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MODELLING AND SIMULATION OF MICROSTRIP CIRCULAR PATCH ANTENNA

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ABSTRACT

A modified circular patch antenna used for ultra-wideband applications operating at a band of frequencies 3 to 10.4 GHz is modeled in this work. The geometry of the antenna has a circular disc monopole copper plate of radius *r* with 50 ohms microstrip feed line that is printed on the same side of the FR4 substrate. The dimensions, L denotes the length and W denote the width of the substrate. The microstrip line width is fixed at 2.6 mm to get 50 Ω impedance. At another side of the substrate, the microstrip feed line bottom section is covered by the copper ground plane of length, 21.25 mm. The performance is mainly based on the feed gap *h* and the dimension of the ground plane. The antenna structure and the final dimensions are fixed after performing an extensive simulation study. The parameters like ground plane, dimensions of the substrate, and size of the feed which affect the performance of the antenna in terms of its various characteristics such as radiation patterns, VSWR, return loss, radiation efficiency and gain are investigated. This modeled antenna is operated at various frequencies and observed that the circular patch antenna can be used for various applications in the ultra-wideband range.

KEYWORDS: UWB (Ultra Wide Band) & Circular Patch

INTRODUCTION

Low cost, light weight, and ease of manufacturing microstrip patch antennas are essential in design of mobile and satellite systems. Larger bandwidths are required in the design of 4G systems. Various techniques were discussed in the literature [1-8] to improve the antenna bandwidth that includes the change in the type of feed, modifying the structure of the patch, and putting slots on the patch. Aring aperture coupled antenna with a single modified ring patch having linear polarization is presented in [1] to improve the gain and bandwidth. A small microstrips lot antenna, which has an improvement in bandwidth on a comparatively thin substrate, is presented in [2]. Here, the antenna size is reduced to 50% compared with typical circular patch antennas.

ANTENNA STRUCTURE

In this paper, aCST MW Studio software is used to design and model an antenna with a circular patch. The first measurement of the ground is taken as 21mm and PEC material is used. The FR4 substrate material is used with the geometry of 50x 42mm on the ground surface. On the substrate plane surface, a circular patch is placed with a radius of 16.4mm. At the bottom of the circular patch, the strip is placed with a dimension of 21.25x42 mm. The circular patch antenna with above the dimensions is modeled as shown in Fig.1. The geometry parameters of the designed antenna have been shown in Table1.

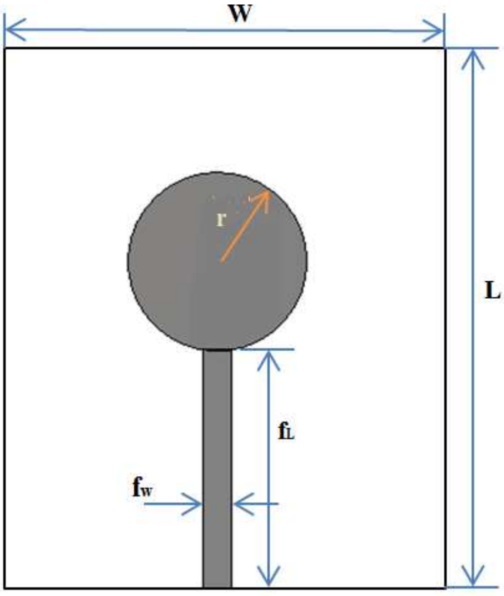

Figure 1(a): Proposed Antenna (Top View)

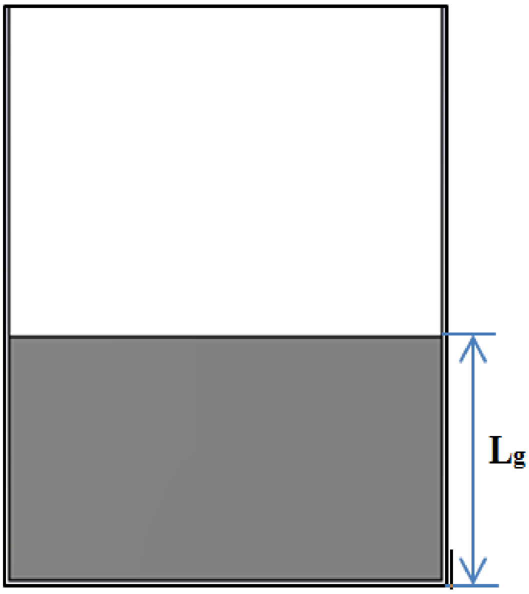

Figure 1(b): Proposed Antenna (Bottom View)

Table 1

Parameter	Dimensions (mm)
L	50
W	42
r	16.4
f_L	21.9
f_w	2.6
L_g	21.25

ANTENNA ELEMENT DESIGN

Initially, the radius of the circular patch antenna is designed using equation (1) and (2).

$$a = \frac{F}{\left\{1+\frac{2h}{\pi \epsilon_r F}\left[ln\left(\frac{\pi F}{2h}\right)+1.7726\right]\right\}^{1/2}} \quad (1)$$

Where $F = \frac{8.791 \times 10^9}{f_r\sqrt{\epsilon_r}}$ (2)

Where ϵ_r is a relative dielectric constant of the substrate, h is the height of the substrate and a is the radius of the circular patch antenna.

ANTENNA RESULTS

CST MW studio software package is used for simulation and modeling of the circular patch antenna. The results such as return loss, VSWR and radiation patterns at different frequencies are obtained and shown in Figure 2-6. The conclusions are drawn based on the results obtained.

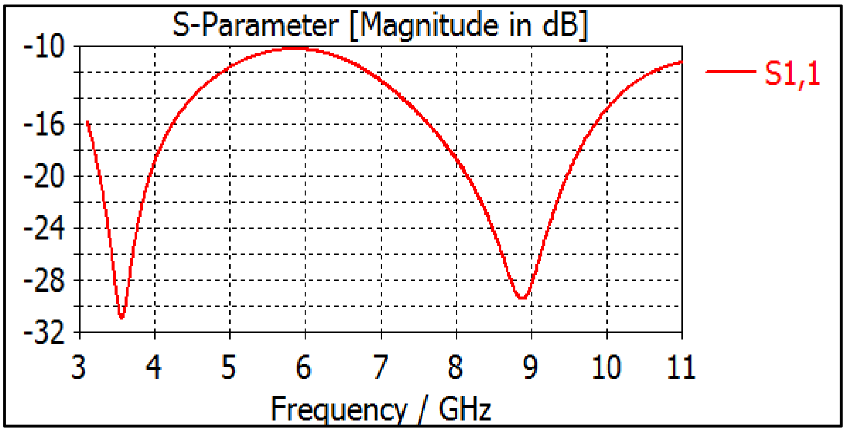

Figure 2: Simulated Return Loss of the Proposed Antenna

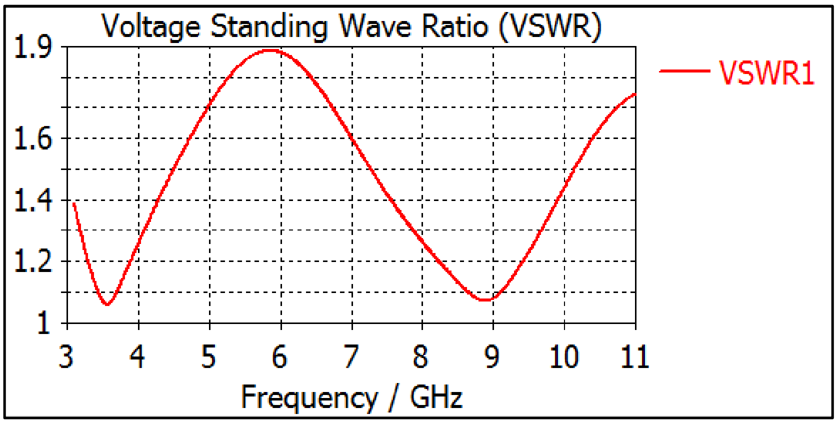

Figure 3: VSWR of the Proposed Antenna

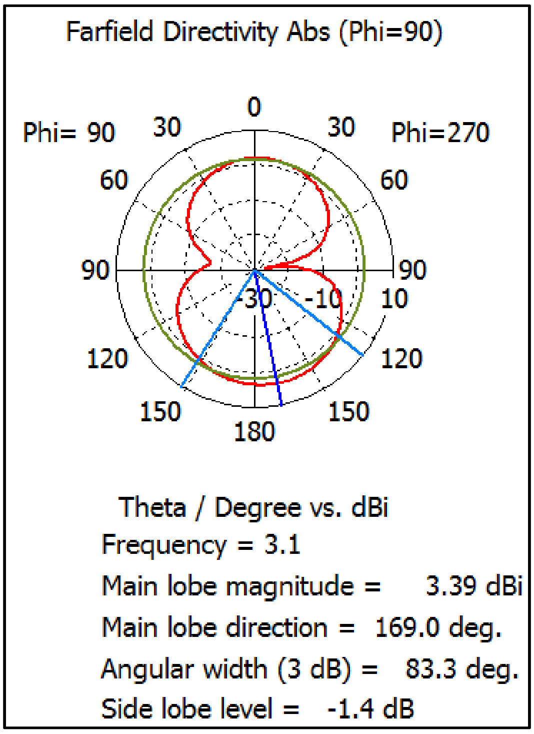

Figure 4: Far-Field Directivity of Circular Patch Antenna at 3.1 GHz

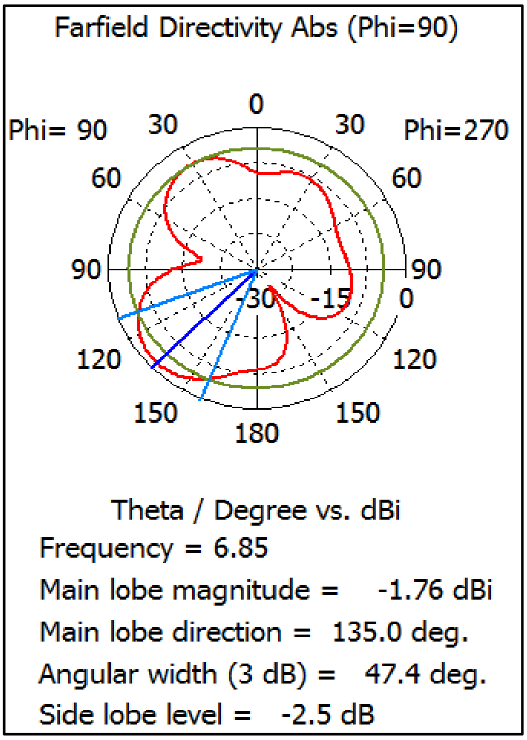

Figure 5: Far-Field Radiation 2D Pattern of Circular Patch Antenna at 6.85 GHz

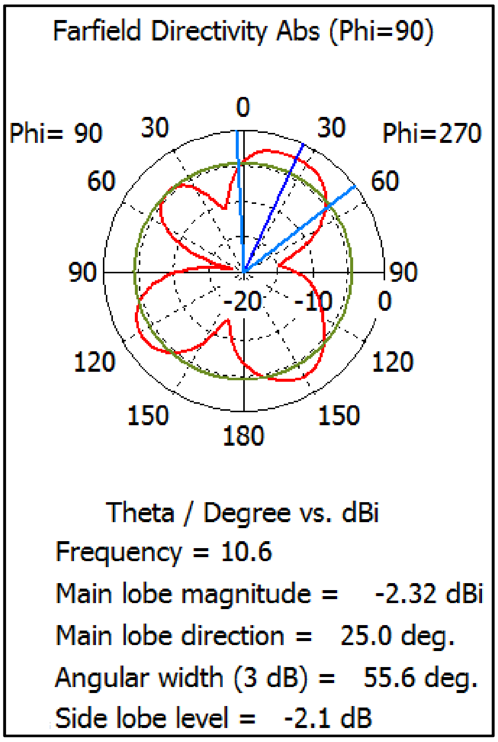

Figure 6: Far Field Radiation 2D Pattern of Circular Patch Antenna at 8.97 GHz

The circular patch and gap in the ground plane serve as a radiator coupling energy from the patch antenna into free space. The radiation pattern at 3.1GHz is shown in figure 4 and its Angular width (3-dB) is about 83.3^0. The Angular width (3-dB) at 6.85 GHz and 8.97GHz are about 47.4^0 and 55.6^0 respectively. The thick blue line indicates the main lobe direction. There are two thin blue colors in the radiation patterns which indicate the Lower and upper 3 dB lines. The difference between the angles of these thin blue lines indicates the 3-dB beamwidth. From the figures, it is observed that the radiation at 3.1GHz and 6.85GHz is due to gap presented in the ground plane. The main lobe direction at these frequencies is towards the bottom of the substrate.

The radiation at 8.97 GHz is due to the circular patch which located on the top of the substrate. The main lobe at this frequency is at an elevation angle of 25^0 which indicates radiation from the patch.

CONCLUSIONS

In this work, an ultra-wideband microstrip circular patch antenna has been proposed which is resonant at 3.72 GHz, 6.85 GHz, and 8.97 GHz respectively with very good impedance bandwidth. The antenna exhibits the return loss well below -10dB for the frequency range mentioned. The effects of the antenna parameters such as patch width, patch step slot dimensions, feed width, ground slotting and substrate permittivity on antenna performance characteristics have been studied and analyzed. The feed size of the antenna is inversely proportional to the port impedance. The dimensions of the microstrip circular patch antenna also have an impact on the antenna performance because the current is mainly distributed along the edge on the radiator. In a broad sense, the ground plane of the antenna designed to perform the operation as an impedance matching circuit, and it tunes the input impedance matching and hence changes the operating bandwidth with the variation of antenna feed size. From the simulation results obtained using CST MW studio software, it is also observed from various characteristics that this monopole circular patch antenna can be used for ultra-wideband applications.

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