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## Contact us

# RF220UF1 Module

6723 Odyssey Drive // Huntsville, AL 35806 // (877) 982-7888 // Synapse-Wireless.com

# SNAP Engine RF220UF1 Modules Overview

The SNAP Engine Model RF220UF1 series consists of an SM220UF1 on a carrier board. It is an IEEE 802.15.4, low-power, highly reliable solution for embedded wireless control and monitoring networks that require high data rates. The Model RF220UF1 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 2Mbits/sec. This low-cost module can have current consumption under 390nA to enable a new generation of battery-driven systems. The RF220UF1 also includes a Skyworks SE2431L front-end module, which provides a power amplifier and LNA for increased range.

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 power consumption. The modules provide up to 15 channels of operation in the ISM 2.4GHz frequency band.

By default, the SNAP operating system automatically forms a mesh network with other nodes immediately on receiving power. No further configuration is necessary. Multiple unrelated SNAP networks can exist within the same area through several configuration options outlined in the SNAP User Guide available from www.synapse-wireless.com.

> **NOTE:** Channel 15 is receive-only due to FCC power restrictions.

## This data sheet covers part number RF220UF1:

- 20 GPIO with 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
- Low power modes:
    - Timed Sleep Mode 1 : 1.27 µA
    - Timed Sleep Mode 2 : 1.47 µA
    - Untimed Sleep Mode : < 390 nA
- Spread Spectrum (DSSS) technology
- Up to 2 Mbps radio data rate
- 2.4 GHz RF Frequency
- AES 128-bit encryption
- Integrated on-board compact F antenna or U.FL connecter
- Solder-able or socket-able

- 4K internal EEPROM

- 6 PWM outputs

- Supports over the air firmware upgrades.
  (This process is further defined in the Portal User Guide.)

## Specifications

**Table 1.1: RF220UF1 Specifications at 23° C and 3.3V unless otherwise noted**

| | | |
|---|---|---|
| **Performance** | Outdoor LOS Range | 3 miles using u.fl antenna<br>.5 mile using on-board F antenna |
| | Transmit Power Output | up to +20 dBm |
| | RF Data Rate | 250Kbps, 500Kbps, 1Mbps, 2Mbps |
| | Receiver Sensitivity | -103 dBm (1% PER, 250Kbps) |
| **Power Requirements** | Supply Voltage | 2.0 - 3.6 V |
| | Transmit Current (Typ@3.3V) | at +20 dBm: 150 mA<br>at +6 dBm: 55 mA |
| | Idle/Receive On (Typ@3.3V) | 22 mA |
| | Idle/Receive Off (Typ@3.3V) | 7.8 mA |
| | Sleep Mode Current (Typ@3.3V) | Timed Sleep: 1.27 µA<br>Untimed Sleep Mode : 390 nA |

| | | |
|---|---|---|
| **General** | Frequency | ISM 2.4 GHz |
| | Spreading Method | Direct Sequence (DSSS) |
| | Modulation | O-QPSK |
| | Dimensions | 33.86mm x 33.86mm |
| | Operating Temperature | - 40 to 85 deg C. |
| | Antenna Options | U.FL and on-board compact F antenna |
| | Weight | 3 grams |
| **Networking** | Topology | SNAP |
| | Error Handling | Retries and acknowledgment |
| | Number of Channels | 15 channels. To avoid exceeding FCC limits, channel 15 operates in a receive only state. |
| **Available I/O** | UARTS with optional HW Flow Control | 2 Ports<br><br>Note: The SNAP boot loader uses UART 1 and will transmit data there on power-up. Consuming these pins for another purpose will prevent node recovery in the case of a lost encryption key or similar situation. For more information, consult the SNAP Reference Manual. |
| | GPIO | 20 total; 7 can be analog-in with 10bit ADC |
| **Agency Approvals** | FCC Part 15.247 | FCC ID: U9O-RF220UF1 |
| | Industry Canada (IC) | 7084A-RF220UF1 |

# RF220UF1 Module Pin Definitions

For pin locations, consult the RF220UF1 Mechanical drawing later in this document.

**Table 1.2: RF220UF1 Pin Assignments**

| RF220UF1 Pin | Pin Name | SNAPpy IO | ATmega128RFA1 Pin Name | Pin Description |
|---|---|---|---|---|
| 1 | GND | | GND | Power Supply |
| 2 | GPIO0 | 7 | PB7_OC0A_OC1C_PCINT7 | IO or PWM or Interrupt |
| 3 | GPIO1 | 6 | PB6_OC1B_PCINT6 | IO or PWM or Interrupt |
| 4 | GPIO2 | 5 | PB5_OC1A_PCINT5 | IO or PWM or Interrupt |
| 5 | GPIO3 | 16 | PE0_RXD0_PDI_PCINT8 | IO or UART0 Rx or Interrupt |
| 6 | GPIO4 | 17 | PE1_TXD0 | IO or UART0 Tx |
| 7 | GPIO5 | 20 | PE4_CTS0_OC3B_INT4 | IO or UART0 CTS Output or PWM or Interrupt |
| 8 | GPIO6 | 21 | PE5_RTS0_OC3C_INT5 | IO or UART0 RTS Input or PWM or Interrupt |
| 9 | GPIO7 | 10 | PD2_RXD1_INT2 | IO or UART1 Rx or Interrupt |
| 10 | GPIO8 | 11 | PD3_TXD_INT3 | IO or UART1 Data Out or Interrupt |
| 11 | GPIO9 | 12 | PD4_CTS1_ICP1 | IO or UART1 CTS output or Input Capture |
| 12 | GPIO10 | 23 | PE7_RTS1_ICP3_INT7_CLK0 | IO or UART1 RTS input or Clock Output Buffer or Interrupt |
| 13 | GPIO11 | 24 | PF0_ADC0 | IO or Analog0 |
| 14 | GPIO12 | 25 | PF1_ADC1 | IO or Analog1 or software SPI MOSI |
| 15 | GPIO13 | 26 | PF2_ADC2_DIG2 | IO or Analog2 or software SPI CLK1 or Antenna Diversity Control |
| 16 | GPIO14 | 18 | PE2_XCK0_AIN0 | IO or software SPI1 MISO or Analog Comparator or External Clock |
| 17 | GPIO15 | 28 | PF4_ADC4_TCK | IO or Analog4 or JTAG Test Clock |

| RF220UF1 Pin | Pin Name | SNAPpy IO | ATmega128RFA1 Pin Name | Pin Description |
|---|---|---|---|---|
| 18 | GPIO16 | 29 | PF5_ADC5_TMS | IO or Analog5 or JTAG Test Mode Select |
| 19 | GPIO17 | 30 | PF6_ADC6_TDO | IO or Analog6 or JTAG Test Data Out or software I$^2$C SDA |
| 20 | GPIO18 | 31 | PF7_ADC7_TDI | IO or Analog7 or JTAG Test Data In or software I$^2$C SCL |
| 21 | VCC | | VCC | Power Supply |
| 22 | GPIO19 | 19 | PE3_OC3A_AIN1 | IO or Analog Comparator or PWM or Output Compare Match |
| 23 | RESET# | | RESET# | Module Reset, Active Low |
| 24 | GND | | GND | Power Supply |

# Electrical Characteristics

Unless otherwise specified in this document, all electrical characteristics conform to the Atmel ATmega 128RFA1 microcontroller. Detailed specifications on all electrical characteristics are available on the Atmel website at

http://www.atmel.com/

**Table 1.3: RF220UF1 DC Characteristics at 25° C**

| Symbol | Parameter | Condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| $V_{CC}$[1] | Supply Voltage | | 2.0 | 3.3 | 3.6 | V |

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

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

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[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 rated at 10V directly at the VCC pin.**
[2] **VREFH is programmable to three fixed values; 1.5V, 1.6V, and 1.8V. The VREFH value will be 1.6 volts if you do not explicitly adjust it by poking the ATmega128RFA1 registers.**
[3] **Each differential analog input may be as high as 3.3V but the single-ended voltage is still limited to the voltage reference.**

# Mechanical Drawings

*RF220UF1 Mechanical Drawing* on page *6* and *Block diagram showing the major subsystems comprising Model RF220UF1* on page *7* are for modules with the compact F antenna and U.FL Connector options.

> **NOTE:** For best performance, the module should be mounted on the outside edge of the circuit board with the antenna side as close to the edge of the board as possible.
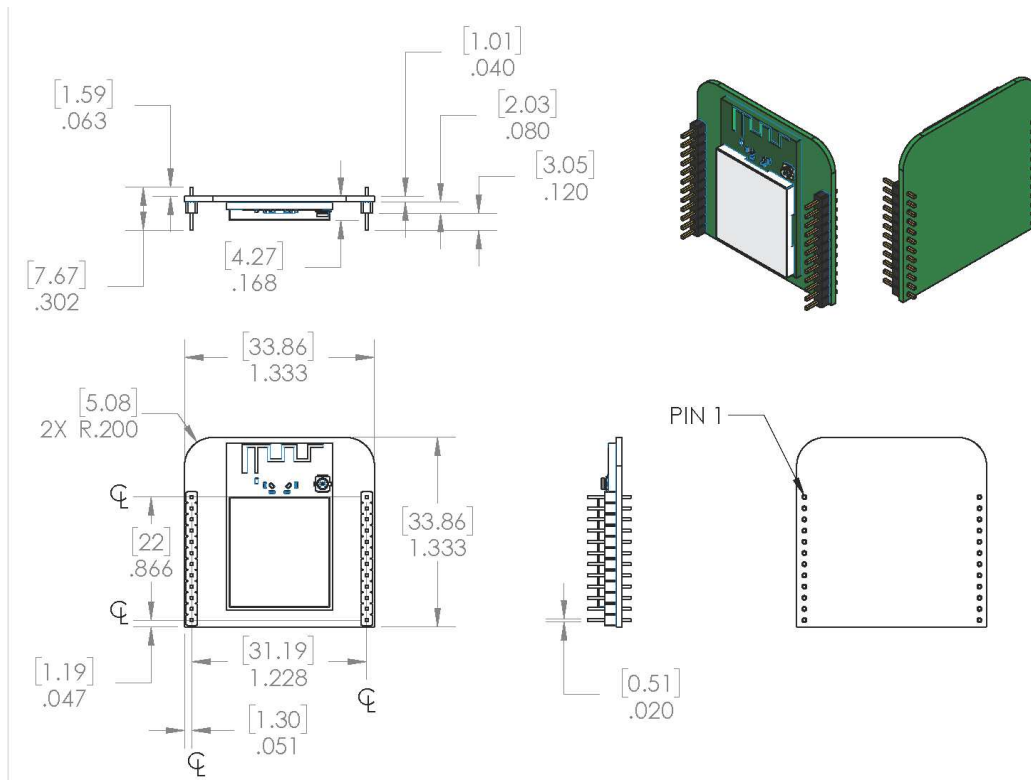


**Figure 1.1: RF220UF1 Mechanical Drawing**

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

**RF220 Module Block Diagram**

Oscillator 16MHz

2.4GHz IEEE 802.15.4

GPIO Pins

Atmel ATmega128RFA1 Microcontroller

Balun

Skyworks SE2431L

LC LP Filter

LC LP Filter

Oscillator 32.768kHz
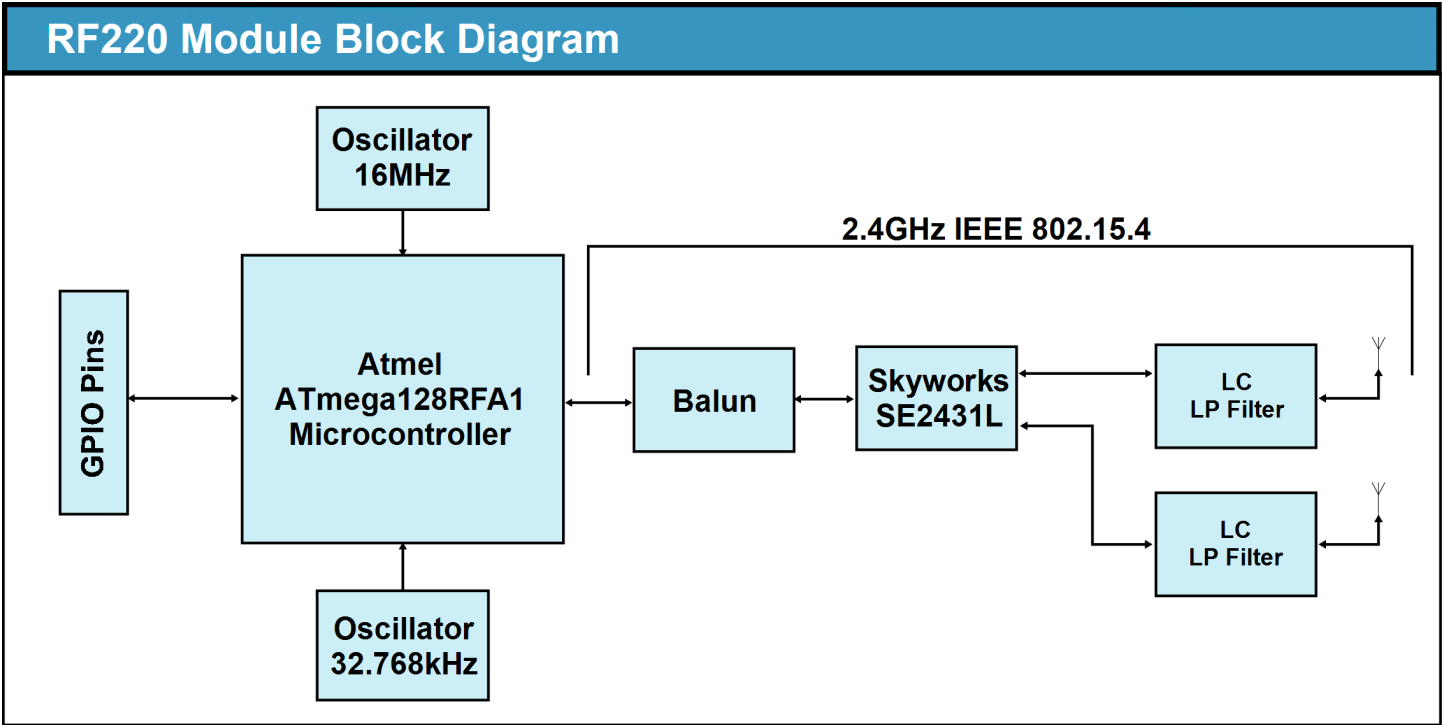
**Figure 1.2: Block diagram showing the major subsystems comprising Model RF220UF1**

## Selecting an Antenna

The RF220UF1 uses the on-board compact F antenna by default. If you wish to use an external U.FL antenna with your application, you will need to set bit 0x0010 of NV ID 64 to 1 and reboot your node. This is a one-time change that will persist through reboots and program changes. To revert to the on-board antenna, change bit 0x0010 of NV ID 64 back to 0 and reboot the node.

## Antenna Gain Performance

**NOTE:** Antenna gain performance information is based on information from the individual companies at the time this document's release. For added assurance, it's best to obtain antenna performance information directly from that antenna's manufacturer.

## HyperLink Technologies HG2405RD-RSP



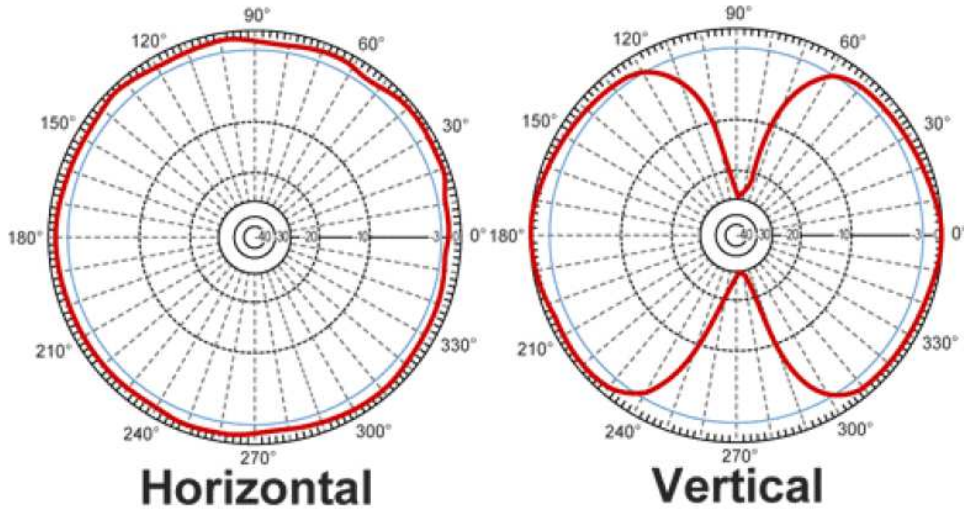**Figure 1.3: HyperLink Technologies HG2405RD-RSP Antenna Gain Performance**

## Pulse W1027
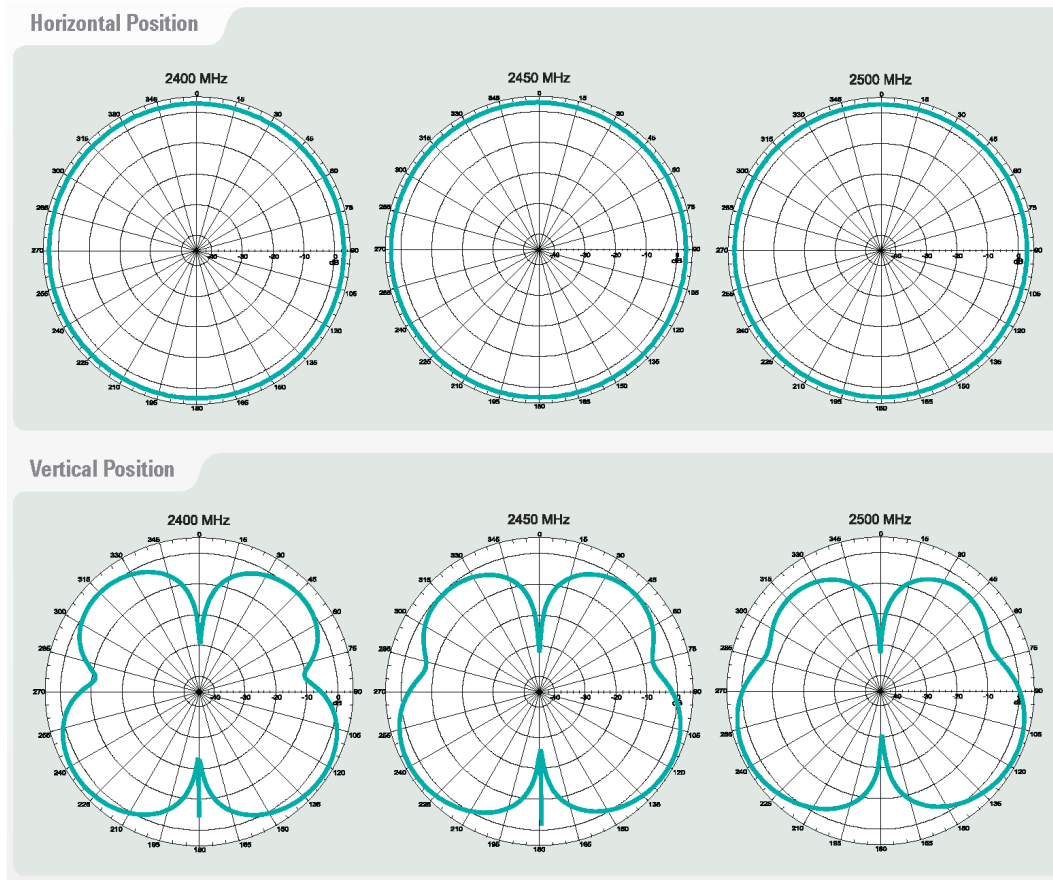


**Figure 1.4: Pulse W1027 Antenna Gain Performance**

# Board Mounting Considerations

## Processing

**Table 1.5: Recommended Reflow Profile**

| Parameter | Value |
|-----------|-------|
| Ramp up rate (from Tsoakmax to Tpeak) | 3º/sec max |
| Minimum Soak Temperature | 150ºC |
| Maximum Soak Temperature | 200ºC |
| Soak Time | 60-120 sec |
| TLiquidus | 217ºC |
| Time above TL | 30-60 sec (recommended: 40 sec) |
| Tpeak | 230º - 250ºC (recommended: 235ºC) |
| Time within 5º of Tpeak | 20-30 sec |
| Time from 25º to Tpeak | 8 min max |
| Ramp down rate | 6ºC/sec max |
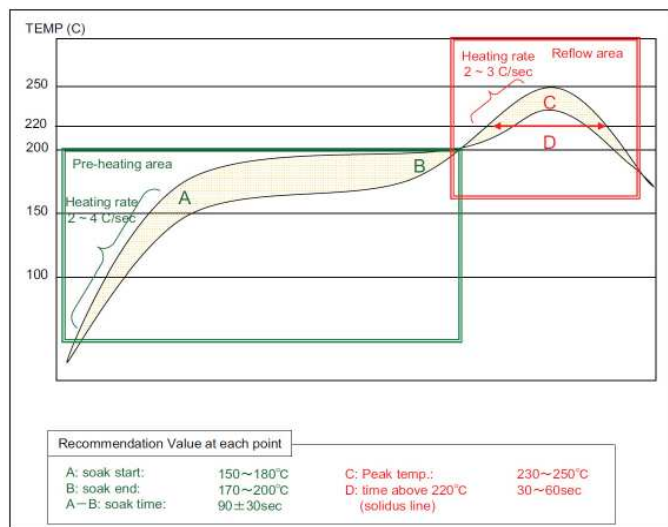


**Figure 1.5: Reflow Profile Graph**

## Additional Grounding

Attempts to improve module or system grounding by soldering braids, wires, or cables onto the module RF shield cover is done at the customer's own risk. The numerous ground pins at the module perimeter should be sufficient for optimum immunity to external RF interference.

# Agency Certifications

## United States (FCC)

The Model RF220 modules comply with Part 15 of the FCC rules and regulations. Compliance with the labeling requirements, FCC not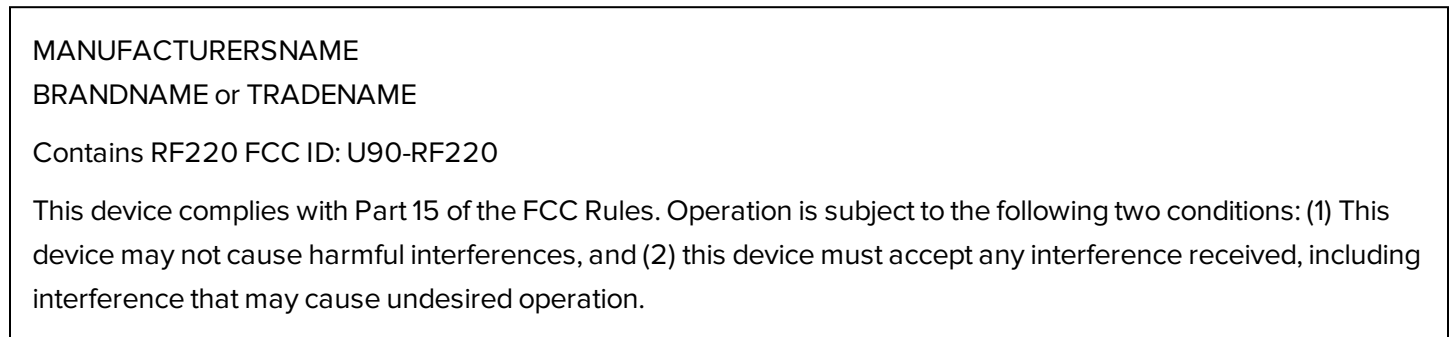ices, and antenna usage guidelines is required. In order to comply with FCC Certification requirements, the Original Equipment Manufacturer (OEM) must fulfill the following requirements.

1. The system integrator must place an exterior label on the outside of the final product housing the RF220 Modules. *FCC Label on page 10* below shows the contents that must be included on this label.
2. RF220 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 *FCC Label on page 10* below.

---

MANUFACTURERSNAME

BRANDNAME or TRADENAME

Contains RF220 FCC ID: U90-RF220

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 1.6: FCC Label**

### FCC Notices

> **WARNING:** The RF220 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 Sections 15.107 and 15.109) before declaring compliance of their final product to Part 15 of the FCC Rules.

**NOTICE:** The RF220 modules have been certified for remote and base radio applications. If the module will be used for portable applications as defined by the FCC, 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.

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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 RF220UF1 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 (EIRP) is not more than that permitted for successful communication. This module has been designed to operate with the antennas listed in *RF220UF1 Approved FCC Antenna on page 11* and *RF220UF1 Approved FCC Antennas on page 11* below. The required antenna impedance is 50 ohms.

**Table 1.6: RF220UF1 Approved FCC Antenna**

| Part Number | Type | Gain | Impedance | Application | Min. Separation |
|---|---|---|---|---|---|
| Compact F Antenna | PC Board Trace Antenna | 0.0 dBi | 50Ω | Fixed/Mobile | 20 cm. |

**Table 1.7: RF220UF1 Approved FCC Antennas**

| Part Number | Type | Gain | Impedance | Application | Min. Separation |
|---|---|---|---|---|---|
| Pulse W1027 | Dipole (quarter-wave RPSMA) | 3.2 dBi | 50Ω | Fixed/Mobile | 20 cm. |
| HyperLink HG2405RD-RSP | Dipole (quarter-wave RPSMA) | 5.5 dBi | 50Ω | Fixed/Mobile | 20 cm. |

For more information on approved antennas, please consult the manufacturer's 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 20 cm 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 (EIRP) 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: RF220UF1, IC: 7084A-RF220UF1 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 : RF220UF1, IC : 7084A-RF220UF1 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 1.8: RF220UF1 Approved IC Antenna**

| Part Number | Type | Gain | Application | Min. Separation |
|---|---|---|---|---|
| Compact F Antenna | PC Board Trace Antenna | 0.0 dBi | Fixed/Mobile | 20 cm. |

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**Table 1.9: RF220UF1 Approved IC Antennas**

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

## IC OEM Labeling Requirements

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 *IC Label on page 13* below.

MANUFACTURERSNAME

BRANDNAME or TRADENAME

MODEL:

Contains RF220 IC: 7084A-RF220

**Figure 1.7: 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 *Combined FCC and IC Label on page 13* below.

MANUFACTURERSNAME
BRANDNAME or TRADENAME

Contains RF220 FCC ID: U9O-RF220
Contains RF220 IC: 7084A-RF220

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 1.8: Combined FCC and IC Label**