HT RM803/903

hitag™ Long Range Reader Module

Product Specification

Version V2.0, 07.01.2013

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1 What You Should Know

Thank you for your interest in hitag™ - Long Range Reader Products from freaquent Froschelectronics GmbH. This document will give you an overview of the product range, technical details and intended applications of the HT RM series.

1.1 Product Introduction

hitag™ - is the name of one of the universal and powerful product lines of the NXP low frequency (125 kHz and 134.2 kHz) family. The contactless read/write system that works with passive transponders is suitable for various applications. Inductive coupling helps you to achieve operating ranges up to 2 meters and the use of cryptography guarantees highest data security.

Anti-collision Mode, which is used in long range operation and within the HT RM 300 family, allows you to handle several transponders that are within the communication field of the antenna at the same time, thus achieving highest operating security and permitting to handle several data transfers quickly and simultaneously. In this context anti-collision becomes an essential element of applications such as animal identification, casino gaming and long range access control. With applications of that type it will always happen that several transponders arrive in the communication field of the antenna at the same time.

Nevertheless, the proximity application also prevents any type of malfunction even if several transponders arrive in the communication field of the antenna at the same time.

1.1.1 Features of the HT RM Product Family

Using HT RM products within your applications offers following features:

- used both in the proximity area (operating range up to about 400 mm) and in the long range area (operating range up to about 2m)
- easy integration
- high noise immunity
- small size
- uncomplicated interfaces
- very powerful RF-part

1.2 Content of this Document and Target Group

This document contains the following information:

- target or goal specifications for product development (objective specification)
- preliminary data; supplementary data may be published later
- final product specifications (product specification)

This product specification is written for customers and interested parties and also for developers and programmers.

1.2.1 Abbreviations and Glossary Terms

ASK	**A**mplitude **S**hift **K**eying
CMOS	**C**omplementary **M**etal **O**xide **S**emiconductor
BCD	**B**it **C**heck **D**elay
CRC	**C**yclic **R**edundancy **C**heck
DSP	**D**igital **S**ignal **P**rocessor
HTRM	**HI**TAG **R**eader **M**odule
LAN	**L**ocal **A**rea **N**etwork
LSB	**L**east **S**ignificant **B**it
RFID	**R**adio **F**requency **Id**entification
USB	**U**niversal **S**erial **B**us

1.2.2 Typographic Conventions

This document uses the following icons and standard text styles:

Attention: Icon and text indicate a situation you have to take care of! Data loss or wrong system behavior may be caused.

Important: Icon and text indicate important information or instructions. This icon also informs about references to other chapters of this manual for detailed information about the current topic!

Example: Icon and text indicate an example!

Bold	Parameters; control elements in windows and dialog boxes; important text
Italics	Foreign or new terms; book titles; wherever you are required to type user-dependent information such as characters or text. If you read, for example, *macro name*, then you are required to type the name of a macro.
UPPERCASELETTERS	Keys; shortcut keys; operating states; file name extensions
`Courier`	Programming examples; source code
Times New Roman	Formulas
Menu | Option	Describes how to select a menu item (here called Option) found in the menu (here called Menu).

1.2.3 Safety Advices

Attention: ***Limiting values*** given are in accordance with the Absolute Maximum Rating System (IEC 134). Stress above one or more of the limiting values may cause permanent damage to the device. These are stress ratings only and operations of the device at these or at any other condition above those given in the section Characteristics of the specification is not implied. Exposure to limiting values for extended periods may affect the devices reliability.

Important: Where application information is given, it is advisory and is not part of the specification.

Attention: These products are ***not designed for use in life support appliances***, devices, or systems where malfunction of these products can reasonably be expected to result in personal injury. Customers of Freaquent Froschelectronics GmbH using or selling these products for use in such applications do so on their own risk and agree to fully indemnify Freaquent Froschelectronics GmbH for any damages resulting from such improper use or sale.

2 Architectural Overview

The following drawing shows the hitag™ - Long Range Reader Module as part of a complete Radio Frequency Identification (RFID) system.

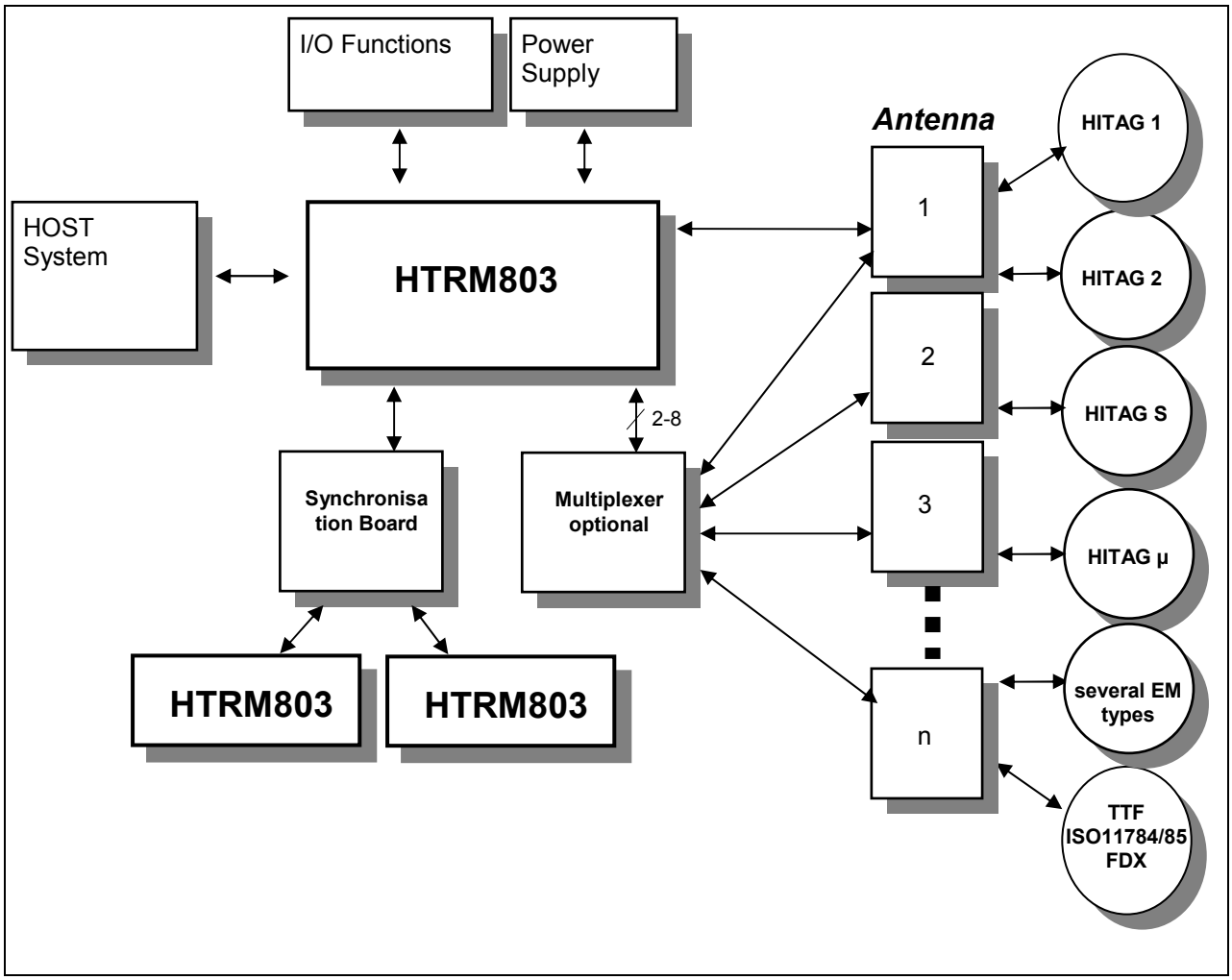


Fig. 1: Architectural overview

2.1 Components in Detail

This chapter will give you detailed information about the components used in a RFID system as shown in figure 1.

2.1.1 Transponders

The hitag™ - Reader Module (HT RM) can communicate with transponders based on following PHILIPS products:

- HITAG 1
- HITAG 2
- HITAG S
- HITAG µ
- EM4102, EM4205, EM4305
- ISO 11784/85 (FDX-B)
- ISO 14223
- ISO 18000.2

2.1.2 Host

The connection to the host (e.g.: µC or PC) is a serial interface on RS232 level (version HT RM803/AED) for data transmission. Optionally wired interface drivers for CMOS (version HT RM803/EED) and RS485 (version HT RM803/CED) are integrated on the Reader Module.

There are several interface options for the serial communication:

- HTRM803/AED
  RS232 (default, Jumper option to switch to Ethernet)
- HTRM803/LAN
  LAN with virtual serial com-port on PC side (default, Jumper option to switch to RS232), optional use as device server.

Important: Please see documentation of board converter module (http://www.lantronix.com)

- HTRM803/CED
  RS485 Hardware option
- HTRM803/EED
  CMOS Hardware option
- HTRM803/USB
  USB optional, on request of customer, with customer vendor ID

2.1.3 I/O Functions

- IN1 and IN2 can be used as input lines
- OUT1 and OUT2 can drive +/- 6mA
- Additional 8 pin output port

2.2 Behavior with Several Transponders

If several HITAG 1 or HITAG S, Hitag µ transponders arrive *simultaneously* within the communication field of the antenna of a hitag™ - Long Range Reader Module, all the HITAG transponders (theoretically up to 2^{32}) within the communication field of the antenna can be read and written simultaneously. Because of the mutual influence of the transponder coils - they detune each other if there are too many too close to each other - the number of the transponders that can be operated simultaneously is limited.

If several HITAG 2 transponders arrive *simultaneously* within the communication field of the antenna of a hitag™ - Long Range Reader Module, the „stronger“ transponder (the nearer one) takes over or - under special circumstances - no communication takes place. If the transponders arrive in the field one after the other, communication is established with the first one, all the other transponders are ignored. This ensures that no two (or several) HITAG 2 transponders will ever be processed (or even worse, written to!) accidentally at the same time. By muting a selected HITAG 2 transponder (HALT Mode) another HITAG 2 transponder that is to be found in the communication field of the antenna can be recognized.

Attention: In case the second (HITAG 2) transponder was already in the field of the antenna and understanding the first command of the reader to (HITAG 2) transponder 1, it might feel addressed too, in that case all the actions done to transponder 1 are also done to transponder 2.

3 Specifications

3.1 Electrical Specifications

3.1.1 Power Supply

The Reader Module contains some filtering circuits for the power supply. Nevertheless some requirements are to be fulfilled by the power supply. This means the maximum ripple of the supply voltages (± 15V) must not exceed the values listed in the following table.

Frequency of the Ripple f [kHz]	Maximum Amplitude of the Ripple u [mVRMS]
$0 \leq f < 0.5$	48
$0.5 \leq f < 20$	7
$20 \leq f < 120$	36
$120 \leq f < 130$	12
$130 \leq f$	48

Important: An appropriate power supply is available at freaquent Froschelectronics GmbH with the order code: **HTAC +-15**.

3.1.1.1 Current Specification

	I_{typ}	I_{max}	I_{stby}
+ 15V	380mA	550mA	40mA
- 15V	- 290mA	- 400mA	- 130mA

I_{typ} ... typical current
I_{max} ... maximum current
I_{stby} ... typical standby current

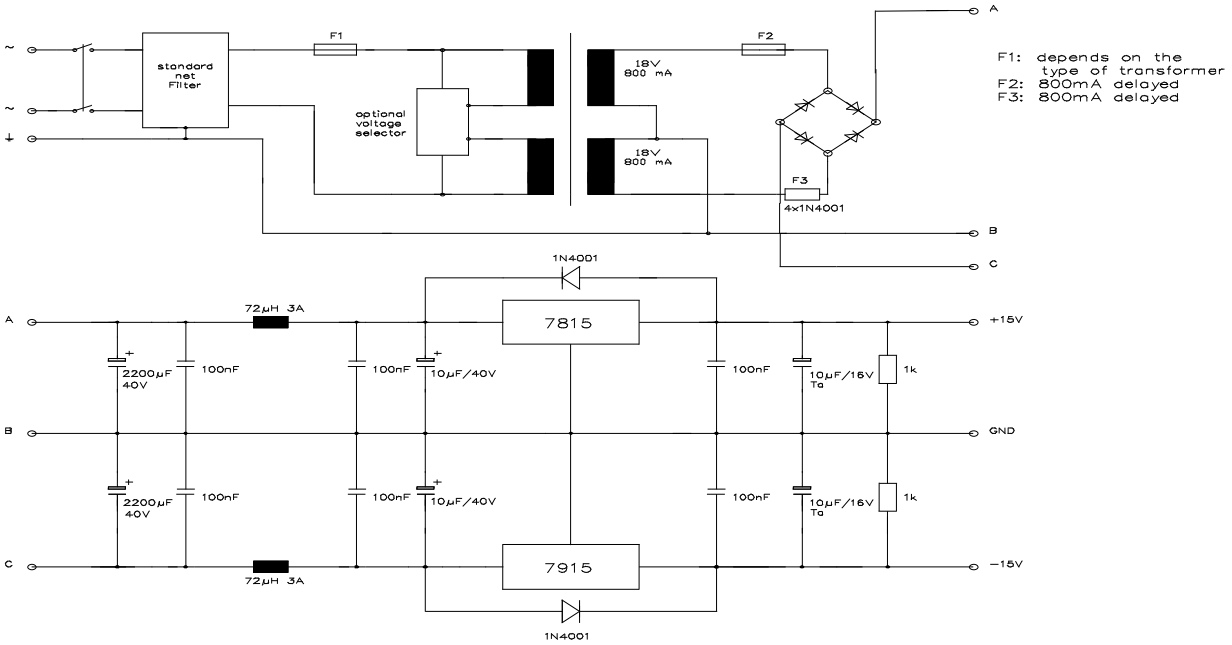


Fig. 2: Current specification

Instead of a transformer type supply unit (see above), a switching frequency power supply unit can be used alternatively. The switching frequency must be in the range of:

165 kHz < f_{switch} < 210 kHz (over temperature, load and production)

3.1.2 Modulation

3.1.2.1 Reader Module ⇒ Transponder

Type of Modulation	Modulation Ratio
amplitude shift keying (ASK)	100 %

That means the carrier is blanked completely, the information is located in the intervals between the pauses.

3.1.2.2 Transponder ⇒ Reader Module

Type of Modulation	Modulation Ratio
amplitude shift keying (ASK)	depending on the distance between transponder and Reader Module

3.1.3 Interface

An interface driver for RS232 (version HT RM803/AED) is integrated on the hitag™ Reader Module.

Optionally the HTRM803 is equipped with a LAN module that can be activated by a jumper setting (version HTRM803/LAN).

Optionally drivers are CMOS (version HT RM803/EED) and RS485 (version HT RM803/CED).

On customer request a USB interface is available too (version HTRM803/USB).

3.1.4 Metallic Environment, Interferences and other Readers

The communication range is impaired by metallic environment and electromagnetic interferences (e.g.: monitors, keyboards). Therefore, you should keep a distance of at least the antenna's diameter to metallic surfaces or loops as well as to electromagnetic interferences. If this is not possible, you have to take preventive measures such as using ferrites or shielding for transponder and antenna. In order to be able to operate two systems side by side without negative influence on communication ranges, you must place the antennas at a minimum distance. To keep this distance low, magnetic shielding must be realized. This topic is handled in detail in the Design Instruction: Antenna Design for the hitag™ - Long Range System. An additional option is the synchronization of up to 3 HTRM803 with a synchronization board.

3.1.5 Temperature Range

Operating	-25° C to +70° C
Storage	-40° C to +85° C

3.2 Mechanical Specifications

3.2.1 Mechanical Dimensions

The following drawing (not to scale) shows the outer dimensions of the hitag™ Reader Module with the four mounting holes, top view (component side).

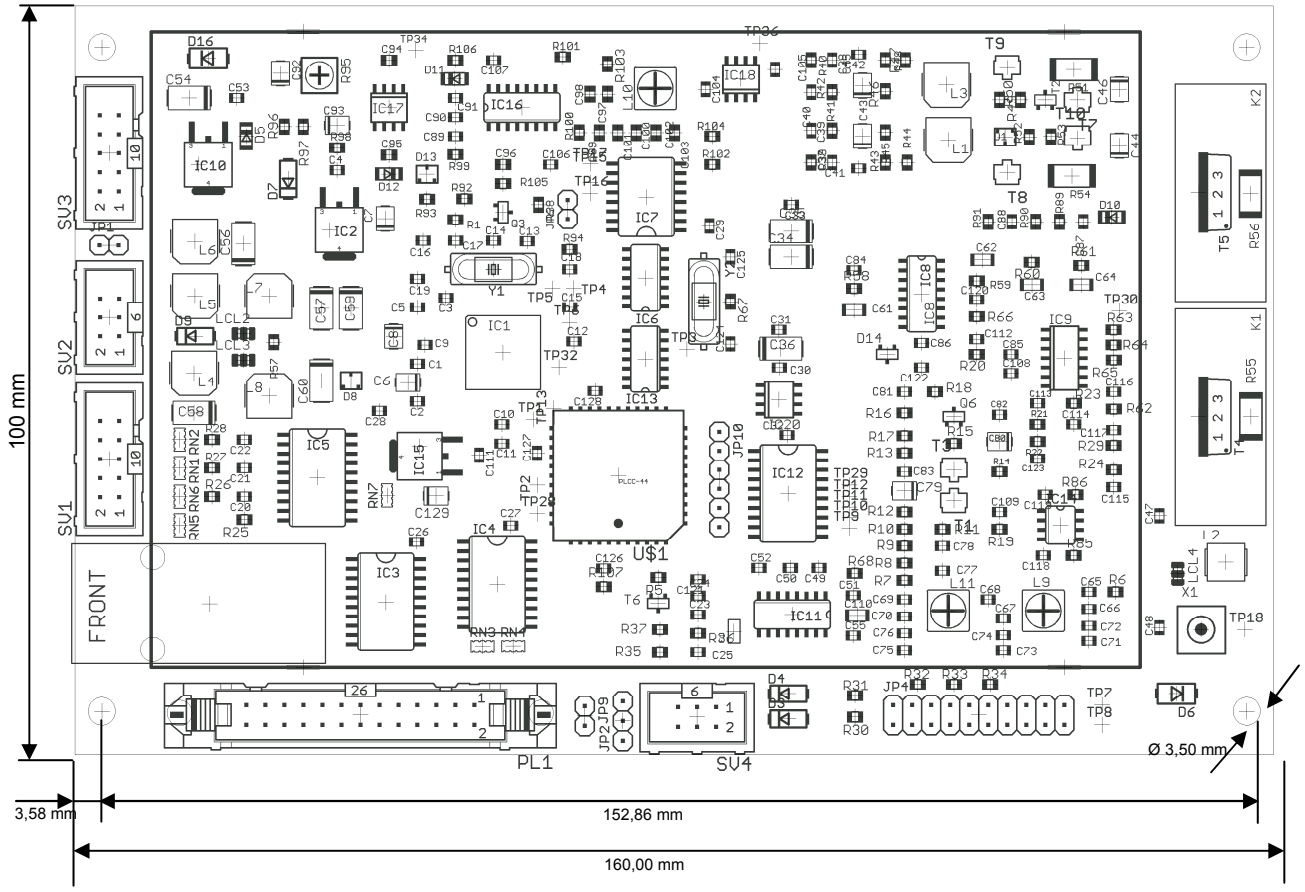


Fig. 3: Mechanical dimensions

Details of the PCB	
Dimension	160 x 100 mm
Height	does not exceed 43 mm

3.2.2 Pin Assignment

The following drawing (not to scale) shows the pin assignment of the HITAG Long Range Reader Module (top view).

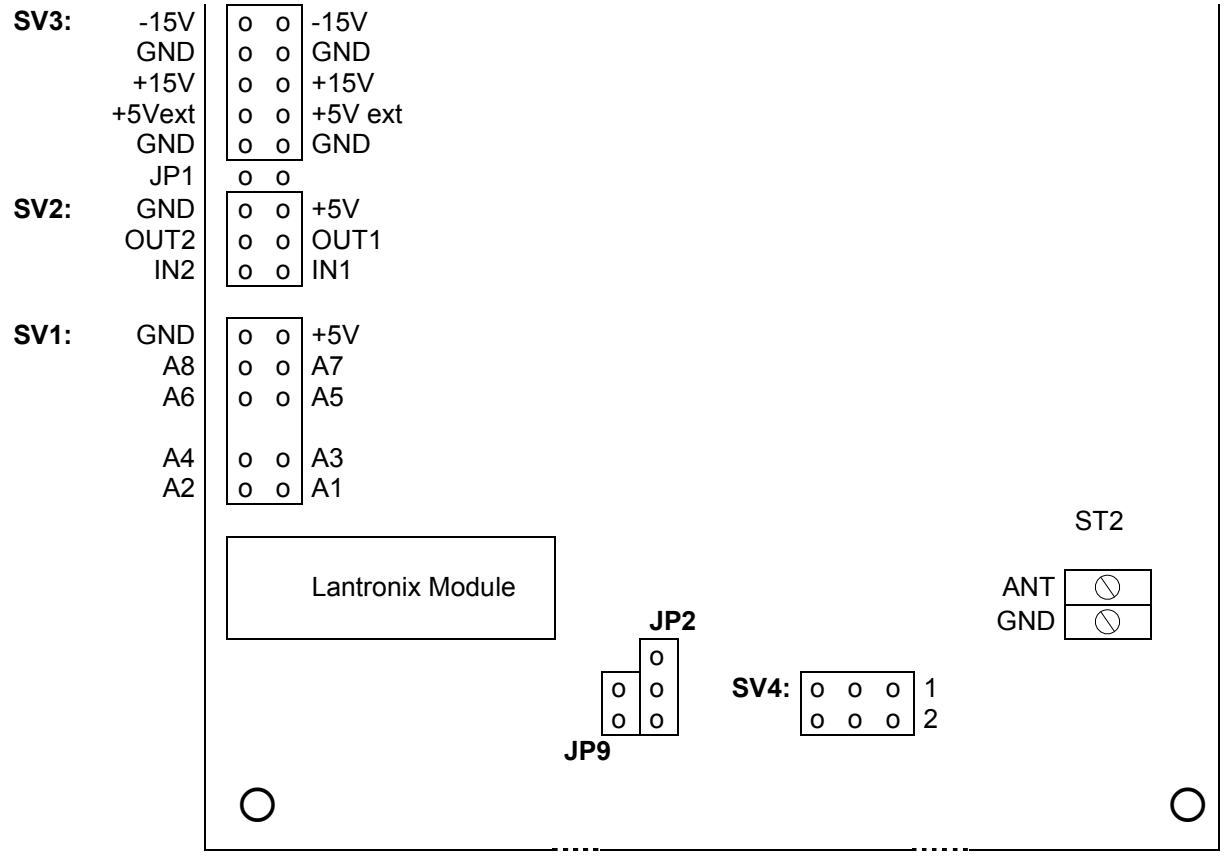


Fig. 4: Pin assignment

In the lower left corner of the PCB a connector is located (SV3) to connect the power supply, the serial interface and the general purpose input pins.

ST2 in the lower right corner of the PCB is used to connect the antenna.

3.2.2.1 Pin Description

	Pin	Pin Name	Type	Description	Comment
SV3	**9,10** **7,8** **5,6** **3,4** **1,2**	-15VIN GND +15VIN +5V ext GND	PWR PWR PWR PWR PWR	power supply	
SV4	**1** **2** **3,4** **5** **6**	TXD RXD GND DDM DDP	OUT IN PWR USB USB	serial interface RS232 standard USB	mounting
SV4:Optional RS485	**1** **2**	INT1 INT2	IN/OUT IN/OUT	serial interface RS485 standard	option as per agreement
SV4 optional: TTL	**1** **2**	TTL IN TTL OUT	IN OUT	serial interface 3.3V TTL	
SV1	**1-8**	A1-A8	OUT	8 CMOS Outputs over 390 Ohm limiting resistor	
SV2	**1,2** **3,4**	IN1,2 OUT1,2	IN OUT	pins for general purpose	
ST2 SMB, SMA		ANT GND	OUT OUT	pins for connection of the antenna	
JP1			Jumper	Connects +5V ext and +5V (intern)	In case Lantronix is used
JP2			Jumper	RS232/LAN selector	
JP9			Jumper	Bootloader Set Pin	

4 Reader Module Functions

4.1 Block Diagram

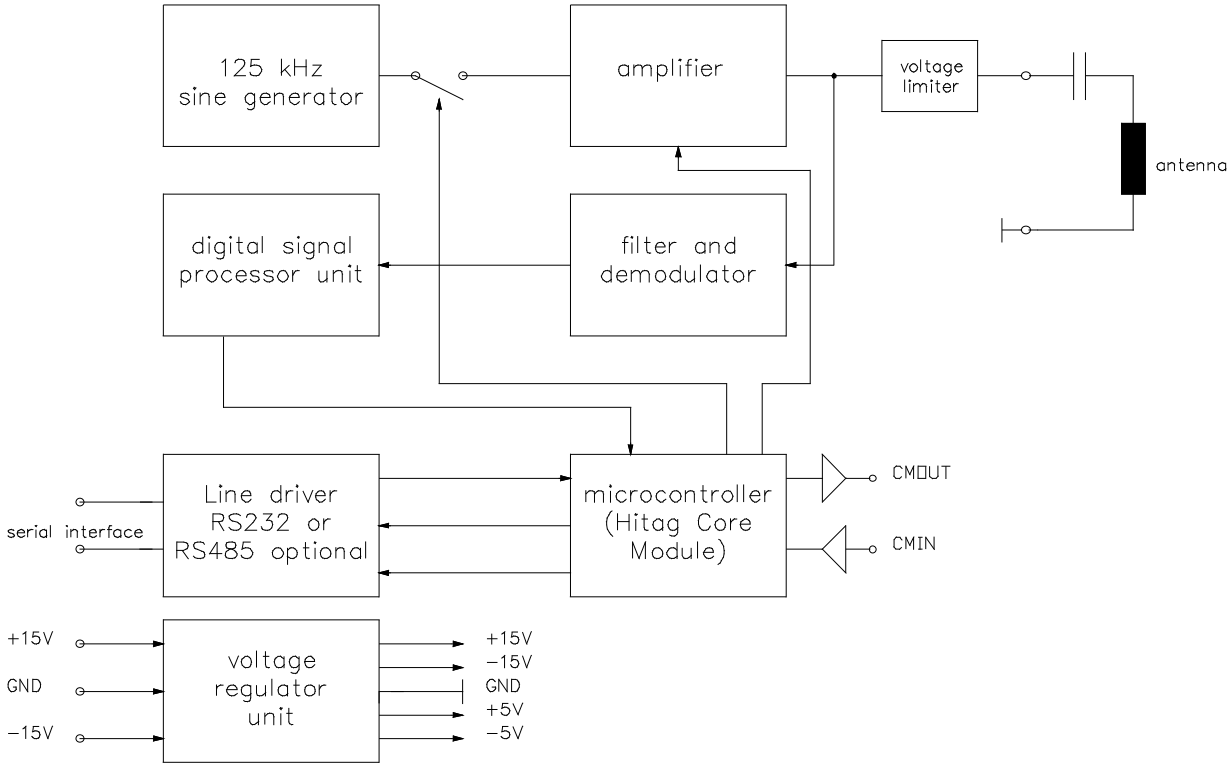


Fig. 5: Reader module functions

4.1.1 Sine Generator, Amplifier and Voltage Limiter

For transmitting power and data to the transponder a sine signal is switched by the micro-controller and amplified. The amplifier is designed as a current source. A voltage limiter is used to hold the output voltage of the amplifier during the decay and transient phases of the sine signal.

4.1.2 Microcontroller

The microcontroller processes the protocol for the communication between the transponders and the read/write unit. The interface signals are converted so that the transponders are able to process them and the outgoing signals from the transponders are converted into interface-compatible signals.

The second essential microcontroller function is its control function. The microcontroller activates and deactivates the transmitter and switches the receiver modes for the different transponders reception.

Additional functions of the microcontroller are controlling the standby mode of the amplifier, detection of detuned or broken antennas (antenna malfunction) and controlling of the input and output for general purpose.

4.1.3 Interface: Microcontroller - HOST

The device communicates with the host (processor, PC, ...) with following specifications:

baud rate (serial interface)	9600
possible baud rate for changes	Up to 115200
start bit	1
data bits	8
stop bit	1
parity bit	no
LSB	sent first

An RS232 interface device is connected to the reader module. Optionally a CMOS, LAN or an RS485 device is possible.

4.1.4 Receiver

After filtering and demodulation of the amplitude modulated signal received from the transponder the received data is converted and passed to the digital signal processing unit (DSP) for further processing.

4.1.5 Digital Signal Processing Unit

The receiving part of the reader module includes bandpass filters which attenuate disturbances (3dB attenuation at 105 kHz and 145 kHz).

The DSP as part of the microcontroller is also responsible for separating the responses of different transponders during anti-collision cycles (multiple transponder operation).

4.1.6 Voltage Regulator Unit

The voltage regulator unit supplies, after filtering, all parts of the reader module with the required voltages.

4.1.7 Antenna

For the design of hitag™ - Long Range Antennas see chapter 6.1.

4.2 Standby Mode

The hitag™ - Long Range Reader Module offers a software controlled standby mode. This mode can be activated and deactivated by the host system via serial interface. During the standby mode the amplifier of the reader module is turned off and the power consumption decreases drastically.

5 How To

In this chapter you will receive information how to start up a HT RM 803 RFID system.

5.1 Connecting the Antenna

The antenna has to be mounted in the following way:

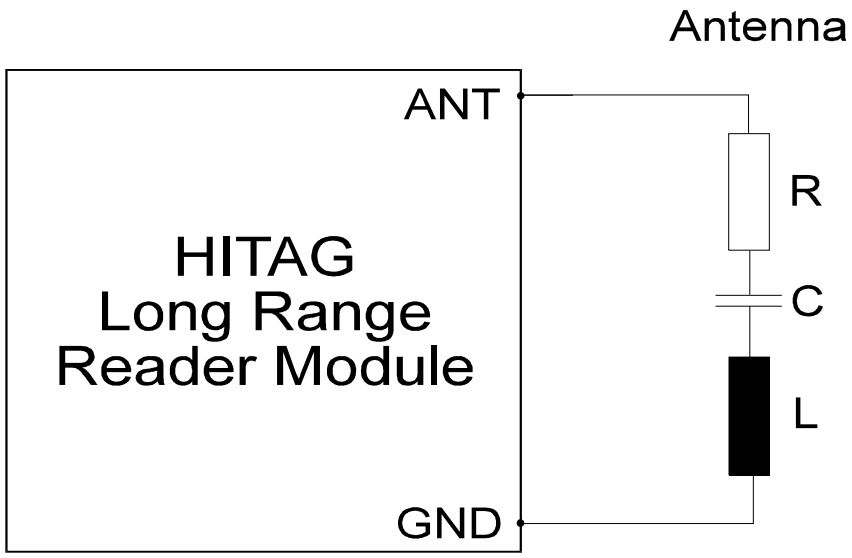


Fig. 6: Connecting the antenna

Important: C is used for tuning the antenna. For more detailed information please see chapter 6.1 (Building hitag™ - Long Range Antennas).

5.2 Connecting the HITAG Reader Module

The connector for the antenna (ST2) is placed in the lower right corner of the PCB of the reader module.

5.2.1 Additional Notes for Connecting

The following list is a summary about hitag™ - Long Range Antennas.

Important: The exact way how to design a hitag™ - Long Range Antenna is described in the document "**Antenna Design for the HITAG™ Long Range System**").

Important:

- Freaquent Froschelectronics GmbH highly emphasizes the research of antenna development.
- The choice of various antenna shapes (the electrical parameters) is characteristic to 125 kHz systems.
- The knowledge is transferred to Freaquent Froschelectronics GmbH customers, in order to enable them to design and build antennas, which fit best for the particular applications (antenna trainings).
- Solutions can be found for almost every environmental scene. (Metal, periodic disturbers, special antenna shapes ...).

5.2.1.1 Possible Arrangements of Antennas

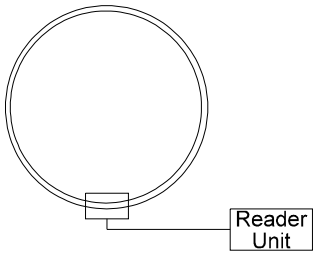


Fig. 7: Loop Antenna

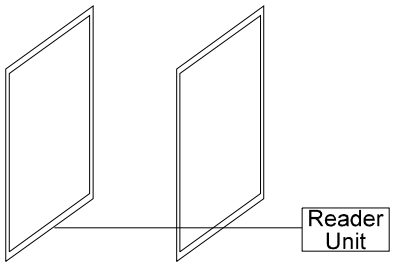


Fig. 8: Gate Antenna

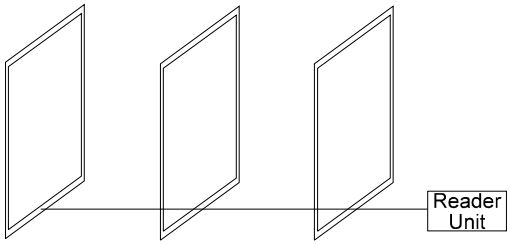


Fig. 9: Double Gate Antenna

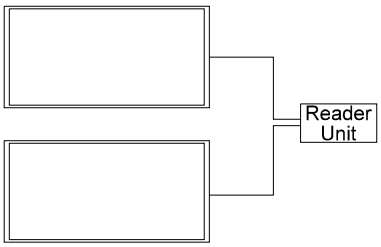


Fig. 10: Antenna Multiplex

The different arrangements are suitable for different applications. So the single loop antenna is used for standard arrangements.

The gate antenna is used for typical access control applications, for access control while passing through the gate.

The double gate antenna is similar to the gate using two rows.

An antenna multiplex system is a cost efficient application, because one reader drives many antennas. The number of multiplexed antennas is only limited by timing restrictions.

By changing the arrangement of the antenna, the total system performance and reliability can be significantly improved. As an example: building gate antennas with opposite magnetic orientation leads to a very reliable system.

5.3 Building HITAG Long Range Antennas

The antenna is an important part of the hitag™ - Long Range System. The antenna must provide energy and data transmission between reader and transponder. Therefore, you should be particularly careful when implementing the antenna in order to achieve optimum results.

5.3.1 Basics

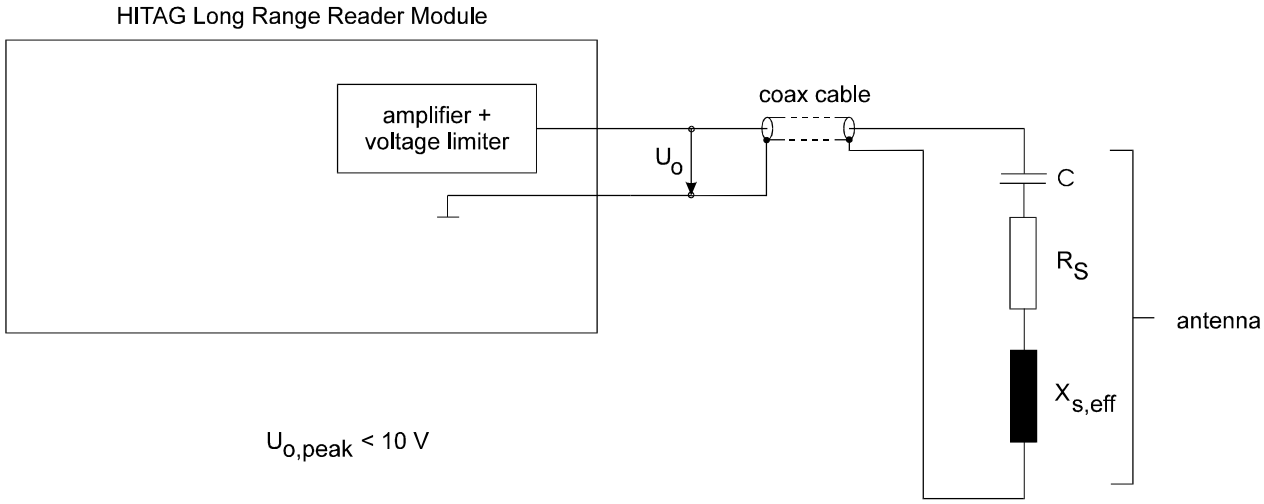


Fig. 11: Building HITAG Long Range Antennas

5.3.2 Specifications

30 < Q < 60 .....quality factor;
400 µH < L < 1300 µH.....inductance of the coil;

5.3.3 Recommended Antenna Cable and Length

The length of the antenna cable should be limited to five meters. In case of longer cables a type with low capacitance and resistance must be used. For standard applications a coaxial cable is recommended (50Ω-coaxial cable for standard applications and 75Ω or 95 Ω-coaxial cable for special applications).

5.3.4 Tuning the Antenna Current

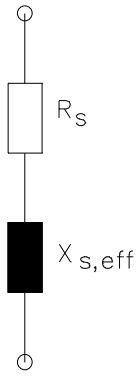
According to the layout diagram of chapter 3.2 the potentiometer R95 is used to tune the current driven through the antenna. The default setting is 200mA. It is not customary to change this value. However, if you want to change the current for a special application, please notice that the range for U_0 is

U_{0peak} < 10 V

5.3.5 Tuning the Antenna Phase

The signal from a transponder is delayed by the decay time of the antenna of the reader module. To achieve optimal performance this signal and the digital signal processing unit of the reader module must be synchronous. Thus it is necessary to store a phase information called "Bit Clock Delay" (BCD), which is a function of the quality factor and the inductance (reactance) of the antenna connected to the reader module.

5.3.5.1 Equivalent Circuit of the Antenna:



$$Q = \frac{X_{s,eff}}{R_S}$$

Fig. 12: Equivalent circuit of the antenna

R_S	...	effective series resistance
$X_{s,eff}$	...	effective series reactance
Q	...	quality factor

The default setting is 9, which is suitable for most cases. Apart from that, the user is able to change the BCD value. The reader module includes a non volatile memory (EEPROM) to store the bit clock delay. To load the BCD value to the reader module the command SetBCD is used.

5.3.5.2 HITAG Antenna Tuning Device

Especially for our hitag™ product line the hitag™ Antenna Tuning Device **HTOT840** was designed. This Tuning Device can be used to tune hitag™ Proximity and hitag™ Long Range Antennas.

5.3.6 Antenna Malfunction Indication

If the antenna is broken or badly detuned, the antenna overload bit is set. This bit can be read by the host system via the serial interface by using the *ReadLRStatus* command.

6 Postal Approval and Disturbers

6.1 Postal Approval

The postal approval can only be granted for final products, not for individual components like the hitag™ - Reader Module. But the reader module is designed in a way that it is possible to obtain the postal approval for a device including the hitag™ - Reader Module.

Important: Electromagnetic emissions comply with the guidelines in FTZ 17 TR 2100, ETS 300 330 and ETS 300 683, electromagnetic immunity complies with the guidelines in ETS 300 683!

6.1.1 EMC, EMI Standards

The following configuration is in compliance with the European Telecommunication Standards:

- hitag™ - Long Range Reader Module HTRM803 or HTRM903
- Power supply according to the recommendations in chapter 3.1.1 (transformer)
- Antenna: 50 x 70 cm, number of turns N=25, inductivity max. L=1.0mH

6.1.2 Successfully Passed Measurements

EMI:	ETSI EM 300330-1 V1.3.1 (2001-06) ETSI EM 300330-2 V1.3.1 (2006-04)
Immunity:	ETSI EN 301 489-3 V1.4.1 (2002-08)
RFI-Emissions:	Limit class B according to EN 55022, 1987

6.1.3 Successfully Passed Measurements of specific system configurations and applications

In several applications with customer specific antennas, housings, configuration additional approvals have been passed with the reader basis HTRM803/903. For further information please contact freaquent Froschelectronics GmbH.

Periodic Disturbers

There are a couple of possible sources for disturbances for a 125 kHz system like hitag™. The hitag™ - Long Range Reader Module is designed to handle this problem and achieve optimal performance under worst conditions.

Long Wave Transmitters, other 125 kHz systems and PC monitors are examples for periodic disturbers which can be relevant for 125 kHz systems. To eliminate these disturbers the digital signal processing unit is used.

After the Start FFT command is sent to the reader module a Fast Fourier Transformation (FFT) is started to locate periodic disturbers. After about 110 ms this calculation is finished and for the following communication between reader module and transponder the located disturbers are eliminated. The command FFT should be executed as often as the application allows.

Important:

- The DSP is able to suppress up to two harmonic electromagnetic disturbances.
- During FFT is running (about 110 ms) communication with a transponder is not possible.

7 Error Handling

7.1 Possible Errors by Connecting the HITAG Long Range Reader Module

The following error list should be checked if any error (e.g. read/write distances that do not reach the specified values) occurs:

- Power supply cable not mounted correctly.
- Power supply not in the specified range (see 3.1.1)
- Serial interface not connected correctly.
- Interference received by the antenna because of an external noise source (e.g. monitor, keyboards).
- Connecting cables of the antenna changed by mistake.
- Antenna is mounted in metal environment.
- Remedial measure: Mount a non-metal space keeper between the antenna and the metal.
- Antenna is not designed following the antenna design instructions.
- Inductance of the antenna is not in the specified range.
- Quality factor of the antenna is not in the specified range.

Important:
The Command names mentioned in the previous chapters are fully described in the document „**Protokoll HTRMxxx V2.5: Interface Protocol Reader - Host**“ or a newer Version

Documents concerning specifications for Transponder and Interface are available at NXP. To obtain this document or the necessary password to it please contact NXP-Docu-control at docu.control@nxp.com or use the fax-template on our CD-ROM.

8 Security Considerations

When developing the hitag™ - system, special consideration was given to security aspects. The following items represent the fundamental framework of the security concept:

- cryptography
- mutual authentication
- password verification and
- Cyclic Redundancy Check (CRC)

8.1 Operating Security

The following mechanisms ensure the operation security of the hitag™ - system.

8.1.1 Anti-Collision Mode

Anti-collision Mode in long range applications permits you to process several HITAG 1 transponders simultaneously. Theoretically up to 2^{32} HITAG 1 transponders can be processed simultaneously. In practice this number is limited, because of the mutual influence of the transponders - they detune each other, if there are too many too close to each other.

In long range applications using HITAG 2 transponders, only one transponder is handled even if there are several transponders within the communication field of the antenna. In this case either no communication takes place or the "stronger" or closer transponder takes over. By muting a selected transponder (HALT Mode) another transponder that is to be found in the communication field of the antenna can be recognized.

8.1.2 Antenna Rupture, Antenna Short Circuit

The hitag™ -Long Range Reader Module does not get permanently damaged in case of an antenna rupture or a brief antenna short circuit. The detection of detuned or broken antennas (antenna malfunction) is possible.

8.2 Data Privacy

The use of cryptography (Stream Cypher), mutual authentication, and password verification prevents monitoring and copying the data channel. Therefore, the area of the transponder that only can be accessed enciphered is called “secret area“.

Attention: To make use of cryptography for HITAG 1 transponders you need keys and logdata.
Keys are used to **initialize the crypto block** and **logdata** are used for **mutual authentication**.

Attention: To make use of cryptography for HITAG 2 and HITAG S transponders you need a key and passwords.
The **Key** is used to **initialize the crypto block** using HITAG 2/S in Crypto Mode and **passwords** are used for **authentication** of HITAG 2/S in Password Mode.

The transponders and the hitag™ - Reader Module are provided with identical transport keys and transport logdata so that you can start operating them right away.

8.2.1 Basic Settings

KeyInit Password	0x00000000
HITAG 1 Keys and Logdata	0x00000000
HITAG 2 Key	0x4D494B524F4E
HITAG 2 Password TAG	0xAA4854
HITAG 2 Password RWD	0x4D494B52
HITAG S Key	0x4D494B524F4E
HITAG S Password TAG	0xCA4854
HITAG S Password RWD	0x4D494B52 (*transport* values predefined by Philips on transponder side and by Freaquent Froschelectronics GmbH on reader side)

Attention: In order to offer our OEM clients high flexibility, the configuration of the transponder memory, password, keys and logdata can be changed.
We strictly recommend to rigorously restricting these possibilities for the end customers (by setting the configuration page to read only, setting password, keys and logdata to neither read nor write).

9 Additional Information

Attention: When you replace or finally decommission products of the HITAG – Long Range Reader Modules, dispose them environmentally aware!

9.1 Ordering Information for HITAG Long Range Reader Modules

Type Name	Description	Ordering Number
HT RM803/AED	RS232 Interface	HT RM803/AED
HT RM803/CED	RS485-Interface	HT RM803/CED
HT RM803/EED	CMOS-Interface	HT RM803/EED
HT RM803/LAN	LAN-Interface	HT RM803/LAN
HT RM903/AED	RS232 Interface	HT RM903/AED
HT RM903/CED	RS485-Interface	HT RM903/CED
HT RM903/EED	CMOS-Interface	HT RM903/EED
HT RM903/LAN	LAN-Interface	HT RM903/LAN

9.2 Manufacturer Data

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