

MF1S703x

MIFARE Classic 4K - Mainstream contactless smart card IC for fast and easy solution development

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Product data sheet
PUBLIC

1. General description

NXP Semiconductors has developed the MIFARE MF1S703x to be used in a contactless smart card according to ISO/IEC 14443 Type A.

The MIFARE MF1S703x IC is used in applications like public transport ticketing and can also be used for various other applications.

1.1 Anti-collision

An intelligent anti-collision function allows to operate more than one card in the field simultaneously. The anti-collision algorithm selects each card individually and ensures that the execution of a transaction with a selected card is performed correctly without interference from another card in the field.

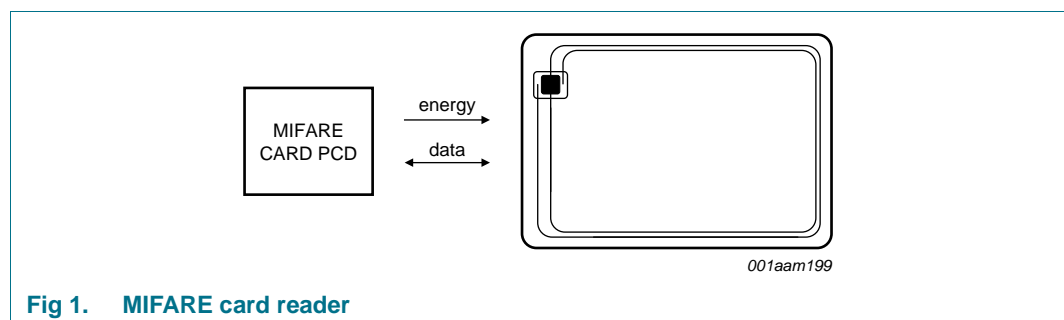


Fig 1. MIFARE card reader

1.2 Simple integration and user convenience

The MF1S703x is designed for simple integration and user convenience which allows complete ticketing transactions to be handled in less than 100 ms.

1.3 Security

- Manufacturer programmed 4 byte Non-Unique IDentifier (NUID) for each device
- Mutual three pass authentication (ISO/IEC DIS 9798-2)
- Individual set of two keys per sector to support multi-application with key hierarchy

1.4 Delivery options

- Die on wafer, bumped die on wafer
- MOA4 contactless module



2. Features and benefits

- Contactless transmission of data and supply energy
- Operating frequency of 13.56 MHz
- Data integrity of 16-bit CRC, parity, bit coding, bit counting
- Typical ticketing transaction time of less than 100 ms (including backup management)
- Operating distance up to 100 mm depending on antenna geometry and reader configuration
- Data transfer of 106 kbit/s
- Anti-collision

2.1 EEPROM

- 4 kB, organized in 32 sectors of 4 blocks and 8 sectors of 16 blocks (one block consists of 16 byte)
- Data retention time of 10 years
- User definable access conditions for each memory block
- Write endurance 100.000 cycles

3. Applications

- Public transportation
- Electronic toll collection
- School and campus cards
- Internet cafés
- Access management
- Car parking
- Employee cards
- Loyalty

4. Quick reference data

Table 1. Quick reference data

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|-------------------------------|-------------------|--------------------------|--------|--------|------|-------|
| C_i | input capacitance | [1] | 14.4 | 16.1 | 17.4 | pF |
| f_i | input frequency | | - | 13.56 | - | MHz |
| EEPROM characteristics | | | | | | |
| t_{ret} | retention time | $T_{amb} = 22\text{ °C}$ | 10 | - | - | year |
| $N_{endu(W)}$ | write endurance | $T_{amb} = 22\text{ °C}$ | 100000 | 200000 | - | cycle |

[1] LCR meter, $T_{amb} = 22\text{ °C}$, $f_i = 13.56\text{ MHz}$, 2 V RMS.

5. Ordering information

Table 2. Ordering information

| Type number | Package | | | Version |
|-------------|-----------------|-------|--|----------------|
| | Commercial Name | Name | Description | |
| MF1S7035DUC | FFC Bump | - | 8 inch wafer, 150 μm thickness, on film frame carrier, electronic fail die marking according to SECSII format), Au bumps | not applicable |
| MF1S7035DUB | FFC | - | 8 inch wafer, 150 μm thickness, on film frame carrier, electronic fail die marking according to SECSII format) | not applicable |
| MF1S7035DA4 | MOA4 | PLLMC | plastic leadless module carrier package; 35 mm wide tape | SOT500-2 |

6. Block diagram

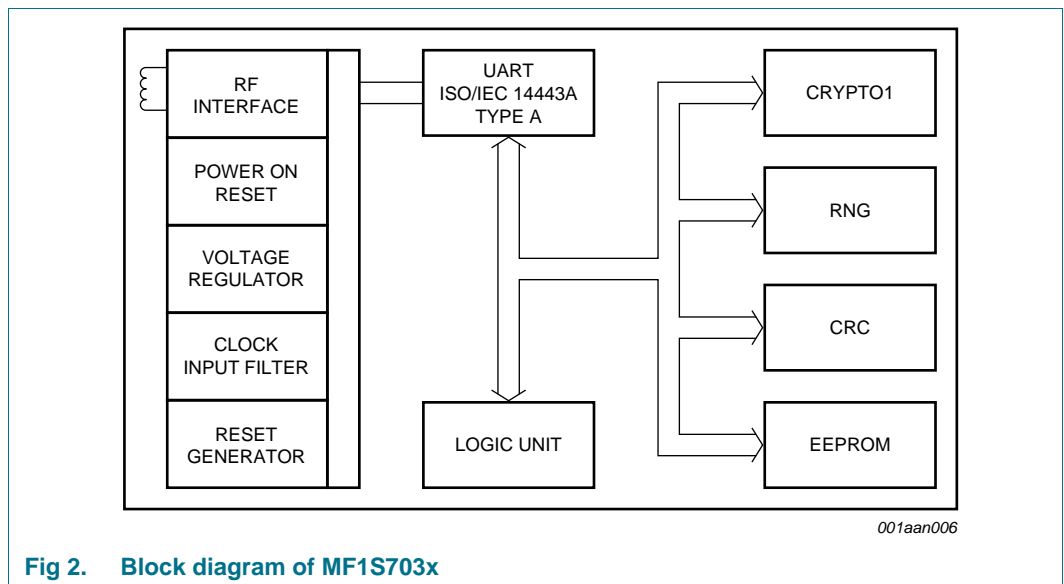


Fig 2. Block diagram of MF1S703x

7. Pinning information

7.1 Pinning

The pinning for the MF1S7035DA4 is shown in [Figure 3](#).

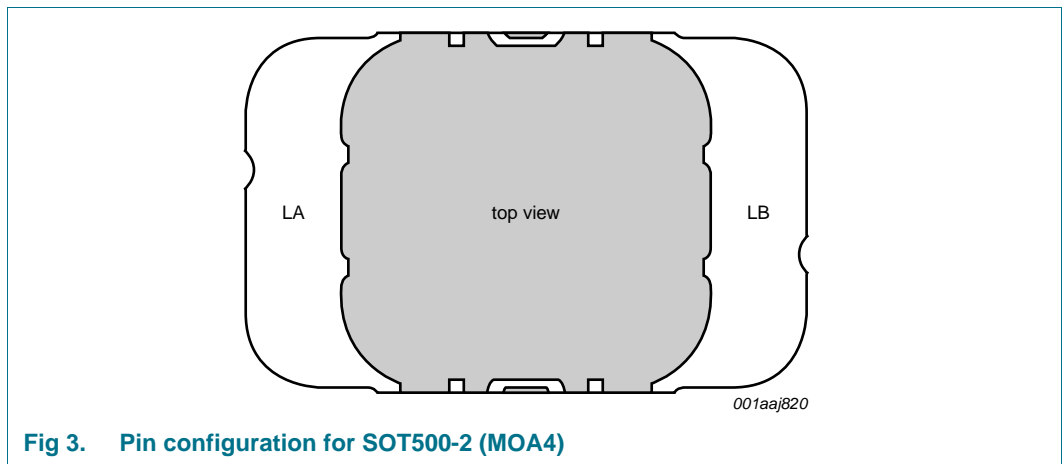


Fig 3. Pin configuration for SOT500-2 (MOA4)

Table 3. Pin allocation table

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

8. Functional description

8.1 Block description

The MF1S703x chip consists of a 4 kB EEPROM, RF interface and Digital Control Unit. Energy and data are transferred via an antenna consisting of a coil with a small number of turns which is directly connected to the MF1S703x. No further external components are necessary. Refer to the document [Ref. 1](#) for details on antenna design.

- RF interface:
 - Modulator/demodulator
 - Rectifier
 - Clock regenerator
 - Power-On Reset (POR)
 - Voltage regulator
- Anti-collision: Multiple cards in the field may be selected and managed in sequence
- Authentication: Preceding any memory operation the authentication procedure ensures that access to a block is only possible via the two keys specified for each block
- Control and Arithmetic Logic Unit: Values are stored in a special redundant format and can be incremented and decremented
- EEPROM interface
- Crypto unit: The CRYPTO1 stream cipher of the MF1S703x is used for authentication and encryption of data exchange.
- EEPROM: 4 kB is organized in 32 sectors with 4 blocks and 8 sectors with 16 blocks each. A block contains 16 bytes. The last block of each sector is called “trailer”, which contains two secret keys and programmable access conditions for each block in this sector.

8.2 Communication principle

The commands are initiated by the reader and controlled by the Digital Control Unit of the MF1S703x. The command response is depending on the state of the IC and for memory operations also on the access conditions valid for the corresponding sector.

8.2.1 Request standard/all

After Power-On Reset (POR) the card answers to a request REQA or wakeup WUPA command with the answer to request code (see [Section 9.4](#), ATQA according to ISO/IEC 14443A).

8.2.2 Anti-collision loop

In the anti-collision loop the identifier of a card is read. If there are several cards in the operating field of the reader, they can be distinguished by their identifier and one can be selected (select card) for further transactions. The unselected cards return to the idle state and wait for a new request command.

Remark: The identifier retrieved from the card is not defined to be unique. For further information regarding handling of non-unique identifiers see [Ref. 7](#).

8.2.3 Select card

With the select card command the reader selects one individual card for authentication and memory related operations. The card returns the Select Acknowledge (SAK) code which determines the type of the selected card, see Section 9.4. For further details refer to the document Ref. 3.

8.2.4 Three pass authentication

After selection of a card the reader specifies the memory location of the following memory access and uses the corresponding key for the three pass authentication procedure. After a successful authentication all memory operations are encrypted.

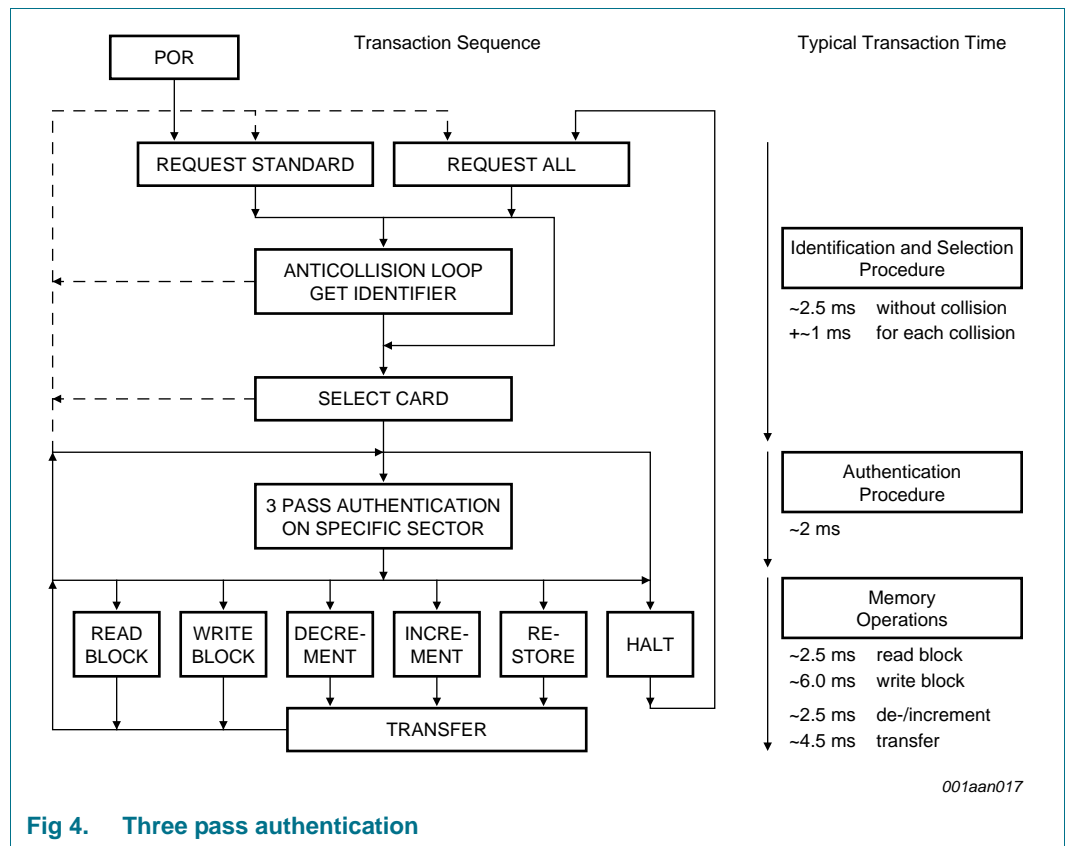


Fig 4. Three pass authentication

8.2.5 Memory operations

After authentication any of the following operations may be performed:

- Read block
- Write block
- Decrement: Decrements the contents of a block and stores the result in an internal data-register
- Increment: Increments the contents of a block and stores the result in an internal data-register
- Restore: Moves the contents of a block into an internal data-register
- Transfer: Writes the contents of the temporary internal data-register to a value block

8.3 Data integrity

Following mechanisms are implemented in the contactless communication link between reader and card to ensure very reliable data transmission:

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

8.4 Three pass authentication sequence

1. The reader specifies the sector to be accessed and chooses key A or B.
2. The card reads the secret key and the access conditions from the sector trailer. Then the card sends a random number as the challenge to the reader (pass one).
3. The reader calculates the response using the secret key and additional input. The response, together with a random challenge from the reader, is then transmitted to the card (pass two).
4. The card verifies the response of the reader by comparing it with its own challenge and then it calculates the response to the challenge and transmits it (pass three).
5. The reader verifies the response of the card by comparing it to its own challenge.

After transmission of the first random challenge the communication between card and reader is encrypted.

8.5 RF interface

The RF-interface is according to the standard for contactless smart cards ISO/IEC 14443 A.

For operation, the carrier field from the reader always needs to be present (with short pauses when transmitting), as it is used for the power supply of the card.

For both directions of data communication there is only one start bit at the beginning of each frame. Each byte is transmitted with a parity bit (odd parity) at the end. The LSB of the byte with the lowest address of the selected block is transmitted first. The maximum frame length is 163 bits (16 data bytes + 2 CRC bytes = $16 \times 9 + 2 \times 9 + 1$ start bit).

8.6 Memory organization

The 4096 × 8 bit EEPROM memory is organized in 32 sectors of 4 blocks and 8 sectors of 16 blocks. One block contains 16 bytes.

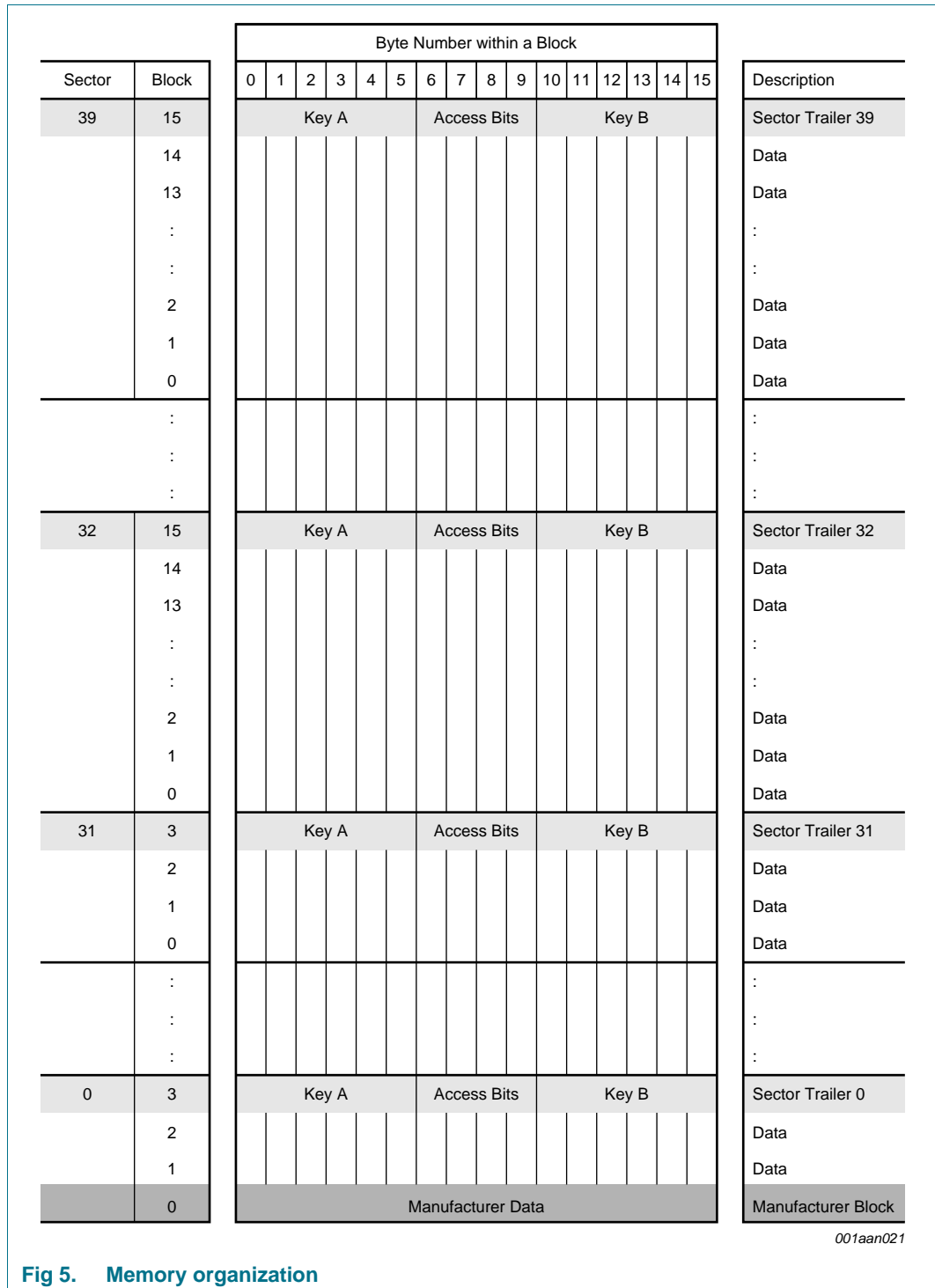
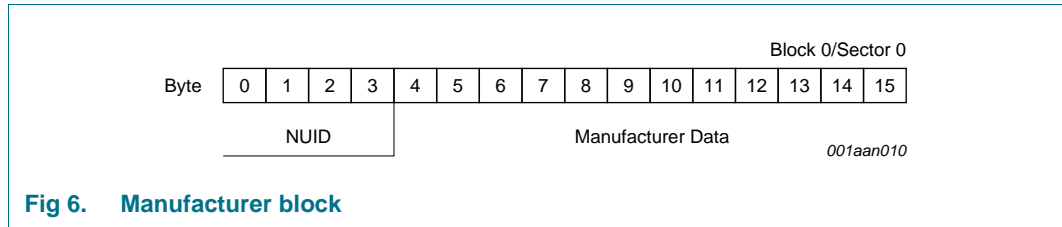


Fig 5. Memory organization

8.6.1 Manufacturer block

This is the first data block (block 0) of the first sector (sector 0). It contains the IC manufacturer data. This block is programmed and write protected in the production test.



8.6.2 Data blocks

The first 32 sectors contain 3 blocks of 16 bytes for storing data (Sector 0 contains only two data blocks and the read-only manufacturer block). The last 8 sectors contain 15 blocks of 16 bytes for storing data.

The data blocks can be configured by the access bits as

- read/write blocks
- value blocks

Value blocks can be used for e.g. electronic purse applications, where additional commands like increment and decrement for direct control of the stored value are provided.

A successful authentication has to be performed to allow any memory operation.

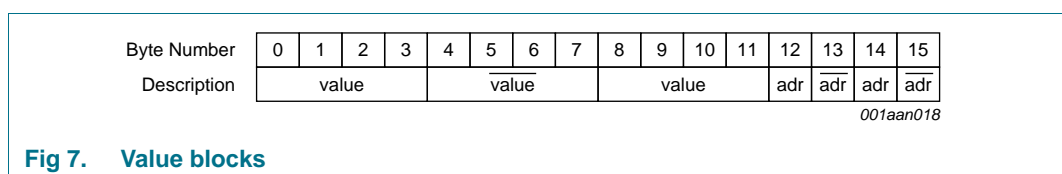
Remark: The default content of the data blocks at delivery is not defined.

8.6.2.1 Value blocks

The value blocks allow performing electronic purse functions (valid commands: read, write, increment, decrement, restore, transfer). Value blocks have a fixed data format which permits error detection and correction and a backup management.

A value block can only be generated through a write operation in the value block 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 save the storage address of a block, when implementing a powerful backup management. The address byte is stored four times, twice inverted and non-inverted. During increment, decrement, restore and transfer operations the address remains unchanged. It can only be altered via a write command.



8.6.3 Sector trailer

The sector trailer is always the last block in one sector (block 3 for the first 32 sectors, block 15 for the last 8 sectors). Each sector has a sector trailer containing the

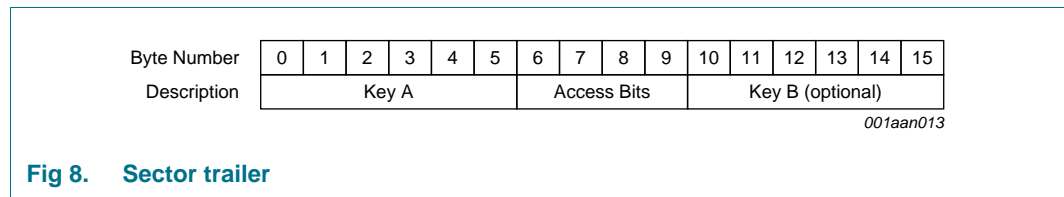
- secret keys A and B (optional), which return logical “0”s when read and
- the access conditions for the blocks of that sector, which are stored in bytes 6...9. The access bits also specify the type (data or value) of the data blocks.

If key B is not needed, the last 6 bytes of the sector trailer can be used as data bytes. The access bits for the sector trailer have to be configured accordingly, see [Section 8.7.2](#).

Byte 9 of the sector trailer is available for user data. For this byte the same access rights as for byte 6, 7 and 8 apply.

When the sector trailer is read, the key bytes are blanked out by returning logical zeros. If Key B is configured to be readable, the data stored in bytes 10 to 15 is returned, see [Section 8.7.2](#).

All keys are set to FFFFFFFFh at chip delivery.



8.7 Memory access

Before any memory operation can be carried out, the card has to be selected and authenticated as described in [Section 8.2](#). The possible memory operations for an addressed block depend on the key used and the access conditions stored in the associated sector trailer.

Table 4. Memory operations

| Operation | Description | Valid for Block Type |
|-----------|--|--------------------------------------|
| Read | reads one memory block | read/write, value and sector trailer |
| Write | writes one memory block | read/write, value and sector trailer |
| Increment | increments the contents of a block and stores the result in the internal data register | value |
| Decrement | decrements the contents of a block and stores the result in the internal data register | value |
| Transfer | writes the contents of the internal data register to a block | value |
| Restore | reads the contents of a block into the internal data register | value |

8.7.1 Access conditions

The access conditions for every data block and sector trailer are defined by 3 bits, which are stored non-inverted and inverted in the sector trailer of the specified sector. For the upper 8 sectors, always 5 blocks share the same access rights (see [Table 5](#)).

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: In the following description the access bits are mentioned in the non-inverted mode only.

The internal logic of the MF1S703x ensures that the commands are executed only after a successful authentication.

Table 5. Access conditions

| Access Bits | Valid Commands | Block (sectors 0 - 31) | Block(s) (sectors 32-39) | Description |
|---|--|------------------------|--------------------------|----------------|
| C ₁₃ C ₂₃ C ₃₃ | read, write | → 3 | 15 | sector trailer |
| C ₁₂ C ₂₂ C ₃₂ | read, write, increment, decrement, transfer, restore | → 2 | 10-14 | data block(s) |
| C ₁₁ C ₂₁ C ₃₁ | read, write, increment, decrement, transfer, restore | → 1 | 5-9 | data block(s) |
| C ₁₀ C ₂₀ C ₃₀ | read, write, increment, decrement, transfer, restore | → 0 | 0-4 | data block(s) |

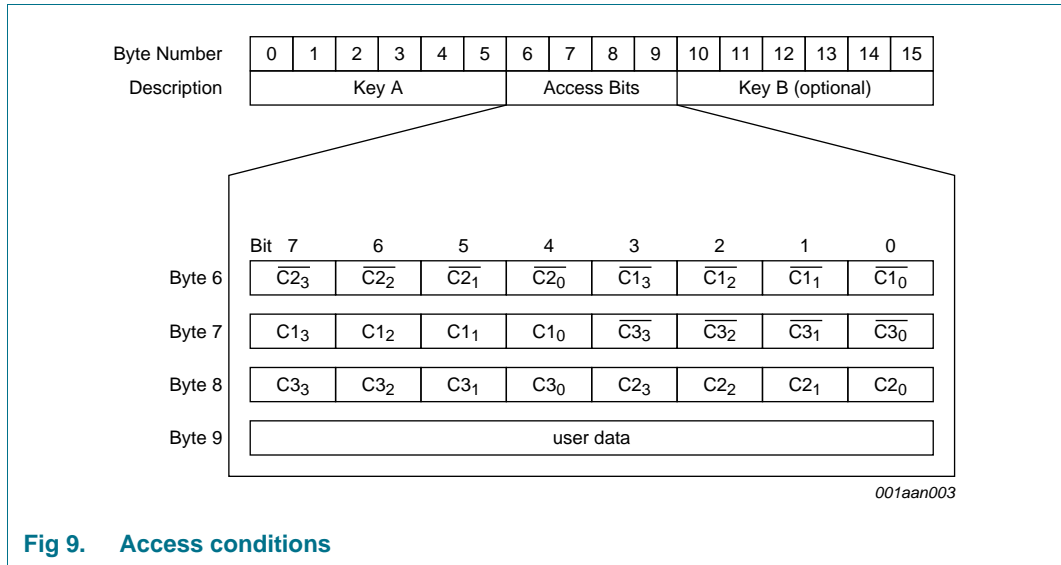


Fig 9. Access conditions

8.7.2 Access conditions for the sector trailer

Depending on the access bits for the sector trailer the read/write access to the keys and the access bits is specified as ‘never’, ‘key A’, ‘key B’ or key A|B’ (key A or key B).

On chip delivery the access conditions for the sector trailers and key A are predefined as transport configuration. Since key B may be read in the transport configuration, new cards must be authenticated with key A to allow memory operations. Since the access bits themselves can also be blocked, special care has to be taken during personalization of cards.

Table 6. Access conditions for the sector trailer

| Access bits | | | Access condition for | | | | | | Remark |
|-------------|----|----|----------------------|-------|-------------|-------|-------|-------|---|
| | | | KEYA | | Access bits | | KEYB | | |
| C1 | C2 | C3 | read | write | read | write | read | write | |
| 0 | 0 | 0 | never | key A | key A | never | key A | key A | Key B may be read ^[1] |
| 0 | 1 | 0 | never | never | key A | never | key A | never | Key B may be read ^[1] |
| 1 | 0 | 0 | never | key B | key A B | never | never | key B | |
| 1 | 1 | 0 | never | never | key A B | never | never | never | |
| 0 | 0 | 1 | never | key A | key A | key A | key A | key A | Key B may be read, transport configuration ^[1] |
| 0 | 1 | 1 | never | key B | key A B | key B | never | key B | |
| 1 | 0 | 1 | never | never | key A B | key B | never | never | |
| 1 | 1 | 1 | never | never | key A B | never | never | never | |

[1] for this access condition key B is readable and may be used for data

8.7.3 Access conditions for data blocks

Depending on the access bits for data blocks (blocks 0...2) the read/write access is specified as 'never', 'key A', 'key B' or 'key A|B' (key A or key B). The setting of the relevant access bits defines the application and the corresponding applicable commands.

- Read/write block: the operations read and write are allowed.
- Value block: Allows the additional value operations increment, decrement, transfer and restore. With access condition '001' only read and decrement are possible which reflects a non-rechargeable card. For access condition '110' recharging is possible by using key B.
- Manufacturer block: the read-only condition is not affected by the access bits setting!
- Key management: in transport configuration key A must be used for authentication to allow any memory operation

Table 7. Access conditions for data blocks

| Access bits | | | Access condition for | | | | Application |
|-------------|----|----|------------------------|--------------------|--------------------|------------------------------|-------------------------|
| C1 | C2 | C3 | read | write | increment | decrement, transfer, restore | |
| 0 | 0 | 0 | key A B ^[1] | key A B1 | key A B1 | key A B1 | transport configuration |
| 0 | 1 | 0 | key A B ^[1] | never | never | never | read/write block |
| 1 | 0 | 0 | key A B ^[1] | key B ¹ | never | never | read/write block |
| 1 | 1 | 0 | key A B ^[1] | key B ¹ | key B ¹ | key A B ¹ | value block |
| 0 | 0 | 1 | key A B ^[1] | never | never | key A B ¹ | value block |
| 0 | 1 | 1 | key B ^[1] | key B ¹ | never | never | read/write block |
| 1 | 0 | 1 | key B ^[1] | never | never | never | read/write block |
| 1 | 1 | 1 | never | never | never | never | read/write block |

[1] if Key B may be read in the corresponding Sector Trailer it cannot serve for authentication (all grey marked lines in previous table). As a consequences, if the reader authenticates any block of a sector which uses the grey marked access conditions and using key B, the card will refuse any subsequent memory access after authentication.

9. Command overview

The MIFARE Classic card activation follows the ISO/IEC 14443-3 type A. After the MIFARE Classic card has been selected, it can either be deactivated using the ISO/IEC 14443 Halt command, or the MIFARE Classic commands can be performed. For more details about the card activation refer to [Ref. 5](#).

9.1 MIFARE Classic command overview

All MIFARE Classic commands use the MIFARE Crypto1 and require an authentication.

All available commands for the MIFARE Classic are shown in [Table 8](#).

Table 8. Command overview

| Command | ISO/IEC 14443 | Command code (hexadecimal) |
|---------------------------|--------------------|----------------------------|
| Request | REQA | 26h (7 bit) |
| Wake-up | WUPA | 52h (7 bit) |
| Anti-collision CL1 | Anti-collision CL1 | 93h 20h |
| Select CL1 | Select CL1 | 93h 70h |
| Halt | Halt | 50h 00h |
| Authentication with Key A | - | 60h |
| Authentication with Key B | - | 61h |
| MIFARE Read | - | 30h |
| MIFARE Write | - | A0h |
| MIFARE Decrement | - | C0h |
| MIFARE Increment | - | C1h |
| MIFARE Restore | - | C2h |
| MIFARE Transfer | - | B0h |

All commands are using the coding and framing as described in [Ref. 4](#) and [Ref. 5](#) if not otherwise specified.

9.2 Timings

The timings shown in this document are not to scale and values are rounded to 1 μ s.

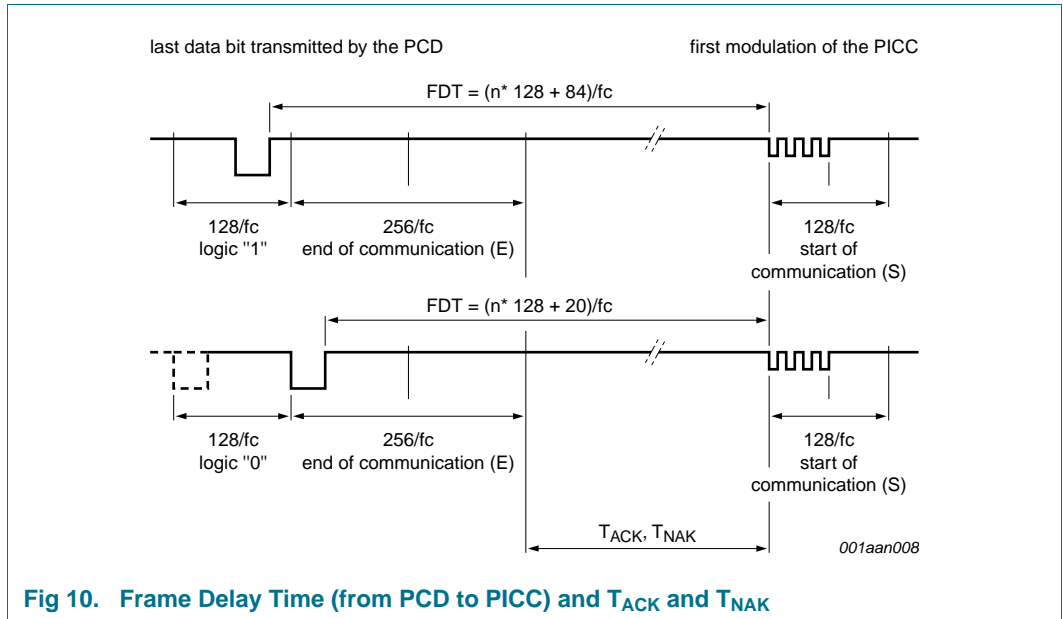
All the given times refer to the data frames including start of communication and end of communication, but do not include the encoding (like the Miller pulses).

Consequently a data frame sent by the PCD contains the start of communication (1 “start bit”) and the end of communication (one logic 0 + 1 bit length of unmodulated carrier).

A data frame sent by the PICC contains the start of communication (1 “start bit”) and the end of communication (1 bit length of no subcarrier).

All timing can be measured according to ISO/IEC 14443-3 frame specification as shown for the Frame Delay Time in [Figure 10](#). For more details refer to [Ref. 4](#) and [Ref. 5](#).

The frame delay time from PICC to PCD must be at least 87 μ s.



Remark: Due to the coding of commands, the measured timings usually exclude (a part of) the end of communication. This needs to be considered, when comparing the specified with the measured times.

9.3 MIFARE Classic ACK and NAK

The MIFARE Classic uses a 4 bit ACK/NAK as shown in [Table 9](#).

Table 9. MIFARE ACK and NAK

| Code (4-bit) | ACK/NAK |
|--------------------|-------------------|
| Ah | Acknowledge (ACK) |
| 0h to 9h, Bh to Fh | NAK |

9.4 ATQA and SAK responses

For details on the type identification procedure please refer to [Ref. 3](#).

The MF1S703x answers to a REQA or WUPA command with the ATQA value shown in [Table 10](#) and to a Select CL1 command with the SAK value shown in [Table 11](#).

Table 10. ATQA response of the MF1S703x

| Response | Hex Value | Bit Number | | | | | | | | | | | | | | | |
|----------|-----------|------------|----|----|----|----|----|----|---|---|---|---|---|---|---|---|---|
| | | 16 | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 |
| ATQA | 00 02h | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |

Table 11. SAK response of the MF1S703x

| Response | Hex Value | Bit Number | | | | | | | |
|----------|-----------|------------|---|---|---|---|---|---|---|
| | | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 |
| SAK | 18h | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 |

10. MIFARE Classic commands

10.1 MIFARE Authentication

The MIFARE authentication is a 3-pass mutual authentication which needs two pairs of command-response. These two parts, MIFARE authentication part 1 and part 2 are shown in [Figure 11](#), [Figure 12](#) and [Table 12](#).

[Table 13](#) shows the required timing.

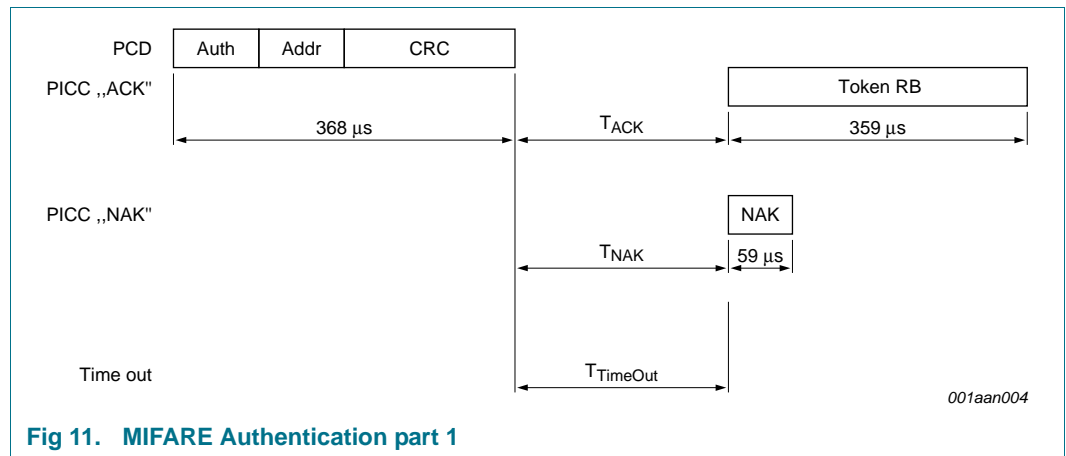


Fig 11. MIFARE Authentication part 1

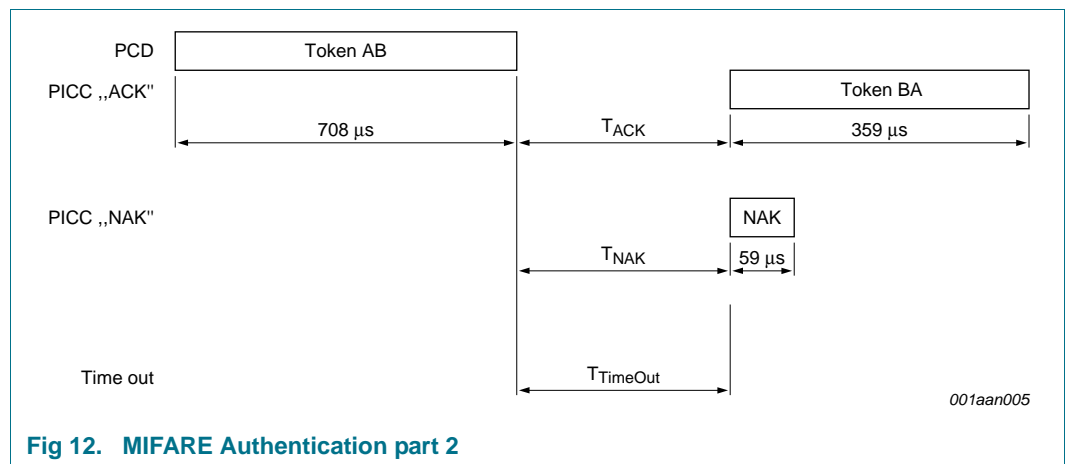


Fig 12. MIFARE Authentication part 2

Table 12. MIFARE authentication command

| Name | Code | Description | Length |
|-------------------|-----------------------------|---|---------|
| Auth (with Key A) | 60h | Authentication with Key A | 1 byte |
| Auth (with Key B) | 61h | Authentication with Key B | 1 byte |
| Addr | - | MIFARE Block address (00h to FFh) | 1 byte |
| CRC | - | CRC according to Ref. 5 | 2 bytes |
| Token RB | - | Challenge 1 (Random Number) | 4 bytes |
| Token AB | - | Challenge 2 (encrypted data) | 8 bytes |
| Token BA | - | Challenge 2 (encrypted data) | 4 bytes |
| NAK | see Table 9 | see Section 9.3 | 4-bit |

Table 13. MIFARE authentication timing

These times exclude the end of communication of the PCD.

| | T _{ACK min} | T _{ACK max} | T _{NAK min} | T _{NAK max} | T _{TimeOut} |
|-----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
| Authentication part 1 | 71 μs | T _{TimeOut} | 71 μs | T _{TimeOut} | 1 ms |
| Authentication part 2 | 71 μs | T _{TimeOut} | 71 μs | T _{TimeOut} | 1 ms |

Remark: The minimum required time between MIFARE Authentication part 1 and part 2 is the minimum required FDT according to [Ref. 5](#). There is no maximum time specified.

Remark: The MIFARE authentication and encryption requires an MIFARE reader IC (e.g. the CL RC632). For more details about the authentication command refer to the corresponding data sheet (e.g. [Ref. 6](#)).

10.2 MIFARE Read

The MIFARE Read requires a block address, and returns the 16 bytes of one MIFARE Classic block. The command structure is shown in [Figure 13](#) and [Table 14](#).

[Table 15](#) shows the required timing.

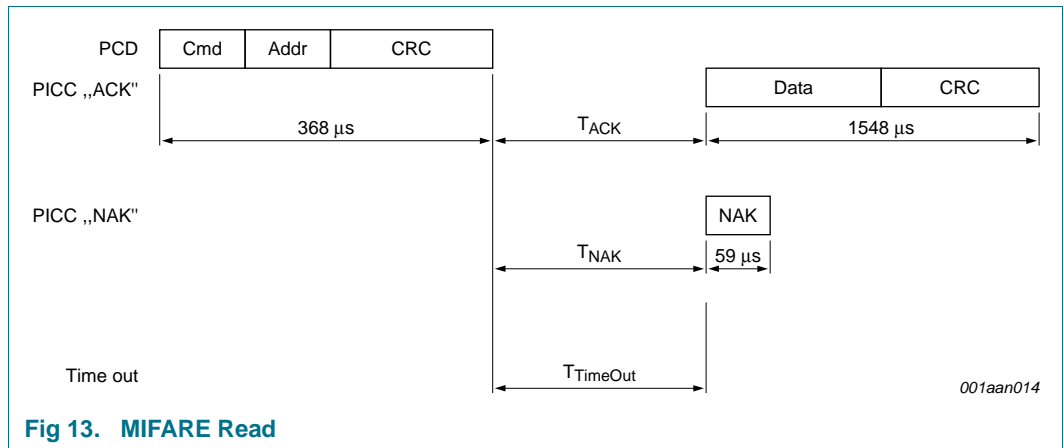


Fig 13. MIFARE Read

Table 14. MIFARE Read command

| Name | Code | Description | Length |
|------|-----------------------------|---|----------|
| Cmd | 30h | Read one block | 1 byte |
| Addr | - | MIFARE Block address (00h to FFh) | 1 byte |
| CRC | - | CRC according to Ref. 5 | 2 bytes |
| Data | - | Data content of the addressed block | 16 bytes |
| NAK | see Table 9 | see Section 9.3 | 4-bit |

Table 15. MIFARE Read timing

These times exclude the end of communication of the PCD.

| | T _{ACK min} | T _{ACK max} | T _{NAK min} | T _{NAK max} | T _{TimeOut} |
|------|----------------------|----------------------|----------------------|----------------------|----------------------|
| Read | 71 μs | T _{TimeOut} | 71 μs | T _{TimeOut} | 5 ms |

10.3 MIFARE Write

The MIFARE Write requires a block address, and writes 16 Bytes of data into the addressed MIFARE Classic 4K block. It needs two pairs of command-response. These two parts, MIFARE Write part 1 and part 2 are shown in [Figure 14](#) and [Figure 15](#) and [Table 16](#).

[Table 17](#) shows the required timing.

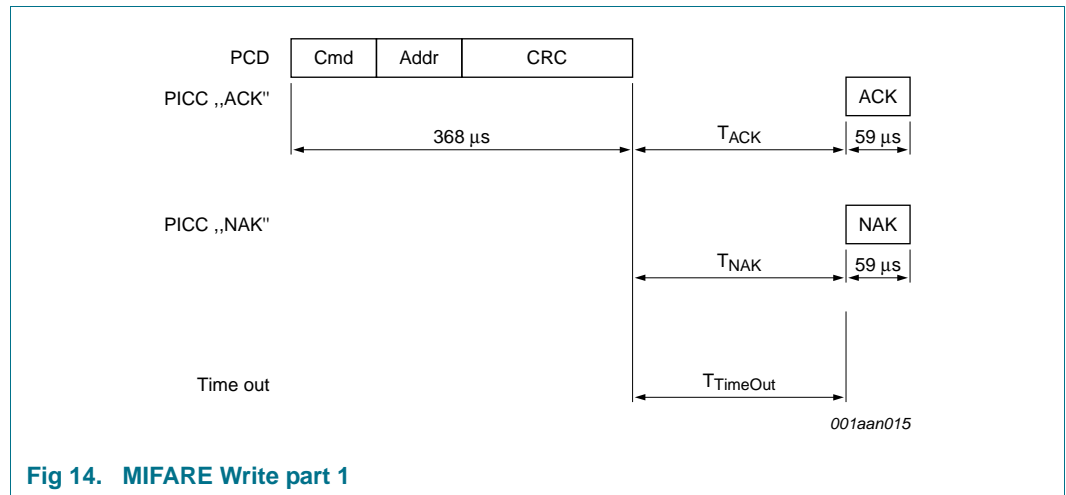


Fig 14. MIFARE Write part 1

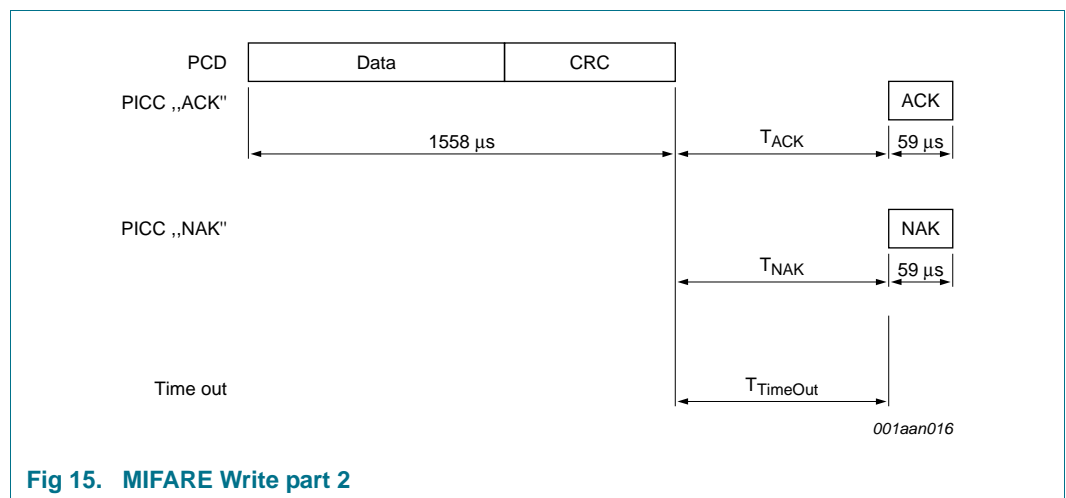


Fig 15. MIFARE Write part 2

Table 16. MIFARE Write command

| Name | Code | Description | Length |
|------|-----------------------------|---|----------|
| Cmd | A0h | Read one block | 1 byte |
| Addr | - | MIFARE Block or Page address (00h to FFh) | 1 byte |
| CRC | - | CRC according to Ref. 5 | 2 bytes |
| Data | - | Data | 16 bytes |
| NAK | see Table 9 | see Section 9.3 | 4-bit |

Table 17. MIFARE Write timing

These times exclude the end of communication of the PCD.

| | T _{ACK min} | T _{ACK max} | T _{NAK min} | T _{NAK max} | T _{TimeOut} |
|--------------|----------------------|----------------------|----------------------|----------------------|----------------------|
| Write part 1 | 71 μs | T _{TimeOut} | 71 μs | T _{TimeOut} | 5 ms |
| Write part 2 | 71 μs | T _{TimeOut} | 71 μs | T _{TimeOut} | 10 ms |

Remark: The minimum required time between MIFARE Write part 1 and part 2 is the minimum required FDT acc. to [Ref. 5](#). There is no maximum time specified.

10.4 MIFARE Increment, Decrement and Restore

The MIFARE Increment requires a source block address and an operand. It adds the operand to the value of the addressed block, and stores the result in a volatile memory.

The MIFARE Decrement requires a source block address and an operand. It subtracts the operand from the value of the addressed block, and stores the result in a volatile memory.

The MIFARE Restore requires a source block address. It copies the value of the addressed block into a volatile memory.

These two parts of each command are shown in [Figure 16](#) and [Figure 17](#) and [Table 18](#).

[Table 19](#) shows the required timing.

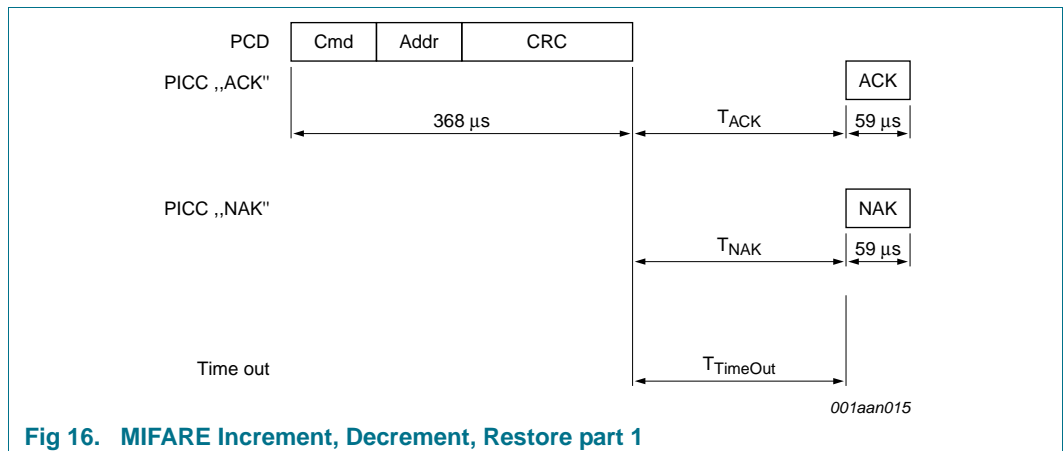
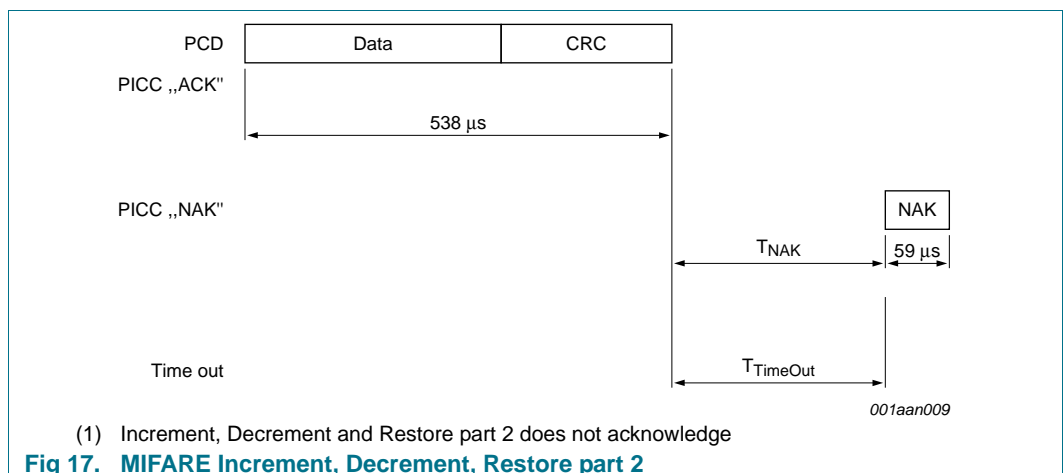


Fig 16. MIFARE Increment, Decrement, Restore part 1



(1) Increment, Decrement and Restore part 2 does not acknowledge
Fig 17. MIFARE Increment, Decrement, Restore part 2

Table 18. MIFARE Increment, Decrement and Restore command

| Name | Code | Description | Length |
|------|-----------------------------|--|---------|
| Cmd | C1h | Increment | 1 byte |
| Cmd | C0h | Decrement | 1 byte |
| Cmd | C2h | Restore | 1 byte |
| Addr | - | MIFARE source block address (00h to FFh) | 1 byte |
| CRC | - | CRC according to Ref. 5 | 2 bytes |
| Data | - | Operand (4 byte signed integer) | 4 bytes |
| NAK | see Table 9 | see Section 9.3 | 4-bit |

Table 19. MIFARE Increment, Decrement and Restore timing

These times exclude the end of communication of the PCD.

| | T _{ACK min} | T _{ACK max} | T _{NAK min} | T _{NAK max} | T _{TimeOut} |
|--|----------------------|----------------------|----------------------|----------------------|----------------------|
| Increment, Decrement, and Restore part 1 | 71 μs | T _{TimeOut} | 71 μs | T _{TimeOut} | 5 ms |
| Increment, Decrement, and Restore part 2 | 71 μs | T _{TimeOut} | 71 μs | T _{TimeOut} | 5 ms |

Remark: The minimum required time between MIFARE Increment, Decrement, and Restore part 1 and part 2 is the minimum required FDT according to [Ref. 5](#). There is no maximum time specified.

Remark: The MIFARE Increment, Decrement, and Restore commands require a MIFARE Transfer to store the value into a destination block.

Remark: The MIFARE Increment, Decrement, and Restore command part 2 does not provide an acknowledgement, so the regular time-out has to be used instead.

10.5 MIFARE Transfer

The MIFARE Transfer requires a destination block address, and writes the value stored in the volatile memory into one MIFARE Classic block. The command structure is shown in [Figure 18](#) and [Table 20](#).

[Table 21](#) shows the required timing.

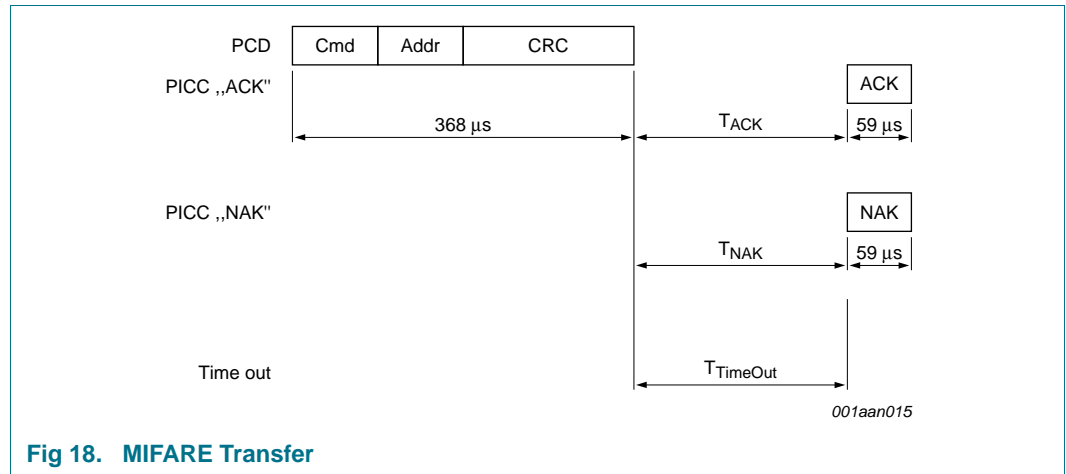


Fig 18. MIFARE Transfer

Table 20. MIFARE Transfer command

| Name | Code | Description | Length |
|------|-----------------------------|---|---------|
| Cmd | B0h | Write value into destination block | 1 byte |
| Addr | - | MIFARE destination block address (00h to FFh) | 1 byte |
| CRC | - | CRC according to Ref. 5 | 2 bytes |
| NAK | see Table 9 | see Section 9.3 | 4-bit |

Table 21. MIFARE Transfer timing

These times exclude the end of communication of the PCD.

| | T _{ACK min} | T _{ACK max} | T _{NAK min} | T _{NAK max} | T _{TimeOut} |
|----------|----------------------|----------------------|----------------------|----------------------|----------------------|
| Transfer | 71 μs | T _{TimeOut} | 71 μs | T _{TimeOut} | 10 ms |

11. Limiting values

Table 22. Limiting values [1][2]

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

| Symbol | Parameter | Min | Max | Unit |
|----------------|-------------------------------------|-------|-----|------|
| I_I | input current | - | 30 | mA |
| $P_{tot}/pack$ | total power dissipation per package | - | 200 | mW |
| T_{stg} | storage temperature | -55 | 125 | °C |
| T_{amb} | ambient temperature | -25 | 70 | °C |
| V_{ESD} | electrostatic discharge voltage | [3] 2 | - | kV |
| I_{lu} | latch-up current | ±100 | - | mA |

[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] MIL Standard 883-C method 3015; Human body model: C = 100 pF, R = 1.5 kΩ

12. Characteristics

Table 23. Characteristics

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|-------------------------------|-------------------|--------------------------|--------|--------|------|-------|
| C_i | input capacitance | [1] | 14.4 | 16.1 | 17.4 | pF |
| f_i | input frequency | | - | 13.56 | - | MHz |
| EEPROM characteristics | | | | | | |
| t_{ret} | retention time | $T_{amb} = 22\text{ °C}$ | 10 | - | - | year |
| $N_{endu(W)}$ | write endurance | $T_{amb} = 22\text{ °C}$ | 100000 | 200000 | - | cycle |

[1] LCR meter, $T_{amb} = 22\text{ °C}$, $f_i = 13.56\text{ MHz}$, 2 V RMS.

13. Wafer specification

Table 24. Wafer specifications MF1S7035DUx

| Wafer | |
|--------------------------------------|--|
| diameter | 200 mm typical (8 inches) |
| thickness | 150 $\mu\text{m} \pm 15 \mu\text{m}$ |
| flatness | not applicable |
| Potential Good Dies per Wafer (PGDW) | 15601 |
| Wafer backside | |
| material | Si |
| treatment | ground and stress relieve |
| roughness | $R_a \text{ max} = 0.5 \mu\text{m}$ $R_t \text{ max} = 5 \mu\text{m}$ |
| Chip dimensions | |
| step size | x = 1420 μm |
| | y = 1340 μm |
| scribe line | x = 86,4 μm |
| | y = 86,4 μm |
| Passivation | |
| type | sandwich structure |
| material | PSG / nitride |
| thickness | 500 nm / 600 nm |

[1] the gap between chips may vary due to changing foil expansion

Table 25. Bond pad specifications

| Bond pads (substrate connected to VSS) | |
|---|---|
| size (metallization) | LA, LB = 118 $\mu\text{m} \times 118 \mu\text{m}$ |
| | VSS ^[1] = 108 $\mu\text{m} \times 108 \mu\text{m}$ |
| | TESTIO ^[1] = 95 $\mu\text{m} \times 110 \mu\text{m}$ |
| size (pad opening) | LA, LB = 90 $\mu\text{m} \times 90 \mu\text{m}$ |
| | VSS ^[1] = 80 $\mu\text{m} \times 80 \mu\text{m}$ |
| | TESTIO ^[1] = 67 $\mu\text{m} \times 82 \mu\text{m}$ |
| material | Al-Cu |
| thickness | 850 nm |

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

Table 26. Bump specifications

| Au bump (substrate connected to VSS) | |
|---|-------------------|
| material | > 99.9 % pure Au |
| hardness | 35 to 80 HV 0.005 |
| shear strength | > 70 MPa |
| height | 18 μm |

Table 26. Bump specifications

| | |
|--------------------------|--|
| 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 = $104 \mu\text{m} \times 104 \mu\text{m}$ |
| | VSS ^[1] = $94 \mu\text{m} \times 94 \mu\text{m}$ |
| | TESTIO ^[1] = $81 \mu\text{m} \times 96 \mu\text{m}$ |
| size variation | $\pm 5 \mu\text{m}$ |
| under bump metallization | sputtered TiW |

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

13.1 Fail die identification

All fail dies are inked according to electrical test results.

Electronic wafer mapping covers the electrical test results and additionally the results of mechanical/visual inspection.

14. Package outline

For more details on the contactless module MOA4 please refer to [Ref. 2](#).

PLLMC: plastic leadless module carrier package; 35 mm wide tape

SOT500-2

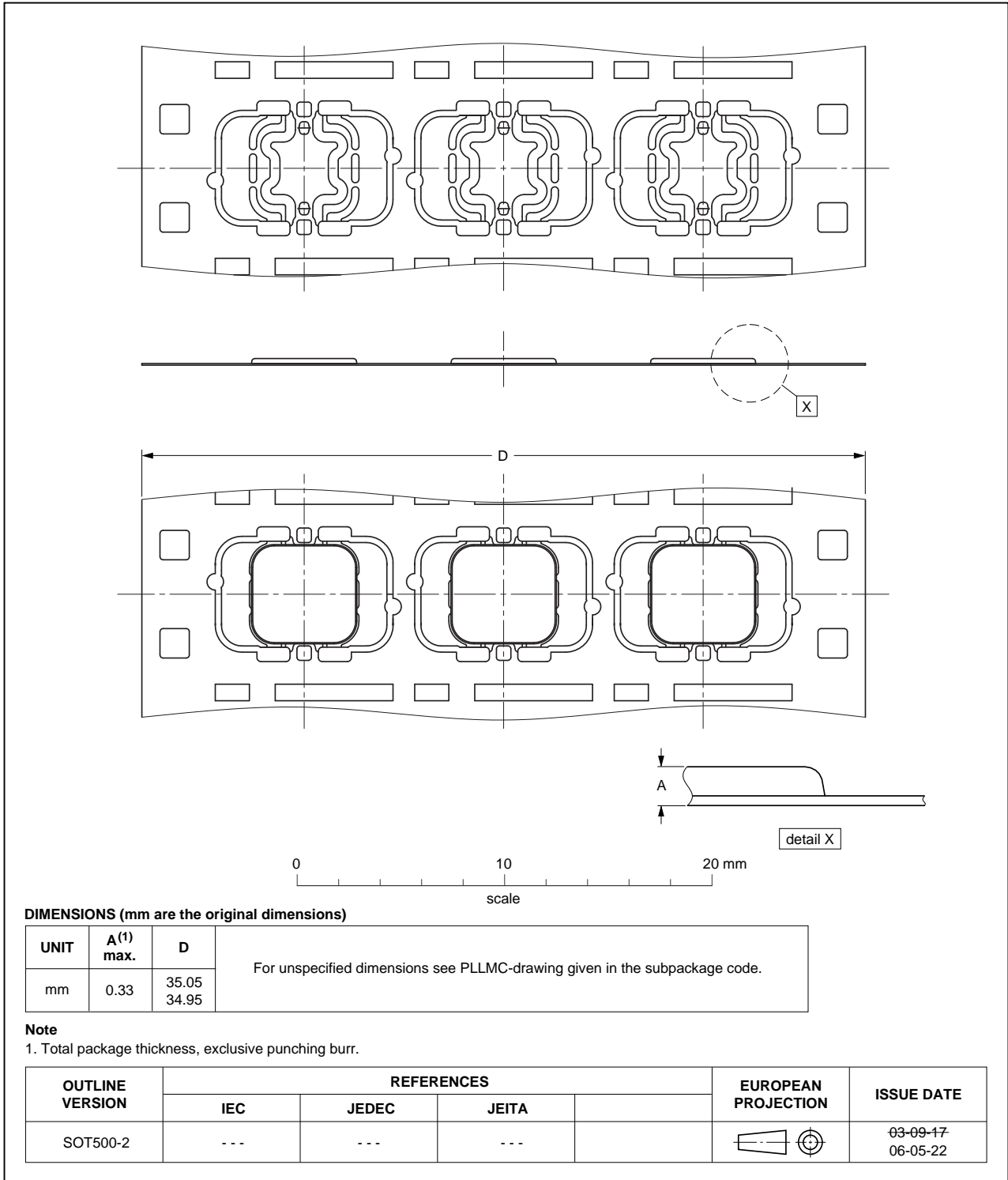


Fig 19. Package outline SOT500-2

PLLMC: plastic leadless module carrier package; 35 mm wide tape

SOT500-3

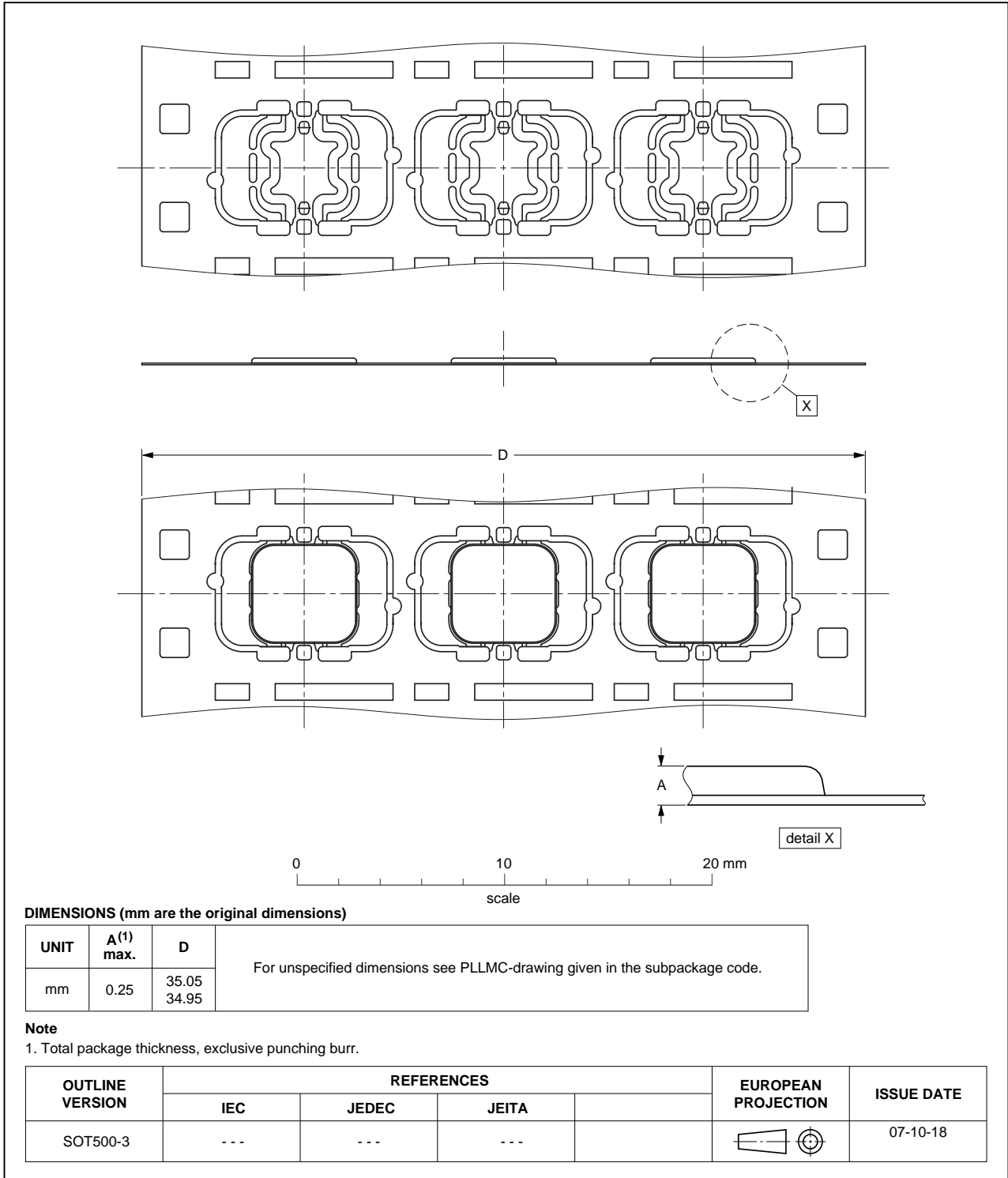


Fig 20. Package outline SOT500-3

15. Bare die outline

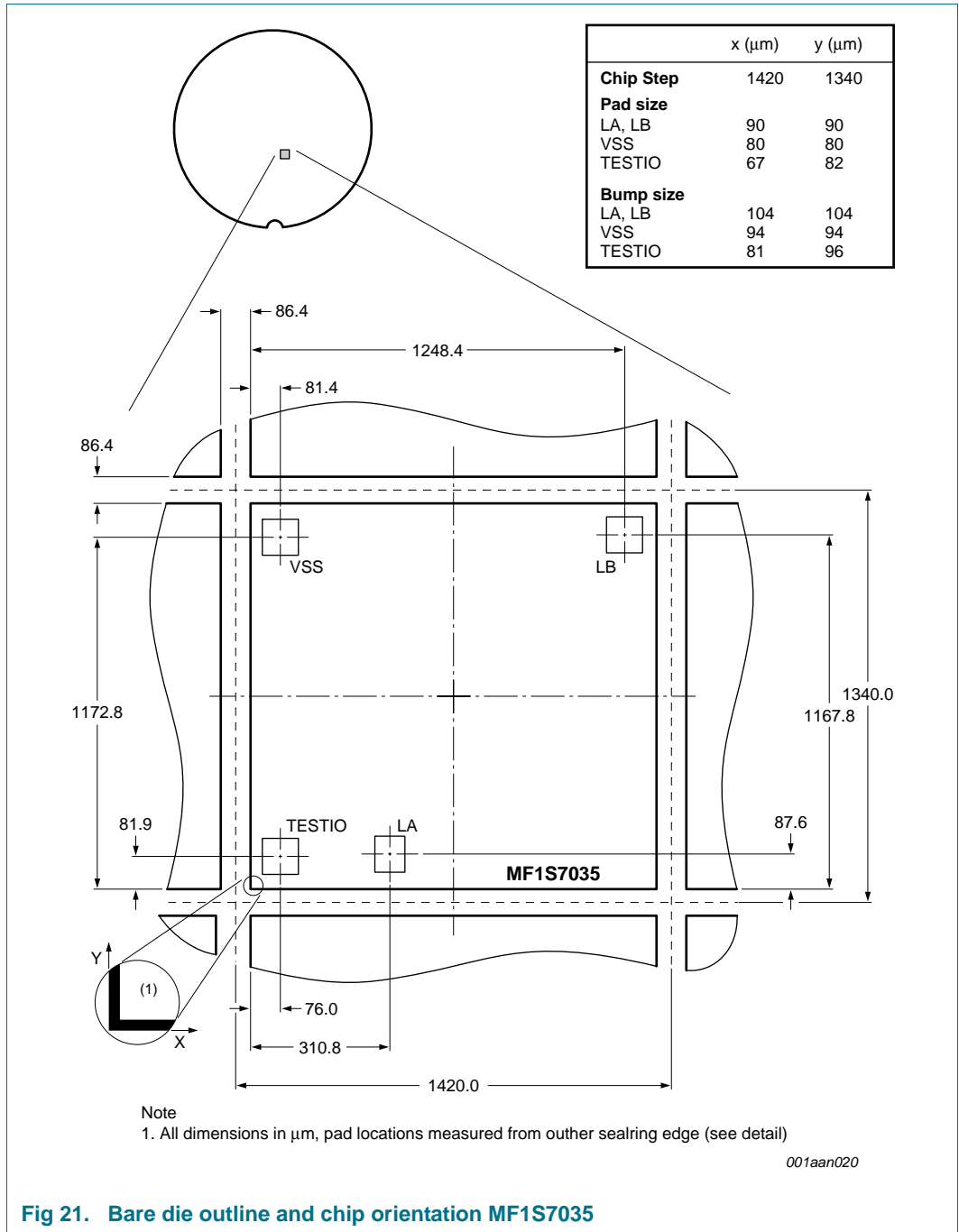


Fig 21. Bare die outline and chip orientation MF1S7035

16. Abbreviations

Table 27. Abbreviations and symbols

| Acronym | Description |
|---------|--|
| ACK | ACKnowledge |
| ATQA | Answer To reQuest, Type A |
| CRC | Cyclic Redundancy Check |
| EEPROM | Electrically Erasable Programmable Read-Only Memory |
| FDT | Frame Delay Time |
| FFC | Film Frame Carrier |
| IC | Integrated Circuit |
| LCR | L = inductance, Capacitance, Resistance (LCR meter) |
| LSB | Least Significant Bit |
| NAK | Not AcKnowledge |
| NUID | Non-Unique IDentifier |
| PCD | Proximity Coupling Device (Contactless Reader) |
| PICC | Proximity Integrated Circuit Card (Contactless Card) |
| POR | Power-On Reset |
| REQA | REQuest command, Type A |
| RF | Radio Frequency |
| RMS | Root Mean Square |
| SAK | Select AcKnowledge, type A |
| SECS-II | SEMI Equipment Communications Standard part 2 |
| TiW | Titanium Tungsten |
| WUPA | Wake-Up Protocol type A |

17. References

- [1] **MIFARE (Card) Coil Design Guide** — Application note, BU-ID Document number 0117**¹
- [2] **Contactless smart card module specification MOA4** — Product data sheet, BU-ID Document number 0823**¹
- [3] **MIFARE Type Identification Procedure** — Application note, BU-ID Document number 0184**¹
- [4] **ISO/IEC 14443-2** — 2001
- [5] **ISO/IEC 14443-3** — 2001
- [6] **MIFARE and I-CODE CL RC632 Multiple protocol contactless reader IC** — Product data sheet
- [7] **MIFARE and handling of UIDs** — Application note, BU-ID Document number 1907**¹

1. ** ... document version number

18. Revision history

Table 28. Revision history

| Document ID | Release date | Data sheet status | Change notice | Supersedes |
|----------------|--------------|--------------------|---------------|------------|
| MF1S703x v.3.0 | 20101202 | Product data sheet | - | - |

19. Legal information

19.1 Data sheet status

| Document status ^{[1][2]} | Product status ^[3] | 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. |

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

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