TiWi5 Transceiver Module

Block Diagram / Theory of Operation - Confidential

LS RESEARCH, LLC
WIRELESS PRODUCT DEVELOPMENT

Last updated
April 10th, 2012

Table of Contents

1 Introduction 3

1.1 Purpose & Scope 3
1.2 Audience 3
1.3 Applicable Documents 3
1.4 Revision History 3

2 Block Diagram 4

3 Theory of Operation 5

1 Introduction

1.1 Purpose & Scope

The purpose of this document is to provide a description of the TiWi5 radio module's block diagram and theory of operation.

1.2 Audience

This document is intended to be read by engineers and technical management. A general knowledge of common engineering practices is assumed.

1.3 Applicable Documents

- TiWi5 Datasheet

1.4 Revision History

Date	Change Description	Revision
4/10/2012	Initial release.	1.0

Table 1 - Revision History

2 Block Diagram

The block diagram for the TiWi5 Radio Module is presented below; the description of operation is presented in the next section.

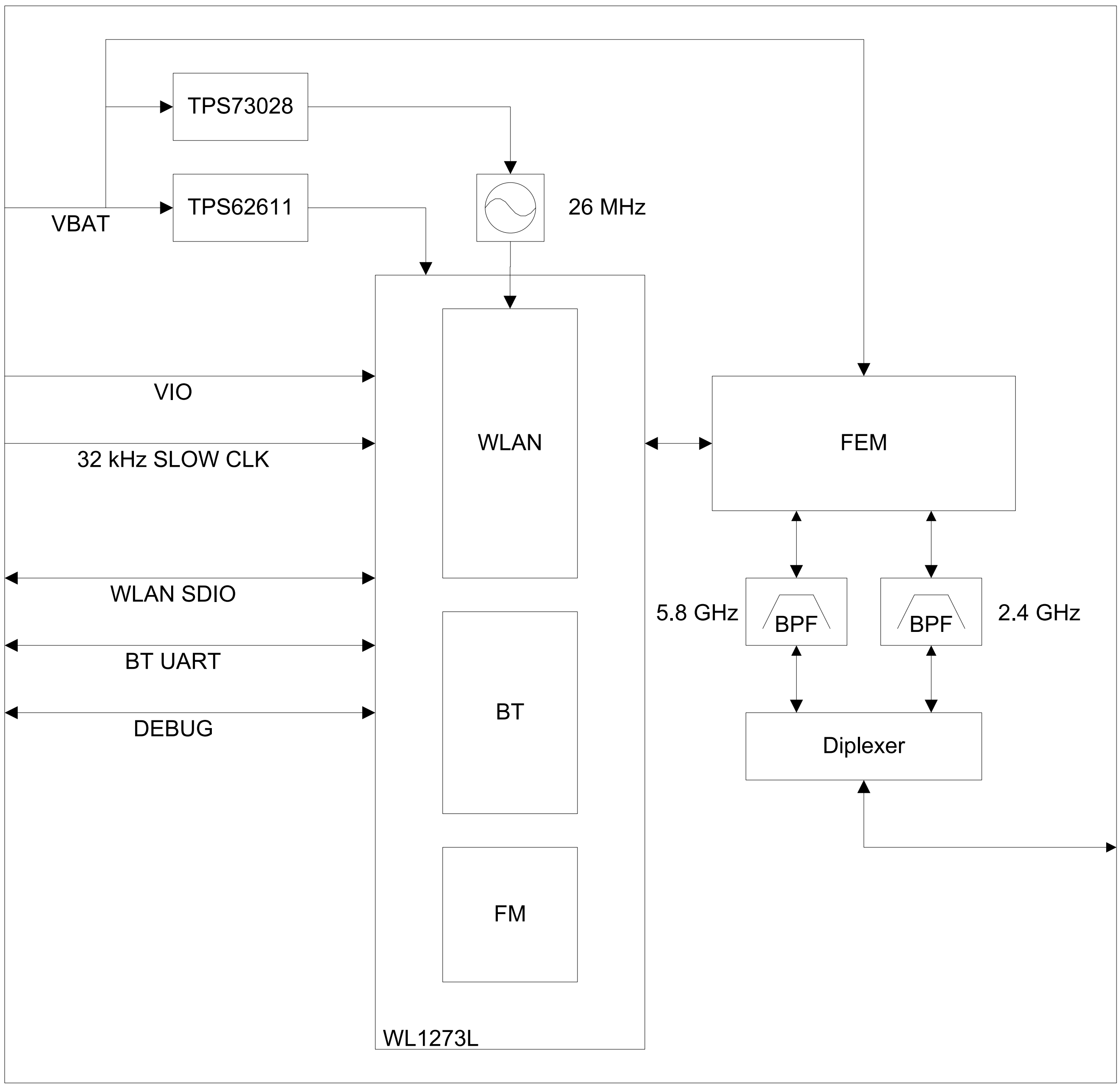


Figure 1 – TiWi5 Block Diagram

3 Theory of Operation

The TiWi5 Module is a radio module that implements an 802.11 b/g/n WLAN (Wireless Local Area Network) transceiver and a Bluetooth (BT) transceiver. A Texas Instruments WL1273L SOIC (System on Integrated Circuit) has two independent transceivers, one for the WLAN functions and one for BT functions. The two radio sections are supported by a FEM (Front End Module), which implements the Power Amplifier Section (PA) and switch duplexing functions. All of the radio functions use an on-module 26 MHz Temperature Compensated Crystal Oscillator (TCXO) as the station frequency reference. Both radios are supported by an on-chip ARM cortex processor. An external 32 kHz clock signal is applied externally for low-power operation of the on-board communications ARM processor.

The data source/sink and command interface for the WLAN transceiver is an SDIO (Secure Digital Input-Output) interface. The data source/sink and command interface for the BT transceiver is through a 4-wire UART Host Control Interface (HCI).

The WL1273L supports 2.4 GHz WLAN, 5.8 GHz WLAN, and 2.4 GHz BT. The FEM module has a port for each 2.4 GHz WLAN and BT, and 5.8 GHz WLAN. The antenna port is duplexed between the 2.4 GHz and 5.8 GHz paths to the FEM. Each antenna path includes a bandpass filter between the FEM and the diplexer.

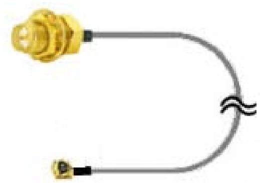
The WLAN transceiver section is based on a direct-conversion vector (I-Q) transmitter and receiver architecture. The local oscillator is generated at four times the carrier frequency, phase-locked, and divided by four for the quadrature LO injections for the 2.4 GHz band and divided by 2 for the 5.8 GHz band. The transmitter signal is routed to the FEM, amplified by the PA section, fed out either the 2.4 GHz or 5.8 GHz port and fed to the antenna terminal. The WLAN receive section is fully realized in the SOIC and the FEM only provides a passive transmission path through the FEM.

The BT transmitter is based on a direct PLL modulation for the FSK-based modulations and uses Polar modulation techniques for the higher EDR rates which employ differential phase-shift keying modulation. The BT receiver uses a near-zero IF architecture. Both the transmit and receive local oscillators are generated at two-times the carrier frequency and divided by two. The BT transmit and receive uses the 2.4 GHz port on the FEM, and goes through the 2.4 GHz bandpass filter and diplexer to the module antenna port. The 26 MHz station reference is used for the BT functions as well.

The radio transceivers and station reference (26 MHz TCXO) power supplies are provided by on-module voltage regulators.

The FM transmitter and Receive functions are not currently supported, and the module is not certified for their application.

Cable Assembly – U.FL to Reverse Polarity SMA Bulkhead Female



ORDERING INFORMATION

Order Number	Description
080-0001	Cable assembly: 105mm in length with reverse polarity SMA female bulkhead and U.FL connector using 1.13mm diameter cable.

SPECIFICATIONS

Specification	Value
Frequency Range	DC to 6GHz (VSWR 1.3 max)
Impedance	50 ohms
Temperature	-40° to +85° C
Rated Voltage	AC 60V
Contact Resistance	20m ohm max – signal and ground
Withstand Voltage	AC 200V
Insulation Resistance	500M ohm minimum/DC 100V
VSWR	< 1.2:1 @ 2400MHz
IL	< 1.0dB @ 2400MHz
Bend Radius	6.8mm minimum

The information in this document is subject to change without notice.
Confirm the data is current by downloading the latest revision from www.lsr.com.

PHYSICAL DIMENSIONS (MM)

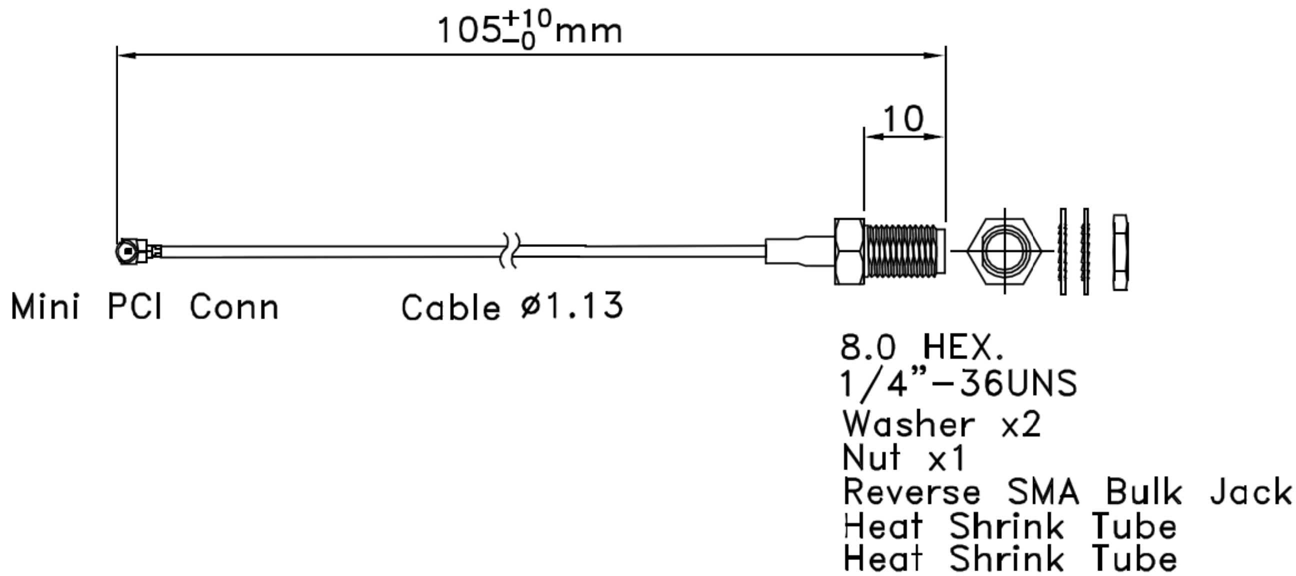


Figure 1

PANEL CUTOUT

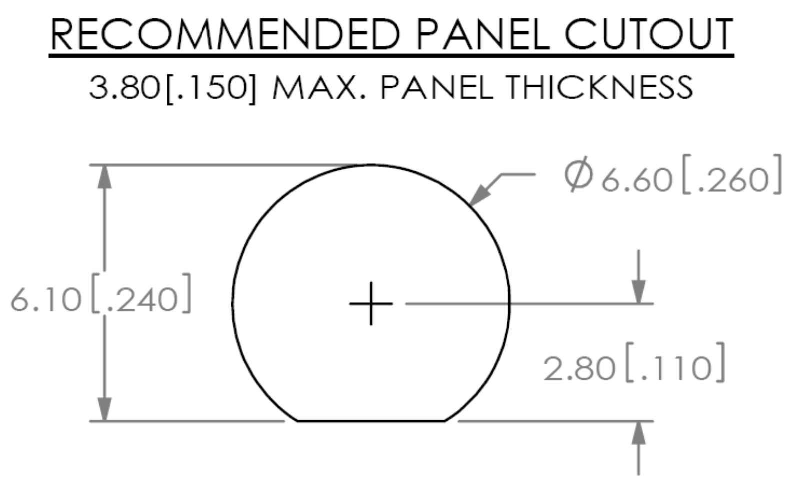


Figure 2

CONTACTING LS RESEARCH

Headquarters	LS Research, LLC W66 N220 Commerce Court Cedarburg, WI 53012-2636 USA Tel: 1(262) 375-4400 Fax: 1(262) 375-4248
Website	www.lsr.com
Technical Support	support@lsr.com
Sales Contact	sales@lsr.com

TIWI5

Antenna Design Guide

Last updated
February 3rd, 2012

Table of Contents

1 Introduction 3

1.1 Purpose & Scope 3
1.2 Applicable Documents 3
1.3 Revision History 3

2 Chip Antenna 4

2.1 Chip Antenna Specifications 4
2.2 Mechanical Dimensions 5
2.3 Terminal Configuration 5
2.4 Typical Radiation Patterns 6

3 Dipole Antenna 8

3.1 Dipole Antenna Specifications 9
3.2 Typical Radiation Patterns 10
3.3 Mechanical Dimensions 13

4 PCB Layout Requirements 14

4.1 Chip Antenna PCB Layout Requirements 15
4.2 Chip Antenna Reference Design PCB 16
4.3 Chip Antenna Reference Design Schematic 17
4.4 Chip Antenna Matching Components 18
4.5 Dipole Antenna PCB Layout Requirements 19
4.6 Dipole Antenna Reference Design PCB 20
4.7 Dipole Antenna Reference Design Schematic 21

5 EMC Compliance 22

5.1 Summary 22
5.2 Module Integration Considerations – Antenna Systems 22
5.3 Module Integration Considerations – Substitute Antenna Systems 23
5.4 Module Integration Considerations – Circuit Implementation 23
5.5 Module Integration Considerations - Top Assembly 23
5.6 Testing Requirements for End-Product 23
5.7 SAR Testing Requirements for End-Product 23

6 Contacting LS Research 24

1 Introduction

1.1 Purpose & Scope

The purpose of this document is to provide details regarding the design and integration of certified antennas to the TiWi5 module. It covers both a PCB mounted Chip Antenna as well as an externally mounted whip antenna. It will inform the reader as to the required PCB layout details and provide expected performance specifications.

1.2 Applicable Documents

- *TiWi5 Datasheet (330-0042)*
- *ModFLEX Accessories 2.4/5.4 GHz Dipole Antenna Datasheet (330-0094)*
- *Johanson Technology 2450AD46A5400 Datasheet*

1.3 Revision History

Date	Change Description	Revision
2/3/2012	Initial release	1.0

Table 1 Revision History

2 Chip Antenna

The Johanson Technology ceramic chip antenna is a passive, surface mount component, based on Low Temperature Co-fired Ceramic (LTCC) technology. This antenna exhibits linear polarization and provides a near omni-directional radiation pattern. It is matched to 50 ohm impedance and is well suited for integration to the LSR TiWi5 radio module.

The chip antenna is used external to the TiWi5 module as part of an overall solution for the LSR TiWi5 radio module.

	Johanson Part Number	Description
	2450AD46A5400E	2.4/5.4 GHz Ceramic Dual Band Chip Antenna

Table 2 – Chip Antenna Overview

2.1 Chip Antenna Specifications

Specification	Value
Peak Gain	+1 dBi
Impedance	50 ohms, Nominal
Type	Dipole
Polarization	Linear
VSWR	≤24 : 1, Maximum
Frequency	2.45/5.4 GHz
Input Power	3W max
Size	8.5mm × 1.6 mm
Operating Temperature	-40 to +85°C

Table 3 – Chip Antenna Specifications

2.2 Mechanical Dimensions

	In	mm
L	0.335 ± 0.008	8.50 ± 0.20
W	0.063 ± 0.008	1.60 ± 0.20
T	0.047 +.004 /-.008	1.20 +0.1 / -0.2
a	0.020 ± 0.006	0.51 ± 0.15
b	0.104 ± 0.006	2.64 ± 0.15
c	0.046 ± 0.006	1.18 ± 0.15

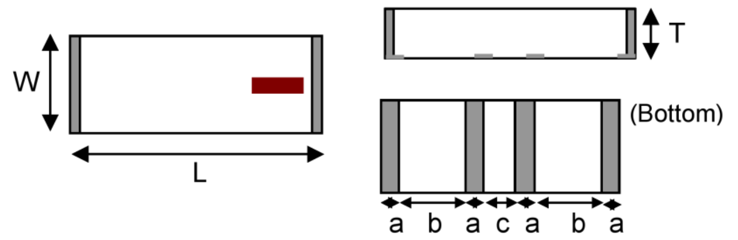


Table 4 – Chip Antenna Mechanical Dimensions

2.3 Terminal Configuration

No.	Function
1	High Band Feed
2	Low Band Feed
3	NC
4	NC

Terminal Configuration

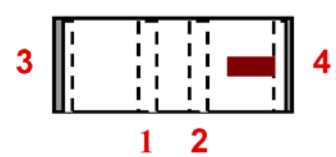


Table 5 – Chip Antenna Terminal Configuration

Typical Radiation Pattern Figure 1 - Chip Antenna Radiation Patterns (5 GHz)

2.4 Typical Radiation Patterns

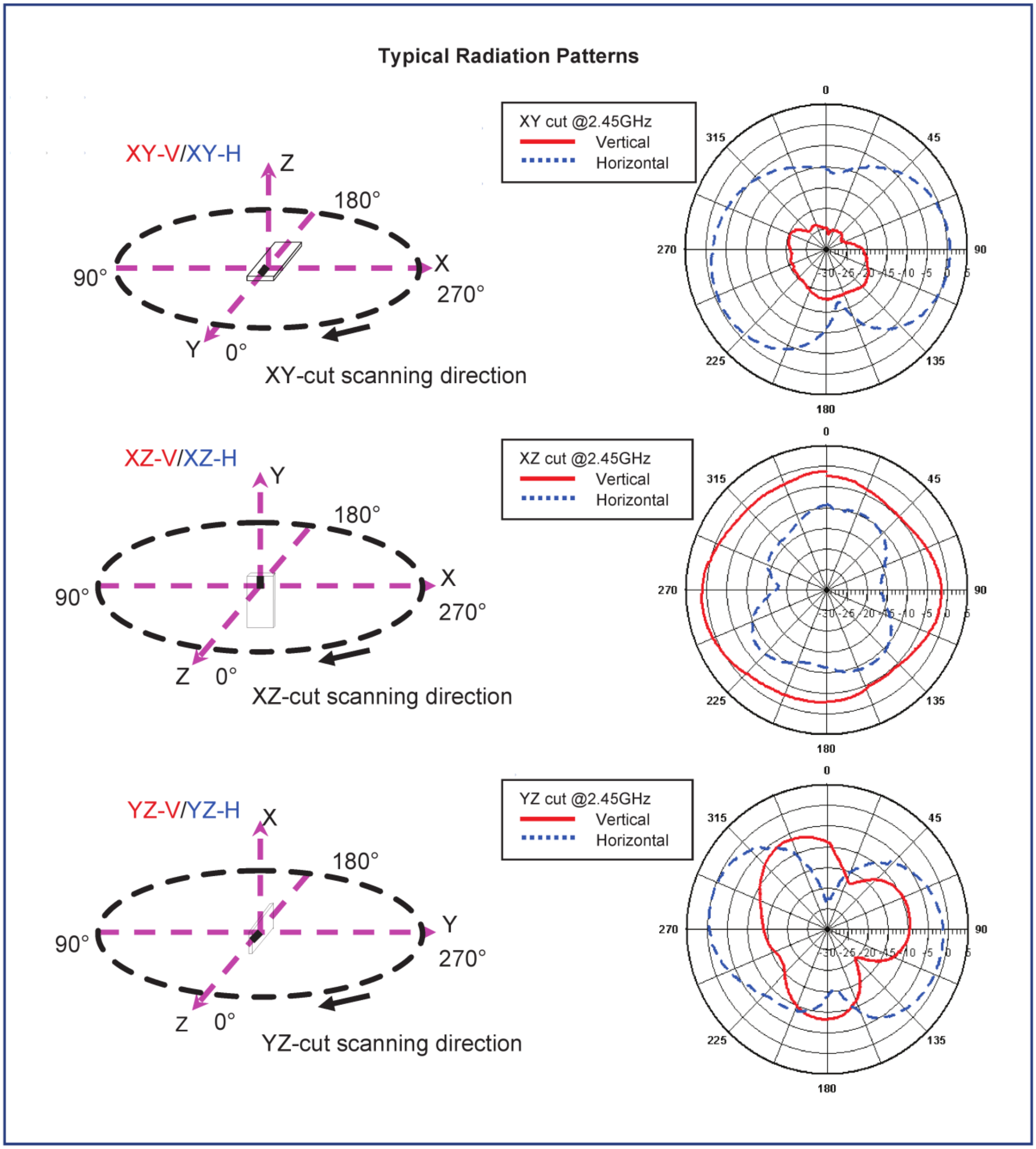


Figure 1 - Chip Antenna Radiation Patterns (2.4 GHz)

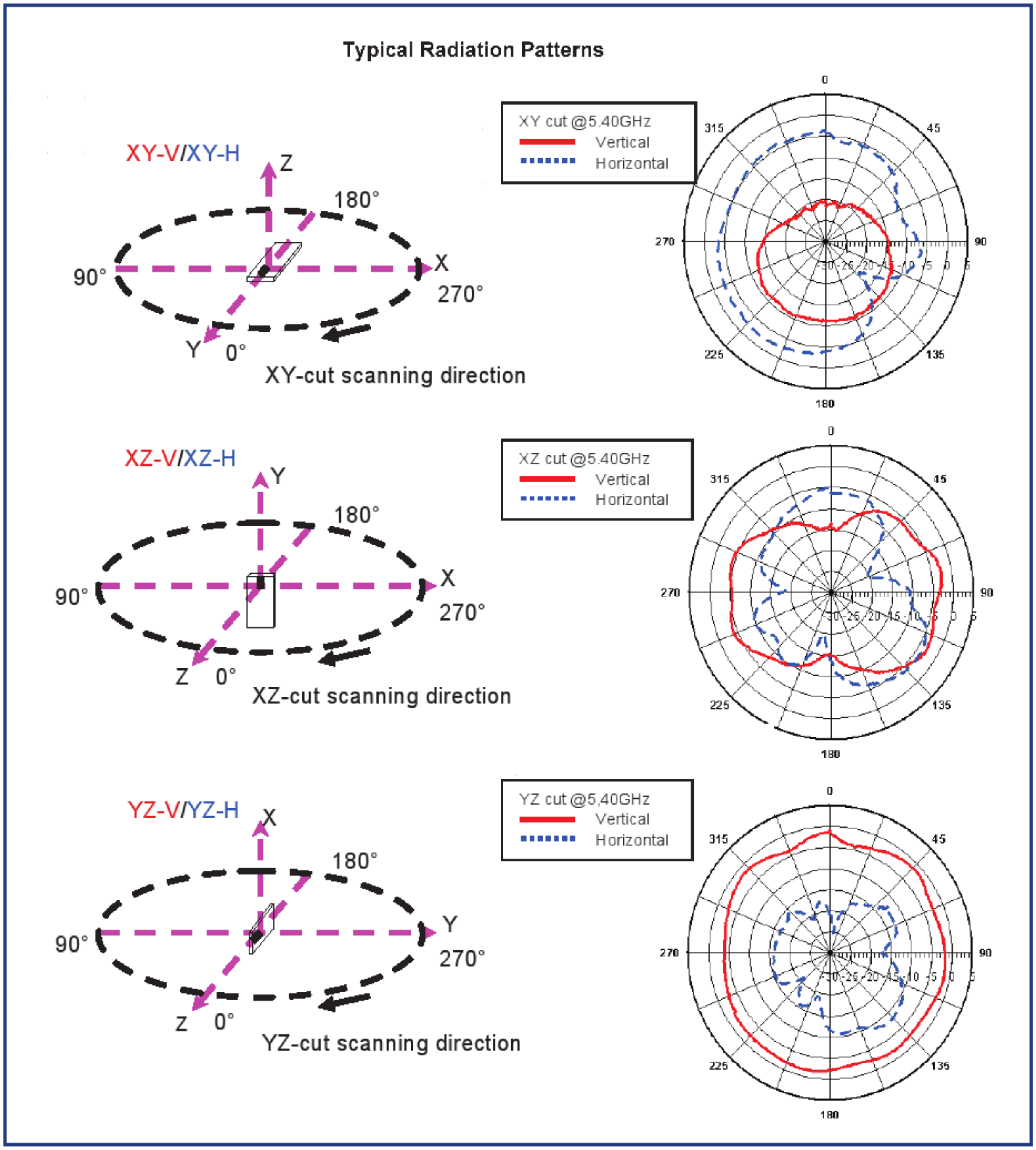


Figure 2 - Chip Antenna Radiation Patterns (5 GHz)

3 Dipole Antenna

The LSR 001-0009 Dipole Antenna is used in conjunction with the LSR 080-0001 U.FL to Reverse Polarity SMA Cable, and the Hirose PCB mounted U.FL connector, to provide an externally mounted antenna solution for the LSR TiWi5 radio module.

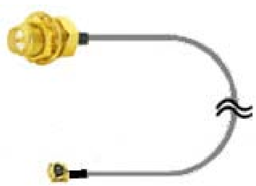
	Part Number	Description
	LS Research 001-0009	2.4/5.5 GHz Dipole Antenna with Reverse Polarity SMA Connector
	LS Research 080-0001	U.FL to Reverse Polarity SMA Bulkhead Cable 105mm
	Hirose U.FL-R-SMT(10)	PCB Mounted U.FL Connector

Table 6 – Dipole Antenna Overview

3.1 Dipole Antenna Specifications

Specification	Value
Gain	+2 dBi
Impedance	50 ohms, Nominal
Type	Dipole
Polarization	Linear Vertical
VSWR	≤2.0：1, Maximum
Frequency	2400-2500MHz, 5150-5850MHz
Weight	22g
Size	137 × 13 mm
Antenna Color	Black

Table 7 – Dipole Antenna Specifications

3.2 Typical Radiation Patterns

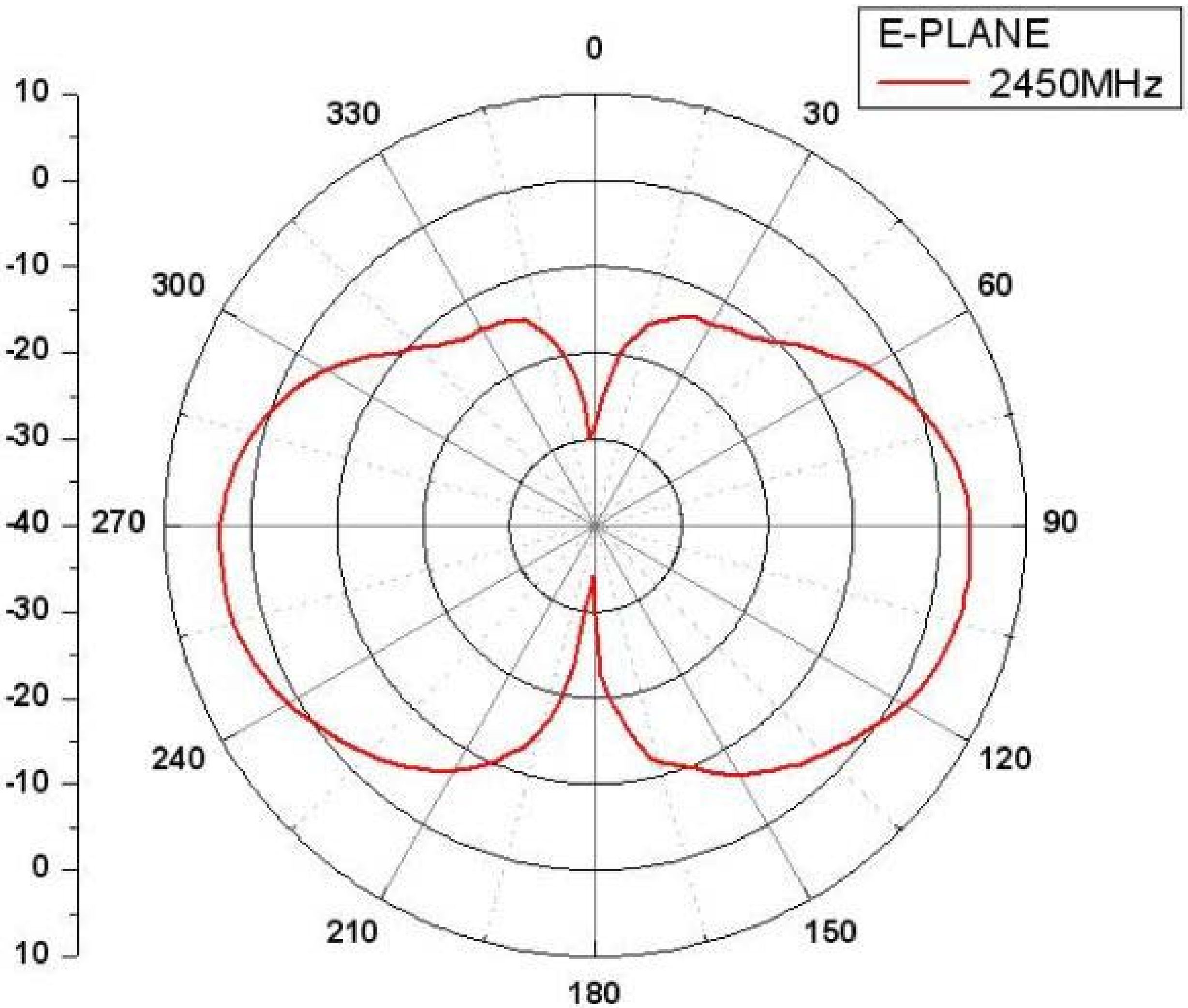


Figure 3 – Dipole Antenna Pattern (LSR Antenna @ 2405 MHz)

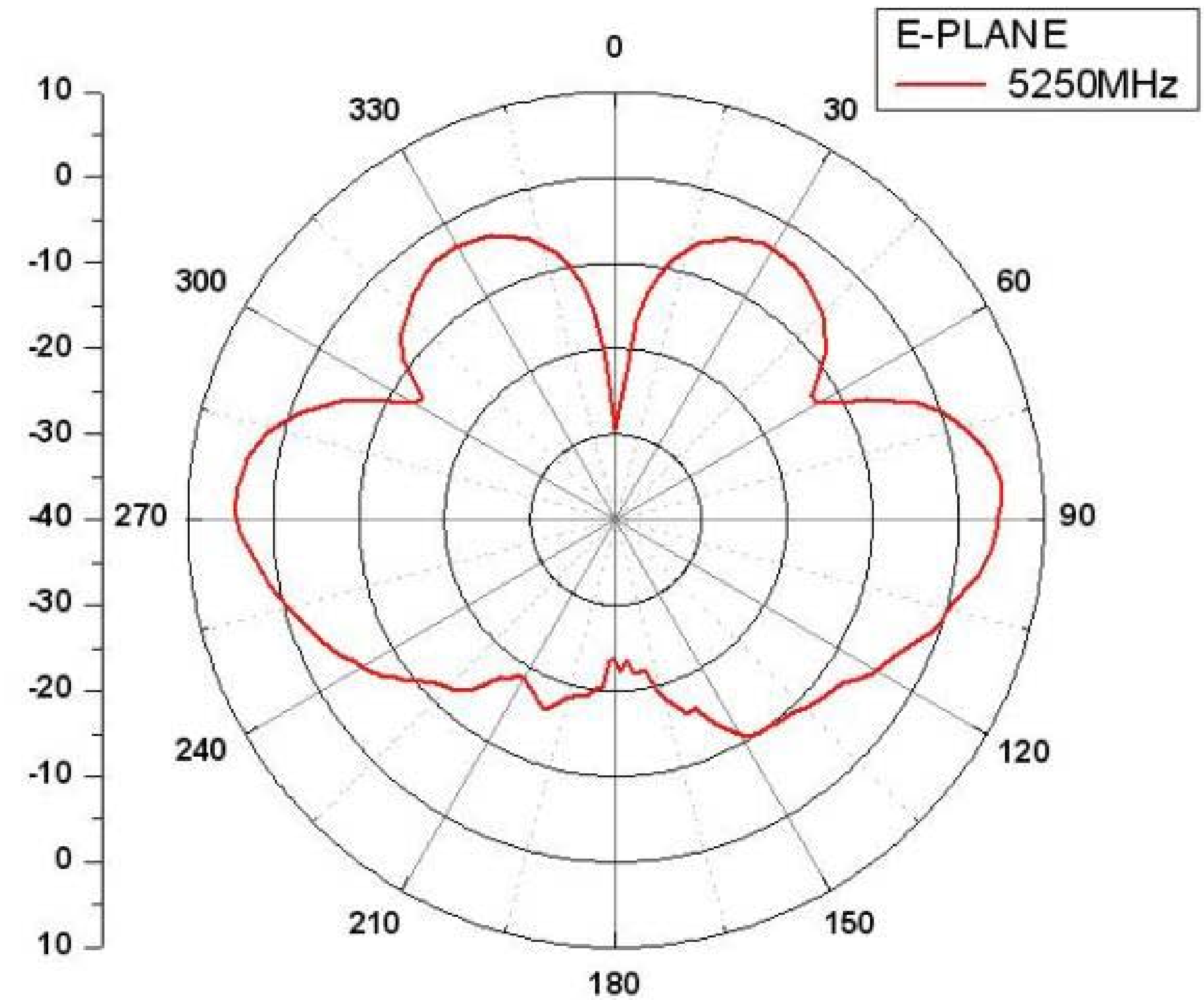


Figure 4 – Dipole Antenna Pattern (LSR Antenna @ 5250 MHz)

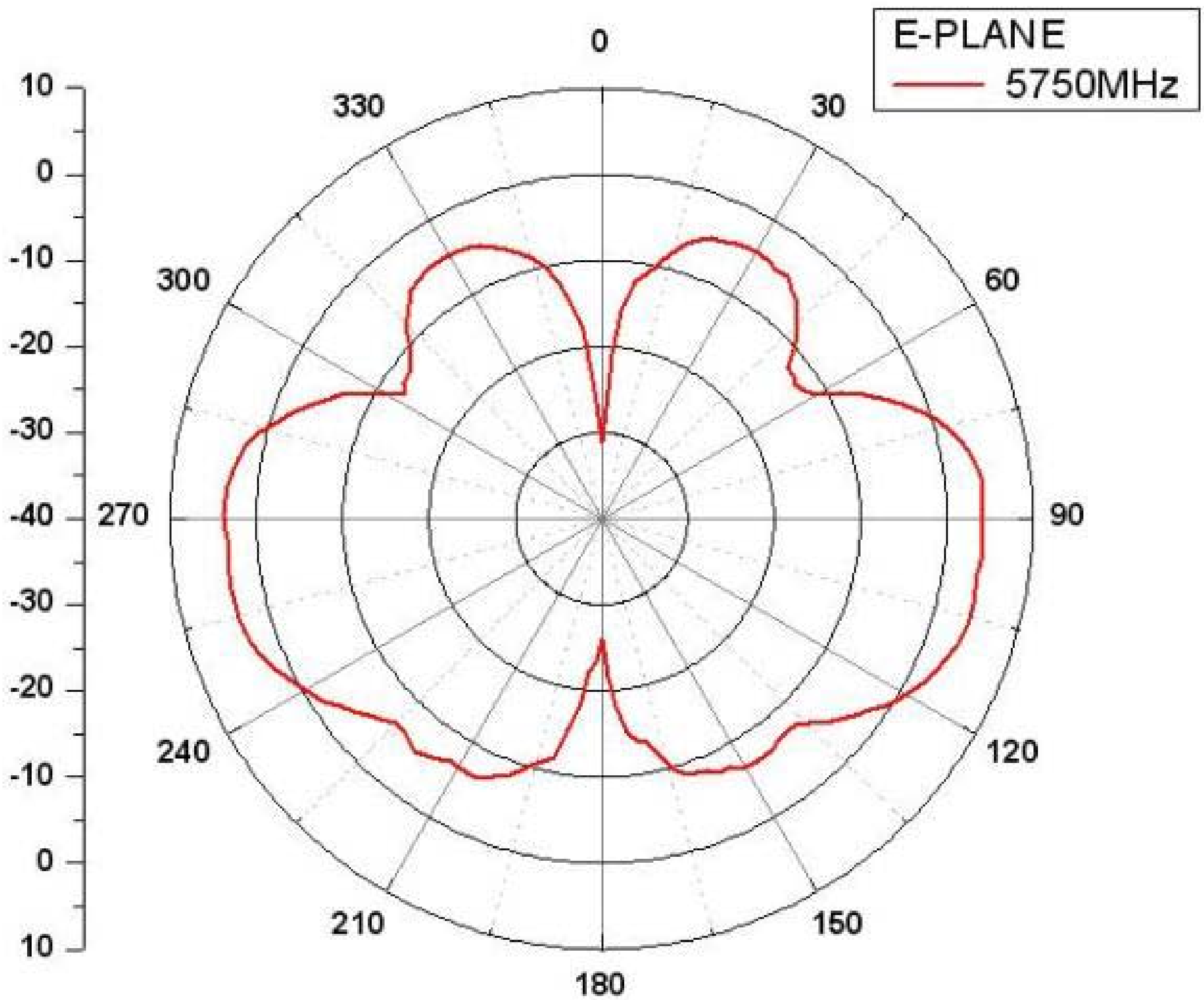


Figure 5 – Dipole Antenna Pattern (LSR Antenna @ 5750 MHz)

3.3 Mechanical Dimensions

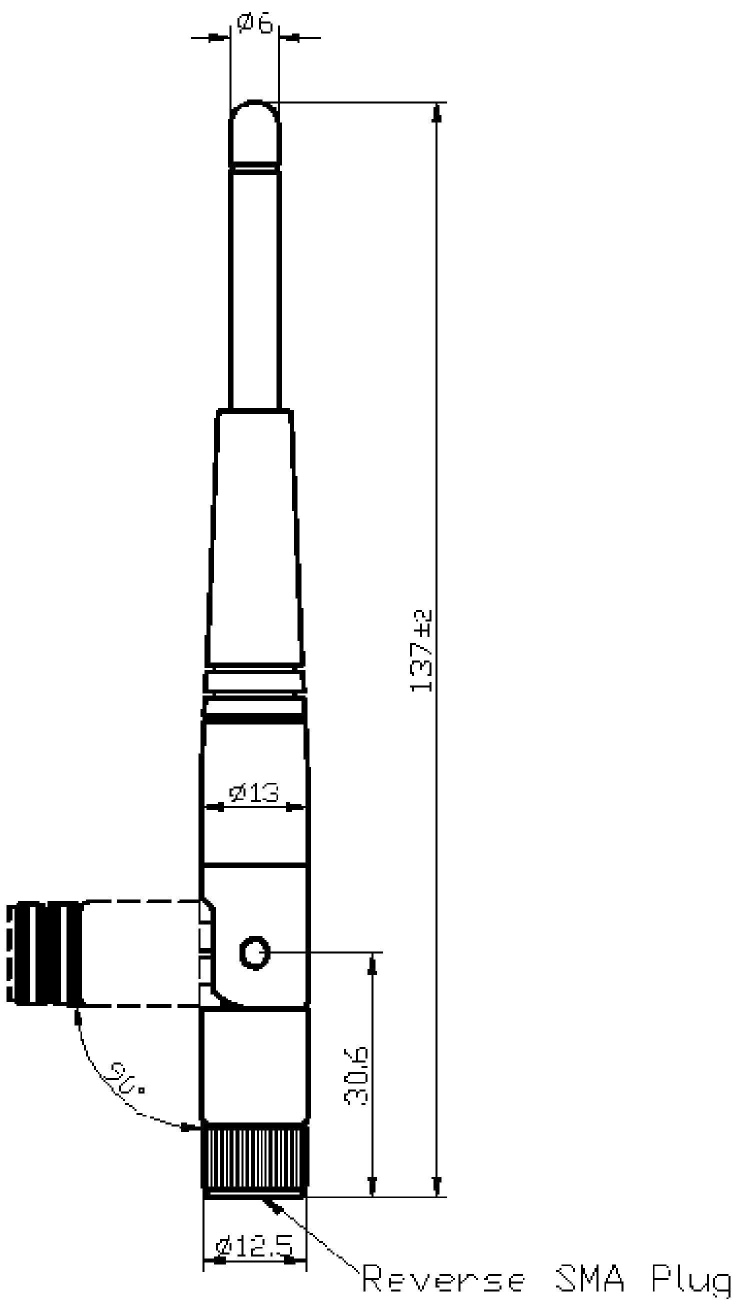


Figure 6 – Dipole Antenna Dimensions

4 PCB Layout Requirements

Since this module and its associated set of approved antennas has been certified by the FCC and Industry Canada (IC) as a Modular Radio, the end user is authorized to integrate this module into an end-product, and is solely responsible for the Unintentional Emissions levels produced by the end-product

In order to preserve the Modular Radio certifications, the integrator of the module must abide by the PCB layout recommendations outlined in the following paragraphs. Any divergence from these recommendations will invalidate the modular radio certifications and require the integrator to re-certify the module and/or end-product.

The module must be used with one of the approved antennas:

1. LS Research 001-0009 center-fed dipole antenna and 080-0001 U.FL to Reverse Polarity SMA connector cable.

2. Johnson 2450AD46A5400 2.4/5.4 GHz Ceramic Chip Antenna.

4.1 Chip Antenna PCB Layout Requirements

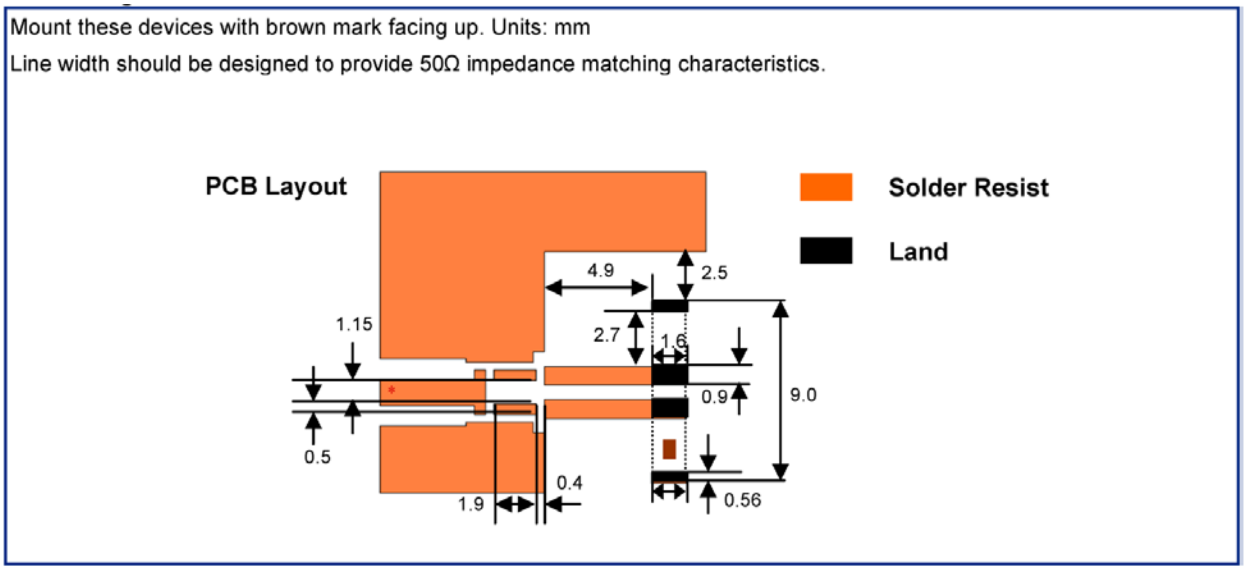


Figure 7 – Chip Antenna PCB Layout Requirements

4.2 Chip Antenna Reference Design PCB

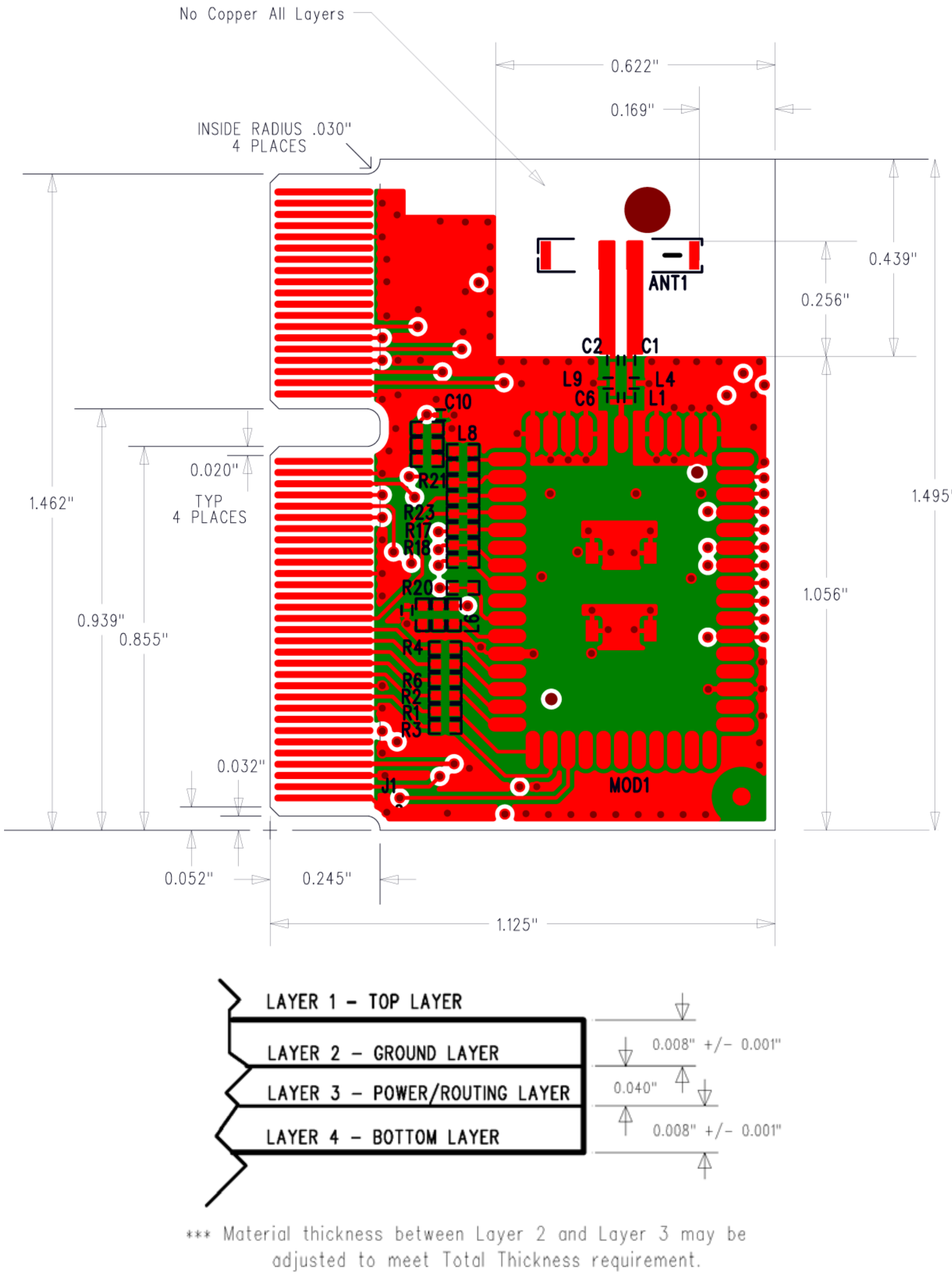


Figure 8 – Chip Antenna Certified Reference Design PCB

4.3 Chip Antenna Reference Design Schematic

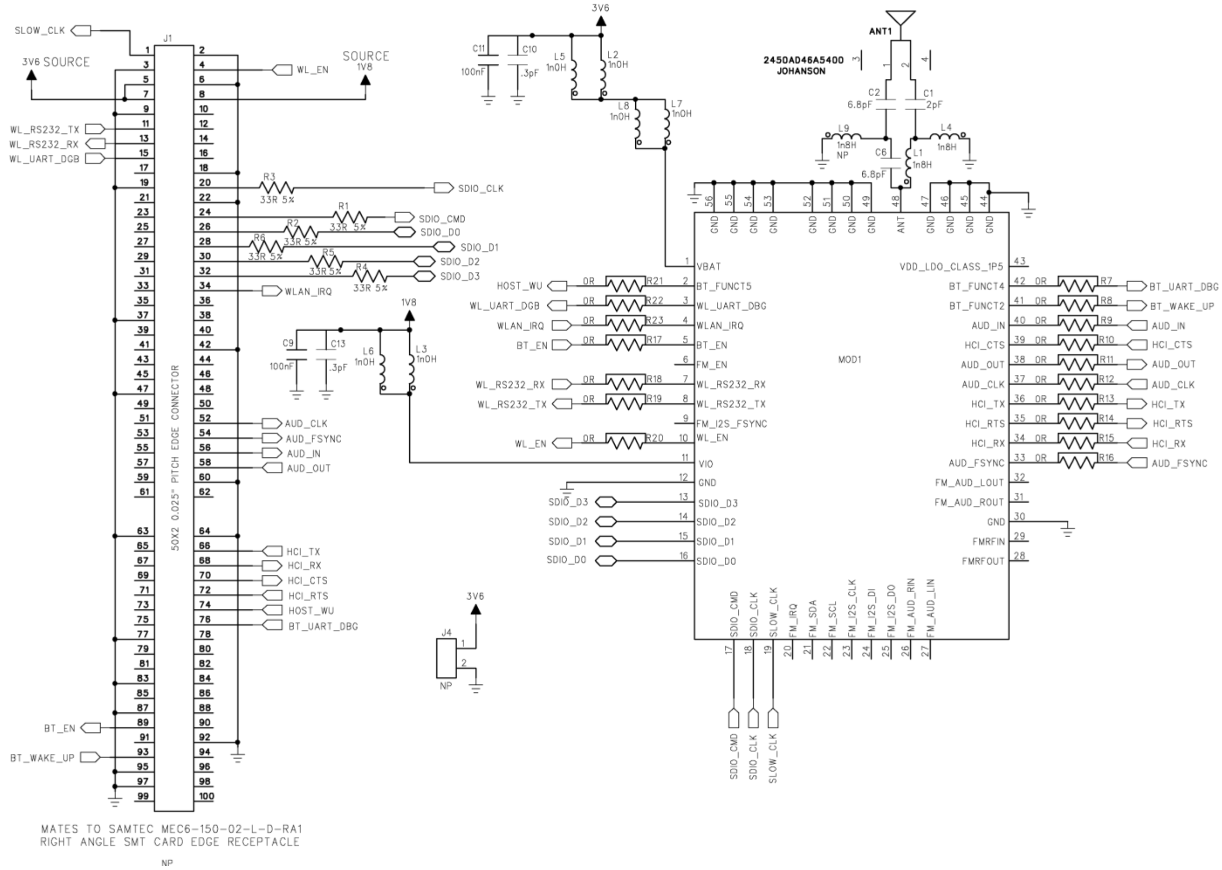


Figure 9 – Chip Antenna Certified Reference Design Schematic

4.4 Chip Antenna Matching Components

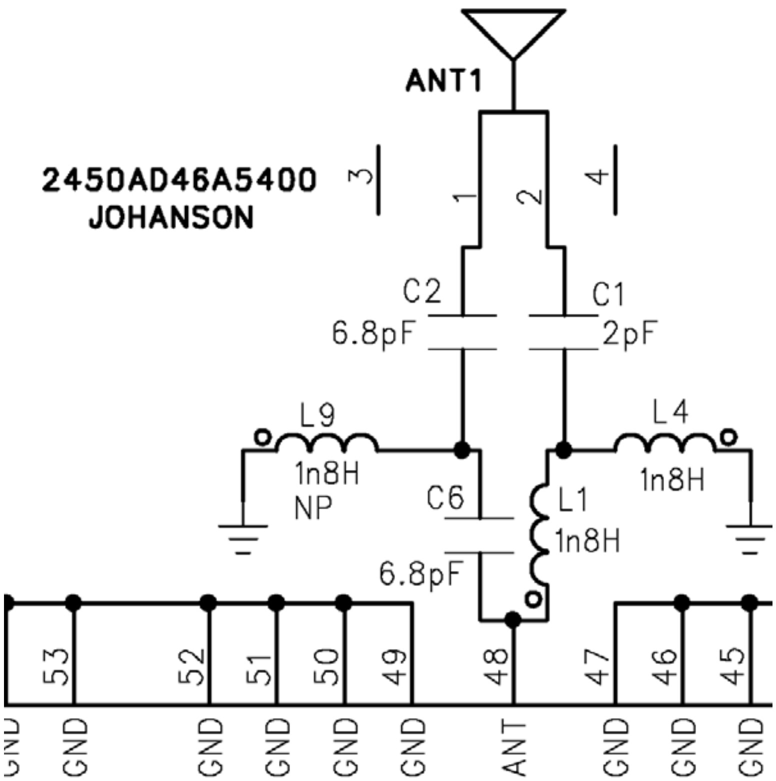


Figure 10 – Chip Antenna Certified Reference Design Matching Components Schematic

The matching circuit for the chip antenna consists of Capacitors C1, C2, C6, and Inductors L1, L4, and L9 (NP - Not Populated). Refer to the table below for specifics on the matching components.

Inductor	Value	Part Number	Description
L1, L4	1.8nH	Johanson L-05B1N8SV6T	0201 SMT INDUCTOR ±0.3nH
L9	1.8nH	Johanson L-05B1N8SV6T	*DO NOT POPULATE
C1	2pF	Johanson 250R05L2R0BV4T	0201 SMT CERAMIC CAPACITOR 25V NPO ±0.1pF
C2, C6	6.8pF	Johanson 250R05L6R8CV4T	0201 SMT CERAMIC CAPACITOR 25V NPO ±0.25pF

Table 8 – Chip Antenna Matching Components

4.5 Dipole Antenna PCB Layout Requirements

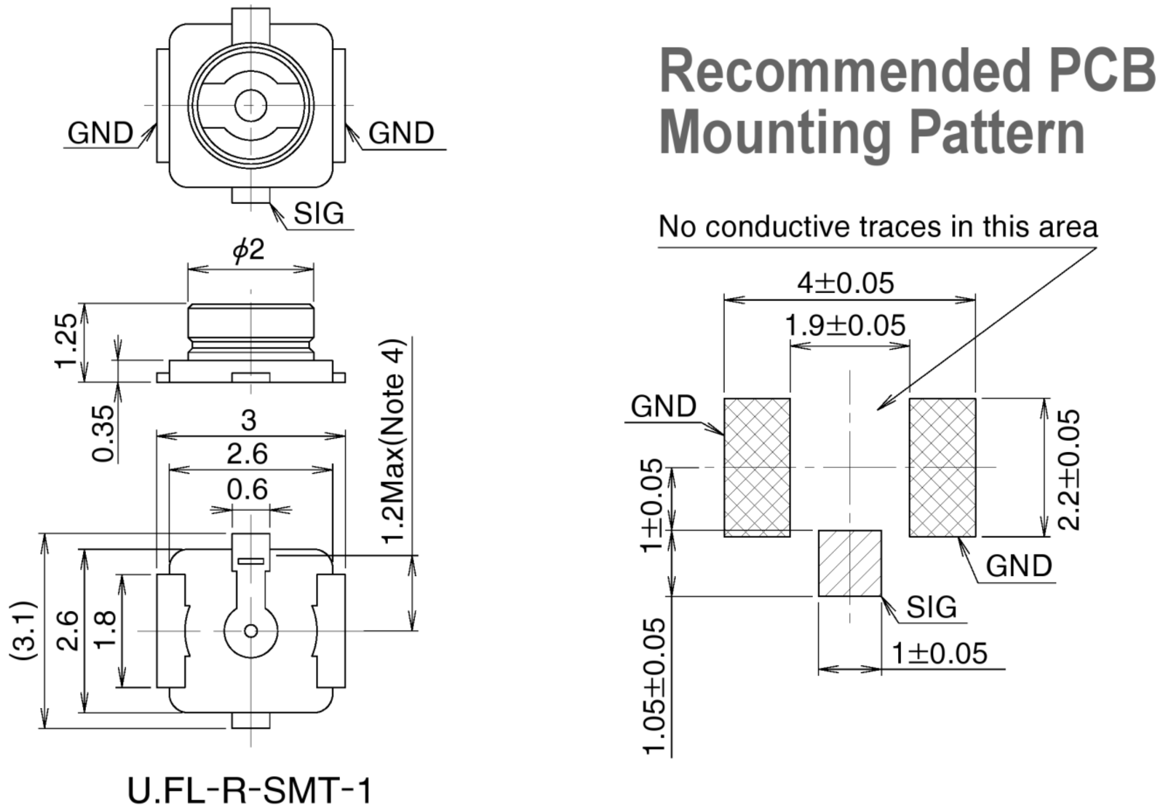


Figure 11 – Dipole Antenna PCB Layout Requirements

4.6 Dipole Antenna Reference Design PCB

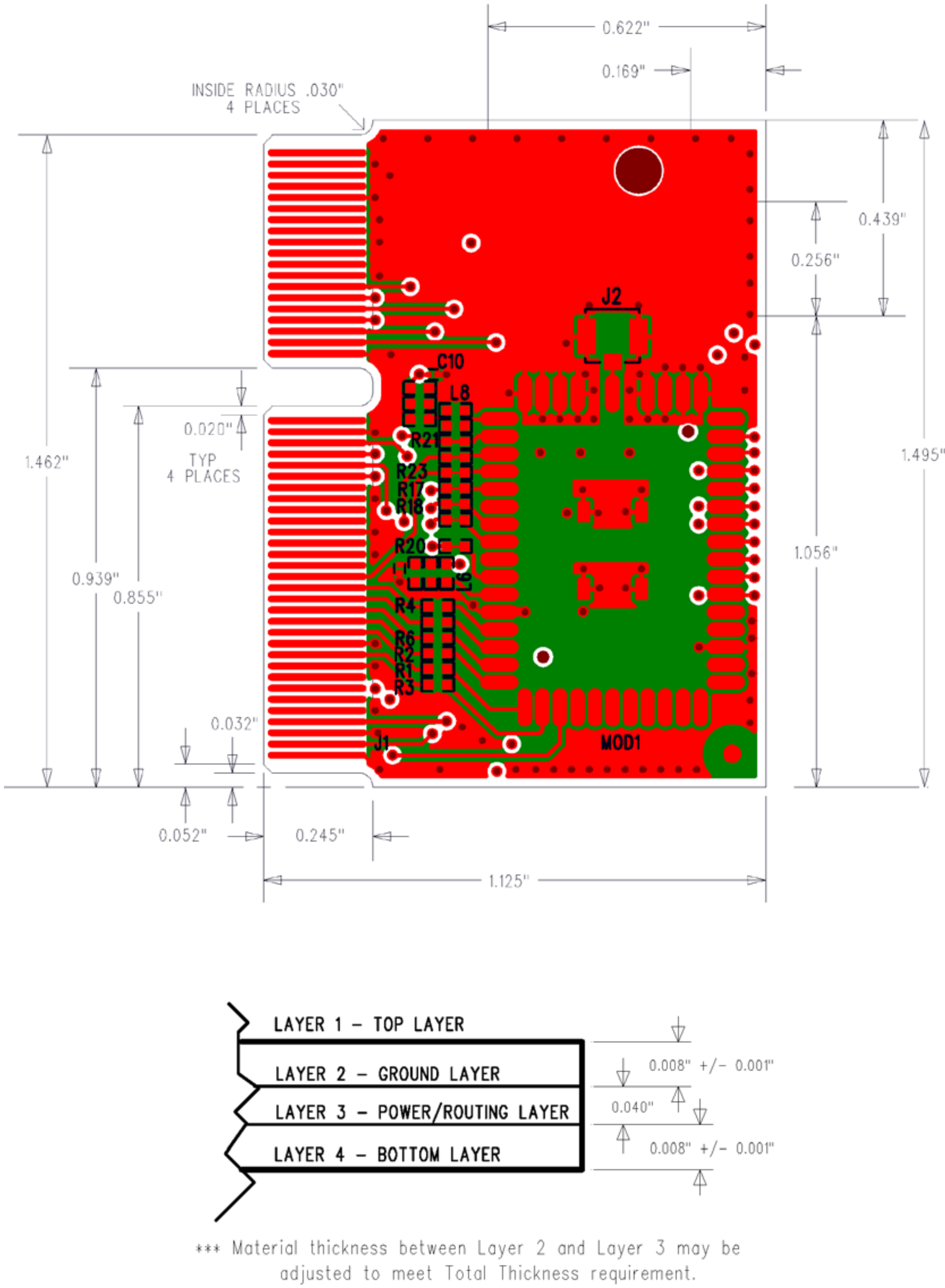


Figure 12 – Dipole Antenna Certified Reference Design PCB

4.7 Dipole Antenna Reference Design Schematic

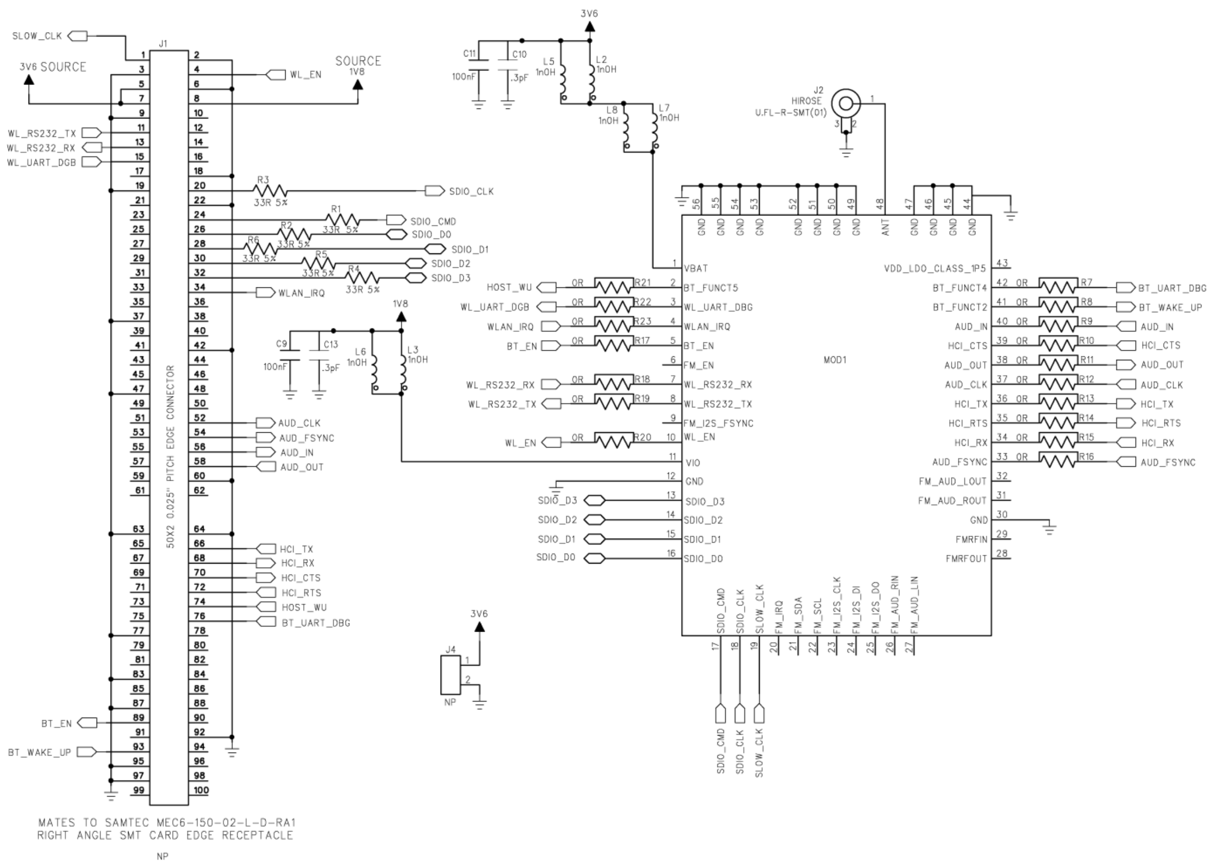


Figure 13 – Dipole Antenna Certified Reference Design Schematic

5 EMC Compliance

5.1 Summary

The TiWi5 module has been tested and approved as a Modular Radio in accordance with the appropriate FCC and IC standards. The supporting test data may be found in the modular test report.

Since this module and its associated set of approved antennas have been certified as a Modular Radio, this allows the end user to integrate this module into an end-product without the requirement of re-certifying the radio module. The module-integrator is responsible for the unintentional conducted and radiated emissions and must ***verify*** that the integrated product is compliant with the rules associated with unintentional radiators. The module integrator is also required to maintain an engineering record of the verification testing and declare on the product through proper labeling and marking that the device is compliant with these particular rules.

The installed module's FCC ID and IC numbers need to be clearly marked on the product with the following verbiage "contains FCC ID: TFB-TIWI501" and "contains IC: 5969A-TIWI501".

The TiWi5 has been certified for use in a mobile configuration, which employs a minimum separation distance of 20 cm from the antenna to the human body or another transmitting radio. For separation distances of 20 cm or less, the module integrator must have the module certification re-evaluated, which will include a modification to the existing certification and additional testing for exposure and SAR requirements.

5.2 Module Integration Considerations – Antenna Systems

The module must be used with one of the approved antennas:

1. LS Research 001-0009 center-fed dipole antenna and LS Research 080-0001 U.FL to Reverse Polarity SMA connector cable.

2. Johnson 2450AD46A5400E 2.4/5.4 GHZ Dual Band Chip Antenna.

The antenna should be placed such that it is minimally disturbed by the product's packaging material. The incorporation of the largest practical free-space clearance around the antenna is important for maximizing overall performance. Further, the antenna must be placed such that at least a 20 cm separation distance is maintained from the human body to the antenna and all other radio transmitters.

5.3 Module Integration Considerations – Substitute Antenna Systems

The module's certification is only valid for the list of approved antennas presented in section 5.2. However, substitute antennas may be used in place of the approved antenna only if the antennas are of the same type and the peak gain is less than or equal to the peak gain of the similar approved antenna. Also the antennas should have similar in-band and out-of-band characteristics.

5.4 Module Integration Considerations – Circuit Implementation

It is recommended that all connection PCB (printed circuit board) traces to the power supply and digital control terminal be as short as possible. Though not necessarily required in all cases, it is a best practice to provide an optional shunt capacitor placement at the module pin on all active and routed power supply and digital control lines. Further, a series damping resistor placement should be incorporated between the module pin/shunt capacitor node and the source/sink of the digital control signals. This provides for effective bypassing and decoupling of digital lines from the radio module, in the event that the application circuit has longer power supply and digital routing.

5.5 Module Integration Considerations - Top Assembly

In addition to the recommendations given for the antenna systems and the module placement onto a product PCB, it is recommended that all wiring and interconnect systems within the product be not routed anywhere close the module and its associated circuitry on the PCB, doing so could change the emission characteristics of the module.

5.6 Testing Requirements for End-Product

Once the module is integrated and the product realized in a mobile configuration, the product must be tested and follow the verification process for Unintentional Conducted and Radiated Emissions in accordance to the FCC and IC guidelines. The module needs to be powered and placed in the receive mode for this test. The receiver must be tuned to its lowest frequency channel, mid-frequency channel, and highest frequency channel. Both the WLAN and BT receivers must be active for the test. The supporting test data does not need to be submitted to the FCC or IC.

5.7 SAR Testing Requirements for End-Product

Since the TiWi5 radio module was certified in a mobile configuration, the end-product does not require SAR testing if the end-product is not used within 20cm of the human body, nor used in conjunction with another radio transmitter.

For portable configurations (antenna-to-body separations of less than 20 cm), the module integrator must have the module certification re-evaluated, which will include a modification to the existing certification and additional testing for exposure and SAR requirements.

6 Contacting LS Research

Headquarters	LS Research, LLC W66 N220 Commerce Court Cedarburg, WI 53012-2636 USA Tel: 1(262) 375-4400 Fax: 1(262) 375-4248
Website	www.lsr.com
Technical Support	forum.lsr.com
Sales Contact	sales@lsr.com

"High Frequency Ceramic Solutions"

2.45 GHz / 5.40 GHz Antenna — **P/N 2450AD46A5400**

Detail Specification: 03/03/05

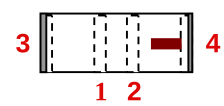
General Specifications

Part Number	2450AD46A5400	
Frequency	Low Band	High Band
Range (Mhz)	2400 - 2500 Mhz	4900 - 5900 Mhz
Return Loss	8.5 dB min.	8.5 dB min.
Peak Gain	1.0 dBi typ. (XZ-V)	-1.5 dBi typ. (YZ-V)
Average Gair	-2.5 dBi typ. (XZ-V)	-2.5 dBi typ. (YZ-V)

Input Power	3 Watts max.
Impedance	50 Ω
Operating Temperature	-40 to +85°C
Reel Quanity	1,000

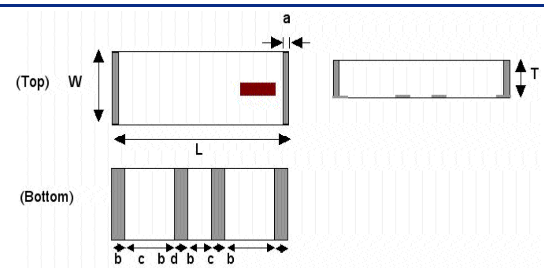
No.	Function
1	High Band Feed
2	Low Band Feed
3	NC
4	NC

Terminal Configuration



Mechanical Dimensions

	In			mm		
L	0.335	±	0.008	8.50	±	0.20
W	0.063	+.004 / -.008		1.60	+0.1 / -0.2	
T	0.047	±	0.008	1.20	±	0.20
a	0.020	±	0.012	0.50	±	0.30
b	0.020	±	0.006	0.51	±	0.15
c	0.104	±	0.006	2.64	±	0.15
d	0.046	±	0.006	1.18	±	0.15

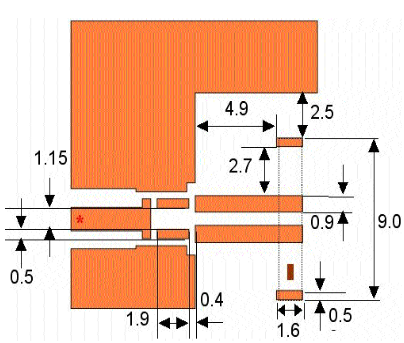


Mounting Considerations

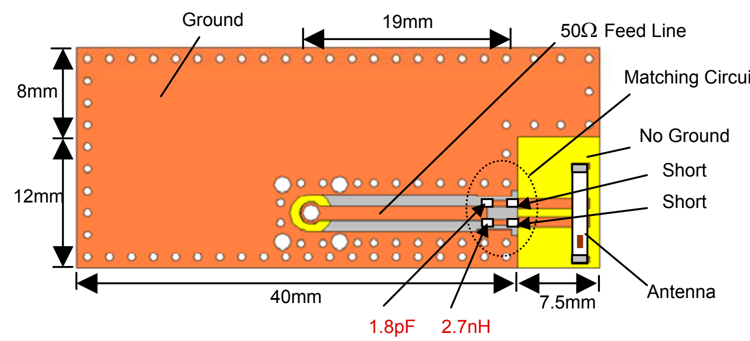
Mount these devices with brown mark facing up. Units: mm

Line width should be designed to provide 50 Ω impedance matching characteristics.

PCB Layout



Test Board for Electrical Characteristic Measurements



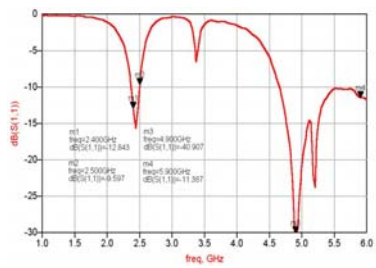
Johanson Technology, Inc. reserves the right to make design changes without notice.
All sales are subject to Johanson Technology, Inc. terms and conditions.

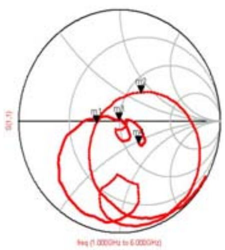
www.johansontechnology.com
931 Via Alondra • Camarillo, CA 93012 • TEL 805.389.1166 FAX 805.389.1821

2.45 GHz / 5.40 GHz Antenna — P/N 2450AD46A5400

Detail Specification: 03/03/05

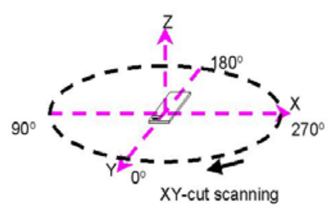
Typical Return Loss

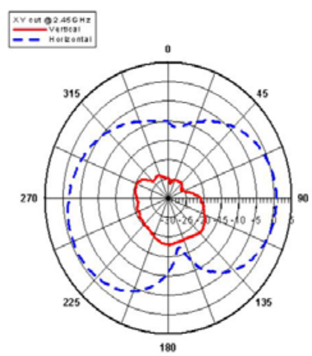




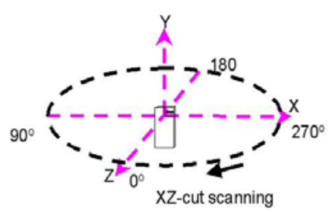
Typical Radiation Patterns

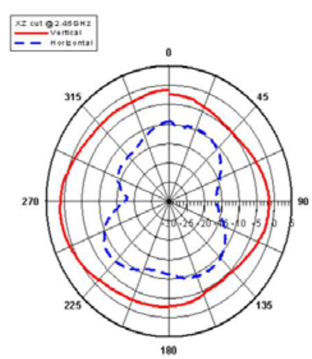
XY-V/XY-H





XZ-V/XZ-H





JOHANSON TECHNOLOGY

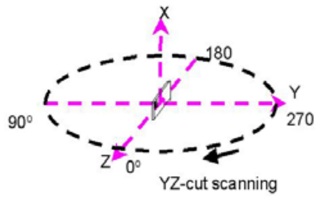
www.johansontechnology.com

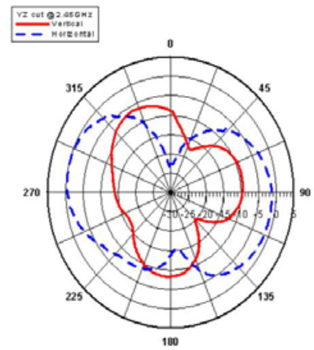
931 Via Alondra • Camarillo, CA 93012 • TEL 805.389.1166 FAX 805.389.1821

"High Frequency Ceramic Solutions"

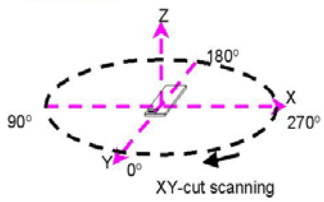
Typical Radiation Patterns

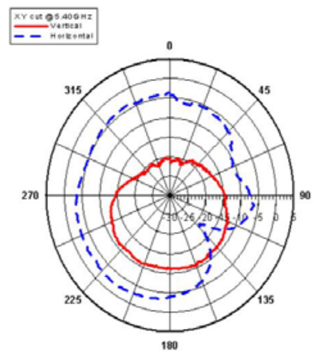
YZ-V/YZ-H



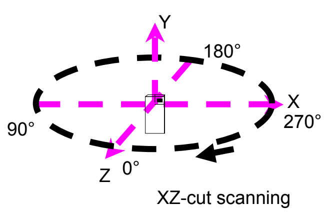


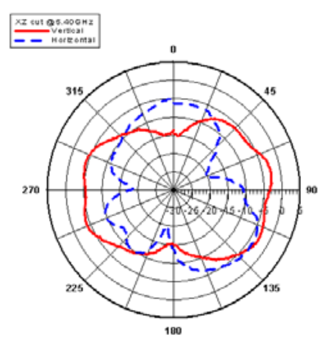
XY-V/XY-H





XZ-V/XZ-H





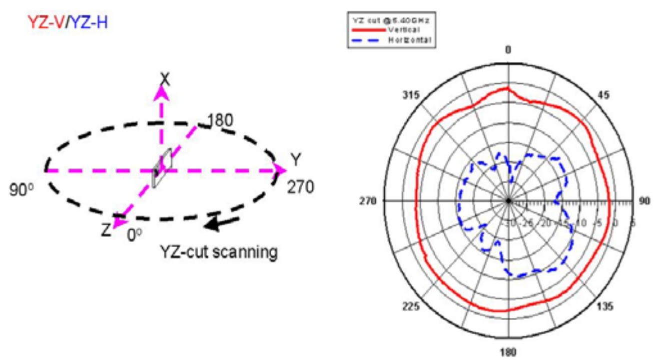
Johanson Technology, Inc. reserves the right to make design changes without notice.
All sales are subject to Johanson Technology, Inc. terms and conditions.

JOHANSON TECHNOLOGY
www.johansontechnology.com
931 Via Alondra • Camarillo, CA 93012 • TEL 805.389.1166 FAX 805.389.1821

2.45 GHz / 5.40 GHz Antenna **P/N 2450AD46A5400**

Detail Specification: 03/03/05

Typical Radiation Patterns



JOHANSON TECHNOLOGY

www.johansontechnology.com
931 Via Alondra • Camarillo, CA 93012 • TEL 805.389.1166 FAX 805.389.1821

2.4 GHz – 2.5 GHz Dipole 2dBi Antenna for Reverse Polarity SMA

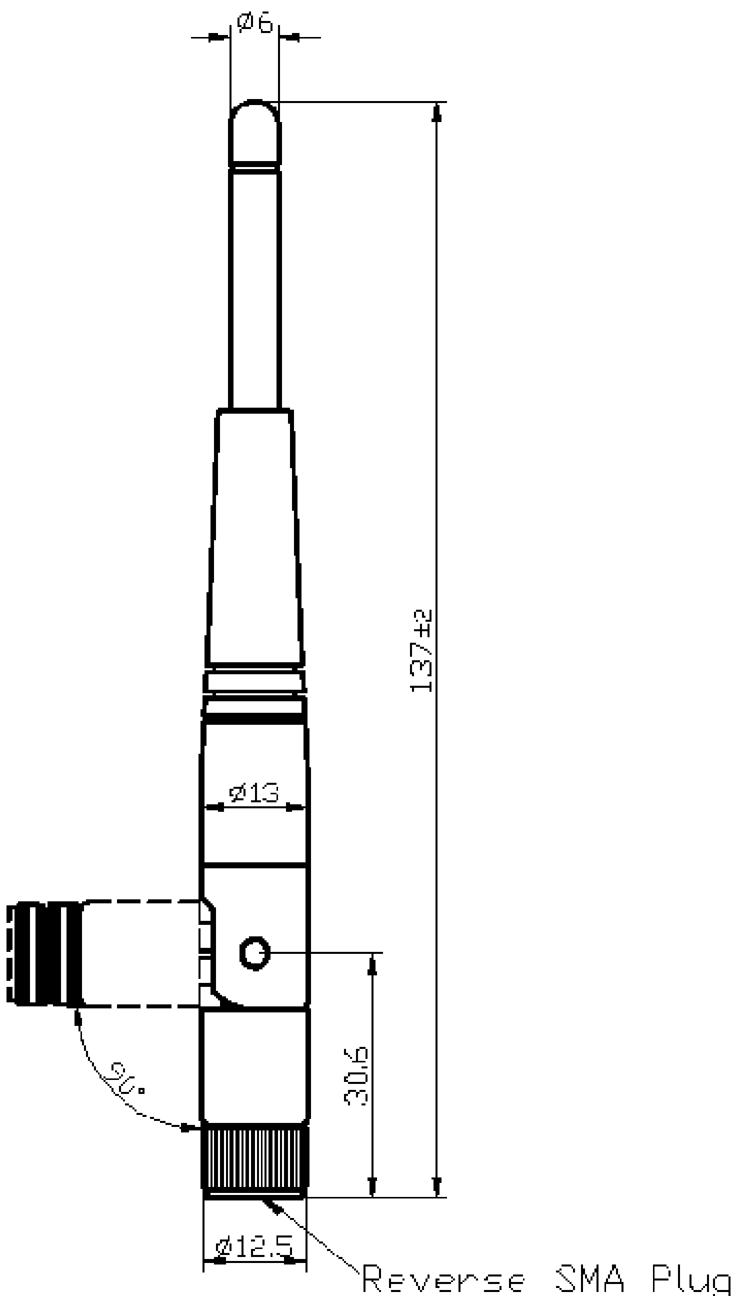
ORDERING INFORMATION

Order Number	Description
001-0009	2.4/5.5 GHz dipole antenna for reverse polarity SMA connector.

SPECIFICATIONS

Specification	Value
Gain	+2 dBi
Impedance	50 ohms, Nominal
Type	Dipole
Polarization	Linear Vertical
VSWR	≤2.0：1, Maximum
Frequency	2400-2500MHz, 5150-5850MHz
Weight	22g
Size	137 × 13 mm
Antenna Color	Black

PHYSICAL DIMENSIONS (MM)



TYPICAL ANTENNA REFLECTION PERFORMANCE

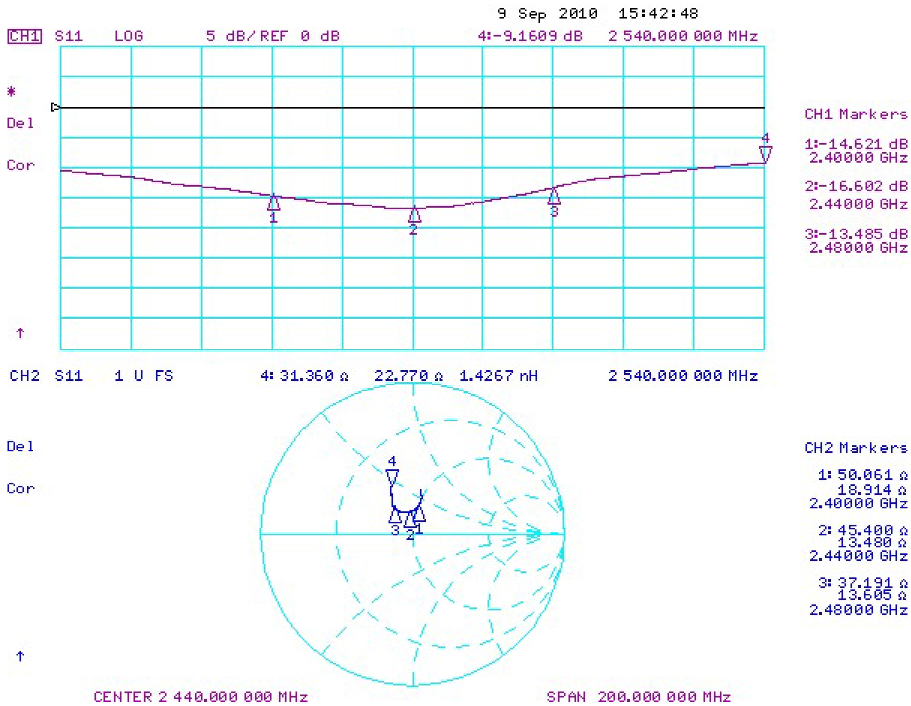


Figure 1 Reflection Parameters for Extended Configuration (S11)

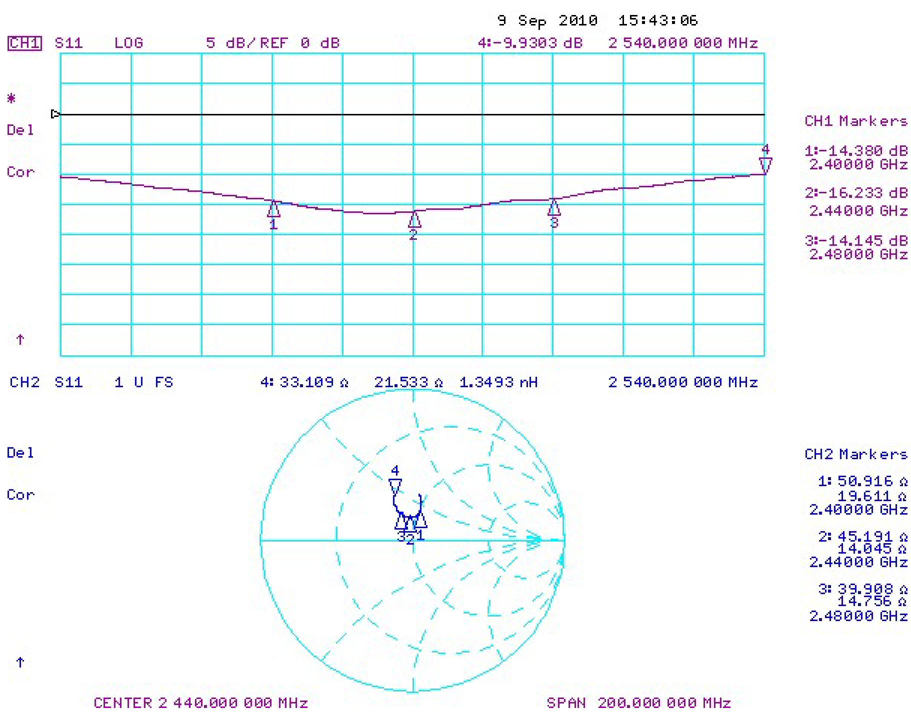
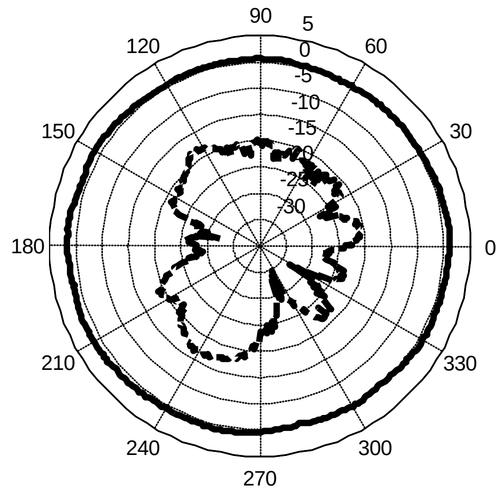


Figure 2 Reflection Parameters for Folded Configuration (S11)

TYPICAL ANTENNA RADIATION PERFORMANCE

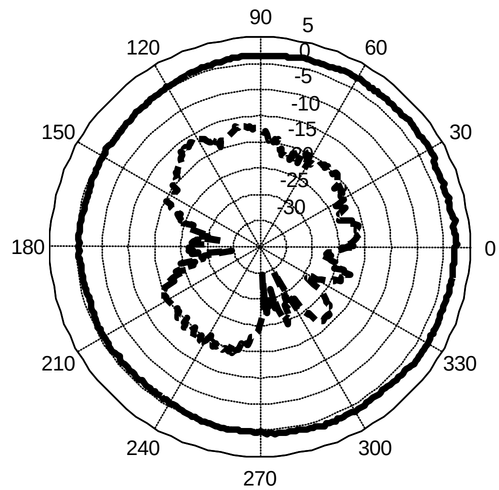
LSR ANTENNA STRAIGHT 2405 MHz



____Vertical Polarization Gain (dBi)

------- Horizontal Polarization Gain (dBi)

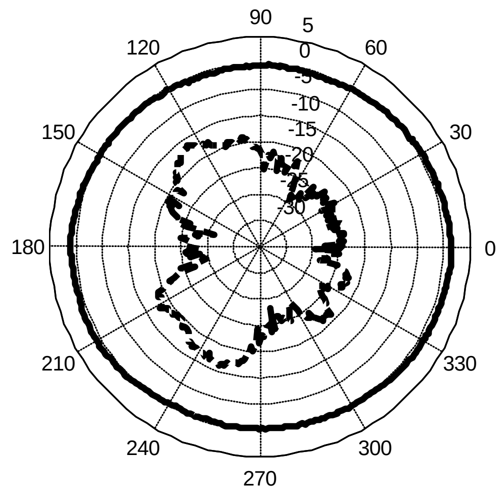
LSR ANTENNA STRAIGHT 2440 MHz



____Vertical Polarization Gain (dBi)

------- Horizontal Polarization Gain (dBi)

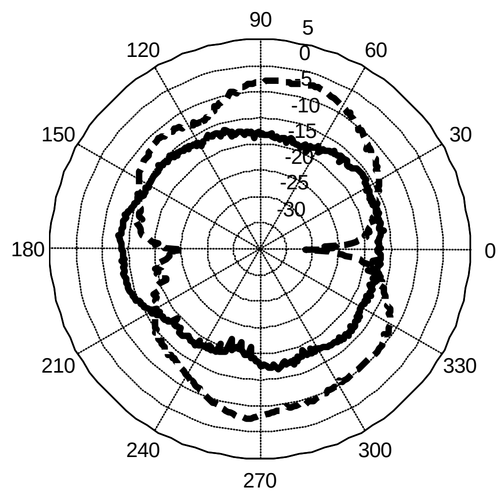
LSR ANTENNA STRAIGHT 2480 MHz



____Vertical Polarization Gain (dBi)

------- Horizontal Polarization Gain (dBi)

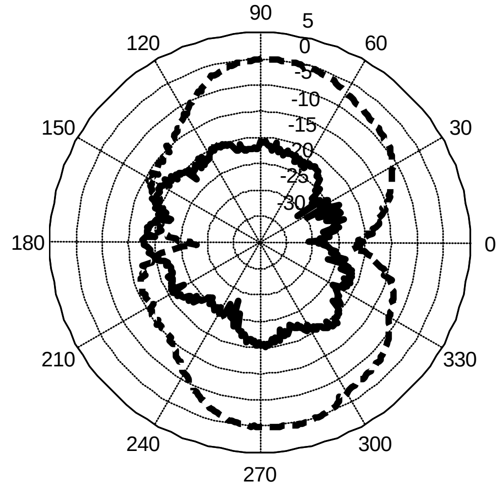
LSR ANTENNA BENT 2405 MHz



____Vertical Polarization Gain (dBi)

------- Horizontal Polarization Gain (dBi)

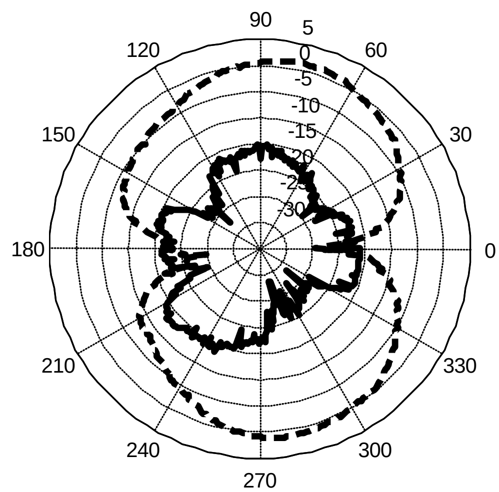
LSR ANTENNA BENT 2440 MHz



____Vertical Polarization Gain (dBi)

------- Horizontal Polarization Gain (dBi)

LSR ANTENNA BENT 2480 MHz



____Vertical Polarization Gain (dBi)

------- Horizontal Polarization Gain (dBi)

CONTACTING LS RESEARCH

Headquarters	LS Research, LLC W66 N220 Commerce Court Cedarburg, WI 53012-2636 USA Tel: 1(262) 375-4400 Fax: 1(262) 375-4248
Website	www.lsr.com
Technical Support	forum.lsr.com
Sales Contact	sales@lsr.com