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High Performance RF module for SIGFOX 902-928MHz

Product Description

The RC1692HP-SIG module is a compact surface-mounted product that measures only 12.7 x 25.4 x 3.5 mm. The module contains a communication controller with embedded SIGFOX protocol software and is certified for operation under FCC and ACMA. Custom variants can be offered with custom functionalities. How to use the embedded SIG protocol is described in the RC16xxxx-SIG User Manual.

Applications

- Internet of Things
- Long range sensor applications
- Asset tracking and monitoring
- Telemetry stations
- Fleet management



Features

- SIGFOX compatibility (IOT)
- SIGFOX Class 0 category
- SIGFOX Zone 2 and Zone 4 domains
- Long range, high reliability
- Ultra narrowband, high-performance radio
- High sensitivity and high selectivity
- High blocking properties
- Completely shielded module
- Pin compatible with other RC16xxHP products from Radiocrafts
- 12.7 x 25.4 x 3.5 mm compact module for SMD mounting
- 2.8 – 3.6 V supply voltage
- Ultra low power modes
- Certified for FCC and ACMA
- Configurable for operation under FCC, or ACMA regulations, most Latin American countries

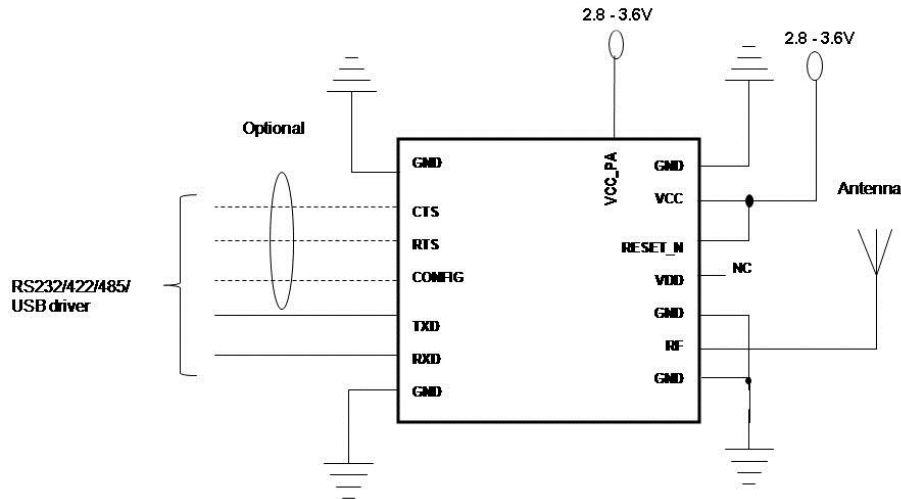
Quick Reference Data

Parameter	RC1692HP-SIG	Unit
Frequency band	902-928	MHz
Data rate (Uplink/Downlink)	600/600	bps
Max output power	+ 25	dBm
Sensitivity (600 bps)	-127	dBm
Supply voltage VCC	2.8 – 3.6	V
Supply voltage Internal PA	2.8 – 3.6	V
Current consumption, RX	36	mA
Current consumption, TX (+25 dBm)	320	mA
Current consumption, SLEEP	Max 2.0	uA
Temperature range	-40 to +85	°C

Part Name Overview

Part name	RF Frequency band	Typ output power	VCC / VCC_PA
RC1692HP-SIG	902-928 MHz	+25 dBm	+3.3V

Typical application circuit:



Note that the VCC_PA pin supply the internal power amplifier only, while the rest of the internal block runs on VCC. They can be connected together (max 3.6V) or separated using individual supply. If VCC_PA is connected together with VCC, the max output power is +24 dBm.

Quick Introduction

How do I transmit data?

Send your data to the RXD pin on the module. Use the UART format with settings (19200, 8, 1, N, no flow control). Up to 12 bytes payload are buffered in the module. The first byte of the message must contain the message length (excluding the length byte itself). The module will transmit the data when the whole packet is received.

How do I receive data?

The module has to be configured to "Uplink and downlink" mode in order to enable two way communication. Any received RF data packet with correct message format (ID, key, CRC) will be sent on the TXD pin with length byte first. The RSSI value (received signal strength) can optionally be added to the message.

What about the antenna?

In most cases a simple quarter wavelength wire or a PCB track will do. Connect a piece of wire to the RF pin with length corresponding to the quarter of a wavelength. For space limited products, contact Radiocrafts and we will recommend the best antenna solution for your application.

How do I change any configuration parameter?

To change configurable parameters, send one byte to the module with the value 0x00 or assert the CONFIG pin. This will take the module into configuration mode. Special commands are then used to access the configuration registers and test modes. Exit from configuration mode by sending the 'X' command. Parameters can be changed permanently and stored in non-volatile memory in the module.

SIGFOX Protocol

The RC1692HP-SIG module implements all the necessary features required to communicate with the SIGFOX backend system.

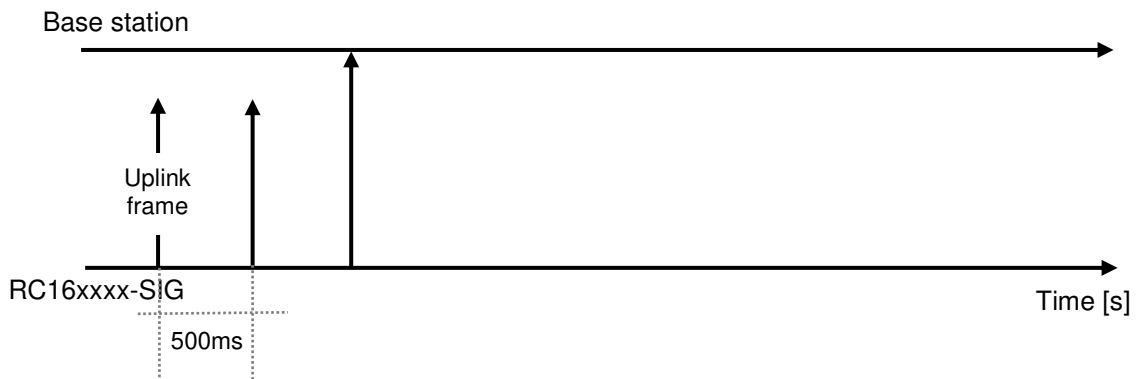
The SIGFOX protocol defines two types of network modes:

1. Only uplink mode
Packets are only transmitted from the RC16xxx-SIG module to the base station. This mode can be used for pure data collection.
2. Uplink and downlink mode
Packets transmitted by the RC16xxx-SIG module are acknowledged by the base station. This mode can be used for controlling applications.

Only uplink mode

Only uplink mode can be summarized as follows:

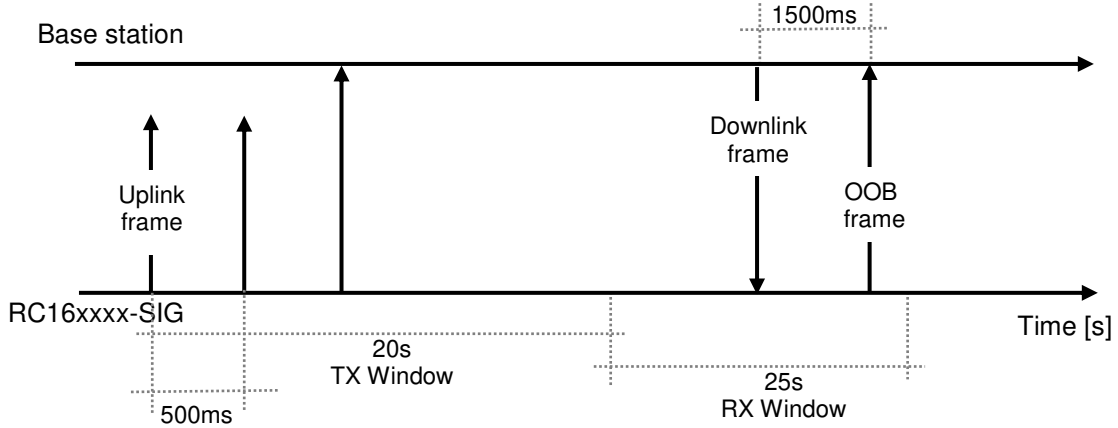
- The RC16xxx-SIG module transmits a frame to the base station.
- This frame is repeated 2 times (the packet is transmitted 3 times all together) with 500ms interval.
- Frequency hopping is implemented between packets.



Uplink and downlink mode

With Uplink and downlink mode, two way communication can be established:

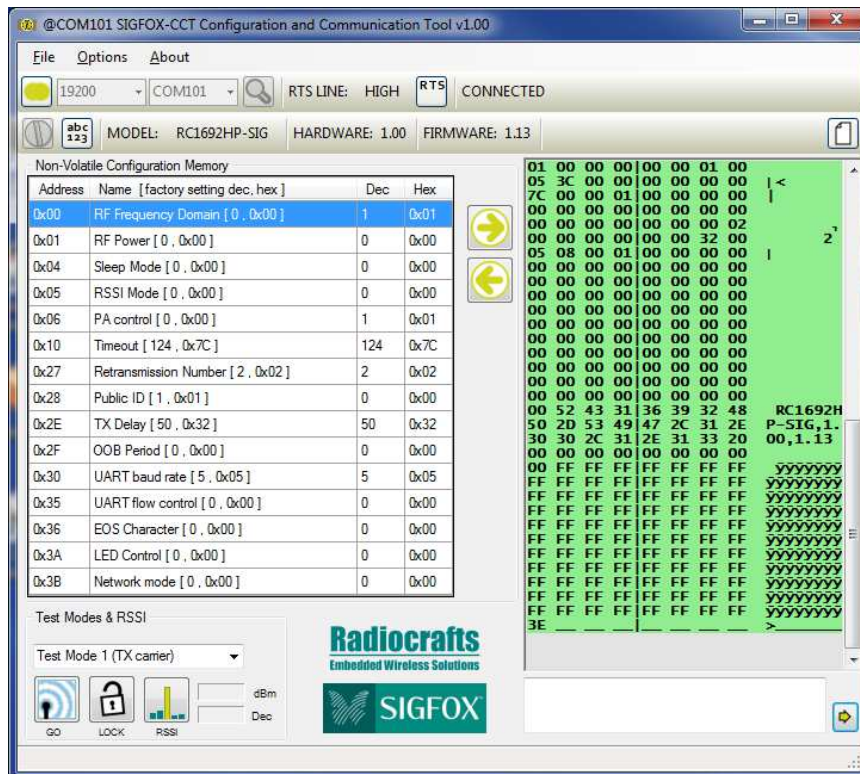
- The RC16xxx-SIG module transmits a frame to the base station.
- The packet is retransmitted <Repeat> times which can be [0,1,2] with 500ms interval.
- Frequency hopping is implemented between packets.
- The Transmission (TX) window lasts until 20s measured from the end of first uplink packet.
- The RC16xxx-SIG module switches to Reception (RX) mode and listens for frames for 25s.
- If a Downlink frame is received, it is decrypted and verified.
- If it is valid, the module acknowledges it with an OOB (OutOfBand) frame after a fixed 1.5s delay (requirement is $1.4s < T < 4s$) and prints the decoded data of downlink frame to UART.



The embedded protocol, configuration commands and configuration memory is described in the RC16xxxx-SIG User Manual.

RCTools

RCTools-SIG is a powerful and easy to use PC suite that helps you during test, development and deployment of the RC16xxxx-SIG. Visit www.radiocrafts.com for a free download and full documentation.



SIGFOX zones

The RC1692HP-SIG module can operate in two different zones / domains:

Model	RF domain	Frequency	SIGFOX Zone
RC1692HP-SIG	0: Reserved	Reserved	RCZ1
	1: US	902MHz	RCZ2
	2: Reserved	Reserved	RCZ3
	3: AU/NZ, Latin America	920MHz	RCZ4

The proper SIGFOX zone can be selected by the user in configuration mode.

The use of RF frequencies, maximum allowed RF power and duty-cycles are limited by national regulations. The RC1692HP-SIG is complying with the applicable directives and requirements of FCC, Australia/New Zealand and most Latin American countries.

Regulatory Compliance Information FCC

The RC1692HP-SIG device complies with Part 15 of the FCC Rules.

Part number	FCC ID
RC1692HP-SIG	Y2NRC1692HP-SIG

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.

Changes or modifications to the equipment not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

If a detachable RF connector is introduced in RF path it must be a non-standard type RP-SMA, U.FI etc. The modules have been approved with the following external quarter wave antennas:

Part number	Manufacturer	Specified gain	Connenctor
W915-RS	EAD	3.0 dBi	RP-SMA
MWR915-RS	EAD	2.0 dBi	RP-SMA
WR868(FWR835021-RS-RA)	EAD	1.0 dBi	RP-SMA
WS868(FWS835021-RS-RA)	EAD	1.0 dBi	RP-SMA
ISM915/B/SMA/RP90	Cti	2.0 dBi	RP-SMA
ISM915/B/SMA/RP	Cti	2.0 dBi	RP-SMA
ANT-916-CW-RH	Linx	-1.3 dBi	RP-SMA
ANT-916-CW-QW	Linx	1.8 dBi	RP-SMA

All monopole quarter wave whip antenna with directional gain of < 3.0 dBi can be used. (ref FCC §15.204 c.4). Any use of antenna with gain > 3 dBi is strictly forbidden without further testing and approval.

Warning: This is device complies with FCC RF radiation exposure limits set forth for an uncontrolled environment. The antenna used for this transmitter must be installed to provide a separation distance of at least 20 cm from all persons and must not be co-located or

operating in conjunction with any other antenna or transmitter. For approval of end product as portable device, separate SAR tests and approval is required for end product.

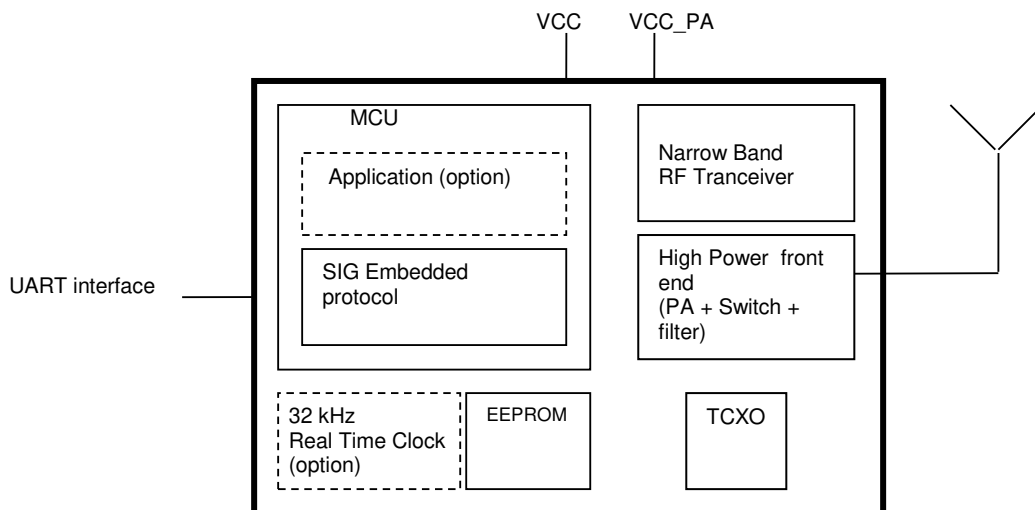
To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (EIRP) is not more than that required for successful communication.

End product marking FCC

The end product including RC1692HP-SIG must include the following text on a visible label:

Contains Transmitter Module FCC ID: Y2NRC1692HP-SIG
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.

Block Diagram



Circuit Description

The module contains a communication controller with embedded SIGFOX protocol software and a high performance narrow band RF transceiver. As an option the module can support a real time clock oscillator.

The communication controller handles the radio packet protocol, the UART interface and controls the RF transceiver. Data to be sent by the host is received at the RXD pin and buffered in the communication controller. The data packet is then assembled before it is transmitted on RF.

The RF transceiver modulates the data to be transmitted on RF frequency, and demodulates data that are received. Digital signal processing technology is used to enhance sensitivity and selectivity.

The high power front end amplifies the signal to +24dBm and advanced filtering topology is included to suppress harmonics and spurs.

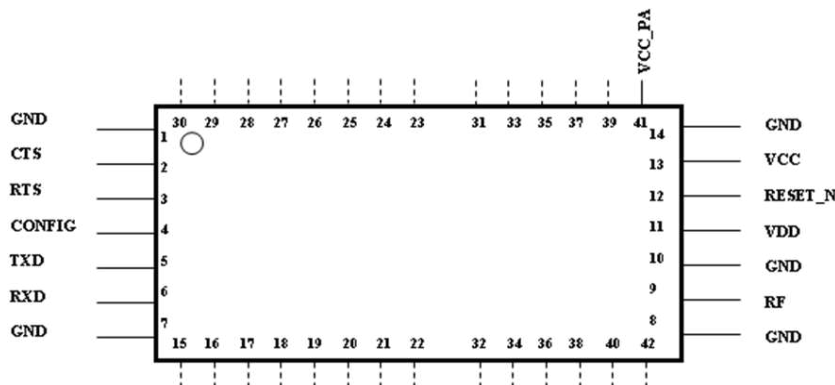
Received data are checked for correct CRC and decrypted by the communication controller. If no CRC errors were detected, the data packet is sent to the host on the TXD line. The data format is fixed, and optionally an RSSI value (signal strength of received packet) can be added to the message.

The asynchronous UART interface consists of RXD and TXD. Optionally CTS or RTS can be used for hardware handshake flow control.

When the CONFIG pin is asserted, the module enters configuration mode and the communication controller interprets data received on the RXD pin as configuration commands. There are commands to change the radio channel, the output power, etc. Permanent changes of the configuration is also possible and are then stored in internal non-volatile memory (Flash).

The supply voltage is connected to the VCC and VCC_PA pin. The module contains an internal voltage regulator for the RF transceiver and can therefore operate over a wide supply voltage range. The module can be set in Sleep mode by UART or pin commands to reduce the power consumption to a minimum.

Pin Assignment

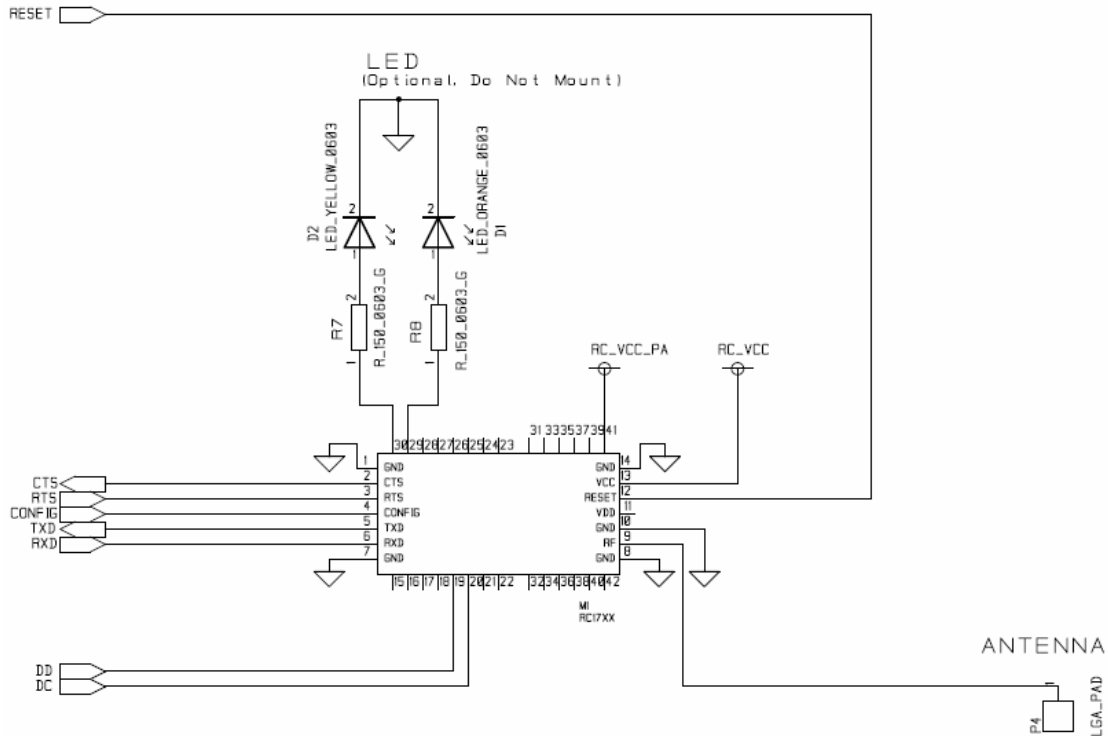


Pin Description

Pin no	Pin name	Description
1	GND	System ground
2	CTS/RXTX	UART Clear to Send / RXTX control (RS485)
3	RTS	UART Request to Send
4	CONFIG	Configuration Enable. Active low.
5	TXD	UART TX Data
6	RXD	UART RX Data
7	GND	System ground
8	GND	System ground
9	RF	RF I/O connection to antenna
10	GND	System ground
11	VDD	Not Connected, Internal Regulator Output
12	Reset	RESET_N. Active Low
13	VCC	Supply voltage input. Internally regulated.
14	GND	System ground
41	VCC_PA	Supply voltage input for Power Amplifier stage. Connect to VCC for RC1692HP-SIG.
15-22 23-30 31-40 42	I/O	For future use and test status pin, Do not connect

Application circuit

A typical application circuit is shown where a MCU is connected to the Radiocrafts module. In normal cases the UART (CTS/RTS is optional) and RESET line is connected to a host MCU running the application. CONFIG pin is needed to set the modules into configuration mode. Pin 29/30 are LED drivers and D1/D2 can be mounted (optional) for debugging (State information).



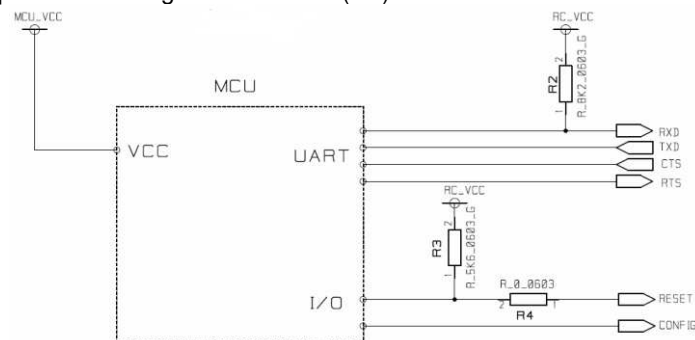
MCU considerations

Some additional external components is needed depending on MCU output driver properties connected to the Radiocrafts module.

If the RESET is driven by a push-pull output, an additional 0 ohm series resistor (R4) shall be inserted as shown in the figure, to allow an external programmer used for firmware upgrade to assert Reset low. During firmware upgrade, R4 must in this case be removed.

In noisy surroundings and where RESET is not driven by a push-pull output, it is recommended to add an external pull-up on RESET using a 5k6 resistor (R3). If the pull-up is stronger the external programmer used for firmware upgrade will not be able to assert RESET low.

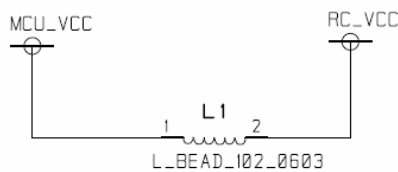
In noisy surroundings and where RXD is not driven by a push-pull output, it is recommended to add an external pull-up on RXD using a 5k6 resistor (R3).



Power Supply

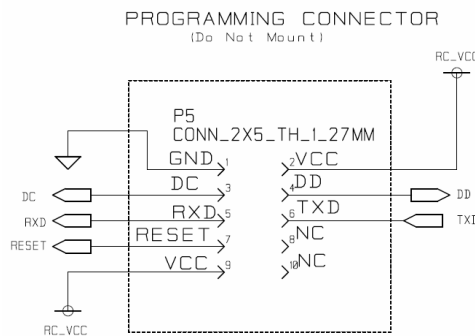
Noisy external circuitry may under certain scenarios affect the transmitted signal on RC1692HP-SIG and precaution should be taken for FCC conformity. Example of circuits that can generate noise on the RC1692HP-SIG transmitted spectrum may be DC/DC converters and some level converters like RS232 and RS485. To increase spectrum margin you can add an EMI filter bead (L1) on the VCC pin of the RC1692HP-SIG module. Alternatively, the RC1692HP-SIG module may be powered (RC_VCC) from a separate voltage regulator. This will ensure that potential switching noise is filtered out from the power supply (RC_VCC) to the module.

Component	Manufacturer	Part number
EMI filter bead (L1), 1500 mA	Murata	Ordering code BLM18SG331TN1



Programming Interface

For future firmware updates and possible custom variants it is recommended to include a 2x5 pins programming connector to the module programming pins. The connector should be a 1.27 mm pitch pin-row (same pitch in both directions), SMD or through-hole version, with the connections shown below. RXD/TXD lines is not in use for firmware upgrade, but is included on spare pins on the connector for debugging purposes.



Antenna Connection

The antenna should be connected to the RF pin. The RF pin is matched to 50 Ohm. If the antenna connector is placed away from the module at the motherboard, the track between the RF pin and the connector should be a 50 Ohm transmission line.

On a two layer board made of FR4 the width of a microstrip transmission line should be 1.8 times the thickness of the board, assuming a dielectric constant of 4.8. The line should be run at the top of the board, and the bottom side should be a ground plane.

Example: For a 1.6 mm thick FR4 board, the width of the trace on the top side should be $1.8 \times 1.6 \text{ mm} = 2.88 \text{ mm}$.

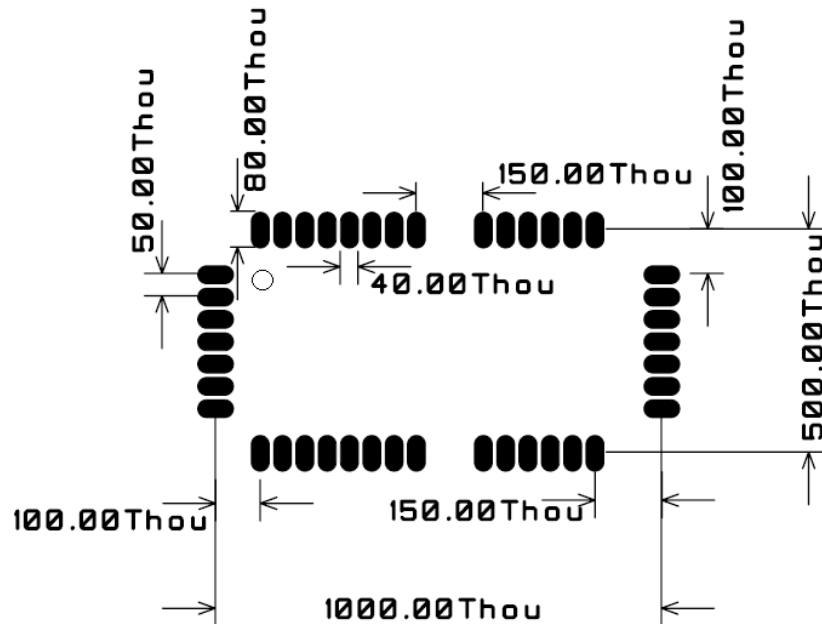
The simplest antenna to use is the quarter wave whip antenna. A quarter wave whip antenna above a ground plane yields 37 Ohm impedance and a matching circuit for 50 Ohm are usually not required.

A PCB antenna can be made as a copper track where the ground plane is removed on the back side. The rest of the PCB board should have a ground plane as large as possible, preferably

as large as the antenna itself, to make it act as a counterweight to the antenna. If the track is shorter than a quarter of a wavelength, the antenna should be matched to 50 ohms.

PCB Layout Recommendations

The recommended layout pads for the module are shown in the figure below. All dimensions are in thousands of an inch (mil). The circle in upper left corner is an orientation mark only, and should not be a part of the copper pattern.

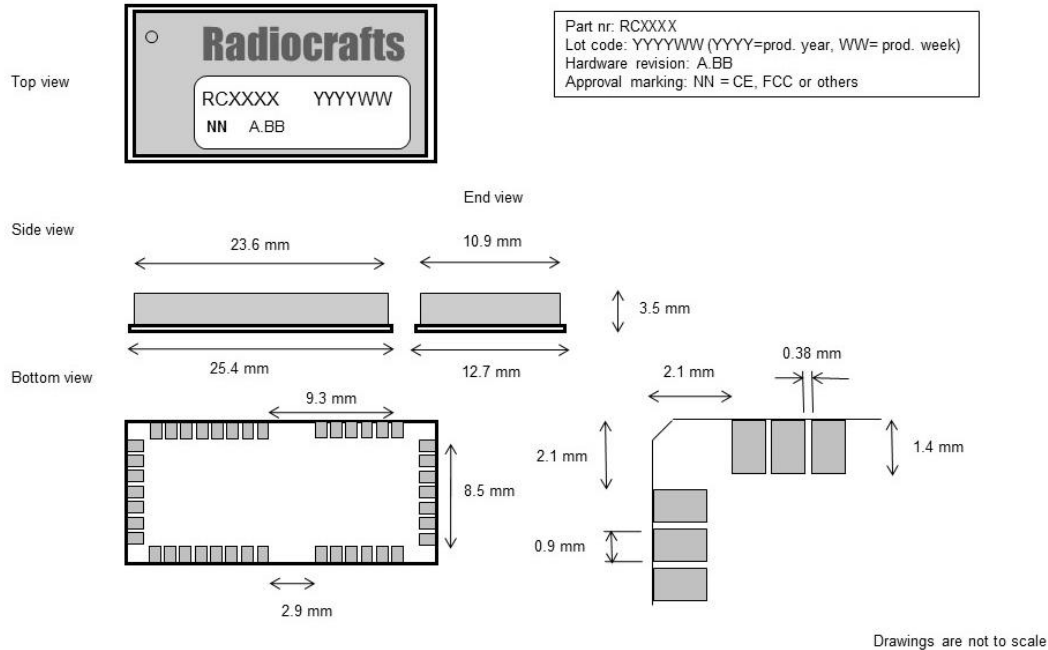


A PCB with two or more layers and with a solid ground plane in one of the inner- or bottom layer(s) is recommended. All GND-pins of the module shall be connected to this ground plane with vias with shortest possible routing, one via per GND-pin.

On the back side of the module there are several vias and pads. These vias and pads shall not be connected, and the area underneath the module should be covered with solder resist. If any routing or vias is required under the module, the routing and vias must be covered with solder resist to prevent short circuiting to the module bottom side vias and pads. It is recommended that vias are tented.

Reserved pins should be soldered to the pads but the pads must be left floating.

Mechanical Drawing



Mechanical Dimensions

The module size is 12.7 x 25.4 x 3.5 mm

Carrier Tape and Reel Specification

Carrier tape and reel is in accordance with EIA Specification 481.

Tape width	Component pitch	Hole pitch	Reel diameter	Units per reel
44 mm	16 mm	4 mm	13"	Max 1000

Soldering Profile Recommendation

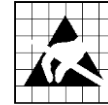
JEDEC standard IEC/JEDEC J-STD-020B (page 11 and 12), Pb-Free Assembly is recommended.

The standard requires that the heat dissipated in the "surroundings" on the PCB is taken into account. The peak temperature should be adjusted so that it is within the window specified in the standard for the actual motherboard.

Aperture for paste stencil is normally areal-reduced by 20-35%, please consult your production facility for best experience aperture reduction.

Absolute Maximum Ratings

Parameter	Min	Max	Unit
VCC	-0.3	3.8	V
VCC_PA	-0.3	3.7	V
Voltage on any pin	-0.3	VCC+0.3V	V
Input RF level		10	dBm
Storage temperature	-50	150	°C
Operating temperature	-40	85	°C



Caution ! ESD sensitive device.
Precaution should be used when handling the device in order to prevent permanent damage.

Under no circumstances the absolute maximum ratings given above should be violated. Stress exceeding one or more of the limiting values may cause permanent damage to the device.

Fresh 3.6V Li batteries normally have a higher open circuit voltage than the nominal 3.6V, but can still be used to power the module as long as it is not exceeding the absolute maximum rating (3.8V). When the module operates in IDLE/RX/TX the loaded battery voltage will usually drop below 3.6V, which is inside the operation voltage range.

Electrical Specifications

T=25°C, VCC = 3.3V, VCC_PA=3.3V if nothing else stated.

Parameter	Min	Typ.	Max	Unit	Condition / Note
Operating frequency RC1692HP-SIG	902		928	MHz	Depends on selected zone/domain.
Input/output impedance			50	Ohm	
Data rate			600	kbit/s	
Frequency tolerance			+/-1.5	ppm	Including 10 years of aging.
Frequency stability aging			1 5	ppm/year ppm/ 10 year	Starting after 10 years
Transmit power RC1692HP-SIG		25	26	dBm	Typical values are for default settings 902.1375MHz
Spurious emission, TX < 1 GHz > 1 GHz Restricted bands			-20 dBc -20 dBc -41 dBm		
Sensitivity: 600 bps		-127		dBm	
Blocking / Interferer rejection / desensitization +/- 2 MHz +/- 10 MHz		74 80		dB	Wanted signal 3 dB above sensitivity level, CW interferer.
Saturation		10		dBm	
Spurious emission, RX			-57	dBm	
Supply voltage, VCC VCC_PA	2.8 2.8	3.3 3.3	3.6 3.6	V V	
Current consumption, RX VCC VCC_PA		36 0.3	38	mA uA	Apply over entire supply voltage range
TX VCC_PA = 3.3V (+25 dBm)		VCC+VCC_PA 320		mA	

Current consumption,SLEEP VCC VCC_PA		0.60 0.02	2.0 1.0	uA uA	
Digital I/O Input logic level, low Input logic level, high	70 %		30 %	V	Of VCC Of VCC
RESET pin Input logic level, low Input logic level, high	70 %		30 %	V	Minimum 250 ns pulse width
UART Baud Rate tolerance		+/- 2		%	UART receiver and transmitter
Configuration memory write cycles	1000				The guaranteed number of write cycles using the 'M' command is limited

Document Revision History

Document Revision	Changes
1.00	First release
1.01	Added details with common power source (VCC_PA = 3.3V).
1.02	Reviewed.
1.03	Modified to VCC_PA = [2.8...3.6V] according to new revision.
1.04	Corrected mechanical height to 3.5mm. Changed text of header.
1.05	Minor text updates
1.06	Added FCC certification and updated product status. Valid for HW 2.10 or later.

Product Status and Definitions

Current Status	Data Sheet Identification	Product Status	Definition
	Advance Information	Planned or under development	This data sheet contains the design specifications for product development. Specifications may change in any manner without notice.
	Preliminary	Engineering Samples and First Production	This data sheet contains preliminary data, and supplementary data will be published at a later date. Radiocrafts reserves the right to make changes at any time without notice in order to improve design and supply the best possible product.
X	No Identification Noted	Full Production	This data sheet contains final specifications. Radiocrafts reserves the right to make changes at any time without notice in order to improve design and supply the best possible product.
	Obsolete	Not in Production	This data sheet contains specifications on a product that has been discontinued by Radiocrafts. The data sheet is printed for reference information only.

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As far as possible, major changes of product specifications and functionality, will be stated in product specific Errata Notes published at the Radiocrafts website. Customers are encouraged to check regularly for the most recent updates on products and support tools.

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