UM2062
User manual

Firmware for the ST25DV-DISCOVERY boards

Introduction

This document describes the functionalities of the STSW-ST25DV001 firmware, developed to fully exploit the capabilities of the ST25DV-DISCOVERY boards, based on ST25DV.

The ST25DV is an IC for contactless applications that can communicate with a microcontroller through an I²C interface; this makes the ST25DV a dynamic tag. On the RF side, the reader (for instance a smart phone) can retrieve and update the content of the tag when close to it.

The reader communicates with the ST25DV-DISCOVERY board using the ISO 15693 protocol, while the STM32F405 microcontroller communicates with the ST25DV through an I²C bus.

With this discovery kit, the ST25DV can be programmed with different contents, following the NFC Forum standard. This means that a smart phone can read it natively, without any specific application being previously installed.

A specific Fast Transfer Mode can be used to transfer data directly to the microcontroller, without using the embedded EEPROM.

Contents

List of tables

List of figures

1 List of acronyms and notational conventions

1.1 Acronyms

APB: Advanced Peripheral Bus

AAR: Android Application Record

BLE: Bluetooth® Low Energy

CAN: Controller Area Network

GPS: Global Positioning System

GPO: General Purpose Output

H2R: Host to Reader

IEC: International Electrotechnical Commission

ISO: International Organization for Standardization

MCU: Micro Controller Unit (microcontroller)

NFC: Near Field Communication

OOB: Out Of Band

R2H: Reader to Host

RF: Radio Frequency

RFID: Radio Frequency Identification

RISC: Reduced Instruction Set Computer

SPI: Serial Peripheral Interface

URI: Uniform Resource Identifier

URL: Uniform Resource Locator

USB: Universal Serial Bus

1.2 Representation of numbers

The following conventions and notations apply in this document unless otherwise stated:

- **Binary numbers** are represented by strings of 0 and 1 digits shown with the most significant bit (MSB) on the left, the least significant bit (LSB) on the right, and "0b" added at the beginning. Example: 0b11110101.
- **Hexadecimal numbers** are represented by using numbers 0 to 9 and characters A to F, and adding "0x" at the beginning. The Most Significant Byte (MSB) is shown on the left and the Least Significant Byte (LSB) on the right. Example: 0xF5.
- **Decimal numbers** are represented without any trailing character. Example: 245.

2 Overview

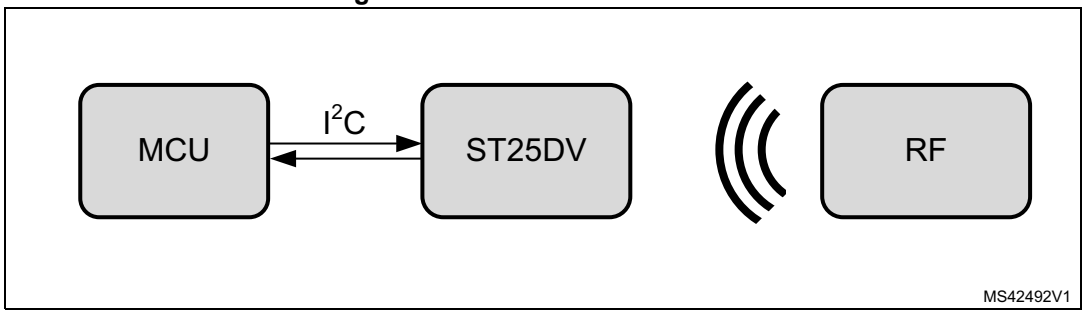
2.1 ST25DV

The ST25DV is a dynamic tag IC for contactless applications (ISO 15693). It manages the RF communication with a reader. It also includes frame coding, RF modulation and manages the anti-collision process.

The ST25DV works as an NFC Forum Type 5 tag, supporting detection, read and write operations.

The ST25DV (see *Figure 1*) can communicate with a reader without any external control.

Figure 1. Communication scheme



2.2 STM32F405

The STM32F405xx microcontrollers are based on the high-performance ARM® Cortex®-M4 32-bit RISC core operating at a frequency of up to 168 MHz. The Cortex®-M4 core features a Floating point unit (FPU) single precision, which supports all ARM® single-precision data-processing instructions and data types. It also implements a full set of DSP instructions and a memory protection unit (MPU) that enhances application security.

The STM32F405xx incorporate high-speed embedded memories (Flash memory up to 1 Mbyte, SRAM up to 192 Kbytes), up to 4 Kbytes of backup SRAM, an extensive range of enhanced I/Os and peripherals connected to two APB buses, three AHB buses and a 32-bit multi-AHB bus matrix.

All devices offer three 12-bit ADCs, two DACs, a low-power RTC, twelve general-purpose 16-bit timers including two PWM timers for motor control, two general-purpose 32-bit timers, a true random number generator (RNG) and a cryptographic acceleration cell. They also feature standard and advanced communication interfaces:

- Up to three I2Cs
- Three SPIs, two I2Ss full duplex: to achieve audio class accuracy, the I2S peripherals can be clocked via a dedicated internal audio PLL or via an external clock enabling synchronization
- Four USARTs and two UARTs
- An USB OTG full-speed and an USB OTG high-speed with full-speed capability (with the ULPI)
- Two CANs
- An SDIO/MMC interface

These features make the STM32F405xx microcontrollers suitable for a wide range of applications, such as

- Motor drive and application control
- Medical equipment
- Industrial applications: PLC, inverters, circuit breakers
- Printers and scanners
- Alarm systems, video intercom and HVAC
- Home and audio appliances

2.3 ST25DV-DISCOVERY boards

The ST25DV-DISCOVERY is an evaluation kit, which allows the user to evaluate the performance of the ST25DV dynamic tag. The kit is composed of two boards:

- motherboard
- ST25DV daughter board

2.3.1 ST25DV-DISCOVERY motherboard

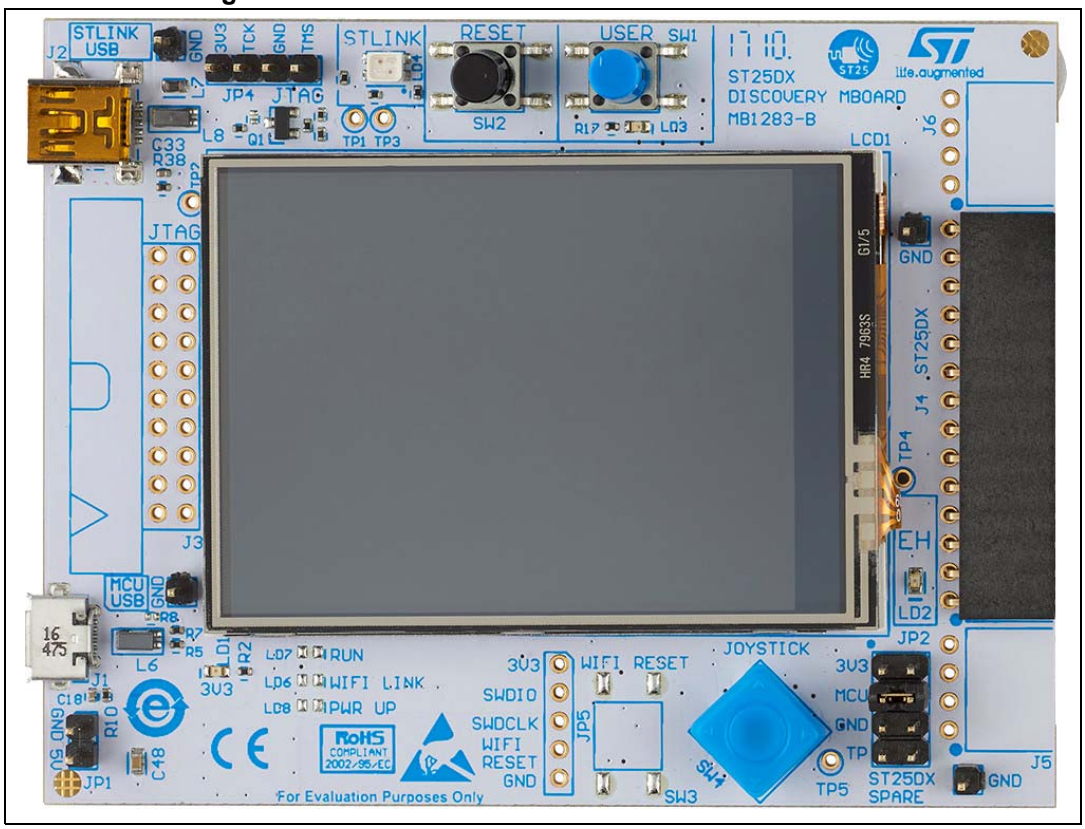
The ST25DV-DISCOVERY is powered through any of the USB bus (micro and mini connectors) and no external power supply is required.

This motherboard embeds the STM32F405VG microcontroller and different peripherals:

- LCD display and touchscreen to interface with the user
- USB connectors to connect to a PC (mini-USB for the STLink debugger and micro-USB available for the user application)
- Optional modules: Wi-Fi® and Bluetooth® Low Energy (BLE) to connect with a smart phone

The connector on the right side of the board is dedicated to the daughter boards that embed the NFC tags.

Figure 2. ST25DX-DISCOVERY motherboard MB1283-B



2.3.2 ST25DV daughter board

This board embeds the ST25DV NFC device and a 31 mm x 30 mm, 13.56 MHz double layer inductive etched antenna (no need for tuning components).

The ST25DV communicates with the STM32F405VG 32-bit MCU via the I²C bus.

Figure 3. ST25DV_Discovery_ANT_C5 board

3 Firmware description

3.1 Prerequisite

The ST25DV products are dynamic tags, their content and configuration can be driven by both a microcontroller (through I²C) and a reader through the RF.

To benefit from the ST25DV demonstration kit, the user must have one of the following:

- A smart phone with the NFC capability enabled, combined with the ST25 NFC App installed on it (see UM2131, available on *www.st.com*)

an NFC reader, such as the CR95HF distributed with the M24LR discovery kit (M24LR-DISCOVERY, to take full advantage of the ST25DV features, use CR95HF transceiver board firmware in version 3.7.0 or higher) combined with the associated PC software (see UM1084, available on *www.st.com*, to take full advantage of the ST25DV features, use PC Software in version 1.9.0 or higher).

The ST25DV is fully compliant with the NFC Forum Type 5 standard. This standard has been introduced recently, hence some features could not be fully supported by the oldest smart phones.

3.2 Main menu

The main menu (see *Figure 4*) is composed of three icons, used to access sub-menus.

Figure 4. ST25DV-DISCOVERY main menu display

Each item allows the user to enter a sub-menu containing a set of use cases, as indicated below:

Discover ST25DV	
Fast Transfer Mode Demo	
NFC NDEF Demos	

Note: If the Wi-Fi® and/or the BLE modules have been added to the board the corresponding icons are available to access the Wi-Fi® and Bluetooth® pairing demonstrations.

To select a category, touch the screen on an icon. Then to start a demonstration, touch the screen on the icon of the desired demonstration (see description below). A long touch on an icon will display, in the top line, the description of the corresponding demonstration(s).

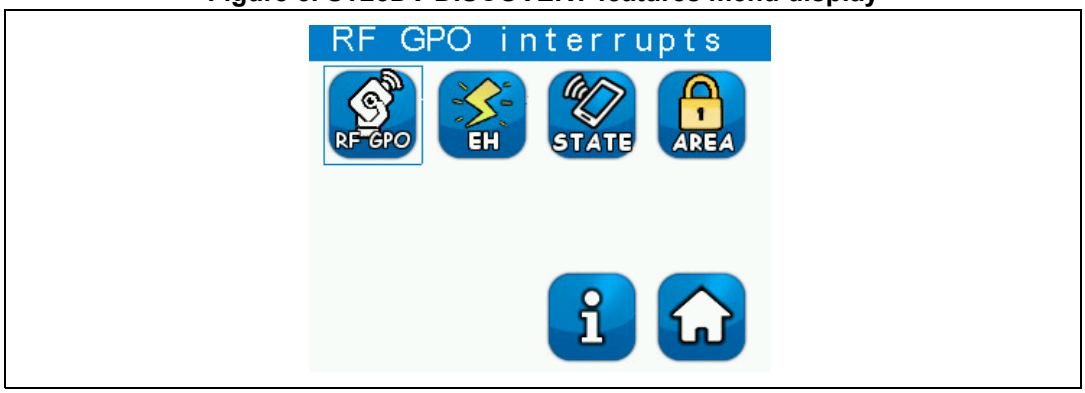
As the purpose of this document is to illustrate the firmware behavior, the descriptions will be detailed from the microcontroller point of view.

3.2.1 Discover ST25DV menu

As shown in *Figure 5*, the “Discover ST25DV” menu proposes several demonstrations of the ST25DV specific features, among them:

- GPO interrupts
- Energy harvesting
- ST25DV states
- Multi-areas and passwords

Figure 5. ST25DV-DISCOVERY features menu display



3.2.2 RF GPO interrupt demo

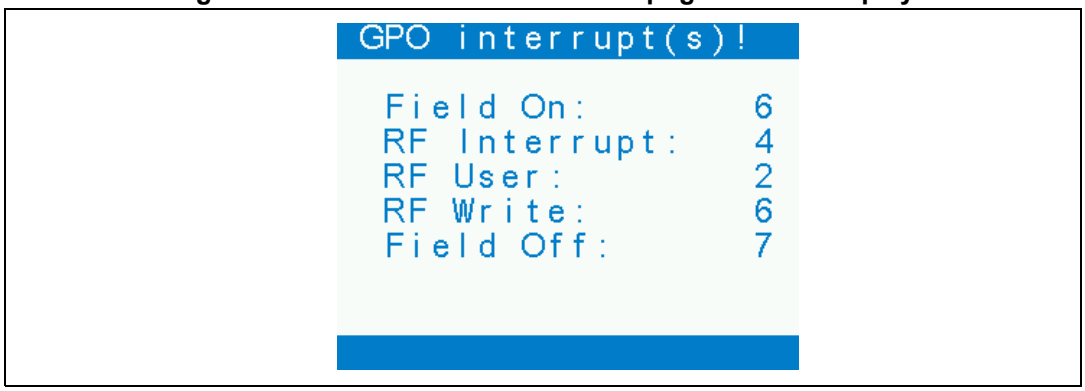
The ST25DV has a GPO that can be used to send interrupts to the microcontroller.

Several kinds of event can be configured on the RF side to trigger the GPO interrupt. In this demonstration all possible interrupt sources are enabled, except the "RF activity", which occurs too often for correct readability when using a smart phone as a reader.

To start the demonstration, select the “GPO control Demo” menu, this will display the instructions until it detects a GPO interrupt.

As soon as the first GPO interrupt is received, the LCD displays the list of sources of received interrupt, and for each of them the number of time they occurred (see *Figure 6*).

Figure 6. ST25DV-DISCOVERY interrupt generation display



The event types and of the way to generate them are listed below:

- Field On: place a reader near the ST25DV
- Field Off: move a reader away from the ST25DV
- EEPROM written: modify the content of the ST25DV
- RF Interrupt: requires the use of a specific reader command, that can be sent either by a smart phone running the ST25 NFC app, or by a reader (see the instructions in *Smart phone GPO management* and *Generating the RF interrupts and RF user interrupts using the CR95HF*, respectively, for the ST25 NFC application and for the CR95HF reader)
- RF User: requires the use of a specific reader command, that can be sent either by a smart phone running the ST25 NFC app or by a reader (see the instructions in *Smart phone GPO management* and *Generating the RF interrupts and RF user interrupts using the CR95HF*, respectively, for the ST25 NFC application and for the CR95HF reader)

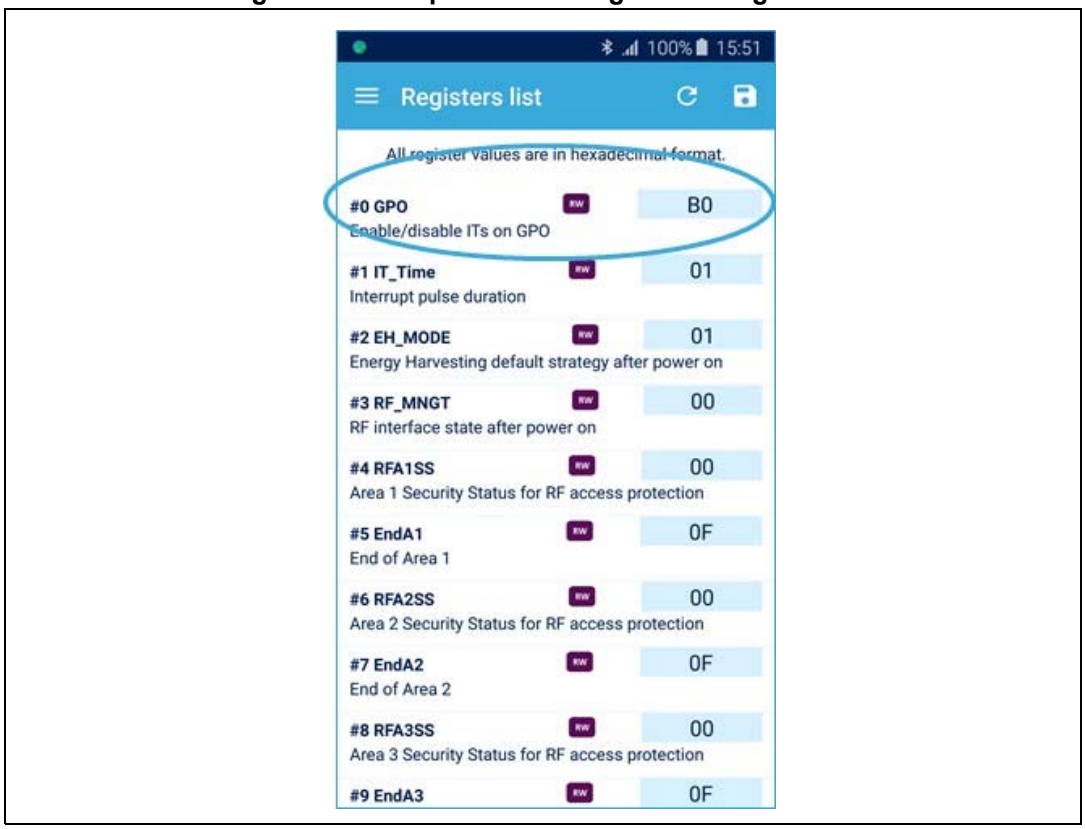
To get the ST25 NFC application, read the ST25DV with a smart phone (after entering the GPO demo), this will automatically open the required application (or propose the installation of the application). The automatic application selection is done using an NDEF with an Android Application Record (AAR).

Note: The mailbox events can also be used to trigger the GPO interrupts; they are not mentioned here, as they would require entering the ST25DV in the Mailbox mode.

Smart phone GPO management

The ST25 NFC application can handle the RF Interrupt and the RF User interrupt using register fields information. Do not forget to present configuration password before any register change.

Figure 7. Smart phone GPO register configuration



The ST25 NFC application can generate the RF Interrupt and the RF User interrupt using features located in the Tools fragment in association with the RF GPO interrupt demonstration.

Generating the RF interrupts and RF user interrupts using the CR95HF

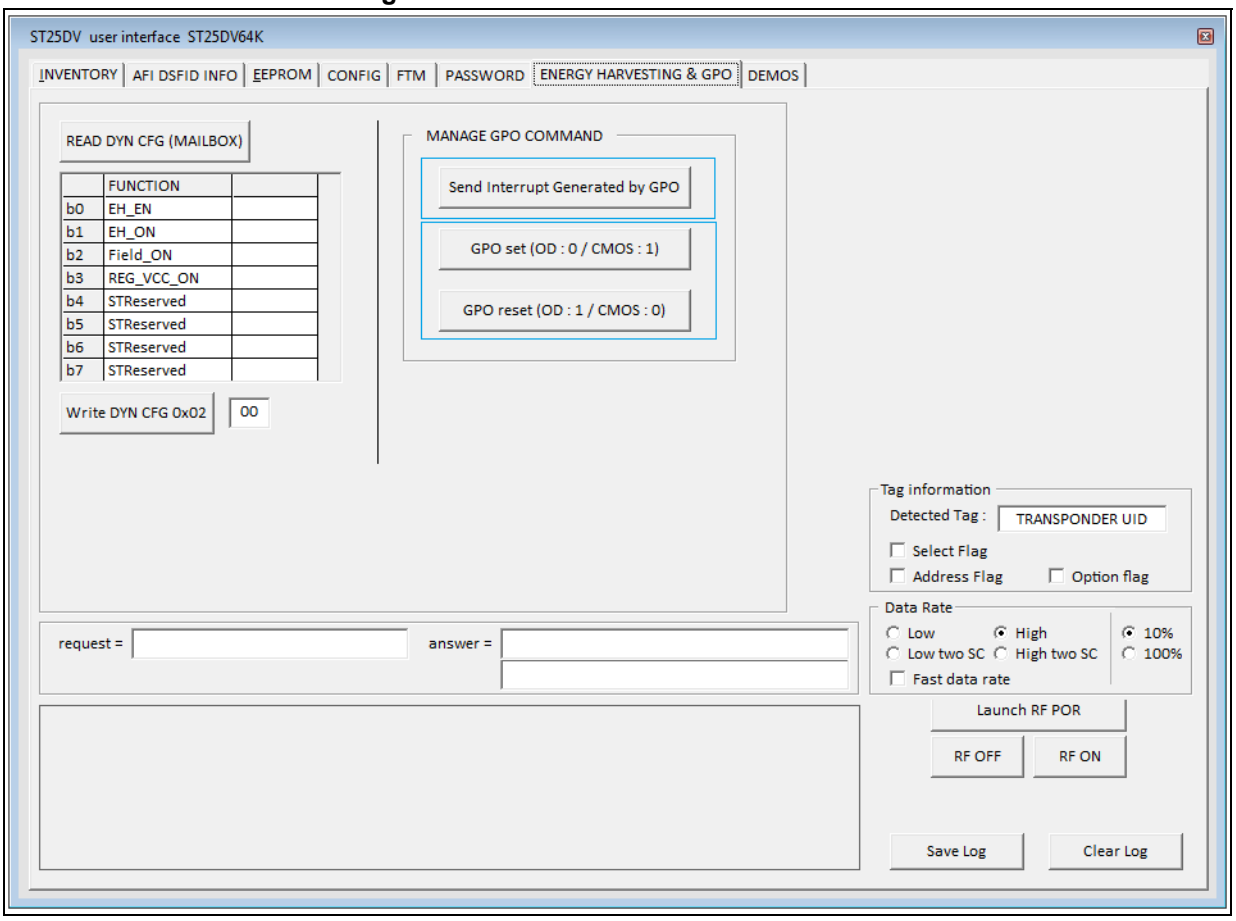
These Interruptions can be generated by any RF reader or Android smart phone.

Using the CR95HF IC and CR95HF PC software, the user will be able to send Interrupts or drive the GPO (see *Figure 8*)

- Select the ST25DV product
- Select ENERGY HARVESTING and GPO tab
- Click on “Send Interrupt Generated by GPO” to send an interrupt on GPO line
- Click on GPO set or GPO reset to be able to drive the GPO line

For additional information about CR95HF PC software, refer to user manual UM1084, available on *www.st.com*.

Figure 8. PC software GPO user interface



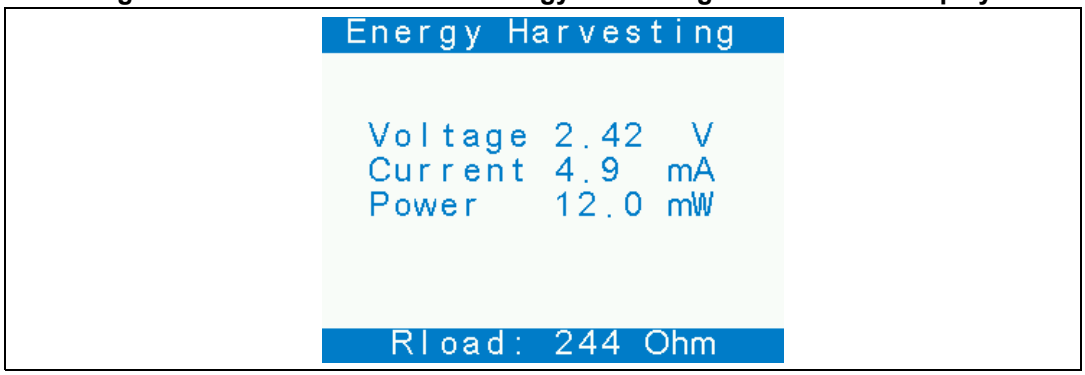
ST25DV energy harvesting demonstration

The ST25DV is able to harvest the energy provided by the RF to power other devices.

This demonstration displays the voltage, current and power provided by the ST25DV. A LED is also powered-up to simulate the effect of the energy harvesting when the RF field is approaching or when it leaves.

The current consumption is simulated by a digital potentiometer set to 240 ohm (plus the measurement resistor).

Figure 9. ST25DV-DISCOVERY energy harvesting measurement display



ST25DV states demonstration

This menu illustrates the possibility to change the state of the ST25DV (for example, to save power). This demonstration proposes three different modes:

1. RF disabled mode: RF commands are interpreted but not executed. ST25DV will respond with the error code 0x0F
2. Sleep mode: all RF communication are disabled, the RF interface does not interpret the commands, but minimizes consumption of RF interface
3. Low power down: the ST25DV is fully inactive from Host-I2C side, but the memory content can be accessed on the RF side

For all above cases, the demonstration consists in writing an NDEF with the ST25 URL, and changing the ST25DV state. A message is displayed that invites the user to try to read the content of the ST25DV, and check that it is not possible.

The content of the ST25DV can be read again as soon as the demonstration screen has been passed.

Note: For the Low power mode, the ST25DXSPARE jumper must be present on the ST25DV-DISCOVERY board on the MCU pin, and a 12-pin package must be used for the ST25DV.

ST25DV multi area and password demonstration

The ST25DV can be configured to define up to four different areas in memory. Each area may have a custom security level, requiring one of the three passwords to be provided in order to read and/or write the memory.

This demonstration sets two different areas:

- Area1 contains an NDEF with a vCard. This area is readable by anyone, but can only be written after presenting the password 1.
- Area2 contains an NDEF with a different vCard. This area cannot be read without the password 1, and cannot be written even after the password presentation.

By default, all the passwords are set to 0000 0000 0000 0000. These values can only be updated from the RF side.

To execute the demonstration, the user must first read the ST25DV without any specific application. The phone should display the vCard stored in Area1.

Then the user can open the ST25 NFC application, and tap the tag again, two areas are detected, and the Area1 vCard is displayed.

The user may try to write a different NDEF to the Area1, and check that the write fails unless password 1 is presented.

If the user selects the Area2 NDEF, the application will request the password1 before displaying the Area2 vCard.

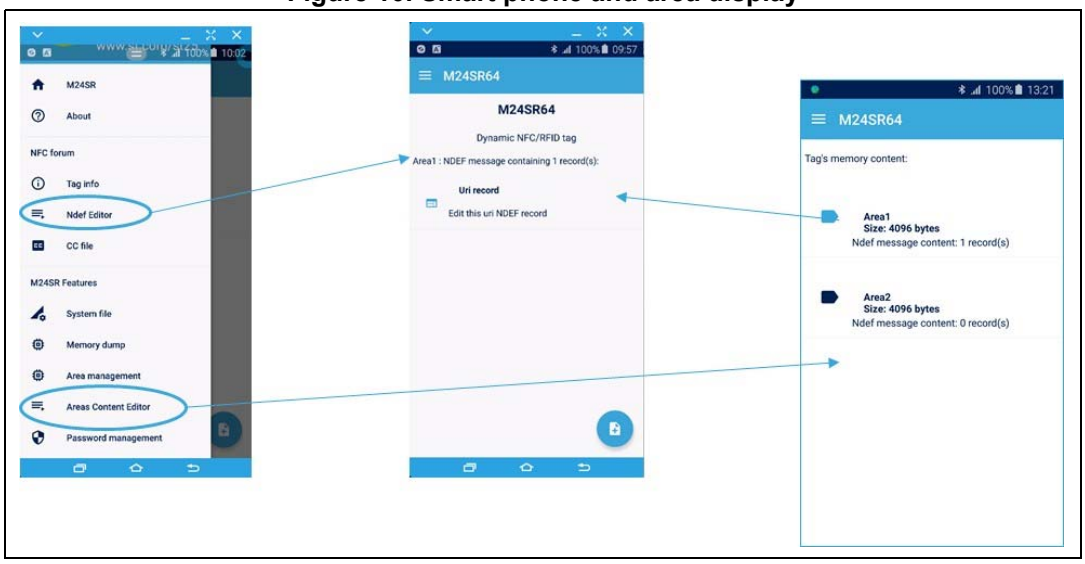
The user may try to write a different NDEF in Area2, this will not work even after presenting the password1. This is expected as the security level of Area2 prevents any write access to the memory.

Smart phone and multi areas

When the tag has been configured in multi areas, the ST25 NFC application can handle areas and present to the user areas and content. User can choose the desired area selecting the corresponding menu in the application drawer.

In case of special protections in an area, the application displays Security Status information. On Click, a popup is used to present the area password needed to access area content.

Figure 10. Smart phone and area display



3.2.3 Fast Transfer Mode Demo menu

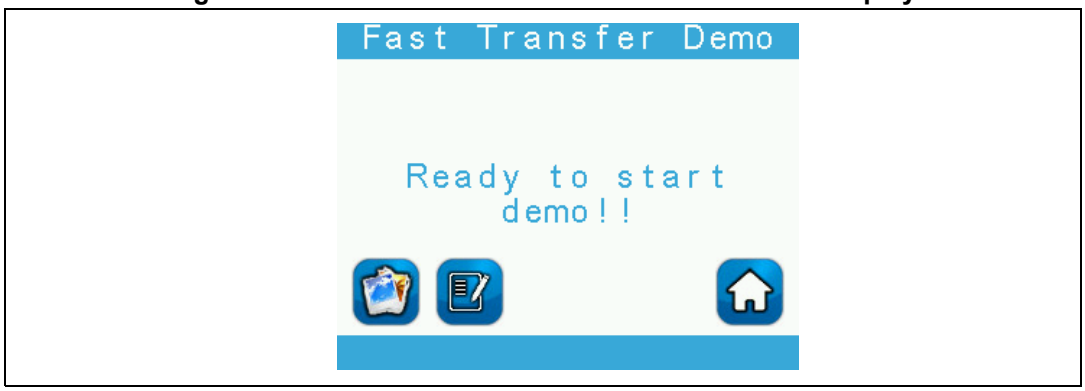
This demonstration is intended to demonstrate the capability of the ST25DV to exchange data between a reader and the MCU in a faster way, than exchanging data through EEPROM, using proprietary protocol through ISO 15693 standard. To perform the data exchange the ST25DV shares a RAM buffer of 256 bytes available for the reader and the MCU (also called Mailbox).

Data exchange can only be carried out in one direction at a time. The mailbox contains indicators that allow the reader to know its status and generate pulses on a GPO, which can be connected to an external interrupt (GPIO input) of the microcontroller. For more details on the Mailbox feature, refer to the ST25DV datasheet.

When the user selects the Fast Transfer Mode icon (see *Figure 4*), a message displays “Starting Demo…”. During this time, the firmware is initialized, enabling the Mailbox functionality and erasing the Flash memory on the MCU (in order to store data downloaded through NFC). Then, when the demonstration has finished its initialization the message “Ready to start demo!!” is displayed, as shown on *Figure 11*.

Note: When Mailbox feature is enabled, EEPROM memory is in read only. To modify EEPROM again you'll need to disable the Mailbox feature.

Figure 11. ST25DV-DISCOVERY Fast Transfer Mode display



The picture and note icons, at the bottom left, point to a sub-menu that allows the user choose a picture or a random data buffer, that will be transferred to a reader (see *Host to Reader image upload* and *Host to Reader data transfer*).

The home icon (bottom right) allows the user to go back to the main menu (*Figure 4*).

At this step, the firmware is waiting for an action from the reader or from the user to start. These actions are described in the next sections.

Smart phone and Fast Transfer Mode use cases

Available actions can be accessed after tag has been taped, and are available in the ST25DV Features or Demonstrations menus within the application Drawer.

Available use cases are

- Mailbox management, enable/disable Mailbox and display Mailbox register fields status
- Data Transfer, to demonstrate basics transfers
- Firmware Upgrade, to demonstrate the firmware upgrade use case
- Picture transfers, to demonstrate how to upload or download pictures
- Stopwatch synchronization, to demonstrate fast transfer with a smart phone

Figure 12. Smart phone and Fast Transfer Mode use cases display

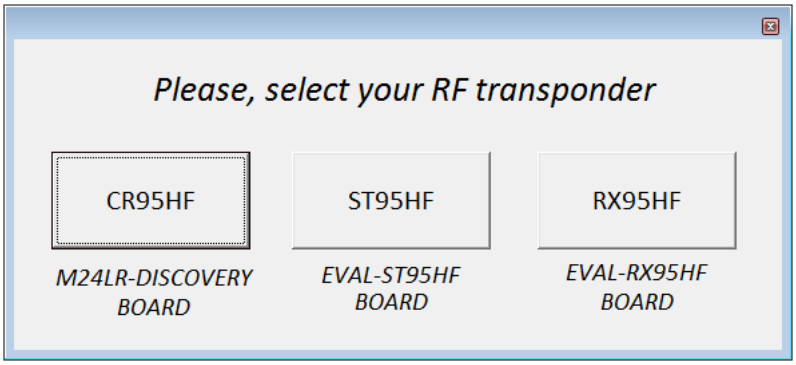
PC software and Fast Transfer Mode use cases

As with Android phones, all the Fast Transfer Mode demonstrations can be played using CR95HF PC software. The CR95HF will be used as a RF reader, for more informations refer to user manual UM1084, available on *www.st.com*.

The following screen captures detail how to start demonstrations.

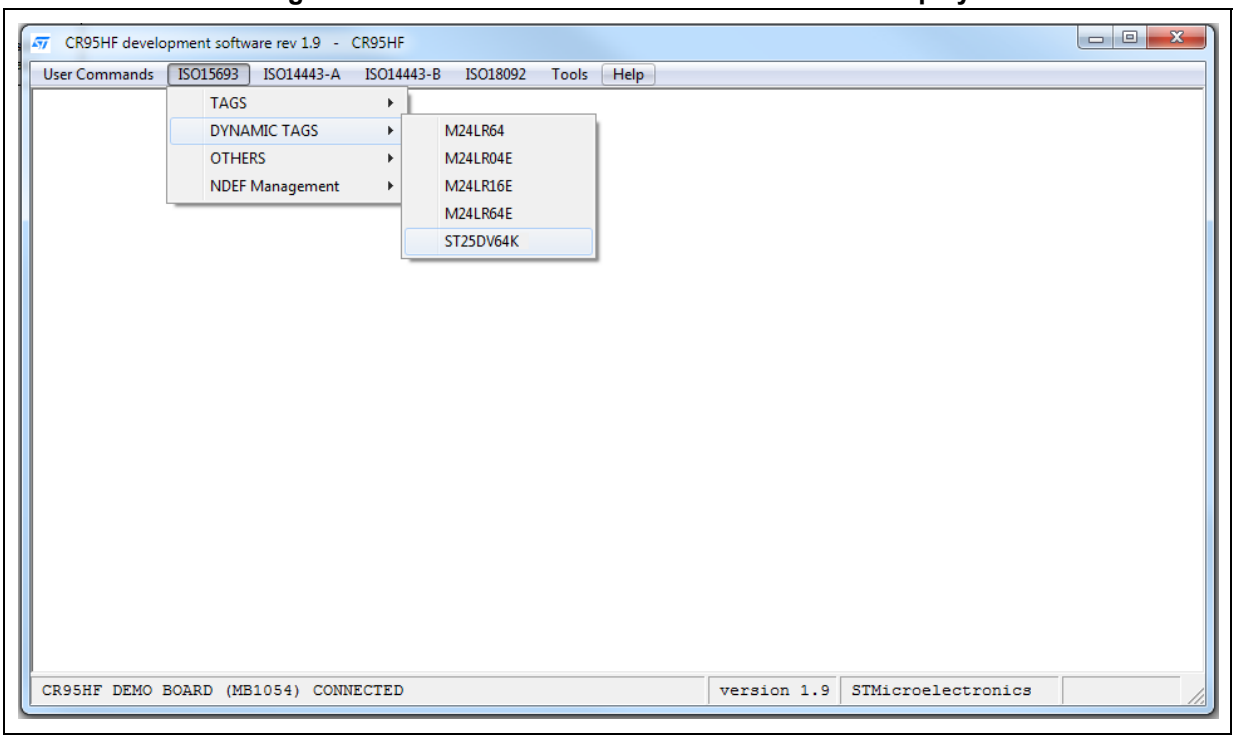
First, launch CR95HF PC software and select CR95HF IC as shown in *Figure 13*.

Figure 13. Software reader device selection display



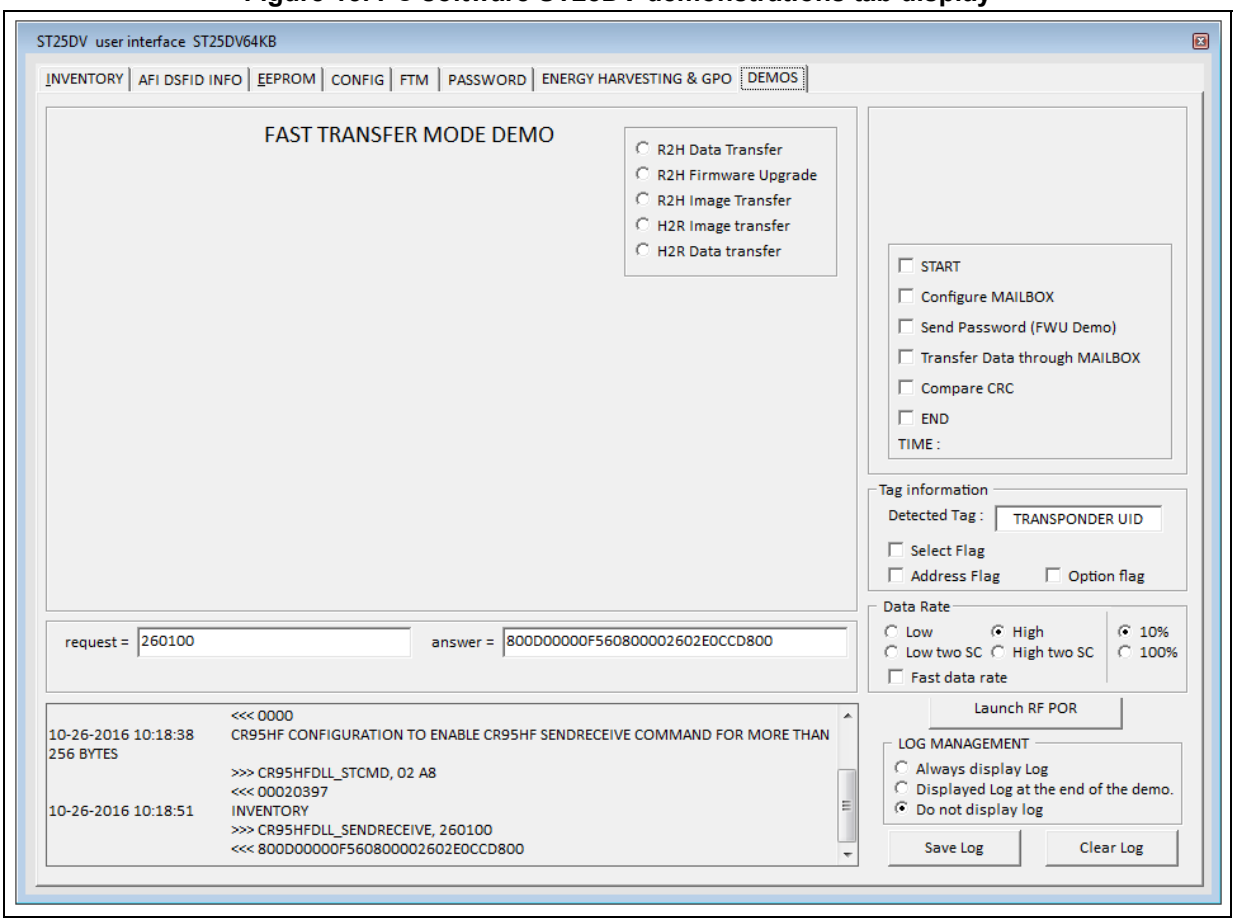
Then, in the ISO15693 menu, point to the dynamic tags sub-menu and select ST25DV line.

Figure 14. PC software ST25DV device selection display



This will open a sub-window dedicated to ST25DV, in this sub-window select the DEMOS tab, this will open the view for demonstrations with ST25DV-DISCOVERY firmware.

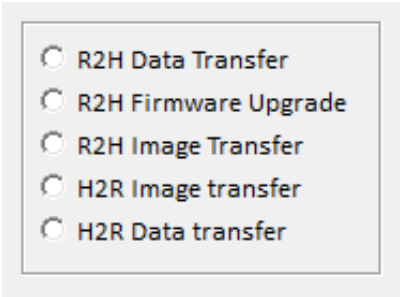
Figure 15. PC software ST25DV demonstrations tab display



Available demonstrations are:

- R2H Data Transfer: transfer of binary file from PC software (using the CR95HF board) to ST25DV-DISCOVERY board
- R2H Firmware Upgrade: transfer of binary file containing a new STM32 firmware from PC software (using CR95HF board) to ST25DV-DISCOVERY board, the ST25DV-DISCOVERY firmware is upgraded
- R2H Image Transfer: transfer of JPG image from PC software (using CR95HF board) to ST25DV-DISCOVERY board, the image is displayed on ST25DV-Discovery LCD
- H2R Image Transfer: transfer of JPG image from ST25DV-DISCOVERY board to the PC software (using CR95HF board), the image is displayed on PC software
- H2R Data Transfer: transfer of binary data from ST25DV-DISCOVERY board to the PC software (using CR95HF board)

Figure 16. PC software list of demonstrations frame display



Protocol definition

As shown in *Figure 17*, the frame comprises a protocol header and data.

Figure 17. FTM protocol frame detail

There are two cases for the frames transmitted:

1. The payload size of the frame is lower than or equal to 251 bytes (small header plus payload is equal to or lower than 256 bytes), see *Figure 18* and *Table 1*.
2. The frame header is greater and the payload is split in several frames to create chunks of less than 256 bytes each, see *Figure 19* and *Table 2*.

Figure 18. FTM simple protocol header detail

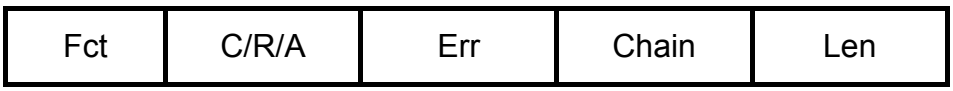


Table 1. FTM simple protocol header description

Byte	Description	Size
Fct	Function	1 byte
C/R/A	Command / Response / Acknowledge	1 byte
Err	Error code	1 byte
Chain	Chained frame	1 byte
Len	Length of Data	1 byte

Figure 19. FTM chained protocol header detail

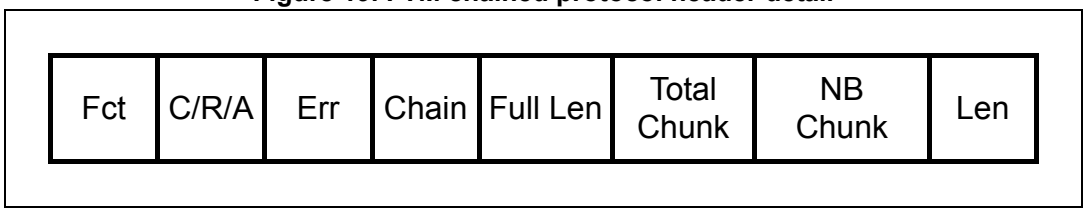


Table 2. FTM chained protocol header description

Byte	Description	Size	Comment
Fct	Function	1 byte	Defines the action that the requester is asking.
C/R/A	Command / Response / Acknowledge	1 byte	Defines if the current frame refers to a command, to an answer, or to an acknowledge.
Err	Error code	1 byte	Used to return an error code when an error is detected.
Chain	Chained frame	1 byte	Used to define if the frame is a simple or a chained one.
Full Len	Full length of Data	4 byte	Indicates the total length of data to transfer.
Total Chunk	Total number of chunks	2 bytes	Indicates the total number of chunks needed to perform the transfer.
NB Chunk	Current chunk number	2 bytes	Indicates, for a specific frame, the current chunk number of that frame.
Len	Length of Data	1 byte	Indicates the data length of the current frame (header excluded).

Either the reader or the host can send commands and responses.

When the transfer starts, the same header is included in each chunk. The sequence of the communication is the following one:

1. The requester sends a command (chained or not)
2. After all data have been transferred the recipient returns the calculated CRC
3. The requester returns an acknowledgment (with or without error).

Protocol bytes details

Table 3 details the function codes used by the firmware in the demonstration.

Table 3. FTM function codes

Function	Code
Data Transfer (R2H)	0x03
Firmware Upgrade	0x04
Image Upload	0x07
Image Download	0x09
Data Transfer (H2R)	0x0A

These commands are intended to demonstrate the capability to exchange data between a reader and a ST25DV using different examples as a firmware upgrade or a picture upload/download transfer, or data transfer.

Table 4 details the C/R/A codes used by the firmware in the demonstration.

Table 4. FTM C/R/A codes

Code	Code
C (Command frame)	0x00
R (Response frame)	0x01
A (Acknowledge frame)	0x02

Table 5 details the error codes used by the firmware in the demonstration.

Table 5. FTM error codes

Code	Code
No Error	0x00
Default Error	0x01
Unknown Function	0x02
Bad Request	0x03
Length Error	0x04
Chunk Error	0x05
Protocol Error	0x06

Table 6 details the chain error codes used by the firmware in the demonstration.

Table 6. Chain error codes

Error	Code
Not chained	0x00
Chained	0x01

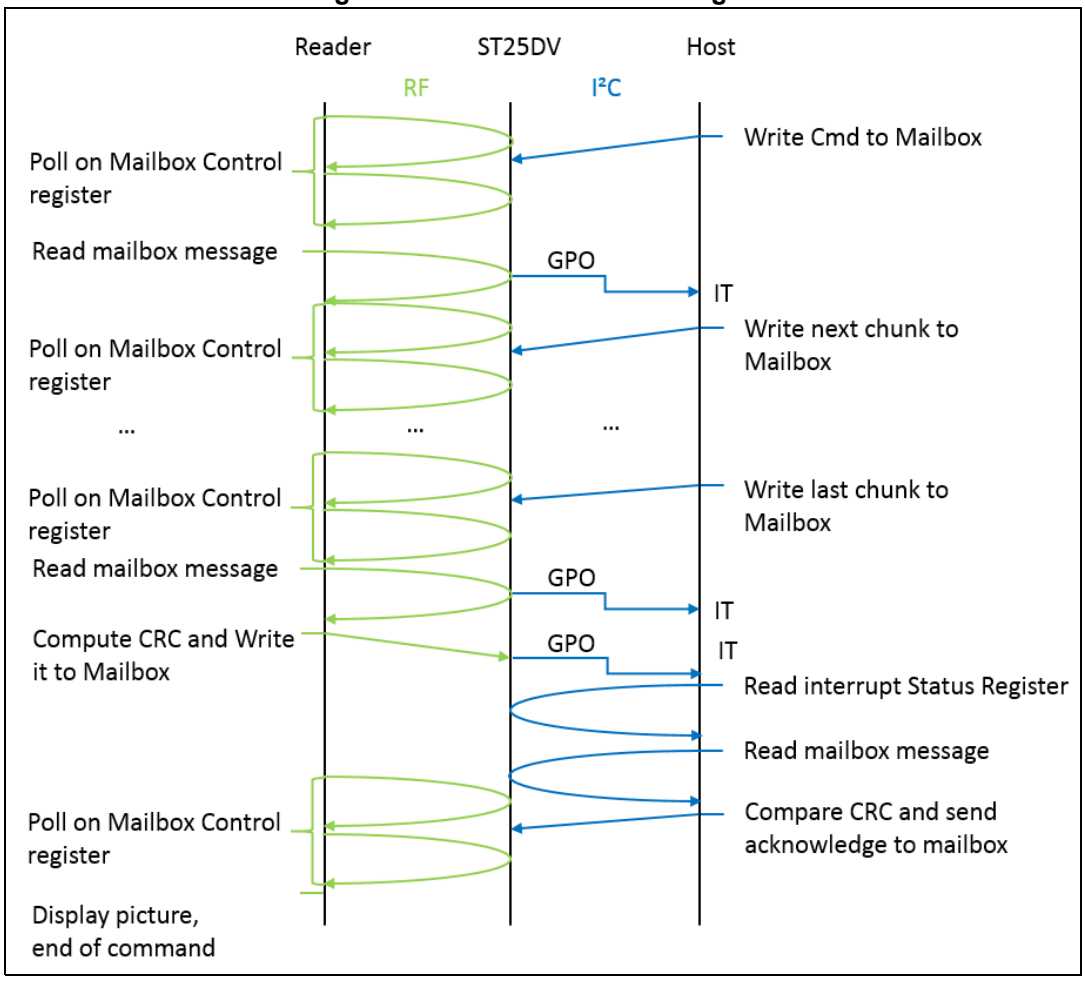
The next bytes (Full length, Total Chunk and Nb Chunk) are written MSB first in the frame. These bytes are described in *Protocol definition*.

Reader to Host data transfer

This function allows the user to send data from the reader to the STM32F405. In this demonstration data are not used after receipt, they are only stored in the Flash memory and CRC calculation is sent to the reader for data integrity check.

Figure 20 details the communication flow from the Reader to the Host (R2H) through the ST25DV during data transfer.

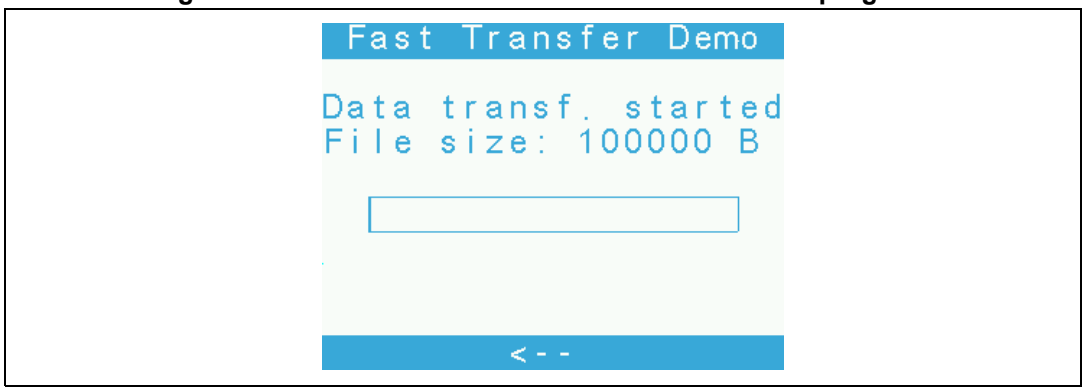
Figure 20. R2H data transfer diagram



To prepare the ST25 Discovery for the R2H data transfer demonstration, power on the board then touch the FTM icon to start the fast transfer mode demonstration (*Figure 11*). The kit is now waiting for a reader action (as can be seen in *Smart phone and Fast Transfer Mode use cases* and *PC software and Fast Transfer Mode use cases*) to continue the demonstration.

During the transfer the full length of data transmitted is displayed and a bar indicates the progress (see *Figure 21*).

Figure 21. ST25DV-DISCOVERY R2H data transfer in progress



When the transfer is successfully completed, the computed CRC and the transfer time are displayed on the screen (*Figure 22*). In case of failure an error message is displayed.

Figure 22. ST25DV-DISCOVERY R2H data transfer done

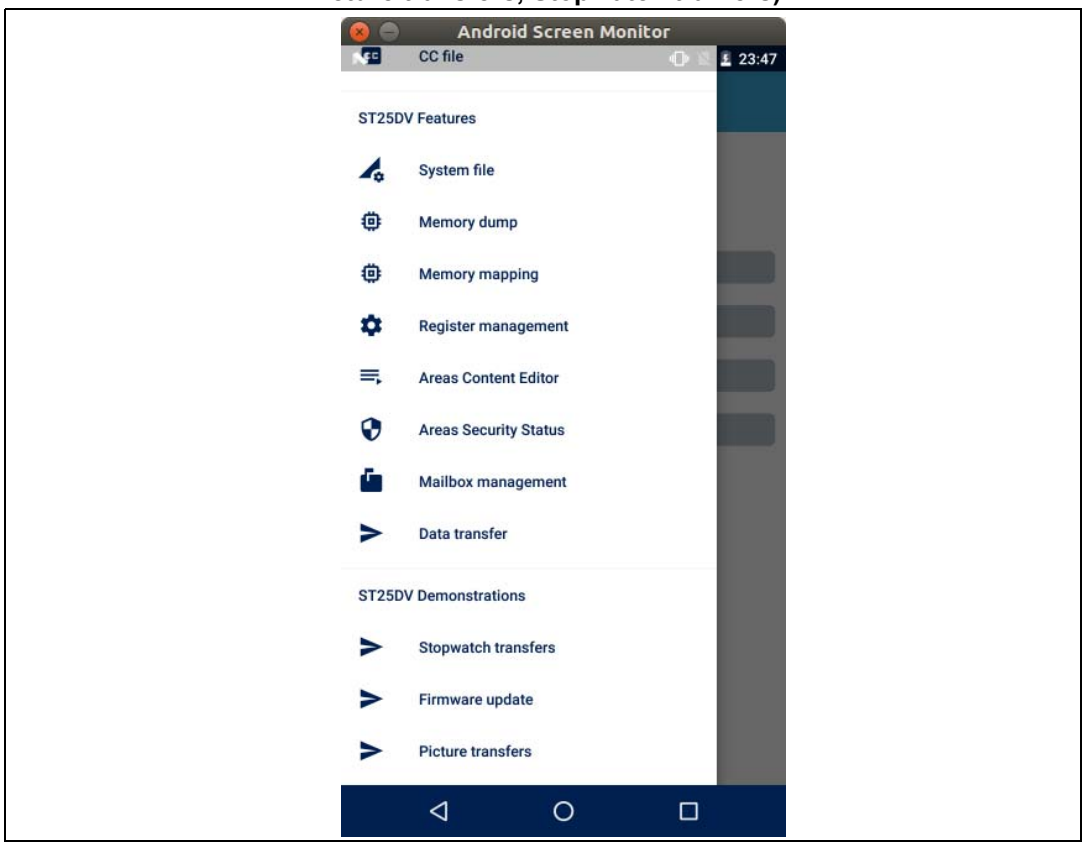
To return to the Fast Transfer Mode demonstration main screen simply touch the screen.

Smart phone and FTM data transfers

Several menus accessible by the drawer menu are dealing with the fast transfer mode data transfers:

- Mailbox management. Radio buttons give the current status of the mailbox, and this menu permits to enable/disable the mailbox feature.
- Data transfer. Three actions are possible:
  - Reading a buffer from the tag to the smart phone
  - Writing random data from the smart phone to the tag
  - Sending data from a file to the tag
- Firmware update. That is the demonstration of firmware update
- Picture transfers. Three actions are possible:
  - Take a picture to upload to the tag
  - Get a picture from the tag (jpeg format)
  - Pick a picture from the smart phone gallery to send to the tag
- Stopwatch transfers: This demonstration shows a chronometer synchronized between the smart phone and the tag using the mailbox. It shows the low latency.

Figure 23. ST25DV drawer menu (Maibox management, Firmware update, Picture transfers, Stopwatch tranfers)



As prerequisite to any data transfers the mailbox has to be enabled, without any pending message. The correct status is shown in *Figure 24*.

Figure 24. Mailbox Status

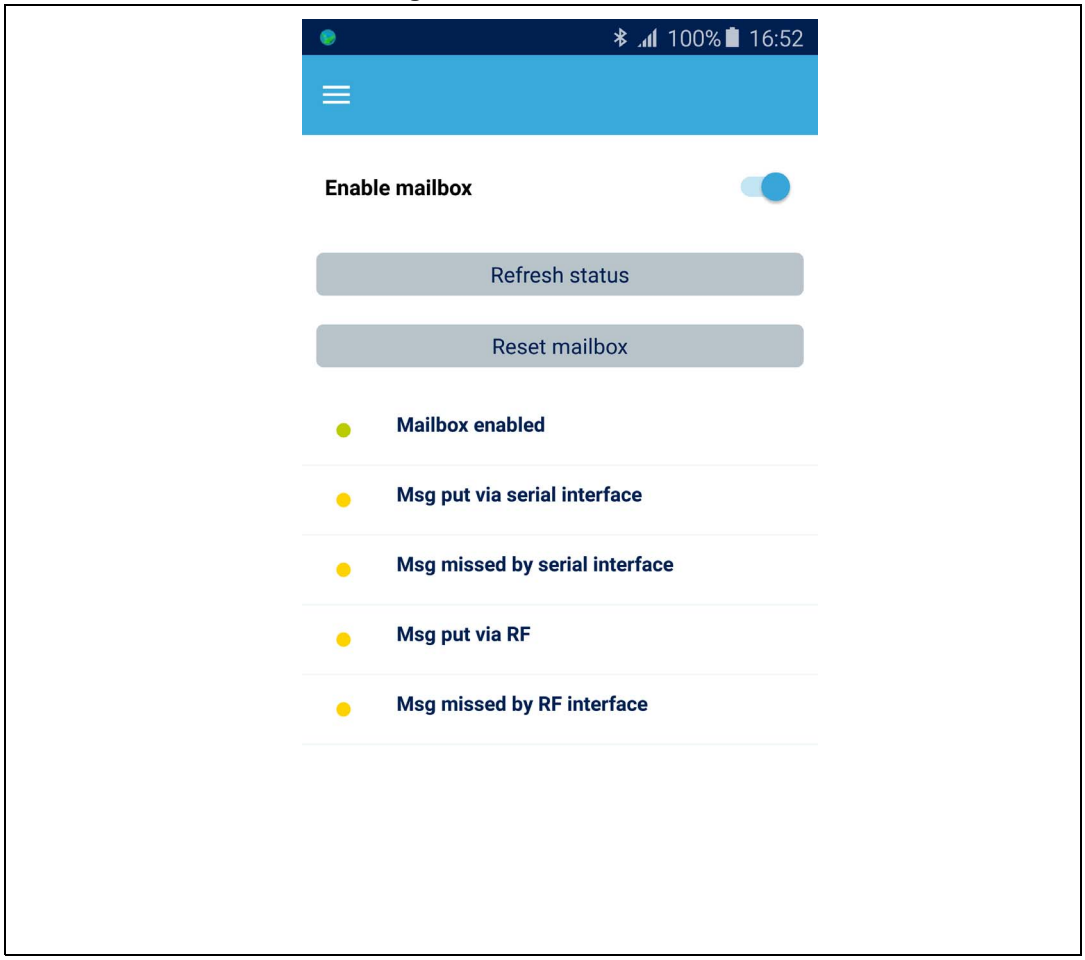
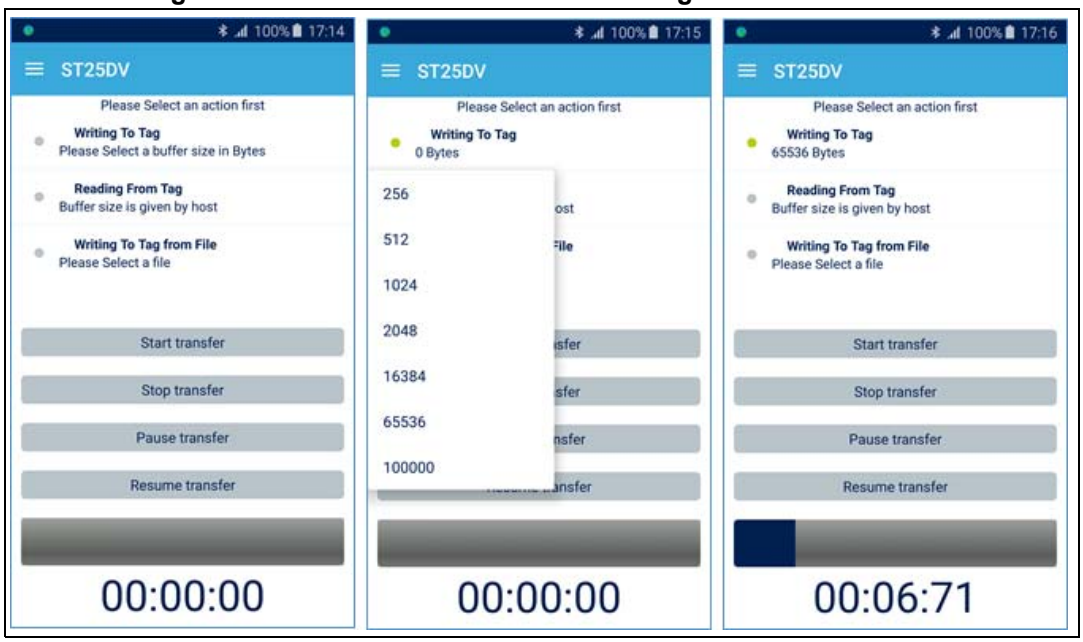


Figure 25. Data transfers from reader to tag of a random buffer



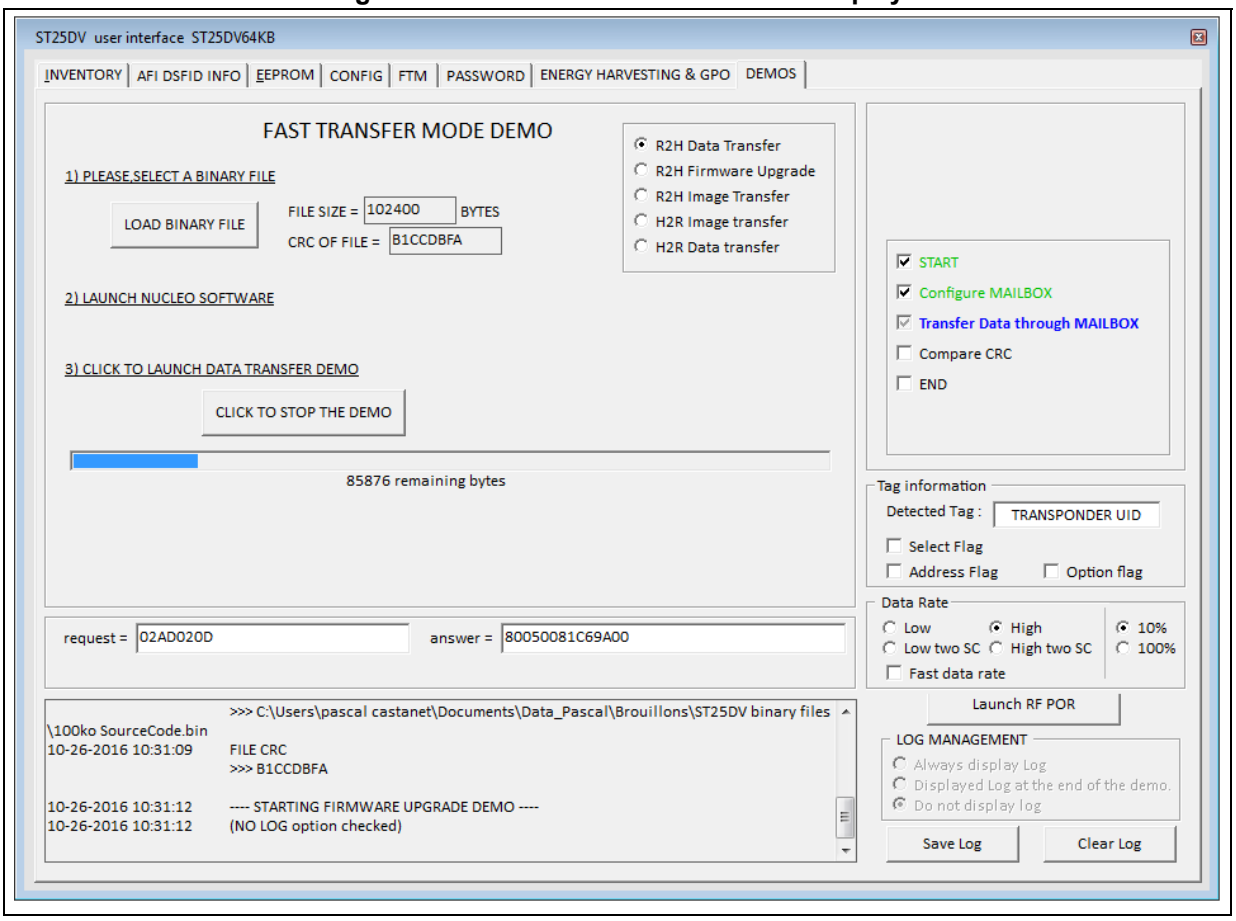
Note: According to data size selected, the corresponding payload data is initialized with random values on which a CRC is computed to be sure that host computes the same data after transfers.

PC software and FTM data transfers

Select R2H Data Transfer radio button, user must now click on “LOAD BINARY FILE” and select a file to be downloaded to the ST25DV-DISCOVERY board. CRC computation is done when loading the file, a pop up informs when loading file is finished.

Then click on “START R2H DATA TRANSFER” to start transfer to the board.

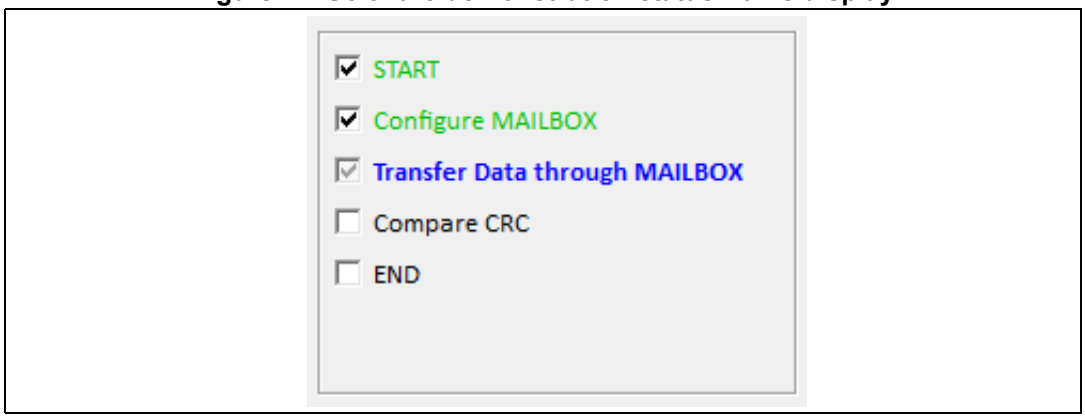
Figure 26. Software R2H data transfer display



The sequence is displayed (*Figure 27*) in the left of the screen, with the following color code:

- Black: step not yet done
- Green: step successfully completed
- Blue: step on going
- Red: error during step

Figure 27. Software demonstration status frame display

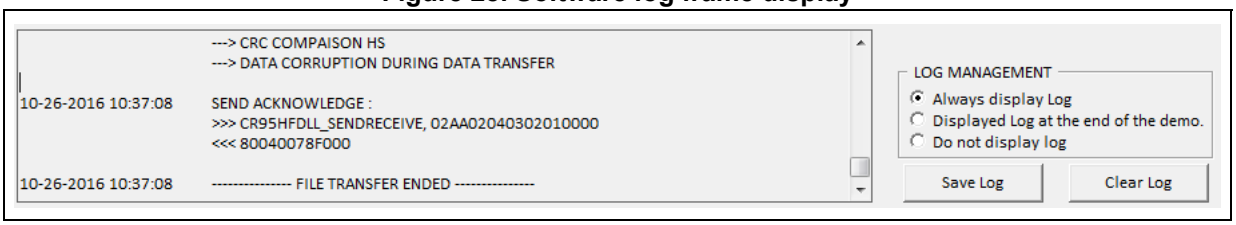


By default, the log (*Figure 28*) is not displayed, as this slows down the demonstration speed.

To analyze the communication and the FTM management, the user needs to choose between the following options:

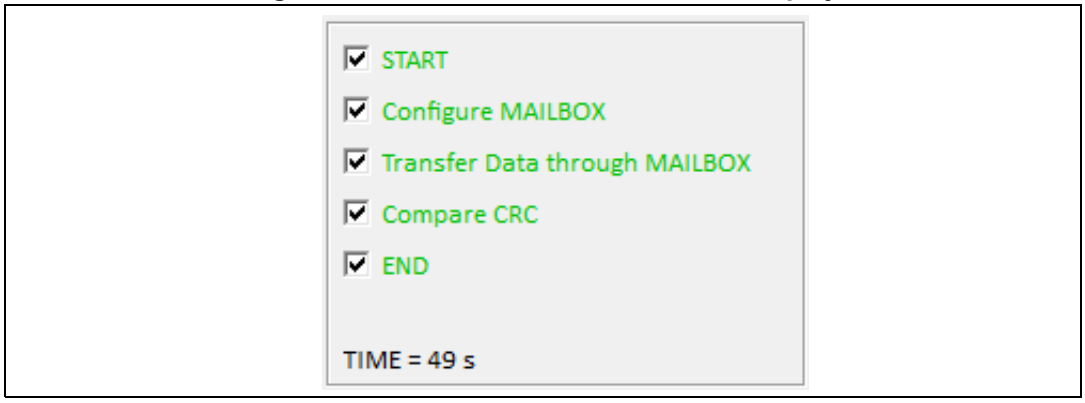
1. Always display the log: the communication between CR95HF and ST25DV will be continuously displayed during the demonstration. This configuration is time consuming, but it allows the user to follow each step of RF communication during transfer.
2. Display log at the end of the demonstration: the communication between CR95HF and ST25DV will be saved and displayed only at the end of the demonstration. This configuration needs less time compared to the previous one, and still allow the user to follow RF communication afterwards.
3. Do not display log: no log will be displayed. This is the faster mode, even PC software and USB communication will take additional time.

Figure 28. Software log frame display



At the end of the demonstration, the CRC calculated by the ST25DV-DISCOVERY board is compared with the CRC calculated by the PC software. Demonstration duration is displayed too (see *Figure 29*).

Figure 29. Software end transfer status display



Reader to Host Firmware Upgrade

This function allows the user to send data (that will be manipulated as binary) from the reader to the STM32F405. They are stored in the Flash memory and at the end of transfer, the following instruction code jumps to the new firmware location, demonstrating the capability to transfer many binary data. For this example, the new firmware is stored in a secondary area in the Flash memory and it is not intended to be used for new demonstrations. To come back to the right first firmware, press the reset button and it will reboot on it.

The firmware upgrade transfer flow is similar to the one of data transfer (see *Figure 20*).

To prepare the ST25 Discovery for the firmware upgrade demonstration, power on the board then touch the FTM icon to start the fast transfer mode demonstration (*Figure 11*).

The kit is now waiting for a reader action (as can be seen on *Smart phone and firmware upgrade* and *PC software and firmware upgrade*) to continue the demonstration. For this demonstration the firmware dedicated to this demonstration can be found on the project folder ST25DV-Discovery\Demonstrations\ST25DVDemo_FwUpgd\Binary.

To be able to execute the firmware download the user first needs to send (from the reader) a correct password (for this demonstration the password is 0x12345678). During the password check, the Flash memory area where the firmware will be stored is erased (*Figure 30*).

Figure 30. ST25DV-DISCOVERY firmware upgrade: password check

If the password is correct the user is authorized to start the transfer (*Figure 31*), if not, the user has to enter a new password to continue (*Figure 32*).

Figure 31. ST25DV-DISCOVERY firmware upgrade: password OK

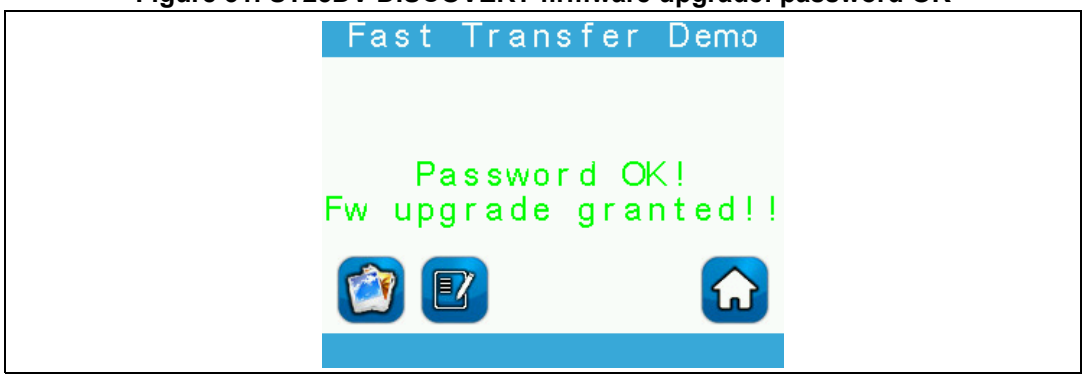
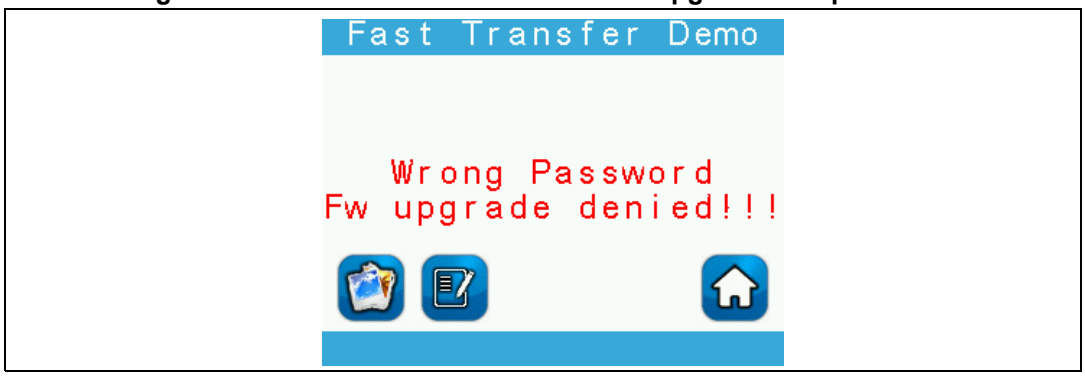
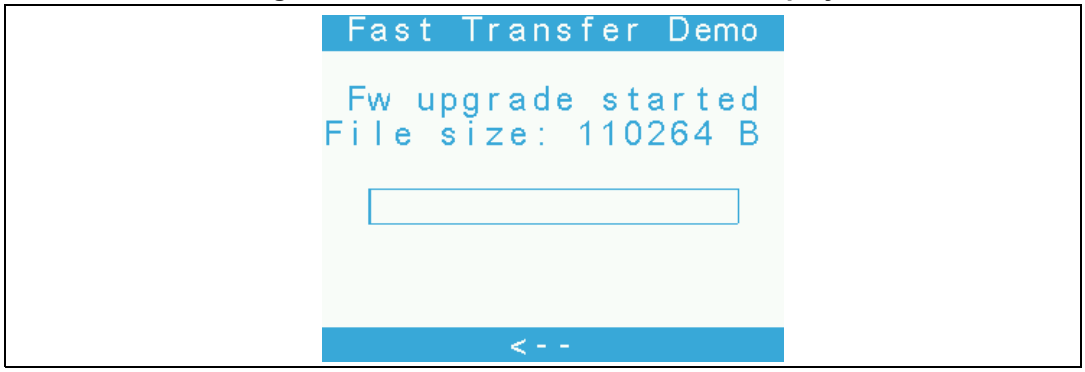


Figure 32. ST25DV-DISCOVERY firmware upgrade: bad password



During the transfer the full length of data transmitted is displayed, and a bar indicates the progress (see *Figure 33*).

Figure 33. Software end transfer status display



When the transfer is successfully completed, the computed CRC and the transfer time are displayed (see *Figure 34*). In case of failure an error message is displayed.

Figure 34. ST25DV-DISCOVERY firmware upgrade: transfer done

To start the new firmware, simply touch the screen.

Smart phone and firmware upgrade

Features:

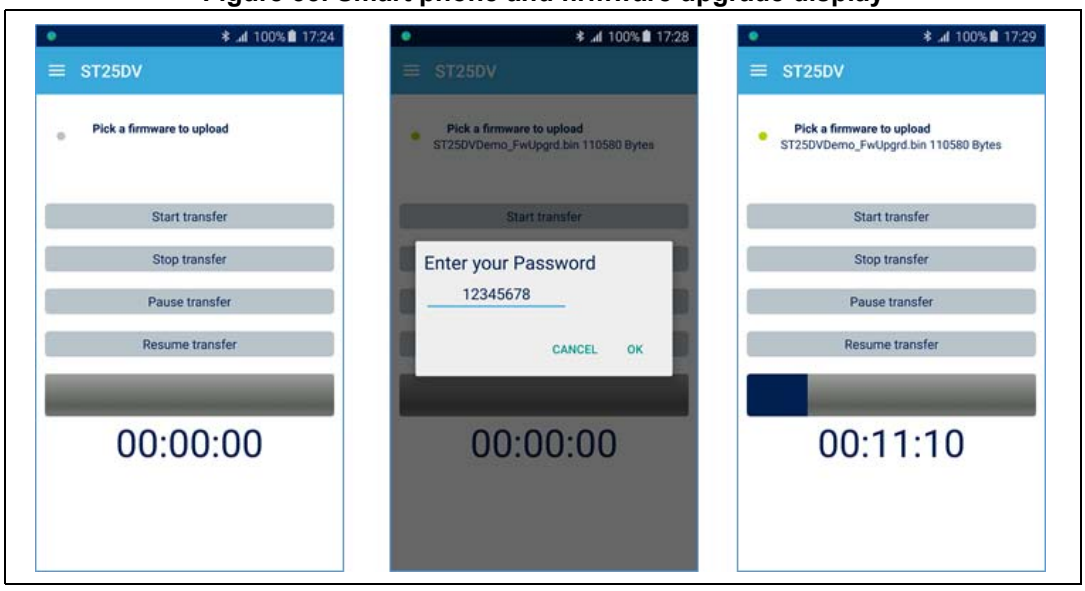
- Upgrade a new firmare to the ST25 discovery board

Note: The firmware must be on the Fast Transfer Mode Demo screen and the MBEN bit must be set in the Mailbox dynamic register.

Demonstration steps:

- Check the mailbox status (Must be enable, withtout any pending messages in the mailbox).
- Select the Firmware update in the drawer menu.
- Select the file to be downloaded (the firmware file must be located in the Download/bintouploadforstSt25FWU directory, and must have a bin extension).
- A pop up asks for a password. By default and for demo purpose the password is 12345678.
- Start download = Start transfer button.
- Smart phone and firmware download.

Figure 35. Smart phone and firmware upgrade display

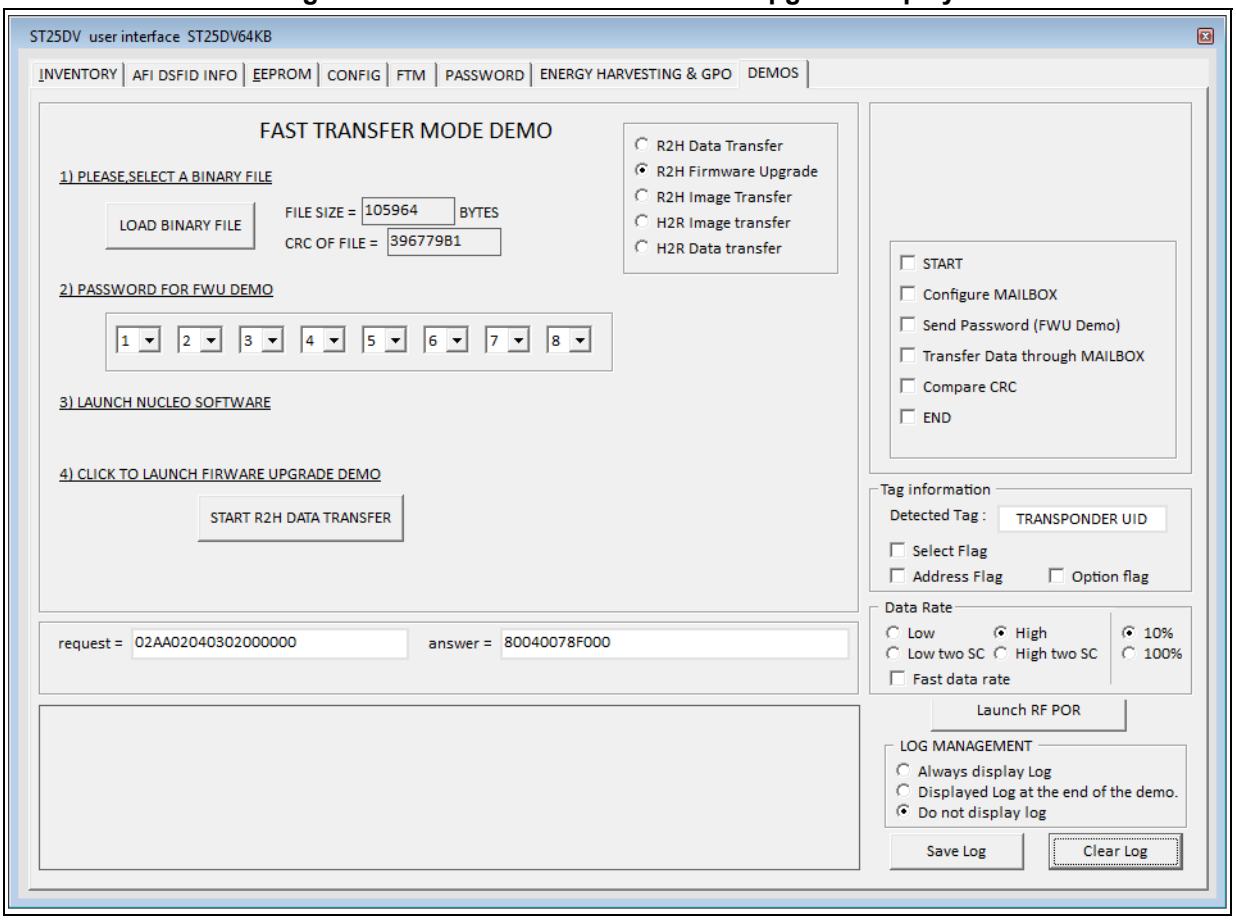


PC software and firmware upgrade

Select R2H Firmware Upgrade radio button demonstration, then click on “LOAD BINARY FILE” and select a binary file to be downloaded to the ST25DV-DISCOVERY board. CRC computation is done when loading the file, a pop up informs when loading file is finished.

In order to start firmware upgrade the user needs to select a password, then to click on “START R2H DATA TRANSFER” to start transfer to the board.

Figure 36. PC software R2H firmware upgrade display



Data transfer is similar to the one described in the previous section.

Reader to Host image download

This function allows sending data from the reader to the STM32F405. In this demonstration data are jpeg images, stored in the Flash memory and displayed when transfer is successful.

The image download transfer is similar to the data transfer flow shown in *Figure 20*.

To prepare the ST25 Discovery for the R2H picture transfer demonstration, power on the board, then touch the FTM icon to start the fast transfer mode demonstration (*Figure 11*).

It is now waiting for a reader action, as can be seen on *Smart phone and picture transfers* and *Smart phone and picture download transfer* to continue the demonstration.

During the transfer the full length of data transmitted is displayed and a progress bar indicates the progress. When transfer is done and successful, computed CRC and transfer duration are displayed on screen. To display the downloaded picture touch the screen. to return to the Fast Transfer Mode demonstration simply touch the screen.

Displayed screens are similar to those of Data transfer (see *Reader to Host data transfer*).

Smart phone and picture transfers

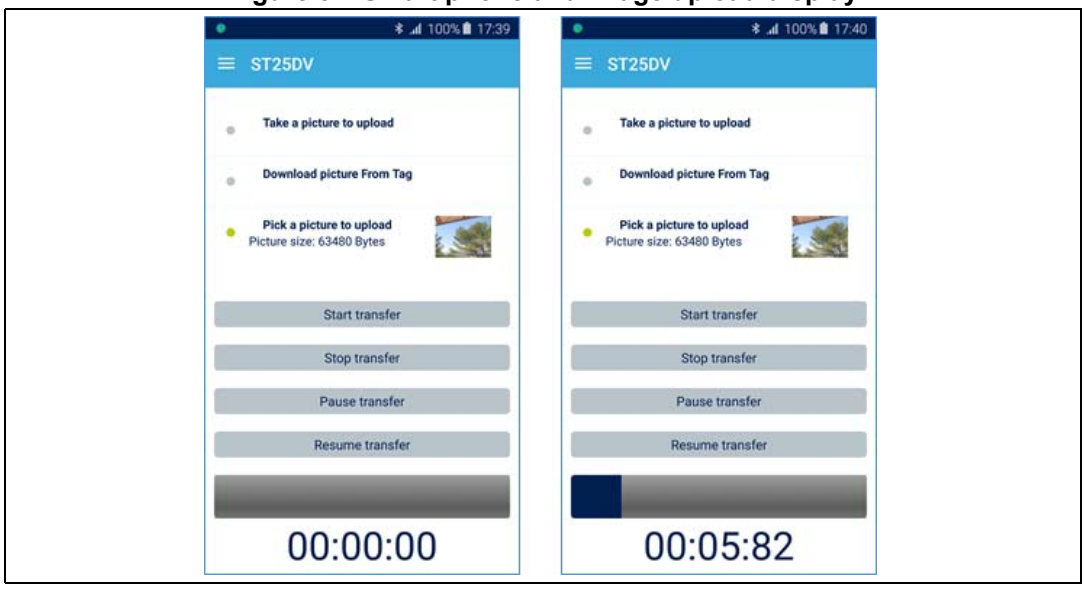
Features:

- Take a picture and send it to the tag (jpeg mode compressed).
- Pick a picture from the phone gallery to send to the tag.
- Upload and display a picture from the tag.

Picture upload steps:

- Check the mailbox status (c.f. drawer menus).
- Select Picture transfers (in drawer menu).
- Select a file by “Pick a picture to upload”.
- Start upload using “Start transfer”.
- Smart phone and picture upload transfers.

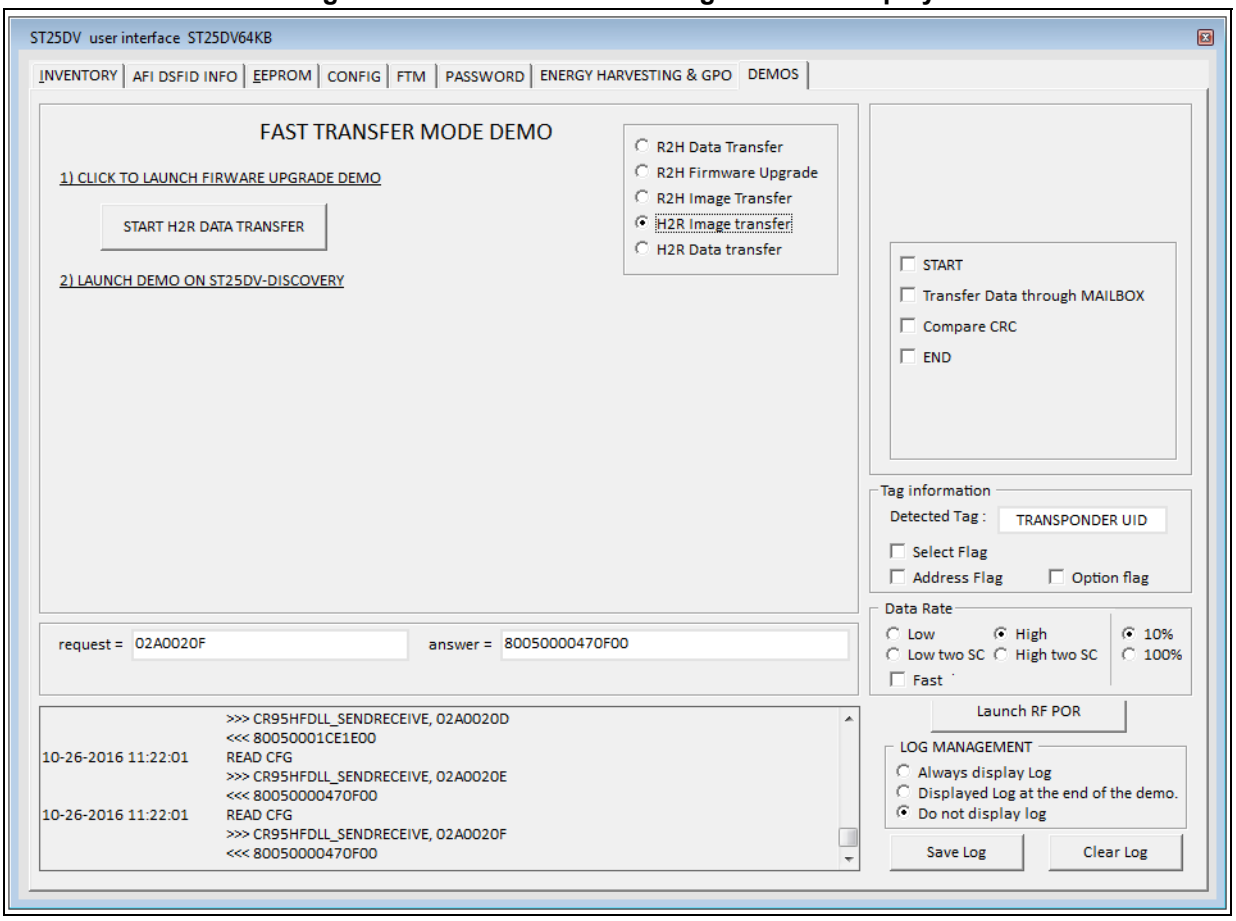
Figure 37. Smart phone and image upload display



Picture download steps:

- Check the mailbox status (c.f. drawer menus).
- Select Picture transfers (in drawer menu).
- Select Picture transfers (in drawer menu).
- Select "Download picture From Tag".
- Start download using “Start transfer” [Starts demo on ST25 Discovery first, then click on the Start transfer button].

Figure 38. PC software R2H image transfer display

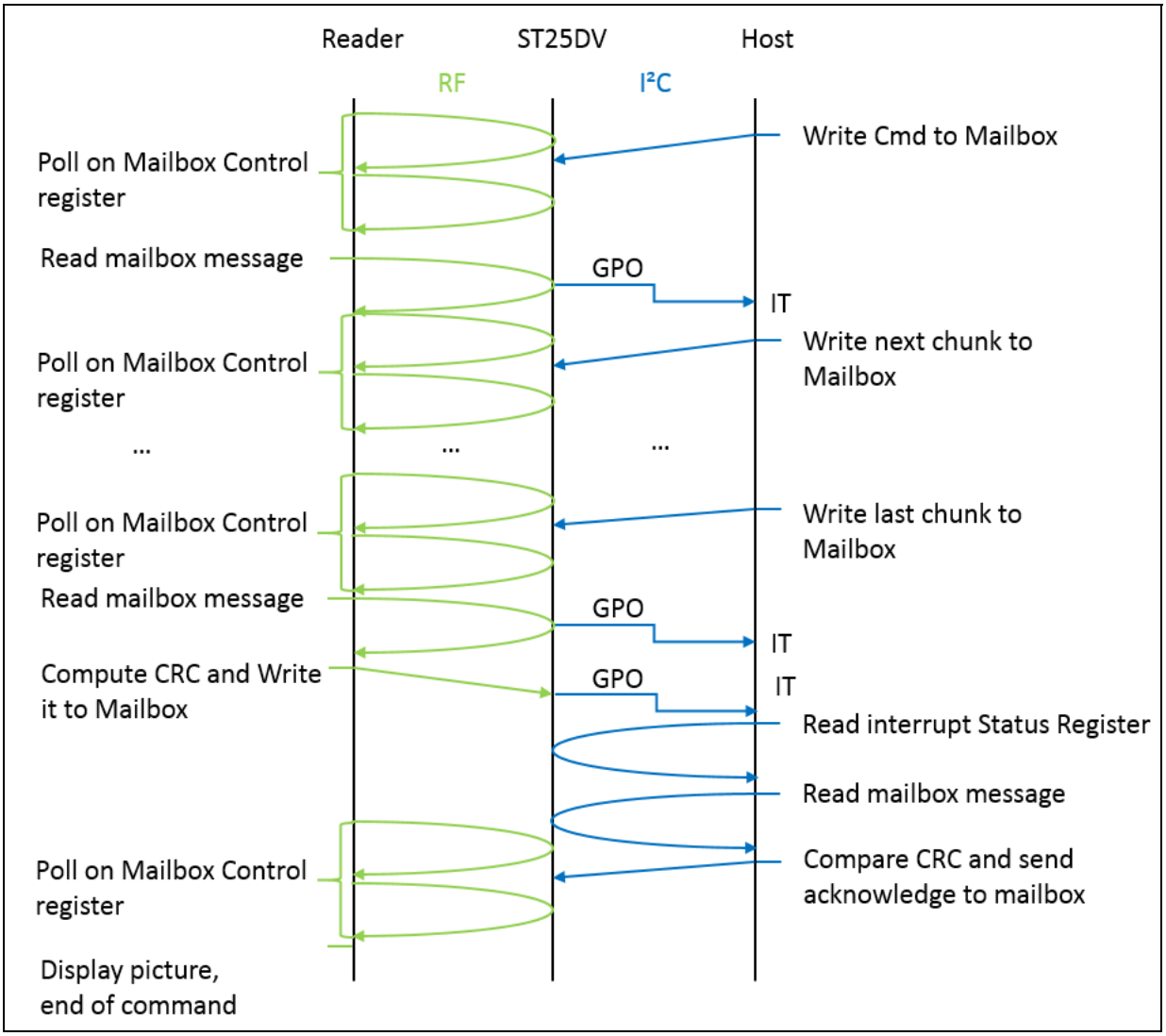


Host to Reader image upload

This function allows the user to send data from the STM32F405 to the reader (H2R).

In this demonstration data are jpeg images, data are written to the mailbox each time this is free, and the MCU is informed by the GPO when the mailbox message is read by the reader. *Figure 39* represents the transfer between the MCU and the reader.

Figure 39. H2R data transfer diagram



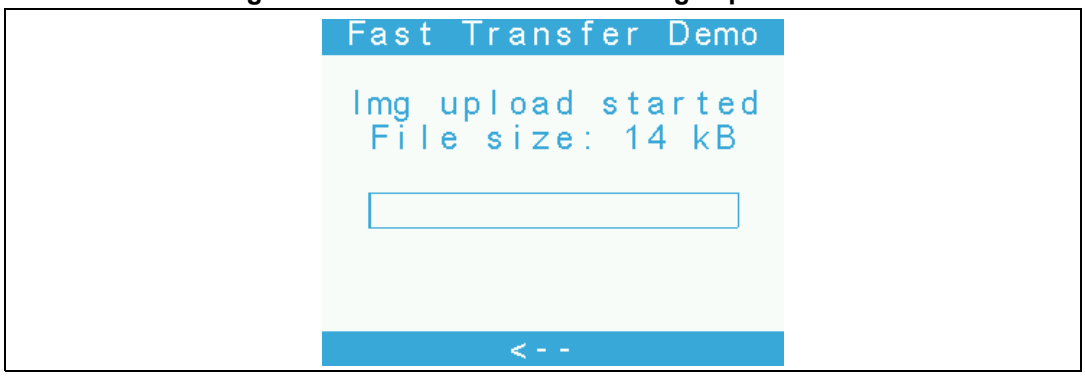
To start this demonstration the user needs to perform an action on firmware side.

The picture icon at bottom left allows the user to enter a new menu (see *Figure 40*), which lets the user choose between pictures to send to the reader. By touching the screen on the left or right border user will see different pictures available for transfer, simply touch the image on screen to select it. To come back and cancel the action, touch the arrow at the bottom of the screen.

Figure 40. ST25DV-DISCOVERY Select picture to upload

After selecting the picture to transfer, the firmware writes the first chunk in the mailbox and waits for the message to be read. During the transfer a file size and a progress bar are displayed, as shown in *Figure 41*.

Figure 41. ST25DV-DISCOVERY Image upload start



The kit is now waiting for the reader to read the message on the mailbox (as can be seen in *Smart phone and picture download transfer* and *PC software and Picture upload transfer*) to continue the demonstration.

When transfer is successfully completed, computed CRC and transfer time are displayed on screen (*Figure 42*). In case of failure an error message is displayed.

Figure 42. ST25DV-DISCOVERY Image upload successful

To return to the Fast Transfer Mode demonstration simply touch the screen.

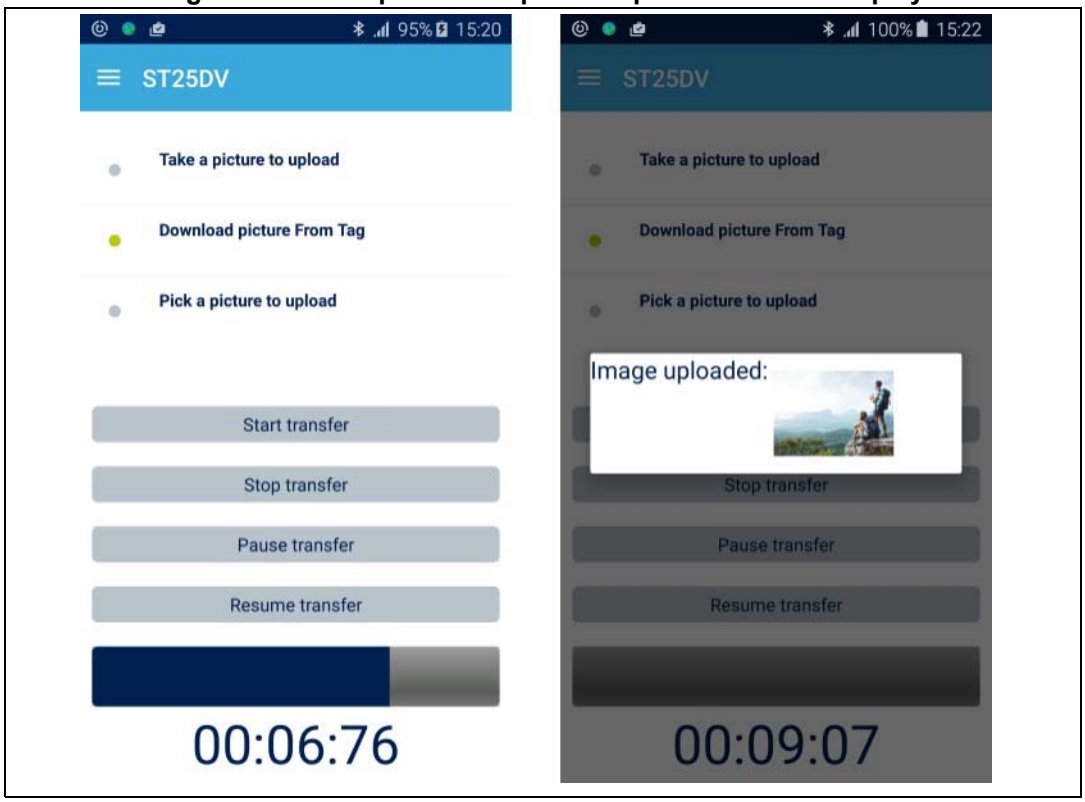
Smart phone and picture download transfer

Features: same as *Smart phone and picture transfers*.

Picture download steps:

- Check MB registers
- Select on host the image you would like to receive
- Select "Download picture From Tag"
- Press “Start transfer” button

Figure 43. Smart phone and picture upload transfers display

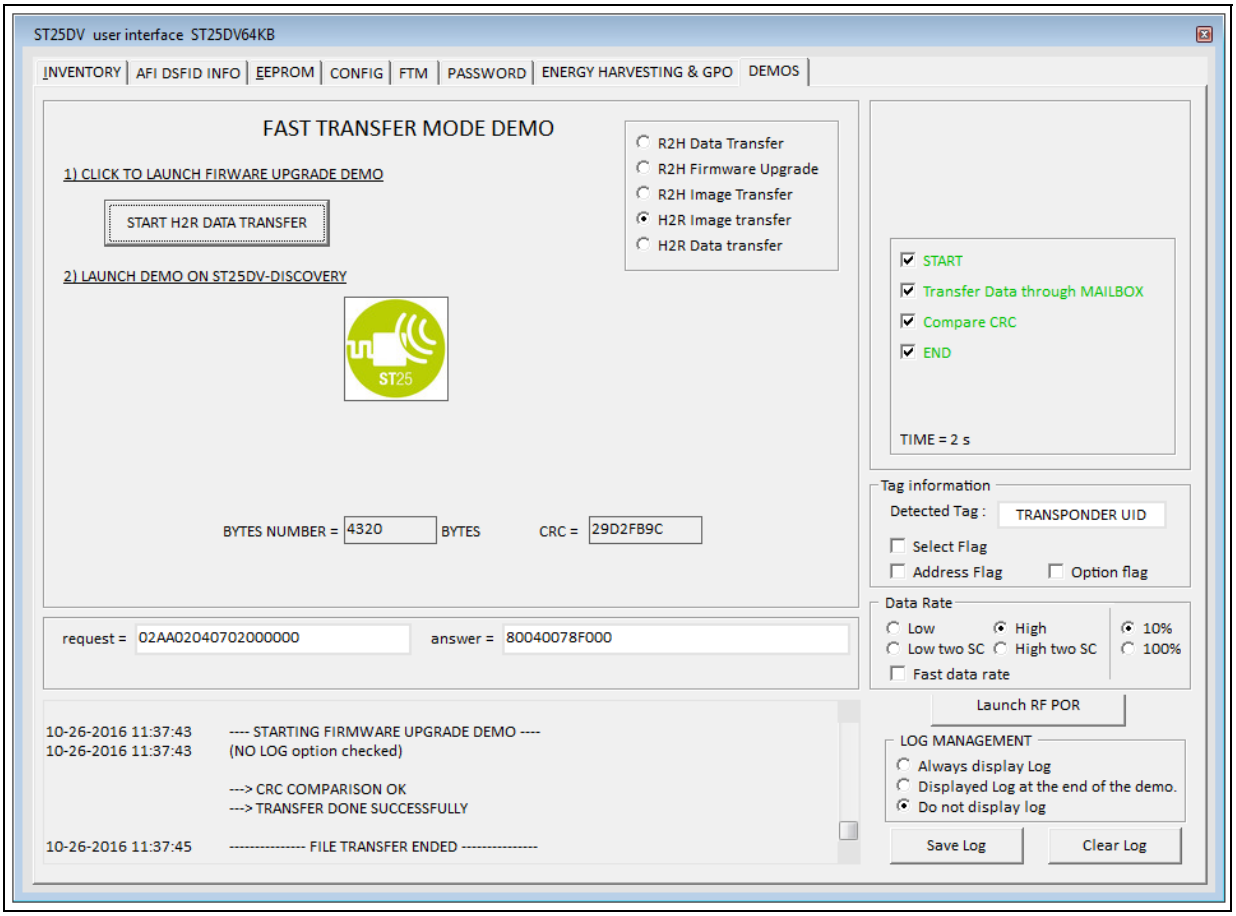


PC software and Picture upload transfer

Select H2R Image Transfer radio button, after having selected a picture from ST25DV-DISCOVERY board user can click on “START H2R DATA TRANSFER” to start transfer from the ST25DV-DISCOVERY board. CRC computation is done when all data have been transferred, then it is sent to the tag.

The demonstration ends when the PC software receives the acknowledge and displays the image.

Figure 44. PC software H2R image transfer display



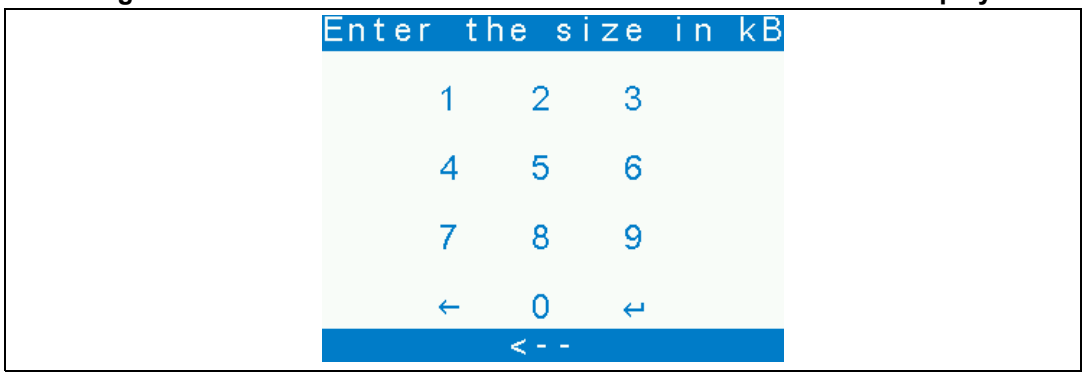
Host to Reader data transfer

This function allows sending data from the STM32F405 to the reader. In this demonstration data are random binary data, Data are written to the mailbox each time it is free, and the MCU is informed, via the GPO, when the mailbox message is read by the reader

Figure 39 shows the transfer between the MCU and the reader (the flow is identical to image upload).

To start this demonstration the user needs to perform an action on firmware side. The data icon at bottom left allows the user to enter a new menu, this menu allows selecting any size of data transfer (from the MCU to a reader) from 1 to 999 kB, using the keyboard shown in *Figure 45*. The arrow on the bottom left allows the user to correct its input. To cancel and return to the Fast Transfer Mode demonstration touch the arrow at the bottom of the screen. After having entered the correct size, touch the return icon.

Figure 45. ST25DV-DISCOVERY select H2R data size to transfer display



The kit is now waiting for a reader to read the message on the mailbox (as can be seen from *Smart phone and H2R data transfer* and *Smart phone and H2R data transfer*) to continue the demonstration.

When transfer is successfully completed, computed CRC and transfer time are displayed (see *Figure 42*). In case of failure, an error message is displayed.

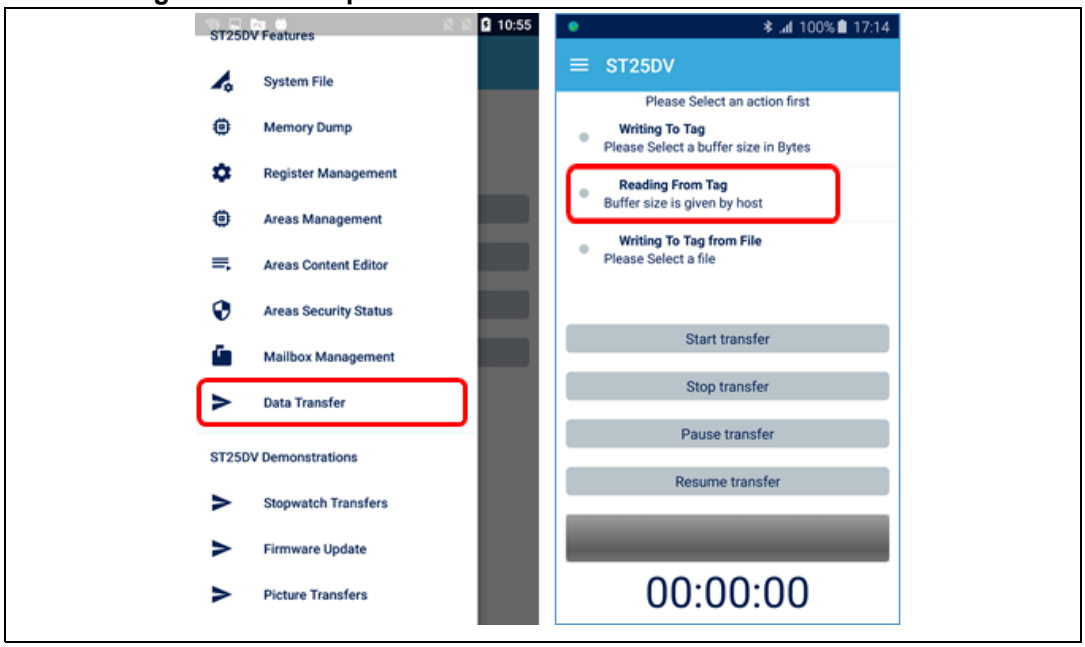
To return to the Fast Transfer Mode Demo simply touch the screen.

Smart phone and H2R data transfer

To start the demonstration after prerequisites setting checked, go to “Data Transfer” menu.

After having selected the buffer size to send from ST25DV-DISCOVERY board, user can click on “Reading from tag” button to start the transfer. CRC computation is done when all data have been transferred, then it is sent to the tag.

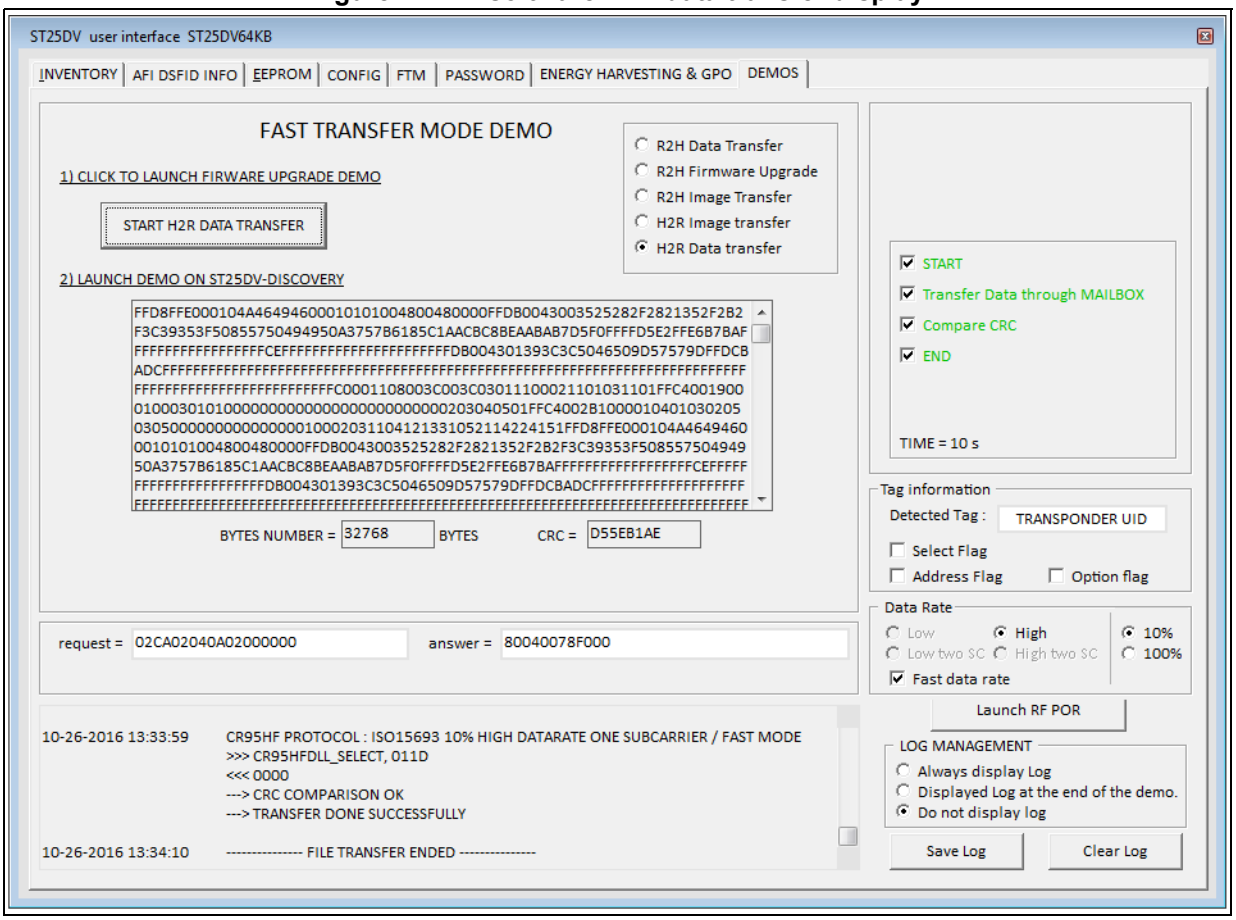
Figure 46. Smart phone and data transfers H2R with selected size



PC software and H2R data transfer

Select H2R Data Transfer radio button, after the selection of the buffer size to be sent from ST25DV-DISCOVERY board user can click on “START H2R DATA TRANSFER” to start the transfer of data from the board. CRC computation is done when all data have been transferred, then it is sent to the tag.

Figure 47. PC software H2R data transfer display



The demonstration ends when the PC software receives the acknowledge and displays data on screen.

Stopwatch demonstration

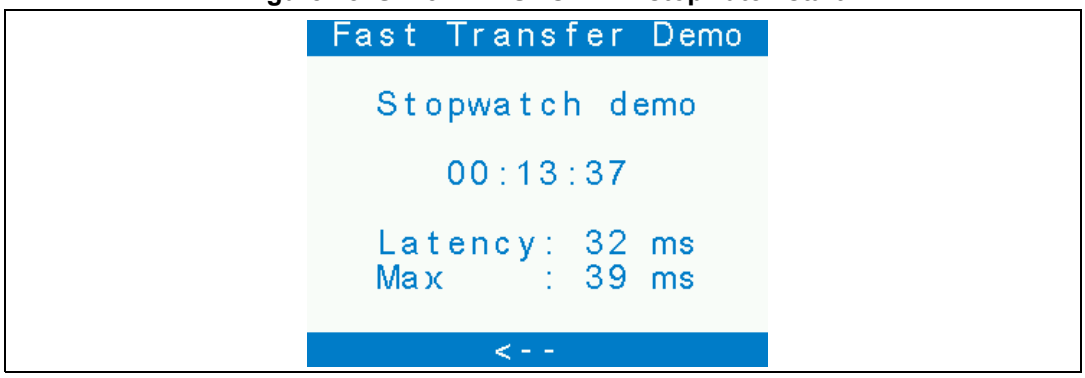
This demonstration shows how fast a smart phone can update the Mailbox.

The smart phone sends, as fast as possible, stopwatch values (8 byte frames) to the MCU using the mailbox. The MCU displays these values on the LCD screen and computes the duration between two consecutive updates. The average and maximum inter-frame durations are refreshed and displayed after 20 frames have been received.

To run the demonstration

1. On the ST25 Discovery board: enter the Fast Transfer Mode menu.
2. On the smart phone: open the ST25 NFC App, tap the ST25DV and go to the “Stopwatch Transfers” menu and click on Start button.

Figure 48. ST25DV-DISCOVERY stopwatch start



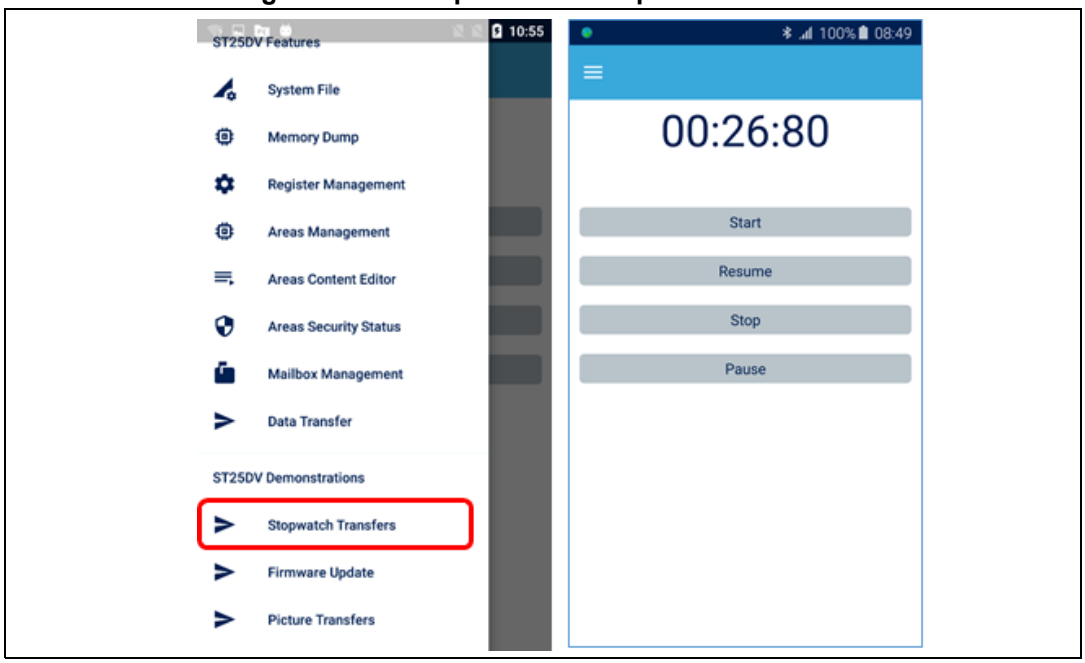
Smart phone and stopwatch transfers

In this demonstration the smart phone sends, as fast as possible, stopwatch values (8 byte frames) to the MCU using the mailbox. The main features are

- Configuration of the “Mail Box” register [Enable / Disable MB, Watchdog)
  - Selection of static or dynamic registers
  - Read Cfg to retrieve MB status
- Start: Starts the stopwatch, the display is updated accordingly and frames are sent to the host if a tag is in the field. The display is updated, starting from 00:00:00 (minutes:seconds:milliseconds)
- Stop: Stops the stopwatch. When restarted, the stopwatch restarts from 00:00:00.
- Pause: Pauses the stopwatch
- Resume: resumes the stopwatch after a pause

On the smart phone open the ST25 NFC App, tap the ST25DV and go to the “Stopwatch Transfers” menu and click on Start button. Pause and Resume buttons can then be used.

Figure 49. Smart phone and stopwatch transfers



3.2.4 NFC NDEF Demos menu

The NFC NDEF Demos menu proposes several demonstrations concerning NDEF messages:

- URI NDEF message (URL and phone number)
- SMS NDEF message
- Email NDEF message
- vCard NDEF message
- Geo-location NDEF message
- Custom (MyApp) NDEF message
- Multi record NDEF message
- Bluetooth® Low Energy OOB NDEF message (requires an additional BLE module)
- Wi-Fi® OOB NDEF message (requires an additional Wi-Fi® module)

Figure 50. ST25DV-DISCOVERY NFC NDEF Demos menu display

URI demonstration

This menu shows how to manage URI content in the ST25DV.

With the MCU, the user can

- Store an NDEF message containing an URL or a phone number (it can then be read with an NFC reader or a smart phone)
- Read any URI that has been stored in the ST25DV. Content of the URI is displayed on the screen.

Figure 51. ST25DV-DISCOVERY read URI display

Note: If, when the MCU reads the ST25DV memory, it does not contain a URI, an error message is displayed.

Smart phone and URI NDEF

Please refer to *Reading and writing NDEF on a smart phone with the ST25 application*.

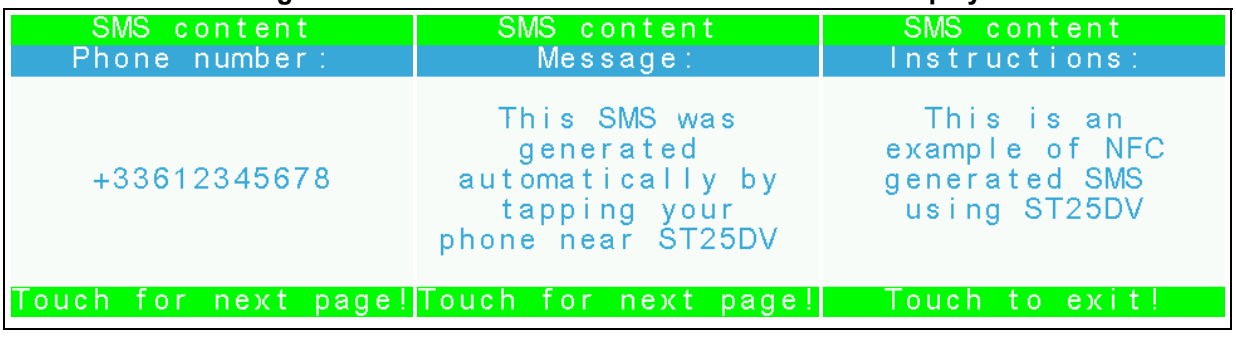
SMS demo

This menu presents how to manage SMS content in the ST25DV.

With the MCU, the user can

- Store an NDEF message containing a SMS (it can then be read with an NFC reader or with a smart phone)
- Read any SMS that has been stored in the ST25DV memory (the SMS is displayed on the screen)

Figure 52. ST25DV-DISCOVERY read SMS content display



Note: If, when the MCU reads the ST25DV memory, it does not contain a SMS, an error message is displayed.

Smart phone and SMS NDEF

Please refer to *Reading and writing NDEF on a smart phone with the ST25 application*.

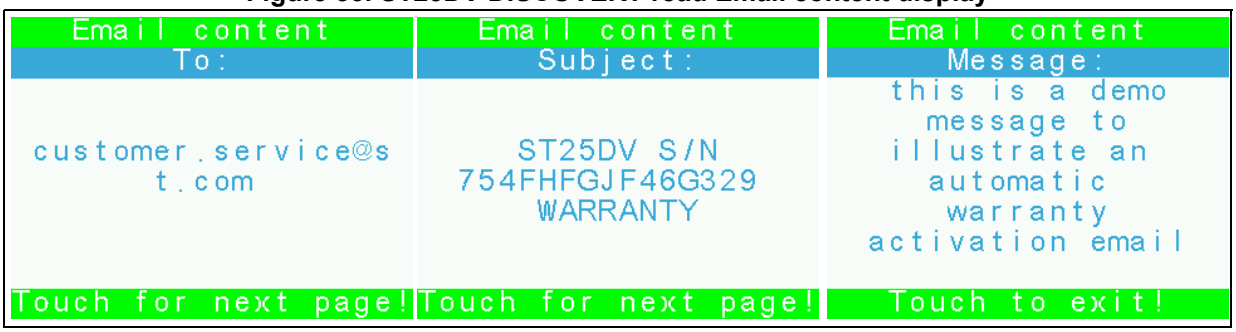
Email demo

This menu presents how to manage e-mail content in the ST25DV.

With the MCU, the user can

- Store an NDEF message containing an e-mail (it can then be read with an NFC reader or with a smart phone)
- Read any e-mail that has been stored in the ST25DV memory. The content of the e-mail is displayed on the screen.

Figure 53. ST25DV-DISCOVERY read Email content display



Note: If, when the MCU reads the ST25DV memory, it does not contain an e-mail, an error message is displayed.

Smart phone and e-mail NDEF

Please refer to *Reading and writing NDEF on a smart phone with the ST25 application*.

vCard demo

This menu presents how to manage vCard content in the ST25DV.

With the MCU, the user can

- Store an NDEF message containing a vCard. Depending on the size of the ST25DV, this vCard may or may not embed a picture
- Read the ST25DV content

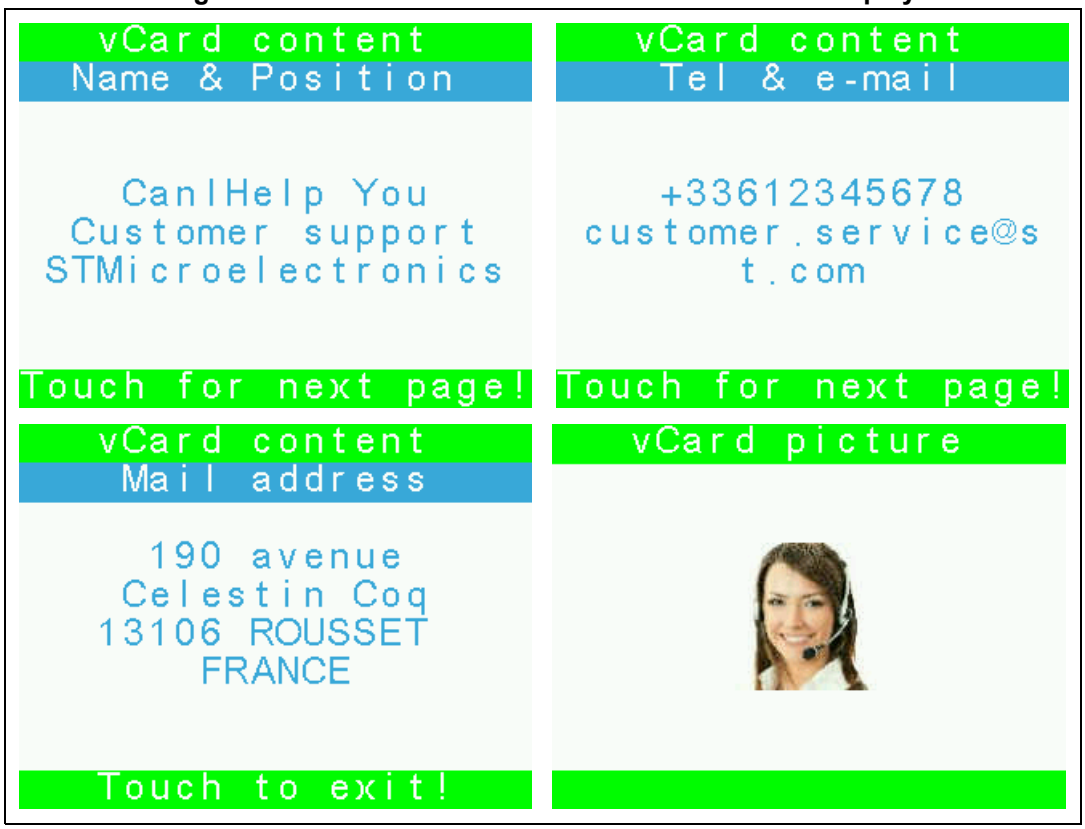
If the vCard has been previously stored, the following information will be displayed on the board screen: name, title, organization, cell phone number, work address and work e-mail.

Note: The vCard with an embedded picture needs around 3 kB of memory and cannot be stored in the smaller memory size ST25DV versions, the ST25DV64 (64 kbits) must be used.

Note: If, when the MCU reads the ST25DV memory, it does not contain a vCard, an error message is displayed.

Note: Only vCard 2.1 has been implemented in this firmware version. If user stores a vCard 3.0 in the ST25DV, the firmware will issue an error message.

Figure 54. ST25DV-DISCOVERY read vCard content display



Smart phone and vCard NDEF

Please refer to *Reading and writing NDEF on a smart phone with the ST25 application*.

Geolocation demo

This menu presents how to manage the geolocation content in the ST25DV.

With the MCU, the user can

- Store an NDEF message containing a geolocation (it can then be read with an NFC reader or with a smart phone)
- Read any geolocation that has been stored in the ST25DV memory, the content is displayed on the screen

Figure 55. ST25DV-DISCOVERY read Geolocation display

Note: If, when the MCU reads the ST25DV memory, it does not contain a Geolocation, an error message is displayed.

MyApp record demonstration

This demonstration shows how to use a proprietary NDEF record to control an application running on the host MCU. As the format of the message follows the NFC Forum NDEF standard, it can be written or read by any device supporting this format.

The MCU waits until a “Proprietary configuration” record is written to the tag, then it updates the LCD display and controls a LED as described in the record.

This demonstration uses the ST25DV GPO to detect that the ST25DV has been written. In the ST25 NFC App, the user shall enter the “compose NDEF” menu, and then select the “Proprietary configuration” record.

From there, the user can:

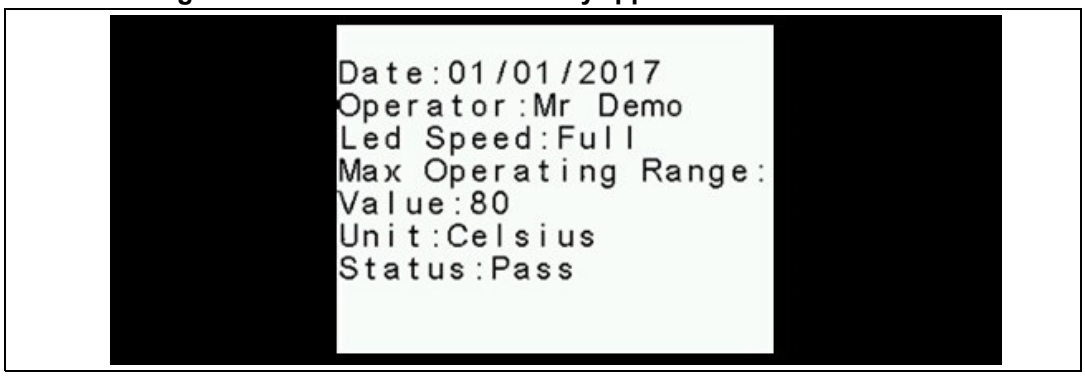
- Select if the LED1 must blink and configure the blinking period.
- Enter the text that will be displayed by the MCU.

Note: The “Proprietary configuration” record allows the user to control up to four LEDs. As the ST25 Discovery board has only one LED, configuring LED2, LED3 or LED4 won’t have any effect.

After changing the setting in the Compose “Proprietary configuration” record menu, the user must click on “Write to tag” and tap the ST25DV. As soon as a new message is written in the ST25DV memory, the MCU reads it and if it finds the expected message, it configures the LED and the LCD as specified in the message.

If the data written to the ST25DV is not a valid “Proprietary configuration” record, the MCU displays an error message and continues waiting for a valid “Proprietary configuration” record to be written.

Figure 56. ST25DV-DISCOVERY MyApp demonstration screen



Multi record demonstration

This menu presents how to manage a multi record NDEF in the ST25DV.

With the MCU, the user can

- Store an NDEF message containing the ST25 URI (it can then be read with an NFC reader or a smart phone)
- Add the ST25 Android Application Record to the existing NDEF message.

For this demonstration the user is requested to read the URI with a smart phone, and check that its preferred browser is open with the ST25 URL (this is the default behavior when URI are natively supported by the smart phone).

Then, after adding the ST25 AAR, when the ST25DV is read with a smart phone, the browser is not open anymore, while the ST25 application is. The URI appears as the first record in the application.

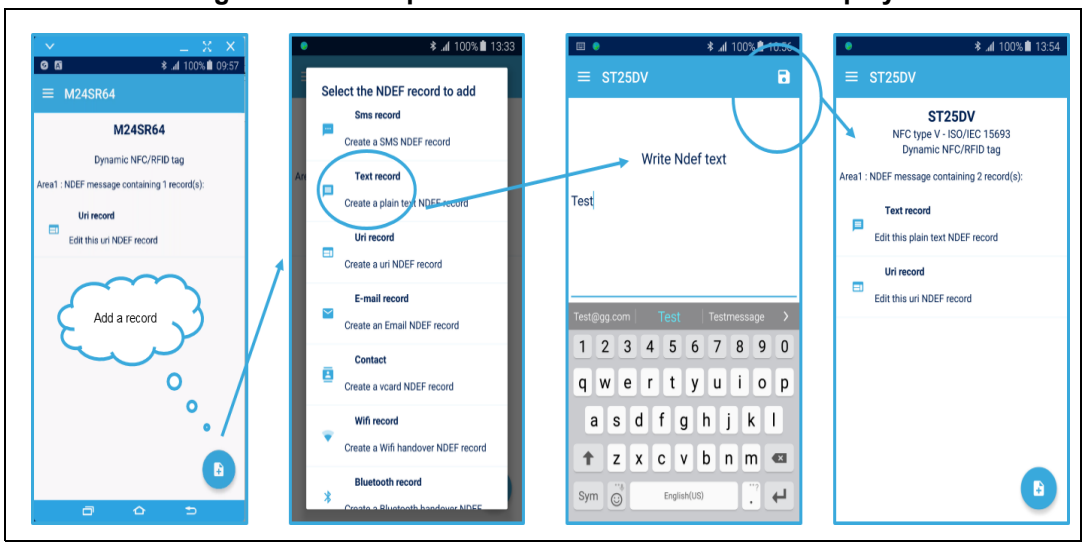
Smart phone and multi records NDEF

This section provide dedicated indications to build multi records NDEF (see *Figure 57*).

How to build each record:

- From “Ndef Editor” menu, click on the ‘+’ at the bottom right corner to add a record. A popup will appear to allow you to choose the record type that you want.
- Fill the record and click on the Floppy icon, in the top right corner, to save the record to the tag.
- Proceed in the same way to add some more records.

Figure 57. Smart phone and Multi records editor display



Bluetooth® Low Energy pairing demonstration (requires an additional BLE module)

This menu indicates how to manage a Bluetooth® Low Energy (BLE) pairing content in the ST25DV. By default, the ST25-DISCOVERY board doesn't feature the BLE module, but the ST BlueNRG module can be added on it.

For this demonstration it is required to read the ST25DV content with a smart phone having the Bluetooth® Low Energy OOB support (e.g. Android 6.0).

With the MCU, the user can

- Store an NDEF message containing the BLE Out-Of-Band (OOB)
- Read a Bluetooth® or BLE OOB previously stored in the ST25DV memory

When the user reads the ST25DV with a smart phone having the BLE support, the smart phone automatically asks confirmation and connects to the BlueNRG module presents on the demonstration board. The MAC address provided by the smart phone is displayed on the screen of the demonstration board as soon as the pairing is completed.

The BlueNRG is configured to act as a Human Interface Device (HID); it will be displayed on the smart phone with this name: HID.

The HID protocol is natively supported by Android 6.0 smart phones, and this demonstration allows the user to control a pointer on the paired phone, by touching the screen of the ST25DV-DISCOVERY board. The screen acts as a touch-pad. The user button on the ST25DV-DISCOVERY board acts as a select button.

Touch the bottom line of the LCD to exit this demonstration.

The user can select the “Change BLE Address” command to prevent spurious connections from previously paired smart phones.

This will change the BLE module device address, with the effect that it will be seen by smart phones as a different device (however the device name - HID - is left unchanged).

Note: Some smart phones require a specific action from the user to enable the HID control (this setting can be located in the Bluetooth® menu of the smart phone).

Smart phone and Bluetooth low energy

Please refer to *Reading and writing NDEF on a smart phone with the ST25 application*.

Wi-Fi® pairing demonstration (requires an additional Wi-Fi® module)

This menu presents how to manage a Wi-Fi® pairing content in the ST25DV. By default, the ST25DV-DISCOVERY board doesn't feature the Wi-Fi® module, but the ST SPWF01 module can be added on it, acting as a mini Wi-Fi® access point.

For this demonstration, it is required to read the ST25DV content with a smart phone with Wi-Fi® support.

With the MCU, the user can

- Store an NDEF message containing a Wi-Fi® Protected Setup (WPS) Out-Of-Band descriptor.
- Read a WPS OOB previously stored in the ST25DV memory.

When the user reads the ST25DV with a smart phone having the Wi-Fi® support, the smart phone automatically asks a confirmation and connects to the SWPF_AS01 Wi-Fi® network. The MAC address provided by the smart phone is displayed on the screen of the demonstration board as soon as the connection is completed.

Note: For the demonstration no Internet access is provided by the board mini Access Point.

Note: If, when the MCU reads the ST25DV memory, it does not contain a WPS OOB, an error message is displayed.

Smart phone and Wi-Fi pairing

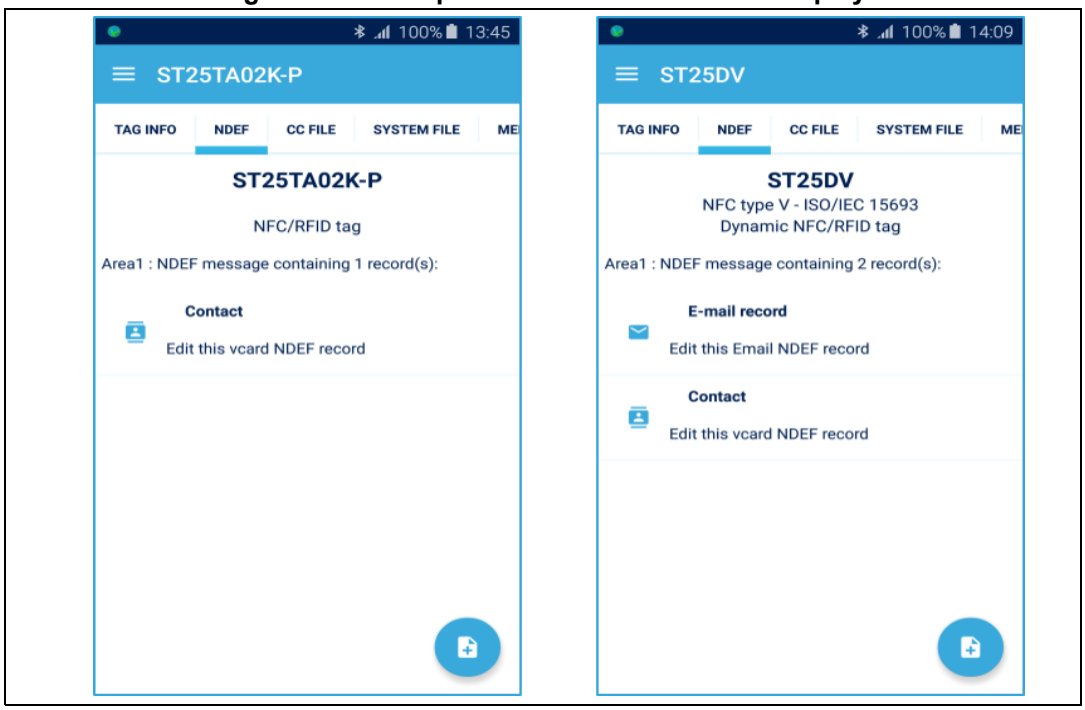
Please refer to *Reading and writing NDEF on a smart phone with the ST25 application*.

Reading and writing NDEF on a smart phone with the ST25 application

The ST25 NFC App enables to read or write NDEF messages.

Read: Tap the tag, if a managed NDEF is discovered, content is accessible from the NDEF tab or NDEF Editor (refers to Android application user manual for more details):

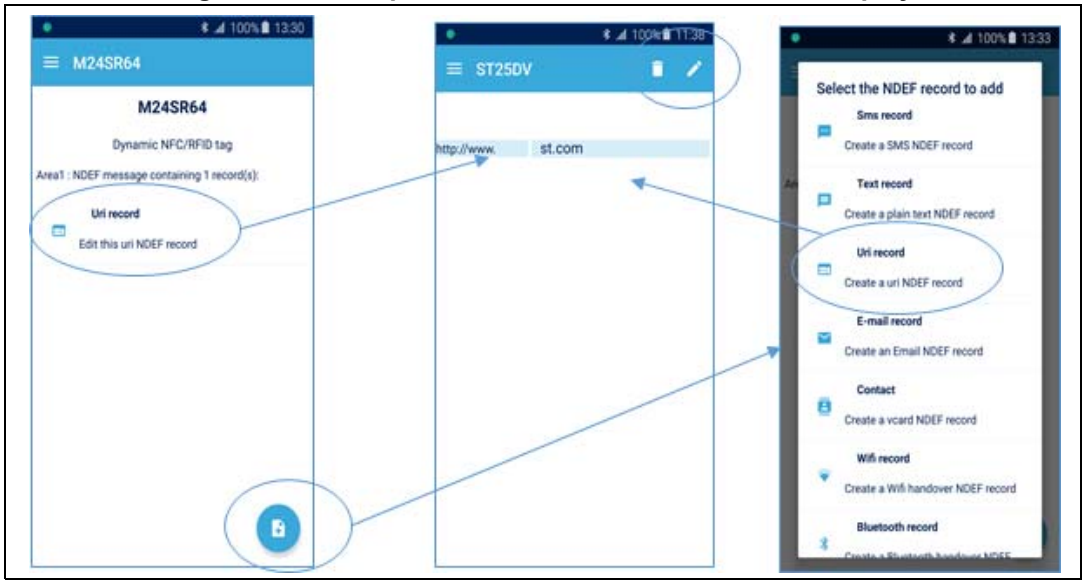
Figure 58. Smart phone and NDEF discover display



Write an NDEF: Select “NDEF editor” and choose the NDEF type you would like to write.

An editor according to the selected type is displayed.

Figure 59. Smart phone and URL NDEF write menu display



Clear EEPROM

This menu allows the user to clear the EEPROM content. The three choices are:

1. Write an empty NDEF
2. Erase the CCFile (replace the first four bytes of memory with 0xFF)
3. Clear EEPROM (fill the whole memory with 0xFF).

4 Revision history

Table 7. Document revision history

Date	Revision	Changes
20-Feb-2017	1	Initial release.
30-May-2017	2	Updated: – Replaced in all document STM32F415 product by STM32F405. – *Figure 2: ST25DX-DISCOVERY motherboard MB1283-B*, *Figure 2: ST25DX-DISCOVERY motherboard MB1283-B*, *Figure 7: Smart phone GPO register configuration*, *Figure 10: Smart phone and area display*, *Figure 12: Smart phone and Fast Transfer Mode use cases display*, *Figure 23: ST25DV drawer menu (Maibox management, Firmware update, Picture transfers, Stopwatch tranfers)*, *Figure 25: Data transfers from reader to tag of a random buffer*, *Figure 35: Smart phone and firmware upgrade display*, *Figure 37: Smart phone and image upload display*, *Figure 43: Smart phone and picture upload transfers display*, *Figure 46: Smart phone and data transfers H2R with selected size*, *Figure 49: Smart phone and stopwatch transfers*, *Figure 57: Smart phone and Multi records editor display*, *Figure 58: Smart phone and NDEF discover display*, *Figure 59: Smart phone and URL NDEF write menu display* – *Section 3.1: Prerequisite*, *Smart phone GPO management*, *Smart phone and multi areas*, *Section 3.2.3: Fast Transfer Mode Demo menu*, *Smart phone and Fast Transfer Mode use cases*, *Smart phone and FTM data transfers*, *Smart phone and firmware upgrade*, *Smart phone and picture transfers*, *Smart phone and stopwatch transfers*, *Smart phone and multi records NDEF* Added: *Figure 24: Mailbox Status* Removed *Figure 8: Smart phone GPO interrupt*, *Figure 58: Smart phone and Multi records discovered display*