2.4 GHz PCB antenna Specification

1   KEYWORDS

It is important to make an exact copy of the antenna
dimensions to obtain optimum performance.
The easiest approach to implement the antenna
in a PCB CAD tool is to import the antenna layout
from a gerber file or a DXF file. Such files are
included in K3HBeacon reference design .
The gerber file is called Inverted_F_Antenna.spl
and the DXF file is called Inverted_F_Antenna.dxf.
If the antenna is implemented on a PCB that
is wider than the antenna, avoid placing components
or having a ground plane close to the end points
of the antenna.

2   INTRODUCTION

The PCB antenna used on the
K3HBeacon 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.

3   Testing Conditions

Antenna Electrical Characteristics

Parameters	Value
Frequency Range	2402~2480MHz
Band Width	120MHz
VSWR	<2.0
Impendence	50 ohm
Gain	0dBi
Polarization	Single
Azimuth	Omni-directional

Product Testing Conditions

Parameters	Value
Working Temp	-30℃ ~ +60℃

4   ANTENNA DESIGN

The PCB antenna on the 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 K3HBeacon and to obtain good performance also when the K3HBeacon 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.
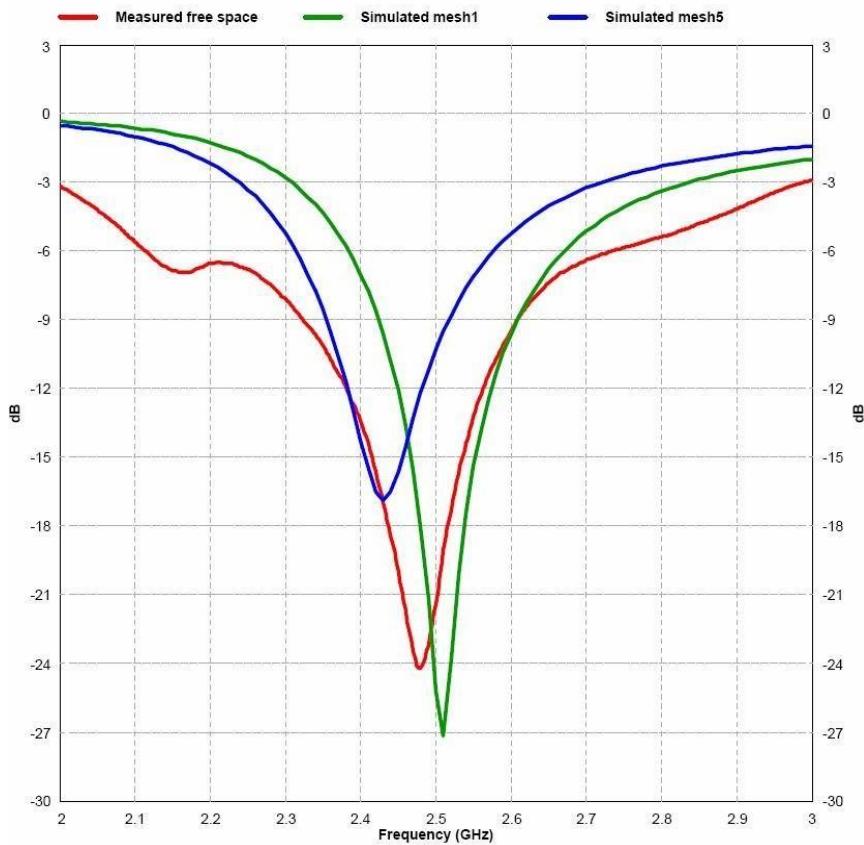
Figure 2: Comparison of Simulation and Measurements Results

4.3 Layout and Implementation
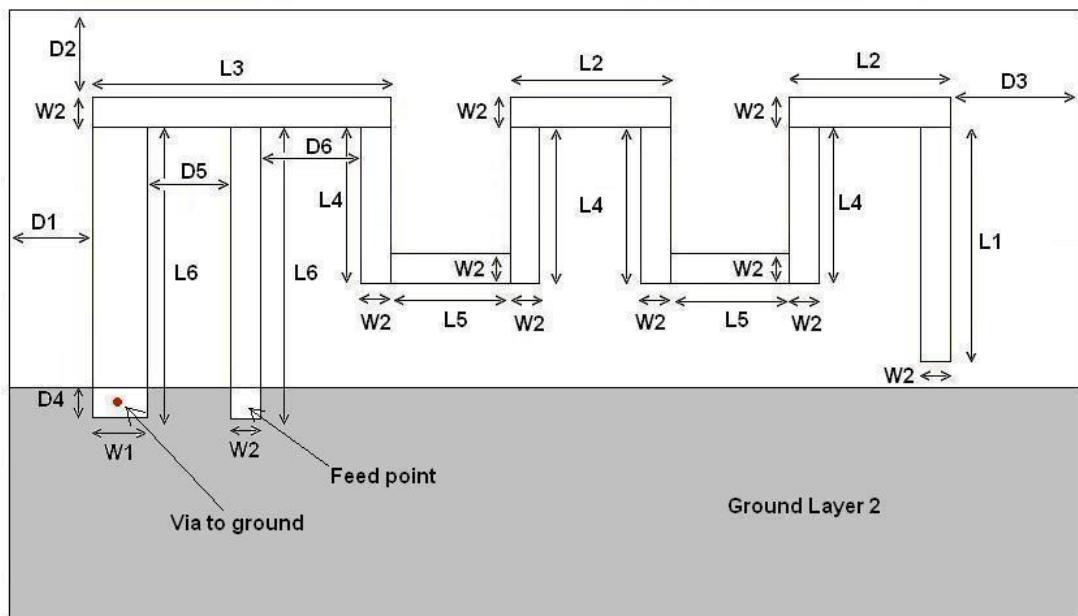
Figure 3: Antenna Dimensions

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.
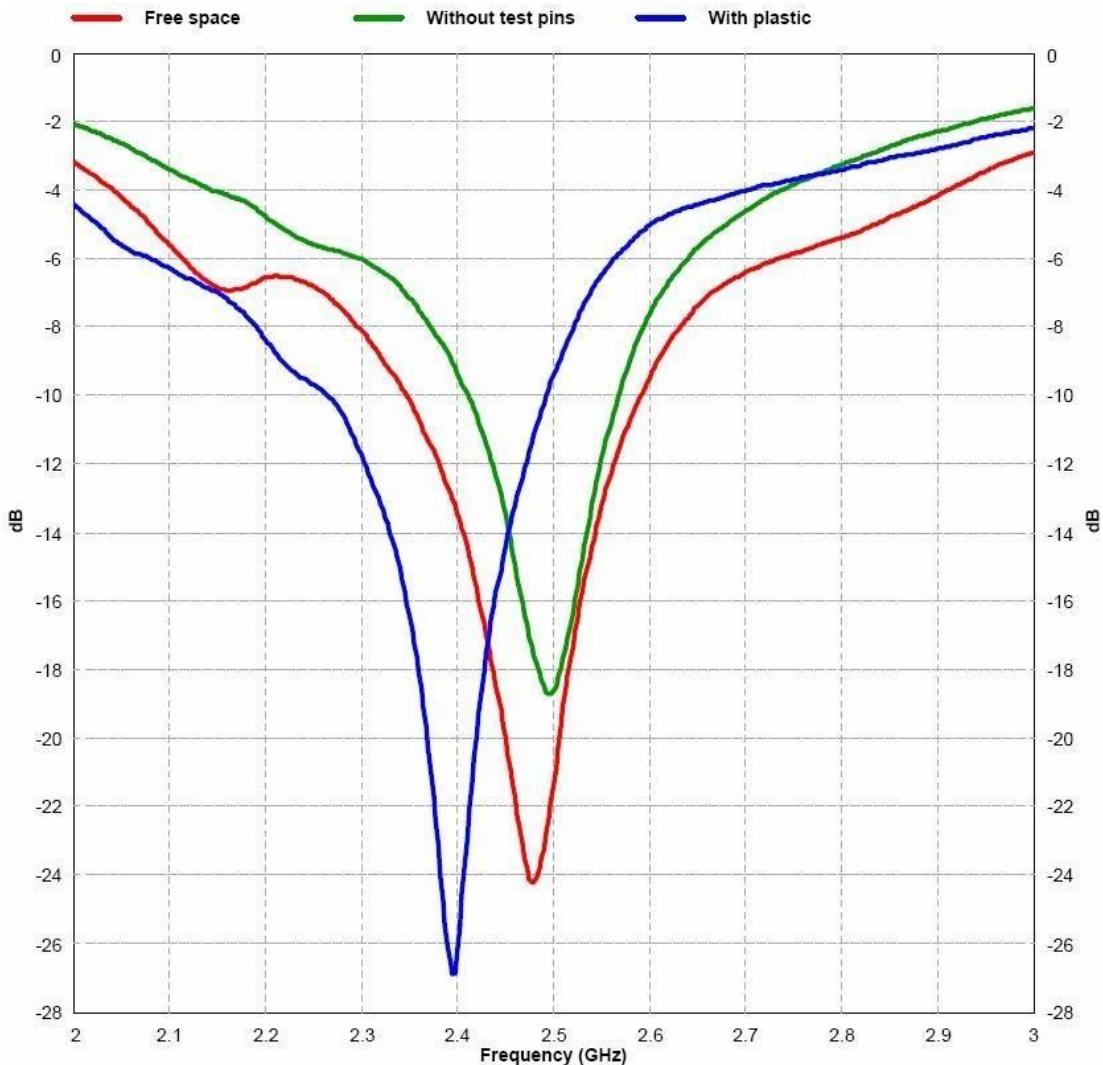
Figure 4: Influence of Plastic Encapsulation and Test Pins

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 K3HBeacon 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 K3HBeacon 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 K3HBeacon to a computer. Figure 13 and Figure 14 shows the radiation pattern when the K3HBeacon is connected to a laptop. All measurements were performed with 0 dBm output power. Figure 6 shows how the different radiation patters are related to the positioning of the antenna.

XY plane   YZ plane
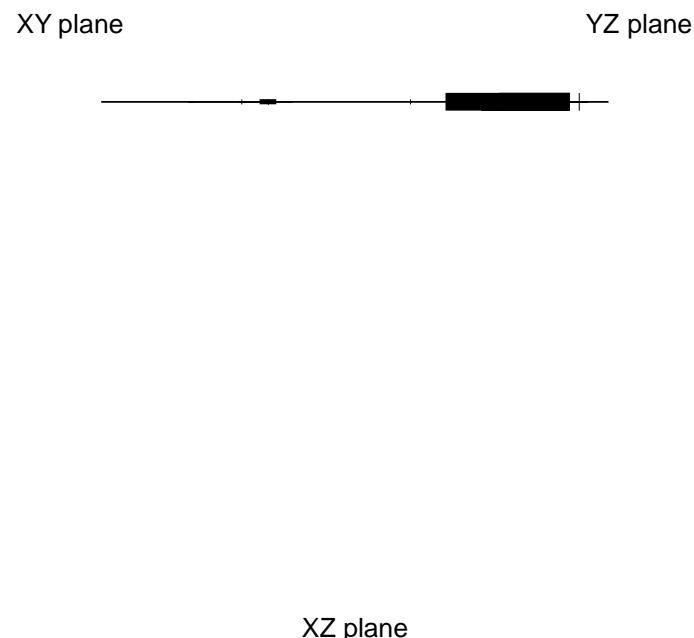
XZ plane

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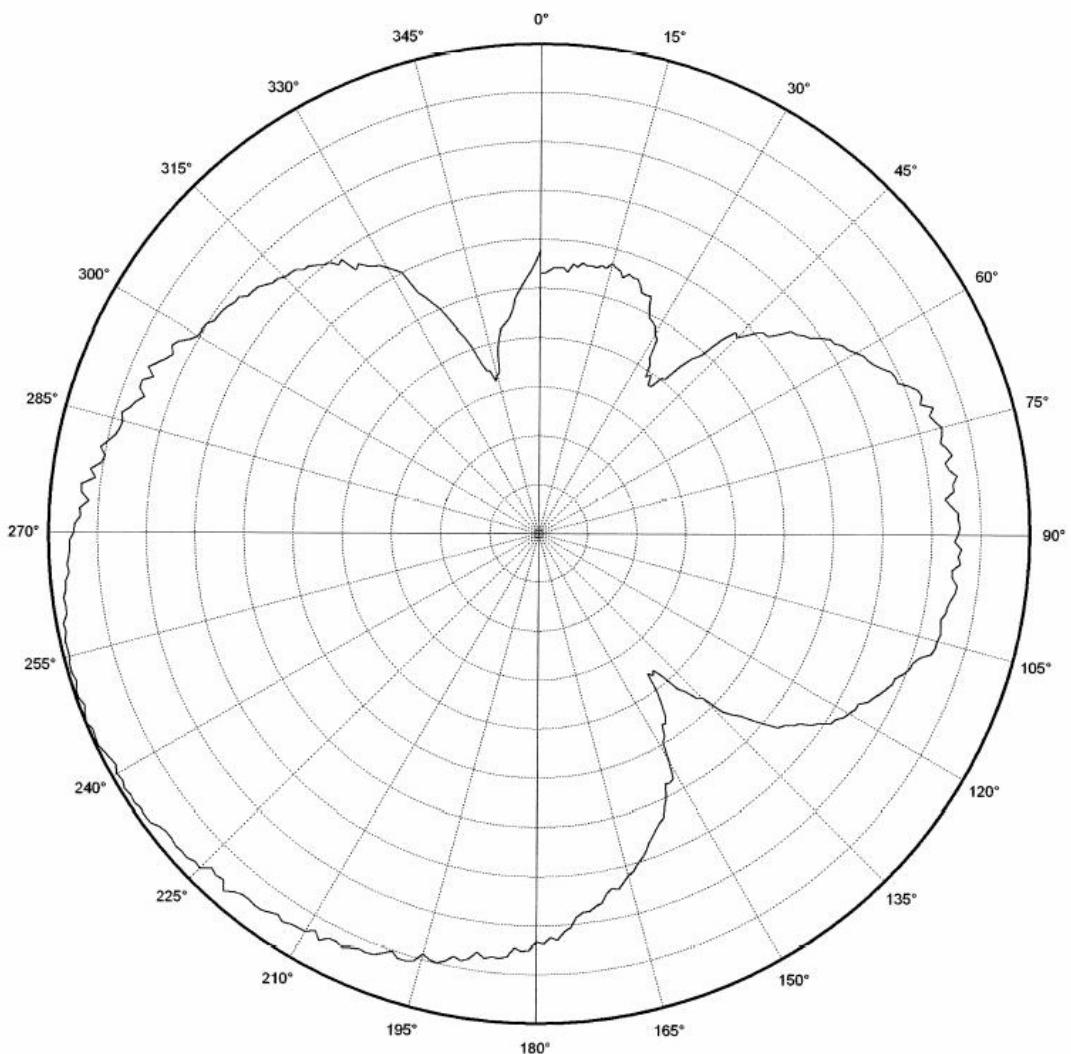
Vertical Polarization

usb XY

CF 2450.000 MHz
4 dB/ div
Ref Lev: .....-2,5..... dBm

Figure 7：XY Plane

Horisontal Polarization

usb XY

CF 2450.000 MHz
5 dB/ div
Ref Lev: ...4.5... dBm
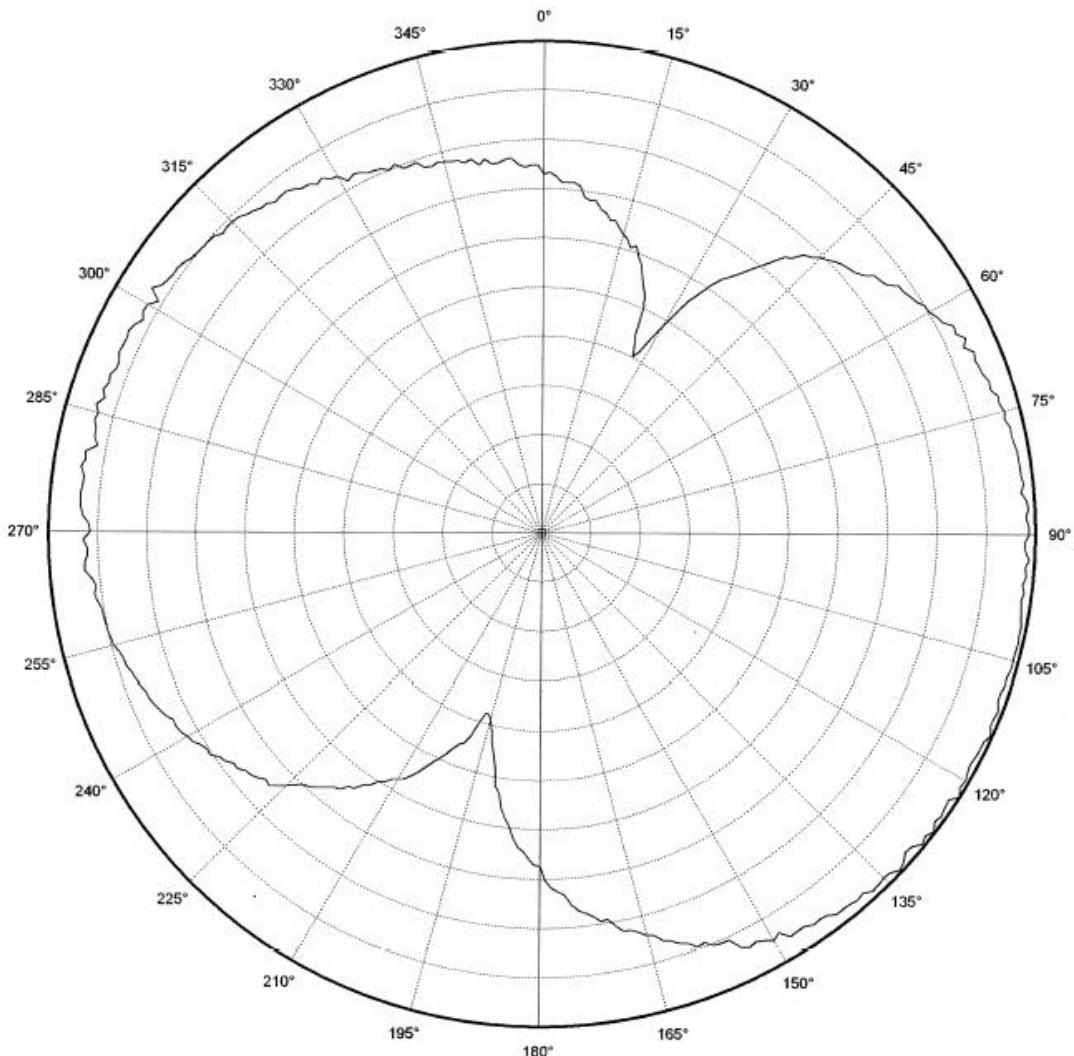
Figure 8: XY Plane
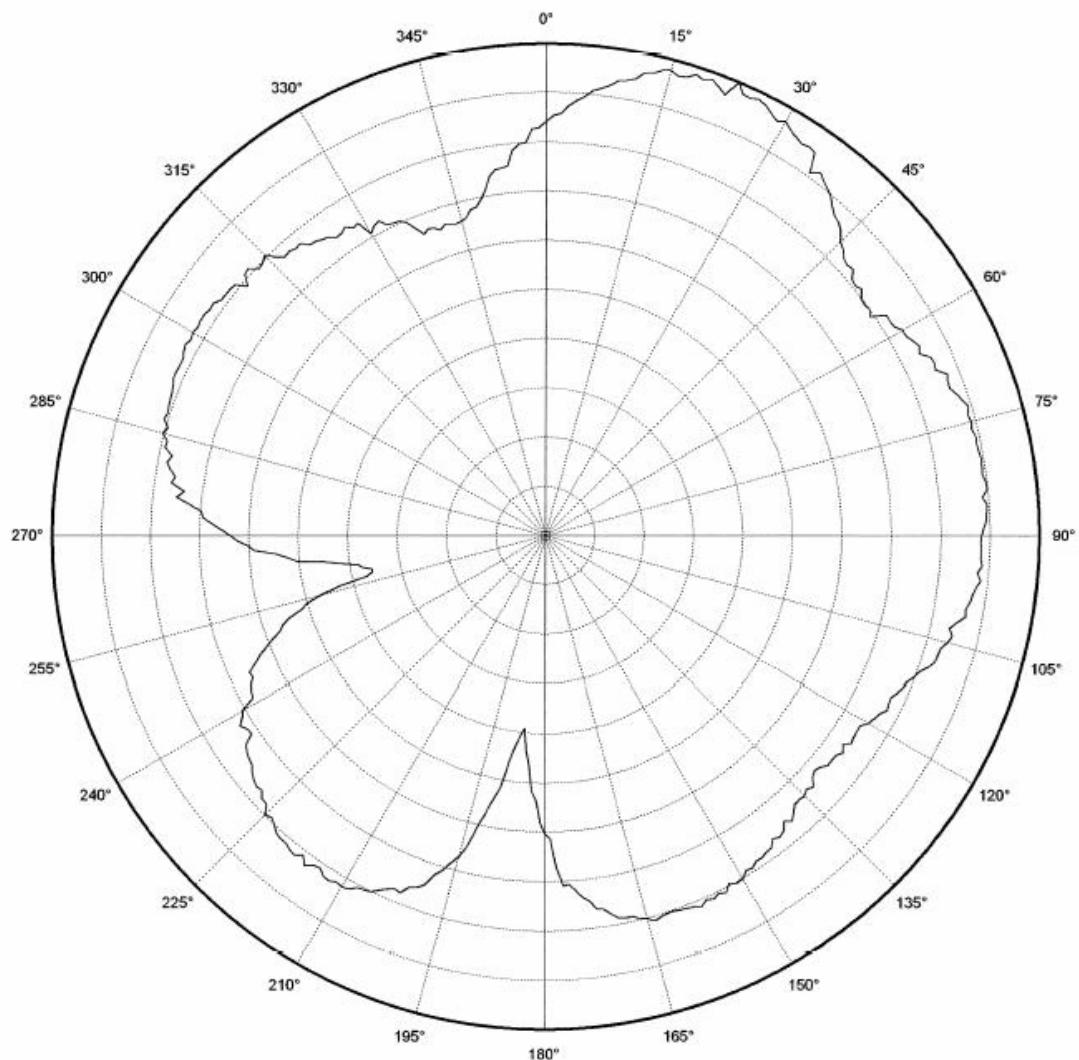
Vertical Polarization

usb XZ

CF 2450.000 MHz
4 dB/ div
Ref Lev: ...2.2... dBm

Figure 9: XZ Plane
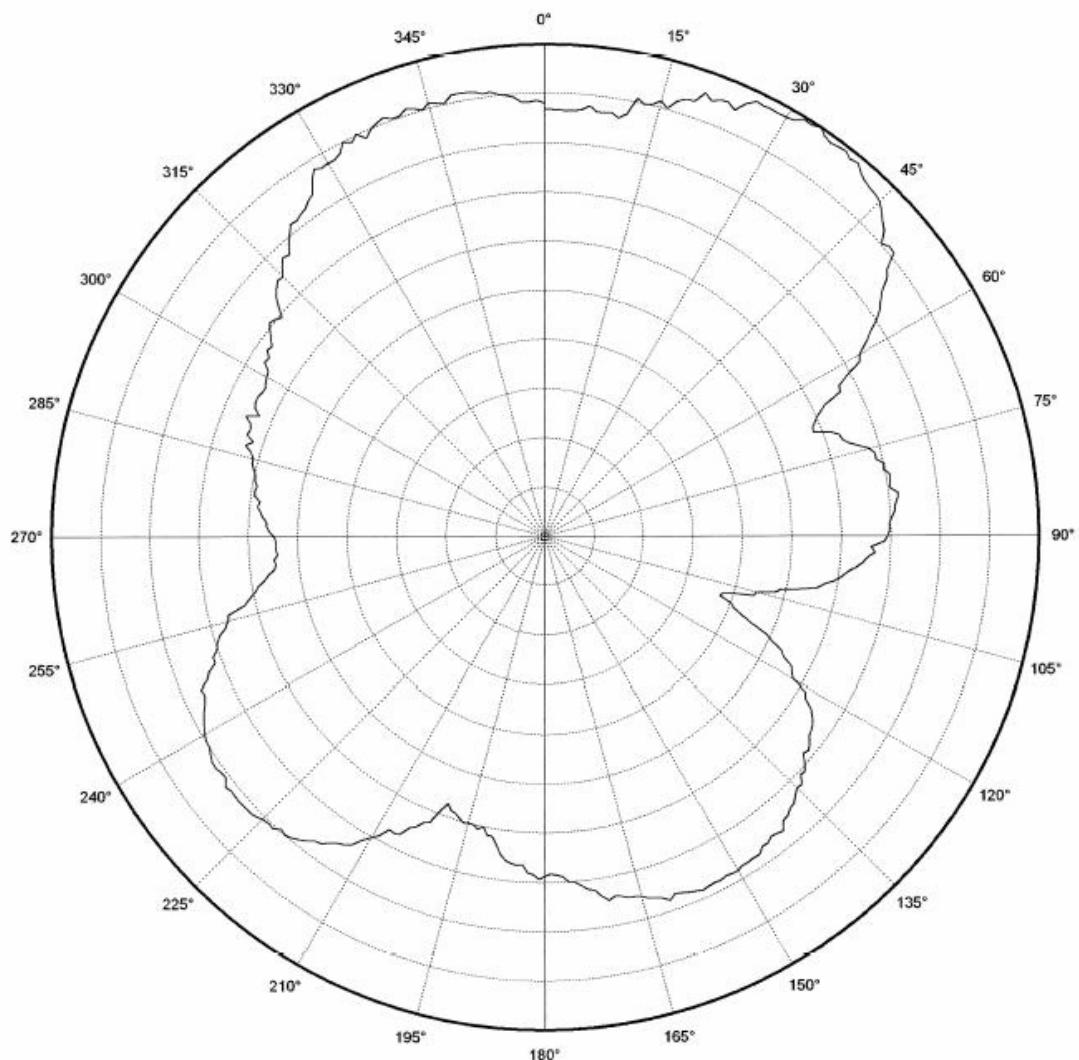
Horisontal Polarization

usb XZ

CF 2450.000 MHz
4 dB/ div
Ref Lev: ....5.3.... dBm

Figure 10: XZ Plane
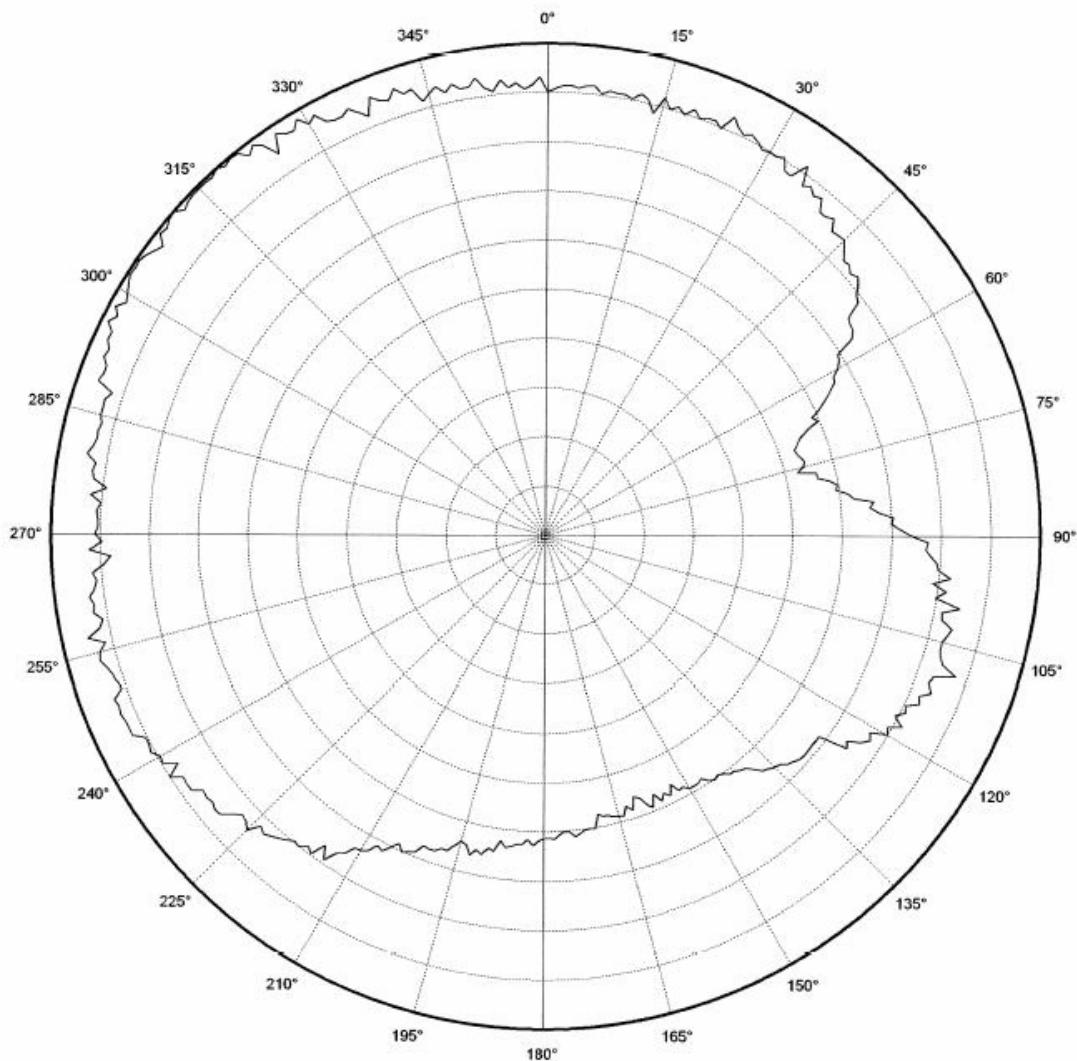
Vertical Polarization

usb YZ

CF 2450.000 MHz
2 dB/ div
Ref Lev: +5.3 dBm

Figure 11: YZ Plane
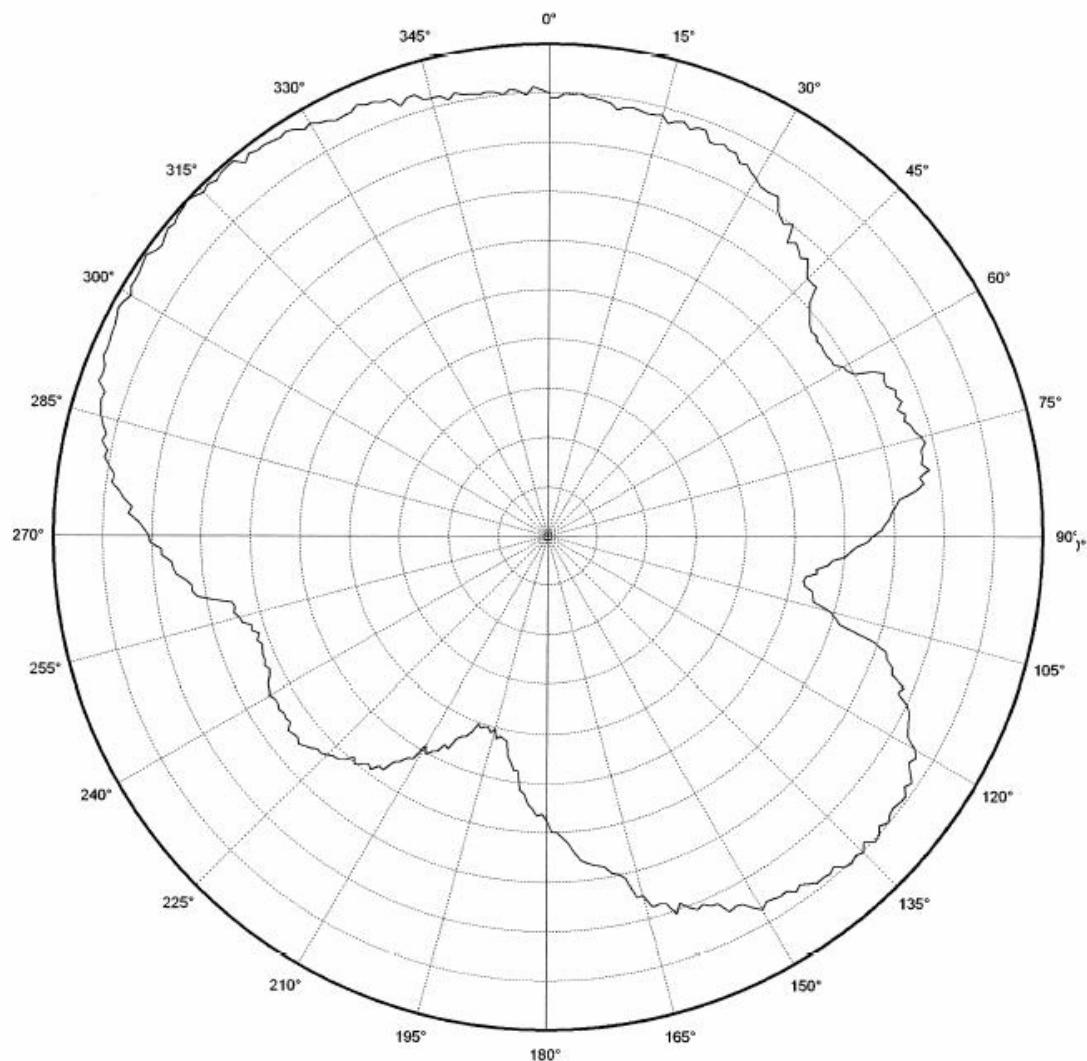
Horisontal Polarization

usb YZ

CF 2450.000 MHz
3 dB/ div
Ref Lev: ....–1,2..... dBm

Figure 12: YZ Plane

Vertical Polarization

Laptop USB XY

CF 2450.000 MHz
5 dB/ div
Ref Lev: -2.0 .... dBm
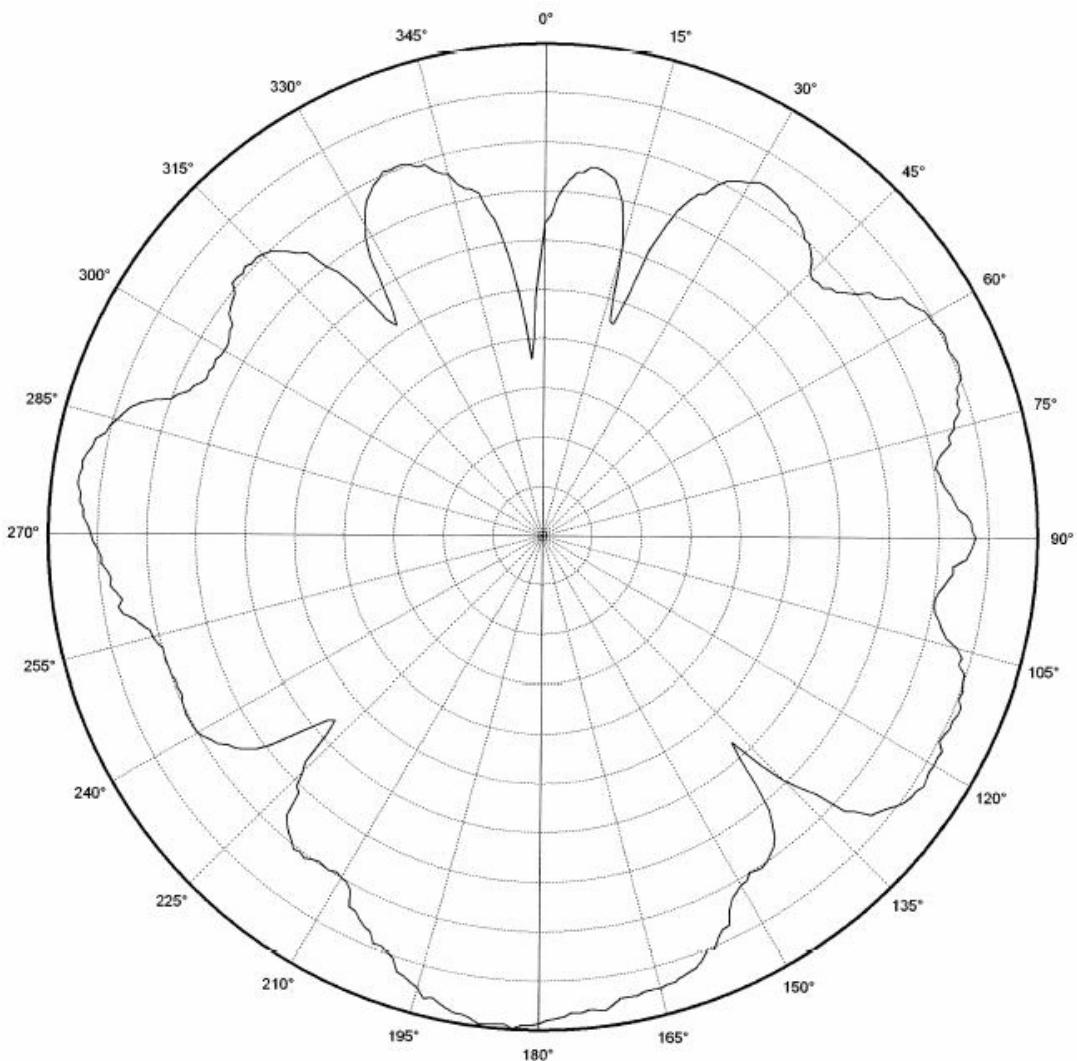
Figure 13: in Laptop XY Plane
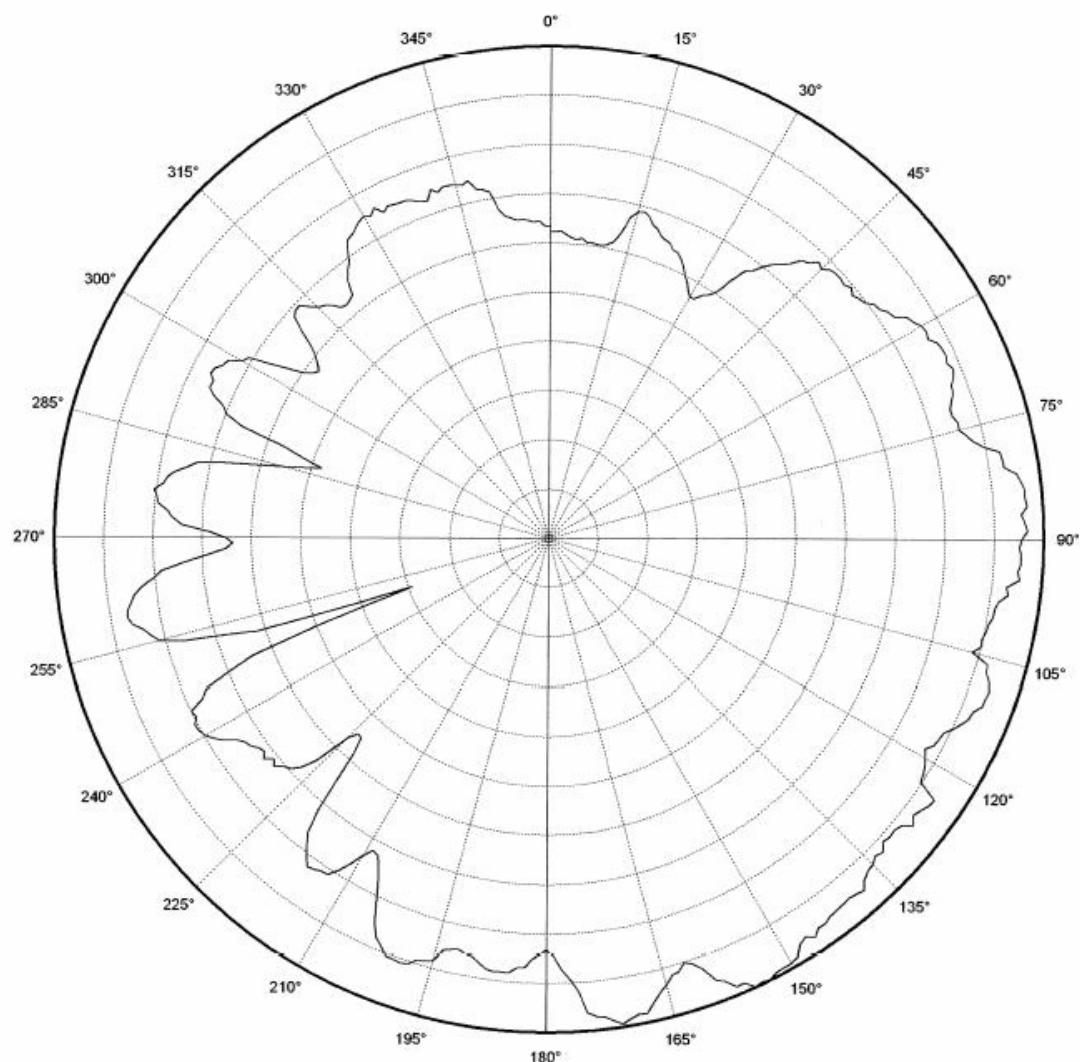
Horisontal Polarization

Laptop USB XY

CF 2450.000 MHz
4 dB/ div
Ref Lev: ...3.3....... dBm

Figure 14: in Laptop XY

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