SL3S1216

UCODE 9xe

Rev. 3.3 — 12 February 2025 **Product data sheet**

1 General description

UCODE 9xe offers high performance and features for use in the most demanding RFID tagging applications.

Particularly well suited for inventory management applications, for example, retail and fashion, baggage tagging, and smart logistics with its great RF performance for any given form factor, UCODE 9xe enables long read ranges and fast inventory of dense RFID tag populations. With its broadband design, it offers the possibility to manufacture true global RFID labels with great performance across worldwide regulations.

2 Features and benefits

2.1 Key features

- Read sensitivity -24 dBm
- Write sensitivity -22 dBm
- 128-bit EPC Memory
- Innovative functionality
  - Drop-in replacement to UCODE 9 due to similar assembled input capacitance
  - Self-Adjust
  - Memory Safeguard
  - Pre-serialization of 96-bit EPC
- Compatible with single-slit antenna
- 96-bit unique tag identifier (TID) factory locked, including 48-bit unique serial number
- EPC Gen2v2.1

2.1.1 Memory

- 128-bit of EPC memory
- Supports pre-serialization of 96-bit EPC
- 96-bit Tag IDentifier (TID) factory-locked
- 48-bit unique serial number factory-encoded into TID
- 32-bit kill password to permanently disable the tag
- Wide operating temperature range: -40 °C up to +85 °C
- Minimum 100k write cycle endurance

2.2 Supported features

- All mandatory commands of the EPCglobal Gen2v2.1 specification are implemented including:
  - Kill Command
- The following optional commands are implemented in conformance with the EPC specification:
  - BlockWrite (2 words, 32-bit)
- Self-Adjust for automated tag performance optimization

3 Applications

3.1 Target market

- Retail
  - Brick and mortar
  - E-commerce
  - Omnichannel
- Supply chain management
- Airline baggage tracking

3.2 Applications

- Highly accurate and fast inventory management, enabling omnichannel retail processes
- Tracking along the supply chain from source to store
- High-speed store checkout process, bringing convenience to the customer
- Loss prevention
- After sales operations: return and warranty management

For other applications, contact NXP Semiconductors for support.

4 Ordering information

Table 1. Ordering information

Type number	Package			
	Name	IC type	Description	Version
SL3S1216FUD2/HAP	Wafer	UCODE 9xe	Die on sawn 12" 120 µm wafer 10 µm Polyimide spacer with Large Pads, Plasma Diced	Not applicable

5 Block diagram

The UCODE 9xe 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 which is then 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.

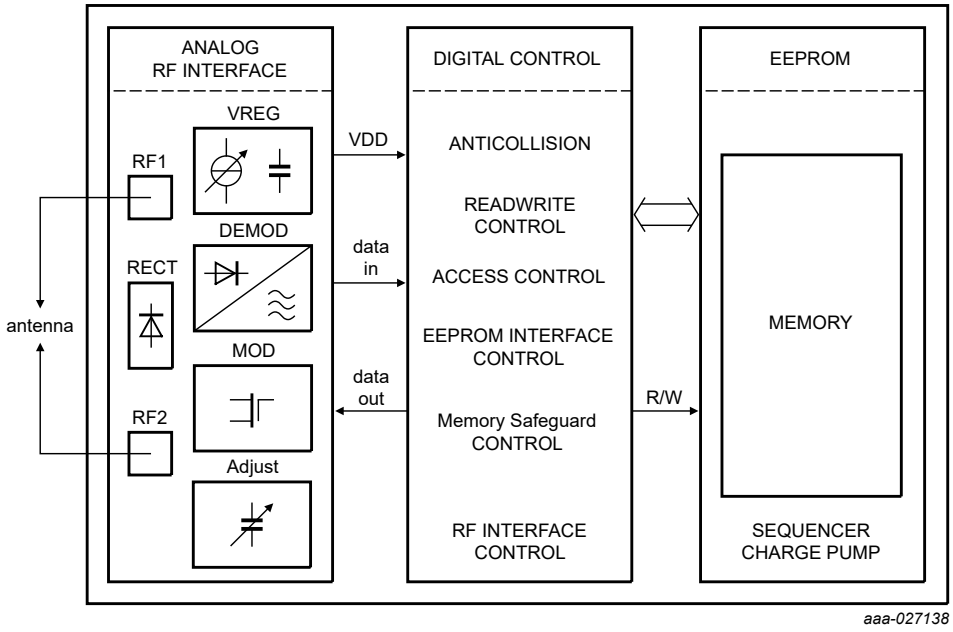


Figure 1. Block diagram of UCODE 9xe IC

6 Pinning information

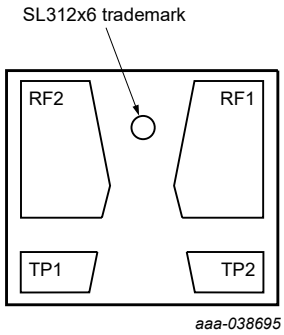


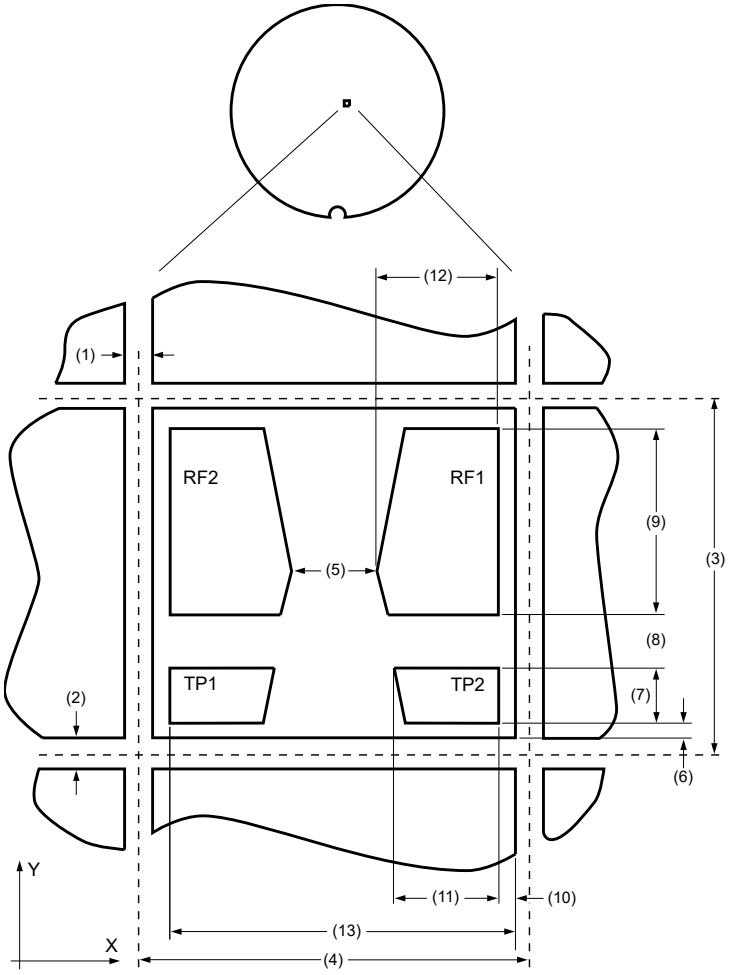
Figure 2. Pinning bare die, Large Pads

6.1 Pin description

Table 2. Pin description bare die

Symbol	Description
TP1	test pad 1
RF1	antenna connector 1
TP2	test pad 2
RF2	antenna connector 2

7 Wafer layout



1. X-scribe line width: typ. 7 µm)
2. Y-scribe line width: typ. 7 µm)
3. Chip step, Y-length: 395.6 µm
4. Chip step, X-length: 434.6 µm
5. Bump to bump distance X (RF1 - RF2): 115 µm
6. Distance bump to metal sealring Y: 16.5 µm
7. Bump size (TP1, TP2) Y: 70.5 µm
8. Bump to bump distance Y (RF1 - TP2, RF2 - TP1): 50 µm
9. Bump size (RF1, RF2) Y: 223.5 µm
10. Distance bump to metal sealring X: 16.5 µm
11. Bump size (TP1, TP2) X: 114.5 µm
12. Bump size (RF1, RF2) X: 134 µm
13. Distance bump to metal sealring X: 399.5 µm

Figure 3. UCODE 9xe, 12" wafer layout, plasma dicing, Large Pads

8 Mechanical specification

UCODE 9xe wafers are available in 120 µm thickness. The 120 µm thick wafer includes a 10 µm Polyimide spacer resulting in less coupling between the antenna and the active circuit, leaving more room for process control (for example, pressure).

8.1 Wafer specification

8.1.1 12-inch Wafer

See [3].

Table 3. 12-inch specification, Plasma Dicing, Large Pads

Wafer	
Designation	each wafer is scribed with batch number and wafer number
Diameter	300 mm (12") unsawn
Thickness	120 µm ± 15 µm
Number of pads	4
Pad location	nondiagonal / placed in chip corners
Process	CMOS 0.14 µm
Batch size	25 wafers
Net printed dies per wafer	389411
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 excluding scribe	0.426 mm × 0.387 mm = 0.16 mm^2
Scribe line width:	X-dimension = 8.6 µm
	Y-dimension = 8.6 µm
Passivation on front	
Type	Sandwich structure
Material	PE-Oxidee (on top)
Thickness	2.25 µm total thickness of passivation
Polyimide spacer	10 µm ± 2 µm
Au pads	
Pad material	> 99.9 % pure Au
Pad hardness	35 – 80 HV 0.005
Pad shear strength	> 70 MPa
Pad height	3 µm

Table 3. 12-inch specification, Plasma Dicing, Large Pads...*continued*

Pad height uniformity	
– within a die	max. 2 µm
– within a wafer	max. 4 µm
Pad flatness	max. 3 µm
Pad size	
– RF1, RF2 (max. details see wafer layout)	134 µm × 223.5 µm
– TP1, TP2 (max. details see wafer layout)	114.5 µm × 70.5 µm
Pad size variation	± 5 µm

8.1.2 Fail die identification

No ink dots 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 [3].

8.1.3 Map file distribution

See [3].

9 Functional description

9.1 Air interface standards

The UCODE 9xe fully supports all parts of the "EPC^{TM} Radio-Frequency Identity Protocols Generation-2 UHF RFID, Specification for RFID Air Interface, Protocol for Communications at 860 MHz to 960 MHz, Version 2.1".

9.2 Power transfer

The interrogator provides an RF field that powers the tag, equipped with a UCODE 9xe. The antenna transforms the impedance of free space to the chip input impedance in order to get the maximum power for the UCODE 9xe on the tag.

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 that is attached to the chip may use a DC connection between the two antenna pads. Therefore the UCODE 9xe also enables loop antenna design.

9.3 Data transfer

9.3.1 Interrogator to tag Link

An interrogator transmits information to the UCODE 9xe by modulating an UHF RF signal. The UCODE 9xe 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.

An interrogator is using a fixed modulation and data rate for the duration of at least one inventory round. It communicates to the UCODE 9xe by modulating an RF carrier.

For further details, refer to [1].

9.3.2 Tag to interrogator Link

Upon transmitting a valid command, an interrogator receives information from a UCODE 9xe tag by transmitting an unmodulated RF carrier and listening for a backscattered reply. The UCODE 9xe 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].

The UCODE 9xe 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.

9.4 Supported commands

UCODE 9xe supports all **mandatory** EPCglobal v2.1 commands including

- KILL command

In addition, the UCODE 9xe supports the following **optional** commands:

- Block Write (32 bit)

9.5 UCODE 9xe memory

The UCODE 9xe memory is implemented according to EPCglobal v2.1:

Table 4. UCODE 9xe memory sections

Name	Size	Bank
Reserved memory (32 bit Kill password) [1]	32 bit	00b
EPC (excluding 16 bit CRC-16 and 16-bit PC)	128 bit	01b
UCODE 9xe Configuration Word	16 bit	01b
TID (including permalocked unique 48-bit serial number)	96 bit	10b

[1] It is strongly recommended to use diversified passwords for individual tags

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

In addition to the four memory banks, one configuration word is available at EPC bank 01 address bit-200h. The configuration word is described in detail in Section 9.6.1

The TID complies to the GS1 EPC Tag Data Standard. See [2].

9.5.1 UCODE 9xe overall memory map

Table 5. UCODE 9xe overall memory map

Bank	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	hardwired to 0, locked memory
Bank 01 EPC	00h to 0Fh	EPC	CRC-16: refer to [1]		memory mapped calculated CRC
	10h to 14h	EPC	EPC length	00110b	unlocked memory
	15h	EPC	UMI	0b	hardwired to 0
	16h	EPC	XPC indicator	0b	hardwired to 0
	17h to 1Fh	EPC	numbering system indicator	00h	unlocked memory
	20h to 9Fh	EPC	EPC	[1]	unlocked memory
Bank 01 Config Word	200h	EPC	RFU	0b	locked memory
	201h	EPC	RFU	0b	locked memory
	202h	EPC	EPC NOK	0b	indicator bit
	203h	EPC	RFU	0b	locked memory
	204h	EPC	RFU	0b	locked memory
	205h	EPC	RFU	0b	locked memory
	206h	EPC	RFU	0b	locked memory
	207h	EPC	Self-Adjust disable	0b	locked memory
	208h	EPC	RFU	0b	locked memory
	209h	EPC	max. backscatter strength	1b	locked memory
	20Ah	EPC	RFU	0b	locked memory
	20Bh	EPC	RFU	0b	locked memory
	20Ch	EPC	RFU	0b	locked memory
	20Dh	EPC	RFU	0b	locked memory
	20Eh	EPC	RFU	0b	locked memory
	20Fh	EPC	RFU	0b	locked memory
Bank 10 TID	00h to 07h	TID	allocation class identifier	1110 0010b	locked memory
	08h to 13h	TID	tag mask designer identifier	1000 0000 0110b	locked memory
	14h	TID	config word indicator	1b[2]	locked memory
	15h to 1Fh	TID	tag model number	TMNR[3]	locked memory
	20h to 2Fh	TID	XTID header	2000h	locked memory
	30h to 5Fh	TID	serial number	SNR	locked memory

[1] `HEX E280 6A16 0000 nnnn nnnn nnnn 0000 0000 or HEX E280 6A96 0000 nnnn nnnn nnnn 0000 0000` where `n` are the nibbles of the SNR from the TID

[2] Indicates the existence of a Configuration Word at the end of the EPC number

[3] See Figure 4

9.5.2 UCODE 9xe TID memory details

	First 48 bit of TID memory	Class ID	Mask Designer ID	Model Number			XTID Header
				Config Word Indicator	Sub Version Nr.	Version (Silicon) Nr.	
UCODE 9xe	E2806A162000	E2h	806h	1b	0100b	0010110b	2000h
	E2806A962000	E2h	806h	1b	0101b	0010110b	2000h

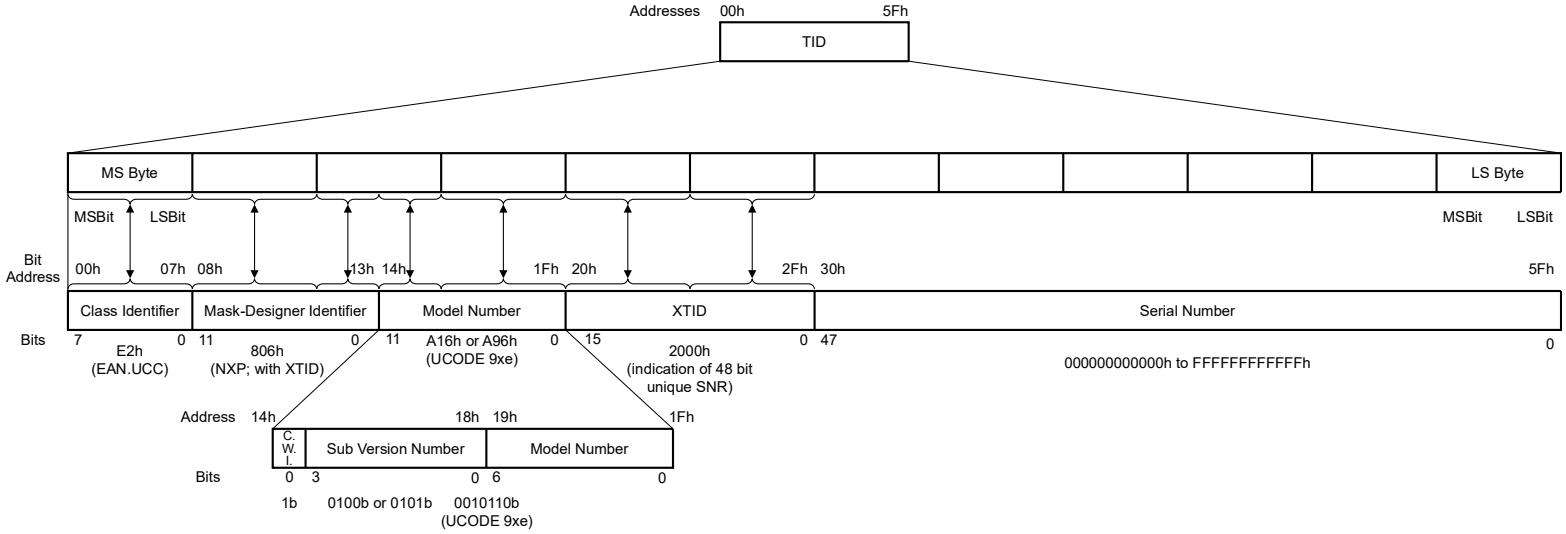


Figure 4. UCODE 9xe TID memory structure

9.6 Supported features

The UCODE 9xe is equipped with a Configuration Word, as mentioned in the memory map at address 200h of the EPC memory.

Bit 14h of the TID indicates the existence of a Configuration Word. This flag enables the selection of configuration word enhanced transponders in mixed tag populations.

9.6.1 UCODE 9xe features control mechanism

In UCODE 9xe the Configutation word is read only memory.

Table 6. Configuration word UCODE 9xe

Indicator bit			Locked memory				
RFU	RFU	EPC NOK	RFU	RFU	RFU	RFU	Self-Adjust disable
0	1	2	3	4	5	6	7

Table 7. Configuration word UCODE 9xe ... continued

Locked memory							
RFU	max.backscatter strength	RFU	RFU	RFU	RFU	RFU	RFU
8	9	10	11	12	13	14	15

The configuration word contains:

- **EPC NOK Indicator bit**: cannot be changed by command
- **Self-Adjust disable** :cannot be changed by command

The self-adjust feature is permanently activated and can not be deactivated.

- **max. backscatter strength** :cannot be changed by command

The max. backscatter strength is permanently activated and can not be deactivated.

A SELECT on the Configuration word is treated as not-matching.

9.6.2 Self-Adjust

9.6.2.1 Description

The UCODE 9xe has an automatic mechanism implemented which adjusts the chip sensitivity to a maximum in the operated environment. This adjustment will be performed at start-up and selects between three different input capacitance values (center capacitance -60 fF / +100 fF). The feature is permanently enabled.

9.6.3 Memory Safeguard

9.6.3.1 Description

The Memory Safeguard of UCODE 9xe consist of two different countermeasures which ensures the integrity of the stored data:

ECC (Error correction code):

The implemented ECC is applied on the complete UCODE 9xe memory and requires no user action. With this feature, a single bit failure in the memory is detected and corrected automatically. In case of 2-bit fail, an indication as described below is given.

EPC Memory:

Config word bit 202h (EPC NOK) provides an indication that a 2-bit failure occurred in the EPC memory by changing its value to "1". In such a case, UCODE 9xe will respond with an EPC value of F's indicating a corrupted EPC. A read of the EPC memory content will provide the actual content.

Parity check:

A parity check on the TID is implemented to offer the possibility to identify a change in the TID. The parity bit (Even parity) will be calculated and locked in the manufacturing process. For a check, the TID content needs to be read out and parity checked.

9.6.4 Pre-serialization of the 96-bit EPC

9.6.4.1 Description

UCODE 9xe is delivered with a pre-serialized content of the 96-bit EPC, which is the initial programmed length of the EPC.

The EPC content is identical to the TID content except of the 16-bit XTID content which is set to 16-bit 0's.

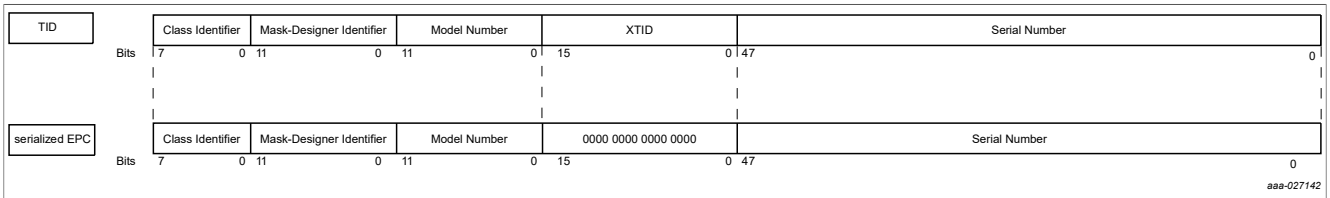


Figure 5. Pre-serialization of 96-bit EPC

9.6.5 Single-slit antenna solution

9.6.5.1 Description

In UCODE 9xe, the test pads TP1 and TP2 are electrically disconnected and therefore can be safely short-circuited to the RF pads (RF1, RF2). See Figure 6.

Single-slit antenna enables easier assembly and antenna design. In addition to the standard antenna assembly, the related increased input capacitance (Table 9) can be used for optimization for different antenna design.

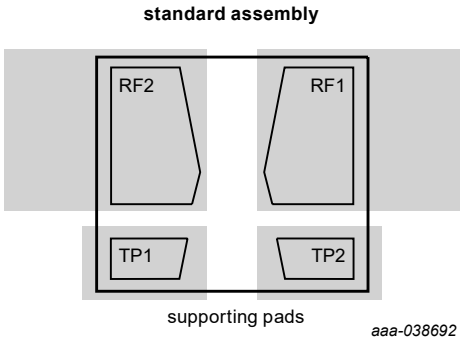


Figure 6. Standard antenna design versus single-slit antenna, Large Pads

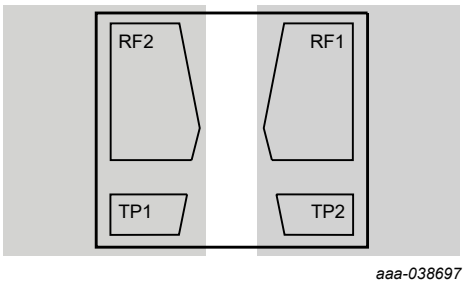


Figure 7. Single-slit assembly, Large Pads

9.6.6 Large pads

9.6.6.1 Description

The large gold pads of UCODE 9xe enable more robust and reliable assembly. This pad design allows for more freedom in the placement accuracy (see Figure 8).

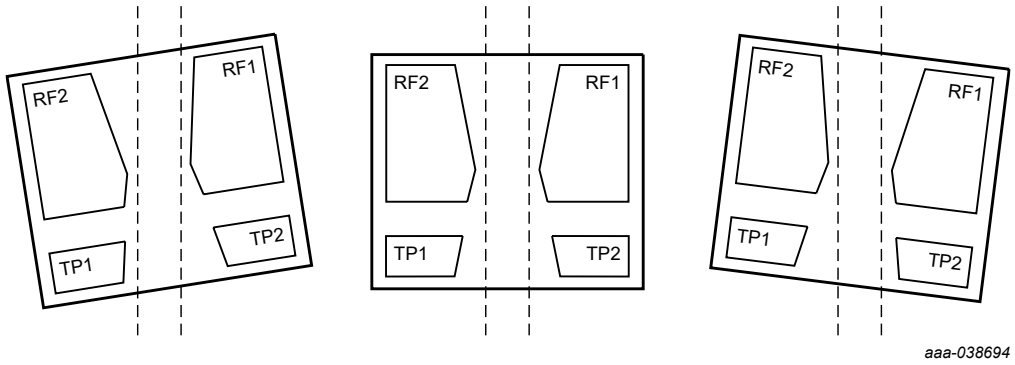


Figure 8. Rotation tolerant pad design

9.6.7 Permalock

UCODE 9xe permalock is implemented according to EPCglobal using the LOCK command with a payload of FFFFFh.

For any payload other than FFFFFh UCODE 9xe backscatters an error code.

10 Limiting values

Table 8. Limiting values

In accordance with the Absolute Maximum Rating System (IEC 60134). Voltages are referenced to RFN. [1] [2]

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 (HBM)[3]	[4]	-	± 2	kV
Pad limitations						
P_i	input power	maximum power dissipation, RF1/RF2 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] According to ANSI/ESDA/JEDEC JS-001

[4] For ESD measurement, the die chip has been mounted into a CDIP8 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.

11 Characteristics

11.1 UCODE 9xe bare die characteristics

Table 9. UCODE 9xe RF interface characteristics (RF1, RF2)

Symbol	Parameter	Conditions		Min	Typ	Max	Unit
f_i	input frequency			840	-	960	MHz
$P_{i(min)}$	minimum input power	READ sensitivity	[1]	-	- 24	-	dBm
$P_{i(min)}$	minimum input power	WRITE sensitivity	[1]	-	-22	-	dBm
t 16bit	encoding speed	16-bit	[2]	-	0.6	-	ms
		32-bit (block write)	[2]	-	1	-	ms
C_i	chip input capacitance	parallel	[3] [4] [5]	-	0.700	-	pF
R_P	chip resistance	parallel	[4]	-	3.6	-	kΩ
Z	chip impedance	915 MHz	[3] [4] [5]	-	10-j248	-	Ω
Z	typical assembled impedance[6]	915 MHz	[7] [8] [5]	-	16-j237		Ω
Z	typical assembled impedance in case of single-slit antenna assembly[9]	915 MHz	[7] [10] [5]	-	10-j191	-	Ω

[1] Tag sensitivity on a 2.15 dBi gain antenna
[2] When the memory content is "0000...".
[3] Measured with a 50 Ω source impedance directly on the chip
[4] At minimum operating power
[5] at center capacitor of Self-Adjust
[6] See Figure 6)
[7] The antenna shall be matched to this impedance
[8] Assuming 35 fF additional assembly capacitance
[9] See Figure 7
[10] Assuming 210 fF additional assembly+test pad capacitance

Table 10. UCODE 9xe memory characteristics

Symbol	Parameter	Conditions		Min	Typ	Max	Unit
EEPROM characteristics							
t_{ret}	retention time	T_{amb} ≤ 55 °C		20	-	-	year
		T_{amb} ≤ 125 °C		1	-	-	year
		T_{amb} ≤ 85 °C		10	-	-	year
$N_{endu(W)}$	write endurance			100k	-	-	cycle

12 Packing information

12.1 Wafer

See [3].

13 Abbreviations

Table 11. Abbreviations

Acronym	Description
CRC	cyclic redundancy check
CW	continuous wave
DSB-ASK	Double Side Band-Amplitude Shift Keying
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)
FM0	bi-phase space modulation
G2	Generation 2
IC	Integrated Circuit
PIE	pulse interval encoding
PSF	product status flag
RF	radio frequency
UHF	ultra high frequency
SECS	Semi Equipment Communication Standard
TID	tag identifier

14 References

[1] EPCglobal: EPC Radio-Frequency Identity Protocols Class-1 Generation-2 UHF RFID Protocol for Communications at 860 MHz – 960 MHz, Version 2.1 (July 2018)

[2] EPCglobal: EPC Tag Data Standard, Release 1.13 (November 2019)

[3] Data sheet - Delivery type description – General specification for 12" wafer on UV-tape with electronic fail die marking, BU-S&C document number: 1862** [1]

1 ** ... document version number

15 Revision history

Table 12. Revision history

Document ID	Release date	Data sheet status	Supersedes
SL3S1216 v.3.3	12 February 2025	Product data sheet	SL3S1216 v.3.2
Modifications:	Editorial changes. • Document security status changed to "Public", no content change.		
SL3S1216 v.3.2	27 May 2024	Product data sheet	SL3S1216 v.3.1
Modifications:	• Section 8.1.1 "12-inch Wafer": Table 3 "12-inch specification, Plasma Dicing, Large Pads": Updated Net printed dies per wafer.		
SL3S1216 v.3.1	24 March 2023	Product data sheet	SL3S1216 v.3.0
Modifications:	• Section 9.5.1 "UCODE 9xe overall memory map": updated. • Section 9.5.2 "UCODE 9xe TID memory details": updated.		
SL3S1216 v.3.0	03 July 2022	Product data sheet	SL3S1216 v.2.0
SL3S1216 v.2.0	11 May 2022	Preliminary data sheet	SL3S1216 v.1.0
SL3S1216 v.1.0	04 April 2022	Objective data sheet	-

Legal information

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 https://www.nxp.com.

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