Improvement of Impedance Matching of a Rectangular Printed Monopole Antenna

Bharat Bhushan Agrawal, Vibha Rani Gupta

Abstract — **In this paper a printed monopole antenna for ultra wide band (UWB) applications is proposed. A rectangular slit with the optimized dimensions is inserted in the ground plane and two square notches are introduced on the upper corners of the patch to improve the impedance bandwidth. The 2:1 VSWR bandwidth of the proposed antenna covers the entire range, 3.1 GHz to 10.6 GHz, of ultra wide band application. Prototype antenna is fabricated with optimized dimensions and its simulated and measured results are compared.**

Keywords –**Printed antenna, Monopole antenna, Impedance matching.**

I. Introduction

The aim of the new generation of the wireless mobile communication is to provide flexible data rates and wide varieties of applications to the mobile users, while serving as many users as possible. This goal has to be achieved under the constraint of limited spectrum and power. The limited spectrum availability requires a new technology that can coexists with the other devices that operates in the same frequency band. UWB has recently emerged as an interesting and potentially significant candidate for next-generation wireless local-area, personal-area and sensor networks, particularly in scenarios which require robust scalable and uncoordinated operation. UWB system has been allocated the frequency band of 3.1 GHz to 10.6 GHz. The wide bandwidths of UWB antennas present new challenges for design, simulation, and modelling.

Recently, it has been demonstrated that a patch monopole antennas are promising candidates for the UWB applications [1, 2]. But It needs the improvement of impedance matching over the desired frequency band of 3.1 GHz to 10.6 GHz. Various techniques to improve the matching over the desired band have been proposed. These include the use of feed gap optimization [3], bevels [4], ground plane shaping [5]. multiple feeds [6], and offset feeding techniques [7]. In this article, a simple technique of introducing a rectangular slit into the ground plane and removing two notches on the upper corners of the patch are shown as an alternative method to optimize bandwidth. The effect of size of the rectangular slit and the notches has also been studied.

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II. Antenna Design

Fig. 1 shows the geometry of the proposed antenna. The First of all a patch with the dimension L_1= 20 mm and W_1= 12 mm without any notch at the upper corner is modelled on a substrate with the dielectric constant (ε_r) 4.4 and thickness 1.6 mm. The patch is mounted over the ground plane of the size L_g =10 mm, W_g= 30 mm and is fed with the help of microstrip line of 50 ohm impedance. Initially the gap (G_w) between the patch and the ground plane was fixed to 1.5 mm. The simulations were performed using IE3D software, a commercial full wave simulator based on Method of Moments (MOM). It was found that the impedance matching is not proper over the entire range of desired frequency.

To improve the impedance matching a slit with the dimension L_2 X W_2 was introduced in the ground plane. The effect of this slit was studied by changing the three parameters L_2, W_2 and G_w. Initially the slit length L_2 was varied from 3.76 mm to 4.75 mm, keeping W_2 and G_w fixed at 3 mm and 1.5 mm respectively. The effect of slit length is shown in the Fig. 2. Next with the optimized value of L_2, which was 4.26 mm and G_w was fixed and W_2 was varied from 2.20 mm to 3.0 mm. It is evident from the Fig. 3, that the optimized value of the W_2 is 2.28 mm. Finally keeping optimized value of L_2 and W_2 fixed, G_w is varied from 1.3 mm to 1.8 mm as shown in Fig.4. This way using the iterative method the optimized value of L_2, W_2 and G_w was found, modelled and simulated. It is evident from the Fig.4 that the slit in the ground plane helps to improve the impedance matching only at the higher frequencies but the lower frequency band needs further improvement.

To improve the impedance matching at the lower frequency two notches with length L_3 and width W_3 were introduced at the upper corner in the patch. Effects of various values of L_3 and W_3 were studied, which is shown in the Fig. 5. It was seen that the notches in the patch helps in improving the impedance matching in the lower frequency range.

III. Results and Discussions

A slit in the ground plane and two slots at the upper corner of the radiating patch were introduced. The dimension of the slit and slots were optimized using the iterative method. With these optimized dimensions antenna was modelled and simulated. The return loss and the gain characteristic of the proposed antenna are shown in the Fig. 6 and Fig. 7 respectively. It is evident from the Fig. 6 that the proposed structure shows a improved impedance matching over the entire range of the UWB application. The measured return loss characteristic is compared in the Fig.6, which shows a good agreement with the simulated result. Gain of the antenna within the specified range of frequency varies from 0.73dBi to 3.7dBi.The E and H plane radiation pattern are shown in the Fig.8 for frequencies 3.3 GHz, 5.7GHz, 7.6 GHz and 10 GHz. For 3.3 GHz and 5.7 GHz the radiation patterns are almost omnidirectional. Whereas for 7.6 GHz. and 10 GHz. a notch appears in the broad side direction due to the higher mode.

IV. Conclusion

A monopole patch antenna with slit in the ground plane and two slots at the upper corners of the radiating patch has been proposed to improve the impedance matching over the entire band of UWB application. Slit in the ground plane helps to improve the matching at higher frequencies, where as the notch on upper corner improves the matching at the lower frequencies.

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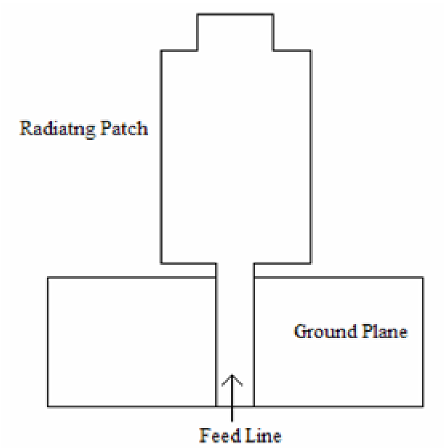

Fig. 1 (a)

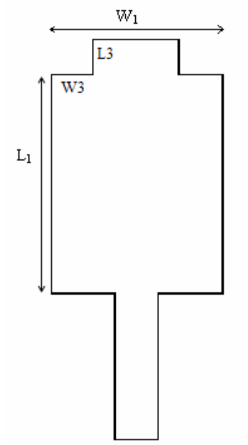

Fig. 1 (b)

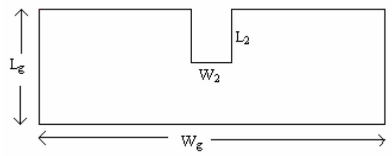

Fig. 1 (c)

Fig. 1(d)

Fig. 1. Geometry of proposed antenna. (a) Complete structure of the proposed antenna. (b) Geometry of the patch with two notches on the upper corners (c) Geometry of the ground plane with the inserted slit. (d) Fabricated antenna with optimized dimensions

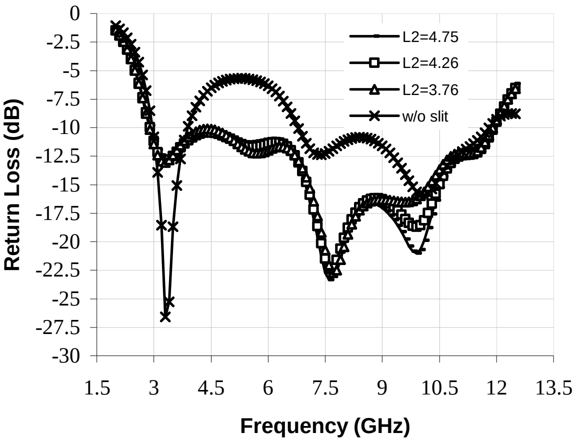

Fig. 2. Effect of slit length L_2 which varies from 3.76 mm to 4.75 mm

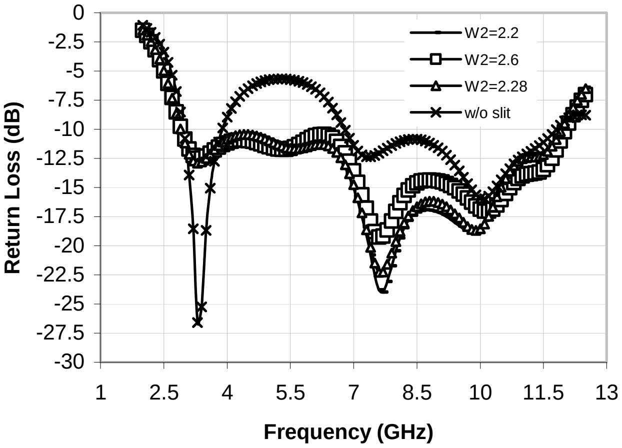

Fig. 3. Effect of slit width W_2 which varies from 2.2 mm to 2.28 mm

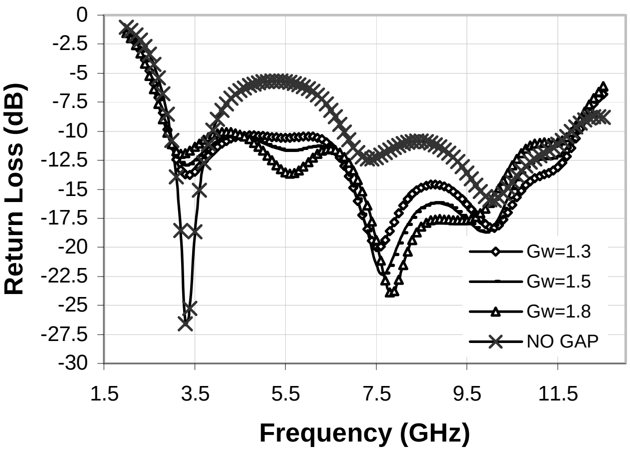

Fig. 4. Effect of gap between patch and ground plane (G_w), which varies from 1.3 mm to 1.8 mm

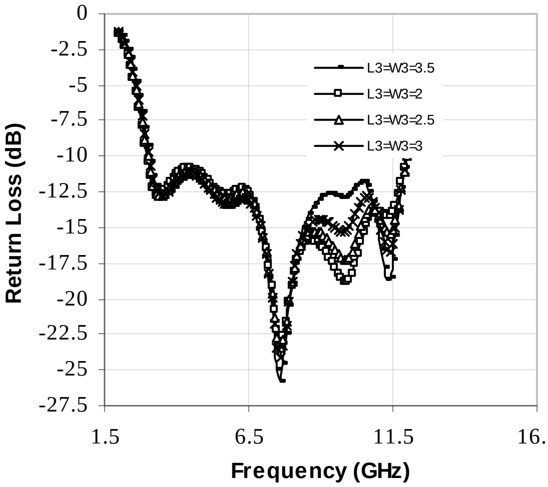

Fig. 5. Effect of notch on the upper corner of the patch, with L_3=W_3 varying from 2.0 mm to 3.5 mm.

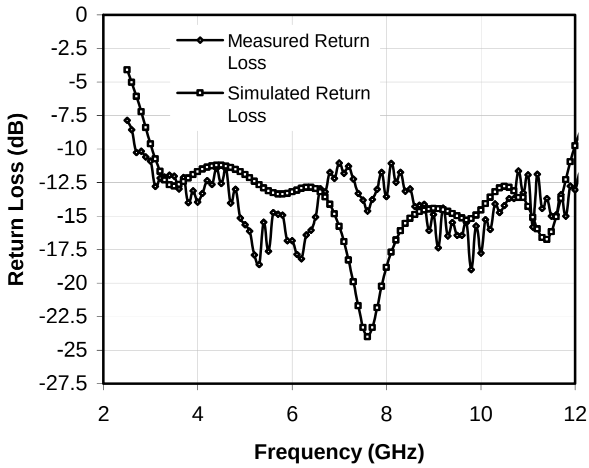

Fig. 6. Comparison of measured and simulated and measured return loss of proposed patch with optimized dimensions

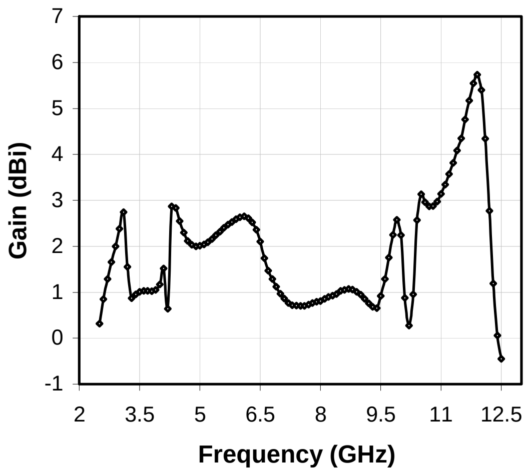

Fig. 7. Gain characteristic of the proposed patch with the optimized dimensions

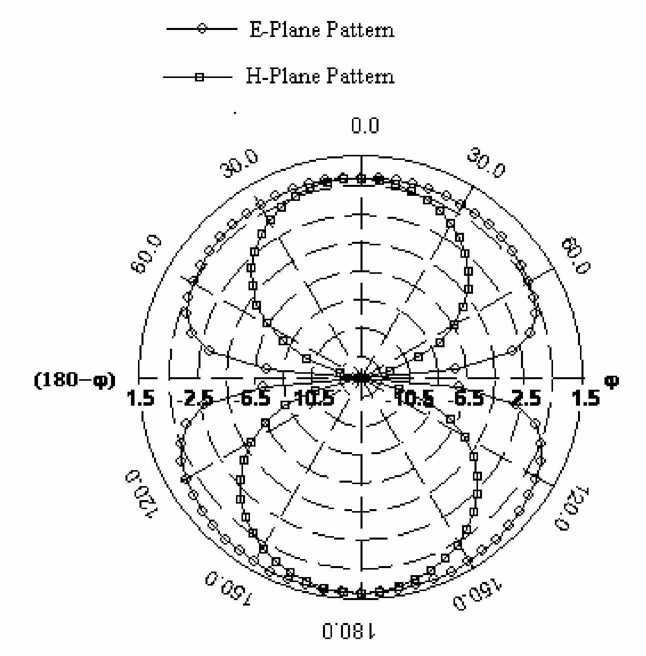

Fig. 8 (a) E and H plane radiation pattern of the proposed antenna at 3.3 GHz

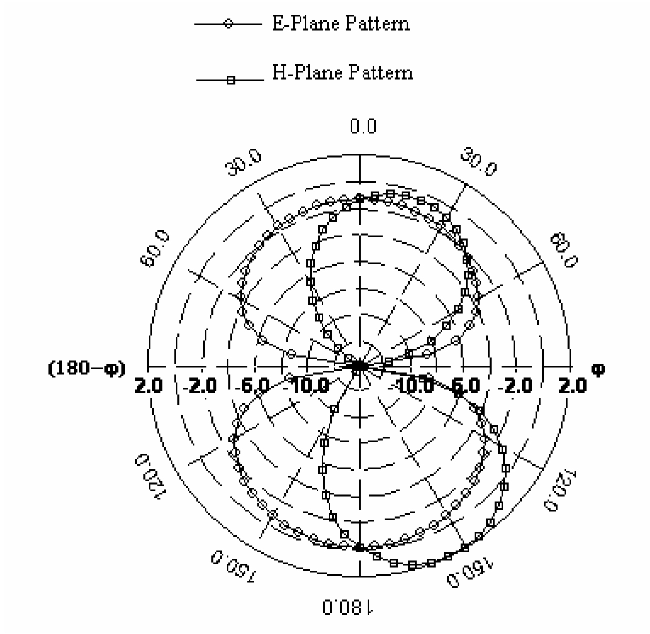

Fig. 8 (b) E and H plane radiation pattern of the proposed antenna at 5.7 GHz

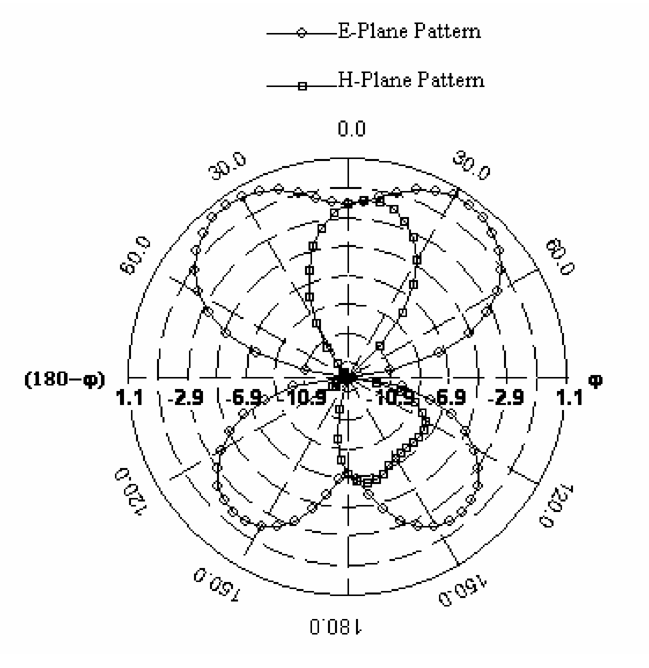

Fig. 8 (c) E and H plane radiation pattern of the proposed antenna at 7.6 GHz

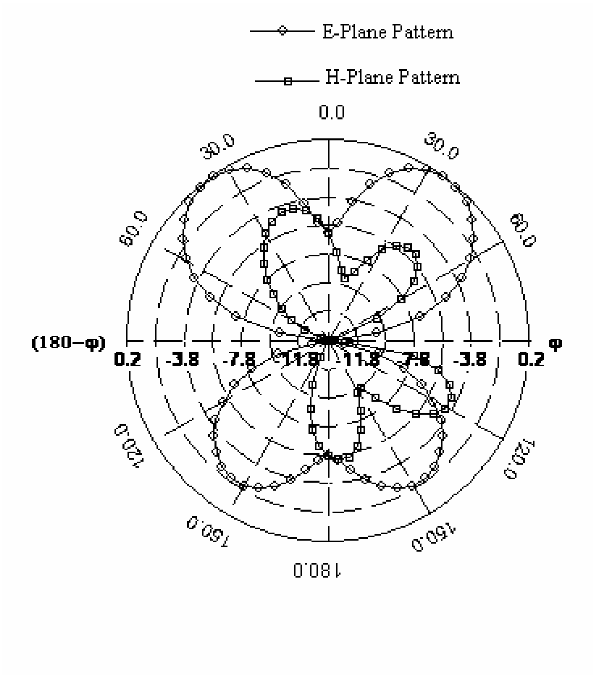

Fig. 8 (d) E and H plane radiation pattern of the proposed antenna at 10GHz