Radiocrafts
Embedded Wireless Solutions

# RC2201HP

## ZigBee®- Ready RF Transceiver Module with Power Amplifier

### Product Description

The RC2201HP/-AT RF Transceiver Modules are a series of compact surface-mounted modules specially designed for wireless star and mesh networks based on IEEE 802.15.4 compliant PHY layer providing 16 channels in the 2.45 GHz world-wide license-free ISM band. An internal power amplifier extends the range compared to other modules. The complete shielded module is only 16.5 x 35.6 x 3.5 mm including an internal chip antenna. The module is also available without the internal antenna and with RF connection on a pin to allow for external antenna. It provides 128 kB flash memory, 32 digital and analogue I/Os including an 8 channel 10 bit ADC, UART and SPI interfaces, making it possible to embed the complete application in this tiny module.

### Applications

- Home control and industrial automation
- Building automation
- OEM equipment
- Fleet and inventory management


### Features

- IEEE 802.15.4 compliant PHY
- 16.5 x 35.6 x 3.5 mm compact shielded module for SMD mounting
- 128 kB Flash memory, 8 kB SRAM, 4 kB EEPROM
- 32 digital and analogue I/Os, 8 channel 10 bit ADC
- UART, SPI and JTAG interfaces
- On-board 32.768 kHz real time clock (RTC)
- High performance direct sequence spread spectrum (DSSS) RF transceiver
- Integrated antenna or RF-on-pin connector options
- 2.7 – 3.6 V supply voltage, MCU and on-board RTC support ultra low power modes
- Conforms with EN 300 440 (Europe), FCC CFR 47 part 15 (US), ARIB STD-T66 (Japan)

### Quick Reference Data

| Parameter | RC2201HP Min | RC2201HP Typ | RC2201HP Max | Unit |
|---|---|---|---|---|
| Frequency band | | 2.400-2.4835 | | GHz |
| Number of channels | | 16 | | |
| Data rate | | 250 | | kbit/s |
| Max output power | | 17 | | dBm |
| 2nd harmonic | | -37 | | dBm |
| 3rd harmonic | | -51 | | dBm |
| Sensitivity (PER 1%) | | -92 | | dBm |
| Adjacent Channel Rejection | | 39 | | dB |
| Alternate Channel Rejection | | 55 | | dB |
| Supply voltage | | 2.7 – 3.6 | | Volt |
| Current consumption, RX | 26 | 28 | 30 | mA |
| Current consumption, TX | 100 | 140 | 165 | mA |
| Current consumption, PD | | 2 | | uA |
| Flash memory | | 128 | | kB |
| RAM | | 8 | | kB |
| EEPROM | | 4 | | kB |
| Operating Temperature | | -30 to +85 | | °C |

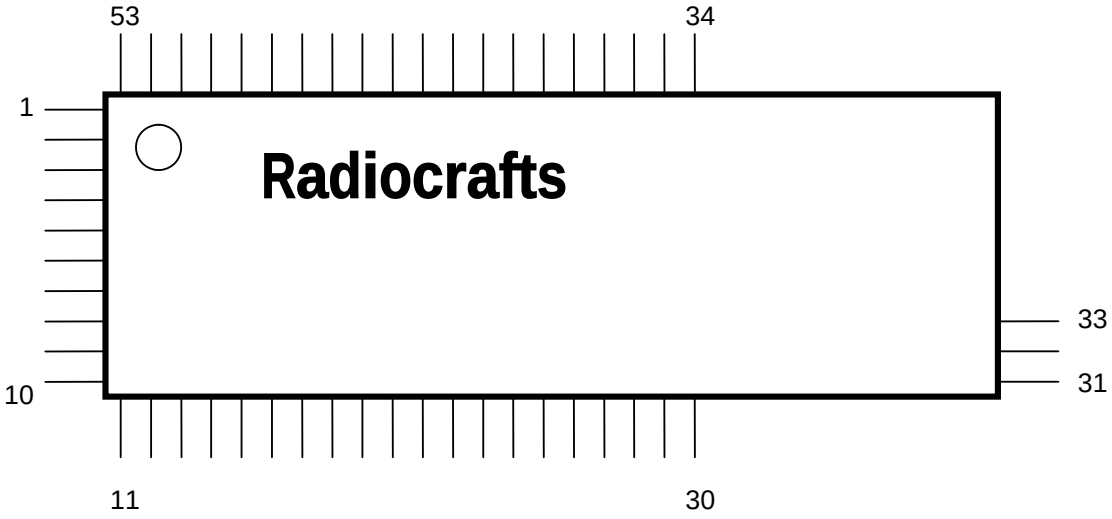
**PRELIMINARY INFORMATION. Specifications and information herein are subject to change without notice.**

## Quick Product Introduction

The RC2201HP series of modules are specially designed to meet the IEEE 802.15.4 standard used by ZigBee and a variety of proprietary network protocols. It includes a power amplifier to extend its range.

Using a pre-qualified module is the fastest way to make an 802.15.4 product and shortest time to market. Because it contains all the RF HW and MCU resources you need in a 100% RF tested and pre-qualified module shorten the qualification and approval process. No RF design or expertise is required to add powerful wireless networking to the product. The module is available with integrated antenna.

## Pin Assignment



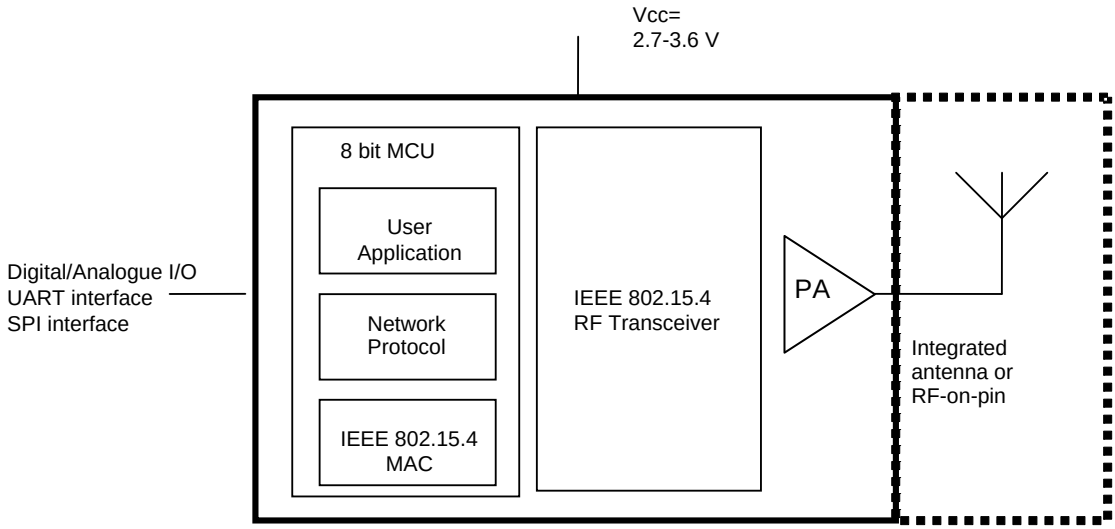

## Pin Description

| Pin no | Pin name | Description and internal MCU connection |
|---|---|---|
| 1 | GND | System ground |
| 2 | VCC | Supply voltage input |
| 3 | PG0 | Digital I/O, PG0 |
| 4 | GND | System ground |
| 5 | PD7(CTS1) | Digital I/O, PD7 / CTS1 |
| 6 | PD5(RTS1) | Digital I/O, PD5 / RTS1 |
| 7 | PG2 | Digital I/O, PG2 |
| 8 | PD3(TXD1) | Digital I/O, PD3 / TXD1 / INT3 |
| 9 | PD2(RXD1) | Digital I/O, PD2 / RXD1 / INT2 |
| 10 | GND | System ground |
| 11 | GND | System ground |
| 12 | PF7/ADC7 | Digital or analogue I/O, PF7, JTAG TDI |
| 13 | PF6/ADC6 | Digital or analogue I/O, PF6, JTAG TDO |
| 14 | PF5/ADC5 | Digital or analogue I/O, PF5, JTAG TMS |
| 15 | PF4/ADC4 | Digital or analogue I/O, PF4, JTAG TCK |
| 16 | PF3/ADC3 | Digital or analogue I/O, PF3 |
| 17 | PF2/ADC2 | Digital or analogue I/O, PF2 |
| 18 | PF1/ADC1 | Digital or analogue I/O, PF1 |
| 19 | PF0/ADC0 | Digital or analogue I/O, PF0 |
| 20 | AREF | Analogue reference voltage pin for the internal A/D Converter. Internally decoupled with 22nF. |
| 21 | PE0 | Digital I/O, PE0 |
| 22 | PE1 | Digital I/O, PE1 |
| 23 | PE2 | Digital I/O, PE2 |
| 24 | PE3 | Digital I/O, PE3 |
| 25 | PE4 | Digital I/O, PE4 / INT4 |
| 26 | PE5 | Digital I/O, PE5 / INT5 |
| 27 | PE6 | Digital I/O, PE6 / INT6 |
| 28 | PE7 | Digital I/O, PE7 / INT7 |
| 29 | 1.8V | Internally regulated voltage. Normally not connect. May be used for AREF |

| | | |
|---|---|---|
| 30 | GND | System ground |
| 31 | GND | System ground |
| 32 | RF | RF I/O connection to antenna, 50 Ohm. Do not connect for integrated antenna or connector variant. |
| 33 | GND | System ground |
| 34 | GND | System ground |
| 35 | PB0 | Do not connect, internally used for CSn |
| 36 | PB1/SCLK | SPI interface must be shared with MAC, ISP SCK |
| 37 | PB2/MOSI | SPI interface must be shared with MAC, ISP MOSI |
| 38 | PB3/MISO | SPI interface must be shared with MAC, ISP MISO |
| 39 | PB4 | Digital I/O, PB4 |
| 40 | PB5 | Do not connect, internally used for VREG_EN |
| 41 | PB6 | Do not connect, internally used for RESETn |
| 42 | PB7 | Digital I/O, PB7 |
| 43 | TOSC2 | Internal 32.768 kHz oscillator |
| 44 | RESET | Internal MCU reset. Active low with internal pull-up. |
| 45 | PD0 / INT0 | Do not connect, internally used for DCLK / FIFOP |
| 46 | PD1 / INT1 | Do not connect, internally used for DIO / FIFO |
| 47 | PD2/RXD1 | Same as pin 9 |
| 48 | PD3/TXD1 | Same as pin 8 |
| 49 | PD4 | Do not connect, internally used for SFD |
| 50 | PD5(RTS1) | Same as pin 6 |
| 51 | PD6 | Do not connect, internally used for CCA |
| 52 | PD7(CTS1) | Same as pin 5 |
| 53 | GND | System ground |

Note 1: UART interface: Pin 8 TXD1, pin 9 RXD1, pin 5 CTS1, pin 6 RTS1
Note 2: SPI interface: Pin 36 SCLK, pin 37 SI, pin 38 SO (chip select at any digital I/O) must be shared with internal MAC software

## Block Diagram




## Embedded resources

MCU: Atmel mega1281
PHY/MAC: Chipcon CC2420

## Circuit Description

The module contains a micro controller unit (MCU) and an IEEE 802.14.4 compliant RF transceiver with internal voltage regulator. The module is intended for running the ZigBee network protocol.

The application software together with the ZigBee protocol software stack can be programmed in Flash memory through JTAG or ISP interfaces. The JTAG interface can also be used for debugging. The MCU runs at 8 MHz and contains on-chip RAM and non-volatile EEPROM memory.

The MCU controls the RF transceiver through an SPI interface and hardware handshake signals. The firmware controlling the RF transceiver is part of the MAC software. The antenna output is internally matched to 50 Ohms, optionally using an integrated antenna.

The supply voltage is connected to the VCC pin. The module contains an internal low noise voltage regulator for the RF transceiver, and can therefore operate over a wide supply voltage range. The regulated voltage is available at the 1.8V pin (pin 29), but should not be used to supply external circuits except for connection to AREF, being a reference for the internal A/D converter.

The module provides 2 UART interfaces, SPI interface, JTAG interface. Totally 32 I/O pins are available to the user. 8 pins can be used for the internal 10 bit A/D converter. 6 of the digital I/Os have interrupt features.

The MCU provides several low power modes with can be utilized to reduce the current consumption in battery operated applications. An internal 32 kHz crystal oscillator can be used for real-time clock and timer applications.

For further details on the RF transceiver (Chipcon CC2420) and MCU (Atmel mega1281), please consult the respective data sheets.

### JTAG interface

The module offers a JTAG interface for Flash and EEPROM programming, as well as for debugging.

Programming through the JTAG interface requires control of the four JTAG specific pins: TCK, TMS, TDI, and TDO. Control of the reset and clock pins is not normally required. To be able to use the JTAG interface, the JTAGEN Fuse must be programmed. The device is default shipped with the fuse programmed. For further information, please refer to the respective MCU data sheet.

The table below show the JTAG pin mapping.

| Signal | RC2201HP pin |
|---|---|
| TDI | 12 |
| TDO | 13 |
| TMS | 14 |
| TCK | 15 |
| RESET | 44 |

Supply and ground must also be connected during programming.

### ISP Interface

The module offers an In-System Programming (ISP) interface for Flash and EEPROM memory programming. The fastest way to do firmware downloading in manufacturing is through the ISP interface rather then the JTAG interface.

The memory arrays can be programmed using the serial interface bus while RESET is pulled to GND. The serial interface consists of pins SCK, PDI/MOSI (input) and PDO/MISO (output).

After RESET is set low, the Programming Enable instruction needs to be executed first before program/erase operations can be executed. More information is available in the respective MCU data sheets.

The table below show the pin mapping for ISP programming.

| Signal | RC2201HP |
|---|---|
| PDI | 21 |
| PDO | 22 |
| SCL | 36 |
| RESET | 44 |

Supply and ground must also be connected during programming.

### Power Management

For the network protocol to allow devices to be powered down, the module can offer a range of power saving modes. Battery operated devices needs to powered down to reduce overall power consumption to a minimum.

The module can be set in several sleep modes using the features of the MCU and turning off the RF transceiver. Sleep modes enable the application to shut down unused modules in the MCU, thereby saving power. The MCU provides various sleep modes allowing the user to tailor the power consumption to the application's requirements. Please refer to the respective MCU data sheets.

In order to ensure that the internal Power On Reset (POR) operates correctly, the maximum rise-time specification for VCC must be met (see Electrical Specifications). If longer rise-time is expected it is recommended to use an external POR circuit attached to the RESET pin (see Application Note AN001). Slow VCC rise-time or short power interruptions may cause improper operation that is not handled by the internal POR. In this case the RESET should be activated in order to ensure proper start-up.

### RF Frequency, Output Power Levels and Data Rates

The following table shows the RF channels as defined by the IEEE 802.15.4 standard.

| RF channel | Frequency |
|---|---|
| 11 | 2405 MHz |
| 12 | 2410 MHz |
| 13 | 2415 MHz |
| 14 | 2420 MHz |
| 15 | 2425 MHz |
| 16 | 2430 MHz |
| 17 | 2435 MHz |
| 18 | 2440 MHz |
| 19 | 2445 MHz |
| 20 | 2450 MHz |
| 21 | 2455 MHz |
| 22 | 2460 MHz |
| 23 | 2465 MHz |
| 24 | 2470 MHz |
| 25 | 2475 MHz |
| 26 | 2480 MHz |

For proprietary solutions (non-IEEE 802.15.4), the RF transceiver can be programmed in steps of 1 MHz.

The output power level can be configured from the firmware in the range -10 to 17 dBm.

The RF transceiver uses direct sequence spread spectrum (DSSS) with 2 Mchip/s chip rate, giving a raw data rate of 250 kbit/s. The modulation format is Offset – Quadrature Phase Shift Keying (O-QPSK). The DSSS makes the communication link robust in noisy environments when sharing the same frequency band with other applications.

The use of RF frequencies and maximum allowed RF power is limited by national regulations. The RC2201HP series is complying with the applicable regulations for the world wide 2.45 GHz ISM band.

Specifically it complies with the European Union R&TTE directive meeting EN 300 328 and EN300 440 class 2. It also meets the FCC CFR47 Part15 regulations for use in the US and the ARIB T-66 for use in Japan.

### Antenna and Range Considerations

As an option the module is delivered with an integrated antenna (RC2201HP-AT). This is highly recommended for most applications, as this gives a very compact solution containing all the critical RF parts within the module.

Range testing using the integrated antenna shows these typical distances:

- 850 meter outdoor line-of-sight (LOS)
- 30-100 meters indoors depending on building material and construction
- 30-50 meters when passing through floors
- 40-100 meters in the same floor

The variation between different orientations of the antenna measured outdoors line-of-sight is typically within +/- 20%.

The integrated antenna is a compact ceramic antenna working as a quarter-wave resonant antenna. Due to the dielectric ceramic material the antenna is shorter than a normal quarter wave antenna (in air), still providing high radiation efficiency, typical 1 dBi under optimum conditions. When placed closer to a ground plane the gain is typical – 1dBi. The antenna is matched for use in the 2.45 GHz band. The radiating part of the antenna is the white ceramic component located outside the shield can. The radiation pattern from the antenna is similar to the donut-shaped radiation from a quarter wave antenna. That is, the maximum radiation is in the plane normal to the length axis of the antenna. For best possible omni-directional radiation the module should be oriented so that the antenna is vertical. To achieve the very best range the transmitting and receiving antenna should be oriented the same way, ensuring the same polarity at both devices. However, indoors reflections of the radio waves in metallic structures tend to spread the polarisation, so even if same orientation is not possible, communication will still take place, but the range is somewhat shorter, typically by 20%.

The antenna end of the module should be kept away (> 10mm) from metallic or other conductive and dielectric materials, and should never be used inside a metallic enclosure.

Compared to lower frequencies, operation at 2.45 GHz is more limited to LOS. Reflections from walls and other objects may give multi-path fading resulting in dead-zones. The ZigBee mesh network topology is used to overcome this fading as it allows for alternative routing paths. The mesh network is therefore highly recommended for increased reliability and extended coverage throughout buildings.

If the option without internal antenna is used, the RF output must be connected to an antenna through the RF pin. The RF input/output is matched to 50 Ohm. If the antenna or 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 quarter wave antenna, like a piece of wire normal to ground plane should have a length equivalent to 95% of the free space wavelength.

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 (in one dimension) as the antenna itself, to make it act as a counterweight to the antenna. A quarter wavelength antenna on a PCB must be shorter than the wire antenna due to the influence of the dielectric material of the PCB. The length reduction depends on the PCB thickness and material, as well as how close to the edge of the board the antenna is placed. Typical reduction is to 75-90 % but must be found empirically.

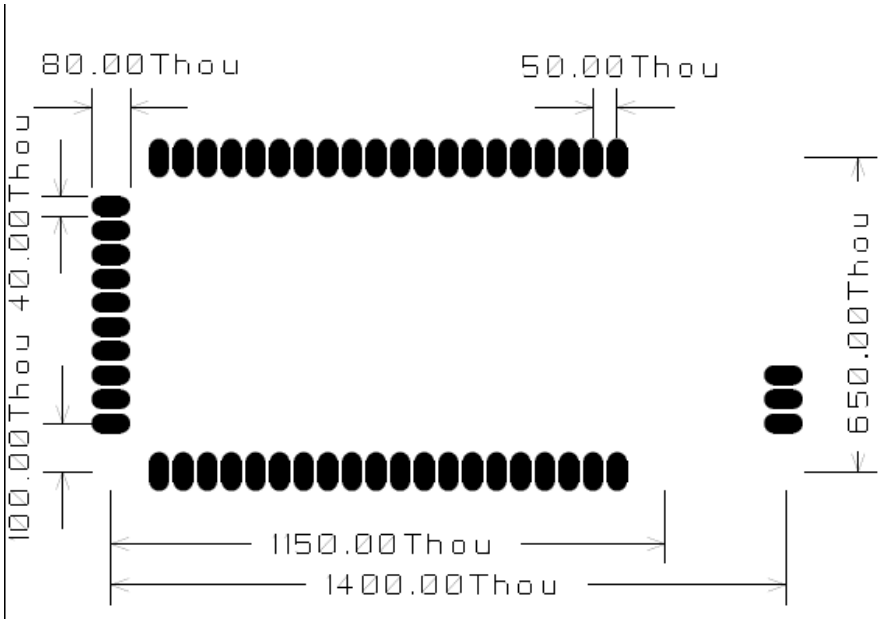
If, for space reasons, the track is made even shorter than the resonating quarter of a wavelength, the antenna should be matched to 50 ohms using a series inductor and a shunt capacitor.

The length of a quarter-wave antenna is given in the table below.

| Frequency [MHz] | Length of whip antenna [cm] | Length of PCB track [cm] |
|---|---|---|
| 2450 | 2.9 | 2.25 – 2.7 |

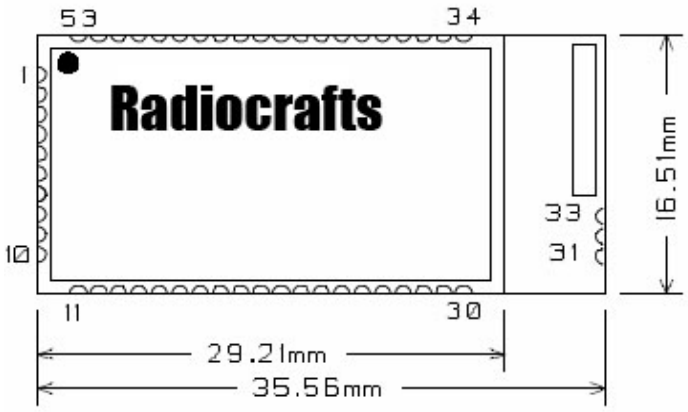
### PCB Layout Recommendations

The recommended layout pads for the module are shown in the figure below (top view, pin 1 is in upper left corner, see pin assignment at page 3). 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.




The area underneath the module should be covered with solder resist in order to prevent short circuiting the test pads on the back side of the module. A solid ground plane is preferred. Unconnected pins should be soldered to the pads, and the pads should be left floating. For the module version with integrated, the RF pad (pin 31) can be soldered, but the pad should not be connected further. The two ground pads (pin 30 and 32 on the right side) should be grounded for all variants.

### Mechanical Drawing




### Mechanical Dimensions

The module size is 0.65” x 1.4” x 0.14” (16.5 x 35.6 x 3.5 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 |
|---|---|---|---|---|
| 56 mm | 20 mm | 4 mm | 13” | Max 800 |

## Absolute Maximum Ratings

| Parameter | Min | Max | Unit |
|---|---|---|---|
| Supply voltage, VCC | -0.3 | 3.6 | V |
| Voltage on any pin | -0.3 | VCC+0.5 | V |
| Input RF level | | 10 | dBm |
| Storage temperature | -50 | 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.

## Electrical Specifications

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

| Parameter | Min | Typ. | Max | Unit | Condition / Note |
|---|---|---|---|---|---|
| Operating frequency | 2405 | | 2480 | MHz | Programmable in 1 MHz steps, 5 MHz steps for IEEE 802.15.4 compliance |
| Number of channels | | 16 | | | For IEEE 802.15.4 compliance |
| Channel spacing | | 5 | | MHz | For IEEE 802.15.4 compliance |
| Input/output impedance | | 50 | | Ohm | |
| Data rate | | 250 | | kbit/s | |
| DSSS chip rate | | 2 | | Mc/s | |
| Frequency stability | | | +/-40 | ppm | |
| Transmit power | -10 | | +17 | dBm | Programmable from firmware |
| Harmonics<br>2nd harmonic<br>3rd harmonic | | <br>-37<br>-51 | | | |
| Spurious emission, TX<br>30 – 1000 MHz<br>1-12.75 GHz<br>1.8-1.9 GHz<br>5.15-5.3 GHz | | | <br>-36<br>-30<br>-47<br>-47 | dBm | Complies with EN 300 328, EN 300 440, FCC CRF47 Part 15 and ARIB STD-T66 |
| Sensitivity | | -92 | | dBm | PER = 1% |
| Adjacent channel rejection<br>+/- 5 MHz | | 46/39 | | dB | At -82 dBm, PER = 1%.<br>0 dB for IEEE 802.15.4 compliance |
| Alternate channel selectivity<br>+/- 10 MHz | | 58/55 | | dB | At -82 dBm, PER = 1%.<br>30 dB for IEEE 802.15.4 compliance |
| Blocking / Interferer rejection / desensitization<br>+/- 5 MHz<br>+/- 10 MHz<br>+/- 20 MHz<br>+/- 50 MHz | <br>-50<br>-45<br>-40<br>-30 | <br>-24<br>-24<br>-24<br>-23 | | dBm | Wanted signal 3 dB above sensitivity level, CW interferer, PER = 1%.<br>Minimum numbers corresponds to class 2 receiver requirements in EN 300 440. |
| Saturation | 0 | 10 | | dBm | |
| Spurious emission, RX<br>30 -1000 MHz<br>1-12.75 GHz | | | <br>-57<br>-47 | dBm | Complies with EN 300 328, EN 300 440, FCC CRF47 Part 15 and ARIB STD-T66 |

| | | | | | |
|---|---|---|---|---|---|
| Supply voltage | 2.7 | | 3.6 | V | |
| Supply voltage rise time | | | 150 | us | If appropriate rise time can not be guaranteed, the RESET pin should be activated after supply voltage is stable. |
| Current consumption, RX | | 30 | | mA | MCU in Idle mode using the 8 MHz oscillator. |
| Current consumption, TX | 100 | 140 | 170 | mA | At typ. 17 dBm output power. MCU in Idle mode using the 8 MHz oscillator. |
| Current consumption, Sleep | | 40 | | µA | MCU in power down while CC2420 are in power sleep. |
| Current consumption, PD | | 2 | | µA | MCU in Power-down mode, watchdog disabled |
| MCU Flash memory | | 128 | | kB | |
| MCU RAM memory | | 8 | | kB | |
| MCU EEPROM memory | | 4 | | kB | |
| MCU clock frequency | | 8 | | MHz | |
| MCU low frequency crystal | | 32.768 | | kHz | |
| Digital I/O<br>Input logic level, low<br>Input logic level, high<br>Output logic level, low (10 mA)<br>Output logic level, high(-10 mA) | <br>-0.5<br>0.6 VCC<br>0<br>2.4 | | <br>0.3 VCC<br>VCC + 0.5<br>0.5<br>3.0 | V | |
| RESET pin<br>Input logic level, low<br>Input logic level, high | <br>-0.5<br>0.9VCC | | <br>0.1 VCC<br>VCC + 0.5 | V | |
| Internal RESET pull-up resistor | 30 | | 60 | kOhm | |
| 1.8V regulated voltage at pin 29 | 1.7 | 1.8 | 1.9 | V | |

## Ordering Information

| Ordering Part Number | Description |
|---|---|
| RC2201HP-AT | ZigBee-ready RF module, 128 kB Flash, integrated antenna |
| RC2201HP | ZigBee-ready RF module, 128 kB Flash, RF only available at pin |

## Document Revision History

| Document Revision | Changes |
|---|---|
| 1.0 | First release |
| 1.01 | New product picture |

## 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. |
| X | 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. |
| | **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. |

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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.

## 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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