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Design of Elliptical Ring Monopole Antenna for Ultrawideband Applications

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Abstract

*A planar elliptical ring monopole antenna is designed for Ultrawideband applications. The studied antenna is very compact and small size (23mm*34mm*0.83mm). The antenna is designed on substrate with relative permittivity of 3.38. Better impedance matching can be obtained by providing dual step feed between elliptical ring and microstrip feed line and by cutting a triangular slot on the upper side of the ground plane. It is suitable for low cost fabrication and easily integrated into printed circuit board*

1. Introduction

Ultrawideband (UWB) technology is mainly used for indoor wireless radio, ground penetrating radars, imaging because of its short range and high bandwidth communication [1]. The frequency band of the UWB technology is 3.1GHz to 10.6GHz. This band is allocated by the Federal Communications Commission (FCC) in 2002.Antenna unit is the one of the main components in the UWB system. Various types' planar monopole antennas have been designed for UWB technology. To provide better impedance bandwidth several techniques like using various disc shapes, bevelling technique etc. Printed monopole antennas are widely used in wireless communication [8]. The main advantages of planar monopole antennas are low cost, ease of fabrication, low profile, and very small size. Shapes normally used for radiator of the monopole antenna are circular, elliptical, hexagonal, square, rectangle etc [5]. Out of these elliptical [7] and hexagonal shapes are commonly used because of it provide good performance. The good impedance matching can be obtained by optimizing the sizes of the radiator and ground plane.

In this paper an elliptical ring monopole antenna is designed and discussed. It can work well mainly at three frequencies in the UWB band. The impedance matching at these frequencies can be improved by providing dual step feed between elliptical ring and microstrip feed line and also cutting a triangular slot on the upper side of the partial ground plane [4]. Since we are using partial ground plane power is radiated under the ground plane also. Mainly used feeding techniques are microstrip line feed, coplanar waveguide, and slotted structure .Comparing to the other feeding techniques microstrip line feed provide low cost for antenna design and good impedance matching in terms of 50-ohm impedance matching and good radiation behaviour. The antenna performance parameters like impedance matching, radiation behaviour and bandwidth are mainly depends on the size and shape of the radiator and ground plane of the antenna. In this paper we designed a monopole antenna in order to operate at three frequencies. Impedance matching at these frequencies can be improved by providing dual step feed between elliptical ring and feed line [2] and also cutting the triangular slot on the upper side of the partial ground plane [3], [6], [9].

2. Antenna Design

The elliptical ring monopole antenna is designed by using FEKO software.

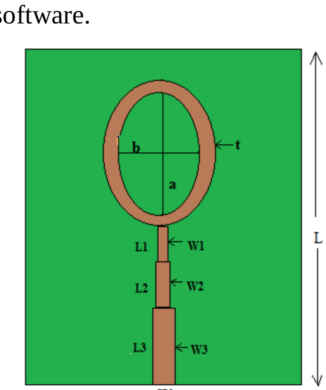

Figure 1: Top view of the Elliptical monopole antenna

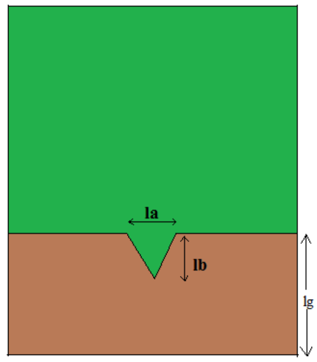

Figure 2: Bottom View of the Elliptical Monopole Antenna

The top view of the proposed antenna is shown in the Figure 1. Elliptical ring monopole is printed on a substrate with permittivity of 3.38 and thickness 0.8mm.In order to improve the impedance matching a dual step feed is provided between microstrip feed line and elliptical ring. Figure 2 shows the bottom view of the proposed antenna. A triangle slot with length 'la' and breadth 'lb' is cut on the upper side of the partial ground plane. The proposed antenna is very compact size (23mm*34mm*0.83mm).

Table 1: Dimensions of the Elliptical ring monopole antenna

Antenna Parameters	**Millimeter**
Length of the Substrate (L)	34
Width of the Substrate (W)	23
Major axis of the Elliptical Ring (a)	7
Minor axis of the Elliptical Ring (b)	5
Length of the Feed line (L3)	8
Width of the Feed line (W3)	2.4
Length of the First microstrip line (L2)	5
Width of the First microstrip line (W2)	2
Length of the 2nd microstrip line (L1)	3
Width of the 2nd microstrip line (W1)	1.6
Length of the partial ground plane (lg)	13.6
Length of the triangular slot (la)	3.6
Height of the triangular slot (lb)	2.6
Thickness of the ring(t)	1

The optimized values of the elliptical monopole antenna are shown in the Table1.

3. Simulated Results

The elliptical ring monopole antenna is designed by FEKO software and antenna performance parameters like return loss, current distributions, the radiation pattern is measured and discussed here.

3.1 Return Loss

In order to radiate antenna well, power return back to the feed should be less. This can be obtained by measuring return loss. Power loss is mainly occurred due to the discontinuity between transmission line and antenna. Scattering parameters or S11- parameters are used to express the return loss. It is usually measured in dB. In the notation S11, first number indicates the responding port number and second number indicating the incident port. In this since both responding and incident ports are same it gives how much power is returned back .If the antenna and feed line are perfectly matched then power reflected from the antenna is reduced and maximum power is delivered to the antenna.S11 parameter of the elliptical ring monopole antenna is shown in the Figure 3.From the graph it is clear that the antenna is work well on mainly three frequencies 3.2GHz, 6.8GHz and 8.5GHz.The first resonance frequency is occurred at around 3.2GHz and corresponding S11 parameter is -26dB.The first resonance frequency mainly depends on dimensions of the elliptical ring. Second resonance frequency occurred at 6.8GHz and corresponding S parameter is about -17dB. Third resonance frequency occurred at 6.8GHz and its S parameter is about -19dB.Antenna radiate well if the S parameter is less than -10dB.

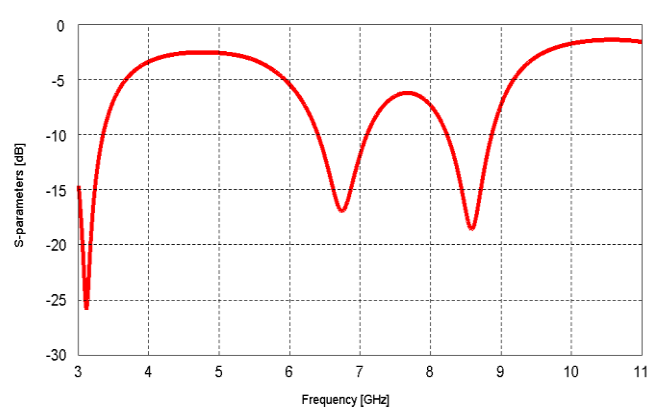

Figure 3: Scattering Parameter of the Elliptical Ring Monopole Antenna

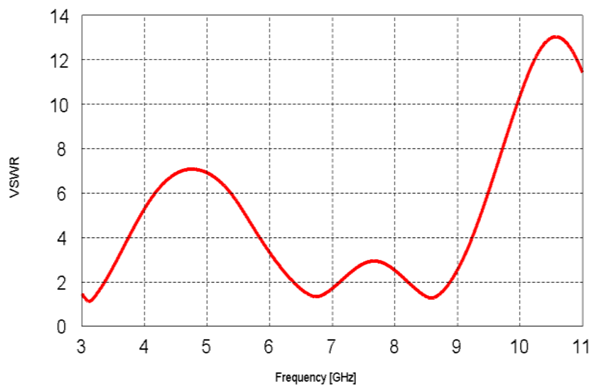

Figure 4: VSWR of the Elliptical Ring Monopole Antenna

3.2 Voltage Standing Wave Ratio (VSWR)

It gives measure about the how well the antenna is impedance matched to the transmission line. For better impedance matching between the antenna and transmission line VSWR should be small. In the ideal case the minimum value of the VSWR is 1. In this case no power is reflected from the antenna. VSWR can be expressed in equation 1

$$VSWR = (1+|\Gamma|) / (1-|\Gamma|) \quad (1)$$

Where 'Γ' is the reflection coefficient. The VSWR of the elliptical ring monopole antenna is shown in the figure 4 .From the graph it is clear that at the operating frequencies (3.2GHz, 6.8GHZ, and 8.5GHz) of the antenna VSWR values are below 2. This indicates that power reflected from the antenna is very less.

3.3 Radiation Pattern

Radiation pattern gives radiated power variance as a function of direction away from the antenna. This power variation can be calculated in far field or near field. The region close to the antenna is called near field or induction field and region far from the antenna is called far field region or radiation field. Antenna patterns are normally measured in the far field region. Since the ground plane is partial antenna radiates below the ground plane also. Figure 5 shows the polar plot representation of the antenna at operating frequencies. It gives the value of E-field in dB at each angle.

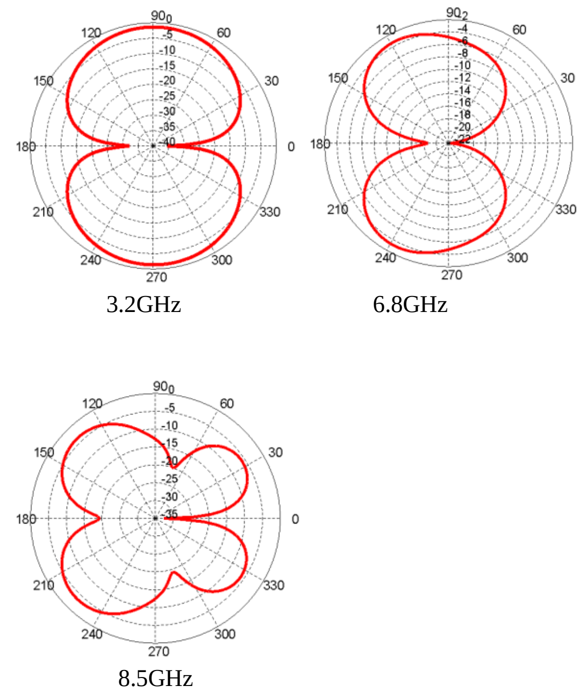

Figure 5: Polar Plot Representation of the Antenna at Different Operating Frequencies

3.3 Current Distribution

The total current distribution on the antenna is the superposition of the characteristic currents with appropriate weighting coefficients .The current distribution of elliptical monopole antenna is varied at each frequency. At resonance frequency maximum current is distributed across the antenna compared with other frequencies.

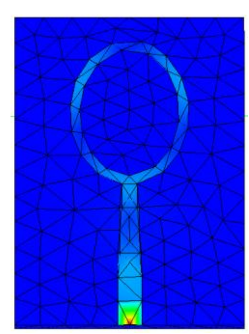

Figure 6: Current Distribution of the Antenna at 3.2GHz

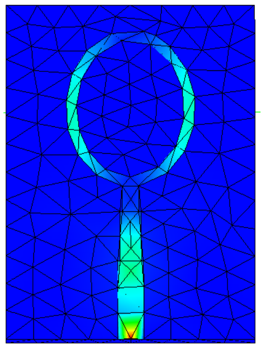

Figure 7: Current Distribution of the Antenna at 6.8GHz

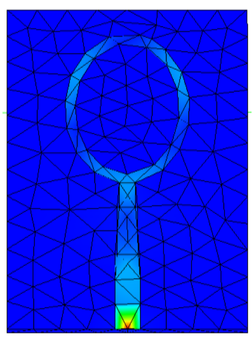

Figure 8: Current Distribution of the Antenna at 8.5GHz

The current distribution of the antenna at different operating frequencies is shown in the Figure 6, 7, 8. At these frequencies maximums current is delivered to the antenna

4. Conclusion

Elliptical ring monopole antenna for UWB applications is designed and analyzed. Results show that it can operate well on three frequencies 3.2GHz, 6.8GHz and 8.5GHz.Impedance matching can be improved by providing dual step feed between elliptical ring and feed line. Further improvement in the impedance matching can be obtained by providing additional steps between elliptical ring and feed line.

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