NTAG I²C *plus* – your entryway to NFC

Public

MobileKnowledge
March 2016

Agenda

Session 9th March: *NTAG I²C plus introduction*

- Introduction, use cases, target markets and benefits
- Positioning and NTAG portfolio
- Memory map
- Key functionalities
  - Field detection
  - SRAM & SRAM mirroring
  - Pass-through mode
  - Energy harvesting
  - Silence mode
  - Memory access management
- Demokit and PSP quick overview
- Ordering details and wrap up

Session 16th March: *NTAG I²C plus product support package*

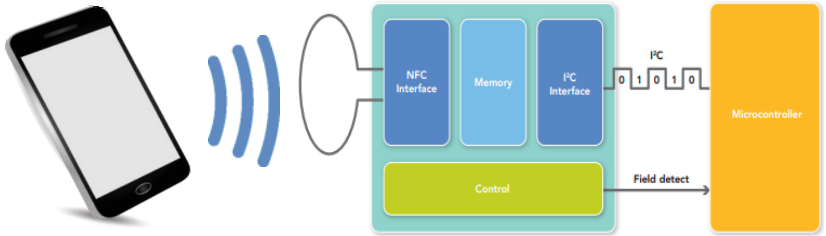
Register here

NXP Training Mobile Knowledge

NTAG I²C *plus* is the simplest, most cost-effective NFC solution

The simplest, most cost-effective NFC solution

- Easy access to data from both RF (Type 2 tag) and from I²C
- Field detection to wake up connected devices
- Energy Harvesting capabilities
- EEPROM for offline data access
- Maximum interoperability with NFC devices
- Flexible memory management
- Originality signature for protection against cloning
- Fast & convenient data exchange via a 64 bytes SRAM buffer
- Small footprint package (1,6*1,6*0,5mm)



NTAG I²C *plus* offers a unique combination

Low bill of material

- Simple antenna design
- Re-use any reference design such as NTAG21x(F) or NTAG I²C
- Very limited set of extra components (e.g. extra cap for antenna tuning 1-2 resistors max)
- Small footprint package (1.6*1.6*0.5mm)

Easy to use / integrate

- Easy access to data from both RF (Type 2 tag) and from I²C, simple commands
- I²C: use generic MCU code
- RF: Use Android library for app development
- Fast & convenient data exchange via 64 bytes SRAM buffer
- 8 pin chip

Ideal for low power operations

- Energy harvesting capabilities
- EEPROM for offline data access

Maximum interoperability with NFC devices

- NFC Forum Type 2 tag compliant

NTAG I²C *plus* is the ideal NFC solution for embedded applications

Wireless pairing and network commissioning

BT pairing
WiFi pairing
Home automation commissioning

Easy pairing: *e.g.: Connect a Bluetooth headphone to your phone*

1. Tap your phone to your headphones on the NFC logo to pair them
2. Network credentials are exchanged, without any manual setting.
3. Bluetooth connection is established

NTAG I²C *plus* is the ideal NFC solution for embedded applications

Zero Power configuration

Product validation
Product personalization
Return logistics
Multiple product variants from a single platform

Zero power configuration*: e.g. : Return logistics*

1. Tap your phone to your consumer electronic device packaging
2. The phone retrieves the stored information such as the product owner, warranty registration, service history records, etc.
3. Return and repair centers can virtually peek inside boxed or sealed products.

NTAG I²C *plus* is the ideal NFC solution for embedded applications

Enhanced user experience with NFC

Administrative access to electronic devices
Self-serve maintenance
FW update
Warranty registration

Enhanced user experience : *e.g.: Self-serve maintenance*

1. Tap your phone to your device on the NFC logo
2. The phone reads the error code, connects to manufacturer servers to get a full diagnostic.
3. Depending on the outcome, phone can indicate simple actions to fix the issue, download new firmware, provide a detailed error description or report to the customer

NTAG I²C *plus* applications and benefits

INDUSTRIAL CALIBRATION

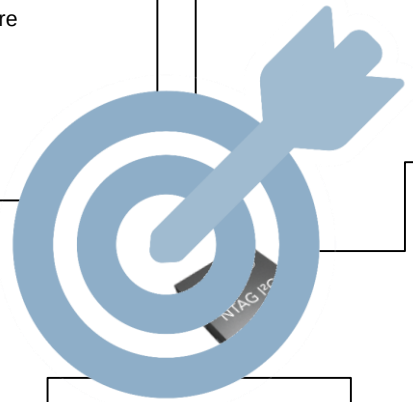
Benefits
- **NFC Forum-compliancy** allows interaction with mobile phones
- **I²C connected EEPROM** can be used to store manufacturing history
- **Energy harvesting** allows operation without power supply/Battery

LOGISTICS

Benefits
- **Zero Power configuration** allows in-the-box configuration at the end of the supply chain
- **Password protection** introduces administrator rights
- **Unique ID** optimizes inventory

IoT

Benefits
- **I²C connected EEPROM** can be used to store network credentials offline & load data once supplied
- **Password authentication** allows secure data handling



SMART METERS

Benefits
- **Password protection** secures metering data Access
- **I²C connected EEPROM** can be used to collect data without expensive display
- **NFC Forum-compliancy** allows interaction with mobile phones

HEALTHCARE

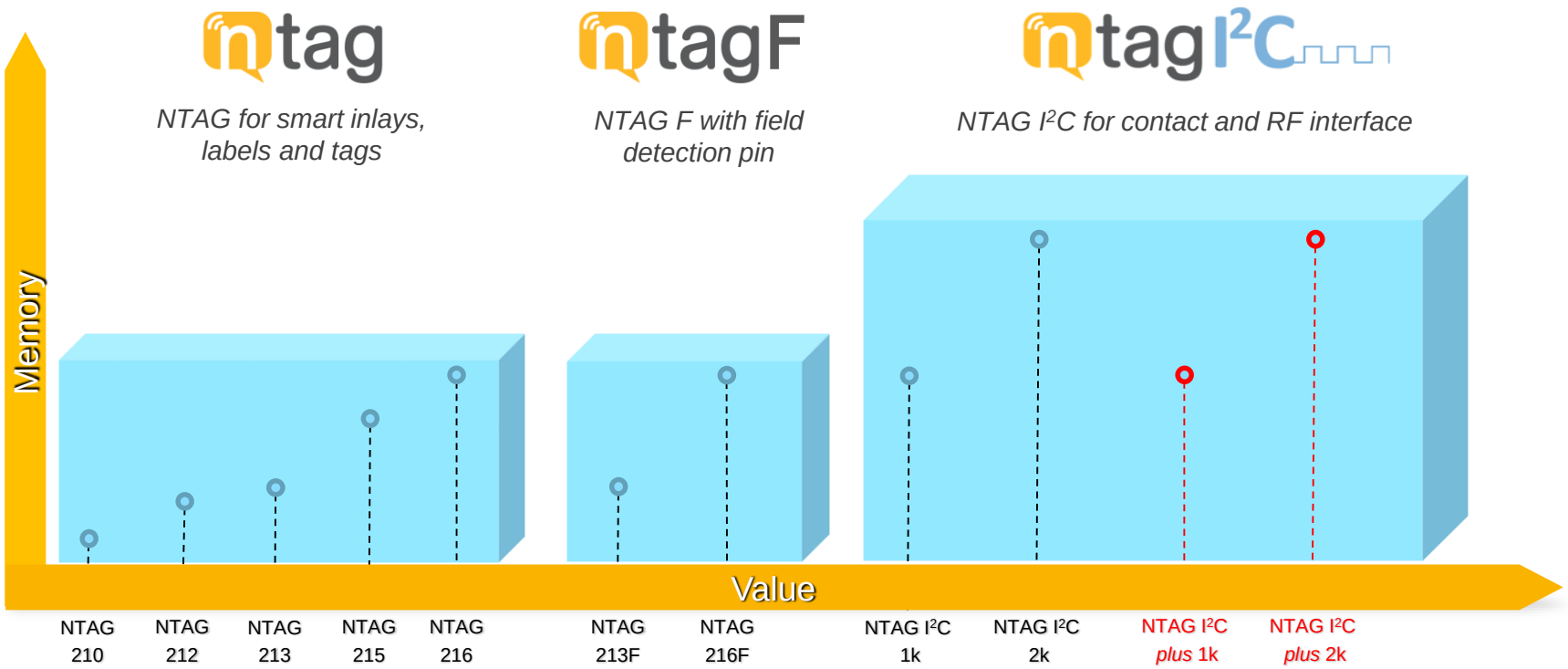
Benefits
- **NFC Forum-compliancy** allows interaction with mobile phones for online diagnostics & automatic ordering of consumables
- **I²C connected EEPROM** can be used to collect data without expensive display

CONSUMER ELECTRONICS

Benefits
- **NFC Forum-compliancy** allows interaction with mobile phones for smooth online registration & troubleshooting
- **I²C connected EEPROM** allows smooth and secure dynamic pairing

Positioning and NTAG portfolio

NTAG portfolio



NTAG I²C vs NTAG I²C *plus*

Feature	NTAG I²C	NTAG I²C *plus*	Comments
RF interface	ISO/IEC14443 2/3 NFC Forum Type 2 Tag compliant	ISO/IEC14443 2/3 NFC Forum Type 2 Tag compliant	
Contact interface	I²C (100 & 400 Khz)	I²C (100 & 400 Khz)	
Memory	888 / 1904 bytes	888 / 1912 bytes	
Energy harvesting	Yes	Yes	
Field detection pin	Yes	Yes	
Backward compatibility	No	**Yes**	**All new features are on top of NTAG I²C and backward compatible to NTAG 21x family**
Interoperability with NFC enabled devices	+	**+++**	**All features are accessible / useable via sector 0**
Memory access protection via RF interface	+	**+++**	**32 bit password for R/W access**
Memory access protection via I²C interface	No	**Yes**	**Restrict access to protected area to read-only or no access at all**
ECC based originality signature	No	**Yes**	**Genuine and simple authentication scheme**
Pass-through performance	+	**+++**	**Four times higher performance due to the introduced FAST_WRITE command**
Delivery form	XQFN8 / TSSOP8	XQFN8 / TSSOP8 **/ SO8**	**New SO8 package**
Temperature range	-40 ºC to 95 ºC	-40 ºC to **105 ºC**	**For industrial applications**

Memory structure and commands

Memory map from NFC perspective

Organization from NFC perspective

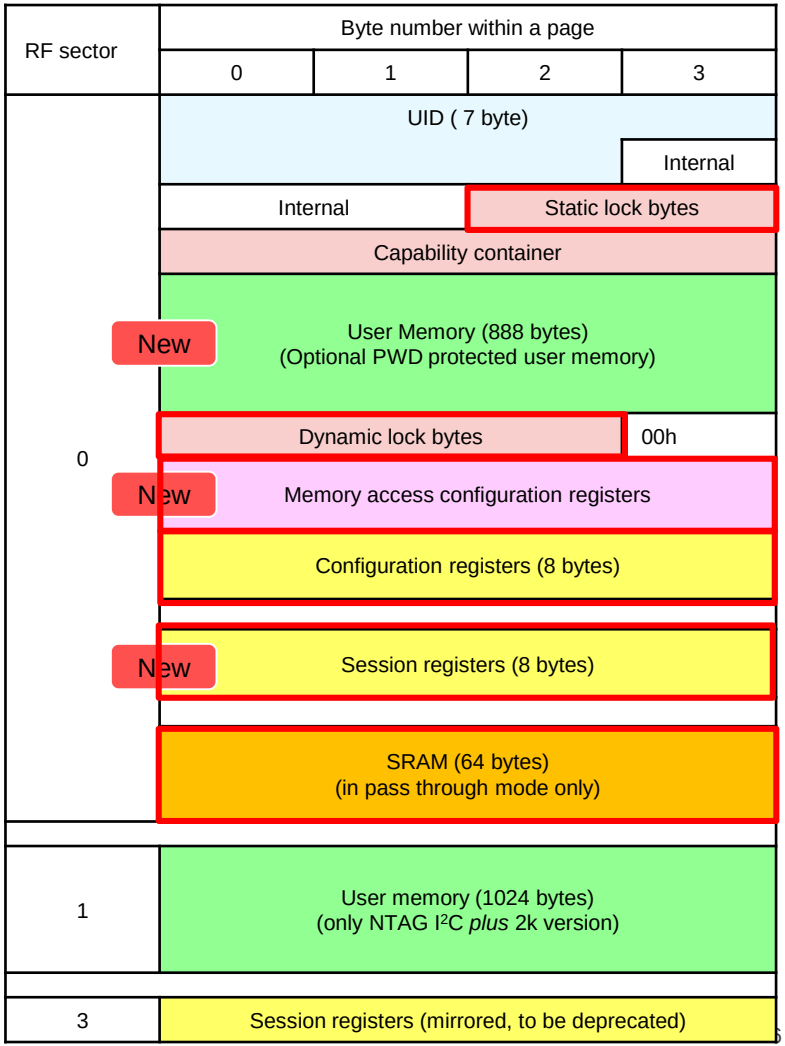
- **4 byte** per **page**
- **256 pages** per **sector**
  - NTAG I²C *plus* 1k: 1 sector of data (888 bytes of user memory)
  - NTAG I²C *plus* 2k: 2 sectors of data (1912 bytes of user memory)

SRAM

- **64 bytes** memory with unlimited endurance for data exchange or frequently changing data.

Special memory blocks

- **Static** and **dynamic lock bits** provide read-only locking mechanism.
- **Memory access bytes** can configure write or read/write password protected memory areas.
- **Configuration registers** bytes define power-up behavior
- **Session registers** bytes contain current configuration and status of the tag



Memory map from I²C interface

Organization from I²C perspective

- 16 byte per block page
- No sectors
- I²C addr is write-only; it is always read as 0x04

SRAM

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Special memory blocks

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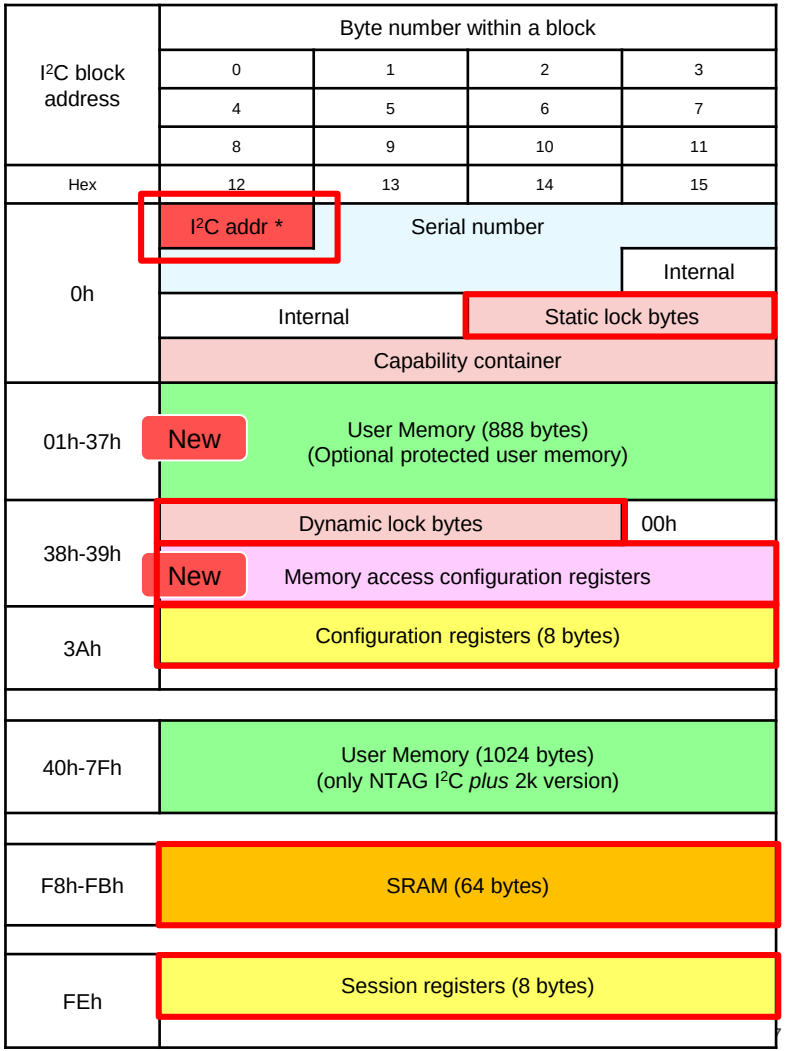


NTAG I²C *plus* - *RF commands*

- The RF-interface is based on the ISO/IEC 14443 Type A standard for contactless smart cards. All memory functions are operated in the ACTIVE state.

	NTAG I²C *plus*	Function
	NFC Forum command	
	Read	Read 16 bytes
	Write	Writes 4 bytes
	SECTOR SELECT	Select the memory sector
	Propietary (Need app)	
	GET VERSION	Identify the IC (Product type, memory size,etc)
	FAST READ	Read 16 bytes up to one complete memory sector
New	FAST_WRITE	Writes 64 bytes to SRAM (only pass through mode)
New	READ_SIG	Returns IC specific 32-byte ECC signature (NXP)
New	PWD_AUTH	Access to protected area (AUTH0, NFC_PROT- defines protection, AUTHLIM- unsuccessful attempts)

NTAG I²C *plus* - *I²C interface commands*

- NTAG I²C *plus* supports the I²C protocol for the contact interface communication.
- For accessing memory and registers there are two different commands
- Read / Write I²C memory operation
  - Access the EEPROM and SRAM
- Read / Write register operation
  - Access the session registers

NTAG I²C *plus*	Function
READ	Reads a EEPROM or SRAM block of 16 bytes
WRITE	Writes a EEPROM or SRAM block of 16 bytes
READ register	Reads a selected byte of session register data
WRITE register	Writes new register data

NTAG I²C *plus* key features

NTAG I²C *plus* key features

Field detection

- Configurable field-detection output signal for data transfer synchronization and device wake up

Energy harvesting

- Energy harvesting from the NFC field to power external devices

SRAM memory

- 64 bytes SRAM volatile memory without write endurance limitation

SRAM mirroring

- Mapping the SRAM memory into the user memory

Pass through mode

- For fast data exchange of large files via the SRAM buffer

Originality signature

- Originality signature based on ECC for simple genuine authentication

NFC silence mode

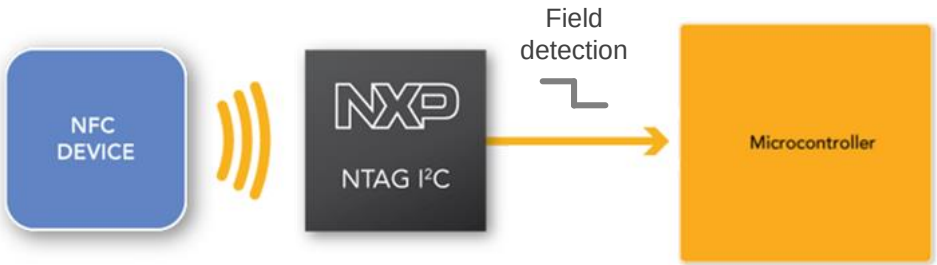
- NFC silence to disable NFC interface

Memory access management

- Memory access configuration from both the NFC and I²C interfaces.

Field detection - *Wake up connected devices*

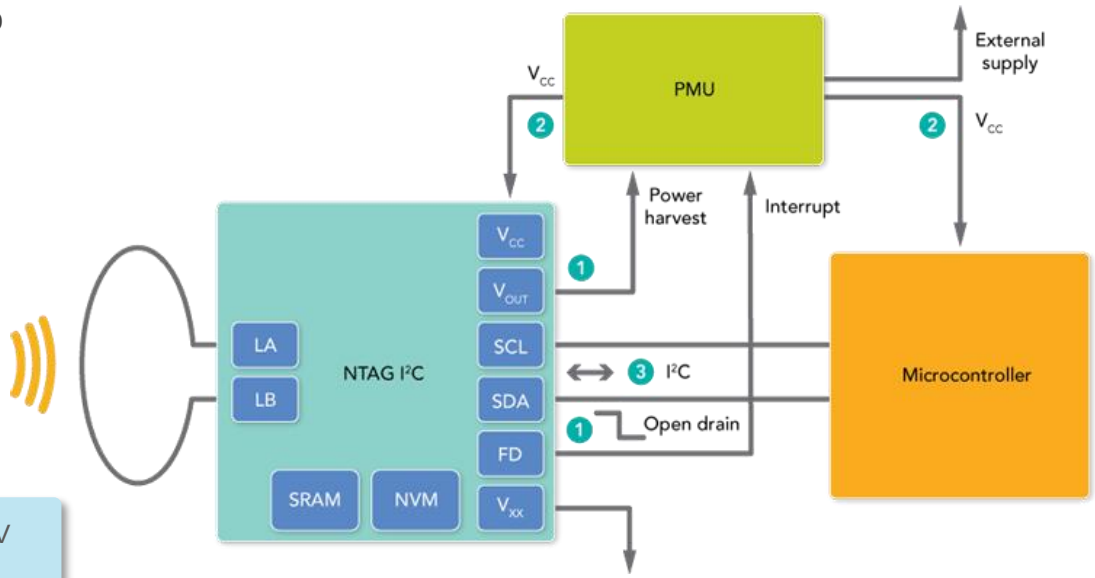
- The field detection provides the capability to trigger an external device or switch on the connected circuitry depending on activities on the NFC interface
- The conditions for the activation of the field detection signal can be:
  - The presence of the NFC field
  - The detection of a valid command (SoC)
  - The selection of the IC
- The conditions for the de-activation of the field detection signal can be:
  - The absence of the NFC field
  - The detection of the HALT state
  - The NFC interface has read the last part of the NDEF message
- The field detection can also be used as a handshake mechanism in the pass through mode to signal new data written in the SRAM.



Field detection is open drain →requires pullup resistor

Energy harvesting from the RF field – *Power a connected microcontroller*

- Generate current and voltage at the Vout pin to power external devices like a MCU from the energy harvested out of the RF field
- The voltage and current harvested depend on various parameters such as:
  - Field strenght generated by the reader
  - The tag antena size
  - The distance from the NFC device
- Power up can be controlled by Field detection for further power management optimization



Class 5 antenna with NFC reader
[2-3]V @ [1-7]mA

NTAG I²C *plus* typically provides 5mA at 2V on the Vout pin with an NFC phone

NFC phone vs NFC reader, also large spread from NFC phones to NFC phones

SRAM memory - *for frequently changing data*

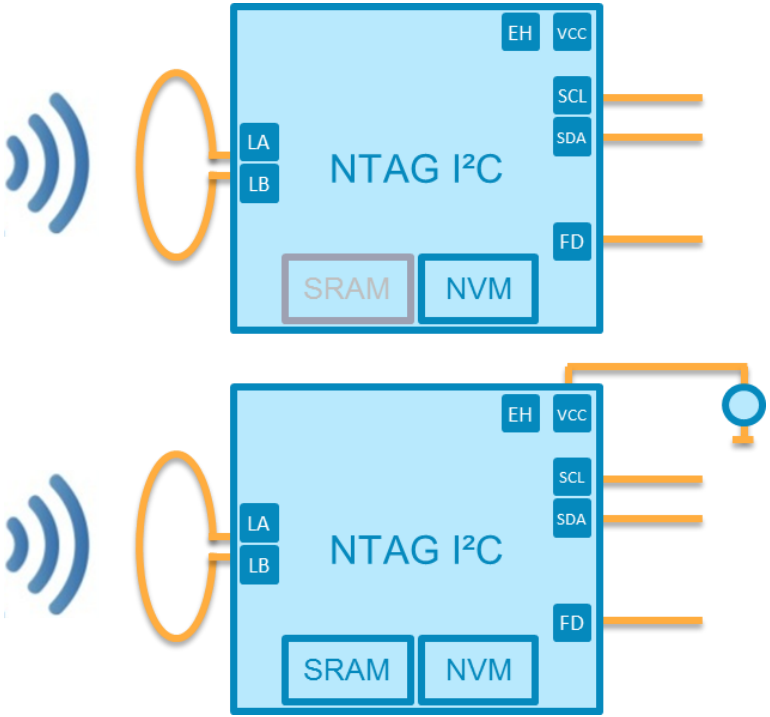
- SRAM is a 64 bytes volatile memory with unlimited endurance
- The SRAM is only available if the tag is powered via the VCC pin
  - Otherwise, tag operates as a normal Type 2 tag with EEPROM memory

From the NFC interface

- SRAM is accessible only in:
  - ***Pass-through mode***: Mirrored to the fixed address F0h to FFh in the first memory sector
  - ***SRAM mirroring*** onto the EEPROM memory space: pages 01h to 74h

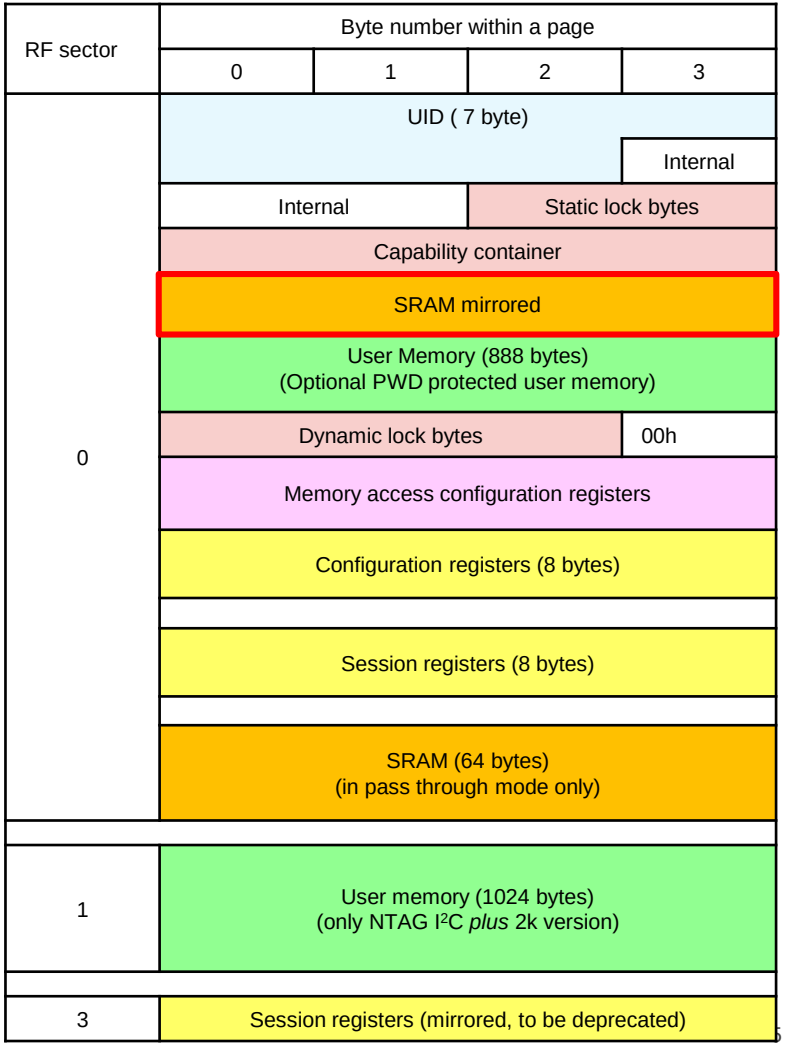
From the I²C interface

- SRAM is always accesible
- Located at addresses F8h to FBh



SRAM mirroring
for dynamic data update

- The SRAM can be mirrored into the user memory
  - Behaves like an overlay, each read and write from RF to those addresses is not executed on the underlying EEPROM, but on the SRAM
  - EEPROM content is not influenced
- Address is given by SRAM_MIRROR_BLOCK register
  - Only addresses with valid user memory are available
- Use case:
  - Dynamic update of e.g: pairing information (write a new key every second)
- Hints:
  - The mirroring is only effective for the RF side, I²C has to use the fixed SRAM address (F8h to FBh).
  - Not compatible with pass-through mode



Pass through mode – *for fast data exchange of large files*

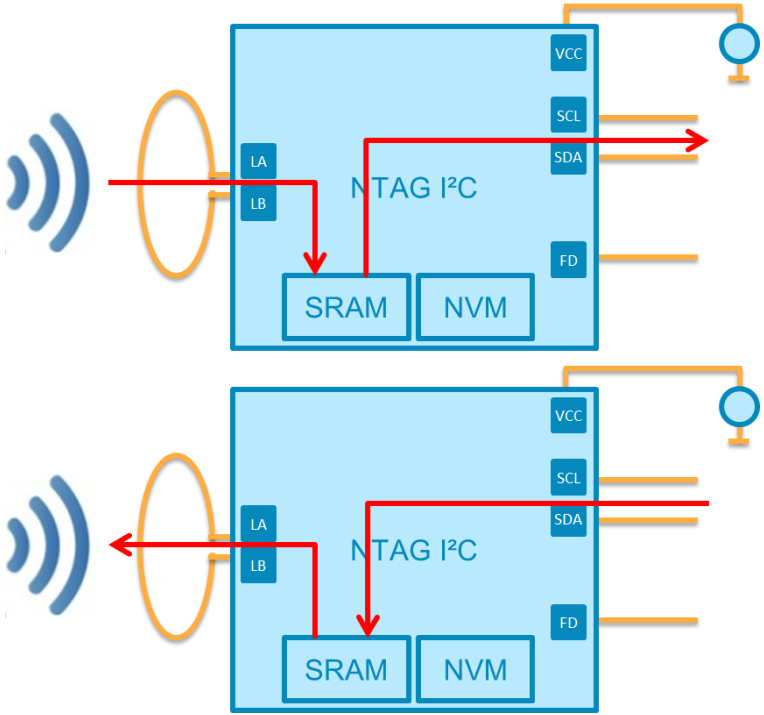
- Pass through mode transfers data from one interface to the other via the 64 byte SRAM saving EEPROM cycles.
- Can be combined with FAST READ and FAST WRITE commands to R/W full SRAM buffer at once
  - NTAG I²C *plus* can achieve 4 times higher throughput compared to NTAG I²C (~8 KBps)
- Data flow synchronization is based on interrupt signal and register settings

<u>RF to I²C data exchange use cases:</u>

- Phone writes data (e.g. configuration) into µC, µC-Firmware update

<u>I²C to RF data exchange use cases:</u>

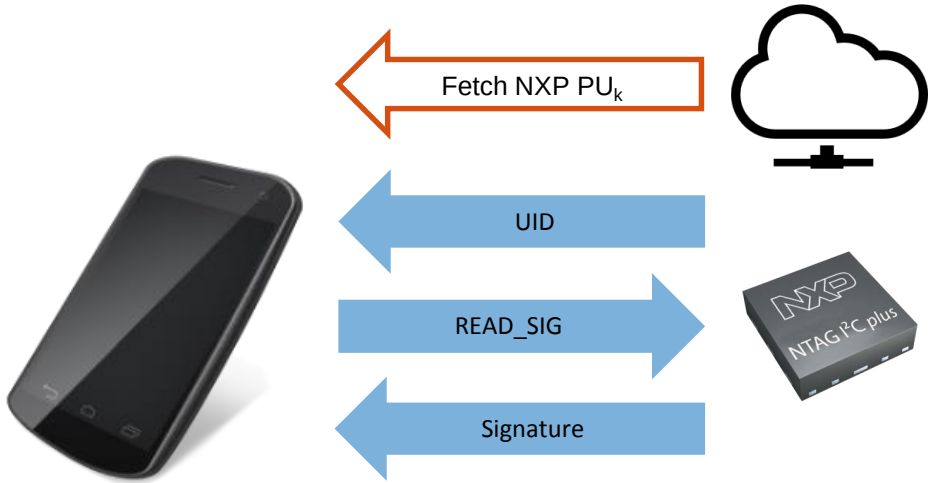
- Download of logging-Data, Service Information, Error descriptions



AN11579 – How to use the NTAG I²C *plus* for bidirectional communication

Originality signature – *to detect cloned tags*

- NTAG I²C *plus* features a cryptographically supported originality check using a digital signature based on standard Elliptic Curve Cryptography (ECC).
- Die individual
  - Each NTAG I²C *plus* UID is signed with an NXP private key and the resulting 32-byte signature is stored in a hidden part of the NTAG I²C *plus* memory during IC production
- This signature can be retrieved using the READ_SIG command and can be verified in the NFC device by using the corresponding ECC public key provided by NXP.



Details on how to check the signature are provided in AN11350

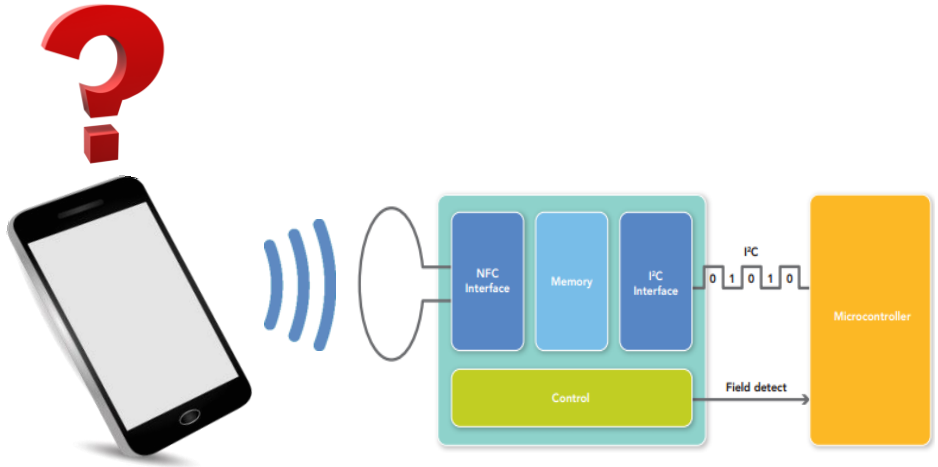
For large orders, NXP can provide a customer specific signature

$$VERIFY = f_2(SIG, UID, Pu_K)$$

$$SIG = f_1(UID, Pr_K)$$

NFC silence – *to hide the tag presence*

- The NFC silence feature disables the demodulator and disables all tag reactions on RF commands
- Allows the tag to “disappear” event if it is still in the reader field.
  - It cannot be read and cannot be detected by a reader



Usage:

- Hide tag presence if the accessory is not able to be powered (battery empty), to avoid confusing the user
- “Privacy” mode to control field detection trigger

Memory access management 

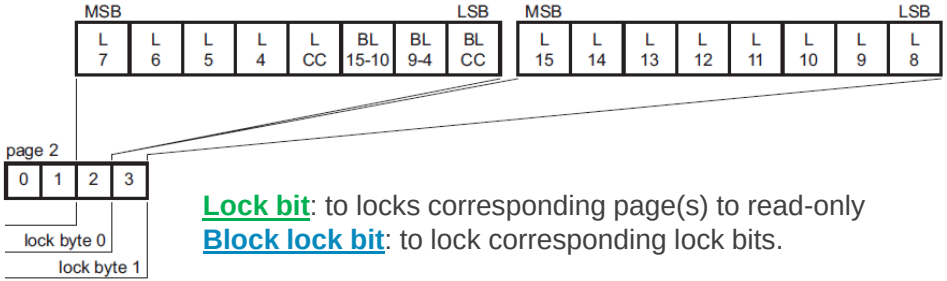
- Static lock bytes

- Dynamic lock bytes

- Memory access protection from NFC and I^2C interfaces

Static lock bytes

- According to NFC Forum Type 2 Tag specification, the bits of byte 2 and byte 3 of page 02h (via NFC) represent the field programmable read-only locking mechanism for pages 03h to 0Fh.



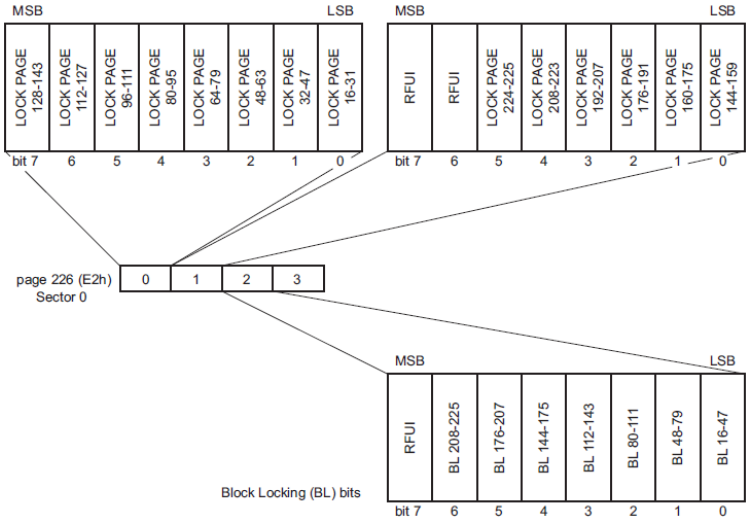
Lock bit: to locks corresponding page(s) to read-only
Block lock bit: to lock corresponding lock bits.

I²C interface keeps read / write access.

RF sector	Byte number within a page			
	0	1	2	3
0	UID (7 byte)			
				Internal
	Internal		Static lock bytes	
	Capability container			
Lock Pages 03h - 0Fh)	User Memory (888 bytes) (Optional PWD protected user memory)			
	Dynamic lock bytes			00h
	Memory access configuration registers			
	Configuration registers (8 bytes)			
	Session registers (8 bytes)			
	SRAM (64 bytes) (in pass through mode only)			
1	User memory (1024 bytes) (only NTAG I²C *plus* 2k version)			
3	Session registers (mirrored, to be deprecated)			

Dynamic lock bytes

- Dynamic lock bytes are the read-only mechanism from page address 16 and onwards
- Granularity of 16 pages for NTAG I²C *plus* 1k and 32 pages for NTAG I²C *plus* 2K.



RF sector	Byte number within a page			
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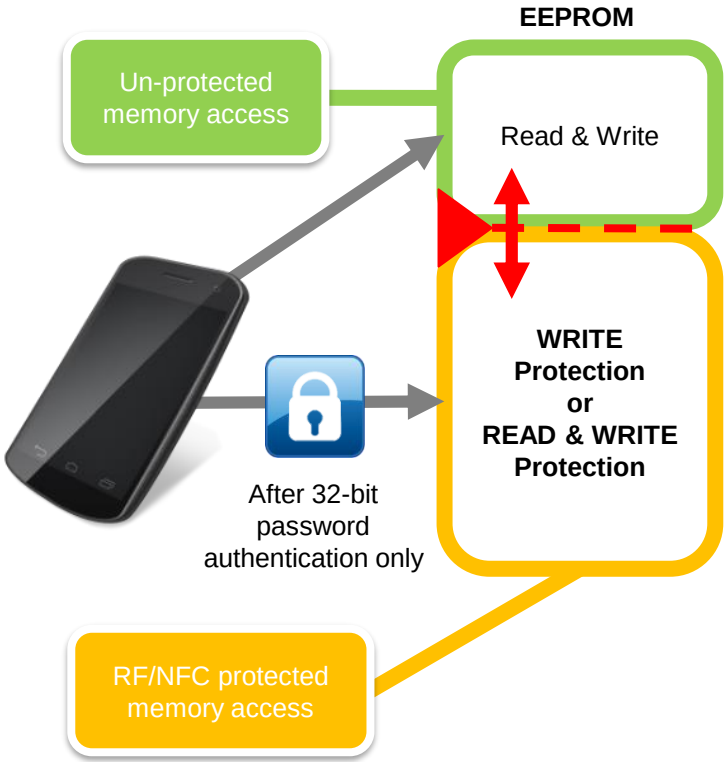
	SRAM (64 bytes) (in pass through mode only)			
1	User memory (1024 bytes) (only NTAG I²C *plus* 2k version)			
3	Session registers (mirrored, to be deprecated)			

Lock Pages 10h - FFh)

Memory access configuration– *from RF/NFC interface*

- 32-bit password
- 16-bit PACK (password auth. acknowledge response)
- Optionally limited number of unsuccessful authentications
  - up to 27 negative attempts
- Write or read/write memory access can be restricted to be allowed only after password authentication
- Memory can be split in open and protected segments
  - Memory boundary is configurable

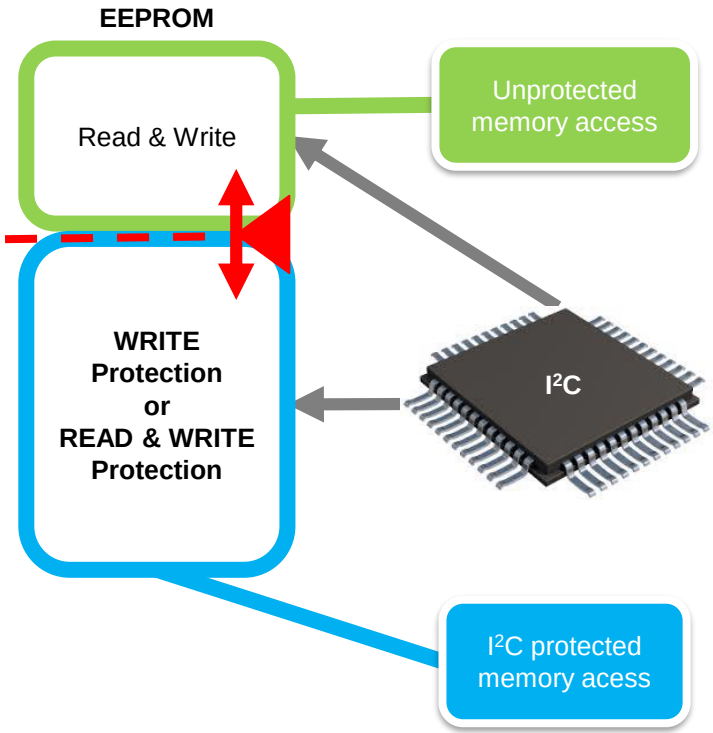
NFC page address (Sector 0)		Byte number from NFC perspective			
Dec	**Hex**	**0**	**1**	**2**	**3**
227	E3h	RFU	RFU	RFU	AUTH0
228	E4h	ACCESS	RFU	RFU	RFU
229	E5h	PWD			
230	E6h	PACK		RFU	RFU
231	E7h	PT_I2C	RFU	RFU	RFU



Memory access configuration– *from I²C interface*

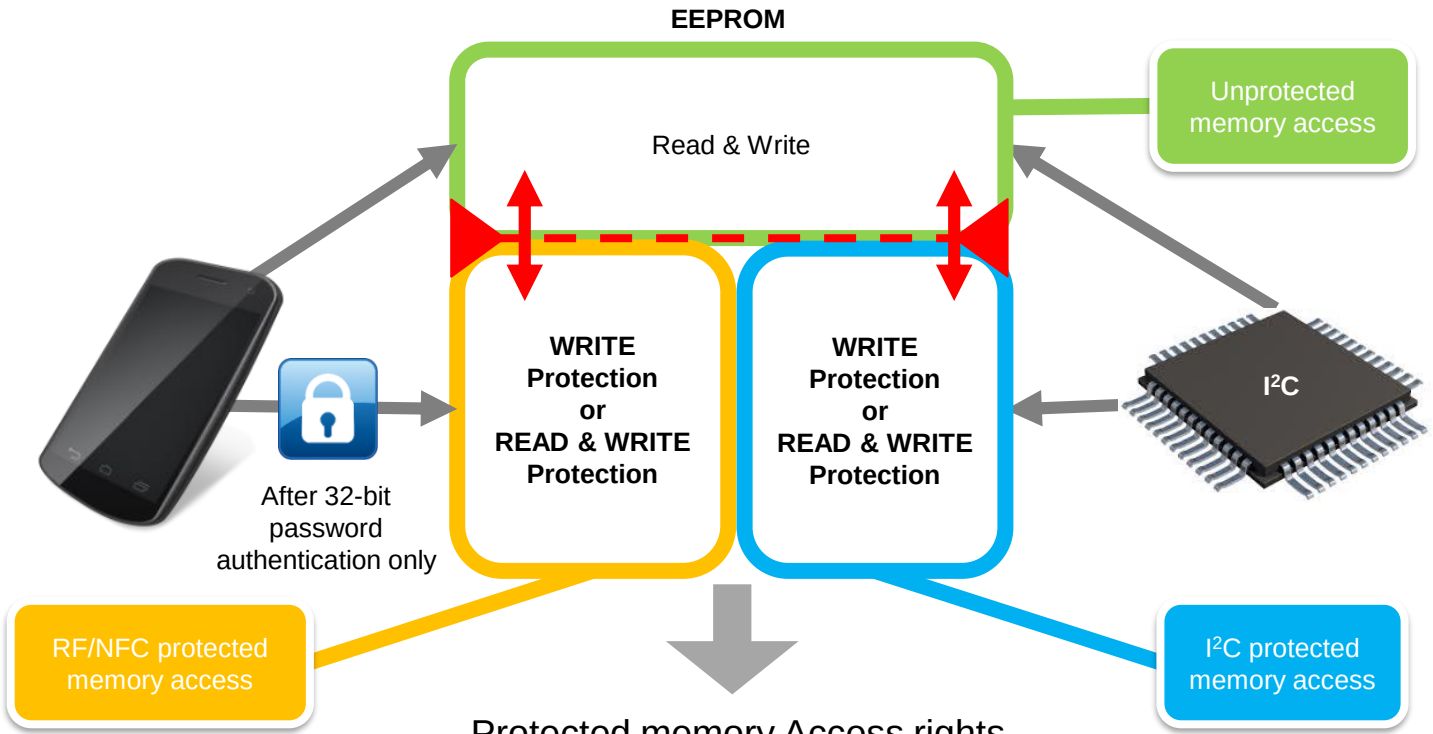
- Different settings possible (via configuration bits)
  - Entire memory accessible from I²C
  - R/W to Unprotected user area, R only to protected area
  - R/W to unprotected area, NAK to protected area
- Note: I²C has always R/W access to:
  - Session registers
  - SRAM buffer
  - Configuration pages including Password Configuration area (but can be locked via one configuration bit)

I²C block address		Byte number from NFC perspective			
Dec	Hex	0	1	2	3
56	38h	RFU	RFU	RFU	AUTH0
57	39h	ACCESS	RFU	RFU	RFU
		PWD			
		PACK		RFU	RFU
		PT_I2C	RFU	RFU	RFU



Memory access configuration

Data protection for both RF and I²C address



NTAG I²C *plus* offers a flexible memory access management

Memory area	RF		I²C	
	Read access	Write access	Read access	Write access
Serial Number	Yes	-	Yes	I²C Address *
Lock bytes / CC	Yes	Yes (OTP, lockable)	Yes	Yes
User Memory	Yes (PWD protection)	Yes (Lockable, PWD protection)	Yes (I2C_PROT)	Yes (I2C_PROT)
Configuration bytes & memory access bytes	Yes (PWD protection)	Yes (Lockable, PWD protection)	Yes	Yes (REG_LOCK_I2C)
SRAM	Yes (PWD protection)	Yes (PWD protection)	Yes	Yes
Session registers	Yes	-	Yes	Yes

* I²C address on block 0 byte only writable but not readable

NTAG I²C *plus* demo kit and product support package

NTAG I²C *plus* Explorer kit demokit and variants

OM5569 / NT322(X)

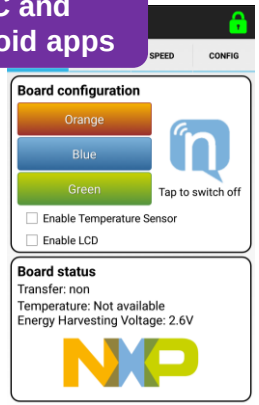
- NTAG I²C Explorer board
  - LPC11U24 MCU
  - NTAG I2C *plus* tag chip interface connector
  - JTAG/SWD connector
  - RGB LED
  - Temperature sensor LM75B
  - Micro USB connector
  - Five push button controls
  - Voltage monitors
  - LCD display
- NTAG I²C antenna board:
  - Only NTAG I²C *plus* connected to antenna (Class 5)
  - Can be connected to demoboard or any I²C interface
- NFC Reader:
  - Identiv uTrust CLOUD 3700F

Demokit name	Contents
OM5569 / NT322**E**	NTAG I²C *plus* Explorer kit with Field Detector Board, flex antenna and SO8 samples
OM5569 / NT322**ER**	NTAG I²C *plus* Explorer kit with Field Detector Board, flex antenna, NFC reader and SO8 samples
OM5569 / NT322**F**	NTAG I²C *plus* Flex Antenna kit with 3 different flex antennas only and SO8 samples

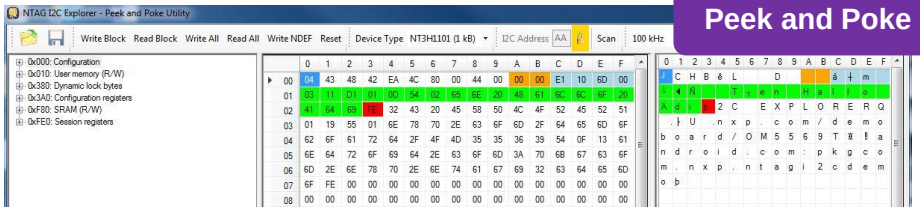
NTAG I²C *plus* support tools and SW

- PC software:
  - PC App for Explorer board
  - Peek and Poke
  - RFIDDiscover
- Android:
  - NTAG I²C demo app
  - MIFARE SDK
- NTAG I²C Explorer board firmware
  - NTAG I²C Explorer bootloader
  - NTAG I²C Explorer demo
  - NTAG I²C Explorer blink

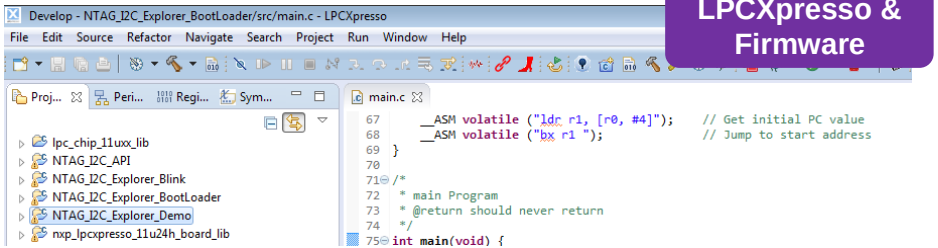
PC and Android apps



Peek and Poke

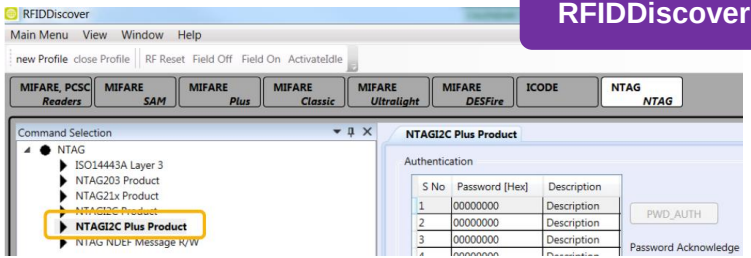


LPCXpresso & Firmware



Android library

RFIDDiscover



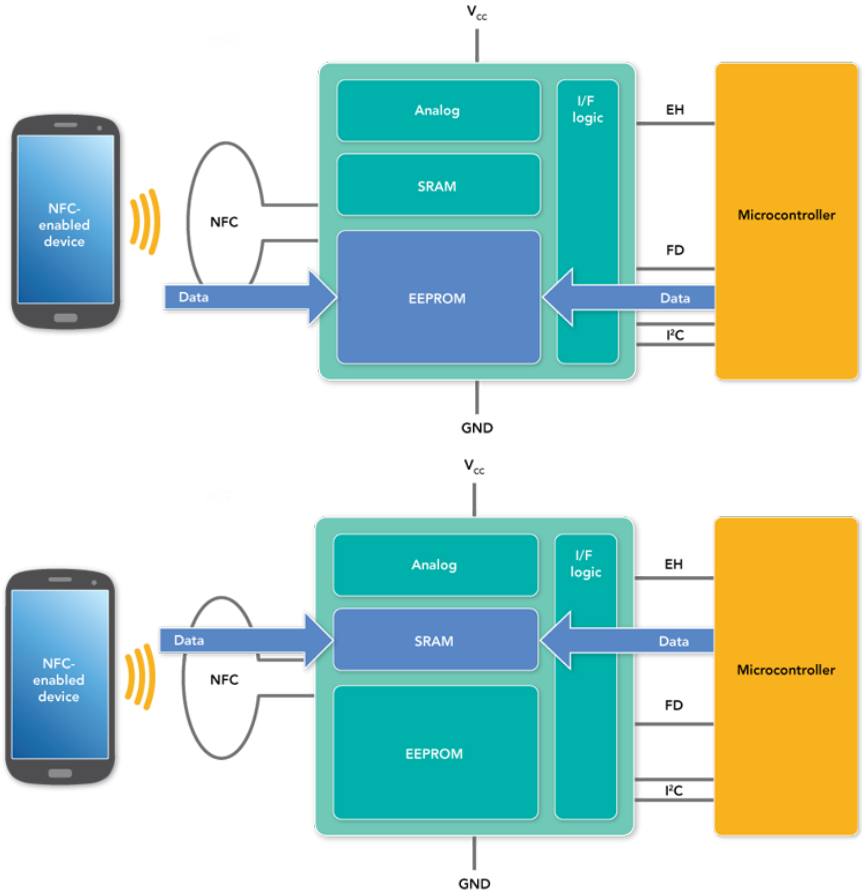
NTAG I²C *plus* support documentation

Material	Link
Application notes	
NTAG Antenna Design Guide	AN11276
NTAG21x Originality Signature Validation	AN11350
NTAG I²C Energy Harvesting	AN11578
How to use NTAG I²C (*plus*) for bidirectional communication	AN11579
NTAG I²C *plus* Memory Configuration Options	AN11786
User guides	
NTAG I²C *plus* Explorer Kit and Android Demo	UM10966
NTAG I²C *plus* Explorer Kit and Peek & Poke	UM10967
Datasheet	
NT3H211 / NT3H2211	Download
Source files	
Android app (Eclipse project) source	Download
PC app (C# Visual Studio) source	Download
Peek and Poke sources	Download
Firmware for Explorer board sources	Download

Final remarks

Data exchange possibilities between I²C and NFC

- EEPROM (Passive / static mode)
  - Write NDEF to EEPROM
  - Synchronization: None, Timing or NDEF Read bit
  - Usage: Near static information which changes infrequently (e.g. **WIFI Pairing info**)
- SRAM / Pass-through Mode (Device powered mode)
  - Write Data to SRAM (any format)
  - Synchronization: Registers, Timing, FD Pin
  - Usage: Down/upload of data, data exchange which should leave no traces in EEPROM (**passwords**)
- SRAM / Mirror Mode
  - Write NDEF to EEPROM, but have SRAM mapped over area with dynamic content
  - Synchronization: None, Timing or NDEF Read bit
  - Usage: Often changing data e.g. every second (**smart meter value**)



NTAG I²C *plus* in a nutshell

The simplest & lowest BoM NFC solution

- Low Bill of Material
- Password authentication and originality signature
- Energy harvesting and field detection
- Full interoperability: NFC Forum and ISO/IEC 14443 compliant
- NTAG I²C *plus* Explorer Kit with design and software sources

Ordering information and samples

NTAG I²C *plus* ordering info

Part number	12NCs	Package	Delivery form	MOQ
NT3H2111W0FTT (1k)	9353 069 32118	TSSOP8	Tape&reel	2.5kpcs
NT3H2211W0FTT (2k)	9353 069 33118	TSSOP8	Tape&reel	2.5kpcs
NT3H2111W0FT1 (1k)	9353 070 09115	SO8	Tape&reel	500pcs
NT3H2211W0FT1 (2k)	9353 070 16115	SO8	Tape&reel	500pcs
NT3H2111W0FHK (1k)	9353 069 39125	XQFN8	Tape&reel	4kpcs
NT3H2211W0FHK (2k)	9353 069 43125	XQFN8	Tape&reel	4kpcs

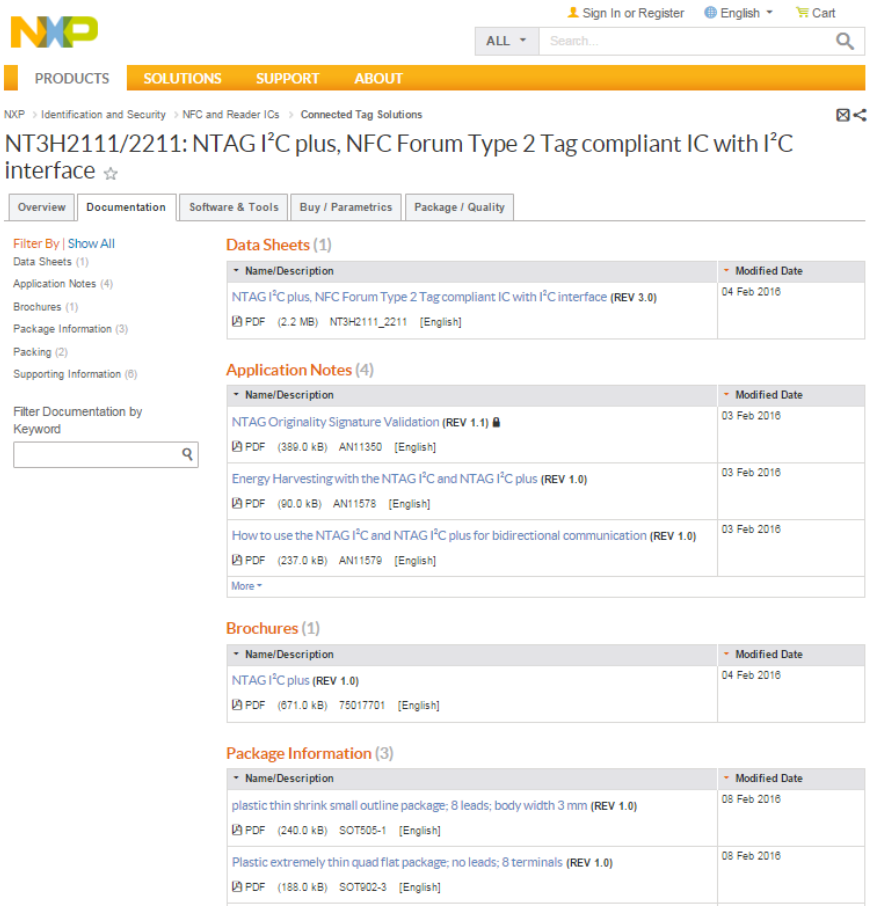
NTAG I²C *plus* development kit

Part number	12NCs	Description	Price
OM5569/NT322E	9353 078 49699	Explorer kit	19,99$
OM5569/NT322ER	9353 078 48699	Explorer kit + USB NFC reader	49,99$
OM5569/NT322F	Only available end of April		9,99$

Do you need more?

Resources and useful links

- NFC Everywhere
  http://www.nxp.com/products/identification-and-security/nfc-and-reader-ics/nfc-everywhere:NFC-TECHNOLOGY
- NFC Everywhere support page
  http://www.nxp.com/techzones/nfc-zone/community.html
- NTAG I²C *plus* product website
  http://www.nxp.com/products/identification-and-security/nfc-and-reader-ics/connected-tag-solutions/ntag-ic-plus-nfc-forum-type-2-tag-compliant-ic-with-ic-interface:NT3H2111_2211
- OM5569/NT322 demokit website
  http://www.nxp.com/products/identification-and-security/nfc-and-reader-ics/connected-tag-solutions/ntag-ic-iplus-i-explorer-kit:OM5569-NT322E
- NXP Tech community
  http://nxpcommunity.force.com/community/CommunityOverview



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Thank you for your attention

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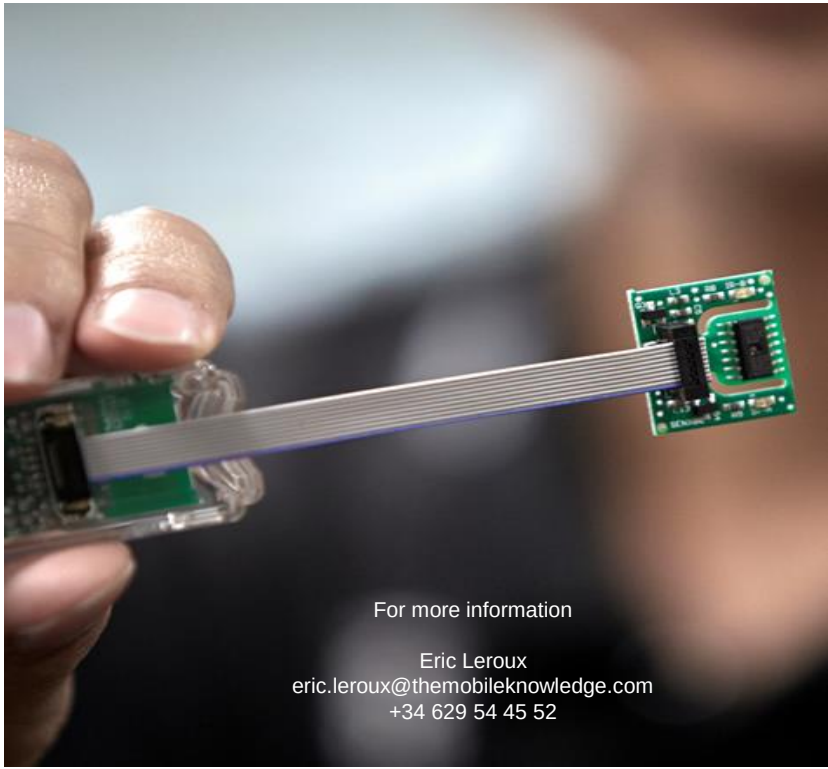
- We are a global competence team of hardware and software technical experts in all areas related to contactless technologies and applications.

- Our services include:
  - Application and system Design Engineering support
  - Project Management
  - Technological Consulting
  - Advanced Technical Training services

- We address all the exploding identification technologies that include NFC, secure micro-controllers for smart cards and mobile applications, reader ICs, smart tags and labels, MIFARE family and authentication devices.



NXP Training Mobile Knowledge

NTAG I²C *plus* – Your entryway to NFC

Jordi Jofre (Speaker) / Eric Leroux (Host)

Thank you for your kind attention!

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- Please check NXP and MobileKnowledge websites for upcoming webinars and training sessions

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