Radiocrafts
Embedded Wireless Solutions

RC1701HP-MSM

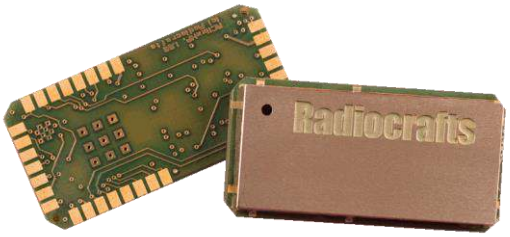
Wireless M-Bus High Power N Mode Sensor Module

Product Description

The RC1701HP-MSM module is a fully integrated, autonomous sensor-enabled, compact surface mounted product that measures only 12.7 x 25.4 x 3.7 mm. The module includes interfaces and drivers for several sensors. Configurable signal processing features are also available. Messages can be sent regularly and/or when a certain condition triggers, such as a sensor value going above a defined threshold. This enables a very compact, integrated and efficient solution for wireless sensor measurements that offers minimal time to market and a minimum amount of coding. The modules are easily interfaced and are set up through an UART interface. Radiocrafts also provides sensor boards for testing and prototyping. Custom variants can be offered with custom functionalities. Details of interfaces and sensory setup is described in the RCxxxxxxx-MSM User Manual. The RC1701HP-MSM meets the EN13757-4:2013 Mode N and is pre-certified for operation under the European radio regulations.

Applications

- Wireless Sensor Networks
- Wireless M-Bus
- Internet of Things
- Industrial remote sensing
- Smart sensors for buildings and smart city
- Telemetry stations



Note: The number of LGA pads differ from photo, see page 8 for details

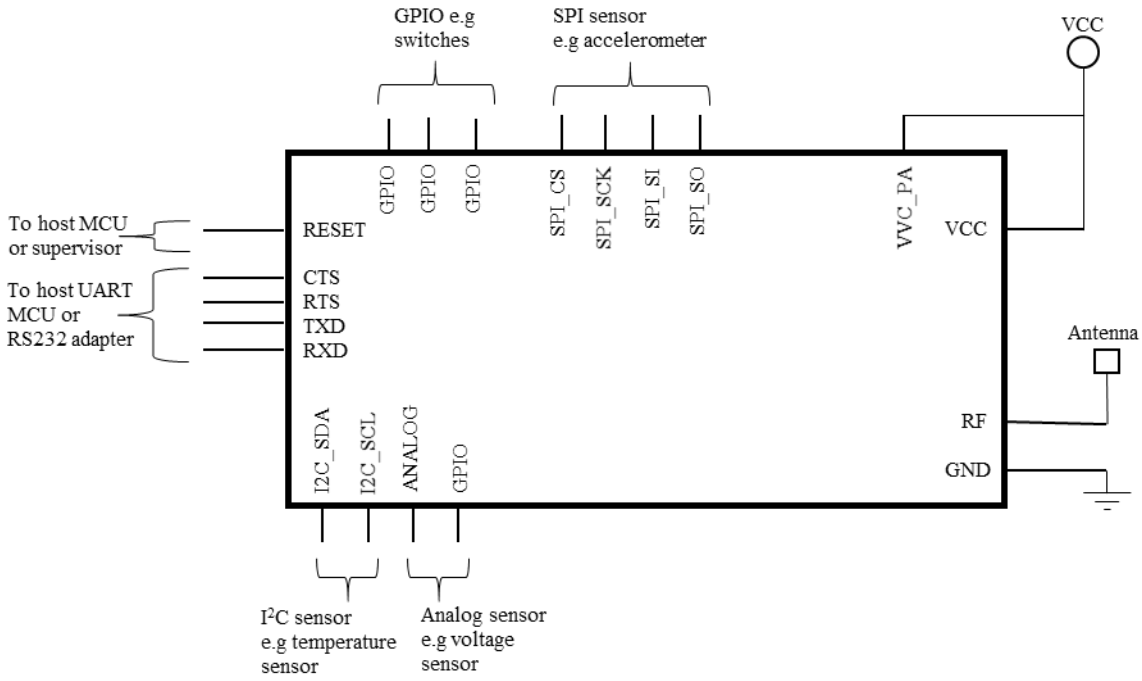
Features

- Sensor interfaces with support for common sensors: Temperature, Humidity, Accelerometer, Voltage and others
- Provides standard electrical interfaces for sensors: I2C, SPI, Analog, and Digital GPIOs
- Provides built-in software drivers for common sensors
- Embedded Wireless M-Bus protocol supporting EN 13757-4:2013 and 2018 mode N
- High power, long range (20 km Line-Of-Sight)
- Industry leading Wireless M-Bus protocol stack
- Completely shielded
- 12.7 x 25.4 x 3.7 mm compact module for SMD mounting
- No external components except antenna
- 2.8 – 3.6 V supply voltage, ultra low power modes
- Conforms with EU RED directive (EN 300 220, EN 301 489, EN 60950)

Quick Reference Data

Parameter	RC1701HP-MSM	Unit
Frequency bands	169.4 – 169.475	MHz
Number of channels	10	
Data rate	2.4, 4.8, 19.2	kbps
Max output power	+ 27	dBm
Supply voltage	2.8 – 3.6	Volt
Current consumption, TX (+27/30 dBm)	403	mA
Current consumption, No connected sensors	Typ. 17	uA
Temperature range	-30 to +85	°C

Typical application circuit



See later for additional schematic information regarding recommended Reset and Power supply filtering, and how to include a firmware upgrade connector.

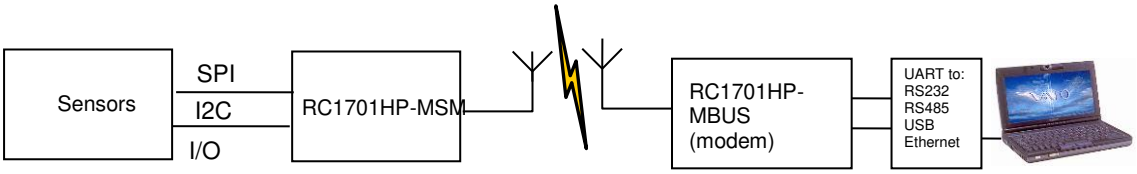
Current Consumption

Current consumption is highly dependent on application. The following table gives an estimate on how much power is used when including different sensors and different sample rates. The numbers are current consumption used by the module in addition to typical current consumption.

Sensor / Frequency	**Every 1 second**	**Every 10 seconds**	**Every 100 seconds**
Sensirion SHT35		2.87 uA	0.29 uA
TI HDC2010		1.02 uA	0.10 uA
GPIO toggle 1 pin every period and sample two others	0.65 uA	0.07uA	0.007 uA
ADC	2.34 uA	0.23 uA	0.023 uA

Wireless M-Bus Sensor Module

The RC1701HP-MSM module acts like a Wireless M-Bus Slave with a sensor interfaces. The embedded protocol transmits the Wireless M-Bus data packets based on application set up and connected sensors. The module is configured through its UART interface using a simple command set. Configuration parameters are stored in non-volatile memory. See MBUS User Manual for details about the embedded wireless MBUS protocol from Radiocrafts.



RF Frequency, Output Power Levels and Data Rates

The following table shows the available RF channels and their corresponding frequencies, nominal output power levels and available data rates (Bold is default setting). The combination of frequency and data rate is specified in EN 13757-4:2013.

Model	RF channel	Output power	Data rate
RC1701 HP-MSM	1: 169.406250 MHz (Channel 1a) 2: 169.418750 Mhz (Channel 1b) **3: 169.431250 MHz (Channel 2a)** 4: 169.443750 MHz (Channel 2b) 5: 169.456250 MHz (Channel 3a) 6: 169.468750 MHz (Channel 3b) 7: 169.412500 MHz (Channel 1) 8: 169.437500 MHz (Channel 2) 9: 169.462500 MHz (Channel 3) 10: 169.437500 MHz (Channel 0)	**PA_POWER=1-5** **5: +27 dBm** 4: +24 dBm 3: +21 dBm 2: +18 dBm 1: +14 dBm	**1: 2.4 kbps GFSK** 2: 4.8 kbps GFSK 4: 19.2 kbps 4GFSK

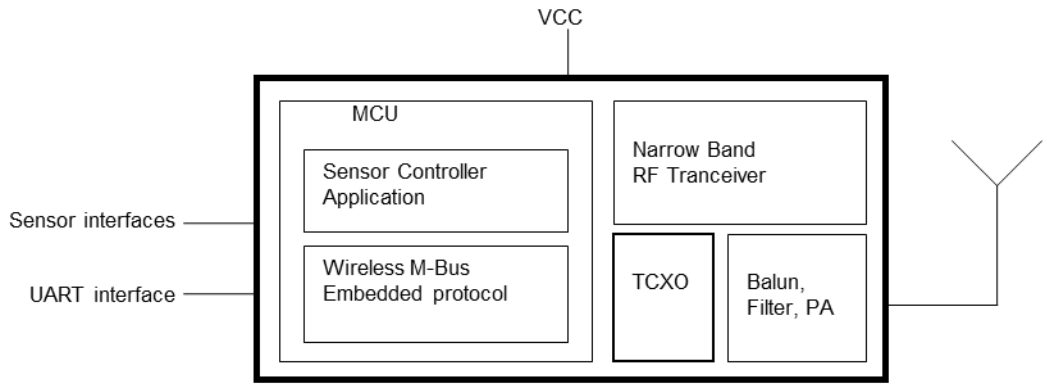
For more details on changing the RF channel, output power or M-Bus mode, refer to the MSM User Manual.

Custom specific Wireless M-Bus application

As an option, custom sensor interfaces and drivers can be integrated in the module *based on customer specification*. All the application layer protocol and timing will be handled internally by the module. Since the protocol for reading out meter information may differ from meter to meter, the embedded firmware is customized for each different meter and application.

Please see chapter “Programming Interface” for a description of how to include a programming connector in your PCB layout to be able to receive updated firmware code from Radiocrafts in a pilot product phase.

Block Diagram



Circuit Description

The module contains a communication controller with embedded Wireless M-Bus protocol software and a high performance RF transceiver.

The communication controller handles the radio packet protocol, the UART interface and controls the RF transceiver. Data to be sent by the host is collected from the sensors based on sensor configuration. The data packet is then assembled with preamble, start-of-frame delimited (SOF), manufacturer ID, unique address information and CRC check sums before it is transmitted on RF.

The RF transceiver modulates the data to be transmitted on RF frequency. Digital signal processing technology is used to enhance sensitivity and selectivity. The high power front end amplifies the signal up to +27 dBm and advanced filtering topology is included to suppress harmonics and spurs.

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

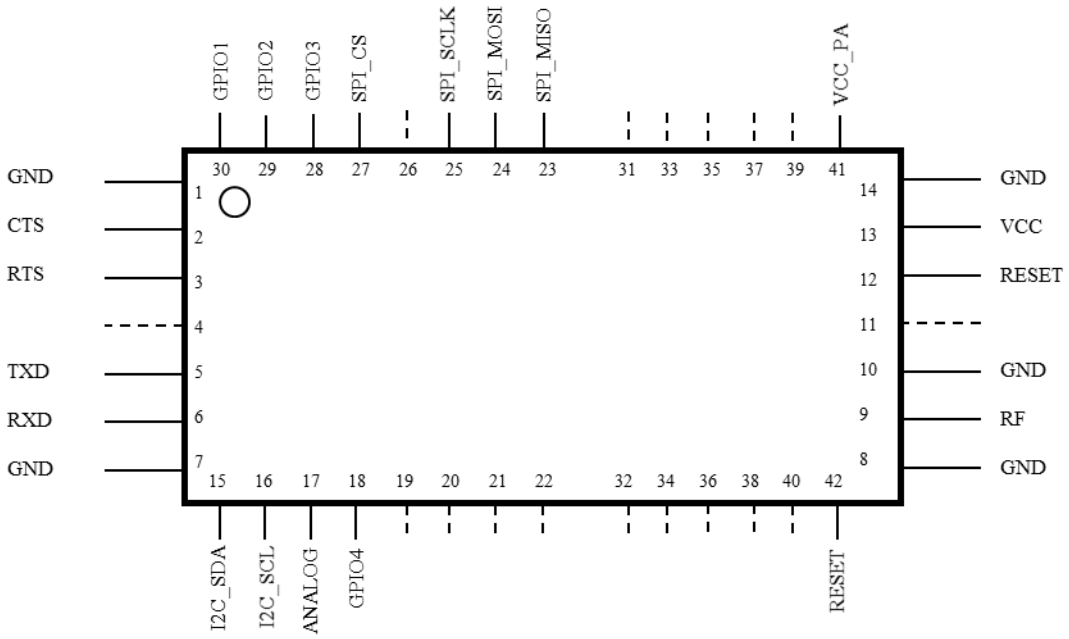
When a 00h value is sent as the first byte, the module enters configuration mode and the communication controller interprets data received on the RXD pin as configuration commands. There are commands to change the radio channel, the output power, etc. Permanent changes of the configuration is also possible and are then stored in internal non-volatile memory (Flash).

The supply voltage is connected to the VCC and VCC_PA pins. The module contains an internal voltage regulator for the RF transceiver and can therefore operate over a wide supply voltage range.

The module automatically enters Sleep mode to reduce the power consumption to a minimum.

Sensors are configured using an array of bytes containing all configuration data. This array is put into the module using the standard UART configuration interface. Please see the RCxxxx-MSM User Manual for details on how to configure the sensors.

Pin Assignment



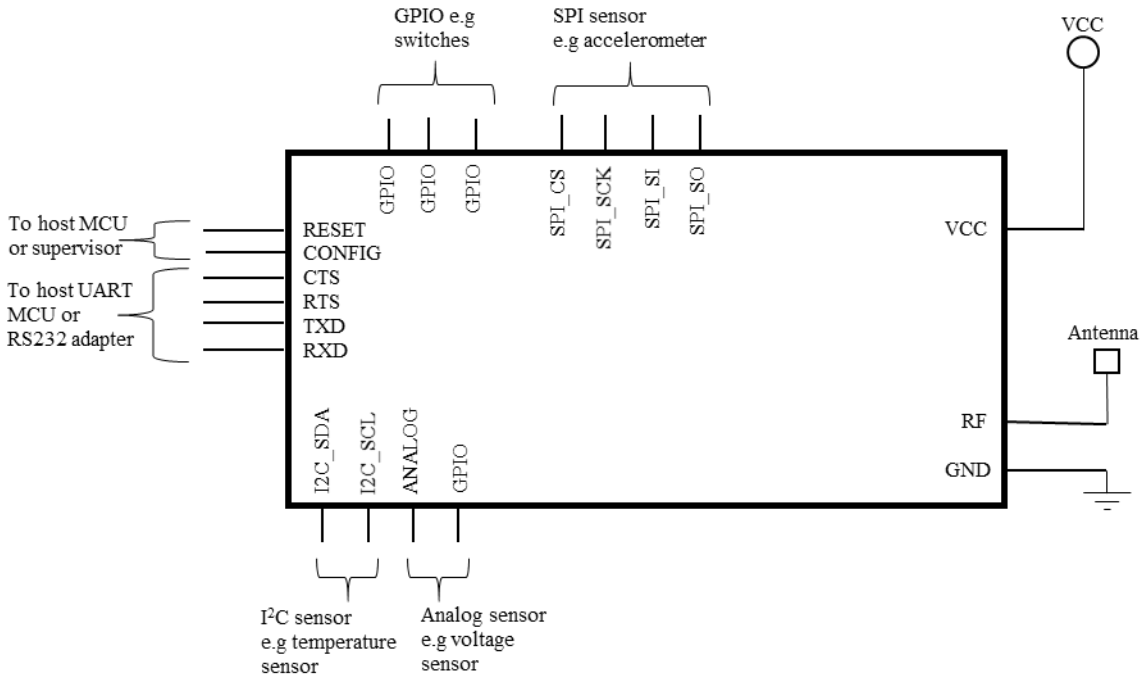
Pin Description

Pin no	Pin name	Description
1	GND	System ground
2	CTS	UART Clear to Send
3	RTS	UART Request to Send
4	RESERVED	Test pins or pins reserved for future use. *Do not connect!*
5	TXD	UART TX Data
6	RXD	UART RX Data Use external max 8k2 kohm pull-up resistor if connected to an open collector output from a host MCU or other high impedance circuitry like level shifters.
7	GND	System ground
8	GND	System ground
9	RF	RF I/O connection to antenna
10	GND	System ground
11	NC	Not connected
12	RESET	Main reset (active low). Should normally be left open. Internal 12 kΩ pull-up resistor.
13	VCC	Supply voltage input. Internally regulated.
14	GND	System ground
15	I2C_SDA	I²C-bus data pin. Connect I²C peripherals (sensors) to this pin. Pullups must be added.
16	I2C_SCL	I²C-bus clock pin. Connect I²C peripherals (sensors) to this pin. Pullups must be added.
17	ANALOG	Analog input

18	GPIO4	General purpose digital I/O
19	DD	Programming interface.
20	DC	Programming interface.
21-22	RESERVED	Test pins or pins reserved for future use. *Do not connect!*
23	SPI_MISO	SPI Master In Slave Out. Connect SPI peripherals (sensors) to this pin
24	SPI_MOSI	SPI Master Out Slave In. Connect SPI peripherals (sensors) to this pin
25	SPI_SCLK	SPI Clock. Connect SPI peripherals (sensors) to this pin
26	RESERVED	Test pins or pins reserved for future use. *Do not connect!*
27	SPI_CS	SPI Chip Select. Connect SPI peripherals (sensors) to this pin
28	GPIO3	General purpose digital I/O
29	GPIO2	General purpose digital I/O
30	GPIO1	General purpose digital I/O
31-40	RESERVED	Test pins or pins reserved for future use. *Do not connect!*
41	VCC_PA	Supply voltage input for Power Amplifier stage. VCC_PA can be connected together with VCC or separated using individual supply.
42	RESERVED	Test pins or pins reserved for future use. *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 do not need to be connected to any controllers such as a host MCU. However, for initial configuration (or reconfiguration), access to the UART is needed. It is also recommended to have access to the RESET and TXD/RXD lines for debugging and test.



Sensor interfaces

The module provides four main electrical sensor interfaces: Digital GPIOs, analog input, SPI and I²C.

The GPIOs can be configured as either input or output. For lowest current consumption, floating GPIOs should be avoided, so pullups should be used when they are configured as inputs with no (or tristate capable) connections.

The analog input is capable of reading any arbitrary voltage between zero and 1.25V.

The I²C is running standard mode, and support clock stretching. External pullup resistors **are needed** on the I²C bus, as the I²C lines are not internally pulled up by resistors. In most cases, 4.7 KOhm resistors can be used.

A full list of supported sensors, trigger conditions and DSP functions are found in the RCxxxxxxx-MSM User Manual.

Analog to Digital Converter

A built-in ADC is used to facilitate 1 generic analog input port, internal temperature measurement and measurement of the supply voltage. The precision of the values reported from the analog depends on the sensor data format described in the RCxxxxxx-MSM User Manual. The modules are calibrated during production. See RCxxxxxx-MSM User Manual for accuracy on specific values.

External connection considerations

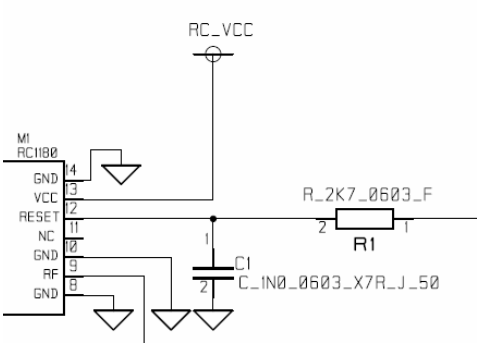
If the RESET is driven by a push-pull output, an additional 0 ohm series resistor should be inserted, to allow an external programmer used for firmware upgrade to assert Reset low. During firmware upgrade, the resistor must in this case be removed.

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. 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.

Reset filter

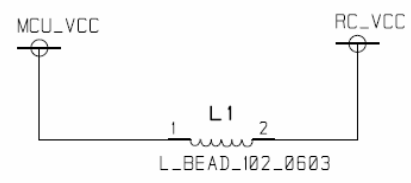
To minimize effect of noise on the Reset-line, the RESET pin on the module (pin 12) must be connected to an external circuitry via an RC-network. It is recommended to connect RESET to a microcontroller I/O-pin. The reset filter should be placed as close as possible to the RESET pin of the module.



Power Supply

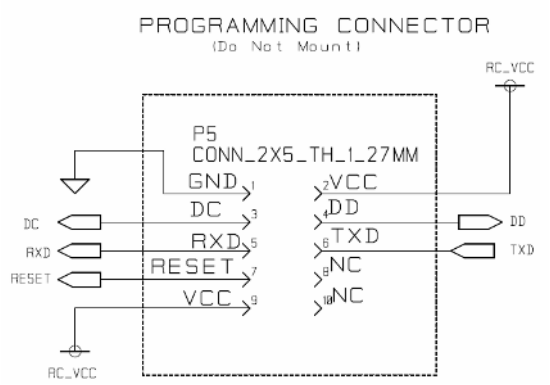
Noisy external circuitry may under certain scenarios affect the transmitted signal on RX1701HP-MSM and precaution should be taken for EU RED conformity. Example of circuits that can generate noise on the RC1701HP-MSM transmitted spectrum may be DC/DC converters and some level converters like RS232 and RS485. To increase spectrum margin it is important to add an EMI filter bead (L1) on the VCC pin of the RC1701HP-MSM module. Alternatively, the RC1701HP-MSM 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 RC1701HP-MSM.

Component	Manufacturer	Part number
EMI filter bead (L1)	Murata	BLM11A102S, ordering code BLM18xx102xN1D



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 x 1.6 mm = 2.88 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.

The length of a quarter wave antenna at 169.4 MHz is typ 42 cm long. Contact Radiocrafts for support on antenna design.

Regulatory Compliance Information

The use of RF frequencies and maximum allowed RF power is limited by national regulations. The RC1701HP-MSM has been designed to comply with the RED directive 2014/53/EU.

According to RED directives, it is the responsibility of Radiocrafts' customers (i.e. RC1701HP-MSM end user) to check that the host product (i.e. final product) is compliant with RED essential requirements. The use of a CE marked radio module can avoid re-certification of the final product, provided that the end user respects the recommendations given by Radiocrafts. A Declaration of Conformity is available from Radiocrafts on request.
The DoC is based on an antenna gain of 0 dBi or lower in band and < -3 dBi below 120 MHz.

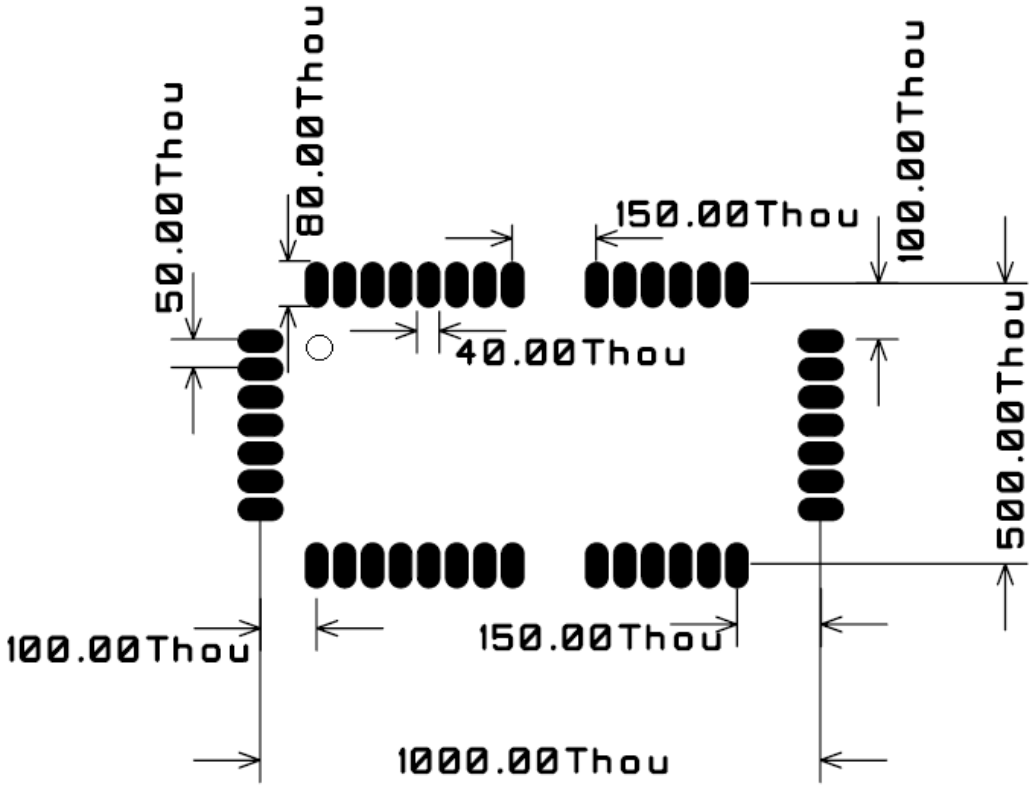
The relevant regulations are subject to change. Radiocrafts AS do not take responsibility for the validity and accuracy of the understanding of the regulations referred above. Radiocrafts only guarantee that this product meets the specifications in this document. Radiocrafts is exempt from any responsibilities related to regulatory compliance.

RCTools

RCTools-MBUS is a powerful and easy to use PC suite that helps you during test, development and deployment of the RC1701HP-MSM. Also, a sensor configuration tool is available to help configuring the sensors. Visit www.radiocrafts.com for free downloads and full documentation on both tools.

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.



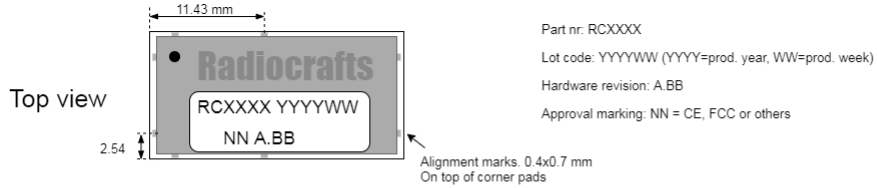
A PCB with two or more layers and with a solid ground plane in one of the inner- or bottom layer(s) is recommended. All GND-pins of the module shall be connected to this ground plane with vias with shortest possible routing, one via per GND-pin.

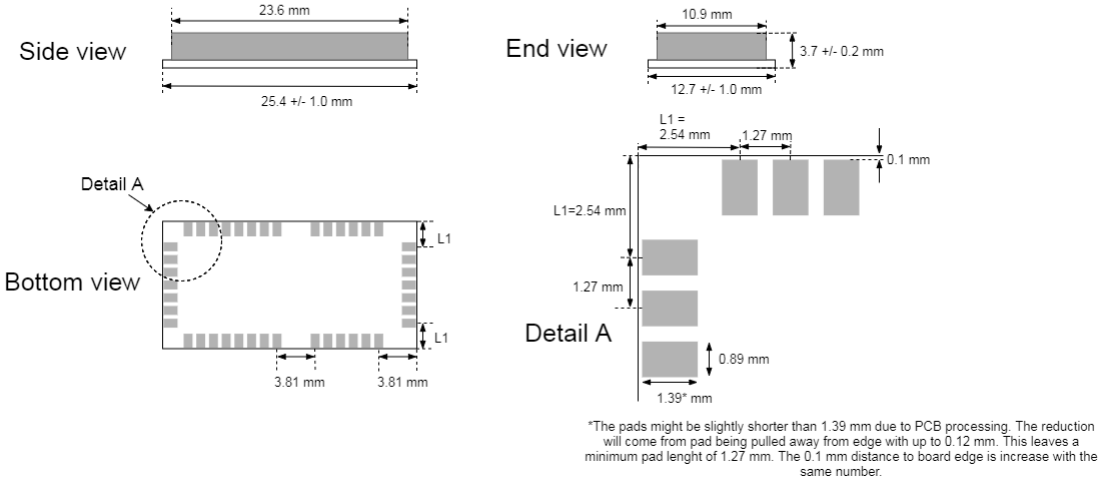
On the back side of the module there are several test pads. These test pads shall not be connected, and the area underneath the module should be covered with solder resist. If any routing or vias is required under the module, the routing and vias must be covered with solder resist to prevent short circuiting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

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

Note that Radiocrafts technical support team is available for schematic and layout review of your design.

Mechanical Drawing





*The pads might be slightly shorter than 1.39 mm due to PCB processing. The reduction will come from pad being pulled away from edge with up to 0.12 mm. This leaves a minimum pad lenght of 1.27 mm. The 0.1 mm distance to board edge is increase with the same number.

Mechanical Dimensions

The module size is 12.7 x 25.4 x 3.7 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 IPC/JEDEC J-STD-020D.1 (page 7 and 8), 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
Supply voltage, VCC Supply voltage, VCC_PA	-0.3 -0.3	3.8 3.8	V 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 TX the loaded battery voltage will usually drop below 3.6V, which is inside the operation voltage range (2.8V – 3.6V).

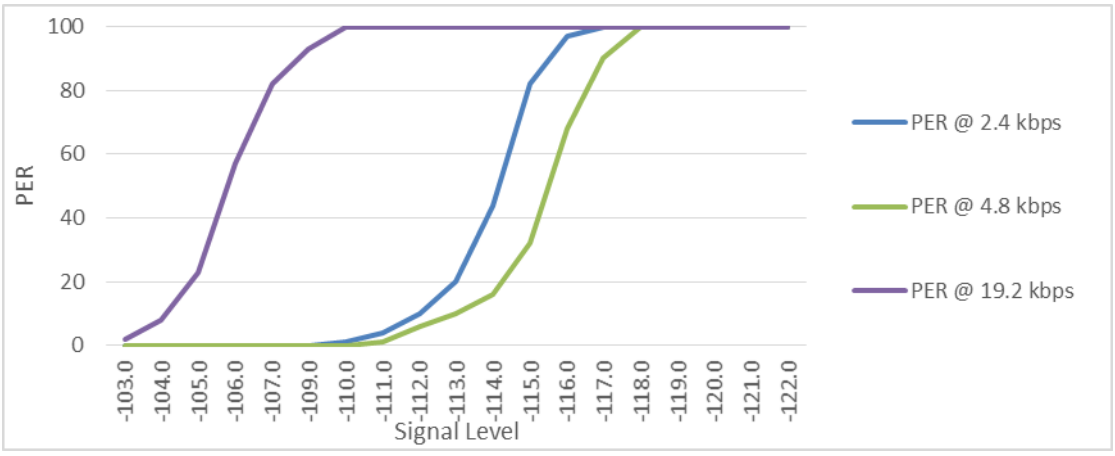
Electrical Specifications

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

Parameter	Min	Typ.	Max	Unit	Condition / Note
Operating frequency	169.4		169.475	MHz	
Number of 12.5 kHz channels Number of 25 kHz channels Number of 50 kHz channels		33 3 5			25 kHz channels for legacy use vs older standard
Input/output impedance		50		Ohm	
Data rate		2.4 4.8 19.2		kbit/s	2GFSK 2GFSK 4GFSK
Frequency tolerance 12.5 kHz channels 50 kHz channels			+/-1.5 +/-4.25	kHz	Including 10 years of aging.
Frequency stability aging			1 5	ppm/year ppm/ 10 year	Starting after 10 years
Transmit power RC1701HP-MSM		27	27.5	dBm	Typical values are for default settings
FSK deviation 2.4 kbps 4.8 kbps 19.2 kbps		 +/- 2.4 +/- 2.4 +/- 7.2 / 2.4		kHz	
Adjacent channel power: 12.5 kHz channels 25 and 50 kHz channels			<-20 <-37	dBm	
Spurious emission, TX < 1 GHz > 1 GHz Restricted bands			 -36 -30 -54	dBm	Restricted bands: 47 MHz – 74 MHz 87.5 MHz – 118 MHz 174 MHz – 230 MHz 470 MHz – 862 MHz
Supply voltage, VCC VCC_PA	 2.8 2.5	 3.3 3.3	 3.6 3.8	 V V	

Parameter	Min	Typ.	Max	Unit	Condition / Note
RC1701HP Current, TX: RF_POWER=5, +27 dBm RF_POWER=4, +24 dBm RF_POWER=3, +20 dBm RF_POWER=2, +17 dBm RF_POWER=1, +14 dBm		VCC_PA+VCC 402.7 mA 268.8 mA 181.2 mA 140.2 mA 107.7 mA		mA	Tested when load = 50 ohm. Note! PA_TABLE_EXT=1-2 and 13/14 will not give 3 dB step due to HW limitations.
RC1701HP TX Current vs Load for RF_POWER=5 (+27 dBm): Load=50 ohm Load=RC kit Antenna Load=Open Load=Short Load pull test for VSWR < 2.0: Load=100 ohm Load=25 ohm Load=50 ohm || 62 nH Load=50 ohm || 15 pF Load=82 ohm || 120 nH Load=82 ohm || 7.5 pF		 402.7 mA 522.1 mA 694.9 mA 219.2 mA 499.3 mA 347.8 mA 340.9 mA 543.0 mA 401.9 mA 586.4 mA			The Demo Board has a 50 Ohm output directly from the RF module. There is no antenna match on the board.
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 Output logic level, low (1µA) Output logic level, high(-1µA)	 70 % 0 TBD		 30 % TBD VCC	 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

Packet Error Rate



Document Revision History

Document Revision	Changes
1.00	First release
1.01	Removed duplicates and updated current consumption
1.02	Updated Mechanical drawing and height information. Please refer to Hardware PCN for revision history

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.

Disclaimer

Radiocrafts AS believes the information contained herein is correct and accurate at the time of this printing. However, Radiocrafts AS reserves the right to make changes to this product without notice. Radiocrafts AS does not assume any responsibility for the use of the described product; neither does it convey any license under its patent rights, or the rights of others. The latest updates are available at the Radiocrafts website or by contacting Radiocrafts directly.

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.

Trademarks

RC232™ is a trademark of Radiocrafts AS. The RC232™ Embedded RF Protocol is used in a range of products from Radiocrafts. The protocol handles host communication, data buffering, error check, addressing and broadcasting. It supports point-to-point, point-to-multipoint and peer-to-peer network topologies.

All other trademarks, registered trademarks and product names are the sole property of their respective owners.

Life Support Policy

This Radiocrafts product is not designed for use in life support appliances, devices, or other systems where malfunction can reasonably be expected to result in significant personal injury to the user, or as a critical component in any life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness. Radiocrafts AS customers using or selling these products for use in such applications do so at their own risk and agree to fully indemnify Radiocrafts AS for any damages resulting from any improper use or sale.

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Application notes library:	https://radiocrafts.com/resources/application-notes/
Whitepapers:	https://radiocrafts.com/resources/articles-white-papers/
Technology overview:	https://radiocrafts.com/technologies/
RF Wireless Expert Training:	https://radiocrafts.com/resources/rf-wireless-expert-training/

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