REFERENCE GUIDE

Hardware Reference Guide

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

Table of Contents

SNAP Engine RF200 Modules Overview 1
- Specifications 2
- RF Module Pin Compatibility 3
- Electrical Characteristics 4
- Mechanical Drawings 7
- Selecting an Antenna 8
- Antenna Gain Performance 8
  - Pulse W1027 9

Agency Certifications 10
- United States (FCC) 10
  - OEM Labeling Requirements 10
  - FCC Notices 10
  - FCC Approved Antennas 11
- Canada (IC) 12
  - CE Approved Antennas 13
  - IC OEM Labeling Requirements 13
  - OEM Labeling Requirements for the European Union 14

SNAP Engine RF200 Modules Overview 16
- Specifications 18
- Module Pin Definitions 19
- Electrical Characteristics 20
- Mechanical Drawings 22
- Board Mounting Considerations 23
- Selecting an Antenna 24
- Antenna Gain Performance 24
  - Pulse W1027 25

Agency Certifications 26
- United States (FCC) 26
  - OEM Labeling Requirements 26
  - FCC Notices 26
  - FCC Approved Antenna 27
- Canada (IC) 28
  - IC OEM Labeling Requirements 29

SNAP Engine RF220UF1 Modules Overview 30
- Specifications 31
- RF220UF1 Module Pin Definitions 32
- Electrical Characteristics 34
- Mechanical Drawings 35
- Selecting an Antenna 37

Antenna Gain Performance 37
HyperLink Technologies HG2405RD-RSP 37
Pulse W1027 38
Board Mounting Considerations 38
Processing 38
Additional Grounding 39
Agency Certifications 40
United States (FCC) 40
OEM Labeling Requirements 40
FCC Notices 40
FCC Approved Antennas 41
Canada (IC) 42
IC OEM Labeling Requirements 43
SNAP Engine RF220SU Module Overview 45
Specifications 46
RF220SU Module Pin Definitions 47
Electrical Characteristics 49
Mechanical Drawings 49
Selecting an Antenna 51
Antenna Gain Performance 51
HyperLink Technologies HG2405RD-RSP 52
Pulse W1027 52
Agency Certifications 53
United States (FCC) 53
OEM Labeling Requirements 53
FCC Notices 53
FCC Approved Antennas 54
Canada (IC) 55
IC OEM Labeling Requirements 56
SNAP Engine SM200 Modules Overview 57
Specifications 58
Module Pin Definitions 59
Electrical Characteristics 62
Mechanical Drawings 66
Antenna Gain Performance 68
Murata LDA312G4413H-280 68
Pulse W1027 68
Board Mounting Considerations 69
Processing 69
Pb-Free Soldering Paste 70
Cleaning 70
Repeating Reflow Soldering 70

Rework 70
Additional Grounding 70
Packaging **71**
Agency Certifications **72**
United States (FCC) 72
OEM Labeling Requirements 72
FCC Notices 72
FCC Approved Antennas 73
Canada (IC) 73
CE Approved Antennas 74
IC OEM Labeling Requirements 75
OEM Labeling Requirements for the European Union 76
SNAP Engine SM220 Modules Overview **78**
SM220 – Surface Mount Module 79
Form Factor 79
Specifications 80
SM220 Module Pin Definitions 82
Electrical Characteristics 86
Mechanical Drawings 87
Selecting an Antenna 89
Antenna Gain Performance 89
HyperLink Technologies HG2405RD-RSP 90
Pulse W1027 90
Board Mounting Considerations 91
Processing 91
Pb-Free Soldering Paste 92
Cleaning 92
Repeating Reflow Soldering 92
Rework 92
Additional Grounding 92
Packaging **93**
Agency Certifications **94**
United States (FCC) 94
OEM Labeling Requirements 94
FCC Notices 94
FCC Approved Antennas 95
Canada (IC) 96
IC OEM Labeling Requirements 97
SN132 SNAPstick USB Module **99**
Introduction 99
On-Board Indicators 99
USB Interface 100

Powering Options 100
SN171 Prototyping Board 102
On-Board Peripherals List 102
Powering Options 103
On-board LEDs 104
On-board Push-Button 104
RS-232 Port 105
Connectivity Options 106
SNAPstick 220 USB to SNAP Bridge 109
Specifications 109
Discontinued Products 111
RF Engine 100 Series Modules Overview 112
Specifications 113
Module Pin Definitions 114
Electrical Characteristics 115
Mechanical Drawings 116
Board Mounting Considerations 117
Agency Certifications 119
United States (FCC) 119
OEM Labeling Requirements 119
FCC Notices 119
FCC Approved Antennas 120
Canada (IC) 121
OEM Labeling Requirements 122
SNAP Engine 266 Series Modules Overview 125
Specifications 127
Module Pin Definitions 127
Electrical Characteristics 128
Mechanical Drawings 130
Board Mounting Considerations 131
Agency Certifications 133
United States (FCC) 133
OEM Labeling Requirements 133
FCC Notices 133
FCC Approved Antennas 134
Canada (IC) 135
OEM Labeling Requirements 136
SNAP Engine 300 Series Modules Overview 137
Specifications 138
Module Pin Definitions 138
Electrical Characteristics 140

Mechanical Drawings 141
Board Mounting Considerations 142
Agency Certifications 145
United States (FCC) 145
OEM Labeling Requirements 145
FCC Notices 145
FCC Approved Antennas 146
Canada (IC) 147
OEM Labeling Requirements 148
SNAP Engines SM700 Series Modules Overview 149
Specifications 151
Module Pin Definitions 152
Electrical Characteristics 154
Mechanical Drawings 155
Board Mounting Considerations 157
Processing 157
Lead-Free Soldering Paste 158
Cleaning 159
Optical Inspection 159
Repeating Reflow Soldering 159
Wave Soldering 159
Hand Soldering 159
Rework 159
Additional Grounding 160
Agency Certifications 163
United States (FCC) 163
OEM Labeling Requirements 163
FCC Notices 163
FCC Approved Antennas 164
Canada (IC) 164
SNAPstick 200 Wireless Adapter 166
Troubleshooting the SNAPstick 200 167
Signal Strength Problems 167
Poor Performance 168
Evaluation Kit – SN111 End Device Demonstration Board 169
Power to the SN111 End Device 170
Power Adapter 170
Battery 170
External Power LED Indicator 171
Power On/Off Switch 171
User I/O 172
Reset Button 172
User Status LED Indicator 172

2-Digit Display 172
External Port Interfaces 172
RS-232 Interface 172
External I/O 173
Relay Switch 173
Sensor Input 174
Evaluation Kit – SN163 Bridge Demonstration Board 177
Power to the SN163 Bridge 177
Power Adapter 178
USB Power 178
Battery 178
External Power LED Indicator 179
Power On/Off Switch 179
User I/O 179
Reset Button 179
User Select Button 179
User Status LED Indicator 179
2-Digit Display 180
External Port Interfaces 180
RS-232 Interface 180
USB Interface 180

SNAP Engine RF200 Modules Overview

The SNAP Engine Model RF200 series includes the RF200P81 and RF200PU1 part numbers. They are IEEE 802.15.4, low-power, highly reliable solutions to embedded wireless control and monitoring network needs that require high data rates. The Model 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 2Mbits/sec. These low-cost modules can have current consumption as low as 0.37 µA 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 Model RF200 modules are approved as an FCC Part 15 unlicensed modular transmitters, as well as having CE Certification and IC Certification. The modules provide up to 16 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 SNAP networks can exist within the same area through configuration options outlined in the SNAP User Guide available from www.synapse-wireless.com.

Data Sheet covers Part Numbers RF200P81 and RF200PU1:

- 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:
  - 0.37 µA with external interrupt
  - 1.37 µA with internal timer running
- Spread Spectrum (DSSS) technology
- Up to 2 Mbps radio data rate
- 2.4 GHz RF Frequency
- AES 128-bit encryption

- Integrated chip antenna or U.FL connecter
- Solder-able or socket-able
- 4K internal EEPROM
- 6 PWM outputs

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

Specifications

Table 1: RF200 Specifications at 25° C and 3.3V unless otherwise noted

Performance	Outdoor LOS Range	Up to 1500/2500 feet at 250Kbps
	Transmit Power Output	3 dBm
	RF Data Rate	250Kbps, 500Kbps, 1Mbps, 2Mbps
	Receiver Sensitivity	-100 dBm (1% PER, 250Kbps)
Power Requirements	Supply Voltage	1.8 - 3.6 V
	Transmit Current (Typ@3.3V)	22.5 mA
	Idle/Receive Current (Typ@3.3V)	20.5 mA
	Power-down Current (Typ@3.3V)	0.37 µA
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	Integrated Chip Antenna / External Antenna
Networking	Topology	SNAP
	Error Handling	Retries and acknowledgement
	Number of Channels	16
Available I/O	UARTS with HW Flow Control	2 Ports
	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 Certified	Certified to EN300 328 Version 1.8.1

RF Module Pin Compatibility

Table 2: RF200P81/PU1 Pin Assignments

RF200 Pin	Name	SNAPpy IO	Description
1	GND		Power Supply
2	GPIO0/OC0A/OC1C/PCINT7/PB7	7	GPIO_0, PWM, or Interrupt
3	GPIO1/OC1B/PCINT6/PB6	6	GPIO_1, PWM, or Interrupt
4	GPIO2/OC1A/PCINT5/PB5	5	GPIO_2, PWM, or Interrupt
5	GPIO3/RXD0/PCINT8/PE0	16	GPIO_3, Interrupt, or UART0 Data Input
6	GPIO4/TXD0/PE1	17	GPIO_4, UART0 Data Output
7	GPIO5/OC3B/INT4/PE4	20	GPIO_5, PWM, Interrupt, or UART0 CTS Output
8	GPIO6/OC3C/INT5/PE5	21	GPIO_6, PWM, Interrupt, or UART0 RTS Input
9	GPIO7/RXD1/INT2/PD2	10	GPIO_7, Interrupt, or UART1 Data Input
10	GPIO8/TXD1/INT3/PD3	11	GPIO_8, Interrupt, or UART1 Data Output
11	GPIO9/ICP1/PD4	12	GPIO_9, or UART1 CTS Output
12	GPIO10/ICP3/INT7/CLK0/PE7	23	GPIO_10, Interrupt, Clock Output, or UART1 RTS Input
13	GPIO11/ADC0/PF0	24	GPIO_11, or Analog In
14	GPIO12/ADC1/P81	25	GPIO_12, SPI MOSI, or Analog In
15	GPIO13/ADC2/DIG2/PF2	26	GPIO_13, SPI SCLK, Antenna Diversity, or Analog In
16	GPIO14/XCK0/AIN0/PE2	18	GPIO_14, SPI MISO, USART CLK, Analog Comparator
17	GPIO15/ADC4/TCK/PF4	28	GPIO_15, JTAG TCK, or Analog In
18	GPIO16/ADC5/TMS/PF5	29	GPIO_16, JTAG TMS, or Analog In

RF200 Pin	Name	SNAPpy IO	Description
19	GPIO17/ADC6/TDO/PF6	30	GPIO_17, JTAG TDO, I^2C SDA, or Analog In
20	GPIO18/ADC7/TDI/PF7	31	GPIO_18, JTAG TDI, I^2C SCL, or Analog In
21	VCC		Power Supply
22	GPIO19/OC3A/AIN1/PE3	19	GPIO_19, PWM, Analog Comparator
23	RESET		Module Reset, Active Low
24	GND		Power Supply

You must preserve access to UART1 as a serial connection in order to be able to serially update firmware on the node, or to recover the node by forced script removal or parameter reset.

Electrical Characteristics

Table 3: RF200 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	0.7 V_{CC}			V
V_{IL}	Input Low Voltage	All Digital Inputs			0.3 V_{CC}	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
IL_{IN}	In Leakage Current	V_{IN} =V_{CC} or V_{SS} , all Pins		<10nA	1	µA

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.

Symbol	Parameter	Condition	Min	Typ	Max	Units
TX-I_{CC}	Transmit Current - Transceiver only	V_{CC} = 3.3V P_{TX} =3dBm		14.5		mA
	Transmit Current - Transceiver and CPU			22.5		mA
RX-I_{CC}	Receive Current - Transceiver only	V_{CC} = 3.3V		12.5[2]		mA
	Receive Current - Transceiver and CPU			20.5[2]		mA
SHDN- I_{CC}	Sleep Current	V_{CC} = 3.3V		0.37		µA

Table 4: ADC Electrical Characteristics (Operating)

Symbol	Parameter	Condition	Min	Typical	Max	Unit
V_{REFH}[3]	ADC Voltage Reference, High	Programmable	1.5	1.6	1.8	V
V_{INDC}	Analog input voltage	Single Ended	0		1.8	V
		Differential[4]	0		3.3	

Table 5: ADC Timing/Performance Characteristics

Symbol	Parameter	Condition	Min	Typical	Max	Unit
R_{AS}	Source impedance at input[5]				3k	kΩ
RES	Conversion Resolution	Single Ended CLKADC <= 4MHz		10		Bits

2 2.4 GHz transceiver current only. Does not include current required to run CPU.
3 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.
4 Each differential analog input may be as high as 3.3V but the single-ended voltage is still limited to the voltage reference.
5 Any analog source with a source impedance greater than 3kΩ will increase the sampling time.

Symbol	Parameter	Condition	Min	Typical	Max	Unit
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

Table 6: Reset, Brown-out and Internal Voltage Characteristics

Symbol	Parameter	Condition	Min	Typical	Max	Unit
$V_{POT\ (rising)}$	Power-on Reset Threshold Voltage (rising)	Power supply fully discharged		1.6		V
$V_{POT\ (falling)}$	Power-on Reset Threshold Voltage (falling)		0.05	0.3		V
t_{POT}	Power-on Reset recovery time	Time of EVDD/DEVDD < V_{POT}	1.0			ms
V_{PSR}	Power-on slope rate		1.8		3300	V/ms
V_{RST}	RSTN Pin Threshold Voltage		$0.1V_{DD}$		$0.9\ V_{DD}$	V
t_{RST}	Minimum pulse width on RSTN Pin			200	300	ns
V_{HYS}	Brown-out Detector Hysteresis			7.5	50	mV
t_{BOD}	Min Pulse Width on Brown-out Reset			100		ns

Mechanical Drawings

The drawings in **RF200P81/PU1 Mechanical Drawing** on page **7**. show the modules with the option of the integrated chip antenna or U.FL Connector.

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.

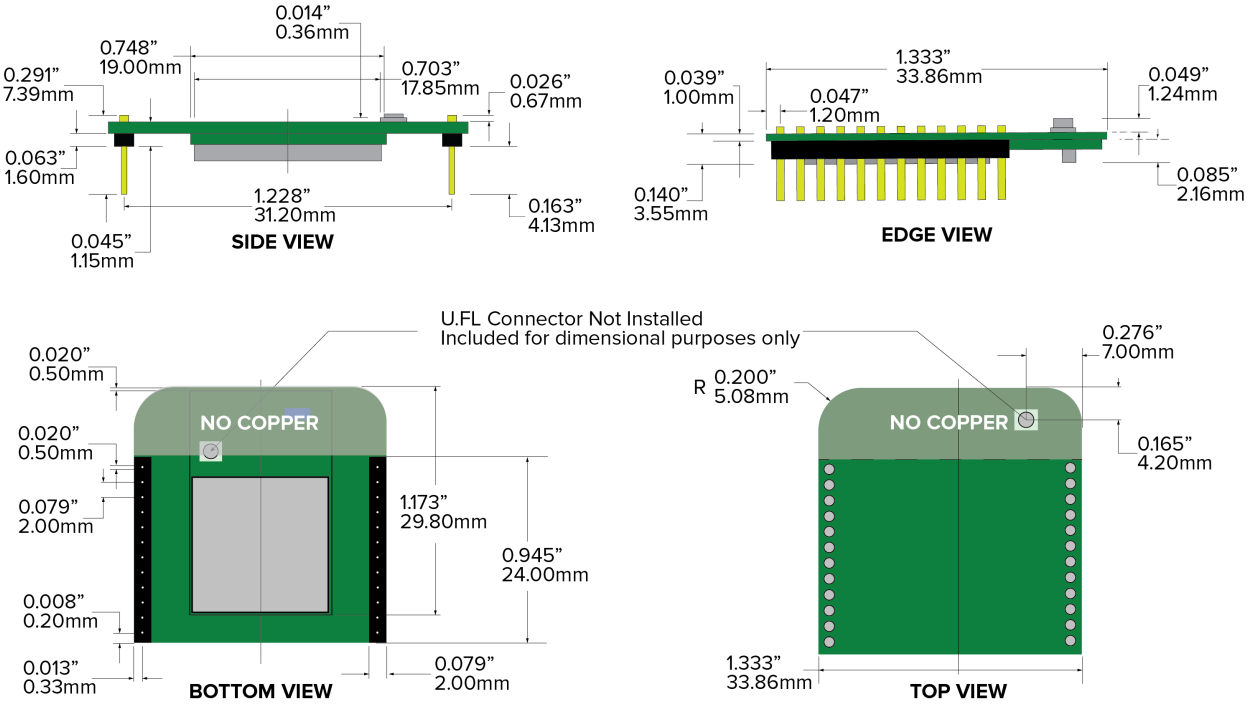


Figure 1: RF200P81/PU1 Mechanical Drawing

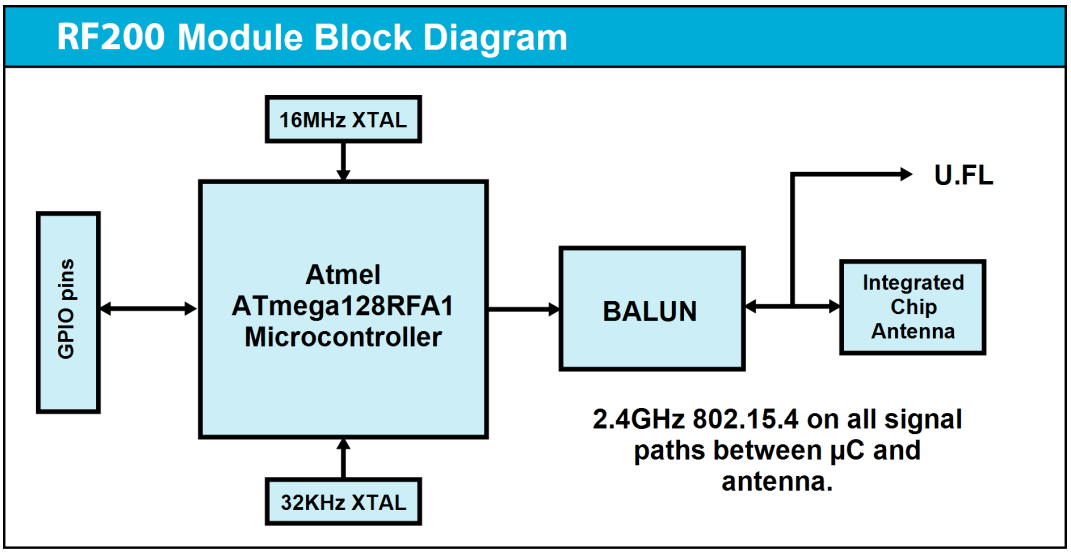


Figure 2: Block diagram showing the major subsystems comprising Model RF200

Selecting an Antenna

The RF200 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. 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.

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.

Pulse W1027

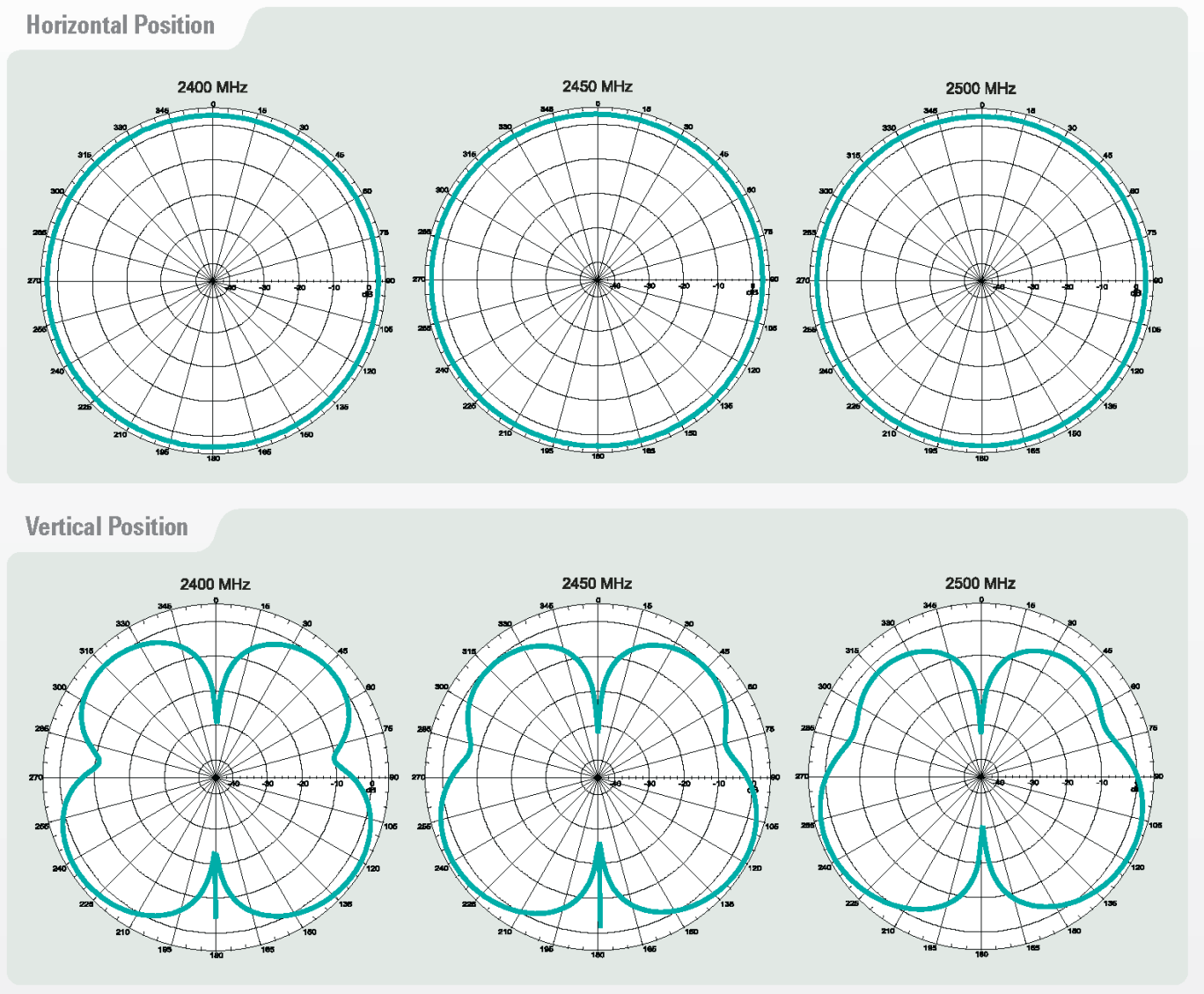


Figure 3: Pulse W1027 Antenna Gain Performance

Agency Certifications

United States (FCC)

The Model RF200 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. **FCC Label** on page **10**. below shows the contents that must be included on 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 **FCC Label** on page **10**. 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 4: 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 Sections 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 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.

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 (EIRP) is not more than that permitted for successful communication. This module has been designed to operate with the antennas listed in **RF200 Approved FCC Antenna** on page **11**. and **RF200 Approved FCC Antenna** on page **11**. . The required antenna impedance is 50 ohms..

Table 7: RF200 Approved FCC Antenna

Part Number	Type	Gain	Application	Min. Separation
Murata LDA312G4413H-280	Chip	-2.3 dBi	Fixed/Mobile	20 cm.

Table 8: RF200 Approved FCC Antenna

Part Number	Type	Gain	Application	Min. Separation
Pulse W1027	Dipole (quarter-wave RPSMA)	3.2 dBi	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 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 (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: 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 9: RF200 Approved IC Antenna

Part Number	Type	Gain	Application	Min. Separation
Murata LDA312G4413H-280	Chip	-2.3 dBi	Fixed/Mobile	20 cm.

Table 10: RF200 Approved IC Antenna

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

CE Approved Antennas

The RF200 modules are CE-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 **RF200 Approved FCC Antenna** on page **11**. and **RF200 Approved FCC Antenna** on page **11**. below. The required antenna impedance is 50 ohms.

Table 11: RF200 Approved FCC Antenna

Part Number	Type	Gain	Application	Min. Separation
Murata LDA312G4413H-280	Chip	-2.3 dBi	Fixed/Mobile	20 cm.

Table 12: RF200 Approved FCC Antenna

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

For more information on approved antennas, please consult the manufacturer's website.

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.

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 **14**. below.

MANUFACTURERSNAME
BRANDNAME or TRADENAME
MODEL:

Contains RF200 IC: 7084A-RF200

Figure 5: 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 **14**. 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 6: Combined FCC and IC Label

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.

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 **Combined FCC, CE and IC Label** on page **15**. .

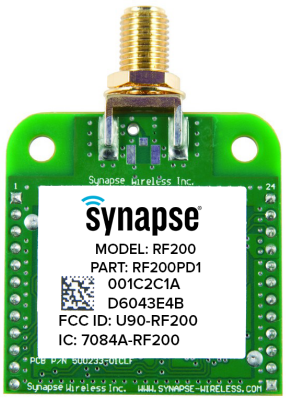
MANUFACTURERSNAME
BRANDNAME or TRADENAME

Contains RF200 FCC ID: U9O-RF200
Contains RF200 IC: 7084A-RF200
CE

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 7: Combined FCC, CE and IC Label

SNAP Engine RF200 Modules Overview



The SNAP Engine Model RF200 Series 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 2Mbits/sec. These low-cost modules can have a range of up to three miles and current consumption as low as 1.6 µA 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.

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.

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
- Low power modes: 1.6 µA with internal timer running
- Spread spectrum (DSSS) technology
- 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 (0.5 miles LoS at 250Kbps)
- Solder-able or socket-able

- 4K internal EEPROM
- 6 PWM outputs

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

Specifications

Table 1: RF200PD1/RF200PF1 Specifications at 25° C and 3.3V unless otherwise noted

Performance	Outdoor LOS Range	RF200PD1: Up to 3 miles at 250Kbps
		RF200PF1: Up to 0.5 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 Certified	Certified to EN300 328 Version 1.8.1

Module Pin Definitions

Table 2: RF200PD1 / RF200PF1 Module Pin Assignments

Pin	SNAPpy IO	Name	Description
1		GND	Power Supply
2	7	GPIO0/OC0A/OC1C/PCINT7/PB7	GPIO_0, PWM, or Interrupt
3	6	GPIO1/OC1B/PCINT6/PB6	GPIO_1, PWM, or Interrupt
4	5	GPIO2/OC1A/PCINT5/PB5	GPIO_2, PWM, or Interrupt
5	16	GPIO3/RXD0/PCINT8/PE0	GPIO_3, Interrupt, or UART0 Data Input
6	17	GPIO4/TXD0/PE1	GPIO_4, UART0 Data Output
7	20	GPIO5/OC3B/INT4/PE4	GPIO_5, PWM, Interrupt, or UART0 CTS Output
8	21	GPIO6/OC3C/INT5/PE5	GPIO_6, PWM, Interrupt, or UART0 RTS Input
9	10	GPIO7/RXD1/INT2/PD2	GPIO_7, Interrupt, or UART1 Data Input
10	11	GPIO8/TXD1/INT3/PD3	GPIO_8, Interrupt, or UART1 Data Output
11	12	GPIO9/ICP1/PD4	GPIO_9, or UART1 CTS Output
12	23	GPIO10/ICP3/INT7/CLK0	GPIO_10, Interrupt, Clock Output, or UART1 RTS Input
13	24	GPIO11/ADC0/PF0	GPIO_11, or Analog In
14	25	GPIO12/ADC1/PF1	GPIO_12, SPI MOSI, or Analog In
15	26	GPIO13/ADC2/DIG2/PF2	GPIO_13, SPI SCLK, Antenna Diversity, or Analog In
16	18	GPIO14/XCK0/AIN0/PE2	GPIO_14, SPI MISO, USART CLK, Analog Comparator
17	28	GPIO15/ADC4/TCK/PF4	GPIO_15, JTAG TCK, or Analog In
18	29	GPIO16/ADC5/TMS/PF5	GPIO_16, JTAG TMS, or Analog In
19	30	GPIO17/ADC6/TDO/PF6	GPIO_17, JTAG TDO, I^2C SDA, or Analog In
20	31	GPIO18/ADC7/TDI/PF7	GPIO_18, JTAG TDI, I^2C SCL, or Analog In
21		VCC	Power Supply
22	19	GPIO19/OC3A/AIN1/PE3	GPIO_19, PWM, Analog Comparator
23		RESET	Module Reset, Active Low
24		GND	Power Supply

You must preserve access to UART1 as a serial connection in order to be able to serially update firmware on the node, or to recover the node by forced script removal or parameter reset.

Electrical Characteristics

Table 3: RF200PD1 / RF200PF1 DC Characteristics at 25° C

Symbol	Parameter	Condition	Min	Typ	Max	Units
V_{CC} [6]	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	0.7 V_{CC}			V
V_{IL}	Input Low Voltage	All Digital Inputs			0.3 V_{CC}	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
IL_{IN}	In Leakage Current	V_{IN}=V_{CC} or V_{SS}, all Pins			TBD	µA
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		µA

Table 4: ADC Electrical Characteristics (Operating)

Symbol	Parameter	Condition	Min	Typical	Max	Unit
V_{REFH} [7]	ADC Voltage Reference, High	Programmable	1.5	1.6	1.8	V
V_{INDC}	Analog input voltage	Single Ended	0		1.8	V
		Differential [8]	0		3.3	

6 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.
7 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.
8 Each differential analog input may be as high as 3.3V but the differential voltage is still limited.

Table 5: ADC Timing/Performance Characteristics

Symbol	Parameter	Condition	Min	Typical	Max	Unit
R_{AS}	Source impedance at input[9]				3k	kΩ
RES	Conversion Resolution	Single Ended CLKADC <= 4MHz		10		Bits
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

Table 6: Reset, Brown-out and Internal Voltage Characteristics

Symbol	Parameter	Condition	Min	Typical	Max	Unit
$V_{POT\ (rising)}$	Power-on Reset Threshold Voltage (rising)	Power supply fully discharged		1.6		V
$V_{POT\ (falling)}$	Power-on Reset Threshold Voltage (falling)		0.05	0.3		V
t_{POT}	Power-on Reset recovery time	Time of EVDD/DEVDD < V_{POT}	1.0			ms
V_{PSR}	Power-on slope rate		1.8		3300	V/ms
V_{RST}	RSTN Pin Threshold Voltage		$0.1V_{DD}$		$0.9\ V_{DD}$	V
t_{RST}	Minimum pulse width on RSTN Pin			200	300	ns

9 Any analog source with a source impedance greater than 3kΩ will increase the sampling time.

Symbol	Parameter	Condition	Min	Typical	Max	Unit
V_{HYS}	Brown-out Detector Hysteresis			7.5	50	mV
t_{BOD}	Min Pulse Width on Brown-out Reset			100		ns

Mechanical Drawings

These drawings in **Mechanical drawings of the RF200PD1 and RF200PF1 Modules** on page **22**. 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.

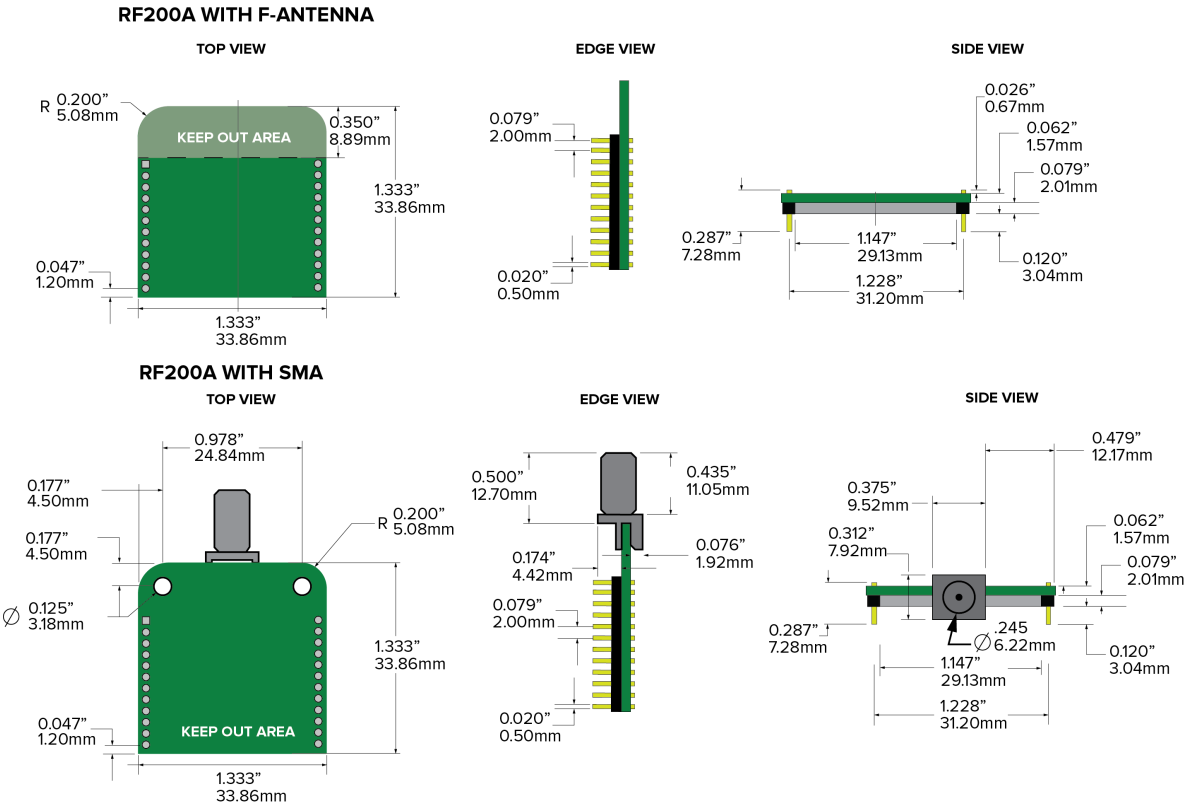


Figure 1: Mechanical drawings of the RF200PD1 and RF200PF1 Modules

Board Mounting Considerations

The RF200PD1 and RF200PF1 modules are designed to mount into a receptacle (socket) on the host board. **RF200PD1 Mounted To Host Board** on page **23**. shows an RF200PD1 module plugged into 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. **RF200PD1 Mounted To Host Board** on page **23**. shows the RF200PD1 with SMA connector mounted to the host board.

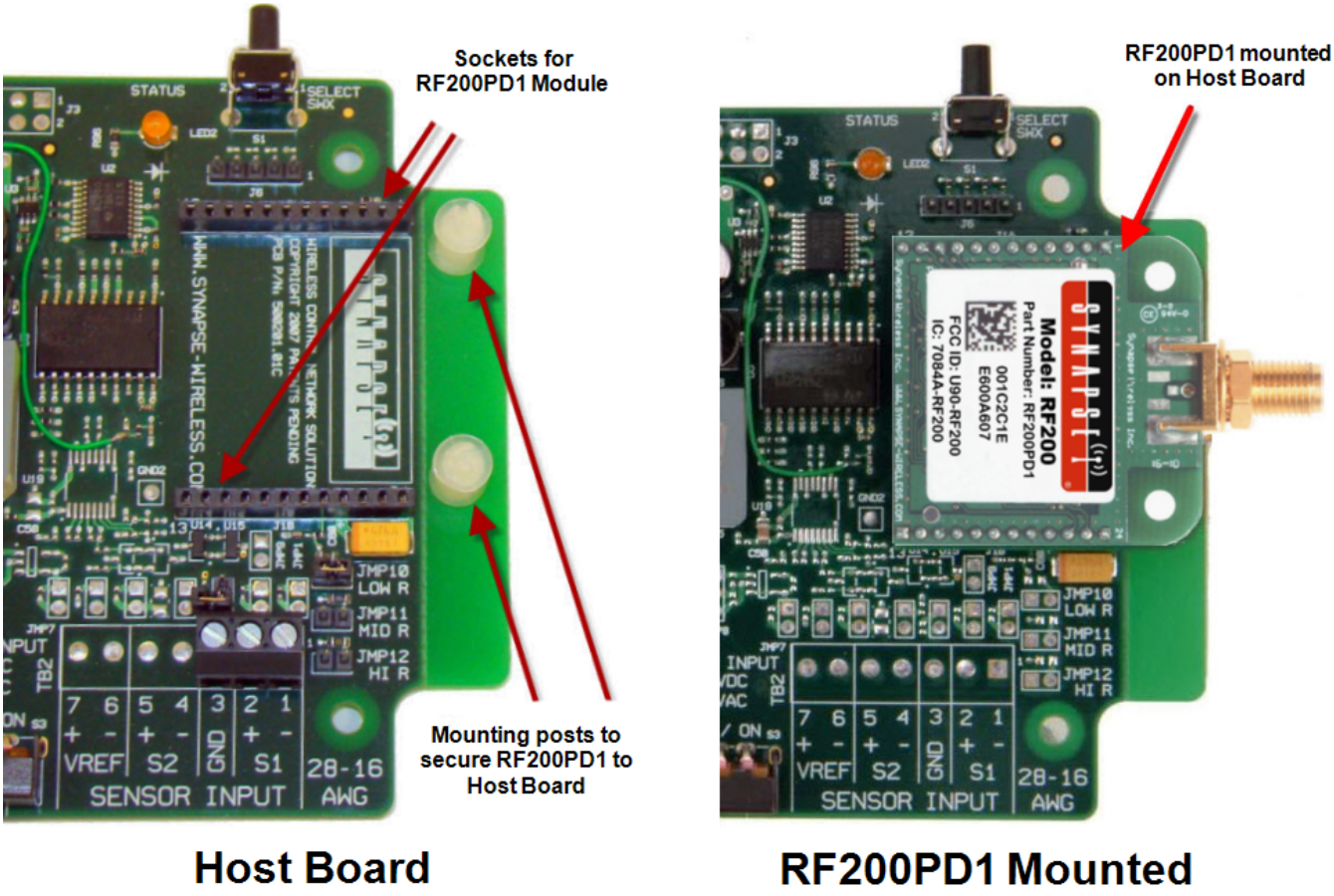


Figure 2: RF200PD1 Mounted To Host Board

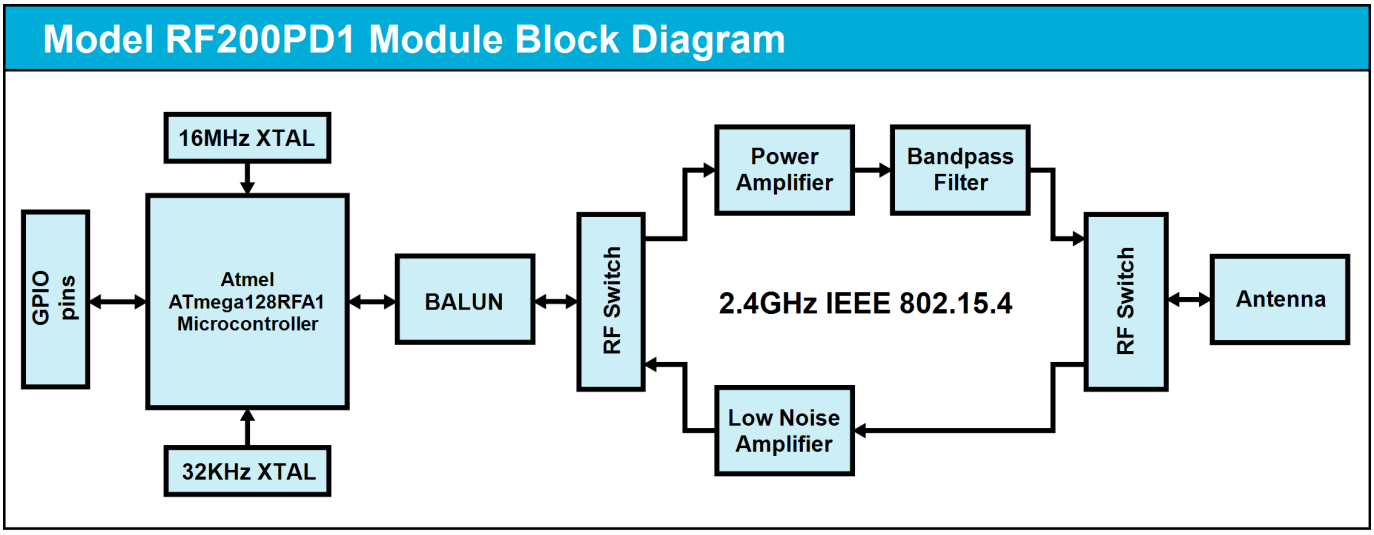


Figure 3: Block diagram showing the major subsystems comprising the RF200

Selecting an Antenna

The RF200 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. 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.

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.

Pulse W1027

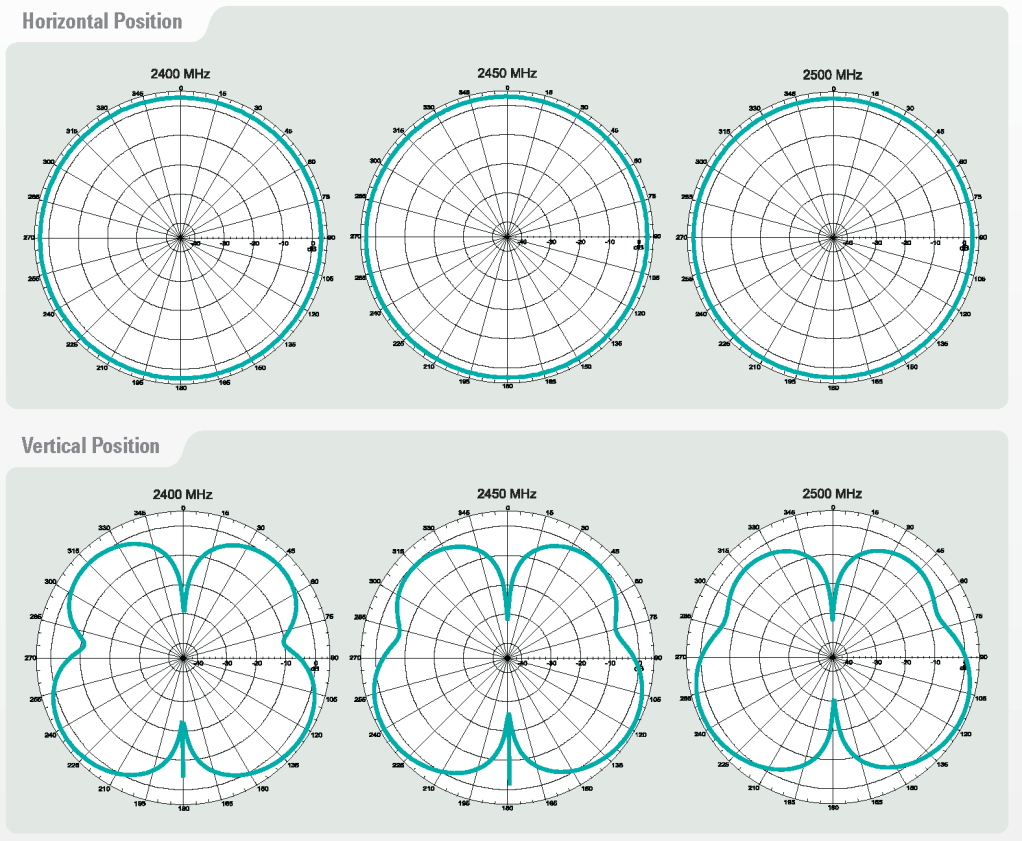


Figure 4: Pulse W1027 Antenna Gain Performance

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 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. **FCC Label** on page **26**. below shows the contents that must be included on 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 **FCC Label** on page **26**. 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 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 Sections 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 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.

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 Antenna

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 (EIRP) is not more than that permitted for successful communication. The RF200PD1 module has been designed to operate with the antenna listed below in **RF200 Approved FCC Antenna** on page **27**. . The required antenna impedance is 50 ohms. The RF200PF1 has a built-in F-antenna.

Table 1: RF200 Approved FCC Antenna

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

For more information on the approved antenna, 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 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 (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: 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: RF200 Approved IC Antenna

Part Number	Type	Gain	Application	Min. Separation
Pulse W1027	Dipole (quarter-wave RPSMA)	3.2 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 **29**. below.

MANUFACTURERSNAME
BRANDNAME or TRADENAME
MODEL:

Contains RF200 IC: 7084A-RF200

Figure 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 **Combined FCC and IC Label** on page **29**. 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 3: Combined FCC and IC Label

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

Performance	Outdoor LOS Range	3 miles using u.fl antenna .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 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 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 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
	CE Certified	Certified to EN300 328 Version 1.8.1

RF220UF1 Module Pin Definitions

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

Table 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

RF220UF1 Pin	Pin Name	SNAPpy IO	ATmega128RFA1 Pin Name	Pin Description
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
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^2C SDA
20	GPIO18	31	PF7_ADC7_TDI	IO or Analog7 or JTAG Test Data In or software I^2C 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 3: RF220UF1 DC Characteristics at 25° C

Symbol	Parameter	Condition	Min	Typ	Max	Units
V_{CC}[10]	Supply Voltage		2.0	3.3	3.6	V

Table 4: ADC Electrical Characteristics (Operating)

Symbol	Parameter	Condition	Min	Typical	Max	Unit
V_{REFH}[11]	ADC Voltage Reference, High	Programmable	1.5	1.6	1.8	V
V_{INDC}	Analog input voltage	Single Ended	0		1.8	V
		Differential[12]	0		3.3	

Mechanical Drawings

RF220UF1 Mechanical Drawing on page **36**. and **Block diagram showing the major subsystems comprising Model RF220UF1** on page **37**. 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.

10 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.
11 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.
12 Each differential analog input may be as high as 3.3V but the single-ended voltage is still limited to the voltage reference.

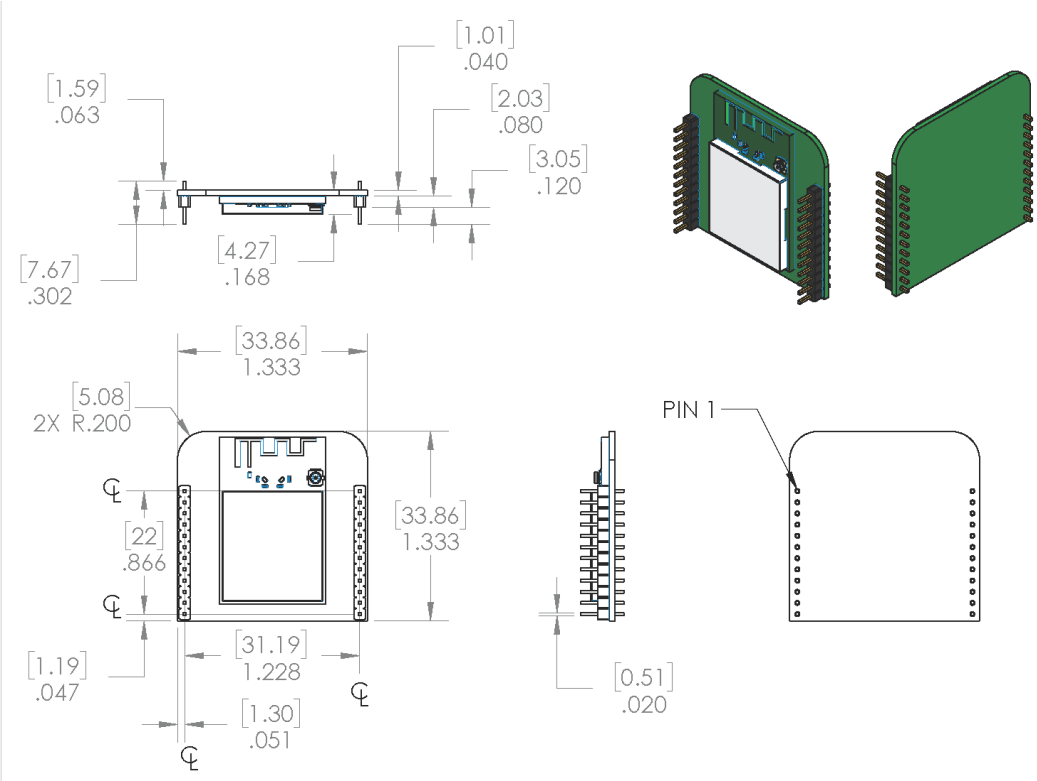


Figure 1: RF220UF1 Mechanical Drawing

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.

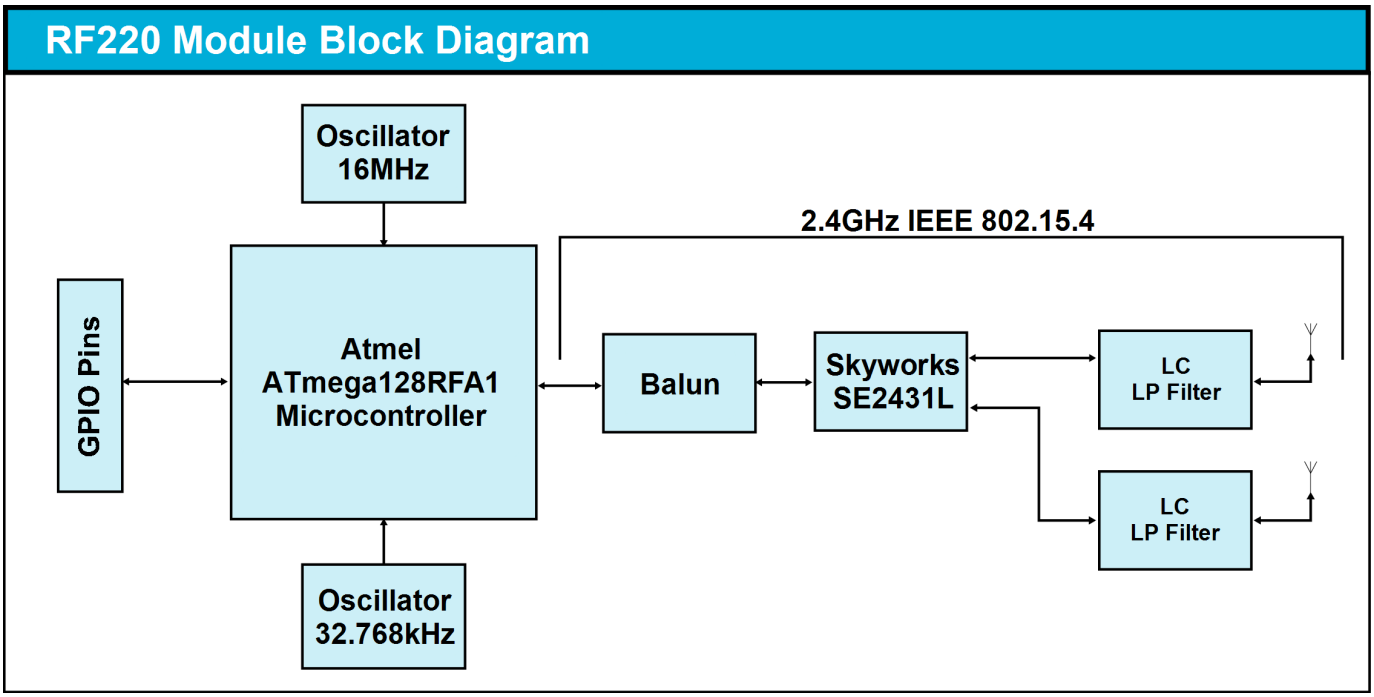


Figure 2: Block diagram showing the major subsystems comprising Model RF220UF1

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

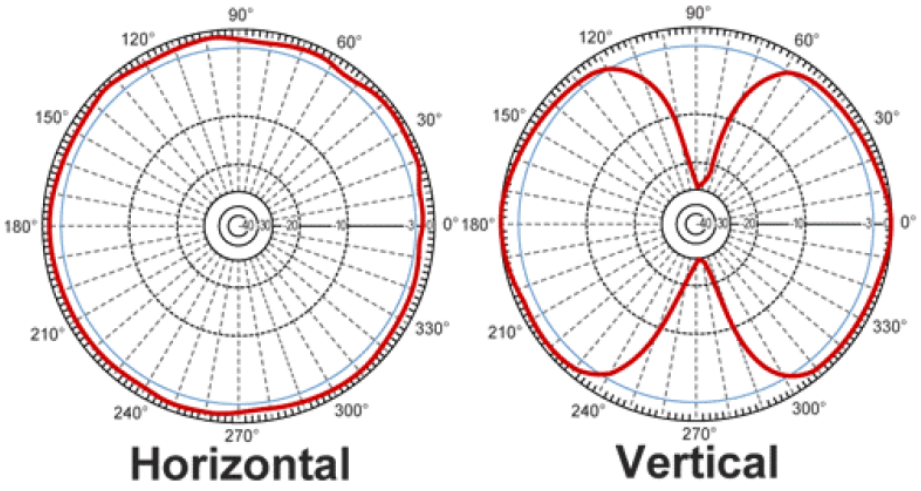


Figure 3: HyperLink Technologies HG2405RD-RSP Antenna Gain Performance

Pulse W1027

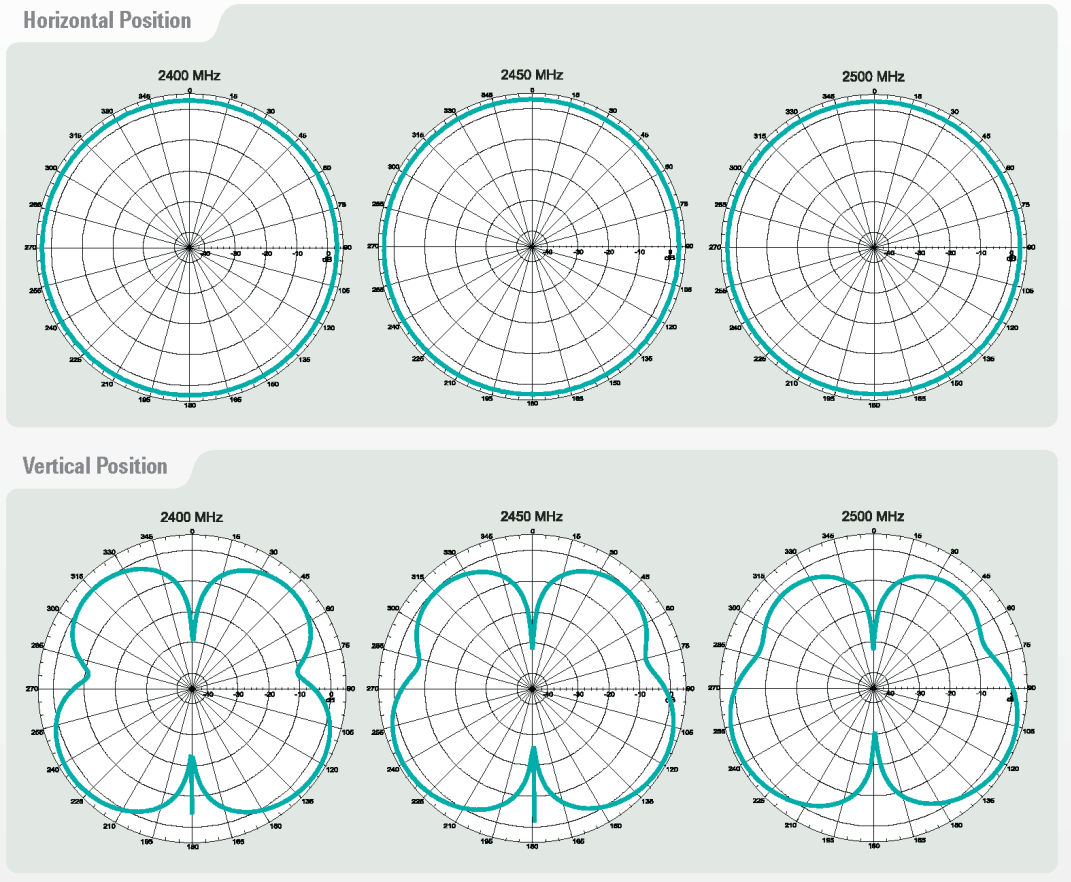


Figure 4: Pulse W1027 Antenna Gain Performance

Board Mounting Considerations

Processing

Table 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

Parameter	Value
Time from 25º to Tpeak	8 min max
Ramp down rate	6ºC/sec max

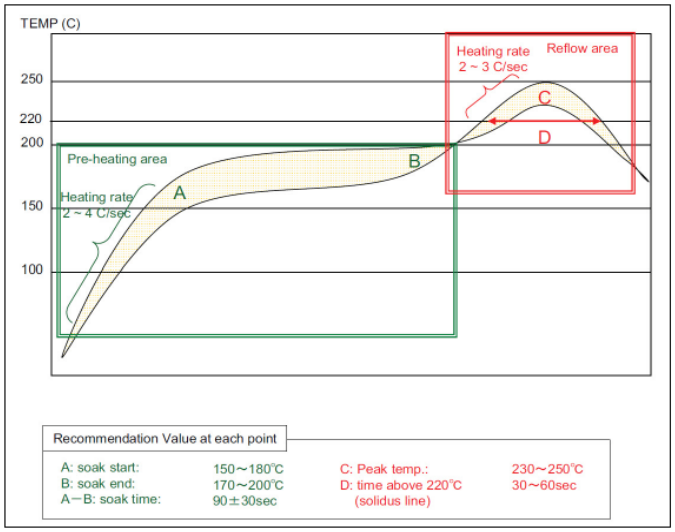


Figure 5: Reflow Profile Graph

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 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 RF220 Modules. **FCC Label** on page **40**. 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 **40**. 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 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.

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 **41**. and **RF220UF1 Approved FCC Antennas** on page **41**. below. The required antenna impedance is 50 ohms.

Table 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 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 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.

Table 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 **43**. below.

MANUFACTURERSNAME
BRANDNAME or TRADENAME
MODEL:

Contains RF220 IC: 7084A-RF220

Figure 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 **44**. below.

MANUFACTURERSNAME
BRANDNAME or TRADENAME

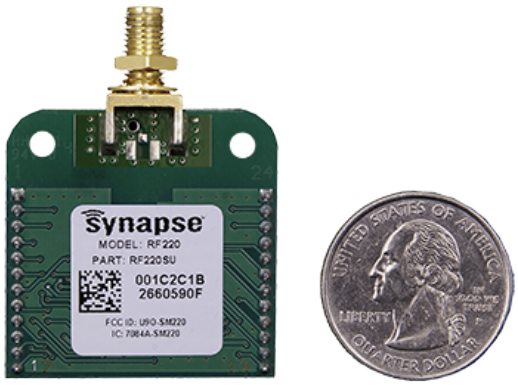
Contains RF220 FCC ID: U9O-RF220
Contains RF220 IC: 7084A-RF220

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 8: Combined FCC and IC Label

SNAP Engine RF220SU Module Overview

The **SNAP Engine Model RF220SU** is an IEEE 802.15.4, low-power, highly reliable solution for embedded wireless control and monitoring networks.



The **RF220SU** 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 **RF220SU** 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. 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 RF220SU :

- 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
- RP-SMA 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: RF220SU Specifications at 23° C and 3.3V unless otherwise noted

Performance	Outdoor LOS Range	Up to 3 miles at 250 Kbps using a 5.5dBi 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 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 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 RP-SMA
	Weight	9 grams
Networking	Topology	SNAP
	Error Handling	Retries and acknowledgement
	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
	GPIO	20 total; 7 can be analog-in with 10bit ADC
Agency Approvals	FCC Part 15.247	U9O-RF220SU
	Industry Canada (IC)	7084A-RF220SU

RF220SU Module Pin Definitions

For pin locations, consult **RF220SUMechanical Drawing** on page **50**. later in this document.

Table 2: RF220SU Pin Assignments

RF220SU 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

RF220SU Pin	Pin Name	SNAPpy IO	ATmega128RFA1 Pin Name	Pin Description
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
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^2C SDA

RF220SU Pin	Pin Name	SNAPpy IO	ATmega128RFA1 Pin Name	Pin Description
20	GPIO18	31	PF7_ADC7_TDI	IO or Analog7 or JTAG Test Data In or software I^2C 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 3: RF220SU DC Characteristics at 25° C

Symbol	Parameter	Condition	Min	Typ	Max	Units
V_{CC}[13]	Supply Voltage		2.0	3.3	3.6	V

Table 4: ADC Electrical Characteristics (Operating)

Symbol	Parameter	Condition	Min	Typical	Max	Unit
V_{REFH}[14]	ADC Voltage Reference, High	Programmable	1.5	1.6	1.8	V
V_{INDC}	Analog input voltage	Single Ended	0		1.8	V
		Differential[15]	0		3.3	

Mechanical Drawings

RF220SUMechanical Drawing on page **50**. and **Block diagram showing the major subsystems comprising Model RF220SU** on page **51**. are for modules with the compact F antenna and U.FL Connector options.

13 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.
14 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.
15 Each differential analog input may be as high as 3.3V but the single-ended voltage is still limited to the voltage reference.

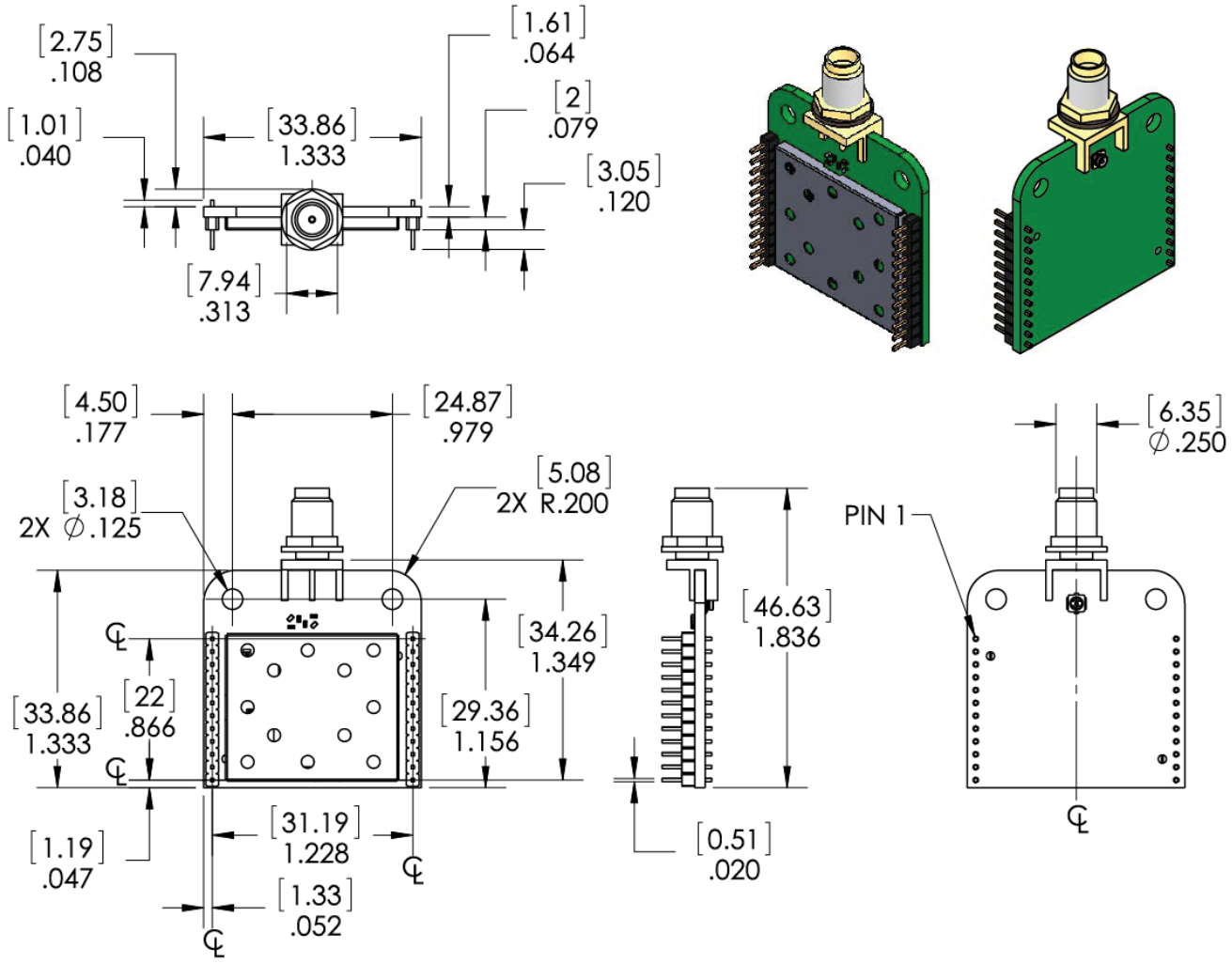


Figure 1: RF220SUMechanical Drawing

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.

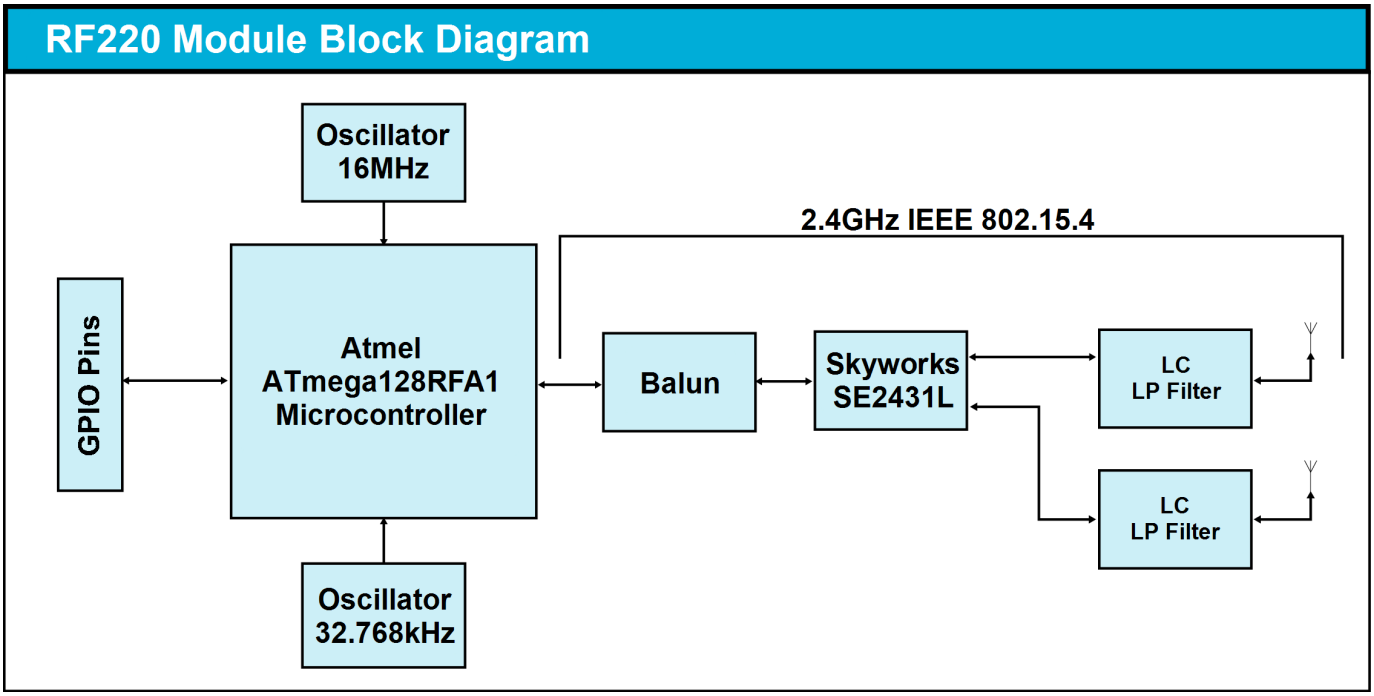


Figure 2: Block diagram showing the major subsystems comprising Model RF220SU

Selecting an Antenna

The **RF220SU** uses the RP-SMA connector 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 RP-SMA 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.

NOTE: A u.fl to SMA cable is included for use of the u.fl port.

HyperLink Technologies HG2405RD-RSP

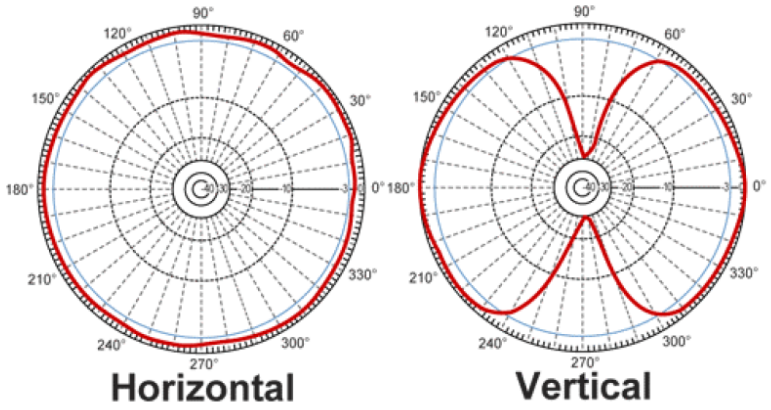


Figure 3: HyperLink Technologies HG2405RD-RSP Antenna Gain Performance

Pulse W1027

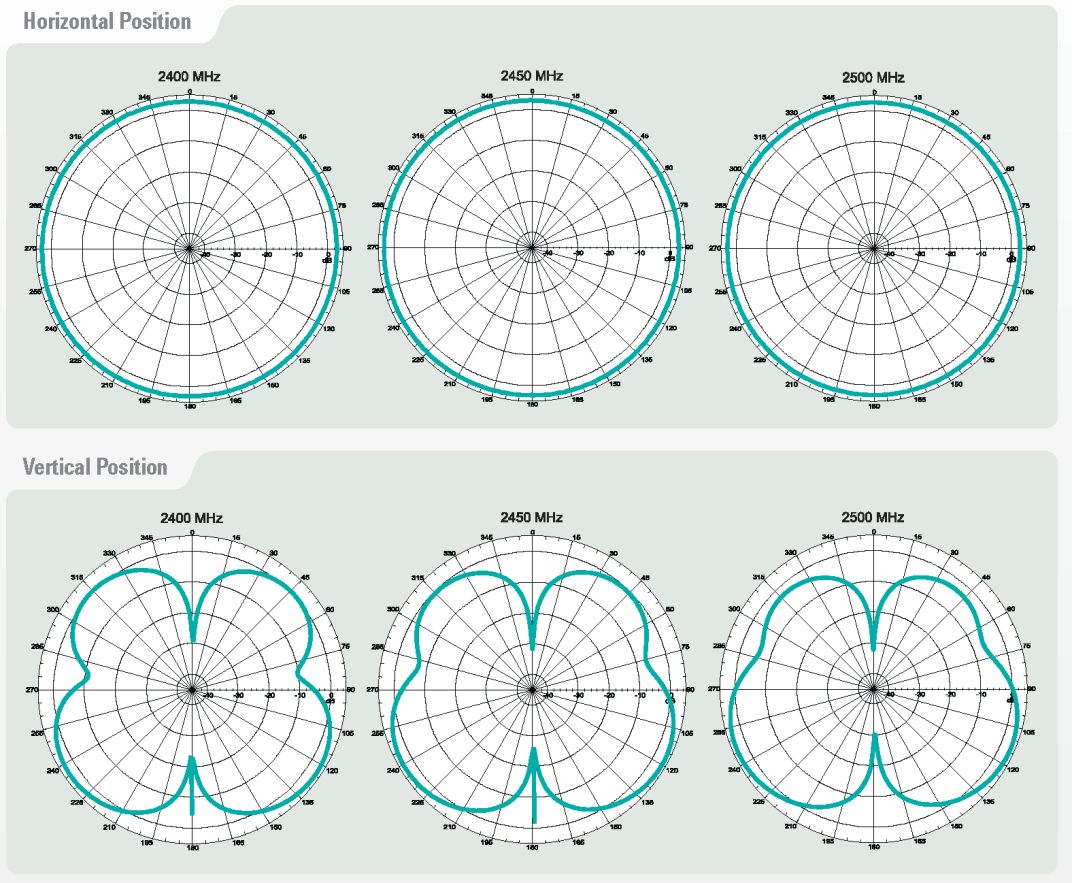


Figure 4: Pulse W1027 Antenna Gain Performance

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 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 RF220 Modules. **FCC Label** on page **53**. 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 **53**. .

MANUFACTURERSNAME
BRANDNAME or TRADENAME

Contains FCC ID: U9O-RF220SU

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 5: 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.

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 RF220SU 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 **RF220SU Approved FCC Antennas** on page **54**. . The required antenna impedance is 50 ohms.

Table 5: RF220SU 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: RF220SU, IC: 7084A-RF220SU has been approved by Industry Canada to operate with the listed antenna types 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 : RF220SU, IC: 7084A-RF220SU 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 6: RF220SU 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 **56**. .

MANUFACTURERSNAME
BRANDNAME or TRADENAME
MODEL:

Contains IC: 7084A-RF220SU

Figure 6: 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 **56**. .

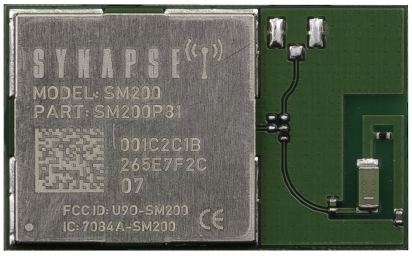
MANUFACTURERSNAME
BRANDNAME or TRADENAME

Contains FCC ID: U90-RF220SU
Contains IC: 7084A-RF220SU

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 7: Combined FCC and IC Label

SNAP Engine SM200 Modules Overview



The SNAP Engine Model SM200 series includes the SM200P81 and SM200PU1 part numbers. They are IEEE 802.15.4, low-power, highly reliable solutions to embedded wireless control and monitoring network needs that require high data rates. The Model SM200 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. These low-cost modules can have current consumption as low as 0.37 µA 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 Model SM200 modules are approved as an FCC Part 15 unlicensed modular transmitters, as well as having CE Certification and IC Certification. The modules provide up to 16 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.

Data Sheet covers Part Numbers SM200P81 and SM200PU1:

- 34 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:
  - 0.37 µA with external interrupt
  - 1.37 µA with internal timer running
- Spread Spectrum (DSSS) technology
- Up to 2 Mbps radio data rate
- 2.4 GHz RF Frequency
- AES 128-bit encryption
- Integrated chip antenna or U.FL connecter
- Surface Mount, Solder-able

- 4K internal EEPROM
- 8 PWM outputs

The SM200 is also available with a U.FL connector. Contact Synapse for details.

NOTE: If your 200 series device shipped from the factory with version 2.4.34 of the SNAP firmware, it now supports over-the-air firmware upgrades. This process is further defined in the Portal User Guide.

Specifications

Table 1: SM200 Specifications at 25° C and 3.3V unless otherwise noted

Performance	Outdoor LOS Range	Up to 1500/2500 feet at 250Kbps
	Transmit Power Output	3 dBm
	RF Data Rate	250Kbps, 500Kbps, 1Mbps, 2Mbps
	Receiver Sensitivity	-100 dBm (1% PER, 250Kbps)
Power Requirements	Supply Voltage	2.0 - 3.6 V
	Transmit Current (Typ@3.3V)	22.5 mA
	Idle/Receive Current (Typ@3.3V)	20.5 mA
	Power-down Current (Typ@3.3V)	0.37 µA
General	Frequency	ISM 2.4 GHz
	Spreading Method	Direct Sequence (DSSS)
	Modulation	O-QPSK
	Dimensions	29.8mm x 19mm
	Operating Temperature	- 40 to 85 deg C.
	Antenna Options	Integrated Chip Antenna / External Antenna
Networking	Topology	SNAP
	Error Handling	Retries and acknowledgement
	Number of Channels	16

Available I/O	UARTS with HW Flow Control	2 Ports
	GPIO	34 total; 7 can be analog-in with 10bit ADC
Agency Approvals	FCC Part 15.247	FCC ID: U9O-SM200
	Industry Canada (IC)	IC: 7084A-SM200
	CE Certified	Certified to EN300 328 Version 1.8.1

You must preserve access to UART0 as a serial connection in order to be able to update firmware on the node, or to recover the node by forced script removal or parameter reset.

Module Pin Definitions

For pin locations, consult the SM200 Mechanical drawing later in this document.

Table 2: SM200PF1/PU1 Pin Assignments

SM200 Pin	SNAPpy IO	Pin Name	Pin Description
A1		GND	Power Supply
A2		VCC	Power Supply
A3		VCC	Power Supply
A4	24	PF0_ADC0	IO or Analog0
A5	26	PF2_ADC2_DIG2	IO or Analog2 or SPI CLK or Antenna Diversity Control
A6	28	PF4_ADC4_TCK	IO or Analog4 or JTAG Test Clock
A7	30	PF6_ADC6_TDO	IO or Analog6 or JTAG Test Data Out or I^2C SDA
A8		GND	Power Supply
B1	18	PE2_XCK0_AIN0	IO or software SPI[16] MISO or Analog Comparator or External Clock
B2	19	PE3_OC3A_AIN1	IO or Analog Comparator or PWM or Output Compare Match
B3	21	PE5_OC3C_INT5	IO or UART0 RTS Input or PWM or Interrupt
B4	25	PF1_ADC1	IO or Analog1 or software SPI[1] MOSI
B5	33	PG1_DIG1	IO
B6	29	PF5_ADC5_TMS	IO or Analog5 or JTAG Test Mode Select

16 Software generated SPI and I^2C functions

SM200 Pin	SNAPpy IO	Pin Name	Pin Description
B7	31	PF7_ADC7_TDI	IO or Analog7 or JTAG Test Data In or software I^2C[1] SCL
B8		GND	Power Supply
C1	16	PE0_RXD0_PCINT8	IO or UART0 Data In or Interrupt
C2	17	PE1_TXD0	IO or UART0 Data Out
C3	20	PE4_OC3B_INT4	IO or UART0 CTS Output or PWM or Interrupt
C4	22	PE6_T3_INT6	IO or Interrupt
C5	23	PE7_ICP3_INT7_CLK0	IO or UART1 RTS input or Clock Output Buffer or Interrupt
C6	27	PF3_ADC3_DIG4	IO or ADC channel 3
C7		NC	
C8		GND	Power Supply
D1	5	PB5_OC1A_PCINT5	IO or PWM or Interrupt
D2	6	PB6_OC1B_PCINT6	IO or PWM or Interrupt
D3	7	PB7_OC0A_OC1C_PCINT7	IO or PWM or Interrupt
D4		NC	
D5		NC	
D6		NC	
D7		NC	
D8		GND	Power Supply
E1	2	PB2_MOSI_ PCINT2[17]	IO or Interrupt
E2	3	PB3_MISO_ PCINT3[2]	IO or Interrupt
E3	4	PB4_OC2A_PCINT4	IO or PWM or Interrupt
E4		NC	
E5		NC	
E6		NC	
E7		NC	
E8		NC	

17 These pins have special I²C and SPI hardware that is not natively supported by SNAP. You could use peek and poke to initialize and enable this hardware functionality, but it is not supported by Synapse and we cannot guarentee your results.

SM200 Pin	SNAPpy IO	Pin Name	Pin Description
F1	0	PB0_SSN_PCINT0[2]	IO or Interrupt
F2	1	PB1_SCK_PCINT1[2]	IO or Interrupt
F3	9	PD1_SDA_INT1[18]	IO or Interrupt
F4	8	PD0_SCL_INT0[3]	IO or Interrupt
F5		NC	
F6		NC	
F7		NC	
F8		GND	Power Supply
G1		CLKI	Must be pulled low during normal operation
G2	15	PD7_T0	IO
G3	12	PD4_ICP1	IO or UART1 CTS output or Input Capture
G4	10	PD2_RXD1_INT2	IO or UART1 Data In or Interrupt
G5	37	PG5_OC0B	IO or PWM
G6		NC	
G7		NC	
G8		GND	Power Supply
H1		GND	Power Supply
H2	14	PD6_T1	IO or Timer/Counter1 clock input
H3	13	PD5_XCK1	IO
H4	11	PD3_TXD1_INT3	IO or UART1 Data Out or Interrupt
H5		RESET#	Module Reset, Active Low
H6		TST	Must be pulled low during normal operation
H7		NC	
H8		GND	Power Supply

As a convenience, here is a cross reference from SM200 pad back to SNAPpy IO.

18 These pins have special I^2C hardware that is not natively supported by SNAP. You can use PEEK and POKE to initiate and enable this hardware functionality, but it is not supported by Synapse and we cannot guarentee your results.

Table 3: SM200/SNAPpy IO Cross Reference

Pad	SNAPpy IO
A4	24
A5	26
A6	28
A7	30
B1	18
B2	19
B3	21
B4	25
B5	33
B6	29
B7	31
C1	16
C2	17
C3	20
C4	22
C5	23
C6	27

Pad	SNAPpy IO
D1	5
D2	6
D3	7
E1	2
E2	3
E3	4
F1	0
F2	1
F3	9
F4	8
G2	15
G3	12
G4	10
G5	37
H2	14
H3	13
H4	11

Electrical Characteristics

Table 4: SM200 DC Characteristics at 25° C

Symbol	Parameter	Condition	Min	Typ	Max	Units
V_{CC}[19]	Supply Voltage		1.8	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	0.7 V_{CC}			V
V_{IL}	Input Low Voltage	All Digital Inputs			0.3 V_{CC}	V
V_{OL}	Output Low Voltage	All drive strengths (2,4,6,8 mA)			0.4	V

19 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.

Symbol	Parameter	Condition	Min	Typ	Max	Units
V_{OH}	Output High Voltage	All drive strengths (2,4,6,8 mA)	V_{CC} - 0.4			V
IL_{IN}	In Leakage Current	V_{IN} =V_{CC} or V_{SS} , all Pins		<10nA	1	µA
TX-I_{CC}	Transmit Current - Transceiver only	V_{CC} = 3.3V P_{TX} =3dBm		14.5		mA
	Transmit Current - Transceiver and CPU			22.5		mA
RX-I_{CC}	Receive Current - Transceiver only	V_{CC} = 3.3V		12.5[20]		mA
	Receive Current - Transceiver and CPU			20.5[2]		mA
SHDN- I_{CC}	Sleep Current	V_{CC} = 3.3V		0.37		µA

Table 5: ADC Electrical Characteristics (Operating)

Symbol	Parameter	Condition	Min	Typical	Max	Unit
V_{REFH}[21]	ADC Voltage Reference, High	Programmable	1.5	1.6	1.8	V
V_{INDC}	Analog input voltage	Single Ended	0		1.8	V
		Differential[22]	0		3.3	

20 2.4 GHz transceiver current only. Does not include current required to run CPU.
21 VREFH is programmable to three fixed values; 1.5V, 1.6V, and 1.8V. The default is 1.6V.
22 Each differential analog input may be as high as 3.3V but the single-ended voltage is still limited to the voltage reference.

Table 6: ADC Timing/Performance Characteristics

Symbol	Parameter	Condition	Min	Typical	Max	Unit
R_{AS}	Source impedance at input[23]				3k	kΩ
RES	Conversion Resolution	Single Ended CLKADC <= 4MHz		10		Bits
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

Table 7: Reset, Brown-out and Internal Voltage Characteristics

Symbol	Parameter	Condition	Min	Typical	Max	Unit
$V_{POT\ (rising)}$	Power-on Reset Threshold Voltage (rising)	Power supply fully discharged		1.6		V
$V_{POT\ (falling)}$	Power-on Reset Threshold Voltage (falling)		0.05	0.3		V
t_{POT}	Power-on Reset recovery time	Time of EVDD/DEVDD < V_{POT}	1.0			ms
V_{PSR}	Power-on slope rate		1.8		3300	V/ms
V_{RST}	RSTN Pin Threshold Voltage		$0.1V_{DD}$		$0.9\ V_{DD}$	V

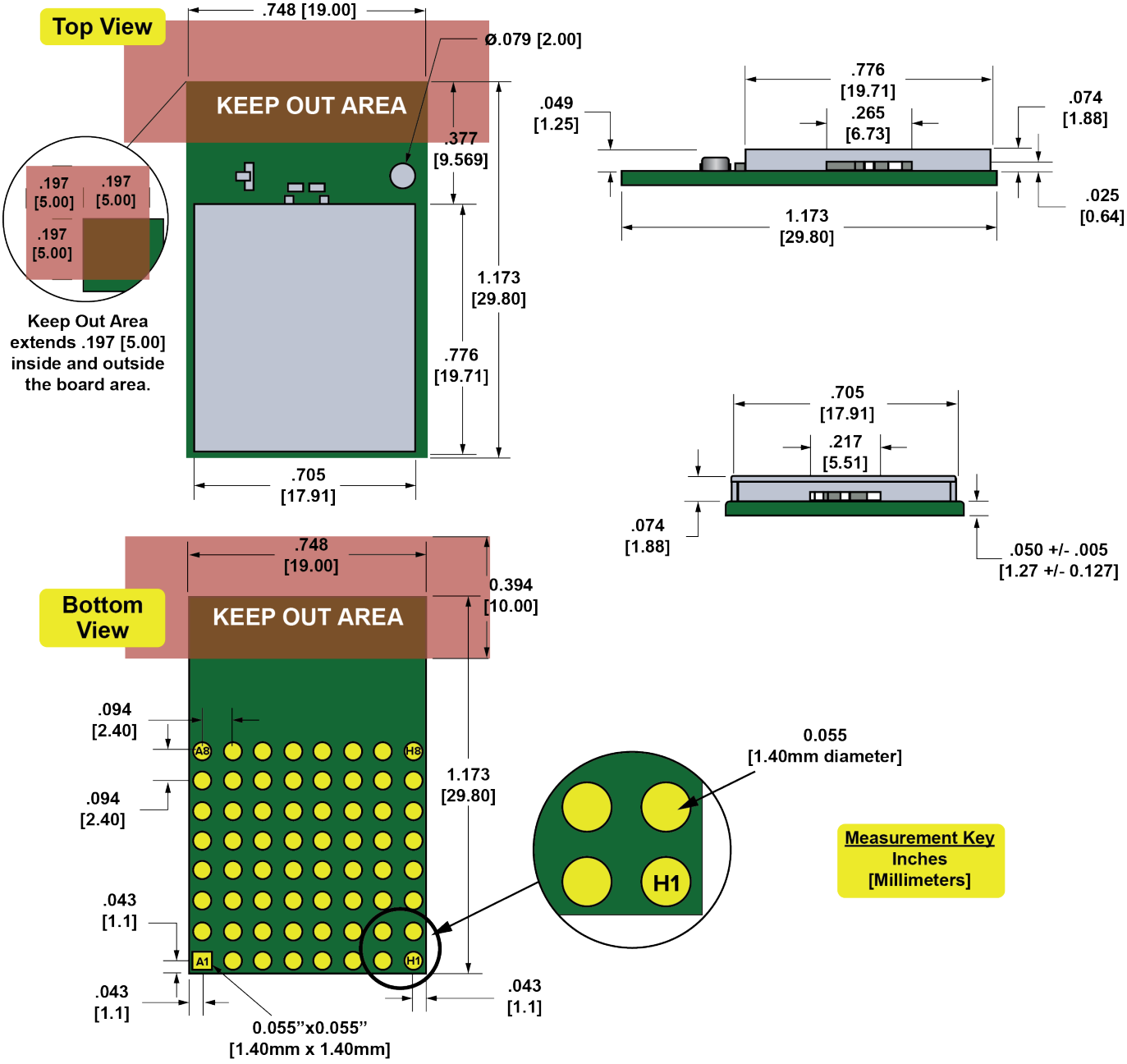
23 Any analog source with a source impedance greater than 3kΩ will increase the sampling time.

Symbol	Parameter	Condition	Min	Typical	Max	Unit
t_{RST}	Minimum pulse width on RSTN Pin			200	300	ns
V_{HYS}	Brown-out Detector Hysteresis			7.5	50	mV
t_{BOD}	Min Pulse Width on Brown-out Reset			100		ns

Mechanical Drawings

The drawings in **SM200PF1/PU1 Mechanical Drawing** on page **67**. and 1.2 show the modules with the option of the integrated chip antenna or U.FL Connector.

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.



NOTE: Metric measurements in millimeters are between brackets, with standard measurements in inches below.

Figure 1: SM200PF1/PU1 Mechanical Drawing

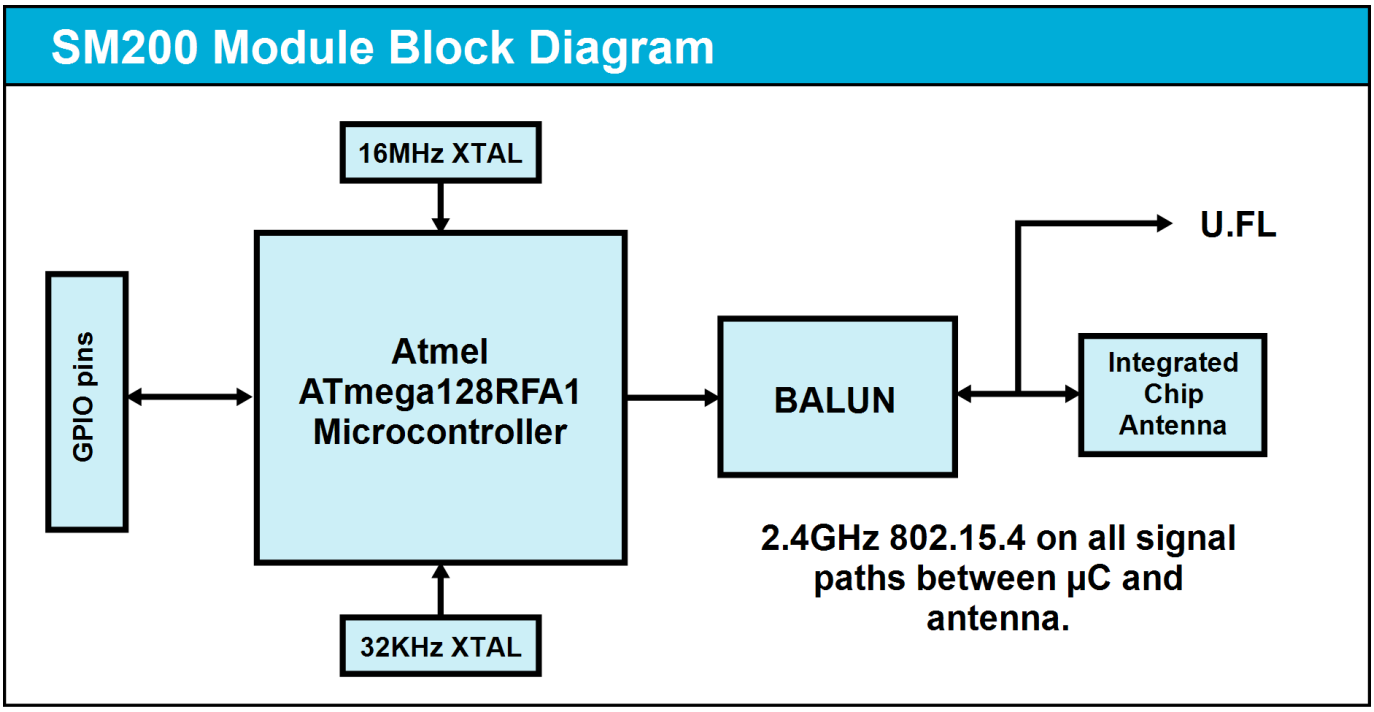


Figure 2: Block diagram showing the major subsystems comprising Model SM200

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.

Murata LDA312G4413H-280

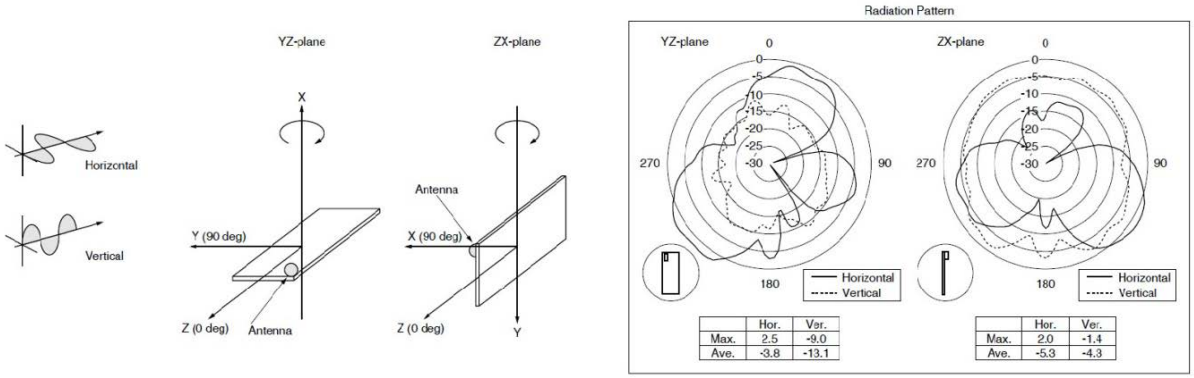


Figure 3: Murata LDA312G4413H-280 Antenna Gain Performance

Pulse W1027

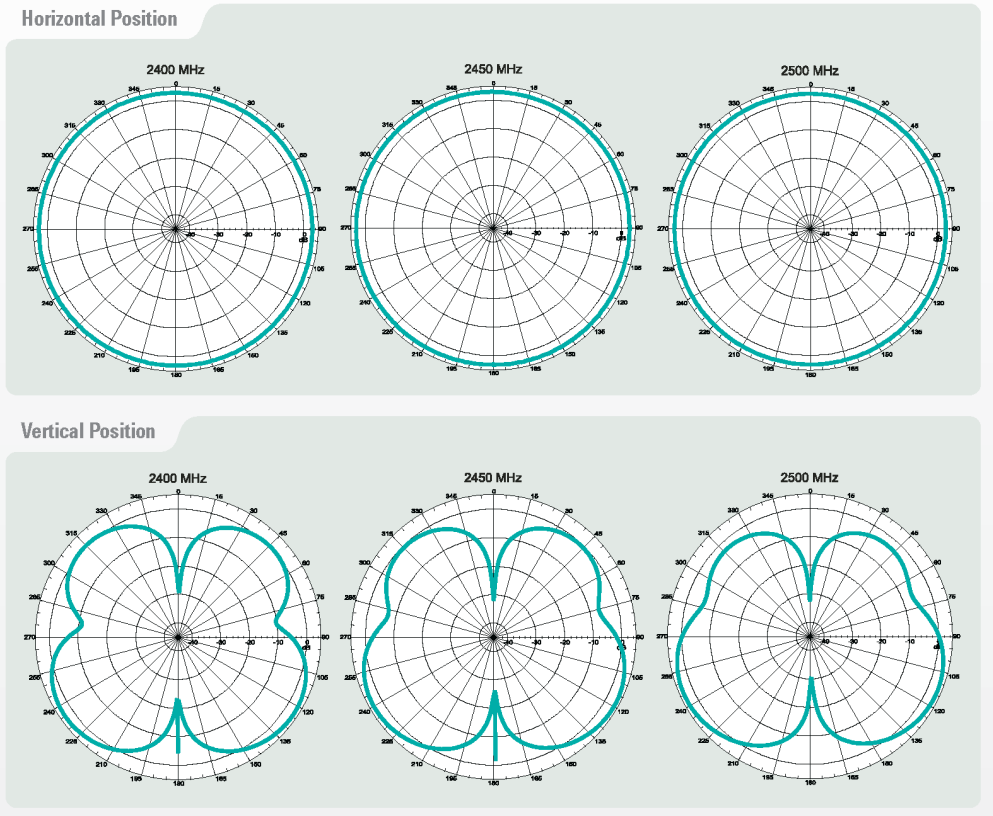


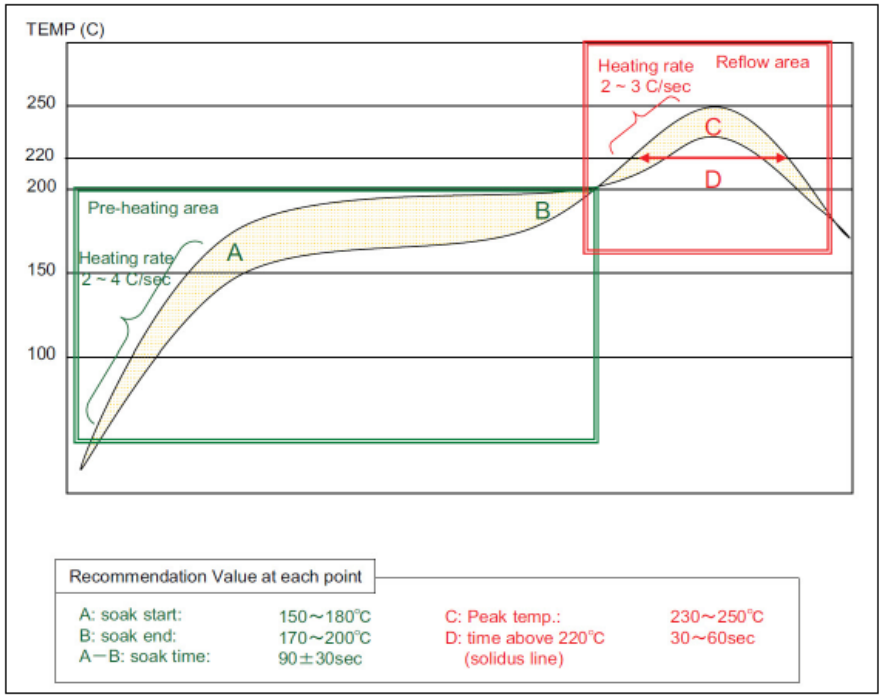
Figure 4: Pulse W1027 Antenna Gain Performance

Board Mounting Considerations

Processing

Table 8: 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



Pb-Free Soldering Paste

Use of “No Clean” soldering paste is strongly recommended, as it does not require cleaning after the soldering process.

Cleaning

In general, cleaning the populated modules is strongly discouraged. Residuals under the module cannot be easily removed with any cleaning process.

- Cleaning with water can lead to capillary effects where water is absorbed into the gap between the host board and the module. The combination of soldering flux residuals and encapsulated water could lead to short circuits between neighboring pads. Water could also damage any stickers or labels.
- Cleaning with alcohol or a similar organic solvent will likely flood soldering flux residuals into the two housings, which is not accessible for post-washing inspection. The solvent could also damage any stickers or labels.
- Ultrasonic cleaning could damage the module permanently.

The recommended approach is to consider using a “no clean” soldering paste and eliminate the post-soldering cleaning step.

Repeating Reflow Soldering

Only a single reflow soldering process is encouraged for host boards.

Rework

The Model SM200 Module can be unsoldered from the host board, but the process is likely to damage the chip and not recommended. If attempting this, use of a hot air rework tool and hot plate for pre-heating from underneath is recommended. Avoid overheating.

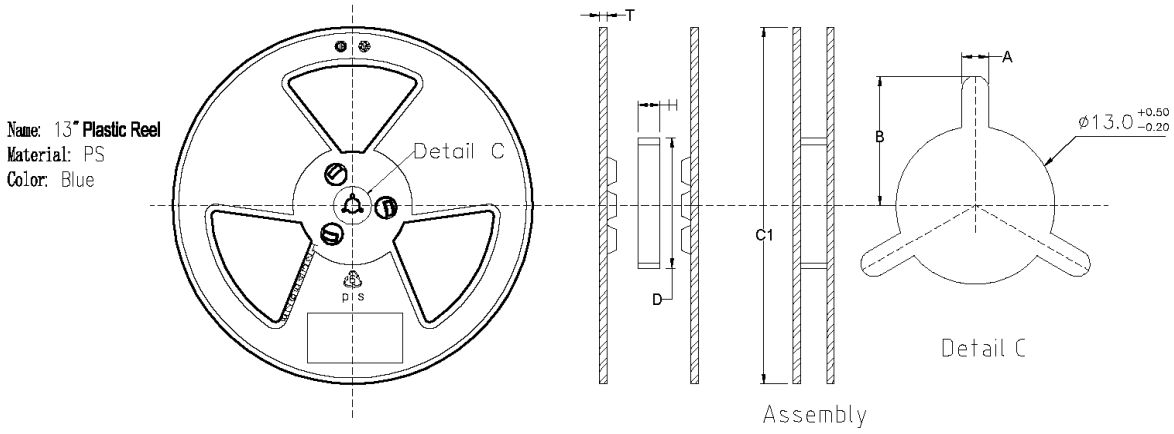
WARNING: Never attempt a rework on the module itself (e.g. replacing individual components). Such actions will terminate warranty coverage.

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.

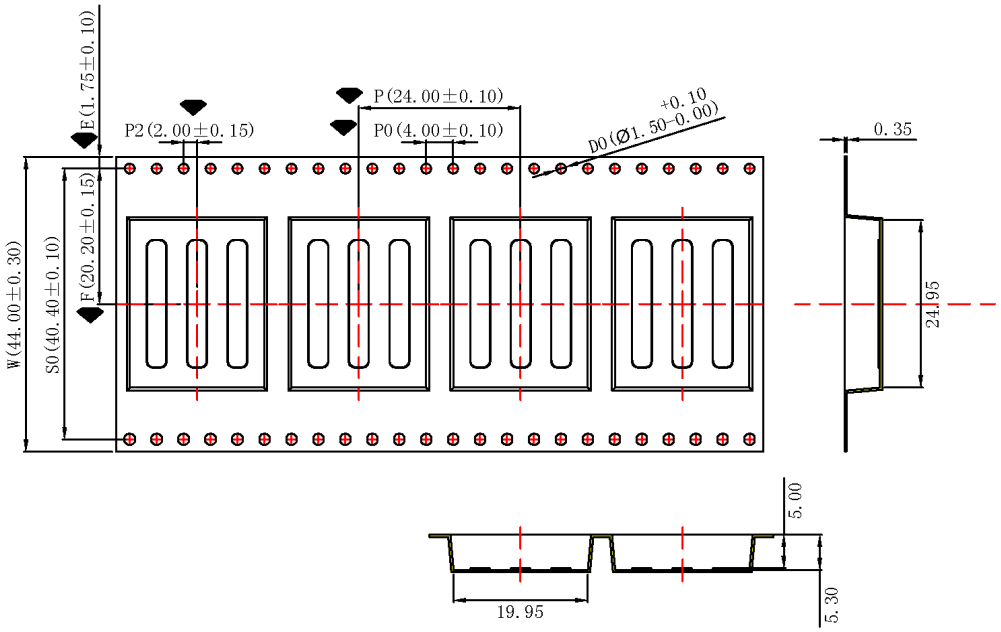
Packaging

Synapse SM series modules are available on plastic reels of carrier tape. The dimensions for those reels are provided below.



H+/-0.5	C1+/-1.0	A+/-0.2	C+0.5 -0.2	T+/-0.3	B+/-0.2	D+/-2.0
44.5	ø330	2.20	13.0	2.20	10.75	99.5

All dimensions are in mm.



1. Sprocket hole pitch cumulative tolerance: +/-0.2mm.
2. Carrier camber not to exceed 1mm in 250mm.
3. All dimensions meet EIA-481-C requirements.
4. Thickness: 0.35mm +/- 0.05mm.
5. Packing length per reel: 12.6 meters.
6. Component load per reel: 500 pieces.

Agency Certifications

United States (FCC)

The Model SM200 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 SM200 Modules. **FCC Label** on page **72**. below shows the contents that must be included on this label.
2. SM200 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 **72**. below.

MANUFACTURERSNAME
BRANDNAME or TRADENAME

Contains SM200 FCC ID: U90-SM200

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: FCC Label

FCC Notices

WARNING: The SM200 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.

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 SM200 modules are FCC-approved for fixed base station, mobile, and portable 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 **SM200 Approved FCC Antennas** on page **73**. and **SM200 Approved FCC Antennas** on page **73**. . The required antenna impedance is 50 ohms..

Table 1: SM200 Approved FCC Antennas

Part Number	Type	Gain	Application	Min. Separation
Murata LDA312G4413H-280	Chip	-2.3 dBi	Fixed/Mobile	20 cm.

Table 2: SM200 Approved FCC Antennas

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

For more information on approved antennas, please consult the manufacturer's website.

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: SM200, IC: 7084A-SM200 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 : SM200, IC : 7084A-SM200 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 3: SM200 Approved IC Antennas

Part Number	Type	Gain	Application	Min. Separation
Murata LDA312G4413H-280	Chip	-2.3 dBi	Fixed/Mobile	20 cm.

Table 4: SM200 Approved IC Antennas

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

CE Approved Antennas

The SM200 modules are CE-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 **SM200 Approved FCC Antennas** on page **73**. and **SM200 Approved FCC Antennas** on page **73**. below. The required antenna impedance is 50 ohms.

Table 5: SM200 Approved CE Antennas

Part Number	Type	Gain	Application	Min. Separation
Murata LDA312G4413H-280	Chip	-2.3 dBi	Fixed/Mobile	20 cm.

Table 6: SM200 Approved CE Antennas

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

For more information on approved antennas, please consult the manufacturer's website.

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.

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 **75**. below.

MANUFACTURERSNAME
BRANDNAME or TRADENAME
MODEL:

Contains SM200 IC: 7084A-SM200

Figure 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 **Combined FCC and IC Label** on page **76**. below.

MANUFACTURERSNAME
BRANDNAME or TRADENAME

Contains SM200 FCC ID: U90-SM200
Contains SM200 IC: 7084A-SM200

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 3: Combined FCC and IC Label

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.

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 **Combined FCC, CE and IC Label** on page **77**. .

MANUFACTURERSNAME

BRANDNAME or TRADENAME

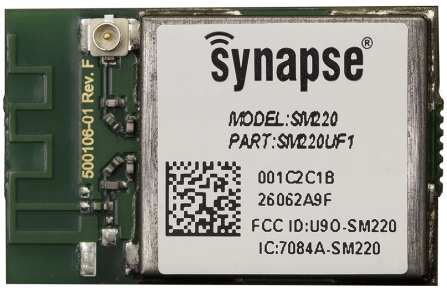
Contains SM200 FCC ID: U90-SM200

Contains SM200 IC: 7084A-SM200

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 4: Combined FCC, CE and IC Label

SNAP Engine SM220 Modules Overview



The SNAP Engine Model SM220 series consists of the SM220UF1 part number. It is an IEEE 802.15.4, low-power, highly reliable solution for embedded wireless control and monitoring networks requiring high data rates. It 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 better enable battery-driven systems. The SM220 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 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 SM220UF1:

- 32 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
- Surface Mount, Solder-able
- 4K internal EEPROM
- 8 PWM outputs
- Supports over the air firmware upgrades.
  (This process is further defined in the Portal User Guide.)

SM220 – Surface Mount Module

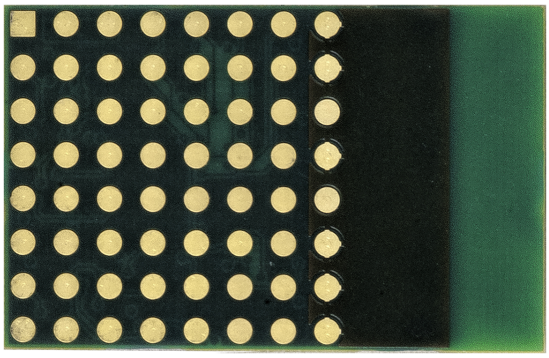
The SM220 is a surface mount module based on the ATmega128RFA1 chip. All the details appropriate for the chip-based version of ATmega128RFA1 SNAP apply to the SM220, with the following additions and exceptions. Pin numbers below refer to the pad on the SM220 footprint, with is a 64-pin arrangement of eight rows ("A" through "H") by eight columns ("1" - "8"). To reference IO pins in your code, use the SNAPpy IO number from the table below.

Form Factor

The SM220 is in a surface mount form-factor. The pad arrangement is shown below.

BOTTOM VIEW

A1	A2	A3	A4	A5	A6	A7	A8
B1	B2	B3	B4	B5	B6	B7	B8
C1	C2	C3	C4	C5	C6	C7	C8
D1	D2	D3	D4	D5	D6	D7	D8
E1	E2	E3	E4	E5	E6	E7	E8
F1	F2	F3	F4	F5	F6	F7	F8
G1	G2	G3	G4	G5	G6	G7	G8
H1	H2	H3	H4	H5	H6	H7	H8



The pad designators "A1" through "H8" will be used throughout the remainder of this document.

Specifications

Table 1: SM220 Specifications at 23° C and 3.3V unless otherwise noted

Performance	Outdoor LOS Range	3 miles using u.fl antenna .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 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 Untimed Sleep Mode : 390 nA
General	Frequency	ISM 2.4 GHz
	Spreading Method	Direct Sequence (DSSS)
	Modulation	O-QPSK
	Dimensions	29.8mm x 19mm
	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 acknowledgement
	Number of Channels	15 fully operational 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
	GPIO	32 total; 7 can be analog-in with 10bit ADC
Agency Approvals	FCC Part 15.247	FCC ID: U9O-SM220
	Industry Canada (IC)	7084A-SM220
	CE Certified	Certified to EN300 328 Version 1.8.1

SM220 Module Pin Definitions

For pin locations, consult the SM220 Mechanical drawing later in this document.

Table 2: SM220UF1 Pin Assignments

SM220 Pin	SNAPpy IO	Pin Name	Pin Description
A1	-	GND	Power Supply
A2	-	VCC	Power Supply
A3	-	VCC	Power Supply
A4	24	PF0_ADC0	IO or Analog0
A5	26	PF2_ADC2_DIG2	IO or Analog2 or software SPI CLK[24] or Antenna Diversity Control
A6	28	PF4_ADC4_TCK	IO or Analog4 or JTAG Test Clock
A7	30	PF6_ADC6_TDO	IO or Analog6 or JTAG Test Data Out or software I^2C[1] SDA
A8	-	GND	Power Supply
B1	18	PE2_XCK0_AIN0	IO or software SPI[1] MISO or Analog Comparator or External Clock
B2	19	PE3_OC3A_AIN1	IO or Analog Comparator or PWM or Output Compare Match
B3	21	PE5_OC3C_INT5	IO or UART0 RTS Input or PWM or Interrupt
B4	25	PF1_ADC1	IO or Analog1 or software SPI[1] MOSI
B5	-	Test Point - Do Not Use	
B6	29	PF5_ADC5_TMS	IO or Analog5 or JTAG Test Mode Select
B7	31	PF7_ADC7_TDI	IO or Analog7 or JTAG Test Data In or software I^2C[1] SCL

24 Software generated SPI and I^2C functions.

SM220 Pin	SNAPpy IO	Pin Name	Pin Description
B8	-	GND	Power Supply
C1	16	PE0_RXD0_PDI_ PCINT8	IO or UART0 Data In or Interrupt
C2	17	PE1_TXD0_PDO	IO or UART0 Data Out
C3	20	PE4_OC3B_INT4	IO or UART0 CTS Output or PWM or Interrupt
C4	22	PE6_T3_INT6	IO or Interrupt
C5	23	PE7_ICP3_INT7_ CLK0	IO or UART1 RTS input or Clock Output Buffer or Interrupt
C6	-	NC	Test Point - Do not use
C7	-	NC	
C8	-	NC	Test Point - Do not use
D1	5	PB5_OC1A_PCINT5	IO or PWM or Interrupt
D2	6	PB6_OC1B_PCINT6	IO or PWM or Interrupt
D3	7	PB7_OC0A_OC1C_P CINT7	IO or PWM or Interrupt
D4	-	NC	
D5	-	NC	
D6	-	NC	
D7	-	NC	
D8	-	GND	Power Supply
E1	2	PB2_MOSI_ PCINT2[25]	IO or Interrupt

25 These pins have special SPI hardware that is not natively supported by SNAP. You can use PEEK and POKE to initiate and enable this hardware functionality, but it is not supported by Synapse and we cannot guarentee your results.

SM220 Pin	SNAPpy IO	Pin Name	Pin Description
E2	3	PB3_MISO_ PCINT3[2]	IO or Interrupt
E3	4	PB4_OC2A_PCINT4	IO or PWM or Interrupt
E4	-	NC	
E5	-	NC	
E6	-	NC	
E7	-	NC	
E8	-	NC	
F1	0	PB0_SSN_PCINT0[2]	IO or Interrupt
F2	1	PB1_SCK_PCINT1[2]	IO or Interrupt
F3	9	PD1_SDA_INT1[26]	IO or Interrupt
F4	8	PD0_SCL_INT0[3]	IO or Interrupt
F5	-	Test Point - Do Not Use	
F6	-	Test Point - Do Not Use	
F7	-	NC	
F8	-	GND	Power Supply
G1	-	CLKI	(Internal 1K pulldown)
G2	15	PD7_T0	IO
G3	12	PD4_ICP1	IO or UART1 CTS output or Input Capture
G4	10	PD2_RXD1_INT2	IO or UART1 Data In or Interrupt
G5	37	PG5_OC0B	IO or PWM

26 These pins have special I^2C hardware that is not natively supported by SNAP. You can use PEEK and POKE to initiate and enable this hardware functionality, but it is not supported by Synapse and we cannot guarentee your results.

SM220 Pin	SNAPpy IO	Pin Name	Pin Description
G6	-	NC	
G7	-	NC	
G8	-	GND	Power Supply
H1	-	GND	Power Supply
H2	14	PD6_T1	IO or Timer/Counter1 clock input
H3	13	PD5_XCK1	IO
H4	11	PD3_TXD1_INT3	IO or UART1 Data Out or Interrupt
H5	-	RESET#	Module Reset, Active Low
H6	-	NC	
H7	-	NC	
H8	-	GND	Power Supply

You must preserve access to UART1 as a serial connection in order to be able to serially update firmware on the node, or to recover the node by forced script removal or parameter reset.

As a convenience, here is a cross reference from SM220 pad back to SNAPpy IO.

Table 3: SM220/SNAPpy IO Cross Reference

Pad	SNAPpy IO
A4	24
A5	26
A6	28
A7	30
B1	18
B2	19
B3	21
B4	25
B6	29
B7	31
C1	16
C2	17
C3	20
C4	22
C5	23
D1	5

Pad	SNAPpy IO
D2	6
D3	7
E1	2
E2	3
E3	4
F1	0
F2	1
F3	9
F4	8
G2	15
G3	12
G4	10
G5	37
H2	14
H3	13
H4	11

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 4: SM220 DC Characteristics at 25° C

Symbol	Parameter	Condition	Min	Typ	Max	Units
V_{CC}[27]	Supply Voltage		2.0	3.3	3.6	V

27 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.

Table 5: ADC Electrical Characteristics (Operating)

Symbol	Parameter	Condition	Min	Typical	Max	Unit
V_{REFH}[28]	ADC Voltage Reference, High	Programmable	1.5	1.6	1.8	V
V_{INDC}	Analog input voltage	Single Ended	0		1.8	V
		Differential[29]	0		3.3	

Mechanical Drawings

SM220UF1 Mechanical Drawing on page **88**. and **Block diagram showing the major subsystems comprising Model SM220** on page **89**. show the modules with the compact F antenna ad U.FL Connector options.

NOTE: The area under and around the module's antenna (marked KEEP OUT AREA and tinted red) should have no components and no copper on any layer of the printed circuit board. Additionally, leave enough clearance around the module for worst case component and processing variances.

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.

28 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.
29 Each differential analog input may be as high as 3.3V but the single-ended voltage is still limited to the voltage reference.

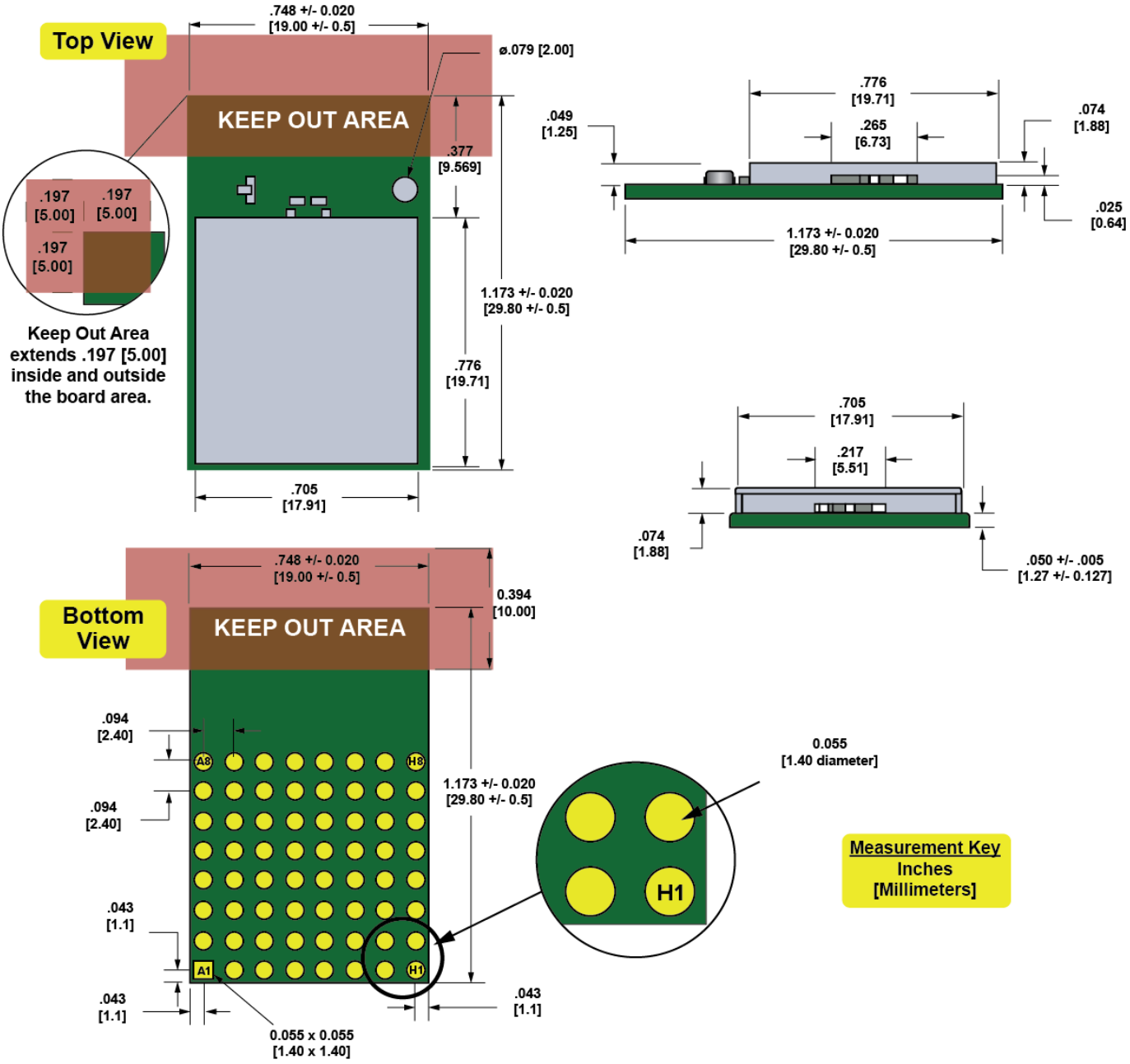


Figure 1: SM220UF1 Mechanical Drawing

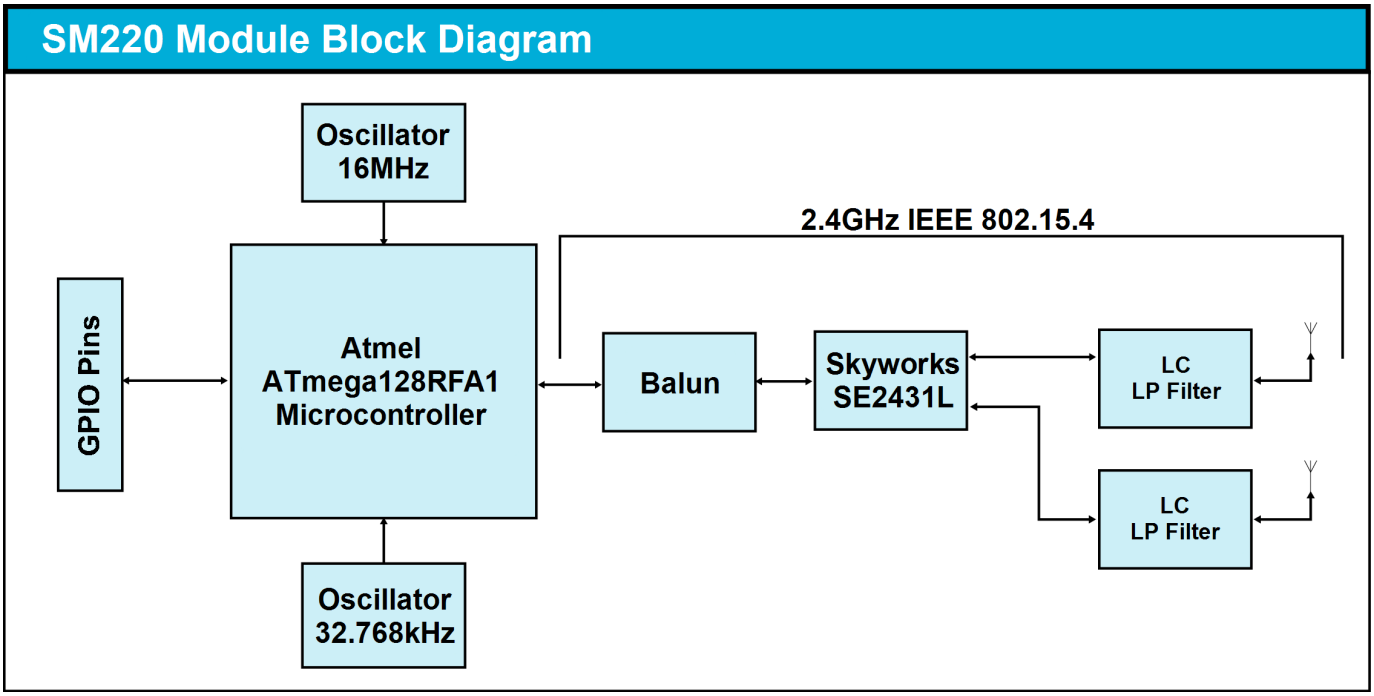


Figure 2: Block diagram showing the major subsystems comprising Model SM220

Selecting an Antenna

The SM220 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. 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.

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

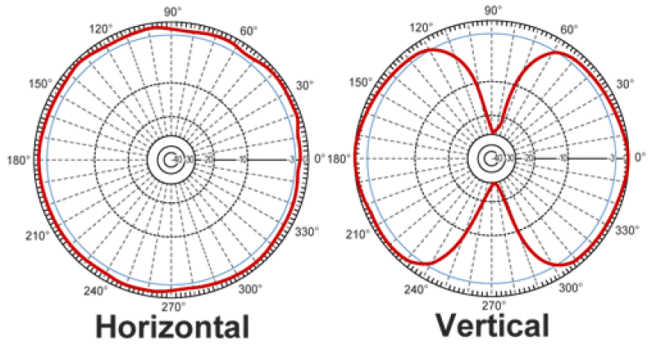


Figure 3: HyperLink Technologies HG2405RD-RSP Antenna Gain Performance

Pulse W1027

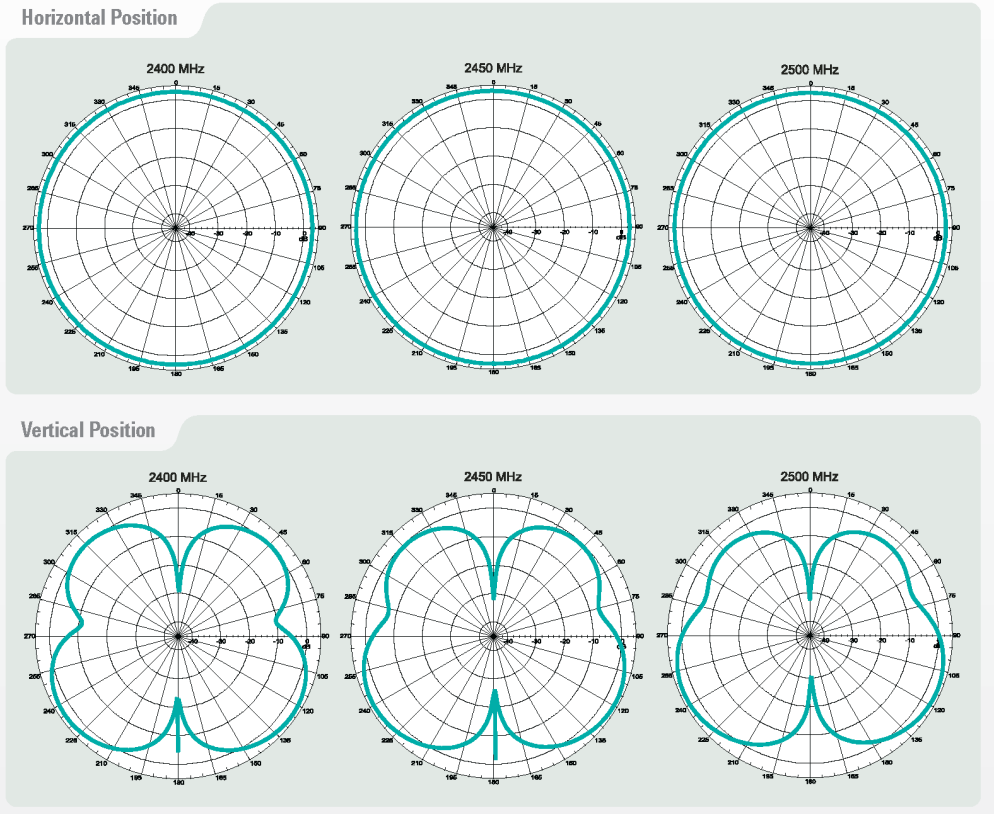


Figure 4: Pulse W1027 Antenna Gain Performance

Board Mounting Considerations

Processing

Table 6: 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

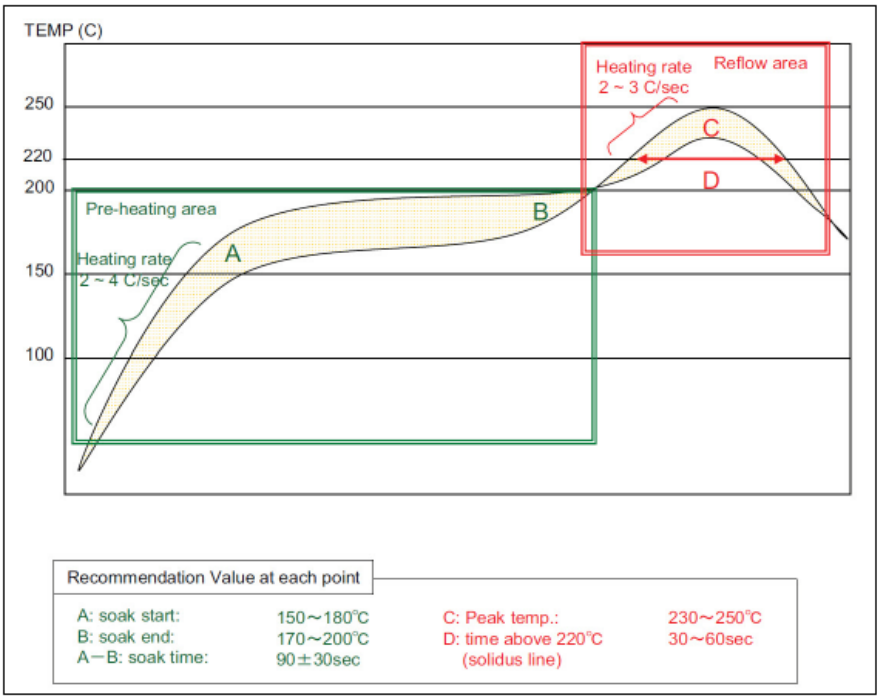


Figure 5: Reflow Profile Graph

Pb-Free Soldering Paste

Use of “No Clean” soldering paste is strongly recommended, as it does not require cleaning after the soldering process.

Cleaning

In general, cleaning the populated modules is strongly discouraged. Residuals under the module cannot be easily removed with any cleaning process.

- Cleaning with water can lead to capillary effects where water is absorbed into the gap between the host board and the module. The combination of soldering flux residuals and encapsulated water could lead to short circuits between neighboring pads. Water could also damage any stickers or labels.
- Cleaning with alcohol or a similar organic solvent will likely flood soldering flux residuals into the two housings, which is not accessible for post-washing inspection. The solvent could also damage any stickers or labels.
- Ultrasonic cleaning could damage the module permanently.

The recommended approach is to consider using a “no clean” soldering paste and eliminate the post-soldering cleaning step.

Repeating Reflow Soldering

Only a single reflow soldering process is encouraged for host boards.

Rework

The Model SM220 Module can be unsoldered from the host board, but the process is likely to damage the chip and not recommended. If attempting this, use of a hot air rework tool and hot plate for pre-heating from underneath is recommended. Avoid overheating.

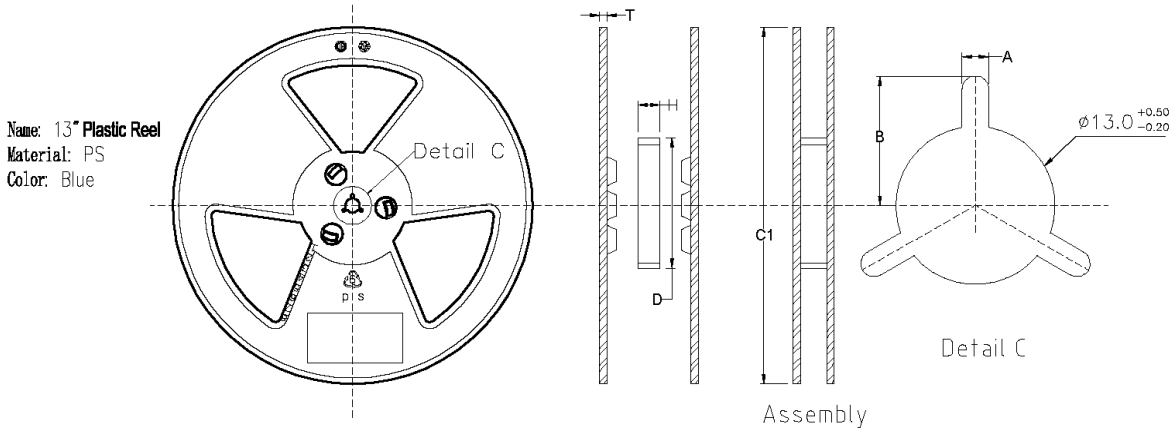
WARNING: Never attempt a rework on the module itself (e.g. replacing individual components). Such actions will terminate warranty coverage.

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.

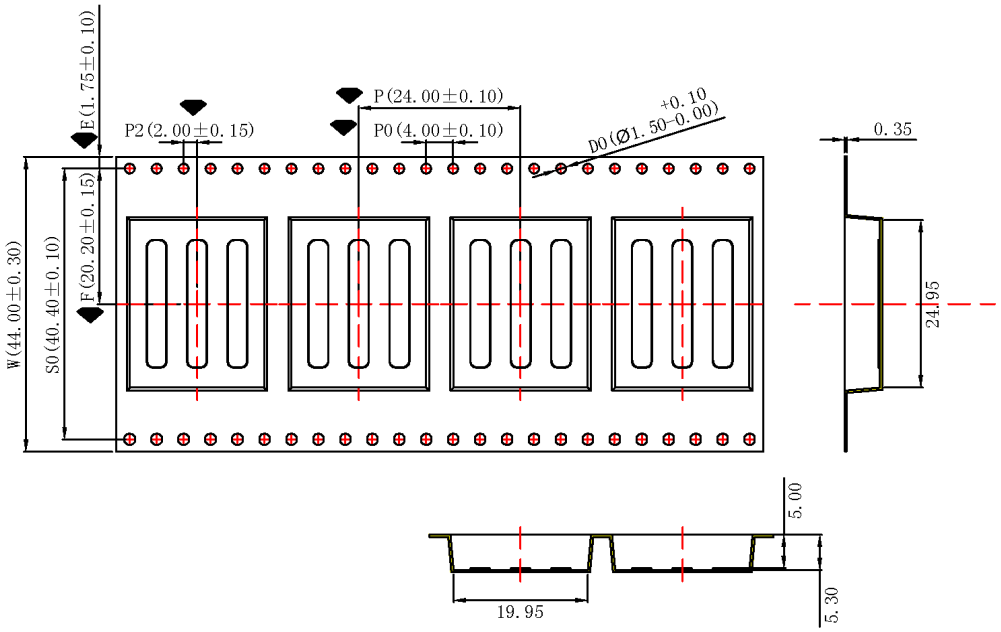
Packaging

Synapse SM series modules are available on plastic reels of carrier tape. The dimensions for those reels are provided below.



H+/-0.5	C1+/-1.0	A+/-0.2	C+0.5 -0.2	T+/-0.3	B+/-0.2	D+/-2.0
44.5	ø330	2.20	13.0	2.20	10.75	99.5

All dimensions are in mm.



1. Sprocket hole pitch cumulative tolerance: +/-0.2mm.
2. Carrier camber not to exceed 1mm in 250mm.
3. All dimensions meet EIA-481-C requirements.
4. Thickness: 0.35mm +/- 0.05mm.
5. Packing length per reel: 12.6 meters.
6. Component load per reel: 500 pieces.

Agency Certifications

United States (FCC)

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 SM220 Modules. **FCC Label** on page **94**. below shows the contents that must be included on this label.
2. SM220 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 **94**. below.

MANUFACTURERSNAME
BRANDNAME or TRADENAME

Contains SM220 FCC ID: U9O-SM220

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 6: FCC Label

FCC Notices

WARNING: The SM220 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 SM220 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.

NOTE: 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.

This device complies with Industry Canada licence-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.

FCC Approved Antennas

The SM220 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 **SM220 Approved FCC Antenna** on page **95**. and **SM220 Approved FCC Antennas** on page **96**. below. The required antenna impedance is 50 ohms.

Table 7: SM220 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 8: SM220 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: SM220, IC: 7084A-SM220 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 : SM220, IC : 7084A-SM220 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 9: SM220 Approved IC Antenna

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

Table 10: SM220 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 **97**. below.

MANUFACTURERSNAME
BRANDNAME or TRADENAME
MODEL:

Contains SM220 IC: 7084A-SM220

Figure 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 **98**. below.

MANUFACTURERSNAME
BRANDNAME or TRADENAME

Contains SM220 FCC ID: U9O-SM220
Contains SM220 IC: 7084A-SM220

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 8: Combined FCC and IC Label

SN132 SNAPstick USB Module

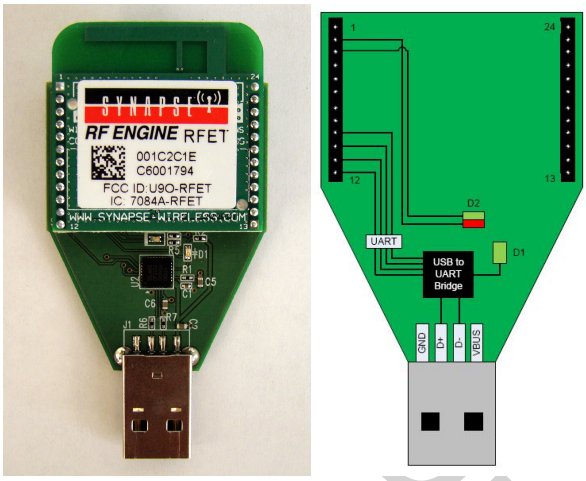


Figure 1: Overhead view of SN132 SNAPstick and block diagram

Introduction

The Synapse SNAPstick is designed to be a compact and easy way to connect a PC to a SNAP wireless network.

The module supports all existing forms of the Synapse SNAP Engine and is fully compatible with Synapse's Portal management software.

On-Board Indicators

A Tri-color LED is available as an output indicator. This component has the ability to emit a red, green, or amber light. It can be controlled by SNAPpy scripts (running on the SNAPstick) that manipulate GPIO pins 0 and 1.

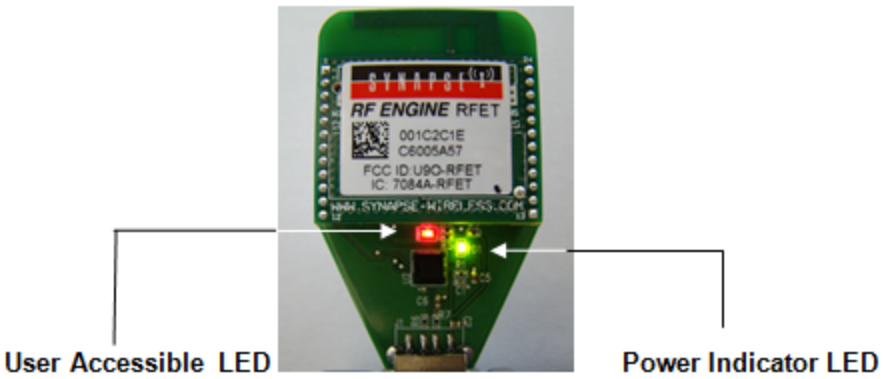


Figure 2: SNAPstick on-board LEDs

The following table describes the how to control the output pins to obtain desired colors. Notice that the LED lines are active LOW.

Table 1: SNAPstick LED Configuration

Desired LED Color	Value of GPIO Pin 0	Value of GPIO Pin 1
Red	Low	High
Green	High	Low
Amber	Low	Low
OFF	High	High

A second green LED is used to indicate that power is being supplied to the module. It cannot be controlled by the user.

The SNAPstick does not provide access to any other of the 18 General Purpose Input/Output (GPIO) pins available on the SNAP Engines.

USB Interface

The USB interface on the SNAPstick communicates with the connected SNAP Engine via internal UART 1. This UART is connected to GPIO pins 7-10. The following table describes their use.

Table 2: SNAPstick UART Connections

Pin Name	Direction of Pin	Description
GPIO 7	Input	UART1 Rx Data
GPIO 8	Output	UART1 Tx Data
GPIO 9	Bidirectional	UART1 CTS
GPIO 10	Bidirectional	UART1 RTS

Powering Options

The SNAPstick can be powered using any form of standard USB connection.

NOTE: It must be a powered-USB connection.

(Examples include: a PC/laptop port, a powered-USB hub, or a stand-alone USB AC adapter)

The module does not require Synapse's Portal software or other software drivers to be installed in order to draw power from the PC's USB port.

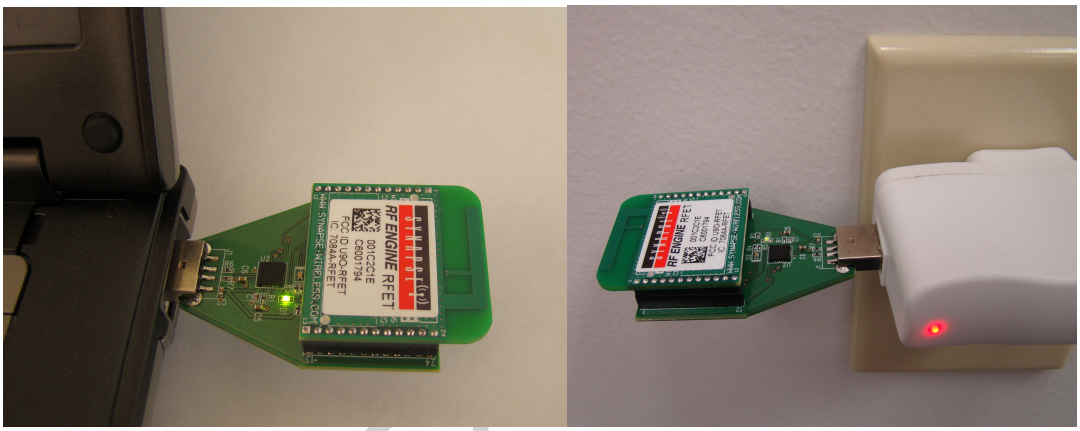


Figure 3: SNAPsticks drawing power from a laptop PC and USB AC Adapter

SN171 Prototyping Board

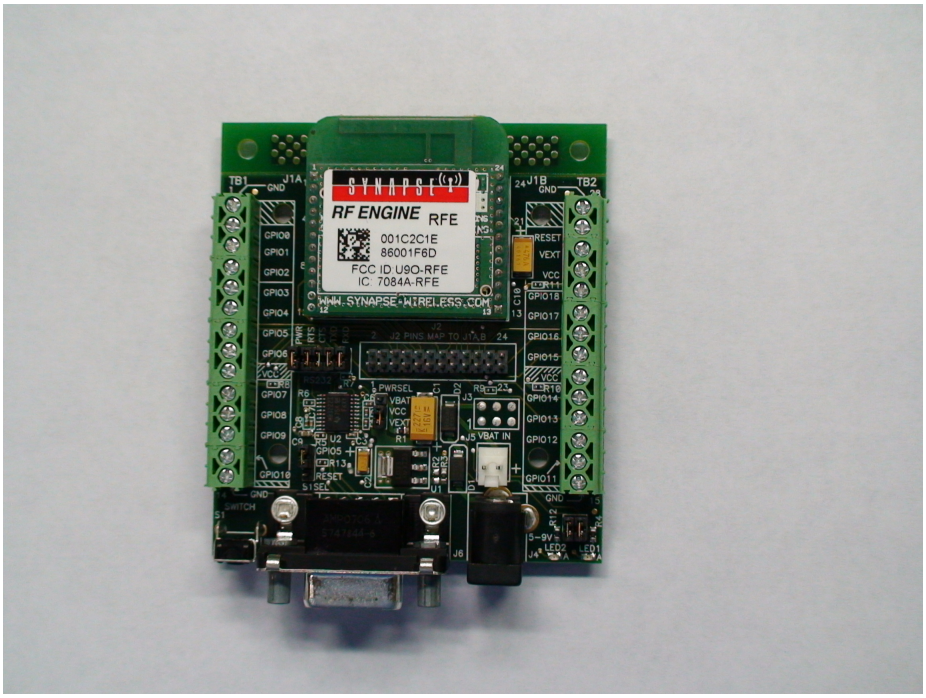


Figure 1: SN171 protoboard

This break-out/prototyping board has been created to make it easier to evaluate the Synapse SNAP Engine (RFE).

The SN171 protoboard provides easy access to **all 20** General Purpose I/O (GPIO) pins of the SNAP Engine, including:

- 20 Digital Inputs or Outputs
- 8 Analog Inputs
- 2 UART ports

Note that the analog input and serial port functionality share pins with the digital I/O – you can only have a total of 20 functions at one time. Please refer to the existing RF200 Series SNAP Engine Datasheet for more details.

On the SN171 protoboard, none of the I/O pins is dedicated to a single function. At the same time, we wanted to make it easy to test drive "basic functionality" like blinking LEDs, reading a push-button switch, and communicating over a serial port. To accomplish this, various jumpers can be installed to connect different SNAP Engine GPIO pins to some on-board peripherals.

On-Board Peripherals List

From a hardware configuration (jumpering) standpoint, there are five hardware sub-systems to be aware of:

- Voltage Regulator
- LED1 – green
- LED2 – yellow
- S1 – push-button switch
- RS-232 port – DB9

Powering Options

The SN171 protoboard can be powered from a two-pin battery connector. Put JMP1 on pins 2 and 3 (connecting VBAT to VCC) and connect a battery (or other 2.7 - 3.4 volt source) to the white two-pin header labeled "J5 VBAT IN".

Table 1: Power Jumper Options

Jumper	When Installed
JMP1	Connect pins 1-2 to get VCC from VEXT
JMP1	Connect pins 2-3 to get VCC from VBAT

Alternatively, you can power the board externally by first connecting JMP1 pins 1 and 2 (connecting VEXT to VCC). You can then bring in 5-9 volts DC power through the barrel connector, or through the VEXT and GND pins on terminal block TB2.

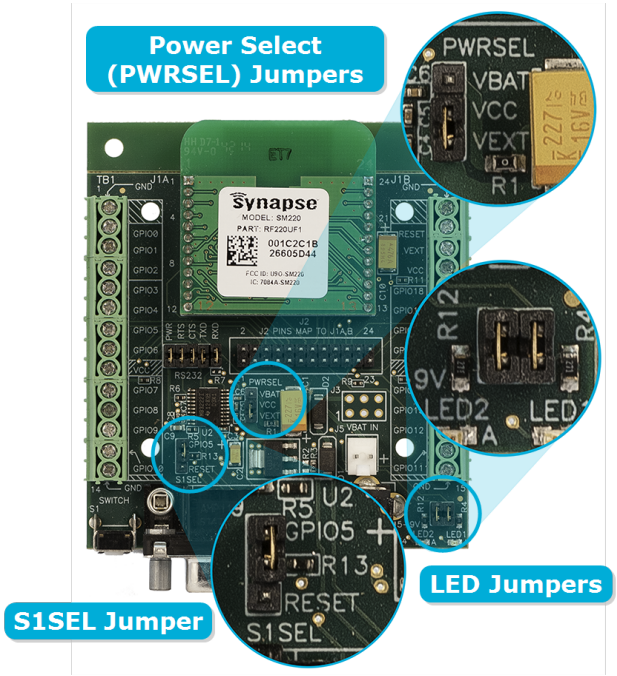


Figure 2: Power Location

On-board LEDs

Table 2: LED Jumpers

Jumper	When Installed
JMP3	LED1 (green) can be controlled via GPIO1
JMP4	LED2 (yellow) can be controlled via GPIO2

Simply remove these jumpers to reclaim these pins for other purposes.

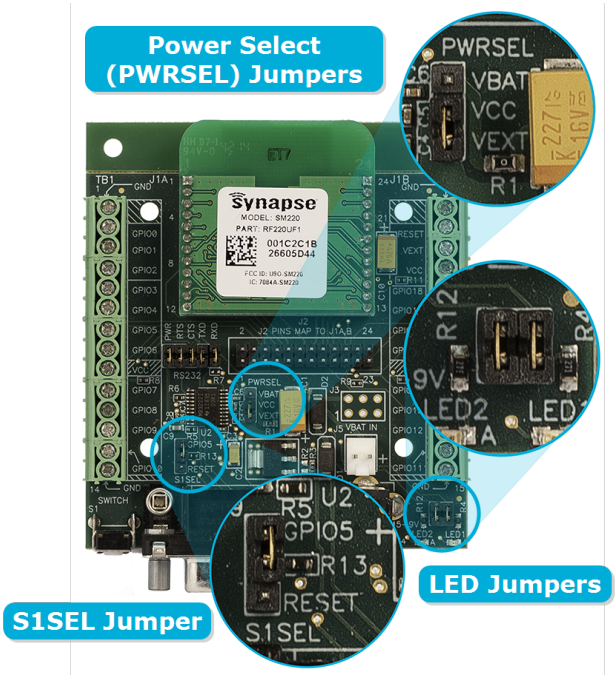


Figure 3: LED Jumper Location

On-board Push-Button

Push-button switch S1 is a normally open momentary contact switch that can be connected to processor reset, pin GPIO5, or neither.

Table 3: Push-Button Jumpers

Jumper	When Installed
JMP9	Connecting pins 1-2 connects S1 to GPIO5
JMP9	Connecting pins 2-3 connects S1 to reset

You can also leave the jumper off entirely, and switch S1 will do nothing.

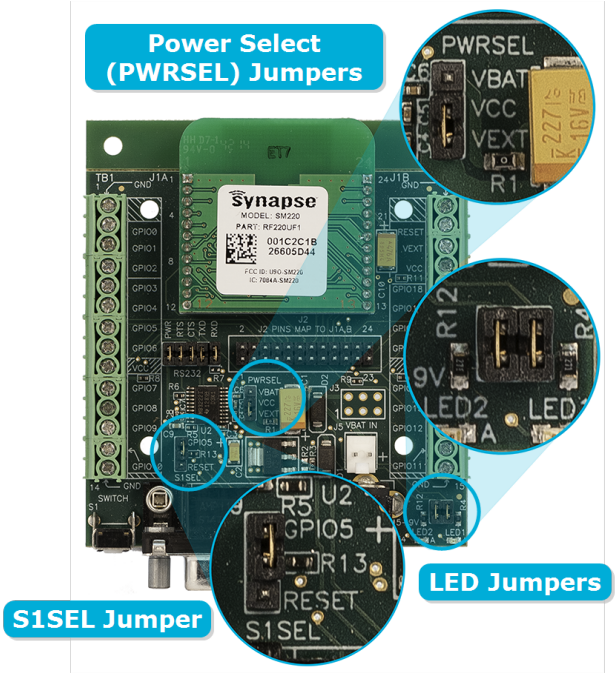


Figure 4: Push-Button Jumper Location

RS-232 Port

The SNAP Engine's UART signals are 3.3 volt logic level, and so must go through a line interface chip before they can directly be used for RS-485, RS-232, etc.

The SN171 protoboard includes a RS-232 line driver that can optionally be used with UART 1 (SCI 2). Note that this is the second serial port of the RF200 Series SNAP Engine. The SNAP Engine serial port is always 3.3 volt logic level.

Table 4: RS-232 Jumpers

Jumper	When Installed
JMP2	The RS-232 chip is powered up
JMP5	UART 1 RXD is RS-232
JMP6	UART 1 TXD is RS-232
JMP7	UART 1 CTS is RS-232
JMP8	UART 1 RTS is RS-232

Remove jumper JMP2 and JMP5 through JMP8 to disable (power down) the RS-232 line driver chip.

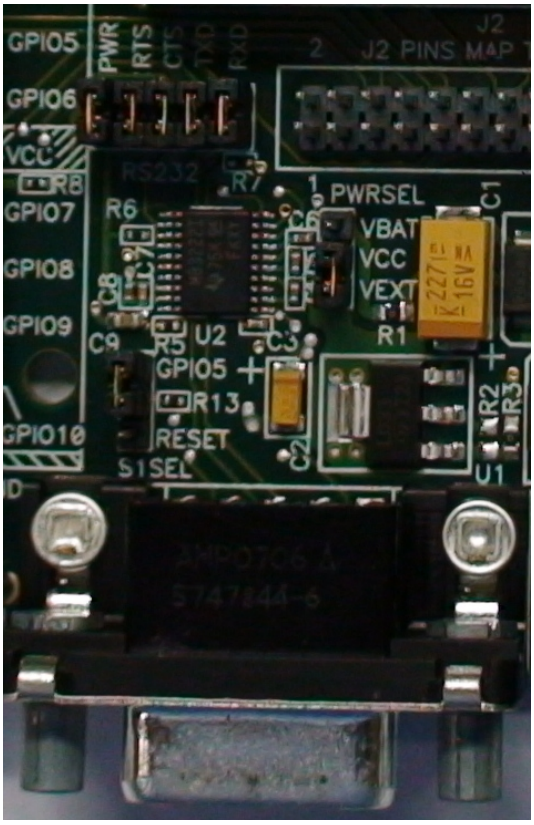


Figure 5: RS-232 Jumpers Locations

Connectivity Options

Two terminal blocks (one on each side of the board) provide access to all but one of the GPIO pins, **plus** various POWER, GND, and RESET signals. (GPIO19 on an Atmel-based SNAP Engine, such as the RF200 or RF220, is not available from the terminal blocks, though you can connect to it using pin 22 on header J2.)

NOTE: These terminal blocks DO NOT have the exact same pinout as the two headers on the SNAP Engine!

The SNAP Engine headers have 24 pins total, the breakout board terminal blocks have 28 pins total. The extra pins are additional GND and POWER connections.

Notice the power (VCC) pin between GPIO6 and GPIO7.

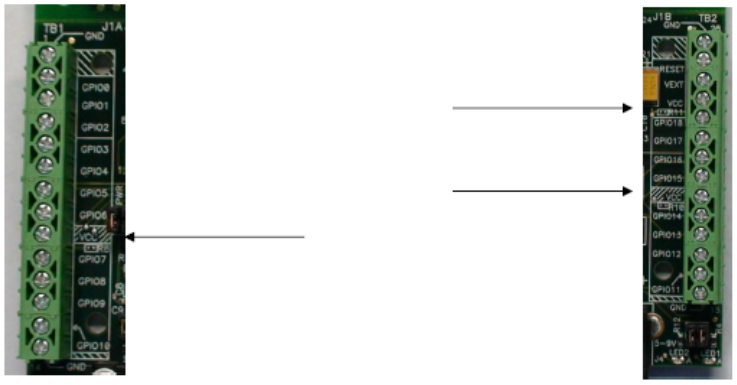


Figure 6: GPIO Terminal Block 1 Figure 7: GPIO Terminal Block 2

Also notice the power (VCC) pin between GPIO14 and GPIO15, and also one next to GPIO18.

In addition to the two terminal blocks, these signals are also available at connector J2 (if loaded) as described in the Connectors table.

Table 5: Connectors

Connector	Description
J1A	12 pin header, one of two that connect to the Synapse SNAP Engine
J1B	12 pin header, the second of two that connect to the SNAP Engine
TB1	14 position terminal block that provides all J1A signals, plus some additional power and ground pins
TB2	14 position terminal block that provides all J1B signals,plus some additional power and ground signals
J2	A 24 pin connector that provides alternate connection points to the SNAP Engine signals **NOTE:** Note that pins 1-12 of J2 map to J1A/TB1 and pins 13-24 of J2 map to J1B/TB2
J3	This is a standard Background Debug Mode (BDM) interface to the microprocessor of an RF100 SNAP Engine. This connector is usually not installed, and is not used for debug mode or programmingon an Atmel-based SNAP Engine, such as an RF200 or RF220.
J4	Barrel connector for external DC power (5 - 9 volt range)

Connector	Description
J5	Connector for external “Battery" power (2.7 - 3.4 volt range)
J6	This is the DB9 connector for the RS-232 line interface

SNAPstick 220 USB to SNAP Bridge

The SNAPstick 220 provides a USB connection between your computer and a SNAP wireless network. It contains an SM220 SNAP module, and has a user programmable multi-color LED for custom applications.

The SNAPstick 220 is powered by the Synapse SNAP network operating system. The SNAP operating system automatically networks SNAP nodes to create a common communications infrastructure for Internet of Things (IoT) solutions.

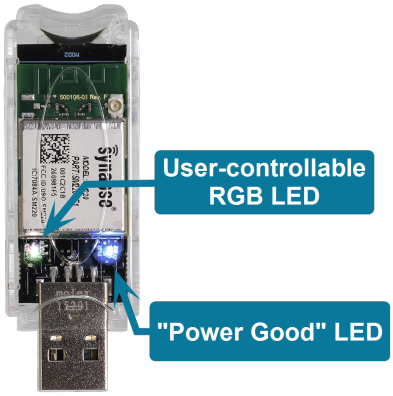
The SNAPstick 220 is an integral part of a SNAP development environment, and is the link between a SNAP network and the Synapse Portal development environment. Portal is a free, comprehensive, development and administration tool for SNAP networks that transforms your computer into a node within a SNAP wireless network, allowing it to participate as a peer or Internet gateway for connected nodes.

Specifications

Performance	SNAP module	SM220
	Transmit Power Output	up to +20 dBm
	RF Data Rate	250Kbps, 500Kbps, 1Mbps, 2Mbps
	Receiver Sensitivity	-103 dBm (1% PER, 250Kbps)
General	Frequency	ISM 2.4 GHz
	Spreading Method	Direct Sequence (DSSS)
	Modulation	O-QPSK
	Dimensions	2.78” x 0.9” x 0.35” 7 cm x 2.29cm x .89cm
	Operating Temperature	32 - 158 deg F. 0 to 70 deg C.
	Weight	13 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.
Agency Approvals	FCC Part 15.247	FCC ID: U9O-RF220UF1
	Industry Canada (IC)	7084A-RF220UF1

* at 23° C and 3.3V unless otherwise noted

The SNAPstick 220 was designed to primarily act as a bridge device. The only user-accessible GPIO is connected to the multi-color LED, controlled by SNAP GPIOs D1, D2, and D3.

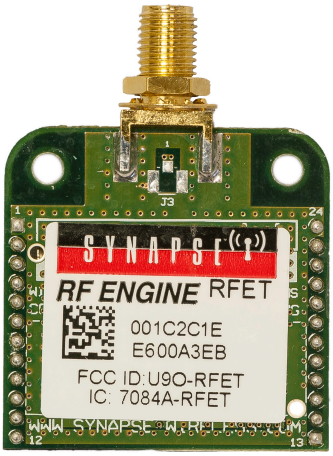


LED State	D1	D2	D3
Off	High (True)	High (True)	High (True)
Red	Low (False)	High (True)	High (True)
Green	High (True)	Low (False)	High (True)
Blue	High (True)	High (True)	Low (False)

Discontinued Products

The remaining products are discontinued and no longer actively supported by Synapse. Related information is presented here for persons who are still using legacy products.

RF Engine 100 Series Modules Overview



The RF Engine 100 Series is the all-in-one solution to your embedded wireless control and monitoring needs. Just apply power and you're instantly connected in a SNAP® mesh network. Typical applications include a wireless serial port, sensor monitoring, actuator control, or an intelligent embedded controller. The RF100 Series offers unmatched performance in a 2.4GHz, IEEE 802.15.4 module. Combined with SNAP firmware, it is the off-the-shelf solution to bring your application to market quickly.

SNAP's on-board Python interpreter provides for rapid application development and over-the-air programming. The RF100 Series 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 RF100PD6 module contains both a power amplifier for transmission and a low noise amplifier in the receive path for extended range.

This data sheet details the RF100PC6 and RF100PD6, which includes:

- 20 GPIO and up to 8 A/D inputs
- 60k flash, with 20k free for over-the-air uploaded user applications
- Powerful, reliable wireless connection in 2.4GHz license-free band
- Spread spectrum (DSSS) technology, which surmounts noisy environments
- Multiple antenna choices:
  - RF100PD6: SMA connector (reverse-polarity) for external antenna
  - RF100PC6: Embedded "F" antenna
- Up to 3-mile range
- Low power modes, down to 1.6 µA with internal timer running
- 19 available general purpose I/Os including:
  - Up to eight analog inputs with 10-bit ADC
  - Two UART ports for control or transparent data
- AES 128-bit encryption
- 1 PWM output

Specifications

Table 1: RF100 Specifications at 25° C

		RF100PD6	RF100PC6
Performance	Outdoor LOS Range	Up to 3 miles at 250Kbps	
	Transmit Power Output	18 dBm	
	RF Data Rate	250Kbps	
	Receiver Sensitivity	-102 dBm (1% PER)	
Power Requirements	Supply Voltage	2.7 - 3.4 V	
	Transmit Current (Typ@3.3V)	115mA	
	Idle/Receive Current (Typ@3.3V)	60mA	
	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	External RPSMA	Integrated F-Antenna
Networking	Topology	SNAP	
	Error Handling	Retries and acknowledgement	
	Number of Channels	16	
Available I/O	UARTS with HW Flow Control	2 Ports	
	GPIO	19 total; 8 can be analog-in with 10-bit ADC	
Agency Approvals	FCC Part 15.247	FCC ID: U9O-RFET	
	Industry Canada (IC)	IC: 7084A-RFET	

Module Pin Definitions

Table 2: RF100 Series Module Pin Assignments

Pin	Name	Description
1	GND	Power Supply
2	GPIO0_TPM1CH2	GPI/O, or Timer1 Channel 2 (ex. PWM out)
3	GPIO1_KBI0	GPI/O, Keyboard Interrupt
4	GPIO2_KBI1	GPI/O, Keyboard Interrupt
5	GPIO3_RX_UART0	GPI/O, or UART0 Data In
6	GPIO4_TX_UART0	GPI/O, or UART0 Data Out
7	GPIO5_KBI4_CTS0	GPI/O, Keyboard Interrupt, or UART0 CTS output
8	GPIO6_KBI5_RTS0	GPI/O, Keyboard Interrupt, or UART0 RTS input
9	GPIO7_RX_UART1	GPI/O, or UART1 Data In
10	GPIO8_TX_UART1	GPI/O, or UART1 Data Out
11	GPIO9_KBI6_CTS1	GPI/O, Keyboard Interrupt, or UART1 CTS output
12	GPIO10_KBI7_RTS1	GPI/O, Keyboard Interrupt, or UART1 RTS input
13	GPIO11_AD7	GPI/O, or Analog In
14	GPIO12_AD6	GPI/O, or Analog In, CBUS CDATA, or SPI MOSI
15	GPIO13_AD5	GPI/O, or Analog In, CBUS CLK, or SPI CLK
16	GPIO14_AD4	GPI/O, or Analog In, CBUS RDATA, or SPI MISO
17	GPIO15_AD3	GPI/O, or Analog In
18	GPIO16_AD2	GPI/O, or Analog In
19	GPIO17_AD1	GPI/O, Analog In, or I^2C SDA
20	GPIO18_AD0	GPI/O, Analog In, or I^2C SCL
21	VCC	Power Supply
22	PTG0/BKDG	Background Debug Communications
23	RESET	Module Reset, Active Low
24	GND	Power Supply

You must preserve access to UART1 as a serial connection in order to be able to update firmware on the node, or to recover the node by forced script removal or parameter reset.

Electrical Characteristics

Table 3: RF100 Series DC Characteristics at 25° C

Symbol	Parameter	Condition	Min	Typ	Max	Units
V_{CC}[30]	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	0.70*V_{CC}			V
V_{IL}	Input Low Voltage	All Digital Inputs			0.35*V_{CC}	V
V_{OL}	Output Low Voltage	All drive strengths (2, 4, 6, 8 mA)			0.5	V
V_{OH}	Output High Voltage	All drive strengths (2, 4, 6, 8 mA)	V_{CC} – 0.5			V
IL_{IN}	In Leakage Current	V_{IN}=V_{CC} or V_{SS}, all Pins		0.025	1.0	µA
TX-I_{CC}	Transmit Current	V_{CC} = 3.3V		115	125	mA
RX-I_{CC}	Receive Current	V_{CC} = 3.3V		60	68	mA
SHDN-I_{CC}	Sleep Current	V_{CC} = 3.3V		1.6		µA

Table 4: ADC Electrical Characteristics (Operating)

Symbol	Parameter	Condition	Min	Typical	Max	Unit
V_{REFH}	Voltage Reference, High	Fixed		V_{CC}	V_{CC}+0.3	V
V_{INDC}	Analog input voltage	Single Ended	-0.03		V_{CC}+0.3	V

Table 5: ADC Timing/Performance Characteristics

Symbol	Parameter	Condition	Min	Typical	Max	Unit
R_{AS}	Source impedance at input.[31]				10k	kΩ
RES	Conversion Resolution		2.031		3.516	mV

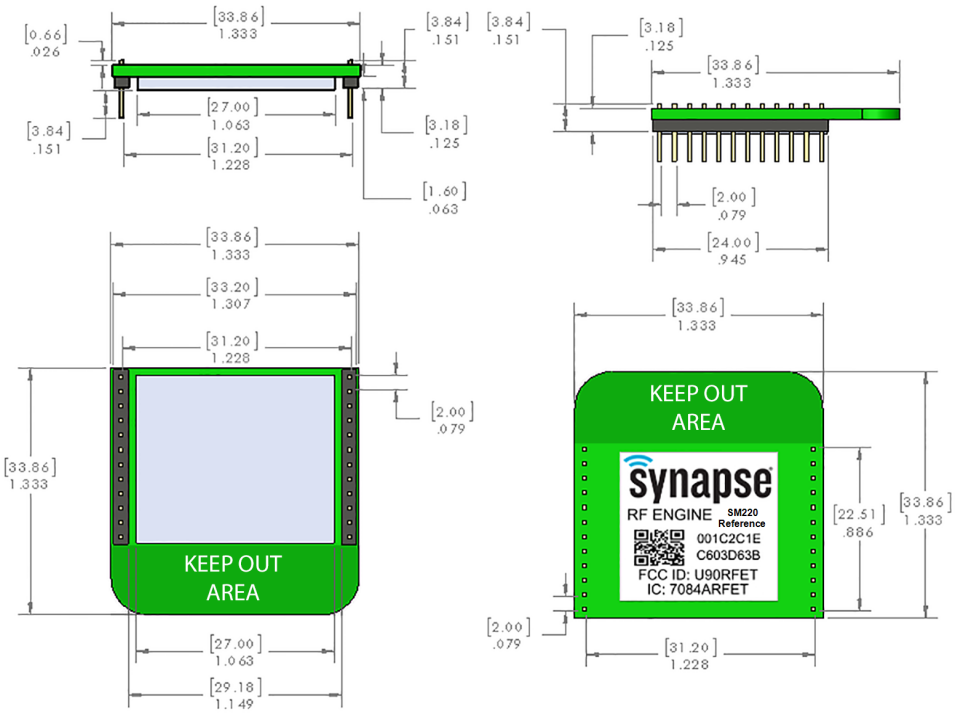
30 Absolute maximum stress rated voltage for VCC is -0.3 to 3.6. It is recommended that bulk capacitance be located as close as possible to the VCC pin on the host board. Ideally, use a single 47µF capacitor at 10V directly at the VCC pin.
31 Any analog source with a source impedance greater than 3kΩ will increase the sampling time.

Symbol	Parameter	Condition	Min	Typical	Max	Unit
DNL	Differential non-linearity			± 0.5		LSB
INL	Integral non-linearity			0.8		LSB
E_{ZS}	Zero-scale error			1.5		LSB
E_G	Gain error			1		LSB

Mechanical Drawings

The drawings in **Mechanical drawings of the RF100 Module** on page **116**. 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.



NOTE: Metric measurements are between brackets, with standard measurements below.

Figure 1: Mechanical drawings of the RF100 Module

Board Mounting Considerations

The RF100 modules are designed to mount into a receptacle (socket) on the host board. **RF100PD6 Mounted To Host Board** on page **117**. shows an RF100PD6 module plugged into 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-T-SV
Surface mount receptacle	Samtec	MMS-112-02-T-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. See **RF100PD6 Mounted To Host Board** on page **117**. for an image of the RF100PD6 with an SEMA connector mounted to the host board.

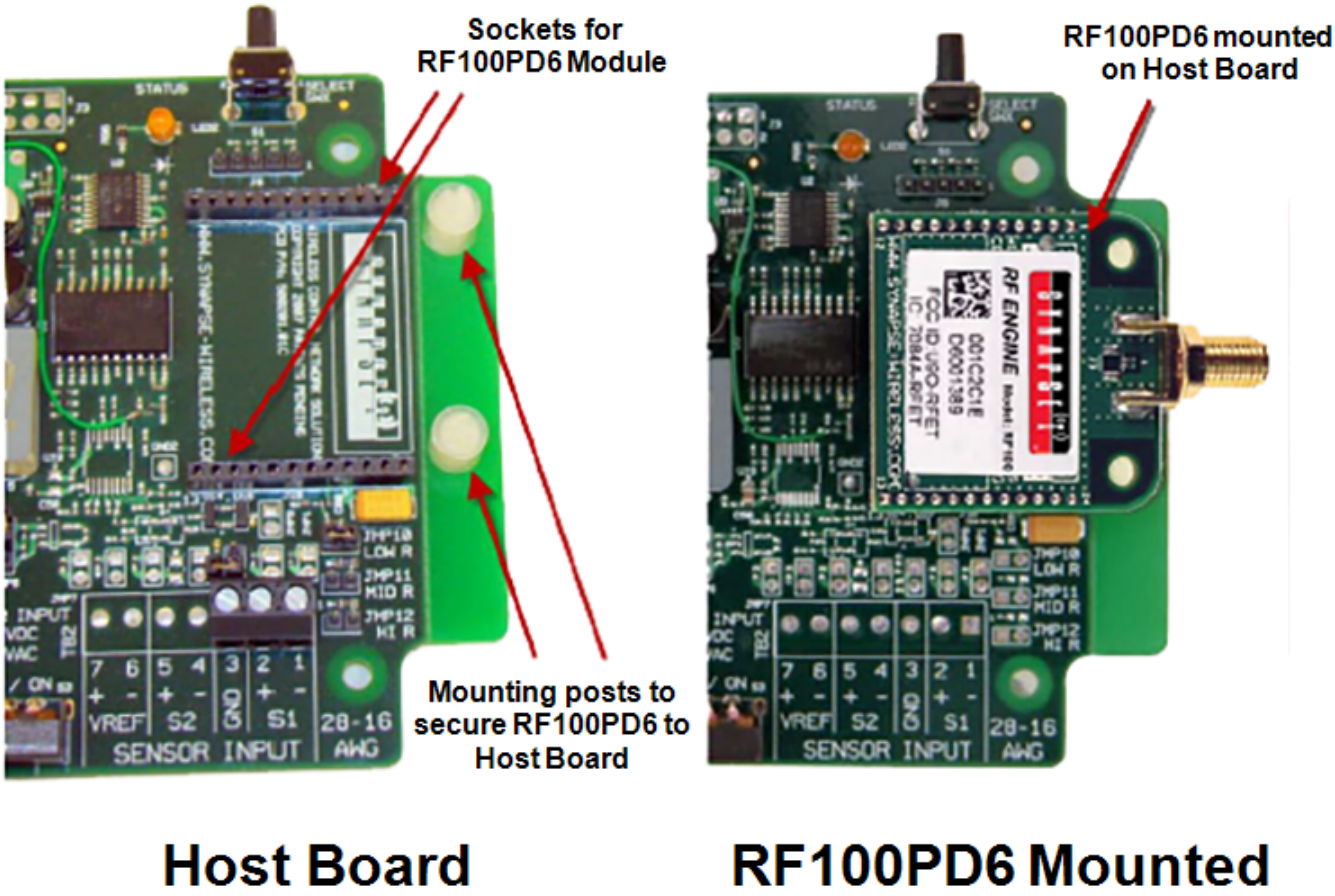


Figure 2: RF100PD6 Mounted To Host Board

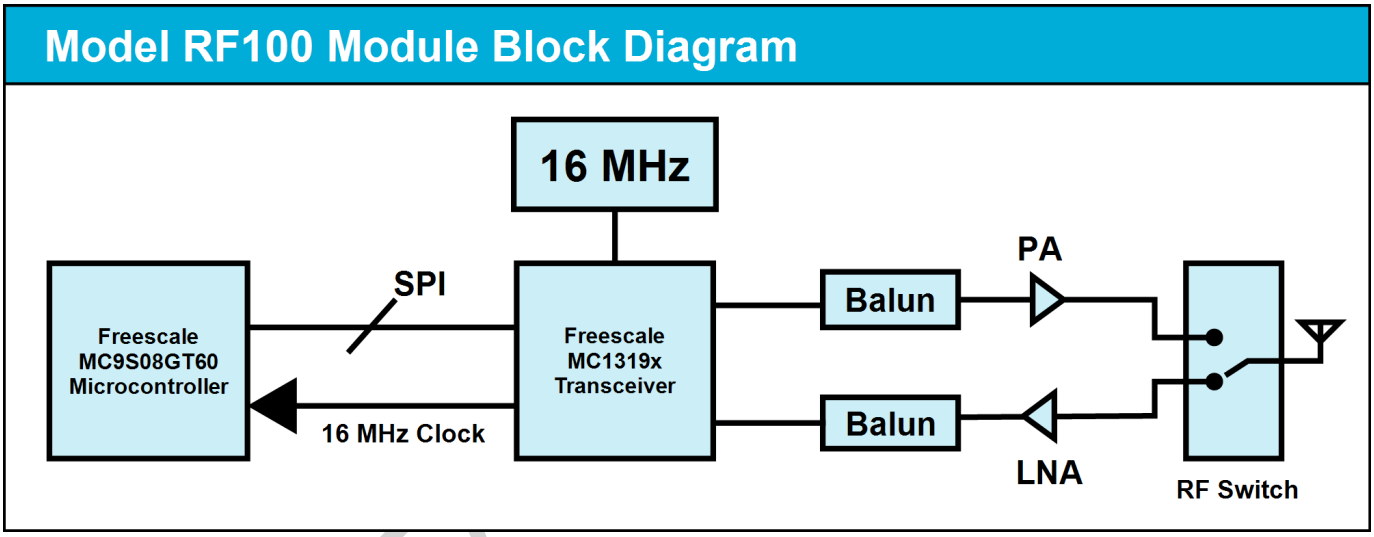


Figure 3: Block diagram showing the major subsystems comprising the RF100

Agency Certifications

United States (FCC)

The Model RF100 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 RF100 Modules. **FCC Label** on page **119**. below shows the contents that must be included on this label.
2. RF100 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 **119**. below.

MANUFACTURERSNAME
BRANDNAME or TRADENAME

Contains RF Engine FCC ID: U90-RF100

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.

* The FCC ID for the RF Engine without external amplifier is “U9O-RFE” which is part number RF100PC1. The FCC ID for the RF Engine with external amplifier is “U9O- RFET” which is part number RF100PD1.

Figure 1: FCC Label

FCC Notices

WARNING: The RF100 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 RF100 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.

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 RF100 modules are FCC-approved for fixed base station and mobile applications on channels 11 thru 26 of the ISM 2.4GHz frequency band as defined in IEEE 802.15 specifications.

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 below in **Approved FCC Antennas** on page **120**. , and having a maximum gain greater than 5dB are strictly prohibited for use with this device. The required antenna impedance is 50 ohms.

Table 1: Approved FCC Antennas

Part Number	Type	Gain	Application	Min. Separation
AC12000	Dipole (quarter-wave RPSMA)	3.2dBi	Fixed/Mobile	20 cm.
AC12001	Dipole (half-wave RPSMA)	5.0dBi	Fixed/Mobile	20 cm.
AC12002	Dipole (quarter-wave RPSMA)	4.9cBi	Fixed/Mobile	20 cm.
AC12003	Dipole (quarter-wave RPSMA)	2.0dBi	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 20cm between the radiator and your body. This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

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.

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.

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: RF100, IC: 7084A-RF100 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: RF100, IC: 7084A-RF100 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: Approved IC Antennas

Part Number	Type	Gain	Application	Min. Separation
AC12000	Dipole (quarter-wave RPSMA)	3.2dBi	Fixed/Mobile	20 cm.
AC12001	Dipole (half-wave RPSMA)	5.0dBi	Fixed/Mobile	20 cm.
AC12002	Dipole (quarter-wave RPSMA)	4.9cBi	Fixed/Mobile	20 cm.
AC12003	Dipole (quarter-wave RPSMA)	2.0dBi	Fixed/Mobile	20 cm.

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 **122**. below.

MANUFACTURERSNAME
BRANDNAME or TRADENAME
MODEL:

Contains RF Engine IC: 7084A-RF100

Figure 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 **Combined FCC and IC Label** on page **123**. below.

MANUFACTURERSNAME
BRANDNAME or TRADENAME

Contains RF Engine FCC ID: U90-RF100
Contains RF Engine IC: 7084A-RF100

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 3: Combined FCC and IC Label

* The FCC ID for the RF Engine without amp is “U9O-RFE” and the IC ID is “7084A- RFE” which is part number RF100PC1. The FCC ID for the RF Engine with amp is “U9O-RFET” and the IC ID is “7084ARFET” which is part number RF100PD1.

SNAP Engine 266 Series Modules Overview

The SNAP Engine 266 Series (Model RF266) 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 RF266PC1 module is pin-compatible with Digi International's XBee® and XBee-PRO® RF modules, and comes pre-loaded with open source code for AT command emulation.

The RF266 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. These low-cost modules can have a range of up to 4,000 feet and current consumption as low as 1.18 µA 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 RF266 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 RF266 contains both a power amplifier for transmission and a low noise amplifier in the receive path for extended range.

This Data Sheet details Part Number RF266PC1

- 15 GPIO, 4 with 10-bit ADC
- 128k flash, 58k free for over-the-air uploaded user apps
- One UART port
- Low power modes:
  - 1.18 µA with internal timer off
  - 2.3 µA with internal timer running
- Spread spectrum (DSSS) technology
- AES 128-bit encryption
- Socket-able or solder-able
- Up to 2 Mbps Data Rate
- 2.4 GHz RF Frequency
- Chip antenna (up to 4000 feet, LoS at 250kbps)
- 4K internal EEPROM
- I^2C and SPI support

- 4 PWM outputs

Specifications

Table 1: RF266 Specifications at 25° C

Performance	Outdoor LOS Range	Up to 4,000 feet at 250Kbps
	Transmit Power Output	20 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)	130mA
	Idle/Receive Current (Typ@3.3V)	25mA
	Power-down Current (Typ@3.3V)	1.18uA with internal timer off 2.3uA with internal timer running
General	Frequency	ISM 2.4 GHz
	Spreading Method	Direct Sequence (DSSS)
	Modulation	O-QPSK
	Dimensions	1.3" (H) x 1.0" (W)
	Operating Temperature	- 40 to 85 deg C.
	Antenna Options	Chip
Networking	Topology	SNAP
	Error Handling	Retries and acknowledgement
	Number of Channels	16
Available I/O	UARTS with HW Flow Control	1 port
	GPIO	15 total; 4 can be analog-in with 10bit ADC
Agency Approvals	FCC Part 15.247	FCC ID: U9O-RF266
	Industry Canada (IC)	IC: 7084A-RF266
	CE available as a custom part. Call for details.	

Module Pin Definitions

Table 2: RF266 Module Pin Assignments

Pin	SNAPpy IO	Name	Description
1		3.3V	Power Supply
2	11	IO_11 PD3 INT3 TXD1	IO_11, UART Data Out, Interrupt

Pin	SNAPpy IO	Name	Description
3	10	IO_10 PD2 INT2 RXD1	IO_10, UART Data In, Interrupt
4	21	IO_21 PE5 INT5 OC3C	IO_21, PWM Output, Interrupt
5		RESET	Module Reset, Active Low
6	20	IO_20 PE4 INT4 OC3B	IO_20, PWM Output, Interrupt
7	19	IO_19 PE3 RTS0 OC3A AIN0	IO19, Analog Comparator, PWM Output, Output Compare Match
8		-	No Connect
9	9	IO_9 PD1 INT1	IO_9, Interrupt, I^2C SDA
10		GND	
11	15	IO_15 PD7	IO_15
12	12	IO_12 PD4 CTS1 ICP1	IO_12, UART1 CTS output, Input Capture
13	8	IO_8 PD0 INT0	IO_8, Interrupt, I^2C SCL
14		-	No Connect
15	37	IO_37 PG5 OC0B	IO_37, PWM Output
16	23	IO_23 PE7 INT7 ICP3	IO_23, UART1 RTS input, Clock Output Buffer, Interrupt
17	31	IO_31 PF7 ADC7	IO_31, ADC7 Input, JTAG Test Data In
18	30	IO_30 PF6 ADC6	IO_30, ADC6 Input, SPI MOSI, JTAG Test Data Out
19	29	IO_29 PF5 ADC5	IO_29, ADC5 Input, SPI SCLK, JTAG Test Mode Select
20	28	IO_28 PF4 ADC4	IO_28, ADC4 Input, SPI MISO, JTAG Test Clock

You must preserve access to UART1 as a serial connection in order to be able to serially update firmware on the node, or to recover the node by forced script removal or parameter reset.

Electrical Characteristics

Table 3: RF266 DC Characteristics at 25° C

Symbol	Parameter	Condition	Min	Typ	Max	Units
V_{CC}[32]	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

32 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.

Symbol	Parameter	Condition	Min	Typ	Max	Units
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
IL_{IN}	In Leakage Current	V_{IN}=V_{CC} or V_{SS}, all Pins		<10 nA	1	µA
TX-I_{CC}	Transmit Current	V_{CC} = 3.3V		130		mA
RX-I_{CC}	Receive Current	V_{CC} = 3.3V		25		mA
SHDN-I_{CC}	Sleep Current	V_{CC} = 3.3V	1.18	2.3	963	µA

Table 4: ADC Electrical Characteristics (Operating)

Symbol	Parameter	Condition	Min	Typical	Max	Unit
V_{REFH}[33]	ADC Voltage Reference, High	Programmable	1.5	1.6	1.8	V
V_{INDC}	Analog input voltage	Single Ended	0		1.8	V
		Differential[34]	0		3.3	

Table 5: ADC Timing/Performance Characteristics

Symbol	Parameter	Condition	Min	Typical	Max	Unit
R_{AS}	Source impedance at input[35]				3k	kΩ
RES	Conversion Resolution	Single Ended CLKADC <= 4MHz		10		Bits
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

Table 6: Reset, Brown-out and Internal Voltage Characteristics

Symbol	Parameter	Condition	Min	Typical	Max	Unit
V_{POT} (rising)	Power-on Reset Threshold Voltage (rising)	Power supply fully discharged		1.6		V

33 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.
34 Each differential analog input may be as high as 3.3V but the differential voltage is still limited.
35 Any analog source with a source impedance greater than 3kΩ will increase the sampling time.

Symbol	Parameter	Condition	Min	Typical	Max	Unit
V_{POT} (falling)	Power-on Reset Threshold Voltage (falling)		0.05	0.3		V
t_{POT}	Power-on Reset recovery time	Time of EVDD/DEVDD < V_{POT}	1.0			ms
V_{PSR}	Power-on slope rate		1.8		3300	V/ms
V_{RST}	RSTN Pin Threshold Voltage		0.1V DD		0.9 V_{DD}	V
t_{RST}	Minimum pulse width on RSTN Pin			200	300	ns
V_{HYS}	Brown-out Detector Hysteresis			7.5	50	mV
t_{BOD}	Min Pulse Width on Brown-out Reset			100		ns

Contact ATMEL for additional details

Mechanical Drawings

The drawings in **Mechanical drawings of the RF266 Module** on page **131**. show the RF266 module mechanical specifications.

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.

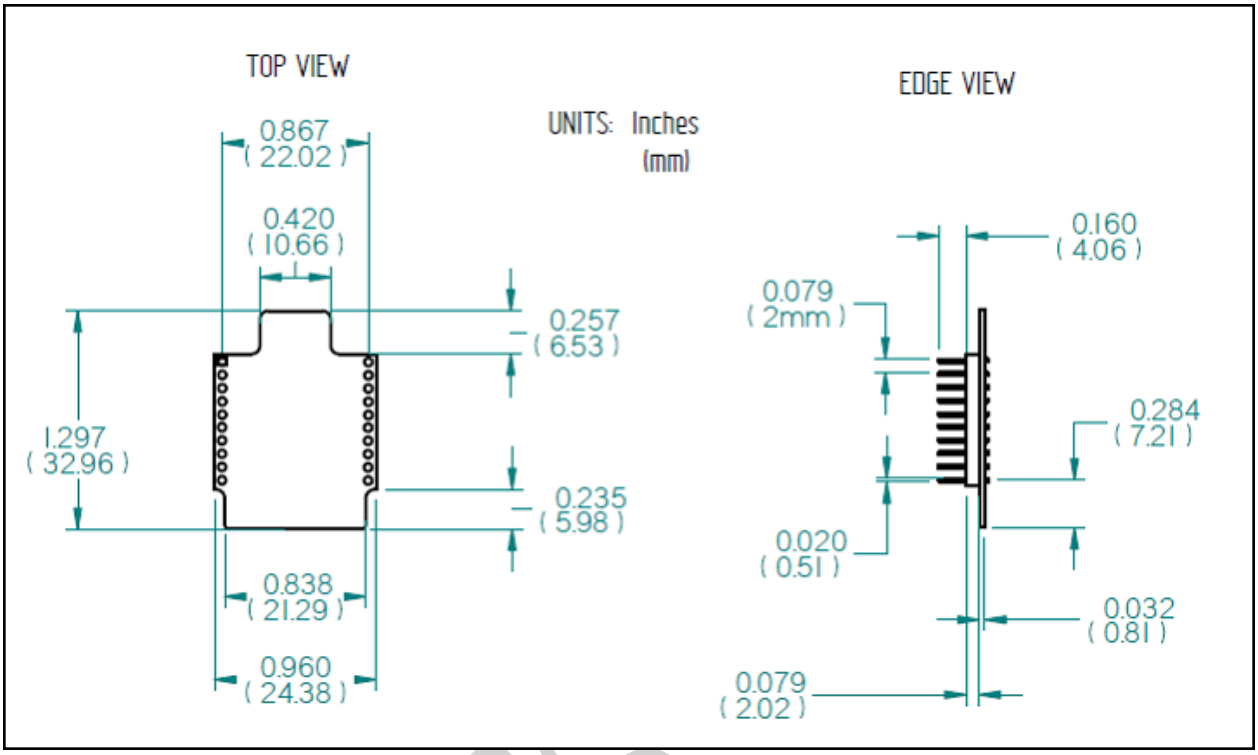


Figure 1: Mechanical drawings of the RF266 Module

Board Mounting Considerations

The RF266 module is designed to mount into a receptacle (socket) on the host board. **RF266PC1 mounted to an example host board** on page **132**. shows an RF266 module plugged in to an example host board. The receptacle sockets are on standard 2mm centers. Suggested receptacles to be used on the host are:

Thru-hole receptacle	Samtec	MMS-110-01-L-SV
Surface mount receptacle	Samtec	MMS-110-02-L-SV

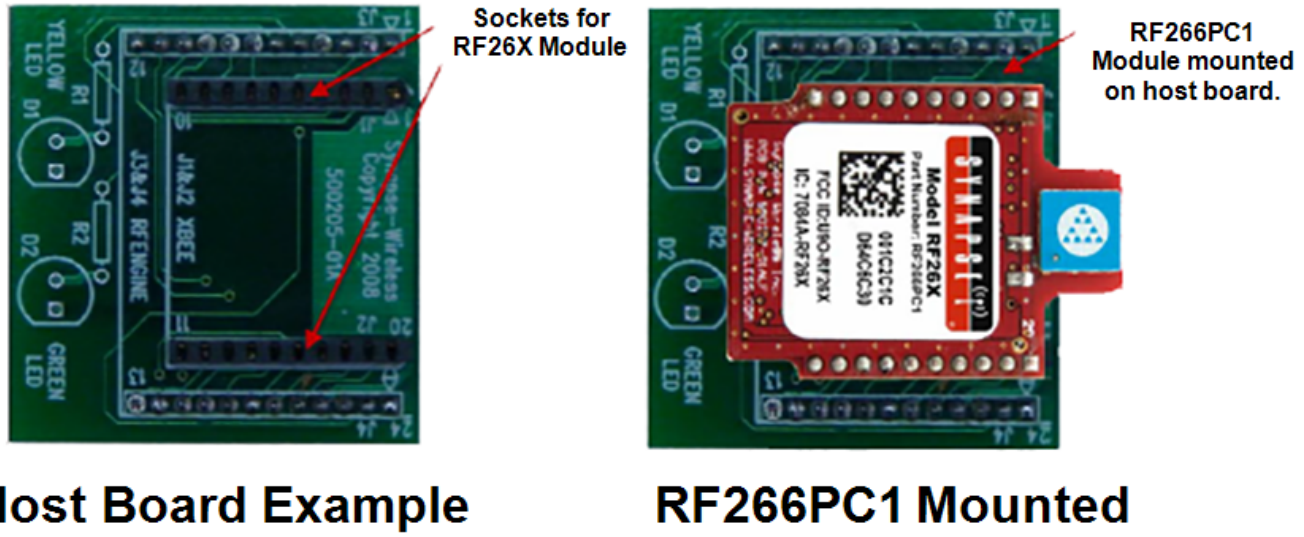


Figure 2: RF266PC1 mounted to an example host board

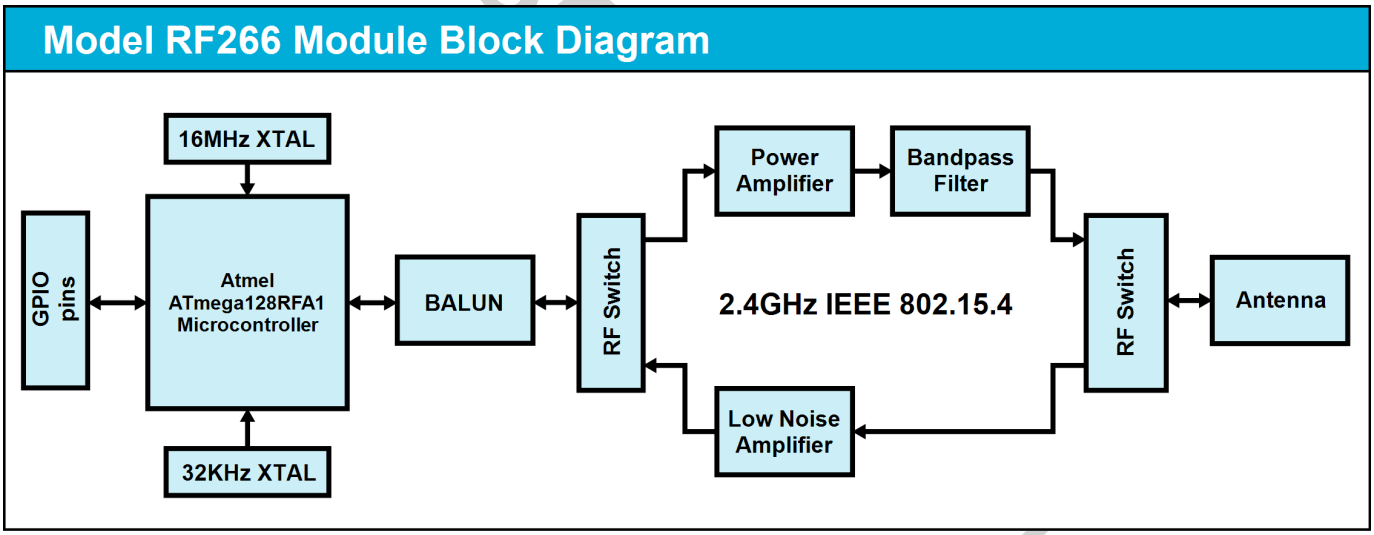


Figure 3: Block diagram showing the major subsystems comprising the RF266

Agency Certifications

United States (FCC)

The Model RF266 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 RF266 Modules. **FCC Label** on page **133**. below shows the contents that must be included on this label.
2. RF266 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 **133**. below.

MANUFACTURERSNAME
BRANDNAME or TRADENAME

Contains RF 26X FCC ID: U90-RF26X

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: FCC Label

FCC Notices

WARNING: The RF266 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 RF266 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.

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 RF266 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 below in **Approved FCC Antennas** on page **134**. . The required antenna impedance is 50 ohms.

Table 1: Approved FCC Antennas

Part Number	Type	Gain	Application	Min. Separation
Fractus: FR05-S1-N-0-001	Chip Antenna	1.9 dBi	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 20cm between the radiator and your body. This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

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.

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

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: RF266, IC: 7084A-RF266 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: RF266, IC: 7084A-RF266 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: Approved IC Antennas

Part Number	Type	Gain	Application	Min. Separation
Fractus: FR05-S1-N-0-001	Chip Antenna	1.9 dBi	Fixed/Mobile	20 cm.

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 **136**. .

MANUFACTURERSNAME
BRANDNAME or TRADENAME
MODEL:

Contains RF 26X IC: 7084A-RF26X

Figure 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 **Combined FCC and IC Label** on page **136**. .

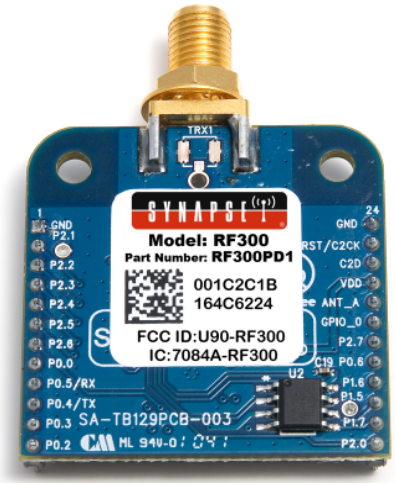
MANUFACTURERSNAME
BRANDNAME or TRADENAME

Contains RF 26X FCC ID: U90-RF26X
Contains RF 26X IC: 7084A-RF26X

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 3: Combined FCC and IC Label

SNAP Engine 300 Series Modules Overview



The SNAP Engine 300 Series (Model Number RF300) is a low power, highly-reliable solution to embedded wireless control and monitoring network needs that require high data rates. The RF300 embeds Synapse's SNAP OS, the industry's first Internet-enabled, wireless, mesh network operating system into the Silicon Laboratories Si1000 single-chip microcontroller with an integrated transceiver that delivers up to 150kbps. These low-cost modules can have a range of up to 3 miles and current consumption less than 16 µA 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 Silicon Laboratories' low-power RF single-chip design saves board space and lowers the overall Bill of Materials and power consumption. The RF300 is approved as an FCC Part 15 unlicensed modular transmitter. The modules provide up to 16 channels of operation in the ISM 915MHz frequency band. The on- board Si1000 transceiver contains both a power amplifier for transmission and a low noise amplifier in the receive path for extended range.

This Data Sheet details Part Number RF300PD1, which includes:

- 15 GPIO and up to 12 A/D inputs
- 192K total FLASH with 64K used by SNAP core, 64K free for uploadable SNAPpy scripts, and 64K reserved
- UART port for control or transparent data
- Low power modes: <16µA with internal timer running
- Frequency Hopping (FHSS) technology
- Socket-able or solder-able
- 150Kbps RF Data Rate
- 915 MHz RF Frequency
- SMA antenna (up to 3 miles LoS)
- AES 128-bit encryption

The RF300 is also available with a U.FL connector.
Contact Synapse for details.

Specifications

Table 1: RF300PD1 Specifications at 25° C

Performance	Outdoor LOS Range	Up to 3 miles at 150Kbps
	Transmit Power Output	20 dBm
	RF Data Rate	150Kbps
	Receiver Sensitivity	-99 dBm (1% PER)
Power Requirements	Supply Voltage	2.7 - 3.6 V
	Transmit Current (Typ@3.3V)	85mA
	Idle/Receive Current (Typ@3.3V)	24.2mA
	Power-down Current (Typ@3.3V)	Timed: .9µA Untimed: .2µA
General	Frequency	ISM 915 MHz
	Spreading Metho d	FHSS
	Modulation	GFSK
	Dimensions	1.333" x 1.333"
	Operating Temperature	- 40 to 85 deg C.
	Antenna Options	External RPSMA
Networking	Topology	SNAP
	Error Handling	Retries and acknowledgement
	Number of Channels	16
Available I/O	UARTS with HW Flow Control	1 Port
	GPIO	15 total; 12 can be analog-in with 10bit ADC
Agency Approvals	FCC Part 15.247	FCC ID: U9O-RF300
	Industry Canada (IC)	IC: 7084A-RF300

Module Pin Definitions

Table 2: RF300PD1 Module Pin Assignments

Pin	SNAPpy IO	Name	Description
1		GND	Power Supply
2	10	GPIO0/ADC17/P2.1	GPIO_0, ADC17, I²C SDA

Pin	SNAPpy IO	Name	Description
3	11	GPIO1/ADC18/P2.2	GPIO_1, ADC18, I²C SCL
4	12	GPIO2/ADC19/P2.3	GPIO_2, ADC19
5	13	GPIO3/ADC20/P2.4	GPIO_3, ADC20
6	14	GPIO4/ADC21/P2.5	GPIO_4, ADC21, SPI MOSI
7	15	GPIO5/ADC22/P2.6	GPIO_5, ADC22, SPI SCLK
8	0	GPIO6/ADC0/P0.0/V_{REF}	GPIO_6, ADC0, Interrupt, External Voltage Reference, SPI MISO
9	4	GPIO7/ADC5/P0.5/UART_RX	GPIO_7, ADC5, Interrupt, UART0 Rx Data Input
10	3	GPIO8/ADC4/P0.4/UART_TX	GPIO_8, ADC4, Interrupt, UART0 Tx Data Output
11	2	GPIO9/ADC3/P0.3/CTS	GPIO_9, ADC3, UART0 CTS Output
12	1	GPIO10/ADC2/P0.2/RTS	GPIO_10, ADC2, Interrupt, UART0 RTS Input
13	(9)	[GPIO11/ADC16/P2.0]	Not Available, Do Not Connect[36]
14	(8)	[GPIO12/ADC15/P1.7]	Not Available, Do Not Connect[1]
15	(6)	[GPIO13/ADC13/P1.5]	Not Available, Do Not Connect[1]
16	(7)	[GPIO14/ADC14/P1.6]	Not Available, Do Not Connect[1]
17	5	GPIO15/ADC6/P0.6/CNVSTR	GPIO_15, ADC6, External "Start Conversion" for ADC0
18	16	GPIO16/P2.7	GPIO_16[37]
19	17	GPIO17	GPIO_17
20	18	ANT_A	GPIO_18 (Output Only)
21		V_{CC}	Power Supply
22		C2D	Background Debug Communications
23		RESET	Module Reset, Active Low
24		GND	Power Supply

You must preserve access to UART0 as a serial connection in order to be able to update firmware on the node, or to recover the node by forced script removal or parameter reset.

36 Pins 13 – 16 are not available for use on the RF300 and should not be tied to any signals. These pins are used for access to the onboard external memory.
37 GPIO16 has limited drive strength as it is routed through a 1Kohm resistor. The signal driven from (or to) GPIO16 can also be read, or driven, on pin 22 (CD2), the debug pin.

Table 3: RF300 Series DC Characteristics at 25° C

Symbol	Parameter		Condition	Min	Typ	Max	Units
V_{CC}[38]	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} - 0.6			V
V_{IL}	Input Low Voltage		All Digital Inputs			0.6	V
V_{OL}	Output Low Voltage	High Drive Strength	I_{OL} = 8.5ma			0.6	V
			I_{OL} = 10uA			0.1	
			I_{OL} = 25mA		Note[39]		
		Low Drive Strength	I_{OL} = 1.4ma			0.6	
			I_{OL} = 10uA			0.1	
			I_{OL} = 4mA		Note[3]		
V_{OH}	Output High Voltage	High Drive Strength	I_{OH} = -3ma	V_{CC} - 0.7			V
			I_{OH}= -10uA	V_{CC} - 0.1			
			I_{OH}= -10mA		Note[3]		
		Low Drive Strength	I_{OL}= 1.4ma	V_{CC} - 0.7			
			I_{OL} = 10uA	V_{CC} - 0.1			
			I_{OL} = 4mA		Note[3]		
IL_{IN}	In Leakage Current		Weak PU On, V_{IN} = 0V, V_{CC} = 3.6V		20	30	uA
TX-I_{CC}	Transmit Current		V_{CC} = 3.3V		85		mA
RX-I_{CC}	Receive Current		V_{CC} = 3.3V		18.5		mA
SHDN-I_{CC}	Sleep Current				8	16	uA

38 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.
39 See Si100X datasheet for output current curves.

Table 4: ADC Electrical Characteristics (Operating)

Symbol	Parameter	Condition	Min	Typical	Max	Unit
V_{REF}	Voltage Reference	Internal-Fast		1.65		V
		Internal-Precision		1.68		
		External	0		V_{CC}	
V_{INDC}	Analog input voltage	Absolute Voltage	0		V_{CC}	V
		ADC Input Range	0		V_{REF}	

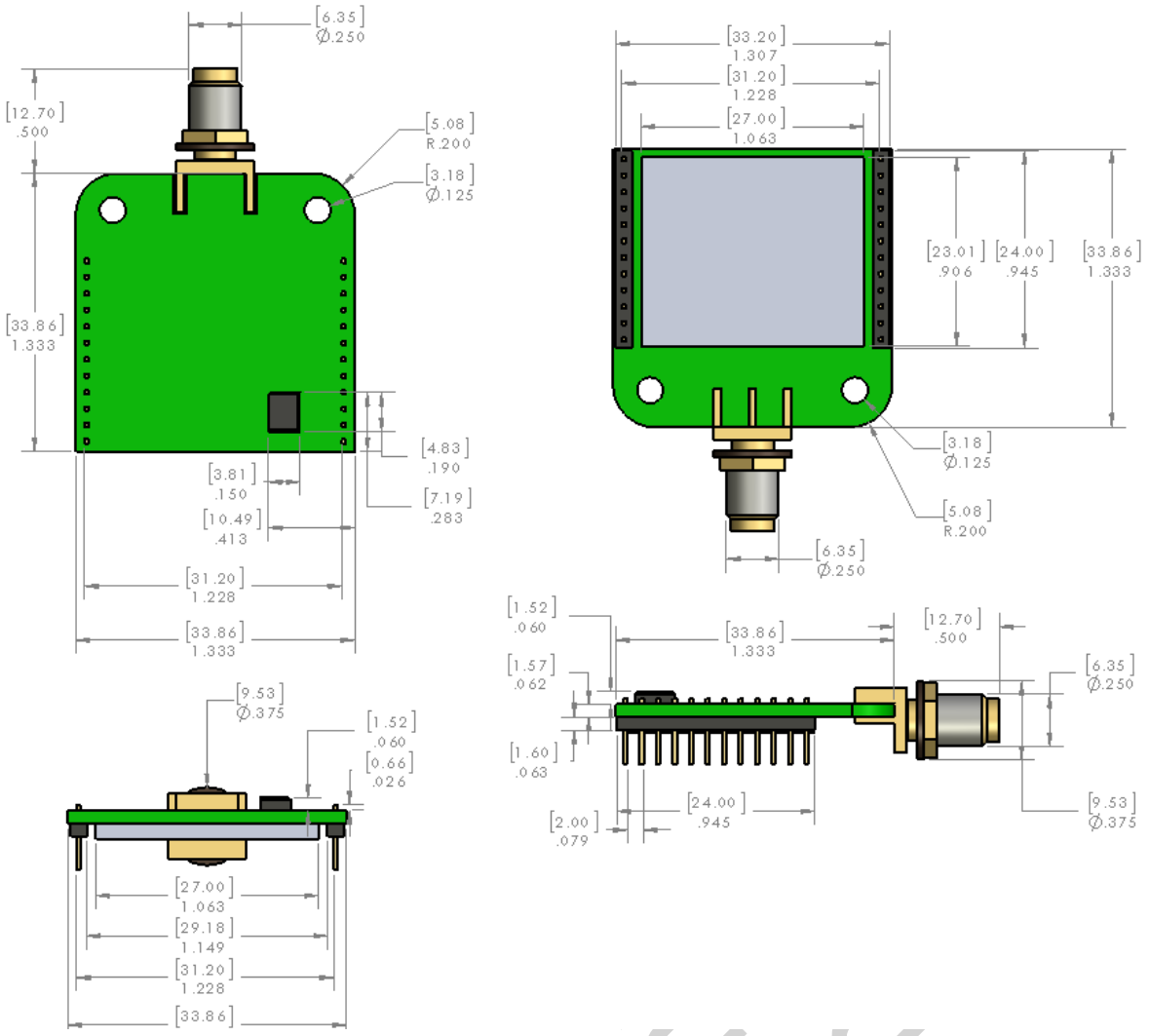
Table 5: ADC Timing/Performance Characteristics

Symbol	Parameter	Condition	Min	Typical	Max	Unit
R_{AS}	Source impedance at input			5		kΩ
RES	Conversion Resolution			10		Bits
INL	Integral non-linearity			0.5	1	LSB
E_{OFF}	Offset Error			<1	2	LSB
E_{FS}	Full Scale Error			1	2.5	LSB

Mechanical Drawings

These drawings in **Mechanical drawings of the RF300PD1 Module** on page **142**. show the module with the RPSMA connector for use with an external 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.



NOTE: Metric measurements are between brackets, with standard measurements below.

Figure 1: Mechanical drawings of the RF300PD1 Module

Board Mounting Considerations

The RF300PD1 module is designed to mount into a receptacle (socket) on the host board. **RF300PD1 Mounted To Host Board** on page **143**. shows an RF300PD1 module plugged into 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. **RF300PD1 Mounted To Host Board** on page **143**. shows the RF300PD1 with SMA connector mounted to the host board.

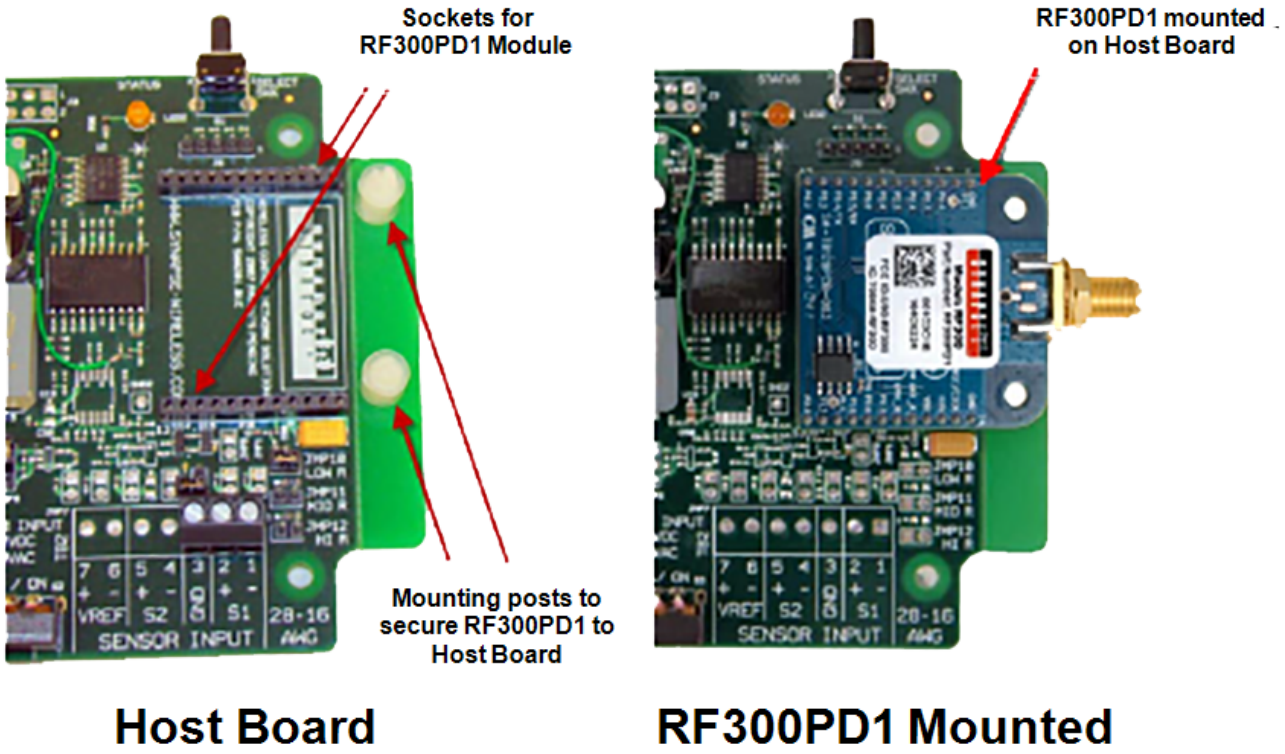


Figure 2: RF300PD1 Mounted To Host Board

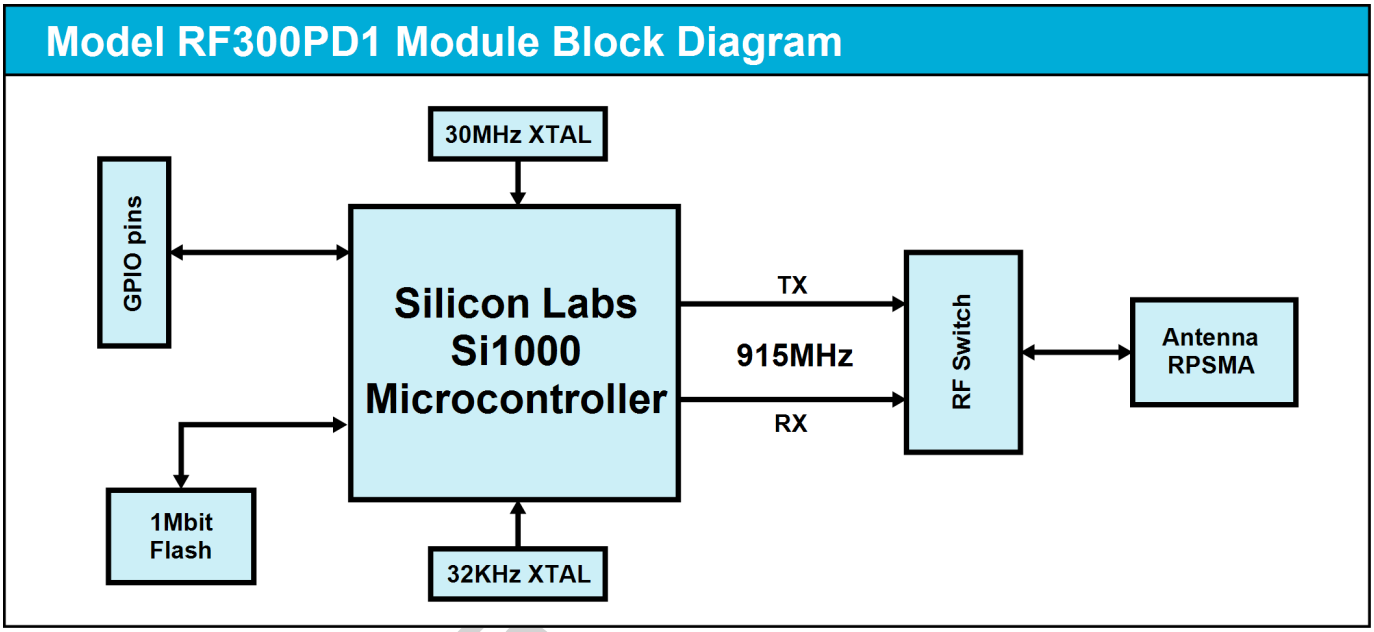


Figure 3: Block diagram showing the major subsystems comprising the RF300PD1

Agency Certifications

United States (FCC)

The Model RF300 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 RF300 Modules. **FCC Label** on page **145**. below shows the contents that must be included on this label.
2. RF300 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 **145**. below.

MANUFACTURERSNAME
BRANDNAME or TRADENAME

Contains RF300 FCC ID: U90-RF300

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: FCC Label

FCC Notices

WARNING: The RF300 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 RF300 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.

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 RF300 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 below in **Approved Antennas** on page **146**. . The required antenna impedance is 50 ohms.

Table 1: Approved Antennas

Part Number	Type	Gain	Application	Min. Separation
Linx ANT-916-CW-RCL	Dipole (quarter-wave RPSMA)	0.47 dBi	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 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 (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: RF300 FCC ID: U90-RF300 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: RF300, IC: 7084A-RF300 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: Approved Antennas

Part Number	Type	Gain	Application	Min. Separation
Linx ANT-916-CW-RCL	Dipole (quarter-wave RPSMA)	-	Fixed/Mobile	20 cm.

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 **148**. below.

MANUFACTURERSNAME
BRANDNAME or TRADENAME
MODEL:

Contains RF300 IC: 7084A-RF300

Figure 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 **Combined FCC and IC Label** on page **148**. below.

MANUFACTURERSNAME
BRANDNAME or TRADENAME

Contains RF300 FCC ID: U90-RF300
Contains RF300 IC: 7084A-RF300

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 3: Combined FCC and IC Label

SNAP Engines SM700 Series Modules Overview

The SNAP Engine SM700 Series is based on the Freescale™ MC13224V transceiver platform. This wireless network module uses an ARM7 32-bit processor with large on-chip memory and integrated 12-bit ADCs.

Like all SNAP Engines, the Model SM700 comes with SNAP® already loaded and ready to perform right out of the box. SNAP is Synapse's award-winning, mesh network operating system that provides wireless connectivity for Internet-to-machine and machine-to-machine communications.

With 96K RAM of memory, large applications can bring intelligence to the very edge of the network for local operations. These applications can be uploaded over-the-air… even mesh hopping across the network to reach their destination. And because of the large memory in the SM700, the core SNAP operating system can also be upgraded over-the-air leaving your network in place and intact.

Very little board space is needed for this SNAP Engine (25mm x 36mm). Even the antenna is integrated to further reduce system size and cost. The SM700 can achieve a range of over 1.5 miles and deliver an output of up to +20dBm. For applications requiring battery power, the Model SM700 can perform at current consumption levels as low as 12 µA.

This document details the SM700PC1 module, which includes:

- Powerful 32-bit TDMI ARM7 microprocessor
- Large on-board memory resources
- 2.4 GHz RF Frequency (2400 - 2483.5 MHz)
- Up to 100mW output power
- 16 RF Channels
- 2.0 to 3.6 Volts Vcc
- Small footprint: 1" x 1.4" (25.4mm x 36.5mm)
- Operating temperature: -40°C to +85°C
- Low current consumption:
  - Transmit mode.....193mA
  - Receive mode.....27mA
  - Sleep mode.....12µA
- Over 1.5 miles range

- AES 128-bit encryption
- FCC, CE and IC certified
- Integrated F-antenna
- Accurate 12-bit ADC for precision sensors
- Small surface-mount IC footprint

Specifications

Table 1: SM700PC1 Specifications at 25° C

Performance	Outdoor LOS Range	Up to 1.5 miles at 250Kbps
	Transmit Power Output	20 dBm
	RF Data Rate	250Kbps
	Receiver Sensitivity	-94 dBm (1% PER)
Power Requirements	Supply Voltage	2.0 - 3.6 V
	Transmit Current (Typ@3.3V)	193mA
	Idle/Receive Current (Typ@3.3V)	30mA
	Power-down Current (Typ@3.3V)	12µA
General	Frequency	ISM 2.4GHz
	Spreading Method	DSSS
	Modulation	O-QPSK
	Dimensions	1" x 1.4" (25.4mm x 36.5mm)
	Operating Temperature	- 40 to 85 deg C.
	Antenna Options	Integrated F-antenna
Networking	Topology	SNAP
	Error Handling	Retries and acknowledgement
	Number of Channels	16
Available I/O	UARTS with HW Flow Control	2
	GPIO	46 total; 12bit ADC; 8 can be analog in with 12b + ADC
Agency Approvals	FCC Part 15.247	FCC ID: U9O-SM700
	Industry Canada (IC)	IC: 7084A-SM700

Module Pin Definitions

Table 2: SM700PC1 Module Pin Assignments

Pin	SNAPpy IO	Name	Description
1		GND	GND
2		GND	GND
3		GND	GND
4	39	ADC2_VREFL	GPIO39, Alternate function: Low reference voltage for ADC2
5	41	ADC1_VREFL	GPIO41, Alternate function: Low reference voltage for ADC1
6	40	ADC1_VREFH	GPIO40, Alternate function: High reference voltage for ADC1
7	38	ADC2_VREFH	GPIO38, Alternate function: Low reference voltage for ADC2
8	30	ADC0	GPIO30, Alternate function: ADC0
9	31	ADC1	GPIO31, Alternate function: ADC1
10	32	ADC2	GPIO32, Alternate function: ADC2
11	33	ADC3	GPIO33, Alternate function: ADC3
12		VCC	High side supply voltage to buck regulator switching MOSFET & IO buffers
13	34	ADC4	GPIO34, Alternate function: ADC4
14	35	ADC5	GPIO35, Alternate function: ADC5
15	36	ADC6	GPIO36, Alternate function: ADC6
16	37	ADC7_RTCK	GPIO37, Alternate function: ADC7 / Return Clock
17	49	TDO	GPIO49, Alternate function: JTAG Test Data Output
18	48	TDI	GPIO48, Alternate function: JTAG Test Data Input
19	47	TCK	GPIO47, Alternate function: JTAG Test Clock Input
20	46	TMS	GPIO46, Alternate function: JTAG Test Mode Select Input
21	21	UART2_RTS	GPIO21, Alternate function: UART2 Request to Send input
22		GND	GND
23	20	UART2_CTS	GPIO20, Alternate function: UART2 Clear to Send output
24	19	UART2_RX	GPIO19, Alternate function: UART2 RX data input
25	18	UART2_TX	GPIO18, Alternate function: GPIO18UART2 TX data output
26	17	UART1_RTS	GPIO17, Alternate function: UART1 Request to Send input
27	16	UART1_CTS	GPIO16, Alternate function: UART1 Clear to Send output

Pin	SNAPpy IO	Name	Description
28	13	I2C_SDA	GPIO13, Alternate function: I^2C Bus data
29	12	I2C_SCL	GPIO12, Alternate function: I^2C Bus clock
30	11	TMR3	GPIO11, Alternate function: Timer 3 IO signal
31		VCC	High side supply voltage to buck regulator switching MOSFET & IO buffers
32	10	TMR2	GPIO10, Alternate function: Timer 2 IO signal
33	9	TMR1	GPIO9, Alternate function: Timer 1 IO signal
34	8	TMR0	GPIO8, Alternate function: Timer 0 IO signal
35	7	SPI_SCK	GPIO7, Alternate function: SPI Port clock
36	14	UART1_TX	GPIO14, Alternate function: UART1 TX data output
37	15	UART1_RX	GPIO15, Alternate function: UART1 RX data input
38		GND	GND
39	6	SPI_MOSI	GPIO6, Alternate function: SPI Port MOSI
40	5	SPI_MISO	GPIO5, Alternate function: SPI Port MISO
41	4	SPI_SS	GPIO4, Alternate function: SPI Port SS
42	3	SSI_BITCK	GPIO3, Alternate function: SSI Bit Clock
43	2	SSI_FSYN	GPIO2, Alternate function: SSI Frame Sync
44	1	SSI_RX	GPIO1, Alternate function: SSI RX data input
45	0	SSI_TX	SSI TX data output / GPIO0
46	29	KBI_7	GPIO29, Alternate function: Keyboard Interface Bit 7
47		COIL_BK	Buck Converter coil drive output
48	28	KBI_6	GPIO28, Alternate function: Keyboard Interface Bit 6
49		RESETB	System reset input
50		LREG_BK_FB	Voltage input to onboard regulators, buck regulator feedback voltage
51		GND	GND
52	27	KBI_5	GPIO27, Alternate function: Keyboard Interface Bit 5
53	26	KBI_4	GPIO26, Alternate function: Keyboard Interface Bit 4
54	25	KBI_3	GPIO25, Alternate function: Keyboard Interface Bit 3
55	24	KBI_2	GPIO24, Alternate function: Keyboard Interface Bit 2
56	23	KBI_1	GPIO23, Alternate function: Keyboard Interface Bit 1

Pin	SNAPpy IO	Name	Description
57	22	KBI_0_HST _ WK	GPIO22, Alternate function: Keyboard Interface Bit 0 / Host Walk-up output
58		GND	GND
59		GND	GND
60		GND	GND

You must preserve access to UART1 as a serial connection in order to be able to serially update firmware on the node, or to recover the node by forced script removal or parameter reset.

Electrical Characteristics

Table 3: SM700 Series DC Characteristics at 25° C

Symbol	Parameter	Condition	Min	Typ	Max	Units
V_{CC}[40]	Supply Voltage		2.1	3.3	3.6	V
T_{OP}	Operating Temp		-40°		85°	°C
T_{STOR}	Storage Temp					°C
V_{IH}	Input Hi Voltage	All Digital Inputs			V_{CC}+.02	V
V_{IL}	Input Low Voltage	All Digital Inputs	-0.3			V
TX-I_{CC}	Transmit Current (at +20 dBm Output Power)	V_{CC} = 3.3V		193 mA		mA
RX-I_{CC}	Receive Current	V_{CC} = 3.3V		30 mA		mA
SHDN-I_{CC}	Sleep Current	V_{CC} = 3.3V		12µA		µA

Table 4: Absolute Maximum Ratings

Description	Min	Max	Unit
Power Supply Voltage	-0.3	3.6	VDC
Voltage on Any Digital Pin	-0.3	VCC + 0.2	VDC
RF Input Power		10	dBm
Reflow Soldering Temperature		260	ºC

40 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.

NOTE: Exceeding the maximum ratings may cause permanent damage to the module.

Table 5: Recommended Operating Conditions

Description	Min	Typ	Max	Unit
Power Supply Voltage (VCC)	2.1		3.6	VDC
Ambient Temperature Range	-40	25	85	ºC
Crystal Reference Oscillator		24		MHz

Mechanical Drawings

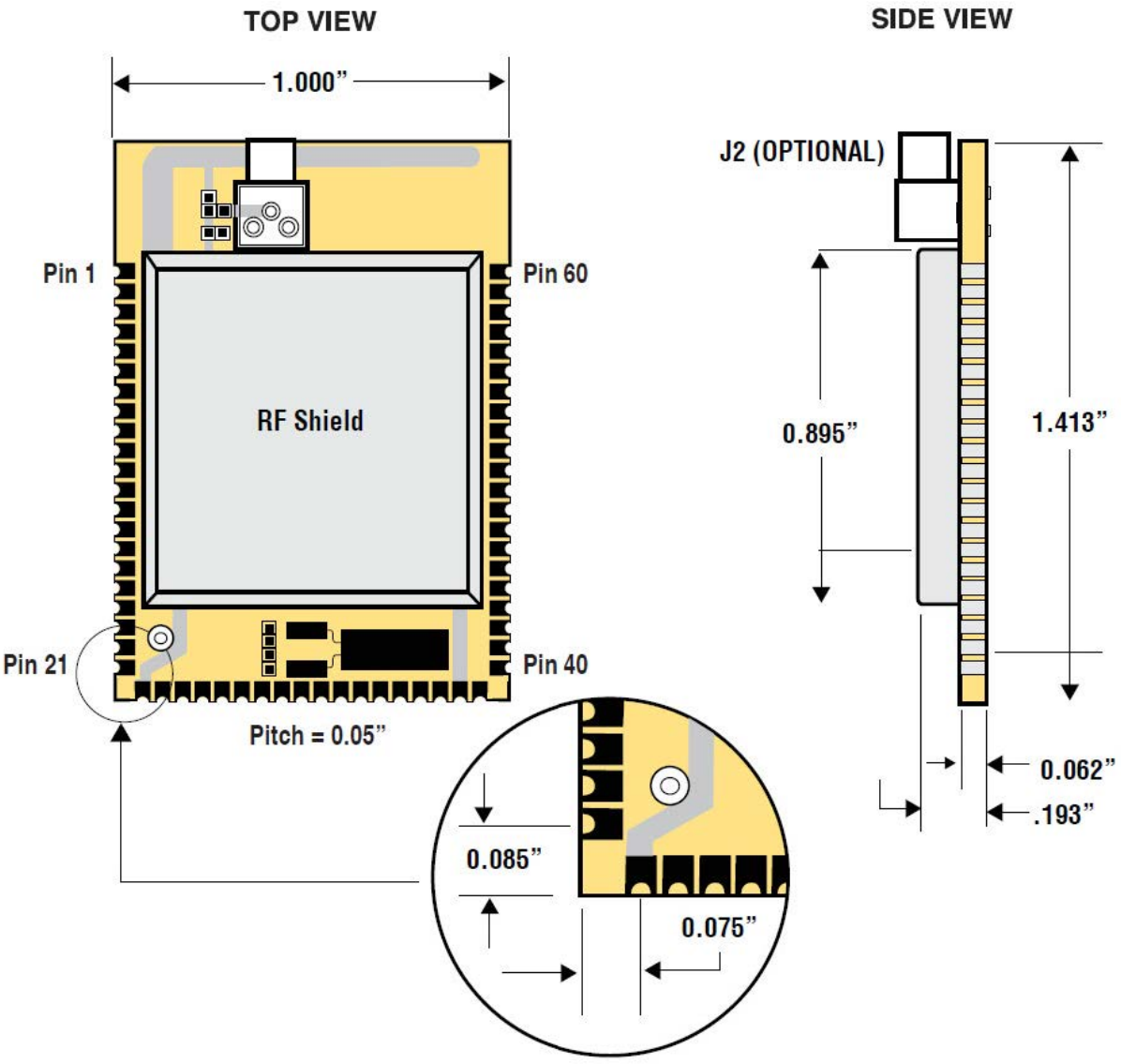


Figure 1: Mechanical drawings of the SM700PC1 Module

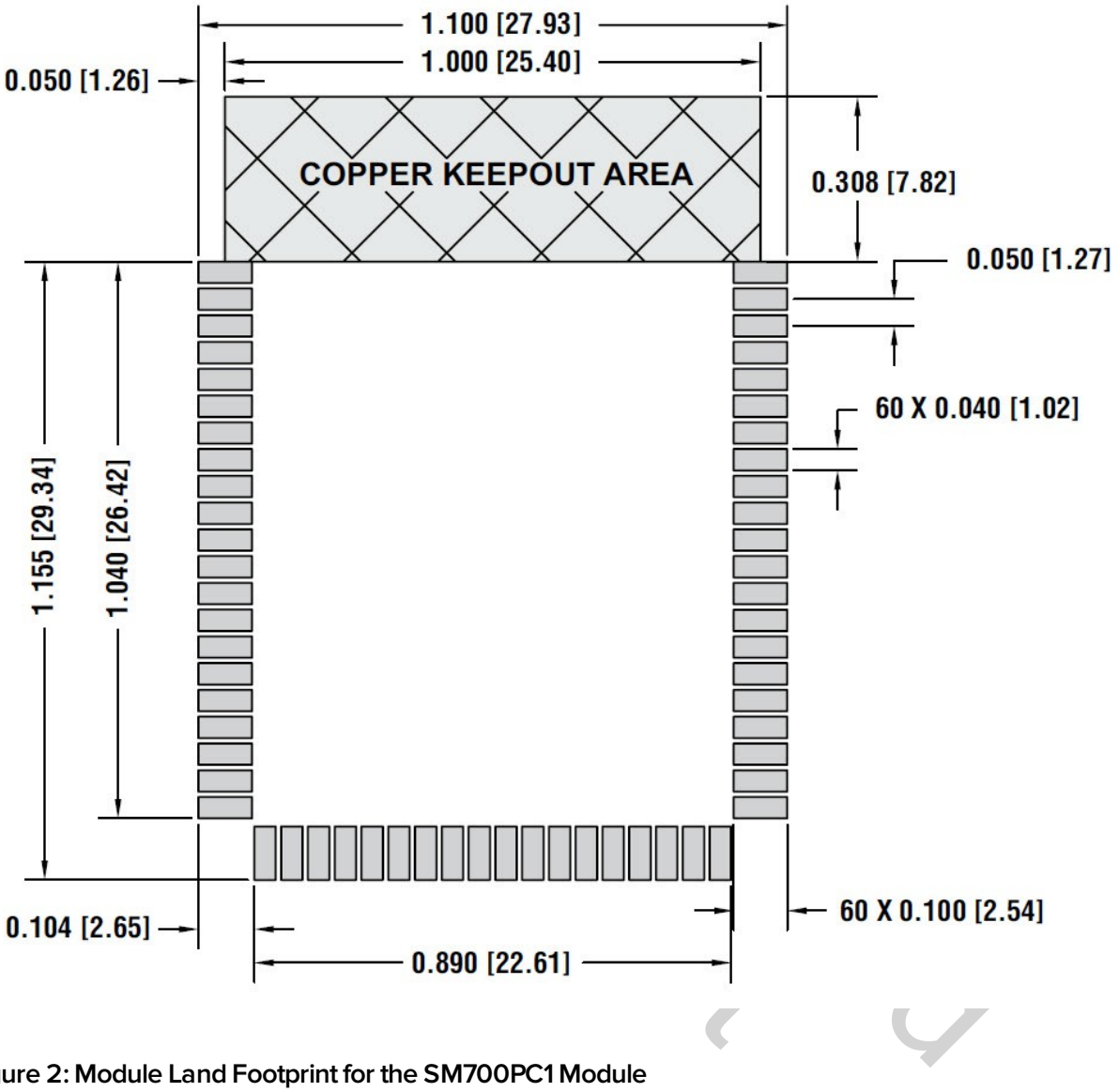


Figure 2: Module Land Footprint for the SM700PC1 Module

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.

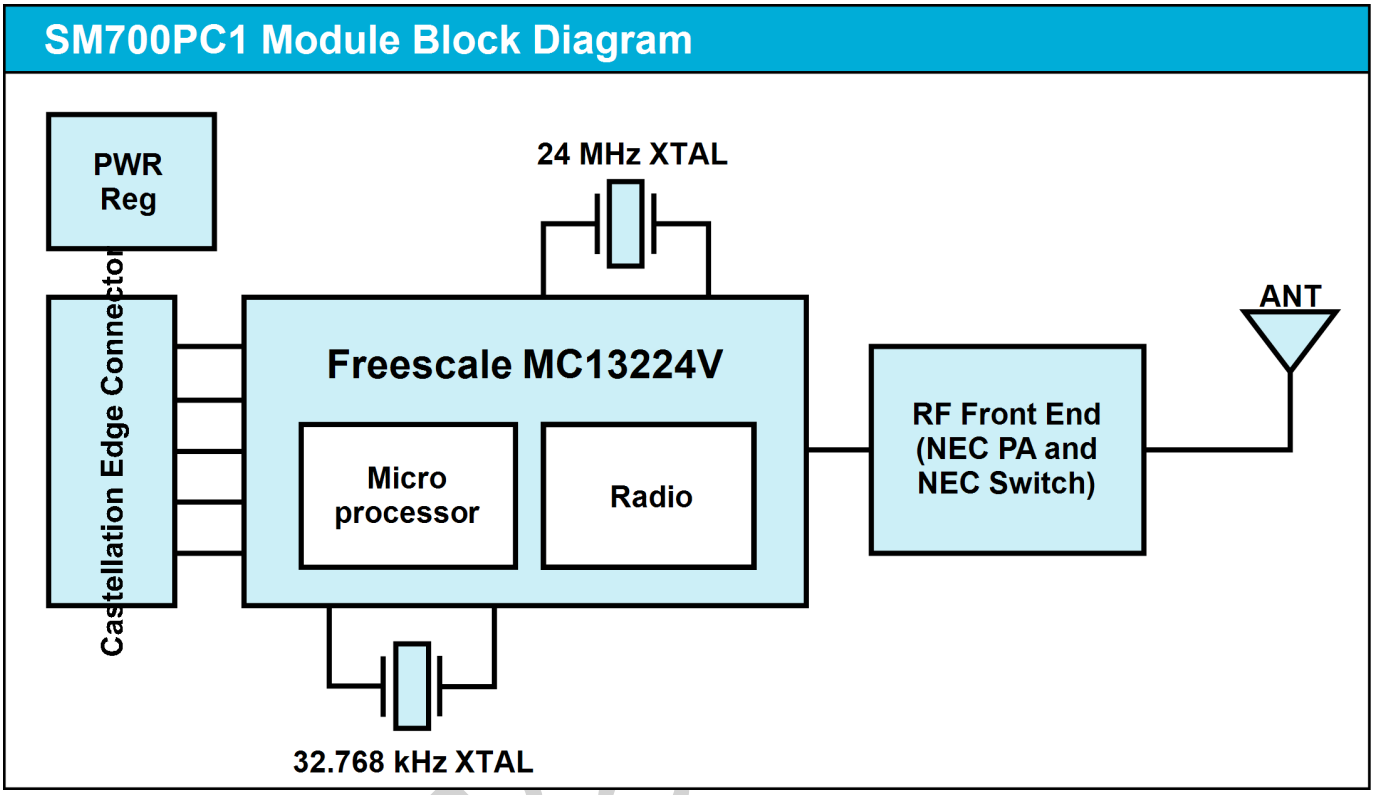


Figure 3: Block diagram showing the major subsystems comprising the SM700PC1

Board Mounting Considerations

Processing

Table 6: 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	60-150 sec
Tpeak	250ºC
Time within 5º of Tpeak	20-30 sec
Time from 25º to Tpeak	8 min max
Ramp down rate	6ºC/sec max

Achieve the brightest possible solder fillets with a good shape and low contact angle.

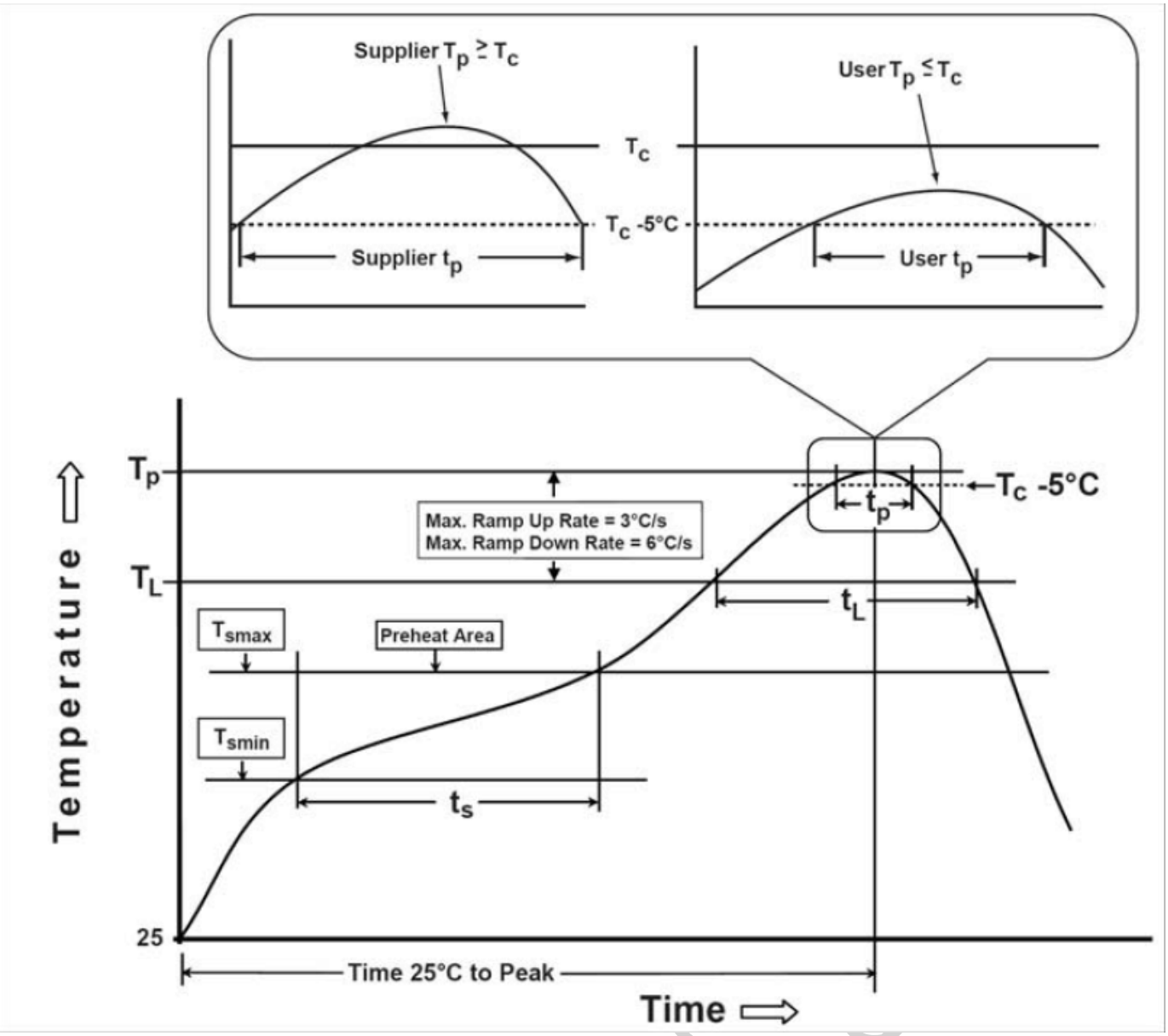


Figure 4: SM700 Peak Reflow Profile

Lead-Free Soldering Paste

Use of “No Clean” soldering paste is strongly recommended, as it does not require cleaning after the soldering process.

NOTE: The quality of solder joints on the castellations (‘half vias’) where they contact the host board should meet the appropriate IPC Specification. See IPC-A-610: Acceptability of Electronic Assemblies, section 8.2.4 Castellated Terminations.

Cleaning

In general, cleaning the populated modules is strongly discouraged. Residuals under the module cannot be easily removed with any cleaning process.

- Cleaning with water can lead to capillary effects where water is absorbed into the gap between the host board and the module. The combination of soldering flux residuals and encapsulated water could lead to short circuits between neighboring pads. Water could also damage any stickers or labels.
- Cleaning with alcohol or a similar organic solvent will likely flood soldering flux residuals into the two housings, which is not accessible for post-washing inspection. The solvent could also damage any stickers or labels.
- Ultrasonic cleaning could damage the module permanently.

The best approach is to consider using a “no clean” soldering paste and eliminate the post-soldering cleaning step.

Optical Inspection

After soldering the Module to the host board, consider optical inspection to check the following:

- Proper alignment and centering of the module over the pads.
- Proper solder joints on all pads.
- Excessive solder or contacts to neighboring pads, or vias.

Repeating Reflow Soldering

Only a single reflow soldering process is encouraged for host boards.

Wave Soldering

If a wave soldering process is required on the host boards due to the presence of leaded components, only a single wave soldering process is encouraged.

Hand Soldering

Hand soldering is possible. Use a soldering iron temperature setting equivalent to 350°C, follow IPC recommendations/ reference document IPC-7711.

Rework

The Model SM700 Module can be unsoldered from the host board. Use of a hot air rework tool and hot plate for pre-heating from underneath is recommended. Avoid overheating.

WARNING: Never attempt a rework on the module itself (e.g. replacing individual components). Such actions will terminate warranty coverage.

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.

Errata

Be sure you are using the latest SNAP firmware, which is the official release for the MC1322X chip and the Model SM700 module. All of the following errata can be found in the SNAP Reference Manual; be sure to read the sections on the MC1322x chip and the SM700 module.

1. Wakeup pins

   Four pins, GPIO_26 through GPIO_29, can be configured to wake the module from sleep. Note that these pins automatically become inputs when entering sleep. Four other pins, GPIO_22 through GPIO_25 automatically become outputs when entering sleep (this behavior is not under software control).

2. Network IDs

   The MC13224 hardware does not function properly with all network IDs. An MC13224 node set to a network ID that fits the pattern 0xn2nn or 0xnAnn will not be able to receive radio transmissions, though it can still send them. This is an issue with the underlying Freescale radio.

   For example:

   Network ID 0xFADE does not work. Network ID 0xFBDE does work.

3. Built-in functions – setPinPullup()

   The setPinPullup() function does not apply a pull-up to GPIO_30 through GPIO_41. No internal pull-ups are available on these pins.

4. Built-in functions – sleep()

   There are four sleep() modes on the MC13224 module. Even-numbered sleep modes do not require that an external 32 kHz crystal be connected and are less accurate with their timing. (The internal clock can be regulated on a node-by-node basis, if necessary, using NV Parameter 65.) Odd-numbered sleep modes provide very accurate timing but require the presence of the external crystal.

Sleep Mode	Details
0, 1	• Fast recovery • GPIO states are maintained during sleep† • Highest current usage
2, 3	• Fast recovery • GPIO states are NOT maintained (though they are reset on waking)

† Pins GPIO_22, GPIO_23, GPIO_24, and GPIO_25 will always shift to being outputs while the node is sleeping in all sleep modes. Pins GPIO_26, GPIO_27, GPIO_28, and GPIO_29 will always shift to being inputs while the node is sleeping in all sleep modes.

Agency Certifications

United States (FCC)

The Model SM700 modules comply with Part 15 of the FCC rules and regulations. Compliance with the labeling requirements, FCC notices, and antenna usage guidelines are 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 SM700 Modules. **FCC Label** on page **163**. below shows the contents that must be included on this label.
2. SM700 Modules may only be used with the antenna that has been tested and approved for use with the module.

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 **163**. below.

MANUFACTURERSNAME
BRANDNAME or TRADENAME

Contains SM700 FCC ID: U90-SM700

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: FCC Label

FCC Notices

WARNING: The SM700 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 SM700 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.

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 SM700 modules are FCC-approved for fixed base station and mobile applications.

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.

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.

MANUFACTURERSNAME
BRANDNAME or TRADENAME
MODEL:

Contains SM700 IC: 7084A-SM700

Figure 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 **Combined FCC and IC Label** on page **165**. below.

MANUFACTURERSNAME
BRANDNAME or TRADENAME

Contains SM700 FCC ID: U90-SM700
Contains SM700 IC: 7084A-SM700

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 3: Combined FCC and IC Label

SNAPstick 200 Wireless Adapter

Figure 1: A SNAPstick 200

The SNAPstick 200 USB device is used to enable a PC to communicate with local SNAP nodes.

This device, based on the ATMEL ATmega128RFA1 hardware, is a USB dongle, about the size of a thumb drive. It is designed to act as a bridge between Synapse's management tool, called Portal, or Synapse's Internet connection capability, called SNAP Connect, and your other SNAP nodes.

Because it is based on the ATmega128RFA1, the SNAPstick 200 has the same capabilities as the underlying hardware, relating to sleep options and radio rates as discussed in-depth in the SNAP Reference Manual.

The USB dongle form factor means that only one UART is available on the SNAPstick 200. UART1 connects through the USB port. If you change the default UART (NV Parameter 12) to 0, you will not be able to communicate directly with the device, and will have to either use Portal to reset the device to Factory Default Parameters (NV Params) or use a different SNAP Device as a bridge and reset the default UART over the air.

Also because of the form factor, you do not have normal access to the GPIO pins on the SNAPstick 200. The device was designed to primarily act as a bridge device. The only feedback available from the device comes in the form of an active-low tri-color LED, controlled by pins 5 and 6, as shown in the following diagram:

LED State	Pin 5	Pin 6
Off	High (True)	High (True)
Red	Low (False)	High (True)
Green	High (True)	Low (False)

LED State	Pin 5	Pin 6
Amber	Low (False)	Low (False)

The SNAPstick 200 includes an internal power amplifier. It also has a 32 kHz crystal, so for most efficient sleep state, you should use sleep mode 1 or 2. Note that there is no way to trigger an external wakeup signal to the device, so you should be careful to only use timed sleep.

Troubleshooting the SNAPstick 200

In the realm of wireless communications, many factors can affect reliable data communications. This section lists a number of known factors and possible remedies.

If your question is not adequately answered here, visit the SNAP support forum on the Synapse Wireless website where you can post a question and interact with other SNAP users. The SNAP Support forum can be accessed at:

forums.synapse-wireless.com/forumdisplay.php?f=11

Signal Strength Problems

SNAP Sticks should communicate well when placed in near proximity of other SNAP nodes. However, they may not communicate well when moved farther apart which may introduce interference with other devices or obstacles such as metal walls. You can make several adjustments to remedy this situation:

- Try orienting the antenna of the other SNAP nodes into different positions. Since antennas work best when they are in the same spatial plane, essentially parallel to one another without being directly above or below each other, try to position the antennas of all your SNAP devices in the same orientation.
- There could be other interference problems in your vicinity such as large metal objects, dense foliage, and other objects that prevent signal transmission or attenuation (signal loss). Microwave ovens can cause interference problems. Try moving the units physically to another usable location to see if signal strength improves.
- Try changing the channel of each device. There are 16 separate channels (0 – 15) spread within the 2.4GHz frequency. Various other 2.4GHz devices, such as cordless phones and WiFi routers, may be flooding one channel, but not another one. Also, although the SNAPstick 200 is permitted to transmit on channel 15, some Synapse Wireless products are restricted from transmitting there. Be sure your communication problem isn't a result of this restriction at the other end of your network.
- Refer to the Advanced Management section for reference to the Synapse Portal® software. This software contains a Channel Analyzer tool that can help you determine which channel has the least traffic interference.

Poor Performance

If you believe your SNAP stick is not performing adequately, this could be caused by a number of factors, such as:

- Poor signal strength – try adjusting the antennas as described above.
- Premature sending of packets, holding on to packets for too long, or just dropped packets – try optimizing the UART parameters for your particular application. Review the UART parameters discussed in the SNAP Reference manual.
- Confirm that your feature bits in NV Parameter 11 are set to indicate that your SNAPstick 200 has a power amplifier. Clearing that feature bit can cause the node to send too much power to the amplifier, causing distortion and a low-quality signal to be generated.

Evaluation Kit – SN111 End Device Demonstration Board

The SN111 End Device provided in the Network Evaluation Kit consists of an I/O Host Board, an RF100 Series SNAP Engine, and SNAP code loaded in the microcontroller of the SNAP Engine. The I/O Host Board provides an RS-232 port to interface to a PC. A description of the features on the SN111 End Device follows. **SN111 End Device** on page **169**. shows the top side of the I/O Host Board and identifies the location of the various features to be discussed. Please refer to this figure to locate all features.

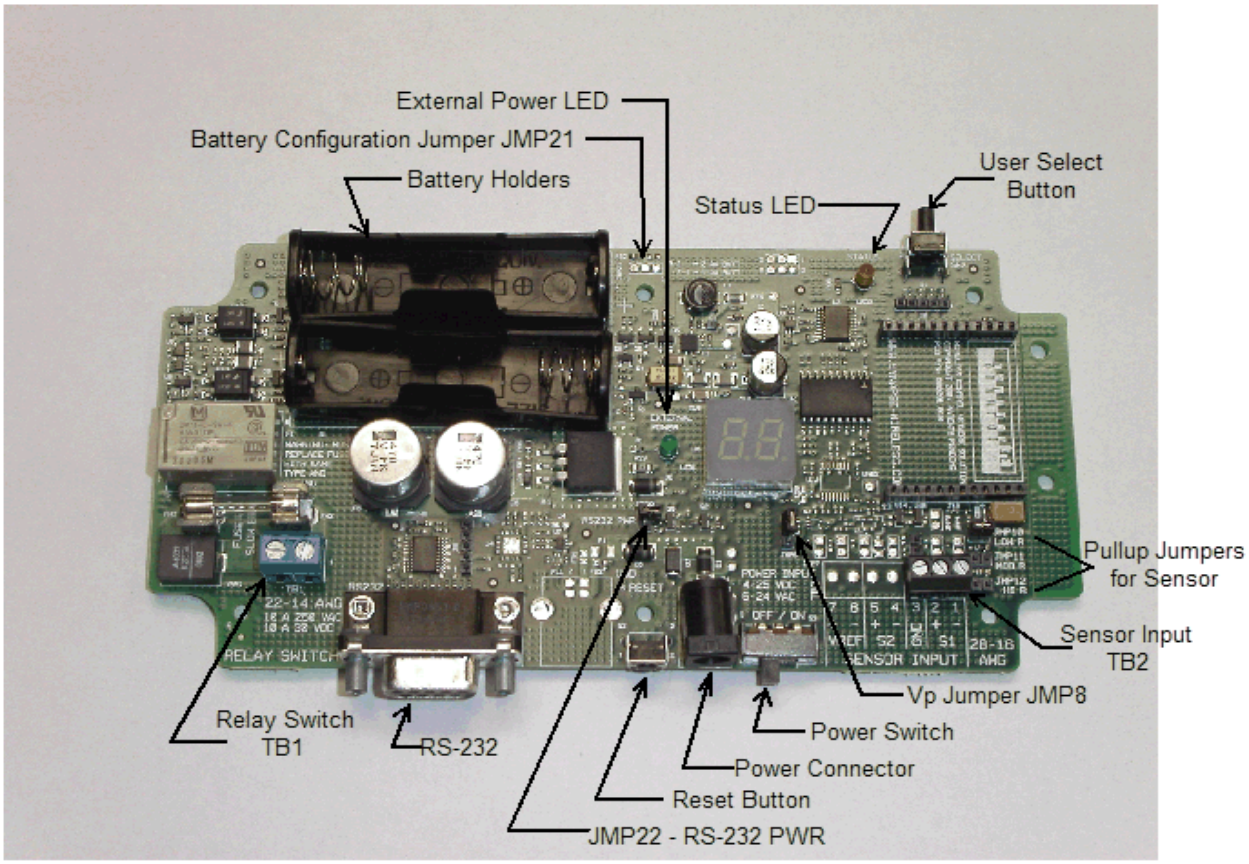


Figure 1: SN111 End Device

The SN111 End Device provides a variety of features. These features consist of several options for supplying power, power on/off switch, an LED indicating that external power is being supplied, hardware reset button, RS-232 port, user select button and LED, a 2 digit seven-segment display, a high voltage/high current relay switch, and support of a resistive type sensor input.

The SN111 End Device should not be used with SNAP Engines based on the ATMEL ATmega123RFA1, the Silicon Labs Si1000, or the CEL ZIC2410. These engines power on in a state that causes conflicts with the relay circuit on the board.

Power to the SN111 End Device

The SN111 End Device provides two options for supplying power to the electronics. The options are: 1) wall transformer power adapter, and, 2) battery. Also, an LED is provided that lights up whenever an external power source is plugged in. Finally, there is an On/Off switch that controls power to the electronics.

NOTE: The power supply design used on the I/O Host Board was chosen to maximize flexibility for supporting different power supply sources. These possible sources include wall transformer power adapters that supply a range of AC and DC input voltages as well as dual and single battery operation. As a result of this flexibility on input power sources, the power supply design has not been optimized for low power operation when the RF100 Series SNAP Engine is in low-power modes. The power supply will draw between 50 to 100 µAmps depending on the input power source when the RF100 Series SNAP Engine is in low power mode. A power supply design optimized for maximum power savings will draw less than 5 µAmps when the RF100 Series SNAP Engine is in low-power mode.

Power Adapter

The provided wall transformer power adapter is used to provide power. The power adapter generates 9V DC and is plugged in to the power connector. The power supply on the I/O Host Board can accept a wide range of power in to the power connector. It supports a range of both AC and DC input power meeting the following specifications: 1) AC Input power between 6VAC to 24VAC; or, 2) DC Input power between 5VDC to 25VDC. Also, there is protection circuitry if positive and negative are reversed on the plug-in jack to the power connector. The power connector is a 2mm male power jack. The wall transformer mating connector should be a 2.1mm female power plug with polarity as shown in **Female Power Plug Polarity** on page **170**. .

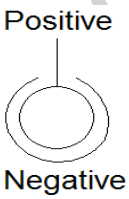


Figure 2: Female Power Plug Polarity

Battery

Finally, AA alkaline batteries can be used to provide power to the electronics on the I/O Host Board. There is a three-pin battery configuration jumper (JMP21) on the I/O Host Board that allows the user to set up for either one battery or two battery operation. If the two pin jumper provided is placed on pin 1 and pin 2 of JMP21, then single battery operation is chosen. In this configuration, the AA battery should be placed in the battery holder nearest the middle of

the I/O Host Board. If the two pin jumper is placed on pin 2 and pin 3 of JMP21, then two battery operation is selected. This is shown in **Battery Configuration Jumpers** on page **171**. below.

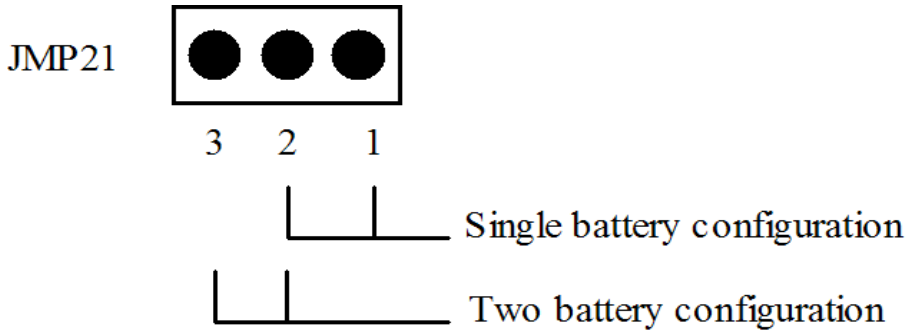


Figure 3: Battery Configuration Jumpers

In many applications where an SN111 End Device would be used, batteries will be the only source of power. Thus, maximum battery life is desired. The two battery configuration will provide twice the battery life; therefore, the SN111 End Device is preconfigured for two battery support with the two pin jumper installed on pin 2 and pin 3 of JMP21. For an SN111 End Device application where wall transformer power is being used, battery power can be used as a backup if the AC power were to go down. In this configuration, the single battery configuration should be chosen by moving the two pin jumper to pin 1 and pin 2 of JMP21.

NOTE: For applications where wall transformer power is being used on the End Device and battery is being used for backup power if the AC power goes down, then configure to single battery operation with the battery configuration jumper.

If batteries are plugged in at the same time power is being provided by the power adapter, then special circuitry on the I/O Host Board will disconnect the battery circuit, thereby disabling the batteries from providing power. Also, there is voltage detection circuitry that allows software to distinguish between battery and external power source so that power consumption can be intelligently monitored. For battery operation, the software will detect low battery voltage and provide “low battery warning” indication.

External Power LED Indicator

The external LED power indicator on the I/O Host Board is provided to offer confirmation that the external power source is providing the proper power to the board electronics. This LED will be on if proper external power is coming in to thru the power connector. It will not be on if power is being supplied to the board by batteries.

Power On/Off Switch

There is a power on/off switch provided on the Interface Host Board. This switch controls power to all on-board electronics and SNAP Engine module except the power supply for external power and external power LED indicator.

NOTE: If external power is coming in from the power connector, the External Power LED Indicator will be "ON" even if the power switch is "OFF."

User I/O

There are several user I/O capabilities on the SN111 End Device. These consists of a hardware reset button, a user select button, a user status LED indicator, and a 2-digit seven segment LED display.

Reset Button

A user button is provided on the SN111 End Device that can be used for various "select" functions.

User Status LED Indicator

An LED is provided on the SN111 End Device that can be used for various "indicator" functions.

2-Digit Display

A 2-digit seven-segment LED display is also provided on the SN111 End Device that can be used for displaying various sets of data and error indicators.

External Port Interfaces

The SN111 End Device has one external port interface. There is an RS-232 interface.

RS-232 Interface

The SN111 End Device has a serial RS-232 interface port. This port has a standard female DE-9 style connector. The pin assignments are shown in the table below.

Table 1: RS-232 Pin Assignments

DB-9 Pin	RS-232 Signal	Description	Implementation
1	DCD	Data-Carrier-Detect	Not connected
2	RxD	Receive Data	Data from SNAP Engine (to host)
3	TxD	Transmit Data	Data to SNAP Engine (from host)
4	DTR	Data-Terminal-Ready	Connected to DSR
5	GND	Ground	Ground
6	DSR	Data-Set-Ready	Connected to DTR
7	RTS	Request To Send	Request from Host to send data

DB-9 Pin	RS-232 Signal	Description	Implementation
8	CTS	Clear To Send	Clear from SNAP Engine for host to send
9	RI	Ring Indicator	Not connected

A standard RS-232 cable for connecting the SN111 End Device to a PC is included with the board.

NOTE: If the I/O Host Board is being powered by batteries, there is a power detection circuit that identifies battery as the power source and removes power to the RS-232 interface. The RS-232 interface draws several milliamps of power continuously, so it would quickly draw down the batteries if left on. In order to bypass this power down circuitry to keep the RS-232 interface on, jumper 22 (identified as JMP22 – RS232 PWR) on the I/O Host Board must be installed

External I/O

The SN111 End Device provides external I/O features. These consist of a high voltage/high current relay switch and a resistive type sensor input.

Relay Switch

The SN111 End Device has an integrated relay switch (normally open) and support circuitry. The relay switch can switch a load on and off that is powered by AC voltages up to 250VAC or DC voltages up to 30VDC. For either type voltage, the relay switch can handle currents to the load of up to 10 amps. The interface into the relay switch on the I/O Host Board is thru the terminal block TB1. This terminal block can accept wire sizes from 22 AWG to 14 AWG. Any type of load, either AC or DC, that falls within the voltages and current ratings listed above can be switched on and off by the relay. Examples of possible loads are: AC light fixtures or AC or DC motors. Typically, the “Neutral” leg of the load is connected thru the relay switch load as shown in the circuit diagram **Relay Circuit** on page **174**. below. Also, the relay circuit on the I/O Host Board has a slow blow protection fuse rated at 10 Amps to protect against an overload condition.

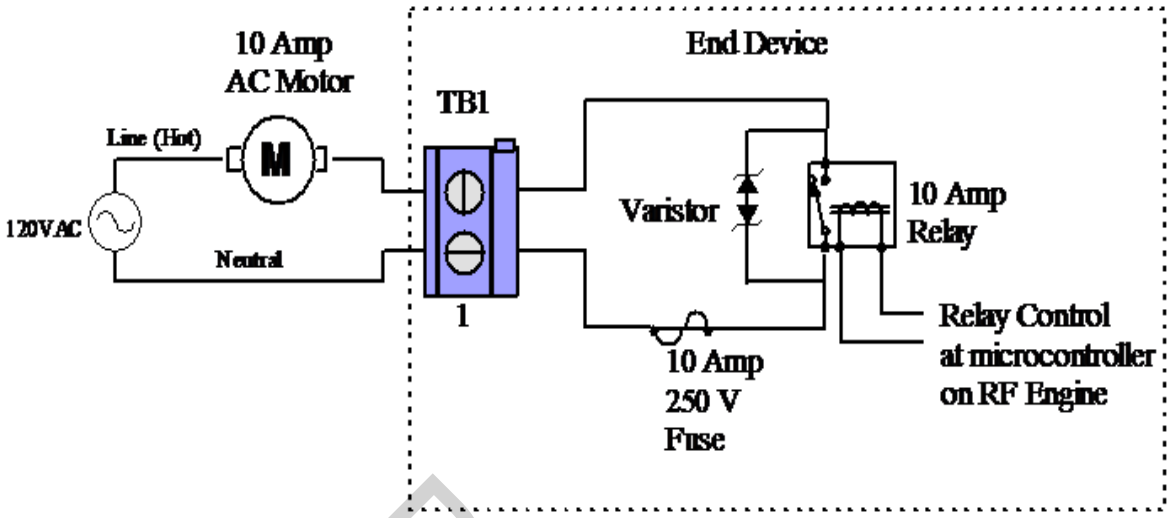


Figure 4: Relay Circuit

To access the relay, set GPIO_16 and GPIO_17 as low outputs. Pulse GPIO_17 to close the relay and pulse GPIO_16 to reset it. If you include synapse.evalBase in your script, after calling detectEvalBoards() you can call the setRelayState (isSet) function to control the relay.

Sensor Input

The SN111 End Device also has circuitry that will accept a resistive type sensor input, such as a thermistor or photo cell. The sensor device is interfaced to the sensor input circuitry on the I/O Host Board thru the terminal block TB2. This terminal block can accept any resistive type sensor directly from the sensor leads or thru wires connecting to the sensor. The wire can be any size between 28 AWG and 16 AWG. The sensor input feeds a resistor divider circuit as shown in **Sensor Circuit** on page **174**. below.

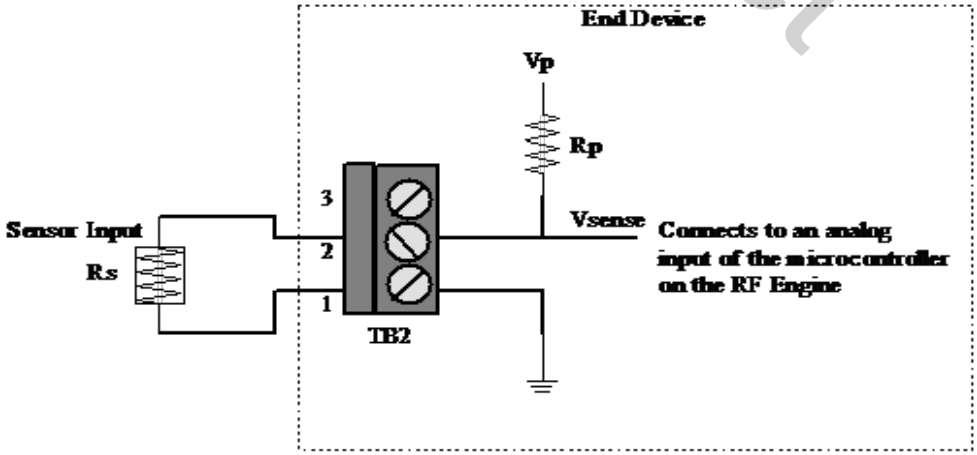


Figure 5: Sensor Circuit

NOTE: For shielded wire applications, the shield can be attached to the ground plane (GND) of the SN111 End Device by connecting the wire shield to pin 3 of TB2 and applying a 2-pin jumper to JMP3 on the SN111 End Device board directly above pin 3 of TB2.

From the resistor divider circuit shown in **Sensor Circuit** on page **174**. and applying Ohm's Law, the resulting output voltage signal (Vsense) is given by the equation:

Vsense = (Vp / (Rp + Rs)) * Rs

Figure 6: Equation 1 – Vsense

where	Vp = 3.2 VDC (Vcc of I/O Host Board)
	Rp = pull-up resistor defined by the Jumper Options for the Sensor Input table below
	Rs = sensor resistance defined by sensor vendor resistance curves versus function sensed
	Vsense = analog voltage that goes to an "analog input" signal n the microcontroller of the SNAP Engine

Example: A thermistor rated as 10k Ω at 25°C is connected into pin 1 and pin 2 of TB2 on the I/O Host Board. If the temperature being sensed by the thermistor is 25°C and the jumper JMP10 is installed and JMP11 and JMP12 are not installed which sets Rp as 10k Ω from Jumper Options for the Sensor Input table, then Vsense can be calculated from **Equation 1 – Vsense** on page **175**. above as:

Vsense = (3.2 / (10k + 10k)) * 10k

= 1.6

The resulting voltage signal (Vsense) from this resistor divider circuit then goes to an "Analog In" signal on the SNAP Engine which goes thru a 10 bit analog to digital conversion in the micro-controller on the SNAP Engine. Using Equation (1) given above and the resistance curves of the sensor being used (values for Rs versus the function sensed by the resistive type sensor), one can generate a table showing the different values of Vsense based on the sensor condition when sampled. The resulting value returned by the 10 bit analog to digital conversion in the SNAP Engine can be used in conjunction with this table to determine the sensor condition.

There are jumper configurable options for the pull-up voltage (identified as Vp) of the resistor divider circuit of **Sensor Circuit** on page **174**. . By applying a two pin jumper to pin 2 and pin 3 of the three pin jumper JMP8, then Vp == 3.2VDC always. If a two pin jumper is applied to pin 1 and pin 2 of JMP8, then Vp == 3.2VDC only when the RF100 Series SNAP Engine signal controlling the external analog source is enabled. See **Figure 27 – Vp Jumper** on page **176**. below. By controlling the pull-up voltage, power consumption can be reduced when running the I/O Host Board

electronics from battery. The RF100 Series SNAP Engine signal controlling the external analog source would only be enabled when an AtoD conversion of the sensor input was being initiated. Otherwise, it would be disabled, removing the pull-up voltage Vp, thereby, eliminating the current drawing of the sensor input resistor divider circuit.

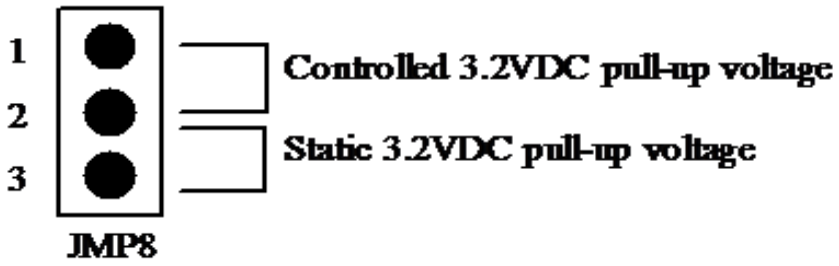


Figure 7: Figure 27 – Vp Jumper

Also, there are different values of resistor pull-up (identified as Rp) by jumper configuration options. These choices of Rp are identified by the Jumper Options for the Sensor Input table below.

Table 2: Jumper Options for the Sensor Input

	Possible Jumper Configurations for Sensor Pull-Up Resistance							
	1	2	3	4	5	6	7	8
JMP10	Omitted	Populated	Omitted	Populated	Omitted	Populated	Omitted	Populated
JMP11	Omitted	Omitted	Populated	Populated	Omitted	Omitted	Populated	Populated
JMP12	Omitted	Omitted	Omitted	Omitted	Populated	Populated	Populated	Populated
Rp (ohms)	Invalid	10K	100K	9.091K	1M	9.901K	9.0909K	9.009K

Evaluation Kit – SN163 Bridge Demonstration Board

The SN163 Bridge provided in the Network Evaluation Kit consists of an Interface Host Board, a SNAP Engine, and SNAP code loaded in the microcontroller of the RF100 Series SNAP Engine. The Interface Host Board offers both an RS-232 port and a USB 2.0 port. Either port can be used to interface to a PC. If both ports are plugged in to the PC, only the USB port will be active. A description of the features on the SN163 Bridge follows. **SN163 Bridge** on page **177**. shows the top side of the Interface Host Board and identifies the location of the various features to be discussed. Please refer to this figure to locate all features.

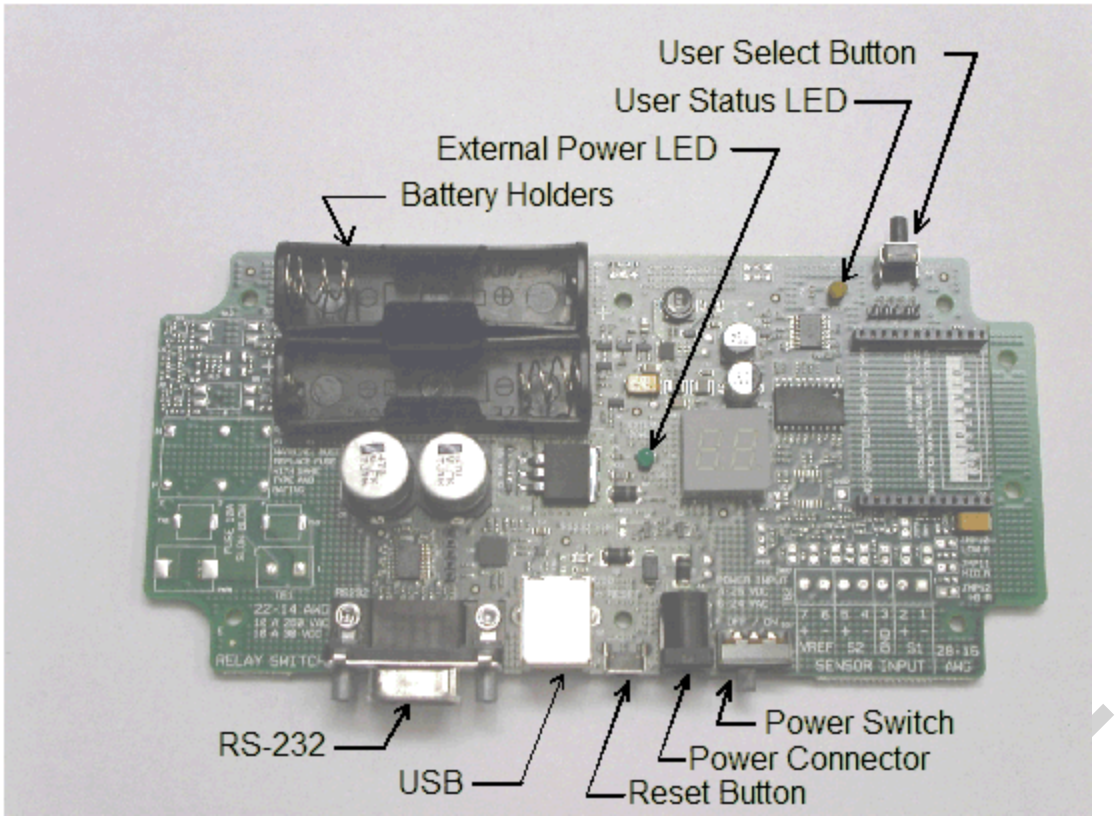


Figure 1: SN163 Bridge

The SN163 Bridge provides a variety of features. These features consist of several options for supplying power, power on/off switch, an LED indicating that external power is being supplied, hardware reset button, RS-232 port, USB 2.0 port, user select button and LED, and a 2 digit seven-segment display.

Power to the SN163 Bridge

The SN163 Bridge provides three options for supplying power to the electronics. The options are: 1) wall transformer power adapter; 2) USB; and, 3) battery. Also, an LED is provided that lights up whenever an external power source is plugged in. Finally, there is an On/Off switch that controls power to the electronics.

Power Adapter

The wall transformer power adapter provided in the kit can be used to provide power. The power adapter generates 9V DC and is plugged in to the power connector. The power supply on the Interface Host Board can accept a wide range of power in to the power connector. It supports a range of both AC and DC input power meeting the following specifications: 1) AC Input power between 6VAC to 24VAC; and, 2) DC Input power between 5VDC to 25VDC. Also, there is protection circuitry if positive and negative are reversed on the plug-in jack to the power connector. The power connector is a 2mm male power jack. The wall transformer mating connector should be a 2.1mm female power plug with polarity as shown in **Female Power Plug Polarity** on page **178**. .

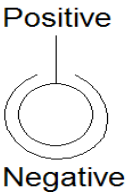


Figure 2: Female Power Plug Polarity

USB Power

Power can be provided to the SN163 Bridge from the USB port. This happens automatically when the USB cable provided in the kit is plugged into the USB port on the Interface Host Board and into an active USB port on the PC (or a USB power adapter).

NOTE: In order for proper operation of the USB port to occur, USB drivers located in the CD provided in the kit must be loaded on the PC. Please refer to instructions on the Quick Start Guide for loading this driver.

Battery

Finally, a single AA alkaline battery can be plugged into the battery holder closest to the middle of the Interface Host Board to provide power to the electronics when wall transformer power or USB power is not available. If a battery is plugged in at the same time power is being provided by either the power adapter or USB, then special circuitry on the Interface Host Board will disconnect the battery circuit thereby disabling the battery from providing power. For the SN163 Bridge, the intended operation is to always use the power adapter or the USB bus for power. The battery should be used as a temporary backup to continue to power the SN163 Bridge if AC power is lost.

The RS-232 interface circuitry and USB interface circuitry on the Interface Host Board consumes several milliamps of current which will draw down the battery quickly if battery is the only power source. Therefore, there is detection circuitry which will shutdown the on-board RS-232 interface and USB interface if the Interface Host Board is being powered by battery.

NOTE: It can be seen that two battery holders are present on the Interface Host Board. For the SN163 Bridge, the battery circuitry is configured for single battery operation to be used primarily as a backup power source as discussed above. Only the battery holder nearest the middle of the Interface Host Board is active. If a battery is plugged in to the battery holder on the edge of the board, it provides no power to the Interface Host Board.

External Power LED Indicator

The external power LED indicator on the Interface Host Board is provided to offer confirmation that the external power source is providing the proper power to the board electronics. This LED will be on if proper external power is coming in to either the power connector or to the USB port. It will not be on if power is being supplied to the board by batteries.

Power On/Off Switch

There is a power on/off switch provided on the Interface Host Board. This switch controls power to all on-board electronics and SNAP Engine module except the power supply for external power and external power LED indicator.

NOTE: If external power is coming in from either the power connector or the USB port, the External Power LED Indicator will be “ON” even if the power switch is “OFF”.

User I/O

There are several user I/O capabilities on the SN163 Bridge. These consists of a hardware reset button, a user select button, a user status LED indicator, and a 2-digit seven segment LED display.

Reset Button

The reset button is used to reset all hardware and re-boot the SNAP Engine.

User Select Button

A user button is provided on the SN163 Bridge that can be used for various “select” functions. This will be discussed in greater detail in the Synapse SNAP Reference Manual.

User Status LED Indicator

An LED is provided on the SN163 Bridge that can be used for various “indicator” functions. This will be discussed in greater detail in the Synapse SNAP Reference Manual.

2-Digit Display

A 2-digit seven-segment LED display is also provided on the SN163 Bridge that can be used for displaying various sets of data and error indicators.

External Port Interfaces

The SN163 Bridge has two external port interfaces. There is an RS-232 interface and a USB 2.0 interface.

RS-232 Interface

The SN163 Bridge has a serial RS-232 interface port. This port has a standard female DB-9 style connector. The pin assignments are shown in the RS-232 Pin Assignments table below.

Table 1: RS-232 Pin Assignments

DB-9 Pin	RS-232 Signal	Description	Implementation
1	DCD	Data-Carrier-Detect	Not connected
2	RxD	Receive Data	Data from SNAP Engine (to host)
3	TxD	Transmit Data	Data to SNAP Engine (from host)
4	DTR	Data-Terminal-Ready	Connected to DSR
5	GND	Ground	Ground
6	DSR	Data-Set-Ready	Connected to DTR
7	RTS	Request To Send	Request from Host to send data
8	CTS	Clear To Send	Clear from SNAP Engine for host to send
9	RI	Ring Indicator	Not connected

Figure 3: RS-232 Pin Assignments

Setup of this port will be discussed in greater detail in the Synapse Portal Software User Guide. A standard RS-232 cable for connecting the SN163 Bridge to a PC has been provided in the kit.

USB Interface

The USB interface on the SN163 Bridge is USB 2.0 compliant. A standard Type-B OEM connector is provided on the USB port of the Interface Host Board. The pin assignments are shown in the USB Pin Assignments table below.

Table 2: USB Pin Assignments

Pin	Signal	Description	Implementation
1	VBUS	Power	Powers the Interface Host Board
2	Data-	Transmitted and Received Data (neg)	Transmit data to and from the SNAP Engine
3	Data+	Transmitted and Received Data (pos)	Transmit data to and from the SNAP Engine
4	GND	Ground	Ground

Figure 4: Table 20 – USB Pin Assignments

Setup of this port will be discussed in greater detail in the Synapse Portal Software User Guide. A standard USB cable for connecting the SN163 Bridge to a PC is provided with the board.

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For further information on any Synapse product or service, contact us at:

Synapse Wireless, Inc.
6723 Odyssey Drive
Huntsville, Alabama 35806
256-852-7888
877-982-7888
256-924-7398 (fax)
www.synapse-wireless.com