

# UM10966

## NTAG I<sup>2</sup>C *plus* Explorer Kit and Android Demo

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User manual  
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### Document information

Info	Content
<b>Keywords</b>	NTAG I <sup>2</sup> C <i>plus</i> , Explorer Kit, Android, NFC tag
<b>Abstract</b>	This User Manual aims at describing the functionalities and how to use the Android and PC application of the NTAG I <sup>2</sup> C <i>plus</i> Explorer kit. Both applications provide exactly the same functionality and have the same look and feel so this User Manual is valid for both.



## Revision history

Rev	Date	Description
1.0	20160216	First release

## Contact information

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

## 1. Object

NTAG I<sup>2</sup>C *plus* Explorer kit is an all-in-one demonstration and development resource to demonstrate the unique properties of the NTAG I<sup>2</sup>C *plus* tag chip. By including a full complement of hardware and software tools, users can not only investigate the capabilities of the chip through the various demonstrations, but also develop and test their own applications (additional LPC-Link2 debug probe<sup>1</sup>).

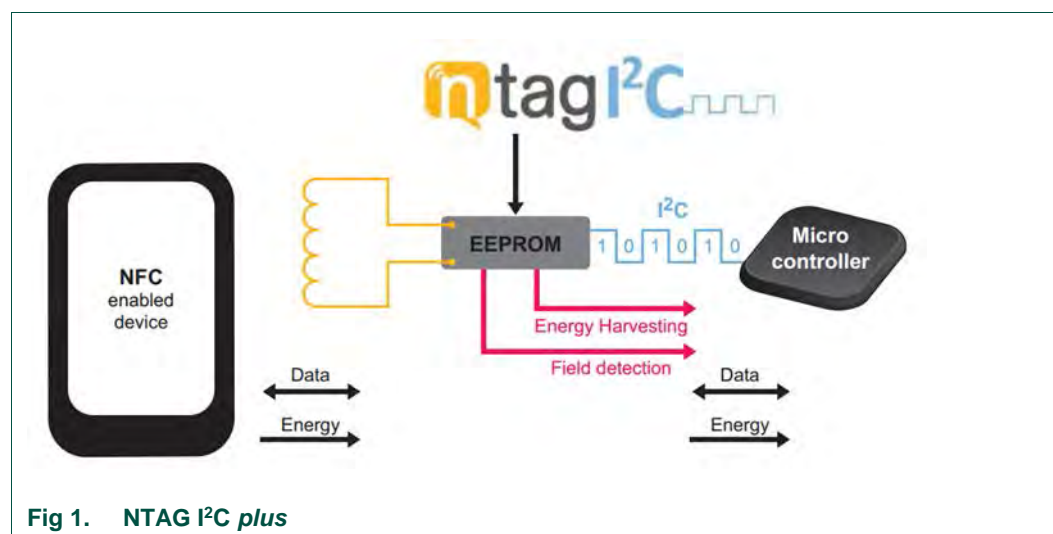
This User Manual explains how to use the NTAG I<sup>2</sup>C *plus* demo application for Android. The Windows app is not detailed in this User Manual since it provides identical functionalities as the Android app, therefore the same User Manual is valid.

Technical aspects related to the IC functioning (i.e. the configuration registers) are beyond the scope of this document. In order to get further technical details please consult the dedicated Datasheet “NTAG I<sup>2</sup>C *plus*, NFC Forum type 2 Tag compliant IC with I<sup>2</sup>C interface” (refer to [\[NTAGI2Cplus\]](#)).

## 2. NTAG I<sup>2</sup>C *plus* introduction

The NTAG I<sup>2</sup>C *plus* is the first product of NXP's NTAG family offering both contactless and contact interfaces. In addition to the passive NFC Forum compliant RF interface, the NTAG I<sup>2</sup>C *plus* product provides an I<sup>2</sup>C interface that allows the IC to communicate with the microcontroller when the chip is powered by an external device, i.e. a mobile phone.

The NTAG I<sup>2</sup>C *plus* operating in energy harvesting mode provides the possibility to supply external low power devices (e.g. microcontrollers) with the energy generated from the RF field of the external NFC device.



The NTAG I<sup>2</sup>C *plus* product has two types of memories:

1. EEPROM memory compliant with the NFC Forum Type 2 Tag implementation.

<sup>1</sup> <https://www.lpcware.com/lpcLink2>

2. 64-byte SRAM memory, which is mapped with the EEPROM memory and is externally powered.

The NTAG I<sup>2</sup>C *plus* features a Pass-Through mode that allows fast download and upload of data from the RF interface to the I<sup>2</sup>C interface and vice versa. This functionality makes use of the SRAM memory that allows fast data transfer between interfaces without the EEPROM performance limitations.

In addition to the I<sup>2</sup>C interface functionality, the NTAG I<sup>2</sup>C *plus* product features a Field Detection Pin for waking up the host-connected devices or synchronizing the data transfer between the two interfaces.

The NTAG I<sup>2</sup>C *plus* offers the possibility to protect the memory access. This protection is done by authenticating the tag with a password. When the tag is protected it is needed to be authenticated in order to connect to the memory. The NTAG I<sup>2</sup>C *plus* also improves the speed when writing into the SRAM memory.

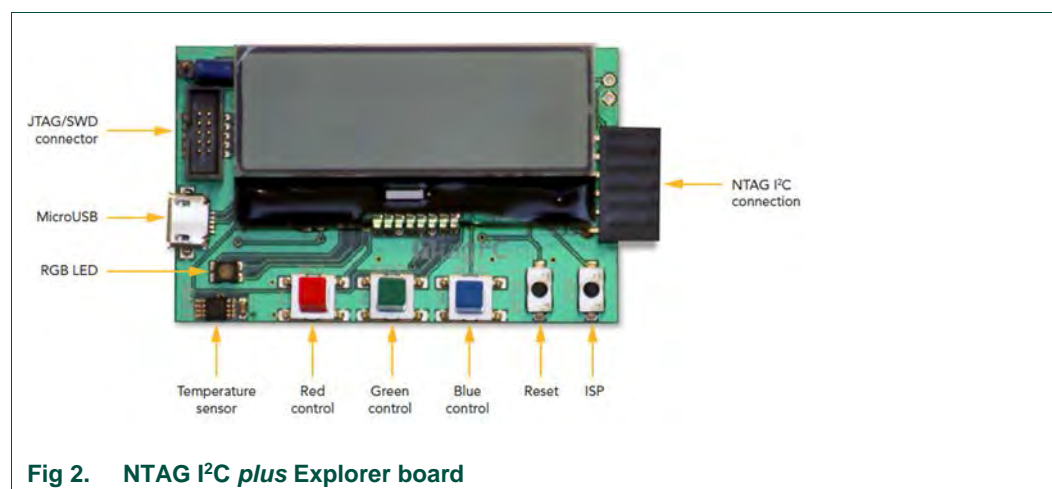
### 3. NTAG I<sup>2</sup>C *plus* Explorer kit contents

The NTAG I<sup>2</sup>C *plus* Explorer kit (NEK) consists of hardware and software tools that developers can use to understand the NXP NTAG I<sup>2</sup>C *plus* tag chip functionality and demonstrate its potential for other application. The kit includes:

#### 3.1 Hardware components

##### 3.1.1 NTAG I<sup>2</sup>C *plus* Explorer board

A hardware board based on the NXP LPC 11U24 microcontroller, with on-board LCD display, NXP LM75B temperature sensor, voltage monitors, I<sup>2</sup>C serial bus connector, JTAG/SWD debug connector, RGB LED micro USB connector and five push button controls.



##### 3.1.2 Antenna board

The antenna board carries the NTAG I<sup>2</sup>C *plus* 1k version itself and provides two interfaces:



3. In the details pane, double-click **Windows Components**, and then double-click **Smart Card**.
4. Right-click **Turn on Smart Card Plug and Play service**, and then click **Edit**.
5. Click **Disabled**, and then click **OK**.
6. Click **Start**, type regedit in the **Search programs and files** box, and then press ENTER.
7. Go through the tree key, on the left, up to the key **HKEY\_LOCAL\_MACHINE \ Software \ Microsoft \ Cryptography \ Calais**.
8. Add a new DWORD value named CardDisconnectPowerDownDelay and set its value to 0.
9. Click **Start**, type services.msc in the **Search programs and files** box, and then press ENTER.
10. Find the smart card service in the list, right-click and click Restart.

## 3.2 Software components

### 3.2.1 NTAG I<sup>2</sup>C *plus* Explorer board firmware

The firmware runs on the NTAG I<sup>2</sup>C *plus* Explorer board and is flashed during production at the MCU which supports the demonstration functionality of the hardware. The delivered NTAG I<sup>2</sup>C *plus* Explorer board firmware consists of three applications:

- **NTAG\_I<sup>2</sup>C\_Explorer\_Bootloader**: This project implements the secondary bootloader application. It is flashed at on-chip memory address starting at 0x0000 0000 and it is the first application to be executed after the MCU boots. This application has three functions:
  - Jump to the start memory of the user application.
  - Enter into Flashing mode functionality.
  - Enter into USB mode (Peek and Poke).
- **NTAG\_I<sup>2</sup>C\_Explorer\_Demo**: This project implements the logic supporting the Android / Windows demonstration applications. It is flashed at on-chip flash memory starting at 0x0000 4000 address and it is executed after the bootloader jumps to the application start address.
- **NTAG\_I<sup>2</sup>C\_Explorer\_Blink**: This is a sample project that sets into blinking mode the NTAG\_I<sup>2</sup>C Explorer board as soon as the RF field is detected. This application is provided to illustrate the NFC flashing functionality and its binary image is provided embedded by default into the Android app (see Section 4.5).

### 3.2.2 Android app

The demo application on an Android NFC phone ("NFC mobile") showcasing the various features of the NTAG I<sup>2</sup>C *plus*. This software component is available for download from the public NXP website as well as at Google Play.

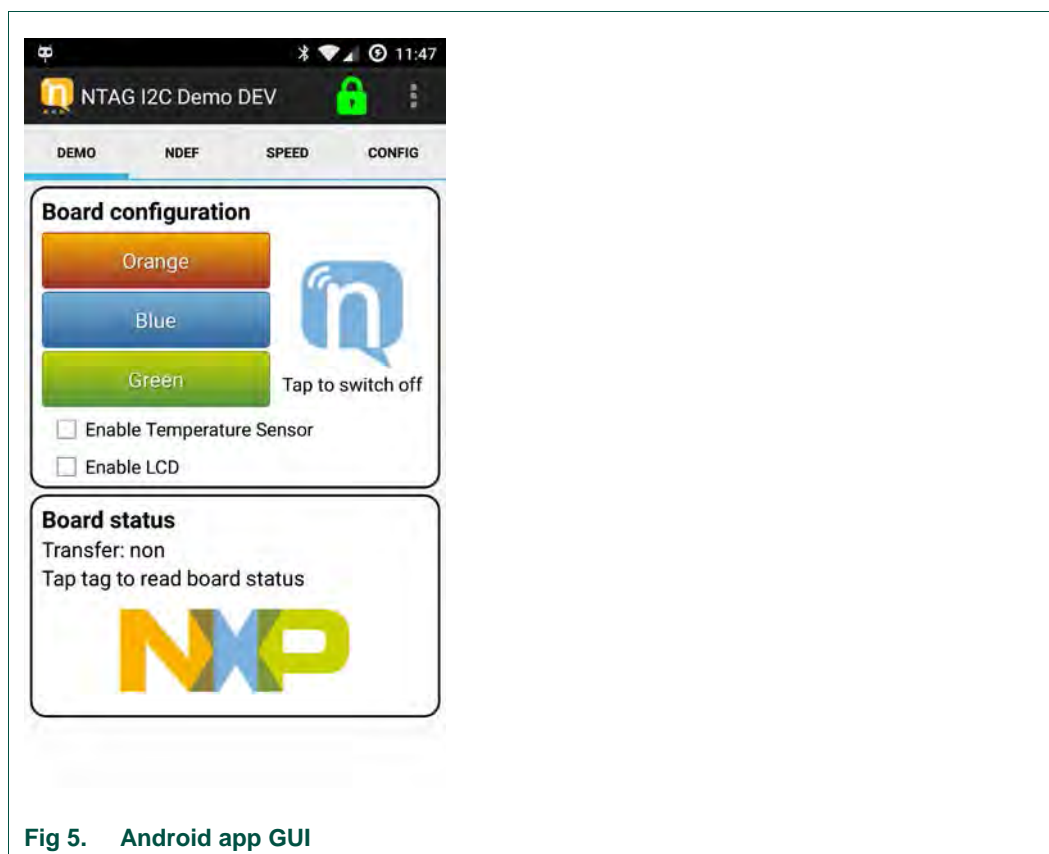


Fig 5. Android app GUI

**Note:** The UM10966 describes in detail how to get started with the Android app tool and the different functionalities it offers.

### 3.2.3 Windows app

Together with the USB reader, the Windows app can be utilized to substitute a missing NFC mobile phone. The Windows app has similar functionalities as the Android app. This software component is available as a download from the public NXP website. The software will include a setup file which will install the Windows App in the folder 'Program files/NXP Semiconductors', this installation process will create a shortcut to the Windows App. No further procedure is required to run this application.

There are some points to take into account when using the Windows App, since it is connected to an external reader via USB. There are sometimes issues with the connection between the reader and the tag, which may get lost. On these cases, it is recommended to reboot the app.

When performing an operation while the tag is blocked and authenticated, after untapping and tapping again the tag, a warning message will be displayed. When the user untaps the tag, the authentication is lost. This warning will guide the user to go to the main screen, the Led Demo tab. Once on the Led Demo tab and the tag out of the reader, it is allowed to tap again. Then the authentication window will be prompted to ask the user for the password.

If the tag is not blocked or it is not a Plus tag, no authentication is needed.

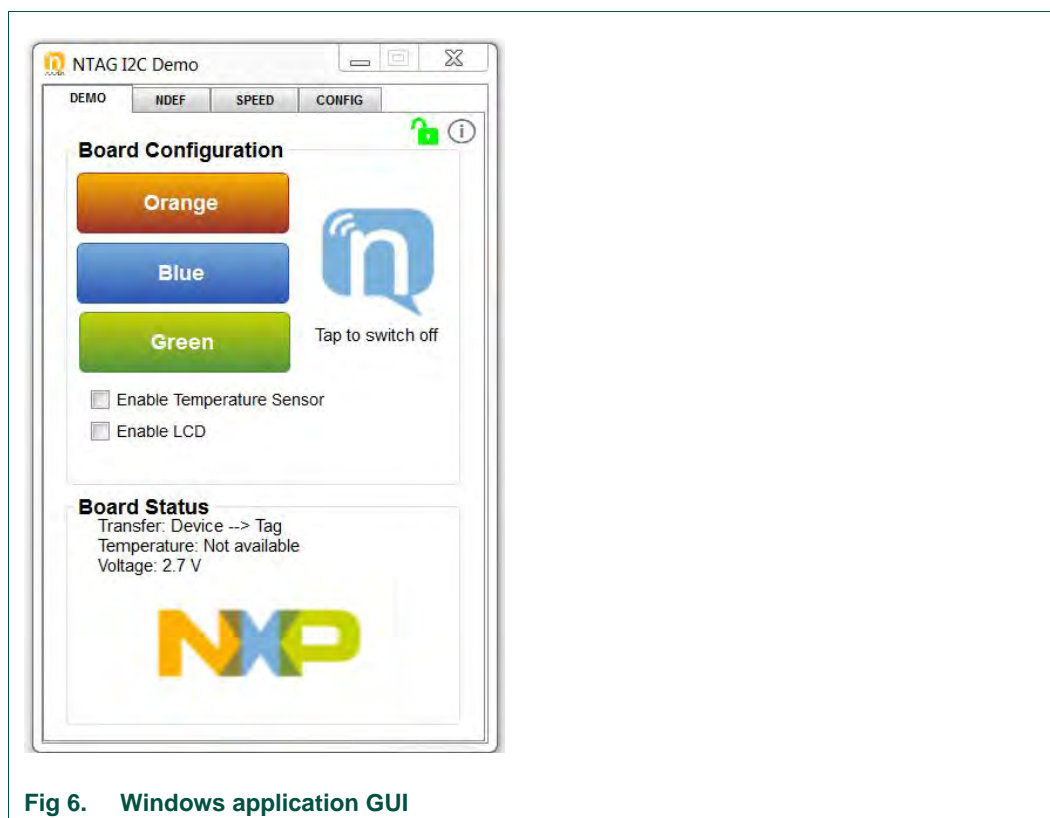


Fig 6. Windows application GUI

**Note:** The Windows application functionalities, GUI and look and feel are intentionally made exactly the same as the Android application. The Windows application is intended to run in a Windows laptop together with the Identiv uTrust CLOUD 3700F reader as a substitute in case an NFC phone is not available. Therefore, this User Manual is valid for both the Android app and Windows application. However, for convenience, only Android app screenshots are shown in this document.

### 3.2.4 Peek and Poke GUI

The Peek and Poke GUI is a Windows app that can be used to examine the detailed memory contents of the NTAG I<sup>2</sup>C plus EEPROM via I<sup>2</sup>C interface. This software component is available as a download from the public NXP website.



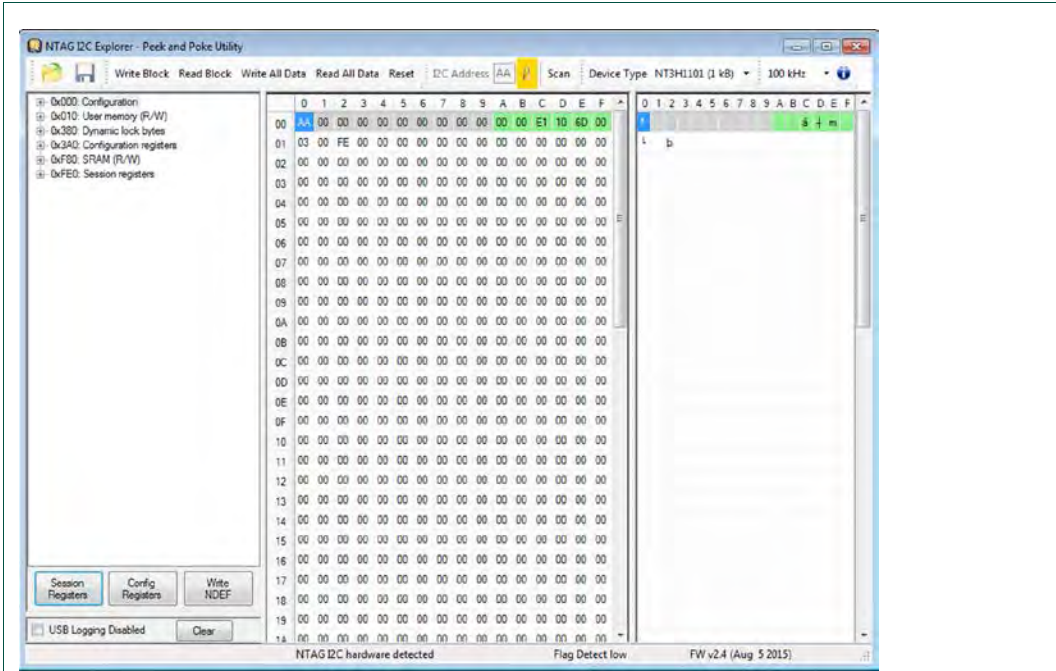


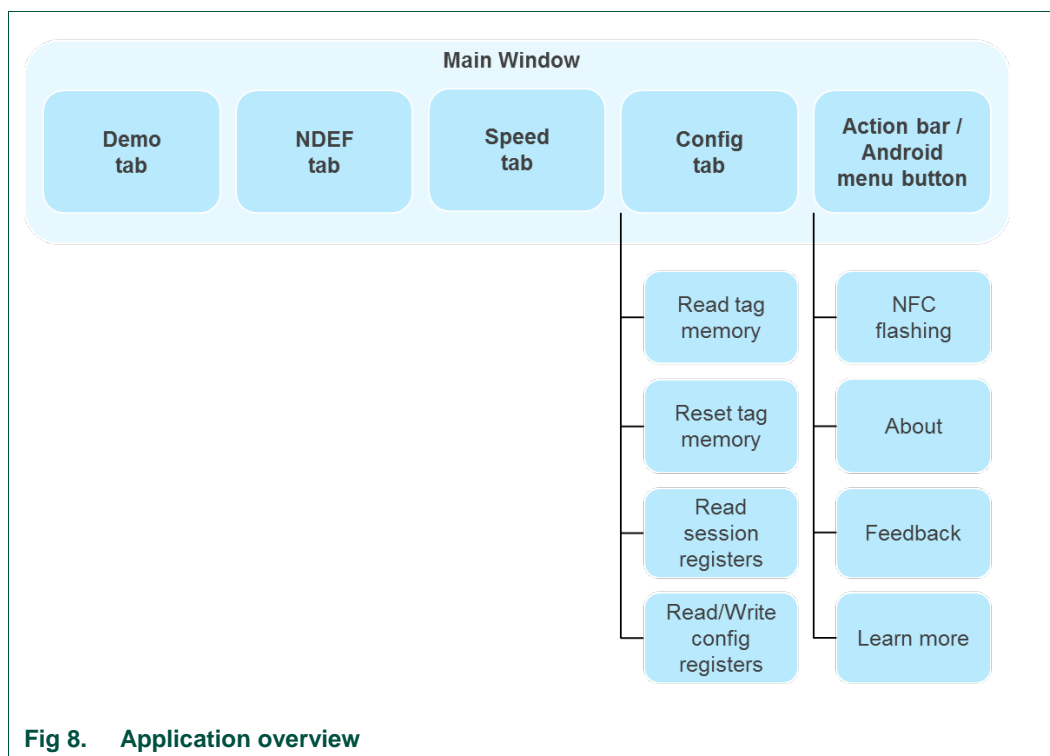
Fig 7. Peek and Poke GUI

**Note:** The UM10967 (refer to [UM10967](#)) describes in detail how to get started with the Peek and Poke tool and the different functionalities it offers.

4. NTAG I<sup>2</sup>C *plus* Explorer Demo app

The Android application is intended to operate on devices running Android version 4.0 and beyond. The application has been optimized for a correct visioning of the graphical elements in smartphones featuring different resolutions.

As may be observed in the next picture, the Android application consists of two demos that can be launched from the main activity of the application and four configuration functionalities that are accessed from the configuration selection view in the main activity.



## 4.1 Demo tab

After the Splash window closes, the Demo tab will appear. This screen allows the user to launch the Demo tab itself, the NDEF demo tab, the Speed demo tab and access the Configuration tab, with all configuration functionalities supported by the application.

Regarding the Demo tab, it allows demonstrating:

- The **Energy harvesting** functionality of the NTAG I<sup>2</sup>C *plus* that enables the powering up of the complete demo kit board with the energy harvested from the RF interface without any battery.
- The **RF to I<sup>2</sup>C** communication enabling us to modify the LED color by pressing the right color on the NFC device screen.
- The **I<sup>2</sup>C to RF** communication as the set of push buttons pressed by the user on the demo kit board reflected on the NFC device screen.
- The dynamic **bidirectional communication** between the two interfaces as the temperature value as well as the voltage on the energy-harvesting pin get dynamically updated on both the low power screen and the NFC device screen.

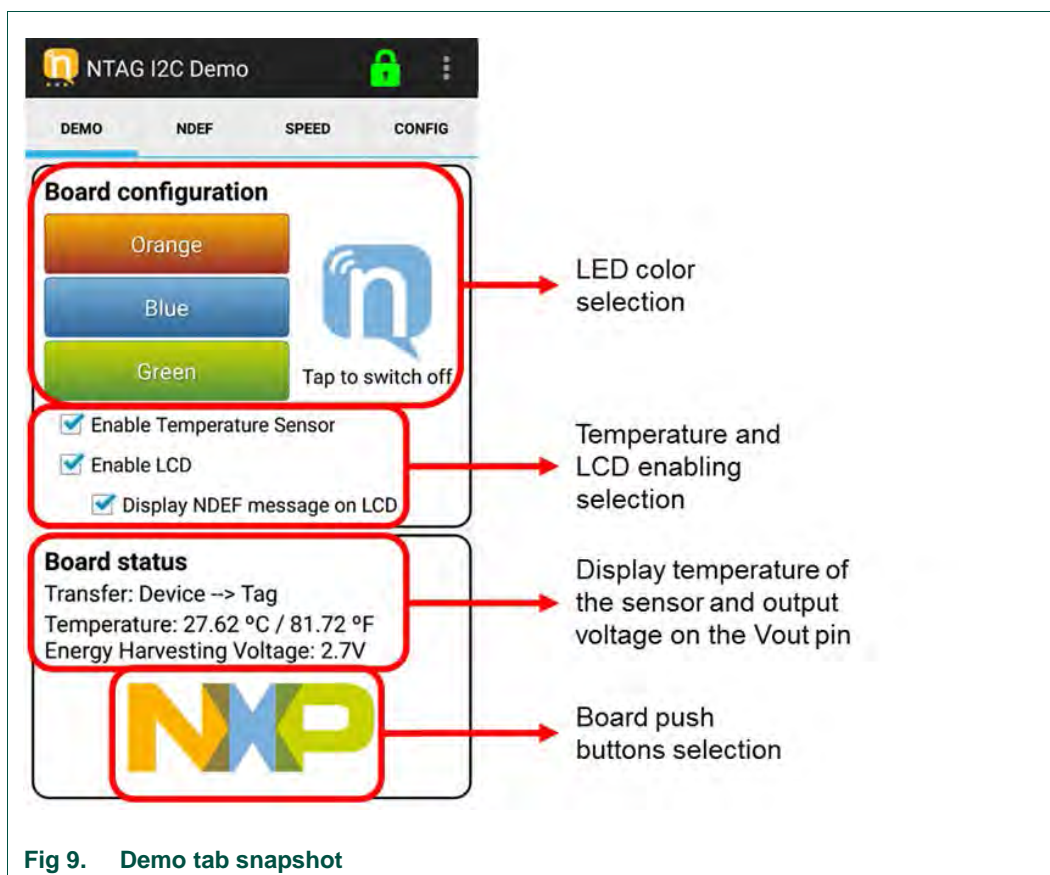


Fig 9. Demo tab snapshot

#### 4.1.1 Configuring NEK board to demonstrate RF to I<sup>2</sup>C communication

The board configuration part of the demonstration shows how the NTAG I<sup>2</sup>C *plus* tag chip passes a command from the RF input through the I<sup>2</sup>C serial interface output to the microprocessor, which in turns acts upon the command and lights the appropriate LED.

1. Touch one of the board configuration buttons (red, blue or green) on your mobile device. The NTAG icon then changes color, indicating the color selection.
2. Tap your mobile device on the antenna. When properly placed, the LED will illuminate in the chosen color. Optionally, the LCD display will display the harvested voltage, the temperature sensed by the board, the default text or the stored NDEF message if the corresponding options are enabled in the board configuration menu.

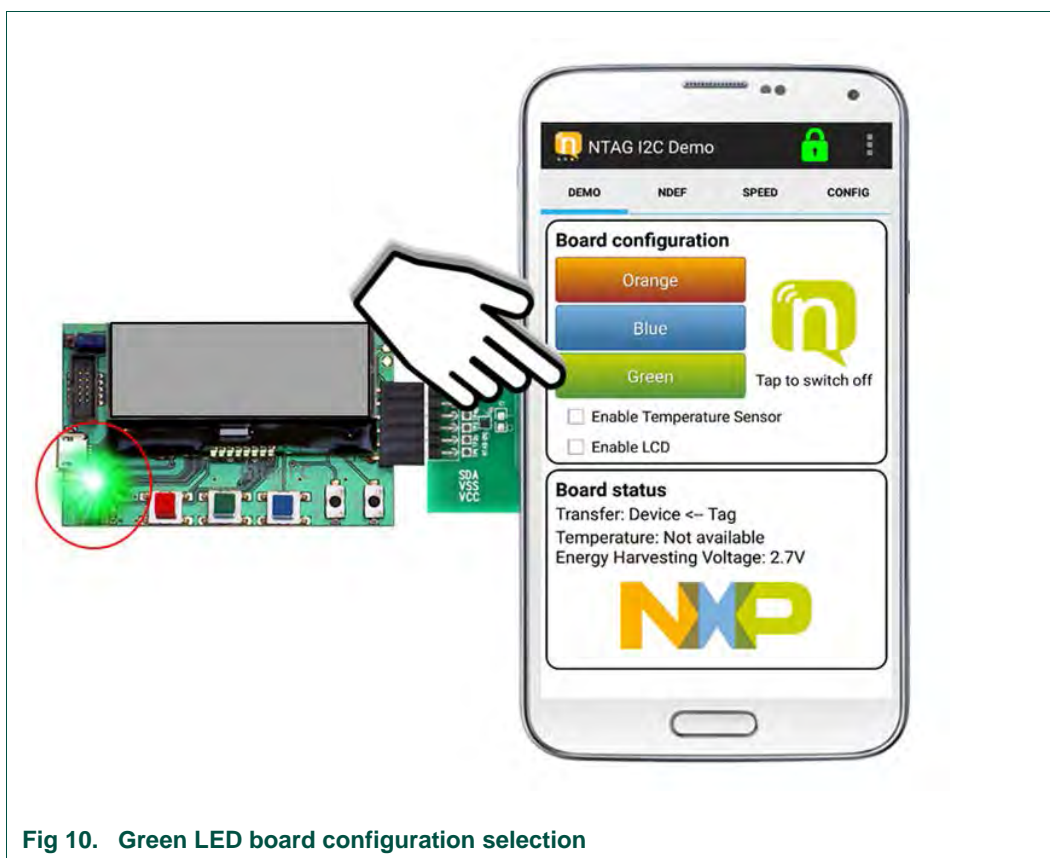


Fig 10. Green LED board configuration selection

#### 4.1.2 Reading board input to demonstrate I<sup>2</sup>C to RF communication

The three colored buttons on the NEK board demonstrate information from the board being transferred from the microprocessor through the I<sup>2</sup>C serial bus to the NTAG I<sup>2</sup>C *plus*, which then sends it via the RF field to the mobile device for display. When pressed, each colored button on the NEK board will cause a corresponding shade off on the board input NXP logo.

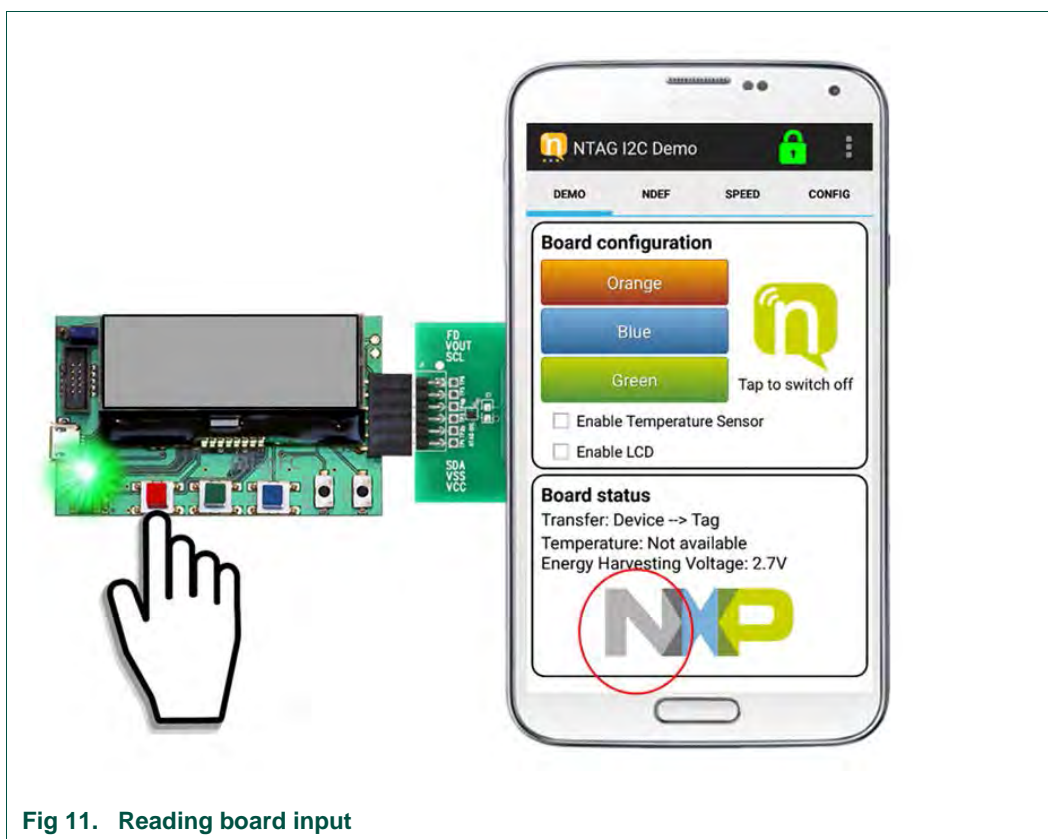


Fig 11. Reading board input

#### 4.1.3 Temperature sensor

The NEK board incorporates a temperature sensor for measuring the ambient temperature. This information can be shown in the Demo tab of the Android/PC application. Additionally it can be shown in the LCD display if the option is checked in the menu.

This operation demonstrates the NTAG I<sup>2</sup>C *plus* chip operating in pass-through mode, in which data passes through its SRAM. It is also another demonstration of passing data from the microprocessor through the I<sup>2</sup>C serial bus to the NTAG I<sup>2</sup>C *plus* tag chip, which in turn sends the data through the RF interface for display on the mobile device.



Fig 12. Temperature sensor demonstrates SRAM pass through mode

#### 4.1.4 Enabling LCD display

You can enable the NEK board LCD by touching the *Enable LCD* selection box. When doing so, the LCD will show the predefined *NTAG I<sup>2</sup>C plus Explorer* text message, the energy harvested and, if enabled, the temperature sensed by the board in Celsius and Fahrenheit degrees.

Once again, this operation demonstrates the NTAG I<sup>2</sup>C *plus* chip operating in pass-through mode sends a command from the RF input through the I<sup>2</sup>C serial interface output to the microprocessor, which in turn acts upon the command and turns on the LCD display.





#### 4.1.5 Displaying NDEF on the NEK board LCD

You can display the NDEF data on the NEK board LCD by touching the *Display NDEF message on LCD* selection box.

Again, this operation demonstrates the NTAG I<sup>2</sup>C *plus* chip operating in pass-through mode. First, the NDEF message is read from the NTAG I<sup>2</sup>C *plus* EEPROM memory and is transferred to the MCU using the SRAM memory, which in turn, displays it in the LCD display.



Fig 14. Displaying NDEF on NEK board LCD

## 4.2 NDEF tab

The NDEF tab allows the user to read or write an NDEF message to the NTAG I<sup>2</sup>C *plus* (actually, it could be used to read or write an NDEF message to any NFC Forum type 2 tag, such as a MIFARE Ultralight, NTAG...).

On the **Read NDEF** mode, the application reads the NDEF from the NTAG I<sup>2</sup>C *plus* and returns its content and the type of NDEF message.

On the **Write NDEF** mode, the application allows the user to write a Text type, URI type, Bluetooth pairing type or Smart Poster NDEF message.

- *Text record* type is used to store plain text data.
- *URI record* type allows NFC tags to trigger actions on the NFC device (usually the smartphone), such as opening a webpage or sending an SMS message.
- *Bluetooth pairing* NDEF messages contain information about a Bluetooth device that allows the smartphone to pair with that Bluetooth device by just tapping the tag. In the case of writing a Bluetooth pairing type message, it is important to remember that the MAC address shall be 6 bytes, in hexadecimal (therefore, 12 characters from 0 to F).
- *Smart Poster* record type defines a structure including a URI record type and a Text record type as building blocks.

The NDEF tab also contains a **Write default NDEF message** button. When this button is pressed, the application automatically writes a Smart Poster message with the text



content: “NTAG I2C plus EXPLORER” and the URI content: [www.nxp.com/demoboard/OM5569](http://www.nxp.com/demoboard/OM5569). Therefore, any NFC phone reading the tag content will be redirected to the NTAG Explorer Kit website.

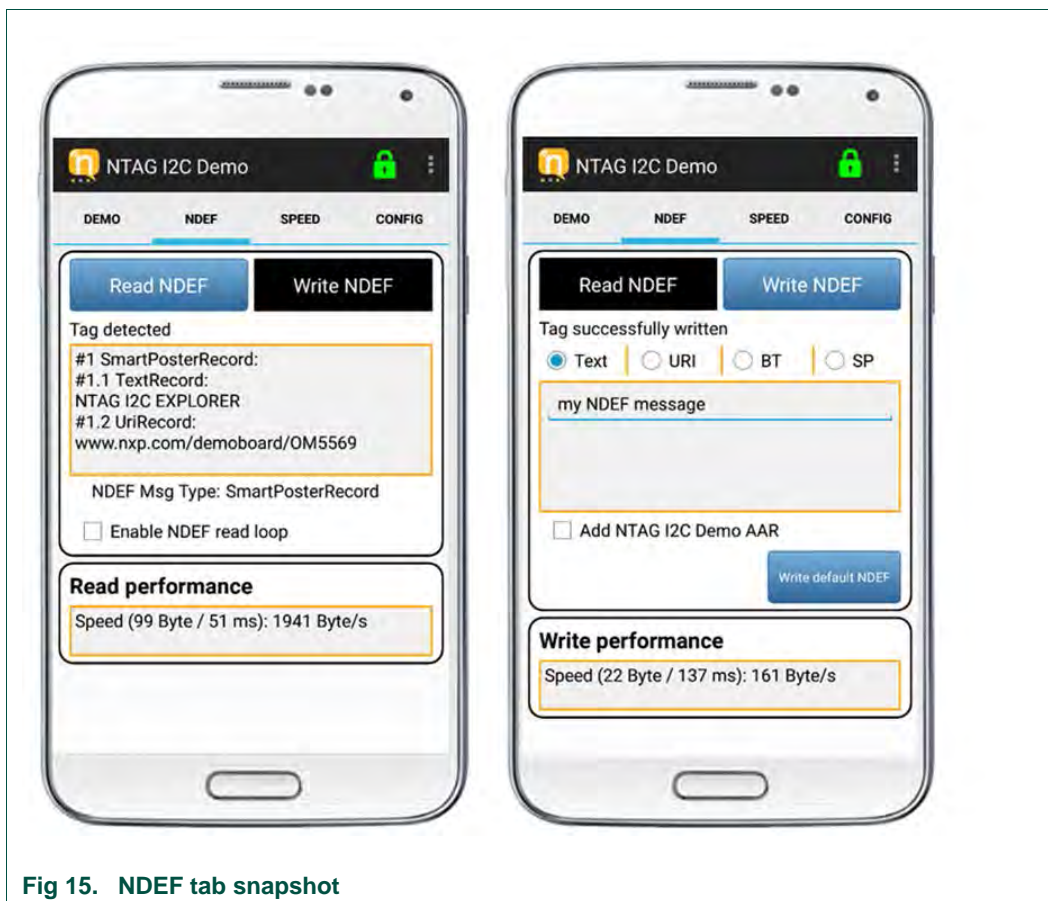


Fig 15. NDEF tab snapshot

When the NDEF message has been successfully written the “write tag successfully done” popup appears temporarily in the application informing the user that the message has been correctly written. There is no need to tap the tag again if you want to write multiple NDEF messages and read them in between.

In order to learn more about the different types of NDEF messages and what structure they have, please refer to the following NFC Forum specifications:

“NFC Data Exchange Format (NDEF) Technical Specifications”

“NFC Record Type Definition (RTD) Technical Specification”

“NFC Text RTD Technical Specification”

“NFC URI RTD Technical Specification”

“NFC Forum Connection Handover Technical Specification”

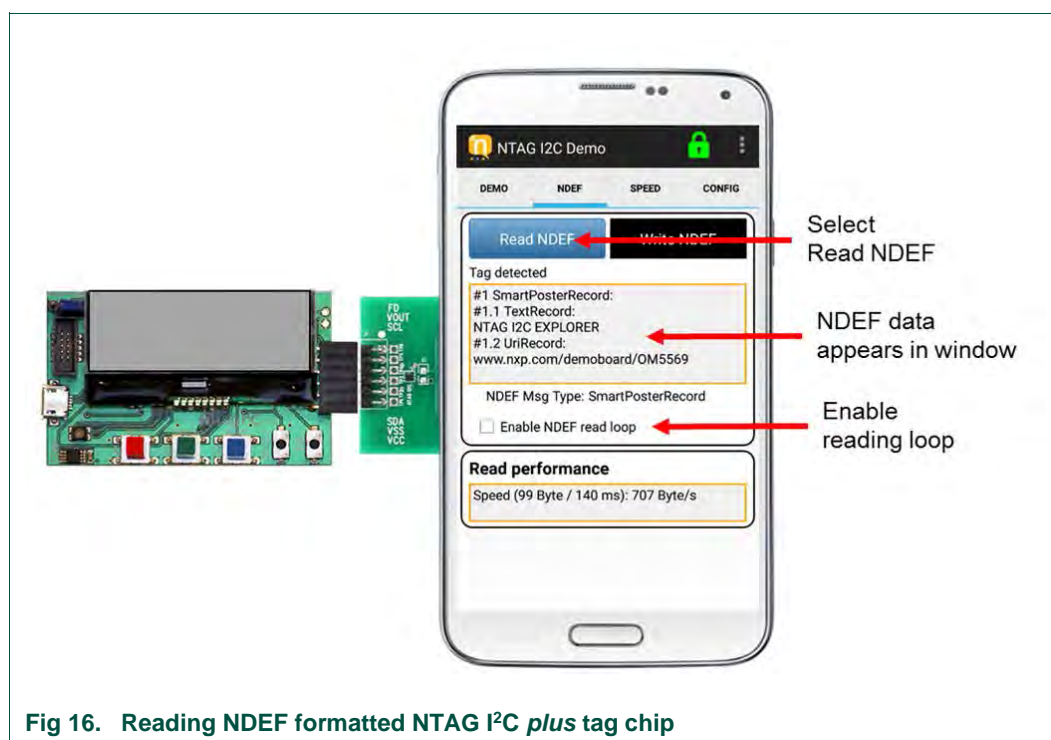
“NFC Smart Poster RTD Technical Specification”

“Bluetooth Secure Simple Pairing Using NFC”

#### 4.2.1 Reading NDEF data

To read a NDEF formatted NTAG I<sup>2</sup>C *plus* tag chip:

1. Select *Read NDEF* from the tab on the right of the mobile device screen.
2. Tap the mobile device onto the antenna.
3. A proper read will result in a message on the mobile device indicating *Read tag successfully done*. If the tag chip has not been NDEF formatted, it will result in a message *NTAG I<sup>2</sup>C plus product is not NDEF formatted*. Additionally, the *Enable NDEF read loop* selection box can be used to set the application to permanently read the EEPROM memory, so any change will automatically appear in the window.



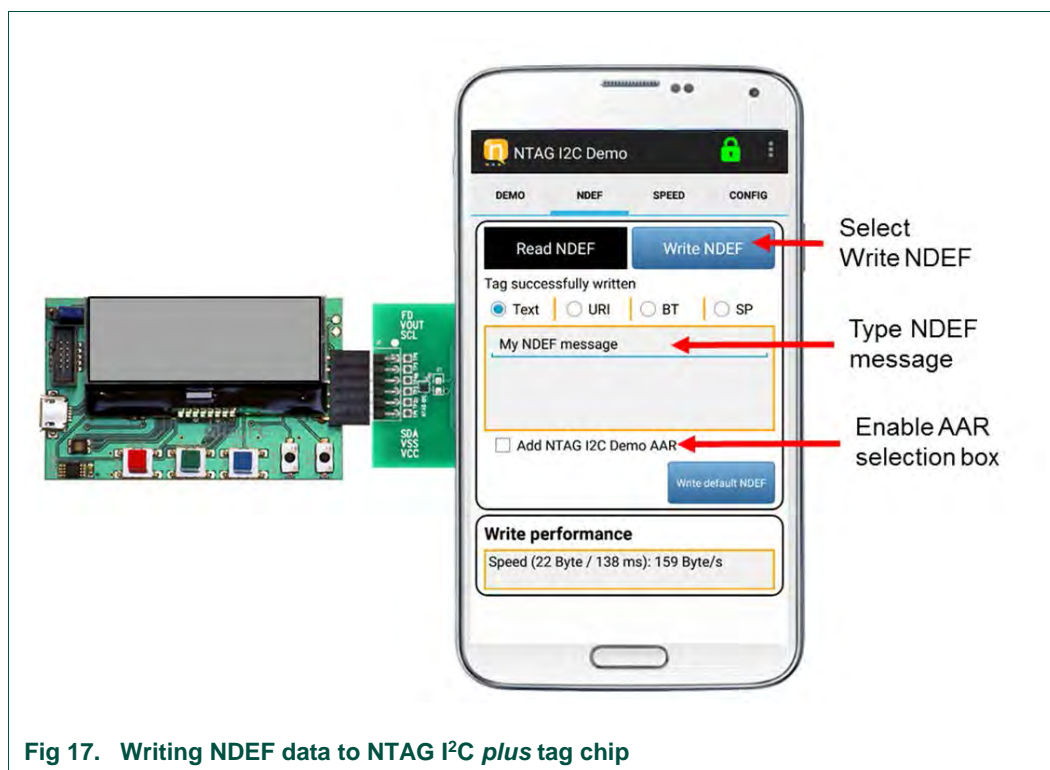
#### 4.2.2 Writing NDEF data

To write an NDEF formatted data into the NTAG I<sup>2</sup>C *plus* tag chip:

1. Select *Write NDEF* from the tab on the right of the mobile device screen.
2. Type a message into the NDEF message area. Or alternatively, press *Write Default NDEF message* on your screen, which writes a NDEF Smart Poster message with the text content: "NTAG I<sup>2</sup>C *plus* EXPLORER" and the URI content: [www.nxp.com/demoboard/OM5569](http://www.nxp.com/demoboard/OM5569). Additionally, you can add to your NDEF message an Android Application Record (AAR), which adds the package name of the NTAG I<sup>2</sup>C *plus* Demo application embedded inside the NDEF record. You can add an AAR to any NDEF record of your NDEF message because Android searches the entire NDEF message for AARs. If it finds an AAR, it starts the application based on the package name inside the AAR. If the

application is not present on the device, Google Play is launched to download the application.

3. Tap the mobile device onto the antenna.
4. A proper write will result in a message on the mobile device indicating *write tag successfully done*.

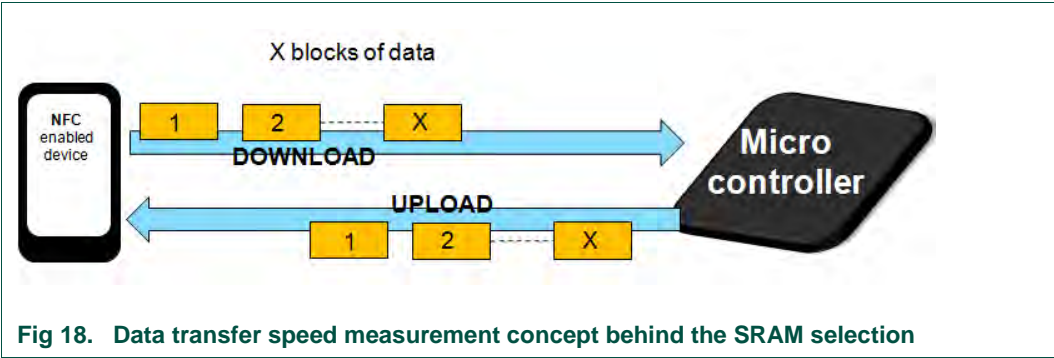


### 4.3 Speed tab

The speed Test Demo measures the transfer bit rate when communicating with the NTAG I<sup>2</sup>C plus Explorer board according to different configurations.

#### 4.3.1 SRAM speed test

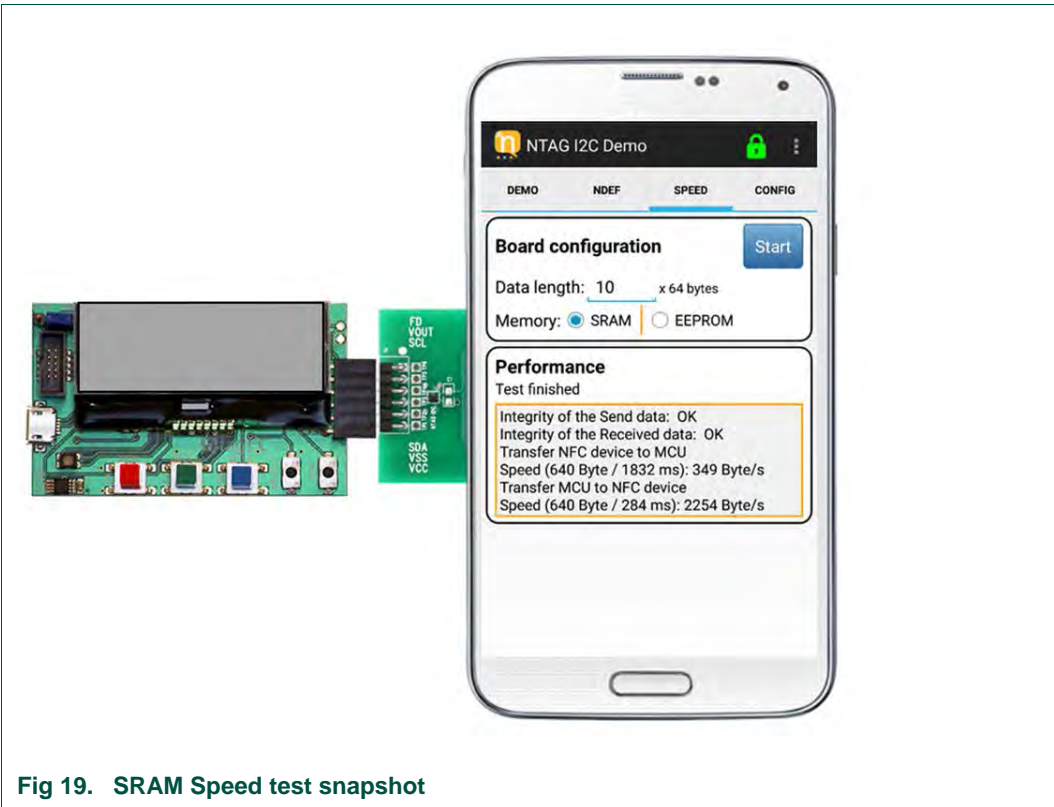
The SRAM speed Test measures the speed at which the data is transferred from the application to the microcontroller through the SRAM (with the NTAG I<sup>2</sup>C plus in Pass-Through mode), and vice versa. First, the application writes data to the SRAM several times, and the microcontroller reads from it. This way, the throughput of the communication in Pass-Through mode from the application to the microcontroller can be obtained. Once this first test has finished, the microcontroller starts writing to the SRAM memory, while the application reads from it. This way, the throughput from the microcontroller to the application can be measured.



Since the size of the SRAM memory is 64 bytes, the data to be transmitted and received has to be a multiple of 64. Actually, what is transmitted is the number of 64-byte blocks defined by the user in the Block multiplier field (20 by default).

The integrity of the data transferred in both directions is checked by appending a CRC32 value in the last block. The CRC32 is calculated for the whole message that has been transferred (for all the blocks). If the CRC32 from the message received by the application is right, it will show an “Integrity of the data: OK” message. On the other hand, if the CRC32 from the message received by the board is right, it will turn on the green LED at the end of the Speed Test.

Once the test has been finished, both the application and the microcontroller indicate whether the integrity check was successful (through a green LED at the microcontroller), and the application shows the time, mean speed and data transferred for both directions.

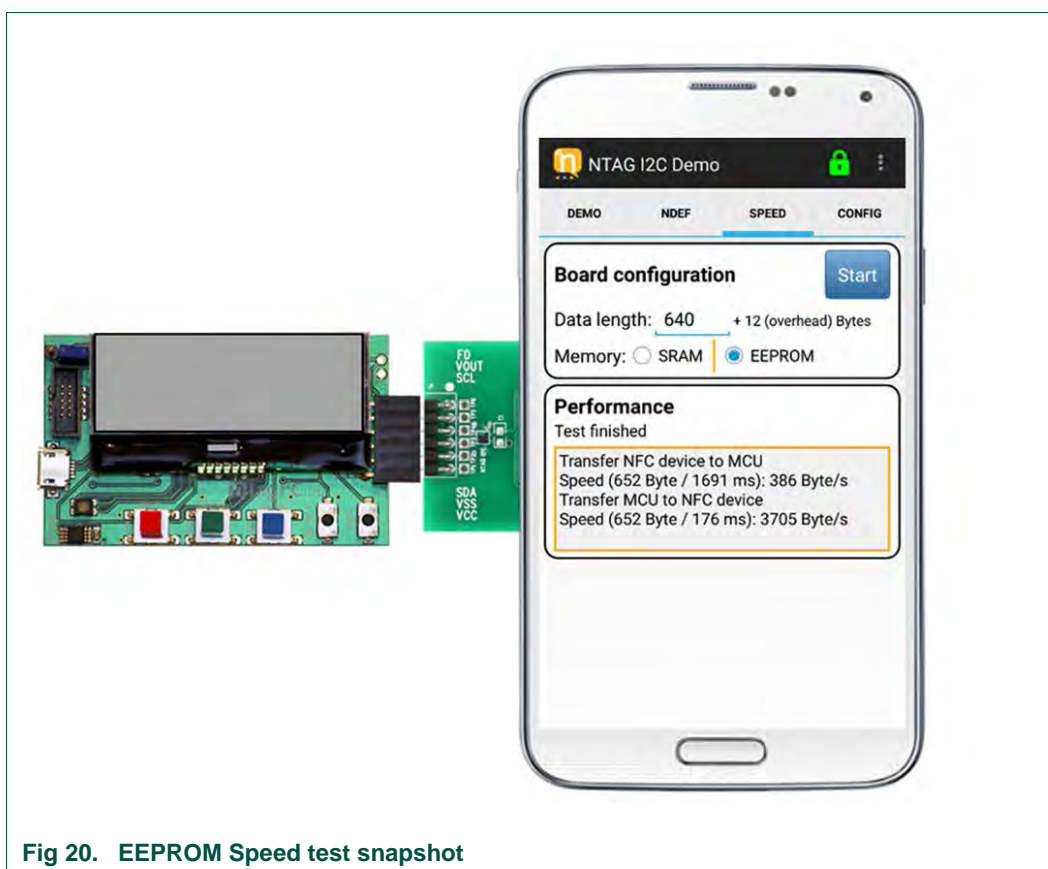


### 4.3.2 EEPROM speed test

The EEPROM Speed Test measures the speed at which the application is able to write and read the EEPROM memory of the NTAG I<sup>2</sup>C *plus*. In order to do this, an NDEF message is written to the EEPROM, and then, the same NDEF message is read. The written NDEF message is a text type message that contains the data in the textbox of the application repeated as many times as indicated in the Block multiplier field.

First, the application creates the NDEF message to be written by creating a string that contains the content from the textbox as many times as indicated, and adding the appropriate header. Then, it writes it to the EEPROM memory by sending as many NFC Forum standard type-2-tag Write commands as necessary, and measuring the time it takes to do so. Once it has finished writing, it reads the NDEF message from the NTAG I<sup>2</sup>C *plus* EEPROM memory.

Once the test is finished, the application shows the number of bytes, mean speed and time for both the reading and writing process. The user can also check the content of the memory to ensure that the NDEF message has been written appropriately.



## 4.4 Configuration tab

This tab shows a selection menu that provides access to the different configuration activities of the NTAG I<sup>2</sup>C *plus* supported by the application. From this screen, the user



may select *Read Tag Memory*, *Reset Tag Memory*, *Read Session Registers* or *Read/Write Configuration registers*.

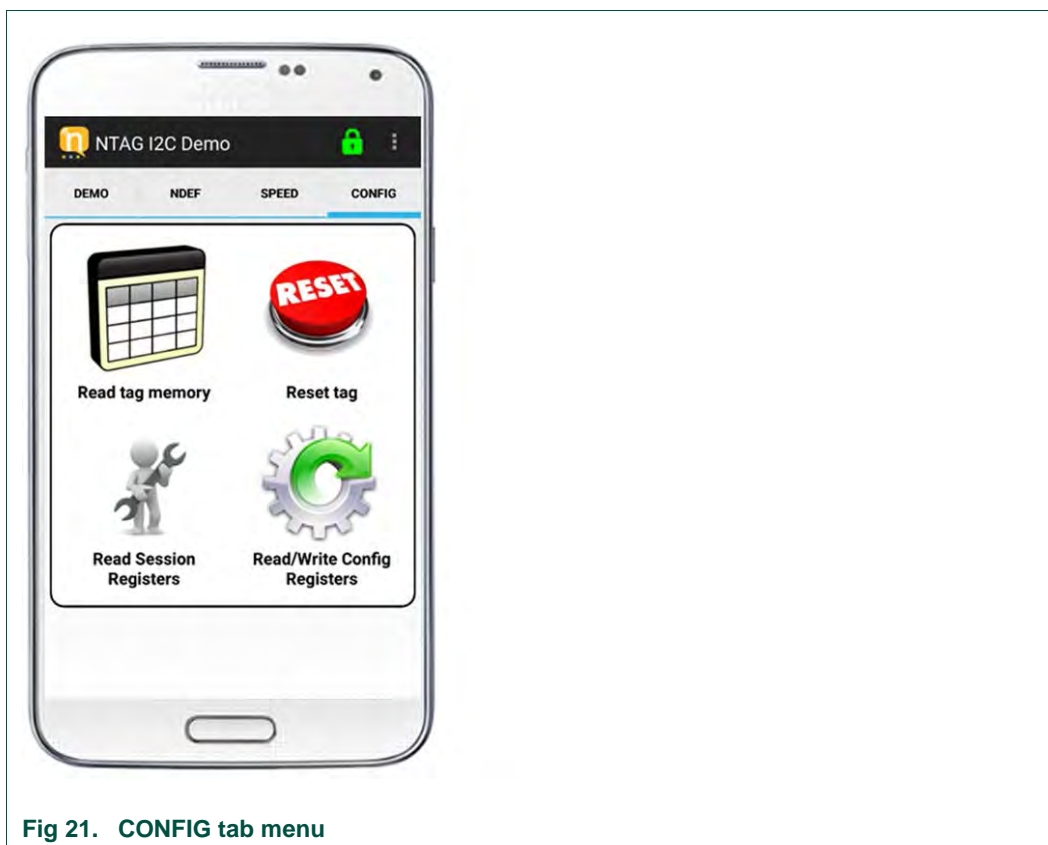


Fig 21. CONFIG tab menu

#### 4.4.1 Reading tag memory

This option reads and displays on the screen the content of the whole memory of the NTAG I<sup>2</sup>C *plus* product. The complete content can be scrolled on the screen. To read the tag memory:

1. Select *Read Tag Memory* from the Configuration tab.
2. Tap the mobile device to the antenna (it might take 2-3 seconds to read the memory content).
3. The screen will display the entire memory contents.

For security reasons, the pages from 0xE2 to 0xFF in the sector 0 are hidden when reading all the memory. These bytes defines the PWD, PACK, AUTH0, PT\_I2C and ACCESS bytes.

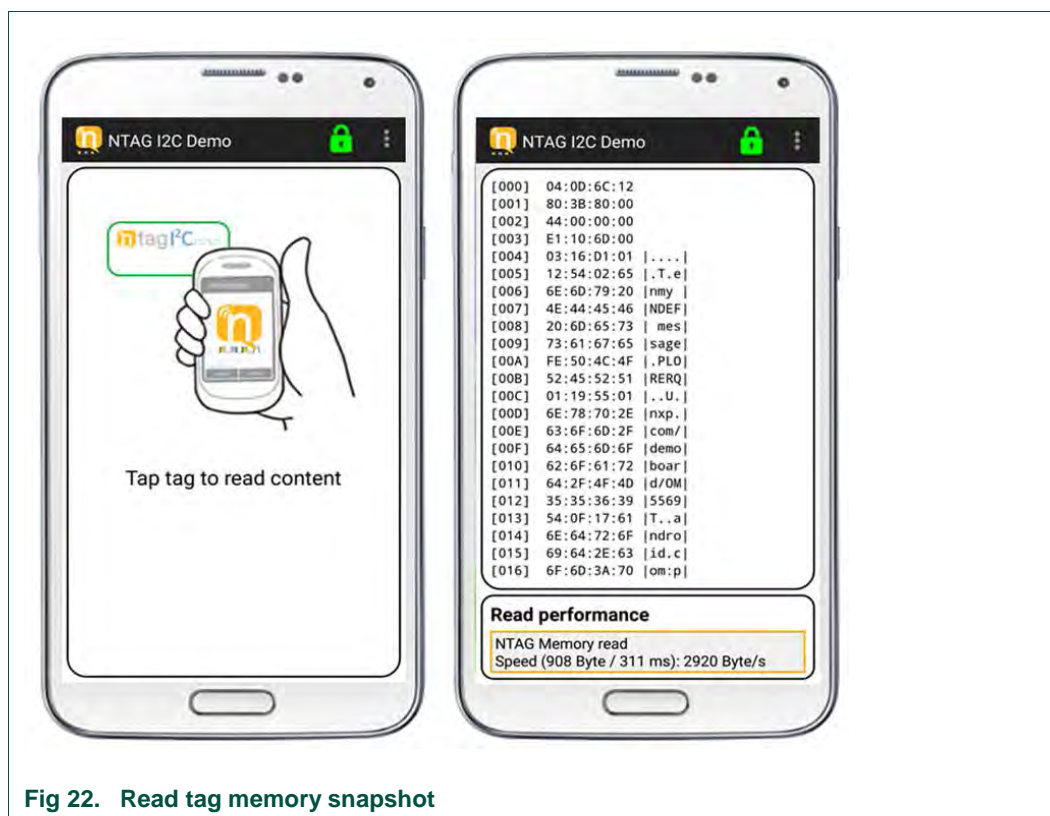


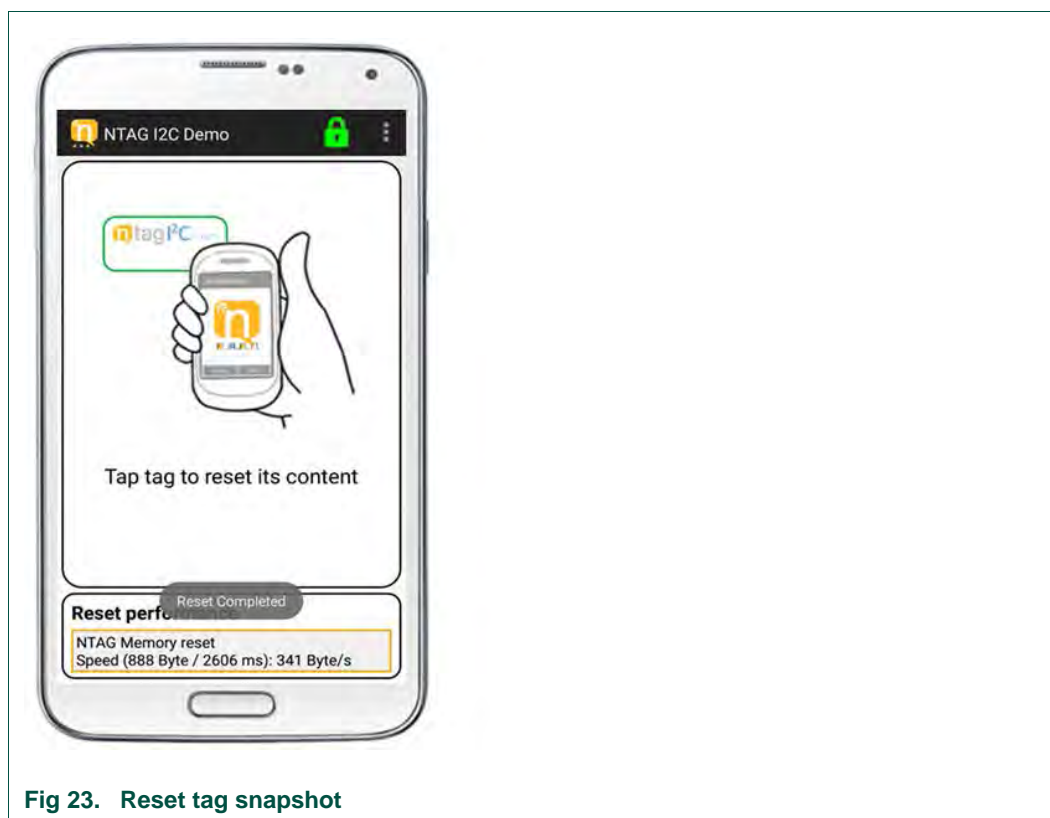
Fig 22. Read tag memory snapshot

#### 4.4.2 Resetting tag memory

This configuration functionality is about resetting the whole user memory of the NTAG I<sup>2</sup>C *plus* product to the original content that was programmed during production.

1. Select *Reset Tag* memory from the *Config* tab screen.
2. Tap the mobile device to the antenna tag. The user should tap the NTAG I<sup>2</sup>C *plus* device for 2-3 seconds to reset the memory content.
3. Upon successful reset, a banner indicating completion will be displayed along the bottom of the screen.

In addition, when the user runs the reset memory on the NTAG I<sup>2</sup>C PLUS version, it will write the PWD to 0xFFFFFFFF, AUTH0 to 0xFF, PACK to 0x0000, ACCESS to 0x00 and PT\_I2C to 0x00. These are the default values for the access configuration.



Alternatively, we can also reset the tag contents if we keep the second button pressed and tap the phone with the NFC communication enabled. When the LED is set to green, the tag memory has been reset to the default NDEF SmartPoster.





Fig 24. Alternative way to reset tag

#### 4.4.3 Reading session registers

This option displays the content of the session registers in the NTAG I<sup>2</sup>C *plus*. Session registers are used to configure or monitor the registers values of the current communication session. Session registers values can be modified within a particular communication session (only via the I<sup>2</sup>C interface, so the application is not able to modify them). However, after Power-On-Reset, these values go back to their default configuration values, which are obtained from the configuration registers.

Session registers values can be read on pages F8h to F9h (sector 3) via the RF interface or at block FEh via the I<sup>2</sup>C interface.

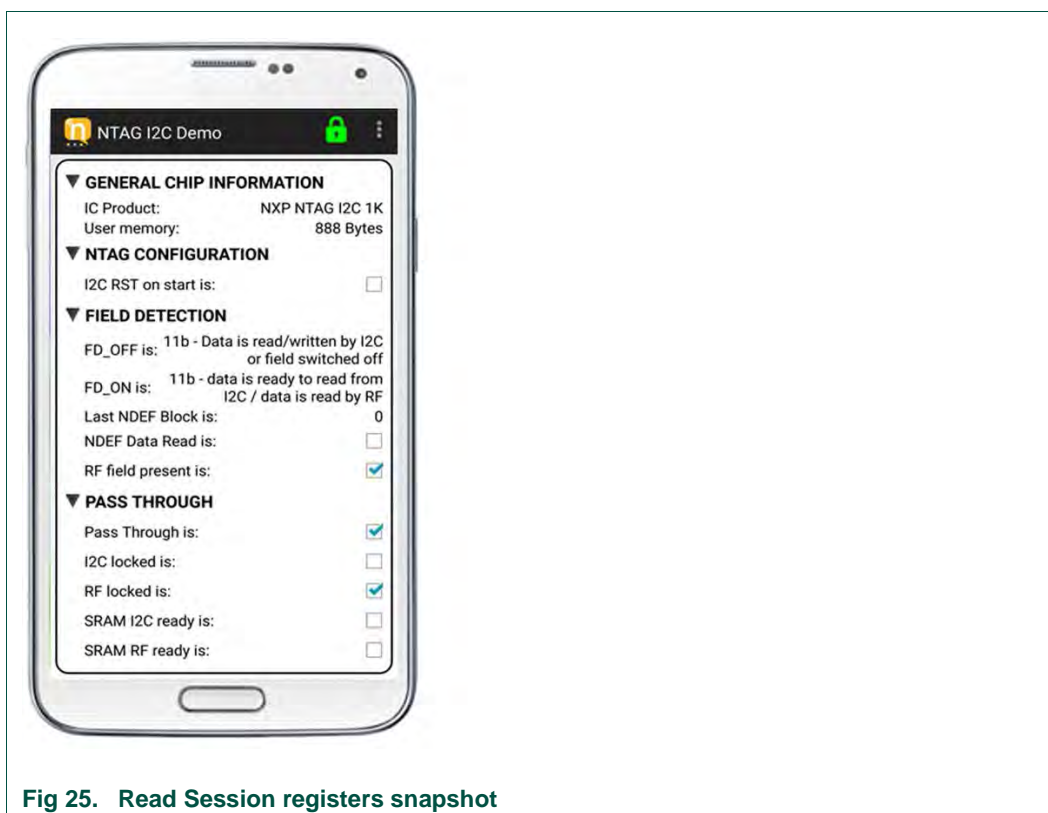


Fig 25. Read Session registers snapshot

To read the tag session registers:

1. Select *Read Session Registers* from the Config tab screen.
2. Tap the mobile device to the tag antenna.
3. Upon successful read, the session registers values will be shown. Tapping on any of the right-facing arrows will bring up more details. A blue mark indicates ON or selected.

Session register values are displayed on the screen divided into different groups:

- **General Chip Information:** General information about the discovered NTAG I<sup>2</sup>C *plus* product. It shows the following information:
  - **IC product:** NTAG I<sup>2</sup>C *plus* chip version.
  - **User Memory:** Size of the user memory of the NTAG I<sup>2</sup>C *plus* chip.
- **NTAG Configuration:** General NTAG configuration:
  - **I<sup>2</sup>C RST on start is:** Shows the content of the I<sup>2</sup>C\_RST\_ON\_OFF bit, which is responsible for enabling a soft reset through an I<sup>2</sup>C repeated start.
- **Field Detection:** Information related to the field detection functionality, which is used for the smart pairing with devices, as it triggers a signal to the connected host when the NTAG I<sup>2</sup>C *plus* product is powered by an external NFC device.
  - **FD\_OFF:** Shows the content of the FD\_OFF bits, which define the event upon which the signal output on the field detection pin is brought up.
  - **FD\_ON:** Shows the content of the FD\_ON bits, which define the event upon which the signal output on the field detection pin is brought down.

- **Last NDEF Page is:** Shows the content of the LAST\_NDEF\_BLOCK byte, this is the address of the last block (I<sup>2</sup>C interface addressing) of the NDEF message.
- **NDEF Data Read is:** Shows the content of the NDEF\_DATA\_READ bit.
- **RF Field present is:** Shows the content of the RF\_FIELD\_PRESENT bit, which indicates if an RF field is detected.
- **Pass through:** Information related to the pass-through functionality, which allows the fast transfer of data between the RF and the I<sup>2</sup>C interface by using a 64 byte SRAM memory.
  - **Pass Through is:** Shows the content of the PTHRU\_ON\_OFF bit, which is responsible for enabling the data transfer via the SRAM memory.
  - **I<sup>2</sup>C locked is:** Shows the content of the I<sup>2</sup>C\_LOCKED bit, which can lock the access to memory to the I<sup>2</sup>C interface.
  - **RF locked is:** Shows the content of the RF\_LOCKED bit, which can lock the access to memory to the RF interface.
  - **SRAM I<sup>2</sup>C ready is:** Shows the content of the SRAM\_I<sup>2</sup>C\_READY bit, which indicates if the data in the SRAM memory is ready to be read by the I<sup>2</sup>C interface.
  - **From RF to I<sup>2</sup>C is:** Shows the content of the PTHRU\_DIR bit, which defines the data flow direction for the data transfer.
- **SRAM Memory settings:** Information about the SRAM mirroring feature. The SRAM memory can be mirrored in the User Memory for RF access by enabling the SRAM mirroring feature.
  - **SRAM Mirror:** Shows the content of the SRAM\_MIRROR\_ON\_OFF bit.
  - **SRAM Mirror block:** Shows the content of the SRAM\_MIRROR\_BLOCK byte, which indicates the address of the first block (I<sup>2</sup>C interface addressing) of the mirror of SRAM memory.
- **I<sup>2</sup>C Settings:** Information about the I<sup>2</sup>C management configuration.
  - **WD\_LS Timer is:** Shows the content of the WDT\_LS byte: the LSB of the watchdog time control register.
  - **WD\_MS Timer:** Shows the content of the WDT\_MS byte: the MSB of the watchdog time control register.
  - **I<sup>2</sup>C Clock stretch:** Shows the content of the I<sup>2</sup>C\_CLOCK\_STR bit, which is responsible for enabling the I<sup>2</sup>C clock stretching.

For further information about the session registers bytes, please refer to the NTAG I<sup>2</sup>C *plus* product data sheet (refer to [\[NTAGI2Cplus\]](#)).

#### 4.4.4 Reading / Writing configuration registers

Configuration registers define the default functionalities of the NTAG I<sup>2</sup>C *plus* to be used for the communication after a Power-On-Reset.

Configuration registers values can be read and written in Pages E8h and E9h (sector 0 for NTAG I<sup>2</sup>C *plus* 1k). The operation to be performed, read or write, in each tap is selected by pressing the Read/Write config buttons on top of the window.

For further information about the configuration registers bytes, please consult the NTAG I<sup>2</sup>C *plus* product datasheet (refer to [NTAGI2Cplus](#)).

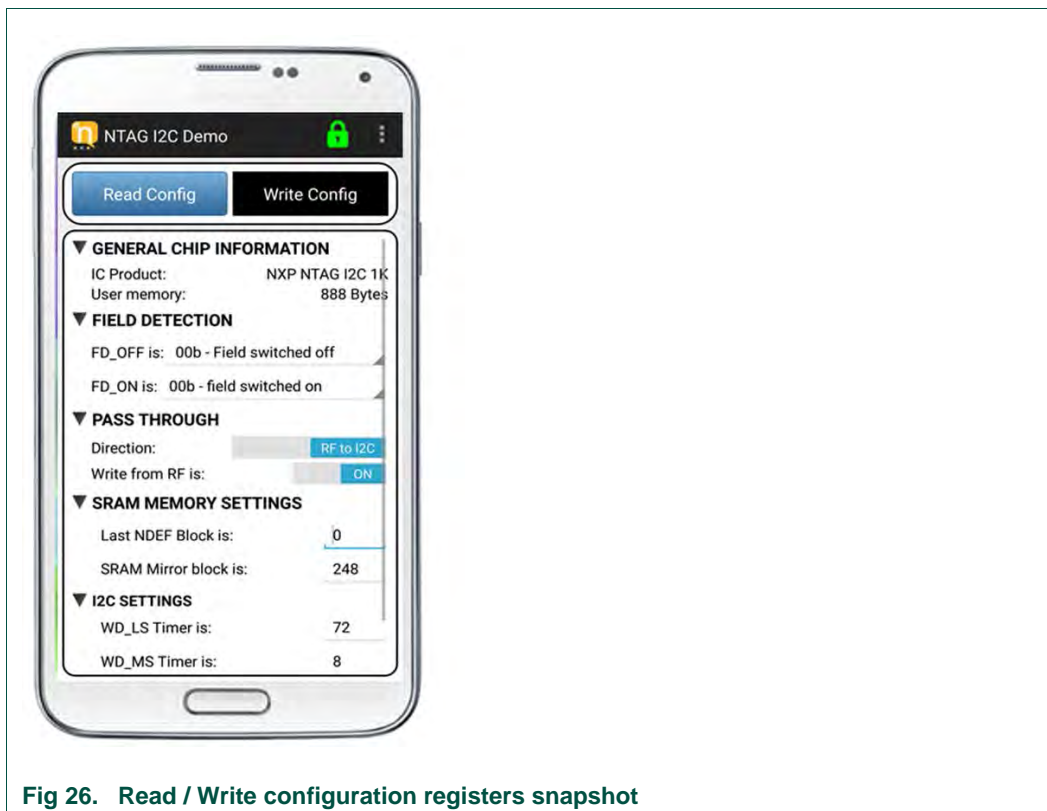


Fig 26. Read / Write configuration registers snapshot

To read configuration registers:

1. Select *Read/Write Config* registers from the Config tab screen.
2. Tap the mobile device to the antenna tag.
3. Upon successful read, the configuration registers values will be shown.
4. To write the configuration registers, switch to Write config. Register contents are controlled either via dropdown menus, direct input or by slider controllers where grey indicates OFF and blue indicates ON.

Configuration register values are displayed on the screen divided into different groups:

- **General Chip Information:** General information about the discovered NTAG I<sup>2</sup>C *plus* product. It shows the following information
  - **IC product:** NTAG I<sup>2</sup>C *plus* chip version
  - **User Memory:** Size of the user memory of the NTAG I<sup>2</sup>C *plus* chip
- **Field Detection:** Information related to the field detection functionality, which is used for the smart pairing with devices, as it triggers a signal to the connected host when the NTAG I<sup>2</sup>C *plus* product is powered by an external NFC device.

- **FD\_OFF:** Shows the content of the FD\_OFF bits, which define the event upon which the signal output on the field detection pin is brought up
  - **FD\_ON:** Shows the content of the FD\_ON bits, which define the event upon which the signal output on the field detection pin is brought down
- **Pass through:** Information related to the pass-through functionality, which allows the fast transfer of data between the RF and the I<sup>2</sup>C interface by using a 64 byte SRAM memory.
  - **Functionality:** Shows the content of the PTHRU\_ON\_OFF bit, which is responsible for enabling the data transfer via the SRAM memory.
  - **Direction:** Shows the content of the TRANSFER\_DIR bit, which defines the data flow direction for the data transfer.
  - **Write from RF:** Shows the content of the TRANSFER\_DIR bit (same as direction), which defines the data flow direction for the data transfer
- **SRAM Memory settings:** Information about the SRAM mirroring feature. The SRAM memory can be mirrored in the User Memory for RF access by enabling the SRAM mirroring feature.
  - **Last NDEF Page:** Shows the content of the LAST\_NDEF\_BLOCK byte, this is the address of the last block (I<sup>2</sup>C interface addressing) of the NDEF message.
  - **SRAM Mirror:** Shows the content of the SRAM\_MIRROR\_ON\_OFF bit.
  - **SRAM Mirror block:** Shows the content of the SRAM\_MIRROR\_BLOCK byte, which indicates the address of the first block (I<sup>2</sup>C interface addressing) of the mirror of SRAM memory.
- **I<sup>2</sup>C Settings:** Information about the I<sup>2</sup>C management configuration.
  - **WD\_LS Timer:** Shows the content of the WDT\_LS byte: the LSB of the watchdog time control register
  - **WD\_MS Timer:** Shows the content of the WDT\_MS byte: the MSB of the watchdog time control register
  - **I<sup>2</sup>C Clock stretch:** Shows the content of the I<sup>2</sup>C\_CLOCK\_STR bit, which is responsible for enabling the I<sup>2</sup>C clock stretching.
  - **I<sup>2</sup>C RST on start:** Shows the content of the I<sup>2</sup>C\_RST\_ON\_OFF bit, which is responsible for enabling a soft reset through an I<sup>2</sup>C repeated start.
- **Access Configuration:** Information about the I<sup>2</sup>C management configuration.
  - **AUTH0:** This is the first page of the Sector 0 where the authentication is needed in order to access the user memory from NFC perspective. By default the AUTH0 value is 0xFF, this means that the password protection is effectively disabled. When the user introduces a new password this AUTH0 will be automatically set to 0x03.
  - **NFC Prot:** Shows the memory protection bit. If set to OFF only the write to the protected area is protected by the password. If set to ON, read and write into the protected area is protected by password.
  - **NFC DIS SEC1:** Shows the NFC access protection to Sector 1. If set to OFF the Sector 1 will be accessible in 2K version. If set to ON, Sector 1 is not accessible and will return NACK0.

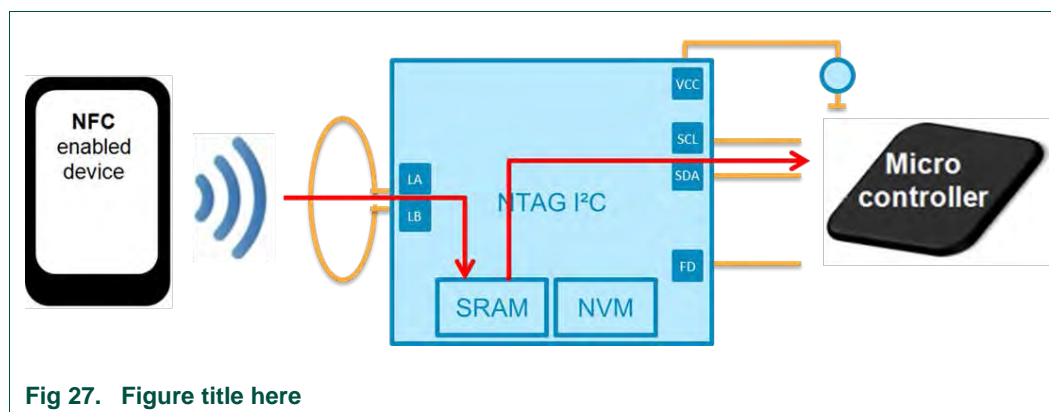
- **AUTHLIM:** Shows limitation of negative password authentication attempts. If the limit is reached then the protected area will no longer be accessible. Set to 0 means that limitation is disabled.
- **2K Prot:** Shows the password protection for Sector 1 for 2k version. If set to OFF, the password authentication for Sector 1 is disabled. Otherwise, if set to ON the password is needed to access to Sector 1.
- **SRAM Prot:** Shows the password protection for pass-through and mirror mode. If set to OFF the password authentication for pass-through mode is disabled. If set to ON then the password authentication to access SRAM in pass-through is required.
- **I<sup>2</sup>C Prot:** Shows the access to protected area from I<sup>2</sup>C perspective. If 0 then the whole user memory is accessible from I<sup>2</sup>C. If this value is 1 then the protected area is read only. Other value will disable the access to protected area.

For further information about the configuration registers bytes, please refer to the NTAG I<sup>2</sup>C *plus* product datasheet (refer to [\[NTAGI2Cplus\]](#)).

## 4.5 Action bar

### 4.5.1 NFC Flashing via NTAG I<sup>2</sup>C *plus* Explorer demo

NTAG I<sup>2</sup>C *plus* connected tag enables data download capability. The on-chip SRAM permits temporary storage of data during the transfer, enabling the tag chip to act as a modem.



#### 4.5.1.1 Design implementation choice

The NEK board embeds a LPC111U24. The following table shows the correspondence between sector numbers and memory addresses for LPC111U2x/1x devices.



Sector number	Sector size [kB]	Address range	LPC11U12/ LPC11U22	LPC11U13/ LPC11U23	LPC11U14/ LPC11U24
0	4	0x0000 0000 - 0x0000 0FFF	yes	yes	yes
1	4	0x0000 1000 - 0x0000 1FFF	yes	yes	yes
2	4	0x0000 2000 - 0x0000 2FFF	yes	yes	yes
3	4	0x0000 3000 - 0x0000 3FFF	yes	yes	yes
4	4	0x0000 4000 - 0x0000 4FFF	-	yes	yes
5	4	0x0000 5000 - 0x0000 5FFF	-	yes	yes
6	4	0x0000 6000 - 0x0000 6FFF	-	-	yes
7	4	0x0000 7000 - 0x0000 7FFF	-	-	yes

**Fig 28. LPC11U1x/2x flash sectors**

The on-chip flash memory of the LPC11U24 is grouped in sectors. The flash memory is divided into 8 sectors of 4 Kb each. Therefore, for LPC11U24 we have 32Kb of Flash memory available.

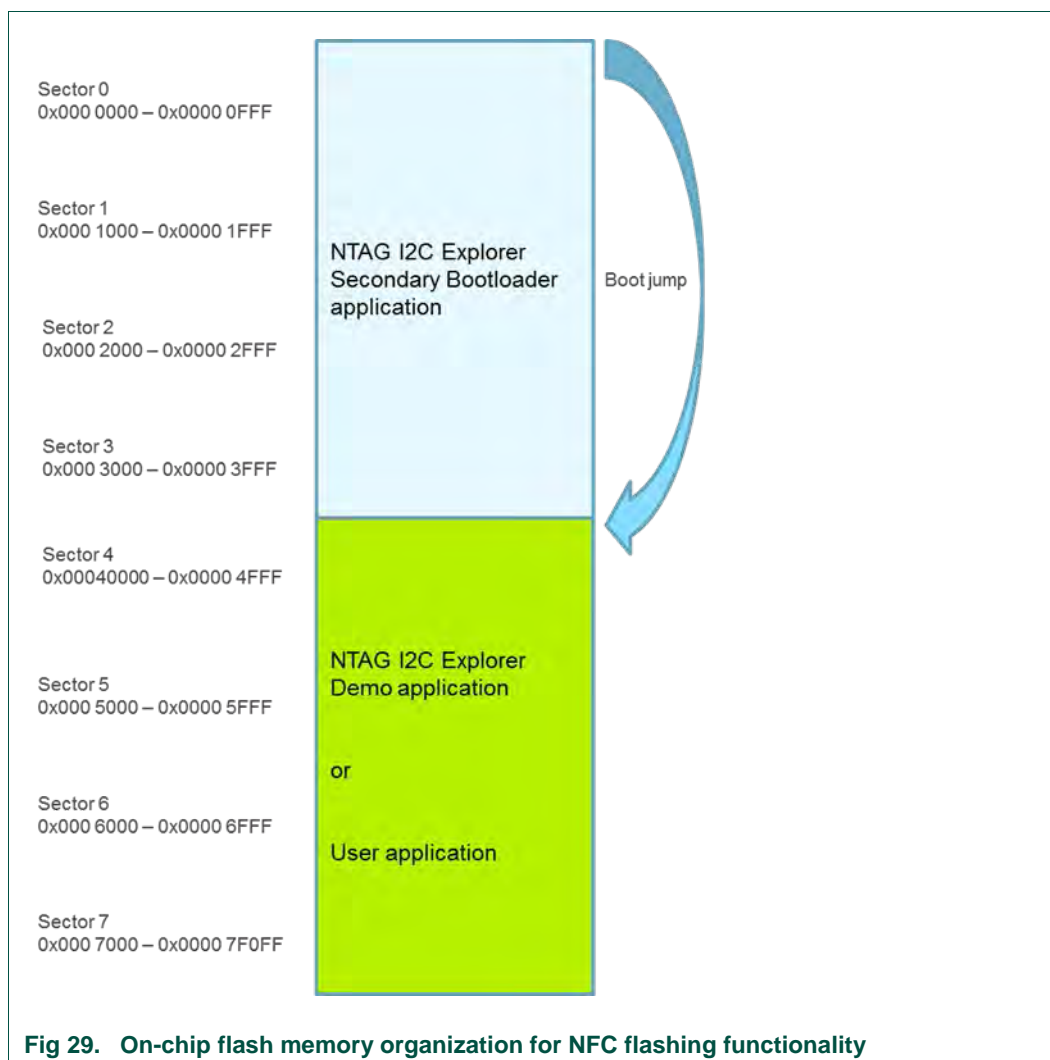
NXP's LPC11U24 microcontroller provides two methods to update the flash contents:

- In-system-programming (ISP): We use this method when we flash new contents using the USB port and a computer (drag-and-drop a binary file).
- In application programming (IAP): Programming is performed by erase and write operation on the on-chip flash memory, as directed by the end-user application code → this is the method we use for NFC flashing.

A secondary bootloader has been implemented in order to enable firmware flashing through NFC interface. A secondary bootloader is a piece of code, which allows a user application code to be downloaded via alternative channels to the USB (i.e.: NFC flashing).

The primary bootloader is the firmware that resides in a microcontroller's boot ROM block and is executed on power-up and resets. After the boot ROM's execution, the secondary bootloader is executed. The secondary bootloader in turn will then execute the end-user application.

Both the secondary bootloader and the user application reside in flash. Therefore, for the secondary bootloader to flash the user application without modifying any of its own code, the user application should be flashed starting the next available sector.



The NEK secondary bootloader implements the IAP functionality that allows to erase/write flash memory sectors directed by the application and the HID drivers for USB communication. In our case, the NEK secondary bootloader occupies 4 flash sectors. This means that this four first memory sectors are never erased since they belong to the secondary bootloader (they must always be there in order to have the NFC flashing functionality available).

Therefore, we have 4 extra flash sectors available for end-user application (16 Kb). In this memory area, we store the NEK Demo (LED, Speed Tests, etc.), the blink application or any other user application. NFC flashing functionality actually re-writes this 16 Kb with the user application send by the Android or PC app via NFC interface. **For this reason, the maximum size of the binary file that can be upgraded through the RF interface is 16 KB.**



#### 4.5.1.2 How to flash new firmware through NFC

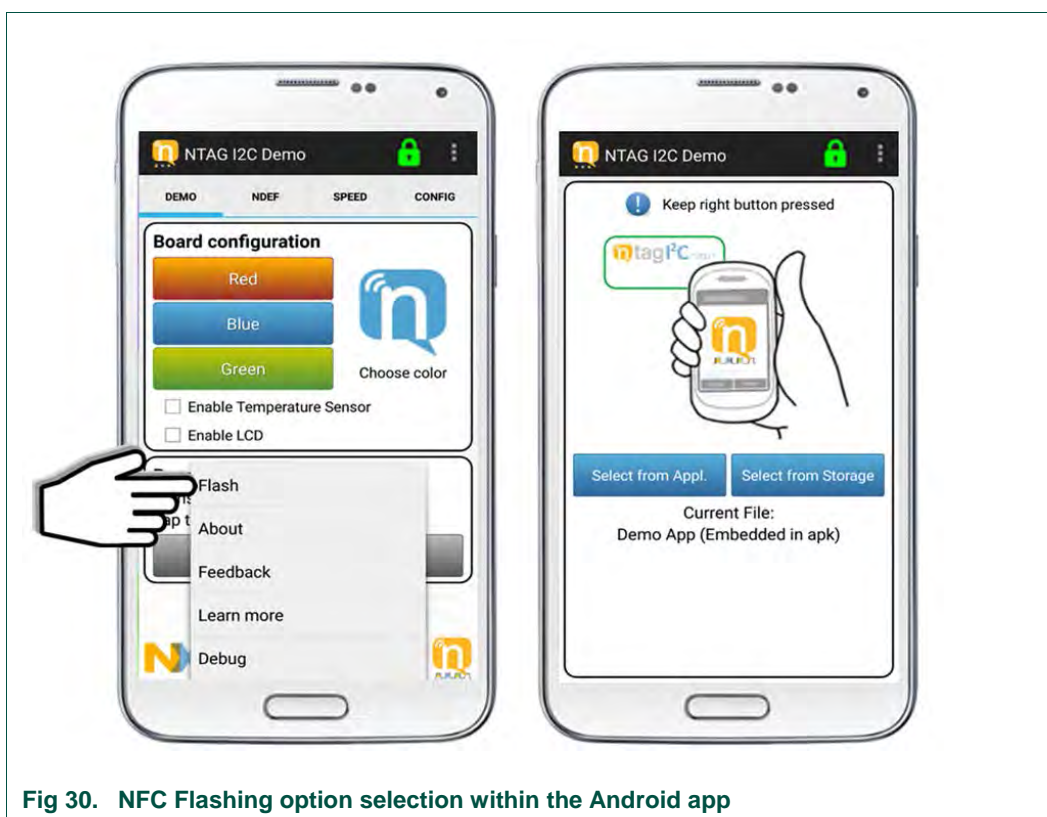
As an illustrative example, we are going to flash the provided Blink application via NFC flashing (green LED blinks when detects the presence of the RF field). After this process, the default NTAG Explorer Demo will be replaced by the Blink application

**Pre-condition:**

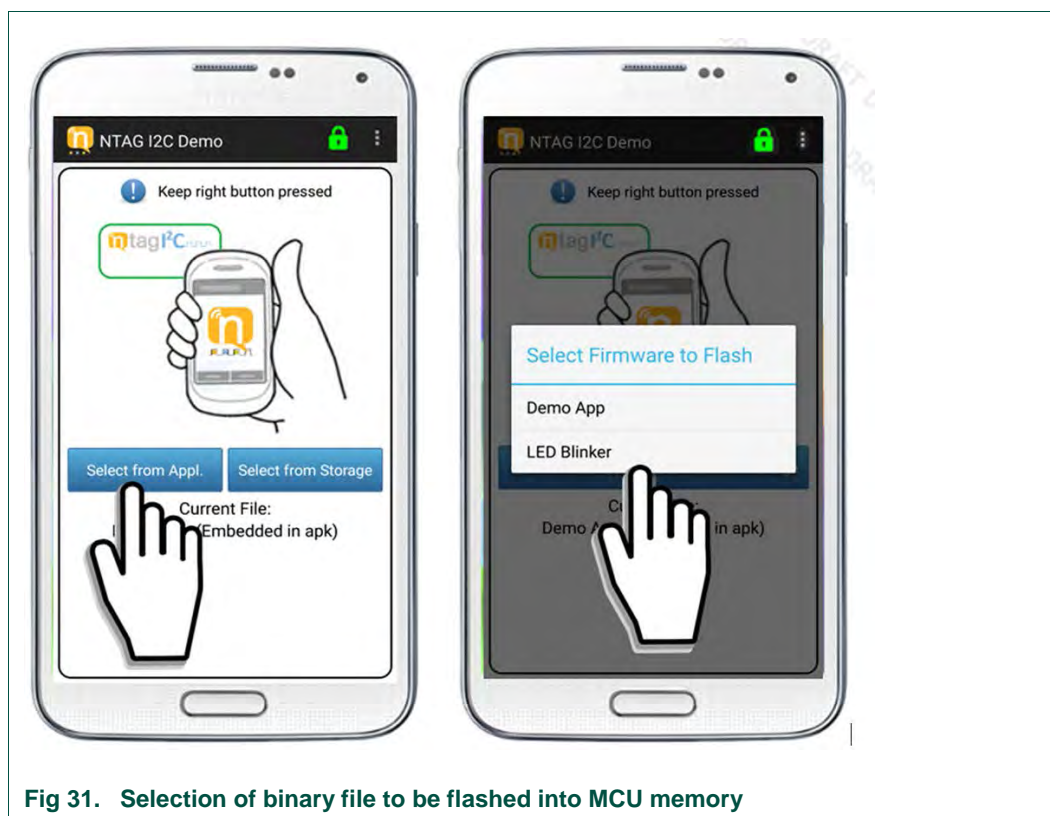
- (1) Install NTAG I<sup>2</sup>C *plus* Demo Android application v1.7.4
- (2) Verify that NEK board firmware version is v3.4

**Main flow:**

- (1) Select the NFC Flashing option in the Android app



- (2) Once in the NFC Flashing menu, we need to select the binary file to be flashed into the NEK board MCU. We have two options:
  - Select the Blink application or Demo application embedded by default in the Android app by clicking on “Select from Appl” button.



**Fig 31. Selection of binary file to be flashed into MCU memory**

- Alternatively, we can select from the phone memory a binary file by clicking on the “Select from Storage” button.

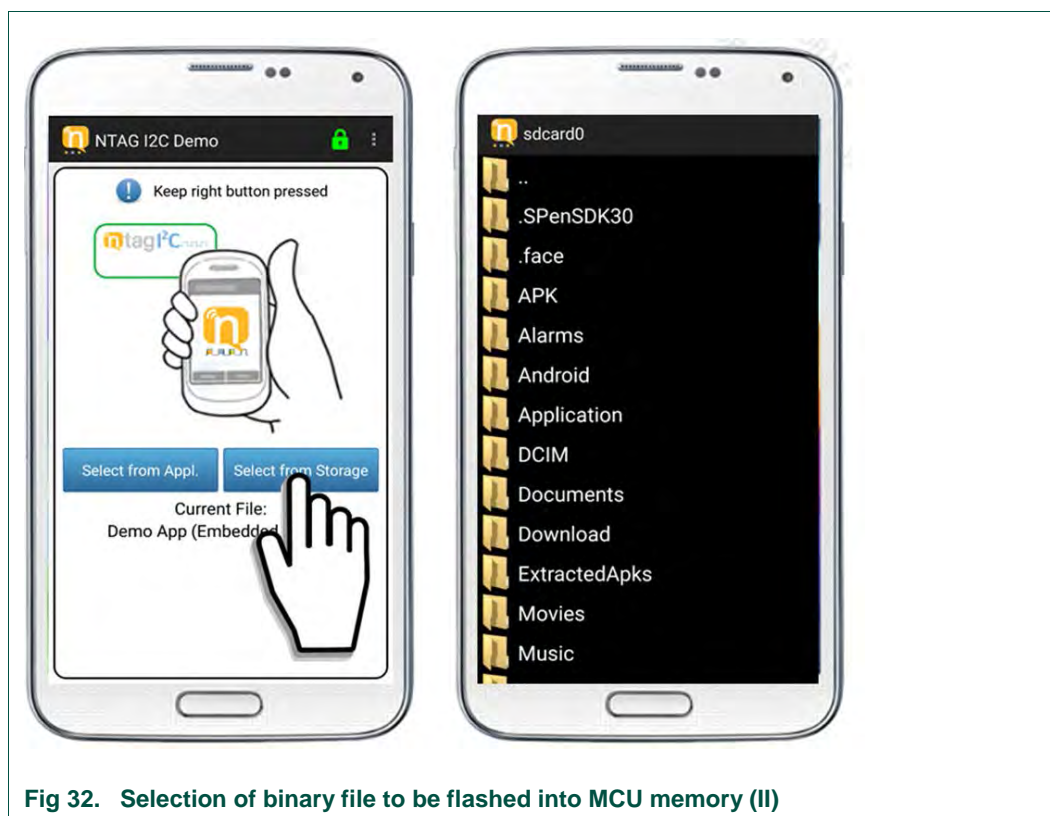


Fig 32. Selection of binary file to be flashed into MCU memory (II)

- (3) NFC Flashing mode is enabled in the NEK board by **pressing the third button (right button) before power up**. While keeping the third button (right button) pressed, we tap the NEK board into the phone NFC sweet spot.

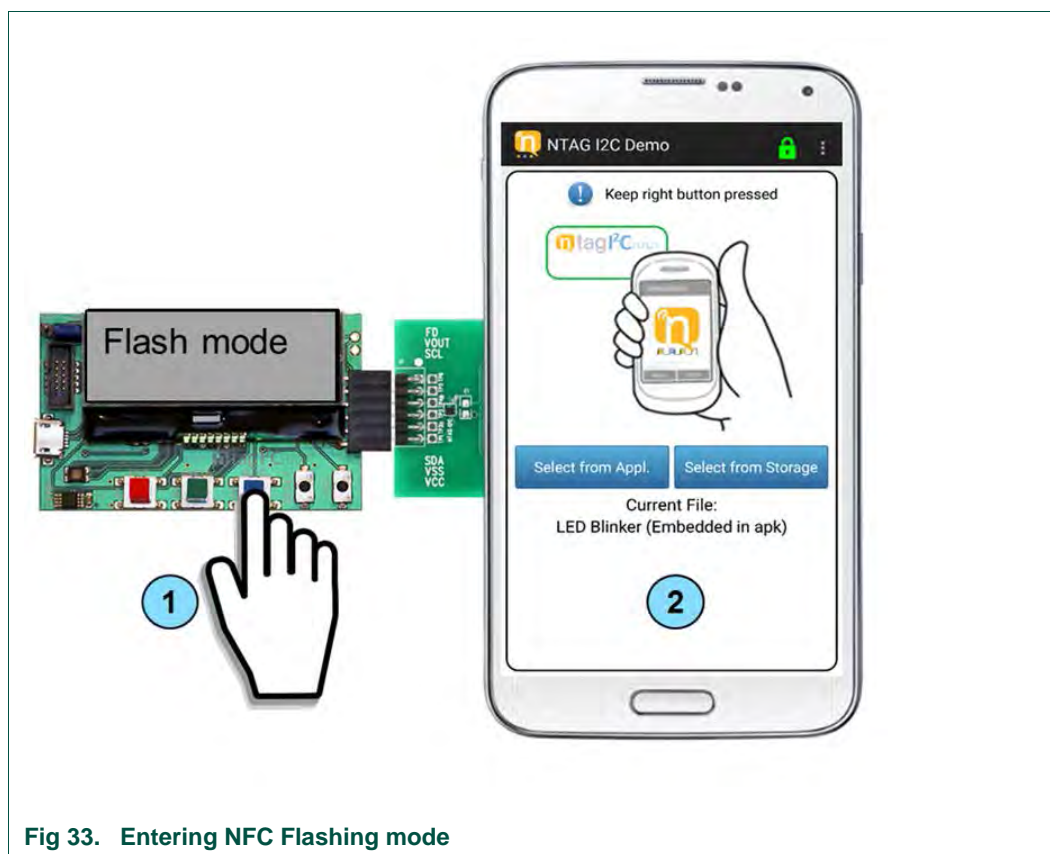
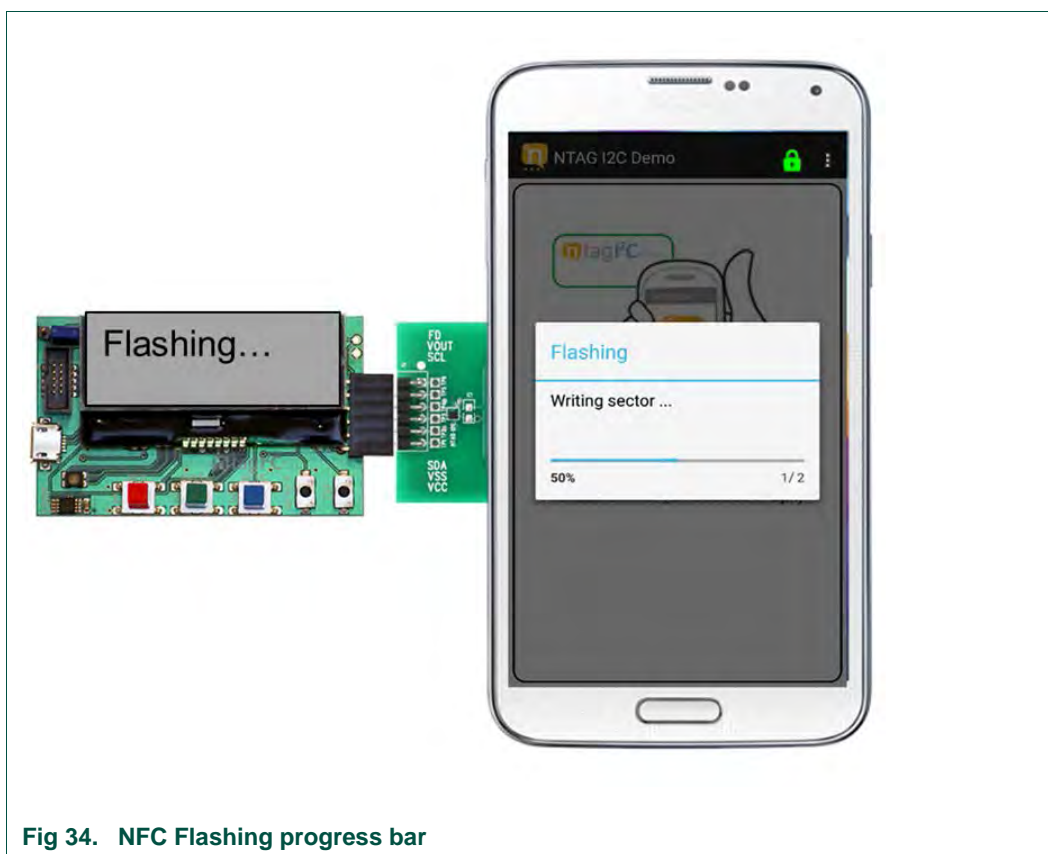


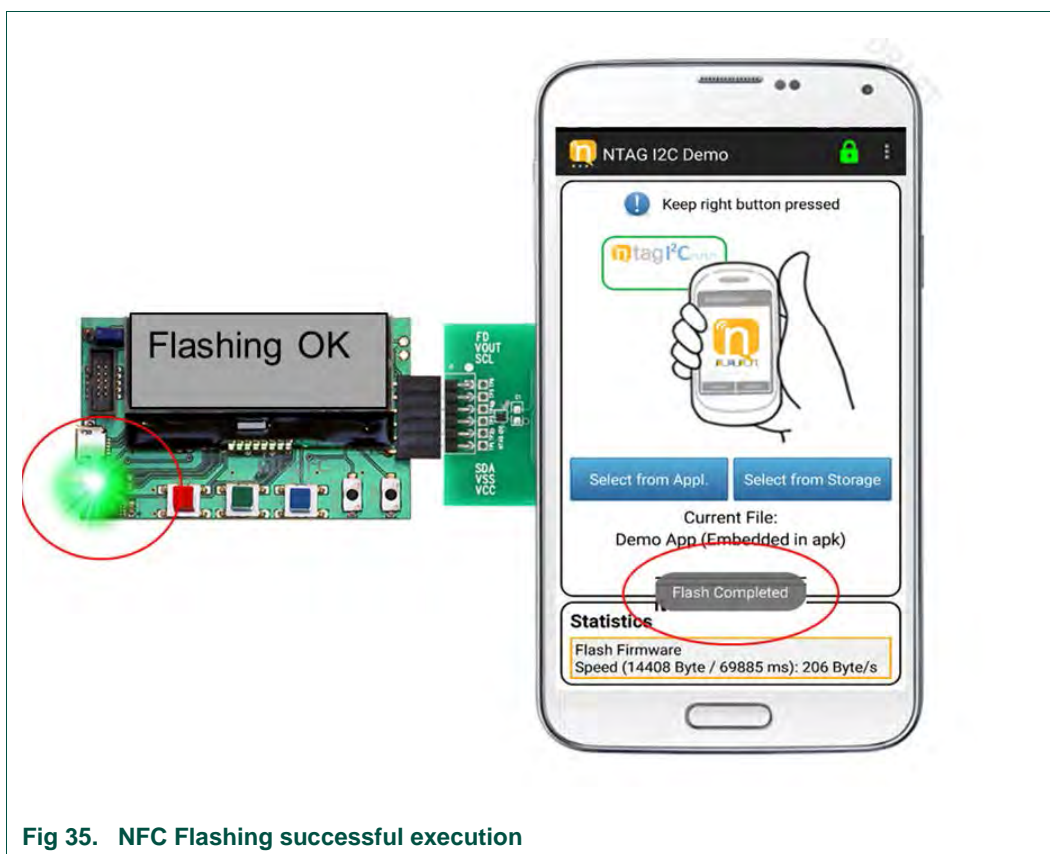
Fig 33. Entering NFC Flashing mode

As soon as we tap the NEK board, the NFC flashing will start. Once the NFC Flashing process has started, we can release the right button. This process may take some seconds, it is important to keep the phone steady until the NFC flashing process has finished (as indicated by the progress bar).

In this example, we flash the Blink application binary file into the MCU memory. For doing so, we need to click on *Select from Appl* button and click on *LED Blinker*.



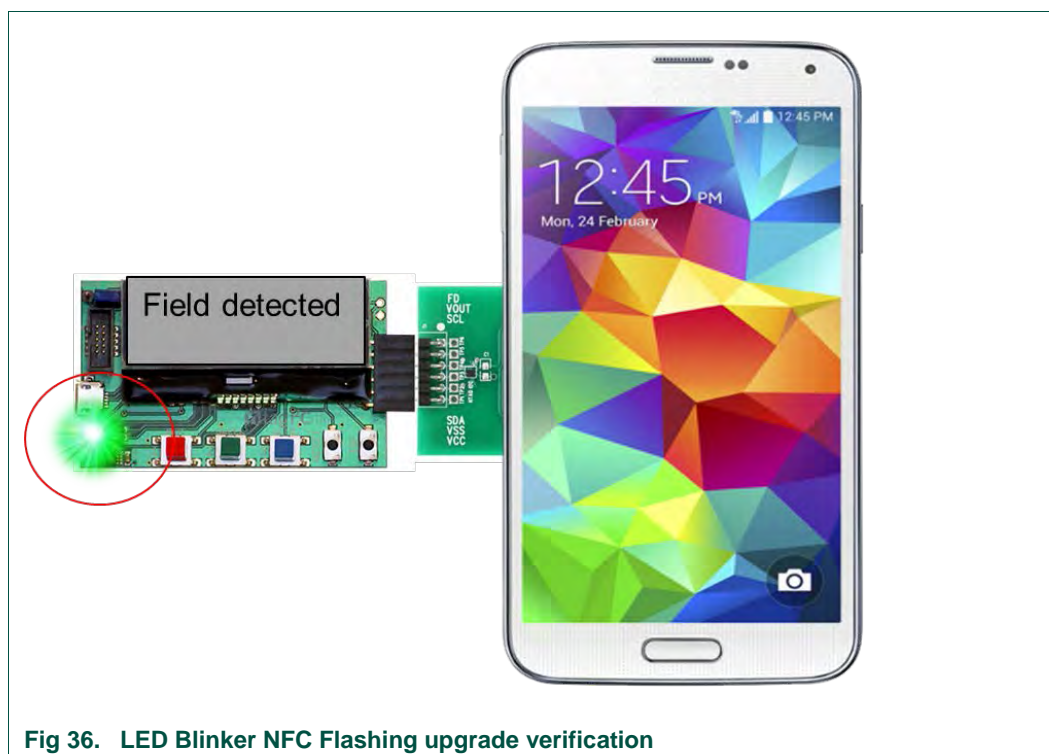
- (4) When the NFC Flashing process has finished, both the Android app and the NEK board notifies it to the user. In the Android app, a message appears on the bottom part of the screen. The NEK board blinks the green LED three times and displays "Flashing OK".



**Fig 35. NFC Flashing successful execution**

- (5) If the process has finished successfully, we can now check if the Blink application is installed and has replaced the previous Demo app.





**Fig 36. LED Blinker NFC Flashing upgrade verification**

- (6) If the process has not finished successfully, (e.g. due to an RF field lost), we can retry as many times as required. For that, we need to go back to Step 1 and repeat the entire process. Note that, if the flashing process has not finished successfully, the previous installed firmware may be not usable, and therefore, we need to retry flashing a new firmware.

### 4.5.2 About

The about functionality can be used to get the version being used for the board design, firmware of the board and the Android app by tapping the board with the NFC enabled device.

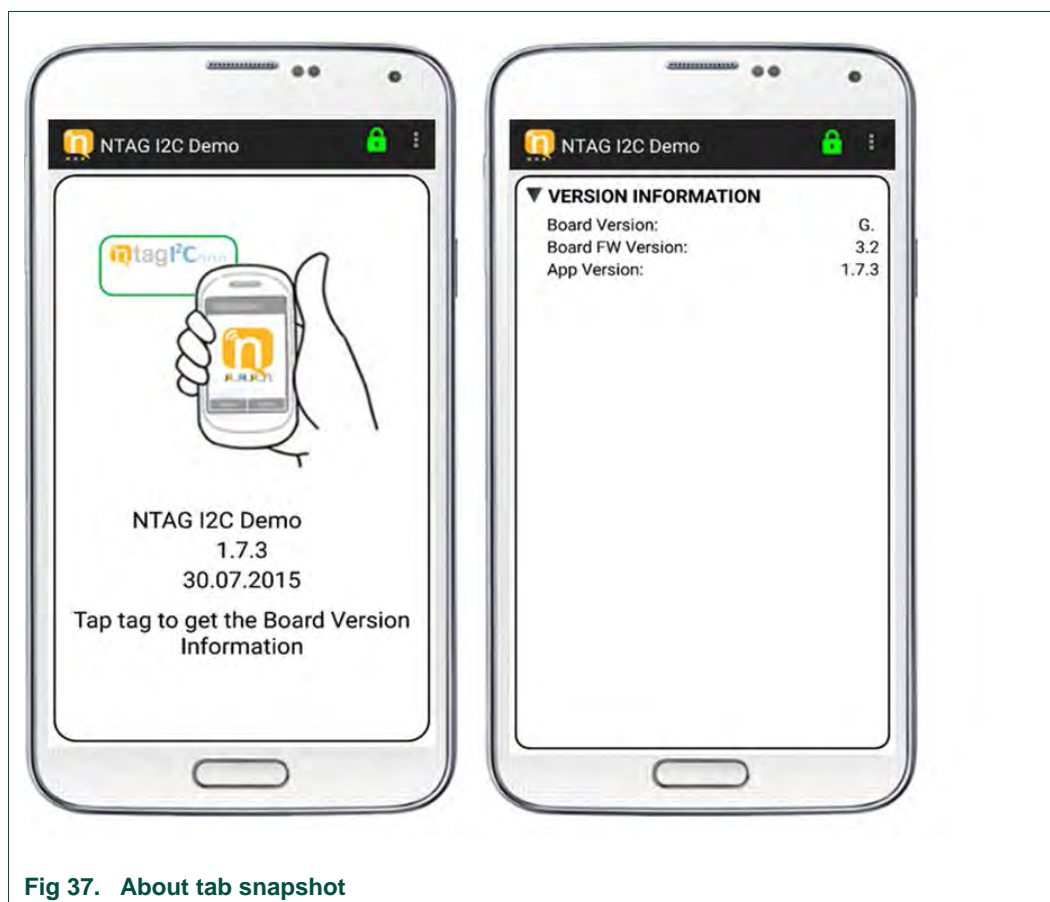


Fig 37. About tab snapshot

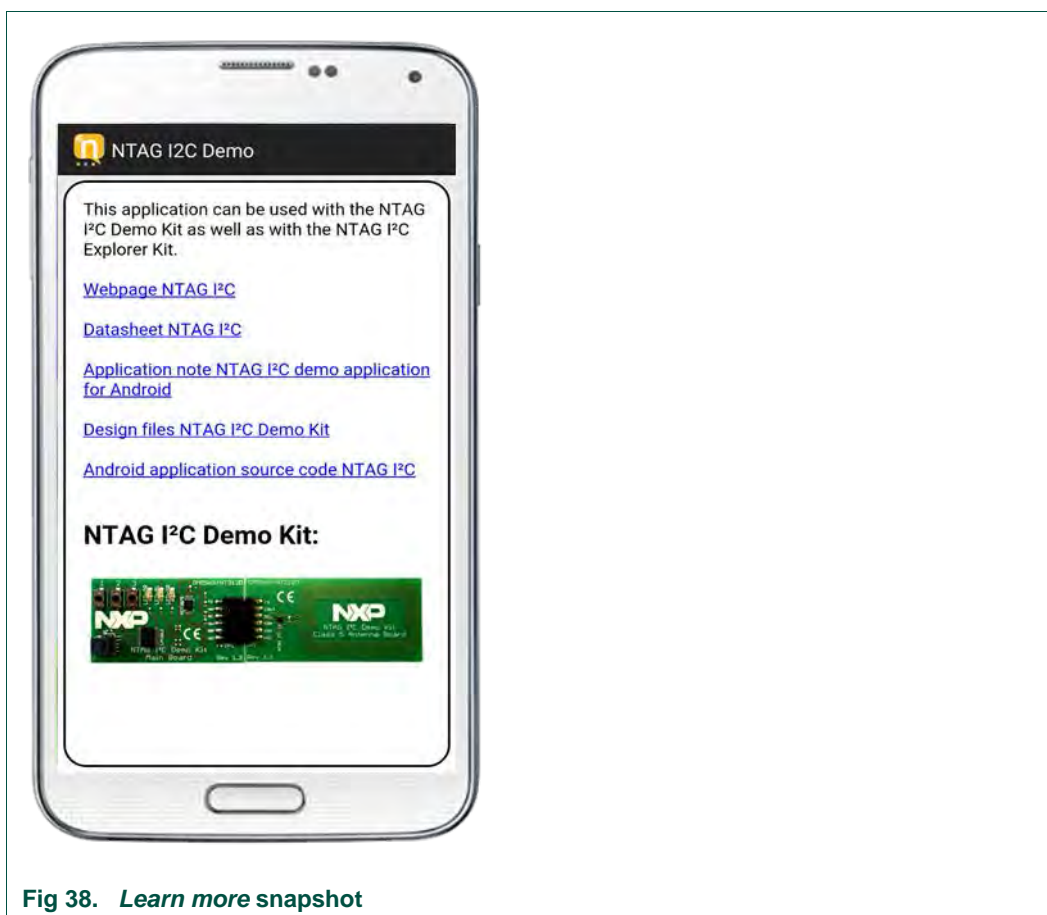
#### 4.5.3 Feedback

This option allows you to report feedback on the Android app directly to the NXP support team.

#### 4.5.4 Learn more

This option will bring you to a set of links with further information about NXP NTAG I<sup>2</sup>C *plus* tag, application notes, and design files and to the Android app source code.

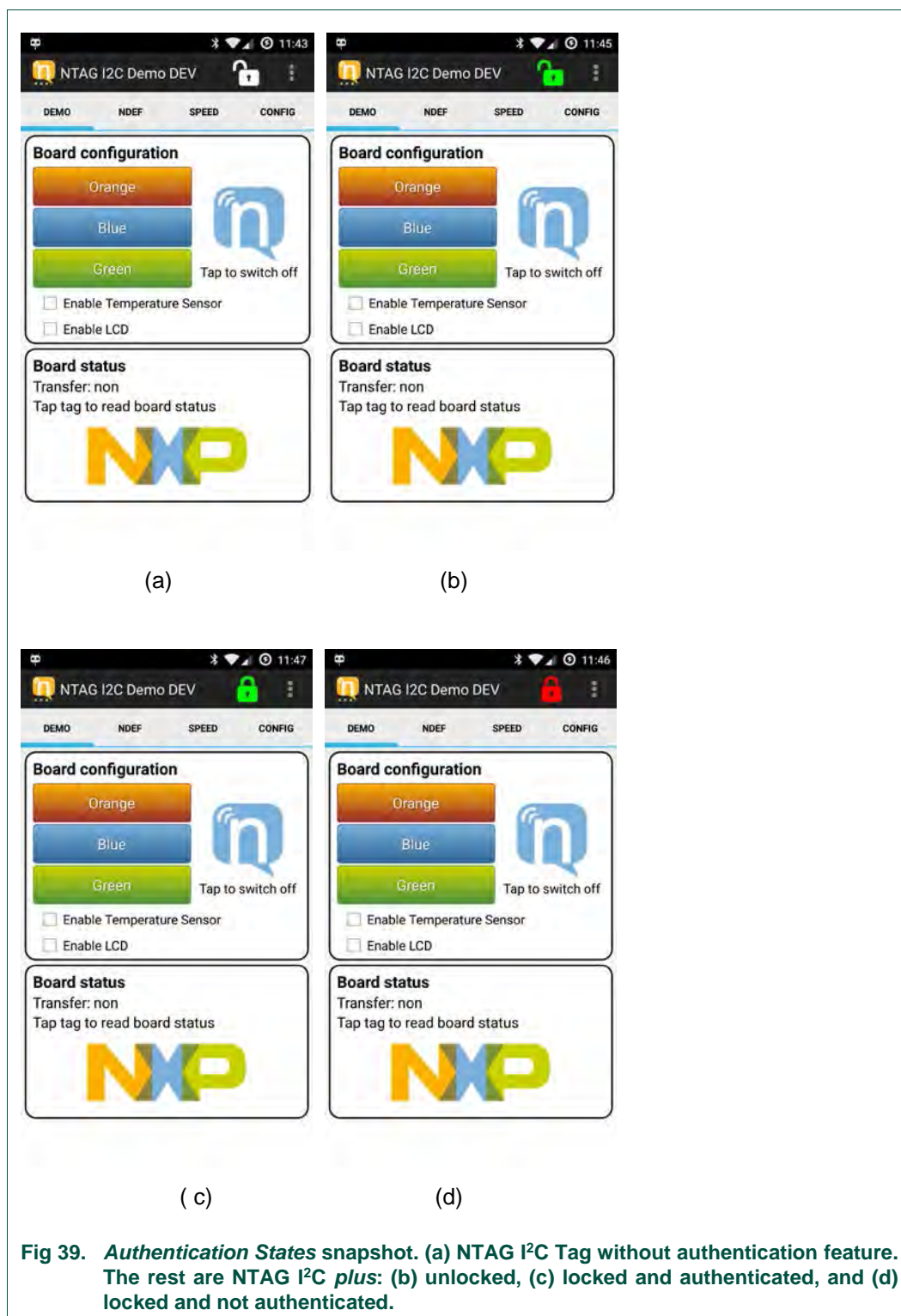




## 4.6 Authentication

The NTAG I<sup>2</sup>C Plus offers authentication to protect memory operations. The device can be locked or not. If it is not locked, the user is able to perform any memory operation. If the device is locked, the user must introduce the correct password to authenticate and access the memory.

The application provides the feature to lock and unlock the device. In the upper right side of the screen there is a locker icon. In case the device is a NTAG I<sup>2</sup>C, which has no authentication feature, the locker will be white and open. This means, the user can interact with all memory. Nonetheless, if the device is a NTG I<sup>2</sup>C *plus*, the following states are possible: the device can be locked or unlocked, and the device can be authenticated or not. In the case, the device is unlocked, there is no need of authentication. This is shown with an open green locker. On the other side, if the device is locked, for a non-authenticated state, the icon shown is a red closed locker, while if it is authenticated then is a green closed locker. The different states are shown in Fig. 39.



In order to lock or unlock the device, the user can press on the locker icon. A password selection menu will be shown, as shown in Fig. 40. If the device is unlocked, then the menu is to set a password. After setting it, the device is locked and authenticated. In case the device is locked, the menu is to authenticate the user with the correct password.

If the user introduces the correct password, the device is unlocked. Fig 41. depicts a state diagram about the authentication procedure.

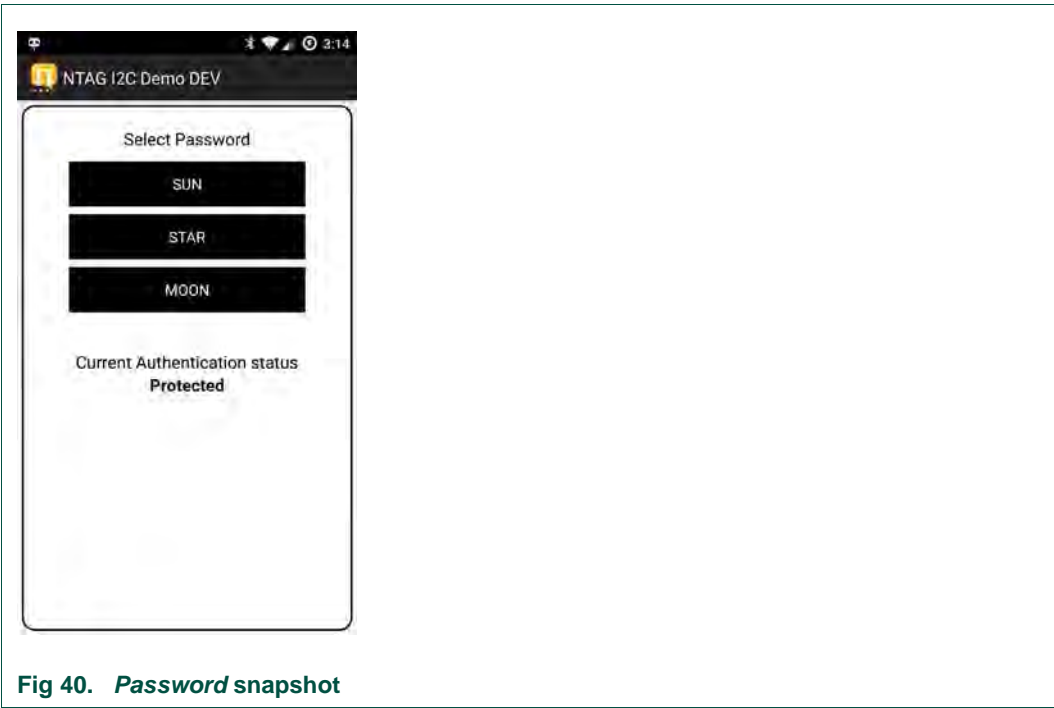


Fig 40. Password snapshot

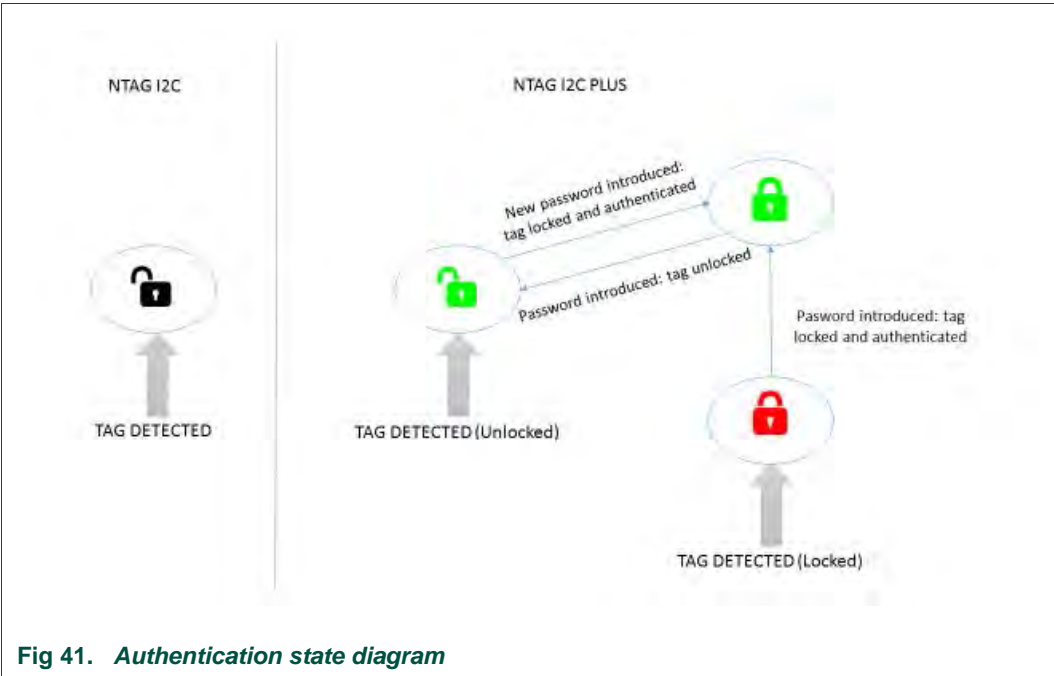


Fig 41. Authentication state diagram

## 5. Federal Communication Commission Interference Statement

### 5.1 FCC Grant

The NTAG I<sup>2</sup>C *plus* Explorer Kit with FCC ID OWROM5569-NT322E has been tested to fulfil the approval requirements ANSI C63.4-2009; FCC Part 15, Subpart C and has passed the tests.

T251-0895/15

Page: 16 (33)



### 6. TEST SUMMARY

STANDARDS (details on first page)	Tested		Sample	
	yes	no	pass	not pass
ANSI C63.4-2009; FCC Part 15, Subpart C	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>

Test	Section within the report	Class	Conclusion
Conducted emission	3.1	/	N/A
Radiated emission	3.2	/	PASS

#### 6.1 Operating voltages/frequencies used for testing

Section.	Test	Operating conditions
7.1	Conducted emission	/
7.2	Radiated emission	DC power supply connection from NTAG I <sup>2</sup> C tag ic

### 5.2 Installation condition

NTAG I<sup>2</sup>C *plus* Explorer Kit is not intended to be reused as a module for integration into end devices. If used, FCC certification needs to be repeated.

## 6. References

[NTAGI2Cplus] NT3H2111/NT3H2211, NTAG I<sup>2</sup>C *plus*, NFC Forum Type 2 Tag compliant IC with I<sup>2</sup>C interface  
[http://www.nxp.com/documents/data\\_sheet/NT3H2111\\_2211.pdf](http://www.nxp.com/documents/data_sheet/NT3H2111_2211.pdf)

[UM10967] NTAG I<sup>2</sup>C *plus* Explorer Kit and Peek & Poke  
[www.nxp.com/documents/user\\_manual/UM10967.pdf](http://www.nxp.com/documents/user_manual/UM10967.pdf)

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