Design of Compact Monopole Antenna for Wireless Communication Applications

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Abstract— In this paper a monopole antenna is designed using HFSS for wireless applications. The designed antenna consists of partial ground plane on the opposite side of the radiator. The antenna performance parameters are plotted and studied. The designed antenna is suitable for satellite applications.

Keywords: Wireless Communication Applications

I. Introduction

A Fractal is a rough, broken geometric form, which can be partitioned into pieces, each of which is (at least) a little duplicate. A property called self-likeness of the whole. Fractals are galaxies and describe several other natural phenomena. In most natural sciences such as physics, chemistry, biology, geology, and even materials science the fractal geometry and its principles have become key tools. Small antennas can be employed in more than one frequency range for the rapid growth of wireless communications. The fractals are very ideal for multi frequency antenna construction because of their auto-similarity and space filling properties. A multi band antenna is of major importance to various applications, such as WIFI and Bluetooth as well as WLAN/WiMAX, in the development of wireless communications systems. A printed monopoly antenna meets the requirements of multi-band, because its low profile, easy construction, easy structure, low cost and omnidirectional radiation are an appealing candidate. Several strategies are utilised to achieve multi-band operations. There are several among them multibranch radiators[1], monopoly slot [2, 3], meander monopoly [4] and fractal forms[5]. An electromagnetic metamaterial is recently employed to improve the performance of antennas (gain, bandwidth and size reduction). Metamaterials are artificial material, which show negative electrical permittivity and magnetic permeability values across a frequency band[6], at the same time. Because of the physical characteristics that naturally occur, metamaterials nowadays are very attractive in a number of life spheres such as the MCUs, the invisible underwater systems, revolutionary electronics, negative refractive index lenses, microwave components, filters, and compact antennae[7]. One of its most notable uses is the application of metamaterials to the design of antennas[8, 9].

II. Antenna Design and Simulation Results

The first stage involves selecting an appropriate dielectric substrate of thickness 'h' and loss tangent. Selection of thicker substrate to design the antennas can achieve broad bandwidth. However, there is one major difference. Dielectric substrates, whether thick or thin, produce force between top conductor and ground plane. When thick substrates are used, electric fields experience less force and attempt to move away from the patch thus increasing the radiation level. However, thick substrate lowers resonant frequency. Therefore, for efficient radiation it would be preferable to use substrates with w/h >1, where 'w' is the width of the patch.

The process for developing a rectangular patch antenna as shown in Fig. is expounded below. The three vital parameters for the design of patch antenna are

Operating frequency (f0): The antenna resonant frequency must be properly chosen which is able to operate under the desired frequency range. In this research antenna operating frequency is taken as 5.5GHz.

Substrate dielectric constant: FR4 epoxy dielectric material relative permittivity of 4.4 is picked in this study.

Substrate height: To make antenna less bulky the thickness of the substrate is selected as 1.57mm.

Using this data, the steps engaged in the calculation of dimension of the patch is described below

Step 1: a practical width that leads to good radiation efficiencies is

$$w = \frac{V_0}{2f_r}\left(\sqrt{\frac{2}{\varepsilon_r+1}}\right) \quad (1)$$

where, w - width of the patch,
fr - resonant frequency,
εr - dielectric constant of the substrate.
Vo - velocity of light in free space=3e8 m/s

Step 2: effective dielectric constant of the patch antenna is determined using

$$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left(1+12\frac{h}{w}\right)^{-1/2} \quad (2)$$

where, h – height of the substrate,
w – width of the patch,
εreff – effective dielectric constant of the patch, $1 < \varepsilon_{reff} < \varepsilon_r$

Step 3: Once width is found extension of the length of the patch (ΔL) is determined using

$$\frac{\Delta L}{h} = 0.412\frac{(\varepsilon_{reff}+0.3)\left(\frac{w}{h}+0.264\right)}{(\varepsilon_{reff}-0.258)\left(\frac{w}{h}+0.8\right)} \quad (3)$$

Step 4: The effective length of the patch can now be determined by

$$L_{eff} = \frac{V_0}{2f_r\sqrt{\varepsilon_r}} \quad (4)$$

where, Leff – effective length of the patch antenna.

Step 5: The actual length of the patch(L) is now calculated using

$$L = L_{eff} - 2\Delta L \quad (5)$$

where, L is the length of the patch antenna.

The monopole antenna with microstrip line feeding is designed using ANSYS HFSS on a less expensive, widely available FR4 epoxy substrate with relative permittivity of 4.4 and dielectric loss tangent of 0.02 for 7.9GHz Satellite application. Fig. 1 shows the antenna structure with patch dimension 09mm x 09mm x 0.1mm and substrate dimension of 15mm x 17mm x 1mm. The ground plane is partial and measures 05mm x 15mm x 0.1mm.

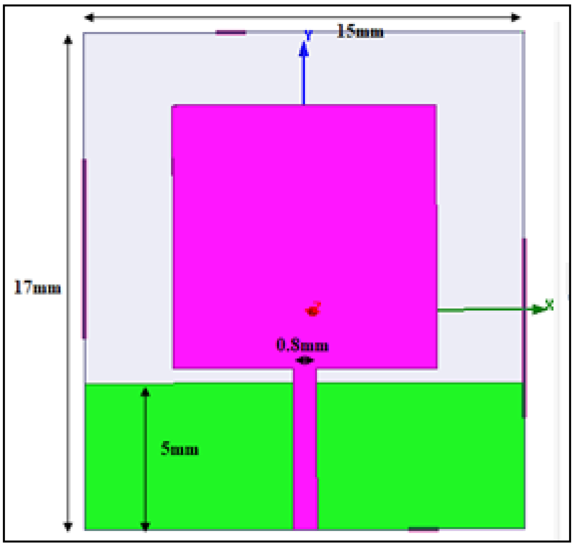

Fig. 1: Microstrip monopole antenna

The construction of the typical monopole Antenna is discussed in Chapter 4. This is similar to the condition when the diode is OFF. For antenna performance a return loss greater than -10dB is desired over the entire operating bandwidth as is typical for communication applications. The simulated return loss plot is shown in Fig. 2.

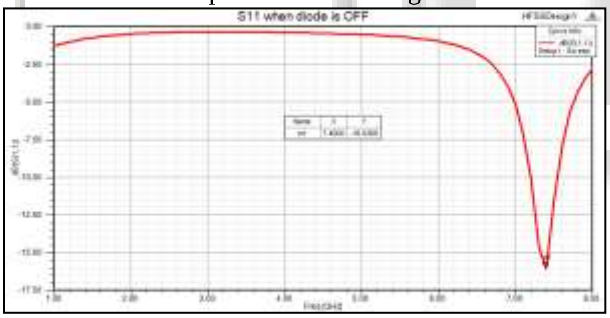

Fig. 2: Return loss plot when diode is OFF

Fig. 3 reveals a low return loss of -16.03dB at 7.4GHz for the antenna. It shows that at that frequency the antenna functions more effectively. Throughout bandwidth calculation, one has to find certain frequencies where the curves break line S11=-10dB. These are 7GHz and 7.8GHz frequencies. So the antenna system's bandwidth is 0.8GHz.

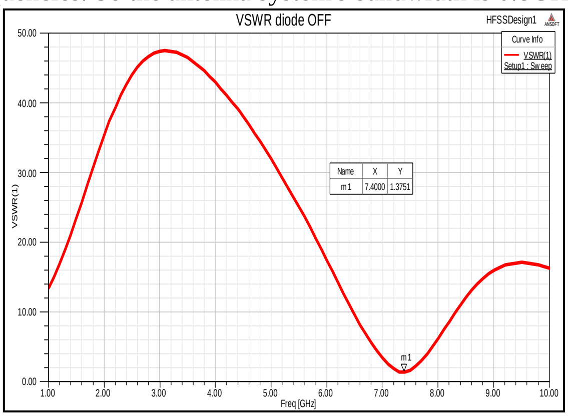

Fig. 3: VSWR when diode is OFF

VSWR is the ratio of the peak standing wave voltage to the minimum voltage level. This demonstrates the amount of discrepancy between antenna and the feed line linked to it. As seen in Fig. 5.2 VSWR for the antenna when diode is OFF is 1.3 at 7.4GHZ. Hence, we can say that the feed line is perfectly matched to the antenna input. As seen in Fig. 4 the radiation pattern of the antenna when diode is OFF is like monopole antenna.

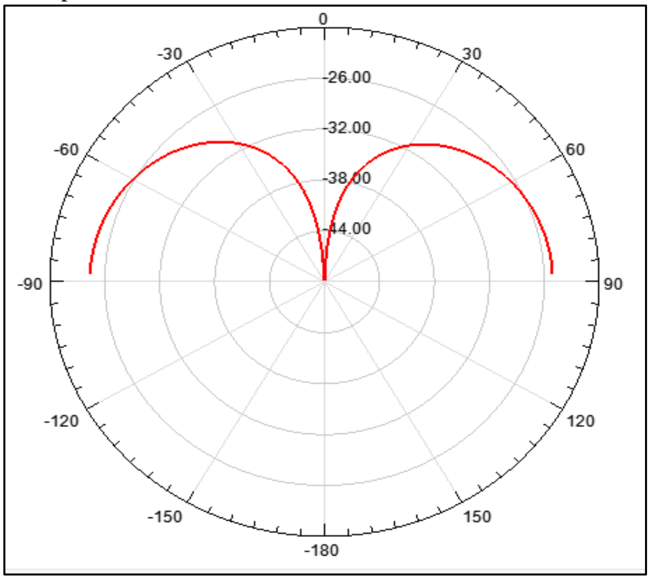

Fig. 4: Radiation pattern when diode is OFF

III. CONCLUSION

In this paper, a monopole antenna is designed for wireless application using HFSS. The designed antenna's performance parameters such as return loss, VSWR, radiation pattern are studied and plotted. In future the antenna will be fabricated and tested.

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