TECHNICAL MANUAL
SNAP Hardware

v1.1

Wireless Technology to Control and Monitor Anything from Anywhere™

Doc# 600-101.01C

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1. RF Engine OEM Modules

RF Engine modules meet IEEE 802.15.4 specifications. These modules provide a low power, highly reliable all-in-one solution to embedded wireless control and monitoring network needs at very low cost. The RF Engine 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. There are two versions of modules. One version has an external power amplifier for extended range. This module will be referred to as RF Engine with external amplifier. The other module has no external power amplifier and is referred to as RF Engine without external amplifier. Figure 1 below consists of block diagrams showing the major subsystems that make up these two versions of RF Engine.

RF Engine With External Amplifier
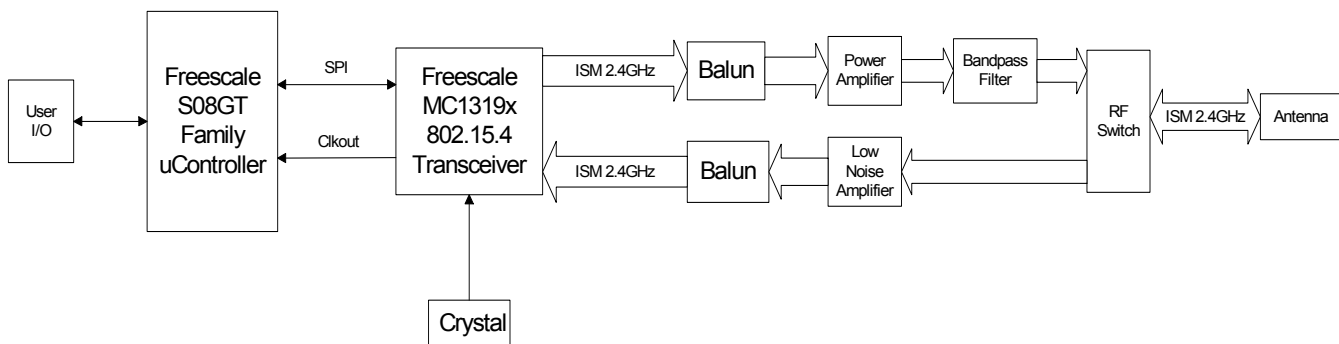
RF Engine Without External Amplifier
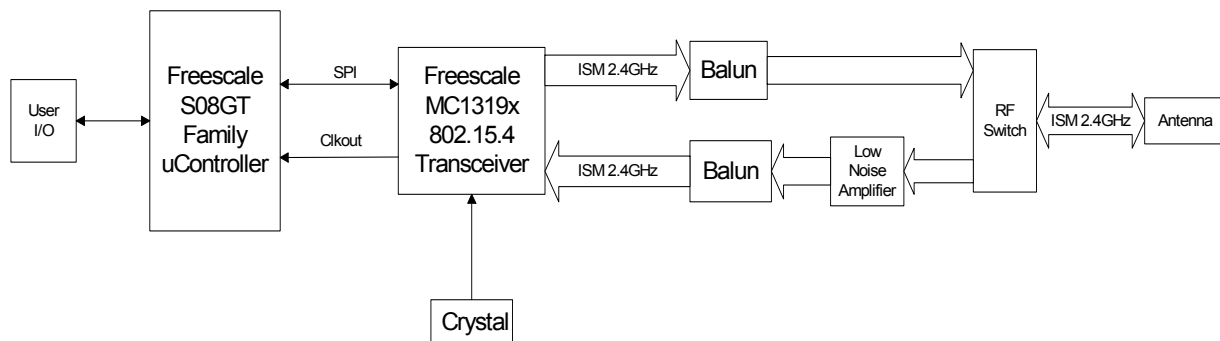
Figure 1 - RF Engine Block Diagrams

Specifications

RF Engine Specifications		Without Ext Amp	With Ext Amp
Performance	Outdoor LOS Range	up to 1000 ft.	up to 3 miles
	Transmit Power Output	4 dBm	18 dBm
	RF Data Rate	250,000 bps	250,000 bps
	Receiver Sensitivity	-102 dBm (1% PER)	-102 dBm (1% PER)
Power Requirements	Supply Voltage	2.7 - 3.4 V	2.7 - 3.4 V
	Radio ON Current (Typ)	65mA	65mA
	Radio OFF Current (Typ)	20mA	20mA
	Power-down Current (sleep mode 0) (Typ)	35uA	35uA
	Power-down Current (sleep mode 1) (Typ)	2.5 uA	2.5uA
General	Frequency	ISM 2.4GHz	ISM 2.4GHz
	Spreading Method	Direct Sequence	Direct Sequence
	Modulation	O-QPSK	O-QPSK
	Dimensions	1.333" x 1.333"	1.333" x 1.333"
	Operating Temperature	~40 to 85 deg C.	~40 to 85 deg C.
	Antenna Options	Integrated F, External RPSMA	Integrated F, External RPSMA
Networking	Topology	SNAP	SNAP
	Error Handling	Retries and acknowledgement	Retries and acknowledgement
	Number of Channels	16	16
Available I/O	UARTS with HW Flow Control	2 Ports - 8 total I/O	2 ports - 8 total I/O
	GPIO	11 total; 8 can be analog in with 10bit ADC	11 total, 8 can be analog in with 10bit ADC
Agency Approvals	FCC Part 15.247	FCC ID: U9O-RFE	FCC ID: U9O-RFET
	Industry Canada (IC)	IC: 7084A-RFE	IC: 7084A-RFET

Table 1 - RF Engine Specifications

Module Pin Definitions

Pin No.	Name	Direction	Description
1	GND	-	Power Supply
2	GPIO0_TPM1CH2	Bidirectional	GPI/O, or Timer1 Channel 2
3	GPIO1_KBI0	Bidirectional	GPI/O, Keyboard In
4	GPIO2_KBI1	Bidirectional	GPI/O, Keyboard In
5	GPIO3_RX_UART0	Input	UART0 Data In
6	GPIO4_TX_UART0	Output	UART0 Data Out
7	GPIO5_KBI4_CTS0	Bidirectional	GPI/O, Keyboard In, or UART0 CTS
8	GPIO6_KBI5_RTS0	Bidirectional	GPI/O, Keyboard In, or UART0 RTS
9	GPIO7_RX_UART1	Input	RS232*/UART1 Data In
10	GPIO8_TX_UART1	Output	RS232*/UART1 Data Out
11	GPIO9_KBI6_CTS1	Bidirectional	GPI/O, Keyboard In, or RS232*/UART1 CTS
12	GPIO10_KBI7_RTS1	Bidirectional	GPI/O, Keyboard In, or RS232*/UART1 RTS
13	GPIO11_AD7	Bidirectional	GPI/O, or Analog In
14	GPIO12_AD6	Bidirectional	GPI/O, or Analog In
15	GPIO13_AD5	Bidirectional	GPI/O, or Analog In
16	GPIO14_AD4	Bidirectional	GPI/O, or Analog In
17	GPIO15_AD3	Bidirectional	GPI/O, or Analog In
18	GPIO16_AD2	Bidirectional	GPI/O, or Analog In
19	GPIO17_AD1	Bidirectional	GPI/O, or Analog In
20	GPIO18_AD0	Bidirectional	GPI/O, or Analog In
21	VCC	-	Power Supply
22	PTG0/BKDG	Bidirectional	Background Debug Communications
23	RESET	Input	Module Reset, Active Low
24	GND	-	Power Supply * RS232 levels only if MAX3232 chip installed

Table 2 - RF Engine Pin Assignments

Electrical Characteristics

Symbol	Parameter	Condition	Min	Typ [1]	Max	Units
V_{CC} [2]	Supply Voltage	With RS232 Option	3	3.2	3.4	V
		Without RS232 Option	2.7	3.2	3.4	V
T_{OP}	Operating Temp		-40		85	°C
V_{IH}	Input Hi Voltage	All Digital Inputs	$.7*V_{CC}$			V
V_{IL}	Input Low Voltage	All Digital Inputs			$0.35*V_{CC}$	V
V_{OL}	Output Low Voltage	(I_{OL} = 2mA)			0.5	V
V_{OH}	Output High Voltage	(I_{OH} = -2mA)	$V_{CC} - 0.5$			V
IL_{IN}	In Leakage Current	$V_{IN}=V_{CC}$ or V_{SS}, all Pins		0.025	1	uA
TX-I_{CC} [3]	Transmit Current	V_{CC} = 3.3V MCU Wait Mode		110		mA
RX-I_{CC} [4]	Receive Current	V_{CC} = 3.3V MCU Wait Mode		50		mA
SHDN-I_{CC}	Shutdown Current	MCU Stop/Doze Mode		35		uA

Table 3 - RF Engine DC Characteristics

Notes:

1   All typicals are measured at 25°C.
2   Absolute maximum stress rated voltage for VCC is -0.3 to 3.6. It is recommend that a bulk decoupling capacitor (47 uF tantalum rated at 6.3volts) be located close to the VCC pin 21 of the RF engine connector on the host board.
3   This is for the maximum transmit power configuration with the external amp.
4   This is the maximum receiver sensitivity configuration.

Symbol	Parameter	Condition	Min	Typical	Max	Unit
V_{REFH}[1]	Reference potential, high				V_{DDAD}[1]	V
I_{REFH}	Reference supply current	Enabled		200	300	uA
		Disabled (Sleep Mode)		<0.01	0.02	uA
V_{INDC}	Analog input voltage[2]		V_{SSAD}-0.3		V_{DDAD}+0.3	

Table 4 - ADC Electrical Characteristics (Operating)

1. V_{REFH} and V_{DDAD} are connected to the VCC pin. V_{REFL} and V_{SSAD} are connected to the GND pin.
2. Maximum electrical operating range, not valid conversion range.

Symbol	Parameter	Condition	Min	Typical	Max	Unit
R_{AS}	Source impedance at input[2]				10	kΩ
V_{AIN}	Analog input voltage[3]		V_{REFL}		V_{REFH}	V
RES	Ideal resolution (1 LSB)[4]	$2.08V \le V_{DDAD} \le 3.6V$	2.031		3.516	mV
DNL	Differential non-linearity[5]			±0.5	±1.0	LSB
INL	Integral non-linearity[6]			±0.5	±1.0	LSB
E_{ZS}	Zero-scale error[7]			±0.5	±1.0	LSB
F_{FS}	Full-scale error[8]			±0.5	±1.0	LSB
E_{IL}	Input leakage error[9]			±0.5	±1.0	LSB
E_{TU}	Total unadjusted error[10]			±0.5	±1.0	LSB

Table 5 - ADC Timing/Performance Characteristics[1]

1. All ACCURACY numbers are based on processor and system being in WAIT state (very little activity and no I/O switching) and that adequate low-pass filtering is present on analog input pins (filter with 0.01 uF to 0.1uF capacitor between analog input and V_{REFL}). Failure to observe these guidelines may result in system or microcontroller noise causing accuracy errors which will vary based on board layout and the type and magnitude of the activity.
2. R_{AS} is the real portion of the impedance of the network driving the analog input pin. Values greater than this amount may not fully charge the input circuitry of the ATD resulting in accuracy error.
3. Analog input must be between V_{REFL} and V_{REFH} for valid conversion. Values greater than V_{REFH} will convert to 0x3FF and less .
4. The resolution is the ideal step size or 1LSB = $(V_{REFH} - V_{REFL})$ / 1024.
5. Differential non-linearity is the difference between the current code width (1LSB). The current code width is the difference in the transition voltages to and from the current code.

6. Integral non-linearity is the difference between the transition voltage to the current code and the adjusted ideal transition voltage for the current code. The adjusted ideal transition voltage is (Current Code – ½) * (1 / ((V_{REFH} + E_{FS}) – (V_{REFL} + E_{ZS}))).
7. Zero-scale error is the difference between the transition to the first valid code and the ideal transition to that code. The ideal transition voltage to a given code is (Current Code – ½) * (1 / (V_{REFH} – V_{REFL})).
8. Full-scale error is the difference between the transition to the last valid code and the ideal transition to that code. The ideal transition voltage to a given code is (Current Code – ½) * (1 / (V_{REFH} – V_{REFL})).
9. Input leakage error is error due to input leakage across the real portion of the impedance of the network driving the analog pin. Reducing the impedance of the network reduces the error.
10. Total unadjusted error is the difference between the transition voltage to the current code and the ideal straight-line transfer function. This measure of error includes inherent quantization error (1/2LSB) and circuit error (differential, integral, zero-scale, and full-scale) error. The specified value of E_{TU} assumes zero E_{IL} (no leakage or zero real source impedance).

User Options

There are several options for the SNAP Module offerings to allow different capabilities for the user. Here is a partial list of these options.

Option	Description
Embedded F-Antenna	With the version of the module with embedded F-antenna, antenna is fully integrated into the module.
External Antenna	With the version of the module with the reverse polarity SMA (RPSMA) connector populated, an external antenna can be attached.
Transmit Amplifier	With the population of an external power amplifier on the transmitter, outdoor line of sight range can be increased from 300 meters to 3000 meters.
Low Noise Amplifier	With the population of an external low noise amplifier on the receiver, receive sensitivity can be improved from -92 dBm to -102 dBm at 1% PER.

Mechanical Drawings

These drawings in Figure 2 show the version of the module with integrated F antenna and the version of the module with the RPSMA connector for use with an external antenna.
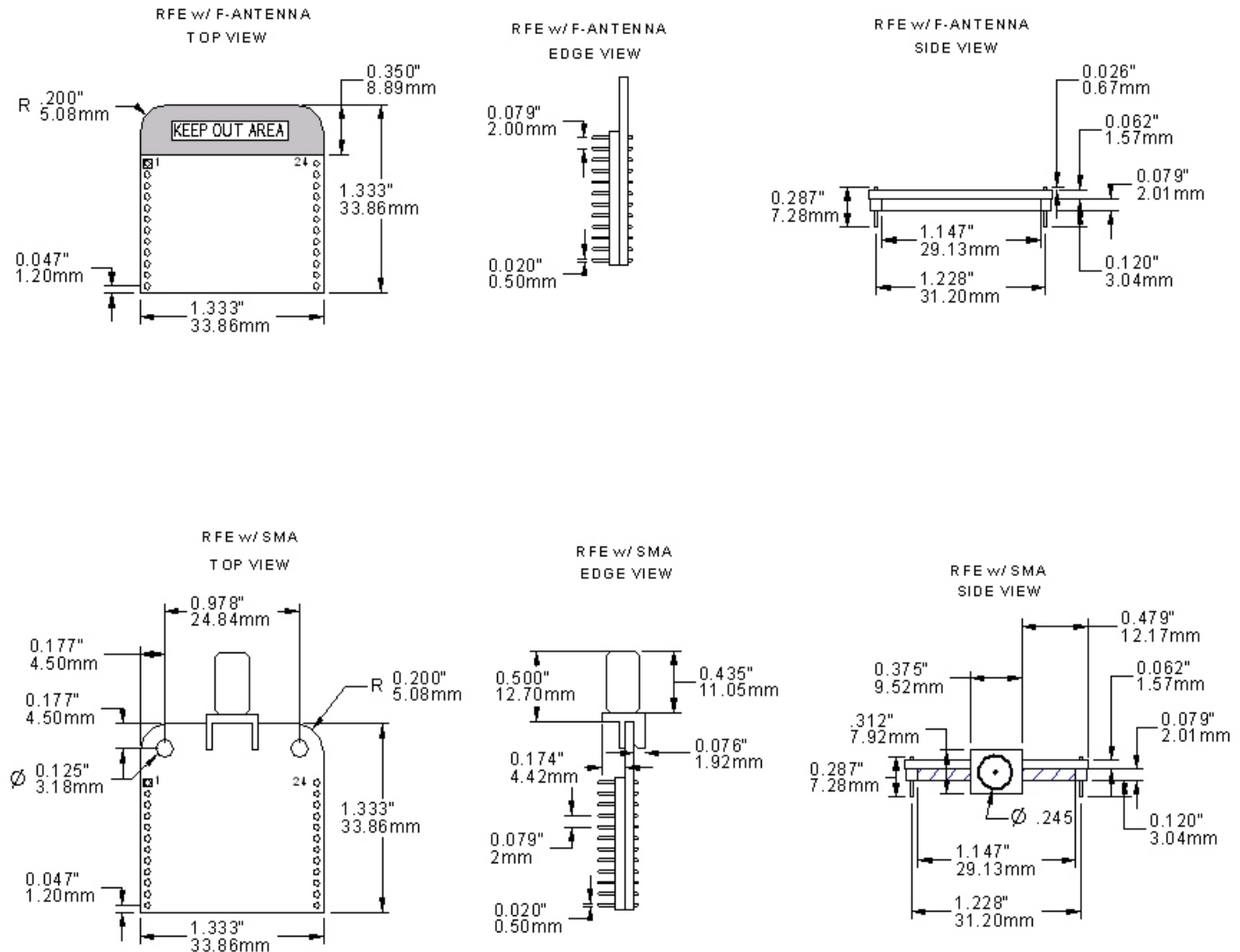
Figure 2 - Mechanical Drawings of the RF Engine Modules

Board Mounting Considerations

The RF Engine modules are designed to mount into a receptacle (socket) on the host board. Figure 3 shows an RF Engine module plugged in to a host board. The receptacle sockets are on standard 2mm centers. Suggested receptacles to be used on the host are:
(1) Thru-hole receptacle: Samtec   MMS-112-01-T-SV
(2) Surface mount receptacle: Samtec   MMS-112-02-T-SV

When the module with SMA connector is used, it is recommended that the mounting holes provided in the module on either side of the SMA connector be used with supporting mounting hardware to hard mount the module to either the host board or to the enclosure to handle the mechanical stresses that can occur when an external antenna is screwed into the SMA. Figure 3 shows the RF Engine with SMA connector mounted to the host board.
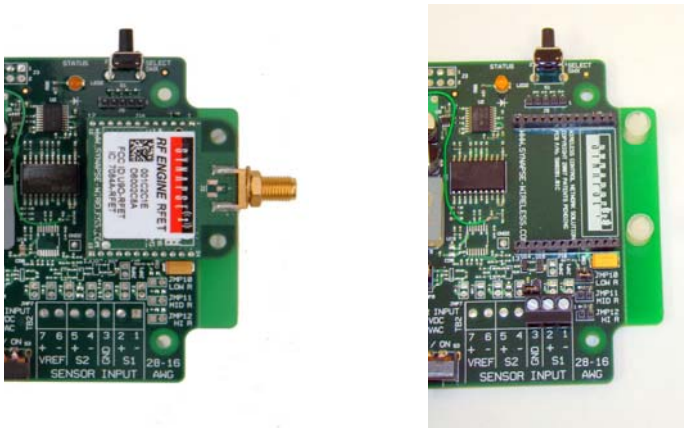
Figure 3 - Host Board with RF Engine Mounted and Mounting Hardware

For the module with integrated F-antenna, in order to maximize RF range in the direction behind the module, it is recommended that no components and no metal (either traces or VCC and GND planes) be on any layers of the host board that lies underneath the module in the area designated by the "Keep Out Area" shown in the mechanical drawings of Figure 2.

When using modules of this type (internal antenna) in conjunction with Synapse demonstration boards, it is also recommended that users remove the PCB mounting tab located directly below the F-antenna.
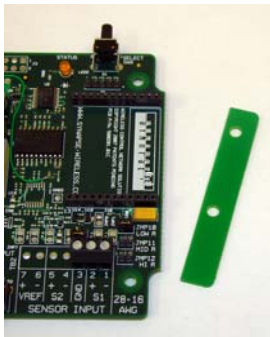
Figure 4 - Host Board with Mounting Tab Removed

Agency Certifications

United States (FCC)

The RF Engine 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 RF Engine Modules. Figure 1 below shows the contents that must be included in this label.
2. RF Engine Modules may only be used with antennas that have been tested and approved for use with the module. Please refer to the antenna tables provided in this section.

OEM Labeling Requirements

NOTICE: The OEM must make sure that FCC labeling requirements are met. This includes a clearly visible exterior label on the outside of the final product housing that displays the contents shown in Figure 5 below.

MANUFACTURERS NAME
BRAND NAME or TRADE NAME

Contains RF Engine FCC ID: U9O-RFE*

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.
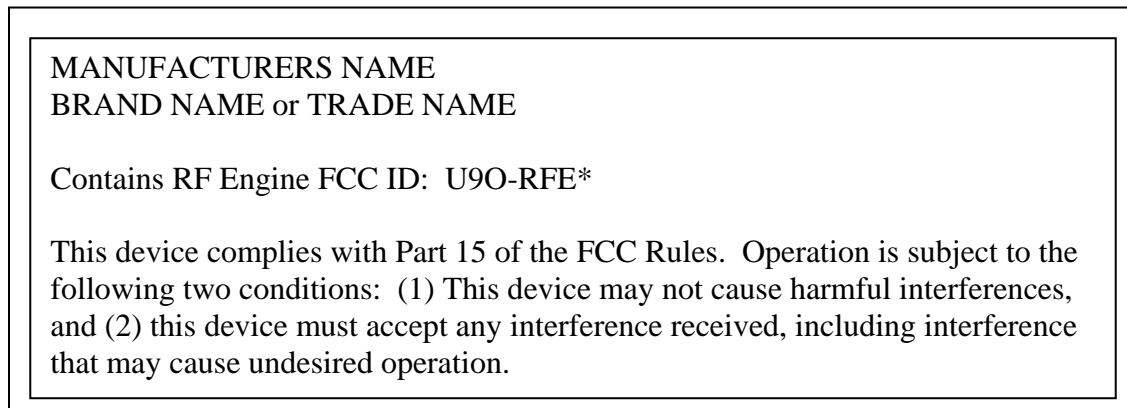
Figure 5 - FCC Label

* The FCC ID for the RF Engine without external amplifier is "U9O-RFE". The FCC ID for the RF Engine with external amplifier is "U9O-RFET"

FCC Notices

WARNING: The RF Engine 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 could void the user's authority to operate the equipment.

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

NOTICE: The RF Engine modules have been certified for remote and base radio applications. If the module will be used for portable applications, the device must undergo SAR testing.

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation.

If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:
- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

FCC Approved Antennas

The RF Engine 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 I.E.E.E 802.15.4 specifications. The FCC requirement for mobile applications states that the antenna must be mounted at least 20 cm (8 in) from nearby persons.

Notice: To reduce potential radio interference to other users, the antenna type and its gain should be chosen so that the equivalent isotropically radiated power (e.i.r.p) is not more than that permitted for successful communication. This module has been designed to operate with the antennas listed below in Table 6, and having a maximum gain of 5 dB. Antennas not included in this list or having a gain greater than 5 dB are strictly prohibited for use with this device.   The required antenna impedance is 50 ohms.

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

Table 6 - Approved Antennas

RF Exposure

WARNING: 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.

Canada (IC)

This Class B digital apparatus meets all requirements of the Canadian Interference Causing Equipment Regulations. Operation is subject to the following conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

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 Figure 6 below.

MANUFACTURERS NAME
BRAND NAME or TRADE NAME
MODEL:
Contains RF Engine IC: 7084A-RFE*

Figure 6 - IC Label
* The IC ID for the RF Engine without amp is "7084A-RFE". The IC ID for the RF Engine with amp is "7084A-RFET"

NOTE: The OEM can choose to implement a single label combined for both FCC and IC labeling requirements. If a combined single label is chosen, there must be a clearly visible label on the outside of the final product housing displaying the contents shown in Figure 7 below.

MANUFACTURERS NAME
BRAND NAME or TRADE NAME

Contains RF Engine FCC ID: U9O-RFE*
Contains RF Engine IC: 7084A-RFE*

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

* The FCC ID for the RF Engine without amp is "U9O-RFE". The FCC ID for the RF Engine with amp is "U9O-RFET". The IC ID for the RF Engine without amp is "7084A-RFE". The IC ID for the RF Engine with amp is "7084A-RFET".

2. Evaluation Kit – SN163 Bridge Demonstration Board

The SN163 Bridge provided in the Network Evaluation Kit consists of an Interface Host Board, an RF Engine, and SNAP code loaded in the microcontroller of the RF 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. Figure 8 shows the top side of the Interface Host Board and identifies the location of the various features to be discussed. Please refer to this picture to locate all features.
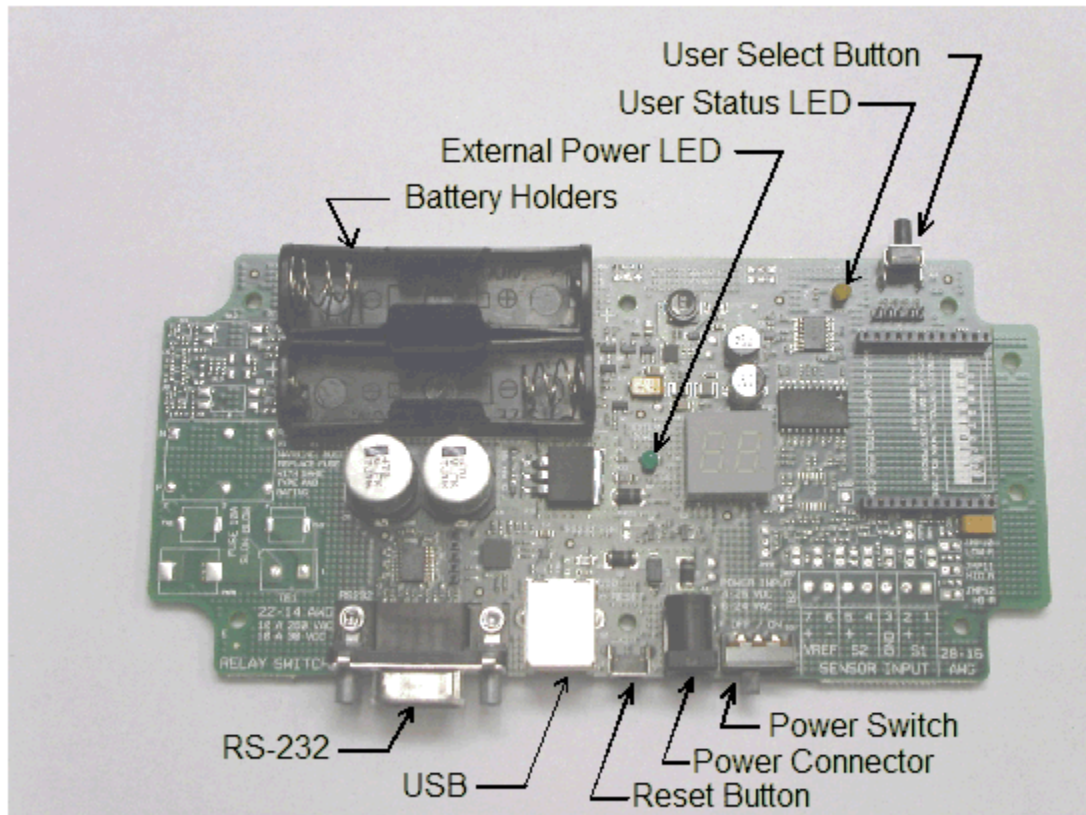
Figure 8 - SN163 Bridge

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 Figure 9.
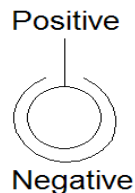
Positive

Negative

Figure 9 - 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.
(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. 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. This will be discussed in greater detail in the Synapse Portal Software Users Guide.

NOTICE: 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 RF Engine module except the power supply for external power and external power LED indicator.

NOTICE: 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 RF 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 Portal Software Users Guide.

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 Portal Software Users Guide.

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. This will be discussed in greater detail in the Synapse Portal Software Users Guide.

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 Table 7 below.

DB-9 Pin	RS-232 Signal	Description	Implementation
1	DCD	Data-Carrier-Detect	Not connected
2	RxD	Receive Data	Data from RF Engine (to host)
3	TxD	Transmit Data	Data to RF 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 RF Engine for host to send
9	RI	Ring Indicator	Not connected

Table 7 - RS-232 Pin Assignments

Setup of this port will be discussed in greater detail in the Synapse Portal Software Users 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 Table 8 below.

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 RF Engine
3	Data+	Transmitted and Received Data (pos)	Transmit data to and from the RF Engine
4	GND	Ground	Ground

Table 8 - USB Pin Assignments

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

3. 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 RF Engine, and SNAP code loaded in the microcontroller of the RF 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. Figure 10 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 picture to locate all features.

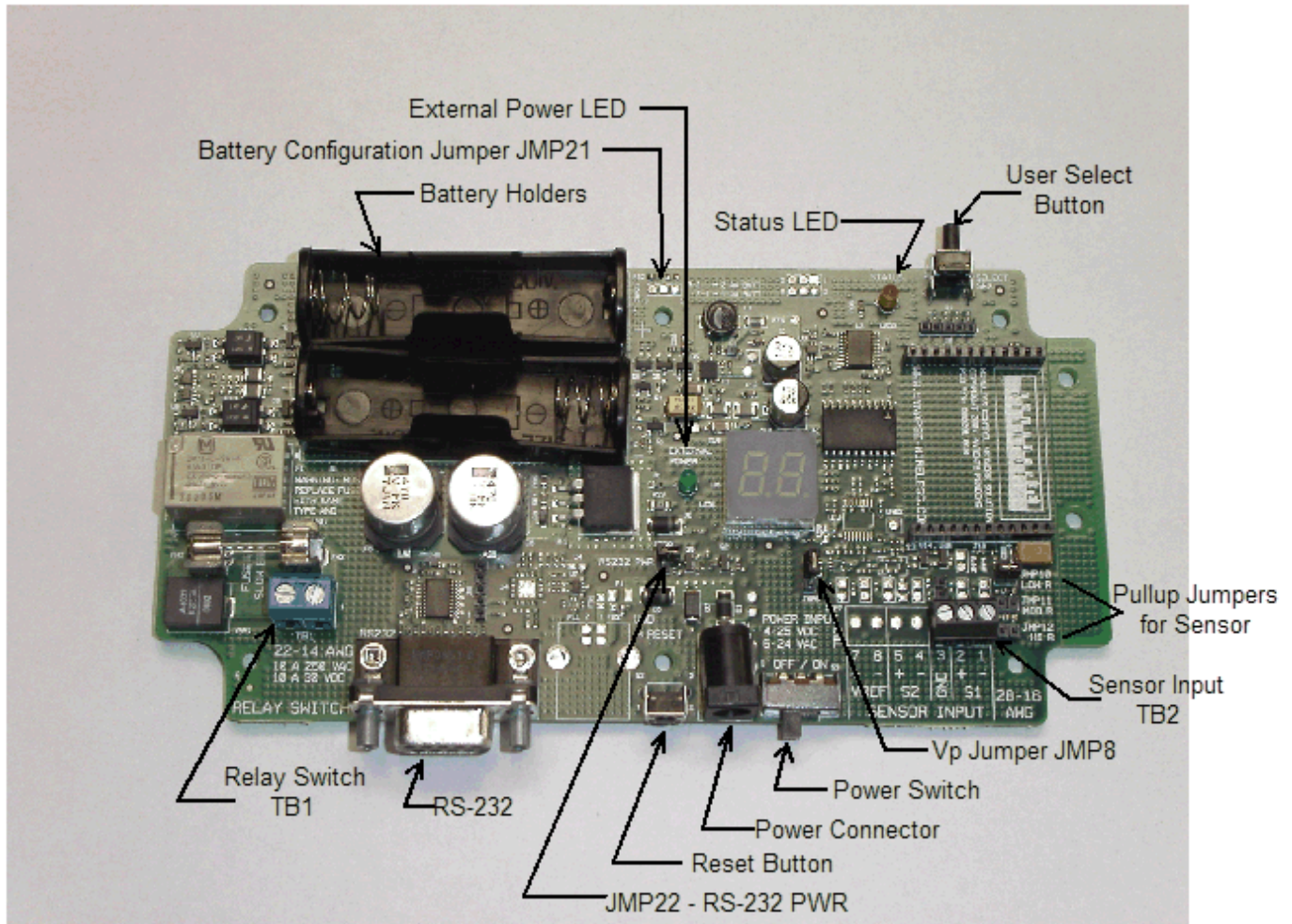**Figure 10 - SN111 End Device**

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.

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.

Notice: 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 RF Engine is in low power modes. The power supply will draw between 50 to 100 uAmps depending on the input power source when the RF Engine is in low power mode. A power supply design optimized for maximum power savings will draw less than 5 uAmps when the RF Engine is in low power mode.

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 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 Figure 11.
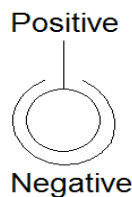
Positive

Negative

Figure 11 - 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 Figure 12 below.
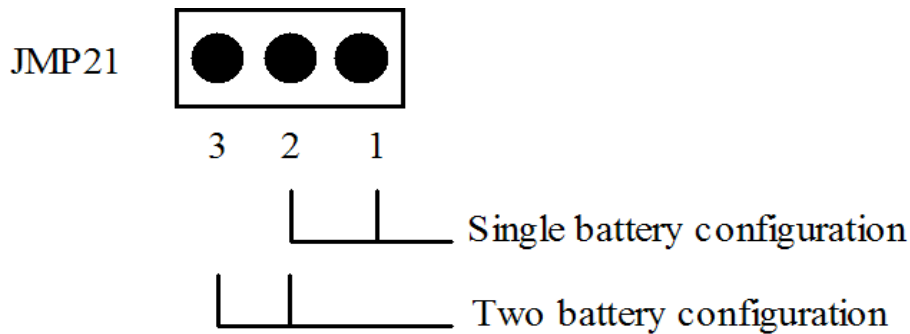
Figure 12 - Battery Configuration Jumpers

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.

Notice: 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 RF Engine module except the power supply for external power and external power LED indicator.

NOTICE: 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 DB-9 style connector. The pin assignments are shown in Table 9 below.

DB-9 Pin	RS-232 Signal	Description	Implementation
1	DCD	Data-Carrier-Detect	Not connected
2	RxD	Receive Data	Data from RF Engine (to host)
3	TxD	Transmit Data	Data to RF 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 RF Engine for host to send
9	RI	Ring Indicator	Not connected

Table 9 - RS-232 Pin Assignments

A standard RS-232 cable for connecting the SN111 End Device to a PC has been provided in the kit.

NOTICE: 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 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. Also, 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 fall 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 Figure 13 elow.
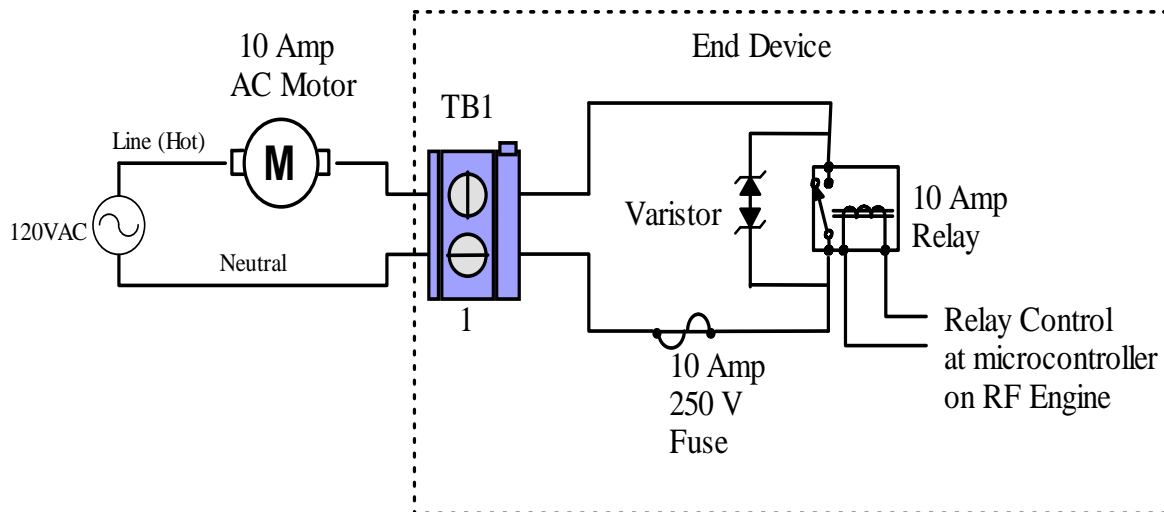

Figure 13 - Relay Circuit

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.

Sensor Input

The SN111 End Device also has circuitry that will accept a resistive type sensor input. Examples of resistive type sensor inputs are: 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 Figure 14 below.
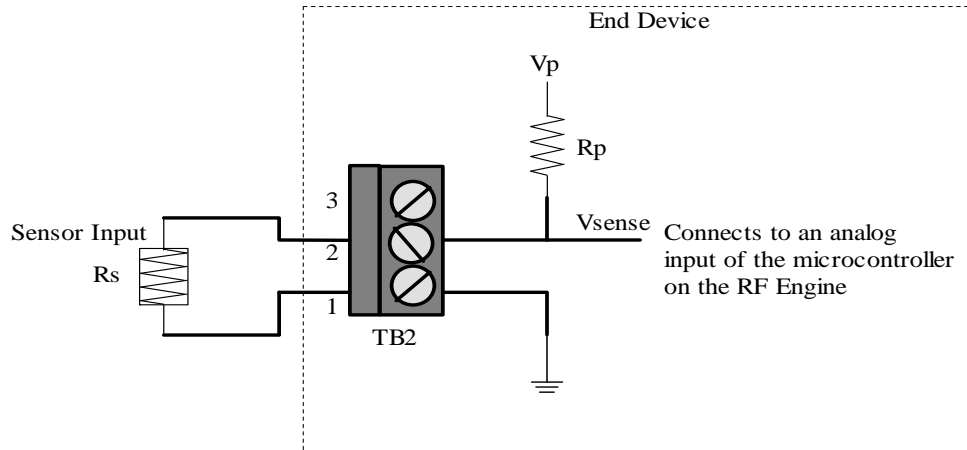

Figure 14 - Sensor Circuit

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 Figure 14 - Sensor CircuitFigure 14 and applying Ohm's Law, the resulting output voltage signal (Vsense) is given by the equation:

$$Vsense = (Vp / (Rp + Rs)) * Rs$$
Equation 1 - Vsense

where Vp = 3.2 VDC (Vcc of I/O Host Board)
Rp = pull-up resistor defined by
Table 10 below
Rs = sensor resistance defined by sensor vendor resistance urves versus function sensed
Vsense = analog voltage that goes to an "analog input" signal n the microcontroller of the RF Engine

Example: **A thermistor rated as 10k ohms 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 ohm from** Table 10, then Vsense can be calculated from Equation 1 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 RF Engine which goes thru a 10 bit analog to digital conversion in the micro-controller on the RF 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 RF 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 Figure 14. 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 RF Engine signal controlling the external analog source is enabled. See Figure 15 below. By controlling the pull-up voltage, power consumption can be reduced when running the I/O Host Board electronics from battery. The RF 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.
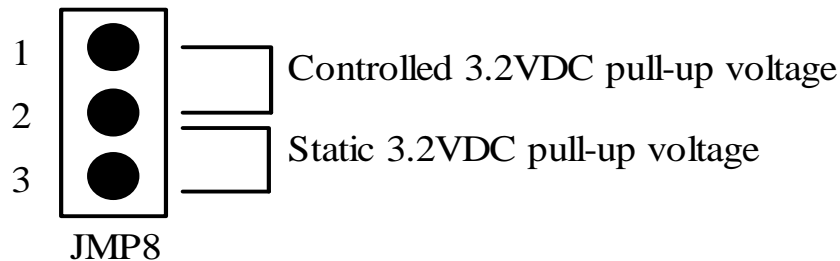

Figure 15 - Vp Jumper

Also, there are different values of resistor pull-up (identified as Rp) by jumper configuration options. These choices of Rp are identified by Table 10 below.

	Possible Jumper Configurations for Sensor Pull-up Resistance							
	1	2	3	4	5	6	7	8
JMP10	N	P	N	P	N	P	N	P
JMP11	N	N	P	P	N	N	P	P
JMP12	N	N	N	N	P	P	P	P
Rp (ohms)	Invalid	10K	100K	9.091K	1M	9.901K	90.909K	9.009K

where :   N   - jumper not populated
              P   - jumper populated
              Invalid   - if no jumpers are installed, then pull-up circuit for sensor input is disconnected

Table 10 - Jumper Options for the Sensor Input

4. Evaluation Kit - SN171 Proto Board

Figure 16 - SN171 Proto Board

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

The SN171 Proto Board provides easy access to **all 19** General Purpose I/O (GPIO) pins of the RF Engine, including:

- 19 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 19 functions at one time. Please refer to the existing RF Engine Datasheet for more details.

On the SN171 Proto Board, none of the I/O pins are 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 RF 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 Proto Board 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".

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

Table 11 - Power Jumper Options

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.
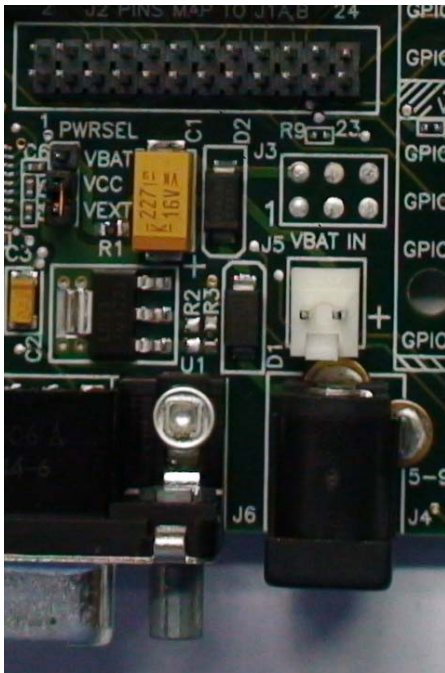

Figure 17 - Power Location

On-board LEDs

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

Table 12 - LED Jumpers

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

Figure 18 - 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.

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

Table 13 - Push-Button Jumpers

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

Figure 19 - Push-Button Jumper Location

RS-232 Port

The RF 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 Proto Board 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 RF Engine. The first RF Engine serial port is always 3.3 volt logic level.

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

Table 14 - RS-232 Jumpers

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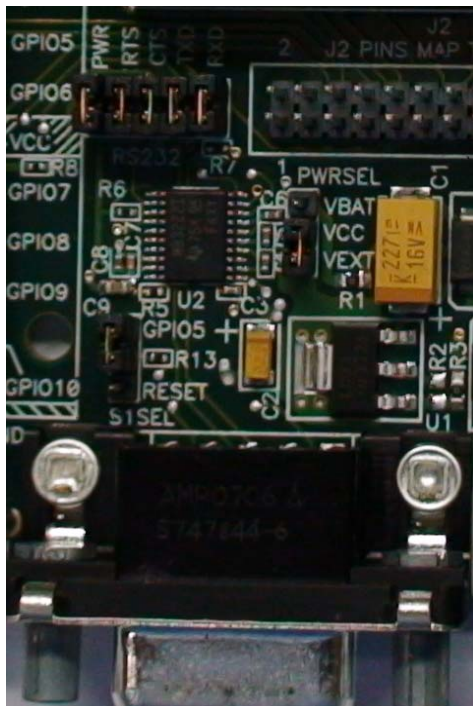

Figure 20 - RS-232 Jumpers Locations

Connectivity Options

Two terminal blocks (one on each side of the board) provide access to all of the GPIO pins, **plus** various POWER, GND, and RESET signals.

NOTE that these terminal blocks DO NOT have the exact same pinout as the two headers on the RF Engine!

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

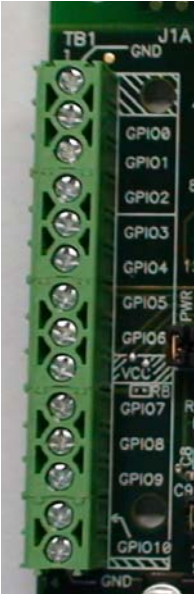Notice the power (VCC) pin between GPIO6 and GPIO7.

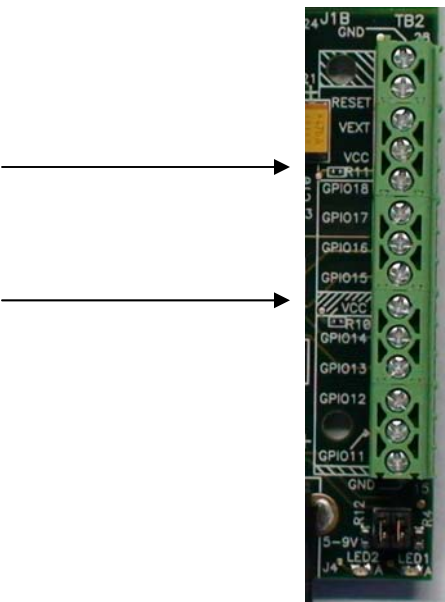**Figure 21 - GPIO Terminal Block 1**

Figure 22 - 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 Table 15.

Connector	Description
J1A	12 pin header, one of two that connect to the Synapse RF Engine
J1B	12 pin header, the second of two that connect to the RF 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 RF Engine signals **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 RF Engine's microprocessor. This connector is usually not installed.
J4	Barrel connector for external DC power (5 - 9 volt range)
J5	Connector for external "Battery" power (2.7 - 3.4 volt range)
J6	This is the DB9 connector for the RS-232 line interface

Table 15 – Connectors

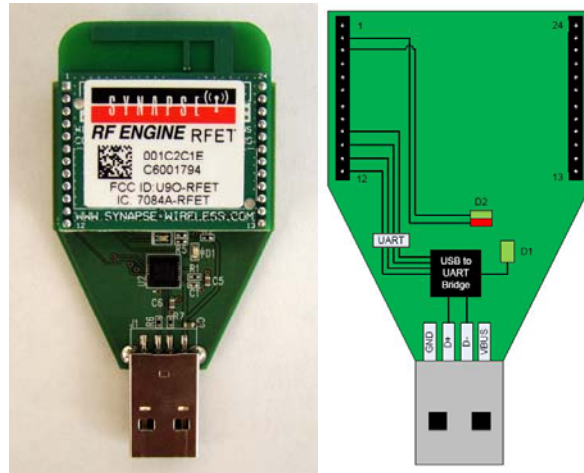# 5. Evaluation Kit - SN132 SNAPstick USB Module

Figure 23 - 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 RF 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.
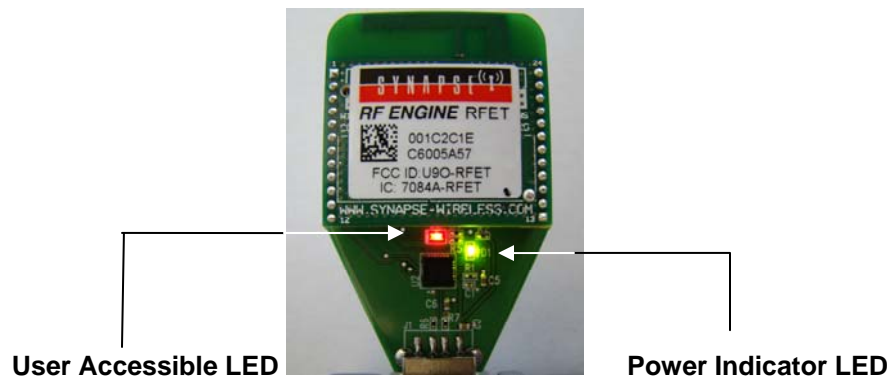

User Accessible LED   **Power Indicator LED**

Figure 24 - 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.

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

Table 16 - SNAPstick LED Configuration

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 17 General Purpose Input/Output (GPIO) pins available on the RF engines.

USB Interface

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

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

Table 17 - SNAPstick UART Connections

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 25 - A SNAPstick drawing power from a laptop PC and USB AC Adapter