

DATA SHEET

I•CODE SLI **Smart Label IC** **SL2 ICS20** Functional Specification

Product Specification

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Revision 3.1

Public



Functional Specification

Standard Label IC SL2 ICS20

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1 FEATURES

1.1 **•CODE SLI RF Interface (ISO/IEC 15693)**

- Contactless transmission of data and supply energy (no battery needed)
- Operating distance: up to 1.5 m (depending on antenna geometry)
- Operating frequency: 13.56 MHz (ISM, world-wide licence free available)
- Fast data transfer: up to 53 kbit/s
- High data integrity: 16 Bit CRC, framing
- True anticollision
- Electronic Article Surveillance (EAS)
- Application Family Identifier (AFI) supported
- Data Storage Format Identifier (DSFID)
- Additional fast anticollision read
- Write distance equal to read distance

1.2 **EEPROM**

- 1024 bits, organised in 32 blocks of 4 byte each
- Data retention of 10 years
- Write endurance 100.000 cycles

1.3 **Security**

- Unique identifier for each device
- Lock mechanism for each user memory block (write protection)
- Lock mechanism for DSFID, AFI, EAS

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2 GENERAL DESCRIPTION

The I•CODE SLI IC is a dedicated chip for intelligent label applications like supply chain management as well as baggage and parcel identification in airline business and mail services. This IC is the first member of a product family of smart label ICs based on the ISO standard ISO/IEC 15693.

The I•CODE system offers the possibility of operating labels simultaneously in the field of the reader antenna (*Anticollision*). It is designed for long range applications.

2.1 Contactless Energy and Data Transfer

Whenever connected to a very simple and cheap type of antenna (as a result of the 13.56 MHz carrier frequency) made out of a few windings printed, wound, etched or punched coil the I•CODE SLI IC can be operated without line of sight up to a distance of 1.5 m (gate width). No battery is needed. When the smart label is positioned in the field of an interrogator antenna, the high speed RF communication interface allows to transmit data with up to 53 kbit/s.

2.2 Anticollision

An intelligent anticollision function allows to operate more than one tag in the field simultaneously. The anticollision algorithm selects each tag individually and ensures that the execution of a transaction with a selected tag is performed correctly without data corruption resulting from other tags in the field.

2.3 Security

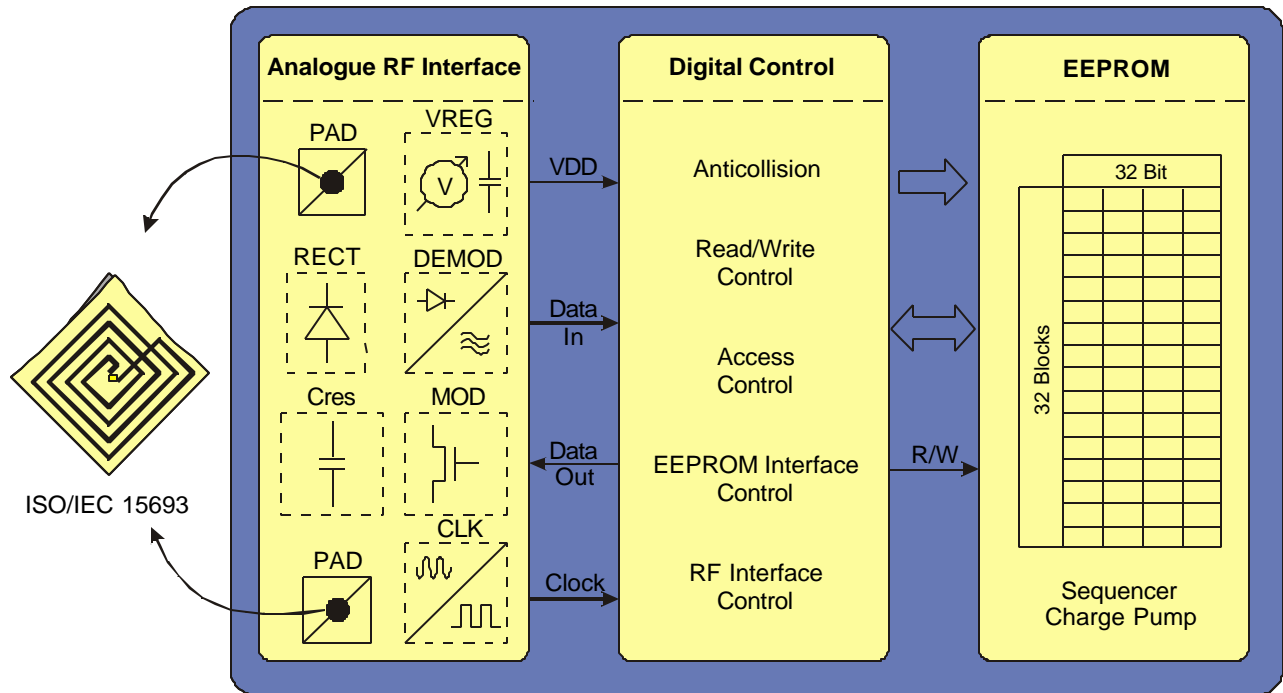
Unique Identifiers, which can not be altered, guarantee the uniqueness of each label.

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3 FUNCTIONAL DESCRIPTION

3.1 Block Description



The label requires no internal power supply. Its contactless interface generates the power supply and the system clock via the resonant circuitry by inductive coupling to the interrogator. The interface also demodulates data that are transmitted from the interrogator to the I•CODE Label, and modulates the electromagnetic field for data transmission from the I•CODE Label to the interrogator.

Data are stored in a non-volatile memory (EEPROM). The EEPROM has a memory capacity of 1024 bit and is organised in 32 blocks consisting of 4 bytes each (1 block = 32 bits). The higher 28 blocks contain user data and the lowest 4 blocks contain the unique identifier, the write access conditions and special data like AFI and DSFID.

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3.2 Memory Organisation

The 1024 bit EEPROM memory is divided into 32 blocks. A block is the smallest access unit. Each block consists of 4 bytes (1 block = 32 bits). Bit 0 in each byte represents the least significant bit (LSB) and bit 7 the most significant bit (MSB), respectively.

| | Byte 0 | Byte 1 | Byte 2 | Byte 3 | |
|----------|-----------------|--------|--------|--------|----------------------------------|
| Block –4 | UID0 | UID1 | UID2 | UID3 | Unique Identifier (lower bytes) |
| Block –3 | UID4 | UID5 | UID6 | UID7 | Unique Identifier (higher bytes) |
| Block –2 | Internally used | EAS | AFI | DSFID | EAS, AFI, DSFID |
| Block –1 | 00 | 00 | 00 | 00 | Write Access Conditions |
| Block 0 | x | x | x | x | User Data |
| Block 1 | x | x | x | x | |
| Block 2 | x | x | x | x | |
| Block 3 | x | x | x | x | |
| Block 4 | x | x | x | x | |
| Block 5 | x | x | x | x | |
| Block 6 | x | x | x | x | |
| Block 7 | x | x | x | x | |
| Block 8 | x | x | x | x | |
| Block 9 | x | x | x | x | |
| Block 10 | x | x | x | x | |
| Block 11 | x | x | x | x | |
| Block 12 | x | x | x | x | |
| Block 13 | x | x | x | x | |
| Block 14 | x | x | x | x | |
| Block 15 | x | x | x | x | |
| Block 16 | x | x | x | x | |
| Block 17 | x | x | x | x | |
| Block 18 | x | x | x | x | |
| Block 19 | x | x | x | x | |
| Block 20 | x | x | x | x | |
| Block 21 | x | x | x | x | |
| Block 22 | x | x | x | x | |
| Block 23 | x | x | x | x | |
| Block 24 | x | x | x | x | |
| Block 25 | x | x | x | x | |
| Block 26 | x | x | x | x | |
| Block 27 | x | x | x | x | User Data |

The values (in hexadecimal notation) shown in the table above are stored in the EEPROM after the wafer production process. The contents of blocks marked with 'x' in the table are **not** defined at delivery.

With read and write commands only blocks 0 to 27 can be addressed.

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3.2.1 UNIQUE IDENTIFIER

The 64 bit unique identifier (UID) is programmed during the production process according to ISO/IEC 15693-3 and cannot be changed afterwards.

The numbering of the 64 bits is done according to ISO/IEC 15693-3 starting with the LSB 1 and ending with the MSB 64. This is in contrast to the general used bit numbering within a byte.

The TAG type is a part of the UID (bit41 to 48, after the manufacturer code which is "04" hex for Philips Semiconductors).

The TAG type of the SL2 ICS20 is "01" hex.

| MSB | | | | | | LSB | |
|-------|----|-------|----|-------|----|-------------------------------|-------|
| 64 | 57 | 56 | 49 | 48 | 41 | 40 | 1 |
| "E0" | | "04" | | "01" | | IC manufacturer serial number | |
| UID 7 | | UID 6 | | UID 5 | | UID 4 | UID 3 |
| | | | | | | UID 2 | UID 1 |
| | | | | | | UID 0 | |

3.2.2 EAS FUNCTION

The LSB of Byte 1 in Block -2 holds the EAS bit (Electronic Article Surveillance mode active → the label responds to an EAS command)

| Block -2, Byte 1 | | | | | | | |
|------------------|---|---|---|---|---|---|-----|
| MSB | | | | | | | LSB |
| X | X | X | X | X | X | X | e |
| | | | | | | | EAS |

EAS: e = 1 → EAS enabled

e = 0 → EAS disabled

Changing of the EAS Configuration must be done in secure environment. The label must not be moved out of the communication field of the antenna during writing! We recommend to put the label close to the antenna and not to remove it during operation.

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3.2.3 APPLICATION FAMILY IDENTIFIER

The I²C CODE system offers the feature to use an Application Family Identifier (AFI) at the *inventory* command and the two custom commands *inventory read* and *fast inventory read* (this allows for example the creation of 'label families').

This 8-bit value is located at Byte 2 in Block -2 as shown in the following figure and is only evaluated if the AFI flag is set in the reader command.

For details please refer to ISO 15693-3.

| Block -2, Byte 2 | | | | | | | |
|------------------|---|---|---|---|---|---|-----|
| MSB | | | | | | | LSB |
| X | X | X | X | X | X | X | X |
| AFI | | | | | | | |

3.2.4 DATA STORAGE FORMAT IDENTIFIER

The Data Storage Format Identifier (DSFID) is located at Byte 3 in Block -2.

For details please refer to ISO/IEC 15693-3.

| Block -2, Byte 3 | | | | | | | |
|------------------|---|---|---|---|---|---|-----|
| MSB | | | | | | | LSB |
| X | X | X | X | X | X | X | X |
| DSFID | | | | | | | |

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3.2.5 WRITE ACCESS CONDITIONS

The Write Access Condition bits in block -1 determine the write access conditions for each of the 28 user blocks and the special data block. These bits can be set only to 1 with a lock command (and never be changed back to 0), i.e. already write protected blocks can never be written to from this moment on.

In block -2 each byte can be individually locked.

| | | Block -1 | | | | | | | | | | | | | | | |
|-------------------------------|--|----------|---|---|---|--------|--------|--------|--------|--------|----|---|---|-----|---|---|---|
| | | Byte 0 | | | | | | | | Byte 1 | | | | | | | |
| | | MSB | | | | LSB | | | | MSB | | | | LSB | | | |
| Condition | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Write access for block number | | 3 | 2 | 1 | 0 | -2 (3) | -2 (2) | -2 (1) | -2 (0) | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 |

| | | Block -1 | | | | | | | | | | | | | | | |
|-------------------------------|--|----------|----|----|----|-----|----|----|----|--------|----|----|----|-----|----|----|----|
| | | Byte 2 | | | | | | | | Byte 3 | | | | | | | |
| | | MSB | | | | LSB | | | | MSB | | | | LSB | | | |
| Condition | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Write access for block number | | 19 | 18 | 17 | 16 | 15 | 14 | 13 | 12 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 |

Changing of the Write Access conditions must be done in secure environment. The label must not be moved out of the communication field of the antenna during writing! We recommend to put the label close to the antenna and not to remove it during operation.

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3.2.6 CONFIGURATION OF DELIVERED ICS

•CODE SLI ICs are delivered with the following configuration by Philips:

- Unique Identifier is unique and read only
- Write Access Conditions allow to change all blocks (with the exception of both UID blocks).
- Status of EAS mode is **not** defined
- AFI is supported and **not** defined
- DSFID is supported and **not** defined
- User Data memory is **not** defined

NOTE: Due to the fact that the EAS mode is undefined at delivery, the EAS MODE shall be set (enable or disable) according to your application requirements during the test or initialisation phase.

3.3 Communication Principle

For detailed description of the protocol and timing please refer to ISO/IEC 15693-2 (modulation, bit-coding, framing) and 15693-3 (anticollision, timing, protocol).

3.4 Supported Commands

3.4.1 MANDATORY COMMANDS

3.4.1.1 *Inventory*

As defined in ISO/IEC 15693-3.

3.4.1.2 *Stay quiet*

As defined in ISO/IEC 15693-3.

3.4.2 OPTIONAL COMMANDS

3.4.2.1 *Read single block*

As defined in ISO/IEC 15693-3.

Option 0 (option flag not set) is supported.

Option 1 (option flag set) is supported.

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3.4.2.2 *Write single block*

As defined in ISO/IEC 15693-3.

Only Option 0 (option flag is not set) is supported.

3.4.2.3 *Lock block*

As defined in ISO/IEC 15693-3.

Only Option 0 (option flag is not set) is supported.

3.4.2.4 *Read multiple blocks*

As defined in ISO/IEC 15693-3.

Option 0 (option flag is not set) is supported.

Option 1 (option flag set) is supported.

Note: If the sum of the first block number and the number of blocks exceeds the total available number of user blocks the number of transmitted blocks is less than the requested number of blocks, which means that the last returned block is the highest available user block, followed by the 16 bit CRC and the EOF.

3.4.2.5 *Select*

As defined in ISO/IEC 15693-3.

3.4.2.6 *Reset to ready*

As defined in ISO/IEC 15693-3.

3.4.2.7 *Write AFI*

As defined in ISO/IEC 15693-3.

Only Option 0 (option flag is not set) is supported.

3.4.2.8 *Lock AFI*

As defined in ISO/IEC 15693-3.

Only Option 0 (option flag is not set) is supported.

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3.4.2.9 Write DSFID

As defined in ISO/IEC 15693-3.

Only Option 0 (option flag is not set) is supported.

3.4.2.10 Lock DSFID

As defined in ISO/IEC 15693-3.

Only Option 0 (option flag is not set) is supported.

3.4.2.11 Get system information

As defined in ISO/IEC 15693-3.

The TAG type of the SL2 ICS20 is "01" hex.

3.4.2.12 Get multiple block security status

As defined in ISO/IEC 15693-3.

Note: If the sum of the first block number and the number of blocks exceeds the total available number of user blocks the number of transmitted security status bytes is less than the requested number, which means that the last returned status byte is the one corresponding to the highest available user block, followed by the 16 bit CRC and the EOF.

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3.4.3 CUSTOM COMMANDS

The manufacturer code of Philips is defined in ISO/IEC 7816-6A1. It has the value "04" hex.

For the structure of custom commands please refer to ISO/IEC 15693-3.

3.4.3.1 *Inventory read*

Command Code = A0 hex

When receiving the *inventory read* request, the \blacklozenge CODE SLI IC performs the same as in the anti-collision sequence, with the difference that instead of the UID and the DSFID the requested memory content is re-transmitted from the \blacklozenge CODE SLI IC.

If an error is detected the \blacklozenge CODE SLI IC remains silent.

If the option flag is set to 0 n blocks of data are re-transmitted. If the option flag is set to 1 n blocks of data and the part of the UID which is not part of the mask are re-transmitted.

The request contains:

- Flags
- *Inventory read* command code
- IC Manufacturer code
- AFI (if the AFI flag is set)
- Mask length
- Mask value (if mask length >0)
- First block number to be read
- Number of blocks to be read
- CRC 16

| SOF | Flags | Inventory Read | IC Mfg. code | Optional AFI | Mask Length | Mask Value | First block number | Number of blocks | CRC16 | EOF |
|-----|--------|----------------|--------------|--------------|-------------|-------------|--------------------|------------------|---------|-----|
| | 8 bits | 8 bits | 8 bits | 8 bits | 8 bits | 0 – 64 bits | 8 bits | 8 bits | 16 bits | |

The `Inventory_flag` must be set to 1.

The meaning of flags 5 to 8 is according to table 5 in ISO/IEC 15693-3.

The number of blocks in the request is one less than the number of blocks that the \blacklozenge CODE SLI IC returns in its response.

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If the Option flag in the request is set to 0 the response contains:

| SOF | Flags | Data | CRC16 | EOF |
|-----|--------|--------------------|---------|-----|
| | 8 bits | Block Length | 16 bits | |
| | | Repeated as needed | | |

The I²C CODE SLI IC reads the requested block(s) and sends back their value in the response. The mechanism and timing of the *Inventory read* command performs the same as at the *Inventory* command which is described in Clause 8 of ISO/IEC 15693-3.

If the Option flag in the request is set to 1 the response contains:

| SOF | Flags | Rest of UID which is not part of the mask and slot number | Data | CRC16 | EOF |
|-----|--------|---|--------------------|---------|-----|
| | 8 bits | 0 to 64 bit | Block Length | 16 bits | |
| | | Multiple of 8 bits | Repeated as needed | | |

The I²C CODE SLI IC reads the requested block(s) and sends back their value in the response. Additionally the bytes of the UID, which are not parts of the mask and the slot number in case of 16 slots, are returned. Instead of a padding with zeros up to the next byte boundary the corresponding bits of the UID are returned. The mechanism and timing of the *Inventory read* command perform the same as at the *Inventory* command which is described in Clause 8 of ISO/IEC 15693-3.

Note: The number of bits of the re-transmitted UID can be calculated as follows:

16 slots: $64 - 4 - \text{mask length rounded up to the next byte boundary}$

1 slot : $64 - \text{mask length rounded up to the next byte boundary}$

Note: If the sum of first block number and number of blocks exceeds the total available number of user blocks the number of transmitted blocks is less than the requested number of blocks, which means that the last returned block is the highest available user block, followed by the 16 bit CRC and the EOF.

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Example: mask length=30

Returned: $64-4-30=30$ gives 4 bytes

| Byte0 | Byte1 | Byte2 | Byte3 | Byte4 | Byte5 | Byte6 | Byte7 | UID | |
|-------------------------------------|-------|-------|-------|----------------|-------|-------|-------|---|-----------------------------|
| mask value incl. padding with zeros | | | | | | | | | transmitted by Interrogator |
| | | | | returned value | | | | transmitted by I ² C CODE SLI IC | |

3.4.3.2 Fast inventory read

Command Code = A1 hex

When receiving the *fast inventory read* command the I²C CODE SLI IC behaves the same as in the *inventory read* command with the following exceptions:

The datarate in the direction I²C CODE SLI IC to the interrogator is twice as defined in ISO/IEC 15693-3 (depending on the `datarate_flag` 53 kbit/s (high datarate) or 13 kbit/s (low datarate)).

The datarate from the interrogator to the I²C CODE SLI IC and the time between the rising edge of the EOF from the interrogator to the I²C CODE SLI IC remain unchanged (stay the same as defined in ISO/IEC 15693-3).

In the direction I²C CODE SLI IC to the interrogator only the single subcarrier mode is supported.

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3.4.3.3 Set EAS

Command Code = A2 hex

This command sets the EAS bit to 1.

Request format

| SOF | Flags | Set EAS | IC Mfg. code | UID | CRC16 | EOF |
|-----|--------|---------|--------------|---------|---------|-----|
| | 8 bits | 8 bits | 8 bits | 64 bits | 16 bits | |

Response format when Error_flag is set

| SOF | Flags | Error Code | CRC16 | EOF |
|-----|--------|------------|---------|-----|
| | 8 bits | 8 bits | 16 bits | |

Response format when Error_flag is NOT set

| SOF | Flags | CRC16 | EOF |
|-----|--------|---------|-----|
| | 8 bits | 16 bits | |

3.4.3.4 Reset EAS

This command sets the EAS bit to 0.

Command Code = A3 hex

Request format

| SOF | Flags | Reset EAS | IC Mfg. code | UID | CRC16 | EOF |
|-----|--------|-----------|--------------|---------|---------|-----|
| | 8 bits | 8 bits | 8 bits | 64 bits | 16 bits | |

Response format when Error_flag is set

| SOF | Flags | Error Code | CRC16 | EOF |
|-----|--------|------------|---------|-----|
| | 8 bits | 8 bits | 16 bits | |

Response format when Error_flag is NOT set

| SOF | Flags | CRC16 | EOF |
|-----|--------|---------|-----|
| | 8 bits | 16 bits | |

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3.4.3.5 Lock EAS

Command Code = A4 hex

This command locks the current state of the EAS bit.

Request format

| SOF | Flags | Lock EAS | IC Mfg. code | UID | CRC16 | EOF |
|-----|--------|----------|--------------|---------|---------|-----|
| | 8 bits | 8 bits | 8 bits | 64 bits | 16 bits | |

Response format when Error_flag is set

| SOF | Flags | Error Code | CRC16 | EOF |
|-----|--------|------------|---------|-----|
| | 8 bits | 8 bits | 16 bits | |

Response format when Error_flag is NOT set

| SOF | Flags | CRC16 | EOF |
|-----|--------|---------|-----|
| | 8 bits | 16 bits | |

3.4.3.6 EAS Alarm

Command Code = A5 hex

If the EAS bit is set to 1 the EAS response is returned from the \blacktriangleright CODE SLI IC

Request format

| SOF | Flags | EAS | IC Mfg. code | UID | CRC16 | EOF |
|-----|--------|--------|--------------|---------|---------|-----|
| | 8 bits | 8 bits | 8 bits | 64 bits | 16 bits | |

If an error is detected the \blacktriangleright CODE SLI IC remains silent

Response format

| SOF | Flags | EAS sequence | CRC16 | EOF |
|-----|--------|--------------|---------|-----|
| | 8 bits | 256 bits | 16 bits | |

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EAS sequence (starting with the LSB, which is transmitted first; read from left to right):

```

11110100 11001101 01000110 00001110 10101011 11100101 00001001 11111110
00010111 10001101 00000001 00011100 01001011 10000001 10010010 01101110
01000001 01011011 01011001 01100001 11110110 11110101 11010001 00001101
10001111 00111001 10001011 01001000 10100101 01001110 11101100 11110111

```

If the EAS bit is set to 0 the I²C CODE SLI IC remains silent.

3.5 Error handling

3.5.1 TRANSMISSION ERRORS

According to ISO/IEC 15693 the Label IC will not respond if a transmission error (CRC, bitcoding, bitcount, wrong framing) is detected and will silently wait for the next correct received command.

3.5.2 NOT SUPPORTED COMMANDS OR OPTIONS

If the received command or option is not supported, the behaviour of the Label IC is depending of the addressing mechanism.

3.5.2.1 *Non Addressed Mode*

The label IC remains silent.

3.5.2.2 *Addressed or Selected Mode*

The addressed or selected label IC responds with the error code "0F" hex (error with no information given or error code is not supported).

If the Inventory flag or the protocol extension flag is set the label IC will not respond if the command or option is not supported.

3.5.3 PARAMETER OUT OF RANGE

3.5.3.1 *Read commands*

If the sum of the first block number and the number of blocks exceeds the total available number of user blocks, the number of transmitted blocks is less than the requested number of blocks, which means that the last returned block is the highest available user block, followed by the 16 bit CRC and the EOF.

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3.5.3.2 *Write and lock commands*

If the address of a block to be written does not exist or a block to be written is locked the behaviour of the Label IC is depending of the addressing mechanism.

3.5.3.2.1 Non Addressed Mode

The label IC remains silent and aborts the command without writing anything.

3.5.3.2.2 Addressed or Selected Mode

The addressed or selected label IC responds with the error code "0F" hex (error with no information given or error code is not supported).

3.6 Data Integrity

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

- 16 bit CRC per block
- Bit count checking
- Bit coding to distinguish between "1", "0", and no information
- Channel monitoring (protocol sequence and bit stream analysis)

3.7 RF Interface

The definition of the RF-interface is according to the standard ISO/IEC 15693-2 and ISO/IEC 15693-3.

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4 INLET/LABEL CHARACTERISATION AND TEST

The parameters recommended to be characterised for the inlet/label are:

| Parameter | Symbol | Conditions |
|---|--------------------|--|
| Resonant frequency | f_{res} | Resonant frequency @ $T_{\text{amb}} = 22\text{ °C}$ @ H_{min} |
| Threshold value of the field strength for <i>read single block</i> command | H_{min} | <i>Read single block</i> command OK |
| Threshold value of the field strength for <i>write single block</i> command | H_{write} | <i>Write single block</i> (and verifying <i>read single block</i>) command OK |

To detect damage of EEPROM cells during production of inlets/labels a final test of the EEPROM after assembly of the inlet/label is recommended. This is necessary to achieve lowest failure rates.

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5 DEFINITIONS

| | |
|--|---|
| Data sheet status | |
| Objective specification | This data sheet contains target or goal specifications for product development. |
| Preliminary specification | This data sheet contains preliminary data; supplementary data may be published later. |
| Product specification | This data sheet contains final product specifications. |
| 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. | |

6 DISCLAIMERS

6.1 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.

6.2 Licence Policy

Purchase of this Philips IC with a functionally according to ISO/IEC 15693 Standard does not convey an implied license under any patent right on this standard. A license for the Philips portfolio of patents on the ISO/IEC 15693 Standard can be obtained via the Philips Intellectual Property and Standards department. For more information please contact the nearest Philips Semiconductors sales office.

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| REVISION | DATE | CPCN | PAGE | DESCRIPTION |
|-----------------|----------------|-------------|-------------|---|
| 1.0 | Nov. 2000 | | | Initial version. |
| 1.1 | August 2001 | | | First update, correction of errors. |
| 1.2 | Sept. 2001 | | | Second update, correction of errors. |
| 1.3 | Nov. 2001 | | | Third update, correction of errors |
| 1.4 | March 2002 | | | Changed security status of the document |
| 2.0 | June 2002 | | | Preliminary Specification; licence policy added |
| 3.0 | Jan. 2003 | | | Product Specification |
| 3.1 | Jan. 2005 | | 11 | Note regarding EAS status added |
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Functional Specification

Standard Label IC SL2 ICS20

NOTES

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