# SL3S1003_1013

## UCODE G2iM and G2iM+

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Product data sheet
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## 1 General description

NXP's UCODE G2iM series transponder ICs offers in addition to the leading-edge read range features such as a Tag Tamper Alarm, Data Transfer, Digital Switch, advanced privacy-protection modes and a 640 bit configurable User Memory.

Very high chip sensitivity (-17.5 dBm) enables longer read ranges with simple, single-port antenna designs. In fashion and retail the UCODE G2iM series improve read rates and provide for theft deterrence. In the electronic device market, they are ideally suited for device configuration, activation, production control and PCB tagging. In authentication applications, they protect brands and guard against counterfeiting. They can also be used to tag containers, electronic vehicles, airline baggage, and more.

In addition to the EPC specifications the UCODE G2iM offers an integrated Product Status Flag (PSF) feature and read protection of the memory content.

The UCODE G2iM+ offers on top of the UCODE G2iM features an integrated tag tamper alarm, digital switch, external supply mode, data transfer mode and real read range reduction. A special feature is the conditional, automatic real read range reduction, where the activation condition can be defined by the user, is newly introduced in the UCODE G2iM+. When connected to a power supply, the READ as well as the WRITE range can be boosted to a sensitivity of -27 dBm.

The UCODE G2iM+ also allows the segmentation of the 640 bit User Memory in up to three segments (open, protected, private) with different access levels (Access- and User Password). For applications which require a longer EPC number the UCODE G2iM+ offers the possibility of up to 448 bit.

# 2 Features and benefits

## 2.1 Key features

- UHF RFID Gen2 tag chip according to EPCglobal v1.2.0
- 256-bit EPC for UCODE G2iM and up to 448-bit EPC for UCODE G2iM+
- Up to 640-bit User Memory which can be segmented in the UCODE G2iM+.
- Private User Memory area protected by special User Password
- Memory read protection
- Integrated Product Status Flag (PSF)
- Tag tamper alarm
- Digital switch
- Data transfer mode
- Real Read Range Reduction (Privacy Mode)
- Conditional Real Read Range Reduction
- External supply mode
- Long read/write ranges due to extremely low-power design
- Reliable operation of multiple tags due to advanced anti-collision
- Broad international operating frequency: from 840 MHz to 960 MHz
- Data retention: 20 years
- Wide specified temperature range: -40 °C up to +85 °C

### 2.1.1 Memory

- 256 bit of EPC memory / up to 448 bit in G2iM+
- 96-bit Tag IDentifier (TID) including 48-bit factory locked unique serial number
- 112-bit User TID memory
- 32-bit Kill Password to permanently disable the tag
- 32-bit Access Password to allow a transition into the secured state
- 32-bit User Password to allow access to the private user memory segment
- Read protection
- BlockWrite (32 bit)
- Write Lock
- BlockPermalock

## 2.2 Key benefits

### 2.2.1 End user benefit

- Outstanding User Memory size of 640 bit
- Prevention of unauthorized memory access through different levels of read protection
- Indication of tag tampering attempt by use of the tag tamper alarm feature
- Electronic device configuration and / or activation by the use of the digital switch / data transfer mode
- Theft deterrence supported by the PSF feature (PSF alarm or EPC code)
- Small label sizes, long read ranges due to high chip sensitivity
- Product identification through unalterable TID range, including a 48 bit serial number

- Reliable operation in dense reader and noisy environments through high interference suppression

### 2.2.2 Antenna design benefits

- High sensitivity enables small and cost efficient antenna designs
- Low Q-Value eases broad band antenna design for global usage

### 2.2.3 Label manufacturer benefit

- Consistent performance on different materials due to low Q-factor
- Ease of assembly and high assembly yields through large chip input capacitance and Polyimide spacer
- Fast first WRITE or BLOCKWRITE of the EPC memory for fast label initialization

## 2.3 Custom commands

- PSF Alarm
  Built-in PSF (Product Status Flag), enables the UHF RFID tag to be used as EAS tag (Electronic Article Surveillance) tag without the need for a back-end data base.
- Read Protect
  Protects all memory content from unauthorized reading.
- ChangeConfig
  Configures the additional features of the chip like external supply mode, tamper alarm, digital switch, read range reduction, privacy mode activation condition or data transfer.

The UCODE G2iM+ is equipped with a number of additional features. Nevertheless, the chip is designed in a way standard EPCglobal READ/WRITE/ACCESS commands can be used to operate the features. No custom commands are needed to take advantage of all the features in case of unlocked EPC memory.

# 3 Applications

## 3.1 Markets

- Fashion (apparel and footwear)
- Retail
- Electronics
- Fast moving consumer goods
- Asset management
- Electronic vehicle identification

## 3.2 Applications

- Supply chain management
  - Item level tagging
  - Pallet and case tracking
- Container identification
- Product authentication
- PCB tagging
- Cost efficient, low level seals
- Wireless firmware download
- Wireless product activation

# 4 Ordering information

**Table 1. Ordering information**

| Type number | Package | | | |
|---|---|---|---|---|
| | Name | IC type | Description | Version |
| SL3S1003FUD/BG | Wafer | G2iM | bumped G2iM die on sawn 8" 120 mm wafer, 7 mm Polyimide spacer | not applicable |
| SL3S1013FUD/BG | Wafer | G2iM+ | bumped G2iM+ die on sawn 8" 120 mm wafer, 7 mm Polyimide spacer | not applicable |
| SL3S1013FTB0 | XSON6 | G2iM+ | plastic extremely thin small outline package; no leads; 6 terminals; body 1 × 1.45 × 0.5 mm | SOT886F1 |

# 5 Marking

**Table 2. Marking codes**

| Type number | Marking code | Comment | Version |
|---|---|---|---|
| SL3S1013FTB0 | US | UCODE G2iM+ | SOT886 |

# 6 Block diagram

The SL3S10x3 IC consists of three major blocks:

- Analog Interface
- Digital Control
- EEPROM

The analog part provides stable supply voltage and demodulates data received from the reader for being processed by the digital part. Further, the modulation transistor of the analog part transmits data back to the reader.

The digital section includes the state machines, processes the protocol and handles communication with the EEPROM, which contains the EPC and the user data.

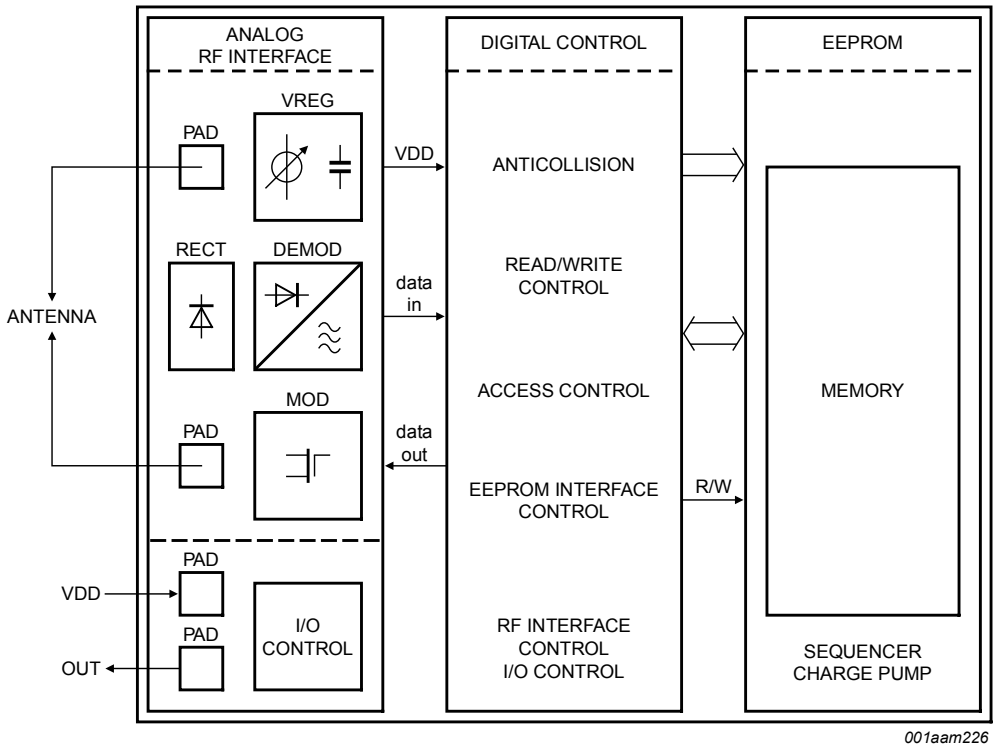



**Figure 1. Block diagram of SL3S10x3 IC**

# 7 Pinning information

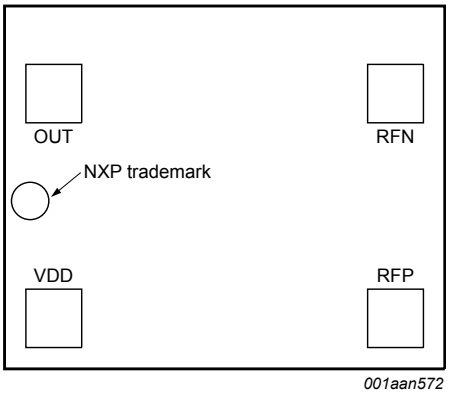



Figure 2. Pinning bare die

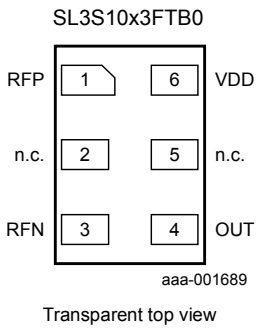



Figure 3. Pin configuration for SOT886

## 7.1 Pin description

Table 3. Pin description bare die

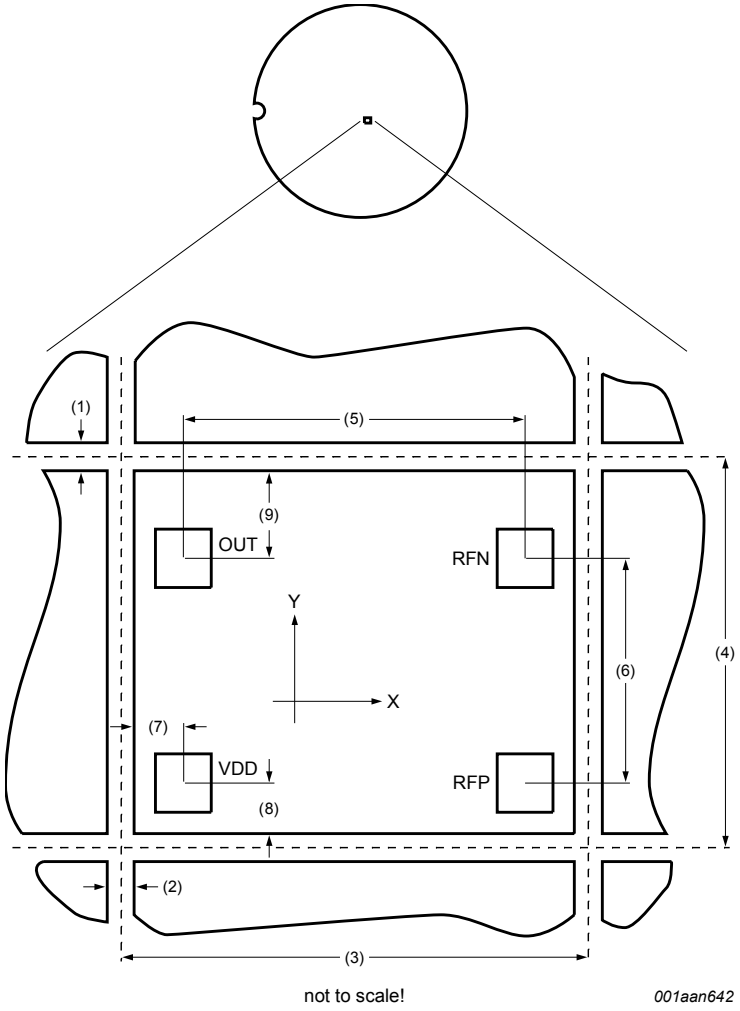
| Symbol | Description |
|---|---|
| OUT | output pin |
| RFN | grounded antenna connector |
| VDD | external supply |
| RFP | ungrounded antenna connector |

Table 4. Pin description SOT886

| Pin | Symbol | Description |
|---|---|---|
| 1 | RFP | ungrounded antenna connector |
| 2 | n.c. | not connected |
| 3 | RFN | grounded antenna connector |
| 4 | OUT | output pin |
| 5 | n.c. | not connected |
| 6 | VDD | external supply |

# 8 Wafer layout

## 8.1 Wafer layout




1. Die to Die distance (metal sealring - metal sealring) 21,4 µm, (X-scribe line width: 15 µm)
2. Die to Die distance (metal sealring - metal sealring) 21,4 µm, (Y-scribe line width: 15 µm)
3. Chip step, x-length: 615 µm
4. Chip step, y-length: 475 µm
5. Bump to bump distance X (OUT - RFN): 513 µm
6. Bump to bump distance Y (RFN - RFP): 333 µm
7. Distance bump to metal sealring X: 43,5 µm (outer edge - top metal)
8. Distance bump to metal sealring (RFP, VDD) Y: 40,3 µm
9. Distance bump to metal sealring (RFN, OUT) Y: 80,3 µm

Bump size X × Y: 60 µm ´ 60 µm

**Remark:** OUT and VDD are used with G2iM+ only

**Figure 4. SL3S10x3 wafer layout**

# 9 Mechanical specification

The SL3S10x3 wafers are offered with 120 mm thickness and 7mm Polyimide spacer. This robust structure with the enhanced Polyimide spacer supports easy assembly due to low assembly variations.

## 9.1 Wafer specification

See [2].

### 9.1.1 Wafer

**Table 5. Specifications**

| | |
|---|---|
| Wafer | |
| Designation | each wafer is scribed with batch number and wafer number |
| Diameter | 200 mm (8") |
| Thickness | 120 µm ±15 µm |
| Number of pads | 4 |
| Pad location | non diagonal/ placed in chip corners |
| Distance pad to pad RFN-RFP | 333.0 µm |
| Distance pad to pad OUT-RFN | 513.0 µm |
| Process | CMOS 0.14 µm |
| Batch size | 25 wafers |
| Potential good dies per wafer | 100544 |
| Wafer backside | |
| Material | Si |
| Treatment | ground and stress release |
| Roughness | $R_a$ max. 0.5 µm, $R_t$ max. 5 µm |
| Chip dimensions | |
| Die size including scribe | 0.615 mm × 0.475 mm = 0.292 $mm^2$ |
| Scribe line width: | x-dimension = 15 µm |
| | y-dimension = 15 µm |
| Passivation on front | |
| Type | Sandwich structure |
| Material | PE-Nitride (on top) |
| Thickness | 1.75 µm total thickness of passivation |
| Polyimide spacer | 7 µm |
| Au bump | |
| Bump material | > 99.9% pure Au |
| Bump hardness | 35 – 80 HV 0.005 |
| Bump shear strength | > 70 MPa |
| Bump height | 25 µm[1] |
| Bump height uniformity | |
| – within a die | ± 2 µm |
| – within a wafer | ± 3 µm |
| – wafer to wafer | ± 4 µm |
| Bump flatness | ± 1.5 µm |
| Bump size | |

| | |
|---|---|
| – RFP, RFN | 60 × 60 µm |
| – OUT, VDD | 60 × 60 µm |
| Bump size variation | ± 5 µm |

[1] Because of the 7 µm spacer, the bump will measure 18 µm relative height protruding the spacer.

### 9.1.2 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 [2]

### 9.1.3 Map file distribution

See [2]

# 10 Functional description

## 10.1 Air interface standards

The UCODE G2iM fully supports all parts of the "Specification for RFID Air Interface EPCglobal, EPCTM Radio-Frequency Identity Protocols, Class-1 Generation-2 UHF RFID, Protocol for Communications at 860 MHz to 960 MHz, Version 1.2.0".

## 10.2 Power transfer

The interrogator provides an RF field that powers the tag, equipped with a UCODE G2iM. The antenna transforms the impedance of free space to the chip input impedance in order to get the maximum possible power for the UCODE G2iM on the tag. The UCODE G2iM+ can also be supplied externally.

The RF field, which is oscillating on the operating frequency provided by the interrogator, is rectified to provide a smoothed DC voltage to the analog and digital modules of the IC.

The antenna attached to the chip may use a DC connection between the two antenna pads which also enables loop antenna design.

## 10.3 Data transfer

### 10.3.1 Reader to tag Link

An interrogator transmits information to the UCODE G2iM by modulating an UHF RF signal. The UCODE G2iM receives both information and operating energy from this RF signal. Tags are passive, meaning that they receive all of their operating energy from the interrogator's RF waveform. In order to further improve the read range the UCODE G2iM can be externally supplied as well so the energy to operate the chip does not need to be transmitted by the reader.

An interrogator is using a fixed modulation and data rate for the duration of at least one inventory round. It communicates to the UCODE G2iM by modulating an RF carrier using DSB-ASK with PIE encoding.

For further details refer to [1]. Interrogator-to-tag (R=>T) communications.

### 10.3.2 Tag to reader Link

An interrogator receives information from a UCODE G2iM by transmitting an unmodulated RF carrier and listening for a backscattered reply. The UCODE G2iM backscatters by switching the reflection coefficient of its antenna between two states in accordance with the data being sent. For further details refer to [1], chapter 6.3.1.3.

The UCODE G2iM communicates information by backscatter-modulating the amplitude and/or phase of the RF carrier. Interrogators shall be capable of demodulating either demodulation type.

The encoding format, selected in response to interrogator commands, is either FM0 baseband or Miller-modulated subcarrier.

## 10.4 UCODE G2iM and UCODE G2iM+ differences

The UCODE G2iM is tailored for application where EPC or TID number space, and User Memory is needed. The UCODE G2iM+ provides beside the segmented memory additional functionality such as tag tamper alarm, external supply operation to further boost read/write range (external supply mode), a privacy mode reducing the read range where the activation criteria (open or short) can be defined or I/O functionality (data transfer to externally connected devices) where required.

The following table provides an overview of UCODE G2iM, UCODE G2iM+ special features.

**Table 6. Overview of UCODE G2iM and UCODE G2iM+ features**

| Features | UCODE G2iM | UCODE G2iM+ |
|---|---|---|
| Read protection (bankwise) | yes | yes |
| PSF (Built-in Product Status Flag) | yes | yes |
| Backscatter strength reduction | yes | yes |
| BlockWrite (32 bit) | yes | yes |
| BlockPermalock | yes | yes |
| User TID (112 bit) | yes | yes |
| Segmented user memory (open, protected, private) | - | yes |
| Additional User Password for private memory | - | yes |
| EPC size selectable (448bit max.) | - | yes |
| Tag tamper alarm | - | yes |
| Digital switch / Digital input | - | yes |
| External supply mode | - | yes |
| Data transfer | - | yes |
| Real read range reduction | - | yes |
| Conditional Real Read Range Reduction | - | yes |

## 10.5 Supported commands

The UCODE G2iM supports all **mandatory** EPCglobal V1.2.0 commands.

In addition the UCODE G2iM supports the following **optional** commands:

- ACCESS
- BlockWrite (32 bit)
- BlockPermalock

The UCODE G2iM features the following **custom** commands described more in detail later:

- ResetReadProtect (backward compatible to UCODE G2X; UCODE G2iL)
- ReadProtect (backward compatible to UCODE G2X; UCODE G2iL)
- ChangeEAS (backward compatible to UCODE G2X; UCODE G2iL)
- EAS_Alarm (backward compatible to UCODE G2X; UCODE G2iL)
- ChangeConfig (backward compatible to UCODE G2iL)

## 10.6 UCODE G2iM and UCODE G2iM+ memory

The UCODE G2iM and UCODE G2iM+ memory is implemented according EPCglobal Class1Gen2 and organized in four banks:

**Table 7. UCODE G2iM and UCODE G2iM+ memory sections**

| Name | Size | Bank |
|---|---|---|
| Reserved memory (32 bit ACCESS and 32 bit KILL password) | 64 bit | 00b |
| EPC (excluding 16 bit CRC-16 and 16 bit PC) (UCODE G2iM)<br>EPC (excluding 16 bit CRC-16 and 16 bit PC) (UCODE G2iM+) | 256 bit<br>128 bit<br>up to<br>448 bit | 01b |
| G2iM Configuration Word (Config-Word) | 16 bit | 01b |
| G2iM Memory Configuration Word (Mem-Config-Word) | 16 bit | 01b |
| TID (including permalocked unique 48 bit serial number; 16bit unalterable XTID-header) | 96 bit | 10b |
| User TID | 112 bit | 10b |
| User memory (UCODE G2iM)<br>User memory can be segmented and configured (UCODE G2iM+) | 512 bit<br>320 bit<br>up to<br>640 bit | 11b |

The logical address of all memory banks begin at zero (00h).

In addition to the four memory banks two configuration words are available. The first to handle the UCODE G2iM memory configuration (Mem-Config-Word) is available at EPC bank 01 address 1F0h and the second to handle UCODE G2iM specific features Config-Word) is available at EPC bank 01 address 200h. The configuration words are described in detail in Section 10.7.1 and Section 10.7.3.

Memory pages (16 bit words) pre-programmed to zero will not execute an erase cycle before writing data to it. This approach accelerates initialization of the chip and enables faster programming of the memory.

### 10.6.1 UCODE G2iM and UCODE G2iM+ overall memory map

**Table 8. UCODE G2iM and UCODE G2iM+ overall memory map**

| Bank address | Memory address | Type | Content | Initial | Remark |
|---|---|---|---|---|---|
| Bank 00 | 00h to 1Fh | reserved | Kill Password | all 00h | unlocked memory |
| | 20h to 3Fh | reserved | Access Password | all 00h | unlocked memory |
| Bank 01<br>EPC | 00h to 0Fh | EPC | CRC-16: refer to [1] | | memory mapped calculated CRC |
| | 10h to 14h | EPC | backscatter length | 00110b | unlocked memory |
| | 15h | EPC | UMI | 0b | calculated according EPC |
| | 16h | EPC | reserved for future use | 0b | hardwired to 0 |
| | 17h to 1Fh | EPC | numbering system indicator | 00h | unlocked memory |
| | 20h to 9Fh | EPC | EPC | [1] | unlocked memory |

| Bank address | Memory address | Type | Content | Initial | Remark |
|---|---|---|---|---|---|
| Bank 01 Memory Config Word | 1F0h to 1F3h | EPC | RFU | 0000b | hardwired to 0000b |
| | 1F4h to 1F7h | EPC | Number of EPC blocks | 0h | unlocked memory |
| | 1F8h to 1FBh | EPC | Number protected memory blocks | 0h | unlocked memory |
| | 1FCh to 1FFh | EPC | Number of private memory blocks | 0h | unlocked memory |
| Bank 01 Config Word | 200h | EPC | tamper alarm flag | 0b[2] | indicator bit |
| | 201h | EPC | external supply flag or input signal | 0b[2] | indicator bit |
| | 202h | EPC | RFU | 0b[2] | locked memory |
| | 203h | EPC | RFU | 0b[2] | locked memory |
| | 204h | EPC | invert digital output: | 0b[2] | temporary bit |
| | 205h | EPC | transparent mode on/off | 0b[2] | temporary bit |
| | 206h | EPC | transparent mode data/raw | 0b[2] | temporary bit |
| | 207h | EPC | conditional read range reduction | 0b[2] | unlocked memory |
| | 208h | EPC | conditional read range reduction<br>open/short | 0b[2] | unlocked memory |
| | 209h | EPC | max. backscatter strength | 1b[2] | unlocked memory |
| | 20Ah | EPC | digital output | 0b[2] | unlocked memory |
| | 20Bh | EPC | read range reduction on/off | 0b[2] | unlocked memory |
| | 20Ch | EPC | read protect User Memory | 0b[2] | locked memory |
| | 20Dh | EPC | read protect EPC Bank | 0b[2] | unlocked memory |
| | 20Eh | EPC | read protect TID | 0b[2] | unlocked memory |
| | 20Fh | EPC | PSF alarm flag | 0b[2] | unlocked memory |
| Bank 10 TID | 00h to 07h | TID | allocation class identifier | 1110 0010b | locked memory |
| | 08h to 13h | TID | tag mask designer identifier | 0000 0000 0110b | locked memory |
| | 14h | TIG | config word indicator | 1b[3] | locked memory |
| | 14h to 1Fh | TID | tag model number | TMNR[4] | locked memory |
| | 20h to 2Fh | TID | XTID Header | 00h | locked memory |
| | 30h to 5Fh | TID | serial number | SNR | locked memory |
| | 60h to CFh | TID | User TID memory | all '0' | unlocked memory |
| Bank 11 USER | 000h to 27Fh | USER | User Memory | undefined | unlocked memory |

[1] UCODE G2iM: HEX E200 680A 0000 0000 0000 0000 (0000 0000)
UCODE G2iM+: HEX E200 680B 0000 0000 0000 0000 (0000 0000)
[2] See also Table 13 for further details.
[3] Indicates the existence of a Configuration Word at the end of the EPC number
[4] See Figure 5

### 10.6.2 UCODE G2iM and UCODE G2iM+ TID memory details

**Table 9. G2iM TID description**

| | | | | Model number | | |
|---|---|---|---|---|---|---|
| **Type** | **First 32 bit of TID memory** | **Class ID** | **Mask designer ID** | **Config Word indicator** | **Sub version number** | **Version (Silicon) number** |
| UCODE G2iM | E200680A | E2h | 006h | 1 | 0000b | 0001010 |
| UCODE G2iM+ | E200680B | E2h | 006h | 1 | 0000b | 0001011 |

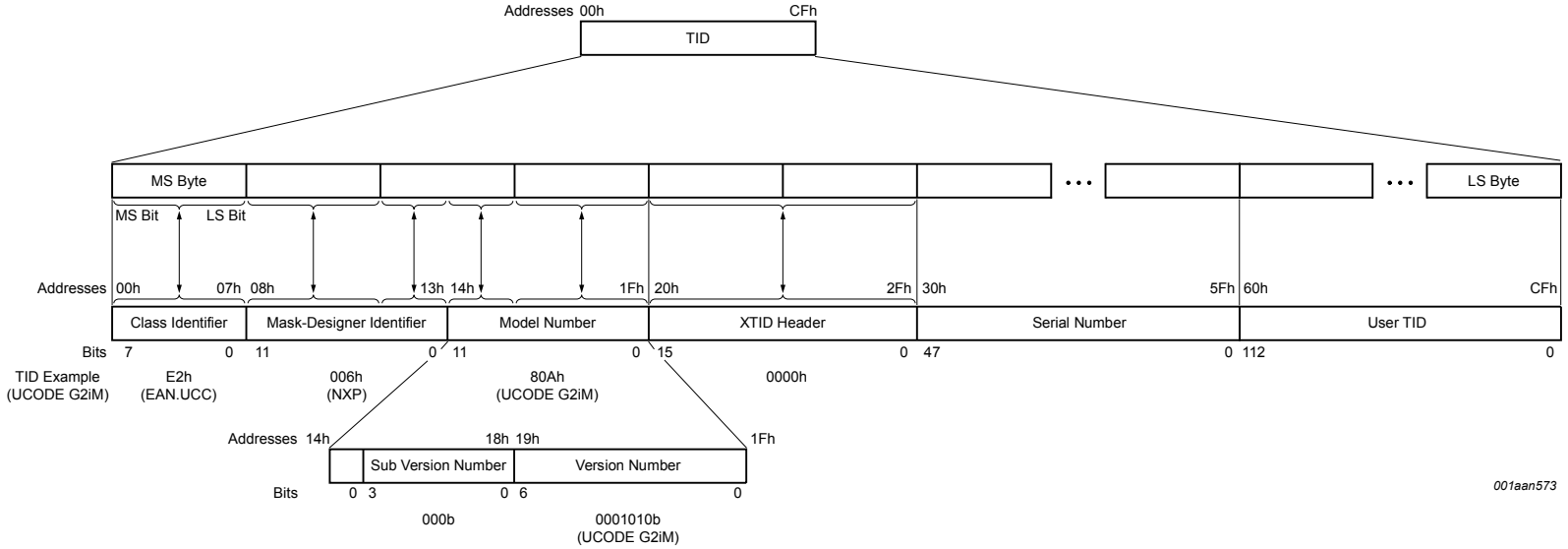



**Figure 5. G2iM TID memory structure**

## 10.7 Custom commands

The UCODE G2iM and UCODE G2iM+ supports a number of additional features and custom commands. Nevertheless, the chip is designed in a way standard EPCglobal READ/WRITE/ACCESS commands can be used to operate the features.

The memory map stated in the previous section describes the Config-Word used to control the additional features located at address 200h as well as the Mem-Config-Word located at 1F0h of the EPC memory. For this reason the standard READ/WRITE commands of an UHF EPCglobal compliant reader can be used to select the flags, activate/deactivate features or define memory segments.

The features can only be activated/deactivated (written) using standard EPC WRITE command as long the EPC is not locked. In case the EPC is locked either the bank needs to be unlocked to apply changes or the ChangeConfig custom command is used to change the settings.

The UCODE G2iM products supports the complete UCODE G2iL command set for backward compatibility reasons.

Bit 14h of the TID indicates the existence of a Configuration Word. This flag will enable selecting Config-Word enhanced transponders in mixed tag populations.

### 10.7.1 ChangeConfig

Although UCODE G2iM is tailored for supply chain management, item level tagging and product authentication the UCODE G2iM+ version enables active interaction with products. Among the password protected features are the capability of download firmware to electronics, activate/deactivate electronics which can also be used as theft deterrence, a dedicated privacy mode by reducing the read range, integrated PSF (Product Status Flag) or Tag Tamper Alarm. In addition to the UCODE G2iL/G2iL+ the activation condition (open/short) for the Read Range Reduction can be defined by the user.

The UCODE G2iM ChangeConfig custom command allows handling the special NXP Semiconductors features described in the following paragraph. Please also see the memory map in Section 10.6 and "Section 10.7.2. If the EPC memory is not write locked the standard EPC READ/WRITE command can be used to change the settings.

#### UCODE G2iM and UCODE G2iM+ special features[4]

UCODE G2iM and UCODE G2iM+ common special features are:

- **Bank wise read protection** (separate for EPC, TID and User Memory)
  EPC bank (except of configuration words), the serial number part of the TID as well as the User TID and the User Memory (open segment) can be read protected independently. When protected reading of the particular memory will return '0'. The flags of the Config-Word can be selected using the standard SELECT command. Only read protected parts will then participate an inventory round.
- **Integrated PSF (Product Status Flag)**
  The PSF is a general purpose flag that can be used as an EAS (Electronic Article Surveillance) flag, quality checked flag or similar.

4 The features can only be manipulated (enabled/disabled) with unlocked EPC bank, otherwise the ChangeConfig command can be used.

The UCODE G2iM offers two ways of detecting an activated PSF. In cases extremely fast detection is needed the EAS_Alarm command can be used. The UCODE G2iM will reply a 64 bit alarm code like described in section EAS_Alarm upon sending the command. As a second option the EPC SELECT command selecting the PSF flag of the Config-Word can be used. In the following inventory round only PSF enabled chips will reply their EPC number.

- **Backscatter strength reduction**
  The UCODE G2iM features two levels of backscatter strengths. Per default maximum backscatter is enabled in order to enable maximum read rates. When clearing the flag the strength can be reduced if needed.

UCODE G2iM+ specific special features are:[1]

- **Real Read Range Reduction 4R (UCODE G2iM+ only)**
  Some applications require the reduction of the read range to close proximity for privacy reasons. Setting the 4R flag will significantly reduce the chip sensitivity to +12 dBm. The +12 dBm have to be available at chip start up (slow increase of field strength is not applicable). For additional privacy, the read protection can be activated in the same configuration step. The related flag of the configuration word can be selected using the standard SELECT command so only chips with reduced read range will be part of an inventory.
  **Remark:** The attenuation will result in only a few centimeter of read range at 36 dBm EIRP!
- **Tag Tamper Alarm (UCODE G2iM+ only)**
  The UCODE G2iM+ Tamper Alarm will flag the status of the VDD to OUT pad connection which can be designed as an predetermined breaking point (see Figure 6).

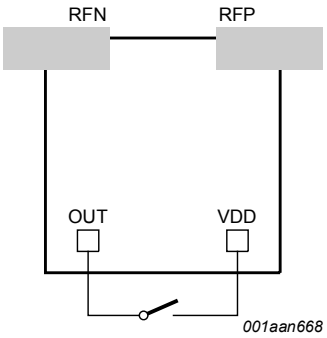



**Figure 6. Schematic of connecting VDD and OUT pad with a predetermined breaking point to turn a standard RFID label into a wireless safety seal**

The status of the pad connection (open/closed) can be read in the configuration register and/or selected using the EPC SELECT. This feature enables the design of a wireless RFID safety seal. When breaking the connection by peeling off the label or manipulating a lock an alarm can be triggered.

- **Conditional Real Read Range Reduction (UCODE G2iM+ only)**
  In addition to the 4R and the Tag Tamper Alarm feature the UCODE G2iM+ offers a feature which combines both in one functionality. This feature allow the automatic activation of the 4R depending on the status of the VDD to OUT pad connection. To offer high flexibility for the applications the 4R activation can be done on short (bit 8 = ’1’) or open (bit 8 =’0’) of the VDD to OUT pad connection. For activation of this feature bit 7 and bit 11 of the Config-Word have to be set to ’1’.
- **Digital Switch** (UCODE G2iM+ only)

By connecting a supply voltage between RFN and VDD the OUT pin of the UCODE G2iM+ can be used as digital switch. Depending on the ‘Digital Output’ bit of the Config-Word register the state of the OUT pin can be switched to VDD or GND.
The state of the OUT pin is persistent in the memory even after KILL or switching off the supply. In absence of external Vsupply, one cannot detect the difference in Ohmic resistance between OUT and VDD, regardless of whether ‘Digital Output’ bit is 0 or 1.
The state of the OUT pin can also be changed temporary by toggling the 'Invert Digital Output' bit.
This feature will allow activating/deactivating externally connected peripherals or can be used as theft deterrence of electronics.

- **Data transfer Mode (UCODE G2iM+ only)**
  In applications where not switching the output like described in "Digital Switch" but external device communication is needed the UCODE G2iM+ Data Transfer Mode can be used by setting the according bit of the Config-Word register. When activated the air interface communication will be directly transferred to the OUT pad of the chip.
  Two modes of data transfer are available and can be switched using the Transparent Mode DATA/RAW bit.
  The default Transparent Mode DATA will remove the Frame Sync of the communication and toggle the output with every raising edge in the RF field. This will allow implementing a Manchester type of data transmission.
  The Transparent Mode RAW will switch the demodulated air interface communication to the OUT pad.
- **External Supply Indicator - Digital Input (UCODE G2iM+ only)**
  The VDD pad of the UCODE G2iM+ can be used as a digital input pin. The state of the pad is directly associated with the External Supply Indicator bit of the configuration register. A simple return signaling (chip to reader) can be implemented by polling this Configuration Word register flag. RF reset is necessary for proper polling.
- **External Supply Mode (G2iM+ only)**
  The UCODE G2iM+ can be supplied externally by connecting 1.85 V (Iout = 0 µA) supply. When externally supplied less energy from the RF field is needed to operate the chip. This will not just enable further improved sensitivity and read ranges (up to -27 dBm) but also enable a write range that is equal to the read range.
  The figure schematically shows the supply connected to the UCODE G2iM+.

**Remark:** When permanently externally supplied there will not be a power-on-reset. This will result in the following limitations:

- When externally supplied session flag S0 will keep it’s state during RF-OFF phase.
- When externally supplied session flag S2, S3, SL will have infinite persistence time and will behave similar to S0.
- Session flag S1 will behave regular like in pure passive operation.

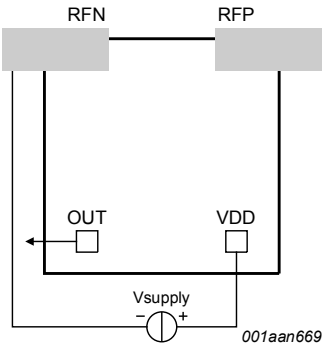



**Figure 7. Schematic of external power supply**

**Table 10. ChangeConfig custom command**

| | Command | RFU | Data | RN | CRC-16 |
|---|---|---|---|---|---|
| No. of bits | 16 | 8 | 16 | 16 | 16 |
| Description | 11100000 00000111 | 00000000 | Toggle bits XOR RN 16 | handle | - |

The bits to be toggled in the configuration register need to be set to '1'.

E.g. sending 0000 0000 0001 0001 XOR RN16 will activate the 4R and PSF. Sending the very same command a second time will disable the features again.

The reply of the ChangeConfig will return the current register setting.

**Table 11. ChangeConfig custom command reply**

| | Header | Status bits | RN | CRC-16 |
|---|---|---|---|---|
| No. of bits | 1 | 16 | 16 | 16 |
| Description | 0 | Config-Word | Handle | - |

**Table 12. ChangeConfig command-response table**

| Starting state | Condition | Response | Next state |
|---|---|---|---|
| ready | all | - | ready |
| arbitrate, reply, acknowledged | all | - | arbitrate |
| open | valid handle Status word needs to change | Backscatter unchanged Config-Word immediately | open |
| | valid handle Status word does not need to change | Backscatter Config-Word immediately | open |
| secured | valid handle Status word needs to change | Backscatter modified Config-Word, when done | secured |
| | valid handle Status word does not need to change | Backscatter Config-Word immediately | secured |
| killed | all | - | killed |

The features can only be activated/deactivated using standard EPC WRITE if the EPC bank is unlocked. The permanent and temporary bits of the Configuration Word can be toggled without the need for an Access Password in case the Access Password is set to zero. In case the EPC bank is locked the lock needs to be removed before applying changes or the ChangeConfig command has to be used.

### 10.7.2 UCODE G2iM and UCODE G2iM+ special features control mechanism

Special features of the UCODE G2iM are managed using a configuration word (Config-Word) located at address 200h in the EPC memory bank.

The entire Config-Word is selectable (using the standard EPC SELECT command), as well as single bits, and can be read using standard EPC READ command and modified using the standard EPC WRITE or ChangeConfig custom command in case the EPC memory is locked for writing.

ChangeConfig can be executed from the OPEN and SECURED state.

The chip will take all "Toggle Bits" for ’0’ if the chip is in the OPEN state or the ACCESS password is zero; therefore it will not alter any status bits, but report the current status only. The command will be ignored with an invalid CRC-16 or an invalid handle. The chip will then remain in the current state. The CRC-16 is calculated from the first command-code bit to the last handle bit.

A ChangeConfig command without frame-sync and proceeding Req_RN will be ignored. The command will also be ignored if any of the RFU bits are toggled.

In order to change the configuration, to activate/deactivate a feature a ’1’ has to be written to the corresponding register flag to toggle the status. E.g. sending 0x0002 to the register will activate the read protection of the TID. Sending the same command a second time will again clear the read protection of the TID. Invalid toggling on indicator or RFU bits are ignored.

Executing the command with zero as payload or in the OPEN state will return the current register settings. The chip will reply to a successful ChangeStatus with an extended preamble regardless of the TRext value of the Query command.

After sending a ChangeConfig an interrogator shall transmit CW for less than TReply or 20ms, where TReply is the time between the interrogator's ChangeConfig command and the chip’s backscattered reply. An interrogator may observe three possible responses after sending a ChangeConfig, depending on the success or failure of the operation

- ChangeConfig succeeded: The chip will backscatter the reply shown above comprising a header (a 0-bit), the current Config-Word setting, the handle, and a CRC-16 calculated over the 0-bit, the Config-Word and the handle. If the interrogator observes this reply within 20 ms then the ChangeConfig completed successfully.
- The chip encounters an error: The chip will backscatter an error code during the CW period rather than the reply shown below (see EPCglobal Spec for error-code definitions and for the reply format).
- ChangeConfig does not succeed: If the interrogator does not observe a reply within 20 ms then the ChangeConfig did not complete successfully. The interrogator may issue a Req_RN command (containing the handle) to verify that the chip is still in the interrogator's field, and may reissue the ChangeConfig command.

The UCODE G2iM configuration word (Config-Word) is located at address 200h of the EPC memory and is structured as following:

**Table 13. Address 200h to 207h**

| Indicator bits | | | | Temporary bits | | | Permanent bits |
|---|---|---|---|---|---|---|---|
| Tamper indicator | External supply indicator | RFU | RFU | Invert Output | Transparent mode on/off | Data mode data/raw | Conditional Read Range Reduction on/off |
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |

**Table 14. Address 208h to 20Fh**

| Permanent bits | | | | | | | |
|---|---|---|---|---|---|---|---|
| Conditional Read Range Reduction open/short | max. backscatter strength | Digital output | Read Range Reduction | Protect UM | Protect EPC | Protect TID | PSF Alarm bit |
| 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |

The configuration word contains three different type of bits:

- **Indicator bits** cannot be changed by command:
  Tag Tamper Alarm Indicator
  External Supply Indicator (digital input)
- **Temporary bits** are reset at power up:
  Invert Output
  Transparent Mode on/off
  Data Mode data/raw
- **Permanent bits**: permanently stored bits in the memory
  Conditional Read Range Reduction on/off
  Conditional Read Range Reduction short/open
  Max. Backscatter Strength
  Digital Output
  Read Range Reduction
  Read Protect User Memory
  Read Protect EPC
  Read Protect TID
  PSF Alarm

### 10.7.3 UCODE G2iM+ memory configuration control mechanism

The segmented user memory available in the UCODE G2iM+ enables a flexible configuration of the device with respect to EPC size and access rights to the User Memory.

The standard configuration offers 256 bit EPC memory and 512 bit open User Memory for UCODE G2iM and 128 bit EPC memory and 640 bit open User Memory for UCODE G2iM+. For applications where more EPC memory is required the UCODE G2iM+ offers the flexibility to extend the 128 bit EPC up to 448 bit (in steps of 64 bit) by reducing the User Memory size accordingly. See Table 15 and Table 17.

**Table 15. EPC / User Memory Standard Configuration (UCODE G2iM)**

| EPC Memory | User Memory |
|---|---|
| | Open |
| 256 bit | 512 bit |

**Table 16. EPC / User Memory Standard Configuration (UCODE G2iM+)**

| EPC Memory | User Memory |
|---|---|
| | Open |
| 128 bit | 640 bit |

**Table 17. EPC / User Memory Max. EPC Configuration (UCODE G2iM+)**

| EPC Memory | User Memory |
|---|---|
| | Open |
| 448 bit | 320 bit |

Beside the possibility to extend the EPC memory the UCDOE G2iM+ offers the possibility to segment the User Memory in up to three areas with different access rights.

- Open: no read/write protection
- Protected: read/write protected by the Access Password
- Private: read/write protected by the User Password (see Section 10.7.4)

The memory configuration can be defined one time, by programming the memory configuration word, at the initialization of the UCODE G2iM+. The UCODE G2iM+ Memory Configuration Word (Mem-Config-Word) is located at address 1F0h of the EPC memory and is structured as following:

**Table 18. Memory Configuration Word, Address 1F0h to 1FFh**

| RFU | | | | Number of EPC blocks | | | | Number of Protected memory blocks | | | | Number of Private memory blocks | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |

- **RFU-Bits**:
  The four RFU bits are fixed to 0000b. These four bits are ignored for access commands (e.g. WRITE).
- **Number of EPC blocks**:
  The 4 bit of this region specify the number of blocks (max. 5) which should be added on top of the standard EPC Memory of 128bit.
- **Number of Protected memory blocks**:
  The 4 bit of this region specify the number of blocks which should be used for the Protected memory region.
- **Number of Private memory blocks**:
  The 4 bit of this region specify the number of blocks which should be used for the Private memory region.

The total amount of User Memory is defined by the number of blocks for EPC-, Open-, Protected- and Private- memory area. Based on the total User Memory size (640 bit)

and the defined block size of 64 bit, the overall number of blocks results in ten blocks. As described in the examples (Table 19 to Table 21) below the blocks used for the EPC-, Open-, Protected- or Private segment can be exchanged according to the application requirements as long as the overall block number is below ten.

The number of blocks allocated to the Open Memory Area are defined by the number of blocks specified in the Mem-Config-Word, therefore the size of the Open Memory area is derived by subtracting the number of defined blocks (Mem-Config-Word) from the total available number of blocks of the User Memory (10 blocks). Undefined blocks are always added to the Open Memory area.

In case an invalid total amount of blocks (exceeds ten) is written to the Mem-Config-Word, the configuration fails and the error code (Locked Memory) will be returned.

The entire Mem-Config-Word is selectable (using the standard EPC SELECT command), as well as single bits, and can be read using standard EPC READ command and modified using the standard EPC WRITE command.

NOTE:

THE MEM-CONFIG-WORD IS ONE TIME PROGRAMMABLE.

Programming has be performed in the secured state.

In case no programming of the memory configuration word is done at the initialization of the UCODE G2iM+ it will be automatically locked upon a lock of any part of the memory.

The following tables will provide a few examples for different memory configurations.

- Standard EPC size, 4 blocks Protected and 3 blocks Private memory which results in 3 blocks Open memory.
  (Mem-Config-Word value: 0043h)
  See Table 19

**Table 19. User Memory Configuration with 3 segments**

| EPC Memory | User Memory | | |
|---|---|---|---|
| | Open | Protected | Private |
| 128 bit | 192 bit | 256 bit | 192 bit |

- Standard EPC size, 3 blocks Protected memory which results in 7 blocks Open memory. (Mem-Config-Word value: 0030h).
  See Table 20

**Table 20. User Memory Configuration with 2 segments (no Private segment)**

| EPC Memory | User Memory | |
|---|---|---|
| | Open | Protected |
| 128 bit | 448 bit | 192 bit |

- 192 bit EPC (1 block EPC added), 6 blocks Private memory which results in 4 blocks Open memory. (Mem-Config-Word value: 0106h)
  See Table 21

Table 21. User Memory Configuration with 2 areas (no Access password protected area)

| EPC Memory | User Memory | |
|---|---|---|
| | Open | Private |
| 192 bit | 192 bit | 384 bit |

### 10.7.4 Private Memory Segment

The Private memory is a part of the User Memory which can be accessed out of the secured state only. Private regions will appear as non existent to not authorized users.

The address of the location of the User Password is not fixed and has therefore to be calculated based on the applied memory configuration.

The 32 bit User Password is located at the end of the User Memory. Since the UCODE G2iM+ memory is configurable and can be segmented the address location of the User Password depends on the Memory configuration done at the initialization.

User Password address calculation:

HEX[(Total number of memory blocks - blocks appointed to EPC)*Blocksize)]

Example:

EPC length: 192

This means that 1 block from the User Memory is required (128 bit + 64 bit)

HEX[(10-1)*64]=HEX[9*64]=HEX[384]=240h

Therefore the User Password for this configuration is located at address 240h to 25Fh

### 10.7.5 ReadProtect [5]

The UCODE G2iM ReadProtect custom command enables reliable read protection of the entire UCODE G2iM memory. Executing ReadProtect from the Secured state will set the ProtectEPC and ProtectTID bits of the Configuration Word to '1'. With the ReadProtect-Bit set the UCODE G2iM will continue to work unaffected but veil its protected content.

The read protection can be removed by executing Reset ReadProtect. The ReadProtect-Bits will than be cleared.

Devices whose access password is zero will ignore the command. A frame-sync must be pre-pended the command.

After sending the ReadProtect command an interrogator shall transmit CW for the lesser of $T_{Reply}$ or 20 ms, where $T_{Reply}$ is the time between the interrogator's ReadProtect command and the backscattered reply. An interrogator may observe three possible responses after sending a ReadProtect, depending on the success or failure of the operation:

- ReadProtect succeeds: After completing the ReadProtect the UCODE G2iM shall backscatter the reply shown in Table 23 comprising a header (a 0-bit), the tag's handle, and a CRC-16 calculated over the 0-bit and handle. Immediately after this reply the UCODE G2iM will render itself to this ReadProtect mode. If the interrogator observes this reply within 20 ms then the ReadProtect completed successfully.

5 Note: The ChangeConfig command can be used instead of "ReadProtect", "ResetReadProtect", "ChangeEAS".

- The UCODE G2iM encounters an error: The UCODE G2iM will backscatter an error code during the CW period rather than the reply shown in the EPCglobal Spec (see Annex I for error-code definitions and for the reply format).
- ReadProtect does not succeed: If the interrogator does not observe a reply within 20 ms then the ReadProtect did not complete successfully. The interrogator may issue a Req_RN command (containing the handle) to verify that the UCODE G2iM is still in the interrogation zone, and may re-initiate the ReadProtect command.

The UCODE G2iM reply to the ReadProtect command will use the extended preamble shown in EPCglobal Spec (Figure 6.11 or Figure 6.15), as appropriate (i.e. a Tag shall reply as if TRext=1) regardless of the TRext value in the Query that initiated the round.

**Table 22. ReadProtect command**

| | Command | RN | CRC-16 |
|---|---|---|---|
| # of bits | 16 | 16 | 16 |
| description | 11100000 00000001 | handle | - |

**Table 23. UCODE G2iM reply to a successful ReadProtect procedure**

| | Header | RN | CRC-16 |
|---|---|---|---|
| # of bits | 1 | 16 | 16 |
| description | 0 | handle | - |

**Table 24. ReadProtect command-response table**

| Starting State | Condition | Response | Next State |
|---|---|---|---|
| ready | all | – | ready |
| arbitrate, reply, acknowledged | all | – | arbitrate |
| open | all | - | open |
| secured | valid handle & invalid access password | – | arbitrate |
| | valid handle & valid non zero access password | Backscatter handle, when done | secured |
| | invalid handle | – | secured |
| killed | all | – | killed |

### 10.7.6 Reset ReadProtect [6]

Reset ReadProtect allows an interrogator to clear the ProtectEPC and ProtectTID bits of the Configuration Word. This will re-enable reading of the related UCODE G2iM memory content.

For details on the command response please refer to Table 25.

6 Note: The ChangeConfig command can be used instead of "ReadProtect", "ResetReadProtect", "ChangeEAS".

After sending a Reset ReadProtect an interrogator shall transmit CW for the lesser of TReply or 20 ms, where TReply is the time between the interrogator's Reset ReadProtect command and the UCODE G2iM backscattered reply. A Req_RN command prior to the Reset ReadProtect is necessary to successfully execute the command. A frame-sync must be pre-pended the command.

An interrogator may observe three possible responses after sending a Reset ReadProtect, depending on the success or failure of the operation:

- Reset ReadProtect succeeds: After completing the Reset ReadProtect a UCODE G2iM will backscatter the reply shown in Table 26 comprising a header (a 0-bit), the handle, and a CRC-16 calculated over the 0-bit and handle. If the interrogator observes this reply within 20 ms then the Reset ReadProtect completed successfully.
- The UCODE G2iM encounters an error: The UCODE G2iM will backscatter an error code during the CW period rather than the reply shown in Table 26 (see EPCglobal Spec for error-code definitions and for the reply format).
- Reset ReadProtect does not succeed: If the interrogator does not observe a reply within 20 ms then the Reset ReadProtect did not complete successfully. The interrogator may issue a Req_RN command (containing the handle) to verify that the G2iM is still in the interrogation zone, and may reissue the Reset ReadProtect command.

The UCODE G2iM reply to the Reset ReadProtect command will use the extended preamble shown in EPCglobal Spec (Figure 6.11 or Figure 6.15), as appropriate (i.e. a UCODE G2iM will reply as if TRext=1 regardless of the TRext value in the Query that initiated the round.

The Reset ReadProtect command is structured as following:

- 16 bit command
- Password: 32 bit Access-Password XOR with 2 times current RN16
  **Remark:** To generate the 32 bit password the 16 bit RN16 is duplicated and used two times to generate the 32 bit (e.g. a RN16 of 1234 will result in 1234 1234).
- 16 bit handle
- CRC-16 calculate over the first command-code bit to the last handle bit

**Table 25. Reset ReadProtect command**

| | Command | Password | RN | CRC-16 |
|---|---|---|---|---|
| # of bits | 16 | 32 | 16 | 16 |
| description | 11100000 00000010 | (access password) ⊗ 2*RN16 | handle | - |

**Table 26. UCODE G2iM reply to a successful Reset ReadProtect command**

| | Header | RN | CRC-16 |
|---|---|---|---|
| # of bits | 1 | 16 | 16 |
| description | 0 | handle | - |

**Table 27. Reset ReadProtect command-response table**

| Starting State | Condition | Response | Next State |
|---|---|---|---|
| ready | all | – | ready |
| arbitrate, reply, acknowledged | all | – | arbitrate |
| open | valid handle & valid access password | Backscatter handle, when done | open |
| | valid handle & invalid access password | – | arbitrate |
| | invalid handle | – | open |
| secured | valid handle & valid access password | Backscatter handle, when done | secured |
| | valid handle & invalid access password | – | arbitrate |
| | invalid handle | – | secured |
| killed | all | – | killed |

### 10.7.7 ChangeEAS [7]

UCODE G2iM equipped RFID tags will also feature a stand-alone operating EAS alarm mechanism for fast and offline electronic article surveillance. The PSF bit of the Config-Word directly relates to the EAS Alarm feature. With an PSF bit set to '1' the tag will reply to an EAS_Alarm command by backscattering a 64 bit alarm code without the need of a Select or Query. The EAS is a built-in solution so no connection to a backend database is required. In case the EAS_Alarm command is not implemented in the reader a standard EPC SELCET to the Config-Word and Query can be used. When using standard SELECT/QUERY the EPC will be returned during inventory.

ChangeEAS can be executed from the Secured state only. The command will be ignored if the Access Password is zero, the command will also be ignored with an invalid CRC-16 or an invalid handle, the UCODE G2iM will than remain in the current state. The CRC-16 is calculated from the first command-code bit to the last handle bit. A frame-sync must be pre-pended the command.

The UCODE G2iM reply to a successful ChangeEAS will use the extended preamble, as appropriate (i.e. a Tag shall reply as if TRext=1) regardless of the TRext value in the Query that initiated the round.

After sending a ChangeEAS an interrogator shall transmit CW for less than TReply or 20 ms, where TReply is the time between the interrogator's ChangeEAS command and the UCODE G2iM backscattered reply. An interrogator may observe three possible responses after sending a ChangeEAS, depending on the success or failure of the operation

- ChangeEAS succeeds: After completing the ChangeEAS a UCODE G2iM will backscatter the reply shown in Table 29 comprising a header (a 0-bit), the handle, and a CRC-16 calculated over the 0-bit and handle. If the interrogator observes this reply within
  20 ms then the ChangeEAS completed successfully.

7 Note: The ChangeConfig command can be used instead of "ReadProtect", "ResetReadProtect", "ChangeEAS".

- The UCODE G2iM encounters an error: The UCODE G2iM will backscatter an error code during the CW period rather than the reply shown in Table 29 (see EPCglobal Spec for error-code definitions and for the reply format).
- ChangeEAS does not succeed: If the interrogator does not observe a reply within 20 ms then the ChangeEAS did not complete successfully. The interrogator may issue a Req_RN command (containing the handle) to verify that the G2iM is still in the interrogator's field, and may reissue the ChangeEAS command.

Upon receiving a valid ChangeEAS command a G2iM will perform the commanded set/reset operation of the PSF bit of the Configuration Word.

If PSF bit is set, the EAS_Alarm command will be available after the next power up and reply the 64 bit EAS code upon execution. Otherwise the EAS_Alarm command will be ignored.

**Table 28. ChangeEAS command**

| | Command | ChangeEas | RN | CRC-16 |
|---|---|---|---|---|
| # of bits | 16 | 1 | 16 | 16 |
| description | 11100000<br>00000011 | 1 ... set PSF bit<br>0 ... reset PSF bit | handle | |

**Table 29. UCODE G2iM reply to a successful ChangeEAS command**

| | Header | RN | CRC-16 |
|---|---|---|---|
| # of bits | 1 | 16 | 16 |
| description | 0 | handle | - |

**Table 30. ChangeEAS command-response table**

| Starting State | Condition | Response | Next state |
|---|---|---|---|
| ready | all | – | ready |
| arbitrate, reply, acknowledged | all | – | arbitrate |
| open | all | – | open |
| secured | valid handle | backscatter handle, when done | secured |
| | invalid handle | – | secured |
| killed | all | – | killed |

### 10.7.8 EAS_Alarm

Upon receiving an EAS_Alarm custom command the UCODE G2iM will immediately backscatter an EAS-Alarmcode in case the PSF bit of the Config-Word is set. The alarm code is returned without any delay caused by Select, Query and without the need for a backend database.

The EAS feature of the UCODE G2iM is available after enabling it by sending a ChangeEAS command described in Section 10.7.7 or after setting the PSF bit of the Config-Word to '1'. With the EAS-Alarm enabled the UCODE G2iM will reply to an EAS_Alarm command by backscattering a fixed 64 bit alarm code. A UCODE G2iM will reply to an EAS_Alarm command from the ready state only. As an alternative to the fast EAS_Alarm command a standard SELECT (upon the Config-Word) and QUERY can be used.

If the PSF bit is reset to '0' by sending a ChangeEAS command in the password protected Secure state or clearing the PSF bit the UCODE G2iM will not reply to an EAS_Alarm command.

The EAS_Alarm command is structured as following:

- 16 bit command
- 16 bit inverted command
- DR (TRcal divide ratio) sets the T=>R link frequency as described in EPCglobal Spec. 6.3.1.2.8 and Table 6.9.
- M (cycles per symbol) sets the T=>R data rate and modulation format as shown in EPCglobal Spec. Table 6.10.
- TRext chooses whether the T=>R preamble is pre-pended with a pilot tone as described in EPCglobal Spec. 6.3.1.3.

A preamble must be pre-pended the EAS_Alarm command according EPCglobal Spec, 6.3.1.2.8.

Upon receiving an EAS_Alarm command the tag loads the CRC5 register with 01001b and backscatters the 64 bit alarm code accordingly. The reader is now able to calculate the CRC5 over the backscattered 64 bits received to verify the received code.

**Table 31. EAS_Alarm command**

| | Command | Inv_Command | DR | M | TRext | CRC-16 |
|---|---|---|---|---|---|---|
| # of bits | 16 | 16 | 1 | 2 | 1 | 16 |
| description | 11100000 **0 0000100** | 00011111<br>11111011 | 0: DR=8<br>1: DR=64/3 | 00: M=1<br>01: M=2<br>10: M=4<br>11: M=8 | 0: no pilot tone<br>1: use pilot tone | - |

**Table 32. UCODE G2iM reply to a successful EAS_Alarm command**

| | Header | EAS Code |
|---|---|---|
| # of bits | 1 | 64 |
| description | 0 | CRC5 (MSB) |

**Table 33. EAS_Alarm command-response table**

| Starting State | Condition | Response | Next state |
|---|---|---|---|
| ready | PSF bit is set<br>PSF bit is cleared | backscatter alarm code<br>-- | ready |
| arbitrate, reply, acknowledged | all | – | arbitrate |
| open | all | – | open |
| secured | all | – | secured |
| killed | all | – | killed |

# 11 Limiting values

**Table 34. Limiting values[1][2]**

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

*Voltages are referenced to RFN*

| Symbol | Parameter | Conditions | | Min | Max | Unit |
|---|---|---|---|---|---|---|
| **Bare die limitations** | | | | | | |
| $T_{stg}$ | storage temperature | | | -55 | +125 | °C |
| $T_{amb}$ | ambient temperature | | | -40 | +85 | °C |
| $V_{ESD}$ | electrostatic discharge voltage | Human body model | [3][4] | - | ±2 | kV |
| **Pad limitations** | | | | | | |
| $V_i$ | input voltage | absolute limits, VDD-OUT pad | | -0.5 | +2.5 | V |
| $I_o$ | output current | absolute limits input/output current, VDD-OUT pad | | -0.5 | +0.5 | mA |
| $P_i$ | input power | maximum power dissipation, RFP pad | | - | 100 | mW |

[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 section 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] ANSI/ESDA/JEDEC JS-001

[4] For ESD measurement, the die chip has been mounted into a CDIP20 package.

**CAUTION**

This device is sensitive to ElectroStatic Discharge (ESD). Observe precautions for handling electrostatic sensitive devices.

Such precautions are described in the *ANSI/ESD S20.20, IEC/ST 61340-5, JESD625-A* or equivalent standards.

# 12 Characteristics

## 12.1 UCODE G2iM and UCODE G2iM+ bare die characteristics

**Table 35. UCODE G2iM and UCODE G2iM+ RF interface characteristics (RFN, RFP)**

| Symbol | Parameter | Conditions | | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|---|
| $f_i$ | input frequency | | | 840 | - | 960 | MHz |
| **Normal mode - no external supply, read range reduction OFF** | | | | | | | |
| $P_{i(min)}$ | minimum input power | READ sensitivity | [1][2][3] | - | -17.5 | - | dBm |
| $P_{i(min)}$ | minimum input power | WRITE,<br>BLOCKWRITE sensitivity, (write range/read range - ratio) | | -<br>- | 30<br>20 | - | % |
| $C_i$ | input capacitance | parallel | [4] | - | 0.77 | - | pF |
| Q | quality factor | 915 MHz | [4] | - | 9.2 | - | - |
| Z | impedance | 866 MHz | [4] | - | 27 -j234 | - | Ω |
| | | 915 MHz | [4] | - | 24 -j222 | - | Ω |
| | | 953MHz | [4] | - | 23 -j213 | - | Ω |
| **External supply mode - VDD pad supplied, read range reduction OFF** | | | | | | | |
| $P_{i(min)}$ | minimum input power | Ext. supplied READ | [1][2] | - | -27 | - | dBm |
| | | Ext. supplied WRITE | [2] | - | -27 | - | dBm |
| Z | impedance | externally supplied, 915 MHz | [4] | - | 8 -j228 | - | Ω |
| **Read range reduction ON - no external supply** | | | | | | | |
| $P_{i(min)}$ | minimum input power | 4R on READ | [1][2][5] | - | +10 | - | dBm |
| | | 4R on WRITE | [2][5] | - | +10 | - | dBm |
| Z | impedance | 4R on, 915 MHz | [4] | - | 16 -j1 | - | Ω |
| **Modulation resistance** | | | | | | | |
| R | resistance | modulation resistance, max. backscatter = off | [6] | - | 170 | - | Ω |
| | | modulation resistance, max. backscatter = on | [7] | - | 55 | - | Ω |

[1] Power to process a Query command.
[2] Measured with a 50 Ω source impedance.
[3] Results in approx. -18 dBm tag sensitivity on a 2 dBi gain antenna.
[4] At minimum operating power.
[5] It has to be assured the reader (system) is capable of providing enough field strength to give +10 dBm at the chip otherwise communication with the chip will not be possible.
[6] Enables tag designs to be within ETSI limits for return link data rates of e.g. 320 kHz/M4.
[7] Will result in up to 10 dB higher tag backscatter power at high field strength.

**Table 36. VDD pin characteristics**

| Symbol | Parameter | Conditions | | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|---|
| **Minimum supply voltage/current - without assisted EEPROM WRITE** | | | [1][2][3] | | | | |
| $V_{DD}$ | supply voltage | minimum voltage | | - | - | 1.8 | V |
| $I_{DD}$ | supply current | minimum current, $I_{out}$ = 0 µA | | - | - | 14 | µA |
| | | $I_{out}$ = 100 µA | | - | - | 120 | µA |
| **Minimum supply voltage/current - assisted EEPROM READ and WRITE** | | | [4][2][3] | | | | |
| $V_{DD}$ | supply voltage | minimum voltage, $I_{out}$ = 0 µA | | - | 1.8 | 1.85 | V |
| | | $I_{out}$ = 100 µA | | - | - | 1.95 | V |
| $I_{DD}$ | supply current | minimum current, $I_{out}$ = 0 µA | | - | - | 135 | µA |
| | | $I_{out}$ = 100 µA | | - | - | 265 | µA |
| **Maximum supply voltage/current** | | | [2][5] | | | | |
| $V_{DD}$ | supply voltage | absolute maximum voltage | | 2.2 | - | - | V |
| $I_{i(max)}$ | maximum input current | absolute maximum current | | 280 | - | - | µA |

[1] Activates Digital Output (OUT pin), increases read range (external supplied).
[2] Operating the chip outside the specified voltage range may lead to undefined behavior.
[3] Either the voltage or the current needs to be above given values to guarantee specified functionality.
[4] Activates Digital Output (OUT pin), increases read and write range (external supplied).
[5] No proper operation is guaranteed if both, voltage and current, limits are exceeded.

**Table 37. G2iM, G2iM+ VDD and OUT pin characteristics**

| Symbol | Parameter | Conditions | | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|---|
| **OUT pin characteristics** | | | | | | | |
| $V_{OL}$ | Low-level output voltage | Isink = 1mA | | - | - | 100 | mV |
| $V_{OH}$ | HIGH-level output voltage | VDD = 1.8 V; Isource = -100 µA | | 1.5 | - | - | V |
| **VDD/OUT pin characteristics** | | | | | | | |
| $C_L$ | load capacitance | VDD - OUT pin max. | [1] | - | - | 5 | pF |
| $V_o$ | output voltage | maximum RF peak voltage on VDD-OUT pins | [2] | - | - | 500 | mV |
| **VDD/OUT pin tamper alarm characteristics** | | | [3] | | | | |
| $R_{L(max)}$ | maximum load resistance | resistance range high | [4] | - | - | <2 | MΩ |
| $R_{L(min)}$ | minimum load resistance | resistance range low | [5] | >20 | - | - | MΩ |

[1] Is the sum of the allowed capacitance of the VDD and OUT pin referenced to RFN.
[2] Is the maximum allowed RF input voltage coupling to the VDD/OUT pin to guarantee undisturbed chip functionality.
[3] Resistance between VDD and OUT pin in checked during power up only.
[4] Resistance range to achieve tamper alarm flag = 1.
[5] Resistance range to achieve tamper alarm flag = 0:

**Table 38. UCODE G2iM and UCODE G2iM+ memory characteristics**

| Symbol | Parameter | Conditions | | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|---|
| **EEPROM characteristics** | | | | | | | |
| $t_{ret}$ | retention time | $T_{amb} \leq 55$ °C | | 20 | - | - | year |
| $N_{endu(W)}$ | write endurance | | | 1000 | 10000[1] | - | cycle |

[1] $T_{amb} \leq 25$ °C

## 12.2 UCODE G2iM+ SOT886 characteristics

**Table 39. G2iM+ RF interface characteristics (RFN, RFP)**

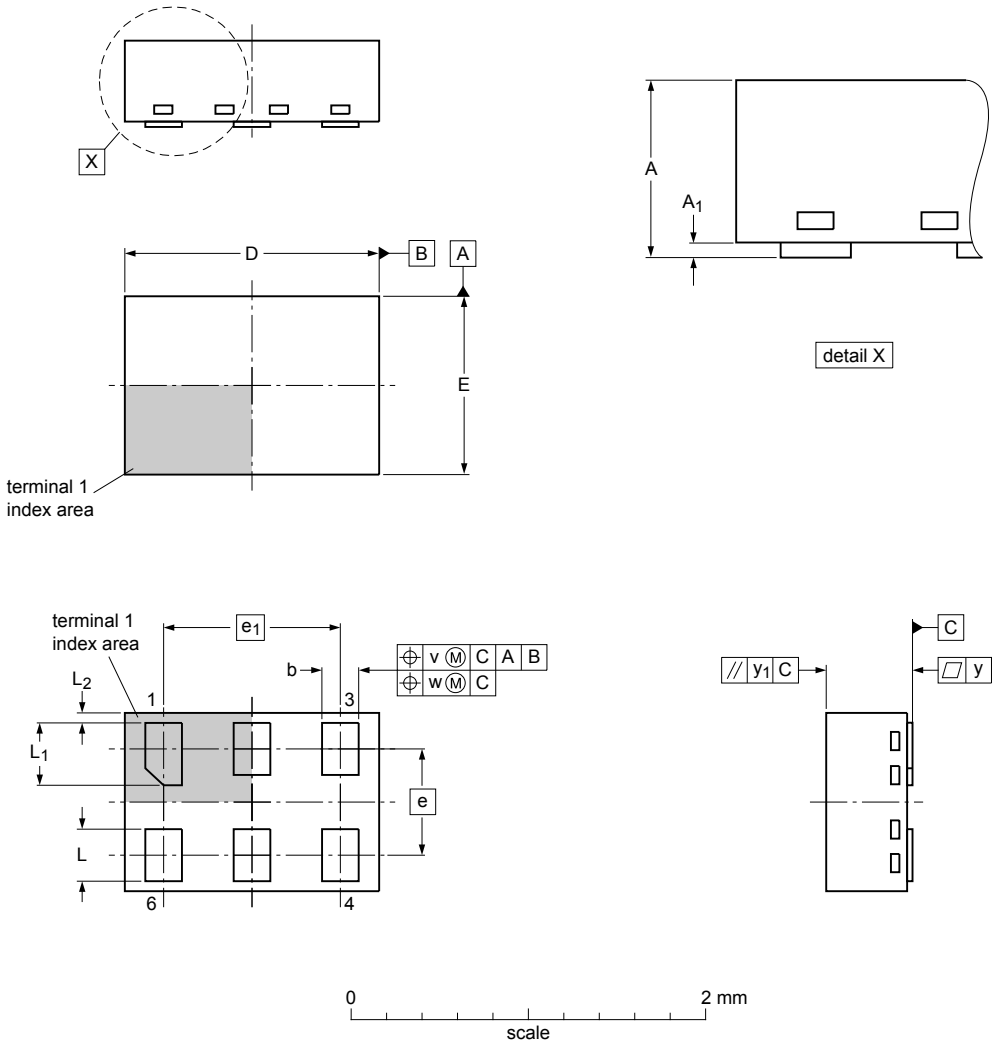
| Symbol | Parameter | Conditions | | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|---|
| **Normal mode - no external supply, read range reduction OFF** | | | | | | | |
| $P_{i(min)}$ | minimum input power | READ sensitivity | [1][2] | - | -17.6 | - | dBm |
| Z | impedance | 915 MHz | [3] | - | 21.2 -j199.7 | - | Ω |
| **Normal mode - externally supply VDD = 1.8V, read range reduction OFF** | | | | | | | |
| Z | impedance | 915 MHz | [3] | - | 6.9 -j205.5 | - | Ω |

[1] Power to process a Query command.
[2] Measured with a 50 Ω source impedance.
[3] At minimum operating power.

**Remark:** For DC and memory characteristics refer to Table 36, Table 37 and Table 38.

# 13 Package outline

**XSON6: plastic, extremely thin small outline package; no leads; 6 terminals; body 1.0 x 1.45 x 0.5 mm** **SOT886-1**




Dimensions (mm are the original dimensions)

| Unit | | A | $A_1$ | b | D | E | e | $e_1$ | L | $L_1$ | $L_2$ | v | w | y | $y_1$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | max | 0.50 | 0.05 | 0.25 | 1.50 | 1.05 | | | 0.35 | 0.40 | 0.10 | | | | |
| mm | nom | | | 0.20 | 1.45 | 1.00 | 0.6 | 1.0 | 0.30 | 0.35 | 0.05 | 0.10 | 0.05 | 0.05 | 0.05 |
| | min | | 0.00 | 0.17 | 1.40 | 0.95 | | | 0.27 | 0.32 | 0.02 | | | | |

Note
1. Plastic or metal protrusions of 0.075 mm maximum per side are not included.

*sot886-1_po*

| Outline version | References | | | | European projection | Issue date |
|---|---|---|---|---|---|---|
| | IEC | JEDEC | JEITA | | | |
| SOT886-1 | | | | | | ~~13-07-03~~ 13-07-10 |

**Figure 8. Package outline SOT886**

# 14 Handling information

## 14.1 Assembly conditions

### 14.1.1 General assembly recommendations

While pads OUT and VDD are not used for UCODE G2iM (SL3S1003), they are still electrically active and therefore must not be connected to the antenna and the RFN and RFP pads.

In case of any doubts, the customer is constrained to contact NXP Semiconductors for further clarification.

### 14.1.2 Label converting

Generally, an optimization of the entire lamination process by label manufacturer is recommended in order to minimize the stress onto the module and guarantee high assembly yield. Roller diameter must not be smaller than 45 mm.

# 15 Packing information

## 15.1 Wafer

See [2]

# 16 Abbreviations

**Table 40. Abbreviations**

| Acronym | Description |
|---|---|
| CRC | Cyclic Redundancy Check |
| CW | Continuous Wave |
| DC | Direct Current |
| EAS | Electronic Article Surveillance |
| EEPROM | Electrically Erasable Programmable Read Only Memory |
| EPC | Electronic Product Code (containing Header, Domain Manager, Object Class and Serial Number) |
| ESD | ElectroStatic Discharge |
| FCS | Flip Chip Strap |
| FM0 | Bi phase space modulation |
| G2 | Generation 2 |
| HBM | Human Body Model |
| IC | Integrated Circuit |
| PSF | Product Status Flag |
| PCB | Printed Circuit Board |
| RF | Radio Frequency |
| UHF | Ultra High Frequency |
| TID | Tag IDentifier |

# 17 References

[1] EPCglobal: EPC Radio-Frequency Identity Protocols Class-1 Generation-2 UHF RFID Protocol for Communications at 860 MHz – 960 MHz, Version 1.1.0 (December 17, 2005)

[2] Data sheet - Delivery type description – General specification for 8" wafer on UV-tape with electronic fail die marking, BU-ID document number: 1093**[8]

8 ** ... document version number

# 18 Revision history

**Table 41. Revision history**

| Document ID | Release date | Data sheet status | Change notice | Supersedes |
|---|---|---|---|---|
| SL3S1003_1013 v. 3.8 | 20190205 | Product data sheet | - | SL3S1003_1013 v. 3.7 |
| Modifications: | • References updated | | | |
| SL3S1003_1013 v. 3.7 | 20150521 | Product data sheet | - | SL3S1003_1013 v. 3.6 |
| Modifications: | • Table 36: current units corrected<br>• Section 10.7.1: "Digital Switch" updated | | | |
| SL3S1003_1013 v. 3.6 | 20141017 | Product data sheet | - | SL3S1003_1013 v. 3.5 |
| Modifications: | • Table 21: corrected<br>• Table 39: corrected | | | |
| SL3S1003_1013 v. 3.5 | 20131107 | Product data sheet | - | SL3S1003_1013 v. 3.4 |
| Modifications: | • Table 1: updated<br>• Table 2: updated<br>• Section 2.2: title updated<br>• Table 39: title updated | | | |
| SL3S1003_1013 v. 3.4 | 20120227 | Product data sheet | - | SL3S1003_1013 v. 3.3 |
| Modifications: | • Figure 4 "SL3S10x3 wafer layout": Figure notes (1) and (2) updated | | | |
| SL3S1003_1013 v. 3.3 | 20120130 | Product data sheet | | SL3S1003_1013 v. 3.2 |
| Modifications: | • Section 14 "Handling information": added | | | |
| SL3S1003_1013 v. 3.2 | 20120111 | Product data sheet | - | SL3S1003_1013 v. 3.1 |
| Modifications: | • Section 8.1 "Wafer layout": figure notes (1), (2), (8) and (9) updated | | | |
| SL3S1003_1013 v. 3.1 | 20111117 | Product data sheet | - | SL3S1003_1013 v. 3.0 |
| Modifications: | • Security status changed into COMPANY PUBLIC<br>• Package delivery form SOT886 added<br>• Section 5 "Marking", Section 13 "Package outline": added | | | |
| SL3S1003_1013 v. 3.0 | 20110503 | Product data sheet | - | SL3S1003_1013 v. 2.0 |
| Modifications: | • Specification status changed into product<br>• Some EPC bit values changed<br>• Table 16 added | | | |
| SL3S1003_1013 v. 2.0 | 20110415 | Preliminary 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. |

[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.

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