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PICDEM™ Z Demonstration Kit User's Guide

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═ ISO/TS 16949:2002 ═

PICDEM™ Z
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NOTES:

PICDEM™ Z DEMONSTRATION KIT USER'S GUIDE

Preface

NOTICE TO CUSTOMERS

All documentation becomes dated, and this manual is no exception. Microchip tools and documentation are constantly evolving to meet customer needs, so some actual dialogs and/or tool descriptions may differ from those in this document. Please refer to our web site (www.microchip.com) to obtain the latest documentation available.

Documents are identified with a "DS" number. This number is located on the bottom of each page, in front of the page number. The numbering convention for the DS number is "DSXXXXXA", where "XXXXX" is the document number and "A" is the revision level of the document.

For the most up-to-date information on development tools, see the MPLAB® IDE on-line help. Select the Help menu, and then Topics to open a list of available on-line help files.

INTRODUCTION

This chapter contains general information that will be useful to know before using the PICDEM™ Z Demonstration Kit. Items discussed include:

- Document Layout
- Conventions Used in this Guide
- Warranty Registration
- Recommended Reading
- The Microchip Web Site
- Development Systems Customer Change Notification Service
- Customer Support

DOCUMENT LAYOUT

This document describes how to use the PICDEM Z Demonstration Kit as a development tool to evaluate and experiment with Microchip wireless solutions. The manual layout is as follows:

- **Chapter 1: Overview** – Describes the PICDEM Z Demonstration Kit and how it works.
- **Chapter 2: Getting Started with the PICDEM™ Z Demonstration Kit** – What you need to know to start using the PICDEM Z Demonstration Kit.
- **Appendix A: PICDEM™ Z Motherboard Schematics** – Hardware information on the PICDEM Z demonstration board.
- **Appendix B: MRF24J40MA PICDEM Z 2.4 GHz RF Board** – Hardware information on the MRF24J40MA PICDEM Z 2.4 GHz RF Board.
- **Appendix C: PICDEM™ Z 2.4 GHz RF Card** – Hardware information on the PICDEM Z 2.4 GHz RF Card.

PICDEM Z Demonstration Kit User's Guide

CONVENTIONS USED IN THIS GUIDE

Where applicable, this manual uses the following documentation conventions:

DOCUMENTATION CONVENTIONS

Description	Represents	Examples
Arial font:		
Italic characters	Referenced books	*MPLAB® IDE User's Guide*
	Emphasized text	...is the *only* compiler...
Initial caps	A window	the Output window
	A dialog	the Settings dialog
	A menu selection	select Enable Programmer
Quotes	A field name in a window or dialog	"Save project before build"
Underlined, italic text with right angle bracket	A menu path	*File>Save*
Bold characters	A dialog button	Click **OK**
	A tab	Click the **Power** tab
Text in angle brackets < >	A key on the keyboard	Press <Enter>, <F1>
0xnnnn	A hexadecimal number where n is a hexadecimal digit	0xFFFF, 0x007A
Courier New font:		
Plain Courier New	Sample source code	`#define START`
	Filenames	`autoexec.bat`
	File paths	`c:\mcc18\h`
	Keywords	`_asm, _endasm, static`
	Command-line options	`-Opa+, -Opa-`
	Bit values	`0, 1`
	A binary number	`'b00100, 'b10`
Italic Courier New	A variable argument	`file`.o, where `file` can be any valid filename
Square brackets [ ]	Optional arguments	`mcc18 [options] file [options]`
Curly brackets and pipe character: { | }	Choice of mutually exclusive arguments; an OR selection	`errorlevel {0|1}`
Ellipses...	Replaces repeated text	`var_name [, var_name...]`
	Represents code supplied by user	`void main (void) { ... }`

WARRANTY REGISTRATION

Please complete the enclosed Warranty Registration Card and mail it promptly. Sending in the Warranty Registration Card entitles users to receive new product updates. Interim software releases are available at the Microchip web site.

RECOMMENDED READING

This user's guide describes how to use the PICDEM™ Z Demonstration Kit. Other useful documents are listed below. The following Microchip documents are available and recommended as supplemental reference resources.

AN1232 "Microchip ZigBee-2006 Residential Stack Protocol" (DS01232)

AN1066, "MiWi™ Wireless Networking Protocol Stack" (DS01066)

AN1204, "Microchip MiWi P2P Wireless Protocol" (DS01204)

AN1192, "MRF24J40 Radio Driver Utility Program" (DS01192)

These application notes describe how you can use the Microchip wireless solutions to quickly build your application. To illustrate the usage of the Microchip Wireless Protocol Stack's working demo, applications are provided in their respective application notes. These demo applications can be used as a reference or simply modified and adapted to your requirements.

THE MICROCHIP WEB SITE

Microchip provides online support via our web site at 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 (FAQs), 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

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DEVELOPMENT SYSTEMS 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, click on Customer Change Notification and follow the registration instructions.

The Development Systems product group categories are:

- **Compilers** – The latest information on Microchip C compilers and other language tools. These include the MPLAB C18 and MPLAB C30 C compilers; MPASM™ and MPLAB ASM30 assemblers; MPLINK™ and MPLAB LINK30 object linkers; and MPLIB™ and MPLAB LIB30 object librarians.
- **Emulators** – The latest information on Microchip in-circuit emulators.This includes the MPLAB ICE 2000 and MPLAB ICE 4000.
- **In-Circuit Debuggers** – The latest information on the Microchip in-circuit debugger, MPLAB ICD 2.
- **MPLAB® IDE** – The latest information on Microchip MPLAB IDE, the Windows® Integrated Development Environment for development systems tools. This list is focused on the MPLAB IDE, MPLAB SIM simulator, MPLAB IDE Project Manager and general editing and debugging features.
- **Programmers** – The latest information on Microchip programmers. These include the MPLAB PM3 and PRO MATE II device programmers and the PICSTART® Plus and PICkit™ 1 development programmers.

CUSTOMER SUPPORT

Users of Microchip products can receive assistance through several channels:

- Distributor or Representative
- Local Sales Office
- Field Application Engineer (FAE)
- Technical Support

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

DOCUMENT REVISION HISTORY

Revision C (November 2008)

- Extensive rewrite of all sections.

Chapter 1. Overview

1.1 INTRODUCTION

This chapter introduces the PICDEM™ Z Demonstration Kit features. This chapter discusses:

- PICDEM™ Z Demonstration Kit Contents
- PICDEM Z Demonstration Kit
- PICDEM™ Z Motherboard
- Wireless Daughter Boards
- PICDEM™ Z CD-ROM

1.2 PICDEM™ Z DEMONSTRATION KIT CONTENTS

The PICDEM Z Demonstration Kit (Part Number DM163027-5) contains the following items:

1. Two PICDEM™ Z Motherboards
2. Two MRF24J40MA PICDEM Z 2.4 GHz RF Boards
3. PICDEM Z CD-ROM
4. ZENA™ Network Analyzer
5. USB Cable
6. ZENA CD-ROM

These items can be ordered separately. Table 1-1 lists the individual part numbers.

TABLE 1-1:   PICDEM™ Z COMPONENT PART NUMBERS

Description	Part Number
PICDEM™ Z Motherboard	AC163027-1
MRF24J40MA PICDEM Z 2.4 GHz RF Board	AC163028
ZENA™ Network Analyzer	DM183023

PICDEM Z Demonstration Kit User's Guide

FIGURE 1-1: **PICDEM™ Z DEMONSTRATION KIT**

1.3 PICDEM Z DEMONSTRATION KIT

The PICDEM Z Demonstration Kit allows developers to evaluate and develop with Microchip wireless solutions. The kit provides two motherboards and two 2.4 GHz MRF24J40MA daughter boards which can be used to form a simple two node wireless network. More nodes can be added by purchasing additional PICDEM Z Demonstration Kits or individual components (see Table 1-1).

The PICDEM Z Demonstration Kit comes preprogrammed with a wireless demo program. Refer to **Chapter 2. "Getting Started with the PICDEM™ Z Demonstration Kit"** to learn how to operate the preprogrammed demo program and how to load other Microchip Wireless Protocols for evaluation and development. Additional wireless protocols can be downloaded from the Microchip Wireless Design Center at http://www.microchip.com/wireless/.

The motherboard is powered by an external power supply via the 2.5 mm coaxial power connector (J1) or portably via a 9V battery (B1).

> **Note:** The 9V wall adapter and 9V battery are not included in the kit. A 9V wall adapter may be ordered from microchipDIRECT under part number AC162039.

The kit comes with the ZENA™ Network Analyzer that graphically displays wireless network traffic following the IEEE 802.15.4™ specification on the 2.4 GHz band. The ZENA Network Analyzer supports IEEE 802.15.4, ZigBee™ and MiWi™ protocols. The software can analyze complete network traffic and graphically display decoded packets. It can also display a graphical representation of the network topology and the messages as they flow through the network. This information can then be saved and/or exported for further analysis. Refer to the User's Guide (DS51606) for more information on the operation of the ZENA Network Analyzer.

Overview

1.4   PICDEM™ Z MOTHERBOARD

The PICDEM Z Motherboard contains many features to enable the evaluation and development of wireless solutions. Figure 1-2 shows the motherboard with a MRF24J40MA Module Daughter Board plugged in. Below is a description of the call outs in the figure. The motherboard schematic, PCB layout and bill of materials are available in Appendix A.

1. Microcontroller 28 and 40-pin DIP Sockets: The sockets allow the use of a variety of 28 and 40-pin DIP package PIC® microcontrollers. The 40-pin socket (U4) contains a PIC18LF4620 microcontroller clocked by a 4 MHz crystal (Y1). The 28-pin socket is unpopulated and is located under the 40-pin DIP package. To use the 28-pin connector, carefully remove the 40-pin DIP microcontroller.

2. Temperature Sensor: The motherboard contains the Microchip TC77 thermal sensor with SPI interface. The TC77 shares the SPI bus with the wireless daughter card plugged into connector J2.

3. LEDs: D1 and D2 are driven by microcontroller ports RA0 and RA1, respectively.

4. Push Button Switches: S2 and S3 are connected to microcontroller ports RB5 and RB4, respectively. There are no external pull-up resistors on the mother-board. Therefore, the internal pull-up on PORTB feature must be enabled.

5. MCLR Push Button Switch: Connected to the MCLR pin of the microcontroller.

6. ICSP™ Jack: The 6-pin RJ-11 jack is used to connect a microcontroller program-mer such as the MPLAB ICD 2 in-circuit debugger or MPLAB REAL ICE™ in-circuit emulator.

7. RS-232 Connector: Allows the motherboard to connect to a PC serial port for interactive control or debugging. The microcontroller USART interfaces to the RS-232 connector via a RS-232 level shifter (U5).

8. Wireless Daughter Card Connector: Connector J2 is a 12-pin connector that supplies 3.3V power, 4-wire SPI, reset, wake and interrupt connections to the micro-controller. The pinout is shown in Figure 1-3. The 12-pin connector is a Samtec P/N LST-106-07-F-D.

9. Prototyping Area: Provided to breadboard additional circuitry for development. Connections to +3.3V, ground and microcontroller I/O signals are provided.

10. Power: The motherboard is powered by an external power supply via the 2.5 mm coaxial power connector (J1) or portably via a 9V battery (B1). The on-board volt-age regulator (U2) is a LP2981, a micropower 100 mA ultra low-dropout regulator in a SOT-23 package. The maximum input voltage for the LP2981 is 16V. The motherboard is protected from accidental reverse power connection by diode D3. When using a 9V battery, S7 switches the power on and off. When powering via an external power supply, J1 will disconnect the battery from the circuit and power the circuit continuously (switch S7 only switches the battery on or off, not the external power source).

CAUTION

Do not exceed the combined current rating of 100 mA for all circuitry or the voltage regulator will overheat and possibly fail.

Note: A 9V wall adapter may be ordered from microchipDIRECT under part number AC162039.

---

11. Measure Current: Jumper JP4 can be used to measure the current draw by all the circuitry on the motherboard past the voltage regulator (U2). To measure the current, cut the PCB trace on the bottom side and insert an ampmeter. You can also install a low value resistor into position R9 and measure the voltage across to determine the current.

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TABLE 1-2: **JUMPERS**

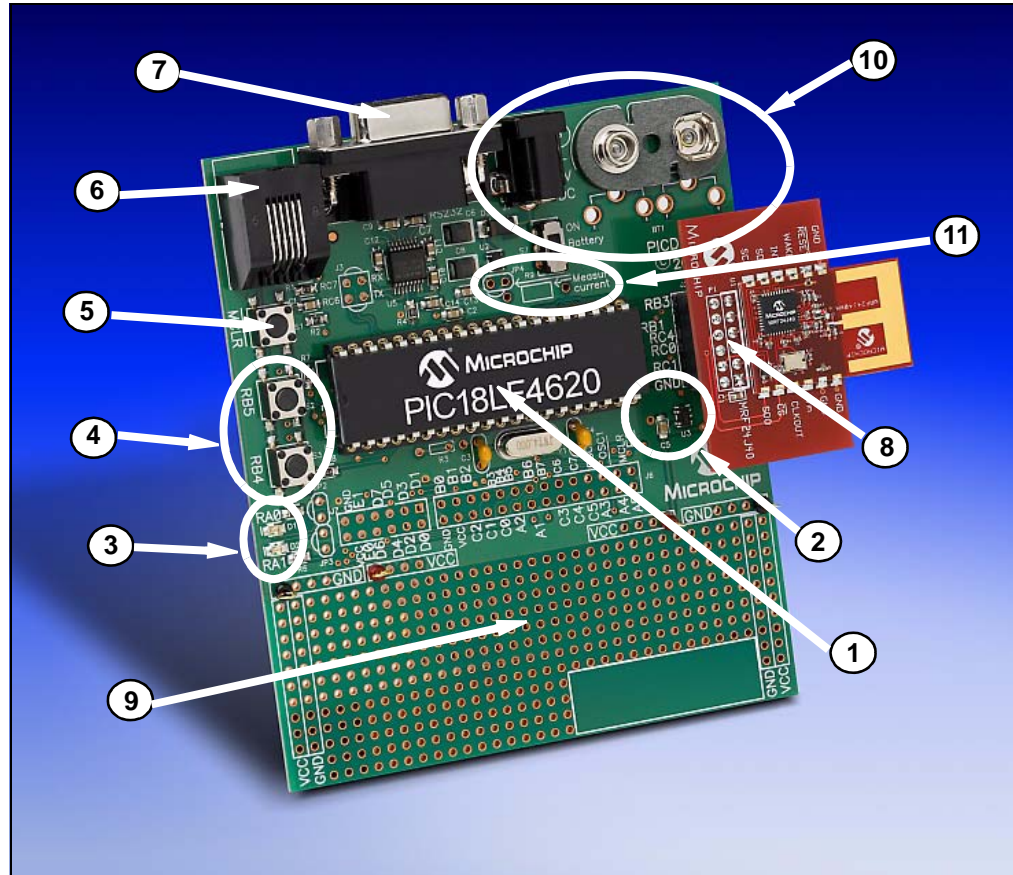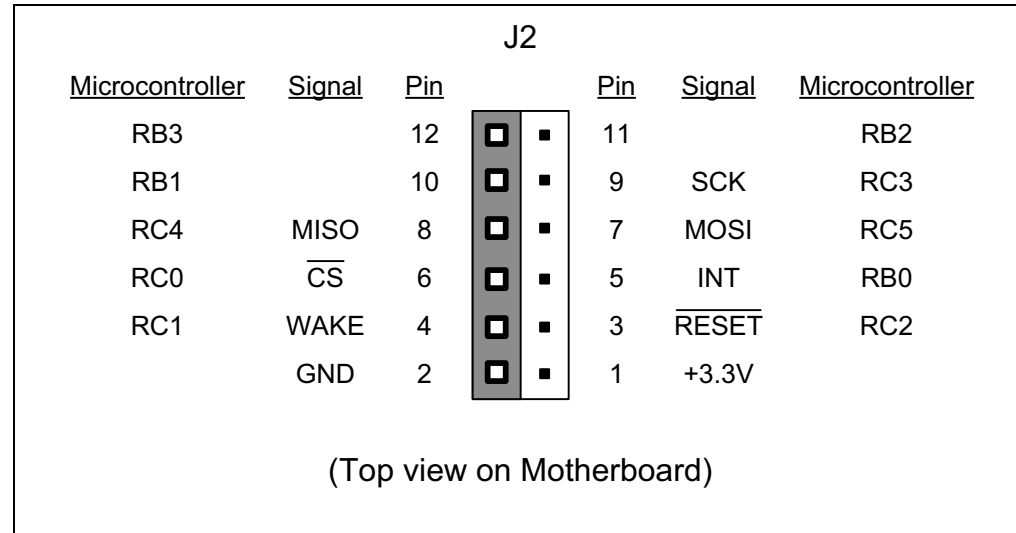| Jumper	Purpose
J3	To connect or disconnect the RS-232 level shifter U5 from the microcontroller USART. The pins are connected by PCB traces.
JP2	To enable or disable LED D1. The pins are connected by PCB traces.
JP3	To enable or disable LED D2. The pins are connected by PCB traces.
JP4	To measure current draw by all circuitry past the voltage regulator U2.

FIGURE 1-2: **PICDEM™ Z MOTHERBOARD**

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FIGURE 1-3: **CONNECTOR J2 PINOUT**

J2

Microcontroller	Signal	Pin			Pin	Signal	Microcontroller
RB3		12	□	▪	11		RB2
RB1		10	□	▪	9	SCK	RC3
RC4	MISO	8	□	▪	7	MOSI	RC5
RC0	$\overline{CS}$	6	□	▪	5	INT	RB0
RC1	WAKE	4	□	▪	3	$\overline{RESET}$	RC2
	GND	2	□	▪	1	+3.3V	

(Top view on Motherboard)

1.5   WIRELESS DAUGHTER BOARDS

The PICDEM Z Motherboard is designed to interface with a variety of wireless daughter boards via connector J2. Connector J2 is a 12-pin connector that supplies 3.3V power, 4-wire SPI, reset, wake and interrupt connections to the microcontroller. The pinout is shown in Figure 1-3. The 12-pin connector is a Samtec P/N LST-106-07-F-D.

1.6   PICDEM™ Z CD-ROM

The PICDEM Z CD-ROM contains documentation on the motherboard, wireless daughter boards, data sheets, application notes and wireless protocol software. Check the Microchip web site for the latest revisions http://www.microchip.com/wireless/.

NOTES:

Chapter 2. Getting Started with the PICDEM™ Z Demonstration Kit

2.1 INTRODUCTION

The PICDEM Z Demonstration Kit can be used with a variety of Microchip software protocol stacks or it can be used to develop proprietary protocol stacks. Microchip software protocol stacks are available as a free download, including source code, from the Microchip website: http://www.microchip.com/wireless/.

The PICDEM Z Demonstration Kit assumes that the user is familiar with Microchip PIC microcontrollers and development tools such as MPLAB IDE. There is a wealth of getting started information on the Microchip website http://www.microchip.com/. Select the *Design>Getting Started* links for more information about microcontrollers and development tools.

Topics covered in this chapter include:

- Microchip ZigBee-2006 Residential Stack Protocol
- Microchip MiWi™ Protocol
- Microchip MiWi P2P Protocol

2.2 MICROCHIP ZIGBEE-2006 RESIDENTIAL STACK PROTOCOL

The ZigBee protocol is a wireless network protocol specifically designed for low data rate, low-cost wireless sensors and control networks. It is based on the IEEE 802.15.4 global standard ensuring interoperability and reliable communication. ZigBee protocol supports star, cluster and mesh wireless network topologies making it well suited for short range and low-power applications. The Microchip ZigBee-2006 protocol is certified to run on the PIC18 and PIC24 families of Microchip PIC microcontrollers and the MRF24J40 2.4 GHz RF Transceiver.

The software stack is available on the PICDEM Z CD-ROM. Check the Microchip web site for the latest revision at http://www.microchip.com/wireless/. Once the software stack is installed, the source code and documentation are available at:
`C:\Microchip Solutions\ZigBee2006Res\`

The PICDEM Z Demonstration Kit is preprogrammed with a ZigBee protocol demo program. Please refer to the "Getting Started: Running the ZigBee-2006 Demo" document located in the directory: `C:\Microchip Solutions\ZigBee2006Res\`

Complete documentation is available in application note A*N1232, "Microchip ZigBee-2006 Residential Stack Protocol"* (DS01232).

PICDEM Z Demonstration Kit User's Guide

2.3   MICROCHIP MiWi™ PROTOCOL

The MiWi Wireless Networking Protocol is a simple protocol designed for low data rate, short distance, low-cost networks. It is an application layer on top of the IEEE 802.15.4 MAC and PHY layers. The MiWi protocol provides an easy-to-use alternative for wireless communication. In particular, it targets smaller applications that have relatively small network sizes with few hops between nodes. The MiWi protocol runs on a variety of Microchip PIC microcontrollers in the PIC18, PIC24 and PIC32 families and the MRF24J40 2.4 GHz RF Transceiver.

The software stack is available on the PICDEM Z CD-ROM. Check the Microchip web site for the latest revision http://www.microchip.com/wireless/. Once the software stack is installed, the source code and documentation are available at:
`C:\Microchip Solutions\MiWi\`

To load and run the MiWi Protocol demonstration program, please refer to the "Getting Started: Running the MiWi™ demo" document located in the above directory.

Complete documentation is available in application note *AN1066, "MiWi™ Wireless Networking Protocol Stack"* (DS01066).

2.4   MICROCHIP MiWi P2P PROTOCOL

The MiWi Peer-to-Peer (P2P) protocol is an application layer on top of the IEEE 802.15.4 MAC and PHY layers that supports peer-to-peer and star topologies. It has no routing mechanism, so the wireless communication coverage is defined by the radio range. Application note *AN1204, "Microchip MiWi P2P Wireless Protocol"* describes the MiWi P2P protocol. It details the supported features and how to implement them. Simple application level data structures and programming interfaces are also described. The MiWi P2P protocol runs on a variety of Microchip PIC microcontrollers in the PIC18, PIC24 and PIC32 families and the MRF24J40 2.4 GHz RF Transceiver.

The software stack is available on the PICDEM Z CD-ROM. Check the Microchip web site for the latest revision at http://www.microchip.com/wireless/. Once the software stack is installed, the source code and documentation are available at:
`C:\Microchip Solutions\P2P\`

To load and run the MiWi P2P Protocol demonstration program, please refer to the "Getting Started: Running the MiWi™ P2P demo" document located in the above directory.

Complete documentation is available in application note *AN1204, "Microchip MiWi P2P Wireless Protocol"* (DS01204).

Appendix A. PICDEM™ Z Motherboard Schematics

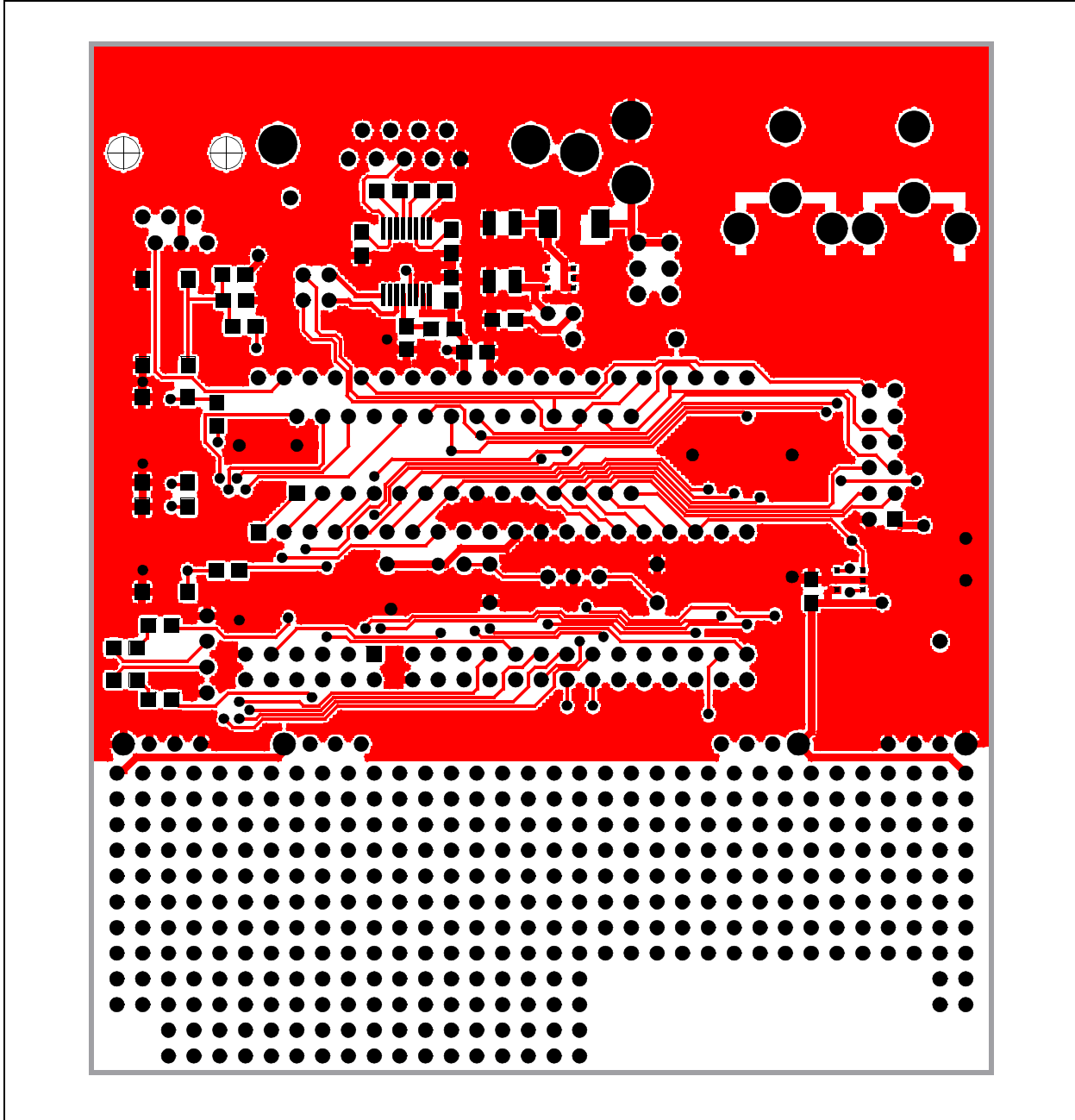## A.1   PICDEM Z MOTHERBOARD SCHEMATICS

The PICDEM Z motherboard schematics are shown here. The RF daughter card schematics are found in the appendices that follow.

Topic included in this appendix are:

- PICDEM Z Motherboard Schematics
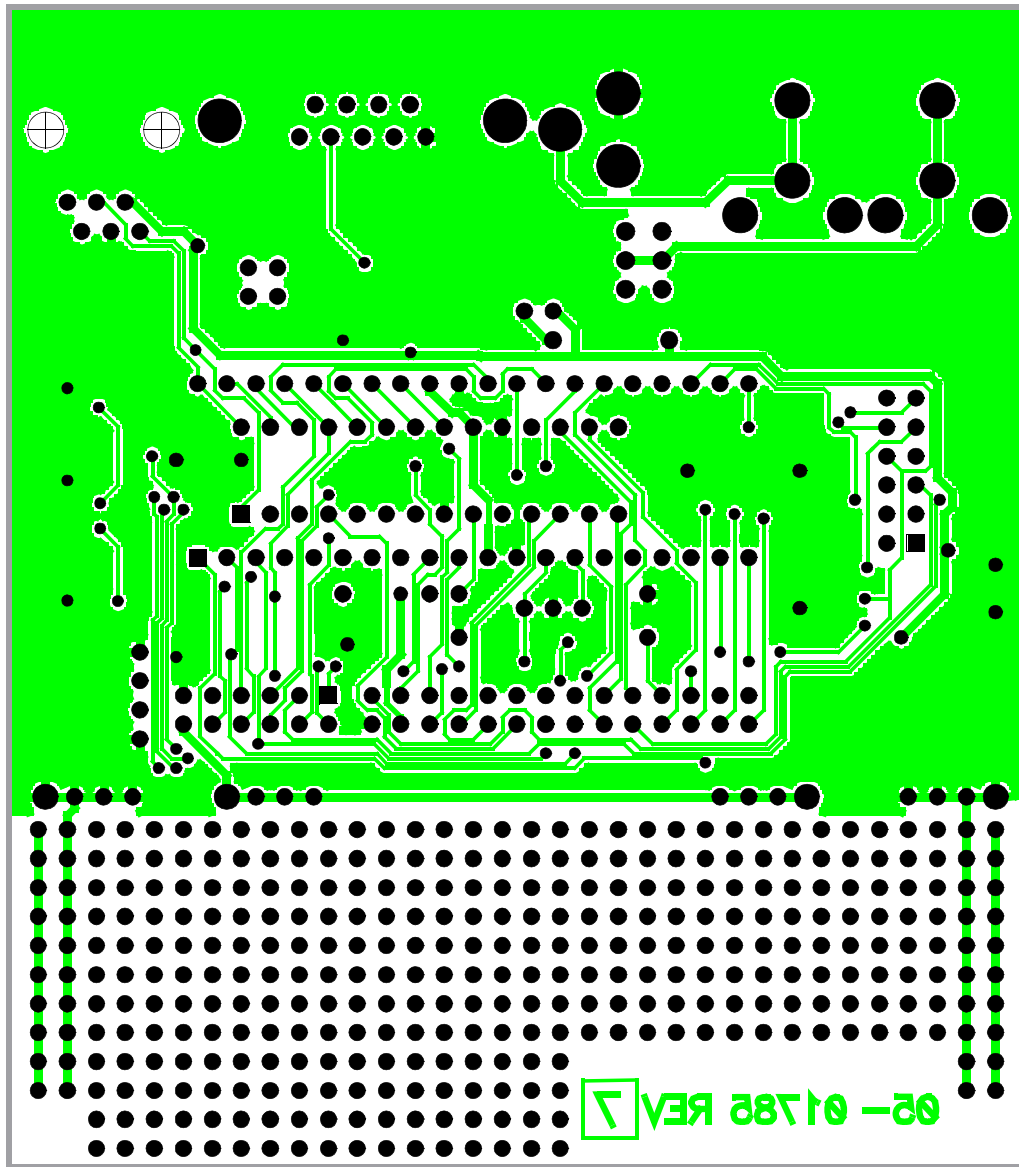- PICDEM Z Motherboard Bill of Materials

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FIGURE A-1: PICDEM™ Z MOTHERBOARD

FIGURE A-2: PICDEM™ Z MOTHERBOARD TOP ASSEMBLY

PICDEM Z Demonstration Kit User's Guide

FIGURE A-3: **PICDEM™ Z MOTHERBOARD LAYER 1**

FIGURE A-4: **PICDEM™ Z MOTHERBOARD LAYER 2**

PICDEM Z Demonstration Kit User's Guide

A.2 PICDEM Z MOTHERBOARD BILL OF MATERIALS

TABLE A-1: PICDEM™ Z MOTHERBOARD BILL OF MATERIALS (BOM)

Reference	Description	Vendor	Vendor P/N
D3	Diode Schottky 20V 1A SMD MELF	Diodes Inc.	1N5817M-13
BT1	Conn Batt Male 9V Horz Snap-on	Keystone Electronics	593
BT1	Conn Batt Fem 9V Horz Snap-on	Keystone Electronics	594
	Conn PC Vert 9V Snap-on	Keystone Electronics	968
C3, C4	22 pF 100V 5% Monolith Cerm Cap	Panasonic - ECG	ECU-S2A220JCA
C1, C2, C5, C7, C9, C10, C11, C12, C13, C14	Cap .1 µF 16V Ceramic X7R 0805	Panasonic - ECG	ECJ-2VB1C104K
C6	Capacitor Tant 2.2 µF 25V 10% SMD	Kemet	T491B225K025AS
C8	Capacitor Tant 3.3 µF 16V 10% SMD	Kemet	T491B335K016AS
Y1	Crystal 4.000 MHz 20 pF HC-49/US	ECS Inc.	ECS-40-20-4
P1	DB9 F		
J1	Conn Powerjack Mini .1" R/A PCMT	Switchcraft Inc.	RAPC712
J3			
J2	2 x 6 .100" Socket/Terminal	Samtec	LST-106-07-F-D
JP2, JP3, JP4			
D1, D2	LED Thin 565NM Grn Diff 0805 SMD	Lumex Opto	SML-LXT0805GW-TR
U2	IC Reg LDO Micropower SOT23-5	National Semiconductor	LP2981AIM5-3.3
U5		Maxim	MAX3221CAE
U1	28-pin Socket	Mill-Max	110-99-328-41-001
U4	40-pin Socket (needs to have no internal ribs)	Mill-Max	110-99-640-41-001
U4	PIC® MCU	Microchip	PIC18LF4620-I/P
R3	No Load		
R5, R6	Res 330 OHM 1/8W 5% 0805 SMD	Yageo America	9C08052A3300JLHFT
R2, R7, R8	Res 470 OHM 1/8W 5% 0805 SMD	Yageo America	9C08052A4700JLHFT
R1	Res 4.7K OHM 1/8W 5% 0805 SMD	Yageo America	9C08052A4701JLHFT
R4	Res 1.0M OHM 1/8W 5% 0805 SMD	Yageo America	9C08052A1004JLHFT
J5	Conn Mod Jack 6-6 R/A PCB 50AU	AMP/Tyco	520470-3
S1, S2, S3	Switch Tact 6MM SMD MOM 230GF	Omron Electronics	B3S-1002
S7	Switch Slide SPDT PC MNT L = 2 MM	E-Switch, Inc.	EG1271
U3	IC Sensor Thermal SPI 3.3V SOT235	Microchip	TC77-3.3MCTTR
	Test Point PC Multi-Purpose Blk	Keystone Electronics	5011
	Test Point PC Multi-Purpose Red	Keystone Electronics	5010

Appendix B. MRF24J40MA PICDEM Z 2.4 GHz RF Board

B.1 INTRODUCTION

This appendix describes the MRF24J40MA Z 2.4 GHz RF Board. Topics covered in this appendix include:

- MRF24J40MA PICDEM Z 2.4 GHz RF Board
- Schematic
- PCB Layout
- Bill of Materials

B.2 MRF24J40MA PICDEM Z 2.4 GHz RF BOARD

The MRF24J40MA PICDEM Z 2.4GHz RF Board (AC163028) is shown in Figure B-1. It features the MRF24J40MA transceiver module. The MRF24J40MA is a fully FCC, IC and ETSI certified module. It is designed to plug into the PICDEM Z Motherboard, or to any application, using a 12-pin connector. The 12-pin connector is available from Samtec P/N LST-106-07-F-D.

For more information about the MRF24J40 IC and module, refer to:

"MRF24J40 2.4 GHz IEEE 802.15.4 RF Transceiver Data Sheet" (DS39776)

"MRF24J40MA 2.4 GHz IEEE 802.15.4 RF Transceiver Module Data Sheet" (DS70329)

Features of the PICDEM Z MRF24J40 2.4 GHz RF Board include:

1. MRF24J40MA Transceiver Module (U1): An IEEE 802.15.4 compliant transceiver module.
2. Daughter Card Connector (P1): Connector P1 is a 12-pin connector used to connect to the PICDEM Z Motherboard or any application with a mating connector. It supplies 3.3V power, 4-wire SPI, reset, wake and interrupt connections to the MRF24J40MA. The pinout is shown in Figure B-2. The 12-pin connector is a Samtec P/N LST-106-07-F-D.
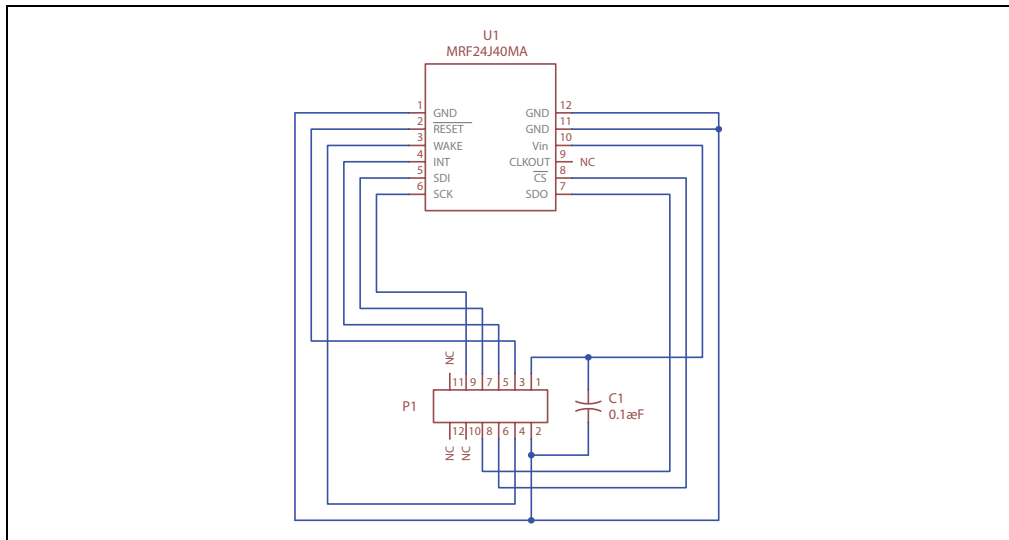
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FIGURE B-1: **MRF24J40MA PICDEM™ Z 2.4 GHz RF BOARD**
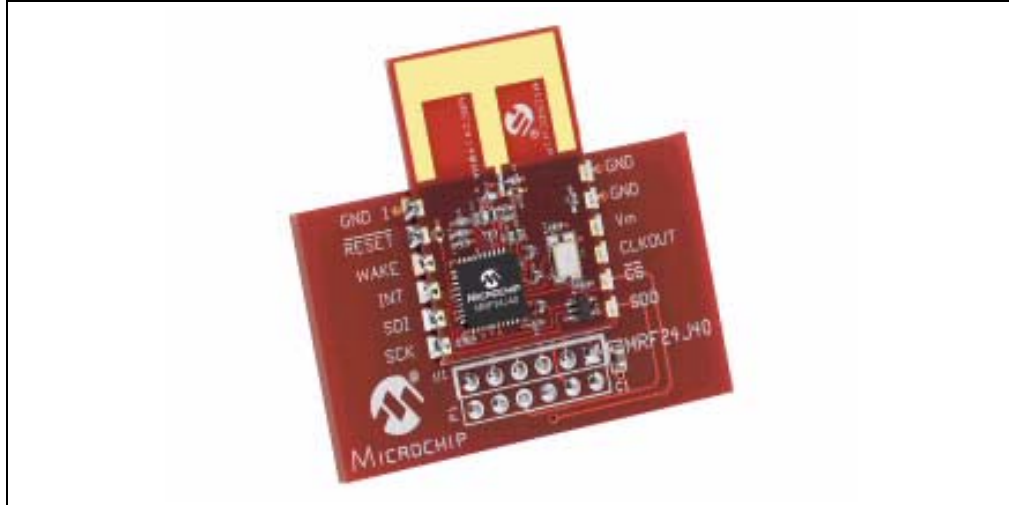
B.3 SCHEMATIC

The schematic for the MRF24J40MA module is available in the MRF24J40MA Data Sheet (DS70329). Figure B-2 shows the schematic of the daughter board with the MRF24J40MA module mounted on it.

FIGURE B-2: **MRF24J40MA PICDEM™ Z GHZ RF BOARD SCHEMATIC**

B.4 PCB LAYOUT

Figure B-3 through Figure B-6 show the PCB layout of the daughter board without the MRF24J40MA module mounted on it.

FIGURE B-3:   **TOP SILKSCREEN**
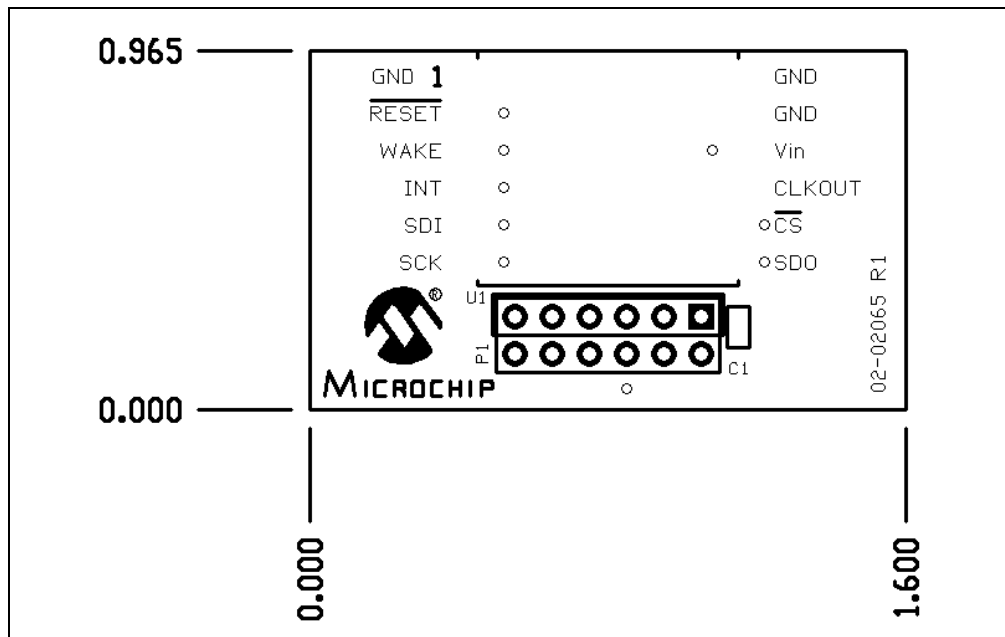
FIGURE B-4:   **TOP COPPER**
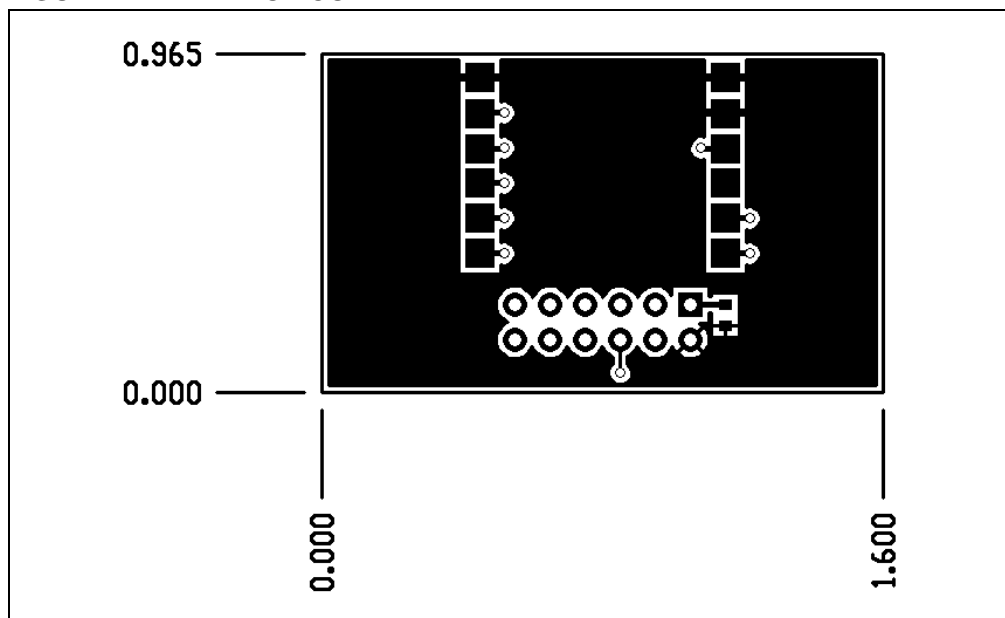
FIGURE B-5: **BOTTOM COPPER**
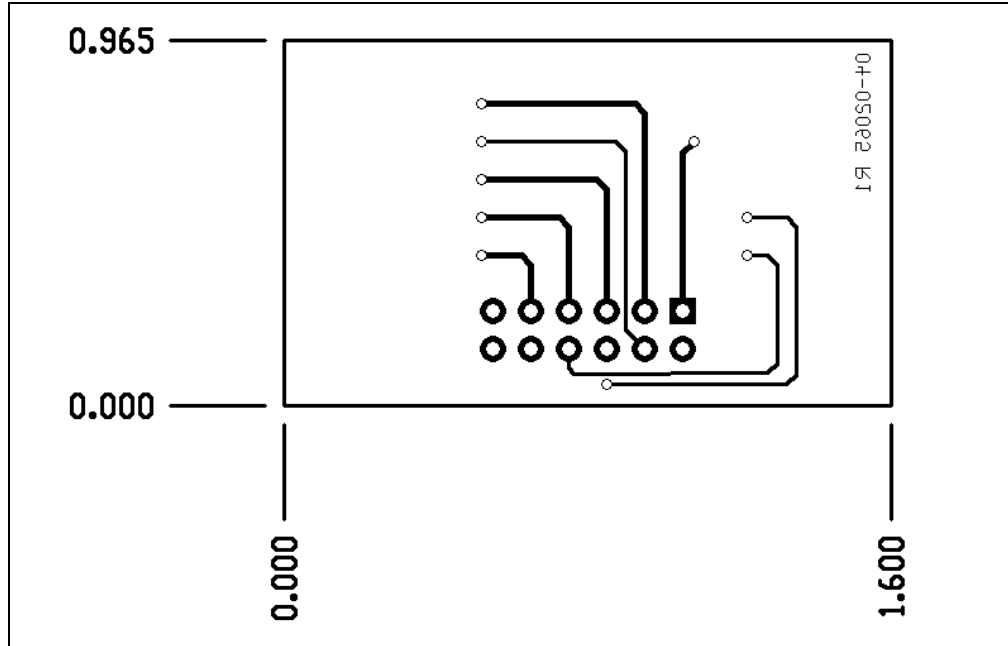
FIGURE B-6: **BOTTOM SILKSCREEN**
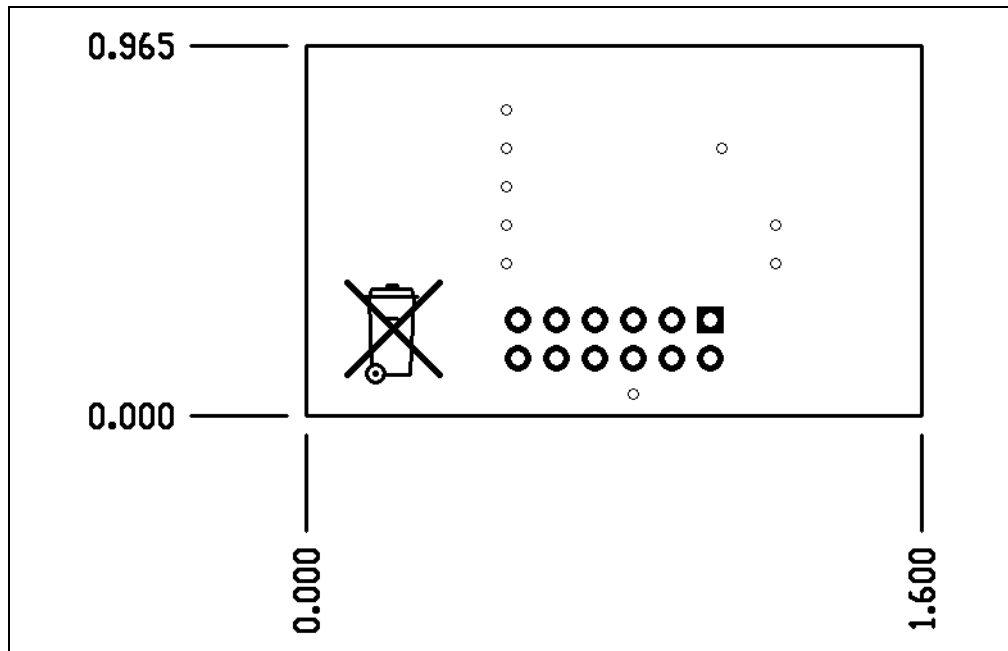
B.5   BILL OF MATERIALS

TABLE B-1:   BILL OF MATERIALS

Reference Designator	Value	Description
U1	MRF24J40MA	IEEE 802.15.4™ Transceiver Module
C1	0.1 uF, 16V, X7R, 10%, 0603	Capacitor, Ceramic
P1	LST-106-07-F-D	Samtec Connector 2x6 Header with Locking Socket

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NOTES:

Appendix C. PICDEM™ Z 2.4 GHz RF Card

C.1   INTRODUCTION

This appendix describes the PICDEM Z MRF24J40 2.4 GHz Daughter Card. Topics discussed in this chapter are:

- The PICDEM™ Z MRF24J40 2.4 GHz Daughter Card
- Schematic
- PCB Layout
- PICDEM Z MRF24J40 Daughter Card Bill of Materials
- PCB Antenna Details

C.2   THE PICDEM™ Z MRF24J40 2.4 GHz DAUGHTER CARD

The PICDEM Z MRF24J40 2.4 GHz Daughter Card (AC163027-4) is shown in Figure C-1. It features the MRF24J40 transceiver IC, all passive circuitry, PCB antenna, and optional SMA connector footprint. It is designed to plug into the PICDEM Z Motherboard, or to any application, using a 12-pin connector or Explorer 16 Development Board using the side edge connector.

The PICDEM Z MRF24J40 2.4 GHz Daughter Card is a good platform to evaluate an inverted F-type PCB antenna. The optional SMA connector can be populated to evaluate external antenna options or to connect to test equipment for measurement.

The PICDEM Z MRF24J40 2.4 GHz Daughter Card may be used as a reference design. The Gerber files are available for download on the at Microchip website http://www.microchip.com/wireless/ and on the PICDEM Z CD-ROM.

More information about the MRF24J40 IC, refer to:

"MRF24J40 2.4 GHz IEEE 802.15.4 RF Transceiver Data Sheet" (DS39776)

Features of the PICDEM Z MRF24J40 2.4 GHz Daughter Card include:

1. MRF24J40 Transceiver IC (U1): An IEEE 802.15.4 compliant transceiver IC in a 40-pin QFN package.
2. Daughter Card Connector (J2): Connector J2 is a 12-pin connector used to connect to the PICDEM Z Motherboard or any application with a mating connector. It supplies 3.3V power, 4-wire SPI, reset, wake and interrupt connections to the MRF24J40. The pinout is shown in Figure C-2. The 12-pin connector is a Samtec P/N LST-106-07-F-D.
3. PCB Edge Connector (J3): Connector J3 is a 30-pin connector used to connect to the Explorer 16 Development Board. It supplies 3.3V power, 4-wire SPI, reset, wake and interrupt connections to the MRF24J40. The pinout is shown in Figure C-2.
4. PCB Antenna: An inverted F-type PCB antenna.
5. Optional SMA Connector (P5): The SMA footprint may be populated with an SMA connector for connecting to an external antenna or test equipment. The PCB antenna is connected by default. To enable the SMA connector and disable the PCB antenna, removed capacitor C38 and move it to position C8.

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> **Note:** The MRF24J40 SDO pin 17 defaults to a low state when nCS is high (the MRF24J40 is not selected). If the MRF24J40 Daughter Card is to share an SPI bus, a tri-state buffer can be placed on the SDO signal to provide a high-impedance signal to the SPI bus. Refer to the *"MRF24J40 Data Sheet"* (DS39776) for more information.

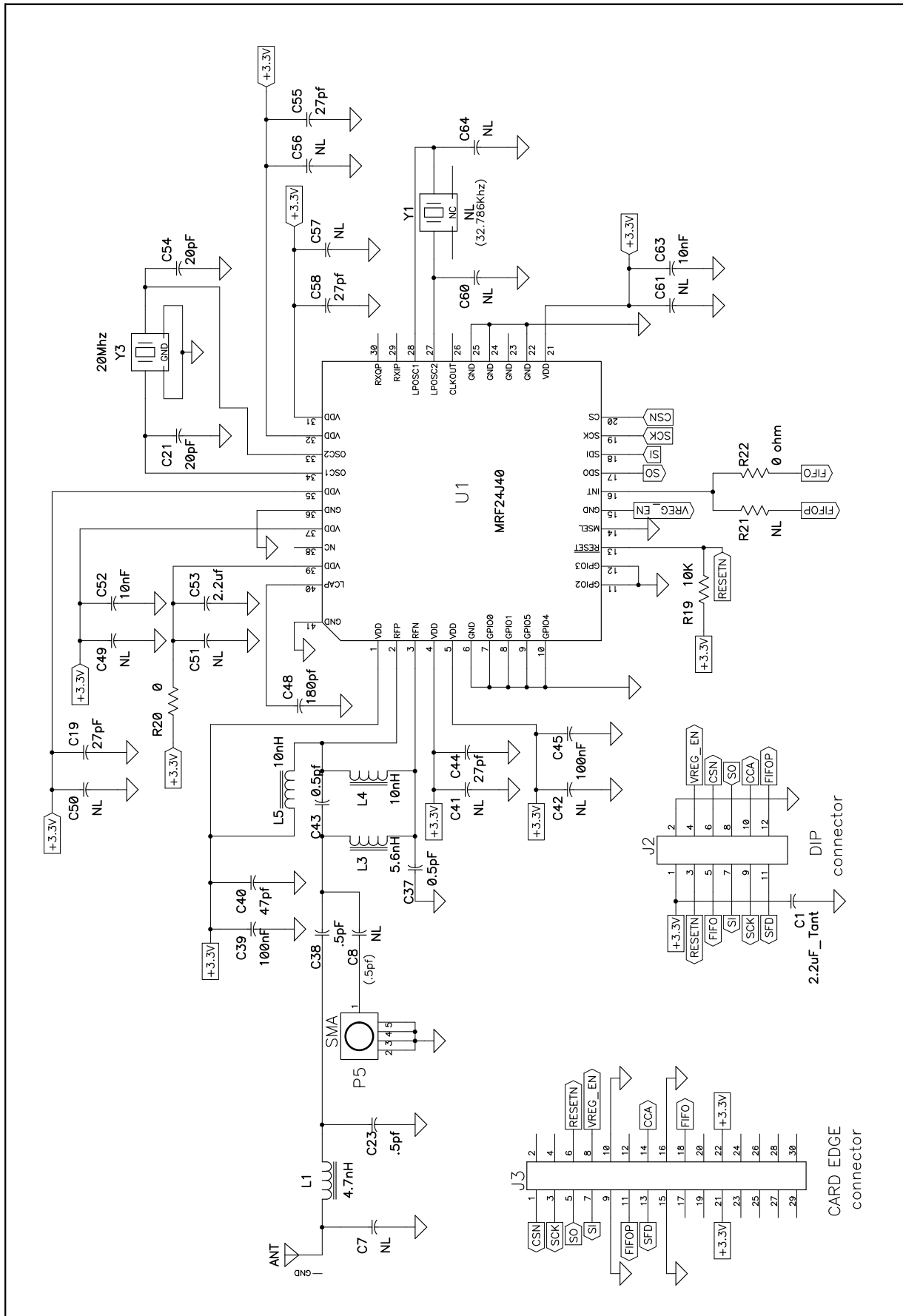**FIGURE C-1:   PICDEM™ Z MRF24J40 2.4 GHZ DAUGHTER CARD**

C.3   SCHEMATIC

The PICDEM Z MRF24J40 2.4 GHz Daughter Card schematic is shown in Figure C-2.

FIGURE C-2: **PICDEM Z MRF24J40 2.4 GHZ DAUGHTER CARD SCHEMATIC**
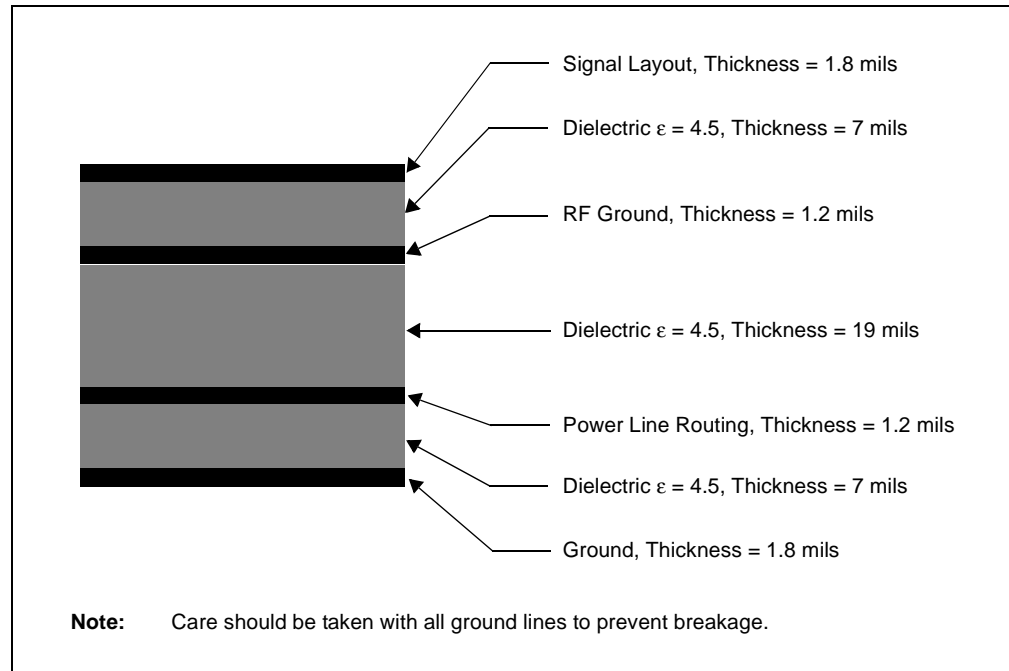
C.4   PCB LAYOUT

The PICDEM Z MRF24J40 2.4 GHz Daughter Card is fabricated as a four layer PCB. The material is FR4 with signal traces in 0.5 oz copper. Figure C-4 through Figure C-9 show the individual layers from top to bottom. Figure C-10 shows the layer stack up.

The following guidelines are intended to aid users in high-frequency PCB layout design. The printed circuit board is comprised of four basic FR4 layers: signal layout, RF ground, power line routing and ground (see Figure C-3). The guidelines will explain the requirements of these layers.

FIGURE C-3:   FOUR BASIC COPPER FR4 LAYERS

Signal Layout, Thickness = 1.8 mils

Dielectric ε = 4.5, Thickness = 7 mils

RF Ground, Thickness = 1.2 mils

Dielectric ε = 4.5, Thickness = 19 mils

Power Line Routing, Thickness = 1.2 mils

Dielectric ε = 4.5, Thickness = 7 mils

Ground, Thickness = 1.8 mils

Note: Care should be taken with all ground lines to prevent breakage.

• It is important to keep the original PCB thickness since any change will affect antenna performance (see total thickness of dielectric) or microstrip lines characteristic impedance.

• The first layer width of a 50Ω characteristic impedance microstrip line is 12 mils.

• Avoid having microstrip lines longer than 2.5 cm, since that line might get very close to a quarter wave length of the working frequency of the board which is 3.0 cm, and start behaving as an antenna.

• Except for the antenna layout, avoid sharp corners since they can act as an antenna. Round corners will eliminate possible future EMI problems.

• Digital lines by definition are prone to be very noisy when handling periodic waveforms and fast clock/switching rates. Avoid laying out a RF signal close to any digital lines.

• A via filled ground patch underneath the IC transceiver is mandatory.

• A power supply must be distributed to each pin in a star topology and low-ESR capacitors must be placed at each pin for proper decoupling noise.

• Thorough decoupling on each power pin is beneficial for reducing in-band transceiver noise, particularly when this noise degrades performance. Usually, low value caps (27-47 pF) combined with large value caps (100 nF) will cover a large spectrum of frequency.

• Passive components (inductors) must be in the high-frequency category and the SRF (Self-Resonant Frequency) should be at least two times higher than the operating frequency.
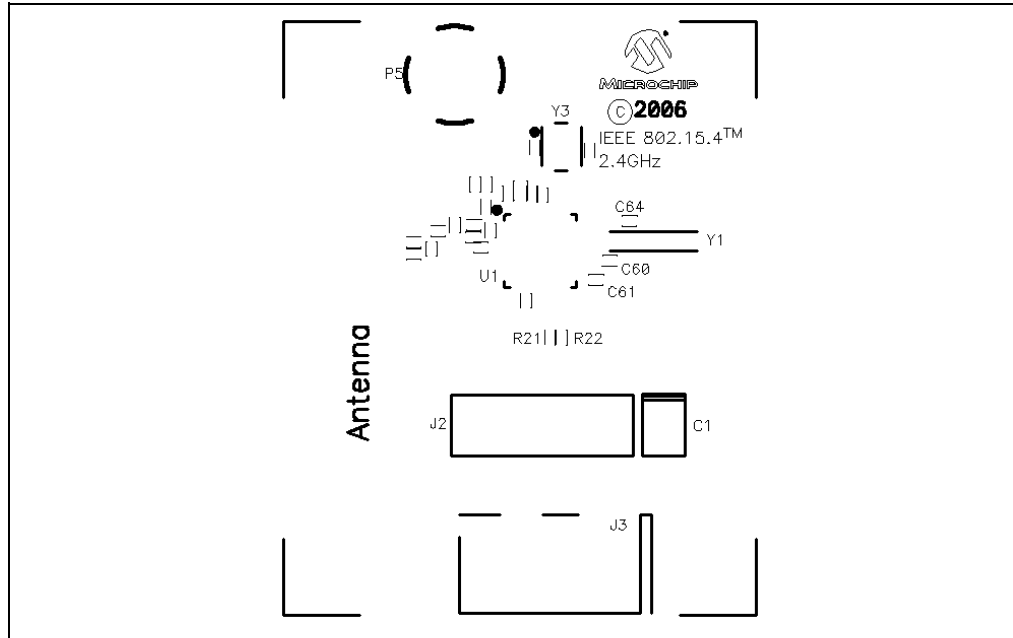
FIGURE C-4: **TOP SILKSCREEN**
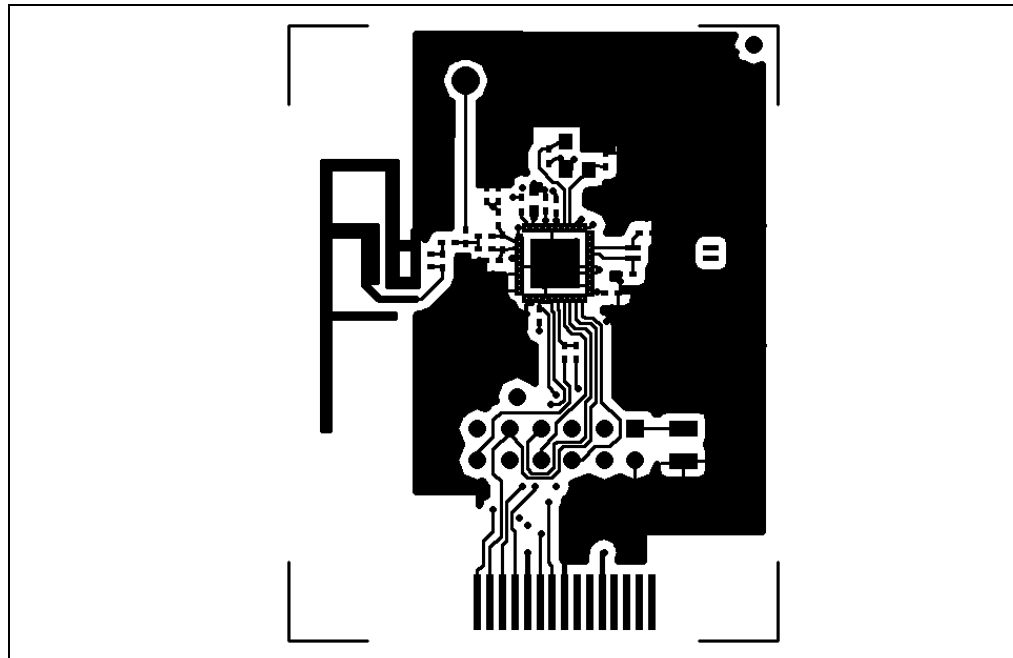

FIGURE C-5: **TOP COPPER – LAYER 1**

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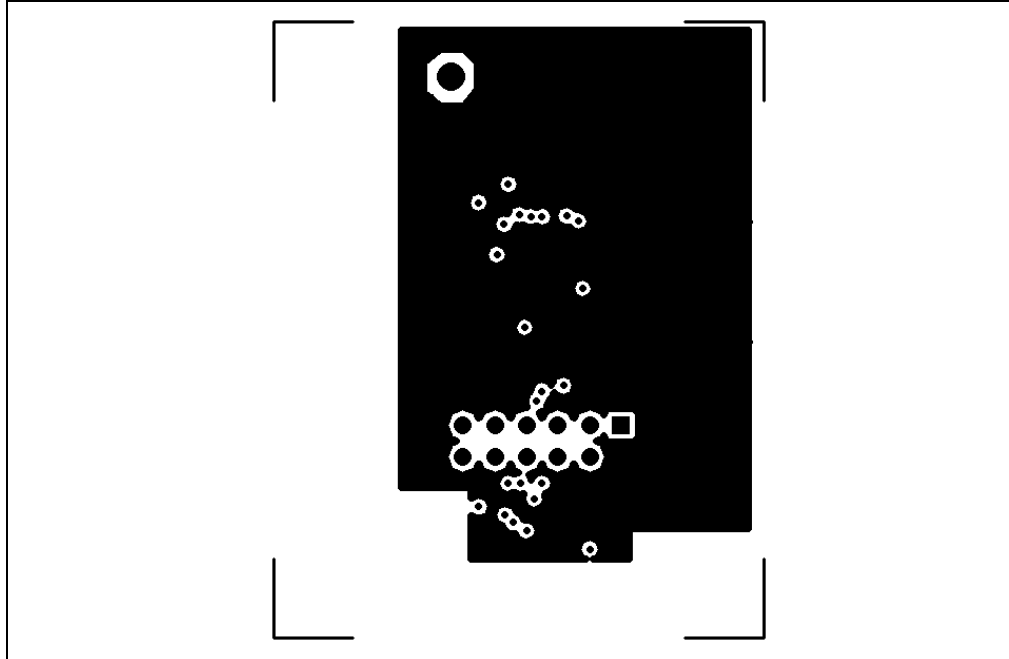**FIGURE C-6:**   **GROUND PLANE – LAYER 2**
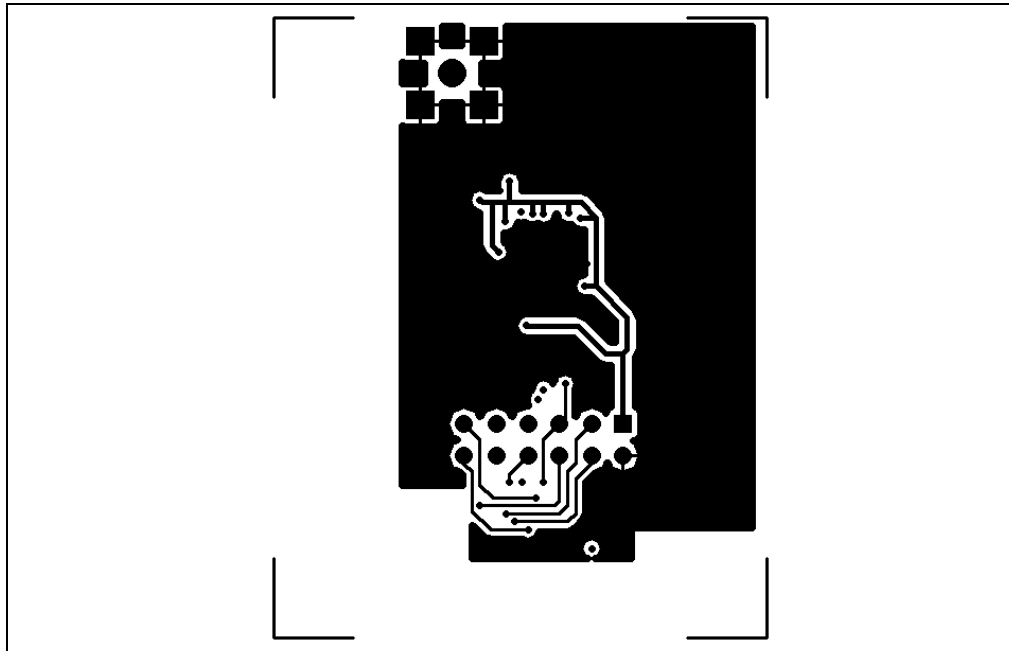

FIGURE C-7:   **POWER PLANE – LAYER 3**

FIGURE C-8:   BOTTOM COPPER – LAYER 4
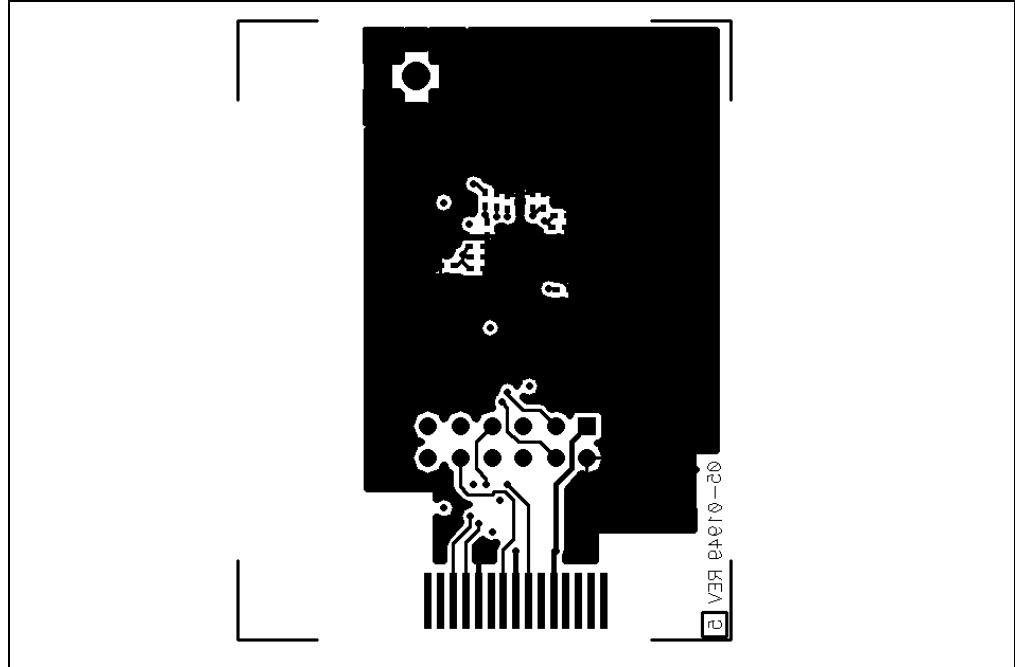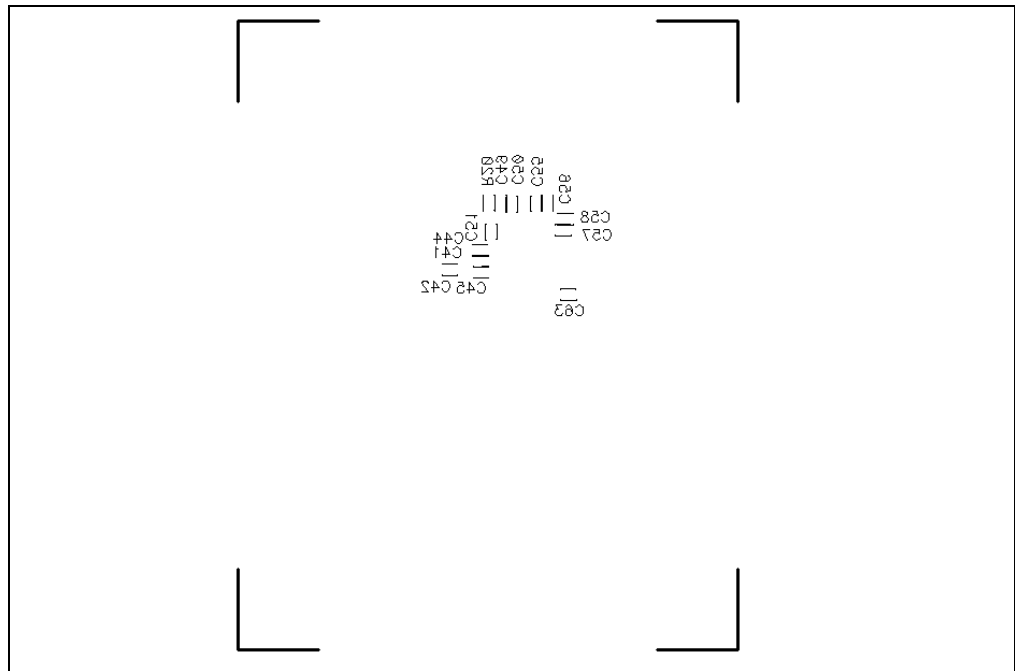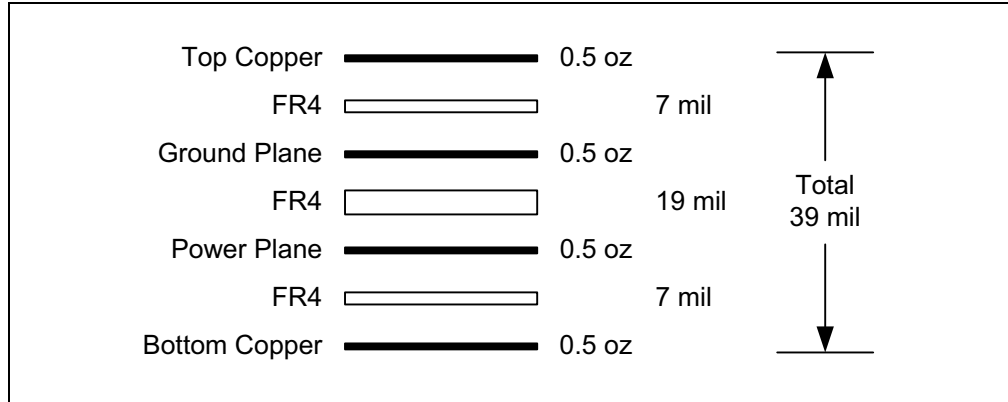

FIGURE C-9:   BOTTOM SILKSCREEN

FIGURE C-10:   PCB STACKUP

Top Copper	0.5 oz	
FR4	7 mil	
Ground Plane	0.5 oz	
FR4	19 mil	Total 39 mil
Power Plane	0.5 oz	
FR4	7 mil	
Bottom Copper	0.5 oz	

C.5   PICDEM Z MRF24J40 DAUGHTER CARD BILL OF MATERIALS

TABLE C-1:   MRF24J40 DAUGHTER CARD BILL OF MATERIALS[1]

Quantity	Component Name	Reference Description	Value	Description	Vendor	Vendor #
1	CAP3528	C1	2.2 µF_Tant	Capacitor TANT, 2.2 µF, 25V, 10%, SMD	Kemet	T491B225K025AT
4	CAP0402	C23, C37, C38, C43	0.5 pF	CAP, Ceramic, 0.5 pF, 50V, NP0, 0402	Yageo America	0402CG508C9B200
2	CAP0402	C21, C54	20 pF	CAP, Ceramic, 20 pF, 50V, 5%, C0G, 0402	Murata Electronics	GRM1555C1H200JZ01D
4	CAP0402	C19, C44, C55, C58	27 pF	CAP, Ceramic, 27 pF, 50V, 0402, SMD	Panasonic - ECG	ECJ-0EC1H270J
1	CAP0402	C40	47 pF	CAP, Ceramic, 47 pF, 50V, C0G, 5%, 0402	TDK Corporation	C1005C0G1H470J
2	CAP0402	C52, C63	10 nF	CAP, Ceramic, 10000 pF, 16V, X7R, 0402	Kemet	C0402C103K4RACTU
2	CAP0402	C39, C45	100 nF	CAP, Ceramic, 100 nF, 10V, X7R, 10%, 0402	Kemet	C0402C104K8PACTU
1	CAP0402	C48	180 pF	CAP, Ceramic, 180 pF, 50V, C0G, 5%, 0402	TDK Corporation	C1005C0G1H181J
1	CAP0603	C53	2.2 µF	CAP, Ceramic, 2.2 µF, 10V, Y5V, 0603	Taiyo Yuden	LMK107F225ZA-T
1	CRYSTAL_ABM8	Y3	20 MHz	Crystal, 20.000 MHz, 18 pF, FUND, SMD	Abracon Corporation	ABM8-20.000MHZ-B2-T
1	MRF24J40_I/ML	U1		MRF24J40, Single Chip Transceiver	Microchip	MRF24J40-I/ML
1	IND0402	L1	4.7 nH	Inductor Multilayer, 4.7 nH, 0402	TDK Corporation	MLK1005S4N7S
1	IND0402	L3	5.6 nH	Inductor Multilayer, 5.6 nH, 0402	TDK Corporation	MLK1005S5N6D
2	IND0402	L4, L5	10 nH	Inductor Multilayer, 10 nH, 0402	TDK Corporation	MLK1005S10NJ
2	RES0402	R20, R22	0Ω	RES, 0Ω, 1/16W, 5%, 0402, SMD	Panasonic - ECG	ERJ-2GE0R00X
1	RES0402	R19	10K	RES, 10 kΩ, 1/16W, 5%, 0402, SMD	Yageo America	RC0402JR-0710KL
1	HDR6X2	J2		.100" Socket/Terminal	Samtec	LST-106-07-F-D

Note 1:   Not placed: C7, C8, C41, C42, P5 and Y1.

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C.6   PCB ANTENNA DETAILS

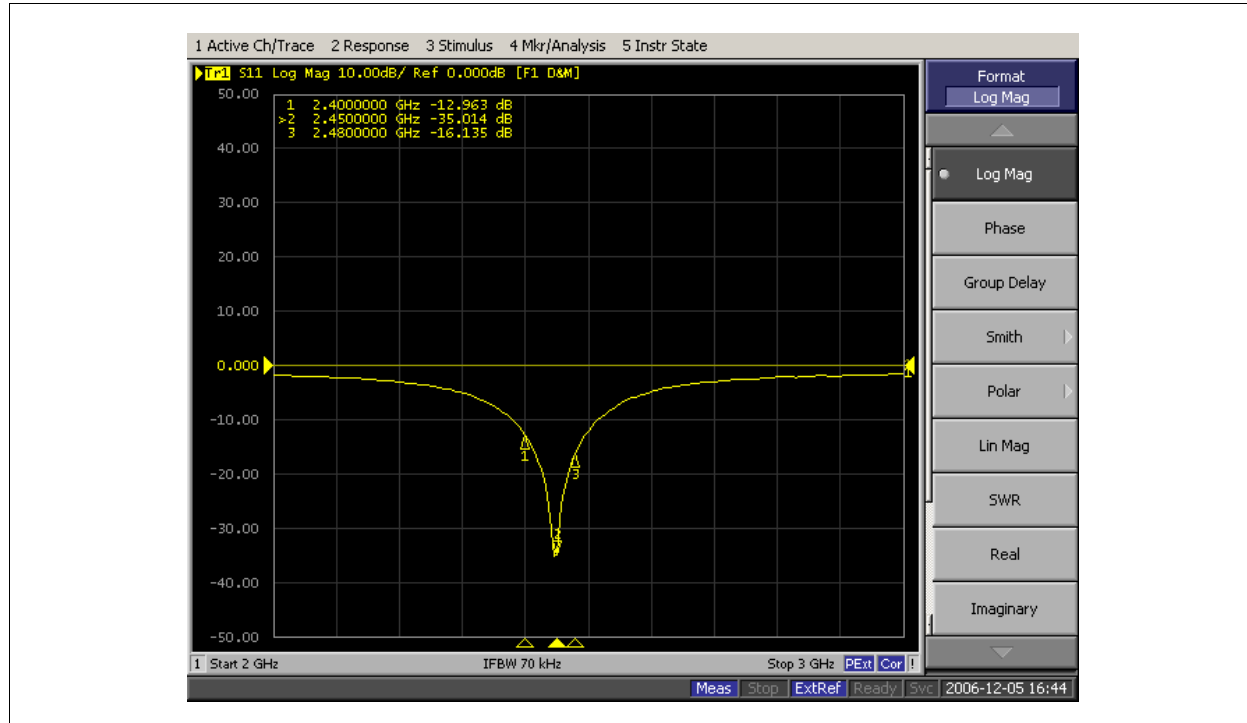**FIGURE C-11:   IMPEDANCE OF THE PCB ANTENNA**

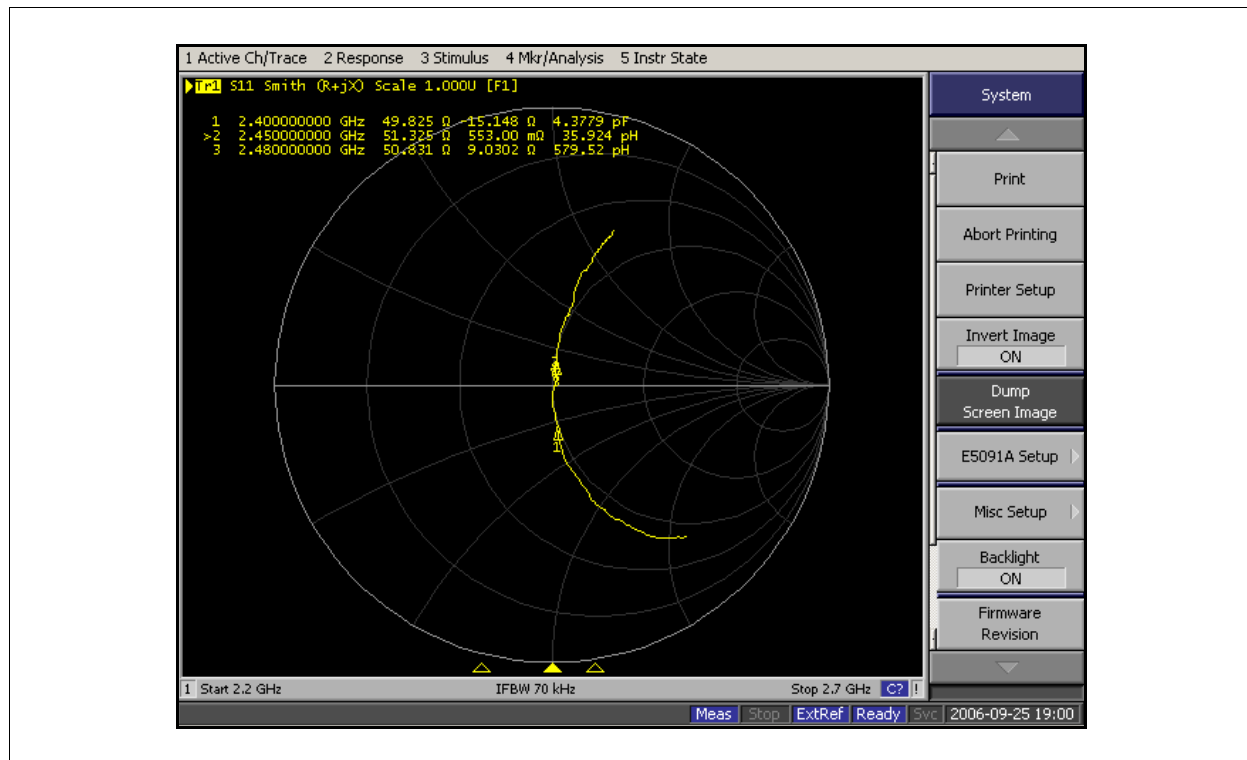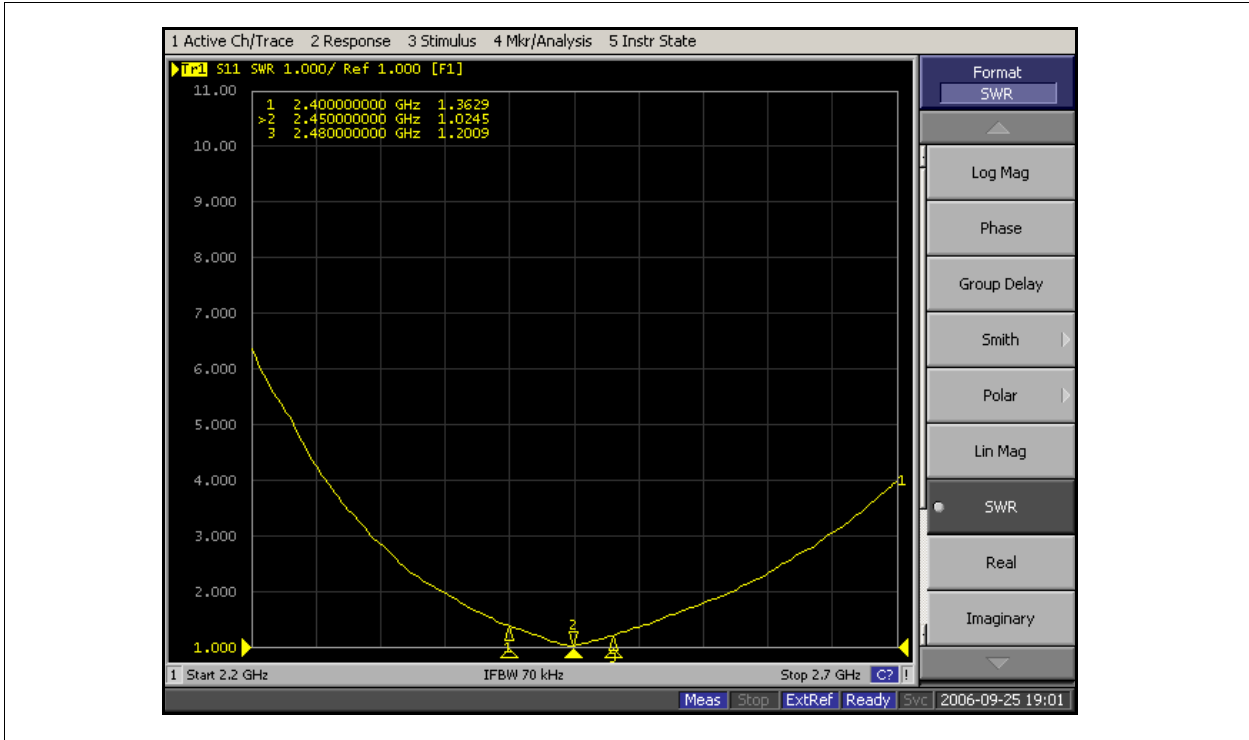**FIGURE C-12:   IMPEDANCE OF THE PCB ANTENNA IN SMITH CHART**

FIGURE C-13: IMPEDANCE OF THE PCB ANTENNA WITH VOLTAGE STANDING WAVE RATIO

The most critical part of maintaining proper impedance is adhering to the specified dimensions of the printed circuit board antenna (see Figure C-14). The antenna dimensions, if altered, will change the specified impedance. As an example, a 1 mm variance will shift the impedance by 5-10 MHz.

> **Note:** This part has been simulated using a HFSS™ simulator by Ansoft Corporation.

FIGURE C-14: PRINTED CIRCUIT BOARD ANTENNA DIMENSIONS[1]

Note 1: Dimensions are in mm and tolerance is +/– 0.05 mm.
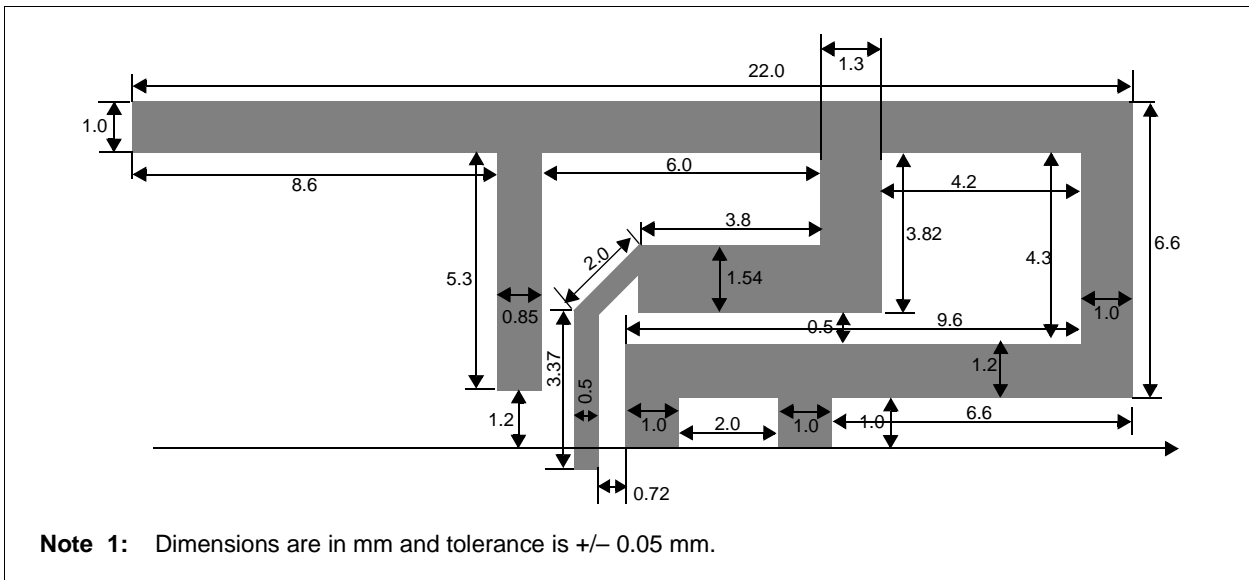
Figure C-15 and Figure C-16 illustrate simulation results of this PCB antenna. Note the simulation results are very close to the measurements.

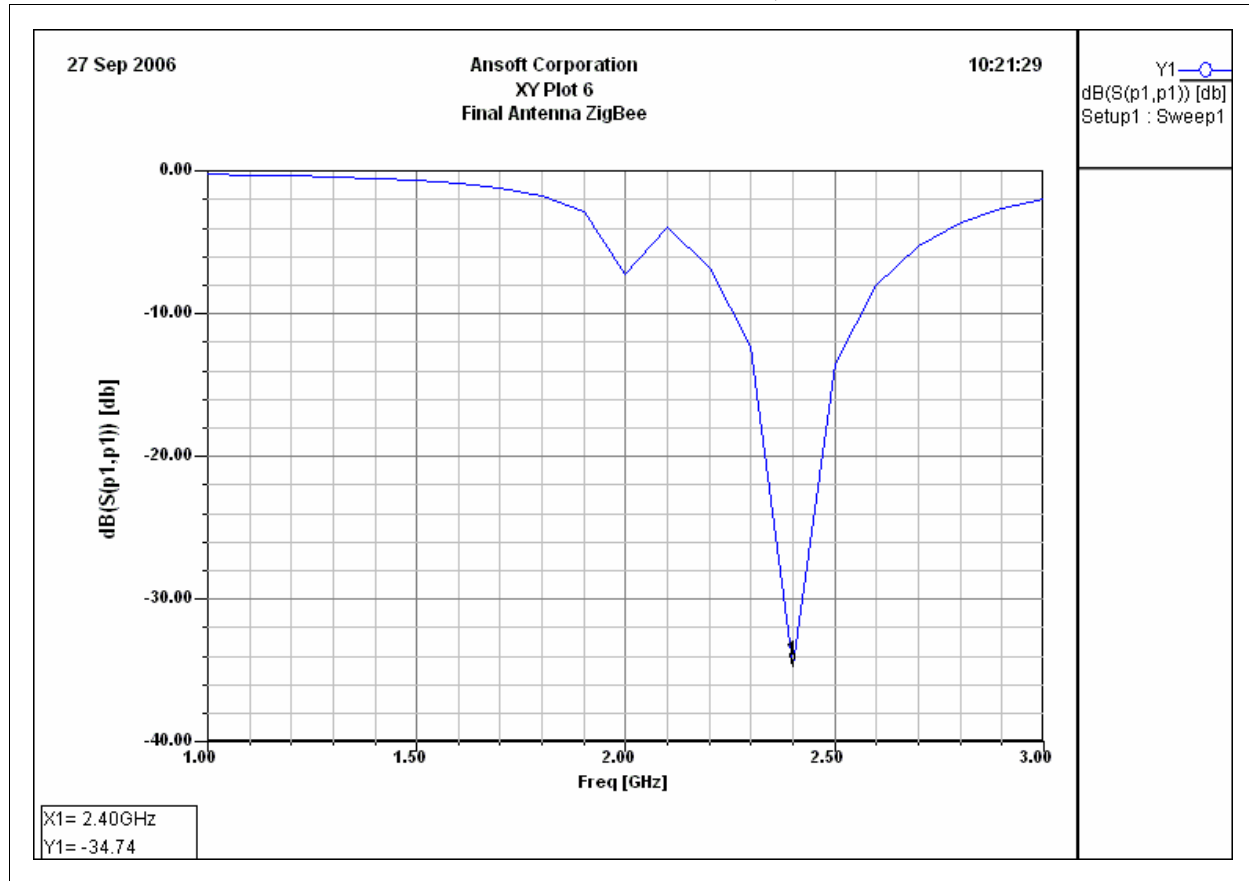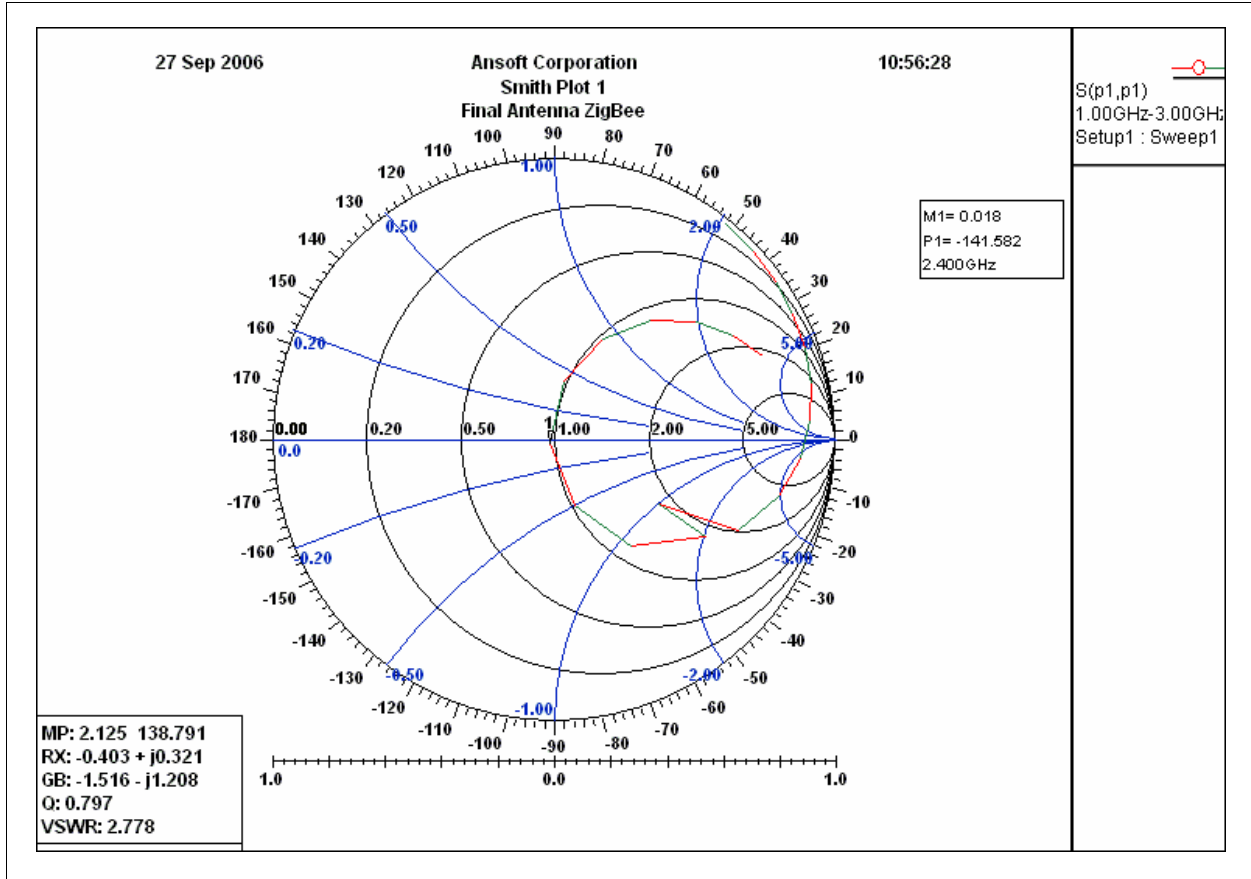**FIGURE C-15:   SIMULATED PCB ANTENNA IMPEDANCE, XY PLOT**

FIGURE C-16: SIMULATED PCB ANTENNA IMPEDANCE, SMITH PLOT

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