TEXAS INSTRUMENTS

Series 2000 Reader System

Standard Radio Frequency Module
RI-RFM-104B

Reference Guide

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TI-RFid
A TEXAS INSTRUMENTS TECHNOLOGY

Edition Two - October 2002

This is the second edition of this manual, it describes the following equipment:

TI-RFid Series 2000 Standard Radio Frequency Module **RI-RFM-104B**

Reference Documentation

Series 2000 Standard Reader Frequency Modules	Data Sheet	11-06-22-078
Series 2000 Reader System RI-STU-MB2A & RI-STU-MB6A	Reference Guide	11-06-21-056
Series 2000 Modules RI-CTL-MB2A / RI-CTL-MB6A	Reference Manual	11-06-21-037

This documentation listed above can be downloaded from the document center at our web site:

http://www.ti-rfid.com

Read This First

About This Guide

This manual describes the TI-RFid Standard Radio Frequency Module (RFM), it provides the information that you will need in order to install the RFM into your RFID system. It is generally targeted at systems integrators or value added resellers.

Regulatory, safety and warranty notices that must be followed are given in Chapter 5.

Conventions

WARNING:

A WARNING IS USED WHERE CARE MUST BE TAKEN, OR A CERTAIN PROCEDURE MUST BE FOLLOWED IN ORDER TO PREVENT INJURY OR HARM TO YOUR HEALTH.

CAUTION:

This indicates information on conditions which must be met, or a procedure which must be followed, which if not heeded could cause permanent damage to the equipment or software.

Note:

Indicates conditions which must be met, or procedures which must be followed, to ensure proper functioning of the equipment or software.

Information:

Indicates information which makes usage of the equipment or software easier

If You Need Assistance

Application Centers are located in Europe, North and South America and the Far East to provide direct support. For more information, please contact your nearest TI-RFid Sales and Application Center. The contact addresses can be found on our home page:

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CHAPTER 1

Introduction

This chapter introduces you to the S2000 Standard RF Module. It tells you what the RF module is for and provides a mechanical description of the construction of the RF module complete with drawings showing the module.

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1.1 General

The S2000 Standard Radio Frequency Module is an integral part of a TI-RFid system, together with a control module or unit and an antenna it is used for wireless identification of TI-RFid transponders.

Main tasks of the RF module are to send an energizing signal via the antenna to initialize a TI-RFid transponder, to demodulate the received transponder identification signal and to write to a transponder. The RF module delivers a digital data stream and a clock signal for further processing to its control unit or module. Furthermore a field strength dependent digital output is available for synchronization purposes.

The RFM is tuned to resonance with the antenna by adjusting the inductance of the tuning coil at the RFM's RF output stage.

1.2 Product Description

The RF module contains all the analog functions of a TI-RFid reading unit that are needed to initialize a TI-RFid transponder and to detect its return signal. The RF module delivers DATA and CLOCK signals for identification data processing. The RF module also sends the necessary programming signals to Read/Write transponders and or Multipage transponders.

The data input and output lines, connected to a data processing unit (for example: TI-RFid Series 2000 control module, or a customer designed control unit), are Low Power Schottky TTL and HCMOS Logic compatible.

A layout of the RFM viewed from the top is shown in Figure 1.

There are four connectors on the RF module, they are:

- ST1 which is used to connect the supply voltages and interface signal lines to the controller unit.
- ST2 which is used for transmitter Carrier Phase Synchronization (CPS).
- ST3 this connector is not mounted on the L-tune RF module.
- ST4 which is used to connect the (optional) Antenna Tuning Indicator (ATI) which can be used for easy antenna tuning during installation.
- ST5, ST6 which are used to connect the receive-only antennas.

The transmit/receive antenna is connected to the RF module by the two M3 screw-connectors: ANT and GNDA.

The RF module can be mounted by means of the four M3 mounting bolts on the underside of the RF module.

1.3 Mechanical Description

The dimensions of the RFM are shown in Figure 2, the dimensions all have a tolerance of ± 1 mm. Further information about the height and weight is given in Table 1.

Figure 1: Top View

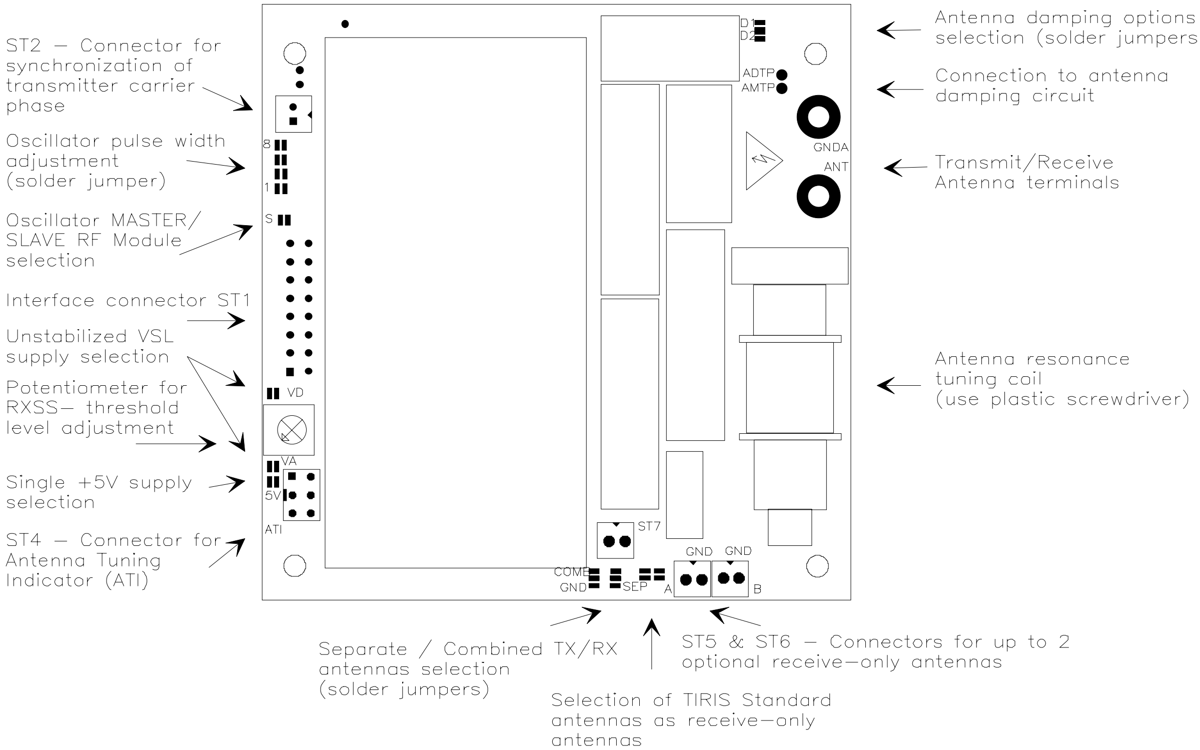

Figure 2: Module Dimensions

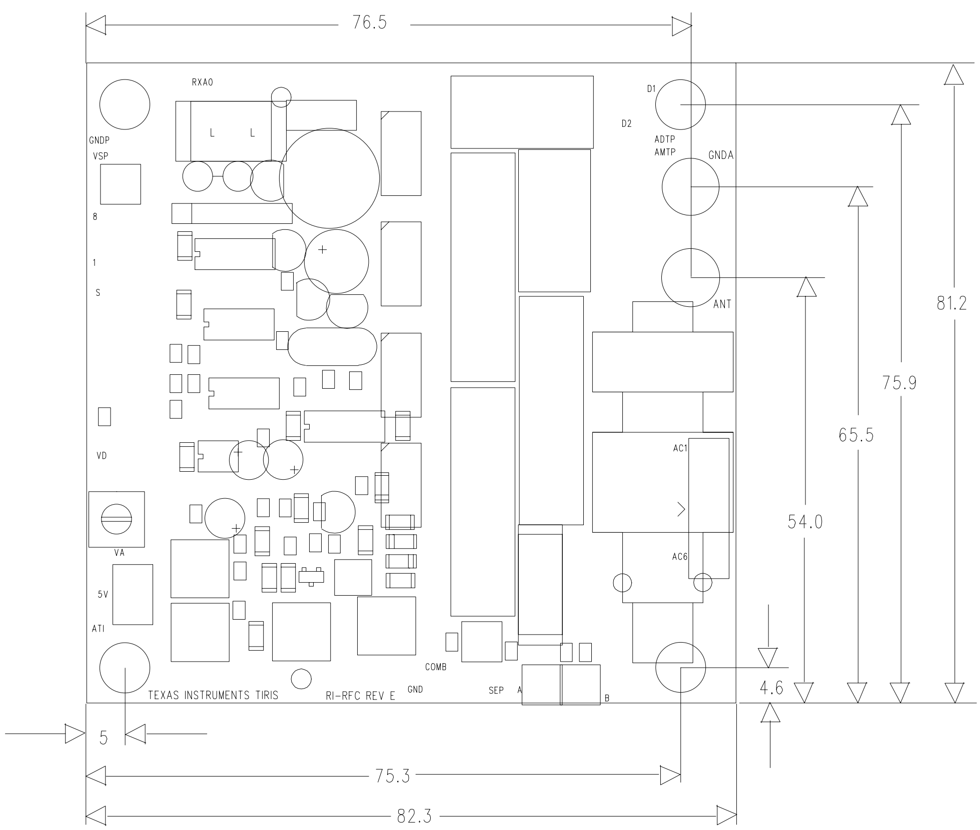

Table 1: Height & Weight

Parameter	Typical	Unit
Height of complete RF module (including mounting bolts)	36.0 +/- 1.5	mm
Weight of complete RF module	170	Grams

CHAPTER 2

Electrical Description

This chapter provides a short description of all features of all functional blocks of the RF module (transmitter, antenna, receiver).

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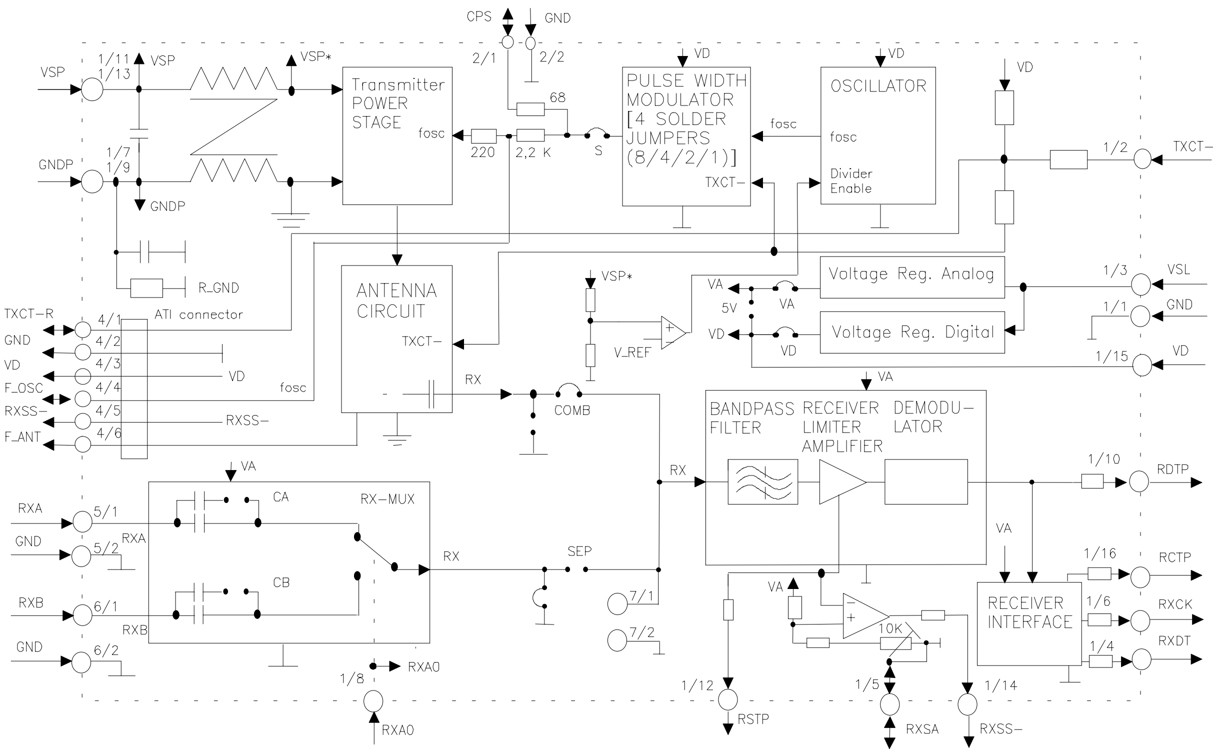
2.1 Introduction

A block schematic of the RF module is shown in Figure 3. The RFM is described at block diagram level in this chapter.

Figure 3: Block Diagram



2.2 Power Supply

The RF module has two built-in voltage regulators to separately supply the logic part and receiver part with regulated voltage. The unregulated input supply voltage for these regulators is connected to VSL and GND pins.

Optionally, the logic and receiver parts can both be connected to a external regulated +5 V supply. When this method is used, two solder bridges on the RF module must be opened and one closed. Then the regulated +5 V supply must be connected to pin VD. See also: Figure 1 and Figure 3.

The transmitter power stage is supplied via separate supply lines VSP and GNDP. Because of the high current for the transmitter power stage, these supply lines are separated from the logic supply lines and have two pins per line.

As the transmitter power stage needs a regulated supply voltage in order to meet FCC/R&TTE regulations and as there is no stabilization on the RF module, the supply voltage for the transmitter power stage must be externally regulated.

Note:

The RF module must not be supplied by Switched Mode Power Supplies (SMPS). This is because most SMPS operate at frequencies around 50 kHz. The harmonics of the generated field can interfere with the TI-RFid receiver. Therefore only use linear power supplies, or SMPS with a fundamental operating frequency of 200 kHz or higher.

The ground pins for the logic part and the transmitter are not connected internally, in order to avoid problems with possibly high resistive GNDP pins and in order to have higher flexibility with long supply lines. The pins GND and GNDP must be connected to each other externally. For more details, refer to Chapter 5: “Installation”.

The transmitter power stage is internally connected to the supply lines GNDP and VSP via a Common Mode Choke Coil, in order to reduce Electromagnetic Interference (EMI) on the supply lines (also see Figure 3).

The regulated transmitter power stage supply can vary in the range from +5 V to +14 V. This means that the supply lines VSP and VSL can be connected together, when the supply voltage is more than +6 V (for details refer to Chapter 4: “Specifications”).

With the option described above, the complete RF module can be supplied from a single +5 V regulated supply.

2.3 Transmitter

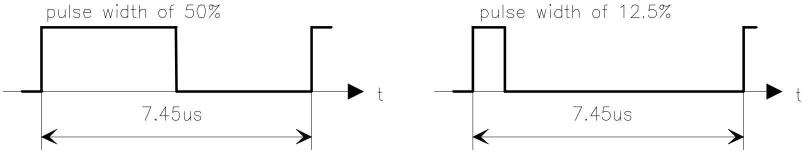
The transmitter frequency is generated by a crystal controlled oscillator. The high crystal frequency is divided to get the transmitter frequency of 134.2 kHz.

The oscillator has a protection feature for the transmitter power stage against current overload of the transmitter power stage. When the transmitter power stage supply voltage VSP accidentally exceeds the 'Absolute Maximum Ratings' (Chapter 4: “Specifications”), the oscillator is disabled and thus the transmitter is switched off.

The transmit frequency (134.2 kHz) from the oscillator is fed to the Pulse Width Modulator (PWM). By means of solder jumpers, the PWM can set the pulse width ratio between 3% and 50% in 16 binary steps. For an example of two different oscillator signal pulse widths see Figure 4. Decreasing the 134.2 kHz frequency pulse width ratio decreases the generated transmit (charge-up) field strength.

Thus it is possible to adjust the generated field strength by selecting different pulse width ratios. For more information about setting the solder jumpers, see both Figure 4 and Chapter 5: “Installation”.

Figure 4: Pulse Width Examples



The PWM and thus the transmitter is activated by connecting the TXCT- signal to ground. The TXCT- input has an internal pull-up resistor. For TXCT- signal input configuration, refer to Chapter 3: “Connectors and Solder Jumpers”. The TXCT- signal has to be active for a certain minimum time (for precise value refer to Chapter 4. “Specifications”).

CAUTION:

The RF module must not be operated in continuous transmit mode. For details of this and other parameters refer to Chapter 4: “Specifications”.

The pulse width modulated transmit frequency is fed to the transmit power stage via another solder bridge and resistors, which are used for the option of transmitter Carrier Phase Synchronization (CPS). See Figure 1 and Figure 3.

In some applications it is necessary to use several charge-up antennas close to each other. Under these circumstances the generated magnetic fields from different antennas superimpose on each other and may cause a beat effect on the magnetic charge-up field, because of the slightly different transmit frequencies of different RF modules.

This effect will not occur when the transmitters feeding these different antennas are all driven by the same oscillator. For this purpose the pulse width modulated transmit frequency is accessible at the connector ST2. All the RF modules to be driven by one oscillator must have their ST2 connectors connected together. An additional solder bridge selects whether the internal oscillator or the external oscillator signal is used. When the solder bridge 'S' is closed, the internal oscillator is used and the RF module is referred to as an oscillator MASTER RF module. When the solder bridge 'S' is open, the external oscillator signal is used and the RF module is referred to as an oscillator SLAVE RF module (also see Figure 1 and Sections 3.2.2 and 5.7).

Note:

Only one oscillator MASTER RF module (and up to five SLAVE RF modules) is allowed per synchronized system.

Finally the pulse width modulated oscillator signal is fed to the transmitter power stage. The transmitter power stage amplifies the oscillator signal and feeds this amplified signal to the antenna circuit, to generate the charge-up field.

The antenna circuit is described in Section 2.4.

2.4 Antenna Circuit

A block diagram of the antenna circuit can be seen in Figure 5.

The antenna circuit is a coil and capacitor resonating at the transmit frequency f_TX of 134.2 kHz. The resonator inductance consists of the tuning coil L_TUNE and the antenna coil L_ANT. The antenna coil L_ANT generates the magnetic charge-up field. Figure 6 shows a schematic of the antenna circuit.

The resonator capacitance consists of capacitor C1 parallel to capacitors C2, C3 and C_COUPLE, which are connected in series. Connecting capacitors in parallel and serial is necessary because of the high resonance voltage and the high current flow through the resonator.

Figure 5: Antenna Circuit Block Diagram

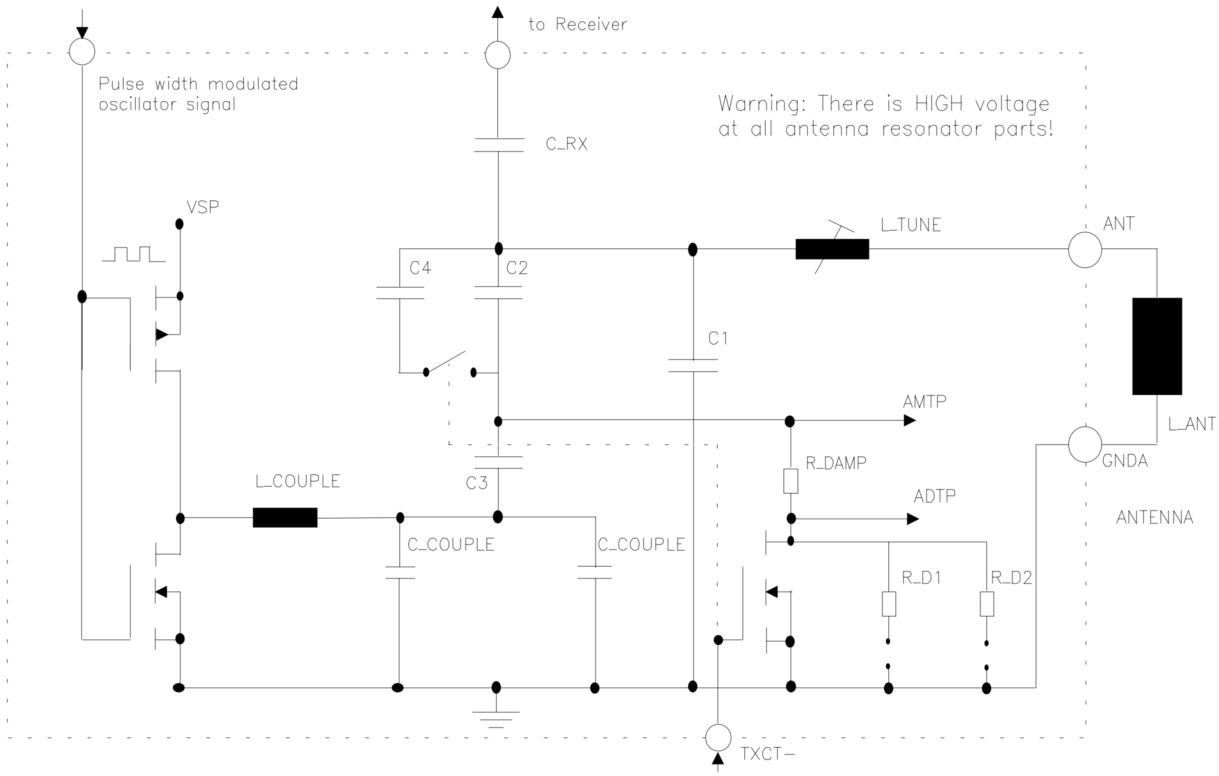
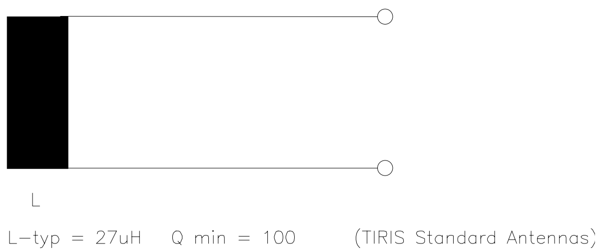


Figure 6: Standard Antenna



In order to get high resonance voltage and thus high charge-up field strength, the antenna circuit has to be tuned to resonance. The tuning coil L_TUNE is used for this purpose. This coil is connected in series with the antenna coil L_ANT and in this way it is possible to change the total inductance of the resonator.

The antenna circuit is tuned to resonance by screwing the ferrite core of the tuning coil L_TUNE in or out (also see Figure 1). This must be done with a plastic screwdriver as a metal screwdriver would affect the inductance of the coil which would lead to incorrect tuning. Therefore please use only the plastic screwdriver which is delivered with the RF module. For information about how to monitor the resonance tuning refer to Chapter 5: “Installation”.

Information:

It is strongly recommended to use the TI-RFid Antenna Tuning Indicator (ATI), for simple antenna resonance tuning monitoring.

WARNING:

CARE MUST BE TAKEN WHEN HANDLING THE RF MODULE. HIGH VOLTAGE ACROSS THE ANTENNA TERMINALS AND ALL ANTENNA RESONATOR PARTS COULD BE HARMFUL TO YOUR HEALTH. IF THE ANTENNA INSULATION IS DAMAGED IT SHOULD NOT BE CONNECTED TO THE RF MODULE.

The antenna resonator is connected to the Power MOS FETs of the transmitter power stage via a coupling coil L_COUPLE.

The antenna resonator has to be damped after the transmit burst, when the RF module is switched to receive mode. A MOS FET is used to do this, the MOS FET connects the damping resistor R_DAMP in parallel to the antenna resonator. In addition, when the damping circuit is active, the capacitor C4 is disconnected in order to adapt the antenna resonance frequency for proper filter bandwidth.

In cases, when low field strength for the larger antennas is necessary, the antenna resonator can additionally be damped by connecting either damping resistor R_D1 or R_D2 to the antenna resonator. This can be done by closing the solder bridges D1 or D2 (also see Figure 1).

The antenna circuit is also used for receiving the signal from the transponder. The received signal is coupled via the capacitor C_RX to the receiver circuit, which is described in Section 2.5.

Note:

The coupling coil L_COUPLE of the transmitter power stage is operated at high magnetic flux. Because of the high level of magnetic flux change, it is possible that this coil makes a significant audible noise. This can also occur with antennas that have ferrite cores (for example: TI-RFid standard stick antenna RI-ANT-S02C).

2.5 Receiver

The received signal from the transponder is a Frequency Shift Keying (FSK) signal with typical Low and High bit frequencies of 134.2 kHz and 123.2 kHz respectively. The signal is received from the antenna resonator, which is capacitive coupled to the receiver.

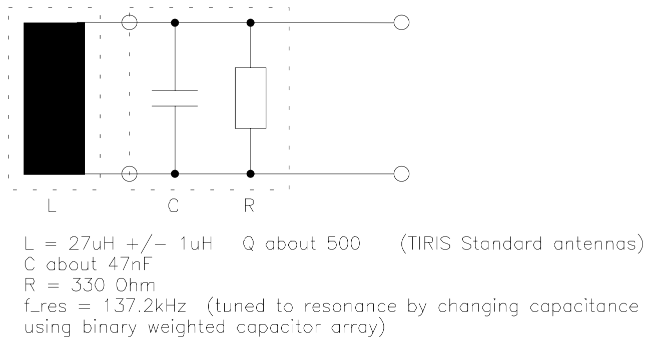
There are two options for the receive antenna. Either a combined transmit/receive antenna, or special receive-only antennas are used. The antenna type selection is done by configuring solder bridges (also see Figure 1 and Figure 3). For combined transmit/receive antenna, the solder bridge 'COMB' has to be closed. For separate transmit and receive antennas, the solder bridge 'SEP' has to be closed, in order to connect the receive multiplexer to the receiver. For both jumpers the unused input path has to be grounded by solder bridges (for details refer to Chapter 3).

When using the receive multiplexer, the active receive channel is selected by the input signal RXA0 (see Figure 3). This select input has an internal pull-up resistor, so that receive channel A is selected as default, when RXA0 is not connected. Connecting RXA0 to ground selects receive channel B.

The combined transmit/receive antenna is a coil as can be seen in Figure 6.

There is an alternative for receive-only antennas. Standard TI-RFid transmit/receive antennas can also be used as receive-only antennas, if they are built up as tuned and damped resonator. A block schematic of a standard TI-RFid antenna for use as a receive-only antenna is shown in Figure 7. For using this type of antenna, additional solder jumpers have to be closed on the RF module (also see Figure 1). For more details refer to Chapter 5: "Installation".

Figure 7: Standard TI-RFid Antenna used as Receive-only



The received signal from the antenna is fed to the receiver. The receiver contains a selective bandpass filter with a typical -3 dB bandwidth of 22 kHz. After the bandpass filter, the signal is amplified by the limiter amplifier and then demodulated. The receiver interface converts the demodulated signal to the Low Power Schottky TTL and HCMOS Logic compatible data signals RXCK and RXDT which contain the data received from the transponder.

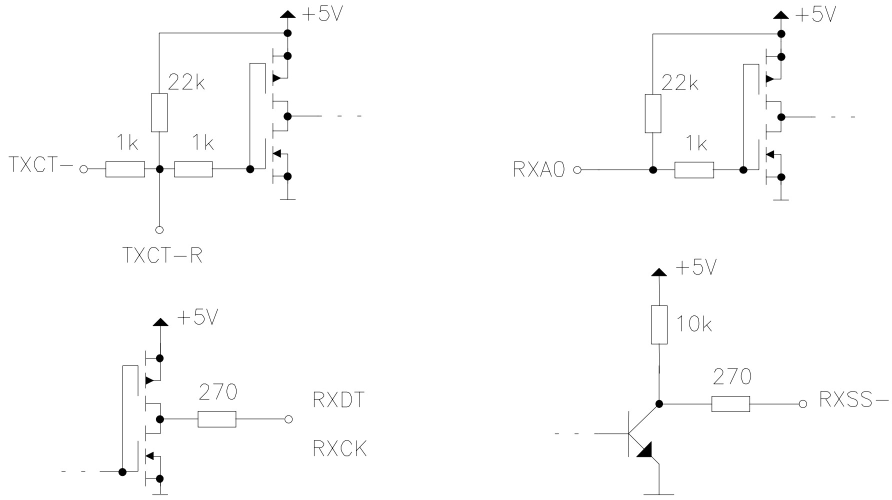
The signal RXCK is the reference clock signal to decode the RXDT data stream. The RXCK signal changes from 'low' to 'high' level in the middle of each data bit and the RXDT signal is valid before and after this positive slope only for a certain time window (for more details refer to Chapter 4: "Specifications" and to the RF Module Sequence Control Preliminary User Specification). The output configuration of the RXDT and RXCK signals is shown in Figure 8.

All input and output signals have protecting series resistors.

The receiver also has a built-in RF receive signal strength detector. The receive signal strength is indicated by the digital output RXSS-. RXSS- becomes active, when the received RF signal strength exceeds a defined level. This threshold level can be adjusted with a potentiometer on the RF module. The potentiometer is located near connector ST1 (see Figure 1 and Figure 3).

The RXSS- output is used to detect when other transmitting reading units in the area are transmitting and thus can be used for wireless synchronization of several reading units.

Figure 8: Output Configurations for Data and Clock Signals



CHAPTER 3

Connectors and Jumpers

This chapter provides a description of the connectors on the RFM and the signals on each pin. It also describes all of the jumpers available on the RFM, together with their effect.

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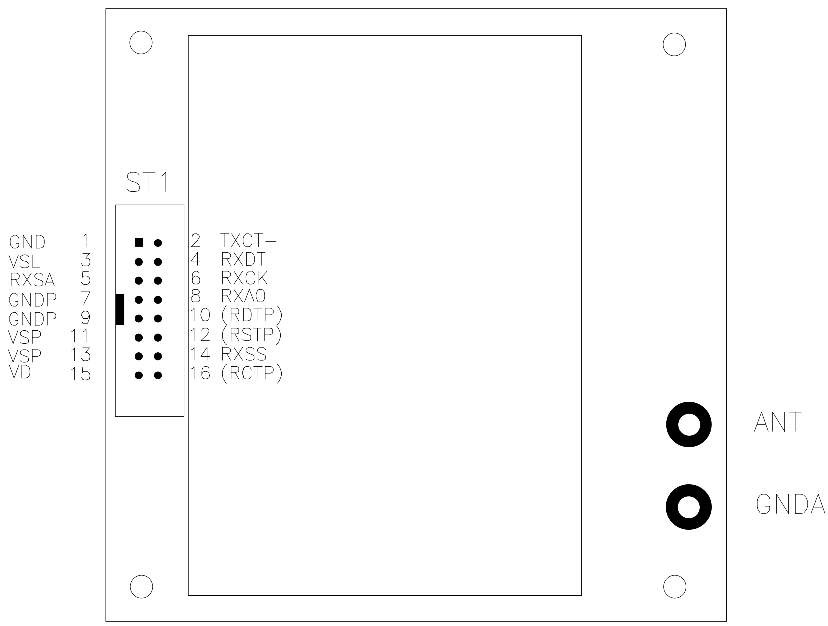
3.1 Connectors

3.1.1 Underneath Module

The bottom view of the RF module is shown in Figure 9. The connector ST1 is accessible from the underside. ST1 is the 16-pin module connector, this carries the supply voltage lines, the data, and the control lines.

Table 2 lists the pin functions for connector ST1. The connector type is AMP Latch 281273-1, 16p.

Figure 9: Bottom View



3.1.2 Top of Module

The top view of the RF module is shown in Figure 10. The connectors ST2, ST4, ST5, ST6, and the antenna terminals are accessible from the top.

Connector ST2 is the 2-pin connector for transmitter Carrier Phase Synchronization, connector ST4 is used to connect the Antenna Tuning Indicator for easy antenna resonance monitoring, and GNDA and ANT are the antenna connectors.

Table 3 lists the pin functions for connector ST2. The connector type is AMP-Quick 828548-2, 2p.

Table 4 lists the pin functions for connector ST4: The connector type is a 6-pole, 2-row pin connector with 2.54 mm pin spacing.

Table 6 lists the pin functions for the antenna connectors: Metric screws M3 must be used.

The basic configuration of the input signals TXCT- and RXA0 and output signals RXDT and RXCK is shown in Figure 8.

Figure 10: Top View with Connector Signals

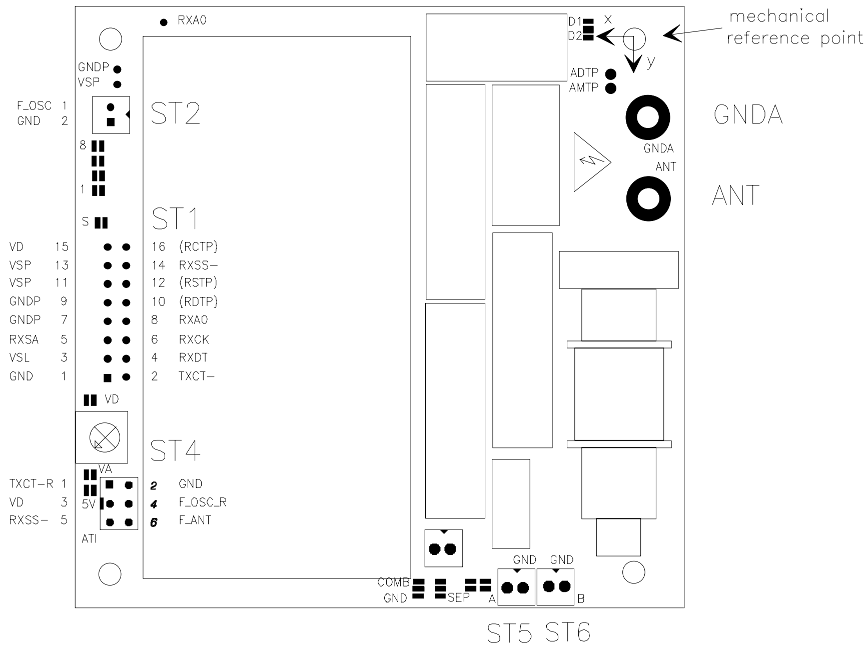


Table 2: ST1 Pin Functions

Pin#	Signal	Direction	Description
1	GND	IN	Logic ground
2	TXCT-	IN	Transmitter control input for activation of transmitter (active low, internal pull-up resistor
3	VSL	IN	Supply voltage for logic and receiver
4	RXDT	OUT	Logic level compatible receiver data signal output
5	RXSA	IN/OUT	Receiver signal strength adjust for RXSS- threshold level
6	RXCK	OUT	Logic level compatible receiver clock output
7	GNDP	IN	Transmitter power stage ground
8	RXA0	IN	Receive multiplexer channel select signal (internal pull-up resistor selects Channel A as default
9	GNDP	IN	Transmitter power stage ground
10	(RDTP)		Receiver test pin (no connection allowed)
11	VSP	IN	Supply voltage for transmitter power stage
12	(RSTP)	OUT	Receiver test pin (no connection allowed, exception see Chapter 5: “Installation”)
13	VSP	IN	Supply voltage for transmitter power stage
14	RXSS-	OUT	Receiver signal strength output (active low)

Pin#	Signal	Direction	Description
15	VD	IN/OUT	Internal regulated logic supply voltage output / externally regulated logic supply voltage input
16	(RCTP)		Receiver test pin (no connection allowed)

CAUTION:

The transmitter ground pins GNDP and logic ground pin GND must be connected together externally. Otherwise the RF module may be permanently damaged.

Table 3: ST2 Pin Functions

Pin#	Signal	Direction	Description
1	F_OSC	IN/OUT	Pulse width modulated transmitter oscillator signal: - output for oscillator MASTER RF module - input for oscillator SLAVE RF module
2	GND	IN	Logic ground

Table 4: ST4 Pin Functions

Pin#	Signal	Direction	Description
1	TXCT-R	IN	Transmitter control signal via resistor (active low)
2	GND	OUT	Logic ground
3	VD	OUT	Internal regulated logic supply voltage output
4	F_OSC-R	IN/OUT	Pulse width modulated transmitter oscillator signal via resistor
5	RXSS-	OUT	Receiver signal strength output (active low)
6	F_ANT	OUT	Antenna resonance frequency output signal (open collector)

Table 5: ST5, ST6 Pin Functions

Pin#	Signal	Direction	Description
1	RXA, RXB	IN	Receive-only antenna resonator
2	GND	IN	Ground

Table 6: Antenna Connectors

Signal	Description
ANT	Antenna resonator (capacitor side)
GNDA	Antenna resonator ground

3.2 Solder Jumpers

The different options, which can be selected by solder jumpers are described in the following sections.

CAUTION:

When closing or opening the solder jumpers, do not use solder temperatures higher than 300 degrees Celsius for longer than 2 seconds. Also, avoid changing the solder jumper settings more than 10 times as there is a risk that the copper will lift off the PCB.

3.2.1 Regulated +5 V Logic Supply

The default setting of the jumpers is for an unregulated supply voltage for the logic part to be connected to the RF module. For this configuration, the solder jumpers 'VA' and 'VD' are closed and solder jumper '5V' is open. 'VA', 'VD' and '5V' is printed on the RF module PCB close to these solder jumpers (see Figure 11). The unregulated supply voltage for the logic must be connected to pin VSL and GND (pin 3 and 1 of connector ST1).

If the logic part of the RF module is to be supplied by a regulated +5 V supply, the solder jumpers 'VA' and 'VD' have to be opened and solder jumper '5V' has to be closed (see Figure 12). The regulated +5 V supply has to be connected to pin VD and GND (pin 15 and 1 of connector ST1).

Figure 11: Jumpers VA & VD set for Unregulated Supply (Default)

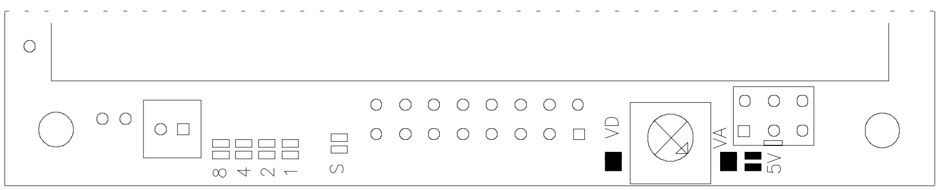
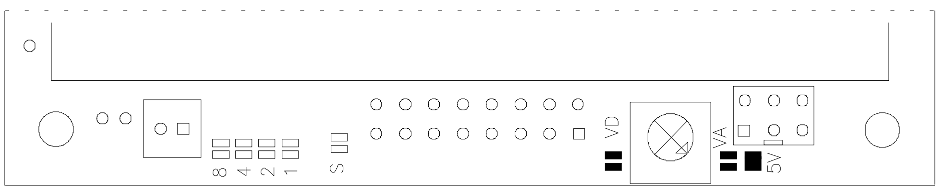


Figure 12: Jumpers VA & VD set for Regulated Supply



3.2.2 Carrier Phase Synchronization

As default setting, the solder jumper 'S' for transmitter Carrier Phase Synchronization (CPS) is closed, thus configuring the RF module as an oscillator MASTER RF module. 'S' is printed on the RF module PCB close to this solder jumper (see Figure 13). The oscillator output signal is accessible at connector ST2.

To configure as an oscillator SLAVE RF module, the solder jumper 'S' must be opened (see Figure 14). The oscillator input signal from the oscillator MASTER RF module has to be supplied to the connector ST2.

Note:

When jumper 'S' is open the RFM is configured as an oscillator SLAVE RF module, and if there is no oscillator signal input at connector ST2 the transmitter does not work.

Figure 13: Jumper S set for Oscillator MASTER RF Module (Default)

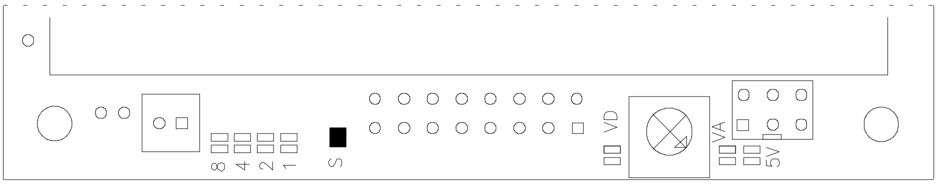
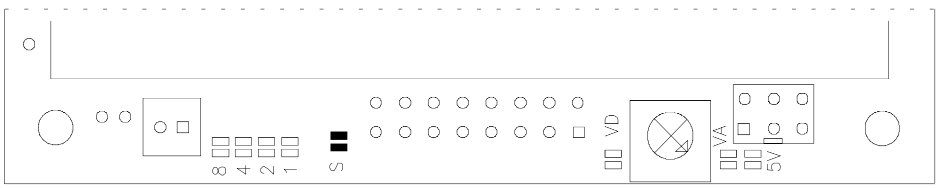


Figure 14: Jumper S set for Oscillator SLAVE RF Module



3.2.3 Pulse Width Modulation

The pulse width of the transmitter oscillator signal can be set by the four solder jumpers '8', '4', '2', '1' in 16 binary steps. '8' and '1' is printed on the RF module PCB close to the most significant (8) and least significant (1) solder jumpers. The four solder jumpers are arranged in ascending weight (see Figure 15). The oscillator pulse width determines the amplitude of the generated field strength. For more details refer to Section 5.5.1: “Adjustment of Oscillator Signal Pulse Width” and Table 12. Figure 16 shows an example of solder jumper setting for 28% pulse width selection.

As default setting, all four solder jumpers are open, selecting 50% pulse width, which gives maximum field strength.

Note:

The pulse width setting of an oscillator SLAVE RF module does not affect the generated pulse width of this module. The pulse width of this oscillator SLAVE RF module is determined by the pulse width setting of the oscillator MASTER RF module.

Figure 15: Oscillator Pulse Width Solder Jumpers (Default Configuration)

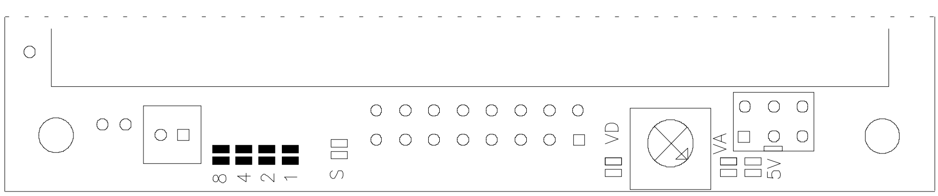
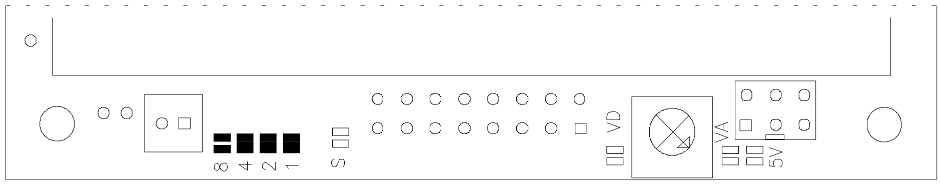


Figure 16: Example - Jumpers set for 28% Oscillator Pulse Width



3.2.4 Additional Antenna Damping

When a lower charge-up field strength is necessary for antenna RI-ANT-G01E, there is the possibility to additionally damp the transmit antennas. This enables a lower transmit field strength, while the receiver parameters remain unchanged. For this purpose solder jumper 'D1' can be closed. 'D1' (and 'D2') is printed on the RF module PCB close to these solder jumpers. For location of solder jumpers see Figure 17.

Solder jumper 'D1' is used in combination with the TI-RFid standard gate antenna RI-ANT-G01E to achieve the field strength required by, for example: German Reg TP (see Figure 18). The optional damping resistor R_D1 gives an additional damping of typically 10 dB. If required for other large antennas, solder jumper 'D2' can be used instead of ‘D1’ to provide damping of typically 13 dB.

As default, the solder bridge is open.

CAUTION:

This damping option can only be used together with the antenna RI-ANT-G01E. When using this damping option, the maximum allowed pulse-width is 40.5% (this corresponds to solder jumpers '8' and '4' open and solder jumpers '2' and '1' closed).

Figure 17: Antenna Damping Solder Jumpers (Default)

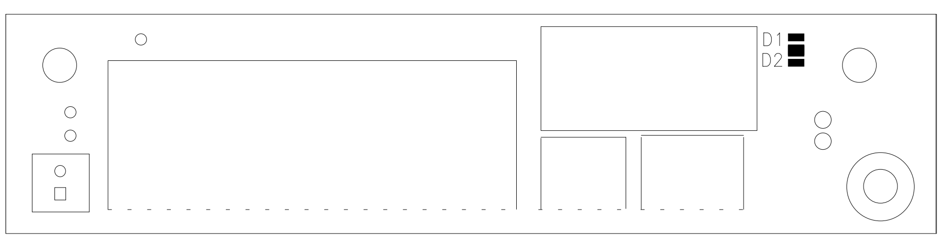
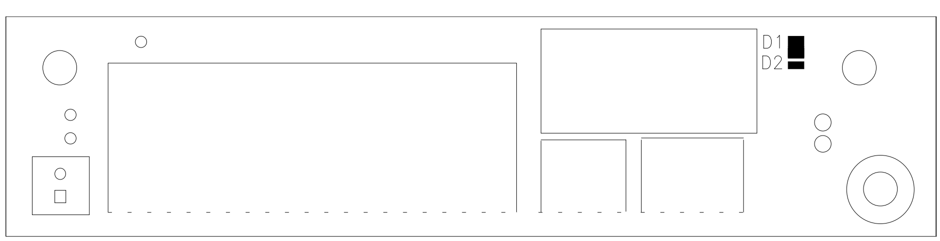


Figure 18: Example - Antenna Jumpers set for G01E (medium) Antenna

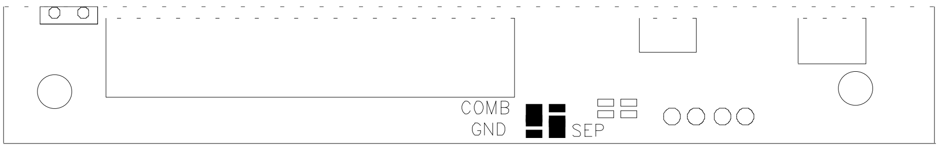


3.2.5 Selection of Combined Transmit/Receive Antenna

This RF module allows the use of combined transmit/receive antennas only.

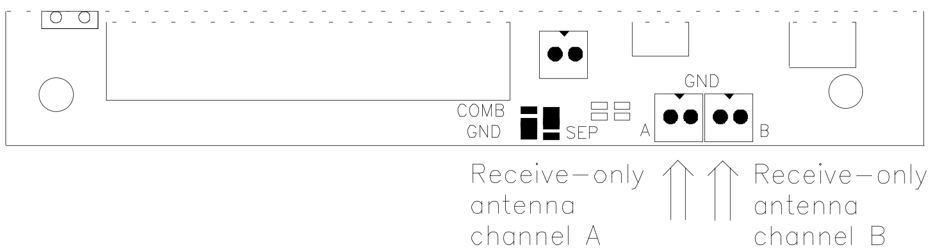
The combined transmit/receive antenna is connected to the antenna terminals ANT and GNDA. For the combined antenna the solder jumper 'COMB' must be closed and solder jumper 'SEP' must be grounded. 'COMB' and 'SEP' is printed on the RF module PCB close to these solder jumpers. For location see Figure 19.

Figure 19: Combined Antenna Jumper Settings (Default)



For separate transmit and receive antennas, the solder jumper 'SEP' must be closed and solder jumper 'COMB' must be grounded. For details and connection of the receive-only antennas also see Figure 20.

Figure 20: Separate Antenna Jumper Settings & Connecting Points



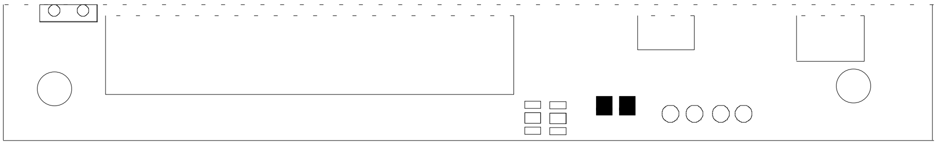
As default, combined transmit/receive antenna configuration is selected (solder jumper 'COMB' closed, solder jumper 'SEP' grounded as shown in Figure 19).

3.2.6 Selection of Receive-Only Antenna Type

If the receive multiplexer option has been selected ('SEP' closed, 'COMB' grounded) there is an additional option of selecting one of two receive-only antennas, which are used together with the receive multiplexer. The solder jumpers 'CA' and 'CB' are used for this purpose. See Figure 21 for location of solder jumpers.

When the solder jumpers 'CA' and 'CB' are open, the TI-RFid standard antenna configured as receive-only antenna must be connected to the receive multiplexer. In order to connect the TIRIS standard antennas to the receive multiplexer, the solder jumpers 'CA' and 'CB' must be closed. Please note that these standard antennas must be connected in parallel to a resistor and capacitor in order to form the correct resonator (see Figure 7).

Figure 21: Antenna Jumpers set for TIRIS Std. Antennas as Rx-Only Ant.



As default, the receive-only antenna is selected, this means that solder jumpers 'CA' and 'CB' are open.

CHAPTER 4

Specifications

This chapter provides the specific details that you will need in order to use the RFM correctly. It includes general data, electrical and timing characteristics.

Topic **Page**

4.1 Recommended Operating Conditions

The specifications given here are at a free-air temperature of 25 °C.

Symbol	Parameter	min.	max.	Unit
V_VSP	Supply voltage of transmitter power stage	5.0	14.0	V
I_VSP	Supply current of transmitter power stage		1.2	A
P_VSP	Power input to transmitter power stage (I_VSP * V_VSP)		16.8	W
V_ANT	Antenna resonance voltage		240	V_{peak}
V_ANT-ATI	Minimum antenna resonance voltage for correct operation of ATI accessory	25		V_{peak}
V_VSL	Supply voltage input for logic part	6.0	25.0	V
I_VD	External current load on internal regulated logic supply voltage output		1.0	mA

4.2 Electrical Characteristics

Symbol	Parameter	min.	typ.	max.	Unit
V_VD	Internal regulated logic supply voltage output	4.75	5.0	5.25	V
I_VSL	Supply current for logic and receiver part in - receive mode - transmit mode		 9.0 11.0		 mA mA
V_TX_off	Switch off threshold level for VSP transmitter power stage supply voltage	16.13	18.0	20.0	V
ViL	Low level input voltage of TXCT- and RXA0	0		0.8	V
ViH	High level input voltage of TXCT- and RXA0	2.4		5.0	V
VoL	Low level output voltage of RXDT and RXCK	0		0.8	V
VoH	High level output voltage of RXDT and RXCK	4.0			V
VoL_R	Low level output voltage of RXSS-			0.8	V
VoH_R	High level output voltage of RXSS- (see note below)				
Fan-In	Low Power Schottky compatible fan-in of signals TXCT- and RXA0 (Iin = -400 µA)			1	
I_IN-TXCT-	Input current for TXCT- signal, when the accessory RI-ACC-ATI1 is connected	2.0	2.5	3.0	mA
Fan-Out	Low Power Schottky compatible fan-out of signals RXDT and RXCK			1	-

Symbol	Parameter	min.	typ.	max.	Unit
FanOut_Rl	Low Power Schottky compatible fan-out of signal RXSS- (low level only)			1	-
FanOut_Rh	Low Power Schottky compatible fan-out of signal RXSS- (high level only) (see note below)				
l_ST1	Cable length for connecting ST1 of the RF module to a controller unit using flat cable		0.5	2.0	m
l_RXSA	Cable length for connecting external resistors to RXSA using twisted pair line (for details refer to Chapter 5)		0.5	5.0	m
l_CPS	Cable length for connecting the Carrier Phase Synchronization signal between two RF modules		1.0	5.0	m
n_CPS	Number of oscillator SLAVE RF modules, which can be driven from one oscillator MASTER RF module		1	5	-
R_D1	Additional antenna damping resistor R_D1 (+/-5%)	760	800	840	Ohm
R_D2	Additional antenna damping resistor R_D2 (+/-5%)	288	303	R318	Ohm
d_R_D1	Additional field strength damping, when using solder jumper D1 (R_D1) in combination with RI_ANT-G01E		10		dB
R_DAMP	Antenna damping resistor (+/-2.5%)	78	80	82	Ohm
L_TUNE	Inductance of antenna tuning coil	1.3	3.0	4.7	µH
C_ANT	Total antenna resonator capacity (+/- 2.5%)	45.8	47.0	48.2	nF
R_GND	Decoupling resistor between GND and GNDP (+/- 5%)	31.3	33	34.7	Ohm

Note:

RXSS- has an internal pull-up resistor of 10 kOhm. Therefore the parameters VoH_R, FanOut_Rh and t_ro_R depend on application specific external components.

4.3 Timing Characteristics

Symbol	Parameter	min.	typ.	max.	Unit
t_TX	Transmit burst length for correct operation (see note 1)	5	50	100	ms
f_OSZ	Internal oscillator frequency	4.2937	4.2944	4.2951	kHz
f_TX	Transmitter output frequency	134.18	134.20	134.22	kHz
f_mRX	Receiver center frequency		128.2		kHz
b_RX	-3 dB bandwidth of receiver		22.0		kHz
t_valid_b	Time of data signal RXDT valid before positive slope of RXCK signal	15	60	129	µs
t_valid_a	Time of data signal RXDT valid after positive slope of RXCK signal	15	60	120	µs
t_ri t_fi	Rise and fall time of input signal TXCT- and RXA0			1 1	µs µs
t_ro t_fo	Rise and fall time of output signals RXDT and RXCK			1 1	µs µs
t_ro_R	Rise time of output signal RXSS-	(see note 2)			
t_fo	Fall time of output signal RXSS-			1	µs
tss_01Tl	Propagation delay time from positive slope of TXCT- to positive slope of RXSS- signal (maximum sensitivity)	500	1000	1500	µs
tss_10Tr	Propagation delay time from negative slope of TXCT- to negative slope of RXSS- signal (minimum sensitivity)	50	100	200	µs
t_short	Maximum time of short circuit between antenna terminals GNDA and ANT			10	s

Note 1:

Because of the transponder parameters, it is necessary to have a minimum charge-up time of 15 ms.

Note 2:

RXSS- has an internal pull-up resistor of 10 kOhm. Therefore the parameters VoH_R, FanOut_Rh and t_ro_R depend on application specific external components.

CAUTION:

The parameter t_short refers to static short circuit of the antenna terminals. Shorting the antenna terminals during operation may cause permanent damage to the RF Module.

CHAPTER 5

Installation

This chapter provides the specific details that you will need in order to install the RFM correctly. It includes a detailed description of the power supply requirements, the antenna characteristics, how to tune the antenna to resonance, how to expand the antenna inductance tuning range and how to adjust the antenna charge-up field strength and the threshold level for wireless synchronization.

In addition it describes the features and usage of the options of this RF module: transmitter carrier phase synchronization and receive multiplexer.

Topic **Page**

5.1 Power Supply

5.1.1 Supply Requirements

The logic and receiver part of the RF module have to be supplied via the VSL and GND pins with unregulated voltage (voltage regulators for the logic and receiver part are built in).

As an option, the logic and receiver part can also be connected to an external regulated +5 V supply. For this purpose the solder bridge setting has to be changed (for details refer to Section 3.2). Then the regulated +5 V supply must be connected to pin VD.

The transmitter power stage is supplied via different supply lines VSP and GNDP. As there is no stabilization on the RF module and as the transmitter power stage needs a regulated supply voltage in order to meet FCC/R&TTE regulations, the supply voltage for the transmitter power stage must be regulated externally in the range from +5 V to +14 V.

Note:

The RF module must not be supplied by Switched Mode Power Supplies (SMPS). This is because most SMPS operate at frequencies around 50 kHz. The harmonics of the generated field can interfere with the TI-RFid receiver. Therefore only use linear power supplies, or SMPS with a fundamental operating frequency of 200 kHz or higher.

Noise from power supplies or noise on the interface lines can interfere with the receiver. Therefore it is recommended to add additional filters in series to the supply and interface lines if the application requires this. For more details refer to Section 5.9: "Noise Verification" and Section 5.10: "Over Voltage Protection".

In order to guarantee full RF module performance, the power supplies should fulfill the specifications for ripple voltage given in Table 7.

Table 7: Power Supply Ripple Specifications

Supply type	Maximum allowed Ripple Voltage	Allowed Ripple Frequency
Unregulated VSL supply	30 mV_{rms}	0 to 100 kHz maximum (sinusoidal)
Regulated +5V VSL supply	300 μV_{rms}	0 to 100 kHz maximum (sinusoidal)
Regulated VSP supply	50 mV_{rms}	0 to 50 kHz maximum (sinusoidal)

Table 8 lists the typical current consumption of the transmitter power stage for the TI-RFid standard antennas, when the RF module transmitter power stage is supplied with VSP = 14 V.

Table 8: Current Consumption for TI-RFid Standard Antennas

Antenna type	Typical Transmitter Supply Current (for VSP = 14V and 50%)
RI-ANT-S01/2	1.2 Amperes DC
RI-ANT-G01	1.0 Amperes DC
RI-ANT-G02	1.2 Amperes DC
RI-ANT-G04	0.9 Amperes DC

5.1.2 Connection of the Supplies

The ground pins for the logic/receiver part and the transmitter power stage are not directly connected internally. The two different grounds must be connected to each other externally. Internally they are just connected via the resistor R_GND, in order to avoid floating grounds in case accidentally the grounds were not connected to each other externally.

The grounds must be connected together externally for two reasons:

1. Possibly high resistive GNDP pins would cause a voltage drop across these connector pins, because of the high transmitter power stage current (this does not apply to the supply pins of the Logic part). If the grounds were connected to each other internally, this would also lift the internal logic ground and cause logic level compatibility problems with the controller unit (also see Figure 22). This is avoided, by connecting the grounds GND and GNDP externally.
2. In order to provide higher flexibility with long supply lines. Long VSP supply lines between the RF module and the controller unit cause a voltage drop across this supply line (again because of the high transmitter power stage supply current). This voltage drop would also lift the logic ground and cause logic level compatibility problems with the controller unit. This can again be avoided by connecting the grounds externally in any of three different ways (see Figure 22):
   a. For cable lengths of up to 0.5 m between the RF module and controller unit, the RFM ground pins GND and GNDP must be connected at the controller unit, as shown in Figure 22. Here the grounds for the VSP, VSL and the controller unit supply are all connected together at the common ground.

      If the voltage drop across the VSP supply line is less than 0.5 V (very likely in this case), the ground pins GND and GNDP can alternatively be connected together at the RF module.

      If your system has a TI-RFid control module, the RF module ground pins GND and GNDP are already connected together in the correct way on that control module.

   b. For cable length between 0.5 m and 2 m, the RFM ground pins GND and GNDP must be connected together at the controller unit in order to avoid logic level compatibility problems caused by the voltage drop across the VSP supply lines (also see Figure 22).

      In this case, connecting the ground pins at the RF module is not allowed, because this would lift the logic ground level.

c. Cable lengths longer than 2 m are not recommended. If, for your application you HAVE to use a cable longer than 2 m, the logic signal connections between the RF module and the controller unit must be done via a differential interface (for example: RS422). Because of different ground potentials at different locations it may also be necessary in this case to provide galvanic separation of the interface signals by, for example: optocouplers.

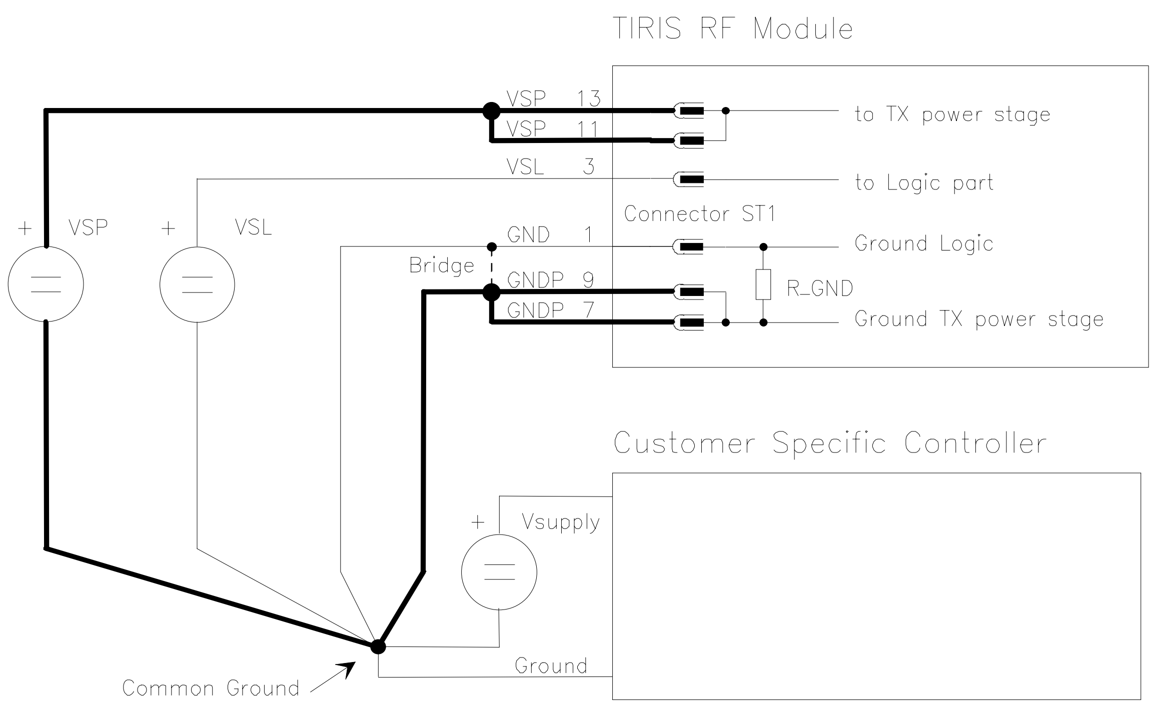
In this case, to avoid problems with difference voltages between GND and GNDP, these pins must always be connected directly at the RF module. A shorting bridge is necessary as close as possible to the RF module for this purpose, as shown in Figure 22.

CAUTIONS:

In all cases, the voltage between GND and GNDP must not exceed ±0.5 V. Otherwise the RF module will be damaged.

The oscillator has a protection feature for the transmitter power stage against current overload of the transmitter power stage. When the transmitter power stage supply voltage VSP exceeds accidentally the 'Absolute Maximum Ratings' (see Chapter 4:: “Specifications”), the oscillator is disabled and thus the transmitter is switched off.

Figure 22: External Ground Connection (GND to GNDP)



5.2 Antenna Requirements

The transmit antenna for the RF module (which is used to charge up the transponder) is a coil (see Figure 6), this coil is part of the antenna resonant circuit (see Figure 3).

In order to achieve the high voltages at the antenna resonant circuit and thus high field strength at the antenna for charge-up (transmit) function, the antenna coil must have a high quality factor. The recommended quality factor for proper operation is listed in Table 9. The quality factor of the antenna may vary, depending on the type, the construction and the size of the antenna. Furthermore, the quality factor depends on the wire type and wire cross-section area used for winding the antenna.

The best wire for winding an antenna is RF litze-wire. This is a wire with a number of small single insulated wires. RF litze-wire gives the highest quality factor and thus the highest charge-up field strength. Therefore we recommend the use of RF litze-wire with maximum single wire diameter of 0.1 mm (4 mil) for winding an antenna. In addition we recommend to use RF litze-wire with at least 120 single insulated wires.

For proper operation of the transmitter and receive function, the antenna has to be tuned to the resonance frequency f_TX. For a detailed description of the antenna resonance tuning procedure, see Section 5.3: “Antenna resonance tuning”.

To ensure that the antenna can be tuned to resonance with the tuning coil on the RF module, the antenna inductance can only vary within the limits given in Table 9.

Table 9: Antenna Characteristics

Parameter	Conditions	min.	typ.	max.	Unit
L_ANT	Antenna inductance range, within which the antenna can be tuned to resonance using the tuning coil on the RF module	26.0	27.0	27.9	µH
Q_ANT	Recommended quality factor of antenna coil for proper operation	100		450	

Basically there are two different kinds of antenna: Gate antennas and Ferrite core (or “stick”) antennas. Gate antennas have no material inside the coil loop, whereas Ferrite core antennas use ferrite material inside the coil loop to increase the quality factor.

However, it must be considered that although a ferrite core antenna may have a very high quality factor under test conditions with low magnetic field strength, this quality factor drops, when a high magnetic field strength is applied to the ferrite core.

Hint:

For more details and characteristics refer to the 'Antenna Reference Guide' (Manual number: 22-21-007).

5.3 Antenna Resonance Tuning

In order to achieve the high charge-up field strength, the antenna resonator frequency must be tuned to the transmitter frequency f_TX (tuning to resonance). This is done by changing the inductance of the antenna resonator coil. To do this, there is a tuning coil on the RF module (also see Figure 1). This tuning coil is in series to the antenna coil. Thus by screwing the ferrite core of the tuning coil in or out, the inductance of the antenna resonator is increased or decreased.

Note:

Adjusting the ferrite core of the tuning coil must be done with a plastic screwdriver, as a metal screwdriver would affect the inductance of the coil which would lead to incorrect tuning. Therefore use only the plastic screwdriver which is delivered with the RF module.

For applications, where the RF module is exposed to vibration, the ferrite core of the tuning coil must be fixed with silicon rubber when tuned!

When you tune the antenna, the resonance condition must be monitored. This can be done using either method A or method B as described following:

Method A: Monitoring Generated Field Strength

Monitor the field strength generated by the RF module and the antenna. Measure the induced RF voltage of a pick-up coil placed at a fixed distance to the antenna. The antenna is tuned to resonance when the voltage at the pick-up coil has reached its maximum value.

For this method, the RF module must be switched into repetitive transmit mode, by operating it from a controller unit. Therefore this method can only be used together with a controller unit.

To measure the output you can use any of these two methods:

- An additional pick-up coil and an oscilloscope
- An additional pick-up coil and a standard voltmeter.

For connection of the RF module and the location of the sensor unit see Figure 23. For sensor unit alternatives see Figure 24.

Figure 23: Monitoring the Generated Field Strength

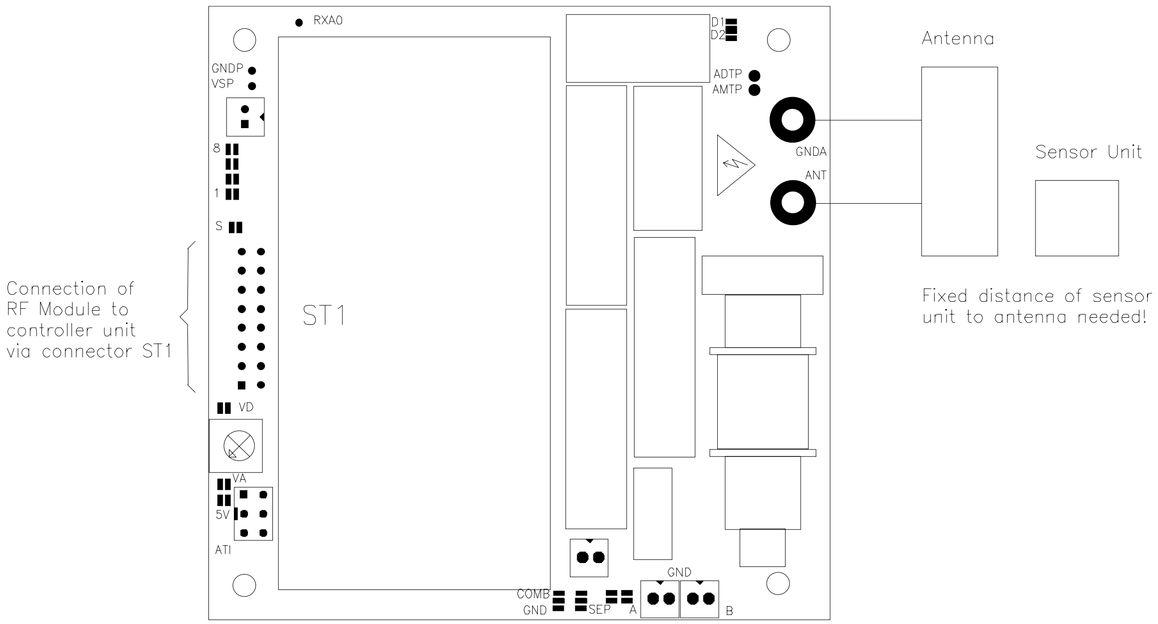
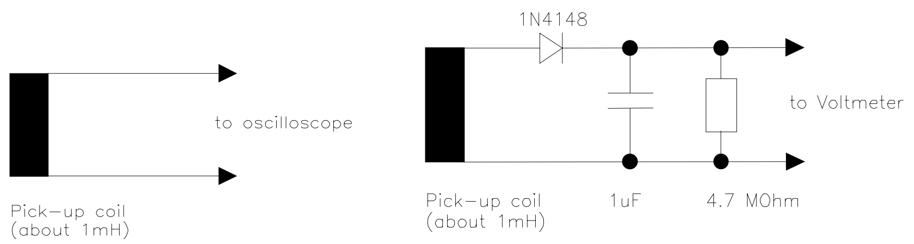


Figure 24: Antenna Tuning Pick-up Coils



Hint:

As the RF module just has to be tuned to the maximum voltage at the pick-up coil, all types of coil can be used as pick-up tool. The inductance of the pick-up coil is of little importance. However, if a pick-up coil with high inductance (a high number of windings and large size) is used, higher voltage is induced at the pick-up coil. Which means that the pick-up coil can be placed further away from the antenna.

Method B) Antenna Tuning Indicator Tool

Monitoring of the correct antenna resonance tuning can be dramatically simplified by using the 'Antenna Tuning Indicator' (ATI) tool RI-ACC-ATI1-00.

This tool offers the feature of operating the transmitter in pulsed mode, independently to the controller unit. Additionally it indicates by LEDs, in which direction the ferrite core must be turned and when the antenna is tuned to resonance. Furthermore, this tool is supplied via the RF module, by just plugging it onto the RF module during the tuning procedure.

Notes:

If an antenna has to be installed in an environment where metal is present, the tuning of the antenna must be done in this environment. This is because metal changes the inductance of the antenna. In addition, the quality factor of the antenna decreases, so that the field strength decreases. The extent of the inductance and quality factor reduction depends on the kind of metal, the distance of the antenna to the metal and the size of the metal.

When the oscillator signal pulse width, or the supply voltage VSP of a RF module with an already tuned ferrite core antenna (for example: RI-ANT-S02C) is changed more than 50%, the ferrite core antenna has to be retuned to the new conditions. This is necessary, because the inductance of a ferrite core antenna changes slightly at different field strengths.

Each antenna is tuned individually to the RF module and this results in the special tuning coil setting for this combination of antenna and RF module only. If a different antenna is connected to the RF module, the new combination has to be tuned to resonance again!

The tuning procedure flow is as follows:

* Switch RF module power supply off
* Connect the antenna to the RF module by means of the two M3 screw connectors
* Install antenna tuning monitoring unit:

  Connect antenna tuning indicator unit to the RF module

  or

  Put field strength sensor unit at fixed distance to antenna and switch RF module into repetitive transmit mode
* Switch RF module power supply on
* Tune antenna to resonance by screwing the ferrite core of the tuning coil in or out until a maximum is achieved
* Switch RF module power supply off
* Disconnect monitoring unit
* Switch RF module power supply on again

==> Antenna resonance tuning is complete!

5.4 Expanding Antenna Tuning Inductance Range

It is possible to expand the tuning range of the antenna inductance. This may be necessary:

- when TI-RFid standard antennas are used close to metal
- when antenna extension cables are used
- when customer specific antennas which might not be within the necessary antenna tuning inductance range are used.

Expanding the antenna tuning inductance range to lower or higher values can be done by connecting additional capacitors in parallel and in series to the antenna resonator. In addition the damping function has to be modified by connecting additional resistors to the antenna damping circuit.

The capacitors and resistors have to be connected in parallel and in series in order to withstand the high voltages and high currents occurring at the antenna resonant circuit.

WARNING:

THERE IS HIGH VOLTAGE AT ALL ANTENNA RESONATOR COMPONENTS, WHICH COULD BE HARMFUL TO YOUR HEALTH! THEREFORE AT ANY TIME THAT YOU ARE WORKING ON THE RF MODULE, SWITCH IT OFF. THE EXTERNAL COMPONENTS MUST BE MOUNTED IN A WAY THAT THEY CANNOT BE TOUCHED BY ACCIDENT.

To ensure that the RF module functions properly when the antenna tuning inductance range is expanded, special capacitors and resistors, as listed below, must be used:

Capacitor type:- Polypropylene film capacitor
- Minimum 1250 V DC operating voltage
- Capacitance tolerance: max. ±5%
- Type: SIEMENS “KP”
  or WIMA “FKP1”

Resistor type: - Metal film resistor
- Minimum 200 V DC operating voltage
- Minimum load rating: 0.25 Watts
- Resistance tolerance: max. ±2%
- Temperature coefficient: max. ±50ppm
- Type: e.g. Minimelf resistors

The antenna tuning inductance range can be decreased to 13.7 µH in six ranges, as shown in Figure 25 and Table 10.

Figure 25: Circuit to Expand Ant. Tuning Range to Lower Values

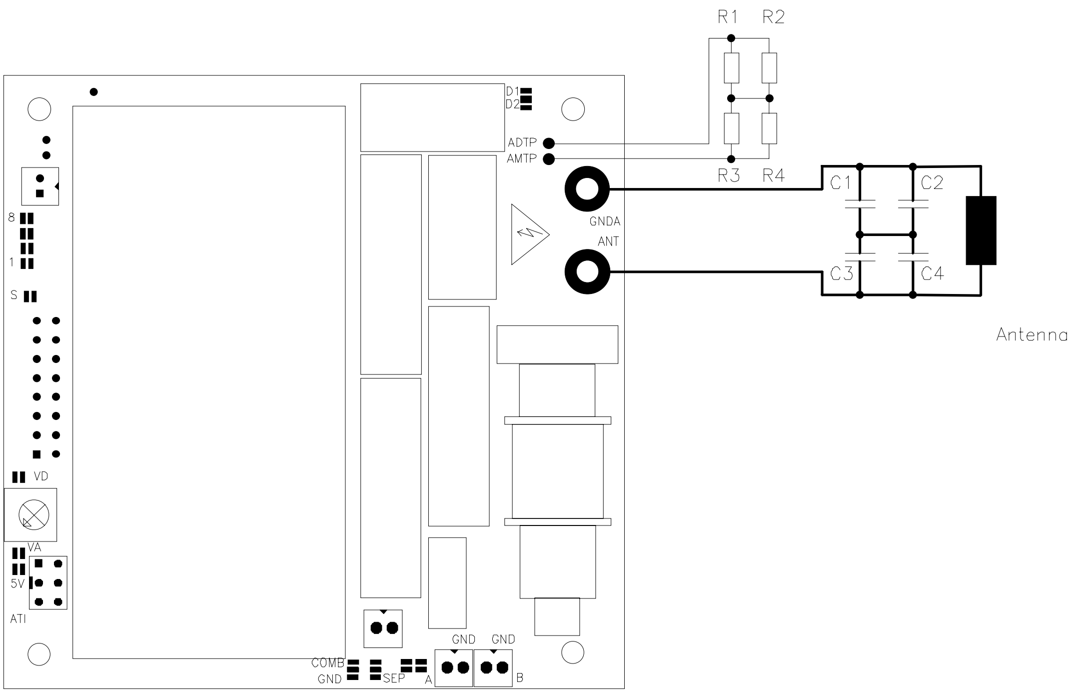


Table 10: Expanding Antenna Tuning Inductance Range to Lower Values

Antenna inductance range	Capacitor value	Resistor value
24.1 µH to 25.9 µH	C1, C2, C3, C4 = 3.3 nF	R1, R2, R3, R4 = 1200 Ohm
22.3 µH to 24.0 µH	C1, C2, C3, C4 = 6.8 nF	R1, R2, R3, R4 = 560 Ohm
20.4 µH to 22.2 µH	C1, C2, C3, C4 = 11 nF (10 nF and 1 nF in parallel)	R1, R2, R3, R4 = 330 Ohm
18.4 µH to 20.3 µH	C1, C2, C3, C4 = 16 nF	R1, R2, R3, R4 = 220 Ohm
16.5 µH to 18.3 µH	C1, C2, C3, C4 = 22 nF	R1, R2, R3, R4 = 180 Ohm
13.7 µH to 16.4 µH	C1, C2, C3, C4 = 32 nF	R1, R2, R3, R4 = 120 Ohm

The antenna tuning inductance range can be increased to 37.6 µH in 7 ranges, as shown in Figure 26 and Table 11.

As shown in Figure 26, three capacitors (C1, C2, C3) are connected in series to the antenna coil. The specification for these capacitors is listed below:

Capacitor type: - Polypropylene film capacitor
- Minimum 1250V DC operating voltage
- Capacitance: 47 nF ±2.5%
- Type: SIEMENS “KP” or WIMA “FKP1”

In addition to C1, C2 and C3, the capacitor C4 must be connected in parallel to the RF module antenna terminals. Different capacitor values have to be used for each range, these values are given in Table 11. Also, the damping function has to be modified by connecting additional resistors to the antenna damping circuit.

Hint:

The adaptation of the antenna inductance can be simplified by using the TI-RFid Accessory Module RI-MOD-LEX1.

Figure 26: Circuit to Expand Ant. Tuning Range to Higher Values

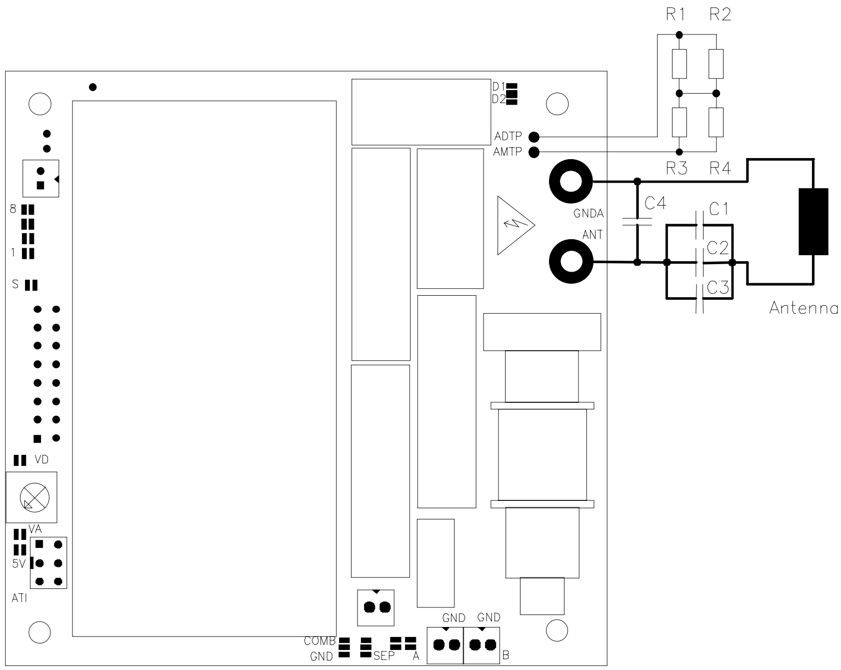


Table 11: Expanding Antenna Tuning Inductance Range to Higher Values

C1, C2 & C3 = 47 nF

Antenna Inductance Range	Capacitor value	Resistor value
28.0 µH to 29.3 µH	C4 = 18.3 nF (parallel 6.8 nF, 6.8 nF, 4.7 nF)	R1, R2, R3, R4 = 120 Ohm
29.4 µH to 31.0 µH	C4 = 13.6 nF (parallel 6.8 nF, 6.8 nF)	R1, R2, R3, R4 = 120 Ohm
31.1 µH to 32.4 µH	C4 = 10 nF	R1, R2, R3, R4 = 120 Ohm
32.5 µH to 33.8 µH	C4 = 6.8 n	R1, R2, R3, R4 = 180 Ohm
33.9 µH to 35.0 µH	C4 = 3.98 nF (parallel 3.3 nF, 0.68 nF)	R2, R3, R4 = 180 Ohm
35.1 µH to 36.2 µH	C4 = 2.2 nF	R1, R2, R3, R4 = 220 Ohm
36.3 µH to 37.6 µH	C4 not needed	R1, R2, R3, R4 = 220 Ohm
Two serial connected TI-RFid standard antennas	C4 = 3.3 nF C2 and C3 not needed	R1, R2, R3, R4 = 120 Ohm

Notes:

It is not recommended to use antennas with quality factors lower than 50. If you have to use such an antenna, no additional damping resistors are necessary.

We recommend that you do not use antennas with inductances lower than 13.7 µH or more than 37.8 µH (except when connecting two antennas in series), because the additional capacitor values become very large.

Antennas with fewer turns (==> smaller inductance) generate less charge-up field strength at same operating conditions and in addition also have less receive sensitivity.

Using capacitors parallel to the antenna resonator changes the coupling of the RF module's TX Power Stage and this reduces the generated field strength.

In order to avoid adaptation problems, we strongly recommend that you only use standard TI-RFid antennas

5.5 Field Strength Adjustment

The generated magnetic field strength determines the charge-up distance of the transponder. The higher the magnetic field strength, the longer the transponder charge-up distance. However, the charge-up distance does not increase linearly with the field strength.

The reading distance of a transponder is determined, amongst other factors, by the charge-up distance and the local noise level. So increasing the charge-up field strength does not necessarily increase the reading distance.

The field strength generated by the RF module depends on the four factors listed below:

1. Quality factor of the antenna.
   The quality factor is a measure of the efficiency of the antenna and therefore the higher the quality factor of the antenna coil, the higher the field strength which is generated by the RF module (assuming that all other parameters remain unchanged).
   The quality factor of the antenna itself depends on the cross-sectional area of the wire, the wire type, the size of the antenna and the type of antenna (Gate or Ferrite antenna). The bigger the cross-section area of the RF litze-wire, the bigger the quality factor of the antenna. RF litze-wire gives a higher quality factor than solid wire (assuming that all other parameters remain unchanged).
2. Size of the antenna.
   The larger the antenna, the higher the field strength which is generated by the RF module, because the antenna covers a bigger area and thus generates a higher flux (assuming that all other parameters remain unchanged).

Hint:

Large antennas have less immunity to noise for receive function than small antennas.

3. Supply voltage of the RF module power stage.

   The higher the supply voltage of the RF module transmitter power stage (VSP voltage), the higher the field strength which is generated by the RF module (assuming that all other parameters remain unchanged).

   However, the generated field strength does not increase linearly with VSP supply voltage. In addition, ferrite core antennas show saturation effects (here saturation means that the ferrite core cannot generate more magnetic field strength, even with a higher input current).

4. The oscillator signal pulse width.

   The bigger the selected transmitter oscillator signal pulse width, the higher the magnetic field strength which is generated by the RF module, because more power is 'fed' into the antenna resonator by the transmitter power stage (assuming that all other parameters remain unchanged).

   For an example of two different oscillator pulse width settings, see Figure 4.

The generated field strength can be measured in several ways. You can measure it using a calibrated field strength meter, or by measuring the antenna resonance voltage using an oscilloscope and then calculating the field strength. For details see 'Antenna Reference Guide' (Manual number 22-21-007).

In summary: the generated field strength of an antenna can be adjusted with the supply voltage VSP of the RF module transmitter power stage and by selecting the corresponding oscillator signal pulse width. Figures 30 to 33 show typical field strength values for all TI-RFid standard antennas for different oscillator signal pulse widths and different transmitter power stage supply voltages.

In cases, when low field strengths should be generated with a large antenna (RI-ANT-G01E, the antenna resonator can additionally be damped by connecting damping resistor R_D1 to the antenna resonator. This can be done by closing the solder bridge D1 (also see Figure 1). Using this optional damping function gives the advantage that the field strength can again be fine tuned (for example: to meet the German Reg TP regulations) with selection of the oscillator signal pulse width in a wide range (to both larger and smaller values).

CAUTION:

This damping option can only be used together with the antenna RI-ANT-G01E. When using this damping option, the maximum allowed pulse-width is 40.5% (this corresponds to solder jumpers '8' and '4' open and solder jumpers '2' and '1' closed).

Figure 27: Field Strength Compared to Pulse Width - 1 (for Antenna RI-ANT-S02C (Typical Values))

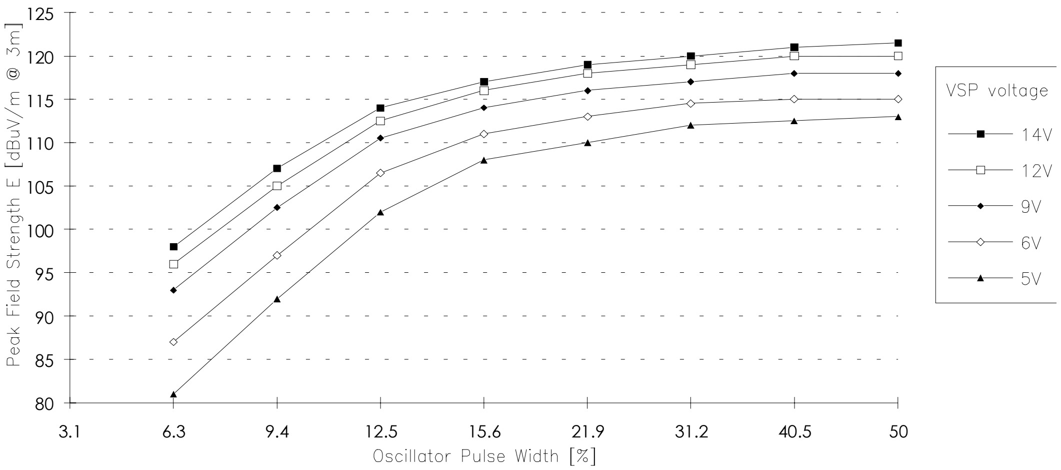


Figure 28: Field Strength Compared to Pulse Width - 2 (for Antenna RI-ANT-G01E (Typical Values))

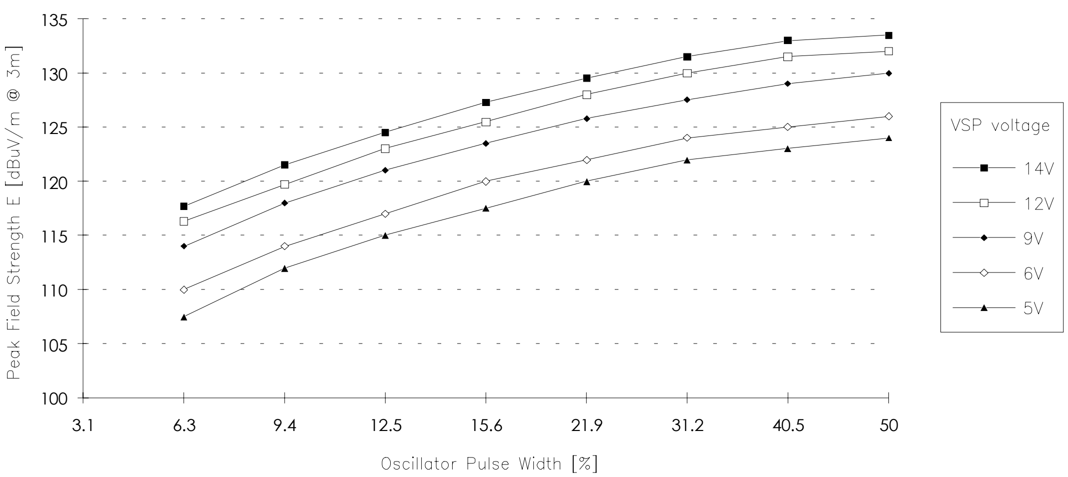
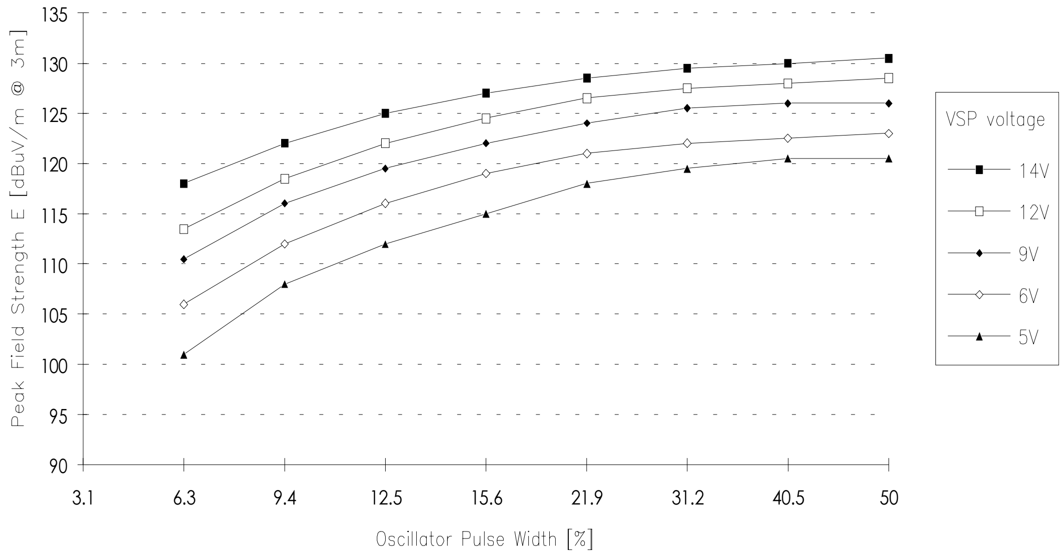


Figure 29: Field Strength Compared to Pulse Width - 3 for Antenna RI-ANT-G02C (Typical Values)



5.5.1 Adjustment of Oscillator Signal Pulse Width

The RF module has a built-in feature to set the pulse width of the transmitter signal coming from the oscillator. This enables the generated field strength to be reduced from 100% down to about 10%.

To do this there are 4 solder jumpers on the upper side of the RF module PCB (close to the connector ST1). These 4 solder jumpers are binary weighted which means that the pulse width can be set to 16 different values. The solder jumper with the least significant value (1 = LSB) is located next to the connector ST1. The other solder jumpers are in ascending order. Thus the solder jumper with the most significant value (8 = MSB) is the most distant one from the connector ST1.

As default setting, these solder jumpers are all open and thus generate a pulse width of 50%. A pulse width of 50% corresponds to maximum possible field strength. By closing the solder jumpers with solder, the field strength is decreased. The relationship between the jumper settings and the pulse width is shown in Table 12.

Table 12: Selected Oscillator Signal Pulse Width / Solder Jumper Setting

Solder jumpers setting				**Oscillator signal pulse width [%]**
MSB ‘8’			**LSB ‘1’**	
-	-	-	-	50
-	-	-	X	46.9
-	-	X	-	43.7
-	-	X	X	40.6
-	X	-	-	37.5
-	X	-	X	34.4
-	X	X	-	31.2
-	X	X	X	28.1
X	-	-	-	25
X	-	-	X	21.9
X	-	X	-	18.8
X	-	X	X	15.6
X	X	-	-	2.5
X	X	-	X	9.4
X	X	X	-	6.3
X	X	X	X	3.1

- means: solder jumper open

X means: solder jumper closed

Note:

The pulse width for the oscillator signal pulse width setting of 3.1% is very short (only 230 ns). The pulse response of the RF module transmitter power stage to this short pulse is different for each RF module. Therefore in order to have reproducible field strength values for different RF modules, it is recommended to not use the pulse width setting of 3.1%.

In the following paragraphs you will find a flow description for adjusting the field strength according to FCC/R&TTE values in combination with TI-RFid standard antennas. This method can only roughly determine the generated field strength, therefore the actual generated field strength should be verified with a calibrated field strength meter, especially for customized antennas. For more details see 'Antenna Reference Guide' (Manual number 22-21-007).

* Find out corresponding field strength regulation for the country.
* Select antenna type (determined by the application, also see 'Antenna Reference Guide' Manual number 22-21-007).
* Select transmitter power stage supply voltage.
* Find out the oscillator signal pulse width needed for this antenna type, this transmitter power stage supply voltage and the corresponding FCC/R&TTE value in Figure 27 to Figure 29. Select corresponding pulse width on the RF module.
* If necessary, use optional antenna damping function, when low field strength (for example: to meet the German Reg TP requirements) is needed for big antennas.

Note:

For proper adjustment of the field strength according to FCC/R&TTE values, especially for customized antennas, a calibrated field strength meter must be used. Field strength measurements have to be taken on a free field test site according to VDE 0871 or equivalent regulation.

5.6 RXSS- Threshold Level Adjustment

The RF module has a built-in receive signal field strength detector with the output signal RXSS- and an on-board potentiometer to adjust the threshold level of field strength detection. The digital output RXSS- is used for wireless synchronization of two or more reading units. This is necessary to ensure that if you have more than one reading unit in an area that they do not interfere with each other. The controller unit software watches the RXSS- signal to detect whether other reading units are transmitting. This means that the controller unit can operate the transmitter of the RF module so that the reading units either transmit simultaneously or alternately. In this way the read cycles of each of the reading units occur at the same time or at secure different times.

Depending on the antenna type used and the local noise level, the RXSS- threshold level has to be adjusted with the potentiometer on the RF module. This must be done, after the antenna has been tuned to resonance.

We recommend that you use the small screwdriver delivered together with the RF module to adjust the RXSS- threshold level. The RXSS- threshold level adjustment potentiometer is located on the upper side of the RF module PCB near connector ST1 (see Figure 1).

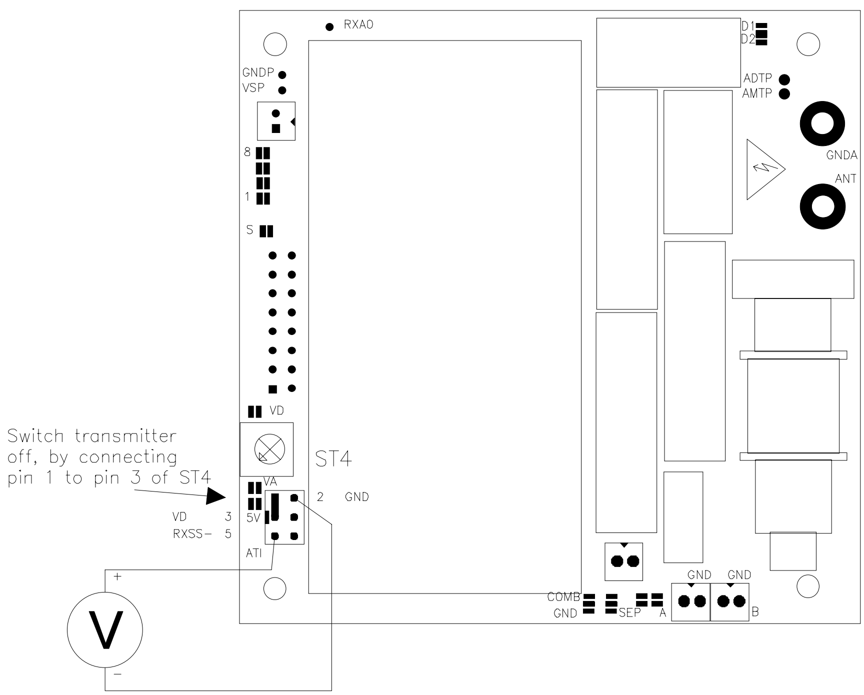
Turning the potentiometer all the way counter-clockwise (left-hand stop), results in maximum threshold sensitivity, this means that the RXSS- signal will be activated at low receive field strength. This is the default position and can be used for standard ferrite core antennas. The sensitivity must be reduced when you are using air coil antennas. If there is high noise level in the area, it may also be necessary to adjust the RXSS- threshold level even for ferrite core antennas.

Adjust the RXSS- threshold level as follows:

* Turn the RXSS- threshold level potentiometer fully counter-clockwise (left-hand stop).
* Deactivate the transmitter by connecting pin 1 to pin 3 of connector ST4, as shown in Figure 30.
* Ensure that no other reading units are transmitting, by connecting pin 1 to pin 3 of connector ST4 of all other RF modules in the area, as shown in Figure 30.
* Eliminate noise sources as much as possible.
* Monitor the voltage at RXSS- output pin with a voltmeter or an oscilloscope as shown in Figure 30.
* Turn the RXSS- threshold level adjustment potentiometer on the RF module clockwise, until the RXSS- output is just statically inactive.

  "Statically" means without voltage spikes on the RXSS- signal. 'Inactive' means, that the receive signal strength is below the RXSS- threshold level and not triggering RXSS- (the RXSS- output voltage remains > 4 V).

Figure 30: Monitor Connect & Tx. Disabling for RXSS Adjustment



Notes:

Reducing the RXSS- threshold level sensitivity (turning the potentiometer clockwise), reduces the sensitivity of the built-in receive signal strength detector. This has the effect that the distance for wireless detection of other transmitting reading units is decreased. This leads to reduction of wireless synchronization distance. The wireless synchronization distance between two reading units is normally about 15 meters for two aligned stick antennas (RI-ANT-S01) with maximum receive field strength detection sensitivity.

When the RXSS- threshold level is adjusted such that it is too sensitive, then the RXSS- output is constantly active (==> low RXSS- output level). Therefore a controller unit would all the time assume that another reading unit is transmitting and would all the time try to synchronize to this other reading unit. Therefore the reading repetition rate would decrease (from approximately 10 to approximately 5 readings per second for TI-RFid control modules). In addition, this reading unit can no longer synchronize to other reading units. Therefore this reading unit interferes with other reading units and reading at all reading units becomes impossible.

The RXSS- threshold level must be adjusted individually for every RF module and antenna (reading system). In addition, the RXSS- threshold level must be individually adjusted to the local noise level in the application area where the antenna is used. As high noise levels mean that the RXSS- threshold level must be adjusted to a less sensitive value, it is recommended to reduce the local noise level, in order to have high synchronization sensitivity (and of course to have a long reading distance).

The RXSS- threshold level must be adjusted in such a way that no spikes occur on the RXSS- signal output, because this leads to incorrect synchronization function. Therefore an oscilloscope should be preferred for adjusting the threshold level.

Hint:

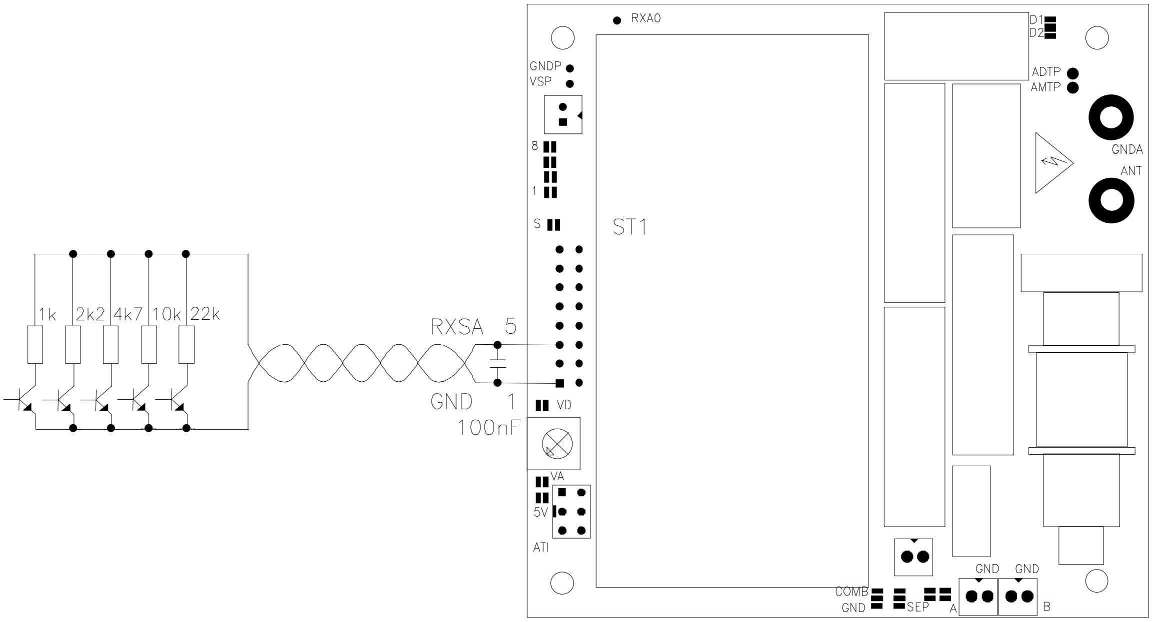
We strongly recommend that you use the 'Antenna Tuning Indicator' (ATI) accessory for adjusting the RXSS- threshold level. This is because the ATI automatically switches the transmitter off and has an internal spike extension circuit, so that the RXSS- threshold level is adjusted in such a way that no spikes occur on the RXSS- output.

There is an additional possibility to adjust the RXSS- threshold level, when the internal potentiometer (10 kOhm) is turned fully clockwise. In this position, the threshold level can be decreased by connecting external resistors from the pin RXSA to ground GND. When a larger distance (more than 0.5 meter) between the external resistors and the RF module is necessary, it is recommended to use twisted pair lines and to connect a ceramic capacitor of 100 nF as close as possible to the pins RXSA and GND of the RF module (also see Figure 31).

Note:

Maximum cable length between external resistors and RXSA pin of RF module depends on the cable used and the electromagnetic noise level in the area. Therefore it is recommended to use only twisted pair lines, or even better, coaxial cable and not to exceed the cable length which is specified in Chapter 4: "Specifications".

Figure 31: Adjusting RXSS with External Resistors



5.7 Transmitter Carrier Phase Synchronization (CPS)

In some applications it is necessary to use several charge-up antennas close to each other. In this circumstance, the magnetic charge-up fields generated by different antennas superimpose on each other and may cause a beat effect on the magnetic charge-up field, due to the slightly different transmit frequencies of different RF modules.

The impact of this effect depends on three factors:

1. The size of the antenna:
   The larger the size of the antennas, the further the distance between the antennas must be, so that this effect does not occur.
2. The magnetic field strength:
   The stronger the generated magnetic field strength, the further the distance between the antennas must be, so that this effect does not occur.
3. The orientation and distance between antennas:
   Increasing the distance between antennas, decreases the impact of this effect.

Note:

Remember that putting two antennas close together also changes antenna inductance, so that the antennas may no longer be tunable to resonance.

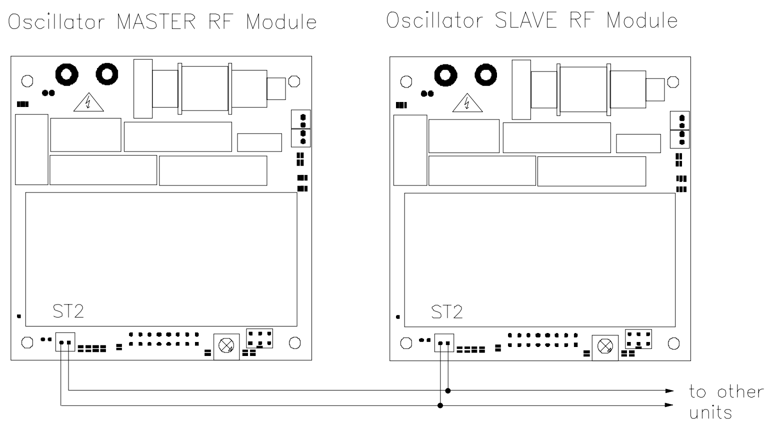
This effect will not occur when the transmitters of different RF modules are operated from the same oscillator signal. This is the reason that the pulse width modulated oscillator signal is accessible at the connector ST2. All RF modules to be driven by one oscillator must have their ST2 connectors connected together as shown in Figure 32.

An additional solder bridge selects whether the internal oscillator or the external oscillator signal is used. When the solder bridge 'S' is closed, the internal oscillator is used and the RF module is referred to as an oscillator MASTER RF module. When the solder bridge 'S' is open, the external oscillator signal is used and the RF module is referred to as an oscillator SLAVE RF module (also see Figure 1).

Note:

Only one oscillator MASTER RF module is allowed per synchronized system.

Figure 32: Connecting for “MASTER/SLAVE” Oscillator Configuration



If you are using several antennas close to each other, you should always check whether the charge-up field strength changes regularly (beat effect). You can check this by verifying the antenna resonance voltage with an oscilloscope. If the antenna resonator voltage changes periodically more than about 5% of the full amplitude we recommend that you use wired transmitter carrier phase synchronization as shown in Figure 32.

In addition, the distances given in table 12 can be used as a guideline on determining when it is necessary to cross-check for beat effect. If the distances between antennas is less than the value given in table 12, you should check for beat effect. The values given in table 12 refer to the distances shown in Figure 33 and are valid for maximum charge-up field strength.

Figure 33: Distance between Antennas (top view)

Table 13: Maximum Distances Between Antennas

Antenna type	Distance D1 [m]	Distance D2 [m]
RI_ANT_S02 <=> RI_ANT_S02	1.0	0.8
RI_ANT_G01 <=> RI_ANT_G01	1.7	1.5
RI_ANT_G02 <=> RI_ANT_G02	1.3	1.0
RI_ANT_G04 <=> RI_ANT_G04	2.0	1.7

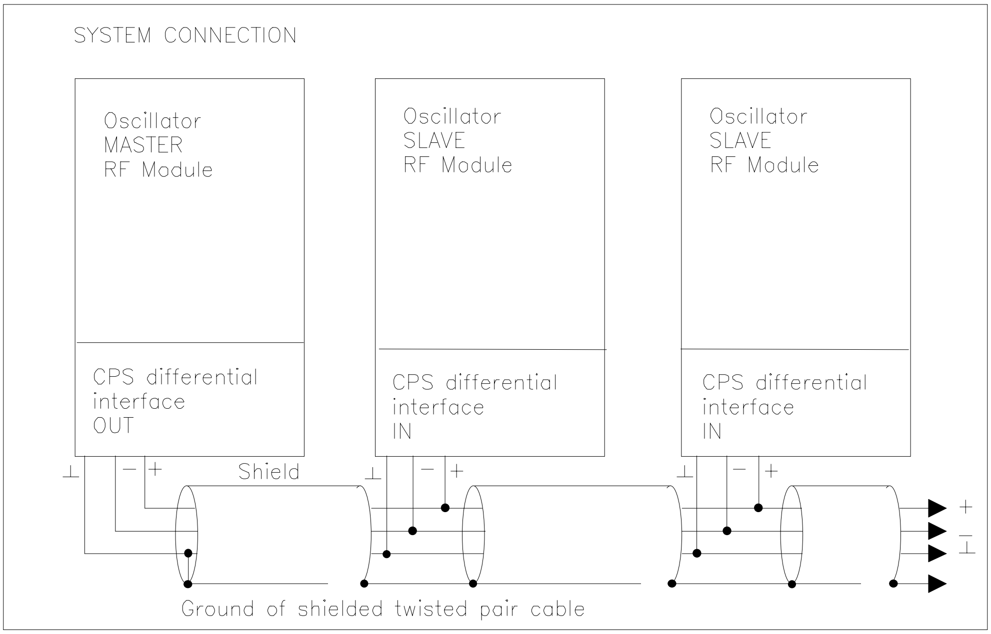
Note:

If a large and small antenna are used (for example: G01 <=> G04) the maximum distance D1 and D2 of the larger antenna should be used.

If an application requires more than one RF module to be used, or a longer Carrier Phase Synchronization line than that specified in Chapter 4:: “Specifications”, it is necessary to drive the pulse width modulated oscillator signal via a differential interface (for example: RS422 interface).

Figure 34 shows how such a system must be connected:

Figure 34: Connecting Multiple RFMs together



A proposal for such an external circuit is shown in Figure 35. It shows a differential interface, which can be configured as transmitter (for oscillator MASTER RF module) and as receiver (for oscillator SLAVE RF modules). This selection can be done with jumper JP1.

The diodes D1 to D5 are used for protection against over voltage spikes on the supply and interface lines. The jumper JP2 connects the RS422 interface line termination resistor. This termination resistor must be installed at the last receiver at the end of the RS422 interface line. Only one termination resistor is allowed per interface line.

Resistor R5 is necessary to limit the current flow on the ground line, which could be caused by different ground potentials at the different locations of the RF module.

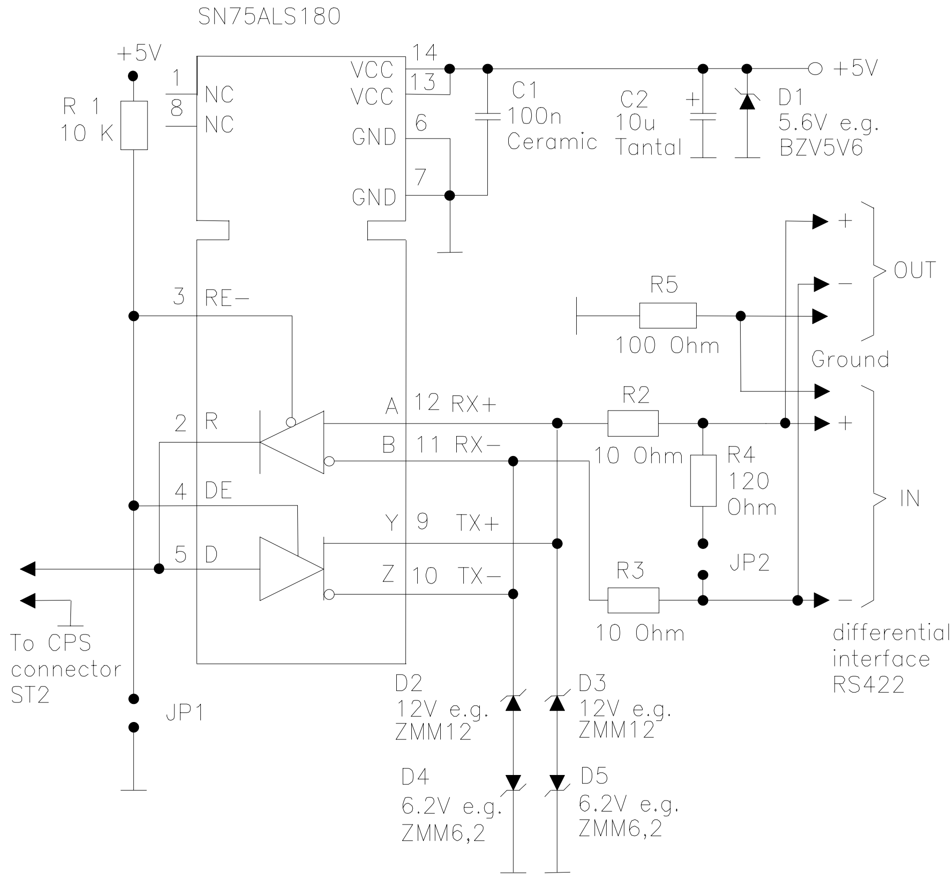
Note:

The circuit shown in Figure 35 allows up to 32 RF modules to be connected together over a total maximum wire length of 100 meters.

When you are using a Carrier Phase Synchronization interface, be careful not to exceed the maximum number of RF modules or the maximum cable length as specified in Chapter 4: “Specifications”.

The pulse width setting of an oscillator SLAVE RF module does not affect the generated pulse width of this module. The pulse width of this oscillator SLAVE RF module is determined by the pulse width setting of the oscillator MASTER RF module.

Figure 35: Circuit and Jumper Settings for RS422 Interface



JP1: OPEN: Oscillator MASTER RF Module
CLOSED: Oscillator SLAVE RF Module

JP2: OPEN: Line termination not installed (Default)
CLOSED: Line termination installed (at end of line only)

CAUTION:

Use over voltage protection components at the CPS connector for CPS lines between 0.5 and 5m, when the circuit shown in Figure 35 is not used. Also see Section 5.10: “Over Voltage Protection”.

Note:

Keep in mind that when using the transmitter Carrier Phase Synchronization feature, it is absolutely necessary that the read cycles of each different controller are synchronized. When the transmitter of the oscillator MASTER RF module is not activated by its controller, the oscillator signal output of the oscillator MASTER RF module is disabled. This means that all the oscillator SLAVE RF modules have no transmitter oscillator input signal and thus none of the oscillator SLAVE RF modules are able to transmit.

Therefore the read cycles of all RF modules connected to this CPS interface must be synchronized and all read cycles must occur simultaneously!

5.8 Receive Multiplexer

This RF module has the option to use special receive-only antennas in combination with the built-in receive multiplexer.

The use of one combined transmit/receive antenna or up to two special receive-only antennas can be selected by solder jumpers (also see Figure 19 and Figure 20).

The receive multiplexer offers the following possibilities:

* The charge-up and receive functions of the antenna are separated allowing more freedom to separately place the charge-up and receive-only antennas to optimize identification area.
* The receive multiplexer allows to charge-up a transponder with one transmit antenna and to read it at either of two different locations, by activating one receive-only antenna out of the two receive-only antennas.

When using the receive multiplexer, the active receive channel is selected by the input signal RXA0. Receive channel A is selected when RXA0 is connected to +5 V or when RXA0 is open. Channel A is selected as default. Connecting RXA0 to ground selects receive channel B.

Standard TI-RFid antennas can be used for receive-only antennas (see Figure 7).

Notes:

A minimum distance between receive-only antennas (and between receive-only antennas and charge-up antenna) must be maintained to ensure that the system functions properly. A distance of at least 20 cm must be between the antennas, so that the parameters of the antennas are not changed and thus proper function is guaranteed.

In addition, a minimum distance of 5 cm from antenna to metal must also be kept.

Figure 36 shows a system configuration for the receive multiplexer.

TI-RFid standard antennas can be used for the charge-up function. However, when using this receive-only antenna option there is more freedom in configuring the charge-up antenna, this is because it only needs to be optimized for the charge-up function. This means that the antenna can be quite big without the usual disadvantage of high noise sensitivity of a big antenna.

The receive path can be either receive channel A or receive channel B via the special receive-only antennas. Again, as these antennas are only used for receive function, they can be optimized for this purpose.

Figure 37 shows a very basic application example for the receive multiplexer: Access control for a doorway, where the direction of the people passing by is also recognized.

The charge-up antenna could be made as a simple single loop round the door.

Figure 36: Receive Multiplexing - Connecting the Antennas

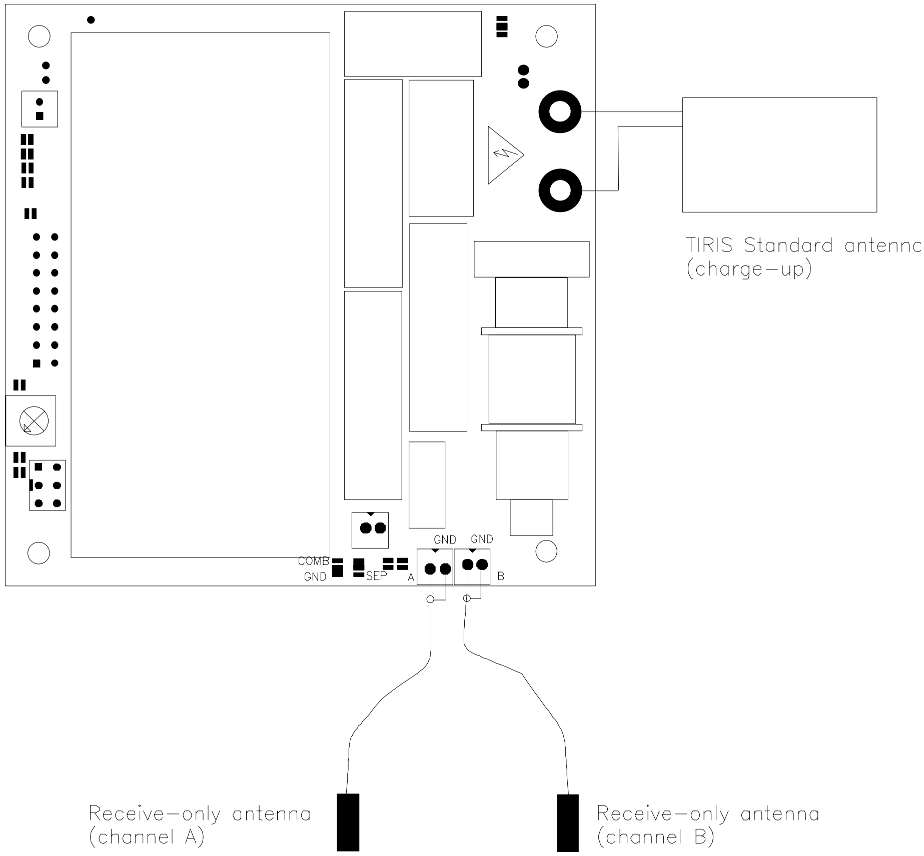
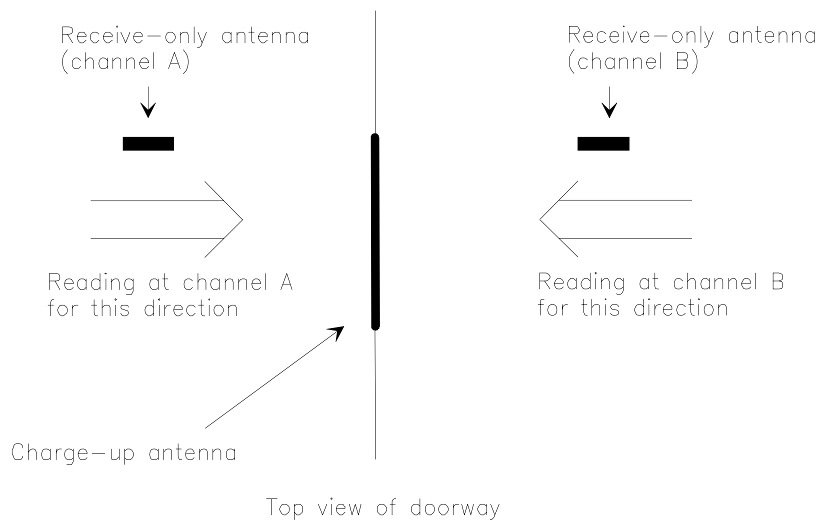


Figure 37: Example of Receive Multiplexing



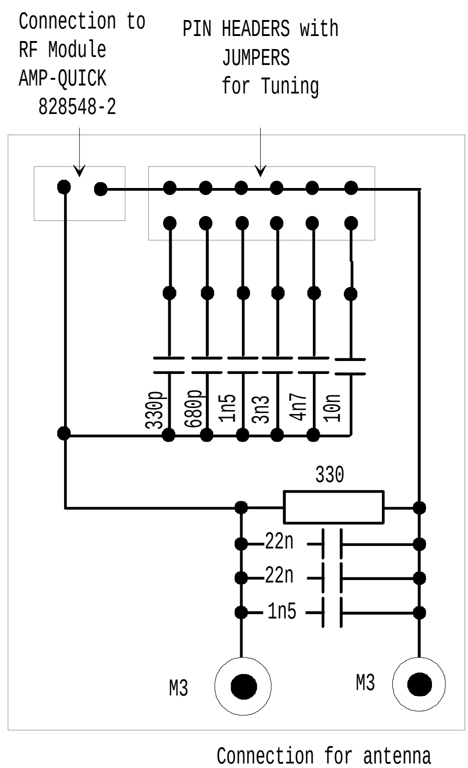
The transponder signal is received via one of the two receive-only antennas. One receive-only antenna is put on each side of the doorway. So it is possible to detect with the channel select function of the receive multiplexer on which side of the doorway the transponder is located.

TI-RFid standard transmit/receive antennas can be used as receive-only antennas, when they are built up as a tuned and damped resonator. For a schematic of this circuit see Figure 7.

When using this type of antenna, additional solder jumpers have to be closed on the RF module, as shown in Figure 20.

To tune this type of receive-only antenna resonance, it is recommended to use a capacitor array as shown in Figure 38.

Figure 38: Converter Board for using Standard Antennas as Receive-only



Note:

Although the voltage value of the capacitors can be as low as 50 V for RX, it is recommended that high value (430 V) capacitors are used.

If the receive antenna is ever in the charge-up field and is not connected to the reader, high voltages that could damage the capacitors could be induced. When the antenna is connected to the reader RX Multiplexer, built-in protection circuits safeguard the board.

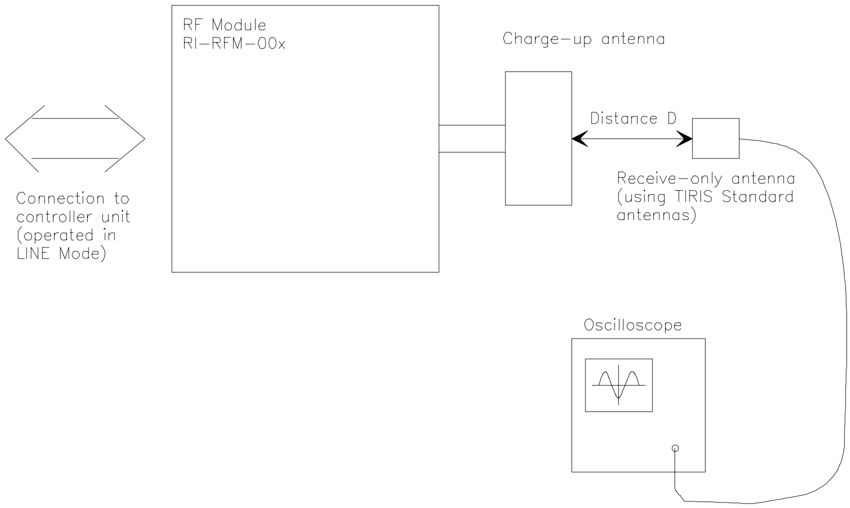
The tuning to resonance can be done either by coupling the 137.2 kHz (the slightly higher frequency is necessary in order to match the bandpass parameters) resonance sine wave signal to the antenna using a sine wave function generator in combination with a coupling coil (==> **Method A**, which should be preferred),

or

the transmitter of the RF module is used to couple a 134.2 kHz sine wave signal to the receive-only antenna (==> **Method B**). This can be done by operating the transmitter of the RF module in pulsed mode via the controller unit.

The correct set-up for method B can be seen in Figure 39. This set-up also applies to method A with the exception that a function generator operating at 137.2 kHz is used instead of the RF module transmitter.

Figure 39: Tuning Receive Only Antennas (Method B)



5.8.1 Tuning procedure:

When using method A, the total capacitance of the receive-only antenna resonator has to be changed until the induced voltage at the receive-only antenna has reached its maximum. We recommend that you use a binary weighted capacitor array as shown in Figure 38 for adjusting the resonance frequency.

When using method B, the total capacitance of the receive-only antenna resonator also has to be changed until the induced voltage at the receive-only antenna has reached its maximum. However in this case, the antenna is tuned to 134.2 kHz and not to 137.2 kHz. Therefore the total capacity has to be reduced by 2.2 nF after the tuning procedure. In this way, the antenna is again tuned to about 137.2 kHz.

* Put the TI-RFid standard antenna plus the converter board at a fixed distance to the charge-up antenna (about 1 meter) and measure the induced voltage at the antenna using an oscilloscope. Ensure that the induced voltage does not exceed the specified voltage for the capacitor and resistor which are used on the converter board (a safe way is to not exceed 40 Vpeak), by changing the distance to the charge-up antenna.
* Tune the receive-only antenna to resonance by changing the capacity on the converter board, until the induced voltage has reached its maximum!

CAUTION:

Be careful with receive-only antennas near charge-up antennas, if the receive-only antennas are not connected to the receive multiplexer. The induced voltage may exceed the rated voltage specified for the capacitor and resistor used for the receive-only antenna. Therefore it is recommended to short circuit receive-only antennas when they are not connected to the RF module. The RF module has on-board clamping diodes protecting the antenna.

Note:

It could be that receive-only antennas still receive a transponder over a short distance (some centimetres), even when the receive channel is disabled.

5.9 Noise Verification

Noise can have a negative effect on the receive performance of the RF module. There are two different kind of noise: radiated and conducted noise. Their characteristics are shown in Table 14.

Table 14: Characteristics of Radiated and Conducted Noise

	Radiated Noise	Conducted Noise
Source	This is radiated from inductive parts for example: deflection coils, motor coils, ...	This is generated from power units, for example: motors, switched mode power supplies. It can be seen as voltage spikes or ripple voltage.
Path	It is radiated via magnetic fields.	It is galvanically conducted via all cables (supply and interface) connected to the RF module.
Effect	Disturbs receive function by magnetic interference with signal from transponder at the antenna.	Leads to malfunction and reduced sensitivity of receiver circuit, because of for example: interfered supply voltage. But conducted noise can also cause in addition radiated noise!

Method to detect and distinguish between noise types:

The principle of this procedure is to eliminate any conducted noise from the supply and all interface lines. In order to do this test the RF module must be powered from a battery (for example: 9 V, 20 mA) in order to eliminate any conducted noise from a power supply. Conducted noise via the interface lines is eliminated for this test by simply disconnecting all interface lines to the RF module.

The measurement criteria for low noise is the amplitude of the receive signal strength detector of the RF module. The test pin RSTP at connector ST1 carries an analog output voltage indicating the receive signal strength. This voltage should be measured in combination with the antenna RI-ANT-G02E. The set-up for this can be seen in Figure 40. This configuration operates the RF module from a battery and has no interface line connected. As the transmitter is switched off for this configuration, a normal battery can be used for this test.

A low noise level is indicated by an RSTP voltage less than about 1.0 VDC when using antenna RI-ANT-G02E.

Note:

Remember that both noise types can be either 'differential' or 'common mode' noise. Use Common Mode Noise filters (for example: a BALUN transformer) to reduce Common Mode Noise and use selective filters to reduce Differential Noise.

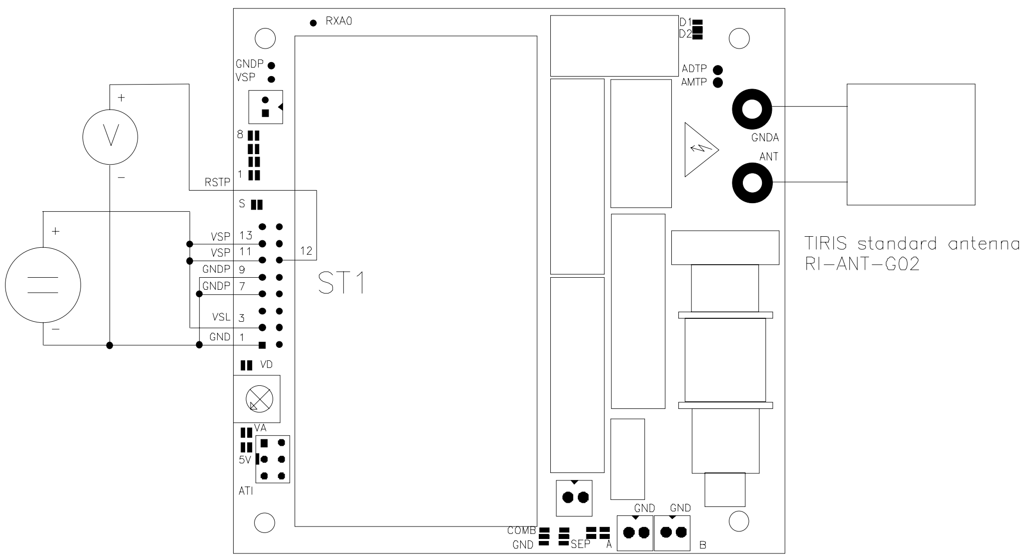
The procedure for testing of noise impact is as follows:

* The normal set-up for the RF module and antenna gives bad reading distance, even though the antenna is correctly tuned for sufficient transponder charge-up.
* Try the configuration shown in Figure 40. If this configuration shows bad noise conditions (RSTP voltage more than about 1.0 VDC), then the problem is radiated noise.

    ==> Eliminate noise sources or try special antennas (for example: Noise Balanced antennas).

    For more details refer to the 'Antenna Reference Guide' (Manual number 22-21-007)

Figure 40: Noise Testing Configuration (Testing RSTP)



* When the configuration of Figure 40 shows good noise conditions (RSTP voltage less than 1.0 Vdc), then the problem is conducted noise.

    Now change the configuration so that the interface lines are again connected to the RF module (but the transmitter still switched off). If the RSTP voltage now indicates bad noise conditions, the conducted noise is coming via the interface lines.

    ==> Try to eliminate the noise on the interface lines. Some proposals are given in Section 5.10: “Over Voltage Protection”.

* When the above configuration (interface lines connected) shows good noise conditions (RSTP voltage less than 1.0 Vdc), then the problem is conducted noise via the supply lines.

    ==> Try to eliminate the noise on the supply lines. Some proposals are given in Section 5.10: “Over Voltage Protection”.

5.10 Over Voltage Protection

For applications, where there is a risk that voltage spikes and noise are on the lines to the RF module, additional protection circuitry and filters must be added. A useful proposal for this is shown in Figure 41. This circuit can be used as a guideline for protection circuitry. However it may be that this is not sufficient for all applications. This has to be checked individually when necessary.

* The supply input has to be protected against voltage spikes. R1 and D1 are used for this purpose. Zener diode D1 clamps the voltage spikes to 18 volts so that the maximum allowed transmitter power stage supply voltage is not exceeded by too much. For diode D1 the type ZY18 is recommended, this type has 2W power dissipation. If you need a higher current dump type ZX18 can be used, this diode has 12.5W power dissipation.

  The Common Mode Choke Coil and the capacitors C1 and C2 are used to reduce the conducted noise coming to the RF module, via the supply lines.

* All input and output signals should be protected with 5.6 V zener diodes. The specified type can dump 1.3W.

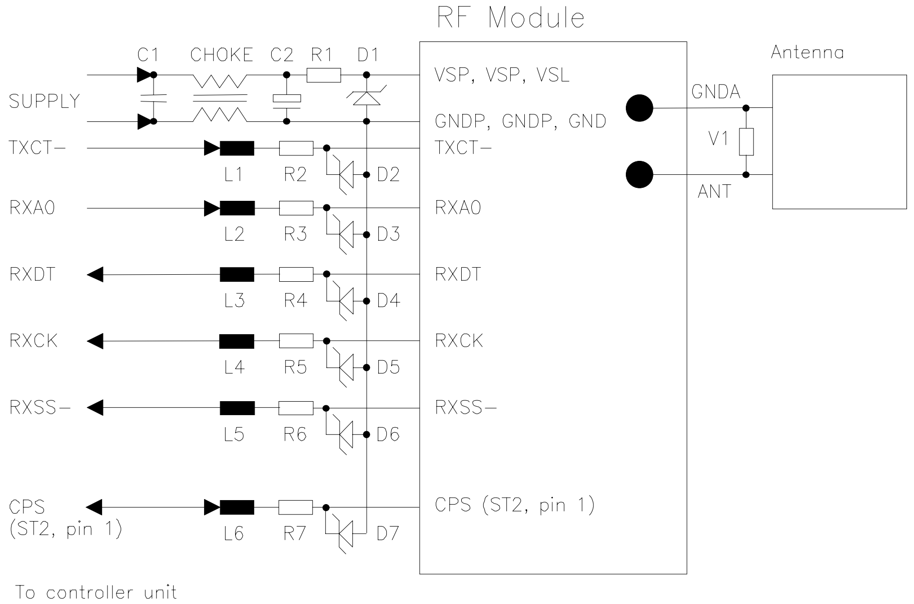
  The coils L1 to L6 are ferrite beads and should put in series to the line, when conducted noise is coming via the interface lines.

  The varistor V1 protects the antenna circuit against high voltage induced at the antenna coil, for example: by lightning. The given type of varistor is a common one and may not always be sufficient for protection in all cases.

Note:

The zener diodes types given in Figure 43 are not special suppresser diodes for fast suppressing of voltage spikes, they are commonly used diodes. If the application requires it, special suppresser diodes should be used.

Figure 41: Circuit for Overvoltage Protection



All components must be mounted close to the RF Module with shortest possible wires!

C1: 100nF Ceramic
C2: 100uF low ESR

CHOKE: Common Mode Choke Coil
L1, L2, L3, L4, L5, L6: Ferrite beads

R1: 1 Ohm / 2W
R2, R3, R4, R5, R6, R7: 22 Ohm / 0.25W

D1: ZY18 respectively ZX18
D2, D3, D4, D5, D6, D7: BZX85C5V6

V1 = Varistor 420V
e.g. SIEMENS
SIOV–S20K420

5.11 Interface Line Extension

As already described in Section 5.1: “Power Supply”, if the interface lines exceed 2 meters it is necessary to drive the signals at connector ST1 via a differential interface. The RS422 differential interface is well suited to drive these interface signals over lines longer than 2 meters.

Two interface converters are necessary, one on the RF module side and one on the controller unit side.

The converter on the controller unit side has to convert the signals TXCT- and RXA0 from HCMOS logic level to RS422 level and the signals RXDT, RXCK and RXSS- from RS422 to HCMOS logic level.

The converter at the RF module side must work the other way round.

A circuit proposal for this is shown in Figure 42 (it shows only the conversion of the signals TXCT-, RXDT, RXCK and RXSS-).

The circuit shows the interface converter at the controller unit on the left side of the drawing. Interface drivers SN75157 and SN75ALS180 are used. The recommended interface line protection circuitry is also shown. The interface cable consists of 4 twisted pairs plus shield. The shield of the interface cable is connected to ground only at the controller unit.

The interface converter at the RF module is shown on the right-hand side of the drawing. Here the interface drivers SN75158 and SN75ALS180 are used. Again the recommended interface line protection circuitry is shown. The converter at the RF module side and the RF module itself are supplied from the controller unit via two power supply cables. Using such long supply cables, causes voltage drop across the cables. This in turn means that the RF module supply voltage is lower which results in a smaller field strength being generated.

In order to avoid this voltage drop across the power supply cables for the RF module, it is recommended to supply the RF module from a local supply at the RF module installation site. In this case, however, there needs to be an additional ground line between the controller unit and the RF module interface circuit, in order to have a defined ground path for the return current of the RS422 interface.

The 100 Ohm series resistor in this ground line is necessary to reduce the current in this ground line, which might be caused by different ground potentials of the controller unit and the RF module. The 100 Ohm series resistor does not affect the RS422 interface function. A circuit proposal is shown in Figure 43.

Figure 42: Conversion Circuit without Own Supply

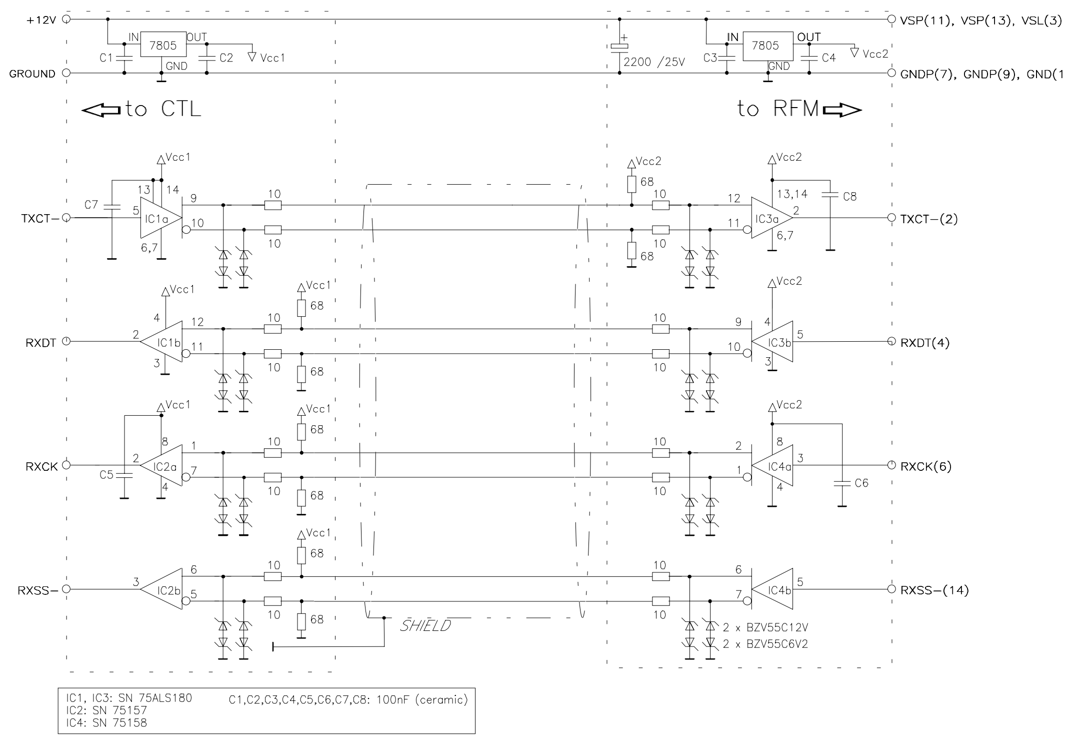
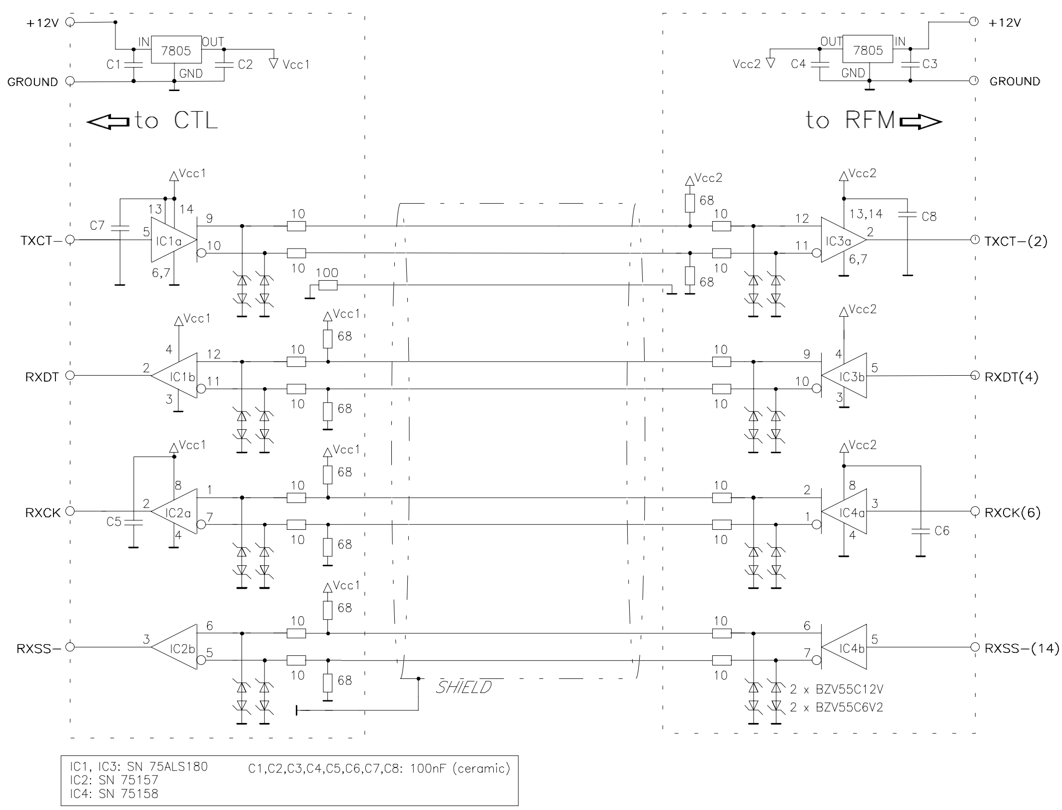
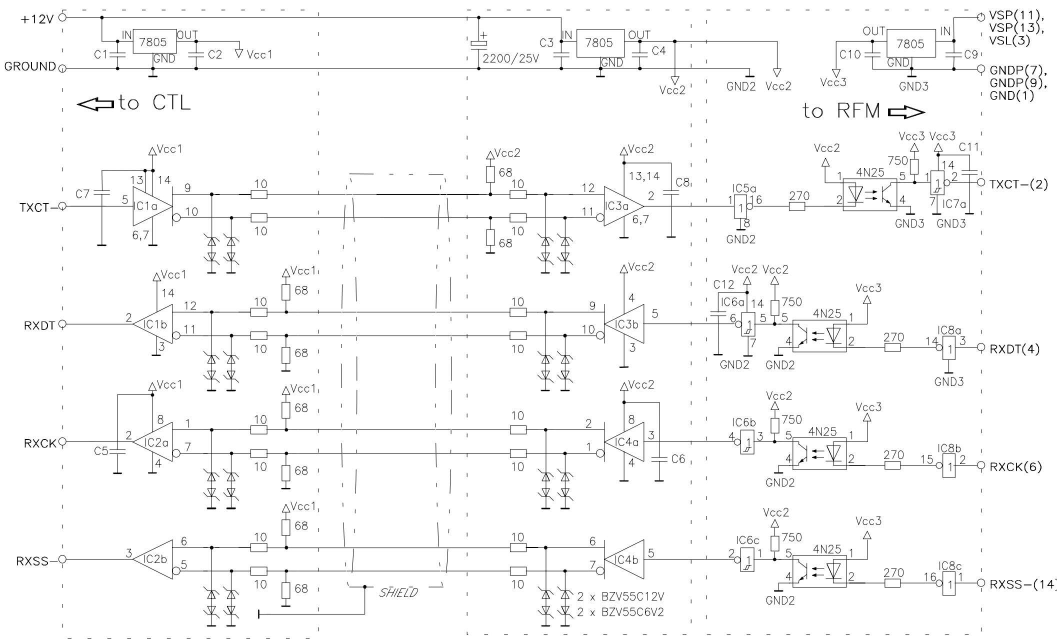


Figure 43: Conversion Circuit



If the ground potential differences between the controller unit and the RF module are too big, there will be a very high current flow through this ground line series resistor. Therefore we recommend that you use additional optical isolators (optocouplers), in order to overcome the problems with different ground potentials. A circuit proposal for this is shown in Figure 44.

Figure 44: Conversion Circuit with Optocouplers



IC1, IC3: SN 75ALS180 IC2: SN 75157 IC4: SN 75158	IC5, IC8: ULN2003 IC6, IC7: 74HC14	C1,C2,C3,C4,C5,C6,C7,C8,C9, C10,C11,C12: 100nF (ceramic)

The interface converter at the controller unit side is the same as that already shown in Figure 41 and Figure 42. The circuit at the RF module side is different. Optocouplers are used here to galvanically separate the interface signals. Schmitt trigger circuits are used to shape the output signals from the optocouplers back to a correct square wave. Darlington transistors are used to drive the high current for the optocoupler LEDs.

The circuitry to the left of the optocouplers is supplied by the controller unit. The circuitry to the right of the optocouplers and the RF module itself are supplied from the local supply at the RF module.

In this way the problems with different ground potentials and supply voltage drop, caused by long cables are avoided and the interface lines can be extended without problems.

Note:

The circuits shown in Figure 42, Figure 43 and Figure 44 are only a proposal for extending the interface line length. It cannot be guaranteed that these circuits will be correct for all applications!

CHAPTER 6

Warnings, Cautions and Notices

This chapter provides the Warnings, Cautions and Notices that are applicable to the Standard RFM.

Topic **Page**

6.1 FCC / R&TTE Regulations

Prior to operating the RFM together with antenna(s), power supply and a control module or other devices, the required FCC or relevant government agency (CE) approvals must be obtained. Sale, lease or operation in some countries may be subject to prior approval by government or other organizations.The TI-RFid RF module generates RF emissions at 134.2 kHz. The radiation of the fundamental and the harmonics will vary with the type of antenna and other devices or functions connected to the RF module.

6.2 FCC Notices (U.S.A)

A typical system configuration containing the RFM has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC rules. It is the responsibility of the system integrators to get their complete system tested and to obtain approvals from the appropriate local authorities before operating or selling this system. Further information regarding the FCC approval is available under FCC ID.: A92 S2000 at http://www.fcc.gov/oet/fccid/.

6.3 CE Conformity (Europe)

The Declaration of Conformity DoC (CE) # 19-06-02-078 for this product is available via our sales offices nearest you. This contact information can be found on our web site at http://www.ti-rfid.com.

The equipment complies with the essential requirements of the Telecommunication Terminal Equipment Act (FTEG) and the R&TTE Directive 99/5/EC when used for its intended purpose.

CE 0682

Any device or system incorporating this module in any other than the originally tested configuration needs to be verified against the requirements of the Telecommunication Terminal Equipment Act (FTEG) and the R&TTE Directive 99/5/EC. A separate Declaration of Conformity must be issued by the system integrator or user of such a system prior to marketing it and operating it in the European Community.

It is the responsibility of the system integrators to get their complete system tested and obtain approvals from the appropriate local authorities before operating or selling the system.

6.4 WARNING

Care must be taken when handling the RF module. High voltage across the antenna terminals, at the tuning coil and some parts of the printed circuit board (PCB) could be harmful to your health. If the antenna insulation is damaged it should not be connected to the RF module.

6.5 CAUTION

This product might be subject to damage by electrostatic discharge (ESD), it should only be handled by ESD protected personnel at ESD secured workplaces.

APPENDIX A

Short Description of Antennas

This Appendix provides the basic characteristics of the standard TI-RFid antennas that can be used together with the RFM.

Gate antenna RI-ANT-G01E

Parameter	Condition	min.	typ.	max.	Unit
L_G01	Antenna inductance range	26.0	27.0	28.0	µH
Q_G01	Quality factor at f = 134.2 kHz	110	130	150	-
l_G01	Length of antenna	-	715	-	mm
h_G01	Height of antenna	-	270	-	mm
w_G01	Width of antenna	-	25	-	mm
l_cable	Length of antenna feeder cable	-	1	-	m

Gate antenna RI-ANT-G02E

Parameter	Condition	min.	typ.	max.	Unit
L_G02	Antenna inductance range	26.0	27.0	28.0	µH
Q_G02	Quality factor at f = 134.2 kHz	130	150	170	-
l_G02	Length of antenna	-	200	-	mm
h_G02	Height of antenna	-	200	-	mm
w_G02	Width of antenna	-	25	-	mm
l_cable	Length of antenna feeder cable	-	1	-	m

Gate antenna RI-ANT-G04E

Parameter	Condition	min.	typ.	max.	Unit
L_G04	Antenna inductance range	25.0	26.0	27.0	μH
Q_G02	Quality factor at f = 134.2 kHz				
l_G02	Length of antenna	-	1018	-	mm
h_G02	Height of antenna	-	518	-	mm
w_G02	Width of antenna	-	47	-	mm

Stick antenna RI-ANT-S01C

Parameter	Condition	min.	typ.	max.	Unit
L_S02	Antenna inductance range	26.0	27.0	28.0	μH
Q_S02	Quality factor at f = 134.2 kHz - unloaded - during operation with high magnetic fields	350 100	370 120	400 140	-
l_S02	Length of antenna	-	140	-	mm
d_S02	Diameter of antenna	-	21	-	mm
l_cable	Length of antenna feeder cable	-	1	-	m

Stick antenna RI-ANT-S02C

Parameter	Condition	min.	typ.	max.	Unit
L_S02	Antenna inductance range	26.0	27.0	28.0	μH
Q_S02	Quality factor at f = 134.2 kHz - unloaded - during operation with high magnetic fields	350 100	370 120	400 140	-
l_S02	Length of antenna	-	140	-	mm
d_S02	Diameter of antenna	-	21	-	mm
l_cable	Length of antenna feeder cable	-	3	-	m

APPENDIX B

Summary of Solder Jumpers

This appendix provides a summary of all the available options selectable by solder jumpers.

All of the usable jumpers on the RF module are listed together with their use. They are listed twice: first in table B-1 in alphabetical order, and then in Table B.2 to Table B.5 in “function groups”.

Table B.1: Jumpers (Alphabetic Listing)

Jumper	Function	Setting
1	Pulse Width Setting (LSB)	See Table 12
2	Pulse Width Setting	See Table 12
4	Pulse Width Setting	See Table 12
8	Pulse Width Setting (MSB)	See Table 12
5V	Power Supply Selection	Closed = Regulated Supply Open = Unregulated Supply
CA	Antenna Selection	Closed = TI-RFid “standard” antenna Open = TI-RFid “standard” antenna as Rx only antenna
CB	Antenna Selection	Closed = TI-RFid “standard” antenna Open = TI-RFid “standard” antenna as Rx only antenna
COMB	Antenna Selection	Closed = Combined TX/RX antenna
D1	Transmit Antenna Damping	Closed = G01E
S	Carrier Phase Synchronization	Closed = MASTER oscillator (or single RF module) Open = SLAVE oscillator
SEP	Antenna Selection	Open (and grounded) = Combined TX/RX antenna
VA	Power Supply Selection	Closed = Unregulated Supply Open = Regulated Supply
VD	Power Supply Selection	Closed = Unregulated Supply Open = Regulated Supply

Table B.2: Pulse Width Setting Jumpers

Jumper	Function	Setting
1	Pulse Width Setting (LSB)	See Table 12
2	Pulse Width Setting	See Table 12
4	Pulse Width Setting	See Table 12
8	Pulse Width Setting (MSB)	See Table 12

Table B.3: Power Supply Jumpers

Jumper	Function	Setting
5V	Power Supply Selection	Closed = Regulated Supply Open = Unregulated Supply
VA	Power Supply Selection	Closed = Unregulated Supply Open = Regulated Supply
VD	Power Supply Selection	Closed = Unregulated Supply Open = Regulated Supply

Table B.4: Antenna Selection Jumpers

Jumper	Function	Setting
COMB	Antenna Selection	Closed = Combined TX/RX antenna Open (and grounded) = Separate antennas for TX and RX
SEP	Antenna Selection	Closed = Separate antennas for TX and RX Open (and grounded) = Combined TX/RX antenna
CA	Antenna Selection	Closed = TI-RFid "standard" antenna Open = TI-RFid "standard" antenna as Rx only antenna
CB	Antenna Selection	Closed = TI-RFid "standard" antenna Open = TI-RFid "standard" antenna as Rx only antenna
D1	Transmit Antenna Damping	Closed = 10 dB damping for Antenna G01E

If you are using the large TI-RFid antenna (RI-ANTG04E) and you need to damp the power output (for example, to meet R&TTE requirements) you can achieve 10 dB damping by using jumper D1.

Table B.5: Master/Slave (Synchronization) Jumpers

Jumper	Function	Setting
S	Carrier Phase Synchronization	Closed = MASTER oscillator (or single RF module) Open = SLAVE oscillator