Speakercraft RF Module DATASHEET

ZigBee Ready Module

1 Product Description

The LS Research Speakercraft RF module is a 2.4 GHz 802.15.4 data transceiver providing a cost-effective solution for data links and wireless networks. The module is based on the Ember EM250 802.15.4/Zigbee platform and supports point to point, point to multi-point, and EmberZNet applications. It provides a true Zigbee module combining an IEEE 802.15.4 compliant radio transceiver with a 16-bit microprocessor.

The Speakercraft RF module utilizes a 100mW power amplifier, providing for enhanced range performance over standard 802.15.4/Zigbee implementations. The module offers a standard integrated PCB trace antenna. Alternatively, the module has the option to be populated with an MMCX connector for use with an external cabled antenna.

The Speakercraft RF module provides a low cost, best in class performance ZigBee Radio Transceiver, in a compact form factor.

2 Key Features

- 100mW output
- Specifically designed for use with EmberZNet
- Small form factor (1.00" x 1.450")
- Integrated antenna
- Supported connector for external antenna
- 16 RF channels (Channel 16 at a reduced power level)
- Long Range: over 4000 feet
- Output power software controlled 1mW – 100mW
- Integrated hardware support for Ember InSight Development Environment
- Non-intrusive debug interface (SIF)
- AES-128 encryption
- Constant RF output power over voltage range of 2.1 – 3.6V
- RoHS compliant
- 128 kB Flash memory
- 5 kB SRAM
- 16-bit XAP2b microprocessor
- 16 GPIO connections
- Two serial controllers with DMA – SPI, I^2C, UART functionality
- Integrated ADC with 12-bit resolution

3 Absolute Maximum Ratings

Rating	Value	Unit
Power Supply Voltage	3.6	Vdc
Voltage on any digital pin	VDD + 0.3, Max 3.6	Vdc
RF Input Power	+10	dBm
Storage Temperature Range	-45 to 125	°C

Note: Under no circumstances exceeding the maximum ratings in Table can be allowed. Such a stress may cause permanent damage to the module or devices

4 Operating Conditions

Characteristic	Min	Typ	Max	Unit
Power Supply Voltage (Vdd)	2.1		3.6	V
Input Frequency	2405		2480	MHz
Ambient Temperature Range	-40	25	85	°C
Logic Input Low Voltage	0		20% Vdd	V
Logic Input High Voltage	80% Vdd		Vdd	V

5 Electrical Specifications

At 25°C, Vdd = 3.3V unless stated otherwise.

5.1 General

Parameter	Min	Typ	Max	Unit
RF Frequency Range	2400		2483.5	MHz
RF Data Rate		250		kbps
Microcontroller Operating Frequency		12		MHz
Flash Memory		128		kB
RAM		5		kB

5.2 Power Consumption

Parameter	Min	Typ	Max	Unit
Transmit Mode (100mW output)		230		mA
Receive Mode		37		mA
Standby Mode				
10mW			5	µA
100mW			5	µA

Boost mode is an optional higher performance radio mode that is software selectable to boost receiver sensitivity.

5.3 Transmitter

Parameter	Min	Typ	Max	Unit
Nominal Output Power		20		dBm
Error Vector Magnitude		15	35	%

5.4 Receiver

Parameter	Min	Typ	Max	Unit
Receiver Sensitivity (1% PER) – normal mode	-92	-96		dBm
Receiver Sensitivity (1% PER) – boost mode	-93	-97		dBm
Saturation (Maximum Input Level) (1% PER)	0			dBm
802.15.4 Adjacent Channel Rejection	35			dB
802.15.4 Alternate Channel Rejection	40			dB
802.11g Rejection (±10 MHz)	40			dB

5.5 Control DC characteristics

Parameter	Min	Typ	Max	Unit
Logic Input Low	0		0.2VDD	V
Logic Input High	0.8VDD		VDD	V
Logic Output Low	0		0.18VDD	V
Logic Output High	0.82VDD		VDD	V
Output source current (standard pad)			4	mA
Output sink current (standard pad)			4	mA
Output source current (high current pad)			8	mA
Output sink current (high current pad)			8	mA
I/O pin pull-up and pull-down resistor		30		kΩ

Please refer to the Ember EM250 datasheet (www.ember.com) for further information or more details regarding the functional descriptions of the system modules.

6 Pin Signals, I/O port configuration

The Speakercraft RF module has 30 I/O interfaces for connection to the user's host board. Figure 1 shows the layout of the 30 pin two row pin header which is shown on the bottom side of the assembly.

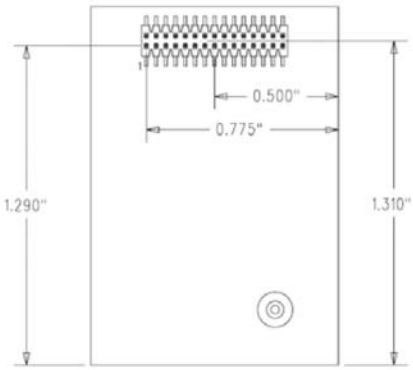


Figure 1

6.1 The I/O pin assignments for the Speakercraft module

Connector Pin Number	Radio Module Signal Name	Description
1	3VDC	3.0 VDC nominal Supply
2	3VDC	3.0 VDC nominal Supply
3	GND	RF Module Board Ground
4	GND	RF Module Board Ground
5	GPIO0	General Purpose IO
6	GPIO1	General Purpose IO
7	GPIO8	General Purpose IO - a logic low signals the station is docked
8	GPIO2	General Purpose IO
9	GPIO9	General Purpose IO – use for serial data from the RF Module
10	GPIO3	General Purpose IO
11	GPIO10	General Purpose IO – use for serial data to the RF Module
12	GPIO4	General Purpose IO
13	GPIO11	General Purpose IO
14	GPIO5	General Purpose IO
15	GPIO12	General Purpose IO
16	GPIO6	General Purpose IO
17	GPIO13	General Purpose IO
18	GPIO7	General Purpose IO
19	GPIO14	General Purpose IO – Connect to “ERROR*” on 3 volt regulator to allow low battery detection.
20	GPIO15	General Purpose IO
21	GPIO16	General Purpose IO
22	LOADB	Flash Programming I’fc
23	MOSI	Flash Programming I’fc
24	MISO	Flash Programming I’fc
25	CLK	Flash Programming I’fc
26	RSTB	RF Module Reset
27	NC	not connected
28	NC	not connected
29	NC	not connected
30	NC	not connected

The module contains 16 GPIO ports that are shared with other peripheral or alternate functions. The alternate functions can be utilized on a variety of different GPIOs as detailed

in the following table of pin assignments and definitions. All the GPIO ports are selectable as input, output, or bi-directional and have an internal pull-up or pull-down.

The integrated Serial Controller SC1 can be configured for SPI (master-only), I²C (master-only), or UART functionality. The Serial Controller SC2 can be configured for SPI (master or slave) or I²C (master-only) operation. The integrated ADC can sample analog signals from three GPIO pins single-ended or differentially. The integrated voltage reference VREF for the ADC can be made available to a GPIO port.

Please consult the Ember EM250 datasheet for details on configuring and controlling the information flow of the Speakercraft RF module interface ports to setup the following:

- GPIO Data Registers
- Alternate function routing
- External Interrupts
- Serial Controller SC1 module (UART mode, SPI Master mode, I²C Master mode)
- Serial Controller SC2 module (SPI modes, I²C Master mode)
- General Purpose Timers
- ADC Module
- Event Manager

7 SIF Interface

The Speakercraft RF module provides access to the SIF module programming and debug interface. Consult the EM250 datasheet for further details on the following features it provides

- Production Testing
- Firmware Download
- Product Control and Characterization
- XAP2b Code Development

8 Power Amplifier Regulator Control Line

The Speakercraft RF module includes a separate 1.8V regulator for the power amplifier bias to enable the consistent module output performance over the wide Vdd voltage range of 2.1 – 3.6 volts. To prevent excessive sleep currents, this regulator needs to be disabled when the module is put into sleep mode.

The following table provides the specifications for the regulator enable control line.
GPIO7

Parameter	Min	Typ	Max	Unit
Regulator enable voltage	0.95			V
Regulator disable voltage			0.4	V
Enable line current (VEN = 0)			0.1	µA
Enable line current (VEN = Vdd)			10	µA
Turn on Time			250	µsec

On the Speakercraft RF module, the regulator control line is brought to the module ports via GPIO7. The host can drive this port, but alternatively, the EM250 can use the default serial digital function of GPIO7 which is as an external voltage regulator enable. Please consult the EM250 datasheet for details on the operation of this function. Note that both approaches preclude the use of the GPIO7 port for any other possible functions including the use as the ADC3 input.

If the application does not put the module to sleep or if sleep current is not an issue, the power amplifier regulator may be permanently enabled by tying the control line high. In this setup, the sleep current will increase by 80µA over the value provided in section 5.2.

9 Antenna

The Speakercraft RF module includes an integrated PCB trace antenna. An optional configuration with an MMCX connector is also available. This will enable the connection to a 50-ohm external antenna of the user's choice.

The integrated PCB antenna topology is an F-antenna. This antenna is used because it is reasonably compact, has a fairly omni-directional radiation pattern, good efficiency, and is very simple. An adequate ground plane is necessary to provide good efficiency. The ground plane of the host board on which the module is mounted increases the effective antenna ground plane size and improves the antenna performance if done per the guidelines provided in this datasheet.

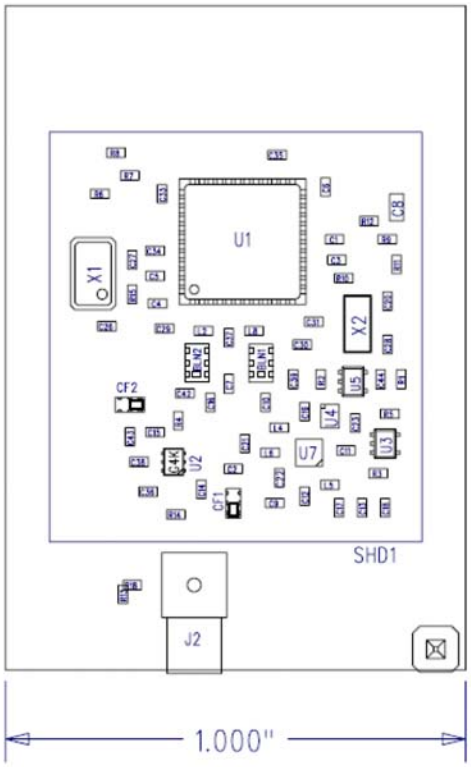
The antenna radiation patterns are dependent upon the host board the Speakercraft RF module is mounted on. Measured radiation patterns of the module alone are available by contacting LS Research.

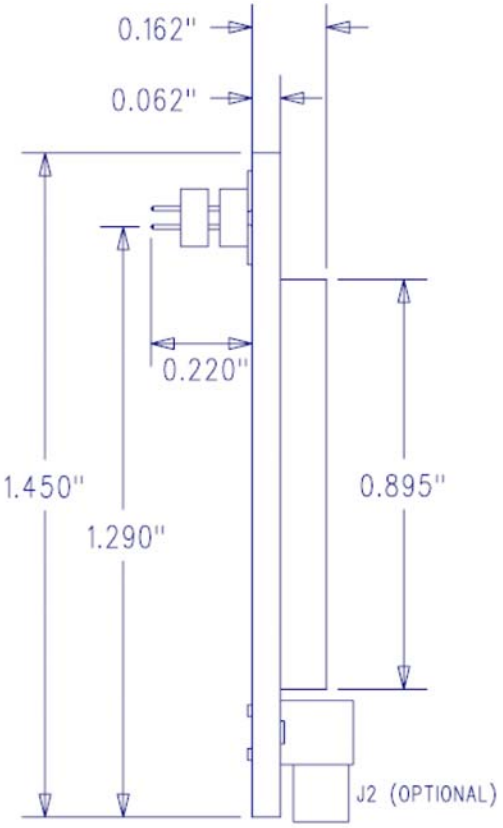
The environment the module is placed in will dictate the range performance. The non-ideal characteristics of the transmission channel result in the transmitted signal producing reflection, diffraction, and/or scattering. All of these factors randomly combine to create extremely complex scenarios.

It is also best to keep some clearance between the antenna and nearby objects. This includes how the module is mounted in the product enclosure. Unless the items on the following list of recommendations are met, the radiation pattern can be heavily distorted.

- Never place ground plane or copper trace routing underneath the antenna.
- Never place the antenna very close to metallic objects.
- In the final product, ensure that any wiring or other components do not get too close to the antenna.
- The antenna will need a reasonable ground plane area on the mother board area to be efficient.
- Do not use a metallic enclosure or metallized plastic for the antenna.
- Try to keep any plastic enclosure greater than 1 cm from the antenna in any orientation.

10 Mechanical Drawing





11 Mounting considerations

The recommended footprint for the Speakercraft RF module is for it to be mounted so the antenna is overhanging the board edge. This will provide the best antenna performance for the PCB trace antenna. It is also recommended to have a ground plane on the host board underneath the rest of the module, up to the recommended PCB edge. This will only improve the antenna performance by increasing the overall ground plane.

Traces can be run underneath the module on the host PCB as long a there is an uninterrupted ground plane on one layer as well. LS Research will provide any guidance and help with the host PCB layout.

Agency Certifications

FCC 15.247 Modular Approval

Compliance Statement (Part 15.19)
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 interference.
2) This device must accept any interference received, including interference that may cause undesired operation.

FCC Interference Statement (Part 15.105 (b))
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 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.

OEM Responsibility to the FCC Rules and Regulations
The **RF Module** has been certified per FCC Part 15 rules for integration into products without further testing or certification. To fulfill the FCC certification requirements the OEM of the **RF Module** must ensure that the information provided on the **RF Module** Label is placed on the outside of the final product.
The **RF Module** is labeled with its own FCC ID Number. If the FCC ID is not visible when the module is installed inside another device, then the outside of the device into which the module is installed must also display a label referring to the enclosed module. This exterior label can use wording such as the following:

"**Contains Transmitter Module FCC ID: V7W001F40RFMODULE**"
or
"**Contains FCC ID: V7W001F40RFMODULE**"

The OEM of the **RF Module** must only use the approved antenna, which has been certified with this module.

The OEM of the **RF Module** must test their final product configuration to comply with Unintentional Radiator Limits before declaring FCC compliance per Part 15 of the FCC rules.

Warning (Part 15.21)
Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

RF Exposure (OET Bulletin 65)
To comply with FCC & Industry Canad RF exposure requirements for mobile transmitting devices, this transmitter should only be used or installed at locations where there is at least 20cm separation distance between the antenna and all persons.

Industry Canada Statement
The term "IC" before the certification/registration number only signifies that the Industry Canada technical specifications were met.

Section 7.1.5 of RSS-GEN
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.

Section 7.1.4 of RSS-GEN
This device has been designed to operate with an antenna having a maximum gain of 2 dB. Antenna having a higher gain is strictly prohibited per regulations of Industry Canada. The required antenna impedance is 50 ohms."

List of all Antennas Acceptable for use with the Transmitter
Nearson 90° Half Wave Dipole
Inverted F PCB

Section 7.1.5 of RSS-GEN
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 required for successful communication.

12 Shipment, Handling, and Storage

12.1 Shipment

The LS Research Speakercraft Modules are delivered in single piece, or 50 piece cartons in individual anti-static bags.

12.2 Handling

The Speakercraft Module is designed and packaged to be processed in an automated assembly line.

! Warning - The Modules contain highly sensitive electronic circuitry. Handling without proper ESD protection may destroy or damage the module permanently.

! Warning - According to JEDEC ISP, the Speakercraft RF Modules are moisture sensitive devices. Appropriate handling instructions and precautions are summarized in Section 2.1. Read carefully to prevent permanent damages due to moisture intake.

11.3 Storage

Storage/Shelf life in sealed bags is 12 months at <40°C and <90% relative humidity.

15 Contact Info

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16 Document history

Revision 0.0 (2-14-2007) Preliminary release

17 Disclaimer

LS Research, LLC believes the information in this document is correct and accurate at the time of release. However, LS Research, LLC reserves the right to make changes to this product without notice.