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Single-Feed Double U-Shaped Micro strip Antenna with Co-Axial Feed for Multi-Bands Applications

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Abstract : *In this paper, a compact double (back to back) U-shaped monopole microstrip patch antenna is presented. The proposed antenna comprises a plane U-shaped rectangular patch element with another inverted U-shaped patch which offers quad band. The overall size of the antenna is 40mm×15.6mm×3.2mm including finite ground feeding mechanism. The antenna operates in four bands which are 3.2-3.6 GHz, 5.8-6.8 GHz, 7.5-9.8GHz, and 10.2-11.9 GHz. Stable Omni-directional radiation patterns in the desired frequency band have been obtained. The proposed geometry was practically realised and tested its parameters. Measured data fairly agree with the simulated results.*
Keywords: *Micro strip Antenna, Finite Ground, and Monopole Antenna.*

I. Introduction

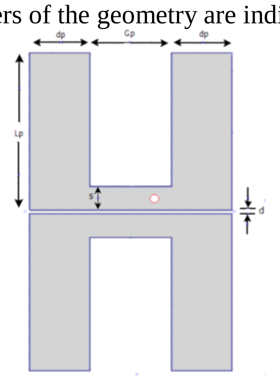
With rapid development of microstrip antenna it has been found that, study of microstrip antenna with symmetrical feed line technique are good candidates for multi-bands applications. A patch antenna with return loss up to -33dB in the frequency range of 2.4 GHz to 2.5GHz (ISM band) and VSWR less than 1.5 was reported in [1-3].

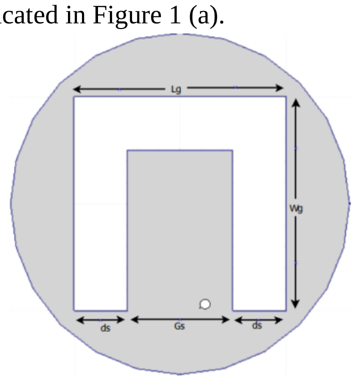
It is well known that slot antennas are used for enhancing the impedance bandwidth as well as exciting the multi-bands operations [1-14]. Authors of [1-3,5] have demonstrated the excitation of dual and triple bands with high gain by embedding U-slots. On the other hand [4] concentrated on the enhancement of impedance bandwidth of their proposed antenna. In another work reported by Behara and Choukikar [6] used particle swarm optimization technique (SOT) to optimize the antenna geometry. Whereas [7-9] have used L shaped slots to improve the impedance bandwidth and exciting 2, 3, and multiple bands.

In this paper we proposed a U-shaped microstrip antenna fed co-axial feed with two U-shaped slots printed on dielectric substrate (pl. ref. Figure 1). The proposed antenna offers multi-bands (four) operations. Basic geometry is presented in Section II. Design and optimization procedure of the proposed antenna is presented in Section III-V. Section VI 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 VII.

II. Antenna Geometry

Figure 1(a) shows the top view of the basic geometry of proposed U-shape monopole antenna for quad bands operation and its ground plane (bottom view) is shown in Figure 1(b).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 3.2mm. A quad-band U-shaped antenna with two U-shaped patch resonator (Figure 1(a)), where a pair of u-shaped microstrip patches placed inverted to each other that facing opposite to each other fed by a co-axial feed. The microstrip patch antenna has a length of L_p = 20mm and width W_p = 26mm. The feed line radius is 0.5mm. The circular ground plane with radius 16mm, the U-shaped slot printed on circular ground plane with dimension L_g and W_g. U-shaped patch with rectangular base is fed by signal conductor. The detailed optimization procedure of the proposed antenna and its optimum dimensions, and characteristics are presented in Section III. All the parameters of the geometry are indicated in Figure 1 (a).





(a)Top view (b) Ground

Figure 1: Geometry of proposed CPW-fed monopole antenna.

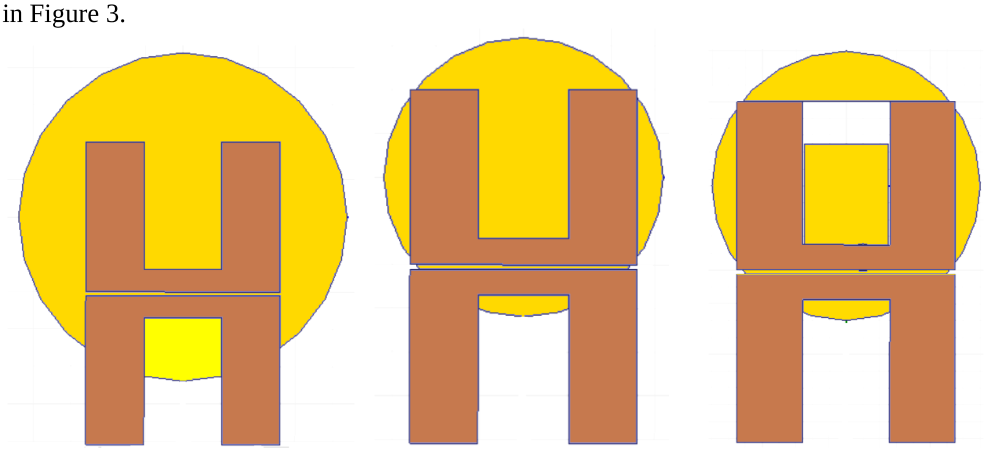
III. Geometry Optimization And Discussions

In this section parametric study is conducted to optimize the proposed antenna. The key design parameters used for the optimization are dimension of U-shape, gap between to U-shape patch and dimension of ground plane (length and width of U-slot. The detailed analysis of these parameters is investigated in the following paragraphs of this section.

IV. Effect Of Ground VARIATION ON ANTENNA PERFORMANCE

As showed in Figure 2, 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 that is without U-slot (type-1). After simulation it found that, only first band is available for type-1. We consistently changed ground plane radius, for this we obtained second, and third band (type-2). Further we introduced u-slot into ground plane to get forth band as presented in Figure 2(type-3). So, the finalized ground planes shape to get four bands.

As showed in Figure 2, 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 circle, covering the entire back. Return loss characteristics of this study are presented in Figure 3.



a) Type 1 b) Type 2 c) Type 3

Figure 2: Variation in number of steps in the staircase profile of ground.

From Figure 2(c) it may be noted that ground plane dimensions are finalized to get quad bands. Further we changed width of U-shape (dp), length of U-shape(s) and gap between U-shape patch(d). Figures (3), (4) and (5) show return loss characteristics plots of this study. From these figures it may be noted that the quad bands can be obtained for W_g= 20mm, L_g=20mm, and L_{g2}=12mm.The finalized dimensions obtained from these parametric studies are presented in Table 1.

Table 1: Optimized dimensions of the proposed geometry.

Parameter	L_p	W_p	G_p	d_p	S	d	L_g	W_g	D_s	G_s
Unit(mm)	20	26	10.4	7.8	3	0.5	20	20	5	10

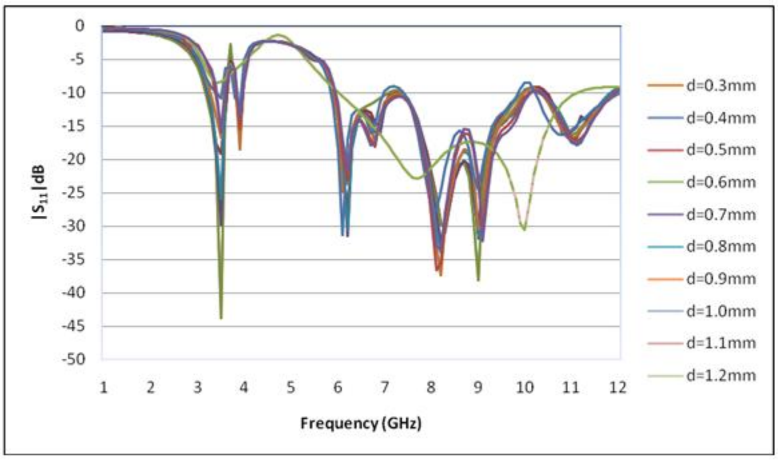


Figure 3: Return loss vs. frequency plot for variation in gap between U-shape patch (d).

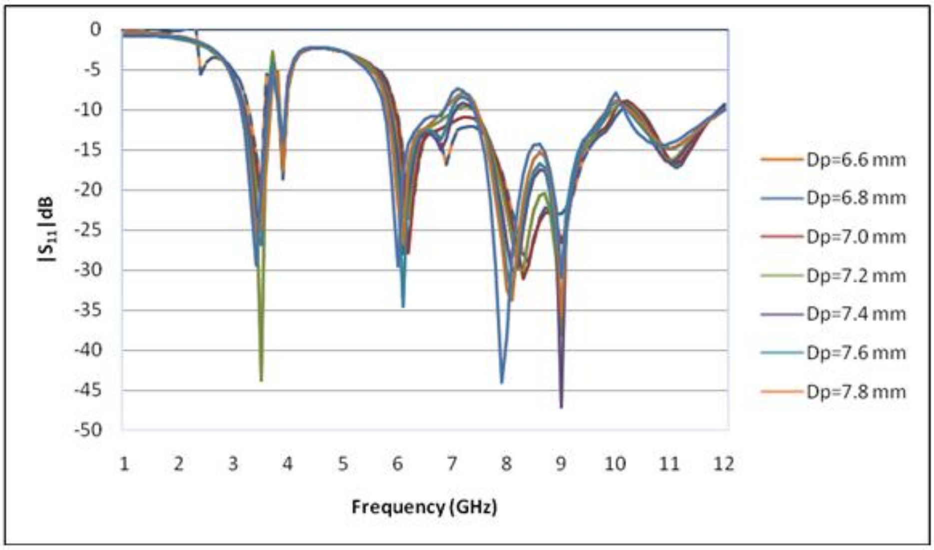


Figure 4: Return loss vs. frequency plot for variation in width of U-shaped patch (*Dp*).

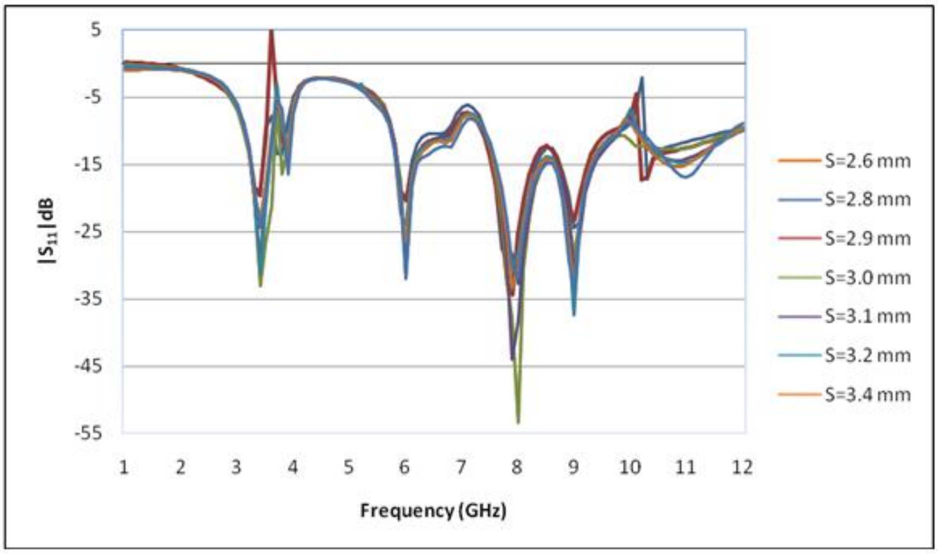


Figure 5: Return loss vs. frequency plot for variation in length of U-shaped patch (*s*).

V. Effect Of U-Shape Dimensions

To study the effect of U-shape dimensions on the antenna performance, its dimension values i.e., d_p , S and d are varied. Initially, distance between two U-shape (d) is varied from 0.3 mm to 1.2 mm in steps of 0.1 mm keeping dimension of ground plane constant. The effects of variation of this study are presented in Figure 3. From Figure 3, it may be noted that the quad bands with return loss less than -30dB are *(2-3.6 GHz), (5.8-6.8 GHz), (7.5-9.8GHz), and (10.2-11.9 GHz)*. Further we simulated for different dimension of U-shape patch that is D_p keeping S and d constant that is d_p= 0.5mm. In this range having return loss less than -35dBm 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.

VI. Experimental Validation Of Simulation Results

The geometry shown in Figure 1 with its optimized dimensions presented in Table 1 was fabricated and tested. The substrate used for the fabrication is the FR4 glass epoxy with dielectric constant of 4.4, and thickness of 3.2mm. A photograph of the fabricated prototype and S_{11} measurement setup is shown in Figure 4(a) and its S_{11} measurement graph shown in Figure 4(b).

From Figure 5 it may be noted that the proposed antenna is having operating frequency range from 1GHz to 12 GHz with four operating bands located at *(2-3.6 GHz), (5.8-6.8 GHz), (7.5-9.8GHz), and (10.2-11.9 GHz)*. Radiation patterns of the geometry are presented at various frequencies in the band of operation (Figure 6) to demonstrate that the patterns are nearly stable across the bands of operations.

(a) S_{11}measurement setup (b) S_{11} measurement

Figure 6: Photographs of the S_{11}measurement

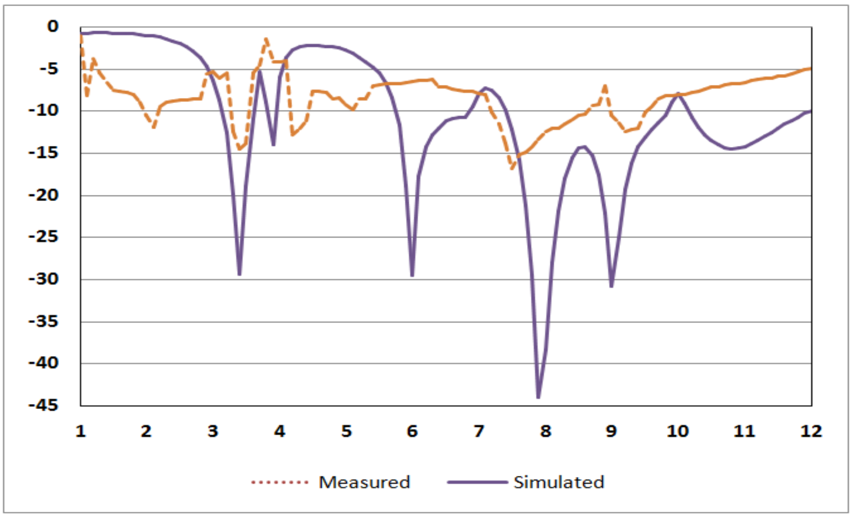
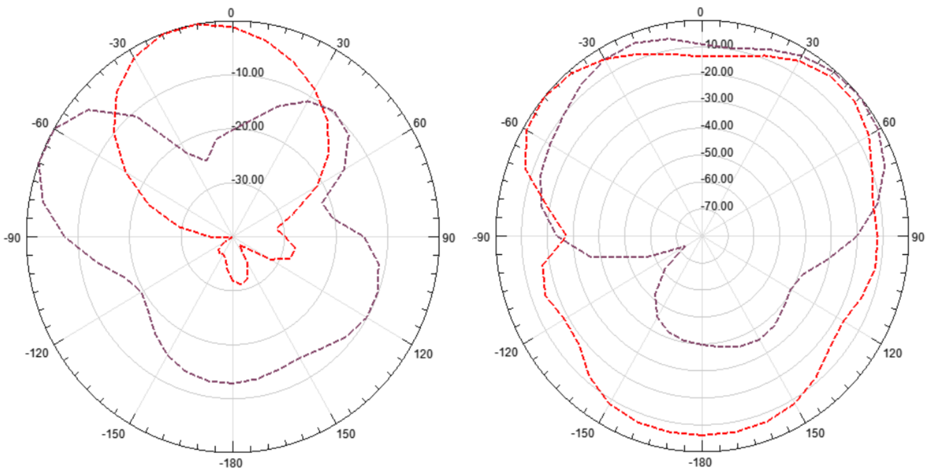


Figure 7: Return loss characteristic comparison.

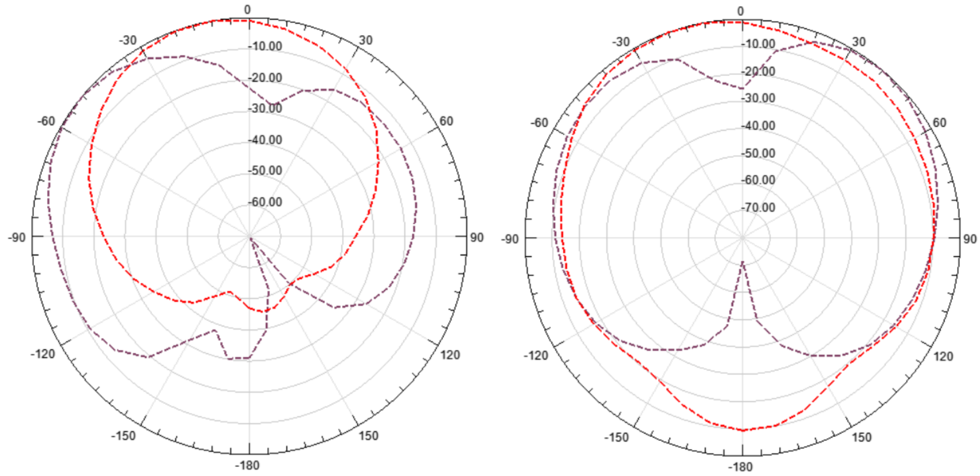
E-plane and H-plane radiation Pattern of proposed antenna is presented in Figures 6(a)-(d) at 3.4 GHz, 6.0GHz, 8.0 GHz and 9.0 GHz respectively

VII. Conclusions

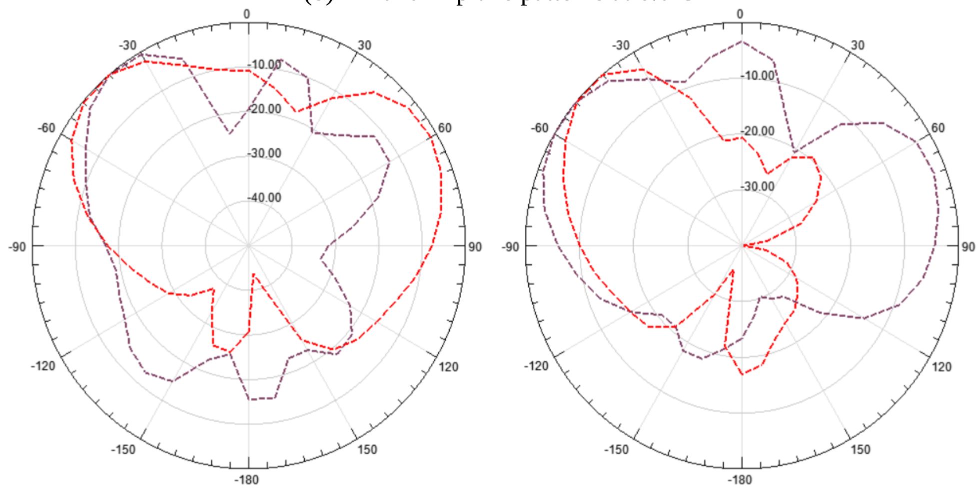
The design optimization of a U-shape patch with finite ground plane antenna has been presented. It has been shown that, with correct selection U-shape dimensions on patch and shape of ground plane, a quad band frequency response can be achieved. With this antenna, we obtained quad bands at *(2-3.6 GHz), (5.8-6.8 GHz), (7.5-9.8GHz), and (10.2-11.9 GHz)*.The proposed antenna was been analyzed using a HFSS simulator and tested with network analyzer. This U-shaped microstrip antenna is practical solution for quad band application.



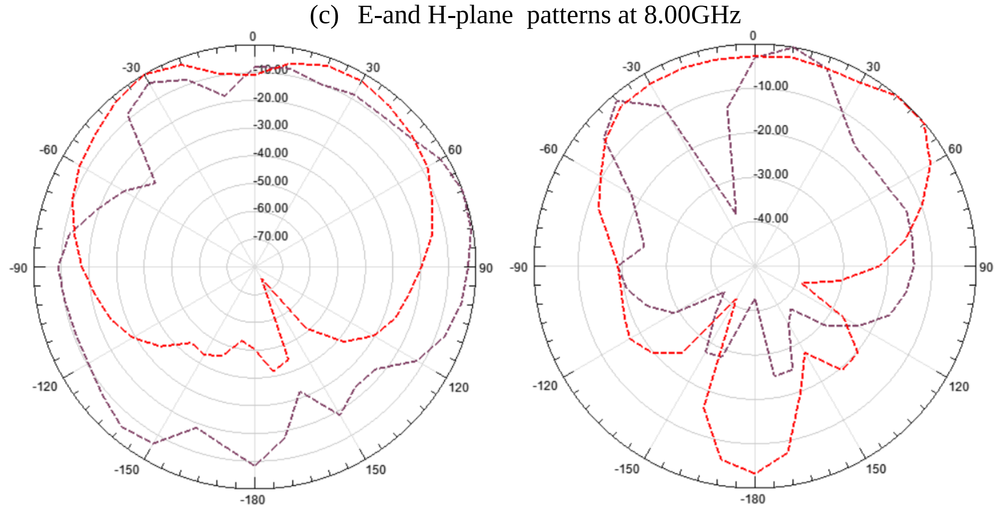
(a) E- and H-plane patterns at 3.4 GHz



(b) E- and H-plane patterns at 6.0 GHz



(c) E-and H-plane patterns at 8.00GHz



(d) E-and H-plane patterns at 9.0 GHz

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

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