uFR serial - Communication protocol for uFR series devices

uFR Series devices can establish communication over FTDI's Virtual COM port, so devices are seen as standard COM port hardware.
Communication parameters are :

Readers with FTDI serial interface:

uFR Classic and uFR Advance readers with USB connection:
Serial communication: 1 Mbps, 8-N-1, Flow control: None;
The RTS pin is used to reset the device. When the RTS is set, the device is in a reset state. When the RTS is clear, the device is in normal state.

uFR BaseHD readers with "uFR support" firmware installed (ex. XR and uFR XRc readers):
Serial communication (using VCOM FTDI driver): 250 kbps, 8-N-1, Flow control: None;

Readers without FTDI serial interface:

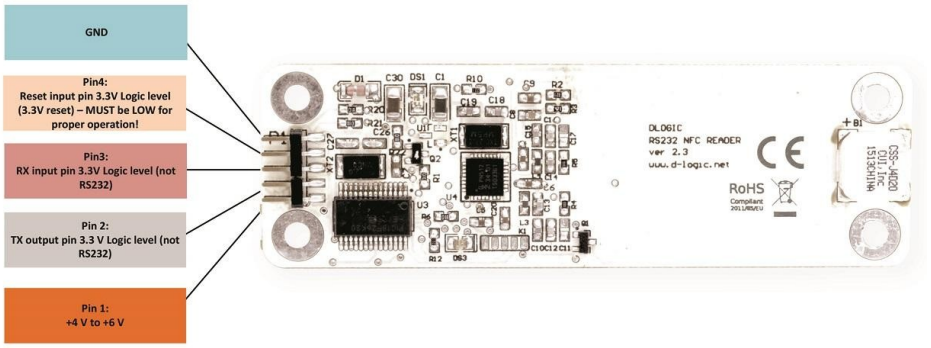
RS485 (connection without USB/RS-485 converter): variable baudrate can be set through software tool. Current baud rate must be known when changing baudrate. Default baudrate is 250 kbps.

uFR Classic Nano RS232 and Card Size RS232:
UART / TTL: 115200 bps, 8-N-1, Flow control: None.
115200 bps is the default baudrate. Variable baudrate can be set through software tool.
Pin number 4 on the connector is used to reset the device. If voltage on this pin is high (3.3 V) then the device is in reset state. If voltage is low (0 V) then the device is in normal working state.

If the device is connected to our RS232 to TTL converter, then the voltage level on pin 4 controls over RTS. When the RTS is clear, the device is in a reset state. When the RTS is set, the device is in normal state.

During firmware update, the RTS pin must be connected to the pin 4 on the device.

Pinout for UART / TTL model is presented below:



uFR Series Nano RS232 model pinout

For communication purposes between reader devices and host PC, D-Logic's proprietary protocol called “uFR serial” is created.

All communication is initiated by the host (PC or other platform) to which the device is connected.

Maximum data transferred by single command or received by one device response, from firmware version 3.9.44 is 256 bytes, and before is 192 bytes.

Generally, there are two types of packets:

CMD – command sent by host to device
ANS – answer sent from device to host

CMD can be short or long set. CMD short set is always 7 byte long while CMD long set – called CMD_EXT can have variable length.

Answer have following types:

ACK – Acknowledgment, everything is OK, device is waiting for next CMD or CMD EXT
ERR – Error occurred, error byte defines ERR_TYPE
RSP – Response from device on CMD or CMD_EXT

Communication constants bytes defines type of packet, which can be seen in first three bytes of each packet.
First byte of each packet is HEADER byte. Second byte is always CMD_CODE. Third byte is TRAILER byte.

Table1. Communication constants

CMD_HEADER	0x55	CMD_TRAILER	0xAA
ACK_HEADER	0xAC	ACK_TRAILER	0xCA
RESPONSE_HEADER	0xDE	RESPONSE_TRAILER	0xED
ERR_HEADER	0xEC	ERR_TRAILER	0xCE

CHECKSUM

All checksums in this document are calculated in the same manner: row of bytes is used for checksum calculation, each byte is XOR-ed with next one until the end of row. Final value is incremented with 0x07.
For example, CMD packet has 7 bytes, where 7th byte is checksum of previous 6 bytes:

CHECKSUM = (Byte1 XOR Byte2 XOR Byte3 XOR Byte4 XOR Byte5 XOR Byte6) + 0x07

CMD codes

Each command has its corresponding value - look at COMMANDS OVERVIEW.

Error codes

If error occurs, device will answer with ERR packet. Each Error has its corresponding value which can be found in table in Appendix: ERROR CODES.

CMD packet

CMD packet can be short – 7 byte long or EXT-ended with variable length. In case of EXT CMD packet, fourth byte of CMD packet is greater than 0, containing integer value – length of CMD_EXT packet. When issuing CMD_EXT, always main CMD 7-byte long packet goes first. If everything as expected, device will answer with ACK packet, waiting for CMD_EXT packet. On error, device will answer with ERR packet. CMD_EXT consists of various different parameters, depending on command type, so CMD_EXT does not have fixed length and order of parameters.

CMD packet has following structure:

Mandatory 7 byte CMD packet structure						
Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
CMD_HEADER	CMD_CODE	CMD_TRAILER	CMD_EXT_Length	CMD_Par0	CMD_Par1	CHECKSUM

Byte 1: CMD_HEADER as defined in Table1.Communication constants, 0x55
Byte 2: CMD_CODE as defined in Table2. CMD_CODE values
Byte 3: CMD_TRAILER as defined in Table1.Communication constants, 0xAA
Byte 4: CMD_EXT_Length: If 0 than the “CMD EXT” is not used); ELSE value is length of whole CMD_EXT packet
Byte 5: CMD_Par0: command parameter0, takes different values depending on command
Byte 6: CMD_Par1: command parameter1, takes different values depending on command
Byte 7: CHECKSUM – Checksum of Bytes 1 to 6 as explained above

CMD_EXT packet has following structure:

CMD_EXT packet structure			
Byte 1	**..**	**Byte N**	**Byte N+1**
Parameter bytes 1 to N			**CMD_EXT_CHECKSUM**

Parameter bytes 1 to N – different parameters, values depends on type of command
CMD_EXT_CHECKSUM - Checksum of bytes 1 to N
CMD_EXT_Length is number of all bytes including CMD_EXT_CHECKSUM; e.g. length is N+1

ANSWER packet types

The device can answer with following packet types:

ACK – Acknowledgment packet

If command and CMD packet are properly configured (structure and checksum) and additional CMD_EXT packet needs to be sent, device will answer with ACK packet.

ERR – Error packet

If error occurred, device will answer with ERR packet. Some commands can return ERR_EXT set. In that case ERR_EXT packet comes immediately after ERR packet.

RSP – Response packet

If properly configured CMD or CMD_EXT packet is sent, device will answer with RSP or RSP_EXT packet, which depends on command issued. For examples, if CMD needs answer which is short enough for RSP packet, there will be no RSP_EXT packet. Otherwise, if CMD or CMD_EXT needs answer with more bytes, RSP_EXT will come immediately after RSP packet. Common situation is when reading data with LinearRead command, where device will answer with row of card data bytes.

ACK – Acknowledgment packet

ACK packet has following structure:

ACK packet structure						
Byte 1	**Byte 2**	**Byte 3**	**Byte 4**	**Byte 5**	**Byte 6**	**Byte 7**
ACK_HEADER	**CMD_CODE**	**CMD_TRAILER**	**Irrelevant, not used in ACK packet**			**CHECKSUM**

Byte 1: ACK_HEADER as defined in Table1.Communication constants, 0x55
Byte 2: CMD_CODE as defined in Table2. CMD_CODE values. Device ACK-nowledge that previous command is properly sent
Byte 3: ACK_HEADER as defined in Table1.Communication constants, 0x55
Byte 4, Byte 5, Byte 6: Not used in ACK packet, values are 0x00

Byte 7: CHECKSUM – Checksum of Bytes 1 to 6 as explained above

ERR – error packet

ERR packet has following structure:

Mandatory 7 byte ERR						
Byte 1	**Byte 2**	**Byte 3**	**Byte 4**	**Byte 5**	**Byte 6**	**Byte 7**
ERR_HEADER	**ERROR_CODE**	**ERR_TRAILER**	**ERR_EXT length**	**Err_Val0**	**Err_Val 1**	**CHECKSUM**

Byte 1: ERR_HEADER as defined in Table1.Communication constants, 0xEC
Byte 2: ERR_CODE as defined in Table3. ERROR CODES.
Byte 3: ERR_TRAILER as defined in Table1.Communication constants, 0xCE
Byte 4: If ERR_EXT exists, this byte contains length of ERR_EXT packet (including ERR_EXT checksum)
Byte 5: Possible additional info on error can be defined in ERR_Val0
Byte 6: Possible additional info on error can be defined in ERR_Val1
Byte 7: CHECKSUM – Checksum of Bytes 1 to 6 as explained above

ERR_EXT and has following structure:

ERR_EXT packet structure			
Byte 1	**..**	**Byte N**	**Byte N+1**
Error bytes 1 to N			**ERR_EXT_CHECKSUM**

Byte 1: First Byte of ERR_EXT
…
Byte N: N-nth Byte of ERR_EXT
Byte N+1: ERR_EXT_CHECKSUM, checksum of Bytes 1 to N, calculated as explained earlier.

RSP – response packet

RSP packet has following structure:

Mandatory 7 byte RSP						
Byte 1	**Byte 2**	**Byte 3**	**Byte 4**	**Byte 5**	**Byte 6**	**Byte 7**
RSP_HEADER	**CMD_CODE**	**RSP_TRAILER**	**RSP_EXT length**	**RSP_Val0**	**RSP_Val 1**	**CHECKSUM**

Byte 1: RSP_HEADER as defined in Table1.Communication constants, 0xED
Byte 2: CMD_CODE as defined in Table2. CMD_CODE values
Byte 3: ERR_TRAILER as defined in Table1.Communication constants, 0xDE
Byte 4: If RSP_EXT exists, this byte contains length of RSP_EXT packet (including RSP_EXT checksum)
Byte 5: Possible additional info on RESPONSE can be defined in RSP_Val0
Byte 6: Possible additional info on RESPONSE can be defined in RSP_Val1

Byte 7: CHECKSUM – Checksum of Bytes 1 to 6 as explained above

RSP_EXT packet structure			
Byte 1	..	Byte N	Byte N+1
RSP bytes 1 to N			RSP_EXT_CHECKSUM

Byte 1: First Byte of RSP_EXT
…
Byte N: N-nth Byte of RSP_EXT
Byte N+1: RSP_EXT_CHECKSUM, checksum of Bytes 1 to N, calculated as explained earlier.

COMMANDS OVERVIEW

Commands are divided into several groups, based on purpose.

Device related commands

General purpose device related commands

GET_READER_TYPE	0x10
GET_READER_SERIAL	0x11
GET_SERIAL_NUMBER	0x40
GET_HARDWARE_VERSION	0x2A
GET_FIRMWARE_VERSION	0x29
GET_BUILD_NUMBER	0x2B
READER_KEY_WRITE	0x12
USER_DATA_READ	0x1B
USER_DATA_WRITE	0x1C
READER_KEYS_LOCK	0x27
READER_KEYS_UNLOCK	0x28

READER_PASSWORD_WRITE	0x33
SELF_RESET	0x30
SET_SPEED_PERMANENTLY	0x4B
GET_SPEED_PARAMETERS	0x4C
SET_UART_SPEED	0x70
RED_LIGHT_CONTROL	0x71
USER_INTERFACE_SIGNAL	0x26
SET_RF_ANALOG_SETTINGS	0x7D
GET_RF_ANALOG_SETTINGS	0x7E
SET_LED_CONFIG	0x6E
DEFAULT_UART_SPEED_SESSION	0xF1

Card related commands

General purpose card related commands

GET_CARD_ID	0x13
GET_CARD_ID_EX	0x2C
GET_DLOGIC_CARD_TYPE	0x3C
GET_LAST_CARD_ID_EX	0x7C

Trailer block manipulation commands

SECTOR_TRAILER_WRITE	0x1A
SECTOR_TRAILER_WRITE_UNSAFE	0x2F

Block manipulation commands

BLOCK_READ	0x16
BLOCK_WRITE	0x17
BLOCK_IN_SECTOR_READ	0x18
BLOCK_IN_SECTOR_WRITE	0x19

Linear data manipulation commands

LINEAR_READ	0x14
LINEAR_WRITE	0x15
LINEAR_FORMAT_CARD	0x25
LIN_ROW_READ	0x45

Value block manipulation commands

Direct block addressing

VALUE_BLOCK_READ	0x1D
VALUE_BLOCK_WRITE	0x1E
VALUE_BLOCK_INC	0x21
VALUE_BLOCK_DEC	0x22

Indirect block addressing

VALUE_BLOCK_IN_SECTOR_READ	0x1F
VALUE_BLOCK_IN_SECTOR_WRITE	0x20
VALUE_BLOCK_IN_SECTOR_INC	0x23
VALUE_BLOCK_IN_SECTOR_DEC	0x24

Commands for DESFIRE cards

GET_DESFIRE_UID	0x80
SET_DESFIRE_KEY	0x81
DESFIRE_WRITE_TO_FILE	0x82
DESFIRE_READ_FROM_FILE	0x83
DESFIRE_CREATE_APPLICATION	0x84
DESFIRE_CREATE_FILE	0x85
DESFIRE_CREATE_AES_KEY	0x86
DESFIRE_GET_KEY_CONFIG	0x87
DESFIRE_CHANGE_KEY_CONFIG	0x88
DESFIRE_DELETE_APPLICATION	0x89
DESFIRE_DELETE_FILE	0x8A
DESFIRE_SET_CONFIGURATION	0x8B
DESFIRE_FORMAT_CARD	0x8C
DESFIRE_FREE_MEM	0x8D
DESFIRE_WRITE_AES_KEY	0x8E
DESFIRE_CREATE_VALUE_FILE	0x8F
DESFIRE_READ_VALUE_FILE	0x9A
DESFIRE_INCREASE_VALUE_FILE	0x9B
DESFIRE_DECREASE_VALUE_FILE	0x9C
DESFIRE_CREATE_RECORD_FILE	0x97
DESFIRE_WRITE_RECORD	0x98
DESFIRE_READ_RECORDS	0x99
DESFIRE_CLEAR_RECORD	0x6D
DESFIRE_GET_APPLICATION_IDS	0xC0

Commands for Mifare Desfire cards

MFP_FIRST_AUTHENTICATE	0x6A
MFP_CHANGE_REG_KEY	0x6B
MFP_GET_UID	0x6C

Commands for NFC Type 2 Tags

GET_NFC_T2T_VERSION	0xB0

READ_COUNTER	0xB1
INCREMENT_COUNTER	0xB2

Command for NFC Type 4 Tags

NT4H_COMMON_CMD	0xB3

Originality checking commands

READ_ECC_SIGNATURE	0xBF

Commands for "asynchronous UID sending" feature

SET_CARD_ID_SEND_CONF	0x3D
GET_CARD_ID_SEND_CONF	0x3E
SET_BAD_SELECT_NR_MAX	0x3F
GET_BAD_SELECT_NR_MAX	0x44

Power saving commands

ENTER_SLEEP_MODE	0x46
LEAVE_SLEEP_MODE	0x47
AUTO_SLEEP_SET	0x4D
AUTO_SLEEP_GET	0x4E

Light and display commands

SET_DISPLAY_DATA	0x72
SET_SPEAKER_FREQUENCY	0x73
SET_DISPLAY_INTENSITY	0x74
GET_DISPLAY_INTENSITY	0x75

uFR BASE Control commands

UFR_XRC_LOCK_OPEN	0x60
UFR_XRC_SET_RELAY_STATE	0x61
UFR_XRC_GET_IO_STATE	0x62

Shared Ram card emulation commands

ENTER_SHARE_RAM_COMM_MODE	0x78
EXIT_SHARE_RAM_COMM_MODE	0x79
READ_SHARE_RAM	0x7A
WRITE_SHARE_RAM	0x7B

ISO 14443-4 protocol commands

I_BLOCK_TRANSCEIVE	0x90
R_BLOCK_TRANSCEIVE	0x91
S_BLOCK_DESELECT	0x92
SET_ISO14433_4_MODE	0x93
APDU_TRANSCEIVE	0x94

uFR Online commands

ESP_SET_IO_STATE	0xF3
ESP_GET_IO_STATE	0xF4
ESP_READER_TIME_WRITE	0xF5
ESP_READER_TIME_READ	0xF6
ESP_READER_EEPROM_READ	0xF7
ESP_SET_DISPLAY_DATA	0xF8
ESP_READER_RESET	0xF9
ESP_READER_PASSWORD_WRITE	0xFA
ESP_READER_EEPROM_WRITE	0xFB
ESP_GET_READER_SERIAL	0xE7

Miscellaneous functions

CHECK_UID_CHANGE	0xE4
RF_RESET	0xE5
GET_READER_STATUS	0xE6
READ_TT_STATUS	0xB4

DEVICE RELATED COMMANDS

GENERAL PURPOSE DEVICE RELATED COMMANDS

GET_READER_TYPE (0x10)

It gives a device (reader) type in size of 4 bytes which is hard coded in the firmware.
uFR Classic has a value of 0xD1150021.
CMD_EXT set is not in use.
CMD_Par0 and CMD_Par1 are not in use.
If everything operates as expected the RSP packet is sent and after that also the RSP_EXT packet of 5 bytes which contains 4 byte DeviceType values (little-endian) and CHECKSUM byte.

Example:

```
Send CMD GET_READER_TYPE
55 10 AA 00 00 00 F6
```

Where

```
55 - CMD_HEADER
10 - CMD_CODE
AA - CMD_TRAILER
00 00 00 - CMD_EX_Length and CMD_Par0 and CMD_Par1 not used
F6 - CHECKSUM
```

Reader answer with RESPONSE – RSP packet followed by RSP_EXT packet

```
DE 10 ED 05 00 00 2D 21 00 15 D1 EC
```

Where RSP PACKET contains

```
DE - RSP_HEADER
10 - CMD_CODE
```

```
ED – RSP_TRAILER
05 – RSP_EXT_Length
00 00 – RSP_Val0 and RSP_Val1 not used
2D – CHECKSUM
```

and RSP_EXT contains

```
21 00 15 D1 – Device type (currently uFR Classic D1 15 00 21, little-endian notation)
EC – CHECKSUM
```

GET_READER_SERIAL (0x11)

It gives the device (reader) serial number with length of 4 bytes. On the older devices, this serial number has been read from the EEPROM MFRC chip.
The CMD_EXT set is not in use.
The CMD_Par0 and CMD_Par1 are not in use.
If everything operates as expected the RESPONSE set is sent and after that also the RESPONSE EXT set of 5 bytes which contains 4 byte ReaderSerialNumber values (little-endian) and at the end one checksum byte.

Example:

```
Send CMD GET_READER_SERIAL
55 11 AA 00 00 00 F5
```

Where

```
55 – CMD_HEADER
11 – CMD_CODE
AA – CMD_TRAILER
00 00 00 – CMD_EX_Length and CMD_Par0 and CMD_Par1 not used
F5 – CHECKSUM
```

Reader answer with RESPONSE – RSP packet followed by RSP_EXT packet

```
DE 11 ED 05 00 00 2E 54 7E 1A 5D 74
```

Where RSP PACKET contains

```
DE – RSP_HEADER
11 – CMD_CODE
ED – RSP_TRAILER
05 – RSP_EXT_Length
00 00 – RSP_Val0 and RSP_Val1 not used
2E – CHECKSUM
```

and RSP_EXT contains

```
54 7E 1A 5D – Device type (currently serial is 5D 1A 7E 54, little-endian notation)
74 – CHECKSUM
```

GET_SERIAL_NUMBER (0x40)

Command returns reader serial number in string representation, like “UF123456”.
The CMD_EXT set is not in use.
The CMD_Par0 and CMD_Par1 are not in use.
Example:

```
Send CMD GET_SERIAL_NUMBER
55 40 AA 00 AA CC E0
```

Where
55 – CMD_HEADER
40 – CMD_CODE
AA – CMD_TRAILER
00 AA CC – CMD_EX_Length and CMD_Par0 and CMD_Par1 not used
E0 – CHECKSUM

Reader answer with RESPONSE – RSP packet followed by RSP_EXT packet
DE 40 ED 09 00 00 81 55 46 31 32 33 34 35 36 1B

Where RSP PACKET contains
DE – RSP_HEADER
40 – CMD_CODE
ED – RSP_TRAILER
09 – RSP_EXT_Length
00 00 – RSP_Val0 and RSP_Val1 not used
81 – CHECKSUM

and RSP_EXT contains
55 46 31 32 33 34 35 36 – Device readers number (currently serial is "UF123456")
1B – CHECKSUM

GET_HARDWARE_VERSION (0x2A)

Returns reader hardware version as two byte representation of higher and lower byte.
The CMD_EXT set is not in use.
The CMD_Par0 and CMD_Par1 are not in use.
High byte of the hardware version is RSP_Val0.
Low byte of hardware version is PSP_Val1

Example:

CMD 55 2A AA 00 00 00 DC
RSP DE 2A ED 00 01 01 20

GET_FIRMWARE_VERSION (0x29)

Returns reader firmware version as two byte representation of higher and lower byte.
The CMD_EXT set is not in use.
The CMD_Par0 and CMD_Par1 are not in use.
High byte of the firmware version is RSP_Val0.
Low byte of the firmware version is PSP_Val1.

Example:

CMD 55 29 AA 00 00 00 DD
RSP DE 29 ED 00 03 09 17

GET_BUILD_NUMBER (0x2B)

Returns reader firmware build version as one byte representation.
The CMD_EXT set is not in use.
The CMD_Par0 and CMD_Par1 are not in use.

Build number of the firmware version is RSP_Val0.

Example:

```
CMD         55 2B AA 00 00 00 DB
RSP         DE 2B ED 00 C8 00 D7
```

READER_KEY_WRITE (0x12)

This function writes MIFARE key into internal EEPROM, at key index location (0 – 31).
• CMD_Par0 is key index
• CMD_Par1 is not in use
• array from 1st to 6th byte of CMD_EXT set contains 6-byte key
• 7th byte of CMD_EXT set is CHECKSUM

Example:

Write Key FF FF FF FF FF FF into key index 00

```
CMD         55 12 AA 07 00 00 F1
ACK         AC 12 CA 07 00 00 7A

CMD_EXT     FF FF FF FF FF FF 07
RSP         DE 12 ED 00 00 00 28
```

USER_DATA_READ (0X1B)

Function gives the 16 bytes from internal EEPROM user space.
The CMD_Par0 and CMD_Par1 are not in use.
• array from 1st to 16th byte of RSP_EXT set contains 16 bytes of user data
• 17th byte of RSP_EXT set is CHECKSUM.

Example:

```
CMD         55 1B AA 00 00 00 EB
RSP         DE 1B ED 11 00 00 40
RSP_EXT     6A 6A 00 00 36 00 00 00 30 00 32 00 38 00 41 00 54
```

USER_DATA_WRITE (0X1C)

This function writes 16 bytes into user space.
The CMD_Par0 and CMD_Par1 are not in use.
• array from 1st to 16th byte of CMD_EXT set contains 16 bytes of user data
• 17th byte of CMD_EXT set is CHECKSUM.

Example:

write into user space values we read in previous example (`6A 6A 00 00 36 00 00 00 30 00 32 00 38 00 41 00 54`)

```
CMD         55 1C AA 11 00 00 F9
ACK         AC 1C CA 11 00 00 72
```

```
CMD_EXT    6A 6A 00 00 36 00 00 00 30 00 32 00 38 00 41 00 54
RSP        DE 1C ED 00 00 00 36
```

READER_KEYS_LOCK (0x27)

If the keys (Mifare, AES, ...) in the reader are not locked - that means everyone can change it. If you want to protect the reader of changing keys then must lock the keys. Initially, uFReader is not locked. You can provide any password what you want, but must contain 8 bytes.

Example:

Lock keys with password “22222222” (we use printable characters for test)

```
CMD        55 27 AA 09 00 00 D8
ACK        AC 27 CA 09 00 00 4F

CMD_EXT    32 32 32 32 32 32 32 32 07
RSP        DE 27 ED 00 00 00 1B
```

READER_KEYS_UNLOCK (0x28)

If you want to change the keys (Mifare, AES, ...) in the reader, reader must be unlocked first.
The same password must be used to unlock as when we locked the reader. If you mistype the password - reader would reset.

Example:

Unlock keys with password “22222222” (we use printable characters for test)

```
CMD        55 28 AA 09 00 00 E5
ACK        AC 28 CA 09 00 00 4E

CMD_EXT    32 32 32 32 32 32 32 32 07
RSP        DE 28 ED 00 00 00 22
```

READER_PASSWORD_WRITE (0x33)

This function is used in Common, Advance and Access Control set of functions.

It defines/changes password which I used for:

- Locking/unlocking keys stored into reader
- Setting date/time of RTC

The CMD_Par0 and CMD_Par1 are not in use.
• array from 1st to 8th byte of CMD_EXT set contains current password, 9th to 16th byte contains new password
• 17th byte of CMD_EXT set is CHECKSUM.

Example:

Current password is “11111111” , new password is “22222222”

```
CMD         55 33 AA 11 00 00 E4
ACK         AC 33 CA 11 00 00 4B
CMD_EXT     31 31 31 31 31 31 31 31 32 32 32 32 32 32 32 32 07
RSP         DE 33 ED 00 00 00 07
```

SELF_RESET (0X30)

Function performs soft restart of device.
The CMD_EXT set is not in use.
The CMD_Par0 and CMD_Par1 are not in use

Example:

```
CMD         55 30 AA 00 00 00 D6

RSP         DE 30 ED 00 00 00 0A
RSP_EXT     03 55 55 BB
```

SET_UART_SPEED (0X70)

Function writes new value of UART's baud rate. For example 115200. Command sending is at current baud rate, ACK is at current baud rate, but response is at new baud rate. In future, the device will communicate at a new baud rate.
The CMD_Par0 and CMD_Par1 are not in use.
• array from 1st to 4th byte of CMD_EXT set contains 4 byte long baud rate (little-endian)
• 5th byte of CMD_EXT set is CHECKSUM.

Example:

```
CMD         55 70 AA 05 00 00 91
ACK         AC 70 CA 00 00 00 1D
CMD_EXT     00 C2 01 00 CA
RSP         ED 70 DE 00 00 00 4A
```

DEFAULT_UART_SPEED_SESSION (0xF1)

Command starts the session on default UART baud rate, regardless of the setting speed of the reader. That is a specific command. First you must reset the reader over the RTS pin. After that you will receive four bytes from the bootloader on default UART baud rate. Command is then sent. It is useful to set UART to default speed if you forget the current speed by executing SET_UART_SPEED with default UART speed.

CMD_Par0 = 1 and CMD_Par0 = 1.
CMD_EXT not in use.
RSP_EXT not in use.

Example:

```
RESET OVER RTS PIN
BOOTLOADER ACK      03 55 55 BB
CMD         55 F1 AA 00 00 00 15
RSP         ED 70 DE 00 00 00 4A
```

RED_LIGHT_CONTROL (0X71)

This function turns on or off red LED lights. If turned on, the green LED will stop flashing.
The CMD_EXT set is not in use.
CMD_Par0 – 0x01 turn red LED on, 0x00 – turn red LED off.
CMD_Par1 is not in use.

Example:

To turn red LED ON, send CMD packet

```
CMD         55 71 AA 00 01 00 96
RSP         DE 71 ED 00 00 00 49
```

To turn red LED OFF, send CMD packet

```
CMD         55 71 AA 00 00 00 95
RSP         DE 71 ED 00 00 00 49
```

For classic uFR Classic, uFR Classic CS and uFR and uFR XL devices.

The function prohibits the blinking of the green diode (if this option is set), and sets color on RGB diodes.

CMD_Par0 – 0x01 set RGB color, 0x00 – turn RGB led off, green is blinking.
CMD_Par1 = 0xC5

CMD_EXT

- 1st byte is intensity of RED light (0 - 255)
- 2nd byte is intensity of GREEN light (0 - 255)
- 3rd byte is intensity of BLUE light (0 - 255)
- 4th byte is intensity of light in % (0 - 100)
- 5th byte is checksum

Example:

RED = 255, GREEN = 255, BLUE = 0, intensity = 50%

```
CMD         55 71 AA 05 01 C5 56
ACK         AC 71 CA 05 01 C5 DD
CMD_EXT     FF FF 00 32 39
RSP         DE 71 ED 00 00 00 49
```

To turn red LED OFF, send CMD packet

```
CMD         55 71 AA 00 00 00 95
RSP         DE 71 ED 00 00 00 49
```

From version 5.0.55.

Before the function calls, the command SET_LED_CONFIG with the CMD_Par0 = 0 must be

called, or the reader is already in mode of blocking automatic signalization. Function sets the color of the RGB diodes. This color stays on the RGB until the command SET_LED_CONFIG with the CMD_Par0 = 0 is called. Intensity of light is defined by a parameter stored using the command SET_DISPLAY_INTENSITY.

CMD_Par0 – 0x02 set RGB color.
CMD_Par1 = 0xC5

CMD_EXT

- 1st byte is intensity of RED light (0 - 255)
- 2nd byte is intensity of GREEN light (0 - 255)
- 3rd byte is intensity of BLUE light (0 - 255)
- 4th byte exists for compatibility reasons, value doesn't matter.
- 5th byte is checksum

Example:

RED = 255, GREEN = 255, BLUE = 0

```
CMD         55 71 AA 05 02 C5 53
ACK         AC 71 CA 05 02 C5 DC
CMD_EXT     FF FF 00 32 39
RSP         DE 71 ED 00 00 00 49
```

From version 5.0.62.

The command sets color on the RGB diodes. This setting will appear when the reader is in sleep mode. Function adjusts the period, and duration of impulse of light. The period is a product of approximately two seconds (2s, 4s, 6s, 8s,...). Maximal duration of impulse of light is 2000 ms.

CMD_Par0 – 0x03 set RGB color for sleep mode.
CMD_Par1 = 0xC5

CMD_EXT

- 1st byte is intensity of RED light (0 - 255)
- 2nd byte is intensity of GREEN light (0 - 255)
- 3rd byte is intensity of BLUE light (0 - 255)
- 4th byte is value of color intensity in percent (0 - 100)
- 5th byte is the number of the 2 seconds period. (1 = 2s, 2 = 4s, 3 = 6s, …)
- 6th byte is duration of impulse of light in ms low byte
- 7th byte is duration of impulse of light in ms high byte
- 8th byte is checksum

Example:

Red = 255, Green = 0, Blue = 255, Intensity = 30%, Period = 3 * 2s = 6s, Duration = 100ms

```
CMD         55 71 AA 08 03 C5 47
ACK         AC 71 CA 08 03 C5 E0
CMD_EXT     FF 00 FF 1E 03 64 00 80
RSP         DE 71 ED 00 00 00 49
```

To turn red LED OFF, send CMD packet

```
CMD         55 71 AA 00 00 00 95
RSP         DE 71 ED 00 00 00 49
```

USER_INTERFACE_SIGNAL (0x26)

This function turns sound and light reader signals. Sound signals are performed by a reader buzzer and light signals are performed by reader LEDs.
There are predefined signal values for sound and light:

light_signal_mode:		beep_signal_mode:	
0	None	0	None
1	Long Green	1	Short
2	Long Red	2	Long
3	Alternation	3	Double Short
4	Flash	4	Triple Short
		5	Triplet Melody

The CMD_EXT set is not in use.
CMD_Par0 is value of light signal mode (0 - 4)
CMD_Par1 is value of beep signal mode (0 - 5)

Example:

light signal mode is Long Green (1), beep signal mode is Long (2)

```
CMD         55 26 AA 00 01 02 E1
RSP         DE 26 ED 00 00 00 1C
```

SET_DISPLAY_DATA (0x72)

This feature works with the LED RING 24 display module. Function enables sending data to the display. A string of data contains information about the intensity of color in each cell of the display. Each cell has three LEDs (red, green and blue). For each cell of the three bytes is necessary. The first byte indicates the intensity of the green color, the second byte indicates the intensity of the red color, and the third byte indicates the intensity of blue color. For example, if the display has 16 cells, an array contains 48 bytes. Value of intensity is in the range from 0 to 255.

CMD_Par0 number of bytes
CMD_Par1 not in use
CMD_EXT contains data for display with checksum

Example:

green = 0, red = 0xFF, blue = 0x80

```
CMD        55 72 AA 49 48 00 93
ACK        AC 72 CA 49 48 00 1C
CMD_EXT    00 FF 80 00 FF 80 00 FF 80 00 FF 80 00 FF 80 00 FF 80 00 FF 80
00 FF 80 00 FF 80 00 FF 80 00 FF 80 00 FF 80 00 FF 80 00 FF 80 00 FF 80
00 FF 80 00 FF 80 00 FF 80 00 FF 80 00 FF 80 00 FF 80 00 FF 80 00 FF 80
00 FF 80 07
RSP        DE 72 ED 00 00 00 48
```

From version 5.0.55

New feature is the RGB port selection. Internal port uses RGB diodes on the reader PCB. Card size reader has two diodes. XL reader has four diodes. External port uses LED RING with RGB diodes.
Before the function calls, the command SET_LED_CONFIG with the CMD_Par0 = 0 must be called, or the reader is already in mode of blocking automatic signalization. Function sets the color of the RGB diodes. This color stays on the RGB until the command SET_LED_CONFIG with the CMD_Par0 = 1 is called. Intensity of light is defined by a parameter stored using the command SET_DISPLAY_INTENSITY.

CMD_Par0 number of bytes
CMD_Par1 - external RGB port = 0, internal RGB port = 1
CMD_EXT contains data for display with checksum

Example:

First RGB green = 0xFF, red = 0, blue = 0. Second RGB green = 0, red = 0, blue = 0xFF

```
CMD        55 72 AA 07 06 01 94
ACK        AC 72 CA 07 06 01 1B
CMD_EXT    FF 00 00 00 00 FF 07
RSP        DE 72 ED 00 00 00 48
```

SET_DISPLAY_INTENSITY (0x74)

Function sets the intensity of light on the display. Value of intensity is in the range 0 to 100.

CMD_Par0 is display intensity
CMD_Par1 not in use
CMD_EXT not in use

Example:

display intensity is 50

```
CMD         55 74 AA 00 32 00 C0
RSP         DE 74 ED 00 00 00 4E
```

GET_DISPLAY_INTENSITY (0x75)

Function gets the intensity of light on the display.
CMD_Par0 not in use
CMD_Par1 not in use
CMD_EXT not in use
RSP_EXT 1st byte is intensity, 2nd byte is checksum

Example:

```
CMD         55 75 AA 00 00 00 91
RSP         DE 75 ED 02 00 00 4B
RSP_EXT     32 39
```

SET_SPEAKER_FREQUENCY (0x73)

Function sets the frequency of the speaker. The speaker is working on this frequency until a new frequency setting. To stop the operation set frequency to zero.

Period of sound frequency calculated according to the following formula

period = 65535 - 1500000 / (2 * frequency in Hertz)

CMD_Par0 is low byte of sound's period
CMD_Par1 is high byte of sound's period

Example:

set frequency of 1600Hz

```
CMD         55 73 AA 00 2B FE 60
RSP         DE 73 ED 00 00 00 47
```

SET_RF_ANALOG_SETTINGS (0x7D)

This function allows you to adjust the value of several registers on PN512. These are registers: RFCfgReg, RxThresholdReg, GsNOnReg, GsNOffReg, CWGsPReg, ModGsPReg. This can be useful if you want to increase the operation distance of card, or when it is necessary to reduce the impact of environmental disturbances.

CMD_Par0 type of communication with tag

ISO14443 type A	0x01
ISO14443 type B	0x02

ISO14443-4 212 Kbps 0x03
ISO14443-4 424 Kbps 0x04

CMD_Par1 0 - user settings, 1 - factory default settings

CMD_EXT
- 1st byte is value of RFCfgReg
- 2nd byte is value of RxThresholdReg
- 3rd byte is value of GsNOnReg
- 4th byte is value of CWGsPReg
- 5th byte is value of GsNOffReg for Type A or ModGsPReg for type B

For ISO14443-4 212 Kbps and ISO14443-4 424 Kbps CMD_EXT contains just first 2 bytes

Example:

RFCfgReg = 0x79, RxThesholdReg = 0x87, GsNonReg = 0x88, CWGsPReg = 0x20, GsNOffReg = 0x88

```
CMD         55 7D AA 06 01 00 8C
ACK         AC 7D CA 06 01 00 23
CMD_EXT     79 87 88 20 88 E5
RSP         DE 7D ED 00 00 00 55
```

GET_RF_ANALOG_SETTINGS (0x7E)

The function reads the value of the registers RFCfgReg, RxThresholdReg, GsNOnReg, GsNOffReg, CWGsPReg, ModGsPReg.

CMD_Par0 type of communication with tag

ISO14443 type A 0x01
ISO14443 type B 0x02
ISO14443-4 212 Kbps 0x03
ISO14443-4 424 Kbps 0x04

The CMD_EXT set is not in use.

RSP_EXT
- 1st byte is value of RFCfgReg
- 2nd byte is value of RxThresholdReg
- 3rd byte is value of GsNOnReg
- 4th byte is value of CWGsPReg
- 5th byte is value of GsNOffReg for Type A or ModGsPReg for type B

For ISO14443-4 212 Kbps and ISO14443-4 424 Kbps RSP_EXT contains just first 2 bytes

SET_LED_CONFIG (0x6E)

Minimal firmware version is 3.9.53
Light signalization configuration. Parameters are written into the device, and they are reloaded after reset or power up.
CMD_Par0 configuration low byte
CMD_Par1 configuration high byte

Green light blinking on - CMD_Par0 bit 0 is 1
Green light blinking off - CMD_Par0 bit 0 is 0

Example:

Green light blinking turn on

```
CMD         55 6E AA 00 01 00 97
RSP         DE 6E ED 00 00 00 64
```

Green light blinking turn off

```
CMD         55 6E AA 00 00 00 98
RSP         DE 6E ED 00 00 00 64
```

UFR_BASE_HD_LOCK_OPEN (0x60)

BASE HD uFR only.

Electric strike switches when the function is called. Pulse duration determined by function.

CMD_Par0 pulse duration in ms low byte
CMD_Par1 pulse duration in ms high byte

Example:

Pulse duration is 300ms (0x12C)

```
CMD         55 60 AA 00 2C 01 B9
RSP         DE 60 ED 00 00 00 5A
```

BARRIER CONTROL device command differences

Function controls two electric actuators on the barrier access control device. If the most significant bit in CMD_ Par1 is set will be activated actuator 1, else will be activated actuator 2. The maximum time that can be set is 0x7FFF ms.

CMD_Par0 duration of active state in ms low byte
CMD_Par1 & 0x7F duration of active state in ms high byte
If CMD_Par1 & 0x80 actuator 1 is active, else actuator 2 is active

Example:

Duration of active state is 5000ms (0x1388), actuator 1 set

```
CMD         55 60 AA 00 88 93 8B
RSP         DE 60 ED 00 00 00 5A
```

UFR_BASE_HD_SET_RELAY_STATE (0x61)

BASE HD uFR only.
Function switches relay.

CMD_Par0 1 - relay on, 0 - relay off

Example:

Relay on.

```
CMD         55 61 AA 00 01 00 A6
RSP         DE 61 ED 00 00 00 59
```

BARRIER CONTROL device command differences

Function switches relay, and sets state of OUT1 to OUT3 outputs

CMD_Par0 1 - relay on, 0 - relay off
Bit 0 of CMD_Par1 1 - OUT1 is high, 0 - OUT1 is low
Bit 1 of CMD_Par1 1 - OUT2 is high, 0 - OUT2 is low
Bit 2 of CMD_Par1 1 - OUT3 is high, 0 - OUT3 is low

Example:

Relay on, OUT 1 is low, OUT2 is low, OUT3 is high

```
CMD         55 61 AA 00 01 04 A2
RSP         DE 61 ED 00 00 00 59
```

UFR_BASE_HD_GET_IO_STATE (0x62)

BASE HD uFR only.
Function returns states of 3 IO pins.

RSP_EXT
1st byte 1- voltage at the intercom terminals detected, 0 - no voltage at the intercom terminals
2nd byte 1 - voltage at DIGIN pin is high, 0 - voltage at DIGIN pin is low.
3rd byte 1 - relay is turn on, 0 - relay is turn off

Example:

```
CMD         55 62 AA 00 00 00 A4
RSP         DE 62 ED 04 00 00 5C
RSP_EXT     01 00 01 07
```

BARRIER CONTROL device command differences

Function returns state of five input pins, four output pins, and two actuators.

RSP_EXT

Bit 0 of 1st byte 1- voltage detected at the IN1, 0 - no voltage at IN1
Bit 1 of 1st byte 1- voltage detected at the IN2, 0 - no voltage at IN2
Bit 2 of 1st byte 1- voltage detected at the IN3, 0 - no voltage at IN3
Bit 3 of 1st byte 1- voltage detected at the IN4, 0 - no voltage at IN4
Bit 4 of 1st byte 1- proximity sensor activated, 0 - proximity sensor is not active

Bit 0 of 2nd byte 1 - relay is on, 0 - relay is off
Bit 1 of 2nd byte 1 - OUT1 is high, 0 - OUT1 is low
Bit 2 of 2nd byte 1 - OUT2 is high, 0 - OUT2 is low
Bit 3 of 2nd byte 1 - OUT3 is high, 0 - OUT3 is low

Bit 0 of 3rd byte 1 - actuator 1 is active, 0 - actuator 1 is not active
Bit 1 of 3rd byte 1 - actuator 2 is active, 0 - actuator 2 is not active

Example:

Voltage on IN1, proximity sensor is active, relay is on, actuator 1 is active

```
CMD         55 62 AA 00 00 00 A4
RSP         DE 62 ED 04 00 00 5C
RSP_EXT     11 01 01 18
```

CARD RELATED COMMANDS

For all the functions for operations with cards the following applies:
• They operates only with one card in the device field
• If there is no card in the field device return error NO_CARD (0x08).
• If there is more than one card in the field the behavior of the device is unpredictable but some of the next cases are possible:

- Gives NO_CARD error or
- Just one card is detected and the device gives its type (this is due to the lack of a cascade of selection and the collision process as described in the ISO14443 standard).

GENERAL PURPOSE CARD RELATED COMMANDS

GET_CARD_ID (0x13)

This function return the serial number of the card which is currently in the readers field and the one byte value that represents its type. For Mifare Classic 1K the type is 0x08, Mifare Classic 4k type is 0x18 and Mifare Classic Mini cards type is 0x09.
The CMD_EXT set is not in use.
The CMD_Par0 and CMD_Par1 are not in use.

If everything operates as expected the RESPONSE set is sent and after that also the RESPONSE EXT set of 5 bytes which contains 4 byte Card UID values (little-endian) and CHECKSUM byte.
RSP_Val0 contains value of the card type.

This function applies only for card with 4-byte UID. For longer UID's, use GET_CARD_ID_EX (0x2C)

Example:

```
CMD         55 13 AA 00 00 00 F3
RSP         DE 13 ED 05 08 00 34
RSP_EXT     13 E2 0A 87 83
```

Where in RSP packet byte 05 represents RSP_EXT_length and byte 08 represents CardType – 0x08 – Mifare Classic.
RSP_EXT returns Card UID (little-endian) and CHECKSUM of UID bytes.

If error occurs, like NO_CARD, device will answer with ERR packet

```
CMD         55 13 AA 00 00 00 F3
ERR         EC 08 CE 00 00 00 31
```

Where byte 08 represents ERR_CODE for NO_CARD error.

GET_CARD_ID_EX (0x2C)

Use this function for cards with UID longer than 4 byte.
This function return the serial number of the card which is currently in the readers field, length of serial number (4 (UID size: single), 7 (UID size: double) or 10 (UID size: triple)), and the one byte value that represents its type. For Mifare Classic 1K the type is 0x08, Mifare Classic 4k type is 0x18 and Mifare Classic Mini cards type is 0x09.
The CMD_EXT set is not in use.
The CMD_Par0 and CMD_Par1 are not in use.
If everything operates as expected the RSP packet is sent and after that also the RSP_EXT packet of 11 bytes which contains card serial number and at the end one checksum byte.
RSP_Val0 contains value of the card type.
RSP_Val1 contains length of card serial number.

Example:

```
CMD         55 2C AA 00 00 00 DA

RSP         DE 2C ED 0B 08 04 1F
RSP_EXT     13 E2 0A 87 00 00 00 00 00 00 83
```

Where in RSP packet byte 0B represents RSP_EXT_Length, byte 08 means Card Type – Mifare Classic 1K, and byte 04 is length of card UID in RSP_EXT packet.
RSP_EXT packet contains card UID bytes and CHECKSUM.

If error occurs, like NO_CARD, device will answer with ERR packet

```
CMD         55 2C AA 00 00 00 DA
ERR         EC 08 CE 00 00 00 31
```

Where byte 08 represents ERR_CODE for NO_CARD error.

GET_LAST_CARD_ID_EX (0x7C)

This function returns UID of last card which was present in RF field of reader. It can handle all three known types: 4, 7 and 10 byte long UIDs. Difference with GetCardIdEx is that card does not be in RF field mandatory, UID value is stored in temporary memory area.
The CMD_EXT set is not in use.
The CMD_Par0 and CMD_Par1 are not in use.
If everything operates as expected the RSP packet is sent and after that also the RSP_EXT packet of 11 bytes which contains card serial number and at the end one checksum byte.
RSP_Val0 contains value of the card type.
RSP_Val1 contains length of card serial number.

Example:

```
CMD         55 7C AA 00 AA CC EC

RSP         DE 7C ED 0B 08 04 4F
RSP_EXT     52 DA D9 95 00 00 00 00 00 00 CB
```

Where in RSP packet byte 0B represents RSP_EXT_Length, byte 08 means Card Type – Mifare Classic 1K, and byte 04 is length of card UID in RSP_EXT packet.
RSP_EXT packet contains card UID bytes and CHECKSUM.

If error occurs, like NO_CARD, device will answer with ERR packet

```
CMD         55 7C AA 00 AA CC EC
ERR         EC 08 CE 00 AA CC 53
```

Where byte 08 represents ERR_CODE for NO_CARD error.

GET_DLOGIC_CARD_TYPE (0x3C)

This function returns card type according to following enumeration list:

DL_MIFARE_ULTRALIGHT	0x01
DL_MIFARE_ULTRALIGHT_EV1_11	0x02
DL_MIFARE_ULTRALIGHT_EV1_21	0x03
DL_MIFARE_ULTRALIGHT_C	0x04
DL_NTAG_203	0x05
DL_NTAG_210	0x06
DL_NTAG_212	0x07
DL_NTAG_213	0x08
DL_NTAG_215	0x09
DL_NTAG_216	0x0A
MIKRON_MIK640D	0x0B
NFC_T2T_GENERIC	0x0C
DL_NT3H_1101	0x0D
DL_NT3H_1201	0x0E
DL_NT3H_2111	0x0F
DL_NT3H_2211	0x10
DL_NTAG_413_DNA	0x11
DL_NTAG_424_DNA	0x12
DL_NTAG_413_DNA_TT	0x13
DL_NTAG_210U	0x14
DL_NTAG_213_TT	0x15
DL_MIFARE_MINI	0x20
DL_MIFARE_CLASSIC_1K	0x21
DL_MIFARE_CLASSIC_4K	0x22
DL_MIFARE_PLUS_S_2K_SL0	0x23
DL_MIFARE_PLUS_S_4K_SL0	0x24
DL_MIFARE_PLUS_X_2K_SL0	0x25
DL_MIFARE_PLUS_X_4K_SL0	0x26
DL_MIFARE_DESFIRE	0x27
DL_MIFARE_DESFIRE_EV1_2K	0x28
DL_MIFARE_DESFIRE_EV1_4K	0x29
DL_MIFARE_DESFIRE_EV1_8K	0x2A
DL_MIFARE_DESFIRE_EV2_2K	0x2B
DL_MIFARE_DESFIRE_EV2_4K	0x2C
DL_MIFARE_DESFIRE_EV2_8K	0x2D
DL_MIFARE_PLUS_S_2K_SL1	0x2E
DL_MIFARE_PLUS_X_2K_SL1	0x2F
DL_MIFARE_PLUS_EV1_2K_SL1	0x30
DL_MIFARE_PLUS_X_2K_SL2	0x31
DL_MIFARE_PLUS_S_2K_SL3	0x32
DL_MIFARE_PLUS_X_2K_SL3	0x33
DL_MIFARE_PLUS_EV1_2K_SL3	0x34
DL_MIFARE_PLUS_S_4K_SL1	0x35
DL_MIFARE_PLUS_X_4K_SL1	0x36
DL_MIFARE_PLUS_EV1_4K_SL1	0x37
DL_MIFARE_PLUS_X_4K_SL2	0x38
DL_MIFARE_PLUS_S_4K_SL3	0x39
DL_MIFARE_PLUS_X_4K_SL3	0x3A
DL_MIFARE_PLUS_EV1_4K_SL3	0x3B
DL_MIFARE_PLUS_SE_SL0	0x3C

DL_MIFARE_PLUS_SE_SL1	0x3D
DL_MIFARE_PLUS_SE_SL3	0x3E
DL_MIFARE_DESFIRE_LIGHT	0x3F
DL_GENERIC_ISO14443_4	0x40
DL_GENERIC_ISO14443_4_TYPE_B	0x41
DL_GENERIC_ISO14443_3_TYPE_B	0x42
DL_MIFARE_PLUS_EV1_2K_SL0	0x43
DL_MIFARE_PLUS_EV1_4K_SL0	0x44
DL_IMEI_UID	0x80

Example:

```
CMD        55 3C AA 00 00 00 CA
RSP        DE 3C ED 00 21 00 35
```

Where byte 21 in RSP packet represents card type – 0x21 – Mifare Classic 1K.

If error occurs, like NO_CARD, device will answer with ERR packet

```
CMD        55 3C AA 00 00 00 CA
ERR        EC 08 CE 00 00 00 31
```

Where byte 08 represents ERR_CODE for NO_CARD error.

FUNCTIONS FOR READING AND WRITING THE DATA INTO THE CARD

Authentication mode considerations for Mifare Classic tags and Mifare Plus tags

The parameter AUTH_MODE affects all the functions and determines authorization before reading or entering data in the card sector. This parameter can have the following values:

- **RKA_AUTH1A 0x00**
- **RKA_AUTH1B 0x01**
- **AKM1_AUTH1A 0x20**
- **AKM1_AUTH1B 0x21**
- **AKM2_AUTH1A 0x40**
- **AKM2_AUTH1B 0x41**
- **PK_AUTH1A 0x60**
- **PK_AUTH1B 0x61**
- **PK_AUTH1A_AES 0x80 (Mifare Plus tags and NT4H tags uFR PLUS only)**
- **PK_AUTH1B_AES 0x81 (Mifare Plus tags uFR PLUS only)**
- **SAM_KEY_AUTH1A 0x10 (key A stored in SAM)**
- **SAM_KEY_AUTH1B 0x11 (key B stored in SAM)**

For firmware versions from 5.0.29.

- **MFP_RKA_AUTH1A 0x02 (Mifare Plus tags in SL3 mode and NT4H tags)**
- **MFP_RKA_AUTH1B 0x03 (Mifare Plus tags in SL3 mode)**
- **MFP_AKM1_AUTH1A 0x22 (Mifare Plus tags in SL3 mode)**
- **MFP_AKM1_AUTH1B 0x23 (Mifare Plus tags in SL3 mode)**
- **MFP_AKM2_AUTH1A 0x42 (Mifare Plus tags in SL3 mode)**
- **MFP_AKM2_AUTH1B 0x43 (Mifare Plus tags in SL3 mode)**

From the names of each of these constants can be concluded that the suffixes 1A and 1B indicate that you want to perform authentication key A or key B.

Prefixes in the names of constants represents modes of authentication, as following:

RKA – abbreviation of Reader Key Authentication. This means that authentication will be done with one of the 32 keys (16 AES keys for Mifare Plus tags) that are stored in reader device. It is assumed that as one of the command parameter that is sent to the reader is the index of the desired key. Indexes are in range 0..31 (0..15 for AES keys).
Mifare Plus card using.
For firmware versions from 5.0.1 to 5.0.28. and RKA_AUTH1A or RKA_AUTH1B uses AES keys from reader AES keys space (index 0 - 15).
For firmware versions from 5.0.29 and RKA_AUTH1A or RKA_AUTH1B uses AES keys which are calculate from Crypto1 keys from reader Crypto1 keys space (index 0 - 31), and for MFP_RKA_AUTH1A or MFP_RKA_AUTH1B uses AES keys from reader AES keys space (index 0 - 15).
AKM1 and AKM2 – abbreviation of Automatic Key Modes. This means that the authentication will be done automatically with the keys stored in reader device and they are indexed on the basis of the block or sector address where the writing or reading is currently done.
This applies to any function for card writing and reading, even for linear modes. I
When using AKM1 mode, keys in range 0 to 15 (0 to 7 for Mifare Plus tags for sectors 0 - 7, and 8 - 15 again) are used as Key A for corresponding sectors, while keys indexed from 16 to 31 (8 to 15 for Mifare Plus tags for sectors 16 - 23, and 24 - 31) are used as Key B for corresponding sectors.

Example for AKM1 keys indexes:

```
Key[00] = Key A Sector 0; Key [01] = Key A Sector [1]; … Key [15] = Key A Sector 15;
Key[16] = Key B Sector 0; Key [17] = Key B Sector [1]; … Key [31] = Key B Sector 15;
```

When using AKM2, keys are indexed by odd and even order, so even keys indexes are used as Key A and odd keys indexes are used as Key B (for Mifare Plus tags key indexes are 0 - 15 for sectors 0 - 15, and they are repeated for sectors 15 - 30).

Example for AKM2 keys indexes:

```
Key[00] = Key A Sector 0; Key [02] = Key A Sector [1]; … Key [30] = Key A Sector 15;
Key[1] = Key B Sector 0; Key [3] = Key B Sector [1]; … Key [31] = Key B Sector 15;
```

For 4k cards, which have 24 sectors more than 1k cards (total 40) for sectors 16 to 31 is used the same method as for indexing sectors 0 to 15 and for sectors 32 to 39 used the same method of indexing and for sectors 0 to 8.

Mifare Plus card using.
For firmware versions from 5.0.29 and AKM1_AUTH1A or AKM1_AUTH1B or AKM2_AUTH1A or AKM2_AUTH1B, reader keys uses in same manner as for Mifare classic card. AES key calculated from Crypto1 key.
For firmware versions from 5.0.1 to 5.0.28 in AKM1_AUTH1A or AKM1_AUTH1B or AKM2_AUTH1A or AKM1_AUTH1A, and version 5.0.29 in MFP_AKM1_AUTH1A or MFP_AKM1_AUTH1B or MFP_AKM2_AUTH1A or MFP_AKM1_AUTH1B, uses reader keys from AES keys space (index 0 - 15).

Example for AKM1 keys indexes:

```
Key[00] = Key A Sector 0; Key [01] = Key A Sector 1; … Key [07] = Key A Sector 7;
Key[00] = Key A Sector 8; Key [01] = Key A Sector 9; … Key [07] = Key A Sector 15;
Key[00] = Key A Sector 16; Key [01] = Key A Sector 17; … Key [07] = Key A Sector 23;
Key[00] = Key A Sector 24; Key [01] = Key A Sector 25; … Key [07] = Key A Sector 31;
Key[00] = Key A Sector 32; Key [01] = Key A Sector 33; … Key [07] = Key A Sector 39;
Key[08] = Key B Sector 0; Key [09] = Key B Sector 1; … Key [15] = Key B Sector 7;
Key[08] = Key B Sector 8; Key [09] = Key B Sector 9; … Key [15] = Key B Sector 15;
Key[08] = Key B Sector 16; Key [09] = Key B Sector 17; … Key [15] = Key B Sector 23;
Key[08] = Key B Sector 24; Key [09] = Key B Sector 25; … Key [15] = Key B Sector 31;
Key[08] = Key B Sector 32; Key [09] = Key B Sector 33; … Key [15] = Key B Sector 39;
```

Example for AKM2 keys indexes:

```
Key[00] = Key A Sector 0; Key [02] = Key A Sector 1; … Key [14] = Key A Sector 7;
Key[01] = Key B Sector 0; Key [03] = Key B Sector 1; … Key [15] = Key B Sector 7;
Key[00] = Key A Sector 8; Key [02] = Key A Sector 9; … Key [14] = Key A Sector 15;
Key[01] = Key B Sector 8; Key [03] = Key B Sector 9; … Key [15] = Key B Sector 15;
Key[00] = Key A Sector 16; Key [02] = Key A Sector 17; … Key [14] = Key A Sector 23;
Key[01] = Key B Sector 16; Key [03] = Key B Sector 17; … Key [15] = Key B Sector 23;
Key[00] = Key A Sector 24; Key [02] = Key A Sector 25; … Key [14] = Key A Sector 31;
Key[01] = Key B Sector 24; Key [03] = Key B Sector 25; … Key [15] = Key B Sector 31;
Key[00] = Key A Sector 32; Key [02] = Key A Sector 33; … Key [14] = Key A Sector 39;
Key[01] = Key B Sector 32; Key [03] = Key B Sector 33; … Key [15] = Key B Sector 39;
```

PK – abbreviation for Provided Key refers to the authentication which is performed with key that is sent as a command parameter. Generally, this mode of authentication should be avoided due to the low level of security it provides, since key is passed as command parameter.
Mifare Plus using.
For firmware versions from 5.0.1 in PK_AUTH1A_AES or PK_AUTH1B_AES mode, 16 bytes AES key provided to reader.
For firmware versions from 5.0.29 in PK_AUTH1A or PK_AUTH1B mode, 6 bytes Crypto1 key provided to reader. AES key calculated from this Crypto1 key.

SAM_KEY - abbreviation for Key stored into SAM (working with uFR CS reader with SAM, and firmware versions 5.100.xx only)

Authentication mode considerations for NTAG 21x and other T2T tags (supported from firmware version 3.9.10)

NTAG 21x and some other T2T tags (such as Ultralight EV1) support different authentication method from the Mifare Classic tags. NTAG 21x tags authentication is done using ISO 14443A-3 PWD_AUTH command, requiring from the reader to transmit secret code (PWD) of 4 bytes the tag, which responds with a PACK (PWD ACKNOWLEDGE). If the transmitted code is equal to that programmed in the tag, he responds with the correct PACK (length 2 bytes). PWD and PACK is typically written into the tag during the personalization process. The configuration pages are used to configure the memory access restriction of the tag. In order to familiarize with the methods of authentication of the NTAG 21x we recommend that you read "NTAG210 / 212, NFC Forum Type 2 Tag IC compliant with 48/128 bytes user memory Product data sheet" or "NTAG213 / 215/216, NFC Forum Type 2 Tag IC compliant with 144/504/888 bytes user memory data sheet Product" or "MF0ULx1, MIFARE Ultralight EV1 - Contactless IC ticket Product data sheet" that can be found

on the manufacturer website. All these documents are marked "PUBLIC COMPANY".

NTAG 21x, Ultralight EV2 and other T2T tags supporting PWD_AUTH, practically use 6 bytes (4 bytes that make up the PWD and 2 bytes of the PACK response) in our uFR readers we use the same mechanism as for Mifare Classic tags. The only difference is that a combined PWD (first 4 bytes of the key) and PACK (the last 2 bytes of the key) now forming a key (6 bytes in length). The resultant key can be prepared in advance and written in the card reader internal EEPROM (NV Memory) for using with Reader Key Authentication (RKA) method, or sent as a parameter of the uFR_COM protocol command using Provided Key (PK) methods.

Note: Reader Key Authentication (RKA) methods with NTAG 21x, Ultralight EV2 and other T2T tags can not be used with uFR Classic and uFR Advanced commercial readers. These methods are possible only with newer reader series like uFR nano, uFR card size readers and HD Base with uFR support installed. On older models for this purpose can be used only Provided Key (PK) methods.

The following constants are declared for the parameter that determines the method for PWD_AUTH for NTAG 21x, Ultralight EV2 and other T2T tags:

```
T2T_NO_PWD_AUTH 0x00
T2T_RKA_PWD_AUTH 0x01
T2T_PK_PWD_AUTH 0x61
```

These constants are used with the following uFR_COM protocol commands:

```
BLOCK_READ
BLOCK_WRITE
LINEAR_READ
LINEAR_WRITE
LIN_ROW_READ
```

and passed as a parameter value controls AUTH_MODE. If you use any other undeclared value as AUTH_MODE, the effect will be the same as if you sent T2T_NO_PWD_AUTH.

When for the AUTH_MODE command parameter you send T2T_RKA_PWD_AUTH or T2T_PK_PWD_AUTH reader will always try to perform PWD_AUTH regardless of the settings in the configuration pages of the tag. For the implementation of the adequate authentication scheme developer is responsible to use T2T_NO_PWD_AUTH for access of the public data that are not protected by a pair of PWD, PACK.

TRAILER BLOCK MANIPULATION COMMANDS

Special blocks called “trailer blocks” defines access bits and rights for Keys A and B for each sector. To read more, refer to NXP documentation about Mifare cards, see http://www.nxp.com/documents/data_sheet/M001053_MF1ICS50_rev5_3.pdf and http://www.nxp.com/documents/data_sheet/MF1S50YYX.pdf

SECTOR_TRAILER_WRITE (0x1A)

Function is used to write keys and access bits into the trailers of the sector. It could be used or sector address mode (without need for block_in_sector_address to be sent because the given

sector is always known) either the block address mode that determines the addressing_mode u CMD_EXT set parameter which can have the following values:
BLOCK_ADDRESS_MODE = 0
SECTOR_ADDRESS_MODE = 1
Access bits are sent separately as 4 bytes that has possible values 0 up to 7.
The device Firmware is formatting the access bits according to the cards specification irreversible blocking of that sector.

The CMD_EXT set is used and its length depends on the authentication mode that is in use.
CMD_Par0 contains AUTH_MODE.

Depending on AUTH_MODE, CMD and CMD_EXT set contains:

RKA_AUTH1x:

• CMD_Par1 in CMD set contains readers index key
• 1st byte of the set contains sector_(block_)address
• 2nd byte of the set contains dummy value
• 3rd byte of the set contains addressing mode
• 4th byte contains 9-byte sector trailer value (anything could be written)
• in 5th to 10th byte of the set is an unencrypted key A for writing
• in 11th to 14th byte are the access bits values for 0 to 3 blocks inside the sector respectively (for Classic 4k cards also the second half of their address space – the rest 2K of space, 11th byte of CMD_EXT set determines the access bits values for the blocks 0 to 4, the 12th byte for blocks 5 to 9 and the 13th byte for blocks 10 to 14 and at the end 14th byte for sector trailer)
• the 15th to 20th byte of the set contains an unencrypted key B for writing
• 21st byte contains checksum

AKMy_AUTH1x:

• CMD_Par1 is not used.
• 1st byte of the set contains sector_(block_)address
• 2nd byte of the set contains dummy value
• 3rd byte of the set contains addressing mode
• 4th byte contains 9-byte sector trailer value (anything could be written)
• in 5th to 10th byte of the set is an unencrypted key A for writing
• in 11th to 14th byte are the access bits values for 0 to 3 blocks inside the sector respectively (for Classic 4k cards also the second half of their address space – the rest 2K of space, 11th byte of CMD_EXT set determines the access bits values for the blocks 0 to 4, the 12th byte for blocks 5 to 9 and the 13th byte for blocks 10 to 14 and at the end 14th byte for sector trailer)
• the 15th to 20th byte of the set contains an unencrypted key B for writing
• 21st byte contains checksum

PK_AUTH1x:

• CMD_Par1 is not used.
• 1st byte of the set contains sector_(block_)address
• 2nd byte of the set contains dummy value

• 3rd byte of the set contains addressing_mode
• 4th byte contains 9-byte sector trailer value (anything could be written)
• array from 5th up to 10th byte contains 6-byte key.
• in 11th to 16th byte of the set is an unencrypted key A for writing
• in 17th to 20th byte are the access bits values for 0 to 3 blocks inside the sector respectively (for Classic 4k cards also the second half of their address space – the rest 2K of space, 11th byte of CMD_EXT set determines the access bits values for the blocks 0 to 4, the 12th byte for blocks 5 to 9 and the 13th byte for blocks 10 to 14 and at the end 14th byte for sector trailer)
• the 21st do 26th byte of the set contains an unencrypted key B for writing
• 27th byte contains checksum
If everything is done as it should it returns the RESPONSE set.
RESPONSE_EXT is not used.

Example:

authentication RKA key A, key number 0, sector address 0, addressing mode 1, key A = 0xFFFFFFFFFFFF, key B = 0xFFFFFFFFFFFF, access bits values 0, 0, 0, 1

```
CMD         55 1A AA 15 00 00 F7
ACK         AC 1A CA 15 00 00 70

CMD_EXT     00 00 01 69 FF FF FF FF FF FF 00 00 00 01 FF FF FF FF FF FF 70
RESP        DE 1A ED 00 00 00 30
```

Mifare Plus using.
For firmware versions from 5.0.29.
For RKA_AUTH1x or AKMy_AUTH1x or PK_AUTH1x mode AES key for authentication, and new AES key A and key B, are calculate from Crypto1 keys. Commands uses in same manner as for Mifare Classic card.

MFP_RKA_AUTH1x:

• CMD_Par1 in CMD set contains readers index of AES keys (0 - 15)
• 1st byte of the set contains sector_(block_)address
• 2nd byte of the set contains dummy value
• 3rd byte of the set contains addressing mode
• 4th byte contains 9-byte sector trailer value (anything could be written)
• in 5th to 10th byte of the set is first 6 bytes of an unencrypted key A for writing
• in 11th to 14th byte are the access bits values for 0 to 3 blocks inside the sector respectively (for Classic 4k cards also the second half of their address space – the rest 2K of space, 11th byte of CMD_EXT set determines the access bits values for the blocks 0 to 4, the 12th byte for blocks 5 to 9 and the 13th byte for blocks 10 to 14 and at the end 14th byte for sector trailer)
• the 15th to 20th byte of the set contains first 6 bytes of an unencrypted key B for writing
• the 21st to 30th byte of the set contains second 10 bytes of unencrypted key A for writing
• the 31st to 40th byte of the set contains second 10 bytes of unencrypted key B for writing
• 41st byte contains checksum

MFP_AKMy_AUTH1x:

• CMD_Par1 is not used.
• 1st byte of the set contains sector_(block_)address
• 2nd byte of the set contains dummy value
• 3rd byte of the set contains addressing mode
• 4th byte contains 9-byte sector trailer value (anything could be written)
• in 5th to 10th byte of the set is an unencrypted key A for writing
• in 11th to 14th byte are the access bits values for 0 to 3 blocks inside the sector respectively (for Classic 4k cards also the second half of their address space – the rest 2K of space, 11th byte of CMD_EXT set determines the access bits values for the blocks 0 to 4, the 12th byte for blocks 5 to 9 and the 13th byte for blocks 10 to 14 and at the end 14th byte for sector trailer)
• the 15th to 20th byte of the set contains an unencrypted key B for writing
• the 21st to 30th byte of the set contains second 10 bytes of unencrypted key A for writing
• the 31st to 40th byte of the set contains second 10 bytes of unencrypted key B for writing
• 41st byte contains checksum

PK_AUTH1x_AES:

• CMD_Par1 is not used.
• 1st byte of the set contains sector_(block_)address
• 2nd byte of the set contains dummy value
• 3rd byte of the set contains addressing_mode
• 4th byte contains 9-byte sector trailer value (anything could be written)
• array from 5th up to 20th byte contains 16-byte AES key.
• in 21st to 26th byte of the set is an unencrypted key A for writing
• in 27th to 30th byte are the access bits values for 0 to 3 blocks inside the sector respectively (for Classic 4k cards also the second half of their address space – the rest 2K of space, 11th byte of CMD_EXT set determines the access bits values for the blocks 0 to 4, the 12th byte for blocks 5 to 9 and the 13th byte for blocks 10 to 14 and at the end 14th byte for sector trailer)
• the 31st do 36th byte of the set contains an unencrypted key B for writing
• the 37th to 46th byte of the set contains second 10 bytes of unencrypted key A for writing
• the 47th to 56th byte of the set contains second 10 bytes of unencrypted key B for writing
• 57th byte contains checksum

If everything is done as it should it returns the RESPONSE set.
RESPONSE_EXT is not used.

SECTOR_TRAILER_WRITE_UNSAFE (0x2F)

It operates as SECTOR_TRAILER_WRITE except it send already formatted sector trailer block to be written without the access bits value check. The command is unsafe because it could lead to irreversible blocking of the entire sector of the card due to improperly formatted value of access bits. Made only for advanced users.

The CMD_EXT set is used and its length depends on the authentication mode that is in use.

CMD_Par0 contains AUTH_MODE.

Depending on AUTH_MODE, CMD and CMD_EXT set contains:

RKA_AUTH1x:

• CMD_Par1 u CMD set contains readers index key
• 1st byte of the set contains sector_(block_)address
• 2nd byte of the set contains dummy value
• 3rd byte of the set contains addressing_mode
• 4th byte of the set contains dummy value
• in 5th to 20th byte of the set is the content of the sector trailer for writing
• 21st byte contains checksum

AKMy_AUTH1x:

• CMD_Par1 is not used.
• 1st byte of the set contains sector_(block_)address
• 2nd byte of the set contains dummy value
• 3rd byte of the set contains addressing_mode
• 4th byte of the set contains dummy value
• in 5th to 20th byte of the set is the content of the sector trailer for writing
• 21st byte contains checksum

PK_AUTH1x:

• CMD_Par1 is not used.
• 1st byte of the set contains sector_(block_)address
• 2nd byte of the set contains dummy value
• 3rd byte of the set contains addressing_mode
• 4th byte of the set contains dummy value
• array from 5th up to 10th bytes contains 6-byte key.
• in 11th to 26th byte of the set is the content of the sector trailer for writing
• 27th byte contains checksum

If everything is done as it should it returns the RESPONSE set.
RESPONSE_EXT is not used.

Example:

authentication RKA key A, key number 0, sector address 0, addressing mode 1, key A = 0xFFFFFFFFFFFF, key B = 0xFFFFFFFFFFFF, access bits values 0xFF078069 (default configuration)

```
CMD         55 2F AA 15 00 00 CC
ACK         AC 2F CA 15 00 00 63

CMD_EXT     00 00 01 00 FF FF FF FF FF FF FF 07 80 69 FF FF FF FF FF FF 17
RESP        DE 2F ED 00 00 00 23
```

BLOCK MANIPULATION COMMANDS

Following commands used direct block addressing, meaning that blocks are indexed in range 0 to 63 for Mifare 1K cards.

BLOCK_READ (0x16)

Reads the whole data block from the card which is in the reader field.
The CMD_EXT set is used and its length depends on authentication mode that is used.

CMD_Par0 contains AUTH_MODE.
Depending on AUTH_MODE, CMD and CMD_EXT set contains:

RKA_AUTH1x:

- CMD_Par1 in CMD set contains key index in the reader
- 1st byte of CMD_EXT set contains block_address
- 2nd, 3rd and 4th byte of CMD_EXT set contains dummy data
- 5th byte contains checksum

Example:

read block 01 with RKA_AUTH1A

```
CMD         55 16 AA 05 00 00 F3
ACK         AC 16 CA 05 00 00 7C

CMD_EXT     01 00 00 00 08

RSP         DE 16 ED 11 00 00 3B
RSP_EXT     00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 07
```

AKMy_AUTH1x:

- CMD_Par1 is not used.
- 1st byte of CMD_EXT set contains block_address
- 2nd, 3rd and 4th byte of CMD_EXT set contains dummy data
- 5th byte contains checksum

PK_AUTH1x:

- CMD_Par1 is not used.
- 1st byte of CMD_EXT set contains block_address
- 2nd, 3rd and 4th byte of CMD_EXT set contains dummy data
- array from 5th to 10th byte contains 6-byte key.
- 11th byte contains checksum

If all operates as it should it turns the RESPONSE set and the RESPONSE_EXT is following with 16 read bytes and checksum at the end.

PK_AUTH1x_AES: (uFR PLUS devices only Mifare Plus tags)

- CMD_Par1 is not used.

• 1st byte of CMD_EXT set contains block_address
• 2nd, 3rd and 4th byte of CMD_EXT set contains dummy data
• array from 5th to 20th byte contains 16-byte AES key.
• 21st byte contains checksum
If all operates as it should it turns the RESPONSE set and the RESPONSE_EXT is following with 16 read bytes and checksum at the end.

Mifare Plus using.
For firmware versions from 5.0.1 to 5.0.28 in RKA_AUTH1x or AKMy_AUTH1x mode uses AES key from reader AES keys space (index 0 - 15).
For firmware versions from 5.0.29 in RKA_AUTH1x or AKMy_AUTH1x mode uses AES key which calculated from reader Crypto1 key (indec 0 - 31).
Firmware versions from 5.0.29

MFP_RKA_AUTH1x:
• CMD_Par1 in CMD set contains AES key index in the reader (0 -15)
• 1st byte of CMD_EXT set contains block_address
• 2nd, 3rd and 4th byte of CMD_EXT set contains dummy data
• 5th byte contains checksum

MFP_AKMy_AUTH1x:
• CMD_Par1 is not used.
• 1st byte of CMD_EXT set contains block_address
• 2nd, 3rd and 4th byte of CMD_EXT set contains dummy data
• 5th byte contains checksum

SAM_KEY_AUTH1x: (uFR CS with SAM and firmware versions 5.100.xx)
• CMD_Par1 in CMD set contains key index in the SAM (1 - 127)
• 1st byte of CMD_EXT set contains block_address
• 2nd, 3rd and 4th byte of CMD_EXT set contains dummy data
• 5th byte contains checksum

BLOCK_WRITE (0x17)

Writes the whole data block into the card that is currently in the readers field. Address mode is used for so called block addressing where for example the first block on Mifare Classic 1k has an address 0 and the last one has the address 63. This command doesn't allow the direct writing into the sector trailer and in the case of its addressing it gives back the FORBIDEN_DIRECT_WRITE_IN_SECTOR_TRAILER.

The CMD_EXT set is used and its length depends on the authentication mode that is in use.

CMD_Par0 contains AUTH_MODE.
Depending on AUTH_MODE, CMD and CMD_EXT set contains:

RKA_AUTH1x:

• CMD_Par1 in CMD set contains readers index key
• 1st byte of CMD_EXT set contains block_address
• 2nd, 3rd and 4th byte of CMD_EXT set contains dummy data
• in 5th to 20th byte of set are placed data for writing into the data block
• 21st byte contains checksum

AKMy_AUTH1x:

• CMD_Par1 is not used.
• 1st byte of CMD_EXT set contains block_address
• 2nd, 3rd and 4th byte of CMD_EXT set contains dummy data
• in 5th to 20th byte of the set are placed the data for writing into the data block
• 21st byte contains checksum

PK_AUTH1x:

• CMD_Par1 is not used.
• 1st byte of CMD_EXT set contains block_address
• 2nd, 3rd and 4th byte CMD_EXT set contains dummy data
• array from 5th to 10th byte contains 6-byte key.
• in 11th too 26th byte are placed the data for writing into the data block
• 27th byte contains checksum.

PK_AUTH1x_AES: (uFR PLUS devices only Mifare Plus tags)

• CMD_Par1 is not used.
• 1st byte of CMD_EXT set contains block_address
• 2nd, 3rd and 4th byte CMD_EXT set contains dummy data
• array from 5th to 20th byte contains 16-byte AES key.
• in 21th too 36th byte are placed the data for writing into the data block
• 37th byte contains checksum.

Mifare Plus using.
For firmware versions from 5.0.1 to 5.0.28 in RKA_AUTH1x or AKMy_AUTH1x mode uses AES key from reader AES keys space (index 0 - 15).
For firmware versions from 5.0.29 in RKA_AUTH1x or AKMy_AUTH1x mode uses AES key which calculated from reader Crypto1 key (indec 0 - 31).
Firmware versions from 5.0.29

MFP_RKA_AUTH1x:

• CMD_Par1 in CMD set contains readers index key
• 1st byte of CMD_EXT set contains block_address
• 2nd, 3rd and 4th byte of CMD_EXT set contains dummy data
• in 5th to 20th byte of set are placed data for writing into the data block

• 21st byte contains checksum

MFP_AKMy_AUTH1x:

• CMD_Par1 is not used.
• 1st byte of CMD_EXT set contains block_address
• 2nd, 3rd and 4th byte of CMD_EXT set contains dummy data
• in 5th to 20th byte of the set are placed the data for writing into the data block
• 21st byte contains checksum

SAM_KEY_AUTH1x: (uFR CS with SAM and firmware versions 5.100.xx)

• CMD_Par1 in CMD set contains key index in the SAM (0 - 127)
• 1st byte of CMD_EXT set contains block_address
• 2nd, 3rd and 4th byte of CMD_EXT set contains dummy data
• in 5th to 20th byte of set are placed data for writing into the data block
• 21st byte contains checksum

If everything is done as it should device answer with RSP packet.

Example:

write “01 02 03 04 05 06 07 08” into block 1 using key “FF FF FF FF FF FF”

```
CMD         55 17 AA 1B 60 00 9A
ACK         AC 17 CA 1B 60 00 11

CMD_EXT     01 00 00 00 FF FF FF FF FF FF 01 02 03 04 05 06 07 08 00 00 00
00 00
            00 00 00 10
RSP         DE 17 ED 00 00 00 2B
```

BLOCK_IN_SECTOR_READ (0x18)

It has the same function as the BLOCK_READ but uses the different address mode for so called sector addressing where is always given the address of the sector and the sector block (as specified in the NXP documentation for Mifare Classic cards). The first sector of the Mifare Classic 1k card for example has the address 0 and the last one has 15. The block addresses of the sector are defined in the interval from 0 to 3 (3rd block of each sector is sector trailer) excluding Mifare Classic 4k cards for which in its second line of address space (the second 2k that is 32nd up to 39th sector) have the block addresses in sector 0 to 15 and the 15th is sector trailer.

Communication command protocol is the same as with BLOCK_READ with following exception:

• 1st byte of the CMD_EXT set contains block_in_sector_address
• 2nd byte of the CMD_EXT set contains sector_address
• 3rd and 4th byte of the CMD_EXT set contains dummy data

Example:

read block 0 in sector 0 with RKA_AUTH1A, key number 0

```
CMD         55 18 AA 05 00 00 E9
ACK         AC 18 CA 05 00 00 82

CMD_EXT     00 00 00 00 07

RSP         DE 18 ED 11 00 00 41
RSP_EXT     47 8F 90 61 39 08 04 00 01 F1 0A F0 1A A2 EB 1D 4F
```

BLOCK_IN_SECTOR_WRITE (0x19)

Has the same function as the BLOCK_WRITE but uses the different address mode, so called sector addressing where the sector address and the address of the block in the sector is always given (as mentioned in NXP documentation for Mifare Classic cards). For example the first sector on Mifare Classic 1k card has the address 0 and the last one has the address 15. The block addresses in sector are in the interval from 0 to 3 (3rd block of each sector is sector trailer) excluding Mifare Classic 4k cards for which in its second line of address space (the second 2k that is 32nd up to 39th sector) have the block addresses in sector 0 to 15 and the 15th is sector trailer. Communication command protocol is the same as with BLOCK_WRITE with following exception:

- 1st byte of CMD_EXT set contains block_in_sector_address
- 2nd byte of CMD_EXT set contains sector_address
- 3rd and 4th byte of CMD_EXT set contains dummy data

Example:

write block 1 in sector 0 with RKA_AUTH1A, key number 0

```
CMD         55 19 AA 15 00 00 FA
ACK         AC 19 CA 15 00 00 71
CMD_EXT     01 00 00 00 00 00 00 00 00 00 FF 07 80 69 FF FF FF FF FF FF 17
RSP         DE 19 ED 00 00 00 31
```

LINEAR DATA MANIPULATION COMMANDS

LINEAR_READ (0x14)

Linear read data from the card. This command concatenates data for successive blocks and sectors into one array of data. It performs something like “continuous reading” of data. It is very convenient for reading data from more blocks or sectors which are in successive order.

uFR PLUS only Mifare Plus tags support. In security level 3 for Mifare Plus tags, multi sector authentication can be used to optimize the performance and minimize the number of authentications. AES keys for sectors which contains blocks for linear read, must be equal. Then you can use a multi block read with authentication for first sector only.

The CMD_EXT set is used whose length depends on the mode of authentication that is used.

CMD_Par0 contains AUTH_MODE.
Depending on AUTH_MODE, CMD and CMD_EXT sets contains:

RKA_AUTH1x:

• CMD_Par1 in CMD set contains key index in the reader
• 1st and 2nd byte of CMD_EXT set contains linear_address (little endian)
• 3rd and 4th byte of CMD_EXT set contains data_length (little endian)
• 5th byte contains checksum

Example:

Read linear data from 0 to 63, length is 64 bytes, using RK AUTH1A

```
CMD         55 14 AA 05 00 00 F5
ACK         AC 14 CA 05 00 00 7E

CMD_EXT     00 00 40 00 47
RSP         DE 14 ED 41 00 00 6D

and DATA we asked for in RSP_EXT

31 32 33 34 35 36 37 38 39 30 00 00 00 00 00 31
32 33 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00

With checksum
38
```

AKMy_AUTH1x:

• CMD_Par1 is not used.
• 1st and 2nd byte of CMD_EXT set contains linear_address (little endian)
• 3rd and 4th byte of CMD_EXT set contains data_length (little endian)
• 5th byte contains checksum

Example: Read linear data from 0 to 31, length is 32 bytes, using AKM1 AUTH1A

```
CMD         55 14 AA 05 20 00 D5
ACK         AC 14 CA 05 20 00 5E

CMD_EXT     00 00 20 00 27
RSP         DE 14 ED 21 00 00 0D

and DATA we asked for in RSP_EXT
31 32 33 34 35 36 37 38 39 30 00 00 00 00 00 31
32 33 00 00 00 00 00 00 00 00 00 00 00 00 00 00

With checksum
38
```

Example: Read linear data from 0 to 31, length is 32 bytes, using AKM1 AUTH1B

```
CMD         55 14 AA 05 21 00 D6
ACK         AC 14 CA 05 21 00 5D

CMD_EXT     00 00 20 00 27
RSP         DE 14 ED 21 00 00 0D

and DATA we asked for in RSP_EXT

31 32 33 34 35 36 37 38 39 30 00 00 00 00 00 31
32 33 00 00 00 00 00 00 00 00 00 00 00 00 00 00

With checksum
38
```

Same applies to AKM2 AUTHA and AUTHB commands.

PK_AUTH1x:

• CMD_Par1 is not used.
• 1st and 2nd byte of CMD_EXT set contains linear_address (little endian)
• 3rd and 4th byte of CMD_EXT set contains data_length (little endian)
• array from 5th to 10th byte contains 6-byte key.
• 11th byte contains checksum.

Example: Read linear data from 16 to 31, length is 16 bytes, using PK AUTH1B and provided key 6 x FF

```
CMD         55 14 AA 0B 61 00 88
ACK         AC 14 CA 0B 61 00 1F

CMD_EXT     10 00 10 00 FF FF FF FF FF FF 07
RSP         DE 14 ED 11 00 00 3D

and DATA we asked for in RSP_EXT

32 33 00 00 00 00 00 00
00 00 00 00 00 00 00 00

with checksum
08
```

SAM_KEY_AUTH1x: (uFR CS with SAM and firmware versions 5.100.xx)

• CMD_Par1 in CMD set contains key index in the SAM (1 - 127)
• 1st and 2nd byte of CMD_EXT set contains linear_address (little endian)
• 3rd and 4th byte of CMD_EXT set contains data_length (little endian)
• 5th byte contains checksum

If everything operates as expected the RSP packet is sent and after that also the RSP_EXT with number of bytes according to the data_length command with checksum at the end.
In case the card is removed from the field or in case of wrong authentication including that some block is read anyway, it turns ERR set with NO_CARD error code or AUTH_ERROR and then the ERR_EXT set which contains the array of the read bytes and CHECKSUM at the end.

LINEAR_READ command utilise FAST_READ ISO 14443-3 command with NTAG21x and Mifare Ultralight EV1 tags.

uFR PLUS devices only. Mifare Plus tags. Firmware versions from 5.0.1 to 5.0.28

RKA_AUTH1x:

• CMD_Par1 in CMD set contains AES key index in the reader (0 - 15)
• 1st and 2nd byte of CMD_EXT set contains linear_address (little endian)
• 3rd and 4th byte of CMD_EXT set contains data_length to 192 bytes (little endian)
• 5th and 6th byte of CMD_EXT set contains true data length if data length bigger than 192 bytes (little endian)
• 7th byte contains checksum
• For reasons of compatibility there is expected Error packet with Error code MFP_MULTI_BLOCKS_READ = 0xB9
• Reading the data is specific and is done in a loop. Reads one data, and if it is 0, then reads another that indicates how much data follows in the package. This is repeated until the required amount of data read. If the first data is different from 0, then loop stops.
• RSP_EXT not in use

PK_AUTH1x_AES:

• CMD_Par1 is not used.
• 1st and 2nd byte of CMD_EXT set contains linear_address (little endian)
• 3rd and 4th byte of CMD_EXT set contains data_length (little endian)
• array from 5th to 20th byte contains 16-byte key.
• 21st byte contains checksum.
• For reasons of compatibility there is expected Error packet with Error code MFP_MULTI_BLOCKS_READ = 0xB9
• Reading the data is specific and is done in a loop. Reads one data, and if it is 0, then reads another that indicates how much data follows in the package. This is repeated until the required amount of data read. If the first data is different from 0, then loop stops.
• RSP_EXT not in use

Example:

Read linear data from 0 - 299, length = 300. AES key is 16 x 0xFF

```
CMD         55 14 AA 17 81 00 84
ACK         AC 14 CA 17 81 00 EB
CMD_EXT     00 00 B8 00 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF
            2C 01 9C

ERR         EC B9 CE 00 FF FF A2

DATA        00 30 41 53 43 49 20 74 65 78 74 20 72 65 61 64 69 6E
            67 20 74 65 73 74 00 00 00 00 00 00 00 00 00 00
            00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
```

```
         00 30 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
         00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
         00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00

         00 30 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
         00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
         00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00

         00 30 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
         00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
         00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00

         00 20 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
         00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00

         00 30 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
         00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
         00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00

         00 1C 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
         00 00 00 00 00 00 00 00 00 00 00 00

         DD (OK)

RSP      DE 14 ED 00 00 00 2E
```

SAM_KEY_AUTH1x: (uFR CS with SAM and firmware versions 5.100.xx)

• CMD_Par1 in CMD set contains key index in the
• 1st and 2nd byte of CMD_EXT set contains linear_address (little endian)
• 3rd and 4th byte of CMD_EXT set contains data_length to 192 bytes (little endian)
• 5th and 6th byte of CMD_EXT set contains true data length if data length bigger than 192 bytes (little endian)
• 7th byte contains checksum
• For reasons of compatibility there is expected Error packet with Error code MFP_MULTI_BLOCKS_READ = 0xB9
• Reading the data is specific and is done in a loop. Reads one data, and if it is 0, then reads another that indicates how much data follows in the package. This is repeated until the required amount of data read. If the first data is different from 0, then loop stops.
• RSP_EXT not in use

For firmware versions from 5.0.29
In RKA_AUTH1x or AKMy_AUTH1x mode, commands are used in the same manner as for Mifare Classic card. AES key calculated from Crypto1 reader key (index 0 - 31).

MFP_RKA_AUTH1x:

• CMD_Par1 in CMD set contains AES key index in the reader (0 - 15)

• 1st and 2nd byte of CMD_EXT set contains linear_address (little endian)
• 3rd and 4th byte of CMD_EXT set contains data_length to 192 bytes (little endian)
• 5th and 6th byte of CMD_EXT set contains true data length if data length bigger than 192 bytes (little endian)
• 7th byte contains checksum
• For reasons of compatibility there is expected Error packet with Error code MFP_MULTI_BLOCKS_READ = 0xB9
• Reading the data is specific and is done in a loop. Reads one data, and if it is 0, then reads another that indicates how much data follows in the package. This is repeated until the required amount of data read. If the first data is different from 0, then loop stops.
• RSP_EXT not in use

MFP_AKMy_AUTH1x:
• CMD_Par1 is not used.
• 1st and 2nd byte of CMD_EXT set contains linear_address (little endian)
• 3rd and 4th byte of CMD_EXT set contains data_length (little endian)
• 5th byte contains checksum

LINEAR_WRITE (0x15)

Linear data writing into the card which is currently in the field of the reader. The verification of each written block is done during the writing.

The CMD_EXT set is used and its length depends on the authentication mode that is used

CMD_Par0 contains AUTH_MODE.

Depending on AUTH_MODE, CMD and CMD_EXT sets contains:

RKA_AUTH1x:
• CMD_Par1 in CMD set contains key index in the reader
• 1st and 2nd byte of CMD_EXT set contains linear_address (little endian)
• 3rd and 4th byte of CMD_EXT set contains data_length (little endian)
• from 5th byte up (data_length + 4) contains data array for writing
• (data_length + 5) byte contains checksum

Example: Write 8 bytes into card string at linear address 08, using RK_AUTH1A, bytes are 10 11...17

```
CMD         55 15 AA 0D 00 00 EE
ACK         AC 15 CA 0D 00 00 85

CMD_EXT     08 00 08 00 10 11 12 13 14 15 16 17 07
RSP         DE 15 ED 00 00 00 2D
```

We can check now if bytes are written using previous examples of LinearRead command.

AKMy_AUTH1x:

• CMD_Par1 is not used.
• 1st and 2nd byte of CMD_EXT set contains linear_address (little endian)
• 3rd and 4th byte of CMD_EXT set contains data_length (little endian)
• from 5th byte up (data_length + 4) contains data array for writing
• (data_length + 5) byte contains checksum

PK_AUTH1x:

• CMD_Par1 is not used.
• 1st and 2nd byte of CMD_EXT set contains linear_address (little endian)
• 3rd and 4th byte of CMD_EXT set contains data_length (little endian)
• array from 5th to 10th byte contains 6- byte key
• 11th byte and up to (data_length + 10) contains data array for writing
• (data_length + 11) byte contains checksum.

uFR PLUS devices only. Mifare Plus tags. Firmware versions from 5.0.1 to 5.0.28.

PK_AUTH1x_AES:

• CMD_Par1 is not used.
• 1st and 2nd byte of CMD_EXT set contains linear_address (little endian)
• 3rd and 4th byte of CMD_EXT set contains data_length (little endian)
• array from 5th to 20th byte contains 16- byte key
• 21st byte and up to (data_length + 20) contains data array for writing
• (data_length + 21) byte contains checksum.

SAM_KEY_AUTH1x: (uFR CS with SAM and firmware versions 5.100.xx)

• CMD_Par1 in CMD set contains key index in the SAM
• 1st and 2nd byte of CMD_EXT set contains linear_address (little endian)
• 3rd and 4th byte of CMD_EXT set contains data_length (little endian)
• from 5th byte up (data_length + 4) contains data array for writing
• (data_length + 5) byte contains checksum

If everything went as expected device answer with RSP packet.
In error case it turns the ERR packet where the RSP_Val0 contains the number of eventual written bytes.

For firmware versions from 5.0.29
In RKA_AUTH1x or AKMy_AUTH1x mode, commands are used in the same manner as for Mifare Classic card. AES key calculated from Crypto1 reader key (index 0 - 31).

MFP_RKA_AUTH1x:

• CMD_Par1 in CMD set contains AES key index in the reader

• 1st and 2nd byte of CMD_EXT set contains linear_address (little endian)
• 3rd and 4th byte of CMD_EXT set contains data_length (little endian)
• from 5th byte up (data_length + 4) contains data array for writing
• (data_length + 5) byte contains checksum

MFP_AKMy_AUTH1x:
• CMD_Par1 is not used.
• 1st and 2nd byte of CMD_EXT set contains linear_address (little endian)
• 3rd and 4th byte of CMD_EXT set contains data_length (little endian)
• from 5th byte up (data_length + 4) contains data array for writing
• (data_length + 5) byte contains checksum

LINEAR_FORMAT_CARD (0x25)

The CMD_EXT set is used and its length depends on the authentication mode that is used.
Since this command can erase data or block card reading if wrong access bits are provided, we strongly suggest to test it first through SDK API examples to figure out what this command does.
For pure erasing data or filling card with 0x00 without changing the keys, it is much easier to use Linear_Write command.

Usage:
CMD_Par0 contains AUTH_MODE.
Depending on AUTH_MODE, CMD and CMD_EXT set contains:

RKA_AUTH1x:
• CMD_Par1 in CMD set contains readers index key
• 1st byte of the set contains access bits value for blocks in sector
• 2nd byte of the set contains access bits value for sector trailers
• 3rd byte of the set contains dummy value
• 4th byte of the set has 9-byte sector trailer value (anything could be written)
• in 5th to 10th byte of the set is new key A
• in 11th to 16th byte of the set is new key B
• 17th byte contains checksum

AKMy_AUTH1x:
• CMD_Par1 is not used.
• 1st byte of the set contains access bits value for blocks in sector
• 2nd byte of the set contains access bits value for sector trailers
• 3rd byte of the set contains dummy value
• 4th byte of the set has 9-byte sector trailer value (anything could be written)
• in 5th to 10th byte of the set is new key A
• in 11th to 16th byte of the set is new key B
• 17th byte contains checksum

PK_AUTH1x:

• CMD_Par1 is not used.
• 1st byte of the set contains access bits value for blocks in sector
• 2nd byte of the set contains access bits value for sector trailers
• 3rd byte of the set contains dummy value
• 4th byte of the set has 9-byte sector trailer value (anything could be written)
• array from 5th up to 10th byte contains 6-byte key for authentication (previous)
• in 11th to 16th byte of the set is new key A
• in 17th to 22nd byte of the set is new key B
• 23rd byte contains checksum

If everything is done as it should device answer with RSP packet.
RSP_EXT is not used.

Example:

Key A is 0xFFFFFFFFFFFF, Key B is 0xFFFFFFFFFFFF, access bits value for blocks is 0, access bits value for sector trailers is 1, authentication mode is RKA_AUTH1A, key number is 0

```
CMD         55 25 AA 11 00 00 D2
ACK         AC 25 CA 11 00 00 59
CMD_EXT     00 01 00 69 FF FF FF FF FF FF FF FF FF FF FF FF 6F
RSP         DE 25 ED 00 10 00 0D
```

Mifare Plus using.
Firmware versions from 5.0.29.
In RKA_AUTH1x or AKMy_AUTH1x or PK_AUTH1x mode, commands are used in the same manner as for Mifare Classic card. AES key for authentication calculated from Crypto1 reader key (index 0 - 31) or provided Crypto1 key. New AES key A and key B are calculate from provided Crypto1 keys. 4K card formatting is about 10 seconds, so it is periodically sent keep alive frame, before response frame.

```
CMD         55 25 AA 11 00 00 D2
ACK         AC 25 CA 11 00 00 59
CMD_EXT     00 01 00 69 FF FF FF FF FF FF FF FF FF FF FF FF 6F
KEEP_ALIVE A1 25 85 00 00 00 08
…
KEEP_ALIVE A1 25 85 00 00 00 08
RSP         DE 25 ED 00 10 00 0D
```

MFP_RKA_AUTH1x:

• CMD_Par1 in CMD set contains readers index key
• 1st byte of the set contains access bits value for blocks in sector
• 2nd byte of the set contains access bits value for sector trailers
• 3rd byte of the set contains dummy value
• 4th byte of the set has 9-byte sector trailer value (anything could be written)
• in 5th to 10th byte of the set are first 6 bytes of new AES key A

• in 11th to 16th byte of the set are first 6 bytes of new AES key B
• in 17th to 26th bytes of the set are last 10 bytes of new AES key A
• in 27th to 36th bytes of the set are last 10 bytes of new AES key B
• 37th byte contains checksum

MFP_AKMy_AUTH1x:

• CMD_Par1 is not used.
• 1st byte of the set contains access bits value for blocks in sector
• 2nd byte of the set contains access bits value for sector trailers
• 3rd byte of the set contains dummy value
• 4th byte of the set has 9-byte sector trailer value (anything could be written)
• in 5th to 10th byte of the set are first 6 bytes of new AES key A
• in 11th to 16th byte of the set are first 6 bytes of new AES key B
• in 17th to 26th bytes of the set are last 10 bytes of new AES key A
• in 27th to 36th bytes of the set are last 10 bytes of new AES key B
• 37th byte contains checksum

PK_AUTH1x_AES:

• CMD_Par1 is not used.
• 1st byte of the set contains access bits value for blocks in sector
• 2nd byte of the set contains access bits value for sector trailers
• 3rd byte of the set contains dummy value
• 4th byte of the set has 9-byte sector trailer value (anything could be written)
• array from 5th up to 20th byte contains 16-byte AES key for authentication (previous)
• in 21th to 26th byte of the set are first 6 bytes of new AES key A
• in 27th to 32nd byte of the set are first 6 bytes of new AES key B
• in 33rd to 42nd bytes of the set are last 10 bytes of new AES key A
• in 43rd to 52nd bytes of the set are last 10 bytes of new AES key B
• 53rd byte contains checksum

LIN_ROW_READ(0x45)

Functions allow you to quickly read data from the card including the sector trailer blocks.
These functions are very similar to the functions for linear reading of users data space. Using this command is the same as using the command LINEAR_READ(0x14)

The CMD_EXT set is used whose length depends on the mode of authentication that is used.
CMD_Par0 contains AUTH_MODE.
Depending on AUTH_MODE, CMD and CMD_EXT sets contains:

RKA_AUTH1x:

• CMD_Par1 in CMD set contains key index in the
• 1st and 2nd byte of CMD_EXT set contains linear_address (little endian)
• 3rd and 4th byte of CMD_EXT set contains data_length (little endian)

• 5th byte contains checksum

AKMy_AUTH1x:

• CMD_Par1 is not used.
• 1st and 2nd byte of CMD_EXT set contains linear_address (little endian)
• 3rd and 4th byte of CMD_EXT set contains data_length (little endian)
• 5th byte contains checksum

PK_AUTH1x:

• CMD_Par1 is not used.
• 1st and 2nd byte of CMD_EXT set contains linear_address (little endian)
• 3rd and 4th byte of CMD_EXT set contains data_length (little endian)
• array from 5th do 10th byte contains 6-byte key.
• 11th byte contains checksum.

Example:

Read data from 0 to 47, length is 48 bytes, using RK AUTH1A key number 0

```
CMD         55 45 AA 05 00 00 C6
ACK         AC 45 CA 05 00 00 2D
CMD_EXT     00 00 30 00 37
RSP         DE 45 ED 31 00 00 4E
RSP_EXT     47 8F 90 61 39 08 04 00 01 F1 0A F0 1A A2 EB 1D 00 00 00 00 00
00 FF
            07 80 69 FF FF FF FF FF FF 00 00 00 00 00 00 FF 07 80 69 FF FF
FF FF
            FF FF 4F
```

VALUE BLOCK MANIPULATION COMMANDS

From firmware version 5.0.36. Mifare Plus X, SE or EV1 value block manipulation support.

DIRECT BLOCK ADDRESSING

VALUE_BLOCK_READ (0x1D)

Reads the 4-byte value of the “value block” of the card which is currently in the reading field. Address mode that is used is so called block addressing where for example the first block of Mifare Classic 1k card has the address 0 and the last one has the address 63.

The CMD_EXT set is used and its length depends on the authentication mode that is used. CMD_Par0 contains AUTH_MODE.

Depending on AUTH_MODE, CMD and CMD_EXT set contains:

RKA_AUTH1x:

• CMD_Par1 in CMD set contains readers index key
• 1st byte of the CMD_EXT set contains block_address
• 2nd, 3rd and 4th byte of the CMD_EXT set contains dummy data
• 5th byte contains checksum

AKMy_AUTH1x:

• CMD_Par1 is not used.
• 1st byte of the CMD_EXT set contains block_address
• 2nd, 3rd and 4th byte of the CMD_EXT set contains dummy data
• 5th byte contains checksum

PK_AUTH1x:

• CMD_Par1 is not used.
• 1st byte of the CMD_EXT set contains block_address
• 2nd, 3rd and 4th byte of the CMD_EXT set contains dummy data
• array from 5th to 10th byte contains 6-byte key.
• 11th byte contains checksum

SAM_KEY_AUTH1x: (uFR CS with SAM and firmware versions 5.100.xx)

• CMD_Par1 in CMD set contains key index in the SAM
• 1st byte of the CMD_EXT set contains block_address
• 2nd, 3rd and 4th byte of the CMD_EXT set contains dummy data
• 5th byte contains checksum

Mifare Plus using. Firmware version from 5.0.36

PK_AUTH1x_AES: (FR PLUS devices only Mifare Plus tags)

• CMD_Par1 is not used.
• 1st byte of CMD_EXT set contains block_address
• 2nd, 3rd and 4th byte of CMD_EXT set contains dummy data
• array from 5th to 20th byte contains 16-byte AES key.
• 21st byte contains checksum

For firmware versions from 5.0.1 to 5.0.28 in RKA_AUTH1x or AKMy_AUTH1x mode uses AES key from reader AES keys space (index 0 - 15).
For firmware versions from 5.0.29 in RKA_AUTH1x or AKMy_AUTH1x mode uses AES key which calculated from reader Crypto1 key (indec 0 - 31).
Firmware versions from 5.0.29

MFP_RKA_AUTH1x:

• CMD_Par1 in CMD set contains AES key index in the reader (0 -15)
• 1st byte of CMD_EXT set contains block_address
• 2nd, 3rd and 4th byte of CMD_EXT set contains dummy data
• 5th byte contains checksum

MFP_AKMy_AUTH1x:

• CMD_Par1 is not used.
• 1st byte of CMD_EXT set contains block_address
• 2nd, 3rd and 4th byte of CMD_EXT set contains dummy data
• 5th byte contains checksum

If everything is OK, device answer with RSP packet followed by RSP_EXT containing 4-byte value and checksum.
RSP_Val0 contains block address (read from block value for powerful backup as mentioned in the Mifare card documentation).
In the case of error the VALUE_BLOCK_ADDR_INVALID (read value of the value block is formatted properly but the address bytes aren't) it returns ERR_EXT set which contains the value of the value block.

Notice that value is in little-endian notation, where negative values are stored as "Two complement's".

Example:

Read Value Block 05 with PK_AUTH1A:

```
CMD         55 1D AA 0B 60 00 90
ACK         AC 1D CA 0B 60 00 17

CMD_EXT     05 00 00 00 FF FF FF FF FF FF 0C
RSP         DE 1D ED 05 00 00 32
RSP_EXT     00 00 00 00 07
```

VALUE_BLOCK_WRITE (0x1E)

Store 4-byte value into "value block".

This command disallow the writing into the trailers of the sector and in case of their addressing it returns the FORBIDEN_DIRECT_WRITE_IN_SECTOR_TRAILER.

The CMD_EXT set is used and its length depends on the authentication mode that is used.

CMD_Par0 contains AUTH_MODE.

Depending on AUTH_MODE, CMD and CMD_EXT set contains:

RKA_AUTH1x:

• CMD_Par1 in CMD set contains readers index key
• 1st byte of the CMD_EXT set contains block_address
• 2nd and 3rd byte of the CMD_EXT set contains dummy data
• 4th byte contains value address
• in 5th to 8th byte of the set is placed the data for writing into the value block

• 9th byte contains checksum

AKMy_AUTH1x:

• CMD_Par1 is not used.
• 1st byte of the CMD_EXT set contains block_address
• 2nd and 3rd byte of the CMD_EXT set contains dummy data
• 4th byte contains value address
• in 5th to 8th byte of the set is placed the data for writing into the value block
• 9th byte contains checksum

PK_AUTH1x:

• CMD_Par1 is not used.
• 1st byte of the CMD_EXT set contains block_address
• 2nd and 3rd byte of the CMD_EXT set contains dummy data
• 4th byte contains value address
• array from 5th up to 10th byte contains 6-byte key.
• in 11th to 14th byte of the set is placed the data for writing into the value block
• 15th byte contains checksum

Example: Store value 01 01 01 01 into block 5 using PK_AUTH1A key FF FF FF FF FF FF

```
CMD         55 1E AA 0F 60 00 95
ACK         AC 1E CA 0F 60 00 1E

CMD_EXT     05 00 00 05 FF FF FF FF FF FF 01 01 01 01 07
RSP         DE 1E ED 00 00 00 34 DE
```

SAM_KEY_AUTH1x: (uFR CS with SAM and firmware versions 5.100.xx)

• CMD_Par1 in CMD set contains key index in the SAM
• 1st byte of the CMD_EXT set contains block_address
• 2nd and 3rd byte of the CMD_EXT set contains dummy data
• 4th byte contains value address
• in 5th to 8th byte of the set is placed the data for writing into the value block
• 9th byte contains checksum

Mifare Plus using. Firmware version from 5.0.36

PK_AUTH1x_AES: (FR PLUS devices only Mifare Plus tags)

• CMD_Par1 is not used.
• 1st byte of the CMD_EXT set contains block_address
• 2nd and 3rd byte of the CMD_EXT set contains dummy data
• 4th byte contains value address
• array from 5th up to 20th byte contains 16-byte key.
• in 21st to 24th byte of the set is placed the data for writing into the value block
• 25th byte contains checksum

For firmware versions from 5.0.1 to 5.0.28 in RKA_AUTH1x or AKMy_AUTH1x mode uses AES

key from reader AES keys space (index 0 - 15).
For firmware versions from 5.0.29 in RKA_AUTH1x or AKMy_AUTH1x mode uses AES key which calculated from reader Crypto1 key (indec 0 - 31).
Firmware versions from 5.0.29

MFP_RKA_AUTH1x:

- CMD_Par1 in CMD set contains AES key index in the reader (0 -15)
- 1st byte of the CMD_EXT set contains block_address
- 2nd and 3rd byte of the CMD_EXT set contains dummy data
- 4th byte contains value address
- in 5th to 8th byte of the set is placed the data for writing into the value block
- 9th byte contains checksum

MFP_AKMy_AUTH1x:

- CMD_Par1 is not used.
- 1st byte of the CMD_EXT set contains block_address
- 2nd and 3rd byte of the CMD_EXT set contains dummy data
- 4th byte contains value address
- in 5th to 8th byte of the set is placed the data for writing into the value block
- 9th byte contains checksum

If everything is OK, device answer with RSP packet. RSP_EXT is not used.

Notice that value is in little-endian notation, where negative values are stored as “Two complement's”. For example, decimal value 65535 should be stored as FF FF 00 00.

VALUE_BLOCK_INC (0x21)

It increases the value of the addressed value block for the 4-byte value increment_val that is send as a command parameter and is been used for so-called block address mode.

The CMD_EXT set is used and its length depends on the authentication mode that is used.

CMD_Par0 contains AUTH_MODE.

Depending on AUTH_MODE, CMD and CMD_EXT set contains:

RKA_AUTH1x:

- CMD_Par1 in CMD set contains readers index key
- 1st byte of the CMD_EXT set contains block_address
- 2nd, 3rd and 4th byte of the CMD_EXT set contains dummy data
- in 5th to 8th byte set is increment_val
- 9th byte contains checksum

AKMy_AUTH1x:

• CMD_Par1 is not used.
• 1st byte of the CMD_EXT set contains block_address
• 2nd, 3rd and 4th byte of the CMD_EXT set contains dummy data
• in 5th to 8th byte set is increment_val
• 9th byte contains checksum

PK_AUTH1x:

• CMD_Par1 is not used.
• 1st byte of the CMD_EXT set contains block_address
• 2nd, 3rd and 4th byte of the CMD_EXT set contains dummy data
• array from 5th up to 10th byte contains 6-byte key
• in 11th to 14th bytes of the set is increment_val
• 15th byte contains checksum.

SAM_KEY_AUTH1x: (uFR CS with SAM and firmware versions 5.100.xx)

• CMD_Par1 in CMD set contains key index into SAM
• 1st byte of the CMD_EXT set contains block_address
• 2nd, 3rd and 4th byte of the CMD_EXT set contains dummy data
• in 5th to 8th byte set is increment_val
• 9th byte contains checksum

Mifare Plus using. Firmware version from 5.0.36

PK_AUTH1x_AES: (FR PLUS devices only Mifare Plus tags)

• CMD_Par1 is not used.
• 1st byte of the CMD_EXT set contains block_address
• 2nd, 3rd and 4th byte of the CMD_EXT set contains dummy data
• array from 5th up to 20th byte contains 16-byte key.
• in 21st to 24th byte of the set is increment_val
• 25th byte contains checksum

For firmware versions from 5.0.1 to 5.0.28 in RKA_AUTH1x or AKMy_AUTH1x mode uses AES key from reader AES keys space (index 0 - 15).
For firmware versions from 5.0.29 in RKA_AUTH1x or AKMy_AUTH1x mode uses AES key which calculated from reader Crypto1 key (indec 0 - 31).
Firmware versions from 5.0.29

MFP_RKA_AUTH1x:

• CMD_Par1 in CMD set contains AES key index in the reader (0 -15)
• 1st byte of the CMD_EXT set contains block_address
• 2nd, 3rd and 4th byte of the CMD_EXT set contains dummy data
• in 5th to 8th byte of the set is increment_val
• 9th byte contains checksum

MFP_AKMy_AUTH1x:

• CMD_Par1 is not used.
• 1st byte of the CMD_EXT set contains block_address
• 2nd, 3rd and 4th byte of the CMD_EXT set contains dummy data
• in 5th to 8th byte of the set is increment_val
• 9th byte contains checksum

If everything is OK, device answer with RSP packet. RSP_EXT packet is not used.

Example:

Increase Value Block 5 with "F0 F0 F0 F0" using PK_AUTH1A with key FF FF FF FF FF FF

```
CMD         55 21 AA 0F 60 00 B8
ACK         AC 21 CA 0F 60 00 2F

CMD_EXT     05 00 00 00 FF FF FF FF FF FF F0 F0 F0 F0 0C
RSP         DE 21 ED 00 00 00 19 DE
```

Notice that when we read now Value Block 5 we will get
RSP and RSP_EXT DE 1D ED 05 05 00 35 F1 F1 F1 71 87,
with value F1 F1 F1 71, stored in little-endian notation, where byte 71 is represented in Two Complement's manner (change of sign +/-).

VALUE_BLOCK_DEC (0x22)

Decrement the value of the addressed value block for 4-byte value decrement_val which is sent as the command parameter. The so-called block address mode is used.

The CMD_EXT set is used and the length of the authentication mode is used.

CMD_Par0 contains AUTH_MODE.

Depending on AUTH_MODE, CMD and CMD_EXT set contains:

RKA_AUTH1x:

• CMD_Par1 in CMD set contains readers index key
• 1st byte of the CMD_EXT set contains block_address
• 2nd, 3rd and 4th byte CMD_EXT set contains dummy data
• in 5th to 8th byte of the set is decrement_val
• 9th byte contains checksum

AKMy_AUTH1x:

• CMD_Par1 is not used.
• 1st byte of the CMD_EXT set contains block_address
• 2nd, 3rd and 4th byte CMD_EXT set contains dummy data

• in 5th to 8th byte of the set is decrement_val
• 9th byte contains checksum

PK_AUTH1x:

• CMD_Par1 is not used.
• 1st byte of the CMD_EXT set contains block_address
• 2nd, 3rd and 4th byte of the CMD_EXT set contains dummy data
• array from 5th up to 10th byte contains 6-byte key.
• in 11th to 14th byte of the set is decrement_val
• 15th byte contains checksum.

SAM_KEY_AUTH1x: (uFR CS with SAM and firmware versions 5.100.xx)

• CMD_Par1 in CMD set contains key index into SAM (1 - 127)
• 1st byte of the CMD_EXT set contains block_address
• 2nd, 3rd and 4th byte CMD_EXT set contains dummy data
• in 5th to 8th byte of the set is decrement_val
• 9th byte contains checksum

Mifare Plus using. Firmware version from 5.0.36

PK_AUTH1x_AES: (FR PLUS devices only Mifare Plus tags)

• CMD_Par1 is not used.
• 1st byte of the CMD_EXT set contains block_address
• 2nd, 3rd and 4th byte of the CMD_EXT set contains dummy data
• array from 5th up to 20th byte contains 16-byte key.
• in 21st to 24th byte of the set is decrement_val
• 25th byte contains checksum

For firmware versions from 5.0.1 to 5.0.28 in RKA_AUTH1x or AKMy_AUTH1x mode uses AES key from reader AES keys space (index 0 - 15).
For firmware versions from 5.0.29 in RKA_AUTH1x or AKMy_AUTH1x mode uses AES key which calculated from reader Crypto1 key (indec 0 - 31).
Firmware versions from 5.0.29

MFP_RKA_AUTH1x:

• CMD_Par1 in CMD set contains AES key index in the reader (0 -15)
• 1st byte of the CMD_EXT set contains block_address
• 2nd, 3rd and 4th byte of the CMD_EXT set contains dummy data
• in 5th to 8th byte of the set is decrement_val
• 9th byte contains checksum

MFP_AKMy_AUTH1x:

• CMD_Par1 is not used.
• 1st byte of the CMD_EXT set contains block_address

• 2nd, 3rd and 4th byte of the CMD_EXT set contains dummy data
• in 5th to 8th byte of the set is decrement_val
• 9th byte contains checksum

If everything is OK, device answer with RSP packet. RSP_EXT packet is not used

Example:

Decrement Value Block 5 with 00 00 00 F0 using PK_AUTH1A with key FF FF FF FF FF FF

```
CMD         55 22 AA 0F 60 00 B9
ACK         AC 22 CA 0F 60 00 32

CMD_EXT     05 00 00 00 FF FF FF FF FF FF 00 00 00 F0 FC
RSP         DE 22 ED 00 00 00 18
```

Notice that when we read now Value Block 5 we will get

```
RSP and RSP_EXT    DE 1D ED 05 05 00 35    F1 F1 F1 01 F7
```

with value F1 F1 F1 01, stored in little-endian notation, where byte 01 is represented in Two Complement's manner (change of sign +/-).

INDIRECT BLOCK ADDRESSING

VALUE_BLOCK_IN_SECTOR_READ (0x1F)

It operates as VALUE_BLOCK_READ but uses the different address mode, so-called sector addressing where are always given the sector address and the block address in the sector (as mentioned in NXP documentation for Mifare Classic cards).
For example the first sector of the Mifare Classic 1k card has the 0 and the last one has the address 15. Block addresses in the sector are in the interval from 0 to 3 (3rd block of each sector is sector trailer) excluding Mifare Classic 4k cards for which in its second half of address space (second 2k with 32 to 39 sector) the addresses of the blocks in sector 0 to 15 and the block 15 is sector trailer.

Communication command protocol is the same as with VALUE_BLOCK_READ with following exception:

• 1st byte of the CMD_EXT set contains block_in_sector_address
• 2nd byte of the CMD_EXT set contains sector_address
• 3rd and 4th byte of the CMD_EXT set contains dummy data.

Device will answer with RSP and RSP_EXT. RSP_Val0 contains direct block address.

Example:

Read Value Block 01 in Sector 01 (is equal to Value Block 5 using direct addressing) using PK_AUTH1A mode with key FF FF FF FF FF FF

```
CMD         55 1F AA 0B 60 00 92
ACK         AC 1F CA 0B 60 00 19

CMD_EXT     01 01 00 00 FF FF FF FF FF FF 07
RSP         DE 1F ED 05 05 00 33
RSP_EXT     F1 F1 F1 01 F7
```

VALUE_BLOCK_IN_SECTOR_WRITE (0x20)

It operates as VALUE_BLOCK_WRITE but uses different address mode, so-called sector addressing where are always given the sector address and the block address in the sector (as mentioned in NXP documentation for Mifare Classic cards). For example the first sector of the Mifare Classic 1k card has the 0 and the last one has the address 15. Block addresses in the sector are in the interval from 0 to 3 (3rd block of each sector is sector trailer) excluding Mifare Classic 4k cards for which in its second half of address space (second 2k with 32 to 39 sector) the addresses of the blocks in sector 0 to 15 and the block 15 is sector trailer.
Communication command protocol is the same as with VALUE_BLOCK_IN_SECTOR_READ with following exception:

- 1st byte of the CMD_EXT set contains block_in_sector_address
- 2nd byte of the CMD_EXT set contains sector_address
- 3rd and 4th byte of the CMD_EXT set contains dummy data

Example:

Write Value Block 00 in Sector 01 (is equal to Value Block 5 using direct addressing) value “80 80 80 80” using PK_AUTH1A mode with key FF FF FF FF FF FF

```
CMD         55 20 AA 0F 60 00 B7
ACK         AC 20 CA 0F 60 00 30

CMD_EXT     01 01 00 00 FF FF FF FF FF FF 80 80 80 80 07
RSP         DE 20 ED 00 00 00 1A
```

VALUE_BLOCK_IN_SECTOR_INC (0x23)

It operates as VALUE_BLOCK_IN_SECTOR_INC but uses the different address mode, so-called sector addressing where are always given the sector address and the block address in the sector (as mentioned in NXP documentation for Mifare Classic cards). For example the first sector of the Mifare Classic 1k card has the 0 and the last one has the address 15. Block addresses in the sector are in the interval from 0 to 3 (3rd block of each sector is sector trailer) excluding Mifare Classic 4k cards for which in its second half of address space (second 2k with 32 to 39 sector) the addresses of the blocks in sector 0 to 15 and the block 15 is sector trailer.
Communication command protocol is the same as with VALUE_BLOCK_INC with following exception:

- 1st byte of the CMD_EXT set contains block_in_sector_address
- 2nd byte of the CMD_EXT set contains sector_address
- 3rd and 4th byte of the CMD_EXT set contains dummy data.

Example:

```
CMD         55 23 AA 0F 60 00 BA
ACK         AC 23 CA 0F 60 00 31

CMD_EXT     01 01 00 00 FF FF FF FF FF FF 60 60 60 60 07
RSP         DE 23 ED 00 00 00 17
```

VALUE_BLOCK_IN_SECTOR_DEC (0x24)

It operates as VALUE_BLOCK_IN_SECTOR_DEC but uses different address mode, so-called sector addressing where are always given the sector address and the block address in the sector (as mentioned in NXP documentation for Mifare Classic cards). For example the first sector of the Mifare Classic 1k card has the 0 and the last one has the address 15. Block addresses in the sector are in the interval from 0 to 3 (3rd block of each sector is sector trailer) excluding Mifare Classic 4k cards for which in its second half of address space (second 2k with 32 to 39 sector) the addresses of the blocks in sector 0 to 15 and the block 15 is sector trailer.
Communication command protocol is the same as with VALUE_BLOCK_DEC with following exception:

- 1st byte of the CMD_EXT set contains block_in_sector_address
- 2nd byte of the CMD_EXT set contains sector_address
- 3rd and 4th byte of the CMD_EXT set contains dummy data

Example:

```
CMD         55 24 AA 0F 60 00 BB
ACK         AC 24 CA 0F 60 00 34

CMD_EXT     01 01 00 00 FF FF FF FF FF FF 60 60 60 60 07
RSP         DE 24 ED 00 00 00 1E
```

Commands for NFC Type 2 Tags

GET_NFC_T2T_VERSION (0xB0)

supported from firmware version 3.8.19
This command returns 8 bytes of the T2T version. All modern T2T chips support this functionality and have in common a total of 8 byte long version response. This function is primarily intended to use with NFC_T2T_GENERIC tags (i.e. tags for which command GET_DLOGIC_CARD_TYPE returns 0x0C in RSP_Val0).

- CMD_Par0 not in use.
- CMD_Par1 not in use.
  CMD_EXT not in use.

On success:

- RSP_Val0 not in use.
- RSP_Val1 not in use.

RSP_EXT will contain 8 bytes of the T2T version. For exact meaning of this version bytes, you have to consult the card manufacturer's documentation.

If card in field doesn't have originality checking support, returned error code is:
UNSUPPORTED_CARD_TYPE (0x11)

Example:

```
CMD        55 B0 AA 00 AA CC 30
RSP        DE B0 ED 09 00 00 91
RSP_EXT    00 04 04 02 01 00 13 03 1A
```

Commands supporting NFC T2T Counters

READ_COUNTER (0xB1)

supported from firmware version 3.9.11
This function is used to read one of the three 24-bit one-way counters in Ultralight EV1 chip family or to read 24-bit NFC counter in NTAG 213, NTAG 215 and NTAG 216 chips.

Counters in the Ultralight EV1 can't be password protected. NFC counters in NTAG 213, NTAG 215 and NTAG 216 chips can be password protected.

CMD_Par0 contains AUTH_MODE.
AUTH_MODE using with this function can be:
T2T_NO_PWD_AUTH (0x00) {same constant value as RKA_AUTH1A}
T2T_RKA_PWD_AUTH (0x01) {same constant value as RKA_AUTH1B}
T2T_PK_PWD_AUTH (0x61) {same constant value as PK_AUTH1B}

Depending on **AUTH_MODE**, CMD and CMD_EXT set contains:

T2T_NO_PWD_AUTH:

• CMD_Par1 contains **counter address** (For Ultralight EV1: 0, 1 or 2. For NTAG21x: 0).
• CMD_EXT not in use.

T2T_RKA_PWD_AUTH:

• CMD_Par1 in CMD set contains readers index key.
• CMD_EXT not in use.

T2T_PK_PWD_AUTH:

• CMD_Par1 is not used.
• 1st byte of CMD_EXT set contains block_address.
• 2nd, 3rd and 4th byte CMD_EXT set contains dummy data.
• array from 5th to 8th byte contains 4-byte T2T password.
• 9th and 10th byte of CMD_EXT set contains 2-byte PAK (password acknowledge).
• 11th byte contains checksum.

If you issue this command without using password authentication but access to the NFC counter is configured to be password protected, this function will return COUNTER_ERROR.

If access to NFC counter is configured to be password protected and PWD-PACK pair sent as a 6-

byte provided key disagrees with PWD-PACK pair configured in tag, this function will return UFR_AUTH_ERROR. If access to NFC counter isn't configured to be password protected, this function will return UFR_AUTH_ERROR.

Example:

```
CMD         55 B1 AA 00 00 01 56
RSP         DE B1 ED 05 00 00 8E
RSP_EXT     07 00 00 00 0E
```

INCREMENT_COUNTER (0xB2)

supported from firmware version 3.9.11

This command is used to increment one of the three 24-bit one-way counters in Ultralight EV1 chip family. Those counters can't be password protected. If the sum of the addressed counter value and the increment value is higher than 0xFFFFFF, the tag replies with an error and does not update the respective counter.

CMD_Par0 not in use.
CMD_Par1 contains counter address (0, 1 or 2).
CMD_EXT contains 4-byte increment value in little endian format, only the 3 least significant bytes are relevant.
RSP_EXP not in use.

Example:

```
CMD         55 B2 AA 05 00 01 50
ACK         AC B2 CA 05 00 01 D7
CMD_EXT     04 00 00 00 0B
RSP         DE B2 ED 00 00 00 88
```

COMMANDS FOR "ASYNCHRONOUS UID SENDING" FEATURE

This feature "Async UID sending" is capability of reader device to send Card UID immediately when card enters into device RF field, without any action initiated by host. This is also exception from rule that communication is always initiated by host to device. Feature can be turned on and off. Baudrate for this feature is different than baudrate of device,.e.g. it can be different. Prefix and suffix are bytes that are used to diversify UID's, like header and trailer bytes of UID.
Device can send UID encapsulated in [Prefix] and [Suffix] when card enters into RF field.
Device can also send "empty UID" when card leaves RF field, meaning only [Prefix][Suffix] will be sent.
Best practice is to set Baud rate different than device communication speed, anything bigger than 9600 Bps to avoid colision with standard communication between device and host.

On the uFR Zero USB series there is an option to enable USB HID keyboard simulation. It is needed to set the baud rate to 0. For example, if baud rate is setted to any other value than 0, UID is sent to UART, but if it is setted to 0 UID is sent as keyboard simulation.

SET_CARD_ID_SEND_CONF (0x3D)

Set the asynchronously card ID sending parameters.

- CMD_Par0 contains send enable flag (bit 0), prefix enable flag (bit 1) and send removed enable flag (bit2).
- When using option Send removed flag, Prefix byte is mandatory
- 1st byte of the CMD_EXT contains prefix character
- 2nd byte of the CMD_EXT contains suffix character
- array from 3rd byte up to 6th byte of the CMD_EXT contains baud rate value
- 7th byte of the CMD_EXT contains internal CRC (xor of bytes CMD_Par0 to 6th byte + 7)
- 8th byte of the CMD_EXT contains checksum

If everything is OK, device answer with RSP packet. RSP_EXT is not used.

Example:

```
CMD       55 3D AA 08 07 00 D4 (send command 3D, bits 0,1,2 high), D4
checksum
ACK       AC 3D CA 08 07 00 5B (ACK OK)

CMD_EXT   CC EE 80 25 00 00 87 07 (prefix CC, suffix EE, speed 9600
(0x2580),
                                  (87 checksum -
07,00,CC,EE,80,25,00,00),
                                  (07 - checksum of CMD_EXT)
RSP       DE 3D ED 00 00 00 15      (RESPONSE OK)speed 9600 (0x2580),
```

When card enter the field, event will occur:

```
HEX  CC 30 34 32 32 43 33 36 32 34 42 32 44 38 31 EE
ASCII     ?  0  4  2  2  C  3  6  2  4  B  2  D  8  1  ?

meaning card UID is 04 22 C3 62 4B 2D 81
```

On card removal, event will occur:

```
CC EE
```

To disable feature, send bits 0,1,2 low:

```
CMD  55 3D AA 00 00 00 C9
RSP  DE 3D ED 00 00 00 15
```

GET_CARD_ID_SEND_CONF (0x3E)

Get the asynchronously card ID sending parameters.
The CMD_EXT set is not in use.
The CMD_Par0 and CMD_Par1 are not in use.
If everything is OK, device answer with RSP packet and after that also the RSP_EXT packet of 9 bytes.
RSP_Val0 and RSP_Val1 are not in use.

- 1st byte of the RESPONSE_EXT contains send enable flag (bit 0), prefix enable flag (bit 1) and send removed enable flag (bit2).
- 2nd byte of the RESPONSE_EXT contains prefix character
- 3rd byte of the RESPONSE_EXT contains suffix character
- array from 4th byte up to 7th byte of the RESPONSE_EXT contains baud rate value
- 8th byte of the RESPONSE_EXT contains internal CRC
- 9th byte of the RESPONSE_EXT contains checksum

Example:

```
CMD       55 3E AA 00 00 00 C8 (send CMD 3E, C8 checksum)

RSP       DE 3E ED 09 00 00 0B (RSP command 3E, 9 byte follows, 0B
checksum)

RSP_EXT   07 CC EE 80 25 00 00 87 0E (07 -bits 0,1,2 high, CC Prefix, EE
suffix,
                                      speed 9600 (0x2580),
                                      87 – checksum
( 07,CC,EE,80,25,00,00),
                                      0E – checksum of RSP_EXT)
```

COMMANDS FOR WORKS WITH DESFIRE CARDS

For uFR CS with SAM and firmware versions 5.100.xx all types of keys into SAM support added.

For uFR PLUS devices and firmware version from 5.0.25 DES, 2K3DES and 3K3DES key support added.

```
enum KEY_TYPE
{
        AES_KEY_TYPE = 0, //AES key KEY_LENGTH = 16 bytes
        DES3K_KEY_TYPE = 1, //3K3DES key KEY_LENGTH =  24 bytes
        DES_KEY_TYPE = 2, //DES key   KEY_LEGNTH = 8 bytes
        DES2K_KEY_TYPE = 3 //2K3DES key KEY_LENGTH = 16 bytes
};
```

DESFIRE_WRITE_AES_KEY (0x8E)

Command writes AES key into reader.
(Old firmwares and AES key)

- CMD_Par0 and CMD_Par1 are 0
- 1st byte of the CMD_EXT contains ordinal number of AES key into reader
- array from 2nd byte up to 17th byte of the CMD_EXT contains AES key
- 18th byte of the CMD_EXT contains checksum

(Firmware version from 5.0.25)

CMD_Par0 = KEY_TYPE and CMD_Par1 = 0
1st byte of the CMD_EXT contains ordinal number of key into reader
array from byte 2 to byte (1 + KEY_LENGTH) of CMD_EXT contains key
byte (2 + KEY_LENGTGH) contains checksum
(For 3K3DES key 2 fields into reader will be occupied. For example, if key stored into field 0, then field 1 also used for this key, first free field is 2)
Device answer with RSP packet.
RSP_EXT
1st byte is 0
2nd byte is error code look at Appendix: ERROR CODES

3rd byte is checksum

Example:

AES key is `00 11 22 33 44 55 66 77 88 99 AA BB CC DD EE FF`, and ordinal number is 3

```
CMD         55 8E AA 12 00 00 6A (send command 8E), 6A checksum
ACK         AC 8E CA 12 00 00 01 (ACK OK)
CMD_EXT     03 00 11 22 33 44 55 66 77 88 99 AA BB CC DD EE FF 0A
RSP         DE 8E ED 03 00 00 C5
RSP_EXT     00 00 07
```

GET_DESFIRE_UID (0x80)

Command returns Unique ID of card, if the Random ID is used.
From firmware version 5.0.32 Desfire Light tag support
(Old firmwares and AES key)

- CMD_Par0 and CMD_Par1 are 0
- 1st byte of the CMD_EXT is 1 if uses internal AES key, or 0 if uses external AES key
- 2nd byte of the CMD_EXT contains ordinal number of internal AES key, or 0 if uses external AES key
- array from 3rd to 18th byte of CMD_EXT contains AES key
- array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)
- 22nd byte contains ordinal key number into application
- 23rd byte contains checksum

(Firmware version from 5.0.25)
CMD_Par0 = (KEY_TYPE << 4) and CMD_Par1 = 0
1st byte of the CMD_EXT is 1 if uses internal key, or 0 if uses external key

- 2nd byte of the CMD_EXT contains ordinal number of internal key, or 0 if uses external key

array from 3rd to 18th byte of CMD_EXT contains key (for AES and 2K3DES all key bytes, for DES 8 key bytes and 8 zeros, for 3K3DES first 16 key bytes)
array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)

- 22nd byte contains ordinal key number into application

(for AES, DES and 2K3DES) 23rd byte contains checksum
(for 3K3DES) array from byte 23 to byte 30 contains last 8 key bytes, and byte 31 contains checksum

(uFR CS with SAM and firmware versions 5.100.xx)

CMD_Par0 = (KEY_TYPE << 4) and CMD_Par1 = 0

1st byte of the CMD_EXT is 2 (using key into SAM)

- 2nd byte of the CMD_EXT contains ordinal number of key into SAM (1 - 127)
- array from 3rd to 18th byte of CMD_EXT contains 16 zeros
- array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)
- 22nd byte contains ordinal key number into application
- 23rd byte contains checksum

Response:
If no error, i.e. error code is CARD_OPERATION_OK, device answer with RSP packet and after that also the RSP_EXT packet of 12 bytes.
RSP_Val0 and RSP_Val1 are not in use.

- array from 1st to 7th byte of RSP_EXT contains 7 bytes length card UID
- 8th and 9th bytes represents card's error code of operation (b9 * 256 + b8), look at Appendix: ERROR CODES for DESFire card operations
-
- 10th and 11th bytes represents execution time of command
- 12th byte is checksum.

If error code is READER_ERROR or NO_CARD_DETECTED, device answer with RSP_EXT packet of 3 bytes.

- 1st and 2nd bytes represents execution time of command
- 3rd byte is checksum.

In other cases, device answer with RSP_EXT packet of 5 bytes.

- 1st and 2nd bytes represents card's error code of operation (b2 * 256 + b1), look at Appendix: ERROR CODES for DESFire card operations
-
- 3rd and 4th bytes represents execution time of command
- 5th byte is checksum.

Example:

Authentication using the internal key ordinal number 3, AID = 0xF00001, ordinal key number into application is 1.

CMD 55 80 AA 17 00 00 6F
(send command 80), 6F checksum
ACK AC 80 CA 17 00 00 F8
(ACK OK)
CMD_EXT 01 03 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 01 00 F0 01 F9
(internal key uses so AES key bytes may have any value (all 00), F9 checksum)

RSP DE 80 ED 0C 00 00 AC
(RSP command 80, 12 bytes follows, 0B checksum)
RSP_EXT 04 01 02 03 05 06 07 B9 0B 0A 00 BF
(UID is 04010203050607, error code is 0BB9, execution time is 000A , checksum is BF)

DESFIRE_FREE_MEM (0x8D)

Command returns the available bytes on the card

The CMD_EXT set is not in use.
The CMD_Par0 and CMD_Par1 are not in use.

If no error, i.e. error code is CARD_OPERATION_OK, device answer with RSP packet and after that also the RSP_EXT packet of 9 bytes.

- 1st and 2nd bytes represents error code of operation (b2 * 256 + b1), look at Appendix: ERROR CODES for DESFire card operations
- 3rd and 4th bytes represents execution time of command
- array from 5th to 8th of RSP_EXT contains quantity of available bytes on card
- 9th byte is checksum

Example:

```
CMD         55 8D AA 00 00 00 79
RSP         DE 8D ED 09 00 00 BE
RSP_EXT     B9 0B 0A 00 E8 03 00 00 5A
(error code 0BB9, execution time 000A,free mem 000003E8 i.e. 1000)
```

DESFIRE_FORMAT_CARD(0x8C)

Function releases all allocated user memory on the card. All applications will be deleted, also all files within those applications will be deleted. Only the card master key, and card master key settings will not be deleted. This operation requires authentication with the card master key.
(Old firmwares and AES key)

- CMD_Par0 and CMD_Par1 are 0
- 1st byte of the CMD_EXT is 1 if uses internal AES key, or 0 if uses external AES key
- 2nd byte of the CMD_EXT contains ordinal number of internal AES key, or 0 if uses external AES key
- array from 3rd to 18th byte of CMD_EXT contains AES key
- 19th byte is checksum

(Firmware version from 5.0.25)

CMD_Par0 = (KEY_TYPE << 4) and CMD_Par1 = 0
1st byte of the CMD_EXT is 1 if uses internal key, or 0 if uses external key

- 2nd byte of the CMD_EXT contains ordinal number of internal key, or 0 if uses external key

array from byte 3 to byte (2 + KEY_LENGTH) contains key
byte 3 + KEY_LENGTH is checksum

(uFR CS with SAM and firmware versions 5.100.xx)

CMD_Par0 = (KEY_TYPE << 4) and CMD_Par1 = 0
1st byte of the CMD_EXT is 2 (using key into SAM)
2nd byte of the CMD_EXT contains ordinal number of key into SAM (0 -127)
array from 3rd to 18th byte of CMD_EXT contains 16 zeros

- 19th byte is checksum

If error code is READER_ERROR or NO_CARD_DETECTED, device answer with RSP_EXT packet of 3 bytes.

- 1st and 2nd bytes represents execution time of command
- 3rd byte is checksum.

In other cases, device answer with RSP_EXT packet of 5 bytes.

- 1st and 2nd bytes represents error code of operation (b2 * 256 + b1)
- 3rd and 4th bytes represents execution time of command
- 5th byte is checksum.

Example:

Authentication using the internal key ordinal number 1

```
CMD         55 8C AA 13 00 00 67                    (send command 8C), 67
checksum
ACK         AC 8C CA 13 00 00 00                    (ACK OK)

CMD_EXT     01 01 00 00 00 00 00 00 00 00 00 00     (internal key uses so AES
key
            00 00 00 00 00 00 07                     bytes may have any value
(all
                                                     00), 07 checksum)
RSP         DE 8C ED 05 00 00 C1            (RSP command 8C, 5 byte follows,
BD checksum)
RSP_EXT     B9 0B AC 0D 1A (error code 0BB9, execution time 0DAC)
```

DESFIRE_SET_CONFIGURATION(0x8B)

Function allows you to activate the Random ID option, and/or Format disable option.
From firmware version 5.0.32 Desfire Light tag support

If these options are activated, then they can not be returned to the factory setting (Random ID disabled, Format card enabled).
This operation requires authentication with the card master key.
(Old firmwares and AES key)

- CMD_Par0 and CMD_Par1 are 0
- 1st byte of the CMD_EXT is 1 if uses internal AES key, or 0 if uses external AES key
- 2nd byte of the CMD_EXT contains ordinal number of internal AES key, or 0 if uses external AES key
- array from 3rd to 18th byte of CMD_EXT contains AES key
- 19th byte is 1 if Random ID enabled or 0 if Random ID disabled
- 20th byte is 1 if format card disabled or 0 if format card enabled
- 21st byte is checksum

(Firmware version from 5.0.25)

CMD_Par0 = (KEY_TYPE << 4) and CMD_Par1 = 0
1st byte of the CMD_EXT is 1 if uses internal key, or 0 if uses external key

- 2nd byte of the CMD_EXT contains ordinal number of internal key, or 0 if uses external key

- array from 3rd to 18th byte of CMD_EXT contains key (for AES and 2K3DES all key bytes, for DES 8 key bytes and 8 zeros, for 3K3DES first 16 key bytes)
- 19th byte is 1 if Random ID enabled or 0 if Random ID disabled
- 20th byte is 1 if format card disabled or 0 if format card enabled

(for AES, DES and 2K3DES) 21st byte contains checksum

(for 3K3DES) array from byte 21 to byte 28 contains last 8 key bytes, and byte 29 contains checksum

(uFR CS with SAM and firmware versions 5.100.xx)

CMD_Par0 = (KEY_TYPE << 4) and CMD_Par1 = 0

1st byte of the CMD_EXT is 2 (using key into SAM)

2nd byte of the CMD_EXT contains ordinal number of key into SAM (0 -127)

array from 3rd to 18th byte of CMD_EXT contains 16 zeros

- 19th byte is 1 if Random ID enabled or 0 if Random ID disabled
- 20th byte is 1 if format card disabled or 0 if format card enabled
- 21st byte is checksum

If error code is READER_ERROR or NO_CARD_DETECTED, device answer with RSP_EXT packet of 3 bytes.

- 1st and 2nd bytes represents execution time of command
- 3rd byte is checksum.

In other cases, device answer with RSP_EXT packet of 5 bytes.

- 1st and 2nd bytes represents error code of operation (b2 * 256 + b1)
- 3rd and 4th bytes represents execution time of command
- 5th byte is checksum.

Example:

Authentication using the internal key ordinal number 1, Random ID enabled, format card disabled

```
CMD         55 8B AA 15 00 00 68                    (send command 8B), 68
checksum
ACK         AC 8B CA 15 00 00 FF                    (ACK OK)

CMD_EXT     01 01 00 00 00 00 00 00 00 00 00 00     (internal key uses so AES
key
            00 00 00 00 00 00 01 00 08               bytes may have any value
(all
                                                     00), Random ID 01,
format card
                                                     00, 08 checksum)
RSP         DE 8B ED 05 00 00 C4                    (RSP command 8B, 5 byte
follows,
                                                     BD checksum)
RSP_EXT     B9 0B 1A 00 AF                  (error code 0BB9, execution time
001A)
```

DESFIRE_GET_KEY_CONFIG(0x87)

Function allows to get card master key and application master key configuration settings. In addition it returns the maximum number of keys which can be stored within selected application.
(Old firmwares and AES key)

- CMD_Par0 and CMD_Par1 are 0
- 1st byte of the CMD_EXT is 1 if uses internal AES key, or 0 if uses external AES key
- 2nd byte of the CMD_EXT contains ordinal number of internal AES key, or 0 if uses external AES key
- array from 3rd to 18th byte of CMD_EXT contains AES key
- array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)
- 22nd byte contains checksum.

(Firmware version from 5.0.25)

CMD_Par0 = (KEY_TYPE << 4) and CMD_Par1 = 0
1st byte of the CMD_EXT is 1 if uses internal key, or 0 if uses external key

- 2nd byte of the CMD_EXT contains ordinal number of internal key, or 0 if uses external key
- array from 3rd to 18th byte of CMD_EXT contains key (for AES and 2K3DES all key bytes, for DES 8 key bytes and 8 zeros, for 3K3DES first 16 key bytes)
- array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)

(for AES, DES and 2K3DES) 22nd byte contains checksum
(for 3K3DES) array from byte 22 to byte 29 contains last 8 key bytes, and byte 30 contains checksum

(uFR CS with SAM and firmware versions 5.100.xx)

CMD_Par0 = (KEY_TYPE << 4) and CMD_Par1 = 0
1st byte of the CMD_EXT is 2 (using key into SAM)
2nd byte of the CMD_EXT contains ordinal number of key into SAM (0 -127)
array from 3rd to 18th byte of CMD_EXT contains 16 zeros

- array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)
- 22nd byte contains checksum.
-

If no error, i.e. error code is CARD_OPERATION_OK, device answer with RSP packet and after that also the RSP_EXT packet of 7 bytes.
RSP_Val0 and RSP_Val1 are not in use.

- 1st and 2nd bytes represents error code of operation (b2 * 256 + b1)
- 3rd and 4th bytes represents execution time of command
- 5th byte is key settings
- 6th byte is maximum number of keys within selected application.
- 7th byte is checksum

If error code is READER_ERROR or NO_CARD_DETECTED, device answer with RSP_EXT packet of 3 bytes.

- 1st and 2nd bytes represents execution time of command
- 3rd byte is checksum.

In other cases, device answer with RSP_EXT packet of 5 bytes.

- 1st and 2nd bytes represents error code of operation (b2 * 256 + b1)

- 3rd and 4th bytes represents execution time of command
- 5th byte is checksum.

Example:

Authentication using the internal key ordinal number 2, AID = 0xF00001

```
CMD         55 87 AA 16 00 00 75 (send command 87), 75 checksum
ACK         AC 87 CA 16 00 00 FE (ACK OK)

CMD_EXT     01 02 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 01 00 F0
CA(internal key uses so AES key bytes may have any value (all 00), CA
checksum)

RSP         DE 87 ED 07 00 00 BA          (RSP command 87, 7 bytes
follows, BA checksum)
RSP_EXT     B9 0B 1A 00 09 03 A9     (error code 0BB9, execution time
001A, key settings 9, maximum number of key 3)
```

DESFIRE_CHANGE_KEY_CONFIG(0x88)

Function allows to set card master key, and application master key configuration settings.
(Old firmwares and AES key)

- CMD_Par0 and CMD_Par1 are 0
- 1st byte of the CMD_EXT is 1 if uses internal AES key, or 0 if uses external AES key
- 2nd byte of the CMD_EXT contains ordinal number of internal AES key, or 0 if uses external AES key
- array from 3rd to 18th byte of CMD_EXT contains AES key
- array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)
- 22nd byte is key settings
- 23rd byte contains checksum.

(Firmware version from 5.0.25)

CMD_Par0 = (KEY_TYPE << 4) and CMD_Par1 = 0
1st byte of the CMD_EXT is 1 if uses internal key, or 0 if uses external key

- 2nd byte of the CMD_EXT contains ordinal number of internal key, or 0 if uses external key
- array from 3rd to 18th byte of CMD_EXT contains key (for AES and 2K3DES all key bytes, for DES 8 key bytes and 8 zeros, for 3K3DES first 16 key bytes)
- array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)

22nd byte is key settings
(for AES, DES and 2K3DES) 23rd byte contains checksum
(for 3K3DES) array from byte 23 to byte 30 contains last 8 key bytes, and byte 31 contains checksum

(uFR CS with SAM and firmware versions 5.100.xx)

CMD_Par0 = (KEY_TYPE << 4) and CMD_Par1 = 0
1st byte of the CMD_EXT is 2 (using key into SAM)

2nd byte of the CMD_EXT contains ordinal number of key into SAM (0 -127)
array from 3rd to 18th byte of CMD_EXT contains 16 zeros
array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)

- 22nd byte is key settings
- 23rd byte contains checksum.

RSP_Val0 and RSP_Val1 are not in use.

If error code is READER_ERROR or NO_CARD_DETECTED, device answer with RSP_EXT packet of 3 bytes.

- 1st and 2nd bytes represents execution time of command
- 3rd byte is checksum.

In other cases, device answer with RSP_EXT packet of 5 bytes.

- 1st and 2nd bytes represents error code of operation (b2 * 256 + b1)
- 3rd and 4th bytes represents execution time of command
- 5th byte is checksum.

Example:

Authentication using the internal key ordinal number 2, AID = 0xF00001, key settings is 9

```
CMD         55 88 AA 17 00 00 67 (send command 88), 67 checksum
ACK         AC 88 CA 17 00 00 00 (ACK OK)

CMD_EXT     01 02 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 01 00 F0
09 02(internal key uses so AES key bytes may have any value (all 00), 02
checksum)

RSP         DE 88 ED 05 00 00 C6          (RSP command 88, 5 bytes
follows, C5 checksum)
RSP_EXT     B9 0B 1A 00 AF (error code 0BB9, execution time 001A)
```

DESFIRE_CHANGE_AES_KEY(0x86)

Function allow to change any AES key on the card. Changing the card master key require current card master key authentication. Authentication for the application keys changing depend on the application master key settings (which key uses for authentication).
From firmware version 5.0.32 Desfire Light tag support

(Old firmwares and AES key)

- CMD_Par0 and CMD_Par1 are 0
- 1st byte of the CMD_EXT bit 0 set if uses internal AES key for authentication, bit 1 set if internal AES key uses as new key, bit 2 set if internal AES key uses as old key, high nibble is ordinal number of internal AES key which uses as old key, if they uses.
- 2nd byte of the CMD_EXT low nibble is ordinal number of internal AES key which uses for

authentication or 0 if uses external AES key, high nibble is ordinal number of internal AES key which uses as new key of 0 if uses external AES key

- array from 3rd to 18th byte of CMD_EXT contains AES key for authentication
- array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)
- 22nd byte is key number into application which uses for authentication
- array from 23rd to 38th byte of CMD_EXT contains new AES key
- 38th byte is key number into application that will be changed
- array from 39th to 54th byte of CMD_EXT contains new AES key
- 55th byte contains checksum.

(Firmware version from 5.0.25)

CMD_Par0 = AUTH_KEY_TYPE | (NEW_KEY_TYPE << 2) and CMD_Par1 = 0

1st byte of the CMD_EXT bit 0 set if uses internal key for authentication, bit 1 set if internal key uses as new key, bit 2 set if internal key uses as old key, high nibble is ordinal number of internal key which uses as old key, if they uses.

- 2nd byte of the CMD_EXT low nibble is ordinal number of internal key which uses for authentication or 0 if uses external key, high nibble is ordinal number of internal key which uses as new key of 0 if uses external key
- array from 3rd to 18th byte of CMD_EXT contains key for authentication (for AES and 2K3DES all key bytes, for DES 8 key bytes and 8 zeros, for 3K3DES first 16 key bytes)
- array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)
- 22nd byte is key number into application which uses for authentication
- array from 23rd to 38th byte of CMD_EXT contains new key (for AES and 2K3DES all key bytes, for DES 8 key bytes and 8 zeros, for 3K3DES first 16 key bytes)
- 38th byte is key number into application that will be changed
- array from 39th to 54th byte of CMD_EXT contains new key (for AES and 2K3DES all key bytes, for DES 8 key bytes and 8 zeros, for 3K3DES first 16 key bytes)
- (for AES, DES and 2K3DES) 55th byte contains checksum.

(for 3K3DES as authentication key) array from byte 55 to byte 62 contains last 8 key bytes of authentication key

(for 3K3DES as new key) array from byte 63 to byte 70 contains last 8 key bytes of new key

(for 3K3DES as new key) array from byte 71 to byte 78 contains last 8 key bytes of old key

(for 3K3DES as authentication and new key) byte 79 is checksum

(for 3K3DES as authentication key and not new key) byte 63 is checksum

(uFR CS with SAM and firmware versions 5.100.xx)

CMD_Par0 = index of key for authentication into SAM | 0x80

CMD_Par1 = index of new key into SAM | 0x80

1st byte of the CMD_EXT = AUTH_KEY_TYPE | (NEW_KEY_TYPE << 2)

2nd byte of the CMD_EXT = index of old key into SAM | 0x80

array from 3rd to 18th byte of CMD_EXT contains 16 zeros

- array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)
- 22nd byte is key number into application which uses for authentication
- array from 23rd to 38th byte of CMD_EXT contains 16 zeros
- 38th byte is key number into application that will be changed
- array from 39th to 54th byte of CMD_EXT contains 16 zeros

- 55th byte contains checksum.

RSP_Val0 and RSP_Val1 are not in use.

If error code is READER_ERROR or NO_CARD_DETECTED, device answer with RSP_EXT packet of 3 bytes.

- 1st and 2nd bytes represents execution time of command
- 3rd byte is checksum.

In other cases, device answer with RSP_EXT packet of 5 bytes.

- 1st and 2nd bytes represents error code of operation (b2 * 256 + b1)
- 3rd and 4th bytes represents execution time of command
- 5th byte is checksum.

Example:

Change the key number 2, into AID 0xF00001. Authentication with master application key key number 0.
Key for authentication is internal key number 1, new key is internal key number 2, and old key is internal key number 3.

```
CMD        55 86 AA 37 00 00 55 (send command 88, 0x37 bytes follows 55
checksum)
ACK        AC 86 CA 37 00 00 DE (ACK OK)

CMD_EXT    33 21 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 01 00 F0
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 02 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 E8(internal key uses so AES key bytes may
have any value (all 00), E8 checksum)

RSP        DE 86 ED 05 00 00 B7           (RSP command 86, 5 bytes
follows, C5 checksum)
RSP_EXT    B9 0B 1A 00 AF (error code 0BB9, execution time 001A)
```

DESFIRE_CREATE_APPLICATION(0x84)

Function allows to create new application on the card. Is the card master key authentication is required, depend on the card master key settings. Maximal number of applications on the card is 28. Each application is linked to set of up 14 different user definable access keys.
(Old firmwares and AES key)

- CMD_Par0 and CMD_Par1 are 0
- 1st byte of the CMD_EXT is 1 if uses internal AES key, or 0 if uses external AES key
- 2nd byte of the CMD_EXT contains ordinal number of internal AES key, or 0 if uses external AES key
- array from 3rd to 18th byte of CMD_EXT contains AES key
- array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)

- 22nd byte is 1 if authentication required, or 0 if no need the authentication
- 23rd byte is application key settings
- 24th byte is maximal number of keys into application
- 25th contains checksum.

(Firmware version from 5.0.25)

CMD_Par0 = APP_TYPE | (KEY_TYPE << 4) and CMD_Par1 = 0

(Application master key type: AES -> APP_TYPE = 0, 3K3DES -> APP_TYPE = 1, DES -> APP_TYPE = 2)

1st byte of the CMD_EXT is 1 if uses internal key, or 0 if uses external key

- 2nd byte of the CMD_EXT contains ordinal number of internal key, or 0 if uses external key
- array from 3rd to 18th byte of CMD_EXT contains key (for AES and 2K3DES all key bytes, for DES 8 key bytes and 8 zeros, for 3K3DES first 16 key bytes)
- array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)
- 22nd byte is 1 if authentication required, or 0 if no need the authentication
- 23rd byte is application key settings
- 24th byte is maximal number of keys into application

(for AES, DES and 2K3DES) 25th byte contains checksum

(for 3K3DES) array from byte 25 to byte 32 contains last 8 key bytes, and byte 32 contains checksum

(uFR CS with SAM and firmware versions 5.100.xx)

CMD_Par0 = APP_TYPE | (KEY_TYPE << 4) and CMD_Par1 = 0

(Application master key type: AES -> APP_TYPE = 0, 3K3DES -> APP_TYPE = 1, DES -> APP_TYPE = 2)

1st byte of the CMD_EXT is 2 (using key into SAM)

2nd byte of the CMD_EXT contains ordinal number of key into SAM (0 -127)

array from 3rd to 18th byte of CMD_EXT contains 16 zeros

array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)

- 22nd byte is 1 if authentication required, or 0 if no need the authentication
- 23rd byte is application key settings
- 24th byte is maximal number of keys into application
- 25th contains checksum.

RSP_Val0 and RSP_Val1 are not in use.

If error code is READER_ERROR or NO_CARD_DETECTED, device answer with RSP_EXT packet of 3 bytes.

- 1st and 2nd bytes represents execution time of command
- 3rd byte is checksum.

In other cases, device answer with RSP_EXT packet of 5 bytes.

- 1st and 2nd bytes represents error code of operation (b2 * 256 + b1)
- 3rd and 4th bytes represents execution time of command
- 5th byte is checksum.

Example:

Authentication using the internal key ordinal number 1, AID = 0xF00002, key settings is 9, maximal number of application keys is 3, authentication required

```
CMD        55 84 AA 19 00 00 69 (send command 84), 69 checksum
ACK        AC 84 CA 19 00 00 02 (ACK OK)

CMD_EXT    01 01 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 02 00 F0
01 09 03 00 (internal key uses so AES key bytes may have any value (all
00), 00 checksum)

RSP        DE 84 ED 05 00 00 B9          (RSP command 84, 5 bytes
follows, B9 checksum)
RSP_EXT    B9 0B 1A 00 AF (error code 0BB9, execution time 001A)
```

DESFIRE_DELETE_APPLICATION(0x89)

Function allows to deactivate application on the card. AID allocation is removed, but deleted memory blocks can only recovered by using Format card function.
(Old firmwares and AES key)

- CMD_Par0 and CMD_Par1 are 0
- 1st byte of the CMD_EXT is 1 if uses internal AES key, or 0 if uses external AES key
- 2nd byte of the CMD_EXT contains ordinal number of internal AES key, or 0 if uses external AES key
- array from 3rd to 18th byte of CMD_EXT contains AES key
- array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)
- 22nd byte contains checksum

(Firmware version from 5.0.25)

CMD_Par0 = KEY_TYPE << 4 and CMD_Par1 = 0
1st byte of the CMD_EXT is 1 if uses internal key, or 0 if uses external key

- 2nd byte of the CMD_EXT contains ordinal number of internal key, or 0 if uses external key
- array from 3rd to 18th byte of CMD_EXT contains key (for AES and 2K3DES all key bytes, for DES 8 key bytes and 8 zeros, for 3K3DES first 16 key bytes)
- array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)

(for AES, DES and 2K3DES) 22nd byte contains checksum
(for 3K3DES) array from byte 22 to byte 29 contains last 8 key bytes, and byte 30 contains checksum

(uFR CS with SAM and firmware versions 5.100.xx)
CMD_Par0 = (KEY_TYPE << 4) and CMD_Par1 = 0
1st byte of the CMD_EXT is 2 (using key into SAM)
2nd byte of the CMD_EXT contains ordinal number of key into SAM (0 -127)
array from 3rd to 18th byte of CMD_EXT contains 16 zeros

- array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)
- 22nd byte contains checksum

(Firmware version from 5.0.37)

CMD_Par0 = KEY_TYPE << 4
CMD_Par1 = 0 -> delete with card master key, 1 -> delete with application master key
1st byte of the CMD_EXT is 1 if uses internal key, or 0 if uses external key

- 2nd byte of the CMD_EXT contains ordinal number of internal key, or 0 if uses external key
- array from 3rd to 18th byte of CMD_EXT contains key (for AES and 2K3DES all key bytes, for DES 8 key bytes and 8 zeros, for 3K3DES first 16 key bytes)
- array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)

(for AES, DES and 2K3DES) 22nd byte contains checksum
(for 3K3DES) array from byte 22 to byte 29 contains last 8 key bytes, and byte 30 contains checksum
(uFR CS with SAM and firmware versions from 5.100.37)
CMD_Par0 = (KEY_TYPE << 4)
CMD_Par1 = 0 -> delete with card master key, 1 -> delete with application master key
1st byte of the CMD_EXT is 2 (using key into SAM)
2nd byte of the CMD_EXT contains ordinal number of key into SAM (0 -127)
array from 3rd to 18th byte of CMD_EXT contains 16 zeros

- array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)
- 22nd byte contains checksum
-

RSP_Val0 and RSP_Val1 are not in use.

If error code is READER_ERROR or NO_CARD_DETECTED, device answer with RSP_EXT packet of 3 bytes.

- 1st and 2nd bytes represents execution time of command
- 3rd byte is checksum.

In other cases, device answer with RSP_EXT packet of 5 bytes.

- 1st and 2nd bytes represents error code of operation (b2 * 256 + b1)
- 3rd and 4th bytes represents execution time of command
- 5th byte is checksum.

Example:

Authentication using the internal key ordinal number 1, AID = 0xF00002

```
CMD        55 89 AA 16 00 00 67 (send command 89), 67 checksum
ACK        AC 89 CA 16 00 00 00 (ACK OK)

CMD_EXT    01 01 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 02 00 F0
F9 (internal key uses so AES key bytes may have any value (all 00), F9
checksum)

RSP        DE 89 ED 05 00 00 C6          (RSP command 89, 5 bytes
follows, C6 checksum)
RSP_EXT    B9 0B 1A 00 AF (error code 0BB9, execution time 001A)
```

DESFIRE_CREATE_STD_FILE(0x85)

Function allows to create file for the storage unformatted user data within existing application on the card. Maximal number of files into application is 32. The file will be created in the currently selected application. Is the application master key authentication is required, depend on the application master key settings.
Communication settings define communication mode between reader and card. The communication modes are:
- plain communication communication settings value is 0x00
- plain communication secured by MACing communication settings value is 0x01
- fully enciphered communication communication settings value is 0x11

Access rights for read, write, read&write and changing, references certain key within application's keys (0 – 13). If value is 14, this means free access, independent of previous authentication. If value is 15, this means deny access (for example if write access is 15 then the file type is read only).
(Old firmwares and AES key)

- CMD_Par0 and CMD_Par1 are 0
- 1st byte of the CMD_EXT is 1 if uses internal AES key, or 0 if uses external AES key
- 2nd byte of the CMD_EXT contains ordinal number of internal AES key, or 0 if uses external AES key
- array from 3rd to 18th byte of CMD_EXT contains AES key
- array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)
- 22nd byte is ID of file that will be created (0 – 31)
- 23rd and 24th bytes represented access rights for read, write, read&write and changing
- (byte 23 = read&write_key_no (high 4 bits) | changing_key_no (low 4 bits)
- byte 24 = read_key_no (high 4 bits) | write_key_no (low 4 bits))
- array from 25th to 28th of CMD_EXT contains file size in bytes
- 29th byte is 1 if authentication required, or 0 if no need the authentication
- 30th byte is communication settings
- 31st byte is checksum

(Firmware version from 5.0.25)

CMD_Par0 = KEY_TYPE << 4 and CMD_Par1 = 0
1st byte of the CMD_EXT is 1 if uses internal key, or 0 if uses external key

- 2nd byte of the CMD_EXT contains ordinal number of internal key, or 0 if uses external key

- array from 3rd to 18th byte of CMD_EXT contains key (for AES and 2K3DES all key bytes, for DES 8 key bytes and 8 zeros, for 3K3DES first 16 key bytes)
- array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)
- 22nd byte is ID of file that will be created (0 – 31)
- 23rd and 24th bytes represented access rights for read, write, read&write and changing
- (byte 23 = read&write_key_no (high 4 bits) | changing_key_no (low 4 bits)
- byte 24 = read_key_no (high 4 bits) | write_key_no (low 4 bits))
- array from 25th to 28th of CMD_EXT contains file size in bytes
- 29th byte is 1 if authentication required, or 0 if no need the authentication
- 30th byte is communication settings
- (for AES, DES and 2K3DES) 31st byte contains checksum
- (for 3K3DES) array from byte 31 to byte 38 contains last 8 key bytes, and byte 39 contains checksum

(uFR CS with SAM and firmware versions 5.100.xx)

CMD_Par0 = (KEY_TYPE << 4) and CMD_Par1 = 0
1st byte of the CMD_EXT is 2 (using key into SAM)
2nd byte of the CMD_EXT contains ordinal number of key into SAM (0 -127)
array from 3rd to 18th byte of CMD_EXT contains 16 zeros

- array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)
  22nd byte is ID of file that will be created (0 – 31)
- 23rd and 24th bytes represented access rights for read, write, read&write and changing
- (byte 23 = read&write_key_no (high 4 bits) | changing_key_no (low 4 bits)
- byte 24 = read_key_no (high 4 bits) | write_key_no (low 4 bits))
- array from 25th to 28th of CMD_EXT contains file size in bytes
- 29th byte is 1 if authentication required, or 0 if no need the authentication
- 30th byte is communication settings
- 31st byte is checksum

RSP_Val0 and RSP_Val1 are not in use.

If error code is READER_ERROR or NO_CARD_DETECTED, device answer with RSP_EXT packet of 3 bytes.

- 1st and 2nd bytes represents execution time of command
- 3rd byte is checksum.

In other cases, device answer with RSP_EXT packet of 5 bytes.

- 1st and 2nd bytes represents error code of operation (b2 * 256 + b1)
- 3rd and 4th bytes represents execution time of command
- 5th byte is checksum.

Example:

Authentication using the internal key ordinal number 1, AID = 0xF00002, authentication required, file ID is 1, communication settings is 0x11, access rights is 0x2110 (read with key 2, write with key 1, read&write with key 1, changing with key 0), file size is 1000 (0x000003E8)

```
CMD        55 85 AA 1F 00 00 67 (send command 89), 67 checksum
ACK        AC 85 CA 1F 00 00 00 (ACK OK)

CMD_EXT    01 01 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 02 00 F0
01 10 21 E8 03 00 00 01 11 40 (internal key uses so AES key bytes may
have any value (all 00), 40 checksum)

RSP        DE 85 ED 05 00 00 BA          (RSP command 85, 5 bytes
follows, BA checksum)
RSP_EXT    B9 0B 1A 00 AF (error code 0BB9, execution time 001A)
```

DESFIRE_DELETE_FILE(0x8A)

Function deactivates a file within currently selected application. Allocated memory blocks associated with deleted file not set free. Only format card function can delete the memory blocks. Is the application master key authentication is required, depend on the application master key settings.

(Old firmwares and AES key)

- CMD_Par0 and CMD_Par1 are 0
- 1st byte of the CMD_EXT is 1 if uses internal AES key, or 0 if uses external AES key
- 2nd byte of the CMD_EXT contains ordinal number of internal AES key, or 0 if uses external AES key
- array from 3rd to 18th byte of CMD_EXT contains AES key
- array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)
- 22nd byte is ID of file that will be deleted (0 – 31)
- 23rd byte is 1 if authentication required, or 0 if no need the authentication
- 24th byte is checksum

(Firmware version from 5.0.25)

CMD_Par0 = KEY_TYPE << 4 and CMD_Par1 = 0

- 1st byte of the CMD_EXT is 1 if uses internal key, or 0 if uses external key
- 2nd byte of the CMD_EXT contains ordinal number of internal key, or 0 if uses external key
- array from 3rd to 18th byte of CMD_EXT contains key (for AES and 2K3DES all key bytes, for DES 8 key bytes and 8 zeros, for 3K3DES first 16 key bytes)
- array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)
- 22nd byte is ID of file that will be deleted (0 – 31)
- 23rd byte is 1 if authentication required, or 0 if no need the authentication
- (for AES, DES and 2K3DES) 24th byte contains checksum
- (for 3K3DES) array from byte 24 to byte 31 contains last 8 key bytes, and byte 32 contains checksum

(uFR CS with SAM and firmware versions 5.100.xx)

CMD_Par0 = (KEY_TYPE << 4) and CMD_Par1 = 0

1st byte of the CMD_EXT is 2 (using key into SAM)

2nd byte of the CMD_EXT contains ordinal number of key into SAM (0 -127)

array from 3rd to 18th byte of CMD_EXT contains 16 zeros

- array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)

22nd byte is ID of file that will be deleted (0 – 31)
- 23rd byte is 1 if authentication required, or 0 if no need the authentication
- 24th byte is checksum

RSP_Val0 and RSP_Val1 are not in use.

If error code is READER_ERROR or NO_CARD_DETECTED, device answer with RSP_EXT packet of 3 bytes.
- 1st and 2nd bytes represents execution time of command
- 3rd byte is checksum.

In other cases, device answer with RSP_EXT packet of 5 bytes.
- 1st and 2nd bytes represents error code of operation (b2 * 256 + b1)
- 3rd and 4th bytes represents execution time of command
- 5th byte is checksum.

Example:

Authentication using the internal key ordinal number 1, AID = 0xF00002, authentication required, file ID is 1

```
CMD         55 8A AA 18 00 00 74 (send command 8A), 74 checksum
ACK         AC 8A CA 18 00 00 FB (ACK OK)

CMD_EXT     01 01 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 02 00 F0
01 01 F9 (internal key uses so AES key bytes may have any value (all
00), F9 checksum)

RSP         DE 8A ED 05 00 00 C3          (RSP command 8A, 5 bytes
follows, C3 checksum)
RSP_EXT     B9 0B 1A 00 AF (error code 0BB9, execution time 001A)
```

DESFIRE_READ_FROM_STD_FILE(0x83)

Function allow to read data from Standard Data File. Read command requires a preceding authentication either with the key specified for Read or Read&Write access.
From firmware version 5.0.32 Desfire Light tag support

(Old firmwares and AES key)
- CMD_Par0 and CMD_Par1 are 0
- 1st byte of the CMD_EXT is 1 if uses internal AES key, or 0 if uses external AES key
- 2nd byte of the CMD_EXT contains ordinal number of internal AES key, or 0 if uses external AES key
- array from 3rd to 18th byte of CMD_EXT contains AES key
- array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)
- 22nd byte is application key number for reading
- 23rd byte is ID of file (0 – 31)

- 23rd byte is 1 if authentication required, or 0 if no need the authentication
- 24th and 25th bytes represents start position for read operation within file
- 26th and 27th bytes represents number of data to be read
- 28th byte is communication settings
- 29th byte is checksum

(Firmware version from 5.0.25)

CMD_Par0 = KEY_TYPE << 4 and CMD_Par1 = 0

1st byte of the CMD_EXT is 1 if uses internal key, or 0 if uses external key

- 2nd byte of the CMD_EXT contains ordinal number of internal key, or 0 if uses external key
- array from 3rd to 18th byte of CMD_EXT contains key (for AES and 2K3DES all key bytes, for DES 8 key bytes and 8 zeros, for 3K3DES first 16 key bytes)
- array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)
- 22nd byte is application key number for reading
- 23rd byte is ID of file (0 – 31)
- 23rd byte is 1 if authentication required, or 0 if no need the authentication
- 24th and 25th bytes represents start position for read operation within file
- 26th and 27th bytes represents number of data to be read
- 28th byte is communication settings

  (for AES, DES and 2K3DES) 29th byte contains checksum
- (for 3K3DES) array from byte 29 to byte 36 contains last 8 key bytes, and byte 37 contains checksum

(uFR CS with SAM and firmware versions 5.100.xx)

CMD_Par0 = (KEY_TYPE << 4) and CMD_Par1 = 0

1st byte of the CMD_EXT is 2 (using key into SAM)

2nd byte of the CMD_EXT contains ordinal number of key into SAM (0 -127)

array from 3rd to 18th byte of CMD_EXT contains 16 zeros

- array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)
- 22nd byte is application key number for reading
- 23rd byte is ID of file (0 – 31)
- 23rd byte is 1 if authentication required, or 0 if no need the authentication
- 24th and 25th bytes represents start position for read operation within file
- 26th and 27th bytes represents number of data to be read
- 28th byte is communication settings
- 29th byte is checksum
-

Reading the data is specific and is done in a loop. Reads one data, and if it is 0, then reads another that indicates how much data follows in the package. This is repeated until the required amount of data read. If the first data is different from 0, then reader will be sent standard response.

RSP_Val0 and RSP_Val1 are not in use.

If error code is READER_ERROR or NO_CARD_DETECTED, device answer with RSP_EXT packet of 3 bytes.

- 1st and 2nd bytes represents execution time of command

- 3rd byte is checksum.

In other cases, device answer with RSP_EXT packet of 5 bytes.

- 1st and 2nd bytes represents error code of operation (b2 * 256 + b1)
- 3rd and 4th bytes represents execution time of command
- 5th byte is checksum.

Example:

Authentication using the internal key ordinal number 3, AID = 0xF00002, authentication required, file ID is 1, reading key number is 2, bytes for read 50 from start address 10, communication settings 0x11

```
CMD         55 83 AA 1D 00 00 68 (send command 83), 68 checksum
ACK         AC 83 CA 1D 00 00 FB (ACK OK)

CMD_EXT     01 03 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 02 00 F0
02 01 01 0A 00 32 00 11 E2 (internal key uses so AES key bytes may have
any value (all 00), E2 checksum)

DATA        00 32 01 02 03 04 05 06 07 08 09 0A 01 02 03 04 05 06 07 08 09
0A 01 02 03 04 05 06 07 08 09 0A 01 02 03 04 05 06 07 08 09 0A 01 02 03
04 05 06 07 08 09 0A

RSP         DE 8A ED 05 00 00 C3            (RSP command 8A, 5 bytes
follows, C3 checksum)
RSP_EXT     B9 0B 1A 00 AF (error code 0BB9, execution time 001A)
```

DESFIRE_WRITE_TO_STD_FILE(0x82)

Function allow to write data to Standard Data File, or to Backup Data File. Write command requires a preceding authentication either with the key specified for Write or Read&Write access. From firmware version 5.0.32 Desfire Light tag support

(Old firmwares and AES key)

- CMD_Par0 and CMD_Par1 are 0
- 1st byte of the CMD_EXT is 1 if uses internal AES key, or 0 if uses external AES key
- 2nd byte of the CMD_EXT contains ordinal number of internal AES key, or 0 if uses external AES key
- array from 3rd to 18th byte of CMD_EXT contains AES key
- array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)
- 22nd byte is application key number for writing
- 23rd byte is ID of file (0 – 31)
- 24th byte is 1 if authentication required, or 0 if no need the authentication
- 25th and 26th bytes represents start position for read operation within file

- 27th and 28th bytes represents number of data to be write
- 29th byte is communication settings
- array from 30th to 30 + block size number of data for writing contains maximal 160 data for writing
- 31 + block size byte is checksum

(Firmware version from 5.0.25)

CMD_Par0 = KEY_TYPE << 4 and CMD_Par1 = 0

- 1st byte of the CMD_EXT is 1 if uses internal key, or 0 if uses external key
- 2nd byte of the CMD_EXT contains ordinal number of internal key, or 0 if uses external key
- array from 3rd to 18th byte of CMD_EXT contains key (for AES and 2K3DES all key bytes, for DES 8 key bytes and 8 zeros, for 3K3DES first 16 key bytes)
- array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)
- 22nd byte is application key number for writing
- 23rd byte is ID of file (0 – 31)
- 24th byte is 1 if authentication required, or 0 if no need the authentication
- 25th and 26th bytes represents start position for read operation within file
- 27th and 28th bytes represents number of data to be write
- 29th byte is communication settings
- array from 30th to 30 + block size number of data for writing contains maximal 160 data for writing

  (for AES, DES and 2K3DES) (31 + block size) byte is checksum
- (for 3K3DES) array from byte (31 + block size) to byte (38 + block size) contains last 8 key bytes, and byte (39 + block size) contains checksum

(uFR CS with SAM and firmware versions 5.100.xx)

CMD_Par0 = (KEY_TYPE << 4) and CMD_Par1 = 0

1st byte of the CMD_EXT is 2 (using key into SAM)

2nd byte of the CMD_EXT contains ordinal number of key into SAM (0 -127)

array from 3rd to 18th byte of CMD_EXT contains 16 zeros

- array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)

  22nd byte is application key number for writing
- 23rd byte is ID of file (0 – 31)
- 24th byte is 1 if authentication required, or 0 if no need the authentication
- 25th and 26th bytes represents start position for read operation within file
- 27th and 28th bytes represents number of data to be write
- 29th byte is communication settings
- array from 30th to 30 + block size number of data for writing contains maximal 160 data for writing
- 31 + block size byte is checksum

If you want to enter more than 160 bytes, then it is done in blocks of up to 160 bytes. After the first block of data reader sent 0xAD if necessary to receive more data, or 0xDD if no need more data, or at any error. When you receive 0xAD then sends a packet in which the first byte indicates how many bytes follow. When you receive 0xDD then follow standard response.

RSP_Val0 and RSP_Val1 are not in use.

If error code is READER_ERROR or NO_CARD_DETECTED, device answer with RSP_EXT packet of 3 bytes.

- 1st and 2nd bytes represents execution time of command
- 3rd byte is checksum.

In other cases, device answer with RSP_EXT packet of 5 bytes.

- 1st and 2nd bytes represents error code of operation (b2 * 256 + b1)
- 3rd and 4th bytes represents execution time of command
- 5th byte is checksum.

Example:

Authentication using the internal key ordinal number 3, AID = 0xF00002, authentication required, file ID is 1, writing key number is 1, bytes for write 50 from start address 10, communication settings 0x11

```
CMD        55 82 AA 51 00 00 33 (send command 82), 33 checksum
ACK        AC 82 CA 51 00 00 BC (ACK OK)

CMD_EXT    01 03 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 02 00 F0
01 01 01 0A 00 32 00 11 01 02 03 04 05 06 07 08 09 0A 01 02 03 04 05 06
07 08 09 0A 01 02 03 04 05 06 07 08 09 0A 01 02 03 04 05 06 07 08 09 0A
01 02 03 04 05 06 07 08 09 0A CRC (internal key uses so AES key bytes
may have any value (all 00), CRC checksum)

DATA       DD  (no need more data)

RSP        DE 82 ED 05 00 00 BB          (RSP command 82, 5 bytes
follows, BB checksum)
RSP_EXT    B9 0B 1A 00 AF (error code 0BB9, execution time 001A)
```

DESFIRE_CREATE_VALUE_FILE(0x8F)

For uFR PLUS devices only.

Function allows to create file for the storage and manipulation of 32 bit signed integer values within existing application on the card. Maximal number of files into application is 32. The file will be created in the currently selected application. Is the application master key authentication is required, depend on the application master key settings.

Communication settings define communication mode between reader and card. The communication modes are:

- plain communication communication settings value is 0x00

- plain communication secured by MACing communication settings value is 0x01

- fully enciphered communication communication settings value is 0x11

Access rights for read, write, read&write and changing, references certain key within application's

keys (0 – 13). If value is 14, this means free access, independent of previous authentication. If value is 15, this means deny access (for example if write access is 15 then the file type is read only).

(Old firmwares and AES key)

- CMD_Par0 and CMD_Par1 are 0
- 1st byte of the CMD_EXT is 1 if uses internal AES key, or 0 if uses external AES key
- 2nd byte of the CMD_EXT contains ordinal number of internal AES key, or 0 if uses external AES key
- array from 3rd to 18th byte of CMD_EXT contains AES key
- array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)
- 22nd byte is ID of file that will be created (0 – 31)
- 23rd and 24th bytes represented access rights for read, write, read&write and changing
- (byte 23 = read&write_key_no (high 4 bits) | changing_key_no (low 4 bits)
- byte 24 = read_key_no (high 4 bits) | write_key_no (low 4 bits))
- array from 25th to 28th byte contains value of lower limit (lowest byte is first)
- array from 29th to 32nd byte contains value of upper limit (lowest byte is first)
- array from 33rd to 36th byte contains initial value of value file (lowest byte is first)
- 37th byte
  bit 0 – limited credit enabled (1 – yes, 0 – no)
  bit 1 – free get value (1 – yes, 0 – no)
  38th byte is 1 if authentication required, or 0 if no need the authentication
- 39th byte is communication settings
- 40st byte is checksum

(Firmware version from 5.0.25)

CMD_Par0 = KEY_TYPE << 4 and CMD_Par1 = 0
1st byte of the CMD_EXT is 1 if uses internal key, or 0 if uses external key

- 2nd byte of the CMD_EXT contains ordinal number of internal key, or 0 if uses external key
- array from 3rd to 18th byte of CMD_EXT contains key (for AES and 2K3DES all key bytes, for DES 8 key bytes and 8 zeros, for 3K3DES first 16 key bytes)
- array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)
- 22nd byte is ID of file that will be created (0 – 31)
- 23rd and 24th bytes represented access rights for read, write, read&write and changing
- (byte 23 = read&write_key_no (high 4 bits) | changing_key_no (low 4 bits)
- byte 24 = read_key_no (high 4 bits) | write_key_no (low 4 bits))
- array from 25th to 28th byte contains value of lower limit (lowest byte is first)
- array from 29th to 32nd byte contains value of upper limit (lowest byte is first)
- array from 33rd to 36th byte contains initial value of value file (lowest byte is first)
- 37th byte
  bit 0 – limited credit enabled (1 – yes, 0 – no)
  bit 1 – free get value (1 – yes, 0 – no)
  38th byte is 1 if authentication required, or 0 if no need the authentication
- 39th byte is communication settings
  (for AES, DES and 2K3DES) 40st byte is checksum byte contains checksum
- (for 3K3DES) array from byte 40 to byte 47 contains last 8 key bytes, and byte 48 contains

checksum

(uFR CS with SAM and firmware versions 5.100.xx)

CMD_Par0 = (KEY_TYPE << 4) and CMD_Par1 = 0

1st byte of the CMD_EXT is 2 (using key into SAM)

2nd byte of the CMD_EXT contains ordinal number of key into SAM (0 -127)

array from 3rd to 18th byte of CMD_EXT contains 16 zeros

- array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)
- 22nd byte is ID of file that will be created (0 – 31)
- 23rd and 24th bytes represented access rights for read, write, read&write and changing
- (byte 23 = read&write_key_no (high 4 bits) | changing_key_no (low 4 bits)
- byte 24 = read_key_no (high 4 bits) | write_key_no (low 4 bits))
- array from 25th to 28th byte contains value of lower limit (lowest byte is first)
- array from 29th to 32nd byte contains value of upper limit (lowest byte is first)
- array from 33rd to 36th byte contains initial value of value file (lowest byte is first)
- 37th byte

  bit 0 – limited credit enabled (1 – yes, 0 – no)

  bit 1 – free get value (1 – yes, 0 – no)

  38th byte is 1 if authentication required, or 0 if no need the authentication
- 39th byte is communication settings
- 40st byte is checksum

If error code is READER_ERROR or NO_CARD_DETECTED, device answer with RSP_EXT packet of 3 bytes.

- 1st and 2nd bytes represents execution time of command
- 3rd byte is checksum.

In other cases, device answer with RSP_EXT packet of 5 bytes.

- 1st and 2nd bytes represents error code of operation (b2 * 256 + b1)
- 3rd and 4th bytes represents execution time of command
- 5th byte is checksum.

Example:

Authentication using the internal key ordinal number 3, AID = 0xF00008, authentication required, file ID is 20, access rights is 0x0000 (read with key 0, write with key 0, read&write with key 0, changing with key 0), lower limit is 100, upper limit is 300, initial value is 200, communication settings 0x0. Upper limit must be bigger than or equal to the lower limit and initial value.

```
CMD        55 8F AA 28 00 00 5F (send command 8F), 5F checksum
ACK        AC 8F CA 28 00 00 C8 (ACK OK)

CMD_EXT     01 03 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 08 00
F0 14 00 00 64 00 00 00 2C 01 00 00 C8 00 00 00 00 01 00 75 CRC
(internal key uses so AES key bytes may have any value (all 00), CRC
checksum)
```

```
RSP        DE 8F ED 05 00 00 C0
RSP_EXT    B9 0B 46 00 FB (error code 0x0BB9, execution time 0x0046)
```

DESFIRE_READ_VALUE_FILE(0x9A)

For uFR PLUS devices only.

Function allow to read value from value files. Read command requires a preceding authentication either with the key specified for Read or Read&Write access.

From firmware version 5.0.32 Desfire Light tag support

(Old firmwares and AES key)

- CMD_Par0 and CMD_Par1 are 0
- 1st byte of the CMD_EXT is 1 if uses internal AES key, or 0 if uses external AES key
- 2nd byte of the CMD_EXT contains ordinal number of internal AES key, or 0 if uses external AES key
- array from 3rd to 18th byte of CMD_EXT contains AES key
- array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)
- 22nd byte is application key number for reading
- 23rd byte is ID of file (0 – 31)
- 24th byte is 1 if authentication required, or 0 if no need the authentication
- 25th and 26th bytes represents start position for read operation within file
- 27th and 28th bytes represents number of data to be write
- 29th byte is communication settings

(Firmware version from 5.0.25)

CMD_Par0 = KEY_TYPE << 4 and CMD_Par1 = 0
1st byte of the CMD_EXT is 1 if uses internal key, or 0 if uses external key

- 2nd byte of the CMD_EXT contains ordinal number of internal key, or 0 if uses external key
- array from 3rd to 18th byte of CMD_EXT contains key (for AES and 2K3DES all key bytes, for DES 8 key bytes and 8 zeros, for 3K3DES first 16 key bytes)
- array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)
- 22nd byte is application key number for reading
- 23rd byte is ID of file (0 – 31)
- 24th byte is 1 if authentication required, or 0 if no need the authentication
- 25th and 26th bytes represents start position for read operation within file
- 27th and 28th bytes represents number of data to be write
- 29th byte is communication settings
- (for AES, DES and 2K3DES) 29th byte is checksum byte contains checksum
- (for 3K3DES) array from byte 29 to byte 36 contains last 8 key bytes, and byte 37 contains checksum

(uFR CS with SAM and firmware versions 5.100.xx)

CMD_Par0 = (KEY_TYPE << 4) and CMD_Par1 = 0
1st byte of the CMD_EXT is 2 (using key into SAM)
2nd byte of the CMD_EXT contains ordinal number of key into SAM (0 -127)
array from 3rd to 18th byte of CMD_EXT contains 16 zeros

- array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)
- 22nd byte is application key number for reading
- 23rd byte is ID of file (0 – 31)
- 24th byte is 1 if authentication required, or 0 if no need the authentication
- 25th and 26th bytes represents start position for read operation within file
- 27th and 28th bytes represents number of data to be write
- 29th byte is communication settings

If no error, i.e. error code is CARD_OPERATION_OK, device answer with RSP packet and after that also the RSP_EXT packet of 9 bytes.
RSP_Val0 and RSP_Val1 are not in use.

- 1st and 2nd bytes represents error code of operation (b2 * 256 + b1)
- 3rd and 4th bytes represents execution time of command
- array from 5th to 8th byte is value of value file
- 9th byte is checksum

If error code is READER_ERROR or NO_CARD_DETECTED, device answer with RSP_EXT packet of 3 bytes.

- 1st and 2nd bytes represents execution time of command
- 3rd byte is checksum.

In other cases, device answer with RSP_EXT packet of 5 bytes.

- 1st and 2nd bytes represents error code of operation (b2 * 256 + b1)
- 3rd and 4th bytes represents execution time of command
- 5th byte is checksum.

Example:

Authentication using the internal key ordinal number 3, AID = 0xF00008, authentication required, file ID is 20, application reading key number is 0.

```
CMD         55 9A AA 1A 00 00 86 (send command 9A), 86 checksum
ACK         AC 9A CA 1A 00 00 ED (ACK OK)

CMD_EXT     01 03 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 08 00
F0 00 14 01 00 F6 (internal key uses so AES key bytes may have any value
(all 00))

RSP         DE 9A ED 09 00 00 A7
RSP_EXT     B9 0B 46 00 C8 00 00 00 43     (error code 0x0BB9, execution
time 0x0046, value 0x000000C8)
```

DESFIRE_INCREASE_VALUE_FILE(0x9B)

For uFR PLUS devices only.

Function allows to increase a value stored in a value files. Credit command requires a preceding authentication with the key specified for Read&Write access.

From firmware version 5.0.32 Desfire Light tag support
From firmware version 5.0.38 Transaction MAC for Desfire Light and Desfire EV2 support

(Old firmwares and AES key)

- CMD_Par0 and CMD_Par1 are 0
- 1st byte of the CMD_EXT is 1 if uses internal AES key, or 0 if uses external AES key
- 2nd byte of the CMD_EXT contains ordinal number of internal AES key, or 0 if uses external AES key
- array from 3rd to 18th byte of CMD_EXT contains AES key
- array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)
- 22nd byte is application key number for read&write
- 23rd byte is ID of file (0 – 31)
- 24th byte is 1 if authentication required, or 0 if no need the authentication
- 25th byte is communication settings
- array from 26th and 29th bytes represents value (must be positive number)
- 30st byte is checksum byte contains checksum

(Firmware version from 5.0.25)

CMD_Par0 = KEY_TYPE << 4 and CMD_Par1 = 0
1st byte of the CMD_EXT is 1 if uses internal key, or 0 if uses external key

- 2nd byte of the CMD_EXT contains ordinal number of internal key, or 0 if uses external key
- array from 3rd to 18th byte of CMD_EXT contains key (for AES and 2K3DES all key bytes, for DES 8 key bytes and 8 zeros, for 3K3DES first 16 key bytes)
- array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)
- 22nd byte is application key number for read&write
- 23rd byte is ID of file (0 – 31)
- 24th byte is 1 if authentication required, or 0 if no need the authentication
- 25th byte is communication settings
- array from 26th and 29th bytes represents value (must be positive number)
  (for AES, DES and 2K3DES) 30st byte is checksum byte contains checksum
- (for 3K3DES) array from byte 30 to byte 37 contains last 8 key bytes, and byte 38 contains checksum

(uFR CS with SAM and firmware versions 5.100.xx)

CMD_Par0 = (KEY_TYPE << 4) and CMD_Par1 = 0
1st byte of the CMD_EXT is 2 (using key into SAM)
2nd byte of the CMD_EXT contains ordinal number of key into SAM (0 -127)
array from 3rd to 18th byte of CMD_EXT contains 16 zeros

- array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)
- 22nd byte is application key number for read&write
- 23rd byte is ID of file (0 – 31)
- 24th byte is 1 if authentication required, or 0 if no need the authentication
- 25th byte is communication settings
- array from 26th and 29th bytes represents value (must be positive number)
- 30st byte is checksum byte contains checksum

(Firmware version from 5.0.38)

tmc_file = 0 -> Transaction MAC is not used

tmc_file = 1 -> Transaction MAC is used Reader ID is not used
tmc_file = 3 -> Transaction MAC is used Reader ID is used
CMD_Par0 = KEY_TYPE << 4 and CMD_Par1 = tmc_file
1st byte of the CMD_EXT is 1 if uses internal key, or 0 if uses external key

- 2nd byte of the CMD_EXT contains ordinal number of internal key, or 0 if uses external key
- array from 3rd to 18th byte of CMD_EXT contains key (for AES and 2K3DES all key bytes, for DES 8 key bytes and 8 zeros, for 3K3DES first 16 key bytes)
- array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)
- 22nd byte is application key number for read&write
- 23rd byte is ID of file (0 – 31)
- 24th byte is 1 if authentication required, or 0 if no need the authentication
- 25th byte is communication settings
- array from 26th and 29th bytes represents value (must be positive number)
  (for AES, DES and 2K3DES) 30st byte is checksum byte contains checksum
- (for 3K3DES) array from byte 30 to byte 37 contains last 8 key bytes, and byte 38 contains checksum

(uFR CS with SAM and firmware from version 5.100.38)

tmc_file = 0 -> Transaction MAC is not used
tmc_file = 1 -> Transaction MAC is used Reader ID is not used
tmc_file = 3 -> Transaction MAC is used Reader ID is used
CMD_Par0 = (KEY_TYPE << 4) and CMD_Par1 = tmc_file
1st byte of the CMD_EXT is 2 (using key into SAM)
2nd byte of the CMD_EXT contains ordinal number of key into SAM (0 -127)
array from 3rd to 18th byte of CMD_EXT contains 16 zeros

- array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)
- 22nd byte is application key number for read&write
- 23rd byte is ID of file (0 – 31)
- 24th byte is 1 if authentication required, or 0 if no need the authentication
- 25th byte is communication settings
- array from 26th and 29th bytes represents value (must be positive number)
- 30st byte is checksum byte contains checksum
-

If error code is READER_ERROR or NO_CARD_DETECTED, device answer with RSP_EXT packet of 3 bytes.

- 1st and 2nd bytes represents execution time of command
- 3rd byte is checksum.

In other cases, device answer with RSP_EXT packet of 5 bytes.

- 1st and 2nd bytes represents error code of operation (b2 * 256 + b1)
- 3rd and 4th bytes represents execution time of command
- 5th byte is checksum.

From version 5.0.38. if tmc_file > 0

1st and 2nd bytes represents error code of operation (b2 * 256 + b1)

- 3rd and 4th bytes represents execution time of command

5th to 20th bytes represent Reader ID
21st to 36th bytes represent Previous Encrypted Reader ID
37th to 40th bytes represent Transaction MAC counter
41st to 48th bytes represent Transaction MAC
49th byte is checksum.

Example:

Authentication using the internal key ordinal number 3, AID = 0xF00008, authentication required, file ID is 20, application read&write key number is 0, increase value is 100

```
CMD         55 9B AA 1E 00 00 81
ACK         AC 9B CA 1E 00 00 EA

CMD_EXT     01 03 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 08 00
F0 00 14 01 00 64 00 00 00 92 (internal key uses so AES key bytes may
have any value (all 00))

RSP         DE 9B ED 05 00 00 B4
RSP_EXT     B9 0B 67 00 DC (error code 0x0BB9, execution time 0x0067)
```

DESFIRE_DECREASE_VALUE_FILE(0x9C)

For uFR PLUS devices only.

Function allows to decrease value from value files. Debit command requires a preceding authentication with on of the keys specified for Read, Write or Read&Write access.

From firmware version 5.0.32 Desfire Light tag support
From firmware version 5.0.38 Transaction MAC for Desfire Light and Desfire EV2 support

(Old firmwares and AES key)

- CMD_Par0 and CMD_Par1 are 0
- 1st byte of the CMD_EXT is 1 if uses internal AES key, or 0 if uses external AES key
- 2nd byte of the CMD_EXT contains ordinal number of internal AES key, or 0 if uses external AES key
- array from 3rd to 18th byte of CMD_EXT contains AES key
- array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)
- 22nd byte is application key number for read, write or read&write
- 23rd byte is ID of file (0 – 31)
- 24th byte is 1 if authentication required, or 0 if no need the authentication
- 25th byte is communication settings
- array from 26th and 29th bytes represents value (must be positive number)
- 30st byte is checksum byte contains checksum

(Firmware version from 5.0.25)

CMD_Par0 = KEY_TYPE << 4 and CMD_Par1 = 0
1st byte of the CMD_EXT is 1 if uses internal key, or 0 if uses external key

- 2nd byte of the CMD_EXT contains ordinal number of internal key, or 0 if uses external key
- array from 3rd to 18th byte of CMD_EXT contains key (for AES and 2K3DES all key bytes,

for DES 8 key bytes and 8 zeros, for 3K3DES first 16 key bytes)
- array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)
- 22nd byte is application key number for read&write
- 23rd byte is ID of file (0 – 31)
- 24th byte is 1 if authentication required, or 0 if no need the authentication
- 25th byte is communication settings
- array from 26th and 29th bytes represents value (must be positive number)
  (for AES, DES and 2K3DES) 30st byte is checksum byte contains checksum
- (for 3K3DES) array from byte 30 to byte 37 contains last 8 key bytes, and byte 38 contains checksum

(uFR CS with SAM and firmware versions 5.100.xx)

CMD_Par0 = (KEY_TYPE << 4) and CMD_Par1 = 0
1st byte of the CMD_EXT is 2 (using key into SAM)
2nd byte of the CMD_EXT contains ordinal number of key into SAM (0 -127)
array from 3rd to 18th byte of CMD_EXT contains 16 zeros
- array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)
  22nd byte is application key number for read, write or read&write
- 23rd byte is ID of file (0 – 31)
- 24th byte is 1 if authentication required, or 0 if no need the authentication
- 25th byte is communication settings
- array from 26th and 29th bytes represents value (must be positive number)
- 30st byte is checksum byte contains checksum

(Firmware version from 5.0.38)

tmc_file = 0 -> Transaction MAC is not used
tmc_file = 1 -> Transaction MAC is used Reader ID is not used
tmc_file = 3 -> Transaction MAC is used Reader ID is used
CMD_Par0 = KEY_TYPE << 4 and CMD_Par1 = tmc_file
1st byte of the CMD_EXT is 1 if uses internal key, or 0 if uses external key
- 2nd byte of the CMD_EXT contains ordinal number of internal key, or 0 if uses external key
- array from 3rd to 18th byte of CMD_EXT contains key (for AES and 2K3DES all key bytes, for DES 8 key bytes and 8 zeros, for 3K3DES first 16 key bytes)
- array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)
- 22nd byte is application key number for read&write
- 23rd byte is ID of file (0 – 31)
- 24th byte is 1 if authentication required, or 0 if no need the authentication
- 25th byte is communication settings
- array from 26th and 29th bytes represents value (must be positive number)
  (for AES, DES and 2K3DES) 30st byte is checksum byte contains checksum
- (for 3K3DES) array from byte 30 to byte 37 contains last 8 key bytes, and byte 38 contains checksum

(uFR CS with SAM and firmware from version 5.100.38)

tmc_file = 0 -> Transaction MAC is not used
tmc_file = 1 -> Transaction MAC is used Reader ID is not used
tmc_file = 3 -> Transaction MAC is used Reader ID is used

CMD_Par0 = (KEY_TYPE << 4) and CMD_Par1 = tmc_file
1st byte of the CMD_EXT is 2 (using key into SAM)
2nd byte of the CMD_EXT contains ordinal number of key into SAM (0 -127)
array from 3rd to 18th byte of CMD_EXT contains 16 zeros
- array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)

22nd byte is application key number for read, write or read&write
- 23rd byte is ID of file (0 – 31)
- 24th byte is 1 if authentication required, or 0 if no need the authentication
- 25th byte is communication settings
- array from 26th and 29th bytes represents value (must be positive number)
- 30st byte is checksum byte contains checksum

If error code is READER_ERROR or NO_CARD_DETECTED, device answer with RSP_EXT packet of 3 bytes.
- 1st and 2nd bytes represents execution time of command
- 3rd byte is checksum.

In other cases, device answer with RSP_EXT packet of 5 bytes.
- 1st and 2nd bytes represents error code of operation (b2 * 256 + b1)
- 3rd and 4th bytes represents execution time of command
- 5th byte is checksum.

From version 5.0.38. if tmc_file > 0
1st and 2nd bytes represents error code of operation (b2 * 256 + b1)
- 3rd and 4th bytes represents execution time of command

5th to 20th bytes represent Reader ID
21st to 36th bytes represent Previous Encrypted Reader ID
37th to 40th bytes represent Transaction MAC counter
41st to 48th bytes represent Transaction MAC
49th byte is checksum.

Example:

Authentication using the internal key ordinal number 3, AID = 0xF00008, authentication required, file ID is 20, application read&write key number is 0, increase value is 100

```
CMD         55 9C AA 1E 00 00 84
ACK         AC 9C CA 1E 00 00 EB

CMD_EXT     01 03 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 08 00
F0 00 14 01 00 64 00 00 00 92 (internal key uses so AES key bytes may
have any value (all 00))

RSP         DE 9C ED 05 00 00 B1
RSP_EXT     B9 0B 67 00 DC (error code 0x0BB9, execution time 0x0067)
```

DESFIRE_GET_APPLICATION_IDS (0xC0)

For uFR PLUS devices only.

Function returns the Application Identifiers for all active applications on a card. Maximal number of application ids is 28.

(Old firmwares and AES key)

- CMD_Par0 and CMD_Par1 are 0
- 1st byte of the CMD_EXT is 1 if uses internal AES key, or 0 if uses external AES key
- 2nd byte of the CMD_EXT contains ordinal number of internal AES key, or 0 if uses external AES key
- array from 3rd to 18th byte of CMD_EXT contains AES key
- 19th byte is 1 if authentication required, or 0 if no need the authentication
- 20st byte is checksum byte contains checksum

(Firmware version from 5.0.25)

CMD_Par0 = KEY_TYPE << 4 and CMD_Par1 = 0

1st byte of the CMD_EXT is 1 if uses internal key, or 0 if uses external key

- 2nd byte of the CMD_EXT contains ordinal number of internal key, or 0 if uses external key
- array from 3rd to 18th byte of CMD_EXT contains key (for AES and 2K3DES all key bytes, for DES 8 key bytes and 8 zeros, for 3K3DES first 16 key bytes)
- 19th byte is 1 if authentication required, or 0 if no need the authentication
  (for AES, DES and 2K3DES) 20st byte is checksum byte contains checksum
- (for 3K3DES) array from byte 20 to byte 27 contains last 8 key bytes, and byte 28 contains checksum

(uFR CS with SAM and firmware versions 5.100.xx)

CMD_Par0 = (KEY_TYPE << 4) and CMD_Par1 = 0

1st byte of the CMD_EXT is 2 (using key into SAM)

2nd byte of the CMD_EXT contains ordinal number of key into SAM (0 -127)

array from 3rd to 18th byte of CMD_EXT contains 16 zeros

19th byte is 1 if authentication required, or 0 if no need the authentication

- 20st byte is checksum byte contains checksum
-

If error code is READER_ERROR or NO_CARD_DETECTED, device answer with RSP_EXT packet of 3 bytes.

- 1st and 2nd bytes represents execution time of command
- 3rd byte is checksum.

In other cases, device answer with RSP_EXT packet of 3 * number_of_ application_ids + 7 bytes.

- 1st and 2nd bytes represents error code of operation (b2 * 256 + b1)
- 3rd and 4th bytes represents execution time of command
- 5th byte is number of application identifiers
- 6th to (6 + 3 * number_of_application_ids)th are triplets of bytes which represents application identifier (little endian numbers)
- (7 + 3 * number_of_application_ids)th is checksum

Example:

Authentication using the internal key ordinal number 2, authentication required.

There are 2 application ID-s 0xA10000 and 0xA20000

```
CMD         55 C0 AA 13 00 00 33
ACK         AC C0 CA 13 00 00 DC

CMD_EXT     01 02 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 09
(internal key uses so AES key bytes may have any value (all 00))

RSP         DE C0 ED 0C 00 00 06
RSP_EXT     B9 0B 67 00 02 00 00 A1 00 00 A2 DB     (error code 0x0BB9,
execution time 0x0067)
```

DESFIRE_CREATE_RECORD_FILE (0xC1)

For uFR PLUS devices only.

Function allows to create file for multiple storage of structural data, within an existing application.

Linear Record File.
Once the file filled completely with data records, further writing to file is not possible unless it is cleared.

Cyclic Record File.
Once the file filled completely with data records, the card automatically overwrites the oldest record with latest written one.

CMD_Par0 = KEY_TYPE << 4 and CMD_Par1 = 0
1st byte of the CMD_EXT is 1 if uses internal key, or 0 if uses external key

- 2nd byte of the CMD_EXT contains ordinal number of internal key, or 0 if uses external key
- array from 3rd to 18th byte of CMD_EXT contains key (for AES and 2K3DES all key bytes, for DES 8 key bytes and 8 zeros, for 3K3DES first 16 key bytes)
- array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)
- 22nd byte is ID of file that will be created (0 – 31)
- 23rd and 24th bytes represented access rights for read, write, read&write and changing
- (byte 23 = read&write_key_no (high 4 bits) | changing_key_no (low 4 bits)
- byte 24 = read_key_no (high 4 bits) | write_key_no (low 4 bits))
- array from 25th to 28th of CMD_EXT contains record size in bytes
- array from 29th to 32nd of CMD_EXT contains maximal number of records
- 33rd byte is 1 if authentication required, or 0 if no need the authentication
- 34th byte is communication settings
- (for AES, DES and 2K3DES) 35th byte contains checksum
- (for 3K3DES) array from byte 35 to byte 42 contains last 8 key bytes, and byte 43 contains checksum

(uFR CS with SAM and firmware versions 5.100.xx)

CMD_Par0 = (KEY_TYPE << 4) and CMD_Par1 = 0
1st byte of the CMD_EXT is 2 (using key into SAM)
2nd byte of the CMD_EXT contains ordinal number of key into SAM (0 -127)
array from 3rd to 18th byte of CMD_EXT contains 16 zeros
array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)

- 22nd byte is ID of file that will be created (0 – 31)

- 23rd and 24th bytes represented access rights for read, write, read&write and changing
- (byte 23 = read&write_key_no (high 4 bits) | changing_key_no (low 4 bits)
- byte 24 = read_key_no (high 4 bits) | write_key_no (low 4 bits))
- array from 25th to 28th of CMD_EXT contains record size in bytes
- array from 29th to 32nd of CMD_EXT contains maximal number of records
- 33rd byte is 1 if authentication required, or 0 if no need the authentication
- 34th byte is communication settings
- 35th byte contains checksum

RSP_Val0 and RSP_Val1 are not in use.

If error code is READER_ERROR or NO_CARD_DETECTED, device answer with RSP_EXT packet of 3 bytes.

- 1st and 2nd bytes represents execution time of command
- 3rd byte is checksum.

In other cases, device answer with RSP_EXT packet of 5 bytes.

- 1st and 2nd bytes represents error code of operation (b2 * 256 + b1)
- 3rd and 4th bytes represents execution time of command
- 5th byte is checksum.

DESFIRE_WRITE_RECORD (0x98)

For uFR PLUS devices only.

Function allows to write data to a record in a Linear Record File or Cyclic Record File. Write command requires a preceding authentication either with the key specified for Write or Read&Write access.

From firmware version 5.0.32 Desfire Light tag support
From firmware version 5.0.38 Transaction MAC for Desfire Light and Desfire EV2 support

(Firmware version from 5.0.xx)

CMD_Par0 = KEY_TYPE << 4 and CMD_Par1 = 0

- 1st byte of the CMD_EXT is 1 if uses internal key, or 0 if uses external key
- 2nd byte of the CMD_EXT contains ordinal number of internal key, or 0 if uses external key
- array from 3rd to 18th byte of CMD_EXT contains key (for AES and 2K3DES all key bytes, for DES 8 key bytes and 8 zeros, for 3K3DES first 16 key bytes)
- array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)
- 22nd byte is application key number for writing
- 23rd byte is ID of file (0 – 31)
- 24th byte is 1 if authentication required, or 0 if no need the authentication
- 25th and 26th bytes represents start position for write operation within file
- 27th and 28th bytes represents number of data to be write
- 29th byte is communication settings
- array from 30th to 30 + block size number of data for writing contains maximal 160 data for writing

(for AES, DES and 2K3DES) (31 + block size) byte is checksum

- (for 3K3DES) array from byte (31 + block size) to byte (38 + block size) contains last 8 key bytes, and byte (39 + block size) contains checksum

(uFR CS with SAM and firmware from versions 5.100.xx)

CMD_Par0 = (KEY_TYPE << 4) and CMD_Par1 = 0
1st byte of the CMD_EXT is 2 (using key into SAM)
2nd byte of the CMD_EXT contains ordinal number of key into SAM (0 -127)
array from 3rd to 18th byte of CMD_EXT contains 16 zeros
array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)
22nd byte is application key number for writing

- 23rd byte is ID of file (0 – 31)
- 24th byte is 1 if authentication required, or 0 if no need the authentication
- 25th and 26th bytes represents start position for write operation within file
- 27th and 28th bytes represents number of data to be write
- 29th byte is communication settings
- array from 30th to 30 + block size number of data for writing contains maximal 160 data for writing

(31 + block size) byte is checksum

(Firmware version from 5.0.38)

tmc_file = 0 -> Transaction MAC is not used
tmc_file = 1 -> Transaction MAC is used Reader ID is not used
tmc_file = 3 -> Transaction MAC is used Reader ID is used
CMD_Par0 = KEY_TYPE << 4 and CMD_Par1 = tmc_file

- 1st byte of the CMD_EXT is 1 if uses internal key, or 0 if uses external key
- 2nd byte of the CMD_EXT contains ordinal number of internal key, or 0 if uses external key
- array from 3rd to 18th byte of CMD_EXT contains key (for AES and 2K3DES all key bytes, for DES 8 key bytes and 8 zeros, for 3K3DES first 16 key bytes)
- array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)
- 22nd byte is application key number for writing
- 23rd byte is ID of file (0 – 31)
- 24th byte is 1 if authentication required, or 0 if no need the authentication
- 25th and 26th bytes represents start position for write operation within file
- 27th and 28th bytes represents number of data to be write
- 29th byte is communication settings
- array from 30th to 30 + block size number of data for writing contains maximal 160 data for writing

(for AES, DES and 2K3DES) (31 + block size) byte is checksum

- (for 3K3DES) array from byte (31 + block size) to byte (38 + block size) contains last 8 key bytes, and byte (39 + block size) contains checksum

(uFR CS with SAM and firmware from version 5.100.38)

tmc_file = 0 -> Transaction MAC is not used
tmc_file = 1 -> Transaction MAC is used Reader ID is not used
tmc_file = 3 -> Transaction MAC is used Reader ID is used
CMD_Par0 = (KEY_TYPE << 4) and CMD_Par1 = tmc_file

1st byte of the CMD_EXT is 2 (using key into SAM)
2nd byte of the CMD_EXT contains ordinal number of key into SAM (0 -127)
array from 3rd to 18th byte of CMD_EXT contains 16 zeros
array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)
22nd byte is application key number for writing

- 23rd byte is ID of file (0 – 31)
- 24th byte is 1 if authentication required, or 0 if no need the authentication
- 25th and 26th bytes represents start position for write operation within file
- 27th and 28th bytes represents number of data to be write
- 29th byte is communication settings
- array from 30th to 30 + block size number of data for writing contains maximal 160 data for writing
  (31 + block size) byte is checksum

If error code is READER_ERROR or NO_CARD_DETECTED, device answer with RSP_EXT packet of 3 bytes.

- 1st and 2nd bytes represents execution time of command
- 3rd byte is checksum.

In other cases, device answer with RSP_EXT packet of 5 bytes.

- 1st and 2nd bytes represents error code of operation (b2 * 256 + b1)
- 3rd and 4th bytes represents execution time of command
- 5th byte is checksum.

From version 5.0.38. if tmc_file > 0

1st and 2nd bytes represents error code of operation (b2 * 256 + b1)

- 3rd and 4th bytes represents execution time of command

5th to 20th bytes represent Reader ID
21st to 36th bytes represent Previous Encrypted Reader ID
37th to 40th bytes represent Transaction MAC counter
41st to 48th bytes represent Transaction MAC
49th byte is checksum.

DESFIRE_READ_RECORDS (0x99)

For uFR PLUS devices only.

Function allows to read data from a record in a Linear Record File or Cyclic Record File. Read command requires a preceding authentication either with the key specified for Write or Read&Write access.

From firmware version 5.0.32 Desfire Light tag support

CMD_Par0 = KEY_TYPE << 4 and CMD_Par1 = 0
1st byte of the CMD_EXT is 1 if uses internal key, or 0 if uses external key

- 2nd byte of the CMD_EXT contains ordinal number of internal key, or 0 if uses external key
- array from 3rd to 18th byte of CMD_EXT contains key (for AES and 2K3DES all key bytes,

for DES 8 key bytes and 8 zeros, for 3K3DES first 16 key bytes)

- array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)
- 22nd byte is application key number for reading
- 23rd byte is ID of file (0 – 31)
- 24th byte is 1 if authentication required, or 0 if no need the authentication
- 25th and 26th bytes represents start position for read operation within file
- 27th and 28th bytes represents number of records to be read
- 29th byte is communication settings
- 30th and 31st bytes represents size of record
- (for AES, DES and 2K3DES) 32nd byte contains checksum
- (for 3K3DES) array from byte 32 to byte 39 contains last 8 key bytes, and byte 40 contains checksum

(uFR CS with SAM and firmware versions 5.100.xx)

CMD_Par0 = (KEY_TYPE << 4) and CMD_Par1 = 0
1st byte of the CMD_EXT is 2 (using key into SAM)
2nd byte of the CMD_EXT contains ordinal number of key into SAM (0 -127)
array from 3rd to 18th byte of CMD_EXT contains 16 zeros
array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)
22nd byte is application key number for reading

- 23rd byte is ID of file (0 – 31)
- 24th byte is 1 if authentication required, or 0 if no need the authentication
- 25th and 26th bytes represents start position for read operation within file
- 27th and 28th bytes represents number of records to be read
- 29th byte is communication settings
- 30th and 31st bytes represents size of record
- 32nd byte contains checksum

Reading the data is specific and is done in a loop. Reads one data, and if it is 0, then reads another that indicates how much data follows in the package. This is repeated until the required amount of data read. If the first data is different from 0, then reader will be sent standard response.

RSP_Val0 and RSP_Val1 are not in use.

If error code is READER_ERROR or NO_CARD_DETECTED, device answer with RSP_EXT packet of 3 bytes.

- 1st and 2nd bytes represents execution time of command
- 3rd byte is checksum.

In other cases, device answer with RSP_EXT packet of 5 bytes.

- 1st and 2nd bytes represents error code of operation (b2 * 256 + b1)
- 3rd and 4th bytes represents execution time of command
- 5th byte is checksum.

DESFIRE_CLEAR_RECORD (0x6D)

For uFR PLUS devices only.

Function allows to reset a Linear Record File or Cyclic Record file to the empty state. Clear command requires a preceding authentication with the key specified for Read&Write access.

From firmware version 5.0.32 Desfire Light tag support
From firmware version 5.0.38 Transaction MAC for Desfire Light and Desfire EV2 support

(Firmware version 5.0.xx)

CMD_Par0 = KEY_TYPE << 4 and CMD_Par1 = 0

- 1st byte of the CMD_EXT is 1 if uses internal key, or 0 if uses external key
- 2nd byte of the CMD_EXT contains ordinal number of internal key, or 0 if uses external key
- array from 3rd to 18th byte of CMD_EXT contains key (for AES and 2K3DES all key bytes, for DES 8 key bytes and 8 zeros, for 3K3DES first 16 key bytes)
- array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)
- 22nd byte is ID of file that will be deleted (0 – 31)
- 23rd byte is 1 if authentication required, or 0 if no need the authentication
- (for AES, DES and 2K3DES) 24th byte contains checksum
- (for 3K3DES) array from byte 24 to byte 31 contains last 8 key bytes, and byte 32 contains checksum

(uFR CS with SAM and firmware versions 5.100.xx)

CMD_Par0 = (KEY_TYPE << 4) and CMD_Par1 = 0
1st byte of the CMD_EXT is 2 (using key into SAM)
2nd byte of the CMD_EXT contains ordinal number of key into SAM (0 -127)
array from 3rd to 18th byte of CMD_EXT contains 16 zeros
array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)
22nd byte is ID of file that will be deleted (0 – 31)

- 23rd byte is 1 if authentication required, or 0 if no need the authentication
- 24th byte contains checksum

(Firmware version from 5.0.38)

tmc_file = 0 -> Transaction MAC is not used
tmc_file = 1 -> Transaction MAC is used Reader ID is not used
tmc_file = 3 -> Transaction MAC is used Reader ID is used
CMD_Par0 = KEY_TYPE << 4 and CMD_Par1 = tmc_file

- 1st byte of the CMD_EXT is 1 if uses internal key, or 0 if uses external key
- 2nd byte of the CMD_EXT contains ordinal number of internal key, or 0 if uses external key
- array from 3rd to 18th byte of CMD_EXT contains key (for AES and 2K3DES all key bytes, for DES 8 key bytes and 8 zeros, for 3K3DES first 16 key bytes)
- array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)
- 22nd byte is ID of file that will be deleted (0 – 31)
- 23rd byte is 1 if authentication required, or 0 if no need the authentication
- 24th byte is Application key number
- (for AES, DES and 2K3DES) 25th byte contains checksum
- (for 3K3DES) array from byte 25 to byte 32 contains last 8 key bytes, and byte 33 contains checksum

(uFR CS with SAM and firmware versions 5.100.xx)

tmc_file = 0 -> Transaction MAC is not used
tmc_file = 1 -> Transaction MAC is used Reader ID is not used
tmc_file = 3 -> Transaction MAC is used Reader ID is used
CMD_Par0 = (KEY_TYPE << 4) and CMD_Par1 = tmc_file
1st byte of the CMD_EXT is 2 (using key into SAM)
2nd byte of the CMD_EXT contains ordinal number of key into SAM (0 -127)
array from 3rd to 18th byte of CMD_EXT contains 16 zeros
array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)
22nd byte is ID of file that will be deleted (0 – 31)

- 23rd byte is 1 if authentication required, or 0 if no need the authentication
- 24th byte contains checksum

RSP_Val0 and RSP_Val1 are not in use.
If error code is READER_ERROR or NO_CARD_DETECTED, device answer with RSP_EXT packet of 3 bytes.

- 1st and 2nd bytes represents execution time of command
- 3rd byte is checksum.

In other cases, device answer with RSP_EXT packet of 5 bytes.

- 1st and 2nd bytes represents error code of operation (b2 * 256 + b1)
- 3rd and 4th bytes represents execution time of command
- 5th byte is checksum.

From version 5.0.38. if tmc_file > 0

1st and 2nd bytes represents error code of operation (b2 * 256 + b1)

- 3rd and 4th bytes represents execution time of command

5th to 20th bytes represent Reader ID
21st to 36th bytes represent Previous Encrypted Reader ID
37th to 40th bytes represent Transaction MAC counter
41st to 48th bytes represent Transaction MAC
49th byte is checksum.

DESFIRE_CREATE_TRANS_MAC_FILE (0xC2)

From firmware version 5.0.38

Function allows to create TransactionMAC file.

CMD_Par0 = KEY_TYPE << 4 and CMD_Par1 = 0
1st byte of the CMD_EXT is 1 if uses internal key, or 0 if uses external key

- 2nd byte of the CMD_EXT contains ordinal number of internal key, or 0 if uses external key
- array from 3rd to 18th byte of CMD_EXT contains key (for AES and 2K3DES all key bytes, for DES 8 key bytes and 8 zeros, for 3K3DES first 16 key bytes)
- array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)
- 22nd byte is ID of file that will be created (0 – 31)

- 23rd byte is communication settings
- 24th and 25th bytes represented access rights for read, write, read&write and changing
- (byte 24 = commit_reader_id_key_no (high 4 bits) | changing_key_no (low 4 bits)
- byte 25 = read_key_no (high 4 bits) | 0x0F)
- array form 26th to 41st byte contains Transaction MAC key
- (for AES, DES and 2K3DES) 42nd byte contains checksum
- (for 3K3DES) array from byte 42 to byte 49 contains last 8 key bytes, and byte 50 contains checksum

(uFR CS with SAM and firmware versions 5.100.38)

CMD_Par0 = (KEY_TYPE << 4) and CMD_Par1 = 0

1st byte of the CMD_EXT is 2 (using key into SAM)

2nd byte of the CMD_EXT contains ordinal number of key into SAM (0 -127)

array from 3rd to 18th byte of CMD_EXT contains 16 zeros

array from 19th to 21st byte of CMD_EXT contains AID (Application ID 3 bytes)

- 22nd byte is ID of file that will be created (0 – 31)
- 23rd byte is communication settings
- 24th and 25th bytes represented access rights for read, write, read&write and changing
- (byte 24 = commit_reader_id_key_no (high 4 bits) | changing_key_no (low 4 bits)
- byte 25 = read_key_no (high 4 bits) | 0x0F)
- array form 26th to 41st byte contains Transaction MAC key
- (for AES, DES and 2K3DES) 42nd byte contains checksum
- (for 3K3DES) array from byte 42 to byte 49 contains last 8 key bytes, and byte 50 contains checksum

RSP_Val0 and RSP_Val1 are not in use.

If error code is READER_ERROR or NO_CARD_DETECTED, device answer with RSP_EXT packet of 3 bytes.

- 1st and 2nd bytes represents execution time of command
- 3rd byte is checksum.

In other cases, device answer with RSP_EXT packet of 5 bytes.

- 1st and 2nd bytes represents error code of operation (b2 * 256 + b1)
- 3rd and 4th bytes represents execution time of command
- 5th byte is checksum.

From version 5.0.38. if tmc_file > 0

1st and 2nd bytes represents error code of operation (b2 * 256 + b1)

- 3rd and 4th bytes represents execution time of command

5th to 20th bytes represent Reader ID

21st to 36th bytes represent Previous Encrypted Reader ID

37th to 40th bytes represent Transaction MAC counter

41st to 48th bytes represent Transaction MAC

49th byte is checksum.

COMMANDS FOR MIFARE PLUS CARDS

MFP_FIRST_AUTHENTICATE (0x6A)

Function is used for optional authentication with AES key when the card is in security level 1 and for switching to the security level 3.
CMD_Par0 is authentication mode (RKA_AUTH1A=0x00 or PK_AUTH1A_AES=0x80)
CMD_Par1 is ordinal number of AES key from reader (0 - 15)
CMD_EXT

- 1st and 2nd bytes represents card key address
- array from 3rd to 18th byte contains AES key
- 19th byte is checksum

The RSP_EXT is not in use

Example:

Switch to security level 3 from security level 1. AES key must be equivalent with key entered into SL3 switch key register during personalization of card, for example key number 4 stored into reader.

```
CMD         55 6A AA 13 00 04 89
ACK         AC 6A CA 13 00 04 22
CMD_EXT     03 90 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 9A
(internal key uses so AES key bytes may have any value (all 00))
RSP         DE 6A ED 00 00 00 60
```

MFP_CHANGE_REG_KEY(0x6B)

Function is used for registers or keys changing when the card is in security level 3.
CMD_Par0 is authentication mode (RKA_AUTH1A=0x00 or PK_AUTH1A_AES=0x80)
CMD_Par1 is ordinal number of AES key from reader (0 - 15)
CMD_EXT

- 1st and 2nd bytes represents card key or register address
- array from 3rd to 18th byte contains new AES key or register data
- 19th and 20th bytes represents card key for authentication address
- array from 21st to 36th byte contains AES key for authentication
- 37th byte is checksum

(uFR CS with SAM and firmware versions 5.100.xx)
CMD_Par0 is authentication mode (SAM_KEY_AUTH1A = 0x10)
CMD_Par1 is ordinal number of AES key for authentication from SAM (1 - 127)
CMD_EXT

- 1st and 2nd bytes represents card key or register address
- array from 3rd to 18th byte contains 16 zeros or register data
- 19th and 20th bytes represents card key for authentication address
- 21st byte is ordinal number of new AES key from SAM (1 - 127)
- 22nd byte is checksum

The RSP_EXT is not in use

Example:

Change the configuration AES key. Authenticate with same key. Old key is 0x11111111111111111111111111111111, new key is 0x22222222222222222222222222222222.

```
CMD         55 6B AA 25 80 00 36
ACK         AC 6B CA 25 80 00 AF
CMD_EXT     01 90 22 22 22 22 22 22 22 22 22 22 22 22 22 22 22 01 90
11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 07
RSP         DE 6B ED 00 00 00 5F
```

MFP_GET_UID(0x6C)

Function is used to read card UID when the Random ID enabled. VC polling ENC, and VC polling MAC key entered during personalization. These keys use in card UID reading process.
CMD_Par0 is authentication mode (RKA_AUTH1A=0x00 or PK_AUTH1A_AES=0x80)
CMD_Par1 is 0
if authentication mode is PK_AUTH1A_AES
CMD_EXT

- array from 1st to 16th byte contains VC polling ENC key
- array from 17th to 32nd byte contains VC polling MAC key
- 33rd byte is checksum

else if authentication mode is RKA_AUTH1A
CMD_EXT

1st byte is ordinal number of internal key contain VC polling ENC key
2nd byte is ordinal number of internal key contain VC polling MAC key
3rd byte is checksum

(uFR CS with SAM and firmware versions 5.100.xx)

CMD_Par0 is authentication mode (SAM_KEY_AUTH1A = 0x10)
1st byte is ordinal number of SAM key contain VC polling ENC key
2nd byte is ordinal number of SAM key contain VC polling MAC key
3rd byte is checksum

RSP_EXT

1st byte is UID length (7 or 4)
array from 2nd to 2 + length byte contains card UID

Example:

VC polling ENC key is 0x22222222222222222222222222222222, VC polling MAC key is 0x11111111111111111111111111111111.

```
CMD         55 6C AA 21 80 00 35
ACK         AC 6C CA 21 80 00 AC
CMD_EXT     22 22 22 22 22 22 22 22 22 22 22 22 22 22 22 22
11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 07
RSP         DE 6C ED 09 00 00 66
RSP_EXT     07 01 02 03 04 05 06 07 0E
```

COMMANDS FOR NT4H CARDS

From firmware version 5.0.32

Supported cards are NT4H1321 (NTAG 413 DNA), NT4H2421Gx (NTAG 424 DNA), and NT4H2421Tx (NTAG 424 DNA TT) card.

NTAG 424 DNA is fully compliant with the NFC Forum Type 4 Tag IC specification (Certification ID: 58562), with the contactless proximity protocol according to ISO/IEC14443-4 and the ISO/IEC 7816-4 based file system and command frames.

NTAG 424 DNA TT comes with smart status awareness, detecting the status of a tamper loop.

Same command is used for the Desfire Light tag in a couple of cases.

NT4H_COMMON_CMD (0xB3)

This command is used for various NT4H commands.

NT4H_SET_GLOBAL_PARAMETERS

Command sets file number, key number, and communication mode, before the using functions for reading and writing data into cards which are used for NTAG 2xx cards. This makes it possible to use existing functions for linear reading and writing.

CMD_PAR0 = 1, CMD_PAR1 = 0
CMD_EXT
1st byte is file number (NTAG 413 - 1 or 2, NTAG 424 - 1 to 3)
2nd byte is application key number (NTAG 413 - 0 to 2, NTAG 424 - 0 to 4)
3rd byte is communication mode of selected file (0 - plain, 1 - macked, 3 - enciphered)
4th byte is checksum
The RSP_EXT is not in use

Example:

File number = 2, key number = 0, communication mode = 0 (plain)

```
CMD         55 B3 AA 04 01 00 50
ACK         AC B3 CA 04 01 00 D7
CMD_EXT     02 00 00 09
RSP         DE B3 ED 00 00 00 87
```

NT4H_CHANGE_FILE_SETTINGS

The commands change the access parameters of an existing standard data file. Length of settings

data, and its content may be various according to NXP documentation.

CMD_PAR0 = 2, CMD_PAR1 = 0
CMD_EXT
1st byte defines internal key using (1 - reader key, 0 - provided key)
2nd byte is ordinal AES key number into reader (0 - 15)
array 3 - 18 is provided AES key
19th byte is card type (NT4H cards = 1, Desfire light = 2)
20th byte is file number (NTAG 413 - 1 or 2, NTAG 424 - 1 to 3, Desfire light 0, 1, 3, 4, 15 or 31)
21st byte is application key number (NTAG 413 - 0 to 2, NTAG 424 - 0 to 4)
22nd byte is communication mode (3 - enciphered)
23rd byte is settings data length
array of settings data length bytes
last byte is checksum
The RSP_EXT is not in use

Example:

File number = 2, current change key number = 0, read key number = 2, write key number = 3, read/write key number = 3, new change key number = 0, communication mode = 0 (plain), authentication mode provided, AES key 16x 0x00.

```
CMD         55 B3 AA 1B 02 00 5C
ACK         AC B3 CA 1B 02 00 D3
CMD_EXT     00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 01 02 00
03 03 00 30 23 17
RSP         DE B3 ED 00 00 00 87
```

NT4H_SET_CARD_CONFIGURATION

Command set card configuration. Authentication with master key required. Length of configuration data, and its content may be various according to NXP documentation.

CMD_PAR0 = 3, CMD_PAR1 = 0
CMD_EXT
1st byte defines internal key using (1 - reader key, 0 - provided key)
2nd byte is ordinal AES key number into reader (0 - 15)
array 3 - 18 is provided AES key
19th byte is card type (NT4H cards = 1)
20th byte is card command options according to NXP documentation.
21st byte is configuration data length
array of configuration data length
last byte is checksum
The RSP_EXT is not in use

Example:

Set Random ID. Option = 0 (PICC configuration), Authentication with provided master key.

```
CMD         55 B3 AA 17 03 00 5F
ACK         AC B3 CA 17 03 00 C8
CMD_EXT     00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 01 00 01
02 09
RSP         DE B3 ED 00 00 00 87
```

NT4H_CHANGE_KEY

Command changes AES key. Authentication with the application master key is required.

CMD_PAR0 = 4, CMD_PAR1 = 0
CMD_EXT
1st byte defines internal key using (1 - reader key, 0 - provided key)
2nd byte is ordinal AES key number into reader (0 - 15)
array 3 - 18 is provided AES key
byte 19 is application key number which will be changed (NTAG 413 - 0 to 2, NTAG 424 - 0 to 4)
array 20 - 35 is new AES key
array 36 - 52 is old AES key if application key number is different from 0
byte 53 is checksum.
The RSP_EXT is not in use

Example:

Key number 2 changing. Master AES key is 16 x 0x00. New AES key is 16 x 0x11. Old AES key is 16 x 0x00. Provided key authentication mode.

```
CMD         55 B3 AA 34 04 00 83
ACK         AC B3 CA 34 04 00 EC
CMD_EXT     00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 02 11 11
11 11 11 11 11 11 11 11 11 11 11 11 11 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 09
RSP         DE B3 ED 00 00 00 87
```

NT4_GET_UID

Command returns card UID if Random ID activated. Valid authentication is required.

CMD_PAR0 = 5, CMD_PAR1 = 0
CMD_EXT
1st byte defines internal key using (1 - reader key, 0 - provided key)
2nd byte is ordinal AES key number into reader (0 - 15)
array 3 - 18 contains provided AES key
byte 19 is application key number (NTAG 413 - 0 to 2, NTAG 424 - 0 to 4)
RSP_EXT
array 1 - 7 contains UID
8th byte is checksum.

Example:

Provided key authentication mode. Key number = 2. AES key is 16 x 0x11.

```
CMD         55 B3 AA 14 05 00 64
ACK         AC B3 CA 14 05 00 CB
CMD_EXT     00 00 11 11 11 11 11 11 11 11 11 11 11 11 11 11 11 02 09
RSP         DE B3 ED 08 00 00 8F
RSP_EXT     04 5B A8 92 76 63 80 F7
```

NT4H_GET_FILE_SETTINGS

Command returns file settings. Length of settings data may be various according to NXP documentation.

CMD_PAR0 = 6, CMD_PAR1 = 0
CMD_EXT
1st and 2nd bytes are 0 (no authentication required)
3rd byte is card type (NT4H cards = 1, Desfire light = 2)
4th byte is file number (NTAG 413 - 1 or 2, NTAG 424 - 1 to 3, Desfire light 0, 1, 3, 4, 15 or 31)
RSP_EXT
Settings data length bytes
the last byte is checksum.

Example:

File number = 2, File is in secure dynamic message mode.

```
CMD         55 B3 AA 05 06 00 56
ACK         AC B3 CA 05 06 00 DD
CMD_EXT     00 00 01 02 0A
RSP         DE B3 ED 14 00 00 9B
RSP_EXT     00 40 E0 EE 00 01 00 C1 FE 22 22 00 00 44 00 00 44 00 00 77
```

NT4H_GET_SDM_READING_COUNTER

Function supports retrieving of the current values of the SDM reading counter.

CMD_PAR0 = 7, CMD_PAR1 = 0
CMD_EXT
1st byte defines internal key using (1 - reader key, 0 - provided key, 0xFF no authentication)
2nd byte is ordinal AES key number into reader (0 - 15)
array 3 - 18 is provided AES key
19th byte is file number (NTAG 413 - 1 or 2, NTAG 424 - 1 to 3)
20th byte is application key number (NTAG 413 - 0 to 2, NTAG 424 - 0 to 4)
21st byte is checksum

RSP_EXT
array 1 - 3 value of counter (little endian)
byte 4 is checksum

Example:

Get SDM reading counter without authentication.

```
CMD         55 B3 AA 15 07 00 65
ACK         AC B3 CA 15 07 00 CE
CMD_EXT     FF 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 02 00 04
RSP         DE B3 ED 04 00 00 8B
RSP_EXT     02 00 00 09
```

DFL_DELETE_TRANSACTION_MAC_FILE

Command delete transaction MAC file.

NOTE: Transaction MAC file exists by factory default. To use the operations with value file, and cyclic record file, this file must be deleted.

CMD_PAR0 = 8, CMD_PAR1 = 0
CMD_EXT
1st byte defines internal key using (1 - reader key, 0 - provided key)
2nd byte is ordinal AES key number into reader (0 - 15)
array 3 - 18 is provided AES key
19th byte is file number = 15
20th byte is checksum

RSP_EXT not in use

NT4H_GET_TT_STATUS

Firmware version 5.0.43. NTAG 424 TT only.
Command supports retrieving of the permanent and current Tag Tamper Status.

CMD_PAR0 = 9, CMD_PAR1 = 0
CMD_EXT
1st byte defines internal key using (1 - reader key, 0 - provided key, 0xFF - no authentication)
2nd byte is ordinal AES key number into reader (0 - 15)
array 3 - 18 is provided AES key
19th byte is tag tamper status key number (0 - 4)
20th byte is checksum

RSP_EXT
1st byte is tag tamper permanent status
2nd byte is tag tamper current status
3rd byte is checksum

Example:

Get tag tamper status. Authentication with provided key 0x00000000000000000000000000000000. Tag tamper status key is 0.

```
CMD         55 B3 AA 14 09 00 58
ACK         AC B3 CA 14 09 00 CF
CMD_EXT     00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 07
RSP         DE B3 ED 03 00 00 8A
RSP_EXT     43 43 07
```

COMMANDS FOR READER SETTINGS

SET_BAD_SELECT_NR_MAX (0x3F)

The function allows you to set the number of unsuccessful card selections before it can be considered that the card is not placed on the reader. Period between two card selections is approximately 10ms. Default value of this parameter is 20 i.e. 200ms. This parameter can be set in the range of 0 to 254.
The CMD_EXT set is not in use.

- CMD_Par0 is bad select card number maximal
- CMD_Par1 = (CMD_Par0 xor A3) + 7

The RSP_EXT is not in use

Example:

Bad select card maximal is 10
CMD_Par0 = 0x0A, CMD_Par1 = (0A xor A3) + 7 = B0

```
CMD         55 3F AA 00 0A B0 81 (send command 3F), 81 checksum
RSP         DE 3F ED 00 00 00 13
```

GET_BAD_SELECT_NR_MAX(0x44)

The function returns value of maximal unsuccessful card selections, which is set in reader.

The CMD_EXT set is not in use.

- CMD_Par0 and CMD_Par1 are 0

RSP_EXT - 1st byte is maximal value of bad select card number

Example:

```
CMD         55 44 AA 00 00 00 C2 (send command 44), C2 checksum
RSP         DE 44 ED 02 00 00 7C
RSP_EXT     0A 11                (number is 0x0A)
```

FUNCTIONS FOR THE READER LOW POWER MODE CONTROL

ENTER_SLEEP_MODE (0x46)

Function allows the low power reader mode. Reader is in sleep mode. RF field is turned off. The reader is waiting for the command to return to normal working mode.
The CMD_EXT set is not in use.
- CMD_Par0 and CMD_Par1 are 0

The RSP_EXT is not in use.

Example:

```
CMD        55 46 AA 00 00 00 C0 (send command 46), C0 checksum
RSP        DE 46 ED 00 00 00 7C
```

LEAVE_SLEEP_MODE (0x47)

Function allows return from low power reader mode to normal working mode.

The CMD_EXT set is not in use.
- CMD_Par0 and CMD_Par1 are 0

The RSP_EXT is not in use.

From version 5.0.23 after the wake up byte sent, must wait 10 ms before the command sending.

Example:

```
WAKE UP BYTE   00
from version 5.0.23 wait 10 ms after the wake up byte sent
CMD        55 47 AA 00 00 00 BF (send command 47), BF checksum
RSP        DE 47 ED 00 00 00 7B
```

AUTO_SLEEP_SET (0x4D)

supported from firmware version 3.8.18

Command description:

This function permanently set auto-sleep functionality of the device. Valid value for the CMD_Par0 range is from 1 to 254 seconds. To permanently disable auto-sleep functionality use 0 or 0xFF for the CMD_Par0 value.
The CMD_EXT is not in use.
- CMD_Par1 are 0 (not in use).

The RSP_EXT is not in use.

AUTO_SLEEP_GET (0x4E)

supported from firmware version 3.8.18

Command description:

This command returns permanently configured auto-sleep wait seconds.
The CMD_EXT is not in use.

- CMD_Par0 and CMD_Par1 are 0 (not in use).

The RSP_EXT is not in use.

- RSP_Val0 containing configured auto-sleep wait seconds.
- RSP_Val1 is 0 (not in use).

Commands for Reader NTAG Emulation Mode

WRITE_EMULATION_NDEF (0x4A)

supported from firmware version 3.8.0

Command description:

Command stores a message record for NTAG emulation mode into the reader EEPROM. The CMD_EXT is used and contains an NDEF message for tag emulation mode. Maximum total size for emulated NDEF message is 144 bytes.
CMD_Par0 and CMD_Par1 are 0 (not in use).
1st and 2nd byte of the CMD_EXT set contains length of the following NDEF message (parameter called ndef_len) maximal length is 144 bytes.
The next ndef_len bytes contains an NDEF message.
last byte of the CMD_EXT set contains checksum

Example:

(NDEF message is URI type with "www.d-logic.net" payload):

```
CMD         55 4A AA 16 00 00 AA
ACK         AC 4A CA 16 00 00 41
CMD_EXT     14 00 03 10 D1 01 0C 55 01 64 2D 6C 6F 67 69 63 2E 6E 65 74 FE
0E
RSP         DE 4A ED 00 00 00 80
```

Possible error codes:

```
WRITE_VERIFICATION_ERROR = 0x70
MAX_SIZE_EXCEEDED = 0x10
```

Write emulation NDEF into reader RAM from firmware version 5.0.33

Command store a message record for NTAG emulation mode in to the reader RAM. The

CMD_EXT is used and contains NDEF message for tag emulation mode. Maximum total size for emulated NDEF message is 1008 bytes. The data is not written into EEPROM of the reader, so they cannot be loaded after the reader reset. This command must be execute after reader reset to use the NTAG emulation.

CMD_Par0 is 1 and CMD_Par1 is 0.
1st and 2nd byte of the CMD_EXT set contains length of the following NDEF message (parameter called ndef_len) maximal length is 1008 bytes.
next part of ndef_len (maximal part size is 240 bytes)
last byte of the CMD_EXT set contains checksum

If you want to enter more than 240 bytes, then it is done in blocks of up to 240 bytes. After the first block of data reader sent 0xAD if necessary to receive more data, or 0xDD if no need more data, or at any error. When you receive 0xAD then sends a packet in which the first byte indicates how many bytes follow. When you receive 0xDD then follow standard response.

RSP_Val0 and RSP_Val1 are not in use.

Example:

NDEF message with maximal length of 1008 bytes. Type Text

```
CMD        55 4A AA F3 01 00 4E
ACK        AC 4A CA F3 01 00 E5
CMD_EXT_1
F0 03 03 FF 03 EB C1 01 00 00 03 E4 54 02 65 6E 33 34 35 36 37 38 39 30
31 32 33 34 35 36 37 38 39 30 31 32 33 34 35 36 37 38 39 30 31 32 33 34
35 36 37 38 39 30 31 32 33 34 35 36 37 38 39 30 31 32 33 34 35 36 37 38
39 30 31 32 33 34 35 36 37 38 39 30 31 32 33 34 35 36 37 38 39 30 31 32
33 34 35 36 37 38 39 30 31 32 33 34 35 36 37 38 39 30 31 32 33 34 35 36
37 38 39 30 31 32 33 34 35 36 37 38 39 30 31 32 33 34 35 36 37 38 39 30
31 32 33 34 35 36 37 38 39 30 31 32 33 34 35 36 37 38 39 30 31 32 33 34
35 36 37 38 39 30 31 32 33 34 35 36 37 38 39 30 31 32 33 34 35 36 37 38
39 30 31 32 33 34 35 36 37 38 39 30 31 32 33 34 35 36 37 38 39 30 31 32
33 34 35 36 37 38 39 30 31 32 33 34 35 36 37 38 39 30 31 32 33 34 35 36
37 38 9D
ACK        AD
CMD_EXT_2
F0 37 38 9D 30 31 32 33 34 35 36 37 38 39 30 31 32 33 34 35 36 37 38 39
30 31 32 33 34 35 36 37 38 39 30 31 32 33 34 35 36 37 38 39 30 31 32 33
34 35 36 37 38 39 30 31 32 33 34 35 36 37 38 39 30 31 32 33 34 35 36 37
38 39 30 31 32 33 34 35 36 37 38 39 30 31 32 33 34 35 36 37 38 39 30 31
32 33 34 35 36 37 38 39 30 31 32 33 34 35 36 37 38 39 30 31 32 33 34 35
36 37 38 39 30 31 32 33 34 35 36 37 38 39 30 31 32 33 34 35 36 37 38 39
30 31 32 33 34 35 36 37 38 39 30 31 32 33 34 35 36 37 38 39 30 31 32 33
34 35 36 37 38 39 30 31 32 33 34 35 36 37 38 39 30 31 32 33 34 35 36 37
38 39 30 31 32 33 34 35 36 37 38 39 30 31 32 33 34 35 36 37 38 39 30 31
32 33 34 35 36 37 38 39 30 31 32 33 34 35 36 37 38 39 30 31 32 33 34 35
36
```

```
ACK         AD
CMD_EXT_3
F0 37 38 39 30 31 32 33 34 35 36 37 38 39 30 31 32 33 34 35 36 37 38 39
30 31 32 33 34 35 36 37 38 39 30 31 32 33 34 35 36 37 38 39 30 31 32 33
34 35 36 37 38 39 30 31 32 33 34 35 36 37 38 39 30 31 32 33 34 35 36 37
38 39 30 31 32 33 34 35 36 37 38 39 30 31 32 33 34 35 36 37 38 39 30 31
32 33 34 35 36 37 38 39 30 31 32 33 34 35 36 37 38 39 30 31 32 33 34 35
36 37 38 39 30 31 32 33 34 35 36 37 38 39 30 31 32 33 34 35 36 37 38 39
30 31 32 33 34 35 36 37 38 39 30 31 32 33 34 35 36 37 38 39 30 31 32 33
34 35 36 37 38 39 30 31 32 33 34 35 36 37 38 39 30 31 32 33 34 35 36 37
38 39 30 31 32 33 34 35 36 37 38 39 30 31 32 33 34 35 36 37 38 39 30 31
32 33 34 35 36 37 38 39 30 31 32 33 34 35 36 37 38 39 30 31 32 33 34 35
36
ACK         AD
CMD_EXT_4
F0 37 38 39 30 31 32 33 34 35 36 37 38 39 30 31 32 33 34 35 36 37 38 39
30 31 32 33 34 35 36 37 38 39 30 31 32 33 34 35 36 37 38 39 30 31 32 33
34 35 36 37 38 39 30 31 32 33 34 35 36 37 38 39 30 31 32 33 34 35 36 37
38 39 30 31 32 33 34 35 36 37 38 39 30 31 32 33 34 35 36 37 38 39 30 31
32 33 34 35 36 37 38 39 30 31 32 33 34 35 36 37 38 39 30 31 32 33 34 35
36 37 38 39 30 31 32 33 34 35 36 37 38 39 30 31 32 33 34 35 36 37 38 39
30 31 32 33 34 35 36 37 38 39 30 31 32 33 34 35 36 37 38 39 30 31 32 33
34 35 36 37 38 39 30 31 32 33 34 35 36 37 38 39 30 31 32 33 34 35 36 37
38 39 30 31 32 33 34 35 36 37 38 39 30 31 32 33 34 35 36 37 38 39 30 31
32 33 34 35 36 37 38 39 30 31 32 33 34 35 36 37 38 39 30 31 32 33 34 35
36
ACK         AD
CMD_EXT_5
30 37 38 39 30 31 32 33 34 35 36 37 38 39 30 31 32 33 34 35 36 37 38 39
30 31 32 33 34 35 36 37 38 39 30 31 32 33 34 35 36 37 38 39 30 31 32 33
34
ACK         DD (NO MORE DATA)
RESP        DE 4A ED 00 00 00 80
```

TAG_EMULATION_START (0x48)

supported from firmware version 3.8.0

Put the reader permanently in a NDEF tag emulation mode. Only way for a reader to exit from this mode is to receive the TAG_EMULATION_STOP command.
In this mode, the reader can only answer to the following commands:

```
WRITE_EMULATION_NDEF (0x4A)
TAG_EMULATION_STOP (0x49)
TAG_EMULATION_START (0x48)
GET_READER_TYPE (0x10)
GET_READER_SERIAL (0x11)
GET_FIRMWARE_VERSION (0x29)
GET_HARDWARE_VERSION (0x2A)
GET_BUILD_NUMBER (0x2B)
GET_SERIAL_NUMBER (0x40)
```

Issuing another commands in this mode, results with the following error code:

```
FORBIDDEN_IN_TAG_EMULATION_MODE = 0x90
```

CMD_Par0 and CMD_Par1 are 0 (not in use).

Possible error codes:

```
WRITE_VERIFICATION_ERROR = 0x70
```

(command resulting in a direct write to a device non-volatile memory)

Example:

```
CMD        55 48 AA 00 00 00 BE
RSP        DE 48 ED 00 00 00 82
```

TAG emulation into RAM start from firmware version 5.0.33

Put the reader permanently in a NDEF tag in RAM emulation mode. Only way for a reader to exit from this mode is to receive the TAG_EMULATION_STOP command, or by reader reset. Use the command GET_READER_STATUS to check if the reader is still in emulation mode (maybe the reader was reset for some reason).

CMD_Par0 is 1 and CMD_Par1 is 0.

TAG_EMULATION_STOP (0x49)

supported from firmware version 3.8.0

Allows the reader permanent exit from a NDEF tag emulation mode.

CMD_Par0 and CMD_Par1 are 0 (not in use).

Possible error codes:

```
WRITE_VERIFICATION_ERROR = 0x70
```

(command resulting in a direct write to a device non-volatile memory)

Example:

```
CMD         55 49 AA 00 00 00 BD
RSP         DE 49 ED 00 00 00 81
```

TAG emulation into RAM stop from firmware version 5.0.33

CMD_Par0 is 1 and CMD_Par1 is 0.

T2T_MIRROR_EMULATION (0xE7)

supported from firmware version 5.0.61
Command supports T2T ASCII mirror functionality into card emulation mode.

TAG emulation T2T mirror counter with reset counter

Command enables the 24 bit NFC counter. Counter increased by the first valid READ command in the NTAG emulation mode, after the external RF field detected. Counter is represented in 6 bytes of ASCII code, when the NDEF message is read. For example if the counter value is 0x56, it will be represented as 000056, at the end of the NDEF message. Position of the counter mirror start byte must be entered as a function parameter. This is the absolute position in the card emulation data array.

Counter value sets to 0.

CMD_Par0 is 1 and CMD_PAR1 is 0.

CMD_EXT 1st byte is 0xEA
CMD_EXT 2nd byte is a low byte of position of the counter.
CMD_EXT 3rd byte is a high byte of position of the counter.
CMD_EXT 4th to 7th bytes are counter value 0.
CMD_EXT 8th byte is checksum.

Example:

Position of the counter is 0x25

```
CMD         55 E7 AA 09 01 00 17
ACK         AC E7 CA 09 01 00 90
CMD_EXT     EA 25 00 00 00 00 00 00 D6
RSP         DE E7 ED 00 00 00 DB
```

TAG emulation T2T mirror counter without reset counter

Same as the previous command, except the reset the counter. **Counter keeps the current value**.
CMD_EXT 4th byte is 0xFF
CMD_EXT 5th byte is 0xFF
CMD_EXT 6th byte is 0xFF
CMD_EXT 7th byte is 0x00

Example:

Position of the counter is 0x25

```
CMD         55 E7 AA 09 01 00 17
ACK         AC E7 CA 09 01 00 90
CMD_EXT     EA 25 00 FF FF FF 00 00 37
RSP         DE E7 ED 00 00 00 DB
```

TAG emulation T2T mirror counter disabled

Command disables the 24 bit NFC counter.

CMD_Par0 is 1 and CMD_PAR1 is 0.

CMD_EXT 1th to 7th bytes are 0. CMD_EXT 8th byte is checksum.

Example:

```
CMD         55 E7 AA 09 01 00 17
ACK         AC E7 CA 09 01 00 90
CMD_EXT     00 00 00 00 00 00 00 00 07
RSP         DE E7 ED 00 00 00 DB
```

Ad-Hoc emulation mode:

This mode enables user controlled emulation from the user application. There is “nfc-rfid-reader-sdk/ufr-examples-ad_hoc_emulation-c” console example written in C, using our uFCoder library (see uFR API). This example demonstrate usage of the uFCoder library functions that implement sending of the following commands:

AD_HOC_EMULATION_START (0x76)

supported from firmware version 3.9.34

Put uFR in emulation mode with ad-hoc emulation parameters (see. SET_AD_HOC_EMULATION_PARAMS and GET_AD_HOC_EMULATION_PARAMS). uFR stays in emulation mode until AD_HOC_EMULATION_STOP command is sent or reader reset.

- The CMD_EXT set is not in use.
- CMD_Par0 and CMD_Par1 are not in use.
- The RSP_EXT is not in use

Example:

```
CMD         55 76 AA 00 AA CC F6
RSP         DE 76 ED 00 00 00 4C
```

AD_HOC_EMULATION_STOP (0x77)

supported from firmware version 3.9.34

Terminate uFR ad-hoc emulation mode.

- The CMD_EXT set is not in use.
- CMD_Par0 and CMD_Par1 are not in use.
- The RSP_EXT is not in use

- **Example:**

```
CMD         55 77 AA 00 AA CC F5
RSP         DE 77 ED 00 00 00 4B
```

GET_EXTERNAL_FIELD_STATE (0x9F)

supported from firmware version 3.9.34

This command returns external field state when uFR is in ad-hoc emulation mode.

- The CMD_EXT set is not in use.
- CMD_Par0 and CMD_Par1 are not in use.
- RSP_Val0 is 0 if external field isn't present or 1 if field is present.
- RSP_Val1 is not in use.
- The RSP_EXT is not in use

- **Example:**

```
CMD         55 9F AA 00 AA CC 0D
RSP         DE 9F ED 00 01 00 B4
```

GET_AD_HOC_EMULATION_PARAMS (0x9D)

supported from firmware version 3.9.35

This command returns current ad-hoc emulation parameters. On uFR power on or reset ad-hoc emulation parameters are set back to their default values.

- The CMD_EXT set is not in use.
- CMD_Par0 and CMD_Par1 are not in use.
- RSP_Val0 contains current ad-hoc threshold parameters. Default value is 0xF7.
- RSP_Val1 contains current ad-hoc receiver gain and RF level values of the RFCfgReg register (most significant bit of this value should be 0 all the time). Default value is 0x79.
- The RSP_EXT is not in use

- **Example:**

```
CMD         55 9D AA 00 AA CC 0B
RSP         DE 9D ED 00 F7 79 27
```

SET_AD_HOC_EMULATION_PARAMS (0x9E)

supported from firmware version 3.9.35

This command set ad-hoc emulation parameters. On uFR power on or reset ad-hoc emulation parameters are set back to their default values.

- The CMD_EXT set is not in use.
- CMD_Par0 contains current ad-hoc threshold parameters. Default value is 0xF7.
- CMD_Par1 contains current ad-hoc receiver gain and RF level values of the RFCfgReg register (most significant bit of this value should be 0 all the time). Default value is 0x79.

- **Example:**

```
CMD         55 9E AA 00 F7 79 F6
RSP         DE 9E ED 00 00 00 B4
```

SET_SPEED_PERMANENTLY (0x4B)

supported from firmware version 3.8.4

Permanently set the requested transceive data rates between reader and ISO14443 – 4A card / tag.

CMD_EXT set not in use.

- CMD_Par0 containing requested transmit speed constant
- CMD_Par1 containing requested receive speed constant

The RSP_EXT not in use.

Valid speed constants are:

Const	*Requested speed*
0	106 kbps (default)
1	212 kbps
2	424 kbps

Possible error codes:

```
WRITE_VERIFICATION_ERROR = 0x70
```

(command resulting in a direct write to a device non-volatile memory)

Example:

```
CMD         55 4B AA 00 02 02 BB
RSP         DE 4B ED 00 00 00 7F
```

GET_SPEED_PARAMETERS (0x4C)

supported from firmware version 3.8.4

This command returns permanently configured transceive data rates between reader and ISO14443 – 4A card / tag.

CMD_EXT set not in use.
The RSP_EXT not in use.

- RSP_Val0 containing configured transmit speed constants
- RSP_Val1 containing configured receive speed constants

Valid speed constants are:

Const	*Configured speed*
0	106 kbps (default)
1	212 kbps
2	424 kbps

Example:

```
CMD        55 4C AA 00 00 00 BA
RSP        DE 4C ED 00 02 02 86
```

Support for ISO 14443-4 protocol commands

Basic commands

SET_ISO14433_4_MODE (0x93)

supported from firmware version 3.9.36

After issuing this command, ISO 14443-4 tag in a field will be selected and RF field polling will be stopped. Furthermore all the other ISO 14443-4 protocol commands can be issued in a sequence (including APDU_TRANSCEIVE). Last command in those sequences should be S_BLOCK_DESELECT.

Example:

```
CMD        55 93 AA 00 AA CC 11
RSP        DE 93 ED 00 00 00 A7
```

SET_ISO14443_4_DL_STORAGE (0x97)

supported from firmware version 4.0.20

After issuing this command, ISO 14443-4 tag in a field will be selected and RF field polling will be stopped. Furthermore all the other ISO 14443-4 protocol commands can be issued in a sequence (including APDU_TRANSCEIVE). Last command in those sequences should be S_BLOCK_DESELECT. This command is identical to SET_ISO14433_4_MODE with a difference that enables fast reading mechanism for a JC DL Storage cards using extended APDU format for case 2E in APDU_TRANSCEIVE command (APDU in format: CLA, INS, P1, P2, 0x00, 0x7F, 0xFF) where 0x7F, 0xFF bytes represents maximum of 0x7FFF = 32767 bytes (big endian convention is in use

in this case). When C-APDU is formatted in that way, I.E. using case 2E APDU format, after 7 bytes of the RSP packet will be two bytes which will define size in bytes (big endian convention) of the following data stream.

Example:

```
CMD        55 97 AA 00 AA CC 26
RSP        DE 97 ED 00 00 00 AB
```

I_BLOCK_TRANSCEIVE (0x90)

supported from firmware version 3.9.36

Used to convey information for use by the application layer.
CMD_Par0 contains command specific flags (0x0C additional chained i block , 0x04 single i block)
CMD_Par1 containing timeout value in [ms]
CMD_EXT contains an i-block body.
RSP_EXT contains an i-block response.

R_BLOCK_TRANSCEIVE (0x91)

supported from firmware version 3.9.36

Used to convey positive or negative acknowledgements. An R-block never contains an INF field. The acknowledgement relates to the last received block.
CMD_Par0 contains acknowledge flag (1 = ACK, 0 = NOT ACK)
CMD_Par1 containing timeout value in [ms]

CMD_EXT not in use.
RSP_EXT contains an i-block response.

S_BLOCK_DESELECT (0x92)

supported from firmware version 3.9.36

Issue this command to deselect tag and restore RF field polling. This command is mandatory at the end of any ISO 14443-4 protocol command sequence.

Example:

```
CMD         55 92 AA 00 64 00 10
RSP         DE 92 ED 00 00 00 A8
```

Support for APDU commands in ISO 14443-4 tags

APDU_TRANSCEIVE (0x94)

supported from firmware version 3.9.39

The majority of the ISO 14443-4 tags supports the APDU message structure according to ISO/IEC 7816-4. For more details you have to check the manual for the tags that you plan to use.
Issuing APDU_TRANSCEIVE command you will send C-APDU to ISO 14443-4 tag selected using SET_ISO14433_4_MODE. After successfully executing APDU_TRANSCEIVE command uFR returns a byte array which contains R-APDU including data field (body) followed by the trailer (SW1 and SW2 APDU status bytes).

- CMD_Par0 not in use
- CMD_Par1 containing timeout value in [ms]

CMD_EXT contains C-APDU (i.e. {CLA, INS, P0, P1, Lc, … Nc bytes … , Le})
RSP_EXT contains R-APDU including a data field (body) followed by the trailer (SW1 and SW2 APDU status bytes).

Short APDU Support

The transceiver communication buffer in uFR devices is accommodated so that it can support all standard i.e short APDU commands and their responses.
The Short APDU command is characterized by the fact that the C-APDU (sent to the uFR device) can have a maximum of 261 bytes (4 bytes of C-APDU header: {CLS, INS, P1, P2}, 1 byte Lc, data bytes {maximum 255 bytes} and 1 Le byte). R-APDU, in the case of the short APDU, can have a maximum of 258 bytes (256 data bytes and 2 SW bytes at the end of the R-APDU stream). The R-APDU must always contain a minimum of 2 SW bytes.
Since the maximum length of the C-APDU command must be encoded in at least 2 bytes (261 is greater than 255 which is the maximum value that can be encoded in one byte only), the uFR COM protocol has been extended to use the fifth byte of the CMD packet (CMD_Par0) as a most significant byte (MSB) of the length of the following CMD_EXT packet, while the least significant byte (LSB) - CMD_EXT_Length is located in the fourth byte of the CMD packet (Little Endian sequence). So, APDU_TRANSCEIVE does not contain CMD_Par0 and this parameter is replaced by CMD_EXT_Length_MSB and the length of the next CMD_EXT packet is encoded in bytes CMD_EXT_Length_MSB and CMD_EXT_Length, which is a 16-bit word. The maximum length of the CMD_EXT packet in the case of a short APDU command can be 262 bytes (261 bytes for C-APDU including one additional CheckXOR7 byte at the end of the stream).
In case of the short APDU, the CMD_Par1 parameter must not be equal to APDU_STREAM_INDICATOR = 0x5A, which will be discussed later in the "Extended APDU support" chapter.
After receiving the ACK and sending the CMD_EXT packet, RSP and RSP_EXT packets are expected to be received. In general if the RSP packet was not received after 1.00 s since the last

byte of the CMD_EXT packet was sent, it can be considered that a communication timeout had occurred due to some critical error. However, there are many APDU commands whose execution time takes much longer than 1.00 s, so the uFR KEEP ALIVE mechanism is used here, which is active as long as the ISO14443-4 tag maintains a connection to the uFR reader according to "Half-duplex block transmission" (T = CL) protocol. The uFR KEEP ALIVE mechanism is described in the next chapter. So, as long as the APDU command is executed on the ISO 14443-4 tag, which lasts longer than the estimated timeout duration (cca 1.00s), uFR will send KEEP_ALIVE packets. After successful execution of the APDU command, the RSP and RSP_EXT packets are returned. Since the short R-APDU can have 258 bytes, which means that RSP_EXT in this case has a length of 259 bytes (additional CheckXOR7 byte at the end of the stream is mandatory), the length of this packet must be encoded in at least 2 bytes similar to the CMD_EXT packet length. Thus, in a similar way, the length of the RSP_EXT packet is encoded in the bytes RSP_EXT_Length and RSP_Val0, where RSP_Val0 has the role of the RSP_EXT_Length_MSB.
In case of the short APDU, the RSP_Val1 command must not be equal to APDU_STREAM_INDICATOR = 0x5A, which will be discussed later in the “Extended APDU support” chapter.

Short APDU Cases:

Case 1:
C-APDU Length is exactly 4 bytes. There are no C-APDU data bytes. After APDU command execution, only 2 SW bytes are expected within the R-APDU (APDU response).

C-APDU:

Byte1	Byte2	Byte3	Byte4
CLS	INS	P1	P2

R-APDU:

Byte1	Byte2
SW1	SW2

It is obvious that there is no extended variant of this APDU case.

Case 2 Short (2S):
C-APDU Length is exactly 5 bytes. There are no C-APDU data bytes. N_e can be from 1 to 256 which is encoded in the L_e field so, when the L_e = 0, N_e is 256 and in all other cases N_e = L_e {`Ne = Le > 0 ? Le : 256;` // C operation for the N_e assignment}
After APDU command execution, maximum N_e bytes and additional two SW bytes are expected within the R-APDU (APDU response). N_e only means that the host device is able to receive so many bytes after the successful execution of the current APDU command. The actual number of response data bytes returned by the tag can be less than N_e or even 0.

C-APDU:

Byte1	Byte2	Byte3	Byte4	Byte5
CLS	INS	P1	P2	L_e

R-APDU:

Byte[0]...Byte[n-3]	Byte1	Byte2
0...N_e response data bytes	SW1	SW2

Case 3 Short (3S):

C-APDU Length is minimum 6 bytes and maximum 5+N_c bytes. N_c=L_c can't be 0 and its maximum value is 255. After APDU command execution, only two SW bytes are expected within the R-APDU (APDU response).

C-APDU:

Byte1	Byte2	Byte3	Byte4	Byte5	Byte[6]...Byte[Lc+5]
CLS	INS	P1	P2	L_c	0...N_c data bytes

R-APDU:

Byte1	Byte2
SW1	SW2

Case 4 Short (4S):

C-APDU Length is minimum 7 bytes and maximum 6+N_c bytes. N_c=L_c can't be 0 and its maximum value is 255.

N_e can be from 1 to 256 which is encoded in the L_e field so, when the L_e=0, N_e is 256 and in all other cases N_e=L_e {**`Ne = Le > 0 ? Le : 256;`** // C operation for the N_e assignment}

After APDU command execution, maximum N_e bytes and additional two SW bytes are expected within the R-APDU (APDU response). N_e only means that the host device is able to receive so many bytes after the successful execution of the APDU command. The actual number of response data bytes returned by the tag can be less than N_e or even 0.

C-APDU:

Byte1	Byte2	Byte3	Byte4	Byte5	Byte[6]...Byte[Lc+5]	Byte[Lc+6]
CLS	INS	P1	P2	L_c	0...N_c data bytes	L_e

R-APDU:

Byte[0]...Byte[n-3]	Byte1	Byte2

0...N_e response data bytes	SW1	SW2

Example:

Issuing NDEF Tag Application Select command (Case 1S):
‘00 A4 04 00 07 D2 76 00 00 85 01 01 00’

```
CMD         55 94 AA 0E 00 CC B0
ACK         AC 94 CA 0E 00 CC 37
CMD_EXT     00 A4 04 00 07 D2 76 00 00 85 01 01 00 8D
RSP         DE 94 ED 03 00 00 AB
RSP_EXT     90 00 97
```

uFR KEEP ALIVE mechanism

To support the APDU commands defined in the ISO 7816-4 standard via the "Half-duplex block transmission" (T=CL) protocol, as a physical layer of data transmission, defined in the ISO 14443-4 standard, it was necessary to expand the uFR COM protocol with a KEEP_ALIVE packet type.

KEEP_ALIVE packet:

Byte1	Byte2	Byte3	Byte4	Byte5	Byte6	Byte7
KEEP_ALIVE_HDR	CMD_CODE	KEEP_ALIVE_TRL	0	0	0	CHECKSUM

KEEP_ALIVE_HDR = 0xA1
CMD_CODE = APDU_TRANSCEIVE = 0x94 {in this case}
KEEP_ALIVE_TRL = 0x85

uFR sends this packet perpetually as long as the current APDU command is executed on the NFC tag and this execution is longer than 1.00s and the tag maintains connection to the uFR via the appropriate physical layer protocol. If the execution of the APDU command takes significantly longer, uFR will repeat the KEEP_ALIVE packet every second until the RSP packet returns (or ERR packet in case of an error).

Attention: In the case of APDU commands whose execution on the NFC tag takes less than approx. 1.00s, no single one KEEP_ALIVE packet will be returned, but RSP and RSP_EXT packets will follow immediately.

Extended APDU Support

Next generation devices that support ISO7816-4 and ISO14443-4 protocols also support Extended APDU commands. The difference between the Short and Extended APDU commands is in the maximum lengths of the C-APDU and R-APDU response and the way these lengths are encoded. The C-APDU header is the same for both short and extended APDU commands and contains {CLS, INS, P1, P2} bytes. So the way of encoding Nc and Ne lengths differs depending on the case of the APDU Extended commands (Cases 2E, 3E and 4E).

Case 2 Extended (2E):

C-APDU Length is exactly 7 bytes. There are no C-APDU data bytes. N_e can be from 1 to 65536 which is encoded in L_e_MSB and L_e_LSB fields so, when the L_e=0x0000, N_e is 65536 and in all other cases N_e=L_e {`Ne = Le > 0 ? Le : 65536;` // C operation for the N_e assignment}
After APDU command execution, maximum N_e bytes and additional two SW bytes are expected within the R-APDU (APDU response). N_e only means that the host device is able to receive so many bytes after the successful execution of the current APDU command. The actual number of response data bytes returned by the tag can be less than N_e or even 0.

C-APDU:

Byte1	Byte2	Byte3	Byte4	Byte5	Byte6	Byte7
CLS	INS	P1	P2	0	L_e_MSB	L_e_LSB

MSB stands for Most Significant Byte
LSB stands for Least Significant Byte (Big Endian byte sequence is in use here)

R-APDU:

Byte[0]...Byte[n-3]	Byte1	Byte2
0...N_e response data bytes	SW1	SW2

Case 3 Extended (3E):
C-APDU length is minimum 8 bytes and maximum 7+N_c bytes. N_c is encoded in L_c_MSB and L_c_LSB bytes which represent a 16-bit word in the Big Endian sequence. N_c=L_c can't be 0 and its maximum value is 65535. After APDU command execution, only two SW bytes are expected within the R-APDU (APDU response).

C-APDU:

Byte1	Byte2	Byte3	Byte4	Byte5	Byte5	Byte6	Byte[8]...Byte[L_c+7]
CLS	INS	P1	P2	0	L_c_MSB	L_c_LSB	0...N_c data bytes

MSB stands for Most Significant Byte
LSB stands for Least Significant Byte (Big Endian byte sequence is in use here)

R-APDU:

Byte[0]...Byte[n-3]	Byte1	Byte2
0...N_e response data bytes	SW1	SW2

Case 4 Extended (4E):
C-APDU Length is minimum 10 bytes and maximum 9+Nc byte. N_c is encoded in L_c_MSB and L_c_LSB bytes which represent a 16-bit word in the Big Endian sequence. N_c=L_c can't be 0 and its maximum value is 65535.
N_e can be from 1 to 65536 which is encoded in L_e_MSB and L_e_LSB fields so, when the

L_e=0x0000, N_e is 65536 and in all other cases N_e=L_e {`Ne = Le > 0 ? Le : 65536;` // C operation for the N_e assignment}
After APDU command execution, maximum N_e bytes and additional two SW bytes are expected within the R-APDU (APDU response). N_e only means that the host device is able to receive so many bytes after the successful execution of the current APDU command. The actual number of response data bytes returned by the tag can be less than N_e or even 0.

C-APDU:

Byte1	Byte2	Byte3	Byte4	Byte5	Byte6	Byte7	Byte[8]...Byte[Lc+7]	Byte[Lc+8]	Byte[Lc+9]
CLS	INS	P1	P2	0	L_c_MSB	L_c_LSB	0...N_c data bytes	L_e_MSB	L_e_LSB

MSB stands for Most Significant Byte
LSB stands for Least Significant Byte (Big Endian byte sequence is in use here)

R-APDU:

Byte[0]...Byte[n-3]	Byte1	Byte2
0...N_e response data bytes	SW1	SW2

In order to support data streams of maximum lengths up to 65536 bytes (64KB), the uFR COM protocol needed to be further expanded. This extension of the uFR COM protocol involves the chained transmission of smaller data chunks of a maximum of 262 bytes. The key to this protocol extension is to use CMD packets with CMD_Par1 set to the value APDU_STREAM_INDICATOR = 0x5A immediately followed by the CMD_EXT packet containing a current chunk, as long there is continued transmission i.e. the next C-APDU chunk.

APDU_STREAM_INDICATOR = 0x5A

After each valid CMD package containing CMD_Par1 = APDU_STREAM_INDICATOR, followed by the CMD_EXT packet containing a current chunk, uFR will respond with a modified ACK packet which is shown in the table below:

Byte1	Byte2	Byte3	Byte4	Byte5	Byte6	Byte7
ACK_HEADER	CMD_CODE	ACK_TRAILER	0	0	APDU_STREAM_INDICATOR	CHECKSUM

In case of an error, the standard ERR packet with the status code is returned and the data transfer process is interrupted.

Poslednji CMD paket C-APDU strima ima CMD_Par1 različit od APDU_STREAM_INDICATOR. Nakon takvog paketa, počinje izvršavanje APDU komande u ciljnom uređaju/tagu i na red dolazi eventualni uFR KEEP_ALIVE mehanizam dok se čeka RSP i RSP_EXT paket.

Napomena: u slučaju Extended APDU komandi čije izvršavanje na ciljnom uređaju traje manje od cca. 1.00s, neće doći do vraćanja niti jednog KEEP_ALIVE paketa već će odziv biti odmah u vidu RSP i RSP_EXT paketa.

Extended APDU response (R-APDU) reception can also be chained i.e. in chunks, and indicator for it is the existence of RSP_Val1 = APDU_STREAM_INDICATOR in the RSP packet. Each such RSP packet is followed by an RSP_EXT packet which contains a valid R-APDU chunk. The last (or only one) RSP packet, followed by an RSP_EXT chunk which contains R-APDU and 2 SW bytes at the end of the R-APDU stream, has an RSP_Val1 different from APDU_STREAM_INDICATOR e.g. RSP_Val1 = 0. The size of individual R-APDU chunks is determined by the buffer size of the ISO14443-4 tag itself, so it can vary from tag to tag. The maximum size of individual R-APDU chunks can be 256 bytes, so 2 bytes are used to encode the length of the RSP_EXT packet in the RSP packet in a similar way to CMD and CMD_EXT (Little Endian) uFR COM protocol extensions, which is already described in the "Short APDU Support" section. So, the RSP_EXT_Length field actually represents RSP_EXT_Length_LSB and RSP_Val0 is RSP_EXT_Length_MSB. It is not possible to know in advance the length of the R-APDU response, so the protocol must rely solely on the described mechanism. It is only known that the R-APDU can be a maximum total length of 65536 + 2 (SW) = 65538 bytes, not counting data overhead due to the use of an additional layer of uFR COM protocol.
In case of an error, the standard ERR packet with the status code is returned and the data transfer process is interrupted.

PKI infrastructure and digital signature support

Fully supported from firmware version 3.9.55

In our product range, we have special cards called “D-Logic JCApp” (working title), which contains support for PKI infrastructure and digital signing. To use these features you have to implement specific APDU command sequences using the APDU_TRANSCEIVE command described before. We have implemented PKI infrastructure and digital signature support in our API (for reference read “**uFR Series NFC reader API**”).

Support for ISO 7816 protocol

The device communicates via ISO7816 UART with the smart card located into the mini smart card holder. Supports synchronous cards which do not use C4/C8.

Basic commands

OPEN_ISO7816_INTERFACE (0x95)

Function activates the smart card and returns an ATR (Answer To Reset) array of bytes from the smart card.

After the successfully executed function, the same APDU commands as for ISO 14443-4 tags can be used, but not at the same time.

SAM AV2 ACTIVATION

If NXP SAM AV2 is locked, this function will unlock the SAM.

CMD_Par0 = 1
CMD_EXT not in use

Example:

```
CMD        55 95 AA 00 01 00 72
RSP        DE 95 ED 1D 00 00 C2
RSP_EXT    3B DF 18 FF 81 F1 FE 43 00 3F 03 83 4D 49 46 41 52 45 20 50 6C
75 73 20 53 41 4D 3B 42
```

GENERAL 7816 SMART CARD ACTIVATION

CMD_Par0 = 4
CMD_EXT not in use
RSP_EXT not in use

Example:

```
CMD        55 95 AA 00 04 00 75
RSP        DE 95 ED 14 00 00 B9
RSP_EXT    3B F9 96 00 00 80 31 FE 45 4A 54 61 78 43 6F 72 65 56 0F 42
```

APDU_switch_to_ISO7816_interface

Function switches the use of APDU to ISO 7816 interface from ISO 14443-4 interface. The smart card must be in the active state.

CMD_Par0 = 2
CMD_EXT not in use
RSP_EXT not in use

Example:

```
CMD         55 95 AA 00 02 00 6F
RSP         DE 95 ED 00 00 00 AD
```

CLOSE_ISO7816_INTERFACE (0x96)

close_ISO7816_interface_no_APDU

Function deactivates the smart card. APDU commands are not used.

CMD_Par0 = 2
CMD_EXT not in use
RSP_EXT not in use

Example:

```
CMD         55 96 AA 00 02 00 72
RSP         DE 96 ED 00 00 00 AC
```

close_ISO7816_interface_APDU_ISO14443_4

Function deactivates the smart card. APDU commands are used by ISO 14443-4 tags. Tag must already be in ISO 14443-4 mode.

CMD_Par0 = 1
CMD_EXT not in use
RSP_EXT not in use

Example:

```
CMD         55 96 AA 00 01 00 6F
RSP         DE 96 ED 00 00 00 AC
```

APDU_switch_to_ISO14443_4_interface

Function switches the use APDU to ISO 14443-4 tags. The smart card stays in active state. Tag must already be in ISO 14443-4 mode.

CMD_Par0 = 3
CMD_EXT not in use
RSP_EXT not in use

Example:

```
CMD         55 96 AA 00 03 00 71
RSP         DE 96 ED 00 00 00 AC
```

APDU_switch_off_from_ISO7816_interface

APDU commands are not used. The smart card stays in active state.

CMD_Par0 = 4
CMD_EXT not in use
RSP_EXT not in use

Example:

```
CMD        55 96 AA 00 04 00 74
RSP        DE 96 ED 00 00 00 AC
```

Originality checking

Supported from firmware version 3.9.8

Some card chips support the originality checking mechanism using Elliptic Curve Digital Signature Algorithm (ECDSA). Chip families that support originality checking mechanisms are NTAG 21x and Mifare Ultralight EV1. For details on originality checking, you must have an non-disclosure agreement (NDA) with the manufacturer who will provide you with the relevant documentation.

uFR originality checking support is based on READ_ECC_SIGNATURE command. For the rest of originality checking procedure you need to use the instructions from the manufacturer documentation.

We have originality checking support completely implemented in our API using uFCoder library function **OriginalityCheck()** (for reference read "**uFR Series NFC reader API**").

READ_ECC_SIGNATURE (0xBF)

Supported from firmware version 3.9.8

This command reads the ECC signature of the card chip UID. Card chip UID is signed using EC private key known only to the manufacturer.

- CMD_Par0 not in use.
- CMD_Par1 not in use.
  CMD_EXT not in use.

On success:

- RSP_Val0 will contain the DlogicCardType code of the card in the field.
- RSP_Val1 will contain the UID length of the card in the field.
  RSP_EXT will contain an ECC signature from the card in the field, in the first 32 bytes, followed by the 10 bytes of UID. UID field in the RSP_EXT data will always have 10 bytes but the RSP_Val1 defines how many of them are relevant.

If card in field doesn't have originality checking support, returned error code is:
UNSUPPORTED_CARD_TYPE (0x11)

Example:

```
CMD         55 BF AA 00 00 00 47
RSP         DE BF ED 2B 0A 07 B1
RSP_EXT     AA 7B 0D 58 CE 43 D7 1A D1 CB 8B 37 56 6B 1E 86
            27 97 34 D7 14 4A 59 40 50 93 B4 B6 F8 7A 53 70
            04 13 95 6A 64 34 80 00 00 00 92
```

From firmware version 5.0.43.
Command supports ECC with variable length.

CMD_PAR0 is 1

- CMD_Par1 not in use.

CMD_EXT not in use.

- RSP_Val0 will contain the DlogicCardType code of the card in the field.
- RSP_Val1 will contain the UID length of the card in the field.

RSP_EXT will contain an ECC signature from the card in the field, followed by the 10 bytes of UID. UID field in the RSP_EXT data will always have 10 bytes but the RSP_Val1 defines how many of them are relevant.

Example:

Read ECC signature from NTAG 424 TT without authentication. ECC signature length is 56 bytes.

```
CMD         55 BF AA 00 01 00 48
RSP         DE BF ED 43 13 07 E2
RSP_EXT     02 D9 33 90 43 1C 8B 37 1F 6C 15 67 0F 7F 52 97 26 D6 E3 C5 EC
D5 81 30 6F 61 89 73 48 F2 0D BC 69 3D 4B 1C 16 E3 A3 88 77 C5 AC 82 A2
DA 15 B7 26 D0 5E 2D 1E B3 48 39 04 75 7C AA 5C 5E 80 00 00 00 70
```

Command supports NTAG 424 and NTAG 424 TT cards if the Random ID is activated.
CMD_PAR0 = 2, CMD_PAR1 = 0
CMD_EXT
1st byte defines internal key using (1 - reader key, 0 - provided key, 0xFF - no authentication)
2nd byte is ordinal AES key number into reader (0 - 15)
array 3 - 18 is provided AES key
19th byte is key number (0 - 4)
20th byte is checksum

RSP_Val0 will contain the DlogicCardType code of the card in the field.
RSP_EXT will contain a 56 bytes long ECC signature from the card in the field, and Random ID.
Note: UID must read with the NT4_GET_UID command.

Example:

Read ECC signature from NTAG 424 TT. Authentication with provided key 0x00000000000000000000000000000000. Key number is 0.

```
CMD         55 BF AA 13 02 00 58
ACK         AC BF CA 13 02 00 CF
CMD_EXT     00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 07
RSP         DE BF ED 43 13 04 DF
RSP_EXT6701 6D 2C C2 0C 5B 21 0C 22 AE F0 57 2E 4B 35 F8 68 84 8E EA E4
D3 25 4E 72 DB 04 66 96 A5 DF 70 B4 E4 C0 45 6E 4B 4F D2 07 DD E5 5C 42
```

```
51 C1 08 C9 4D 96 64 3E 20 BA 08 40 B1 05 00 00 00 00 00 00 6C
```

From firmware version 5.0.43.
Command supports Desfire EV2 and Desfire Light cards.
Command supports NTAG 424 and NTAG 424 TT cards if the Random ID is activated.
CMD_PAR0 = KEY_TYPE | 0x03
AES_KEY_TYPE = 0x00,
DES3K_KEY_TYPE = 0x10,
DES_KEY_TYPE = 0x20,
DES2K_KEY_TYPE = 0x30

CMD_PAR1 = 0
CMD_EXT
1st byte defines internal key using (1 - reader key, 0 - provided key)
2nd byte is ordinal AES key number into reader (0 - 15)
array 3 - 18 is provided key (8 bytes DES, 16 bytes AES and 2K3DES, or first 16 bytes of 3K3DES)
array 19 - 21 is AID
22st byte is application key number
23rd byte is 1 if authentication is required, or 0 if not.
24rd byte is checksum.

(if 3K3DES key, then array 24 - 31 is last 8 bytes of 3K3DES key, and 32nd byte is checksum)

RSP_Val0 will contain the DlogicCardType code of the card in the field.
RSP_EXT will contain a 56 bytes long ECC signature from the card in the field, and Random ID or UID.
Note: If Random ID is activated, then the UID must be read with the GET_DESFIRE_UID command.

Example:

Random ID isn't activated.

```
CMD        55 BF AA 18 03 00 62
ACK        AC BF CA 18 03 00 C9
CMD_EXT    00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 07
RSP        DE BF ED 43 3F 07 FE
RSP_EXT 1A E4 0E 9A 35 57 5A 13 47 56 76 46 B7 0F 0B 0D 85 BD 25 DE 02 62 36 2A 1C C0 DF 59 3C 48 D8 6E F9 D8 06 E9 0F 83 46 6A 40 96 5C 0A 26 26 9F AA 9C 1F 7D 4F 11 FD 5C A2 04 43 5B 0A FF 64 80 00 00 00 93
```

Example:

Random ID is activated. Provided 2K3DES key 0x0102030405060708091011121314151 6. AID = 0xD20000. Application key number is 0. Authentication is required.

```
CMD         55 BF AA 18 33 00 72
ACK         AC BF CA 18 33 00 F9
CMD_EXT     00 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 00 00 D2
00 01 CC
RSP         DE BF ED 43 2B 04 E7
RSP_EXT 24 1F 8C E1 07 1B 6D FE 3E E1 F2 40 97 82 33 5D 17 86 35 14 65
30 6A 9F 54 5E 6D 48 1D 5A FA 98 71 EE 36 17 45 B8 F3 3E DD E8 2A 8F 18
EB 49 79 96 C8 9F F8 D8 6A E0 4B 08 FC CB 23 00 00 00 00 00 00 3B
```

Anti-collision support i.e. multi card reader mode

Supported from firmware version 5.0.1 (for uFR PLUS devices only)

After power on or resetting the reader it is in a “single card” mode of operation. In this mode the reader can only work with one card in the field and the card is selected automatically.

uFR PLUS devices can be placed in so-called “anti-collision” mode of operation using ENABLE_ANTI_COLLISION command. In that mode reader can work with multiple cards in the field. Fundamental problem in a “anti-collision” mode of operation is the amount of energy that is required to power the cards in the field. Different types of cards require more or less energy. So the maximum number of cards with which reader can work simultaneously depends on specific needs for powering different cards in the field. The reader can work with up to 4 cards that have low average consumption, at a time. Cards that have low average consumption include the following models: Mifare Ultralight, Mifare Classic, Ntag series.

All the card models which supports modern cryptography mechanisms have higher power consumption. So in the case of Mifare Desfire, Mifare Ultralight C, Mifare Plus, Java Cards and other high consumption cards there should be no more then 2 cards in the reader field at a time.

ENABLE_ANTI_COLLISION (0x2D)

This command puts the reader in an “anti-collision” mode of operation.

CMD_Par0 and CMD_Par1 not in use.
CMD_EXT and RSP_EXT not in use.

Example:

```
CMD         55 2D AA 00 00 00 D9
RSP         DE 2D ED 00 00 00 25
```

DISABLE_ANTI_COLLISION (0x2E)

Exits from “anti-collision” mode of operation i.e. put the reader into “single card” mode of operation.

CMD_Par0 and CMD_Par1 not in use.
RSP_Val0 and RSP_Val1 not in use.
CMD_EXT and RSP_EXT not in use.

Example:

```
CMD         55 2E AA 00 00 00 D8
RSP         DE 2E ED 00 00 00 24
```

ENUM_CARDS (0x37)

If the reader is in an “anti-collision” mode of operation, this command enumerates cards which are found in the reader field. Otherwise the command reports ANTI_COLLISION_DISABLED error code.

All the following commands: LIST_CARDS, SELECT_CARD and DESELECT_CARD, work with UIDs from the actual UID list of the enumerated cards, which is obtained by the last ENUM_CARDS command issuing.

CMD_Par0 and CMD_Par1 not in use.
RSP_Val0 and RSP_Val1 not in use.
CMD_EXT and RSP_EXT not in use.

Example:

```
CMD         55 37 AA 00 00 00 CF
RSP         DE 37 ED 00 02 16 17
```

LIST_CARDS (0x38)

Before issuing this command you must issue the ENUM_CARDS command first.
CMD_Par0 and CMD_Par1 not in use.
CMD_EXT not in use.
RSP_Val0 contains the number of the cards detected in the reader field.
RSP_Val1 contains the length of the UID list, in bytes.
RSP_EXT contains the UID list of the card in the reader field.
For each UID, of the cards detected in the reader field, there are 11 “UID record bytes” allocated in the list. First of those 11 bytes allocated designate actual UID length immediately followed by the exactly 10 bytes of UID (which is maximum hypothetical UID size). E.g, if the actual UID length is 4 bytes, you should ignore the last 6 bytes of the UID record.

Example 1 (there is only 1 card in the field):

```
CMD         55 38 AA 00 00 00 CE
RSP         DE 38 ED 0C 01 0B 14
RSP_EXT     07 04 48 76 B2 04 35 80 00 00 00 45
```

Example 2 (there is 2 cards in the field):

```
CMD         55 38 AA 00 00 00 CE
RSP         DE 38 ED 17 02 16 0F
RSP_EXT     07 04 13 95 6A 64 34 80 00 00 00
            04 C5 58 3E E6 00 00 00 00 00 00 85
```

Example 3 (there is 3 cards in the field):

```
CMD         55 38 AA 00 00 00 CE
RSP         DE 38 ED 22 03 21 12
RSP_EXT     07 04 13 95 6A 64 34 80 00 00 00
            04 C5 58 3E E6 E2 00 00 00 00 00
            07 04 48 76 B2 04 35 80 00 00 00 A9
```

SELECT_CARD (0x39)

This command selects one of the cards whose UID is on the actual UID list of the enumerated cards. If there are any of the cards previously selected by issuing this command you will get an error CARD_ALREADY_SELECTED and you should issue the DESELECT_CARD command prior using this command, in such a case.
CMD_Par0 contains card UID size
CMD_Par1 not in use.
CMD_EXT contains card UID (have to be “card UID size” bytes as designated by the CMD_Par0).
RSP_EXT not in use.
RSP_Val0 contains selected card type (see GET_DLOGIC_CARD_TYPE enumeration).
RSP_Val1 not in use.

Example:

```
CMD         55 39 AA 05 04 00 CE
ACK         AC 39 CA 05 04 00 65
CMD_EXT     C5 58 3E E6 4C
RSP         DE 39 ED 00 21 00 32
```

DESELECT_CARD (0x3A)

Deselects previously selected card issuing SELECT_CARD command.
CMD_Par0 and CMD_Par1 not in use.
RSP_Val0 and RSP_Val1 not in use.
CMD_EXT and RSP_EXT not in use.

Example:

```
CMD         55 3A AA 00 00 00 CC
RSP         DE 3A ED 00 00 00 10
```

GET_ANTI_COLLISION_STATUS (0x3B)

Using this command you can get the current anti-collision status of the reader.
CMD_Par0 and CMD_Par1 not in use.
CMD_EXT and RSP_EXT not in use.
RSP_Val0 contains 1 if the reader is in a “anti-collision” mode of operation, otherwise 0.
RSP_Val1 contains 1 if the reader is in a “anti-collision” mode of operation and there is selected

card, otherwise 0.

Example:

```
CMD         55 3B AA 00 00 00 CB
RSP         DE 3B ED 00 01 01 0F
```

Commands for uFR Online

ESP_SET_IO_STATE (0xF3)

uFR Online only.
Function set IO pin state.

CMD_Par0 pin number
CMD_Par1 IO state 0 - low, 1 - high, 2 - input
RSP_Val0 and RSP_Val1 not in use.
CMD_EXT is optional.
CMD_EXT 1st byte is a time-delayed state (low in example). 2nd and 3rd are time in milliseconds (13 88 is 5000ms). The 4th byte is CMD_EXT checksum.
RSP_EXT not in use.

Example:

IO pin 3 high level.

```
CMD         55 F3 AA 00 03 01 15
RSP         DE F3 ED 00 00 00 C7
```

Example 1:

IO pin 3 high level and set low level after 5000ms.

```
CMD         55 F3 AA 04 03 01 11 00 13 88 A2
RSP         DE F3 ED 00 00 00 C7
```

ESP_GET_IO_STATE (0xF4)

uFR Online only.
Function gets IO pin states.

CMD_Par0 and CMD_Par1 not in use.
RSP_Val0 and RSP_Val1 not in use.
CMD_EXT not in use.

Example:

Get IO pins state. All pins set as input

```
CMD         55 F4 AA 00 00 00 12
RSP         DE F4 ED 00 00 00 CE
RSP_EXT     02 02 02 02 02 02 07
```

ESP_READER_TIME_WRITE (0xF5)

uFR Online only.
Function to set RTC date/time.

CMD_Par0 and CMD_Par1 not in use.
RSP_Val0 and RSP_Val1 not in use.
CMD_EXT contains year, month, day, hour, minutes, seconds

Example:

Set date and time to 2019-06-20 10:01:02

```
CMD         55 F5 AA 07 00 00 14
ACK         AC F5 CA 07 00 00 60
CMD_EXT     13 06 14 0A 01 02 0F
RSP         DE F5 ED 00 00 00 CD
```

ESP_READER_TIME_READ (0xF6)

uFR Online only.
Function to get RTC date/time.

CMD_Par0 and CMD_Par1 not in use.
RSP_Val0 and RSP_Val1 not in use.
RSP_EXT 1st to 8th byte contains password, 9th to 14th byte contains date/time.

Example:

Get 2019-06-20 10:01:02 date and time from device. Password is '11111111'.

```
CMD         55 F6 AA 00 00 00 10
RSP         DE F6 ED 00 00 00 CC
RSP_EXT     31 31 31 31 31 31 31 31 13 06 14 0A 01 02 0F
```

ESP_READER_EEPROM_READ (0xF7)

uFR Online only.
Function to read uFR Online EEPROM data.

CMD_Par0 and CMD_Par1 not in use.
CMD_EXT 1st to 4th byte contains EEPROM address, 5th to 8th byte contains length of data to read. (little endian)
RSP_Val0 and RSP_Val1 not in use
RSP_EXT contains requested EEPROM data

Example:

Read 5 bytes (0xFF, 0xFF, 0xFF, 0xFF, 0xFF) from address 0x00

```
CMD         55 F7 AA 09 00 00 08
ACK         AC F7 CA 09 00 00 9F
CMD_EXT     00 00 00 00 00 00 00 05 0C
RSP         DE F7 ED 05 00 00 C8
RSP_EXT     FF FF FF FF FF 06
```

ESP_READER_EEPROM_WRITE (0xFB)

uFR Online only.
Function to write uFR Online EEPROM data.

CMD_Par0 and CMD_Par1 not in use.
CMD_EXT 1st to 4th byte contains EEPROM address, 5th to 8th byte contains length of data to read, 9th to 16th byte contains password, bytes from 17th contain data. (little endian)
RSP_Val0 and RSP_Val1 not in use
RSP_EXT not in use

Example:

Write 5 bytes (0xFF, 0xFF, 0xFF, 0xFF, 0xFF) to address 0x00. Password is '11111111'.

```
CMD         55 FB AA 16 00 00 19
ACK         AC FB CA 16 00 00 92
CMD_EXT     00 00 00 00 00 00 00 05 31 31 31 31 31 31 31 31
            FF FF FF FF FF 01
RSP         DE FB ED 00 00 00 CF
```

ESP_SET_DISPLAY_DATA (0xF8)

uFR Online only.
Function enables sending data to the uFR Online LED. A string of data contains information about the intensity of color in each cell. Each cell has three LEDs (red, green and blue). For each cell of the three bytes is necessary. The first byte indicates the intensity of the red color, the second byte indicates the intensity of the green color, and the third byte indicates the intensity of blue color.

From firmware version 2.7.6, RGB LEDs can be connected to pin 5 of P5 connector (GPIO connector - ESP pin 18). First 6 bytes in display_data array will be sent to internal RGB LEDs, additional bytes will be sent to external connected RGB. There is no limit for number of external cells.

CMD_Par0 and CMD_Par1 contain LED light duration in ms. If duration is 0, light will never turn off

CMD_EXT contains data for display with checksum
RSP_Val0 and RSP_Val1 not in use
RSP_EXT not in use

Example:

red = 0x10, green = 0xFF, blue = 0x20, duration = 100ms

```
CMD         55 F8 AA 02 00 64 0C
ACK         AC F8 CA 02 00 64 FF
CMD_EXT     10 FF 20 10 FF 20 07
RSP         DE F8 ED 00 00 00 D2
```

ESP_READER_RESET (0xF9)

uFR Online only.
Function resets device connected to uFR Online.

CMD_Par0 - always set to 0.
CMD_Par1 not in use.
RSP_Val0 and RSP_Val1 not in use.
CMD_EXT and RSP_EXT not in use.

Example:

Reset device.

```
CMD         55 F9 AA 00 00 00 0D
RSP         DE F9 ED 00 00 00 D1
```

ESP_SET_TRANSPARENT_READER (0xF9)

uFR Online only.
Function set transparent reader connected to uFR Online.

CMD_Par0 - set 1 for first device(default) or 2 for external connected reader.
CMD_Par1 not in use.
RSP_Val0 and RSP_Val1 not in use.
CMD_EXT and RSP_EXT not in use.

Example:

Set first reader as transparent device.

```
CMD         55 F9 AA 00 01 00 0E
RSP         DE F9 ED 00 00 00 D1
```

Set external reader as transparent device.

```
CMD         55 F9 AA 00 02 00 0B
RSP         DE F9 ED 00 00 00 D1
```

ESP_READER_PASSWORD_WRITE (0xFA)

uFR Online only.
Function to write uFR Online password.

CMD_Par0 and CMD_Par1 not in use.
CMD_EXT 1st to 8th byte contains old password, bytes from 9th to 16th contains new password.
RSP_Val0 and RSP_Val1 not in use
RSP_EXT not in use

Example:

Write a new password '22222222'. Old password is '11111111'.

```
CMD         55 FA AA 11 00 00 1B
ACK         AC FA CA 11 00 00 94
CMD_EXT     31 31 31 31 31 31 31 31 32 32 32 32 32 32 32 32 07
RSP         DE FA ED 00 00 00 D0
```

ESP_GET_READER_SERIAL (0xE7)

It gives the uFR Online serial number with length of 4 bytes. The CMD_EXT set is not in use.
The CMD_Par0 and CMD_Par1 are not in use.
If everything operates as expected the RESPONSE set is sent and after that also the RESPONSE EXT set of 5 bytes which contains 4 byte ReaderSerialNumber values (little-endian) and at the end one checksum byte.

Example:

```
Send CMD GET_READER_SERIAL
55 E7 AA 00 00 00 1F
```

Where

```
55 – CMD_HEADER
E7 – CMD_CODE
AA – CMD_TRAILER
00 00 00 – CMD_EX_Length and CMD_Par0 and CMD_Par1 not used
1F – CHECKSUM
```

Reader answer with RESPONSE – RSP packet followed by RSP_EXT packet

```
DE E7 ED 05 00 00 D8 54 7E 1A 5D 74
```

Where RSP PACKET contains

```
DE – RSP_HEADER
E7 – CMD_CODE
ED – RSP_TRAILER
05 – RSP_EXT_Length
00 00 – RSP_Val0 and RSP_Val1 not used
D8 – CHECKSUM
```

and RSP_EXT contains

```
54 7E 1A 5D – Device serial number(currently serial is 5D 1A 7E 54, little-endian
notation)
74 – CHECKSUM
```

Miscellaneous commands

CHECK_UID_CHANGE (0xE4)

From firmware version 5.0.27
Function tries to change the UID on the card. On some cards (e.g. Magic Classic) changing UID is possible.

CMD_Par0 and CMD_Par1 not in use.
CMD_EXT not in use
RSP_EXT not in use

Example:

If “Magic Classic” card is tested, then function returns OK, else function returns error code.

```
CMD        55 E4 AA 00 00 00 22
RSP        DE E4 ED 00 00 00 DE
```

RF_RESET (0xE5)

From firmware version 5.0.27
Command reset RF field at the reader. The RF field will be off, and then on after 50ms.

CMD_Par0 and CMD_Par1 not in use.
CMD_EXT not in use
RSP_EXT not in use

Example:

```
CMD        55         E5         AA         00         00         00         21
RSP        DE E5 ED 00 00 00 DD
```

From firmware version 5.0.51.
In the multi card reader mode.

RF_ON

Command switch on RF field at the reader.
CMD_Par0 = 1
CMD_EXT not in use
RSP_EXT not in use

Example:

```
CMD        55         E5         AA         00         01         00         22
RSP        DE E5 ED 00 00 00 DD
```

RF_OFF

Command switch off RF field at the reader. The RF field can be switched on by RF_ON, or ENUM_CARDS, or DISABLE_ANTICOLISION command.
CMD_Par0 = 2
CMD_EXT not in use
RSP_EXT not in use

Example:

```
CMD        55         E5         AA         00         02         00         1F
RSP        DE E5 ED 00 00 00 DD
```

GET_READER_STATUS (0xE6)

From firmware version 5.0.33
Function returns various reader states. The reader states are defined into following structures. This function is useful for checking if the reader is still in emulation mode after the command TAG_EMULATION_START.

```
typedef                enum                E_EMULATION_MODES
{
        TAG_EMU_DISABLED                        =                0,
        TAG_EMU_DEDICATED,
        TAG_EMU_COMBINED,
        TAG_EMU_AUTO_AD_HOC
}emul_modes_t;

typedef enum E_EMULATION_STATES
{
        EMULATION_NONE = 0,
        EMULATION_IDLE,
        EMULATION_AUTO_COLL,
        EMULATION_ACTIVE,
        EMULATION_HALT,
        EMULATION_POWER_OFF
}emul_states_t;

typedef enum E_PCD_MGR_STATES
{
        PCD_MGR_NO_RF_GENERATED = 0,
        PCD_MGR_14443A_POLLING,
        PCD_MGR_14443A_SELECTED,
        PCD_MGR_CE_DEDICATED,
        PCD_MGR_CE_COMBO_START,
```

```
        PCD_MGR_CE_COMBO,
        PCD_MGR_CE_COMBO_IN_FIELD
}pcd_states_t;
```

CMD_Par0 and CMD_Par1 not in use.
CMD_EXT not in use
RSP_EXT
1st byte is reader state from pcd_states_t structure
- normal working mode states are PCD_MGR_NO_RF_GENERATED or PCD_MGR_14443A_POLLING or PCD_MGR_14443A_SELECTED.
- NTAG emulation mode state is PCD_MGR_CE_DEDICATED
2nd byte is emulation mode from emul_modes_t structure
- normal working mode state is TAG_EMU_DISABLED
- NTAG emulation mode state is TAG_EMU_DEDICATED
3rd byte is emulation state form emul_states_t structure
4th bytes is reader sleep mode indicator
0 - reader is in normal or emulation mode
1 - reader is in sleep mode
5th byte is checksum

Example:

```
WAKE UP BYTE    00    (send just before command)
CMD         55          E6          AA          00          00          00          20
RSP         DE E6 ED 05 00 00 D7
RSP_EXT     03 01 01 00 0A
```

READ_TT_STATUS (0xB4)

From firmware version 5.0.60
Function provides the information about the tag tamper status which is detected when the NTAG 213 TT is powered by an RF field.

CMD_Par0 and CMD_Par1 not in use.
CMD_EXT not in use
RSP_EXT
array 1 - 4 is Tag Tamper Message
byte 5 is Tag Tamper status
byte 6 is checksum

Example:

Tag tamper message is A1 B2 C3 D4, tag tamper status is open ‘O’ 0x4F

```
CMD         55          B4          AA          00          00          00          52
RSP         DE          B4          ED          06          00          00          88
RSP_EXT     A1 B2 C3 D4 4F 52
```

Access control commands

UFR_XRC_LOCK_OPEN (0x60)

Electric strike switches when the function is called. Pulse duration determined by command.

CMD_Par0 is a low byte of pulse duration in ms.
CMD_Par1 is a high byte of pulse duration in ms.
CMD_EXT not in use.

Example:

Pulse duration is 100ms.

```
CMD     55      60      AA      00      64      00      02
RSP     DE 60 ED 00 00 00 5A
```

UFR_XRC_SET_RELAY_STATE (0x61)

Command switches relay, and control output pin.

If CMD_Par1 is 0, then the command is used for relay switching off and on.
CMD_Par0 is 1 relay on, and CMD_Par0 is 0 relay off.
CMD_EXT not in use.

Example:

Relay on.

```
CMD     55      61      AA      00      01      00      A6
RSP     DE 61 ED 00 00 00 59
```

Example:

Relay off.

```
CMD     55      61      AA      00      00      00      A5
RSP     DE 61 ED 00 00 00 59
```

If CMD_Par1 is 1, then the command is used for output pin control.
CMD_Par0 is 0.
CMD_EXT
1st byte is the ordinal number of hardware specific output pin.
2nd byte - 1 output is inverted, 0 output is normal.
3rd byte - number of on-off cycles. If the cycle number is 0, the output state will be infinite, or until this will be changed with the next function call (output state is 1 if the invert is 0, and 0 if invert is 1).

4th byte - on duration in ms low byte. If the invert is 0 output state is 1, and if invert is 1 output state is 0.
5th byte - on duration in ms high byte.
6th byte - off duration in ms low byte. If the invert is 0 output state is 0, and if invert is 1 output state is 1. This state of the output pin remains after the completion of the on-off cycle.
7th byte - off duration in ms high byte.
8th byte is checksum.

Example:

Ordinal number is 1, invert is 0, number of cycles is 3, on duration is 100ms, off duration is 50ms.

```
CMD         55 61 AA 08 00 01 9E
ACK         AC 61 CA 08 00 01 15
CMD_EXT     01        00        03        64        00        32        00        5B
RSP         DE 61 ED 00 00 00 59
```

UFR_XRC_GET_IO_STATE (0x62)

Commands returns states of 3 IO pins, or returns status of one input pin.

If CMD_Par0 is 0, then the command returns states of 3 IO pins.
CMD_Par1 is 0.
CMD_EXT not in use.
RSP_EXT
1st byte - voltage on optical isolated input 1, no voltage 0
2nd byte - state of digital input pin 1 or 0
3rd byte - state of relay (1 on, 0 off)
4th byte is checksum

Example:

Voltage on optical isolated input, no voltage on the digital input, relay off.

```
CMD         55 62 AA 00 00 00 A4
RSP         DE          62          ED          04          00          00          5C
RSP_EXT     01 00 00 08
```

If CMD_Par0 is not 0 then the command returns the state of the input pin.
CMD_Par0 is the ordinal number of hardware specific input pin.
CMD_Par1 is 0.
CMD_EXT not in use.
RSP_EXT
1st byte is the state of the input pin.
2nd byte is checksum.

Example:

State of input pin with ordinal number 1

```
CMD         55 62 AA 00 01 00 A3
RSP         DE          62          ED          02          00          00          5A
RSP_EXT     00 07
```

Appendix: ERROR CODES

ERROR	VALUE

OK	0x00
COMMUNICATION_ERROR	0x01
CHKSUM_ERROR	0x02
READING_ERROR	0x03
WRITING_ERROR	0x04
BUFFER_OVERFLOW	0x05
MAX_ADDRESS_EXCEEDED	0x06
MAX_KEY_INDEX_EXCEEDED	0x07
NO_CARD	0x08
COMMAND_NOT_SUPPORTED	0x09
FORBIDEN_DIRECT_WRITE_IN_SECTOR_TRAILER	0x0A
ADDRESSED_BLOCK_IS_NOT_SECTOR_TRAILER	0x0B
WRONG_ADDRESS_MODE	0x0C
WRONG_ACCESS_BITS_VALUES	0x0D
AUTH_ERROR	0x0E
PARAMETERS_ERROR	0x0F
MAX_SIZE_EXCEEDED	0x10
UNSUPPORTED_CARD_TYPE	0x11
COUNTER_ERROR	0x12
WRITE_VERIFICATION_ERROR	0x70
BUFFER_SIZE_EXCEEDED	0x71
VALUE_BLOCK_INVALID	0x72
VALUE_BLOCK_ADDR_INVALID	0x73
VALUE_BLOCK_MANIPULATION_ERROR	0x74
WRONG_UI_MODE	0x75
KEYS_LOCKED	0x76
KEYS_UNLOCKED	0x77
WRONG_PASSWORD	0x78
CAN_NOT_LOCK_DEVICE	0x79
CAN_NOT_UNLOCK_DEVICE	0x7A
DEVICE_EEPROM_BUSY	0x7B
RTC_SET_ERROR	0x7C
EEPROM_ERROR	0x7D
NO_CARDS_ENUMERRATED	0x7E
CARD_ALREADY_SELECTED	0x7F
WRONG_CARD_TYPE	0x80
FORBIDDEN_IN_TAG_EMULATION_MODE	0x90
Mifare Plus tags errors	
MFP_COMMAND_OVERFLOW	0xB0
MFP_INVALID_MAC	0xB1
MFP_INVALID_BLOCK_NR	0xB2
MFP_NOT_EXIST_BLOCK_NR	0xB3
MFP_COND_OF_USE_ERROR	0xB4
MFP_LENGTH_ERROR	0xB5
MFP_GENERAL_MANIP_ERROR	0xB6

MFP_SWITCH_TO_ISO14443_4_ERROR	0xB7
MFP_ILLEGAL_STATUS_CODE	0xB8
MFP_MULTI_BLOCKS_READ	0xB9
NT4H tags errors	
NT4H_COMMAND_ABORTED	0xC0
NT4H_LENGTH_ERROR	0xC1
NT4H_PARAMETER_ERROR	0xC2
NT4H_NO_SUCH_KEY	0xC3
NT4H_PERMISSION_DENIED	0xC4
NT4H_AUTHENTICATION_DELAY	0xC5
NT4H_MEMORY_ERROR	0xC6
NT4H_INTEGRITY_ERROR	0xC7
NT4H_FILE_NOT_FOUND	0xC8
NT4H_BOUNDARY_ERROR	0xC9
NT4H_INVALID_MAC	0xCA
NT4H_NO_CHANGES	0xCB

Appendix: ERROR CODES for DESFire card operations

```
#define DATA_OVERFLOW                2990
#define READER_ERROR                 2999
#define NO_CARD_DETECTED                   3000
#define CARD_OPERATION_OK            3001
#define WRONG_KEY_TYPE               3002
#define KEY_AUTH_ERROR               3003
#define CARD_CRYPTO_ERROR            3004
#define READER_CARD_COMM_ERROR             3005
#define PC_READER_COMM_ERROR         3006
#define COMMIT_TRANSACTION_NO_REPLY 3007
#define COMMIT_TRANSACTION_ERROR     3008
#define NO_ISO1444_4_CARD            3009
#define NOT_SUPPORTED_KEY_TYPE       3010



/* Status and error codes */

#define OPERATION_OK            0x0C00
#define NO_CHANGES              0x0C0C
#define OUT_OF_EEPROM_ERROR     0x0C0E
#define ILLEGAL_COMMAND_CODE    0x0C1C
#define INTEGRITY_ERROR         0x0C1E
#define NO_SUCH_KEY             0x0C40
#define LENGTH_ERROR            0x0C7E
#define PERMISSION_DENIED       0x0C9D
#define PARAMETER_ERROR         0x0C9E
#define APPLICATION_NOT_FOUND   0x0CA0
#define APPL_INTEGRITY_ERROR    0x0CA1
#define AUTHENTICATION_ERROR    0x0CAE
#define ADDITIONAL_FRAME        0x0CAF
```

```
#define BOUNDARY_ERROR          0x0CBE
#define PICC_INTEGRITY_ERROR    0x0CC1
#define COMMAND_ABORTED         0x0CCA
#define PICC_DISABLED_ERROR     0x0CCD
#define COUNT_ERROR             0x0CCE
#define DUPLICATE_ERROR         0x0CDE
#define EEPROM_ERROR_DES        0x0CEE
#define FILE_NOT_FOUND          0x0CF0
#define FILE_INTEGRITY_ERROR    0x0CF1
```

Change log:

Firmware version 5.0.1 and later apply only to uFR PLUS devices

Date	Description	doc. revision	refers to the firmware ver.
2022-10-26	ESP_SET_IO_STATE parameters updated	1.33	
2022-09-08	Access control commands	1.32	
2022-03-14	RGB signalization in the sleep mode	1.31	5.0.62
2022-02-24	Tag emulation T2T mirror counter support	1.30	5.0.61
2022-01-19	NTAG 213 TT support	1.29	5.0.60
2021-12-27	Extended APDU support	1.28	5.0.57
2021-10-18	SET_DISPLAY_DATA command has new feature for internal RGB modules, RED_LIGHT_CONTROL command changed	1.27	5.0.55
2021-09-01	Support for ISO 7816 protocol	1.26	5.0.44
2021-08-31	uFR Online GPIO time control added	1.25	
2021-01-11	RF field on/off in the multi card mode	1.23	5.0.51
2020-10-19	Desfire EV2 and Desfire Light ECC signature read support	1.22	5.0.44
2020-10-09	NTAG 424 TT support.	1.21	5.0.43
2020-07-17	Leave sleep mode command bug fix	1.20	5.0.23
2020-04-10	Transaction MAC for Desfire Light and Desfire EV2 support	1.19	5.0.38
2020-02-27	Mifare Plus X, SE or EV1 value block operations support	1.18	5.0.36
2020-02-20	Desfire light tag support	1.17	5.0.32
2020-02-20	COMMANDS FOR NT4H CARDS	1.16	5.0.32
2020-02-18	Default UART speed session.	1.15	5.0.1
2020-02-18	NTAG emulation mode in RAM (1008 bytes user memory). Get reader status	1.14	5.0.33
2019-10-30	For Mifare Plus card in SL3 uses functions for Mifare Classic card. AES key calculated from Crypto1 key.	1.13	5.0.29
2019-10-1	Check if UID changeable and RF reset	1.12	5.0.27
2019-10-1	SAM support for uFR CS with SAM	1.12	5.100.27
2019-08-15	Desfire operations with Linear and Cyclic records.	1.11	5.0.25
2019-08-14	Desfire DES, 2K3DES, and 3K3DES internal key support	1.10	5.0.25
2019-06-21	Added uFR Online commands.	1.9	
2019-05-17	Added description for a new command: code 0x97, SET_ISO14443_4_DL_STORAGE.	1.8	5.0.20
2019-05-17	All references to “ISO 14443-4A” have been changed to “ISO	1.8	from

	14443-4” because uFR firmwares support ISO 14443-4A and ISO 14443-4B types both from 3.9.49 firmware version.		3.9.49
2019-05-16	Desfire get application identifiers added	1.7	5.0.19
2018-10-01	Anti-collision support (multi card reader mode) added	1.6	5.0.1
2018-07-05	Mifare Plus commands added. Diferencies for block read and write and linear read. uFR PLUS devices only.	1.5	
2018-07-04	Mifare Desfire value file manipulation functions. uFR PLUS devices only.	1.4	
2018-06-08	Added missing descriptions for READER_KEYS_LOCK, READER_KEYS_UNLOCK, and READER_PASSWORD_WRITE commands. Added hardware reset explanation.	1.3	
2018-06-08	Originality checking and READ_ECC_SIGNATURE command.	1.3	3.9.8
2018-06-08	Added missing descriptions for READ_COUNTER and INCREMENT_COUNTER commands (NFC Type 2 Tags)	1.3	3.9.11
2018-06-08	Added missing description for GET_NFC_T2T_VERSION command (NFC Type 2 Tags)	1.3	3.8.19
2018-06-08	Added missing card type constants in GET_DLOGIC_CARD_TYPE table.	1.3	
2018-05-31	SET_LED_CONFIG command added	1.2	3.9.53
2018-05-30	DESFIRE_WRITE_AES_KEY, and GET_DESFIRE_UID examples are corrected	1.1	
2018-05-30	Appendix: ERROR CODES for DESFire card operations	1.1	
2018-05-29	PKI infrastructure and digital signature support	1.1	3.9.55
2018-05-29	Changed date format in a Change log. Now we use a more universal ‘yyyy-mm-dd’ date format.	1.1	-
2017-06-29	Support for APDU commands in ISO 14443-4A tags	1.0	3.9.39
2017-05-23	Support for ISO 14443-4A protocol commands	1.0	3.9.36
2017-05-03	Commands for Ad-Hoc emulation mode parameters manipulation. (GET_AD_HOC_EMULATION_PARAMS and SET_AD_HOC_EMULATION_PARAMS).	1.0	3.9.35
2017-05-03	Ad-Hoc emulation mode commands.	1.0	3.9.34
2016-08-06	FAST_READ ISO14443-3 command with LINEAR_READ utilisation.	1.0	3.9.14
2016-06-06	Title “Authentication mode considerations” changed to “Authentication mode considerations for Mifare Classic tags”	1.0	
2016-06-06	New Title “Authentication mode considerations for NTAG 21x and other T2T tags”	1.0	3.9.10