

Application Note

EHAG 13,56 MHz Multitag Reader Module ME-H102022xx / ME-6160xx

Firmware: 0.9v

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1 Scope

The 13,56 MHz Multitag Reader Module is a proximity reading device supporting a wide range of 13,56 MHz tag. It supports ISO15693, Icode®, Tagit®, Mifare® Standard, Mifare® Ultralight, SR176 and ISO14443 Type B cards. Using an external antenna and a serial interface it can be easily connected to a PC. The Plug and Play version has an integrated antenna and serial interface.

The first part of the documentation described general functions and memory management of different tags. A listing of the memory map is given in detail if necessary.

The second part lists the OEM module and describes the pin out.

The next chapter lists all commands and introduce to them. Each command is explained and an example illustrates the usage. FAQs highlight general issues of the handling of the 13,56 MHz Multitag Reader Module.

The appendices describes the Plug and Play Module, the custom coil design, matching circuit and all steps to upgrade the Plug and Play board to +12V supply voltage.

Additionally the use of the TempeSense® label is high lightened.

2 Definitions and abbreviations

2.1 Definitions:

2.1.1 Anticollision loop

Algorithm processed to identify and handle a dialogue between VCD and one or more VICCs in its antenna field.

2.1.2 Hex notation

A hexadecimal value is noted with a following h. i.e. A1h has the value A1 hexadecimal.

2.1.3 ASCII notation

ASCII characters are listed within apostrophes, i.e. 'x' means a single x.

2.2 Abbreviations

AFI	Application family identifier
BCC	Binary Calculated Checksum
CRC	Cyclic redundancy check
DSFID	Data storage format identifier
ETX	End of transmission frame
LSB	Least significant bit
MFR	Manufacturer
MSB	Most significant bit
RFU	Reserved for future use
OTP	One time programming
STATID	Station ID
STX	Start of transmission frame
UID	Unique identifier
VCD	Vicinity coupling device
VICC	Vicinity integrated circuit card

Figure 2-1: Abbreviations

3 Tag organization

3.1 State diagram

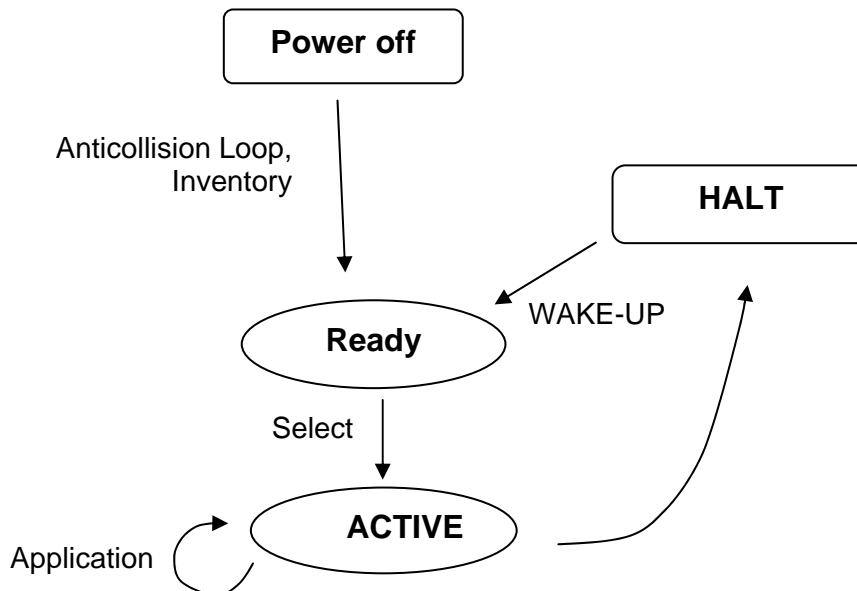


Figure 3-1: State Diagram

The state diagram shows the different states of a tag. First the tag must be power up. Next command initialize a tag using the anticollision or inventory command. A selection of a tag is necessary to interact with a tag of interest especially if more than one tag is present at the same time. Only selected tags are capable to response to higher commands such as read or write page data.

READY state	A tag enters the READY state after it receives a valid inventory or anticollision command. At this state the tag all serial numbers are known and the tag is ready to select.
ACTIVE state	After a selection the tag is in the ACTIVE state. Only an activated tag can respond to a read or write command.
HALT state	The HALT command disables a tag for further communication. The tag is still in the field but dies not respond to any command. To activate a tag and to put it back to the Ready state a WAKE-UP command has to be used.

3.2 Supported labels

	Serial number	Read page	Write page	Lock page	Transfer command	Comments
ISO15693					(¹)	
EM 4135	√	√	√	√	√	
Icode® SLI	√	√	√	√	√	
LRI512	√	√	√	√	√	
SRF55VxxP	√	√	√	√	√	Encryption not supported
SRF55VxxS	√	-	-	-	√	Temperature logging
Tagit® HFI	√	√	√	√	√	
TempSense	√	√	√	√	√	
Tagit®	√	√	√	√	-	
Icode®	√	√	√	√	-	
ISO14443A						
Mifare® Std.	√	-	-	-	-	Limited reading performance
Mifare® Ultralight	√	√	√	√	-	Limited reading performance
MF1IC70	√	-	-	-	-	Limited reading performance
Mifare ProX	√	-	-	-	-	Limited reading performance
SLE55R16	√	-	-	-	-	Limited reading performance
ISO14443B						
SLE66CL160S	√	-	-	-	-	Limited reading performance
SR176	√	√	√	√	-	Limited reading performance

Figure 3-2: Supported tags

(¹) Only commands within 320µs after the EOF are recognized

3.3 ISO 15693

The reader can communicate with ISO15693 tags. An anticollision is needed if multiple instances of tags are in the same antenna field. The reader detects each type of ISO15693 labels and handles them individually

3.3.1 Coding of UID

The UID of a tag is defined in ISO/IEC 15693-3. All tags compliant to ISO15693 support the specified format. The UID is factory programmed and cannot be changed. The UID is needed for the anticollision sequence to separate several tags in the same antenna field.

Byte							
7	6	5	4	3	2	1	0
E0h	MFR Code	Serial number					

Figure 3-3: Coding of ISO 15693 UID

The MFR Code is listed in ISO/IEC 7816-6:1996/Amd.1: 2000(E). Following manufacturer are tested with our reader

MFR-Code	Company
02h	ST Microelectronics
04h	Philips Semiconductors
05h	Infineon Technologies AG
07h	Texas Instrument
16h	EM Microelectronic-Marin SA

Figure 3-4: Manufacturer codes

3.3.2 Memory organization

An ISO15693 tag is separated into two blocks. An administrative block which contains the UID, AFI, DSFID and the lock page state. The user block is free for custom use. The chip manufacturer defines the amount of bytes and number of pages of each tag. As default four bytes are used for several tags.

Page address	Byte			
	0	1	2	3
3Fh	User data			
...	...			
00h	User data			
Administrative block				

Figure 3-5: Memory organization of ISO 15693

3.3.3 My-D Label (SRF55VxxP)

My-D labels are specific labels of Infineon. These labels show a different memory organization. Two different modes of tags are supported: plain and secure mode. At the moment only plain mode tags are supported in full functionality. Only serial numbers are supported in secure mode.

Two different cards with 320 bytes or 1k bytes EEPROM memory are available. The EEPROM memory is divided into pages.

Each tag is split into two parts: The administrative blocks (00h, 01h, 02h) and the user area. Administrative pages are read only and cannot be changed. User data is free for use. Additionally user data pages can be locked. This procedure is irreversible.

The EEPROM of SRF55V10P is organized in 128 pages addressed 00h to 7Fh. The EEPROM of SRF55V02P consists of 32 pages addressed 00h to 1Fh.

Address	Page									
	0	1	2	3	4	5	6	7		
7Fh	User data								SRF55V02P	SRF55V10P
...	...									
3Fh	User data									
...	...									
03h	User data									
02h										
01h										
00h	Serial number (UID)									

Figure 3-6: SRF55VxxP memory organization

3.3.3.1 UID

The UID of SRF55Vxx labels starts with 60h or E0h.

3.3.3.2 Security Bit

Bit 45 of the UID defines the secure mode of the SRF55Vxx. If set the tag supports security algorithm and is not accessible with the reader device

Bit 45	Description
1	Tag supports crypto security mechanism
0	Chip supports plain mode only

Figure 3-7: Security bit

3.3.4 EM 4135

The EM4135 is an ISO15693 compliant label of EM Microelectronic-Marin SA. It has eight bytes per page as the same as the My-D label. It only supports 35 pages. The administrative area holds the information of the access condition and the UID.

Address	Page							
	0	1	2	3	4	5	6	7
24h	User data							
...	...							
00h	User data							
	Administrative area							

Figure 3-8: Memory organization of EM 4135

3.4 Icode®

Icode® labels stores data is stored in a non-volatile EEPROM. Its capacity is 512 bits organized in 16 blocks consisting 4 bytes each (1 block = 32 bits). First 3 blocks contain administrative data.

3.4.1 Memory organization

Page address	Byte			
	0	1	2	3
0Fh	User data			
...	...			
05h	User data			
04h	Family code identifier / User data			
03h	Special function (EAS) / User data			
02h	Write access condition			
01h	Serial number			
00h	Serial number			

Figure 3-9: Icode® memory organization

3.4.2 Serial number

The serial number of a label is defined at the manufacturer process. It is stored on page 00h and page 01h. LSB is stored first.

3.4.3 Write access condition

Page 02h contains the write access condition for each page. Each page can be set to read only (bits are set to 0). This procedure is irreversible. Locking page 2 no further changed of the access condition can be done. Always two bits must be change at the same time. This register is implemented as OTP.

Byte 0				Byte 1				Byte 2				Byte 3											
MSB		LSB		MSB		LSB		MSB		LSB		MSB		LSB									
1	1	1	1	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3	2	1	0	7	6	5	4	B	A	9	8	F	E	D	C								
Special function	Write access	Serial number	Serial number	User data	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	User data								

Figure 3-10: Write access condition bytes

3.4.4 Special function (EAS), AFI

Special Functions (EAS) and Family Code/Application Identifier are additional features. For more information refer to the Icode® manual.

3.4.5 User data

All other blocks are free for use and can be changed according the state of the write access conditions.

3.5 TAGIT

TAGIT labels are organized in a wide range of different page size and number of pages. Automatically the reader detects the correct memory organization.

Switching on the Extended ID mode (see chapter instruction set) the reader appends two bytes to the UID containing the page size and the number of pages of a label.

3.6 SR176

The SR176 label contains only 64 bytes of data organized in two bytes per page.

3.6.1 Memory organization

Page address	Byte 1	Byte 0	
0Fh	Lock byte	RFU	Chip ID
0Eh	User data		
...	...		
04h	User data		
03h	Serial number		
02h	Serial number		
01h	Serial number		
00h	Serial number		

Figure 3-11: SR176 memory organization

3.6.2 Serial number UID

The UID is stored at the first 4 pages. Page 00h contains the LSB of the UID.

Page 03h		Page 02h		Page 01h		Page 00h	
Byte 1h	Byte 0	Byte 1	Byte 0	Byte 1	Byte 0	Byte 1	Byte 0

Figure 3-12: SR176 Serial number

3.6.3 Lock byte

The lock byte defines the write access condition of a pair of pages. Each bit can only be set once. This procedure is irreversible. This byte is implemented as OTP.

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Page 0Eh Page 0Fh	Page 0Ch Page 0Dh	Page 0Ah Page 0Bh	Page 08h Page 09h	Page 06h Page 07h	Page 04h Page 05h	Page 02h Page 03h	Page 00h Page 01h

Figure 3-13: Lock byte

3.6.4 Chip ID

The Chip ID is defined in the low nibble of page 0Fh. It is manufacturer set and is used internally to select and separate single tags.

3.7 ISO 14443

The reader can only handle single tags according ISO 14443 type A or B. The reader only identifies single tags and returns its serial number.

All other command such as read, write, select are not supported.

The Mifare[®] transponder family consists of various 13.56 MHZ transponders according to ISO14443. For more details refer to ISO14443 part 1-4.

3.8 Mifare[®] Ultralight

Mifare[®] Ultralight tags have no crypto algorithm included. They are designed for a small data volume.

3.8.1 Memory organization

Page address	Byte			
	3	2	1	0
0Fh	User data			
...				
04h	User data			
03h	OTP			
02h	Lock bytes		reserved	
01h	Serial number			
00h	Serial number			

Figure 3-14: Memory organization of Mifare[®] Ultralight

3.8.2 Serial number

The UID consists of 7 bytes. The first part of the UID is stored on page 00h the second on page 01h. The storage format on page 00h fulfills ISO14443 Type A. The UID is factory programmed and cannot be changed.

3.8.3 Lock bytes

On page 2 the lock bytes are stored. Each bit specifies a page or block. Once a bit is set it cannot be changed anymore. This process is irreversible. If a block lock bit is set all pages within this block are read only regardless the single lock states. This register is implemented as OTP

Byte 1								Byte 0							
MSB				LSB				MSB				LSB			
7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Page F	Page E	Page D	Page C	Page B	Page A	Page 9	Page 8	Page 7	Page 6	Page 5	Page 4	OTP	Block A-F	Block 4-9	OTP

Figure 3-15: Lock bytes of Mifare® Ultralight

3.8.4 OTP bytes

Page 3 is implemented as OTP register. All bits are factory programmed to 0. Once a bit is set it cannot be changed furthermore. It can be used as a 32 bit one-time counter.

3.8.5 User data

User data is free for use. It can be changed according the write access condition.

4 Hardware

4.1 Pin out of OEM Module

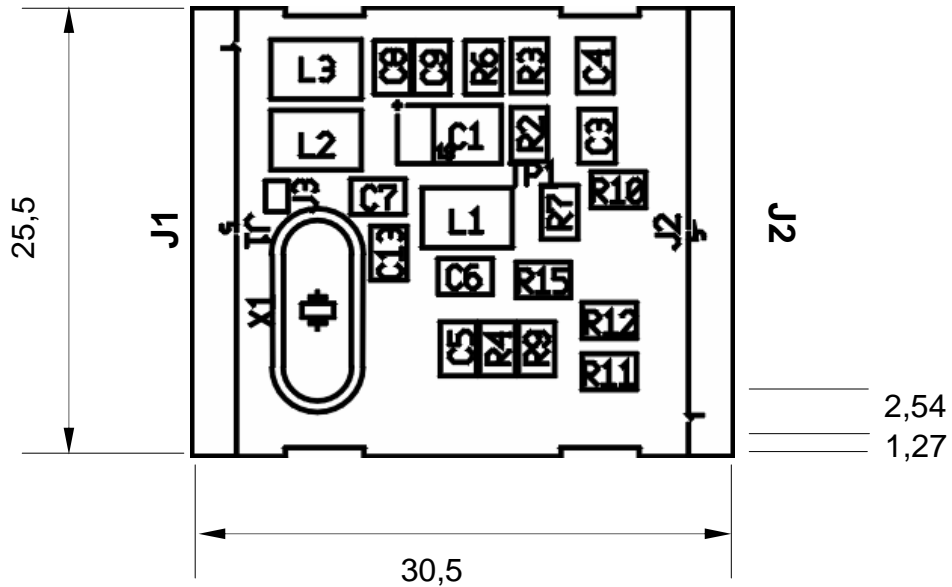


Figure 4-1: Pin out of the reader device

4.1.1 Pin out of J1

PIN	PIN Nr	Description
ARX	1	Antenna RX
ATX1	2	Antenna TX1
VDD	3	+5 V DC
GND	4	Ground
RFU	5	Reserved for future use
TGND	6	Antenna Ground
RFU	7	Reserved for future use
RFU	8	Reserved for future use
RFU	9	Reserved for future use
RFU	10	Reserved for future use

Figure 4-2: Pin out of jumper 1

4.1.2 Pin out of J2

PIN	PIN Nr	Description
VDD	20	+5 V DC
GND	19	Ground
LEDg	18	LED green (reading LED)
LEDr	17	LED red
EN	16	Enable reader, open or logic high
RFU	15	Reserved for future use
USER	14	User Port
DIR	13	Direction of RS 485
TX	12	TX to PC
RX	11	RX from PC

Figure 4-3: Pin out of jumper 2

4.1.3 Electrical characteristics of PINs

PIN	PIN Nr	Voltage	Current (max)	Description
RX TX	11 12	USART ²	-	To RS232, RS485 device driver
USER	14	TTL ³	25 mA	User sets logic state
EN	16	ST ⁴	25 mA	Low will disable the reader device
LEDr	17	GND	25 mA	Logic Low, used for LED
LEDg	18	LED	25 mA	With 330 Ω (internal)
ARX ATX1 TGND	1 2 6	(depends on antenna tuning)	200 mA _{PP}	Antenna input Antenna output Antenna output (GND)
RFU	5,7,8,9, 10,15	-	-	Not connected
GND	4,19	GND	-	Supply Ground
VDD	3,20	+5 V DC	150 mA	Supply Voltage
DIR	13	TTL	25 mA	RS485 direction

Figure 4-4: Electrical characteristics of pins

² Universal Synchronous Asynchronous Receiver Transmitter

³ TTL buffer output / input

⁴ Schmitt trigger buffer output

5 Software

As a default data is transmitted at 9600,n,8,1. Two protocol modes are supported. The protocol mode is configured in the reader EEPROM. As factory default, the ASCII protocol is used.

5.1 ASCII Protocol

This protocol was designed for easy handling. The commands can be issued using a terminal program. Data is transmitted as ASCII hexadecimal that can be displayed on any terminal program (e.g. HyperTerminal).

Command	Data
Various length	Various length

Figure 5-1: ASCII protocol frame

5.2 Binary Protocol

This protocol was designed for industrial applications with synchronization and frame checking. Also an addressing byte for party lines (master slave, multi drop) is included.

The protocol usually requires a device driver. Data is transmitted binary.

STX	Station ID	Length	Data	BCC	ETX
1 byte	1 byte	1 byte	Various length	1 byte	1 byte

Figure 5-2: Binary protocol frame

5.2.1 STX

Start of transmission (02h)

5.2.2 Station ID

Unique ID of the station

00h: reserved for the bus master. Readers send response to this device ID

FFh: Broadcast message. All devices will execute the command.

5.2.3 Length

Length of the data block

5.2.4 Data

This part contains the command and data. The command values are the same as in ASCII protocol mode ('x', 's', ...). Data is transmitted binary.

The length of the command block depends on the instruction.

5.2.5 Block Check Character (BCC)

The BCC is used to detect transmission errors. The BCC is calculated XORing each byte of the transmission frame excluding the STX/BCC and ETX character.

$$BCC = (StatID) \text{ xor } (Length) \text{ xor } (Command / Data_0) \text{ xor } \dots \text{ xor } (Command / Data_N)$$

5.2.6 ETX

End of transmission. (03h)

5.2.7 Remarks

If the reader device receives an invalid instruction frame (i.e. BCC wrong) or the requested station ID does not match the internal ID of the reader, the command is not executed. The reader waits for the next valid frame.

Use the binary timeout (see protocol configuration register) to detect incomplete binary frames.

5.2.8 Examples:

02h	64h	01h	78h	1Dh	03h
STX	Station ID	Length	'x'	BCC	ETX

This instruction frame will reset the reader module with the station ID 64h.

5.3 Instruction Set

Following table describes all commands of the reader device. Each command returns an answer to the host. Exceptions are mentioned explicitly. The green LED is acknowledging a successfully executed command. The red LED indicates an error.

5.3.1 Overview

Command	Description
'x'	Reset
'v'	Get version
'c'	Continuous read
's'	Select
'm'	MultiTag select / tag list
'r'	Read page
'rp'	Read EEPROM register
'w'	Write page
'wp'	Write EEPROM register
'oX'	Set tag type
'o+X'	Include tag type
'o-X'	Exclude tag type
'k'	Lock page
't'	Transfer data telegram
'dr' / 'dg' / 'dn'	Set LED
'g'	Get ID
'poff' / 'pon'	Antenna power off/on
'pr' / 'pw'	Read / write user port

Figure 5-3: Command overview

5.3.2 Error Codes

Following figure shows an overview of all error messages of the reader device.

Error Code	Description
'?’	Unknown command
'F'	General failure
'I'	Invalid data format, this error occurs only in ASCII mode. The reader assumes a hexadecimal value but receives bad data
'N'	No tag in the field
'U'	Read data does not match written data, block might be write protected or write process fails.
'X'	Page is already locked. Lock command fails

Figure 5-4: Error codes

5.3.3 EEPROM memory organization

Following figure lists the EEPROM register of the reader device.

Page	Description
00h...04h	Unique device ID; read only
05h...09h	administrative data, RFU
0Ah	Station ID
0Bh	Protocol configuration
0Ch	Baud rate
0Dh	Binary watchdog timer
0Eh	Operation mode
0Fh	Timeout value
10h	RFU
11h	Start page
12h	Number of pages
13h...1Fh	RFU
20h...FFh	User data

Figure 5-5: EEPROM memory

5.3.3.1 Unique device ID (00h-04h)

The unique device ID identifies a reader module. It is factory programmed and cannot be changed.

5.3.3.2 Station ID (0Ah)

The station ID is used in binary mode to address a device in party line set up. The station ID has the range of 01h to FEh and can be freely set. The value 00h is reserved for the bus master. All readers send a response to this device.

The broadcast message (FFh) forces all readers to response to the command.

Default value is 01h.

5.3.3.3 Protocol configuration (0Bh)

The PCON register specifies general behavior of the reader device.

Default value is 01h.

Protocol configuration register							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Extend- ed ID	Page read	Single shot	LED	Lock mode	BWDT	Protocol	Auto start

Figure 5-6: Protocol configuration register

5.3.3.3.1 Auto start (default 1)

If set the reader device will start up in continuous read mode automatically. Auto start has only effect in ASCII protocol mode.

5.3.3.3.2 Protocol (default 0)

If set the reader uses binary protocol mode. As default ASCII protocol is used. See section binary protocol for further information on the binary protocol format.

5.3.3.3.3 Binary timeout (default 0)

If set the reader sets up a binary timeout internally. This bit should be enabled in binary protocol mode to ensure correct framing.

5.3.3.3.4 Lock mode (default 0)

If set the reader locks itself to the first recognized tag type automatically. Other tag types are not recognized. Only a reset or a change operation mode command cancels the lock state.

5.3.3.3.5 LED (default 0)

If set the reader suppresses any LED activity. The user manages the state of the LEDs.

5.3.3.3.6 Single shot (default 0)

If set the reader displays the serial number of a tag only once within a specified timeout. The time out is defined at EEPROM register 0Fh. 00h indicated no delay. The delay time can be adjusted stepwise in 100 msec steps.

5.3.3.3.7 Page read (default 0)

If set the reader sends the content of a page specified at EEPROM register 11h instead of the serial number. Additionally the reader device reads following pages defined at EEPROM register 12h.

5.3.3.3.8 Extend ID (default 0)

If set Tagit® and ISO14443 Type B cards returns additional information.

Tag type	Number of Bytes	Description
Tagit®	2	page size, number of pages
ISO14443B	7	application data, Protocol Identifier

Figure 5-7: Extended ID

5.3.3.4 Baud rate (0Ch)

The baud rate register defines the communication speed of the reader device. Default value is 00h.

Baud rate register							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
RFU	RFU	RFU	RFU	RFU	RFU	BS1	BS0

Figure 5-8: Baud rate register

This register defines the baud rate of the device.

BS1	BS0	Baud rate
0	0	9600 baud (default)
0	1	19200 baud
1	0	38400 baud
1	1	57600 baud

Figure 5-9: Baud rate settings

Following figure describes the communication settings

Description
8 data bits
No parity bit
1 stop bit
No flow control

Figure 5-10: Communication settings

5.3.3.5 Binary watchdog timer (0Dh)

The binary watchdog timer defines the maximum delay time between two byte in binary protocol mode sent from the host to the reader. In binary protocol mode the binary watchdog timer should be enabled in order to detect incomplete or corrupted frames.

The value FFh is reversed and should not be used.

The value 00h sets the timeout to a minimum.

Default value is FEh.

5.3.3.6 Operation mode (0Eh)

The operation mode register defines which tag types the reader supports. This register enables fast tag recognition because only defined tag types are requested.

Operation mode register							
Bit 7 (MSB)	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0 (LSB)
RFU	RFU	SR176	ISO14443B	ISO1443A	Icode®	Tagit®	ISO15693

Figure 5-11: Operation mode register

5.3.3.7 Timeout value (0Fh)

The timeout value defines the delay time between two responses of the reader. It has only effect in continuous read mode. To enable the timeout the single shot flag has to be set. See above protocol configuration register. One timeout slice is 100msec. Exact timing depends on the used protocol.

Value 00h indicates no delay time.

Default value is 0Ah (1 sec).

5.3.3.8 Start page (10h)

The EEPROM register defines the start page address in page read mode. To enable this function the page read flag has to be set. See above protocol configuration register.

The reader will send the content of this page instead of the serial number. This mode is only supported for ISO15693, Icode® and Tagit® tags. The reader does not check the integrity of the page address. If an error occurs or a not valid page is read nothing is returned.

Default value is 00h.

5.3.3.9 Number of pages (12h)

The number of pages describes how many following pages are read. The start address is specified at EEPROM register 10h. The reader returns all pages and sends in the end a <CR> + <LF>. In binary protocol mode each page is send separately. No terminator is sent in the end.

Value 00h is reserved and should not be used.

Default value is 01h (one page is read).

5.3.3.10 User data (20h-FFh)

User data is free for use.

5.3.4 Reset

This command executes a power on (software) reset. New configuration settings will be loaded.

5.3.4.1 Command

Command	Data
'x'	none

5.3.4.2 Answer

Answer	Description
none	ASCII Mode: "ISO 1.0" + CR + LF Binary Mode: none

This command will reset the reader module as well as all tags in the antenna field. The reader starts according the startup settings.

5.3.4.3 Reset Timing

The power up timing depends on environmental conditions such as voltage ramp up. For handheld devices the timing may depend on the charging state of the battery.

5.3.5 Get Version

This command returns the current version of the reader module.

5.3.5.1 Command

Command	Data
'v'	none

5.3.5.2 Answer

Answer	Description
none	ASCII Mode: "ISO 1.0" + CR + LF Binary Mode: 02 00 07 49 53 4F 20 31 2E 30 31 03

5.3.5.3 Example

Command	Description
v	ISO 1.0 Version of the reader module

5.3.6 Continuous Read

The reader device reads and displays the serial numbers continuously while one or more tags remain in the field. This command stops if any character is sent to the reader module. The reader module returns the character 'S' (53h).

Only different tag types are detected at the same time. Use the multitag list command (see chapter 5.3.8) if more than one ISO15693 tag are present.

The reader supports different tag types. Though a single continuous read instruction needs a specific time. To increase the reading performance switch to a single tag mode. Results depend on the startup conditions. See chapter read EEPROM register for more details of startup configurations.

5.3.6.1 Command

Command	Data
'c'	none

5.3.6.2 Answer

Answer	Description
data	Leading character (1 byte) + serial number (n bytes)

Number of bytes depends on tag type.

This command is not supported in binary protocol mode.

5.3.6.3 Leading character

The leading character specifies a single tag type. It can be used to determine the present tag type and control tag specific commands. Card types have different UID length, e.g. ISO15693 cards use an 8 byte UID whereas standard ISO14443 Type A cards 4.

Following table describes all leading characters of supported tag types.

Tag type	UID length	Description
'V'	8 bytes	ISO 15693
'T'	4 bytes	Tagit®
'I'	8 bytes	Icode®
'M'	Var. size	Mifare® Ultralight, ISO 14443 Type A
'S'	8 bytes	SR176
'Z'	4 bytes	ISO1443 Type B

Figure 5-12: Leading character of continuous read mode

5.3.6.4 Continuous read mode at start up (default enabled)

Continuous read mode at startup could be activated using the utility program.

5.3.6.5 Lock mode (default disabled)

If set the reader locks to the first recognized tag type. This speeds up the communication to a tag in continuous read mode. The reader only uses this tag type anymore.

5.3.6.6 Extended ID (default disabled)

If set Tagit® and ISO14443 Type B cards returns additional information.

Tag type	Number of Bytes	Description
Tagit®	2	page size, number of pages
ISO14443B	7	Application data, Protocol Identifier

Figure 5-13: Extended ID

5.3.6.7 SingleShot function (default disabled)

If enabled the reader replies the serial number only once. Then the reader waits until a timeout is reached. One time slice is around 100 ms. The timeout value has the range of one byte and is stored in EEPROM register 0Fh.

5.3.6.8 PageRead function (default disabled)

If enabled the reader sends a page content instead of the serial number back to the host. The reader starts at the page specified in the EEPROM register 11h and reads as many as following pages defined at EEPROM register 12h. A single command is terminated with an <CR> + <LF>.

In binary protocol mode each page is transmitted separately. At the end no <CR> + <LF> is transmitted.

5.3.6.9 LED function (default disabled)

Using the LED active flag the reader suppresses an activity of the LED. The user can set the LED state using the commands of switching on/off LED.

5.3.6.10 Simple access control applications

Serial numbers are not encrypted and always sent plain to the reader. This results in a low-level security application.

5.3.7 Select

This command selects a single card in the antenna field. It can only be used in single tag mode. In case of success the command returns the UID of the selected card.

5.3.7.1 Command

Command	Data
's'	none

5.3.7.2 Answer

Answer	Description
data	Leading character (1 byte) + serial number
'N'	Error: No Tag in the field

5.3.7.3 Select a single tag

No previous continuous read is required.

5.3.7.4 Extended ID (default)

If set Tagit® and ISO14443 Type B cards return additional information. See above for more information of the Extended ID.

5.3.7.5 Multiple tags

This command is designed for fast access to a single tag in the field. If multiple cards are used in the field the 'm' instruction for the select procedure has to be used.

5.3.7.6 Example

s	E000112233445566 Select the card of type ISO15693 with the UID E000112233445566
---	---

5.3.8 Multi Tag Selection / List

This command detects several ISO15693 tags at the same time. It replaces the fast select command in multiple tag surroundings. The Multi Tag list command lists all tags with its serial numbers. Using the Multi Tag Select command to address a single or a group of tag together. Each tag has to be selected separately

5.3.8.1 Command

Command	Data
'm'	Serial number (8 bytes)

5.3.8.2 Answer

Answer	Description
data	'V' + serial number (8 bytes)
'N'	Error: No Tag in the field

5.3.8.3 Multi tag list

Sending a <CR> (0Dh) as first parameter the reader returns a list of all present tags in the field. In the end the amount of detect tags are returned. A Multi Tag list command resets all tags in the antenna field.

5.3.8.4 Reading distance

Each card needs a specific amount of power. The reader always provides the same power. Therefore the reading distance will decrease if more tags are present.

5.3.8.5 Multi tag select

Using the eight-byte serial number as parameter the according tag will be selected. High-level interactions can be performed addressing only this card. All other tags are still present but not used.

5.3.8.6 Maximum number of tags

The maximum number of tags in the antenna field is limited to the physical characteristics of the antenna. Internally the software can handle up to 40 tags (theoretical maximum).

5.3.8.7 Example

Command	Description
m<CR>	VE000123456789012 → first card VE000112233445566 → second card 02 → number of detect tags
mE000123456789012	E000123456789012 Select card with its serial number

5.3.9 Read page

This command reads a data block on a card. Size of returned data depends on the used tag. A valid page address depends on the present tag. E.g. an Icode® tag supports only 16 pages, an ISO15693 SRF55V10P 128 pages.

5.3.9.1 Command

Command	Data
'r'	page address (1 byte)

5.3.9.2 Answer

Answer	Description
data	page data (depends on tag type)
'F'	Error: read failure
'N'	Error: No tag in field

5.3.9.3 Page data

Page data depends on the used tag. Following table describes the default page sizes. Internally the reader handles the correct data frame size.

Tag type	Page size	Description
ISO15693	4 8	As default SRF50VxxP, EM 4135
Tagit®	Var. size	Depends on tag organization
Icode®	4	
SR176	2	
Mifare® Ultralight	4	
ISO14443A	-	Not supported
ISO14443B	-	Not supported

Figure 5-14: page data

5.3.9.4 No tag in field 'N'

The tag does not respond. There is either no tag present or not addressed.

5.3.9.5 Read failure 'F'

This error is displayed if the reader receives bad data. Additionally this error is generated if a page is read which is not physically located on the card.

5.3.9.6 Examples

r05	00112233 reads page 05. page data is 00112233
-----	--

5.3.10 Read reader EEPROM

Reads the internal reader EEPROM. It contains all startup parameters and the device ID. Changes of the startup settings will only be taken into effect after a reset of the device.

5.3.10.1 Command

Command	Data
'rp'	EEPROM address (1 byte)

5.3.10.2 Answer

Answer	Description
data	EEPROM data (1 bytes)

5.3.10.3 Example

Command	Description
rp0B	01 Reads protocol configuration register.

5.3.11 Write page

This command writes data to a page. A read after write is done automatically to ensure correct writing.

5.3.11.1 Command

Command	Data
'w'	page address (1 byte) + data (n bytes)

5.3.11.2 Answer

Answer	Description
data	'w' + page data (depends on tag type)
'N'	Error: No tag in field
'F'	Error: Write failure
'U'	Error: read after write incorrect

5.3.11.3 Page data

Page data depends on the used tag. Following table describes the default page sizes. Internally the reader handles the correct data frame size.

Tag type	Page size	Description
ISO15693	4 8	As default SRF50VxxP, EM 4135
Tagit®	n	Depends on tag organization
Icode®	4	
SR176	2	
Mifare® Ultralight	4	
ISO14443A	-	Not supported
ISO14443B	-	Not supported

Figure 5-15: page data

5.3.11.4 No tag error 'N'

This error is returned if no tag is present.

5.3.11.5 Write failure 'F'

This error is displayed if bad transmission conditions are given. If the page address exceeds the physical number of pages of a tag this error is thrown too.

5.3.11.6 Read after write error 'U'

After each write access to a TAG a read is done automatically. This error is thrown if read data does not match the written data. E.g. the page is read only.

5.3.11.7 Example

Command	Description
w0511223344	w11223344 writes data 11223344 on page 05.

5.3.12 Write EEPROM

Writes to the internal reader EEPROM. It contains all startup parameters and the device ID. Changes of the startup settings will only be taken into effect after a reset of the device.

5.3.12.1 Command

Command	Data
'wp'	page address (1 byte) + data (1 byte)

5.3.12.2 Answer

Answer	Description
data	EEPROM data (1 bytes)

5.3.12.3 Example

Command	Description
wp0A01	01 Set EEPROM address 0A (Station ID) to 01h

5.3.13 Set tag type

This command switches the reader to a specific tag type. The continuous read function will speed up because only this tag type is recognized. These changes are not stored into the EEPROM. After a reset the reader starts as defined in the startup configuration.

5.3.13.1 Command

Command	Data
'o'	Leading character (1 byte)

5.3.13.2 Answer

Answer	Description
none	String of tag type

5.3.13.3 Leading character

Tag type	String	Description
'a'	"ALL"	All tag types
'i'	"ICODE"	Icode®
'm'	"ISO14443A"	Mifare® Ultralight, ISO 14443 Type A
's'	"SR176"	SR176
't'	"TAGIT"	Tagit®
'v'	"ISO15693"	ISO 15693
'z'	"ISO14443B"	ISO1443 Type B

Figure 5-16: List of leading characters

5.3.13.4 Example

Command	Description
ov	ISO15693 Set the reader device to ISO15693 tags

5.3.14 Include tag type

This command includes a specific tag type to the reader device.

5.3.14.1 Command

Command	Data
'o+'	Leading character (1 byte)

5.3.14.2 Answer

Answer	Description
none	String of tag type

5.3.14.3 Leading character

See chapter 5.3.13.3.

5.3.14.4 Example

Command	Description
o+t	+TAGIT Include Tagit® protocol to the reader device

5.3.15 Exclude tag type

This command excludes a specific tag type from the reader device.

5.3.15.1 Command

Command	Data
'o-'	Leading character (1 byte)

5.3.15.2 Answer

Answer	Description
none	String of tag type

5.3.15.3 Leading character

See 5.3.13.3.

5.3.15.4 Example

Command	Description
o-i	-ICODE Exclude Icode® protocol from the reader device

5.3.16 Lock page

This command locks a page permanently. It only supports ISO15693 and Tagit® tags. Icode® and Mifare® Ultralight tags can be locked using the write command. See tag organization for more details.

5.3.16.1 Command

Command	Data
'k'	Page address (1 byte)

5.3.16.2 Answer

Answer	Description
data	'k' + page address
'F'	Error: Lock failure
'X'	Error: Page already locked

5.3.16.3 Example

Command	Description
k05	K05 Lock page 05.

5.3.17 Transfer data telegram

This command sends a custom data block to a card. First the proper tag type has to be specified using the set tag type command. The reader device only supports ISO15693. The command shows a specific command frame for each tag type.

The maximum frame size is limited to 200 bytes each.

5.3.17.1 ISO15693

The reader set the according flag of the protocol automatically. Only FM and high data rate can be used.

5.3.17.2 Command

Command	Data
't'	Downlink length (1 byte) + Uplink length (1 byte) + data (n bytes)

5.3.17.3 Answer

Answer	Description
data	Response of card
'F'	Error: General failure

5.3.17.4 Downlink length

The downlink length includes only the data. The CRC is computed automatically and shall not be included.

5.3.17.5 Uplink length

The uplink length is need due to no length information is included in the protocol. The user has to know the exact response length of the command. The CRC shall not be included in the length.

5.3.17.6 Data

Data consists of following frame.

Flags	Command code	UID	Data
(1 byte)	(1 byte)	(8 bytes)	(n bytes)

Figure 5-17: ISO15693 data frame

5.3.17.6.1 Flags

Flags have to be correct in order to succeed. Following figure describes the flag byte. RFU bits are set automatically and cannot be changed. The inventory flag has to be set executing the inventory command.

Bit	Flag name	Value	Description
0	RFU	1	Reserved for future use
1	RFU	1	Reserved for future use
2	Inventory	0	Flags bit 5 to 8 see Figure 5-19
		1	Flags bit 5 to 8 see Figure 5-20
3	RFU	0	Reserved for future use

Figure 5-18: ISO15693 request flags bit 0 to 3

Bit	Flag name	Value	Description
4	Select	0	Command is executed according the address flag.
		1	Only selected tags execute the command. The address flag shall be set to 0
5	Address	0	UID is not included in the command.
		1	UID is included. Only the addressed tag executes the command. The select flag shall be set to 0.
6	Option	x	Defined in the command code description. Default is 0.
7	RFU	0	Reserved for future use

Figure 5-19: ISO15693 request flags bit 4 to 7

Bit	Flag name	Value	Description
4	AFI	0	AFI field is not present
		1	AFI field is present
5	Slots	0	16 slots
		1	1 slot
6	Option	x	Defined in the command code description. Default is 0.
7	RFU	0	Reserved for future use

Figure 5-20: ISO15693 request flags bit 4 to 7, inventory flag is set

5.3.17.6.2 Command code

Refer to ISO15693-3 or the tag manufacturer documentation for more details.

5.3.17.6.3 UID

The UID is optional. If address flag is set it is mandatory. Only the addressed VICC executes the command. All other tags remain quit.

5.3.17.6.4 Data

Depends on command code.

5.3.17.7 Answer

The length of the answer is specified in the uplink length byte. Following figure shows a complete response data frame.

Flags	Data	CRC
(1 byte)	(n byte)	(2 bytes)

Figure 5-21: ISO15693 response format

If the less bytes are send from the card than specified in the length byte following bytes are even displayed:

Byte 1	Byte 2 - up to length bytes
80h	00h

Figure 5-22: ISO15693 response trailer

5.3.17.7.1 Response flags

Bit	Flag name	Value	Description
0	Error	0	No error
		1	Error is thrown
1,2,3, 4,5,6, 7	RFU	0	Reserved for future use

Figure 5-23: ISO15693 response flags

5.3.17.7.2 Error

If the error flag is set the VICC has generated an error. Next byte contains the error code. Refer to the card manufacturer documentation for specific details of the error.

5.3.17.8 Example

Command	Description
T030A270100	000066554433221100E0 Inventory response of card E000112233445566

5.3.18 Set LED

This command controls the LED. If the LED flag is set the automatic LED is deactivated. The user can set the state of the LED manually.

5.3.18.1 Command

Command	Data
'd'	LED state (1 byte)

5.3.18.2 Answer

Answer	Description
none	String of LED state

5.3.18.3 LED

Command	Answer	Description
'dg'	DG	Switch on LED green, LED red off
'dr'	DR	Switch on LED red, LED green off
'dn'	DN	Switch off both LEDs

Figure 5-24: LED response

5.3.18.4 Examples

Command	Description
dr	DR Switch on LED red

5.3.19 Get ID

This command returns the station ID of the reader device. The answer is time slotted to be able to detect all devices in party line mode.

5.3.19.1 Command

Command	Data
'g'	none

5.3.19.2 Answer

Answer	Description
data	Station ID of the reader device (1 byte)

5.3.19.2.1 ASCII mode

The station ID has only effect in binary mode.

5.3.19.3 Time slotted answer

In party line mode more than one reader can be used simultaneously. The time slotted answer allows a separation of all connected devices. The station ID is used to determine the correct time slot.

The reader supports up to 254 unique time slots. Following formula allows calculating the needed time of one time slot. Only one baud rate on the same party line is supported.

$$T_0[s] = \frac{10}{\text{Baudrate}} * 6$$

Figure 5-25: Time slot formula

Following figure shows a timing diagram of time slotted answers.

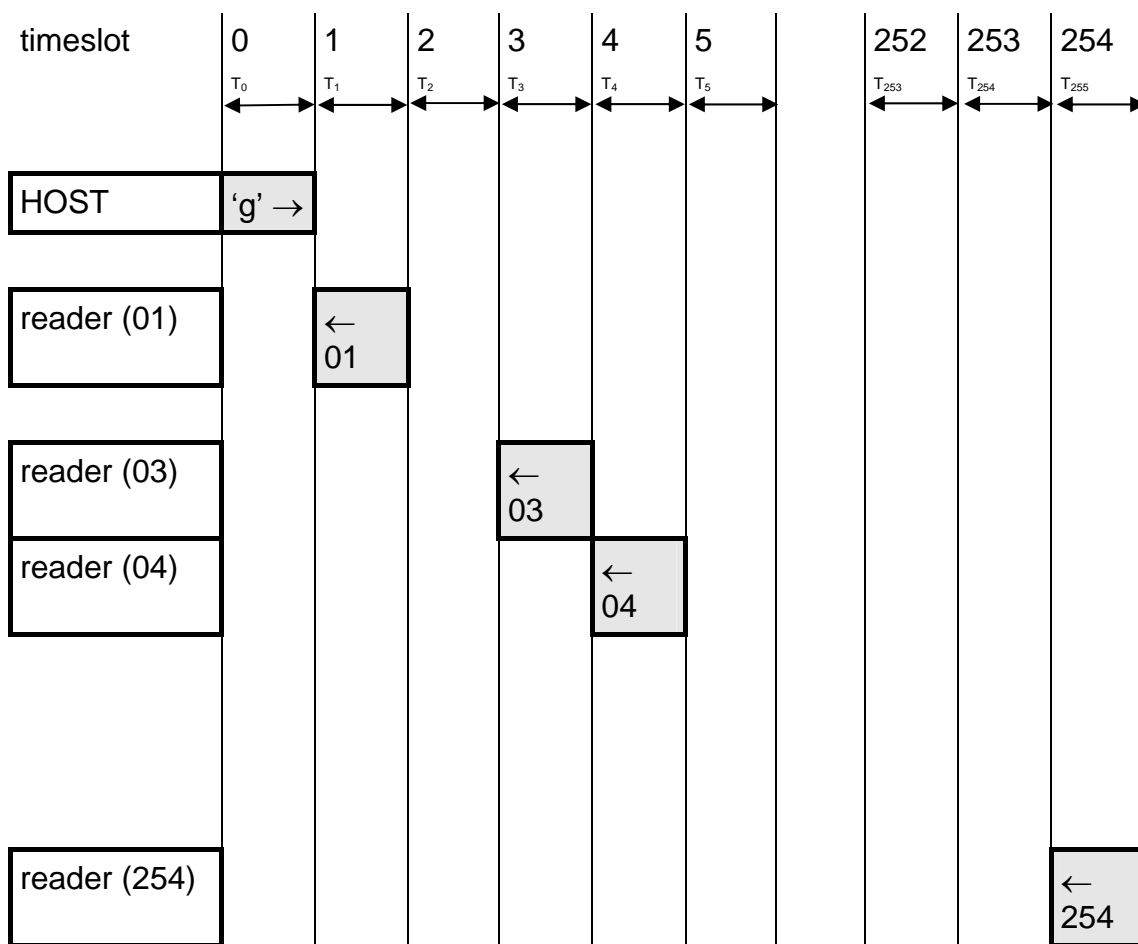


Figure 5-26: Timing diagram of time slotted answers

5.3.20 Antenna power on/off

This command controls the antenna power.

5.3.20.1 Command

Command	Data
'pon'	Switch on reader
'poff'	Reader enters the stand by mode

5.3.20.2 Answer

Answer	Description
'P'	Positive acknowledge

5.3.20.3 Power off

The reader enters the stand by mode. Power consumption is decreases. All tags in the antenna field are powered off and reset. The stand by mode is only entered manually.

To switch off the whole unit pin 16 (Enable) has to set to logic low.

5.3.20.4 Power on

The reader leaves the stand by mode and is ready for the next command. Sending a tag command (i.e. select, continuous read) the reader is powered up.

5.3.20.5 Example

Command	Description
poff	P Reader enters stand by mode

5.3.21 Read/Write User Port

This command will set or read the state of the USER port (pin 14) of the OEM reader device. The port can be set either as output or as input.

5.3.21.1 Command

Command	Data
'pr'	none
'pw'	State of user port (1 Byte)

5.3.21.2 Answer

Answer	Description
data	State of user port (1 Byte)

5.3.21.3 Read port

The port read command returns the actually state of the USER port.

Port state	Description
00	USER port is low
01	USER port is high

Figure 5-27: Read USER port return values

5.3.21.4 Write port

Port state	Description
00	Sets USER port to low
01	Sets USER port to high

Figure 5-28: Write User port settings

5.3.21.5 Remarks

If user port is used as an output a 1k Ω resistor has to be integrated into the wire. Otherwise the reader device may cause damage.

5.3.21.6 Example

Command	Description
Pr	00 user port is logic low.
pw01	01 Sets USER port state to high

6 Timing

The timing is measured between request and response of the reader. Additionally to the process timing the protocol timing must be included. It depends on protocol mode as well as on the baud rate.

Command	Time _{Fail}	Time _{Typ}	Time _{Max}
	[ms]	[ms]	[ms]
Reset ⁵			
Power up	-	80,0	85,0
Software (x)	-	2,98	3,06
Get version (v)	-	0,206	-
Continuous read (c) ⁶			
All	-	13,6	164,0
ISO 15693	-	13,6	14,1
Tagit	-	20,4	21,0
Icode	-	31,0	32,0
SR176	-	26,4	54,0
ISO 14443 Type A	-	18,0	19,0
Ultralight	-	26,0	27,0
ISO 14443 Type B	-	14,8	15,5
Page read (start up option)			
All	-	22,4	105,0
ISO 15693	-	22,4	23,6
Tagit	-	37,6	38,0
Icode	-	37,2	38,0
Select (s)			
All	392,0	20,5	392,0
ISO 15693	50,8	20,5	21,0
Tagit	81,6	20,4	21,0
Icode	116,0	31,0	32,0
SR176	54,8	26,4	54,0
ISO 14443 Type A	43,8	18,0	19,0
Ultralight	43,8	26,0	27,0

⁵ Reset will cause an error if reader IC Initialization fails

⁶ Continuous read will only return successful readings

ISO 14443 Type B	44,2	14,8	15,5
Multitag list (m)			
1 card	156,0	85,6	87,0
2 cards	156,0	85,6	87,0
Multitag select (m)	9,2	6,6	7,0
Read page (r)			
ISO 15693	25,6	5,28	25,6
Tagit	67,6	17,0	67,6
Icode	34,8	7,0	34,8
SR176	7,6	2,4	7,6
ISO 14443 Type A	18,0	-	-
Ultralight	11,6	4,8	11,6
ISO 14443 Type B	0,16	-	-
Read EEPROM (rp)	-	200	-
Write page (w)			
ISO 15693	41,8	19,1	22
Tagit	79,2	45,2	79,2
Icode	52,0	24,0	52,0
SR176	10,4	8,8	10,4
ISO 14443 Type A	24,0	-	-
Ultralight	24,0	10,4	24,0
ISO 14443 Type B	0,232	-	-
Write EEPROM (wp)	-	4,7	-
Set tag type (oX) ⁷	-	0,154	1,85
Include tag type (o+X)	-	1,0	1,36
Exclude tag type (o-X)	-	1,0	1,36
Lock page (k)			
ISO 15693	272	27,2	30,8
Tagit			
Transfer data telegram	-	Var	-
Set LED (dr, dg, dn)	-	0,16	-
Get Station ID (g)	-	0,16	-
Antenna power on (poff)	-	0,24	-

⁷ depends on tag type

Antenna power off (pon)	-	0,24	-
Port read (pr)	-	0,20	-
Port write (pw)	-	0,16	-
Unknown command	0,24	-	-

7 Frequently Ask Questions

7.1 Getting started

To test and interface the 13,56 MHz Multitag Reader Module, no sophisticated μ P development system is needed. All you need is a PC, a connection cable and a power supply for the reader. If you are using Microsoft Windows (98/NT/2000...), take following steps:

1. Make sure, that your reader is RS232-interface type
1. Start HyperTerminal
2. Create a new connection (FILE/NEW CONNECTION)
3. Enter name of connection as you like (i.e. 'ISO 1.0')
4. Select connect COM2 (COM1) direct connection
5. Connection setup 9600,8,n,1,no handshake
6. Connect the reader to COM2 (COM1) of the PC and apply appropriate the supply voltage. The reader sends a string to the PC (e.g. "ISO 1.0"). This string denotes the firmware provided by your reader module
7. Put a tag to your reader. Serial numbers should be displayed properly
8. Enter commands via keyboard. They are transmitted to the reader and the reader replies with its response.

If using an operating system different from Microsoft Windows you may use any other terminal program which is capable of receiving/transmitting via the serial port of your PC.

7.2 How can I adjust the reading performance of different tags?

Due to different tags of different tag manufacturers the antenna tuning has to be adapted. The Plug and Play reader module is factory tuned for ISO 15693 tags. To switch to Mifare tags the tuning capacitor (see APPENDIX A) has to be adjusted correctly.

Following steps have to be done:

1. Connect the reader to the PC
2. Set the reader to the specific tag type
3. Start continuous reading mode ('c')
4. Place a tag within the antenna field.
5. Tune the capacitor until the LED is flickering.
6. Increase the distance between the tag and the reader
7. Repeat steps 5 and 6 until no better performance can be reached.

Now the reader is optimal tuned of a specific tag type.

7.2.1 Remarks

If more than one tag has to be read all steps mentioned above have to be performed for each tag type. The reading distance of one tag in multi tag recognition mode might be less than in an optimal tuned antenna field.

7.3 Release notes

7.3.1 Version 0.9x

7.3.1.1 New features added to version 0.9x:

- o Anticollision ISO15693
- o Single shot of UID including delay time
- o Page read as continuous read default
- o Set of tag type is selectable
- o Tagit® and ISO14443B supports extend ID
- o Tagit® lock page
- o Set LED manually
- o SR176 new edition
- o EM4135

7.3.1.2 Changes made to version 0.9x

- o Continuous read sends a 'S' after quitting
- o Leading character of 'ISO1444B' has changed to 'Z'
- o 'MifareB' tag type has changed to 'ISO14443B'
- o 'Mifare' tag type has changed to 'ISO14443A'

7.3.1.3 Bug fixes

- o Transfer data command supports up to 200 bytes
- o Icode® is fully supported
- o SR176 new is fully supported
- o Full support of ISO15693 lock page

7.3.2 Revision History

Date	Revision
9/19/2003	V0.9v rev 1.0

8 APPENDIX A

8.1 P & P module (version 3)

8.1.1 Pin out

All distances are listed in mm!

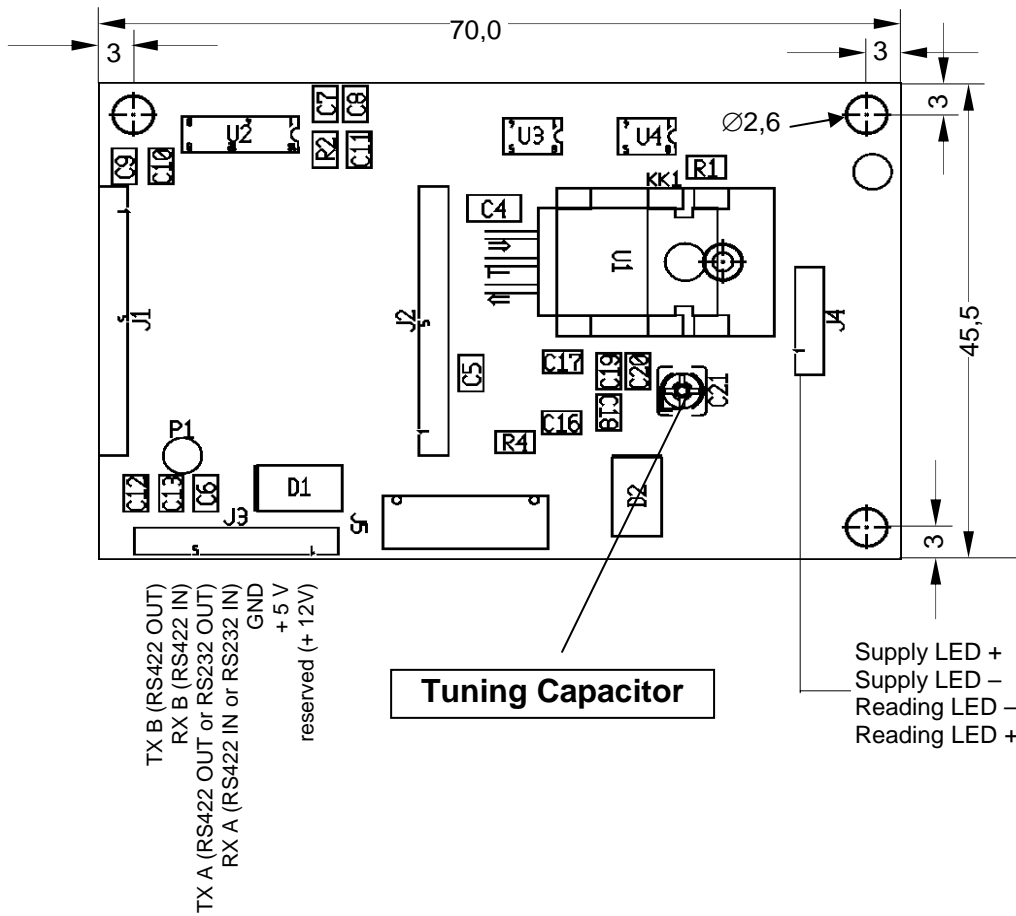


Figure 8-1: Plug & Play Reader Module

8.1.2 Supply voltage 12V

Following components have to be added:

Component	Description
U1	Voltage Regulator 7805
D1	TMM BAT42
C4	330 nF, 50V, Shape 1206
C5	100 nF, 50V, Shape 0805

Figure 8-2: 12 V components

8.1.3 RS485/422

Using the RS485 bus following changes are necessary.

Remove following items:

Component	Description
U2	Sipex SP202EEN

Figure 8-3: RS232 device driver

Add following items:

Component	Description
U3	Sipex SP485REN
U4	Sipex SP485REN

Figure 8-4: RS485 device driver

8.1.3.1 RS422

RS422 is a four-wire communication. The reader module does not support full duplex at the same time.

8.1.3.2 RS485

Connect following pins of J3:

Pin	Description
4, 5	RXA, TXA, used as line A
6, 7	RXB, TXB, used as line B

Figure 8-5: Pin connection of RS485

9 APPENDIX B:

9.1 Antenna design

9.1.1 Layout

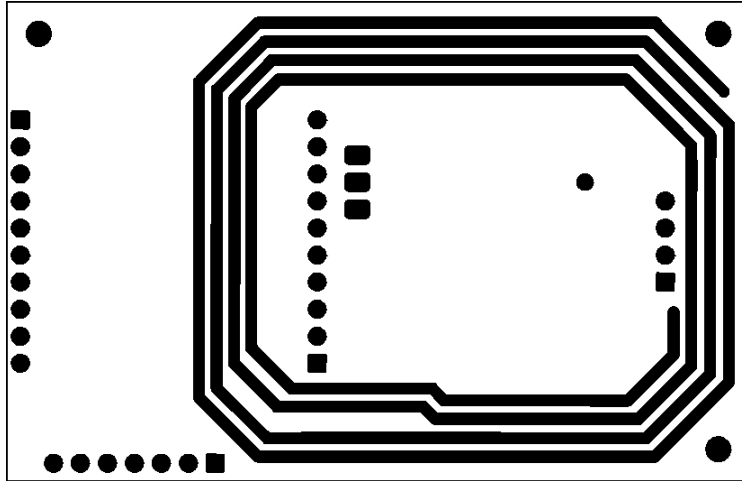


Figure 9-1: Antenna layout

9.1.2 Mechanical data:

Dimension	51x42 mm
Wire width	1,27 mm; 35 um Cu thickness
Distance between 2 turns	1,75 mm
Number of turns	4

Figure 9-2: Coil design - mechanical data

9.1.3 Electrical data

Inductivity	1,2 μ H
Resistance	0,33 Ω

Figure 9-3: Coil design – electrical data

9.1.4 Antenna matching circuit:

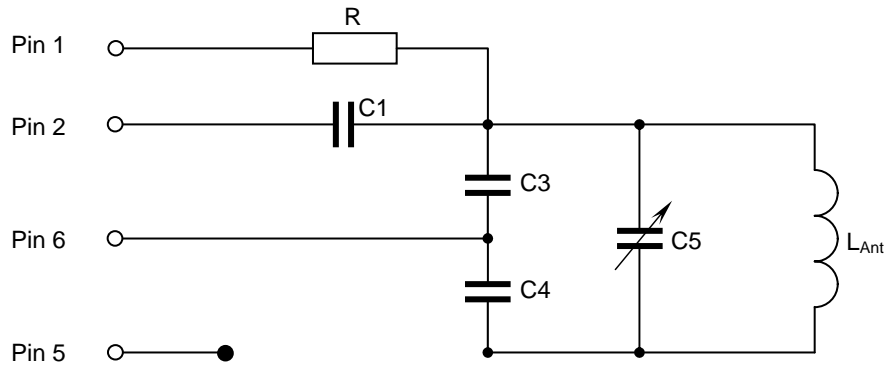


Figure 9-4: Antenna matching circuit

9.1.4.1 Connecting scheme

Pin Nr	Pin	Description
1	ARX	Antenna RX
2	ATX1	Antenna TX
5	RFU	Not connected
6	TGND	Antenna ground

Figure 9-5: Antenna connecting scheme

9.1.4.2 Component values:

Component	Description
C1	100 pF
C3	68 pF
C4	0R0 (jumper)
C5	8-40 pF
R	8,2 kΩ

Figure 9-6: Antenna components

10 APPENDIX C

10.1 TempSense® KSW Transponder

The TempSense® KSW transponder is an ISO15693 compliant tag. The reader has to be set up for this tag type.

10.1.1 How to start with

- Connect the module to the power supply and the PC.
- Start the ISO Reader Utility program.
- Inquire Reader first in order to get a correct connection to the module
- Switch to the KSW label.

Alternatively you can use any terminal program (i.e. HyperTerminal).

For more details of the KSW transponder please contact KSW Microtec AG.
<http://www.ksw-microtec.de>

11 References

ISO/IEC 15693, Part 1-4, Contact less integrated circuit(s) cards – vicinity cards

ISO/IEC 14443, Part 1-4,

TempSense KSW Tags, <http://www.ksw-microtec.de>