SL3S1204

UCODE 7

Rev. 3.0 — 22 May 2013
263630

Product short data sheet
COMPANY PUBLIC

1. General description

NXP's UCODE 7 IC is the leading-edge EPC Gen2 RFID chip that offers best-in-class performance and features for use in the most demanding RFID tagging applications.

Particularly well suited for inventory management application, like e.g Retail and Fashion, with its leading edge RF performance for any given form factor, UCODE 7 enables long read distance and fast inventory of dense RFID tag population. With its broadband design, it offers the possibility to manufacture true global RFID label with best-in-class performance over worldwide regulations.

The device also provides an automatic self pre-serialization feature for 96-bit EPC, following the industry aligned Multi Vendor Chip-based serialization scheme, and a Parallel encoding feature. For applications where the same 58-bit Stock Keeping Unit (SKU) needs to be encoded on multiple tags, at the same time, a combination of both features improves and simplifies the tag initialization process.

On top UCODE 7 offers a Tag Power Indicator for RFID tag initialization optimization and a Product Status Flag for Electronic Article Surveillance (EAS) application.

2. Features and benefits

2.1 Key features

- Read sensitivity −21 dBm
- Write sensitivity −16 dBm
- Parallel encoding mode: 100 items in 60ms
- Encoding speed: 16 bits per millisecond
- Innovative functionalities
  - Tag Power Indicator
  - Automatic self pre-serialization for 96-bit EPC
  - Integrated Product Status Flag (PSF)
- Compatible with single-slit antenna
- Up to 128-bit EPC
- 96-bit Unique Tag Identifier (TID) factory locked, including 48-bit unique serial number
- EPC Gen2 v2.0 ready

2.1.1 Memory

- Up to 128-bit of EPC memory
- Supports self pre-serialization for 96-bit EPC
- 96-bit Tag IDentifier (TID) factory locked
- 48-bit unique serial number factory-encoded into TID
- No User Memory
- 32-bit kill password to permanently disable the tag
- 32-bit access password
- Wide operating temperature range: −40 °C up to +85 °C
- Minimum 100.000 write cycle endurance

2.2 Key benefits

2.2.1 End user benefit

- Long READ and WRITE ranges due to leading edge chip sensitivity
- Very fast bulk encoding
- Product identification through unalterable extended TID range, including a 48-bit serial number
- Reliable operation in dense reader and noisy environments through high interference rejection

2.2.2 Antenna design benefits

- High sensitivity enables smaller and cost efficient antenna designs for the same retail category
- Tag Power Indicator features enables very high density of inlay on rolls without cross-talk issues during writing/encoding
- The different input capacitance for the single slit antenna solution provides an additional possibility in tuning of the impedance for the antenna design

2.2.3 Label manufacturer benefit

- Large RF pad-to-pad distance to ease antenna design
- Symmetric RF inputs are less sensitive to process variation
- Single slit antenna for a more mechanically stable antenna connection
- Automatic self pre-serialization of the 96-bit EPC
- Extremely fast encoding of the EPC content

2.3 Supported features

- All mandatory commands of EPC global specification V.1.2.0 are implemented including:
  - (Perma)LOCK
  - Kill Command
- The following optional commands are implemented in conformance with the EPC specification:
  - Access
  - BlockWrite (2 words, 32-bit)
- Product Status Flag bit: enables the UHF RFID tag to be used as EAS (Electronic Article Surveillance) tag without the need for a back-end data base.
- Tag Power Indicator: enables the reader to select only ICs/tags that have enough power to be written to.
- Parallel encoding: allows for the ability to bring (multiple) tag(s) quickly to the OPEN state and hence allowing single tags to be identified simply, without timing restrictions, or multiple tags to be e.g. written to at the same time, considerably reducing the encoding process

All supported features of UCODE 7 can be activated using standard EPCglobal READ / WRITE / ACCESS / SELECT commands. No custom commands are needed to take advantage of all the features in case of unlocked EPC memory. The parallel encoding feature may however require a firmware upgrade of the reader to use its full potential.

3. Applications

3.1 Markets

- Retail/Fashion (apparel, footwear, jewelry, cosmetics)
- Fast Moving Consumer Goods

3.2 Applications

- Retail Inventory management
- Supply chain management
- Loss prevention
- Asset management

Outside the applications mentioned above, please contact NXP Semiconductors for support.

4. Quick reference data

Table 1. Quick reference data

Symbol	Parameter	Conditions		Min	Typ	Max	Unit
f_i	input frequency			840	-	960	MHz
$P_{i(min)}$	minimum input power	READ sensitivity	[1][3][8]	-	–21	-	dBm
$P_{i(min)}$	minimum input power	WRITE sensitivity	[2]	-	–16	-	dBm
t 16bit	Encoding speed	16-bit	[5]	-	1	-	ms
		32-bit (block write)	[5]	-	1.8	-	ms
C_i	Chip input capacitance	parallel	[3][4]	-	0.63	-	pF
Z	Chip impedance	866 MHz	[3][4]	-	14.5-j293	-	Ω
		915 MHz	[3][4]	-	12.5-j277	-	Ω
		953 MHz	[3][4]	-	12.5-j267	-	Ω
Z	Typical assembled impedance [9]	915MHz	[6]	-	18-j245		Ω
Z	Typical assembled impedance [9] in case of single-slit antenna assembly	915MHz	[6][7]	-	13.5-j195	-	Ω
Tag Power Indicator mode							
$P_{i(min)}$	minimum input power level to be able to select the tag		[2]	-	–15	-	dBm

[1] Power to process a QUERY command

[2] Tag sensitivity on a 2dBi gain antenna

[3] Measured with a 50 Ω source impedance directly on the chip

[4] At minimum operating power

[5] When the memory content is “0000...”.

[6] The antenna shall be matched to this impedance

[7] Depending on the specific assembly process, sensitivity losses of few tenths of dB might occur

[8] Results in approximately -21,5dBm tag sensitivity with a 2dBi gain antenna

[9] Assuming a 80fF additional input capacitance, 250fF in case of single slit antenna

5. Ordering information

Table 2. Ordering information

Type number	Package			
	Name	IC type	Description	Version
SL3S1204FUD/BG	Wafer	UCODE 7	bumped die on sawn 8” 120 μm wafer 7 μm Polyimide spacer	not applicable

6. Block diagram

The SL3S1204 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.

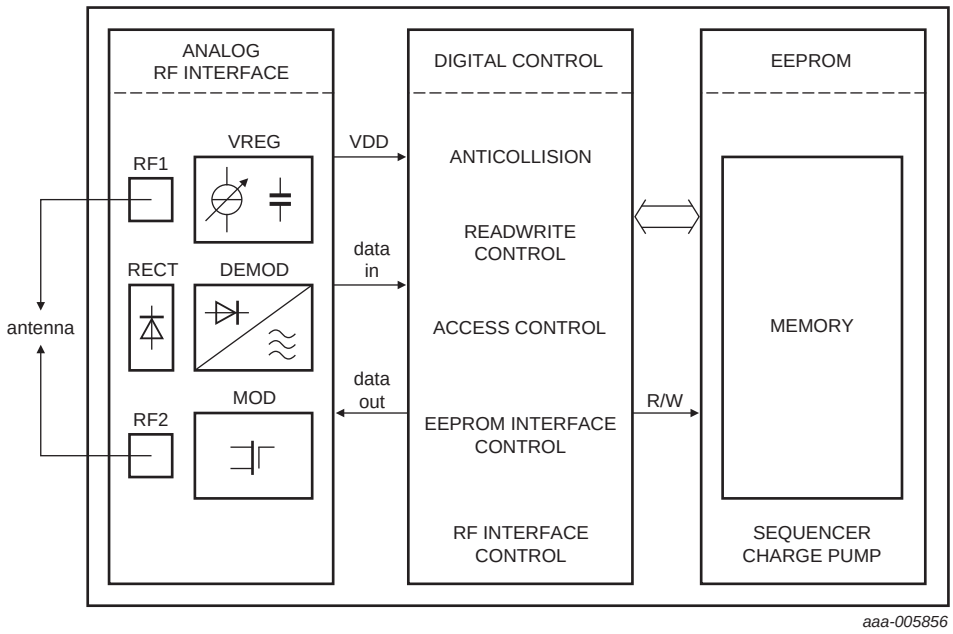


Fig 1. Block diagram of UCODE 7 IC

7. Pinning information

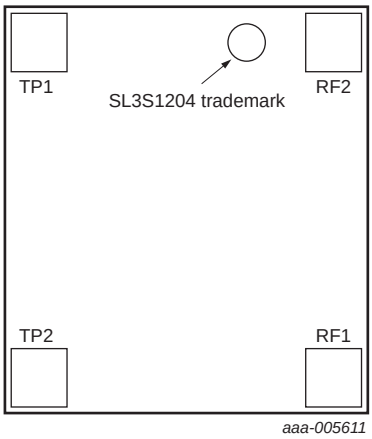


Fig 2. Pinning bare die

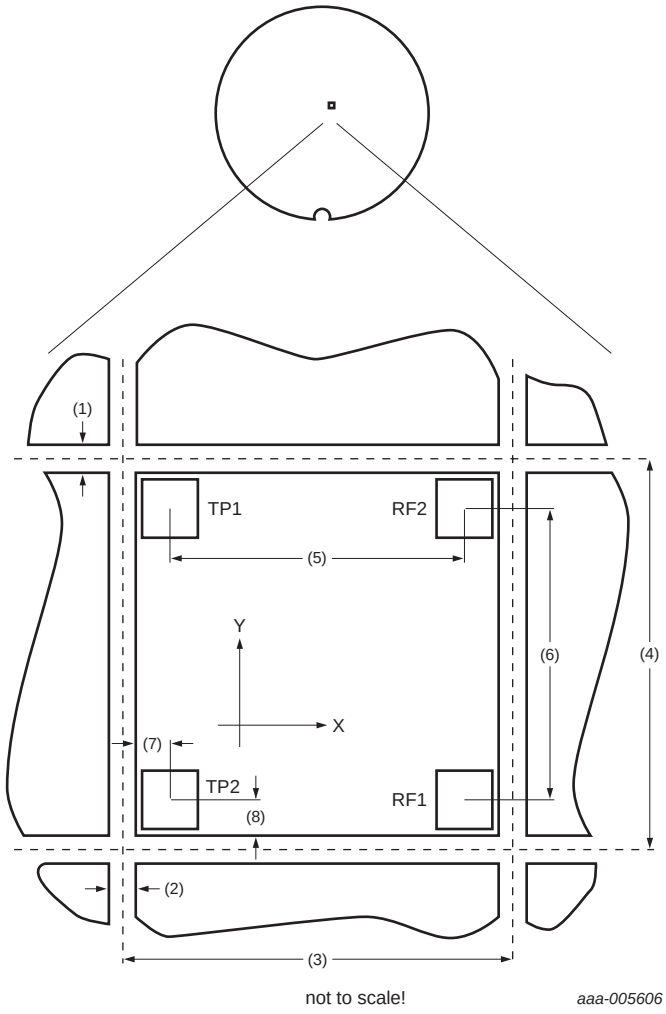
7.1 Pin description

Table 3. Pin description bare die

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

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: 460 μm
(4) Chip step, y-length: 505 μm
(5) Bump to bump distance X (TP1 - RF2): 358 μm
(6) Bump to bump distance Y (RF1 - RF2): 403 μm
(7) Distance bump to metal sealring X: 40,3 μm (outer edge - top metal)
(8) Distance bump to metal sealring Y: 40,3 μm
Bump size X x Y: 60 μm x 60 μm
Remark: TP1 and TP2 are electrically disconnected after dicing

Fig 3. UCODE 7 wafer layout

9. Mechanical specification

The UCODE 7 wafers are available in 120 μm thickness. The 120 μm thick wafer is enhanced with 7μm Polyimide spacer resulting in less coupling between the antenna and the active circuit, leaving more room for process control (like pressure).

9.1 Wafer specification

See Ref. 21 “Data sheet - Delivery type description – General specification for 8” wafer on UV-tape with electronic fail die marking, BU-ID document number: 1093**”.

9.1.1 Wafer

Table 4. Specifications

Wafer	
Designation	each wafer is scribed with batch number and wafer number
Diameter	200 mm (8”) unsawn - 205 mm typical sawn on foil
Thickness	
SL3S1204FUD	120 μm ± 15 μm
Number of pads	4
Pad location	non diagonal / placed in chip corners
Distance pad to pad RF1-RF2	403.0 μm
Distance pad to pad TP1-RF2	358.0 μm
Process	CMOS 0.14 μm
Batch size	25 wafers
Potential good dies per wafer	126.524
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	0.490 mm × 0.445 mm = 0.218 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 ± 1 μm
Au bump	
Bump material	> 99.9 % pure Au
Bump hardness	35 – 80 HV 0.005
Bump shear strength	> 70 MPa

Table 4. Specifications

Bump height	
SL3S1204FUD/BG	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	
– RF1, RF2	60 × 60 μm
– TP1, TP2	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 Ref. 21 “Data sheet - Delivery type description – General specification for 8” wafer on UV-tape with electronic fail die marking, BU-ID document number: 1093**”

9.1.3 Map file distribution

See Ref. 21 “Data sheet - Delivery type description – General specification for 8” wafer on UV-tape with electronic fail die marking, BU-ID document number: 1093**”

10. Functional description

10.1 Air interface standards

The UCODE 7 fully supports all parts of the "Specification for RFID Air Interface EPCglobal, EPC 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 7. The antenna transforms the impedance of free space to the chip input impedance in order to get the maximum possible power for the UCODE 7 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 7 also enables loop antenna design.

10.3 Data transfer

10.3.1 Interrogator to tag Link

An interrogator transmits information to the UCODE 7 by modulating an UHF RF signal. The UCODE 7 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 7 by modulating an RF carrier.

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

10.3.2 Tag to interrogator Link

Upon transmitting a valid command an interrogator receives information from a UCODE 7 tag by transmitting an unmodulated RF carrier and listening for a backscattered reply. The UCODE 7 backscatters by switching the reflection coefficient of its antenna between two states in accordance with the data being sent. For further details refer to Ref. 1, chapter 6.3.1.3.

The UCODE 7 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 Supported commands

The UCODE 7 supports all **mandatory** EPCglobal V1.2.0 commands including

- Kill command
- (perma) LOCK command

In addition the G2iL supports the following **optional** commands:

- ACCESS
- Block Write (32 bit)

10.5 UCODE 7 memory

The UCODE 7 memory is implemented according EPCglobal Class1Gen2 and organized in three banks:

Table 5. UCODE 7 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)	128 bit	01b
UCODE 7 Configuration Word	16 bit	01b
TID (including permalocked unique 48 bit serial number)	96 bit	10b

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

In addition to the three memory banks one configuration word to handle the UCODE 7 specific features is available at EPC bank 01 address bit-200h. The configuration word is described in detail in 9.6.

The TID complies to the extended tag Identification scheme according GS1 EPC Tag Data Standard 1.6.

The EPC content will follow a self pre-serialization scheme following the Multi Vendor Chip-based serialization scheme (Ref. 23).

11. Limiting values

Table 6. 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]	-	± 2	kV
Pad limitations					
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] For ESD measurement, the die chip has been mounted into a CDIP20 package.

12. Characteristics

12.1 UCODE 7 bare die characteristics

Table 7. UCODE 7 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][3][8]	-	–21	-	dBm
$P_{i(min)}$	minimum input power	WRITE sensitivity	[2]	-	–16	-	dBm
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		915 MHz	[3][4]	-	12.5-j277	-	Ω
		953 MHz	[3][4]	-	12.5-j267	-	Ω
Z	Typical assembled impedance [9]	915MHz	[6]	-	18-j245		Ω
Z	Typical assembled impedance [9] in case of single-slit antenna assembly	915MHz	[6][7]	-	13.5-j195	-	Ω
Tag Power Indicator mode							
$P_{i(min)}$	minimum input power level to be able to select the tag		[2]	-	–15	-	dBm

[1] Power to process a QUERY command

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[3] Measured with a 50 Ω source impedance directly on the chip

[4] At minimum operating power

[5] When the memory content is “0000...”.

[6] The antenna shall be matched to this impedance

[7] Depending on the specific assembly process, sensitivity losses of few tenths of dB might occur

[8] Results in approximately -21,5dBm tag sensitivity with a 2dBi gain antenna

[9] Assuming a 80fF additional input capacitance, 250fF in case of single slit antenna

13. Packing information

13.1 Wafer

See Ref. 21 “Data sheet - Delivery type description – General specification for 8” wafer on UV-tape with electronic fail die marking, BU-ID document number: 1093**”

14. Abbreviations

Table 8. 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

15. 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] EPCglobal: EPC Tag Data Standards

[3] EPCglobal (2004): FMCG RFID Physical Requirements Document (draft)

[4] EPCglobal (2004): Class-1 Generation-2 UHF RFID Implementation Reference (draft)

[5] European Telecommunications Standards Institute (ETSI), EN 302 208: Electromagnetic compatibility and radio spectrum matters (ERM) – Radio-frequency identification equipment operating in the band 865 MHz to 868 MHz with power levels up to 2 W, Part 1 – Technical characteristics and test methods

[6] European Telecommunications Standards Institute (ETSI), EN 302 208: Electromagnetic compatibility and radio spectrum matters (ERM) – Radio-frequency identification equipment operating in the band 865 MHz to 868 MHz with power levels up to 2 W, Part 2 – Harmonized EN under article 3.2 of the R&TTE directive

[7] [CEPT1]: CEPT REC 70-03 Annex 1

[8] [ETSI1]: ETSI EN 330 220-1, 2

[9] RTCal is the Interrogator-to-Tag calibration symbol length defined in the EPCglobal specification

[10] [ETSI3]: ETSI EN 302 208-1, 2 V<1.1.1> (2004-09-Electromagnetic compatibility And Radio spectrum Matters (ERM) Radio Frequency Identification Equipment operating in the band 865 - MHz to 868 MHz with power levels up to 2 W Part 1: Technical characteristics and test methods.

[11] [FCC1]: FCC 47 Part 15 Section 247

[12] ISO/IEC Directives, Part 2: Rules for the structure and drafting of International Standards

[13] ISO/IEC 3309: Information technology – Telecommunications and information exchange between systems – High-level data link control (HDLC) procedures – Frame structure

[14] ISO/IEC 15961: Information technology, Automatic identification and data capture – Radio frequency identification (RFID) for item management – Data protocol: application interface

[15] ISO/IEC 15962: Information technology, Automatic identification and data capture techniques – Radio frequency identification (RFID) for item management – Data protocol: data encoding rules and logical memory functions

[16] ISO/IEC 15963: Information technology — Radio frequency identification for item management — Unique identification for RF tags

[17] ISO/IEC 18000-1: Information technology — Radio frequency identification for item management — Part 1: Reference architecture and definition of parameters to be standardized

[18] ISO/IEC 18000-6: Information technology automatic identification and data capture techniques — Radio frequency identification for item management air interface — Part 6: Parameters for air interface communications at 860–960 MHz

[19] ISO/IEC 19762: Information technology AIDC techniques – Harmonized vocabulary – Part 3: radio-frequency identification (RFID)

[20] U.S. Code of Federal Regulations (CFR), Title 47, Chapter I, Part 15: Radio-frequency devices, U.S. Federal Communications Commission.

[21] Data sheet - Delivery type description – General specification for 8” wafer on UV-tape with electronic fail die marking, BU-ID document number: 1093**[1]

[22] Application note - AN11274 – FAQ on UCODE 7

[23] Release Note - Formulas for Multi-Vendor Chip-Based Serialization (MCS) and FastEPC, BU-ID document number: 2498**

1. ** ... document version number

16. Revision history

Table 9. Revision history

Document ID	Release date	Data sheet status	Change notice	Supersedes
SL3S1204_SDS v.3.0	20130522	Product short data sheet		SL3S1204_SDS v.1.0
Modifications	• Editorial changes • Table 1 “Quick reference data”: updated • Figure 3 “UCODE 7 wafer layout”: updated • Table 7 “UCODE 7 RF interface characteristics (RF1, RF2)”: updated			
SL3S1204_SDS v.1.0	20130422	Objective short data sheet	-	-

17. Legal information

17.1 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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19. Contents

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