Texas Instruments Registration and Identification System

TIRIS Technology by Texas Instruments™

Remote Antenna RFM System

RI-RFM-008A (discontinued)

Reference Manual

11-06-21-033 20 May 1997

Edition Notice: Second Edition - May 1997

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

TIRIS Remote Antenna RFM System RI-RFM-008A

Some changes have been made to pages 32 and 33 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 RA-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 RA-RFM.

Prior to operating the RA-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 organisations.

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

The TIRIS RA-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 RA-RFM in the United States. In order to form a functioning radio frequency (RF) device, the RA-RFM must be connected to a suitable Antenna, power supply, and control circuitry. **A radio frequency device may not be operated unless authorised 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 authorisation.**

FCC authorisation 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 authorisation 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 RA-RFM in a specific site or sites. Experimental authorisations are appropriate to cover operations during the development of an RF device. A grant of equipment authorisation (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 RA-RFM SHOULD BE OPERATED ONLY UNDER AN EXPERIMENTAL LICENSE ISSUED BY THE FCC AND MAY NOT BE MARKETED. BEFORE ANY DEVICE CONTAINING THIS RA-RFM IS MARKETED, AN EQUIPMENT AUTHORISATION FOR THE DEVICE MUST BE OBTAINED FROM THE FCC.

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

WARNING

Care must be taken when handling the RA-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 RA-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 RA-RFM.

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1. Introduction

1.1 General

This manual provides information about the TIRIS Remote Antenna RFM (RA-RFM) System. It describes the system and how to install it.

1.2 Reference

Power RFM (RI-RFM-007A) Reference Manual (Manual number 11-06-29-026).

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

S2000 Control Module (RI-CTL-MB2A/MB6A) Ref. Manual (Manual number 11-06-29-037).

1.3 Product Description

The RA-RFM System is used together with a Control Module and an Antenna for wireless identification of TIRIS transponders.

The Remote Antenna RFM System comprises an RFM and a Tuning Box which enables the RFM to be connected to an antenna up to 120 m away.

The main task of the RA-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.

1.4 Product Option Coding

For product codes and order numbers of RA-RFM System, Antennas, Control Modules and combinations of these, please contact your regional TIRIS Application Center. The RA-RFM System described in this manual is:

RI-RFM-008A

1.5 About this Manual

This manual contains the following parts:

Section 1 Introduction: An introduction to this manual and general information about the Remote Antenna RFM System.

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

Section 3 Specifications: A list of all the electrical and mechanical parameters of the Remote Antenna RFM System.

Section 4 Installing the Remote Antenna RFM System: A detailed description of the power supply requirements, the antenna characteristics, how to change the inductance range of the Tuning Box, how to tune the antenna to resonance, how to fine tune the system, how to adjust the antenna charge-up field strength and the threshold level for wireless read cycle synchronisation.

In addition it describes the following options that are implemented in the Remote Antenna RFM: transmitter carrier phase synchronisation 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 system.**

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

HINT: Indicates information which makes usage of the system easier.

2. Product Function

2.1 General

The Remote Antenna RFM together with its Tuning Box allows you to use a long (up to 120 m) symmetrically shielded antenna cable (Twin-Ax) between an antenna and the Reader unit.

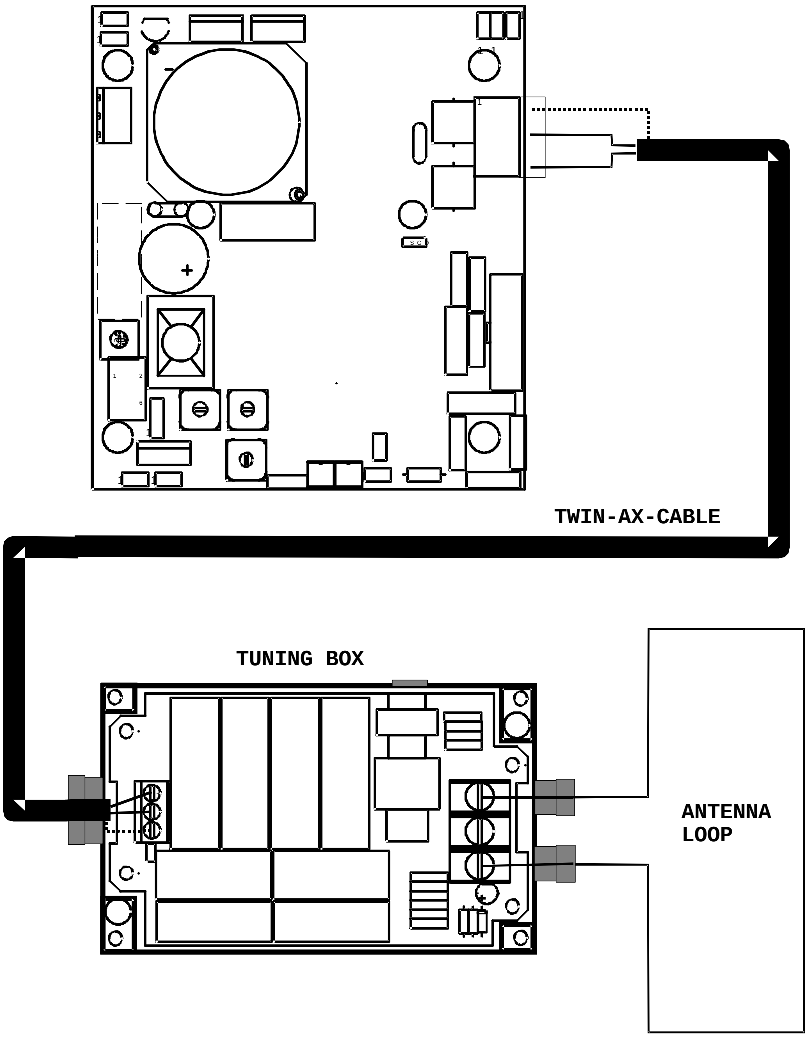

Figure 1: System Schematic Diagram

The Remote Antenna RFM System contains all the analog functions of a TIRIS reading unit that are needed to initialize a TIRIS transponder and to detect its return signal. The Remote Antenna RFM delivers DATA and CLOCK signals for identification data processing. The Remote Antenna 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, or a customer designed Control Unit), are Low-Power Schottky TTL and HCMOS Logic compatible.

There are eight connectors on the Remote Antenna RFM, they are:

J1	which is used to connect the supply voltages and interface signal lines to the Remote Antenna RFM.
J2	which is used to connect the (optional) Antenna Tuning Indicator (ATI), which can be used for easy antenna tuning . The main antenna resonance tuning must be done at the Tuning Box near the antenna.
J4	which is the connector for one receive-only antenna.
J5	which is the connector for direct access to the receiver input.
J6	which is used for antenna fine resonance tuning. It is used to connect the additional capacitors in parallel to the antenna cable.
J11	which is the connector to receiver signal strength test pin RSTP
R312	these are solder pins which allow field strength adjustment resistors to be connected into the circuit.
J310	which is used for transmitter Carrier Phase Synchronization (CPS).

In addition to the above connectors, there is a 3-pin antenna connector to connect the RFM via a symmetrically shielded antenna cable (Twin-Ax) to the Tuning Box.

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

The Tuning Box is normally fixed into place physically at the remote location (for example: in-ground), if required there are 2 mounting holes that can be accessed if the Tuning Box cover is removed.

WARNING

Care must be taken when handling the RA-RFM System. HIGH VOLTAGE across the antenna terminals and all antenna resonator parts could be harmful to your health.

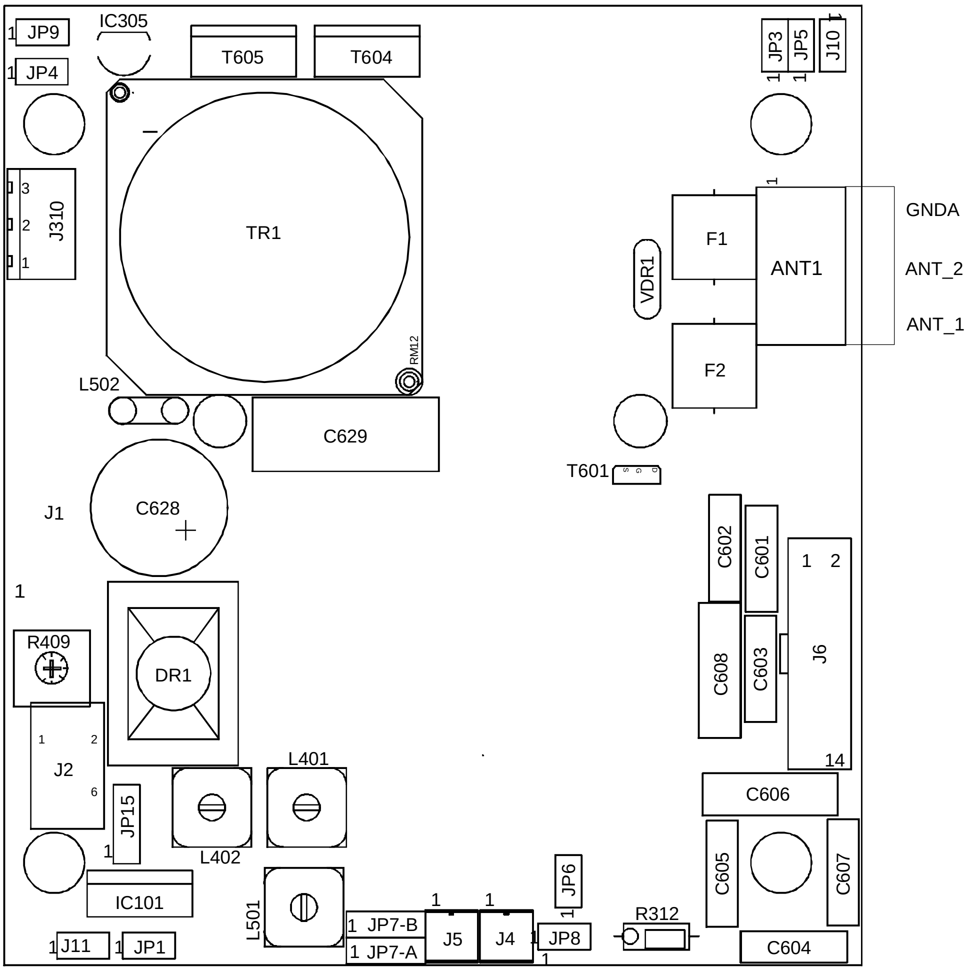

Figure 2: Top View of the RFM

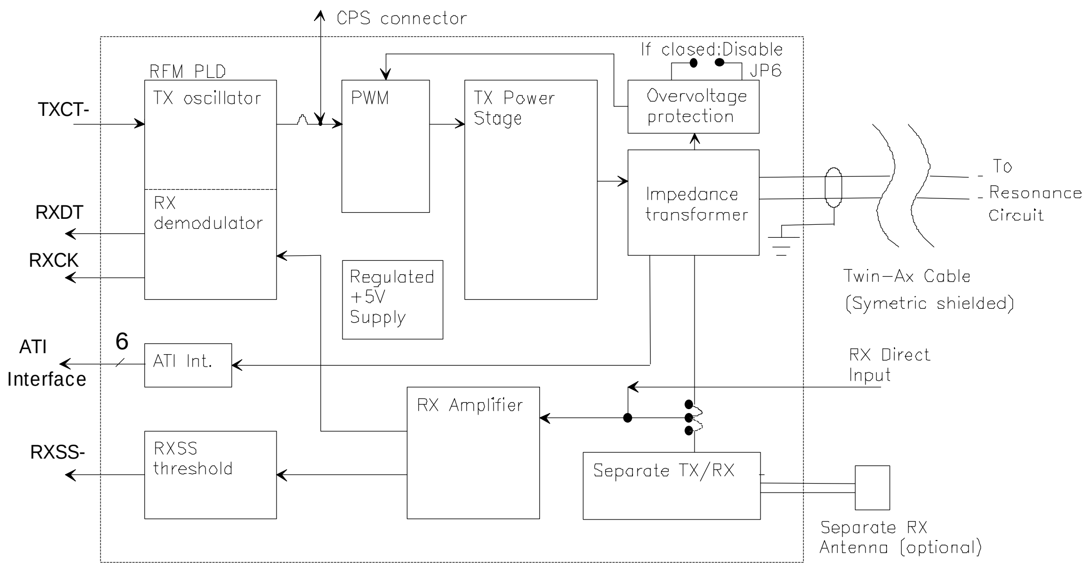

Figure 3: Block Diagram RFM

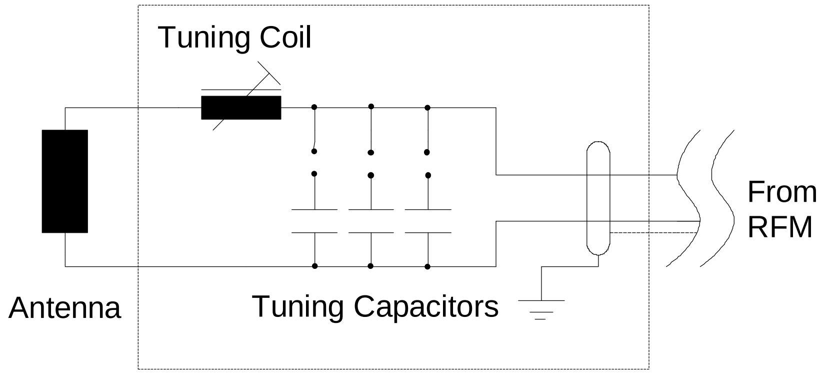

Figure 4: Block Diagram Tuning Box

2.1.1 Transmitter

The RA-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 RA-RFM, the supply voltage for the transmitter power stage must be **externally** regulated.

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: “Installing the Remote Antenna RF module”.

The transmitter power stage is internally connected to the supply lines GNDP and VSP via a common mode choke coil, in order to reduce Electromagnetic Interference (EMI) on the supply lines.

The regulated transmitter power stage supply can vary in the range from +7 V to +24 V. 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 +5 V supply. When this method is used, jumper JP1 on the RA-RFM must be opened and the regulated +5 V supply must be connected to pin VD (see figure 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 for the option of transmitter Carrier Phase Synchronization (CPS, see figure 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 superimpose on each other and may cause a beat effect on the magnetic charge-up field, because of the slightly different transmit frequencies of different 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 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 is inserted between pins 1 and 3 of connector J310, the internal oscillator is used and the RFM is referred to as an oscillator MASTER RFM. When the wire bridge is not in, the external oscillator signal is used and the RFM is referred to as an oscillator SLAVE RFM (see also figure 2).

Note: *Only one oscillator MASTER RFM (and up to five SLAVE RFMs) is allowed per synchronised system - w/o additional external driver circuit.*

The transmit frequency (134.2 kHz) from the oscillator is fed to the Pulse Width Modulator (PWM). By means of a resistor connected to the RA-RFM, the PWM can set the pulse width ratio between 0% and 50%. For an example of two different oscillator signal pulse widths see figure 5. 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 4.4 “Field Strength Adjustment”.

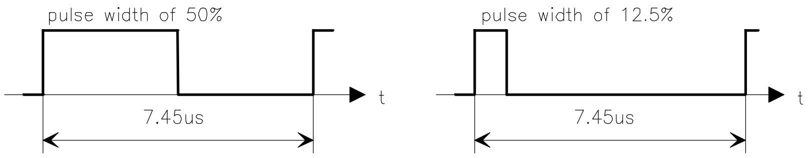

Figure 5: Pulse Width Examples

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 minimum time (for precise value refer to Section 3.5 “Timing Characteristics”).

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

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 smaller pulse widths than 50%, the RA-RFM 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.

Note: *As the RA-RFM is not shielded by a metal case, it may be necessary to shield it, when the RA-RFM is located directly in the antenna field.*

The antenna circuit is described in Section 2.1.2 “RF Input/Output Circuit”.

The RA-RFM transmitter also sends the necessary programming and addressing signals to Read/Write and Multipage transponders.

2.1.2 RF Input/Output Circuit

A block diagram of the antenna circuit can be seen in figure 6.

The RFM together with the Tuning Box (which is connected via a symmetric shielded antenna cable (Twin-Ax)), generates in combination the magnetic charge-up field.

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 and an adjustable series coil (L1) as shown in figures 7 and 8.

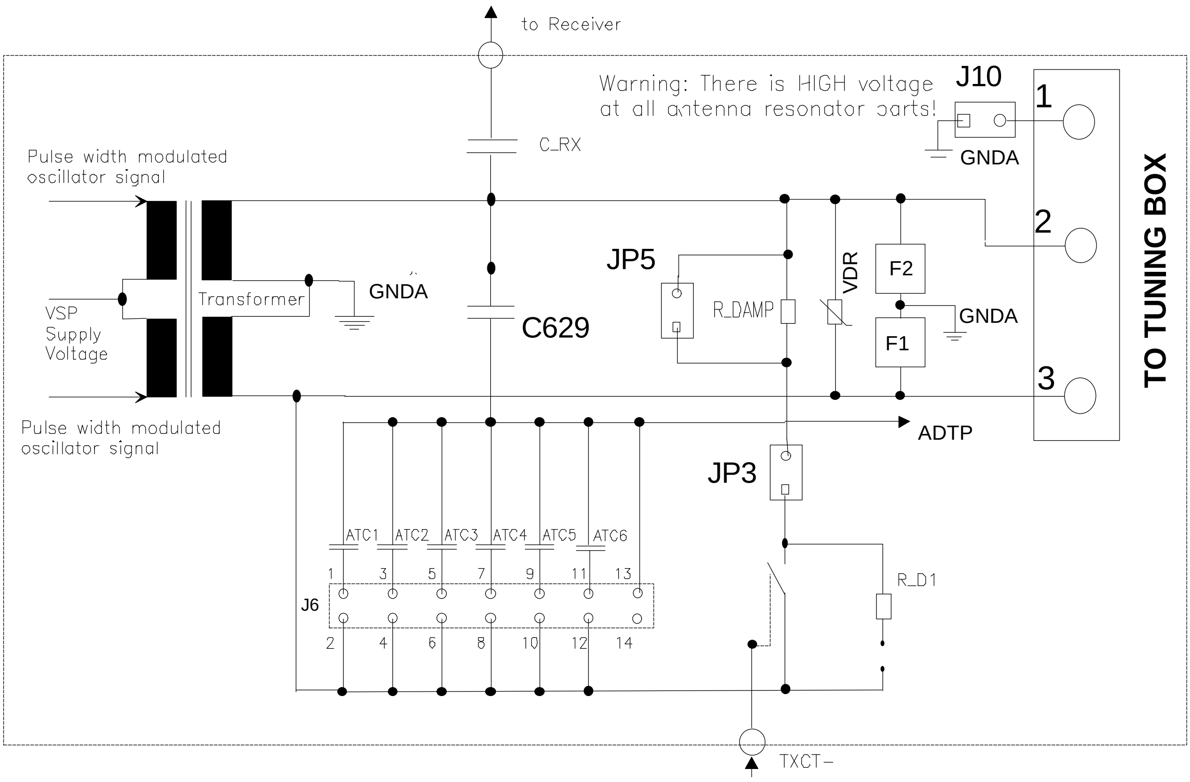

Figure 6: RF Input Output Circuit Block Diagram

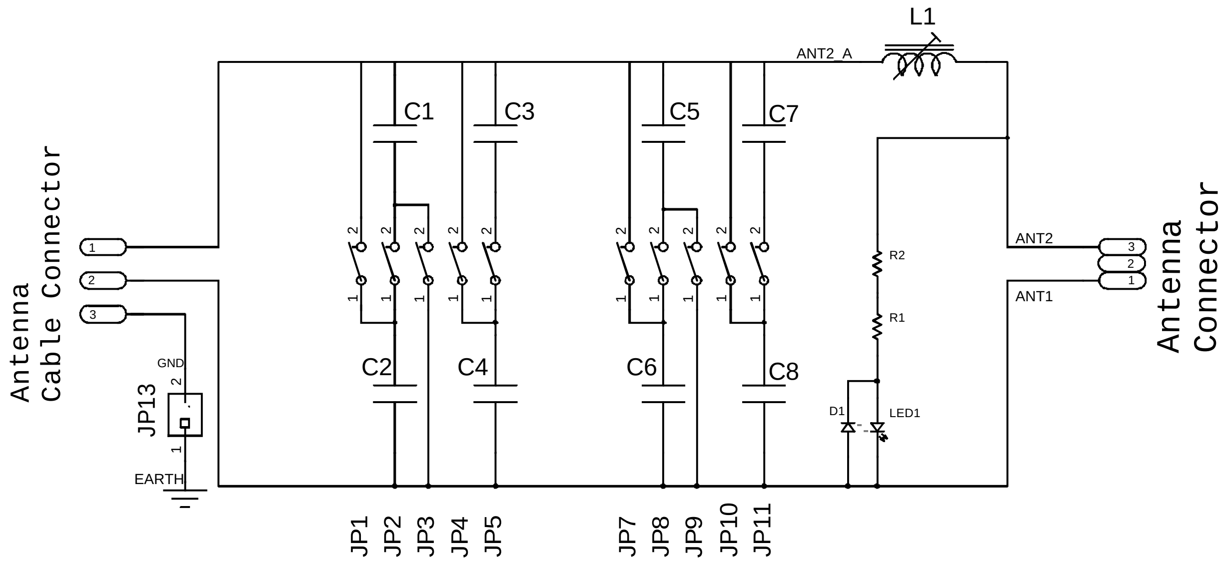

Figure 7: Tuning Box Schematic

The total resonance capacitance is as follows:

Capacitance of the Tuning Box
+
Cable capacitance
+
Fine tuning capacitance on the RFM

The main resonance capacitance consists of capacitors C1, C2, C3, C4, C5, C6, C7 and C8 in the Tuning Box. Connecting capacitors in parallel and serial is necessary because of the high resonance voltage and the high current flow through the resonator. Each resonance capacitor can be switched in or out of the circuit by a single Jumper in order to tune the RFM to resonance (match the RFM to different antenna inductances).

CAUTION: If only one capacitor is switched parallel to the resonance circuit, the allowed resonance voltage is 280 Vp (560 Vpp).

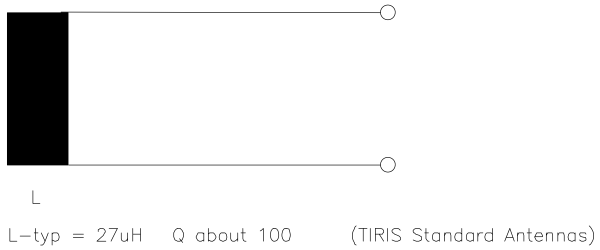

Figure 8: Standard Antenna

In order to get high resonance voltage and thus high charge-up field strength, the antenna circuit has to be tuned to resonance. For this purpose the tuning coil in the Tuning Box is used. For an additional fine tuning on the RFM side, capacitors can be connected parallel to the antenna cable and in this way it is possible to change the total capacitance of the resonator.

The fine tuning capacitors on the RFM are ATC1, ATC2, ATC3, ATC4, ATC5 and ATC6 . 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. The six tuning capacitors can be switched by jumper.

The RA-RFM transformer's secondary winding is split into two windings. These windings are wound in such a way that Common Mode Noise that is coupled to both antenna cables is canceled out. The RX-only input at connector J4 has no Common Mode Noise reduction feature.

WARNING

Care must be taken when handling the RA-RFM System. 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 RA-RFM System.

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 RA-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.

The antenna circuit is also used for receiving the signal from the transponder. The received signal is coupled via the capacitor C_RX to the receiver circuit, which is described in Section 2.1.3.

2.1.3 Receiver

The received signal from the transponder is a Frequency Shift Keying (FSK) signal with typical Low and High bit frequencies of 134.2 kHz and 123.2 kHz respectively. The signal is received from the antenna resonator, which is 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 via configuring jumpers (see figure 2). For combined transmit/receive antenna, jumper JP7A must be set position 2-3 and jumper JP7B to position 1-2. For separate transmit and receive antennas, jumper JP7A must be set position 1-2 and jumper JP7B to position 2-3.

The combined transmit/receive antenna is just a coil as can be seen in figure 8.

Receive-only antennas are tuned resonators with a certain resonance frequency. These antennas can only be used for receive function. They do not work for charge-up function. A block schematic of a receive-only antenna is shown in figure 9.

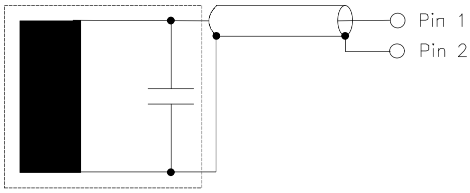

Figure 9: Receive-only Antenna

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 10. When you are using this type of antenna, jumper JP8 on the RA-RFM must be closed (see figure 2). Refer also Section 4.8 “Receive-only Antenna”.

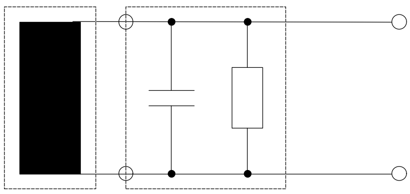

Figure 10: Standard Gate Antennas used as Receive-only

The received signal from either antenna is fed to the receiver. The receiver contains a selective bandpass filter (for characteristics, please refer to Section 3.5 “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 3.5 “Timing Characteristics). The output configuration of the RXDT, RXCK signal, and the RXSS- output and the TXCT- and TXCT-R inputs are shown in figure 11.

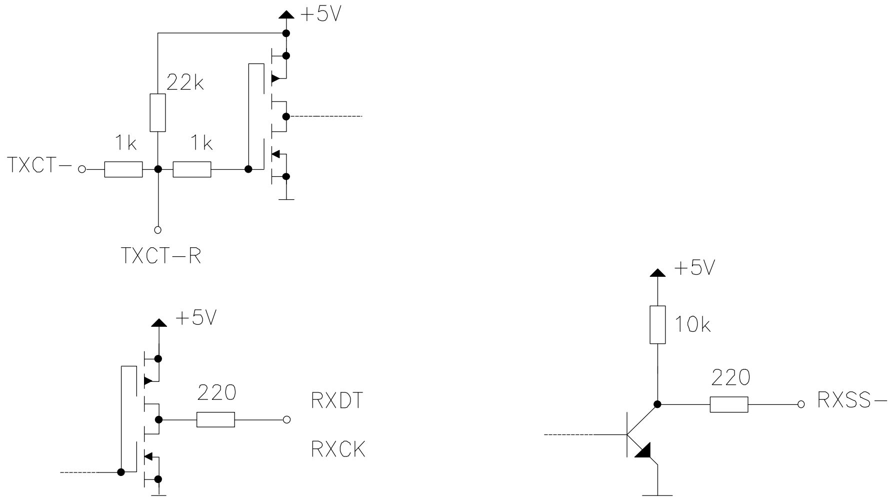

Figure 11: Configurations for Input and Output Signals

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 RA-RFM. The potentiometer is located near connector J1 (see figure 2).

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 RA-RFM is shown in figure 12. 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.

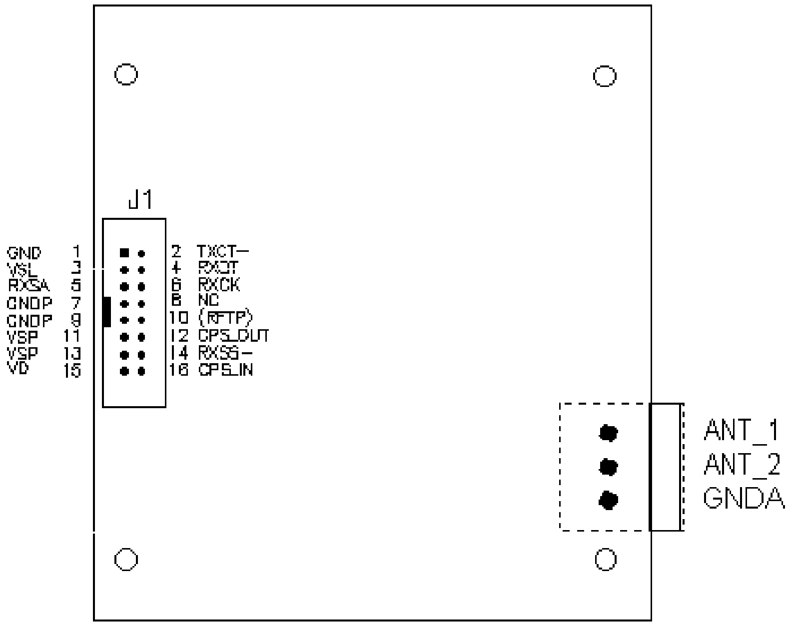

Figure 12: Bottom View

The top view of the RA-RFM is shown in figure 2. The connectors J2, J310, J4, J5, J11 and J6 and the 3-pin antenna connector are accessible from the side.

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 and J11 is the connector to receiver signal strength test pin RSTP. ANT_1 and ANT_2 are the antenna terminal connectors.

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

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

Table 4 lists the pin functions for the antenna terminal connectors. Metric M3 screws must be used to connect the cable to the Tuning Box.

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 J2. 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 11.

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 RA-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 not accessible at connector J1, 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	Logic ground
3	CPS_IN	IN	Carrier Phase Synchronization oscillator signal input

Note: *The RA-RFM is delivered with pins 1 and 3 of connector J310 connected together by an external wire bridge at connector J310. Ensure that the wire bridge at connector J310 is always properly connected for a MASTER RFM.*

Table 3: J2 Pin Functions

Pin#	Signal	Direction	Description
1	TXCT-R	IN	Transmitter control signal via resistor (active low)
2	GND	IN	Logic ground
3	VD	IN	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: Connector ANT1 (to Tuning Box)

Pin#	Signal	Direction	Description
1	GNDA	OUT	Ground for cable shield
2	ANT_1	IN/OUT	Symmetrical antenna input/output 1
3	ANT_2	IN/OUT	Symmetrical antenna input/output 2

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	ATC1	Antenna output 2
3	ATC2	Antenna tuning capacitor 2 (weighted value 2)
4	ACT2	Antenna output 2
5	ATC3	Antenna tuning capacitor 3 (weighted value 4)
6	ATT3	Antenna output 2
7	ATC4	Antenna tuning capacitor 4 (weighted value 8)
8	ATC4	Antenna output 2
9	ATC5	Antenna tuning capacitor 5 (weighted value 16)
10	ATC5	Antenna output 2
11	ATC6	Antenna tuning capacitor 6 (weighted value 32)
12	ATC6	Antenna output 2
13	AMTP	Antenna circuit test point (antenna resonator midpoint)
14	NC	

Note: *The antenna circuit test pin AMTP must not be connected in any way.*

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 the following Section. The jumper location is shown in figure 13.

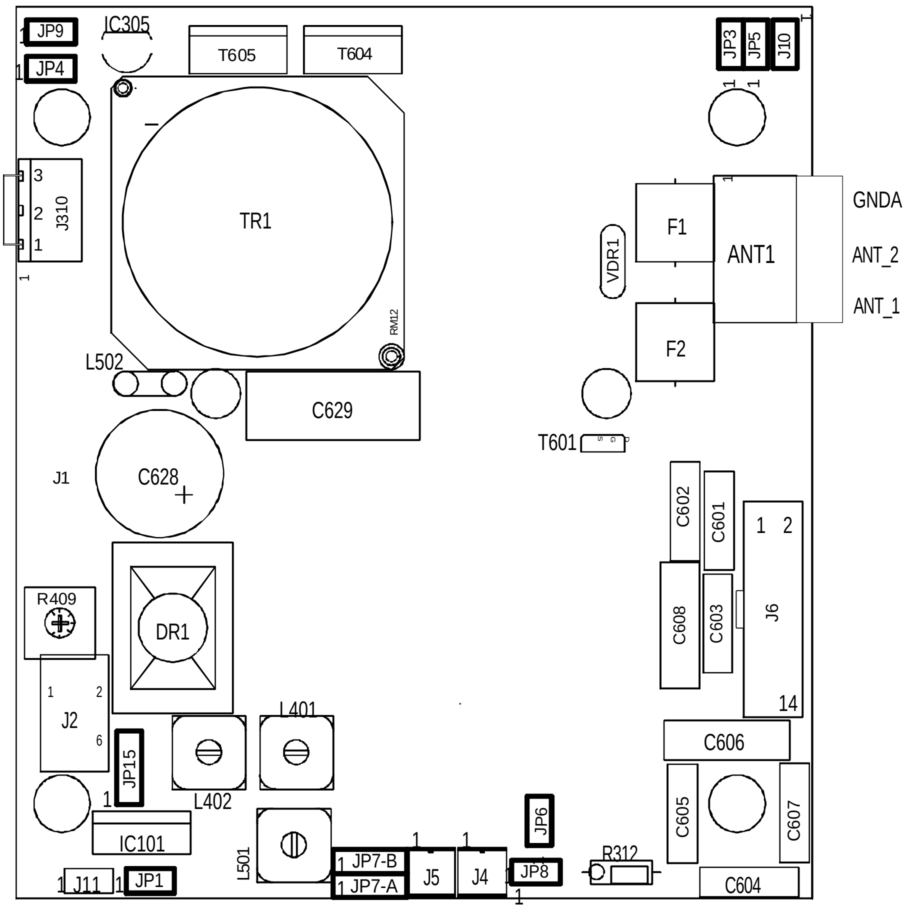

Figure 13: Location of Jumpers

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 RA-RFM. For this configuration, the jumper JP1 is closed. The unregulated supply voltage for the logic must be connected to pin VSL and GND (pins 3 and 1 of connector J1).

If the logic part of the RA-RFM is to be supplied by a regulated +5 V supply, the jumper JP1 has to 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 RA-RFM as an oscillator MASTER RFM. The oscillator output signal is accessible at pins 1 and 2 (= ground) of connector J310.

To configure as an oscillator SLAVE RFM, the wire bridge has to be removed at connector J310. The oscillator input signal from the oscillator MASTER RFM has to be supplied to pins 3 and 2 (= ground) of connector J310.

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

2.2.2.3 Pulse Width Modulation

This is in fact a resistor and not a jumper. Connecting the resistor R312 to the RA-RFM is necessary to set the generated field strength. For more details refer to Section 4.4 "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 is done on each RA-RFM individually. The field strength adjustment is not affected by Carrier Phase Synchronisation.*

2.2.2.4 Selection of Combined Transmit/Receive Antenna or Separate Antennas

The RA-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 ANT_1 and ANT_2. When you are using the combined antenna the jumper JP7A must be closed at position 2-3 and jumper JP7B must be closed at position 1-2. For location see figure 14.

Combined transmit/receive antenna configuration is selected as default.

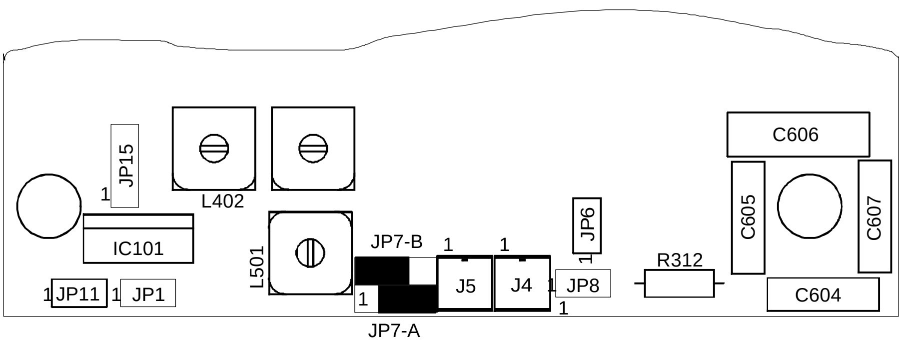

Figure 14: Combined Antenna Jumper Settings (Default)

When you are using separate transmit and receive antennas jumper JP7A must be closed at position 1-2 and jumper JP7B must be closed at position 2-3. For location see figure 15.

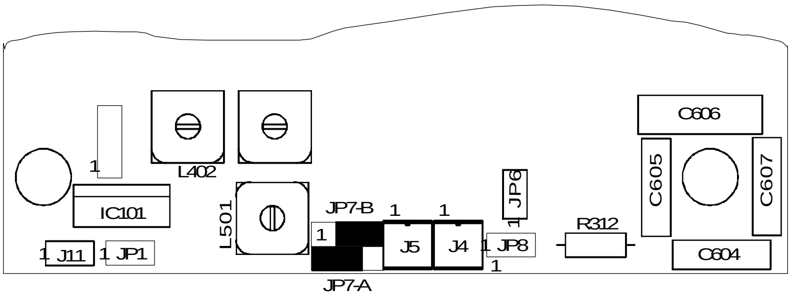

Figure 15: Separate Antenna Jumper Setting

2.2.2.5 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 RA-RFM System. The jumper JP8 is used for this purpose.

When the jumper JP8 is open, a standard receive-only antenna must be connected to the connector J4. The antenna circuit is shown in figure 9.

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 (see figure 10 and Section 4.8 “Receive-only Antenna” for details of the converter board).

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

2.2.2.6 Connection of Damping Circuit

When jumper JP3 is closed, the internal damping circuit is used. This is the default setting. If it is necessary to change the damping resistance of the of the RA-RFM you can add a resistor on JP5.

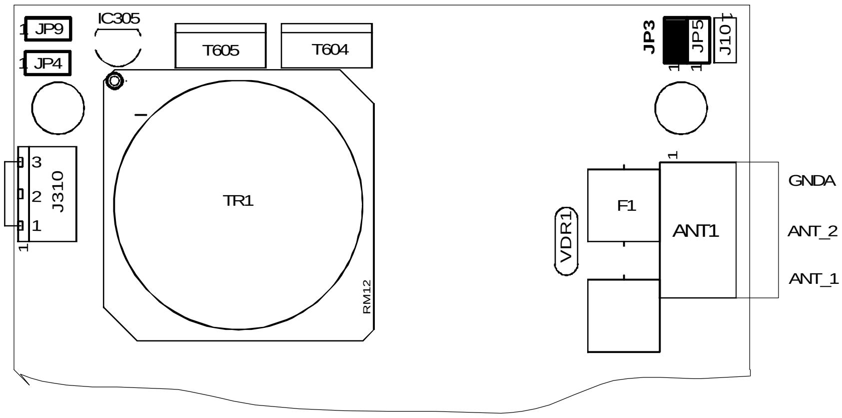

Figure 16: Internal Damping Connection JP3

2.2.2.7 Connecting Transformer Common Points to Ground

JP4 is for repair and maintenance purposes only. For correct operation it must be closed.

2.2.2.8 Connecting RA-RFM Ground to Earth

In cases where earthing of the RA-RFM Ground GNDP is necessary, it is possible to connect the mounting bolt, which is located at connector J310, to the RA-RFM Ground GNDP via jumper JP9. This jumper is open by default.

2.2.2.9 Connecting Antenna Cable shield to Ground

In cases where earthing of the antenna cable shield is necessary, it is possible to close J10 on the RFM. Earthing the cable shield is also necessary in order to reduce the RF emission via the antenna cable.

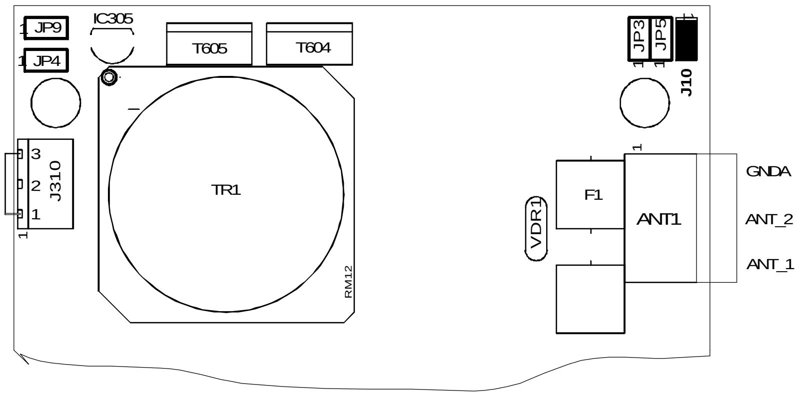

Figure 17: Antenna Cable Shield to Ground J10

2.2.2.10 Ground Bypass

Jumper JP15 allows the ground leg of the Common Mode Choke Coil to be bypassed for special applications (position 2-3: ground leg active - default; position 1-2: bypass ground leg for special applications). For correct operation in standard applications, jumper JP15 must be connected as shown in figure 18 (default setting). Jumper JP15 should not be removed by the customer.

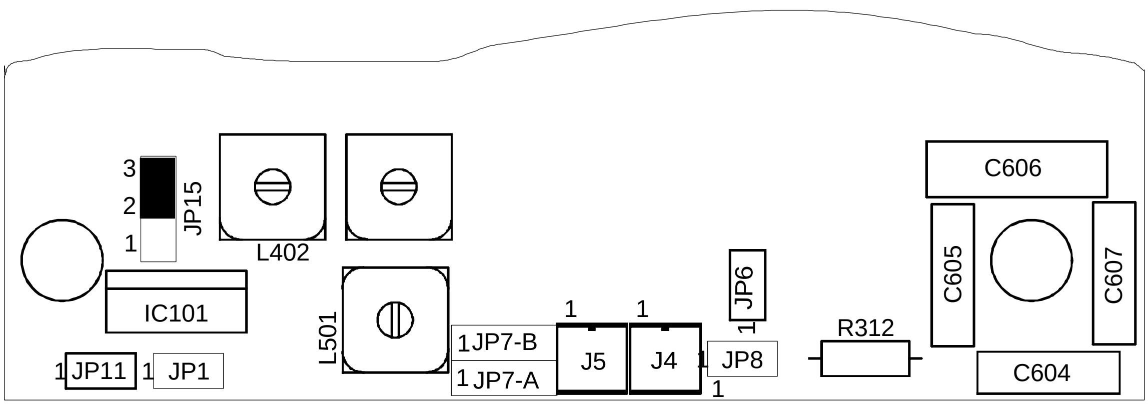

Figure 18: Ground Bypass Jumper JP15

2.2.2.11 RF Overvoltage Protection

The antenna resonance voltage is internally limited in order not to damage the RA-RFM System if no load (antenna) is connected.

When JP6 is open the RF overvoltage protection is enabled. The RF output voltage on the ANT_1 connector is limited to 700 Vpp. When the antenna Voltage is below 700 Vpp the limiter has no effect .

As default, the Jumper JP6 is open.

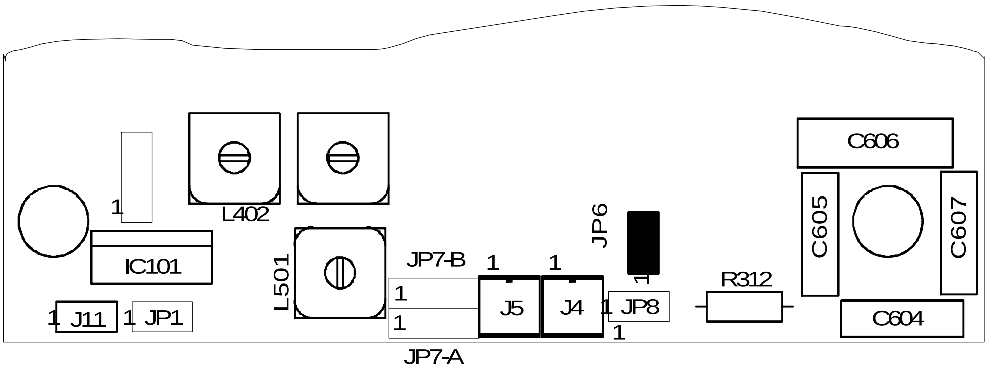

Figure 19: RF Voltage Limitation

CAUTION: If JP6 is closed, do not run the RA-RFM System without an antenna connected to it.

2.3 Tuning Box Connectors and Jumpers

A circuit diagram of the Tuning Box is given in figure 7.

2.3.1 Connector and Signals

2.3.1.1 Antenna Connector

Table 9: Antenna Connector

Pin#	Signal	Direction	Description
1	ANT	IN/OUT	Symmetric antenna signal
2	NC		Not connected
3	ANT	IN/OUT	Symmetric antenna signal via series L

2.3.1.2 Antenna Cable Connector

Table 10: Antenna Cable Connector

Pin#	Signal	Direction	Description
1	ANT	IN/OUT	Symmetric antenna signal from/to RFM
2	ANT	IN/OUT	Symmetric antenna signal from/to RFM
3	GND	IN	Cable-shield to housing ground

2.3.2 Jumpers

2.3.2.1 Tuning Capacitor Jumper

Table 11: Tuning Capacitor Jumpers

	Capacitance [nF]	Max Resonance Voltage peak-peak (VRF_max)	Description
JP1	33	560	Capacitor C2
JP2	16.5	800	Capacitor C1, C2 in series
JP3	33	560	Capacitor C1
JP4	33	560	Capacitor C4
JP5	16.5	800	Capacitor C3, C4 in series
JP7	15	560	Capacitor C6
JP8	7.5	800	Capacitor C5, C6 in series
JP9	15	560	Capacitor C5
JP10	10	560	Capacitor C8
JP11	5	800	Capacitor C7, C8 in series

2.3.2.2 Jumper J13 Housing to Cable shield

Table 12: J13 Earth Ground Tuning Box

Pin#	Signal	Direction	Description
1	Earth	OUT	Housing ground
2	GND	IN	Shield Twin Ax Cable

2.3.3 Power indicator

LED1 indicates the presence of the power voltage.

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 (at RA-RFM terminals)	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 RA-RFM System. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

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

Install proper heat sinks when operating the RA-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	14.0	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	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-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):

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

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

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

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

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

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

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 - receive mode - transmit mode	 25 15	 35 25	 55 55	 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			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	-
RX_sens	Receiver sensitivity for a clear data demodulation (necessary signal voltage at antenna resonator) * signal fed in at between GNDA and ANT_1		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 Level Adjustment).		0.5	5.0	m
l_J1	Cable length for connecting J1 of the RA-RFM to a controller unit using flat cable		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 RA-RFMs		1.0	5.0	m
n_CPS	Number of oscillator SLAVE RA-RFMs, which can be driven from one oscillator MASTER RA-RFM		1	5	-
Com_Mode	Common Mode Noise reduction ratio for noise coupled to both antenna terminals ANT_1 and ANT_2		20		dB
R_DAMP	Antenna damping resistor (+/-2.5%)	487.5	500	512.5	Ohm
R_GND	Decoupling resistor between GND and GNDP (+/- 5%)	64.6	68	71.4	Ohm
C_ATC1	Antenna tuning capacity (+/-5%), C601	95	100	105	pF
C_ATC2	Antenna tuning capacity (+/-5%), C602	209	220	231	pF
C_ATC3	Antenna tuning capacity (+/-5%), C603	446	470	493	pF
C_ATC4	Antenna tuning capacity (+/-5%), C605	950	1000	1050	pF
C_ATC5	Antenna tuning capacity (+/-5%), C606	2090	2200	2310	pF
C_ATC6	Antenna tuning capacity (+/-5%), C608	4465	4700	4935	pF
C_ANT	Total antenna resonator capacity (+/- 5%)	8255	8690	9124	pF
I_VSP-50	Current consumption of transmitter power stage together with Antenna RI-ANT-G02C and pulse width setting of 50% * VSP=14V, (JP6 closed)		2.5		A DC

3.4 Environmental data

Antenna resonance voltage reduction over temperature range (using RA-RFM System together with TIRIS Standard Gate Antenna RI-ANT-G02C, resonator tuned to optimum): -10% (typical value)

3.5 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	127.0	128.2	129.5	kHz
b_RX	-3 dB bandwidth of receiver	19.5	22.0	24.5	kHz
f_dem	Data demodulation threshold frequency between LOW and HIGH bit	129.1	129.5	130.2	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

Notes: *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 RA-RFM System.

3.6 Mechanical data

The mechanical data is given in the table below.

Parameter	typical	Unit
Height of complete RA-RFM (including mounting bolts)	44.0 +/- 1.5	mm
Height of Tuning Box	57.0 +/- 3.0	mm
Weight of RA-RFM	160	Gram
Weight of Tuning Box	650	Gram
Protection class of Tuning Box	IP65	

The RA-RFM heat sink has the option of two M3 press nuts on the top of the RA-RFM to enable it to be screwed to another heat sink. See figure 20 for position of these press nuts.

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

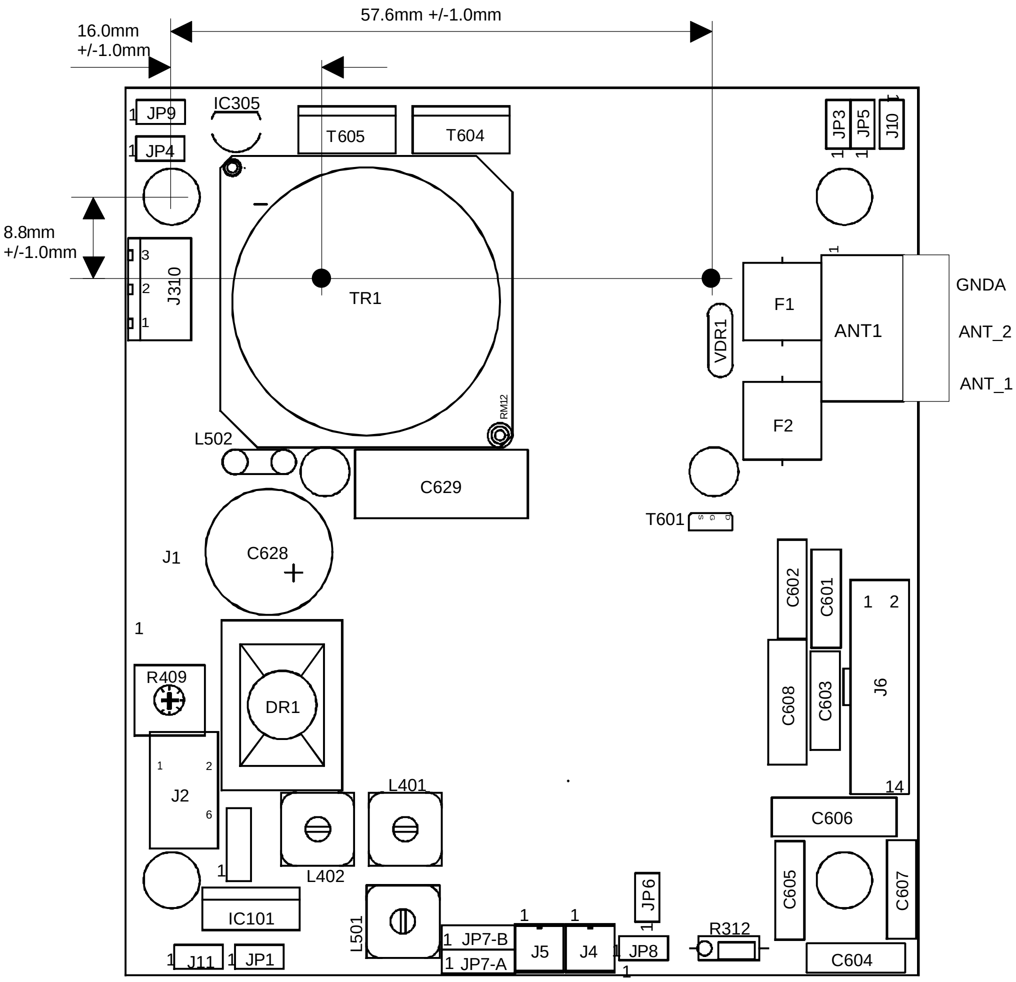

Figure 20: Optional Position of M3 Press Nuts on Heat sink

The mechanical data about the RFM is given in figure 21. All measures are in millimeters with a tolerance of +/- 0.25 mm (unless otherwise noted). The mechanical data about the Tuning Box is given in figure 22. All measurements are in millimeters with a tolerance of +/- 3 mm.

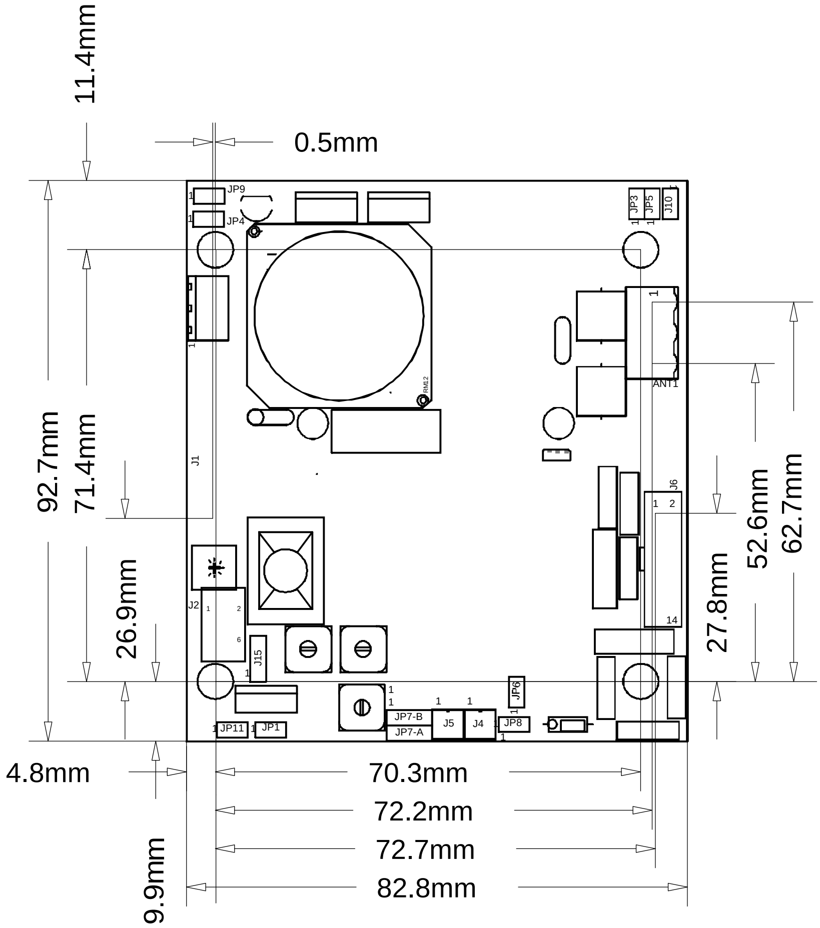

Figure 21: Mechanical Dimensions of the RFM

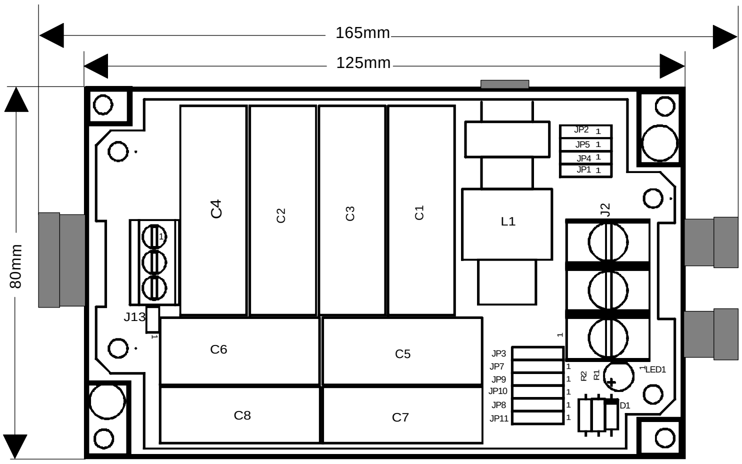

Figure 22: Mechanical Dimensions of the Tuning Box

4. Installing the Remote Antenna RFM System

4.1 Power Supply

4.1.1 Supply Requirements

The logic and receiver part of the RA-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 the jumper JP1 has to be opened (for location refer to Section 2.2 “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 RA-RFM and as the transmitter power stage needs a regulated supply voltage to meet FCC/PTT regulations, the supply voltage for the transmitter power stage must be regulated externally. For voltage supply range please see Section 3 “Specifications”.

Note: *The RA-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.*

Noise from power supplies or noise on the interface lines can interfere with the receiver. Therefore we recommend that you add additional filters in series to the supply and interface lines if the application requires this. For more details refer to Sections 4.9 “Noise Verification and 4.10 “ Over Voltage Protection”.

In order to guarantee full RA-RFM performance, the power supplies should fulfill the specifications for ripple voltage given in table 13.

Table 13: 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)

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 controller unit (see also figure 23). 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 RA-RFM and the controller unit cause a voltage drop across this supply line (again because of the high transmitter power stage supply current). This voltage drop would also lift the logic ground and cause logic level compatibility problems with the controller unit. This can again be avoided by connecting the grounds externally in any of three different ways (see figure 23).

    a. For cable lengths of up to 0.5 m between the RA-RFM and controller unit, the RFM ground pins GND and GNDP must be connected at the controller unit, as shown in figure 23. Here the grounds for the VSP, VSL and the controller unit supply are all connected together at the common ground.

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

       If your system has a TIRIS Control Module, the RA-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 controller unit in order to avoid logic level compatibility problems caused by the voltage drop across the VSP supply lines (see figure 23).

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

       In this case, to avoid problems with difference voltages between GND and GNDP, these pins must always be connected directly at the RA-RFM. A shorting bridge is necessary as close as possible to the RA-RFM for this purpose, as shown in figure 23.

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

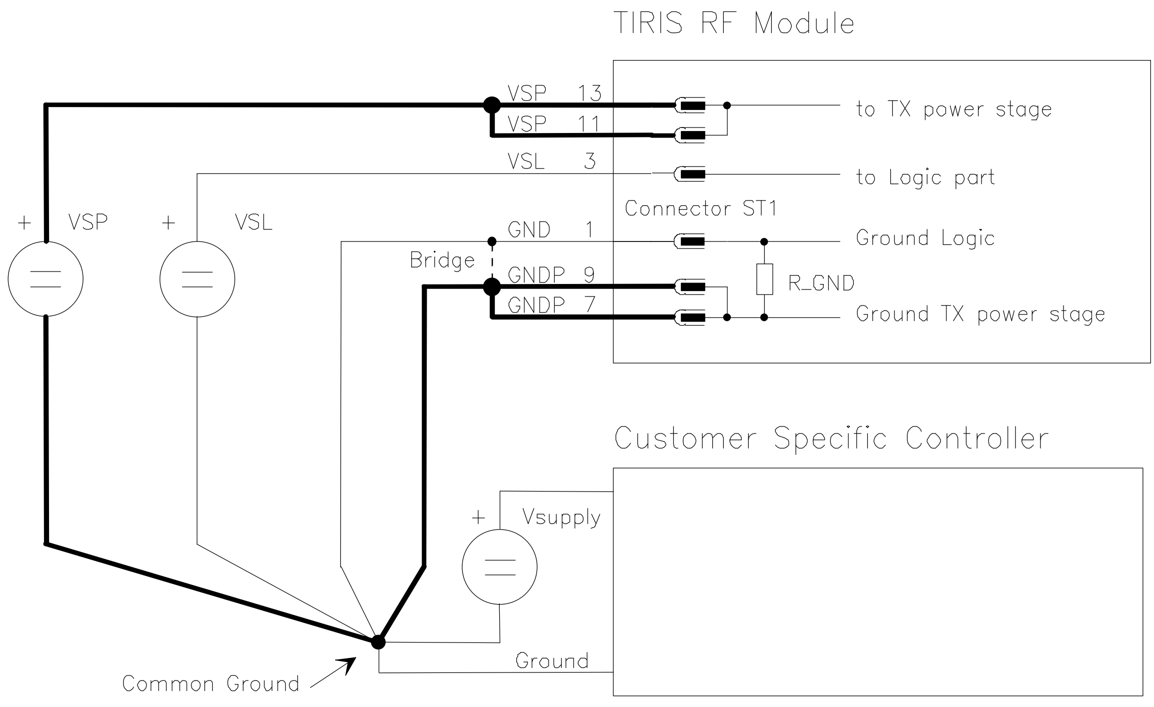

Figure 23: External Ground Connection (GND to GNDP)

4.2 Antenna Requirements

The transmit antenna for the RA-RFM (which is used to charge up the transponder) is a coil (see figure 8). This coil is part of the antenna resonant circuit (see figure 3).

The recommended quality factor for proper operation is listed in table 14. 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.

For proper operation of the transmitter and receive function, the antenna has to be tuned to the resonance frequency f_TX. For a detailed description of the antenna resonance tuning procedure, refer to Section 4.3 “Antenna Resonance Tuning”.

To ensure that the antenna can be tuned to resonance with the RA-RFM, the antenna inductance can only vary within the limits given in table 14.

Table 14: Antenna Characteristics

Parameter	Conditions	min.	typ.	max.	Unit
L_ANT	Antenna inductance range, within which the antenna can be tuned to resonance	8.0	27.0	80.0	μH
Q_ANT	Recommended quality factor of antenna coil for proper operation		100		

Basically there are three different kind of antennas: Gate antennas, In-ground 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. In-ground antennas are most customized single loop antennas with a low Q, which are installed in the ground area.

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 see '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 in the Tuning Box. Fine tuning can be done by the tuning coil in the Tuning Box. For greater flexibiltity of retuning from the RFM (after fine tuning at the Tuning Box) C_ATC5 should be connected before the fine tuning is done at the Tuning Box.

To retune the Remote Antenna system from the RFM, six binary weighted tuning capacitors (C_ATC1 to C_ATC6) have been built-in (see also figure 6). 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 RA-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 2).

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

A) Monitoring Generated Field Strength

Monitor the field strength generated by the RA-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 voltage at the pick-up coil has reached its maximum value.

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

To measure the output you can use any of these 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.

For sensor unit alternatives see figure 24.

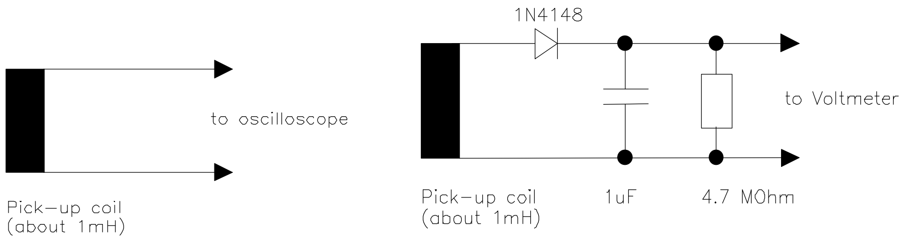

Figure 24: Antenna Tuning Pick-up Coils

HINT: As the RA-RFM only 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).

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 an RA-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 RA-RFM System and this results in the special tuning jumper arrangement for this combination of antenna and RA-RFM System only. If a different antenna is connected to the RA-RFM System, the new combination has to be tuned to resonance again!

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

* Switch RA-RFM power supply off.

* If the fine tuning option on the RFM is going to be used, close Jumper ATC_5 (J6, pin11-12).

* Calculate the resonance capacitance (see figure 25 and/or the equation in the top cover of the Tuning Box)**.**

* Set the Tuning Range Jumper in the Tuning Box which is closest to the calculated value (according to table 15).

* Connect the Tuning Box via the Twin-Ax cable to the RA-RFM by means of the ANT1 connector.

* Install antenna tuning monitoring unit.
  (Oscilloscope with a simple pick-up coil or a RF Voltmeter).

* Switch RA-RFM power supply on.

* Tune the antenna to maximum by the series coil in the Tuning Box.

* Retune antenna to resonance by changing the tuning capacity.

* Switch RA-RFM power supply off.

* Switch RA-RFM power supply on again.

* If necessary retune the system by switching the fine tune capacitors on the RFM in or out of circuit.

==> Antenna resonance tuning is complete!

Table 15: Tuning Range Setting

Jumper setting	C_tunb *	C_deviation **	Tun-Range	Cable	V-RF_max
	[nF]	[nF]	[uH]	[meter]	[V]
JP2	16.5	+-0.5			800Vpp
JP2, JP11	21.5	+-0.7			800Vpp
JP2, JP8	23.5	+-1			800Vpp
JP2, JP5	33	+-1.5			800Vpp
JP2, JP5, JP11	38	+-2.3			800Vpp
JP2, JP5, JP8, JP11	45.5	+-3	27	5 to 40	800Vpp
JP3, **JP4**	66	+-7			**560Vpp**
JP2, **JP4, JP7, JP10**	74.5	+-7	16	5 to 40	**560Vpp**
JP1, JP3, JP5	82,5	+-10			**560Vpp**
JP1, JP3, JP5, **JP10**	92.5	+-12			**560Vpp**
JP1, JP3, JP4, JP7, JP10	124	+-20	8	5 to 120	**560Vpp**

** = capacity that needs to be adjusted in the Tuning Box.*

*** = specifies the allowed tolerance within which the corresponding jumper setting is valid.*

The columns Tun-Range and Cable show some examples of the jumper settings for a particular antenna inductance and cable length. The column VRF_max shows the maximum allowed resonance voltage at the antenna terminals.

In order to calculate C_tunb please use the formula shown in figure 25.

$$C\_res. = \frac{1406.45}{L\_ant. + 3} \quad [\,uH, nF\,]$$

$$C\_tunb. = C\_res. - C\_cable - 2.2 \quad [\,nF\,]$$

Default setting : 45.5nF for 27uH and cable length up to 40 meter

Figure 25: Formula to Calculate the Resonance Capacitance

Retuning of a system: At the RA-RFM start with no jumpers (shorting bridges) connected. While monitoring the resonance condition (according to method A or B described above), plug the jumpers and out (==> connecting and disconnecting the tuning capacitors) in such a way that the total tuning capacity increases in steps of the smallest tuning capacity C_ATC1.

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

> First no jumpers are plugged in.
> Next connect C_ATC1.
> Then disconnect C_ATC1 and connect C_ATC2.
> For the next step connect both 1 and C_ATC2 (and so on).

The tuning steps do not show an absolutely continuously increasing function, this is because of component tolerances. Therefore it may happen, when the tuning value is 'counted up' by one binary step that the total tuning capacity really **decreases** (especially from tuning step 31 to 32). This can result in the generated field strength not steadily increasing (as shown in figure 25).

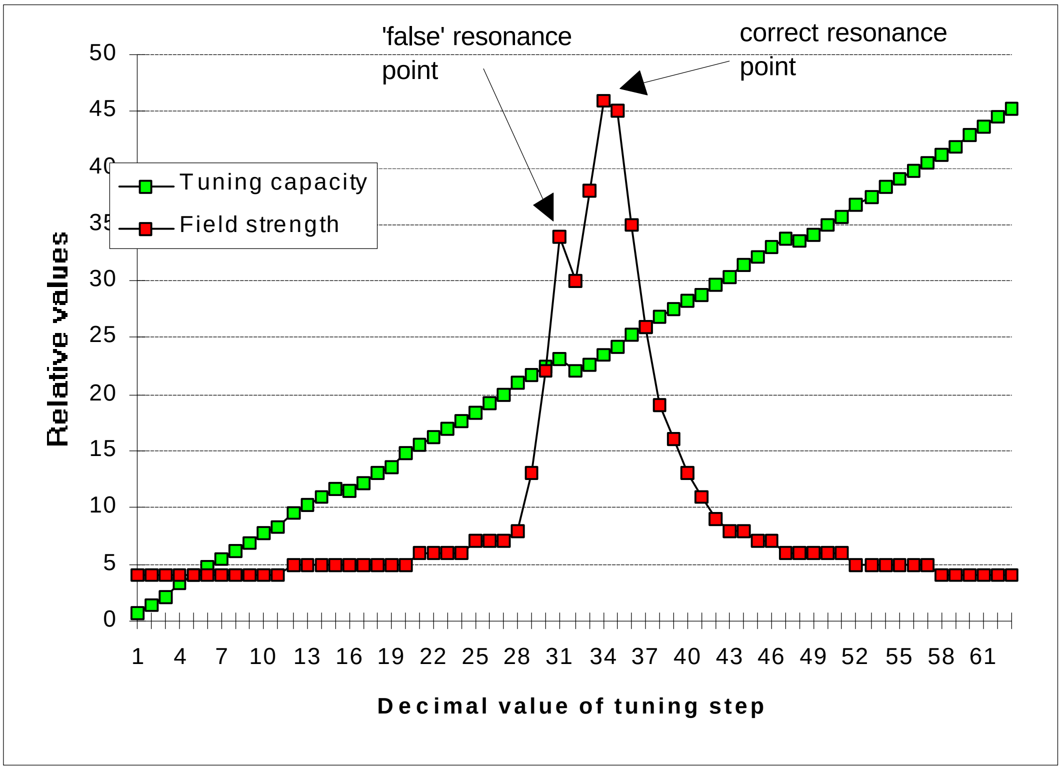

Figure 26: Tuning example showing increase of fine tuning capacity and generated field strength (typical values)

Note: *The lower the antenna inductance is, the lower the influence of the fine tuning capacitor on the resonance circuit.*

If you change the pulse width of the transmitter power stage, the antenna must be tuned to resonance again.

4.4 Field Strength Adjustment

The generated magnetic field strength determines the charge-up distance of the transponder. The higher the magnetic field strength, the greater 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 RA-RFM System 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 RA-RFM System (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 RA-RFM System, because the antenna covers a bigger area and thus generates a higher flux (assuming that all other parameters remain unchanged).

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

3. Supply voltage of the RA-RFM power stage.

   The higher the supply voltage of the RA-RFM transmitter power stage (VSP voltage), the higher the field strength which is generated by the RA-RFM System (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 RA-RFM System, because more power is 'pumped' 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 5.

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

4.5 Adjustment of Oscillator Signal Pulse Width

The RA-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 about 0%.

For this purpose there is a pulse width setting resistor R312 on the RA-RFM PCB (refer to figure 2 for location). Inserting a smaller resistance value for R312 decreases the pulse width 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 16 provides an overview of oscillator signal pulse width and corresponding size of field strength reduction, when different oscillator signal pulse widths are selected by connecting different values for resistor R312. In addition, the generated field strength is nearly linear to the transmitter power stage supply voltage, thus by increasing the transmitter power stage supply voltage by factor 2, doubles the generated field strength, which results in 6dB more in field strength.

Table 16: 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 RA-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%.

Note: *The pulse width for the oscillator signal pulse width setting of 5% and smaller is very short. The pulse response of the RA-RFM transmitter power stage to this short pulse is different for each RA-RFM. Therefore in order to have reproducible field strength values for different RA-RFMs, we recommend that you* ***do 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 customized antennas. For more details see 'Antenna Reference Guide' (Manual number 22-21-007).

* Find out corresponding field strength regulation for the country. As guideline refer to 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, the transmitter power stage supply voltage and the corresponding FCC/PTT value. Select the corresponding pulse width on the RA-RFM according to table 16.

* If necessary, use optional antenna damping function, when low field strength is needed for big 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 RA-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** read cycle synchronization of two or more reading units. This is necessary to ensure that if you have more than one reading unit in an area that they do not interfere with each other. The controller unit software monitors the RXSS- signal to detect whether other reading units are transmitting. This means that the controller unit can operate the transmitter of the RA-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.

Note: *Apart from using wireless read cycle synchronisation, the TIRIS S2000 Control Module offers several other methods for wired synchronisation. Please refer to the S2000 CTL Module Manual for more information.*

Depending on the antenna type used and the local noise level, the RXSS- threshold level has to be adjusted with the potentiometer on the RA-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 RA-RFM PCB near connector J1 (see also figure 2).

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 RA-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 RA-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 read cycle synchronisation distance. The wireless read cycle synchronisation 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 controller unit 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 RA-RFM System and antenna. 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 synchronisation sensitivity (and of course to have a long reading distance).

The RXSS- threshold level must be adjusted in the way that no spikes occur on the RXSS- signal output, because this leads to incorrect synchronisation 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 RA-RFM is necessary, it is recommended to use twisted pair lines and to connect a ceramic capacitor of 100 nF as close as possible to the pins RXSA and GND of the RA-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".*

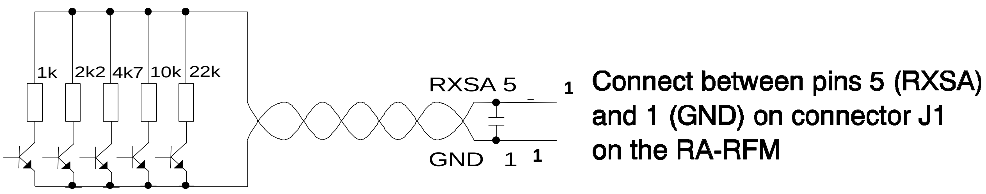

Figure 27: Adjusting RXSS with External Resistors

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 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 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 RFMs to be driven by one oscillator must have their J310 connectors connected together as shown in figure 28.

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 RA-RFM is referred to as an oscillator MASTER RFM. When there is no wire bridge, the external oscillator signal is used and the RA-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.

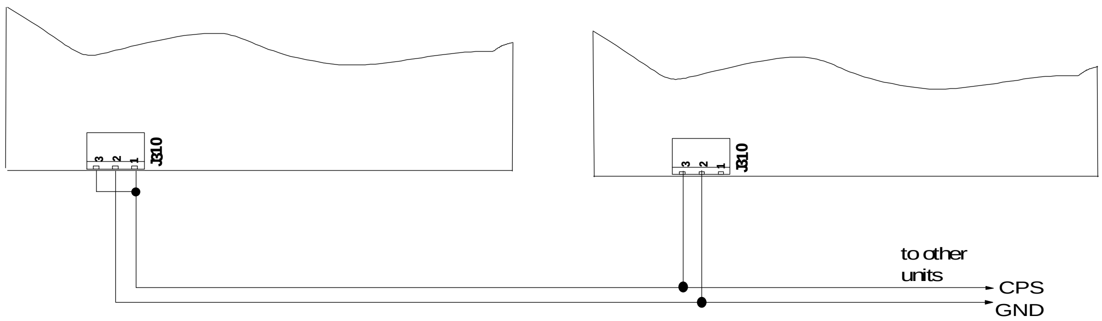

Figure 28: Connecting RFMs together for "MASTER/SLAVE" Oscillator Configuration

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 28.

In addition, the distances given in table 17 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 17, you should check for beat effect. The values given in table 17 refer to the distances shown in figure 29 and are valid for maximum charge-up field strength.

Figure 29: Distance between Antennas (top view)

Table 17: 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 RFM s 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 RFM , when using transmitter Carrier Phase Synchronization (CPS).

If an application requires more than one 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 30 shows how such a system must be connected:

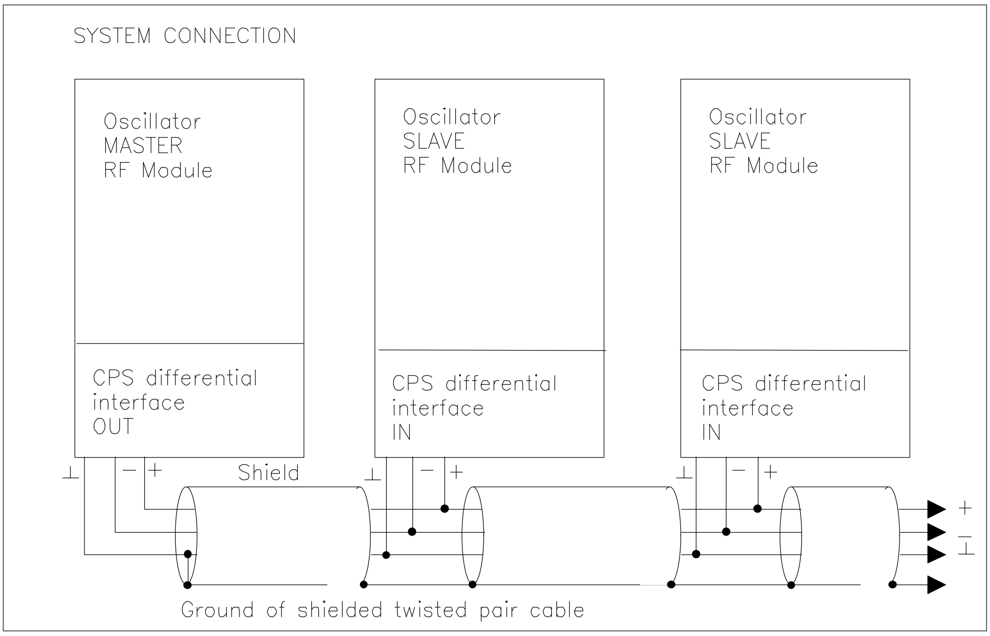

Figure 30: Connecting Multiple RFMs together

A proposal for such an external circuit is shown in figure 31. 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 31 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.

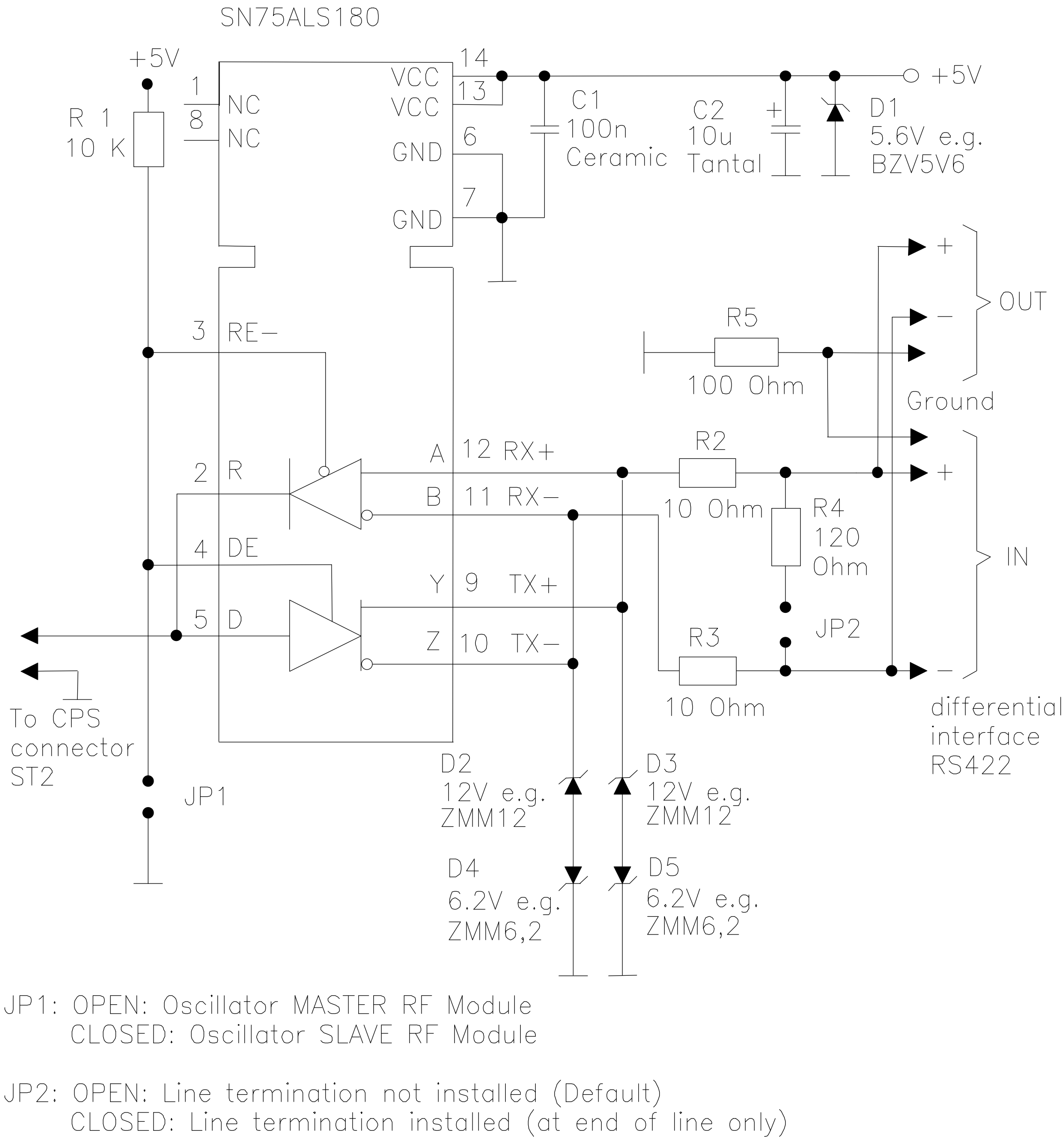

Figure 31: Circuit and Jumper Settings for RS422 Interface

CAUTION: Use over voltage protection components at the CPS connector for CPS lines between 0.5 and 5m, when the circuit shown in figure 31 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

The RA-RFM has the option to use one special receive-only antenna. However, because of the nature of Remote Antenna Systems, receive only applications are very limited. Please refer to the Power RFM (RI-RFM-007A) Reference Manual (Document number 11-06-29-026) for further information.

4.9 Noise Verification

Noise can have a negative effect on the receive performance of the RA-RFM. There are two different kind of noise: radiated and conducted noise. Remember that both noise types can be either **'differential'** or **'common mode'** noise.

Table 18: 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 RA-RFM 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 RA-RFM.

The measurement criteria for low noise is the amplitude of the receive signal strength detector of the RA-RFM. The test pin RSTP at connector J1 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 32. This configuration operates the RA-RFM 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.

The procedure for testing of noise impact is as follows:

* The normal set-up for the RA-RFM and antenna gives bad reading distance, even though the antenna is correctly tuned for sufficient transponder charge-up.

* Try the configuration shown in figure 32. 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)

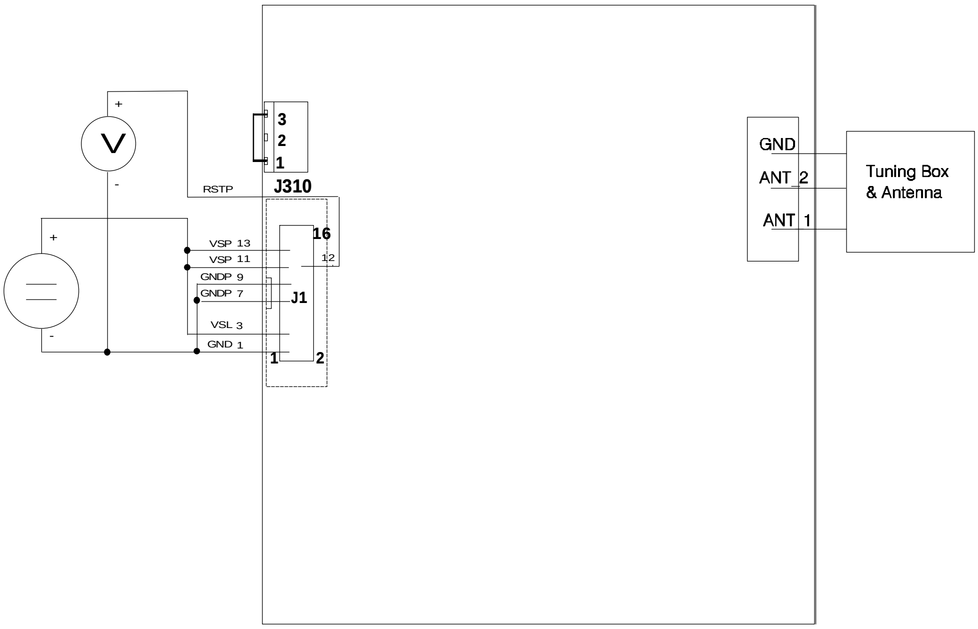

Figure 32: Noise Testing Configuration (Testing RSTP)

* When the configuration of figure 32 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 RA-RFM (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".

Note: The RA-RFM has a built-in function to suppress Common Mode Noise coupled to the TX/RX antenna.

4.10 Over Voltage Protection

For applications, where there is the risk that voltage spikes and noise are on the lines to the RA-RFM, additional protection circuitry and filters must be added. A useful proposal for this is shown in figure 33. 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 33 are* **not special suppresser diodes** *for fast suppressing of voltage spikes, they are commonly used diodes. If the application requires it, special suppresser diodes should be used.*

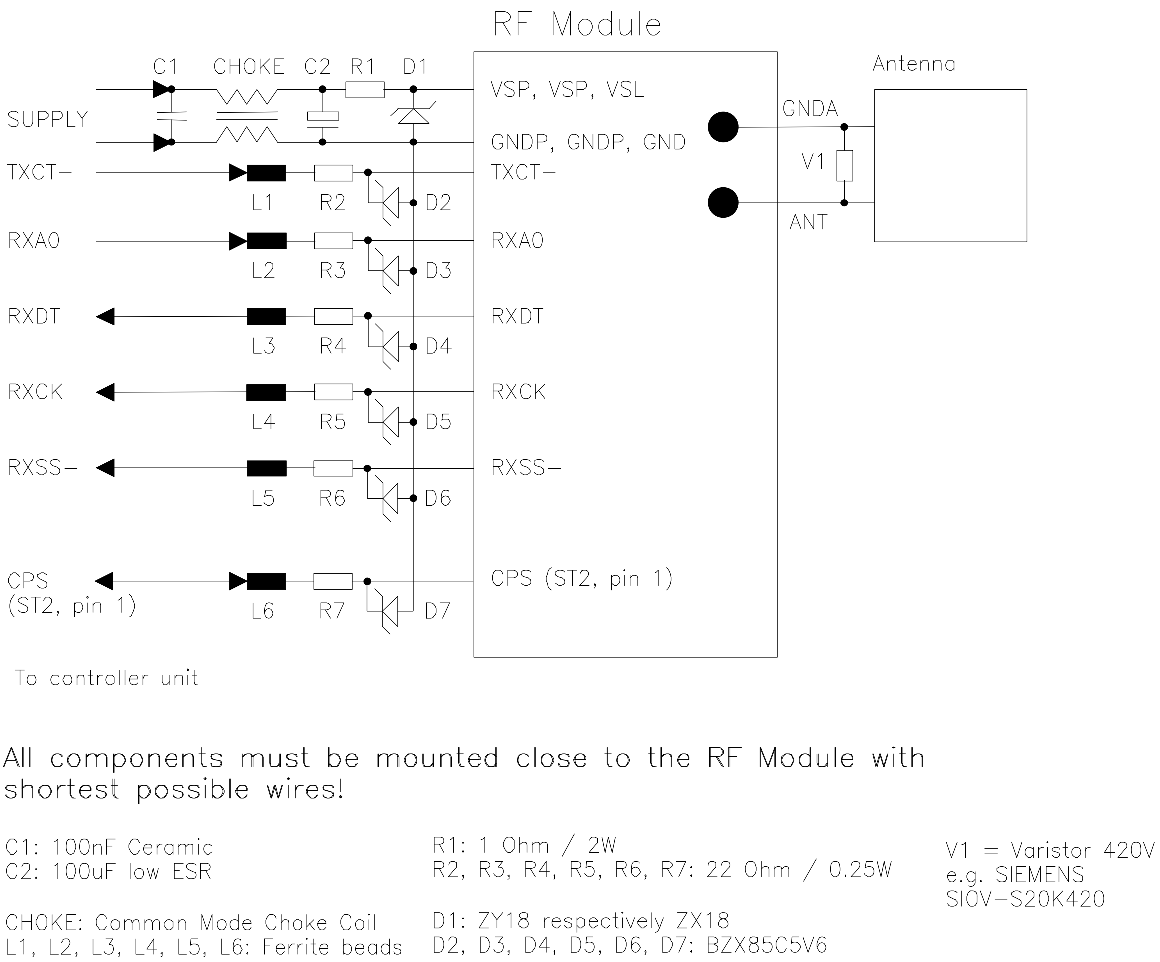

Figure 33: Circuit for Overvoltage Protection

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 J1 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 RA-RFMside 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 RA-RFMside must work the other way round.

A circuit proposal for this is shown in figure 34 (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 RA-RFM 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 RA-RFM side and the RA-RFM 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 RA-RFM 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 RA-RFM from a local supply at the RA-RFM installation site. In this case, however, there needs to be an additional ground line between the Control Module and the RA-RFM 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 35.

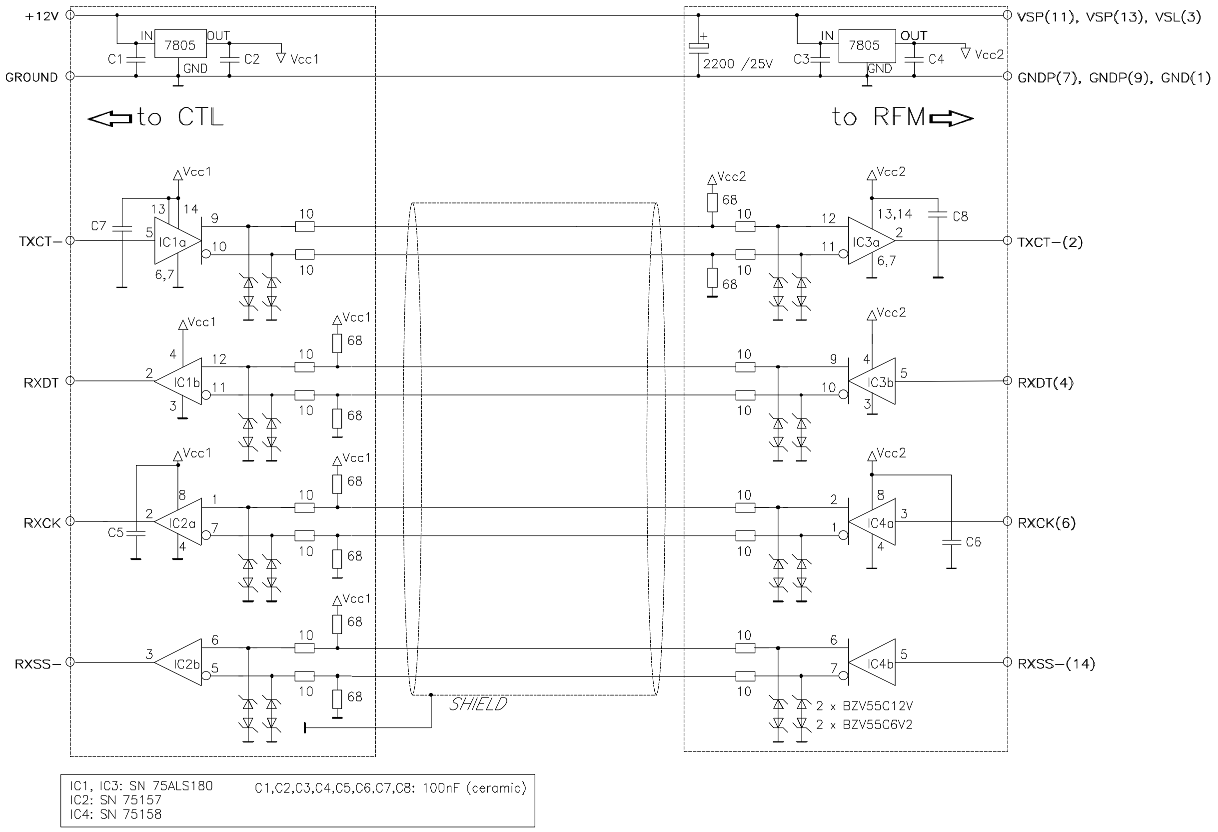

Figure 34: Conversion Circuit without Own Supply

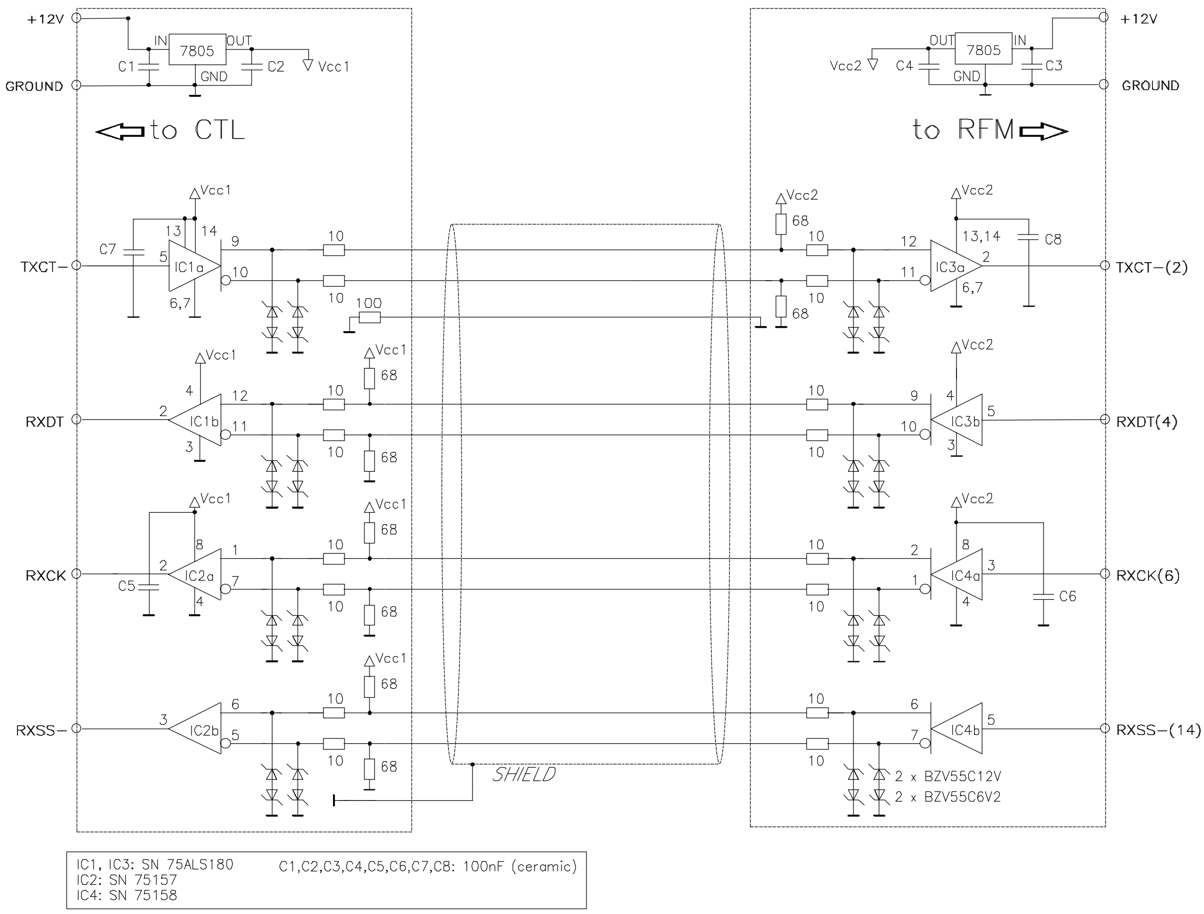

Figure 35: Conversion Circuit

If the ground potential differences between the Control Module and the RA-RFM 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 36.

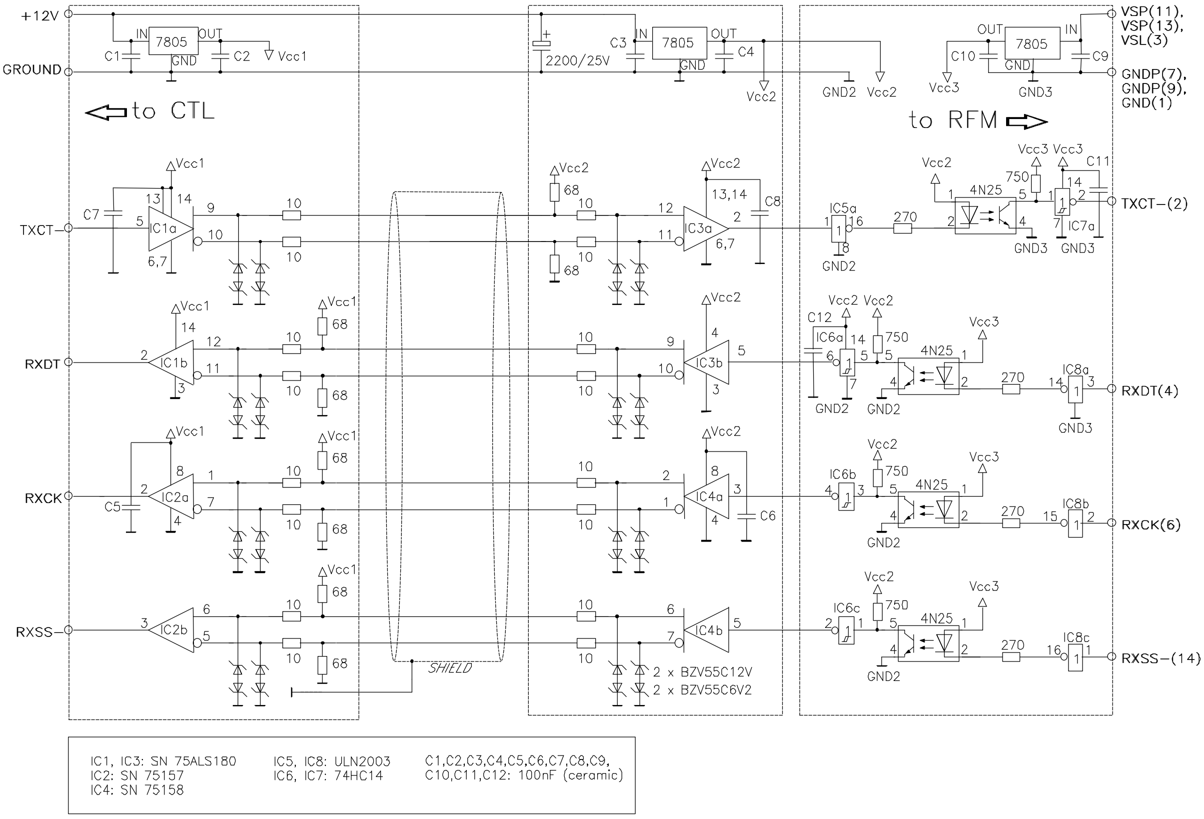

Figure 36: Conversion Circuit with Optocouplers

The interface converter at the Control Module side is the same as that already shown in figures 34 and 35. The circuit at the RA-RFM 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 RA-RFM 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 34, 35 and 36 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 37 and 38. 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 :*

*D E = 20 * exponent * log (d1/d2) [dBmV/m]*

D E	:	*field strength difference which has to be added to or subtracted from the known field strength value in dBmV/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 W

or:

H [dBmA/m] = E [dBmV/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.

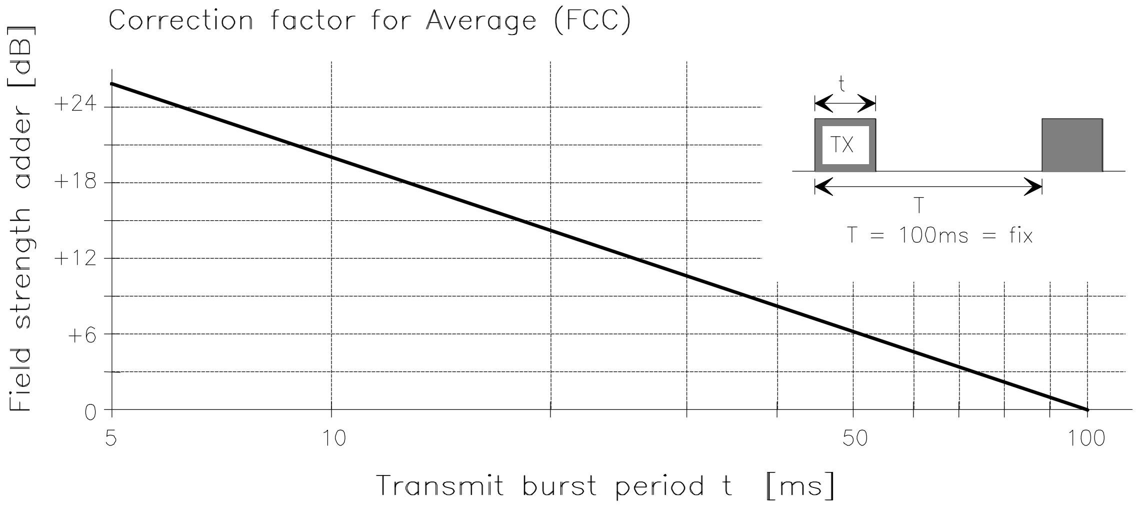

Figure 37: Field Strength Level Correction Factor Using Average Detector

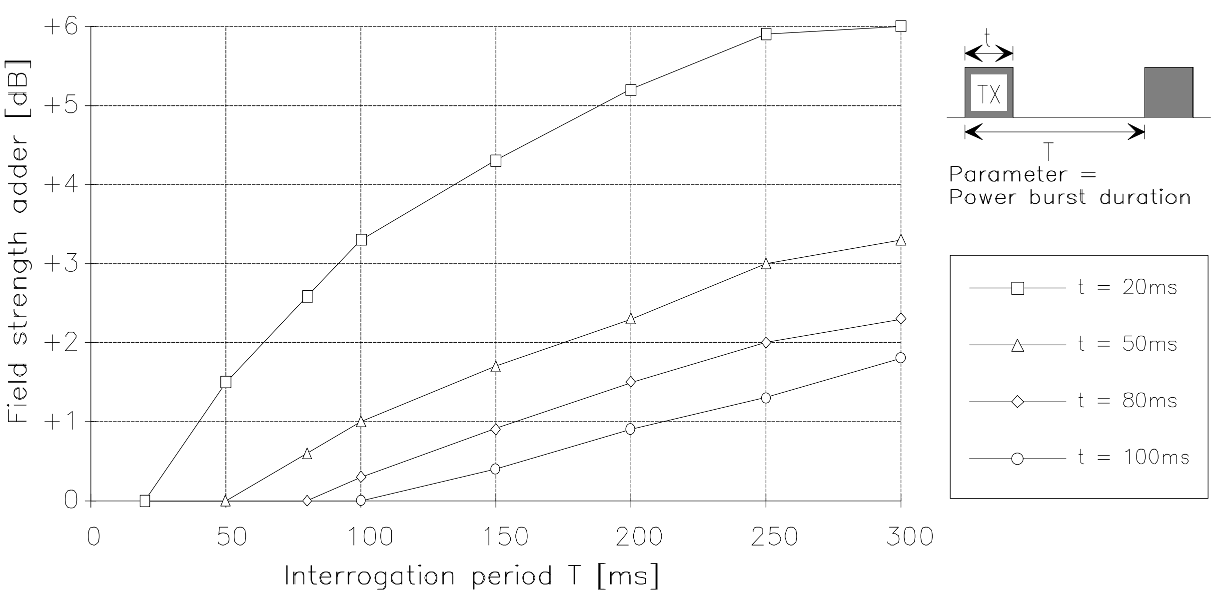

Figure 38: Field Strength Level Correction Factor Using CISPR Detector