

Effect Of Circular Ground Plane On The Radiation Characteristics Of The Circularly Polarized Antenna

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Abstract

The object of this paper is to examine the effect of circular ground plane on the radiation characteristics of the circularly polarized antenna. The design of circularly polarized antenna is having overall radius 21.25mm and the height 1.18mm. A feeding pin and shorting pin are introduced inside the circular patch for achieving desired circularly polarized performance. This antenna is designed to operate within the frequency range from 2.5GHz to 5.5GHz. This frequency range covers the WLAN band, lower and median bands of Wi-Max and lower band of UWB communication systems. The antenna design is done by using the CST Microwave Studio Simulator. The circularly polarized antenna shows the main lobe magnitude of 336.1dB and the enhanced gain of 24.04 dB. Good circularly polarized properties and high gain are obtained from the simulated results.

Keywords: Radiation pattern, circular ground plane, gain, Far-field directivity, Main lobe magnitude.

1. Introduction

In modern research on high gain circularly polarized antennas has been developed by an increasing interest in the use of wireless communication applications. For near ground communications [13] where both the transmitter and receiver antennas are placed near the ground is by many orders of magnitude lower than any other antenna orientation configurations [12]. Applications such as unattended ground sensors (UGS), vertically polarized antennas with omnidirectional radiation pattern are highly desired. As [16]-[17] the antenna size reduction is obviously major problem in wireless communication devices. Therefore several methods have been investigated for extremely short monopole antennas [2]-[3] with very high lateral dimensions, while maintaining high radiation efficiency. With the development of wireless communication devices and mobile phone technology [4]-[5], it has become significant to provide low profile antennas with omnidirectional radiation pattern [6]. There are various size reduction techniques used in the design of

small antennas in which reactive inductive loading and reactive capacitive loading. In [7], electrically small antennas are further investigated and the performance such as impedance matching, the radiation pattern, the radiation efficiency, quality factor (Q), and polarization to be reported. In [8], the antenna is characterized with fractal geometries and the performance, it can be summarized that increasing the fractal dimension of the antenna leads to a higher degree of miniaturization.

Applications of fractal geometry are becoming mostly used in the fields of science and engineering. Antenna miniaturization can generally be categorized into two methods are Miniaturizing the antenna topology using space filling compression technique and Antenna miniaturization using magneto-dielectric materials [9]. The spatial network Method [18]-[19] provides strong radiation with an omnidirectional pattern in the horizontal direction. The dielectric truncation [14]-[15] is not close to the source, and then the space wave power is unaffected. It gives better efficiency. For certain applications, where the bandwidth can be compromised, it is found that by a comprehensive analysis of a new wide bandwidth compact antenna called (WC) wide compact J-pole antenna provided 50% impedance bandwidth [10]. Although these exist many antenna miniaturization techniques [11], most of them cannot provide high gain. However it is difficult to implement in practice, because these antennas include a multilayer geometry. An extremely (LMMMA) low profile multi element miniaturized monopole antenna [20] based on superposition of multiple quarter-wave segments that are meandered and spiraled around to suppress the radiation from horizontal currents above the ground plane. The LMMMA produces purely vertically polarization which leads to lower gain. Recently, the design of circularly polarized antenna in which the techniques such as in-plane capacitive, inductive coupling, shorting pin are achieved by improved polarization purity and high gain.

2. Antenna Design and Analysis

Many methods are used to improve the performance of circularly polarized antenna. Here the basic idea of providing high gain of antenna by modifying the length and shape of ground plane that is issued a better angular width and sufficient return loss. This research are investigated such type of circularly polarized antenna and monopole antenna. A quarter wave monopole antennas on a finite circular ground plane is constructed and simulated [14].

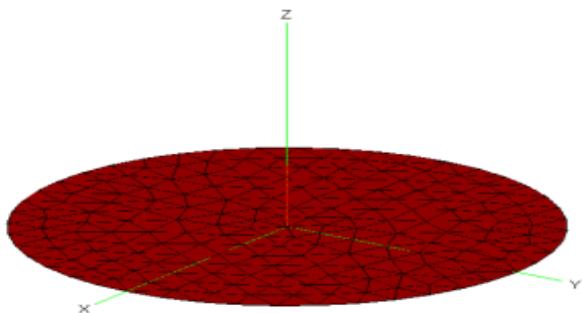


Fig. 1 The circular ground plane with the monopole antenna placed at the center above it.

The above figure shows the circular ground plane with the monopole antenna placed at the center above it. The circular plane ground was assumed to have varying circumferences of four, six, eight and ten of the wavelengths and the wire has a radius of 1×10^{-5} of a wavelength. The free space wavelength was chosen as 6 m (approximately 50 MHz).

The below figure shows the proposed circularly polarized antenna used the ground plane as circular. The following steps were used to design the circularly polarized antenna with total dimension is 21.25mm x 1.18mm using CST as,

- 1) Initially the circular ground plane was designed in CST with radius and height as 21.25mm and 0.59mm respectively. Here using the material as aluminum nitride substrate having relative permittivity $\epsilon_r = 8.6$, substrate height $h = 0.59$ mm.
- 2) Above the circular ground plane metallic substrate is placed in the middle which was designed with radius and height as 21.25mm and 0.59mm respectively. Here using the material as aluminum nitride substrate having relative permittivity $\epsilon_r = 8.6$, substrate height $h = 0.59$ mm.
- 3) Then the circular patch was designed radius and height as 10mm and 1mm respectively. Here

using the material as aluminum nitride substrate having relative permittivity $\epsilon_r = 8.6$, substrate height $h = 0.59$ mm.

- 4) The vertical feeding pin and shorting pin were inserted in the circular patch. The radius and height of the pins were given as 0.5mm and 2mm respectively.
- 5) The above design was based on the equivalent circuit model. The above circularly polarized antenna design was based on the equivalent circuit model. The lumped elements were placed in the corresponding layers to increase gain and polarization purity.
- 6) The values of the inductance and capacitances are related to the diameter of two pins and the width, length and height of metal sheets, respectively. The substrate used in this design has a dielectric constant of 2.2 and dielectric loss tangent of 0.0009.
- 7) The inductors $L_1=2$ nH, $L_2=5$ nH are placed in the feeding pin and shorting pin respectively, the inductors are $L_3=1.9$ nH, $L_4=1$ nH were inserted in the metallic patch and the shunt capacitor $C_1=0.5$ pF, $C_2=0.5$ pF was placed in the metallic patch.
- 8) The lumped elements were connected by using the wires to the metallic patch. Then the discrete port is used to feeding the patch antenna.
- 9) The values of the inductance and capacitances are related to the diameter of two pins and the width, radius and height of metal sheets, respectively.

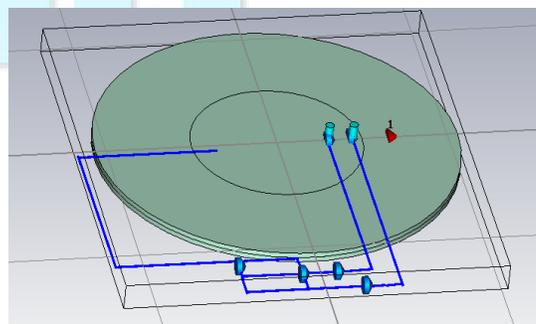


Fig. 2 The circularly polarized antenna design with the circular ground plane

3. Results and Discussion

The following results were obtained after careful simulations using CST software in which the ground plane which was circular ground plane was defined.

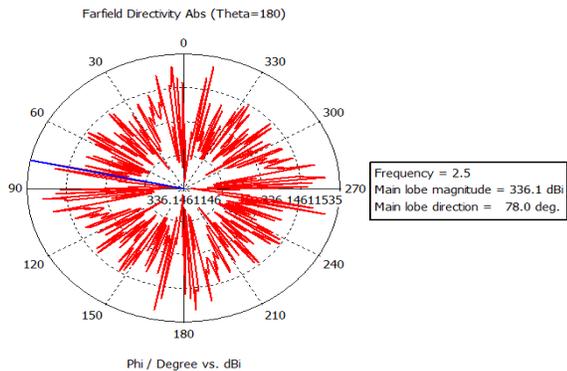


Fig. 3(a)

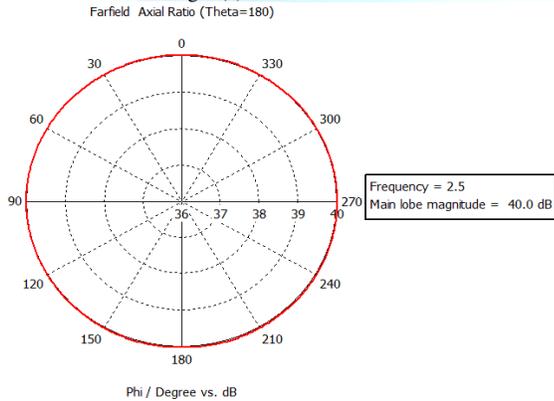


Fig. 3(b)

Fig. 3 Simulated (a) Farfield directivity abs (theta=180°) and (b) Farfield axial ratio (theta =180°)

In the above figure shows farfield directivity absolute value at theta=180°. It provides the radiation pattern and the main lobe magnitude value as 336.1dB. Here the frequency range as 2.5 GHz. Figure shows the farfield directivity axial ratio at phi=180°. The main lobe magnitude as 40dB. The gain of this circularly polarized antenna is 24.04dB.

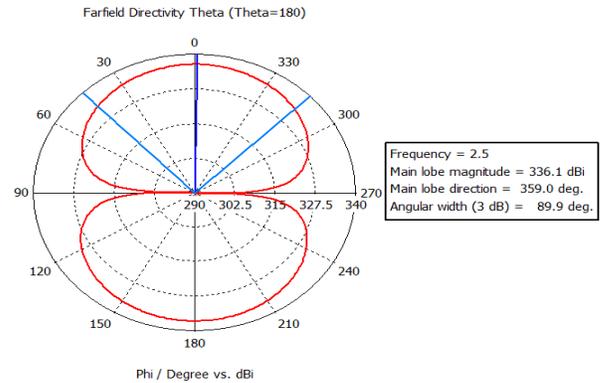


Fig. 4(a)

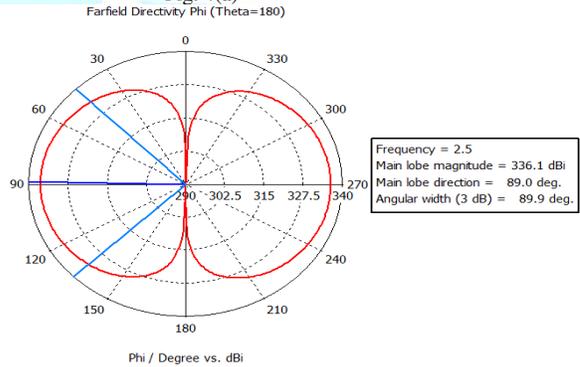


Fig. 4(b)

Fig. 4 Simulated (a) Farfield directivity theta (theta=180°) and (b) Farfield directivity phi(theta =180°)

In the above figure shows farfield directivity theta value at theta=180°. It provides the figure of eight radiation pattern and the main lobe magnitude value as 336.1dB. Here the frequency range as 2.5 GHz. Figure shows the farfield directivity phi value at theta=180°. The main lobe magnitude as 336.1dB. The gain of this circularly polarized antenna is 24.04dB.

Table 1: Output parameters

Parameters	Main lobe direction	Gain	Beam width	Main lobe magnitude
Values	359.0 degree	24.04dB	89.9 degree	336.1dB

4. Conclusions

In this paper, the effect of circular ground plane on the radiation characteristics of the circularly polarized antenna is done using CST and the radiation pattern performance of the E-plane and H-plane system were found. The newly developed circularly polarized antenna topology provides better angular width, improved polarization purity and very high gain compared to other existing antennas. The presented antenna shows a maximum gain of 24.04 dB. The circular ground plane on the radiation characteristics of the circularly polarized antenna is suitable for mobile radio communications, wireless communications with high gain.

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