

Introduction

This document describes the firmware functionalities of the M24SR-DISCOVERY board. This document helps the user to understand how this firmware works.

M24SR can communicate with an MCU, this make M24SR a dynamic tag. Indeed the reader (for instance a smartphone) can retrieve different content staying close to the M24SR.

The reader communicates with the M24SR-DISCOVERY board through the 14443A protocol. The MCU communicates with the M24SR by an I²C bus. The MCU of the M24SR-DISCOVERY is an STM32F103.

With this discovery kit, the M24SR can be programmed with different content following the NFC forum format. This means that a smartphone can read it natively without any specific application previously installed. Then depending on the content, its behavior can change regarding the smartphone and the OS version.

A proprietary mode has also been developed, to illustrate other ways to use the M24SR; in this case, a specific application must be installed. (Available only for Android smartphones).

Note: All information content in this document is applicable for M24SR-DISCOVERY Standard and Premium editions, unless otherwise specified.

This documentation was written with M24SR discovery firmware version v1.1.1; the board is delivered with software version v1.1.0; the differences between these releases are only due to the cleaning of code, mainly for the Doxygen documentation. No functional modifications have been added.

Contents

- 1 Overview 4**
 - 1.1 M24SR overview 4
 - 1.2 STM32F103 overview 4
 - 1.3 M24SR-DISCOVERY board 4

- 2 Firmware description 6**
 - 2.1 Main menu 6
 - 2.2 URI item 7
 - 2.3 SMS item 8
 - 2.4 Email item 9
 - 2.5 Vcard item 10
 - 2.6 Bluetooth pairing item (only on the Premium edition) 11
 - 2.7 Geo item 13
 - 2.8 My app item 13
 - 2.9 M24SR presentation item 14
 - 2.10 M24SR RF disable item 15
 - 2.11 GPO control item 15
 - 2.12 M24SR password item 16
 - 2.13 Disclaimer item 18

- Appendix A Acronym and notational conventions 19**

- Revision history 20**

List of figures

Figure 1.	Communication chart	4
Figure 2.	M24SR-DISCOVERY board (Premium edition shown).	5
Figure 3.	Main menu (Premium edition).	7
Figure 4.	Main menu (Standard edition)	7
Figure 5.	URI item	7
Figure 6.	URI	8
Figure 7.	SMS item	8
Figure 8.	SMS	9
Figure 9.	Email item	9
Figure 10.	Email.	10
Figure 11.	Vcard item.	10
Figure 12.	Vcard	10
Figure 13.	Bluetooth pairing item	11
Figure 14.	Song information example	12
Figure 15.	Geo item	13
Figure 16.	Geolocation.	13
Figure 17.	My app item	13
Figure 18.	Information provided by smartphone	14
Figure 19.	M24SR presentation item	14
Figure 20.	M24SR RF disable item	15
Figure 21.	GPO control item	15
Figure 22.	M24SR-DISCOVERY interrupt generation	16
Figure 23.	M24SR password item	16
Figure 24.	M24SR-DISCOVERY password	17
Figure 25.	Disclaimer item	18
Figure 26.	M24SR-DISCOVERY firmware version	18

1 Overview

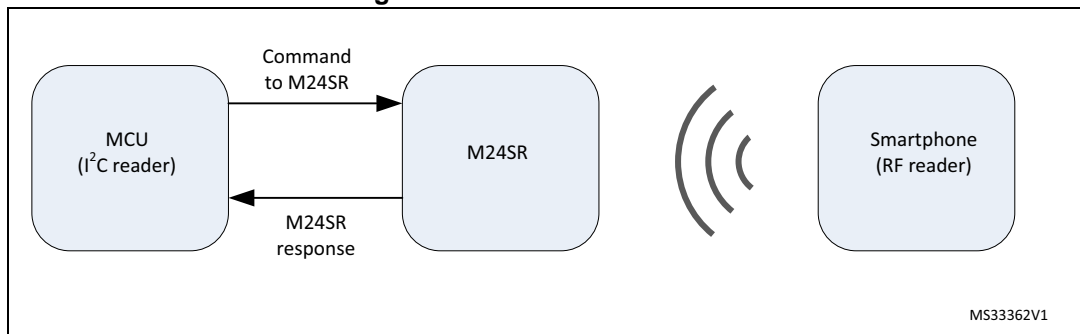
1.1 M24SR overview

M24SR is a dynamic tag IC for contactless applications (ISO 14443A). It manages the RF communication with a reader. It includes frame coding, RF modulation and manages the anti-collision process itself.

The M24SR works as an NFC Forum Type 4 tag, supporting the detection, the reading and the writing operations.

M24SR can communicate with a reader without any external control.

Figure 1. Communication chart



Note: For more details concerning the M24SR device, refer to the corresponding datasheet.

1.2 STM32F103 overview

The STM32F103xx integrates a high-performance ARM Cortex™-M3 32-bit RISC core operating at a 72 MHz frequency, high-speed embedded memories (Flash memory up to 128 Kbytes and SRAM up to 20 Kbytes), and an extensive range of enhanced I/Os and peripherals connected to two APB buses. All devices offer two 12-bit ADCs, three general purpose 16-bit timers plus one PWM timer, as well as standard and advanced communication interfaces: up to two I²Cs and SPIs, three USARTs, a USB and a CAN.

These features make the STM32F103xx microcontroller suitable for a wide range of applications such as motor drives, application control, medical and handheld equipment, PC and gaming peripherals, GPS platforms, industrial applications, PLCs, inverters, printers, scanners, alarm systems, video intercoms, and HVACs.

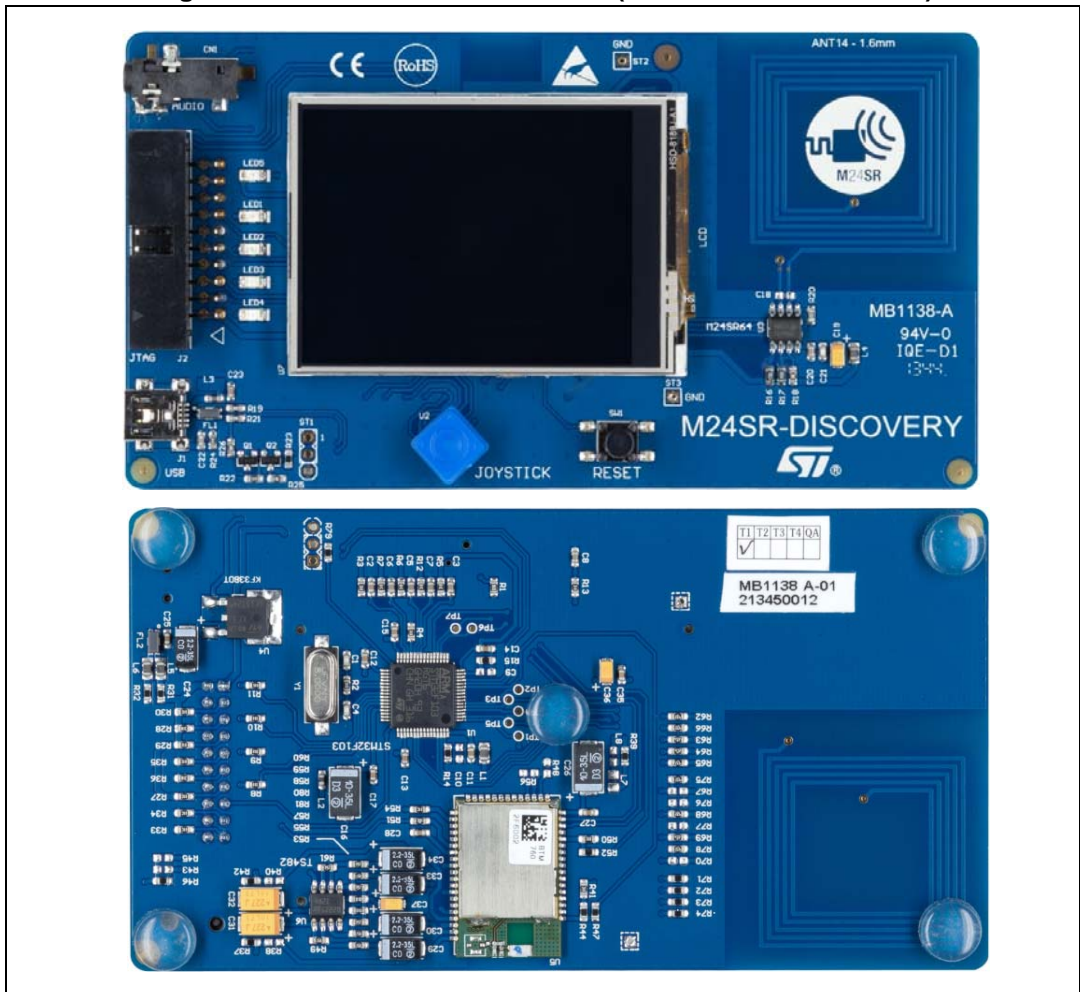
1.3 M24SR-DISCOVERY board

The M24SR-DISCOVERY is an evaluation kit which allows to evaluate the performances of an ST M24SR dynamic tag.

The M24SR-DISCOVERY is powered through the USB bus and no external power supply is required. It includes an M24SR tag, a 31 x 30 mm 13.56 MHz double layer inductive etched antenna (no need of tuning components).

By default, the M24SR communicates with the STM32F103RG 32-bit MCU via the I²C bus.

Figure 2. M24SR-DISCOVERY board (Premium edition shown)



2 Firmware description

Prerequisite

The user has an NFC smartphone with the NFC capability enabled.

As M24SR is a dynamic tag, the interesting point is to show that a reader can see different content in front of the M24SR. For this purpose, the next examples have been thought to be performed with the interaction of the M24SR-DISCOVERY and a smartphone.

Note: Reading the NFC forum content in the M24SR will be natively performed by your smartphone. But writing the NFC forum content will need to use a dedicated application.

For this reason, the goal of the demonstration is to change the M24SR content by I²C (with MCU) and check the updated content by RF (with smartphone). But it is also possible to change the M24SR content using your smartphone and to check the updated content with the MCU.

2.1 Main menu

The main menu is composed of icons allowing access to different items. Each item illustrates an M24SR use case.

Note: On the Premium edition, one more icon is available to illustrate a Bluetooth pairing use case.

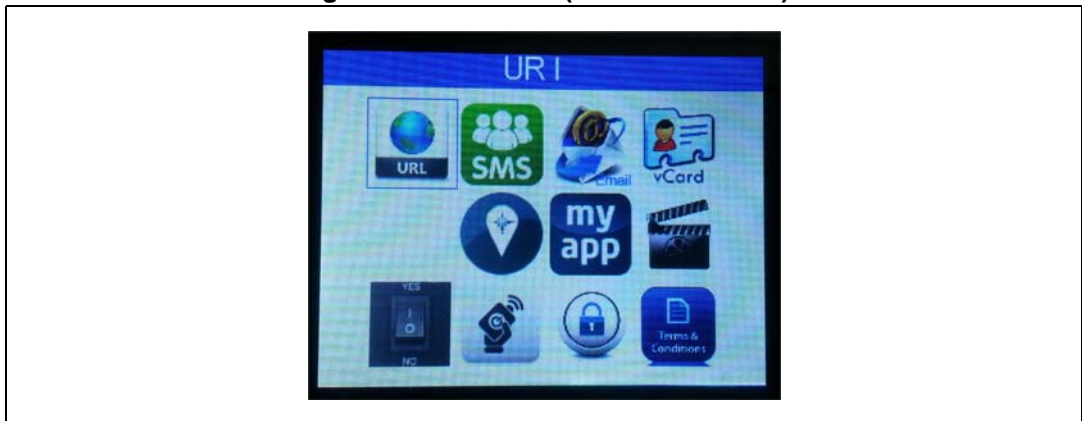
The organization is as follows:

- NFC forum compliant example
 - URI item
 - SMS item
 - Email item
 - Vcard item
 - Bluetooth item (premium edition only)
 - Geolocation item
 - My App item (NFC forum compliant but needing a dedicated application)
- Product Presentation
 - M24SR presentation item
- Product feature
 - RF Disable item
 - GPO control item
 - Password item
- Software version information
 - Disclaimer item

Figure 3. Main menu (Premium edition)



Figure 4. Main menu (Standard edition)



To select a use case, move the blue square on the icon of your choice using the joystick and press it to select the item.

As this document purpose is to illustrate the firmware behavior, the next item description has been chosen to explain it from an MCU point of view.

2.2 URI item

Figure 5. URI item



This menu presents how to manage the URI content in the M24SR.

With the MCU, you can:

- store an URL or a phone number,
- read the M24SR content.

If the URI has been previously stored, the following information will be displayed on the board screen: URI protocol, URI content, and optionally information.

Figure 6. URI



In the case, the M24SR content does not represent a URI; an error message will warn the user that the content in the M24SR does not represent a URI.

2.3 SMS item

Figure 7. SMS item



This menu presents how to manage an SMS content in the M24SR.

With the MCU, you can:

- store an SMS,
- read the M24SR content.

if the SMS has been previously stored, the following information will be displayed on the board screen: Phone number, SMS message and, optionally, instruction.

Figure 8. SMS



Note: An error message will warn the user if the M24SR content does not represent an SMS.

2.4 Email item

Figure 9. Email item



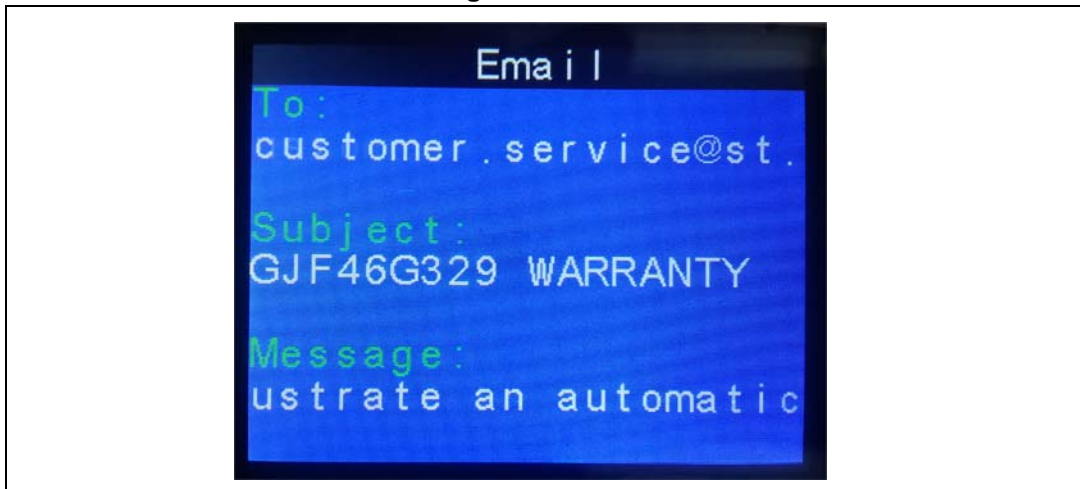
This menu presents how to manage the Email content in the M24SR.

With the MCU, you can:

- store an Email,
- read the M24SR content.

if the Email has been previously stored, the following information will be displayed on the board screen: Email address, Email subject, and Email message.

Figure 10. Email



Note: An error message will warn the user if the M24SR content does not represent an Email.

2.5 Vcard item

Figure 11. Vcard item



This menu presents how to manage a vCard content in the M24SR.

With the MCU, you can:

- store a Vcard,
- read the M24SR content.

If the Vcard has been previously stored, the following information will be displayed on the board screen: name, title, organization, one Phone number (cell, home tel or work tel), one address (home add or work add), one e-mail (home Email or work Email). See Remark 1.

Figure 12. Vcard



Note: An error message will warn the user if the M24SR content does not represent a Vcard.

Three remarks shall be considered:

1. If the Vcard information content is too important (due to the screen limitation), a choice is made in the content display on screen.
2. Only Vcard 2.1 has been implemented in the v1.1.1 firmware version. If you store a Vcard 3.0 in the M24SR, the firmware will warn you that it does not support this version.
3. The firmware does not embed a jpg decoder. if you download a Vcard with a smartphone to the M24SR with a picture inside, the firmware will retrieve the data and display it but will replace the picture by a default embedded one.

2.6 Bluetooth pairing item (only on the Premium edition)

Figure 13. Bluetooth pairing item



This menu presents how to manage a Bluetooth pairing content in the M24SR.

For this example, only storing data with an MCU and reading it with a smartphone makes sense.

Note: Your smartphone must have the Bluetooth capability.

The BT menu has 3 options:

- Configure the M24SR for a BT pairing operation
- Song information
- Possibility to pair a new device

1. Configure the M24SR for a BT pairing operation

With an MCU, you can store the Bluetooth mac address of the chip in the M24SR. Then if you bring your smartphone close to the M24SR, your smartphone will automatically connect to the M24SR-DISCOVERY Bluetooth chip.

2. Song information (provided that you have an MP3 with song information on your smartphone, and a player installed.)

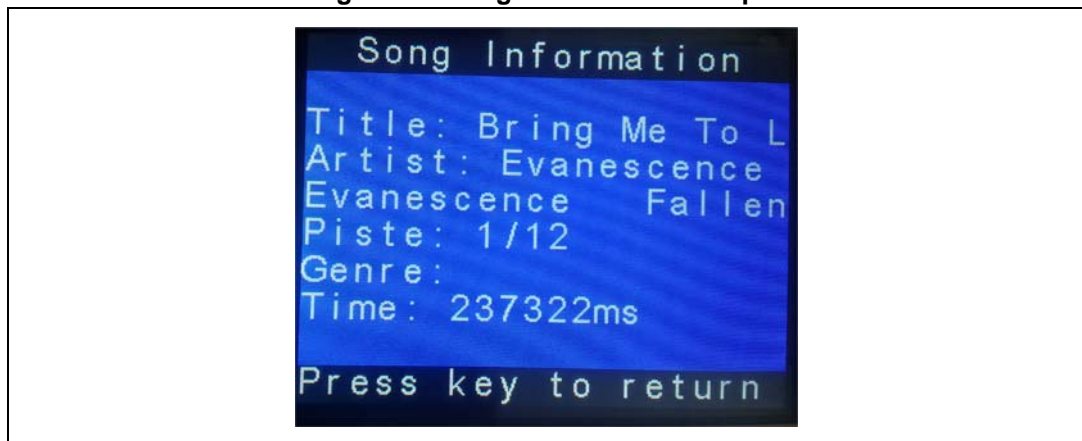
The following events may occur just after bringing your smartphone close to the M24SR:

- BT pairing is made
- MP3 player is automatically started (need to be configured with BT event on smartphone side)
- MP3 information is provided to the M24SR-DISCOVERY and displayed on screen, while music can be listened with the provided headset.

The MP3 information managed by firmware is: title, artist, album, piste, genre and time. In case the MP3 does not content waiting information, the field stays blank.

Here is an example of an MP3 containing part of the possible information the firmware is waiting for:

Figure 14. Song information example



3. Pair new device

This option allows the user to disconnect the Bluetooth link between the M24SR-DISCOVERY and the smartphone, and prepares the BT module to accept another connection. You can then bring a new smartphone close to the M24SR for pairing.

Tips:

- If the Bluetooth module is available on your board, blue LED n° 3 is ON at power-on.
- When pairing a smartphone is allowed, LED n° 5 is blinking.

2.7 Geo item

Figure 15. Geo item



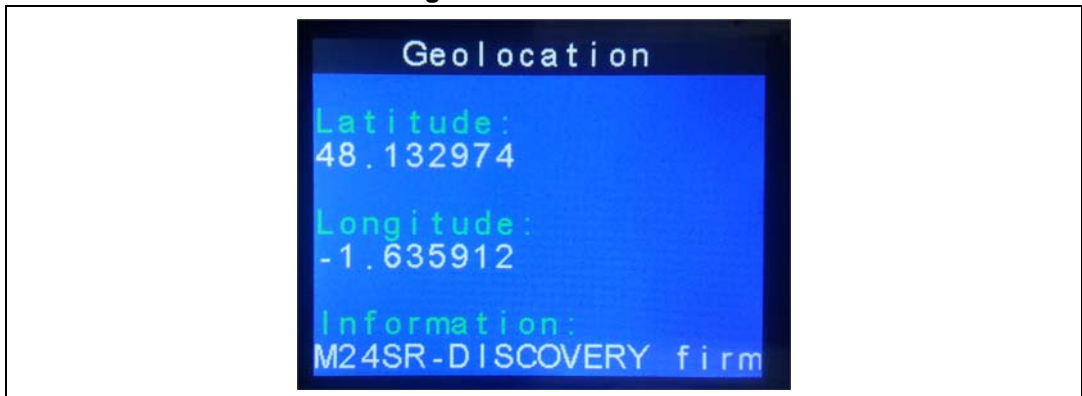
This menu presents how to manage the geolocation content in the M24SR.

With the MCU, you can:

- store a geolocation,
- read the M24SR content.

If the geolocation has been previously stored, the following information will be displayed on the board screen: Latitude, Longitude and, optionally, some information.

Figure 16. Geolocation



Note: An error message will warn the user if the M24SR content does not represent a geolocation.

2.8 My app item

Figure 17. My app item



This menu shows how to create your own application to realize your product task by using the standardized NFC forum protocol.

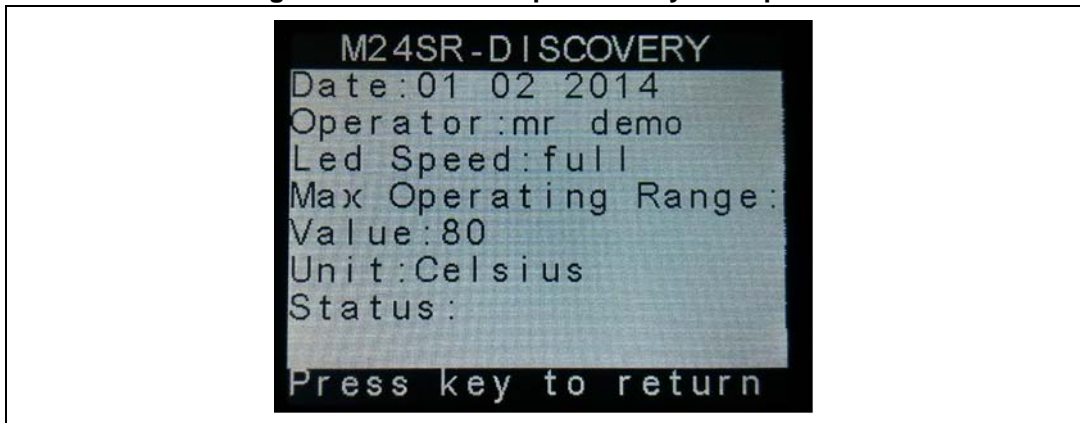
This is a big advantage because this means that you do not have to manage the RF part, everything being managed by your smartphone and M24SR. You just have to share your proprietary data between your application and your product equipped with the M24SR.

To illustrate this mode, an application has been developed to control the M24SR-DISCOVERY LEDs and to update the information display on the LCD.

With AAR (Android Application Record), it is possible, in the M24SR, to store a message which will automatically start the appropriate application (or will drive you to the play store to download it if you have not installed it on your smartphone).

This mechanism has been implemented in this demonstration: after selecting Download Phone App or Launch Demo App, the M24SR will be loaded with an AAR. Then, when bringing your smartphone close to the M24SR, the application will automatically start, let you drive the LEDs and provide your information to the M24SR-DISCOVERY, which will display it on the LCD.

Figure 18. Information provided by smartphone



2.9 M24SR presentation item

Figure 19. M24SR presentation item



This menu shows a quick presentation of the M24SR device.

You also have the antenna matrix to inform your customers of its availability, and to help them design the antenna that will best fit their product design.

Note: For more information, please contact us.

2.10 M24SR RF disable item

Figure 20. M24SR RF disable item



This simple menu illustrates the possibility to disconnect the RF interface of the M24SR.

For instance, you can put content in the M24SR with your smartphone, go to the RF disable menu and disable the RF, then try to read back the M24SR content with your smartphone. The M24SR is no more detected by your smartphone.

While RF is disabled, the MCU can still access the M24SR by I²C, and you can modify the M24SR content using the available menu. To modify the M24SR content, go back to the RF disable menu, enable RF, and read back the M24SR with your smartphone. The M24SR content has changed as compare to the content you initially put with your smartphone.

Tips:

- When RF is enabled, LED n° 2 is on.
- WHEN RF is disabled, LED n° 2 is off.

2.11 GPO control item

Figure 21. GPO control item



The M24SR provides one GPO to send interrupts to the MCU.

Before explaining the application, here is a short summary of the GPO management. (For more explanation, refer to the datasheet)

GPO has 3 different configurations regarding the M24SR state:

1. No RF and I²C session is opened on the M24SR side: GPO is not driven, GPO is high-Z but pull-upped externally on the M24SR-DISCOVERY board.
2. An I²C session is opened: the GPO behavior follows the configuration set for the I²C session. This firmware demonstration is used to know when M24SR responses are available.
3. An RF session is opened: the GPO behavior follows the configuration set for the RF session. This menu is used to send an interrupt to the MCU when RF decides to do it.

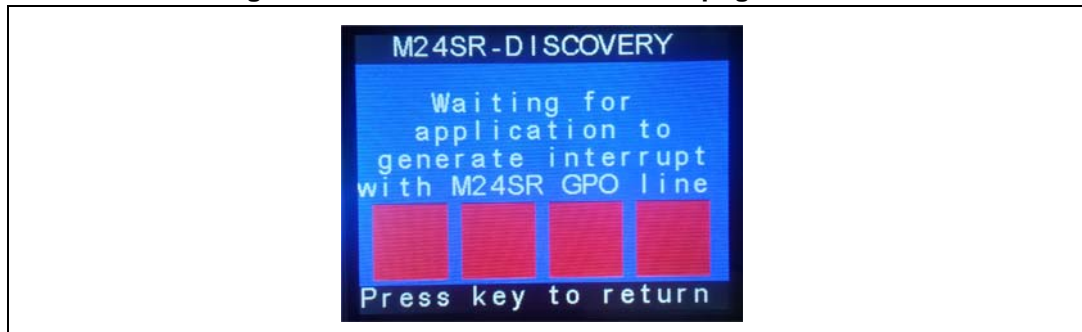
The GPO is a hardware feature which is not covered by NFC forum, so you need a dedicated feature in your application to control the GPO.

With AAR (Android Application Record), it is possible to store a message in the M24SR that will automatically start the appropriate application (or drive you to the play store to download it if you have not installed it on your smartphone).

This mechanism has been implemented in this demonstration: after selecting Download Phone App or GPO Control Demo, the M24SR will be loaded with an AAR. Then, when bringing your smartphone close to the M24SR, the application will automatically start and you will be able to drive GPO.

In this demonstration, the MCU configures the M24SR to give GPO control to the application. Each time an interrupt is generated by the application, the color of a square on the LCD changes from red to green or from green to red.

Figure 22. M24SR-DISCOVERY interrupt generation



2.12 M24SR password item

Figure 23. M24SR password item



The M24SR provides a feature to set, read or/and write a password.

Before explaining the application, here is a short summary of the password management. (For more explanation, refer to the datasheet).

To understand how it works, the user must be aware of the M24SR password strategy:

- M24SR has always 2 128 bits passwords saved inside the chip (1 read password and 1 write password).
By default the passwords are 0x00000000000000000000000000000000.
- Then, the password can be activated or not. This means that the password exists but it is not necessarily required to access the M24SR data.
- If the password is activated, it will be required when trying to access the M24SR in read or write mode (depending if the password is activated or not).
- To activate a password, the password saved in the M24SR must be presented.
- To change a read password, a write password saved in the M24SR must be presented (as it has been considered as a write operation).
- To change a write password, a write password saved in the M24SR must be presented.
- These read and write passwords can be used through I²C and RF accesses.

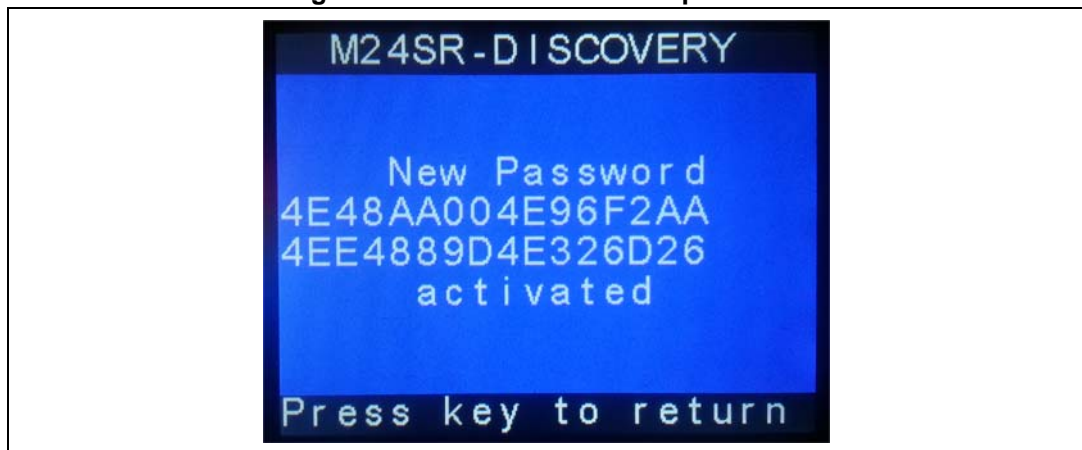
On top of that implementation, a super user mode has been put in place by creating a super password named I²C password (because it can be used only through the M24SR I²C interface). This password can be used to modify read and write passwords.

Inside the M24SR password menu, you will find 3 choices: Pwd authentication, Force limited access and Super User mode.

1. For a **Pwd authentication**, you can enable or disable the use of a read or/and write password.

As it was not convenient for the M24SR-DISCOVERY user to enter a 128-bit password, the choice has been made to create a pseudo random password to lock the M24SR content and to display it on LCD to let the user know it (see [Figure 24](#)).

Figure 24. M24SR-DISCOVERY password



To test the feature, you can proceed as follows:

- Load the M24SR with an SMS content, for instance
- Set the read password.

If you try to read the M24SR with a smartphone, natively, it will not work.

Use the M24SR demo application, and you will be prompted to enter the read password: enter the password displayed on the M24SR-DISCOVERY LCD display.

The M24SR content is read by your smartphone.

This function is adapted if you want to secure your M24SR content and let only a sterling source modifying the M24SR content. In this case, the password can be known by this reliable application.

2. The **Force limited access** can be seen as a stronger feature than a password because you can lock read or write capabilities but a reader cannot unlock it. You can set a read-only mode or a write-only mode.
NFC forum deals with the read-only mode, and this mode will be supported by a smartphone.
The write-only mode was not specified, so it will work only with dedicated applications.
3. The **Super User mode** uses the I²C password to unlock the M24SR (useful if you lock the memory using the M24SR application).

Tips: When M24SR content is locked with a read or write password, the red LED n° 1 is On.

2.13 Disclaimer item

Figure 25. Disclaimer item



The purpose of this menu is just to provide the version of the firmware you are using.

Figure 26. M24SR-DISCOVERY firmware version



Appendix A Acronym and notational conventions

Acronym

APB: Advanced Peripheral Bus
AAR: Android Application record
CAN: Controller Area Network
GPS: Global Positioning System
IEC: International electrotechnical commission
ISO: International Organization for Standardization
MCU: Micro controller unit
NFC: Near field communication
RF: Radio frequency
RFID: Radio frequency identification
RISC: Reduced Instruction Set Computer
SPI: Serial Peripheral Interface
USB: Universal serial bus

Representation of Numbers

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

Binary number representation

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 number representation

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 number representation

Decimal numbers are represented as is, without any trailing character.

Example: 245

Revision history

Table 1. Document revision history

Date	Revision	Changes
07-Feb-2014	1	Initial release.

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