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Line Fed Inverted Double L-Shape with Rectangular Slot Microstrip Antenna for Quad Band Application

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ABSTRACT

In this paper, a compact slotted rectangular microstrip with Inverted double L-shape monopole narrowband patch antenna is presented. The proposed antenna comprises a planar patch element with five rectangular slots which offer quad band. The impedance bandwidth can be tuned by changing dimension of rectangular slot and ground plane geometry parameters (length and/or its width). The overall size of the antenna is 47mm × 48mm × 0.8mm including finite ground feeding mechanism. The antenna operates in four bands which are 0.92-0.98GHz, 2.1-2.25GHz, 3.3-3.4GHz, and 4.87-4.95 GHz. Stable Omni-directional radiation patterns in the desired narrowband band have been obtained. The proposed geometry was practically good solution for quad band application.

Keywords:— *Microstrip Antenna, Finite Ground, and Monopole Antenna.*

I. INTRODUCTION

With rapid development of microstrip antenna it has been found that, study of microstrip antenna with symmetrical feed line technique are good candidates for multi -bands applications. A patch antenna with return loss up to -33dB in the frequency range of 2.4 GHz to 2.5GHz (ISM band) and VSWR less than 1.5 was reported in [1]. With further study and optimization of dual band microstrip antenna [2] it has been found that the return loss for dual band frequency at 2.4GHz is -43dB and at 3GHz is -27dB. To get compact size and maintaining optimum performance of antenna for multiple bandsi.e., dual band, triple band antennas etc., various shapes of antenna was integrated [3]. As suggested in [4], introducing slot into patch (L-Shape), increasesthe impedance bandwidth up to 13%. To enhance bandwidth further various shapes like L-shape, U-shape etc., slotswere introduced to obtain bandwidth up to 42% [5, 6]. On the other hand [7] and [8] proposed bandwidth enhancement techniques that use photonic band gap structure and wideband stacked microstrip antennas, respectively. By introducing stacked microstrip antenna bandwidth and gain was enhanced. While Designing of symmetrical microstrip antenna, it has been found that microstrip antenna has narrow Bandwidth [9], Asymmetrical position of patch antenna on ground affect the performance of antenna that is to enhance bandwidth it was also found that asymmetrical position of slot on patch affects performance of antenna [10] that is asymmetrical L-shape, U-shape position of slot on patch affects the performance. In another study [10, 11] reported asymmetrical L-shaped slot on patch antenna for UWB application with acceptable return loss that is -10dB and peak gain of 2.2 to 6.1 dBi for operating bandwidth 3.01-11.30 GHz frequencies.

The bowtie microstrip patch antenna is a good candidate for multi-frequency. The common methods for achieving multi-frequency performances are as follows: 1) using several different resonant modes of a single microstrip patch; 2) changing surface instantaneous current distributions of resonance modes by loading or etching slot on a single patch [12]–[15]; 3) utilizing multiple microstrip patches on the single-layer substrate. In [16], a novel design for the modified bowtie slot antenna with a rectangular tuning stub for 2.4/5.2/5.8-GHz triple-band wireless applications is presented.

In this paper we proposed abowtie antennafed byline feed with three triangular slots printed symmetrically on each triangle (pl. ref. Figure 1). The proposed antenna offers multi-bands (four) operations. Design and optimization procedure of the proposed antenna is presented in Section 3. Section 4 presents the validation of the fabricated prototype and discussions on the measured results are also presented there. Finally, conclusions of this study are presented in Section 5.

II. Proposed work

The antenna is symmetrical with respect to the longitudinal direction. Substrate used for the design is FR4 with dielectric constant of 4.4, and thickness of 0.8mm. A quad-band bowtie antenna with five slots on the patch resonator (figure 1), where a pair of isosceles L-shape slot is introduced on either side of feed line with input impedance of 50 Ohms is depicted. The microstrip patch antenna has a length of L_p = 60mm and width W_p = 70mm. The feed line dimensions are length (L_f) and width (W_f). Two equal finite ground planes, each with dimensions of length L_g and width W_g are placed symmetrically on either side of the feed-line. Triangular shaped patch with rectangular base is fed by signal conductor. Figure 1 shows the top view of the basic geometry of proposed rectangular monopole antenna for quad bands operation and its ground plane (bottom view) is shown in Figure 2. The detailed optimization procedure of the proposed antenna and its optimum dimensions, and characteristics are presented in Section 3. All the parameters of the geometry are indicated in Figure 1.

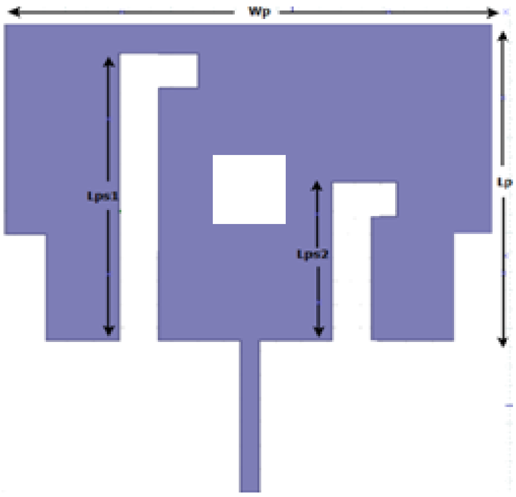


Figure 1: Geometry of proposed CPW-fed monopole antenna. (Top view)

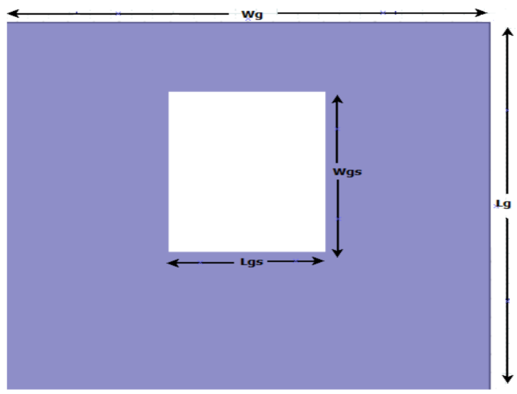


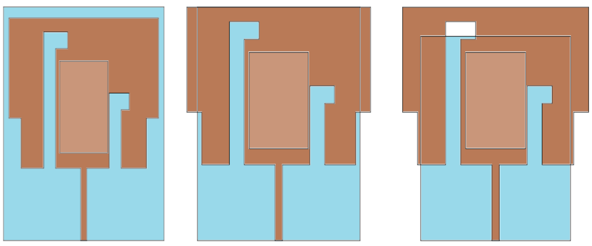
Figure 2: Geometry of proposed CPW-fed monopole antenna (Bottom view)

III. GEOMETRY OPTIMIZATION AND DISCUSSIONS

In this section parametric study is conducted to optimize the proposed antenna. The key design parameters used for the optimization are number of triangle on patch and dimension of ground plane (length and width), and rectangular base dimensions. The detailed analysis of these parameters is investigated in the following paragraphs of this section.

3.1 Effect of Ground Geometry

As showed in figure 3, ground plane of the geometry is varied to see its effect on the performance of antenna. For this, ground plane is changed to different shape. Initially, the ground plane is kept for entire plane (type-1). After simulation it found that, only first band is available for type-1. We consistently changed ground plane dimension as presented in Figure 2 i.e.,type -2 and type-3, for this we obtained second, and third band. Further we changed ground plane to get forth band as presented in Figure 2 that is type-4. So, the finalized ground plane shape to get four bands is type -4 figure 2.



(b) Type 1&2 (c) Type 3

Figure 3: Variation in number of steps in the staircase profile of ground.

As showed in Figure 3, ground plane of the geometry is varied to see its effect on the performance of antenna. For this, upper and lower ground plane is changed. The ground plane is located on the reverse side of the substrate in the shape of a rectangle, covering the entire back. Return loss characteristics of this study are presented in figure 3.

From figure 4 it may be noted that ground plane is divided into two parts to obtain fourth band. In the first attempt length of ground i.e., L_{g1} and L_{g2} are varied in steps of 0.2mm by keeping its width and all other parameters constant.

After optimizing the length, width of the ground is optimized. Figures 4 and 4 show return loss characteristics plots of this study. From these figures it may be noted that the quad band scan be obtained for W_g= 50mm, L_{g1}=47.7mm, and L_{g2}=12mm. The finalized dimensions obtained from these parametric studies are presented in Table 1.

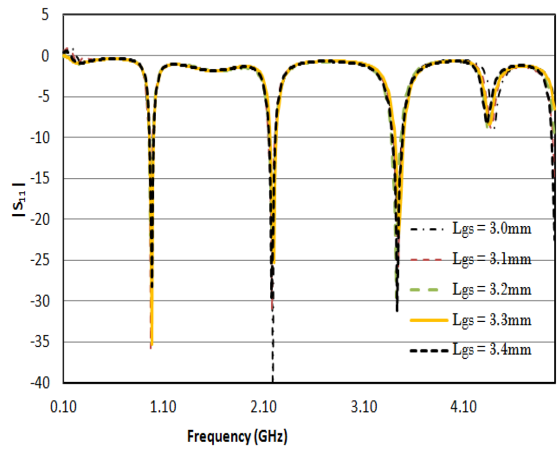


Figure 4: Return loss vs. frequency plot for variation in length of ground plane (L_{g1} and L_{g2}).

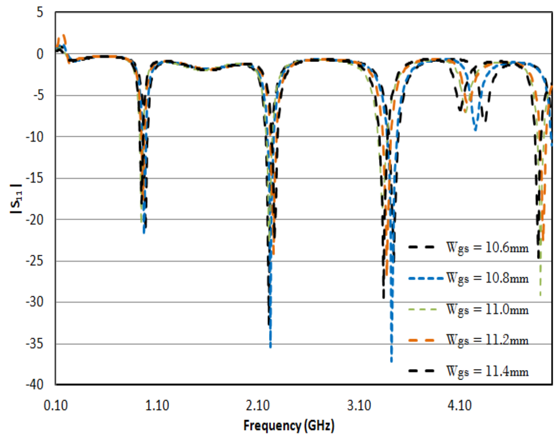


Figure 5: Return loss vs. frequency plot for variation in width of ground plane (W_g)

Table 1: Optimized Dimensions of the Proposed Geometry.

Parameter	L_p	W_p	L_{g1}	L_{g2}	W_g	L_t	W_f	L_f
Unit (mm)	62	72	47.79	13	52	3.3	1.6	29

3.2 Effect of Rectangular Base Dimensions

To study the effect various parameter like dimension of ground, dimension of patch, dimension of rectangular slot and rectangular base dimensions on the antenna performance, its length values i.e., L_{g1} and L_{g2} are varied. Initially, the length of upper rectangle(L_{g1}) is varied from 45 mm to 50 mm in steps of 1 mm keeping width of the rectangular base constant (50mm). The effects of variation of this study are presented in Figure 4. From Figure 5, it may be noted that the quad bands with return loss less than -10dB are (0.93-0.98GHz), (2.18-2.27GHz), (3.29-3.42GHz), and (4.85-4.94GHz). Further we simulated for different width of ground plane by keeping length constant that is L_{g1}= 47.7mm. In this range having return loss less than -20dBm for all quad bands with lower cut-off frequency remains nearly constant whereas upper cut-off frequency varies slightly i.e., impedance bandwidth varies with respect to this parameter (L_g).

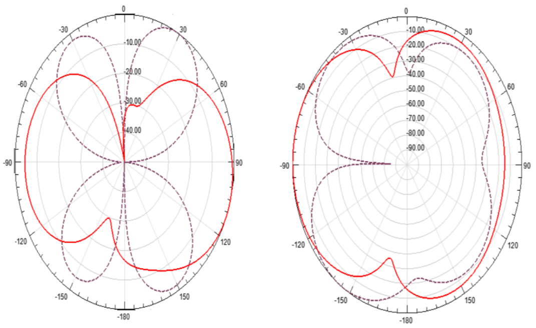


Figure 6 : E- and H-plane patterns at 0.97 GHz radiation patterns at various frequencies throughout the band of operation

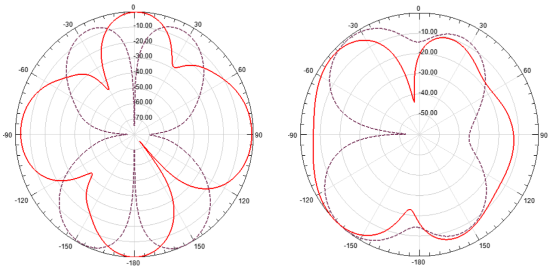


Figure 7 : E- and H-plane patterns at 2.23 GHz radiation patterns at various frequencies throughout the band of operation

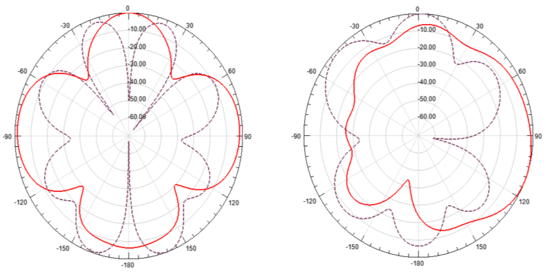


Figure 8 :E-plane and H-plane patterns at 3.3GHz radiation patterns at various frequencies throughout the band of operation

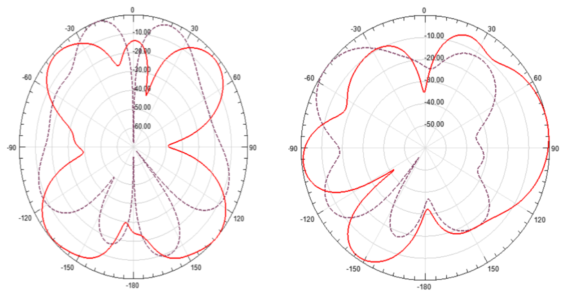


Figure 8: E-plane and H-plane patterns at 4.7 GHz radiation patterns at various frequencies throughout the band of operation

III. Conclusion

The design optimization of a three triangular slots patch with finite ground plane antenna has been presented. It has been shown that, with correct selection of slot dimensions on patch and shape of ground plane, a quad band frequency response can be achieved. With this antenna, we obtained quad bands 0.92-0.98GHz, 2.1-2.25GHz, 3.3-3.4GHz, and 4.87-4.95 GHz.The proposed antenna was been analyzed using a HFSS simulator.

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