DATA SHEET

hitag

HTCM400
HITAG core module hardware

Product specification
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Semiconductors

PHILIPS

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HITAG core module hardware HTCM400

1 FEATURES

- Compact size
- Communication with all HITAG transponders and various other 125 kHZ transponders
- Data encryption, key handling
- Fast and easy system integration
- Serial CMOS interface
- Simple antenna design
- 5 V power supply voltage
- Meets all requirements for CE and EMI approval.

2 APPLICATIONS

- HITAG proximity readers
- HITAG long range readers.

3 GENERAL DESCRIPTION

HITAG(1) is the name of one of the universal and powerful product lines of our 125 kHz family. The contactless read/write system that works with passive transponders is suitable for various applications. Inductive coupling helps you to achieve operating distances up to 1000 mm and the use of cryptography guarantees highest data security.

Anticollision mode, which is used only in long range operation, 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 anticollision becomes an essential element of applications such as ski-ticketing 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.

(1) HITAG - is a trademark of Philips Semiconductors Gratkorn GmbH.

hitag

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.

The HITAG product family is used both in the proximity area (operating range up to approximately 200 mm) and in the long range area (operating range to approximately 1000 mm).

In both cases the HITAG core module forms the central part as illustrated in Figs 9 and 11.

The HITAG core module provides you with a universal, cost-effective and small module. The use of modular architecture guarantees versatile usability and easy integration into bigger systems. The HITAG core module enables communication with HITAG 1 and HITAG 2 transponders.

Easy integration and application of the HITAG core module is due to:

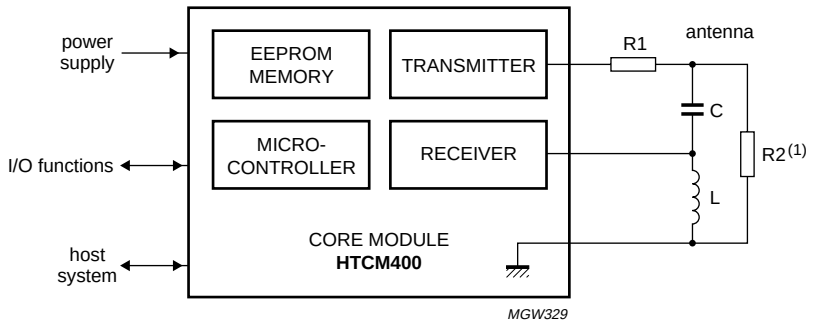
- Small size
- Uncomplicated interfaces.

Based on the core module delivered by Philips and using only a few additional components, every client can build his individually designed proximity reader without difficulty. Moreover, you can obtain the long range reader module HTRM800 (with an additional high frequency component) from Philips, if long range applications are required.

4 ORDERING INFORMATION

PART NUMBER	NAME	ORDER CODE (12NC)
HTCM400/EAE	HITAG core module	9352 339 00122

5 BLOCK DIAGRAM



(1) R2 has only to be used for antenna cable lengths of more than 500 mm.

Fig.1 Block diagram.

6 PINNING

SYMBOL	PIN	TYPE(1)	FUNCTION
TXDEN	1	O	control pin providing connection to an RS485 interface; note 2
RXLOW_DSP	2	I	interface to the HITAG long range board
RXHIGH_DSP	3	I	
RXCOL_DSP	4	I	
TXµPL_DSP	5	O	
SCLK_DSP	6	I	
SFFT_DSP	7	O	
i.c.	8	–	internally connected; this pin must not be connected
ACNMAN_DSP	9	O	interface to the HITAG long range board
HINMIRO_DSP	10	O	
RxD	11	I	serial interface input from host; note 2
TxD	12	O	serial interface output to host; note 2
i.c.	13	–	internally connected; this pin must not be connected
i.c.	14	–	internally connected; this pin must not be connected
OUT1	15	O	output pins of the microcontroller for controlling e.g. a LED (connection of e.g. a BS170 or BSS123 as driver); note 2
OUT2	16	O	
IN1	17	I	input pins for optional switch; must be active LOW; maximum input voltage 5 V; internal pull-up resistors are provided; note 2
IN2	18	I	
DVDD	19	P	digital supply voltage (5 V)
DGND	20	P	digital ground supply
n.c.	21	–	not connected
AVDD	22	P	analog supply voltage (5 V)
AGND	23	P	analog ground supply

SYMBOL	PIN	TYPE(1)	FUNCTION
NRESET	24	O	output from the Power-on reset circuit; can be used as a reset signal (sink current is typical 10 mA and minimum 2 mA)
n.c.	25	–	not connected
TX1	26	O	antenna output
RX	27	I	antenna input

Notes

1. O = output pin; I = input pin; P = power supply pin.
2. Input or output current on any pin is 1.5 mA; maximum capacitive load on any pin is 80 pF.

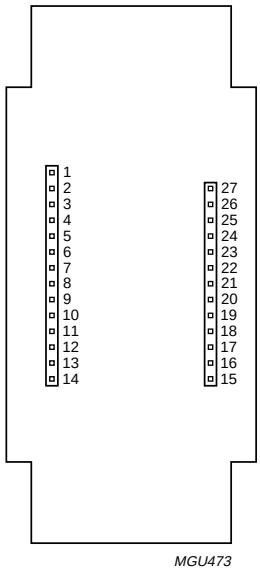


Fig.2 Core module with its pin connectors and pin numbering (seen from below the module).

7 FUNCTIONAL DESCRIPTION

7.1 System overview

The HITAG core module is a compact module used in read and write devices for the 125 kHz family.

With only a few external components (antenna coupling network, interface driver and voltage decoupling) you can use the HTCM400 as the central part of a HITAG reader module (see Fig.3).

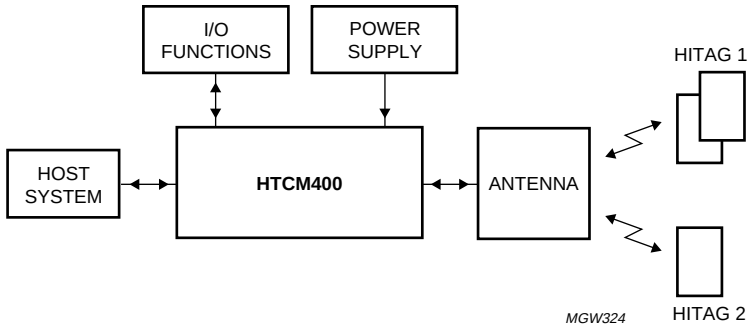


Fig.3 System overview.

7.1.1 TRANSPONDERS

The HTCM400 integrated into a read and write device can communicate with Philips HITAG 1 and HITAG 2 transponders.

7.1.2 HOST SYSTEM

The connection to the host (e.g. microprocessor or PC) is a serial interface on CMOS level for data transmissions over shorter distances. You can connect an RS232 as well as an RS422 interface device. If you use an additional pin of the HTCM400 (pin TXDEN) as control pin, you can realize an RS485 interface.

7.1.3 I/O FUNCTIONS

The I/O lines form the connection to potential keys and LEDs; two lines are wired as inputs and two as outputs.

7.1.4 CONNECTING THE ANTENNA

Connect an antenna as shown in Fig.4

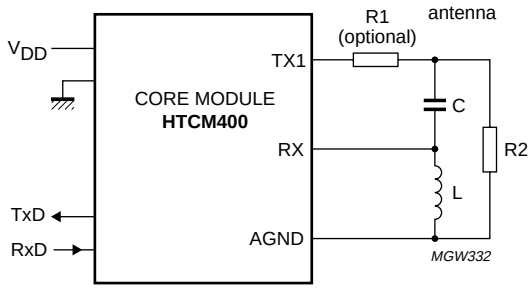


Fig.4 Connecting the antenna.

The resistor R1 has to be used if the antenna voltage is too high (see Section 11.7). With the capacitor C the antenna tuning is done. R2 has only to be used for antenna cable lengths of more than 500 mm and is used for damping.

For more details concerning the design of HITAG proximity antennas, see Section 11.

7.1.5 Behaviour with several transponders

If several HITAG transponders arrive simultaneously within the communication field of the antenna of a HITAG proximity 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 other transponders are ignored.

Nevertheless, it is possible to mute transponders so that several HITAG transponders can be accessed sequentially. This ensures that no two (or several) HITAG transponders will ever be processed (above all written to) accidentally at the same time.

If a HITAG long range reader module is used, anticollision mode is applied, which makes it possible to read and write all the HITAG 1 transponders (theoretical up to 2^{32}) within the communication field of the antenna 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.

7.2 Core module software

The software description is given in document “*HTCM400, HTRM440 Family, HTRM800 Family Interface Protocol Reader - Host*”.

7.3 Core module hardware

7.3.1 EEPROM

The EEPROM is used to store non-volatile data such as personalization data, keys, passwords, configurations and status information.

7.3.2 Microcontroller

The microcontroller processes the protocol for the communication between the transponders and the read and write unit. The interface signals are converted so that a HITAG 1 or HITAG 2 transponder is able to process them and the outgoing signals from the transponder are converted into interface-compatible signals.

The second essential microcontroller function is its control function. The microcontroller activates and deactivates the transmitter and selects the EEPROM.

7.3.3 Interface: microcontroller - host

The device communicates with the host (microcontroller or PC) via a serial interface using a baud rate of 9600 baud. Data transfer details are: 1 start bit, 8 data bits, 1 stop bit and no parity bit, the least significant bit is sent first.

An RS232 interface device can be connected to the HTCM400. Optionally an RS422 or an RS485 device is possible.

7.3.4 Transmitter and receiver

The transmitter receives data from the microcontroller and modulates the carrier.

The receiver demodulates the received data and passes them on to the microcontroller for further processing.

7.3.5 Antenna

For the design of HITAG proximity antennas, see Section 11.

7.3.6 HITAG long range reader module

The HITAG long range reader module (HTRM800) supplied by Philips uses some of the module pins as interface to an additional high frequency part and a Digital Signal Processor (DSP) part.

7.3.7 Interface: microcontroller - HITAG long range board

This interface is not wired with proximity applications (leave pins open).

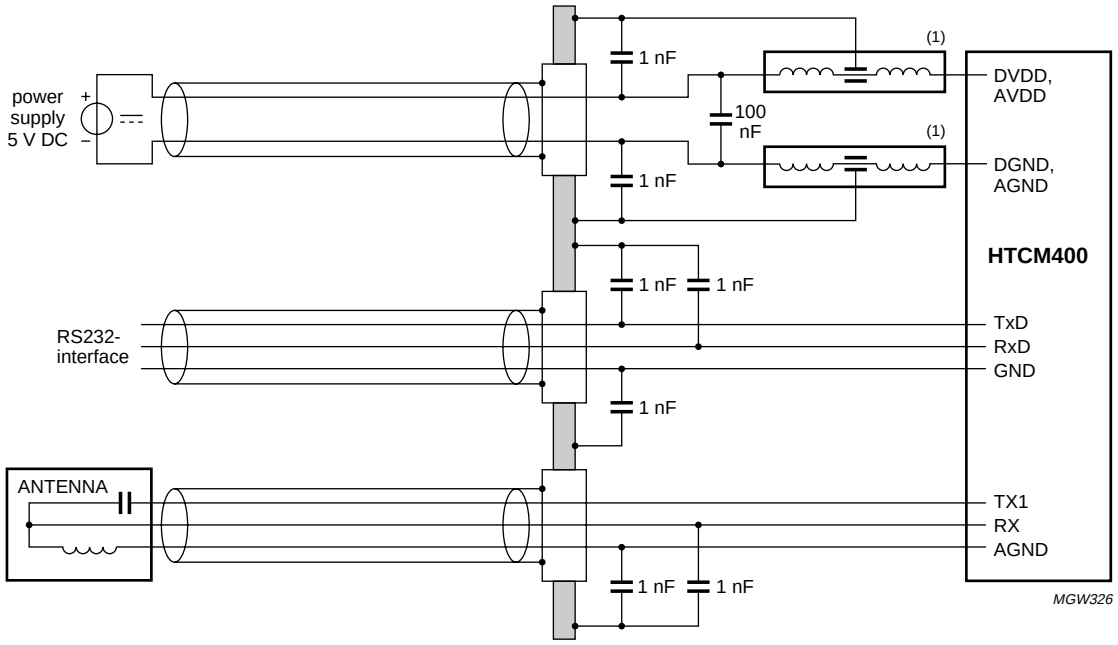
7.4 Postal approval

The postal approval can only be granted for final products, not just for components like the HTCM400. But the core module is designed in a way that it is possible to get the postal approval for a device including the HTCM400, if you follow the design instructions given by Philips.

Electromagnetic emission comply with the guidelines in FTZ 17 TR 2100 and ETS 300 683. Electromagnetic immunity complies with the guidelines in ETS 300 683.

7.4.1 COMMON MODE FILTERING

Figure 5 shows the basic configuration using the HTCM400 used to comply with the standards and some additional circuits which are recommended.



(1) SMD filter Murata NFM61R10T102.

Fig.5 Common mode filtering.

The design consists of a virtual ground layer (drawn grey in Fig.5). All entering wires are blocked by 1 nF ceramic capacitors to this layer to prevent common mode disturbances from entering the following circuits. The virtual ground layer is floating, it is not connected to the ground itself.

A recommended metal housing that covers the HTCM400 would also be connected to the floating layer.

7.4.2 Filtering of the supply voltages

The transmitter of the HTCM400 is supplied via pins AVDD and AGND. Disturbances on these supply pins are amplified and may reduce the performance of the system. For that reason especially the analog supply voltage (pin AVDD) must be filtered in addition to the common mode filtering described in Fig.5.

On the other hand the spurious emissions at the supply connections (pins DVDD and DGND) caused by the digital parts of the module must be limited.

A suppressor diode protects the core module from ESD to the power supply line (see Fig.6).

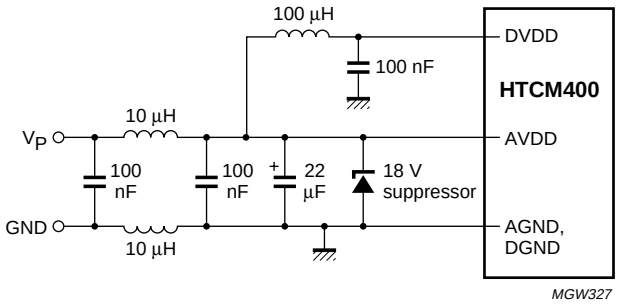


Fig.6 Power supply filtering.

7.4.3 Filtering of the antenna circuit

In case of using an external antenna with shielded antenna cable, no additional filtering should be necessary. In case of a heavy disturbed environment, an additional filter circuit is recommended when using external antennas (see Fig.7).

Using this filter will reduce the reading performance by approximately 20%.

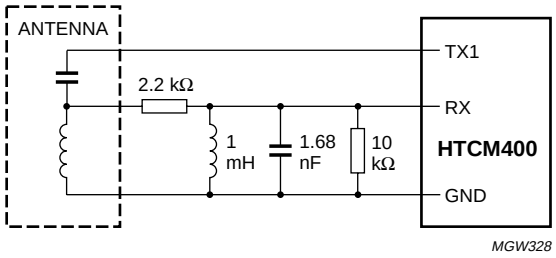


Fig.7 Filtering of the antenna circuit.

7.4.4 ESD protection

All I/Os should be protected by common circuits consisting of series resistors and suppressor diodes. The transmitter output is already protected by a series resistor and internal diodes of the driving FETs. To protect the receiver's input, a 40 V bi-directional suppresser diode at pin TX1 is recommended. If the additional filter shown in Fig.7 is used, no more protection circuits are needed.

7.5 Security considerations

Developing the HTCM400 special consideration was given to aspects of security. The following items represent the fundamental framework of the security concept:

- Cryptography
- Mutual authentication
- Password verification and
- Cyclic Redundancy Check (CRC).

7.6 Data reliability

All the commands and data transferred from the HTRM440 to the transponder are secured by Cyclic Redundancy Check (CRC).

7.6.1 CRC OF A DATA STREAM BETWEEN READER MODULE AND TRANSPONDER

This check is carried out in the transponder.

Every data stream sent (commands, addresses and user data) from the HTRM440 to the transponder is first checked for data errors by a transponder-integrated 8-bit CRC generator and then executed. Normally the transponder responds to each data stream from the HITAG proximity reader module with an acknowledge signal or with a data signal or with a data block. The CRC is formed over commands and addresses or the plain data respectively and in the case of encrypted mode it is also encrypted. The generator polynomial of the transponder CRC generator reads:

$u^8 + u^4 + u^3 + u^2 + 1 \ldots\ldots\ldots\ldots = 0x1D$

and the CRC preassignment is: 0xFF.

Detailed instructions how to use and calculate Cyclic Redundancy Check (CRC) are available in an additional document.

7.6.2 CHECKING USER DATA

This check is carried out in the HITAG proximity reader module.

Security of the data read from the transponder by the HITAG proximity reader module remains with the user for reasons of flexibility. Therefore, you can choose flexible check sums and store them in the EEPROM together with the data. You can protect sensitive data better than less sensitive data, thus permitting optimized operation times.

7.6.3 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’.

To make use of cryptography you need secret data: keys and logdata.

Keys are used to initialize the crypto block and logdata are used for mutual authentication.

The transponders and the HITAG proximity reader module are provided with identical transport keys and transport logdata so that you can start operating them right away (see Table 1).

Table 1 Transport values predefined by Philips.

SYSTEM	PARAMETER	VALUE
HITAG 1	keyinit password	0x00000000
	keys	0x00000000
	logdata	0x00000000
HITAG 2	keyinit password	0x00000000
	key	0x4D494B524F4E
	password TAG	0xAA4854
	password RWD	0x4D494B52

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 restrict these possibilities for the end customers (by setting the configuration page to read only, setting password, keys and logdata to neither read nor write).

See also “*HTCM400, HTRM440 Family, HTRM800 Family Interface Protocol Reader - Host*”.

7.7 Operating security

The following mechanisms ensure the operation security of the HITAG system:

- Anticollision mode
- Monitoring the supply voltage
- Antenna rupture or short-circuit.

7.7.1 ANTICOLLISION MODE

Anticollision mode in long range applications permits you to process several HITAG 1 transponders simultaneously. Theoretically up to 2^{32} 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 proximity applications using HITAG 1 or 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.

7.7.2 MONITORING THE SUPPLY VOLTAGE

Supply voltage is controlled by a Watchdog circuit which triggers a system reset if the supply voltage drops below 4.75 V or if the microcontroller fails.

7.7.3 ANTENNA RUPTURE OR SHORT-CIRCUIT

The HTCM400 does not get permanently damaged in case of an antenna rupture or a brief antenna short-circuit.

8 ELECTRICAL SPECIFICATIONS

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
Power supply						
V_P	DC supply voltage		4.75	5.0	5.25	V
I_P	DC supply current		–	–	100	mA
P	power dissipation		–	0.5	–	W
$V_{ripple(p-p)}$	ripple voltage (peak-to-peak value)	f_{ripple} is <10 kHz; note 1	–	–	5	mV
		f_{ripple} is 10 to 20 kHz; note 1	–	–	25	mV
		f_{ripple} is ≥20 kHz; note 1	–	–	40	mV
Modulation						
m_{TX}	modulation ratio of reader module to transponder	Amplitude Shift Keying (ASK)	–	100(2)	–	%
m_{RX}	modulation ratio of transponder to reader module	Amplitude Shift Keying (ASK); note 3	–	–	–	%
Temperature						
T_{oper}	operating temperature		–25	–	+85	°C
T_{stg}	storage temperature		–40	–	+85	°C

Notes

1. With the power supply filter described in Section 7.4.2.
2. The carrier is periodically blanked completely, the information is located in the intervals between the pauses.
3. Modulation ratio depending on the distance between transponder and reader module.

9 MECHANICAL SPECIFICATIONS

The module consists of the Printed-Circuit Board (PCB) and one 14-pole and one 13-pole pin connector that protrudes from the PCB.

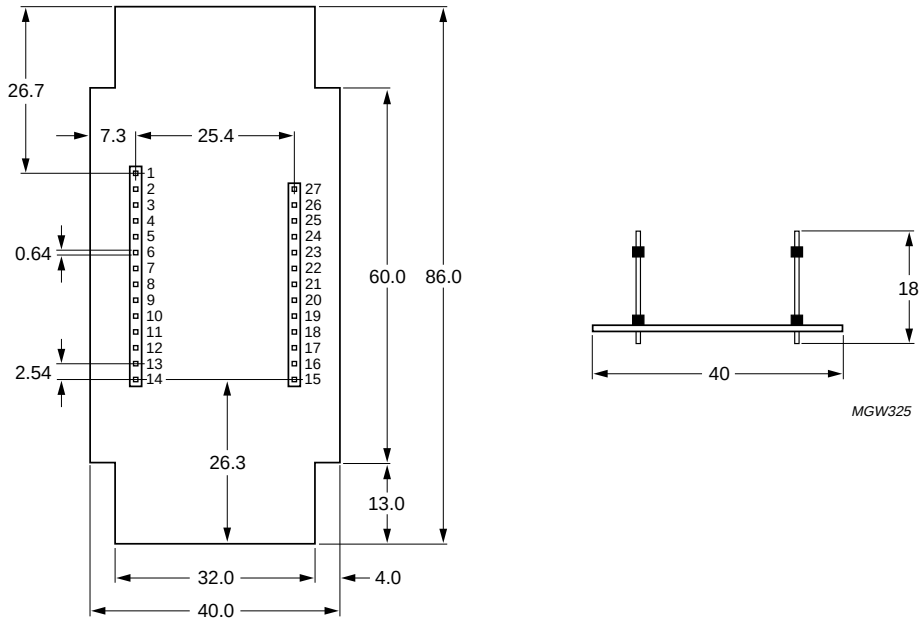
9.1 Mounting the module

You can mount the module onto a base printed-circuit board by soldering or plugging.

9.2 Dimensions

The outer dimensions of the PCB are: $86 \times 40 \times 7$ mm.

The module including the pin connectors is approximately 18 mm high.



Dimensions are in mm.

Fig.8 Dimensions (seen from below the module) and pins protruding.

10 APPLICATION INFORMATION

10.1 Metallic environment, interferences

The communication range is impaired by metallic environment and electromagnetic interferences (e.g. monitors and 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 for transponders and antennas or shielding for antennas.

10.2 Distance between two antennas

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 of four times the antenna diameter. If you place them at a closer distance be sure to use suitable shielding or synchronization.

10.3 To build a proximity reader

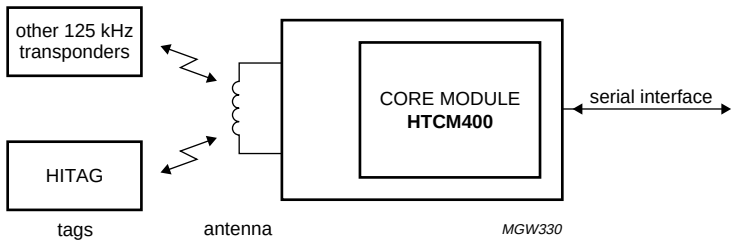


Fig.9 Block diagram of proximity reader module.

10.3.1 CONNECTION OF THE HTCM400 IN ORDER TO BUILD A PROXIMITY READ AND WRITE DEVICE.

A few external components are needed to make the HTCM400 a proximity read and write device (see Fig.10).

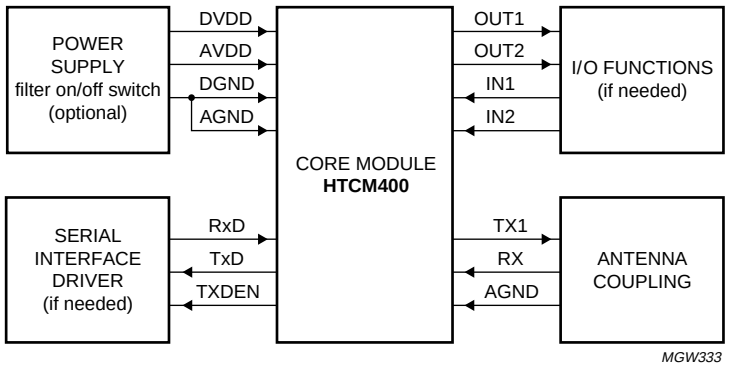


Fig.10 Building a proximity read/write device.

10.3.2 POWER SUPPLY

The HTCM400 requires a DC voltage of 5 V ± 5% and it is absolutely necessary to use a low resistance (<0.7 Ω) power supply. Voltage regulation is required and separate supplies for analog and digital parts are recommended. See Section 8 for maximum allowed power supply ripple amplitudes.

10.3.3 INTERFACE DRIVER

Signal transmission for direct connection to the host can be done over the serial CMOS interface. For short distances the transmission can be done over an RS232 interface, longer distances require integration of an RS485 or RS422 interface component. If you use an RS485 interface, pin TXDEN is used as control pin.

10.3.4 I/O FUNCTIONS

If necessary, you can connect these inputs and outputs to drivers for LEDs and switches.

10.4 To build a long range reader

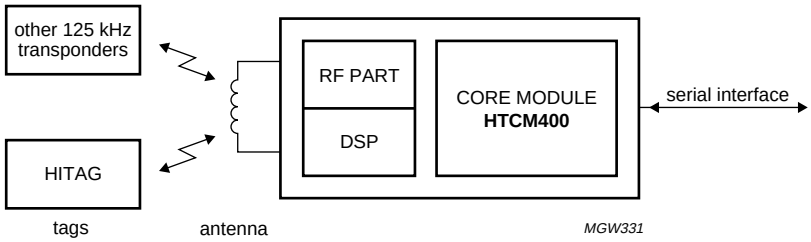


Fig.11 Block diagram of long range reader module.

10.5 Possible sources of errors by connecting the HTCM400

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

- Power supply cable not mounted correctly
- Bad filtering of the power supply; remedial measure: filtering as described in Section 7.4.2
- DC power supply not within the specified range (V_P = 5 V ± 5%)
- RS232 interface not connected correctly
- Interference received by the HTCM400 because of the digital part of a possible additional circuit board. Remedial measure: shielding of the additional circuit board
- Interference received by the HTCM400 because of an external noise source. Remedial measure: housing of metal or shielding
- Interference received by the antenna because of an external noise source (e.g. monitor or keys). Remedial measure: removal of the antenna from the interfering area
- 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 design instructions of Section 11
- Inductance of the antenna is too high
- Quality factor of the antenna is too high (Q > 40)
- Antenna current is too high
- Antenna voltage is too high.

11 INSTRUCTIONS FOR BUILDING HITAG PROXIMITY ANTENNAS

The antenna is an important part in the data transmission process between read and write device and transponder. Therefore, you should be particularly careful when implementing the antenna in order to achieve optimum results.

An essential aspect in dimensioning HITAG proximity antennas is the ratio between the antenna diameter and the diameter of the transponder coil. This ratio should be within the limit values 3 and 1. If the ratio is too big or too small read/write distances can decrease and difficulties during data transmission may occur. For applications in which the transponders are only to be read, you can also use antennas that do not meet these instructions.

11.1 Basics

Figure 12 shows the general architecture of a HITAG proximity antenna and its connection to the HTCM400.

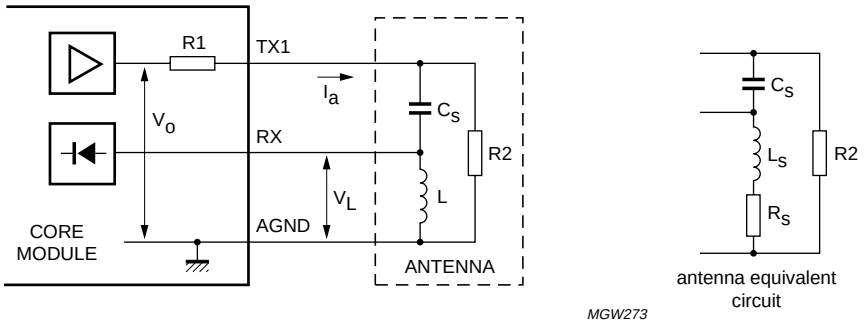


Fig.12 Architecture of a proximity antenna.

When developing an antenna, it is important to take into consideration the read/write device limits, i.e. maximum antenna current and maximum voltage at the receiver input. With an output voltage V_o of approximately 2.5 V (p-p) the following limits apply to the HTCM400:

- Maximum antenna current is 100 mA (p-p)
- Maximum input voltage at the receiver (V_L) is 32 V (p-p).

The resistor R1 (22 Ω) in Fig.12 is used as current limiter. It protects the output stage in the event of a possible short circuit in the antenna and is already integrated in the HTCM400. R2 (approximately 600 to 1000 Ω) has only to be used for antenna cable lengths of more than 50 cm.

11.2 Antenna coil

The inductance of the coil should be between 350 and 500 μH.

The antenna quality factor (Q) should be approximately 40.

$$Q = \frac{2 \times \pi \times f \times L}{R_s}$$

If the Q factor is too high, it must be reduced with an additional resistor. It is better not to use this additional resistor, but instead to use a smaller wire diameter of the coil.

The following formula describes the approximate calculation of the number of windings for a desired inductance and antenna geometry:

$$L = 2 \times a \times \ln\left(\frac{a}{D} - K\right) \times N^{1.9}$$

where:

L is desired inductance in nH

a is antenna circumference in cm

D is wire diameter in cm

N is number of windings

K is a geometrical constant:

For a circular antenna K = 1.01

For a square antenna K = 1.47.

Remark: the factor K is normally much smaller than $\frac{a}{D}$ and can therefore be left out: $N \approx \sqrt[1.9]{\frac{L}{2 \times a \times \ln\left(\frac{a}{D}\right)}}$

11.3 Measuring the inductance

The inductance of the coil designed according to the instructions as given in Section 11.2 can be measured using the measuring set-up as shown in Fig.13.

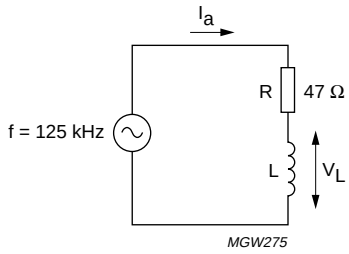


Fig.13 Measuring the inductance of the coil.

A sinus signal of 125 kHz is fed using a function generator. If you measure the current I_a and the antenna voltage V_L you can calculate the inductance according to the formula:

$$L = \frac{V_L}{\omega \times I_a} \text{ where } \omega = 2 \times \pi \times f.$$

11.4 Antenna cable length

For optimal performance, the antenna cable length should not exceed 5 m.

11.5 Antenna tuning

You have to tune the antenna in its final form with the connecting cable. You must not make any changes to the antenna coil or the connecting cable after you finished tuning because mechanical changes influence the electrical values and the antenna is detuned again.

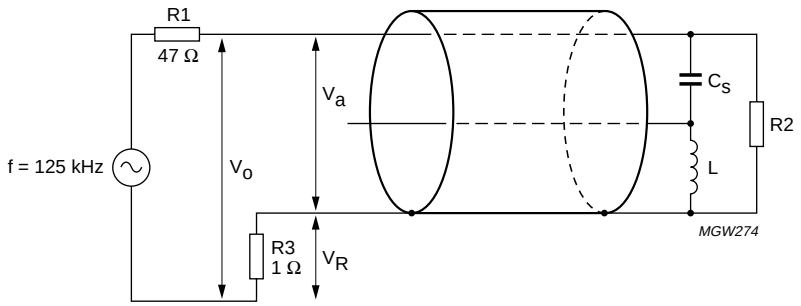


Fig.14 Tuning the antenna.

A sinus signal of 125 kHz is fed to the antenna using a frequency generator. You measure the voltages V_a and V_R with an oscilloscope. Then you change the frequency until V_a and V_R are in phase. If the resonance frequency now is too high, you have to increase C_S. If it is too low, you have to decrease C_S.

The aim is to get a resonance frequency of 125 kHz using C_S.

The resonant frequency has to be in the range of 125 ± 4 kHz.

11.6 Determining the serial resistance of the antenna

Use an oscilloscope to measure V_a and V_R at a frequency of 125 kHz. You can calculate the serial resistance R_S of the antenna with the following formulas: $I_a = \frac{V_R}{R3}$ and

$$R_s = \frac{V_a}{I_a}$$

11.7 Checking the antenna voltage V_L

Before connecting the antenna to the read and write device in Fig.15, you must carry out a check calculation of the input level of the read and write device according to the next formulas in order to prevent damage.

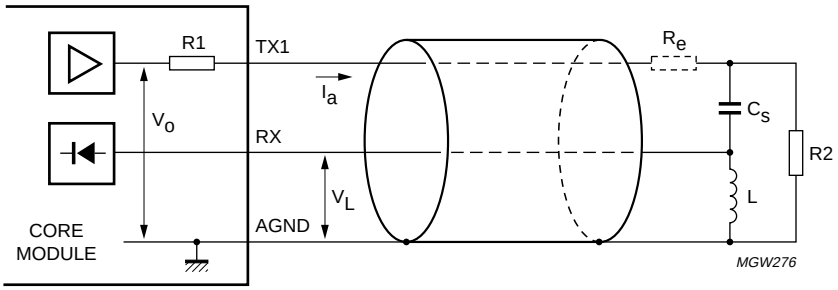


Fig.15 Calculation check of the input level.

$$I_a = \frac{V_o}{R1 + R_s + R_e}$$

$V_o \approx 2.5$ V

$V_L = L \times \omega \times I_a$ where $\omega = 2 \times \pi \times f$ (f = 125 kHz)

The maximum value for V_L reads 32 V (p-p), safeguarding against damage to the input level of the read/write device:

- With V_L < 32 V (p-p) the resistance R_e can be omitted
- With V_L > 32 V (p-p) you have to calculate and insert R_e according to the following formula:

  $$R_e = L \times \omega \times \frac{V_o}{V_{L(max)}} - R1 - R_s \text{ and}$$

  $R_e \geq L \times \omega \times 0.078 - 22 - R_s$

11.8 Procedure for practical antenna design

The procedure how to design a HITAG proximity antenna is described in the previous sections. The main steps are the following:

- The desired inductance for the antenna coil can be chosen in a range between 350 and 500 µH; e.g. L = 420 µH
- The number of windings N can be calculated with the following formula: $N = \sqrt[1.9]{\frac{L(nH)}{2 \times a \times \ln\left(\frac{a}{D}\right) - K}}$

  For L = 420 µH:

  $$N = \sqrt[1.9]{\frac{420000}{2 \times a \times \ln\left(\frac{a}{D}\right) - K}} = \sqrt[1.9]{\frac{633}{a \times \ln\left(\frac{a}{D}\right)}}$$

  Remark: the factor K (see Section 11.2) normally is much smaller than $\frac{a}{D}$ and therefore can be left out.
- Now the antenna can be built up with the desired dimensions (circumference a) with the calculated number of turns.

  Remark: the antenna coil must be changed afterwards because with the mechanical dimensions the electrical specifications are changing too. That means the number of turns, the shape, arrangement of the coil windings and antenna supply cable must be in their final form.

  Remark: metal influences the electrical characteristics of the antenna very much. That is why all future tasks have to be done with the antenna in its final environment if metal will be in the antenna's neighbourhood (distance of the metal shorter than the maximum antenna diameter)
- Measurement of the inductance L of the antenna is described in Section 11.3
- Determination of the serial capacitor C_S is described in Section 11.5

  Remark: the capacitance of the antenna supply cable can be measured or found out in the data sheet of the cable (e.g. C_p = 180 pF/m)
- Now the antenna has to be tuned according to Section 11.5. The tuning is acceptable if the resonant frequency is within a range of 125 ± 4 kHz
- The serial resistance R_S of the antenna is the impedance of the tuned antenna and is an ohmic resistance at the resonance frequency (f = 125 kHz). It can be calculated as shown in Section 11.6
- To get a satisfactory reading distance the quality factor of the antenna coil (for non-metal environment) should be approximately Q = 40. The quality factor of a coil is calculated as follows: $Q = \frac{\omega \times L}{R_s} = \frac{2 \times \pi \times f \times L}{R_s}$
- By knowing R_S and the dropping resistor (R1 = 22 kΩ) it is possible to calculate the current I_a and the antenna voltage V_L.

  It is very important to calculate the antenna voltage before connecting the antenna to the HTCM400 to avoid damage. Is the calculated value of V_L higher than 32 V (p-p) a resistor R_e has to be integrated to protect the module output circuit. The resistor has to be placed as shown in Section 11.7
- After checking the antenna voltage connect your antenna to the HTCM400 and measure the read/write distances with your transponders. If the read/write distances do not fulfil your expectations, the following points should be considered:
  - The size of the antenna and the size of the transponder have to be in a defined ratio (between 3 and 1). That means, if you increase the antenna over a certain size, the maximum read/write distances will decrease by the use of the same transponder
  - The optimal shape of the antenna coil is a circle. The performance of a square shaped coil is much better than that of a rectangular shaped coil (with the same circumference)
  - To get better read/write distances the quality factor of the antenna coil should be increased, but it must not be higher than Q = 40. This can be reached by the following measures:

– All conducting material has to be removed from the antenna environment
– A thicker wire can be used for the coil
– Ferrite can be placed behind the antenna coil to concentrate the field
– Extension of the antenna area
– There can be better results by trying another number of turns.

Attention: all these measures must not differ from the antenna design instructions of Section 11.

Remark: with additional dropping resistors R1 and R_e the quality factor of the whole antenna system is approximately 15.

11.9 Reference antennas

Designing an antenna in the way described in Chapter 11 you could use the following values:

Ø 0.4 mm Cu; lacquer wire; 35 turns

Diameter of the turns (internal) is 145 mm

Tuning frequency is 125 kHz

Tuning capacity depending on the length of the antenna cable and the exact way of winding.

This antenna is best suitable for HITAG 1 and 2 cards. In this performance reading distances of approximately 150 mm should be achieved.

A further antenna configuration:

Ø 0.224 mm Cu; lacquer wire; 52 turns

Diameter of the turns (internal) is 65 mm

Tuning frequency is 125 kHz

Tuning capacity depending on the length of the antenna cable and the exact way of winding.

In this case cards and coins can be used and the following approximate communication distances should be achieved:

Read distances with HITAG 1 and 2 card: 120 mm

Read distances with HITAG 1 and 2 coin: 65 mm.

The third antenna configuration is the smallest one:

Ø 0.224 mm Cu; lacquer wire; 85 turns

Diameter of the turns (internal) is 35 mm

Tuning frequency is 125 kHz

Tuning capacity depending on the length of the antenna cable and the exact way of winding.

Using this antenna coins and pills can be operated up to the following approximate distances:

Read distance with HITAG 1 coin: 58 mm

Read distance with HITAG 1 pill: 28 mm.

All distances are given in free air at room temperature.

12 SURVEY OF REFERENCED DOCUMENTS

CATEGORY	TITLE
Data sheet	*“HTCM400, HTRM440 Family, HTRM800 Family HITAG Interface Protocol Reader - Host”*

13 DATA SHEET STATUS

DATA SHEET STATUS[1]	PRODUCT STATUS[2]	DEFINITIONS
Objective data	Development	This data sheet contains data from the objective specification for product development. Philips Semiconductors reserves the right to change the specification in any manner without notice.
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