1 Product Description

The RC18x2HP-IPM is a series of high power 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 RC18x2HP-IPM is used to implement all the nodes in the network including leaf nodes, wireless router nodes and root-node/border routers.

The module incudes ICI, the intelligent C-programmable I/O, along with all neccesary drivers and the operating system. ICI allows the user to program his own intelligent sensor/actuator inteface, or any other applciation 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 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 I/O (ICI) easy to use C-based SDK to directly inteface 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
- Frequency hopping via TSCH (6TiSCH) (Availeble for RIIM-SDK 1.20.0 and later)
- Automatic acknowledge and retransmission

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

Parameter	RC1882HPCF-IPM	RC1892HPCF-IPM	Unit
Frequency band	865-870	902-928	MHz
Max output power	27[1]	27	dBm
Sensitivity (BER 1%) @50kb/s	-111	-111	dBm
Supply voltage	2.3 - 3.6	2.3 - 3.6	V
Current consumption, RX/TX	12.5 / 350	12.5 / 350	mA
Current consumption, Shutdown	2	2	uA
User application flash memory	32	32	kB
User application RAM	8	8	kB
Internal SPI Flash	1024	1024	kB
Operating Temperature	-30 to +85	-30 to +85	°C

[1] HW revision 1.00 is limited to 26 dBm, later revisions are 27 dBm.

5 RIIM overview

The RIIM network consists of these key elements

- The RIIM SDK
  - Software development kit with application frameworks and tools for creating and uploading end applications to the RC18x2HP-IPM
- The IPM module
  - The IPM module can be configured as root, router or leaf node.
    - As a root node it acts as the base of the mesh network. It can connect to an external network via ethernet or custom user application on other interfaces such as UART
    - As a router node, it will be able to transport packets in the RIIM mesh network
    - As a leaf node, it is not able to transport packets to other nodes except its parent. This mode uses the least amount of energy.
  - All modes supports customer ICI applications and external connections. Applications use the same RIIM Software Development Kit (SDK) for all node types.

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

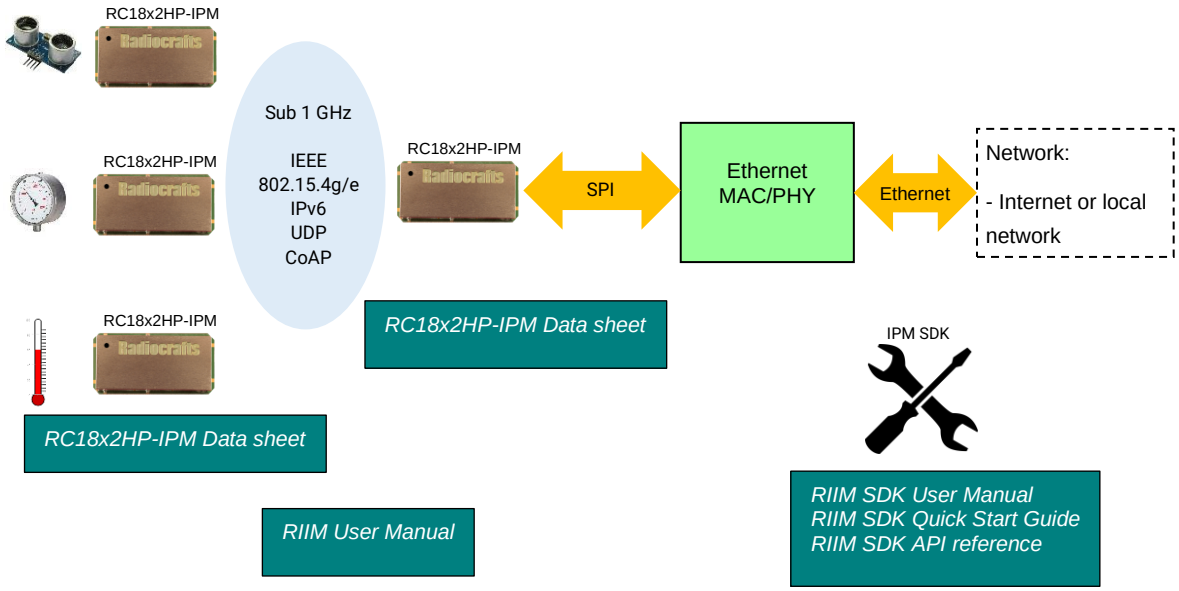


Figure 1. RIIM network – system and documentation overview

6 Firmware structure

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

- The bootloader
- The platform image
- Application image

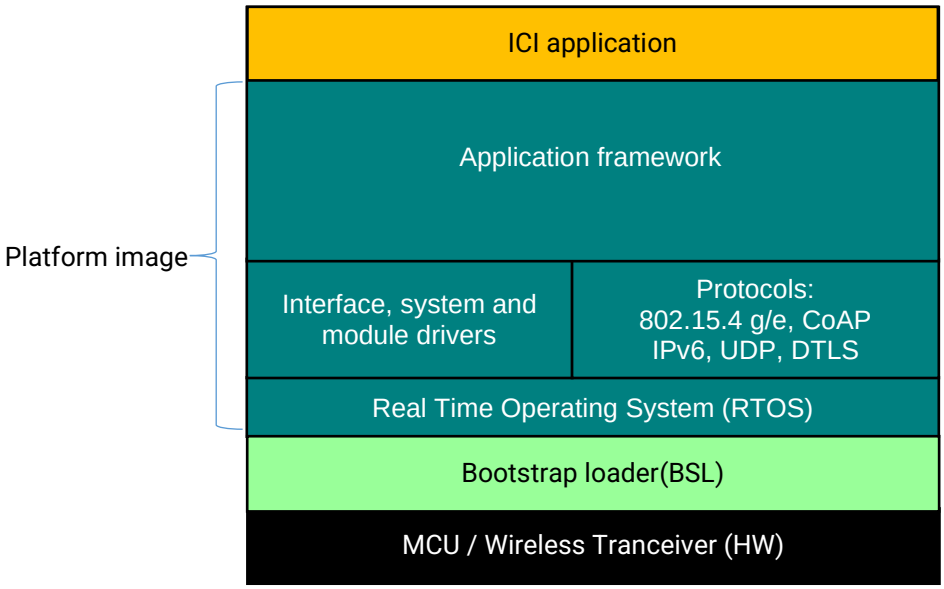


Figure 2. System overview

The bootloader is preloaded from Radiocrafts. It allows the user to upload new platform images or unique application images. The bootloader also allows the 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 operates 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 the operating system, network stacks, drivers and application frameworks. The newest revision will be available from Radiocrafts SDK download 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)

RC18x2HP-IPM allows each user to write his own application with minimal time and effort. This is accomplished through an SDK, which consists of 3 key blocks

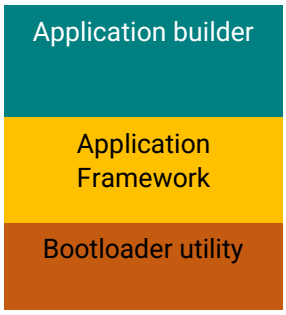


Figure 3. Software Development Kit

The application framework acts as the skeletal support to build an application. It abstracts the resources such that the developer does not need to dive into all the details of the processor, network stack or operating system. This consept is referred to as Intelligent C-programmable I/O (ICI).

The application framework comes with a ready-made base application that the user can tailor to his needs. The tailoring is accomplished through defining events and writing the event handlers. The base application reduces the workload on the user and reduces test and validation time for each new application.

For the developer the main interaction with the application framework is through an intuitive API, describing how the user can interface with the radio/network and high level drivers.
See the document *RIIM SDK User Manual* and *RIIM API Reference* for details.

In each event handler, the user can send and receive data through the different interfaces, access memory, invoke network function or even do complex data algorithms and data processing.

Application builder is a set of free tools to generate the application image based on user's application code.

Bootloader utlity is a free tool that allows secure uploading of application images to the module. It also allows writing of encryption keys in the module during production.

More details on the application builder and the bootloader utility is given in *RIIM SDK User Manual.*

8 Intelligent C-programmable I/O (ICI)

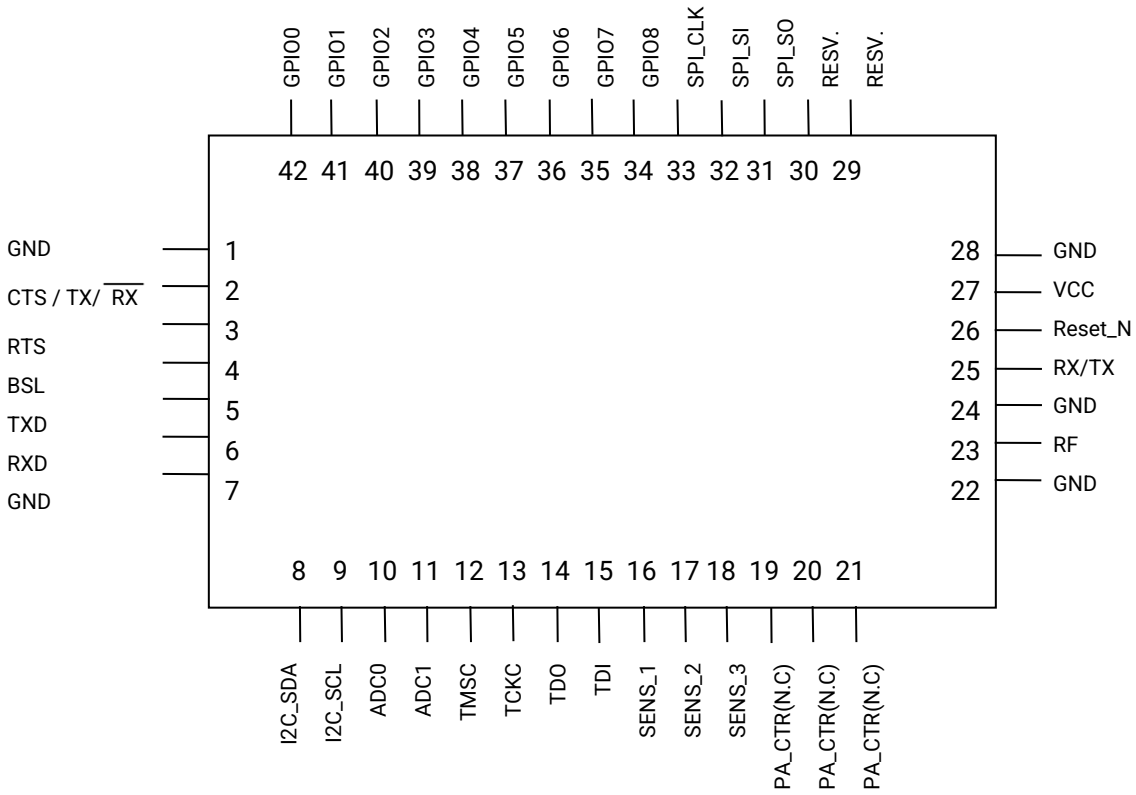
The ICI application is written in high-level C-language, using a powerful API that is available in the SDK. The API removes the need for the developer to understand the underlying architecture and resources in the module.
In its simplest form, the ICI application is just configuring the radio network, 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.
The ICI application also has 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 / TX/ $\overline{RX}$	UART flow control ;TX/ $\overline{RX}$ for RS485 direction
3	RTS	UART flow control
4	BSL	Enable boot strap loader (Keep low during reset/power up to force modul into bootloader mode)
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	ADC0	Analog input
11	ADC1	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_CTR	Internally used signal to control PA. Do not connect.
20	PA_CTR	Internally used signal to control PA. Do not connect.
21	PA_CTR	Internally used signal to control PA. Do not connect.
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	By scaling down input. Input must follow Absolute Maximum Ratings.
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	MUST BE ADDED EXTERNALLY
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	millisecond 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 (@3.6V)*		
	Single channel CSMA	TSCH / Frequency hopping (*TSCH_HIGH_THROUGHPUT_SENSOR_DATA setting*)	Sleeping mesh TSCH (*TSCH_LOW_POWER setting*)
Border router	12.5 mA	12.5 mA	12.5 mA
Mesh Router	12.5 mA	1.4 mA	0.22 mA
Sleeping leaf node	25 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 Regulatory Compliance Information

The use of RF frequencies and maximum allowed transmitted RF power is limited by national regulations.

The RC1882HP has been have been designed to comply with regulations (RED directive 2014/53/EU in Europe) and GSR 564 in India.

The RC1892HP has been designed to comply to FCC/IC requirement for US/Canada and ACMA requirement in Australia

18 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.

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

19 Wake-on timing/response time

For a device sleeping(leaf node in Single channel or mesh router in TSCH), they can be woken by external interrupt on GPIO or UART. The wake up is defined as the time from an event (e.g. negative flank on a pin) to the event handler runs in the operating system. If a device is already awake, this is called a response time.

Parameter	*Mode*		
	Single channel CSMA (Sleeping)	TSCH /Frequency hopping	Single channel CSMA (Awake)
Wake on time	160 µs (typ)	250 µs (typ)	90 us (typ response time)

20 RF channels

The RF channels in are configured through the ICI application and follow IEEE802.15.4g standard for MR-FSK operating mode #1.
For RC1882HPCF if channel 32 shall be used as is allows for up to 27 dBm output power.
The channel numbering for 863-870 MHz band is given below. For all other channels than channel 32, output power must be adjusted down for compliance to RED directive in Europe.

Channels 10-18 can be used in India for the 865-867 MHz license free band.

Table 1 Channels in 863-870 MHz band

Channel	*Center frequency [MHz]*	
0	863.125	Channels 0-9 can be set in FW but performance is not characterized below 865 MHz
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**	**India WPC**
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	

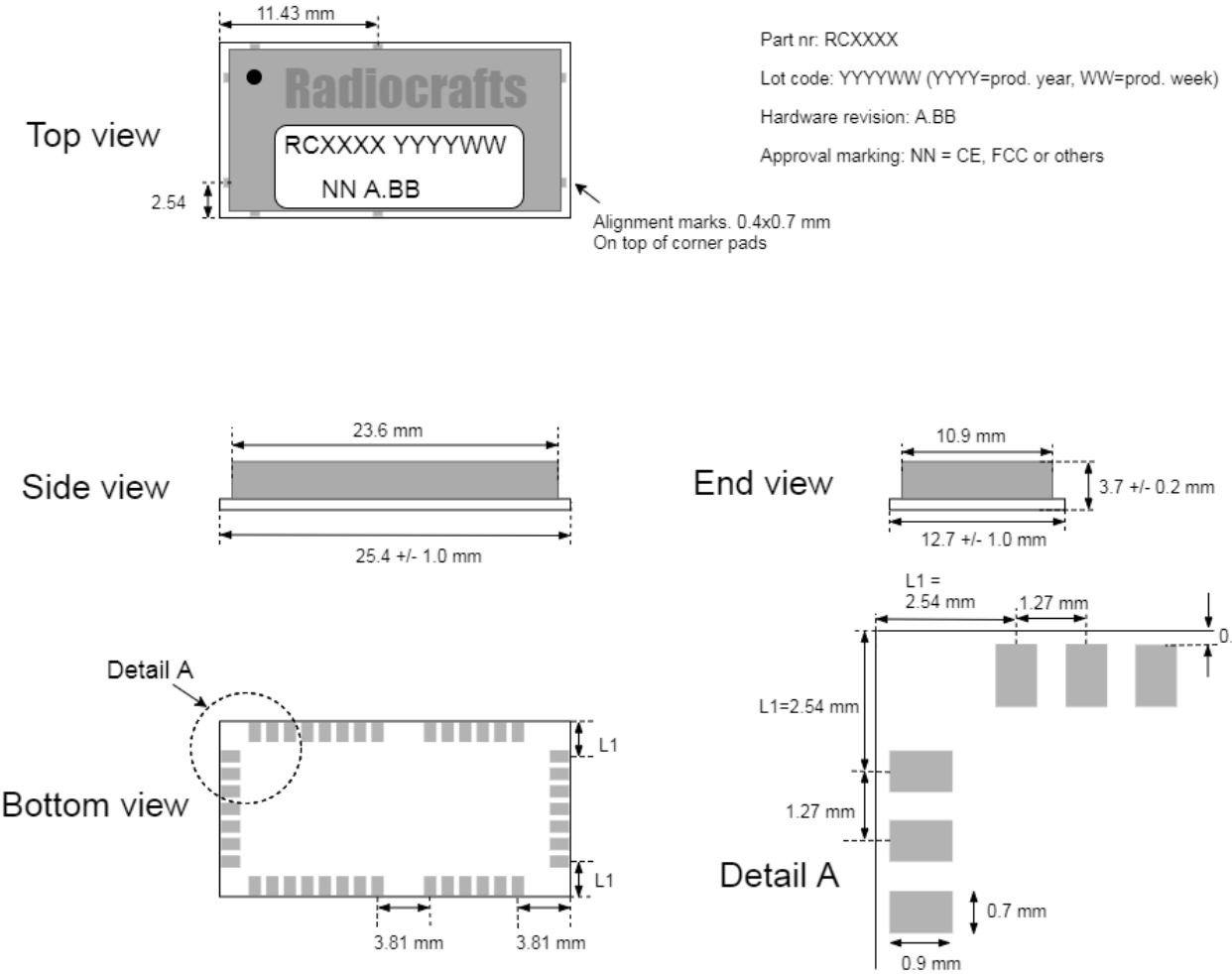
23	867.725	
24	867.925	
25	868.125	
26	868.325	
27	868.525	
28	868.725	
29	868.925	
30	869.125	
31	869.325	
32	**869.525**	**EU/REC**
33	869.725	

RC1892HP for frequency hopping (TSCH) radio in 915 MHz band, 50 channels are used to comply to FCC. These are 903.0-913.8 MHz (28 channels with 400kHz channel spacing) and 914.4-927 MHz (22 channels with 600 kHz spacing). All channels are used the equally over time. This ensures compatibility vs FCC.

The module can also be set to operate in the AU/NZ band from 915 -928 MHz. This is done by frequency hopping on 919.4 – 927.0 MHz (20 channels with 400 kHz spacing). This is according to requirements in AS/NZS 4268-2012.

The module can operate in frequency hopping mode for Vietnam at 918.8-921.8 MHz (*RF_BAND_920_VNM*). This mode includes 16 hopping channels and conforms to Circular 46/2016/TT-BTTTT.

21 Mechanical Drawing



22 Mechanical Dimensions

The module size is 12.7 x 25.4 x 3.7 mm.

23 Carrier Tape and Reel Specification

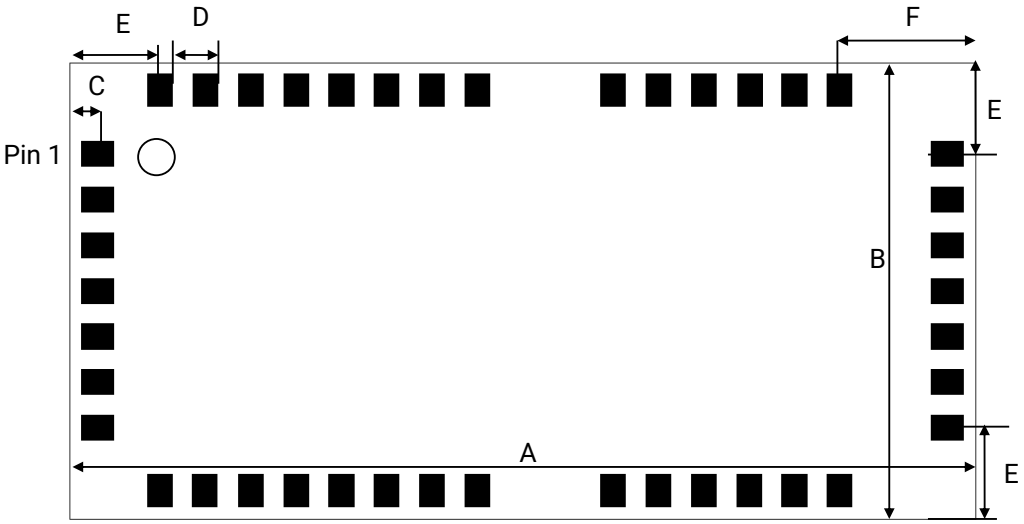
Carrier tape and reel is in accordance with EIA Specification 481.

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

24 PCB Layout Recommendations

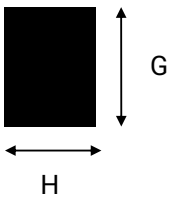
The recommended layout pads for the module are shown in the figure below.

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.

25 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.

26 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.

27 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	865		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		27	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		- 111		dBm	BER = 1%, 50 kbps 2 FSK, IEEE 802.15.4g mandatory settings
Saturation		0		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	 2.3		 3.6	 V	
Current consumption, RX		12.5		mA	VCC = 3.6V
Current consumption, TX		350		mA	Output power 27 dBm, VCC = 3.6V
Current consumption, Deep Sleep Active sleep		 1.1 25		 uA uA	Leaf nodes only Node maintaing network connection. 27 dBm output power
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	
MCU clock frequency		48		MHz	
MCU low frequency crystal		32.768		kHz	Optional

Parameter	Min	Typ.	Max	Unit	Condition / Note
Antenna VSWR		<2:1	3:1		

28 Ordering number

Ordering number	Definition	
RC1882HPCF-IPM	865-870 MHz, EU/India variant	Standard product Includes -C 32 kHz RTC crystal -F 1024 kB SPI flash for OTA
RC1892HPCF-IPM	902.928 MHz, US/CAN/AU variant	

*other variant available for turn-key projects

29 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.

30 Document changes

Revision	Info
1.00	Initial release
1.01	Product status changed to No Identificaiton Noted Added info on the channels for India
1.1	Updateed info on channels for US/FCC and Australia/New Zealand
1.2	Updated with new current consumption based on SDK 3.0.0. Updated with wake-on timing
1.2.1	Corrected an error in data sheet regarding pull up resistors. Pull up resistors on I2C bus must be added externally.
1.3	Renaming ADC pin to match SDK documentation

Disclaimer

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Radiocrafts Webpage

For more info go to our web page : https://radiocrafts.com/
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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