

SL2S2002_SL2S2102

ICODE SLIX

Rev. 3.4 — 10 August 2017

178034

Product data sheet
COMPANY PUBLIC

1 General description

The ICODE SLIX IC is a dedicated chip for intelligent label applications such as libraries, product authentication in different industries such as pharmaceutical, medical devices and alcohol, as well as production management in different areas of the industry. This IC is the third generation of a product family of smart label ICs based on the ISO standards ISO/IEC 15693 ([Ref. 1](#)) and ISO/IEC 18000-3 ([Ref. 4](#)), prolonging a successful story of NXP in the field of vicinity identification systems.

The ICODE system offers the possibility of operating labels simultaneously in the field of the reader antenna (anticollision). It is designed for long range applications.

1.1 Contactless energy and data transfer

Whenever connected to a very simple and easy-to-produce 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 ICODE SLIX 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 enables data to be transmitted up to 53 kbit/s.

1.2 Anticollision

An intelligent anticollision function enables several tags to operate 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.

1.3 Security and privacy aspects

- Unique IDentifier (UID):
The UID cannot be altered and guarantees the uniqueness of each label.
- Password protected EAS and AFI functionality:
The 32-bit EAS/AFI password enables the addressed label to be set in a mode where the EAS status and the AFI value can only be changed if the correct EAS/AFI password is transmitted to the label within the mentioned commands.



2 Features and benefits

2.1 ICODE SLIX 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 freely available)
- Fast data transfer: up to 53 kbit/s
- High data integrity: 16-bit CRC, framing
- True anticollision
- Password protected Electronic Article Surveillance (EAS)
- Password protected Application Family Identifier (AFI)
- Data Storage Format Identifier (DSFID)
- Additional fast anticollision read
- Write distance equal to read distance

2.2 EEPROM

- 1024 bits, organized in 32 blocks of 4 bytes each
- 50 years data retention
- Write endurance of 100000 cycles

2.3 Security

- Unique identifier for each device
- Lock mechanism for each user memory block (write protection)
- Lock mechanism for DSFID, AFI, EAS
- Password (32-bit) protected EAS and AFI functionality

3 Applications

- Libraries
- Item level tagging in pharmaceutical supply chains
- Counterfeit protection for consumer goods
- Industrial applications
- Asset and document tracking

4 Ordering information

Table 1. Ordering information

Type number	Package		Version
	Name	Description	
SL2S2002FUD	wafer	sawn, bumped wafer, 120 μm , on film frame carrier, C_i between LA and LB = 23.5 pF (typical)	-
SL2S2102FUD	wafer	sawn, bumped wafer, 120 μm , on film frame carrier, C_i between LA and LB = 97 pF (typical)	-
SL2S2002FTB	XSON3	plastic extremely thin small outline package; no leads; 3 terminals; body 1 x 1.45 x 0.5 mm; C_i between LA and LB = 23.5 pF (typical)	SOT1122
SL2S2102FTB	XSON3	plastic extremely thin small outline package; no leads; 3 terminals; body 1 x 1.45 x 0.5 mm; C_i between LA and LB = 97 pF (typical)	SOT1122
SL2S2002FA8	MOA8	plastic lead less module carrier package; 35 mm wide tape; C_i between LA and LB = 23.5 pF (typical)	SOT500-4

5 Block diagram

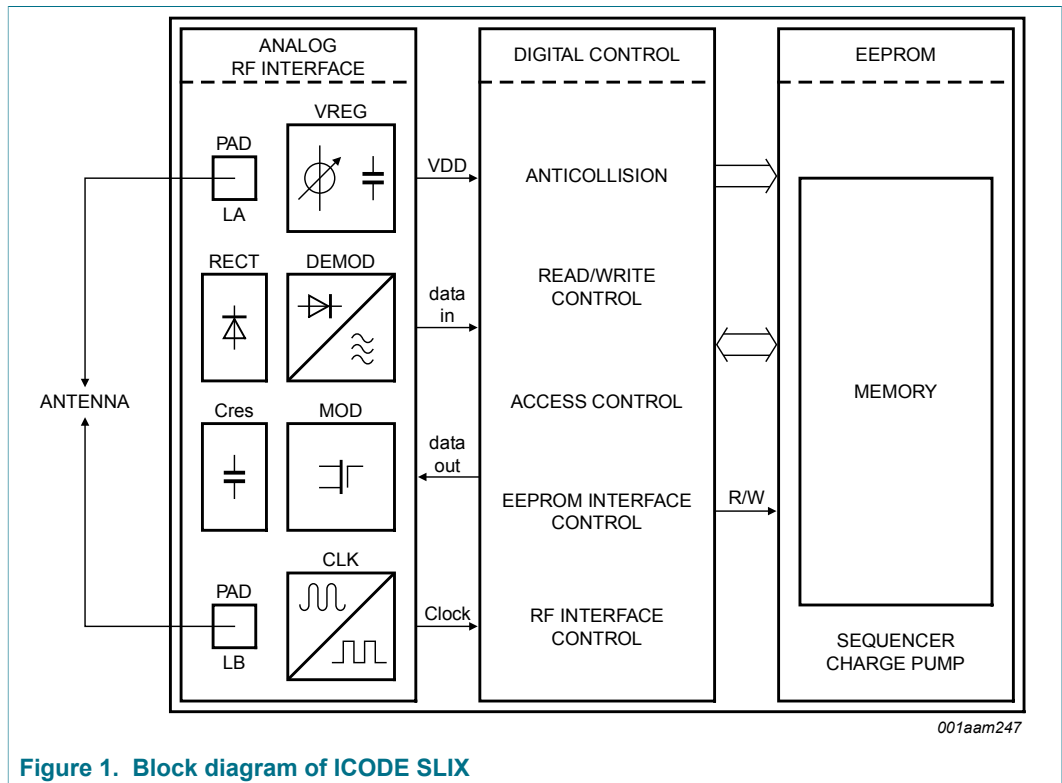


Figure 1. Block diagram of ICODE SLIX

6 Pinning information

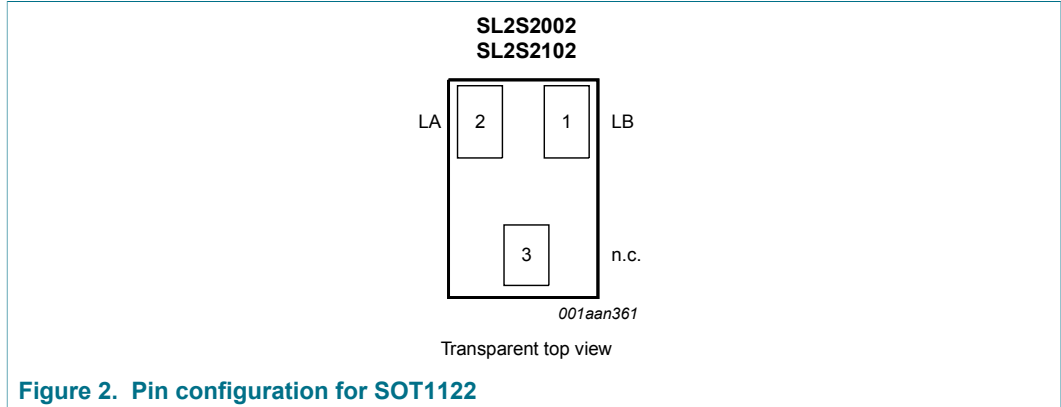


Table 2. Pin description SOT1122

Pin	Symbol	Description
1	LB	antenna RF input
2	LA	antenna RF input
3	n.c.	not connected

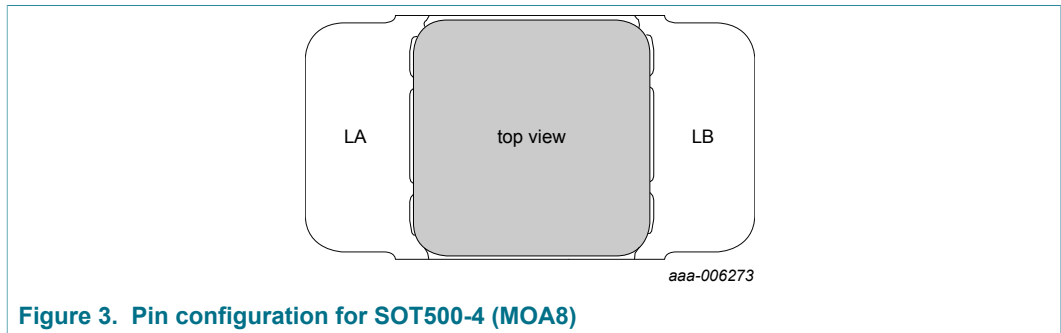


Table 3. Pin description SOT500-4 (MOA8)

Pin	Symbol	Description
LA	LA	antenna RF input
LB	LB	antenna RF input

7 Wafer layout

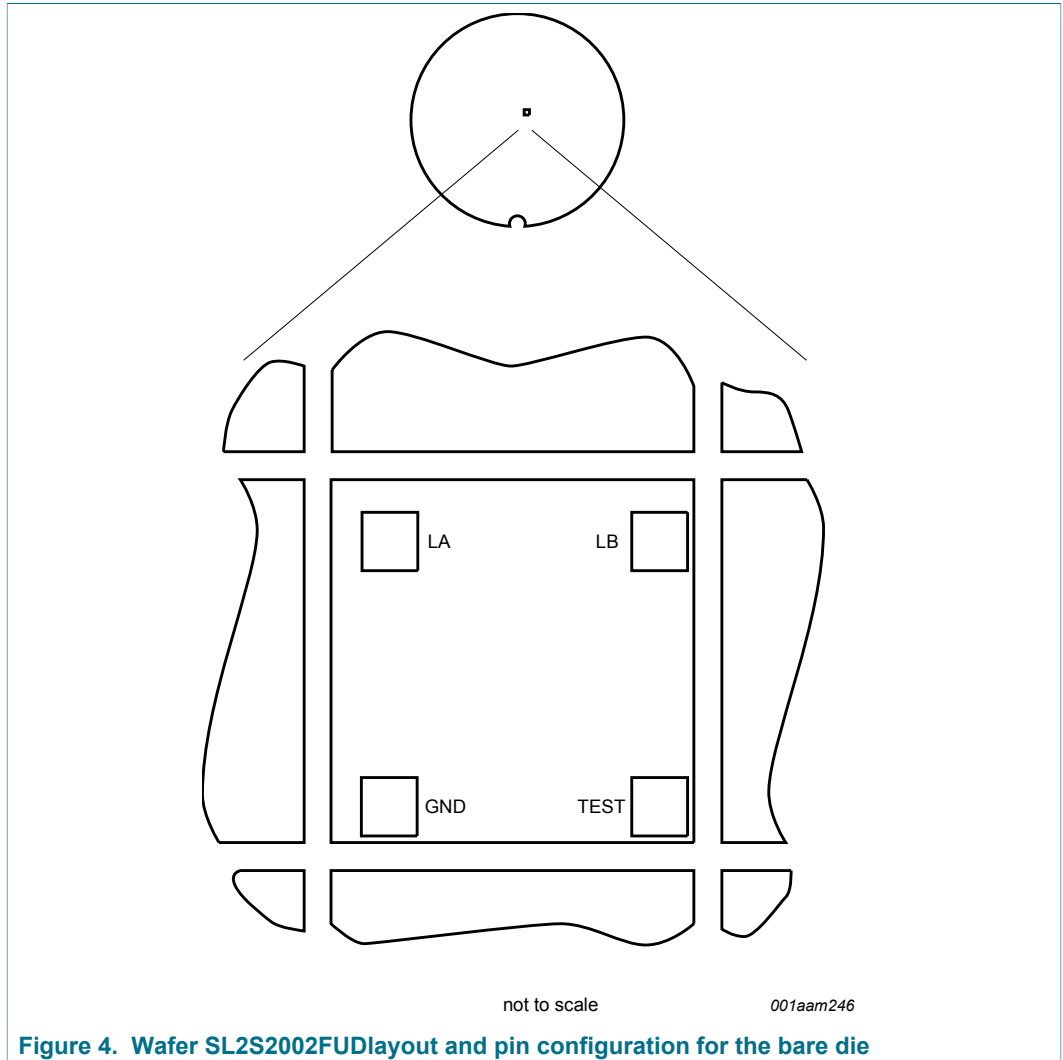


Figure 4. Wafer SL2S2002FUD layout and pin configuration for the bare die

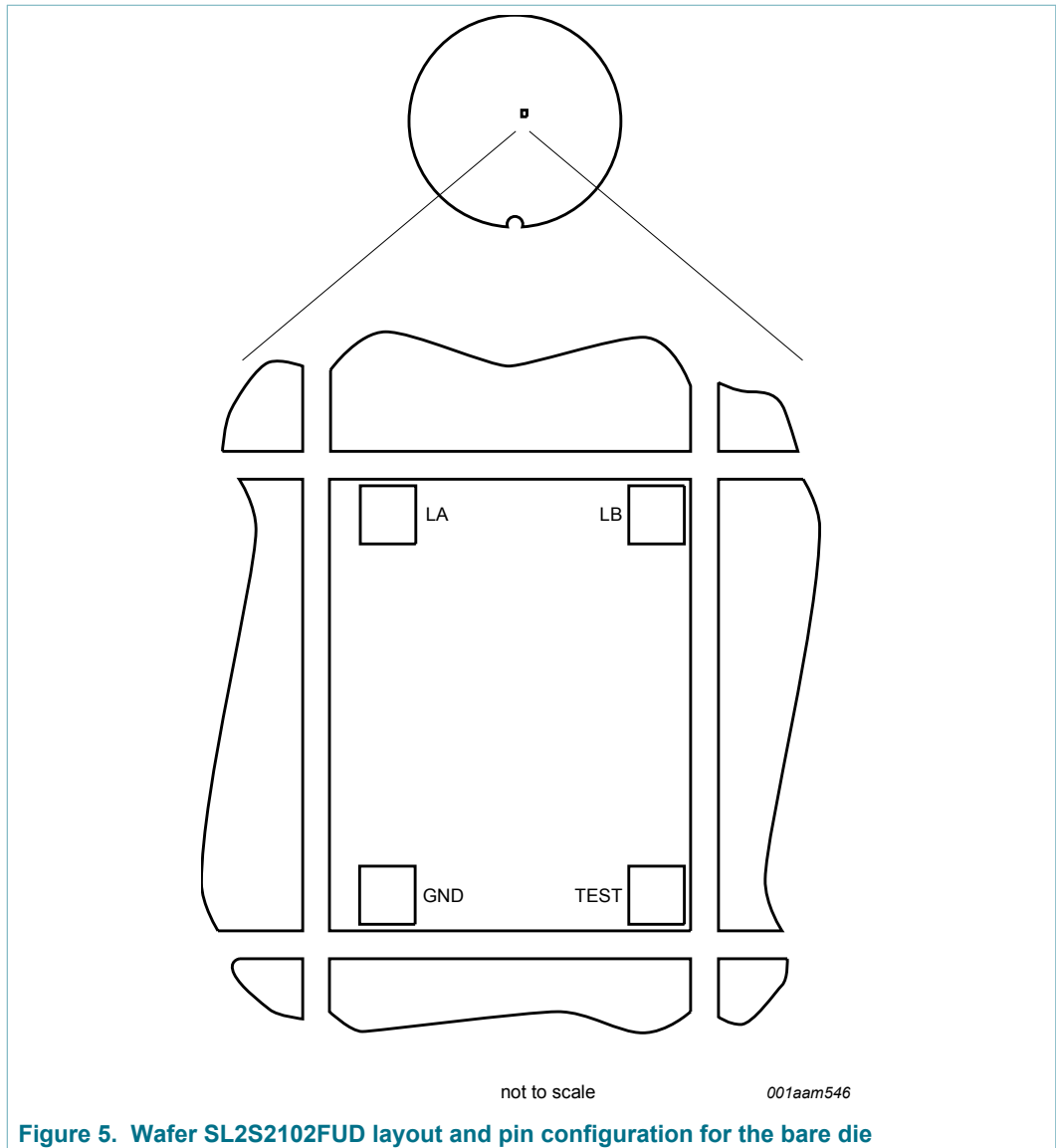


Figure 5. Wafer SL2S2102FUD layout and pin configuration for the bare die

7.1 Bonding pad description

Table 4. Bonding pad description

Symbol	Description
LA	antenna RF input
LB	antenna RF input
GND	ground
TEST	test input

8 Mechanical specification

8.1 Wafer specification

See [Ref. 6 "General specification for 8" wafer on UV-tape with electronic fail die marking"](#).

Table 5. Wafer specification

Wafer	
Designation	each wafer is enscribed with batch number and wafer number
Diameter	200 mm (8 inches)
Thickness	120 $\mu\text{m} \pm 15 \mu\text{m}$
Process	CMOS 0.14 μm
Batch size	25 wafers
Dies per wafer	
SL2S2002FUD	110050
SL2S2102FUD	88225
Wafer backside	
Material	Si
Treatment	ground and stress release
Roughness	R_a minimum = 0.5 μm R_t maximum = 5 μm
Chip dimensions	
Die size without scribe	
SL2S2002FUD	520 $\mu\text{m} \times 484 \mu\text{m} = 251680 \mu\text{m}^2$
SL2S2102FUD	520 $\mu\text{m} \times 607 \mu\text{m} = 315640 \mu\text{m}^2$
Scribe line width	
X-dimension	15 μm (scribe line width measured between nitride edges)
Y-dimension	15 μm (scribe line width measured between nitride edges)
Number of pads	4
Pad location	non-diagonal/placed in chip corners
Distance pad to pad LA to LB	400 μm
Distance pad to pad LB to TEST	
SL2S2002FUD	360 μm
SL2S2102FUD	517 μm
Passivation on front	
Type	sandwich structure
Material	PE-nitride (on top)
Thickness	1.75 μm total thickness of passivation

Au bump	
Material	>99.9 % pure Au
Hardness	35 HV to 80 HV 0.005
Shear strength	>70 MPa
Height	18 μm
Height uniformity	
within a die	$\pm 2 \mu\text{m}$
within a wafer	$\pm 3 \mu\text{m}$
wafer to wafer	$\pm 4 \mu\text{m}$
Bump flatness	$\pm 1.5 \mu\text{m}$
Bump size	
LA, LB	60 μm \times 60 μm
TEST, GND	60 μm \times 60 μm
variation	$\pm 5 \mu\text{m}$
Under bump metallization	sputtered TiW

8.1.1 Fail die identification

No inkdots are applied to the wafer.

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

See [Ref. 6 "General specification for 8" wafer on UV-tape with electronic fail die marking"](#).

8.1.2 Map file distribution

See [Ref. 6 "General specification for 8" wafer on UV-tape with electronic fail die marking"](#).

9 Functional description

9.1 Block description

The ICODE SLIX IC consists of three major blocks:

- Analog RF interface
- Digital controller
- EEPROM

The analog section provides stable supply voltage and demodulates data received from the reader for processing by the digital section. The analog section’s modulation transistor also transmits data back to the reader.

The digital section includes the state machines, processes the protocol and handles communication with the EEPROM.

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 ICODE Label, and modulates the electromagnetic field for data transmission from the ICODE Label to the interrogator.

Data are stored in a non-volatile memory (EEPROM).

9.2 Memory organization

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.

The memory is divided into 2 parts:

- Configuration area
Within this part of the memory all required information is stored, such as UID, write protection, access control information, passwords, AFI and EAS. This memory area cannot be directly accessed.
- User memory
Within the 896 bit memory area the user data are stored. Direct read/write access to this part of the memory is possible depending on the related write protection conditions.

Table 6. Memory organization

Block	Byte 0	Byte 1	Byte 2	Byte 3	Description
					Configuration area for internal use
0					User memory: 28 blocks, 4 bytes each, 112 bytes in total.
1					
2					
:	:	:	:	:	
25					
26					

Block	Byte 0	Byte 1	Byte 2	Byte 3	Description
27					

Blocks 0 to 27 can be addressed with read and write commands only.

9.2.1 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 64 bits are numbered according to ISO/IEC 15693-3 starting with LSB 1 and ending with MSB 64. This is in contrast to the general used bit numbering within a byte.

The TAG type is a part of the UID (bit 41 to 48, next to the manufacturer code which is "04h" for NXP Semiconductors).

The TAG type of the ICODE SLIX IC is "01h".

Bit 37 is set to logic 1 for the ICODE SLIX IC which indicates that this type supports the password protected EAS/AFI feature (not supported by ICODE SLI SL2ICS2001 with bit 37 set to logic 0).

Table 7. Unique identifier

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

9.2.2 Configuration of delivered ICs

ICODE SLIX ICs are delivered with the following configuration by NXP Semiconductors:

- Unique identifier is unique and read only
- Write access conditions allow change to user blocks, AFI, DSFID, EAS and passwords
- Status of EAS mode is not defined
- AFI is supported and not defined
- All EAS/AFI password bytes are 00h
- EAS and AFI password protection is disabled
- DSFID is supported and not defined
- User data memory is not defined

Remark: Because the EAS mode is undefined at delivery, the EAS mode shall be set (enabled or disabled) according to your application requirements during the test or initialization phase.

Remark: If EAS and/or AFI password protection is not required in the targeted application, it is recommended a random EAS/AFI password is written during the label initialization.

9.3 Communication principle

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

9.4 Supported commands

9.4.1 Mandatory commands

9.4.1.1 INVENTORY

As defined in ISO/IEC 15693-3.

9.4.1.2 STAY QUIET

As defined in ISO/IEC 15693-3.

9.4.2 Optional commands

9.4.2.1 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.

9.4.2.2 WRITE SINGLE BLOCK

As defined in ISO/IEC 15693-3.

Option 0 (Option flag not set) is supported.

Option 1 (Option flag set) is supported.

9.4.2.3 LOCK BLOCK

As defined in ISO/IEC 15693-3.

Option 0 (Option flag not set) is supported.

Option 1 (Option flag set) is supported.

9.4.2.4 READ MULTIPLE BLOCKS

As defined in ISO/IEC 15693-3.

Option 0 (Option flag not set) is supported.

Option 1 (Option flag set) is supported.

Remark: 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.

9.4.2.5 SELECT

As defined in ISO/IEC 15693-3.

9.4.2.6 RESET TO READY

As defined in ISO/IEC 15693-3.

9.4.2.7 WRITE AFI

As defined in ISO/IEC 15693-3.

Option 0 (Option flag not set) is supported.

Option 1 (Option flag set) is supported.

Remark: This command maybe password protected, refer to [Section 9.4.3.11 "PASSWORD PROTECT EAS/AFI"](#).

9.4.2.8 LOCK AFI

As defined in ISO/IEC 15693-3.

Option 0 (Option flag not set) is supported.

Option 1 (Option flag set) is supported.

Remark: This command maybe password protected, refer to [Section 9.4.3.11 "PASSWORD PROTECT EAS/AFI"](#).

9.4.2.9 WRITE DSFID

As defined in ISO/IEC 15693-3.

Option 0 (Option flag not set) is supported.

Option 1 (Option flag set) is supported.

9.4.2.10 LOCK DSFID

As defined in ISO/IEC 15693-3.

Option 0 (Option flag not set) is supported.

Option 1 (Option flag set) is supported.

9.4.2.11 GET SYSTEM INFORMATION

As defined in ISO/IEC 15693-3.

The TAG type of the ICODE SLIX is "01h".

9.4.2.12 GET MULTIPLE BLOCK SECURITY STATUS

As defined in ISO/IEC 15693-3.

Remark: 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.

9.4.3 Custom commands

The manufacturer code of NXP Semiconductors is defined in ISO/IEC 7816-6A1 ([Ref. 5](#)). It has the value "04h".

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

If not explicitly specified differently all address modes are supported.

9.4.3.1 GET RANDOM NUMBER

Command code = B2h

The GET RANDOM NUMBER command is required to receive a random number from the label IC. The passwords that will be transmitted with the SET PASSWORD command have to be calculated with the password and the random number (see [Section 9.4.3.2 "SET PASSWORD"](#)).

The different passwords are addressed with the password identifier.

Table 8. Request format

SOF	Flags	GET RANDOM NUMBER	IC Mfg code	UID	CRC16	EOF
-	8 bits	8 bits	8 bits	64 bits optional	16 bits	-

Table 9. Response format when Error_flag set

SOF	Flags	Error code	CRC16	EOF
-	8 bits	8 bits	16 bits	-

Table 10. Response format when Error_flag NOT set

SOF	Flags	Random number	CRC16	EOF
-	8 bits	16 bits	16 bits	-

9.4.3.2 SET PASSWORD

Command code = B3h

The SET PASSWORD command enables the EAS/AFI password to be transmitted to the label to access EAS and/or AFI (if the EAS and/or AFI password is enabled). The SET PASSWORD command has to be executed just once for the related password if the label is powered.

Remark: The SET PASSWORD command can only be executed in Addressed or Selected mode.

The XOR password has to be calculated with the password and two times the received random number from the last GET RANDOM NUMBER command:

$\text{XOR_Password}[31:0] = \text{Password}[31:0] \text{ XOR } \{\text{Random_Number}[15:0], \text{Random_Number}[15:0]\}$.

The EAS/AFI password is addressed with the password identifier.

Table 11. Request format

SOF	Flags	SET PASSWORD	IC Mfg code	UID	Password identifier	XOR password	CRC16	EOF
-	8 bits	8 bits	8 bits	64 bits optional	8 bits	32 bits	16 bits	-

Table 12. Password Identifier

Password identifier	Password
10h	EAS/AFI

Table 13. Response format when Error_flag set

SOF	Flags	Error code	CRC16	EOF
-	8 bits	8 bits	16 bits	-

Table 14. Response format when Error_flag NOT set

SOF	Flags	CRC16	EOF
-	8 bits	16 bits	-

Remark: If the IC receives an invalid password, it will not execute any following command until a Power-On Reset (POR) (RF reset) is executed.

9.4.3.3 WRITE PASSWORD

Command code = B4h

The WRITE PASSWORD command enables a new password to be written into the related memory if the related old password has already been transmitted with a SET PASSWORD command and the addressed password is not locked (see [Section 9.4.3.4 "LOCK PASSWORD"](#)).

Remark: The WRITE PASSWORD command can only be executed in addressed or selected mode. The new password takes effect immediately which means that the

new password has to be transmitted with the SET PASSWORD command to access protected blocks.

The EAS/AFI password is addressed with the password identifier.

The timing of the command is write alike.

Option 0 (Option flag not set) is supported.

Option 1 (Option flag set) is supported.

Table 15. Request format

SOF	Flags	WRITE PASSWORD	IC Mfg code	UID	Password identifier	Password	CRC16	EOF
-	8 bits	8 bits	8 bits	64 bits optional	8 bits	32 bits	16 bits	-

Table 16. Password identifier

Password identifier	Password
10h	EAS/AFI

Table 17. Response format when Error_flag set

SOF	Flags	Error code	CRC16	EOF
-	8 bits	8 bits	16 bits	-

Table 18. Response format when Error_flag NOT set

SOF	Flags	CRC16	EOF
-	8 bits	16 bits	-

9.4.3.4 LOCK PASSWORD

Command code = B5h

The LOCK PASSWORD command enables the addressed password to be locked if the related password has already been transmitted with a SET PASSWORD command. A locked password cannot be changed.

The EAS/AFI password is addressed with the password identifier.

The timing of the command is write alike.

Option 0 (Option flag not set) is supported.

Option 1 (Option flag set) is supported.

Table 19. Request format

SOF	Flags	LOCK PASSWORD	IC Mfg code	UID	Password identifier	CRC16	EOF
-	8 bits	8 bits	8 bits	64 bits optional	8 bits	16 bits	-

Table 20. Password identifier

Password identifier	Password
10h	EAS/AFI

Table 21. Response format when Error_flag set

SOF	Flags	Error code	CRC16	EOF
-	8 bits	8 bits	16 bits	-

Table 22. Response format when Error_flag NOT set

SOF	Flags	CRC16	EOF
-	8 bits	16 bits	-

9.4.3.5 INVENTORY READ

Command code = A0h

When receiving the INVENTORY READ request, the ICODE SLIX IC performs the same as the anticollision sequence, with the difference that instead of the UID and the DSFID, the requested memory content is re-transmitted from the ICODE SLIX IC.

If an error is detected, the ICODE SLIX IC remains silent.

If the Option flag is set to logic 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 AFI flag set)
- Mask length
- Mask value (if mask length > 0)
- First block number to be read
- Number of blocks to be read
- CRC 16

Table 23. Request format

SOF	Flags	INVENTORY READ	IC Mfg code	AFI	Mask length	Mask value	First block number	Number of blocks	CRC16	EOF
-	8 bits	8 bits	8 bits	8 bits optional	8 bits	0 to 64 bits	8 bits	8 bits	16 bits	-

The Inventory_flag must be set to logic 1.

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

The number of blocks in the request is one less than the number of blocks that the ICODE SLIX IC returns in its response.

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

Table 24. Response format: Option flag logic 0

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

The ICODE SLIX 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 the INVENTORY command which is described in clause 8 of ISO/IEC 15693-3.

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

Table 25. Response format: Option flag logic 1

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 ICODE SLIX 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 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 the INVENTORY command which is described in clause 8 of ISO/IEC 15693-3.

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

- 16 slots: 60 bits (bit 64 to bit 4) - mask length rounded up to the next byte boundary
- 1 slot: 64 bits - mask length rounded up to the next byte boundary

Remark: 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.

Example: mask length = 30 bits

Returned: bit 64 to bit 4 (30 bits) = 30 gives 4 bytes

Table 26. Example: mask length = 30

Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	UID
mask value including padding with zeros				-				transmitted by interrogator
				returned value				transmitted by ICODE SLIX IC

9.4.3.6 FAST INVENTORY READ

Command code = A1h

When receiving the FAST INVENTORY READ command the ICODE SLIX IC behaves the same as the INVENTORY READ command with the following exceptions:

The data rate in the direction ICODE SLIX IC to the interrogator is twice that defined in ISO/IEC 15693-3 depending on the Datarate_flag 53 kbit (high data rate) or 13 kbit (low data rate).

The data rate from the interrogator to the ICODE SLIX IC and the time between the rising edge of the EOF from the interrogator to the ICODE SLIX IC remain unchanged (stay the same as defined in ISO/IEC 15693-3).

In the ICODE SLIX IC to the interrogator direction, only the single subcarrier mode is supported.

9.4.3.7 SET EAS

Command code = A2h

The SET EAS command enables the EAS mode if the EAS mode is not locked. If the EAS mode is password protected the EAS password has to be first transmitted with the SET PASSWORD command.

The timing of the command is write alike.

Option 0 (Option flag not set) is supported.

Option 1 (Option flag set) is supported.

Table 27. Request format

SOF	Flags	SET EAS	IC Mfg code	UID	CRC16	EOF
-	8 bits	8 bits	8 bits	64 bits optional	16 bits	-

Table 28. Response format when Error_flag set

SOF	Flags	Error code	CRC16	EOF
-	8 bits	8 bits	16 bits	-

Table 29. Response format when Error_flag NOT set

SOF	Flags	CRC16	EOF
-	8 bits	16 bits	-

9.4.3.8 RESET EAS

Command code = A3h

The RESET EAS command disables the EAS mode if the EAS mode is not locked. If the EAS mode is password protected the EAS password has to be first transmitted with the SET PASSWORD command.

The timing of the command is write alike.

Option 0 (Option flag not set) is supported.

Option 1 (Option flag set) is supported.

Table 30. Request format

SOF	Flags	RESET EAS	IC Mfg code	UID	CRC16	EOF
-	8 bits	8 bits	8 bits	64 bits optional	16 bits	-

Table 31. Response format when Error_flag set

SOF	Flags	Error code	CRC16	EOF
-	8 bits	8 bits	16 bits	-

Table 32. Response format when Error_flag NOT set

SOF	Flags	CRC16	EOF
-	8 bits	16 bits	-

9.4.3.9 LOCK EAS

Command code = A4h

The LOCK EAS command locks the current state of the EAS mode and the EAS ID. If the EAS mode is password protected the EAS password has to be first transmitted with the SET PASSWORD command.

The timing of the command is write alike.

Option 0 (Option flag not set) is supported.

Option 1 (Option flag set) is supported.

Table 33. Request format

SOF	Flags	LOCK EAS	IC Mfg code	UID	CRC16	EOF
-	8 bits	8 bits	8 bits	64 bits optional	16 bits	-

Table 34. Response format when Error_flag set

SOF	Flags	Error code	CRC16	EOF
-	8 bits	8 bits	16 bits	-

Table 35. Response format when Error_flag NOT set

SOF	Flags	CRC16	EOF
-	8 bits	16 bits	-

9.4.3.10 EAS ALARM

Command code = A5h

If the EAS mode is enabled, the EAS sequence is returned from the ICODE SLIX IC.

Table 36. Request format

SOF	Flags	EAS ALARM	IC Mfg code	UID	CRC16	EOF
-	8 bits	8 bits	8 bits	64 bits optional	16 bits	-

If an error is detected the ICODE SLIX IC remains silent.

Table 37. Response format

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

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 mode is disabled the ICODE SLIX IC remains silent.

9.4.3.11 PASSWORD PROTECT EAS/AFI

Command code = A6h

The PASSWORD PROTECT EAS/AFI command enables the password protection for EAS and/or AFI if the EAS/AFI password is first transmitted with the SET PASSWORD command.

Option flag set to logic 0: EAS will be password protected.

Option flag set to logic 1: AFI will be password protected.

Both password protections (AFI and EAS) can be enabled separately.

Remark: Independent of the Option flag, this write-alike command will be executed like a write command with Option flag 0 (Option flag not set).

Once the EAS/AFI password protection is enabled, it is not possible to change back to unprotected EAS and/or AFI.

The timing of the command is write alike (as write command with Option flag 0).

Table 38. Request format

SOF	Flags	PASSWORD PROTECT EAS/ AFI	IC Mfg code	UID	CRC16	EOF
-	8 bits	8 bits	8 bits	64 bits optional	16 bits	-

Table 39. Response format when Error_flag set

SOF	Flags	Error code	CRC16	EOF
-	8 bits	8 bits	16 bits	-

Table 40. Response format when Error_flag NOT set

SOF	Flags	CRC16	EOF
-	8 bits	16 bits	-

9.5 Error handling

9.5.1 Transmission errors

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

9.5.2 Not supported commands or options

If the received command or option is not supported, the behavior of the label IC depends on the addressing mechanism.

9.5.2.1 Non Addressed Mode

The label IC remains silent.

9.5.2.2 Addressed or Selected Mode

The addressed or selected label IC responds with the error code "0Fh" (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.

9.5.3 Parameter out of range

9.5.3.1 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.

9.5.3.2 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 depends on the addressing mechanism.

Non Addressed Mode

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

Addressed or Selected Mode

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

9.6 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 logic 1, logic 0, and no information
- Channel monitoring (protocol sequence and bit stream analysis)

9.7 RF interface

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

10 Limiting values

Table 41. Limiting values (Wafer)^{[1][2]}

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

Symbol	Parameter	Conditions		Min	Max	Unit
T _{stg}	storage temperature			-55	+125	°C
P _{tot}	total power dissipation			-	125	mW
T _j	junction temperature			-40	+85	°C
I _{i(max)}	maximum input current	LA to LB; peak	[3]	-	±60	mA
I _I	input current	LA to LB; RMS		-	30	mA
V _{ESD}	electrostatic discharge voltage	Human body model	[4]	-	±2	kV

[1] Stresses above those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any conditions other than those described in the operating conditions and electrical characteristics sections of this specification is not implied.

[2] This product includes circuitry specifically designed for the protection of its internal devices from the damaging effects of excessive static charge. Nonetheless, it is suggested that conventional precautions be taken to avoid applying greater than the rated maxima.

[3] The voltage between LA and LB is limited by the on-chip voltage limitation circuitry (corresponding to parameter I_I).

[4] For ESD measurement, the IC was mounted in a CDIP8 package.

11 Characteristics

11.1 Memory characteristics

Table 42. EEPROM characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
t_{ret}	retention time	$T_{amb} \leq 55 \text{ }^\circ\text{C}$	50	-	-	year
$N_{endu(W)}$	write endurance		100000	-	-	cycle

11.2 Interface characteristics

Table 43. Interface characteristics

Typical ratings are not guaranteed. The values listed are at room temperature.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit	
f_i	input frequency		[1] 13.553	13.56	13.567	MHz	
$V_{i(RMS)min}$	minimum RMS input voltage	operating read/write	1.5	-	1.7	V	
$P_{i(min)}$	minimum input power	operating	[2] -	40	-	μW	
C_i	input capacitance	between LA and LB	[3]				
		SL2S2002FUD SL2S2002FTB SL2S2002FA8		22.3	23.5	24.7	pF
		SL2S2102FUD SL2S2102FTB		92	97	102	pF

[1] Bandwidth limitation (± 7 kHz) according to ISM band regulations.

[2] Including losses in the resonant capacitor and rectifier.

[3] Measured with an HP4285A LCR meter at 13.56 MHz and 2 V RMS.

12 Marking

12.1 Marking SOT1122

Table 44. Marking SOT1122

Type number	Marking code
SL2S2002FTB	20
SL2S2102FTB	21

13 Package outline

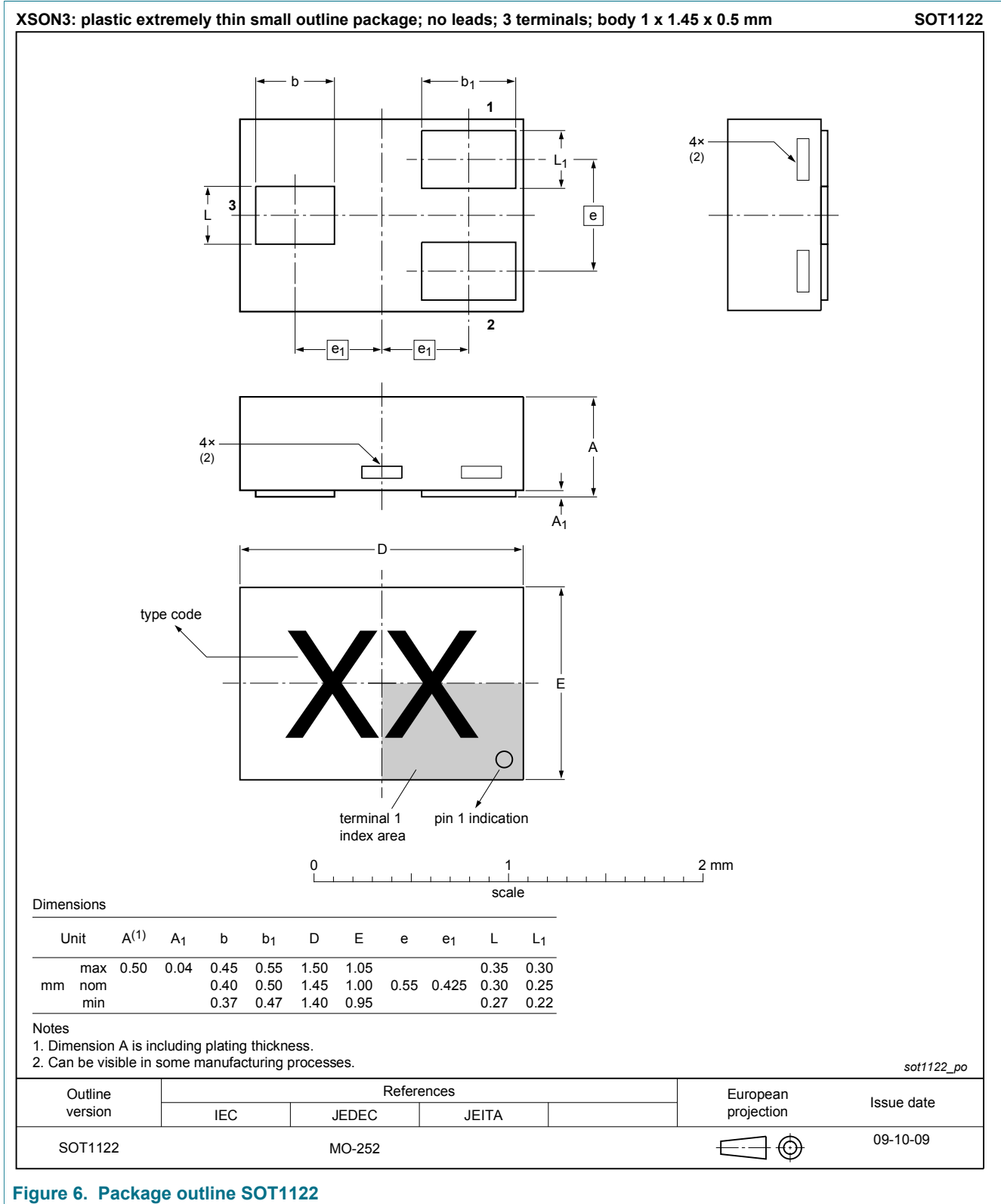


Figure 6. Package outline SOT1122

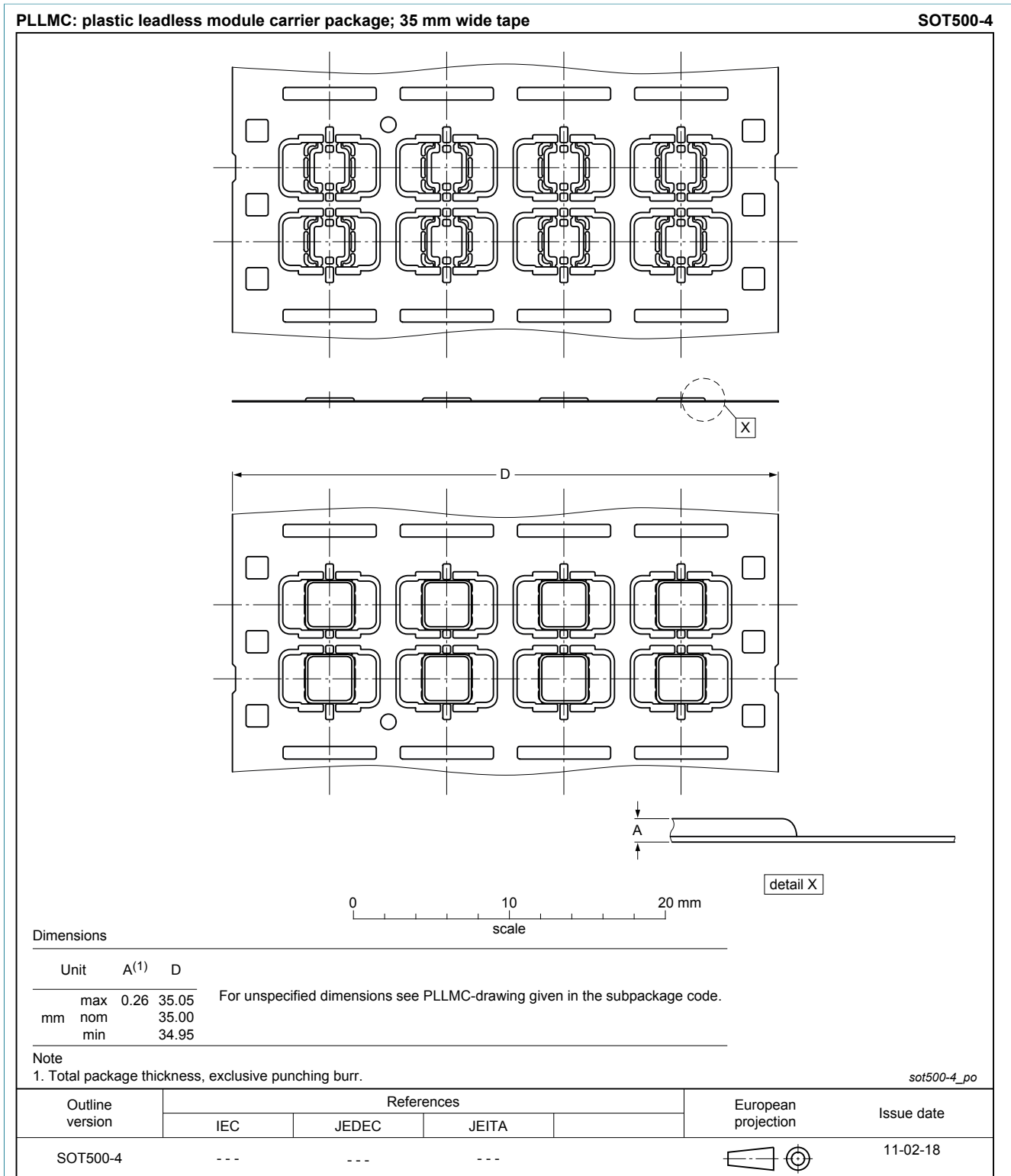
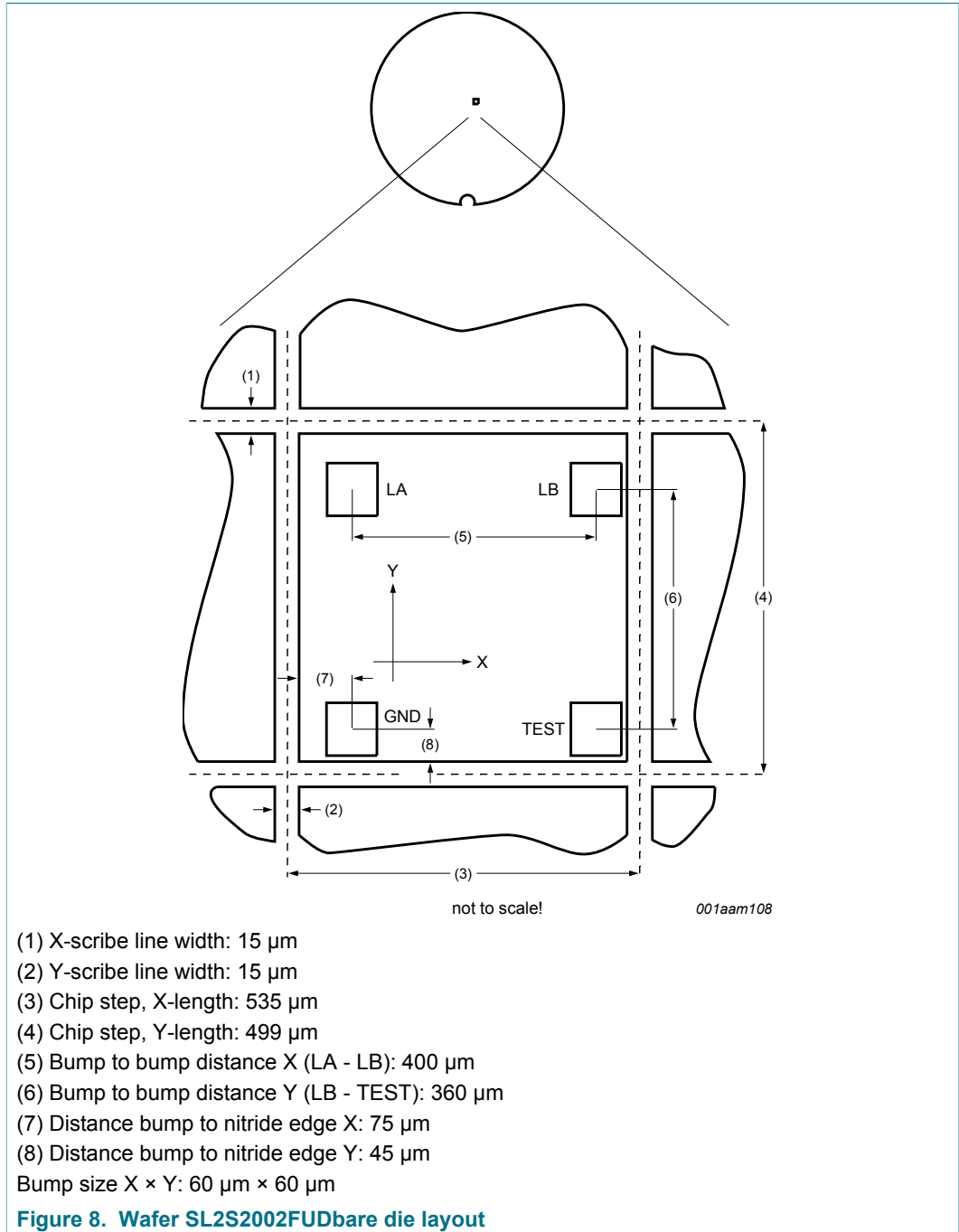


Figure 7. Package outline SOT500-4

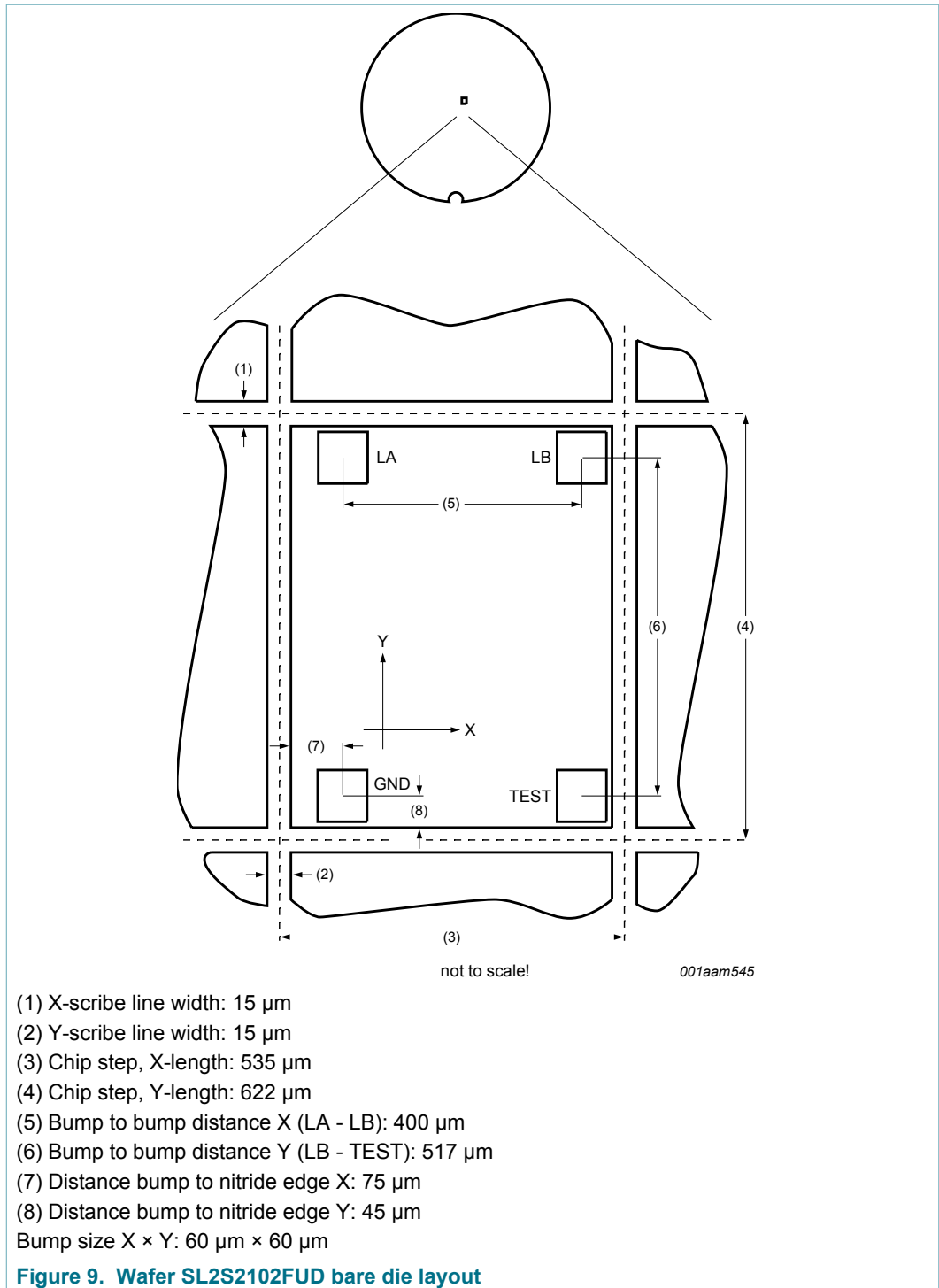
For more details on the contactless MOA8 module see [Ref. 7](#).

14 Bare die outline



- (1) X-scribe line width: 15 μm
 - (2) Y-scribe line width: 15 μm
 - (3) Chip step, X-length: 535 μm
 - (4) Chip step, Y-length: 499 μm
 - (5) Bump to bump distance X (LA - LB): 400 μm
 - (6) Bump to bump distance Y (LB - TEST): 360 μm
 - (7) Distance bump to nitride edge X: 75 μm
 - (8) Distance bump to nitride edge Y: 45 μm
- Bump size X \times Y: 60 μm \times 60 μm

Figure 8. Wafer SL2S2002FUDbare die layout



- (1) X-scribe line width: 15 μm
- (2) Y-scribe line width: 15 μm
- (3) Chip step, X-length: 535 μm
- (4) Chip step, Y-length: 622 μm
- (5) Bump to bump distance X (LA - LB): 400 μm
- (6) Bump to bump distance Y (LB - TEST): 517 μm
- (7) Distance bump to nitride edge X: 75 μm
- (8) Distance bump to nitride edge Y: 45 μm
- Bump size X × Y: 60 μm × 60 μm

Figure 9. Wafer SL2S2102FUD bare die layout

15 Abbreviations

Table 45. Abbreviations

Acronym	Description
AFI	Application Family Identifier
CRC	Cyclic Redundancy Check
DSFID	Data Storage Format Identifier
EAS	Electronic Article Surveillance
EEPROM	Electrically Erasable Programmable Read Only Memory
EOF	End Of Frame
IC	Integrated Circuit
LCR	Inductance, Capacitance, Resistance
LSB	Least Significant Byte/Bit
MSB	Most Significant Byte/Bit
RF	Radio Frequency
SOF	Start Of Frame
UID	Unique Identifier

16 References

[1]

ISO Standard

ISO/IEC 15693 - Identification cards - Contactless integrated circuit cards - Vicinity cards.

[2]

ISO Standard

ISO/IEC 15693-2 -Identification cards - Contactless integrated circuit cards - Vicinity cards - Part 2: Air interface and initialization.

[3]

ISO Standard

ISO/IEC 15693-3 -Identification cards - Contactless integrated circuit cards - Vicinity cards - Part 3: Anticollision and transmission protocol.

[4]

ISO Standard

ISO/IEC 18000-3 - Information technology - Radio frequency identification for item management - Part 3: Parameters for air interface communications at 13.56 MHz.

[5]

ISO Standard

ISO/IEC 7816-6 - Identification cards - Integrated circuit cards - Part 6: Interindustry data elements for interchange.

[6]

General specification for 8" wafer on UV-tape with electronic fail die marking

Delivery type description – BL-ID document number: 1093**¹.

[7]

Contactless smart card module specification MOA8

Delivery Type Description, BU-ID Document number 1636**¹.

¹ ** ... document version number

17 Revision history

Table 46. Revision history

Document ID	Release date	Data sheet status	Change notice	Supersedes
SL2S2002_SL2S2102 v3.4	20170810	Product data sheet	-	SL2S2002_SL2S2102 v3.3
Modifications:	<ul style="list-style-type: none"> • Addition of SL2S2002FA8 with SOT500-4 (MOA8) package 			
SL2S2002_SL2S2102 v3.3	20120823	Product data sheet	-	SL2S2002_SL2S2102 v3.2
Modifications:	<ul style="list-style-type: none"> • Security level changed into "COMPANY PUBLIC" 			
SL2S2002_SL2S2102 v3.2	20110110	Product data sheet	-	SL2S2002_SL2S2102 v3.1
Modifications:	<ul style="list-style-type: none"> • Type numbers SL2S2002FTB and SL2S2102FTB added • Section 6 "Pinning information", Section 12 "Marking" and Section 13 "Package outline" added 			
SL2S2002_SL2S2102 v3.1	20100908	Product data sheet	-	SL2S2002 v3.0
Modifications:	<ul style="list-style-type: none"> • Added type number SL2S2102 • Document layout updated • Table 43: symbols and parameter descriptions updated 			
SL2S2002 v3.0	20100527	Product data sheet	-	178020
178020	20100430	Preliminary data sheet	-	178010
178010	20100205	Objective data sheet	-	-

18 Legal information

18.1 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.

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

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

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

18.2 Definitions

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

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

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

18.3 Disclaimers

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

Right to make changes — NXP Semiconductors reserves the right to make changes to information published in this document, including without limitation specifications and product descriptions, at any time and without notice. This document supersedes and replaces all information supplied prior to the publication hereof.

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

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

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

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

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

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

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

Non-automotive qualified products — Unless this data sheet expressly states that this specific NXP Semiconductors product is automotive qualified, the product is not suitable for automotive use. It is neither qualified nor tested in accordance with automotive testing or application requirements. NXP Semiconductors accepts no liability for inclusion and/or use of non-automotive qualified products in automotive equipment or applications. In the event that customer uses the product for design-in and use in automotive applications to automotive specifications and standards, customer (a) shall use the product without NXP Semiconductors' warranty of the product for such automotive applications, use and specifications, and (b) whenever

customer uses the product for automotive applications beyond NXP Semiconductors' specifications such use shall be solely at customer's own risk, and (c) customer fully indemnifies NXP Semiconductors for any liability, damages or failed product claims resulting from customer design and use of the product for automotive applications beyond NXP Semiconductors' standard warranty and NXP Semiconductors' product specifications.

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

18.4 Trademarks

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

ICODE and I-CODE — are trademarks of NXP B.V.

Tables

Tab. 1.	Ordering information	4	Tab. 31.	Response format when Error_flag set	21
Tab. 2.	Pin description SOT1122	6	Tab. 32.	Response format when Error_flag NOT set	21
Tab. 3.	Pin description SOT500-4 (MOA8)	6	Tab. 33.	Request format	21
Tab. 4.	Bonding pad description	8	Tab. 34.	Response format when Error_flag set	22
Tab. 5.	Wafer specification	9	Tab. 35.	Response format when Error_flag NOT set	22
Tab. 6.	Memory organization	11	Tab. 36.	Request format	22
Tab. 7.	Unique identifier	12	Tab. 37.	Response format	22
Tab. 8.	Request format	15	Tab. 38.	Request format	23
Tab. 9.	Response format when Error_flag set	15	Tab. 39.	Response format when Error_flag set	23
Tab. 10.	Response format when Error_flag NOT set	15	Tab. 40.	Response format when Error_flag NOT set	23
Tab. 11.	Request format	16	Tab. 41.	Limiting values (Wafer)Stresses above those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any conditions other than those described in the operating conditions and electrical characteristics sections of this specification is not implied. This product includes circuitry specifically designed for the protection of its internal devices from the damaging effects of excessive static charge. Nonetheless, it is suggested that conventional precautions be taken to avoid applying greater than the rated maxima.	25
Tab. 12.	Password Identifier	16	Tab. 42.	EEPROM characteristics	26
Tab. 13.	Response format when Error_flag set	16	Tab. 43.	Interface characteristics	26
Tab. 14.	Response format when Error_flag NOT set	16	Tab. 44.	Marking SOT1122	27
Tab. 15.	Request format	17	Tab. 45.	Abbreviations	32
Tab. 16.	Password identifier	17	Tab. 46.	Revision history	34
Tab. 17.	Response format when Error_flag set	17			
Tab. 18.	Response format when Error_flag NOT set	17			
Tab. 19.	Request format	18			
Tab. 20.	Password identifier	18			
Tab. 21.	Response format when Error_flag set	18			
Tab. 22.	Response format when Error_flag NOT set	18			
Tab. 23.	Request format	19			
Tab. 24.	Response format: Option flag logic 0	19			
Tab. 25.	Response format: Option flag logic 1	19			
Tab. 26.	Example: mask length = 30	20			
Tab. 27.	Request format	20			
Tab. 28.	Response format when Error_flag set	20			
Tab. 29.	Response format when Error_flag NOT set	20			
Tab. 30.	Request format	21			

Figures

Fig. 1.	Block diagram of ICODE SLIX	5	Fig. 5.	Wafer SL2S2102FUD layout and pin configuration for the bare die	8
Fig. 2.	Pin configuration for SOT1122	6	Fig. 6.	Package outline SOT1122	28
Fig. 3.	Pin configuration for SOT500-4 (MOA8)	6	Fig. 7.	Package outline SOT500-4	29
Fig. 4.	Wafer SL2S2002FUD layout and pin configuration for the bare die	7	Fig. 8.	Wafer SL2S2002FUD bare die layout	30
			Fig. 9.	Wafer SL2S2102FUD bare die layout	31

Contents

1	General description	1	9.4.3.11	PASSWORD PROTECT EAS/AFI	22
1.1	Contactless energy and data transfer	1	9.5	Error handling	23
1.2	Anticollision	1	9.5.1	Transmission errors	23
1.3	Security and privacy aspects	1	9.5.2	Not supported commands or options	23
2	Features and benefits	2	9.5.2.1	Non Addressed Mode	23
2.1	ICODE SLIX RF interface (ISO/IEC 15693)	2	9.5.2.2	Addressed or Selected Mode	23
2.2	EEPROM	2	9.5.3	Parameter out of range	24
2.3	Security	2	9.5.3.1	Read commands	24
3	Applications	3	9.5.3.2	Write and lock commands	24
4	Ordering information	4	9.6	Data integrity	24
5	Block diagram	5	9.7	RF interface	24
6	Pinning information	6	10	Limiting values	25
7	Wafer layout	7	11	Characteristics	26
7.1	Bonding pad description	8	11.1	Memory characteristics	26
8	Mechanical specification	9	11.2	Interface characteristics	26
8.1	Wafer specification	9	12	Marking	27
8.1.1	Fail die identification	10	12.1	Marking SOT1122	27
8.1.2	Map file distribution	10	13	Package outline	28
9	Functional description	11	14	Bare die outline	30
9.1	Block description	11	15	Abbreviations	32
9.2	Memory organization	11	16	References	33
9.2.1	Unique identifier	12	17	Revision history	34
9.2.2	Configuration of delivered ICs	12	18	Legal information	35
9.3	Communication principle	13			
9.4	Supported commands	13			
9.4.1	Mandatory commands	13			
9.4.1.1	INVENTORY	13			
9.4.1.2	STAY QUIET	13			
9.4.2	Optional commands	13			
9.4.2.1	READ SINGLE BLOCK	13			
9.4.2.2	WRITE SINGLE BLOCK	13			
9.4.2.3	LOCK BLOCK	13			
9.4.2.4	READ MULTIPLE BLOCKS	13			
9.4.2.5	SELECT	14			
9.4.2.6	RESET TO READY	14			
9.4.2.7	WRITE AFI	14			
9.4.2.8	LOCK AFI	14			
9.4.2.9	WRITE DSFID	14			
9.4.2.10	LOCK DSFID	14			
9.4.2.11	GET SYSTEM INFORMATION	14			
9.4.2.12	GET MULTIPLE BLOCK SECURITY STATUS	15			
9.4.3	Custom commands	15			
9.4.3.1	GET RANDOM NUMBER	15			
9.4.3.2	SET PASSWORD	15			
9.4.3.3	WRITE PASSWORD	16			
9.4.3.4	LOCK PASSWORD	17			
9.4.3.5	INVENTORY READ	18			
9.4.3.6	FAST INVENTORY READ	20			
9.4.3.7	SET EAS	20			
9.4.3.8	RESET EAS	21			
9.4.3.9	LOCK EAS	21			
9.4.3.10	EAS ALARM	22			

Please be aware that important notices concerning this document and the product(s) described herein, have been included in section 'Legal information'.

© NXP B.V. 2017.

All rights reserved.

For more information, please visit: <http://www.nxp.com>

For sales office addresses, please send an email to: salesaddresses@nxp.com

Date of release: 10 August 2017

Document identifier: SL2S2002_SL2S2102

Document number: 178034