

TiWi5

Antenna Design Guide



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1.1 Introduction

1.2 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.

1.3 Applicable Documents

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

1.4 Revision History

Date	Change Description	Revision
2/3/2012	Initial release	1.0
9/11/2014	Removed Figure 7	1.1
6/17/2015	Added notes regarding module is not certified as a DFS Master, hence AP mode is not allowed in the 5 GHz band.	1.2

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	Terminal Configuration
1	High Band Feed	
2	Low Band Feed	
3	NC	
4	NC	

Table 5 – Chip Antenna Terminal Configuration

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

2.4 Typical Radiation Patterns

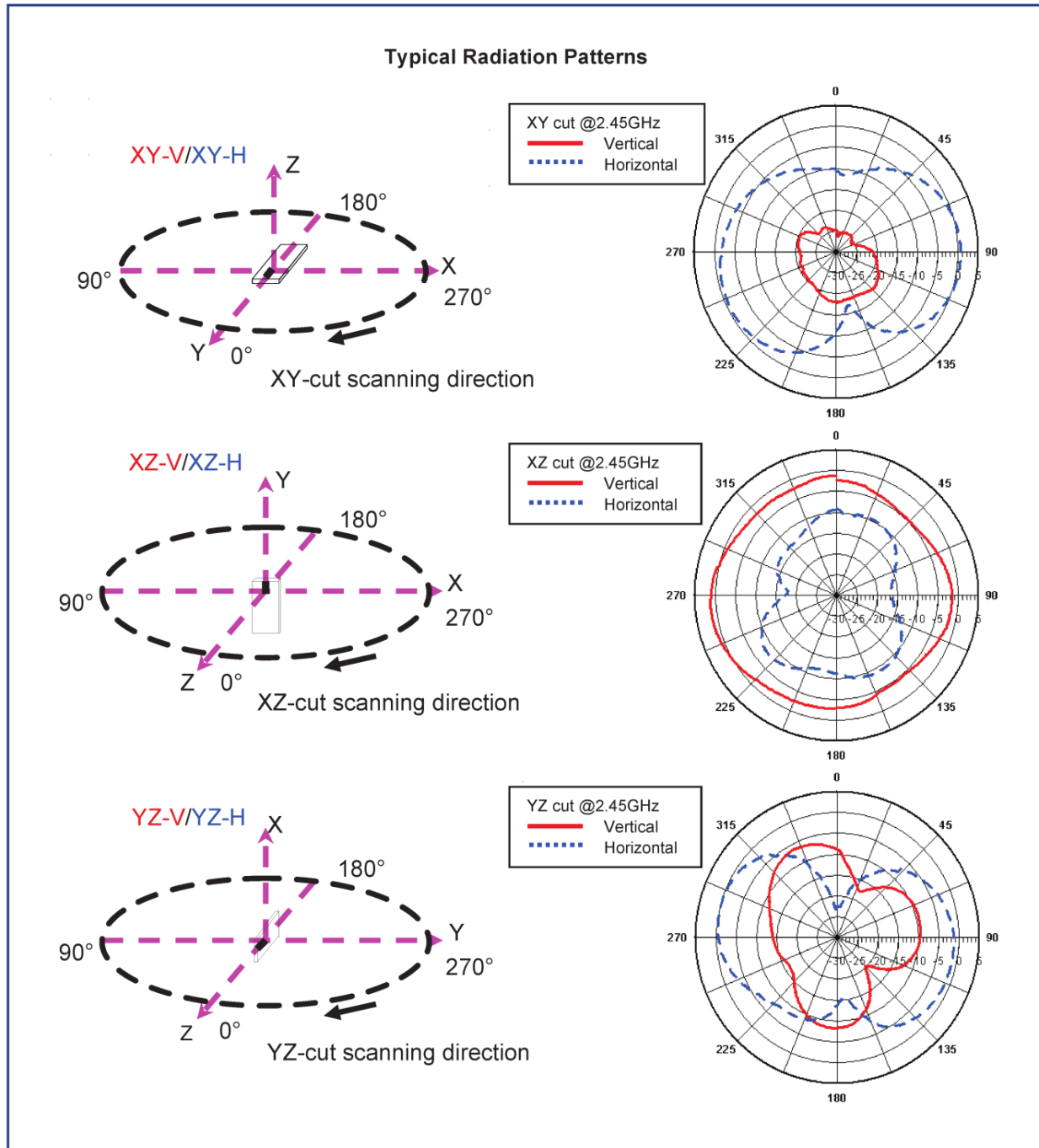


Figure 1 - Chip Antenna Radiation Patterns (2.4 GHz)

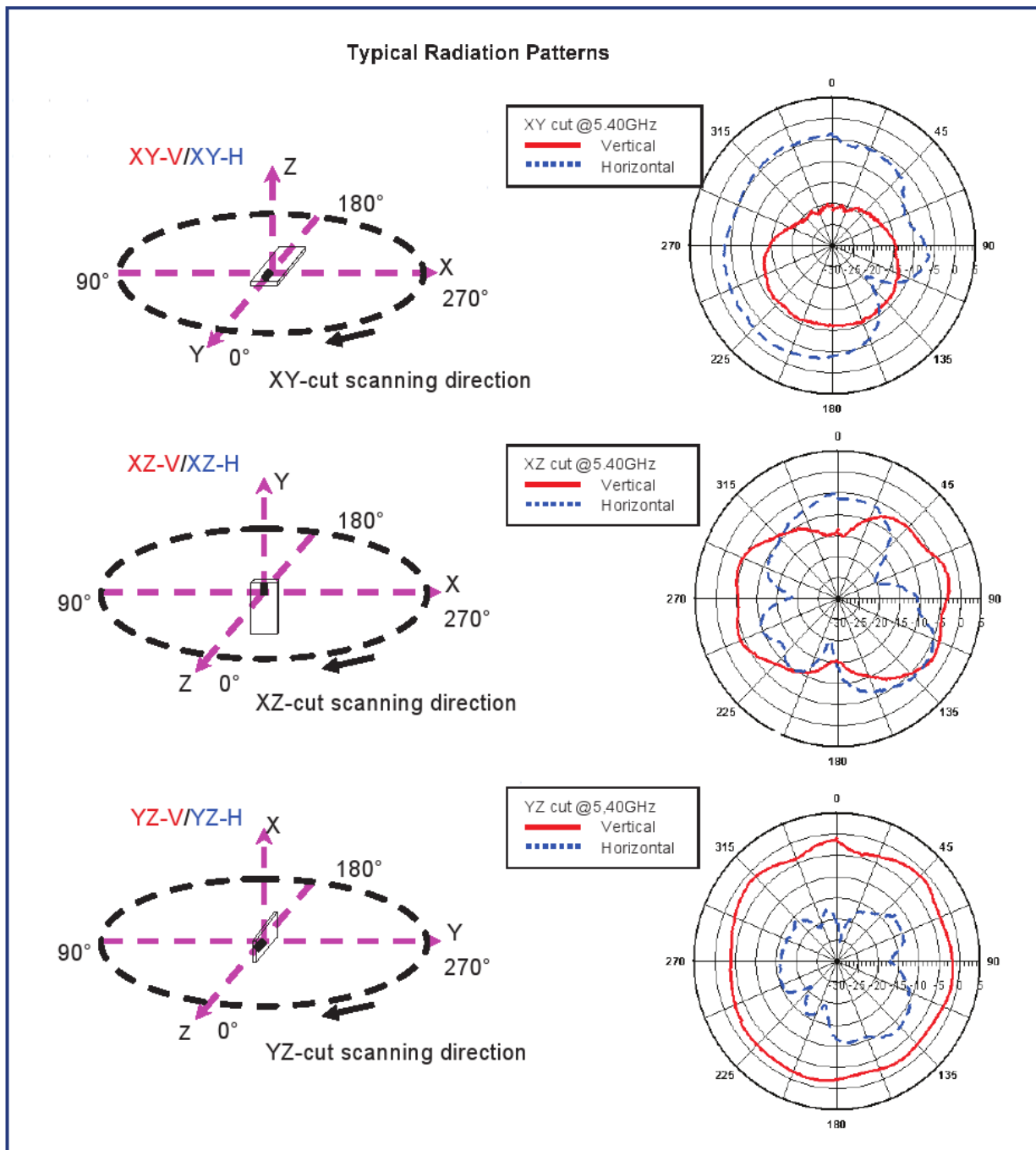


Figure 2 - Chip Antenna Radiation Patterns (5 GHz)

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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.



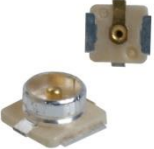
	Part Number	Description
	<p>LS Research 001-0009</p>	<p>2.4/5.5 GHz Dipole Antenna with Reverse Polarity SMA Connector</p>
	<p>LS Research 080-0001</p>	<p>U.FL to Reverse Polarity SMA Bulkhead Cable 105mm</p>
	<p>Hirose U.FL-R-SMT(10)</p>	<p>PCB Mounted U.FL Connector</p>

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

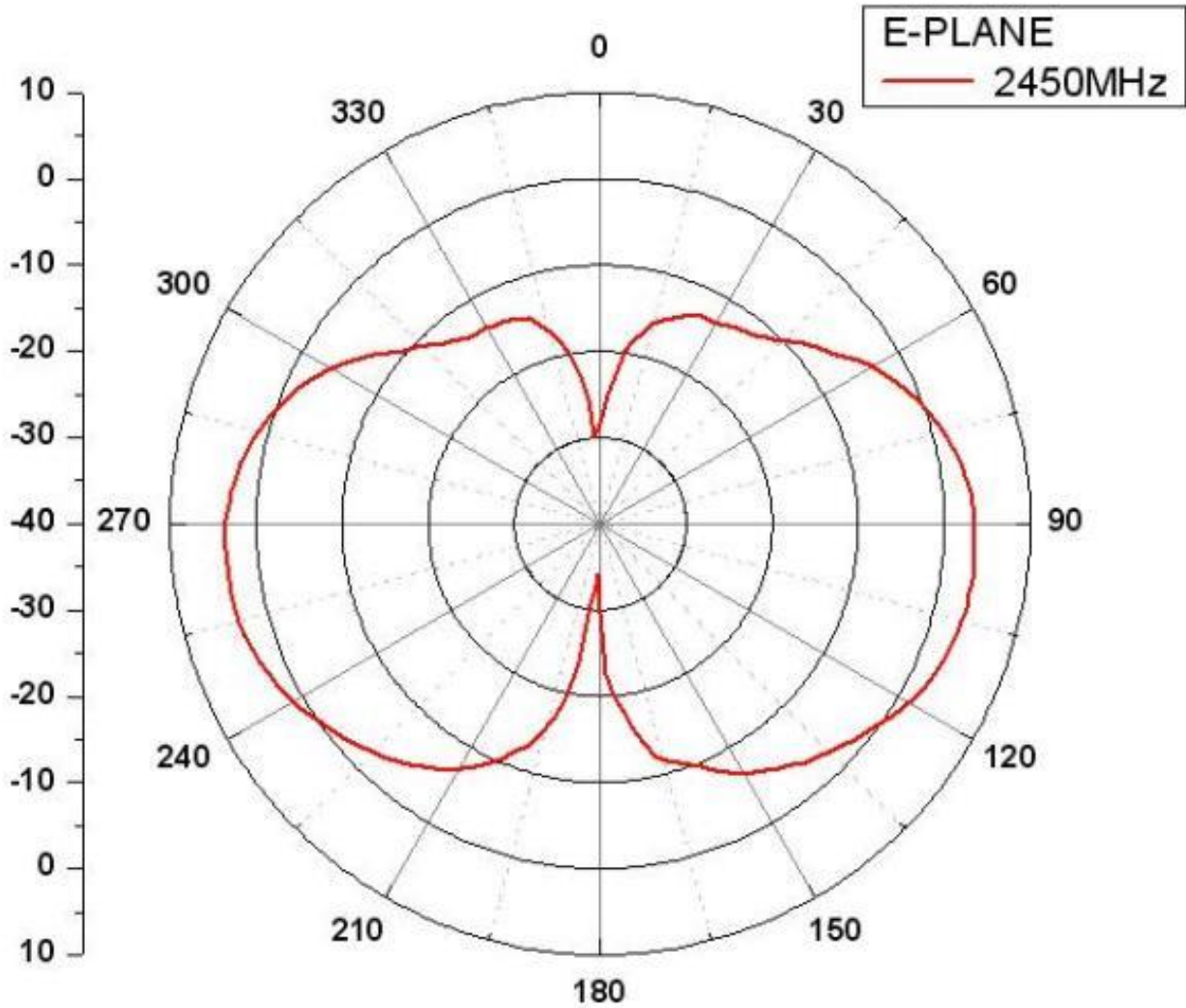


Figure 3 – Dipole Antenna Pattern (LSR Antenna @ 2405 MHz)

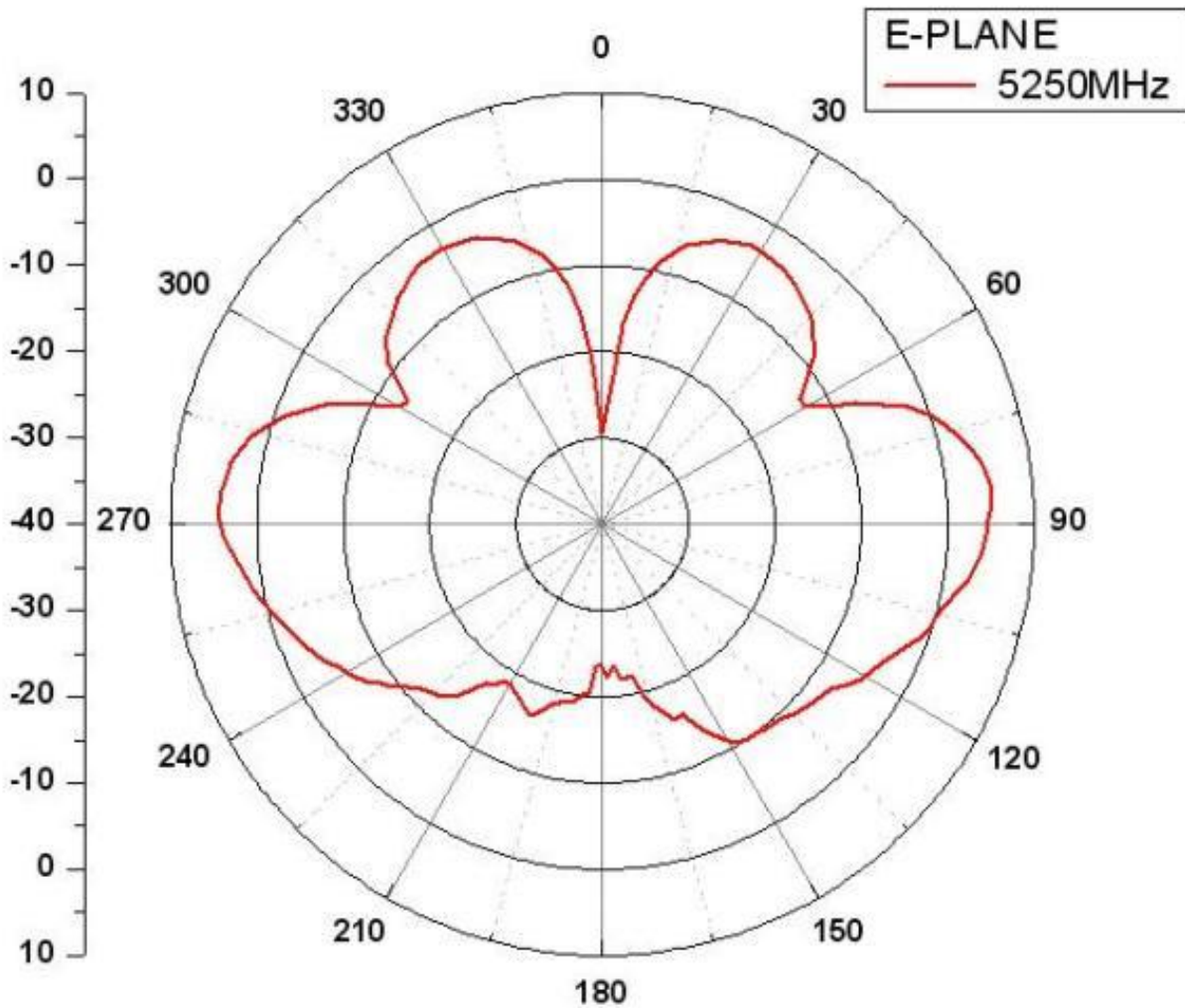


Figure 4 – Dipole Antenna Pattern (LSR Antenna @ 5250 MHz)

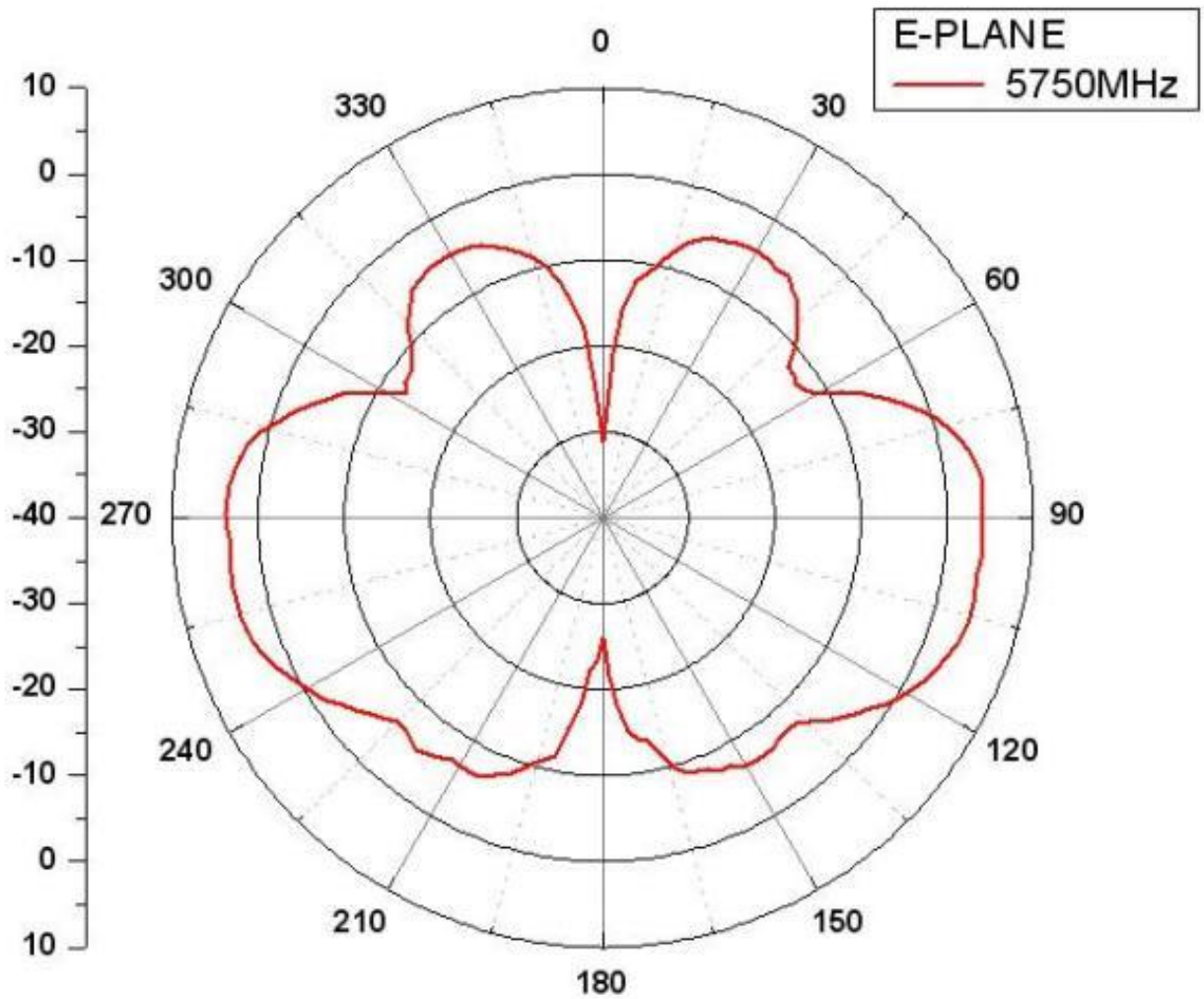


Figure 5 – Dipole Antenna Pattern (LSR Antenna @ 5750 MHz)

3.3 Mechanical Dimensions

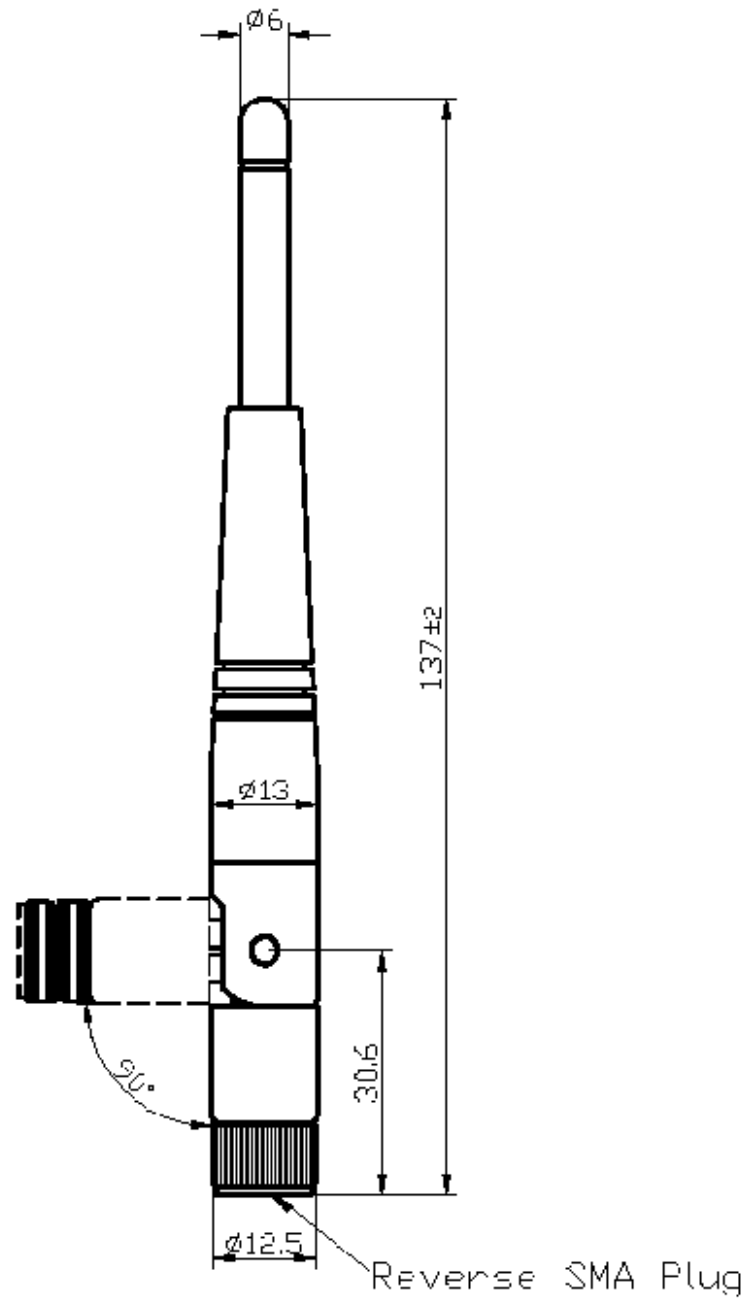


Figure 6 – Dipole Antenna Dimensions

4 PCB Layout Requirements

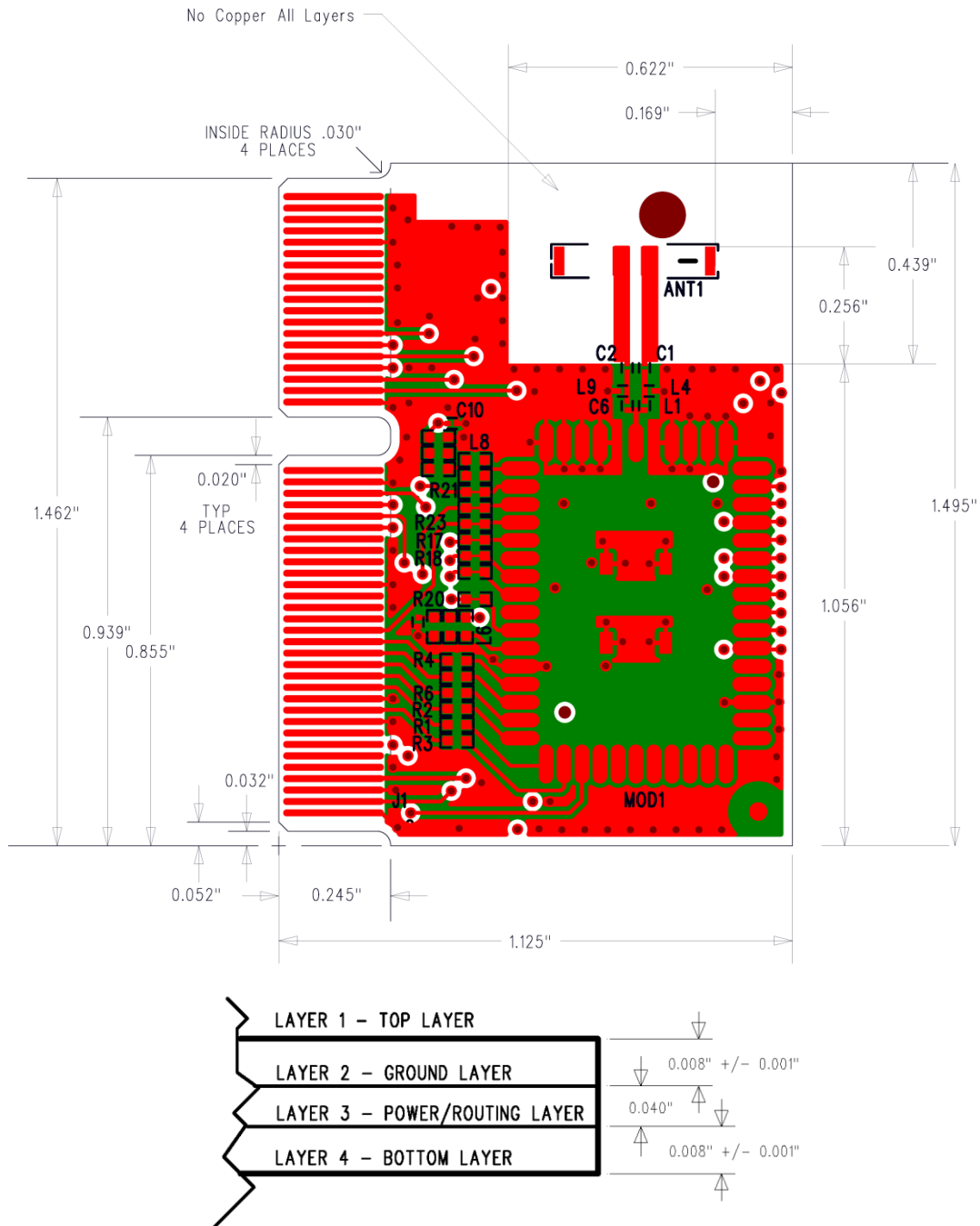
Since this module and its associated set of approved antennas has been certified by the FCC and Industry Canada (IC) as a Modular Radio, the end user is authorized to integrate this module into an end-product, and is solely responsible for the Unintentional Emissions levels produced by the end-product

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 Reference Design PCB



*** Material thickness between Layer 2 and Layer 3 may be adjusted to meet Total Thickness requirement.

Figure 7 – Chip Antenna Certified Reference Design PCB

4.2 Chip Antenna Reference Design Schematic

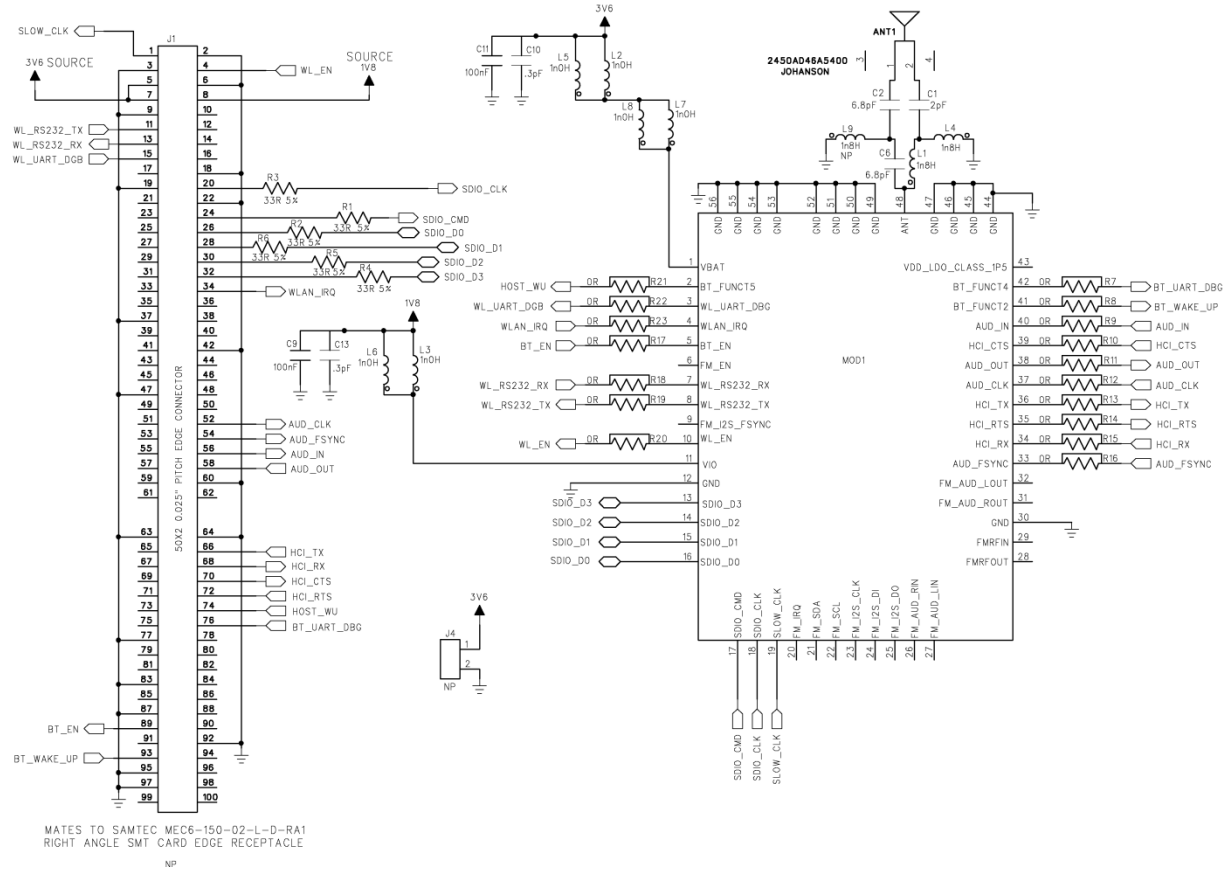


Figure 8 – Chip Antenna Certified Reference Design Schematic

4.3 Chip Antenna Matching Components

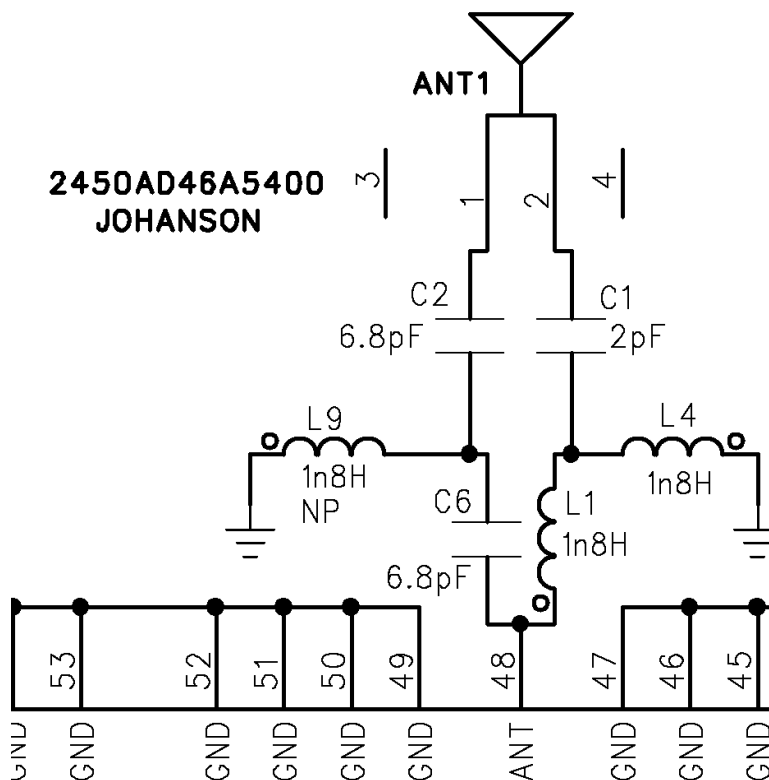


Figure 9 – Chip Antenna Certified Reference Design Matching Components Schematic

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

Table 8 – Chip Antenna Matching Components

4.4 Dipole Antenna PCB Layout Requirements

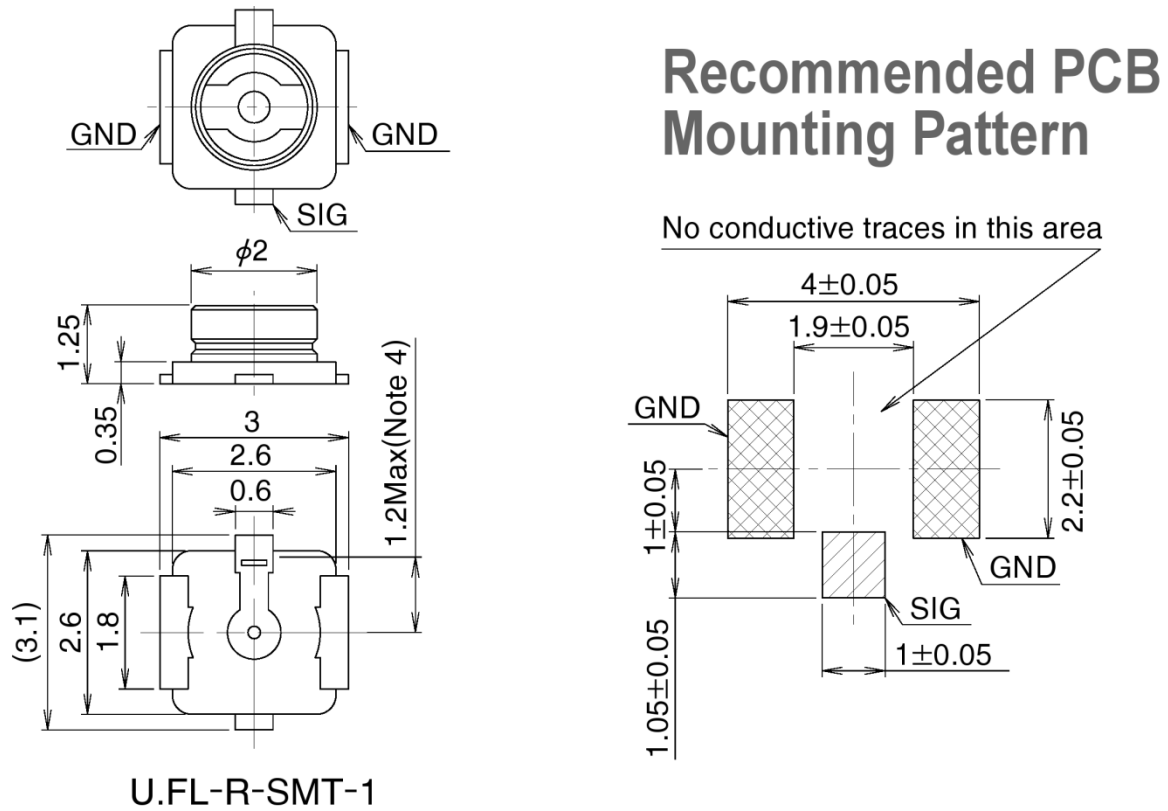
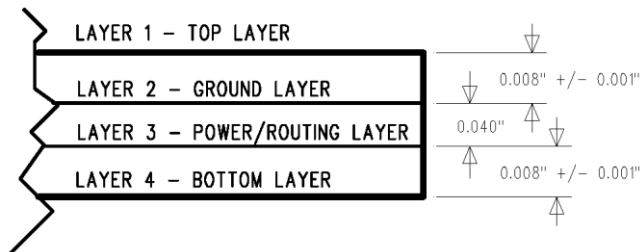
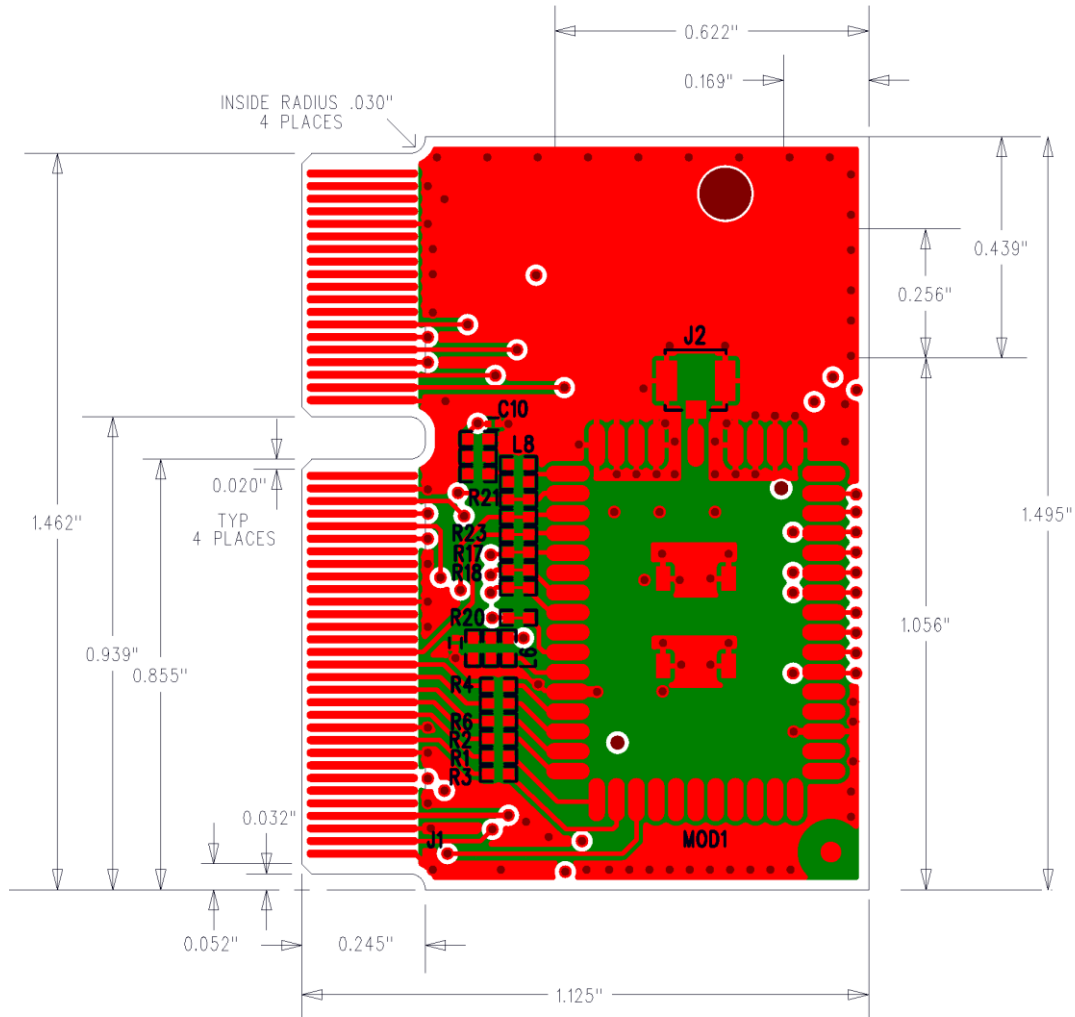


Figure 10 – Dipole Antenna PCB Layout Requirements

4.5 Dipole Antenna Reference Design PCB



*** Material thickness between Layer 2 and Layer 3 may be adjusted to meet Total Thickness requirement.

Figure 11 – Dipole Antenna Certified Reference Design PCB

4.6 Dipole Antenna Reference Design Schematic

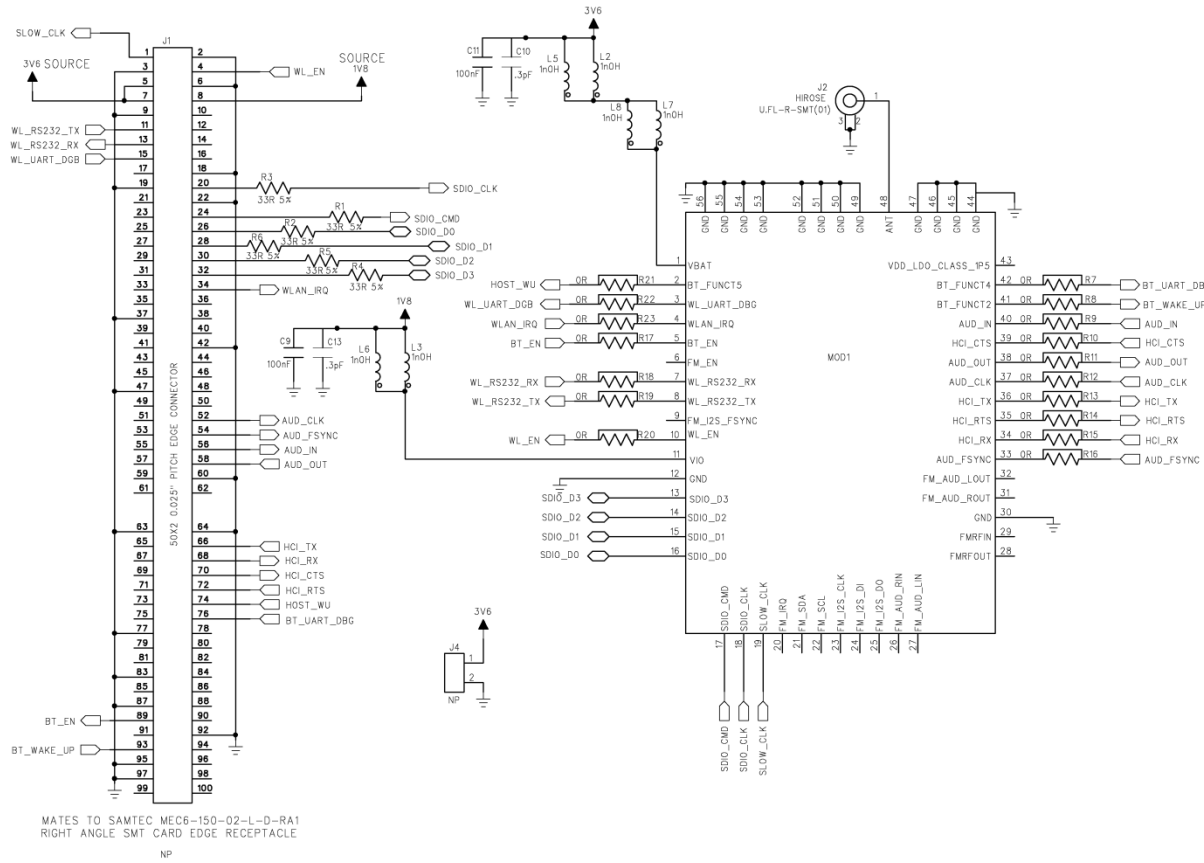


Figure 12 – Dipole Antenna Certified Reference Design Schematic

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.

The TiWi5 module was not certified as a DFS Master, and therefore the AP mode is not allowed in the 5 GHz bands. The AP mode is allowed to be used in the 2.4 GHz band. Software cannot prevent the usage of the AP mode in the 5 GHz band, so it is the module-integrators responsibility to ensure the 5 GHz AP mode is not used.

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. Johanson 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

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