

# MF1P(H)x2

## MIFARE Plus EV2

Rev. 3.1 — 9 August 2021

Product short data sheet  
COMPANY PUBLIC

## 1 General description

---

MIFARE Plus EV2 (MF1P(H)x2) is the latest addition to the MIFARE Plus product family with enhanced performance at best in class security and flexibility. MIFARE Plus EV2 is Common Criteria EAL5+ security certified product serving the same security certification level as demanded for banking and electronic passport contactless IC products. It is the new benchmark to the mainstream contactless smart card applications with the possibility to upgrade existing infrastructure and services in a seamless way and with minimum effort. Based on these parameters MIFARE Plus EV2 is a trusted platform targeting the secure authentication of people with an intuitive convenient user experience.

MIFARE Plus EV2 is fully backward compatible to its predecessor as well as to the MIFARE Classic EV1 products. After the card personalization MIFARE Plus EV2 allows AES (Advanced Encryption Standard) for authentication, data integrity and encryption. MIFARE Plus is based on open global standards for both air interface and cryptographic methods at the highest security level.

MIFARE Plus EV2 contains features like the fully encrypted communication mode enabling contactless applications to address privacy sensitive applications. With its optional support of Random ID, it enables compliance with latest user data protection regulations.

MIFARE Plus EV2 is fully compliant with the contactless proximity smart card protocol according to ISO/IEC 14443-4. ISO/IEC 7816-4 is supported in security level 3 based on AES protocol to making it compatible with the majority of existing contactless infrastructure devices and with NFC devices, such as NFC enabled mobile handsets. Its contactless performance supports superior user convenience and reading distances up to 10 cm.

The non-volatile memory of the MIFARE Plus EV2 is organized in sectors of blocks with either 2k or 4k byte memory to allow a seamless migration from legacy to more advanced products by a step-by-step upgrade of existing infrastructures to higher security, where needed. That is served with the possibility of sector-wise security upgrades of the card.

MIFARE Plus EV2 allows in the MIFARE Classic EV1 backward compatible mode to restrict data and value blocks as well SectorTrailers without the need to permanently lock these blocks and related SectorTrailer(s). That is enabled by restriction of an update operation to blocks configured as restricted configuration block independent of the access condition configuration of the SectorTrailer.

MIFARE Plus EV2 offers a Transaction Timer feature to allow the card issuer to configure a maximum time a transaction can take. Furthermore, a Transaction Message Authentication (TMAC) is supported that allows operators of, e.g., payment applications to calculate a cryptographic checksum over the complete transaction enabling the verification of a transaction by a clearing entity.

MIFARE Plus EV2 is designed to support standards Class 1 smart cards antenna designs with a 17 pF input capacitance as well as smaller form factors, i.e. key fobs,



wristbands, by providing 70 pF input capacitance delivery forms. This ensures high user convenience throughout different form factors. This ensures high user convenience throughout different form factors.

Furthermore, MIFARE Plus EV2 offers two ways to check the originality of the product. Either based on a symmetric AES authentication with the 128-bit AES originality key or an asymmetric ECC-based NXP Originality Signature to verify the origin of a ticket with a certain confidence.

## 2 Features and benefits

- 2 kB, 4 kB non-volatile memory
- 7-byte UID, 4-byte NUID
- Supports ISO/IEC 14443-3 <sup>1</sup> Random ID for all UID types
- Communication speed up to 848 kbit/s
- Freely configurable access conditions
- Security Level (SL) concept for seamless migration from legacy infrastructure to high-level SL3 security
- Sequential writing of the personalization keys (in SL0)
- AES-128 cryptography for authentication and secure messaging (optional in SL1, mandatory in SL3)
- SL3 CardSecurityLevel or sector-by-sector security level upgrade possible (SectorSecurityLevel)
- SL1SL3Mix mode to allow secure backend connections into SL1 sectors
- Configuration block to restrict update operations for Data/Value Blocks and Sector Trailers in the MIFARE Classic EV1 backwards compatible mode
- Multi-sector authentication, multi-block read and write
- Anti-tearing mechanism for AES keys and for data block writing
- Virtual card concept using ISO/IEC 7816-4 compliant selection method
- Proximity check fully ISO/IEC 14443-3 compliant
- Transaction MAC on value and data blocks
- Transaction Timer to mitigate Man-in-the-Middle attacks
- Direct commit personalization from SL0 to SL1 or SL3
- Common Criteria Certification: EAL5+ <sup>2</sup>
- ECC-based NXP Originality Signature
- AES-based originality key leveraging the AES authentication

<sup>1</sup> ISO/IEC 14443-x used in this data-sheet refers to ISO/IEC 14443 Type A.

<sup>2</sup> (AVA\_VAN.5 implying resistance against attackers with HIGH attack potential)

### 3 Applications

- Public transportation
- Access management
- Event ticketing
- Electronic voucher
- Loyalty card
- Micro-payment

### 4 Quick reference data

Table 1. Quick reference data

| Symbol   | Parameter                                | Conditions                                    | Min     | Typ       | Max | Unit       |
|--|--|---|---------|-----------|-----|------------|
| $f_i$  | input frequency                          |   | -       | 13.56     | -   | MHz        |
| $V_{\min, LA-LB}$  | LA/LB minimum voltage at $H_{\min}$      |   | -       | 2.2       | -   | V          |
| $Z_{LA-LB}$  | LA/LB impedance at $H_{\min}$            |   | -       | 1.2       | -   | k $\Omega$ |
| $C_i$  | input capacitance MF1Px2 <sup>[1]</sup>  | $T_{\text{amb}} = 25\text{ }^{\circ}\text{C}$ | -       | 17        | -   | pF         |
|  | input capacitance MF1PHx2 <sup>[1]</sup> | $T_{\text{amb}} = 25\text{ }^{\circ}\text{C}$ | -       | 66.5      | -   | pF         |
| <b>Non-Volatile memory characteristics characteristics</b> |  |   |         |           |     |            |
| $t_{\text{ret}}$   | retention time                           | $T_{\text{amb}} = 25\text{ }^{\circ}\text{C}$ | 25      | -         | -   | year       |
| $N_{\text{endu(W)}}$                                       | write endurance                          | $T_{\text{amb}} = 25\text{ }^{\circ}\text{C}$ | 200,000 | 1,000,000 | -   | cycle      |

[1]  $f_i = 13.56\text{ MHz}$ ;  $2.2\text{ V RMS}$

## 5 Ordering information

Table 2. MF1Px2

| Type number    | Package |  |          | Configuration |            |             |
|----------------|---------|--|----------|---------------|------------|-------------|
|                | Name    | Description  | Version  | Non-Volatile  | Input Cap. | UID         |
| MF1P2201DUD/00 | FFC     | 12-inch wafer (Sawn, 120 µm thickness) <sup>[1]</sup>  | SOT500-2 | 2k byte       | 17 pF      | 7-byte      |
| MF1P2231DUD/00 | FFC     | 12-inch wafer (Sawn, 120 µm thickness) <sup>[1]</sup>  | SOT500-2 | 2k byte       | 17 pF      | 4-byte NUID |
| MF1P4201DUD/00 | FFC     | 12-inch wafer (Sawn, 120 µm thickness) <sup>[1]</sup>  | SOT500-2 | 4k byte       | 17 pF      | 7-byte      |
| MF1P4231DUD/00 | FFC     | 12-inch wafer (Sawn, 120 µm thickness) <sup>[1]</sup>  | SOT500-2 | 4k byte       | 17 pF      | 4-byte NUID |
| MF1P2200DA8/00 | MOA8    | Plastic leadless module carrier package <sup>[2]</sup> | SOT500-4 | 2k byte       | 17 pF      | 7-byte      |
| MF1P2230DA8/00 | MOA8    | Plastic leadless module carrier package <sup>[2]</sup> | SOT500-4 | 2k byte       | 17 pF      | 4-byte NUID |
| MF1P4200DA8/00 | MOA8    | Plastic leadless module carrier package <sup>[2]</sup> | SOT500-4 | 4k byte       | 17 pF      | 7-byte      |
| MF1P4230DA8/00 | MOA8    | Plastic leadless module carrier package <sup>[2]</sup> | SOT500-4 | 4k byte       | 17 pF      | 4-byte NUID |
| MF1P2200DA4/00 | MOA4    | Plastic leadless module carrier package <sup>[2]</sup> | SOT500-2 | 2k byte       | 17 pF      | 7-byte      |
| MF1P2230DA4/00 | MOA4    | Plastic leadless module carrier package <sup>[2]</sup> | SOT500-2 | 2k byte       | 17 pF      | 4-byte NUID |
| MF1P4200DA4/00 | MOA4    | Plastic leadless module carrier package <sup>[2]</sup> | SOT500-2 | 4k byte       | 17 pF      | 7-byte      |
| MF1P4230DA4/00 | MOA4    | Plastic leadless module carrier package <sup>[2]</sup> | SOT500-2 | 4k byte       | 17 pF      | 4-byte NUID |

[1] 12-inch wafer (Sawn; on film frame carrier; electronic fail die marking according to SECS-II format), see [\[1\]](#)

[2] Plastic lead-less module carrier package; 35 mm wide tape

Table 3. MF1PHx2

| Type number     | Package |  |          | Configuration |            |             |
|-----------------|---------|--|----------|---------------|------------|-------------|
|                 | Name    | Description  | Version  | Non-Volatile  | Input Cap. | UID         |
| MF1PH2201DUD/00 | FFC     | 12-inch wafer (Sawn, 120 µm thickness) <sup>[1]</sup>  | SOT500-2 | 2k byte       | 70 pF      | 7-byte      |
| MF1PH2231DUD/00 | FFC     | 12-inch wafer (Sawn, 120 µm thickness) <sup>[1]</sup>  | SOT500-2 | 2k byte       | 70 pF      | 4-byte NUID |
| MF1PH4201DUD/00 | FFC     | 12-inch wafer (Sawn, 120 µm thickness) <sup>[1]</sup>  | SOT500-2 | 4k byte       | 70 pF      | 7-byte      |
| MF1PH4231DUD/00 | FFC     | 12-inch wafer (Sawn, 120 µm thickness) <sup>[1]</sup>  | SOT500-2 | 4k byte       | 70 pF      | 4-byte NUID |
| MF1PH2200DA8/00 | MOA8    | Plastic leadless module carrier package <sup>[2]</sup> | SOT500-4 | 2k byte       | 70 pF      | 7-byte      |
| MF1PH2230DA8/00 | MOA8    | Plastic leadless module carrier package <sup>[2]</sup> | SOT500-4 | 2k byte       | 70 pF      | 4-byte NUID |
| MF1PH4200DA8/00 | MOA8    | Plastic leadless module carrier package <sup>[2]</sup> | SOT500-4 | 4k byte       | 70 pF      | 7-byte      |
| MF1PH4230DA8/00 | MOA8    | Plastic leadless module carrier package <sup>[2]</sup> | SOT500-4 | 4k byte       | 70 pF      | 4-byte NUID |
| MF1PH2200DA4/00 | MOA4    | Plastic leadless module carrier package <sup>[2]</sup> | SOT500-2 | 2k byte       | 70 pF      | 7-byte      |
| MF1PH2230DA4/00 | MOA4    | Plastic leadless module carrier package <sup>[2]</sup> | SOT500-2 | 2k byte       | 70 pF      | 4-byte NUID |
| MF1PH4200DA4/00 | MOA4    | Plastic leadless module carrier package <sup>[2]</sup> | SOT500-2 | 4k byte       | 70 pF      | 7-byte      |
| MF1PH4230DA4/00 | MOA4    | Plastic leadless module carrier package <sup>[2]</sup> | SOT500-2 | 4k byte       | 70 pF      | 4-byte NUID |

[1] 12-inch wafer (Sawn; on film frame carrier; electronic fail die marking according to SECS-II format), see [\[1\]](#)

[2] Plastic lead-less module carrier package; 35 mm wide tape

6 Block diagram

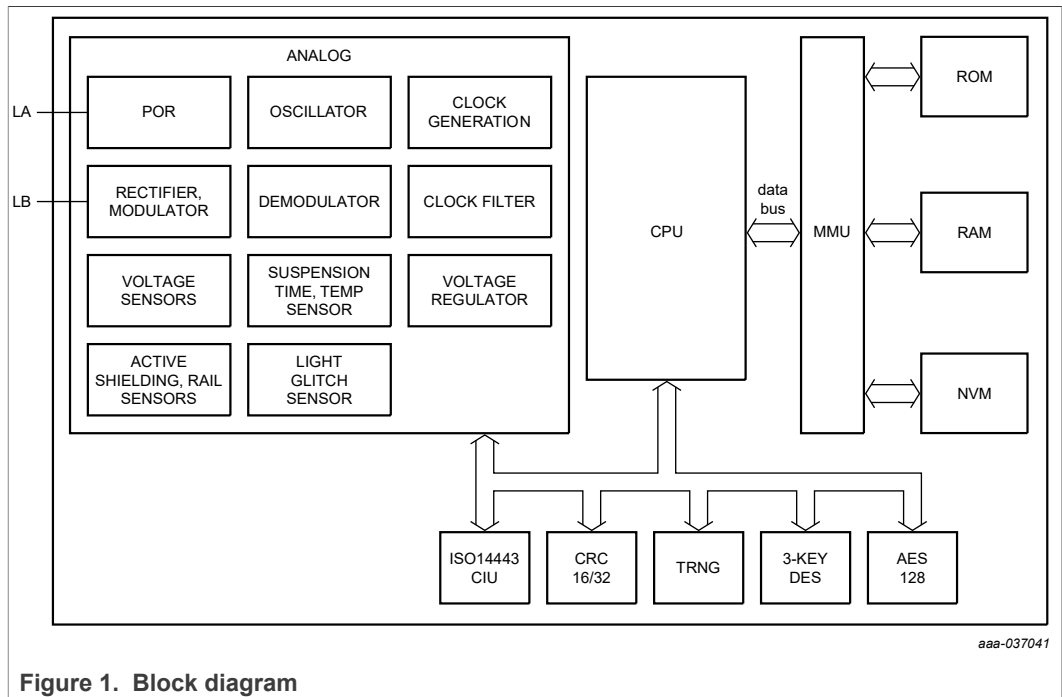
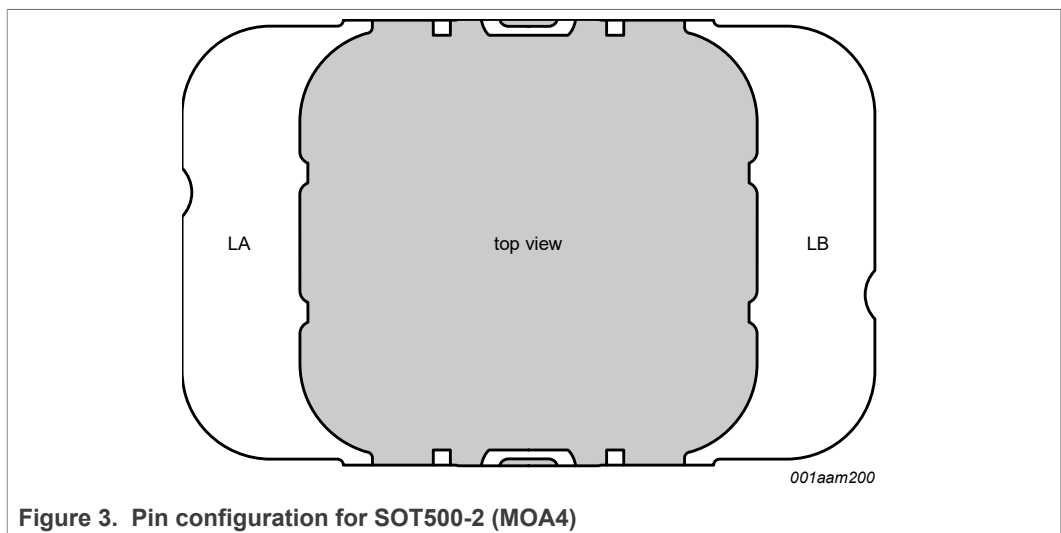
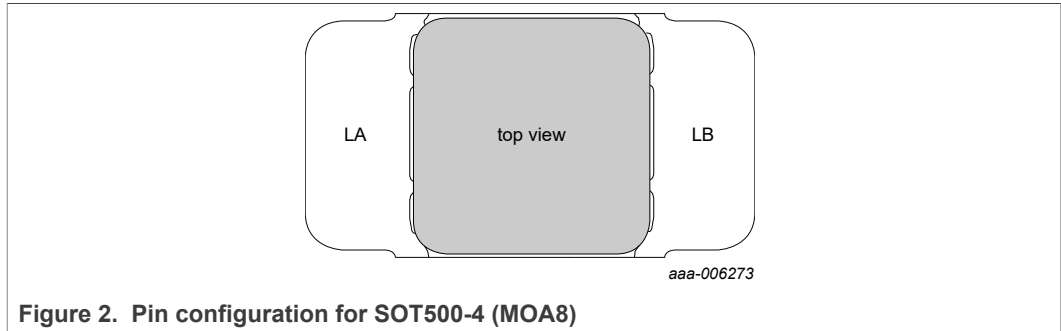


Figure 1. Block diagram

## 7 Pinning information

### 7.1 Pinning



### 7.2 Pin description

Table 4. Pin description (MOA4 and MOB6)

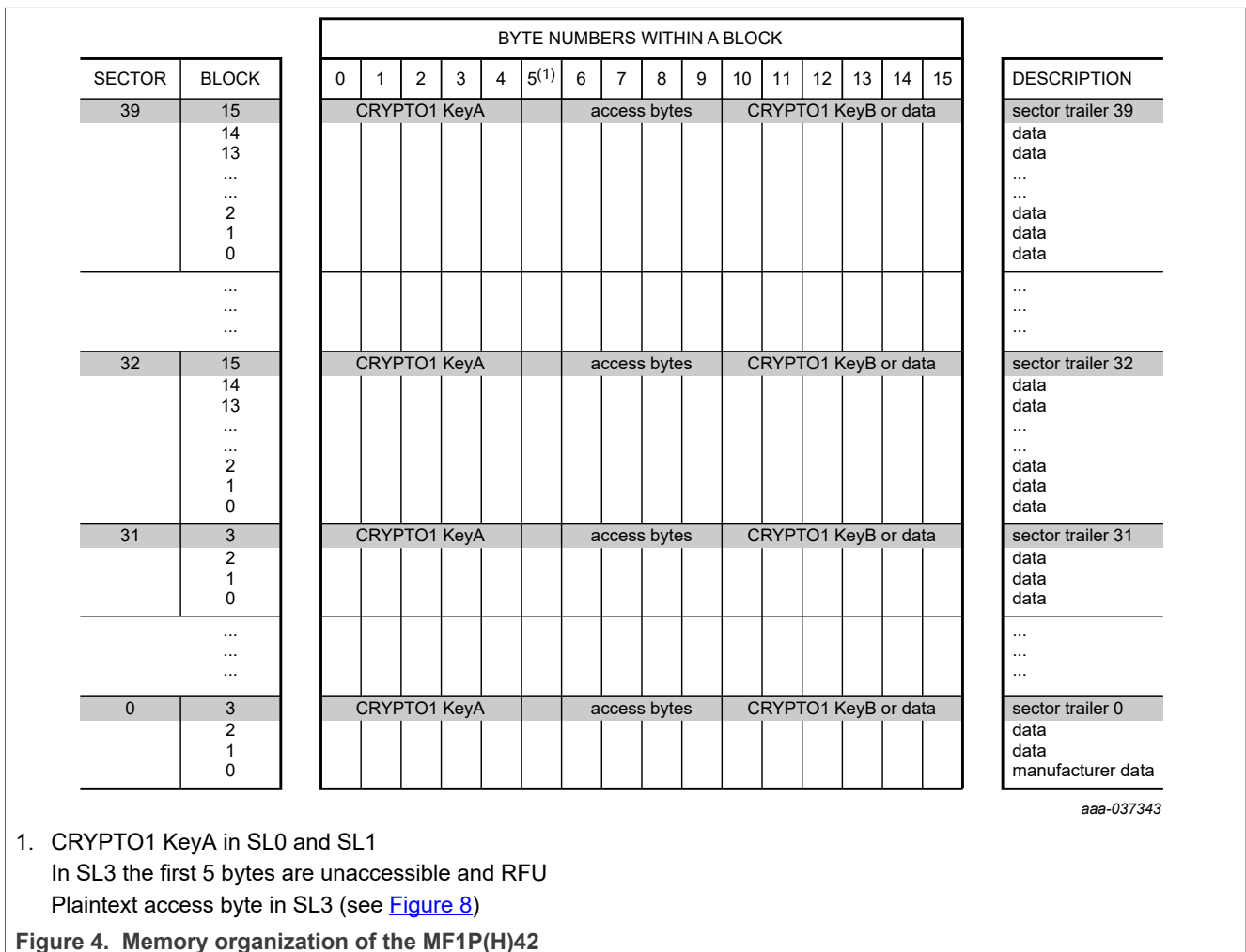
| Symbol | Pin | Description                |
|--------|-----|----------------------------|
| LA     | LA  | antenna coil connection LA |
| LB     | LB  | antenna coil connection LB |

## 8 Functional description

### 8.1 Memory organization

The non-volatile memory of the MF1P(H)22 is organized in 32 sectors of 4 blocks (from sector 0d to 31d). The MF1P(H)42 has in addition 8 sectors of 16 blocks (from sector 32d to 39d). Each block consists of 16 bytes.

In the block 0 of sector 0 are stored the NXP manufacturer data of the IC (see [Section 8.1.1](#)) while the upper block of each sector contains the sector trailer (see [Section 8.1.3](#)). The remaining blocks of each sector can be used to store data and are called DaVaBlocks (see [Section 8.1.2](#))

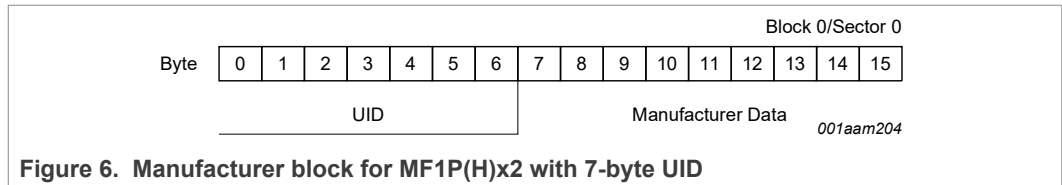
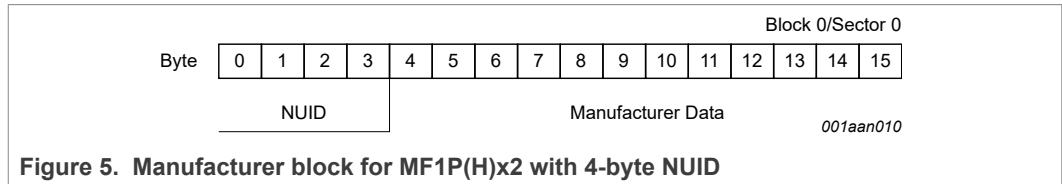


**Remark:** The memory map does not show the AES keys and configuration blocks. The MF1P(H)22 only includes the lower 32 sectors.

**8.1.1 Manufacturer block**

The manufacturer data are stored in the manufacturer block, which is the first data block (block 0) of the first sector (sector 0). Due to security and system requirements, this block is write protected during production.

The manufacturer block is shown in [Figure 5](#) and [Figure 6](#) for the 4-byte NUID and 7-byte UID version respectively.



**8.1.2 Data blocks**

In data blocks, it is possible to store:

- generic binary data
- value blocks to store numbers (e.g. counters)

Value blocks offer the advantage to use additional special commands to increment or decrement the numerical content (see [Value operations](#)) and require a special formatting of the block (see [Section 8.1.2.1](#)).

**8.1.2.1 Value blocks**

The value blocks allow counter functions (valid commands: read, write, increment, decrement, restore, transfer). They have a fixed data format that permits error detection and correction with backup management. A value block can only be generated through a write or transfer operation of the following format:

- Value: Signifies a signed 4-byte value. The lowest significant byte of a value is stored in the lowest address byte. Negative values are stored in standard 2’s complement format. For reasons of data integrity and security, a value is stored three times, twice non-inverted and once inverted.
- Adr: Signifies a 1-byte address, which can be used to store any data, e.g. the storage address of a block. The address byte is stored four times, twice inverted and non-inverted. During increment, decrement, restore operations the address (block number) remains unchanged. The address byte is copied from source to destination within the transfer command.

For performance reasons SL3 offers also combined increment/decrement operation with transfer operation, see [Value operations](#).



|             |       |   |   |       |   |   |       |   |   |     |     |     |     |    |    |    |  |
|-------------|-------|---|---|-------|---|---|-------|---|---|-----|-----|-----|-----|----|----|----|--|
| Byte Number | 0     | 1 | 2 | 3     | 4 | 5 | 6     | 7 | 8 | 9   | 10  | 11  | 12  | 13 | 14 | 15 |  |
| Description | value |   |   | value |   |   | value |   |   | adr | adr | adr | adr |    |    |    |  |

*001aan018*

**Figure 7. Value blocks formatting**

An example of a valid value block format for the decimal value 1234567d and the block address 17d is shown in [Table 5](#). First, the decimal value has to be converted to the hexadecimal representation of 0012D687h. The LSByte of the hexadecimal value is stored in Byte 0, the MSByte in Byte 3. The bit inverted hexadecimal representation of the value is FFED2978h where the LSByte is stored in Byte 4 and the MSByte in Byte 7.

The hexadecimal value of the address in the example is 11h, the bit inverted hexadecimal value is EEh.

**Table 5. Value block format example**

|              |       |    |    |       |    |    |       |    |    |     |     |     |     |    |    |    |  |
|--------------|-------|----|----|-------|----|----|-------|----|----|-----|-----|-----|-----|----|----|----|--|
| Byte Number  | 0     | 1  | 2  | 3     | 4  | 5  | 6     | 7  | 8  | 9   | 10  | 11  | 12  | 13 | 14 | 15 |  |
| Description  | value |    |    | value |    |    | value |    |    | adr | adr | adr | adr |    |    |    |  |
| Values [hex] | 87    | D6 | 12 | 00    | 78 | 29 | ED    | FF | 87 | D6  | 12  | 00  | 11  | EE | 11 | EE |  |

The DataBlocks and ValueBlocks are together called DaVaBlocks.

**8.1.3 Sector trailer**

Each sector has a sector trailer in the upper block. This sector trailer is located in 4th block of each sector in the first 2 kB (sector 0 to sector 31) of the NV-memory and in 16th block of each sector in the upper 2 kB (sector 32 to sector 39) of the 4 kB NV-memory.

|             |                 |   |   |   |                     |   |   |   |                         |   |    |    |    |    |    |    |
|-------------|-----------------|---|---|---|---------------------|---|---|---|-------------------------|---|----|----|----|----|----|----|
| Byte Number | 0               | 1 | 2 | 3 | 4                   | 5 | 6 | 7 | 8                       | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| Description | CRYPTO1 KeyA    |   |   |   | Access Bytes        |   |   |   | CRYPTO1 KeyB            |   |    |    |    |    |    |    |
|             | Not used in SL3 |   |   |   | Access Bytes in SL3 |   |   |   | Data or not used in SL3 |   |    |    |    |    |    |    |

*aaa-028386*

**Figure 8. Sector trailer**

Each sector trailer holds:

- secret CRYPTO1 keys A and B (Key B is optional)
- access conditions for the four blocks or sixteen blocks of that sector, which are stored in bytes 6 to 8. The access bits also specify the type (data or value) of the DaVaBlocks.
- byte 5 defines if plain communication can be used in SL3 after authentication. In SL3, the global DefaultPlainAC byte from the MFPConfigurationBlock is used (see [MFPConfigurationBlock](#)) unless the access condition byte for plain communication is modified for each sector separately by overwriting Byte 5 in the corresponding sector trailer. In SL1SL3Mix mode, the DefaultPlainAC byte is always used and cannot be changed by writing to the sector trailer.

In MF1P(H)x2, every write operation is secured with an anti-tearing mechanism.

**8.1.3.1 Access conditions**

In each sector trailer the access bytes determine the access condition (read, write, value operation) for the DaVaBlocks as well as the sector trailers itself. The access conditions

for every DaVaBlocks and sector trailer are defined by 3 bits, which are stored non-inverted and inverted in the sector trailer of the respective sector.

The access bits control the rights of memory access using the secret keys A and B. The access conditions may be altered, provided one knows the relevant key and the current access condition allows this operation.

**Remark:** With each memory access, the internal logic verifies the format of the access conditions. If it detects a format violation the whole sector is irreversibly blocked.

**Remark:** MF1P(H)x2 does not verify the format during update and will allow an inconsistent trailer data.

In the following description, the access bits are mentioned in the non-inverted mode only. The internal logic ensures that the commands are executed only after an authentication procedure.

Table 6. Access bit mapping to blocks

| Access Bits                                     | Valid Commands                                       |   | Block in sectors 0 to 31 | Block(s) in sectors 32 to 39 <sup>[1]</sup> | Description    |
|---|--|---|--------------------------|---|----------------|
| C1 <sub>3</sub> C2 <sub>3</sub> C3 <sub>3</sub> | read, write  | → | 3                        | 15  | sector trailer |
| C1 <sub>2</sub> C2 <sub>2</sub> C3 <sub>2</sub> | read, write, increment, decrement, transfer, restore | → | 2                        | 10, 11, 12, 13, 14                          | data block     |
| C1 <sub>1</sub> C2 <sub>1</sub> C3 <sub>1</sub> | read, write, increment, decrement, transfer, restore | → | 1                        | 5, 6, 7, 8, 9                               | data block     |
| C1 <sub>0</sub> C2 <sub>0</sub> C3 <sub>0</sub> | read, write, increment, decrement, transfer, restore | → | 0 <sup>[2]</sup>         | 0, 1, 2, 3, 4                               | data block     |

[1] Only available in MF1P(H)42  
 [2] Block 0 of Sector 0 is always read only

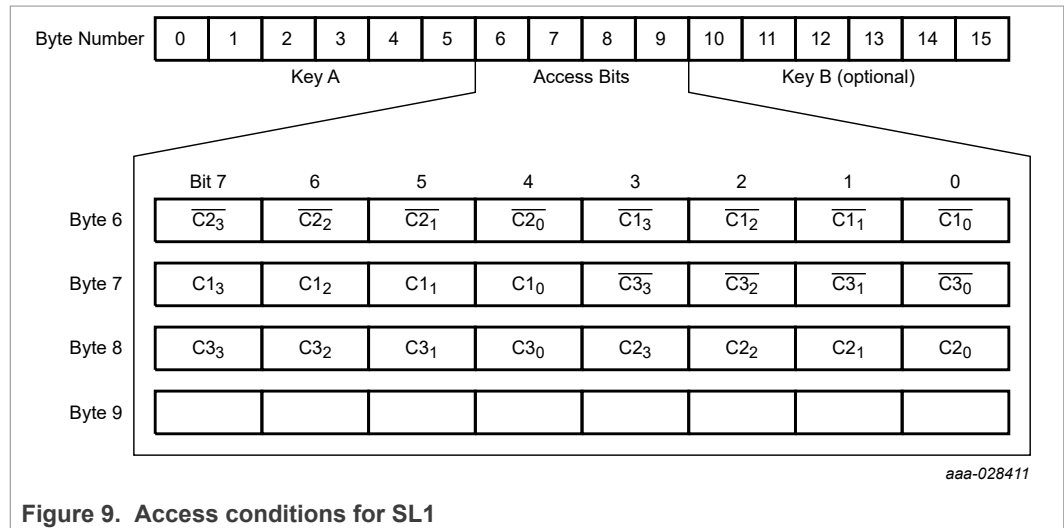


Figure 9. Access conditions for SL1

8.1.4 AES keys and other system data

Neither AES keys nor other system data like the VCSystemData blocks are shown in the memory map. The keys are stored on top of the other data and can be updated and

used by referencing the Key Number (see [Table 1](#)). In SL3, anti-tearing is supported for the update of AES keys as well as for the update of the sector trailer. This anti-tearing mechanism is done by the PICC itself. The non-volatile memory stays in a defined status, even if the PICC is brought out of the field during write operations. The PICC ensures that the data is either the unchanged or fully updated to the new value. It is up to the PCD to determine the state on the next PICC activation"

The write access condition described in [Table 1](#) for the Crypto1 keys in SL1 is the same as for the AES keys in SL3.

**Note:** There is also a configuration block to restrict update operations (i.e. increment) for DaVaBlocks and Sector Trailers in the MIFARE Classic backwards compatibility mode in SL1, see [SL1 Update Restrictions](#).

### 8.1.5 Originality function

The originality check allows verification of the genuineness of MIFARE Plus EV2. MF1P(H)x2 offers two ways to check the originality of the MIFARE Plus EV2 contactless IC: the first is based on a symmetric authentication, the second works on the verification of an asymmetric signature retrieved from the card.

The symmetric originality function is implemented by an AES authentication as described in [AuthenticateFirst](#) and [AuthenticateNonFirst](#) with the OriginalityKey1 (see [Key and block number overview](#)). The authentication with the 128-bit AES Originality key can be performed in all security levels, supporting ISO/IEC 14443-3&4 protocol layer (see also [Section 8.2.2](#)).

The asymmetric originality signature is based on ECC and only requires a public key for the verification, which is done outside the card (see [\[7\]](#)). The Read\_Sig command can be used in both ISO/IEC 14443-3 and ISO/IEC 14443-4 protocols to retrieve the signature. If the PICC is not configured for Random ID, the command is freely available, i.e. there is no authentication required. If the PICC is configured for Random ID, an authentication with any authentication key is required.

If there is an active authentication, the secure messaging depends on the ISO/IEC 14443 activation. In SL1 after ISO/IEC 14443-3 activation, the command is encrypted with CRYPTO1 as for all other commands. In SL1 or SL3 after ISO/IEC 14443-4 activation, the command is to be MACed and the response is encrypted and MACed as shown in [Figure 10](#). The read counter is incremented after validating the command before sending the response. This is done according to the same principles as for [ReadEncryptedMAC\\_MACed](#).

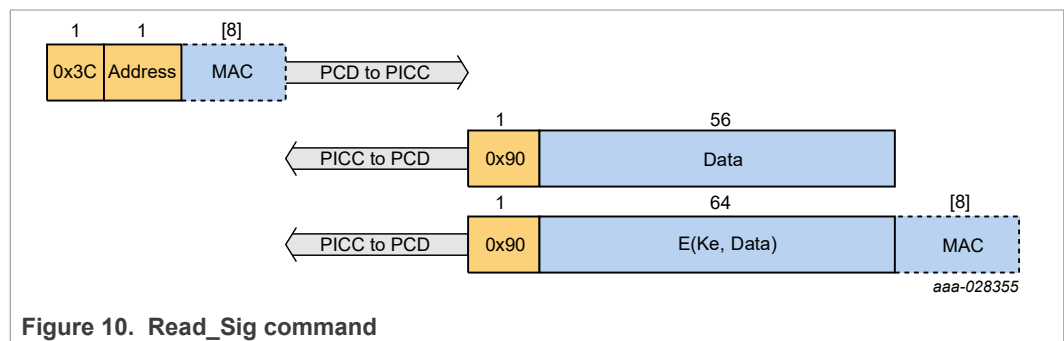


Figure 10. Read\_Sig command

Table 7. Read\_Sig

| Name                       | Length  | Value | Description  |
|----------------------------|---|-------|--|
| Description:               | Retrieve the ECC originality check signature. |       |  |
| <b>Command Parameters:</b> |   |       |  |
| Cmd                        | 1   | 3Ch   | Command code.  |
| Address                    | 1   | 00h   | Targeted ECC originality check signature. Other address values are RFU.                                |
| MAC                        | [8]   | any   | Optional, only present if authenticated after ISO/IEC 14443-4 activation<br>MAC over the command       |
| <b>Responses:</b>          |   |       |  |
| Resp.OK                    | 1   | 90h   | OK   |
| Data                       | 56  | any   | NXP Originality Signature  |
| E(Ke, Data)                | 64  | any   | The NXPOriginalitySignature is encrypted with the session key as generated in the last authentication. |
| MAC                        | [8]   | any   | Optional, only present if authenticated after ISO/IEC 14443-4 activation<br>MAC over the response      |
| Resp.ErrCmdInvalid         | 1   | 0Bh   | Not allowed without valid authentication due to Random ID configuration.                               |
| Resp.ErrFormat             | 1   | 0Ch   | Command length different from 2 byte or unsupported address  |

## 8.2 Card activation and communication protocol

The ISO/IEC 14443-3 anti-collision mechanism allows for simultaneous handling of multiple PICCs in the field. The anti-collision algorithm selects each PICC individually and ensures that the execution of a transaction with a selected PICC is performed correctly without data corruption from other PICCs in the field.

There are two different UID versions of the PICC which are programmed and locked in the manufacturer block:

1. unique 7-byte serial number (7-byte UID)
2. non-unique 4-byte serial number (4-byte NUID)

Due to security and system requirements, these bytes are write-protected after being programmed by the PICC manufacturer at production time.

**Remark:** The programmed 4-byte NUID serial number is not globally unique which has to be considered in the contactless system design. See [19] for further information regarding handling of UIDs.

The customer has to decide which UID length to use when ordering the product (see Table 2 for ordering information).

A MF1P(H)x2 with 7-byte UID supports the additional UID configuration options as defined in [2] using the MF\_PersonalizeUIDUsage command after ISO/IEC 14443-3 activation. Note that the MF\_PersonalizeUIDUsage command can only be sent once.

The configuration chosen affects the ISO/IEC 14443 activation and the MIFARE Classic authentication. The defined activation sequence applies for both ISO/IEC 14443-3 and ISO/IEC 14443-4 activation, except for Sequence2 described in [2] which can only be applied with an ISO/IEC 14443-3 activation. As a consequence, if UIDF1 configuration has been chosen, the MF1P(H)x2 only supports Sequence1 for an ISO/IEC14443-4 activation.

The chosen configuration by the MF\_PersonalizeUIDUsage command is reflected by the UseRID configuration byte in the FieldConfigurationBlock. On the other hand, the configuration chosen by the MF\_PersonalizeUIDUsage command is overwritten by the UseRID configuration when updating the FieldConfigurationBlock, see [FieldConfigurationBlock](#).

In case Random ID is configured, the real UID can be retrieved using the ISOSelect and ISOExternalAuthenticate commands described in [ISOSelect](#) and [ISOExternalAuthenticate](#) or by reading out block 0 of sector 0.

**Remark:** A full power cycle needs to be performed after each configuration change in order to ensure proper setting of the activation parameters.

### 8.2.1 Backwards compatibility protocol

The MIFARE Classic backwards compatibility of this product in SL1 runs on the same protocol layer as MIFARE Classic 1K/4K. The protocol is formed out of the following components:

- Frame definition: according to ISO/IEC 14443-3
- Bit encoding: according to ISO/IEC 14443-2
- Error code handling: handling is proprietary as error codes are formatted in half bytes. The used error codes (NAK - Not Acknowledge) are described in [Status code overview](#)
- Command specification: commands are proprietary. Please use the specification as in [2] and [3] and the additional commands which are only implemented in MIFARE Plus as described in this data sheet.

### 8.2.2 ISO/IEC 14443-4 protocol

The ISO/IEC 14443-4 protocol (also known as T=CL) is used in many processor cards. For MIFARE Plus EV2 this protocol is used in the following security levels:

- SL0: all commands
- SL1: for the sector or card level SL switch, the AES originality function, AES Key update, configuration data update, GetVersion and Read\_Sig
- SL3: all commands

**Remark:** The ISO/IEC 14443-4 protocol is also used to operate any sector that has been switched to SL3 or SL1SL3Mix mode, when using SL3 commands.

### 8.2.3 ISO/IEC 7816-4 support

Next to the native command set, MIFARE Plus EV2 also supports ISO/IEC 7816-4 commands (see [9]). MF1P(H)x2 supports an optional wrapping into ISO/IEC 7816-4 APDUs of the native command set available after ISO/IEC 14443-4 activation for all security levels (including Proximity Checking, see [Proximity Check](#)). On top, the following standard ISO/IEC 7816-4 commands are supported for Virtual Card Selection, as defined and described in [Virtual Card Architecture](#):

- [ISOSelect](#) with INS code A4h
- [ISOExternalAuthenticate](#) with INS code 82h

### 8.3 Security level switching

There are three security levels of the product:

- SL0: initial delivery configuration, user for card personalization
- SL1: 3-Pass CRYPTO1 Authentication (MIFARE Classic EV1 backwards compatibility mode) with optional AES authentication, optional 3-Pass AES Authentication and secure messaging and the configuration block to restrict update operations (e.g. increment, decrement and/or data write) for DaVaBlocks and Sector Trailers.
- SL3: 3-Pass Authentication based on AES, new data manipulation commands secured by encryption and an AES-based MACing method

Security level switching can be done for the whole card (CardSecurityLevel) or for dedicated sectors only (SectorSecurityLevel). In case of dedicated sectors, these can also be switched to a SL1SL3MixMode, where both SL1 and SL3 operations are accepted. Security level switching, both at card or at sector level, is only possible to a higher security level and not to a lower security level. The added feature in SL1 allows to restrict update operations (e.g. increment, decrement and/or data write) for DaVaBlocks and Sector Trailers in the MIFARE Classic backwards compatibility mode in SL1, see [SL1 Update Restrictions](#).

In case dedicated sectors have been migrated to higher security levels, the overall PICC behavior remains by default according to lowest security level of one of its sectors. By default, the PICC also uses the ATQA/SAK of the lowest security level during the ISO/IEC 14443-3 activation, if these are different for the different security levels. These parameters can be switched to indicate the higher security level before the PICC is completely migrated to a higher security level by means of a configuration option (see [MFPConfigurationBlock](#)). Once all sectors are switched to a certain security level, the overall PICC is automatically switched to this security level.

### 8.4 Security level 0 - SL0

SL0 is the initial delivery configuration of the PICC. The card activation as well as the protocol can be performed in one of the following two ways:

- ISO/IEC 14443-3 (see [Section 8.2.1](#))
- ISO/IEC 14443-4

Depending on the chosen protocol layer, the commands described in the following sections are integrated into the specific protocol. In this level only the originality check, GetVersion and updating of the AES keys as well as all data blocks is possible.

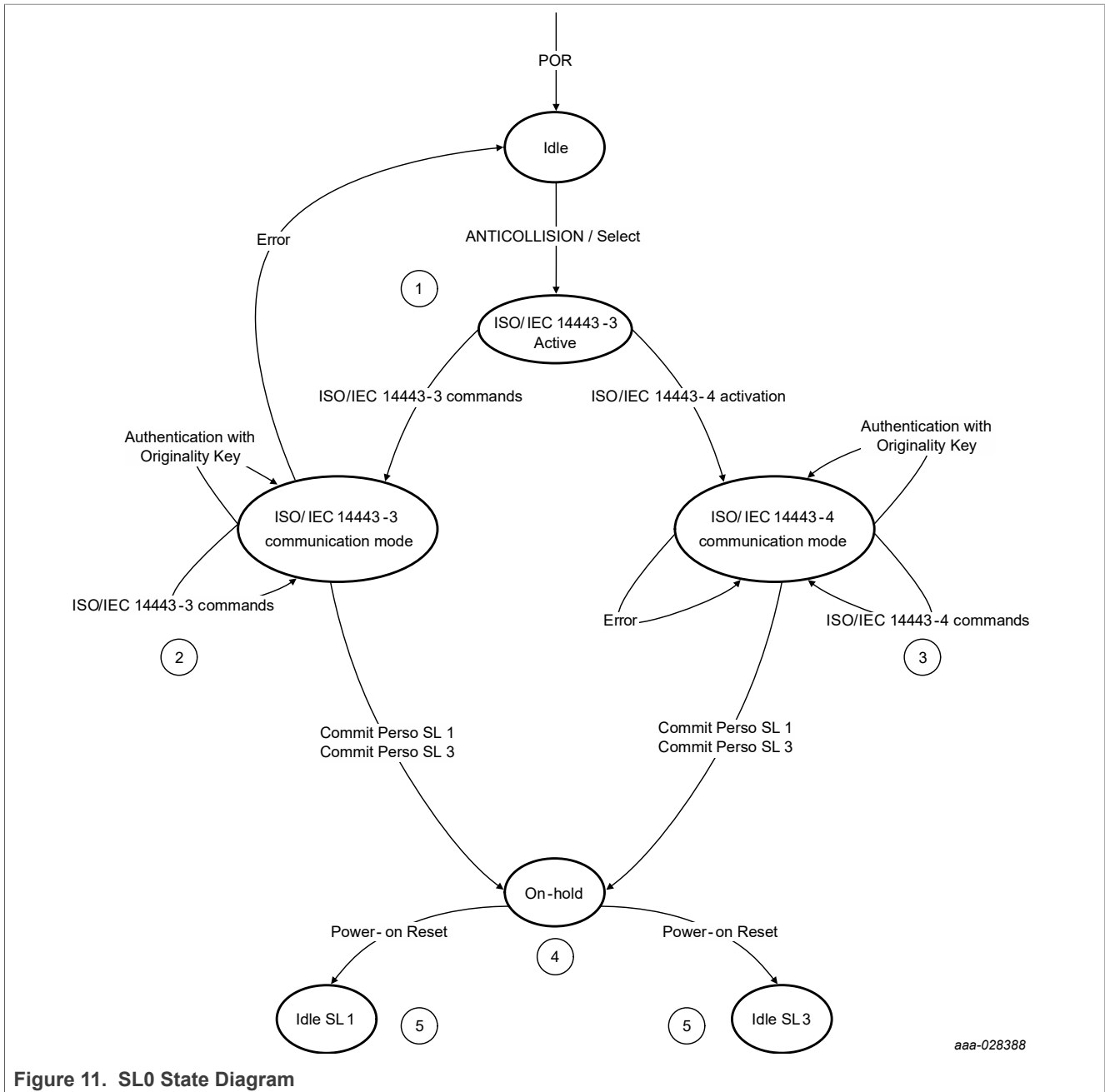


Figure 11. SL0 State Diagram

1. After the anti-collision loop (CL1 for 4BNUID and CL1 + CL2 for 7BUID) the PICC can be activated)
2. With ISO/IEC 14443-3 commands, it is possible to pre-personalize the PICC.
3. Alternatively it is possible to pre-personalize the PICC using ISO/IEC 14443-4 commands. In both communication layers, it is possible to verify the authenticity of the PICC with the authentication OriginalityKey1.
4. When the pre-personalization of the PICC is finished it is possible to upgrade the PICC from SL0 either to SL1 or directly to SL3 with CommitPerso command (see [CommitReaderID](#))
5. A reactivation is needed to activate the PICC to SL1 or SL3.

The following mandatory AES keys must be written using the WritePerso command (see [WritePerso](#)) before the PICC can be switched to SL1 or SL3. Security level switching is performed the CommitPerso command (see [CommitPerso](#)):

- CardConfigurationKey
- CardMasterKey
- L3SwitchKey (not necessary if card is directly switched to SL3 with the CommitPerso command)

It is also highly recommended to change all sector AES keys as well as the data within this security level in a secure environment.

## 8.5 Security level 1 - SL1

SL1 offers the same functionality as a MIFARE Classic EV1 1K/4K using the SL1 backwards compatibility mode. The MIFARE Classic EV1 1K/4K products are specified in [\[2\]](#) and [\[3\]](#). The protocol is also used in the same way as in the MIFARE Classic EV1 1K/4K (see [Section 8.2.1](#)). Furthermore, an additional optional AES authentication is available in this level without affecting the MIFARE Classic 1K/4K functionality. The authenticity of the card can be proven using strong cryptographic means with this additional functionality.

Response timings may differ to the MIFARE Classic EV1 1K/4K products.

In addition to the backwards compatibility mode, after a successful ISO/IEC 14443-4 activation the originality function can be executed or the CardSecurityLevel or SectorSecurityLevel switched to higher security levels. In addition, the same features as available in the previous MIFARE Plus versions. Since MIFARE Plus EV1 the possibility is offered to update AESSectorKeys and VCSysData. The behavior in SL1 is explained based on the state diagram shown in [Figure 12](#).



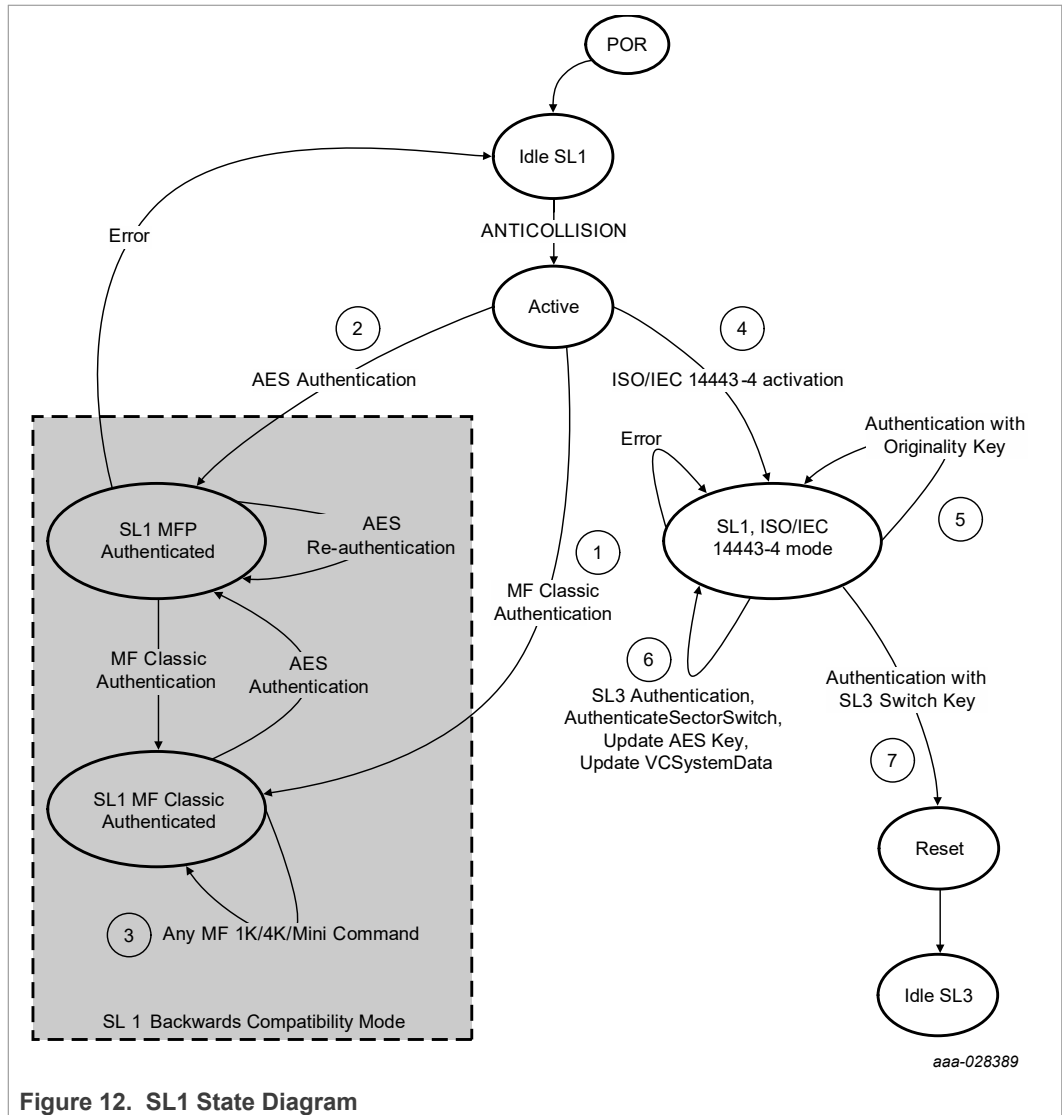


Figure 12. SL1 State Diagram

After an anti-collision loop the card can be, similar as in SL0, put either to backwards compatibility mode or an ISO/IEC 14443-4 mode.

1. Identically as in MIFARE Classic 1K/4K, a CRYPTO1 authentication activates the MF Classic authenticated state.
2. Alternatively, an AES authentication with the SL1CardAuthKey (see [Key and block number overview](#)) it is possible to move to SL1 MFP authenticated state. Here a CRYPTO1 authentication is also possible. As shown in the state diagram, the AES authentication is optional and can be performed anytime in the backwards compatibility mode. An AES authentication moves the PICC to the SL1 MFP Authenticated state, meaning the CRYPTO1 authentication has to be repeated in order to access the data again. Keys for AES and CRYPTO1 authentication are not cryptographically bound.
3. In the state SL1 MF Classic Authenticated, the MF1P(H)x2 behaves as MIFARE Classic EV1 1K/4K, see [2] and [3], with the possibility of an optional AES authentication.

4. A full card activation to ISO/IEC 14443-4 is needed to ...

- 4.1

- Authenticate with the OriginalityKey1 or ...

- 4.2

- Perform full SL3 authentication and secure messaging for sectors which are switched to SL3 SectorSecurityLevel or to SL1SL3Mix mode or update AES keys or VCSYSTEMDATA or ...

- 4.3

- Authenticate with the L3SwitchKey. The authentication can be done both as AuthenticateFirst or AuthenticateNonFirst. Respective Keys as described in [Key and block number overview](#) have to be used. After authentication with L3SwitchKey a reset and card activation are needed to start operating in the SL3.

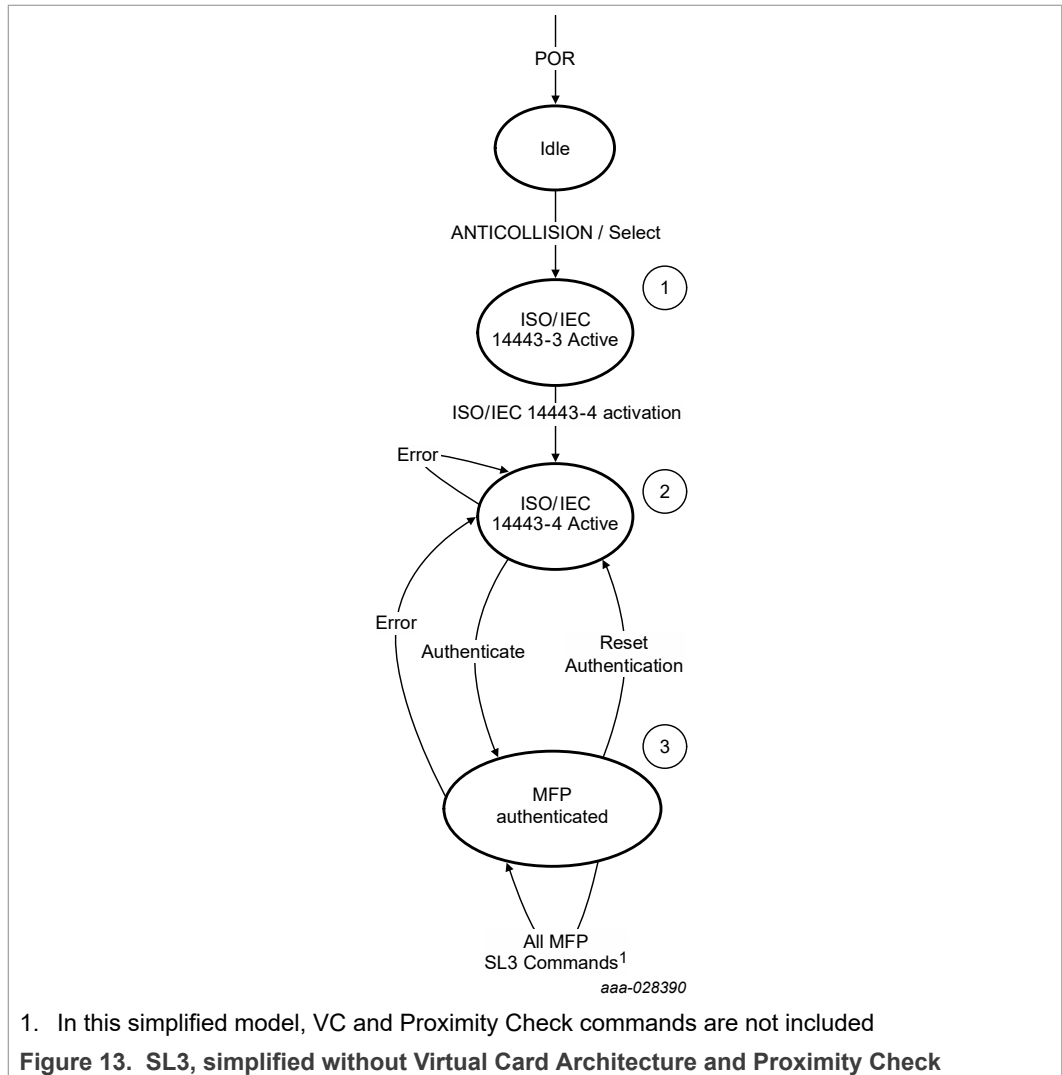
MIFARE Plus EV2 can be operated like previous MIFARE Plus products in SL1, which means that all memory operations on each sector are requiring legacy MIFARE Classic EV1 commands using CRYPTO1 enciphering. In SL1, update operations can be restricted with the configuration block for DaVaBlocks and Sector Trailers to restrict e.g. increment operations. Since release of MIFARE Plus EV1, the flexibility is offered to either switch distinct sectors to SL3 and operate them in AES secure messaging or enable SL1SL3MixMode on distinct sectors. Sectors in SL1SL3MixMode can be operated either using the backwards compatible MIFARE Classic EV1 commands when activated to ISO/IEC 14443-3 or using AES secure messaging when activated to ISO/IEC 14443-4. In example, this enables end-to-end communication to a MIFARE Plus EV2 using a secure AES channel while leaving the operation in the application on MIFARE Classic EV1 commands for a migration period.

**Remark:** The possibility to activate the MF1P(H)x2 in ISO/IEC 14443-4 can be prevented by using the SetConfigSL1 command, see [SetConfigSL1](#). This feature can be used to satisfy legacy infrastructure requirements.

## 8.6 Security level 3 - SL3

The operation in SL3 is solely based on the ISO/IEC 14443-4 protocol layer. The usage of the communication in layer 3 backward compatible to MIFARE Classic is not possible anymore. After the activation to ISO/IEC 14443-4, the authentication in any sector can be done only with AES keys while CRYPTO1 based operations are not possible anymore. In SL3 confidentiality and integrity are secured by two separate session keys.

As shown in the simplified state diagram in [Figure 13](#), the PICC has to be first activate in layer 3 mode (state 1) then in layer 4 (state 2). In the MFP authenticated state (state 3), all MFP commands are possible.



In SL3, an AES authentication between PICC and reader is conducted, where two keys are generated as a function of the random numbers of the PICC as well as the reader and the shared key. These two unpredictable keys are exclusively used to secure the data which is exchanged on the interface between the card and reader. One of the two keys is used to ensure the confidentiality of the command and response while the other key ensures the integrity of the command and response.

The reader can decide which security needs to be used in the communication between PICC and reader. In the simplest case, all commands carry a MAC, such that the PICC only accepts commands from the reader with which it is authenticated. Tampering of operands and messages is detected by checking the MAC. All responses contain a MAC, so that the reader on each response knows that neither the command nor the response has been tampered with.

If performance is the highest priority, the card can be configured to allow MACs for read commands to be omitted. The card then accepts read commands without knowing whether they are genuine. However, there is a mechanism by which the reader can still determine whether or not the read response was resulting from the unmodified read command that it sent.

Other commands, like write commands, always need to have a MAC appended to ensure that no memory changes are carried out without proving the authenticity of the command.

The reader can decide for each command whether a MAC is included in the response. When the appropriate MAC is received, due to linked MACs (see [Integrity](#)) the reader knows that the command and commands before it were properly executed.

All commands between two consecutive First Authenticate commands belong to one transaction and the MACing mechanism assures integrity of the whole transaction.

If the MAC on read responses is omitted, the integrity of all read responses within one session can still be verified by including a MAC on one read response before issuing the next AuthenticateFirst or AuthenticateNonFirst command.

Note that in the case of using a MAC for assuring correct execution of write commands or value operations used within more than one session, the assurance that can be obtained depends on the keys used in this and all of the preceding sessions.

If performance matters more than confidentiality of the transaction, each data block in a sector can be configured to allow or disallow sending/receiving plain data.

## 9 Look-Up tables

### 9.1 SL0, SL1, SL3: ISO/IEC 14443-3 commands

Table 8. ISO/IEC 14443-3 commands

| Command                                   | Description   |
|---|---|
| REQA                                      | REQA and ATQA are implemented according to ISO/IEC 14443-3.   |
| WUPA                                      | the WAKE-UP is implemented according to ISO/IEC 14443-3.  |
| ANTICOLLISION /<br>SELECT Cascade level 1 | the ANTICOLLISION and SELECT commands are implemented according to ISO/IEC 14443-3. The response is part 1 of the UID.  |
| ANTICOLLISION /<br>SELECT Cascade level 2 | the ANTICOLLISION and SELECT commands are implemented according to ISO/IEC 14443-3. The response is part 2 of the UID and is only required for double size UID variants (7-byte UID version). |
| HALT                                      | the HALT command is implemented according to ISO/IEC 14443-3  |

### 9.2 SL0, SL1, SL3: ISO/IEC 14443-4 commands

Table 9. ISO/IEC 14443-4 commands

| Command  | Description  |
|----------|--|
| RATS     | the response to the RATS command identifies the PICC type to the PCD.  |
| PPS      | the PPS command allows individual selection of the communication baud rate between PCD and PICC. It is possible to individually set the communication baud rate independently for both directions. |
| DESELECT | de-selection according to ISO/IEC 14443-4.   |

Please also see [\[5\]](#) as well as on the settings of ATQA, SAK and ATS in [\[4\]](#).

### 9.3 SL0 command overview

Table 10. SL0 command overview

| Command  | HEX Code     | Description   |
|--|--------------|---|
| <b>Commands available after ISO/IEC 14443-3 activation</b> |              |   |
| Read_Sig   | 3Ch          | Retrieve the ECC originality check signature.   |
| WritePerso   | A8h          | pre Personalization of AES Keys and all blocks  |
| CommitPerso  | AAh          | switch to SL1 or SL3  |
| AuthenticateFirst (part 1)                                 | 70h /<br>73h | first authenticate  |
| AuthenticateNonFirst (part 1)                              | 76h          | following authenticate  |
| AuthenticateContinue (part 2)                              | 72h          | second authentication step  |
| VCSupportLastISOL3   | 4Bh          | check if the Virtual Card Concept is supported, communicate PCD capabilities and retrieve the UID |
| <b>Commands available after ISO/IEC 14443-4 activation</b> |              |   |

Table 10. SL0 command overview...continued

| Command  | HEX Code  | Description                                    |
|--|-----------|--|
| GetVersion   | 60h       | returns manufacturing related data of the PICC |
| Read_Sig   | 3Ch       | Retrieve the ECC originality check signature.  |
| WritePerso   | A8h       | pre Personalization of AES Keys and all blocks |
| CommitPerso  | AAh       | switch to SL1 or SL3                           |
| AuthenticateFirst (part 1)   | 70h / 73h | first authenticate                             |
| AuthenticateNonFirst (part 1)  | 76h       | following authenticate                         |
| AuthenticateContinue (part 2)  | 72h       | second authentication step                     |
| <b>VC commands available after ISO/IEC 14443-4 activation, using ISO/IEC 7816-4 protocol</b> |           |  |
| ISOSelect  | A4h       | Select virtual card                            |

## 9.4 SL1 command overview

Table 11. SL1 command overview

| Command  | HEX Code  | Description   |
|--|-----------|---|
| <b>MIFARE Classic commands</b>   |           |   |
| MF Authenticate KeyA   | 60h       | authentication with KeyA  |
| MF Authenticate KeyB   | 61h       | authentication with KeyB  |
| MF Read  | 30h       | reading data  |
| MF Write   | A0h       | writing data  |
| MF Increment   | C1h       | incrementing a value  |
| MF Decrement   | C0h       | decrementing a value  |
| MF Restore   | C2h       | restoring a value   |
| MF Transfer  | B0h       | transferring a value  |
| <b>Commands using backwards compatibility protocol, see <a href="#">Section 8.2.1</a>.</b> |           |   |
| Read_Sig   | 3Ch       | Retrieve the ECC originality check signature.   |
| SetConfigSL1   | 44h       | used to change MIFARE Plus EV1 specific configuration data.                             |
| MF_PersonalizeUIDUsage   | 40h       | Personalize UID Usage as described in <a href="#">[2]</a>                               |
| AuthenticateFirst (part 1)   | 70h / 73h | first authenticate, protocol used as described in <a href="#">Section 8.2.1</a>         |
| AuthenticateNonFirst (part 1)  | 76h       | following authenticate, protocol used as described in <a href="#">Section 8.2.1</a>     |
| AuthenticateContinue (part 2)  | 72h       | second authentication step, protocol used as described in <a href="#">Section 8.2.1</a> |
| ReadPlainNoMAC_UnMACed   | 36h       | reading in plain, no MAC on response, no MAC on command                                 |

Table 11. SL1 command overview...continued

| Command  | HEX Code  | Description   |
|--|-----------|---|
| VCSupportLastISOL3   | 4Bh       | check if the Virtual Card Concept is supported, communicate PCD capabilities and retrieve the UID |
| <b>Authentication commands available after ISO/IEC 14443-4 activation <sup>[1]</sup></b>     |           |   |
| GetVersion   | 60h       | returns manufacturing related data of the PICC  |
| Read_Sig   | 3Ch       | Retrieve the ECC originality check signature.   |
| AuthenticateFirst (part 1)   | 70h / 73h | first authenticate  |
| AuthenticateNonFirst (part 1)  | 76h       | following authenticate  |
| AuthenticateSectorSwitch (part 1)  | 7Ah       | used to switch single sectors to SL3, see <a href="#">AuthenticateSectorSwitch</a>                |
| AuthenticateContinue (part 2)  | 72h       | second authentication step  |
| ResetAuth  | 78h       | reset the authentication  |
| <b>Memory commands available after ISO/IEC 14443-4 activation <sup>[2]</sup></b>             |           |   |
| WriteEncryptedNoMAC  | A0h       | writing encrypted, no MAC on response, MAC on command   |
| WriteEncryptedMAC  | A1h       | writing encrypted, MAC on response, MAC on command  |
| <b>Proximity check commands available after ISO/IEC 14443-4 activation</b>                   |           |   |
| PreparePC  | F0h       | prepare for the Proximity Check   |
| ProximityCheck   | F2h       | perform the precise measurement for the proximity check   |
| VerifyPC   | FDh       | verify the proximity check  |
| <b>VC commands available after ISO/IEC 14443-4 activation, using ISO/IEC 7816-4 protocol</b> |           |   |
| ISOSelect  | A4h       | Select virtual card   |
| ISOExternalAuthenticate  | 82h       | Authenticate PD   |

[1] for security level switch, the originality function, sector security level switch and updating of AES keys and VCSysData blocks

[2] for updating of AES keys and VCSysData blocks

In addition to the commands listed in [Table 11](#), all commands defined for SL3 communication are available for those sectors which have been switch to SL3 or SL1SL3Mix mode using the AuthenticateSectorSwitch feature.

## 9.5 SL3 command overview

Table 12. SL3 command overview

| Command                     | HEX code | Description                                    |
|-----------------------------|----------|--|
| <b>MIFARE Plus commands</b> |          |  |
| GetVersion                  | 60h      | returns manufacturing related data of the PICC |

Table 12. SL3 command overview...continued

| Command                       | HEX code  | Description  |
|-------------------------------|-----------|--|
| Read_Sig                      | 3Ch       | Retrieve the ECC originality check signature.                      |
| AuthenticateFirst (part 1)    | 70h / 73h | first authenticate   |
| AuthenticateNonFirst (part 1) | 76h       | following Authenticate   |
| AuthenticateContinue (part 2) | 72h       | second authentication step   |
| ResetAuth                     | 78h       | reset the authentication   |
| Additional Frame              | AFh       | proceed to next response frame in GetVersion                       |
| <b>READ commands</b>          |           |  |
| ReadEncryptedNoMAC_MACed      | 30h       | reading encrypted, no MAC on response, MAC on command              |
| ReadEncryptedMAC_MACed        | 31h       | reading encrypted, MAC on response, MAC on command                 |
| ReadPlainNoMAC_MACed          | 32h       | reading in plain, no MAC on response, MAC on command               |
| ReadPlainMAC_MACed            | 33h       | reading in plain, MAC on response, MAC on command                  |
| ReadEncryptedNoMAC_UnMACed    | 34h       | reading encrypted, no MAC on response, no MAC on command           |
| ReadEncryptedMAC_UnMACed      | 35h       | reading encrypted, MAC on response, no MAC on command              |
| ReadPlainNoMAC_UnMACed        | 36h       | reading in plain, no MAC on response, no MAC on command            |
| ReadPlainMAC_UnMACed          | 37h       | reading in plain, MAC on response, no MAC on command               |
| <b>WRITE commands</b>         |           |  |
| WriteEncryptedNoMAC           | A0h       | writing encrypted, no MAC on response, MAC on command              |
| WriteEncryptedMAC             | A1h       | writing encrypted, MAC on response, MAC on command                 |
| WritePlainNoMAC               | A2h       | writing in plain, no MAC on response, MAC on command               |
| WritePlainMAC                 | A3h       | writing in plain, MAC on response, MAC on command                  |
| <b>VALUE operations</b>       |           |  |
| IncrementNoMAC                | B0h       | incrementing a value encrypted, no MAC on response, MAC on command |
| IncrementMAC                  | B1h       | incrementing a value encrypted, MAC on response, MAC on command    |
| DecrementNoMAC                | B2h       | decrementing a value encrypted, no MAC on response, MAC on command |



Table 12. SL3 command overview...continued

| Command  | HEX code | Description  |
|--|----------|--|
| DecrementMAC                                     | B3h      | decrementing a value encrypted, MAC on response, MAC on command                              |
| TransferNoMAC                                    | B4h      | transferring a value, no MAC on response, MAC on command                                     |
| TransferMAC                                      | B5h      | transferring a value, MAC on response, MAC on command  |
| IncrementTransferNoMAC                           | B6h      | combined incrementing and transferring a value encrypted, no MAC on response, MAC on command |
| IncrementTransferMAC                             | B7h      | combined incrementing and transferring a value encrypted, MAC on response, MAC on command    |
| DecrementTransferNoMAC                           | B8h      | combined decrementing and transferring a value encrypted, no MAC on response, MAC on command |
| DecrementTransferMAC                             | B9h      | combined decrementing and transferring a value encrypted, MAC on response, MAC on command    |
| RestoreNoMAC                                     | C2h      | restoring a value, no MAC on response, MAC on command  |
| RestoreMAC                                       | C3h      | restoring a value, MAC on response, MAC on command   |
| <b>Proximity check commands</b>                  |          |  |
| PreparePC  | F0h      | prepare for the Proximity Check  |
| ProximityCheck                                   | F2h      | perform the precise measurement for the proximity check                                      |
| VerifyPC   | FDh      | verify the proximity check   |
| <b>VC commands using ISO/IEC 7816-4 protocol</b> |          |  |
| ISOSelect  | A4h      | Select virtual card  |
| ISOExternalAuthenticate                          | 82h      | Authenticate PD  |
| <b>Transaction MAC commands</b>                  |          |  |
| CommitReaderID                                   | C8h      | commit reader ID for Transaction MAC   |

## 10 Limiting values

**Table 13. Limiting values**

[1] [2]

In accordance with the Absolute Maximum Rating System (IEC 60134).

| Symbol          | Parameter                                       | Conditions  | Min | Max | Unit |
|-----------------|---|---|-----|-----|------|
| $P_{d,max}$     | maximum power dissipation                       |   | -   | 240 | mW   |
| $I_{LA-LB,max}$ | maximum input current at the antenna pads LA/LB |   | -   | 86  | mA   |
| $T_{stg}$       | storage temperature                             |   | -55 | 125 | °C   |
| $T_{amb}$       | ambient temperature                             |   | -25 | 85  | °C   |
| $V_{ESD}$       | electrostatic discharge voltage on LA/LB        | human body model (HBM) <sup>[3]</sup> ,<br>C = 100 pF, R = 1.5 kΩ | -   | 4   | kV   |

[1] Stresses above one or more of the limiting values may cause permanent damage to the device.

[2] Exposure to limiting values for extended periods may affect device reliability.

[3] According to ANSI/ESDA/JEDEC JS-001.

### CAUTION



This device is sensitive to ElectroStatic Discharge (ESD). Observe precautions for handling electrostatic sensitive devices. Such precautions are described in the *ANSI/ESD S20.20*, *IEC/ST 61340-5*, *JESD625-A* or equivalent standards.

## 11 Abbreviations

Table 14. Abbreviations

| Acronym | Description  |
|---------|--|
| AES     | Advanced Encryption Standard                           |
| APDU    | Application Protocol Data Unit                         |
| ATQA    | Answer To reQuest                                      |
| ATS     | Answer To Select                                       |
| BCC     | Bit Count Check  |
| EEPROM  | Electrically Erasable Programmable Read-Only Memory    |
| LCR     | L = inductance, Capacitance, Resistance (LCR meter)    |
| MAC     | Message Authentication Code                            |
| NUID    | Non-Unique IDentifier                                  |
| NV      | Non-Volatile memory                                    |
| PCD     | Proximity Coupling Device (Contactless Reader)         |
| PICC    | Proximity Integrated Circuit Card (Contactless Card)   |
| PPS     | Protocol Parameter Selection                           |
| RATS    | Request Answer To Select                               |
| REQA    | REQuest Answer   |
| SAK     | Select AcKnowledge, type A                             |
| SECS-II | SEMI Equipment Communications Standard part 2          |
| SEMI    | Semiconductors Equipment and Materials International   |
| SL      | Security level   |
| UID     | Unique IDentifier                                      |
| VC      | Virtual Card, one MIFARE Plus PICC is one virtual card |
| WUPA    | Wake Up Protocol A                                     |

## 12 References

[1]

### MF1P(H)x2 Wafer specification

Data sheet addendum, BU S&C Doc. No. 3441\*\*<sup>3</sup>

[2]

### MIFARE Classic EV1 1K

Product data sheet, MF1S50YYX\_V1 MIFARE Classic EV1 1K - Mainstream contactless smart card IC for fast and easy solution development, [https://www.nxp.com/docs/en/data-sheet/MF1S50YYX\\_V1.pdf](https://www.nxp.com/docs/en/data-sheet/MF1S50YYX_V1.pdf)

[3]

### MIFARE Classic EV1 4K

Product data sheet, MF1S70YYX\_V1 MIFARE Classic EV1 4K - Mainstream contactless smart card IC for fast and easy solution development, [https://www.nxp.com/docs/en/data-sheet/MF1S70YYX\\_V1.pdf](https://www.nxp.com/docs/en/data-sheet/MF1S70YYX_V1.pdf)

[4]

### AN10833 MIFARE Type Identification Procedure

Application note, <https://www.nxp.com/docs/en/application-note/AN10833.pdf>

[5]

### AN10834 ISO 14443 PICC Selection

Application note, <https://www.nxp.com/docs/en/application-note/AN10834.pdf>

[6]

### AN10922 Symmetric key diversifications

Application note, <https://www.nxp.com/docs/en/application-note/AN10922.pdf>

[7]

### AN4462 MIFARE Plus EV2 Originality Signature Validation

Application note, BU S&C Doc.No. 4462\*\*<sup>3</sup>

[8]

### ISO/IEC 14443-3:2018

Identification cards - Contactless integrated circuit(s) cards - Proximity cards - Part 3: Initialization and anti-collision.

[9]

### ISO/IEC 14443-4:2018

Identification cards - Contactless integrated circuit(s) cards - Proximity cards - Part 4: Transmission protocol.

[10]

### ISO/IEC 7816-4:2013

---

<sup>3</sup> \*\* ... DocStore document version number

Identification cards – Integrated circuit cards – Part 4: Organization, security and commands for interchange.

[11]

**ISO/IEC 7816-5:2004**

Identification cards – Integrated circuit cards – Part 5: Registration of application providers.

[12]

**ISO/IEC 9797-1:2011**

Message Authentication Codes (MACs) – Part 1: Mechanisms using a block cipher.

[13]

**DATA ENCRYPTION STANDARD**

National Institute of Standards and Technology (NIST). Federal Information Processing Standards Publication 46-3, October 1999.

[14]

Recommendation for the Triple Data Encryption Algorithm (TDEA) Block Cipher

National Institute of Standards and Technology (NIST). NIST Special Publication 800-67, May 2004.

[15]

Specification for the Advanced Encryption Standard (AES)

National Institute of Standards and Technology (NIST). Federal Information Processing Standards Publication 197, November 2001.

[16]

Recommendation for Block Cipher Modes of Operation: Methods and Techniques

National Institute of Standards and Technology (NIST). NIST Special Publication 800-38A, December 2001.

[17]

Recommendation for Block Cipher Modes of Operation: The CMAC Mode for Authentication

National Institute of Standards and Technology (NIST). NIST Special Publication 800-38B, May 2005.

[18]

Recommendation for key derivation using pseudorandom functions

National Institute of Standards and Technology (NIST). NIST Special Publication 800-108, November 2008.

[19]

**AN10927 MIFARE product and handling of UIDs**

Application note, <https://www.nxp.com/docs/en/application-note/AN10927.pdf>

[20]

**AN11909 How to create an Installation Identifier (IID)**

Application note, <https://www.nxp.com/docs/en/application-note/AN11909.pdf>

[21]

Global Platform card specification

Globalplatform. Version 2.2.1, January 2011

[22]

Global Platform - contactless services

Globalplatform card - contactless services - card specification. v2.2 - Amendment C, Version 1.1, April 2013

[23]

Sun Microsystems

Java card <http://www.oracle.com/technetwork/java/javacard/overview/index.html>.

[24]

**Contactless smart card module specification MOA4**

Delivery Type Description, BU S&C Doc.No. 0823\*\*<sup>3</sup>

[25]

**Contactless smart card module specification MOA8**

Delivery Type Description, BU S&C Doc.No. 1636\*\*<sup>3</sup>

[26]

**General specification for 12" wafer on UV-tape; delivery types**

Delivery Type Description, BU S&C Doc.No. 1862\*\*<sup>3</sup>

[27]

**Certicom Research. Sec 1:**

Elliptic curve cryptography. Version 2.0, May 2009.

[28]

**Certicom Research. Sec 2:**

Recommended elliptic curve domain parameters. Version 2.0, January 2010.

## 13 Revision history

Table 15. Revision history

| Document ID         | Release date  | Data sheet status        | Supersedes          |
|---------------------|---|--------------------------|---------------------|
| MF1P(H)x2_SDS v.3.1 | 20210809  | Short product data sheet | MF1P(H)x2_SDS v.3.0 |
| Modifications:      | • <a href="#">Section 12 "References"</a> : updated |                          |                     |
| MF1P(H)x2_SDS v.3.0 | 20200622  | Short product data sheet | -                   |
| Modifications:      | • First release                                     |                          |                     |

## 14 Legal information

### 14.1 Data sheet status

| Document status <sup>[1][2]</sup> | Product status <sup>[3]</sup> | Definition  |
|-----------------------------------|-------------------------------|---|
| Objective [short] data sheet      | Development                   | This document contains data from the objective specification for product development. |
| Preliminary [short] data sheet    | Qualification                 | This document contains data from the preliminary specification.                       |
| Product [short] data sheet        | Production                    | This document contains the product specification.                                     |

[1] Please consult the most recently issued document before initiating or completing a design.

[2] The term 'short data sheet' is explained in section "Definitions".

[3] The product status of device(s) described in this document may have changed since this document was published and may differ in case of multiple devices. The latest product status information is available on the Internet at URL <http://www.nxp.com>.

### 14.2 Definitions

**Draft** — A draft status on a document indicates that the content is still under internal review and subject to formal approval, which may result in modifications or additions. NXP Semiconductors does not give any representations or warranties as to the accuracy or completeness of information included in a draft version of a document and shall have no liability for the consequences of use of such information.

**Short data sheet** — A short data sheet is an extract from a full data sheet with the same product type number(s) and title. A short data sheet is intended for quick reference only and should not be relied upon to contain detailed and full information. For detailed and full information see the relevant full data sheet, which is available on request via the local NXP Semiconductors sales office. In case of any inconsistency or conflict with the short data sheet, the full data sheet shall prevail.

**Product specification** — The information and data provided in a Product data sheet shall define the specification of the product as agreed between NXP Semiconductors and its customer, unless NXP Semiconductors and customer have explicitly agreed otherwise in writing. In no event however, shall an agreement be valid in which the NXP Semiconductors product is deemed to offer functions and qualities beyond those described in the Product data sheet.

### 14.3 Disclaimers

**Limited warranty and liability** — Information in this document is believed to be accurate and reliable. However, NXP Semiconductors does not give any representations or warranties, expressed or implied, as to the accuracy or completeness of such information and shall have no liability for the consequences of use of such information. NXP Semiconductors takes no responsibility for the content in this document if provided by an information source outside of NXP Semiconductors. In no event shall NXP Semiconductors be liable for any indirect, incidental, punitive, special or consequential damages (including - without limitation - lost profits, lost savings, business interruption, costs related to the removal or replacement of any products or rework charges) whether or not such damages are based on tort (including negligence), warranty, breach of contract or any other legal theory. Notwithstanding any damages that customer might incur for any reason whatsoever, NXP Semiconductors' aggregate and cumulative liability towards customer for the products described herein shall be limited in accordance with the Terms and conditions of commercial sale of NXP Semiconductors.

**Right to make changes** — NXP Semiconductors reserves the right to make changes to information published in this document, including without limitation specifications and product descriptions, at any time and without

notice. This document supersedes and replaces all information supplied prior to the publication hereof.

**Suitability for use** — NXP Semiconductors products are not designed, authorized or warranted to be suitable for use in life support, life-critical or safety-critical systems or equipment, nor in applications where failure or malfunction of an NXP Semiconductors product can reasonably be expected to result in personal injury, death or severe property or environmental damage. NXP Semiconductors and its suppliers accept no liability for inclusion and/or use of NXP Semiconductors products in such equipment or applications and therefore such inclusion and/or use is at the customer's own risk.

**Applications** — Applications that are described herein for any of these products are for illustrative purposes only. NXP Semiconductors makes no representation or warranty that such applications will be suitable for the specified use without further testing or modification. Customers are responsible for the design and operation of their applications and products using NXP Semiconductors products, and NXP Semiconductors accepts no liability for any assistance with applications or customer product design. It is customer's sole responsibility to determine whether the NXP Semiconductors product is suitable and fit for the customer's applications and products planned, as well as for the planned application and use of customer's third party customer(s). Customers should provide appropriate design and operating safeguards to minimize the risks associated with their applications and products. NXP Semiconductors does not accept any liability related to any default, damage, costs or problem which is based on any weakness or default in the customer's applications or products, or the application or use by customer's third party customer(s). Customer is responsible for doing all necessary testing for the customer's applications and products using NXP Semiconductors products in order to avoid a default of the applications and the products or of the application or use by customer's third party customer(s). NXP does not accept any liability in this respect.

**Limiting values** — Stress above one or more limiting values (as defined in the Absolute Maximum Ratings System of IEC 60134) will cause permanent damage to the device. Limiting values are stress ratings only and (proper) operation of the device at these or any other conditions above those given in the Recommended operating conditions section (if present) or the Characteristics sections of this document is not warranted. Constant or repeated exposure to limiting values will permanently and irreversibly affect the quality and reliability of the device.

**Terms and conditions of commercial sale** — NXP Semiconductors products are sold subject to the general terms and conditions of commercial sale, as published at <http://www.nxp.com/profile/terms>, unless otherwise agreed in a valid written individual agreement. In case an individual agreement is concluded only the terms and conditions of the respective agreement shall apply. NXP Semiconductors hereby expressly objects to applying the customer's general terms and conditions with regard to the purchase of NXP Semiconductors products by customer.



**No offer to sell or license** — Nothing in this document may be interpreted or construed as an offer to sell products that is open for acceptance or the grant, conveyance or implication of any license under any copyrights, patents or other industrial or intellectual property rights.

**Quick reference data** — The Quick reference data is an extract of the product data given in the Limiting values and Characteristics sections of this document, and as such is not complete, exhaustive or legally binding.

**Export control** — This document as well as the item(s) described herein may be subject to export control regulations. Export might require a prior authorization from competent authorities.

**Non-automotive qualified products** — Unless this data sheet expressly states that this specific NXP Semiconductors product is automotive qualified, the product is not suitable for automotive use. It is neither qualified nor tested in accordance with automotive testing or application requirements. NXP Semiconductors accepts no liability for inclusion and/or use of non-automotive qualified products in automotive equipment or applications. In the event that customer uses the product for design-in and use in automotive applications to automotive specifications and standards, customer (a) shall use the product without NXP Semiconductors' warranty of the product for such automotive applications, use and specifications, and (b) whenever customer uses the product for automotive applications beyond NXP Semiconductors' specifications such use shall be solely at customer's own risk, and (c) customer fully indemnifies NXP Semiconductors for any liability, damages or failed product claims resulting from customer design and use of the product for automotive applications beyond NXP Semiconductors' standard warranty and NXP Semiconductors' product specifications.

**Translations** — A non-English (translated) version of a document is for reference only. The English version shall prevail in case of any discrepancy between the translated and English versions.

**Security** — Customer understands that all NXP products may be subject to unidentified or documented vulnerabilities. Customer is responsible for the design and operation of its applications and products throughout their lifecycles to reduce the effect of these vulnerabilities on customer's applications and products. Customer's responsibility also extends to other open and/or proprietary technologies supported by NXP products for use

in customer's applications. NXP accepts no liability for any vulnerability. Customer should regularly check security updates from NXP and follow up appropriately. Customer shall select products with security features that best meet rules, regulations, and standards of the intended application and make the ultimate design decisions regarding its products and is solely responsible for compliance with all legal, regulatory, and security related requirements concerning its products, regardless of any information or support that may be provided by NXP. NXP has a Product Security Incident Response Team (PSIRT) (reachable at PSIRT@nxp.com) that manages the investigation, reporting, and solution release to security vulnerabilities of NXP products.

## 14.4 Licenses

### ICs with DPA Countermeasures functionality



NXP ICs containing functionality implementing countermeasures to Differential Power Analysis and Simple Power Analysis are produced and sold under applicable license from Cryptography Research, Inc.

## 14.5 Trademarks

Notice: All referenced brands, product names, service names and trademarks are the property of their respective owners.

**MIFARE** — is a trademark of NXP B.V.

**DESFire** — is a trademark of NXP B.V.

**MIFARE Plus** — is a trademark of NXP B.V.

**MIFARE Ultralight** — is a trademark of NXP B.V.

**MIFARE Classic** — is a trademark of NXP B.V.

**NXP** — wordmark and logo are trademarks of NXP B.V.