

# EM250 Radio Communication Module

## Technical Specification

The Ember EM250 radio communication module (RCM) offers a complete ZigBee wireless solution for development and deployment of a low-data-rate, low-power ZigBee application. The four-layer (FR4) RCM features the Ember EM250, a 2.4GHz, IEEE 802.15.4-2003 SOC running the Ember ZigBee-compliant EmberZNet stack. In addition, it contains a 28-pin RCM interface connector, an MC-Card RF Switch, a ceramic SMT antenna, and two low-profile crystals (32.768kHz and 24MHz).

Together with the EM250 breakout board and InSight Adapter, the RCM makes up a single instance of the EmberZNet development kit. The RCM directly attaches to the EM250 breakout board, remotely attaches to the InSight Adapter through the InSight Port cable, or can be operated as a stand-alone node (under battery power). Therefore, the EM250 RCM offers the highest degree of flexibility when developing a ZigBee application.

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## Features

The EM250 RCM offers:

- Selectable RF interface (MC-Card switch or ceramic antenna)
- RX sensitivity of -97dBm typ. (-98 in boost mode) at 1% packet error rate
- +3dBm TX output power (+5dBm in boost mode)
- 16 RF channels spaced 5 MHz apart (2.405, 2.410, ... 2.480 GHz)
- Low supply voltage (2.1V to 3.6V)
- Minimal current draw (35mA in RX, 35mA in TX; VCC at 3.0V)
- Operation over the industrial temperature range -40°C to +85°C
- Access to all 17 EM250 GPIOs
- Access to SIF signals
- Access to the InSight Desktop packet trace interface
- FCC and CE (EMC and RTT&E) compliant (certification pending)
- IEEE 802.15.4-2003 PHY and MAC Level 1 compliant

The RF characteristics stated within the *EM250 Datasheet* were validated on the EM250 RCM.

Table 1 illustrates the key RF characteristics of the EM250 RCM.

Table 1. RF characteristics

Parameter	Min.	Typ.	Max.	Unit
Frequency band (16 – 5MHz wide channels)	2.405		2.480	GHz
RX sensitivity (1% PER, 20-byte packet):				
Normal mode	- 92	- 97		dBm
Boost mode	- 93	- 98		dBm
Maximum TX power:				
Normal mode		3		dBm
Boost mode		5		dBm
Error Vector Magnitude:				
Normal mode		15	25	%
Boost mode		15	25	%
Adjacent channel rejection (defined by IEEE 802.15.4 spec)				
+/- 5MHz		35		dB
+/- 10MHz		40		dB
802.11(g) rejection		40		dB

Table 2 lists the DC electrical characteristics of the EM250 RCM.

Table 2. DC electrical characteristics

Parameter	Min.	Typ.	Max.	Unit
VDD supply (VBRD)	2.1		3.6	V
RX mode current (VBRD = 3.0V)				
Normal Mode		35.5		mA
Boost Mode		37.5		mA
TX active current (VBRD = 3.0V)				
Normal Mode		35.5		mA
Boost Mode		41.5		mA
Sleep mode current				
32.768kHz Osc, 25C		1.3		μA
RC Osc, 25C		1.0		μA

Table 3 shows the GPIO digital signal levels for the EM250 RCM.

Table 3. GPIO digital signal levels

Parameter	Min.	Typ.	Max.	Unit
Input voltage for Logic Level 0	0		0.2*VBRD	V
Input voltage for Logic Level 1	0.8*VBRD		VBRD	V
Output voltage for Logic Level 0	0		0.18*VBRD	V
Output voltage for Logic Level 1	0.82*VBRD		VBRD	V
Input current for Logic Level 0			-0.5	μA
Input current for Logic Level 1			0.5	μA
Output current source				
GPIO[12:0]			4	mA
GPIO[16:13]			8	mA
Total output current (all GPIO)			40	mA

Table 4 lists mechanical and physical characteristics of the EM250 RCM.

Table 4. Mechanical and physical characteristics

Item	Description
RCM dimensions	1.61 in. x 0.95 in.
Antenna	Ceramic SMT antenna (ANT1)
GPIO interface	28-pin, 0.05" pitch, dual row connector (J2)
InSight Port connector	10-pin, 0.05" pitch, dual row connector (InSight Port) (J1)
Indicators	Two LEDs: <ul style="list-style-type: none"> <li>• Red (DS1)</li> <li>• Yellow (DS2)</li> </ul>
RF interface	MC-Card switch for direct attachment to test equipment (J3)
Certifications	<ul style="list-style-type: none"> <li>• FCC CFR47 Part 15</li> <li>• CE EMC and RTT&amp;E Directive</li> <li>• ARIB</li> <li>• IEEE 802.15.4-2003 PHY</li> <li>• IEEE 802.15.4-2003 MAC Level 1</li> <li>• ZigBee Level 1</li> </ul>

## Components

Figure 1 and Figure 2 illustrate the components on layer 1 (top side) and layer 4, respectively.

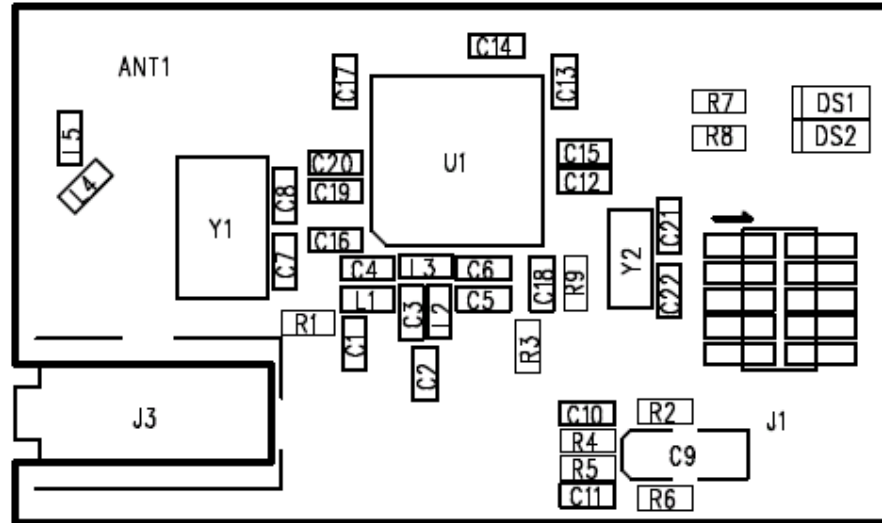


Figure 1. Assembly print for layer 1

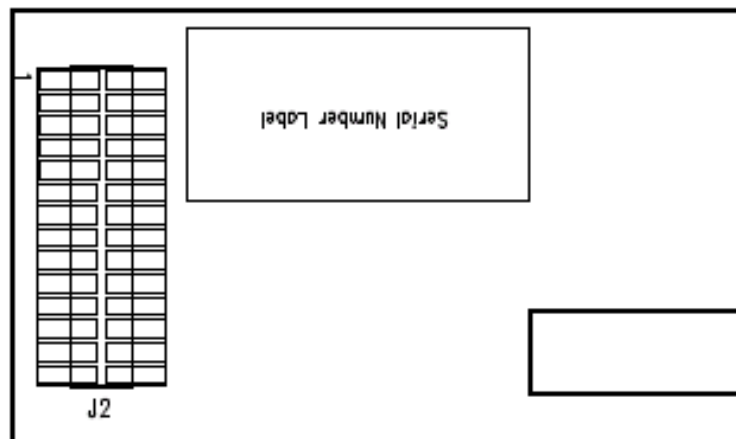


Figure 2. Assembly print for layer 4

### EM250 (U1)

The EM250, a true ZigBee SOC wireless solution, integrates an IEEE 802.15.4-2003 transceiver with a 16-bit XAP2b microprocessor. It provides a hardware MAC that supports automatic acknowledgement generation and reception, complex packet filtering, and a packet trace interface for InSight Desktop, providing a true PHY level packet sniff. In addition, it contains 128 kB of integrated flash, 5 kB of integrated RAM, a simulated EEPROM, and a number of application peripherals that target low-power, low-data-rate ZigBee applications.

These include:

- Two general-purpose 16-bit timers
- ADC
- Serial Controller 1 (UART, SPI, and I<sup>2</sup>C)
- Serial Controller 2 (SPI and I<sup>2</sup>C)
- Watchdog timer and power-on-reset
- Sleep timer (using either the 32.768kHz or RC oscillator as a source)
- Integrated 1.8V voltage regulator

The EM250 contains a protected area of flash, called the Flash Information Area (FIA), for permanent storage of customer manufacturing tokens.

Within the emberJoinNetwork API, there is a networkParams Structure that defines (among other things) the radioTXPower and radioChannel. Table 5 and Table 6 indicate the valid arguments for these two parameters.

Table 5. radioTXPower settings versus actual TX power

radioTXPower (decimal, signed)	Actual TX power (dBm)	radioTXPower (decimal, signed)	Actual TX power (dBm)
+4	+3 (+5 in boost mode)	-12	-12
+3	+3	-13	-12
+2	+2	-14	-14
+1	+1	-15	-14
0	0	-16	-16
-1	-1	-17	-16
-2	-2	-18	-16
-3	-3	-19	-16
-4	-4	-20	-20
-5	-6	-21	-20
-7	-7	-22	-20
-8	-8	-23	-20
-9	-9	-24	-20
-10	-10	-25	-20
-11	-10	-26	-26

**Note:** The actual TX Power value (in dBm) varies depending upon voltage supply, temperature, and PCB component tolerances. However, the radioTXPower setting is linear from settings +3 to -10 dBm and is non-linear from -12 to -26 dBm.

Table 6. Valid EM250 channel settings

radioChannel (decimal)	Center Frequency (GHz)	radioChannel (decimal)	Center Frequency (GHz)
11	2.405	19	2.445
12	2.410	20	2.450
13	2.415	21	2.455
14	2.420	22	2.460
15	2.425	23	2.465
16	2.430	24	2.470
17	2.435	25	2.475
18	2.440	26	2.480

For more information on the EM250, please refer to the *EM250 Datasheet*.

### InSight Port (J1)

The 10-pin, dual-row, 0.05-inch pitch InSight Port is the programming and debug interface for the RCM. It contains the four SIF signals (SIF\_MOSI, SIF\_MISO, SIF\_LOADB, and SIF\_CLK), two packet trace signals (PTI\_EN and PTI\_DATA), and voltage and ground connections. Through the InSight Port cable, it connects directly to the InSight Adapter, which allows programming and debug access within InSight Desktop.

The part used on the RCM is from Samtec (MFG P/N: FTSH-105-01-F-DV-K). It is keyed to guarantee proper connection with the InSight Port cable (Samtec P/N: FFSD-05-D-12.00-01-N). Figure 3 illustrates the pinout for the InSight Port, and Table 7 describes the pins.

VBRD	1	2	SIF_MISO
GND	3	4	SIF_MOSI
GND	5	6	SIF_CLK
nSIF_LOAD	7	8	nRESET
PTI_EN	9	10	PTI_DATA

Figure 3. InSight Port pinout

Table 7. Insight Port pins

Pin #	Signal Name	Direction	Description
1	VBRD	Power	2.1 to 3.6V supply for the RCM
2	SIF_MISO	Output	Serial interface, master in, slave out
3	GND	Power	Ground
4	SIF_MOSI	Input	Serial interface, master out, slave in
5	GND	Power	Ground
6	SIF_CLK	Input	Serial interface, clock (internal pull-down within EM250)
7	nSIF_LOAD	I/O	Serial interface, load strobe (open collector with internal pull-up within EM250)
8	nRESET	Input	Active low, EM250 reset (internal pull-up within EM250)
9	PTI_EN	Output	Packet trace frame signal
10	PTI_DATA	Output	Packet trace data signal; 500kbps

### MC-Card RF Switch (J3) and Antenna (ANT1)

In order to offer a flexible module solution, the EM250 RCM contains two RF ports, an MC-Card RF switch, and a ceramic antenna. If an application specifies a requirement that cannot be met by the ceramic antenna, you can attach an external antenna to the RCM through the MC-Card switch.

#### MC-Card RF Switch (J3)

The MC-Card RF switch from Radiall (MFG P/N: R199.005.890W) is a gold-finished, brass and beryllium copper mechanical switch designed to minimize insertion loss and maximize isolation between two RF interfaces. Table 8 details the key features of the MC-Card RF switch.

Table 8. MC-Card RF switch features

Parameter	Min.	Typ.	Max.	Unit
Insertion loss		0.25	.35	dB
Isolation		40		dB
Durability	5,000			Matings

**Note:** Ember ships one MC-Card-to-SMA cable assembly with each JumpStart or full developer kit). When attached to the MC-Card Switch, the cable assembly has 40 dB of isolation between the switch port and the antenna feed

### Antenna (ANT1)

The EM250 RCM comes with a Murata ceramic antenna (MFG P/N: ANCW12G45SAA117TT1) designed for the 2.4GHz ISM Band. Table 9 details the key parameters of the ceramic antenna.

Table 9. Ceramic antenna parameters

Parameter	Min.	Typ.	Max.	Unit
F <sub>0</sub>		2450		MHz
Bandwidth		100		MHz
VSWR			2.5	V/V
Impedance		50		Ohms

### RCM Interface Connector (J2)

The 28-pin, dual-row, 0.05-inch pitch connector on the bottom side of the RCM allows access to all 17 EM250 GPIOs, EM250 SIF signals, power (VBRD), and ground. This connector attaches directly to the EM250 Breakout Board and provides a robust and stable interface. To reduce the time spent in the application development phase, a software developer can attach the EM250 RCM directly to a custom board, provided that the proper mating connector is used. The connector on the RCM is from Samtec (MFG P/N: FTSH-114-04-F-DV).

The EM250 GPIO Signals are routed to this connector and exposed on the Breakout Board for application development. The connector also accesses the board voltage (VBRD) and to ground (GND), as shown in Table 7. Therefore, a SW Developer can assemble a simple battery pack and attach it to the RCM for remote application development.

Figure 4 shows the pinout of the RCM interface connector, and Table 10 describes the pinout and signal names. For more information on the alternate functions of the EM250 GPIO, please refer to the *EM250 Datasheet*.

VBRD	1	2	VBRD
GPIO1	3	4	GPIO2
GPIO12	5	6	GPIO0
GPIO3	7	8	GPIO11
GPIO5	9	10	GPIO4
GPIO7	11	12	GPIO6
GPIO9	13	14	GPIO8
nRESET	15	16	GPIO10
GND	17	18	GND
SIF_CLK	19	20	SIF_MISO
SIF_MOSI	21	22	nSIF_LOAD
GPIO16	23	24	GPIO15
GPIO14	25	26	GPIO13
GND	27	28	GND

Figure 4. RCM interface connector (J2)

Table 10. Pinout and signal names of the RCM interface connector

Pin #	Signal name	Direction*	Description
1	VBRD	Power	2.1 to 3.6V DC power supply for RCM
2	VBRD	Power	2.1 to 3.6V DC power supply for RCM
3	GPIO1	I/O	Digital I/O
4	GPIO2	I/O	Digital I/O
5	GPIO12	I/O	Digital I/O
6	GPIO0	I/O	Digital I/O
7	GPIO3	I/O	Digital I/O
8	GPIO11	I/O	Digital I/O
9	GPIO5	I/O	Digital I/O
10	GPIO4	I/O	Digital I/O
11	GPIO7	I/O	Digital I/O

Pin #	Signal name	Direction*	Description
12	GPIO6	I/O	Digital I/O
13	GPIO9	I/O	Digital I/O
14	GPIO8	I/O	Digital I/O
15	nRESET	Input	Active low chip reset (internal pull-up within EM250)
16	GPIO10	I/O	Digital I/O
17	GND	Power	Ground connection
18	GND	Power	Ground connection
19	SIF_CLK	Input	Serial interface, clock signal (internal pull-down within EM250)
20	SIF_MISO	Output	Serial interface, master in/slave out
21	SIF_MOSI	Input	Serial interface, master out/slave in
22	nSIF_LOAD	I/O	Serial interface, load strobe (open collector with internal pull-down within EM250)
23	GPIO16	I/O	Digital I/O
24	GPIO15	I/O	Digital I/O
25	GPIO14	I/O	Digital I/O
26	GPIO13	I/O	Digital I/O
27	GND	Power	Ground connection
28	GND	Power	Ground connection

\* with respect to the RCM

### RF Balun (C1, C2, C3, L1, L2, and L3)

Due to the differential signal traces within the EM250 (U1), an external balun circuit must drive the unbalanced antenna port. To keep costs low, Ember focused on a discrete, lumped-element LC balun, minimizing the number of inductors and using lower-cost elements where applicable.

This balun performs three primary functions:

- Matches the unbalanced 50 Ohms to the balanced 200 ohms of the EM250.
- Minimizes EVM by tuning PA Bond Wire inductance.
- Maximizes conducted 2<sup>nd</sup> harmonic suppression.

Due to the complex nature of developing the balun, Ember strongly urges application teams to resist changing the balun component values.

### High-Frequency Crystal (Y1)

The high-frequency crystal is a 24MHz, surface-mount, two-pin, 3.5 x 6 mm package crystal oscillator.

Table 11 lists the tolerances for this crystal. The manufacturer used for this module is ILSI America (MFG P/N: ILCX08-JG5F18-24.000MHZ). All EM250 RCMs are tested to ensure the frequency tolerance is at +/- 10ppm at room temperature.

Table 11. Frequency tolerances for the high-frequency crystal

Crystal requirements	Frequency tolerance
Total frequency error	+/-40ppm (as specified within the IEEE 802.15.4-2003 standard)
Calibration error	+/- 10ppm
Temperature error	+/- 20ppm
Aging	+/- 5ppm

### Low-Frequency Crystal (Y2)

The watch crystal is a 32.768kHz, surface-mount, two-pin, 3.2 x 1.2 mm crystal. The manufacturer used for this module is ILSI America (MFG P/N: IL3X-HX5-12.5-32.768KHZ). This crystal is optional if the internal RC oscillator is used to drive the EM250 sleep timer.

### LED Indicators (DS1 and DS2)

Four EM250 GPIOs (GPIO[13], GPIO[14], GPIO[15], GPIO[16]) allow for high output drive for LEDs. The EM250 RCM uses two of these GPIOs to drive DS1 and DS2. In most of the Ember sample applications, these LEDs are defined as Heartbeat and Activity to give immediate indication that the software application and network stack are operating correctly. Since these are attached to EM250 GPIO[13] and GPIO[14], respectively, they are available for debugging at the application level.



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