



Application Note 427

Title: **EM4095 RFID Reader User Guide**

Product Family: **RFID**

Part Number: EMDB409

Keywords: EM4095, EMDB409, ISO 11784/ 11785, Animal mode, Read Only, EM4200, EM4450, EM4205, EM4305, EM6869

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1. Introduction 2

 1.1. Setup 2

 Setup - Driver Installation 2

 1.2. User's guide 6

2. Starting EMDB409 Application Software..... 7

3. Graphics User Interface 7

4. Operation Selector 8

 4.1. Animal mode transponder 9

 4.2. Read Only mode transponder 10

 4.3. EM4450 transponder 11

 4.4. EM4205 / EM4305 Transponder 15

 4.5. EM6869 transponder (LF interface)..... 20

 4.6. Bootloader 25

5. Error handling 27

6. Other software 27



1. Introduction

Welcome to the EM4095 RFID Reader (EMDB409 Reader) user's guide.

To further utilise the EM4095 RFID Reader, the minimum hardware and software requirements are;
Windows® NT/XP, 10MB HDD space, 800x600 pixels video resolution

1.1. Setup

Following steps describe the first time initialization of the EMDB409 Reader Application Software when on start up using USB cable.

Setup - Driver Installation

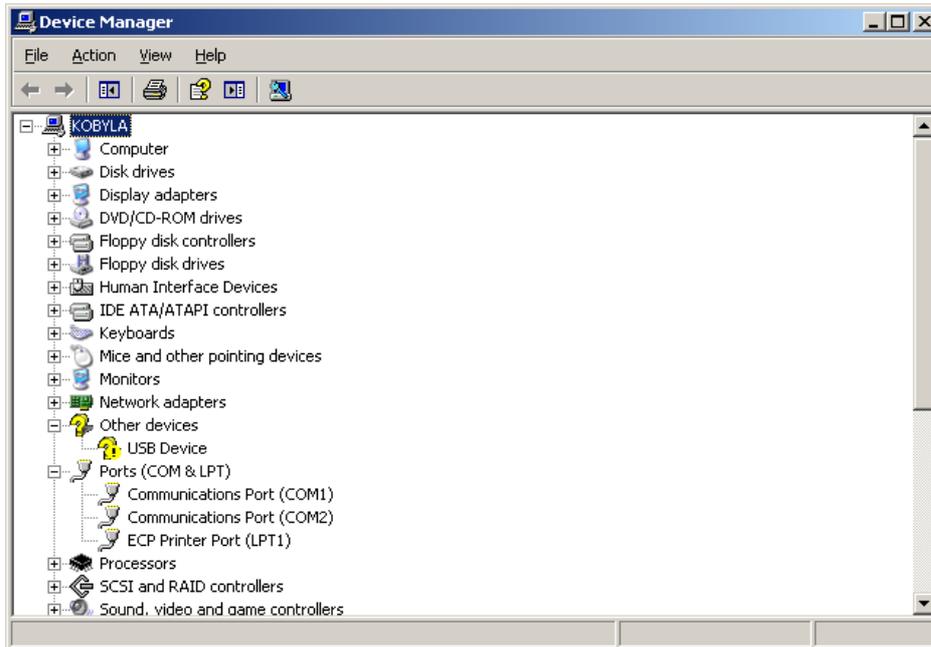
At first, please unpack the EM4095 RFID Reader base station, installation CD, USB cable, transponder samples, and the power supply adapter from the EM4095 RFID Reader box. Following steps describe the first-time initialization of the EMDB409 Reader Application Software when using USB cable (and assuming the drivers have not been installed yet):

1. Log-in as administrator
2. Launch the Setup.exe executable found in the CD root directory
3. Follow the application software installation wizard to install the application software.
4. Connect the EMDB409 Reader to the USB port using USB cable
5. Connect the power supply adapter to the EMDB409 Reader and power it on
6. The operating system detects the reader is connected and initiates the driver installation sequence

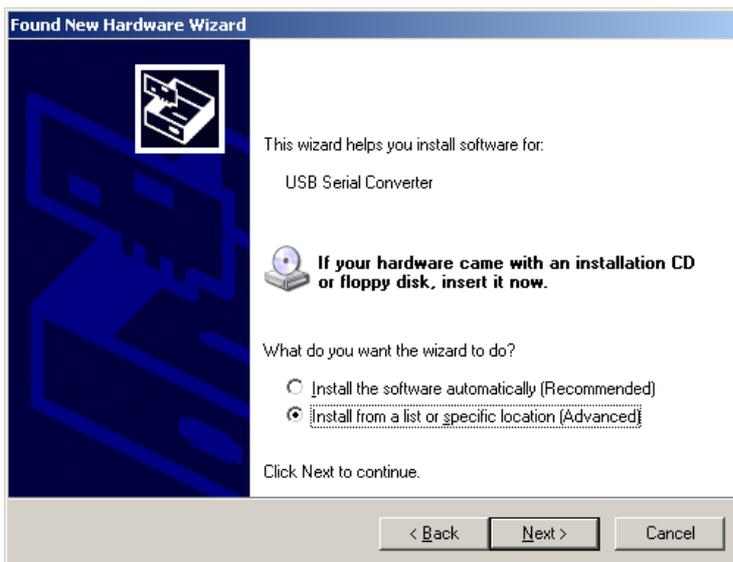


Select "No, not this time" and click on Next button.

Note: optionally, it can be observed in the Device Manager. To open the device manager, click on Start->Control Panels->System icon, select the Hardware tab, and click on Device Manager button. Following window shall appear, with the reader device indicated by the "Other Devices -> USB Device" item.



7. The “USB Device” is the USB Serial Converter and operating system will ask for its driver files location;



Select “Install from a list or specific location (Advanced)” item and click on Next button.

8. The operating system displays a dialog to enter the driver location;



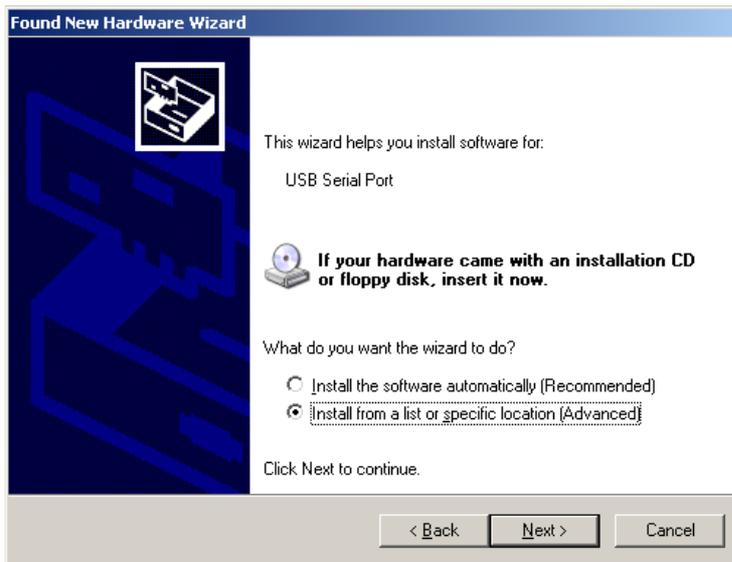
Click on Browse button and locate the driver directory on the installation CD (for example; “Your CD/DVD drive letter”:\Drivers\CDM20602”. Finally click on Next button.

9. Operating system starts the USB Serial Converted driver installation. It may require a confirmation on installation of unsigned driver, as a standard policy.

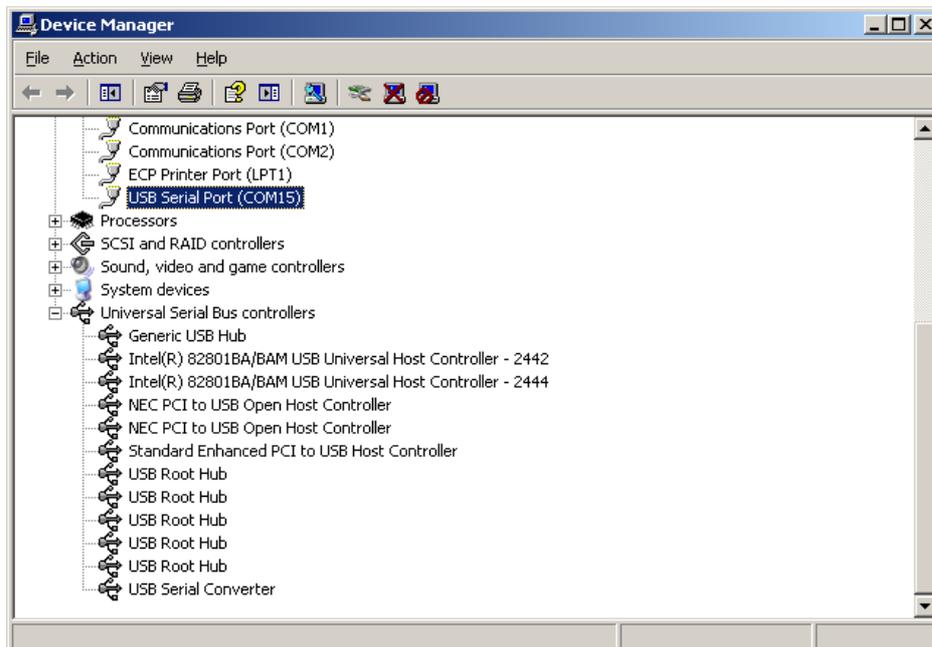


Click on “Continue Anyway” button.

10. After the USB Serial Converter driver installation, the operating system initiates a second sequence to install the USB Serial Port driver. The operating system will ask for the driver again.



11. Hence;
 - a. In newly displayed Wizard dialog, select “Install from a list or specific location (Advanced)” item and click on Next button.
 - b. In newly displayed Driver location dialog, leave the “Your CD/DVD drive letter”:\Drivers\CDM20602” in the location edit box and click on Next button
 - c. Confirm the “Continue Anyway” query
12. When the operating system finishes the installation, the correctly installed driver (with the reader connected and powered on) shall be indicated in the Device manager as “USB Serial Port”;

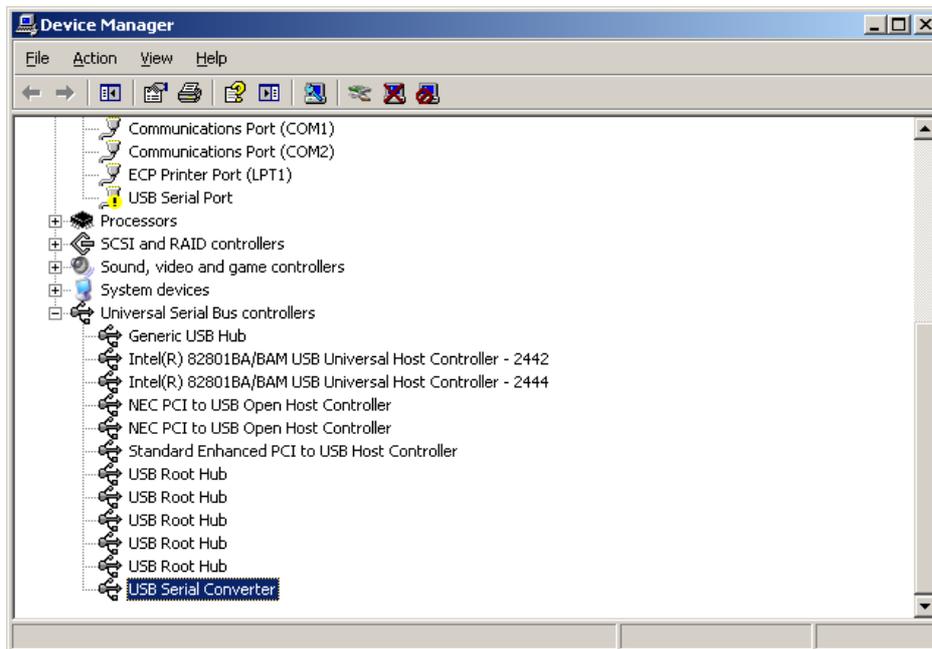


Application software start

1. In the Start->All programs menu, locate the EMDB409 Reader application software and launch it
2. Within EMDB409 Reader application software, select a menu Reader Connection -> Connect. The application finds every available virtual COM ports that are provided by FTDI USB drivers.
3. Choose the appropriate COM port in the Com Port List Box and click on Connect button to establish the connection.
4. The OK field inside the status bar and status window signalize a successful initialization while the reader connection modal window is closed automatically. Otherwise, status bar signalizes an error.

Possible problems caused by EMDB409 Application Software and their suggested solutions:

1. No COM port is found - the operating system is not properly configured or the insufficient privileges are applied. Please inspect the hardware device list of your PC to check there is a USB<->COM converter device present while the EMDB409 Reader is connected via USB cable and powered on and the drivers have been installed correctly.
2. To determine the virtual COM port (system way) - please inspect the hardware device list of your PC to check there is a USB<->COM converter device present while the EMDB409 Reader is connected via USB cable and powered on and the drivers have been installed correctly. On some systems, the virtual COM port number may collide with other virtual devices; in such case, please fix the COM port manually to another not-yet used port number.
3. To determine the virtual COM port (easy way) - run the EMDB409 Reader Application Software and select menu Reader Connection -> Connect. Remember the COM ports listed in the COM Port List Box. Then, connect the EMDB409 Reader via USB cable and power it on. After several seconds, the operating system creates a new virtual COM port, thus, click on Refresh button and check what a new port appears in the COM Port List Box.
4. The reader doesn't respond on startup - please determine the virtual COM port number and presence as described above.
5. Partially installed drivers - if the USB Serial Converter driver is installed only, open the device manager;



Then click on "USB Serial Port" with right mouse button, and select "Update driver" item. Continue the installation queries according to the step 11 above.

1.2. User's guide

Follow this user's guide chapters that describe the functionality of EMDB409 Reader application software and show how to communicate with the RFID transponders easily. The same information can be found in the EMDB409 Reader Application help available through pressing the key F1.

2. Starting EMDB409 Application Software

Following steps describe the standard initialization of the EMDB409 Reader Application Software when using USB cable assuming the drivers are already installed:

1. Connect the EMDB409 Reader to the USB port using USB cable
2. Connect the power supply adapter to the EMDB409 Reader and power it on
3. Run EMDB409 Reader Application Software
4. Select a menu Reader Connection -> Connect – the application finds every available COM port by trying to open it. Every available COM port is inserted into the Com Port List Box.
5. Choose the appropriate COM port in the Com Port List Box and click on Connect button to establish the connection
6. The OK field inside the status bar and status window signalize a successful initialization while the reader connection modal window is closed automatically. Otherwise, status bar signalizes an error.

3. Graphics User Interface

The EMDB409 Application Software graphics user interface is split into two panels separated by a status bar. The upper panel displays a transponder specific frame (controls, commands, editable fields, etc). No transponder specific frame is displayed after the connection is established (see Figure 1 Graphics User Interface). The bottom panel contains a Message Window.

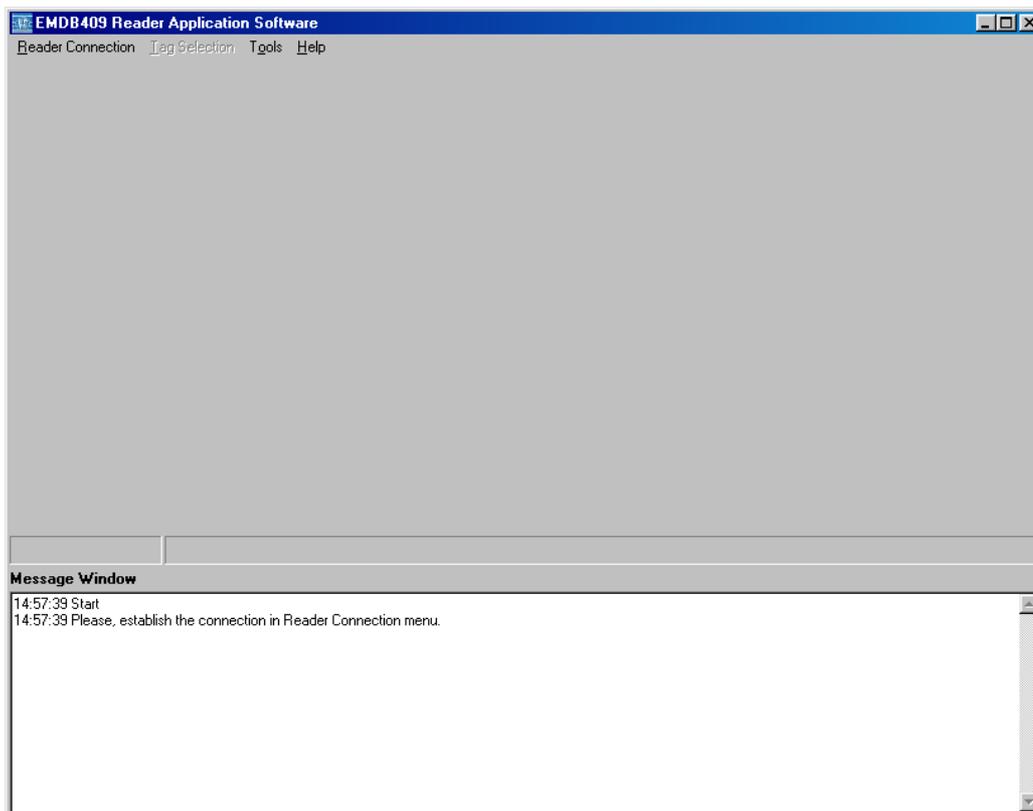


Figure 2 Start-up graphic user interface

Status Bar

For all the commands the first field of status bar displays a Status (result) of the recent command execution;

- O.K.
- ERROR

Message Window

Message Window displays the commands and their responses actually processed by the application software. Although the message window can be hidden, it displays useful information about the results of the commands.



4. Operation Selector

Until the communication with the EMDB409 Reader is established, following menus are available;

- Reader Connection menu
 - Connect – to establish the connection
 - Exit – to exit the application software
- Tools menu
 - Message Window Visibility – to show/hide the message window
 - Clear Message window – to clear the message window
 - Bootloader – to upload a new firmware to the EMDB409 Reader

As soon as the communication with the EMDB409 Reader is established, the communication menus are enabled. The communication menus comprise:

- Tag Selection menu
 - Animal mode - to read transponders programmed with Animal mode data
 - Read Only mode - to read transponders programmed with Read Only UID
 - EM4450 - to communicate with EM4450 transponder
 - EM4205/EM4305 - to communicate with EM4205 or EM4305 transponder
 - EM6869 - to communicate with EM6869 transponder
- Tools menu
 - Field ON – RF field on
 - Field OFF – RF field off
 - Field Reset – Field off and field on

Note: EM4100, EM4102, EM4105, EM4150, EM4350, EM4550, EM4026, and EM4x69 transponders are obsolete products.

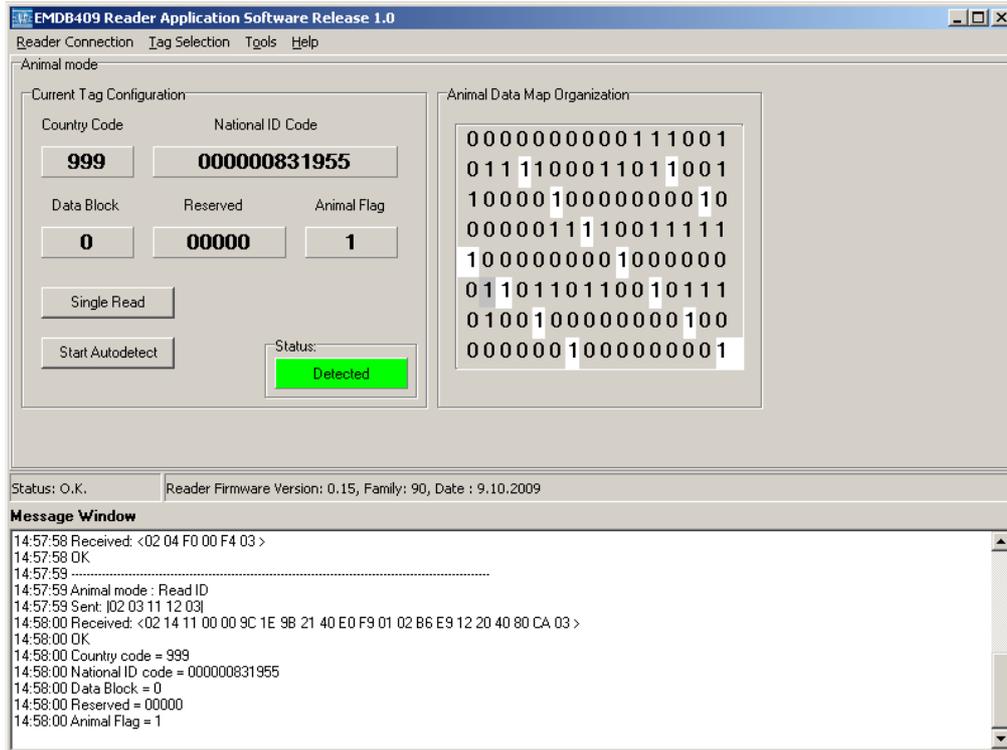


4.1. Animal mode transponder

EMDB409 Reader is capable of reading the UID of Animal mode transponder.

Animal mode Read UID

1. Select a Tag Selection ->Animal mode menu
2. Place a single Animal mode tag on the EMDB409 Reader
3. Click on Single Read button



Click on Start Autodetect button to run continuous Read of Animal mode UID.

To emulate Animal mode tags by EM4205/EM4305, refer to Animal Application Software on the installation CD (EMDB409 Reader AN Application Software).

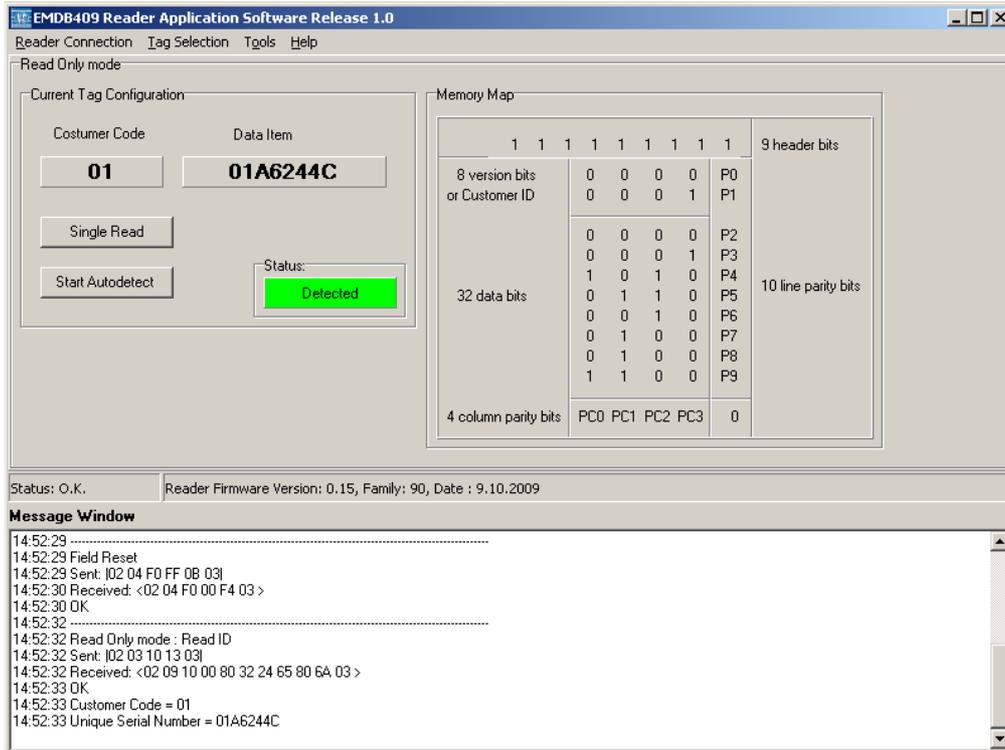


4.2. Read Only mode transponder

EMDB409 Reader is capable of reading UID of transponders programmed with Read Only data structure.

Read Only mode Read UID

1. Select a Tag Selection ->Read Only mode menu
2. Place a single Read Only mode tag on the EMDB409 Reader
3. Click on Single Read button



Click on Start Autodetect button to run continuous Read of Read Only mode UID.

To emulate Read Only tags by EM4x69, refer to Read Only Application Software on the installation CD (EMDB409 Reader RO Application Software).

4.3. EM4450 transponder

Following notes describe typical usage of the EMDB409 Application Software graphics user interface for family of EM4x50 transponders.

Setup

1. Select a Tag Selection -> EM4450 menu (see Figure 4 EM4450 Communication Frame)
2. Place a single EM4450 tag on the EMDB409 Reader

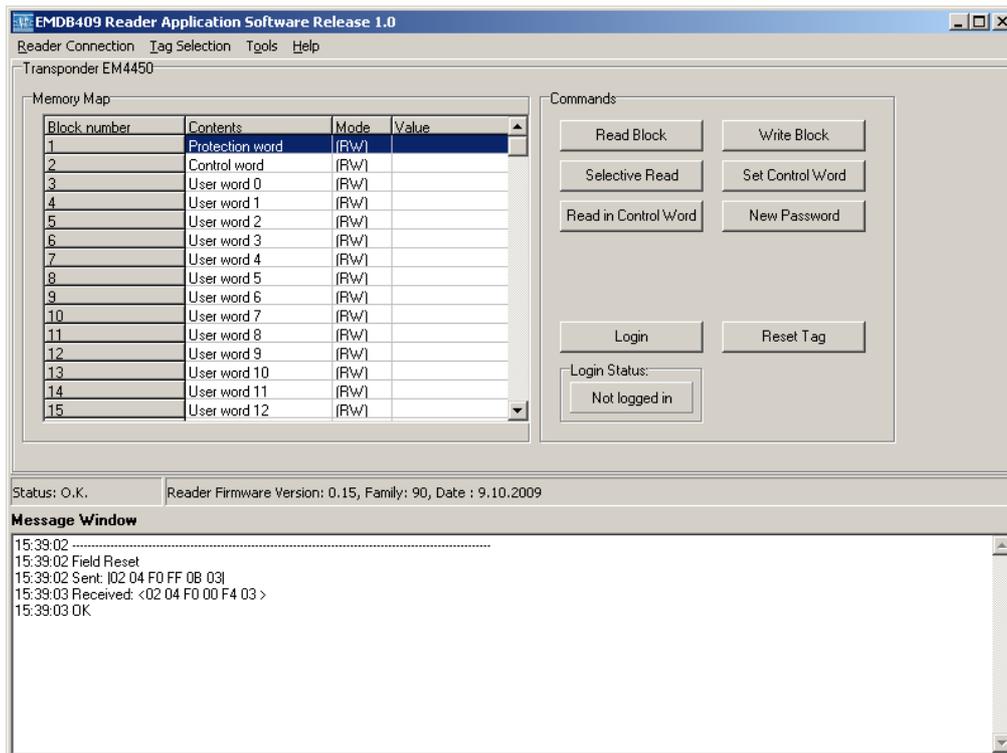


Figure 3 EM4450 communication frame

Read Block

1. Click into the Memory Map table to select a block to be read
2. Click on Read Block button

Write Block

1. Click into the Memory Map table to select a block to be written
2. Click on Write Block button
3. Enter the new block value (see Figure 5 Enter new value)
4. Click on Ok button

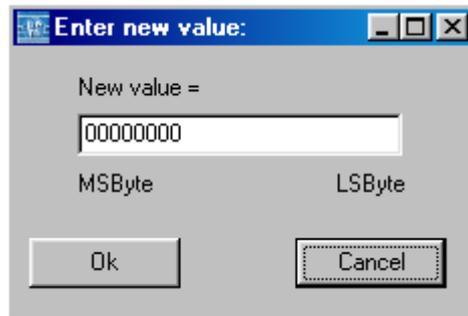


Figure 4 Enter new value

Note: The Write Block command can be used only for Read/Write (RW) Blocks

Login

Login command is used to access protected memory areas. The login status is displayed in the Login Status window.

1. Click on Login button
2. Enter the current password value (see Figure 6 Enter password)
3. Click on Ok button



Figure 5 Enter password

Selective Read

Selective Read command is used to read blocks that are defined between First Block Read value and Last Block Read value.

1. Click on Selective Read button
2. Enter the First and Last Block values (see Figure 7 Enter Blocks values)
3. Click on Ok button

Note: Possible values are: $1 \leq \text{First Block value} \leq \text{Last Block value} \leq 33$

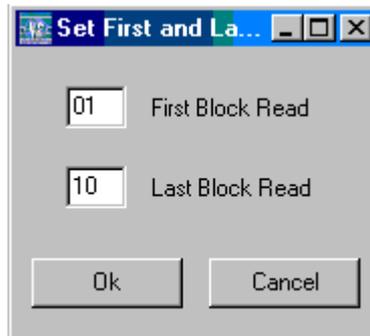


Figure 6 Enter block addresses

Set Control Word

Set Control Word command is used to set the Control Word which stored in the Block 2. When you click on Set Control Word button, the reader reads actual content of the Control Word first.

Sets new value of the Control Word

1. Click on Set Control Word button
2. Change the setting of the Control Word (see Figure 8 Set Control Word)
3. Click on Set button

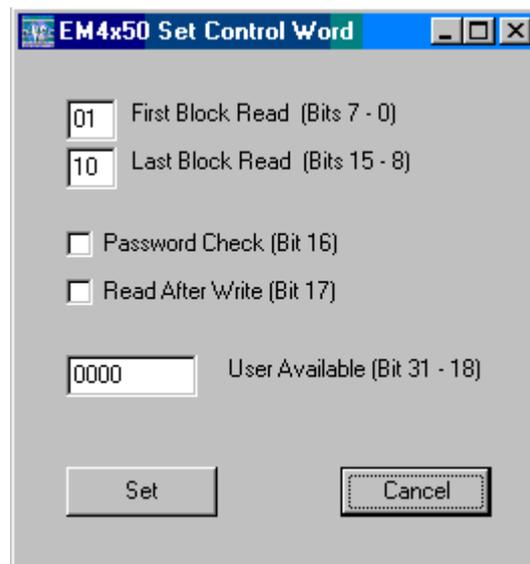


Figure 7 Set control word

Read In Control Word

Read in Control Word command reads values of the First Block Read and Last Block Read in the Control Word and then it reads these blocks.

New Password

New Password command is used to change current password value.

1. Click on New Password command
2. Enter Current password value (see Figure 9 Passwords values)
3. Enter New password value
4. Click on Ok button



Figure 8 Password selection window

Reset Tag

Reset Tag command returns the tag from any mode to the Standard Read Mode in which the tag sends data continuously, word by word from the memory section defined by the First Block Read and Last Block Read in the Control Word.

4.4. EM4205 / EM4305 Transponder

Following notes describe typical usage of the EMDB409 Application Software graphics user interface for EM4205 or EM4305 transponders.

Setup

1. Select a Tag Selection -> EM4305 menu (see following figure)
2. Place a single EM4305 or EM4205 tag on the EMDB409 Reader

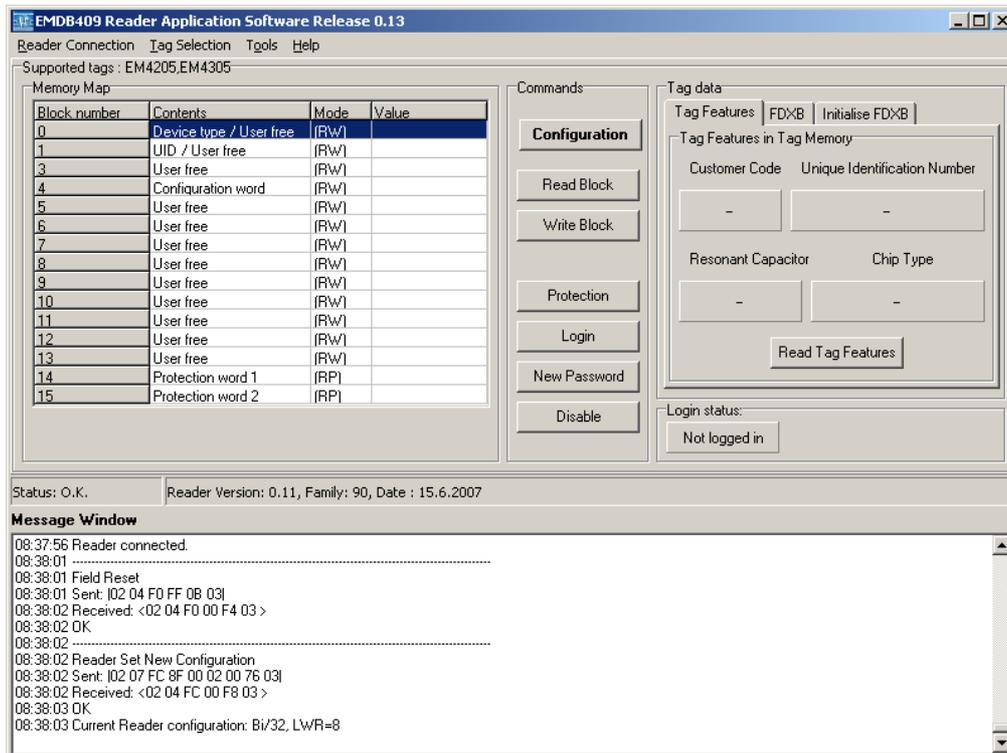


Figure 9 EM4205/EM4305 communication frame

Before using any command it is necessary to ensure that the reader and EM4305 or EM4205 transponder have the same configuration. To configure both the reader and transponder, please use the Configuration command. After entering the EM4305 frame, the reader is configured to Biphase RF/32 downlink communication automatically, i.e. the default EM4205 / EM4305 downlink communication configuration.

Configuration

Configuration command is used for configuration EM4305, EM4205 and EM4095 RFID Reader.

Configuration of Code, Data Rate and LWR for EM4305, EM4205 and EM4095 RFID Reader

1. Click on Configuration button in main window for EM4305 or EM4205 transponder
2. Choose Configuration mode, Code/Data Rate and Last Word Read (LWR). For example; both EM4305 and Reader configuration, Bi/32, and LWR=8.
3. Click on Set button

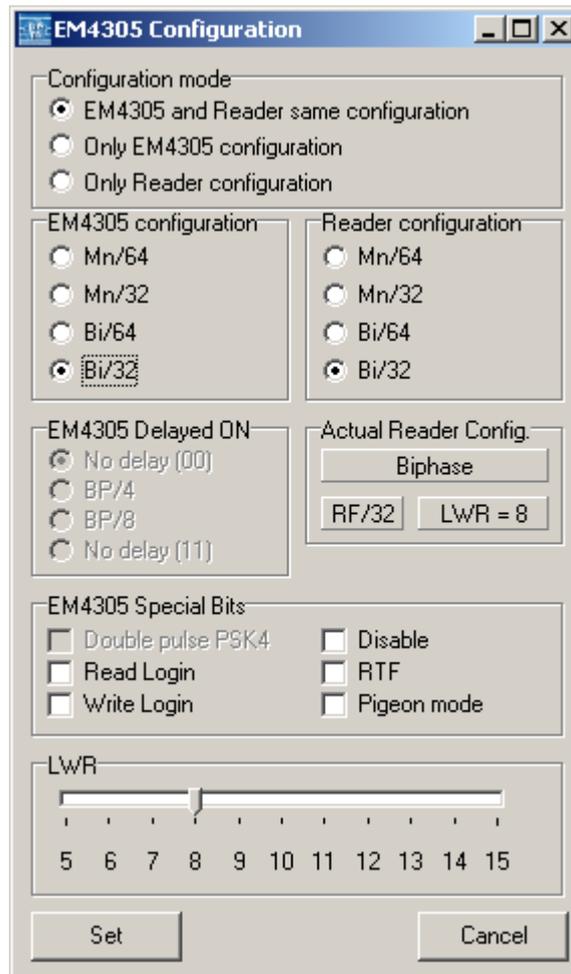


Figure 10 EM4205/EM4305 configuration window

If the configuration command proceeds successfully the Configuration window closes automatically. Otherwise, the configuration needs to be repeated or cancelled until successful.

Further guide assumes the reader and the tag configuration matches.

Read Block

1. Click into the Memory Map table to select a block to be read.
2. Click on Read Block button
3. Click on Ok button

Write Block

1. Click into the Memory Map table to select a block to be written.
2. Click on Write Block button
3. Enter the new block value.
4. Click on Ok button

Note: The Write Block command can be used only for Read/Write (RW) Block

Login

Sending Login command is necessary before sending any password protected command. The status of Login command is visible in Login Status window under the Login button.

1. Click on Login button
2. Enter actual password value
3. Click on Ok Button



Figure 11 Enter the password value

New Password

New Password command is used to change the actual password value. Before changing the password values the transponder has to be in Logged state (see Login Status).

1. If the Login Status is in Not logged state, use Login command to log-in
2. Enter new password value
3. Click on Ok button

Protection

Protection command protects Blocks in the transponder memory from being written. After clicking on Protection button the reader sends a command to read current value of the Protection Word. The already protected Blocks are ticked and they have gray color.

Warning: The bits in Protection word that are stored in the Protection words (Block 14 and 15) are one time programmable (OTP) which means that once they have been set they can not be reset any more.

1. Click on Protection button
2. Tick the blocks which you would like protect
3. Click on Set button in Set Protection Bits window
4. Click on Yes button in Warning window



Figure 12 EM4205/EM4305 Protection selection window



Disable

Disable command is accepted in the case the Disable bit in Tag Special Bits is set to 1 (see Configuration -> EM4305 Special bits selection). When this command is detected EM4305 or EM4205 tag stops all operations until power-up. In case the Disable command is not accepted (Disable bit is set to 0) EM4305 or EM4205 tag returns in Default Read mode.

Within the EM4305 frame, the FDXB and Initialise FDXB indices provide the controls to read and configure the EM4205 or EM4305 tag into the Animal mode (FDXB).

FDXB continuous read

1. Select the FDXB index
2. Check the Auto Read checkbox

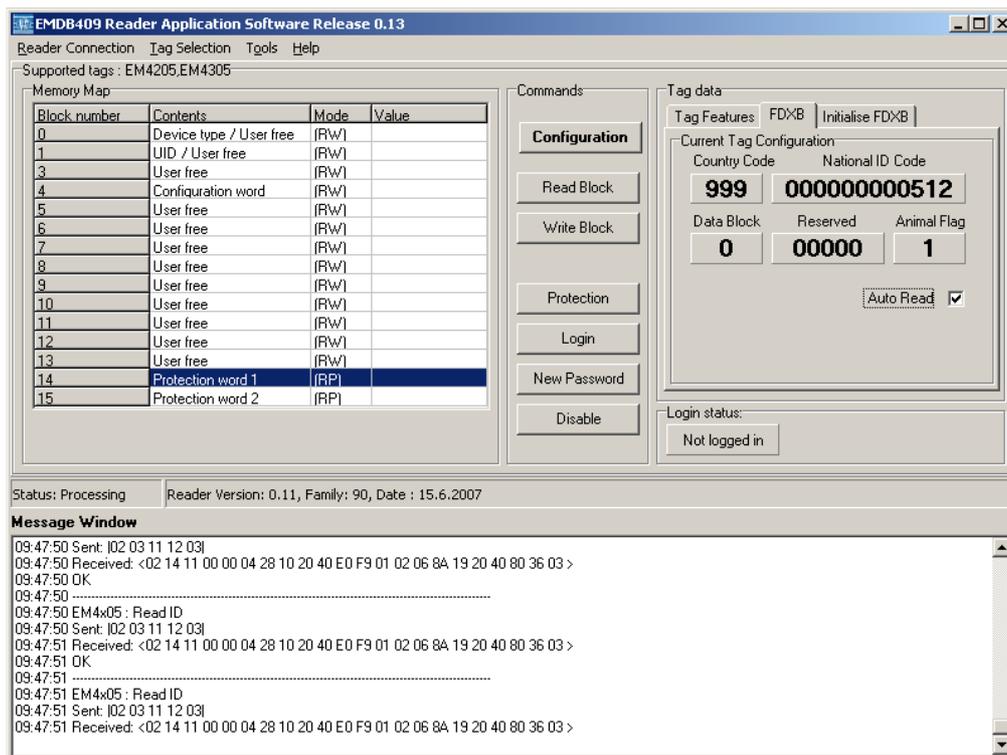


Figure 13 Reading EM4205/EM4305 configured in FDXB mode

When the Auto Read checkbox is checked, the application software detects the presence of the FDXB configured tags in the RF field, the FDXB data is displayed in appropriate panels. The same continuous detection is available in Tag Selection -> EM4005 / EM4105 frame.

Initialise FDXB (Write)

1. Switch to the Initialise FDXB index
2. Enter the desired FDXB data contents
3. Click on Write button within the Initialise FDXB index

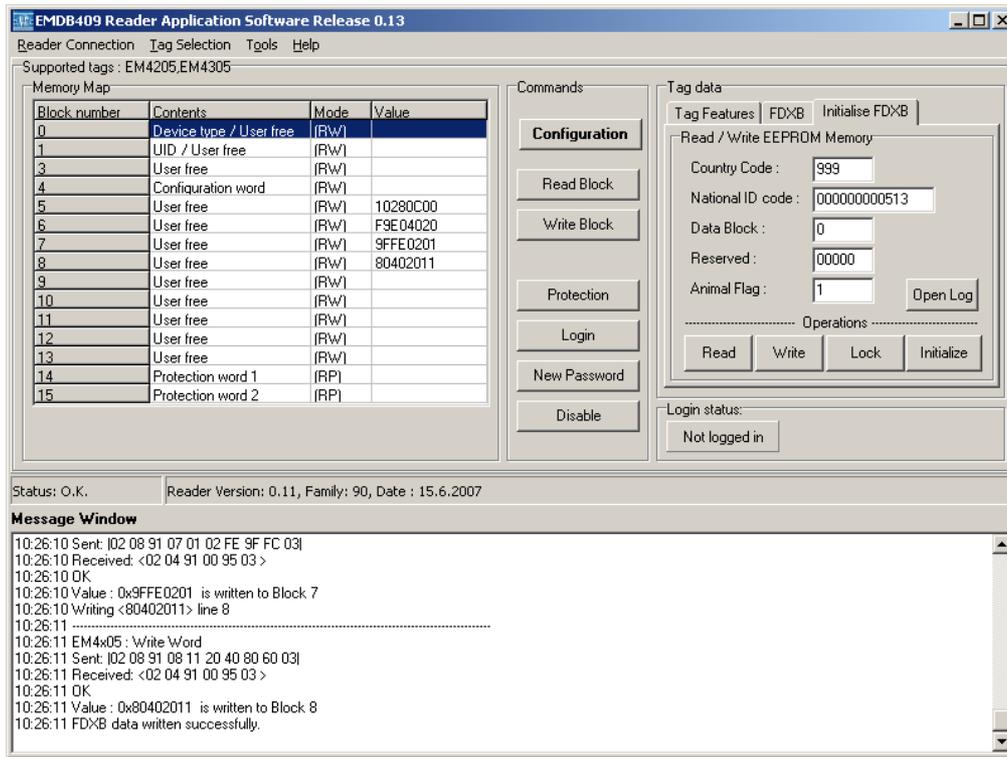


Figure 14 Initialising EM4205/EM4305 in FDXB mode

Analogously, Read (to verify the FDXB data), Lock (to lock blocks 4-8), and Initialise (to write the FDXB configuration word along the FDXB data) functions can be invoked by clicking on appropriate buttons.

Note: The FDXB index / Auto Read feature uses the default read FDXB data capture, i.e. no command is sent to the tag, just the FDXB downlink response is captured freely. On the other hand, Initialise FDXB index commands emit the EM4205/EM4305 commands, i.e. uplink command is also sent by the reader.

4.5. EM6869 transponder (LF interface)

Following notes describe typical usage of the EMD409 Application Software graphics user interface for EM6869 transponders.

Setup

1. Select a Tag Selection -> EM6869 menu (see following figure)
2. Place a single EM6869 tag on the EMD409 Reader

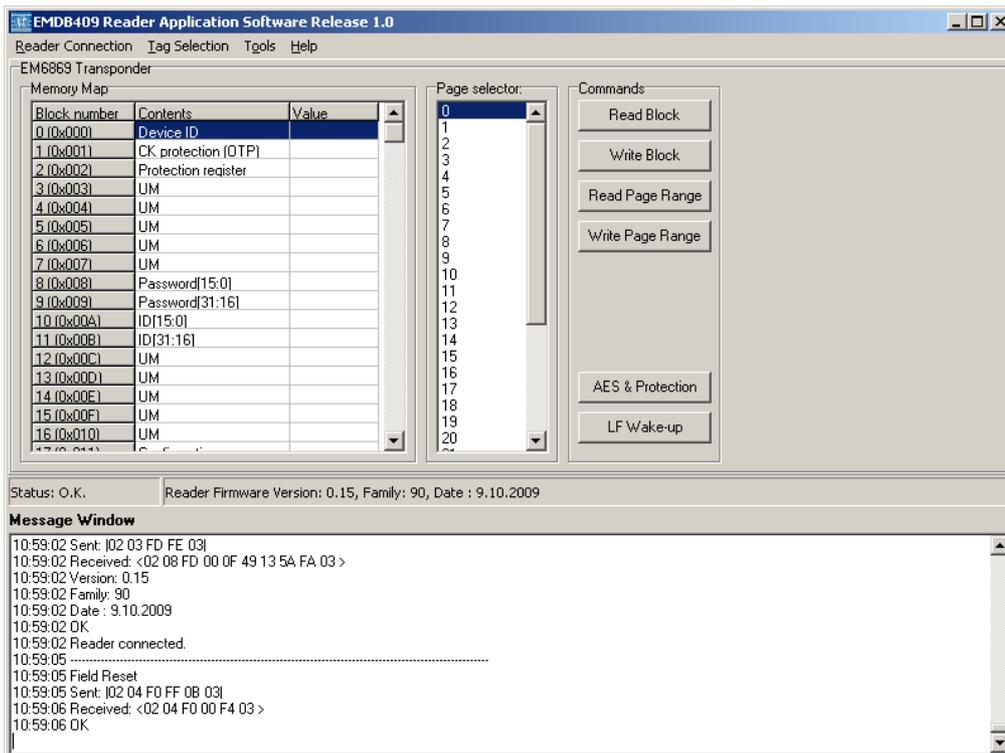


Figure 15 EM6869 communication frame

Tag position

EM6869 is typically equipped with very small SMD antenna (usually on ferrite core). In order to communicate with such transponder successfully the transponder antenna must be placed on the EMD409 reader antenna logo directly, the antenna axis shall be perpendicular to the plastic box surface.

Read Block

Select the page number in Page selector and select the block number line in the Memory map. Click on Read Block button to obtain the block contents.

Read Page Range

A range of consequent blocks can be selected and read by single reader command Read Page Range. When single block is selected in the Memory map, the reader will read complete page (see example below).

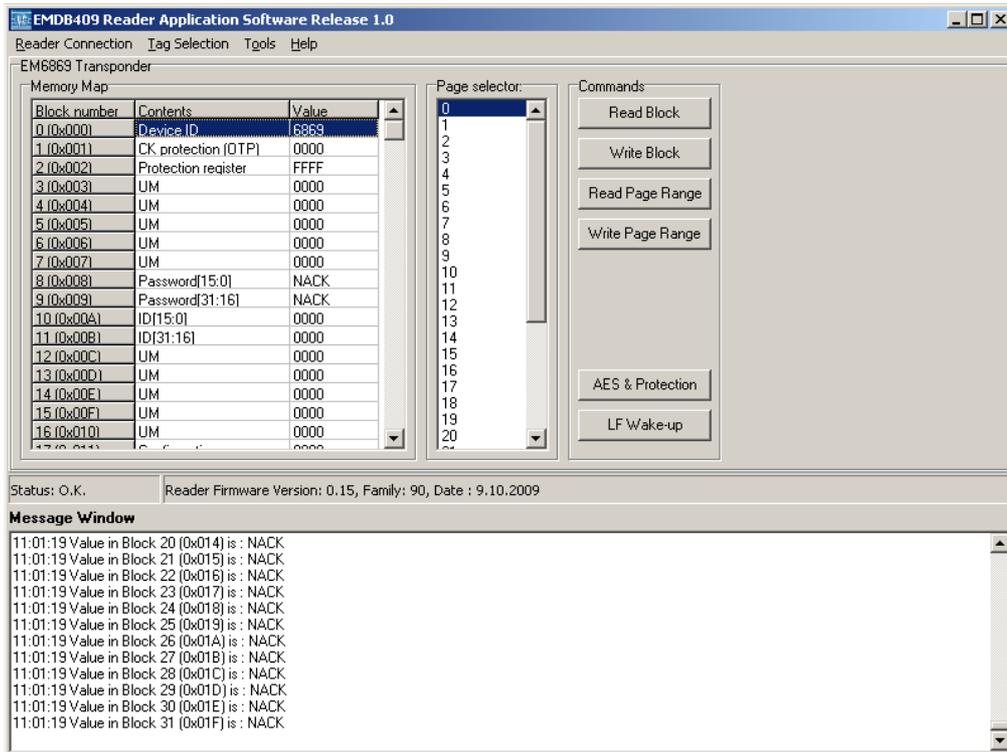


Figure 16 Whole page read example

EMDB409 firmware uses Read Word (0-1023) command to read each block separately. The tag may reject the reading of each block by NACK response.

Write Page Range

Similarly, EMDb409 firmware can write up to 16 blocks by single reader command; select the page in Page selector and consequent range of words in the Memory map and click on Write Page Range button (see 3 blocks example below).

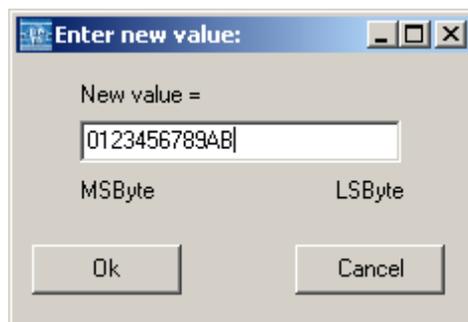


Figure 17 Write 3 words example

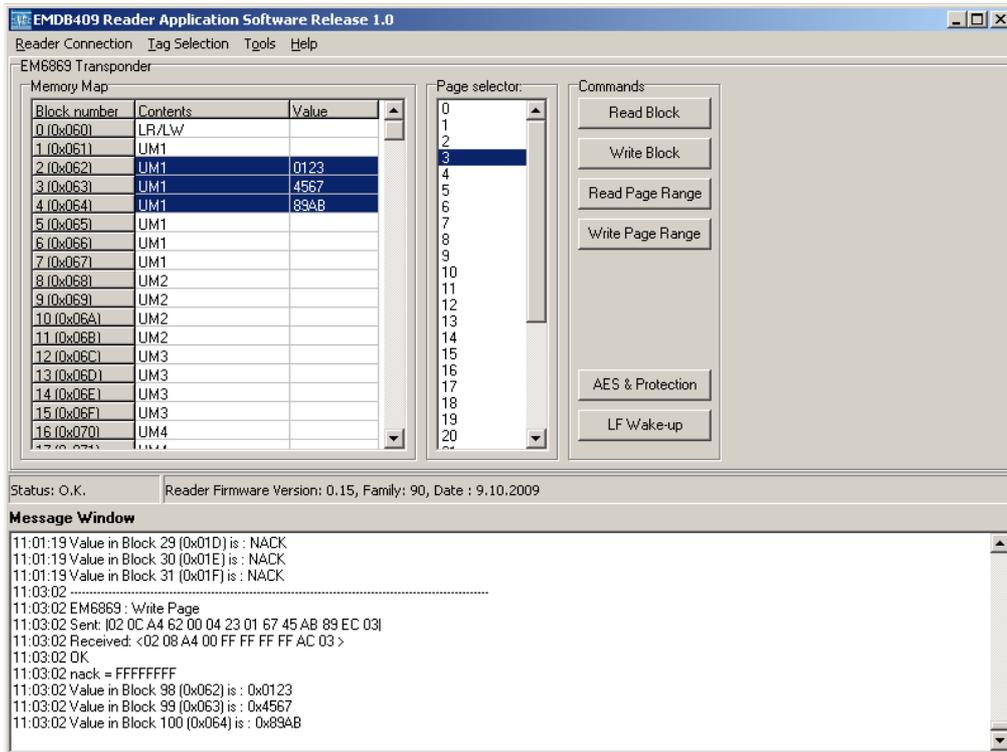


Figure 18 Write 3 words example result

AES and Protection

The application software provides partial control of EM6869 transponder AES configuration including the key and random number setup, click on AES & Protection button.

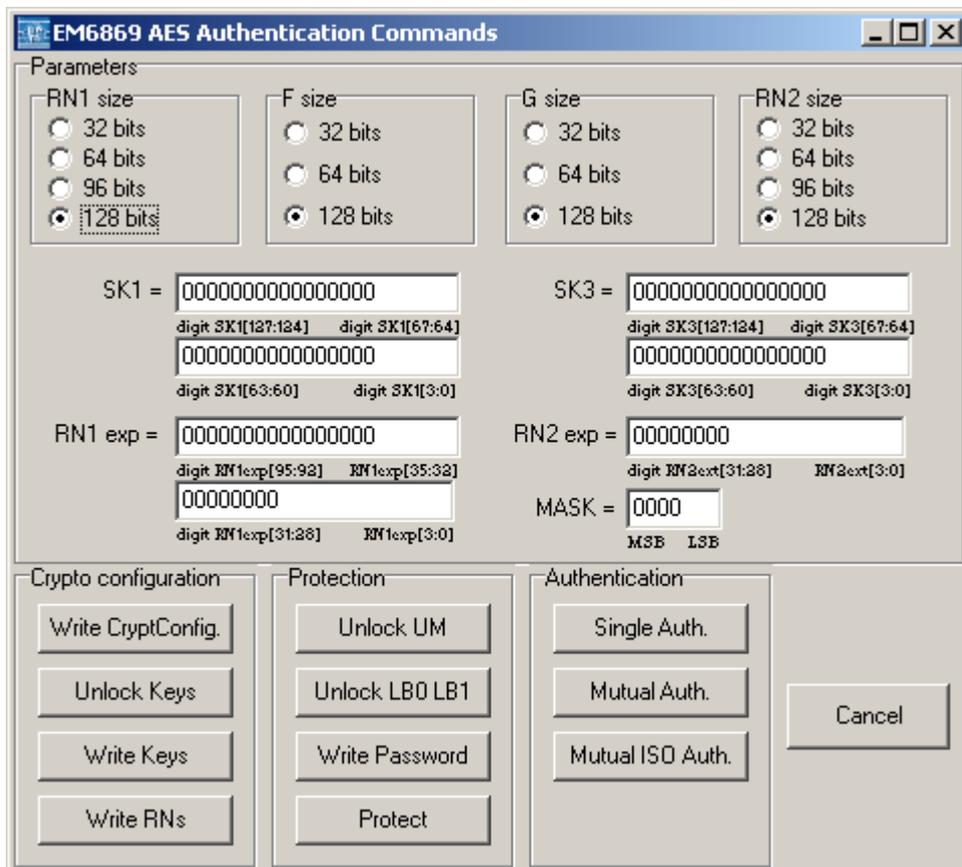


Figure 19 AES & Protection window



The EM6869 AES Authentication Commands window contains the selection of random number RN1 and RN2 size, function F and G size, secure key SK1 and SK3 contents, random number RN1 and RN2 expansion, and the Mask. **All these values selected are used by the Crypto configuration, Protection, and Authentication commands invoked by clicking on corresponding buttons; the application software assumes that the tag is configured with matching values.**

If the select configuration does not match the settings of the tag, the Crypto configuration, Protection, and Authentication commands usually fail.

Optionally, the values in this window can be used to be written into the tag's appropriate blocks.

Write Crypto Configuration

As the first step, the EM6869 tag Crypt Configuration shall be initialized. Please refer to EM6869 datasheet on Crypt Configuration word settings and its meaning in relation to EM6869 AES Authentication commands. Set the desired RN1 and RN2 size, function F and G size and click on "Write CryptConfig" button.

Note: the crypto configuration change is possible as long as tag's Protection register LBP bit is not set (i.e. LBP = '1').

Tag Key change

To change the SK1 and SK3 key contents in the tag, fill the current correct SK1[31:0] password part in its edit box. Click on Unlock Keys command to enable the key change. After the Unlock Keys command is executed successfully, fill the new SK1 and SK3 key contents into the edit boxes and click on Write Keys button.

Note: it is recommended to save the new key value in some notepad.

Note: the tag's key change is possible as long as tag's Protection register LB1 bit is not set (i.e. LB1 = '1').

Tag RN exp/Mask change

EM6869 Authentication commands use AES 128b cipher which usually involves one or two 128bit random numbers in the calculation. In order to decrease the number of words exchanged between the tag and the reader during the authentication, EM6869 allows the RN1 and RN2 size exchanged being reduced to 32, 64 or 96 bits. When the exchanged RN1 or RN2 size is shorter than 128b, both tag and reader need to extend them internally with arbitrary value into 128b for AES calculation. Such arbitrary value is called RN1 expansion and RN2 expansion, the actual values are stored in the tag memory; RN1 exp, RN2 exp register.

Another arbitrary value, the Mask, is required for Single and Mutual Authentication commands to when function F is set to 128b.

Fill new RN1 exp, RN2 exp, and Mask value into the corresponding edit boxes and click on Write RNs button.

Note: RN exp/Mask change is possible as long as tag's Protection register LBP bit is not set (i.e. LBP = '1').

AES authentication

With above Crypto Configuration, Key, and RN exp/Mask settings updated, all three EM6869 authentication commands can be performed.

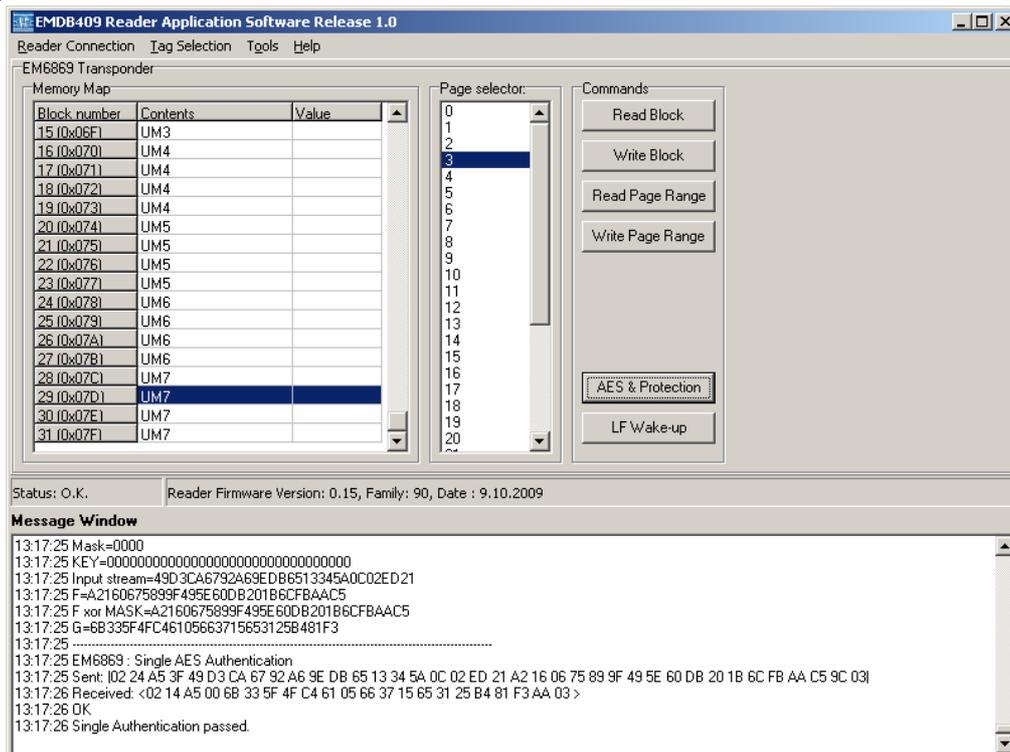


Figure 20 Single AES Authentication example



User Memory Protection

Unlock UM button can be used to temporarily disable the protection of words locked in User Pages (lock bits located in the word 0 of each User Page). Correct SK3 key value is required.

Protection

Protection register contents can be set by means of Protection button. The current tag Protection word is read, and selected lock bits can be set and written back to the tag.

Please refer to EM6869 datasheet on Configuration register settings. The Configuration register access is controlled by LB0 protection bit which can be reset by means of Unlock LB0 LB1 button using the tag Password registers. (The tag Password contents can be also changed using Write Password button.)

4.6. Bootloader

Following notes describe a process of uploading a new firmware into the EMDB409 Reader. It is possible to upload the firmware without performing an establishment of the connection.

Setup

1. Connect the USB cable and power supply adapter to the EMDB409 Reader
2. Select a Tools -> Bootloader

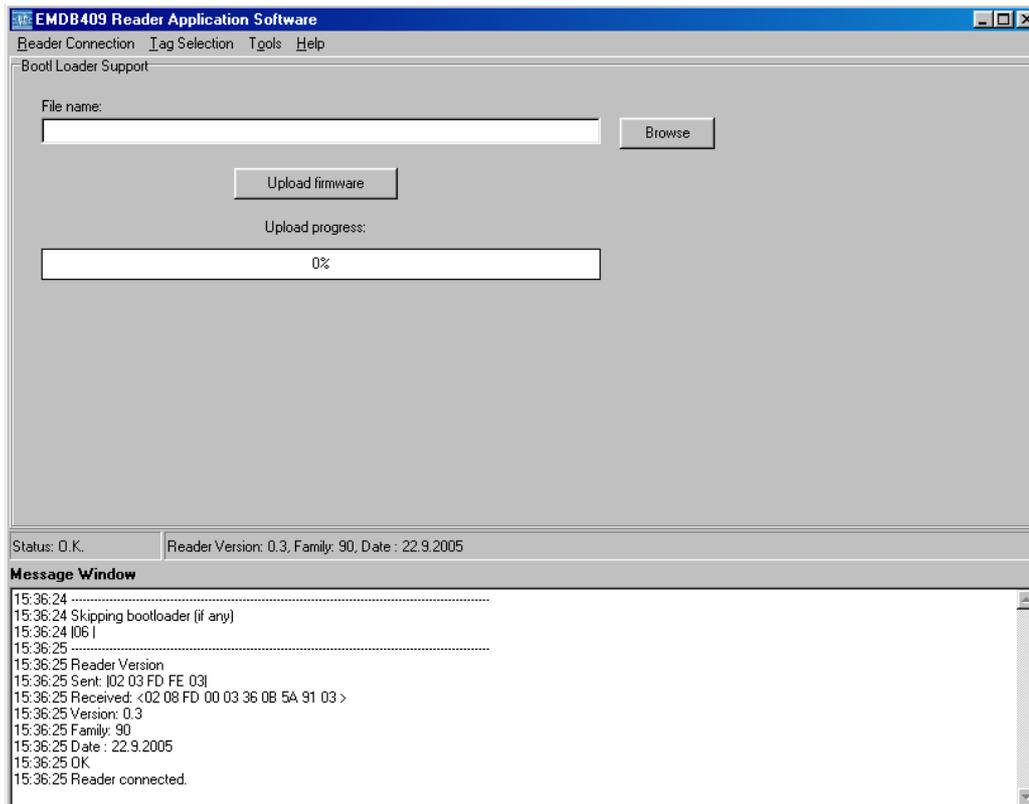


Figure 21 Bootloader communication frame

Click on Browse button to enter a complete path of the new firmware hex file. If the firmware hex file is imported to the PC memory successfully, Upload firmware button is enabled.

Upload firmware

1. Click on Upload firmware button
2. If the EMDB409 Reader connection is not yet established, the EMDB409 application software asks for the COM port – select the appropriate port the EMDB409 is connected to

Upload firmware process lasts about 1 minute. If the firmware is uploaded successfully, the connection is established automatically (see Figure 19 Firmware is uploaded successfully). In the second item of the status bar, current firmware version, family, and date of creation is displayed.

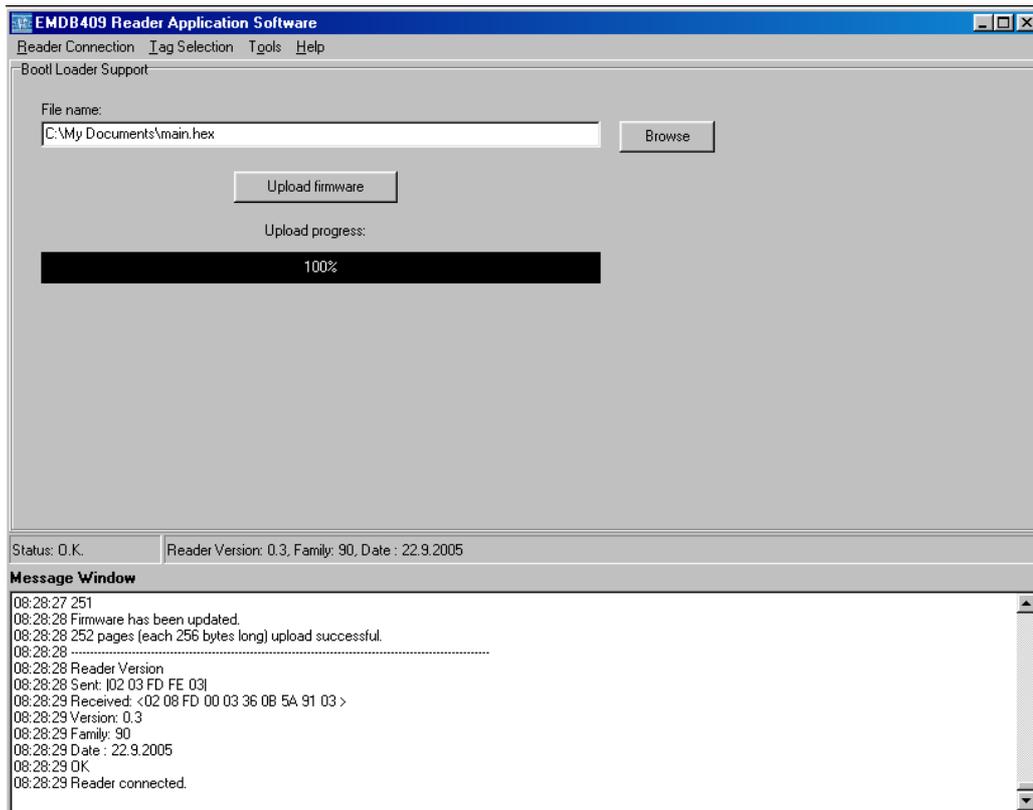


Figure 22 Firmware is uploaded successfully



5. Error handling

There are three kinds of errors:

- Reader Communication errors (e.g.; USB cable has been disconnected accidentally and the EMDB409 reader does not answer at all) – check the USB cable and power supply adapter are connected correctly, then the connection has to reestablished unconditionally (Reader Connection -> Connect menu)
- Tag Communication errors – insufficient RF energy (e.g.; tag response has CRC error) - try to change the position of the tag or mutual position among the tags in respect to the reader antenna
- Tag Communication errors – protocol issue (e.g.; no response from the tag) – try to determine whether the tag is the type it is considered to be or whether the tag is in some altered mode it is not expected to respond

6. Other software

Beside the EMDB409 Reader Application Software, which is located on the installation CD and described in this user's guide, the dedicated application software exists. It is EMDB409 Reader AN Application Software and EMDB409 Reader RO Application Software. EMDB409 Reader ANM Application Software can be used to emulate Animal mode tags and EMDB409 Reader RO Application Software can be used to emulate Read Only tags by EM4205 / EM4305 transponders.

Please, check the EM Microelectronic web pages to download the latest release of the software.