FlexNotch

Adhesive-Backed Flexible Notch Antenna
2400-2500 MHz

The Ezurio FlexNotch is the only adhesive-backed, flexible notch antenna that can be easily custom-trimmed for maximum range within a specific enclosure. Paired with the antenna design expertise offered by Ezurio, FlexNotch provides a simple, repeatable process for optimizing antenna tuning to deliver maximum range for your application.

Features and Benefits

- Can be installed on flat or curved surfaces
- Simple custom options with trimming length
- Quick and easy installation
- Flexible, ultra-low profile
- RoHS-compliant
- Adhesive holds to surface during humidity exposure and hot/cold cycles

Electrical Specifications	
Operating Frequency (MHz)	2400 - 2480
Peak Gain (dBi)	2.0
Average Gain (dBi)	> -1.6
VSWR	< 2.5:1
Nominal Impedance (Ohms)	50
Polarization	Linear
Azimuth Beam Width	

Mechanical Specifications	
Dimensions – mm (in.)	32.0 x 21.08 (1.26 x 0.83)
Weight – g (oz.)	0.85 (0.03)
Antenna Color	Clear yellow
Adhesive	3M 100 MP
Connector Height (max) – mm (in.)	MHF1 (U.FL): 2.5 (0.098) MHF4L: 1.4 (0.055)

Environmental Specifications	
Operating Temperature – °C (°F)	-40°C to +85°C (-40°F to +185°F)
Material Substance Compliance	RoHS Compliant

Ordering Information

Part Number	Description
001-0015	2.4 GHz FlexNotch antenna with U.FL cable, 100 mm
001-0023	2.4 GHz FlexNotch antenna with MHF4L cable, 100 mm

Mechanical Drawing

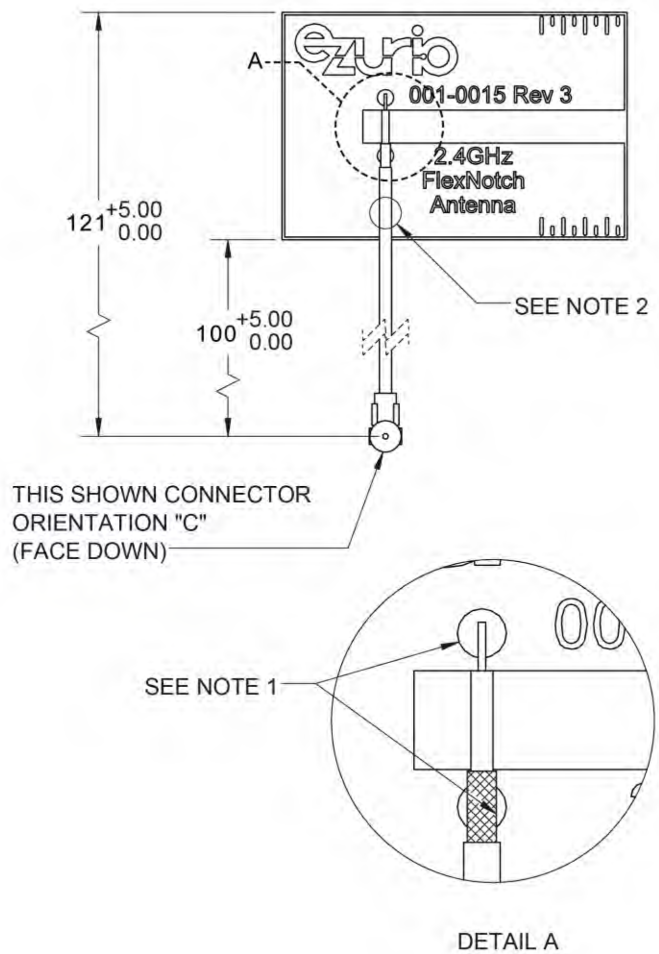


Figure 1: FlexNotch mechanical drawing

Antenna Testing

Test Setup

Antenna measurements such as VSWR were measured with an Agilent E5071C Vector Network Analyzer. Radiation patterns were measured with an Agilent 5181A Signal Generator and Agilent E4445A Spectrum Analyzer in a three-meter anechoic chamber.

Flat surface measurements were done with the antenna centered on a 1.5-millimeter thick plate of Polycarbonate.

Flat Surface Antenna Measurements

VSWR

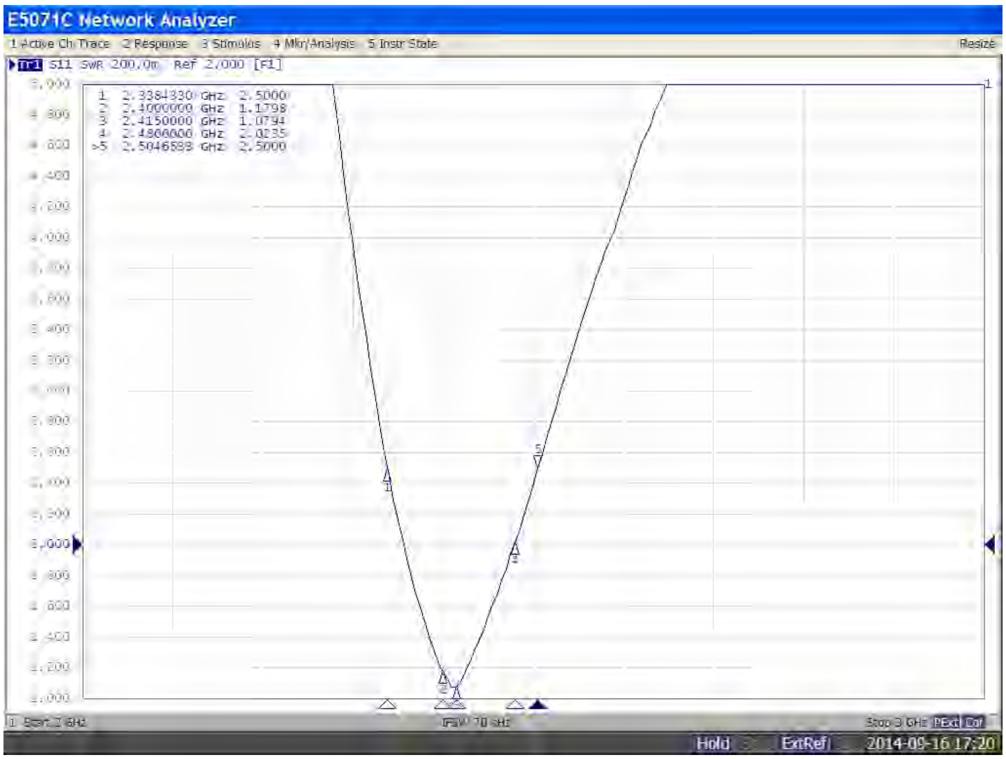


Figure 2: Antenna VSWR measured on a 1.5 mm thick plate of polycarbonate

Flat Surface Antenna Radiation Performance

FlexNotch antenna centered on a 1.5 mm thick plate of polycarbonate

Antenna Measurement Set-Up – Horizontal Orientation

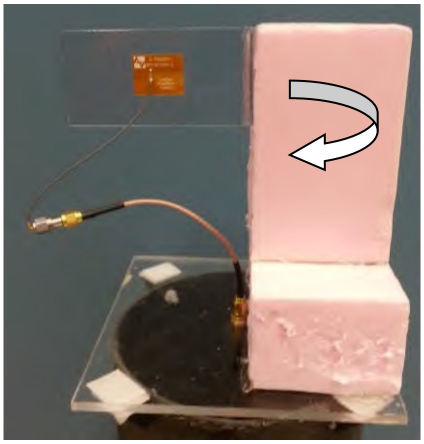


Figure 3: Horizontal orientation measurement

Horizontal Orientation at 2440 MHz

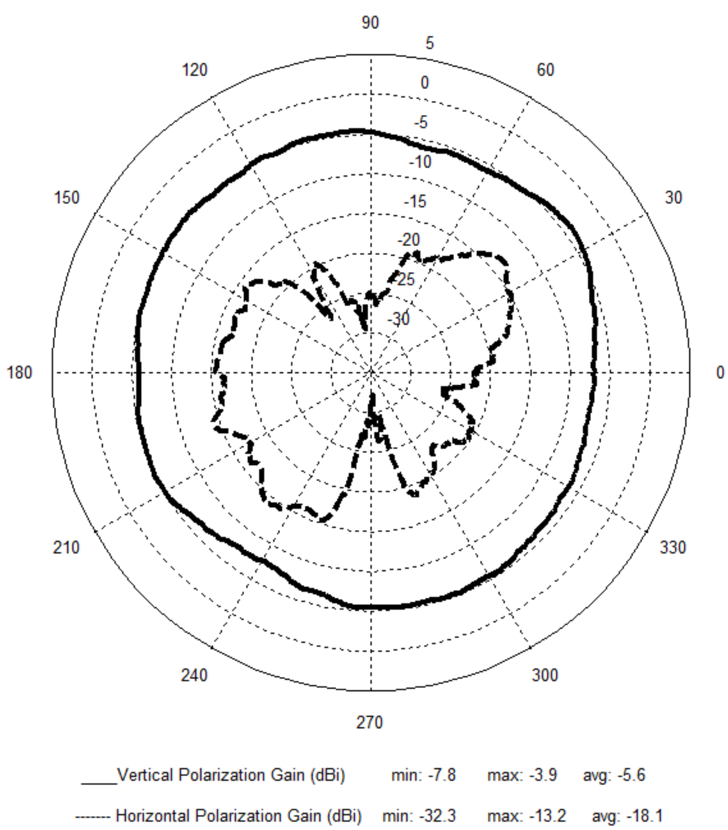


Figure 4: Horizontal orientation pattern

Antenna Measurement Set-Up – Vertical Orientation

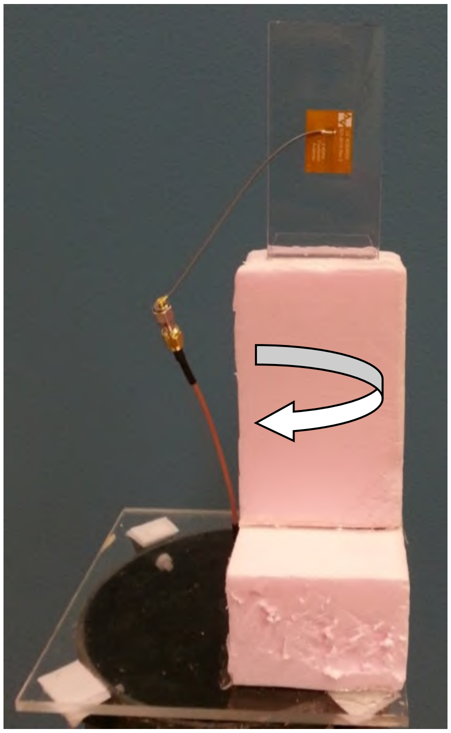


Figure 5: Vertical orientation measurement

Vertical Orientation at 2440 MHz

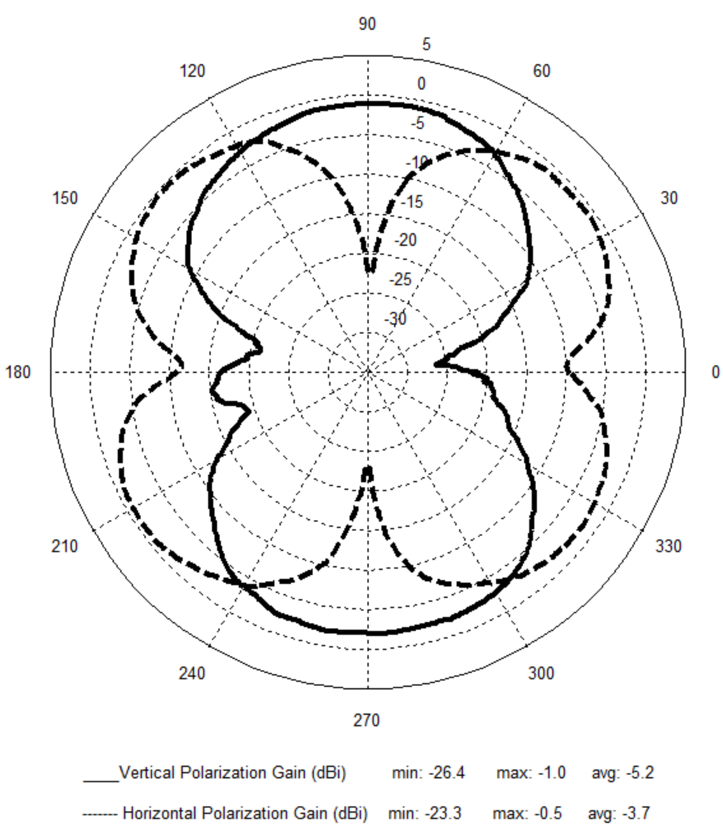


Figure 6: Vertical orientation pattern

Antenna Measurement Set-Up – Flat Orientation

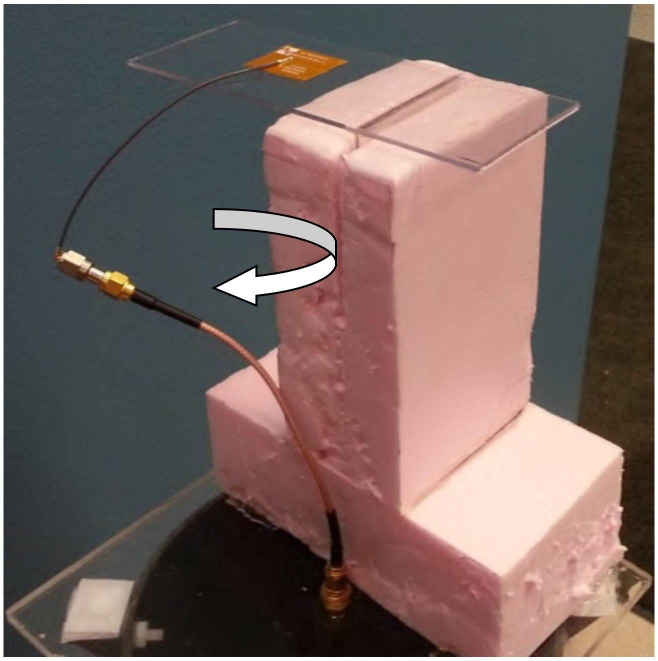


Figure 7: Flat orientation measurement

Flat Orientation at 2440 MHz

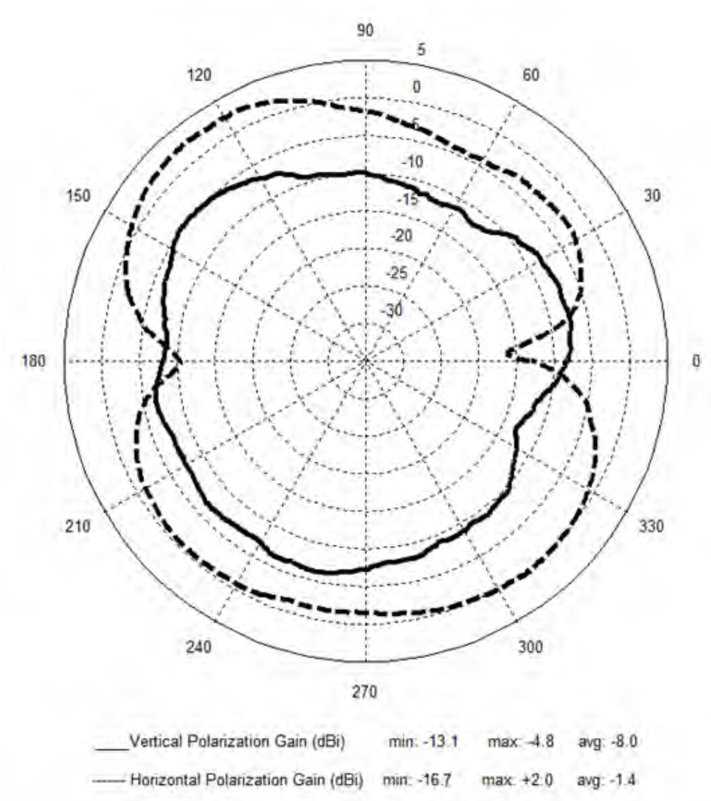


Figure 8: Flat orientation pattern

Optimal Installation Guide

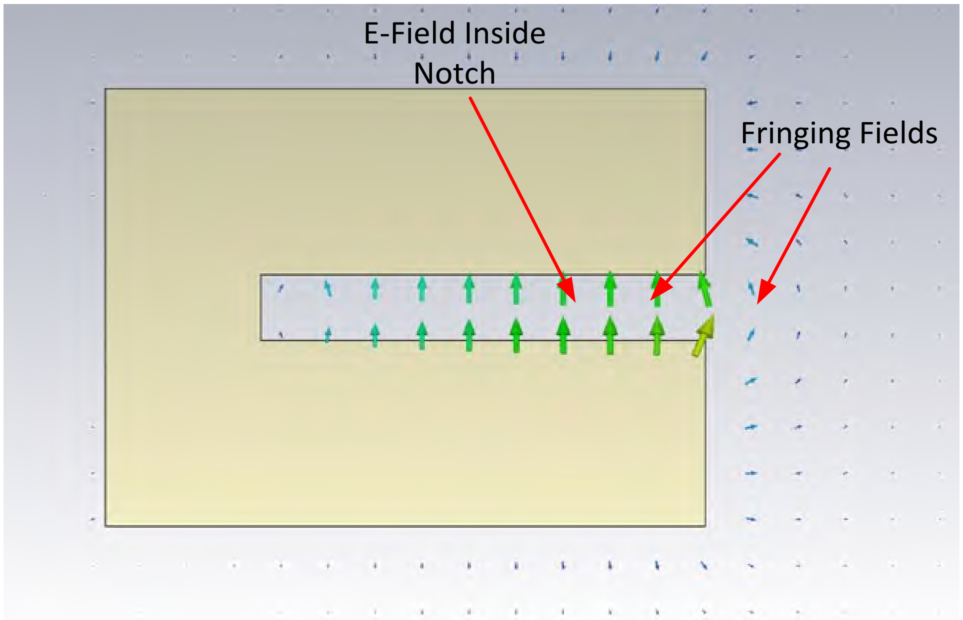


Figure 9: E-field radiation from FlexNotch; taken from CST simulation

The FlexNotch should be kept clear of any non-metal objects (such as plastics) on top of it by at least 5 mm (see Figure 10). Similarly, all four sides of the FlexNotch should be kept clear of any non-metal object by at least one millimeter (See Figures 11-14). Mounting the FlexNotch 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.

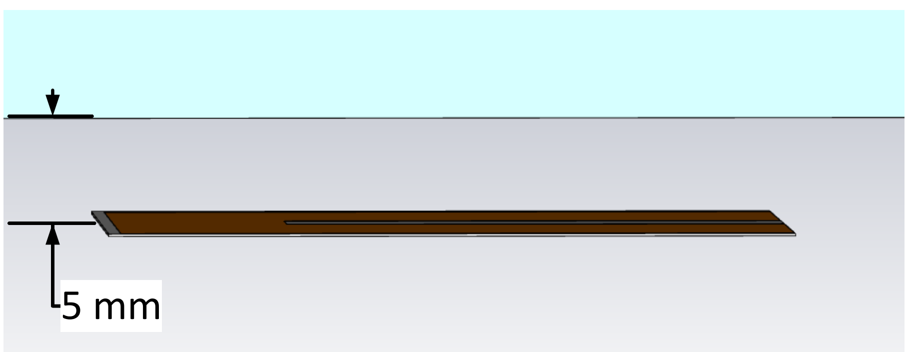


Figure 10: Above FlexNotch clearance

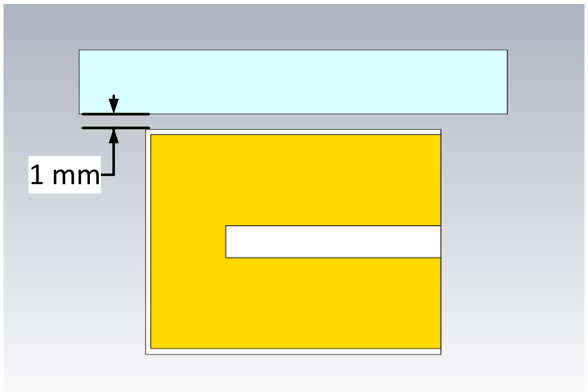


Figure 11: Top clearance

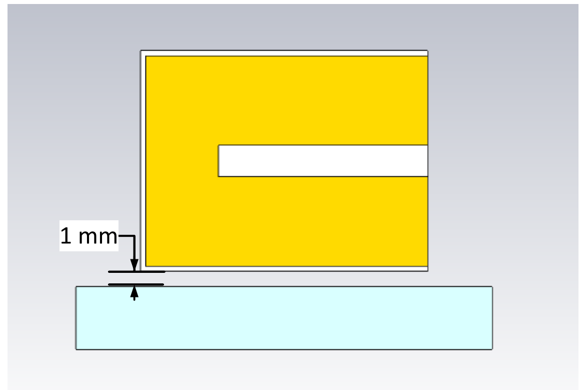


Figure 12: Bottom clearance

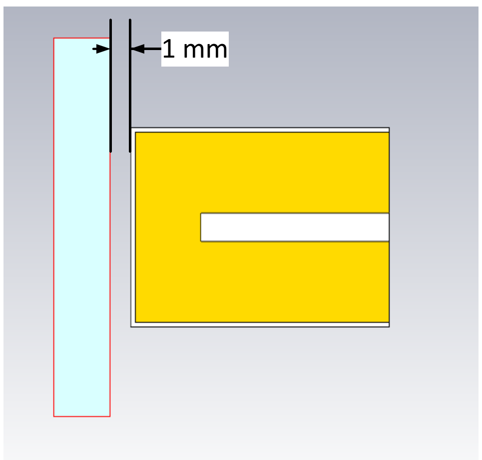


Figure 13: Left 'Cold' Side Clearance

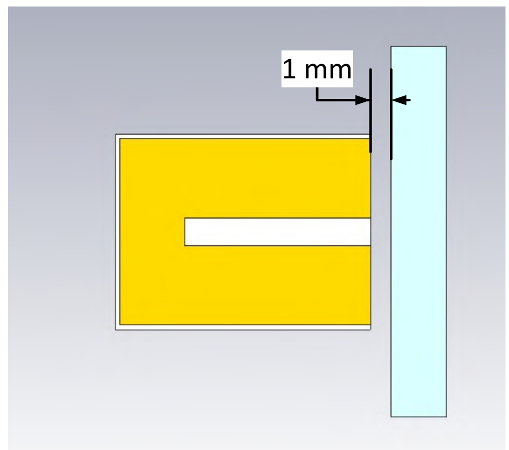


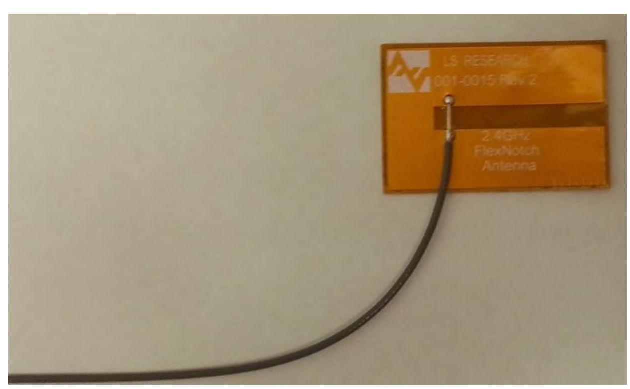
Figure 14: Open Side Clearance

The ideal material on which to mount the FlexNotch for maximum performance is 1.5-millimeter-thick polycarbonate. If the FlexNotch is mounted on a different material, the tuning will change which could cause a decrease in performance. Ezurio can retune the FlexNotch for specific implementations and different materials on request.

The coaxial cable feeding the FlexNotch should be routed away from the antenna. Do not run the coaxial cable above the FlexNotch or near the open end of the notch. The cable should be routed perpendicular to the side of the FlexNotch (this is the way the cable comes assembled), around the cold side, or away from the ground wall. All three of these options are shown in **Figures 11-14**.

Perpendicular to the side

Around the 'Cold' Side



Away from the Notch wall

Figure 15: Recommended cable routing

As with any antenna, do not place conductive materials or objects near the antenna. The radiated fields from the antenna induce currents on the conductive surface which results in those currents producing their own radiation. These re-radiating fields from the metal will interfere with the fields radiating from the FlexNotch (this is true for any antenna). Other objects, such as an LCD display, placed in close proximity 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. The following are 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

Flex Limits of the FlexNotch

One of the unique features of the FlexNotch 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 FlexNotch 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, we recommend that you contact Ezurio for assistance.

Figure 16: Convex-mounted

The FlexNotch should not be flexed in a concave position with a radius less than 16 millimeters. Similar to the restrictions on the convex position, there is potential for the adhesive to peel off over time if the FlexNotch is bent beyond a 16-millimeter radius. If a tighter radius of curvature is required, we recommend that you contact Ezurio for assistance. The FlexNotch is not designed to be twisted or crumpled. The adhesive back should lay flush with the surface on which it is mounted.

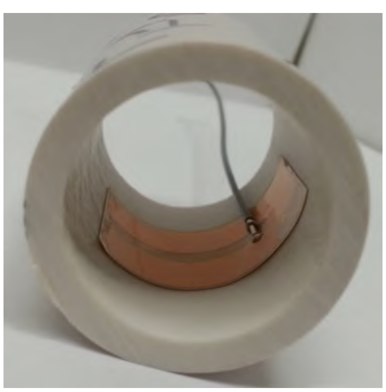


Figure 17: Concave-mounted

Mounting on Metal and Body Loaded Applications

The FlexNotch can tolerate being near conductive surfaces. A one-millimeter clearance should be observed between the top, bottom, and cold sides of the FlexNotch from any metal (see Figures 11-14). Metal should be kept away from the open end of the FlexNotch by at least 10 millimeters. However, any metal in close proximity to the open end will disrupt the radiation pattern and could cause a decrease in antenna gain.

Keep any metal above the FlexNotch away by at least 10 millimeters to prevent the antenna from detuning. However, this still causes some distortion of the radiation pattern.

Note: Do NOT mount the FlexNotch on a metal surface.

These same guidelines also apply to body worn applications.

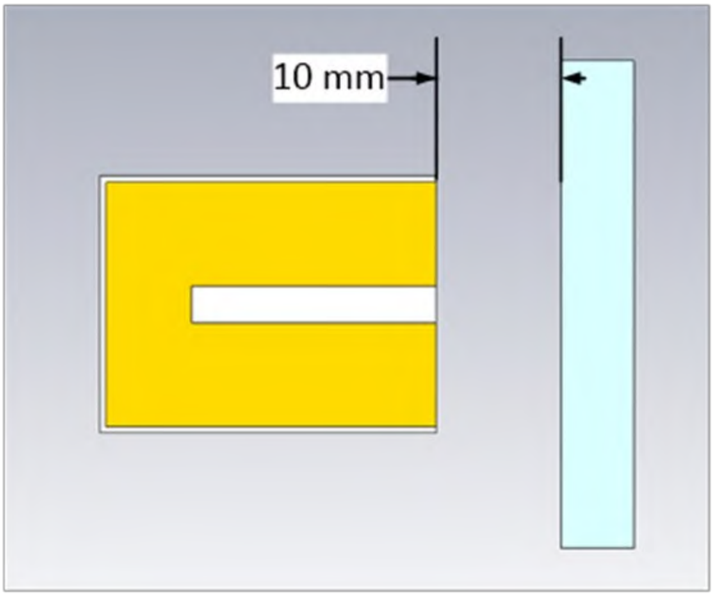


Figure 18: Open side metal clearance

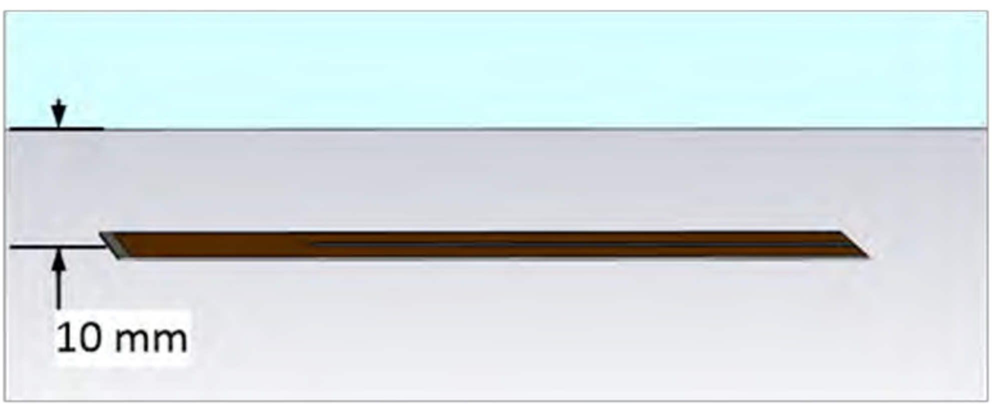


Figure 19: Above notch metal clearance

Customer-Specific Tuning

Ezurio can assist with custom tuning of the antenna for your specific end product. Simply send Ezurio a sample of your enclosure or platform and we will tune an antenna for you. We will then send the results back indicating to which trim mark the antenna should be cut to optimize performance. You then trim the antenna to the indicated hash mark and stick it to your product at the time of assembly.

Additional Information

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

Headquarters	Ezurio 50 S. Main St. Suite 1100 Akron, OH 44308 USA
Website	http://www.ezurio.com
Technical Support	http://www.ezurio.com/resources/support
Sales Contact	http://www.ezurio.com/contact

Note: Information contained in this document is subject to change.

Ezurio's products are subject to standard Terms & Conditions.

i-FlexPIFA™ Mini Series 2400-2480 MHz

Mini Inverted Flexible PIFA Antenna

Datasheet *v2.0*

1 Features and Benefits

- Quick and easy installation
- Smallest form factor i-FlexPIFA™
- Adhesive holds to surface during humidity exposure and hot/cold cycles
- RoHS-compliant
- Radiation direction maximized on adhesive side for outward-facing orientation
- Patent Number: 9450307

- Can be installed in the following ways:
  - On different non-conductive surfaces and thicknesses
  - On flat or curved surfaces
  - MIMO array element
  - On the front or top face of an enclosure interior (alternative placement to FlexPIFA)

Specifications	
Frequency (MHz)	2400 - 2480
Peak Gain (dBi)	+2.0
Average Efficiency (dB)	> -2.5
VSWR (MHz)	< 2.5:1
Impedance (Ω)	50
Polarization	Linear

Mechanical Specifications		
Antenna Type	Inverted Ground Flexible Planar Inverted F Antenna (i-FlexPIFA)	
Dimensions – mm (inches)	35.9 x 11.0 x 2.9 (1.41 x 0.43 x 0.114)	
Weight – g (oz.)	1.10 (0.039)	
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

2 Configuration

Part Number	Cable Length	Connector
EFG2401A3S-10MHF1	100 mm	MHF1
EFG2401A3S-10MH4L	100 mm	MHF4L

Note: Specifications are based on the 100mm cable length, standard antenna version with MHF1 / U.FL connector. Varying the cable length or type or connector will cause variations in these antenna specifications.

3 Mechanical Drawing

3.1 Physical Dimensions (in mm) of the EFG2401A with a 100mm Long Cable

Figure 1: i-FlexPIFA$_{mini}$ mechanical drawing of EFG2401A Antenna

4 Flat Surface Antenna Measurements

Flat surface measurements were performed with the antenna centered on a 1.6 mm-thick plate of polycarbonate.

4.1 VSWR

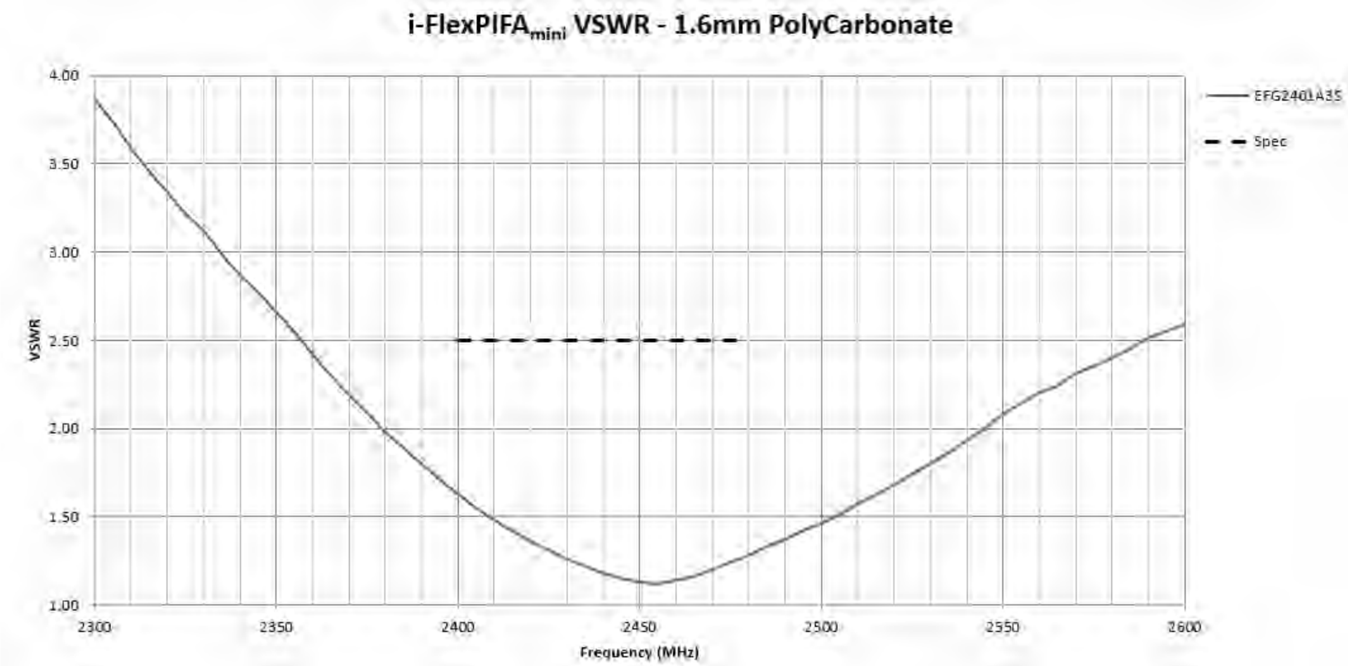


Figure 2: Antenna VSWR measured on a 1.6 mm-thick plate of polycarbonate with a nominal value of 1.27 across the operating frequency

4.2 RETURN LOSS

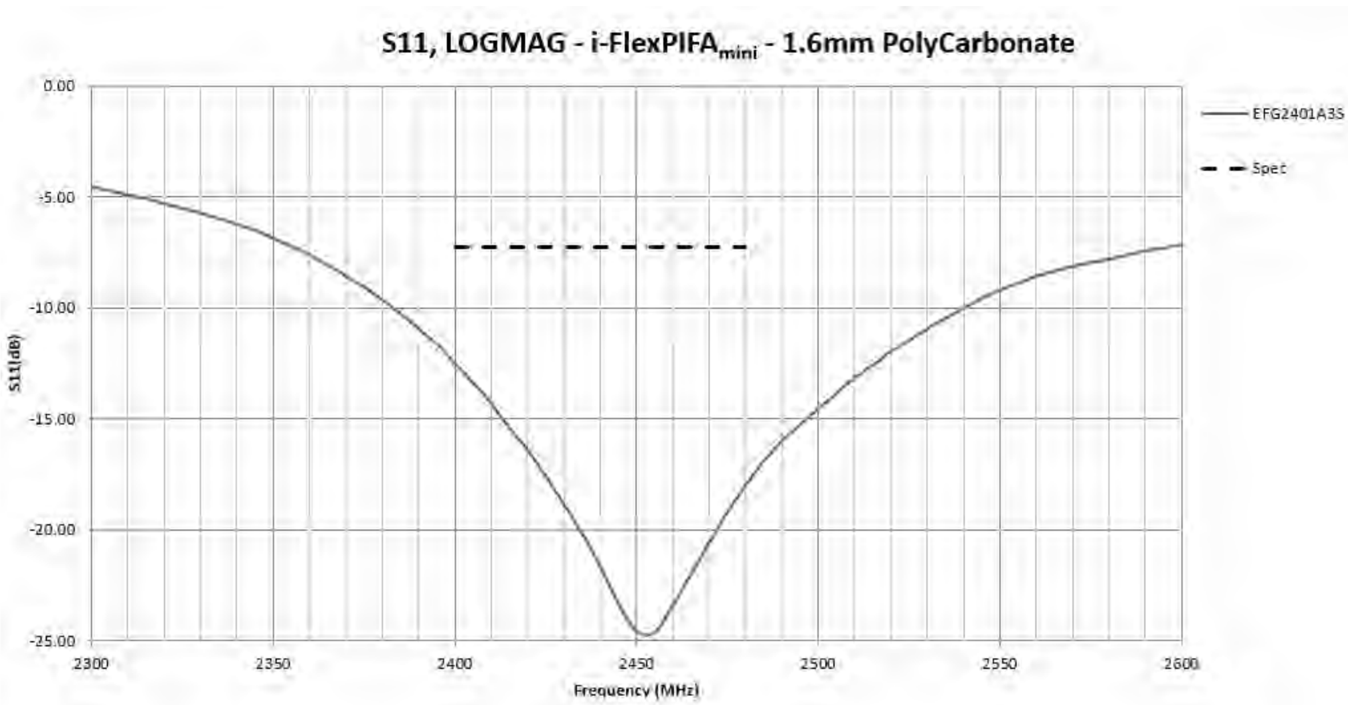


Figure 3: Antenna Return Loss measured on a 1.6 mm-thick plate of polycarbonate with a nominal value of -17.6dB across the operating frequency

5 Antenna Chamber Test Setup

Antenna measurements such as VSWR and S11 were measured with an Agilent E5071C vector network analyzer. Radiation patterns were measured with a Rohde & Schwarz ZNB8-4PORT vector network analyzer in a Howland Company 3100 chamber equivalent. Phase center is nine inches above the Phi positioner.

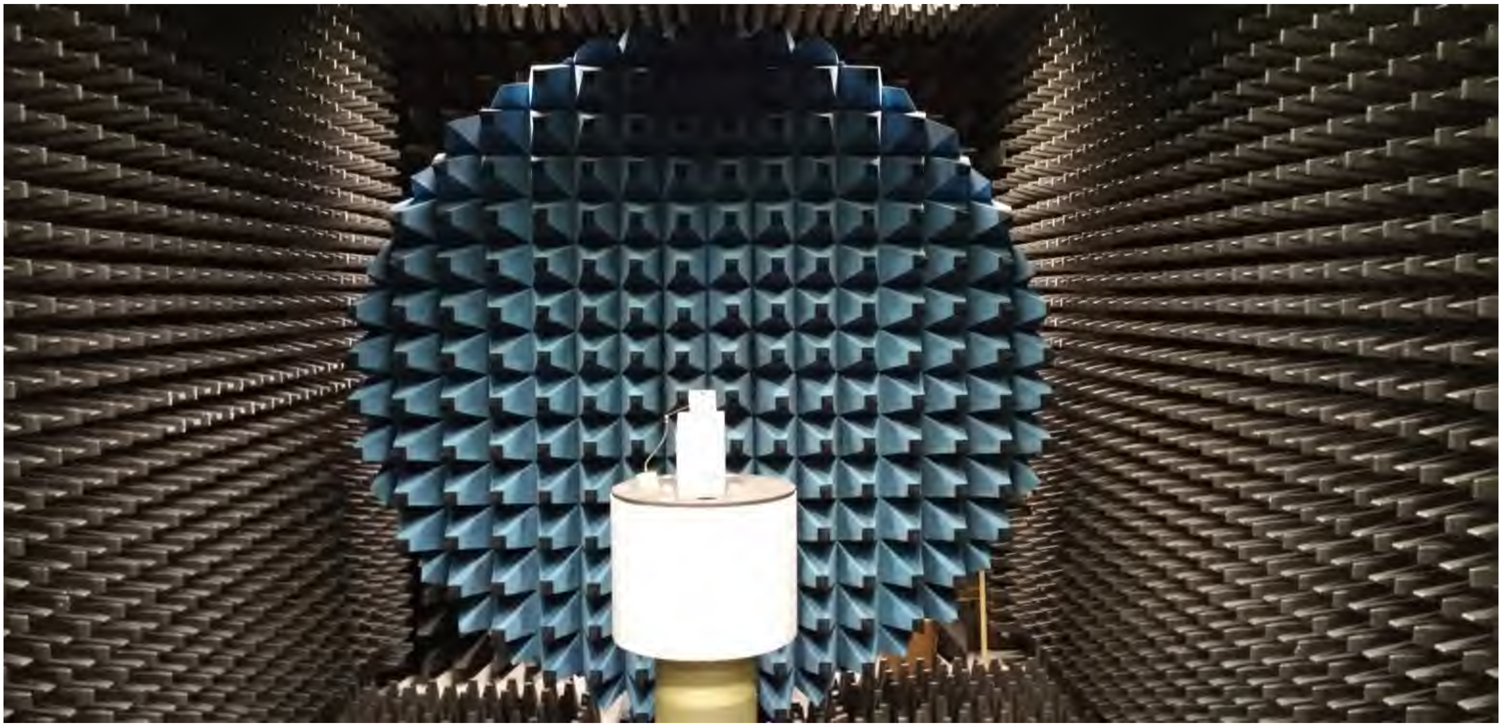


Figure 4: Howland Company 3100 Antenna chamber

6 Antenna Radiation Performance

6.1 FlexPIFA centered on a 1.6 mm-thick plate of polycarbonate

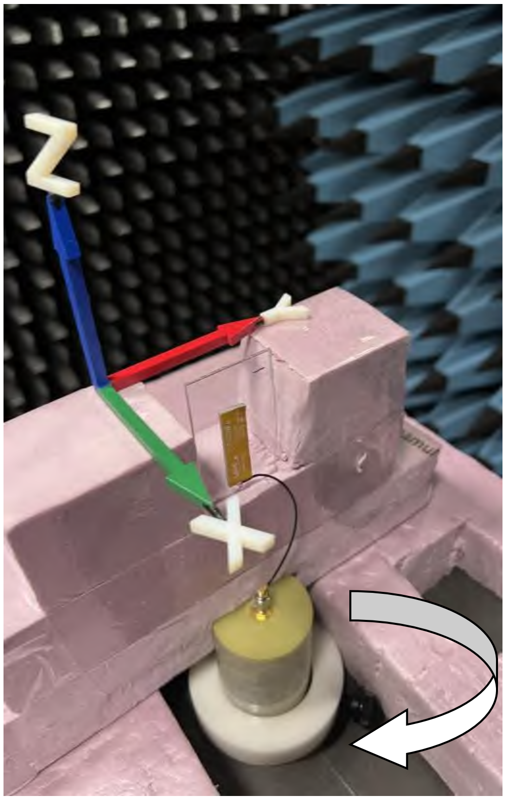
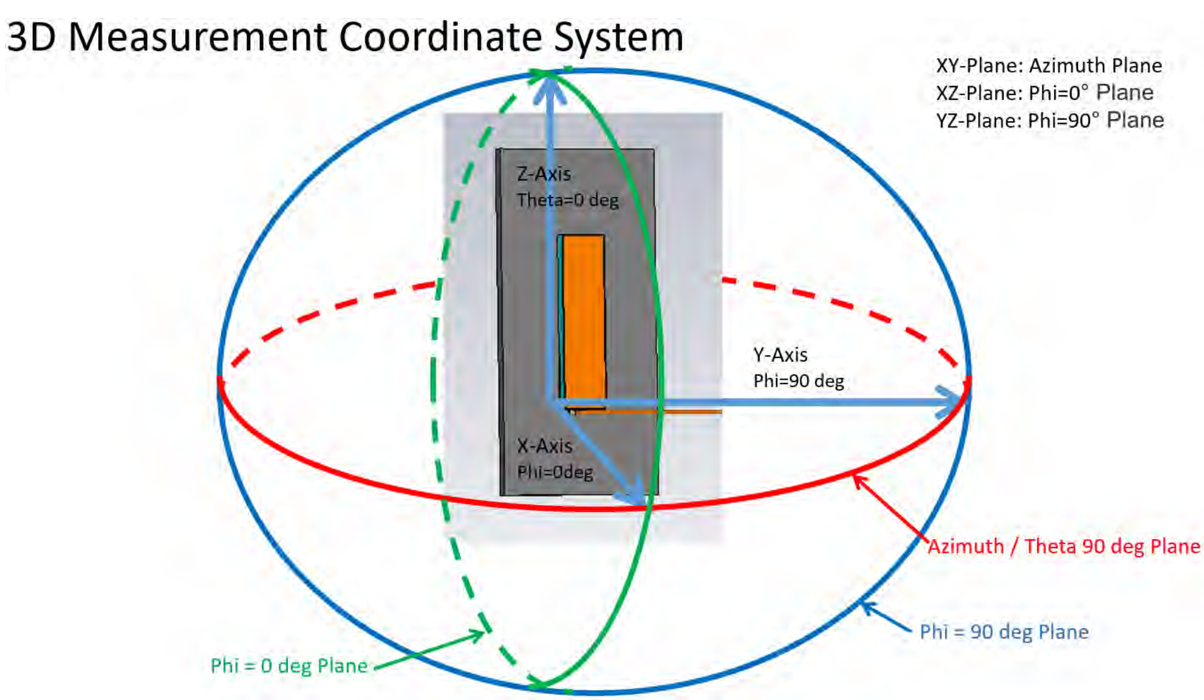
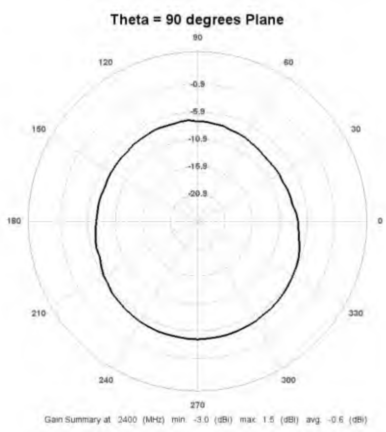


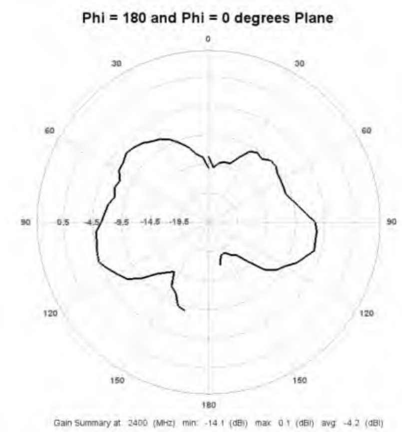
Figure 5: Flat surface setup

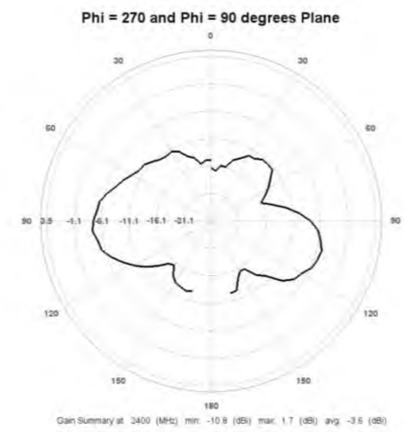


6.2 Radiation Patterns – 2D Plots

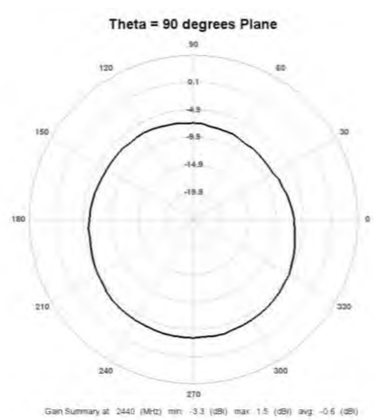
6.2.1 2D Plots at 2400 MHz

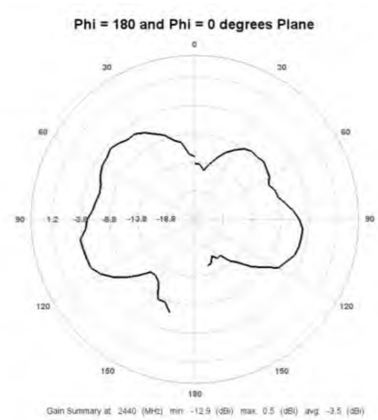


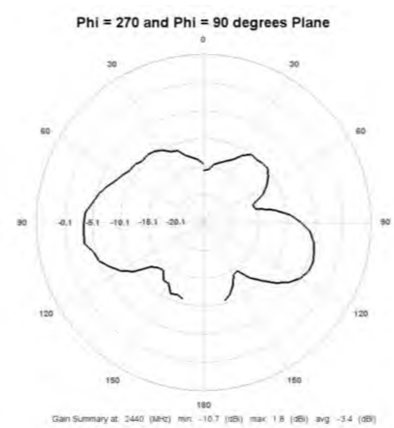




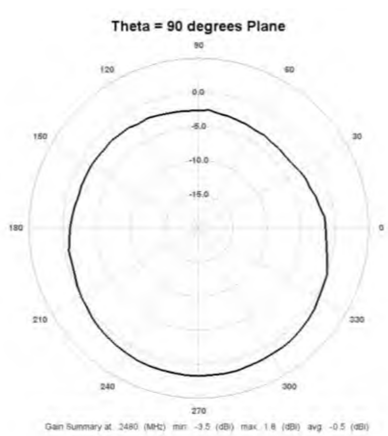
6.2.2 2D Plots at 2440 MHz

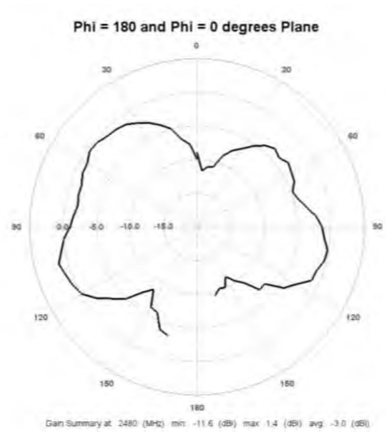


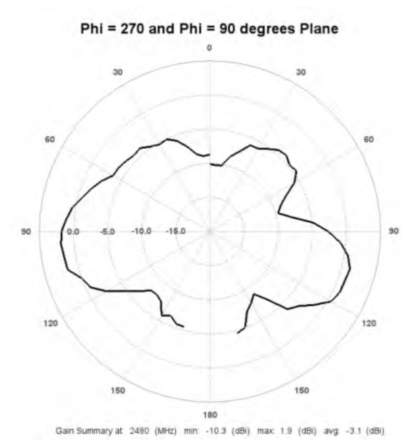




6.2.3 2D Plots at 2480 MHz







6.3 Radiation Patterns – 3D Plots

6.3.1 3D Plots at 2400 MHz

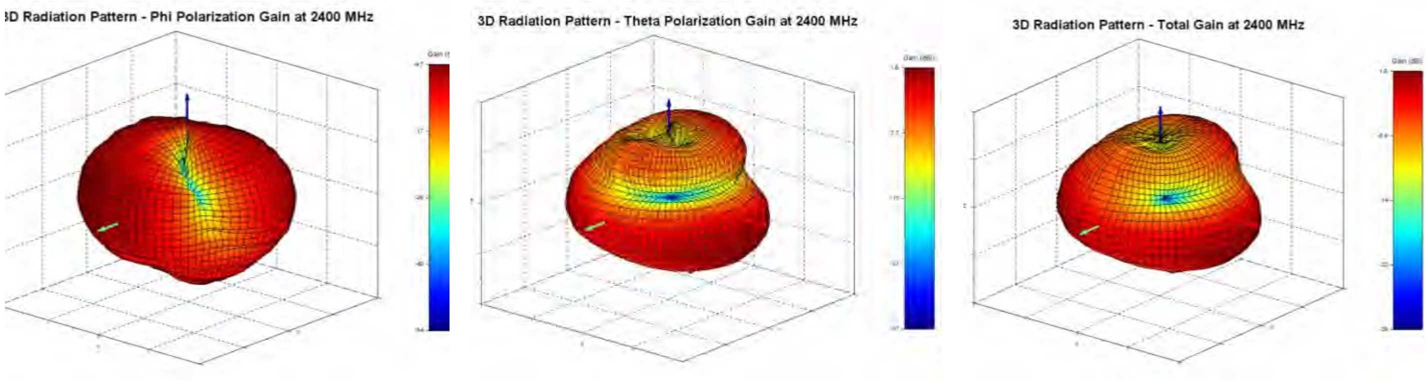


Figure 6: Phi polarization, Theta polarization and, and total gain plots – 2400 MHz

6.3.2 3D Plots at 2440 MHz

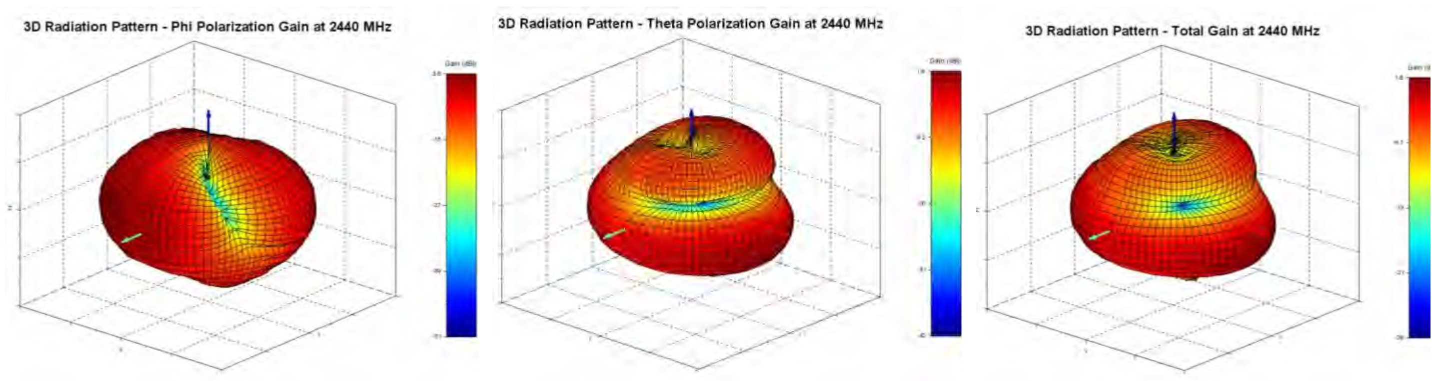


Figure 7: Phi polarization, Theta polarization and, and total gain plots – 2440 MHz

6.3.3 3D Plots at 2480 MHz

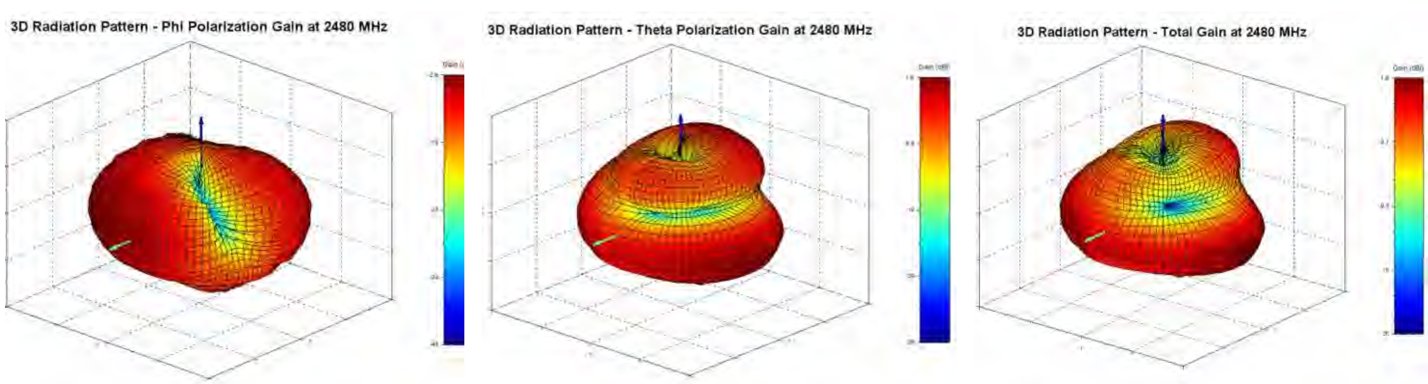


Figure 8: Phi polarization, Theta polarization and, and total gain plots – 2480 MHz

6.4 Efficiency

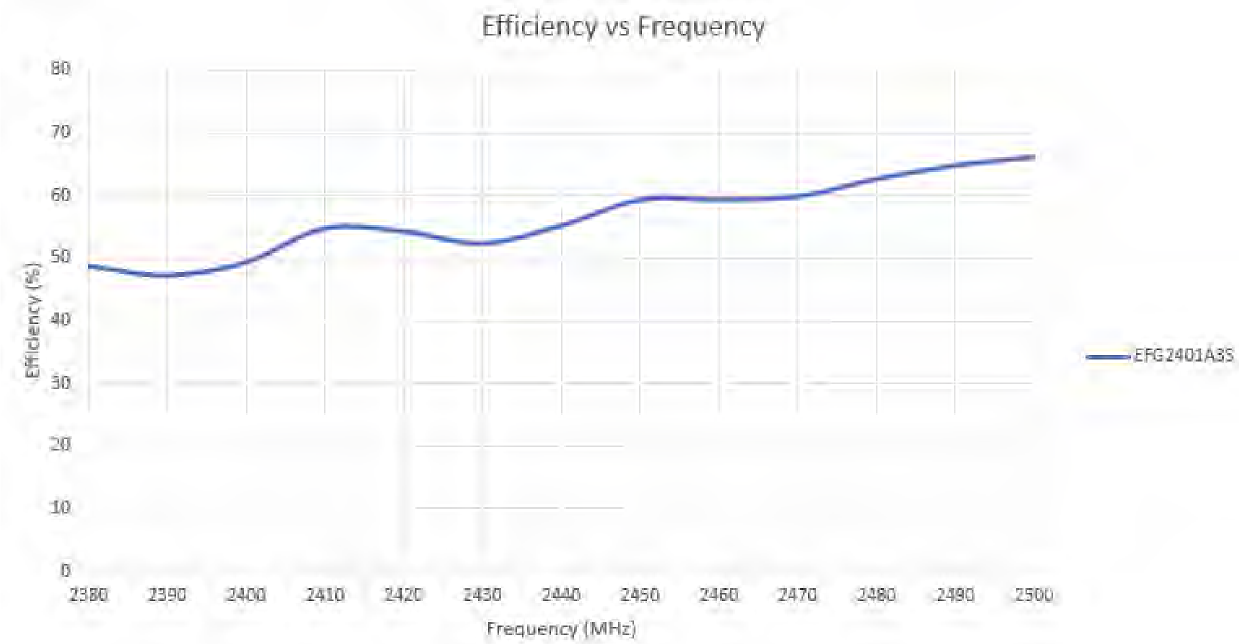


Figure 9: Antenna Efficiency measured on a 1.6 mm-thick plate of polycarbonate with a nominal value of -2.5dB across the operating frequency

6.5 Antenna Gain

Total Gain vs. Frequency (as per IEEE definition)

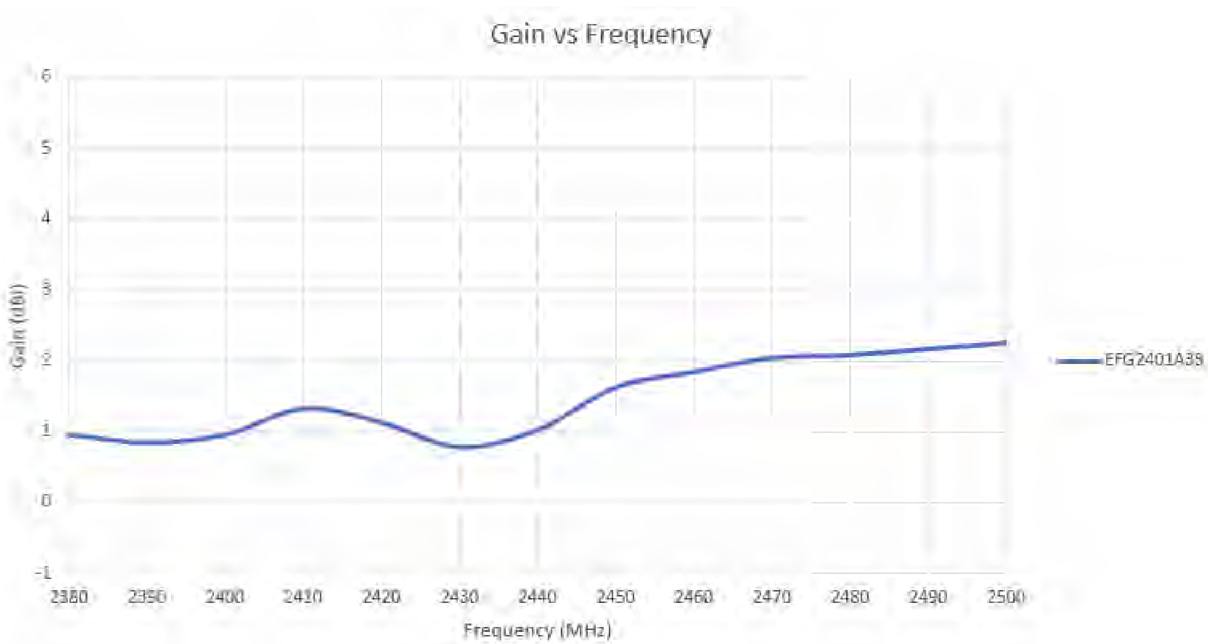


Figure 10: Antenna Gain measured on a 1.6 mm-thick plate of polycarbonate with a nominal value of 1.4dBi across the operating frequency

Peak Gain from Theta and Phi Polarization vs. Frequency

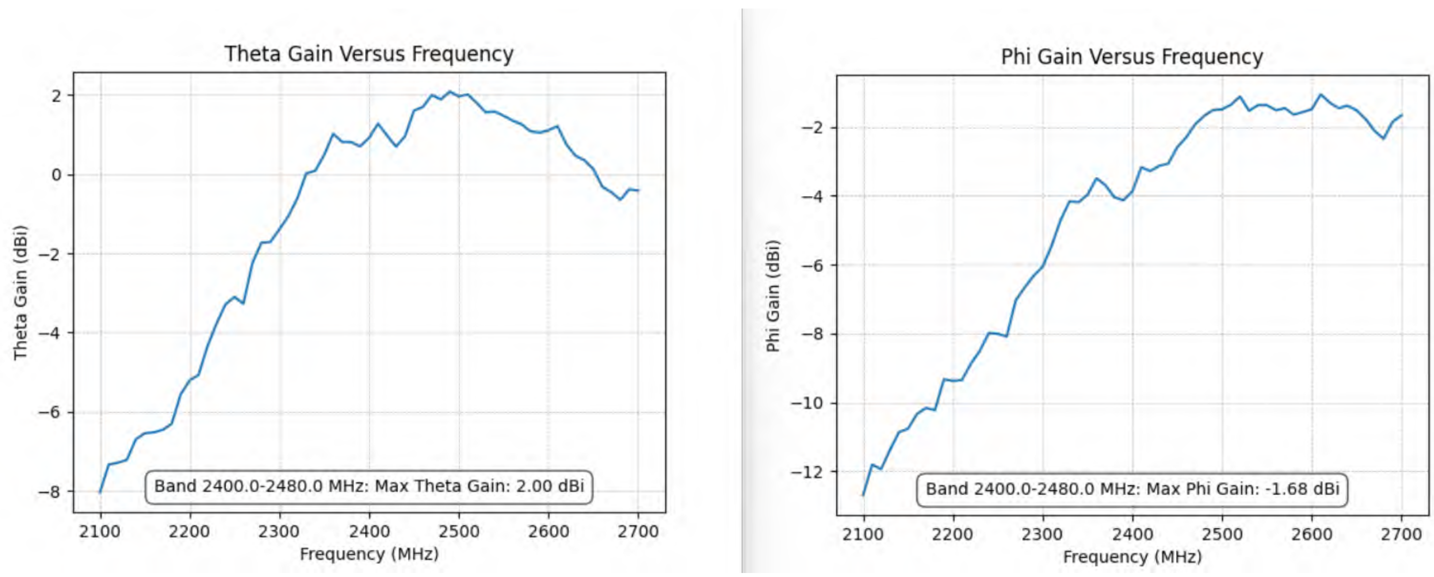


Figure 11: Peak Theta Polarization Gain and Phi Polarization Gain vs Frequency, measured on a 1.6mm-thick plate of polycarbonate

7 Antenna Placement & Keep Out Region

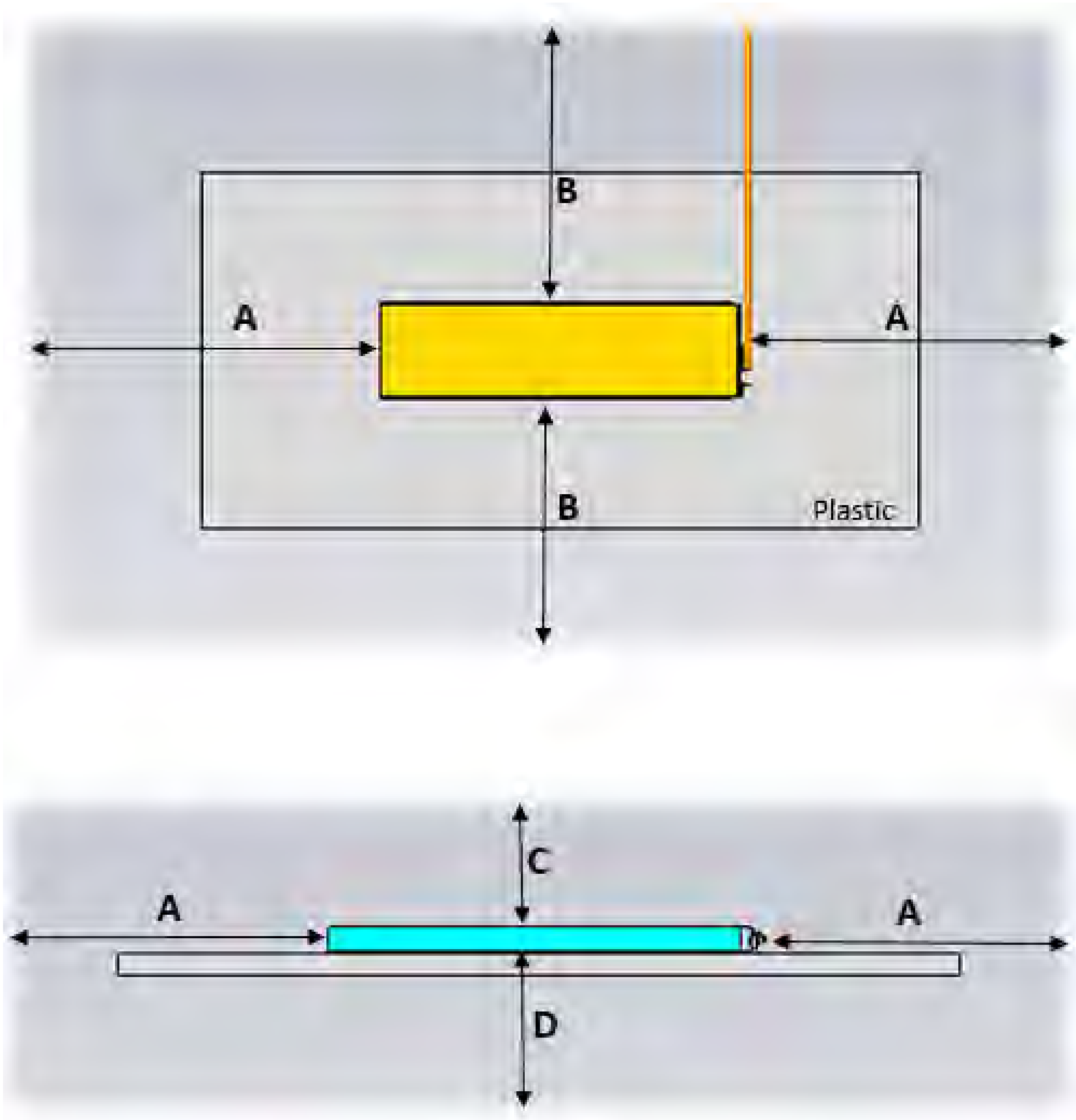
7.1 Antenna Placement

The i-FlexPIFA is designed to be attached to dielectric surfaces encountered in plastic packaging of wireless communications devices. The nominal attachment surface used in its design and characterization is an 80 mm x 40 mm, 1.6-millimeter thick, Polycarbonate sheet.

The VSWR of the i-FlexPIFA$_{mini}$ is shown below for the following materials and thicknesses **outside** of these specifications:

Material	Thickness (mm)	Max VSWR
[illegible]	1.0	[illegible]
[illegible]	3.0	1.9
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
ABS	1.6	1.6
ABS	3.8	1.9
Nylon	1.6	1.4
Nylon	3.2	2.4
Acrylic	1.5	1.7
Acrylic	3.0	2.5
Delrin	1.6	1.6
Delrin	3.2	2.4
PBT	0.8	1.6
PBT	1.6	2.5
PETG	1.4	1.6
PETG	2.8	2.1
Polypropylene	1.6	2.4
Polypropylene	3.2	1.5
Polyetherimide	1.6	1.6
Polyetherimide	3.8	2.5
PVC Tube 0.060in [illegible]	4.5	2.6
PVC Tube ID 50mm	4.5	1.5

7.2 Antenna Conductive Material Keep Out Region



Keep Out Region Distance (mm)			
A	B	C	D
5	5	3	10

Notes:

- Antenna is designed to be mounted on polycarbonate with a nominal thickness of 2.25mm (1.5mm - 3mm)
- Diagram is not to scale

8 Product Labeling History

Rev 2.0 - Initial Production Release

9 Revision History

Version	Date	Notes	Approver
0.1	16 Nov 2023	Preliminary Release	Adam Engelbrecht
1.0	8 Apr 2024	Initial Release	Adam Engelbrecht
2.0	14 Aug 2024	Ezurio rebranding	Dave Drogowski

10 Additional Information

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

Headquarters	Ezurio 50 S. Main St. Suite 1100 Akron, OH 44308 USA
Website	http://www.ezurio.com
Technical Support	http://www.ezurio.com/resources/support
Sales Contact	http://www.ezurio.com/contact

Note: Information contained in this document is subject to change.

The evolution of technology has brought the need to communicate everywhere and at all times without being confined to one space. Our antennas feature wide bandwidth to enhance the performance and application of portable wireless devices based on standards such as 802.11 and Bluetooth®. The antennas are specifically designed to be embedded inside devices for aesthetically pleasing integration with high durability.

Features and Benefits

- Versatile, easy-to-use for 2.4 to 2.5 GHz Bluetooth® and IEEE 802.11 devices
- Designed for an easy connection to radio cards
- Has a ground plane incorporated into the resonator structure – no additional ground plane is required to radiate efficiently
- Uses patented PCB Microsphere technology

Electrical Specifications	
Operating Frequency (MHz)	2.4 – 2.5 GHz
VSWR – Max	<2.5:1
Peak Gain - Max (dBi)	2
Nominal Impedance (Ohms)	50
Polarization	Linear

Mechanical Specifications	
Dimensions – mm (in.)	44.45 x 12.7 x 0.81 mm (1.75 x 0.5 x 0.032 in.)
Weight – g (oz.)	2 g (0.071 oz.)

CONFIGURATION

Part Number	Cable Length	Connector
MAF94045	100 mm, Ø 1.13 mm	IPEX MHF
MAF94102	100 mm, RG178	Flying Lead
MAF95096	100 mm, RG178	Right Angle MMCX
EBL2400A1-10MH4L	100 mm, Ø 1.13 mm	MHF4
EBL2400R1-20MHF4	200 mm, Ø 1.13 mm	MHF4

Note: Specifications are based on the 100mm cable length, standard antenna version with MHF1 / U.FL connector. Varying the cable length or type or connector will cause variations in these antenna specifications.

Ezurio's products are subject to standard Terms & Conditions.

Flat Surface Antenna Measurements

Flat surface measurements were performed with the antenna in free space.

VSWR

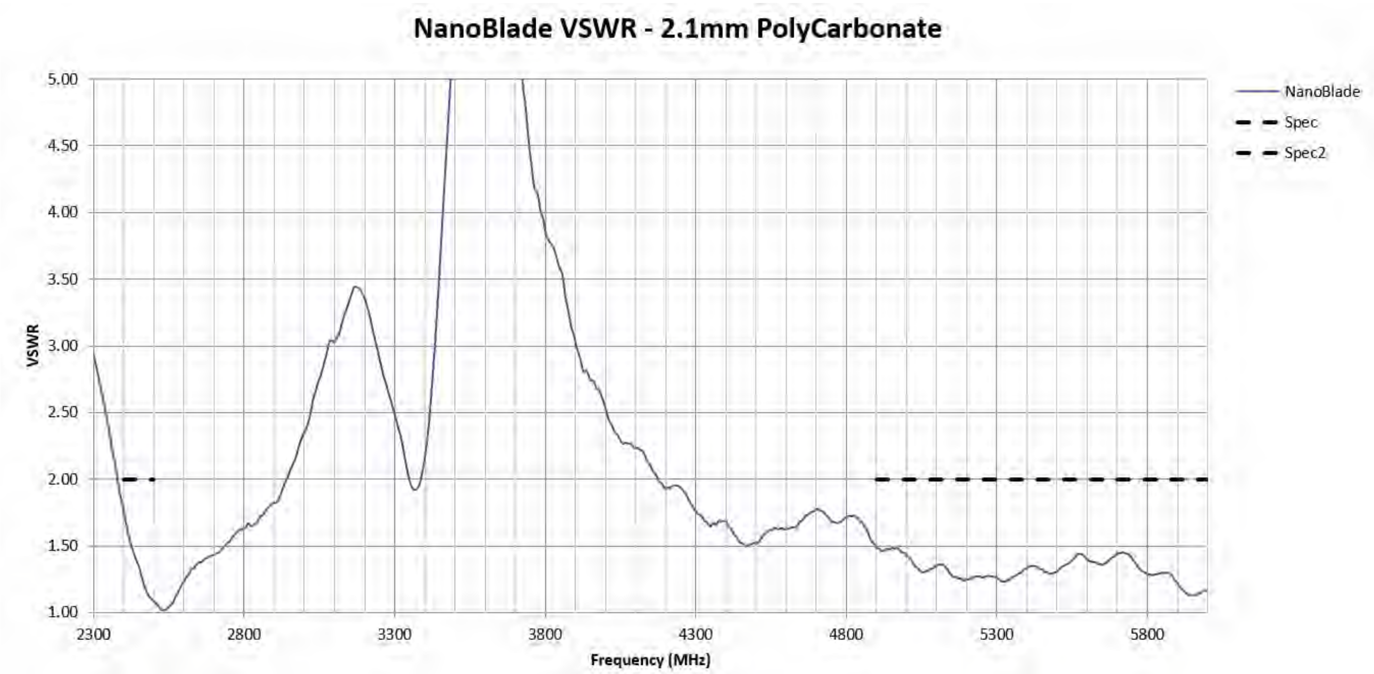


Figure 1: Antenna VSWR measured in *free space*

RETURN LOSS

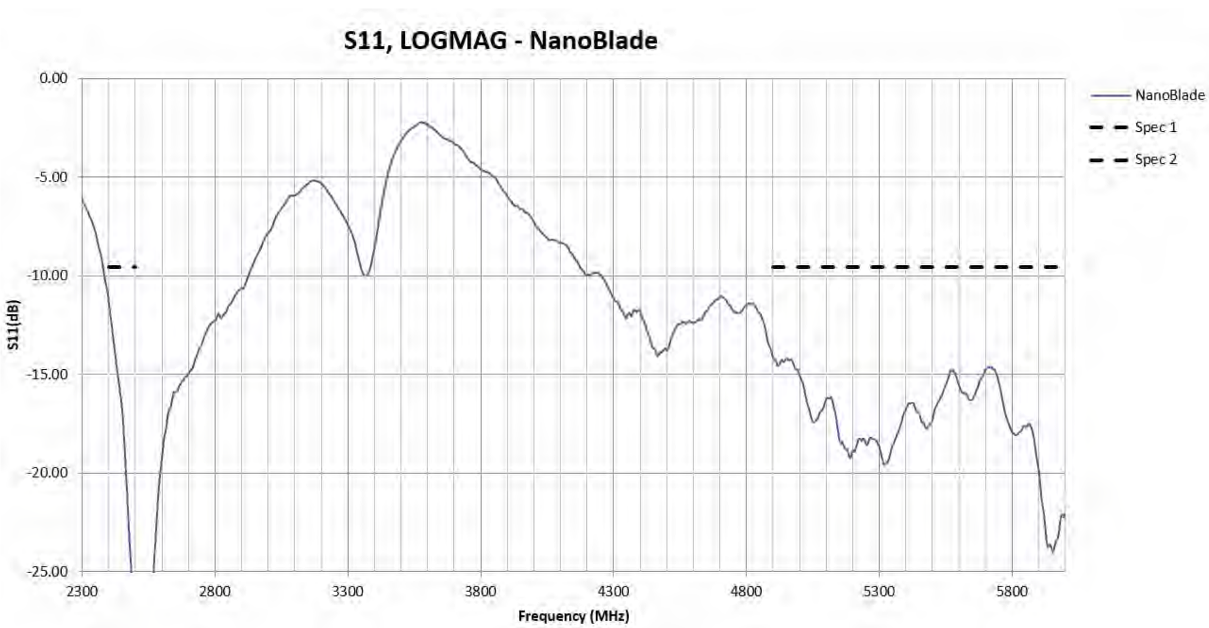


Figure 2: Antenna Return Loss measured in free space

Antenna Chamber Test Setup

Antenna measurements such as VSWR and S11 were measured with an Agilent E5071C vector network analyzer. Radiation patterns were measured with a Rohde & Schwarz ZNB8-4PORT vector network analyzer in a Howland Company 3100 chamber equivalent. Phase center is nine inches above the Phi positioner.

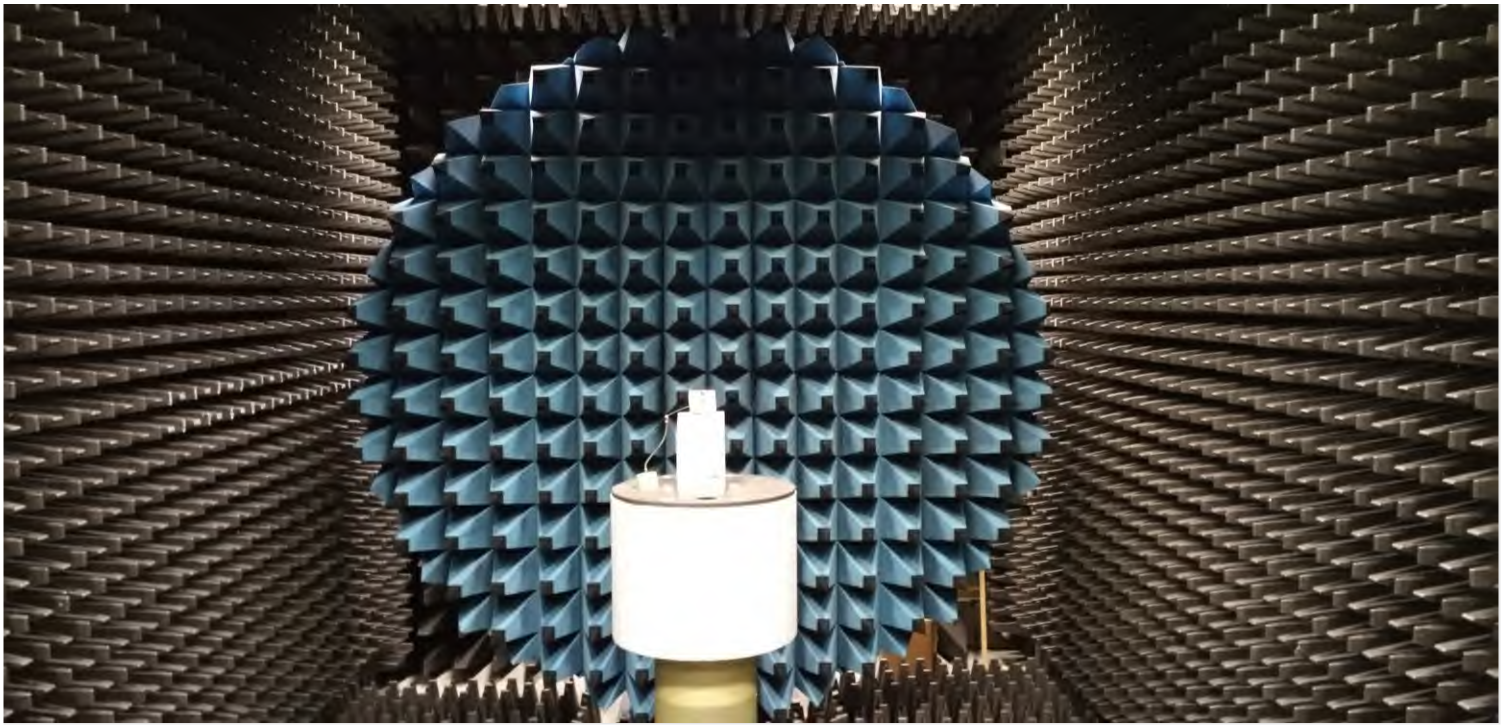


Figure 3: Howland Company 3100 Antenna chamber

Antenna Radiation Performance

NanoBlue centered in free space or on polycarbonate

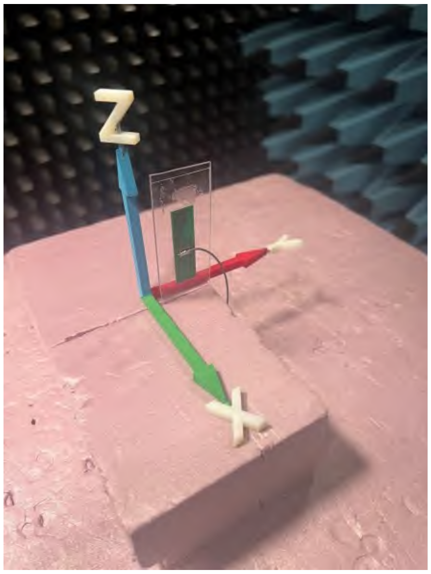
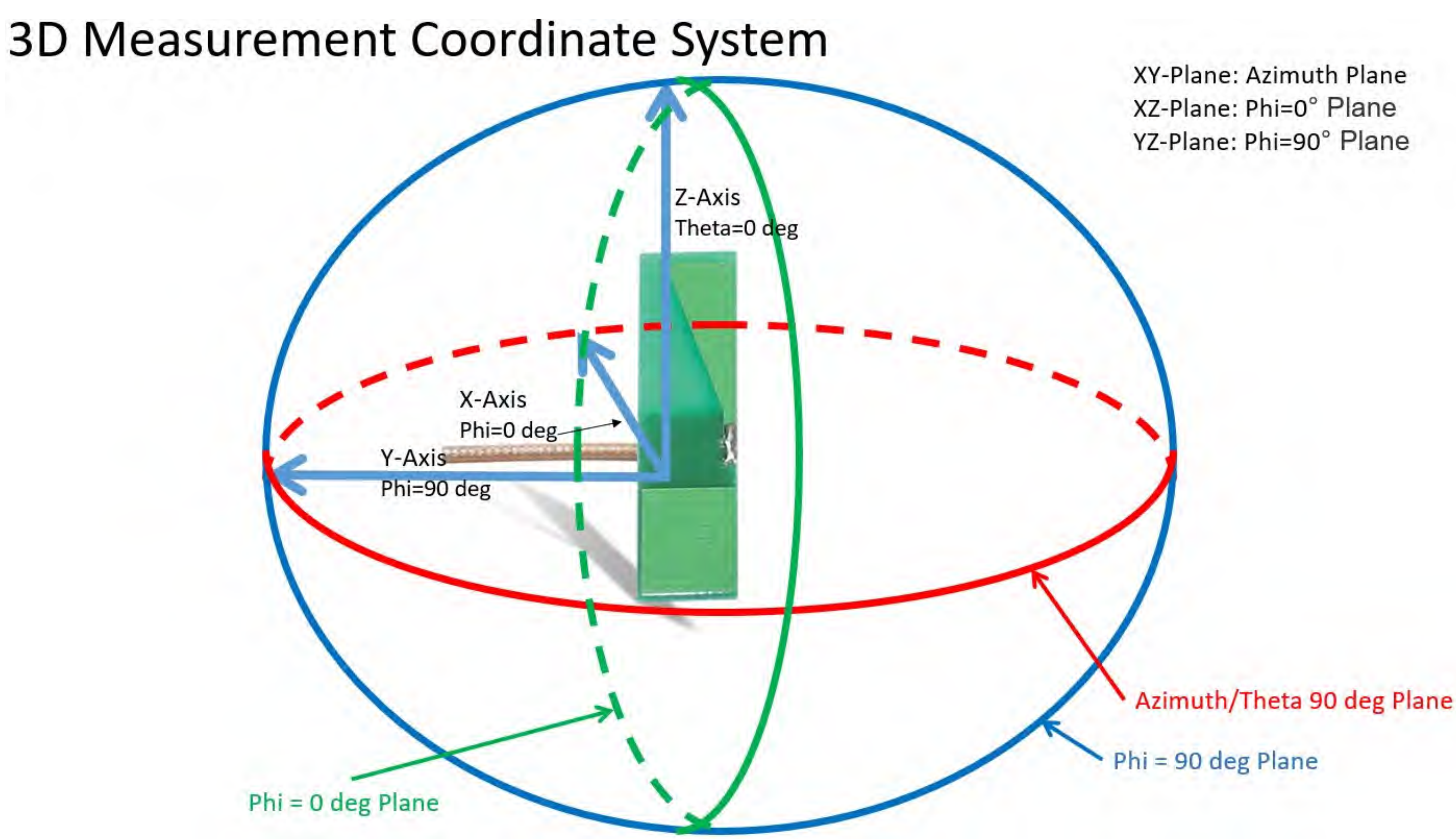
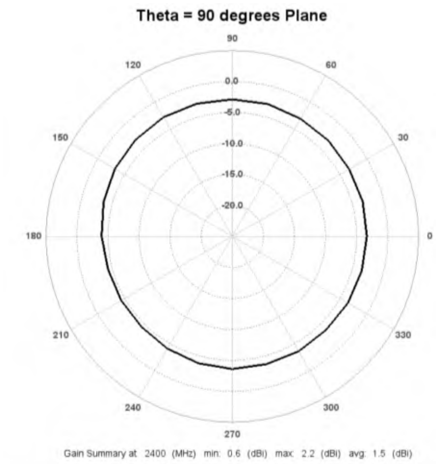


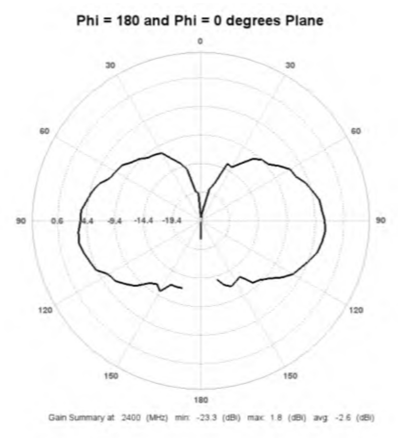
Figure 4: Flat surface setup

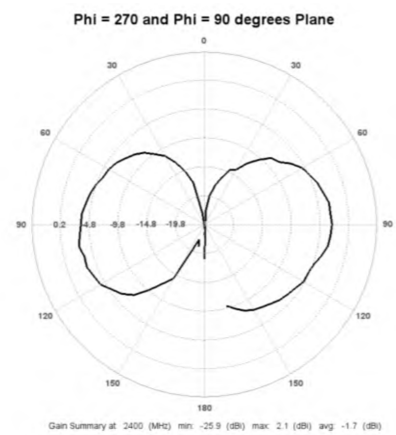


RADIATION PATTERNS – 2D Plots

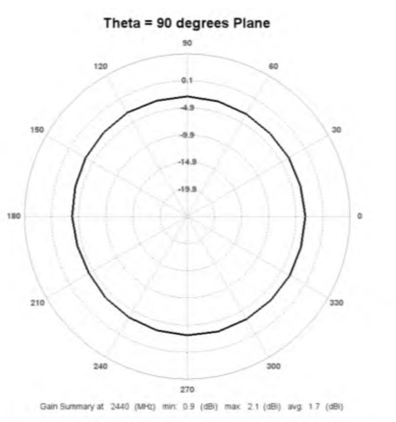
2D Plots at 2400 MHz

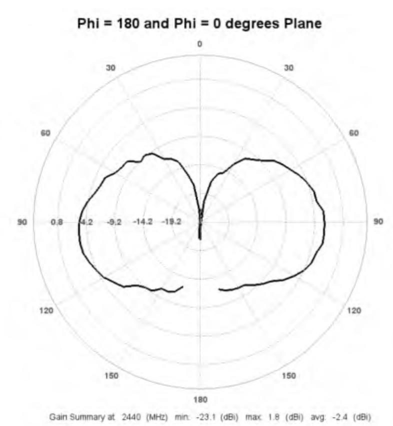


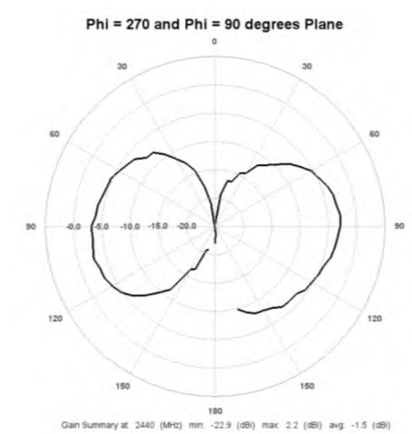




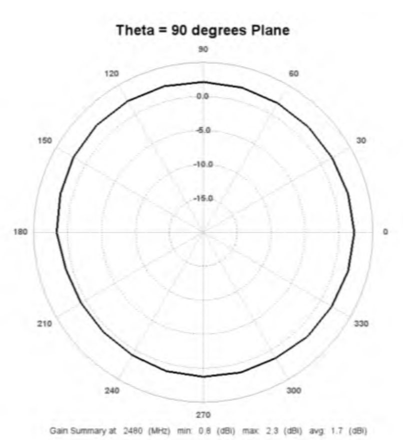
2D Plots at 2440 MHz

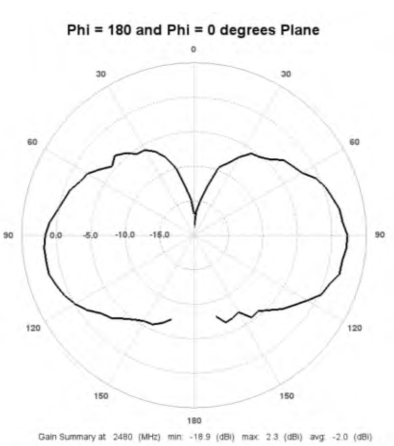


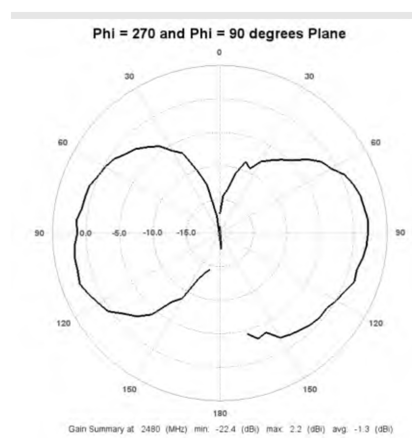




2D Plots at 2480 MHz







RADIATION PATTERNS – 3D Plots

3D Plots at 2400 MHz

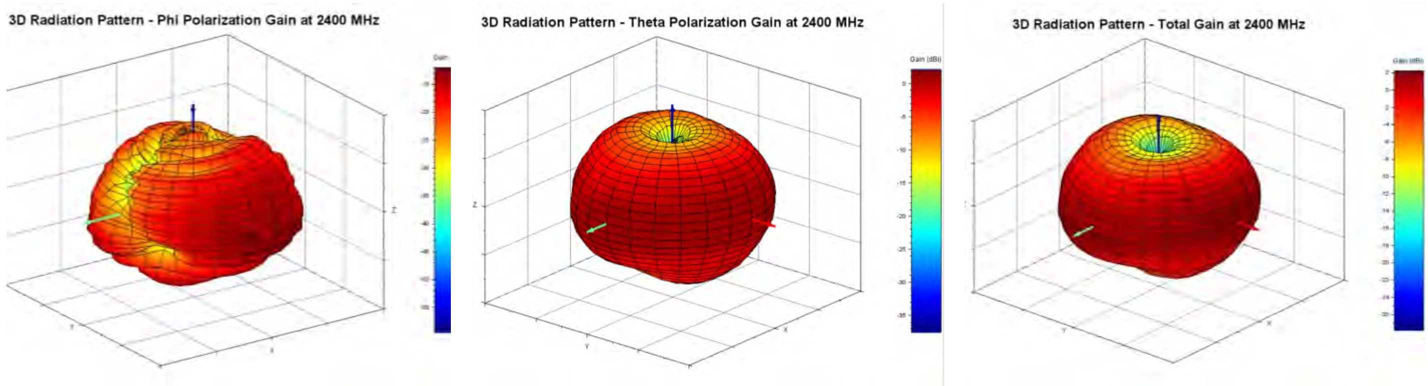


Figure 5: Phi polarization, Theta polarization and, and total gain plots – 2400 MHz

3D Plots at 2440 MHz

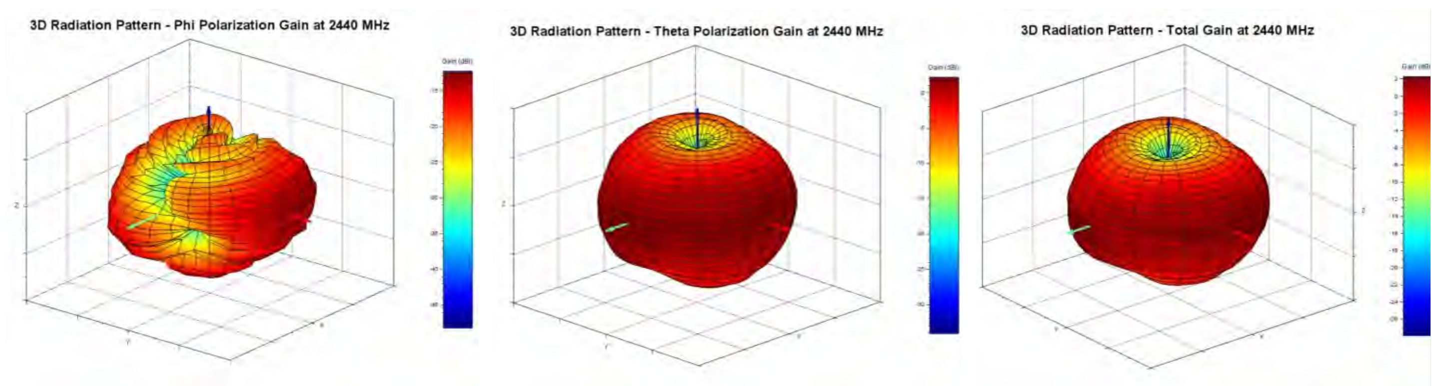


Figure 6: Phi polarization, Theta polarization and, and total gain plots – 2440 MHz

3D Plots at 2480 MHz

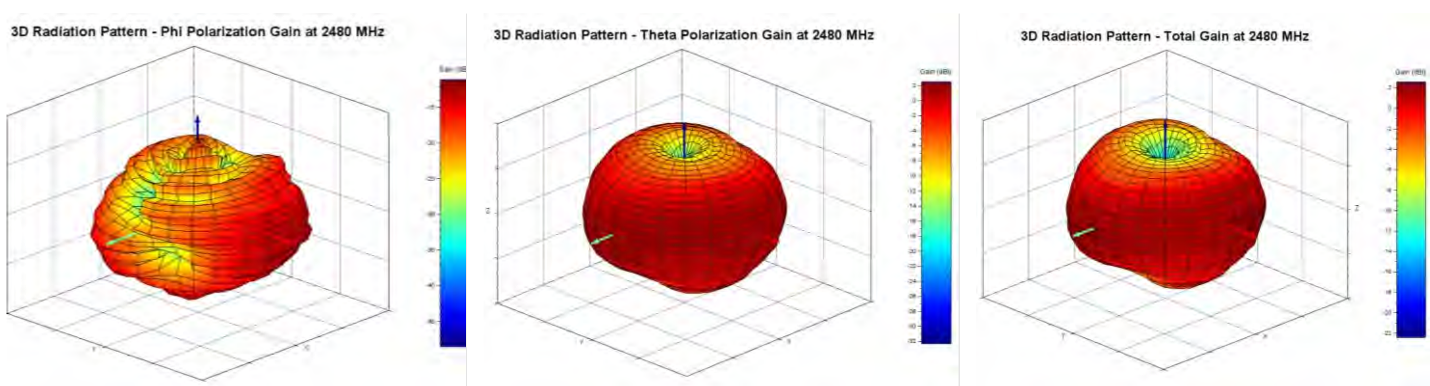


Figure 7: Phi polarization, Theta polarization and, and total gain plots – 2480 MHz

EFFICIENCY

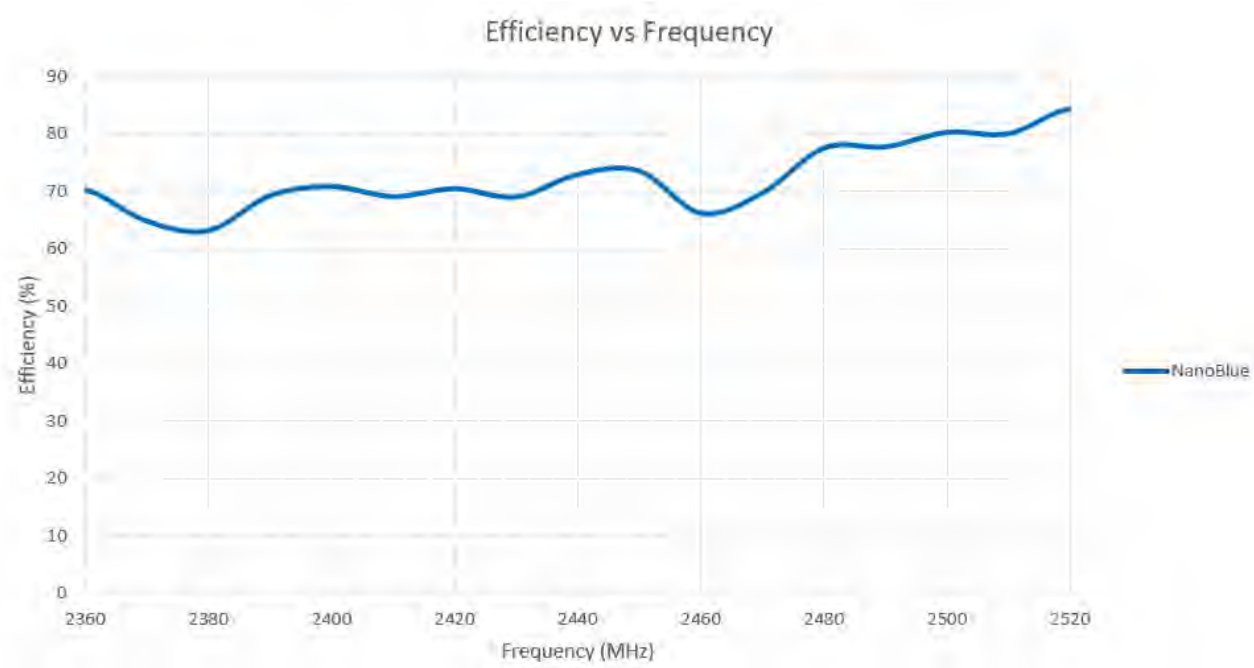


Figure 8: Antenna efficiency measured in free space with a nominal value of -1.5dB across the operating frequency

ANTENNA GAIN

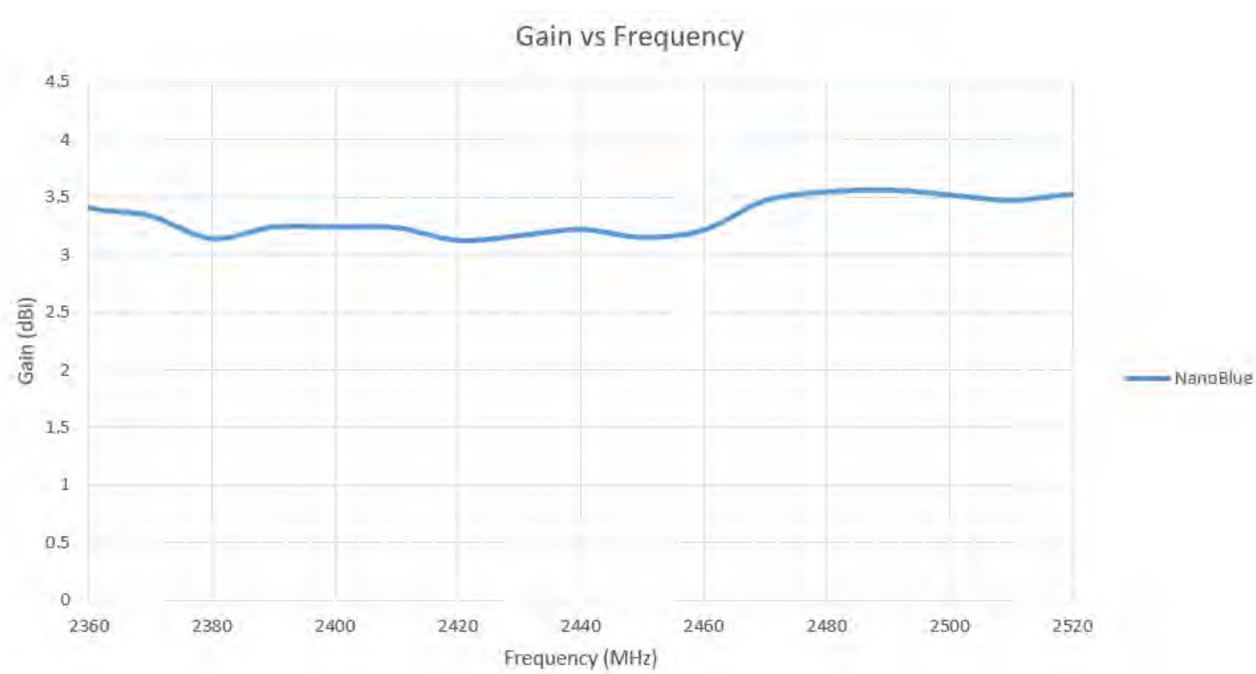
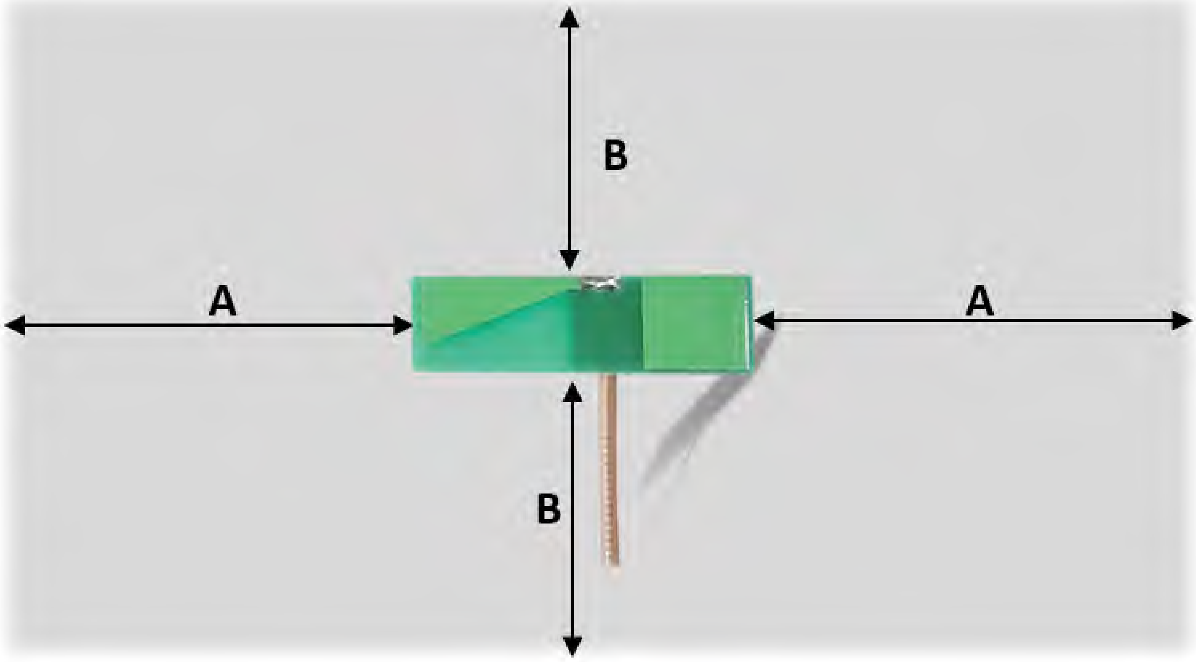
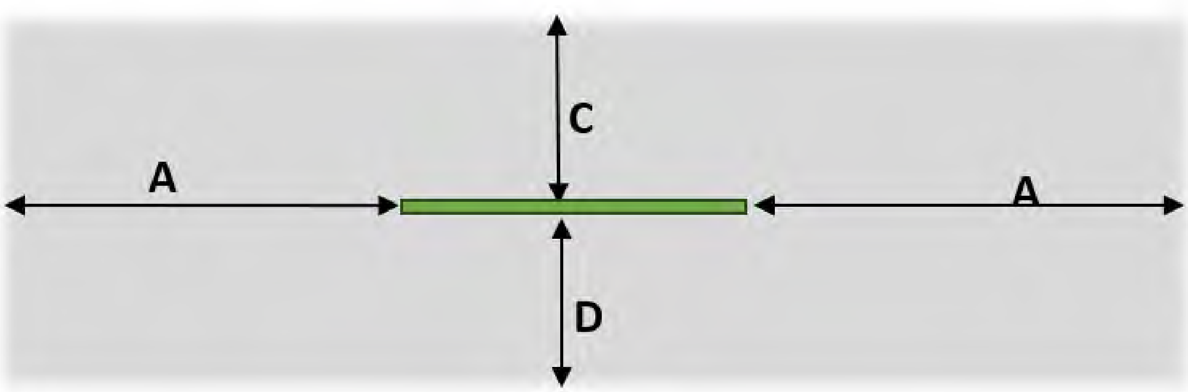


Figure 9: Antenna gain measured in free space

Antenna Placement & Keep Out Region





Keep Out Region Distance (mm)			
A	B	C	D
5	5	10	10

Notes:

- Antenna can be mounted on polycarbonate with a nominal thickness of 2.25mm (1.5mm - 3mm)
- Diagram is not to scale

Additional Information

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

Headquarters	Ezurio 50 S. Main St. Suite 1100 Akron, OH 44308 USA
Website	http://www.ezurio.com
Technical Support	http://www.ezurio.com/resources/support
Sales Contact	http://www.ezurio.com/contact

Note: Information contained in this document is subject to change.

Ezurio's products are subject to standard Terms & Conditions.

1 Features and Benefits

- 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
Peak Gain (dBi)	+2.0
Average Gain (dBi)	> -1.5
VSWR (MHz)	< 2.0:1
Impedance (Ω)	50
Polarization	Linear

MECHANICAL SPECIFICATIONS		
Antenna Type	Flexible Planar Inverted F Antenna (FlexPIFA)	
Dimensions – mm (inches)	40.1 x 11.0 x 2.5 (1.58 x 0.43 x 0.098)	
Weight – g (oz.)	1.13 (0.040)	
Color	Clear yellow	
Adhesive	3M 100MP	
Connector Mating Height (max) – mm	MHF1 (U.FL)	2.5
	MHF4L	1.4

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

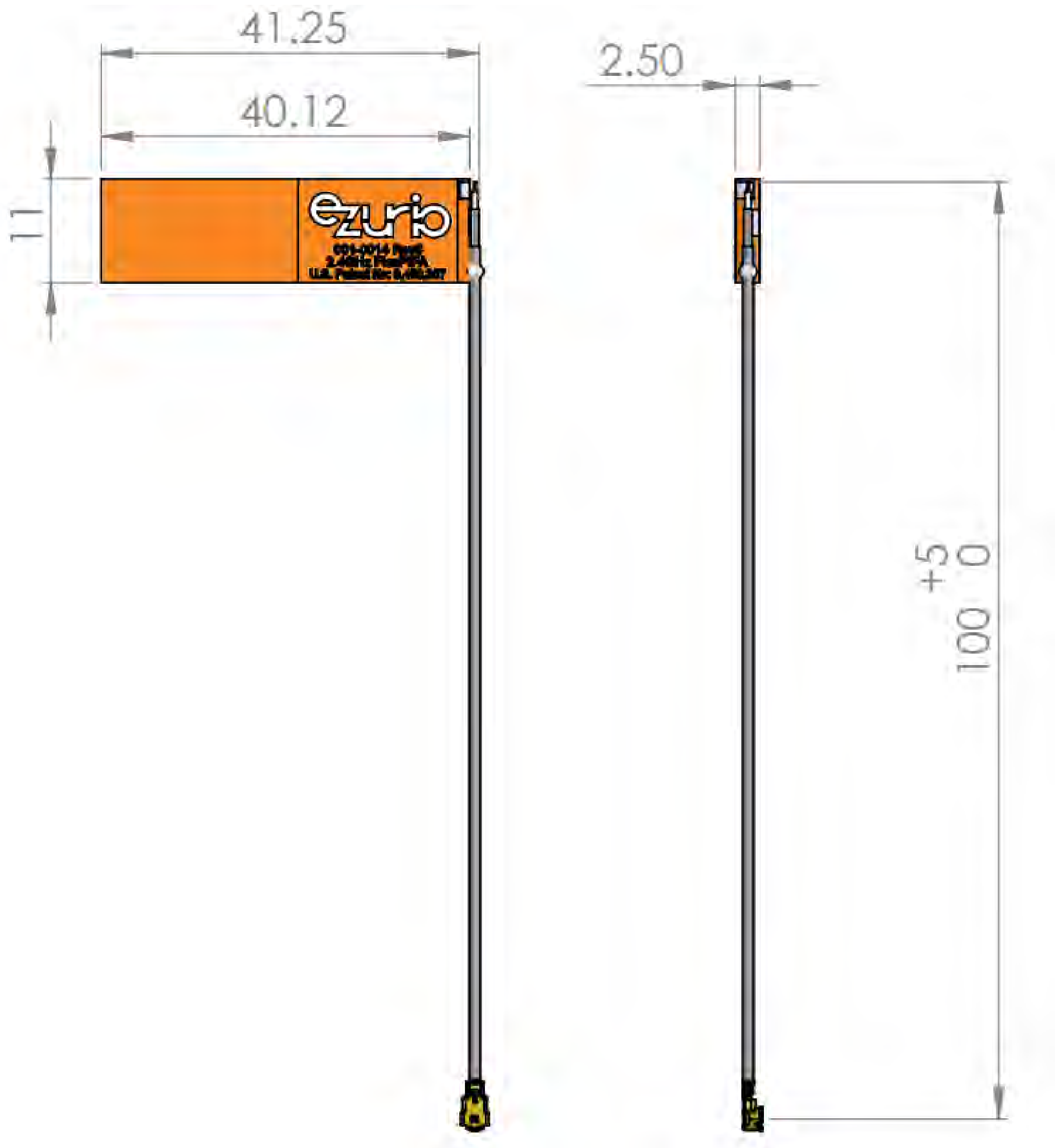
2 Configuration

PART NUMBER	CABLE LENGTH	CONNECTOR
001-0014	100 mm	MHF1
001-0022	100 mm	MHF4L
001-0025	100 mm	MHF1
EFB2400A3S-13MHF1	130 mm	MHF1
EFB2400A3S-22MHF1	220 mm	MHF1

Note: Specifications are based on the 100mm cable length, standard antenna version with MHF1 / U.FL connector. Varying the cable length or type or connector will cause variations in these antenna specifications.

3 Mechanical Configuration

3.1 Physical Dimensions of 001-0014, 001-0022 and EFB2400A3S-22MHF1 (Right hand orientation)



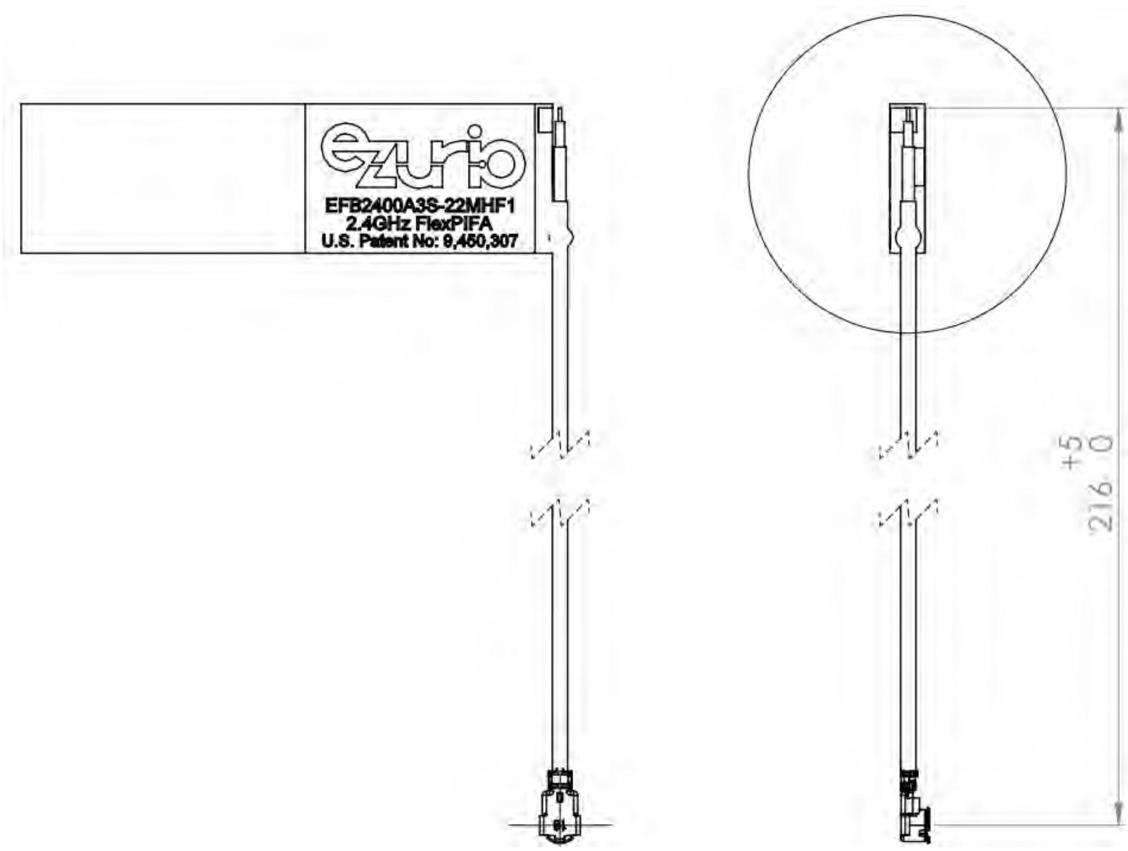


Figure 1: FlexPIFA mechanical drawing of 001-0014, 001-0022, and EFB2400A3S-22MHF1

3.2 Physical Dimensions of EFB2400A3S-13MHF1

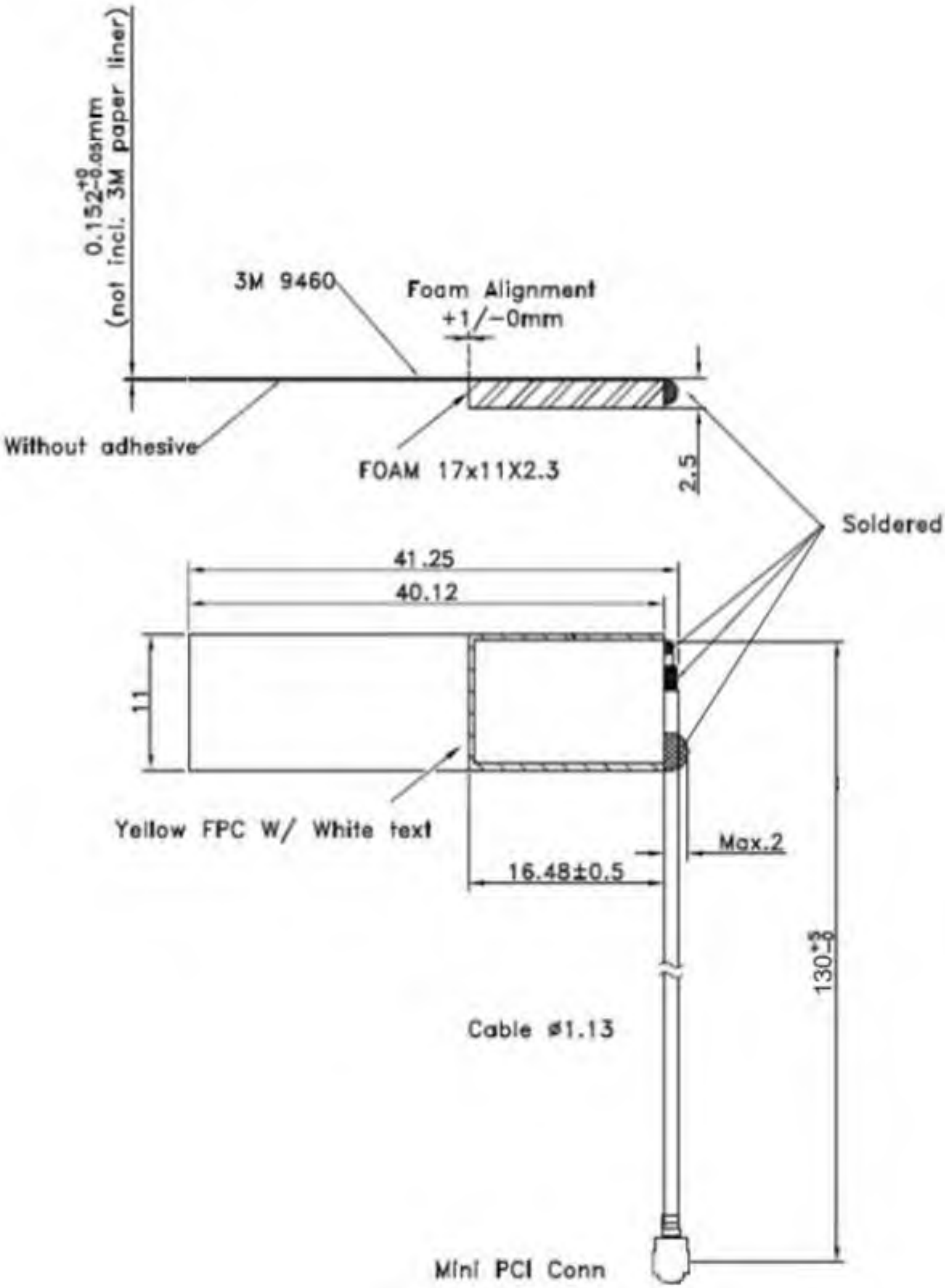


Figure 2: FlexPIFA mechanical drawing of EFB2400A3S-13MHF1

3.3 Physical Dimensions of 001-0025 (Left hand orientation)

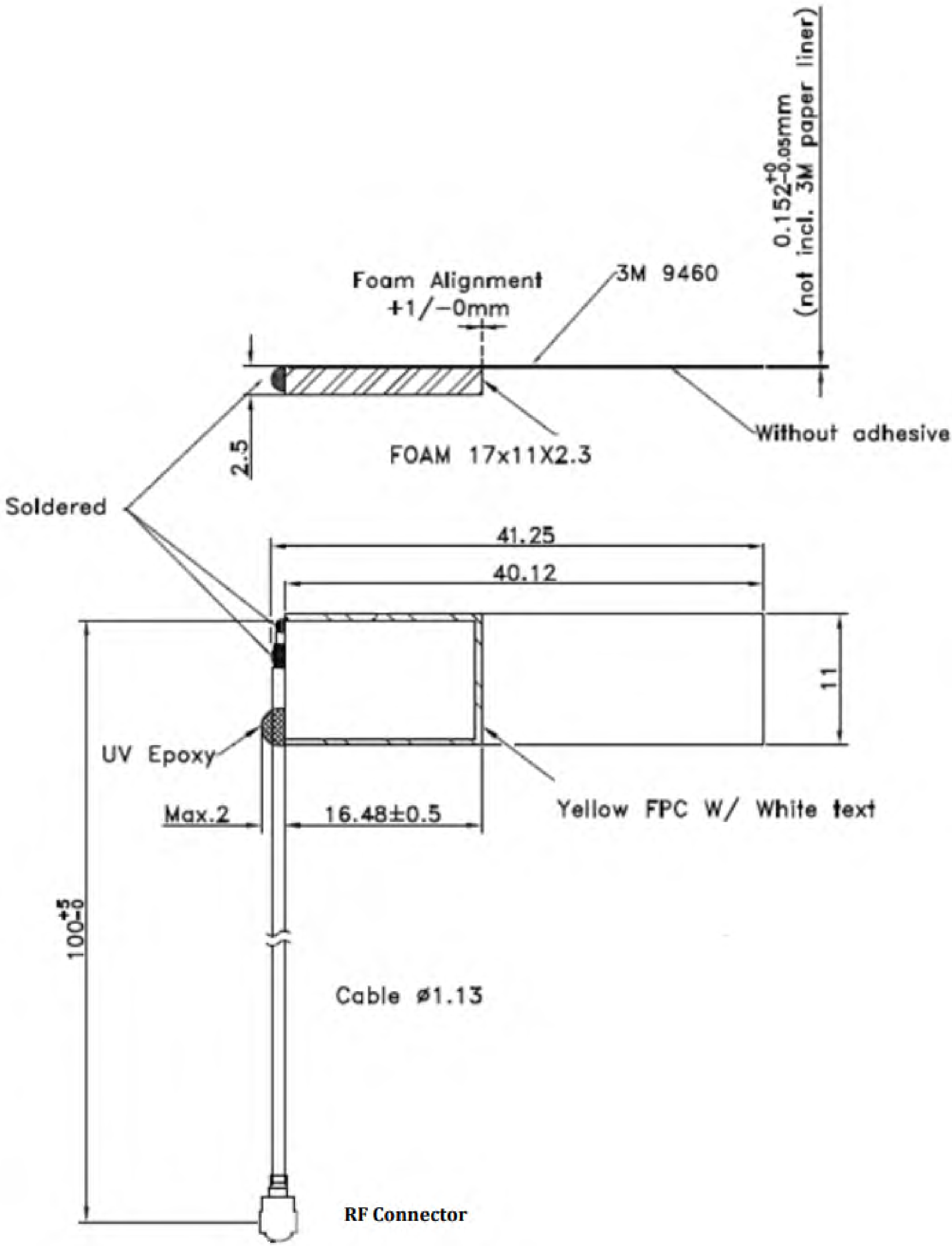


Figure 3: FlexPIFA mechanical drawing of 001-0025

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.

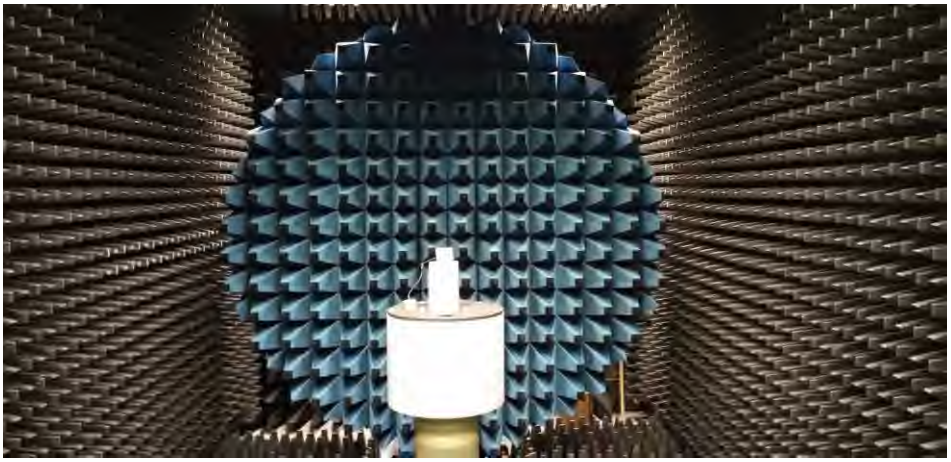


Figure 4: Antenna chamber

4 Flat Surface Antenna measurements

4.1 VSWR

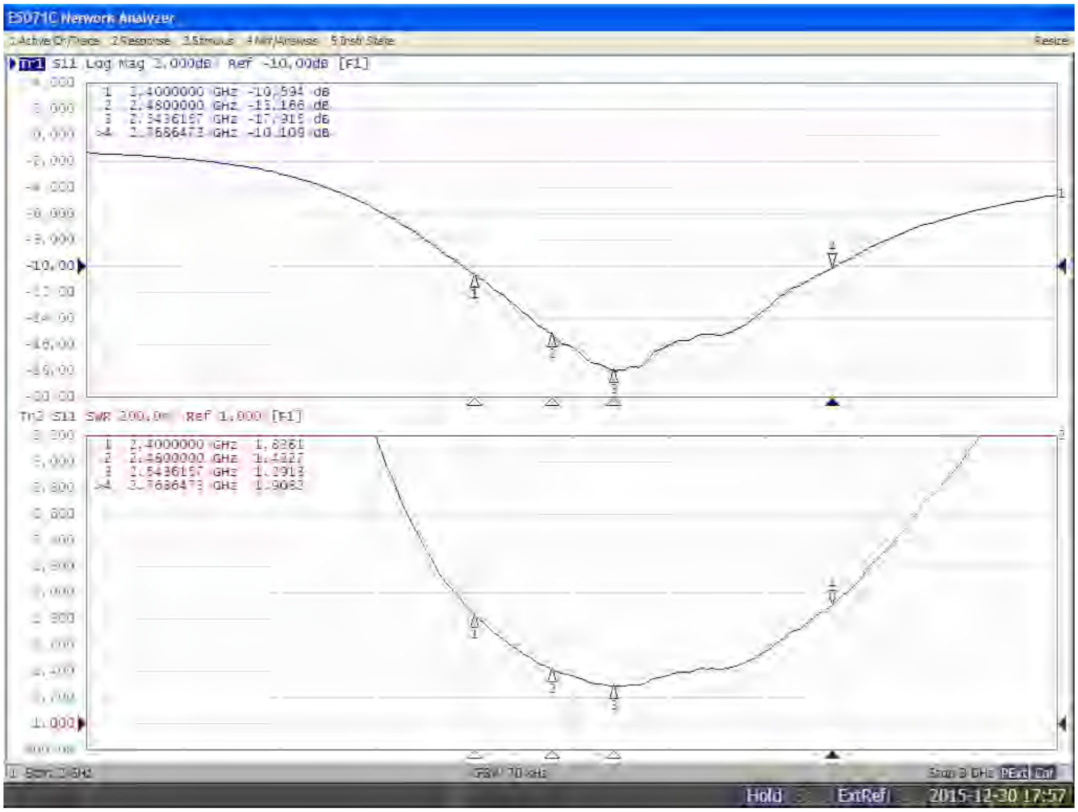


Figure 5: Antenna VSWR measured on a 1.5 mm-thick plate of polycarbonate

5 Flat surface Antenna Radiation Performance

5.1 FlexPIFA centered on a 1.5 mm-thick plate of polycarbonate

Antenna Measurement Set-Up

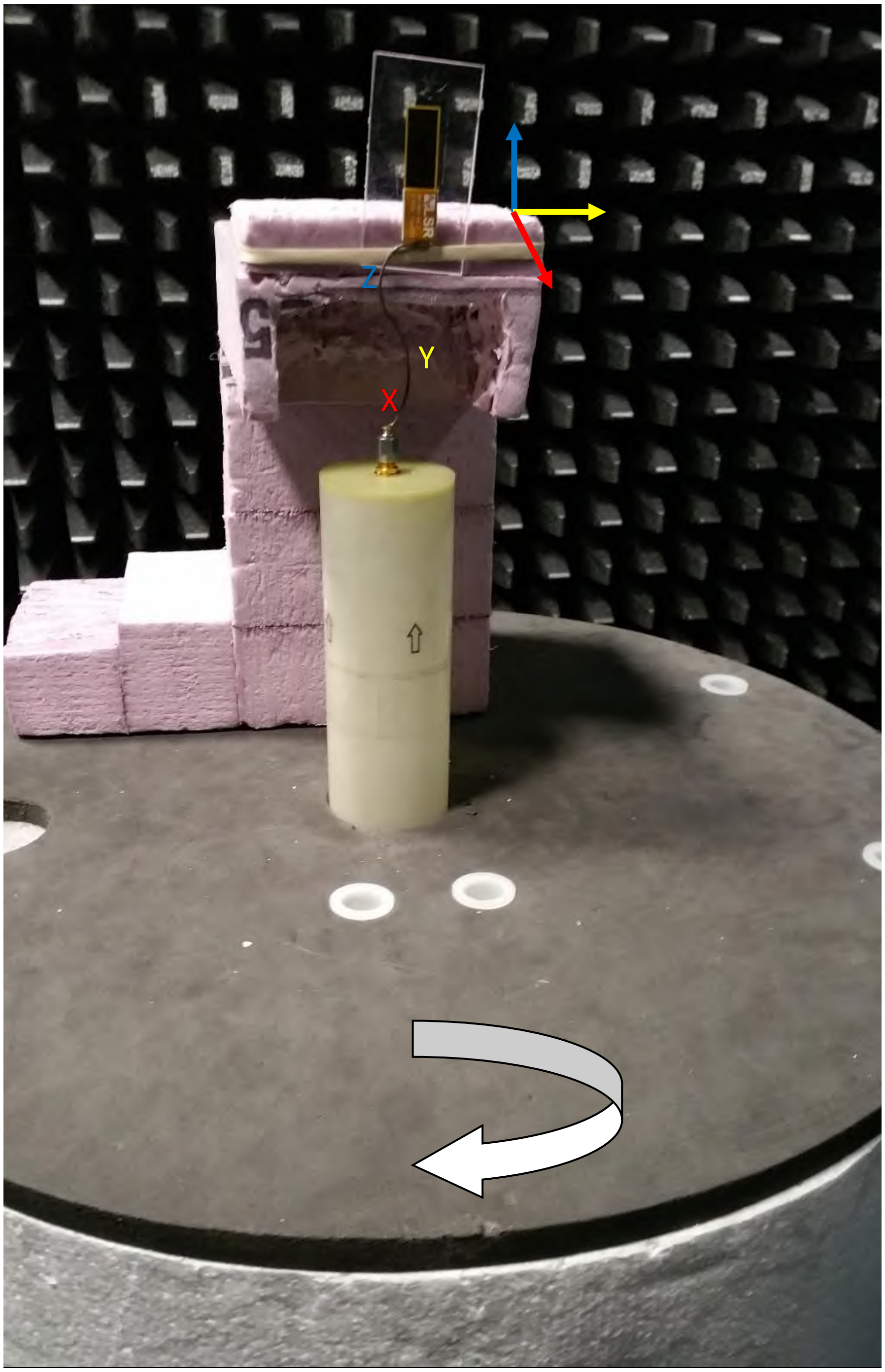


Figure 6: Flat surface setup

5.1.1 Azimuthal Conical Cuts at 2400 MHz

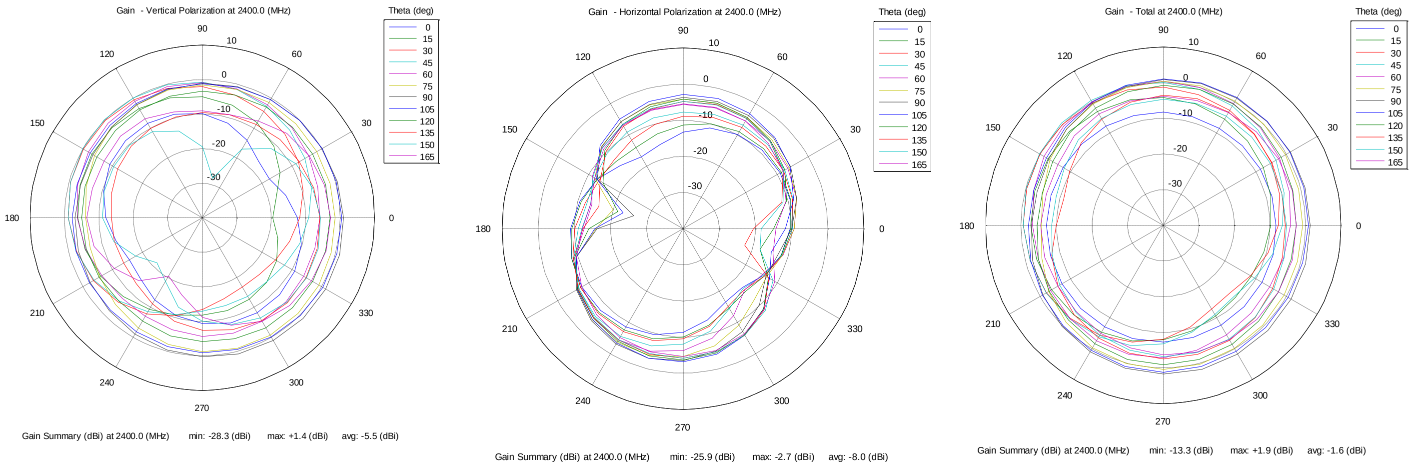


Figure 7: Vertical, horizontal, and total gain patterns – 2400 MHz

5.1.2 3D Plots at 2400 MHz

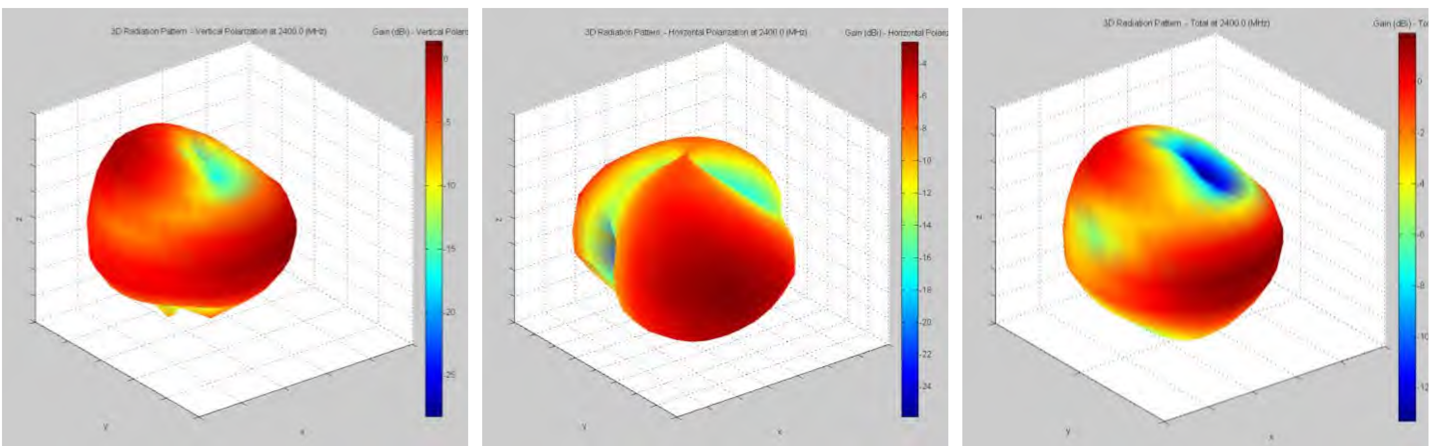


Figure 8: Vertical, horizontal, and total gain plots – 2400 MHz

5.1.3 Azimuthal Conical Cuts at 2440 MHz

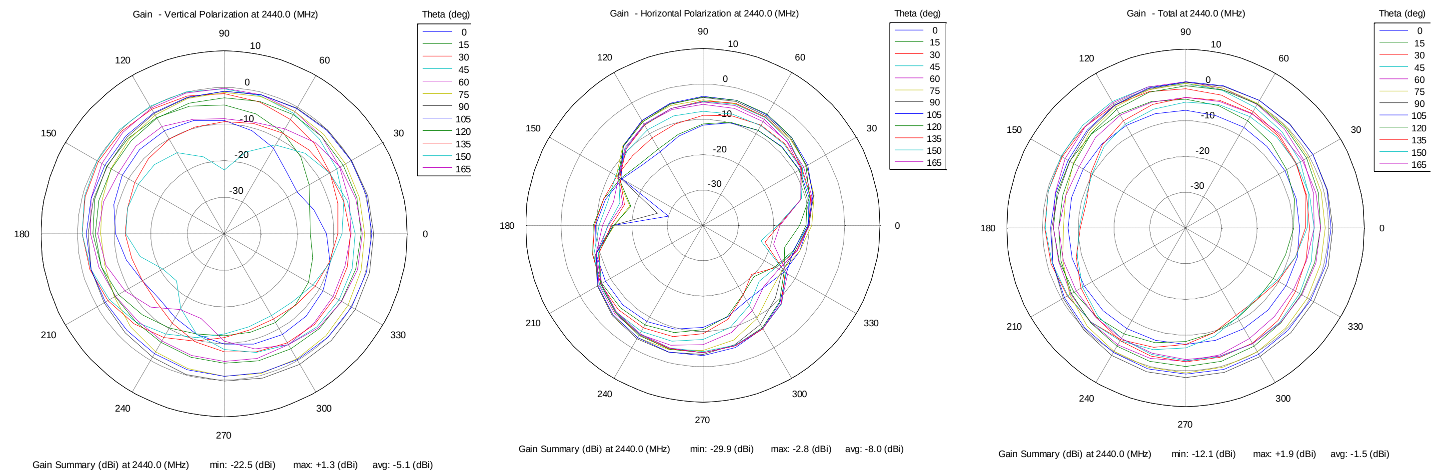


Figure 9: Vertical, horizontal, and total gain patterns – 2440 MHz

5.1.4 3D Plots at 2440 MHz

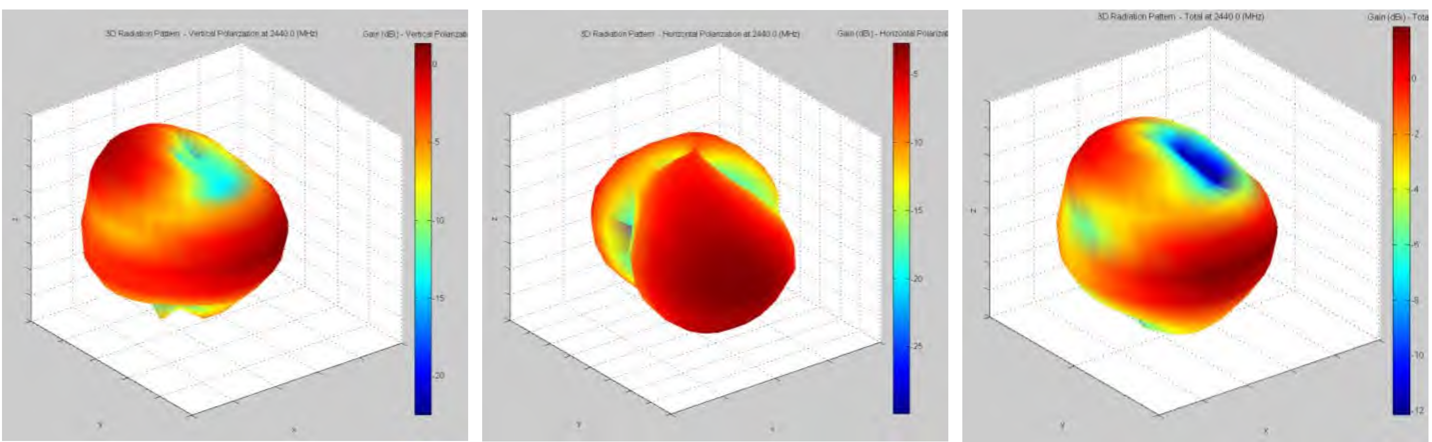


Figure 10: Vertical, horizontal, and total gain plots – 2440 MHz

5.1.5 Azimuthal Conical Cuts at 2480 MHz

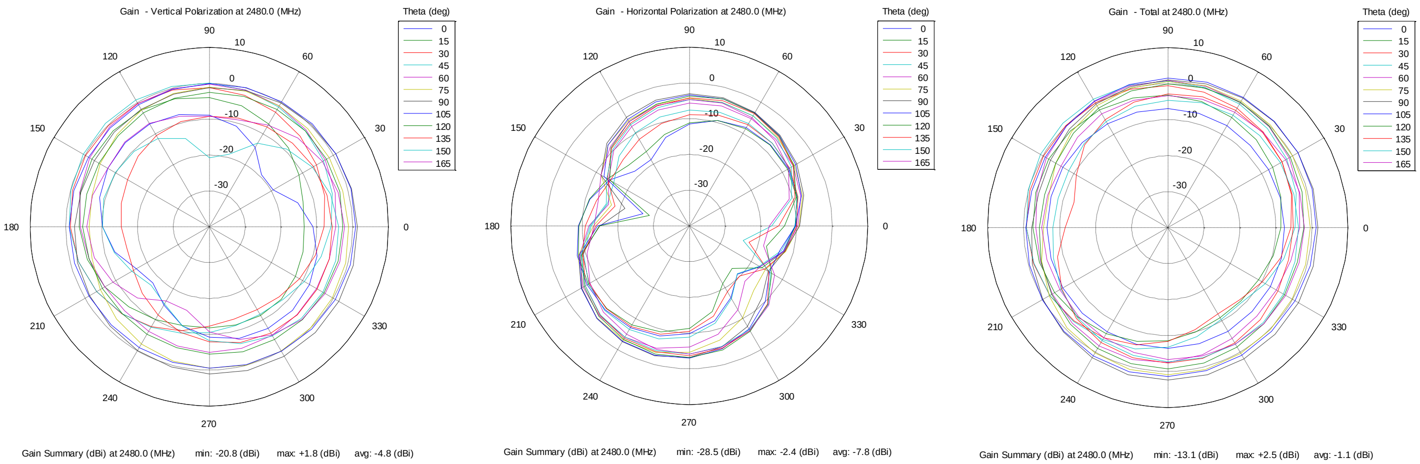


Figure 11: Vertical, horizontal, and total gain patterns – 2480 MHz

5.1.6 3D Plots at 2480 MHz

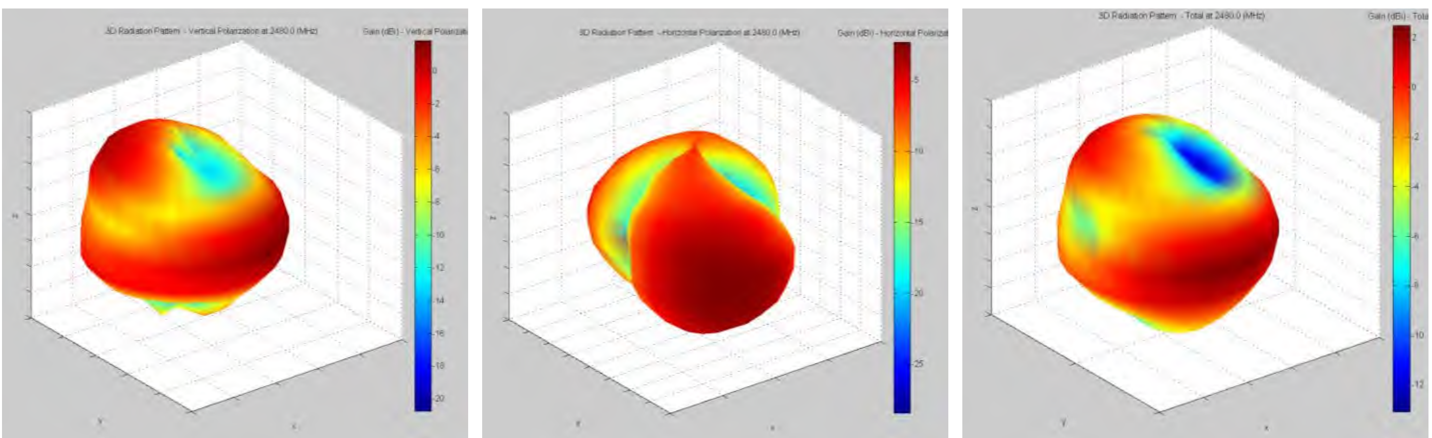


Figure 12: Vertical, horizontal, and total gain plots – 2480 MHz

6 Curved surface Antenna Radiation Performance

6.1 FlexPIFA outside 51 mm outer diameter PVC tube

6.1.1 Antenna Measurement Set-Up

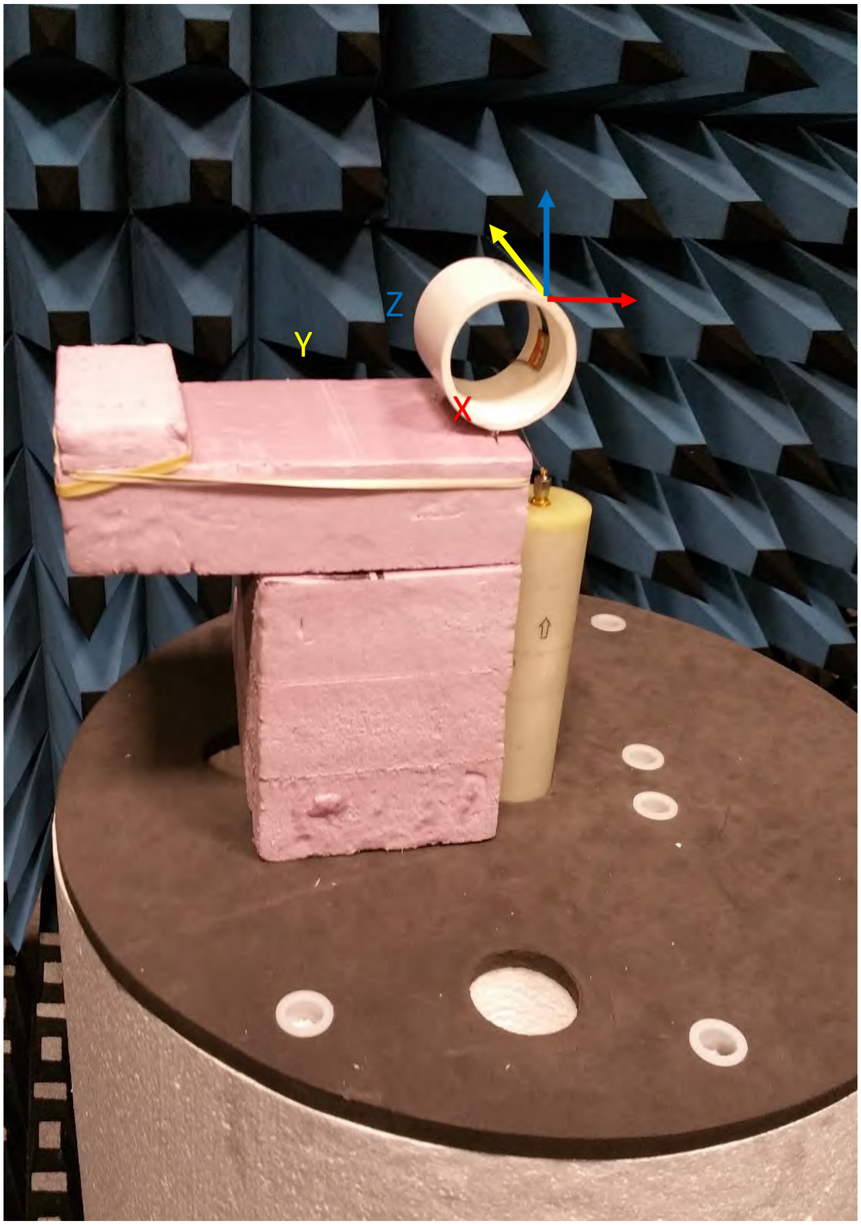


Figure 13: Outer diameter setup

6.1.2 Azimuthal Conical Cuts at 2440 MHz

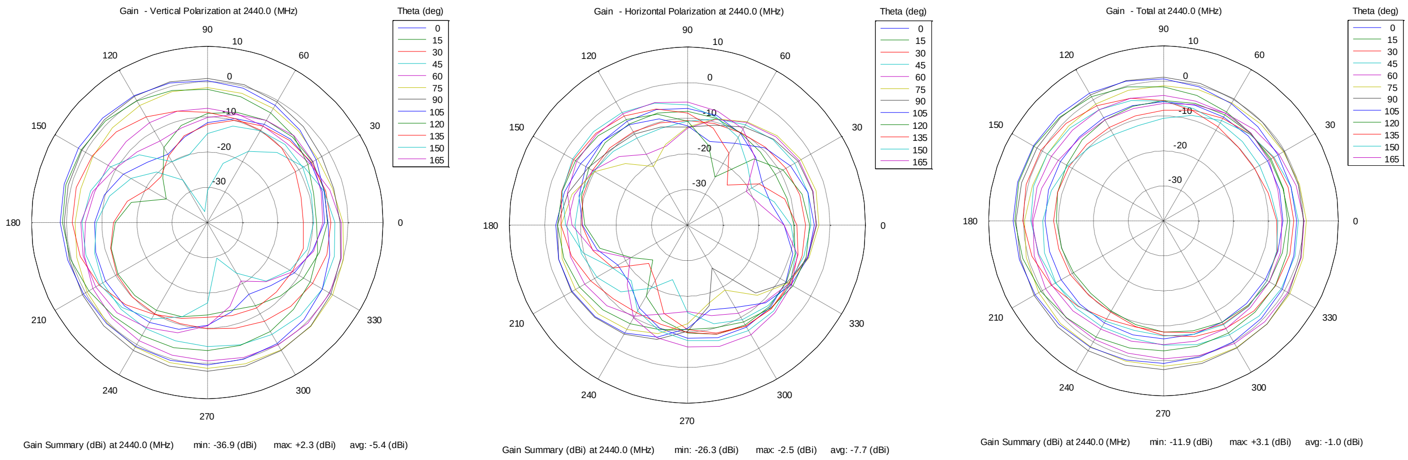


Figure 14: Vertical, horizontal, and total gain patterns – 2440 MHz

6.1.3 3D Plots at 2440 MHz

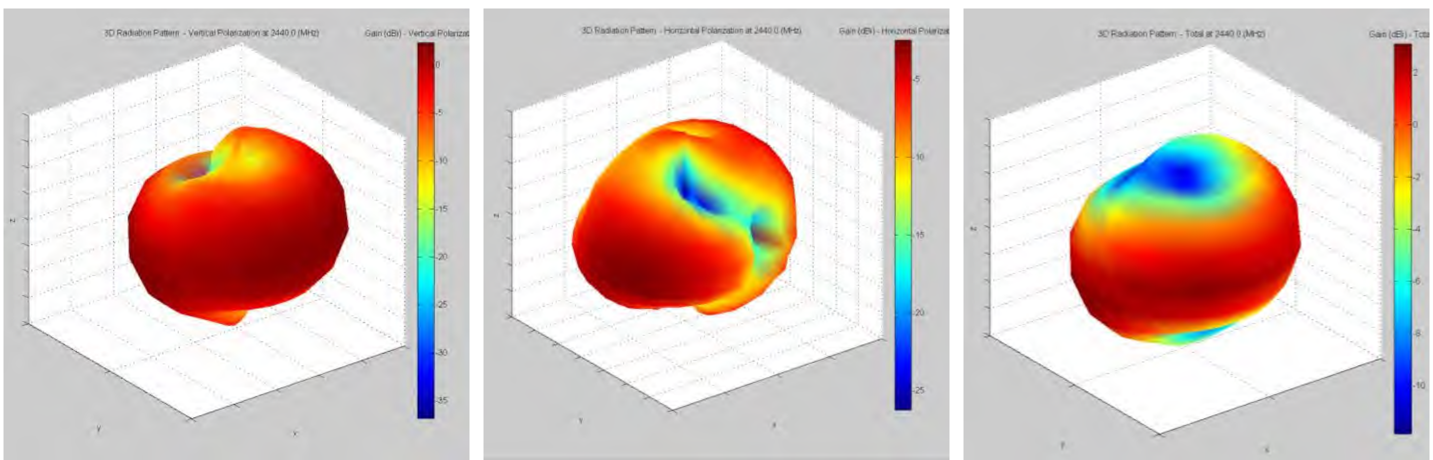


Figure 15: Vertical, horizontal, and total gain plots – 2440 MHz

6.2 FlexPIFA inside 52 mm inner diameter PVC tube

6.2.1 Antenna Measurement Setup

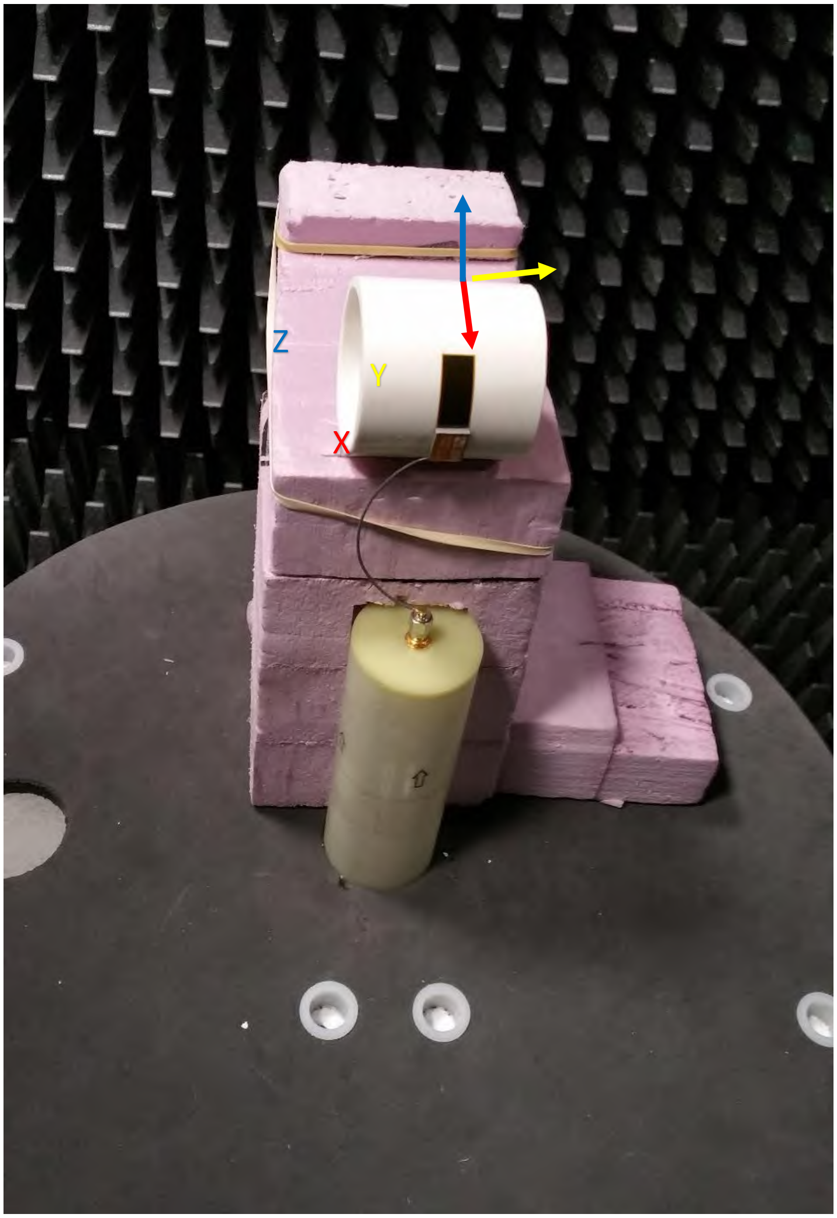


Figure 16: Inner diameter setup

6.2.2 Azimuthal Conical Cuts at 2440 MHz

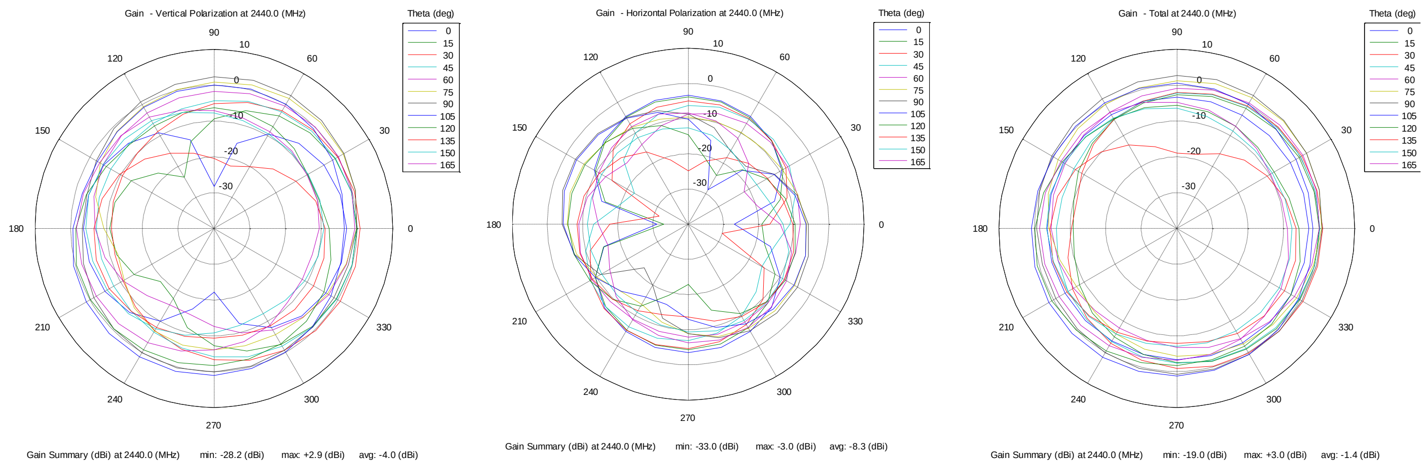


Figure 17: Vertical, horizontal, and total gain patterns – 2440 MHz

6.2.3 3D Plots at 2440 MHz

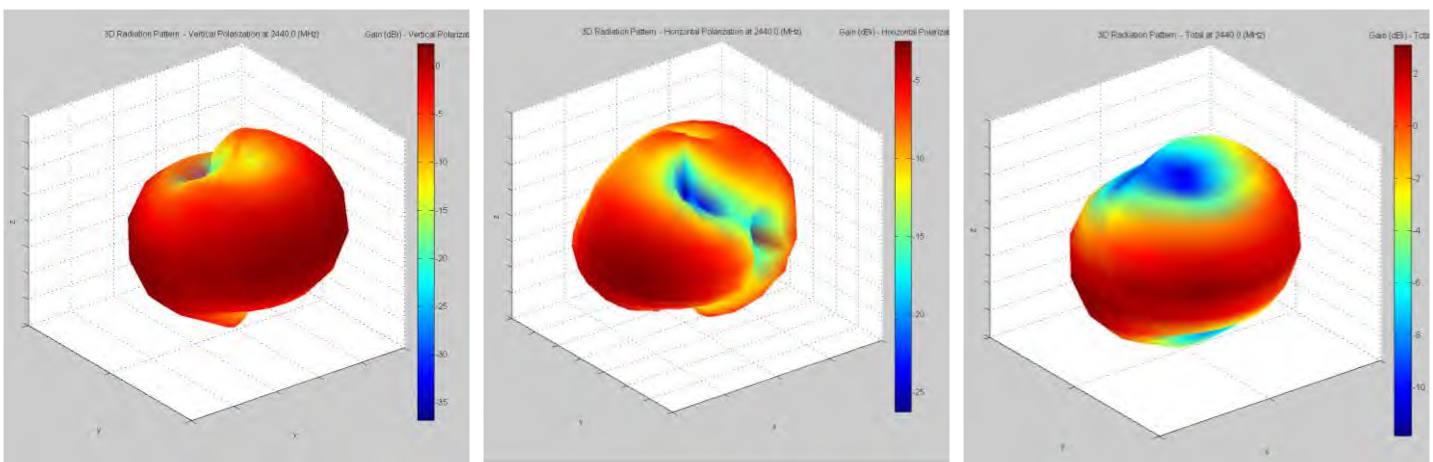


Figure 18: Vertical, horizontal, and total gain plots – 2440 MHz

7 Optimal installation Guide

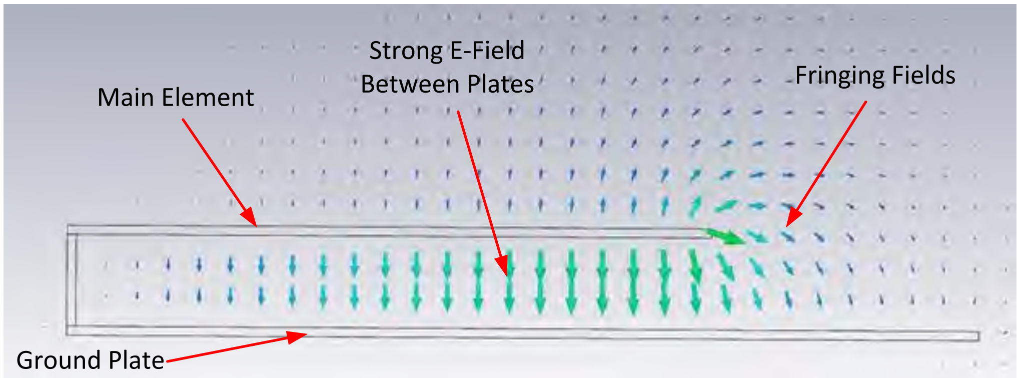


Figure 19: E-field radiation from FlexPIFA – taken from CST simulation

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 20). Similarly, the two long sides of the FlexPIFA should be kept clear of any non-metal object by at least two millimeters (See Figure 21). 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.

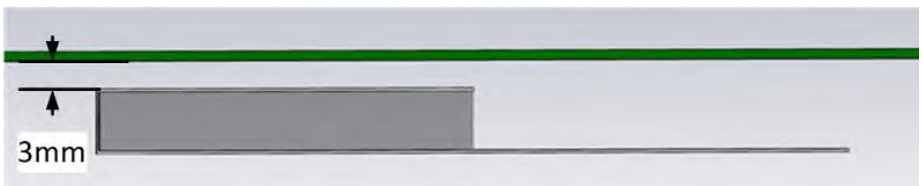
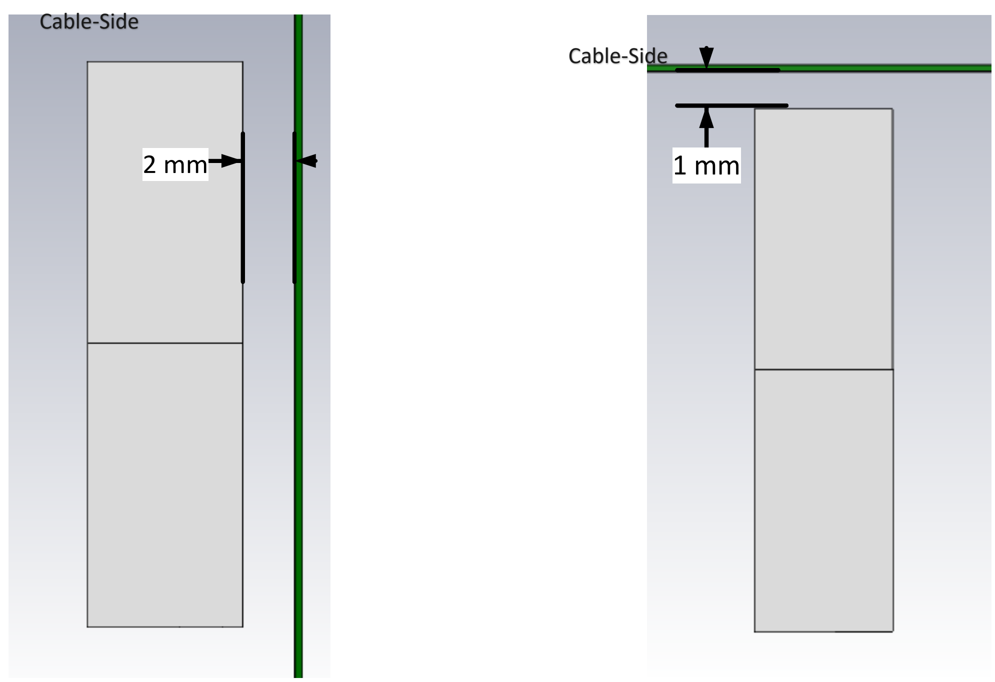


Figure 20: Top clearance

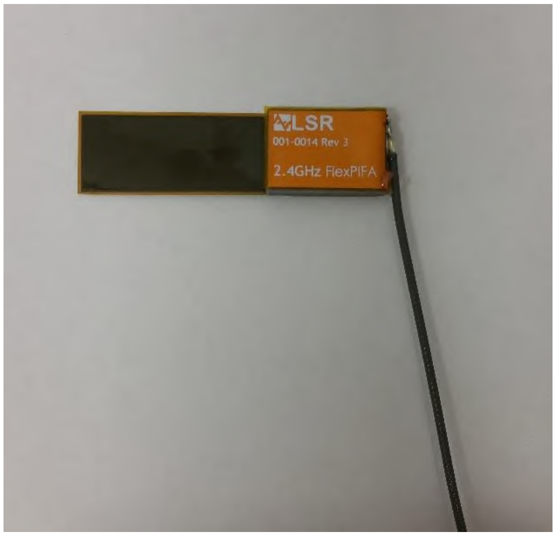


Side Clearance ***Ground Wall Clearance***

Figure 21: Side and ground wall clearance

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 22.



Perpendicular to the side

Away from the ground wall

Figure 22: 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

7.1.1 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 Ezurio for assistance.

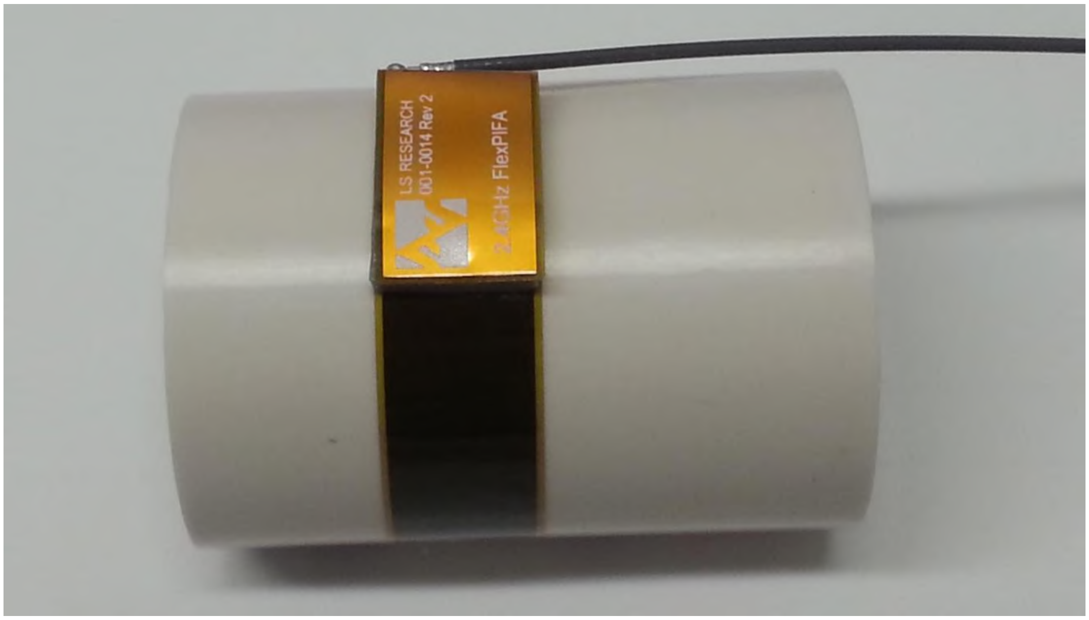


Figure 23: Convex-mounted

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 Ezurio for assistance.

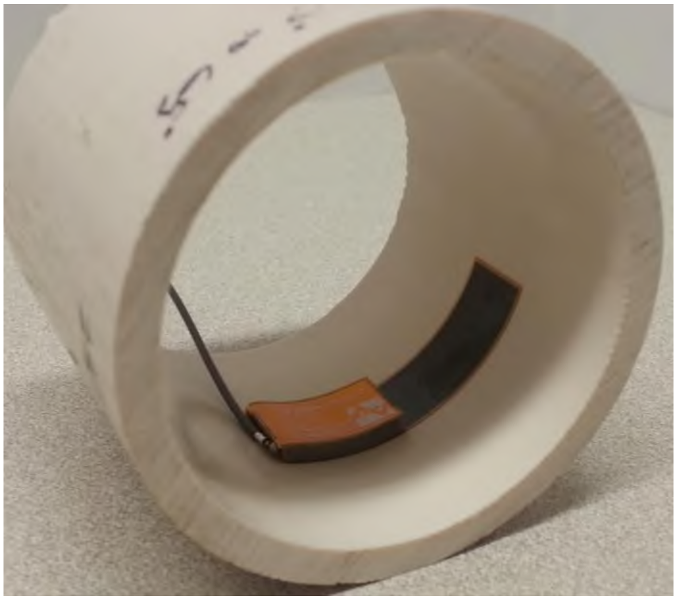


Figure 24: Concave-mounted

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

7.1.2 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 19). 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 Ezurio for a custom antenna build to help meet your application needs.

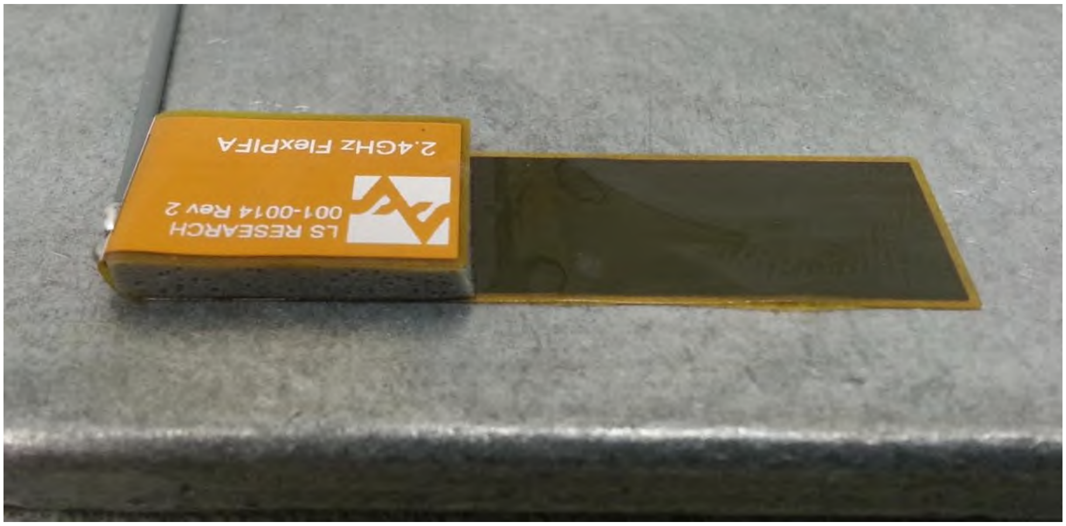


Figure 25: FlexPIFA mounted on metal

Do not mount the FlexPIFA where metal is within ten millimeters above the main element (see Figure 27). 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 26). 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.

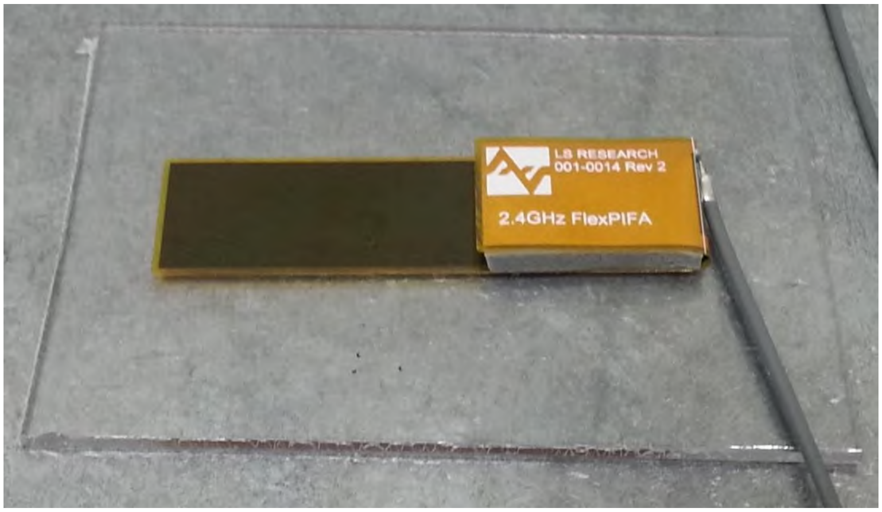


Figure 26: FlexPIFA mounted on metal Surface with 1.5 mm thick polycarbonate spacer

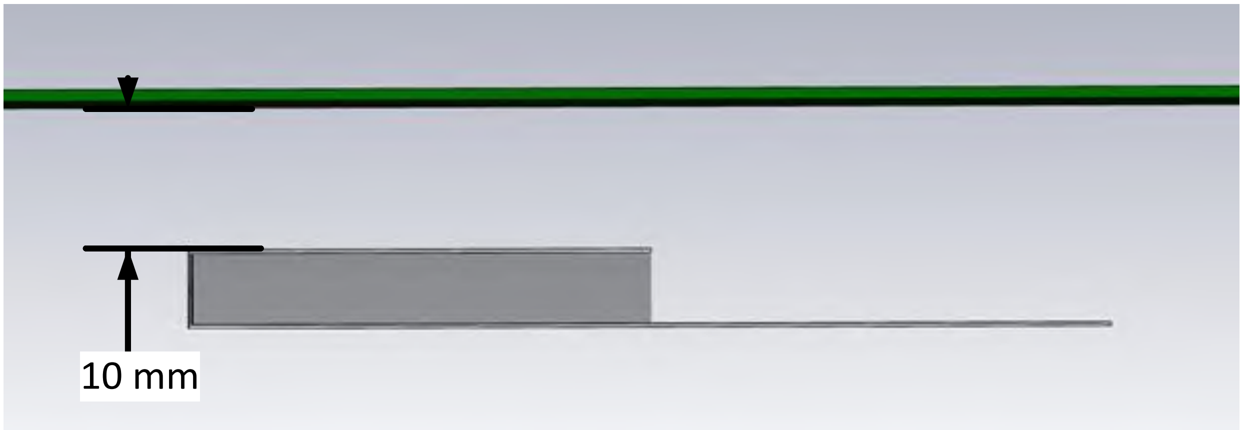


Figure 27: Metal near main element

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 27.

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 28 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 28: FlexPIFA integrated into bracelet

8 Additional Information

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

Headquarters	Ezurio 50 S. Main St. Suite 1100 Akron, OH 44308 USA
Website	http://www.ezurio.com
Technical Support	http://www.ezurio.com/resources/support
Sales Contact	http://www.ezurio.com/contact

Note: Information contained in this document is subject to change.

i-FlexPIFA™ Series

Inverted Flexible PIFA Antenna – 2400-2480 MHz

Datasheet *v3.0*

1 Features and Benefits

- Quick and easy installation
- Adhesive holds to surface during humidity exposure and hot/cold cycles
- RoHS-compliant
- Radiation direction maximized on adhesive side for outward-facing orientation
- Patent Number: 9450307

- Can be installed in the following ways:
  - On different non-conductive surfaces and thicknesses
  - On flat or curved surfaces
  - MIMO array element
  - On the front or top face of an enclosure interior (alternative placement to FlexPIFA)

- Pallet base dimensions: 120 cm x 80 cm x 14 cm
- Full loaded dimensions: 120 cm x 80 cm x 164 cm
- 20 master cartons (4 x 5 layout), 60 kg total
- 32000 antennas per pallet

- Pallet base dimensions: 120 cm x 80 cm x 14 cm
- Full loaded dimensions: 120 cm x 80 cm x 133 cm
- 16 master cartons (4 x 4 layout), 50.4 kg total
- 25600 antennas per pallet

SPECIFICATIONS	
Frequency (MHz)	2400 - 2480
Peak Gain (dBi)	+3.1
Average Efficiency (dB)	> -2.1
VSWR (MHz)	< 2.5:1
Impedance (Ω)	50
Polarization	Linear

MECHANICAL SPECIFICATIONS		
Antenna Type	Inverted Ground Flexible Planar Inverted F Antenna (i-FlexPIFA)	
Dimensions – mm (inches)	40.9 x 11.0 x 2.9 (1.61 x 0.43 x 0.114)	
Weight – g (oz.)	1.13 (0.040)	
Color	Clear yellow	
Adhesive	3M 100MP	
Connector Mating Height (max) – mm	MHF1 (U.FL)	2.5
	MHF4L	1.4

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

2 Configuration

PART NUMBER	CABLE LENGTH	CONNECTOR
EFG2400A3S-10MHF1	100 mm	MHF1
EFG2400A3S-10MH4L	100 mm	MHF4L

Note: Specifications are based on the 100mm cable length, standard antenna version with MHF1 / U.FL connector. Varying the cable length or type or connector will cause variations in these antenna specifications.

3 Mechanical Drawing

3.1 Physical Dimensions (in mm) of the EFG2400A with a 100mm Long Cable

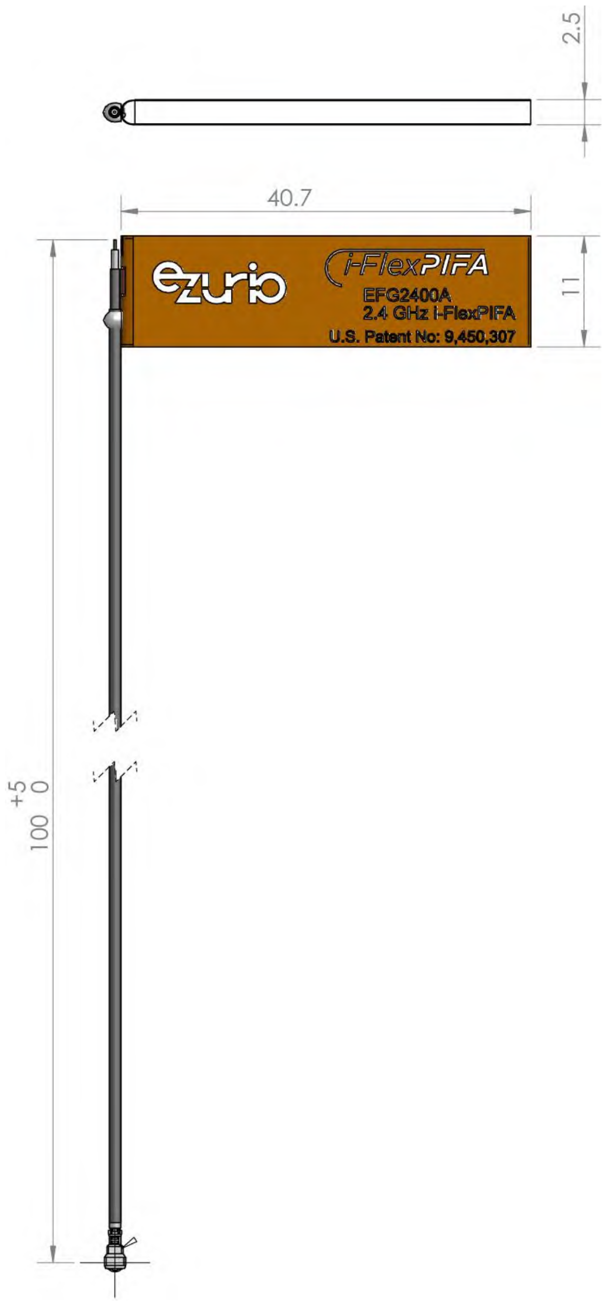


Figure 1: i-FlexPIFA mechanical drawing of

RF Connector

4 Flat Surface Antenna Measurements

Flat surface measurements were performed with the antenna centered on a 1.5 mm-thick plate of polycarbonate.

4.1 VSWR

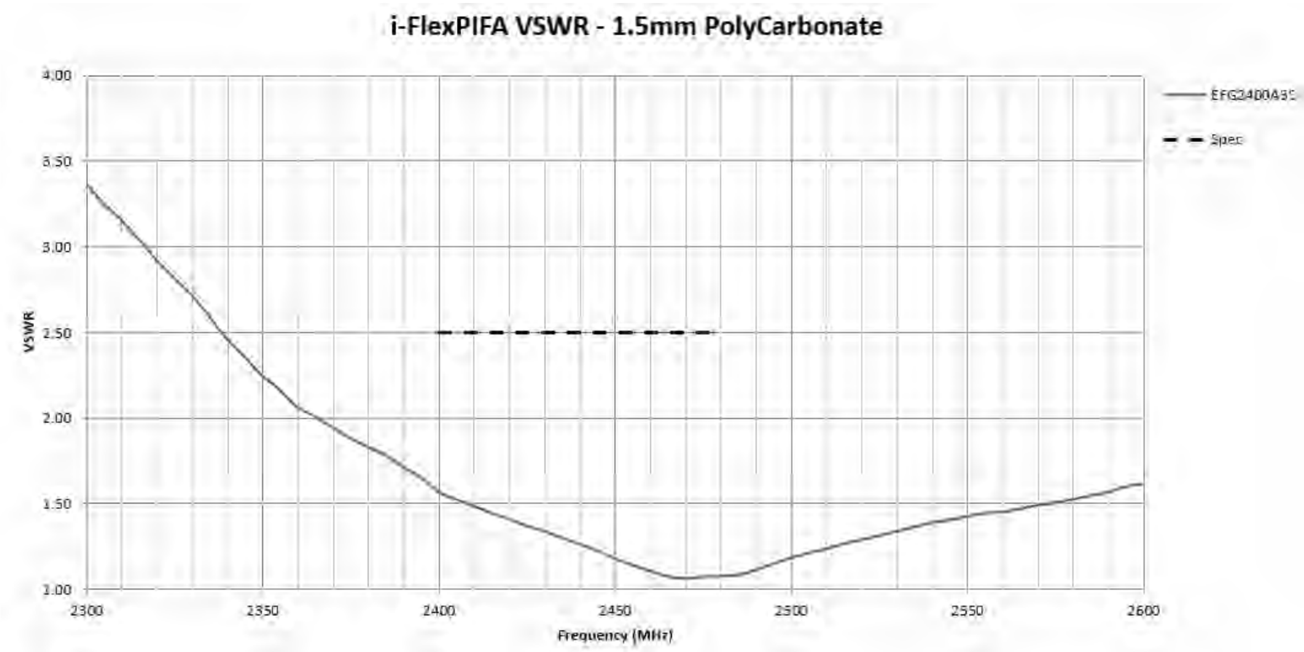


Figure 2: Antenna VSWR measured on a 1.5 mm-thick plate of polycarbonate with a nominal value of 1.26 across the operating frequency

4.2 Return Loss

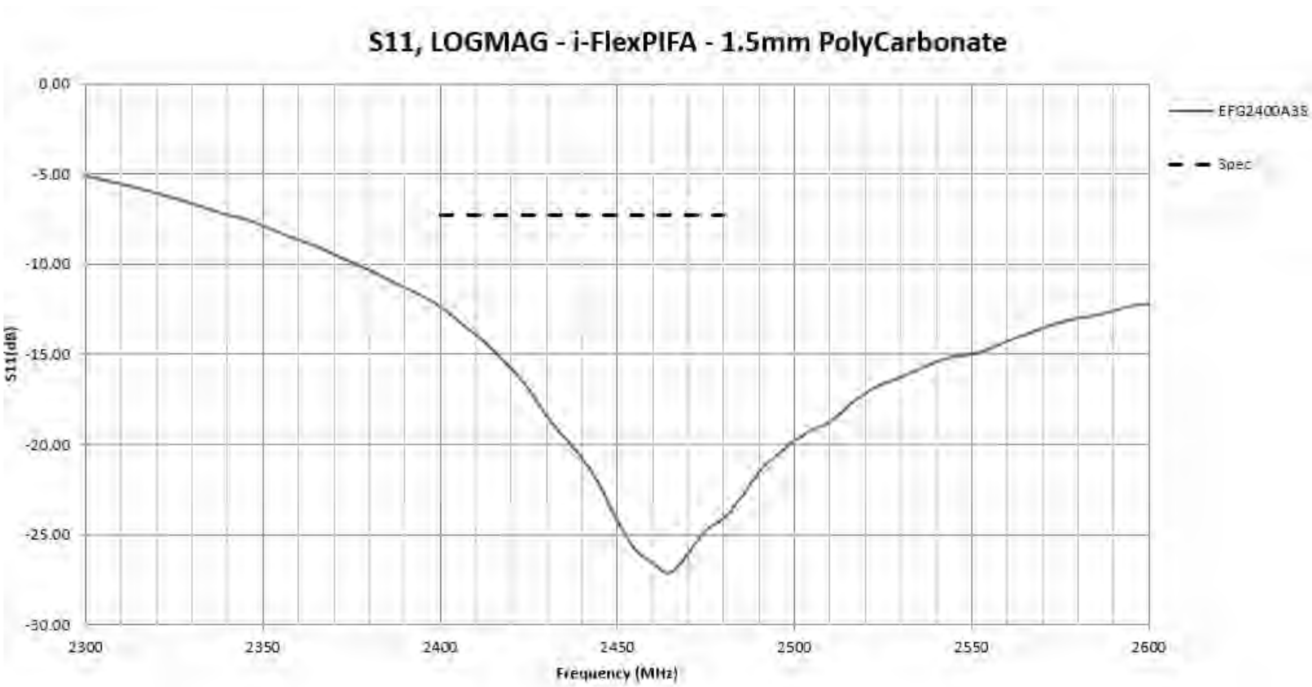


Figure 3: Antenna Return Loss measured on a 1.5 mm-thick plate of polycarbonate with a nominal value of -17.7dB across the operating frequency

5 Antenna Chamber Test Setup

Antenna measurements such as VSWR and S11 were measured with an Agilent E5071C vector network analyzer. Radiation patterns were measured with a Rohde & Schwarz ZNB8-4PORT vector network analyzer in a Howland Company 3100 chamber equivalent. Phase center is nine inches above the Phi positioner.

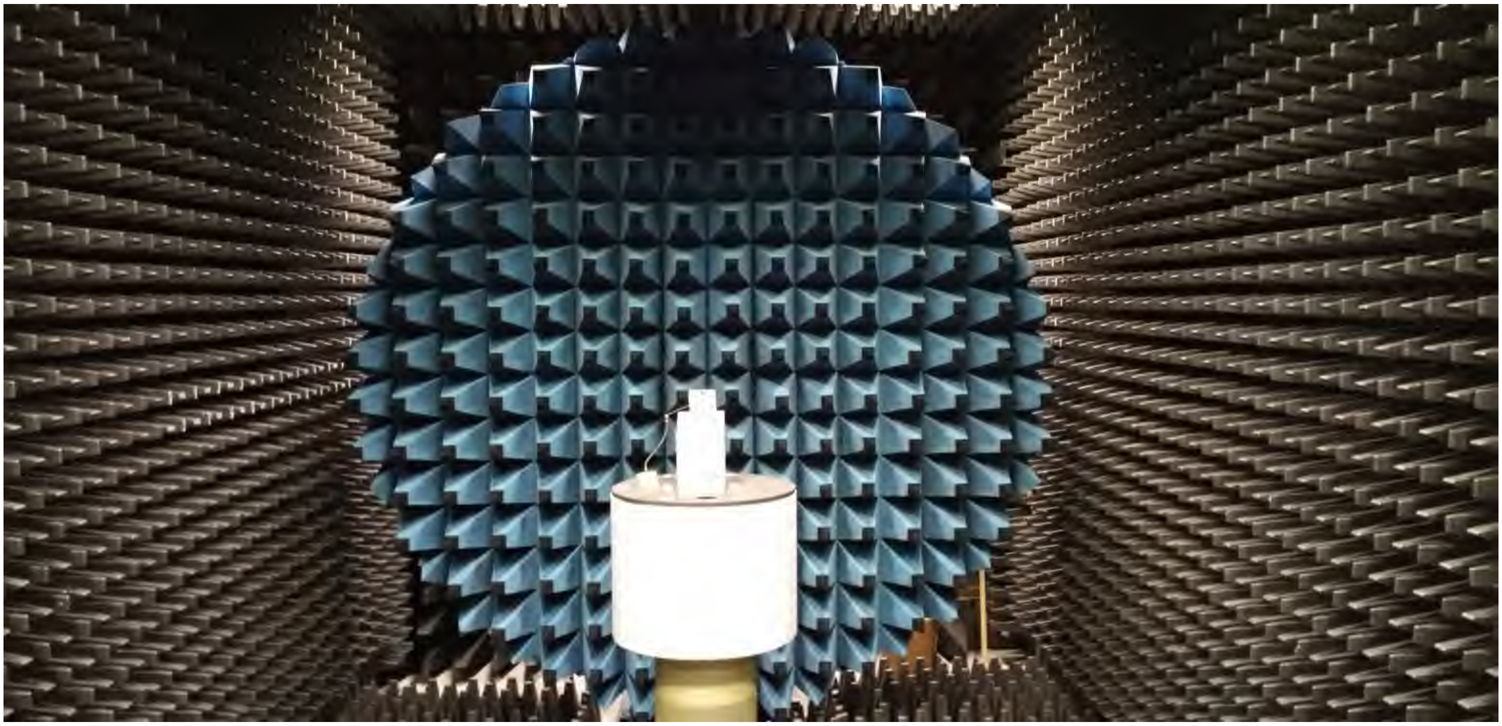


Figure 4: Howland Company 3100 Antenna chamber

6 Antenna Radiation Performance

6.1 FlexPIFA centered on a 1.5 mm-thick plate of polycarbonate

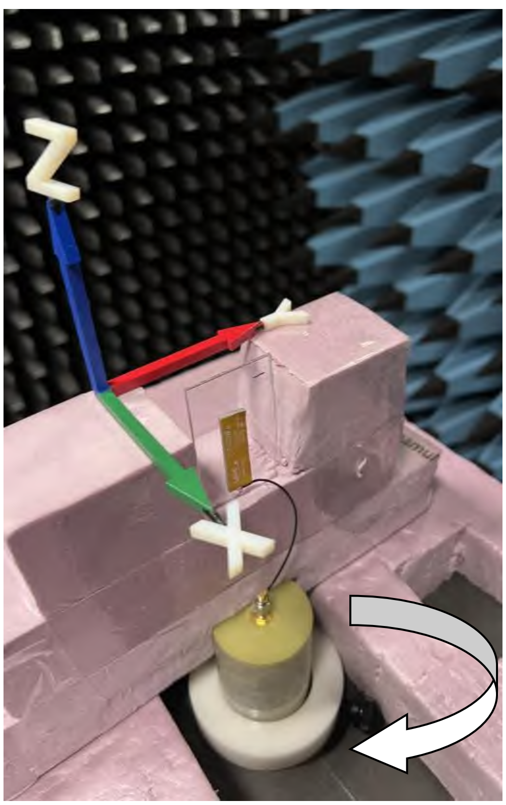
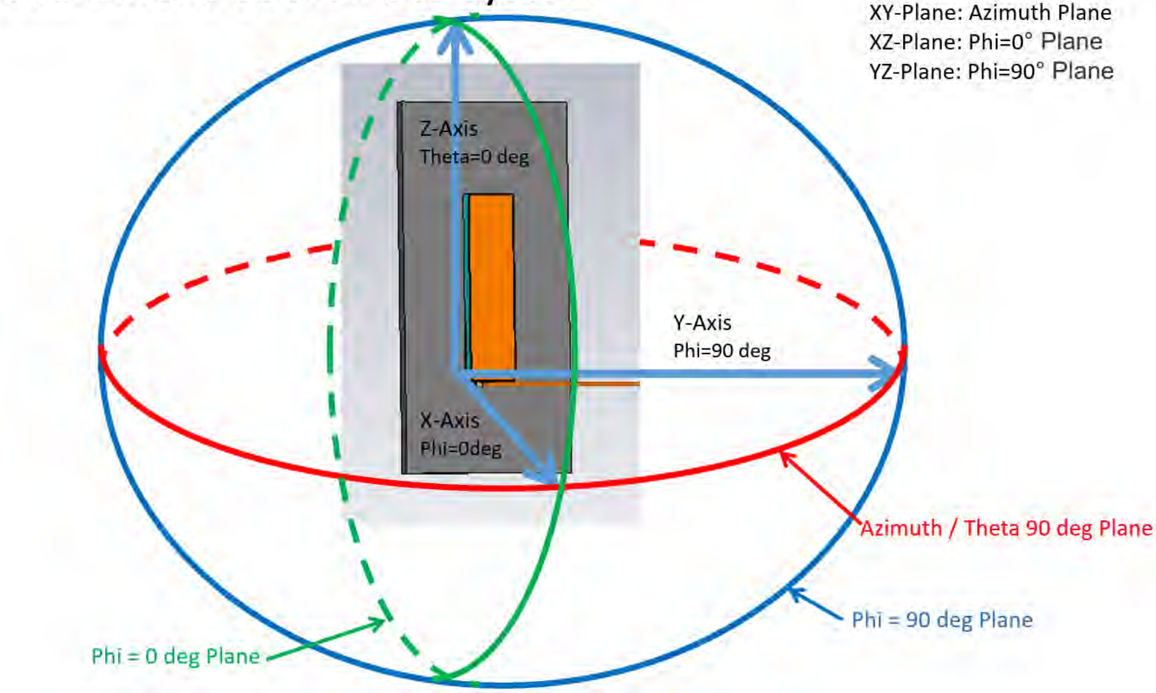


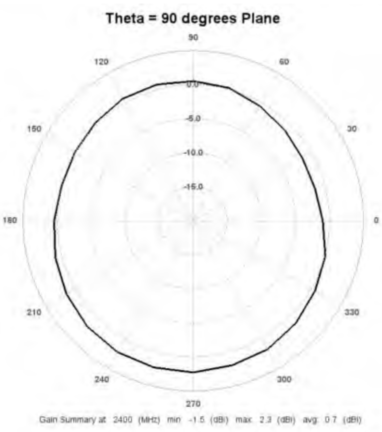
Figure 5: Flat surface setup

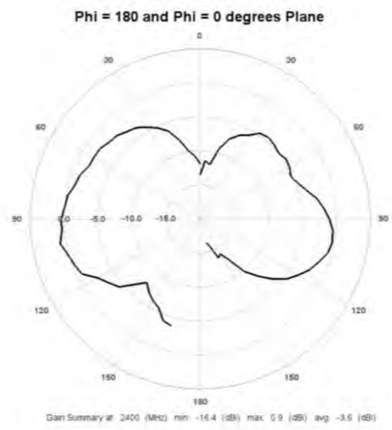
3D Measurement Coordinate System

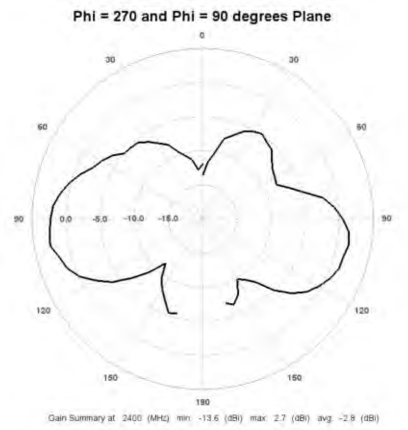


6.2 Radiation Patterns – 2D Plots

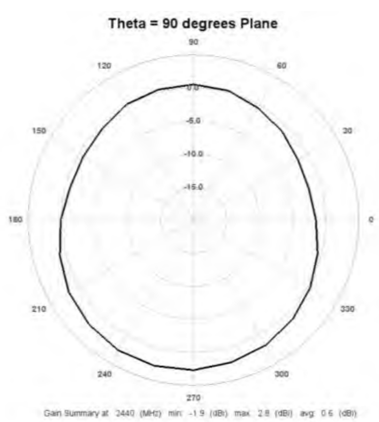
6.2.1 2D Plots at 2400 MHz

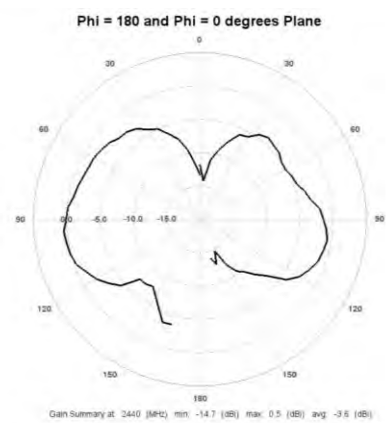


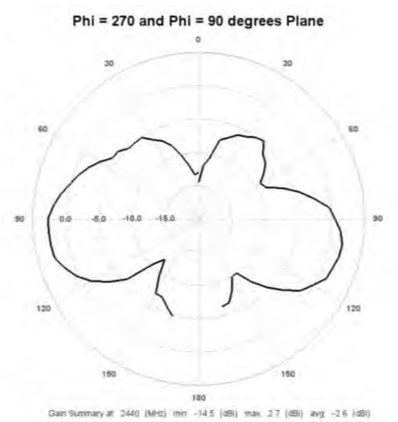




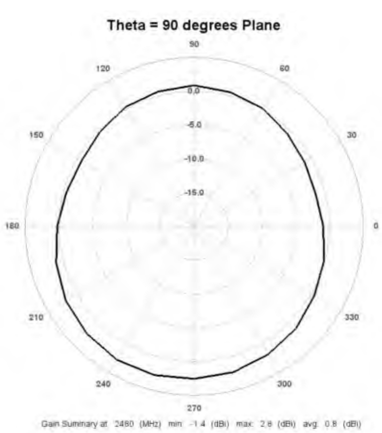
6.2.2 2D Plots at 2440 MHz

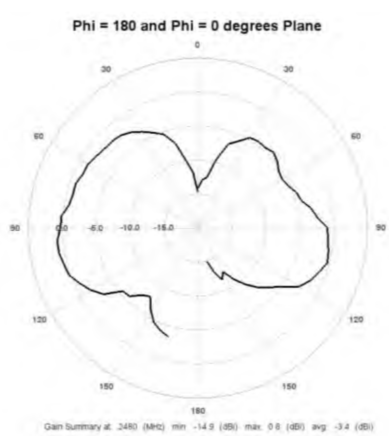


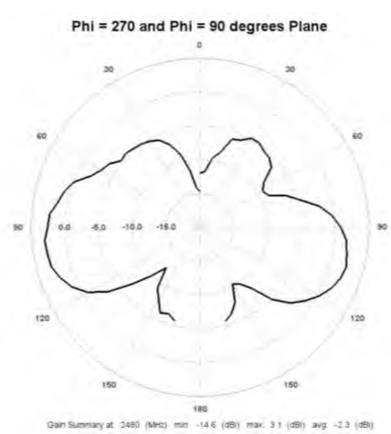




6.2.3 2D Plots at 2480 MHz







6.3 Radiation Patterns – 3D Plots

6.3.1 3D Plots at 2400 MHz

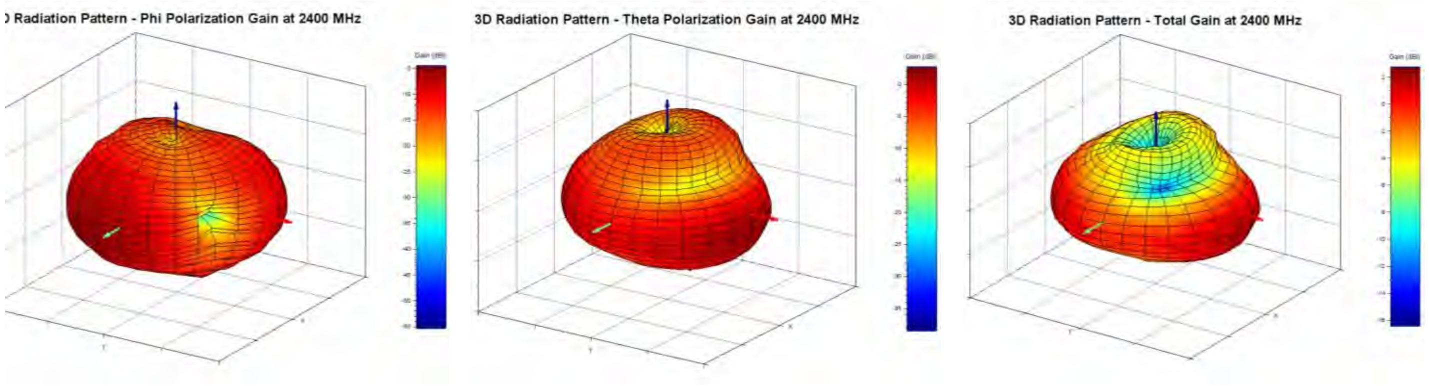


Figure 6: Phi polarization, Theta polarization and, and total gain plots – 2400 MHz

6.3.2 3D Plots at 2440 MHz

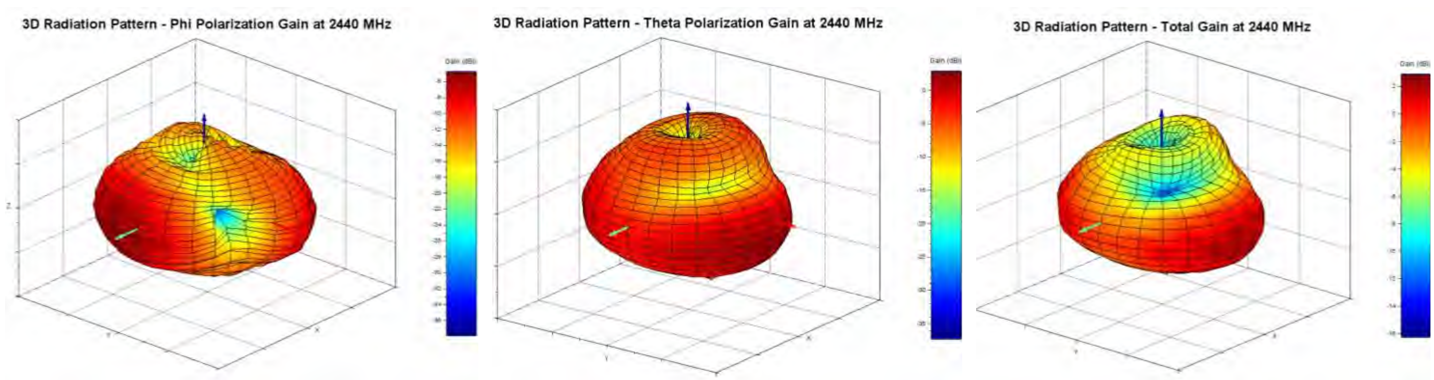


Figure 7: Phi polarization, Theta polarization and, and total gain plots – 2440 MHz

6.3.3 3D Plots at 2480 MHz

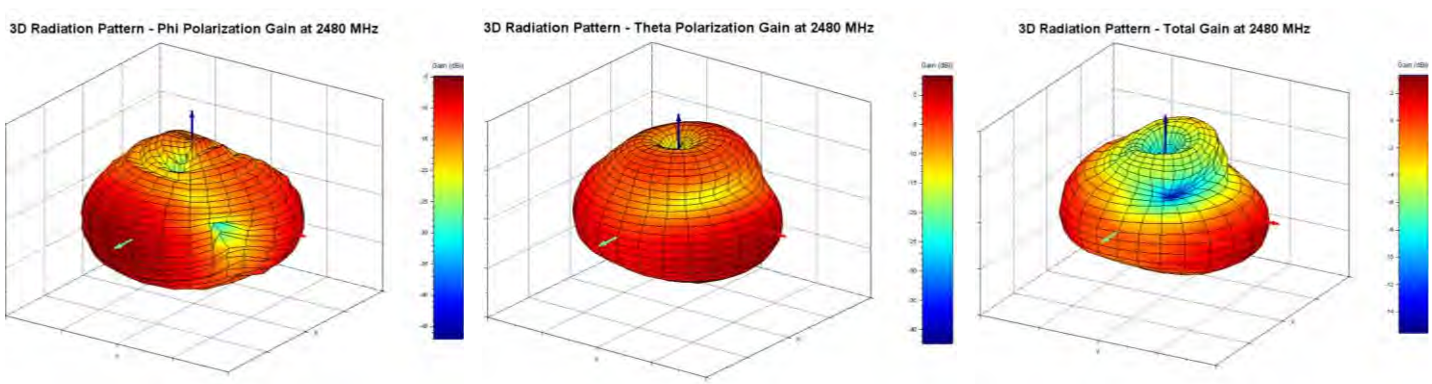


Figure 8: Phi polarization, Theta polarization and, and total gain plots – 2480 MHz

6.4 Efficiency

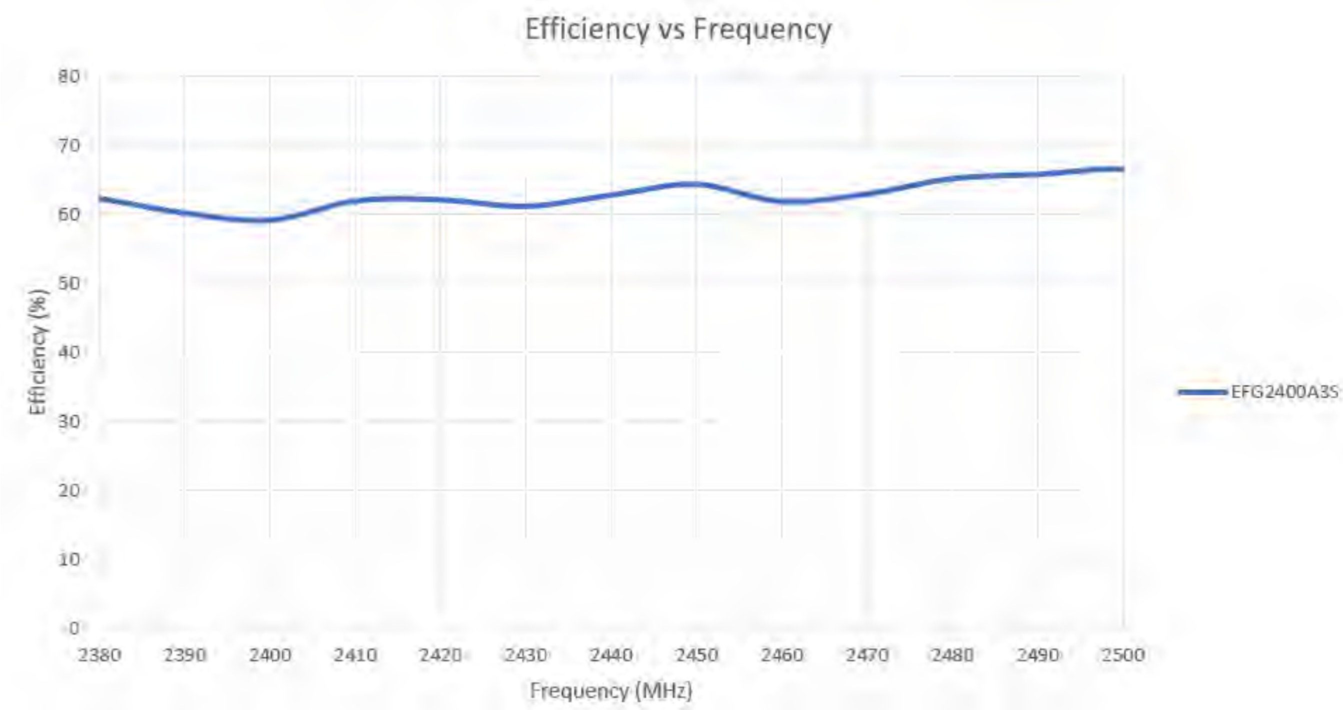


Figure 9: Antenna Efficiency measured on a 1.5 mm-thick plate of polycarbonate with a nominal value of -2.1dB across the operating frequency

6.5 Antenna Gain

Total Gain vs. Frequency (as per IEEE definition)

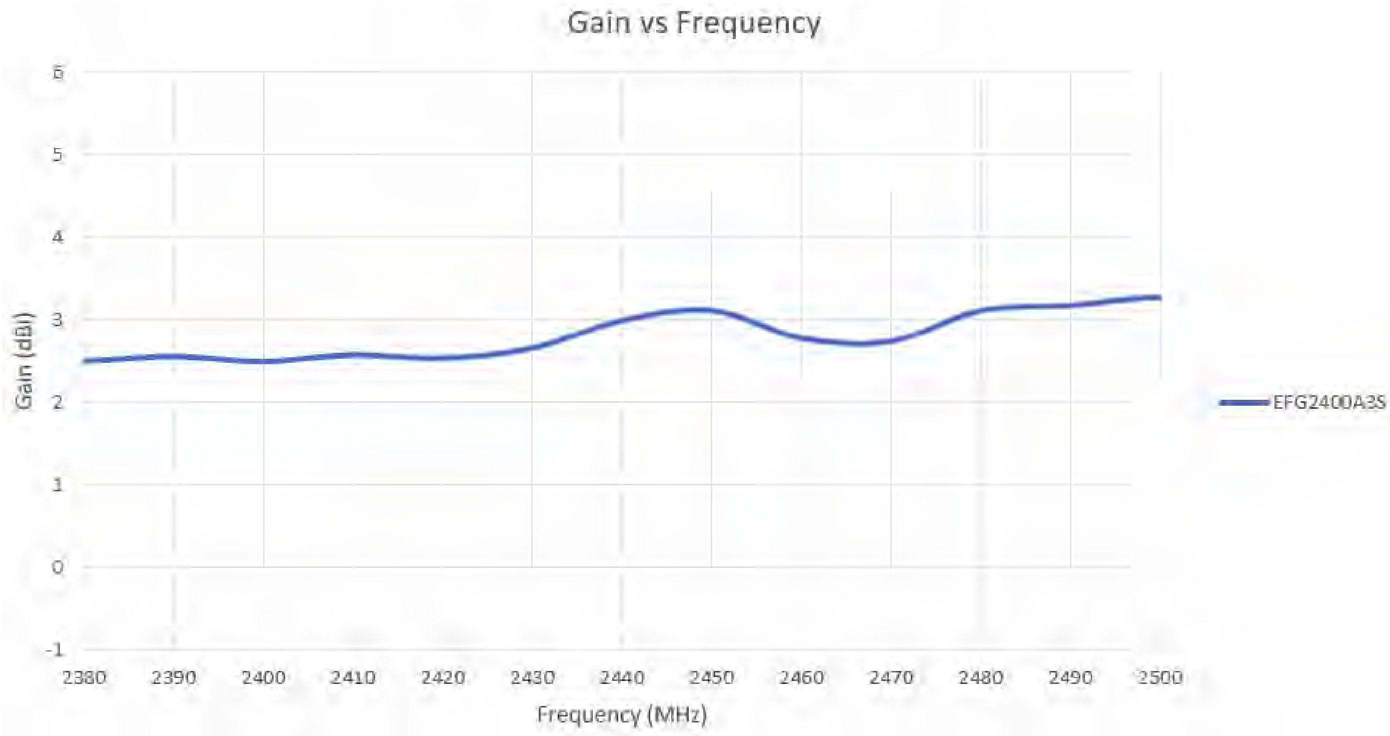


Figure 10: Antenna Gain measured on a 1.5 mm-thick plate of polycarbonate with a nominal value of 2.8dBi across the operating frequency

Peak Gain from Theta and Phi Polarization vs. Frequency

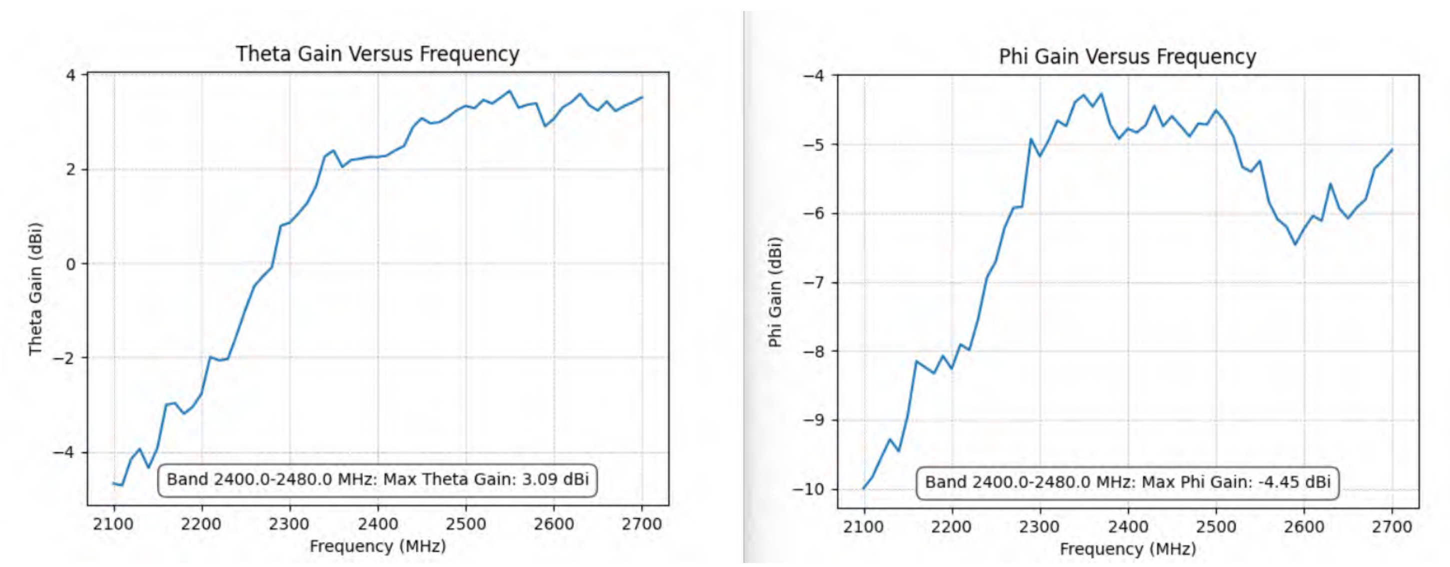


Figure 11: Peak Theta Polarization Gain and Phi Polarization Gain vs Frequency, measured on a 1.5mm-thick plate of polycarbonate

7 Antenna Placement & Keep Out Region

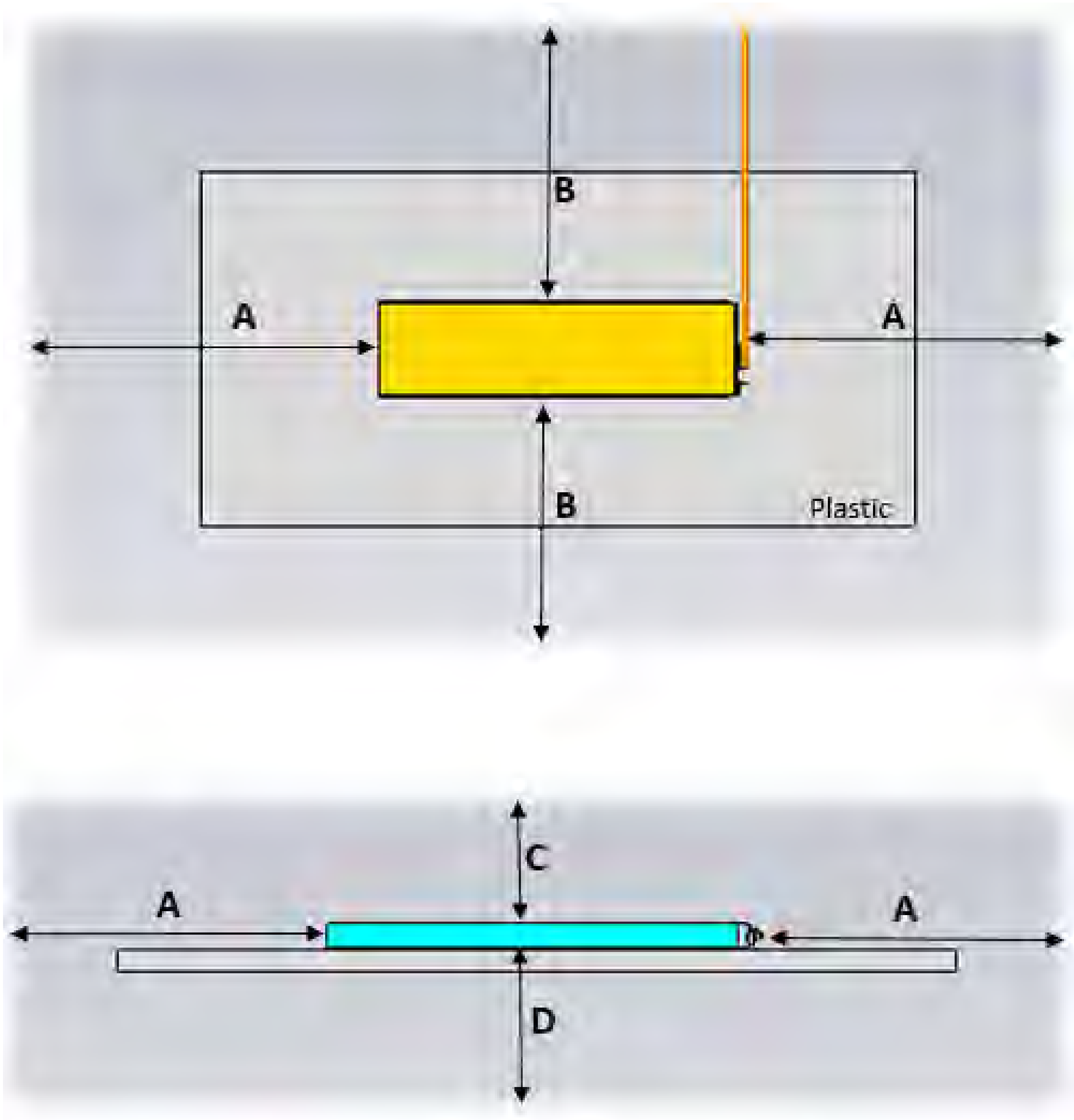
7.1 Antenna Placement

The i-FlexPIFA is designed to be attached to dielectric surfaces encountered in plastic packaging of wireless communications devices. The nominal attachment surface used in its design and characterization is a 120 mm x 70 mm, 1.5-millimeter thick, Polycarbonate sheet.

The VSWR of the i-FlexPIFA is shown below for the following materials and thicknesses **<u>outside</u>** of these specifications:

Material	Thickness (mm)	Max VSWR
Polycarbonate	[illegible]	[illegible]
Polycarbonate	[illegible]	[illegible]
Polycarbonate	[illegible]	[illegible]
Polycarbonate	[illegible]	[illegible]
ABS	[illegible]	[illegible]
ABS	[illegible]	[illegible]
Nylon	[illegible]	[illegible]
Nylon	[illegible]	[illegible]
Ceramic	[illegible]	[illegible]
Ceramic	[illegible]	[illegible]
Delrin	[illegible]	[illegible]
Delrin	[illegible]	[illegible]
FR4	0.8	1.7
FR4	[illegible]	[illegible]
PETG	[illegible]	[illegible]
PETG	[illegible]	[illegible]
Polypropylene	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
PVC [illegible]	4.5	[illegible]
PVC [illegible]	[illegible]	[illegible]

7.2 Antenna Conductive Material Keep Out Region



Keep Out Region Distance (mm)			
A	B	C	D
5	5	3	10

Notes:

- Antenna is designed to be mounted on polycarbonate with a nominal thickness of 2.25mm (1.mm - 3mm)
- Diagram is not to scale

8 Product Revision History

Rev 2.0 - Initial Production Release

9 Revision History

Version	Date	Notes	Contributors	Approver
1.0	20 Dec 2022	Initial Release		Adam Engelbrecht
2.0	31 Oct 2023	Added Antenna Placement & Keep Out Region		Adam Engelbrecht
3.0	13 May 2024	Ezurio rebranding	Sue White	Dave Drogowski

10 Additional Information

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

Headquarters	Ezurio 50 S. Main St. Suite 1100 Akron, OH 44308 USA
Website	http://www.ezurio.com
Technical Support	http://www.ezurio.com/resources/support
Sales Contact	http://www.ezurio.com/contact

Note: Information contained in this document is subject to change.

Datasheet

mFlexPIFA

2.4 – 2.5 GHz mFlexPIFA +2 dBi Antenna, 100 mm cable length with U.FL or MHF4L connector

Version 3.1

Revision History

Version	Date	Notes	Contributors	Approver
2.0	15 Aug 2017	Initial release on website		Sue White
2.1	20 Mar 2018	Added new antenna connector information; transitioned to new template; updated contact information; updated mounting guidelines		Jay White
2.2	14 Jul 2023	Updated 2D Antenna Drawing		
3.0	21 Oct 2024	Ezurio rebranding	Sue White	Dave Drogowski
3.1	3 Feb 2025	Fix antenna images in Optimal Installation Guide	Dave Drogowski	Elaine Baxter

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1 Ordering Information

Table 1: Ordering information

Order Number	Description
001-0030	mFlexPIFA – 2.4 GHz embedded metal FlexPIFA antenna, 100 mm cable length w/ U.FL connector
EFA2400A3S-10MH4L	mFlexPIFA – 2.4 GHz embedded metal FlexPIFA antenna, 100 mm cable length w/MHF4L connector

2 Key Features

- Designed to be installed directly on metal
- Can be installed on different conductive surfaces and thicknesses
- Quick and easy Installation
- Adhesive holds to surface during humidity exposure and hot/cold cycles

3 Specifications

Table 2: mFlexPIFA specifications

Specification	Value
Peak Gain	+2 dBi
Average Gain	>-4.2 dBi
Impedance	50 ohms
Type	Flexible Planar Inverted F Antenna (FlexPIFA)
Polarization	Linear
VSWR	≤ 3.0:1, 2400 - 2480 MHz
Frequency	2400 - 2480 MHz
Weight	1.8 g
Size	25.4 mm × 23.4 mm × 2.5 mm
Antenna Color	Clear Yellow
Adhesive	3M 100MP
Operating Temp	-40°C to +85°C
Connector Height	U.FL: 2.5 mm maximum
Connector Height	MHF4L: 1.7 mm maximum

4 Physical Dimensions

4.1 001-0030

Note: All measurements are in millimetres (mm).

Figure 1: Physical dimensions

5 Test Setup

Antenna measurements such as VSWR are measured with an Agilent E5071C Vector Network Analyzer. Radiation patterns

are measured with a CMT Planar 804/1 Vector Network Analyzer in a Howland Company 3100 Chamber equivalent. Phase Center is 9 inches above the Phi positioner.

Flat surface measurements are done with the antenna centered on a 100 x 100 mm, 0.35 mm thick brass plate. Curved surface measurements are taken by placing the antenna on a curved surface made of 0.35 mm thick brass.

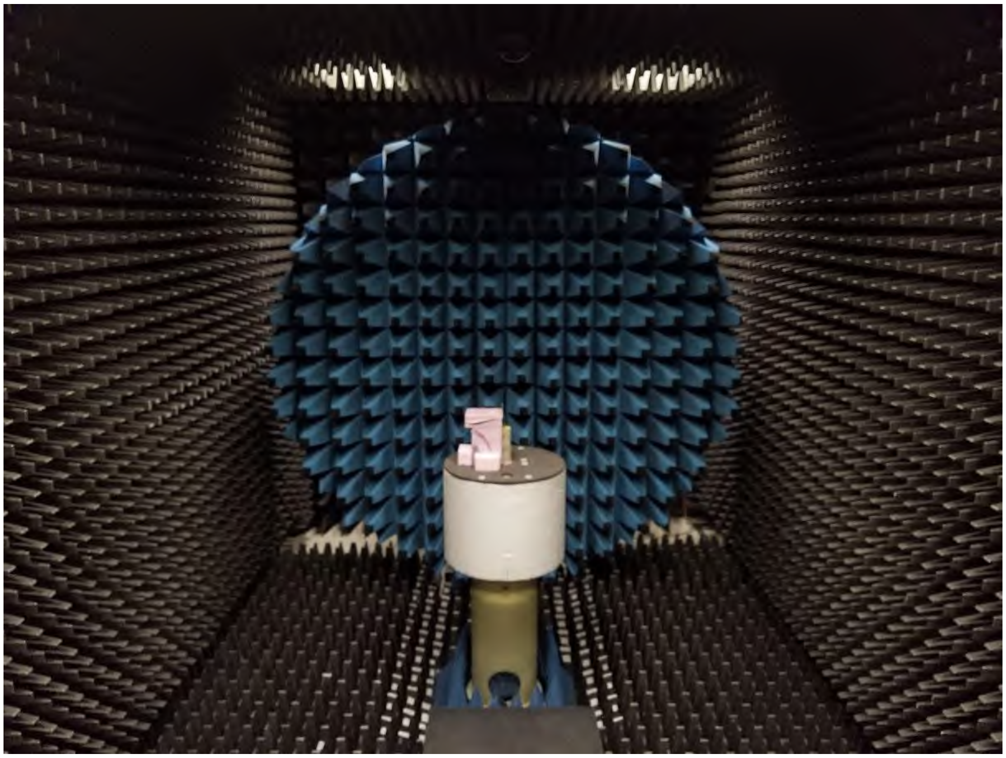

Figure 2 Antenna Chamber

6 Flat Surface Antenna Measurements

6.1 Return Loss

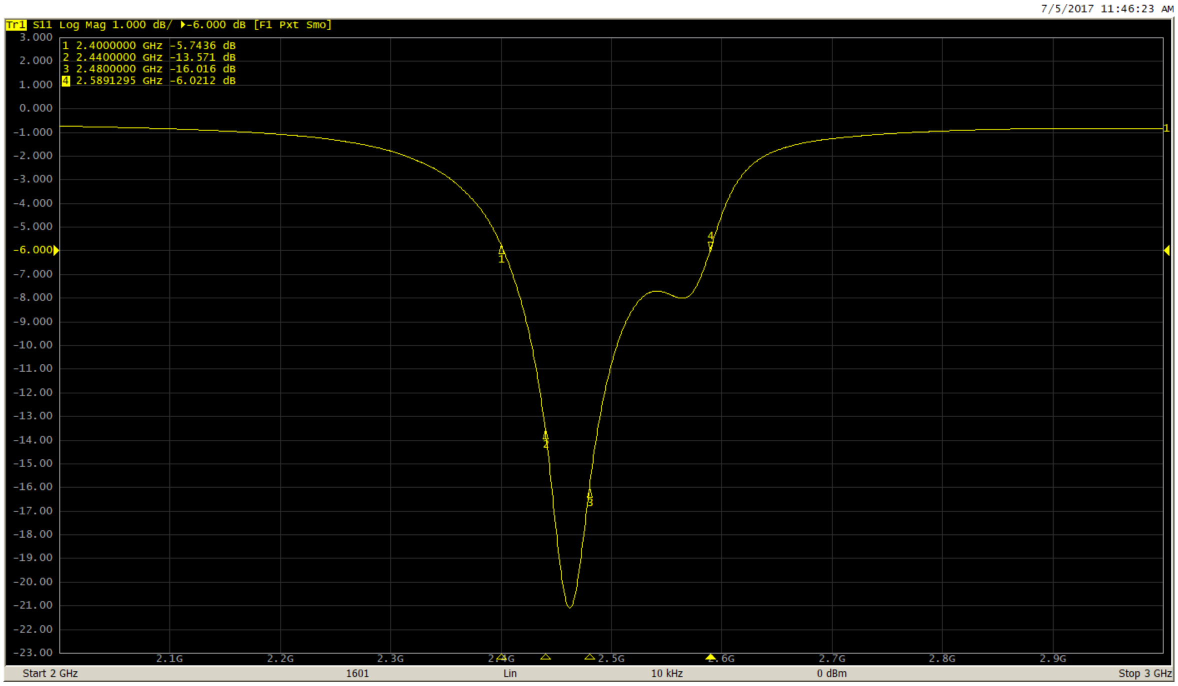

Figure 3: Return loss measured on a 0.35 mm thick, 100 x 100 mm brass plate

7 Flat Surface Antenna Radiation Performance

7.1 Antenna Setup

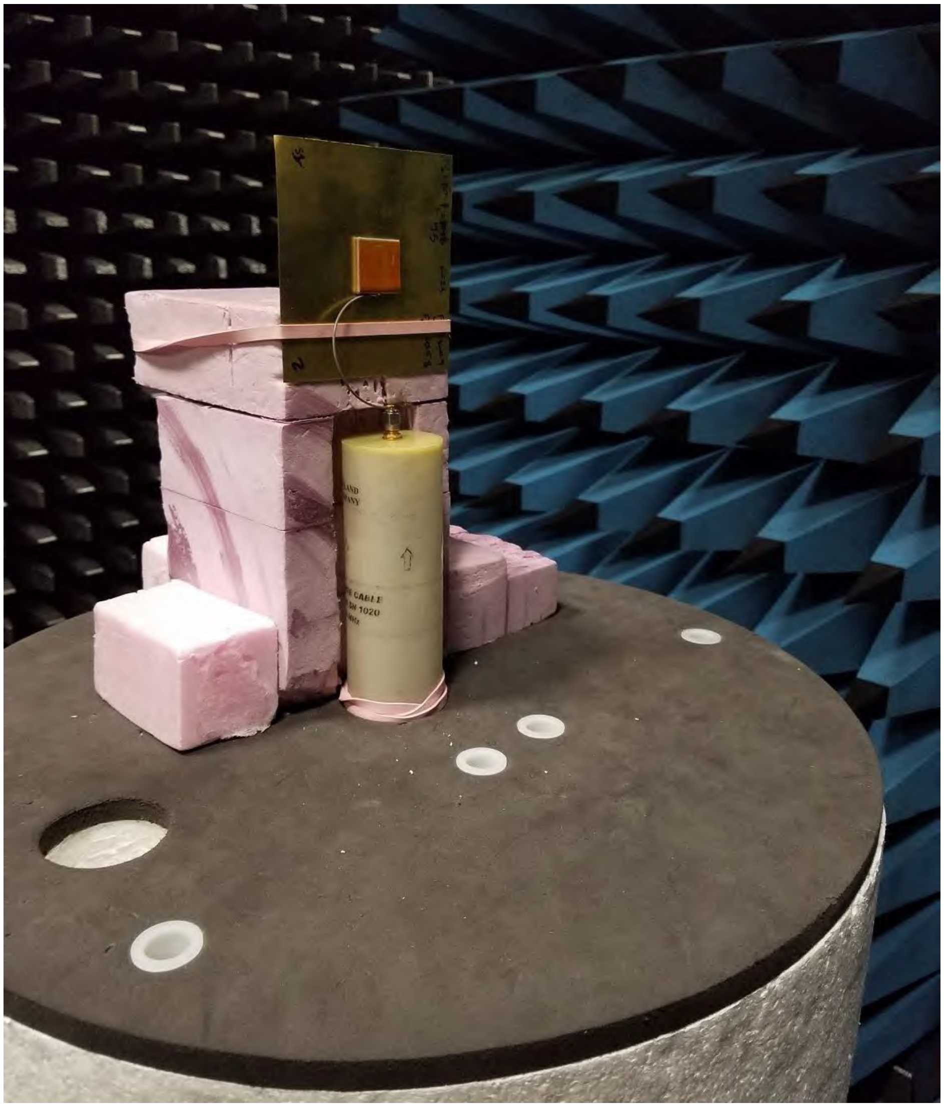

Figure 4: Flat surface setup

7.2 Results – Flat Surface

2400 MHz

Azimuthal Conical Cuts at 2400 MHz

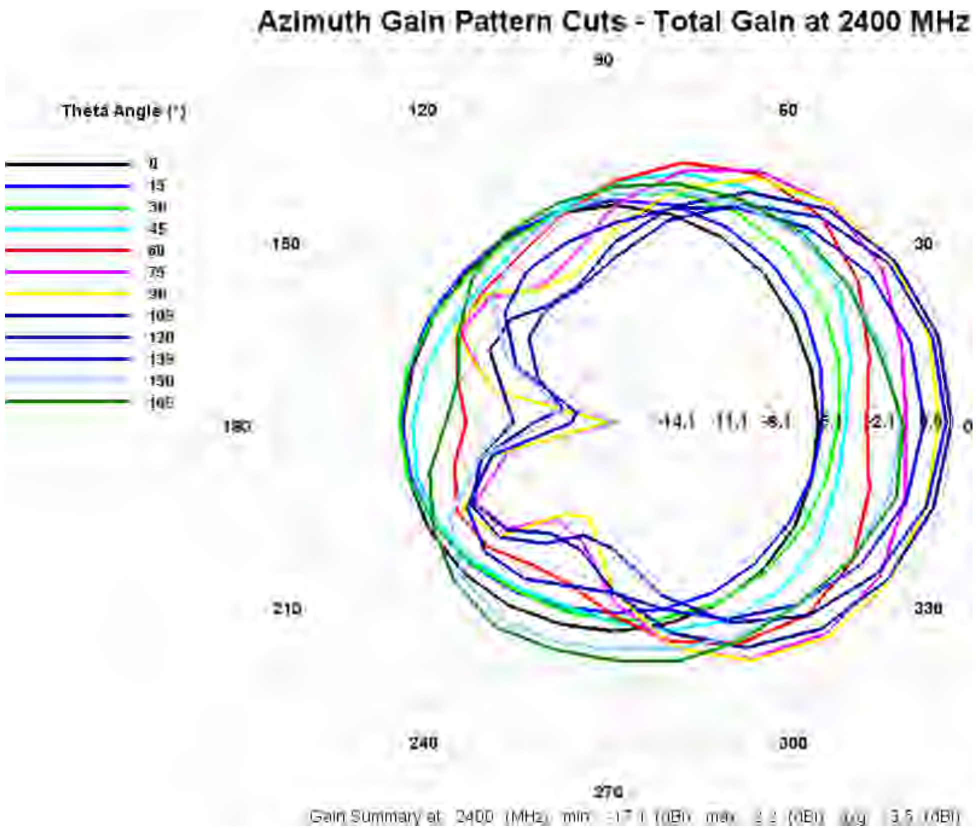

Figure 5: Total gain pattern – 2400 MHz

3D Plots at 2400 MHz

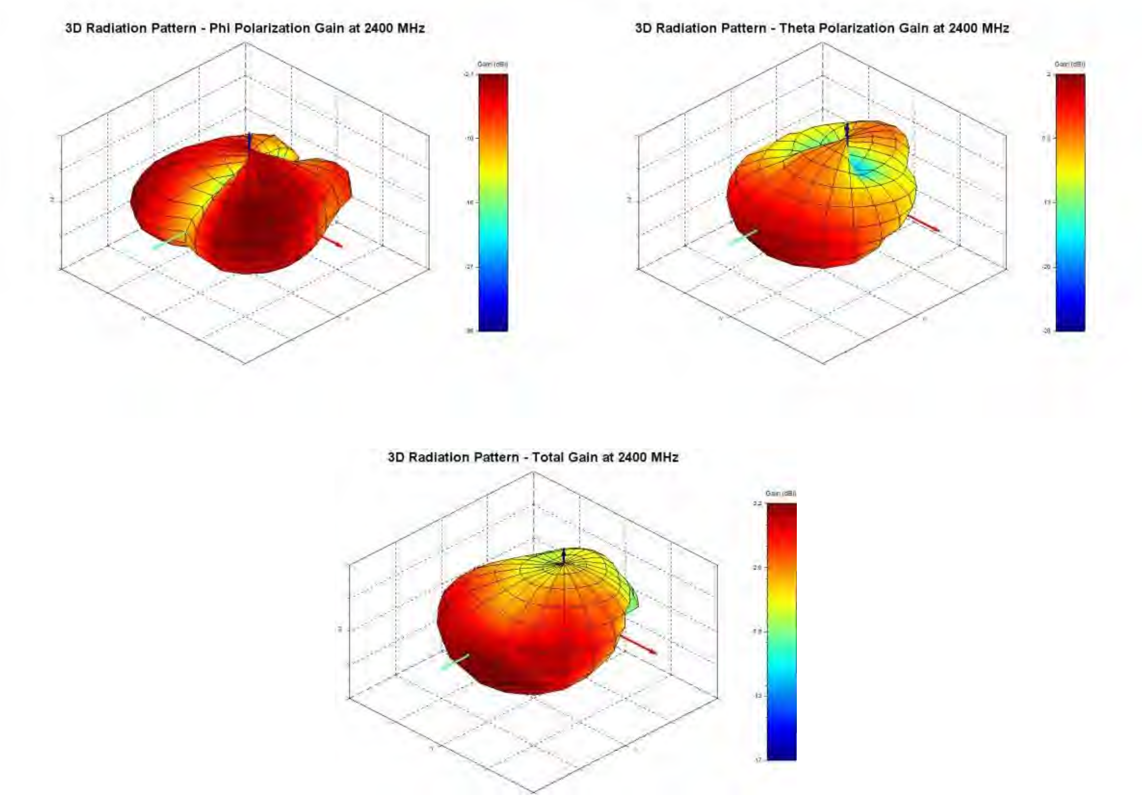

Figure 6: Phi, theta, and total gain plots – 2400 MHz

2440 MHz

Azimuthal Conical Cuts at 2440 MHz

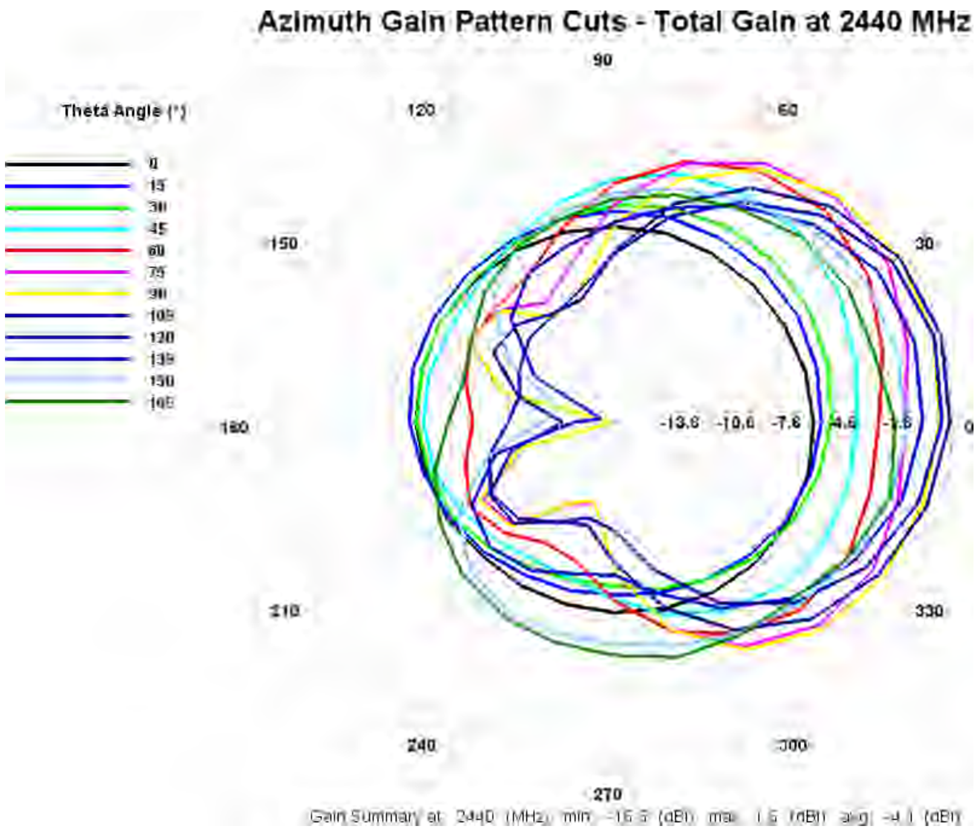

Figure 7: Total gain pattern – 2440 MHz

3D Plots at 2440 MHz

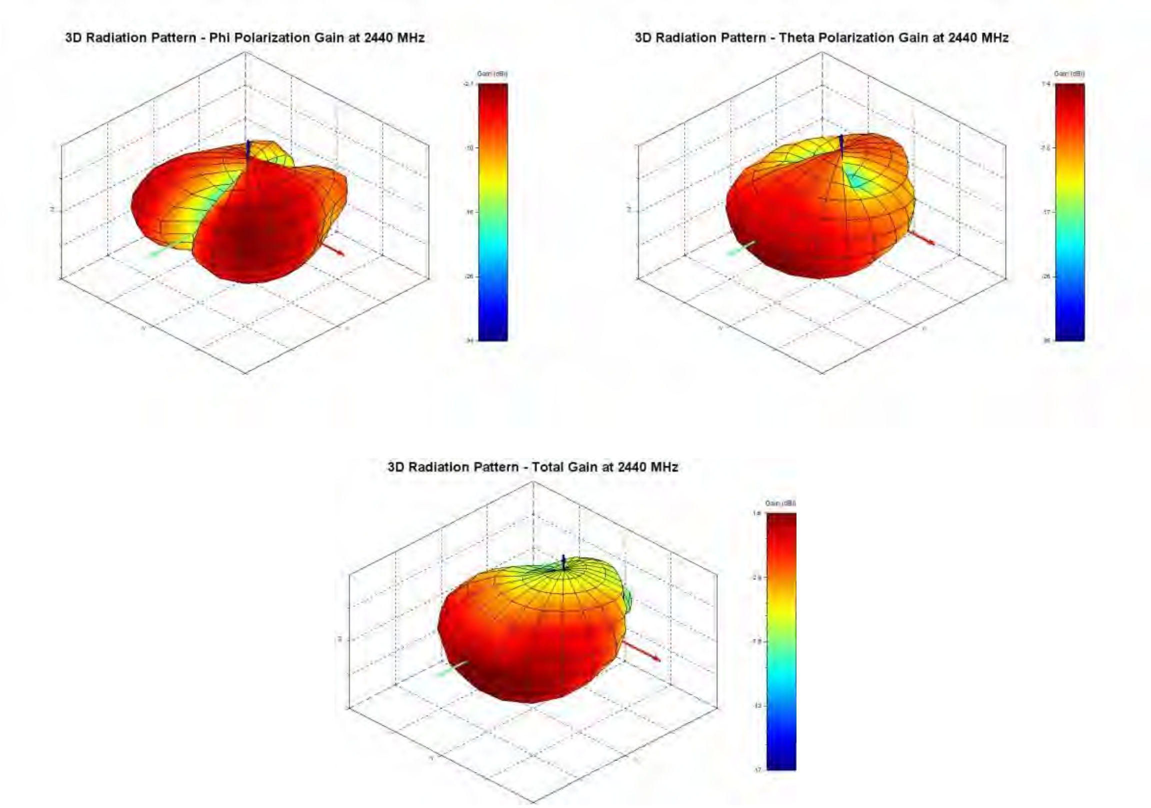

Figure 8: Phi, theta, and total gain plots – 2440 MHz

2480 MHz

Azimuthal Conical Cuts at 2480 MHz

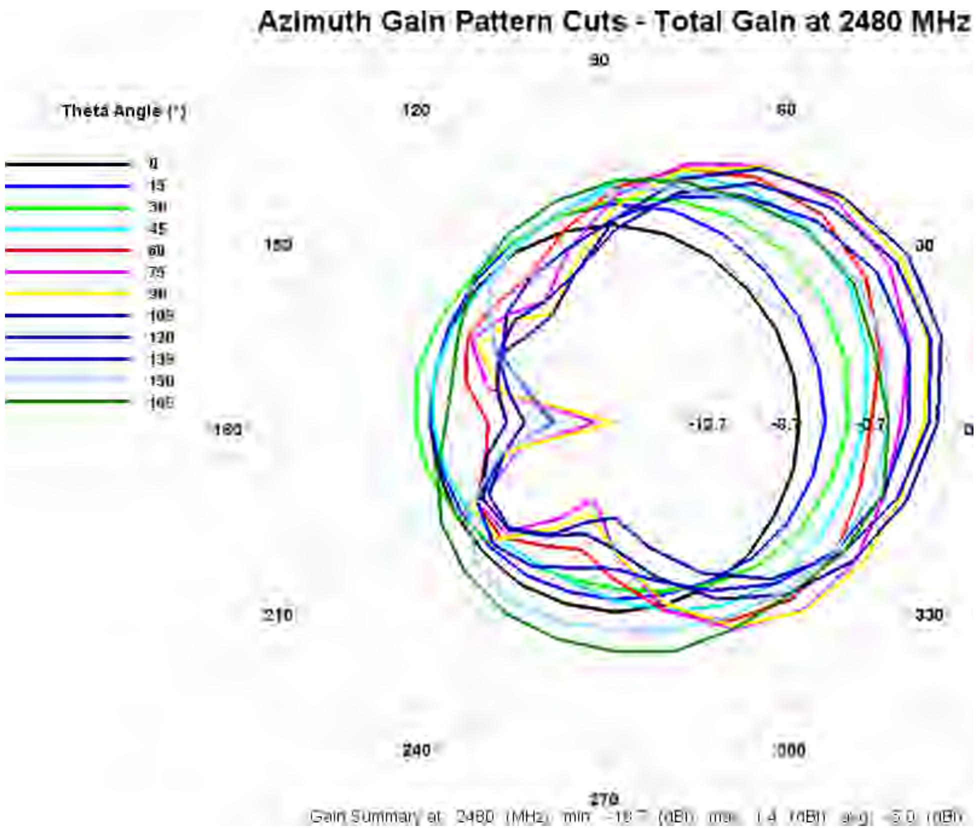

Figure 9: Total gain pattern – 2480 MHz

3D Plots at 2480 MHz

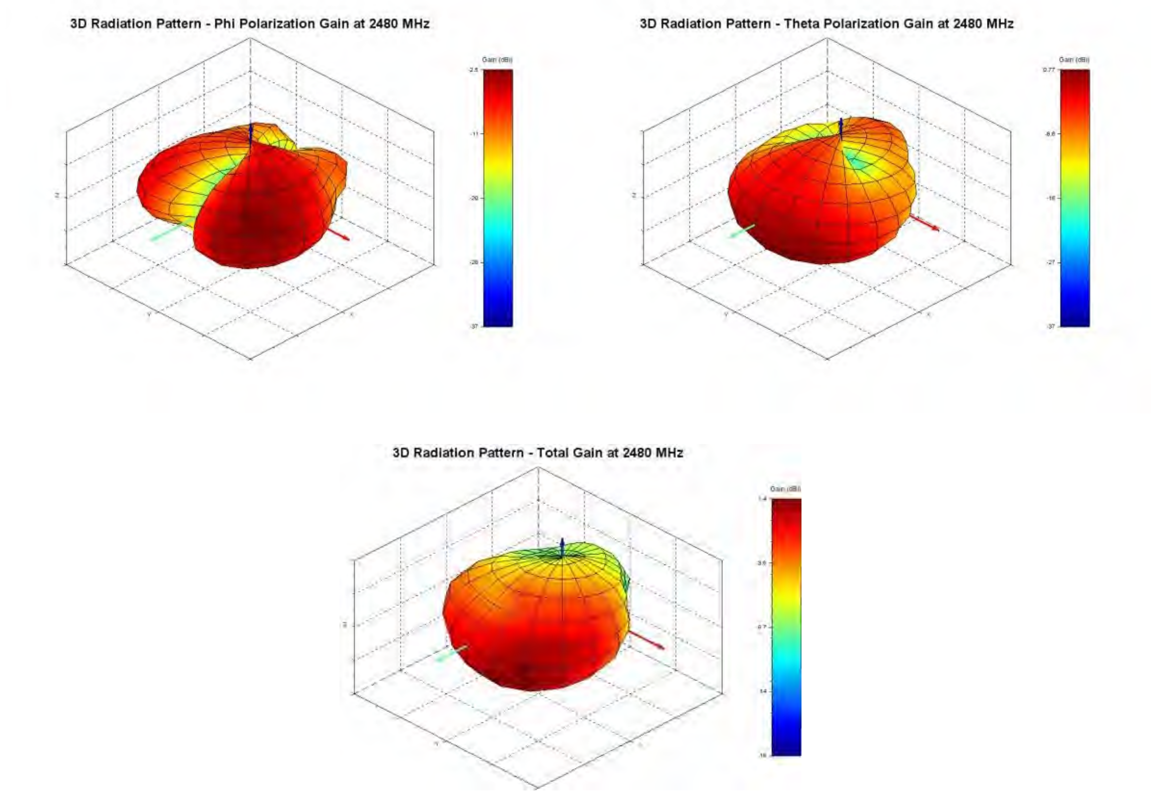

Figure 10: Phi, theta, and total gain plots – 2480 MHz

8 Curved Surface Antenna Radiation Performance

8.1 Antenna Setup

The mFlexPIFA is placed on the outside of a 60-mm outer diameter metal tube.

Figure 11: Convex curve setup

8.2 Results – Curved Surface

2440 MHz

Azimuthal Conical Cuts at 2440 MHz

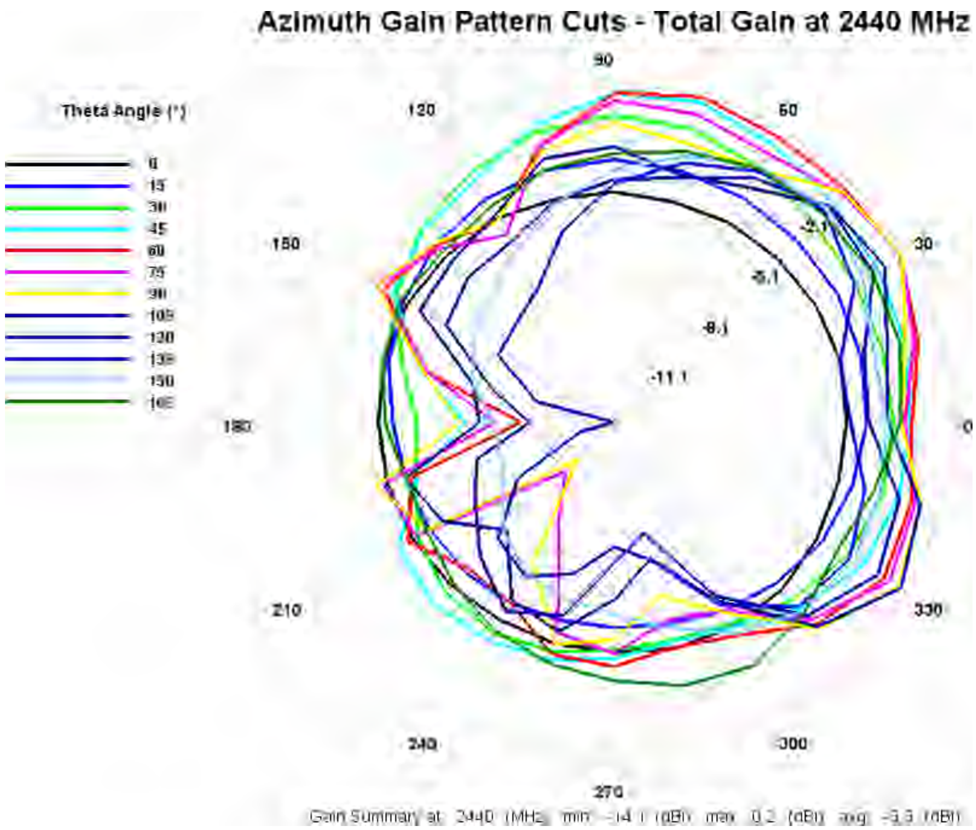

Figure 12: Total gain pattern – 2440 MHz

3D Plots at 2440 MHz

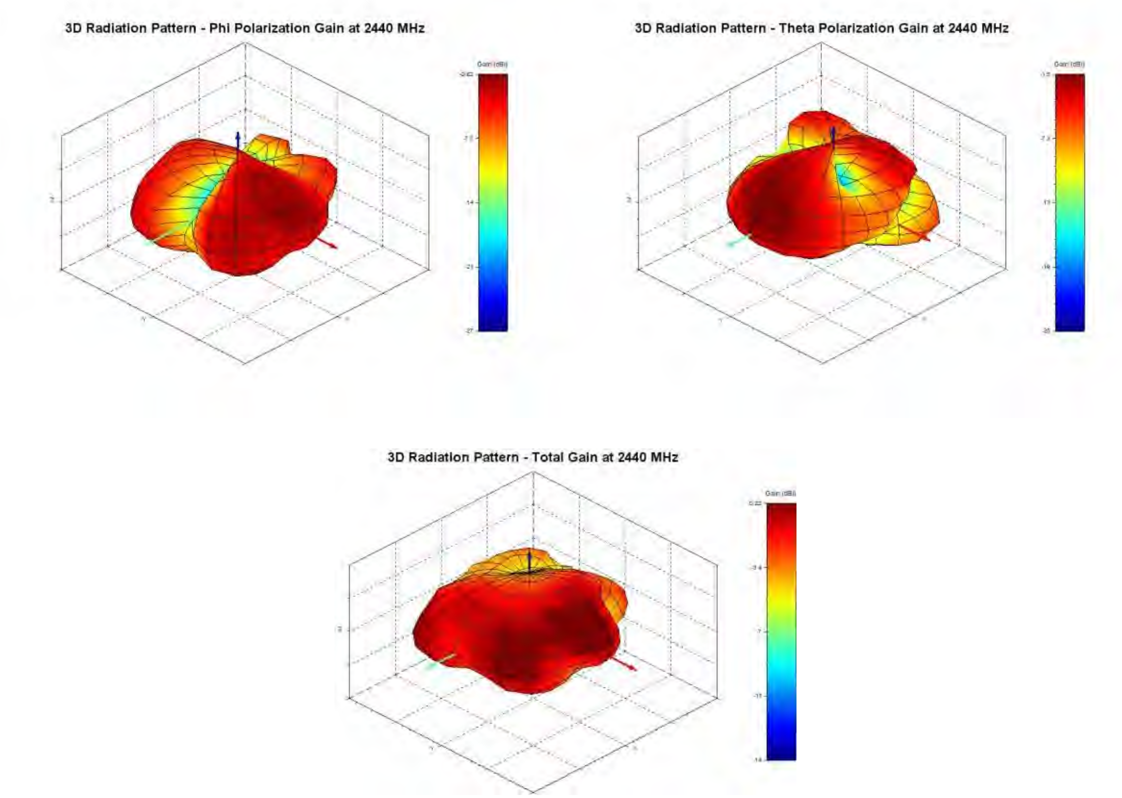

Figure 13: Phi, theta, and total gain plots – 2440 MHz

9 Optimal Installation Guide

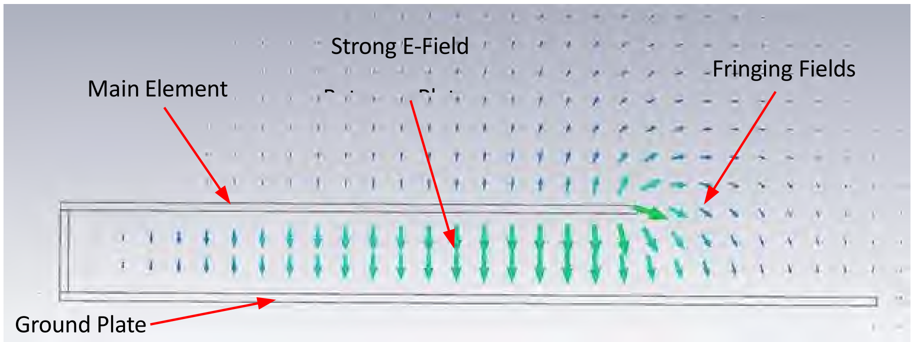

Figure 14: E-field radiation from the FlexPIFA. Taken from CST simulation

Keep the main element clear of any non-metal objects (such as plastics) on top of it by at least three millimeters (see Figure 15).

Figure 15: Top clearance

Similarly, keep the two long sides of the mFlexPIFA clear of any non-metal objects by at least two millimeters (see Figure 16). For metal objects, the top side of the mFlex should be kept clear by at least two millimeters and the bottom side of the mFlex at least 12 millimeters (see Figure 17). Images below are based on the 2.4GHz FlexPIFA (Ezurio PN: 001-0014) and used for reference only.

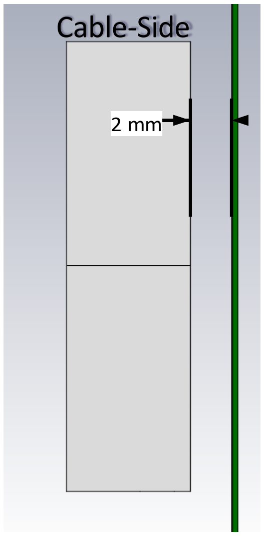

Figure 16: Non-metal side clearance (Top View)

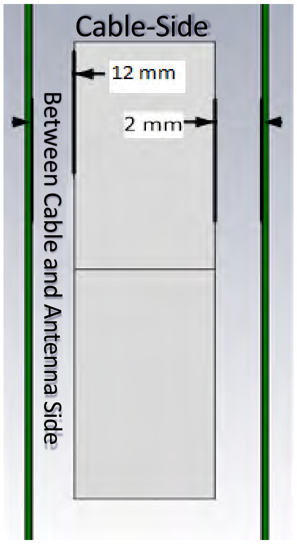

Figure 17: Metal side clearance (Top View

A one-millimeter clearance should be observed from the ground wall to any non-metal object (Figure 18). A 15-millimeter clearance should be observed for metal objects (Figure 19).

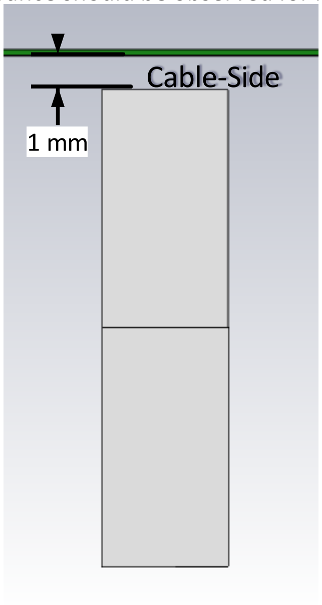

Figure 18: Non-metal ground wall clearance

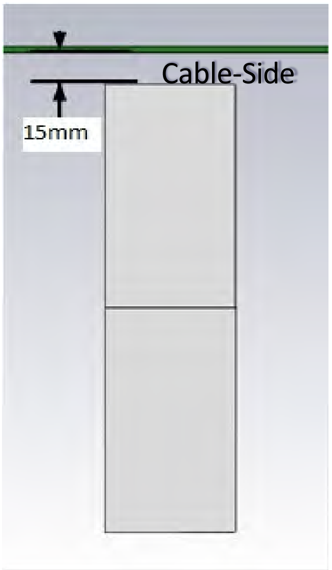

Figure 19: Metal ground wall clearance

Important! Mounting the mFlexPIFA 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.

The ideal material for the mFlexPIFA to be mounted on (for maximum performance) is brass. However, as previously mentioned, the mFlexPIFA can tolerate other metallic surfaces and thicknesses and still radiate effectively. Depending on the type of material, the mFlexPIFA may be detuned.

The coaxial cable feeding the mFlexPIFA should be routed away from the antenna. Do not run the coaxial cable over the top of the mFlexPIFA or near the tip of the main element. The cable should be routed perpendicular to the side of the

Perpendicular to the Side

Away from the Ground Wall

Figure 20: Recommended cable routing

As with any antenna, do not place objects near the antenna (except as described in the next section). Other objects, such as an LCD display, placed near the antenna may not affect its tuning but can distort the radiation pattern. Materials that absorb electromagnetic fields should be kept away from the antenna to maximize performance.

- Wire routing
- Speakers – These generate magnetic fields Battery location
- Proximity to human body
- Display screen – These absorb radiation

9.1 Flex Limits of the mFlexPIFA

One of the unique features of the mFlexPIFA is its ability to flex. However, due to the adhesive, there are limits to how much the antenna can be flexed and still remain secured to the device. The mFlexPIFA should not be flexed in a convex position with a radius less than 60 millimeters. Going smaller than this may result in the antenna peeling off the surface over time. Should a tighter radius of curvature be required, we recommend that you contact Ezurio for assistance.

Figure 21: Convex mounted

We do not recommend mounting the mFlexPIFA in a metal-enclosed concave position. In this scenario, the limiting factor is performance. The ground plate of the antenna is pressed closer to the main element. The fringing fields developing off the end of the element are responsible for most of the radiation. In a concave position, the fringing fields are adversely affected, and gain suffers. This can also potentially create a Faraday's cage and cancel most of the RF radiation from the antenna.

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

10 Additional Information

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

Headquarters	Ezurio 50 S. Main St. Suite 1100 Akron, OH 44308 USA
Website	http://www.ezurio.com
Technical Support	http://www.ezurio.com/resources/support
Sales Contact	http://www.ezurio.com/contact

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