



DATA SHEET

## RF Engine 200 Series

**Model Number: RF200, Part  
Numbers: RF200PD1 and  
RF200PF1**

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# 1. RF Engine 200 Series Modules Overview

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The RF Engine 200 Series (Model Number RF200) is an IEEE 802.15.4, low power, highly-reliable solution to embedded wireless control and monitoring network needs that require high data rates. The RF200 embeds Synapse's SNAP OS, the industry's first Internet-enabled, wireless mesh network operating system into the Atmel ATmega128RFA1 single-chip AVR® microcontroller with an integrated transceiver that delivers up to 2Mbps/sec. These low-cost modules can have a range of up to three miles and power consumption as low as 1.6  $\mu$ A to enable a new generation of battery- driven systems.

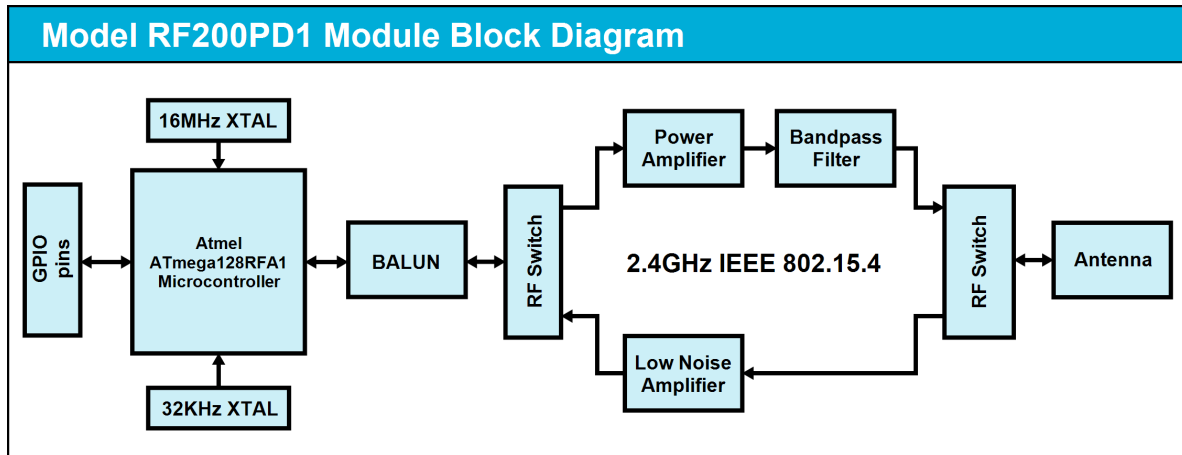
SNAP's on-board Python interpreter provides for rapid application development and over-the-air programming, while Atmel's low-power RF single-chip design saves board space and lowers the overall Bill of Materials and power consumption. The RF200 is approved as an FCC Part 15 unlicensed modular transmitter. The modules provide up to 16 channels of operation in the ISM 2.4GHz frequency band. The RF200 module contains both a power amplifier for transmission and a low noise amplifier in the receive path for extended range.

## This Data Sheet details part numbers RF200PD1 and RF200PF1:

- 20 GPIO and up to 7 A/D inputs
- 128k flash, 58.5k free for over-the-air uploaded user apps
- Two UART ports for control or transparent data which surmounts noisy environments
- Low power modes: 1.6  $\mu$ A with internal timer running
- Spread spectrum (DSSS) technology
- Socket-able or solder-able
- Up to 2 Mbps Data Rate
- 2.4 GHz RF Frequency
- Spread Spectrum (DSSS) technology
- AES 128-bit encryption
- RF200PD1: SMA antenna (3 miles LoS at 250Kbps)
- RF200PF1: F-Antenna (2.5 miles LoS at 250Kbps)



The RF200 is also available with a u.FL connector. Contact Synapse for details.



**Figure 1.1: Block diagram showing the major subsystems comprising the RF200**

# Specifications

**Table 1.1: RF200PD1/RF200PF1 Specifications**

|                    |                                                  |                                                                            |
|--------------------|--------------------------------------------------|----------------------------------------------------------------------------|
| Performance        | Outdoor LOS Range                                | RF200PD1: Up to 3 miles at 250Kbps<br>RF200PF1: Up to 2.5 miles at 250Kbps |
|                    | Transmit Power Output                            | 15 dBm                                                                     |
|                    | RF Data Rate                                     | 250Kbps, 500Kbps, 1Mbps, 2Mbps                                             |
|                    | Receiver Sensitivity                             | -103 dBm (1% PER)                                                          |
| Power Requirements | Supply Voltage                                   | 2.7 - 3.6 V                                                                |
|                    | Transmit Current (Typ@3.3V)                      | 80mA                                                                       |
|                    | Idle/Receive Current (Typ@3.3V)                  | 20mA                                                                       |
|                    | Power-down Current (Typ@3.3V)                    | 1.6uA                                                                      |
| General            | Frequency                                        | ISM 2.4 GHz                                                                |
|                    | Spreading Method                                 | Direct Sequence (DSSS)                                                     |
|                    | Modulation                                       | O-QPSK                                                                     |
|                    | Dimensions                                       | 1.333" x 1.333"                                                            |
|                    | Operating Temperature                            | - 40 to 85 deg C.                                                          |
|                    | Antenna Options                                  | RF200PD1: External RPSMA                                                   |
|                    |                                                  | RF200PF1: F- antenna                                                       |
| Networking         | Topology                                         | SNAP                                                                       |
|                    | Error Handling                                   | Retries and acknowledgement                                                |
|                    | Number of Channels                               | 16                                                                         |
| Available I/O      | UARTS with HW Flow Control                       | 2 Ports - 8 total I/O                                                      |
|                    | GPIO                                             | 20 total; 7 can be analog-in with 10bit ADC                                |
| Agency Approvals   | FCC Part 15.247                                  | FCC ID: U9O-RF200                                                          |
|                    | Industry Canada (IC)                             | IC: 7084A-RF200                                                            |
|                    | CE available as a custom part. Call for details. |                                                                            |

## Module Pin Definitions

**Table 1.2: RF200PD1 / RF200PF1 Module Pin Assignments**

| Pin | Name                       | Description                                                   |
|-----|----------------------------|---------------------------------------------------------------|
| 1   | GND                        | Power Supply                                                  |
| 2   | GPIO0/OC0A/OC1C/PCINT7/PB7 | GPIO_0, PWM, or Interrupt                                     |
| 3   | GPIO1/OC1B/PCINT6/PB6      | GPIO_1, PWM, or Interrupt                                     |
| 4   | GPIO2/OC1A/PCINT5/PB5      | GPIO_2, PWM, or Interrupt                                     |
| 5   | GPIO3/RXD0/PCINT8/PE0      | GPIO_3, Interrupt, or UART0 Data Input                        |
| 6   | GPIO4/TXD0/PE1             | GPIO_4, UART0 Data Output                                     |
| 7   | GPIO5/OC3B/INT4/PE4        | GPIO_5, PWM, Interrupt, or UART0 CTS Output                   |
| 8   | GPIO6/OC3C/INT5/PE5        | GPIO_6, PWM, Interrupt, or UART0 RTS Input                    |
| 9   | GPIO7/RXD1/INT2/PD2        | GPIO_7, Interrupt, or UART1 Data Input                        |
| 10  | GPIO8/TXD1/INT3/PD3        | GPIO_8, Interrupt, or UART1 Data Output                       |
| 11  | GPIO9/ICP1/PD4             | GPIO_9, or UART1 CTS Output                                   |
| 12  | GPIO10/ICP3/INT7/CLK0      | GPIO_10, Interrupt, Clock Output, or UART1 RTS Input          |
| 13  | GPIO11/ADC0/PF0            | GPIO_11, or Analog In                                         |
| 14  | GPIO12/ADC1/PF1            | GPIO_12, SPI MOSI, or Analog In                               |
| 15  | GPIO13/ADC2/DIG2/PF2       | GPIO_13, SPI SCLK, Antenna Diversity, or Analog In            |
| 16  | GPIO14/XCK0/AIN0/PE2       | GPIO_14, SPI MISO, USART CLK, Analog Comparator, or Analog In |
| 17  | GPIO15/ADC4/TCK/PF4        | GPIO_15, JTAG TCK, or Analog In                               |
| 18  | GPIO16/ADC5/TMS/PF5        | GPIO_16, JTAG TMS, or Analog In                               |
| 19  | GPIO17/ADC6/TDO/PF6        | GPIO_17, JTAG TDO, I <sup>2</sup> C SDA, or Analog In         |
| 20  | GPIO18/ADC7/TDI/PF7        | GPIO_18, JTAG TDI, I <sup>2</sup> C SCL, or Analog In         |
| 21  | VCC                        | Power Supply                                                  |
| 22  | GPIO19/OC3A/AIN1/PE3       | GPIO_19, PWM, Analog Comparator                               |
| 23  | RESET                      | Module Reset, Active Low                                      |
| 24  | GND                        | Power Supply                                                  |

## Electrical Characteristics

**Table 1.3: RF200PD1 / RF200PF1 DC Characteristics at 25° C**

| Symbol        | Parameter           | Condition                                | Min            | Typ | Max | Units |
|---------------|---------------------|------------------------------------------|----------------|-----|-----|-------|
| $V_{CC}^1$    | Supply Voltage      |                                          | 2.7            | 3.3 | 3.6 | V     |
| $T_{OP}$      | Operating Temp      |                                          | -40            |     | 85  | °C    |
| $T_{STOR}$    | Storage Temp        |                                          | -40            |     | 125 | °C    |
| $V_{IH}$      | Input Hi Voltage    | All Digital Inputs                       | $V_{CC} - 0.4$ |     |     | V     |
| $V_{IL}$      | Input Low Voltage   | All Digital Inputs                       |                |     | 0.4 | V     |
| $V_{OL}$      | Output Low Voltage  | All drive strengths (2,4,6,8 mA)         |                |     | 0.4 | V     |
| $V_{OH}$      | Output High Voltage | All drive strengths (2,4,6,8 mA)         | $V_{CC} - 0.4$ |     |     | V     |
| $I_{L_{IN}}$  | In Leakage Current  | $V_{IN} = V_{CC}$ or $V_{SS}$ , all Pins |                |     | TBD | uA    |
| $TX-I_{CC}$   | Transmit Current    | $V_{CC} = 3.3V$                          |                | 80  |     | mA    |
| $RX-I_{CC}$   | Receive Current     | $V_{CC} = 3.3V$                          |                | 20  |     | mA    |
| $SHDN-I_{CC}$ | Sleep Current       | $V_{CC} = 3.3V$                          |                | 1.6 |     | uA    |

**Table 1.4: ADC Electrical Characteristics (Operating)**

| Symbol       | Parameter               | Condition                 | Min | Typical | Max | Unit |
|--------------|-------------------------|---------------------------|-----|---------|-----|------|
| $V_{REFH}^2$ | Voltage Reference, High | Programmable              | 1.5 | 1.6     | 1.8 | V    |
| $V_{INDC}$   | Analog input voltage    | Single Ended              | 0   |         | 1.8 | V    |
|              |                         | Differential <sup>3</sup> | 0   |         | 3.3 |      |

1 Absolute maximum stress rated voltage for VCC is -0.3 to 3.6. It is recommended that bulk capacitance be located as close as possible to the VCC pin on the host board. Ideally, use a single 47µF capacitor at 10V directly at the VCC pin.

2 VREFH is programmable to three fixed values; 1.5V, 1.6V, and 1.8V. The default is 1.6V.

3 Each differential analog input may be as high as 3.3V but the differential voltage is still limited.

**Table 1.5: ADC Timing/Performance Characteristics**

| Symbol   | Parameter                              | Condition                       | Min  | Typical | Max | Unit       |
|----------|----------------------------------------|---------------------------------|------|---------|-----|------------|
| $R_{AS}$ | Source impedance at input <sup>4</sup> |                                 |      |         | 3k  | k $\Omega$ |
| RES      | Conversion Resolution                  | Single Ended CLKADC $\leq$ 4MHz |      | 10      |     | Bits       |
|          |                                        | Single Ended CLKADC $>$ 8MHz    |      | 8       |     |            |
| DNL      | Differential non-linearity             | $V_{REFH} = 1.6V$ CLKADC=4MHz   | -0.5 |         |     | LSB        |
| INL      | Integral non-linearity                 | $V_{REFH} = 1.6V$ CLKADC=4MHz   |      | 0.8     |     | LSB        |
| $E_{ZS}$ | Zero-scale error                       |                                 |      | 1.5     |     | LSB        |
| $E_G$    | Gain error                             |                                 |      | 1       |     | LSB        |

## Mechanical Drawings

These drawings in **Figure 1.2** show the module with the RPSMA connector for use with an external antenna, and the keep out area for the F-antenna.

**NOTE:** The area under the module's antenna (marked NO COPPER or KEEP OUT AREA) should have no components, no traces, and no copper on any layer of the printed circuit board.

<sup>4</sup> Any analog source with a source impedance greater than 3k $\Omega$  will increase the sampling time.

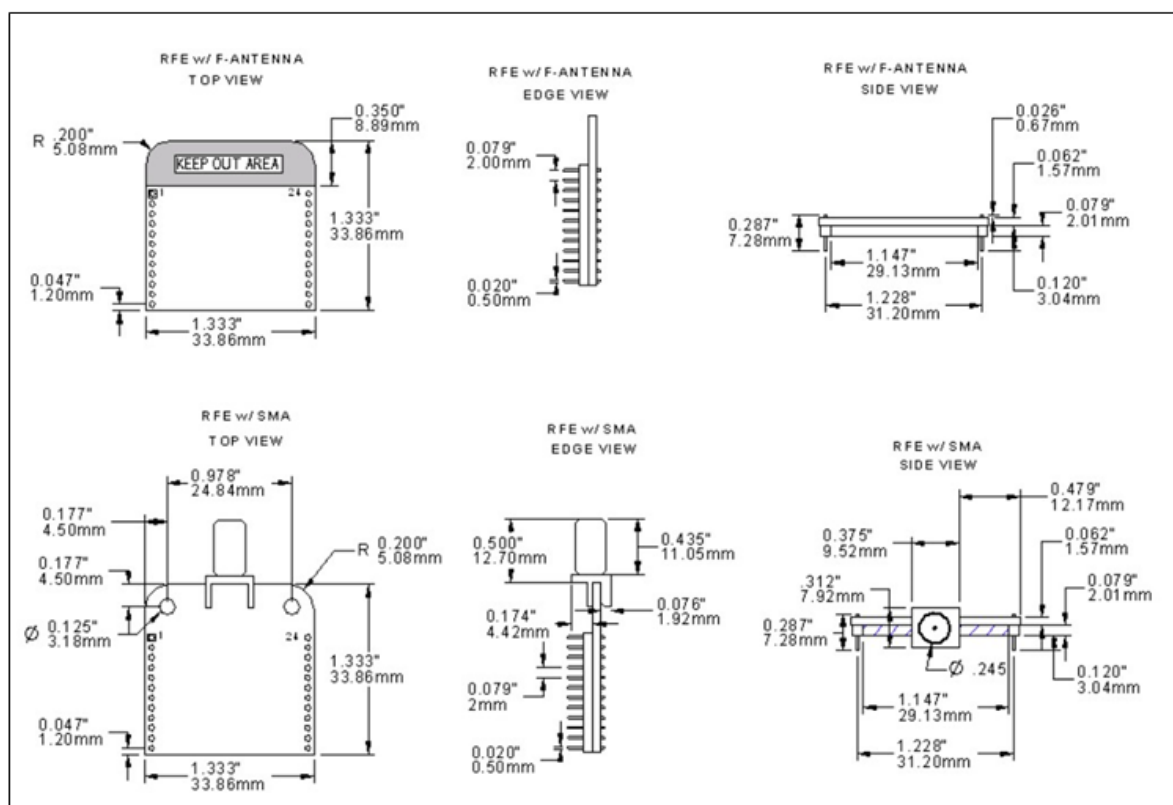


Figure 1.2: Mechanical drawings of the RF200PD1 and RF200PF1 Modules

## Board Mounting Considerations

The RF200PD1 and RF200PF1 modules are designed to mount into a receptacle (socket) on the host board. **Figure 1.3** shows an RF200PD1 module plugged in to a host board. The receptacle sockets are on standard 2mm centers. Suggested receptacles to be used on the host are:

|                          |        |                 |
|--------------------------|--------|-----------------|
| Thru-hole receptacle     | Samtec | MMS-112-01-L-SV |
| Surface mount receptacle | Samtec | MMS-112-02-L-SV |

It is recommended that the mounting holes provided in the module on either side of the SMA connector be used with supporting mounting hardware to hard mount the module to either the host board or to the enclosure to handle the mechanical stresses that can occur when an external antenna is screwed into the SMA. **Figure 1.3** shows the RF200PD1 with SMA connector mounted to the host board.

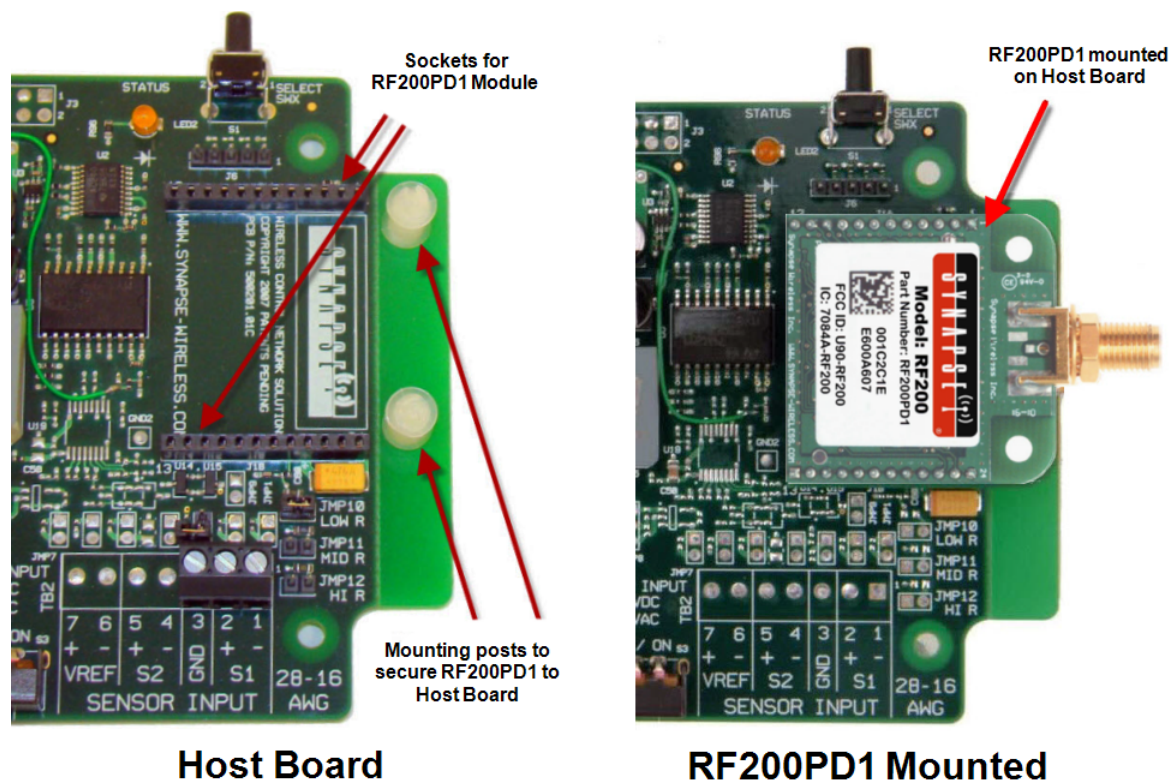


Figure 1.3: RF200PD1 Mounted To Host Board

## 2. Agency Certifications

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### United States (FCC)

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The Model SM220 modules comply with Part 15 of the FCC rules and regulations. Compliance with the labeling requirements, FCC notices and antenna usage guidelines is required. In order to comply with FCC Certification requirements, the Original Equipment Manufacturer (OEM) must fulfill the following requirements.

1. The system integrator must place an exterior label on the outside of the final product housing the RF200 Modules. **Figure 2.1** below shows the contents that must be included in this label.
2. RF200 Modules may only be used with the antenna that has been tested and approved for use with the module. Please refer to the antenna table provided in this section.

### OEM Labeling Requirements

**NOTICE:** The OEM must make sure that FCC labeling requirements are met. This includes a clearly visible exterior label on the outside of the final product housing that displays the contents shown in **Figure 2.1** below.

MANUFACTURERSNAME  
BRANDNAME or TRADENAME

Contains RF200 FCC ID: U90-RF200

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interferences, and (2) this device must accept any interference received, including interference that may cause undesired operation.

**Figure 2.1: FCC Label**

### FCC Notices

**WARNING!** The RF200 modules have been tested by the FCC for use with other products without further certification (as per FCC Section 2.1091). Changes or modifications to this device not expressly approved by Synapse Wireless Inc. could void the user's authority to operate the equipment.

**NOTICE:** OEM's must certify final end product to comply with unintentional radiators (FCC Section 15.107 and 15.109) before declaring compliance of their final product to Part 15 of the FCC Rules.

**NOTICE:** The RF200 modules have been certified for remote and base radio applications. If the module will be used for portable (as defined by the FCC) applications, the device must undergo SAR testing.

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful

interference in a residential installation. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation.

If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

## FCC Approved Antennas

The RF200 modules are FCC-approved for fixed base station and mobile applications.

**Notice:** To reduce potential radio interference to other users, the antenna type and its gain should be chosen so that the equivalent isotropically radiated power (e.i.r.p.) is not more than that permitted for successful communication. The RF200PD1 module has been designed to operate with the antennas listed below in **Table 2.1**. The required antenna impedance is 50 ohms. The RF200PF1 has a built-in F-antenna.

**Table 2.1: Approved FCC Antennas**

| Part Number         | Type                        | Gain    | Application  | Min. Separation |
|---------------------|-----------------------------|---------|--------------|-----------------|
| L-com HG2405RD-RSP* | Dipole (quarter-wave RPSMA) | 5.5 dBi | Fixed/Mobile | 20 cm.          |
| Pulse W1027         | Dipole (quarter-wave RPSMA) | 3.2 dBi | Fixed/Mobile | 20 cm.          |

\* The 5.5 dBi antenna is approved for use in cases that are approved in writing by Synapse.

For more information on approved antennas, please consult the manufacturers website.

**WARNING!: RF Exposure:** This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance 20cm between the radiator and your body. This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

**NOTICE:** The preceding statement must be included as a CAUTION statement in OEM product manuals in order to alert users of FCC RF Exposure compliance.

**NOTE:** Antenna and transmitters may be co-located or operated in conjunction with this device only if the transmitters do not simultaneously transmit. Otherwise, additional regulatory requirements will apply.

## Canada (IC)

This device complies with Industry Canada license-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

*Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes : (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.*

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication.

*Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante.*

This radio transmitter Model: RF200, IC: 7084A-RF200 has been approved by Industry Canada to operate with the antenna types listed below with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

*Le présent émetteur radio Model: RF200, IC: 7084A-RF200 a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés ci-dessous et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur.*

**Table 2.2: Approved IC Antennas**

| Part Number | Type                        | Gain    | Application  | Min. Separation |
|-------------|-----------------------------|---------|--------------|-----------------|
| Pulse W1027 | Dipole (quarter-wave RPSMA) | 3.2 dBi | Fixed/Mobile | 20 cm.          |

## OEM Labeling Requirements for the European Union

The “CE” mark must be placed on the OEM product in a visible location. The CE mark will consist of the Initials “CE” with the following form:

If the CE marking is reduced or enlarged, the proportions given in the following drawing must be adhered too.

The CE mark must be a minimum of 5mm in height.

The CE marking must be affixed visibly, legibly and indelibly.



Since the 2400-2483.5 MHz band is not harmonized by a few countries throughout Europe, the Restriction sign must be placed to the right of the CE marking as shown in the drawing.

Labeling requirements for Industry Canada are similar to those of the FCC.  
A clearly visible label on the outside of the final product housing must display the contents shown in **Figure 2.2** below.



MANUFACTURERSNAME  
BRANDNAME or TRADENAME  
MODEL:

Contains RF200 IC: 7084A-RF200

**Figure 2.2: IC Label**

**NOTE:** The OEM can choose to implement a single label combined for both FCC and IC labeling requirements. If a combined single label is chosen, there must be a clearly visible label on the outside of the final product housing displaying the contents shown in **Figure 2.3** below.

MANUFACTURERSNAME  
BRANDNAME or TRADENAME

Contains RF200 FCC ID: U90-RF200  
Contains RF200 IC: 7084A-RF200

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interferences, and (2) this device must accept any interference received, including interference that may cause undesired operation.

**Figure 2.3: Combined FCC and IC Label**

**NOTE:** The OEM can choose to implement a single label combined for FCC, CE and IC labeling requirements. If a combined single label is chosen, there must be a clearly visible label on the outside of the final product housing displaying the contents shown in **Figure 2.4**.

MANUFACTURERSNAME  
BRANDNAME or TRADENAME

Contains RF200 FCC ID: U90-RF200

Contains RF200 IC: 7084A-RF200



This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interferences, and (2) this device must accept any interference received, including interference that may cause undesired operation.

**Figure 2.4: Combined FCC, CE and IC Label**





