MRF450 User Manual

4 April 2019

U115.0.0 User Manual for MRF450

FCC Statements

15.19 – Two Part Warning

This device complies with Part 15 of the FCC rules. Operation is subject to the following two conditions:

(1) This device may not cause harmful interference and

(2) This device must accept any interference received, including interference that may cause undesired operation.

15.21 – Unauthorized Modification

NOTICE: The manufacturer is not responsible for any unauthorized modifications to this equipment made by the user. Such modifications could void the user's authority to operate the equipment.

15.27 – Special Accessories

This device is supplied with special accessories that include an RF adapter cable and antenna. These special accessories must be used with the device. It is the responsibility of the user to use the needed special accessories supplied with the equipment.

15.105(b) – Note:

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

Industry Canada Statements

RSS-GEN 7.1.2 – Transmitter Antenna / Antenne de L'émetteur

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (EIRP) is not more than that necessary for successful communication.

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante.

This radio transmitter 7955A-SRF309 has been approved by Industry Canada to operate with the antenna types listed below with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Le présent émetteur radio 7955A-SRF309 a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés ci-dessous et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur.

Approved Antenna List / Liste Antenne Approuvé				
Manufacturer	**Part Number**	**Stock Number**	**Gain**	**Impedance**
Nearson Or Equivalent	L324TR-440 Or Equivalent	J5-11	+0dBi peak	50 Ohm

RSS-GEN 7.1.3 – Notice / Délai

This device complies with Industry Canada licence-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes : (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Table of Contents

List of Figures

List of Tables

Notes and Observations

Cervis, Inc. Safety Precautions

- ✓ ***Read and follow all instructions.***
- ✓ ***Failure to abide by Safety Precautions may cause equipment failure, loss of authority to operate the equipment, and personal injury.***
- ✓ ***Use and maintain proper wiring. Follow equipment manufacturer instructions. Improper, loose, and frayed wiring can cause system failure, equipment damage, and intermittent operation.***
- ✓ ***Changes or modifications made to equipment not expressly approved by the manufacturer will void the warranty.***
- ✓ ***Equipment owner/operators must abide by all applicable Federal, State, and Local laws concerning equipment installation and operation. Failure to comply could result in penalties and could void user authority to operate the equipment.***
- ✓ ***Make sure that the machinery and surrounding area is clear before operating. Do not activate a remote control system until certain that it is safe to do so.***
- ✓ ***Turn off the module power before attempting any maintenance. This will prevent accidental operation of the controlled machinery.***
- ✓ ***Do not allow liquid to enter the module enclosure. Do not use high-pressure equipment to clean the module.***
- ✓ ***Operate and store units only within the specified operation and storage temperatures defined in this document's Specifications section.***

1.0 MRF450 Introduction

The MRF450 receive/transmit module (RTM) is:

- Based on a Silicon Labs Si4464 single-chip radio frequency (RF) transceiver integrated circuit (RFIC).
- Integrated into Cervis, Inc. products, providing wireless RF connectivity.
- Interoperable with various other Cervis, Inc. RTMs that use the same modulation and message data structure. Interoperability with non-Cervis, Inc. RTMs—while possible—is not supported.
- Most commonly applied in half-duplex master/slave systems: the master transmits a message to a slave, the slave transmits a reply to the master. Other operating modes are possible, if applicable rules and regulations are not violated.
- Realized as a solder-down leadless printed circuit board (PCB) module (part number 16000300). The Type 4 form factor is a unique, proprietary mechanical design.

The module:

- Operates in the 450 MHz to 470 MHz frequency range, with a maximum conducted RF transmit power of +16.07dBm (40mW) at the antenna port.
- Generates RF signals similar to the Zigbee standard: IEEE 802.15.4-2006. The modulation method is 4-Gaussian frequency shift keying (4-GFSK).
- Has internal control registers that the host application can access via a serial peripheral interface (SPI) bus. These registers control all aspects of how the RTM is used, which must comply with all applicable rules and regulations.

1.1 MRF450 Features

- United States Federal Communications Commission (FCC) Part 90.231 and 15 Certified
- Industry Canada (IC) Certified
- 450–470 MHz Operation, including sidebands
- Selectable Channels in 100 KHz steps
- 4-Gaussian Frequency Shift Keying (4-GFSK) modulation
- 12 kbps Data Rate
- Up to +16.07dBm peak Conducted Output Power
- IEEE 802.15.4-2006 messaging
- SPI host interface
- Simple power requirements: 3.0–3.3V low noise regulated, 25–100mA

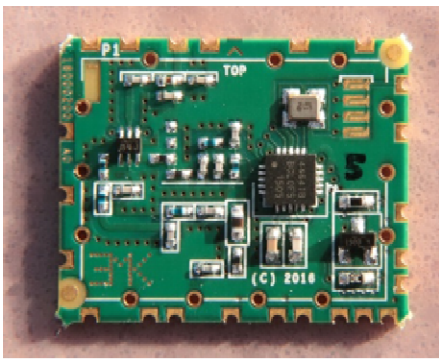

Figure 1. MRF450 RTM Section Front

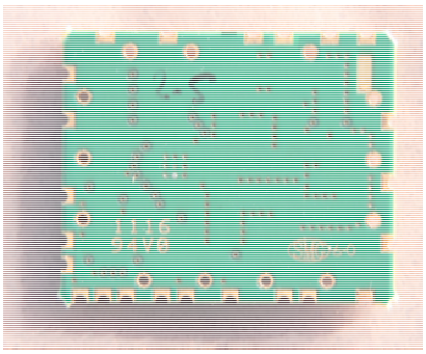

Figure 2. MRF450 RTM Section Back

1.2 MRF450 Pinouts

Table 1 lists the MRF450 RTM interface signals.

Table 1. MRF450 Type 4 Interface Signals

Name	Signal Type	Description
SPI_CLK	SPI data clock in	Clock from SPI master
GND	Ground	Low impedance ground
MISO	SPI data out	Data from SPI slave
MOSI	SPI data in	Data from SPI master
RF_SLP_TR	RFIC control	Multipurpose control signal from master
/RF_RST	RFIC reset	Active Low from SPI master
/RF_CS	RFIC chip select	Active Low from SPI master
RF_IRQ	RFIC interrupt output	Input to SPI master
RF1_3VD	+3.0–3.3V	RF and logic power. Low noise 100mA max.
RF1_3VA	+3.0–3.3V	RF analog power. Low noise 25mA max.
RF_PAEN	Enable external PA	Active High from SPI master
RF_HGM/BPA	Enable external LNA or Read BPA jumper	Function not used in MRF450 Input to SPI master

Name	Signal Type	Description
RF Port	Antenna connection	50-Ohm RF In/Out port

The P/N 16000300 PCB assembly includes all circuits and features required to properly implement the MRF450 Type 4.

Figure 3. MRF450 RTM, Front Side with Shield and Label.

Type 4 Module Application Engineering

The Type 4 module requires the host application to provide:

- Suitable mechanical and electrical mounting
- Control and power signals
- An approved antenna that is properly mounted
- A proper RF transmission line to connect the module's RF port to the antenna feed port

Provision	Description
Mounting	This module must be mounted over a ground plane that extends at least 8mm from the RF shield edges. All connections between the host application and the module must be soldered.
Control and Power Signals	All power, ground, and control signal connections listed in Table 1—except RF_HGM/BPA—must be made.
RF Transmission Line	The RF connection between the module RF port and the antenna feed port must have a nominal 50-Ohm impedance, have low insertion loss, and be as short as practical. Microstrip transmission line may be implemented as part of the host PCB. Coaxial cable may be used to connect the module to an external antenna. Coaxial cable can be attached either with a suitable connector or may be directly soldered to where the host PCB attaches to the module's RF port. If a replaceable external antenna is used, the user-accessible external connection must be a unique type, such as RP-TNC or RP-SMA.
Grounding	The MRF450 module must be connected to a good RF ground plane that is part of the host circuit board.

2.0 MRF450 Installation

When integrating an MRF450 RTM in a host application, the host application's user manual must include all text in the "FCC Statements" and "Industry Canada Statements" (see this manual's Forward Material). The text must not be modified in any way and presented in a conspicuous manner that the end user can be reasonably expected to see.

When integrating the MRF450 RTM into host application hardware, users must properly connect all the circuits—except RF_HGM/BPA—identified in Table 1 to suitable host application signals. The host application firmware must properly control the RTM to ensure that emitted RF signals comply with all applicable regulatory approvals.

The MRF450 RTM is always used with an included, approved antenna type – either internal fixed or external replaceable. If a fixed internal antenna is included as part of the RTM's host application, the host's on-board coaxial cable connectors are not populated, and a direct connection is made to the internal antenna. If an external antenna is included as part of the RTM's host application, one of the host's on-board coaxial cable connectors is populated, and a coaxial cable connection is made to the external antenna port. The host application designer chooses the particular type of coaxial connector that is installed. The internal coaxial cable connector is not accessible to users; so it does not need to be unique.

When included, external replaceable antennas always have a unique connector, such as RP-N, RP-SMA, RP-BNC, or RP-TNC. Use a suitable internal coaxial cable jumper with appropriate connectors to connect the MRF450 RTM host application external antenna port to the external antenna. A particular host application's details influences the jumper coaxial cable design, but the external connector must always be an acceptable, unique type.

The coaxial cable used to make the jumper between the MRF450 RTM and the external antenna mounting port must be suitable for use in the 450–470 MHz band and have 50-Ohm impedance. While a low loss cable such as an RG-316 is suggested, other cable models may be used if the signal loss is small.

External coaxial cables may be used to help mount a replaceable external antenna in a more useful location. Such cabling must have appropriate unique connectors throughout and must be made from low loss 50-Ohm coaxial cable. Cables equivalent to LMR-195 are suitable for lengths up to 30 feet. Longer cables must have suitably lower signal loss, typically using larger cable such as LMR-240, LMR-300, or larger (or equivalent). At some point, a practical limit is reached where losses in extension cables negate any gains from relocating the antenna.

3.0 MRF450 Tune-up Procedure

Proper RF operation requires tuning the RFIC crystal oscillator. The RFIC includes a digital mechanism to adjust the crystal oscillator balancing capacitance. The host firmware must include a mechanism to access and adjust the tuning values.

All Cervis, Inc. products that use the MRF450 RTM include a special operational bit that, when set, enters an interactive tuning mode. In the tuning mode, the RFIC is set to output a constant carrier signal at a specified frequency (default = 460 MHz). Operators observe the constant carrier signal on a suitable device, such as a calibrated frequency counter or spectrum analyzer. If the displayed frequency is too low, increase the tune value; and if the frequency is too high, decrease the tune value. Repeat this operation until the constant carrier is exact. Then, write the tuning value into non-volatile memory, and clear the tuning bit.

4.0 MRF450 Electrical Characteristics

4.1 Supply Voltage and Current

The MRF450 RTM (the components under the RF shield) requires the host application to include a low noise—linear regulator instead of a switching regulator—regulated 3.0–3.3 VDC source that can provide 20mA without losing regulation. The RTM does not provide under-voltage, over-voltage, or reverse polarity protection; so use caution when applying power.

All external connection points designated as signal “GND” should be connected to the host application “GND” circuit to maintain as low a resistive and reactive impedance as practical. The PCB hosting the RTM should be fabricated with low impedance copper floods that connect to “GND”. The grounded copper area around the RTM must extend at least 8mm on all sides of the RTM.

The MRF450 RTM can safely operate with a supply voltage over the range of 3.0–3.3V with minimal changes in RF performance. Testing was performed at 3.3V, the preferred supply voltage.

4.2 Operating Current

The MRF450 RTM has four primary operating conditions that draw differing amounts of current from to 3.0–3.3V power source:

Condition	Description	Current Load
Off	RTM is powered down	Minimal load
PLL_ON	RTM is ready to transmit or receive	~5mA
RX	RTM is receiving a message	~25mA
TX	RTM is transmitting a message	~25–100mA Depending on TX output power

4.3 SPI

The SPI between the RTM (slave) and the host application (master) microcontroller requires four signals:

Name	Description
SCLK	The serial data clock from the SPI master; must be less than 8 MHz
MOSI	Serial data from the SPI master
MISO	Serial data from the SPI slave
RF_CS	Chip select from the SPI master

The host application microcontroller must establish the SPI controller setting to be compatible with the SPI timing specified by the RFIC data sheet (see Section 5.1).

5.0 MRF450RF Characteristics

5.1 General RF Information

The RFIC used in the MRF450 RTM implements proprietary RF modulation modes. Details may be found in the Silicon Labs Si4464 RFIC data sheet:

https://www.silabs.com/documents/public/data-sheets/Si4464-63-61-60.pdf

MRF450 RTM modulation type = 4-GFSK.

Data rate = 12 kbps.

Visit our Web site at: www.cervisinc.com