

1 KEYWORDS

- *KG04S*
- *2.4 GHz*
- *Inverted F Antenna*

2 INTRODUCTION

The PCB antenna used on the KG04S reference design is described in this application note.

This application note describes the antenna dimensions, the RF performance

and considerations for complying with regulatory limits when using this design.

The antenna design requires no more than 15.2 x 5.7 mm of space and ensures a VSWR ratio of less than 2 across the 2.4 GHz ISM band when connected to a 50 ohm source.

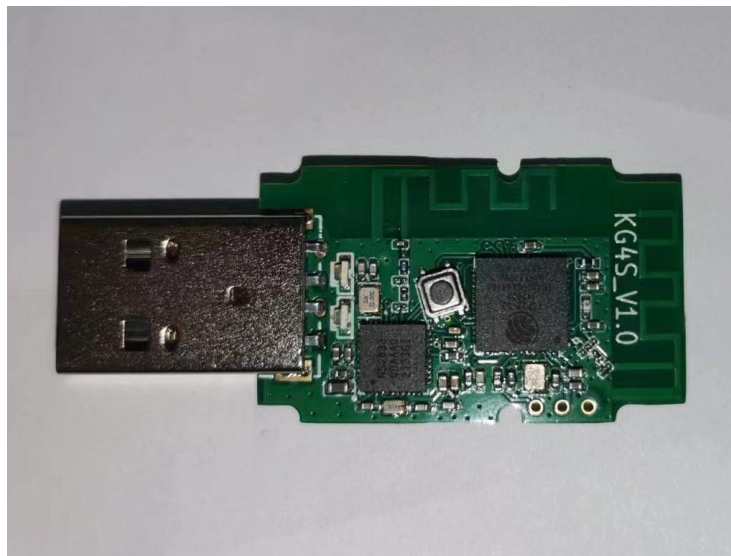


Figure 1: KG04S

3 Testing Conditions

Antenna Electrical Characteristics

Parameters	Value
Frequency Range	2400~2480MHz
Band Width	120MHz
VSWR	<2.0
Impedence	50 ohm
Gain	0dBi
Polarization	Single
Azimuth	Omni-directional

Product Testing Conditions

Parameters	Value
Working Temp	-30°C ~ +60°C

4 ANTENNA DESIGN

The PCB antenna on the KG04S reference design is a meandered Inverted F Antenna (IFA). The IFA was designed to match an impedance of 50 ohm at 2.45 GHz. Thus no additional matching components are necessary.

4.1 Design Goals

The reflection at the feed point of the antenna determines how much of the applied power is delivered to the antenna. A reflection of less than -10 dB across the 2.4 GHz ISM band, when connected to a 50 ohm source, was a design goal. Reflection of less than -10 dB, or VSWR less than 2, ensures that more than 90% of the available power is delivered to the antenna. Bandwidth is in this document defined as the frequency band where more than 90% of the available power is delivered to the antenna. Another design goal was to fit the size of the PCB antenna on a KG04S and to obtain good performance also when the KG04S is connected to a computer.

4.2 Simulation

IE3D from Zeland, which is an electromagnetic simulation tool, was used to design the antenna. The accuracy of the simulation is controlled by the mesh. An increase of the mesh increases the simulation time. Thus, for initial simulations mesh = 1 should be used. When a fairly good result is achieved a higher mesh should be used to obtain more accurate results. Comparison of simulation and measurement results shows that the measured reflection is between the result obtained with mesh = 5 and mesh = 1; see Figure 2 for details.

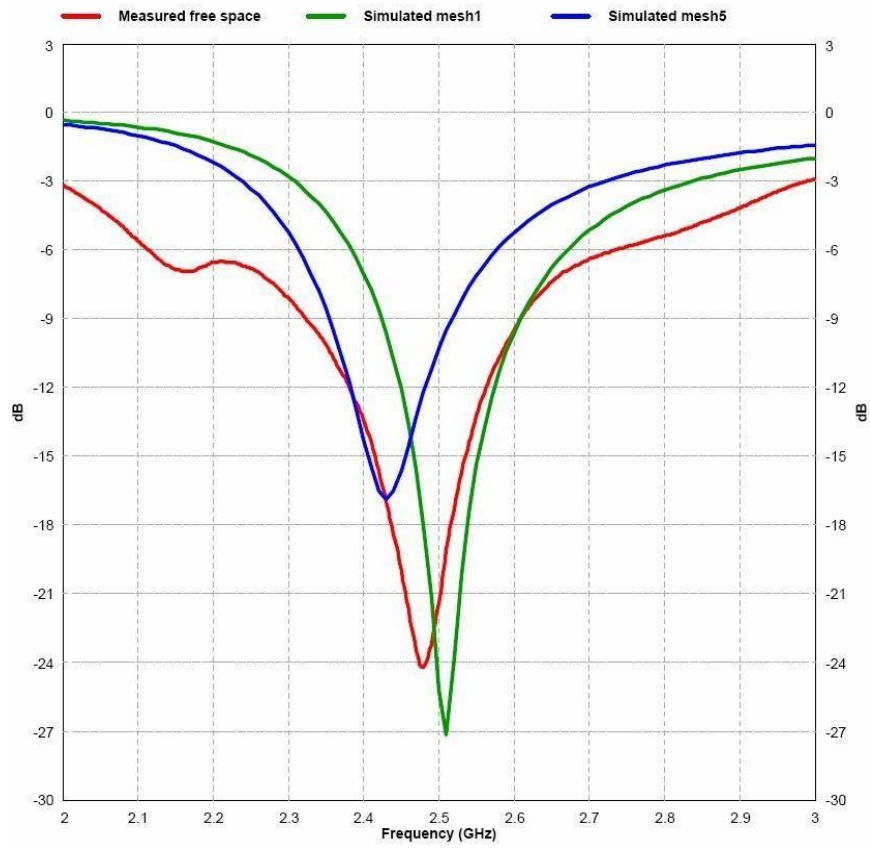


Figure 2: Comparison of Simulation and Measurements Results

4.3 Layout and Implementation

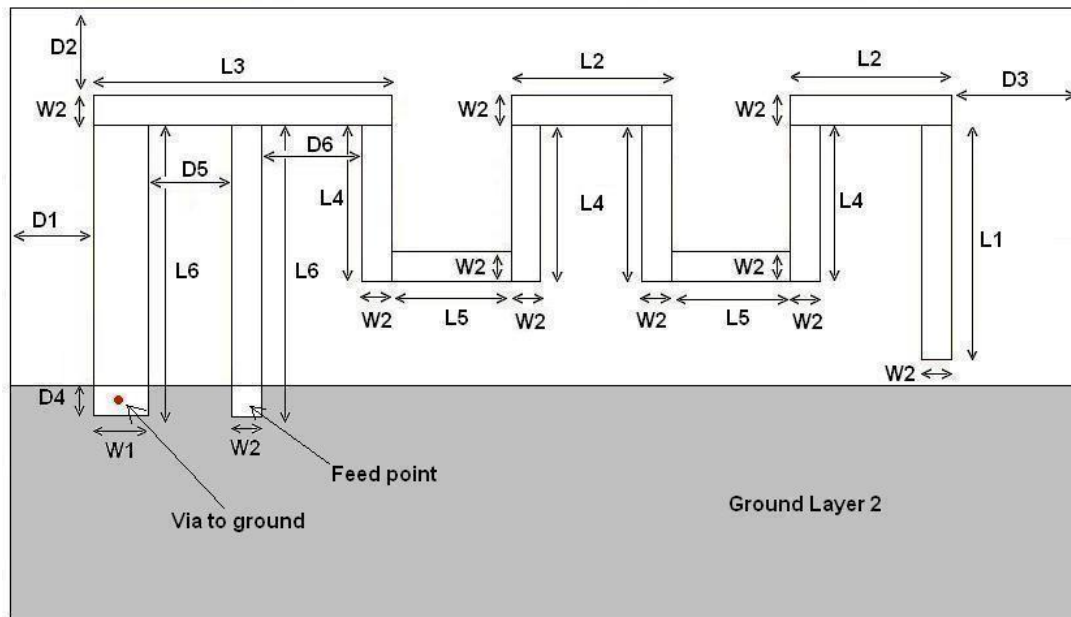


Figure 3: Antenna Dimensions

L1	3.94 mm
L2	2.70 mm
L3	5.00 mm
L4	2.64 mm
L5	2.00 mm
L6	4.90 mm
W1	0.90 mm
W2	0.50 mm
D1	0.50 mm
D2	0.30 mm
D3	0.30 mm
D4	0.50 mm
D5	1.40mm
D6	1.70 mm

Table 1: Antenna Dimensions

5 TEST RESULTS

5.1 Reflection

All the reflection measurements were performed with a network analyzer connected to a semi-rigid coax cable, which was soldered to the feed point of the antenna. Because of the small size antenna and the small ground plane this kind of measurements is heavily affected by the presence and placement of the coax cable. This influence can result in a small uncertainty in resonance frequency and measured reflection. Typically different placement of the semi-rigid coax cable could change the resonance frequency with 5 -10 MHz and the reflection with 3 - 4 dB.

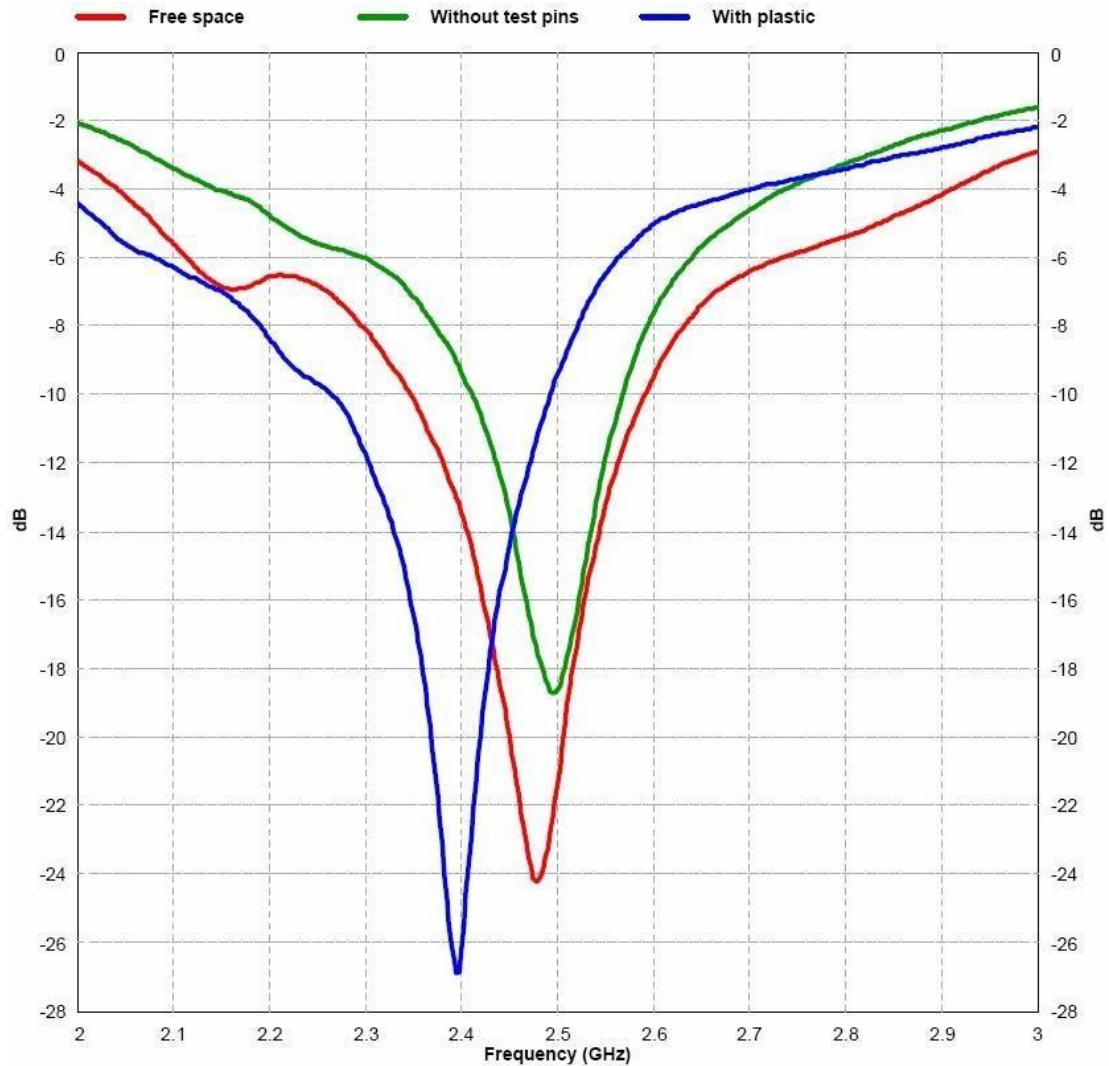


Figure 4: Influence of Plastic Encapsulation and Test Pins



This part of the PCB will typically be omitted in a final application. The red and green graph on Figure 4 shows that removing this part of the PCB has a small impact on the performance. Figure 4 also shows that plastic encapsulation of the KG04S will shift the resonance frequency to a lower frequency. This can be compensated by making the antenna slightly shorter.



5.2 Radiation Pattern

The radiation pattern for the antenna implemented on the KG04S reference design has been measured in an anechoic chamber. Figure 7 through Figure 12 shows radiation patterns for three planes, XY, XZ and YZ, measured with vertical and horizontal polarization. All these measurement were performed without connecting the KG04S to a computer. Figure 13 and Figure 14 shows the radiation pattern when the KG04S is connected to a laptop. All measurements were performed with 0 dBm output power. Figure 6 shows how the different radiation patterns are related to the positioning of the antenna.

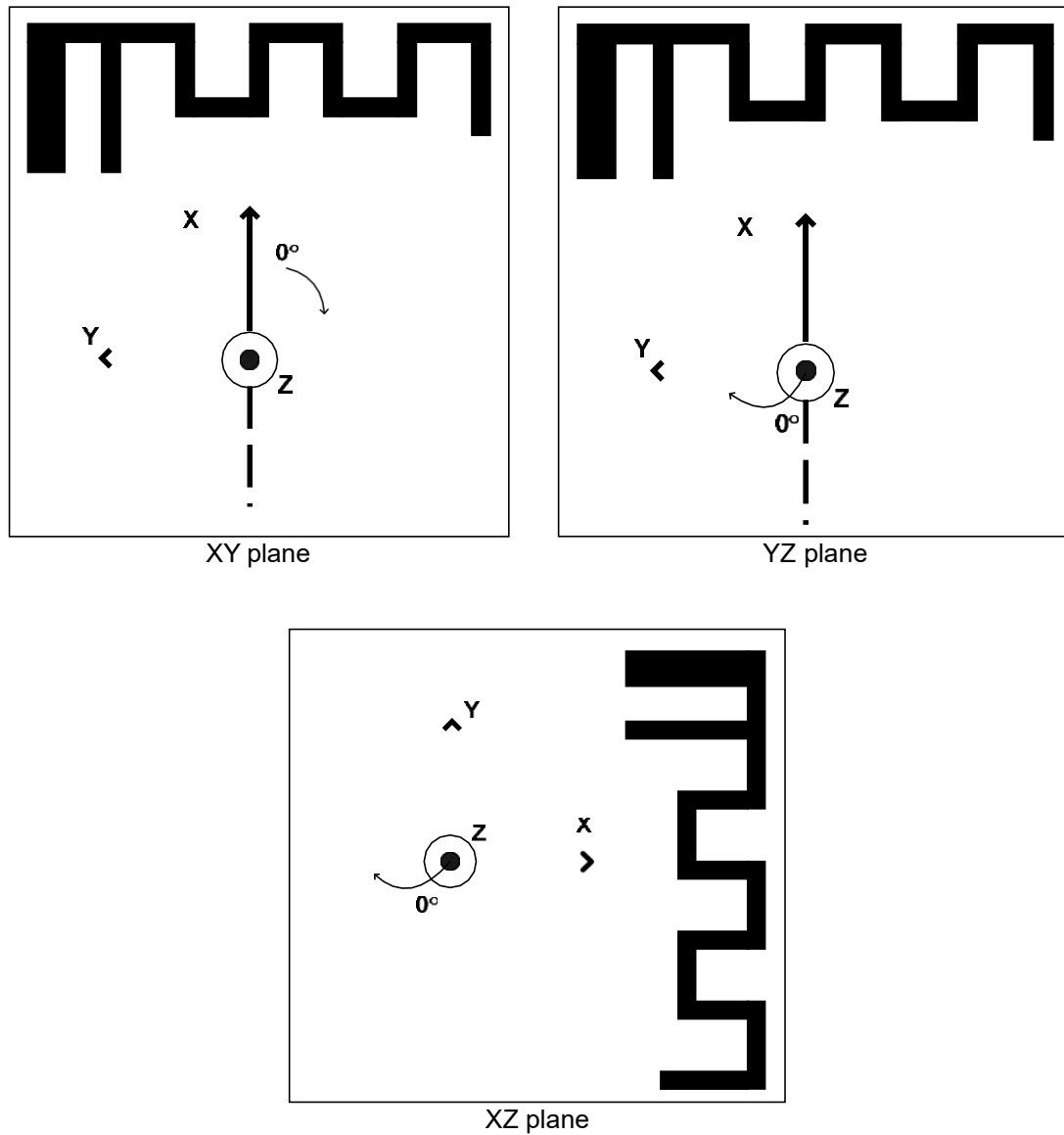
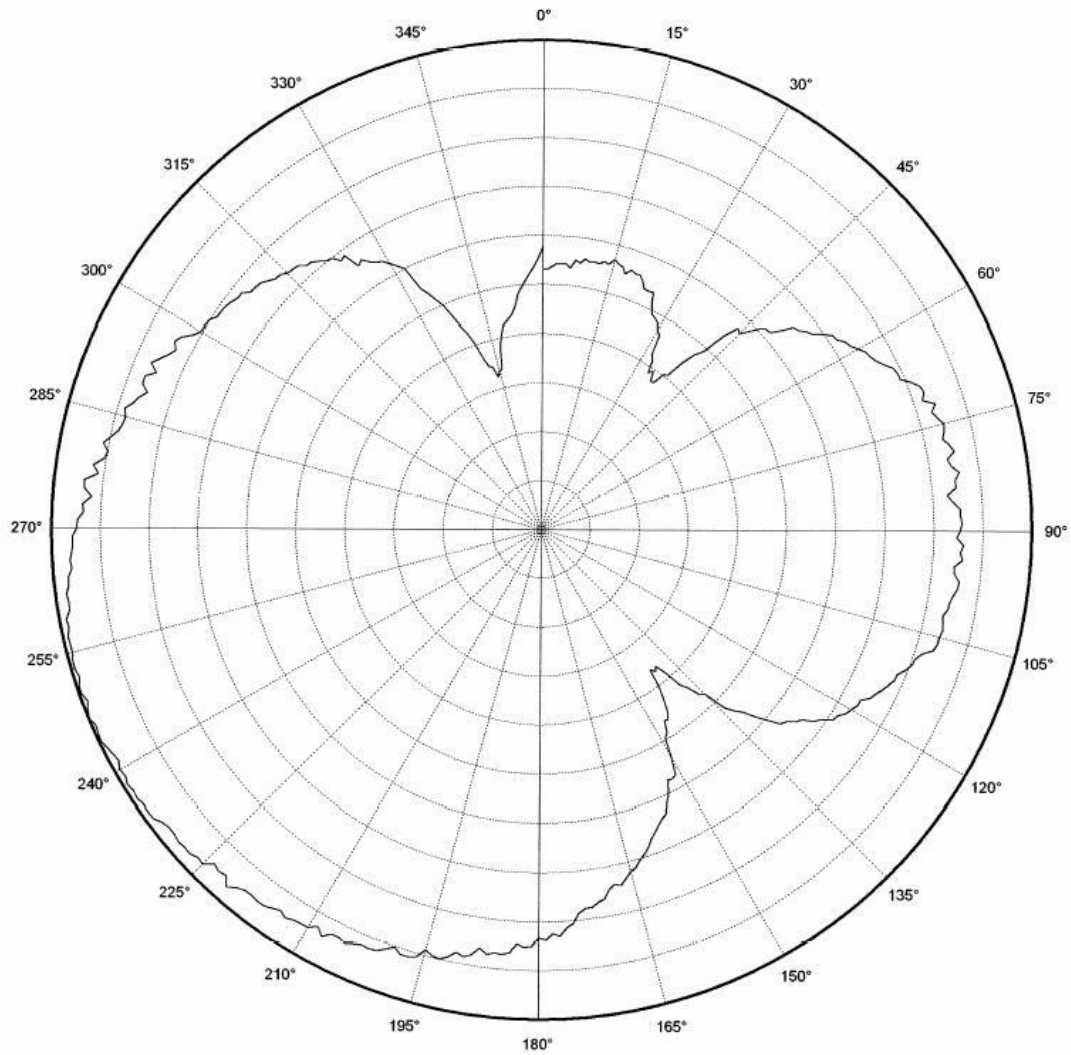


Figure 6: How to Relate the Antenna to the Radiation Patterns



Vertical Polarization

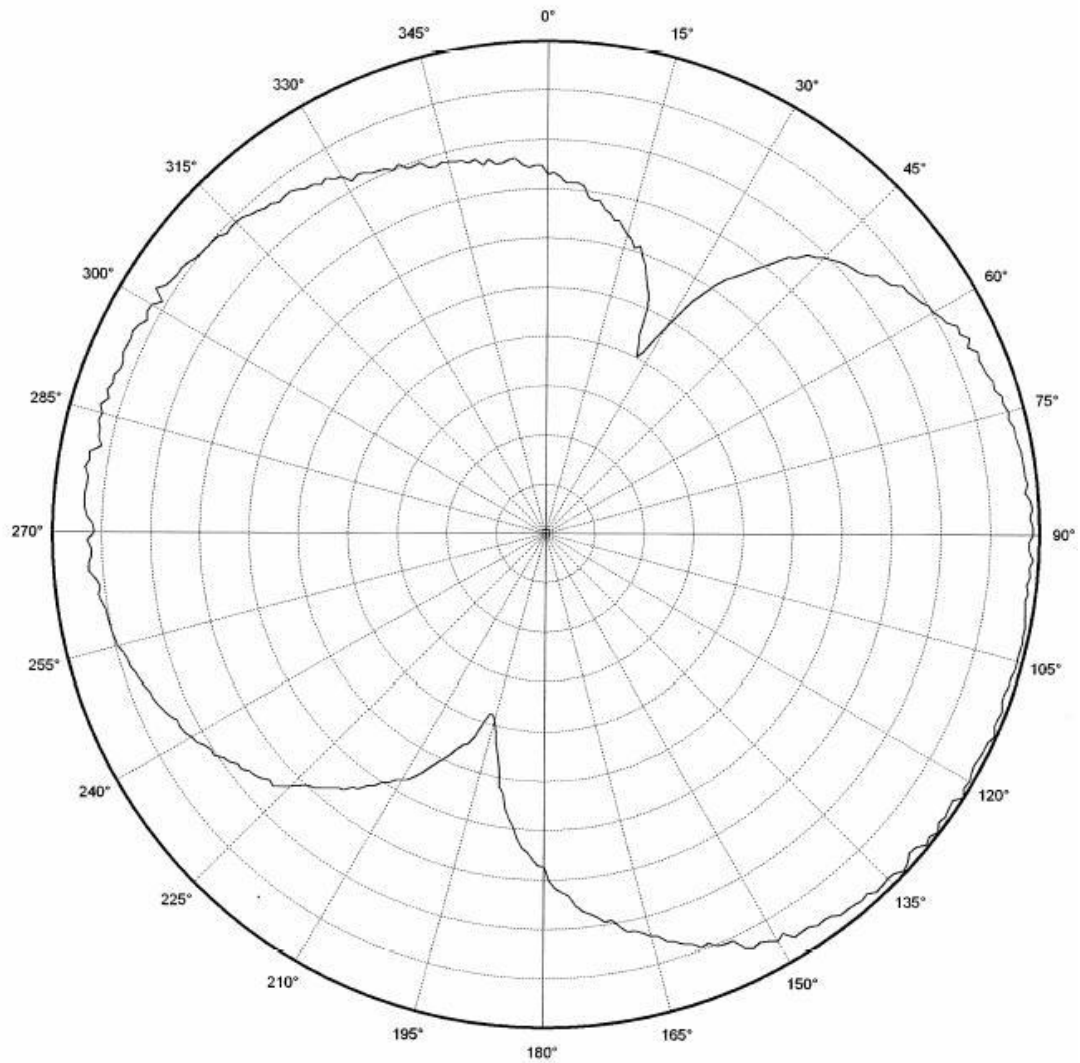
usb XY

CF 2450.000 MHz

4 dB/ div

Ref Lev: -2.5dBi

Figure 7: KG04S XY Plane



Horizontal Polarization

usb XY

CF 2450.000 MHz

5 dB/ div

Ref Lev: -0.5dBi

Figure 8:KG04S XY Plane

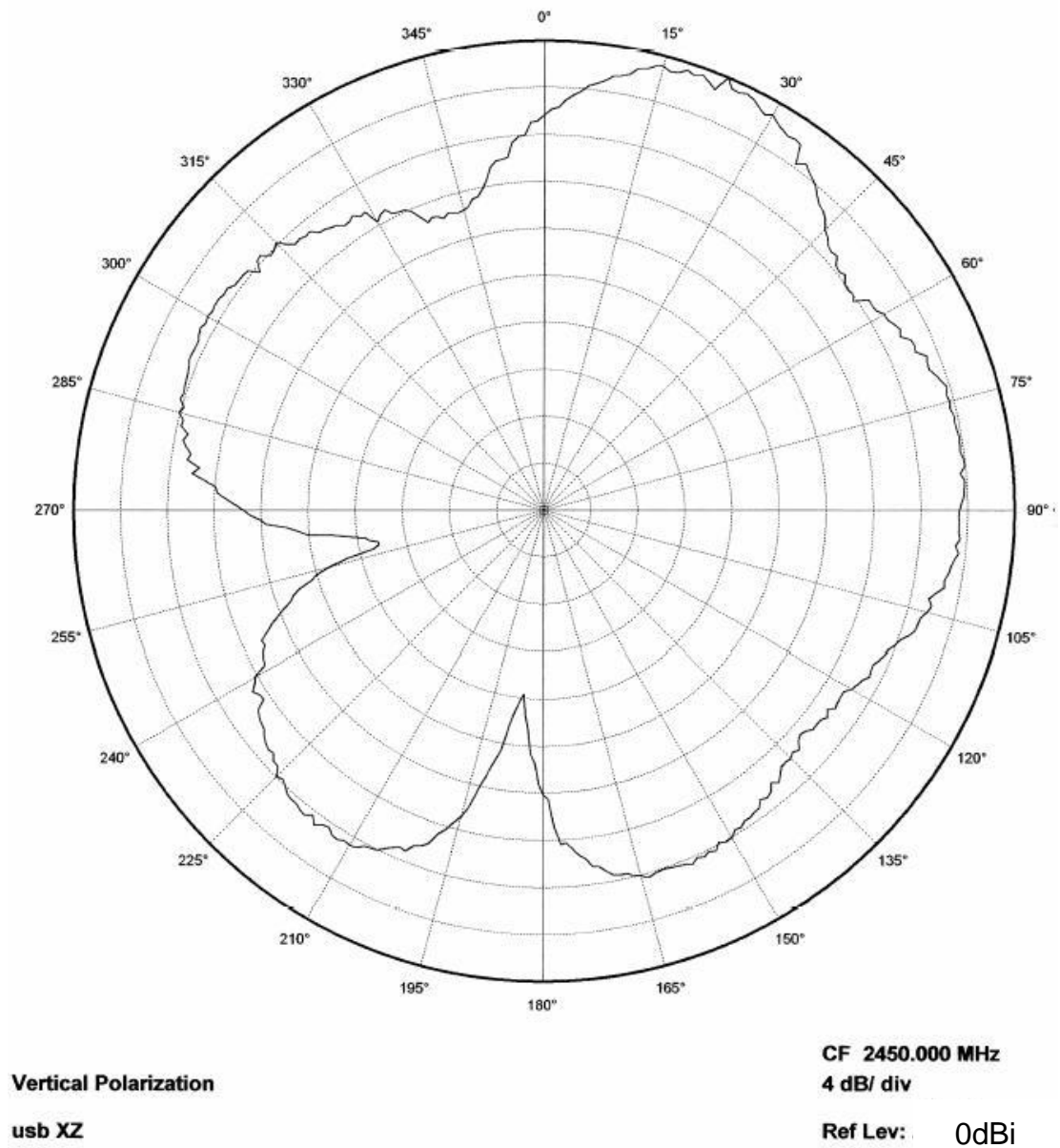


Figure 9: KG04S XZ Plane

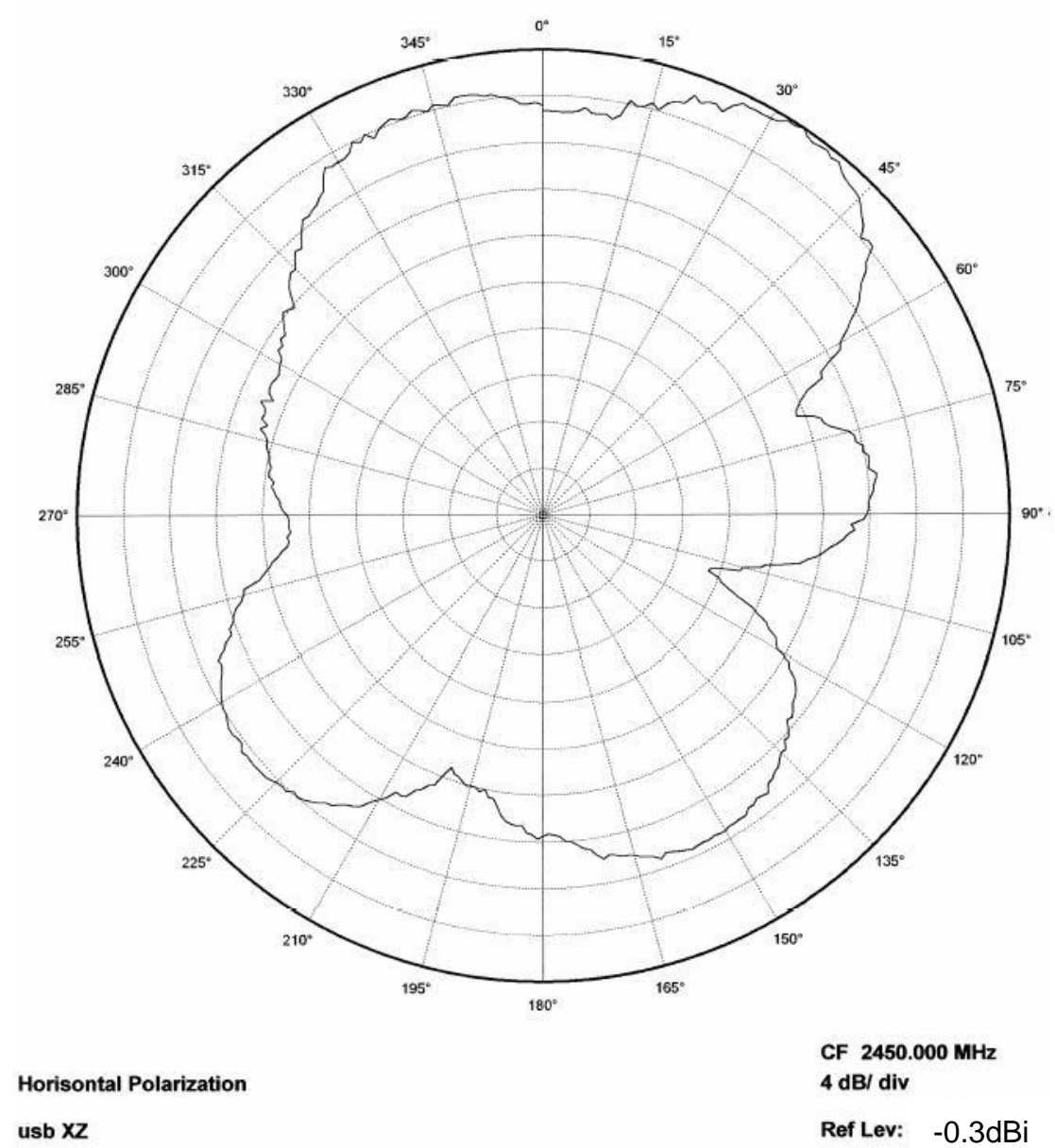
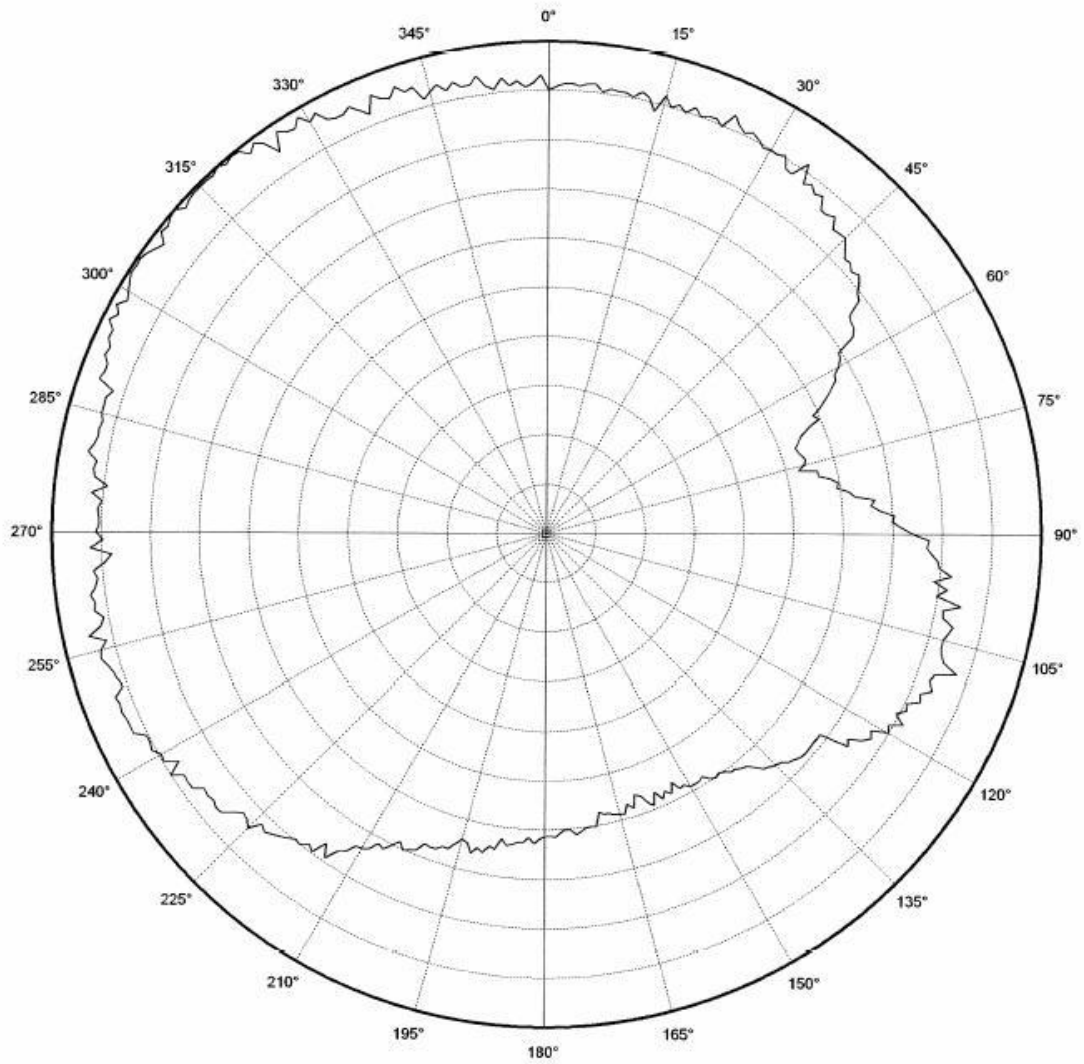


Figure 10: KG04S XZ Plane



Vertical Polarization

usb YZ

CF 2450.000 MHz

2 dB/ div

Ref Lev: -0.1dBi

Figure 11: KG04S YZ Plane

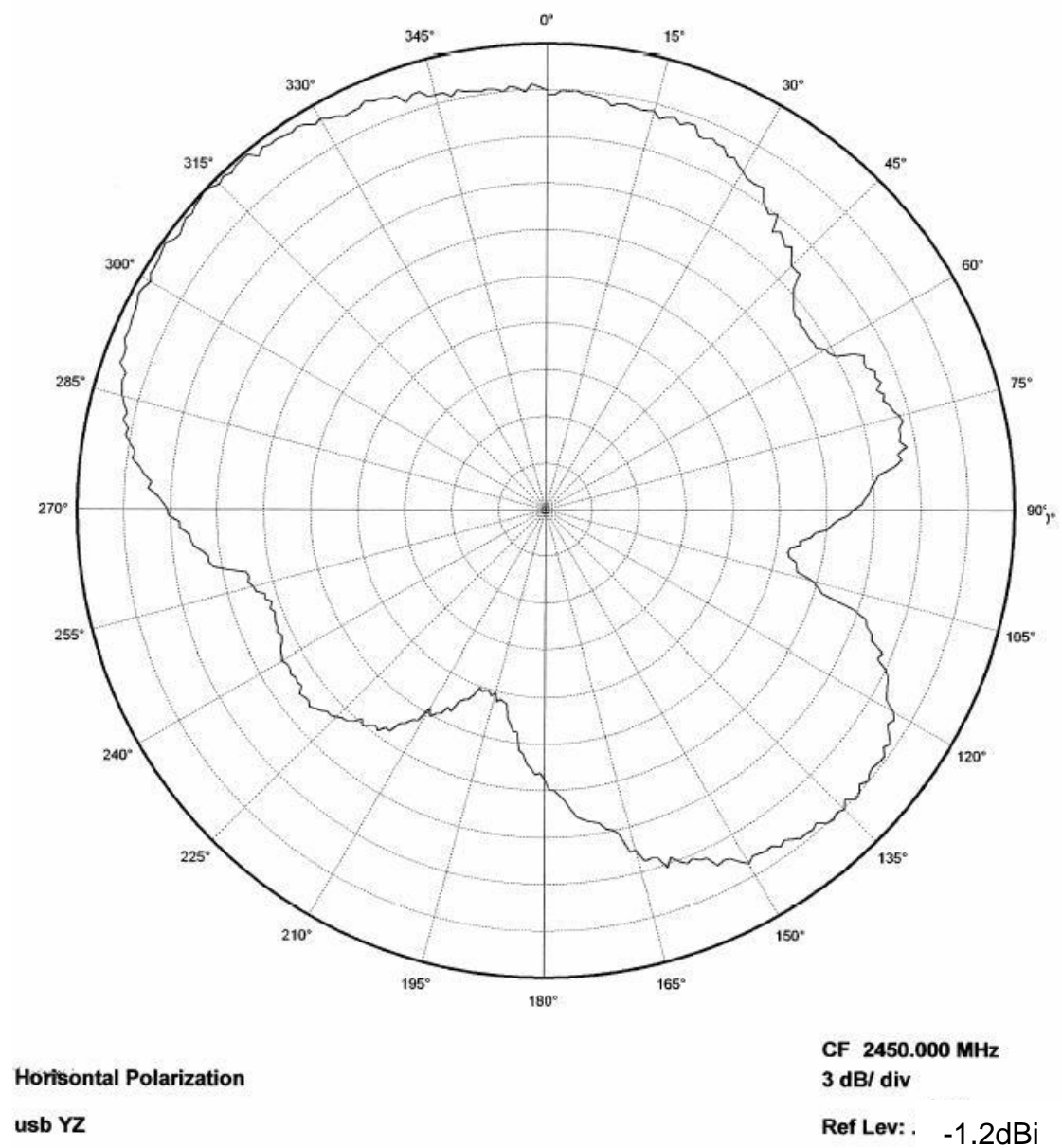
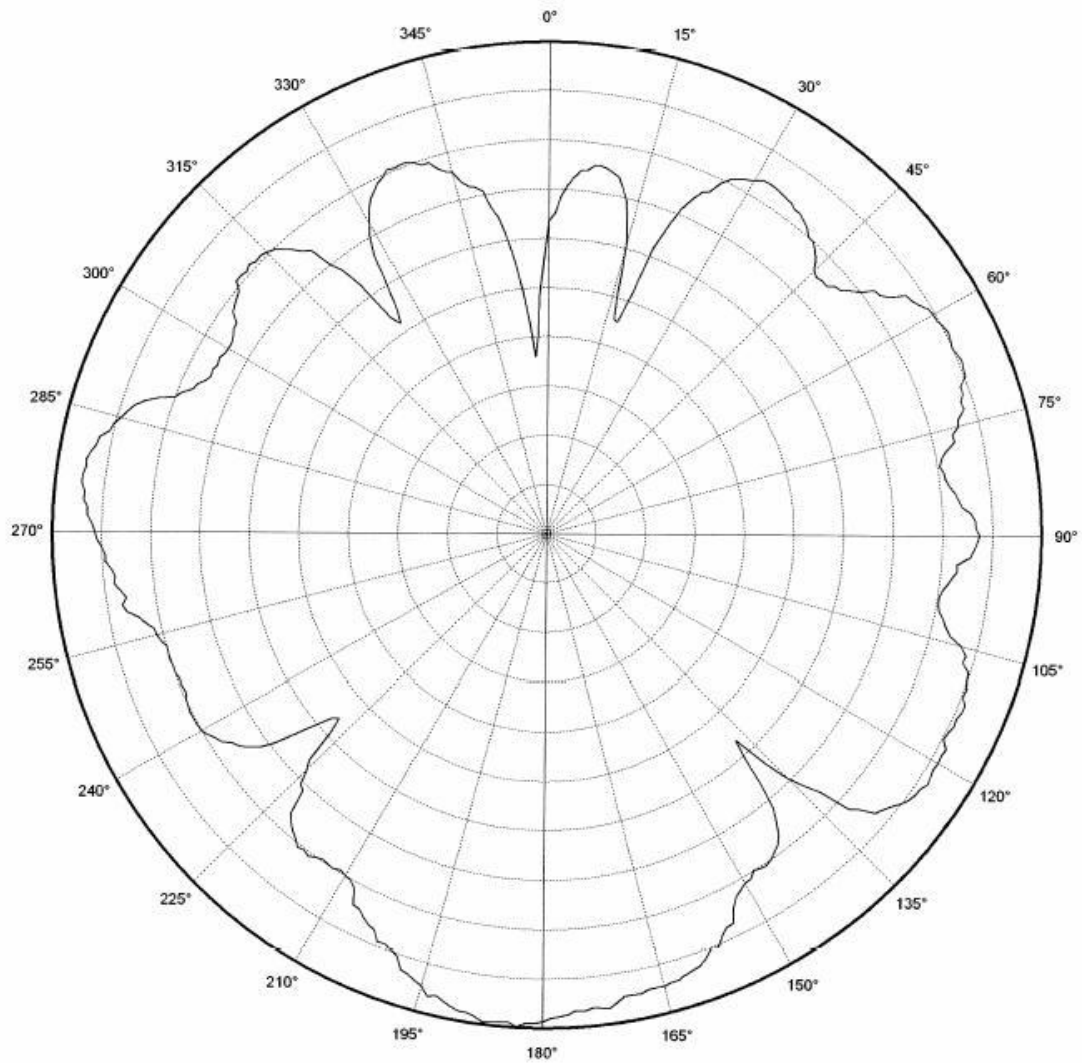


Figure 12: KG04S YZ Plane



Vertical Polarization
Laptop USB XY

CF 2450.000 MHz
5 dB/ div
Ref Lev: -1.3dBi

Figure 13: KG04S in Laptop XY Plane

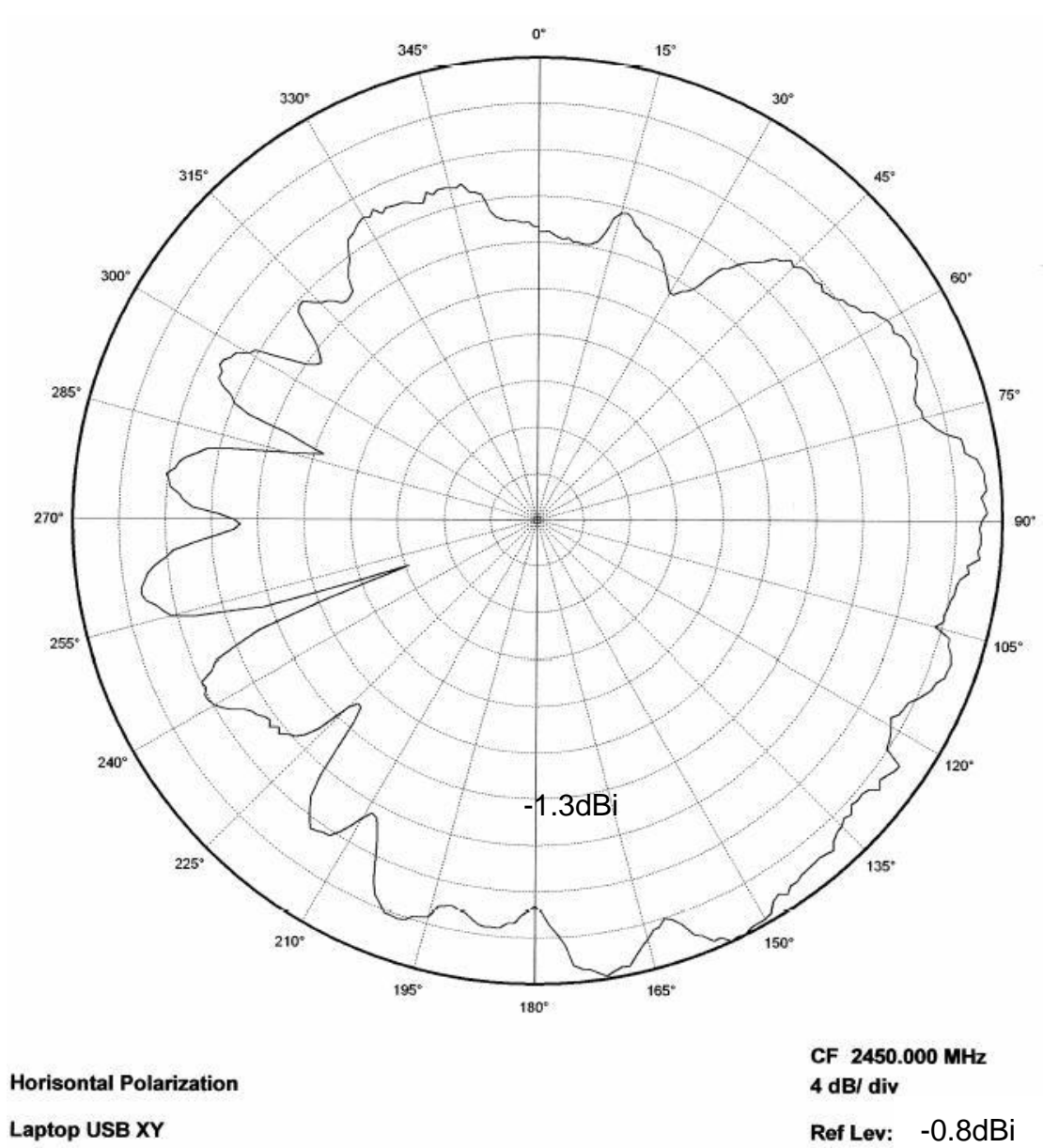


Figure 14: KG04S in Laptop XY