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Design of Elliptical Microstrip Antenna for Ultra Wide Band Claims

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ABSTRACT

In this paper, Elliptical Microstrip Patch Antenna for Ultra Wide Band frequency ranging from 3.1 GHz to 10.6 GHz has been proposed. The design of the antenna concentrations on increasing the bandwidth by using an elliptical patch so that many claims can be covered on a single patch antenna. The antenna works over an Ultra Wideband frequency as allotted by the Federal Communications Commission (FCC). The antenna shows a good VSWR and Return Loss over the complete frequency range. The antenna has been designed according to some proposed and known formulae. The results are simulated using High Frequency Structure Simulator (HFSS 13.0) software. Simulated and measured results are presented for the proposed antenna.

Index Term: *UWB, Microstrip, Elliptical, Patch, Antenna, Monopole.*

Introduction

Antennas have essential position in the field of wireless communication. With the quick expansion and development of wireless broadband technologies we need light weight, low cost, and small size antennas. Wide development has been attained in the field of UWB schemes, meanwhile its adoption by the Federal Communications Commission "FCC" in 2002. The Federal Communication Commission (FCC) has released a bandwidth of 7.5GHz (from 3.1GHz to 10.6GHz) for ultra wideband wireless communications [7]. Due to its high bandwidth and very short pulses, UWB radio wave propagation offers very high data rate which may be up to numerous hundred Megabits per seconds (Mbps). Ultra-Wideband (UWB) is a communication method, quickly used in wireless networking to attain high bandwidth connections with low power consumption [1]-[4]. In many UWB based claims like highly modernize aircraft, satellite spacecraft and missile applications, where size, installation and aerodynamic profile are constraints and low profile antennas are essential. Presently there are numerous governmental and commercial applications, such as wireless communications & mobile radios that show like specifications. To satisfy above requirements, microstrip antennas could be used.

A Microstrip device in its simplest form is a sandwich of two parallel conducting layers detached by a single layer of dielectric substrate [1]-[2]. The upper conductor is called as a metallic patch (usually Copper or Gold), which is a small fraction of a wavelength. The lower conductor is a ground plane which should be unlimited tentatively. The patch and ground-plane are detached by a di-electric substrate which is typically non-magnetic. The dielectric constant of the substrate ranges from 1.17 to about 25.The effectiveness of a microstrip antenna depends upon patch size, shape, substrate thickness, dielectric constant of substrate, feed point type and its location, etc. It is suggested that for good antenna performance, a thick dielectric substrate layer having a low dielectric constant is necessary for larger bandwidth, better efficiency and radiation, leading to a larger antenna size. The patch can be of any shape, be it circular, elliptical, triangular, helical, rectangular, etc,..

Since, microstrip antenna suffers from disadvantage of narrow bandwidth, many results have been introduced, some of them signifying the use of dissimilar forms of the patch that covers several mode surface current waves, which causes resonance at multiband frequencies and lastly extend the impedance bandwidth across the UWB range [3]-[5]. The abilities of UWB are it works over an ultra-wide bandwidth, acceptable radiation properties over the entire frequency range, a good impulse response with negligible distortion and low power consumption.

Elliptical microstrip patch antennas (EMSA) are the ones we are considering as their geometry signifies more abilities for a variety of low-profile antenna claims [8]-[10]. Out of the several shapes used in the microstrip antenna like rectangular, circular, square, helical the elliptical shape has numerous advantages like providing larger flexibility in the design and it has the largest bandwidth in the range of GHz. It has been found that elliptical antenna may give better return loss, good directivity and radiation pattern when we are ready to concession somewhat over the size of antenna [8].

A. Antenna Design

The designed printed elliptical monopole antenna PEMA is shown in Fig. 1 and the design parameters are calculated using the following steps:

$$fl = \frac{7.2}{(l + r + p) \times k} \quad (1)$$

L=2B & r=A

Where, *fl* is the lower edge frequency, *P* is the 50Ω feed line length, which has been projected in this design to be equal to 0.3 mm, while, and the come near to value of *εeff* is given by:

$$\varepsilon eff = \frac{(\epsilon r+1)}{2} \quad (2)$$

For FR4 substrate with thickness of 1.6 mm, *εeff is* approximated to be equal to 1.27.The parameters; *L*, *r* and *P*, in (1) are all that by selecting *A* = 14mm and *B* =12mm at 3.1 GHz as an estimated lower cut off frequency.

B. Microstrip Line Width (Wstrl)

The line width can be calculated from the following equation:

$$z0 = \frac{87}{\sqrt{\epsilon r+1.41}} ln\left(\frac{5.98h}{0.8wstrl+t}\right) \quad (3)$$

Where *Z0* is the characteristic impedance of the line, *h* is the substrate thickness which has been taken 1.6mm as a typical value for the FR4 substrate, *t* is the metallization thickness taken as 0.035 mm, Wstrl is the microstrip feed line width and *εr* for FR4 substrate is 4.3. Therefore according to (3), for characteristic impedance of 50 Ω, Wstrl must be 3mm.

C. Ground Plane Layer Length (Lg)

The ground plane length has been found to be equal to $\lambda/4$ at the lower band-edge frequency 3.1 GHz as in the following calculations:

$$Lg = \lambda/4 = c/4kfl \quad (4)$$

Where, k here is same as seen in equation (1).

Accordingly, the parameter ground plane length has been calculated as 20 mm.

Fig1 and Fig2 show Geometry of the designed PEMA antenna, with design parameters as follows:

A= 14 mm, B=12 mm, X= 55 mm, Wstrl= 3 mm, Y=56 mm, LG=20mm, P= 0.3 mm, dielectric 4.4; FR4 substrate width of 1.6 mm.

D. Substrate Dimensions

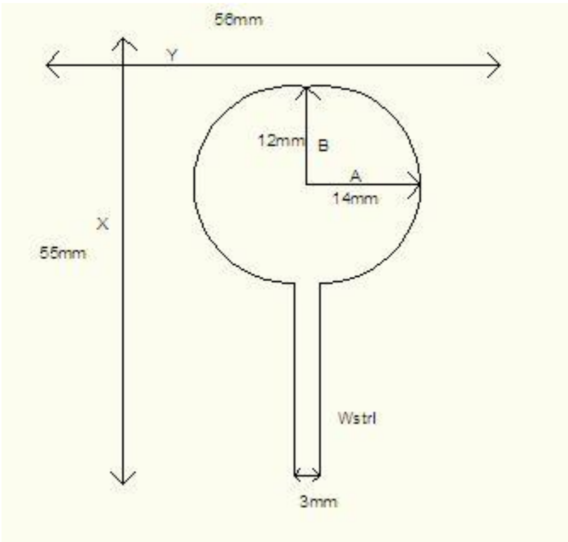


Fig.1. Top view

After calculating the above parameters the overall dimensions are decided for the substrate.

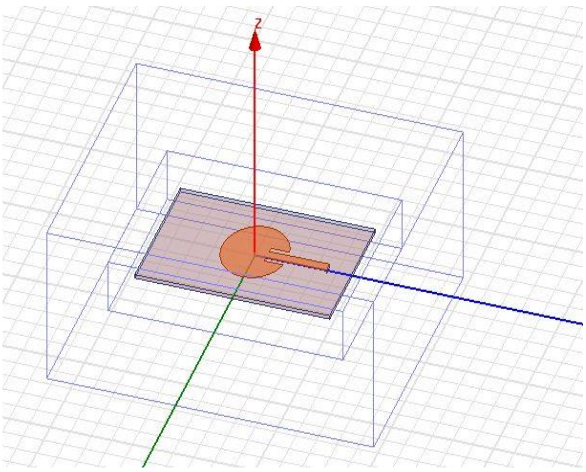


Fig 2. Antenna view in HFSS tool

In the present paper, an elliptical microstrip patch antenna for Ultra Wide Band applications has been designed. We are using elliptical patch because it provides comparatively larger bandwidth than others.

The partial ground plane method is used in this antenna, since it offers increased bandwidth, hence it is called elliptical monopole antenna.

Design Specifications of Proposed Antenna at Different Frequencies: (All units in mm)

Frequency	3.2Ghz	6.22Ghz
Patch dimension along X	3.83	1.91
Patch dimensions along Y	3.18	1.53
Substrate thickness	62mil	62mil
Substrate dimensions along X	6.7	3.8
Substrate dimensions along Y	9.53	4.69
Inset distance	0.971	0.468
Inset gap	0.243	0.243
Feed width	0.485	0.485
Feed length	2.948	1.469

Simulated Result

A. Return Loss

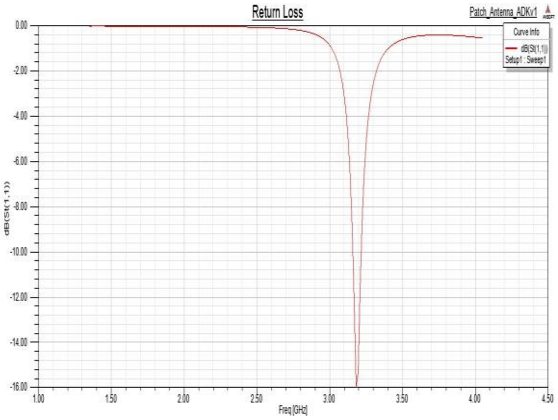


Fig.3: Return loss at 3.2 Ghz

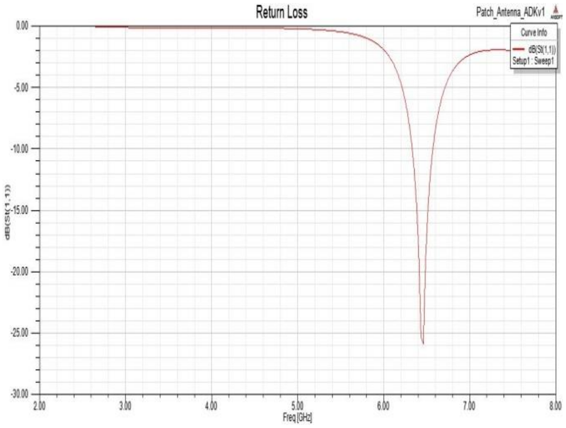
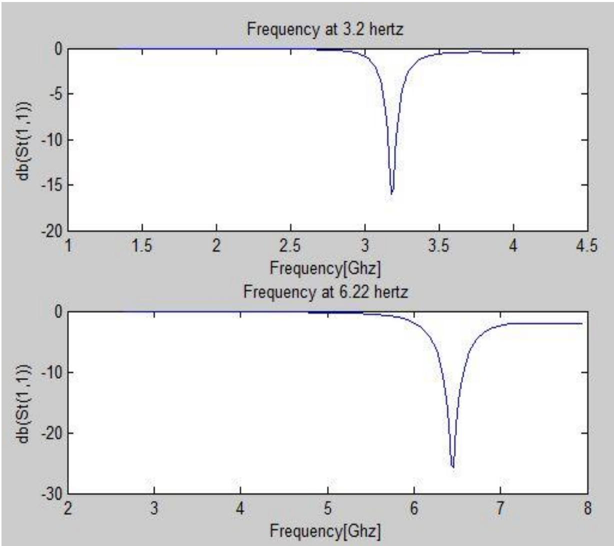


Fig.4: Return loss at 6.22 Ghz

Fig.3 and Fig.4 shows the plot for return loss at 3.2Ghz, 6.22Ghz. The –10 dB return loss bandwidth of the antenna should cover 3.2 GHz to 10.6 GHz to satisfy the UWB system applications. As seen in the plot for that the return loss curve has resonance frequencies at 3.2 GHz, 6.22 GHz and 9.42GHz return loss the graph is below -10dB for the desired frequency range hence, this graph is satisfied for better performance. It is observed.

Comparison between Return Loss



B. Gain

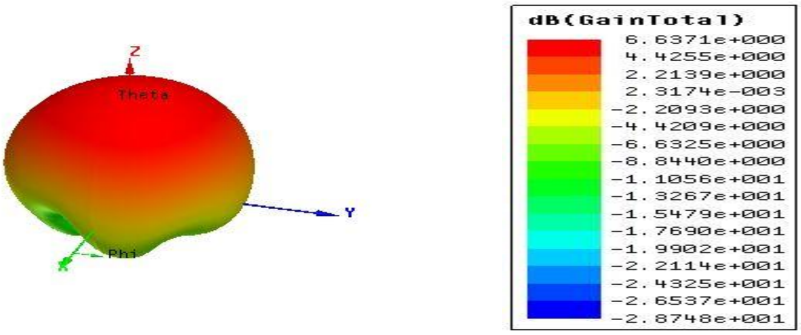


Fig.5: Gain at 3.2GHz

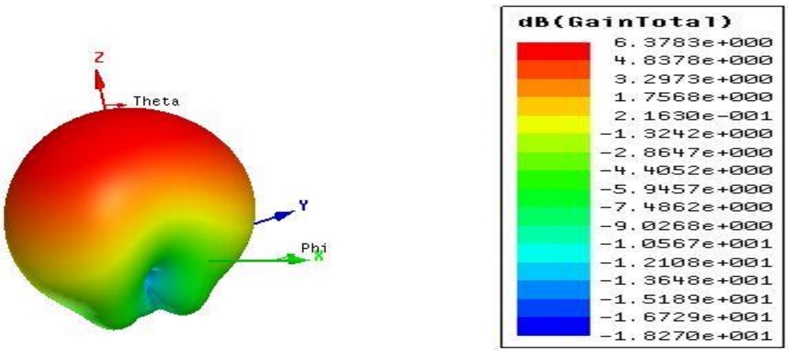


Fig.6: Gain at 6.22 Ghz

I S S N : 2 5 8 2 - 3 9 8 1

The measured radiation patterns of the antenna on the E-plane and H-plane at resonant frequencies of 3.1 GHz and 6.22 GHz are shown in Fig 5and Fig 6. The results show reasonable omnidirectional radiation pattern .The omnidirectional antenna is capable of transmitting in all the possible directions with equal intensities.

For perfect impedance matching, the reactance should be negligible and impedance should be 50 Ω. From the plot above we can see the impedance is approximately 50 Ω, hence it is satisfied.

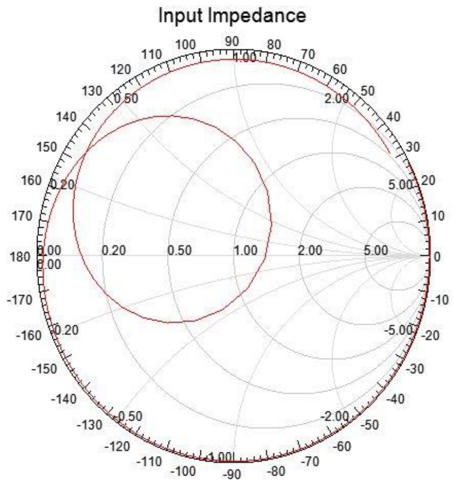


Fig.7: Impedance at 3.2Ghz

C. Impedance

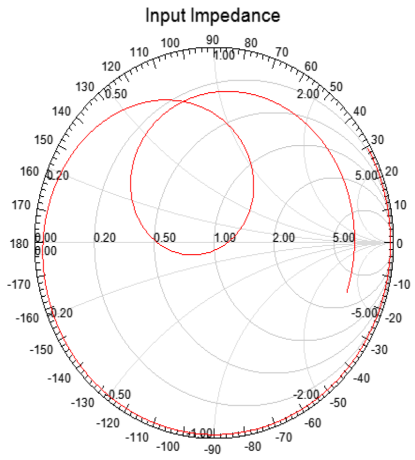


Fig.8: Impedance at 6.22Ghz

Conclusion & Future Scope

The desired and simulated result is approximately same. To further improve the performance of antenna a slit or slot can be added to the antenna. The antenna can also be modified to work as a reconfigurable antenna.

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