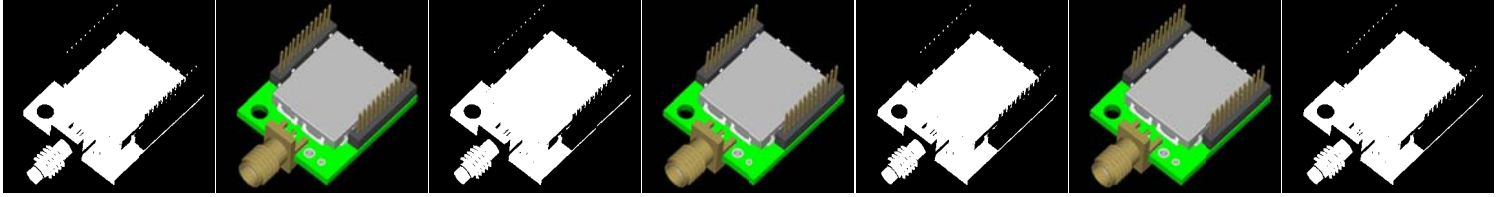
Hubbell Building Automation

WIHUBB RF Module

Users Manual

5/6/2010



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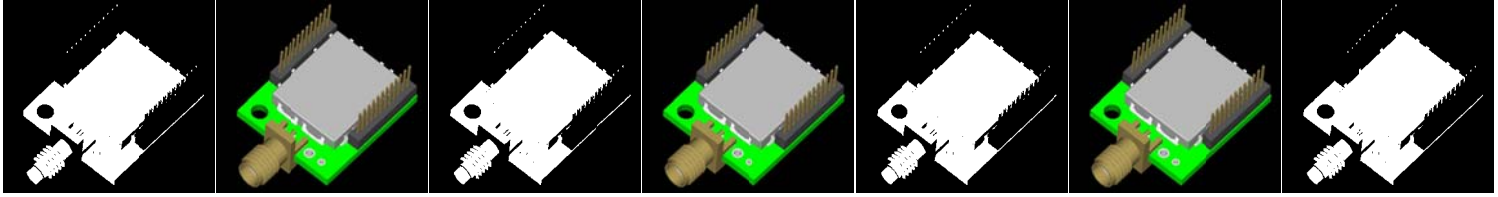

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1. RF MODULE OVERVIEW

1.1. WiHubb RF Module Description

The WiHubb RF Module is the basis for Hubbell Building Automation's next generation of networked lighting controls. The WiHubb RF Module combines a highly integrated CMOS ISM transceiver operating from 902.74MHz to 927.74MHz with a CIP-51 microcontroller core and 19 pins of digital and analog I/O. A 30MHz onboard crystal is included for the RF section and a 32.768KHz crystal is included for real time clock control. Board-level connections to a board-edge SMA connector are provided. Two 12-pin, 1.27mm-pitch male headers are provided for integration of the module with various carrier boards to create wirelessly networked lighting controls products that include switch-stations, power-packs, photocells (for daylight harvesting), occupancy sensors, and relay modules.

Sensitivity of the WiHubb RF Module in receive mode is -118dBm, and transmit power can be configured from +11 to +20dBm in four stages. Data rate is fixed at 128kbps, with 50 selectable base channels. Data link robustness between nodes is increased by having the nodes hop across 50 pseudo-randomly selected channels. Isolation between the receive and transmit channels is maintained through an RF switch which is controlled with digital I/O lines from the transceiver.

A MAC layer protocol called EZMAC®PRO from Silicon Laboratories is utilized for configuration and maintenance of the ISM transceiver's functional settings. The MAC protocol runs in the background in two interrupt service routines and provides callbacks to notify the application layer during the occurrence of important events such as Packet Received, Packet Sent, Sync Word Received, Listen Before Talk Timeout, No Ack, Packet Forwarding. The MAC layer protocol simplifies control of the wireless data link by creating an API upon which the WiHubb RF Module application is built. Packet forwarding, with a maximum radius (hop count) of 3, is provided by the protocol, and packet sequencing and maintenance of a packet forwarding table handled automatically.

Collision avoidance is implemented in an automated "Listen Before Talk" algorithm which includes customizable parameters such as the "LBT Interval" and the "MAX LBT RETRIES". These parameters assist with randomizing the LBT algorithm

Nodes are organized into peer-to-peer networks during the commissioning process without the need for a master node. During the commissioning process, a "Group", "Zone", and "Node" network address is assigned to each node and subsequent received packets are filtered on the basis of this network address. If the received packets do not match the node's assigned network address, the packet is ignored. Maximum packet size is 64 bytes and packet data is encrypted with AES-128 using a key that is common across the network.

2. RF MODULE TYPICAL APPLICATIONS

- Lighting Controls
- Building Automation
- Wireless Sensor Networks

Two 12-pin, 1.27mm-pitch male headers are provided for integration of the WiHubb RF module with various carrier boards to create wirelessly networked lighting controls products that include switch-stations, power-packs, photocells (for daylight harvesting), occupancy sensors, and relay modules.

Operating from 902.74MHz to 927.74MHz, with variable transmit power, the WiHubb RF module offers superior penetration of building materials (compared with 2.4GHz technology) for interior installations, and extended line-of-site range for exterior applications.

2.1. Technical Specifications

Input Voltage Range	1.8 – 3.6VDC
Voltage on Analog Inputs (maximum ratings)	-0.3 to +3.9VDC
TX Mode Current (@ +20dBm)	85mA
(@ +13dBM)	30mA
RX Mode Current	18.5mA
Frequency Range	902.74 – 927.74MHz
Transmit Power	+20,+17,+14,+11dBm, software selectable
RX Sensitivity (@128kbps)	-101dBm
Data Rate	128kpbs
Modulation Type	GSK (Gaussian Shift Keying)
Programmed ID	6-byte MAC ID, factory-programmed
Frequency Hop Channels	up to 4 channels, software selectable
Frequency Hop Time	200uS
Number of Communication Channels	50

2.2. Physical Dimensions

Dimensions of PCB (mm)	25.4 x 22 x 8.13, including header pins
Dimensions of Connectors (mm)	15.24 x 4.98 x 8.13
Antenna Connector (RP-SMA board edge in mm)	6.35 x 6.35 x 11.43

2.3. Environmental Conditions

Operating Temperature (°C)	-40 to +85
Storage Temperature (°C)	-55 to +85

2.4. Ordering Information

HBA Part Number	Frequency (MHz)
WIHUBB –RF-001	902.74 – 927.74

3. RF MODULE FUNCTIONAL BLOCK DIAGRAM

3. MODULE FUNCTIONAL BLOCK DIAGRAM

The WiHubb RF Module has 19 input/output (I/O) lines. One of the I/O lines includes the on-chip Silicon Laboratories 2-Wire C2D debug interface for on-chip flash programming and in-system debugging.

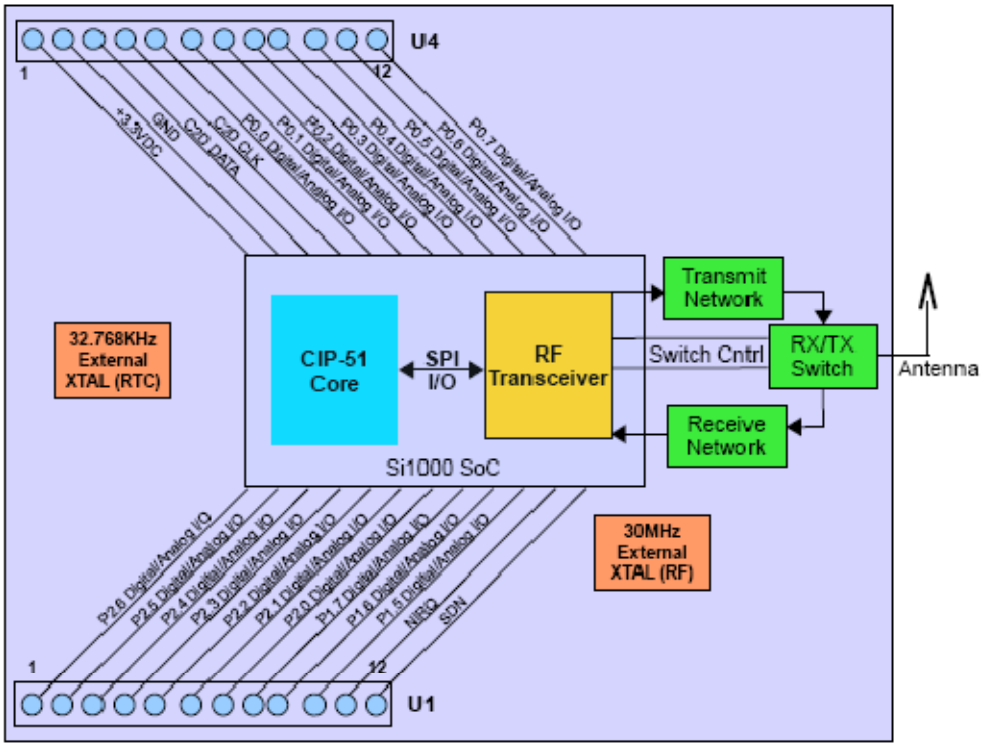


Figure 1 WiHubb RF Module Block Diagram

3.2. Pin Description

Connector Designator	Pin#	Function(s)
U4	1	+3,3VDC (VDD)
U4	2	Ground
U4	3	C2D – bi-directional data signal for C2 debug interface. Port 2.7 – GPIO only
U4	4	CLK – C2D clock interface
U4	5	Port 0.0 – GPIO or Analog I/O

		External Interrupt 0 or 1
U4	6	Port 0.1 – GPIO or Analog I/O External Interrupt 0 or 1
U4	7	Port 0.2 – GPIO or Analog I/O External Interrupt 0 or 1
U4	8	Port 0.3 – GPIO or Analog I/O External Interrupt 0 or 1
U4	9	Port 0.4 – GPIO or Analog I/O UART TX (May be moved with I/O crossbar adjustment) External Interrupt 0 or 1
U4	10	Port 0.5 – GPIO or Analog I/O UART RX (May be moved with I/O crossbar adjustment) External Interrupt 0 or 1
U4	11	Port 0.6 – GPIO or Analog I/O External Interrupt 0 or 1
U4	12	Port 0.7 – GPIO or Analog In External Interrupt 0 or 1
U1	1	Port 2.6 – GPIO or Analog In
U1	2	Port 2.5 – GPIO or Analog In
U1	3	Port 2.4 – GPIO or Analog In
U1	4	Port 2.3 – GPIO or Analog In
U1	5	Port 2.2 – GPIO or Analog In
U1	6	Port 2.1 – GPIO or Analog In
U1	7	Port 2.0 – GPIO or Analog In
U1	8	Port 1.7 – GPIO or Analog In
U1	9	Port 1.6 – GPIO or Analog In
U1	10	Port 1.5 – GPIO or Analog In
U1	11	NIRQ – Non-maskable IRQ from Transceiver
U1	12	SDN – Transceiver Shutdown control pins

4. DETAILED DESCRIPTION OF PIN FUNCTIONS

4.1. Selecting I/O Functions

I/O functions are designated at compile time according to the runtime image selected and programmed via the C2D debug interface into the WiHubb flash memory. There are no user-configurable I/O settings or changes that can be made via the WiHubb RF communications protocol.

4.2. GPIO

All port GPIO pins are 5V tolerant when used as digital inputs or open-drain outputs.

For Port I/Os configured as push-pull outputs, current is sourced from the VDD/DC+ supply.

4.3. Analog I/O

The ADC (analog-to-digital converter) in the CIP-51 microcontroller core is a 300ksps, 10-bit successive-approximation-register (SAR) ADC with integrated track-and-hold and programmable window detector.

4.4. NIRQ

This line is routed to the processor. Depending on the configuration of the transceiver functions using EZMAC®PRO, one or more of the following events will generate an interrupt on the NIRQ line:

Valid Sync Word Detected

Valid Preamble Detected

Invalid Preamble Detected

RSSI Sense - Detected level exceeds the programmed threshold

Wake-Up-Timer

Low Battery Detected

Chip Ready - Once the 30MHz crystal has been enabled

Power-on-Reset event detected

4.5. SDN

Shutdown input pin. 0–VDD V digital input. SDN should be = 0 in all modes except Shutdown mode. When SDN =1 the transceiver is place in its lowest power mode and the contents of the registers are lost. Usually this pin is routed to one of the GPIO pins on the processor via the carrier board to enable power-down control of the transceiver.

4.6. External Interrupt 0

This interrupt is mapped in EZMAC®PRO to the NIRQ line from the transceiver. This interrupt input is used as a signal for the MAC protocol to read the transceiver interrupt status registers and adjust the MAC protocol receive and transmit software state machines as appropriate. This interrupt is not available for user applications.

4.7. External Interrupt 1

This interrupt may be mapped to any input on Port 0, exclusive of the Port 0 interrupt occupied by External Interrupt 0.

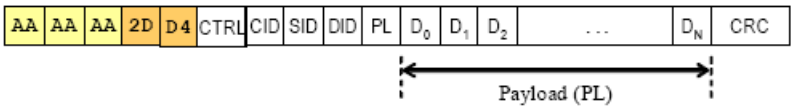
5. DETAILED PACKET DESCRIPTION

5.1. Modulation Type

The WiHubb RF Module utilizes Gaussian Frequency Shift Keying (GFSK) so as to limit the spectrum occupied by a given channel.

5.2. Packet Format

Synchronization and error control is enabled by preamble and sync-word header bytes included with the packet data. Format of packets, including the header data and CRC is shown in the following diagram and table:



Name	Description	Size [bytes]
AA AA AA AA AA	Preamble	min. 5
2D D4	Synchron pattern	2
CTRL [1]	Control byte	1
CID [2]	Customer ID	1
SID	Sender ID	1
DID	Destination ID	1
PL [2]	Payload Length	1
D_0 ... D_N	Data bytes	0 ... 64
CRC	Cyclic Redundancy Code	2

Notes:
1. This byte is used only for the extended packet configuration mode.
2. Optional field; may not be used on simple applications.

The Control Byte (CTRL) is used for configuration of packet forwarding. The Customer ID (CID), Sender ID (SID), and Destination ID (DID) may be used for packet filtering at the MAC layer. The CRC is 16-bits in length.

5.3. Communication Protocol

The WiHubb RF module communication protocol includes two main classes of messages: Broadcast Messages, and Functional Messages. Broadcast messages are intended for global management of a WiHubb wireless network and for use by commissioning or management applications, including a web server. Broadcast message are common across all WiHubb RF nodes in a WiHubb network.

Functional messages are intended for use between end-item nodes in a WiHubb wireless network. Interpretation of functional messages depends on the message source and on the receiving node. For example, WiHubb nodes configured as switch-stations can source/send “Open Relay” or “Close Relay” messages, but the switch-station nodes will not interpret “Open Relay” or “Close Relay” messages.

The EZMAC®PRO MAC-layer protocol enables groups with up to 255 members. This addressing is extended at the application layer by the use of Group, Area, and Zone network addressing parameters, with each parameter functioning as follows:

Group: Multi-byte bitfield indicating assignment of a node to one or more groups. The Group network addressing parameter is non-exclusive, meaning that a node may have one or more bits set in the bitfield, indicating membership in one or more groups.

Area: Multi-byte parameter, mutually-exclusive, indicating membership of a node in one of 999 possible Areas. Each node may be assigned to only one WiHubb Area.

Zone: Multi-byte parameter, mutually-exclusive, indicating membership of a node in one of 999 possible Zones. Each node may be assigned to only one WiHubb Zone.

The Group, Area, and Zone address parameters are stored in serial EEPROM may be programmed into a node and read back from the node using Broadcast messaging.

5.4. Broadcast Message Packet Format

A Broadcast message packet consists of 2 header bytes and up to 62 data bytes as shown in the table below:

Broadcast Packet ID
Broadcast Packet Type
Broadcast Packet Data Byte 1
Broadcast Packet Data Byte 2
…
Broadcast Packet Data Byte 62

Broadcast Packet ID:	0xFF
Broadcast Packet Type:	0x01 (Discover Topology Request)
	0x02 (Set Transmit Power)
	0x06 (Set Network ID)
Broadcast Packet Data:	Depends on Packet Type

5.5. Discover Topology Broadcast Packet

This packet is transmitted and received by every node on a WiHubb wireless network. This packet is the first step in a process of identifying each functional node on the network. Active nodes respond to this

packet with a Discover Topology Response. The Discover Topology Broadcast Packet is encoded as follows:

0xFF
0x01

The Discover Topology Response is encoded as follows:

0x52
0x02
Zone (3 bytes)
Group (13 bytes)
Area (3 bytes)
Serial Number (6 bytes)
Manufacturing Code (6 bytes)

The Zone, Group, and Area network addresses are user-programmable. The Serial Number and Manufacturing Code are non-user-programmable.

5.6. Set Transmit Power Broadcast Packet

This command sets every node in a Zone-Group-Area network address to a fixed transmit power level. Transmit power level may be set from +1dBm to +10dBm in four steps. The Set Transmit Power Broadcast Packet is encoded as follows:

0xFF
0x02
Zone (3 bytes)
Group (13 bytes)
Area (3 bytes)
Serial Number (6 bytes)
Manufacturing Code (6 bytes)
Transmit Power Level (1 byte)

5.7. Set Network ID

WiHubb Network Ids are provided to enable the concept of “binding” or assigning various nodes together in a logical network. For example, a set of occupancy sensors may be logically bound to a set of lighting fixtures by assigning both the sensor-nodes and the lighting fixture-nodes the same network Ids. The Set Network ID packet is encoded as follows:

0xFF
0x06
Serial Number (6 bytes)
Zone (3 bytes)
Group (13 bytes)
Area (3 bytes)

5.8. Functional Message Packet Format

Functional messages are transmitted with application layer network IDs including Zone, Group, and Area address bytes that are interpreted by receiving nodes to determine if a functional message is intended for it or not. Functional messages that are received and determined to match the assigned network ID of the node are then processed according to the assigned function for the node. For example, a Fixture node will process a Relay Open/Close message or a Dim Up/Down message. A switch-station will interpret but not process a Relay Open/Close message or a Dim Up/Down message.

6. WIHUBB RF MODULE CARRIER BOARD

6.1 WiHubb RF Module Carrier Board Description

The WiHubb RF Module Carrier provides, at a minimum, +3.3VDC @ 1A in a self-contained switching power source (90-277VAC input, 50-50Hz) routed to 2 pins on the female 12-pin, 1.27mm pitch header. Regulated +5.0VDC and +8.0VDC outputs are provided by this power source but are unused.

Depending on the end-item application, the WiHubb RF Module Carrier Board includes a combination of the following circuits and functions:

Serial EEPROM: Non-volatile memory is used for storing runtime data (schedules, logging data, alarm events, temperature), transceiver configuration data (channel settings, transmit power, timeouts), relay open/close calibration data, photocell calibration data, serial number, and manufacturing date codes. If no serial EEPROM is present on the carrier board when the WiHubb RF Module is energized (or the

serial EEPROM is corrupt), the WiHubb RF Module transceiver is configured with the following default settings:

Channel #:	1
Transmit Power:	20 dBm
Listen Before Talk:	Enabled
Frequency Search:	Enabled
Frequency Search Count:	52
Data Rate:	128kbps
RSSI Threshold:	-60dBm

Relay and Relay Driver Circuitry: Two digital I/O lines are used to control each latching relay, or a total of four GPIO lines for up to two latching relays mounted on the carrier board. Current capacity depends upon the installed relay.

AC Current Sensing: A single-axis magnetic field sensor based on the Hall Effect is used for sensing current up to 40A. This sensor measures load current only, not current consumed by either the carrier board or the WiHubb RF module. Output from this sensor is routed to one of the analog input pins on the WiHubb RF module. This input may be used for calculation of power consumed by the load as well as diagnostics

RS-232 Serial Interface: RS-232 TX and RX interface line are provided by level translation IC. A 3-pin header enables connection between the carrier board and any computer with a serial port. The WiHubb Web Server application makes use of this port for commissioning and managing WiHubb wireless networks.

Switches: Two momentary switches enable user input directly into the WiHubb RF Module. These switches may be utilized for a 2-switch station, or additional switches may be wired into other WiHubb RF Module GPIO pins to enable a larger array of switches.

LED: An LED is installed and may be used to indicate reception or transmission of a data packet.

Zero Crossing Sense Circuit: Relays (when installed) are opened and closed in synchronization with the AC voltage zero crossing (within a certain tolerance specified in milliseconds) to minimize arcing and extend the life of the relay contacts. The zero crossing sense signal is routed into one of the WiHubb RF module GPIO inputs where it is configured as an interrupt.

AC Voltage Monitor Circuit: This circuit, when combined with the AC Current Sense output, allows calculation of instantaneous and average power delivered to the load.

Dimmer Circuit: This circuit, in combination with an electronically dimmable ballast, enables dimming of fluorescent lighting. A low frequency (6KHz – 12KHz) PWM (Pulse Width Modulation) signal from the WiHubb RF module is integrated by this circuit into an analog voltage ranging from 0 to +10VDC, depending on the signal's duty cycle. 0VDC output from this circuit corresponds with a lamp that is fully off, while +10VDC output equals full intensity.

Debug Port: A 10-pin header is provided for interface with a Silicon Laboratories USB debug adapter. This debug adapter is the only way to load software into a new WiHubb RF Module.

7. AGENCY CERTIFICATIONS

FCC Certification

7.1 Statement According to FCC Part 15.21

NOTE: Modifications not expressly approved by Hubbell Building Automation may void the user's authority to operate the WiHubb RF Module.

7.2 OEM Requirements

- End users of products, which contain the WiHubb RF module must not have the ability to alter the firmware that governs the operation of the module. The agency grant is valid only when the module is incorporated into a final product by OEM integrators.

- The end-user must not be provided with instructions to remove, adjust or install the module.

- The Original Equipment Manufacturer (OEM) must ensure that FCC labeling requirements are met. This includes a clearly visible label on the outside of the final product. Attaching a label to a removable portion of the final product, such as a battery cover, is not permitted. The label must include the following text:

  Contains FCC ID: YH9WIHUBB

  The enclosed device complies with Part 15 of the FCC Rules. Operation is subject to the following two 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.

- The user manual for the end product must also contain the text given above.

- The module must be used with only the following approved antenna(s):

  ¼λ Dipole (915MHz) with Reverse Polarity SMA connector

IC (Industry Canada) Certification

7.3 Statement According to IC (Industry Canada) Radio Standards Specification General Requirements, Section 7.1.4 Transmitter Antenna

NOTE: This device has been designed to work with the antennas listed below, and having a maximum gain of 5dB. Antennas not on this list or having a gain greater than dB are strictly prohibited for use with this device. The required antenna impedance is 50 ohms:

Antenna Factor ANT-916-CW-HWR-RPS (with Reverse Polarity SMA Connector)

7.4 Statement According to IC (Industry Canada) Radio Standards Specification General Requirements, Section 7.1.5 User Manual

NOTE: Operation is subject to the following two conditions: (1) this device many not cause interference and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that permitted for successful communication.