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Circular Microstrip Patch Monopole Antenna for Wireless Communication

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ABSTRACT
A compact monopole microstrip circular patch antenna having defected ground plane(DGP) with center notch is presented in this paper. This circular patch antenna is feed by microstrip line feed. Optimum results are observed when gap between the radiating patch and DGP is 1.5mm and for centered feeding of microstrip feedline. The obtained reflection coefficient is less than -10dB for a wide frequency range of 1.9GHz to 14 GHz which covers the complete bandwidth of ultrawideband (UWB- ranges from 3.1-10.6 GHz). The proposed antenna has been designed on a FR4 substrate with dielectric constant $\epsilon r = 4.4$, loss tangent (tan δ) = 0.02. The radiation pattern is directional in E-plane and nearly omnidirectional in H-plane. Efficiency decreases at the higher frequency edge due to the lossy substrate and it is upto 70%. The UWB antenna is simulated using CAD FEKO 6.2 suit electromagnetic simulator using MoM (Method of Moment).

Key words : Patch antenna, UWB, Radiating patch, Ground plane, Method of Moment

1. INTRODUCTION

Since the wireless communication has been defined researchers have shown their interest to improve the bandwidth from narrowband to the wideband. To achive this bandwidth a microstrip patch antenna [1-2] represents one of the most commonly utilized printed antennas in practice. A narrow bandwidth is, however, the main drawback of the microstrip patch antennas. Some approaches have been therefore developed for bandwidth enhancement are discussed further.

The origin of microstrip antennas apparently dates back to 1953, when Deschamps proposed the use of microstrip feed lines to feed an array of printed antenna elements.[3] The printed antenna elements introduced there were not microstrip patches, but flared planar horns. The microstrip patch antenna was first introduced by Munson in a symposium paper in 1972,[4] which was followed by a journal paper in 1974.[5] These papers discussed both the wraparound microstrip antenna and the rectangular patch. Shortly after Munson's symposium paper, Howell also discussed rectangular patch antennas in another symposium paper[6] in which he credits Munson with the basic idea by referencing a private communication. In a later journal paper, Howell introduced the circular patch as well as the circularly polarized patch antenna.[7-8] Soon after the introduction of the micro strip antenna, papers appeared describing methods of analysis for these antennas, including the transmission-line model,[9] the cavity model,[10].The main purpose of these aforementioned antennas is to achieve the higher bandwidth for the compact sized antennas.

On February 14, 2002, the Federal Communications Commission (FCC) of the United States adopted the First Report and Order that permitted the commercial operation of ultra wideband (UWB) technology (FCC, 2002). The FCC allocated a bandwidth of 7.5GHz, i.e. from 3.1GHz to 10.6GHz, to unlicensed use for UWB applications.[11] UWB systems operate at extremely low power transmission levels, and hence UWB signals do not cause significant interference to other wireless systems. The UWB technology is one of the viable candidates for short-range indoor radio communication systems supporting very high bit rates services and applications.

As the microstrip antennas are having various advantages as are low profile, conformable to planer & non planer surfaces, simple, low cost also easy to manufacture using modern printed circuit technology they are widely used in various applications. The radiating patch can be of square, rectangular, circular or any other configuration. But square, rectangular, circular & strip line shape are most common because of their radiation characteristics, especially low cross polarization [1-2]. For many years significant research activities and interests have been aroused in wideband applications for different communication applications [12]-[13]. Recently various academic and industrial fields also shown their interest to explore various UWB antennas [14].

The main challenge in antenna designing is to achieve the wide impedance bandwidth while maintaining high radiation efficiency. A planar antenna is also desirable given that there are several additional constraints and challenges for the design of a wideband system antenna.

In this article we present a circular patch planer monopole antenna which has partial ground plane structure with microstrip feedline. To achieve the maximum impedance bandwidth, a rectangular notch is placed at the center of partial ground which is now defected ground plane(DGP). The proposed antenna is simulated using CAD FEKO 6.2 suit electromagnetic simulator using MoM (Method of Moment). Simulated results are presented to demonstrate the performance of a suggested antenna.

2. ANTENNA DESIGN

Figure. 1 shows the configuration of circular monopole microstrip patch antenna having defected ground plane with rectangular center notch.

The proposed antenna, has the dimension of 40mm X 55mm (W_{sub} X L_{sub}), is constructed on FR4 substrate with thickness of 1.6 mm and relative dielectric constant of 4.4 having loss tangent (tan δ) of 0.02. The width W_f of the micro strip feed line is fixed at 3 mm. On the upper surface of the substrate, a circular patch with radious of R is printed. The rectangular patch has a distance of to the ground plane printed on the back surface of the substrate. By cutting the rectangular notch L_1 X W_1 of suitable dimensions at the center of monopole's ground plane, it is observed that much enhanced impedance bandwidth can be achieved for the proposed antenna. This thing occurs because of the designed notch affects the electromagnetic coupling between patch and ground plane.

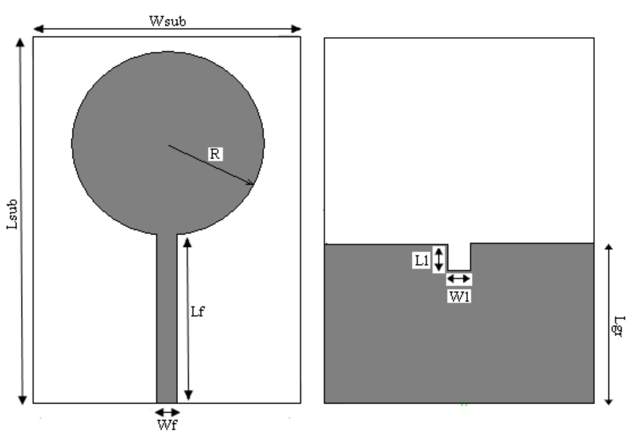


Figure. 1. Configuration of the proposed microstrip-fed monopole antenna.

Also the distance between cicular radiating patch and ground plane is 1.5mm obtained by the way of simulation . This parameter is important to determine the sensitivity of impedance matching.

The optimized dimensions of proposed antenna are as follows: Wsub =40mm, Lsub=55mm, R=14mm, Wf =3, L1 =4mm, W1 =3.5mm, Lf=25.5mm, Lgr=24mm. This is found that using these dimensions the antenna satisfies requirements of wideband antenna for wireless communication from 1.9GHz to 14Ghz. Which compiles the various narrowband systems such as WPAN i.e. bluetooth (2.4-2.48GHz), WiMAX (3.3-3.7GHz), C band for satellite communication (3.7-4.2GHz) and WLAN2 (5.15-5.825GHz) which are related to the ultrawideband systems(3.1-10.6GHz). And hence we can say that proposed antenna covers the completely band ranges of S(2-4GHz), C(4-8GHz), X(8-12GHz) and partially Ku band(12-14GHz).

3.RESULT & DISCUSSION

In this section, theoretical results of proposed circular monopole patch antenna with DGP are presented which is simulated and designed using CADFEKO simulation software version 6.2 [15].

Firstly the primitive antenna is taken, which consists of a circular patch and partial ground plane which do not have any notch at the center. By the way of simulation the current distribution of this primitive antenna is observed. After analyzing the current distribution of an monopole antenna it is observed that some part in the ground plane is not radiating properly. So by the designing the notch of L1 X W1 at the center of partial ground plane completely wider range of application bandwidth is obtained. Figure. 2. Shows the simulated reflection coefficient of an antenna obtained after designing of defected ground plane. It shows the obtained band is below -10dB.

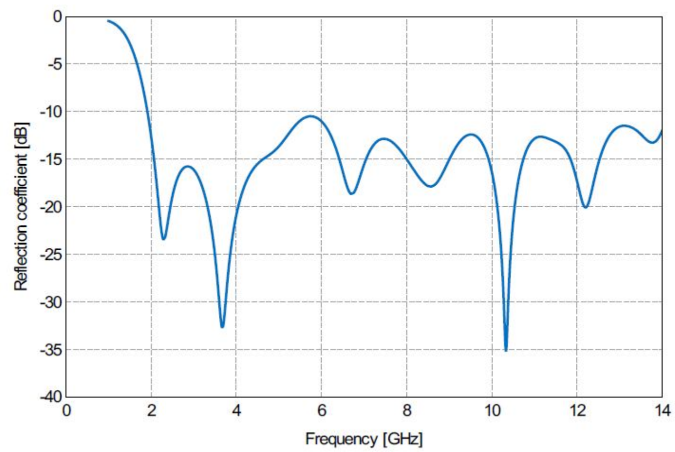


Figure. 2. Simulated reflection coefficient of an antenna

The antenna also exhibits the impedance bandwidth obtained after the simulation which proves optimized VSWR<2. The obtained radiation efficiency of an antenna is good one at the lower frequency edges and it is upto 90% but it is decreased at the higher edges due to the lossey substrate nature of FR4 and is decreased upto 60%. Figure.3. shows the simulated VSWR and in figure. 4. Simulated efficiency of an antenna is observed. Which approves the proposed antenna is a good handheld equipment for wireless communication.

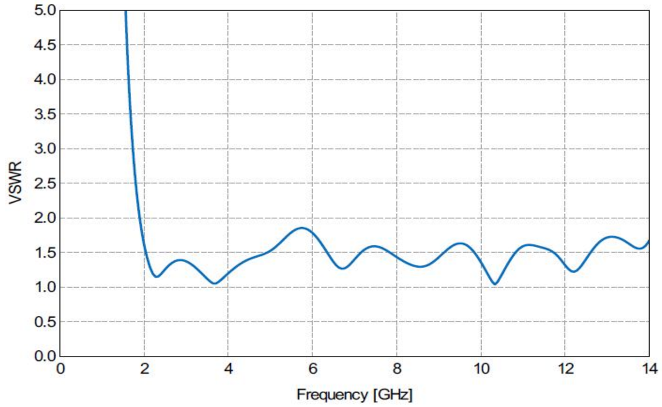


Figure. 3. Simulated VSWR of an antenna

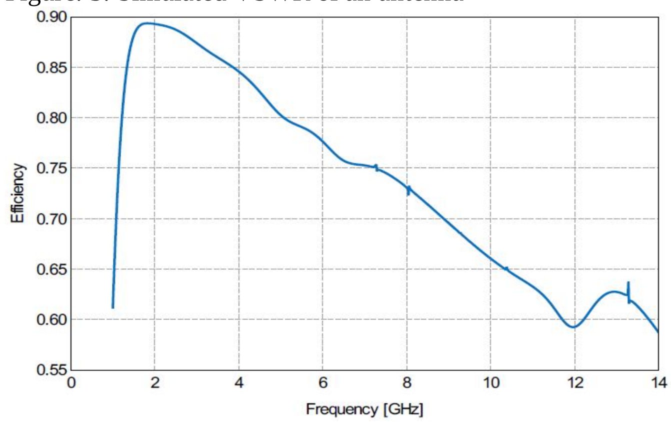
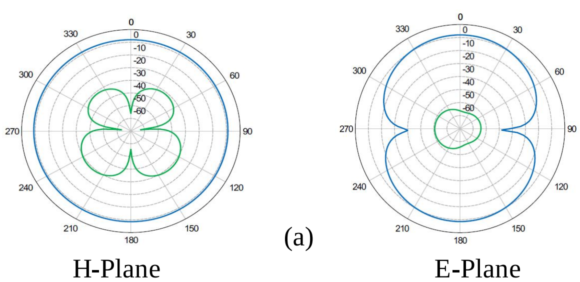


Figure. 4. Simulated radiation efficiency of an antenna

In figure 5. various radiation patterns obtained for E-plane and H-plane at 2GHz, 3.5GHz, 5.5GHz and 9GHz frequencies are shown. The Ludwig co-polarization and cross polarization is obtained for both E-plane and H-plane. Typical butterfly shaped pattern is obtained at lower edge frequencies and As the frequency increases the number of lobes starts varying for some cases the number of lobes starts increasing for H-plane. While in case of E-plane the cross polarization of an antenna is smallest one at lower edge of frequency which leads to obatain the higher gain of antenna and at higher frequency this cross polarization is varying which leads to variation in the gain of an antenna.



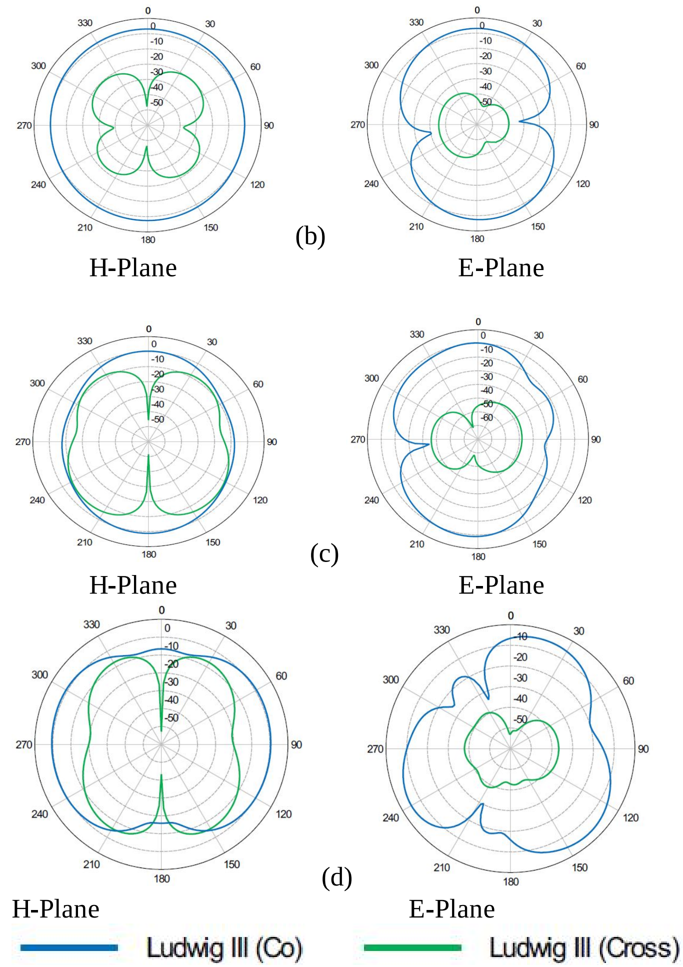


Figure.5. Simulated radiation patterns of the dual band-notched antenna at the frequencies of (a) 2, (b)3.5, (c)5.5 and (d)9GHz.

4. CONCLUSION

The Circular microstrip patch planar monopole antenna has been designed and simulated using CADFEKO 6.2 simulator version for wireless communication application. The rectangular notch is obtained at the center of ground plane to enhance the bandwidth by the way of parametric analysis using microstrip feed line. The reflection coefficient is obtained is of below -10dB and obtained frequency is 1.9GHz to 14GHz also VSWR<2 for the same. The radiation pattern is directional in E-plane and nearly omnidirectional in H-plane. Efficiency decreased at the higher frequency edge due to the lossy substrate. The results and discussion proves that the designed antenna is a good component for hand held wireless applications.

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