## TITLE

# WIFI 6E PCB CABLED BALANCED ANTENNA

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## WIFI 6E PCB CABLED BALANCED 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 PCB Cable Balanced Antenna

Series Number: 146187 Series

#### 2.2 DESCRIPTION

Series 146187 is a balanced, dipole-type, high efficiency antenna for applications, including WiFi 6E, Bluetooth, Zigbee and others. This antenna is made from poly PCB material with small size.

#### 2.3 PRODUCT STRUCTURE INFORMATION

Please refer to PS-1461870100 for full information.



ANTENNA 3D VIEW

## 3.0 APPLICABLE DOCUMENTS

| DOCUMENT | NUMBER | DESCRIPTION |
|---|---|---|
| Sale Drawing (SD) | SD-1461870050 | Mechanical Dimension of the product |
| Product Specification (PS) | PS-1461870100 | Product Specification |
| Packing Drawing (PK) | PK-1461870100 | Product packaging specifications |

## 4.0 ANTENNA PERFORMANCE

### 4.1 RF TEST CONDITIONS

All measurements are done of the antenna in free space with VNA Agilent E5071C and Over-The-Air (OTA) chamber. All measurements in this document are done with the part no.1461870100 with a cable length of 100mm.

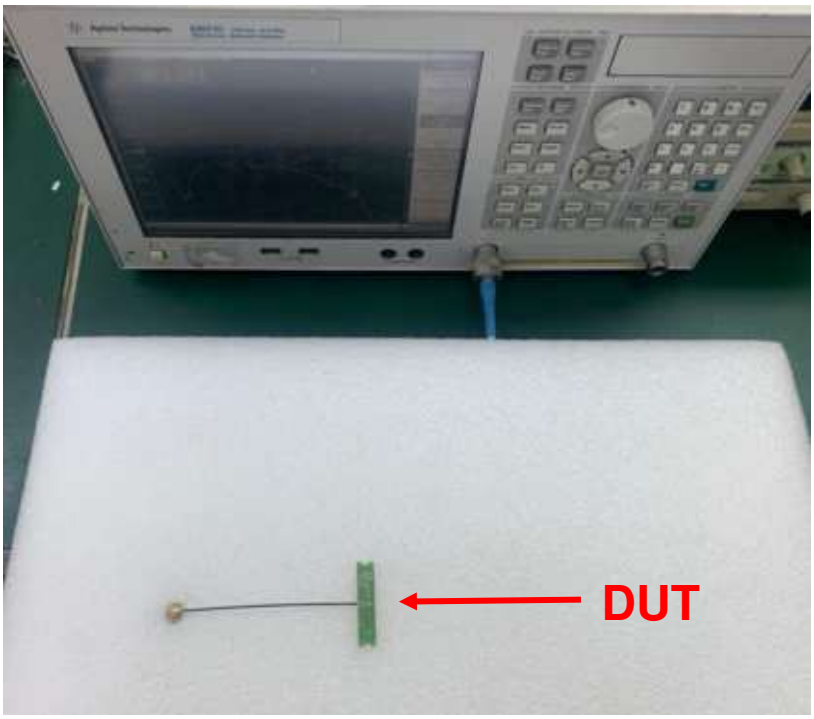



**FIGURE4.1.1 ANTENNA IN FREE SPACE WITH VNA AGILENT E5071C**

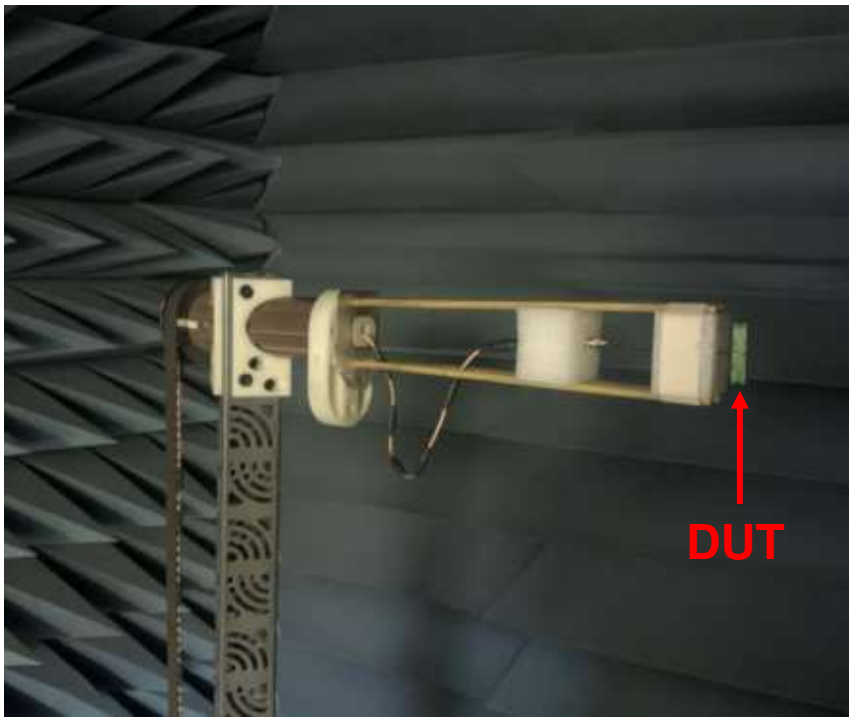



**FIGURE4.1.2 ANTENNA IN FREE SPACE WITH OTA CHAMBER**

| DESCRIPTION | EQUIPMENT | REQUIREMENT | | |
|---|---|---|---|---|
| Frequency Range | VNA E5071C | 2.4-2.5GHz | 5.15-5.85GHz | 5.925-7.125GHz |
| Return Loss | VNA E5071C | <- 10dB | <- 10dB | <- 5dB |
| Peak Gain (Max) | OTA Chamber | 2.8dBi | 4.0dBi | 4.3dBi |
| Average Total Efficiency | OTA Chamber | >80% | >80% | >70% |
| Polarization | OTA Chamber | Linear | | |
| Input Impedance | VNA E5071C | 50 ohms | | |

Note that the above antenna performance is measured with just the antenna in 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.

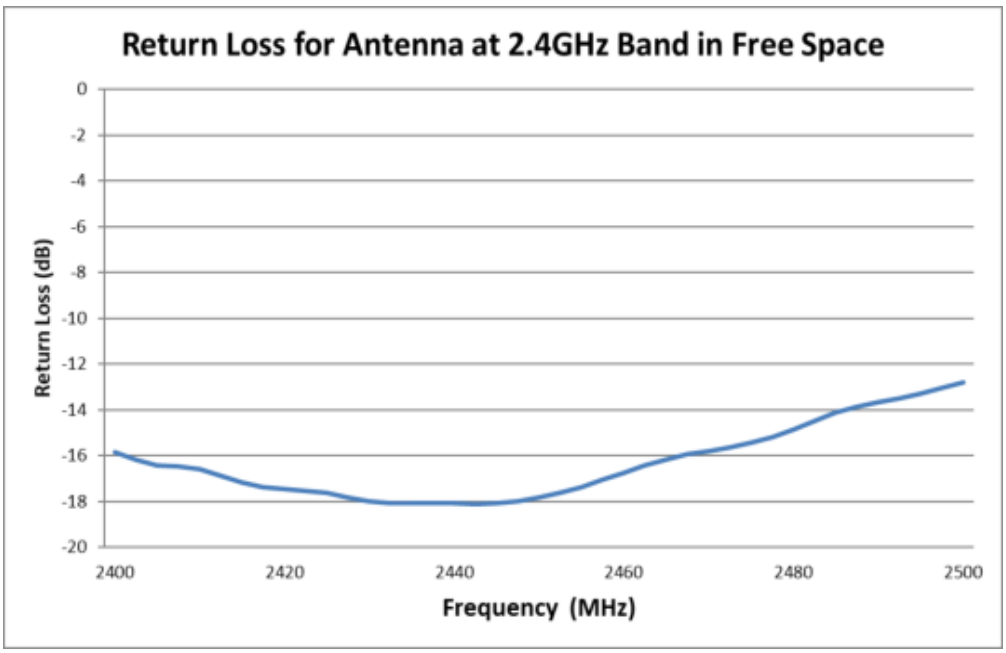



**FIGURE 4.3.1 RETURN LOSS OF ANTENNA AT 2.4GHZ BAND IN FREE SPACE**

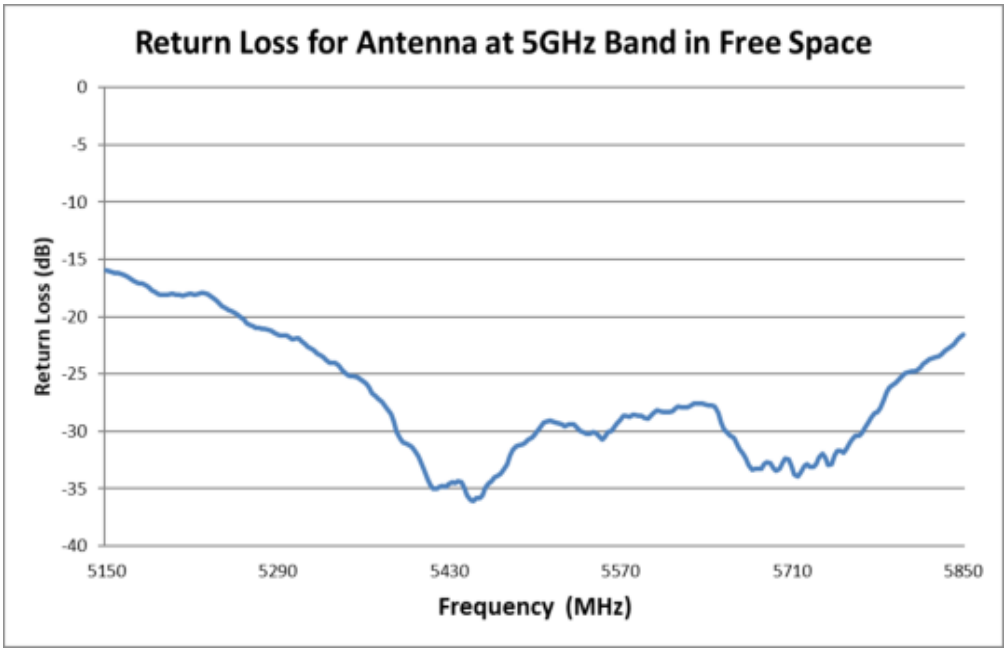



**FIGURE 4.3.2 RETURN LOSS OF ANTENNA AT 5GHZ BAND IN FREE SPACE**

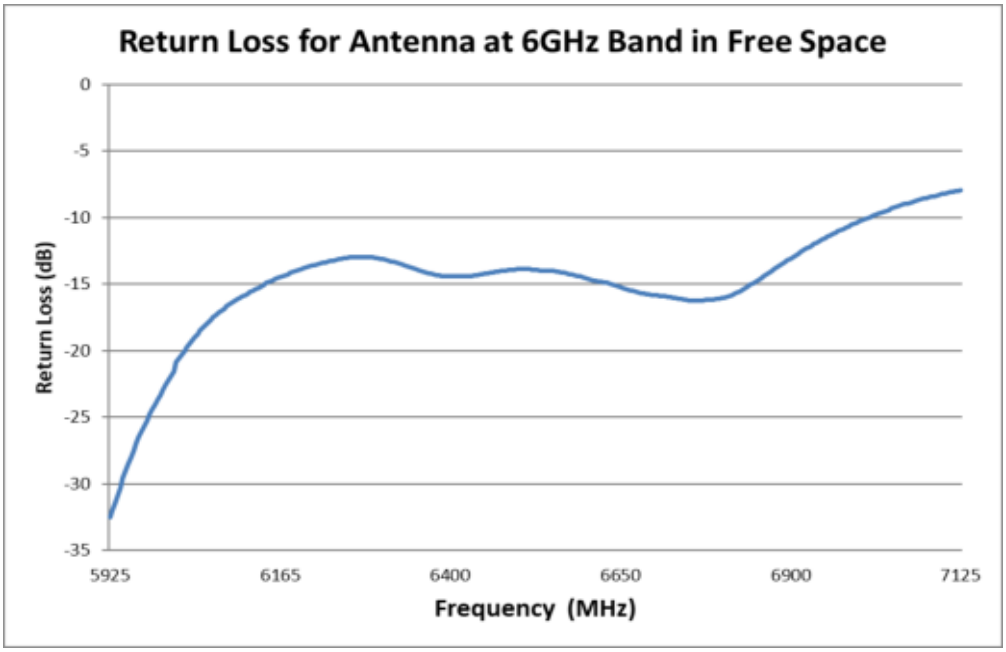



**FIGURE 4.3.3 RETURN LOSS OF ANTENNA AT 6GHZ BAND IN FREE SPACE**

### 4.4 EFFICIENCY PLOT

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

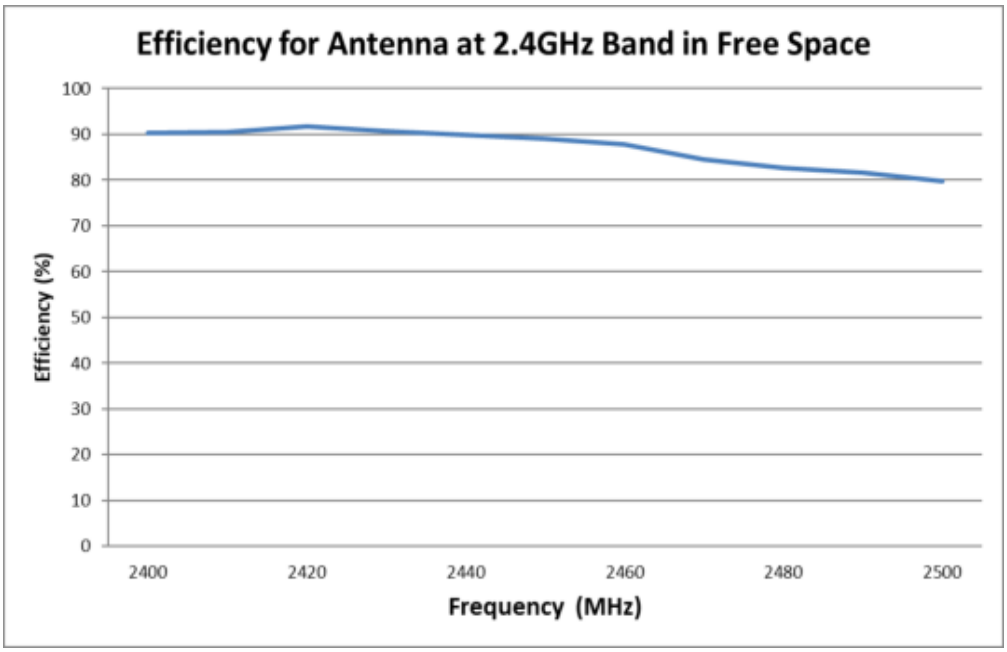



**FIGURE 4.4.1 EFFICIENCY OF ANTENNA AT 2.4GHZ BAND IN FREE SPACE**

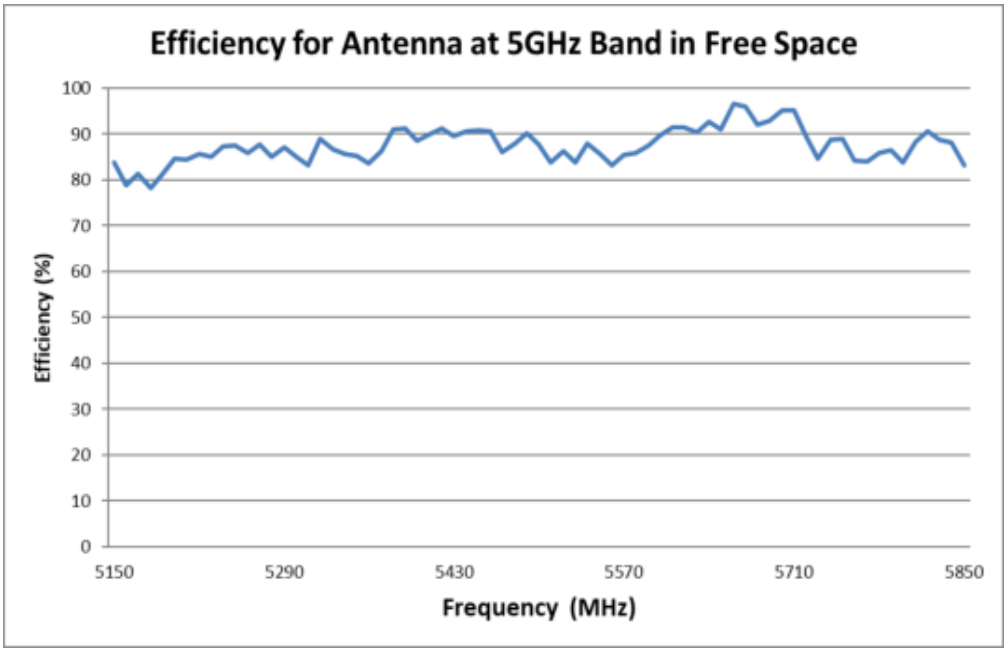



**FIGURE 4.4.2 EFFICIENCY OF ANTENNA AT 5GHZ BAND IN FREE SPACE**

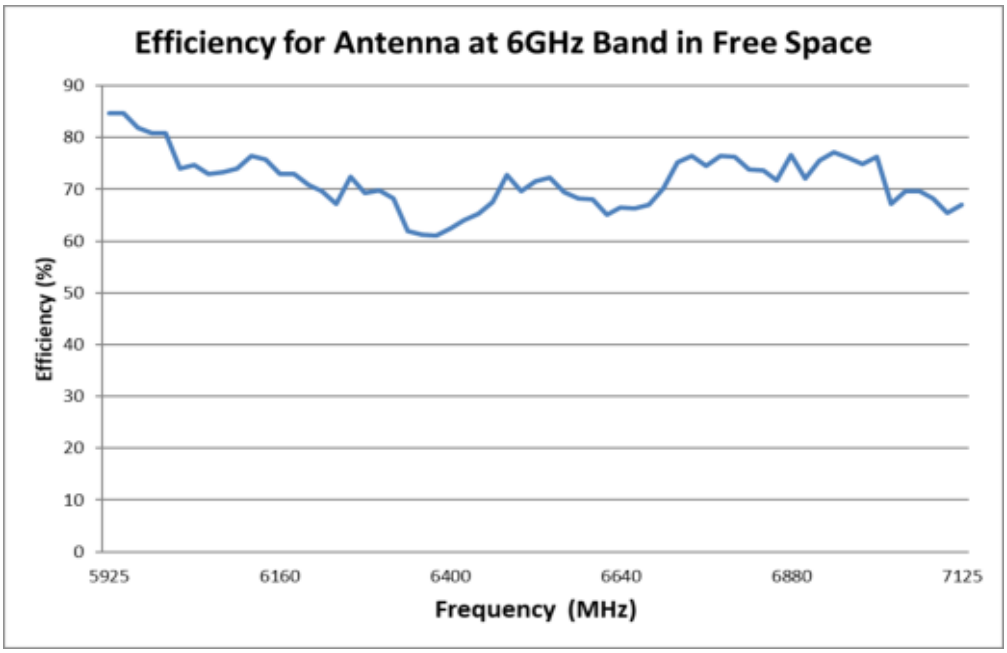



**FIGURE 4.4.3 EFFICIENCY OF ANTENNA AT 6GHZ BAND IN FREE SPACE**

### 4.5 RADIATION PATTERN

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

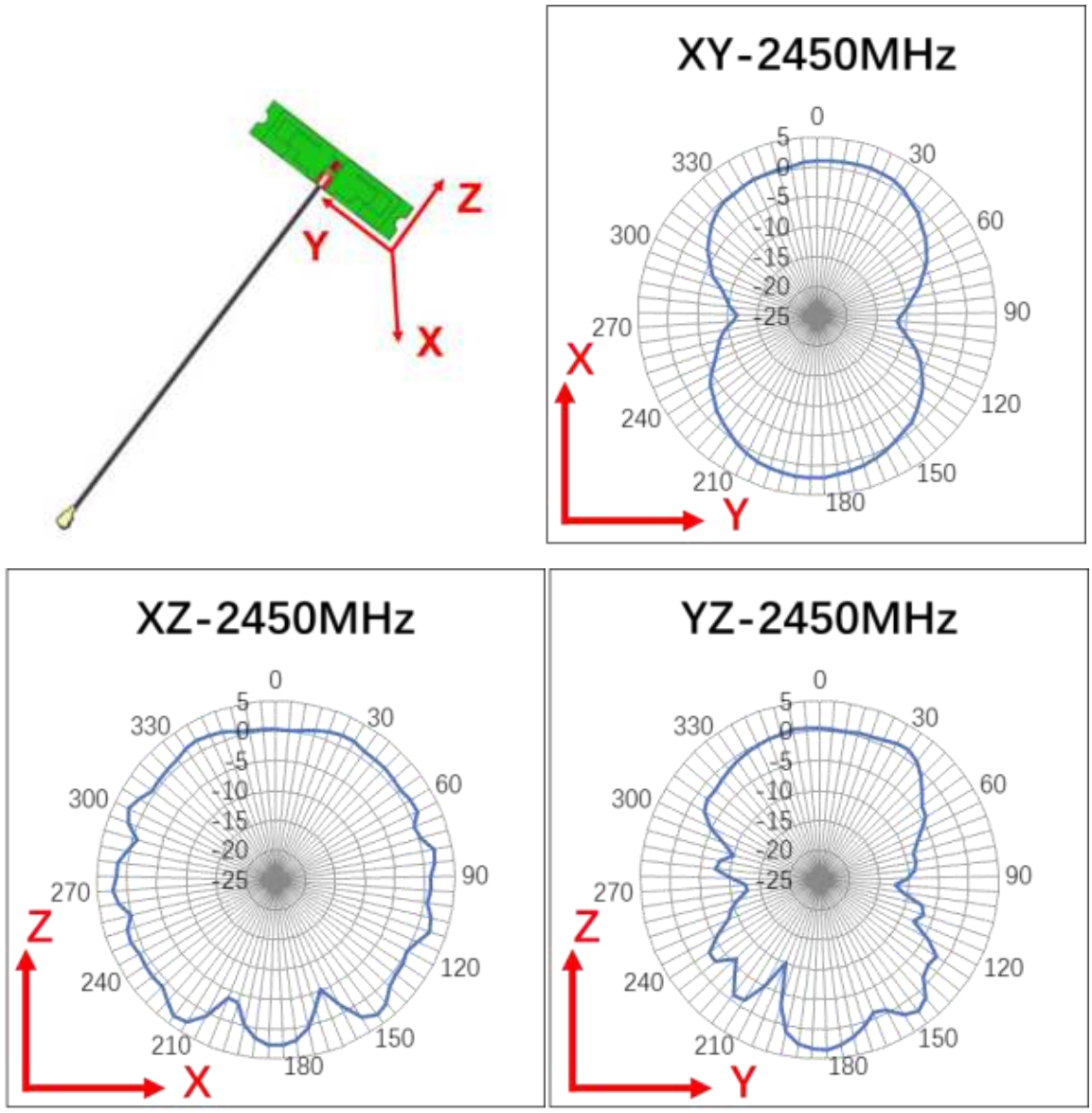



**FIGURE 4.5.1 2D RADIATION PATTERN OF ANTENNA AT 2450MHZ IN FREE SPACE**

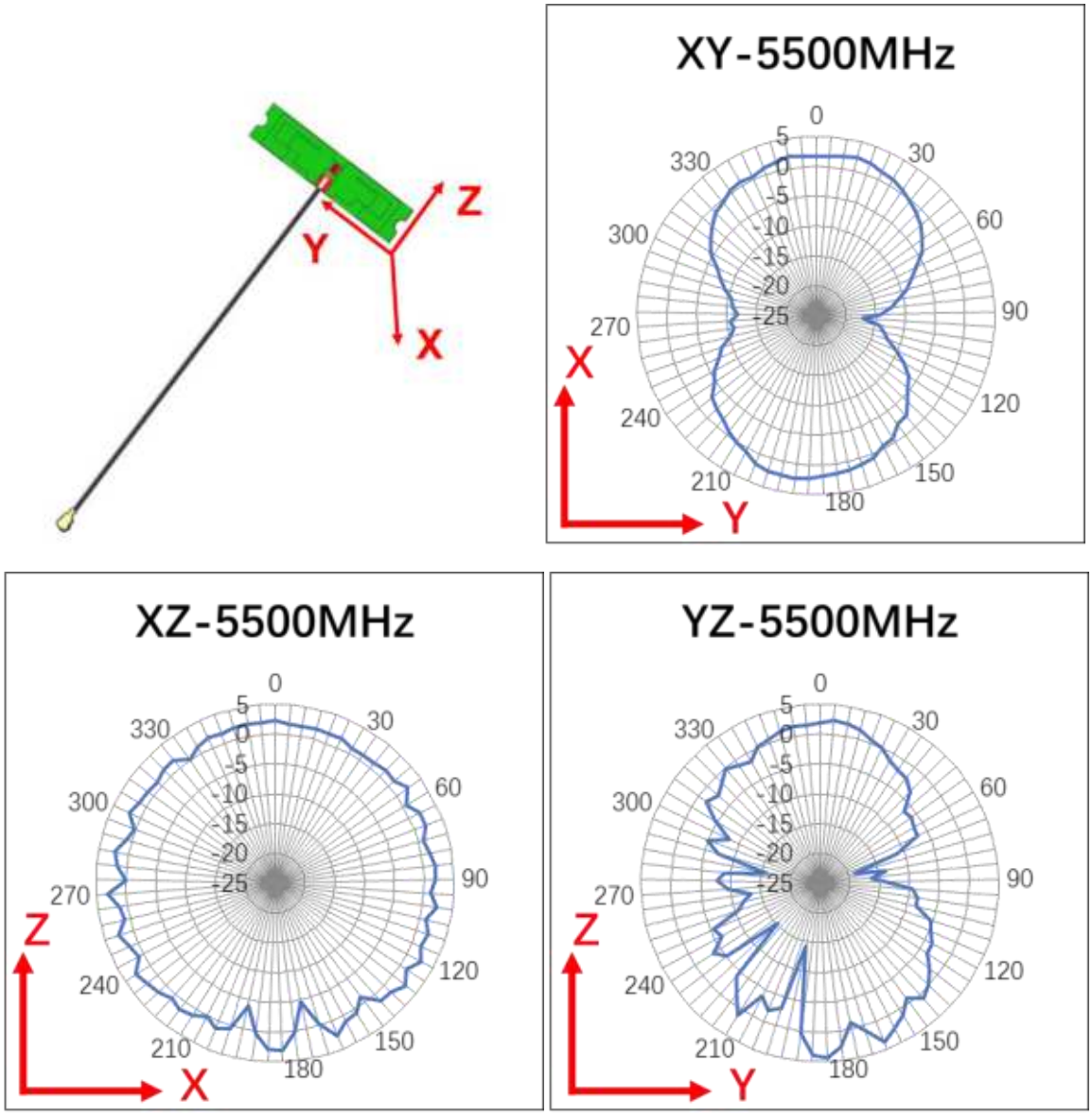



**FIGURE 4.5.2 2D RADIATION PATTERN OF ANTENNA AT 5500MHZ IN FREE SPACE**

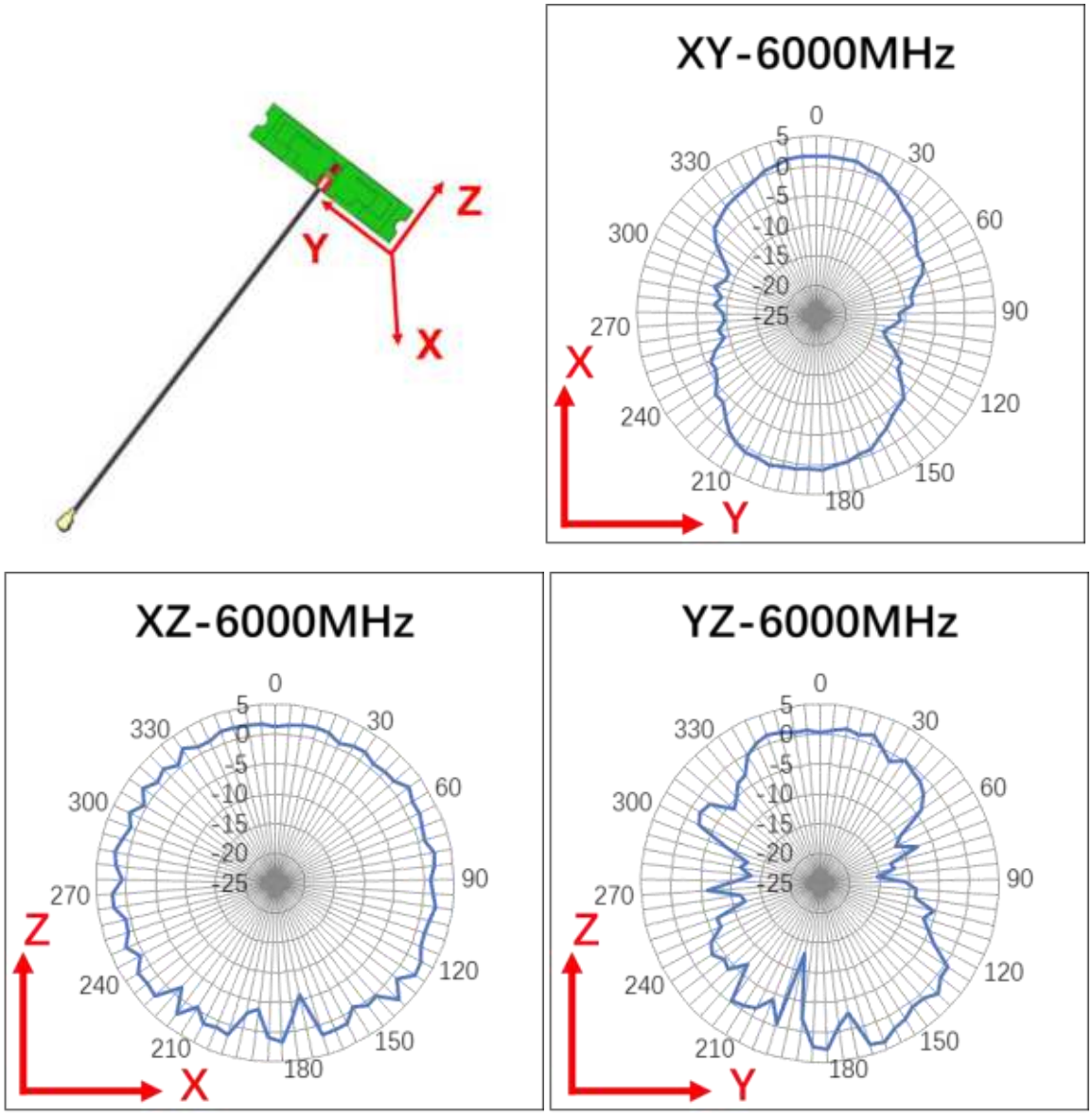



**FIGURE 4.5.3 2D RADIATION PATTERN OF ANTENNA AT 6000MHZ IN FREE SPACE**

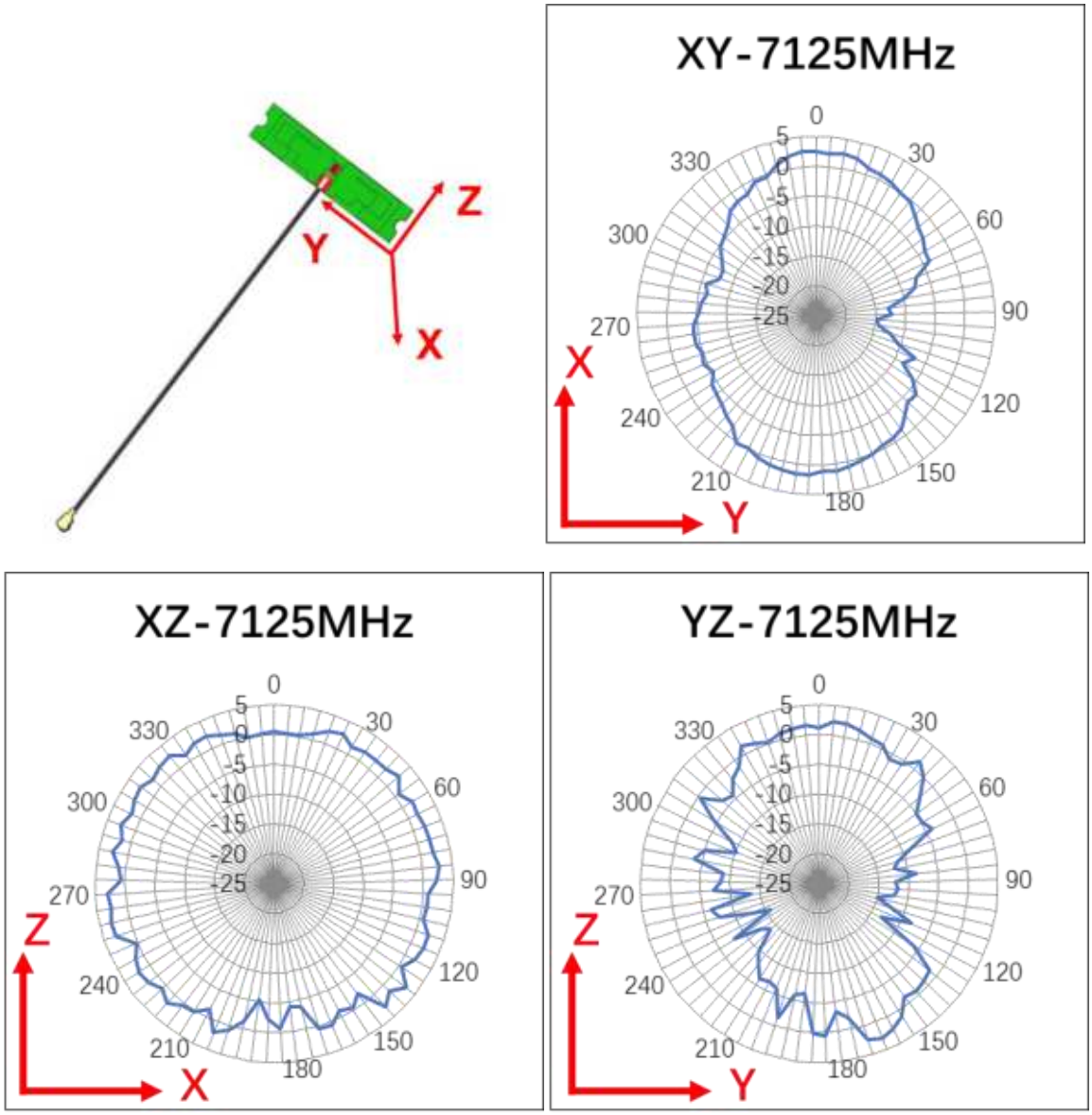



**FIGURE 4.5.4 2D RADIATION PATTERN OF ANTENNA AT 7125HZ IN FREE SPACE**

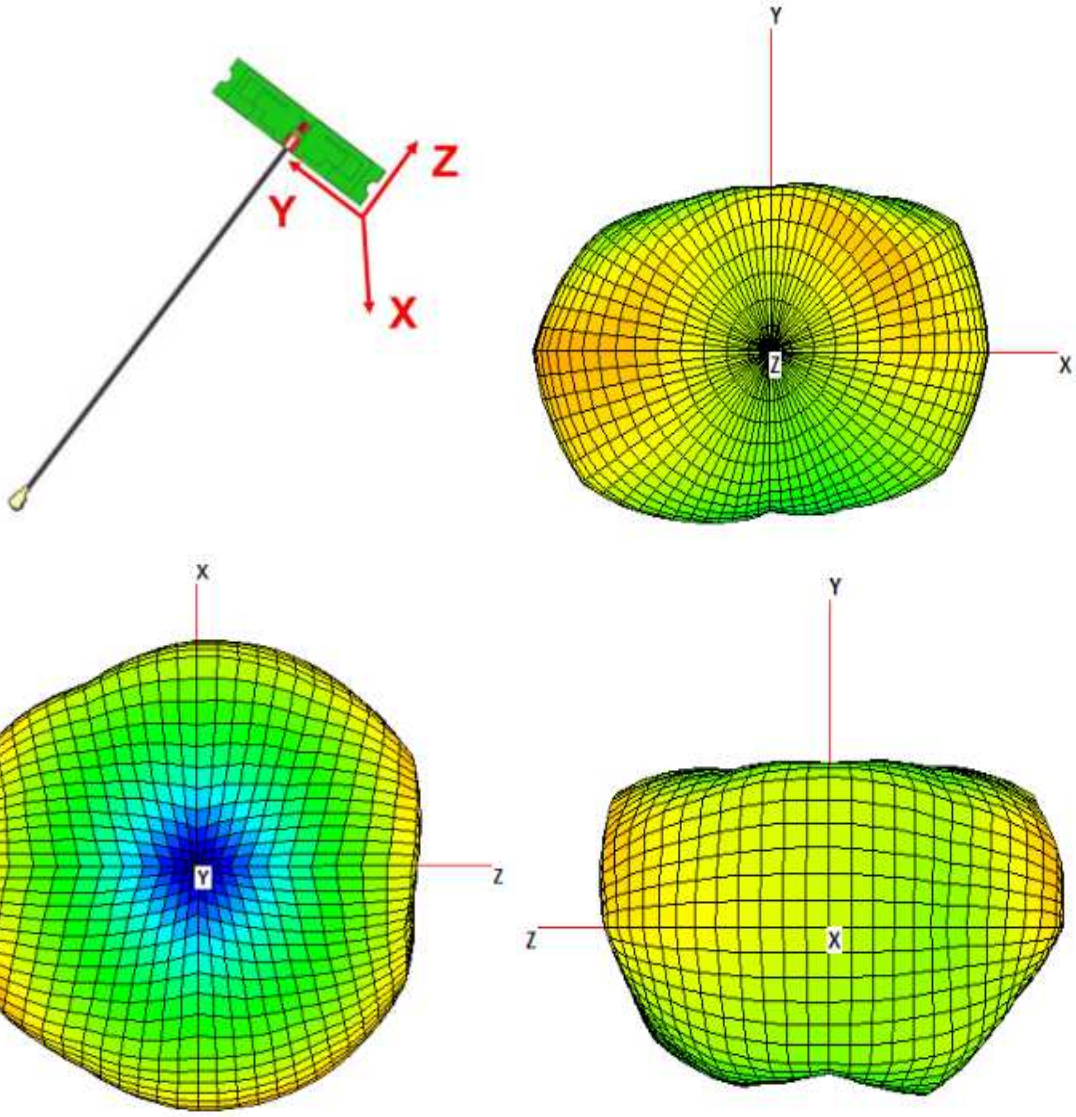



**FIGURE 4.5.5 3D RADIATION PATTERN OF ANTENNA AT 2450MHZ IN FREE SPACE**

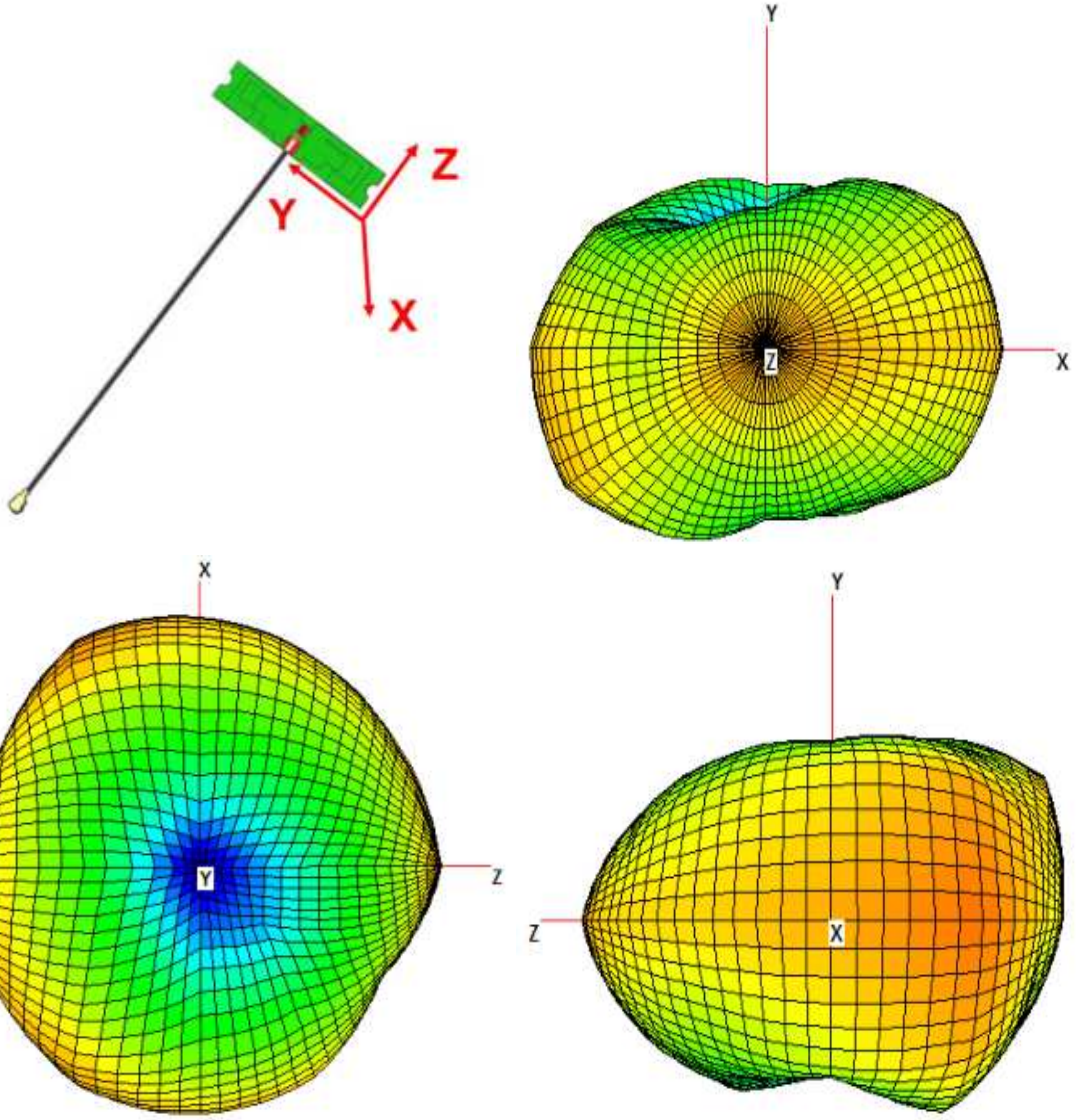



**FIGURE 4.5.6 3D RADIATION PATTERN OF ANTENNA AT 5500MHZ IN FREE SPACE**

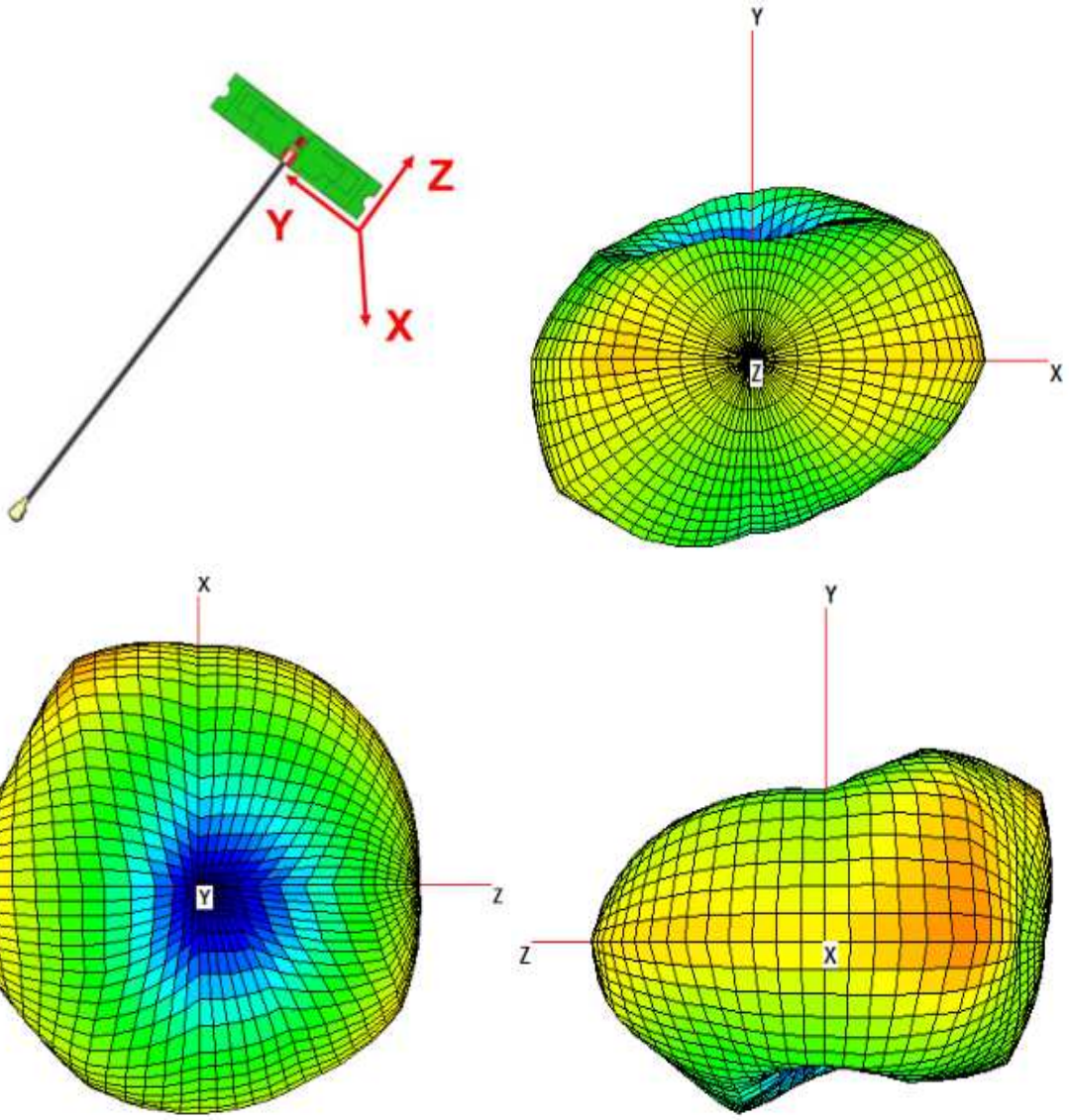



**FIGURE 4.5.7 3D RADIATION PATTERN OF ANTENNA AT 6000MHZ IN FREE SPACE**

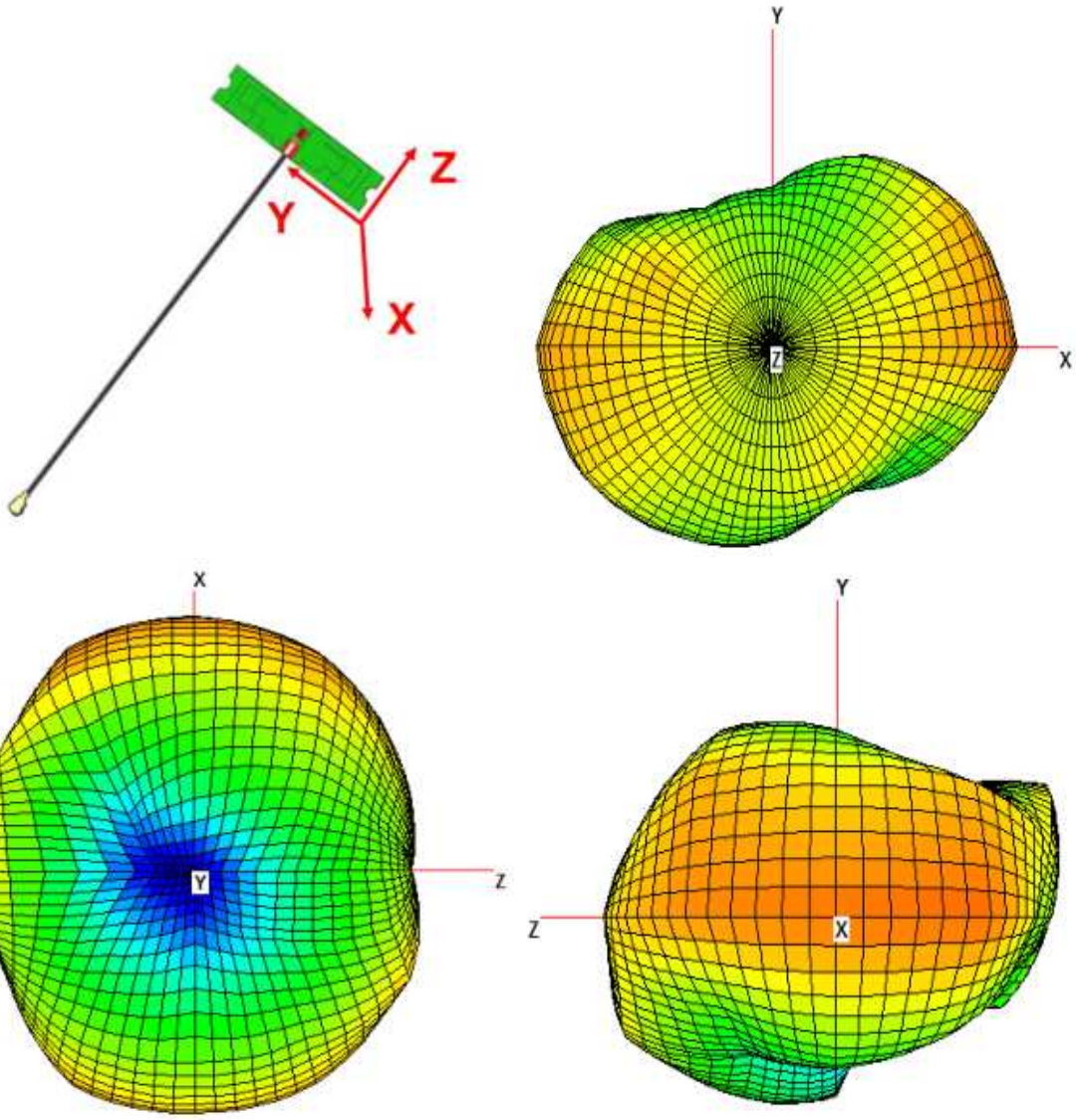



**FIGURE 4.5.8 3D RADIATION PATTERN OF ANTENNA AT 7125MHZ IN FREE SPACE**

## 5.0 ASSEMBLY GUIDELINE

During the assembly of the antenna in a device, the cable needs to be positioned away from the antenna as shown in Figure 5.1. The cable has to be away from the pattern at least 5mm as shown in Figure 5.2. The PCB has to be away from the housing height at least 5mm as shown in Figure 5.3. If customer would like to paste this product on a plastic cover, we suggest using flex version of this standard antenna, whose part number is 1461530100.

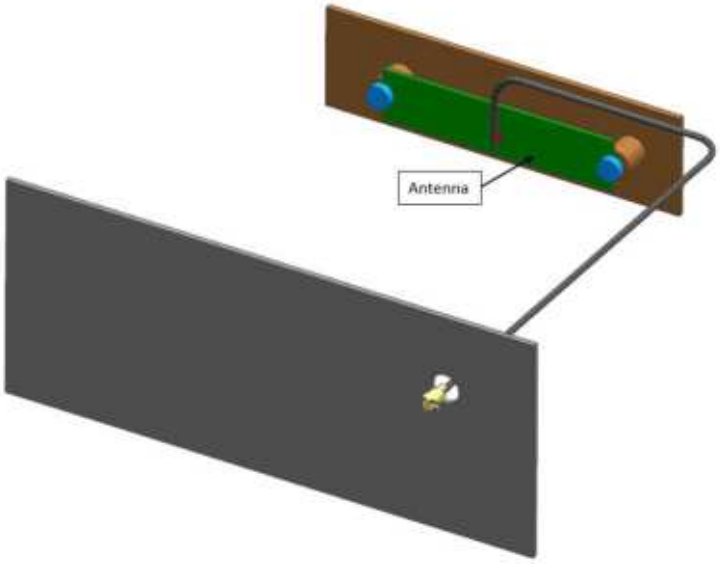



**FIGURE 5.1 ASSEMBLY GUIDELINE**

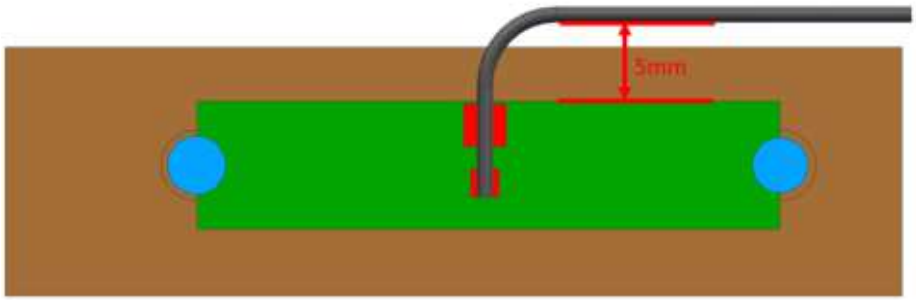



**FIGURE 5.2 CABLE BENDING**

The columnar material can be plastic with metal nut or pure plastic. However, pure metal for columnar is not recommended. During the assembly of the PCB, twist force must be less than 3kgf.

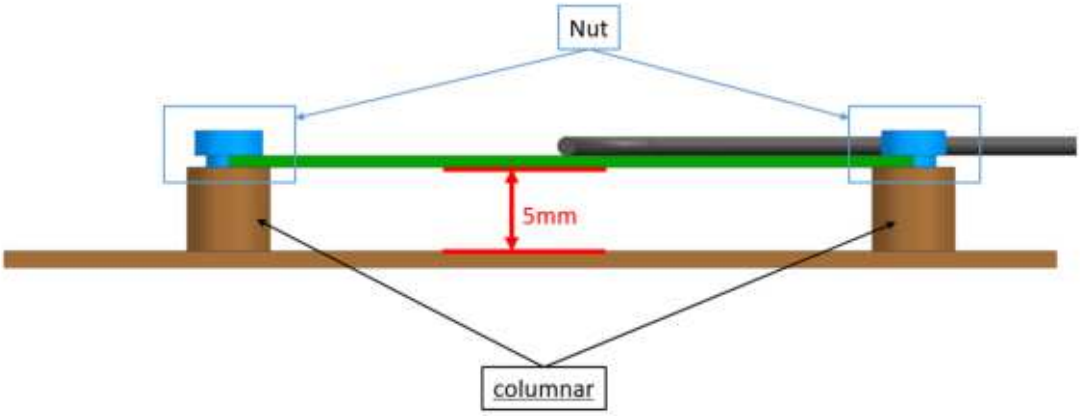



**FIGURE 5.3 ANTENNA ASSEMBLY HEIGHT**

## 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.

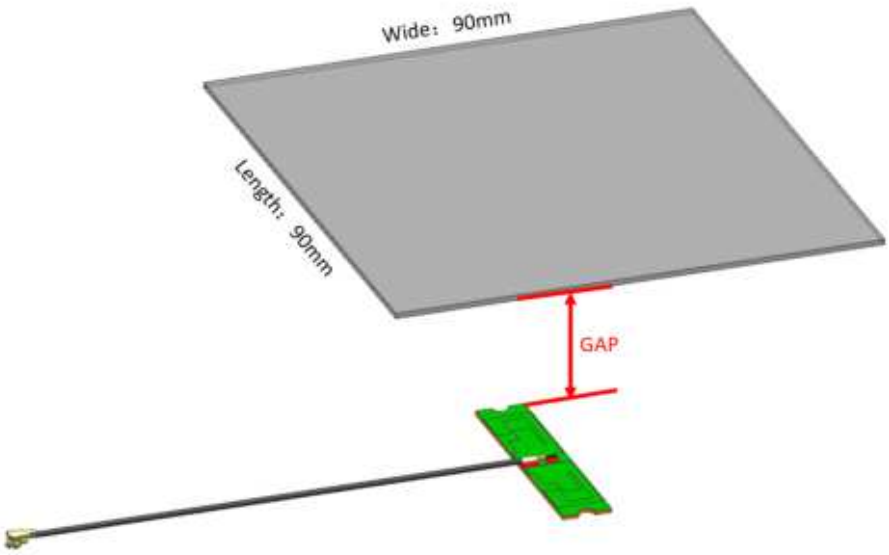



**FIGURE 6.1.1 FOUR LOCATIONS WITH PARALLEL PLANE GROUND**

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.

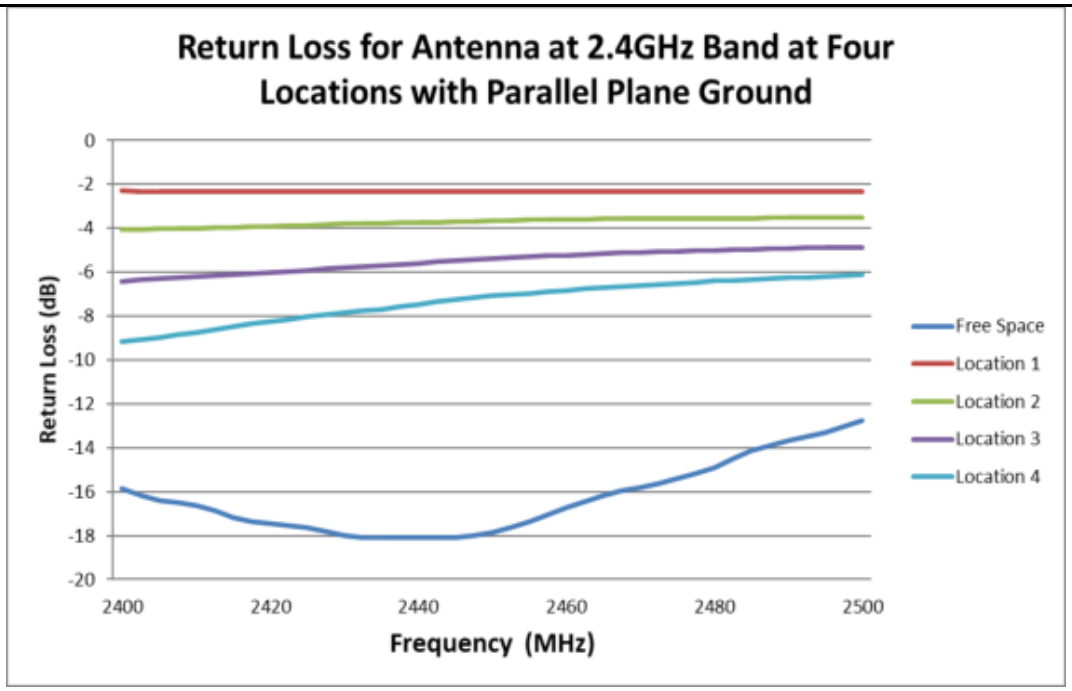



**FIGURE 6.1.2 RETURN LOSS OF ANTENNA AT 2.4GHZ BAND AT FOUR LOCATIONS WITH PARALLEL PLANE GROUND**

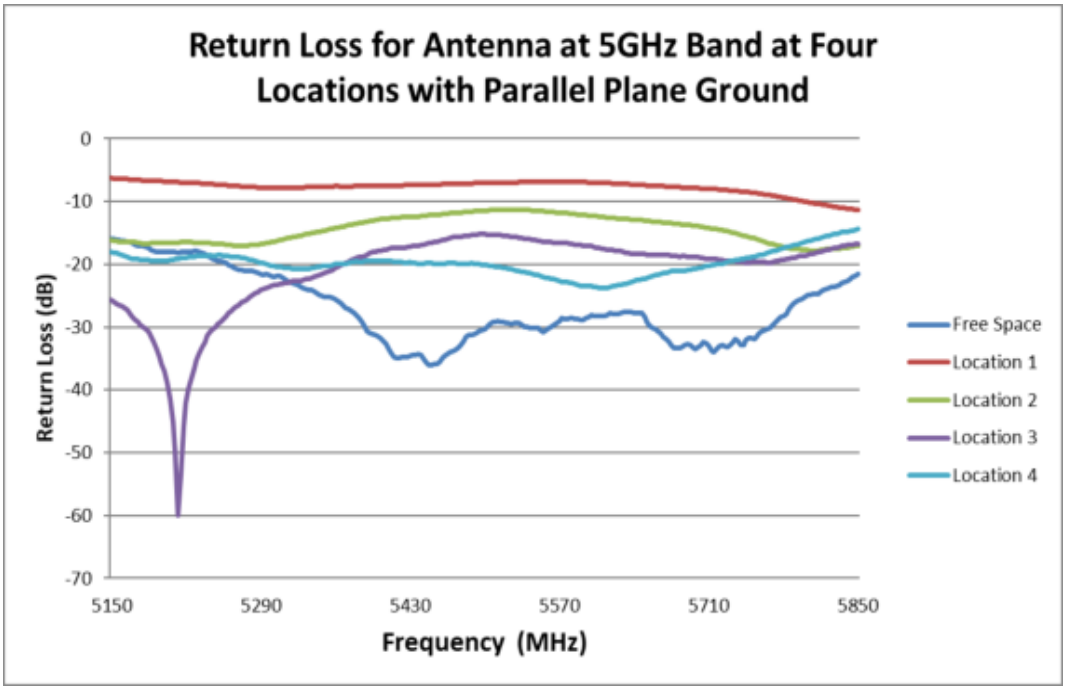



**FIGURE 6.1.3 RERURN LOSS OF ANTENNA AT 5GHZ BAND AT FOUR LOCATIONS WITH PARALLEL PLANE GROUND**

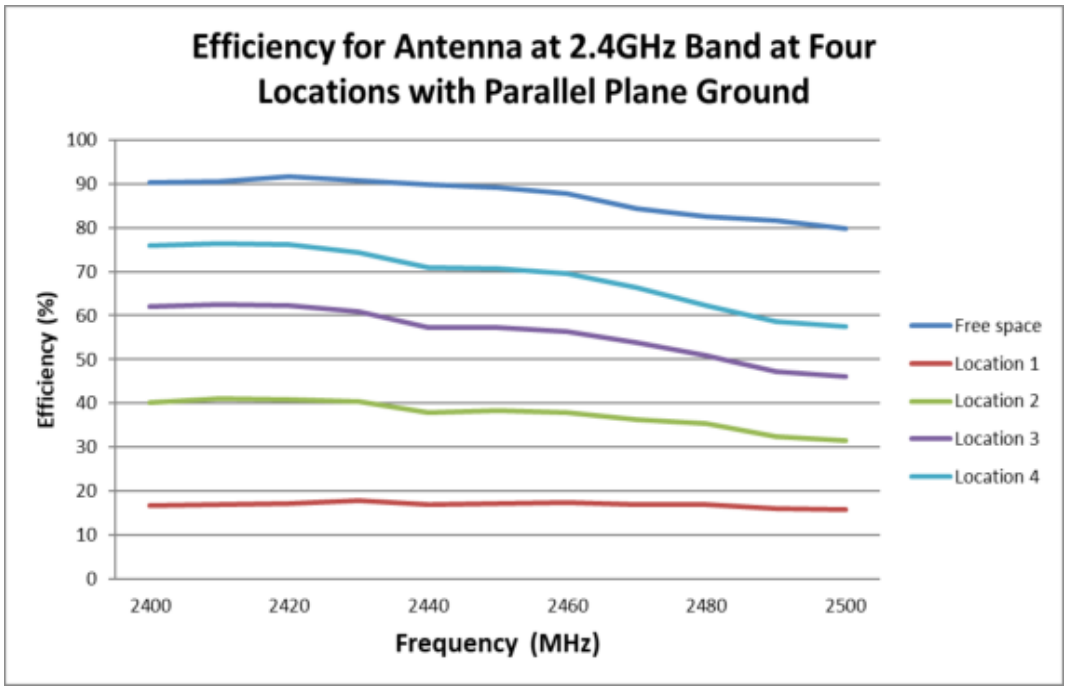



**FIGURE 6.1.4 EFFICIENCY OF ANTENNA AT 2.4GHZ BAND AT FOUR LOCATIONS WITH PARALLEL PLANE GROUND**

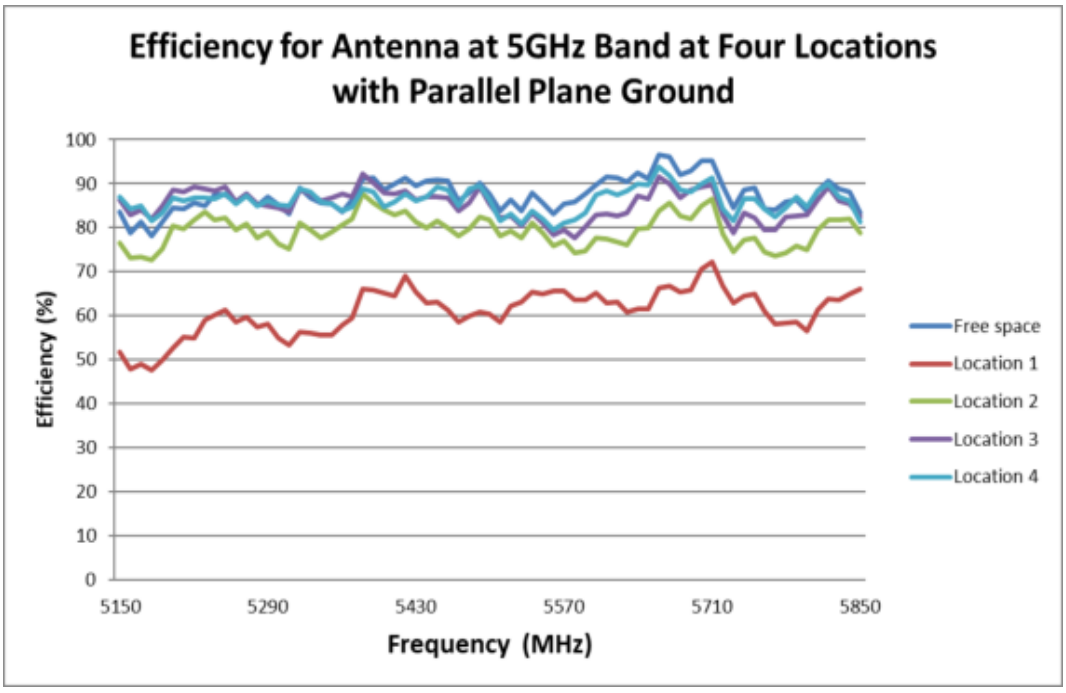



**FIGURE 6.1.5 EFFICIENCY OF ANTENNA AT 5GHZ BAND AT FOUR LOCATIONS WITH PARALLEL PLANE GROUND**

### 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.

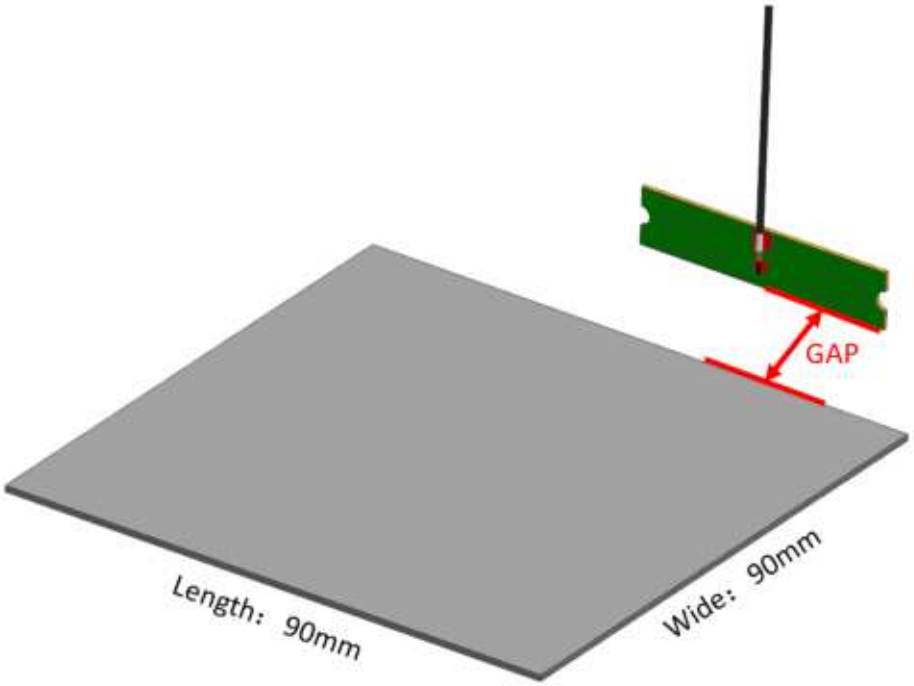



**FIGURE 6.2.1 FOUR LOCATIONS WITH VERTICAL PLANE GROUND**

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.

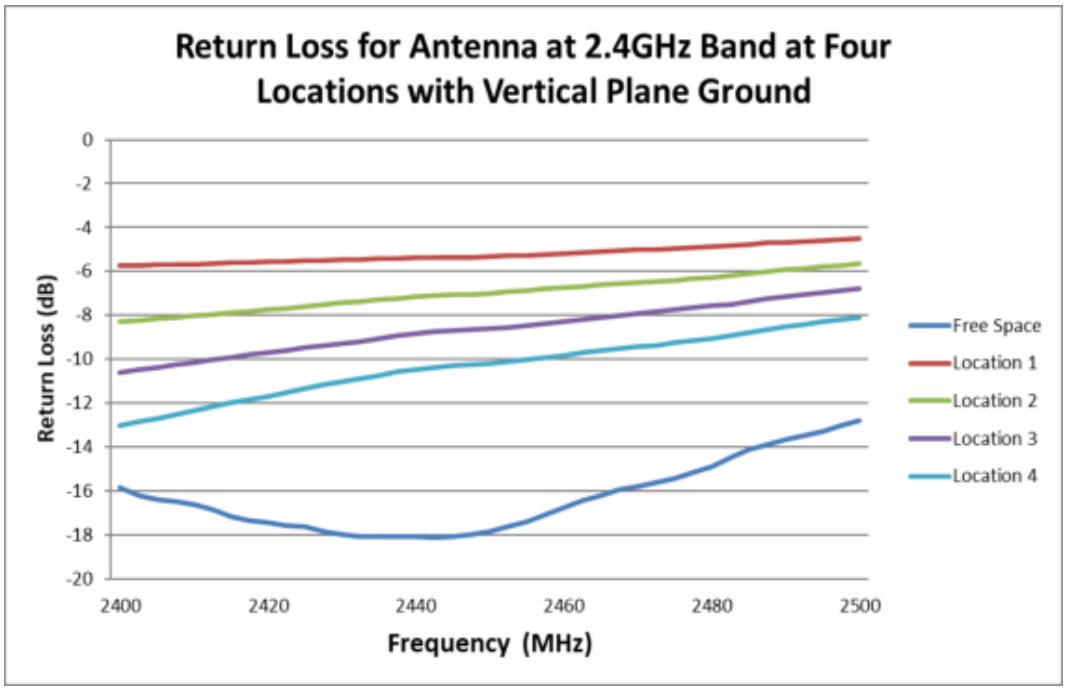



**FIGURE 6.2.2 RETURN LOSS OF ANTENNA AT 2.4GHZ BAND AT FOUR LOCATIONS WITH VERTICAL PLANE GROUND**

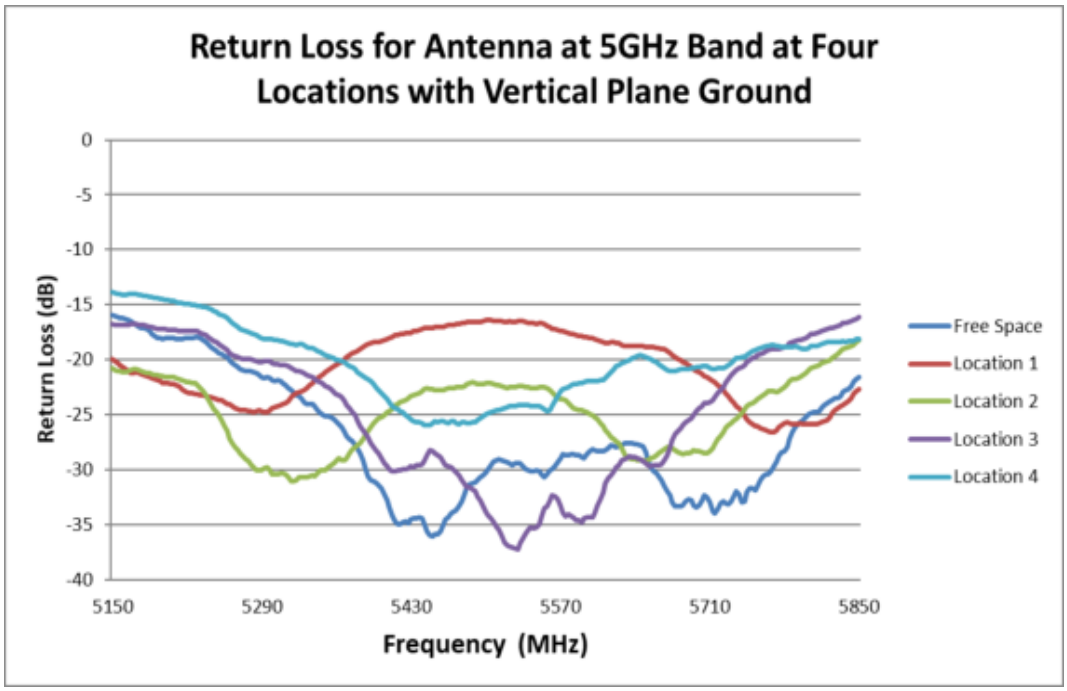



**FIGURE 6.2.3 RETURN LOSS OF ANTENNA AT 5GHZ BAND AT FOUR LOCATIONS WITH VERTICAL PLANE GROUND**

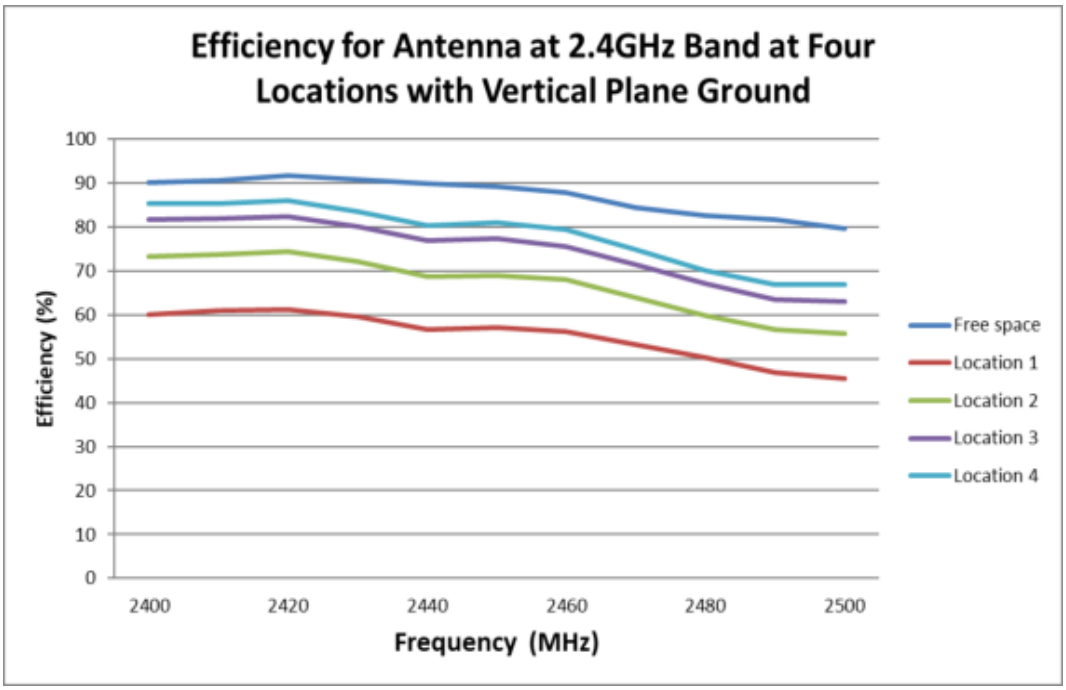



**FIGURE 6.2.4 EFFICIENCY OF ANTENNA AT 2.4GHZ BAND AT FOUR LOCATIONS WITH VERTICAL PLANE GROUND**

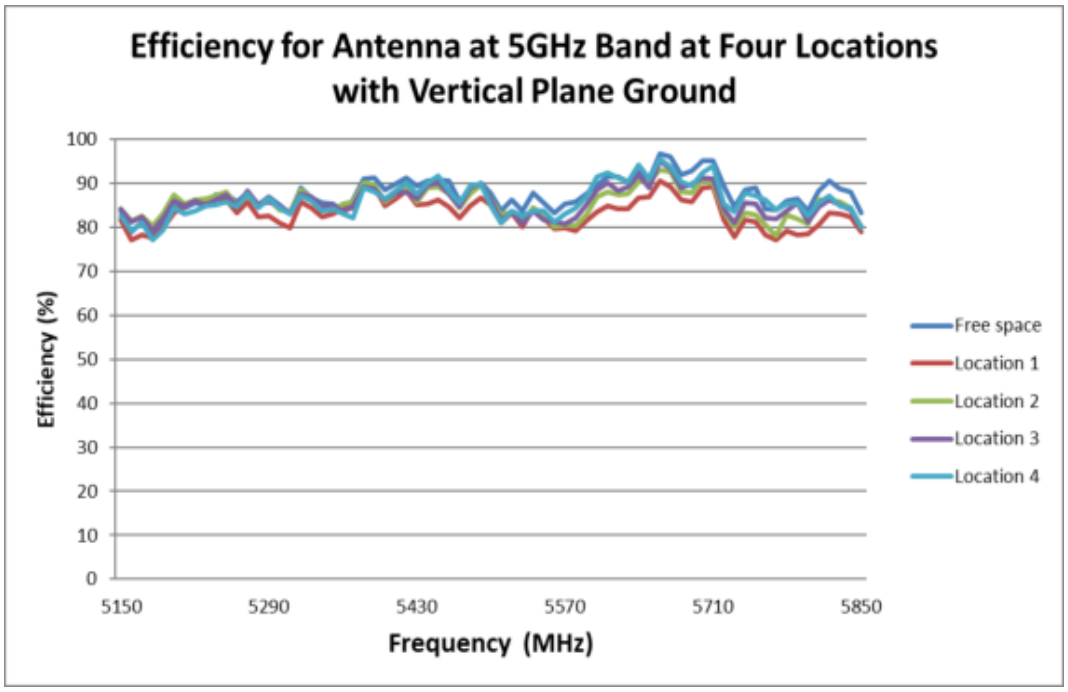



**FIGURE 6.2.5 EFFICIENCY OF ANTENNA AT 5GHZ BAND AT FOUR LOCATIONS WITH VERTICAL PLANE GROUND**

## 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~6GHz | 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 | -0.31 | 93.20 | 0.2m*3.5dB/m | -1.01 | 79.32 |
| 2420 | -0.23 | 94.75 | | -0.93 | 80.65 |
| 2440 | -0.32 | 92.93 | | -1.02 | 79.09 |
| 2460 | -0.42 | 90.88 | | -1.12 | 77.35 |
| 2480 | -0.72 | 84.64 | | -1.42 | 72.04 |
| 2500 | -0.98 | 79.72 | | -1.98 | 63.32 |
| 5150 | -0.77 | 83.70 | 0.2*5.5dB/m | -1.87 | 64.97 |
| 5200 | -0.73 | 84.60 | | -1.83 | 65.67 |
| 5250 | -0.58 | 87.57 | | -1.68 | 67.98 |
| 5300 | -0.70 | 85.13 | | -1.80 | 66.08 |
| 5350 | -0.69 | 85.32 | | -1.79 | 66.23 |
| 5400 | -0.53 | 88.60 | | -1.63 | 68.78 |
| 5450 | -0.41 | 90.90 | | -1.51 | 70.56 |
| 5500 | -0.57 | 87.76 | | -1.67 | 68.12 |
| 5550 | -0.67 | 85.61 | | -1.77 | 66.46 |
| 5600 | -0.47 | 89.77 | | -1.57 | 69.69 |
| 5650 | -0.41 | 91.02 | | -1.51 | 70.66 |
| 5700 | -0.22 | 95.13 | | -1.32 | 73.85 |
| 5750 | -0.51 | 88.95 | | -1.61 | 69.05 |
| 5800 | -0.76 | 83.86 | | -1.86 | 65.10 |
| 5850 | -0.80 | 83.26 | | -1.90 | 64.63 |

| | 100mm cable | | | 300mm cable | |
|---|---|---|---|---|---|
| Frequency (MHz) | Efficiency (dB) | Efficiency (%) | cable loss | Efficiency (dB) | Efficiency (%) |
| | X | | X-LOSS=Y | Y | |
| 6000 | -1.34 | 73.38 | 0.2*6.5dB/m | -2.64 | 54.39 |
| 6100 | -1.24 | 75.23 | | -2.54 | 55.77 |
| 6200 | -1.44 | 71.76 | | -2.74 | 53.20 |
| 6300 | -1.46 | 71.53 | | -2.76 | 53.02 |
| 6400 | -1.66 | 62.29 | | -2.96 | 50.64 |
| 6500 | -1.57 | 69.64 | | -2.87 | 51.63 |
| 6600 | -1.66 | 67.31 | | -2.96 | 50.59 |
| 6700 | -1.69 | 67.75 | | -2.99 | 50.22 |
| 6800 | -1.15 | 76.75 | | -2.45 | 56.90 |
| 6900 | -1.18 | 76.22 | | -2.48 | 56.50 |
| 7000 | -1.03 | 78.80 | | -2.33 | 58.42 |
| 7100 | -1.22 | 65.83 | | -2.52 | 56.03 |
| 7125 | -1.34 | 73.40 | | -2.64 | 54.42 |

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 |
| F | 2020/05/27 | Add 6-7.125GHz band |