

# MF0ICU1

## MIFARE Ultralight contactless single-ticket IC

Rev. 3.9 — 23 July 2014  
028639

Product data sheet  
COMPANY PUBLIC

## 1. General description

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The MIFARE MF0ICU1 has been developed by NXP Semiconductors to be used in a contactless smart ticket or smart card in combination with a Proximity Coupling Devices (PCD) in accordance with ISO/IEC 14443 A (see [Ref. 1](#)). It is intended for use as single trip or limited use tickets in public transportation networks, loyalty cards or day passes for events as a replacement for conventional ticketing solutions such as paper tickets, magnetic stripe tickets or coins.

As the usage of contactless proximity smart cards becomes more and more common, transport and event operators are switching to completely contactless solutions. The introduction of the MIFARE Ultralight for limited use tickets may lead to a reduction of system installation and maintenance costs. Terminals may be less vulnerable to damage and mechanical failures caused by ticket jams. MF0ICU1 can easily be integrated into existing schemes and even standard paper ticket vending equipment can be upgraded. This solution for low cost tickets can help operators to reduce the circulation of cash within the system.

The mechanical and electronical specifications of MIFARE Ultralight are tailored to meet the requirements of paper ticket manufacturers.

### 1.1 Contactless energy and data transfer

In the MIFARE system, the MF0ICU1 is connected to a coil with a few turns. The MF0ICU1 fits the TFC.0 (Edmondson) and TFC.1 (ISO) ticket formats as defined in BS EN753-2.

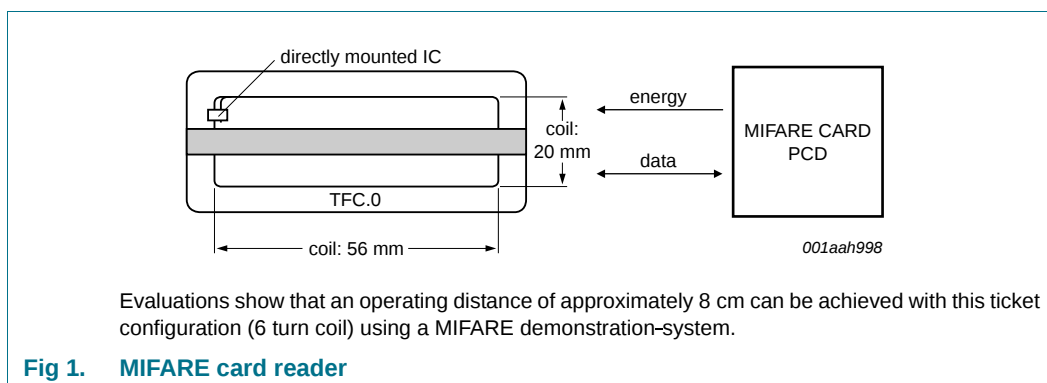
TFC.1 format tickets are supported by the MF0ICU10 chip which features a 17 pF on-chip resonance capacitor.

The smaller TFC.0 format tickets are supported by the MF0ICU11 chip which features a 50 pF on-chip resonance capacitor.

### 1.2 Anticollision

An intelligent anticollision function enables simultaneous multiscard operation. The anticollision algorithm individually selects each card and ensures correct execution of a transaction with the selected card without interference from another card in the field.





### 1.2.1 Cascaded Unique Identification (UID)

The anticollision function is based on an IC individual serial number called Unique Identification (UID) for each IC. The UID of the MF0ICU1 comprises 7 bytes and supports ISO/IEC 14443-3 cascade level 2.

## 1.3 Security

- 7-byte UID in accordance with ISO/IEC 14443-3 for each device
- 32-bit user definable One-Time Programmable (OTP) area
- Field programmable read-only locking function per page

## 1.4 Naming conventions

**Table 1. Naming conventions**

| MF0xxU1w/D<br>MF0xxU1w01W/y7DL | Description                                                                                                                                                            |
|--------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| MF                             | MIFARE family                                                                                                                                                          |
| 0                              | Ultralight product family                                                                                                                                              |
| xx                             | Identifier for the package type<br>IC ... bare die<br>MOA4 ... contactless module                                                                                      |
| U1                             | Product: Ultralight                                                                                                                                                    |
| w                              | One character identifier for input capacitance<br>0 ... 17 pF<br>1 ... 50 pF                                                                                           |
| /D                             | Fixed ending for module type                                                                                                                                           |
| /y7DL                          | y is a single character identifier for the wafer type<br>S... bare die, 75 µm thickness, Au bumps, e-map file<br>U... bare die, 120 µm thickness, Au bumps, e-map file |

## 2. Features and benefits

### 2.1 MIFARE RF interface ISO/IEC 14443 A

- Contactless transmission of data and supply energy
- Operating frequency of 13.56 MHz
- Data integrity of 16-bit CRC, parity, bit coding, bit counting
- 7 byte serial number (cascade level 2 according to ISO/IEC 14443-3)
- Fast counter transaction: < 10 ms
- Operating distance up to 100 mm depending on antenna geometry and reader configuration
- Data transfer of 106 kbit/s
- True anticollision
- Typical ticketing transaction: < 35 ms

### 2.2 EEPROM

- 512-bit, organized in 16 pages with 4 bytes per page
- 32-bit user definable One-Time Programmable (OTP) area
- Data retention time of 5 years
- Field programmable read-only locking function per page
- 384-bit user Read/Write area (12 pages)
- Write endurance 10000 cycles

## 3. Quick reference data

Table 2. Characteristics

| Symbol                 | Parameter         | Conditions               |                     | Min   | Typ   | Max   | Unit  |
|------------------------|-------------------|--------------------------|---------------------|-------|-------|-------|-------|
| f <sub>i</sub>         | input frequency   |                          |                     | -     | 13.56 | -     | MHz   |
| C <sub>i</sub>         | input capacitance | 17 pF version            | <a href="#">[1]</a> | 14.85 | 17.0  | 20.13 | pF    |
|                        |                   | 50 pF version            | <a href="#">[1]</a> | 42.5  | 50.0  | 57.5  | pF    |
| EEPROM characteristics |                   |                          |                     |       |       |       |       |
| t <sub>cy(W)</sub>     | write cycle time  |                          |                     | -     | 3.8   | -     | ms    |
| t <sub>ret</sub>       | retention time    | T <sub>amb</sub> = 22 °C |                     | 5     | -     | -     | year  |
| N <sub>endu(W)</sub>   | write endurance   | T <sub>amb</sub> = 22 °C |                     | 10000 | -     | -     | cycle |

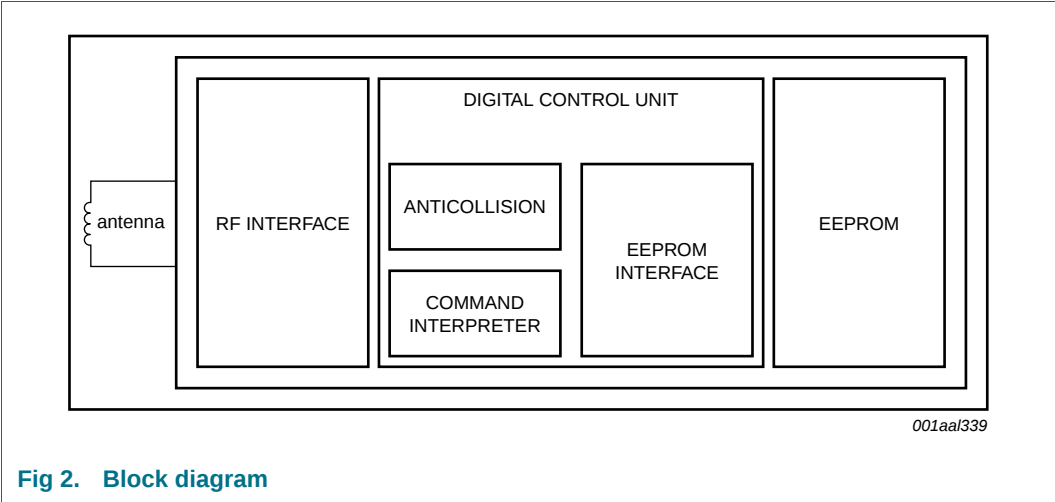
[1] LCR meter HP 4285:  $T_{amb} = 22\text{ °C}$ ,  $C_p$ -D,  $f_i = 13.56\text{ MHz}$ , 2 Veff.

4. Ordering information

Table 3. Ordering information

| Type number      | Package         |       |                                                                                                                                                        |          |
|------------------|-----------------|-------|--------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
|                  | Commercial Name | Name  | Description                                                                                                                                            | Version  |
| MF0ICU1001W/S7DL | FFC             | -     | 8 inch wafer, sawn, 75 μm thickness, on film frame carrier, electronic fail die marking according to SECSII format, Au bumps, 17 pF input capacitance  | -        |
| MF0ICU1101W/S7DL | FFC             | -     | 8 inch wafer, sawn, 75 μm thickness, on film frame carrier, electronic fail die marking according to SECSII format, Au bumps, 50 pF input capacitance  | -        |
| MF0ICU1001W/U7DL | FFC             | -     | 8 inch wafer, sawn, 120 μm thickness, on film frame carrier, electronic fail die marking according to SECSII format, Au bumps, 17 pF input capacitance | -        |
| MF0ICU1101W/U7DL | FFC             | -     | 8 inch wafer, sawn, 120 μm thickness, on film frame carrier, electronic fail die marking according to SECSII format, Au bumps, 50 pF input capacitance | -        |
| MF0MOA4U10/D     | MOA4            | PLLMC | plastic leadless module carrier package; 35 mm SOT500-2 wide tape, 17 pF input capacitance                                                             | SOT500-2 |

5. Block diagram



6. Pinning information

6.1 Pinning

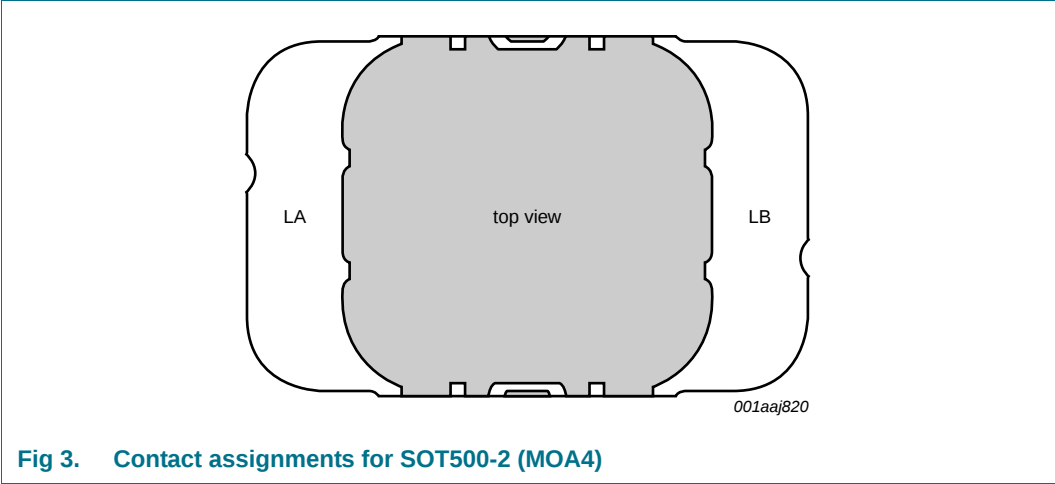


Table 4. Bonding pad assignments to smart card contactless module

| Contactless interface module |        | MF0ICU1DA4/01              |
|------------------------------|--------|----------------------------|
| Antenna contacts             | Symbol | Description                |
| LA                           | LA     | antenna coil connection LA |
| LB                           | LB     | antenna coil connection LB |

## 7. Functional description

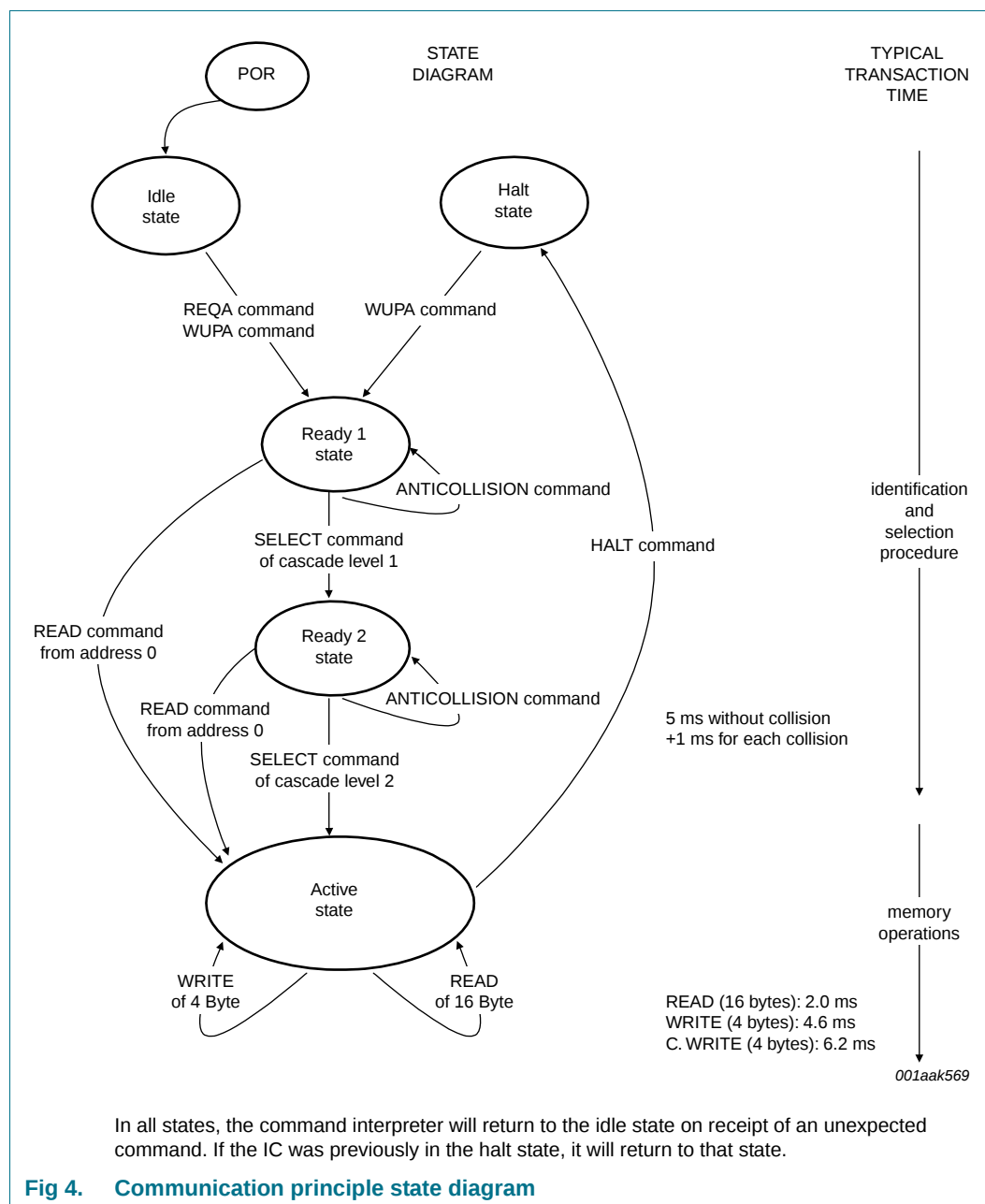
### 7.1 Block description

The MF0ICU1 chip consists of a 512-bit EEPROM, RF interface and Digital Control Unit (DCU). Energy and data are transferred via an antenna consisting of a coil with a small number of turns which is directly connected to the MF0ICU1. No further external components are necessary. Please refer to [Ref. 6](#) for details on antenna design.

- RF interface:
  - Modulator/demodulator
  - Rectifier
  - Clock regenerator
  - Power-On Reset (POR)
  - Voltage regulator
- Anticollision: Multiple cards may be selected and managed in sequence
- Command interpreter: Processes commands supported by the MF0ICU1 to access the memory
- EEPROM interface
- EEPROM: 512 bits, organized in 16 pages of 4 bytes per page.
  - 80 bits reserved for manufacturer data
  - 16 bits used for the read-only locking mechanism
  - 32 bits available as OTP area
  - 384 bits user programmable Read/Write memory

## 7.2 Communication overview

Commands are initiated by the PCD and controlled by the MF0ICU1's command interpreter. This processes the internal states and generates the appropriate response.



### 7.2.1 Idle state

After a Power-On Reset (POR), the MF0ICU1 switches directly to the idle state. It only exits this state when a REQA or a WUPA command is received from the PCD. Any other data received while in the idle state is interpreted as an error and the MF0ICU1 remains Idle.

After a correctly executed HALT command out of the ACTIVE state, the halt state changes to the wait state which can be exited with a WUPA command.

### 7.2.2 Ready 1 state

In this state, the MF0ICU1 supports the PCD when resolving the first part of its UID (3 bytes) with the ANTICOLLISION or SELECT command from cascade level 1. This state is exited correctly after execution of either of the following commands:

- SELECT command from cascade level 1: the PCD switches the MF0ICU1 into Ready 2 state where the second part of the UID is resolved.
- READ command (from address 0): all anticollision mechanisms are bypassed and the MF0ICU1 switches directly to the active state.

**Remark:** If more than one MF0ICU1 is in the PCD field, a READ command from address 0 causes a collision due to the different serial numbers and all MF0ICU1 devices are selected.

**Remark:** Any other data received in the Ready 1 state is interpreted as an error and depending on its previous state the MF0ICU1 returns to the wait, idle or halt state.

### 7.2.3 Ready 2 state

In this state, the MF0ICU1 supports the PCD when resolving the second part of its UID (4 bytes) with the cascade level 2 ANTICOLLISION command. This state is usually exited using the cascade level 2 SELECT command.

Alternatively, state Ready 2 may be skipped using a READ command (from address 0) as described in state Ready 1.

**Remark:** If more than one MF0ICU1 is in the PCD field, a READ command from address 0 causes a collision due to the different serial numbers and all MF0ICU1 devices are selected.

**Remark:** The response of the MF0ICU1 to the cascade level 2 SELECT command is the Select Acknowledge (SAK) byte. In accordance with ISO/IEC 14443 this byte indicates if the anticollision cascade procedure has finished. It also defines the type of device selected for the MIFARE architecture platform. The MF0ICU1 is now uniquely selected and only this device will communicate with the PCD even when other contactless devices are present in the PCD field.

**Remark:** Any other data received when the device is in this state is interpreted as an error and depending on its previous state the MF0ICU1 returns to the wait, idle or halt state.

### 7.2.4 Active state

In the active state either a 16-byte READ or 4-byte WRITE command can be performed. The ACTIVE state is gracefully exited with the HLTA command and upon reception the MF0ICU1 transits to the HALT state. Any other data received when the device is in this state is interpreted as an error. Depending on its previous state the MF0ICU1 returns to either the IDLE state or HALT state.

### 7.2.5 Halt state

The HALT and IDLE states constitute the two wait states implemented in the MF0ICU1. An already processed MF0ICU1 can be set into the HALT state using the HLTA command. In the anticollision phase, this state helps the PCD to distinguish between processed cards and cards yet to be selected. The MF0ICU1 can only exit this state on execution of the WUPA command. Any other data received when the device is in this state is interpreted as an error and the MF0ICU1 state remains unchanged. Refer to [Ref. 3](#) for correct implementation of an anticollision procedure based on the IDLE and HALT states and the REQA and WUPA commands.

## 7.3 Data integrity

Reliable data transmission is ensured over the contactless communication link between PCD and MF0ICU1 as follows:

- 16-bit CRC for each block
- Parity bits for each byte
- Bit count checking
- Bit coding to distinguish between logic 1, logic 0 and no information
- Channel monitoring (protocol sequence and bit stream analysis)

## 7.4 RF interface

The RF interface is based on the ISO/IEC 14443 A standard for contactless smart cards. The RF field from the PCD is always present as it is used for the card power supply. However, it is sequentially interrupted during data transmission to allow the data to be sent. There is only one start bit at the beginning of each frame for data communication irrespective of direction. Each byte is transmitted with an odd parity bit at the end of the byte. The LSB of the byte with the lowest selected block address is transmitted first. The maximum frame length is 163-bit:  
(16 data bytes + 2 CRC bytes =  $16 * 9 + 2 * 9 + 1$  start bit = 163).

## 7.5 Memory organization

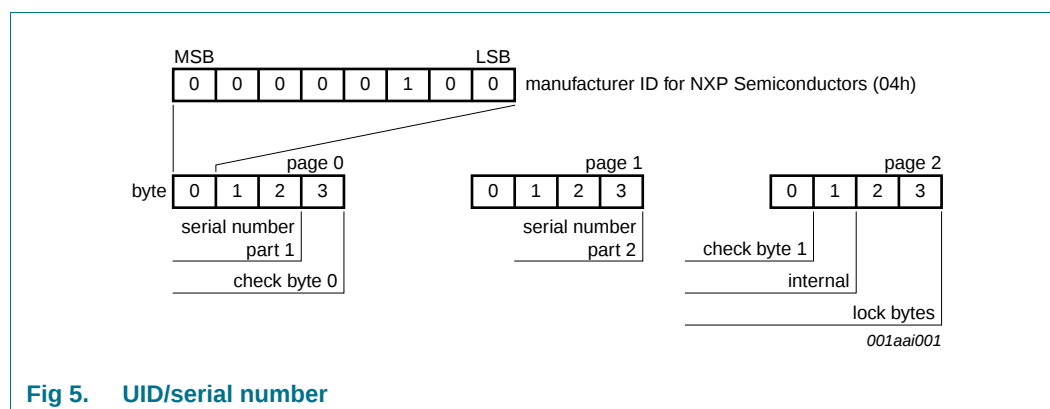
The 512-bit EEPROM memory is organized in 16 pages with 4 bytes per page. In the erased state the EEPROM cells are read as logic 0, in the written state as logic 1.

**Table 5. Memory organization**

| Page address |            | Byte number   |          |            |            |
|--------------|------------|---------------|----------|------------|------------|
| Decimal      | Hex        | 0             | 1        | 2          | 3          |
| 0            | 00h        | serial number |          |            |            |
| 1            | 01h        | serial number |          |            |            |
| 2            | 02h        | serial number | internal | lock bytes | lock bytes |
| 3            | 03h        | OTP           | OTP      | OTP        | OTP        |
| 4 to 15      | 04h to 0Fh | user memory   |          |            |            |

### 7.5.1 UID/serial number

The unique 7-byte serial number (UID) and its two check bytes are programmed into the first 9 bytes of memory covering page addresses 00h, 01h and the first byte of page 02h. The second byte of page address 02h is reserved for internal data. These bytes are programmed by the IC manufacturer and because of the security requirements are write protected.



**Fig 5. UID/serial number**

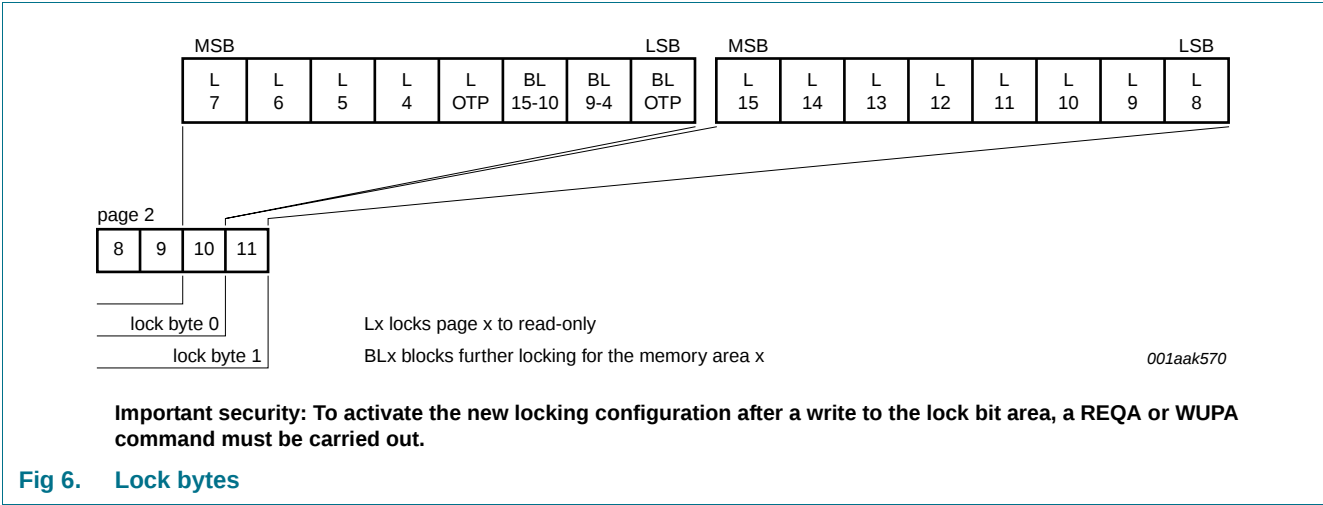
In accordance with ISO/IEC 14443-3 Check Byte0 (BCC0) is defined as  $CT \oplus SN0 \oplus SN1 \oplus SN2$  and Check Byte 1 (BCC1) is defined as  $SN3 \oplus SN4 \oplus SN5 \oplus SN6$ .

SN0 holds the Manufacturer ID for NXP Semiconductors (04h) in accordance with ISO/IEC 14443-3 and ISO/IEC 7816-6 AMD.1

7.5.2 Lock bytes

The bits of byte 02h and 03h of page 02h represent the field programmable read-only locking mechanism. Each page from 03h (OTP) to 0Eh can be individually locked by setting the corresponding locking bit Lx to logic 1 to prevent further write access. After locking, the page becomes read-only memory.

The three least significant bits of lock byte 0 are the block-locking bits. Bit 2 deals with pages 0Fh to 0Ah, bit 01h deals with pages 09h to 04h and bit 0 deals with page 03h (OTP). Once the block-locking bits are set, the locking configuration for the corresponding memory area is frozen.



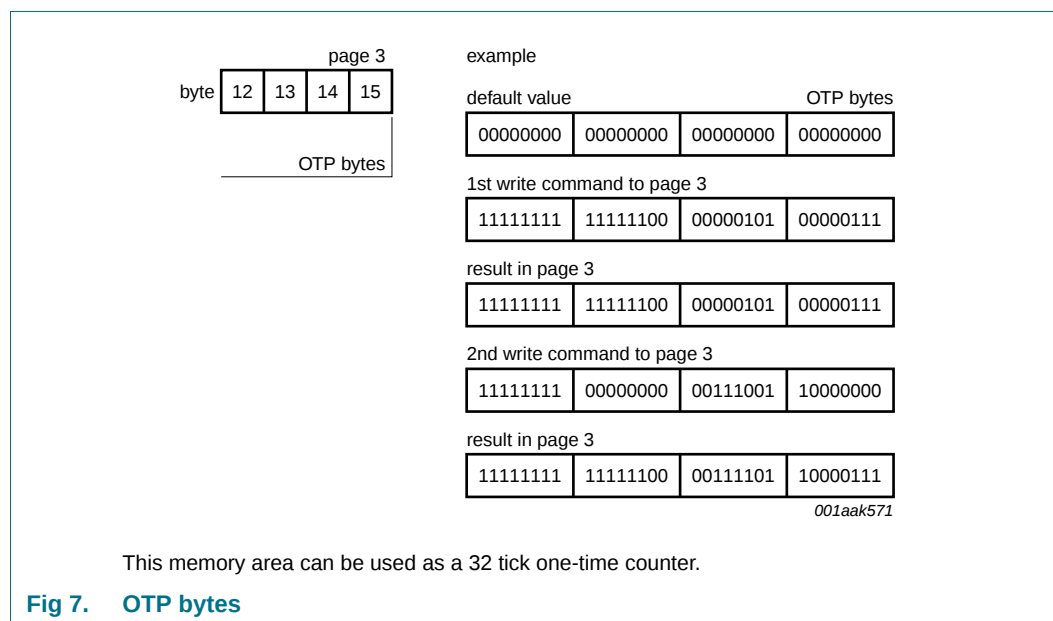
In [Figure 6](#) for example if BL15-10 is set to logic 1, then bits L15 to L10 (lock byte 2 bit[7:2]) can no longer be changed.

The locking and block-locking bits are set by a WRITE command to page 2. Bytes 2 and 3 of the WRITE command, and the contents of the lock bytes are bitwise OR'ed and the result then becomes the new contents of the lock bytes. This process is irreversible if a bit is set to logic 1, it cannot be changed back to logic 0.

The contents of bytes 0 and 1 of page 2 are unaffected by the corresponding data bytes of the WRITE command.

### 7.5.3 OTP bytes

Page 03h is the OTP page and it is preset so that all bits are set to logic 0 after production. These bytes can be bitwise modified using the WRITE command.



The WRITE command bytes and the current contents of the OTP bytes are bitwise OR'ed. The result is the new OTP byte contents. This process is irreversible and if a bit is set to logic 1, it cannot be changed back to logic 0.

### 7.5.4 Data pages

Pages 04h to 0Fh are the user read/write area.

After production the data pages are initialized to the following values:

- Page 04h is initialized to FFh
- Pages 05h to 15h are initialized to 00h

7.6 Command set

The MF0ICU1 comprises the following command set:

7.6.1 REQA

Table 6. REQA

| Command | Code        | Parameter | Data | Integrity mechanism | Response    |
|---------|-------------|-----------|------|---------------------|-------------|
| REQA    | 26h (7-bit) | -         | -    | parity              | ATQA 44 00h |

The MF0ICU1 accepts the REQA command only in the idle state. The response is the 2-byte ATQA (44 00h). REQA and ATQA commands are fully implemented in accordance with ISO/IEC 14443-3.

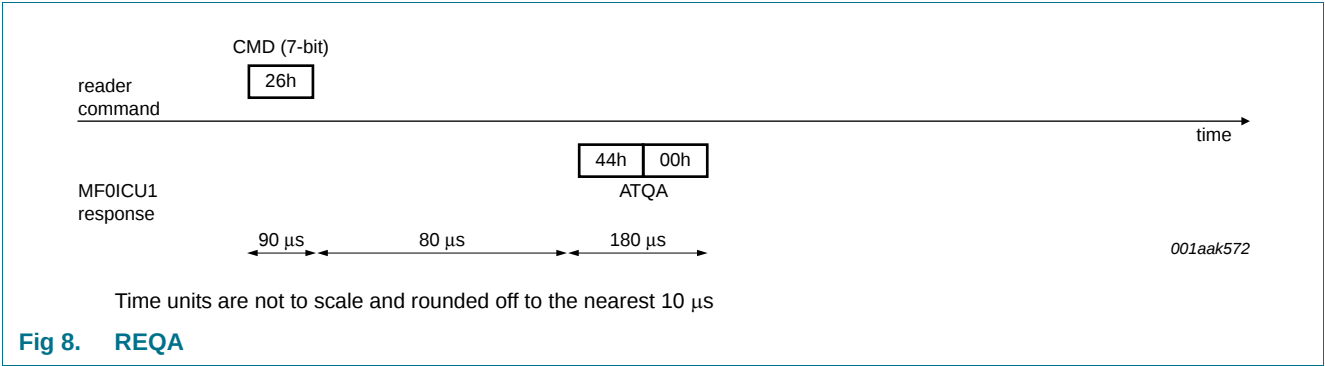


Fig 8. REQA

7.6.2 WUPA

Table 7. WUPA

| Command | Code        | Parameter | Data | Integrity mechanism | Response    |
|---------|-------------|-----------|------|---------------------|-------------|
| WUPA    | 52h (7-bit) | -         | -    | parity              | ATQA 44 00h |

The MF0ICU1 accepts the WUPA command only in the idle and halt states. The response is the 2-byte ATQA (44 00h). WUPA command is fully implemented in accordance with ISO/IEC 14443-3.

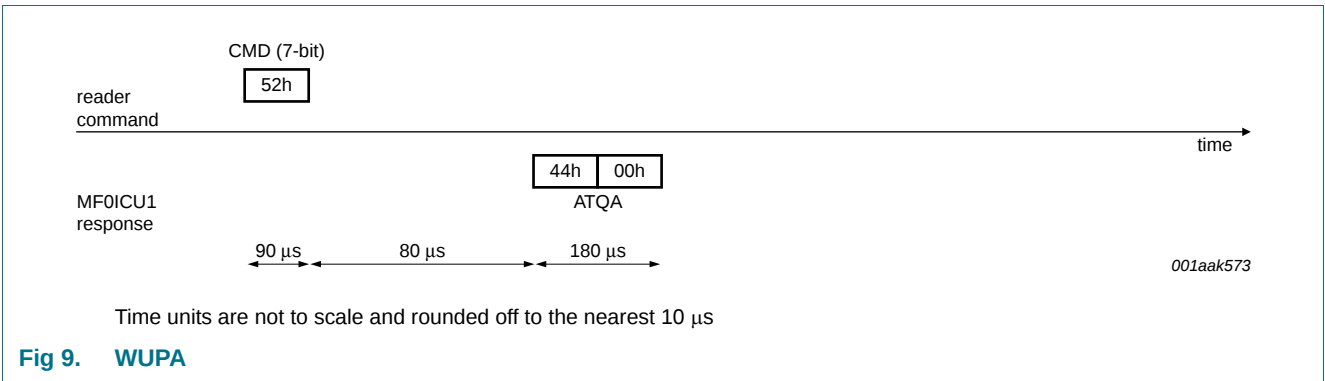


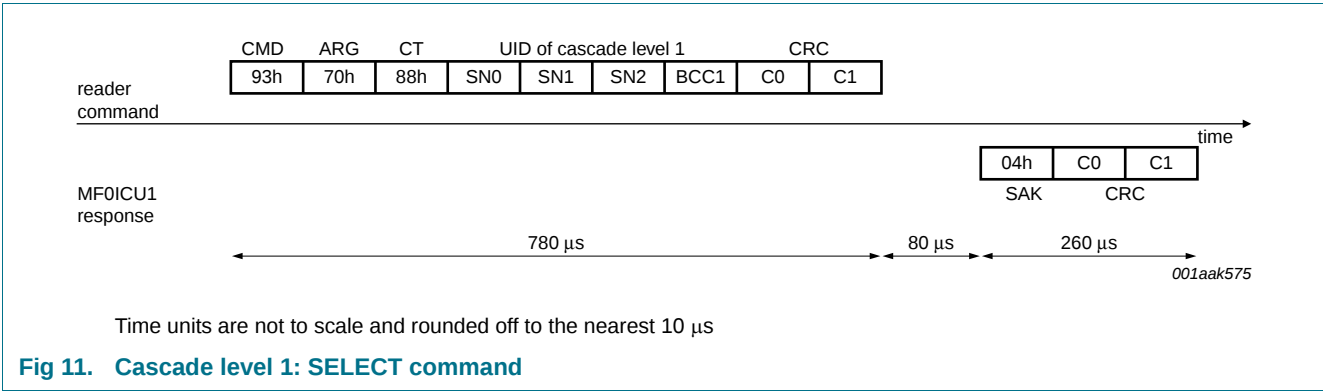
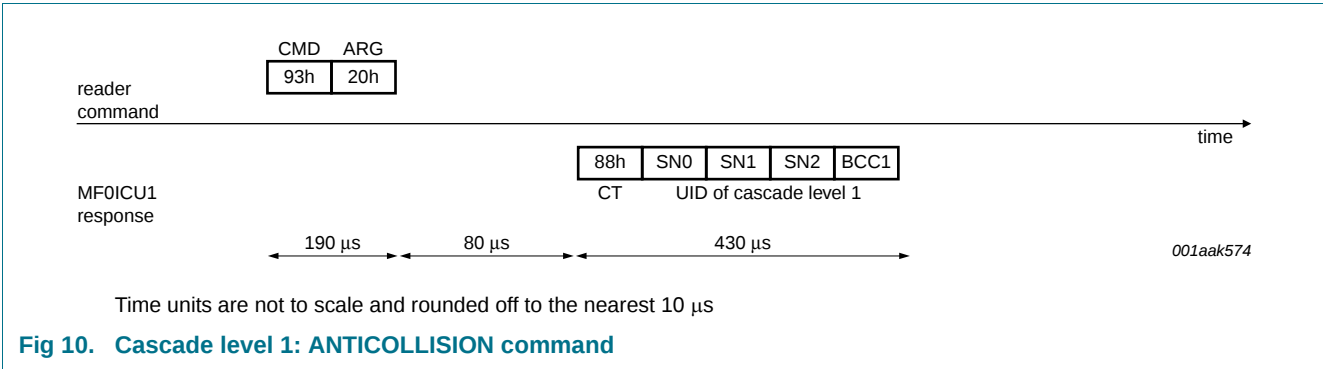
Fig 9. WUPA

7.6.3 Cascade level 1: ANTICOLLISION and SELECT commands

Table 8. Cascade level 1: ANTICOLLISION and SELECT commands

| Command       | Code | Parameter  | Data               | Integrity mechanism | Response     |
|---------------|------|------------|--------------------|---------------------|--------------|
| ANTICOLLISION | 93h  | 20h to 67h | part of the UID    | parity              | parts of UID |
| SELECT        | 93h  | 70h        | UID: first 3 bytes | parity, BCC, CRC    | SAK (04h)    |

The ANTICOLLISION and SELECT commands are based on the same command code. Only the parameter byte is different. This byte is as the 70h definition in case of the SELECT command. The MF0ICU1 accepts these commands only in the Ready 1 state. The response is part 1 of the UID for the anticollision and SAK (04h) for SELECT.

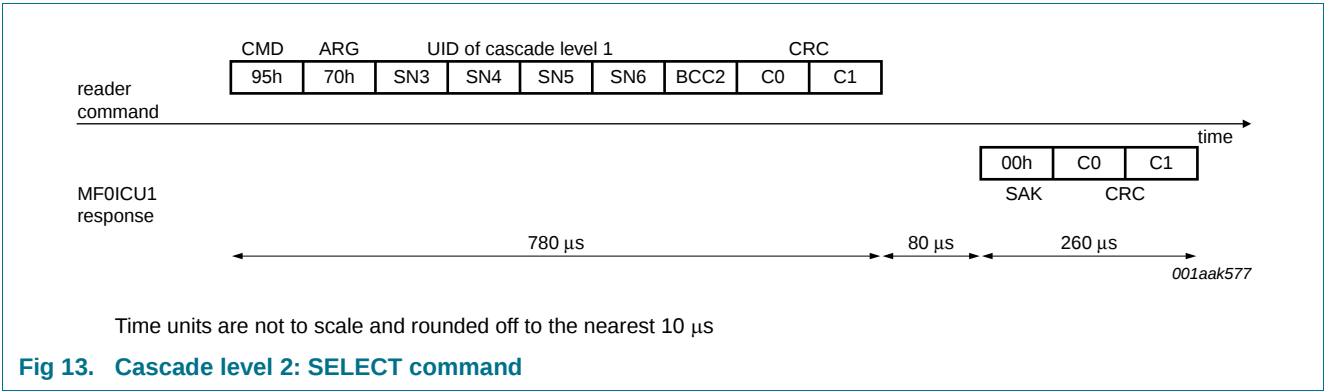
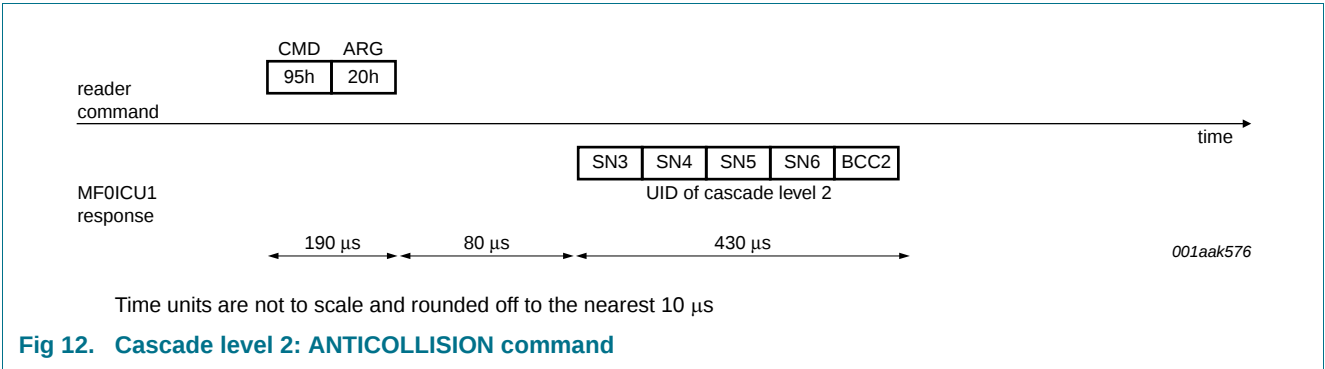


7.6.4 Cascade level 2: ANTICOLLISION and SELECT commands

Table 9. Cascade level 2: ANTICOLLISION and SELECT commands

| Command       | Code | Parameter  | Data                | Integrity mechanism | Response     |
|---------------|------|------------|---------------------|---------------------|--------------|
| ANTICOLLISION | 95h  | 20h to 67h | part of the UID     | parity              | parts of UID |
| SELECT        | 95h  | 70h        | UID: second 4 bytes | parity, BCC, CRC    | SAK (00h)    |

The ANTICOLLISION and SELECT commands are based on the same command code. Only the parameter byte is different. This byte is as the 70h definition in case of the SELECT command. The MF0ICU1 accepts these commands only in the Ready 2 state. The response is part 2 of the UID for the anticollision and SAK (04h) for SELECT.

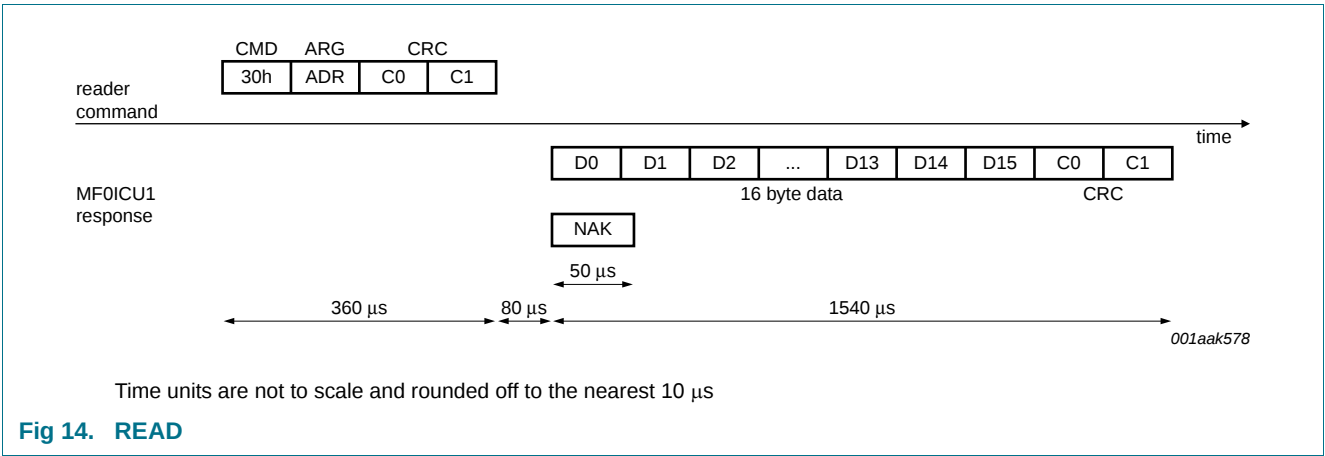


7.6.5 READ

Table 10. READ

| Command | Code | Parameter address | Data | Integrity mechanism | Response     |
|---------|------|-------------------|------|---------------------|--------------|
| READ    | 30h  | 00h to 0Fh        | -    | CRC                 | 16-byte Data |

The READ command needs the page address as a parameter. Only addresses 00h to 0Fh are decoded. The MF0ICU1 returns a NAK for higher addresses. The MF0ICU1 responds to the READ command by sending 16 bytes starting from the page address defined by the command argument. For example; if address (ADR) is 03h then pages 03h, 04h, 05h, 06h are returned. A roll-back is implemented for example; if address (ADR) is 0Eh, then the contents of pages 0Eh, 0Fh, 00h and 01h are returned).

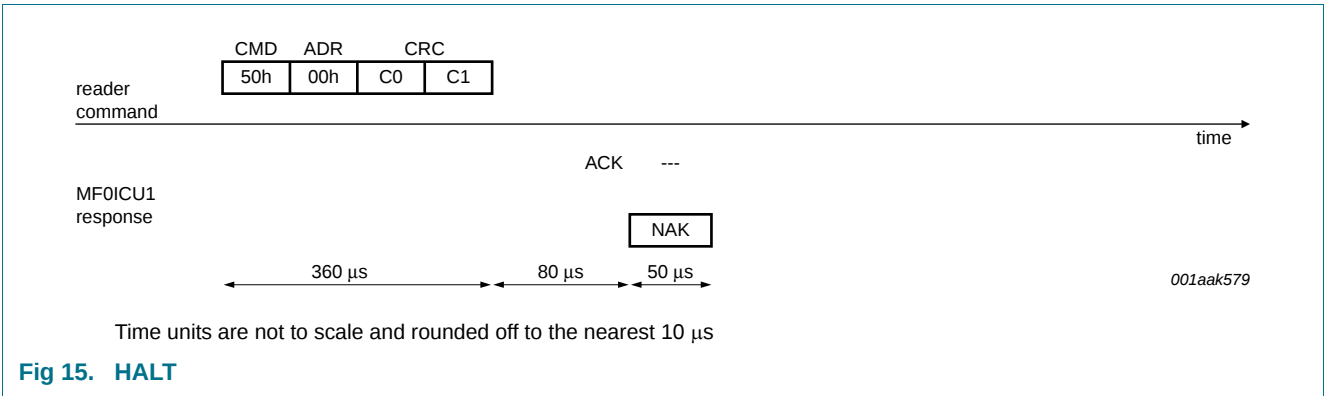


7.6.6 HALT

Table 11. HALT

| Command | Code | Parameter address | Data | Integrity mechanism | Response         |
|---------|------|-------------------|------|---------------------|------------------|
| HALT    | 50h  | 00h               | -    | parity, CRC         | passive ACK, NAK |

The HALT command is used to set the MF0ICU1 ICs into a different wait state (halt instead of idle), enabling devices whose UIDs are already known because they have passed the anticollision procedure, to be separated from devices yet to be identified by their UIDs. This mechanism is a very efficient way of finding all contactless devices in the PCD field.

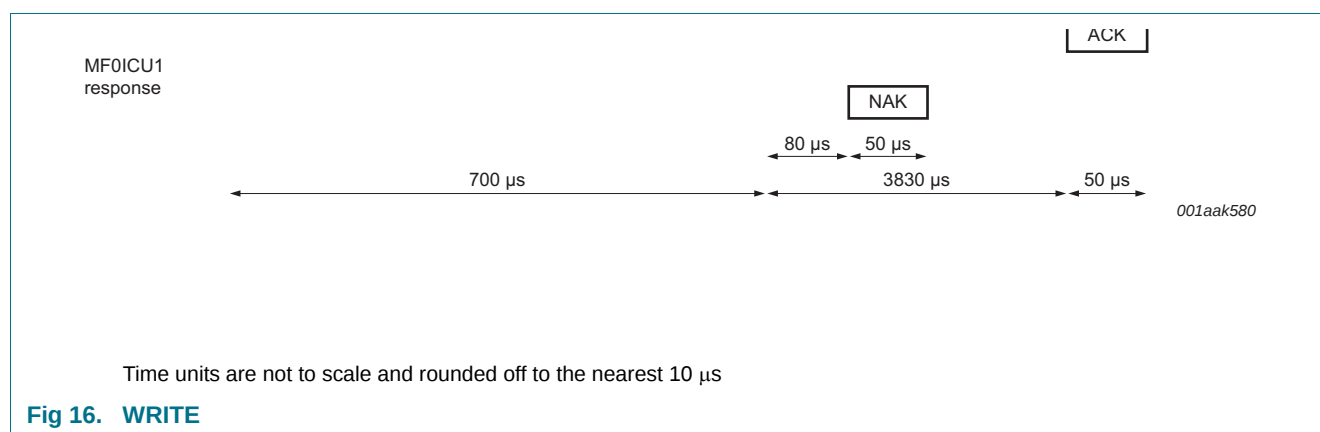


## 7.6.7 WRITE

Table 12. WRITE

| Command | Code | Parameter address | Data   | Code | Parameter |
|---------|------|-------------------|--------|------|-----------|
| WRITE   | A2h  | 00h to 0Fh        | 4-byte | A2h  | 0 to 7    |

The WRITE command is used to program the lock bytes in page 02h, the OTP bytes in page 03h and the data bytes in pages 04h to 0Fh. A WRITE command is performed page-wise, programming 4 bytes in a row.

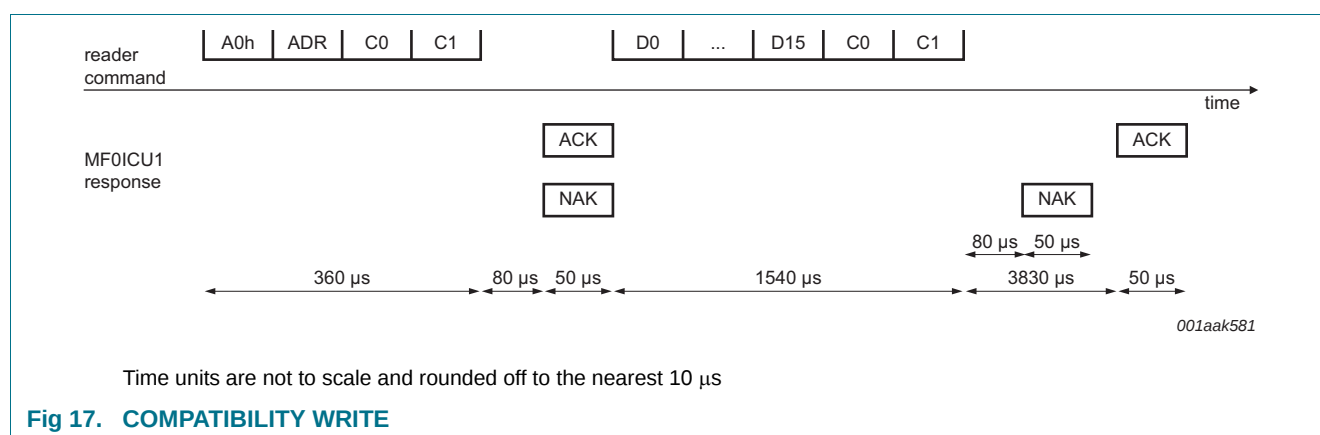


## 7.6.8 COMPATIBILITY WRITE

Table 13. COMPATIBILITY WRITE

| Command             | Code | Parameter address | Data    | Integrity mechanism | Response   |
|---------------------|------|-------------------|---------|---------------------|------------|
| COMPATIBILITY WRITE | A0h  | 00h to 0Fh        | 16-byte | parity, CRC         | ACK or NAK |

The COMPATIBILITY WRITE command was implemented to accommodate the established MIFARE PCD infrastructure. Even though 16 bytes are transferred to the MF0ICU1, only the least significant 4 bytes (bytes 0 to 3) are written to the specified address. It is recommended to set the remaining bytes 04h to 0Fh to all logic 0.



## 7.7 Summary of relevant data for device identification

Table 14. Summary of relevant data for device identification

| Code                  | Type        | Value | Binary Format                                                                                                    | Remark                                                      |
|-----------------------|-------------|-------|------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------|
| ATQA                  | 2-byte      | 44h   | 0000 0000 0100 0100;<br>1 <sup>st</sup> 1 indicates cascade level 2<br>2 <sup>nd</sup> 1 indicates MIFARE family | hard coded                                                  |
| CT                    | 1-byte      | 88h   | 1000 1000                                                                                                        | hard coded                                                  |
|                       | cascade tag |       | ensures collision with cascade level 1 products                                                                  |                                                             |
| SAK (cascade level 1) | 1-byte      | 04h   | 0000 0100; 1 indicates additional cascade level                                                                  | hard coded                                                  |
| SAK (cascade level 2) | 1-byte      | 00h   | 0000 0000; indicates complete UID and MF0ICU1 functionality                                                      | hard coded                                                  |
| manufacturer Byte     | 1-byte      | 04h   | 0000 0100; indicates manufacturer NXP Semiconductors                                                             | in accordance with ISO/IEC 14443-3 and ISO/IEC 7816-6 AMD.1 |

## 8. Limiting values

**Table 15. Limiting values**

*In accordance with the Absolute Maximum Rating System (IEC 60134)*<sup>[1]</sup>

| Symbol    | Parameter                       | Conditions                      |                | Min  | Max <sup>[2][3]</sup> | Unit |
|-----------|---------------------------------|---------------------------------|----------------|------|-----------------------|------|
| $I_I$     | input current                   |                                 |                | -    | 30                    | mA   |
| $T_{stg}$ | storage temperature             |                                 |                | -55  | 125                   | °C   |
| $T_{amb}$ | ambient temperature             |                                 |                | -25  | 70                    | °C   |
| $V_{ESD}$ | electrostatic discharge voltage | measured between pins LA and LB | <sup>[4]</sup> | 2    | -                     | kV   |
| $I_{lu}$  | latch-up current                |                                 |                | ±100 | -                     | mA   |

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

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

[3] These are stress ratings only. Operation of the device at these or any other conditions above those given in [Section 9.1](#) of the specification is not implied.

[4] JEDEC norm JESD22-A114; Human body model: C = 100 pF, R = 1.5 kΩ.

## 9. Characteristics

### 9.1 Electrical characteristics

**Table 16. Characteristics**

| Symbol                 | Parameter         | Conditions               |                     | Min   | Typ   | Max   | Unit  |
|------------------------|-------------------|--------------------------|---------------------|-------|-------|-------|-------|
| f <sub>i</sub>         | input frequency   |                          |                     | -     | 13.56 | -     | MHz   |
| C <sub>i</sub>         | input capacitance | 17 pF version            | <a href="#">[1]</a> | 14.85 | 17.0  | 20.13 | pF    |
|                        |                   | 50 pF version            | <a href="#">[1]</a> | 42.5  | 50.0  | 57.5  | pF    |
| EEPROM characteristics |                   |                          |                     |       |       |       |       |
| t <sub>cy(W)</sub>     | write cycle time  |                          |                     | -     | 3.8   | -     | ms    |
| t <sub>ret</sub>       | retention time    | T <sub>amb</sub> = 22 °C |                     | 5     | -     | -     | year  |
| N <sub>endu(W)</sub>   | write endurance   | T <sub>amb</sub> = 22 °C |                     | 10000 | -     | -     | cycle |

[1] LCR meter HP 4285:  $T_{amb} = 22\text{ °C}$ , Cp-D,  $f_i = 13.56\text{ MHz}$ , 2 Veff.

## 10. Wafer specification

For more details on the wafer delivery forms see [Ref. 8](#).

**Table 17. Specifications**

|                                             |                                                                         |
|---------------------------------------------|-------------------------------------------------------------------------|
| <b>Wafer</b>                                |                                                                         |
| diameter                                    | 200 mm (8 inches)                                                       |
| maximum diameter after foil expansion       | 210 mm                                                                  |
| die separation process                      | laser dicing                                                            |
| thickness                                   | 120 $\mu\text{m}$ $\pm$ 15 $\mu\text{m}$ (U7DL types)                   |
|                                             | 75 $\mu\text{m}$ $\pm$ 10 $\mu\text{m}$ (S7DL types)                    |
| flatness                                    | not applicable                                                          |
| Potential Good Dies per Wafer (PGDW)        | 72778                                                                   |
| <b>Wafer underside</b>                      |                                                                         |
| material                                    | Si                                                                      |
| flatness                                    | not applicable                                                          |
| roughness                                   | $R_a$ max = 0.5 $\mu\text{m}$                                           |
|                                             | $R_t$ max = 5 $\mu\text{m}$                                             |
| <b>Chip dimensions</b>                      |                                                                         |
| step size <sup>[1]</sup>                    | x = 645 $\mu\text{m}$                                                   |
|                                             | y = 665 $\mu\text{m}$                                                   |
| gap between chips <sup>[1]</sup>            | typical = 20 $\mu\text{m}$                                              |
|                                             | minimum = 5 $\mu\text{m}$                                               |
| <b>Passivation</b>                          |                                                                         |
| type                                        | sandwich structure                                                      |
| material                                    | PSG/nitride (on top)                                                    |
| thickness                                   | 500 nm/600 nm                                                           |
| <b>Au bump (substrate connected to VSS)</b> |                                                                         |
| material                                    | 99.9 % pure Au                                                          |
| hardness                                    | 35 to 80 HV 0.005                                                       |
| shear strength                              | >70 MPa                                                                 |
| height                                      | 18 $\mu\text{m}$                                                        |
| height uniformity                           | within a die = $\pm$ 2 $\mu\text{m}$                                    |
|                                             | within a wafer = $\pm$ 3 $\mu\text{m}$                                  |
|                                             | wafer to wafer = $\pm$ 4 $\mu\text{m}$                                  |
| flatness                                    | minimum = $\pm$ 1.5 $\mu\text{m}$                                       |
| size                                        | LA, LB = 90 $\mu\text{m}$ $\times$ 90 $\mu\text{m}$                     |
|                                             | VSS, TESTIO <sup>[2]</sup> = 60 $\mu\text{m}$ $\times$ 60 $\mu\text{m}$ |
| size variation                              | $\pm$ 5 $\mu\text{m}$                                                   |
| under bump metallization                    | sputtered TiW                                                           |

[1] The step size and the gap between chips may vary due to changing foil expansion

[2] Pads VSS and TESTIO are disconnected when wafer is sawn.

## 10.1 Fail die identification

The wafers are not inked.

Electronic wafer mapping (SECS II format) covers the electrical test results and the additional mechanical/visual inspection results.

11. Package outline

For further details on the contactless module MOA4 please refer to [Ref. 7](#).

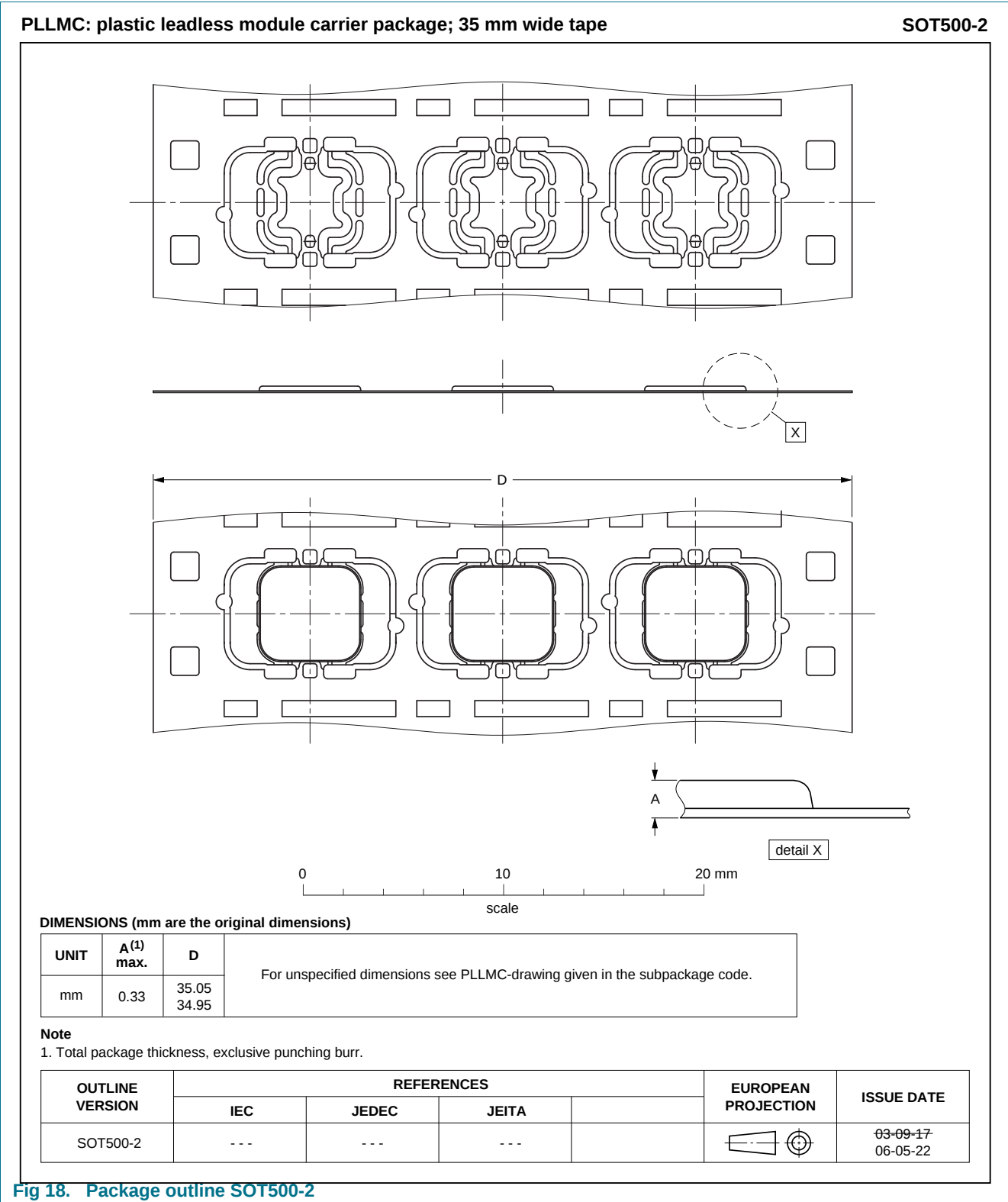


Fig 18. Package outline SOT500-2

12. Bare die outline

For more details on the wafer delivery forms, see [Ref. 8](#).

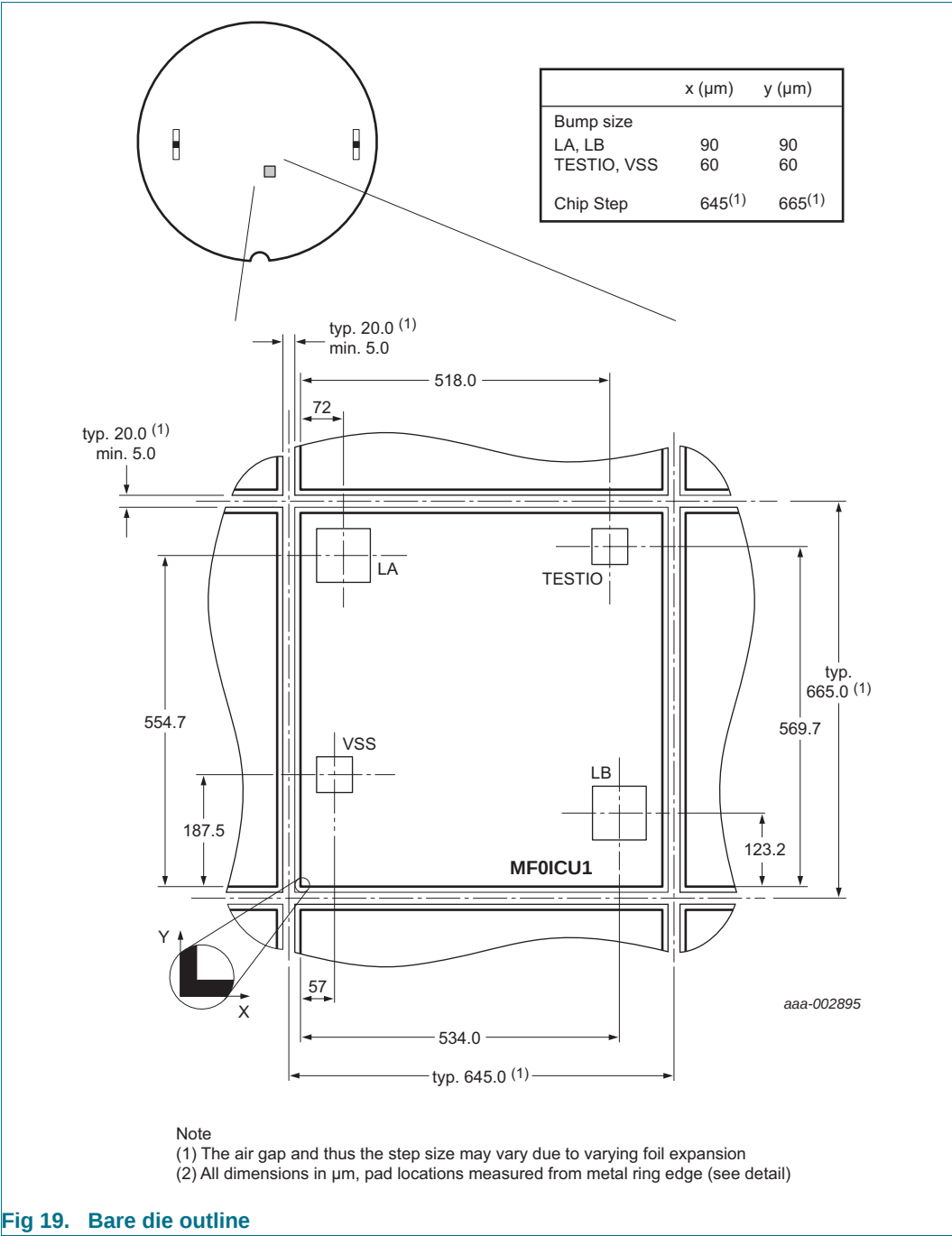


Fig 19. Bare die outline

## 13. Abbreviations

Table 18. Abbreviations

| Acronym     | Description                                         |
|-------------|-----------------------------------------------------|
| ARG         | Argument                                            |
| ATQA        | Answer To Request (type A)                          |
| BCC         | Block Check Character                               |
| CMD         | Command                                             |
| CRC         | Cyclic Redundancy Check                             |
| CT          | Cascade Tag                                         |
| EEPROM      | Electrically Erasable Programmable Read-Only Memory |
| LSB         | Least Significant Bit                               |
| MSB         | Most Significant Bit                                |
| NAK         | Negative Acknowledge                                |
| OTP         | One-Time Programmable                               |
| Passive ACK | Passive (implicit) ACKnowledge without PICC answer  |
| PCD         | Proximity Coupling Device                           |
| PGDW        | Potential Good Dies per Wafer                       |
| PICC        | Proximity Integrated Circuit Card                   |
| POR         | Power-On Reset                                      |
| REQA        | Request Answer (type A)                             |
| RF          | Radio Frequency                                     |
| SAK         | Select ACKnowledge (type A)                         |
| UID         | Unique IDentifier/IDentification                    |
| WUPA        | Wake-UP command (type A)                            |

## 14. References

- [1] **ISO/IEC 14443 A** — International Organization for Standardization/International Electrotechnical Commission: Identification cards - Contactless integrated circuit(s) cards - Proximity cards, part 1-4, Type A
- [2] **MIFARE Interface Platform Type Identification Procedure** — Application note, BL-ID Document number 0184, Version number \*\*[1](#)
- [3] **MIFARE ISO/IEC 14443 PICC Selection** — Application note, BL-ID Document number 1308, Version number \*\*[1](#)
- [4] **MIFARE Ultralight Features and Hints** — Application note, BL-ID Document number 0731, Version number \*\*[1](#)
- [5] **MIFARE Ultralight as Type 2 Tag** — Application note, BL-ID Document number 1303, Version number \*\*[1](#)
- [6] **MIFARE (Card) Coil Design Guide** — Application note, BL-ID Document number 0117, Version number \*\*[1](#)
- [7] **Contactless smart card module specification MOA4** — Delivery Type Description, BU-ID Document number 0823\*\*[1](#)
- [8] **General specification for 8" wafer on UV-tape with electronic fail die marking; delivery types** — Delivery Type Description, BU-ID Document number 1093\*\*[1](#)

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1. \*\* ... document version number

## 15. Revision history

**Table 19. Revision history**

| Document ID    | Release date                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Data sheet status      | Change notice | Supersedes |
|----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|---------------|------------|
| MF0ICU1 v.3.9  | 20140723                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Product data sheet     | -             | MF0ICU1_38 |
| Modifications: | <ul style="list-style-type: none"> <li>• <a href="#">Figure 19 "Bare die outline"</a>: updated</li> <li>• Corrected typo in <a href="#">Section 7.5.2 "Lock bytes"</a> Lock Bytes for the block locking bit 2</li> <li>• Corrected wafer thickness tolerance for 75 µm thin wafers</li> <li>• Corrected bump size for VSS pad</li> <li>• Corrected reference <a href="#">Ref. 8</a> to wafer delivery with electronic fail die marking</li> <li>• New template structure applied</li> <li>• Editorial changes</li> </ul> |                        |               |            |
| MF0ICU1 v.3.8  | 20101222                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Product data sheet     | -             | MF0ICU1_37 |
| Modifications: | <ul style="list-style-type: none"> <li>• Unit of write endurance corrected in cycles</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                          |                        |               |            |
| MF0ICU1_37     | 20100414                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Product data sheet     | -             | 028636     |
| Modifications: | <ul style="list-style-type: none"> <li>• Figure 4 "Chip orientation and bondpad locations": format updated</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                    |                        |               |            |
| 028636         | 20100212                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Product data sheet     | -             | 028635     |
| Modifications: | <ul style="list-style-type: none"> <li>• Updated information on memory content after production</li> <li>• Information on laser dicing types included (no separate wafer addendum needed)</li> <li>• Packaging information included</li> <li>• Fig. 4 "Chip orientation and bondpad locations": format updated</li> <li>• Multiple minor changes</li> <li>• Section 5 "Legal information": updated</li> </ul>                                                                                                            |                        |               |            |
| 028635         | 20080820                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Product data sheet     | -             | 028634     |
| Modifications: | <ul style="list-style-type: none"> <li>• Section 1 "General description" and Section 2 "Features": rephrasing of sentences</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                    |                        |               |            |
| 028634         | 20080204                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Product data sheet     | -             | 028633     |
| Modifications: | <ul style="list-style-type: none"> <li>• Update</li> <li>• General rewording of MIFARE designation and commercial conditions</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                  |                        |               |            |
| 028633         | July 2008                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Product data sheet     | -             | 028632     |
| Modifications: | <ul style="list-style-type: none"> <li>• exchange of figures 11 and 13</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                        |                        |               |            |
| 028632         | April 2007                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Product data sheet     | -             | 028631     |
| Modifications: | <ul style="list-style-type: none"> <li>• The format of this data sheet has been redesigned to comply with the new identity guidelines of NXP Semiconductors.</li> <li>• Legal texts have been adapted to the new company name.</li> </ul>                                                                                                                                                                                                                                                                                |                        |               |            |
| 028631         | March 2007                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Product data sheet     | -             | 028630     |
| 028630         | March 2003                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Product data sheet     | -             | 028625     |
| 028625         | March 2003                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Preliminary data sheet | -             | 028624     |
| 028624         | February 2003                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Preliminary data sheet | -             | 028623     |
| 028623         | January 2003                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Preliminary data sheet | -             | 028622     |
| 028622         | January 2003                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Preliminary data sheet | -             | 028621     |
| 028621         | January 2003                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Preliminary data sheet | -             | 028620     |
| 028620         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Preliminary data sheet | -             | 028610     |

**Table 19.** Revision history ...continued

| Document ID | Release date | Data sheet status    | Change notice | Supersedes |
|-------------|--------------|----------------------|---------------|------------|
| 028610      |              | Objective data sheet | -             | -          |

## 16. Legal information

### 16.1 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".

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