Antenna Test Report

Report No.: TEOT2204000165E4
Test Plan: Non-compliance with ISO17025

Applicant Name: Microchip technology
Manufacturer Name: Microchip technology

Product Name: WBZ450 LGA
Model Number: WBZ450 LGA

Measurements performed at
SGS Taiwan Ltd.
Hwaya District, Taiwan

Issued Date: May 06, 2022

	Name	Date & Signature
Prepared by:	Shawn Yen Supervisor	Shawn Yen May 06, 2022
Approved by:	Dragon Wu Asst. Manager	Dragon Wu May 06, 2022

Distribution

Measurement System Information

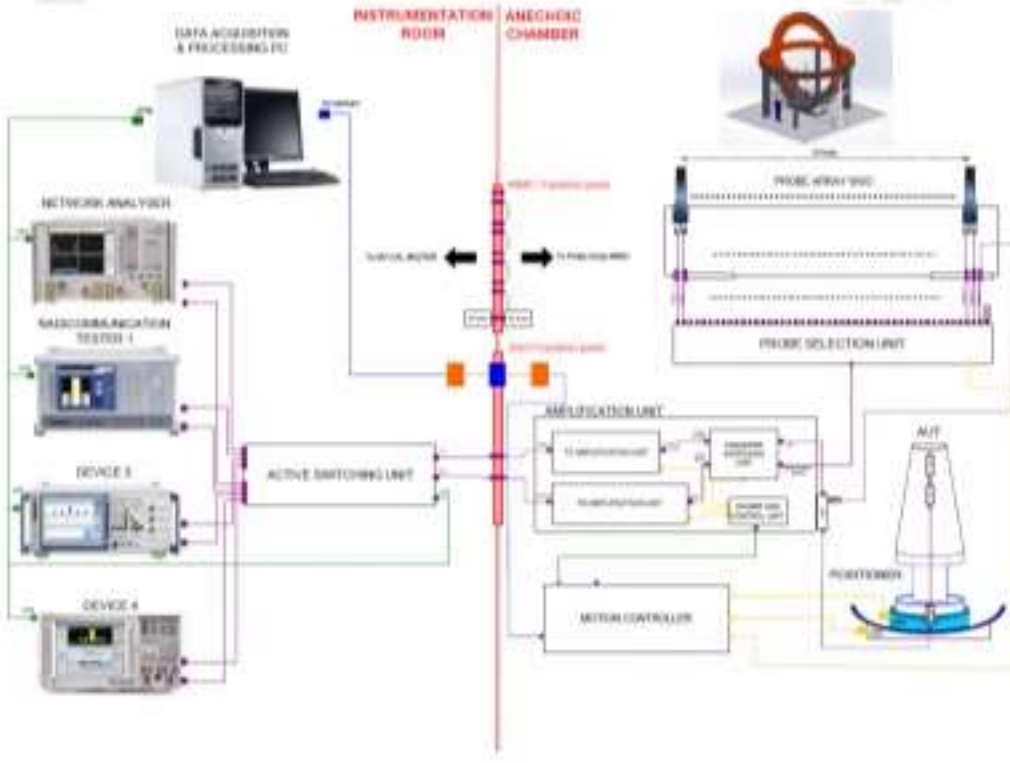
General Information

Testing Condition:

- Temperature: 22±3°C
- Humidity: <80%

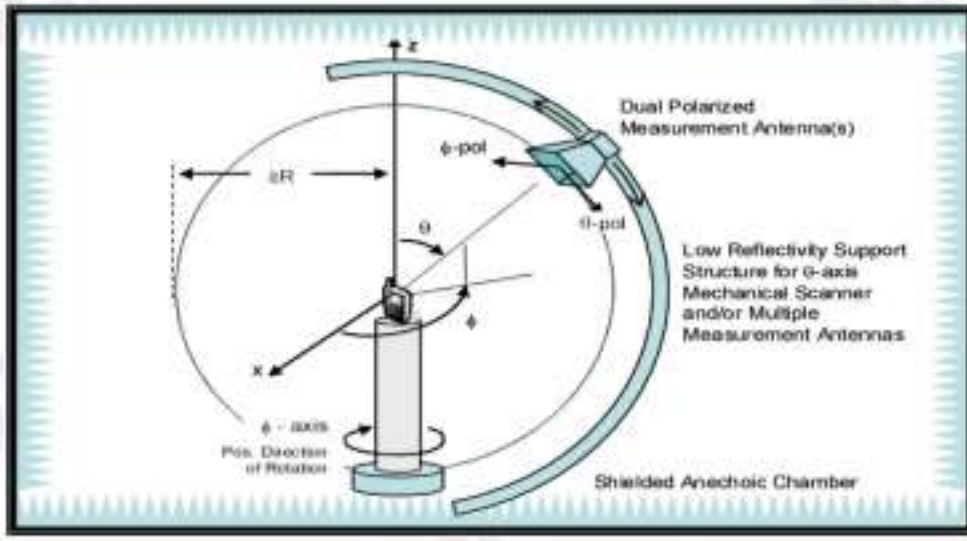
Measurement Facility:

- Measurement Chamber: MVG 3D fully anechoic chamber and its measuring system (Stargate-24-L)
- Base Station Simulator: Anritsu MT8820C (or R&S CMU200)
- Network Analyzer: Agilent E5071C



Measurements are performed in a MVG **Stargate-24-L** with the StarAct interface for a base station simulator. The **Stargate-24-L** has 23 probe antennas mounted with equal spacing on a circular arch. Electronic switching of the probe antennas provides outstanding measurement speed. The geometry of the setup, with only a Styrofoam column within 1.6 meters of the EUT, ensures minimum interference and low ripple on the measured radiation patterns. The DUT is placed on top of the pedestal, in the center of the system.

Typical Setup for MVG Stargate-24-L:



Instruments View

Inside View

Testing Laboratory: Identification of the Responsible Test Laboratory.

- **OTA Laboratory:**
  SGS Taiwan Ltd. Wireless Laboratory
  No.134, Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan 24803.
  Telephone: +886 2 2299 3279
  Fax: +886 2 2298 0488
  Internet: http://www.tw.sgs.com

- **Testing Location:**
  No. 2, Keji 1st Rd., Hwaya Technology Park, Guishan District, Taoyuan City, Taiwan 33383.

Details of Applicant:

Applicant's name:	**Microchip technology**
Applicant's address:	**6F,No.24-2,Industry E. RD. IV, HsinChu Science Park, HsinChu 30077, Taiwan**
Contact person:	**Yeung Kai Hong**
Telephone:	**+886-3-577-8366 ext 8764**
Fax:	**N/A**
E-mail:	**hong.yeung@microchip.com**

Details of Manufacturer:

Manufacturer's name:	**Microchip technology**
Manufacturer's address:	**6F,No.24-2,Industry E. RD. IV, HsinChu Science Park, HsinChu 30077, Taiwan**
Contact person:	**Yeung Kai Hong**
Telephone:	**+886-3-577-8366 ext 8764**
Fax:	**N/A**
E-mail:	**hong.yeung@microchip.com**

Details of EUT:

Device Description:	**WBZ450 LGA**
Device Manufacturer:	**Microchip technology**
Device Model:	**WBZ450 LGA**
Hardware Version:	**N/A**
Software Version:	**N/A**
Frequency Range:	**2400MHz ~ 2500MHz** **Step size: 10MHz**
Antenna Type:	**Internal antenna**

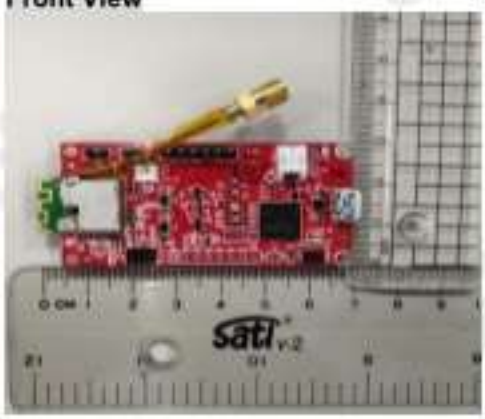
PCB antenna Curiosity board Matching		
C15	**2.5pF**	**GJM0335C1H2R5BB01**
C25	**2.3nH**	**LQP03HQ2N3B02**
12'' x 14'' board Matching		
C15	**2.2pF**	**GJM0335C1H2R2BB01**
C25	**2.3nH**	**LQP03HQ22N3B02**

Duration of Tests:

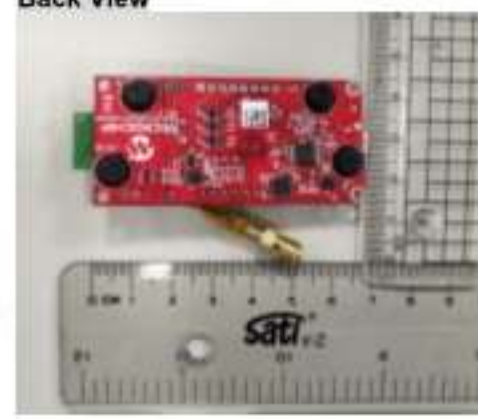
Sample Receive Date:	**2022-04-27**
Test Starting Date:	**2022-04-27**
Test Ending Date:	**2022-04-27**
Report Issued Date:	**2022-05-06**

Photographs of EUT:

Front View



Back View



List of Equipment

Equipment Summary Sheet

Equipment Description	Manufacturer	Identification no.	Current calibration date	Next calibration date
Universal Radio Communication tester	Anritsu	MT8820C	2021/10/12	2022/10/11
Network Analyzer	Agilent	E5071C	2022/01/12	2023/01/11
Sleeve Dipole	MVG	SD740	2022/01/07	2025/01/06
Dual Ridge Horn	MVG	SH800	2021/11/09	2022/11/08
Dipole antenna	ETS-Lindgren	3126-700	2020/10/13	2023/10/12
Stargate-24-L probe array	MVG	Stargate-24-L	2021/11/11	2022/11/10
Measurement software	MVG	SPM V1.9	N/A	N/A

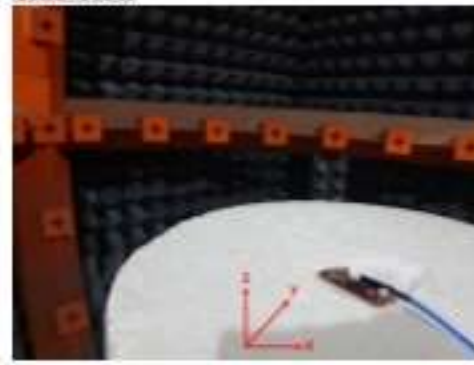
Antenna Gain and Efficiency

WBZ450 LGA			
Freq(MHz)	Peak Gain. dBi	Efficiency	Average . dBi
2400.00	2.82	40.78%	-3.90
2410.00	3.31	45.82%	-3.39
2420.00	3.69	49.01%	-3.10
2430.00	3.91	50.21%	-2.99
2440.00	4.14	52.63%	-2.79
2450.00	4.08	52.34%	-2.81
2460.00	3.86	50.13%	-3.00
2470.00	3.79	48.91%	-3.11
2480.00	3.48	45.69%	-3.40
2490.00	3.14	43.13%	-3.65
2500.00	2.60	40.30%	-3.95

Test Setup

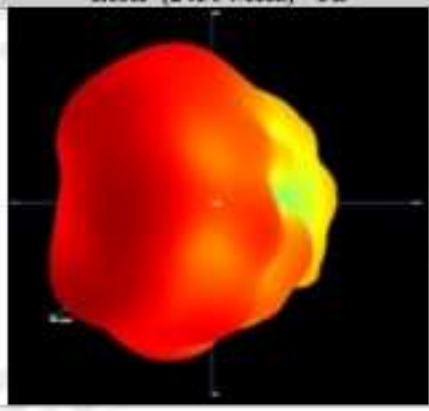
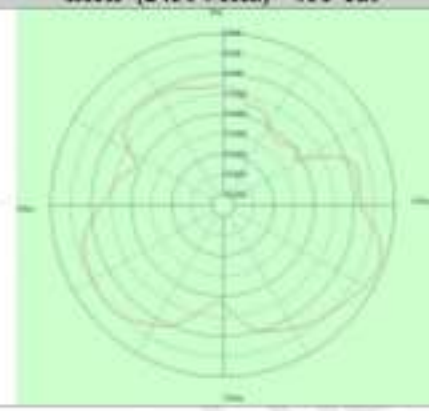
Front View

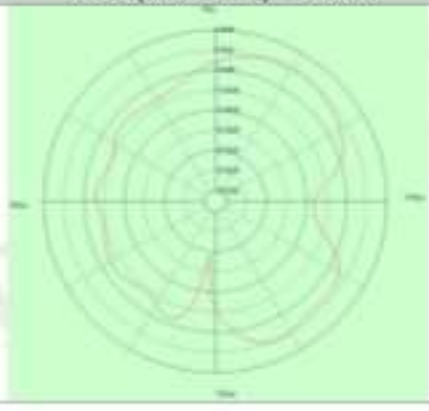
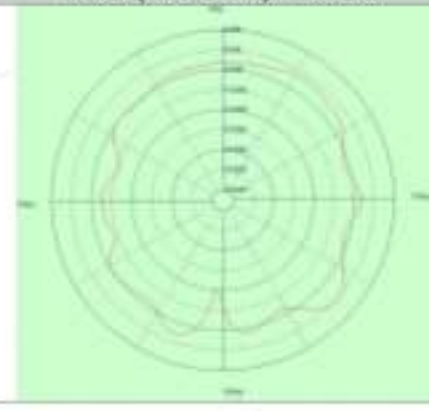
Side View



Antenna 3D Plot Matrix

All plots in this section show the total EIRP (EIRPθ + EIRPφ) with the +x-axis pointing out of the page, +y-axis pointing right, and +z-axis pointing up.

Free Space EIRP (2450 MHz) - 3D	Free Space EIRP (2450 MHz) – XY cut
	

Free Space EIRP (2450 MHz) – XZ cut	Free Space EIRP (2450 MHz) – YZ cut
	

End of Report

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

ORDERING INFORMATION

Order Number	Description
001-0001	2.4 GHz Dipole Antenna for Reverse Polarity SMA Connector.
080-0001	U.FL to Reverse Polarity SMA Cable, 105mm

Table 1 Orderable Part Numbers

SPECIFICATIONS

Specification	Value
Peak Gain	+2 dBi
Impedance	50 ohms, Nominal
Type	Dipole
Polarization	Linear Vertical
VSWR	≤2.5 : 1, Maximum
Frequency	2400-2500MHz
Weight	13g
Size	105×10 mm
Antenna Color	Black
Operating Temp	-20°C to +65°C
UL Rating	UL 94HB

Table 2 Specifications

PHYSICAL DIMENSIONS (MM)

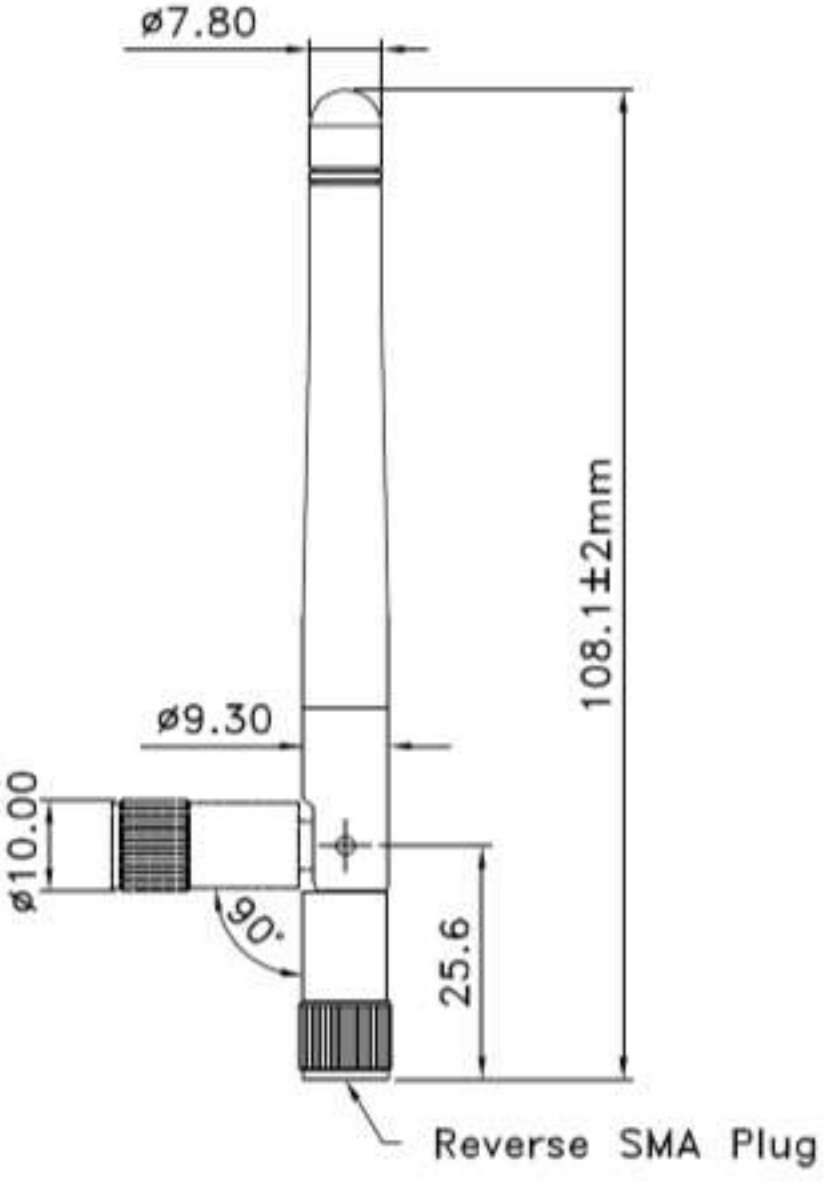


Figure 1 Physical Dimensions

TYPICAL ANTENNA REFLECTION PERFORMANCE

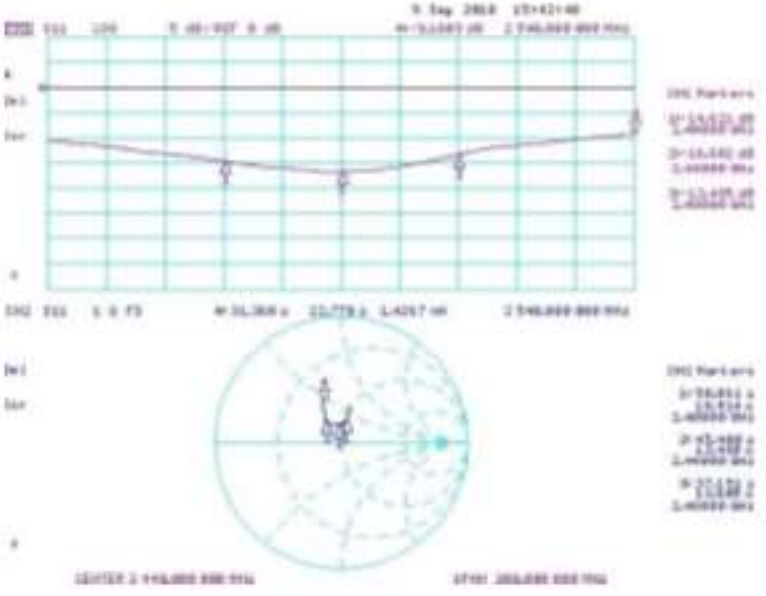


Figure 2 Reflection Parameters for Extended Configuration (S11)

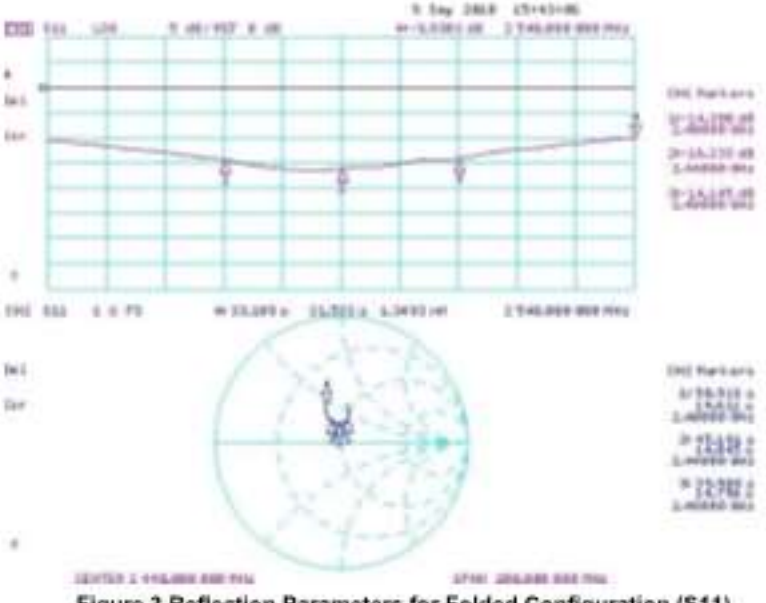
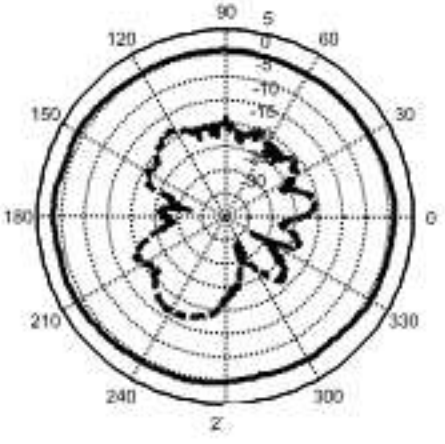


Figure 3 Reflection Parameters for Folded Configuration (S11)

TYPICAL ANTENNA RADIATION PERFORMANCE

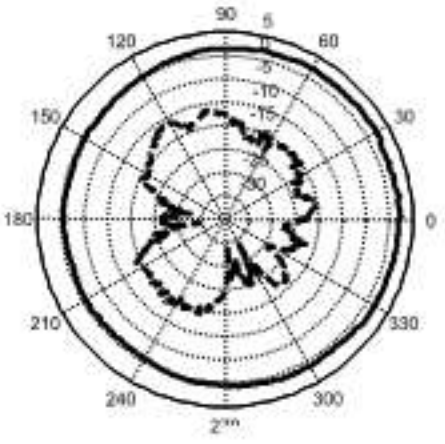
LSR ANTENNA STRAIGHT 2405 MHz



____Vertical Polarization Gain (dBi)

—— Horizontal Polarization Gain (dBi) min: -29.7 max: -11.2 avg: -17.7

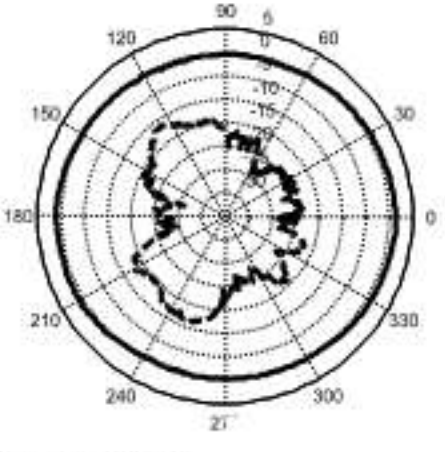
LSR ANTENNA STRAIGHT 2440 MHz



___Vertical Polarization Gain (dBi)

—— Horizontal Polarization Gain (dBi) min: -28.0 max: -11.4 avg: -17.9

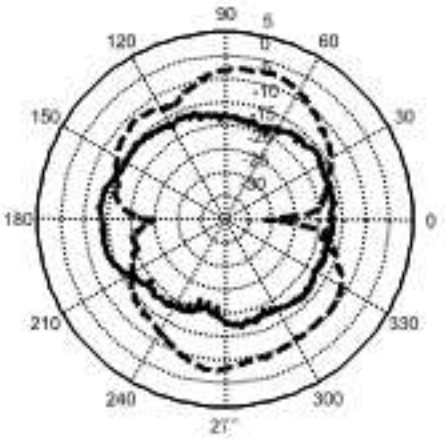
LSR ANTENNA STRAIGHT 2480 MHz



___Vertical Polarization Gain (dBi)

—— Horizontal Polarization Gain (dBi) min: -28.0 max: -11.1 avg: -17.7

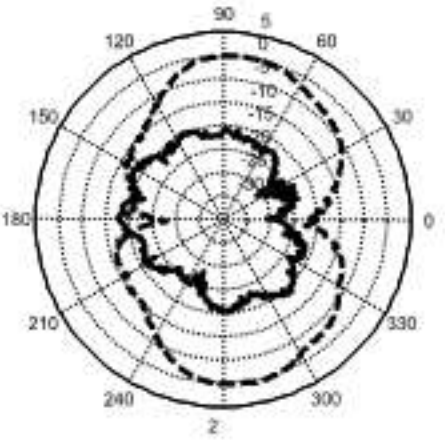
LSR ANTENNA BENT 2405 MHz



____Vertical Polarization Gain (dBi)

------ Horizontal Polarization Gain (dBi) min: -26.2 max: -2.1 avg: -6.9

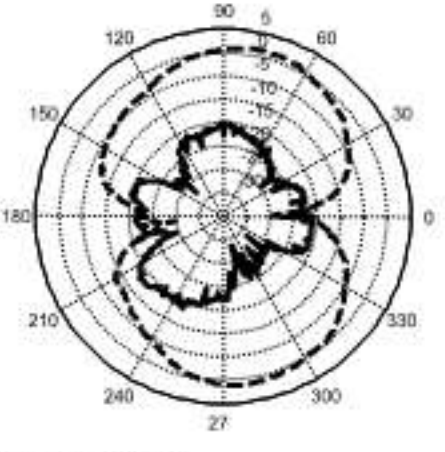
LSR ANTENNA BENT 2440 MHz



____Vertical Polarization Gain (dBi)

------ Horizontal Polarization Gain (dBi) min: -22.8 max: +0.6 avg: -7.1

LSR ANTENNA BENT 2480 MHz



____Vertical Polarization Gain (dBi)

------ Horizontal Polarization Gain (dBi) min: -24.7 max: +1.4 avg: -5.7

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

Laird
CONNECTIVITY

FlexPIFA

5-dBi Antenna with U.FL Cable 2.4 GHz/5.5 GHz

FEATURES AND BENEFITS

- Dual band antenna – 2.4 GHz and 5.5 GHz
- Quick and easy installation
- Adhesive holds to surface during humidity exposure and hot/cold cycles
- RoHS-compliant
- Can be installed in the following ways:
  - On different non-conductive surfaces and thicknesses
  - Near metals or the human body
  - On flat or curved surfaces

SPECIFICATIONS		
Frequency (MHz)	2400 - 2480	4900 - 5900
Peak Gain (dBi)	+2.5	+3.0
Average Gain (dBi)	> -2.5	> -3.4
VSWR (MHz)	<2.5:1	<3.0:1
Impedance (Ω)	50	
Antenna Type	Flexible Planar Inverted F (FlexPIFA)	
Polarization	Linear	

MECHANICAL SPECIFICATIONS		
Dimensions – mm (inches)	38.5 x 12.7 x 2.5 (1.52 x 0.5 x 0.098)	
Weight – g (oz.)	1.13 (0.040)	
Color	Clear yellow	
Adhesive	3M 100MP	
Connector Mating Height (max) – mm	MHF1 (U.FL) MHF4L	2.5 1.4

ENVIRONMENTAL SPECIFICATIONS	
Operating Temperature – °C (°F)	-40 to +85°C (-40 to +185°F)
Material Substance Compliance	RoHS

CONFIGURATION

PART NUMBER	CABLE LENGTH	CONNECTOR
001-0016	100 mm	U.FL
001-0021	100 mm	MHF4L
EFB2455A3S-16MHF1	160 mm	MHF4L

Americas: +1-800-492-2320
Europe: +44-1628-858-940
Hong Kong: +852 2923 0610

MECHANICAL DRAWING

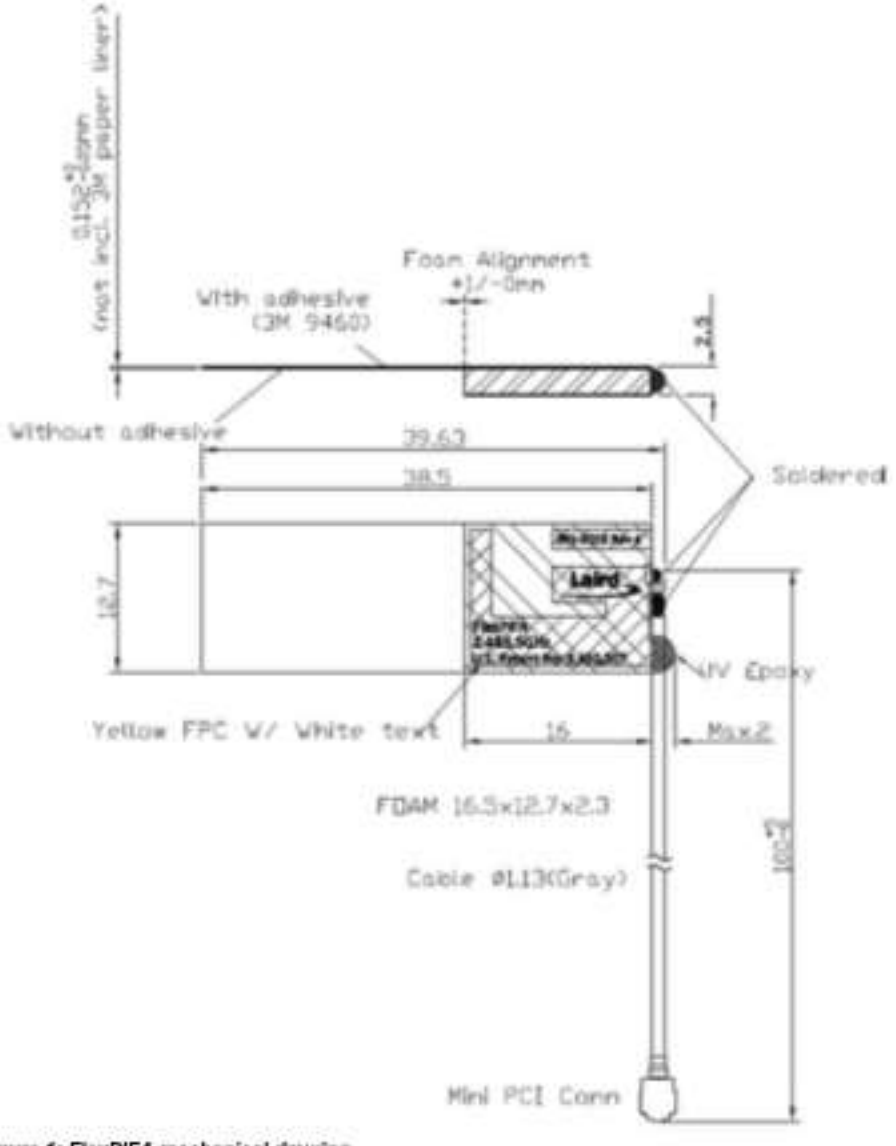


Figure 1: FlexPIFA mechanical drawing

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Hong Kong: +852 2923 0610

Test Setup

Antenna measurements such as VSWR were measured with an Agilent E5071C vector network analyzer. Radiation patterns were measured with a CMT Planar 804/1 vector network analyzer in a Howland Company 3100 chamber equivalent. Phase center is nine inches above the Phi positioner.

Flat surface measurements were done with the antenna centered on a 1.5 mm-thick plate of polycarbonate. Curved surface measurements were taken by placing the antenna on the inside and outside of different diameter PVC tubing.

Figure 2: Antenna chamber

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FLAT SURFACE ANTENNA MEASUREMENTS

Return Loss

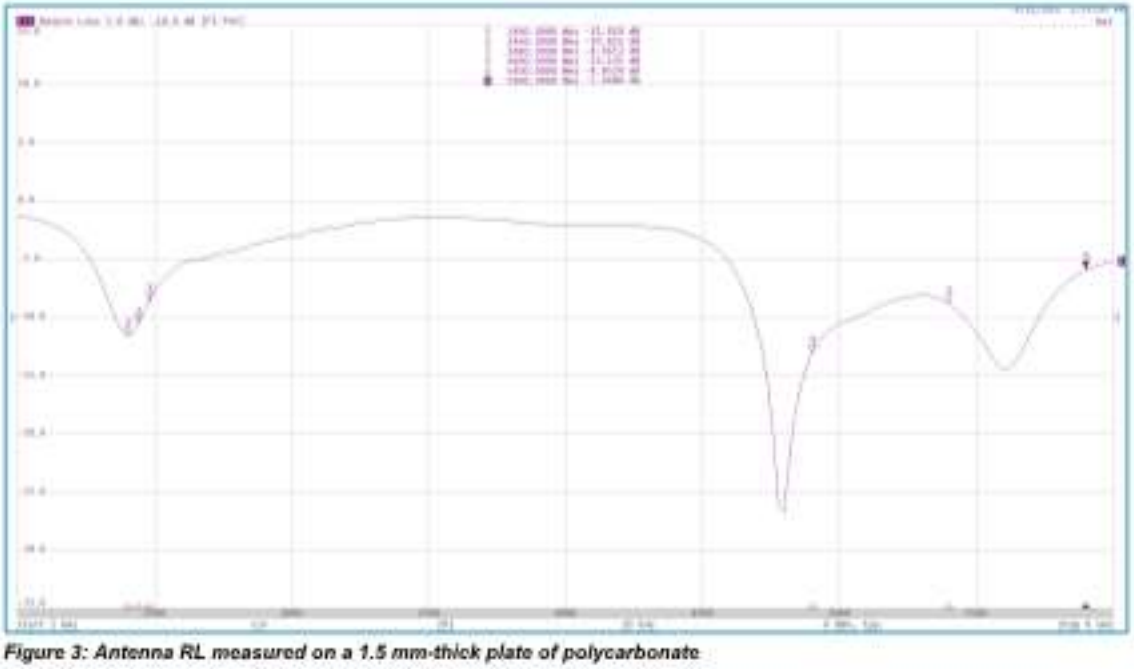

Figure 3: Antenna RL measured on a 1.5 mm-thick plate of polycarbonate

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Hong Kong: +852 2923 0610

Flat surface Antenna Radiation Performance

FlexPIFA centered on a 1.5 mm-thick plate of polycarbonate

Antenna Measurement Set Up

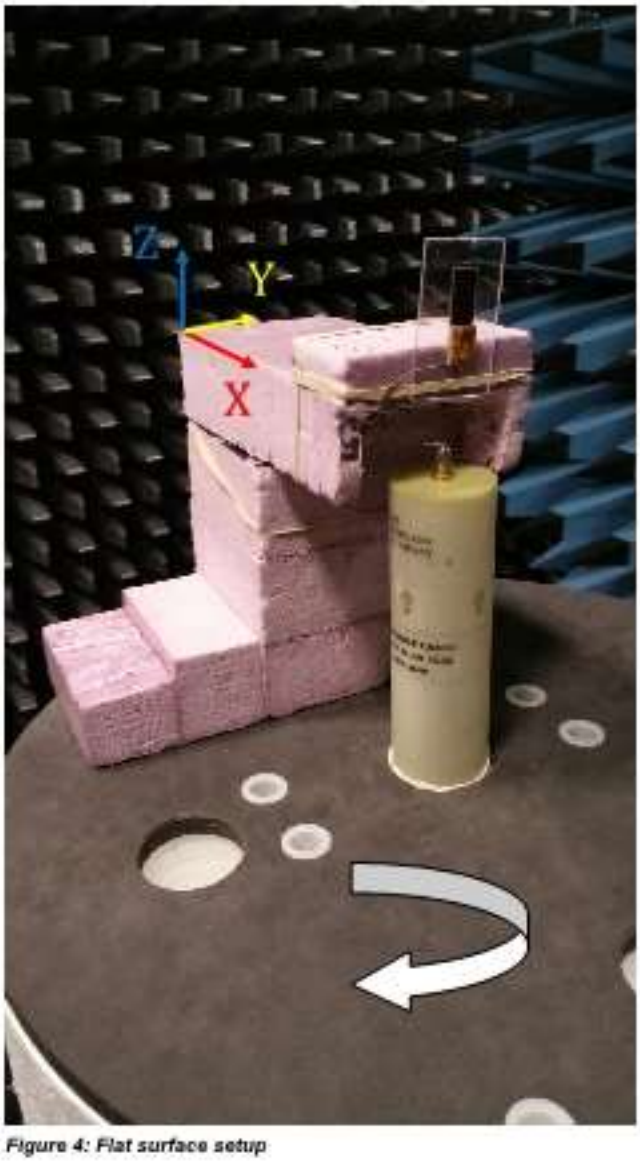

Figure 4: Flat surface setup

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2.4 GHz Band

Azimuthal Conical Cuts at 2440 MHz

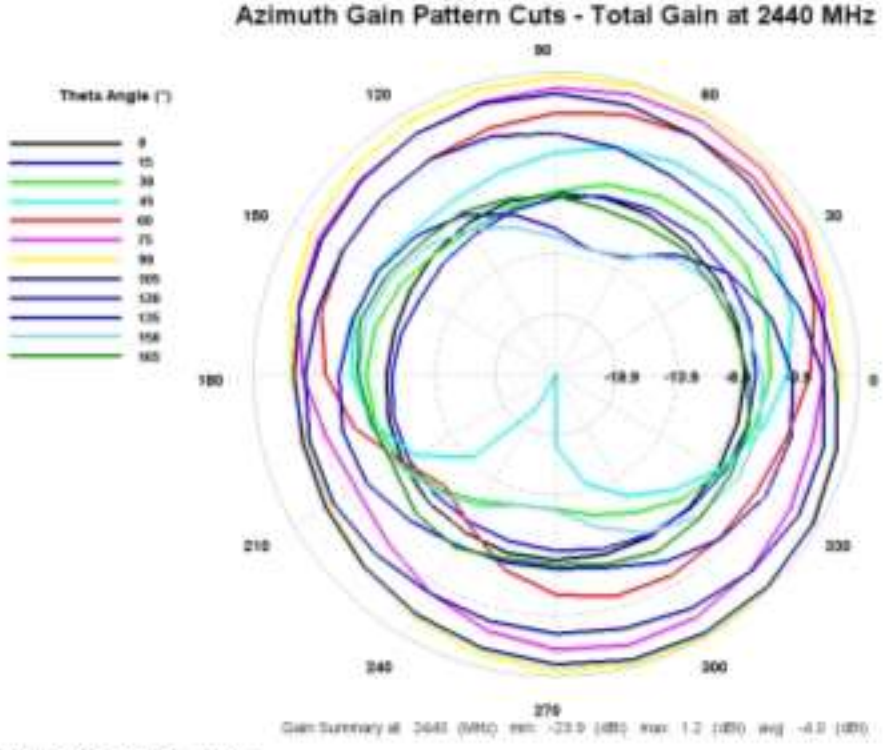

Figure 5: Total gain pattern

3D Plots at 2440 MHz

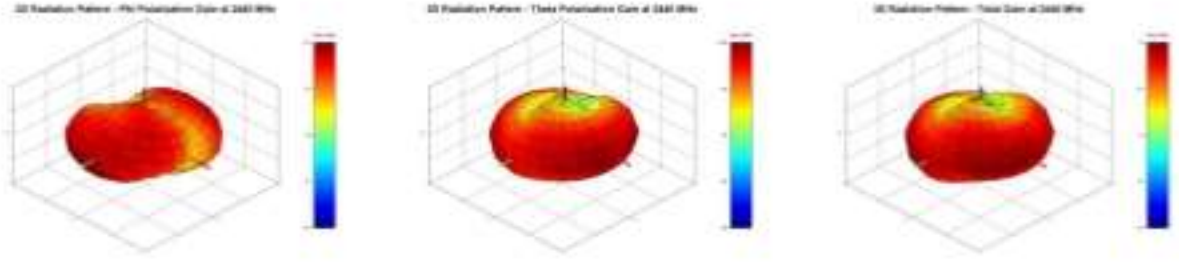

Figure 6: Phi, Theta, and total gain plots

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5 GHz Band

Azimuthal Conical Cuts at 4900 MHz

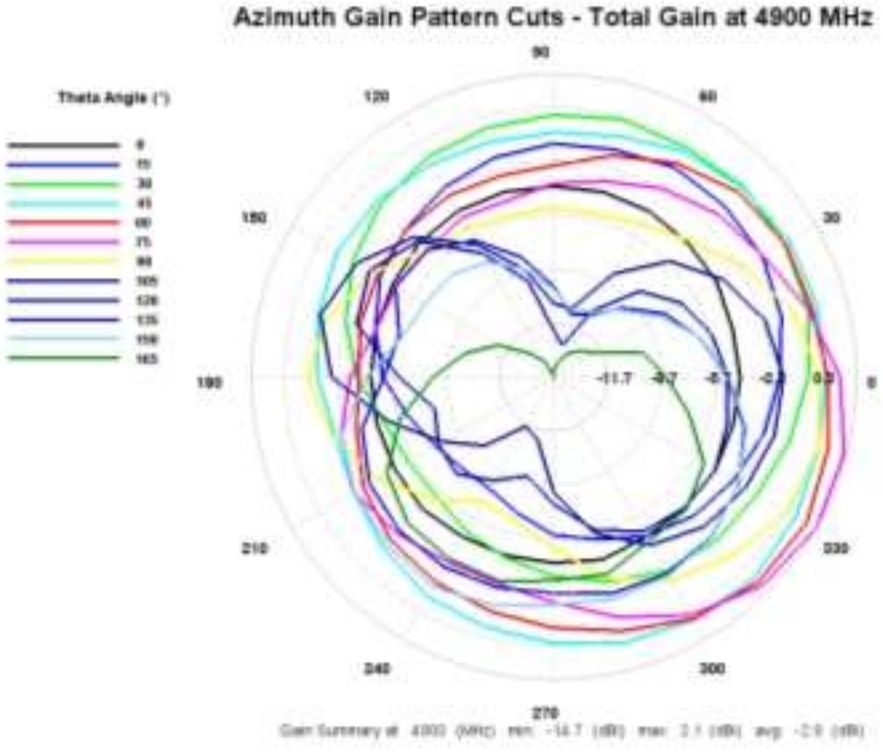

Figure 7: Total gain pattern

3D Plots at 4900 MHz

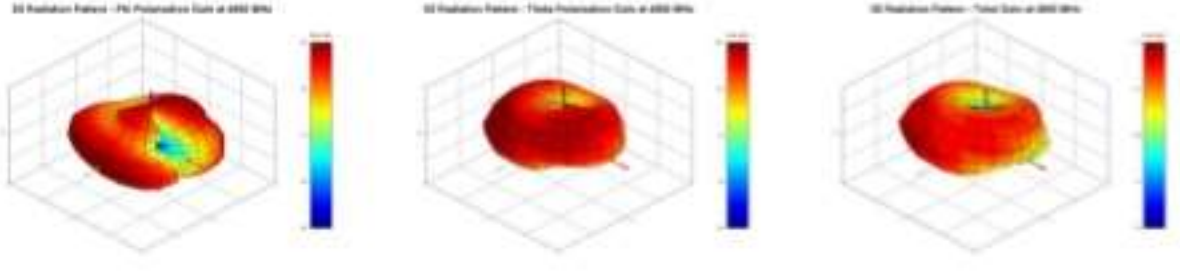

Figure 8: Phi, Theta, and total gain plots

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Azimuthal Conical Cuts at 5400 MHz

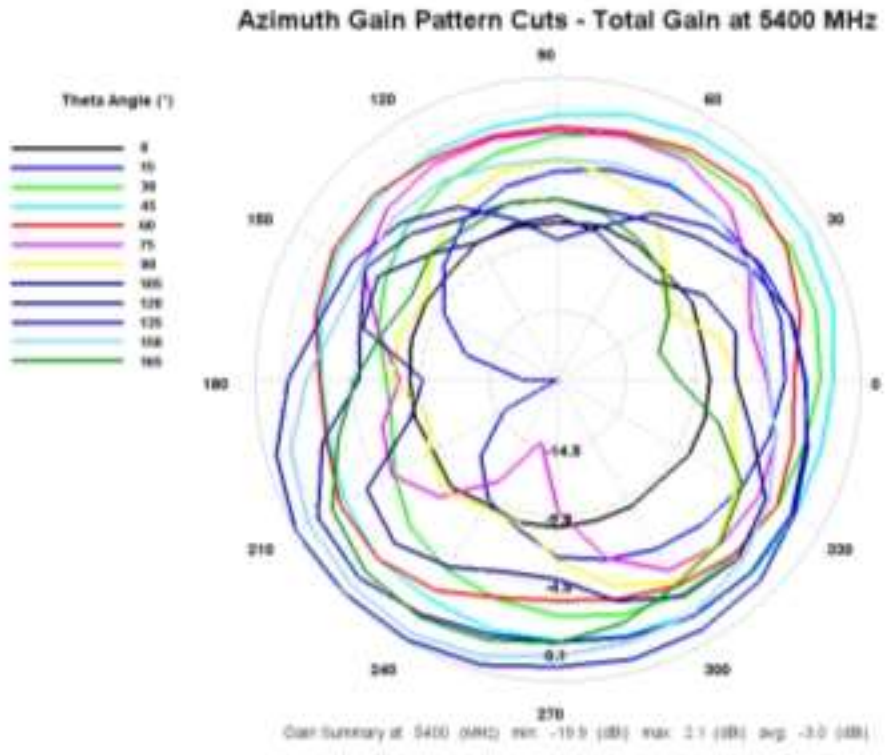

Figure 9: Total gain pattern

3D Plots at 5400 MHz

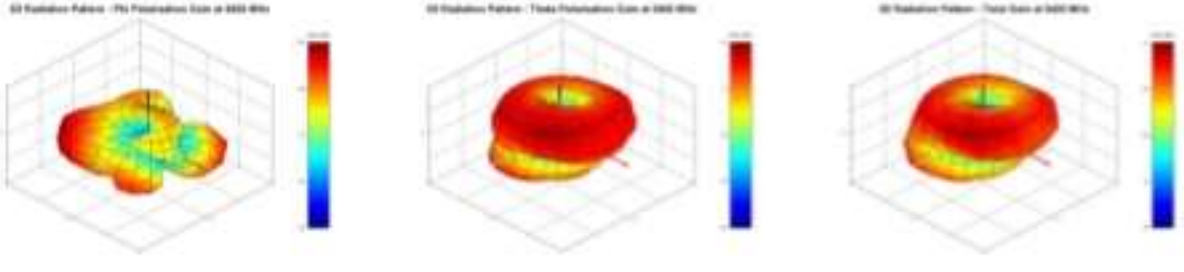

Figure 10: Phi, Theta, and total gain plots

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Azimuthal Conical Cuts at 5900 MHz

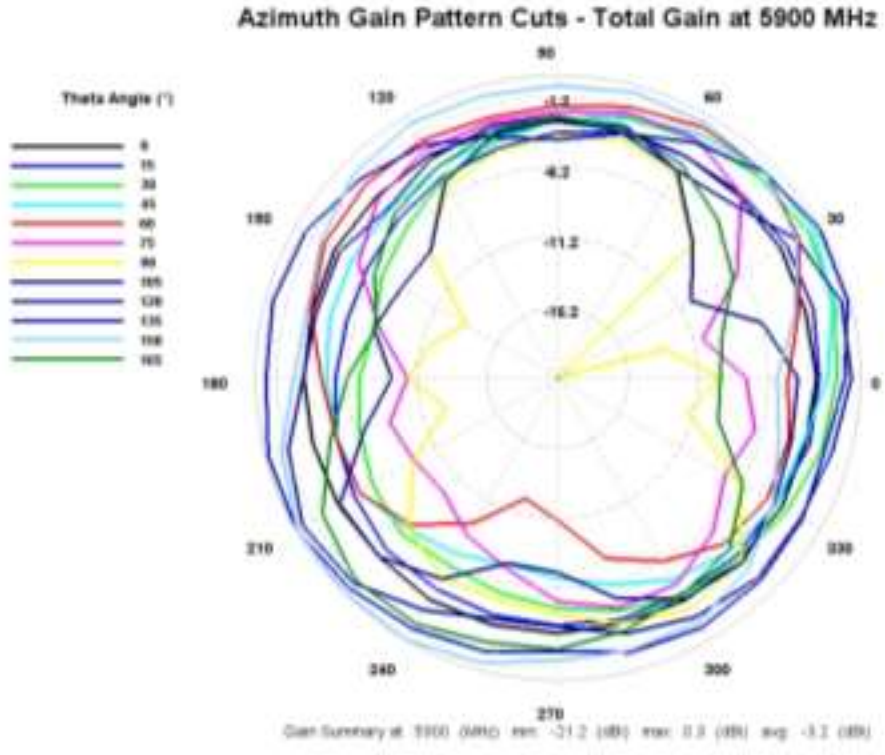

Figure 11: Total gain pattern

3D Plots at 5900 MHz

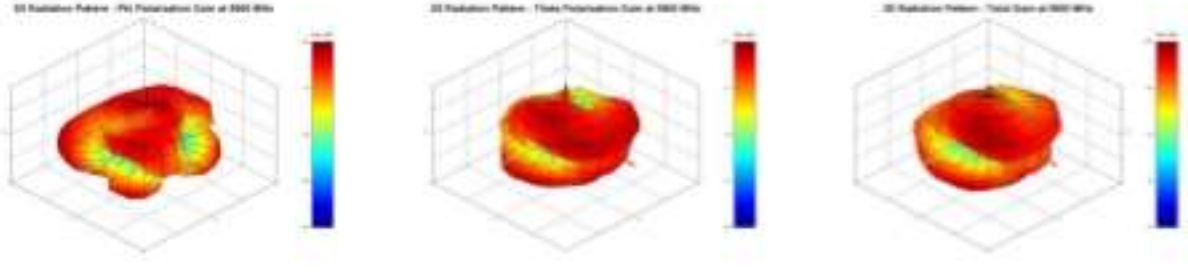

Figure 12: Phi, Theta, and total gain plots

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Hong Kong: +852 2923 0610

Curved Surface Antenna Radiation Performance

FlexPIFA outside 60 mm outer diameter PVC tube

Antenna Measurement Set Up

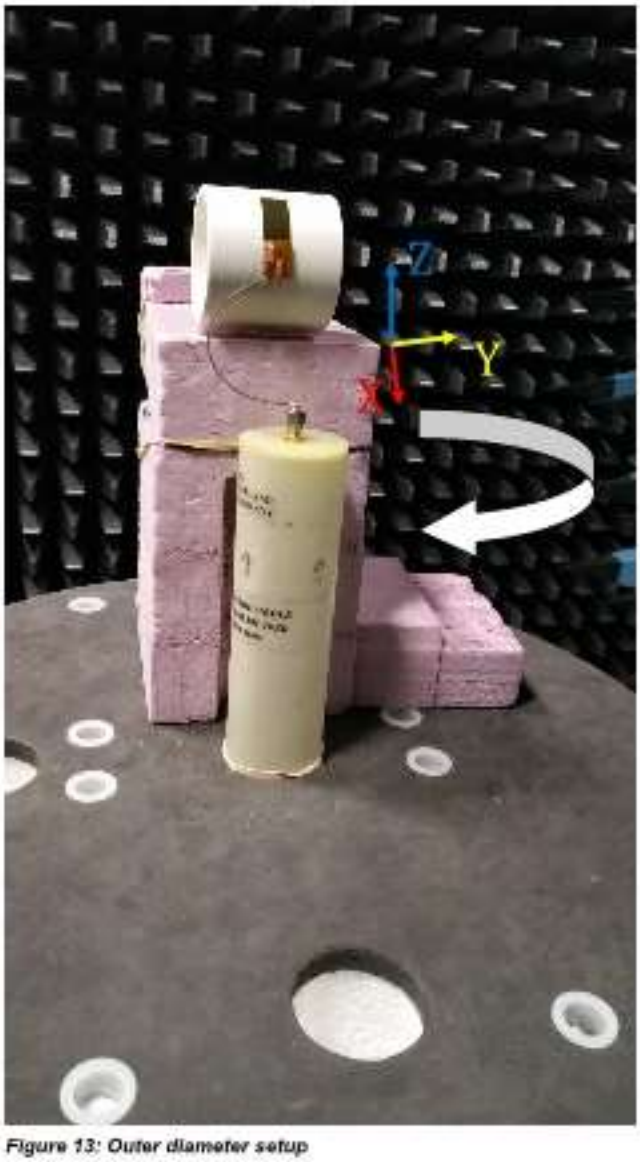

Figure 13: Outer diameter setup

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Hong Kong: +852 2923 0610

2.4 GHz Band

Azimuthal Conical Cuts at 2440 MHz

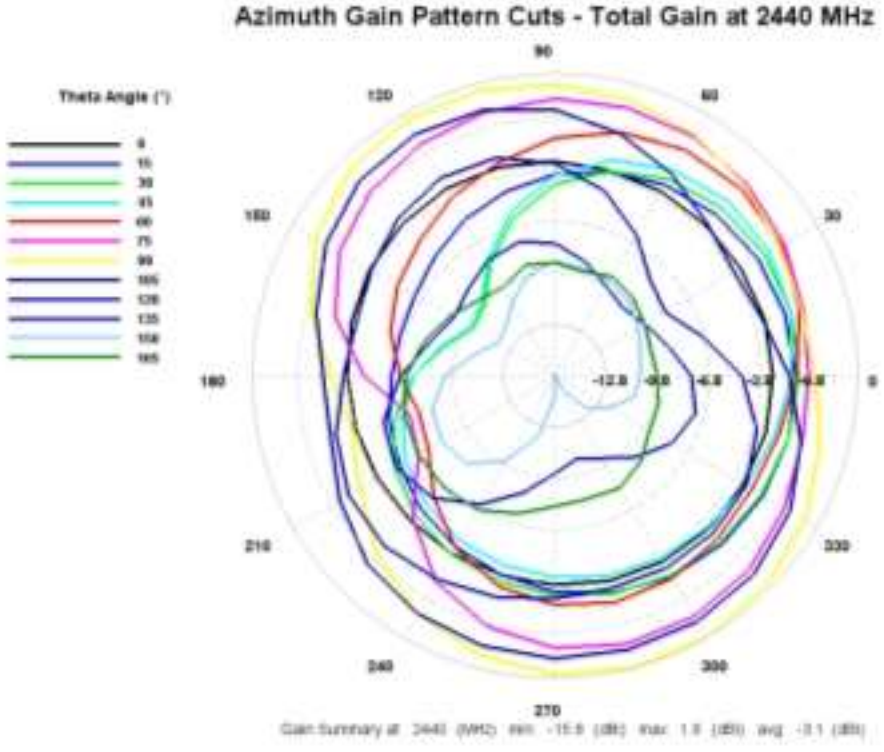

Figure 14: Total gain pattern

3D Plots at 2440 MHz

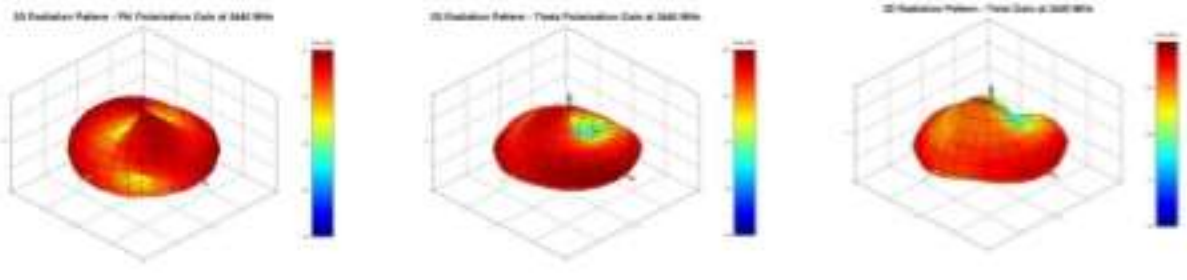

Figure 15: Phi, Theta, and total gain plots

Americas: +1-800-492-2320
Europe: +44-1628-858-940
Hong Kong: +852 2923 0610

5 GHz Band

Azimuthal Conical Cuts at 4900 MHz

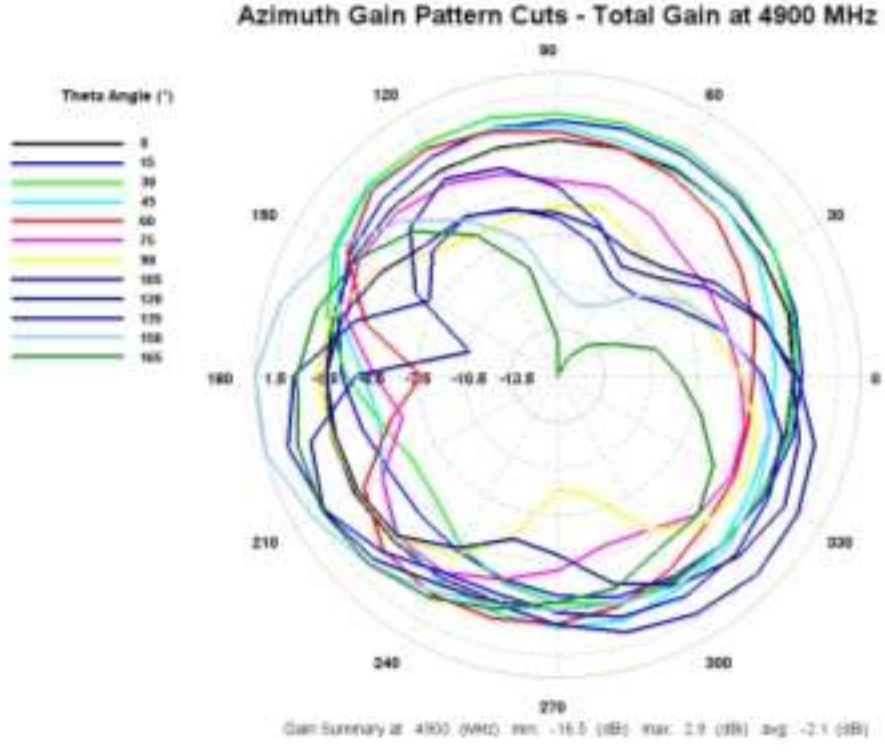

Figure 16: Total gain pattern

3D Plots at 4900 MHz

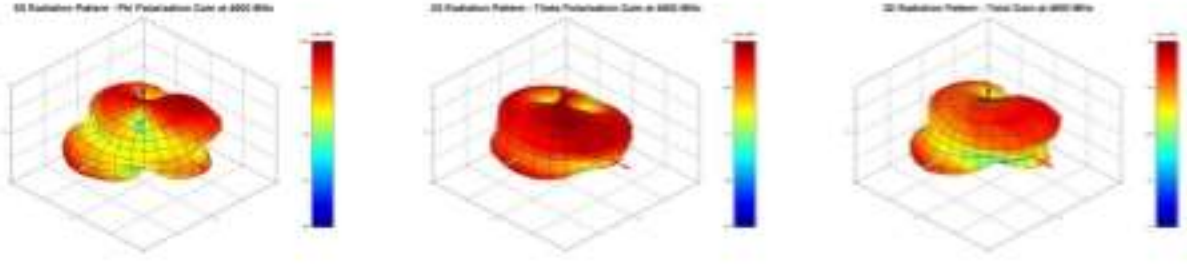

Figure 17: Phi, Theta, and total gain plots

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Hong Kong: +852 2923 0610

Azimuthal Conical Cuts at 5400 MHz

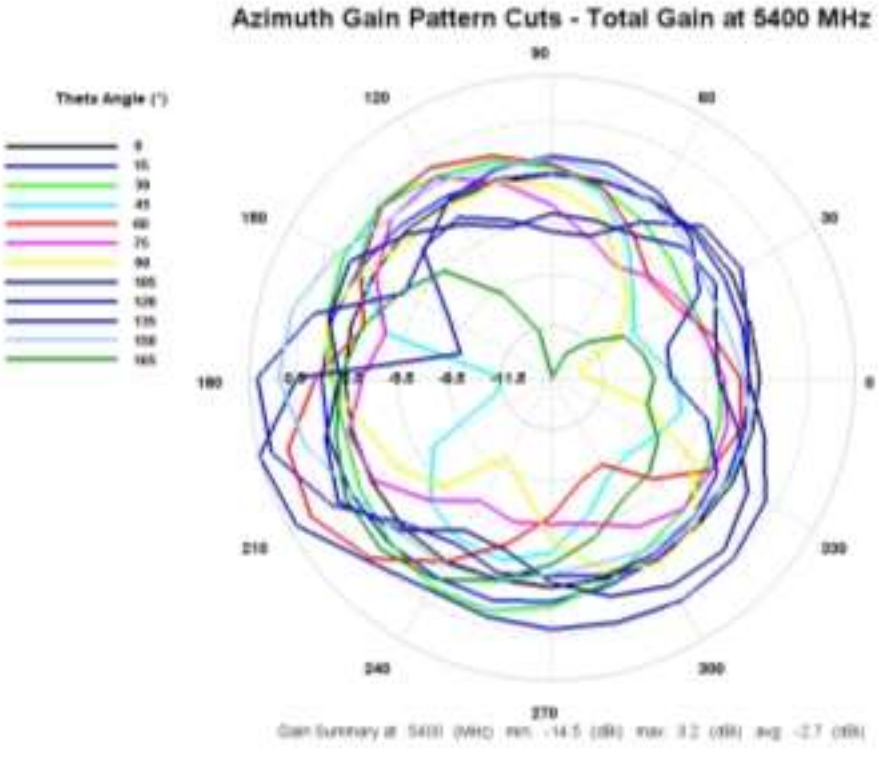

Figure 18: Total gain pattern

3D Plots at 5400 MHz

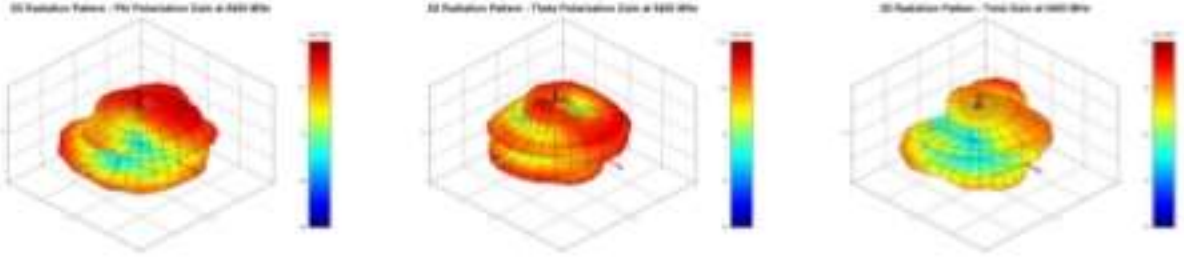

Figure 19: Phi, Theta, and total gain plots

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Europe: +44-1628-858-940
Hong Kong: +852 2923 0610

Azimuthal Conical Cuts at 5900 MHz

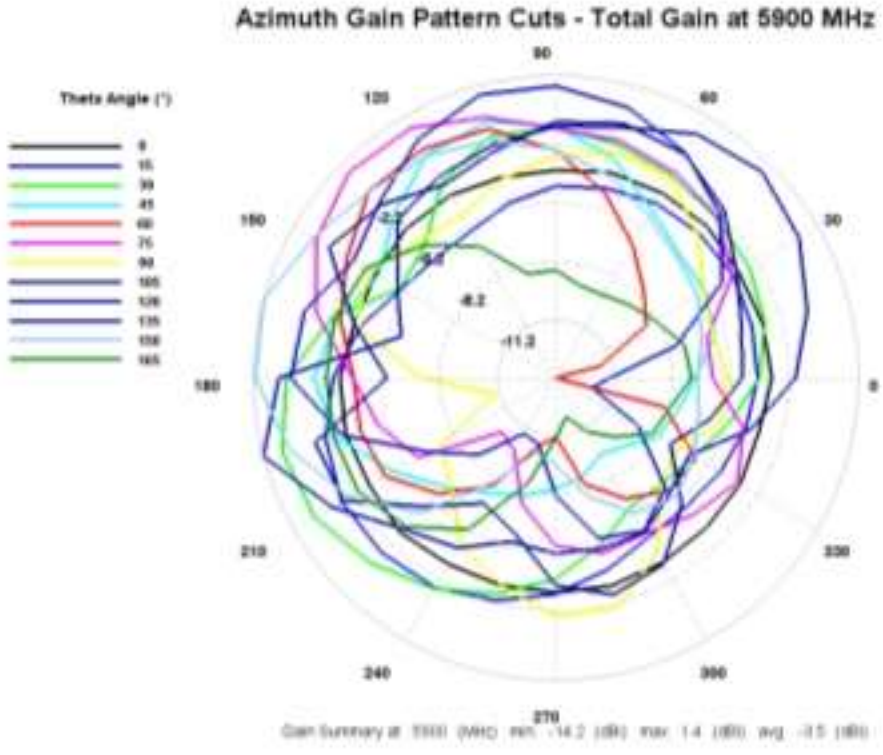

Figure 20: Total gain pattern

3D Plots at 5900 MHz

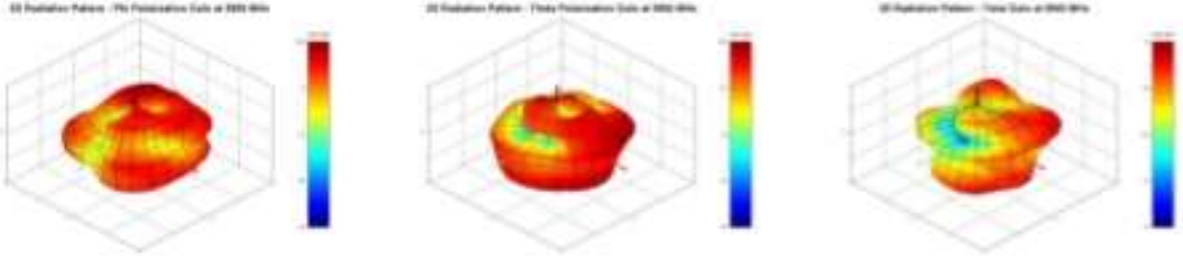

Figure 21: Phi, Theta, and total gain plots

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FlexPIFA inside 52 mm inner diameter PVC tube

Antenna Measurement Setup

Figure 22: Inner diameter setup

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2.4 GHz Band

Azimuthal Conical Cuts at 2440 MHz

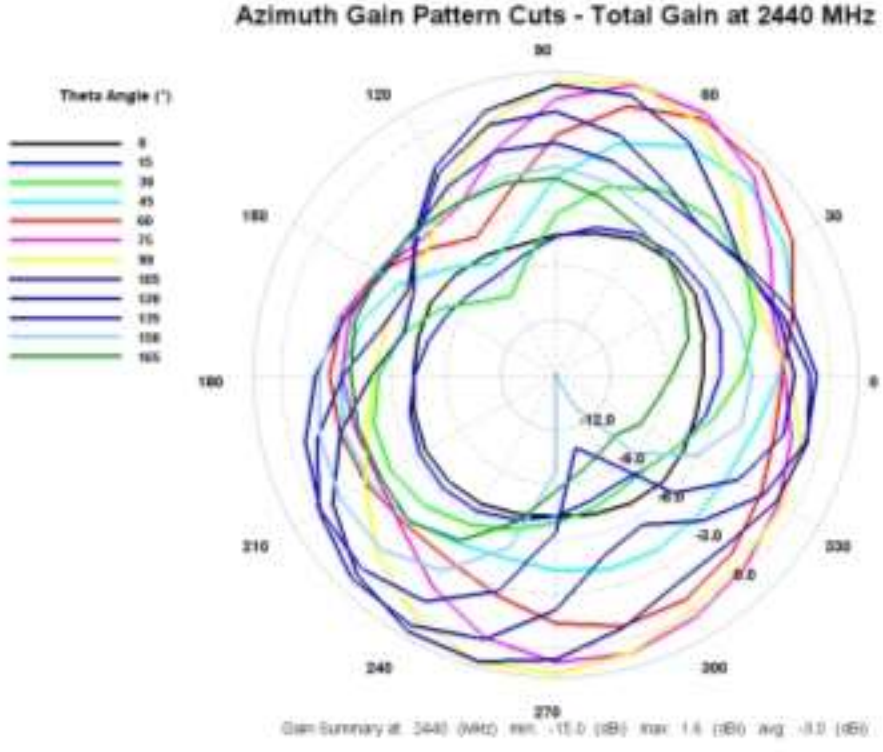

Figure 23: Total gain pattern

3D Plots at 2440 MHz

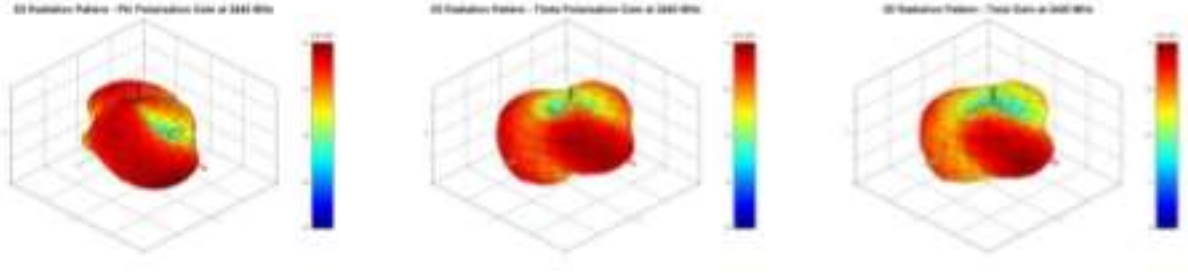

Figure 24: Phi, Theta, and total gain plots

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5 GHz Band

Azimuthal Conical Cuts at 4900 MHz

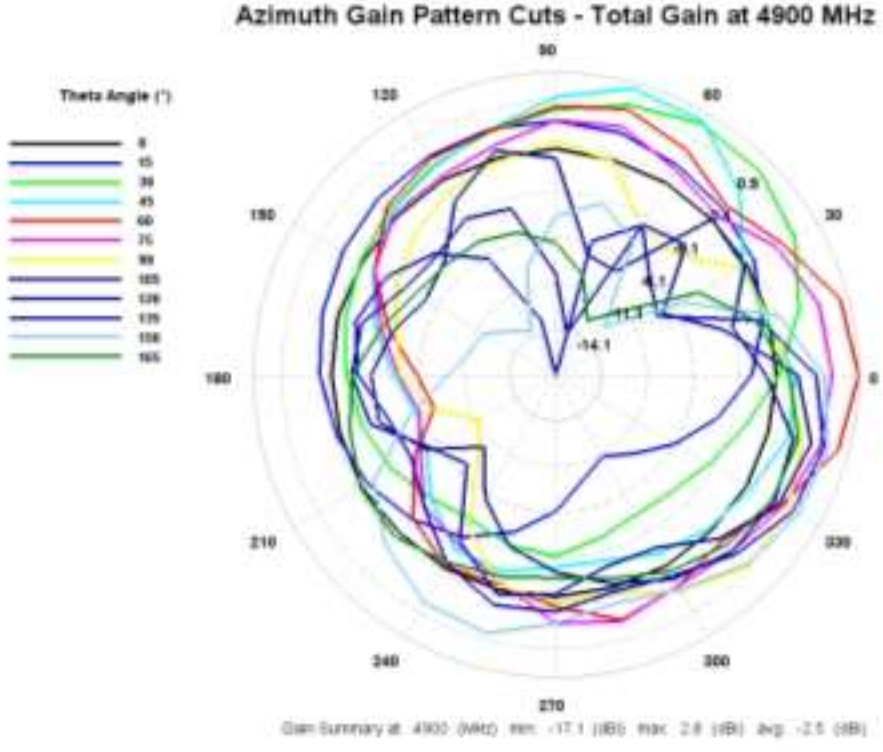

Figure 25: Total gain pattern

3D Plots at 4900 MHz

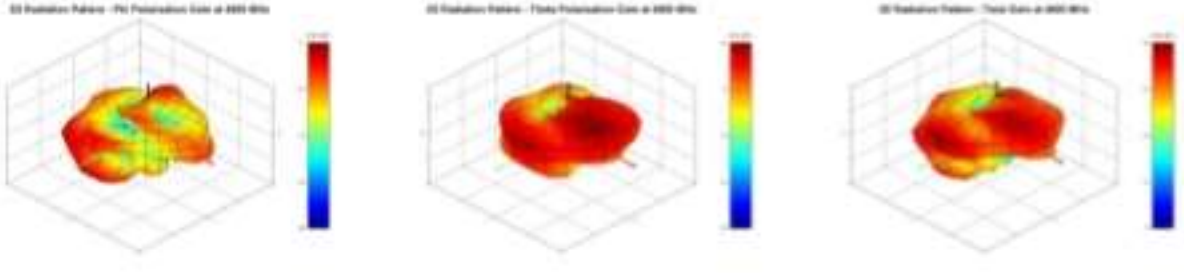

Figure 26: Phi, Theta, and total gain plots

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Hong Kong: +852 2923 0610

Azimuthal Conical Cuts at 5400 MHz

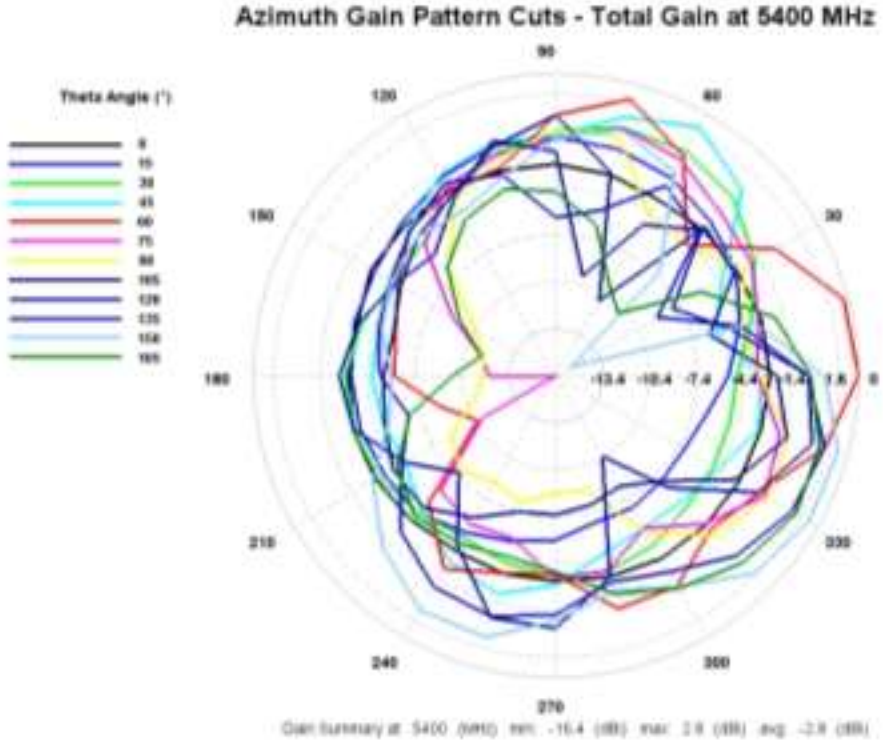

Figure 27: Total gain pattern

3D Plots at 5400 MHz

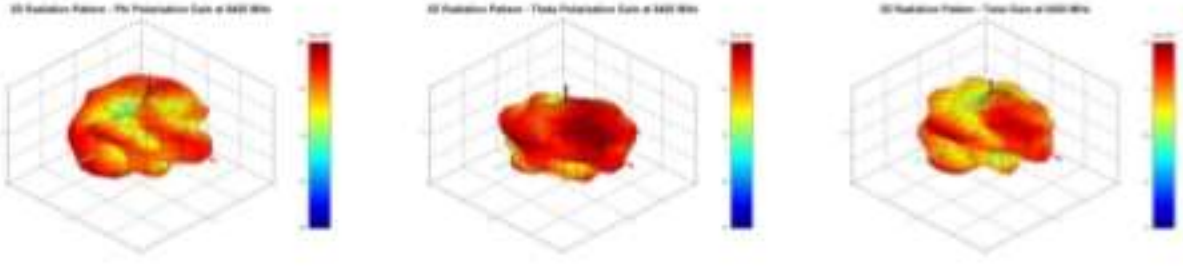

Figure 28: Phi, Theta, and total gain plots

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Hong Kong: +852 2923 0610

Azimuthal Conical Cuts at 5900 MHz

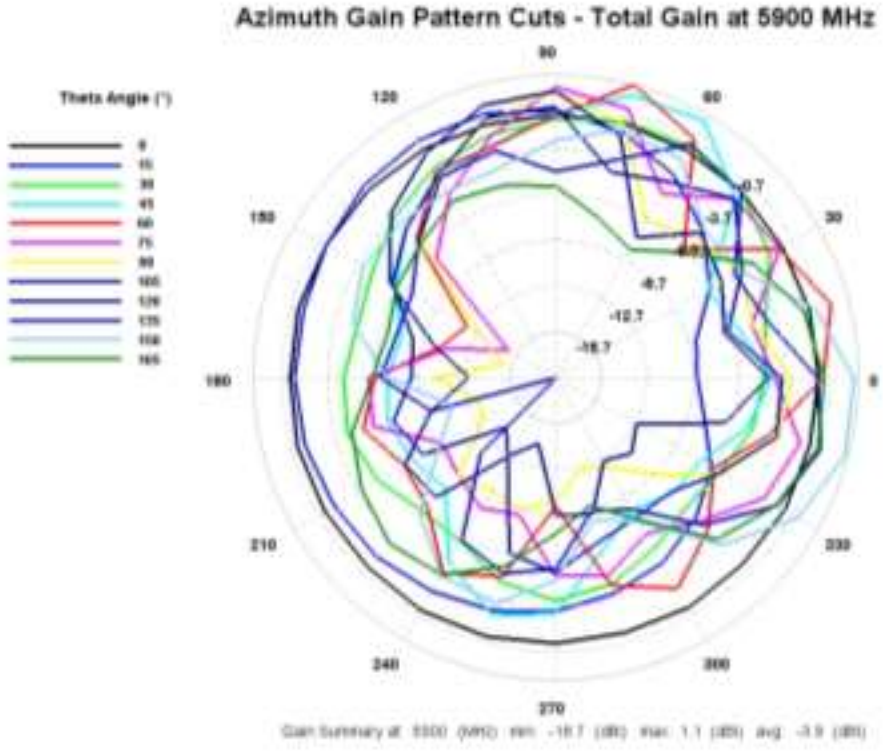

Figure 29: Total gain pattern

3D Plots at 5900 MHz

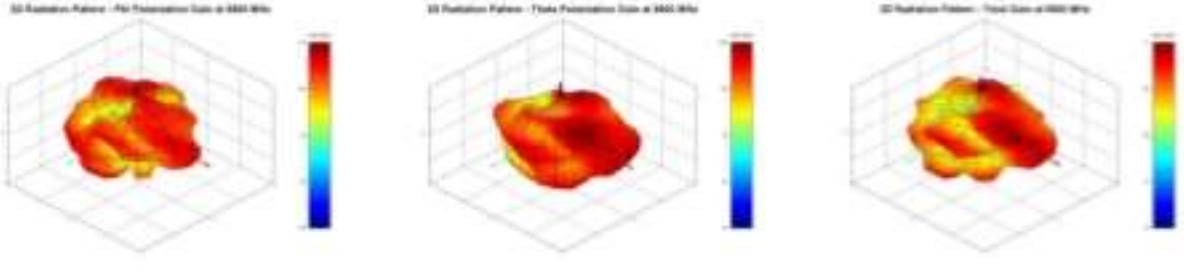

Figure 30: Phi, Theta, and total gain plots

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Optimal Installation Guide

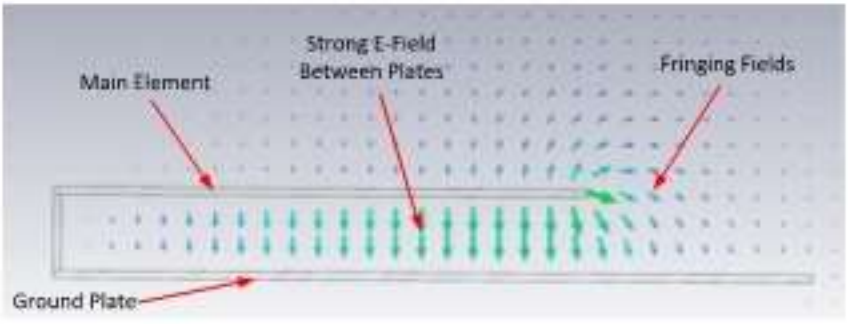


Figure 31: E-field radiation from FlexPIFA – taken from CST simulation

The main element should be kept clear of any non-metal objects (such as plastics) on top of it by at least three millimeters (see Figure 32). Similarly, the two long sides of the FlexPIFA should be kept clear of any non-metal object by at least two millimeters (See Figure 33). A one-millimeter clearance should be observed from the ground wall to any non-metal object. Mounting the FlexPIFA in a situation that does not allow for these clearance recommendations may change the gain characteristics stated in the datasheet, which could impact overall range of the wireless system.

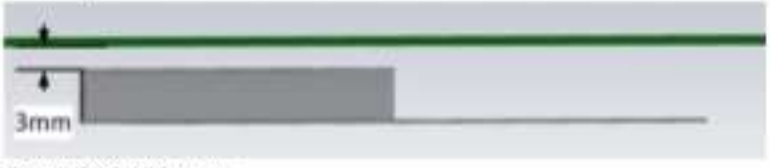
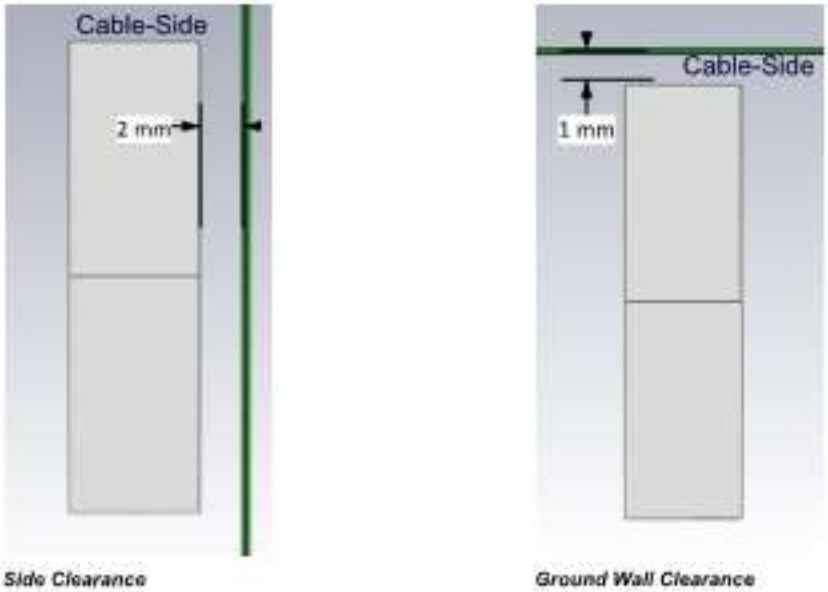


Figure 32: Top clearance



Side Clearance ***Ground Wall Clearance***

Figure 33: Side and ground wall clearance

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The ideal material on which to mount the FlexPIFA is 1.5-millimeter thick polycarbonate for maximum performance. However, as previously mentioned, the FlexPIFA can tolerate other non-metallic surfaces and thicknesses and still radiate effectively. Depending on the type of material, the FlexPIFA may be detuned.

The coaxial cable feeding the FlexPIFA should be routed away from the antenna. Do not run the coaxial cable over the top of the FlexPIFA or near the tip of the main element. The cable should be routed perpendicular to the side of the FlexPIFA (this is the way the cable comes assembled) or away from the ground wall. These options are shown in Figure 34.

Perpendicular to the side

Away from the ground wall

Figure 34: Recommended cable routing

As with any antenna, care should be taken not to place conductive materials or objects near the antenna (except as described in the next section). The radiated fields from the antenna induce currents on the surface of the metal; as a result, those currents then produce their own radiation. These re-radiating fields from the metal interfere with the fields radiating from the FlexPIFA (this is true for any antenna). Other objects, such as an LCD display, placed close to the antenna may not affect its tuning but it can distort the radiation pattern. Materials that absorb electromagnetic fields should be kept away from the antenna to maximize performance. Common things to keep in mind when placing the antenna:

- Wire routing
- Speakers – These generate magnetic fields
- Metal chassis and frames
- Battery location
- Proximity to human body
- Display screen – These absorb radiation
- Paint – Do not use metallic coating or flakes

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Flex Limits of the FlexPIFA

One of the unique features of the FlexPIFA is its ability to flex. However, due to the adhesive, there are limits as to how much the antenna can be flexed and remain secured to the device. The FlexPIFA should not be flexed in a convex position with a radius less than 16 millimeters. Going smaller than this may result in the antenna peeling off the surface over time. Should a tighter radius of curvature be required, contact Laird Connectivity for assistance.

Figure 35: Convex-mounted

The FlexPIFA should not be flexed in a concave position with a radius less than 25 millimeters. In this scenario, the limiting factor is performance. The ground plate of the antenna is pressed closer to the main element. As previously discussed in the introduction of this datasheet, the fringing fields developing off the end of the element are responsible for most of the radiation. In a concave position with a radius of curvature less than 25 millimeters, the fringing fields are adversely affected and gain suffers. If a tighter radius of curvature is required, contact Laird Connectivity for assistance.

Figure 36: Concave-mounted

The FlexPIFA is not designed to be twisted or crumpled. The adhesive back should lay flush with the surface on which it is mounted.

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Mounting on Metal and Body Loaded Applications

The FlexPIFA can tolerate being mounted on conductive surfaces. There will be some detuning of the antenna, which translates into some gain reduction. Even though the FlexPIFA is optimized to work on non-metallic surfaces, it still radiates efficiently due to the fringing fields (see Figure 31). The ground plate of the FlexPIFA carries the adhesive backing; placing the antenna onto a metal surface simply enlarges the size of the ground beneath the main element. Previously, the fringing fields only interacted with the small ground of the FlexPIFA, however they are now interacting with the much larger ground. The fringing fields still develop and radiate, but the antenna will no longer tune as well to the 2.4 GHz frequency band. Consequently, the VSWR increases and there is some loss in radiated power. If the FlexPIFA cannot meet your range requirements after being implemented on a metal surface, contact Laird Connectivity for a custom antenna build to help meet your application needs.

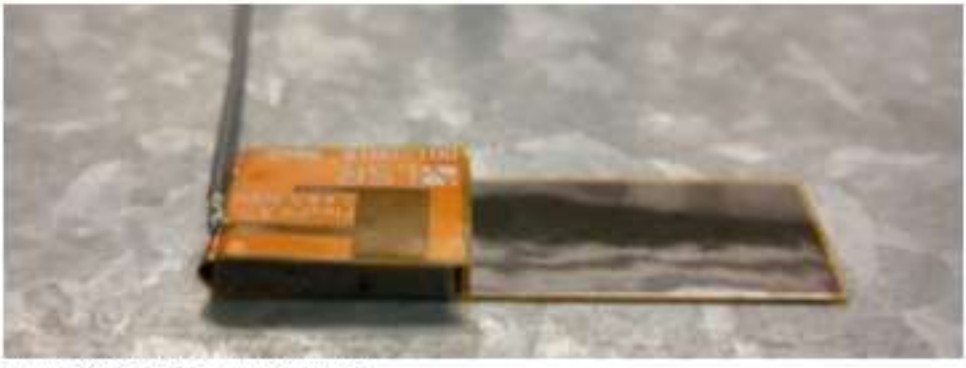

Figure 37: FlexPIFA mounted on metal

Do not mount the FlexPIFA where metal is within ten millimeters above the main element (see Figure 39). Not only does this severely limit the radiation pattern (mainly due to the re-radiation problem previously described) it detunes the antenna inside of this range.

Similarly, the two long sides of the FlexPIFA should be kept clear of any metal object by at least five millimeters. These keep out requirements pertaining to ***conductive*** materials only and are different from those listed in the previous sections which apply to ***non-conductive*** materials. In general, it is good practice to always keep metals as far away from the antenna as possible.

For the best performance, a spacer should be placed between the FlexPIFA and the conductive surface (see Figure 38). The spacer should be 1.5 millimeters thick polycarbonate. This will significantly improve performance and tuning of the FlexPIFA on a metal surface. Other non-conductive materials such as ABS plastic can be used; however, polycarbonate provides the best results.

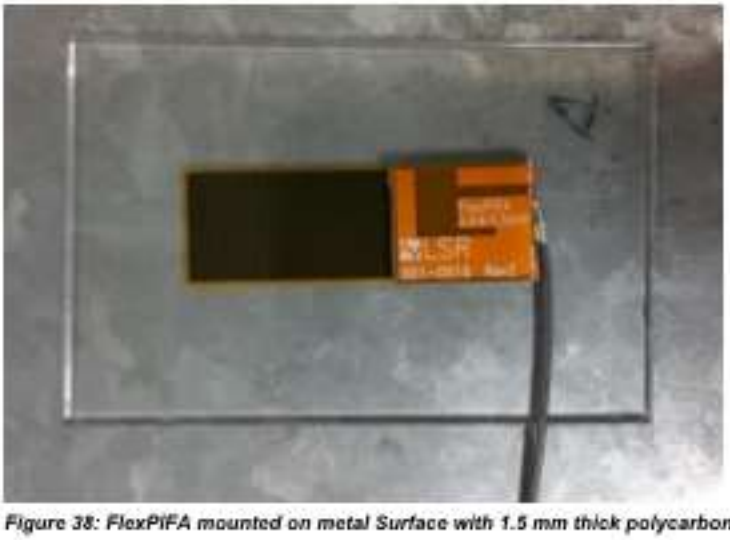

Figure 38: FlexPIFA mounted on metal Surface with 1.5 mm thick polycarbonate spacer

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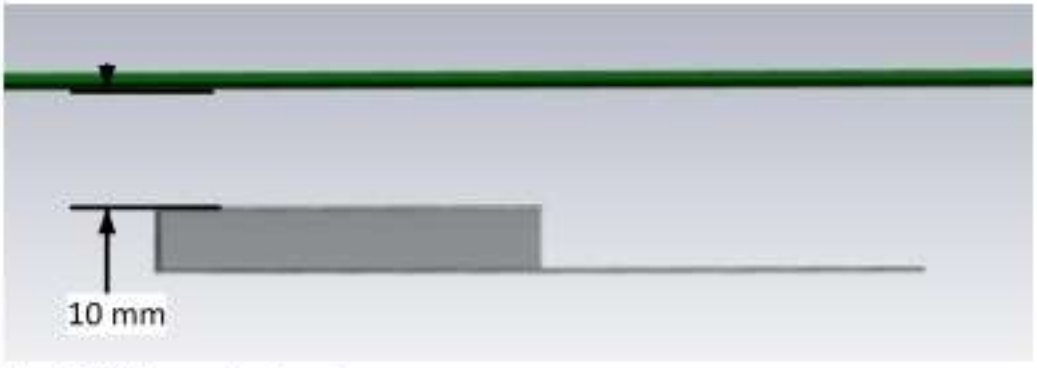

Figure 39: Metal near main element

For body-worn applications, the FlexPIFA can tolerate the presence of the human body. We do not recommend that you mount the antenna directly on body tissue to avoid detuning the FlexPIFA.

Additionally, the human body is an excellent absorber of 2.4 GHz RF signals. As a result, expect a reduction in range due to the presence of a body. In a body-worn application, the ground plate of the FlexPIFA should be closest to the body tissue. The main element should be pointed away from the body. Additionally, for handheld devices, the FlexPIFA should be mounted in a location where it is not covered by the hand. If the antenna is mounted in a location where the main element is covered or near a human body, ensure that there is at least a ten-millimeter separation distance between the main element and the body as shown in Figure 39.

Additionally, when the FlexPIFA is mounted very close to body tissue, use a spacer to create separation distance between the body tissue and ground plate. This ensures maximum performance and prevents the antenna from detuning. As previously mentioned, the ideal spacer material is 1.5 mm thick polycarbonate.

Quite often this separation distance between the body tissue and the FlexPIFA is already provided by the enclosure. Figure 40 is an example of a bracelet with the FlexPIFA integrated inside it. The enclosure provides enough spacing between the antenna and body tissue to prevent any major detuning. The enclosure is made of polycarbonate.

Figure 40: FlexPIFA integrated into bracelet

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Product Revision History

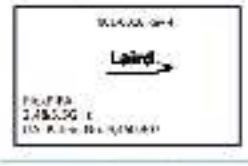
001-0016

Rev 1: Prototype Release

Rev 2: Initial Production Release

Rev 3: Updated FPC (Improve Tuning)

Rev 4: Updated Silkscreen (Laird Logo and U.S. Patent)



Rev 5: Changed Supplier – Color Change to Antenna

001-0021

Rev 1: Initial Production Release

Rev 2: Updated FPC (Improve Tuning)

Rev 3: Updated Silkscreen (Laird Logo and U.S. Patent)

Rev 4: Changed Supplier – Color Change to Antenna

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Additional Assistance

Please contact your local Laird Connectivity sales representative or our support team for further assistance:

Support Center	https://connectivity.lairdtech.com/resources/support	
Email	wireless.support@lairdtech.com	
Phone	Americas:	+1-800-492-2320
	Europe:	+44-1628-858-940
	Hong Kong:	+852 2923 0610
Web	https://connectivity.lairdtech.com/wireless-modules/bluetooth-modules	

RoHS

TITLE

WIFI 6E FLEX CABLE BALANCE ANTENNA

TABLE OF CONTENTS

WIFI 6E FLEX CABLE BALANCE ANTENNA

1.0 SCOPE

This specification describes the antenna application and surrounding. The information in this document is for reference and benchmark purposes only. The user is responsible for validating antenna rf performance based on the user's actual implementation.

Antenna illustrations in this document are generic representations. They are not intended to be an image of any antenna listed in the scope.

2.0 PRODUCT DESCRIPTION

2.1 PRODUCT NAME AND SERIES NUMBER (S)

Product name: WIFI 6E flex cable balance antenna

Series Number: 146153

2.2 DESCRIPTION

Series 146153 is a balanced, dipole-type, high efficiency antenna for 2.4/5/6 GHz applications, including WiFi 6E, Bluetooth, Zigbee and others. This antenna is made from poly flexible material with small size 35*9*0.1mm and has double-sided adhesive tape for easy "peel and stick" mounting. This balanced antenna with ground plane independent design offers various cable length options for ease of integration into various devices.

2.3 PRODUCT STRUCTURE INFORMATION

Please refer to PS-1461530100 for full information.

ANTENNA 3D VIEW

3.0 APPLICABLE DOCUMENTS

DOCUMENT	NUMBER	DESCRIPTION
Sale Drawing (SD)	SD-1461530050	Mechanical Dimension of the product
	SD-1461531050	
Product Specification (PS)	PS-1461530100	Product Specification
Packing Drawing (PK)	PK-1461530100	Product packaging specifications

4.0 ANTENNA PERFORMANCE

4.1 RF TEST CONDITIONS

All measurements are done of the antenna mounted on a PC/ABS material block of 1.5mm thickness with VNA Agilent E5071C and Over-The-Air (OTA) chamber. All measurements in this document are done with the part no.1461530100 with a cable length of 100mm.

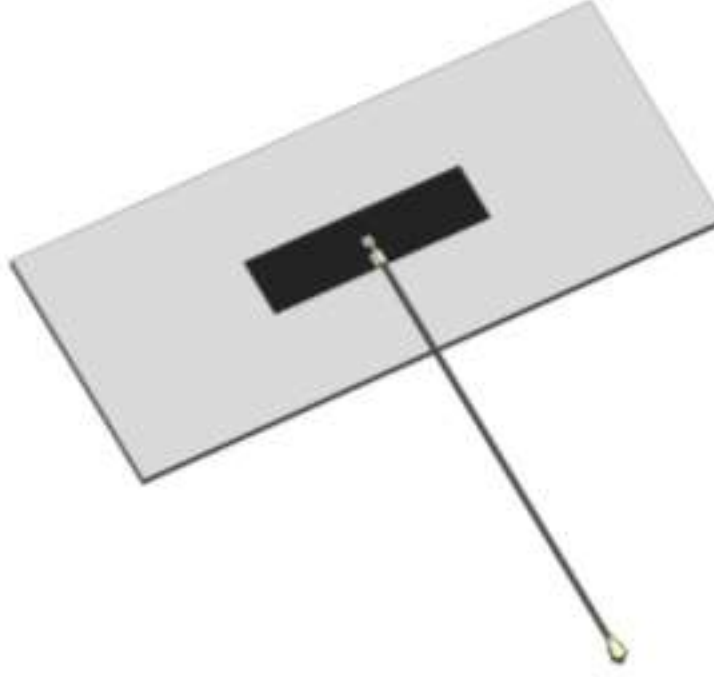


FIGURE4.1.1 ANTENNA LOADED WITH PC/ABS BLOCK OF 1.5 MM THICKNESS

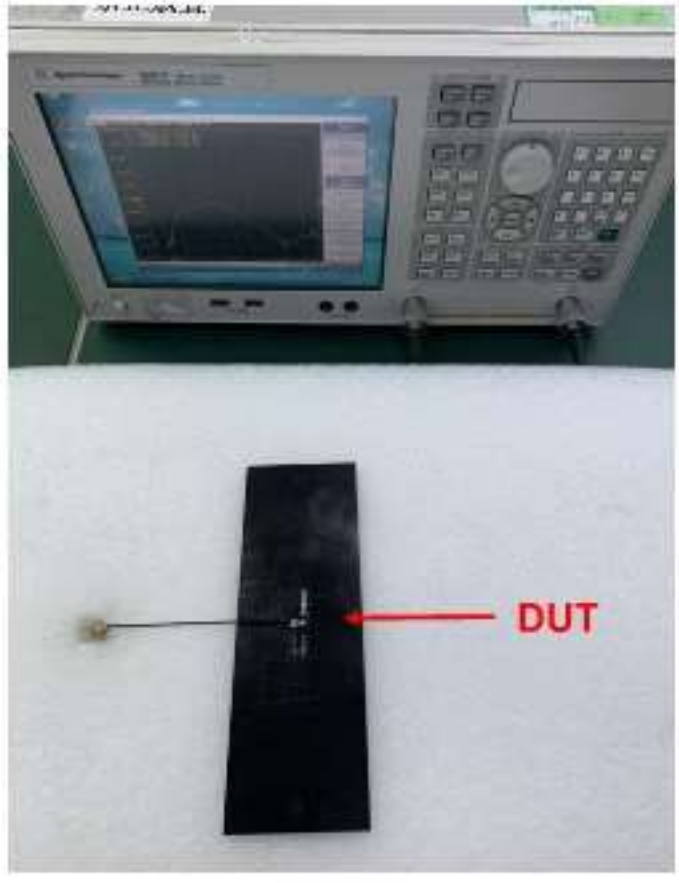


FIGURE4.1.2 ANTENNA LOADED WITH PC/ABS BLOCK OF 1.5 MM THICKNESS WITH VNA

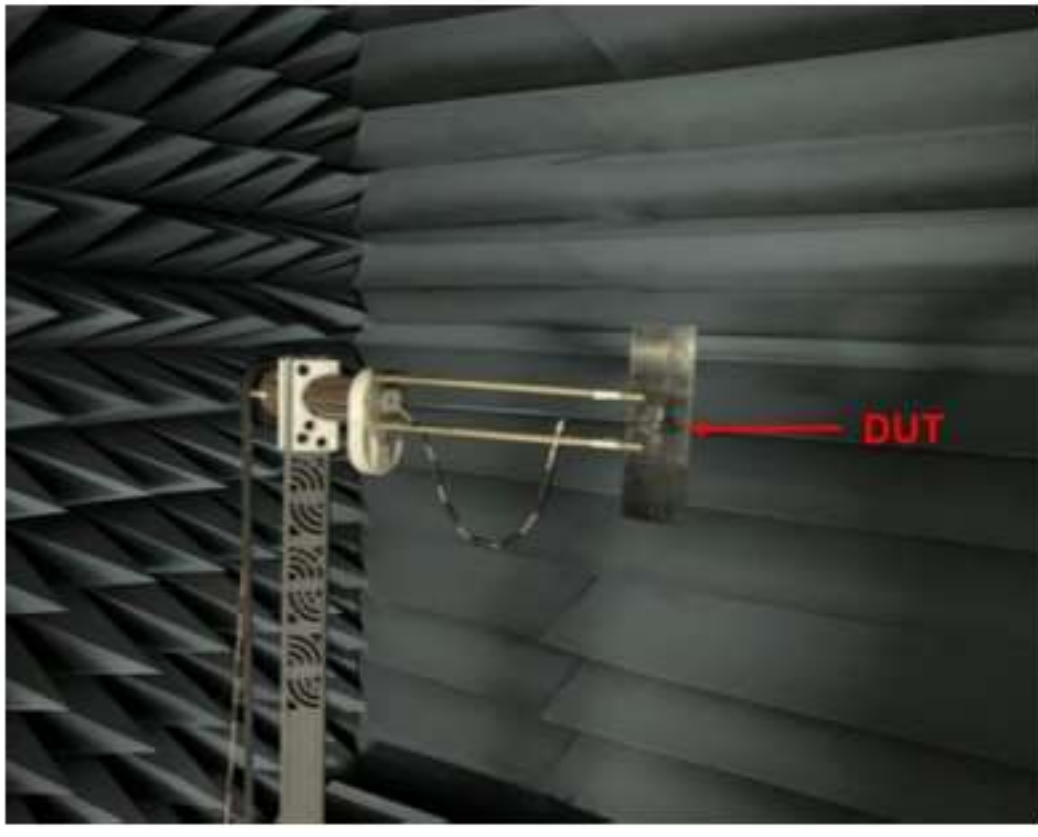


FIGURE4.1.3 ANTENNA LOADED WITH PC/ABS BLOCK OF 1.5 MM THICKNESS WITH OTA CHAMBER

4.2 ANTENNA PERFORMANCE

All measurements in this document are done with the part no.1461530100 with a cable length of 100mm

DESCRIPTION	EQUIPMENT	REQUIREMENT		
Frequency Range	VNA E5071C	2.4-2.5GHz	5.15-5.85GHz	5.925-7.125GHz
Return Loss	VNA E5071C	<- 10dB		
Peak Gain (Max)	OTA Chamber	3.0dBi	4.0dBi	5.5dBi
Average Total Efficiency	OTA Chamber	>75%	>75%	>70%
Polarization	OTA Chamber	Linear		
Input Impedance	VNA E5071C	50 ohms		

Note that the above antenna performance is measured with just the antenna mounted on a PC/ABS block to similar a free-space condition. When implement into the system, the frequency resonant might be off-tune due to the loading of surrounding components especially metal plane. This off-tune can be compensated through matching. Although module manufacturers specify a peak gain limit, it is based on free-space conditions. The peak gain will be degraded by 1 to 2dBi in the actual implementation as the radiation pattern will change due to the surround components. As such, during selection of antenna, you can select one with high peak gain to compensate for the loss. Molex can offer assistant to choose the best location and best tuning in-order to meet this peak gain requirement.

4.3 RETURN LOSS PLOT

All measurements in this document are done with a cable length of 100mm.

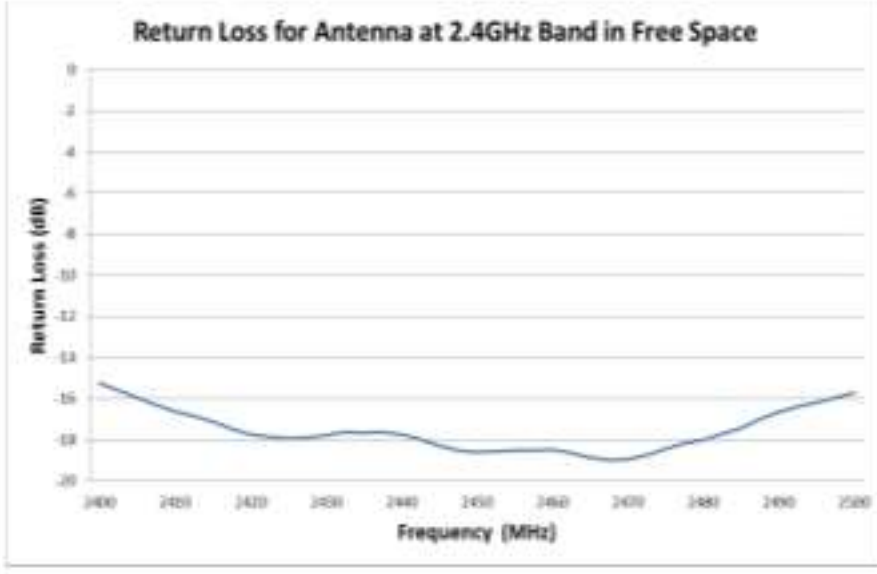


FIGURE 4.3.1 RETURN LOSS OF ANTENNA AT 2.4GHZ BAND IN FREE SPACE

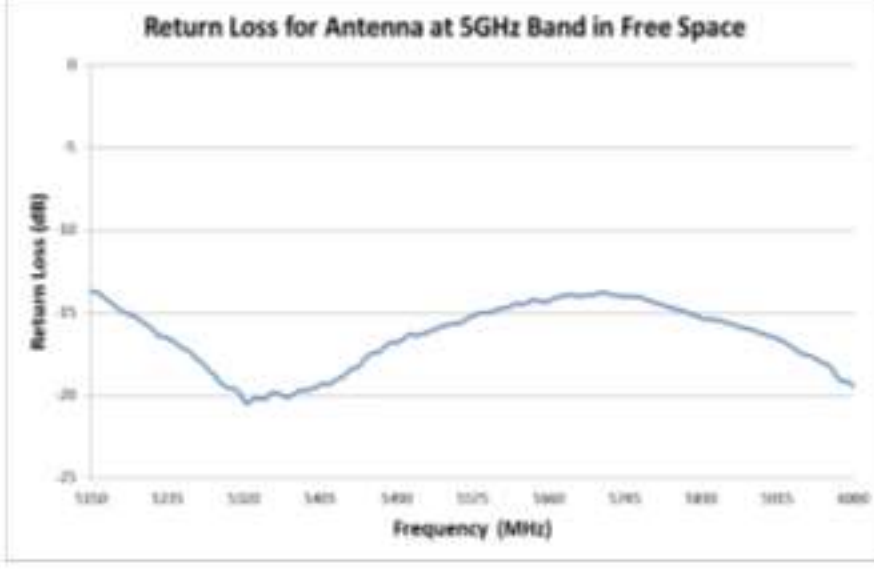


FIGURE 4.3.2 RETURN LOSS OF ANTENNA AT 5GHZ BAND IN FREE SPACE

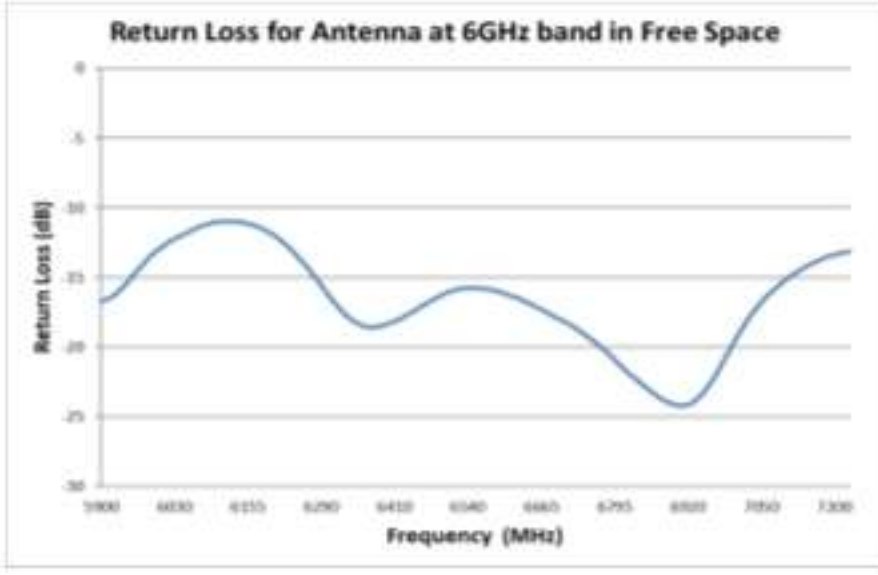


FIGURE 4.3.3 RETURN LOSS OF ANTENNA AT 6GHZ BAND IN FREE SPACE

4.4 EFFICIENCY PLOT

All measurements in this document are done with a cable length of 100mm.

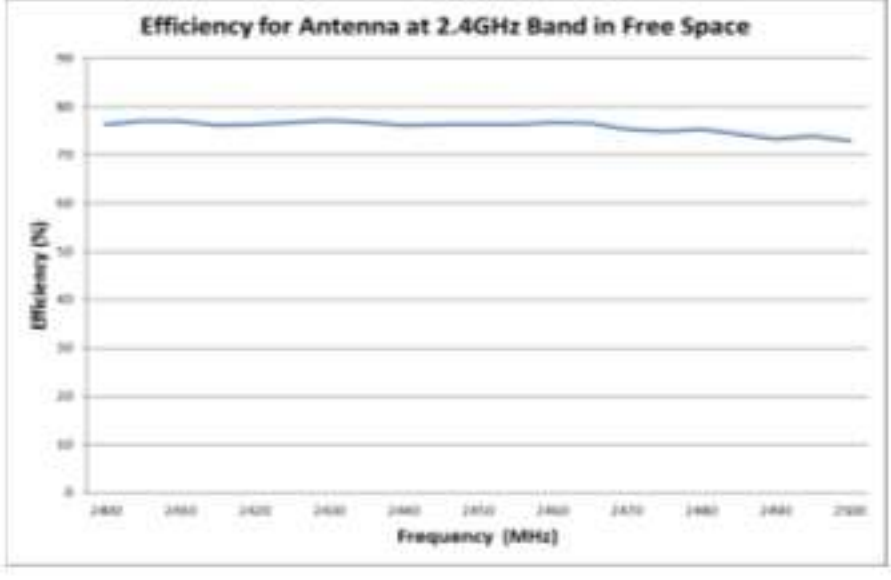


FIGURE 4.4.1 EFFICIENCY OF ANTENNA AT 2.4GHZ BAND IN FREE SPACE

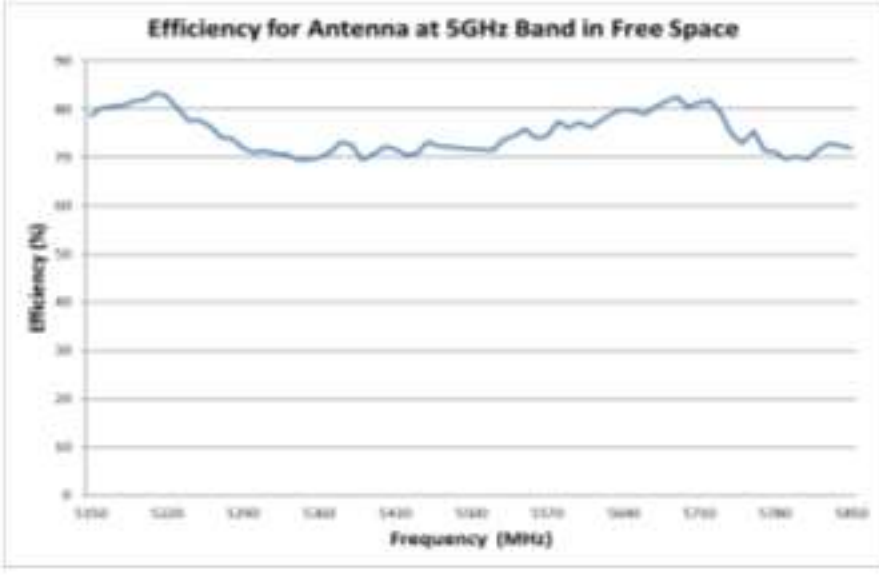


FIGURE 4.4.2 EFFICIENCY OF ANTENNA AT 5GHZ BAND IN FREE SPACE

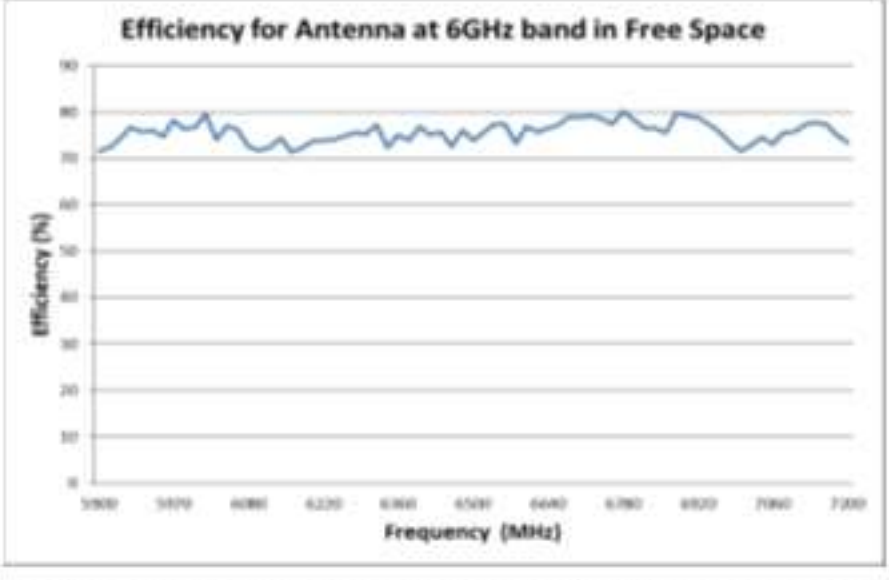


FIGURE 4.4.3 EFFICIENCY OF ANTENNA AT 6GHZ BAND IN FREE SPACE

4.5 RADIATION PATTERN

All measurements in this document are done with a cable length of 100mm.

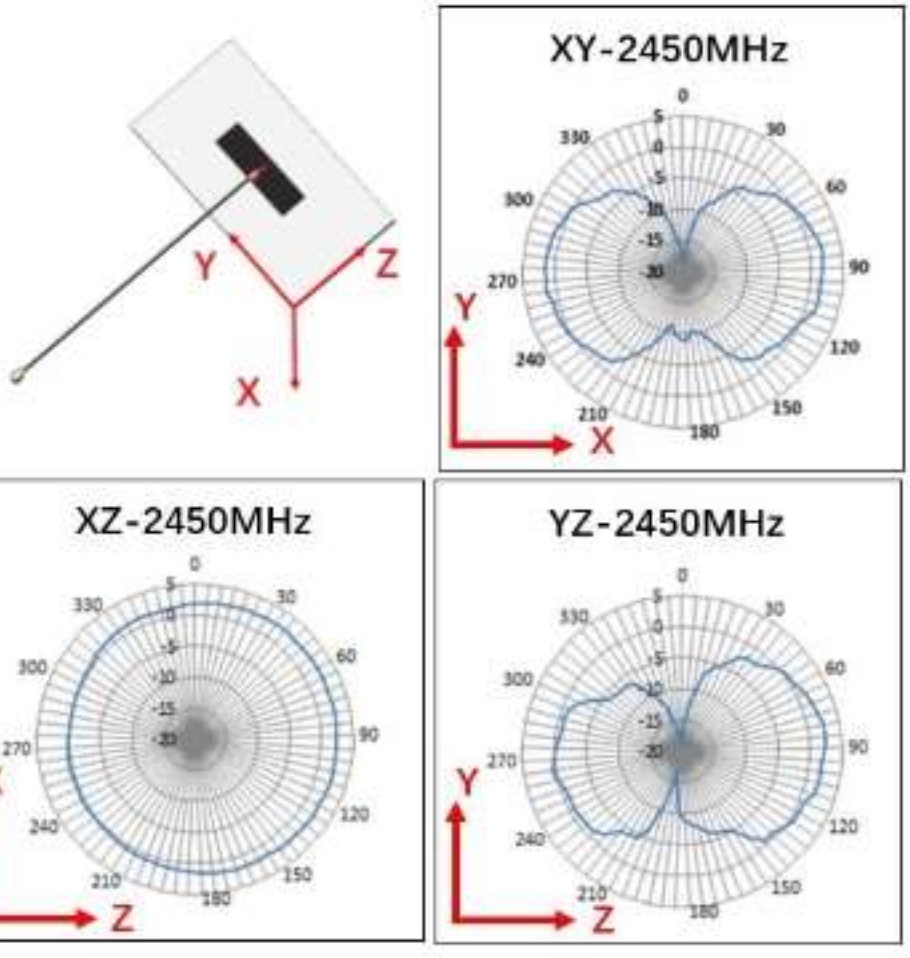


FIGURE 4.5.1 2D RADIATION PATTERN OF ANTENNA AT 2450MHZ IN FREE SPACE

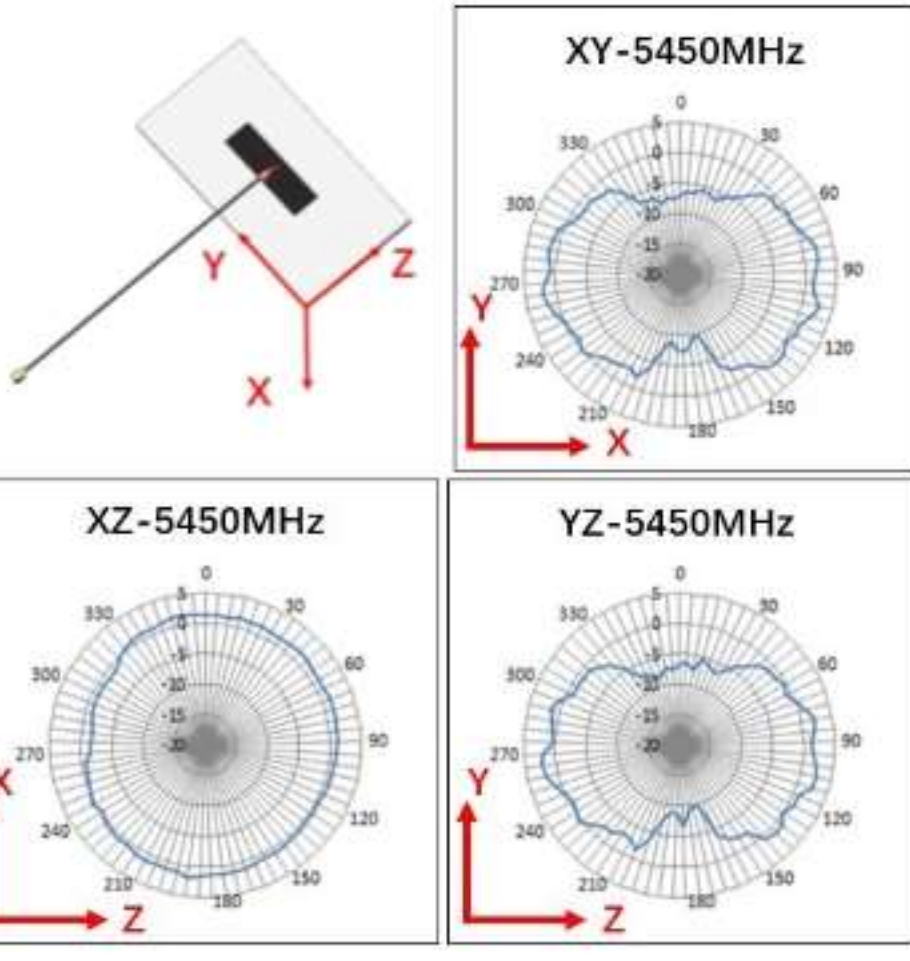
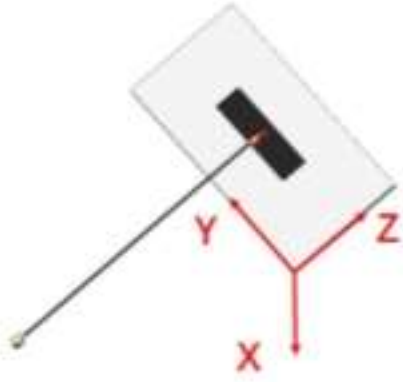
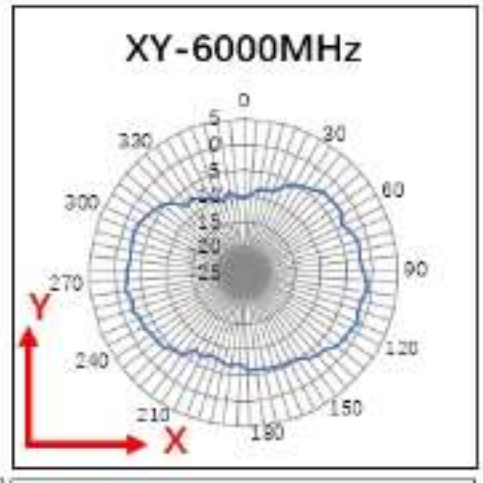
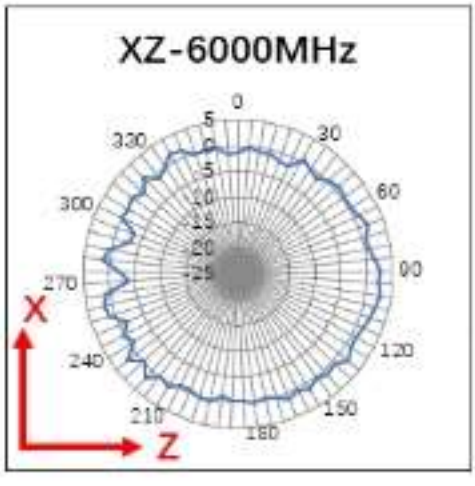


FIGURE 4.5.2 2D RADIATION PATTERN OF ANTENNA AT 5450MHZ IN FREE SPACE







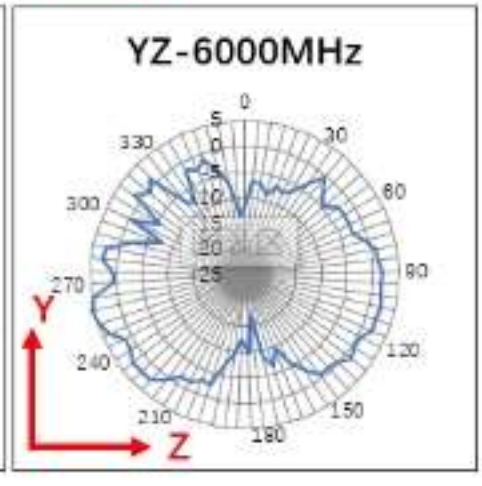


FIGURE 4.5.3 2D RADIATION PATTERN OF ANTENNA AT 6000MHZ IN FREE SPACE

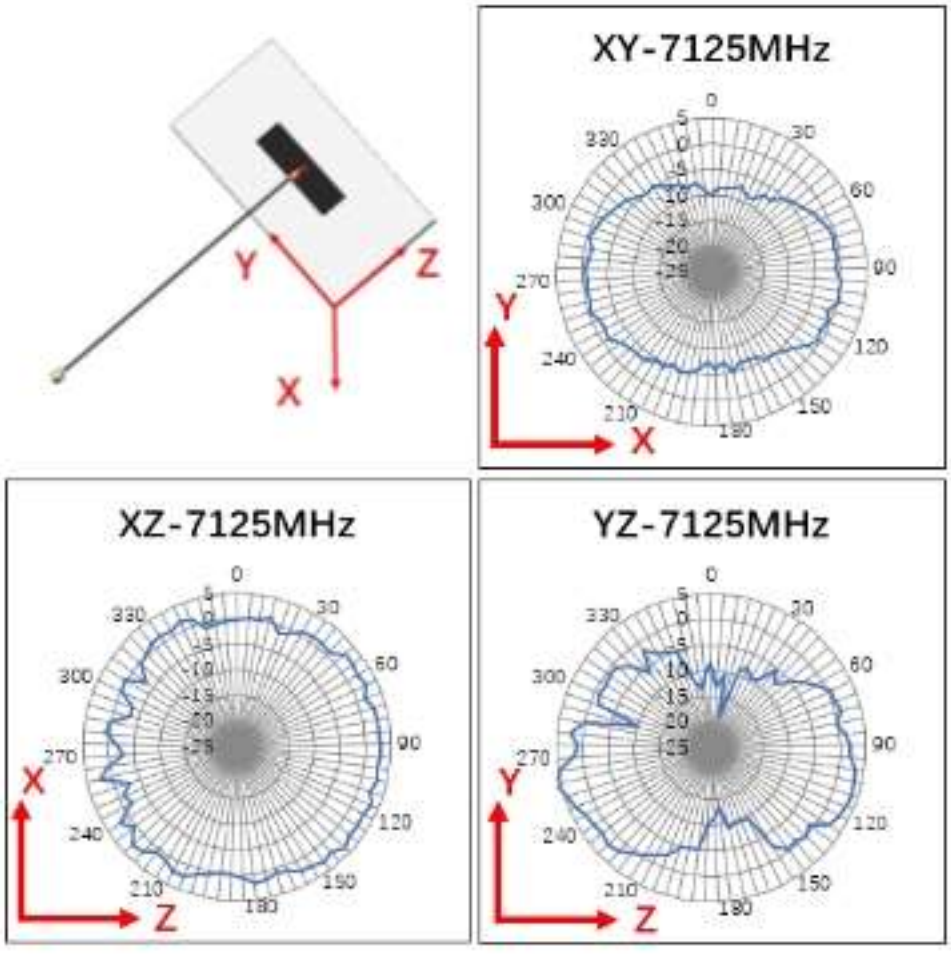


FIGURE 4.5.4 2D RADIATION PATTERN OF ANTENNA AT 7125MHZ IN FREE SPACE

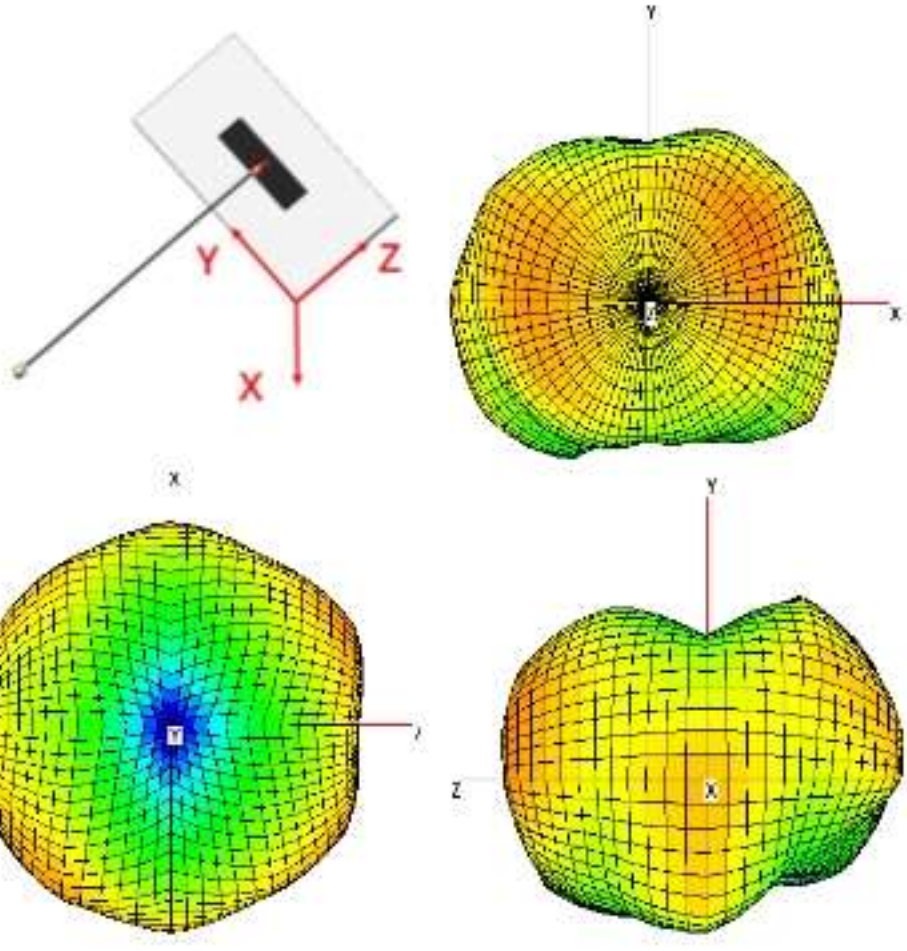


FIGURE 4.5.5 3D RADIATION PATTERN OF ANTENNA AT 2450MHZ BAND IN FREE SPACE

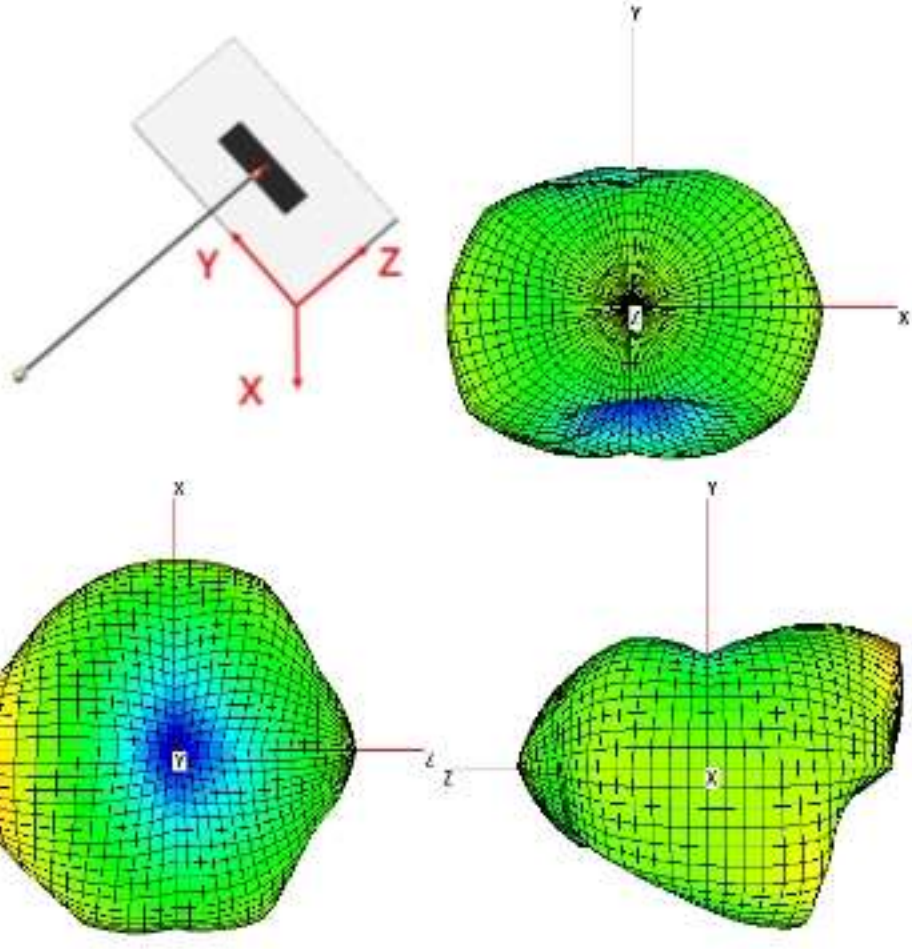


FIGURE 4.5.6 3D RADIATION PATTERN OF ANTENNA AT 5450MHZ BAND IN FREE SPACE

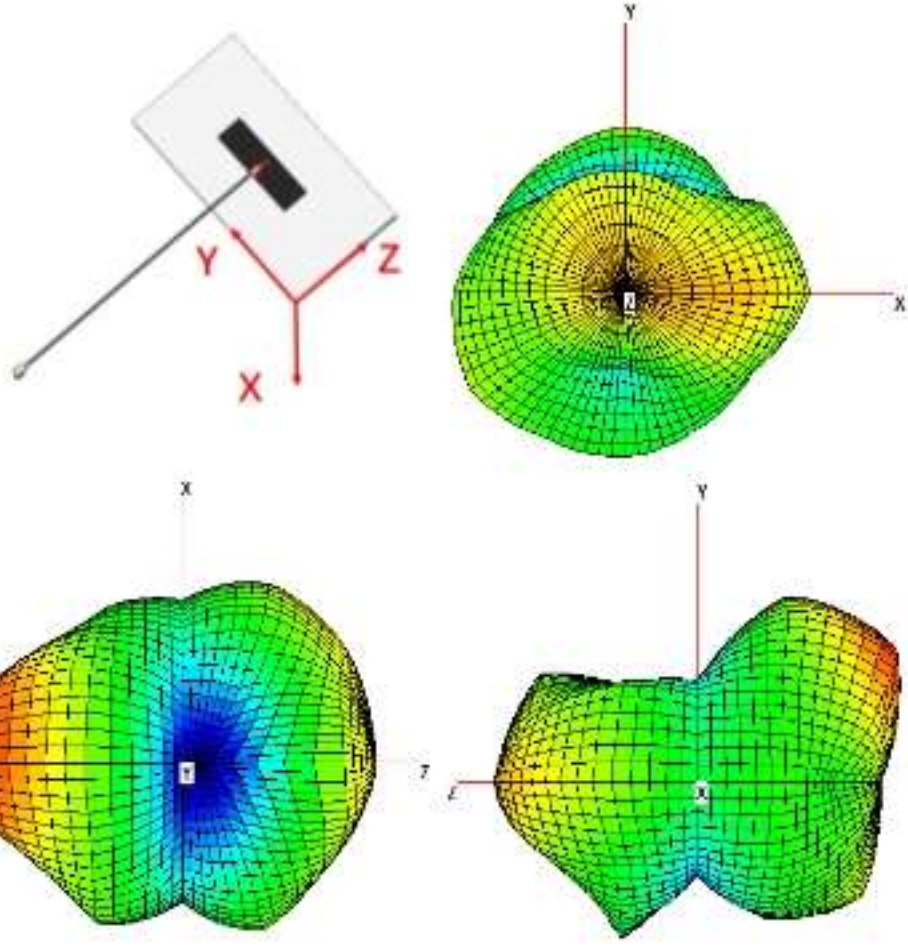


FIGURE 4.5.7 3D RADIATION PATTERN OF ANTENNA AT 6000MHZ BAND IN FREE SPACE

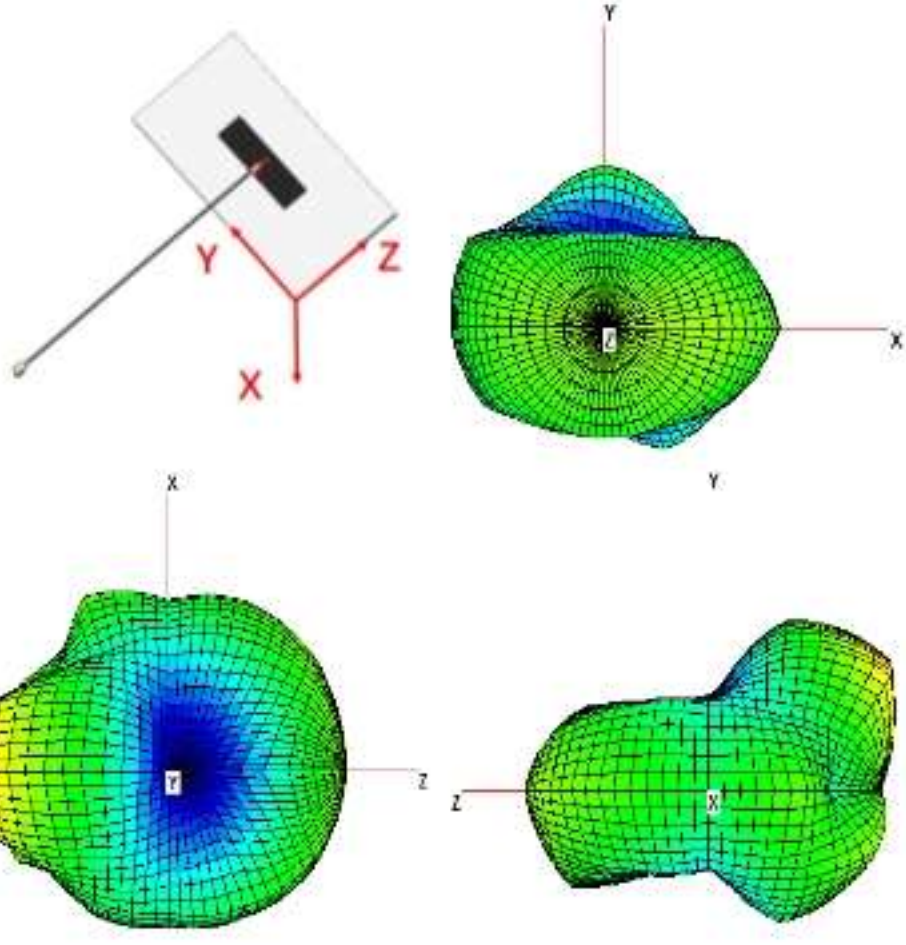


FIGURE 4.5.8 3D RADIATION PATTERN OF ANTENNA AT 7125MHZ BAND IN FREE SPACE

5.0 ASSEMBLY GUIDELINE

The flex antenna comes with an adhesive 3m9077 for assemble onto the plastic wall of the system. The surface should be smooth with ra<1.6um and need to clean the surface before sticking this product. The antenna cannot be placed on a metallic surface.

5.1 HOW TO TEAR FLEX RELEASE PAPER

1. Find cut line on flex back side

2. Bend flex slight along cut line

3. Tear release paper

5.2 CABLE BENDING

During the assembly of the antenna in a device, the cable needs to be positioned away from the antenna flex to achieve best performance. The cable must be away from the Flex edge at least 5mm as shown in figure 5.2.1. If the cable bends into the antenna flex, the antenna performance will be degraded.

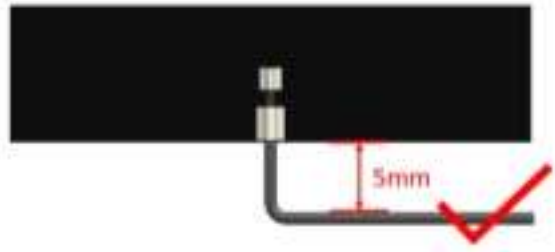


FIGURE 5.2.1 RECOMMENDED CABLE BENDING RANGE

FIGURE 5.2.2 UNRECOMMENDED CABLE BENDING RANGE

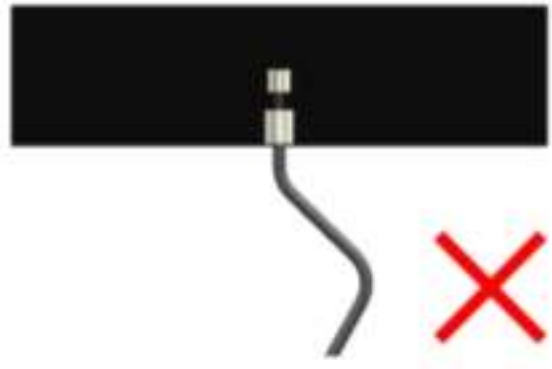


FIGURE 5.2.3 MULTIPLE BENDING OF CABLES IS NOT RECOMMENDED

6.0 RF PERFORMANCE AS A FUNCTION OF IMPLEMENTATION

6.1 ANTENNA RF PERFORMANCE AS A FUNCTION OF DIFFERENT LOCATIONS WITH PARALLEL PLANE GROUND

Four locations with parallel plane ground have been evaluated and these locations are shown in figure 6.1.1. The plane ground size is 90mm*90mm and we move the plane ground to four locations for each test. The antenna performance is better with larger distance between antenna and parallel plane ground. The minimum distance between antenna and plane ground is recommended to be 15mm to achieve acceptable RF performance.

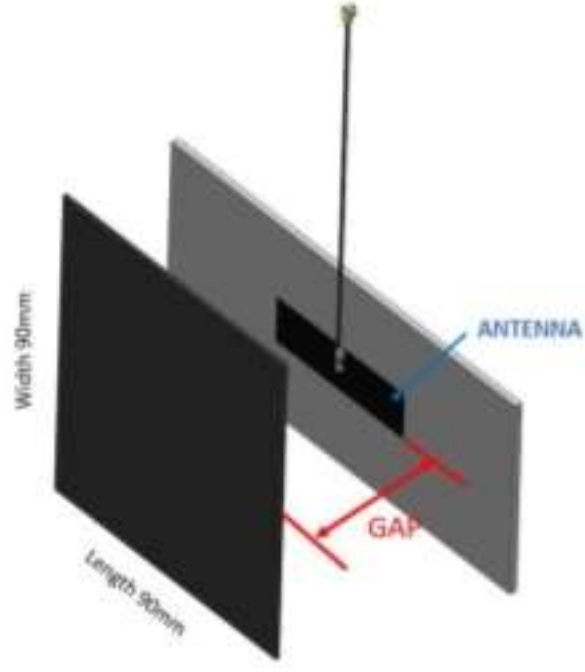


FIGURE 6.1.1 FOUR LOCATIONS WITH PARALLEL PLANE GROUND

Ground Size: 90mm*90mm;
Location 1: Distance between antenna and plane (GAP) ground is about 5mm;
Location 2: Distance between antenna and plane (GAP) ground is about 10mm;
Location 3: Distance between antenna and plane (GAP) ground is about 15mm;
Location 4: Distance between antenna and plane (GAP) ground is about 20mm.

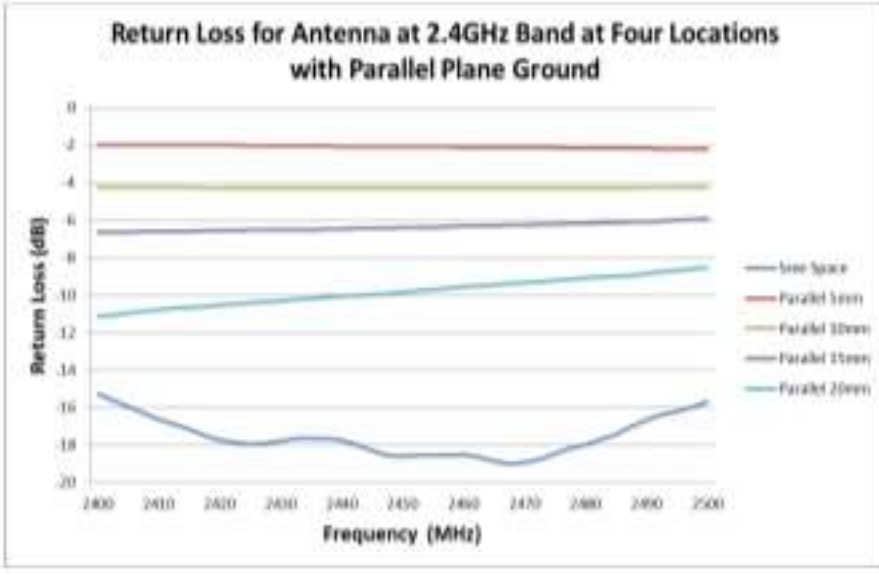


FIGURE 6.1.2 RETURN LOSS OF ANTENNA AT 2.4GHZ BAND AT FOUR LOCATIONS WITH PARALLEL PLANE GROUND

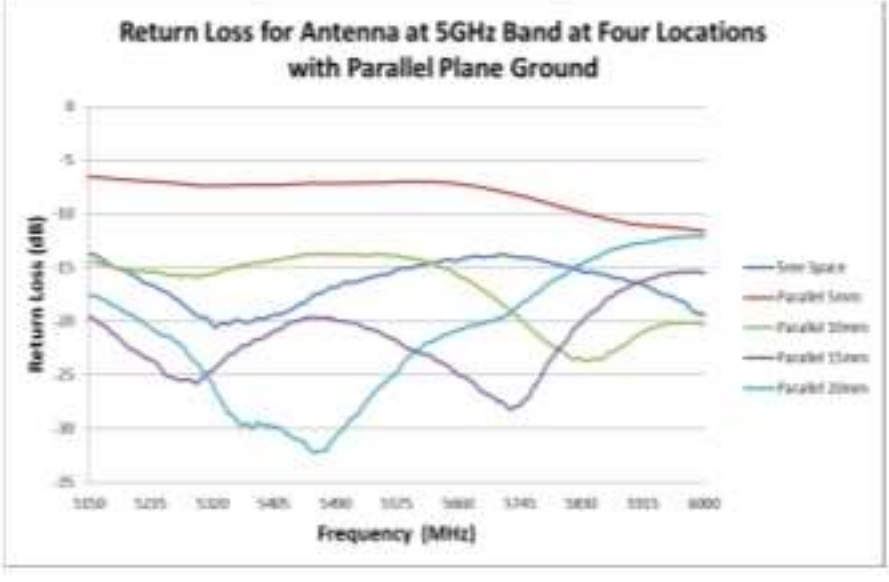


FIGURE 6.1.3 RERURN LOSS OF ANTENNA AT 5GHZ BAND AT FOUR LOCATIONS WITH PARALLEL PLANE GROUND

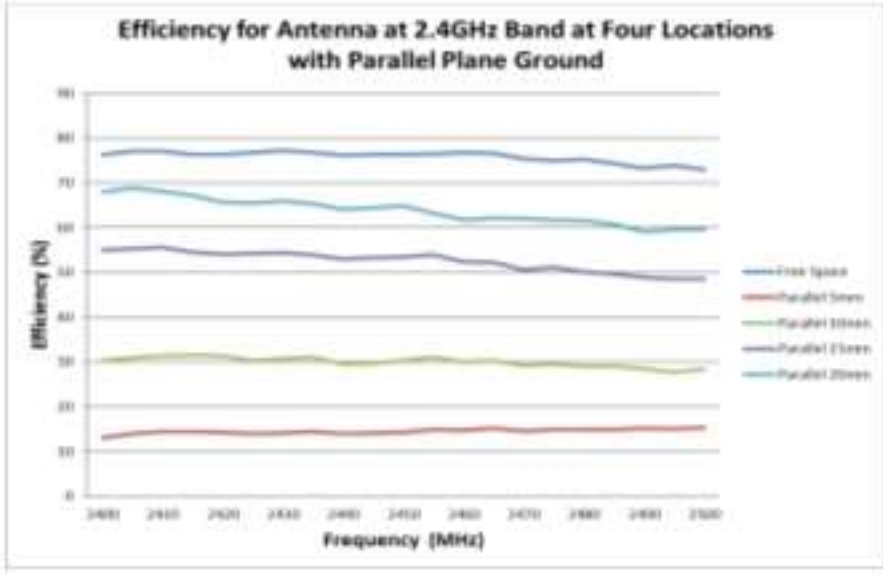


FIGURE 6.1.4 EFFICIENCY OF ANTENNA AT 2.4GHZ BAND AT FOUR LOCATIONS WITH PARALLEL PLANE GROUND

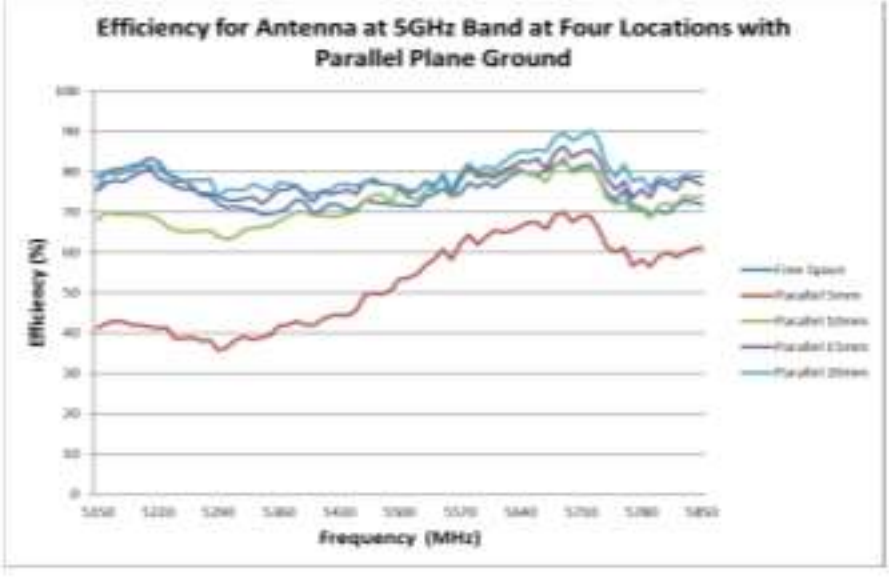


FIGURE 6.1.5 EFFICIENCY OF ANTENNA AT 5GHZ BAND AT FOUR LOCATIONS WITH PARALLEL PLANE GROUND

6.2 ANTENNA RF PERFORMANCE AS A FUNCTION OF DIFFERENT LOCATIONS WITH VERTICAL PLANE GROUND

Four locations with vertical plane ground have been evaluated and these locations are shown in figure 6.2.1. The plane ground size is 90mm*90mm and we move the plane ground to four locations for each test. The antenna performance is better with larger distance between antenna and vertical plane ground. The minimum distance between antenna and plane ground is recommended to be 5mm to achieve acceptable RF performance.

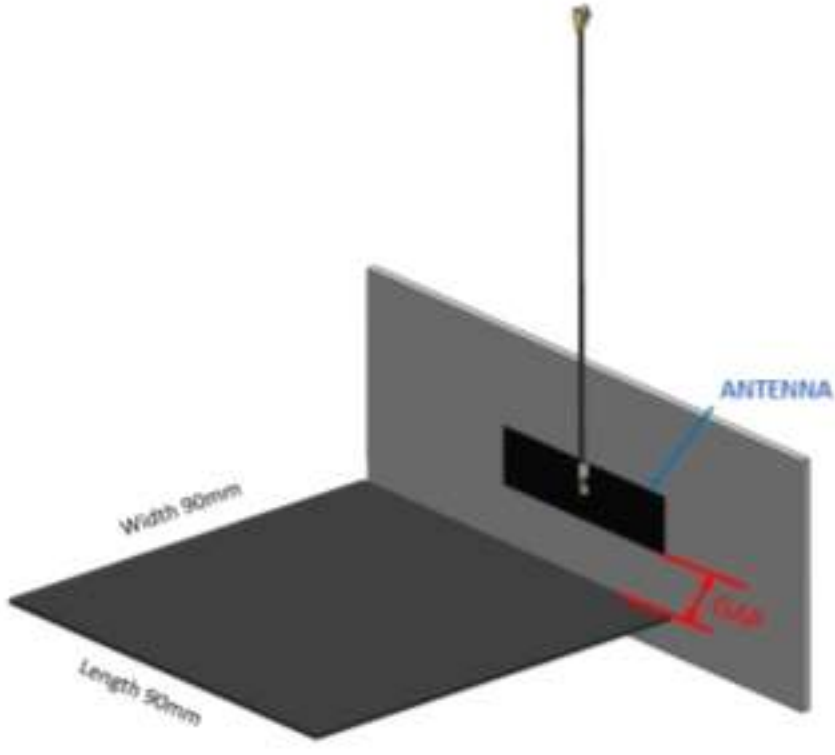


FIGURE 6.2.1 FOUR LOCATIONS WITH VERTICAL PLANE GROUND

Ground Size: 90mm*90mm;
Location 1: Distance between antenna and plane (GAP) ground is about 5mm;
Location 2: Distance between antenna and plane (GAP) ground is about 10mm;
Location 3: Distance between antenna and plane (GAP) ground is about 15mm;
Location 4: Distance between antenna and plane (GAP) ground is about 20mm.

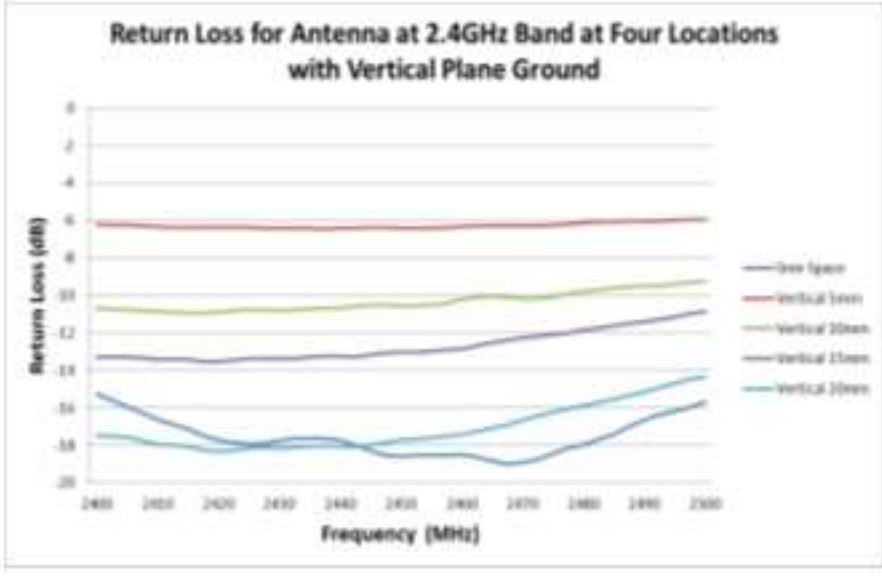


FIGURE 6.2.2 RETURN LOSS OF ANTENNA AT 2.4GHZ BAND AT FOUR LOCATIONS WITH VERTICAL PLANE GROUND

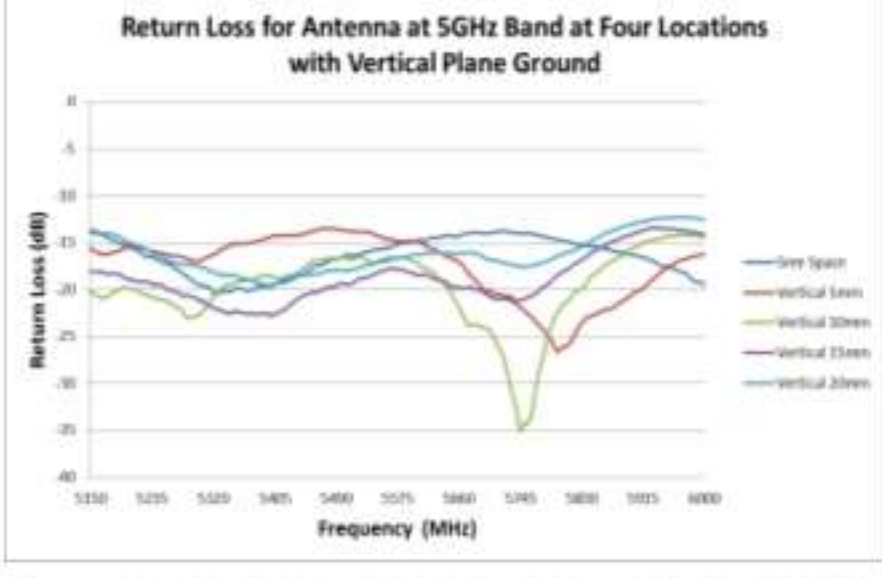


FIGURE 6.2.3 RETURN LOSS OF ANTENNA AT 5GHZ BAND AT FOUR LOCATIONS WITH VERTICAL PLANE GROUND

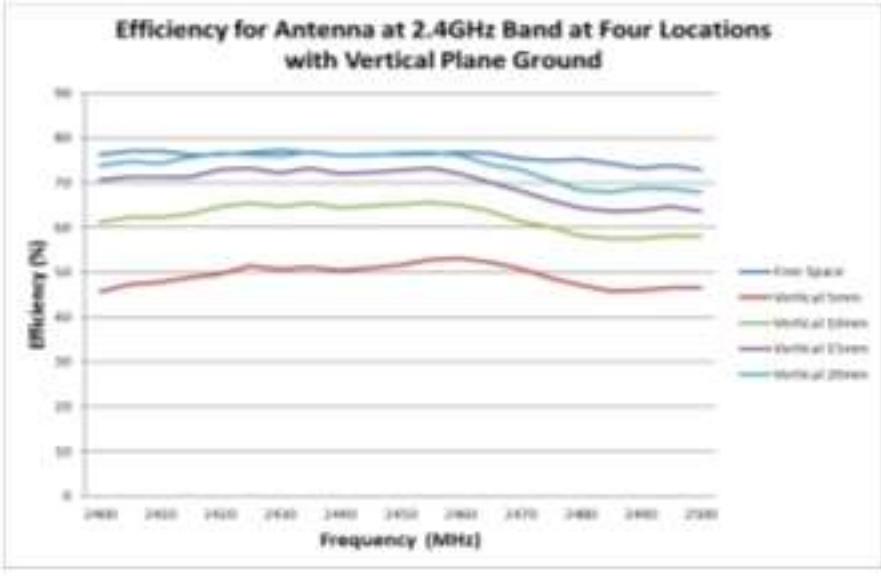


FIGURE 6.2.4 EFFICIENCY OF ANTENNA AT 2.4GHZ BAND AT FOUR LOCATIONS WITH VERTICAL PLANE GROUND

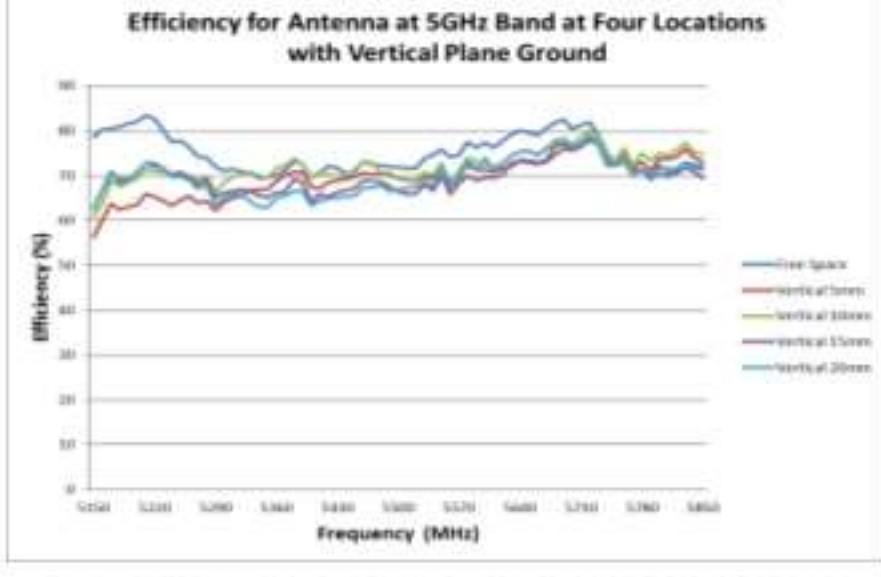


FIGURE 6.2.5 EFFICIENCY OF ANTENNA AT 5GHZ BAND AT FOUR LOCATIONS WITH VERTICAL PLANE GROUND

6.3 ANTENNA RF PERFORMANCE AS A FUNCTION OF DIFFERENT DISTANCES WITH PARALLEL PLANE GROUND

Four locations with the parallel plane ground have been evaluated and these locations are shown in figure 6.3.1. The plane ground size is 90mm*90mm and we move the plane ground to four locations for each test. The antenna performance is better with larger distance between the antenna and the parallel plane ground. The minimum distance between the antenna and the plane ground is recommended to be 5mm to achieve acceptable RF performance.

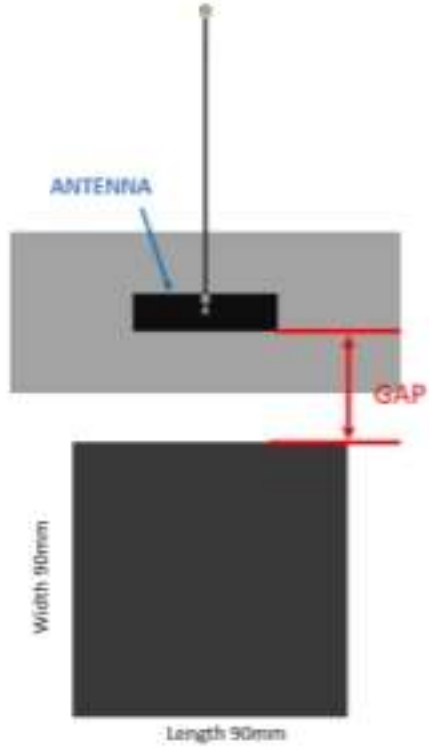


FIGURE 6.3.1 FOUR LOCATIONS WITH PARALLEL PLANE GROUND

Ground Size: 90mm*90mm;
Location 1: Distance between antenna and plane (GAP) ground is about 5mm;
Location 2: Distance between antenna and plane (GAP) ground is about 10mm;
Location 3: Distance between antenna and plane (GAP) ground is about 15mm;
Location 4: Distance between antenna and plane (GAP) ground is about 20mm.

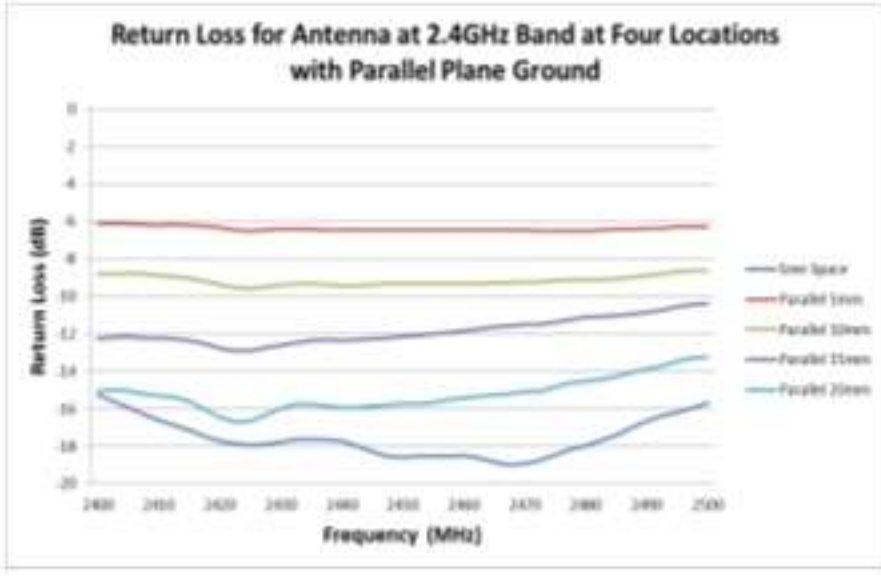


FIGURE 6.3.2 RETURN LOSS OF ANTENNA AT 2.4GHZ BAND AT FOUR LOCATIONS WITH PARALLEL PLANE GROUND

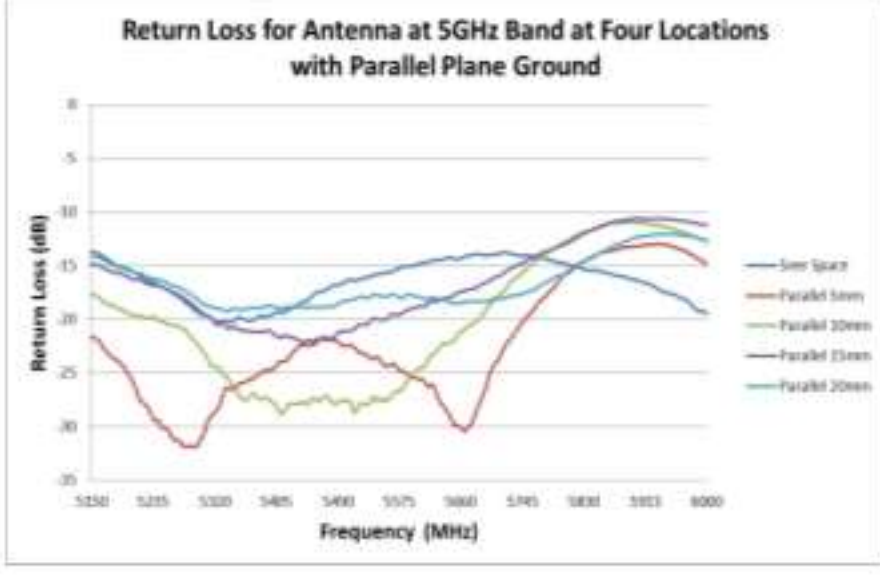


FIGURE 6.3.3 RETURN LOSS OF ANTENNA AT 5GHZ BAND AT FOUR LOCATIONS WITH PARALLEL PLANE GROUND

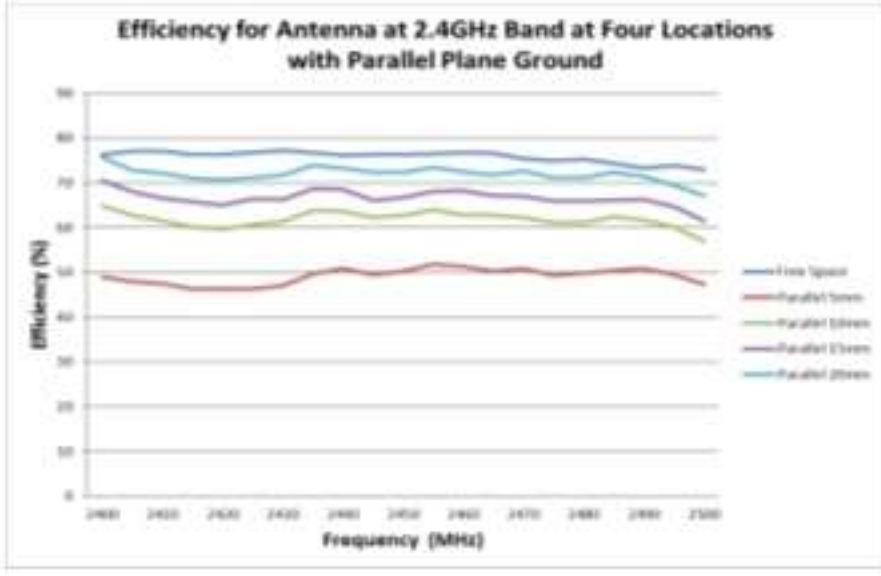


FIGURE 6.3.4 EFFICIENCY OF ANTENNA AT 2.4GHZ BAND AT FOUR LOCATIONS WITH PARALLEL PLANE GROUND

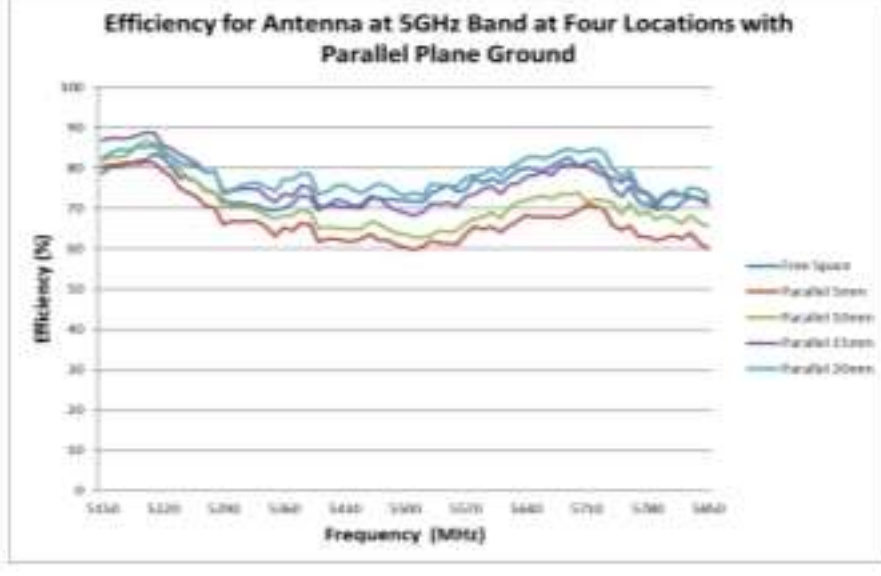


FIGURE 6.3.5 EFFICIENCY OF ANTENNA AT 5GHZ BAND AT FOUR LOCATIONS WITH PARALLEL PLANE GROUND

7.0 THE ANTENNA PERFORMANCE VARIATION WITH CABLE LENGTH

7.0.1 CABLE LOSS

ITEM	DESCRIPTION	TEST CONDITION	REQUIREMENT		
7.0.1.1	Frequency Range	2 GHz~7.125GHz	2GHz~3GHz	5GHz~6GHz	6-7.125GHz
7.0.1.2	Attenuation	1m cable measured by VNA5071C	≤3.5dB/m	≤5.5dB/m	≤6.5dB/m

7.0.2 CABLE LENGTH AFFECT THE ANTENNA PERFORMANCE

Balance antenna resonance is insensitive by cable length, but the cable loss will affect the total efficiency. Refer to 7.0.1

7.0.3 FOR EXAMPLE

Base on the 100mm cable performance, we can mostly compute the 300mm cable's.

	100mm cable			300mm cable	
Frequency (MHz)	Efficiency (dB)	Efficiency (%)	cable loss	Efficiency (dB)	Efficiency (%)
	X		X-LOSS=Y	Y	
2400	-1.09	77.77	0.2m*3.5dB/m	-1.79	66.19
2420	-1.05	78.43		-1.75	66.76
2440	-1.15	76.82		-1.85	65.38
2460	-1.17	76.41		-1.87	65.03
2480	-1.19	76.00		-1.89	64.68
2500	-1.23	75.37		-1.93	64.15
5150	-1.10	77.71	0.2*5.5dB/m	-2.20	60.32
5200	-1.13	77.08		-2.23	59.83
5250	-1.13	77.11		-2.23	59.85
5300	-1.20	75.88		-2.30	58.90
5350	-1.33	73.54		-2.43	57.08
5400	-1.23	75.30		-2.33	58.45
5450	-1.16	76.50		-2.26	59.38
5500	-0.92	80.93		-2.02	62.82
5550	-0.92	80.95		-2.02	62.84
5600	-0.95	80.42		-2.05	62.42
5650	-0.97	79.94		-2.07	62.05
5700	-1.00	79.37		-2.10	61.61
5750	-1.06	78.38		-2.16	60.84
5800	-1.20	75.94		-2.30	58.95
5850	-1.11	77.51		-2.21	60.17
5900	-1.27	74.69		-2.37	57.98
5925	-1.30	74.20		-2.40	57.60
5950	-1.19	76.11		-2.29	59.08

	100mm cable			300mm cable	
Frequency (MHz)	Efficiency (dB)	Efficiency (%)	cable loss	Efficiency (dB)	Efficiency (%)
	X		X-LOSS=Y	Y	
6000	-1.00	79.43	0.2*6.5dB/m	-2.30	58.88
6100	-1.44	71.71		-2.74	53.16
6200	-1.32	73.73		-2.62	54.66
6300	-1.23	75.26		-2.53	55.79
6400	-1.14	76.91		-2.44	57.01
6500	-1.32	73.72		-2.62	54.65
6600	-1.12	77.19		-2.42	57.22
6700	-1.03	78.87		-2.33	58.46
6800	-1.05	78.50		-2.35	58.20
6900	-1.01	79.23		-2.31	58.73
7000	-1.45	71.60		-2.75	53.07
7100	-1.20	75.84		-2.50	56.22
7125	-1.11	77.44		-2.41	57.41

The data is just for your reference, all accurate performance should be according to the test results in the OTA chamber

8.0 CHANGE HISTORY

CHANGE HISTORY		
REV	DATA	DESCRIPTION
H	2020/06/18	Update 2D Figure and add 6-7.125GHz band
H1	2020/08/26	Change 2D 2450MHz 5450MHz pattern
J	2021/08/12	Change 2D of 6000MHz 7125MHz pattern

Compact 2.4 GHz WiFi/BL FR4 Antenna

ABAR1504-S2450

15.0 x 4.0 x 0.8 mm
RoHS/RoHS II Compliant
MSL = NA

Features

- Most compact cabled 2.4GHz antenna, 15 x 4 mm
- Low Profile of 0.8 mm
- Linear Polarization
- Low VSWR
- Gain of 2.28 dBi
- Easy integration using cable and connector
- Ø1.13 mm cable and IPEX Connector

Applications

- IoT
- Wearables
- Home automation
- WiFi/Bluetooth/ZigBee
- Appliances
- Security

Electrical Specifications

Parameters	Min.	Typ.	Max.	Units	Notes
Operating Frequency Range		2400-2484		MHz	
Frequency	2400	2450	2500		
VSWR	2.70	1.63	1.66	dBi	
Peak Gain	1.52	2.28	1.89		
Average Gain	-5.92	-5.16	-5.54	%	
Polarization		Linear			
Impedance		50		Ω	

Mechanical Specification

Parameters	Description
Cable Type	Ø1.13 mm
Cable Length	250 mm
Connector	IPEX

Environmental Specification

Parameters	Description
Operating Temperature	-40°C to +85°C
Storage Temperature	-40°C to +85°C
Relative Humidity	0 ~ 95 %

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Phone: 512-371-6159 | Fax: 512-351-8858
For terms and conditions of sales, please visit:
www.abracon.com

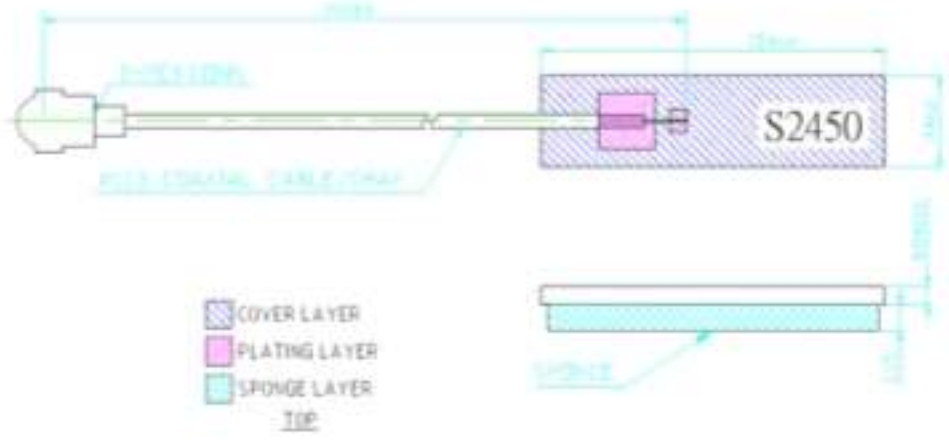
REVISED: 11-9-20

Compact 2.4 GHz WiFi/BL FR4 Antenna

ABAR1504-S2450

15.0 x 4.0 x 0.8 mm
RoHS/RoHS II Compliant
MSL = NA

Product Dimensions



Dimensions: mm

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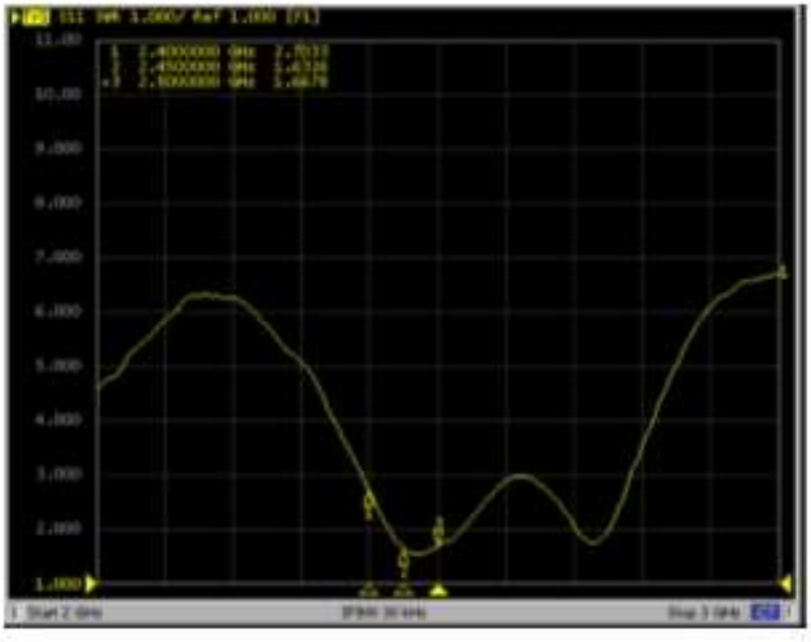
REVISED: 11-9-20

Compact 2.4 GHz WiFi/BL FR4 Antenna

ABAR1504-S2450

15.0 x 4.0 x 0.8 mm
RoHS/RoHS II Compliant
MSL = NA

VSWR



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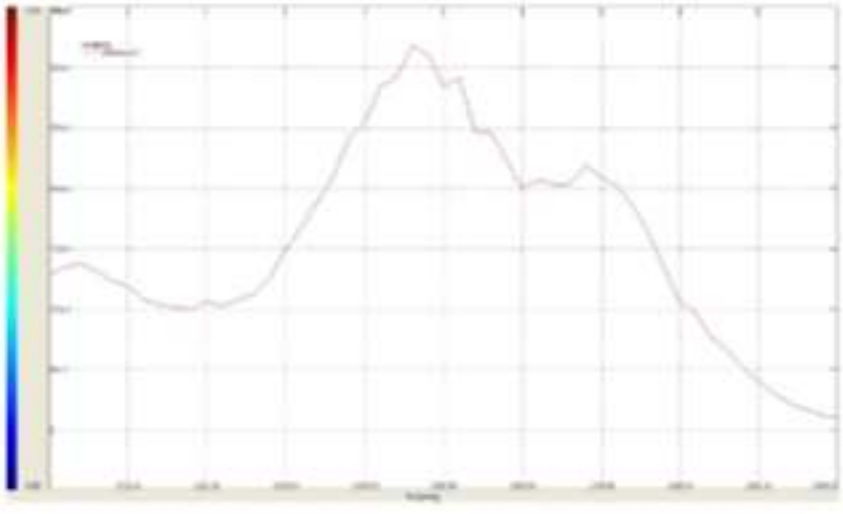
ISO9001-2015
CERTIFIED

Compact 2.4 GHz WiFi/BL FR4 Antenna

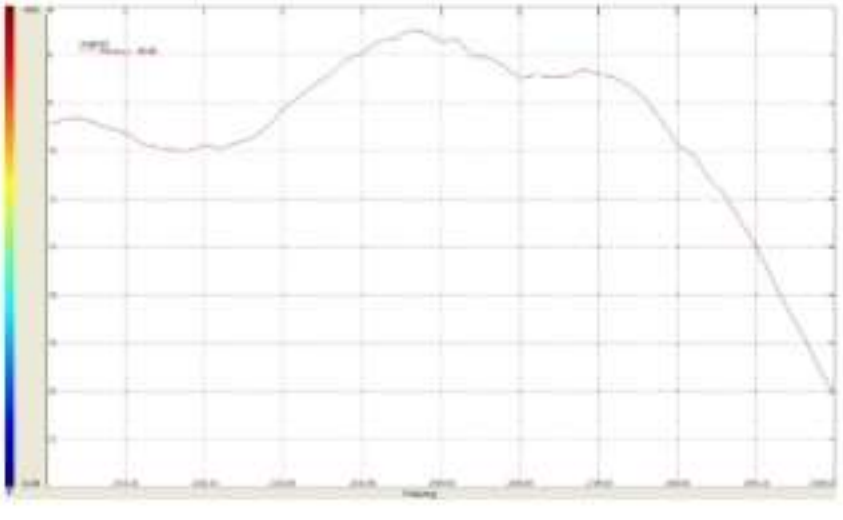
ABAR1504-S2450

15.0 x 4.0 x 0.8 mm
RoHS/RoHS II Compliant
MSL = NA

Efficiency



Average Gain



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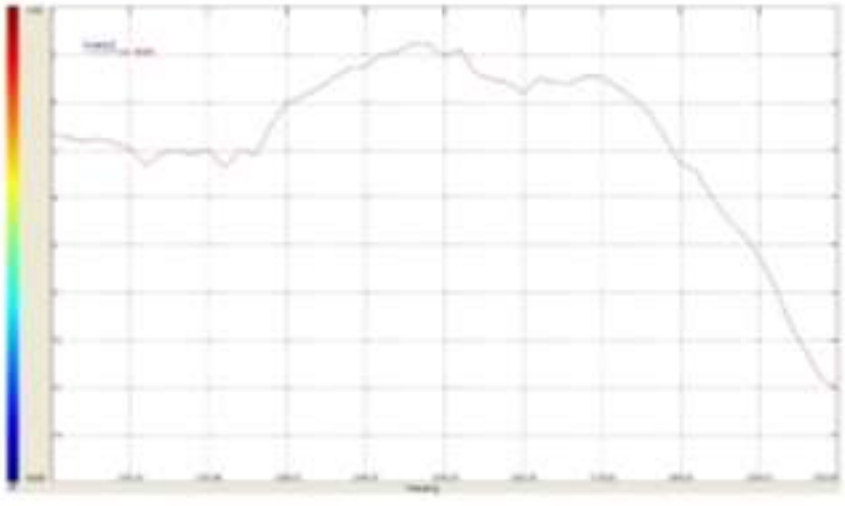
REVISED: 11-9-20

Compact 2.4 GHz WiFi/BL FR4 Antenna

ABAR1504-S2450

15.0 x 4.0 x 0.8 mm
RoHS/RoHS II Compliant
MSL = NA

Peak Gain



BT	2400 MHz	2450 MHz	2500 MHz
Efficiency (%)	25.56	30.50	28.50
Average Gain (dBi)	-5.92	-5.16	-5.54
Peak Gain (dBi)	1.52	2.28	1.89

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Phone: 512-371-6159 | Fax: 512-351-8858
For terms and conditions of sales, please visit:
www.abracon.com

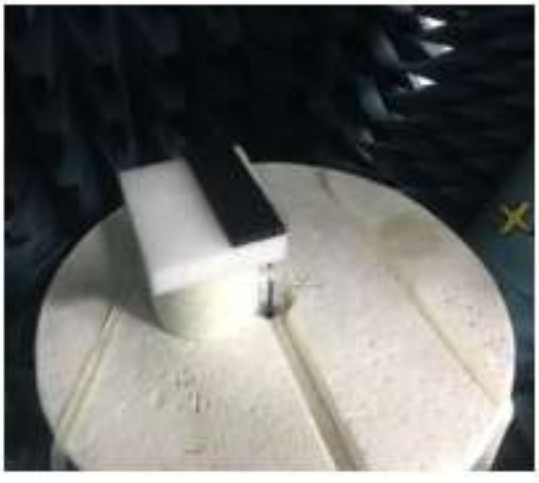
REVISED: 11-9-20

Compact 2.4 GHz WiFi/BL FR4 Antenna

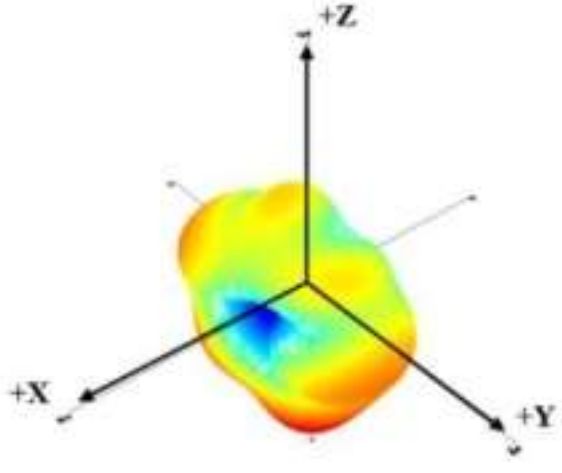
ABAR1504-S2450

15.0 x 4.0 x 0.8 mm
RoHS/RoHS II Compliant
MSL = NA

Radiation Pattern @ 2450MHz



3D Pattern



2450 MHz

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REVISED: 11-9-20

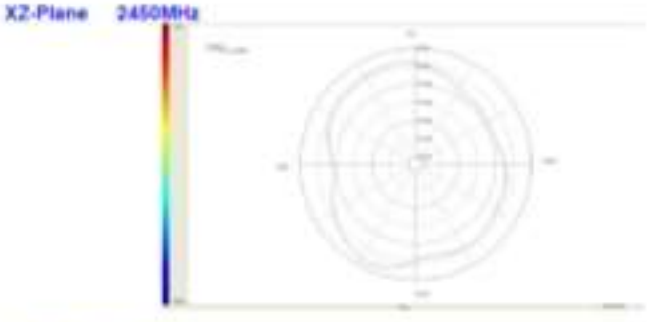
Compact 2.4 GHz WiFi/BL FR4 Antenna

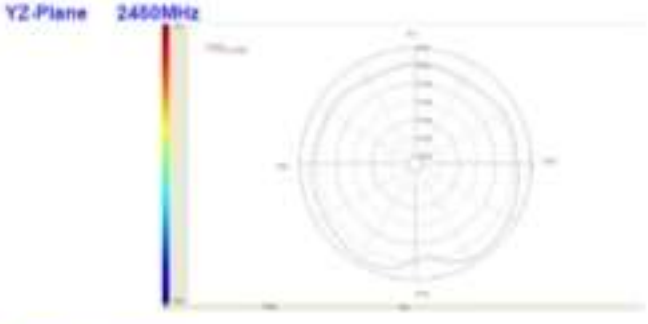
ABAR1504-S2450

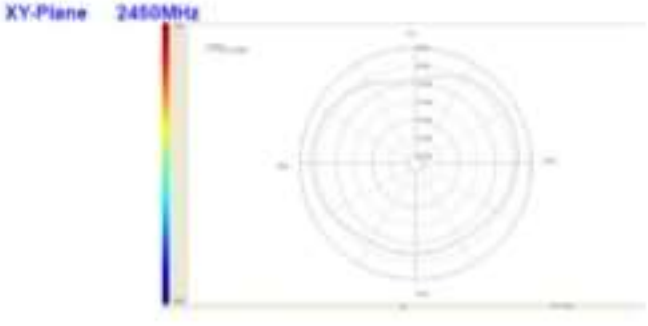
15.0 x 4.0 x 0.8 mm
RoHS/RoHS II Compliant
MSL = NA

2D Pattern

Measurement Plane	XZ	YZ	XY
2450 MHz	-1.91 dBi	-1.24 dBi	-3.25 dBi







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REVISED: 11-9-20

Compact 2.4 GHz WiFi/BL FR4 Antenna

ABAR1504-S2450

15.0 x 4.0 x 0.8 mm
RoHS/RoHS II Compliant
MSL = NA

Packaging

Each carton is 330 x 280 x 254 mm and has 3600 pcs of antenna.

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For terms and conditions of sales, please visit:
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REVISED: 11-9-20

Datasheet

ANT-2.4-LPW-125
2.4 GHz Panel-Mount Dipole Antenna

The ANT-2.4-LPW-125 (LPW) is a panel-mount dipole antenna for Bluetooth®, ZigBee® and other 2.4 GHz ISM applications including WiFi/WLAN.

The snap-in panel mount provides for easy and secure installation and the hinged whip with 3-position detent allows for optimal antenna positioning.

Connection is made to the radio via a 125 mm long, 1.13 mm coaxial cable terminated in an MHF1/U.FL-compatible plug connector.

Features

- Performance
  - VSWR: ≤ 1.5
  - Peak Gain: 2.8 dBi
  - Efficiency: 83%
- Snap-in panel mount
  - 9.5 mm (0.37 in) diameter hole
- 93.7 mm (3.69 in) long
- Hinged with detents for straight, 45 degree and 90 degree positioning
- MHF1/U.FL-compatible plug (female socket) connector attached to 125 mm of 1.13 mm coax cable
- Omnidirectional radiation pattern

Applications

- 2.4 GHz applications
  - Bluetooth® and ZigBee®
- Single-band WiFi / WLAN
  - WiFi 4
  - 802.11b/g/n
- Smart Home networking
- Sensing and remote monitoring
- Internet of Things (IoT) devices
- Gateways

Ordering Information

Part Number	Description
ANT-2.4-LPW-125	Antenna with MHF1/U.FL-compatible connector on 125 mm (4.92 in) 1.13 mm coax cable

Available from Linx Technologies and select distributors and representatives.

Electrical Specifications

ANT-2.4-LPW-125	2.4 GHz
Frequency Range	2.4 GHz to 2.485 GHz
VSWR (max.)	1.5
Return Loss (max.)	-14.6
Peak Gain (dBi)	2.8
Average Gain (dBi)	-1.0
Efficiency (%)	83
Polarization	Linear
Radiation	Omnidirectional
Max Power	10 W
Wavelength	1/2-wave
Electrical Type	Dipole
Impedance	50 Ω
Connection	MHF1/U.FL-compatible plug, female socket
Coaxial Cable	Type: 1.13 mm / Length: 125 mm (4.92 in)
Weight	6.1 g (0.22 oz)
Height	93.7 mm (3.69 in)
Operating Temperature Range	-20 °C to +85 °C

Electrical specifications and plots measured in Bent-90 configuration.

Packaging Information

The ANT-2.4-LPW-125 antennas are individually sealed in a clear plastic bag. Individual packages are packed in a bag of 50, seven bags of 50 to a box and twenty boxes to a carton. Distribution channels may offer alternative packaging options.

Product Dimensions

Figure 1 shows the overall dimensions and mounting information for the LPW antenna. The antenna's hinged whip can be tilted 90 degrees and has detents at 0, 45 and 90 degrees.

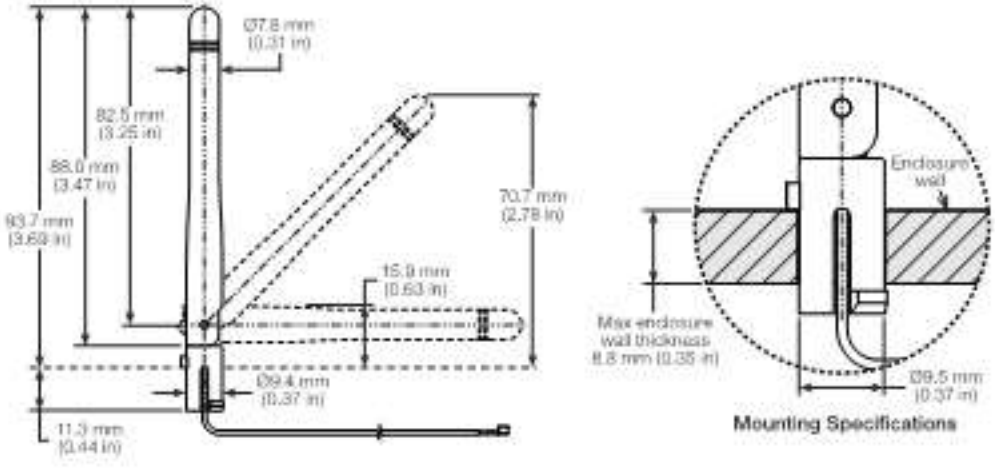


Figure 1. ANT-2.4-LPW-125 Dimensions and Mounting Data

Antenna Orientation - Bent 90 Degrees

The charts on the following pages represent data taken with the antenna Bent-90 degrees, as shown in Figure 2.

Figure 2. LPW Antenna, Bent 90 Degrees (Bent-90)

VSWR

Figure 3 provides the voltage standing wave ratio (VSWR) across the antenna bandwidth. VSWR describes the power reflected from the antenna back to the radio. A lower VSWR value indicates better antenna performance at a given frequency. Reflected power is also shown on the right-side vertical axis as a gauge of the percentage of transmitter power reflected back from the antenna.

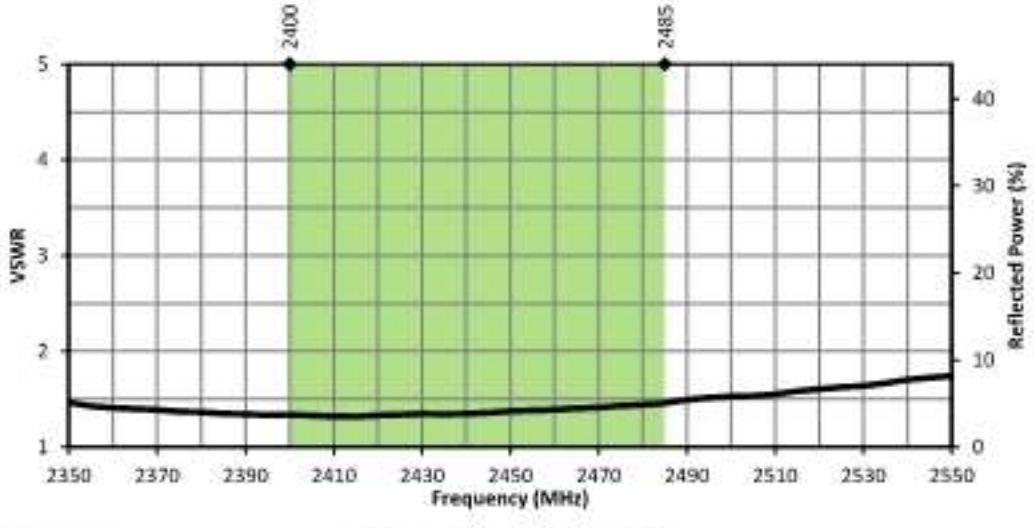


Figure 3. LPW VSWR, Bent-90

Return Loss

Return loss (Figure 4), represents the loss in power at the antenna due to reflected signals. Like VSWR, a lower return loss value indicates better antenna performance at a given frequency.

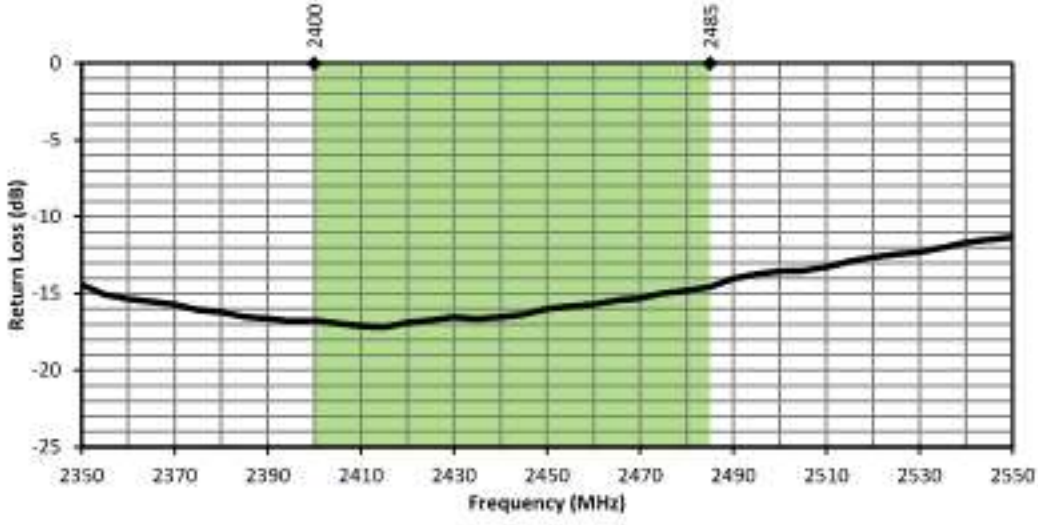


Figure 4. LPW Return Loss, Bent-90

Peak Gain

The peak gain across the antenna bandwidth is shown in Figure 5. Peak gain represents the maximum antenna input power concentration across 3-dimensional space, and therefore peak performance at a given frequency, but does not consider any directionality in the gain pattern.

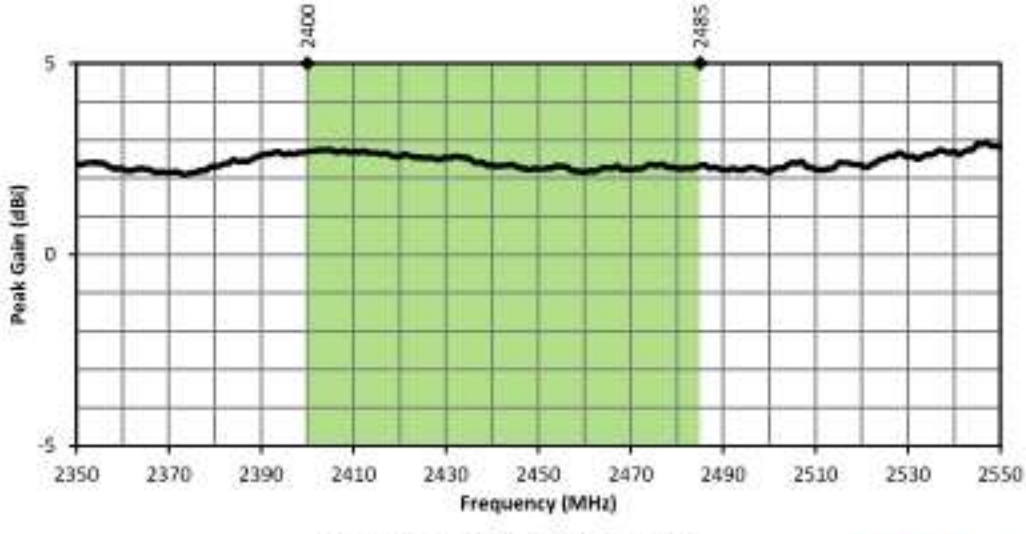


Figure 5. LPW Peak Gain, Bent-90

Average Gain

Average gain (Figure 6), is the average of all antenna gain in 3-dimensional space at each frequency, providing an indication of overall performance without expressing antenna directionality.

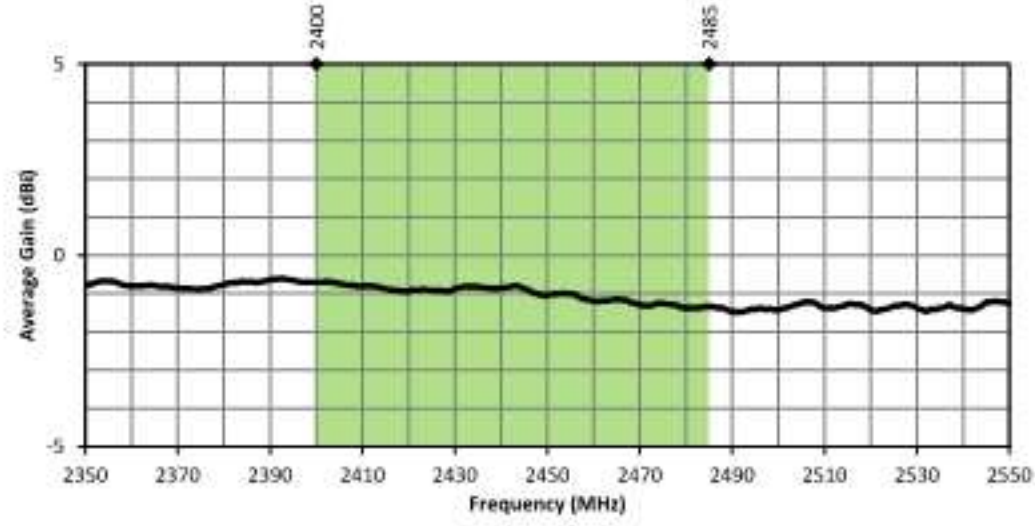


Figure 6. LPW Average Gain, Bent-90

Radiation Efficiency

Radiation efficiency (Figure 7), shows the ratio of power delivered to the antenna relative to the power radiated at the antenna, expressed as a percentage, where a higher percentage indicates better performance at a given frequency.

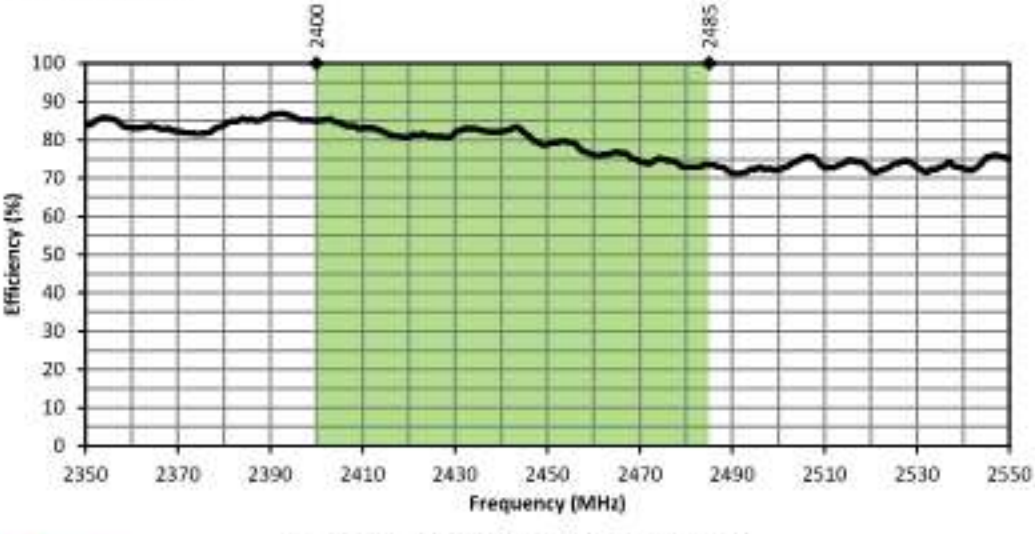


Figure 7. LPW Radiation Efficiency, Bent-90

Radiation Patterns

Radiation patterns provide information about the directionality and 3-dimensional gain performance of the antenna by plotting gain at specific frequencies in three orthogonal planes. Antenna radiation patterns for a Bent-90 orientation are shown in Figure 8 using polar plots covering 360 degrees. The antenna graphic provides reference to the plane of the column of plots below it. Note: when viewed with typical PDF viewing software, zooming into radiation patterns is possible to reveal fine detail.

Radiation Patterns - Bent-90 Degrees

2400 MHz to 2485 MHz (2450 MHz)

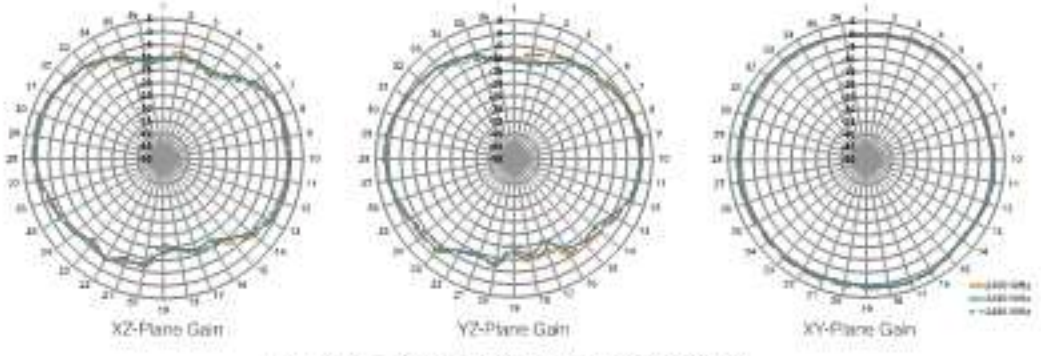


Figure 8. Radiation Patterns for LPW, Bent-90

Antenna Orientation - Straight

The charts on the following pages represent data taken with the antenna oriented straight, as shown in Figure 9.

Figure 9. LPD Antenna Shown Straight

VSWR

Figure 10 provides the voltage standing wave ratio (VSWR) across the antenna bandwidth. VSWR describes the power reflected from the antenna back to the radio. A lower VSWR value indicates better antenna performance at a given frequency. Reflected power is also shown on the right-side vertical axis as a gauge of the percentage of transmitter power reflected back from the antenna.

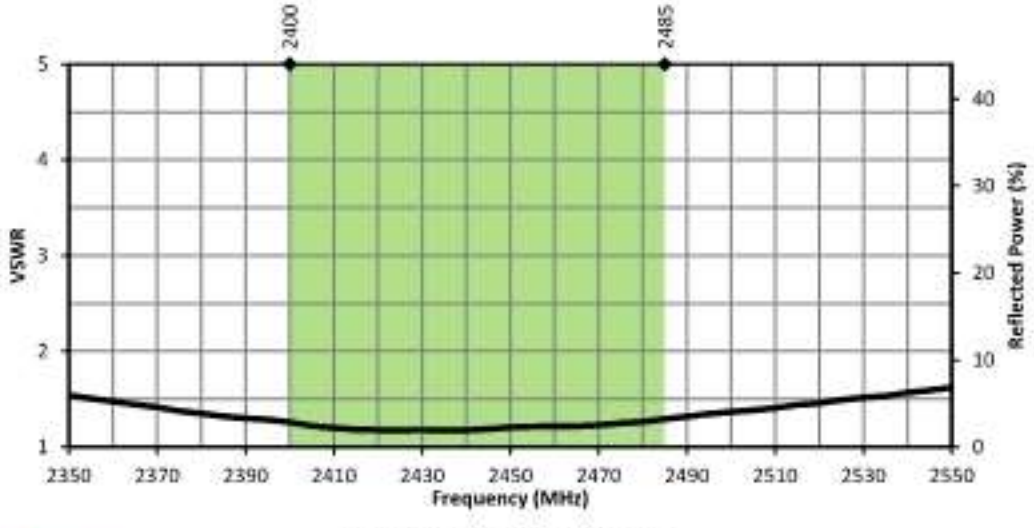


Figure 10. LPW VSWR, Straight

Return Loss

Return loss (Figure 11), represents the loss in power at the antenna due to reflected signals. Like VSWR, a lower return loss value indicates better antenna performance at a given frequency.

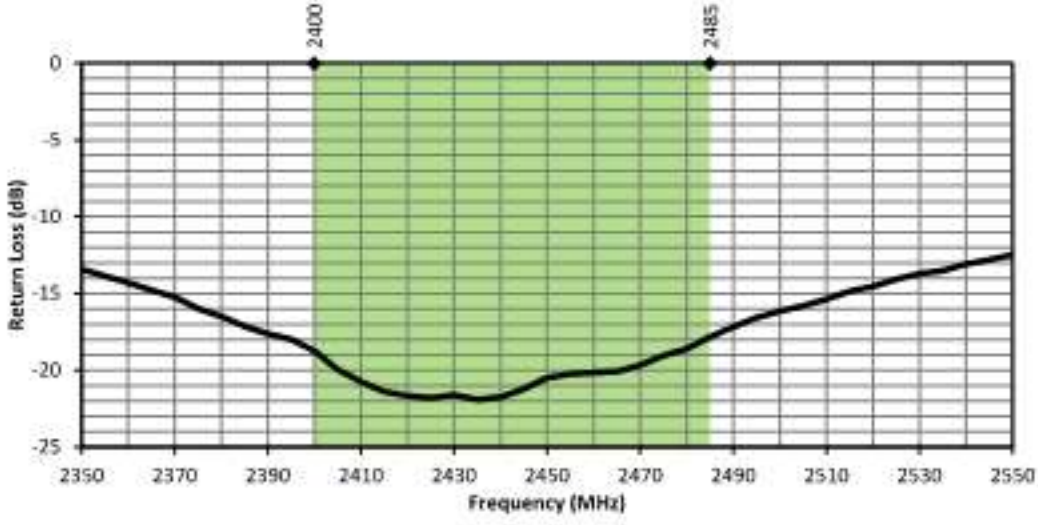


Figure 11. LPW Return Loss, Straight

Peak Gain

The peak gain across the antenna bandwidth is shown in Figure 12. Peak gain represents the maximum antenna input power concentration across 3-dimensional space, and therefore peak performance at a given frequency, but does not consider any directionality in the gain pattern.

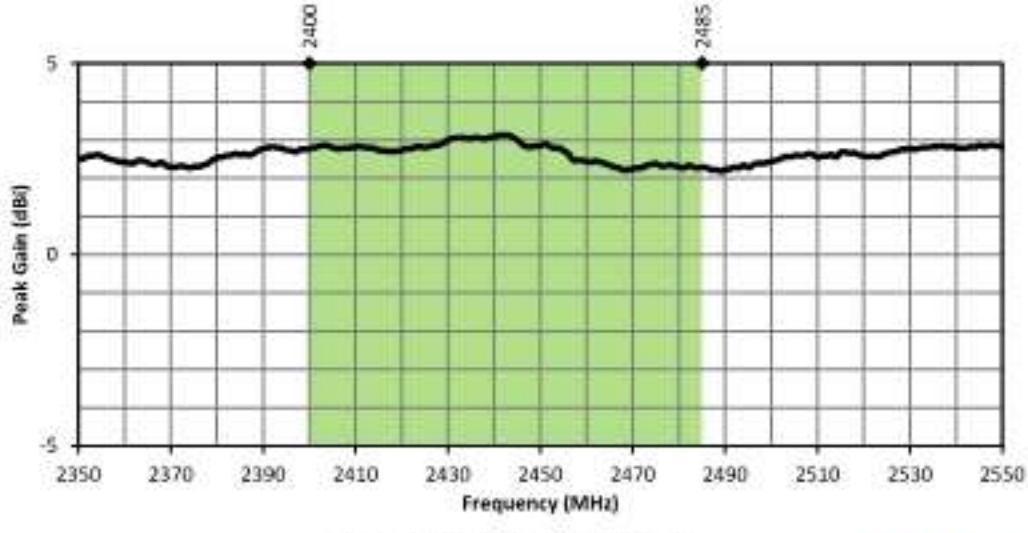


Figure 12. LPW Peak Gain, Straight

Average Gain

Average gain (Figure 13), is the average of all antenna gain in 3-dimensional space at each frequency, providing an indication of overall performance without expressing antenna directionality.

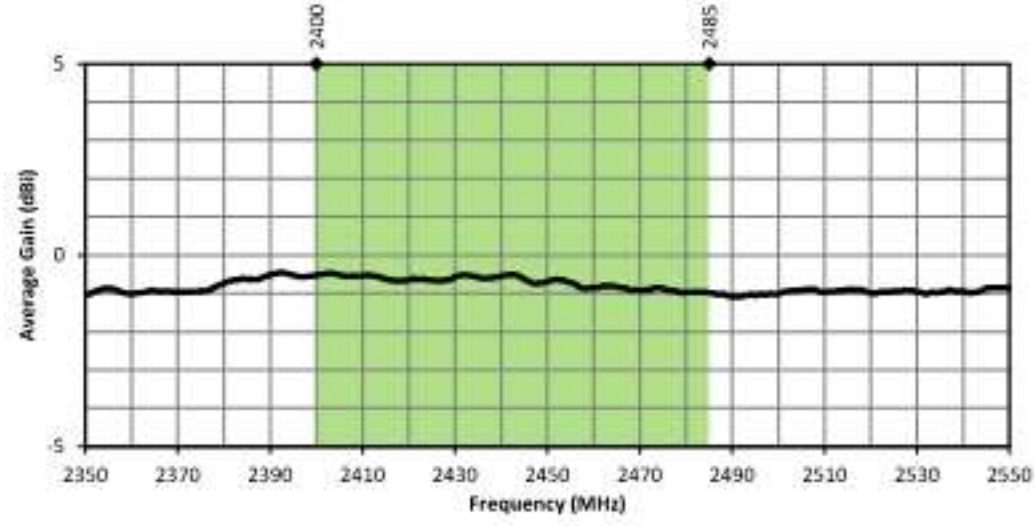


Figure 13. LPW Average Gain, Straight

Radiation Efficiency

Radiation efficiency (Figure 14), shows the ratio of power delivered to the antenna relative to the power radiated at the antenna, expressed as a percentage, where a higher percentage indicates better performance at a given frequency.

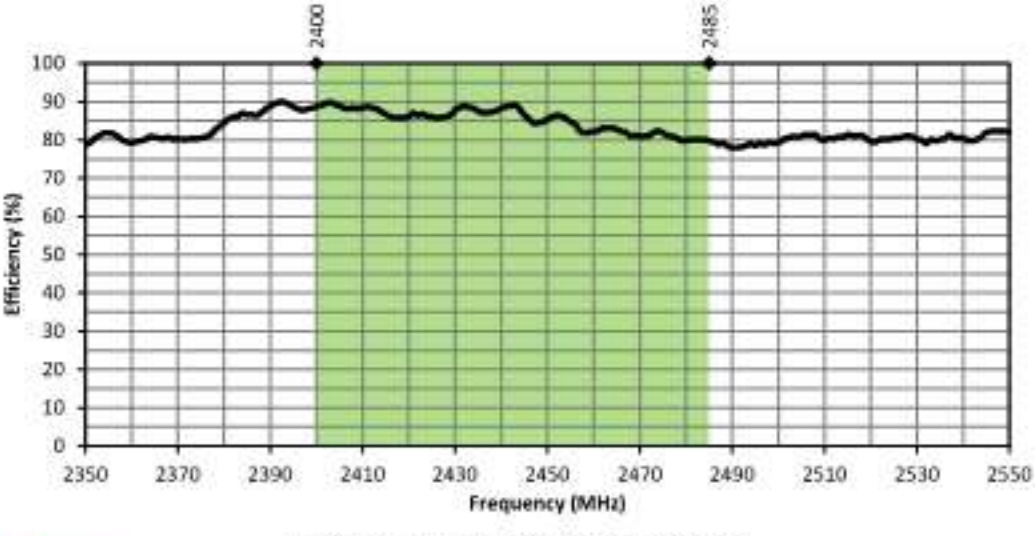


Figure 14. LPW Radiation Efficiency, Straight

Radiation Patterns

Radiation patterns provide information about the directionality and 3-dimensional gain performance of the antenna by plotting gain at specific frequencies in three orthogonal planes. Antenna radiation patterns for a Straight orientation are shown in Figure 15 using polar plots covering 360 degrees. The antenna graphic provides reference to the plane of the column of plots below it. Note: when viewed with typical PDF viewing software, zooming into radiation patterns is possible to reveal fine detail.

Radiation Patterns - Straight

2400 MHz to 2485 MHz (2450 MHz)

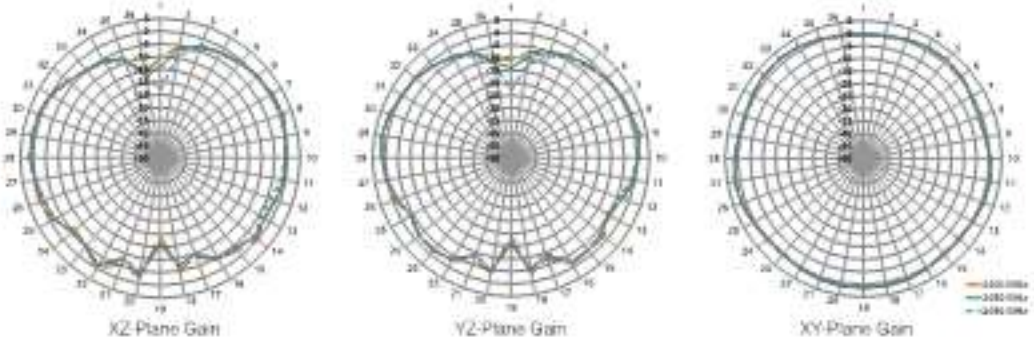


Figure 15. Radiation Patterns for LPW, Straight

Antenna Definitions and Useful Formulas

VSWR - Voltage Standing Wave Ratio. VSWR is a unitless ratio that describes the power reflected from the antenna back to the radio. A lower VSWR value indicates better antenna performance at a given frequency. VSWR is easily derived from Return Loss.

$$\text{VSWR} = \frac{10^{\left[\frac{\text{Return Loss}}{20}\right]} + 1}{10^{\left[\frac{\text{Return Loss}}{20}\right]} - 1}$$

Return Loss - Return loss represents the loss in power at the antenna due to reflected signals, measured in decibels. A lower return loss value indicates better antenna performance at a given frequency. Return Loss is easily derived from VSWR.

$$\text{Return Loss} = -20\log_{10}\left|\frac{\text{VSWR} - 1}{\text{VSWR} + 1}\right|$$

Efficiency (η) - The total power radiated from an antenna divided by the input power at the feed point of the antenna as a percentage.

Total Radiated Efficiency - (TRE) The total efficiency of an antenna solution comprising the radiation efficiency of the antenna and the transmitted (forward) efficiency from the transmitter.

$$\text{TRE} = \eta \cdot \left(1 - \left(\frac{\text{VSWR} - 1}{\text{VSWR} + 1}\right)^2\right)$$

Gain - The ratio of an antenna's efficiency in a given direction (G) to the power produced by a theoretical lossless (100% efficient) isotropic antenna. The gain of an antenna is almost always expressed in decibels.

$$G_{dBi} = 10\log_{10}(G)$$

$$G_{dBd} = G_{dBi} - 2.51\text{dB}$$

Peak Gain - The highest antenna gain across all directions for a given frequency range. A directional antenna will have a very high peak gain compared to average gain.

Average Gain - The average gain across all directions for a given frequency range.

Maximum Power - The maximum signal power which may be applied to an antenna feed point, typically measured in watts (W).

Reflected Power - A portion of the forward power reflected back toward the amplifier due to a mismatch at the antenna port.

$$\left(\frac{\text{VSWR} - 1}{\text{VSWR} + 1}\right)^2$$

decibel (dB) - A logarithmic unit of measure of the power of an electrical signal.

decibel isotropic (dBi) - A comparative measure in decibels between an antenna under test and an isotropic radiator.

decibel relative to a dipole (dBd) - A comparative measure in decibels between an antenna under test and an ideal half-wave dipole.

Dipole - An ideal dipole comprises a straight electrical conductor measuring 1/2 wavelength from end to end connected at the center to a feed point for the radio.

Isotropic Radiator - A theoretical antenna which radiates energy equally in all directions as a perfect sphere.

Omnidirectional - Term describing an antenna radiation pattern that is uniform in all directions. An isotropic antenna is the theoretical perfect omnidirectional antenna. An ideal dipole antenna has a donut-shaped radiation pattern and other practical antenna implementations will have less perfect but generally omnidirectional radiation patterns which are typically plotted on three axes.

Website: http://linxtechnologies.com
Linx Offices: 159 Ort Lane, Merlin, OR, US 97532
Phone: +1 (541) 471-6256
E-MAIL: info@linxtechnologies.com

Doc # DS20078-49ANT Replaces (DS20015-49ANT)

ALEAD technology

Specifications

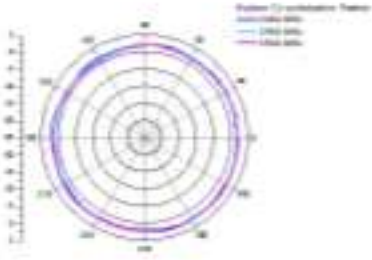
RFA-02-P05-D034

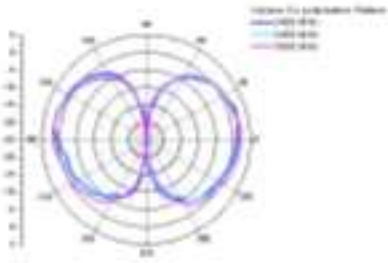
Electrical Specifications

Frequency range	2400 MHz – 2500 MHz
Peak Gain	2 dBi
Average gain	1 dBi
VSWR	2.0 : 1 Max.
Polarization	Linear, vertical
Power handling	1W (cw)
Impedance	50 Ω
Connector	I-PEX
Cable	Ø1.13mm

Environmental & Mechanical Characteristics

Temperature	- 10℃ to +55℃
Humidity	95% @ 25℃





ALEAD technology
22F., No.526, Xueqin Rd., Shulin Dist., New Taipei City 238, Taiwan (R.O.C.)
Tel : +886-2-89707048 www.alead.com.tw

ALEAD technology

Specifications

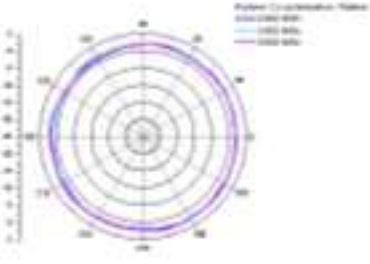
RFA-02-P33-D034

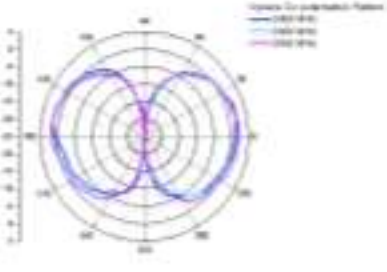
Electrical Specifications

Frequency range	2400 MHz – 2500 MHz
Peak gain	2dBi
VSWR	2.0 : 1 Max.
Polarization	Linear, vertical
Power handling	1W (cw)
Impedance	50 Ω
Connector	I-PEX
Cable	Ø1.13mm

Environmental & Mechanical Characteristics

Temperature	- 10℃ to +55℃
Humidity	95% @ 25℃





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Tel : +886-2-89707048 www.alead.com.tw

Pulse
a YAGEO company

Series: Internal PCB

TECHNICAL DATA SHEET

Description: 2.4-2.5GHz PCB Antenna with coax feed

PART NUMBER:W3525BXXX

Features:

- 2400-2500 MHz
- Size: 10.7 x 47.7 x 0.8 mm
- Gain 1.5dBi
- Radiation pattern Omni
- Cable length, see page 2
- Connector U.FL compatible
- RoHS Compliant

Applications:

- 2.4GHz ISM band radios
- WiFi, Bluetooth, BLE, ZigBee
- Devices requiring internal antenna
- Security, IoT, Monitoring, Industrial applications

All dimensions are in mm / inches

Issue: 2105

RoHS COMPLIANT

In the effort to improve our products, we reserve the right to make changes judged to be necessary

For more information:

Pulse Worldwide Headquarters
15255 Innovation Drive #100
San Diego, CA 92128
USA
Tel: 1-858-674-8100

Pulse/Larsen Antennas
18110 SE 34th St Bldg 2 Suite 250
Vancouver, WA 98683
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Herrenberg, Germany
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Pulse (Suzhou) Wireless Products Co. Inc.
99 Huo Ju Road#29 Bldg.4th Phase
Suzhou New District
Jiangsu Province, Suzhou 215009 PR China
Tel: 86 512 6807 9388

Pulse
a YAGEO company

TECHNICAL DATA SHEET

Description: 2.4-2.5GHz PCB Antenna with coax feed

Series: Internal PCB

PART NUMBER:W3525BXXX

This document covers all product variants of the following product family

Part Number	Cable Length	Adhesive Tape	Cable type	Connector type	Frequency	Max Gain
W3525B039	3.9" / 100 mm	N.A.	Ø1.13mm Coax Cable, Gray color	I-PEX MHF or euivalent, Compatible with U.FL	2.4 GHz	2 dBi
W3525B052	5.2" / 132.1 mm	N.A.				
W3525B100	10" / 254 mm	N.A.				
W3525B039T	3.9" / 100 mm	3M 467 (T=0.05mm)				
W3525B150T	150 mm	3M 467 (T=0.05mm)				
W3525B250	250 mm	N.A.				
W3525B250T	250 mm	3M 467 (T=0.05mm)				
W3525B254T	254 mm	3M 467 (T=0.05mm)				

RoHS COMPLIANT

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18110 SE 34th St Bldg 2 Suite 250
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Europe Headquarters
Pulse GmbH & Co. KG
Zeppelinstrasse 15
Herrenberg, Germany
Tel: 49 7032 7806 0

Pulse (Suzhou) Wireless Products Co. Inc.
99 Huo Ju Road#29 Bldg.4th Phase
Suzhou New District
Jiangsu Province, Suzhou 215009 PR China
Tel: 86 512 6807 9388

Pulse
a YAGEO company

TECHNICAL DATA SHEET

Description: 2.4-2.5GHz PCB Antenna with coax feed

Series: Internal PCB

PART NUMBER: W3525BXXX

ELECTRICAL SPECIFICATIONS

Antenna Type	Dipole PCB+Cable
Frequency	2400-2500MHz
Nominal Impedance	50 Ω
VSWR	2.5:1
Radiation Pattern	Omni
Gain	1.5dBi
Efficiency	55%
Polarization	Vertical
Power Withstanding	1W

MECHANICAL SPECIFICATIONS

Overall Length	10.7x47.7x0.8mm
Antenna Material	PCB
Connector type	I-PEX or equivalent
Cable type	MI-113 Gray

ENVIRONMENTAL SPECIFICATIONS

Operating Temperature	-40° C~+85 ° C
Storage Temperature	-40° C~+85 °C
RoHS Compliant	Yes

OTHER SPECIFICATIONS

Pulse
a YAGEO company

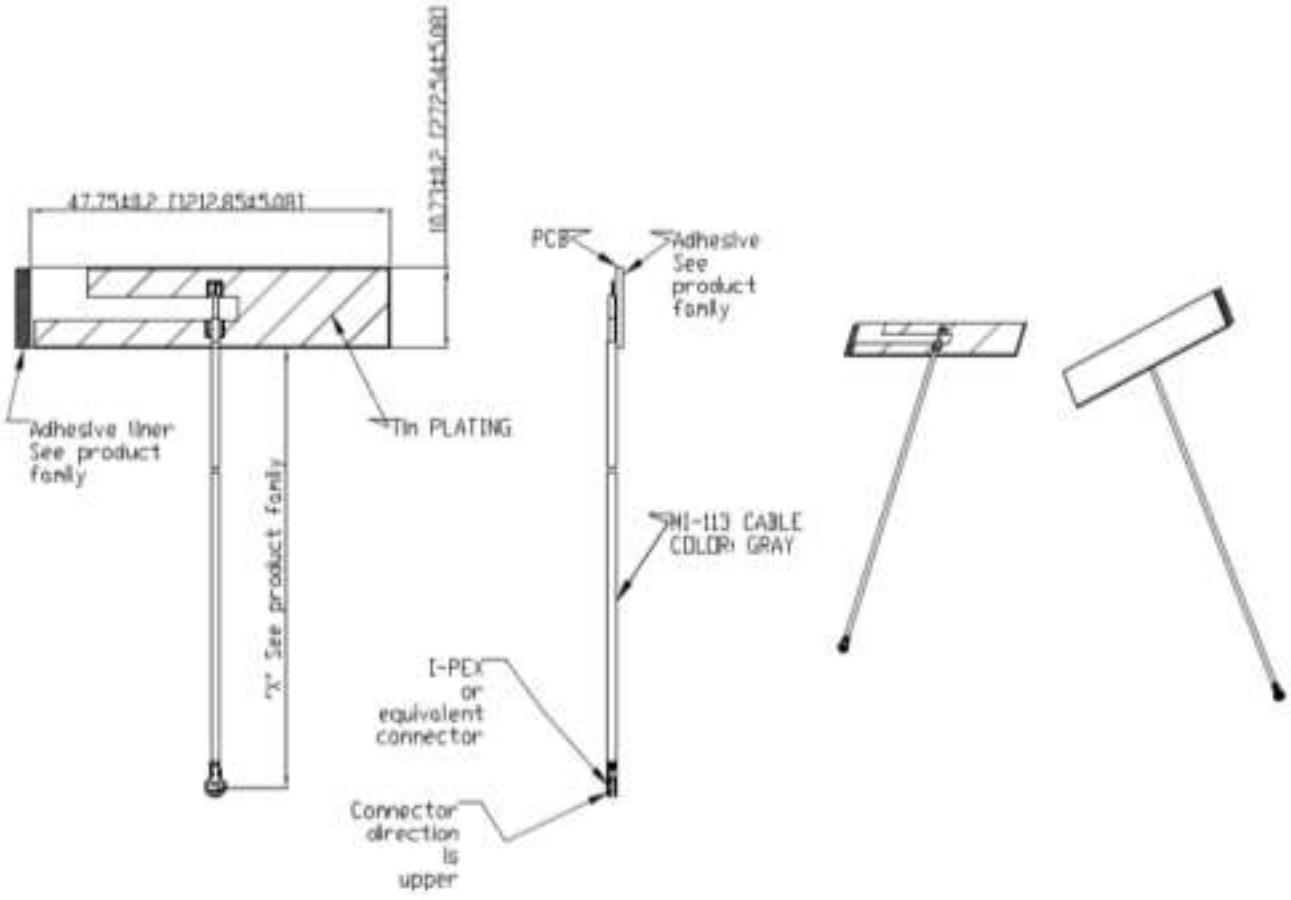
TECHNICAL DATA SHEET

Description: 2.4-2.5GHz PCB Antenna with coax feed

Series: Internal PCB

PART NUMBER: W3525BXXX

MECHANICAL DRAWING



Part Number	Frequency(GHz)	Max Gain(dBi)	Impedance(ohm)	PWB Length(in/mm)	Cable Length(in/mm)	Adhesive Tape
W3525B039	2.4	2	50	1.87/47.7	3.9/100	N/A
W3525B052	2.4	2	50	1.87/47.7	5.2/132.1	N/A
W3525B100	2.4	2	50	1.87/47.7	10/254	N/A
W3525B039T	2.4	2	50	1.87/47.7	3.9/100	Required

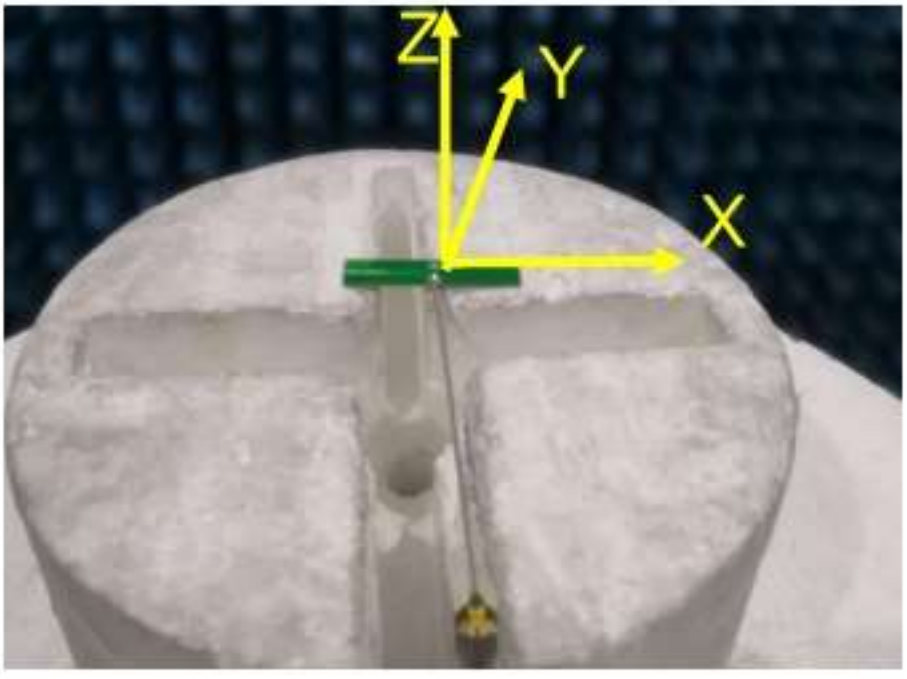
Dimension unit: mm/inch

Description: 2.4-2.5GHz PCB Antenna with coax feed

Series: Internal PCB

PART NUMBER: W3525BXXX

TEST SETUP



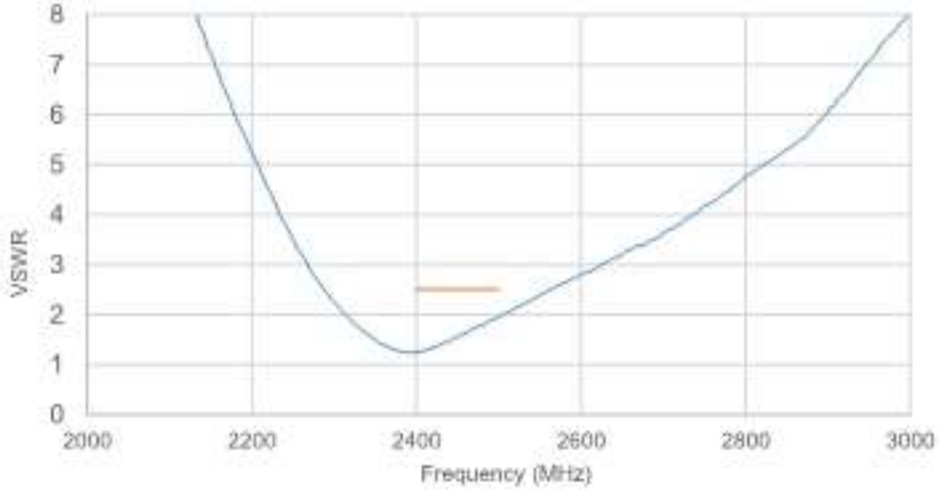
Description: 2.4-2.5GHz PCB Antenna with coax feed

Series: Internal PCB

PART NUMBER: W3525BXXX

CHARTS

VSWR

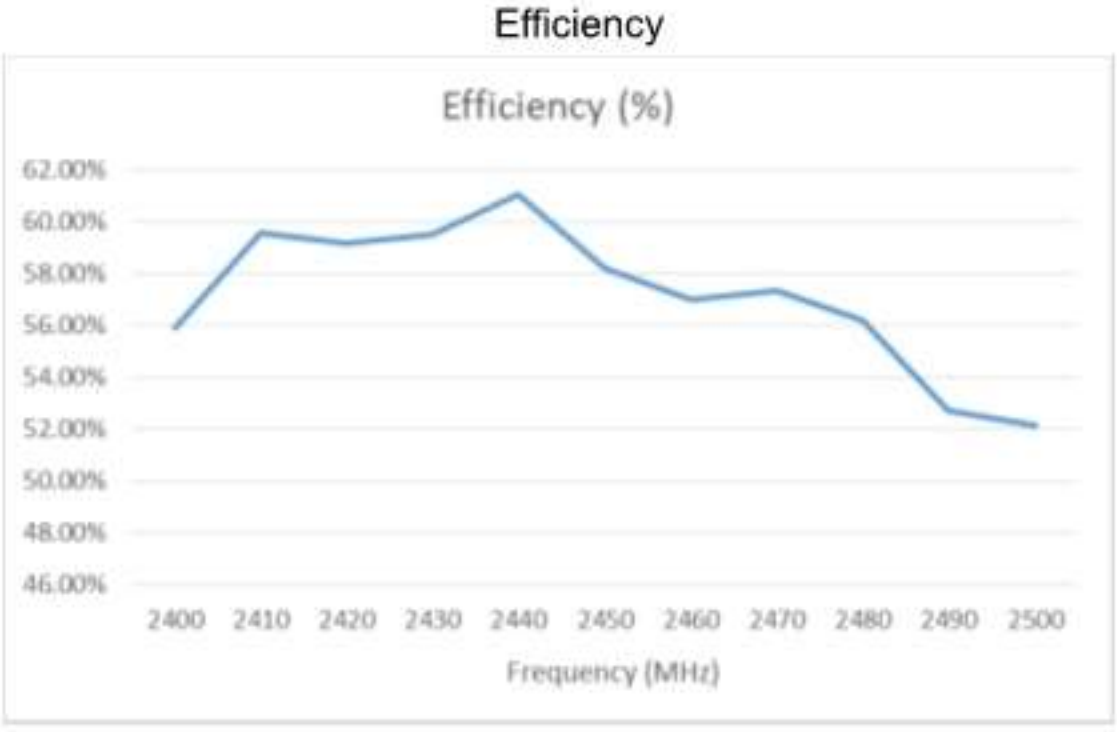


Description: 2.4-2.5GHz PCB Antenna with coax feed

Series: Internal PCB

PART NUMBER: W3525BXXX

CHARTS



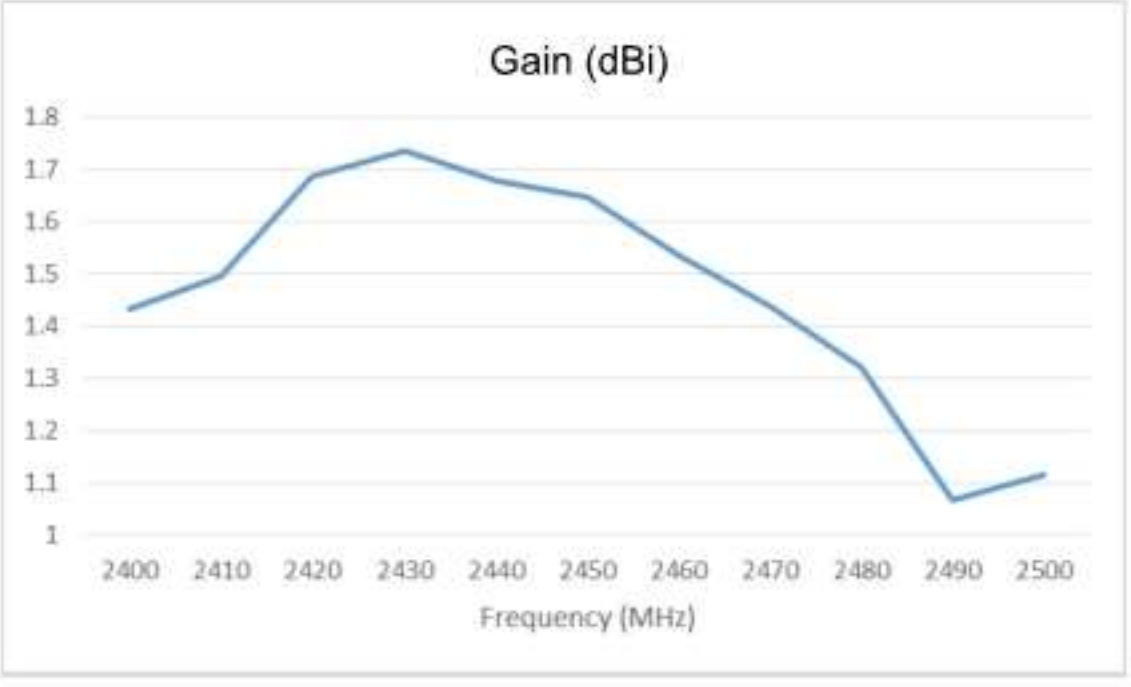
Description: 2.4-2.5GHz PCB Antenna with coax feed

Series: Internal PCB

PART NUMBER: W3525BXXX

CHARTS

Gain



Description: 2.4-2.5GHz PCB Antenna with coax feed

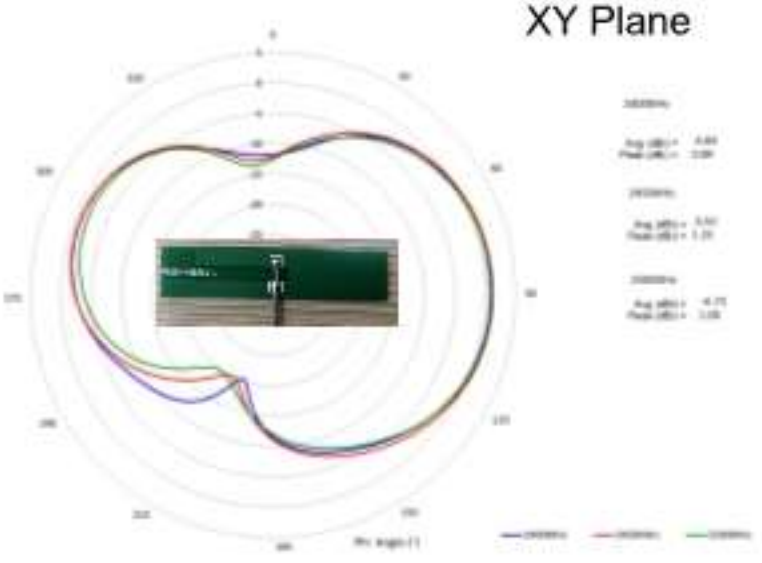
Series: Internal PCB

PART NUMBER: W3525BXXX

CHARTS

Free Space Radiation Pattern

XY Plane



Description: 2.4-2.5GHz PCB Antenna with coax feed

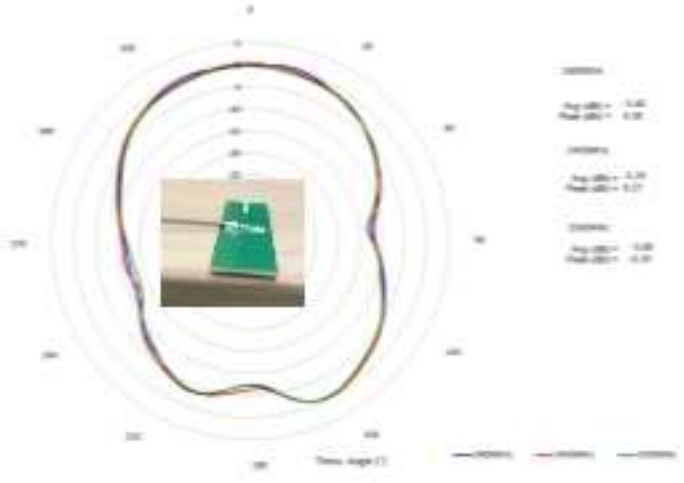
Series: Internal PCB

PART NUMBER: W3525BXXX

CHARTS

Free Space Radiation Pattern

XZ Plane



Description: 2.4-2.5GHz PCB Antenna with coax feed

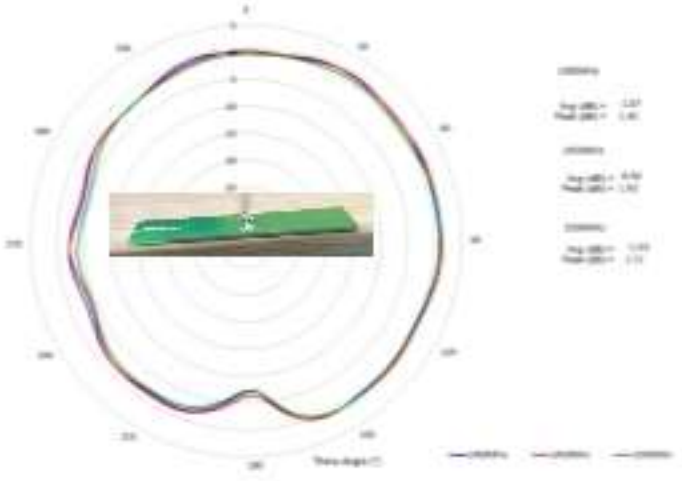
Series: Internal PCB

PART NUMBER: W3525BXXX

CHARTS

Free Space Radiation Pattern

YZ Plane



Description: 2.4-2.5GHz PCB Antenna with coax feed

Series: Internal PCB

PART NUMBER: W3525BXXX

PACKAGING

For W3525B039 and W3525B039T and W3525B052
10pcs antennas packing packed in 1 sealed bag
10pcs sealed bags (total 100pcs antennas) packed in 1 foam bag
12pcs foam bags (total 1200pcs antennas) packed in 1 carton
460x235x140mm

For W3525B100
5pcs antennas packing packed in 1 sealed bag
20pcs sealed bags (total 100pcs antennas) packed in 1 foam bag
12pcs foam bags (total 1200pcs antennas) packed in 1 carton
460x235x140mm