



# **MRF24J40MB**

## **Data Sheet**

2.4 GHz IEEE Std. 802.15.4™  
20 dBm RF Transceiver Module

---

**Note the following details of the code protection feature on Microchip devices:**

- Microchip products meet the specification contained in their particular Microchip Data Sheet.
- Microchip believes that its family of products is one of the most secure families of its kind on the market today, when used in the intended manner and under normal conditions.
- There are dishonest and possibly illegal methods used to breach the code protection feature. All of these methods, to our knowledge, require using the Microchip products in a manner outside the operating specifications contained in Microchip's Data Sheets. Most likely, the person doing so is engaged in theft of intellectual property.
- Microchip is willing to work with the customer who is concerned about the integrity of their code.
- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of their code. Code protection does not mean that we are guaranteeing the product as "unbreakable."

Code protection is constantly evolving. We at Microchip are committed to continuously improving the code protection features of our products. Attempts to break Microchip's code protection feature may be a violation of the Digital Millennium Copyright Act. If such acts allow unauthorized access to your software or other copyrighted work, you may have a right to sue for relief under that Act.

---

Information contained in this publication regarding device applications and the like is provided only for your convenience and may be superseded by updates. It is your responsibility to ensure that your application meets with your specifications. MICROCHIP MAKES NO REPRESENTATIONS OR WARRANTIES OF ANY KIND WHETHER EXPRESS OR IMPLIED, WRITTEN OR ORAL, STATUTORY OR OTHERWISE, RELATED TO THE INFORMATION, INCLUDING BUT NOT LIMITED TO ITS CONDITION, QUALITY, PERFORMANCE, MERCHANTABILITY OR FITNESS FOR PURPOSE. Microchip disclaims all liability arising from this information and its use. Use of Microchip devices in life support and/or safety applications is entirely at the buyer's risk, and the buyer agrees to defend, indemnify and hold harmless Microchip from any and all damages, claims, suits, or expenses resulting from such use. No licenses are conveyed, implicitly or otherwise, under any Microchip intellectual property rights.

**Trademarks**

The Microchip name and logo, the Microchip logo, dsPIC, KEELOQ, KEELOQ logo, MPLAB, PIC, PICmicro, PICSTART, rfPIC and UNI/O are registered trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

FilterLab, Hampshire, HI-TECH C, Linear Active Thermistor, MXDEV, MXLAB, SEEVAL and The Embedded Control Solutions Company are registered trademarks of Microchip Technology Incorporated in the U.S.A.

Analog-for-the-Digital Age, Application Maestro, CodeGuard, dsPICDEM, dsPICDEM.net, dsPICworks, dsSPEAK, ECAN, ECONOMONITOR, FanSense, HI-TIDE, In-Circuit Serial Programming, ICSP, Mindi, MiWi, MPASM, MPLAB Certified logo, MPLIB, MPLINK, mTouch, Octopus, Omniscient Code Generation, PICC, PICC-18, PICDEM, PICDEM.net, PICKit, PICtail, PIC<sup>32</sup> logo, REAL ICE, rLAB, Select Mode, Total Endurance, TSHARC, UniWinDriver, WiperLock and ZENA are trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

SQTP is a service mark of Microchip Technology Incorporated in the U.S.A.

All other trademarks mentioned herein are property of their respective companies.

© 2009, Microchip Technology Incorporated, Printed in the U.S.A., All Rights Reserved.

 Printed on recycled paper.

**QUALITY MANAGEMENT SYSTEM**  
**CERTIFIED BY DNV**  
**== ISO/TS 16949:2002 ==**

*Microchip received ISO/TS-16949:2002 certification for its worldwide headquarters, design and wafer fabrication facilities in Chandler and Tempe, Arizona; Gresham, Oregon and design centers in California and India. The Company's quality system processes and procedures are for its PIC<sup>®</sup> MCUs and dsPIC<sup>®</sup> DSCs, KEELOQ<sup>®</sup> code hopping devices, Serial EEPROMs, microperipherals, nonvolatile memory and analog products. In addition, Microchip's quality system for the design and manufacture of development systems is ISO 9001:2000 certified.*

## 2.4 GHz IEEE Std. 802.15.4™ 20 dBm RF Transceiver Module

### Features:

- IEEE Std. 802.15.4™ Compliant RF Transceiver
- Supports ZigBee®, MiWi™, MiWi P2P and Proprietary Wireless Networking Protocols
- Small Size: 0.9" x 1.3" (22.9 mm x 33.0 mm), Surface Mountable
- Integrated Crystal, Internal Voltage Regulator, Matching Circuitry, Power Amplifier, Low Noise Amplifier and PCB Antenna
- Easy Integration into Final Product – Minimize Product Development, Quicker Time to Market
- Radio Regulation Certified for United States (FCC), Canada (IC) and Europe (ETSI)
- Compatible with Microchip Microcontroller Families (PIC16F, PIC18F, PIC24F/H, dsPIC33 and PIC32)
- Up to 4000 ft. Range

### Operational:

- Operating Voltage: 2.4-3.6V (3.3V typical)
- Temperature Range: -40°C to +85°C Industrial
- Simple, Four-Wire SPI Interface
- Low-Current Consumption:
  - RX mode: 25 mA (typical)
  - TX mode: 130 mA (typical)
  - Sleep: 5 μA (typical)

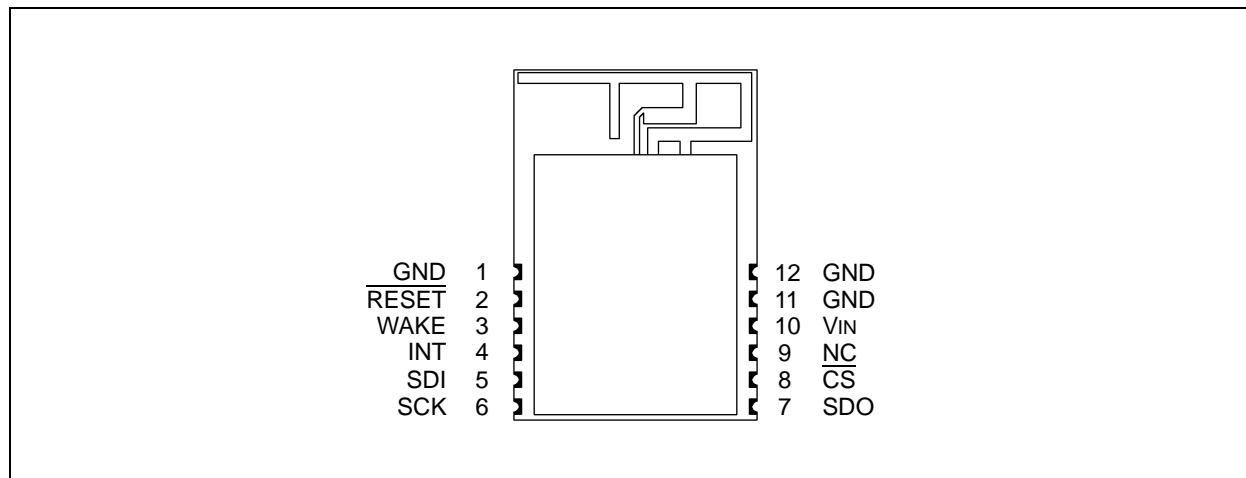
### RF/Analog Features:

- ISM Band 2.405-2.475 GHz Operation
- Data Rate: 250 kbps
- -102 dBm Typical Sensitivity with -23 dBm Maximum Input Level
- +20 dBm Typical Output Power with 56 dB TX Power Control Range
- Integrated Low Phase Noise VCO, Frequency Synthesizer and PLL Loop Filter
- Digital VCO and Filter Calibration
- Integrated RSSI ADC and I/Q DACs
- Integrated LDO
- High Receiver and RSSI Dynamic Range

### MAC/Baseband Features:

- Hardware CSMA-CA Mechanism, Automatic ACK Response and FCS Check
- Independent Beacon, Transmit and GTS FIFO
- Supports all CCA modes and RSS/LQI
- Automatic Packet Retransmit Capable
- Hardware Security Engine (AES-128) with CTR, CCM and CBC-MAC modes
- Supports Encryption and Decryption for MAC Sublayer and Upper Layer

**FIGURE 1: PIN DIAGRAM**



# MRF24J40MB

---

## Table of Contents

1.0 Device Overview .....	3
2.0 Circuit Description .....	9
3.0 Regulatory Approval.....	19
4.0 Electrical Characteristics .....	23
Appendix A: Revision History.....	25
Index .....	27
The Microchip Web Site.....	29
Customer Change Notification Service .....	29
Customer Support .....	29
Reader Response .....	30
Product Identification System.....	31

## TO OUR VALUED CUSTOMERS

It is our intention to provide our valued customers with the best documentation possible to ensure successful use of your Microchip products. To this end, we will continue to improve our publications to better suit your needs. Our publications will be refined and enhanced as new volumes and updates are introduced.

If you have any questions or comments regarding this publication, please contact the Marketing Communications Department via E-mail at [docerrors@microchip.com](mailto:docerrors@microchip.com) or fax the **Reader Response Form** in the back of this data sheet to (480) 792-4150. We welcome your feedback.

### Most Current Data Sheet

To obtain the most up-to-date version of this data sheet, please register at our Worldwide Web site at:

<http://www.microchip.com>

You can determine the version of a data sheet by examining its literature number found on the bottom outside corner of any page. The last character of the literature number is the version number, (e.g., DS30000A is version A of document DS30000).

### Errata

An errata sheet, describing minor operational differences from the data sheet and recommended workarounds, may exist for current devices. As device/documentation issues become known to us, we will publish an errata sheet. The errata will specify the revision of silicon and revision of document to which it applies.

To determine if an errata sheet exists for a particular device, please check with one of the following:

- Microchip's Worldwide Web site; <http://www.microchip.com>
- Your local Microchip sales office (see last page)

When contacting a sales office, please specify which device, revision of silicon and data sheet (include literature number) you are using.

### Customer Notification System

Register on our web site at [www.microchip.com](http://www.microchip.com) to receive the most current information on all of our products.

## 1.0 DEVICE OVERVIEW

The MRF24J40MB is a 2.4 GHz IEEE Std. 802.15.4™ compliant, surface mount module with integrated crystal, internal voltage regulator, matching circuitry, Power Amplifier, Low Noise Amplifier and PCB antenna. The MRF24J40MB module operates in the non-licensed 2.4 GHz frequency band. The integrated module design frees the integrator from extensive RF and antenna design, and regulatory compliance testing, allowing quicker time to market.

The MRF24J40MB module is compatible with Microchip's ZigBee®, MiWi™ and MiWi P2P software stacks. Each software stack is available as a free download, including source code, from the Microchip web site: <http://www.microchip.com/wireless>.

The MRF24J40MB module has received regulatory approvals for modular devices in the United States (FCC), Canada (IC) and Europe (ETSI). Modular approval removes the need for expensive RF and antenna design, and allows the end user to place the MRF24J40MB module inside a finished product and not require regulatory testing for an intentional radiator (RF transmitter).

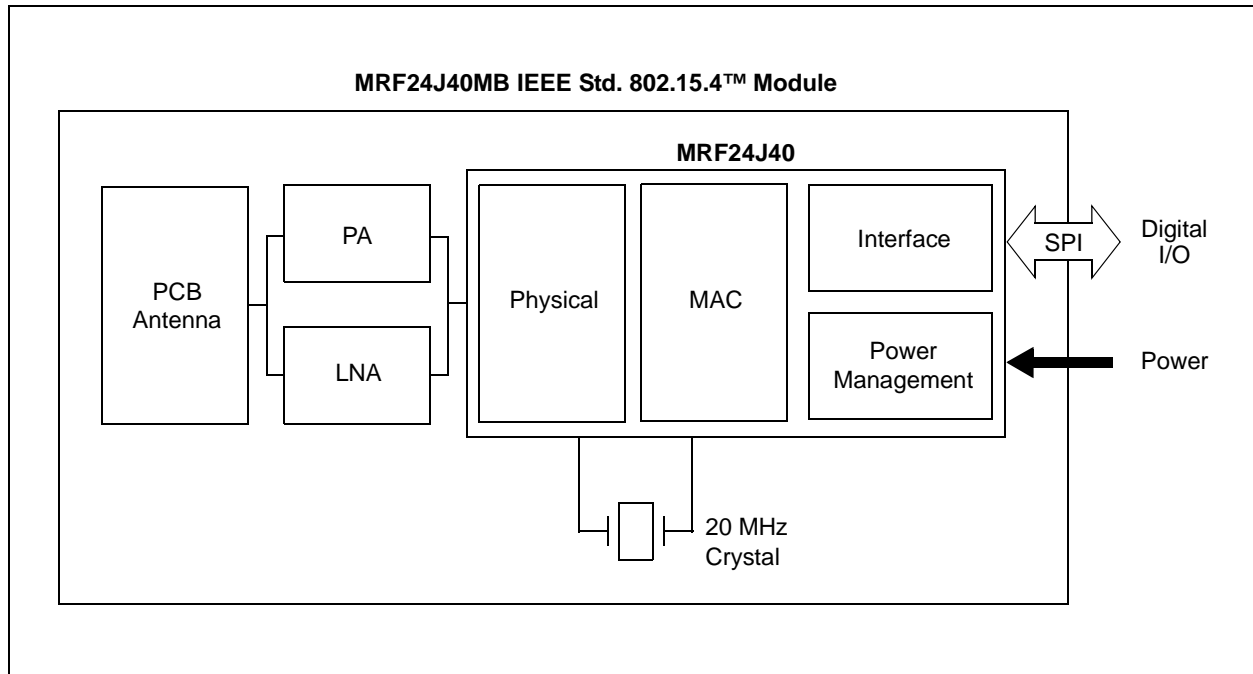
**Note:** See Section 3.0 "Regulatory Approval" for specific requirements to be followed by the integrator.

## 1.1 Interface Description

Figure 1-1 shows a simplified block diagram of the MRF24J40MB module. The module is based on the Microchip Technology MRF24J40 IEEE 802.15.4™ 2.4 GHz RF Transceiver IC. The module interfaces to many popular Microchip PIC® microcontrollers via a 4-wire serial SPI interface, interrupt, wake, Reset, power and ground, as shown in Figure 1-2. Table 1-1 provides the pin descriptions.

Data communications with the MRF24J40MB module are documented in the "MRF24J40 IEEE 802.15.4™ 2.4 GHz RF Transceiver Data Sheet" (DS39776). Refer to the MRF24J40 Data Sheet for specific serial interface protocol and register definitions.

**FIGURE 1-1: MRF24J40MB BLOCK DIAGRAM**



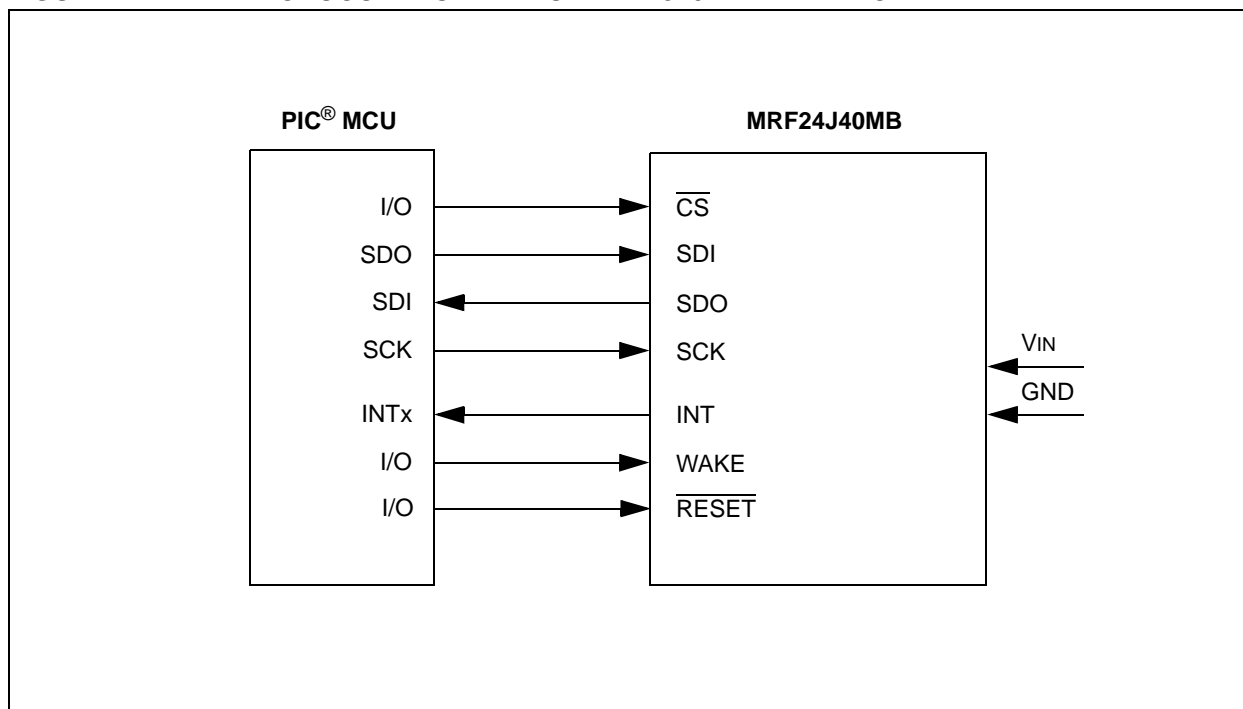
# MRF24J40MB

**TABLE 1-1: PIN DESCRIPTION**

Pin	Symbol	Type	Description
1	GND	Power	Ground
2	$\overline{\text{RESET}}$	DI	Global hardware Reset pin
3	WAKE	DI	External wake-up trigger
4	INT	DO	Interrupt pin to microcontroller
5	SDI	DI	Serial interface data input
6	SCK	DI	Serial interface clock
7	SDO	DO	Serial interface data output from MRF24J40
8	$\overline{\text{CS}}$	DI	Serial interface enable
9	NC	—	No connection
10	VIN	Power	Power supply
11	GND	Ground	Ground
12	GND	Ground	Ground

**Legend:** Pin type abbreviation: D = Digital, I = Input, O = Output

**FIGURE 1-2: MICROCONTROLLER TO MRF24J40MB INTERFACE**

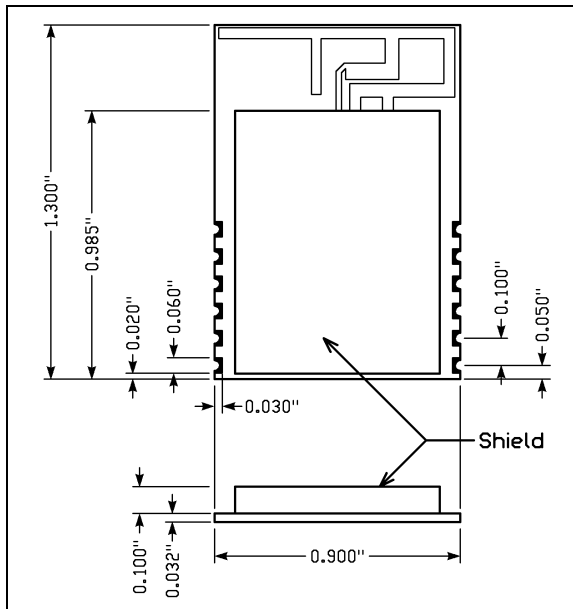


## 1.2 Mounting Details

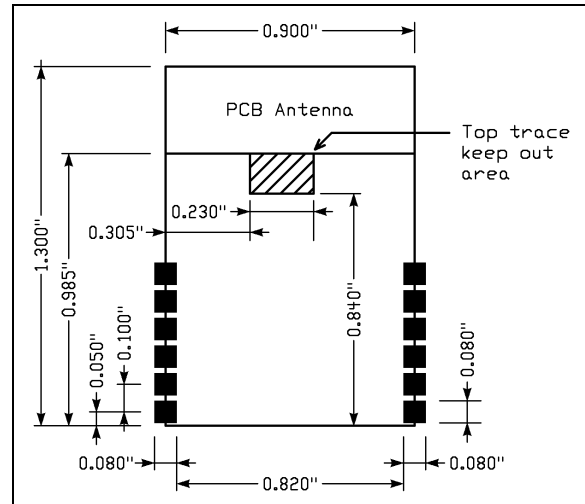
The MRF24J40MB is a surface mountable module. Module dimensions are shown in Figure 1-3. The module Printed Circuit Board (PCB) is 0.032" thick with castellated mounting points on the edge. Figure 1-4 is a recommended host PCB footprint for the MRF24J40MB.

The MRF24J40MB has an integrated PCB antenna. For the best performance, follow the mounting details shown in Figure 1-5. It is recommended that the module be mounted on the edge of the host PCB, and an area around the antenna, approximately 1.2", be kept clear of metal objects. A host PCB ground plane around the MRF24J40MB acts as a counterpoise to the PCB antenna. It is recommended to extend the ground plane at least 0.4" around the module.

**FIGURE 1-3: MODULE DETAILS**

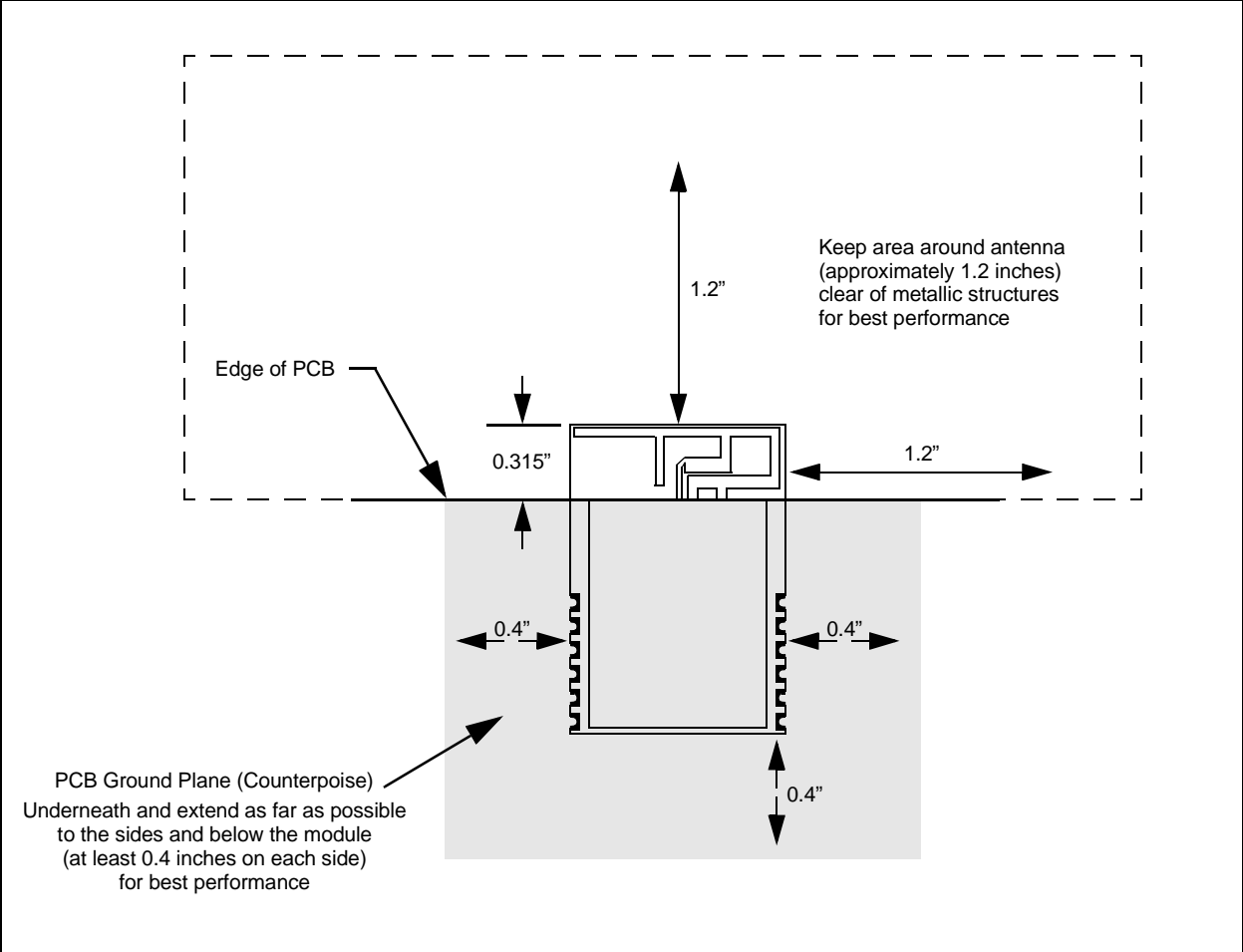


**FIGURE 1-4: RECOMMENDED PCB FOOTPRINT**



# MRF24J40MB

FIGURE 1-5: MOUNTING DETAILS





## 1.3 Operation

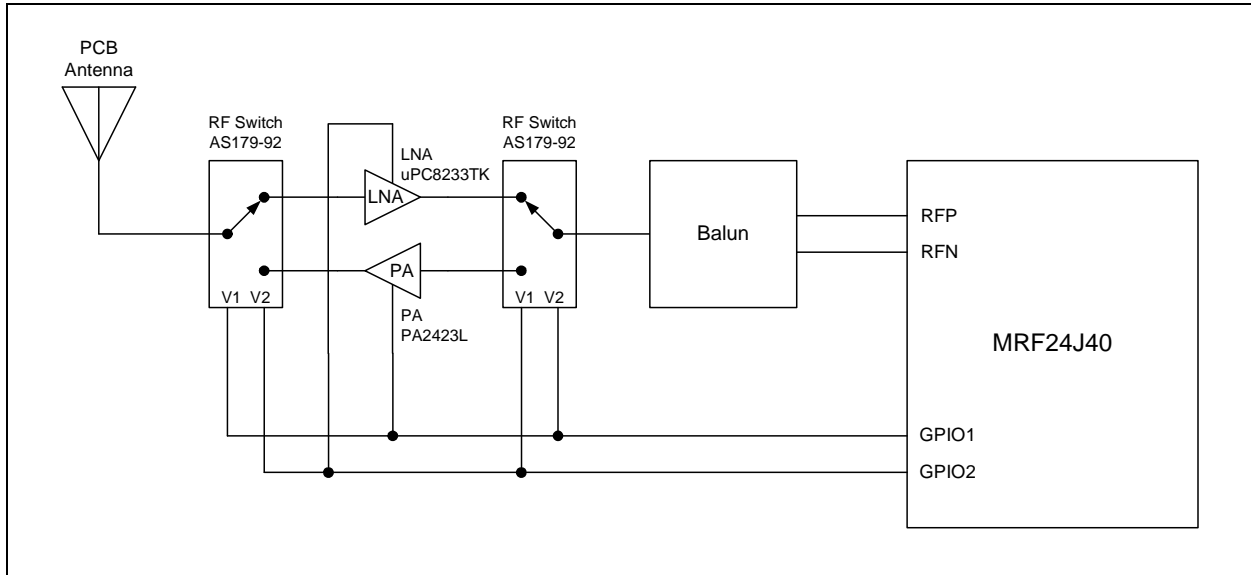
### 1.3.1 PA/LNA CONTROL

Operation of the Power Amplifier (PA) IC3 and Low Noise Amplifier (LNA) IC5 is controlled by the MRF24J40 internal RF state machine via RF switches, IC2 and IC4, and the GPIO1 and GPIO2 pins on the MRF24J40. Figure 1-6 shows the PA/LNA block diagram. Figure 2-1 is the schematic diagram for the module.

The internal RF state machine is configured for the PA/LNA mode by setting TESTMODE (0x22F<2:0>) = 111. Pins, GPIO1 and GPIO2, then control the RF switches, PA and LNA automatically when the MRF24J40 receives and transmits data.

**Note:** A complete explanation of the operation of the PA/LNA control is documented in the “MRF24J40 Data Sheet” (DS39776), Section 4.2 “External PA/LNA Control”.

**FIGURE 1-6: PA/LNA BLOCK DIAGRAM**



### 1.3.2 ENERGY DETECTION (ED)

Before performing an energy detection (see Section 3.6.1 “RSSI Firmware Request (RSSI Mode 1)” in the “MRF24J40 Data Sheet” (DS39776)), perform the following steps:

1. Configure the internal RF state machine to normal operation (TESTMODE (0x22F<2:0>) = 000).
2. Configure GPIO2 and GPIO1 direction for the output (TRISGP2 (0x34<2>) = 1 and TRISGP1 (0x34<1>) = 1).
3. Set GPIO2 (0x33<2>) = 1 and GPIO1 (0x32<1>) = 0. This enables the LNA and disables the PA.
4. Perform the energy detection following the steps in Section 3.6.1 “RSSI Firmware Request (RSSI Mode 1)” in the “MRF24J40 Data Sheet” (DS39776).

**Note:** The LNA will amplify the received signal. The RSSI value will include the receive signal strength plus the LNA amplification.

### 1.3.3 SLEEP

To get the lowest power consumption from the MRF24J40MB module during Sleep, it is necessary to disable both the PA and LNA. To do this, perform the following steps:

1. Configure the internal RF state machine to normal operation (TESTMODE (0x22F<2:0>) = 000).
2. Configure the GPIO2 and GPIO1 direction for output (TRISGP2 (0x34<2>) = 1 and TRISGP1 (0x34<1>) = 1).
3. Set GPIO2 (0x33<2>) = 0 and GPIO1 (0x32<1>) = 0. This disables the LNA and the PA.
4. Put the MRF24J40 to Sleep following the steps in the “MRF24J40 Data Sheet” (DS39776).

When waking the module, re-enable the PA/LNA mode.

# MRF24J40MB

---

NOTES:

## 2.0 CIRCUIT DESCRIPTION

The MRF24J40MB is a complete 2.4 GHz IEEE Std. 802.15.4™ compliant surface mount module with integrated crystal, internal voltage regulator, matching circuitry, Power Amplifier, Low Noise Amplifier and PCB antenna. The MRF24J40MB module interfaces to many popular Microchip PIC microcontrollers via a 4-wire serial SPI interface, interrupt, wake, Reset, power and ground. Data communications with the MRF24J40MB module are documented in the "*MRF24J40 IEEE 802.15.4™ 2.4 GHz RF Transceiver Data Sheet*" (DS39776). Refer to the MRF24J40 Data Sheet for specific serial interface protocol and register definitions.

## 2.1 Schematic

A schematic diagram of the module is shown in Figure 2-1 and the Bill of Materials (BOM) is shown in Table 2-1.

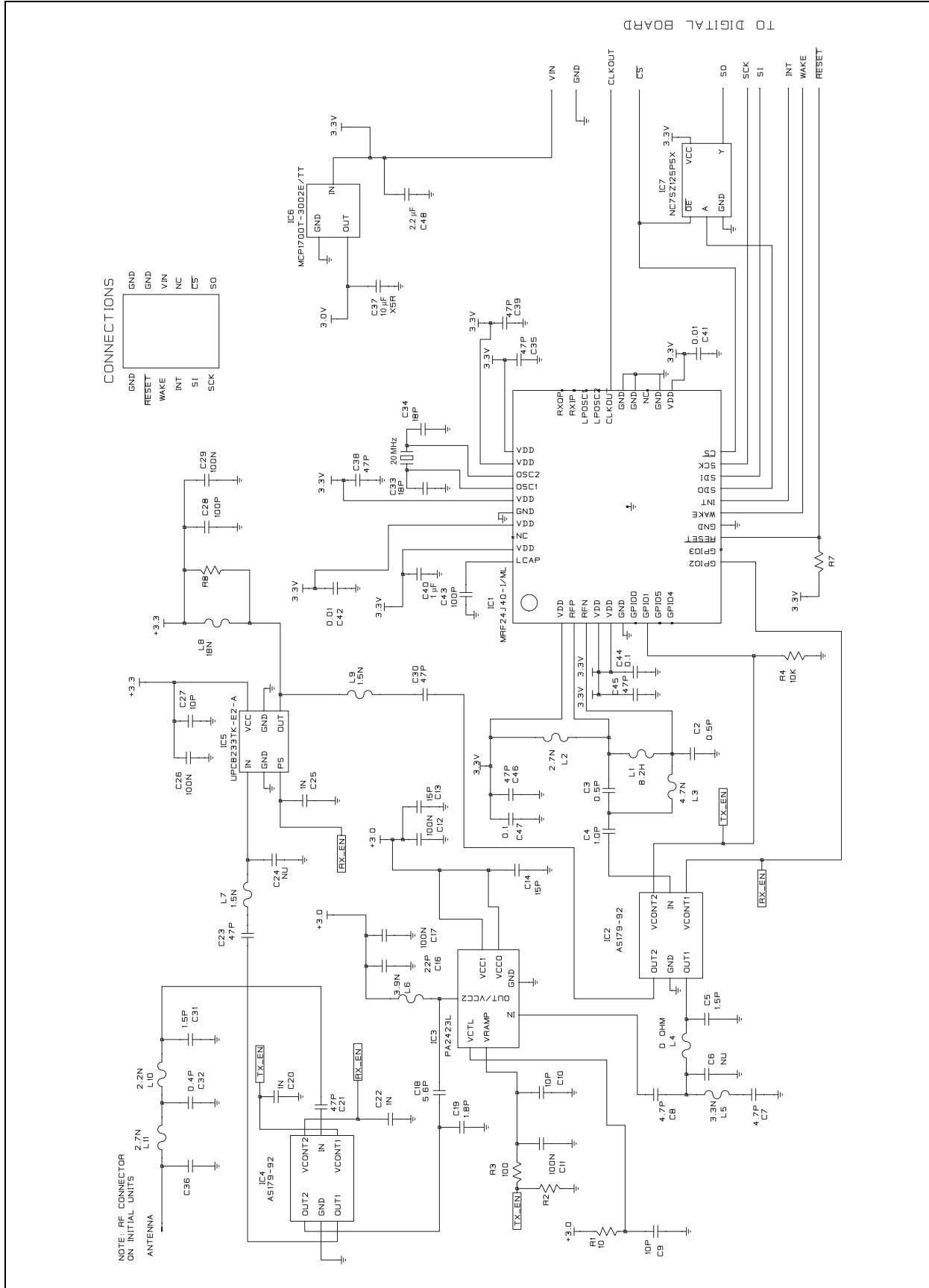
The MRF24J40MB module is based on the Microchip Technology MRF24J40 IEEE 802.15.4™ 2.4 GHz RF Transceiver IC (U1). The serial I/O (SCK, SDI, SDO and CS), RESET, WAKE and INT pins are brought out to the module pins. The SDO signal is tri-state buffered by IC7 to solve a silicon errata, where the SDO signal does not release to a high-impedance state, after the CS pin returns to its inactive state.

Crystal, X1, is a 20 MHz crystal with a frequency tolerance of  $\pm 10$  ppm @ 25°C to meet the IEEE Std. 802.15.4 symbol rate tolerance of  $\pm 40$  ppm.

A balun is formed by components: L1, L2, L3, C2, C3 and C4. L2 is also a pull-up for the RFP and RFN pins on the MRF24J40. C4 also acts as a DC block capacitor. RF switches, IC2 and IC4, switch between the power amplifier, IC3, when transmitting and low noise amplifier, IC5, when receiving. A low-pass filter is formed by components: L10, L11, C31, C32 and C36. The remaining passive components provide bias and decoupling.

# MRF24J40MB

FIGURE 2-1: MRF24J40MB SCHEMATIC



**TABLE 2-1: MRF24J40MB BILL OF MATERIALS**

Designator	Description	Manufacturer	Part Number
C2	Chip Capacitor 0402 COG 0.5P	Johanson Technology	500R07S0R5AV4T
C3	Chip Capacitor 0402 COG 0.5P	Johanson Technology	500R07S0R5AV4T
C4	Chip Capacitor 0402 COG 1.0P	Johanson Technology	500R07S1R0BV4T
C5	Chip Capacitor 0402 COG 1.5P	Murata	GRM1555C1H1R5CZ01D
C6	Not Used		
C7	Chip Capacitor 0402 COG 4.7P	Murata	GRM1555C1H4R7CZ01D
C8	Chip Capacitor 0402 COG 4.7P	Murata	GRM1555C1H4R7CZ01D
C9	Chip Capacitor 0402 COG 10P	Murata	GRM1555C1H100JZ01D
C10	Chip Capacitor 0402 COG 10P	Murata	GRM1555C1H100JZ01D
C11	Chip Capacitor 0402 X5R 100N	Murata	GRM155R61A104KA01D
C12	Chip Capacitor 0402 X5R 100N	Murata	GRM155R61A104KA01D
C13	Chip Capacitor 0402 COG 15P	Murata	GRM1555C1H150JZ01D
C14	Chip Capacitor 0402 COG 15P	Murata	GRM1555C1H150JZ01D
C16	Chip Capacitor 0402 COG 22P	Murata	GRM1555C1H220JZ01D
C17	Chip Capacitor 0402 X5R 100N	Murata	GRM155R61A104KA01D
C18	Chip Capacitor 0402 COG 5.6P	Murata	GRM1555C1H5R6CZ01D
C19	Chip Capacitor 0402 COG 1.8P	Murata	GRM1555C1H1R8CZ01D
C20	Chip Capacitor 0402 X7R 1N	Murata	GRM155R71H102KA01D
C21	Chip Capacitor 0402 COG 47P	Murata	GRM1555C1H470JZ01D
C22	Chip Capacitor 0402 X7R 1N	Murata	GRM155R71H102KA01D
C23	Chip Capacitor 0402 COG 47P	Murata	GRM1555C1H470JZ01D
C24	Not Used		
C25	Chip Capacitor 0402 X7R 1N	Murata	GRM155R71H102KA01D
C26	Chip Capacitor 0402 X5R 100N	Murata	GRM155R61A104KA01D
C27	Chip Capacitor 0402 COG 10P	Murata	GRM1555C1H100JZ01D
C28	Chip Capacitor 0402 COG 100P	Murata	GRM1555C1H101JZ01D
C29	Chip Capacitor 0402 X5R 100N	Murata	GRM155R61A104KA01D
C30	Chip Capacitor 0402 COG 47P	Murata	GRM1555C1H470JZ01D
C31	Chip Capacitor 0402 COG 1.5P	Johanson Technology	500R07S1R5BV4T
C32	Chip Capacitor 0402 COG 0.4P	Johanson Technology	500R07S0R4AV4T
C33	Chip Capacitor 0402 COG 18P	Murata	GRM1555C1H180JZ01D
C34	Chip Capacitor 0402 COG 18P	Murata	GRM1555C1H180JZ01D
C35	Chip Capacitor 0402 COG 47P	Murata	GRM1555C1H470JZ01D
C36	Not Used		
C37	Chip Capacitor 0805 X5R 10U	Murata	GRM21BR60J106ME19L
C38	Chip Capacitor 0402 COG 47P	Murata	GRM1555C1H470JZ01D
C39	Chip Capacitor 0402 COG 47P	Murata	GRM1555C1H470JZ01D
C40	Chip Capacitor 0402 X5R 1U	Murata	GRM155R60J105ME19D
C41	Chip Capacitor 0402 X7R 10N	Murata	GRM155R71E103KA01D
C42	Chip Capacitor 0402 X7R 10N	Murata	GRM155R71E103KA01D
C43	Chip Capacitor 0402 COG 100P	Murata	GRM1555C1H101JZ01D
C44	Chip Capacitor 0402 X5R 100N	Murata	GRM155R61A104KA01D
C45	Chip Capacitor 0402 COG 47P	Murata	GRM1555C1H470JZ01D

**Note:** Capacitors and inductors cannot be substituted.

# MRF24J40MB

TABLE 2-1: MRF24J40MB BILL OF MATERIALS (CONTINUED)

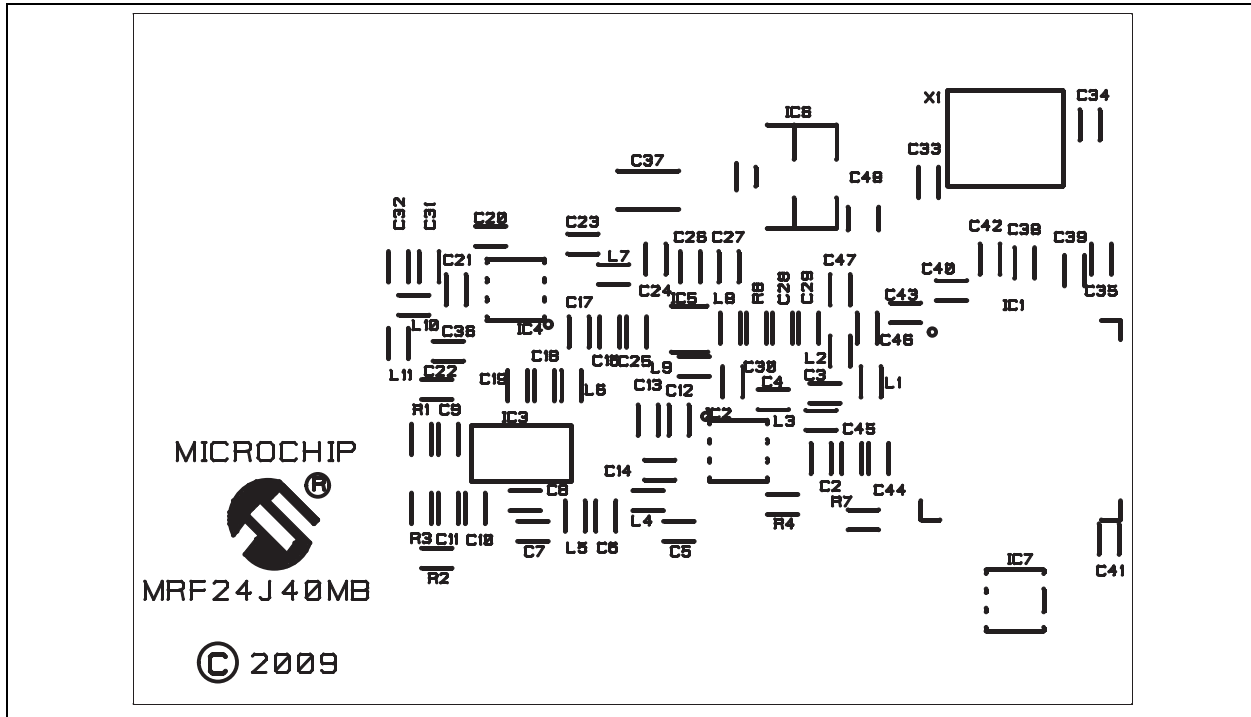
Designator	Description	Manufacturer	Part Number
C46	Chip Capacitor 0402 X5R 100N	Murata	GRM155R61A104KA01D
C47	Chip Capacitor 0402 COG 47P	Murata	GRM1555C1H470JZ01D
C48	Chip Capacitor 0603 X5R 2.2U	Murata	GRM188R60J225ME01D
IC1	802.15.4 Radio	Microchip	MRF24J40-I/ML
IC2	Switch SPDT	Skyworks	AS179-92
IC3	Power Amplifier	SiGe	PA2423L-R
IC4	Switch SPDT	Skyworks	AS179-92
IC5	Low Noise Amplifier	NEC	UPC8233TK-E2-A
IC6	Voltage Regulator	Microchip	MCP1700T-3302E/TT
IC7	Buffer-SC70 Package	Fairchild	NC7SZ125P5X
L1	Chip Inductor 0402 8.2N	Panasonic	ELJ-RF8N2JFB
L2	Chip Inductor 0402 2.7N	Panasonic	ELJ-RF2N7DFB
L3	Chip Inductor 0402 4.7N	Panasonic	ELJ-RF4N7DFB
L4	Chip Resistor 0402 00hms	Dale	CRCW04020000Z0ED
L5	Chip Inductor 0402 3.3N	Panasonic	ELJ-RF3N3DFB
L6	Chip Inductor 0402 3.9N	Panasonic	ELJ-RF3N9DFB
L7	Chip Inductor 0402 1.5N	Panasonic	ELJ-RF1N5DFB
L8	Chip Inductor 0402 18N	Panasonic	ELJ-RF18NJFB
L9	Chip Inductor 0402 1.5N	Panasonic	ELJ-RF1N5DFB
L10	Chip Inductor 0402 2.2N	Panasonic	ELJ-RF2N2DFB
L11	Chip Inductor 0402 2.7N	Panasonic	ELJ-RF2N7DFB
R1	Chip Resistor 0402 10Ohms 5%	Dale	CRCW040210R0JNED
R2	Not Used		
R3	Chip Resistor 0402 2.2Ohms 5%	Dale	CRCW04022R20JNED
R4	Chip Resistor 0402 10K 5%	Dale	CRCW040210K0JNED
R7	Not Used		
R8	Not Used		
S	Shield-Custom	TBD	
X1	20 MHz Crystal	Abracon	ABM8-156-20.0000MHZ-T

**Note:** Capacitors and inductors cannot be substituted.

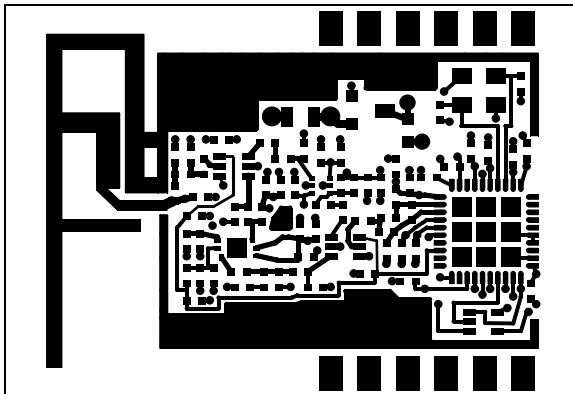
## 2.2 Printed Circuit Board

The MRF24J40MB module printed circuit board is constructed with FR4 material, four layers and 0.032 inches thick. The layers are shown in Figure 2-2 through Figure 2-6. The stack up of the PCB is shown in Figure 2-7.

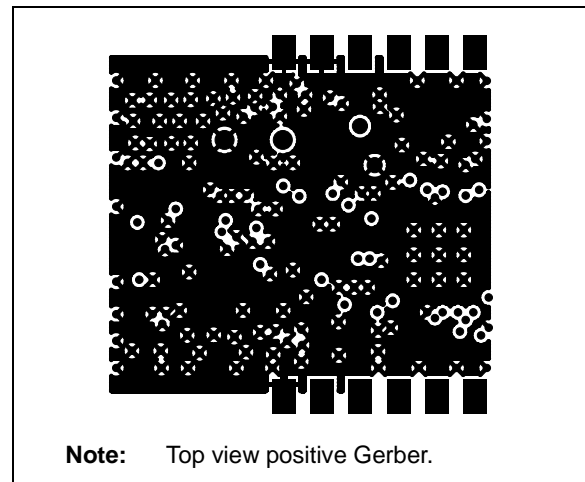
**FIGURE 2-2: TOP SILK SCREEN**



**FIGURE 2-3: TOP COPPER**

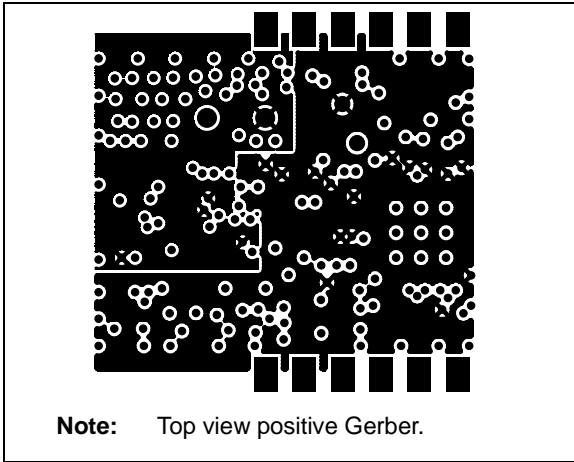


**FIGURE 2-4: LAYER 2 – GROUND PLANE**

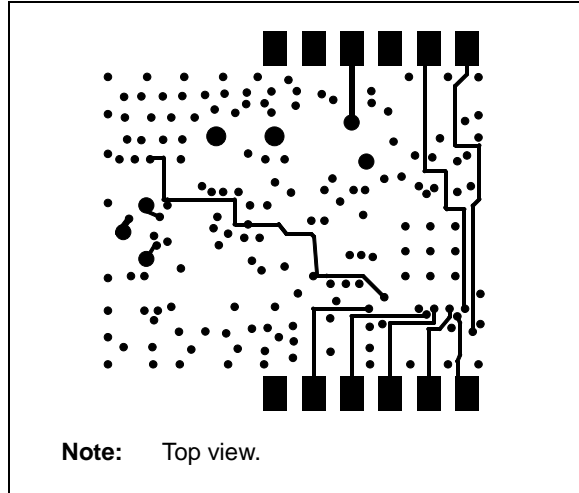


# MRF24J40MB

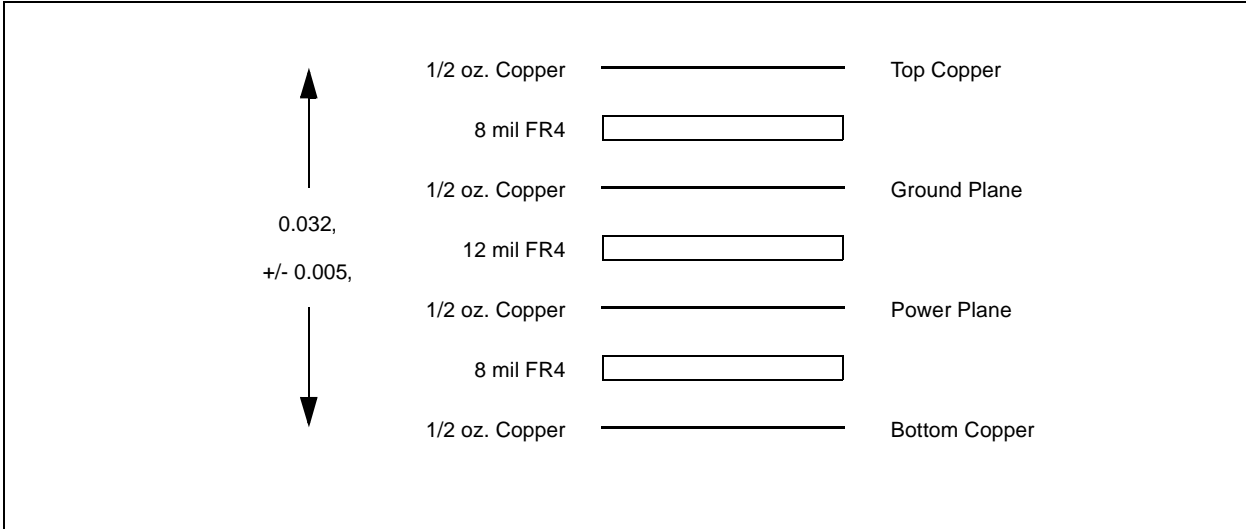
**FIGURE 2-5: LAYER 3 – POWER PLANE**



**FIGURE 2-6: BOTTOM COPPER**



**FIGURE 2-7: PCB LAYER STACK UP**





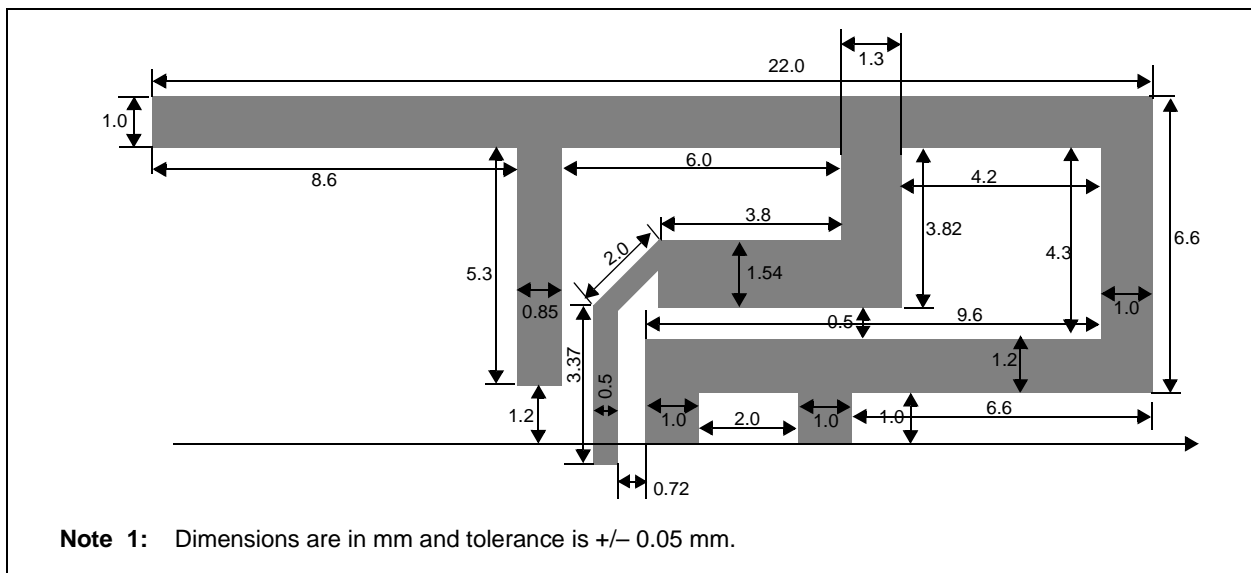
## 2.3 PCB Antenna

The PCB antenna is fabricated on the top copper trace. Figure 2-8 shows the trace dimensions. The layers below the antenna have no copper traces. The ground and power planes under the components serve as a counterpoise to the PCB antenna. Additional ground plane on the host PCB will substantially enhance the performance of the module. For best performance, place the module on the host PCB following the recommendations in **Section 1.2 “Mounting Details”**.

The Printed Circuit Board (PCB) antenna was designed and simulated using Ansoft Designer<sup>®</sup> and HFSS<sup>™</sup> 3D full-wave solver software by Ansoft Corporation

(www.ansoft.com) and tested in an anechoic room. The design goal was to create a compact, low-cost antenna with the best radiation pattern. Figure 2-9 shows the simulation drawing and Figure 2-10 and Figure 2-11 show the 2D and 3D radiation patterns, respectively. As shown by the radiation patterns, the performance of the antenna is dependant upon the orientation of the module. Figure 2-12 shows the impedance simulation and Figure 2-13 shows the SWR simulation. The discrete matching circuitry matches the impedance of the antenna with the MRF24J40 transceiver IC.

**FIGURE 2-8: PCB ANTENNA DIMENSIONS**



# MRF24J40MB

FIGURE 2-9: PCB ANTENNA SIMULATION DRAWING

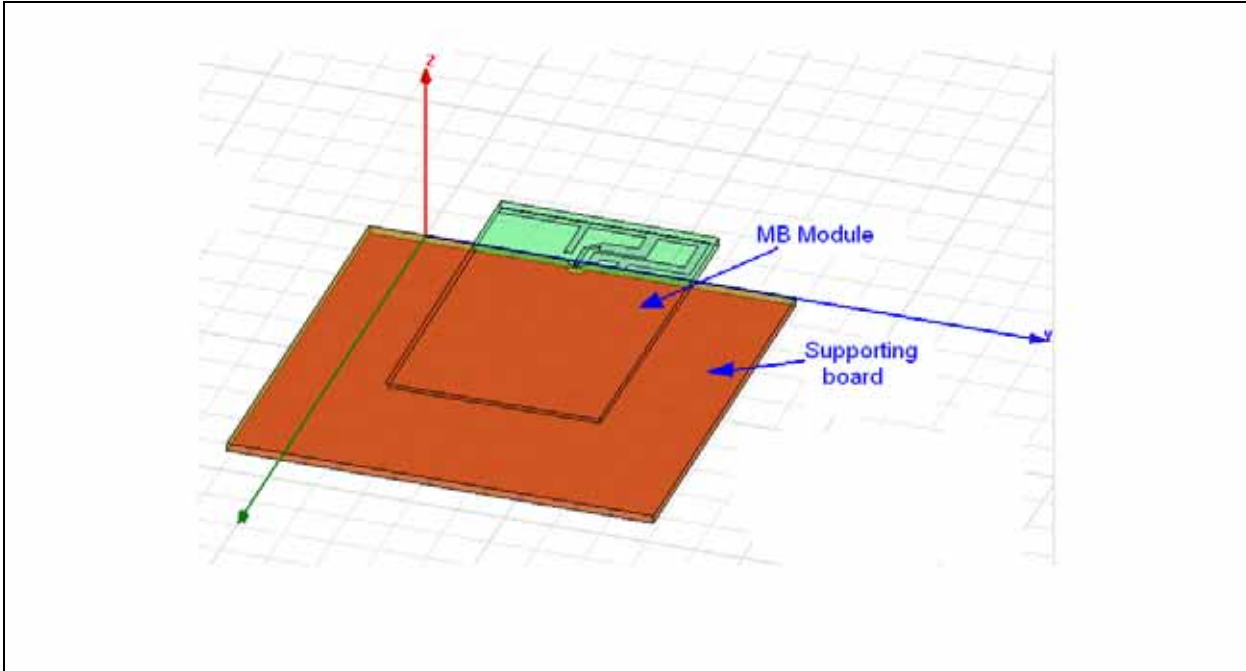
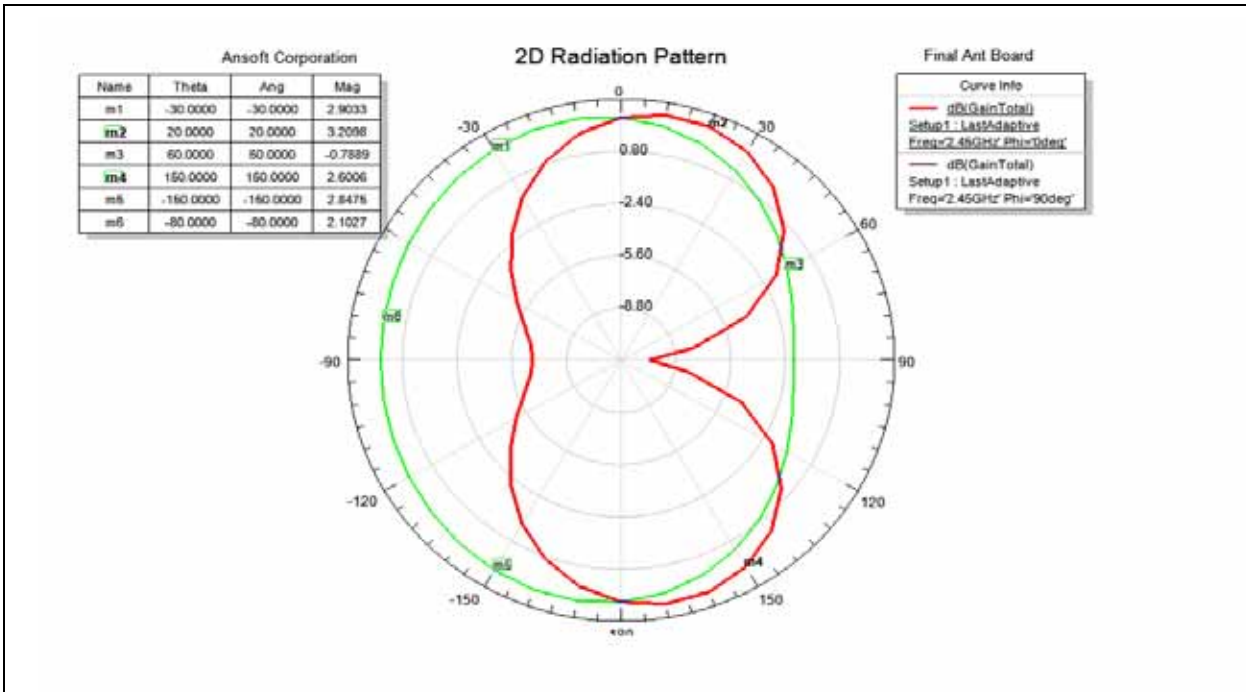
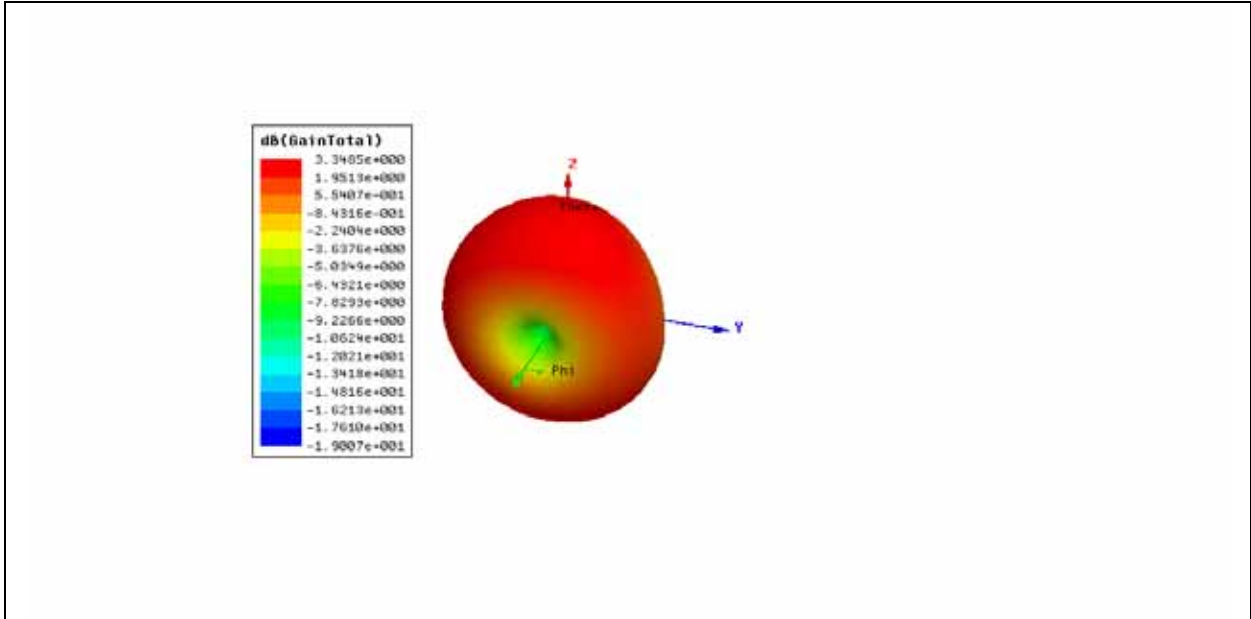


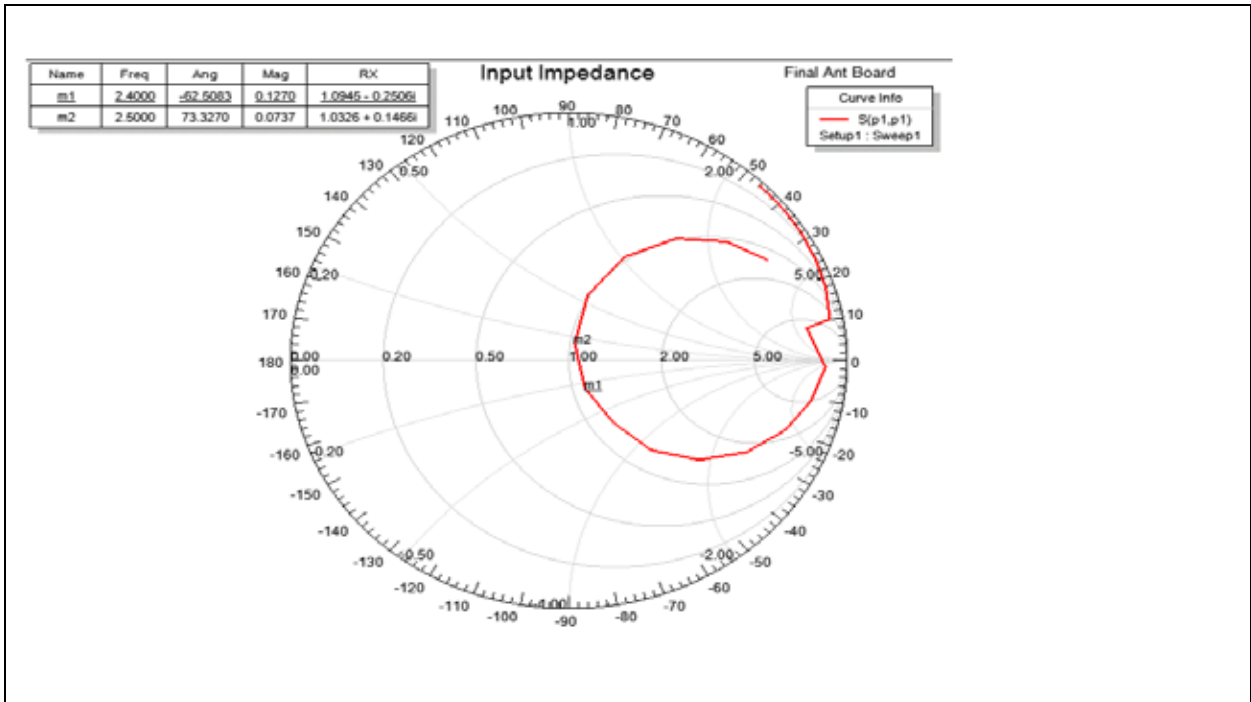
FIGURE 2-10: SIMULATED 2D RADIATION PATTERN



**FIGURE 2-11: SIMULATED 3D RADIATION PATTERN**

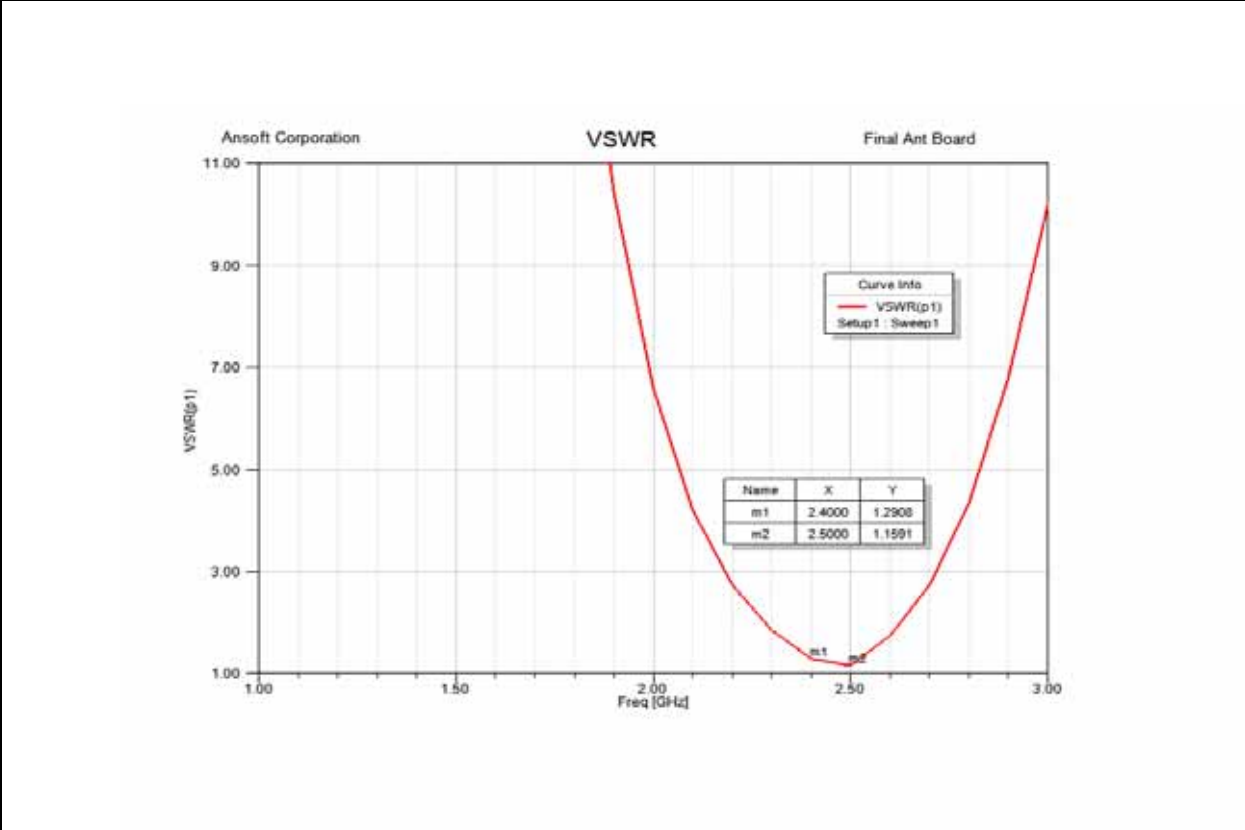


**FIGURE 2-12: SIMULATED PCB ANTENNA IMPEDANCE**



# MRF24J40MB

FIGURE 2-13: SIMULATED PCB ANTENNA SWR



## 3.0 REGULATORY APPROVAL

The MRF24J40MB module has received regulatory approvals for modular devices in the United States, Canada and European countries. Modular approval allows the end user to place the MRF24J40MB module inside a finished product and not require regulatory testing for an intentional radiator (RF transmitter), provided no changes or modifications are made to the module circuitry. Changes or modifications could void the user's authority to operate the equipment. The end user must comply with all of the instructions provided by the Grantee, which indicate installation and/or operating conditions necessary for compliance.

The integrator may still be responsible for testing the end product for any additional compliance requirements required with this module, installed (for example: digital device emission, PC peripheral requirements, etc.) in the specific country that the end device will be marketed.

Annex F of the IEEE Std. 802.15.4 document has a good summary of regulatory requirements in various countries concerning IEEE Std. 802.15.4 devices. The standard can be downloaded from the IEEE Standards web page: <http://standards.ieee.org/getieee802/802.15.html>.

Refer to the specific country radio regulations for details on regulatory compliance.

### 3.1 United States

The MRF24J40MB has received Federal Communications Commission (FCC) CFR47 Telecommunications, Part 15 Subpart C "Intentional Radiators" 15.247 and modular approval in accordance with FCC Public Notice DA 00-1407 Released: June 26, 2000, Part 15 Unlicensed Modular Transmitter Approval. The MRF24J40MB module can be integrated into a finished product without obtaining subsequent and separate FCC approvals.

The MRF24J40MB module has been labeled with its own FCC ID number, and if the FCC ID is not visible when the module is installed inside another device, then the outside of the finished product 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:  
OA3MRF24J40MB  
-or-  
Contains FCC ID: OA3MRF24J40MB  
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, and (2) this device must accept any interference received, including interference that may cause undesired operation.

The user's manual should include the following statement:

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.

#### 3.1.1 MRF24J40MB SETTINGS

To meet the FCC requirements, the following settings must be observed by the integrator:

- The MRF24J40MB transmit power setting (RFFCON3 0x203) cannot exceed -1.9 dB.
- Only channels 11 through 25 may be selected (RFFCON0 0x200).

#### 3.1.2 RF EXPOSURE

All transmitters regulated by FCC must comply with RF exposure requirements. OET Bulletin 65 "Evaluating Compliance with FCC Guidelines for Human Exposure to Radio Frequency Electromagnetic Fields" provides assistance in determining whether proposed or existing transmitting facilities, operations or devices comply with limits for human exposure to Radio Frequency (RF) fields adopted by the Federal Communications Commission (FCC). The bulletin offers guidelines and suggestions for evaluating compliance.

If appropriate, compliance with exposure guidelines for mobile and unlicensed devices can be accomplished by the use of warning labels and by providing users with information concerning minimum separation distances from transmitting structures and proper installation of antennas.

# MRF24J40MB

---

The following statement must be included as a CAUTION statement in manuals and OEM products to alert users of FCC RF exposure compliance:

To satisfy FCC RF exposure requirements for mobile and base station transmission devices, a separation distance of 20 cm or more should be maintained between the antenna of this device and persons during operation. To ensure compliance, operation at closer than this distance is not recommended.

The antenna(s) used for this transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

If the MRF24J40MB module is used in a portable application (antenna is less than 20 cm from persons during operation), the integrator is responsible for performing Specific Absorption Rate (SAR) testing in accordance with FCC rules 2.1091.

### 3.1.3 HELPFUL WEB SITES

Federal Communications Commission (FCC):  
<http://www.fcc.gov>

## 3.2 Canada

The MRF24J40MB module has been certified for use in Canada under Industry Canada (IC) Radio Standards Specification (RSS) RSS-210 and RSS-Gen.

From Section 7.1.1, RSS-Gen, Issue 2, June 2007, Modular Transmitter Approval:

Host devices which contain separately certified modules do not need to be recertified, provided that they meet the following conditions:

- a) The host device, as a stand-alone unit without any separately certified modules, complies with all applicable Radio Standards Specifications.
- b) The host device and all the separately certified modules it contains jointly meet the RF exposure compliance requirements of RSS-102, if applicable.
- c) The host device complies with the certification labeling requirements of each of the modules it contains.

**Note:** Compliance of a module in its final configuration is the responsibility of the applicant. A host device will not be considered certified if the instructions regarding antenna configuration provided in the original description, of one or more separately certified modules it contains, were not followed

From Section 5.2, RSS-Gen, Issue 2, June 2007, Equipment Labels:

All Category I radio equipment intended for use in Canada shall permanently display on each transmitter, receiver or inseparable combination thereof, the applicant's name (i.e., manufacturer's name, trade name or brand name), model number and certification number. This information shall be affixed in such a manner as to not be removable except by destruction or defacement. The size of the lettering shall be legible without the aid of magnification, but is not required to be larger than an 8-point font size. If the device is too small to meet this condition, the information can be included in the user manual upon agreement with Industry Canada.

Label:

Contains IC: 7693A-24J40MB

From Section 7.1.6, RSS-Gen, Issue 2, June 2007, Digital Circuits:

If the device contains digital circuitry that is not directly associated with the radio transmitter, the device shall also have to comply with ICES-003, Class A or B as appropriate, except for ICES-003 labeling requirements. The test data obtained (for the ICES-003 tests) shall be kept by the manufacturer or importer whose name appears on the equipment label, and made available to Industry Canada on request, for as long as the model is being marketed in Canada.

### 3.2.1 MRF24J40MB SETTINGS

To meet Industry Canada (IC) requirements, the following settings must be observed by the integrator:

- The MRF24J40MB transmit power setting (RFCON3 0x203) cannot exceed -1.9 dB.
- Only channels 11 through 25 may be selected (RFCON0 0x200).

### 3.2.2 HELPFUL WEB SITES

Industry Canada: <http://www.ic.gc.ca/>

## 3.3 Europe

The MRF24J40MB module has been certified for use in European countries. The following testing has been completed:

Test standard ETSI EN 300 328 V1.7.1 (2006-10):

- Maximum Transmit Power
- Maximum EIRP Spectral Density
- Frequency Range
- Radiated Emissions

Test standards ETSI EN 301 489-1:2008 and ETSI EN 301 489-17:2008:

- Radiated Emissions
- Electrostatic Discharge
- Radiated RF Susceptibility

A helpful document that can be used as a starting point in understanding the use of Short Range Devices (SRD) in Europe is the European Radio Communications Committee (ERC) Recommendation 70-03 E, downloadable from the European Radio Communications Office (ERO): <http://www.ero.dk>.

The end user is responsible for ensuring compliance with harmonized frequencies and labeling requirements for each country the end device is marketed and sold.

### 3.3.1 MRF24J40MB SETTINGS

To meet ETSI requirements, the following settings must be observed by the integrator:

- The MRF24J40MB transmit power setting (RFCON3 0x203) cannot exceed -14.9 dB. This is to meet the requirements of ETSI EN 300 328 v1.7.1 (2006-05), Maximum e.i.r.p. spectral density limit, Section 4.3.2.2, "For wideband modulations other than FHSS (e.g., DSSS, OFDM, etc.), the maximum e.i.r.p. spectral density is limited to 10 mW per MHz". The output power of the MRF24J40MB module, at this setting with the PA enabled, is 9 dBm.
- Only channels 11 through 25 may be selected (RFCON0 0x200).

### 3.3.2 HELPFUL WEB SITES:

Radio and Telecommunications Terminal Equipment (R&TTE):

[http://ec.europa.eu/enterprise/rtte/index\\_en.htm](http://ec.europa.eu/enterprise/rtte/index_en.htm)

European Conference of Postal and Telecommunications Administrations (CEPT): <http://www.cept.org/>

European Telecommunications Standards Institute (ETSI): <http://www.etsi.org/>

European Radio Communications Office (ERO): <http://www.ero.dk/>

# MRF24J40MB

---

NOTES:



## 4.0 ELECTRICAL CHARACTERISTICS

**TABLE 4-1: RECOMMENDED OPERATING CONDITIONS**

Parameters	Min	Typ	Max	Units
Ambient Operating Temperature	-40	—	+85	°C
Supply Voltage for RF, Analog and Digital Circuits	2.4	—	3.6	V
Supply Voltage for Digital I/O	2.4	3.3	3.6	V
Input High Voltage (V <sub>IH</sub> )	0.5 x V <sub>DD</sub>	—	V <sub>DD</sub> + 0.3	V
Input Low Voltage (V <sub>IL</sub> )	-0.3	—	0.2 x V <sub>DD</sub>	V

**TABLE 4-2: CURRENT CONSUMPTION**

(T<sub>A</sub> = 25°C, V<sub>DD</sub> = 3.3V)

Chip Mode	Condition	Min	Typ	Max	Units
Sleep	Sleep Clock Disabled	—	5 μA	—	μA
TX	At Maximum Output Power	—	130 mA	—	mA
RX		—	25 mA	—	mA

**TABLE 4-3: RECEIVER AC CHARACTERISTICS**

Typical values are at T<sub>A</sub> = 25°C, V<sub>DD</sub> = 3.3V, LO Frequency = 2.445 GHz

Parameters	Condition	Min	Typ	Max	Units
RF Input Frequency	Compatible to IEEE Std. 802.15.4™, 2003	2.405	—	2.480	GHz
RF Sensitivity		—	-102	—	dBm
Maximum RF Input		-23	—	—	dBm
LO Leakage	Measured at Balun Matching Network Input at Frequency, 2.405-2.48 GHz	—	-60	—	dBm
Input Return Loss		-8	-12	—	dB
Noise Figure (including matching)		—	1.9	—	dB
Adjacent Channel Rejection	@ +/-5 MHz	30	—	—	dB
Alternate Channel Rejection	@ +/-10 MHz	40	—	—	dB
RSSI Range		—	50	—	dB
RSSI Error		-5	—	5	dB

# MRF24J40MB

---

**TABLE 4-4: TRANSMITTER AC CHARACTERISTICS**

Typical values are at  $T_A = 25^\circ\text{C}$ ,  $V_{DD} = 3.3\text{V}$ , LO Frequency = 2.445 GHz

Parameters	Condition	Min	Typ	Max	Units
RF Carrier Frequency		2.405	—	2.475	GHz
Maximum RF Output Power		—	20	—	dBm
RF Output Power Control Range		—	56	—	dB
TX Gain Control Resolution	Programmed by Register	—	1.25	—	dB
Carrier Suppression		—	-30	—	dBc
TX Spectrum Mask for O-QPSK Signal	Offset Frequency > 3.5 MHz, at 0 dBm Output Power	-33	—	—	dBm
TX EVM		—	15	—	%

## APPENDIX A: REVISION HISTORY

### Revision A (June 2009)

Original release of this document.

### Revision B (August 2009)

Added **Section 3.0 “Regulatory Approval”**.

# MRF24J40MB

---

NOTES:

## INDEX

### A

AC Characteristics	
Receiver .....	23
Transmitter .....	24
Antenna Impedance	
Simulated PCB .....	17

### B

Bill of Materials (BOM) .....	11
Block Diagrams	
Microcontroller to MRF24J40MB Interface .....	4
MRF24J40MB .....	3
PA/LNA .....	7

### C

Circuit Description .....	9
Customer Change Notification Service .....	28
Customer Notification Service .....	28
Customer Support .....	28

### D

Details	
Module .....	5
Mounting .....	6
Recommended PCB Footprint .....	5

### E

Electrical Characteristics .....	23
Current Consumption .....	23
Recommended Operating Conditions .....	23
Errata .....	2
European Radio Communications (ERC) .....	21

### F

FCC ID Number .....	19
FCC RF Exposure Compliance .....	20

### H

Helpful Web Sites .....	20, 21
-------------------------	--------

### I

Interface Description .....	3
Internet Address .....	28

### M

MAC/Baseband Features .....	1
Microchip Internet Web Site .....	28
MiWi P2P .....	3
MiWi Protocol .....	3
More Information .....	2
Customer Notification System .....	2
Errata .....	2
Mounting Details .....	5
MRF24J40 Data Sheet .....	3, 9

### O

Operation	
Energy Detection (ED) .....	7
PA/LNA Control .....	7
Sleep .....	7
Overview .....	3

### P

PCB Antenna .....	15
Dimensions .....	15
Simulation Drawing .....	16
SWR .....	18
PCB Layers	
Bottom Copper .....	14
Layer 2 – Ground Plane .....	13
Layer 3 – Power Plane .....	14
Stack Up .....	14
Top Copper .....	13
Top Silk Screen .....	13
Pin Description .....	4
Pin Diagram .....	1
Printed Circuit Board (PCB) .....	13

### R

Radiation Pattern	
2D .....	16
3D .....	17
Reader Response .....	29
Regulatory Approval .....	19
Canada .....	20
Settings .....	20
Europe .....	21
Settings .....	21
United States .....	19
Settings .....	19
Revision History .....	25
RF Exposure .....	19
RF/Analog Features .....	1

### S

Schematic	
MRF24J40MB .....	10
Serial I/O	
SCK, SDI, SDO, $\overline{CS}$ .....	9
Short Range Devices (SRD) .....	21
Specific Absorption Rate (SAR) .....	20
SPI .....	9

### W

WWW Address .....	28
WWW, On-Line Support .....	2

### Z

ZigBee Protocol .....	3
-----------------------	---

# MRF24J40MB

---

NOTES:

## THE MICROCHIP WEB SITE

Microchip provides online support via our WWW site at [www.microchip.com](http://www.microchip.com). This web site is used as a means to make files and information easily available to customers. Accessible by using your favorite Internet browser, the web site contains the following information:

- **Product Support** – Data sheets and errata, application notes and sample programs, design resources, user's guides and hardware support documents, latest software releases and archived software
- **General Technical Support** – Frequently Asked Questions (FAQ), technical support requests, online discussion groups, Microchip consultant program member listing
- **Business of Microchip** – Product selector and ordering guides, latest Microchip press releases, listing of seminars and events, listings of Microchip sales offices, distributors and factory representatives

## CUSTOMER CHANGE NOTIFICATION SERVICE

Microchip's customer notification service helps keep customers current on Microchip products. Subscribers will receive e-mail notification whenever there are changes, updates, revisions or errata related to a specified product family or development tool of interest.

To register, access the Microchip web site at [www.microchip.com](http://www.microchip.com), click on Customer Change Notification and follow the registration instructions.

## CUSTOMER SUPPORT

Users of Microchip products can receive assistance through several channels:

- Distributor or Representative
- Local Sales Office
- Field Application Engineer (FAE)
- Technical Support
- Development Systems Information Line

Customers should contact their distributor, representative or field application engineer (FAE) for support. Local sales offices are also available to help customers. A listing of sales offices and locations is included in the back of this document.

**Technical support is available through the web site at: <http://support.microchip.com>**

# MRF24J40MB

---



---

## READER RESPONSE

It is our intention to provide you with the best documentation possible to ensure successful use of your Microchip product. If you wish to provide your comments on organization, clarity, subject matter, and ways in which our documentation can better serve you, please FAX your comments to the Technical Publications Manager at (480) 792-4150.

Please list the following information, and use this outline to provide us with your comments about this document.

To: Technical Publications Manager Total Pages Sent \_\_\_\_\_  
 RE: Reader Response  
 From: Name \_\_\_\_\_  
 Company \_\_\_\_\_  
 Address \_\_\_\_\_  
 City / State / ZIP / Country \_\_\_\_\_  
 Telephone: (\_\_\_\_\_) \_\_\_\_\_ - \_\_\_\_\_ FAX: (\_\_\_\_\_) \_\_\_\_\_ - \_\_\_\_\_

Application (optional):

Would you like a reply? \_\_\_Y \_\_\_N

Device: MRF24J40MB Literature Number: DS70599B

Questions:

1. What are the best features of this document?  
 \_\_\_\_\_  
 \_\_\_\_\_
2. How does this document meet your hardware and software development needs?  
 \_\_\_\_\_  
 \_\_\_\_\_
3. Do you find the organization of this document easy to follow? If not, why?  
 \_\_\_\_\_  
 \_\_\_\_\_
4. What additions to the document do you think would enhance the structure and subject?  
 \_\_\_\_\_  
 \_\_\_\_\_
5. What deletions from the document could be made without affecting the overall usefulness?  
 \_\_\_\_\_  
 \_\_\_\_\_
6. Is there any incorrect or misleading information (what and where)?  
 \_\_\_\_\_  
 \_\_\_\_\_
7. How would you improve this document?  
 \_\_\_\_\_  
 \_\_\_\_\_



## PRODUCT IDENTIFICATION SYSTEM

To order or obtain information, e.g., on pricing or delivery, refer to the factory or the listed sales office.

<u>PART NO.</u>	M	X	I	-X
Device	Module	Module Type	Tape and Reel	Temperature Range
Device	MRF24J40MB; VDD range 2.4V to 3.6V			
Temperature Range	I	=	-40°C to +85°C	(Industrial)

**Examples:**

- a) MRF24J40MB-I = Industrial temp. tray
- b) MRF24J40MBT-I = Industrial temp., tape and reel.



## WORLDWIDE SALES AND SERVICE

### AMERICAS

**Corporate Office**  
2355 West Chandler Blvd.  
Chandler, AZ 85224-6199  
Tel: 480-792-7200  
Fax: 480-792-7277  
Technical Support:  
<http://support.microchip.com>  
Web Address:  
[www.microchip.com](http://www.microchip.com)

**Atlanta**  
Duluth, GA  
Tel: 678-957-9614  
Fax: 678-957-1455

**Boston**  
Westborough, MA  
Tel: 774-760-0087  
Fax: 774-760-0088

**Chicago**  
Itasca, IL  
Tel: 630-285-0071  
Fax: 630-285-0075

**Cleveland**  
Independence, OH  
Tel: 216-447-0464  
Fax: 216-447-0643

**Dallas**  
Addison, TX  
Tel: 972-818-7423  
Fax: 972-818-2924

**Detroit**  
Farmington Hills, MI  
Tel: 248-538-2250  
Fax: 248-538-2260

**Kokomo**  
Kokomo, IN  
Tel: 765-864-8360  
Fax: 765-864-8387

**Los Angeles**  
Mission Viejo, CA  
Tel: 949-462-9523  
Fax: 949-462-9608

**Santa Clara**  
Santa Clara, CA  
Tel: 408-961-6444  
Fax: 408-961-6445

**Toronto**  
Mississauga, Ontario,  
Canada  
Tel: 905-673-0699  
Fax: 905-673-6509

### ASIA/PACIFIC

**Asia Pacific Office**  
Suites 3707-14, 37th Floor  
Tower 6, The Gateway  
Harbour City, Kowloon  
Hong Kong  
Tel: 852-2401-1200  
Fax: 852-2401-3431

**Australia - Sydney**  
Tel: 61-2-9868-6733  
Fax: 61-2-9868-6755

**China - Beijing**  
Tel: 86-10-8528-2100  
Fax: 86-10-8528-2104

**China - Chengdu**  
Tel: 86-28-8665-5511  
Fax: 86-28-8665-7889

**China - Hong Kong SAR**  
Tel: 852-2401-1200  
Fax: 852-2401-3431

**China - Nanjing**  
Tel: 86-25-8473-2460  
Fax: 86-25-8473-2470

**China - Qingdao**  
Tel: 86-532-8502-7355  
Fax: 86-532-8502-7205

**China - Shanghai**  
Tel: 86-21-5407-5533  
Fax: 86-21-5407-5066

**China - Shenyang**  
Tel: 86-24-2334-2829  
Fax: 86-24-2334-2393

**China - Shenzhen**  
Tel: 86-755-8203-2660  
Fax: 86-755-8203-1760

**China - Wuhan**  
Tel: 86-27-5980-5300  
Fax: 86-27-5980-5118

**China - Xiamen**  
Tel: 86-592-2388138  
Fax: 86-592-2388130

**China - Xian**  
Tel: 86-29-8833-7252  
Fax: 86-29-8833-7256

**China - Zhuhai**  
Tel: 86-756-3210040  
Fax: 86-756-3210049

### ASIA/PACIFIC

**India - Bangalore**  
Tel: 91-80-3090-4444  
Fax: 91-80-3090-4080

**India - New Delhi**  
Tel: 91-11-4160-8631  
Fax: 91-11-4160-8632

**India - Pune**  
Tel: 91-20-2566-1512  
Fax: 91-20-2566-1513

**Japan - Yokohama**  
Tel: 81-45-471- 6166  
Fax: 81-45-471-6122

**Korea - Daegu**  
Tel: 82-53-744-4301  
Fax: 82-53-744-4302

**Korea - Seoul**  
Tel: 82-2-554-7200  
Fax: 82-2-558-5932 or  
82-2-558-5934

**Malaysia - Kuala Lumpur**  
Tel: 60-3-6201-9857  
Fax: 60-3-6201-9859

**Malaysia - Penang**  
Tel: 60-4-227-8870  
Fax: 60-4-227-4068

**Philippines - Manila**  
Tel: 63-2-634-9065  
Fax: 63-2-634-9069

**Singapore**  
Tel: 65-6334-8870  
Fax: 65-6334-8850

**Taiwan - Hsin Chu**  
Tel: 886-3-6578-300  
Fax: 886-3-6578-370

**Taiwan - Kaohsiung**  
Tel: 886-7-536-4818  
Fax: 886-7-536-4803

**Taiwan - Taipei**  
Tel: 886-2-2500-6610  
Fax: 886-2-2508-0102

**Thailand - Bangkok**  
Tel: 66-2-694-1351  
Fax: 66-2-694-1350

### EUROPE

**Austria - Wels**  
Tel: 43-7242-2244-39  
Fax: 43-7242-2244-393

**Denmark - Copenhagen**  
Tel: 45-4450-2828  
Fax: 45-4485-2829

**France - Paris**  
Tel: 33-1-69-53-63-20  
Fax: 33-1-69-30-90-79

**Germany - Munich**  
Tel: 49-89-627-144-0  
Fax: 49-89-627-144-44

**Italy - Milan**  
Tel: 39-0331-742611  
Fax: 39-0331-466781

**Netherlands - Drunen**  
Tel: 31-416-690399  
Fax: 31-416-690340

**Spain - Madrid**  
Tel: 34-91-708-08-90  
Fax: 34-91-708-08-91

**UK - Wokingham**  
Tel: 44-118-921-5869  
Fax: 44-118-921-5820

03/26/09