



# EM260 Radio Communication Module Technical Specification: SPI/UART Version

When combined with a host microcontroller, the EM260 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 EM260, a 2.4GHz, IEEE 802.15.4-2003 Network Processor running the Ember ZigBee-compliant EmberZNet PRO stack. It contains two 6-pin RCM interface connectors for access to the EmberZNet Serial Protocol (EZSP) and connection to a host microcontroller. In addition, the RCM contains an RF switch connector, a ceramic SMT antenna, a low-profile crystal (24MHz), and a ceramic balun.

Together with the EM260 SPI/UART Breakout Board and InSight Adapter, the RCM makes up a single instance of the EmberZNet PRO development kit. The RCM attaches directly to the EM260 SPI/UART Breakout Board, which contains the host microcontroller. The ZigBee application runs from the host microcontroller and communicates to the RCM using EZSP over synchronous serial (SPI) or asynchronous serial (UART). For more information on EZSP, refer to the *EM260 Datasheet* (120-0260-000). The 10-pin InSight Port on the RCM allows connectivity to InSight Desktop for debug.

## New in this Revision

Changed occurrences of 'Rangetest' to 'nodetest' in the "RF Measurements" section.

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## EM260 RCM Features

**Warning:** Please clearly identify the EM260 hardware version you are using. The EM260 SPI/UART RCM (130-0461-000) mates with the EM260 SPI/UART Breakout Board (130-0471-000), whereas the EM260 SPI-only RCM (130-0460-000) mates with the EM260 SPI-only Breakout Board (130-0470-000). These hardware versions are not compatible with each other. Please see Figure 1 to identify which hardware version you are using. If you are using the SPI-only version, please consult technical specification 2005 instead of this document.

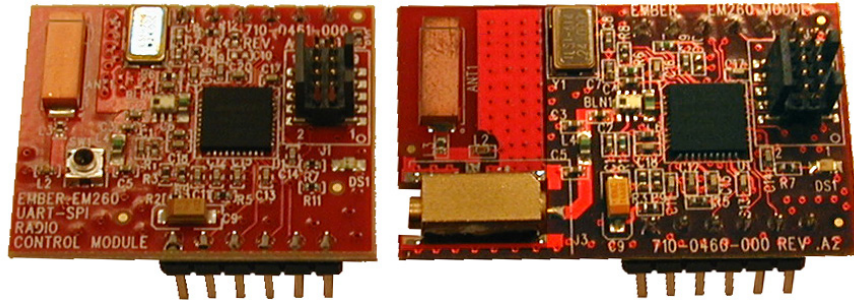


Figure 1. Hardware comparison

The EM260 RCM offers:

- Selectable RF interface (Murata RF connector or ceramic antenna)
- RX sensitivity of -99dBm typ. (-100 in boost mode) at 1% packet error rate
- +2.5dBm TX output power (+4.5dBm 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 of -40°C to +85°C
- Access to EZSP over synchronous serial (SPI) or EZSP over asynchronous serial (UART)
- Access to the InSight Desktop packet trace and debug interface
- FCC and CE (EMC and RTT&E) compliant (pre-scan completed)
- IEEE 802.15.4-2003 PHY and MAC Level 1 compliant

The RF characteristics stated in the *EM260 Datasheet* (120-0260-000) were validated on the EM260 RCM.

Table 1 illustrates the key RF characteristics of the EM260 RCM.

Table 1. RF characteristics

Parameter	Min.	Typ.	Max.	Unit
Frequency band (16 5-MHz wide channels)	2.405		2.480	GHz
RX sensitivity (1% PER, 20-byte packet):				
Normal mode		- 99	- 94	dBm
Boost mode		- 100	- 95	dBm
Maximum TX power:				
Normal mode		2.5		dBm
Boost mode		4.5		dBm
Error Vector Magnitude:				
Normal mode		5	15	%
Boost mode		5	15	%
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 EM260 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		36		mA
Boost mode		38		mA
TX active current (VBRD = 3.0V):				
Normal mode		36		mA
Boost mode		42		mA
Sleep mode current:				
RC Osc, 25C		1.0		μA

Table 3 shows the GPIO digital signal levels for the EM260 RCM.

Table 3. GPIO digital signal levels

Parameter	Min.	Typ.	Max.	Unit
Input voltage for Logic Level 0 (EZSP)	0		0.2*VBRD	V
Input voltage for Logic Level 1 (EZSP)	0.8*VBRD		VBRD	V
Output voltage for Logic Level 0 (EZSP)	0		0.18*VBRD	V
Output voltage for Logic Level 1 (EZSP)	0.82*VBRD		VBRD	V
Input current for Logic Level 0 (EZSP)			-0.5	μA
Input current for Logic Level 1 (EZSP)			0.5	μA
Output current source (TX_ACTIVE)			1	mA

Table 4 lists the mechanical and physical characteristics of the EM260 RCM.

Table 4. Mechanical and physical characteristics

Item	Description
RCM dimensions	1.212 in. x 1.000 in.
Antenna	Ceramic SMT antenna (ANT1)
EZSP interface	Two 6-pin, 0.1" pitch, single row connectors (J2A and J2B)
InSight Port connector	10-pin, 0.05" pitch, dual row connector (InSight Port) (J1)
Indicators	One LED: Red (DS1)
RF interface	Murata RF switch connector for switching antenna out of the circuit and directly attaching to test equipment (J3)
Certifications (pre-scan only)	FCC CFR47 Part 15 CE EMC and RTT&E Directive ARIB IEEE 802.15.4-2003 PHY IEEE 802.15.4-2003 MAC Level 1 ZigBee Level 1

**EM260 RCM  
Components**

Figure 2 and Figure 3 illustrate the components on layer 1 (top side) and layer 4, respectively.

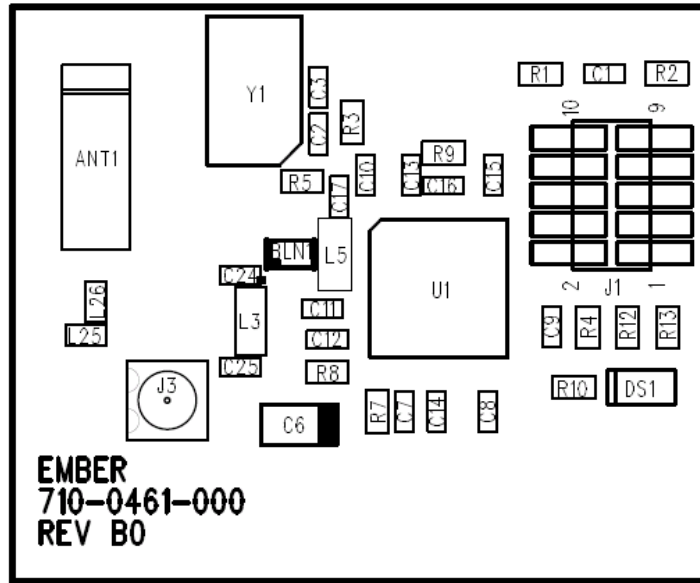


Figure 2. Assembly print for layer 1

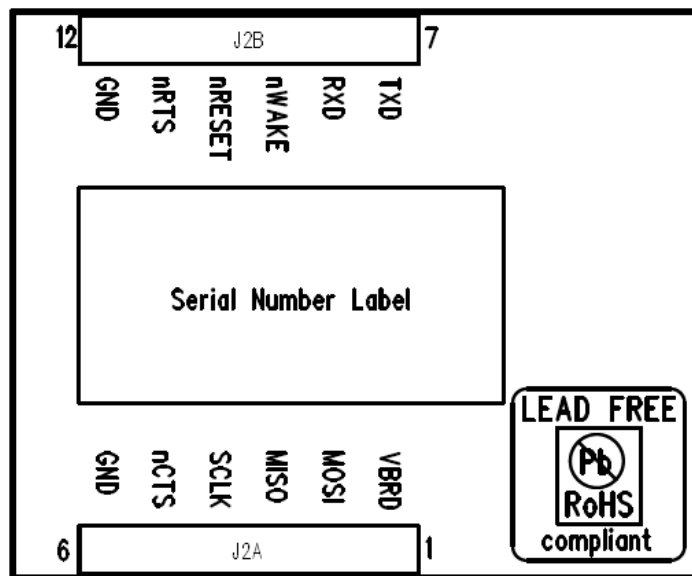


Figure 3. Assembly print for layer 4

## EM260 (U1)

The EM260, a true ZigBee Network Processor wireless solution, integrates an IEEE 802.15.4-2003 transceiver with a Network Processor core. 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.

The EM260 contains an integrated 1.8V regulator to provide proper core voltage to the analog and digital cells within the EM260. This regulator requires off-chip decoupling.

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

Table 5. Available radioTXPower settings

radioTXPower (decimal, signed)
+3
+2
+1
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-11
-12
-14
-17
-20
-26
-43

**Note:** The actual TX power value (in dBm) varies depending on voltage supply, temperature, and PCB component tolerances. However, the `radioTXPower` setting is linear from settings +3 to -9 dBm and is non-linear from -11 to -43 dBm.

Table 6. Valid EM260 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 EM260, refer to the *EM260 Datasheet* (120-0260-000).

### 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 the 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 4 illustrates the pinout for the InSight Port, and Table 7 describes the pins.

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

Figure 4. 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	SDBG	Output	Debug signal to be used on future pin-compatible products
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 EM260)
7	nSIF_LOAD	I/O	Serial interface, load strobe (open collector with internal pull-up within EM260)
8	nRESET	Input	Active low, EM260 reset (internal pull-up within EM260)
9	PTI_EN	Output	Packet trace frame signal
10	PTI_DATA	Output	Packet trace data signal; 500kbps

### Murata RF switch connector (J3) and antenna (ANT1)

In order to offer a flexible module solution, the EM260 RCM contains two RF ports, a Murata RF switch connector, 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 Murata RF switch connector.

### Murata RF switch connector (J3)

The Murata RF switch connector from Murata (MFG P/N: MM8430-2600B) is a gold-finished, stainless steel 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 Murata RF switch connector.

Table 8. Murata RF switch connector features

Parameter	Min.	Typ.	Max.	Unit
Insertion loss		0.1		dB
Isolation		20		dB
Durability	500			Matings

**Note:** Ember ships one Murata-to-SMA cable assembly (MFG P/N: MXHS83QE3000) with each development kit). When attached to the Murata RF switch connector, the cable assembly has at least 15-20 dB of isolation (20 dB minimum from DC to 3GHz, 15 dB minimum from 3GHz to 6GHz) between the switch port and the antenna feed.

### Antenna (ANT1)

The EM260 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. In addition, this document's appendix contains the field pattern and matching exercise performed by Murata on the RCM.

Table 9. Ceramic antenna parameters

Parameter	Min.	Typ.	Max.	Unit
F <sub>0</sub>		2,450		MHz
Bandwidth		100		MHz
VSWR			2.5	V/V
Impedance		50		Ohms

### EZSP interface connectors (J2)

Two 6-pin, single-row, 0.1-inch pitch connectors on the bottom side of the RCM allows access to the EZSP over synchronous serial (SPI) or asynchronous serial (UART). These connectors attach directly to the EM260 Breakout Board and provide a robust and stable interface to the host microcontroller. These connectors are designed to fit in a standard DIP socket footprint. To reduce the time spent in the application development phase, a software developer can attach the EM260 RCM directly to a custom board, provided that the proper mating connector is used. Both connectors on the RCM are from Molex (MFG P/N: 22-28-4063).

Figure 5 and Figure 6 show the pinouts of the RCM interface connectors (J2A and J2B, respectively), and Table 10 and Table 11 describe the pinout and signal names for the J2A and J2B, respectively. For more information, refer to the *EM260 Datasheet* (120-0260-000).

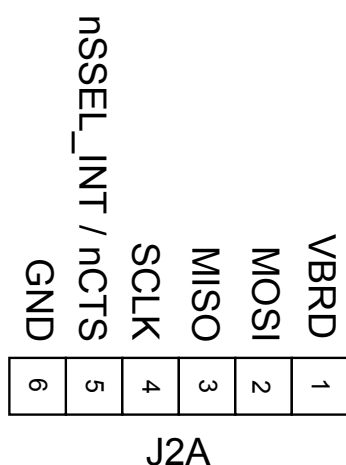


Figure 5. RCM interface connector (J2A)

Table 10. Pinout and signal names of the RCM interface connector (J2A)

Pin #	Signal Name	Direction*	Description
1	VBRD	Power	2.1 to 3.6V DC power supply for RCM
2	MOSI	Input	SPI data, master out/slave in (from Host to EM260)
3	MISO	Output	SPI data, master in/slave out (from EM260 to Host)
4	SCLK	Input	SPI clock (Host to EM260)
5	nSSEL_INT / nCTS	Input	SPI mode: Active low SPI slave select (Host to EM260) UART mode: Clear to send signal from Host to EM260
6	GND	Power	Ground connection

\* with respect to the RCM

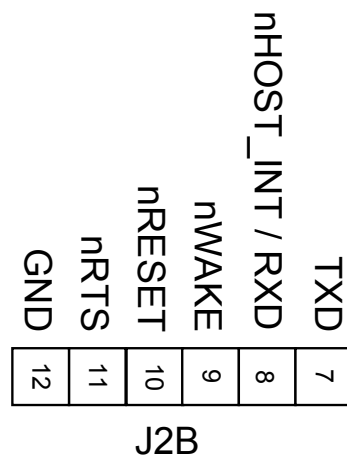


Figure 6. RCM interface connector (J2B)

Table 11. Pinout and signal names of the RCM interface connector (J2B)

Pin #	Signal Name	Direction*	Description
7	TXD	Output	UART mode: Transmit data from EM260 to Host microcontroller (should be connected to RXD on the Host)
8	nHOST_INT / RXD	Output/Input	SPI mode: Host interrupt (from EM260 to Host) UART mode: EM260 RX data signal (should be connected to TXD on the Host)
9	nWAKE	Input	Wake interrupt (from Host to EM260)
10	nRESET	I/O	Active low chip reset (internal pull-up)
11	nRTS	Output	UART mode: Ready to send signal from EM260 to Host
12	GND	Power	Ground connection

\* with respect to the RCM

### RF balun (BLN1 and L5)

Due to the differential signal traces within the EM260 (U1), an external balun circuit must drive the unbalanced antenna port. To keep implementation costs low, Ember focused on a ceramic balun, minimizing the degrees of tuning freedom to a single element, L5.

This balun performs three primary functions:

- Matches the unbalanced 50 Ohms to the balanced 200 Ohms of the EM260.
- Minimizes EVM by tuning PA bond wire inductance.
- Allows for a 1.8V DC path into the RF port of the EM260.

**Caution:** 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 12 lists this crystal's tolerances. The manufacturer used for this module is Abracon (MFG P/N: ABM3B-24.000MHZ-D-R60-1-W-T). All EM260 RCMs are tested to ensure the frequency tolerance is at +/- 15ppm at room temperature.

Table 12. Frequency tolerances for the high-frequency crystal

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

### LED indicator (DS1)

The EM260 RCM uses one of its high-output drive signals to drive DS1 on the RCM. This LED is driven by a LINK\_ACTIVITY signal to provide a visual indication of the health of the RCM.

### Mechanical drawing of EM260 RCM

Figure 7 illustrates the mechanical drawing of the EM260 RCM for direct attachment to a carrier board.

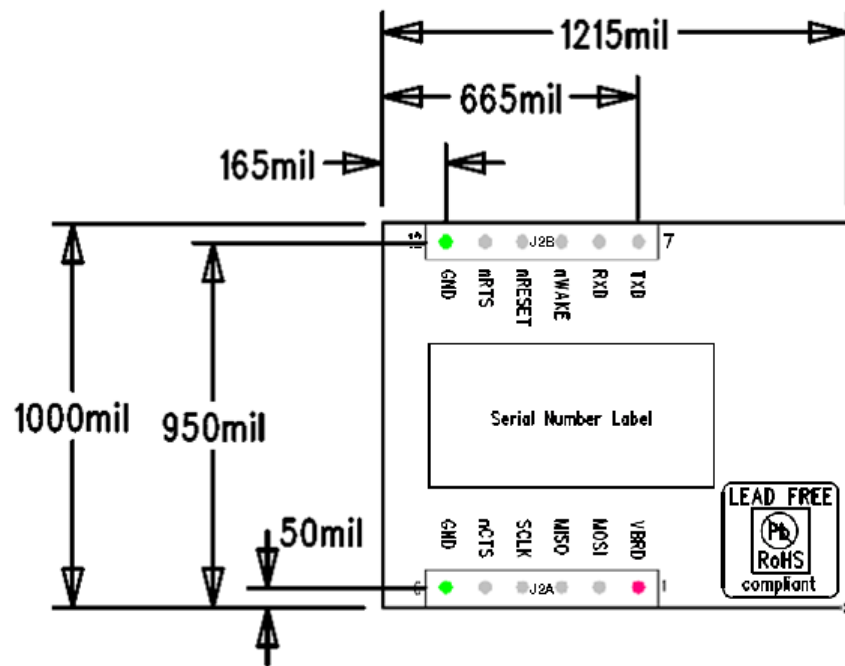


Figure 7. EM260 with dimensions (in inches)

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## RF Measurements

In order to perform RF measurements (TX power, RX sensitivity, ACR, and so on) with the EM260 RCM, the following steps should be followed:

- Attach the RCM to the Breakout Board.
- Attach the InSight Port Cable to the RCM and the InSight Adapter
- Load the nodetest software image on the EM260.
- Connect the Murata-to-SMA adapter cable to the Murata RF switch connector on the RCM. This cable should be in your development kit.
- The SMA end of the adapter can be attached to test equipment.
- Use the nodetest commands over virtual UART to put the RCM into different RX and TX test states.

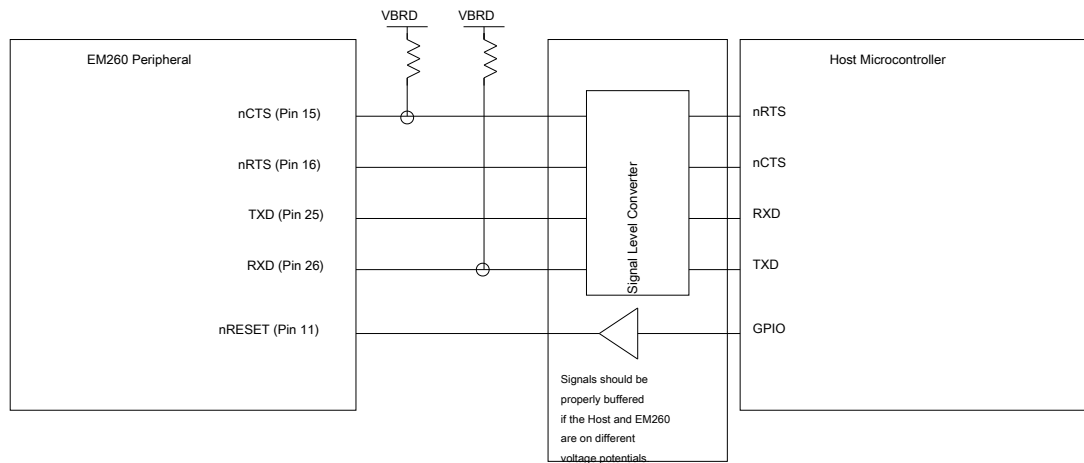
For more information on the nodetest application, please refer to the application note *Bringing Up Custom Devices for the EM260* (120-5041-000).

## Schematics of the EM260 RCM

### Block Diagrams

Ember supports the EM260 EZSP over Asynchronous or Synchronous Serial.

#### EZSP over Asynchronous Serial (UART)



#### EZSP over Synchronous Serial (SPI)

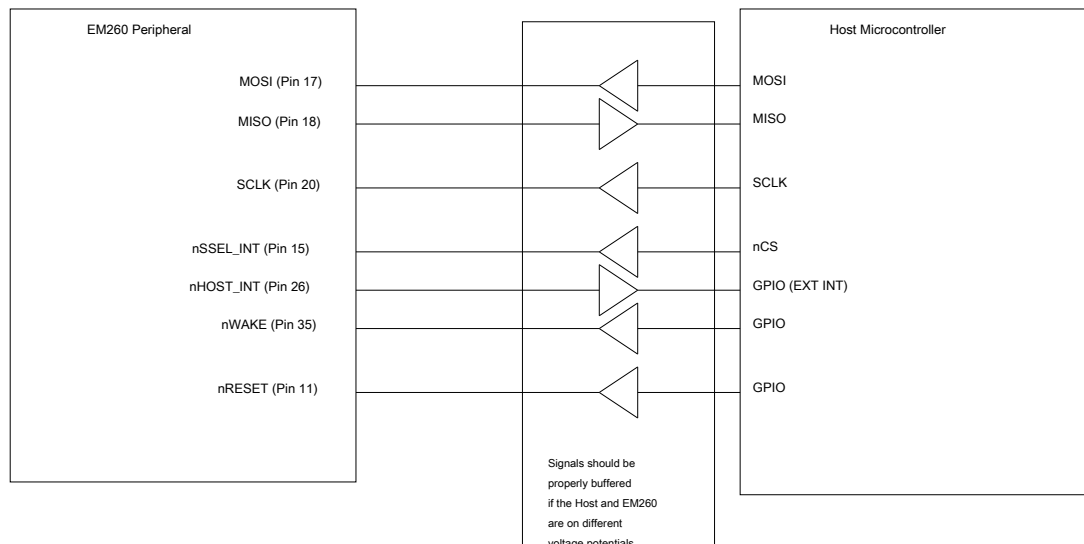


Figure 8. Schematic of the RCM - block diagrams (1 of 4)

The components on this page are mandatory for EM260-based designs.

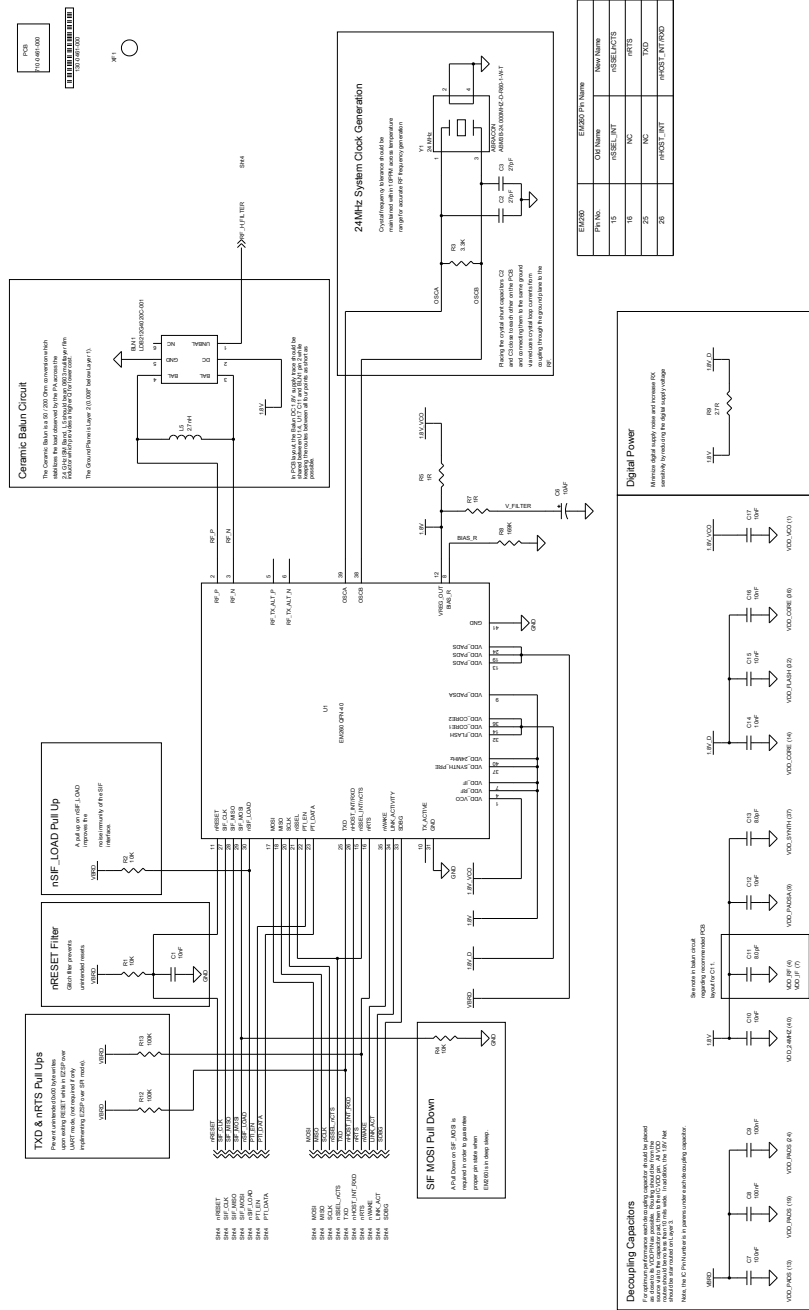


Figure 9. Schematic of the RCM - EM260 and off-chip components (2 of 4)

The Items below are Optional and they can be omitted by the Customer

The Items below can be used as shown or modified by the Customer.

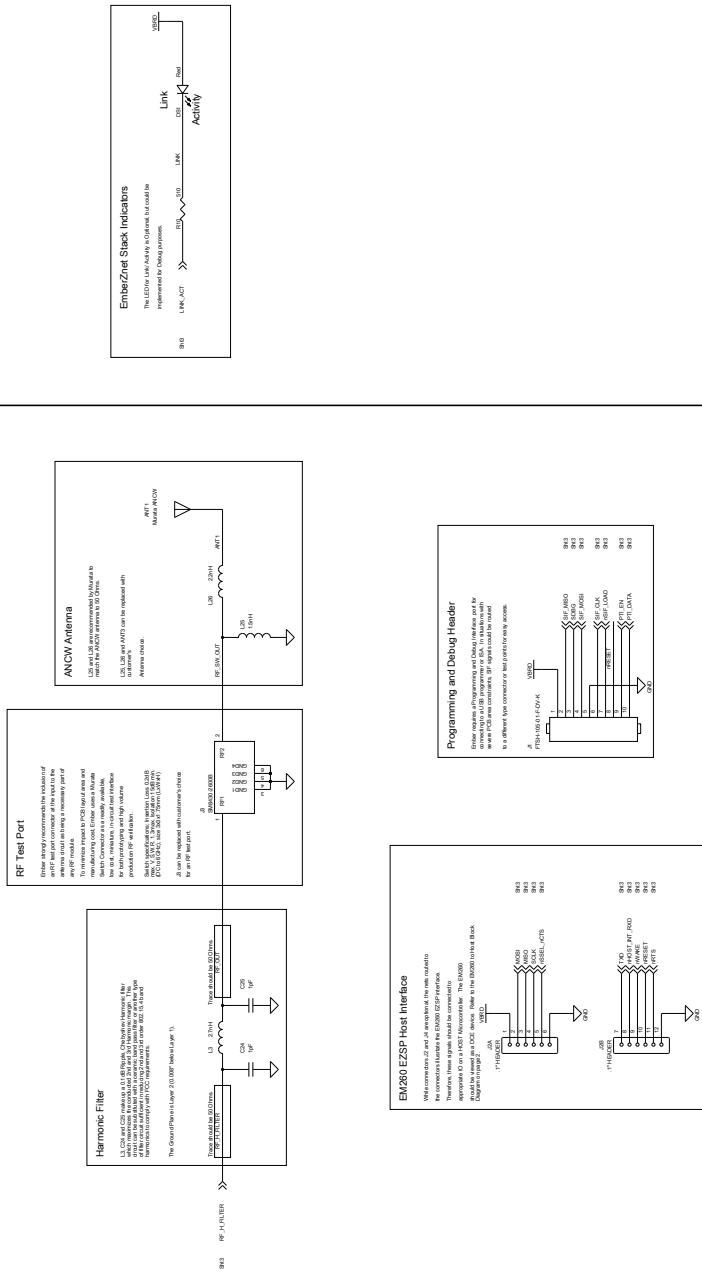


Figure 10. Schematic of the RCM - optional components (3 of 4)

## Revision History:

## --- Version A0 ---

\* Released: 03/05/2007

\* Initial Version released, Version A0

## --- Version A1 ---

\* Released: 07/26/2007

\* A1 Version contains the following changes from A0

1. Changed L2 from 1.8 nH to 0 Ohms
2. Changed L3 from 0 Ohms to 9pF
3. Changed R4 from 0 ohms to 2.7 Ohms
4. Updated the Test Connector and Antenna note regarding SW1, L2 and L3
5. Moved the Digital VDD Filter from the Optional Section (page 4) to the mandatory section (page 3)
6. Changed EM260 pin 3 label from RF\_IN to RF\_N
7. Changed net label from nSELL\_INT\_nCTS to nSELL\_nCTS

## --- Version B0 ---

\* Released: 01/09/2008

\* B0 Version contains the following changes from A1:

1. Removed C1, C2, C10, R1 and R9
2. Added Resistors to block diagram on page 2
3. Changed R6 from 0 ohm to 1 ohm
4. Added note in Ceramic Balun block regarding PCB layout of C8 decoupling capacitor
5. Moved Harmonic filter components, C3, C5 and L4 to the Optional Components page
6. Combined J2 and J4 into a single, 2 part schematic symbol
7. Updated note in Test Connector block regarding necessity of test connector
8. Changed L1 from 3.3nH to 2.7nH
9. Changed C4 from 8pF to 10nF
10. Changed L6 from 2.0nH to 2.2nH
11. Added note to 24MHz System Clock Generation circuit
12. Updated component reference designators from Master Reference Design Schematic. See Table 1;

Table 1. Reference Designator Changes From Rev. A1 to Rev. B0

Rev. A1	Rev. B0
ANT1	ANT1
BLN1	BLN1
C1	Removed
C2	Removed
C3	C24
C4	C17
C5	C25
C6	C11
C7	C2
C8	C3
C9	C6
C10	Removed
C11	C1
C12	C7
C13	C8
C14	C9
C15	C14
C16	C10
C17	C15
C18	C12
C19	C13
C20	C16
DS1	DS1
J1	J1
J2	J2A
J3	J3
J4	J2B
L1	L5
L2	L25
L3	L26
L4	L3
R1	Removed
R2	R7
R3	R8
R4	R9
R5	R1
R6	R5
R7	R10
R8	R3
R9	Removed
R10	R2
R11	R4
R12	R12
R13	R13
U1	U1
Y1	Y1

Figure 11. Schematic of the RCM - notes page (4 of 4)

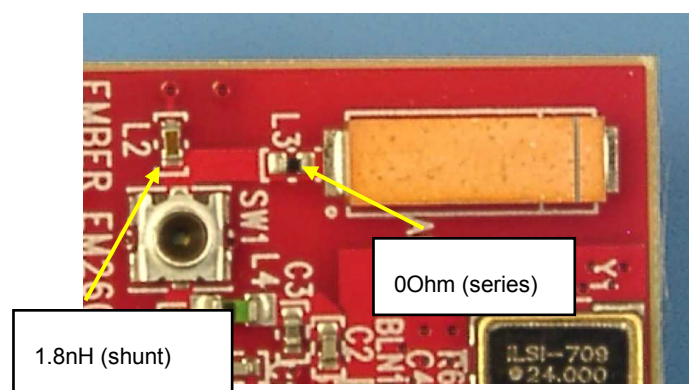
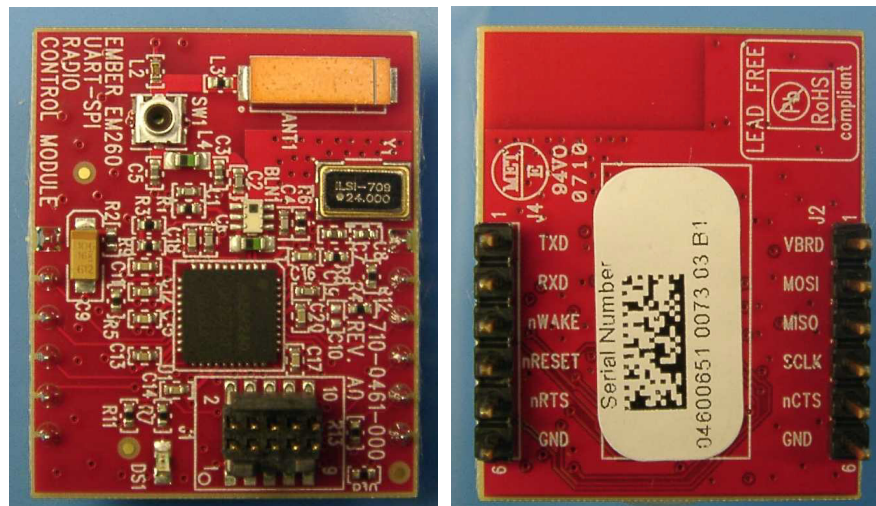
## Appendix: Murata Chip Dielectric Antenna Matching for EM260

In most wireless applications, a certain amount of antenna tuning is required to guarantee a 50-Ohm interface and allow for the maximum performance. Because Ember uses a Murata ceramic antenna on its RCM, Ember worked with Murata to provide the best tuning configuration for the RCM. (Note: This is a free service offered by Murata to its customers.) Once the tuning was completed, Murata provided a report of the work accomplished. An excerpt from that report is included in this appendix.

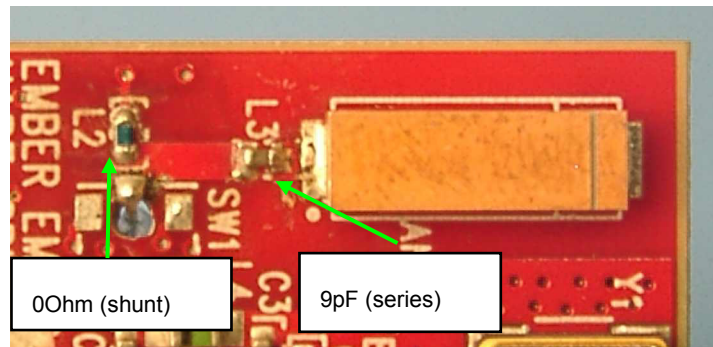
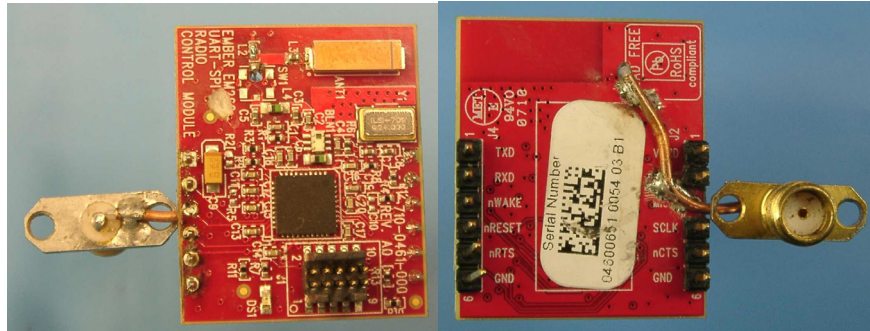
The following materials are the result of testing of revision A0 of the EM260 RCM. Please note that the component values determined here apply only to revision A0 of the EM260 RCM and that revision A1 and above will have different values.

### Measurement condition

Condition 1: Initial condition



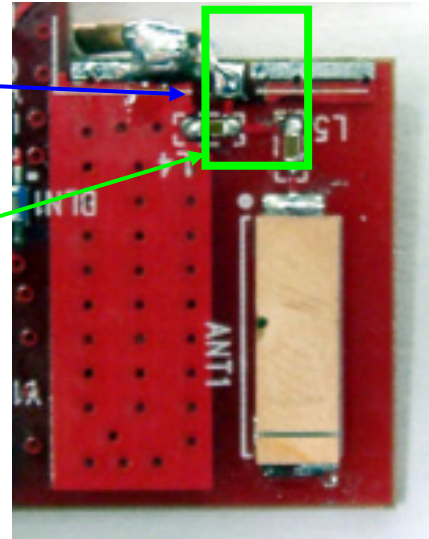
Condition 2: After matching optimization



Comparison with previous board

Shunt element is connected to the GND directly.

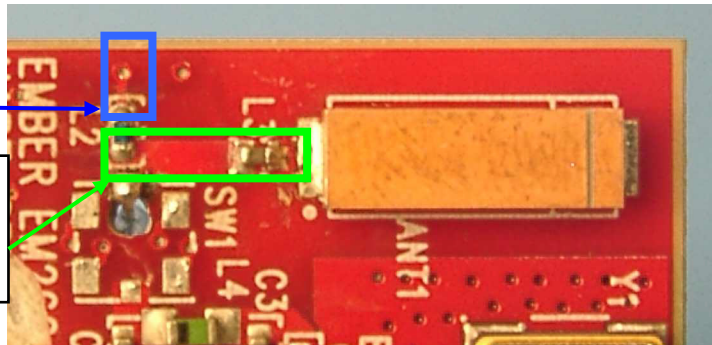
The length between antenna and a series element is relatively short.



Previous board (Report No.: REM06003)

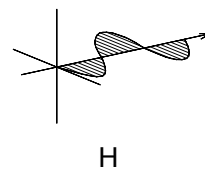
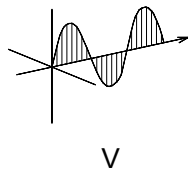
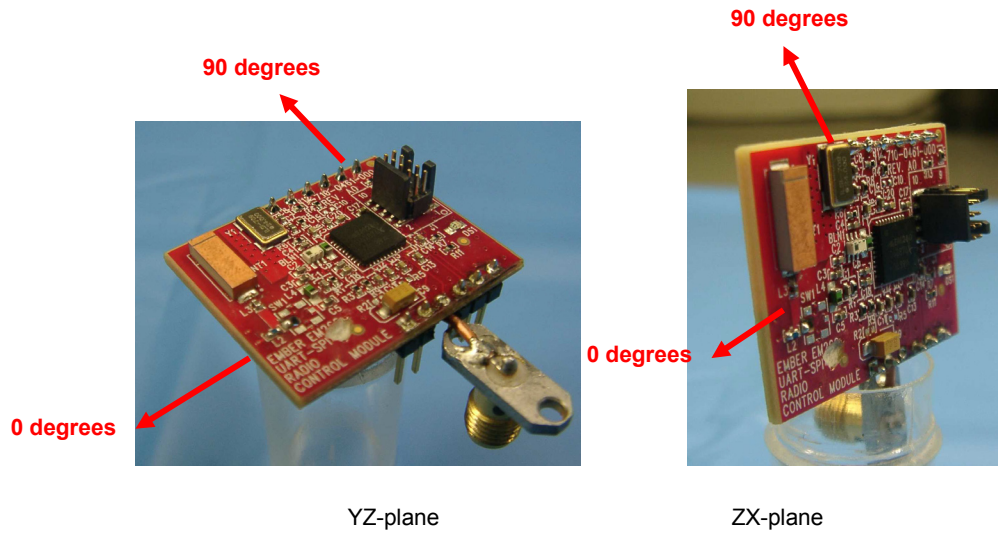
Some length strip line between a shunt element and via hole.

The length between antenna and a series element is longer than



Latest board

**Measurement direction**

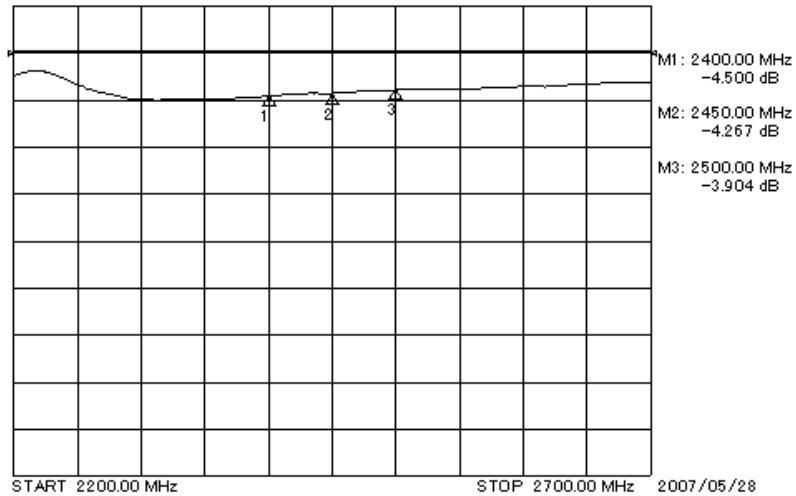


## Measurement result

### Return loss

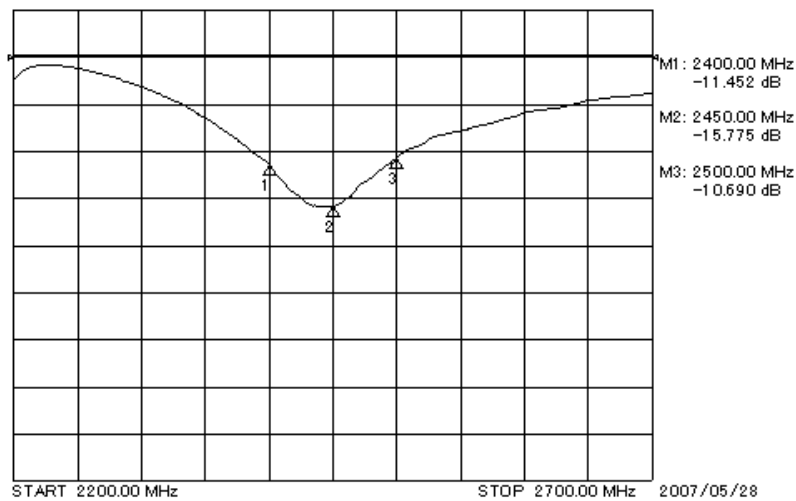
Condition 1: Initial condition

S11 logMAG 5dB/REF0dB



Condition 2: After matching optimization

S11 logMAG 5dB/REF0dB



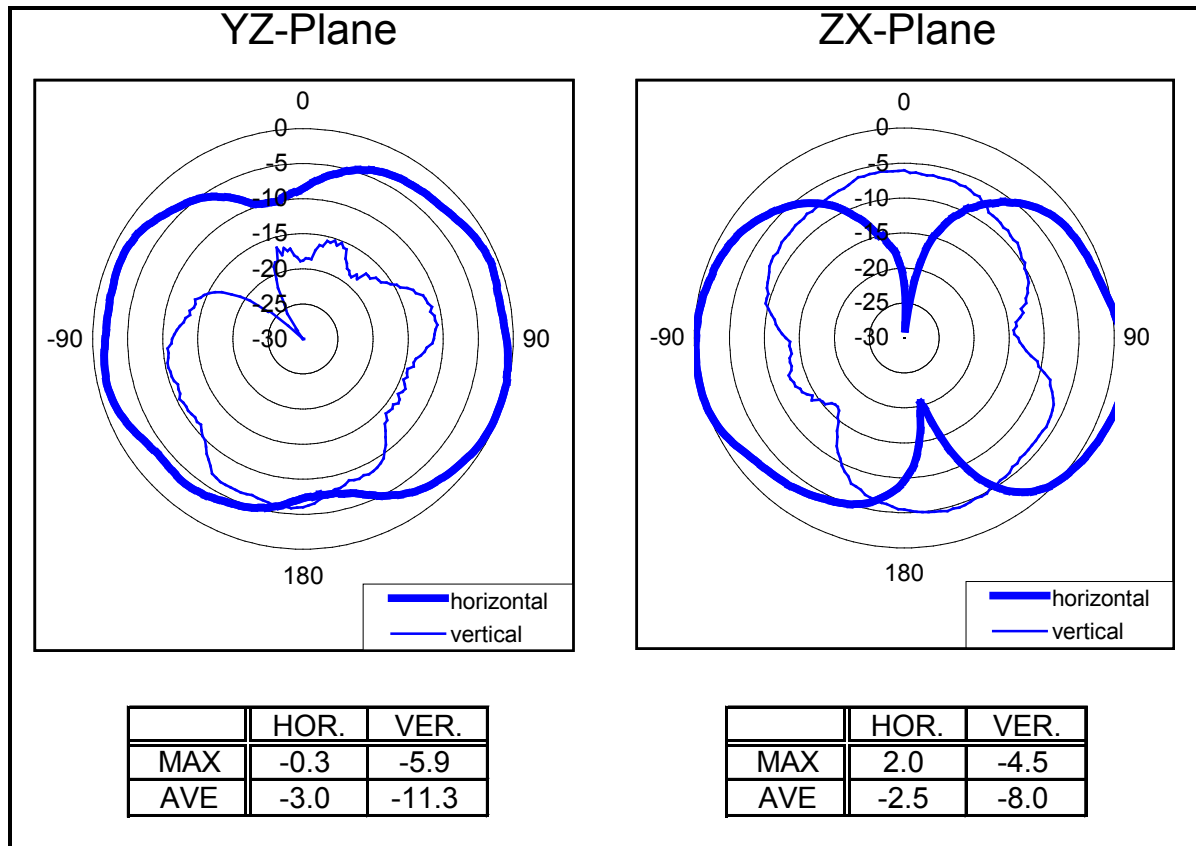
Antenna gain

Condition 2: After matching optimization

LINEAR POLARIZATION		YZ-Plane		ZX-Plane		Efficiency
		hor.	ver.	hor.	ver.	
2400 MHz	MAX	0.4	-6.4	2.8	-5.3	-0.6
	AVE	-2.8	-11.5	-2.1	-9.0	
2450 MHz	MAX	<b>-0.3</b>	<b>-5.9</b>	<b>2.0</b>	<b>-4.5</b>	<b>-0.8</b>
	AVE	<b>-3.0</b>	<b>-11.3</b>	<b>-2.5</b>	<b>-8.0</b>	
2500 MHz	MAX	-0.1	-6.5	2.0	-5.7	-1.2
	AVE	-3.6	-12.0	-2.8	-8.7	

Radiation Pattern

Condition 2: After matching optimization



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**After Reading This Document**

If you have questions or require assistance with the procedures described in this document, contact Ember Customer Support. The Ember Customer Support portal provides a wide array of hardware and software documentation such as FAQ's, reference designs, user guides, application notes, and the latest software available to download. To obtain support on all Ember products and to gain access to the Ember Customer Support portal, visit [http://www.ember.com/support\\_index.html](http://www.ember.com/support_index.html).

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