Radiocrafts
Embedded Wireless Solutions

RC11X0-MBUS

Wireless M-Bus Multi-Mode RF Transceiver Module (EN 13757-4:2012 ported to regional frequencies)

Product Description

The RC11X0-MBUS RF Transceiver Module is a compact surface-mounted high performance module with embedded Wireless M-Bus protocol. This data sheet applies for the non-European version of the Wireless M-Bus and complies to EN 13757-4 except for channel frequencies. Different frequencies for S, T and R mode are implemented to support the powerful wireless M-Bus protocol where the nominal operational frequencies are not license free. EN 13757-4 is an open standard which aims for equipment interoperation and has dedicated modes optimized for battery operated devices. The network topology is point to multipoint or peer to peer with an optional repeater. The module has a UART interface for serial communication and -configuration and a one-pin antenna connection. When used with quarter-wave antennas a line-of-sight range of over 800 meters can be achieved (2-3 km for High Power version).

Applications

- Wireless M-Bus (Meter-Bus)
- Automatic Meter Reading (AMR)
- Advanced Metering Infrastructure (AMI)
- Electricity-, Gas- and Water meters
- Heat meters, Heat cost allocators
- Readers and concentrators



Features

- Embedded Wireless M-Bus protocol supporting EN 13757-4:2012 mode S, T, C and R2
- 12.7 x 25.4 x 3.3 mm compact module for SMD mounting
- Easy to use UART interface for communication and configuration
- Wide supply voltage range, 2.0 – 3.6 V
- Ultra low power modes for extended battery lifetime
- 2 channels in mode S T and C, 10 channels in mode R2
- No external components except antenna
- Designed for EX compliance

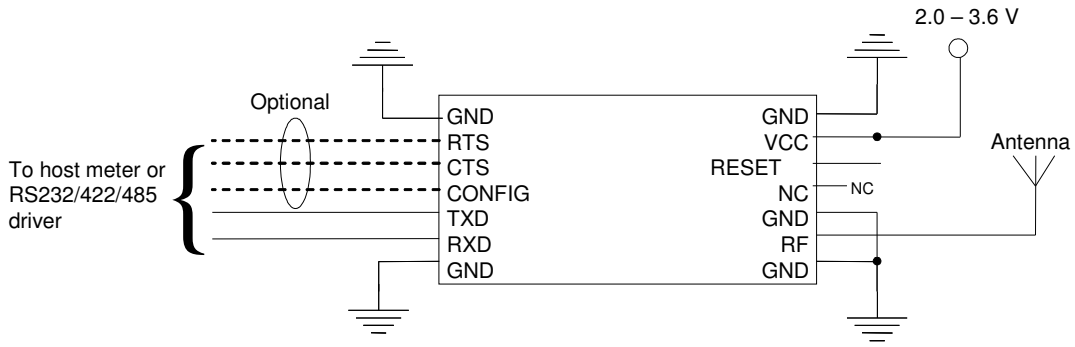
Quick Reference Data

Parameter	RC1140-MBUS	RC1160-MBUS	RC1170-MBUS	RC1170HP-MBUS	Unit
Frequency bands	433.05 – 434.70	868.7 – 869.2	865.1 – 866.9	865.1 – 866.9	MHz
Number of channels	12	1	12	12	
Data rate (R2, S, T)	4.8, 32.768, 100	32.768, 100	4.8, 32.768, 100	4.8, 32.768, 100	kchip/s
Max output power	10	10	10	27	dBm
Sensitivity, R/S/T	-106/-102/-101	-102/-101	-106/-102/-101	-105/-101/-100	dBm
Supply voltage	2.0 – 3.6	2.0 – 3.6	2.0 – 3.6	2.7 – 3.3	Volt
Current consumption, RX/TX	24 / 37	24 / 37	24 / 37	24 / 560	mA
SLEEP current	Typ 0.3	Typ 0.3	Typ 0.3	Typ 3.4	uA
Temperature range	-40 to +85	-40 to +85	-40 to +85	-40 to +85	°C
Conforms with	EN300220, EN301489, Anatel Resoution 506-2008	EN300220, EN301489	G.S.R. 564(E)/168(E)	G.S.R. 564(E)/168(E)	
Target market	World wide	Russia	India	India	

RC11X0-MBUS Embedded Firmware Solutions

The RC11X0-MBUS modules are available with different embedded firmware solutions, implementing specific feature sets on the same hardware. Detailed information on how to use the different feature set is described in the RC11X0-MBUS User Manual. See the Radiocrafts' webpage for latest revision.

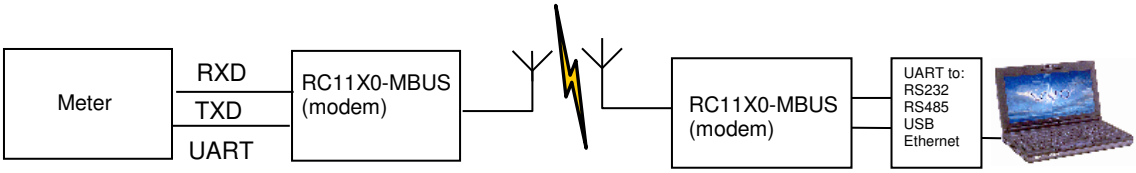
Typical application circuit



See page 7 for additional schematic information regarding recommended Reset and Power supply filtering, and how to include firmware upgrade connector.

Wireless M-Bus Modem

The standard RC11X0-MBUS module acts like a wireless M-Bus modem with a UART interface. The embedded protocol transmits and receives the wireless M-Bus data packets based on application messages from an external source (the meter or the concentrator). The module is configured through its UART interface using a simple command set. Configuration parameters are stored in non-volatile memory. The module can be set in Sleep mode with very low current consumption, and wake up on a UART command. See MBUS User Manual for details about the embedded wireless MBUS protocol from Radiocrafts.



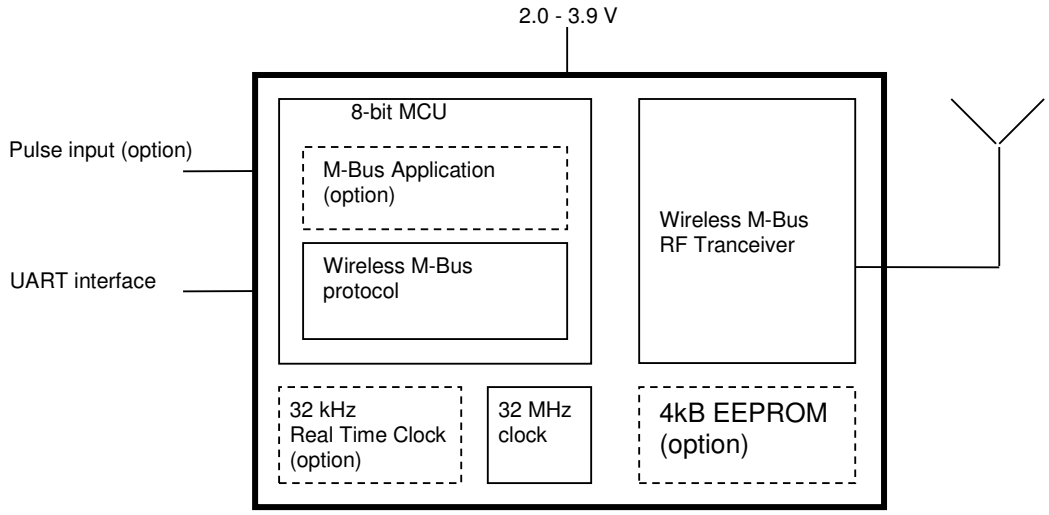
RF Frequency, Output Power Levels and Data Rates

The following table shows the available RF channels and their corresponding frequencies, nominal output power levels and available data rates. The combination of frequency and data rate is determined by the M-Bus mode. For article numbers with R mode, the RF channel selection must be selected between 1-10. The module automatically updates RF Channel 11 and 12 for S, T and C mode.

Model	RF channel	Output power
RC1140-MBUS	1-10: f_{RF}=434.03+(N-1)*0.06 MHz where N is the channel number 11 (used in S, T2 mode): f_{RF}=433.500 MHz 12 (used in T1 and T2 mode): **f_{RF}=434.475 MHz** C mode frequency same as T mode Factory setting: 1: 433.030 MHz (apply for R mode only)	1: -20 dBm 2: -10 dBm 3: 0 dBm 4: 5 dBm **5: 10 dBm**
RC1160-MBUS	1-10 (normally R mode, not applicable in this variant) 11 (used in S, T2 mode): f_{RF}=868.95 MHz 12 (used in T1 and T2 mode): **f_{RF}=868.95 MHz** C mode frequency same as T mode	1: -20 dBm 2: -10 dBm 3: 0 dBm 4: 5 dBm **5: 10 dBm**
RC1170(HP)-MBUS	1-10: f_{RF}=865.1+(N-1)*0.2 MHz where N is the channel number 11 (used in S, T2 mode): **f_{RF}=865.500 MHz** 12 (used in T1 and T2 mode): f_{RF}=865.500 MHz C mode frequency same as T mode. T og C mode may not meet local regulations due to bandwidth limitations. See OMS specifications for details. Factory setting: 1: 865.1 MHz (apply for R mode only)	1: -20 dBm (0 dBm) 2: -10 dBm (10 dBm) 3: 0 dBm (14 dBm) 4: 5 dBm (20 dBm) **5: 10 dBm (27 dBm)** (Numbers in brackets are for HP-version)

Numbers in **bold** are default settings. For more details on changing the RF channel, output power or M-Bus mode, refer to the MBUS User Manual.

Block Diagram



Circuit Description

The module contains a communication controller with embedded Wireless M-Bus protocol software and a high performance RF transceiver. As an option the module can support a real time clock oscillator and EEPROM memory.

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 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, and demodulates data that are received. Digital signal processing technology is used to enhance sensitivity and selectivity.

Received data are checked for correct CRC 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 configurable, 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 a 00h value is sent as the first byte (replacing the Length byte), or 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).

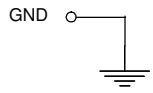
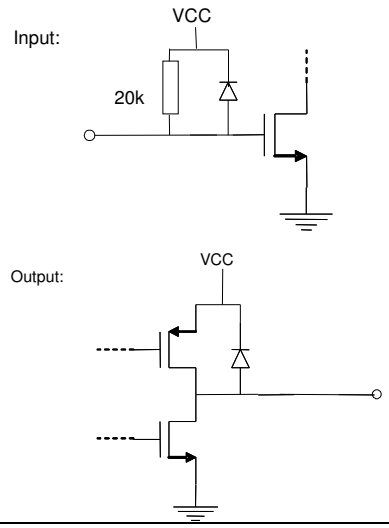
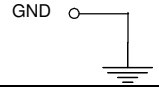
The supply voltage is connected to the VCC pin. The module contains an internal voltage regulator for the RF transceiver and can therefore operate over a wide supply voltage range.

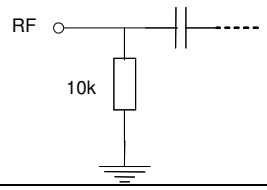
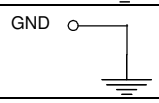
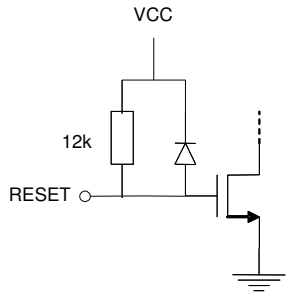
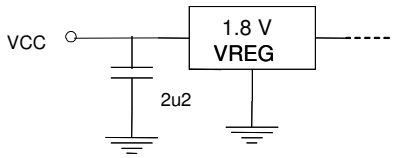
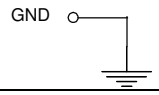
The module can be set in Sleep mode by UART commands to reduce the power consumption to a minimum.

Pin Assignment



Pin Description

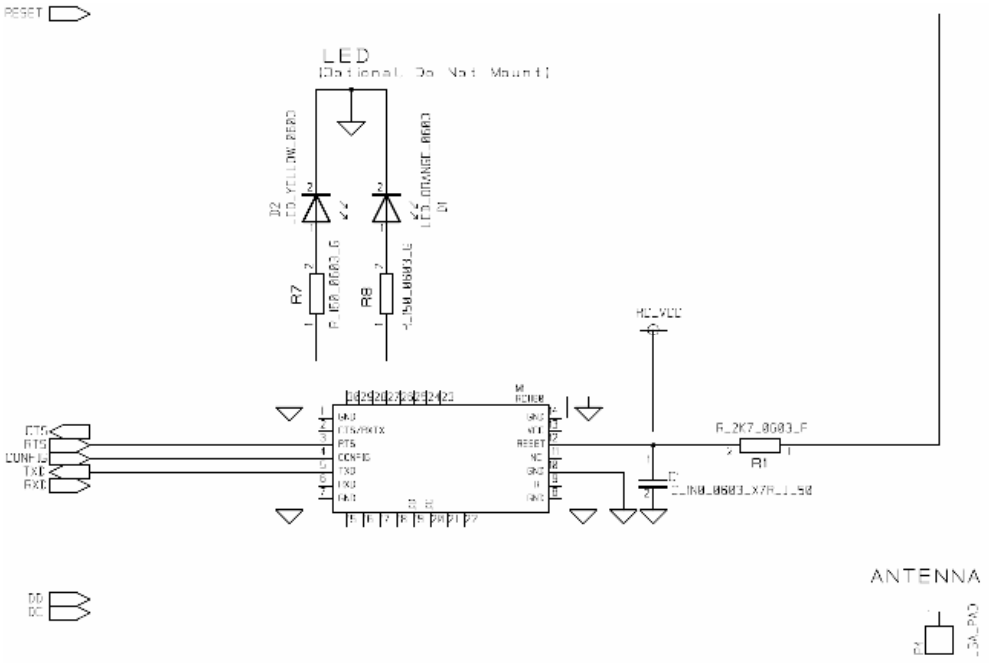
Pin no	Pin name	Description	Equivalent circuit
1	GND	System ground	
2	CTS	UART Clear to Send	
3	RTS	UART Request to Send	
4	CONFIG	Configuration Enable. Active low. Should normally be set high	
5	TXD	UART TX Data	
6	RXD	UART RX Data Use external max 8k2 kohm pull-up resistor if connected to an open collector 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. Note: For HP versions, an additional 2k7 series resistor and a 1nF shunt capacitor is added directly on the RESET pin inside the module	
13	VCC	Supply voltage input. Internally regulated.	
14	GND	System ground	
15-22	RESERVED	Test pins or pins reserved for future use. *Do not connect!*	
23-30	RESERVED	Test pins or pins reserved for future use. *Do not connect!*	

Note 1: For UART communication the TXD and RXD are used for serial data, and CTS and RTS for flow control (optional). RXD should be high when not sending data to the module.
Note 2: The CONFIG pin can be used to enter configuration mode (change of default settings) as an alternative to the 0x00 command. Active low.
Note 3: Other digital interfaces may be specified upon request.

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 is optional since a UART command can replace the CONFIG pin on the MBUS modules. Pin 29/30 are LED drivers and D1/D2 can be mounted (optional) for debugging (State information).



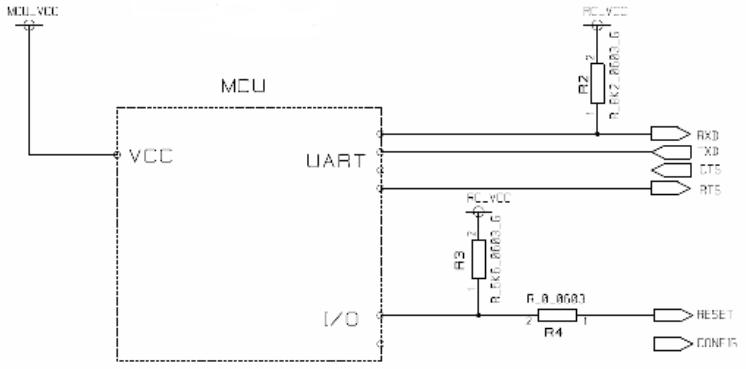
MCU considerations

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.

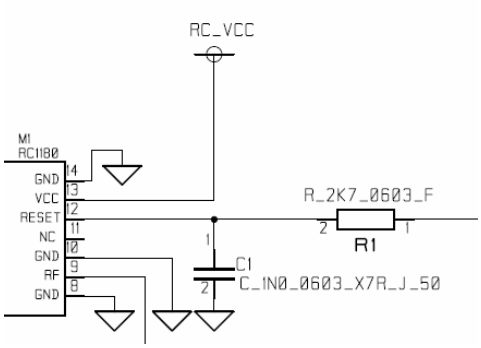
In noisy surroundings and where RESET is not driven by a push-pull output, it is recommended to add an external pull-up on RESET using a 5k6 resistor (R3). If the pull-up is stronger the external programmer used for firmware upgrade will not be able to assert RESET low.

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).



Reset filter

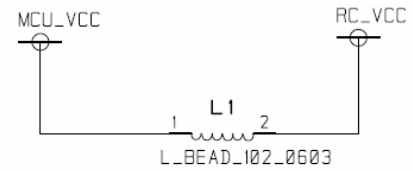
To minimize effect of noise on the Reset-line, the RESET pin on the module (pin 12) must be connected to an external circuitry via an RC-network. It is recommended to connect RESET to a microcontroller I/O-pin. The reset filter should be placed as close as possible to the RESET pin of the module.



Power Supply

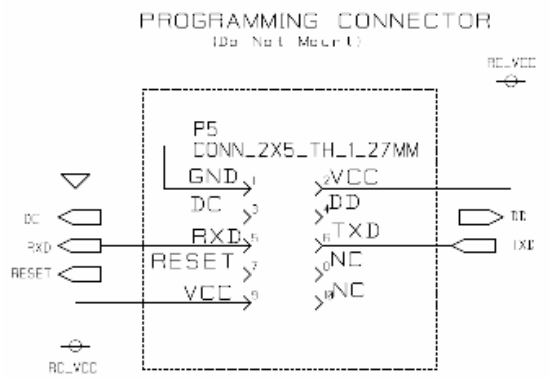
Noisy external circuitry may under certain scenarios affect the transmitted signal on RC1180-MBUS and precaution should be taken for EU R&TTE conformity. Example of circuits that can generate noise on the RC1180-MBUS transmitted spectrum may be DC/DC converters and some level converters like RS232 and RS485. To increase spectrum margin it is important to add an EMI filter bead (L1) on the VCC pin of the RC1180-MBUS module. Alternatively, the RC1180-MBUS 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 RC1180-MBUS.

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 lengths of a quarter wave antenna for different operational frequencies are given in the table below.

Frequency [MHz]	Length [cm]
433	16.4
865	8.2
866	8.2

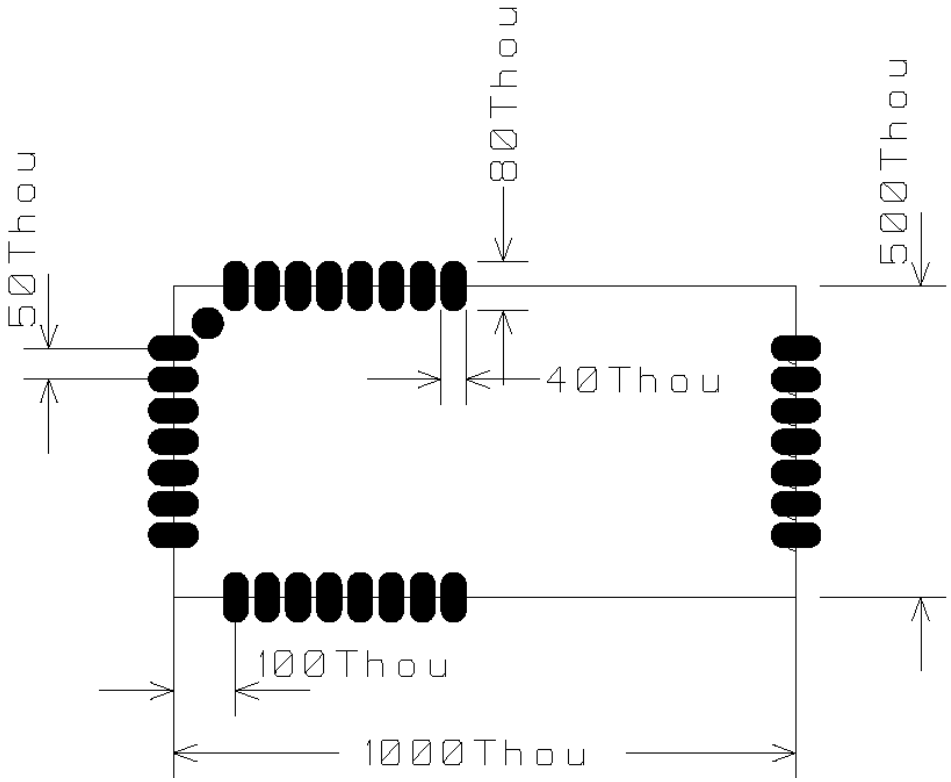
Regulatory Compliance Information

The use of RF frequencies and maximum allowed RF power is limited by national regulations. The RC11X0-MBUS has been designed to comply with the R&TTE directive 1999/5/EC.

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.

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.



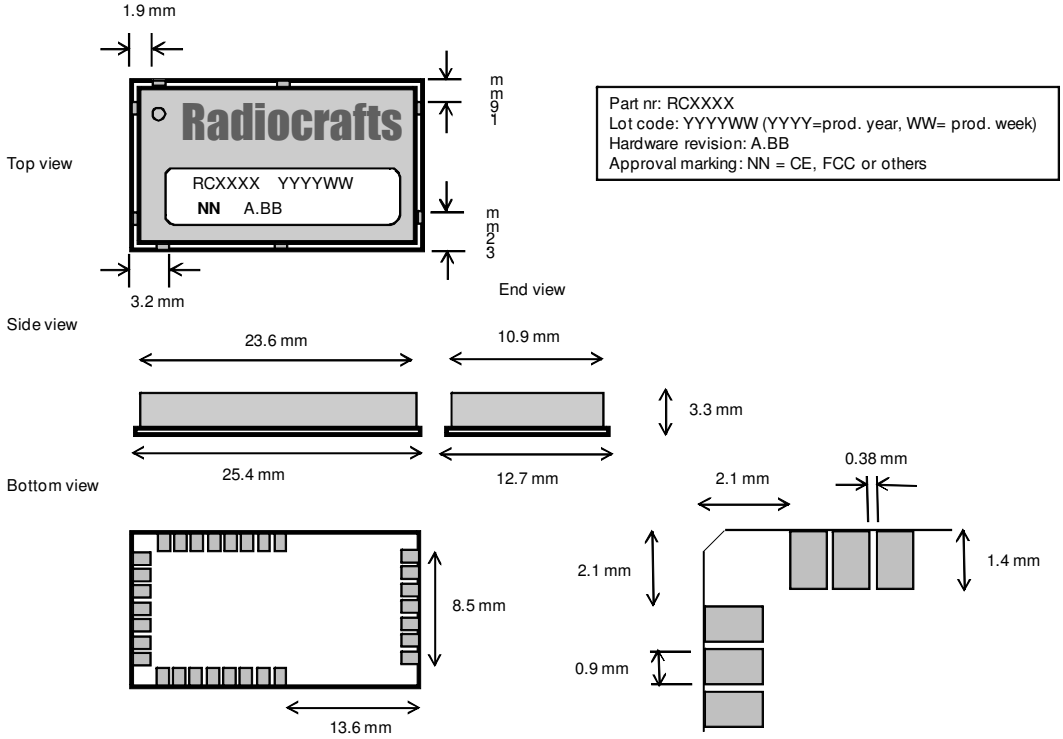
A PCB with two or more layers and with a solid ground plane in one of the inner- or bottom layer(s) is recommended. All GND-pins of the module shall be connected to this ground plane with vias with shortest possible routing, one via per GND-pin.

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 free-of-charge schematic and layout review of your design.

Mechanical Drawing



Drawings are not to scale

Alignment marking: On the top side there are 8 alignment markers which align with the corresponding pad on the bottom side.

Mechanical Dimensions

The module size is 12.7 x 25.4 x 3.3 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%. A nominal stencil thickness of 0.1 - 0.12 mm is recommended. Consult your production facility for best experience aperture reduction.

Absolute Maximum Ratings

Parameter	Min	Max	Unit
Supply voltage, VCC	-0.3	3.9	V
Voltage on any pin	-0.3	VCC+0.3V Max 3.9 V	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 (3.9V). 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 (2.0V – 3.6V).

Electrical Specifications

T=25°C, VCC = 3.0V if nothing else stated.

Parameter	Min	Typ.	Max	Unit	Condition / Note
Operating frequency	433.05 868.7 865.1		434.7 869.2 866.9	MHz MHz	RC1140-MBUS RC1160-MBUS RC1170(HP)-MBUS
Number of channels		12 1 12			RC1140-MBUS RC1160-MBUS RC1170(HP)-MBUS
Input/output impedance		50		Ohm	
Chip rate S-mode T-mode R2-mode		 32.768 100 4.8		kchip/s	
Data rate S-mode T-mode R2-mode		 16.384 66.67 2.4		kbit/s	S and R2 mode use Manchester coding. T mode uses 3-of-6 coding. T2 use a combination of both.
Frequency stability S and T mode R2 mode			 +/-40 +/-20	ppm	Including 10 years of aging. TBD limited temperature range for R2 mode
Frequency stability aging			1	ppm/year	Starting after 10 years
Transmit power	 -20 (0)	 9 (27)	 10 (28)	dBm	Typical values are for default settings. (For High Power version)
FSK deviation S-mode T-mode R2-mode		 +/- 50 +/- 50 +/- 6		kHz	
Adjacent channel power		TBD		dBc	
Occupied bandwidth		TBD		kHz	99.5%
Spurious emission, TX RX1140 < 1 GHz > 1 GHz RC1170/RC1160 < 1 GHz > 1 GHz			 -49 -41 -36 -30	dBm	

Sensitivity S-mode T-mode R2-mode	 -100 -100 -105	 -102 -101 -106		dBm	Measured at 1% BER / 80% PER of 20 byte packets. HP versions has typical 1 dB less sensitivity
Adjacent channel rejection		29		dB	
Alternate channel selectivity		53		dB	
Image channel rejection		28		dB	
Blocking / Interferer rejection / desensitization +/- 1 MHz +/- 2 MHz +/- 5 MHz +/- 10 MHz	 30 35 50 60	 43 49 68 72		dB	Wanted signal 3 dB above sensitivity level, CW interferer. (Minimum numbers corresponds to class 2 receiver requirements in EN300220).
Saturation		-14		dBm	
Spurious emission, RX			-57	dBm	
Supply voltage	2.0		3.6	V	2.7 – 3.3V for HP versions
Current consumption, RX/IDLE UART IDLE	 1.7	 24 	 3.6	mA	Apply over entire supply voltage range UART IDLE current depends on UART Baud Rate. Max value for baud rates >14.4 kbaud and 1.7 ma for lower baud rates
Current consumption, TX RF_POWER=5, 10 dBm RF_POWER=4, 5 dBm RF_POWER=3, 1 dBm RF_POWER=2, -10 dBm RF_POWER=1, -20 dBm		 37 32 24 19 18		mA	Apply over entire supply voltage range
Current consumption, TX High Power versions RF_POWER=5, 27 dBm RF_POWER=4, 25 dBm RF_POWER=3, 14 dBm RF_POWER=2, 10 dBm RF_POWER=1, 0 dBm		 560 530 80 60 20			
Current consumption, SLEEP		0.1 (3.4)	1.0 (10)	uA	(For High Power versions)
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

Document Revision History

Document Revision	Changes
2.10	First release for RC1140-MBUS
2.20	RC1170(HP)-MBUS and RC1160-MBUS included
2.21	Minor corrections
2.22	- RC1140-MBUS frequency update - RC1160-MBUS frequency update - C mode info added - Minor corrections - improved application circuit
2.23	- RC1140-MBUS frequency correction - RC1170-MBUS frequency correction
2.24	- RC1140 HW 2.20 improvement on harmonics included - Absolut max voltage vs Max Supply voltage clarification

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.

APPENDIX A

(OPTIONAL CUSTOMER SPECIFIC VERSIONS, AVAILABLE ON REQUEST)

Full wireless M-Bus application

As an option, a full wireless M-Bus application layer can be integrated in the module *based on customer specification*. In this case all the application layer protocol and timing will be handled internally by the module. An S0 (1-pin) pulse interface and/or a serial interface can be used to read out values from any meter. 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.

These are some of the features that can be used in a customized application:

- 4 kB EEPROM for storing meter data
- 32 kHz oscillator for real time clock time stamps
- AES-128 encryption
- Sleep timers
- Message acknowledgement and re-transmissions
- Digital I/O pins for tamper detection, alarms and installation
- A/D converter for analogue sensors

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.

One-Button Installation

Due to the two-way transceiver capability of the RC11X0-MBUS module, a simple and robust installation procedure can be used even for S1 and T1 (one-way) operation modes.

In a full M-Bus application, the Radiocraft’s unique “one-button” installation feature simplifies the installation and reduces installation time substantially. Using an external push-button and a LED connected to dedicated pins on the module, the installation procedure is very simple:

- Press the install button on concentrator
- Press the install button on meter
- Wait 5 seconds for two way communication between meter and concentrator
- See installation LED go on for OK installation (Blinking for error during installation)

Please contact Radiocrafts for customer specific requests.

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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.

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.

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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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