MRF24J40MB
Data Sheet

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

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MRF24J40MB

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 Certification pending 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)

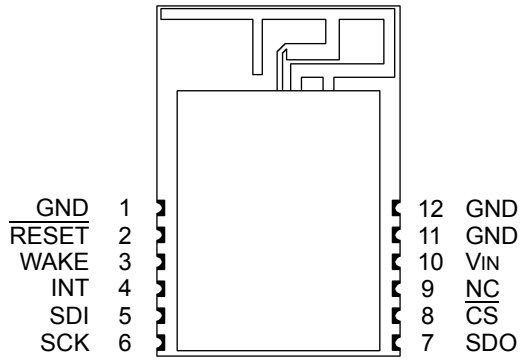
RF/Analog Features:

- ISM Band 2.405-2.48 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



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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.

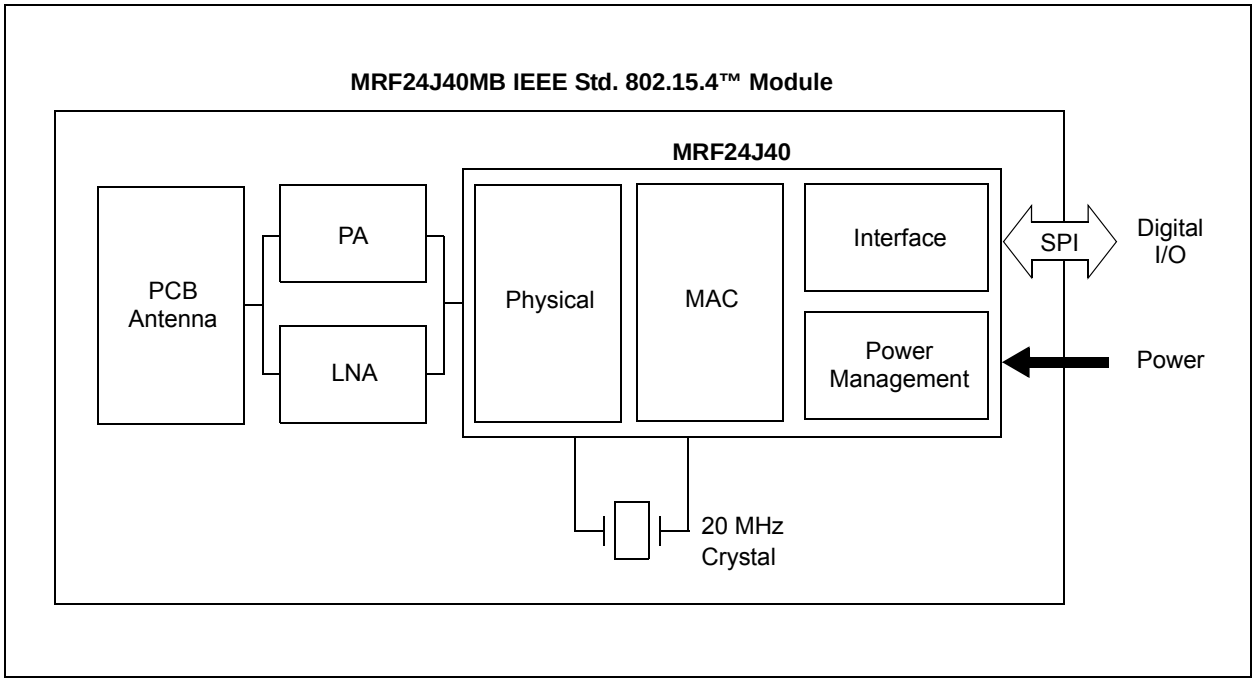
The MRF24J40MB module is pending regulatory approvals for modular devices in the United States (FCC), Canada (IC) and Europe (ETSI). Modular approval removes the need for expensive RF and antenna design and allows the end user to place the MRF24J40MB module inside a finished product and not require regulatory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

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 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



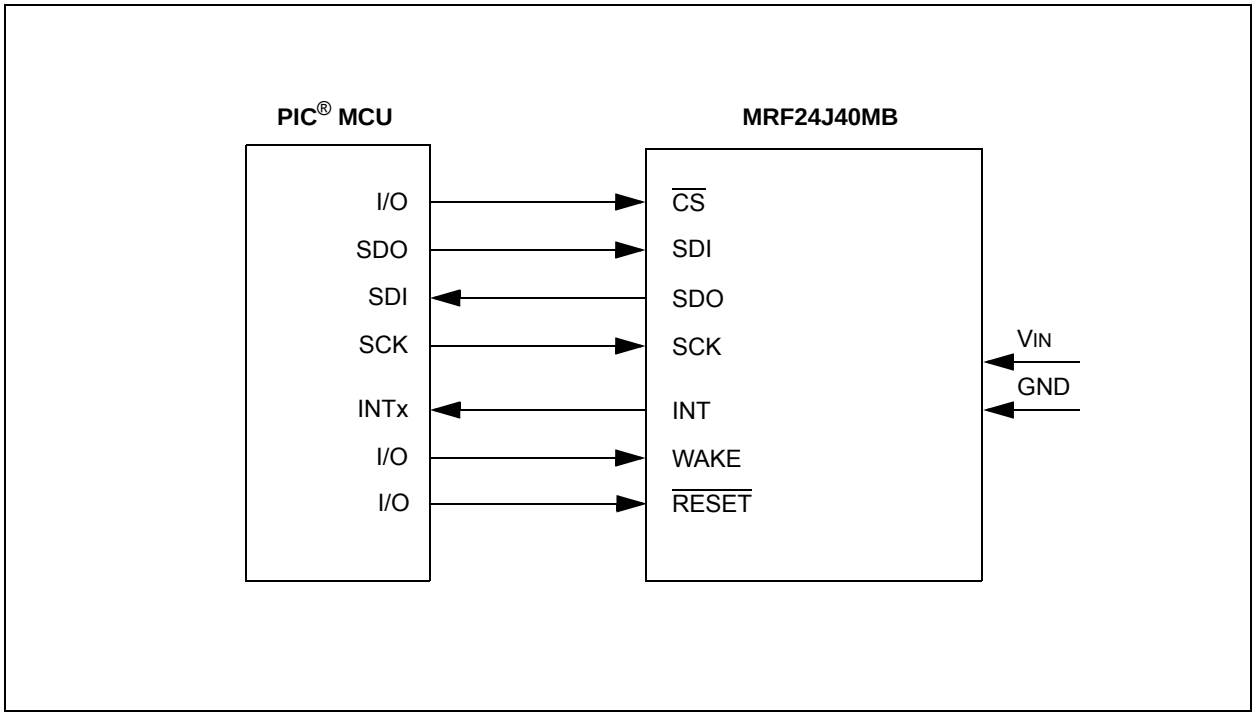
Note:	This device has not been authorized as required by the rules of the Federal Communications Commission. This device is not, and may not be, offered for sale or lease, or sold or leased, until authorization is obtained.

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 extend at least 0.4" around the module.

FIGURE 1-3: MODULE DETAILS

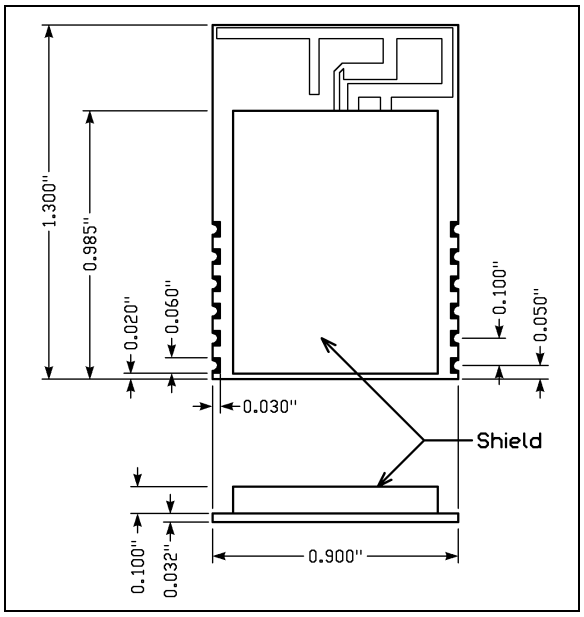


FIGURE 1-4: RECOMMENDED PCB FOOTPRINT

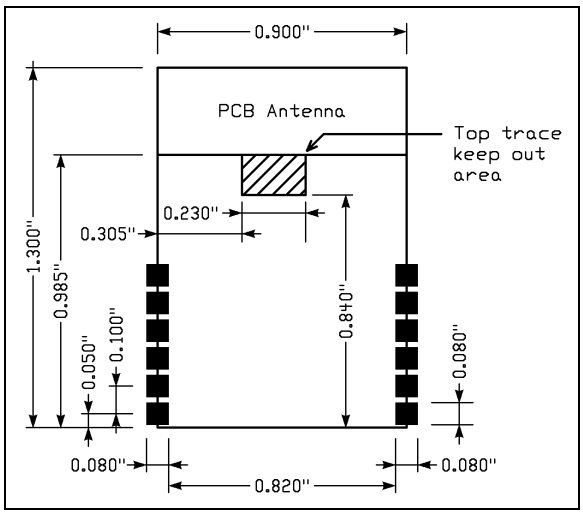
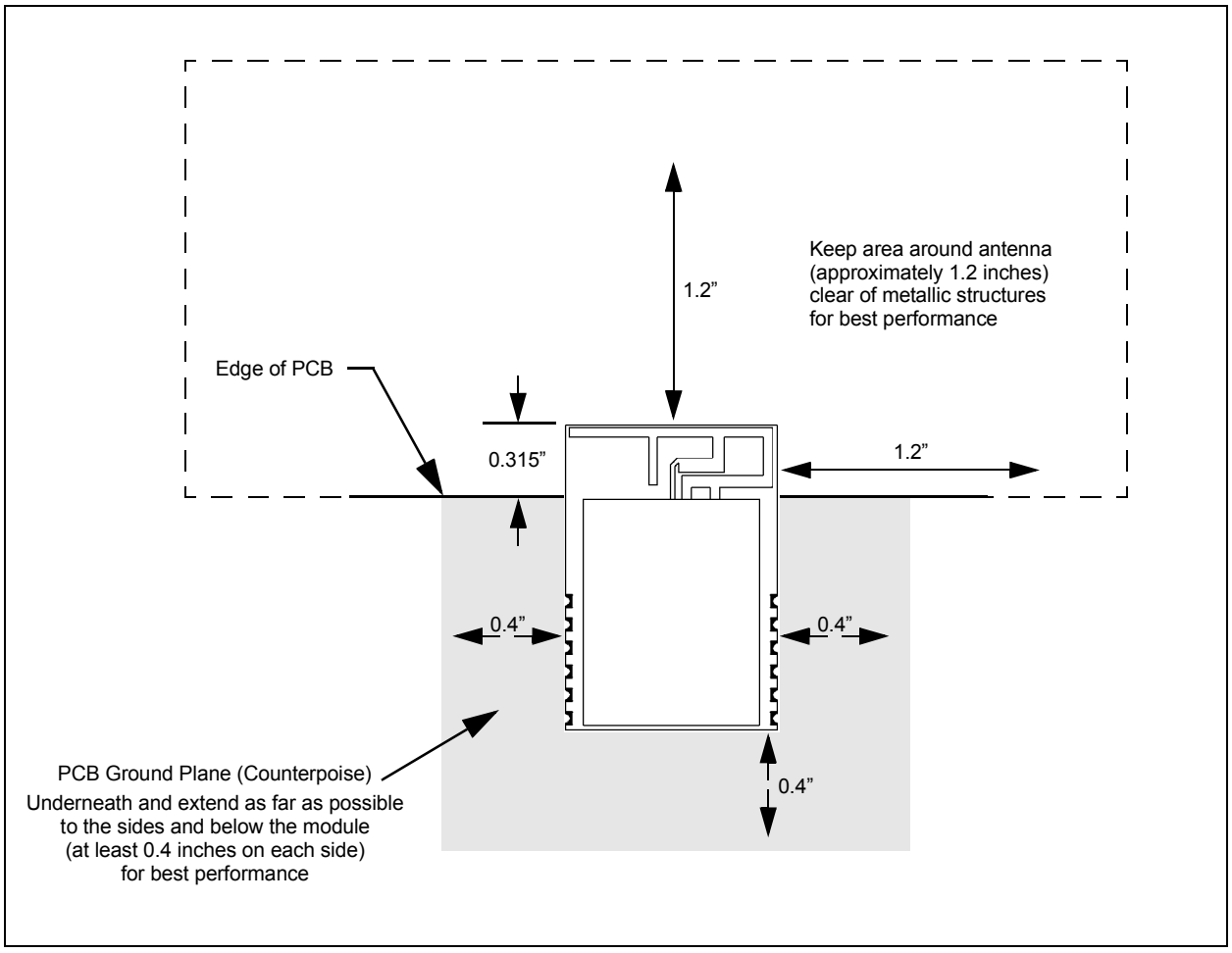


FIGURE 1-5: MOUNTING DETAILS



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 $\overline{CS}$), $\overline{RESET}$, 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 $\overline{CS}$ pin returns to its inactive state.

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

A balun is formed by components: L1, L3, C2 and C3. L2 is an RF choke and pull-up for the RFP and RFN pins on the MRF24J40. C4 is 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.

FIGURE 2-1: MRF24J40MB SCHEMATIC

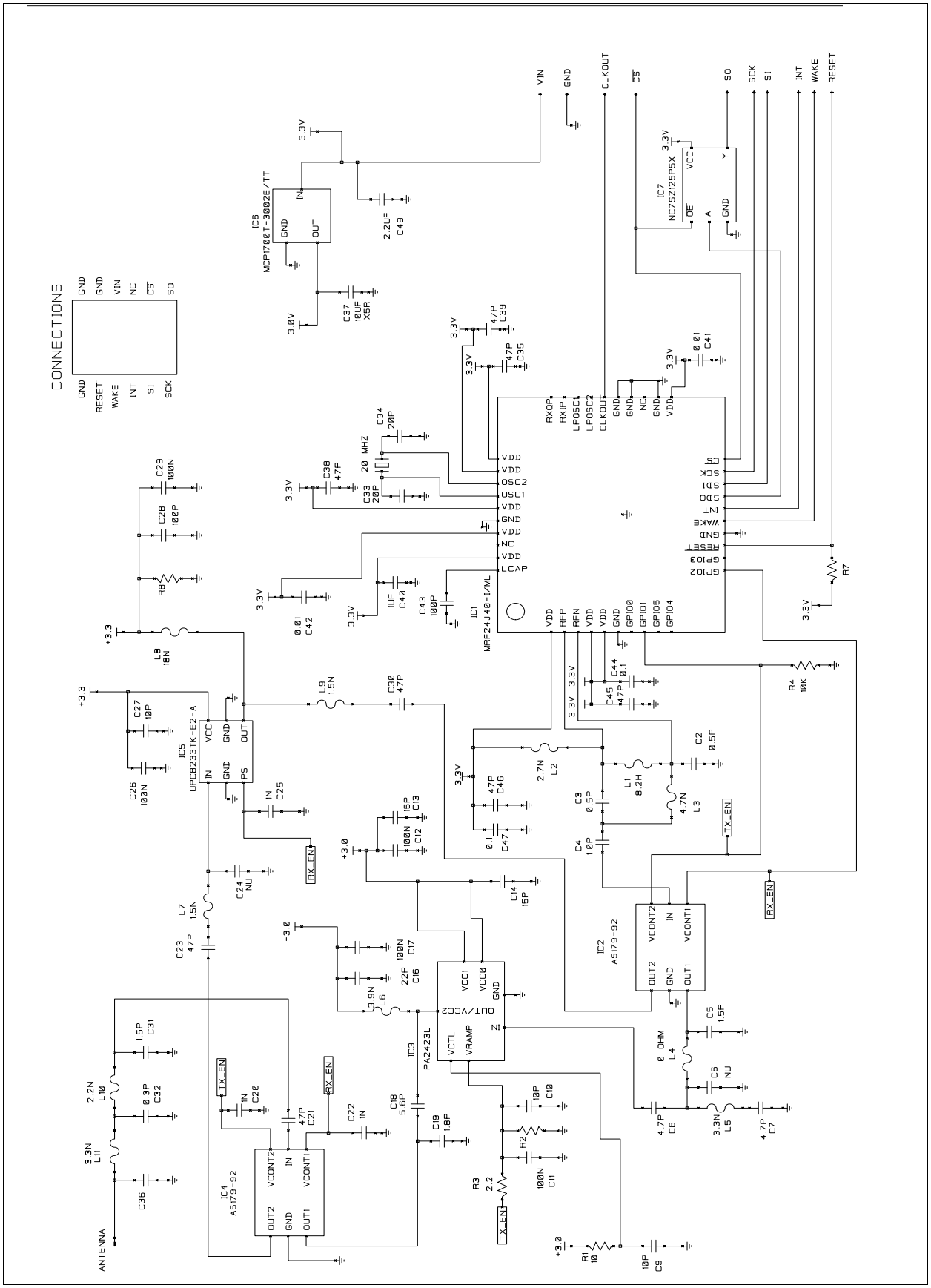


TABLE 2-1: MRF24J40MB BILL OF MATERIALS

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
C46	Chip Capacitor 0402 X5R 100N	Murata	GRM155R61A104KA01D

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

Designator	Description	Manufacturer	Part Number
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 0Ohms	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

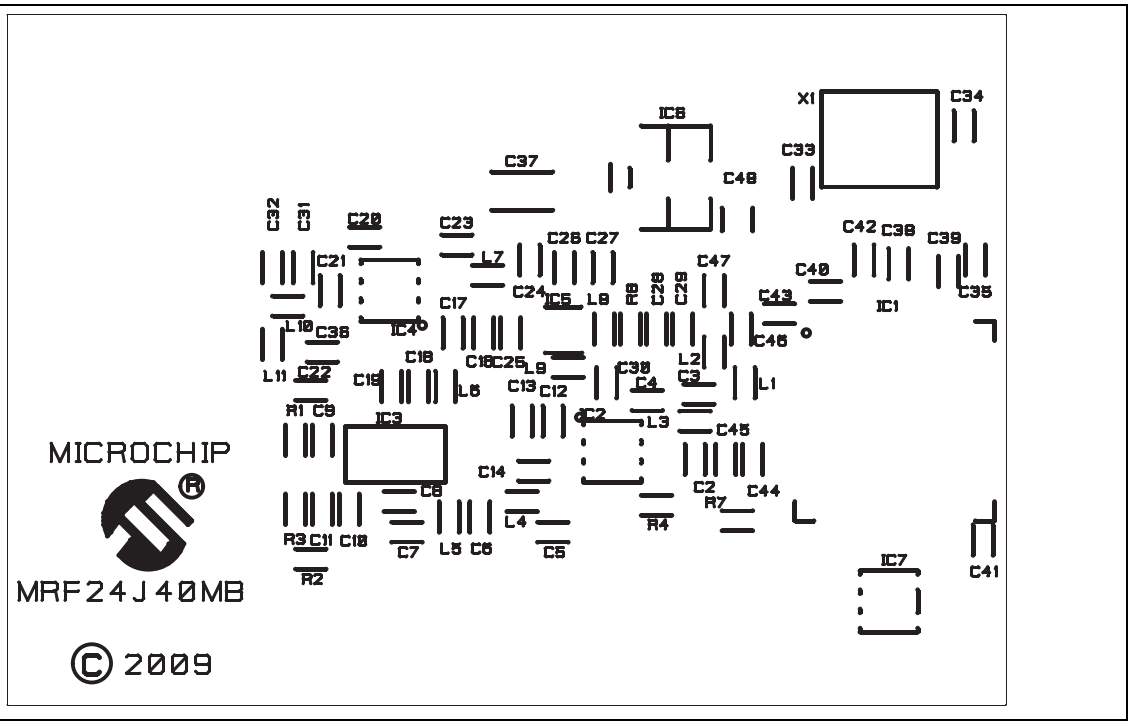


FIGURE 2-3: TOP COPPER

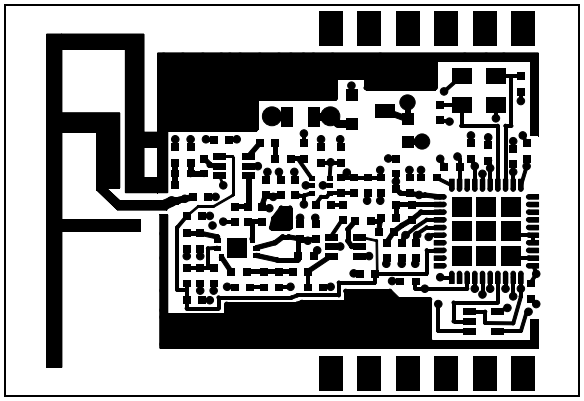
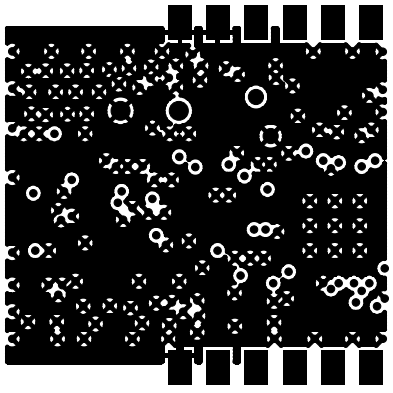
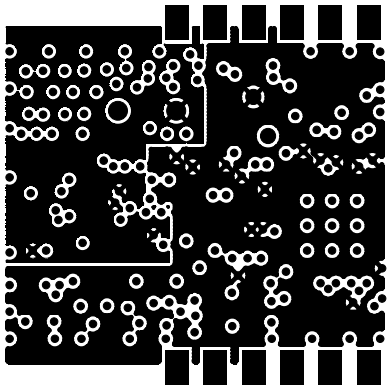


FIGURE 2-4: LAYER 2 – GROUND PLANE



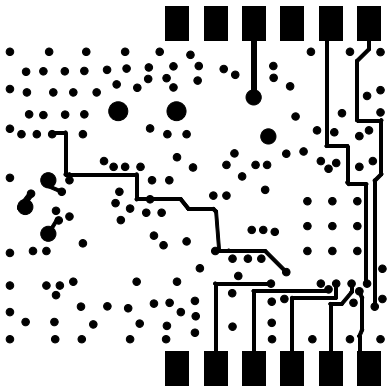
Note: Top view negative Gerber.

FIGURE 2-5: LAYER 3 – POWER PLANE



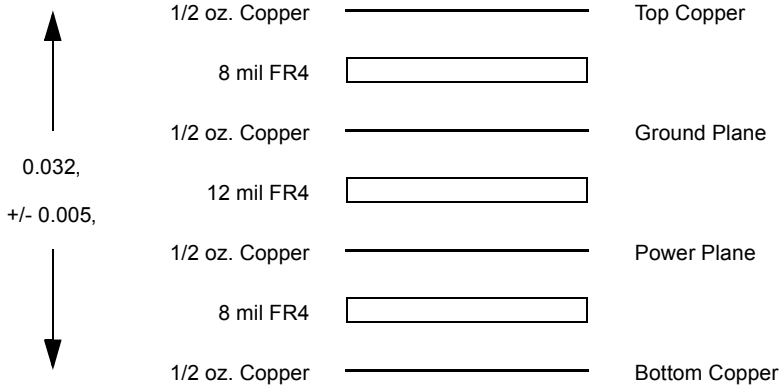
Note: Top view negative Gerber.

FIGURE 2-6: BOTTOM COPPER



Note: Top view.

FIGURE 2-7: PCB LAYER STACK UP

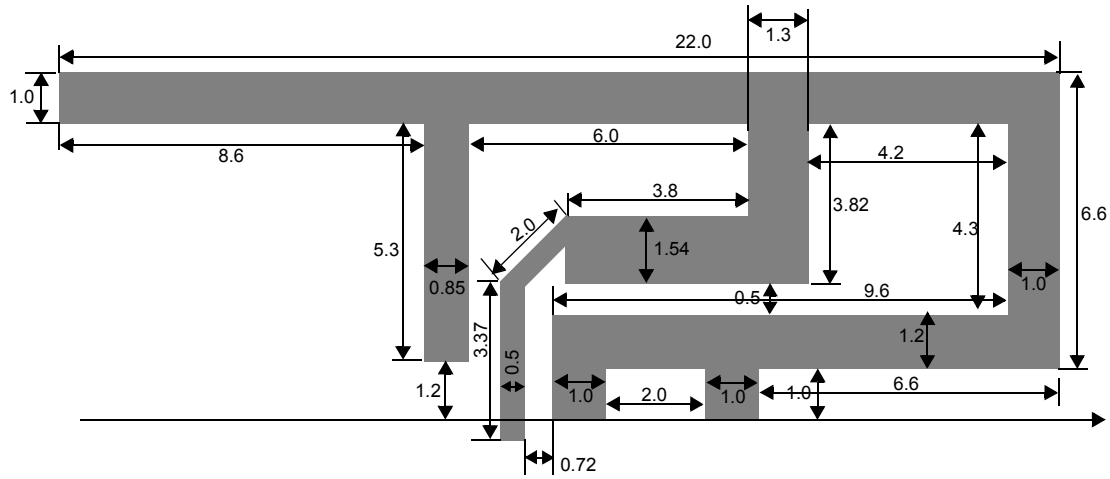


2.3 PCB Antenna

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® and HFSS™ 3D full-wave solver software by Ansoft Corporation (www.ansoft.com). 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



Note 1: Dimensions are in mm and tolerance is +/– 0.05 mm.

FIGURE 2-9: PCB ANTENNA SIMULATION DRAWING

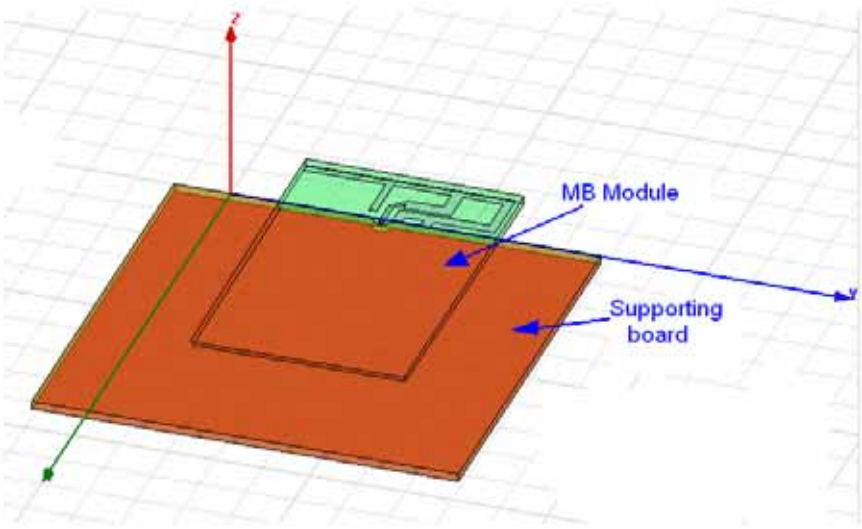


FIGURE 2-10: SIMULATED 2D RADIATION PATTERN

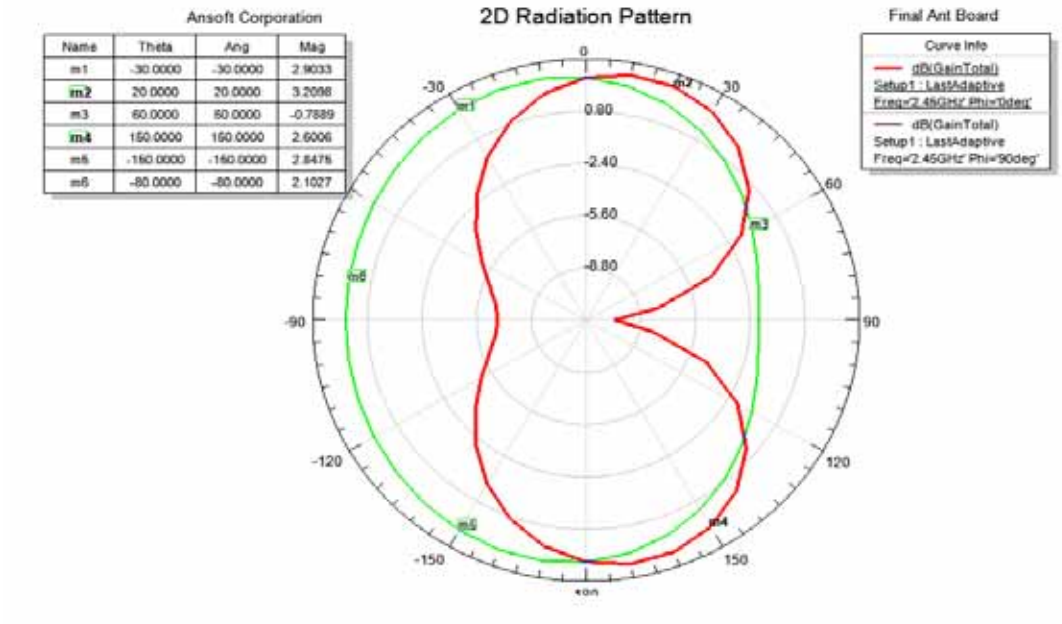


FIGURE 2-11: SIMULATED 3D RADIATION PATTERN

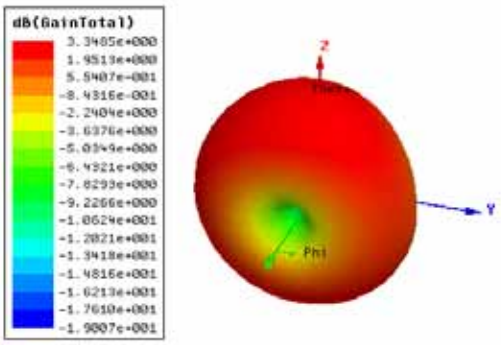


FIGURE 2-12: SIMULATED PCB ANTENNA IMPEDANCE

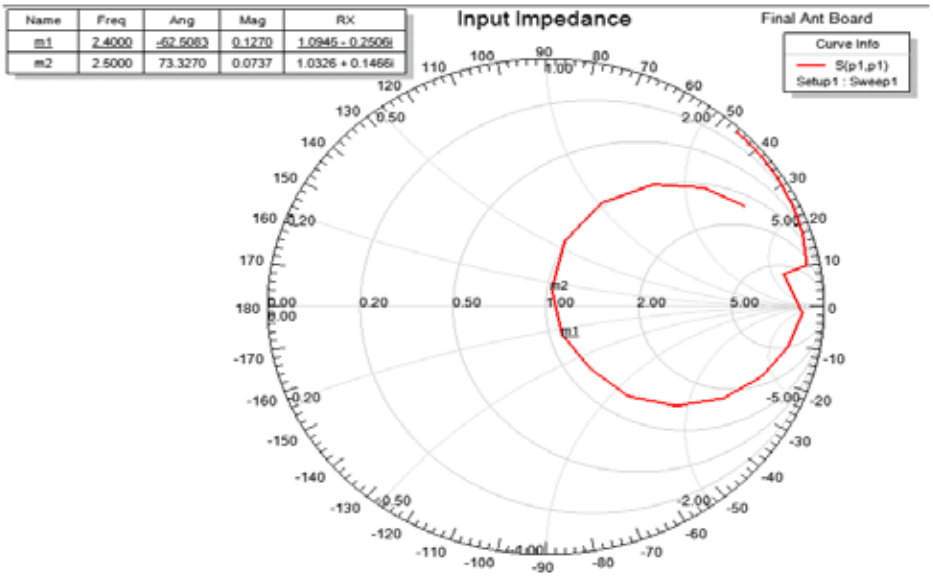
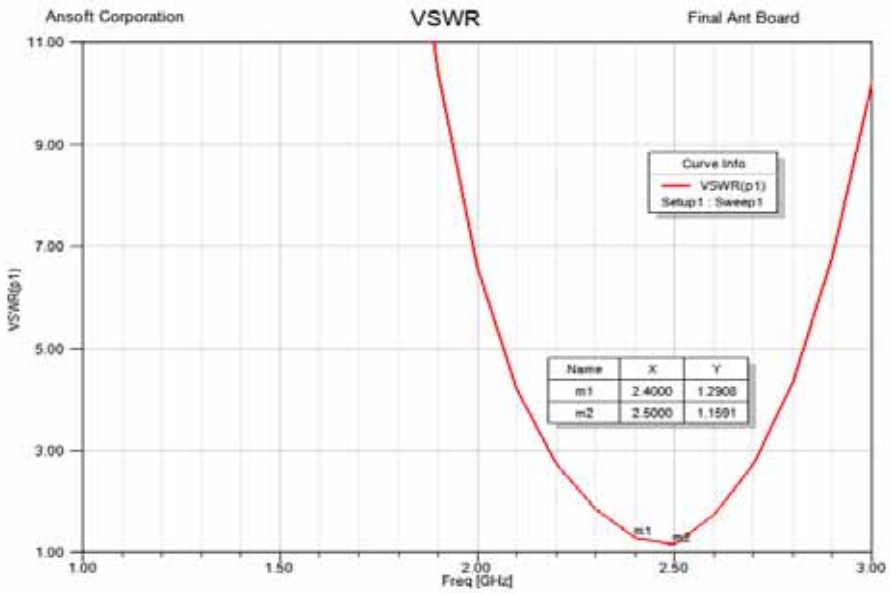


FIGURE 2-13: SIMULATED PCB ANTENNA SWR



3.0 ELECTRICAL CHARACTERISTICS

TABLE 3-1: 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_{IH})	0.5 x V_{DD}	—	V_{DD} + 0.3	V
Input Low Voltage (V_{IL})	-0.3	—	0.2 x V_{DD}	V

TABLE 3-2: CURRENT CONSUMPTION

(T_A = 25°C, V_{DD} = 3.3V)

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

TABLE 3-3: RECEIVER AC CHARACTERISTICS

Typical values are at T_A = 25°C, V_{DD} = 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

TABLE 3-4: TRANSMITTER AC CHARACTERISTICS

Typical values are at T_A = 25°C, V_{DD} = 3.3V, LO Frequency = 2.445 GHz

Parameters	Condition	Min	Typ	Max	Units
RF Carrier Frequency		2.405	—	2.480	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.

NOTES:

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NOTES:

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PART NO.	M	X	T	-X
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Device	MRF24J40MB; V_{DD} range 2.4V to 3.6V	
Temperature Range	I =	-40°C to +85°C (Industrial)

Examples:

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