Design of Elliptical Microstrip Antenna for Ultra Wide Band Applications

Ajinkya Pingale, Aniket Shende, Ashay Jadhav, Chaitanya Ghanote, Umang Sonare

***Abstract*— In this paper, Elliptical Microstrip Patch Antenna for Ultra Wide Band frequency ranging from 3.1 GHz to 10.6 GHz has been suggested. The design of the antenna focuses on increasing the bandwidth by using an elliptical patch so that many applications can be covered on a single patch antenna. The antenna operates over an Ultra Wideband frequency as allocated by the Federal Communications Commission (FCC). The proposed antenna is designed on FR4 PCB having size 55 mm x 56 mm x 1.6 mm. The antenna exhibits a good VSWR and Return Loss over the entire frequency range. The antenna has been designed according to some suggested 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 Terms* — UWB, Microstrip, Elliptical, Patch, Antenna, monopole.**

I. INTRODUCTION

Antennas have fundamental importance in the field of wireless communication. With the rapid development and advancement of wireless broadband technologies we require light weight, low cost, and small size antennas. Extensive progress has been achieved in the field of UWB systems, since 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 provides very high data rate which may be up to several hundred Megabits per seconds (Mbps). Ultra-Wideband (UWB) is a communication method, rapidly used in wireless networking to achieve high bandwidth connections with low power utilization [1]-[4]. In many UWB based applications like highly modernize aircraft, satellite spacecraft and missile applications, where size, installation and aerodynamic profile are constraints and low profile antennas are essential. Currently there are various governmental and commercial applications, such as wireless communications & mobile radios that exhibit similar 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 separated 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 infinite theoretically. The patch and ground-plane are separated by a di-electric substrate which is usually non-magnetic.

The dielectric constant of the substrate ranges from 1.17 to about 25.The efficiency of a microstrip antenna depends upon patch size, shape, substrate thickness, dielectric constant of substrate, feed point type and its location, etc. It is recommended that for good antenna performance, a thick dielectric substrate layer having a low dielectric constant is desirable 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 drawback of narrow bandwidth, many solutions have been introduced, some of them suggesting the use of different shapes of the patch that covers multiple mode surface current waves, which causes resonance at multiband frequencies and finally widen the impedance bandwidth across the UWB range [3]-[5]. The capabilities of UWB are it operates over an ultra-wide bandwidth, satisfactory radiation properties over the entire frequency range, a good impulse response with minimal distortion and low power utilization.

Elliptical microstrip patch antennas (EMSA) are the ones we are considering as their geometry represents greater potentials for a variety of low-profile antenna applications [8]-[10]. Out of the various shapes used in the microstrip antenna like rectangular, circular, square, helical the elliptical shape has several 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 compromise somewhat over the size of antenna [8].

II. ANTENNA DESIGN

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

A. Patch Size (A & B):

The size of PEMA can be calculated via the following equations:

$$f_L = \frac{7.2}{(L + r + P) \times k} GHz \qquad (1)$$

$$L = 2B$$

$$r = \frac{A}{4}$$

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Ajinkya Pingale, RGCER, Nagpur, India, Mob. No. 8237842037
Aniket Shende, RGCER, Nagpur, India, Mob. No. 8087977327
Ashay Jadhav, RGCER, Nagpur, India, Mob. No. 9764080281
Chaitanya Ghanote, RGCER, Nagpur, India, Mob. No. 9158911499
Umang Sonare, RGCER, Nagpur, India, Mob. No. 8446566647

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

$$\varepsilon_{eff} = \frac{\varepsilon r + 1}{2} \qquad (2)$$

For FR4 substrate with thickness of 1.6 mm, ε_{eff} *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 (W_{strl}):

The line width can be calculated from the following equation:

$$Z_O = \frac{87}{\sqrt{\varepsilon r + 1.41}} \ln\left(\frac{5.98h}{0.8W_{strl} + t}\right) \qquad (3)$$

Where Z_0 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, W_{strl} is the microstrip feed line width and εr for FR4 substrate is 4.3. Therefore according to (3), for characteristic impedance of 50 Ω, W_{strl} must be 3mm.

C. Ground Plane Layer Length (L_G):

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:

$$L_G = \frac{\lambda}{4} = \frac{c}{4kf_L} \qquad (4)$$

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 shows Geometry of the designed PEMA antenna, with design parameters as follows: A= 14 mm, B=12 mm, X= 55 mm, W_{strl}= 3 mm, Y=56 mm, L_G=20mm, P= 0.3 mm, dielectric 4.4; FR4 substrate width of 1.6 mm.

D. Substrate Dimensions:

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

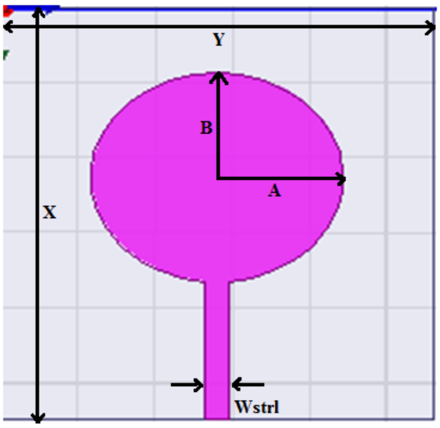

Fig.1: Front View of Antenna

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.

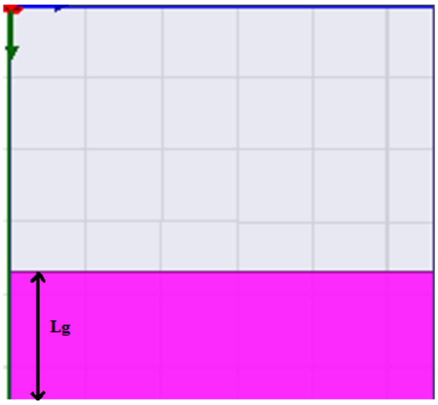

Fig.2: Bottom View of Antenna

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

III. Simulated Result

A. Return Loss:

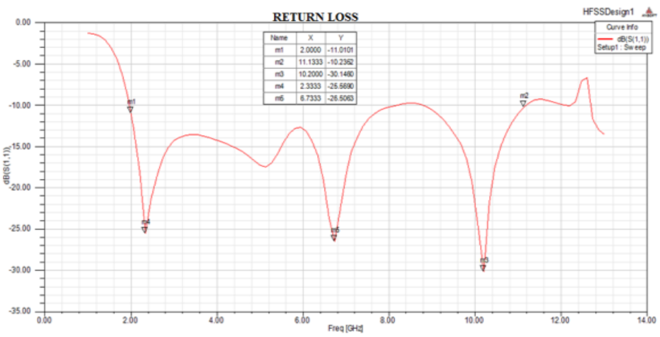

Fig.3: Reflection Coefficients vs. Frequency

Fig.3 shows the plot for reflection coefficient versus frequency. The –10 dB return loss bandwidth of the antenna should cover 3.1 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 2.33 GHz, 6.88 GHz and 10.22 GHz return loss the graph is below -10dB for the desired frequency range hence, this graph is satisfied for better performance. It is observed.

B. Voltage Standing Wave Ratio (VSWR):

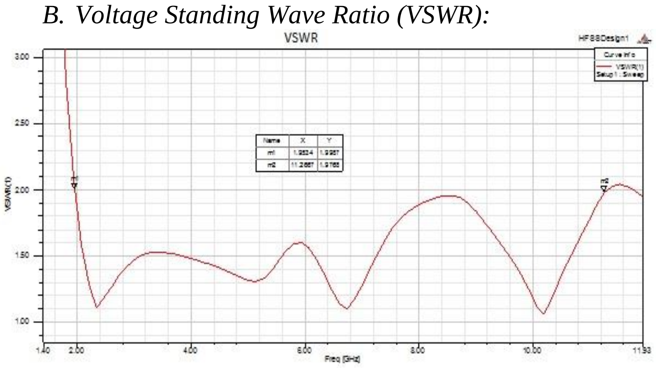

Fig.4: VSWR vs. Frequency

Fig.4 shows the plot for VSWR versus frequency. The plot specifies the value of VSWR between 1 and 2 which satisfies the UWB characteristics and for the same region the return loss is also less than -10 dB.

C. Gain:

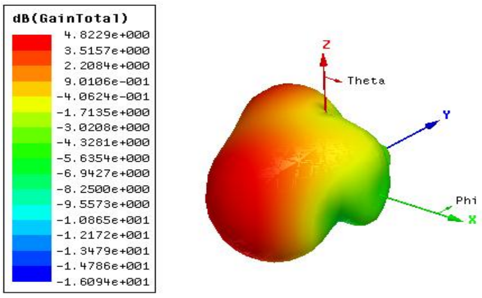

Fig.5: Gain at 2.3333 GHz

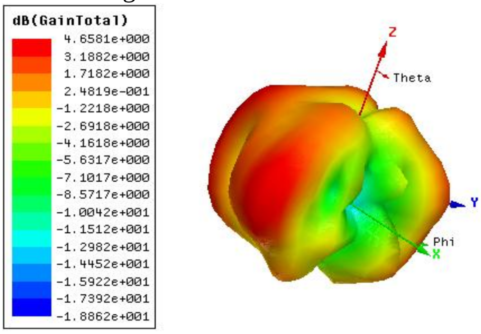

Fig.6: Gain at 6.7333 GHz

The measured radiation patterns of the antenna on the E-plane and H-plane at resonant frequencies of 2.33 GHz and 6.733 GHz are shown in Fig 5 and Fig 6. The results show reasonable omnidirectional radiation pattern .The omnidirectional antenna is capable of transmitting in all the possible directions with equal intensities.

D. Impedance:

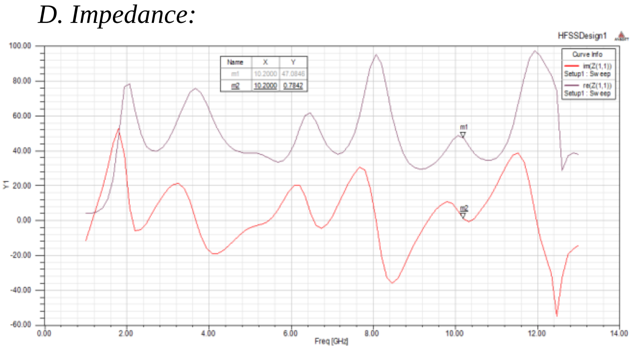

Fig.7: Impedance vs. Frequency

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.

E. Current Distribution:

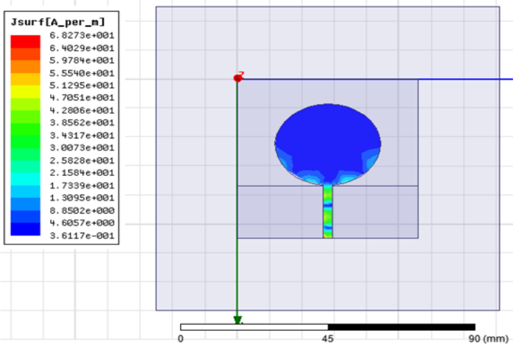

Fig.8: Current Distribution in antenna

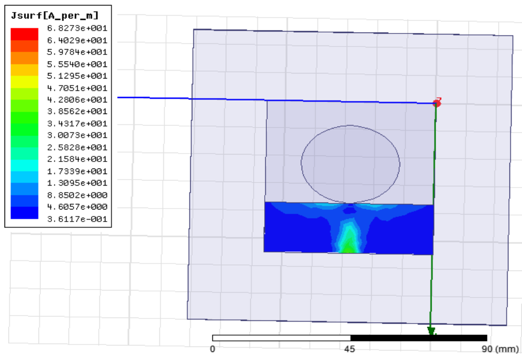

Fig.9: Current Distributions in Ground Plane

Fig.8 and Fig.9 shows the current distribution in the patch and ground plane respectively. The current is distributed mainly along the edges and the feed point. On the ground plane, the current is distributed mainly on the upper edge.

IV. 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.

V. References

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Biography

Aniket Shende, studying final year B.E. in Electronics & Telecommunication in Rashtrasant Tukodoji Maharaj Nagpur University, Nagpur, India. His area of interest is Antenna & Control Systems.

Ashay Jadhav studying final year B.E. in Electronics & Telecommunication in Rashtrasant Tukodoji Maharaj Nagpur University, Nagpur, India. His area of interest is Antenna & Mobile Communication.

**Ajinkya Pingale,** studying final year B.E. in Electronics & Telecommunication in Rashtrasant Tukodoji Maharaj Nagpur University, Nagpur, India. His area of interest is microstrip Antennas and communication engineering.

 **Chaitanya Ghanote**, studying final year B.E. in Electronics & Telecommunication in Rashtrasant Tukodoji Maharaj Nagpur University, Nagpur, India. . His area of interest is Antenna & optical comm.

.**Umang Sonare**, studying final year B.E. in Electronics & Telecommunication in Rashtrasant Tukodoji Maharaj Nagpur University, Nagpur, India. . His area of interest is Antenna & radar communication