Product Description

The RC1880-SPR is a sub-1 GHz programmable ultra-low power module for RIIoT™ (Radiocrafts Industrial Internet of Things). It is based on the open standard IEEE802.15.4 g/e. The RC1880-SPR can be used stand-alone as a programmable node module in a low power sensor/actuator network with 802.15.4 g/e compatibility, or as part of the RIIoT (Radiocrafts Industrial IoT) network.

The module is pre-programmed with an operating system, a network stack, all low and high level drivers and an application framework. This allows the user to program his own "app" (application) on top of the existing firmware with minimal effort. The programming capability of the module removes the need for additional MCU, and therefore reduces overall cost and power consumption.

The complete RIIOT Network also includes the RC1880-GPR for secure and reliable concentrator access and the RIIOT Net Controller to manage the RF network and to provide a simple interface for Cloud applications

Applications

- Energy harvesting sensor application
- Coin cell battery systems
- IIOT applications
- Smart Sensor Technologies
- Energy Management and Sustainability
- Green House Monitoring
- Elderly Care
- Fire Detection
- Home Security
- 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

Features

- 9 programmable GPIO
- I2C bus
- Up to 9 different SPI busses
- UART
- 2 ADC inputs
- Unique SDK for quick development and deployment
- Ultra-low power for coin cell battery or energy harvesting
- Based on open standards IEEE 802.15.4 g/e
- Frequency hopping option
- AES128 network/MAC and application security
- Reliable communication, Automatic acknowledge and retransmission
- Broadcast support
- 8 km Line-of-sight range in 5 kb/s mode
- OTA support
- CBOR data encoding

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

Parameter	RC1880-SPR	Unit
Frequency band	862-930	MHz
Max output power	14	dBm
Sensitivity (BER 1%) @50kb/s	-110	dBm
Supply voltage	1.8 - 3.8	V
Current consumption, RX/TX	6.2 / 26.5	mA
Current consumption, Shutdown	185	nA
Flash memory	128	kB
RAM	20	kB
Internal EEPROM (optional)	4	kB
Internal SPI Flash(optional)	256	kB
Operating Temperature	-40 to +85	°C

Ordering number

Ordering number	*Definition*
RC1880CEF-SPR *	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

RIIoT network

The RIIoT network consists of some key elements

- The RC1880-SPR module
  - The module that can be programmed with user application through the RIIoT SPR Software Development Kit (SDK)
- The RIIoT SPR SDK
  - Software development kit with Application framework and tool for building and uploading end application to the RC1880-SPR module
- The RC1880-GPR module for use in the gateway/concentrator
  - Support the concentrator of the gateway. Normally connected to a Linux gateway, but can also be controlled by MCU through a UART protocol
- The RIIoT Net Controller Linux middleware
  - A middleware SW that can be used on a Linux gateway. Interfaces the RC1880-GPR module and supply user application a socket interface for controlling and sending/receiving data through the wireless network.

Below is an illustartion of the different element and the docuemention availeble

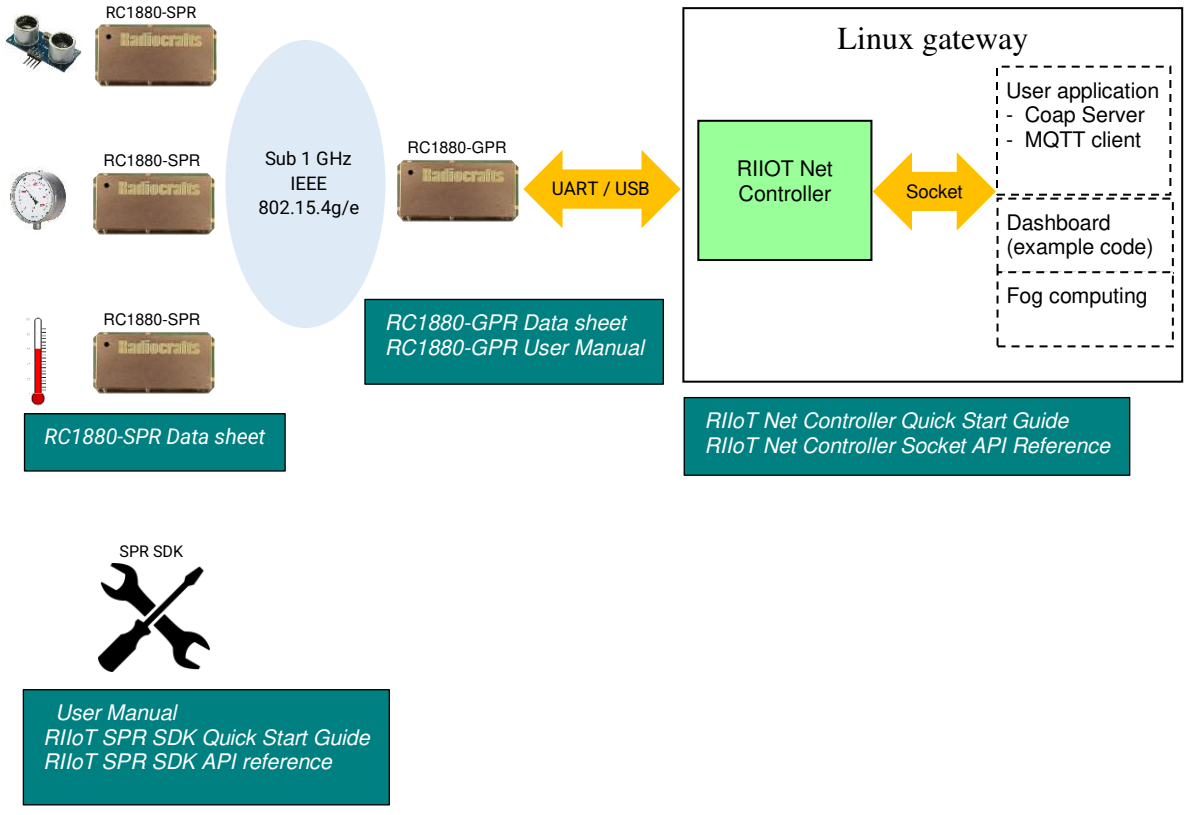


Figure 1. RIIoT network – system and documentation overview

Firmware structure

The SPR module program memory is divided in 3 different segments.

- The bootloader
- The platform image
- Application code space

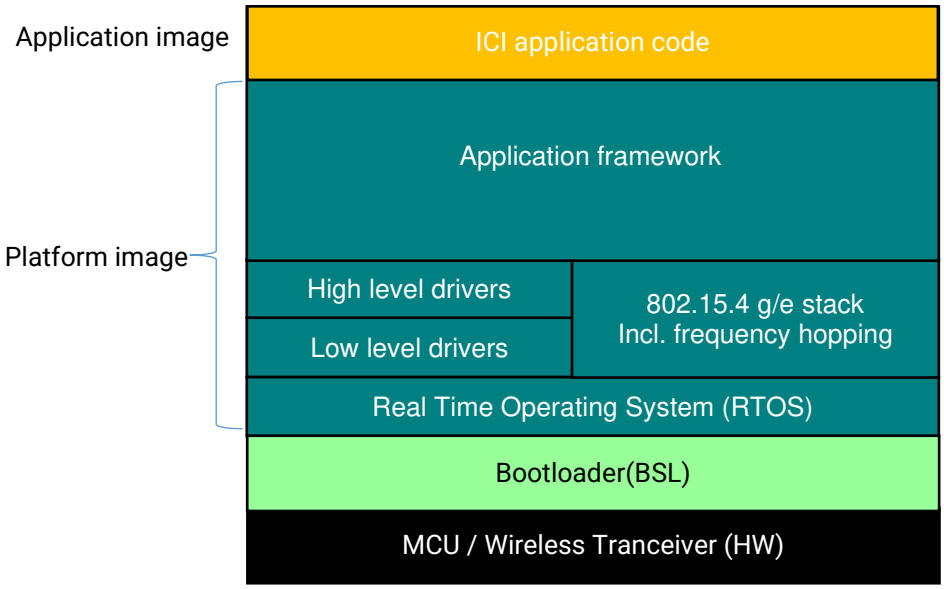


Figure 2. System overview

The bootloader is preloaded from Radiocrafts. It allows user to upload new platform image or unique application image generated by each 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.

The platform image is the main firmware part and includes operating system, IEEE 802.15.4g/e stack, 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 module.

The application code space has available 4 kB of flash space and 500 bytes of static variables.

Different platform images

The platform image is available in different variant in the SDK, and offers different features to the user.

- 50 kb/s, single channel or frequency hopping. (default on modules from factory)
- 5 kb/s single channel
- 5 kb/s frequency hopping

The platform image is also revision controlled, so for newest revision please always check with latest SDK on Radiocrafts webpage.

Software Development Kit (SDK)

RC1880-SPR allows each user to write his own application with minimal time and effort. This is accomplished through a SDK, which consists of 3 key blocks

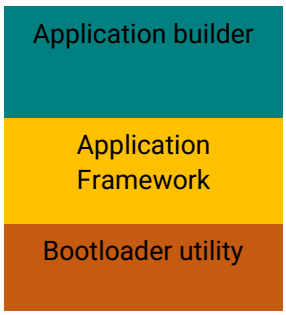


Figure 3. Software Development Kit

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 (i:zi)

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 *RIIoT SPR SDK User Manual* and *RIIoT SPR SDK API Reference* for details.

In each event handler, user can send and receive data though serial ports, read/write GPIOs, access memory, invoke network function or even do complex data algorithm 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 allow 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 *RIIoT SPR SDK User Manual*.

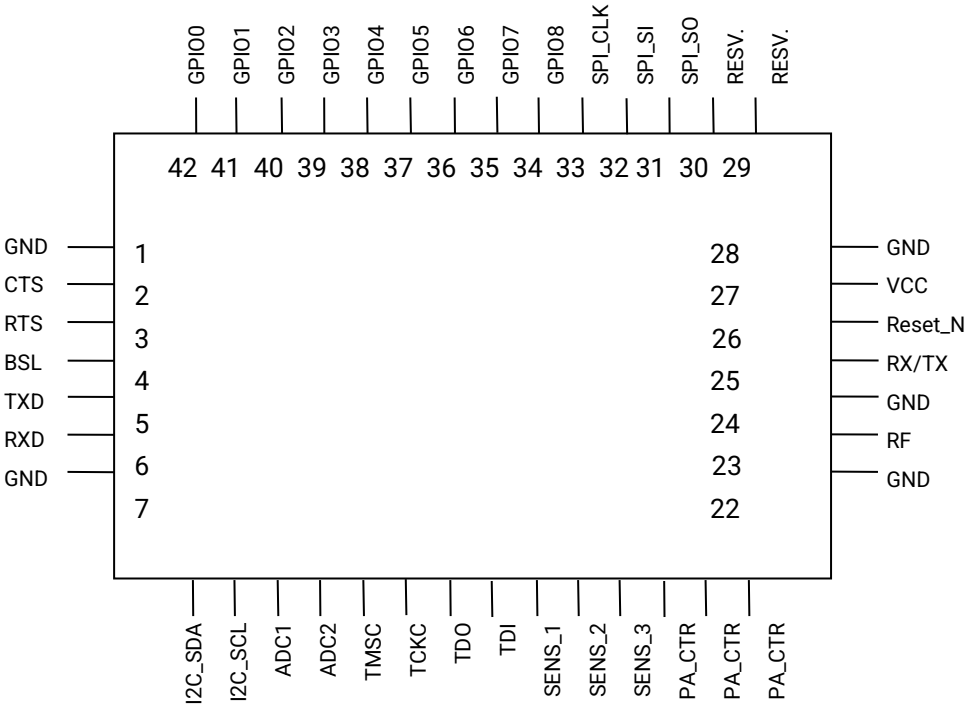
Intelligent C-programmable I/O (i:zi)

The i:zi programming concept is described in detail in SPR SDK documentation. Below is shown an example application that read a temperature sensor every 10 seconds and send data to the concentrator. This is a very small example with only 39 code lines.

Example : i:zi code

```
#include "spr_app.h"

/********* Constants ***********/
#define SHT35_I2C_ADDRESS 0x44
#define SENSOR_ID_SHT35 0x01

/********* Private Variables ***************/
static TimerId readSensorTimer;
static uint16_t temperature;
static uint16_t humidity;
static uint8_t temperature_l,temperature_h, humidity_l, humidity_h;

/********* Private Function Declarations ***************/
static void readSensor(void);

/********* Public Functions ***************/

/**
* Setup() is called by the framework on startup
*/
void Setup()
{
    Network.setFreqBand(FREQ_868_MHZ);
    Network.setDataRate(DATA_RATE_50_KBPS);
    uint8_t channelMask[CHANNEL_BITMAP_SIZE] = {0x00,};
    channelMask[0] = 0x01; //just scan the first channel
    Network.setChannelMask(channelMask);
    Network.setAutoJoin(true);
    I2C.init(I2C_400KHZ);
    readSensorTimer = Timer.create(PERIODIC, 10*SECOND, readSensor);
    Timer.start(readSensorTimer);
}

/********* Private Functions ***************/
static void readSensor(void)
{
    uint8_t writeBuffer[2] = {0x2C, 0x06};
    uint8_t readBuffer[6];

    SPR_Status status = I2C.transfer(SHT35_I2C_ADDRESS, writeBuffer, sizeof(writeBuffer),readBuffer,
sizeof(readBuffer));
    if (SPR_OK == status)
    {
        // unpacks the data from the byte buffer into 16-bit integer variables
        uint16_t temperature_raw = Util.unpack_uint16_msb(readBuffer, 0);
        uint16_t humidity_raw = Util.unpack_uint16_msb(readBuffer, 3);

        temperature = (uint16_t)((uint32_t)temperature_raw*17500/0xFFFF - 4500);
        humidity = (uint16_t)((uint32_t)humidity_raw*10000/0xFFFF);
    }
    temperature_l=(uint8_t)(temperature&&0x00FF);
    temperature_h=(uint8_t)(temperature>>8);

    humidity_l=(uint8_t)(humidity&&0x00FF);
    humidity_h=(uint8_t)(humidity>>8);

    uint8_t message[] = {SENSOR_ID_SHT35, temperature_l, temperature_h,humidity_l, humidity_h);
    Network.send(sizeof(message), message);
}
```

Pin Assignment



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
9	I2C SCL	I2C SCL
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_CTR	Reserved for future use
20	PA_CTR	Reserved for future use
21	PA_CTR	Reserved for future use
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
35	GPIO_7	General purpose I/O pin
36	GPIO_6	General purpose I/O pin
37	GPIO_5	General purpose I/O pin
38	GPIO_4	General purpose I/O pin
39	GPIO_3	General purpose I/O pin
40	GPIO_2	General purpose I/O pin
41	GPIO_1	General purpose I/O pin
42	GPIO_0	General purpose I/O pin

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.

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, 200 ksamples/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	

SPI Parameters

Parameter	Value	Description
SPI clock rate max	12 MHz	
SPI clock rate min	100 kHz	Lowest rate verified.
SPI mode	Master	
Modes supported	0,1,2 and 3	
SPI chip select	SW chip select (GPIO 0-8)	
SPI delay	70 us	Delay from SPI transfer is called untill first clock edge

I2C Parameters

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

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

Timers

Parameter	*Value*	*Description*
Resolution	1 ms	
Max length	2^{32} ms ~50 days	millisecond days
Timer types	One-shot Periodic	

Timing

Parameter	*Value(typical)*	*Description*
Wake-up	210-340 us	Time from sleep to interrupt cauing wake can be handled
HW interrupt handling time	110 us	Time from HW interrupt(GPIO) to event handler starts.
Idle to sleep	880 us	Time from no events pending untill device is in sleep mode.

Channels

The RC1880-SPR follows the channel mapping of IEEE802.15.4g

Channel	Frequency [MHz]	Channel	Frequency [MHz]	Channel	Frequency [MHz]	Channel	Frequency MHz]
1	863.125	11	865.125	21	867.125	31	869.125
2	863.325	12	865.325	22	867.325	32	869.325
3	863.525	13	865.525	23	867.525	33	869.525
4	863.725	14	865.725	24	867.725	34	869.725
5	863.925	15	865.925	25	867.925		
6	864.125	16	866.125	26	868.125		
7	864.325	17	866.325	27	868.325		
8	864.525	18	866.525	28	868.525		
9	864.725	19	866.725	29	868.725		
10	864.925	20	866.925	30	868.925		

Figure 4. Channels for 868 MHz band

Channel	Frequency [MHz]	Channel	Frequency [MHz]	Channel	Frequency [MHz]	Channel	Frequency MHz]
1	902.2	34	908.8	67	915.4	100	922
2	902.4	35	909	68	915.6	101	922.2
3	902.6	36	909.2	69	915.8	102	922.4
4	902.8	37	909.4	70	916	103	922.6
5	903	38	909.6	71	916.2	104	922.8
6	903.2	39	909.8	72	916.4	105	923

7	903.4	40	910	73	916.6	106	923.2
8	903.6	41	910.2	74	916.8	107	923.4
9	903.8	42	910.4	75	917	108	923.6
10	904	43	910.6	76	917.2	109	923.8
11	904.2	44	910.8	77	917.4	110	924
12	904.4	45	911	78	917.6	111	924.2
13	904.6	46	911.2	79	917.8	112	924.4
14	904.8	47	911.4	80	918	113	924.6
15	905	48	911.6	81	918.2	114	924.8
16	905.2	49	911.8	82	918.4	115	925
17	905.4	50	912	83	918.6	116	925.2
18	905.6	51	912.2	84	918.8	117	925.4
19	905.8	52	912.4	85	919	118	925.6
20	906	53	912.6	86	919.2	119	925.8
21	906.2	54	912.8	87	919.4	120	926
22	906.4	55	913	88	919.6	121	926.2
23	906.6	56	913.2	89	919.8	122	926.4
24	906.8	57	913.4	90	920	123	926.6
25	907	58	913.6	91	920.2	124	926.8
26	907.2	59	913.8	92	920.4	125	927
27	907.4	60	914	93	920.6	126	927.2
28	907.6	61	914.2	94	920.8	127	927.4
29	907.8	62	914.4	95	921	128	927.6
30	908	63	914.6	96	921.2	129	927.8
31	908.2	64	914.8	97	921.4		
32	908.4	65	915	98	921.6		
33	908.6	66	915.2	99	921.8		

Figure 5. Channels for 915 MHz

Battery lifetime

The end node/leaf nodes in RIIoT based on RC1880-SPR are well suited for battery operation.

To calculate battery lifetime on a RC1880SPR product, please consider the following.

- Battery capacity
- Battery capacity reduction due
  - Self-leakage in battery
  - Environmental reduction. (battery id normally specified at 20 degree Celsius)
  - Pulse reduction. Capacity is specified at 1 mA constant current.

- Sleep current 1.7 uA
- Awake time doing data processing/sensor reading
- Time between transmission and number of bytes to transmit on RF
- Current during an RF transmission with acknowledge. Below in Figure 6 and Figure 7 the current consumption profiles for two different RF packets are shown at 50 kb/s data rate.

  Based on the capacity in (mAh) and the average usage, the expected battery lifetime can be found.

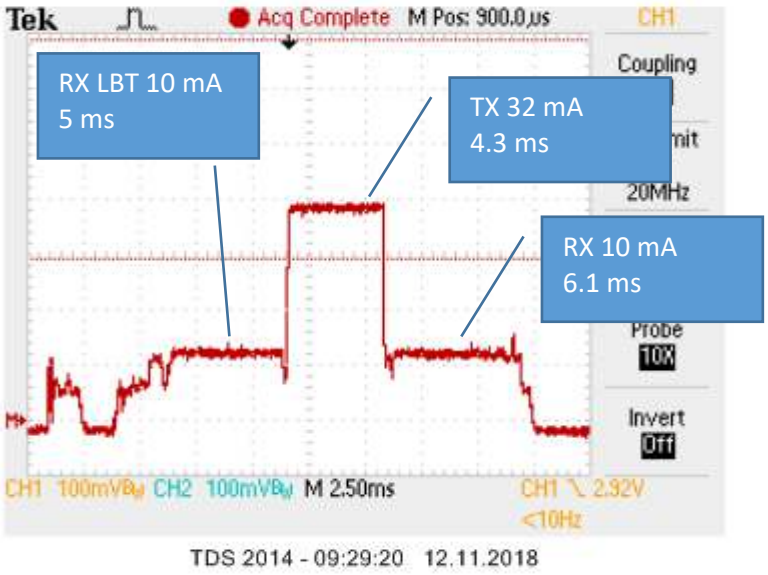


Figure 6. Current consumption for one data polling

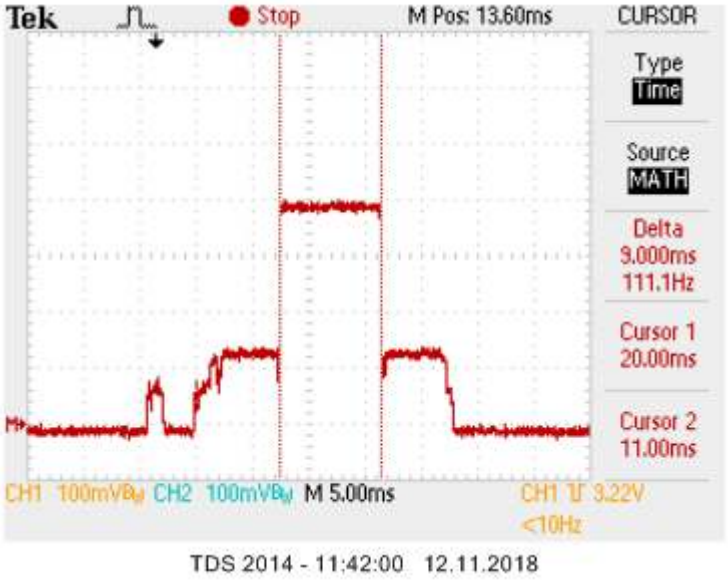
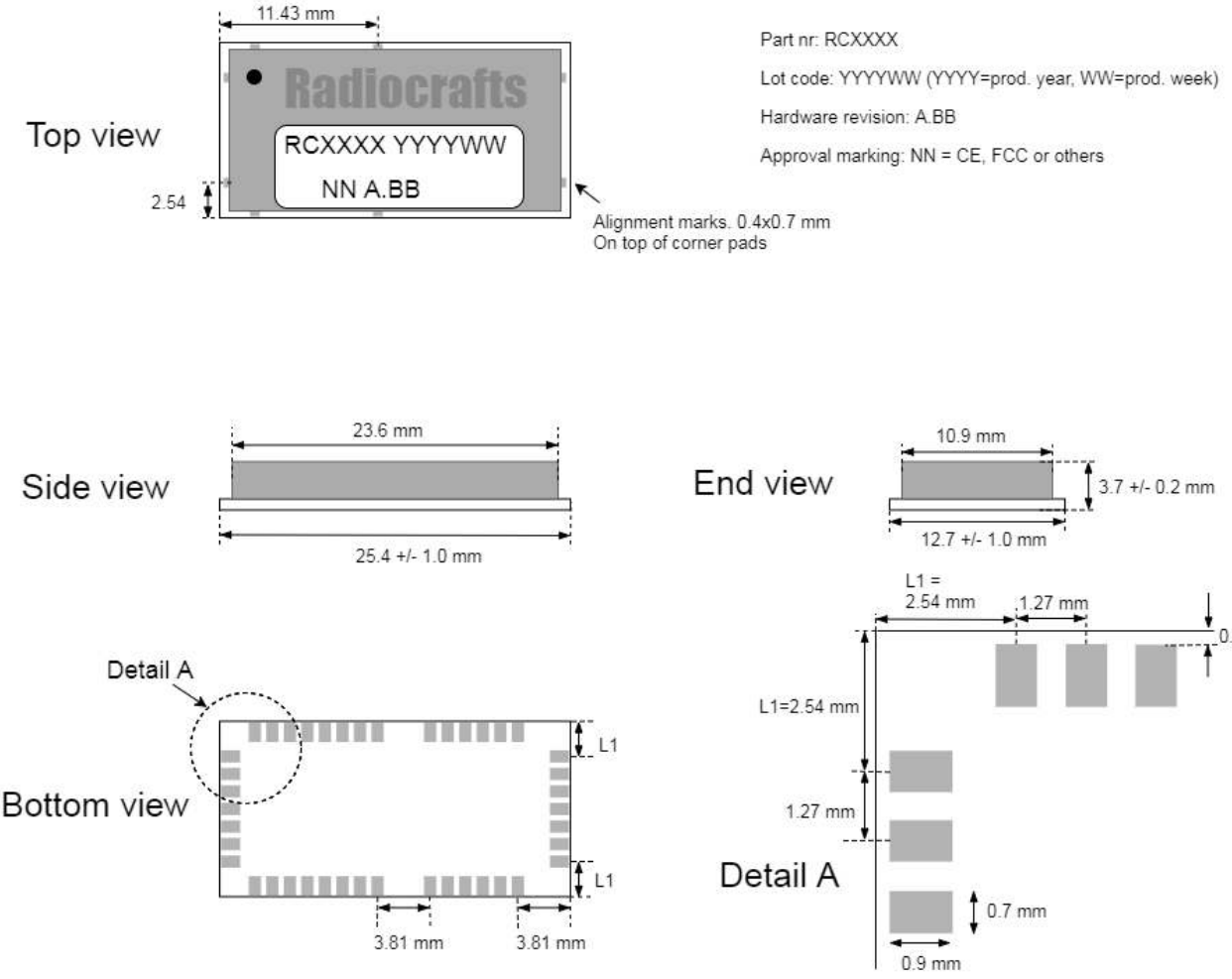


Figure 7. Current consumption tranmission of 30 application bytes bytes

Regulatory Compliance Information

The use of RF frequencies and maximum allowed transmitted RF power is limited by national regulations. The RC1880 have been designed to comply with world wide regulations (RED directive 2014/53/EU in Europe, ARIB for Japan, G.S.R. 542(E)/45(E) for India, and FCC for the US). Final approval needs to be done with the end product embedded firmware.

Mechanical Drawing



Mechanical Dimensions

The module size is 12.7 x 25.4 x 3.7 mm.

Carrier Tape and Reel Specification

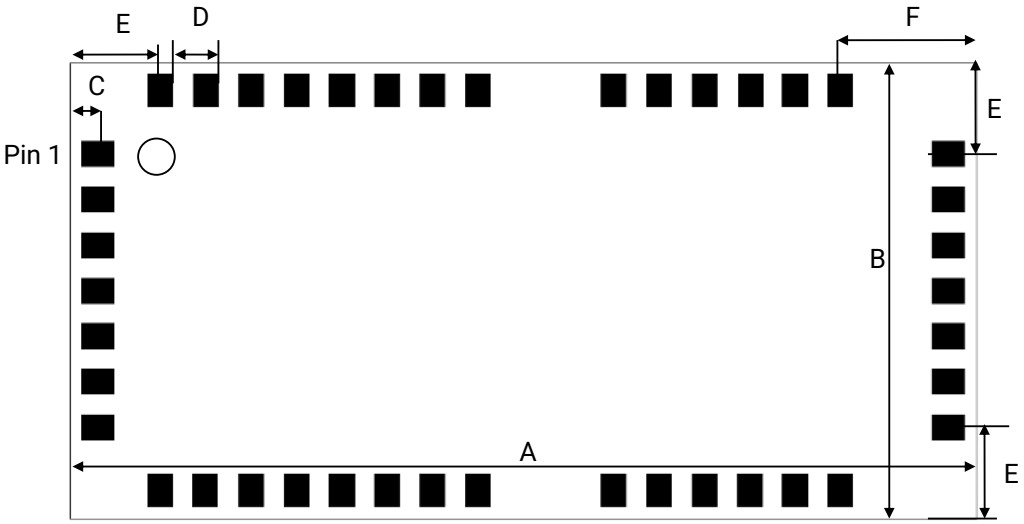
Carrier tape and reel is in accordance with EIA Specification 481.

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

PCB Layout Recommendations

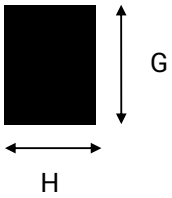
The recommended layout pads for the module are shown in the figure below.

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.

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.

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	-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.

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	862		930	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		 -52 -58			@ max output power
Spurious emission, TX, 868 MHz 30 – 1000 MHz 30 – 1000 MHz 1-12.75 GHz Spurious emission, TX, 915 MHz 30 – 88 MHz 88 – 960 MHz 960 – 2390 MHz 1-12.75 GHz		 < -66 < -65 < -55 < -43	 -59 -51 -37	 dBm dBm dBm	 EN 300 220 restricted band EN 300 220 un-restricted band Within FCC restricted band Within FCC restricted band Within FCC restricted band Outside FCC 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		 -70		 dBm	Complies with EN 300 320 CRF47 Part 15 and ARIB STD-T66
Supply voltage Recommended operating voltage	1.8		3.8	V	
Current consumption, RX		6.2		mA	VCC = 3.6V
Current consumption, TX		26.5 19		mA	Output power 14 dBm, VCC = 3.6V Output power 12 dBm.
Current consumption, Sleep, RTC based on Crystal		 1.7		 uA	 0.7 Radio, 1.0 in FOTA flash

Parameter	Min	Typ.	Max	Unit	Condition / Note
RAM memory		20		kB	
SoC internal Flash memory		128		kB	
SPI Flash memory		256		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		

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.

Changes

1.00	2018-11-01	First release
1.10	2018-12-17	Editorial changes in figure 2. Updated with battery lifetime calculation
1.20	2019-03-19	Added channel number and also added info on default and optional platform codes
		Added ordering number details

Disclaimer

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

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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.

Radiocrafts Technical Support

Knowledge base:	https://radiocrafts.com/knowledge-base/
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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