1 Product Description

The RC1882-IPM is a sub-1 GHz programmable ultra-low power module for RIIM (Radiocrafts Industrial IP Mesh). It is based on the open radio standard IEEE802.15.4 g/e, and implements IPv6 internet addressing with support for UDP, CoAP and encryption. The RC1882-IPM is used to implement all the nodes in the network including Leaf nodes, Mesh Router nodes and Border Router nodes.

The module works together with RIIM SDK(Software Development Kit) and ICI (Intelligent C-programmable Interface). The RIIM SDK include all the tools and documentation needed to work with the module. ICI allows the user to program his own intelligent sensor/actuator inteface, or any other application with minimal effort. The programming capability of the module makes it possible to interface to any sensor/actuator or combination of sensors/actuators, thereby removing the need for an additional MCU to reduce overall cost and power consumption.

2 Applications

- Coin cell battery systems
- IIoT applications
- Smart Sensor Technologies
- Energy Management and Sustainability
- Green House Monitoring and control
- Elderly Care
- Fire Detection
- Home Security
- Indoor Air Quality Monitoring
- Industrial Temperature Control
- Medical Climate Control
- Predictive Maintenance
- Tank Level/Flow Monitoring
- Facilities and Infrastructure Management
- Radiation and Leak Detection
- Irrigation monitor and control

3 Features

- Internet interoperability via IPv6 / IPv4 addressing, UDP packet transmission, DTLS encryption and CoAP protocol.
- Multi-hop mesh technology.
- Self building and self healing network.
- Over The Air (OTA) updates
- Very high node count mesh
- Long RF range, several hundred meter LOS
- Many electrical interfaces: 9 programmable GPIOs, I2C bus, SPI bus, UART and 2 ADC inputs
- Intelligent C-Programmable Interface (ICI) easy to use C-based SDK to directly interface any sensor/actuator
- Ultra-low power for coin cell battery or energy harvesting
- Pre-certified radio
- Based on open radio standards IEEE 802.15.4 g/e
- Automatic acknowledge and retransmission
- Support for external power amplifier and LNA via control signals

4 Quick Reference Data (typical at 3.6V, 868 MHz, 50 kb/s)

Parameter	RC1882-IPM	Unit
Frequency band	862-930	MHz
Max output power	14	dBm
Sensitivity (BER 1%) @50kb/s	-110	dBm
Supply voltage	2.3 - 3.6	V
Current consumption, RX/TX	6.0 / 25	mA
Current consumption, Sleepy node - connected to network	4.7	uA
User application flash memory	32	kB
User application RAM	8	kB
Internal EEPROM (optional)	4	kB
Internal SPI Flash	1024	kB
Operating Temperature	-30 to +85	°C

5 RIIM overview

The RIIM network consists of these key elements

- The RIIM SDK
  - Software development kit with ICI application frameworks and tools for creating and uploading end ICI applications to the RC1882-IPM
- The RC1882-IPM module
  - The RC1882-IPM module can be configured as Border Router node, Mesh Router node or Leaf node.
    - As a Border Router it acts as the base of the mesh network. It can connect to an external network via ethernet or custom user ICI application on other interfaces such as UART
    - As a Mesh Router, it will be able to transport packets in the RIIM mesh network
    - As a Leaf, it is not able to transport packets to other nodes except its parent. This mode uses the least amount of energy.
  - All node configurations require an ICI application for RF and interface configuration and the user application. The same RIIM Software Development Kit (SDK) is used to create the ICI application for all node configurations.

  Below is an illustration of the different elements and the documentation available

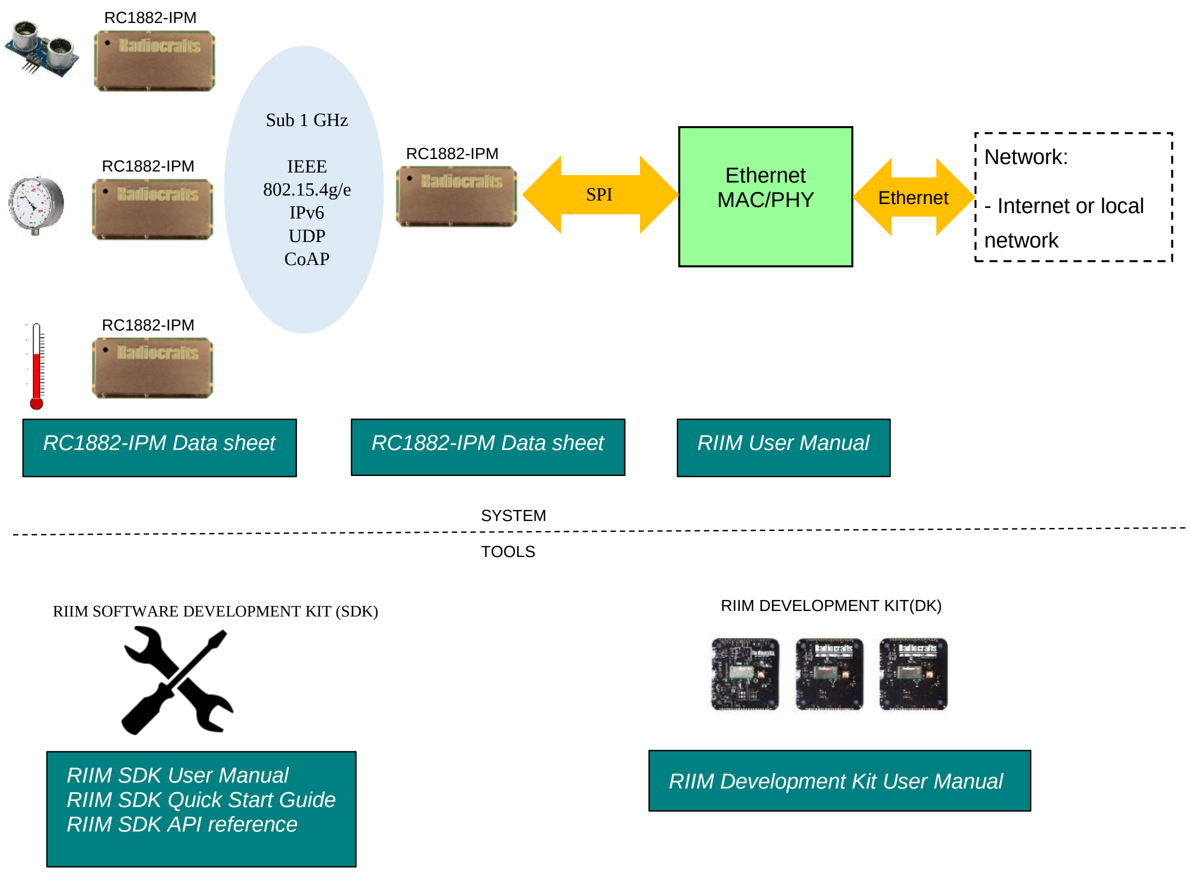


Figure 1. RIIM network – system and documentation overview

6 Firmware structure

The RIIM module's program memory is divided in 3 different segments.

- The bootloader
- The platform image
- ICI application image

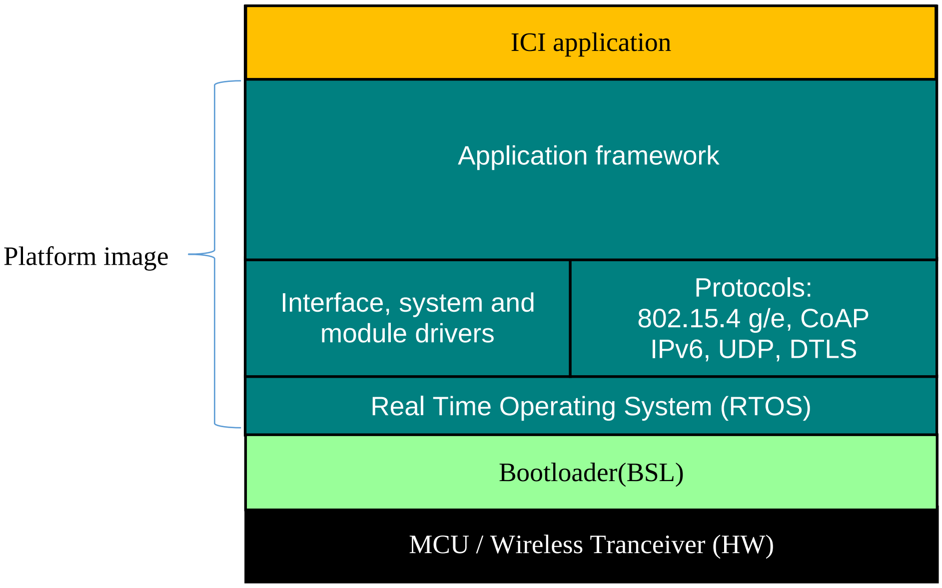


Figure 2. System overview

The bootloader is preloaded from Radiocrafts. It allows user to upload new platform image or unique application image generated by the customer. The bootloader also allows user to program unique encryption keys into the device. These keys are not possible to read out. The bootloader uses the standard UART port and operate at 115200 baud.

Note that the bootloader also leaves all GPIO in tristate mode at power up. If a specific application requires controlled high or low level during start up, an external pull-up/pull-down is mandatory.

The platform image is the main firmware part and includes operating system, network stacks, drivers and application framework. This firmware image is preloaded from Radiocrafts and newer revisions will be made available from Radiocrafts as an encrypted image. When downloading a new platform image through the bootloader, the image will be decrypted internally in the module.

The application code space has available 32 kB of flash space and 8 kB of RAM.

7 Software Development Kit (SDK)

The RIIM SDK is needed to work with the RC1882-IPM module. The SDK can be downloaded from www.radiocrafts.com. The SDK includes its own separate documentation.

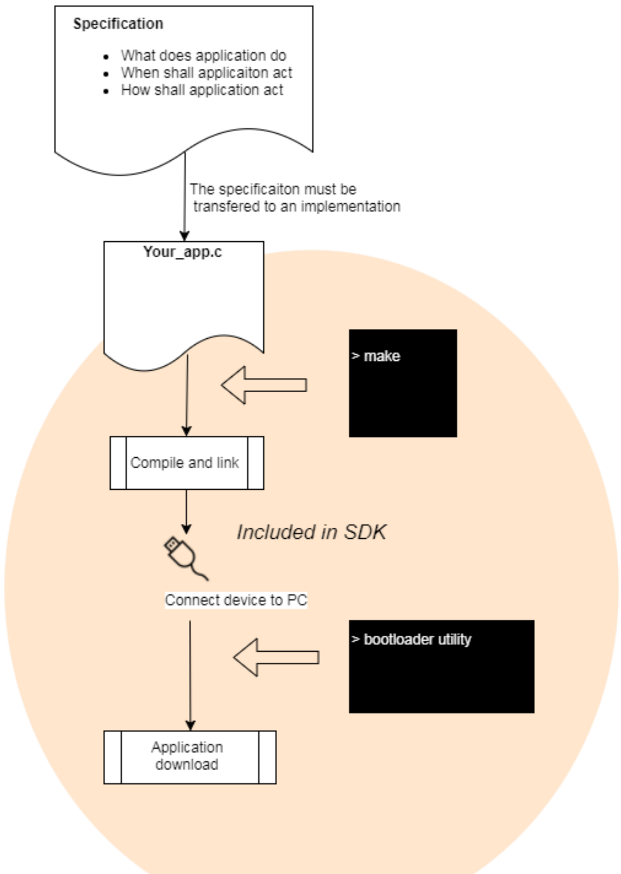


Figure 3. Workflow using RIIM SDK

8 Intelligent C-programmable interfaces (ICI)

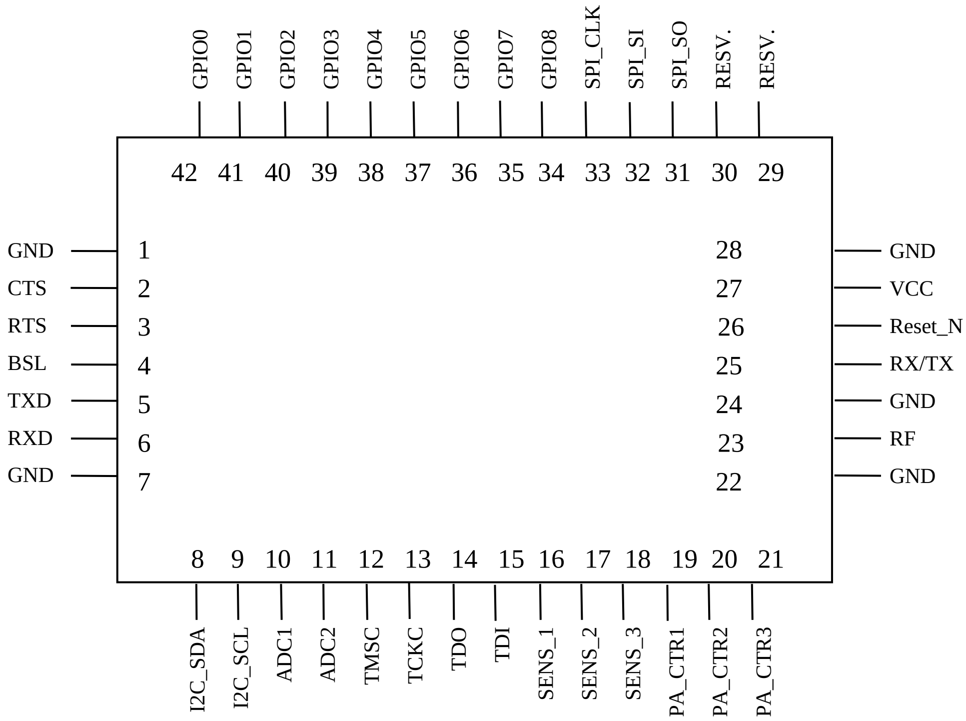
The ICI application is written in a high-level C-language, using a powerful API that is available in the SDK. The API removes the need for the developer to understand the underlying architecture and resources in the module.
In its simplest form, the ICI application is just configuring the radio network, the modules hardware interfaces and defining when to read and write to those interfaces. This can typically be done with less than 100 lines of code and within a few hours. Examples included in SDK are normally a good starting point.
And the ICI application also have the capability of including complex data processing and advanced features, such as averaging and threshold detection using one or many sensors in combination or to create complex sensor interfaces. The flash space available for the ICI application is 32 kB

See the *RIIM SDK User Manual*, *RIIM SDK API Reference* and the *RIIM SDK Quick Start* documents for more information.

Example : ICI code

```
#include "RIIM_UAPI.h"

const uint8_t IP_Addr[4]={0,0,0,0};
const uint8_t IP_Mask[4]={255,255,255,0};
const uint8_t IP_GW[4]={192,168,150,1};

RIIM_SETUP()
{
    Util.printf("Starting RIIM Root Node\n");

    // Setup network and RF
    Network.startBorderRouter(NULL,IP_Addr,IP_Mask,IP_GW);

    return UAPI_OK;
}
```

9 Pin Assignment



10 Pin Description

Pin no	*Pin name*	*Description*
1	GND	System ground
2	CTS	UART flow control
3	RTS	UART flow control
4	BSL	Enable boot strap loader
5	TXD	Configurable I/O pin
6	RXD	Configurable I/O pin
7	GND	System ground
8	I2C SDA	I2C SDA, internal 4.7k pullup
9	I2C SCL	I2C SCL, internal 4.7k pullup
10	ADC1	Analog input
11	ADC2	Analog input
12	TMSC	JTAG interface
13	TCKC	JTAG interface
14	TDO	JTAG interface
15	TDI	JTAG interface
16	SENS_1	Reserved for future use
17	SENS_2	Reserved for future use

18	SENS_3	Reserved for future use
19	PA_CTR1	Power Amplifier Control – High when radio is active. Low when idle.
20	PA_CTR2	
21	PA_CTR3	Power Amplifier Control – High when radio is active and transmitting. Low when receiving.
22	GND	System ground
23	RF	RF I/O connection to antenna
24	GND	System ground
25	RX/TX	Not connected
26	RESET_N	Reset (Active low)
27	VCC	Supply voltage
28	GND	System ground
29	RESV.	Reserved for future use
30	SPI_CS_I	SPI CS for internal flash - DO NOT CONNECT
31	SPI_SO	SPI bus
32	SPI_SI	SPI bus
33	SPI_CLK	SPI bus
34	GPIO_8	General purpose I/O pin. Pin is tristated by module during bootloading. Add pull-up if used as SPI chip select(CS) for external SPI devices.
35	GPIO_7	
36	GPIO_6	
37	GPIO_5	
38	GPIO_4	
39	GPIO_3	
40	GPIO_2	
41	GPIO_1	
42	GPIO_0	

Note 1: Pins 8 and 9 are suggested as I2C interface. They can be configured otherwise, but are connected to an optional internal EEPROM with I2C address = 000. It is recommended to leave these pins as I2C. Sensors and actuators or any other I2C device can be connected to these pins and accessed from the module.

11 ADC Parameters

Parameter	*Value*	*Description*	
# bits	12	Bits	
Input impedance	>1	Mohm	
Internal reference	4.3	V	
External reference voltage	VDD	V	
ENOB Effective number of bits	10.0		Internal reference, 200ksamples/s 9.6 kHz tone
THD Total harmonic distortion	-65	dB	
SINAD and SNDR Signal-to-noise and distortion ratio	62	dB	
SFDR Spurious-free dynamic range	74	dB	

12 SPI Parameters

Parameter	*Value*	*Description*
SPI clock rate max	12 MHz	
SPI mode	Master	
Modes supported	0,1,2 and 3	
SPI chip select	SW chip select (GPIO 0-8)	**Note** that when using an SPI device the CS must have external pull-up, since the bootloader uses SPI BUS vs internal flash

13 I2C Parameters

Parameter	*Value*	*Description*
I2C clock rate	100/400 kHz	
Pull up resistor	4.7 kΩ	Embedded in module
Clock stretching support	Yes	

14 GPIO parameters

Parameter	*Value*	*Description*
Number of GPIO	9	
Pull up resistor	25 kΩ	Typical
Pull down resistor	85 kΩ	Typical
Source/sink current	2 mA	Max
VIH	0.8*VCC	Minimum input voltage to be reliable read as high
VIL	0.2*VCC	Maximum input voltage to be reliable read as low
Status during bootloading	Tri-state	

15 Timers

Parameter	*Value*	*Description*
Resolution	7 ms	User can set a timer with 1 ms resolution, but actual resolution the time the event is handled is 7 ms.
Max length	2^32 ms = ~49 days	
Timer types	One-shot Periodic	

16 Current consumption

Current consumption on the module will depend on which role it has in the network and what function it is setup to perform.

Role	*Typical default current consumption*		
	Single channel CSMA	TSCH / Frequency hopping	Sleeping mesh TSCH
Border router	9 mA	6 mA	6 mA
Mesh Router	9 mA	0.9 mA	0.19 mA[1]
Sleeping leaf node	4.7 µA		

These number include the network maintenance functions, but actual current consumption depends on the application running on the node. See the RIIM User Manual for detailed examples on how to estimate current consumption.

17 Timing, Latency and Throughput

See the RIIM User Manual for details and examples on how to calculate these for real world applications.

Parameter	*Value*		*Description*
	Single channel CSMA	TSCH /Frequency hopping	
On-air time	160 µs / Byte	160 µs / Byte	Time for transmitting 1 byte at 50 kbps
Neighbor acknowledgement	< 1 ms	< 1 ms	
Routing processing time per hop	Typ. 45 ms	Average 425 ms[2]	
Node response time	Typ. 40 ms	Average 420 ms	

As with all radio these are not 100% predictable. For instance, the radio includes listen-before-talk to increase robustness and reduce interference. Also packet loss and the automatic retransmission will cause an extra delay.

[1] For TSCH this number changes with how the stack is setup. This number is based on a slot for sending data is available every 680 ms and a timeslot for sending broadcast messages is available every 920ms.
By using longer time interval, the current consumption can go down, but latency will go up and max throughput will be reduced.

[2] See RIIM User Manual for details on how routing delay can be calculated for TSCH

18 RF channels

The RF channels in are configured through the ICI application and follow IEEE802.15.4g standard for MR-FSK operating mode #1.
The channels in the 863-870 MHz are given below

Table 1 Channels in 863-870 MHz band

Channel	*Center frequency [MHz]*
0	863.125
1	863.325
2	863.525
3	863.725
4	863.925
5	864.125
6	864.325
7	864.525
8	864.725
9	864.925
10	865.125
11	865.325
12	865.525
13	865.725
14	865.925
15	866.125
16	866.325
17	866.525
18	866.725
19	866.925
20	867.125
21	867.325
22	867.525
23	867.725
24	867.925
25	868.125
26	868.325
27	868.525
28	868.725
29	868.925
30	869.125
31	869.325
32	869.525
33	869.725

For the 902-928 MHz frequency band IEEE 802.15.4g defines 129 channel 902.2 + 0.2*N MHz

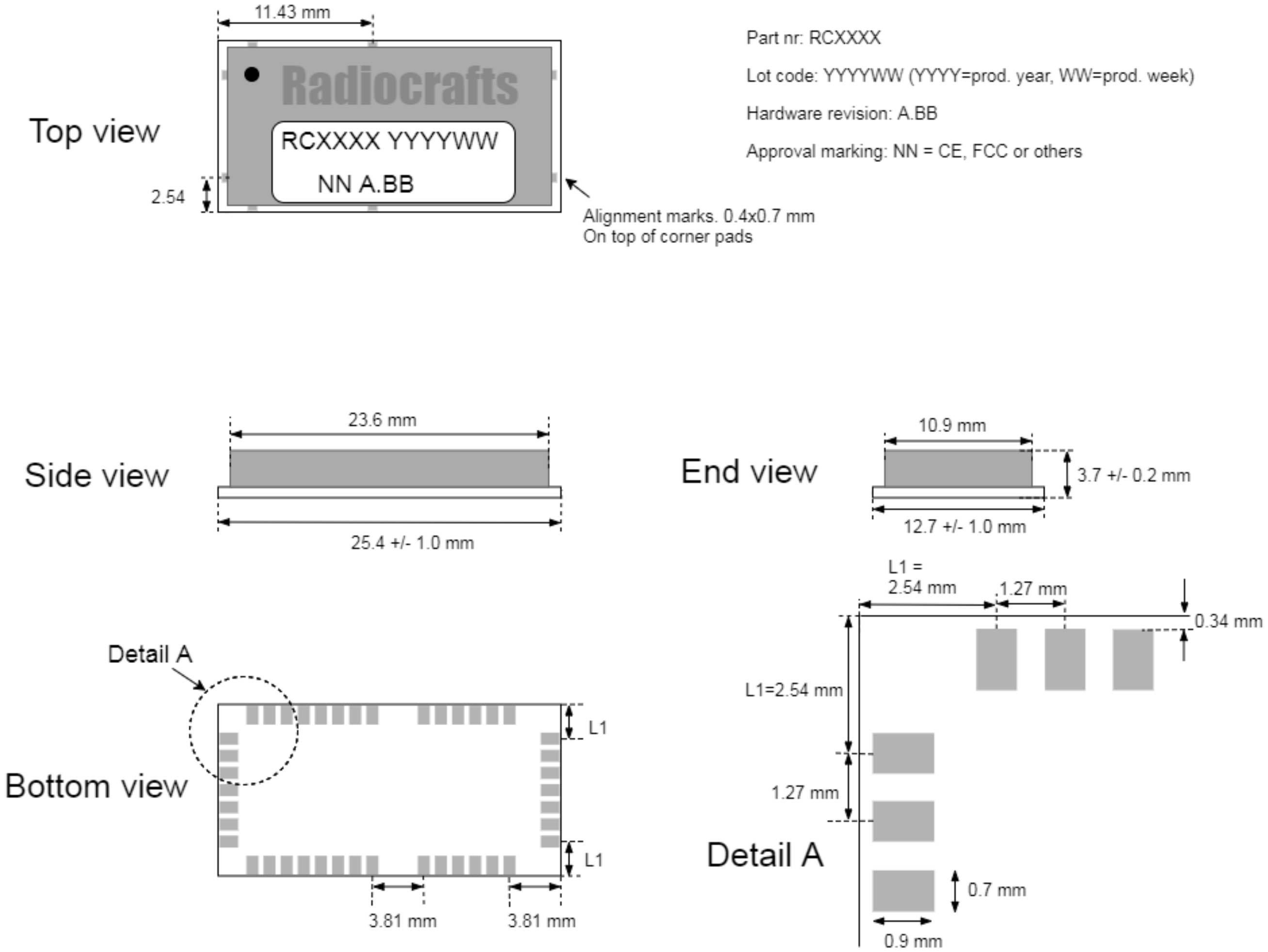
When used as frequency hopping radio the 868 MHz band it utilizes 16 channels. (These are shaded grey in Table 1)

For frequency hopping (TSCH) radio in 915 MHz band, 50 channels are used in order to comply to FCC.
These are 904.2 MHz -914.0 MHz with 200 kHz raster.

19 Regulatory Compliance Information

The use of RF frequencies and maximum allowed transmitted RF power is limited by national regulations. The RC1882 have been designed to comply with regulations (RED directive 2014/53/EU in Europe). Final approval needs to be done with the end product embedded firmware. RC1882 is also design to be complienet to FCC §15.247 with frequency hopping on 50 channels.

20 Mechanical Drawing



21 Mechanical Dimensions

The module size is 12.7 x 25.4 x 3.7 mm.

22 Carrier Tape and Reel Specification

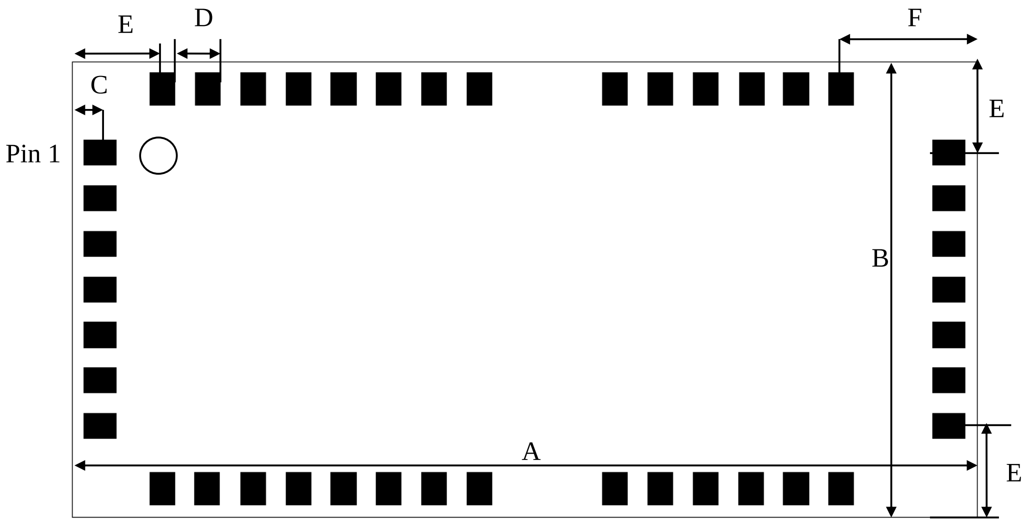
Carrier tape and reel is in accordance with EIA Specification 481.

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

23 PCB Layout Recommendations

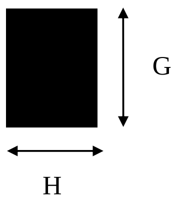
The recommended layout pads for the module are shown in the figure below.

The circle in upper left corner is an orientation mark only, and should not be a part of the copper pattern.



Dimention	*Length [mm] (mil)*	*Comment*
A	25.4 (1000)	Length of module
B	12.7 (500)	Width of module
C	0.79 (31)	Module edge vs centre of pad (Valid for all pads)
D	1.27 (50)	Pad to pad distance
E	2.54 (100)	Modul edge to pad (centre)
F	3.81 (150)	Modul edge to pad (centre)
G	0.9 (35.4)	Length of pad/recommend footprint pad
H	0.7 (27.6)	Width of pad/recommend footprint pad

Recommended pad design is shown below.



The recommended footprint for solder soldering is a one-to-one mapping between the LGA pad on module and the footprint.

For prototype build a solder hot plate is recommended. If the prototype is soldered manually by soldering iron, it is recommend to extend the pads of the footprint out from the module to make is accessible for a soldering iron.

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.

Routing or vias under the module is not recommended as per IPC-recommendation. 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 electrically (no connection).

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

24 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. Nominal stencil thickness of 0.1-0.12 mm recommended.

25 Absolute Maximum Ratings

Parameter	*Min*	*Max*	*Unit*
Supply voltage, VCC	-0.3	4.1	V
Voltage on any pin	-0.3	VCC + 0.3 (max 4.1)	V
Input RF level		10	dBm
Storage temperature	-40	150	°C
Operating temperature	-30	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.

26 Electrical Specifications

T=25°C, VCC = 3.3V, 868 MHz, 50 ohm if nothing else stated.

Parameter	*Min*	*Typ.*	*Max*	*Unit*	*Condition / Note*
Operating frequency	863		928	MHz	
Input/output impedance		50		Ohm	
Data rate		50		kbit/s	
Frequency stability			+/- 10 +/-15 +20/-26	ppm ppm ppm	Initially Temperature drift -30°-85° Temperature drift -40°-85° Other stability option available on request
Transmit power	-10		14	dBm	Programmable from firmware
Harmonics 2nd harmonic 3rd harmonic		 -44 -43		 dBm dBm	@ max output power
Spurious emission, TX, 868 MHz 30 – 1000 MHz 30 – 1000 MHz 1-12.75 GHz			 -54 -36 -30	 dBm dBm dBm	 EN 300 220 restricted band EN 300 220 un-restricted band
Sensitivity		- 110		dBm	BER = 1%, 50 kbps 2 FSK, IEEE 802.15.4g mandatory settings
Saturation		10		dBm	
Spurious emission, RX 1-12.75 GHz		 -59		 dBm	Complies with EN 300 220 CRF47 Part 15 and ARIB STD-T66
Supply voltage Recommended operating voltage	 1.8		 3.8	 V	
Current consumption, RX		6.0		mA	VCC = 3.6V
Current consumption, TX		25 18		mA	Output power 14 dBm, VCC = 3.6V Output power 12 dBm.
Current consumption, Deep Sleep Active Sleep		 1.05 4.7		 uA uA	Leaf nodes only Node maintaing network connection
RAM memory *RAM available for ICI application*		88 8		kB kB	
SoC internal Flash memory *Flash available for ICI application*		352 32		kB kB	
SPI Flash memory		1024		kB	Optional
I2C EEPROM		4		kB	Optional
MCU clock frequency		48		MHz	
MCU low frequency crystal		32.768		kHz	Optional
Antenna VSWR		<2:1	3:1		

27 Ordering number

Ordering number	*Definition*
RC1882CEF-IPM *	Standard product Includes -C 32 kHz RTC crystal -E 2 kBI2C EEPROM -F 1024 kB SPI flash for OTA

*other variant available for turn-key projects

28 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.**
	Not recommended for new designs	Last time buy available	Product close to end of lifetime
	Obsolete	Not in Production Optionally accepting order with Minimum Order Quantity	This data sheet contains specifications on a product that has been discontinued by Radiocrafts. The data sheet is printed for reference information only.

Document Revision History

Document Revision	Changes
1.00	Preliminary Information
1.20	Updated example, added PA control
1.30	Added more info on frequencies and active sleep current. Aligned some terms with other document for clarity.
1.40	Added timing, update current consumptions. Corrected figure showing pin logical names. ISC_SDA and I2C_SCL was wrong in figure but correct in table. Now it is correct in both. Added info on TCSH frequency hopping
1.41	Corrected pin assignment figure offsets

Disclaimer

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Radiocrafts Webpage

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There you can find Knowledge base and Document Library that includes Application notes, Whitepapers, Declaration of Conformity, User Manuals, Data Sheet and more.

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