is opened for other commands. In case of bad PIN provided, the PIN auth is disengaged.

Status Words

SW	Description
0x9000	Success
0x6A80	Data too short or path not multiple of 4
0x6A88	Pinless path not defined (P1=0x03)
0x6985	No key loaded
0x63Cx	Wrong PIN
0x6700	Data length mismatch with expected PIN
0x6B00	Unknown P1 or P2, or P2=2 with P1 not k1

11.9 DECRYPT

Request APDU (encrypted)

CLA	INS	P1	P2	LC	Data
0x80	0xC4	Mode	0x00	var	MAC Encrypted data

Preconditions: Secure Channel opened, PIN or user auth, seed loaded.

Generates a symmetric secret for simplified ECIES using an EC key in the BIP32 tree. This command is inspired by DECipher in OpenPGP smartcards. This allows an asymmetric encryption using a key in the card seed tree. Anyone can encrypt with a public key from the card, and only the (private) key in the card can decrypt.

During the seed loading, the card saves in a dedicated key slot the result of a fixed derivation path. The child EC key used for this command is fixed (relative to a given seed). The path is computed with SLIP17 for the URI “openpgp://cryptnox” with index=0:

```
m/17'/910196630'/2006168372'/332516148'/580566270'
```

The symmetric key is computed as $\text{SHA256}(k \parallel \text{PubKey})$, where k is the private ECP256r1 key in the “decrypt” key slot.

P1 values

P1	Description
0x00	Output symmetric key
0x01	Decrypt data in card using the derived AES key

P1=0x00 — Output symmetric key (plaintext)

Field	Size	Description
PIN	9B	Right-padded with 0x00 (omit if user auth done)
PubKey	65B	Third-party EC R1 uncompressed point (04 X Y)

Total: 74B (with PIN) or 65B (user auth).

Response Data (P1=0x00) — 32 bytes

Field	Size	Description
Symmetric key	32B	$\text{SHA256}(\text{ECDH}) = \text{IV}(16\text{B}) \parallel \text{AESkey}(16\text{B})$

P1=0x01 — Decrypt in card (plaintext)

When P1 is not 0, the hashed ECDH is used internally as an AES128 key: $\text{IV} \parallel \text{Key}$, with CBC. The padding is left to the outer system, so data must be padded to 16 bytes alignment (and un-padded by the caller).

Field	Size	Description
PIN	9B	Right-padded with 0x00 (omit if user auth done)
PubKey	65B	Third-party EC R1 uncompressed point
Encrypted data	n × 16B	AES-CBC encrypted data (must be 16-byte aligned)

Response Data (P1=0x01)

Field	Size	Description
Decrypted data	var	Plaintext output

Example usage: Let's call the user Alice and her friend Bob. Alice reads the “encrypt” public key by calling GET_PUBKEY with derive-from-master and derive-r1 for the SLIP17 path, getting PKA. Alice shares this public key with Bob. Bob generates an ephemeral ECr1 key pair kb/PKB, computes $\text{key} = \text{SHA256}(\text{kb} \parallel \text{PKA})$ to get IV | AESkey, encrypts the message with AES-CBC, and shares the ciphertext with Alice along with PKB. Alice calls DECRYPT with PIN | PKB | ciphertext and the card gives out the decrypted data.

The PIN/noPIN case in the data is inferred from the current user key auth status. If a user auth was performed with a user signature (CheckUserKey), this command expects no PIN. If no user auth was validated, this command expects a PIN prepending the data.

The PIN state is changed by this command: if wrong PIN, the auth is reset. If correct, the PIN is validated.

Status Words

SW	Description
0x9000	Success
0x6A80	Incorrect data length
0x6985	No key/seed loaded
0x63Cx	Wrong PIN
0x6982	Data too large (outside secure channel)

11.10 GENERATE RSA SEED WRAP KEY

Request APDU (encrypted)

CLA	INS	P1	P2	LC	Data
0x80	0xF9	0x00	0x00	var	MAC Encrypted data

Preconditions: Secure Channel must be opened.

This command generates an RSA key pair on the card that can be used to wrap (encrypt) the card's seed for secure export. The RSA key size is specified in the request data.

Request Data (plaintext)

Field	Size	Description
RSA key size	2B	Big-endian RSA key size in bits (e.g. 0x0800 = 2048)

Status Words

SW	Description
0x9000	Success
0x6A80	Invalid key size

11.11 SIGN PUBLIC

Request APDU (encrypted)

CLA	INS	P1	P2	LC	Data
0x80	0xC6	Key type	0x00	—	None (or MAC only)

Preconditions: Secure Channel opened, PIN or challenge-response validated, seed loaded.

This command certifies (signs) the current blockchain public key using the card's static private key. This allows external parties to verify that a given blockchain public key genuinely belongs to this card, by checking the signature against the card's certificate.

P1 values

P1	Description
0x00	Current key (k1)
0x10	Current key (r1)
0x20	Current key (Ed25519)

Response Data

Field	Size	Description
Signature	70-72B	ASN.1 DER ECDSA signature over the current blockchain public key, signed with the card's static private key

Status Words

SW	Description
0x9000	Success
0x6985	No key loaded or PIN not verified
0x6A86	Invalid P1

11.12 RESET

Request APDU (encrypted)

CLA	INS	P1	P2	LC	Data
0x80	0xFD	0x00	0x00	var	MAC Encrypted PUK

Preconditions: Secure Channel must be opened.

When the PUK code is sent into the RESET command, the card is reset. The reset PUK code is chosen during the initialization stage. The PUK reset code is a 12 characters long string, which allows a full reset of the card. On top of this 12 chars secret, the reset is also secured by the user pairing key mechanism (if secret). That means that resetting a card requires, on top of the PUK, to know the PairingKey to send the command encrypted. Still, the PUK can act as a PairingKey on its own.

The reset command erases everything in the card, and makes the card as it was before the initialization. All data in the card will be reset, with no way to recover (except from seed/mnemonic recovery).

Request Data (plaintext) — 12 bytes

Field	Size	Description
PUK	12B	PUK code

Note

The PUK tries are unlimited, but there's an internal loop hash that takes time inside the card for each try. Every 12 tries, a power cycle is required to perform new tries.

In the case of a power loss during reset, the card can only have its blockchain keys deleted. The card would have the flag “seeded” false and “initialized” true. This would need another reset for a full reset, or the keys need to be generated/loaded again.

Status Words

SW	Description
0x9000	Success
0x63Cx	Wrong PUK (x = remaining tries before power cycle)
0x63C0	Power cycle required before new PUK attempts
0x6A80	Data length is not 12 bytes

12 Data commands

12.1 GET CARD INFO / READ DATA

Request APDU (encrypted)

CLA	INS	P1	P2	LC	Data
0x80	0xFA	Mode	Selector	—	None (or MAC only)

Preconditions: Secure Channel must be opened.

This command is the main data-retrieval interface of the card. Depending on the P1/P2 combination, it returns card-level metadata, user key slot information, or arbitrary user data pages. It is used after establishing a secure channel to inspect the card's state and read back stored data.

P1/P2 combinations

P1	P2	Description
0x00	0x00	Card info (name, email, signature counter)
0x01-0x03	0x00	User key slot info (slot = P1)
0x00	0x01-0x0F	User data pages (page = P2-1)

Response Data — P1=0, P2=0 (Card info)

When both P1 and P2 are zero, the card returns general identity and status information that was set during initialization with the INIT command. This is useful to display the cardholder's name and email, check whether a key has been loaded, and monitor the signing activity through the signature counter.

Field	Size	Description
Key source info	1B	0x00 = no key; 'K' = single k1 pair; 'X' = extended k1 node; 'L' = external seed; 'S' = internal seed; 'D' = dual generation (see Seed management)
Name length	1B	Length of owner name
Name	0-20B	Owner name (as set during INIT)
Email length	1B	Length of owner email
Email	0-60B	Owner email (as set during INIT)
Signature counter	4B	Big-endian unsigned integer, incremented with each SIGN

Response Data — P1=1-3, P2=0 (User key slot)

When P1 is set to a slot index (1–3) with P2=0, the card returns the description and public

key stored in that user key slot. These were originally written with the [ADD USER KEY](#) command. This requires PIN verification or a successful challenge-response beforehand.

Field	Size	Description
Info text	64B	User-provided description (fixed 64 bytes, as written by ADD USER KEY)
Public key	65B or 256B	EC R1 uncompressed (65B for slot 1/3) or RSA modulus (256B for slot 2)

Response Data — P2=1-3 (User data pages)

When P2 is set to a page index (1–3), the card returns the user data stored on that page. Pages are written with the [WRITE DATA](#) command and can hold up to 1200 bytes each, for a total of 3600 bytes of user-defined storage. This also requires PIN or challenge-response.

Field	Size	Description
User data	0-1200B	Data from the requested page

Status Words

SW	Description
0x9000	Success
0x6985	Secure channel not opened, or PIN/challenge not validated (required when P1>0 or P2>0)
0x6B00	Invalid P1/P2 combination or user data slot out of range

Note

When reading user data (P2>0), the command must be sent using the extended frame format header to receive data larger than 256 bytes. This is required by the ISO 7816 standard for long response payloads, even though the command frame itself is short.

12.2 GET HISTORY

Request APDU (encrypted)

CLA	INS	P1	P2	LC	Data
0x80	0xFB	Slot	0x00	—	None (or MAC only)

Preconditions: Secure Channel opened, PIN or challenge-response validated.

The card maintains a circular history buffer of the last 149 signing operations. Each entry records the value of the signature counter at the time of signing and the 32-byte hash that

was signed. This allows the host application to audit past transactions and verify that the card's signing history matches expected blockchain activity.

The history slot number is provided in P1 (0 to 148). Slot 0 is the most recent entry.

Response Data — 36 bytes

Field	Size	Description
Signing counter	4B	Big-endian unsigned integer (counter value at time of signing)
Signed hash	32B	The 32-byte hash that was signed in this transaction

Status Words

SW	Description
0x9000	Success
0x6985	Secure channel not opened or PIN/challenge not performed
0x6A86	Invalid P1 (slot number out of range, must be 0–148)

12.3 WRITE DATA

Request APDU (encrypted)

CLA	INS	P1	P2	LC	Data
0x80	0xFC	Mode	Page	var	MAC Encrypted data

Preconditions: Secure Channel opened, PIN or challenge-response validated.

This command writes data to one of two storage areas: the user data pages (P1=0) or the custom bytes field (P1=1) that is returned in every SELECT response.

P1=0x00 — Write user data page

The card provides three pages of user-defined storage, each up to 1200 bytes, for a total of 3600 bytes. Pages are indexed by P2 (0 to 2) and must be written sequentially starting from page 0. The total user data length is computed as $(P2 \times 1200) + \text{data_size}$, meaning that lower pages are considered fully written. The card verifies that previous pages were fully written before allowing a higher page to be written; otherwise it returns 0x6985.

For example, writing 200 bytes with P2=1 sets the total user data length to 1400 bytes (1200 for page 0 + 200 for page 1). The data can later be read back with the [READ DATA](#) command.

Field	Size	Description
User data	1-1200B	Data for this page

P1=0x01 — Write custom bytes

The custom bytes are 16 bytes of public data that are returned in every SELECT response. They can be used to provide personal hints about how to authenticate with the card, or to indicate what is stored inside. Take care that anyone who has physical access to the card can freely read these bytes.

By default, the custom bytes are set to 16 times 0x00.

Field	Size	Description
Custom bytes	16B	Public data returned in every SELECT response

Status Words

SW	Description
0x9000	Success
0x6985	PIN not validated, or previous pages not fully written (P1=0)
0x6700	Data length incorrect (>1200B for P1=0, or not exactly 16B for P1=1)
0x6A86	P1 not 0 nor 1, or P2 out of range (0–2)
0x6982	Data too large (outside secure channel frame capacity)

12.4 GET PUBKEY

Request APDU (encrypted, or plaintext for pinless/clear read)

CLA	INS	P1	P2	LC	Data
0x80	0xC2	Derive	Export	var	MAC Encrypted path (or empty)

Preconditions: Secure Channel opened, PIN or challenge-response validated (except pinless or clear public key read), key loaded.

This is the primary command for exporting public keys from the card. It can return the current key's public key, the current derivation path, or a full BIP32 extended public key (xpub). It also supports on-the-fly derivation: the card computes the derived key from a given path without changing the card's current derivation state, which is useful when the host needs a public key at a specific path for address generation without affecting the signing key.

P1 values

P1	Description
0x00	Current key k1
0x10	Current key r1
0x20	Current key Ed25519
0x01	Derive with k1 (OR with bits 7-6 for derivation source)
0x11	Derive with r1 (OR with bits 7-6 for derivation source)
0x21	Derive with Ed25519 (OR with bits 7-6 for derivation source + derive flag)

When using derivation (P1 LSB = 1), the source key can be selected by OR'ing P1 with the same derivation source flags as the `DERIVE KEY` command:

- Bits 7-6 = 00: derive from master
- Bits 7-6 = 01: derive from parent
- Bits 7-6 = 10: derive from current

P2 values

P2	Description
0x00	Read current derivation path
0x01	Read public key
0x02	Read extended public key (BIP32 xpub, P1 must be 0x00)

Request Data — P1=0x01/0x11/0x21 (derive, plaintext)

Field	Size	Description
Path elements	n x 4B	32-bit big-endian integers (1 to 8 levels)

When P1=0x00/0x10/0x20 with P2=0x00 or P2=0x01, no data is required.

Response Data — P2=0x00 (path)

Field	Size	Description
Path elements	n x 4B	Current derivation path as 32-bit big-endian integers

Response Data — P2=0x01 (public key)

Field	Size	Description
Public key	65B	EC uncompressed point (04 X Y)

Response Data — P2=0x02 (extended public key)

The xpub export must first be enabled using *SET PUB EXPORT* (P1=0). By default this capability is disabled from factory and after reset.

The response approximately matches the binary serialization format defined in the BIP32 standard. The difference is the fingerprint is given as 32 bytes (the full SHA-256 of the parent key) instead of the standard 4 bytes — the host must apply an external RIPEMD-160 computation and take the first 4 bytes to obtain the final BIP32 fingerprint (except for the master key, which is all zeros). There is no checksum, as the data is not Base58-encoded.

Field	Size	Description
Version	4B	BIP32 version bytes (default: BTC mainnet 0x0488B21E)
Depth	1B	Derivation depth
Fingerprint	32B	Parent key fingerprint (needs external RIPEMD-160 to get 4B)
Child number	4B	Child index
Chain code	32B	BIP32 chain code
Public key	33B	Compressed public key

The xpub can only be read at depth ≥ 3 , in compliance with the BIP44 standard (the first 3 levels are hardened). The first 4 version bytes can be changed on the fly by the host to match the target blockchain; the card always sends BTC mainnet version bytes by default.

The extended public key is useful for wallet software to derive the last account address levels outside the card, manage address changes for each transaction, compute payment addresses in advance, and scan the address chain — all without requiring the card for each derivation.

Pinless and clear read modes

The public key can be read without PIN or secure channel in two scenarios:

1. **Pinless path:** If a pinless path was set with [SET PINLESS PATH](#), and the current derivation path starts with the EIP-1581 prefix (m/43' /60' /1581' / . . .), the public key (P2=1) can be read without authentication. No derivation is allowed in this mode.
2. **Clear public key read:** If enabled via [SET PUB EXPORT](#) (P1=1), the current public key (P1=0/0x10, P2=1) can be read without PIN or secure channel. This is designed for point-of-sale systems that need to read the card's payment address via NFC tap. No derivation is allowed in this mode.

Note

Using the derive option (P1 LSB=1), the card expects a path in the data. There is no way to derive with a null path within this command, so the master key cannot be read via live derivation. If the master public key is needed, set it as the current key with `DERIVE KEY` and then read the current key.

Status Words

SW	Description
0x9000	Success
0x6985	Not initialized, no key loaded, PIN not verified, or xpub export disabled
0x6A80	Malformed path
0x6A86	Invalid P1/P2 combination (e.g. P2=2 with P1 != 0)
0x6A88	Pinless path not set up, or clear read not allowed
0x6986	xpub requested at depth < 3
0x6983	Pinless query but current path not in the allowed range
0x6700	Current key requested with data present, or derive requested without data

13 User key & configuration commands

13.1 ADD USER KEY

Request APDU (encrypted)

CLA	INS	P1	P2	LC	Data
0x80	0xD5	0x00	0x00	var	MAC Encrypted data

Preconditions: Secure Channel must be opened.

This command registers a user public key in one of five slots. User keys provide an alternative authentication mechanism to the PIN: instead of typing a numeric code, the user proves identity by signing a challenge or a transaction hash with their private key. This enables integration with hardware security modules like iOS Secure Enclave, PC TPMs, or external FIDO authenticators.

Each slot accepts a different key type, and once a key is written to a slot, it must be deleted with [DELETE USER KEY](#) before a new key can be stored in the same slot. The key is accompanied by a 64-byte free-text description that can be read back with the [READ DATA](#) command (P1=slot index, P2=0).

Request Data — Slot 1 (EC 256r1, plaintext) — 142 bytes

Slot 1 stores an EC secp256r1 public key in X9.62 uncompressed format. This is the standard NIST P-256 curve, widely supported by secure enclaves and TPMs.

Field	Size	Description
Slot index	1B	0x01
Info text	64B	User-defined description (fixed 64 bytes, padded if shorter)
Public key	65B	EC 256r1 uncompressed (04 X Y)
PUK	12B	PUK for authorization

Request Data — Slot 2 (RSA 2048, plaintext) — 333 bytes

Slot 2 stores a 2048-bit RSA public key. Only the modulus is transmitted; the public exponent is fixed at 65537 (0x010001) and is not sent.

Field	Size	Description
Slot index	1B	0x02
Info text	64B	User-defined description (fixed 64 bytes)
RSA modulus	256B	2048-bit modulus, big-endian. Exponent must be 65537.
PUK	12B	PUK for authorization

Note

RSA commands require the extended frame format header, as the payload exceeds 256 bytes.

Request Data — Slot 3 (FIDO, plaintext) — variable

Slot 3 is a special slot designed for FIDO2/WebAuthn authenticators. In addition to the EC public key, it stores the FIDO credential identifier, which is needed by the host to request an assertion from the external authenticator during the *CHECK USER KEY* flow.

Field	Size	Description
Slot index	1B	0x03
Info text	64B	User-defined description (fixed 64 bytes)
CredID length	1B	Length of credential ID (up to 64)
CredID	1-64B	FIDO credential identifier
EC public key	65B	EC 256r1 uncompressed (04 X Y)
PUK	12B	PUK for authorization

Request Data — Slot 4 (EC 256r1, plaintext) — 142 bytes

Slot 4 stores an EC secp256r1 public key, identical in format to slot 1.

Field	Size	Description
Slot index	1B	0x04
Info text	64B	User-defined description (fixed 64 bytes, padded if shorter)
Public key	65B	EC 256r1 uncompressed (04 X Y)
PUK	12B	PUK for authorization

Request Data — Slot 5 (EC 256r1, plaintext) — 142 bytes

Slot 5 stores an EC secp256r1 public key, identical in format to slot 1.

Field	Size	Description
Slot index	1B	0x05
Info text	64B	User-defined description (fixed 64 bytes, padded if shorter)
Public key	65B	EC 256r1 uncompressed (04 X Y)
PUK	12B	PUK for authorization

Status Words

SW	Description
0x9000	Success
0x6A80	Invalid slot index
0x6700	Incorrect data length
0x6985	PIN not provided
0x6984	Invalid public key
0x6986	Slot already has a key (delete first)

Note

For the current implementation, EC public keys are not tested for point-on-curve validity when saved. On JCOP 4 platforms, the underlying hardware performs this validation implicitly during cryptographic operations.

13.2 CHECK USER KEY

Request APDU (encrypted)

CLA	INS	P1	P2	LC	Data
0x80	0xD6	Mode	0x00	var	MAC Encrypted data

Preconditions: Secure Channel must be opened.

This command authenticates the user using a public key previously registered with [ADD USER KEY](#). A successful user key authentication is equivalent to a PIN verification. There are two distinct authentication modes, serving different purposes:

1. **Auth for Sign** (P1=0x00 or P1=0x10): The user signs the transaction hash(es) to authorize a subsequent **SIGN** command. The card verifies the signature and, on success, unlocks the **SIGN** command for exactly those hash(es).
2. **Challenge-Response** (P1=0x01 then P1=0x02): The user requests a random challenge from the card, signs it with their private key, and sends the signature back. On success, this unlocks all commands that normally require PIN (except **SIGN**).

Important

The card cannot be simultaneously unlocked for “PIN” commands and for **SIGN**. When the PIN is not used, management commands must be unlocked via challenge-response (P1=1/2), then the **SIGN** must be unlocked separately via auth-for-sign (P1=0/0x10).

P1=0x00 — Auth for Sign (single hash)

Field	Size	Description
Slot index	1B	0x01-0x05
Hash	32B	Transaction hash to authorize
Signature	var	EC 256r1 ASN.1 DER (slot 1/3/4/5) or RSA 2048 PKCS#1 (slot 2)

On success (response = 0x01), the SIGN command is unlocked for this specific hash only.

P1=0x10 — Auth for Sign (hash list)

When multiple transactions need to be signed in one session, this mode accepts a list of up to 4 hashes (or 3 for FIDO slot). The signed message includes a count byte followed by the concatenated hashes.

Field	Size	Description
Slot index	1B	0x01-0x05
Hash count	1B	Number of hashes (1–4, or 1–3 for FIDO)
Hash list	n x 32B	Hashes to authorize (32B each)
Signature	var	EC 256r1 ASN.1 DER (slot 1/3/4/5) or RSA 2048 PKCS#1 (slot 2)

P1=0x01 — Challenge Request

No data required (or MAC only). The card generates a random 256-bit nonce and returns it. This challenge must then be signed by the user and submitted with P1=0x02.

Response Data — 32 bytes

Field	Size	Description
Challenge	32B	Random 256-bit nonce

Note

An active challenge survives an applet deselect. The host may disconnect the card between the request (P1=1) and the response (P1=2), then re-open a Secure Channel before submitting the response.

P1=0x02 — Challenge Response

The user submits the signed challenge to prove they hold the private key. The hash is not included in the data because the card uses the challenge it generated internally.

Field	Size	Description
Slot index	1B	0x01-0x05
Signature	var	Signature of the challenge (hash is provided by card internally)

On success (response = 0x01), this unlocks commands requiring PIN (except SIGN).

Note

The challenge is strictly single-use. Each P1=0x02 consumes the active nonce regardless of whether the signature verifies (response = 0x01) or not (response = 0x00). Replaying the same signature, or retrying a different one against the same nonce, is rejected with 0x6985. A new challenge must be requested via P1=0x01.

Important

While a challenge is active, only the following commands may be issued without invalidating it: Get Manufacturer Certificate (0xF7), Get Card Certificate (0xF8), Open Secure Channel (0x10), Mutually Authenticate (0x11), and the response itself (this command with P1=0x02). These are the commands required to re-open a Secure Channel after a deselect. Any other APDU (VERIFY PIN, DERIVE KEY, SIGN, ...) resets the auth FSM to IDLE before being processed, so a subsequent P1=0x02 is rejected with 0x6985.

P1P2=0x0301 — Read FIDO Credential ID

Returns the credential ID associated with the FIDO user key slot (slot 3), which the host needs to request an assertion from the external FIDO authenticator.

Response Data:

Field	Size	Description
CredID length	1B	Length of credential ID
CredID	var	FIDO credential identifier

FIDO Registration and Authentication Flow

The following diagram illustrates the complete FIDO2 user registration and authentication flow between the external FIDO authenticator, the host PC, and the wallet card:

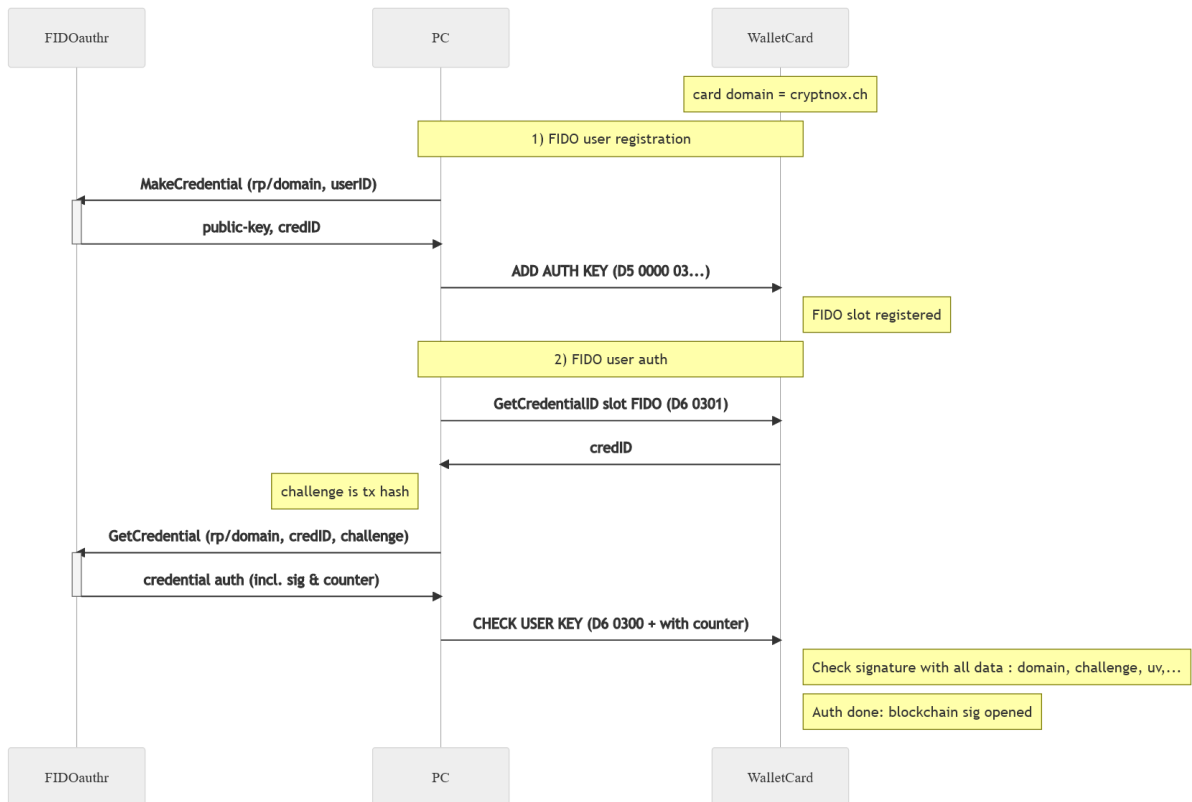


Fig. 1: FIDO2 user registration (ADD USER KEY) and authentication (CHECK USER KEY) sequence.

FIDO Signature Format (Slot 3)

When slot 3 is used for auth-for-sign or challenge-response, the data format differs from EC/RSA slots because it must include the FIDO monotonic counter. The card verifies the signature as a WebAuthn “user verified” assertion:

```
sha256(rp_id) | 0x05 | counter | sha256(clientData)
```

Where `rp_id` = "cryptnox.ch" and `clientData` is a fixed JSON template:

```
{
  "type": "webauthn.get",
  "origin": "https://cryptnox.ch",
  "challenge": "<base64url-encoded hash>",
  "clientExtensions": {}
}
```

FIDO auth-for-sign data format:

Field	Size	Description
Hash(es)	32-97B	Transaction hash(es) to authorize
Counter	4B	FIDO monotonic counter
EC signature	var	EC 256r1 ASN.1 DER

FIDO challenge-response data format (P1=0x02):

Field	Size	Description
Counter	4B	FIDO monotonic counter
EC signature	var	EC 256r1 ASN.1 DER

The FIDO slot is limited to 3 hashes (instead of 4) when using the hash-list mode (P1=0x10).

Response Data (all modes except Challenge Request and CredID read) — 1 byte

Field	Size	Description
Result	1B	0x01 = success, 0x00 = signature verification failed

Note

A return value of 0x00 with status 0x9000 means the signature was not properly verified: either the signature is invalid or the user key for this slot was not initialized. After any P1=2 attempt (failed or successful), a new challenge must be requested via P1=1 before the next P1=2; the challenge is single-use.

Status Words

SW	Description
0x9000	Success (check result byte for verification outcome)
0x6A80	Invalid slot index or incorrect data
0x6985	FIDO key not registered (CredID read), P1=2 sent without an active challenge (no prior P1=1, already consumed, or invalidated by a non-allowlisted APDU)

13.3 DELETE USER KEY

Request APDU (encrypted)

CLA	INS	P1	P2	LC	Data
0x80	0xD7	0x00	0x00	var	MAC Encrypted data

Preconditions: Secure Channel must be opened.

Deletes the user public key from the specified slot. Once a key has been written to a slot with [ADD USER KEY](#), it cannot be overwritten directly — it must first be deleted with this command. The PUK is required for authorization, providing an additional layer of protection against unauthorized key removal.

Request Data (plaintext) — 13 bytes

Field	Size	Description
Slot index	1B	0x01-0x05
PUK	12B	PUK for authorization

Status Words

SW	Description
0x9000	Success
0x6A80	Invalid slot index
0x6700	Data length not 13 bytes
0x63Cx	Wrong PUK (x = remaining tries before power cycle)
0x6986	Slot is empty (nothing to delete)

13.4 SET PINLESS PATH

Request APDU (encrypted)

CLA	INS	P1	P2	LC	Data
0x80	0xC1	0x00	0x00	var	MAC Encrypted data

Preconditions: Secure Channel opened, seed or extended key loaded.

This command enables the pinless signing feature, which allows the `SIGN` command to be executed without PIN authentication or even a secure channel. This is specifically designed for contactless (NFC) payment transactions where typing a PIN is impractical, such as tap-and-pay at a point of sale.

For security, the pinless path is restricted to a BIP32 derivation path that must begin with the EIP-1581 prefix `m/43'/60'/1581'`. EIP-1581 defines a purpose path for non-wallet usage of keys, providing a clear segregation between pinless keys and standard PIN-protected wallet keys. Despite this naming, the keys can still be used for wallet transactions — the path restriction is purely a security boundary.

The path must be at least 3 levels deep and at most 8 levels. It is provided as raw 32-bit big-endian integers, 4 bytes per level, in the same format as the `DERIVE KEY` command.

This feature only supports the K1 (secp256k1) key pair.

Request Data — Enable pinless (plaintext)

Field	Size	Description
PUK	12B	PUK for authorization
Path elements	12-32B	3-8 levels x 4 bytes (32-bit big-endian)

Path must start with `m/43'/60'/1581'` (EIP-1581 prefix):

```
0x80000002B | 0x80000003C | 0x80000062D | ...
```

Request Data — Disable pinless (plaintext)

To disable the pinless feature, send the command with only the PUK and no path data. The PUK verification still applies.

Field	Size	Description
PUK	12B	PUK for authorization (no path = disable)

Status Words

SW	Description
0x9000	Success
0x63Cx	Wrong PUK (x = remaining tries before power cycle)
0x6A80	Data length not a multiple of 4, or path not between 12 and 32 bytes
0x6983	Path doesn't start with EIP-1581 prefix (<code>m/43'/60'/1581'</code>)
0x6985	No seed or extended key loaded (checked before PUK)

13.5 SET PIN AUTH

Request APDU (encrypted)

CLA	INS	P1	P2	LC	Data
0x80	0xC3	0x00	0x00	var	MAC Encrypted data

Preconditions: Secure Channel must be opened.

This command controls whether PIN-based authentication is allowed. By default, both PIN and user key authentication are available. Disabling PIN auth forces the user to authenticate exclusively through the [CHECK USER KEY](#) mechanism (EC/RSA/FIDO signatures).

This is useful in high-security deployments where a numeric PIN is considered insufficient and all authentication must go through a hardware key (Secure Enclave, TPM, FIDO authenticator).

When disabling PIN auth (status byte > 0), the card verifies that at least one user public key has been registered; otherwise it returns 0x6986. This prevents accidentally locking the user out of the card.

To re-enable PIN auth, call this command with the status byte set to 0x00.

Request Data (plaintext) — 13 bytes

Field	Size	Description
Status	1B	0x00 = enable PIN auth; >0 = disable PIN auth
PUK	12B	PUK for authorization

Status Words

SW	Description
0x9000	Success
0x63Cx	Wrong PUK (x = remaining tries before power cycle)
0x6A80	Data length is not 13 bytes
0x6986	Disable requested but no user public key loaded

13.6 SET PUB EXPORT

Request APDU (encrypted)

CLA	INS	P1	P2	LC	Data
0x80	0xC5	Feature	0x00	var	MAC Encrypted data

Preconditions: Secure Channel opened, seed loaded.

This command controls two independent public key export features. Both are disabled by default from factory and after every card reset, ensuring that public key data is not accidentally exposed.

P1=0x00 — Extended public key (xpub) export

Enables or disables the ability to read extended public keys (BIP32 xpub) via the [GET PUB-KEY](#) command with P2=0x02. The xpub contains the chain code and is sufficient to derive all child public keys at that level and below, making it a sensitive piece of data that allows address enumeration.

P1=0x01 — Clear public key reading (without PIN or SC)

Enables or disables the ability to read the current public key without PIN verification or even a secure channel. This is designed for point-of-sale scenarios where a reader needs to identify the card's payment address via a simple NFC tap. When enabled, the public key can be read by anyone with physical access to the card.

P1 values

P1	Description
0x00	xpub export capability
0x01	Clear public key reading (without PIN or SC)

Request Data (plaintext) — 13 bytes

Field	Size	Description
Status	1B	0x00 = disable; >0 = enable
PUK	12B	PUK for authorization

Status Words

SW	Description
0x9000	Success
0x63Cx	Wrong PUK (x = remaining tries before power cycle)
0x6A80	Data length is not 13 bytes
0x6985	No seed or extended key loaded
0x6A86	P1 is not 0 or 1

14 MuSig2 commands (BIP-327)

The card implements the on-card half of the BIP-327 MuSig2 multi-signature protocol. MuSig2 produces a single Schnorr (BIP-340) signature that is indistinguishable from a non-MuSig signature on-chain, while requiring two communication rounds between cosigners. The card acts as one of the cosigners holding its share of the aggregate private key; key aggregation, nonce aggregation and the host-side Taproot tweak are performed off-card.

The protocol uses three commands run in sequence:

1. **NONCE GEN** (INS 0xC7) — the card generates its own pair of secret nonces (k_1 , k_2) and returns the matching public pair (R_1 , R_2).
2. **LOAD COSIGNER KEY** (INS 0xC8 P1=01) — the host sends each cosigner public key (including the card's own) so the card can build the KeyAgg list hash L incrementally.
3. **PARTIAL SIGN** (INS 0xC8 P1=02) — the host sends the aggregate nonce ($aggR_1$, $aggR_2$), the aggregate public key Q , and the message hash. The card returns its 32-byte partial signature.

Note

The card is curve-fixed on secp256k1 for MuSig2. Only the wallet's k_1 key (or the pinless k_1 key if applicable) is usable as the signing key. The card never aggregates the partial signatures itself — aggregation is the host's responsibility.

Protocol state machine

The card enforces the protocol order with an internal state machine. Calls outside the expected sequence are rejected with 0x6985.

State	Set by	Accepts
IDLE	Card reset, after PARTIAL SIGN, after rejected PARTIAL SIGN	NONCE GEN
NONCE_GENERATED	Successful NONCE GEN	LOAD COSIGNER KEY, NONCE GEN (restarts)
WAIT_COSIGNERS	First successful LOAD COSIGNER KEY	LOAD COSIGNER KEY (more), PARTIAL SIGN

After a card disconnect between LOAD COSIGNER KEY and PARTIAL SIGN, the card auto-demotes back to NONCE_GENERATED so the host can resend the cosigner list. The active nonce pair (k_1 , k_2) and the binding to the card's signing key remain available across a disconnect, so NONCE GEN does not need to be re-issued.

14.1 NONCE GEN

Request APDU (encrypted)

CLA	INS	P1	P2	LC	Data
0x80	0xC7	0x00	0x00	0x00	MAC

Preconditions: Secure Channel opened, seed loaded, PIN or user-key authentication performed (or pinless path active).

Generates the card's MuSig2 secret nonce pair (k_1 , k_2) and returns the corresponding public points (R_1 , R_2). The returned nonces are bound to the card's signing key $pk = sk * G$: `LOAD COSIGNER KEY` uses this binding to detect pk in the cosigner list, and `PARTIAL SIGN` verifies the signing key has not changed in between (BIP-327 requires $pk == seckey[64:97]$).

The secret nonces are derived per BIP-327 NonceGen. Two successive `NONCE GEN` calls always produce different nonce pairs.

Response Data — 66 bytes

Field	Size	Description
R1	33B	Compressed EC point $k_1 * G$
R2	33B	Compressed EC point $k_2 * G$

Note

An active nonce pair (k_1 , k_2) remains available across a card disconnect. It is destroyed after `PARTIAL SIGN` (successful or rejected), after a full reset, and at the start of any new `NONCE GEN` call. The host is expected to use each nonce pair exactly once; reusing nonces across two different messages leaks the private key by linear algebra. The card enforces this by destroying the nonces after each sign.

Status Words

SW	Description
0x9000	Success
0x6985	PIN or user-key auth not performed, or seed not loaded

14.2 LOAD COSIGNER KEY

Request APDU (encrypted)

CLA	INS	P1	P2	LC	Data
0x80	0xC8	0x01	0x00	0x21	MAC Encrypted data

Preconditions: Secure Channel opened, PIN or user-key authentication performed (or pinless path active), state is `NONCE_GENERATED` or `WAIT_COSIGNERS`.

Feeds one cosigner public key (33-byte compressed) into the incremental KeyAgg list hash $L = \text{sha256}(\text{"KeyAgg list"} \parallel \text{pk1} \parallel \text{pk2} \parallel \dots \parallel \text{pkN})$. Must be called once per cosigner, including the card's own key. The order must match the order the host uses to compute the aggregate public key Q .

A maximum of 32 cosigners can be loaded in a single session; the 33rd call is rejected with 0x6985.

While processing each key, the card compares it against its own signing key pk . If a match is found, `PARTIAL_SIGN` will be allowed to proceed, mirroring the BIP-327 Sign algorithm's check pk in `pubkeys`.

Request Data — 33 bytes

Field	Size	Description
Cosigner pubkey	33B	Compressed EC point (02 X or 03 X)

Status Words

SW	Description
0x9000	Success
0x6700	Data length is not 33 bytes
0x6985	State is not <code>NONCE_GENERATED</code> or <code>WAIT_COSIGNERS</code> , PIN / user-auth not performed, or cosigner-count limit (32) reached

14.3 PARTIAL SIGN

Request APDU (encrypted)

CLA	INS	P1	P2	LC	Data
0x80	0xC8	0x02	0x00	0xC3	MAC Encrypted data

Preconditions: Secure Channel opened, state is `WAIT_COSIGNERS`, PIN or user-key auth performed (or pinless path active), card's own key seen via `LOAD_COSIGNER_KEY`.

Computes and returns the card's partial signature s_i per BIP-327 Sign:

```

b  = tagged_hash("MuSig/noncecoef", aggR1 || aggR2 || Q.x || msg) mod n
R  = aggR1 + b * aggR2
e  = tagged_hash("BIP0340/challenge", R.x || Q.x || msg) mod n
a_i = tagged_hash("KeyAgg coefficient", L || pk_i) mod n
s_i = (k1 + b * k2 + e * a_i * sk) mod n

```

The card never returns R , e , a_i or any other intermediate; only s_i . After the call, the active nonce pair ($k1$, $k2$) is destroyed and the state machine returns to IDLE regardless of the outcome; a new NONCE GEN is required for the next signature.

Before returning s_i , the card verifies the BIP-327 PartialSigVerifyInternal equation $s_i * G == R e^* + e * a_i * g' * P$ on its own partial signature. If the equation does not hold, the call is rejected with 0x6985 and the signing session is terminated; the host must restart from a new NONCE GEN.

Request Data — 195 bytes

Field	Size	Description
aggR1	65B	Uncompressed EC point (04 X Y), sum of cosigners' R1
aggR2	65B	Uncompressed EC point (04 X Y), sum of cosigners' R2
aggPubKey Q	33B	Compressed aggregate public key (host-computed, must already be tweaked if Taproot)
Message	32B	Message hash (typically a Taproot sig_msg)

Response Data — 32 bytes

Field	Size	Description
Partial signature s_i	32B	Scalar mod n

Note

The aggregate public key q provided in the request must already include the host-side Taproot tweak when applicable. The card does not apply BIP-341 tweaks. Sending an untweaked Q for a Taproot output yields a signature that will not verify under the on-chain key.

Important

PARTIAL SIGN is single-use per NONCE GEN call. The nonces are destroyed before the function returns and the state goes back to IDLE, so a second PARTIAL SIGN against the same aggR1, aggR2 is rejected. To sign another message, run a full NONCE GEN → LOAD COSIGNER KEY (× N) → PARTIAL SIGN cycle.

Status Words

SW	Description
0x9000	Success
0x6700	Data length is not 195 bytes
0x6985	State is not WAIT_COSIGNERS, card's own key not in cosigner list, PIN/user-auth not performed, or BIP-327 internal check failed (R at infinity, a_i == 0, pk != seckey[64:97], s >= n, etc.)
0x6F00	Internal computation failure (operands out of range); the signing session is terminated on this path

14.4 References

- BIP-327 — *MuSig2 for BIP340-compatible Multi-Signatures*
- BIP-340 — *Schnorr Signatures for secp256k1*
- BIP-341 — *Taproot: SegWit version 1 spending rules* (host-side tweak only)

15 Status codes reference

15.1 Standard status words

SW	Description
0x9000	Success. When secure channel is open, this is always the outer SW; the real SW is encrypted in the response data.
0x63Cx	Authentication failure. x = remaining tries. 0x63C0 = no tries left (power cycle required for PIN, or PUK tries exhausted for this session).
0x6700	Wrong data length.
0x6982	Security status not satisfied. MAC verification failed — secure channel is aborted. Returned without MAC.
0x6983	Path not allowed (e.g., pinless path does not start with EIP-1581).
0x6984	Invalid data (decryption failed, invalid public key).
0x6985	Conditions not satisfied (secure channel not open, PIN not verified, card not initialized, seed not loaded).
0x6986	Command not allowed (key slot already filled, PIN auth disabled, xpub at depth < 3).
0x6A80	Incorrect data parameters (invalid format, bad PIN format, malformed path).
0x6A86	Incorrect P1/P2 parameter.
0x6A88	Referenced data not found (pinless path not set, clear pubkey read not allowed).
0x6B00	Wrong parameters (invalid parent key, unknown P1/P2 value).
0x6D00	Instruction not supported (e.g., INIT on already initialized card).
0x9840	PUK verification not successful (used in CHANGE PIN with P1=PUK).

15.2 Secure channel status words

When the secure channel is open, all response status words are 0x9000 in the outer (plaintext) APDU. The actual status word is the last 2 bytes of the decrypted response data.

The only exception is 0x6982, which indicates the secure channel has been aborted and is returned in plaintext (without MAC).

See also

Secure channel for the full encryption/decryption process and MAC generation details.

15.3 PIN retry behavior

Counter	Behavior
Per-session (transient)	3 tries per power cycle. After 3 failures, returns 0x63C0 until power cycle.
Persistent	6 total tries across sessions. Depleted = PIN blocked, requires PUK to unblock.

See also

[VERIFY PIN](#) and cmd-unblock-pin for the full APDU specifications.

15.4 PUK retry behavior

Counter	Behavior
Per-session (transient)	12 tries per power cycle. After 12 failures, returns 0x63C0 until power cycle.
Persistent	None. PUK tries are unlimited across power cycles.

See also

[Lifecycle management](#) for details on card reset using the PUK.

16 Cryptographic assets

The Cryptnox Hardware Wallet card manages several cryptographic assets throughout its life-cycle. This section provides an overview of all key material, credentials, and derived secrets handled by the card.

16.1 Factory Dual Basic Group Secret

Scope	Secure Element (factory-loaded)
Description	EC secret used for the dual generation protocol and to sign public material exchanged between paired cards. Protects the integrity of the dual-gen exchange.
Notes	Loaded at factory; used in dual generation signatures.

16.2 Card long-term attestation key

Scope	Secure Element (card keypair)
Description	Card's permanent EC keypair (R1) used to sign the card certificate and authenticate ephemeral session keys.
Notes	Readable only as the certificate via GET MANUFACTURER CERTIFICATE / GET CARD CERTIFICATE.

16.3 Session ephemeral private key

Scope	Secure Element (ephemeral, per session)
Description	Short-lived EC private key generated inside the card and used for ECDH in the secure channel. Never exported.
Notes	Exposed externally only as the card's ephemeral public key inside the basic card certificate (GET CARD CERTIFICATE).

16.4 Pairing key

Scope	Card secure storage (32 bytes)
Description	The 32-byte secret used to derive AES/MAC session keys with a host for the authenticated secure channel. There is one pairing key slot; can be public if desired but normally kept secret.
Notes	Set at INIT; used in OPEN_SECURE_CHANNEL key derivation; changeable with CHANGE_PAIRING_KEY. Fallback: a PUK-derived pairing key (SHA-256 ³² of PUK) can be used (index 0xFF).

16.5 Secure Channel session keys (AES / MAC)

Scope	Volatile (session only)
Description	Keys derived from ECDH(SessionCardPriv, SessionUserPub) PairingKey SessionSalt via SHA-512, split into AES and MAC keys. Protect confidentiality and integrity of APDUs while the channel is open.
Notes	Derived during OPEN_SECURE_CHANNEL. Not persistent.

16.6 PIN

Scope	Card secure storage
Description	User numeric PIN (4–9 digits) used to authenticate the user for most protected operations. PIN verification state is session-valid until a signature or deselect/power-off.
Notes	INIT, VERIFY_PIN, CHANGE_PIN, UNBLOCK_PIN. Retry counters and power-cycle rules apply.

16.7 PUK

Scope	Card secure storage (12 bytes)
Description	Card reset/unblock secret. Used to unblock PIN, authorize PUK-protected changes (e.g., change pairing key, set pinless path, set pub export), and perform RESET.
Notes	INIT, RESET, CHANGE_PAIRING_KEY, SET_PIN_AUTH. Unlimited attempts but throttled with power-cycle behavior.

16.8 PUK-derived pairing fallback

Scope	Derived (fallback)
Description	Deterministic pairing key obtained by hashing the PUK 32 times with SHA-256; usable as pairing key index 0xFF if pairing information is lost.
Notes	Used via <code>OPEN SECURE CHANNEL</code> with <code>P1=0xFF</code> .

16.9 User private keys (off-card)

Scope	Host device (e.g., TPM / Secure Enclave)
Description	Private keys kept on a host device used to perform challenge-response authentication against the card. The card stores only the corresponding public key. These act as PIN replacements.
Notes	Card stores public keys in slots via <code>ADD USER KEY</code> ; verification via <code>CHECK USER KEY</code> . Private keys must be protected by the host.

16.10 FIDO credential (slot 3)

Scope	Card slot (credential ID + public key)
Description	FIDO credential identifier and associated EC public key. Used to verify WebAuthn-style signatures for PIN replacement or signing authorization.
Notes	<code>ADD USER KEY</code> (slot 3) stores credential ID length, credential ID, EC public key, and PUK. Verified via <code>CHECK USER KEY</code> .

16.11 Pinless path derivation settings

Scope	Card secure storage
Description	The BIP32 derivation path used for PIN-less signing (e.g., <code>m/43'/60'/1581'/...</code>); guarded by PUK to set/unset. Enables transactions without PIN when used via the pinless <code>SIGN</code> mode.
Notes	<code>SET PINLESS PATH</code> with PUK. Pinless signing via <code>SIGN</code> with <code>P1=0x03</code> .

16.12 Dual-generation partial secrets

Scope	Secure Element (temporary during dual-gen)
Description	During the dual-generation protocol, two cards each generate a partial secret and exchange signed public material to produce a shared seed (SHA-256(ECDH)). Each card stores its part; the final shared seed becomes the card seed.
Notes	LOAD KEY with P1=0x04 / P1=0x05 sequence. Signature checks use the Basic Group Secret.

16.13 Master seed

Scope	Secure Element (non-exportable)
Description	The 256-bit master seed (BIP32 / SLIP-0010) – the root of all derived blockchain keys. From this single seed, three independent key hierarchies are derived: secp256k1 (Bitcoin, Ethereum), secp256r1 (FIDO, secure messaging), and EdDSA (Ed25519, Solana, Cardano). This is the ultimate cryptographic asset: it cannot be read or exported, only destroyed via RESET with PUK.
Notes	Generated on-card (GENERATE KEY) or loaded (LOAD KEY with P1=0x03). Once set, it cannot be changed except by RESET with PUK.

Important

All cryptographic assets stored in the Secure Element are strictly non-exportable. Private keys and seeds never leave the card boundary. Recovery is only possible through dual-generated backup cards or re-importing an externally held seed.

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