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A Printed Half Circular Stepped Triangular Monopole Antenna for UWB Systems

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Abstract: This paper presents a study of a printed half circular with stepped triangular monopole antenna for UWB systems. Printed on a dielectric substrate and fed by a 50 Ω microstrip line, the proposed antenna shows satisfactory radiation characteristics within the operating bandwidth of 9.7 GHz in the range of 2.8 GHz to 12.5 GHz for a return loss (S11) of less than -10 dB. Compared to the rectangular stepped configuration, the proposed antenna has larger bandwidth and better impedance matching. The designed antenna gives gain in the range of 2.8 dB to 5.3 dB over the bandwidth.

Keywords: Circular patch antenna, ultrawide band (UWB) antenna, microstrip feed line, partial ground plane.

I. INTRODUCTION

Due to their very high bandwidth, low power requirements and reduced fading effects from multipath, ultrawide band (UWB) communication systems have been primarily considered for research studies recently. The approaching major commercial deployment of UWB systems have arisen new interests in the area of UWB antennas. UWB have major applications in short range and high speed wireless systems such as, in military applications, medical applications, radars, robotics and other wireless communication systems like personal area networks and wide area networks. Recent UWB antenna designs give emphasis on miniaturization, easy fabrication and integration with associated electronics and UWB systems. Earlier methods were used to increase the bandwidth of a microstrip patch antenna by simply increasing the thickness of the dielectric substrate. But, loss of low profile characteristics of the antenna was found by using this method [4]. So, to overcome this problem and to get UWB bandwidth, circular patch antennas are used. Circular patch antennas are commonly used for the widest and most demanding communication applications. Wide frequency bandwidth, multi-frequency operations, frequency agility, ease of fabrication and feed line flexibility can be obtained from the circular patch antennas. Circular patch antennas also give more directivity than the rectangular patch antennas [5]. So, due to these properties circular patch antennas are prominently used for UWB systems.

In this paper, a design of printed half circular disc monopole is presented. The antenna consists of a printed half circular disc and a triangular patch with two steps, fed by a microstrip line having an UWB operating bandwidth. Gain of the proposed antenna varies from 2.8 dB to 5.3 dB. The results show that the proposed antenna can achieve a return loss less than -10 dB over a bandwidth in the range of 2.8 GHz to 12.5 GHz. By changing different design parameters of the antenna, varied return loss impedance bandwidth is realized. In section II, the design of the proposed antenna is described.

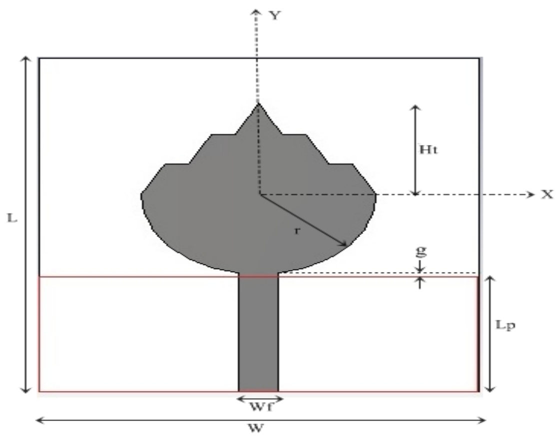

Fig. 1. Geometry of the proposed antenna.

In section III, the simulated results are shown and discussed. Conclusions of this paper are given in the section IV.

II. ANTENNA DESIGN

The design of the proposed UWB printed monopole antenna is shown in Fig. 1. The antenna consists of a half circular disc of radius r = 10.8 mm and a stepped triangular patch having height H_t = 12 mm. The antenna feeding is a 50 Ω microstrip feedline with width W_f = 3.6 mm. Rogers RT duroid 5880 substrate is used in the design having thickness 1.575 mm and dielectric constant ϵ_r = 2.2. The length and the width of the dielectric substrate are L = 45 mm and W = 40 mm respectively.

A conducting ground plane which covers only a portion of the feed line is placed on the other side of the substrate.In order to obtain UWB bandwidth, the antenna is designed with partial ground plane. The gap between the ground plane and the feeding point is ‘g’. The ground plane is having length L_p = 15.5 mm and width W = 40 mm. In order to obtain UWB bandwidth, the antenna is designed with partial ground plane. The gap between the ground

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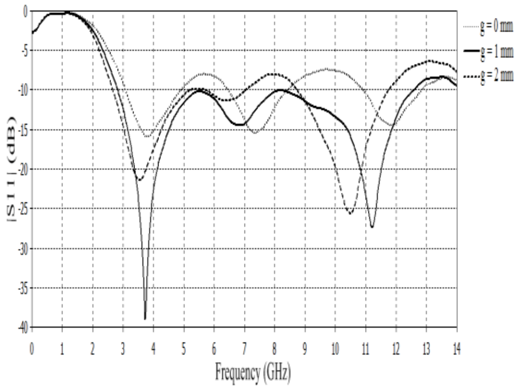

Fig. 2. Simulated return loss curves for g = 0 mm, g = 1 mm and g = 2 mm.

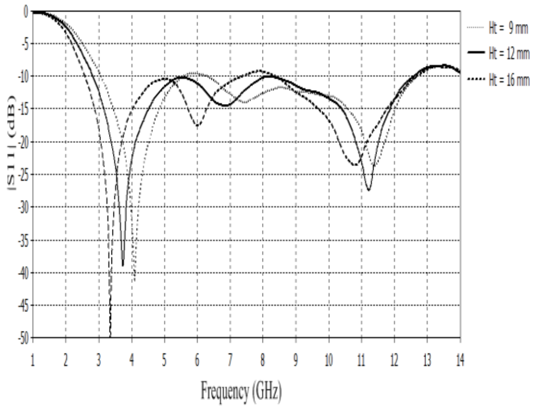

Fig. 3. Simulated return loss curves for H_t= 9 mm, H_t= 12 mm and H_t = 16 mm.

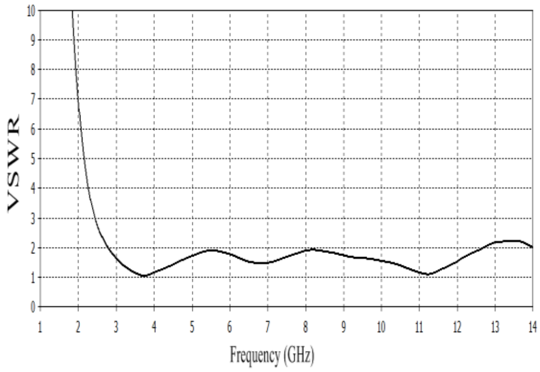

Fig. 4. VSWR magnitude of the antenna.

III. RESULTS

The simulations are performed using CST Microwave Studio package.

The simulated antenna return loss curves for the different values of the feed gap (g) are shown in Fig. 2.

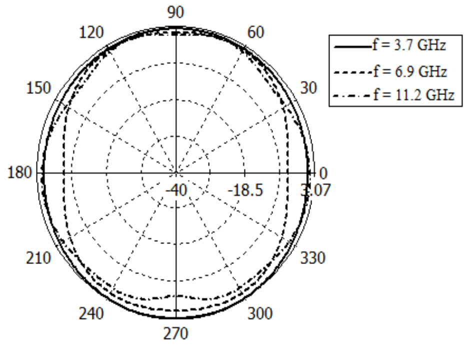

Fig. 5. H-plane radiation pattern.

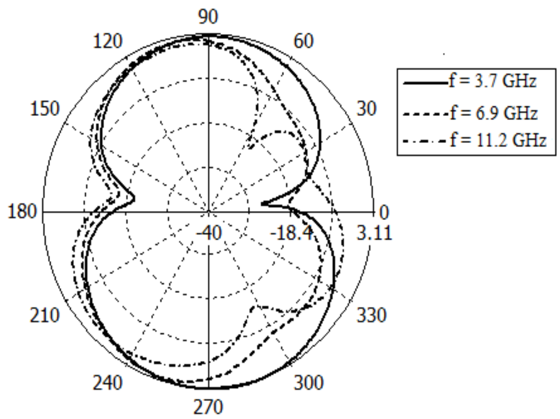

Fig. 6. E-plane radiation pattern.

From the shown figure, it can be observed that the -10 dB return loss impedance bandwidth changes with the change in the value of the feed gap (g). The -10 dB return loss bandwidth is 2.8 GHz to 12.5 GHz, giving a total bandwidth of 9.7 GHz. Fig. 3 shows the change in the return loss impedance bandwidth due to change in the height of the triangular patch (H_t). It shows that the bandwidth of the antenna increases if the height is increased and vice versa. The optimum results come for the feed gap value g =1 mm and the triangle height H_t = 12 mm.

The triangular patch mounted on the top of the half circular patch is used because triangular patch gives better suppression for side lobes than a rectangular patch [3]. The cutting steps in the proposed design increases the antenna perimeter without disturbing the current distribution of the antenna. Due to this, the surface current takes longer path and this decreases the lower resonant frequency which leads to achieve maximum frequency bandwidth [2]. Simulated Voltage Standing Wave Ratio (VSWR) magnitude with respect to frequency is shown in Fig. 4. To show UWB characteristics by an antenna, it is required that the VSWR should remain in the range of 1 to 2 throughout the frequency band [6]. So, from the VSWR plot, it can be noticed that the VSWR of the proposed antenna is varying from 1 to 2 throughout the frequency band.Normalized radiation patterns are calculated at frequencies 3.7 GHz, 6.9 GHz and 11.2 GHz to show the antenna's performance at UWB frequency range.

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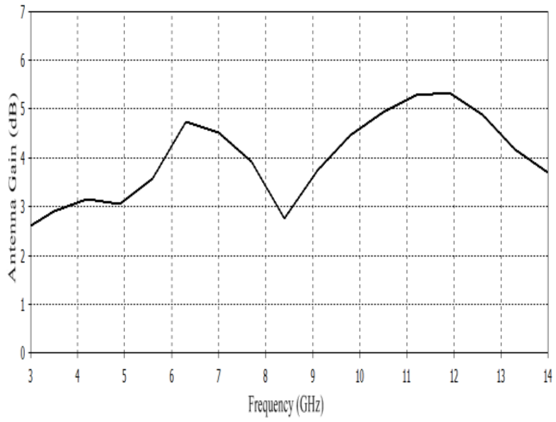

Fig. 7. Gain of the antenna.

H-plane and E-plane radiation patterns are shown in Fig. 5 and Fig. 6 respectively. It can be observed that H-plane radiation pattern is omnidirectional at lower frequency (3.7 GHz) and is almost omnidirectional at higher frequencies (6.9 GHz and 11.2 GHz). As from Fig. 5, it can be observed that the E-plane radiation pattern becomes more directional with increase in the frequency. The antenna shows monopole type E-plane radiation pattern at frequency f = 3.7 GHz. E-plane patterns have a null in the broad side and the main beam is around 120°. The antenna shows stable H-plane radiation patterns throughout the bandwidth.

The gain (in dB) of the proposed antenna versus frequency plot is shown in Fig. 7. From the plot it can be noticed that higher gain is obtained at higher frequencies. In the frequency band, the minimum gain is 2.8 dB at 8.4 GHz and the maximum gain is 5.3 dB at 11.9 GHz.

IV. CONCLUSION

In this paper, a UWB printed monopole half circular with stepped triangular antenna has been realized for a bandwidth of 9.7 GHz in the range of 2.8 GHz to 12.5 GHz for a return loss of less than -10 dB. Gain of the antenna varies from 2.8 GHz to 5.3 GHz over the frequency spectrum. Clearly, the designed antenna gives best performance for the feed gap of 1mm and the height of the triangle of 12 mm. The proposed antenna also shows good omnidirectional radiation patterns. This antenna has good potential for UWB applications. Further improvements could be possible, if instead of the triangular stepping some other stepped designed is used above the half circular patch.

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