

***Series 2000 Reader System***  
***Mini-RFM RI-RFM-003B***

***Reference Guide***

***November 2000***

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***TIRIS*** *Technology by  
Texas Instruments™*

***SCBU021***

# ***Series 2000 Reader System***

***Mini-RFM RI-RFM-003B***

## ***Reference Guide***

***TIRIS*** Technology by  
Texas Instruments™

Literature Number: SCBU021  
November 2000



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## ***Read This First***

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### **Edition Three - November 2000**

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

TIRIS™ Mini-Radio Frequency Module RI-RFM-003B

### **About This Guide**

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

Regulatory, safety and warranty notices that must be followed are given in Chapter 6.

## Conventions

### **WARNING**

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

### **CAUTION**

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

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

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**Note:** Indicates information which makes usage of the equipment or software easier.

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## If You Need Assistance

Application Centers are located in Europe, North and South America, the Far East and Australia to provide direct support. For more information, please contact your nearest TIRIS Sales and Application Center. The contact addresses can be found on our home page: <http://www.tiris.com>

## Trademarks

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## Introduction

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This chapter introduces you to the Mini-RFM. It tells you what the module is for, provides an overview of the complete system and the product itself. It also provides a mechanical description of the construction of the Mini-RFM.

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## 1.1 General

This manual provides information about the TIRIS™ Mini-Radio Frequency Module RI-RFM-003B. It describes the module and how to integrate it into your RFID system.

This guide should be used in conjunction with the RFM Sequence Control Reference Manual (document number 11-06-21-049) which describes the timing and sequence of radio communications between the TIRIS transponder and the radio frequency module.

## 1.2 System Overview

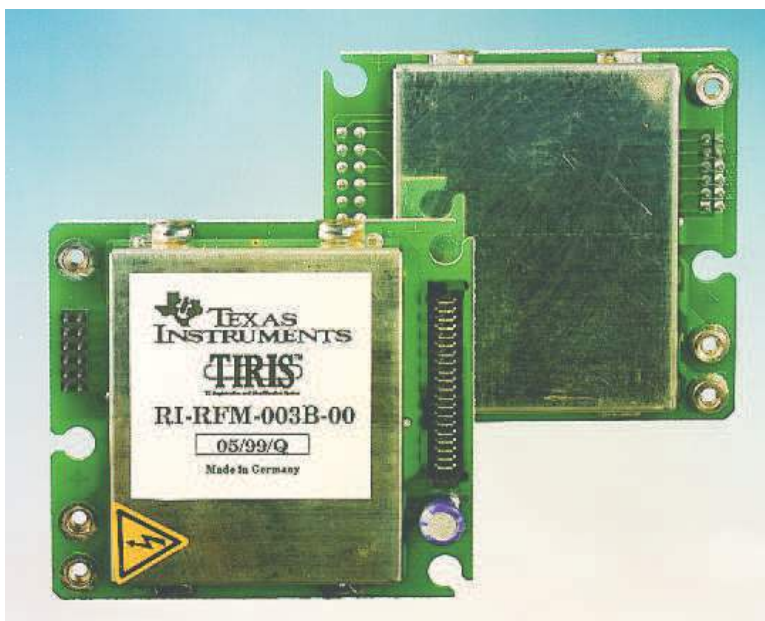
The three major parts of a TIRIS system are the transponder, antenna and reader.

When a transponder is to be read, the reader sends out a 134.2 kHz power pulse lasting approximately 50 ms to the antenna. The field generated by this power pulse is collected by the antenna in the transponder that is tuned to the same frequency. This received energy is stored in a small capacitor within the transponder. When the power pulse has finished, the transponder immediately transmits its data back to the reader, using the energy stored within its capacitor as the power source.

## 1.3 Product Description

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

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



**Figure 1-1. The RI-RFM-003B**

Its small size and low supply voltage makes the Mini-RFM well suited for portable reading/writing units, as well as for stationary equipment where medium read/write range and speed is sufficient.

The data input and output lines are compatible with the HCMOS-logic family.



## **1.4 Mechanical Construction**

The RF module has a simple mechanical construction where all the components are mounted on the printed circuit board (PCB). The components of the upper and lower side of the PCB are protected by metal shields. The PCB also carries the connectors ST1, ST2 and the antenna terminals A1 to A3 which are captive nuts soldered to the PCB. These captive nuts allow durable low resistance connection with the ring terminals of the antenna.



## ***Electrical Description***

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This chapter provides an electrical description to block diagram level of how the Mini-RFM works.

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## 2.1 General

The RF module is the interface between the TIRIS transponder and the data processing unit of a TIRIS Reader. It contains circuitry to:

- Send a charge-up signal to a TIRIS transponder
- Program a read/write transponder
- To receive the signal from the transponder and to prepare the received signal for digital decoding.

Figure 2-1 shows the block diagram of the RF module and unless otherwise noted the following description refers to this schematic.

## 2.2 Transmitter

The transmitter control logic generates the transmitter output frequency from a crystal-controlled oscillator. This signal is amplified by the push-pull transmitter power stage which is connected to the antenna terminal A1. The supply current  $I_{VSP}$  of the transmitter output stage depends on the quality factor of the antenna being used and the supply voltage  $VSP$ . The Mini-RFM's antenna circuit is shown in Figure 2-2.

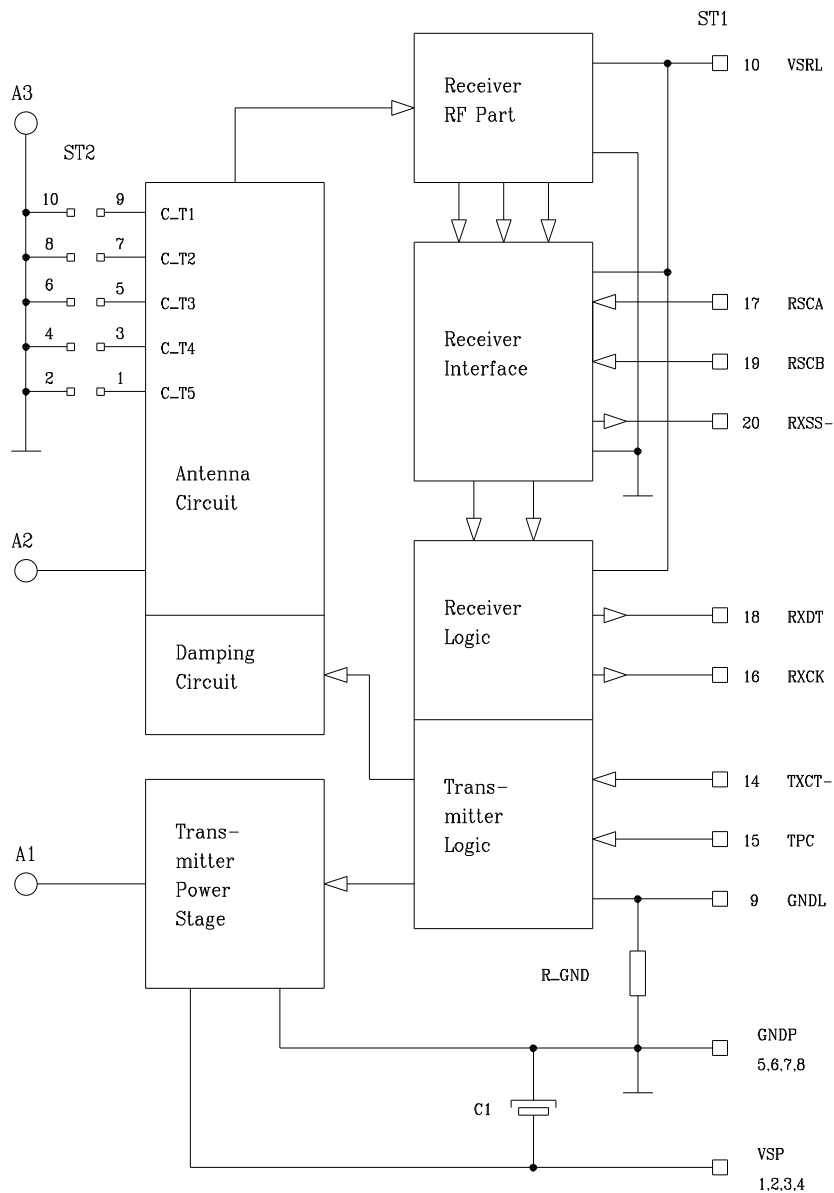
### **CAUTION**

Because of the necessarily low impedance of the output stage, a short-circuit from antenna terminal A1 either to the ground or to the supply voltage can damage the output stage if the supply current is not limited.

The transmitter control signal TXCT- activates the transmitter as long as it is low. In receive mode when TXCT- is high the antenna terminal A1 has a low impedance path to the ground.

The transmitter power control signal TPC controls the intensity of the transmitter charge pulse by changing the duty cycle of the power stage control signal. The level of the RF power output can be reduced by setting the TPC signal to low. TPC controls the power setting of the RF signal which is used to make-up the power-burst. Both input signals TXCT- and TPC have internal pullup resistors.

Because of the limited heatsink possibilities of the transmitter power transistors the duty cycle of the power pulse must not be allowed to exceed that shown in Figure 4-1.



**Figure 2-1. Mini-RFM Block Diagram**

## 2.3 Receiver

The receiver comprises three parts: the RF part, the interface and the logic.

The selective amplifier in the RF Part of the receiver:

- Amplifies the RF signal received from the antenna circuit, then
- Demodulates the FSK signal from the TIRIS transponder, and
- Generates an analog voltage (RSSI) that provides an indication of the received signal strength.

The demodulated FSK signal, carrier signal and analog signal strength voltage are all connected to the receiver interface. The demodulated data signal and the carrier signal are converted to logic signals, and connected to the receiver logic for further processing. The signal strength indicator voltage is converted into RXSS- which is fed directly to the module connector ST1. The function of the RXSS- signal is explained in more detail in section 5.3.

The receiver logic generates the receiver data signal RXDT and the receiver clock signal RXCK to allow a simple data processing. The NRZ data stream of RXDT contains the identification data, the protection data and the framing bits. The clock signal RXCK is used as time reference for the data stream of RXDT. The RXCK signal changes from low to high level in the middle of each data bit.

## 2.4 Antenna Circuit

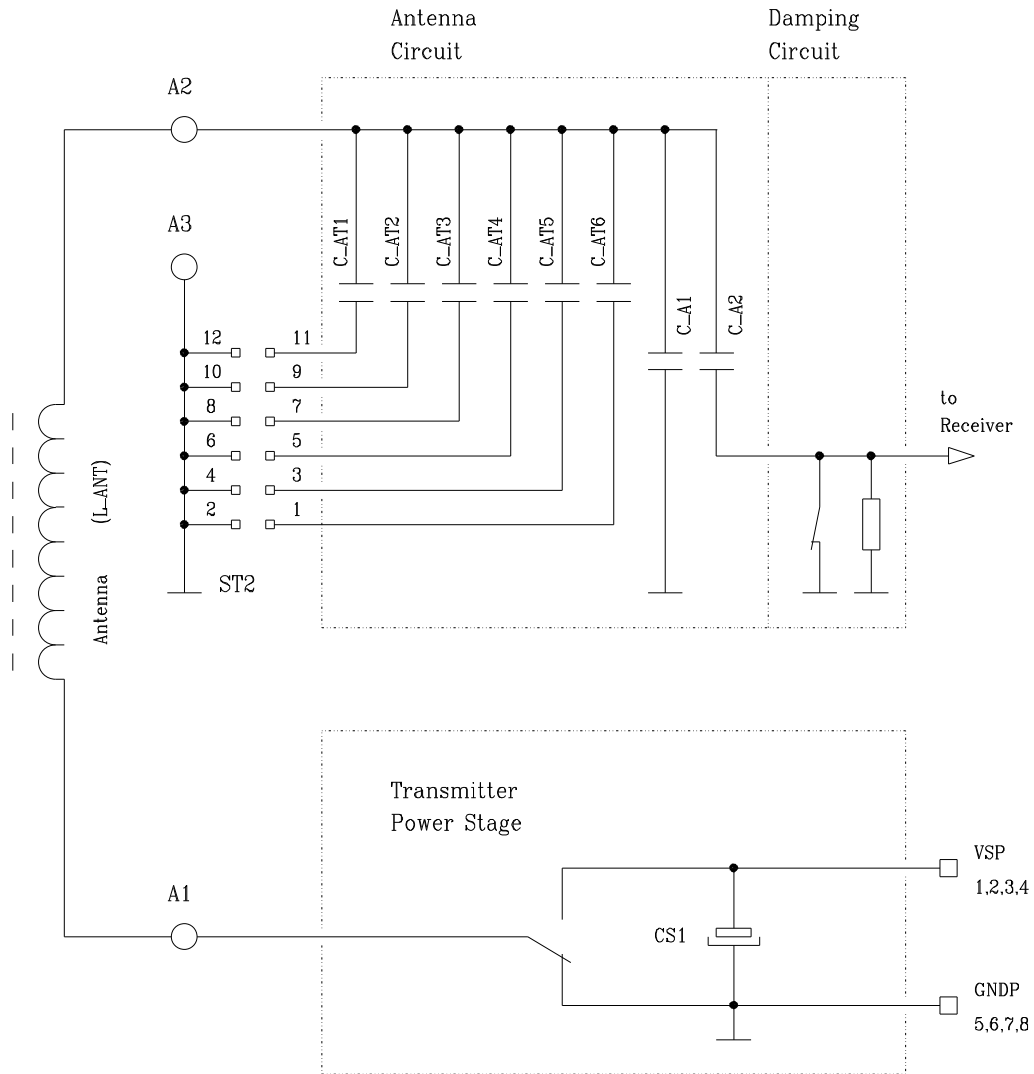
Figure 2-2 shows a simplified schematic of the antenna circuit. The antenna coil L\_ANT is not part of the module but together with the antenna circuit's built-in capacitors it forms a resonance circuit. The resonant current through the antenna coil generates the magnetic field which charges (and programs) the transponder.

For the system to transmit and receive correctly, the antenna must be precisely tuned to the transmitter output frequency  $f_{TXO}$  to compensate for the (allowed) tolerances of the antenna coil L\_Ant and the antenna capacitors C\_A1 and C\_A2. To enable this tuning, six tuning capacitors C\_AT1 to C\_AT6 have been added to the antenna circuit. Their values are binary weighted in normalized steps of 1, 2, 4, 8, 16, and 32. C\_AT1 has the smallest value corresponding to the normalized value 1. C\_AT2 has the double capacitance of C\_AT1, so that C\_AT2 corresponds to the normalized value 2 and so on. With this capacitance array and six jumpers, 64 different capacitance values can be tuned. Each of the five tuning pins has its adjacent antenna ground pin for a simple short circuit with jumpers.

The antenna terminal A3, which is not used in normal applications and the antenna ground pins of ST2 have same potential as GNDP but should be used only for antenna purposes and not as a convenient ground connection.

The damping circuit is part of the antenna circuit and damps the antenna circuit by reducing the quality factor of the built-in antenna circuit capacitor connected to the terminal A2. The quality factor is reduced during the receive mode when the TXCT- signal is high.

Information about the tuning of the antenna circuit is given in section 5.6.



**Figure 2-2. Mini-RFM's Antenna Circuit**





## Connectors

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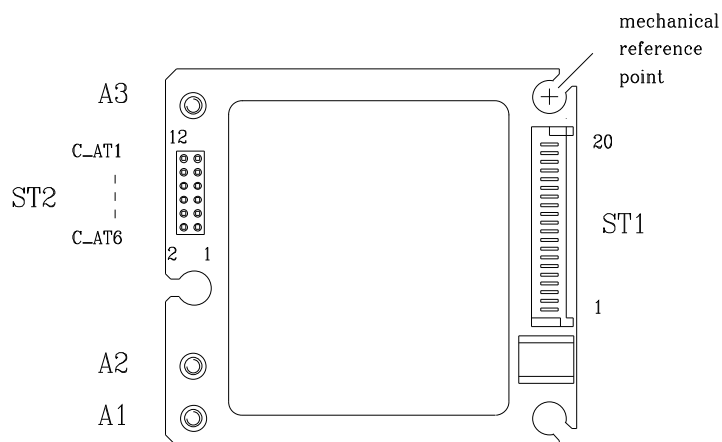
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This chapter contains a listing of the module's two connectors (ST1 and ST2) together with a list of the signals contained on each pin.

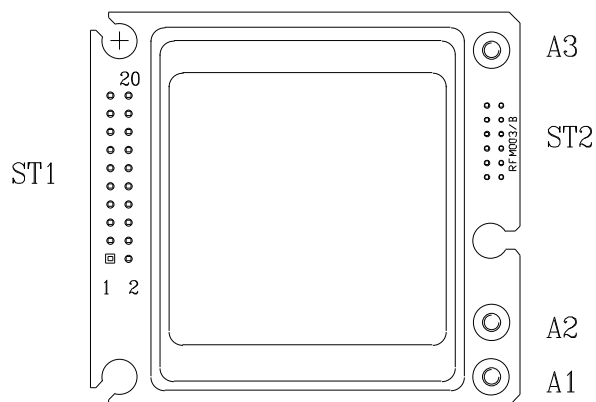
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### 3.1 Connector Location

Figure 3-1 and Figure 3-2 show the location of the terminals on the PCB from the top and from the bottom.



**Figure 3-1. Top View**



**Figure 3-2. Bottom View**

### 3.2 Connector ST1

**Table 3-1. Module Connector - ST1**

| PIN. | NAME  | PURPOSE  |
|------|-------|--|
| 1    | VSP   | Supply Voltage for Power Stage (+)                       |
| 2    | VSP   | Supply Voltage for Power Stage (+)                       |
| 3    | VSP   | Supply Voltage for Power Stage (+)                       |
| 4    | VSP   | Supply Voltage for Power Stage (+)                       |
| 5    | GNDP  | Ground for Power Stage (-)                               |
| 6    | GNDP  | Ground for Power Stage (-)                               |
| 7    | GNDP  | Ground for Power Stage (-)                               |
| 8    | GNDP  | Ground for Power Stage (-)                               |
| 9    | GNDL  | Ground for Logic (-)                                     |
| 10   | VSRL  | Regulated Supply voltage for Receiver and Logic (+)      |
| 11   | N.C.  | Not connected  |
| 12   | N.C.  | Not connected  |
| 13   | N.C.  | Not connected  |
| 14   | TXCT- | Transmitter Control Input, inverted                      |
| 15   | TPC   | Transmitter Power Control Input                          |
| 16   | RXCK  | Receiver Clock Output                                    |
| 17   | RSCA  | Receiver Synchronization Level Control Input, weighted 1 |
| 18   | RXDT  | Receiver Data Output                                     |
| 19   | RSCB  | Receiver Synchronization Level Control Input, weighted 2 |
| 20   | RXSS- | Receiver signal strength output, inverted                |

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**Note:** Supply terminals GNDP and GNDL must be connected externally.

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### 3.3 Connector ST2

**Table 3-2. Antenna Tuning Connector - ST2**

| PIN. | SIGNAL | PURPOSE   |
|------|--------|---|
| 1    | C_AT6  | Antenna Tuning Capacitor 5, (weighted value 32) |
| 2    | GNDP   | Antenna ground                                  |
| 3    | C_AT5  | Antenna Tuning Capacitor 5, (weighted value 16) |
| 4    | GNDP   | Antenna ground                                  |
| 5    | C_AT4  | Antenna Tuning Capacitor 4, (weighted value 8)  |
| 6    | GNDP   | Antenna ground                                  |
| 7    | C_AT3  | Antenna Tuning Capacitor 3, (weighted value 4)  |
| 8    | GNDP   | Antenna ground                                  |
| 9    | C_AT2  | Antenna Tuning Capacitor 2, (weighted value 2)  |
| 10   | GNDP   | Antenna ground                                  |
| 11   | C_AT1  | Antenna Tuning Capacitor 1, (weighted value 1)  |
| 12   | GNDP   | Antenna ground                                  |

### 3.4 Antenna Connector

**Table 3-3. Antenna Connector**

| <b>PIN NUMBER</b> | <b>PURPOSE</b>        |
|-------------------|-----------------------|
| A1                | Antenna terminal 1    |
| A2                | Antenna terminal 2    |
| A3                | Antenna ground (GNDP) |

**CAUTION**

Never try to connect the antenna between A1 and A3, or A2 and A3; as this will damage the module.

## Specifications

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This chapter provides the specific details that you will need in order to use the TIRIS Mini-Radio Frequency Module RI-RFM-003B correctly. It includes general data, electrical characteristics, timing characteristics and mechanical data.

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#### 4.1 Recommended Operating Conditions

Operating free-air temperature range..... 0 to 50°C

Storage temperature range..... –25 to 85°C

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**Note:** Free-air temperature: air temperature immediately surrounding the Mini-RFM. 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 ratings given here.

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| Parameter | Description                                | Condition | Pin No. of ST1 | MIN  | MAX  | Unit |
|-----------|--|-----------|----------------|------|------|------|
| VSRL      | Supply voltage for logic                   |           | 10             | 4.75 | 5.25 | V    |
| VSP       | Supply voltage for transmitter power stage |           | 1, 2, 3, 4     | 4.5  | 6    | V    |
| VIL       | Low level input voltage for TXCT- and TPC  | VSRL = 5  | 14, 15         | 0    | 1    | V    |
| VIH       | High level input voltage for TXCT- and TPC | VSRL = 5  | 14, 15         | 4    | 5    | V    |

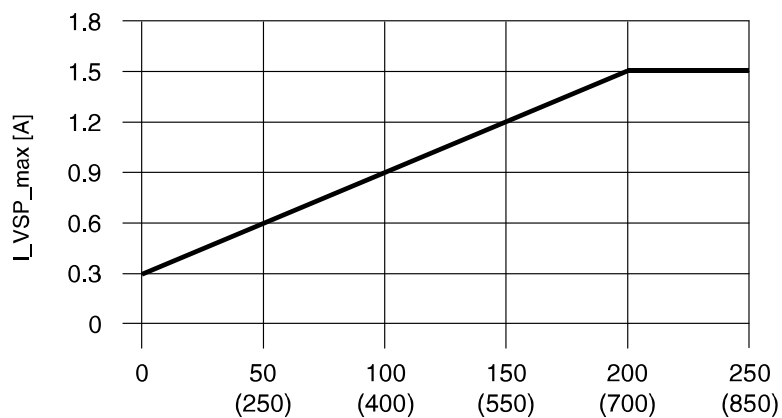
## 4.2 Electrical Characteristics

at  $T_{amb}=25^{\circ}\text{C}$ ,  $V_{SRL}=5\text{ V}$  (unless otherwise noted)

**Note:** The voltage difference between GNDL and GNDP must not exceed 0.5 V.

| Parameter | Description  | Condition                      | Pin No. of ST1  | MIN  | NOM | MAX  | Unit          |
|-----------|--|--------------------------------|-----------------|------|-----|------|---------------|
| I_VSRL    | Supply current for logic and receiver                                |                                | 10              |      |     | 80   | mA            |
| I_VSP     | Supply current for transmitter power stage with antenna Ri-ANT-P02A  | VSP=5V<br>TXCT=low<br>TPC=high | 1, 2, 3, 4      | 0.5  |     | 1.2  | A             |
| I_VSP_L   | Leakage current for transmitter power stage with antenna Ri-ANT-P02A | VSP=5V<br>TXCT=high            | 1, 2, 3, 4      |      |     | 50   | $\mu\text{A}$ |
| R_up      | Pull-up resistor from TXCT- and TPC to VSRL                          |                                |                 |      | 22  |      | k $\Omega$    |
| I_IL      | Low level input current for TCXT- and TPC                            | V_IL=0V                        | 14, 15          | -180 |     | -300 | $\mu\text{A}$ |
| I_IH      | High level input current for TCXT- and TPC                           | V_IL=4V                        | 14, 15          | -30  |     | -60  | $\mu\text{A}$ |
| I_IL      | Low level input current for RSCA and RSCB                            | V_IL=0V                        | 17, 19          |      |     | -30  | $\mu\text{A}$ |
| I_IH      | High level input current for RSCA and RSCB                           | V_IH=5V                        | 17, 19          |      |     | 30   | $\mu\text{A}$ |
| V_OH      | High level output voltage for RXCK, RXDT and RXSS-                   | I_OH=-2mA                      | 16, 18, 20      | 2, 4 |     |      | V             |
| V_OH      | High level output voltage for RXCK, RXDT and RXSS-                   | I_OH=-1mA                      | 16, 18, 20      | 4    |     |      | V             |
| V_OL      | Low level output voltage for RXCK, RXDT and RXSS-                    | I_OL=-2mA                      | 16, 18, 20      |      |     | 0.5  | V             |
| R_GND     | Decoupling resistor between GNDL and GNDP                            |                                | 9 to 5, 6, 7, 8 |      | 33  |      | $\Omega$      |

| Parameter  | Description                         | Condition           | Pin No. of ST2 | MIN  | NOM  | MAX  | Unit |
|------------|-------------------------------------|---------------------|----------------|------|------|------|------|
| C_A1 +C_A2 | Antenna capacity                    | Without tuning cap. | A2             | 10.6 |      | 11.8 | nF   |
| C_AT6      | Antenna tuning capacity weighted 32 |                     | 1              | 1425 | 1500 | 1575 | pF   |
| C_AT5      | Antenna tuning capacity weighted 16 |                     | 3              | 740  | 780  | 820  | pF   |
| C_AT4      | Antenna tuning capacity weighted 8  |                     | 5              | 370  | 391  | 410  | pF   |
| C_AT3      | Antenna tuning capacity weighted 4  |                     | 7              | 209  | 220  | 231  | pF   |
| C_AT2      | Antenna tuning capacity weighted 2  |                     | 9              | 95   | 100  | 105  | pF   |
| C_AT1      | Antenna tuning capacity weighted 1  |                     | 11             | 50   | 56   | 64   | pF   |



Time t\_off between 2 charge pulses of 50 ms [ms]

Values in brackets ( ) are for time t\_off between 2 write cycles

**Figure 4-1. Maximum Supply Current I\_VSP versus t\_off (Power Stage)**



### 4.3 Timing Characteristics

at  $T_{amb}=0 - 50^{\circ}\text{C}$ ,  $V_{SRL}=5\text{ V}$ ,  $V_{SP}=5\text{ V}$

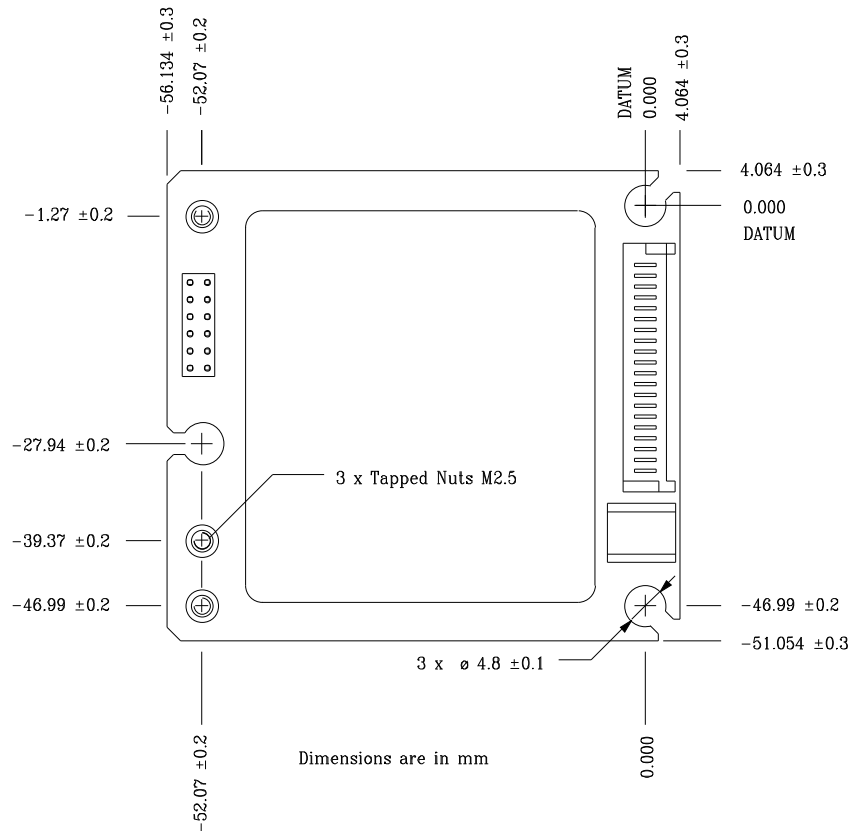
| Parameter         | Description  | Condition                      | Pin No. of ST1 | MIN   | NOM    | MAX   | Unit          |
|-------------------|--|--------------------------------|----------------|-------|--------|-------|---------------|
| f_TX              | Transmitter frequency                                      |                                | A1             | 134.1 | 134.2  | 134.3 | kHz           |
| f_OSC             | Internal oscillator frequency                              |                                |                |       | 4294.4 |       | kHz           |
| f_mRX             | Center frequency of receiver                               |                                |                |       | 128.2  |       | kHz           |
| b_RX              | Bandwidth of receiver                                      |                                |                |       | 22     |       | kHz           |
| t_rin,<br>t_fin   | Rise and fall time of the input signals TXCT- and TPC      |                                | 14, 15         |       |        | 100   | ns            |
| t_rout,<br>t_fout | Rise and fall time of the output signals RXCK, RXDT, RXSS- |                                | 17, 18, 20     |       |        | 1     | $\mu\text{s}$ |
| f_REPwrt          | Repetition rate to program with Antenna = RI-ANT-P02A      | t_wrt = 310 ms<br>TPC = high   |                |       |        | 1     | Hz            |
| f_REPrd           | Repetition rate to read with Antenna = RI-ANT-P02A         | t_charge = 50 ms<br>TPC = high |                |       |        | 4     | Hz            |
| t_offL            | Transmitter OFF-time for databit = "L"                     | t_bit = 2 ms                   |                |       | 0.5    |       | ms            |
| t_offH            | Transmitter OFF-time for databit = "H"                     | t_bit = 2 ms                   |                |       | 1.2    |       | ms            |

### 4.4 Mechanical Data

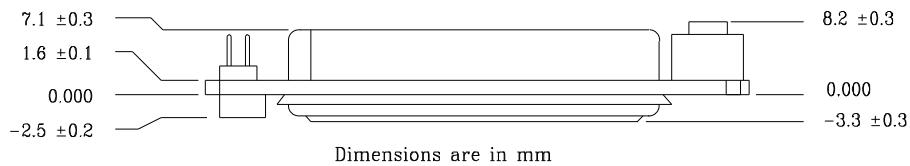
|                      |         |
|----------------------|---------|
| Length               | 60.2 mm |
| Width                | 55.1 mm |
| Height, body         | 10.4 mm |
| Height, at connector | 11.5 mm |
| Weight               | 40 g    |

*Mechanical Data*

Figure 4-2 shows the top view and Figure 4-3 shows the side view of the RF module, both drawings show the most important dimensions. The center of the upper right mounting hole serves as reference point for all dimensions.



**Figure 4-2. Mechanical Dimensions - Top View**



**Figure 4-3. Mechanical Dimensions - Side View**

## ***Installation and Use***

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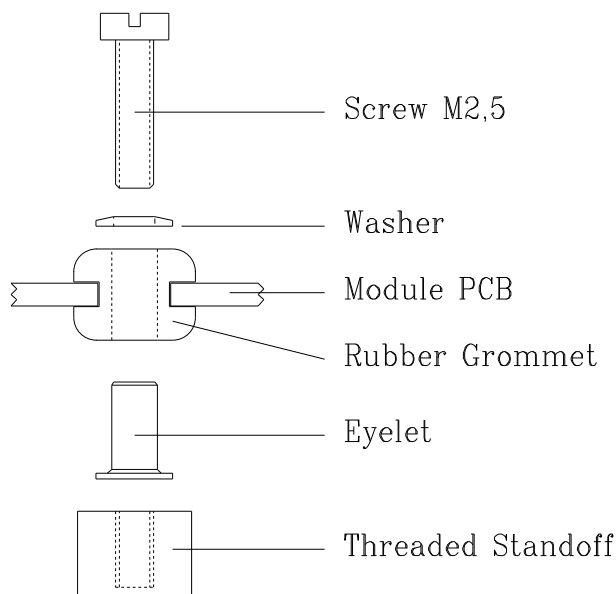
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This chapter provides the specific details that you will need in order to install the TIRIS Mini-RFM correctly. It includes a detailed description of the power supply requirements, the antenna characteristics, the connecting cable and how to tune the antenna to resonance.

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## 5.1 Mechanical Mounting

To protect the RF module from strong mechanical shock and vibration, grommets are inserted into the mounting hole of the PCB as shown in Figure 5-1. Because the grommets are made of soft material, eyelets or spacers must be inserted into them when the RF module is mounted with screws.



**Figure 5-1. PCB Mounting Proposal**

---

**Note:** Take care when disconnecting ST1 that you pull the plug straight out and do not apply any sideways strain to the plastic guides.

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## 5.2 Supply Voltage

The module uses two different supply lines each with a separate ground line. The receiver and the logic are supplied via the VSRL and GNDL pins from a voltage regulated power supply. The transmitter power stage with its relatively high current consumption is supplied via the VSP and GNDP pins. The supply voltage range for VSP is wider than for VSL. This allows the direct connection of VSP to a four cell NiCd battery, if the variation of the power pulse field strength caused by the variation of the battery voltage is acceptable.

Both ground lines GNDL and GNDP are decoupled inside the RFM with the resistor R\_GND and the capacitor C\_GND and have to be connected together externally as shown in Figure 5-2 or Figure 5-3 (depending on your power supply). This technique allows the power ground level GNDP to float in a certain range against the logic ground level GNDL without creating adverse effects to the control signals from and to the control unit. Floating GNDP can happen during transmit time if you are using a long supply line between the RF module and a control module.

Figure 5-2 shows an example of how to supply the RF module in a battery supplied reading unit where short lines are possible.

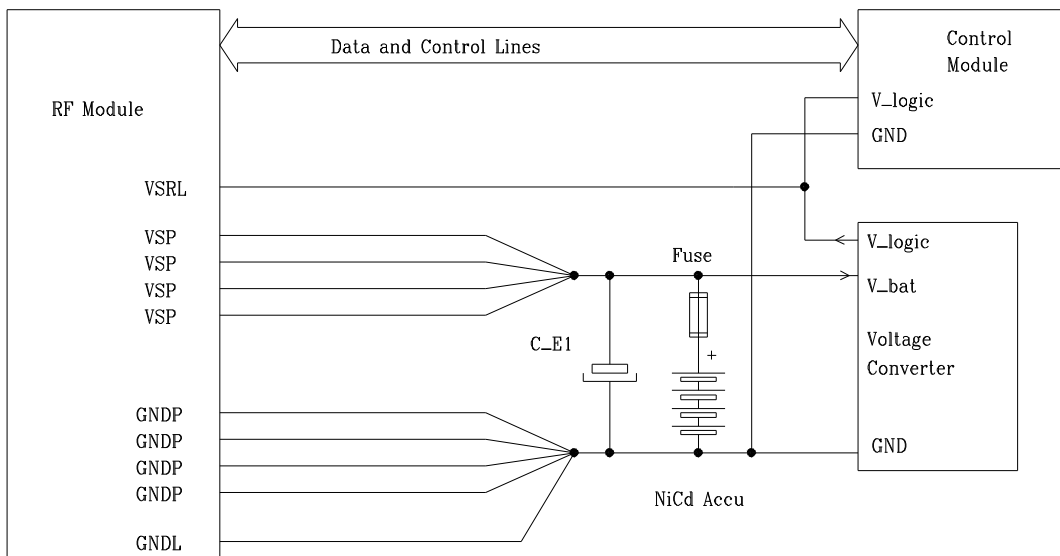
Figure 5-3 shows an example of how to wire a stationary application where long supply lines (over 15 cm) are used. The capacitor C\_E1 between the VSP and GNDP pins is necessary to reduce the RF ripple voltage and EMI on the supply line and must have low impedance at the transmit frequency (ESR = Equivalent Serial Resistor). In addition the common mode choke coil (choke) and the capacitor C\_E2 also reduce the EMI during transmit time. These components should be placed as closely as possible to the RF module connector ST1.

The capacitor values shown in Figure 5-2 and Figure 5-3 are for general use and can vary according to different application requirements.

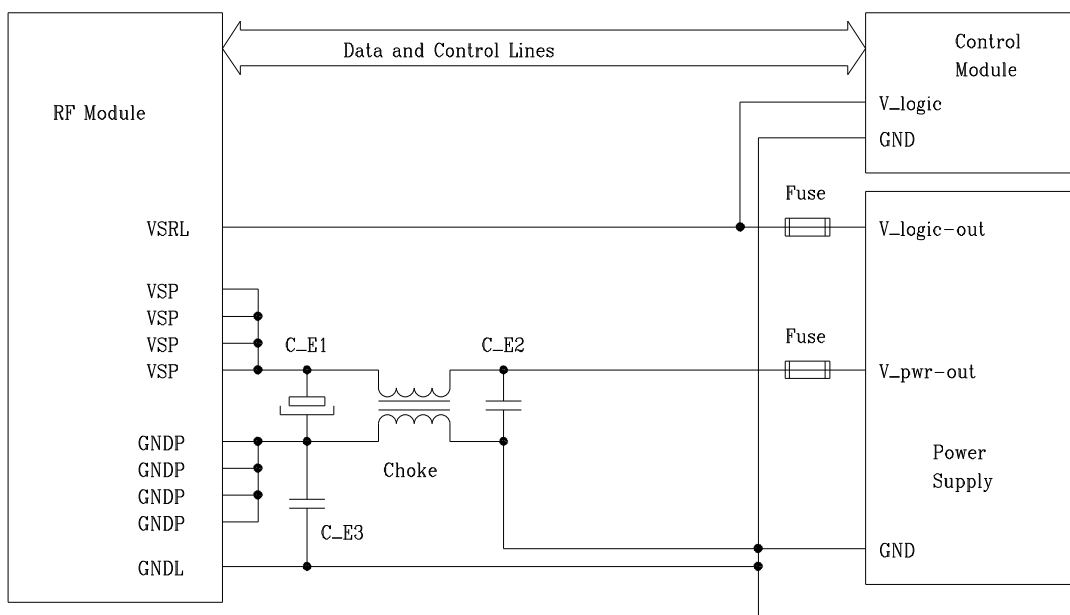
Regardless of which kind of power supply you use, we recommend that you build in fuses or electronic current limitations in between the RF module and the power supplies to avoid any damage in case of short circuit. The value of the fuse depends very much on the application, for example: the current consumption of the module which in turn depends on several factors, such as: the antenna used, whether or not a capacitor is connected and its size.

**Note:** The fuse load for VSP under normal conditions is less than 1 A.

However, if the Mini-RFM is connected into an application where the power is permanently on (hot connecting), the load could surge by several amps due to the current in capacitor CS1 inside the Mini-RFM.



**Figure 5-2. Supply Line Wiring for Short Supply Lines**



**Figure 5-3. Supply Line Wiring for a Separated Power Supply**

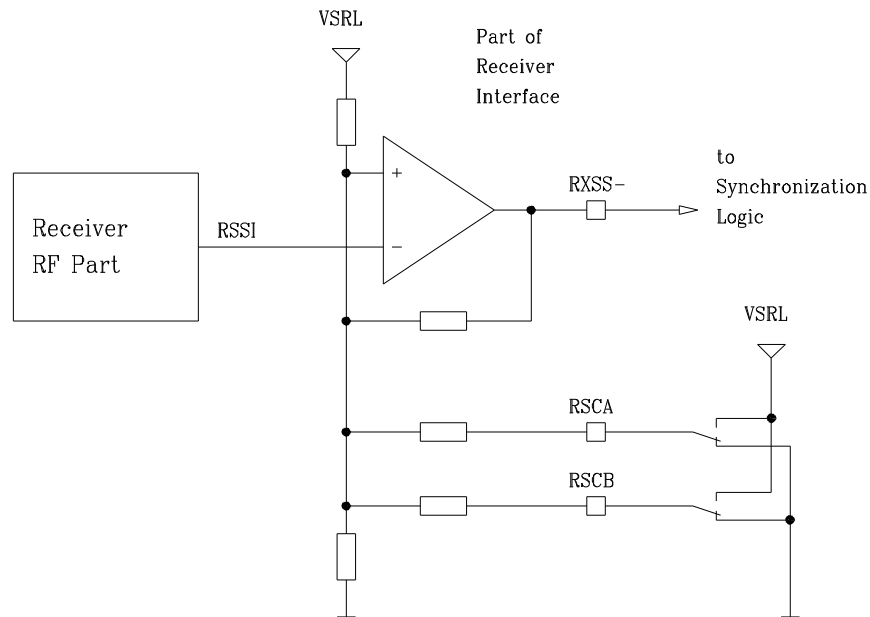
### 5.3 Receiver Signal Strength Output RXSS-

If you are going to operate more than one TIRIS reader in a local area, the systems should be synchronized to each other. An intelligent control unit achieves this synchronization by sampling for the presence or absence of the field strength indicator signal RXSS-. A power pulse in the area will cause RXSS- to be active. If the signal RXSS- is present the control unit ensures that the RF module transmits either simultaneously or sequentially to any other RFMs in the area.

The RXSS- output switches to low if the received signal strength exceeds the internal reference level. This reference level can be adjusted with the two receiver signal strength control inputs RSCA and RSCB.

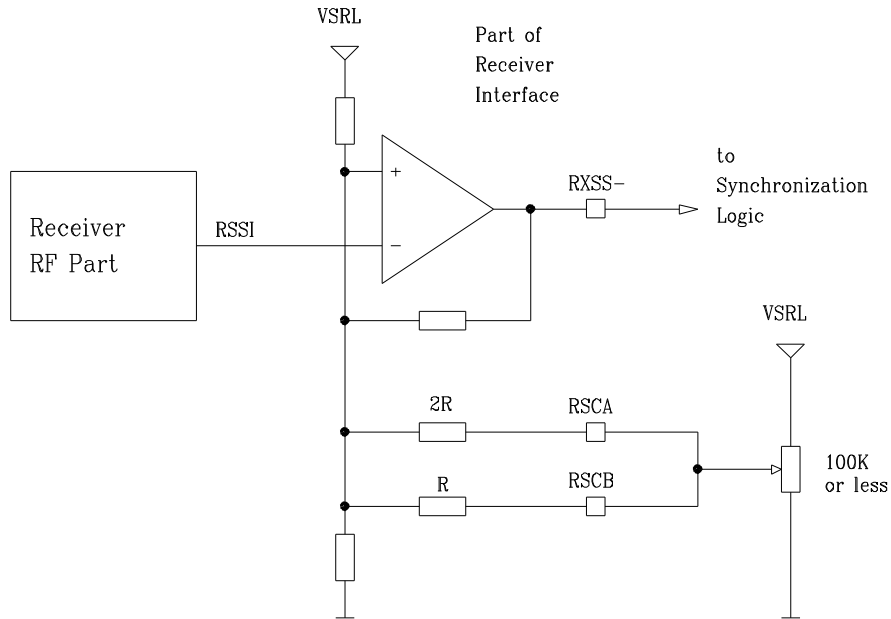
Figure 5-4 and Figure 5-5 show the basic schematic of the signal strength indicator and two methods of adjusting the switching level.

The circuit shown in Figure 5-4 works as a simple D/A converter where the digital inputs RSCA and RSCB are switched either to the ground GNDL or to the supply voltage VSRL. Because of the high input impedance of RSCA and RSCB, the switches can be replaced by computer controlled outputs. Such a circuit can adjust the sensitivities in four steps. A fifth step is given if both inputs are open.



**Figure 5-4. Synchronization Output Control - Digital Adjustment**

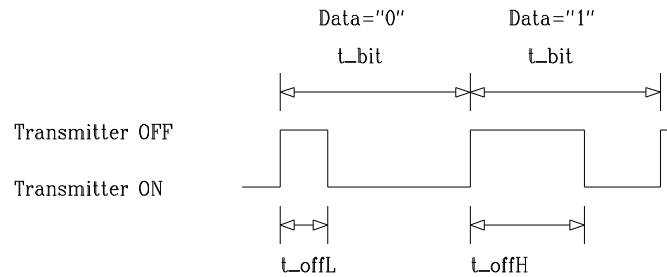
An analog adjustment of the sensitivity level can be realized if a potentiometer is used as shown in Figure 5-5 or if a variable voltage source is used to bias one or both of the control inputs RSCA and RSCB.



**Figure 5-5. Synchronization Output Control - Analog Adjustment**

## 5.4 Programming a Transponder

To write data to a read/write transponder the transmitter of the RF module must be switched off and on periodically after the power pulse is completed. As shown in Figure 5-6 each data bit has the same length  $t_{bit}$ , but the duration  $t_{offL}$  or  $t_{offH}$  during which the transmitter is switched off, determines the value of the bit. Because the antenna circuit of the module and the connected antenna form a resonance circuit with a specific rise and fall characteristic of the resonance voltage, different RF module and antenna combinations might need different  $t_{offL}$  and  $t_{offH}$  timing. The values  $t_{offL}$  and  $t_{offH}$  shown in section 4.3 Timing Characteristics are the times applied to TXCT-. A high Q antenna such as RI-ANT-P02A is used.



**Figure 5-6. Write Pulse Timing for TXCT-**

A detailed description of the complete programming sequence is given in the Sequence Control Manual (document number 11-06-21-049).

## 5.5 Antenna Requirements

The antenna for a TIRIS RF module is a coil with the inductance  $L_{ANT}$  and the Q-factor  $Q_{ANT}$ . To ensure that the antenna can be tuned to resonance with the tuning capacitors inside the RF Module, the inductance  $L_{ANT}$  for an air coil antenna can vary in the limits given below:

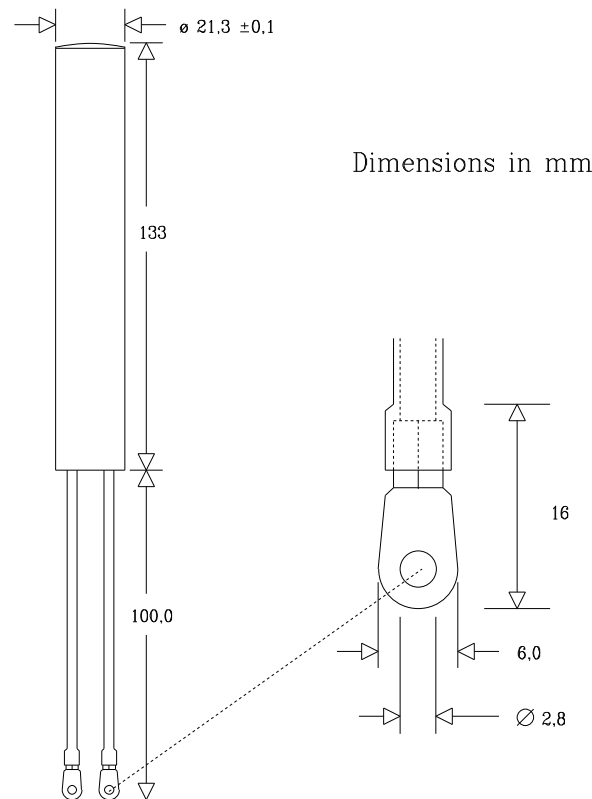
- $L_{ANT} = 115$  to  $117 \mu\text{H}$  (at  $f=134.2$  kHz,  $V=1\text{V}$ )
- $Q_{ANT} = 200$  or better is recommended for good read/write range.

Some factors which often influence each other, are listed below.

- a. The size and the construction of the antenna coil is a key factor for the generated magnetic field strength. The larger the area of an air coil antenna or the longer a ferrite core antenna is, the higher the field strength for a given RFM set-up and a given Q-factor of the antenna coil.
- b. The quality factor of the antenna coil is a parameter indicating its efficiency. The quality depends on the construction and the wire used for the coil. Because of the high frequency, litz-wire is needed for a high Q-factor. The higher the Q-factor of the antenna coil the more energy can be “pulled” from the RF module for a given RF module set-up. If an antenna with ferrite core is used, it must be kept in mind that it may have a very high quality factor under test conditions, but the quality factor will drop if a high magnetic field is applied to the ferrite core.
- c. A very important factor for a good read/write range is the correct orientation / polarization between the transponder antenna and the antenna of the read/write unit.
- d. Noise, i.e. magnetic interference energy in or close to the TIRIS frequency range can reduce the read range remarkably. Sources of interference can be, for example: electronic equipment with built-in switch mode power supplies, monitors and TV-sets with their magnetic deflection, which are not shielded enough. In such conditions you may be able to obtain better read/write ranges with a smaller antenna rather than a large one. The reason for this is that a large antenna collects signals within a larger area and therefore produces a stronger interference signal compared with the relatively small transponder signal. Under some conditions, charging and/or writing to the transponder works excellently, but the reading unit cannot detect the transponder signal.

Figure 5-7 shows the dimensions of the ferrite stick antenna RI-ANT-P02A available for the RF Module RI-RFM-003B.





**Figure 5-7. Stick Antenna RI-ANT-P02A**

## 5.6 Antenna Tuning

In order to get all the available field strength from the antenna, it must be tuned to resonance. To do this, the following set-up and equipment are required.

### 5.6.1 To Switch-ON the Transmitter

The reading/writing unit or test set up should be able to switch the RF module's transmitter to a fast repeating reading mode or continuous wave mode. If a continuous wave mode is applied, care must be taken not to exceed the duty cycle limitation as given in section 4.3. Time when the transmitter is switched on but during which the current consumption is less than  $I_{VSPcont}$ , does not add to the duty cycle.

### 5.6.2 To Tune the Antenna Circuit

The built-in tuning capacitors  $C_{AT1}$  to  $C_{AT6}$  which are available at ST2 should be used to tune the resonance frequency of the antenna circuit to the output frequency of the transmitter. The most simple method of tuning is to use a switch box connected to the antenna tuning connector ST2, this will allow the capacity of the antenna resonant circuit to be increased by connecting the built-in tuning capacitors to the ground.

The switch box in its simplest version is an array of six well isolated, high voltage proof ON/OFF switches, which are connected to the antenna tuning connector ST2 (Antenna Tuning Switch Box RI-ACC-ATS1).

If you have to tune a lot of Mini-RFMs (for example on a production run) it would be helpful to build a computer (or electronically) controlled tuning box which allows you to start the tuning procedure and then set the jumpers according to the result of the tuning. The cable from the switch box to the connector ST2 should be as short as possible (less than 20 cm) in order to get the same tuning results as with the jumpers.

### 5.6.3 To Detect the Correct Tuning

There are two basic methods to detect the correct tuning point, they are:

- One method is to tune the antenna circuit to maximum current consumption of the transmitter power stage by inserting a current meter into the VSP-line which is an easy way for production. The lines of the meter should be as short as possible, or they must be RF decoupled close to the RF module.
- The second method is to tune the antenna circuit to the maximum of the magnetic field strength generated by the antenna.

### 5.6.4 Tuning Procedure

**WARNING**

**CARE MUST BE TAKEN WHEN HANDLING THE MINI-RFM. HIGH VOLTAGE ACROSS THE ANTENNA TERMINALS AND TUNING CONNECTORS COULD BE HARMFUL TO YOUR HEALTH. IF THE ANTENNA INSULATION IS DAMAGED IT MUST NOT BE CONNECTED TO THE MINI-RFM.**

Ensure that the reader is switched OFF.

Connect the antenna to the RF Module.

Remove all jumpers from the tuning connector ST2 and connect the switch box with all six switches in the OFF position.

Switch the RF module transmitter ON (continuous or fast reading mode).

While watching the current meter, increase tuning capacity with the switch box step-by-step until you find a peak.

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**Note:** If you are using a switch box, do not forget that the capacitors attached to the jumpers are binary weighted, and that you should set the switches in a binary way:

|              |              |             |
|--------------|--------------|-------------|
| Switch 1 ON  |              |             |
| Switch 1 OFF | Switch 2 ON  |             |
| Switch 1 ON  | Switch 2 ON  |             |
| Switch 1 OFF | Switch 2 OFF | Switch 3 ON |
| and so on.   |              |             |

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When you find a peak continue with two more steps and check in case you find another, higher peak. Looking for a possible second peak is necessary because the capacitors of the tuning network have overlapping capacitance, which causes discontinuous capacitance steps.

Check if the power stage supply current or the field strength has the correct value for that application.

Switch the transmitter OFF, disconnect the switch box and then plug-in jumpers at all the places where the switches are in the ON position.

Switch ON the equipment again and check if the current or field strength are almost the same as they were with the switch box connected.

Switch OFF the transmitter or reading unit. Tuning is completed.

## Warnings, Cautions, and Notices

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This chapter provides the Warnings, Cautions and Notices that are relevant to the Mini-RFM.

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## 6.1 FCC/Telecommunications Regulations

The TIRIS RF Module generates RF emissions at 134.2 kHz. The radiation of the fundamental and the harmonics will vary with the type of antenna and other devices or functions connected to the RF module.

The required FCC or Telecommunications approvals must be obtained prior to operating the TIRIS RF Module with antenna(s), power supply and a control module or other devices.

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

## 6.2 Important Note to Purchasers/Users of the Mini-RFM in the USA

The TIRIS RF Module 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 RF Module in the United States. In order to form a functioning radio frequency RF device, the RF Module must be connected to a suitable antenna, power supply, and control circuitry. A radio frequency device may not be operated unless authorized by the FCC nor may a radio frequency device be marketed (i.e. sold, leased, imported, or advertised for sale or lease) without the prior grant of an FCC equipment authorization.

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

An equipment authorization has already been issued for use of the RF Module and other TIRIS equipment (including antennas) in certain configurations. This authorization does not cover all possible combinations of equipment and, in particular, covers only specific antenna configurations. Should a user desire to use the RF Module in a configuration not yet approved, TI can assist that customer to obtain the necessary equipment approval.

## 6.3 Warning

Care must be taken when handling the RF Module. High voltage across the antenna terminals and tuning connector could be harmful to your health. If the antenna insulation is damaged it should not be connected to the RF Module.

## 6.4 Cautions

The RF Module might be subject to damage by electrostatic discharge (ESD) and should therefore only be handled by ESD protected personnel at ESD secured workplaces.

The transmitter power output stage can be damaged, if the antenna terminal A1 has a short circuit either to the ground or to the supply voltage and no current limitation is applied.

The transmitter power output stage can operate only with a limited duty cycle. This subject needs to be given attention especially during the antenna tuning procedure.

The ground pins GNDL and GNDP have to be connected externally to avoid damage to the RF Module.

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