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Design of CPW-Fed U-Shaped Microstrip Antenna for Wireless Applications

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Abstract

In this paper design of coplanar waveguide (CPW)–fed U-Shaped Microstrip antenna for wireless applications is presented. The antenna is designed using FR4 substrate with the dielectric constant of 4.4 and the substrate thickness of 1.6mm. The parametric study is performed to understand the characteristics of the proposed antenna. The antenna operates in broad frequency bands from 3.27GHz to 5.72 GHz covering some of wireless local area network (WLAN) and worldwide interoperability for microwave access (WiMAX) bands. The maximum simulated gain of the proposed antenna is 6.5 dBi at 5.3 GHz frequency. The antenna designs and performances are analyzed using Zealand IE3D software.

1. Introduction

Antenna is one of the important elements of the wireless communications systems. Without antenna wireless communication between two entities is a failure. Communication plays considerable role in the worldwide society now days and the communication systems are quickly switching from “wired to wireless”. Wireless technology provides less expensive alternative and a flexible way for communication. Antenna design thus become one of the most important field in the communication studies. One of the types of antenna is the microstrip antenna[1]. The microstrip antenna have various advantages such as small size, low-cost of fabrication process, low profile of antenna, light in weight, ease of installation process and integration with many feed types. However, the general microstrip antennas have some disadvantages such as narrow bandwidth, low gain etc [2]. However, such kinds of antennas mostly need a large size of ground plane, which is often printed on the different side of the substrate from the radiating plane, and thus a via-hole connection is always necessary for feeding the signal and this increases the manufacture difficulty and cost. Recently, a great interest in coplanar waveguide (CPW)-fed antennas has been found because of their many attractive features such as wider bandwidth, better impedance matching, low radiation loss, simplest structure of a single metallic layer, no soldering point, and easy integration with active devices or monolithic microwave integrated circuits and broad bandwidth, etc. Some popular antenna designs suitable for WLAN and WiMAX operation for 2.4/5.2/5.8 GHz and 2.5/3.5/5.5 GHz bands has been reported in [3-9]. The rapid developments of wireless communication systems, especially the WLAN and WiMAX applications, which cover all the bands of have aroused much interest in the research of antennas with multiple bands or broadband. In [10], novel broadband design of a coplanar waveguide (CPW)-fed planar monopole antenna with double plus shape slots is proposed.

In this paper, a proposed antenna design with CPW fed has been used for wireless applications. The proposed antenna consist of U-Shaped patch element which contains multiple branches. Details of the antenna design are described, and simulated return loss and antenna gain results are represented and discussed in the following section. The parametric study is performed to understand the characteristics of the proposed antenna.

2. Antenna Design

The geometry of the proposed finite ground coplanar waveguide (CPW) fed is shown in Figure 1.

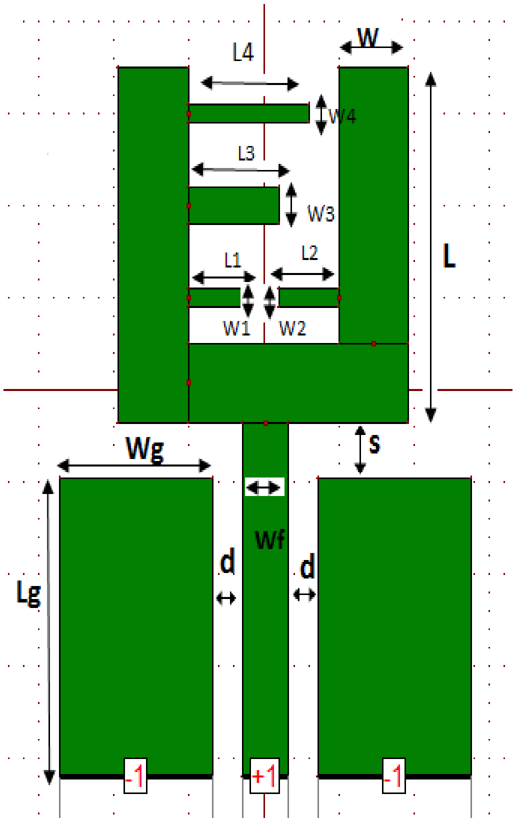


Figure 1: Geometry of the proposed CPW-fed microstrip antenna.

The proposed antenna was designed on FR4 substrate with dielectric constant 4.4 and thickness 1.6 mm. A 50-ohm feed-line of width Wf =3 mm was used to excite the antenna. The FR4 is a fire electrical grade dielectric made with epoxy material reinforced with a woven fiberglass material. “FR4” means “flame retardant” and type 4 indicates woven glass reinforced epoxy resin. The proposed antenna has a single layer metallic structure on one side of FR4 substrate layer whereas the other side is without any metallization. The final optimized dimensions of proposed antenna are length of U-Shaped patch element is L= 19.3mm, width W = 4.57mm and with spacing between ground plane and feed-line d = 0.9mm. Two equal finite ground planes, each with dimensions of length of ground plane Lg=16.2 mm and width of ground plane Wg=10.2 mm are placed symmetrically on each side of the CPW feed-line. The space between the U-patch and ground plane S=3mm. Length of branch strip L1=4 mm, width of the branch strip W1=1 mm, length of branch strip L2=4 mm, mm, width of the branch strip W2=1 mm , length of branch strip L3= 6mm, width of the branch strip W3=2 mm, length of branch strip L4= 8mm, width of the branch strip W1=1 mm. The optimum parameters are obtained with the aid of IE3D software [12].

3. Simulation Results and Discussion

The simulated return loss and parametric study results for the antenna are also obtained. The simulated return loss of proposed antenna is show in figure 2. The antenna operates in broad frequency bands from 3.27GHz to 5.72 GHz covering some of wireless local area network (WLAN) and worldwide interoperability for microwave access (WiMAX) bands with bandwidth of 2.45GHz , three resonant modes are excited and return loss of -45dB is reached. Impedance bandwidth is 55%.

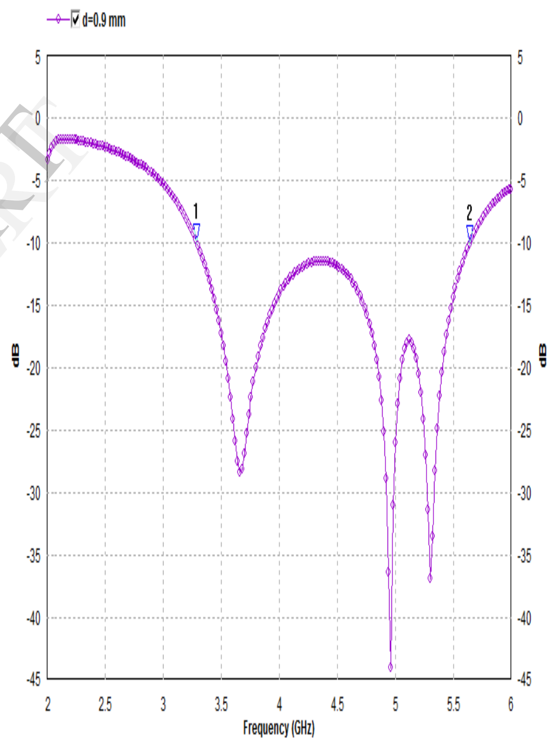


Figure 2: Return Loss of proposed antenna

The parametric study is carried out by simulating the antenna with one geometry parameter slightly changed from the reference design while all the other parameters are fixed. For this, the effect of gap distance d on the performance of antenna are studied and presented. Figure 3 shows the effect of variation of gap distance (d) between the feed-line and the ground plane on return loss. It is observed from the simulation results study that at d=0.9mm the antenna work in broad frequency bands from 3.27 GHz to 5.72 GHz, on increasing the gap distance d the broadband antenna become dual band antenna at d=1.4mm with lower band ranging from 3.38 to 4.28GHz with bandwidth of 900MHz and upper bands ranging from 4.57 GHz to 5.74GHz with bandwidth of 1.17 GHz.

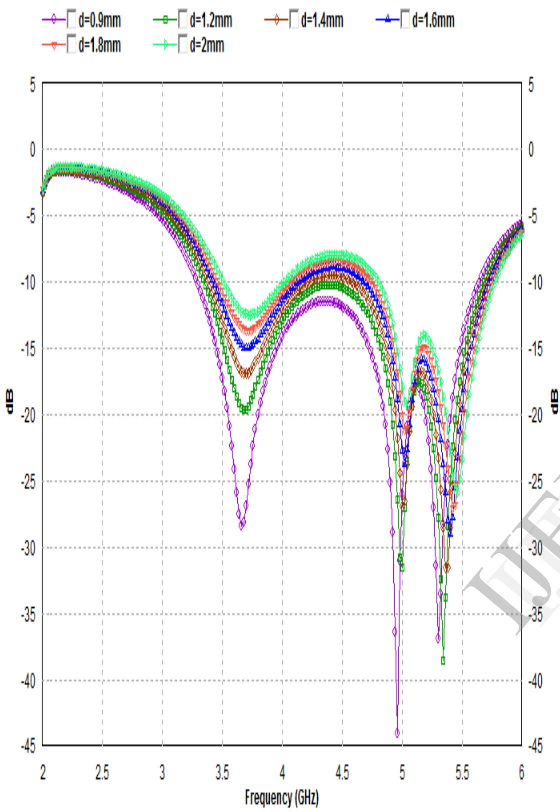


Figure 3 : Effect of variation of gap distance (d) between the feed-line and the ground plane on return loss

At distance between the feed-line and ground plane d=0.9mm the antenna work in broad frequency bands. Figure 4 shows the variation on the return losses due to change in gap between the patch element and ground plane i.e. S at d=0.9mm which shows that variation of S doesn't show significant effect on bandwidth.

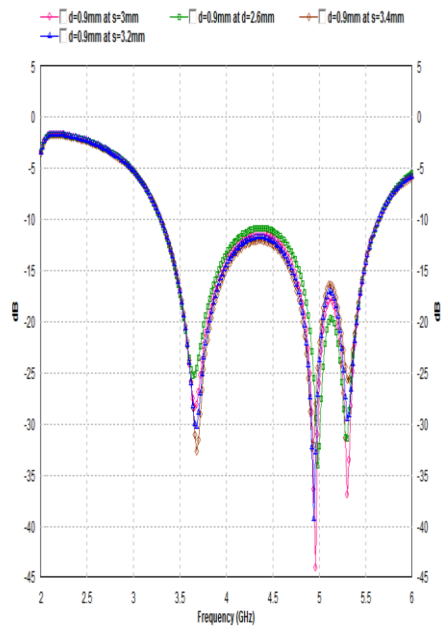


Figure 4 : Effect of variation of distance S on return loss at d=0.9mm

At distance between the feed-line and ground plane d=1.4mm the antenna start work as dual band antenna. Figure 5 shows the variation on the return losses due to change in gap between the patch element and ground plane i.e. S at d=1.4mm which shows that with increase in gap distance S return loss start increases in both lower and upper bands .

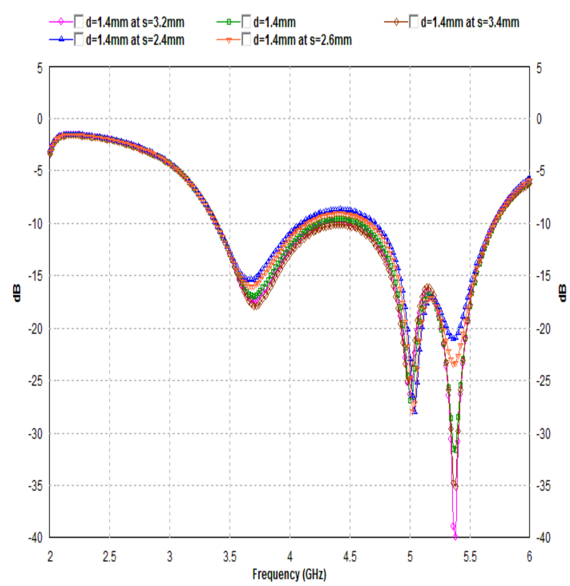


Figure 5 : Effect of variation of distance S on return loss at d=1.4mm

Figure 6 shows the gain of the antenna. The maximum simulated gain of the proposed antenna is 6.5 dBi at 5.3 GHz frequency. It is observed that maximum gain of U-Shaped patch antenna without multiple branches is 4.5dBi, thus significant enhancement of gain is observed with adding multiple branches strips to U-Shaped patch element.

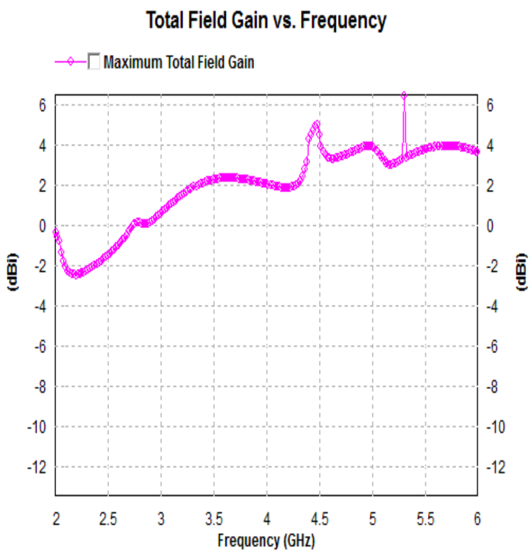


Figure 6: Simulated Gain of the proposed antenna

Simulation studies indicate that the maximum antenna efficiency is approximately 99.95% at 5.32GHz. Figure 7 shows the efficiency curve of proposed antenna.

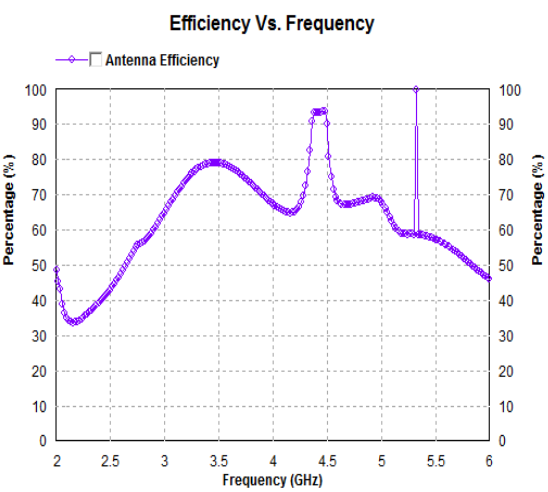
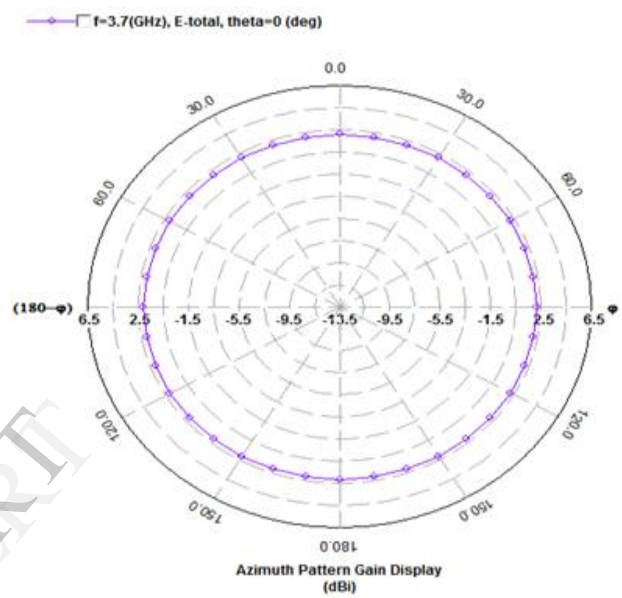
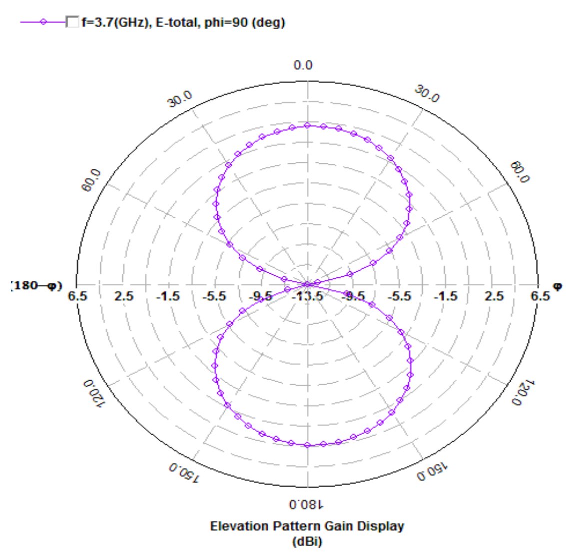


Figure 7: Antenna efficiency of proposed antenna

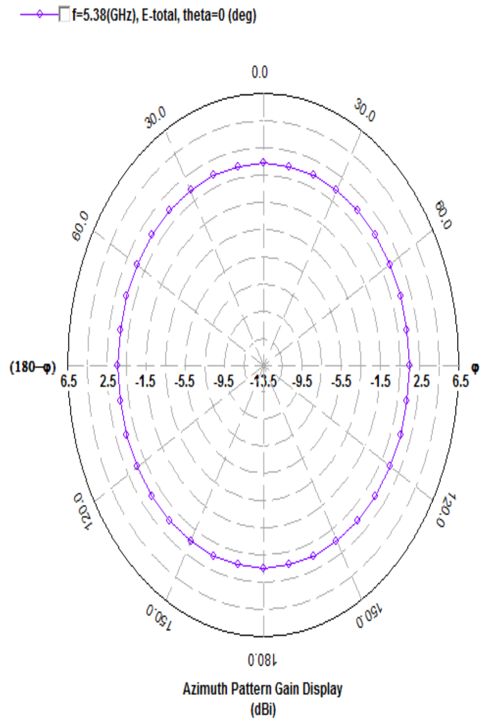
The 2D radiation pattern of the antenna are shown at different frequencies are show in figure 8. The simulated radiation patterns cut in the Azimuth plane and cut in the elevation plane for the proposed antenna is presented in the figure. Similar to monopole kind of antenna, the radiation pattern obtained in the Azimuth plane are similar to omni-directional and nearly figure of eight radiation pattern is obtained in the elevation plane.



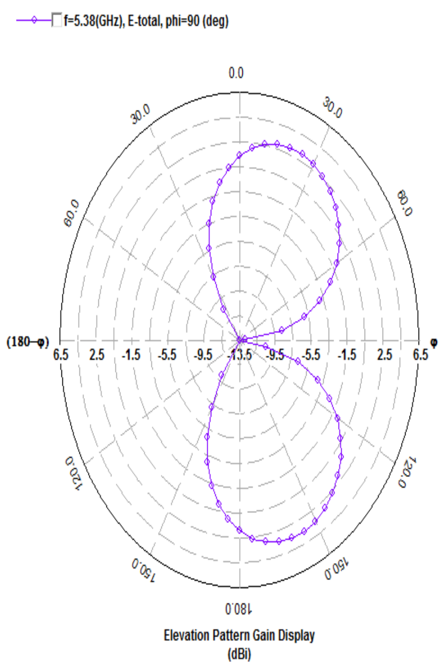
(a)



(b)



(c)



(d)

Fig 8: 2D Radiation pattern of proposed antenna

4. Conclusion

Coplanar waveguide (CPW)–fed U-Shaped Microstrip antenna for wireless applications has been designed and simulated using Zealand IE3D software. The parametric study is performed to understand the characteristics of the proposed antenna. It is observed from the simulation results study that when spacing between ground plane and feed length is d=0.9mm the antenna work in single broad frequency bands from 3.27GHz to 5.72GHz with bandwidth of 2.45GHz and when spacing between ground plane and feed length is d=1.4mm it start working as dual band antenna with lower band ranging from 3.38 to 4.28GHz with bandwidth of 900MHz and upper bands ranging from 4.57 GHz to 5.74 GHz with bandwidth of 1.17 GHz. The maximum simulated gain of the proposed antenna is 6.5 dBi at 5.3 GHz frequency. Moreover, the proposed antenna has several advantages, such as small size, higher gains, good radiation patterns and good efficiency. These characteristics are very attractive for some wireless communication systems.

5. References

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