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TIRIS Technology by Texas Instruments™

Power Radio
Frequency Module

RI-RFM-007A (discontinued)

Reference Manual

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Edition Notice: **Third Edition - May 1997**

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

TIRIS Power Radio Frequency Module RI-RFM-007A

Some changes have been made to pages 27 and 28 where more details about how to control and check the power consumption have been provided.

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Important Notice

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FCC/PTT Regulations

The TIRIS Power RFM 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 Power RFM.

Prior to operating the Power RFM together with antenna(s), power supply and a control module or other devices, the required FCC, PTT or relevant government agency approvals must be obtained.

Sale, lease or operation in some countries may be subject to prior approval by the government or other organizations.

Important note to Purchasers/Users of the TIRIS Power RFM in the U.S.A.

The TIRIS Power RFM product is considered by the Federal Communications Commission (FCC) to be a "subassembly". As such, no prior approval is required to import, sell or otherwise market the Power RFM in the United States. In order to form a functioning radio frequency (RF) device, the Power RFM must be connected to a suitable antenna, power supply, and control circuitry. **A radio frequency device may not be operated unless authorized by the FCC nor may a radio frequency device be marketed (i.e. sold, leased, imported, or advertised for sale or lease) without the prior grant of an FCC equipment authorization.**

FCC authorization to operate an RF device may take one of two forms: first, the FCC may grant the user an experimental license; second, the FCC may issue an equipment authorization permitting use of the RF device on an unlicensed basis. TI can assist the user in obtaining an experimental license that will cover a specific installation of the Power RFM in a specific site or sites. Experimental authorizations are appropriate to cover operations during the development of an RF device. A grant of equipment authorization (known as "certification") must be obtained from the FCC before RF devices are marketed or operated on a non development basis.

> DEVICES CONSTRUCTED FOR EVALUATION INCORPORATING THIS POWER RFM SHOULD BE OPERATED ONLY UNDER AN EXPERIMENTAL LICENSE ISSUED BY THE FCC AND MAY NOT BE MARKETED. BEFORE ANY DEVICE CONTAINING THIS POWER RFM IS MARKETED, AN EQUIPMENT AUTHORIZATION FOR THE DEVICE MUST BE OBTAINED FROM THE FCC.

Prospective marketers of devices containing this Power RFM are responsible for obtaining the necessary equipment authorization. Upon request TI can provide assistance in obtaining FCC approval to market devices incorporating this Power RFM.

WARNING

Care must be taken when handling the Power RFM. 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 the antenna should not be connected to the Power RFM.

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.

The transmitter power output stage can only operate with a limited duty cycle. Please pay attention to this fact whilst performing the antenna tuning procedure.

The ground pins GND and GNDP have to be connected externally to avoid damage of the Power RFM.

1. Introduction

1.1 General

This document provides information about the TIRIS Power Radio Frequency Module (Power RFM). It describes the module and how to install it.

1.2 Reference

We refer to one other document within this description, that is:

'Antenna Reference Guide' (Manual number 22-21-007).

1.3 Product Description

The Power RFM is an integral part of TIRIS. Together with a Control Module and an Antenna it is used for wireless identification of TIRIS transponders.

The main task of the Power RFM is to send an energizing signal via the antenna to initialize the transponder, to demodulate the received identification signal and then send the data together with clock signals to a Control Module. It is also used to send programming data to Read/Write and Multipage transponders.

The Power RFM is able to generate a higher field strength level than the RI-RFM-xx4x RF Module family.

1.4 Product Option Coding

For product codes and order numbers of Power RFM, Antennas, Control Modules and combinations of these, please contact your regional TIRIS Application Center.

1.5 About this Description

This Description contains the following parts relevant for the operation of the Power RFM:

Section 2 Product Description A short description of all features and functional blocks of the Power RFM (transmitter, antenna, receiver). It also lists all the connector signals and describes all options selectable via jumpers.

Section 3 Specifications A list of electrical and mechanical parameters of the Power RFM.

Section 4 Installing the Power RFM 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 following options implemented in the Power RFM: transmitter carrier phase synchronization and receive-only antenna.

Certain conventions are used in order to display important information in this description, these conventions are:

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 Power RFM.

***Note**: Indicates conditions which must be met, or procedures which must be followed, to ensure proper functioning of the Power RFM.*

HINT: Indicates information which makes usage of the Power RFM easier.

2. Product Description
2.1 General

The Power RFM contains all the analogue functions of a TIRIS reading unit that are needed to initialize a TIRIS transponder and to detect its return signal. The Power RFM delivers DATA and CLOCK signals for identification data processing. The Power RFM also sends the necessary programming and addressing signals to Read/Write and Multipage transponders.

The data input and output lines, connected to a data processing unit (for example: TIRIS Series 2000 Control Module) are Low-Power Schottky TTL and HCMOS Logic compatible.

There are eight connectors on the Power RFM. These are:

J1	Connector for supply voltages and interface signal lines to the Power RFM
J310	Connector for Transmitter Carrier Phase Synchronization (CPS)
J6	Connector for Antenna Resonance Tuning. It is used to connect the tuning capacitors.
J2	Connector for the (optional) Antenna Tuning Indicator (ATI), which can be used for easy antenna tuning during installation.
J4	Connector for one receive-only antenna.
J5	Connector for direct access to the receiver input.
J11	Connector to Receiver signal strength test pin RSTP
R312	Solder pins for connecting field strength adjustment resistor

In addition there are the antenna terminals ANT1 and ANT2 to connect the transmit/receive (TX/RX) antenna to the Power RFM via two M3 screw-connectors.

The Power RFM can be mounted by means of the four M3 mounting bolts on the bottom side of the RF Module.

A layout of the Power RFM viewed from the top is shown in figure 1. A block schematic of the Power RFM is shown in figure 2. The Power RFM is described at block diagram level in the following section.

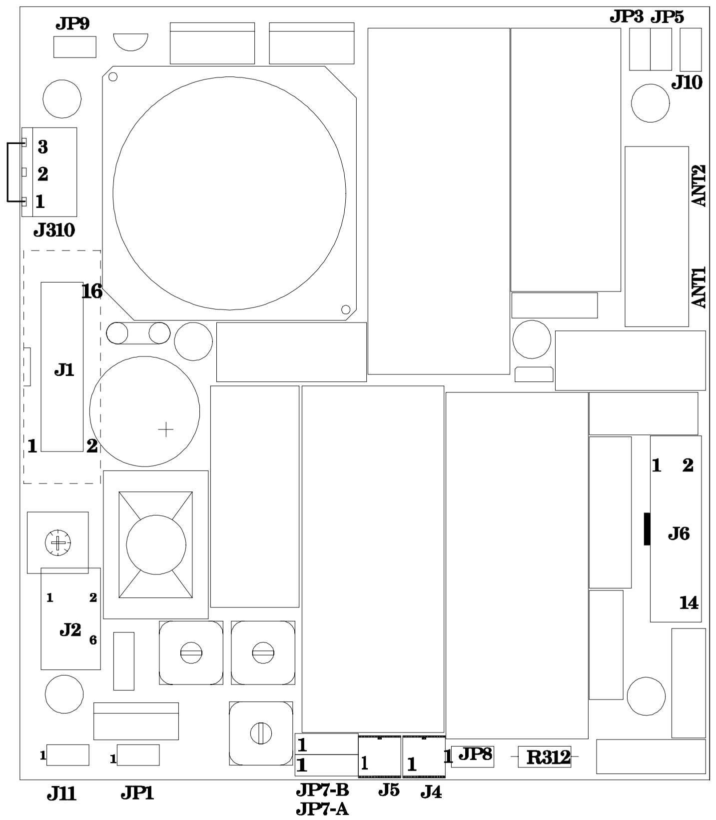


Figure 1: Top View

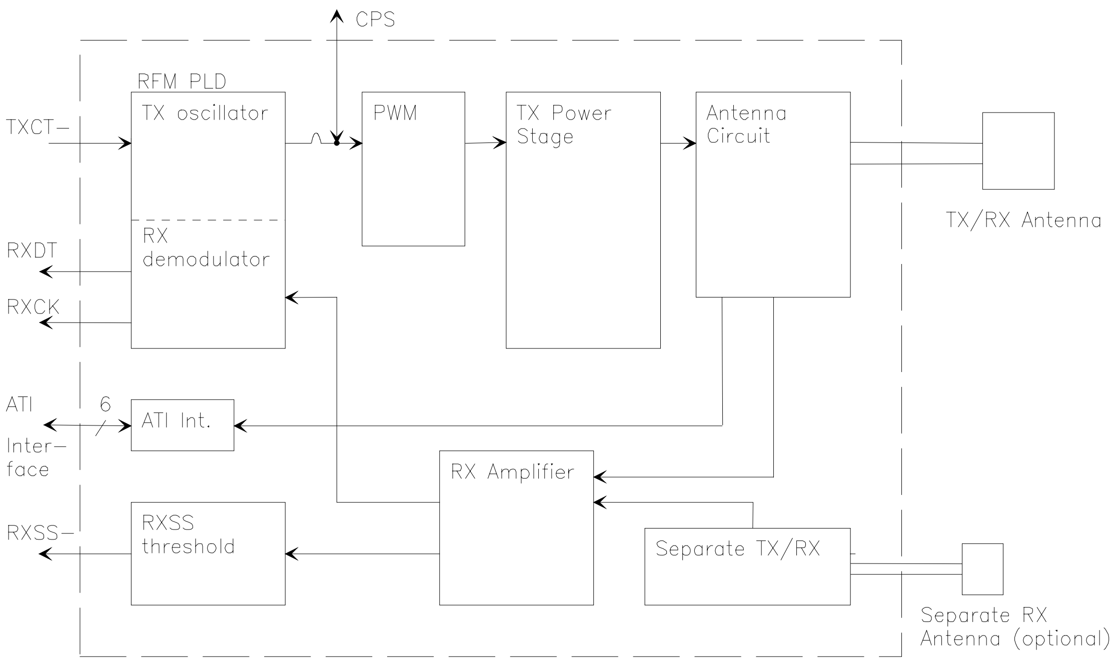


Figure 2: Block Diagram

2.1.1 Transmitter

The Power RFM has a built-in voltage regulator to 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.

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/PTT regulations and as there is no stabilization on the Power RFM, 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 TIRIS 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 Section 4.1 “Power Supply”.

The regulated transmitter power stage supply can vary in the range from +7V to +24V. This means that the supply lines VSP and VSL can be connected together, when the supply voltage is +7 V or more (for details refer to Section 3 “Specifications”).

Note: *This RFM has a temperature compensation circuit built into it which will switch off the transmitter power stage if an over-current situation causes the temperature to exceed the allowed limits. After recovery (when the temperature drops again) the RFM reverts to normal operation. If this happens it is an indication that the RFM is not being operated within the allowed specifications.*

Optionally, the logic and receiver parts can both be connected to an external regulated +5V supply. When this method is used, a jumper on the Power RFM must be opened. Then the regulated +5 V supply needs be connected to pin VD (see figures 1 &2).

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 is fed to the pulse width modulation circuit via connector J310. This connector is used to allow the option of transmitter Carrier Phase Synchronization (CPS) see figures 1 and 2.

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 super-impose on each other and may cause a beat effect on the magnetic charge-up field because of the slightly different transmit frequencies of different Power RFMs.

This effect will not occur when the transmitters feeding these different antennas are all driven by the same oscillator. For this purpose the transmit frequency is accessible at the connector J310. All the Power RFMs to be driven by one oscillator must have their J310 connectors connected together. A wire bridge selects whether the internal or external oscillator signal is used. When a wire bridge from pin 1 to pin 3 of connector J310 is inserted, the internal oscillator is used and the Power RFM is referred to as an oscillator MASTER RFM. When the wire bridge is not in, the external oscillator signal is used and the Power RFM is referred to as an oscillator SLAVE RFM (see figure 1).

Note: *Only one oscillator MASTER RFM (and up to five SLAVE RFMs) is allowed per synchronised system - unless additional external driver circuits are used.*

The transmit frequency (134.2 kHz) from the oscillator is fed to the Pulse Width Modulator (PWM). By changing the value of a resistor the PWM can set the pulse width ratio between 0% and 50%. For an example of two different oscillator signal pulse widths see figure 3. 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 field strength, refer to Section 4.5 “Field Strength Adjustment”.

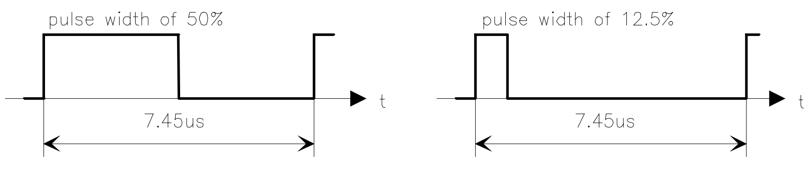


Figure 3: Pulse Width Examples

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 Section 2.2 “RFM Connectors and Jumpers”. The TXCT- signal has to be active for a certain minimum time (for precise value refer to Section 3.4 “Timing Characteristics”).

CAUTION: The Power RFM must not be operated in continuous transmit mode, when operated at full Power Output. For details please refer to Section 3 “Specifications”.

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.

CAUTION: When using pulse widths smaller than 50%, the Power RF Module transmitter power stage works in a less efficient way. This leads to an increased power dissipation and thus to higher temperature increase of the transmitter power stage, so ensure that more cooling is provided.

The special feature of the Power RFM is that it is suitable for generating higher field strength than other currently available TIRIS RF Modules.

Note: *If the Power RFM is going to be physically located within the antenna field, it may be necessary to shield the module.*

The antenna circuit is described in Section 2.1.2 “Antenna Circuit”.

2.1.2 Antenna Circuit

A block diagram of the antenna circuit can be seen in figure 4.

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 antenna coil L_ANT. The antenna coil L_ANT generates the magnetic charge-up field. Figure 5 shows a schematic of Standard TIRIS antennas. .

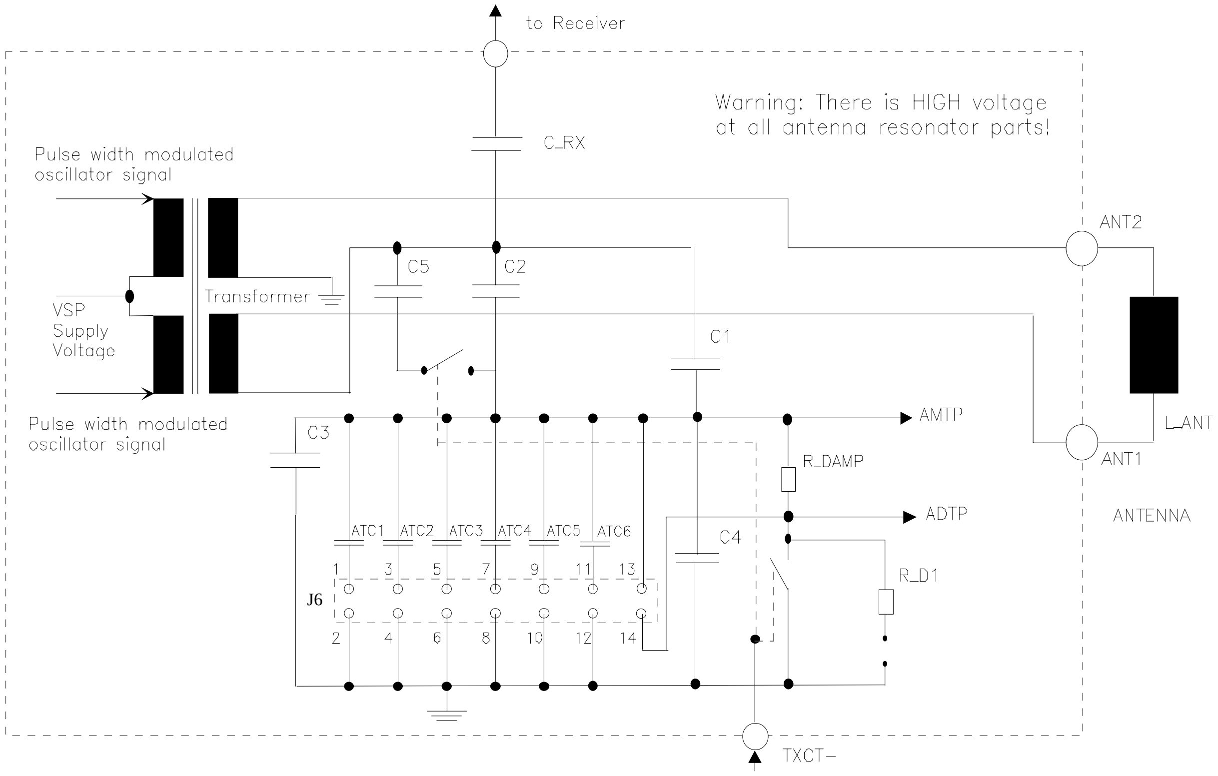


Figure 4: Antenna Circuit Block Diagram

The resonator capacitance consists of capacitors C1, C2, C3 and C4. Connecting capacitors in parallel and serial is necessary because of the high resonance voltage and the high current flow through the resonator.

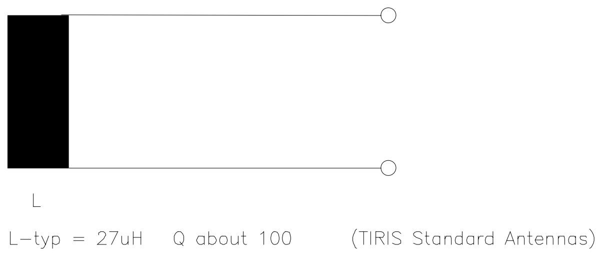


Figure 5: Standard Antenna

In order to get high resonance voltage and thus high charge-up field strength, the antenna circuit has to be tuned to resonance. Tuning capacitors are used to do this, these capacitors are connected parallel to C3 and C4.

To compensate for the tolerances of the antenna coil and the capacitors C1, C2, C3 and C4, six tuning capacitors (ATC1 to ATC6) have been built in. Their values are weighted in steps of 1, 2, 4, 8, 16 and 32, where ATC1 has the smallest value corresponding to the factor 1. ATC2 has double the capacity of ATC1, so that ATC2 corresponds to the factor 2 and so on. Each of the six tuning pins has an adjacent ground pin for antenna tuning, using shorting bridges (jumpers). The antenna ground pins GNDA should be used for antenna tuning only. For information about how to perform the resonance tuning refer to Section 4.3 “Antenna Resonance Tuning”.

The Power RFM transformer’s secondary winding is split into two turns. These windings are wound in such a way that Common Mode Noise that is coupled to both antenna cables is canceled out. For information about the Common Mode Noise reduction ration, please refer to Section 3.3 “Electrical Characteristics”.

The RX-only input at connector J4 has **no** Common Mode Noise reduction feature.

WARNING

Care must be taken when handling the Power RFM. HIGH VOLTAGE across the antenna terminals and all antenna resonator parts could be harmful to your health. If the antenna insulation is damaged the antenna should not be connected to the Power RFM.

The antenna resonator is connected to the Power MOS FETs of the transmitter power stage via the transformer.

The antenna resonator has to be damped after the transmit burst, when the Power RFM is switched to receive mode. MOS FETs are used to do this. The MOS FETs connect the damping resistor R_DAMP in parallel to the antenna resonator. In addition, when the damping circuit is active, it disconnects the capacitor C5, in order to adapt the antenna resonance frequency for proper filter bandwidth.

In cases, when low field strength for the larger antennas is necessary (Vpeak <60 V), the antenna resonator can additionally be damped by connecting damping resistor R_D1. This can be done by closing jumper JP5 (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 the next section.

Note: *The transformer of the transmitter power stage is operated at high magnetic flux. Because of the high level of magnetic flux change, it is possible that the transformer will make a significantly audible noise. This can also occur with antennas that have ferrite cores (TIRIS Standard Stick Antennas RI-ANT-S01C and RI-ANT-S02C). The noise does not indicate that anything is wrong.*

2.1.3 Receiver

The signal received 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 capacitively coupled to the receiver.

There are two options for the receive antenna. Either a combined transmit/receive antenna or a special receive-only antenna can be used. The antenna type selection is done by configuring jumpers (see figure 1):

> For combined transmit/receive antenna, jumper JP7A must to be set to position 2-3 and jumper JP7B to position 1-2.
>
> For separate transmit and receive antennas, jumper JP7A must be set to position 1-2 and jumper JP7B to position 2-3.

The combined transmit/receive antenna is a coil as can be seen in figure 5.

A receive-only antenna is a tuned resonator with a certain resonance frequency. This antenna can only be used for receive function. It does not work for charge-up function. A block schematic of a receive-only antenna is shown in figure 6.

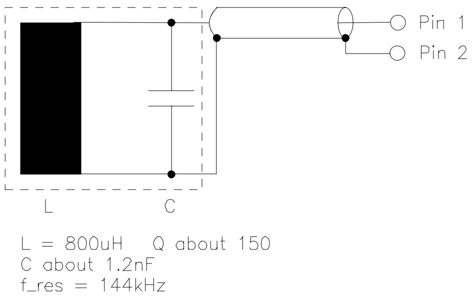


Figure 6: Receive-only Antenna

There is another alternative for receive-only antennas. Standard TIRIS 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 TIRIS antenna for use as a receive-only antenna is shown in figure 7. When using this type of antenna, jumper JP8 (see figure 1) has to be closed to adapt the receiver bandpass filter. Refer also to Section 4.8 “Receive-only Antenna”.

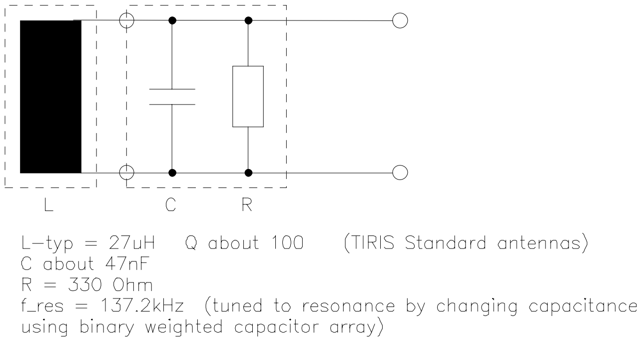


Figure 7: Standard TIRIS Antennas used as Receive-only

The received signal from either antenna is fed to the receiver. The receiver contains a selective bandpass filter (for characteristics, please refer to Section 3.4 “Timing Characteristics”). 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 during each data bit and the RXDT signal is valid before and after this positive slope for a certain time window (for more details refer to Section 3.4 “Timing Characteristics”). The output configuration of the RXDT, RXCK and RXSS- output signals, and the TXCT- and TXCT-R inputs are shown in figure 8.

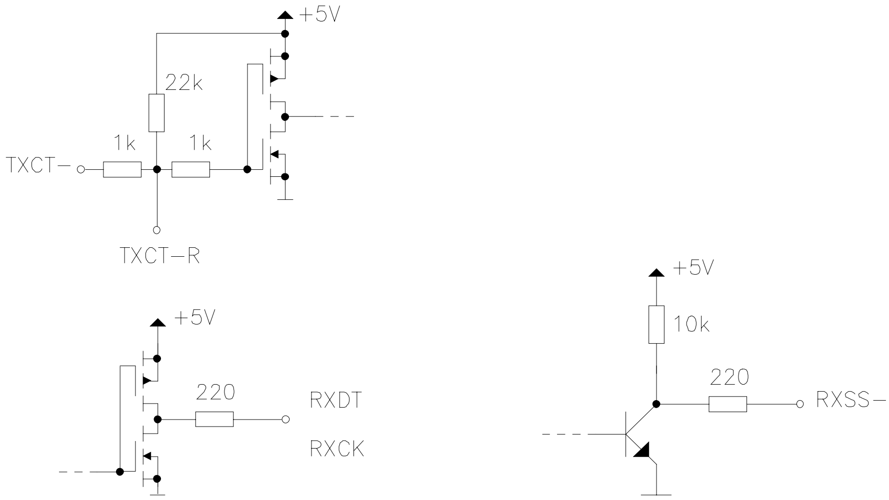


Figure 8: Configurations for Input and Output Signals

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 (= logic LOW level), when the received RF signal strength exceeds a defined level. This threshold level can be adjusted with a potentiometer on the Power RFM. The potentiometer is located near connector J2 (see figure 1).

The RXSS- output is used for detection of other transmitting reading units and thus can be used for wireless read cycle synchronization of several reading units.

2.2 RFM Connectors and Jumpers

2.2.1 Connectors and Signal I/O Configurations

The bottom view of the Power RFM is shown in figure 9. The connector J1 is accessible from the underside. J1 is the 16-pin module connector, this carries the supply voltage lines, the data, and the control lines.

Table 1 lists the pin functions for connector J1.

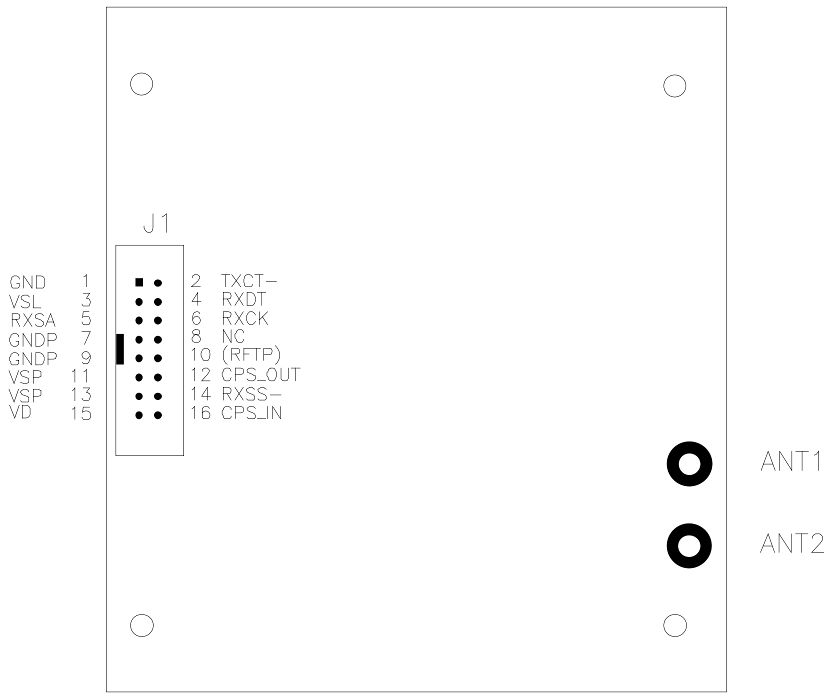


Figure 9: Bottom View

The top view of the Power RFM is shown in figure 1. The connectors J2, J310, J4, J5, J11 and J6 and the antenna terminals are accessible from the top.

Connector J310 is the 3-pin connector for transmitter Carrier Phase Synchronization, connector J6 is used to tune the antenna to resonance using jumper connections to ground, connector J2 is used to connect the Antenna Tuning Indicator for easy antenna resonance monitoring, J4 is used to connect the receive-only antenna, J5 is the 'Receiver Direct Input' connector (for future use) and J11 is the connector to receiver signal strength test pin RSTP. ANT1 and ANT2 are the antenna terminal connectors.

Table 2 lists the pin functions for connector J310. The connector type is 3-pin screw block terminal with a pin spacing of 3.5 mm..

Table 3 lists the pin functions for the ATI connector J2: The connector type is a 6-pole, 2 row pin connector with 2.54 mm pin spacing.

Table 4 lists the pin functions for the antenna terminal connectors: Metric screws M3 are used for connecting the antenna.

Table 5 lists the pin functions for the receive-only antenna connector J4. The connector type is AMP-Quick 828548-2, 2p.

Table 6 lists the pin functions for the receive direct input connector J5. The connector type is AMP-Quick 828548-2, 2p.

Table 7 lists the pin functions for the antenna tuning connector J6. The type is a 14-pole, 2 row pin connector with 2.54 mm spacing.

Table 8 lists the pin functions of the connector J11 for the receiver signal strength test signal RSTP: The connector type is a 2-pin connector with 2.54 mm pin spacing.

The basic configuration of the input signals TXCT- and TXCT-R and the output signals RXDT, RXCK and RXSS- is shown in figure 8.

Table 1: J1 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	NC		No connection
9	GNDP	IN	Transmitter power stage ground
10	(RFTP)		Receiver frequency test pin (no connection allowed)
11	VSP	IN	Supply voltage for transmitter power stage
12	CPS_OUT	OUT	Carrier Phase Synchronization oscillator signal output
13	VSP	IN	Supply voltage for transmitter power stage
14	RXSS-	OUT	Receiver signal strength output (active low)
15	VD	IN/OUT	Internal regulated logic supply voltage output / externally regulated logic supply voltage input
16	CPS_IN	IN	Carrier Phase Synchronization oscillator signal input

CAUTION: The transmitter ground pins GNDP and logic ground pin GND must be connected together externally. Otherwise the Power RFM may be permanently damaged.

Note: *The receiver test pins at the connector J1* ***must not*** *be connected in any way. The test pin for the receiver signal strength RSTP is no longer accessible at connector J1, instead it is accessible at connector J11.*

Table 2: J310 Pin Functions

Pin#	Signal	Direction	Description
1	CPS_OUT	OUT	Carrier Phase Synchronization oscillator signal output
2	GND	IN / OUT	Logic ground
3	CPS_IN	IN	Carrier Phase Synchronization oscillator signal input

Note: *By default pins 1 and 3 of connector J310 are connected together by an external wire bridge at connector J310. If you are using the Power RFM's internal Oscillator (MASTER RFM), ensure that the wire bridge at connector J310 is always properly connected.*

Table 3: J2 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 4: Antenna Connectors

Signal	Description
ANT1	Antenna resonator (capacitor side)
ANT2	Antenna resonator (transformer side)

Table 5: J4 Pin Functions

Pin#	Signal	Direction	Description
1	RX	IN	Receive-only antenna resonator input
2	GNDA	IN	Ground Antenna

Table 6: J5 Pin Functions

Pin#	Signal	Direction	Description
1	RXdirect	IN/OUT	Receiver direct input
2	GNDA	IN	Ground Antenna

Table 7: J6 Pin Functions

Pin#	Signal	Description
1	ATC1	Antenna tuning capacitor 1 (weighted value 1)
2	GNDA	Ground antenna circuit
3	ATC2	Antenna tuning capacitor 2 (weighted value 2)
4	GNDA	Ground antenna circuit
5	ATC3	Antenna tuning capacitor 3 (weighted value 4)
6	GNDA	Ground antenna circuit
7	ATC4	Antenna tuning capacitor 4 (weighted value 8)
8	GNDA	Ground antenna circuit
9	ATC5	Antenna tuning capacitor 5 (weighted value 16)
10	GNDA	Ground antenna circuit
11	ATC6	Antenna tuning capacitor 6 (weighted value 32)
12	GNDA	Ground antenna circuit
13	AMTP	Antenna circuit test point (antenna resonator midpoint)
14	ADTP	Antenna circuit test point (antenna resonator damping)

Notes: *The antenna circuit test pins AMTP and ADTP must not be connected in any way. Pin 14 (ADTP) of connector J6 is cut, in order to avoid possible short circuiting of damping circuit and in order to allow polarizing of Antenna Tuning Switch Box connector.*

The connector J10 is connected in parallel to pins 13 and 14 of J6, and for the reason just given above, should not be used. J10 will be used for further options but is not described in this version of the manual

Table 8: J11 Pin Functions

Pin#	Signal	Direction	Description
1	RSTP	OUT	Receiver signal strength test pin
2	GND	OUT	Ground

2.2.2 Jumpers

The different options, which can be selected by jumpers are described in this section. See figure 10 for the jumper location.

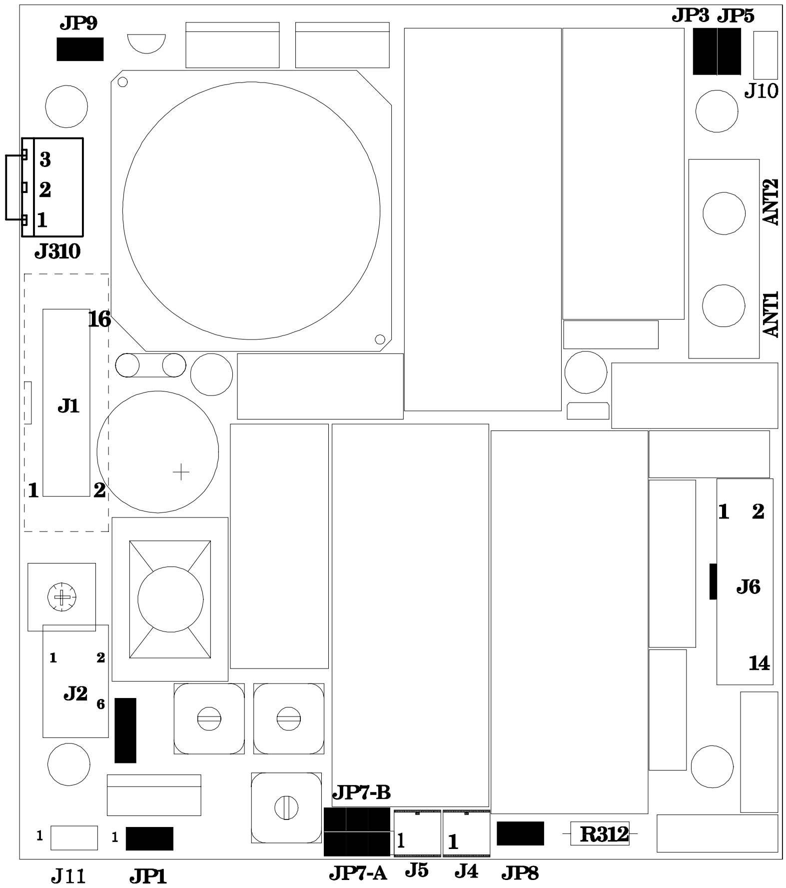


Figure 10: Location of Jumpers

2.2.2.1 Regulated +5 V Logic Supply

The default setting of the jumper is for an unregulated supply voltage for the logic part to be connected to the Power RFM. For this configuration, jumper JP1 is closed. The unregulated supply voltage for the logic must be connected to pin VSL and GND (Pin 3 and 1 of connector J1).

If the logic part of the Power RFM is to be supplied by a regulated +5 V supply, jumper JP1 must be opened. The regulated +5 V supply has to be connected to pin VD and GND (pins 15 and 1 of connector J1).

2.2.2.2 Carrier Phase Synchronization

This is not a jumper, but a wire bridge at the connector J310.

As default setting the wire bridge for transmitter Carrier Phase Synchronization (CPS) is inserted at connector J310, thus configuring the Power RFM as an oscillator MASTER RFM. The oscillator output signal is accessible at pins 1 and 2 (= ground) of connector J310.

To configure the Power RFM as an oscillator SLAVE RFM, remove the wire bridge from connector J310. In this case the oscillator input signal from the oscillator MASTER RFM has to be supplied to pins 3 and 2 (= ground) of connector J310.

Note: *If the wire bridge is not inserted at connector J310, the Power RFM is configured as an oscillator SLAVE RFM, and if there is no oscillator signal input at connector J310 the transmitter will not work.*

2.2.2.3 Pulse Width Modulation

This again is not a jumper. Connection of the resistor R312 to the Power RFM is necessary to set the generated field strength. For more details refer to Section 4.5 “Field Strength Adjustment”.

As default setting, no resistor is connected, thus selecting 50% pulse width, which gives maximum field strength.

Note: *The pulse width setting for adjusting the field strength must be done on each Power RFM individually. The field strength adjustment is not affected by Carrier Phase Synchronization.*

2.2.2.4 Additional Antenna Damping

When a lower charge-up field strength is necessary for larger antennas, there is the possibility to additionally damp the transmit antenna. This allows a lower transmit field strength, whilst the receiver parameters remain unchanged. For this purpose jumper JP5 can be closed to provide an additional 8 dB of damping. For location of jumper see figure 10.

Jumper JP5 is used in combination with the TIRIS Standard gate antenna RI-ANT-G03C to achieve the field strength limits required for some FCC/PTT regulations. Please refer to Section 3.3 “Electrical Characteristics” for the damping factor of this transmit antenna damping option.

As default, jumper JP5 is open.

CAUTION: This damping option can only be used together with the TIRIS standard antennas RI-ANT-G01 and RI-ANT-G03.

In addition, only a certain maximum antenna resonance voltage is allowed for this option. Please refer to Section 3.2 “Recommended Operating Conditions” for details.

2.2.2.5 Selection of Combined Transmit/Receive Antenna or Separate Antennas

The Power RFM allows the use of a combined transmit/receive antenna, or the option of separate transmit and receive antennas.

The combined transmit/receive antenna is connected to the antenna terminals ANT1 and ANT2. For the combined antenna jumper JP7A must be closed at position 2-3 and jumper JP7B must be closed at position 1-2. For location see figure 11.

As default, combined transmit/receive antenna configuration is selected.

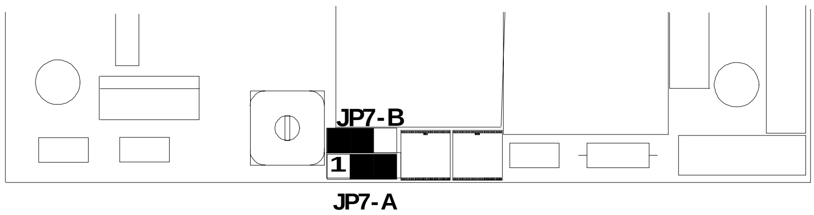


Figure 11: Combined Antenna Jumper Settings (Default)

For separate transmit and receive functions, jumper JP7A must be closed at position 1-2 and jumper JP7B must be closed at position 2-3. For location refer to figure 12.

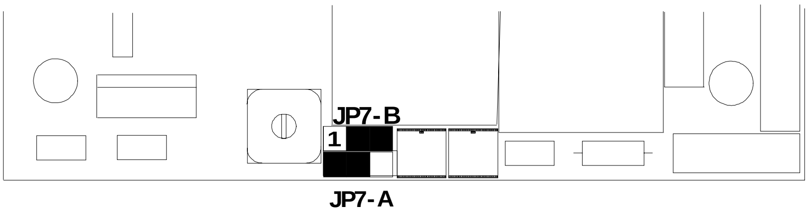


Figure 12: Separate Antenna Jumper Setting

2.2.2.6 Selection of Receive-Only Antenna Type

If the separate transmit/receive antenna option has been selected, there is an additional option of selecting one of two different types of receive-only antenna, which can be used together with the Power RFM. Jumper JP8 is used for this purpose.

When jumper JP8 is open a receive-only antenna should be connected to the connector J4. This receive-only antenna is a tuned resonator (the antenna circuit is shown in figure 6). In order to use the TIRIS standard antennas as receive-only antennas, jumper JP8 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 (refer to figure 7 for an antenna schematic and to Section 4.8 “Receive-only Antenna” for converter board details).

As default, receive-only antenna is selected. This means that jumper JP8 is open.

2.2.2.7 Connection of damping circuit

If antennas other than Standard TIRIS Antennas are used together with the Power RFM, it may be necessary to adapt the damping function of the antenna circuit to this antenna. For this purpose, the damping resistor on the Power RFM can be disconnected from the damping MOS FET via jumper JP3. Then an external damping network can be connected across the pins of connector J10 (see figure 10).

When jumper JP3 is closed, the internal damping circuit is used. This is the default setting.

2.2.2.8 Connecting Power RFM Ground to Earth

If earthing of the Power RFM Ground GNDP is necessary, it is possible to connect the mounting bolt, which is located at connector J310, to the Power RFM Ground GNDP via jumper JP9. Thus the Power RFM Ground GNDP can be earthed. This jumper is open by default.

3. Specifications

3.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)

Logic supply voltage	V_VSL	+26	V DC
Transmitter power stage supply voltage	V_VSP	+26	V DC
Supply current for transmitter power stage	I_VSP	2.5	A DC
Instantaneous power	PI_VSP	65	W
Peak pulse power input to transmitter power stage	P_VSP	35	W
Antenna resonance voltage	V_ANT	400	Vpeak
Antenna resonance voltage (PWM = 25%)	V_ANT-25	220	Vpeak
Antenna resonance voltage for damping option using jumper JP5	V_ANT-D1	70	Vpeak
Output current of internal regulated logic supply voltage VD	I_VD	2.0	mA
Maximum voltage difference between pins GND and GNDP	delta-V	±0.5	V
Operating free-air temperature range	T_oper	-25 to +70	^{o}C
Storage temperature range	T_store	-40 to +85	^{o}C

Note: *Free-air temperature: air temperature immediately surrounding the RF Module. If the module is incorporated into a housing, it must be guaranteed by proper design or cooling that the internal temperature does not exceed the absolute maximum ratings.*

CAUTION: Exceeding recommended maximum ratings may lead to permanent damage to the Power RFM. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

The Power RFM must not be operated in continuous transmit mode, when operated at full Power Output.

Install proper heatsinks when operating the Power RFM at pulse widths smaller than 50%.

3.2 Recommended Operating Conditions

at a free-air temperature of 25 ^{o}C

Symbol	Parameter	min.	typ.	max.	Unit
V_VSP	Supply voltage of transmitter power stage	7.0	12.0	24.0	V DC
I_VSP	Current consumption of transmitter power stage (*Caution: please refer to the formula below this table*)		1.5	2.5	A
P_VSP	Peak pulse power input to transmitter power stage (I_VSP * V_VSP * Duty Cycle)			30	W
V_ANT	Antenna resonance voltage		250	380	Vpeak
V_ANT-25	Antenna resonance voltage (Pulse width setting = 25%)			200	Vpeak
V_ANT-D1	Antenna resonance voltage for damping option using jumper JP5		50	60	Vpeak
V_ANT-ATI	Minimum antenna resonance voltage for correct operation of ATI accessory	25			Vpeak
V_VSL	Supply voltage input for logic part	7.0		24.0	V DC
I_VD	External current load on internal regulated logic supply voltage output			1.0	mA

In order to keep the power consumption (P_VSP) below 30 W it is advisable to limit I_VSP. The maximum allowable I_VSP can be determined as follows (in the following examples we have used a supply voltage of 24 V_VSP):

$$I\_VSP = \frac{P\_VSP}{V\_VSP \times \text{Duty Cycle}}$$

where: $$\text{Duty Cycle} = \frac{\text{Power on time}}{\text{Total Read Cycle Time}}$$

Example 1: Using Standard/Default Settings (≈10 read cycles/second):

$$I\_VSP = \frac{30W}{24V \times 0.5} = 2.5A \qquad \text{Duty Cycle} = \frac{50}{100} = 0.5$$

Example 2: Configured to No Sync (≈12 read cycles/second):

$$I\_VSP = \frac{30W}{24V \times 0.625} = 2A \qquad \text{Duty Cycle} = \frac{50}{80} = 0.625$$

The following methods can be used to measure the actual I_VSP value:

1. Use a battery powered oscilloscope to measure the voltage drop across a 0.1 Ω resistor placed in the DCIN+ line, and then calculate the actual current using the formula I = V/R.
2. If you do not have a battery powered oscilloscope, measure the potential at both sides of the resistor (signal scope probe) with the GND scope probe at DCIN- and determine the potential difference.

Ensure that the measured I_VSP value does not exceed the calculated value (using the above formula).

3.3 Electrical Characteristics

Symbol	**Parameter**	**min.**	**typ.**	**max.**	**Unit**
V_VD	Internal regulated logic supply voltage output at pin 15 of connector J1	4.75	5.0	5.25	V
I_VSL	Supply current for logic and receiver part in transmit and receive mode	14	18	22	mA
ViL	Low level input voltage of TXCT-	0	0.4	0.8	V
ViH	High level input voltage of TXCT-	2.4		5.0	V
VoL	Low level output voltage of RXDT and RXCK	0	0.4	0.8	V
VoH	High level output voltage of RXDT and RXCK	4.0		VD	V
VoL_R	Low level output voltage of RXSS-			0.8	V
VoH_R	High level output voltage of RXSS- (see note below)			VD	
Fan-In	Low Power Schottky compatible fan-in of signals TXCT- (Iin = -400µA)			1	-
I_IN-TXCT-	Input current for TXCT- signal, when the Accessory Module RI-ACC-ATI2 is connected	2.0	2.5	3.0	mA
Fan-Out	Low Power Schottky compatible fan-out of signals RXDT and RXCK			3	-
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)				
RX_sens	Receiver sensitivity for a clear data demodulation (necessary signal voltage at antenna resonator) * signal fed in at between GNDA and ANT1		200		µV
V_RXSA	Voltage level at pin RXSA for minimum and maximum RXSS- sensitivity (for voltage input, as well as for voltage output)	0		1.6	V
l_RXSA	Cable length for connecting external resistors to RXSA using twisted pair line (for details refer to Section 4.6 “RXSS-Threshold Adjustment”)	0	0.5	5.0	m
l_J1	Cable length for connecting J1 of the Power RFM to a Control Module using flat cable	0	0.5	2.0	m

Note: *RXSS- has an internal pull-up resistor of 10 kOhm. Therefore the parameter VoH_R, depends on application specific external components.*

3.3 Electrical Characteristics (continued)

Symbol	Parameter	min.	typ.	max.	Unit
l_CPS	Cable length for connecting the Carrier Phase Synchronization signal between two Power RFMs	0	1.0	5.0	m
n_CPS	Number of oscillator SLAVE Power RFMs, which can be driven from one oscillator MASTER Power RFM	1		5	-
R_JP5	Additional antenna damping resistor R_JP5 (+/- 5%)	158	166	175	Ohm
d_R_JP5	Additional field strength damping, when using jumper JP5 in combination with RI_ANT-G03C		8		dB
Com_Mode	Common Mode Noise reduction ratio for noise coupled to both antenna terminals ANT1 and ANT2		20		dB
R_DAMP	Antenna damping resistor (+/-2.5%)	48	50	52	Ohm
R_GND	Decoupling resistor between GND and GNDP (+/- 5%)	64.6	68	71.4	Ohm
C_ATC1	Antenna tuning capacity (+/-5%)	646	680	714	pF
C_ATC2	Antenna tuning capacity (+/-5%)	1.43	1.5	1.58	nF
C_ATC3	Antenna tuning capacity (+/-5%)	3.14	3.3	3.47	nF
C_ATC4	Antenna tuning capacity (+/-5%)	5.89	6.2	6.51	nF
C_ATC5	Antenna tuning capacity (+/-5%)	10.9	11.5	12.1	nF
C_ATC6	Antenna tuning capacity (+/-5%)	20.9	22	23.1	nF
C_ANT	Total antenna resonator capacity (+/- 5%)	44.6	47.0	49.4	nF
I_VSP-50	Current consumption of transmitter power stage together with antenna RI-ANT-G02C and pulse width setting of 50% * VSP=12V		1.9		A DC
I_VSP-37	Current consumption of transmitter power stage together with antenna RI-ANT-G02C and pulse width setting of 37% * VSP=12V		1.5		A DC
I_VSP-25	Current consumption of transmitter power stage together with antenna RI-ANT-G02C and pulse width setting of 25% * VSP=12V		1.1		A DC
I_VSP-12	Current consumption of transmitter power stage together with antenna RI-ANT-G02C and pulse width setting of 12% * VSP=12V		0.5		A DC

3.4 Timing Characteristics

Symbol	**Parameter**	**min.**	**typ.**	**max**	**Unit**
t_TX	Transmit burst length for correct operation (see note below)	5	50	100	ms
f_OSZ	Internal oscillator frequency	17.174	17.177	17.180	MHz
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
f_dem	Data demodulation threshold frequency between LOW and HIGH bit		129.5		kHz
t_dtck	Delay time from beginning of data bit at RXDT being valid to positive slope of RXCK signal	20			µs
t_dtvd	Time for data bit of RXDT signal being valid after positive slope of RXCK	90			µs
t_ckhi	Time for clock signal RXCK being high	55			µs
t_ri t_fi	Necessary rise and fall times for input signal TXCT- and TXCT-R			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- (no external connection)			1	µs
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 ANT1 and ANT2 and for short circuit of ANT1 or ANT2 to GNDA			10	s

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

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 Power RFM.

3.5 Mechanical data

The mechanical data is given in the table below.

Parameter	typical	Unit
Height of complete Power RFM (including mounting bolts)	44.0 +/- 1.5	mm
Weight of complete Power RFM	270	g

The Power RFM heatsink has the option of two M3 press nuts on the top of the Power RFM to allow it to be screwed to another heatsink. See figure 13 for position of these press nuts.

Note: *The heatsink is connected to the antenna resonator ground GNDA. When connecting the heatsink to a housing, the heatsink must be insulated from the housing.*

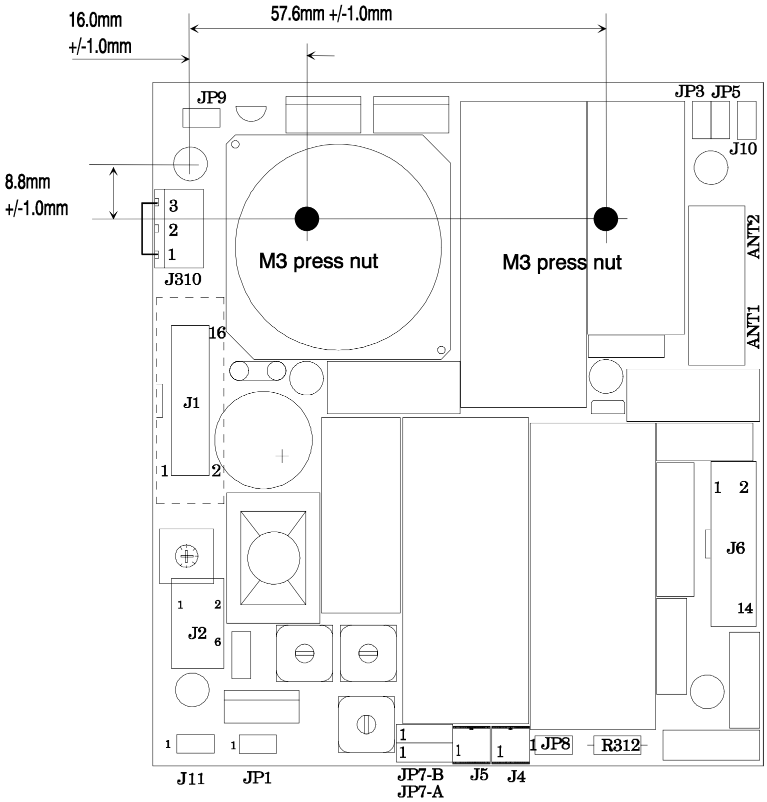


Figure 13: Optional Position of M3 press nuts on heatsink

The mechanical data is given in figure 14. All measures are in millimeters with a tolerance of +/- 0.25 mm (unless otherwise noted).

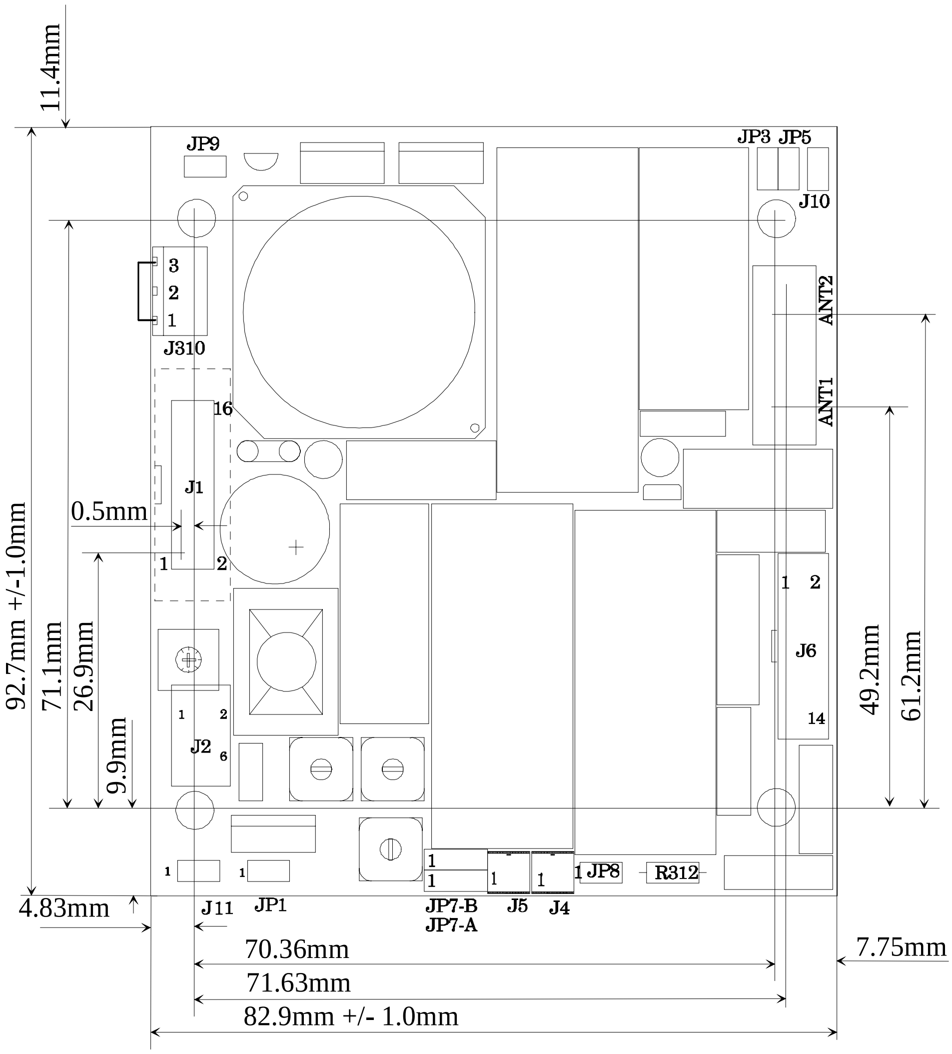


Figure 14: Mechanical Dimensions

4. Installing the Power RFM

4.1 Power Supply

4.1.1 Supply Requirements

The logic and receiver part of the Power RFM must be supplied via the VSL and GND pins with unregulated voltage.

As an option, the logic and receiver part can also be connected to an external regulated +5V supply. For this purpose jumper JP1 has to be opened (for location refer to Section 2.2 “RFM Connectors and Jumpers”). Then the regulated +5 V supply has to 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 Power RFM and as the transmitter power stage needs a regulated supply voltage in order to meet FCC/PTT regulations, the supply voltage for the transmitter power stage must be regulated externally. For voltage supply range please refer to Section 3 “Specifications”.

Note: *The Power RFM should not be supplied by Switched Mode Power Supplies (SMPS) as most SMPS operate at frequencies around 50 kHz. The harmonics of the generated field can interfere with the TIRIS receiver. Therefore only linear power supplies, or SMPS with* ***a fundamental operating frequency of 200 kHz or higher*** *are recommended.*

Also, 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 4.9 “Noise Verification” and Section 4.10 “Over Voltage Protection”.

In order to guarantee full Power RFM performance, the power supplies should fulfill the specifications for ripple voltage given in table 9.

Table 9: Power Supply Ripple Specifications

Supply type	**Maximum allowed Ripple Voltage**	**Allowed Ripple Frequency**
Unregulated VSL supply	30 mVrms	0 to 100 kHz maximum (sinusoidal)
Regulated +5 V VSL supply	300 µVrms	0 to 100 kHz maximum (sinusoidal)
Regulated VSP supply	50 mVrms	0 to 50 kHz maximum (sinusoidal)

Table 10 lists the typical current consumption of the transmitter power stage and the antenna voltage for the TIRIS Standard Antennas, when the Power RFM transmitter power stage is supplied with VSP = 12V at a pulse width of 50%.

Table 10: Current consumption and Antenna voltage for TIRIS Standard Antennas
(for VSP = 12V and 50% pulse width)

Antenna type	**Typical Transmitter Supply Current**	**Typical Antenna Resonance Voltage**
RI-ANT-S01C	2.0 Amperes DC	270 Vp
RI-ANT-S02C	2.0 Amperes DC	270 Vp
RI-ANT-G01C	1.6 Amperes DC	210 Vp
RI-ANT-G02C	1.9 Amperes DC	250 Vp
RI-ANT-G03C	1.5 Amperes DC	190 Vp

4.1.2 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 only 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 Control Module (see figure 15). 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 Power RFM and the Control Module 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 Control Module. This can again be avoided by connecting the grounds externally in any of three different ways (see figure 15):

a. For cable lengths of up to 0.5 m between the Power RFM and Control Module, the RFM ground pins GND and GNDP must be connected at the Control Module, as shown in figure 15. Here the grounds for the VSP, VSL and the Control Module supply are all connected together at the common ground.

   Alternatively, 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 be connected together at the Power RFM.

   If your system has a TIRIS Control Module, the Power RFM 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 Control Module in order to avoid logic level compatibility problems caused by the voltage drop across the VSP supply lines (see figure 15).

   In this case, connecting the ground pins at the Power RFM 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 Power RFM and the Control Module should be done via a differential interface (for example: RS422). Because of different ground potentials at different locations it may also be necessary to provide galvanic separation of the interface signals by, for example: opto-couplers.

   In this case, to avoid problems with difference voltages between GND and GNDP, these pins must always be connected directly at the Power RFM. A shorting bridge is necessary as close as possible to the Power RFM for this purpose, as shown in figure 15.

CAUTION: The voltage between GND and GNDP must not exceed ±0.5 V. Otherwise the Power RFM will be damaged.

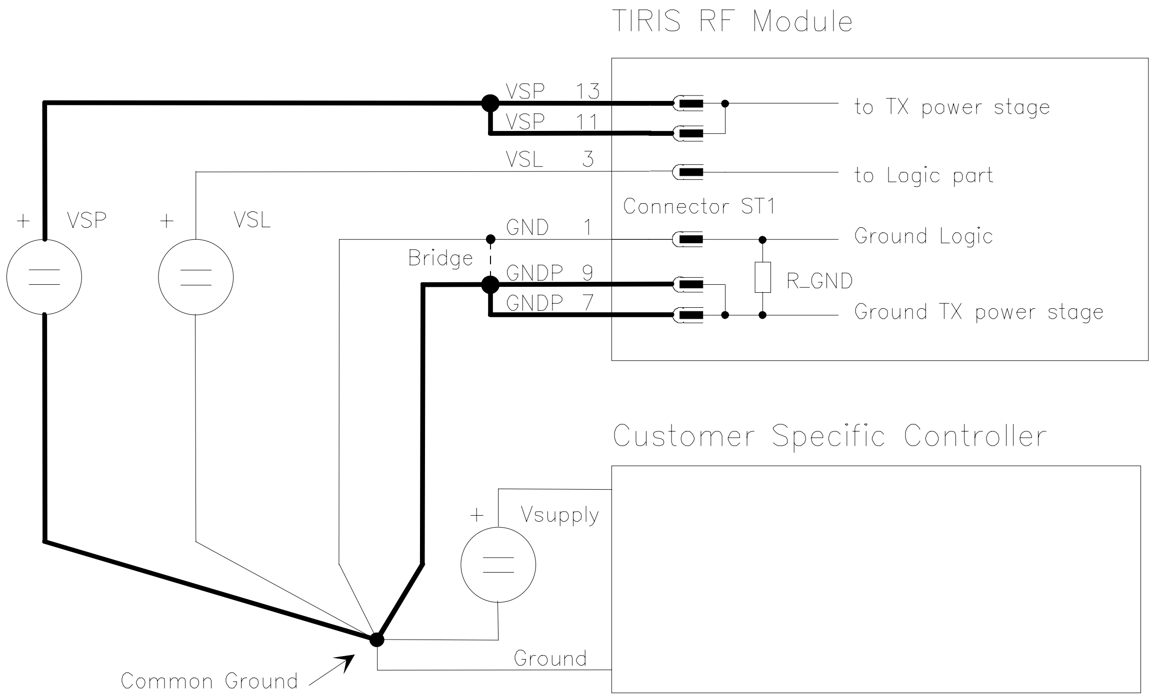


Figure 15: External Ground Connection (GND to GNDP)

4.2 Antenna Requirements

The transmit antenna for the Power RFM (which is used to charge up the transponder) is a coil (see figure 5). This coil is part of the antenna resonance circuit (see figure 2).

In order to achieve the high voltages at the antenna resonance 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 11. 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 using RF litze-wire with maximum single wire diameter of 0.1 mm (4 mil) for winding an antenna. In addition we recommend the use of RF litze-wire with at least 120 single insulated wires.

Note: *If such a high Q is not required (for example: large in-ground antennas), standard litze wire or sufficiently well insulated oxygen free wire can be used.*

In order to make sure that the transmitter and receiver work properly , the antenna must be tuned to the resonance frequency f_TX. For a detailed description of the antenna resonance tuning procedure, refer to Section 4.3 Antenna Resonance Tuning”.

To ensure that the antenna can be tuned to resonance with the Power RFM, the antenna inductance can only vary within the limits given in table 11.

Table 11: Antenna Characteristics

Parameter	**Conditions**	**min.**	**typ.**	**max.**	**Unit**
L_ANT	Antenna inductance range, within which the antenna can be tuned to resonance	26.0	27.0	27.9	µH
Q_ANT	Recommended quality factor of antenna coil for proper operation	100		150	-

Basically there are two kinds of antenna: gate antennas and ferrite core 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 decreases, 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).

4.3 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 capacitance of the antenna resonator.

To compensate the tolerances of the antenna coil and the capacitors, six binary weighted tuning capacitors (C_ATC1 to C_ATC6) have been built-in (refer also to figure 4). Their values are weighted in steps of 1, 2, 4, 8, 16 and 32, where C_ATC1 has the smallest value corresponding to the factor 1. C_ATC2 has double the capacity of C_ATC1, so that C_ATC2 corresponds to the factor 2 and so on. Each of the 6 tuning pins has an adjacent ground pin for antenna tuning, using shorting bridges (jumpers).

HINT: It is strongly recommended to use the TIRIS Accessory 'Antenna Tuning Switch' Box RI-ACC-ATS1 for operating the tuning capacitors on the Power RFM, when tuning the antenna to resonance.

In order to make it easier to plug the Switch Box to the connector J6 , an arrow is printed onto the PCB to show where to put the polarization nose (see also connector J6 on figure 1).

When you tune the antenna, the resonance condition must be monitored. This can be done using either of the methods described following:

<u>A) Monitoring Generated Field Strength</u>

Monitor the field strength generated by the Power RFM 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 measured voltage has reached its maximum value.

For this method, the Power RFM must be switched into repetitive transmit mode, by operating it from a Control Module. Therefore this method can only be used together with a Control Module.

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

- An additional pick-up coil and an oscilloscope
- An additional pick-up coil and a standard voltmeter
- Measure the voltage across ANT 1 & 2 (be careful as high voltage is present on these terminals)), refer to the CAUTION below:

CAUTION: If an oscilloscope is used for this measurement, the voltage must be measured between ANT 1 and the Power Supply ground, or ANT 1 and the signal ground.

For sensor unit alternatives see figure 16.

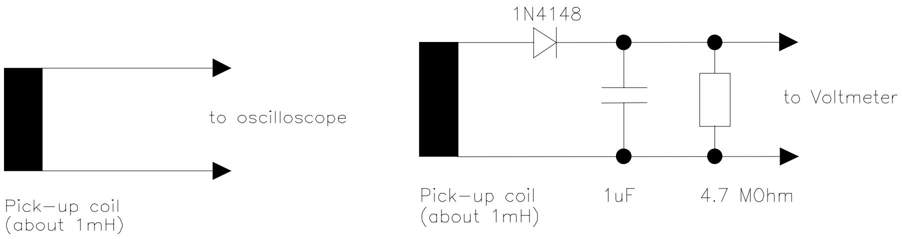


Figure 16: Antenna Tuning Pick-up Coils

HINT: As the Power RFM 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. This means that the pick-up coil can be placed further away from the antenna.

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-ATI2.

This tool offers the feature of operating the transmitter in pulsed mode, independently to the Control Module. Additionally it indicates by LEDs, whether the tuning capacity has to be increased or decreased (IN = increase and OUT = decrease) 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.

Following notes refer to antenna resonance tuning in general:

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 Power RFM with an already tuned ferrite core antenna (for example: RI-ANT-S01C) is changed more than 50%, the ferrite core antenna has to be re-tuned 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 Power RFM and this results in the special tuning jumper arrangement for this combination of antenna and Power RFM only. If a different antenna is connected to the Power RFM, the new combination has to be tuned to resonance again!

<u>The tuning procedure flow is as follows:</u>

* Switch Power RFM power supply off
* Connect the antenna to the Power RFM by means of the two M3 screw connectors
* Install antenna tuning monitoring unit.
* Switch Power RFM power supply on
* Tune antenna to resonance by changing the tuning capacity
* Switch Power RFM power supply off
* Disconnect monitoring unit
* Switch Power RFM power supply on again

==> Antenna resonance tuning is complete!

Tuning a 'new' antenna to the RF Module is started with no jumpers (shorting bridges) connected. While monitoring the resonance condition (according to method A or B described above), the jumpers must be plugged in or out (==> connecting and disconnecting the tuning capacitors) in such a way that the total tuning capacity will increase in steps of the smallest tuning capacity C_ATC1.

The 'counting-up' of the binary weighted tuning capacitors is done in the following way:

> First no jumpers are plugged in.
> Next, connect C_ATC1.
> Then disconnect C_ATC1 and connected C_ATC2.
> For the next step connect both C_ATC1 and C_ATC2 (and so on).

See also the flow chart in figure 18 and the corresponding example.

The tuning steps do not show an absolutely continuously increasing function, this is because of unavoidable component tolerances. Therefore it may happen, when the tuning value is increased by one binary step, that the total tuning capacity actually **decreases** (especially from tuning step 31 to 32). This can result in the generated field strength not steadily increasing (as shown in figure 17).

This is not true, when using the Antenna Tuning Indicator tool (ATI). The indicated resonance condition there is always correct.

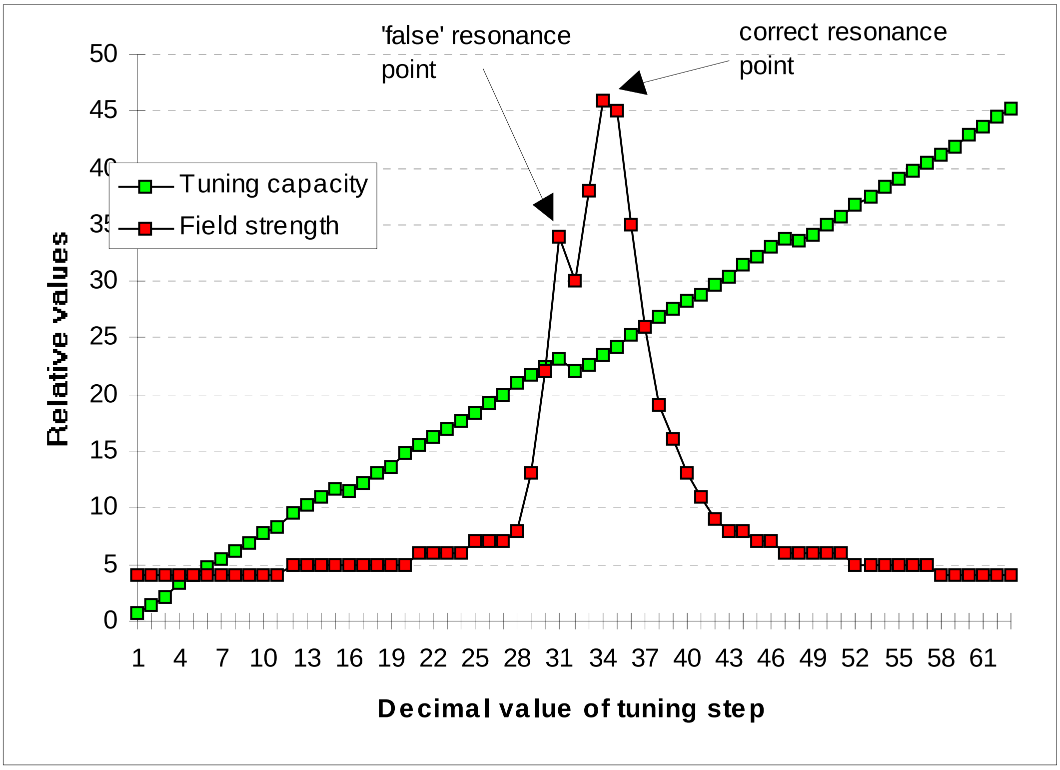


Figure 17: Tuning example showing increase of total tuning capacity and generated field strength (typical values)

Therefore it is recommended to do the resonance tuning according to the flow-chart shown in figure 18.

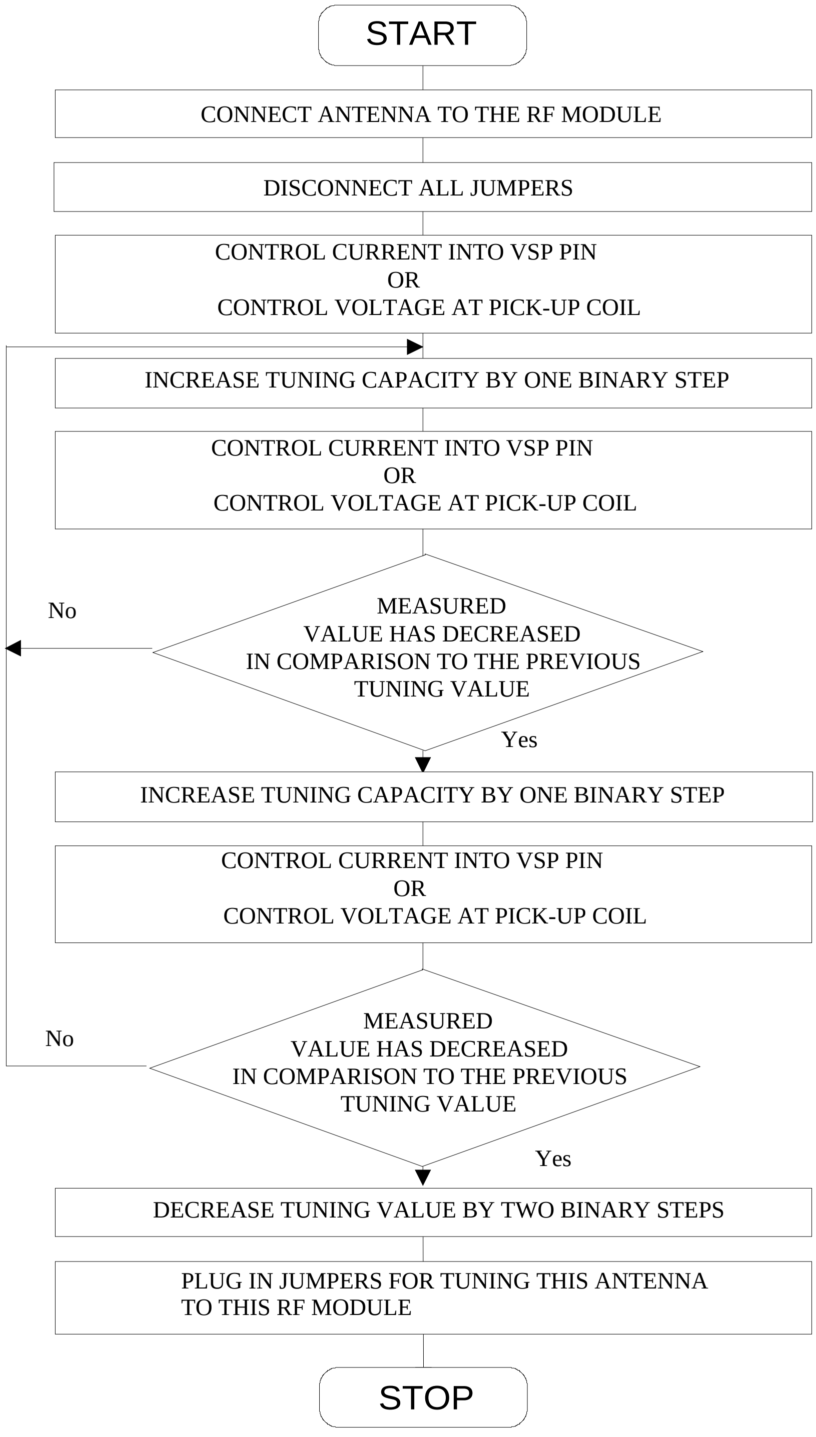


Figure 18: Flow-chart for tuning the antenna to resonance

The following example shows the jumper arrangement at the connector J6 and the induced voltage at a pick-up coil, when tuning an antenna to resonance (the voltage values for the pick-up coil are just relative values):

Example: Tuning an antenna to resonance

Connector J6						Induced voltage at a pick-up coil	Tuning step (decimal value)	Comment
ATC6	ATC5	ATC4	ATC3	ATC2	ATC1			
-	-	-	-	-	-	40	0	
-	-	-	-	-	X	40	1	
-	-	-	-	X	-	40	2	
-	-	-	-	X	X	42	3	
-	-	-	X	-	-	42	4	no significant change
-	-	-	X	-	X	42	5	of generated field
-	-	-	X	X	-	45	6	strength

and so on

-	X	X	X	X	-	220	30	
-	X	X	X	X	X	340	31	not real maximum
X	-	-	-	-	-	300	32	
X	-	-	-	-	X	380	33	
X	-	-	-	X	-	**450**	34	**real maximum**
X	-	-	-	X	X	440	35	
X	-	-	X	-	-	350	36	
X	-	-	X	-	X	260	37	
X	-	-	X	X	-	190	38	

(**-** means jumper **not plugged in**, **X** means jumper **plugged in**)

Result: Antenna is tuned to resonance at step 34. For this antenna and Power RFM combination, plug in jumpers at position ATC6 and ATC2.

Note: *When changing the pulse width for operating the transmitter power stage, the antenna has to be retuned to resonance.*

4.4 Expanding Antenna Tuning Inductance Range

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

- when TIRIS 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.

It is possible to expand the tuning range of the antenna inductance by using the TIRIS Antenna Inductance Expansion Module RI-MOD-LEXx or by connecting additional capacitors as described following.

Note: *Please remember that the capacitors of external modules have to be able to withstand higher voltages when used together with the Power RFM.*

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 resonance 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 1250V DC operating voltage
- Capacitance tolerance: max. ±5%
- Type: SIEMENS "KP" or WIMA "FKP1"

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

The antenna tuning inductance range can be decreased to 13.7 µH in six ranges, as shown in figure 19 and table 12.

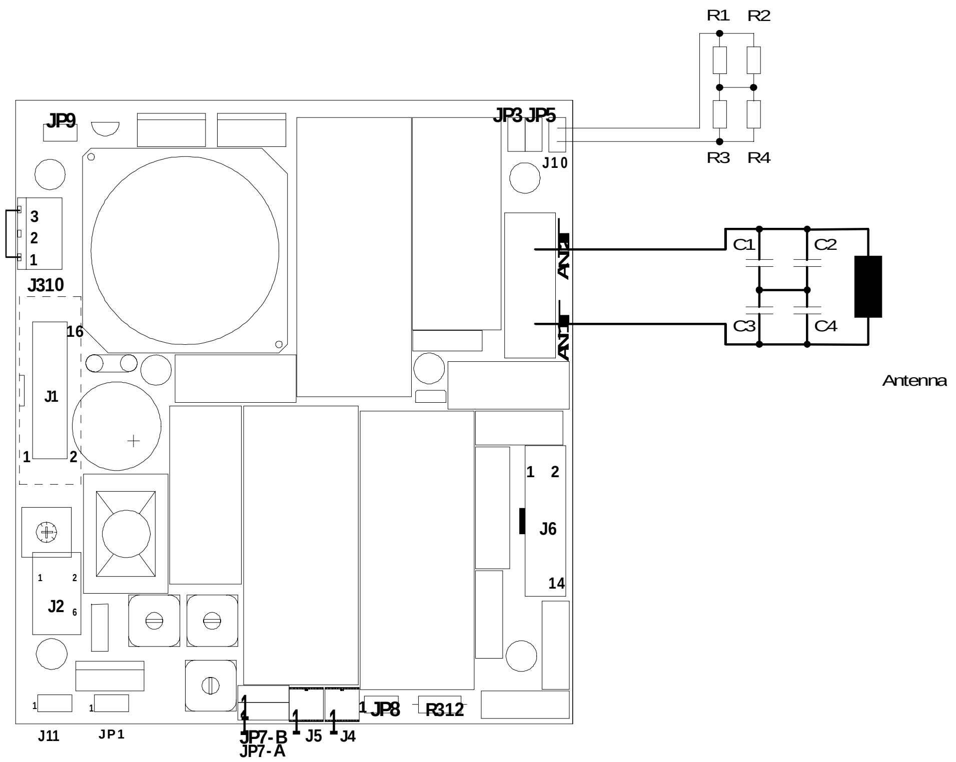


Figure 19: Circuit for Expanding Antenna Tuning Range to Lower Values

Table 12: Capacitor and Resistor Values for 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 20 and table 13.

As shown in figure 20, 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 1250 Vdc 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 13. Also, the damping function has to be modified by connecting additional resistors to the antenna damping circuit.

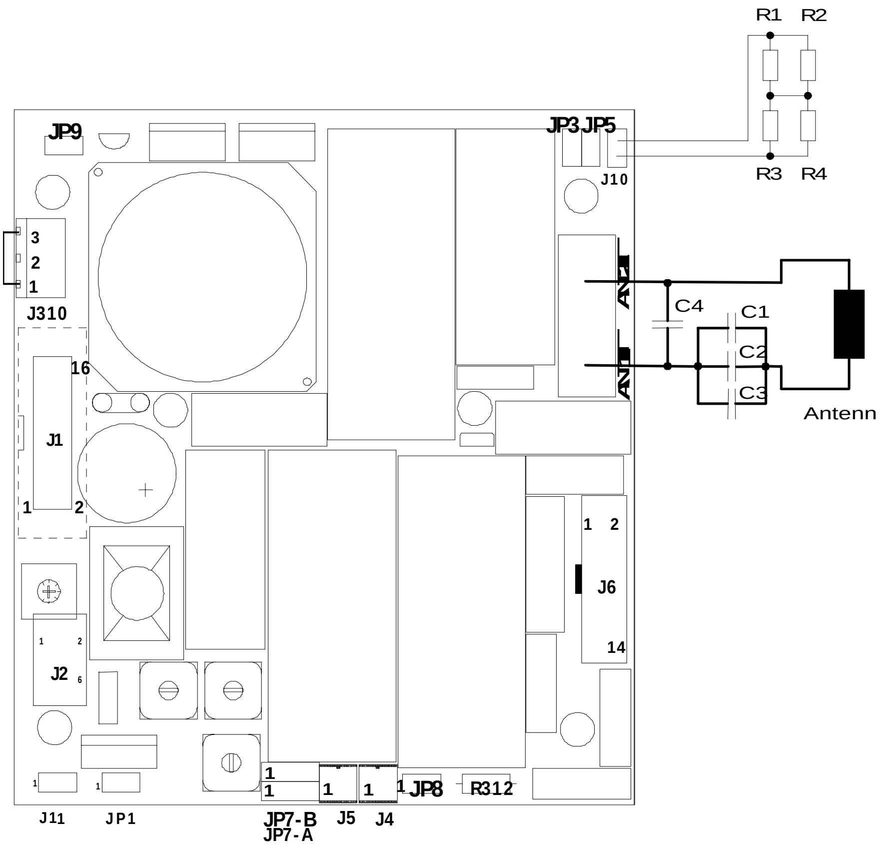


Figure 20: Circuit for Expanding Antenna Tuning Range to Higher Values

Table 13: Capacitor Values 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 nF	R1, R2, R3, R4 = 180 Ohm
33.9 µH to 35.0 µH	C4 = 3.98 nF (parallel 3.3 nF, 0.68 nF)	R1, 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 TIRIS 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 do have to use such an antenna, no additional damping resistors are necessary.*

Therefore 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 TIRIS antennas

4.5 Field Strength Adjustment

The generated magnetic field strength determines the charge-up distance of the transponder. The higher the magnetic field strength, the further 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 Power RFM 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 Power RFM (assuming that all other parameters remain unchanged).

   The quality factor of the antenna itself depends on the cross-section 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 higher 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 Power RFM, 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 Power RFM power stage.

   The higher the supply voltage of the Power RFM transmitter power stage (VSP voltage), the higher the field strength which is generated by the Power RFM (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 Power RFM, 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 3.

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 Power RFM transmitter power stage **and** by selecting the corresponding oscillator signal pulse width.

In cases, when low field strengths should be generated with large antennas (RI-ANT-G01C and RI-ANT-G03C), the antenna resonator can additionally be damped by closing jumper JP5.
Using this optional damping function gives the advantage that the field strength can again be fine tuned to meet FCC/PTT 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 TIRIS standard antennas RI-ANT-G01C and RI-ANT-G03C. In addition, only a certain maximum antenna resonance voltage is allowed for this option. Please refer to Section 3.2 “Recommended Operating Conditions” for details.

4.5.1 Adjustment of Oscillator Signal Pulse Width

The Power RFM has the 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 50% down to 0%.

For this purpose there is a pulse width setting resistor (R312) on the Power RFM (see figure 1 for location). Inserting a smaller resistance value for R312 decreases the pulse width is and thus also the field strength. As default, no resistor R312 is connected. Thus the maximum pulse width of 50% and maximum field strength is selected. By connecting a shorting bridge for resistor R312, the smallest pulse width of about 0% is selected.

Table 14 provides an overview of oscillator signal pulse width and corresponding field strength reduction when different oscillator signal pulse widths are selected by connecting different values for resistor R312.

The generated field strength is nearly linear to the Transmitter Power Stage supply voltage. Therefore, if you increase the Transmitter Power Stage Supply voltage by factor 2, the generated field strength doubles, which calculates 6 dB more in field strength.

Table 15 provides an overview of field strength levels for TIRIS Standard Antennas used together with the Power RFM. The values given in table 15 are reduced by the corresponding values given in table 14, when different pulse widths are selected.

Table 14: Oscillator Signal Pulse Width Versus Resistor R312 Value

Resistor value for R312 [kΩ]	**Oscillator signal pulse width [%]**	**Field strength reduction [dB]**
open	50	0
151	37	-3
59	25	-6
17	12	-12
10	6	-18
shorted	0	∞

CAUTION: When using pulse widths smaller than 50%, the Power RF Module transmitter power stage works in a less efficient way. This leads to an increased power dissipation and thus to higher temperature increase of the transmitter power stage.

Ensure that the antenna resonance voltage does not exceed 200 Vp when the selected oscillator signal pulse width setting is smaller than 25%.

Table 15: Field strength levels for TIRIS Standard Antennas
used together with Power RFM (conditions: VSP = 12 VDC, pulse width = 50%, simulation values)

Antenna type	**Peak Field strength level at 3m in dBμV/m**
RI-ANT-G01C	142
RI-ANT-G02C	134
RI-ANT-G03C	149

Note: *The pulse width for the oscillator signal pulse width setting of 5% and smaller is very short. The pulse response of the Power RFM transmitter power stage to this short pulse is different for each Power RFM. Therefore in order to have reproducible field strength values for different Power RFMs, it is recommended to* ***not use*** *the smallest pulse width setting.*

In the following section you will find a flow description for adjusting the field strength according to FCC/PTT values in combination with TIRIS 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 customised antennas. For more details see 'Antenna Reference Guide' (Manual number 22-21-007).

* Find out corresponding field strength regulation for the country. As guideline see Appendix A: PTT/FCC regulations”.

* Select antenna type (determined by the application, see also '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/PTT value, as given in tables 14 and 15. Select corresponding pulse width on the Power RFM.

* If necessary, use optional antenna damping function, when low field strength is needed for large antennas.

Note: *For proper adjustment of the field strength according to FCC/PTT values, especially for customised 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.*

4.6 RXSS- Threshold Level Adjustment

The Power RFM 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 Control Module software monitors the RXSS- signal to detect whether other reading units are transmitting. This means that the Control Module can operate the transmitter of the Power RFM 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 Power RFM. This needs to be done, after the antenna has been tuned to resonance.

It is recommended to use a small screwdriver to adjust the RXSS- threshold level. The RXSS- threshold level adjustment potentiometer is located on the upper side of the Power RFM PCB near connector J1 (see figure 1).

Turning the potentiometer all the way clockwise (right-hand stop), results in minimum threshold sensitivity, this means that the RXSS- signal will be activated at high receive field strength. This is the default position and can be used for standard gate antennas. The sensitivity can be increased when you are using ferrite core antennas. If there is high noise level in the area, it is necessary to adjust the RXSS- threshold level.

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 J2 (using a jumper).

* Ensure that no other reading units are transmitting, by connecting pin 1 to pin 3 of connector J2 (jumper) of all other Power RFMs in the area.

* Monitor the voltage at RXSS- output pin with a voltmeter or an oscilloscope

* Turn the RXSS- threshold level adjustment potentiometer on the Power RFM 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).

* Remove all jumpers connected to J2

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-S01C) 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 Control Module would all the time assume that another reading unit is transmitting and would all the time try to synchronise to this other reading unit. Therefore the reading repetition rate would decrease (from approximately 10 to approximately 5 readings per second for TIRIS Control Modules). In addition, this reading unit can no longer synchronise 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 Power RFM 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 so that no spikes occur on the RXSS- signal output, because they lead to incorrect synchronization function. Therefore an oscilloscope should be preferred for adjusting the threshold level.

HINT: It is strongly recommended to 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 Power RFM is necessary, we recommend that you use twisted pair lines and connect a ceramic capacitor of 100 nF as close as possible to the pins RXSA and GND of the Power RFM.

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 Section 3: "Specifications".*

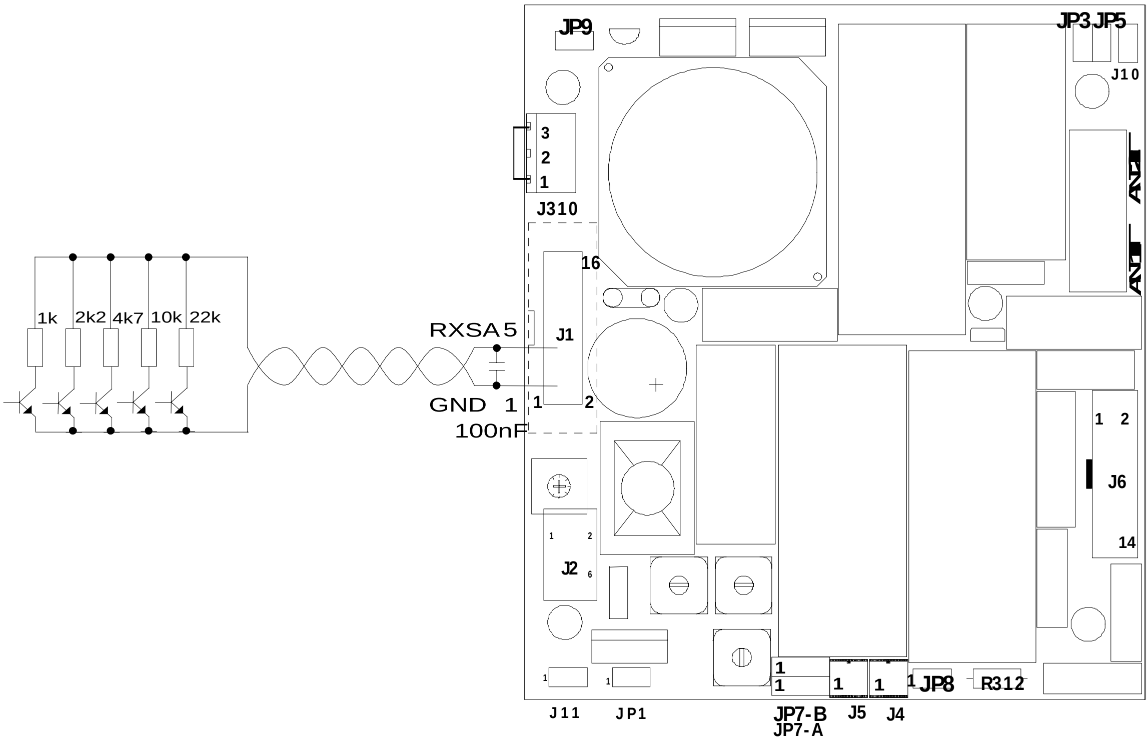


Figure 21: Adjusting RXSS with External Resistors

4.7 Transmitter Carrier Phase Synchronization (CPS)

In some applications it is necessary to use several charge-up antennas close to each other. Under these circumstances, 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 Power RFMs.

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 tuneable to resonance. For details see 'Antenna Reference Manual' (Manual number 22-21-007).*

This effect will not occur if the transmitters of different Power RFMs are operated from the same oscillator signal. This is the reason that the pulse width modulated oscillator signal is accessible at the connector J310. All Power RFMs to be driven by one oscillator must have their J310 connectors connected together as shown in figure 22.

A wire bridge at connector J310 determines whether the internal oscillator or the external oscillator signal is used. When the wire bridge is inserted between pins 1 and 3 of connector J310, the internal oscillator is used and the Power RFM is referred to as an oscillator MASTER RFM. When there is no wire bridge, the external oscillator signal is used and the Power RFM is referred to as an oscillator SLAVE RFM (see also figure 1).

Note: *Only one oscillator MASTER RFM is allowed per synchronised system. Ensure that the wire bridge at connector J310 is always properly connected for a MASTER RFM.*

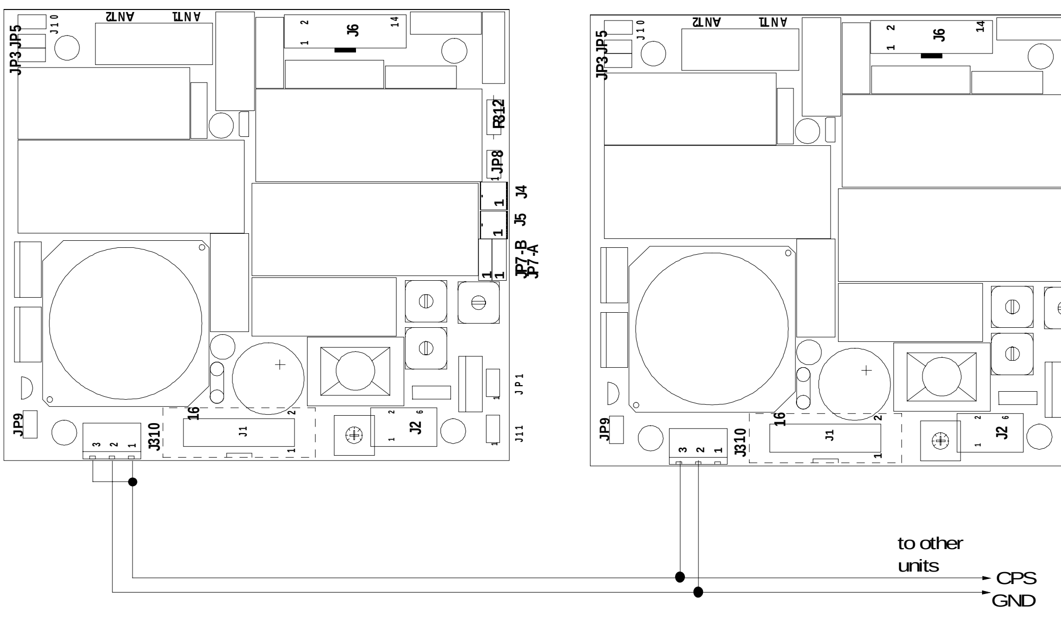


Figure 22: Connecting RFMs together for "MASTER/SLAVE" Oscillator Configuration

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 by more than about 5% of the full amplitude it is appropriate to use wired transmitter carrier phase synchronization as shown in figure 22.

In addition, the distances given in table 16 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 16, you should check for beat effect. The values given in table 16 refer to the distances shown in figure 23 and are valid for maximum charge-up field strength.

Figure 23: Distance between Antennas (top view)

Table 16: Maximum Distances Between Antennas

Antenna type	**Distance D1 [m]**	**Distance D2 [m]**
RI_ANT_S01 <=> RI_ANT_S01C	1.0	0.8
RI_ANT_S02 <=> RI_ANT_S02C	1.0	0.8
RI_ANT_G01 <=> RI_ANT_G01C	1.7	1.5
RI_ANT_G02 <=> RI_ANT_G02C	1.3	1.0
RI_ANT_G03 <=> RI_ANT_G03C	2.0	1.7

CAUTION: Use over voltage protection components at the CPS connector for CPS lines between 0.5 and 5m.

Note: *Keep in mind that when using the transmitter Carrier Phase Synchronization feature, it is absolutely necessary that the read cycles of each of the different Control Modules are synchronised. When the transmitter of the oscillator MASTER RFM is not activated by its Control Module, the oscillator signal output of the oscillator MASTER RFM is disabled. This means that all the oscillator SLAVE RFMs have no transmitter oscillator input signal and thus none of the oscillator SLAVE RFMs are able to transmit.*

Therefore the read cycles of all Power RFMs connected to this CPS interface must be synchronised and all read cycles must occur ***simultaneously!***

Refer to the Hardware and Software Manuals for the TIRIS Control Modules for more information about the wiring and settings that have to be done to synchronize the Power RFM, when using transmitter Carrier Phase Synchronization (CPS).

If an application requires more than one Power RFM to be used, or a longer Carrier Phase Synchronization line than that specified in Section 3 “Specifications”, it is necessary to drive the pulse width modulated oscillator signal via a differential interface (for example: RS422 interface).

Figure 24 shows how such a system must be connected:

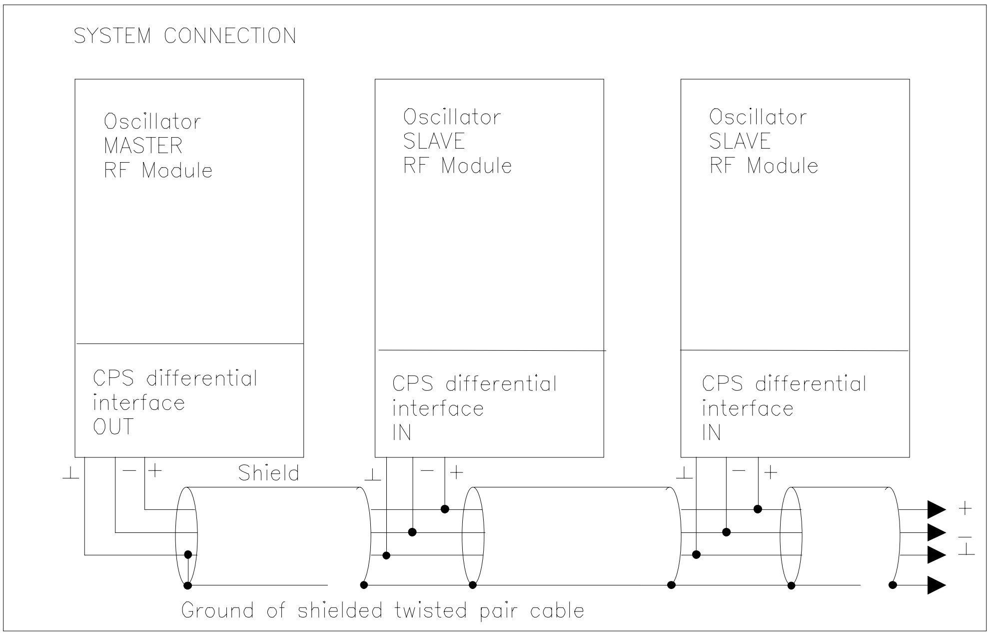


Figure 24: Connecting Multiple RFMs together

A proposal for such an external circuit is shown in figure 25. 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 25 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 Section 3: "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.

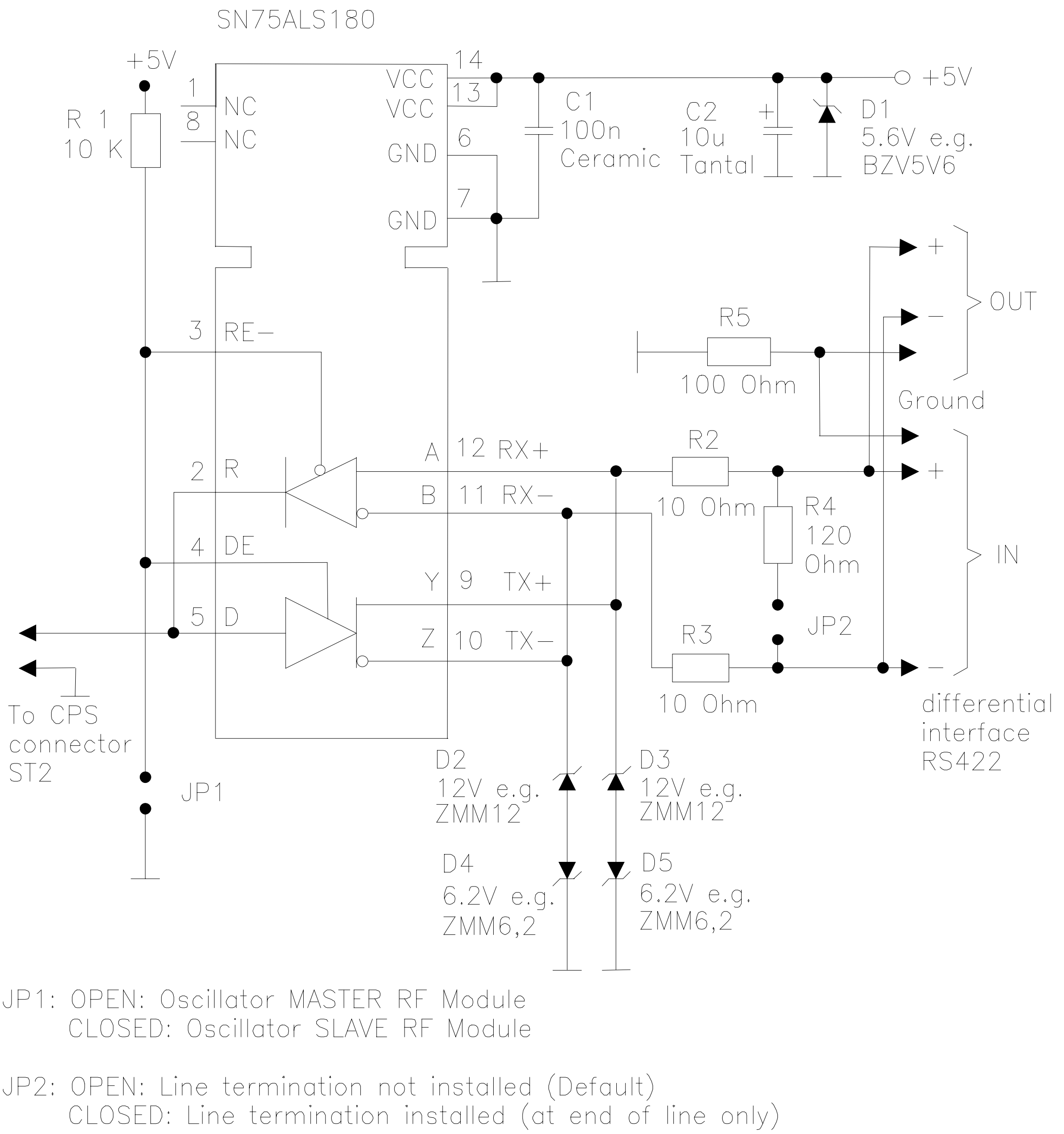


Figure 25: Circuit and Jumper Settings for RS422 Interface

CAUTION: Use over voltage protection components at the CPS connector for CPS lines between 0.5 and 5m, when the circuit shown in figure 25 is not used. See also Section 4.10: "Over Voltage Protection".

Note: *The CPS signals are also accessible at connector J1. Thus the necessary interface extension could also be placed on a Control Module.*

4.8 Receive-only Antenna

This Power RFM has the option to use a receive-only antenna.

The use of combined transmit/receive antenna or receive-only antenna can be selected by the jumpers JP7A and JP7B. See figure 1 for location of jumpers and for location of connector J4 for connecting the receive-only antenna.

The receive-only antenna offers the following possibility:

* 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 optimise the identification area.

TIRIS standard antennas can be used for the charge-up function. However, when using this receive-only option there is more freedom in configuring the charge-up antenna because it only needs to be optimised 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.

A receive only antenna is a tuned resonator with a defined resonance frequency, it can only be used for receive function. This antenna type does not work for charge-up function. For a block schematic of a receive-only antenna see figure 6.

There is another alternative for receive-only antennas. TIRIS Standard transmit/receive antennas can also 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 jumper JP8 has to be closed on the Power RFM, as shown in figure 10.

To tune this type of receive-only antenna resonance, we recommend using a capacitor array as shown in figure 26.

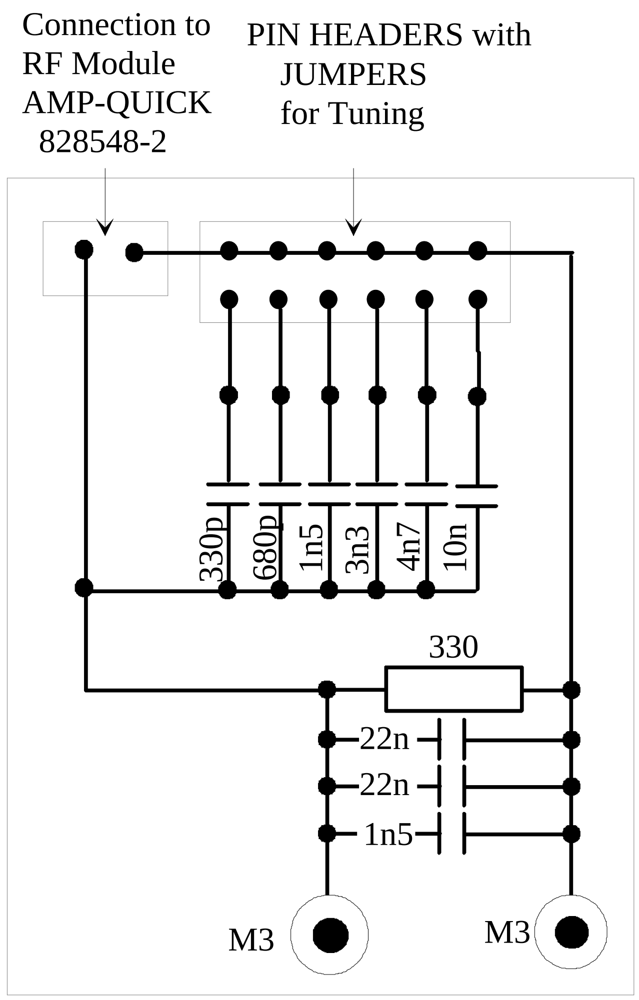


Figure 26: Converter Board for using Standard Antennas as Receive-only

Note: *Although the voltage value of the capacitors can be as low as 50 V for RX, we recommend that high value (430*V*) capacitors are used.*

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

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 Control Module.

The correct set-up for method B can be seen in figure 27. 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.

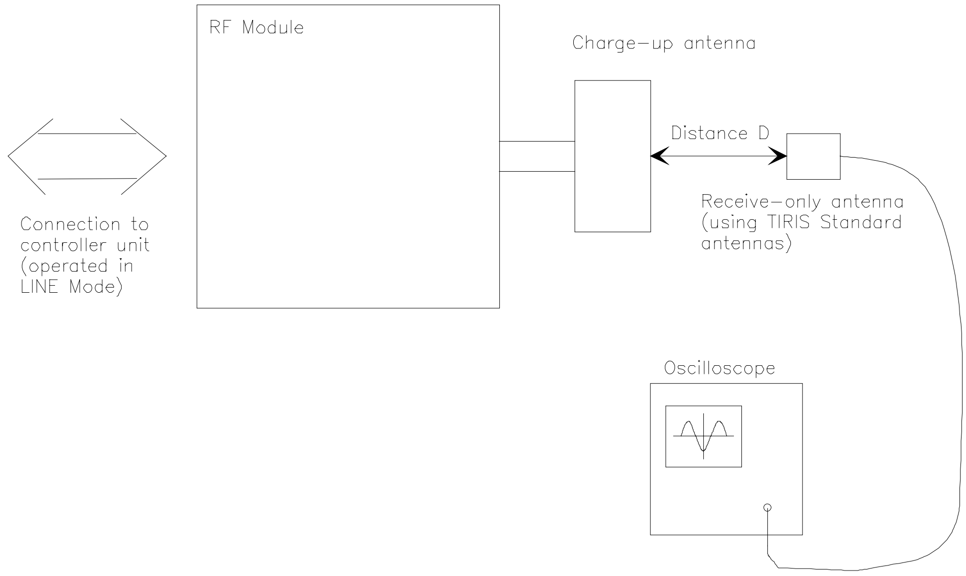


Figure 27: Tuning Receive Only Antennas (Method B)

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 26) 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 TIRIS standard antenna plus 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. The induced voltage may exceed the rated voltage specified for the capacitor and resistor used for the receive-only antenna. Therefore we recommend that you short circuit receive-only antennas when they are not connected to the RF Module. The RF Module has on-board clamping diodes, thus protecting the antenna.

Note: *It may happen that these receive-only antennas still can receive a transponder signal over a short distance (some centimetres), even when the receive channel is disabled.*

4.9 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 17.

Table 17: 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-G02. The set-up for this can be seen in figure 28. 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-G02.

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 28. 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 (e.g. Noise Balanced antennas). For more details refer to the 'Antenna Reference Guide' (Manual number 22-21-007)

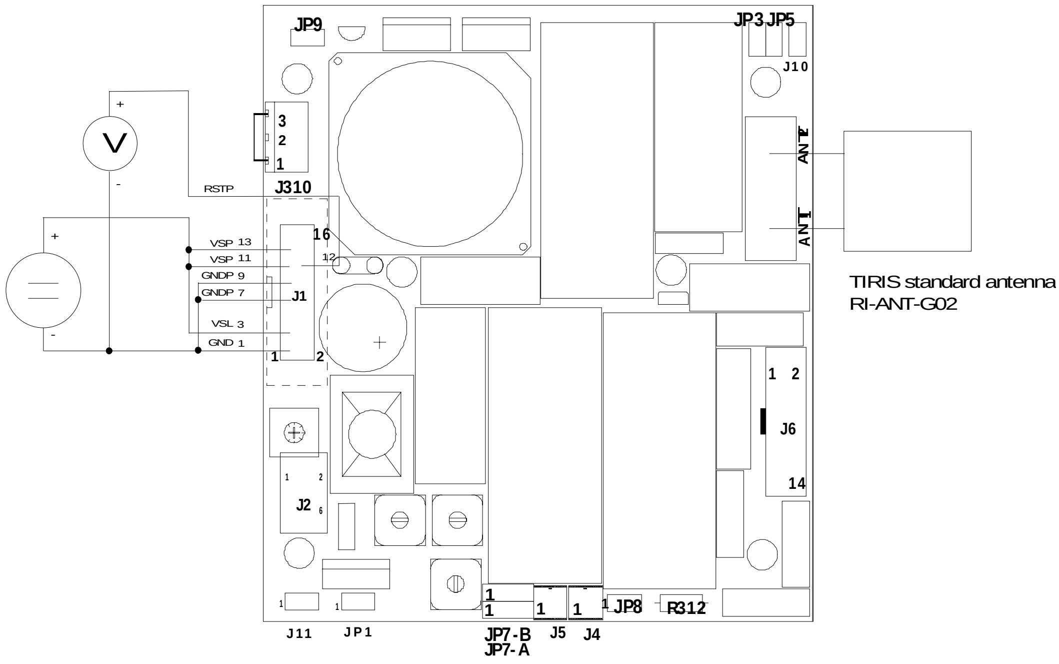


Figure 28: Noise Testing Configuration (Testing RSTP)

* When the configuration of figure 28 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 4.10: "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 4.10: "Over Voltage Protection".

4.10 Over Voltage Protection

For applications, where there is the 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 29. 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 2 W power dissipation. If you need a higher current dump type ZX18 can be used, this diode has 12.5 W power dissipation.

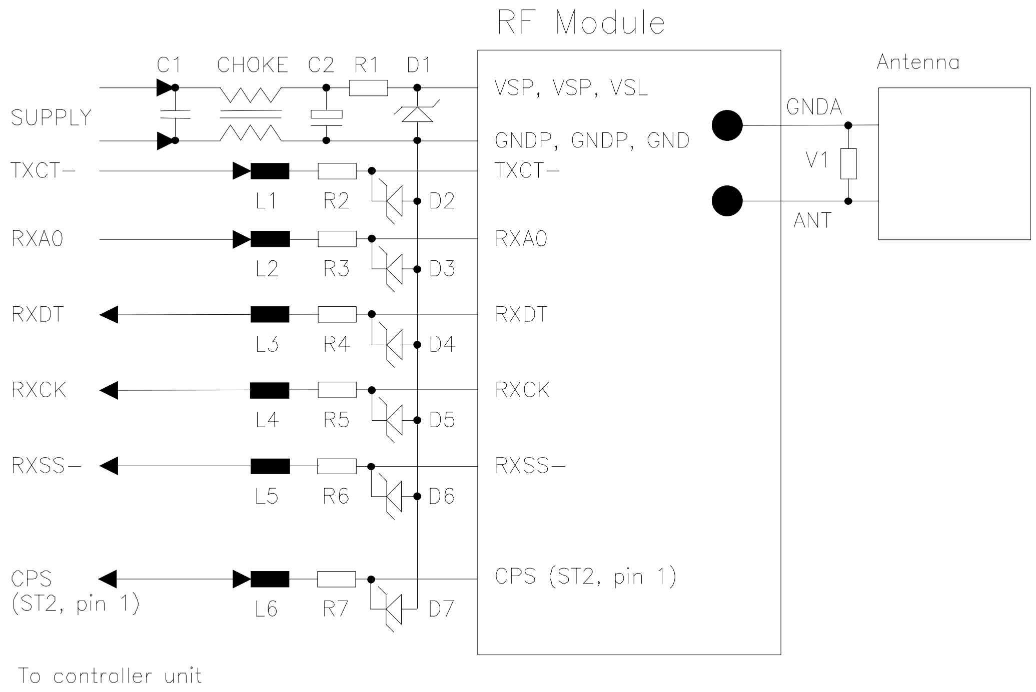
  The Common Mode Choke Coil and the capacitors C1 and C2 are used to reduce the conducted noise coming to the RF Module, via the supply lines.

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

  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 29 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.*



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

Figure 29: Circuit for Overvoltage Protection

4.11 Interface Line Extension

As already described in Section 4.1: "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 Control Module side.

The converter on the Control Module side has to convert the signal TXCT- 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 30 (it shows only the conversion of the signals TXCT-, RXDT, RXCK and RXSS-).

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

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 Control Module via two power supply cables. Using such long supply cables causes a 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 Control Module 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 Control Module and the RF Module. The 100 Ohm series resistor does not affect the RS422 interface function. A circuit proposal is shown in figure 31.

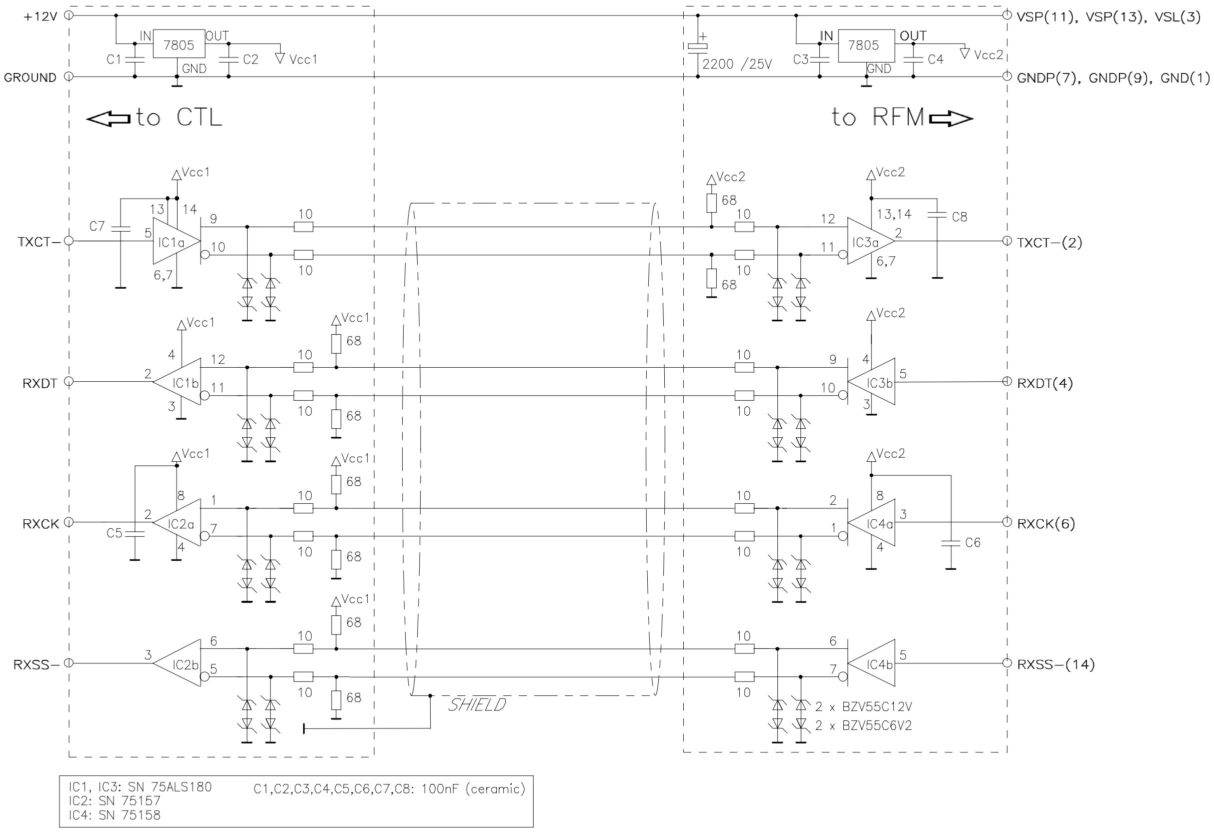


Figure 30: Conversion Circuit without Own Supply

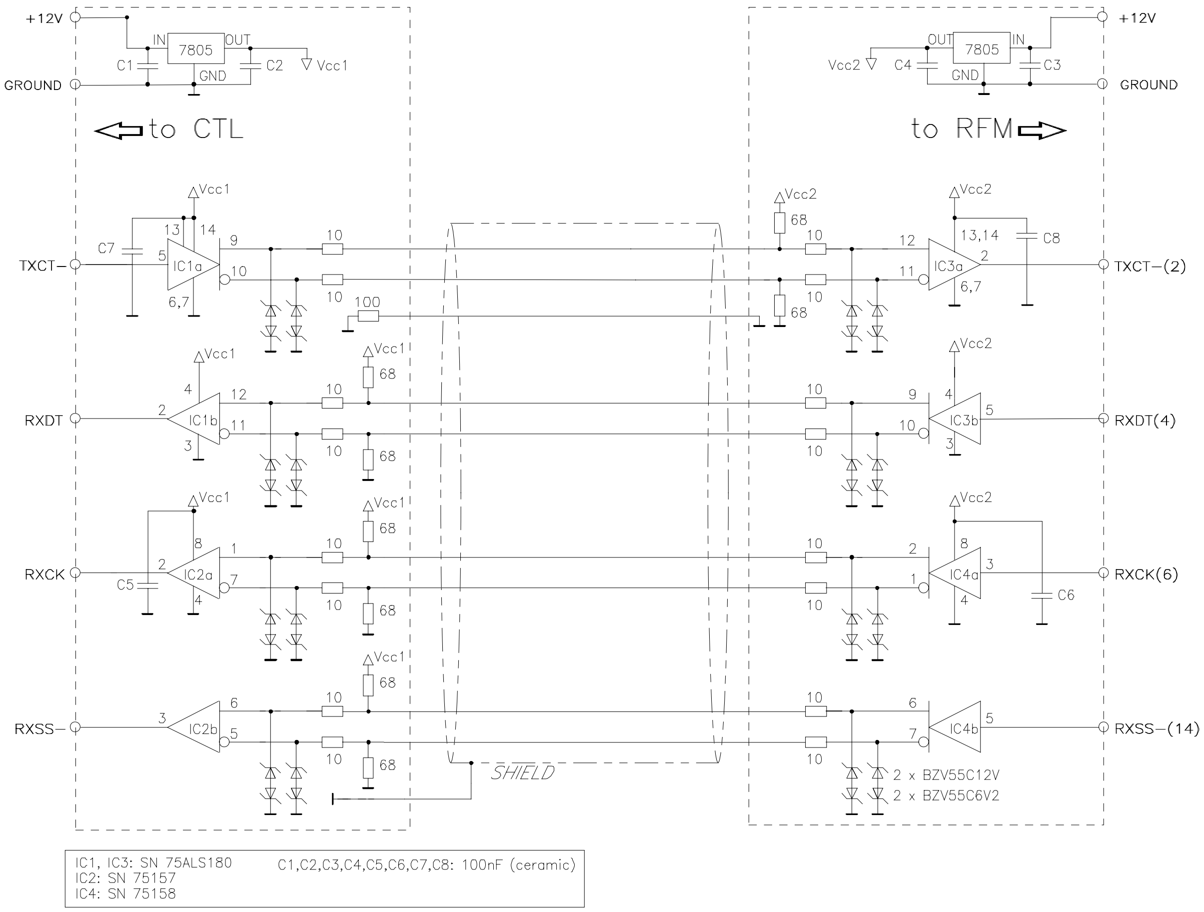


Figure 31: Conversion Circuit

If the ground potential differences between the Control Module 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 32.

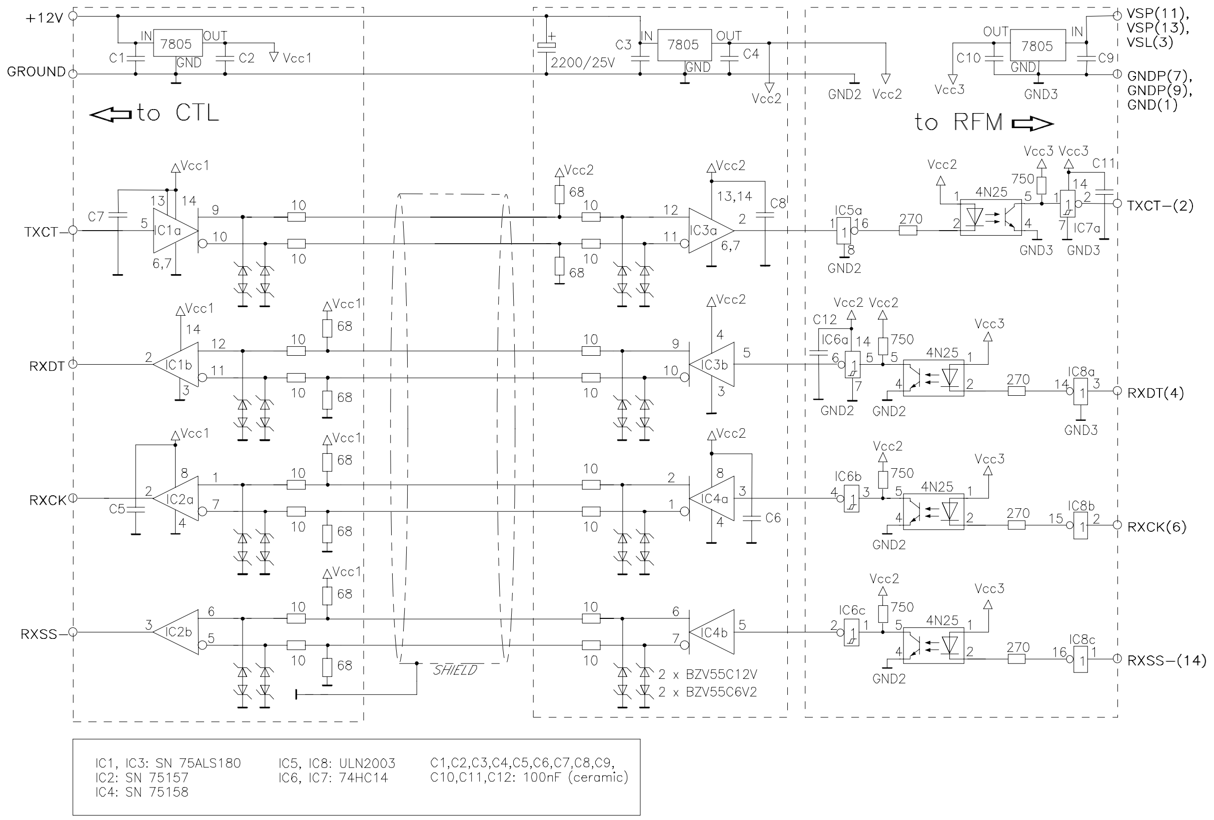


Figure 32: Conversion Circuit with Optocouplers

The interface converter at the Control Module side is the same as that already shown in figures 30 and 31. 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 Control Module. 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 figures 29, 30 and 31 are only a proposal for extending the interface line length. It cannot be guaranteed that these circuits will be correct for all applications!*

Appendix A: PTT/FCC regulations

The field strength limits for the fundamental radiation for various countries are listed in table C-1. (Status: May 1996, this information is subject to change and may not be complete.)

Note: *The figures given here are to the best of our knowledge correct as of May 1996. For the current status please contact the relevant authority in your country.*

Table A-1: Field strength limits for various countries

Country	*Agency*	*Specification*		*Calculated @ D = 3 meter*	*Detection Method*
	Limit	*Unit*	*Distance*	*(exp=3.0)*	
ETSI (note 2)	65	dBμA/m	10 meter	148	Peak
DENMARK	see ETSI				
FINLAND	see ETSI				
NORWAY	see ETSI				
SWEDEN	see ETSI				
SWITZERLAND	see ETSI				
AUSTRALIA	30	μV/m	350 meter	154	Peak
BELGIUM	25	mA/m	3 meter	140	Peak
FRANCE	15	μV/m	353 meter	148	Peak
GERMANY	65	dBμV/m	30 meter	122**	CISPR
ITALY	30W RF output to antenna				Peak
JAPAN	15	μV/m	356 meter	148	Peak
NETHERLANDS	126	mA/m	1 meter	125	CISPR
NEW ZEALAND	83	dBμV/m	30 meter	143	Peak
UNITED KINGDOM	removable Antenna 10W RF output to antenna				Peak
UNITED STATES	18	μV/m	300 meter	139**	Average

* exp = 2.85)

***Note 1**: For proper adjustments of the indicated PTT values, a calibrated field strength meter must be used. Field strength measurement have to be taken on a free field test site according to VDE 0871 or an equivalent regulation.*

TIRIS operates with intermittent power. TIRIS peak radiation may exceed nominal values depending on the signal measurement method (CISPR or average). For applications of the correction factors, see figures 47 and 48. These correction factors have to be added to the values given in the above table. (See also ETSI Final Draft Sept. 1994 I-ETS 300 330 item 6.7 “Pulse modulated signal below 135 kHz”).

***Note 2:** The regulation I-ETS 300 330 (Sept. 1994) is applied. The regulation can be subject to change.*

In some countries PTT approvals have been given based on test reports according to the I-ETS 300 330.

Note 3: *Field strength conversion between different distances is done according to the formula :*

$$\Delta E = 20 * exponent * \log(d1/d2) \quad [dB\mu V/m]$$

ΔE	:	*field strength difference which has to be added to or subtracted from the known field strength value in dBμV/m*
d1	:	*distance of the known field strength value*
d2	:	*distance of the desired field strength value*

Field strength conversion between H and E is :

$$H [A/m] = E [V/m] / 377\ \Omega$$

or:

$$H [dB\mu A/m] = E [dB\mu V/m] - 51.5\ dB$$

This is a nominal calculation, not valid for near-field conditions, but applicable in this case, because all field strength measurement equipment is calibrated according to this formula.

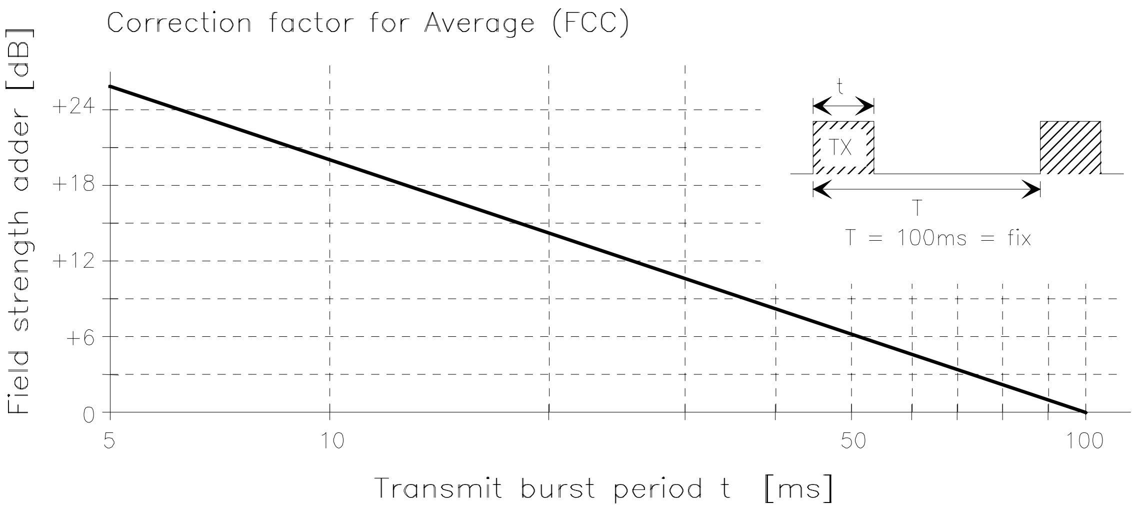


Figure 33: Field Strength Level Correction Factor Using Average Detector

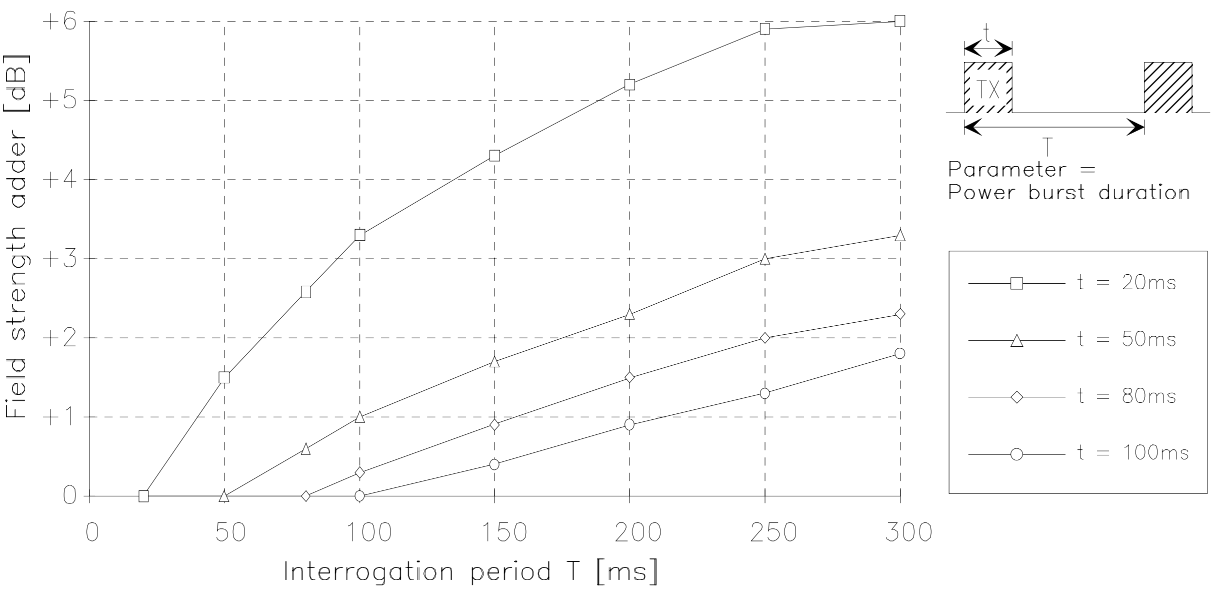


Figure 34: Field Strength Level Correction Factor Using CISPR Detector