DATA SHEET

mifare® light
Card IC
MF1ICL10
Functional Specification

Product Specification
Revision 1.2

May 1997

Philips Semiconductors
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MIFARE® is a trademark of Philips Electronics N.V.
1. General

The MIFARE® LIGHT Card IC was developed to cover the „small memory applications“ of the MIFARE® Technology Platform with a high focus on chip size optimisation. This derivative of the MIFARE®1 S50 Smart Card IC is fully compatible with the MIFARE® read/write devices and thus, can be operated within the field proven infrastructure. Different types of cards can cover the specific needs and requirements for card users within the whole system: MIFARE® LIGHT as cost optimised small memory product for a single application (e.g. electronic 10-trip ticket). MIFARE®1 S50 as multiapplication card and MIFARE® PLUS as Dual-mode Card making use of both the contact and contactless card infrastructure.

Various configuration options make the MIFARE® LIGHT easily adaptable to different needs. The 384 bit low power EEPROM memory is configured in 12 pages with 4 bytes each. The unique 32 bit serial number ensures reliable identification of the card. The 16 bit value counter is hardware protected against transaction interrupts. One key can be used to secure the decrease function and another one for the reloading function. The reloading function can also be completely disabled which is interesting for disposable token or stored value cards. Access conditions to user programmable memory (128 bits or 192 bits if the counter is not used) can be individually programmed based on pairs of pages.

1.1. Features

- 384 Bit EEPROM memory
- 16 bit value counter (with on-chip supported antitearing function)
- 128 bit user programmable memory (192 bit if the counter is not used)
- user definable access conditions based on two keys
- unique 32 bit serial number
- compatible to MIFARE® read/write device modules
  - 13.56 MHz operating frequency
  - high data integrity (16 bit CRC, parity, bit coding, bit counting, channel monitoring)
  - high speed (106 kBaud)
  - anticollision
  - MIFARE®1 authentication and RF channel encryption
- up to 10 cm operating distance with card size antenna
- no battery necessary for card
- single chip allows reliable card construction
2. Memory-Organisation and Access-Conditions

The MIFARE® LIGHT has a total memory of 384-Bit EEPROM. The 384-Bit EEPROM consists of 12 pages a 32 Bits:

The following shows the Memory organisation.

<table>
<thead>
<tr>
<th></th>
<th>byte 0</th>
<th>byte 1</th>
<th>byte 2</th>
<th>byte 3</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>page 0</td>
<td>SerNr(0) SerNr(1) SerNr(2) SerNr(3)</td>
<td>BLOCK0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>page 1</td>
<td>SerNr(4) Size Code Type(0) Type(1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>page 2</td>
<td>Data(0) Data(1) Data(2) Data(3)</td>
<td>Data1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>page 3</td>
<td>Data(4) Data(5) Data(6) Data(7)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>page 4</td>
<td>Value(0) Value(1) Value_b(0) Value_b(1)</td>
<td>Value</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>page 5</td>
<td>Value(0) Value(1) Value_b(0) Value_b(1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>page 6</td>
<td>KeyA(0) KeyA(1) KeyA(2) KeyA(3)</td>
<td>KeyA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>page 7</td>
<td>KeyA(4) KeyA(5) AC-A AC-A_b</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>page 8</td>
<td>KeyB(0) KeyB(1) KeyB(2) KeyB(3)</td>
<td>KeyB</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>page 9</td>
<td>KeyB(4) KeyB(5) AC-B AC-B_b</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>page A</td>
<td>Data(0) Data(1) Data(2) Data(3)</td>
<td>Data2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>page B</td>
<td>Data(4) Data(5) Data(6) Data(7)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The first 2 pages are reserved for Serial-Number, and additional coding information. They are read only.

The pages 2 and 3 and the last 2 pages are used to store general data. The read- and write-permission is programmable and defined by the access conditions.

The pages 4 and 5 may be used for electronic purse functions. The unsigned 16-Bit-Value is stored twice (regular and inverse) for security reasons and to identify data inconsistency. For reloading the value counter the write function has to be used (there is no increase function). The write-permission is programmable and can be disabled for disposable cards.

The pages 6 to 9 are reserved for the 2 keys and their access conditions. This allows to build a key hierarchy in the system where different functions and permissions are associated with either key A or key B. (e.g. decreasing values with key A, rewriting with Key B). The write-permission to the key/access condition page is programmable.
2.1. **Access-Conditions**

The access conditions are stored in the second page of each key. They are stored twice for security reasons and consist of 6 *Enable*-Flags:

<table>
<thead>
<tr>
<th>bit 7</th>
<th>-</th>
</tr>
</thead>
<tbody>
<tr>
<td>bit 6</td>
<td>-</td>
</tr>
<tr>
<td>bit 5</td>
<td>Data2 - Write-Enable</td>
</tr>
<tr>
<td>bit 4</td>
<td>Data2 - Read-Enable</td>
</tr>
<tr>
<td>bit 3</td>
<td>Key + AC - Write-Enable</td>
</tr>
<tr>
<td>bit 2</td>
<td>Value - Write-Enable</td>
</tr>
<tr>
<td>bit 1</td>
<td>Data1 - Write-Enable</td>
</tr>
<tr>
<td>bit 0</td>
<td>Data1 - Read-Enable</td>
</tr>
</tbody>
</table>

If bit 3 in the access conditions for key B is programmed to „1“ , it’s also possible to change key A and its access conditions after authentication with key B.

**Note:** Each key has its own separately stored access conditions (two keys, two access condition zones), which define the rights granted if an authentication has been successfully performed with this key. With Mifare1 S50 all access conditions are stored in the sector trailer within 4 bytes.

In addition there exist some „hard-wired“ access conditions:

- reading BLOCK0 is always allowed after SELECT
- the command HALT is always allowed after SELECT
- reading key-data is never possible
- reading the access conditions is allowed after authentication with any key
- the command DECREMENT is only allowed for page 4 or 5 after authentication with any key
- reading a value-block is allowed after authentication with any key
3. Protocol and Commands

Regarding Coding, Parity, Block-length, CRC and Timing all commands but DECIncrement are fully compatible to MF1 S50.

MIFARE® LIGHT supports the following commands:

REQUEST:       STD (0x26), ALL (0x52)  
                Tag Type = 0x0010

RWD:           26
MF1L10:        10 00

SELECT, GET SERIAL NUMBER, ANTICOLLISION:  
The timing and commands to select a MF1 L10 are fully compatible to MF1 S50.  
ATS, Answer To Select (select return code; former „size“) = 0b10000001

MIFARE light functionality is indicated with bit 0 = „1“ of ATS code. Remaining bits are used to identify functionality of other ICs.

AUTHENTICATE:  
The 2 commands „Authenticate with key A“ (0x60) and „Authenticate with key B“ (0x61) are fully compatible to MF1 S50.

HALT:

RWD:           50 y C0 C1
MF1L10:        ----
NACK:          5
WRITE:
It is possible to write 4 bytes (one page) at a time.

RWD: 
<table>
<thead>
<tr>
<th>COM</th>
<th>ADR</th>
<th>CRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>A0</td>
<td>0x</td>
<td>C0</td>
</tr>
</tbody>
</table>

DATA: 
| D0 | D1 | D2 | D3 | y0 | y1 | ... | y10 | y11 | C0 | C1 |

ACK

MF1L10: 
| A  |

NACK

ADR: Page address

page-erase-time: 1.45 ms
page-write-time: 1.45 ms

READ:
It is possible to read 8 bytes (two pages) at a time.
The 8 byte data always consist of 2 pages of the same kind (0 and 1, 2 and 3, 4 and 5, ...)

RWD: 
<table>
<thead>
<tr>
<th>COM</th>
<th>ADR</th>
<th>CRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>0x</td>
<td>C0</td>
</tr>
</tbody>
</table>

DATA: 
| D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | y0 | ... | y7 | C0 | C1 |

ACK

NACK

ADR: Page address

DECREASE:

RWD: 
<table>
<thead>
<tr>
<th>COM</th>
<th>ADR</th>
<th>CRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>C0</td>
<td>0x</td>
<td>C0</td>
</tr>
</tbody>
</table>

VALUE: 
| V0 | V1 | y0 | y1 | C0 | C1 |

ACK

NACK

ADR: Page address
Value: unsigned 16-Bit-Value

new value erase-time: 1.45 ms
new value write-time: 1.45 ms
old value erase-time: 1.45 ms
3.1. Value Management:

The new DECREASE -protocol provides a very reliable anti tearing mechanism which is supported by the hardware of the MF1 L10.
Initially two values are stored to pages 4 and 5 in a cyclic manner.

Following sequence is applied:

1) The RWD (Read write device) reads both values and identifies the actual one.
2) The RWD sends the DECREASE -command with the address of this value and the value to deduct.
3) The MIFARE® LIGHT calculates the new value and automatically transfers (writes) the result to the other page (the not actual one).
4) The source value is erased automatically. So after a correct transaction there is only one valid value.

The MF1 S50-commands TRANSFER, RESTORE and INCREMENT are not supported by the MIFARE® LIGHT!
Definitions

<table>
<thead>
<tr>
<th>Data sheet status</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective specification</td>
<td>This data sheet contains target or goal specifications for product development.</td>
</tr>
<tr>
<td>Preliminary specification</td>
<td>This data sheet contains preliminary data; supplementary data may be published later.</td>
</tr>
<tr>
<td>Product specification</td>
<td>This data sheet contains final product specifications.</td>
</tr>
</tbody>
</table>

Limiting values

Limiting values given are in accordance with the Absolute Maximum Rating System (IEC 134). Stress above one or more of the limiting values may cause permanent damage to the device. These are stress ratings only and operation of the device at these or at any other conditions above those given in the Characteristics section of the specification is not implied. Exposure to limiting values for extended periods may affect device reliability.

Application information

Where application information is given, it is advisory and does not form part of the specification.

Life support applications

These products are not designed for use in life support appliances, devices, or systems where malfunction of these products can reasonably be expected to result in personal injury. Philips customers using or selling these products for use in such applications do so on their own risk and agree to fully indemnify Philips for any damages resulting from such improper use or sale.