IOSR Journal of Electronics and Communication Engineering (IOSR-JECE)
e-ISSN: 2278-2834,p- ISSN: 2278-8735.Volume 11, Issue 5, Ver. III (Sep.-Oct .2016), PP 22-27
www.iosrjournals.org

Single-Feed Triangular Slotted Microstrip Bowtie Antenna for Quad-bands Applications

Rekha N. Garje [1], Veeresh G. Kasabegoudar [2]
[1, 2]P.G. Dept. MBES College of Engineering, Ambajogai, India, 431 517

Abstract: *In this paper, a compact slotted triangular microstrip bow-tie monopole patch antenna is presented. The proposed antenna comprises a planar triangular patch element with three triangular slots which offer quad band. The impedance bandwidth can be tuned by changing the ground plane geometry parameters (length and/or its width). The overall size of the antenna is 70mm×60mm×0.8mm including finite ground feeding mechanism. The antenna operates in four bands which are 4.78-5.12GHz, 5.8-6.22GHz, 7.21-7.62GHz, and9.18-10GHz.StableOmni-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: *Microstrip Antenna, Finite Ground, and Monopole Antenna***.**

I. Introduction

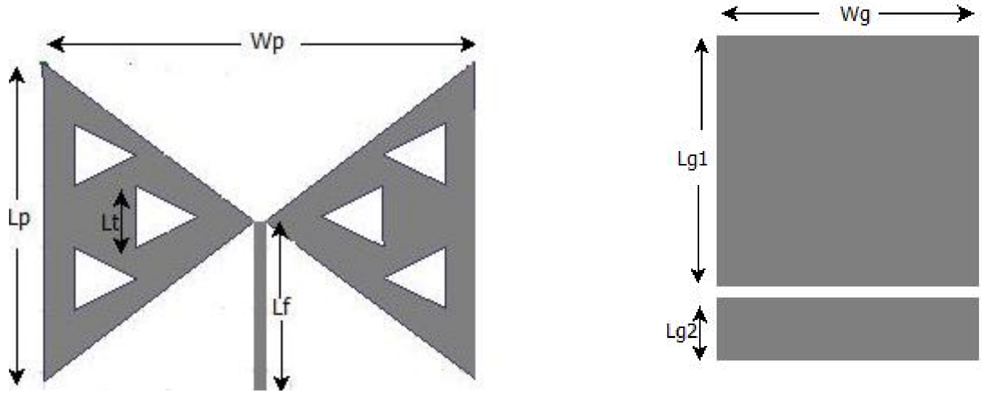
With rapid development of microstrip antenna it has been found that, study of microstrip antenna with symmetrical feed line technique are good candidates for multi-bands applications. A patch antenna with return loss up to -33dB in the frequency range of 2.4 GHz to 2.5GHz (ISM band) and VSWR less than 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 bands i.e., dual band, triple band antennas etc., various shapes of antenna was integrated [3]. As suggested in [4], introducing slot into patch (L-Shape) increases the impedance bandwidth up to 13%. To enhance bandwidth further various shapes like L-shape, U-shape etc., slots were 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 a bowtie antenna fed by line 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. Antenna Geometry

Figure 1(a) shows the top view of the basic geometry of proposed triangular 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 0.8mm.A quad-band bowtie antenna with three slots on the patch resonator (Figure 1(a)), where a pair of isosceles triangle microstrip patches fed by a microstrip 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. 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 (a).



(a)Top view (b) Ground

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

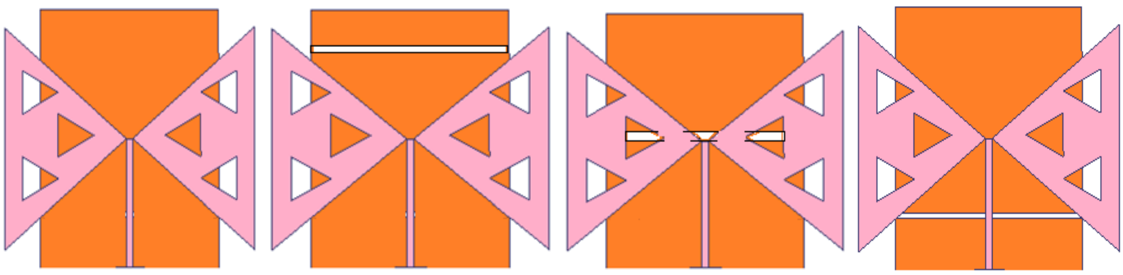
III. Geometry Optimization and Discussions

In this section parametric study is conducted to optimize the proposed antenna. The key design parameters used for the optimization are 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.

IV. Effect of Ground Geometry

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 (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).

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 rectangle, covering the entire back. Return loss characteristics of this study are presented in Figure 3.



a) Type 1 b) Type 2 c) Type 3 d) type 4

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

From Figure 3 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 3 and 4 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= 50mm, L_{g1}=47.7mm, and L_{g2}=12mm.The finalized dimensions obtained from these parametric studies are presented in Table 1.

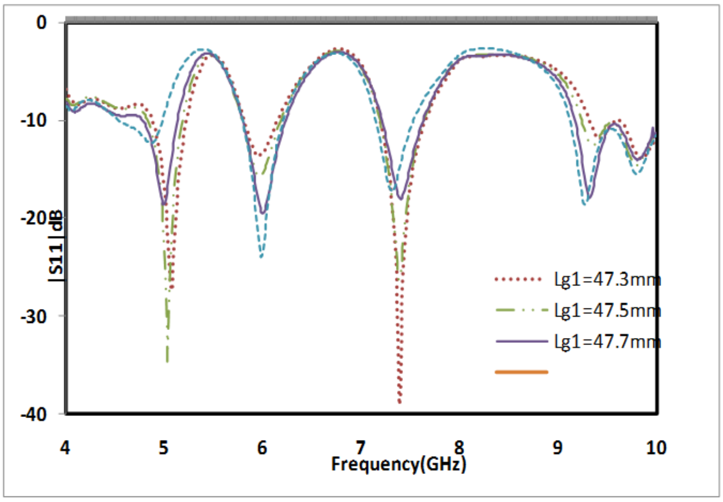


Figure 3: Return loss vs. frequency plot for variation in length of ground plane (L_{g1} and L_{g2}).

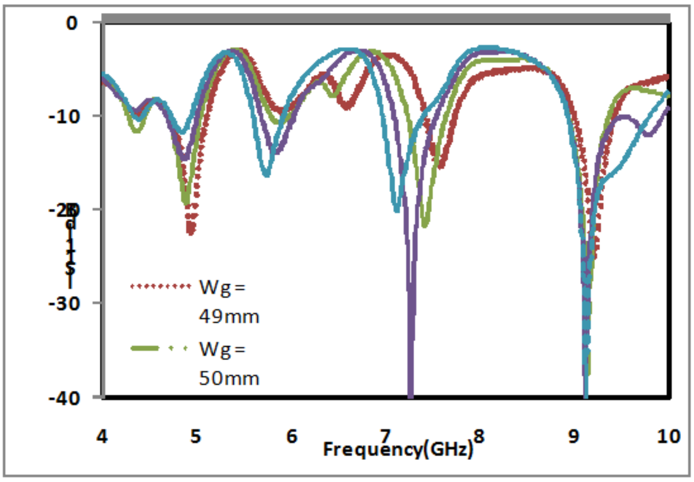


Figure 4: Return loss vs. frequency plot for variation in width of ground plane (W_g).

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)	60	70	47.7	12	50	3	1.8	30

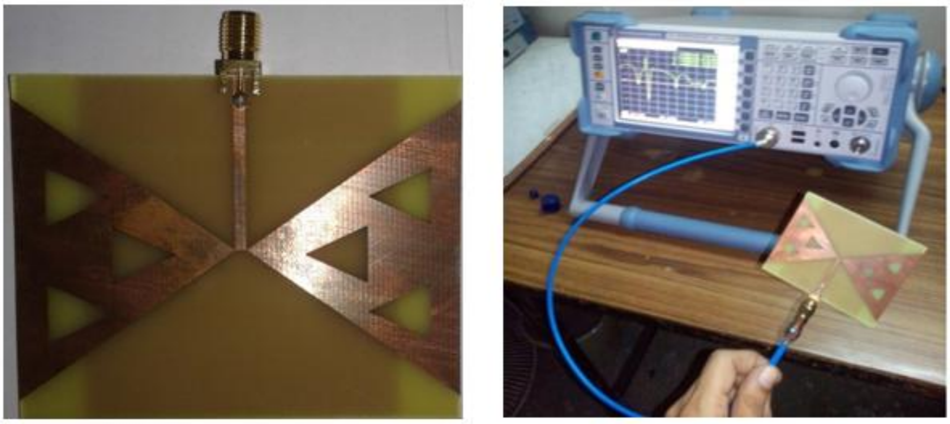
V. Effect of Rectangular Base Dimensions

To study the effect of rectangular base dimensions on the antenna performance, its length values i.e., L_{g1} and L_{g2}arevaried. 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 3. From Figure 3, it may be noted that the quad bands with return loss less than -10dB are (4.78-5.17GHz), (5.79-6.21GHz), (7.21-7.62GHz), and (9.24-10GHz). 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).

VI. Experimental Results and Discussions

The geometry shown in Figure 1 with its optimized dimensions presented in Table 1was fabricated and tested. The substrate used for the fabrication is the FR4 glass epoxy with dielectric constant of 4.4, and thickness of 0.8mm. A photograph of the fabricated prototype is shown in Figure 4(a) and its S_{11} measurement setup is shown in Figure 4(b). Return loss measurement is presented in Figure 5(a) and comparisons of measured and simulated values are compared in Figure 5(b). The measured results fairly agree with the simulated values.

From Figure 5 it may be noted that the proposed antenna is having operating frequency range from 4GHz to 12 GHz with four operating bands located at (4.78-5.17GHz), (5.79-6.21GHz), (7.21-7.62GHz), and (9.24-10GHz).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)Fabricated prototype (b) S_{11}measurement setup

Figure 4: Photographs of the fabricated antenna and its measurement setup.

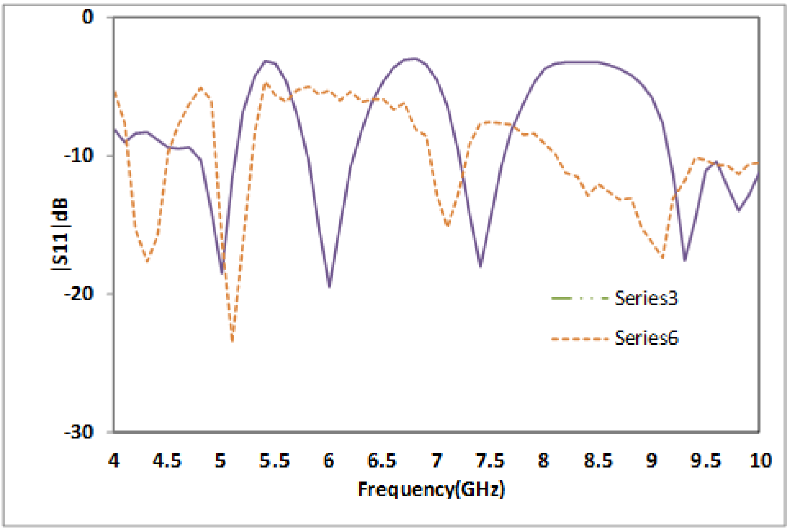
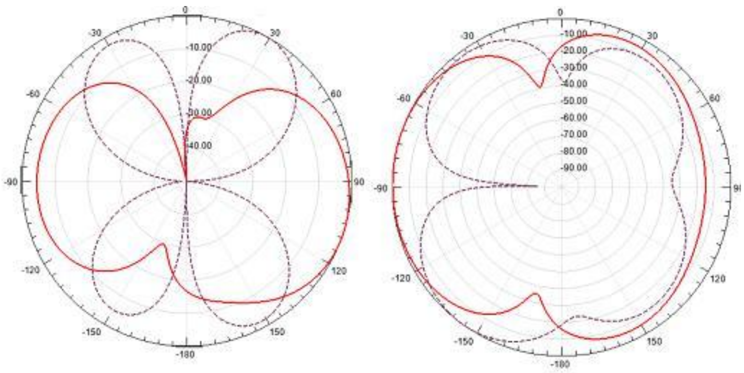


Figure 5: Return loss characteristic comparison.

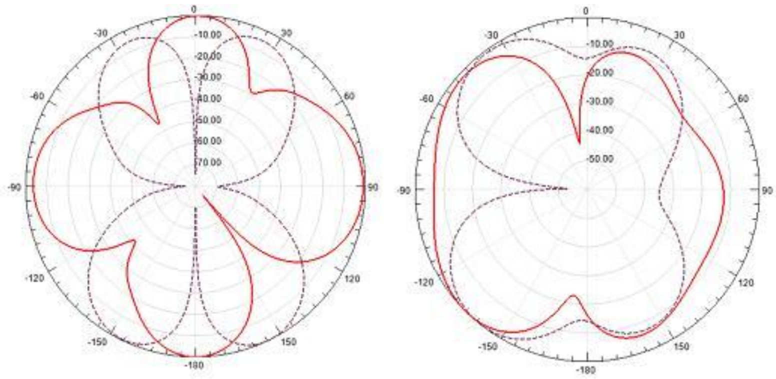
E-plane and H-plane radiation Pattern of proposed antenna is presented in Figures 6(a)-(d) at 5.0GHz, 6.0GHz, 7.4GHz and 9.9GHz respectively

VII. Conclusion

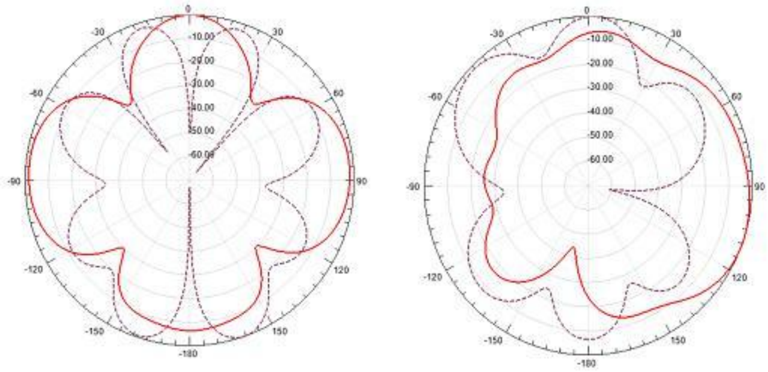
The design optimization of a three triangular slots patch with finite ground plane antenna has been presented. It has been shown that, with correct selection of slot dimensions on patch and shape of ground plane, a quad band frequency response can be achieved. With this antenna, we obtained quad bands at4.78-5.12GHz, 5.8-6.22GHz, 7.21-7.62GHz, and 9.18-10GHz.The proposed antenna was been analyzed using a HFSS simulator and tested with network analyzer.



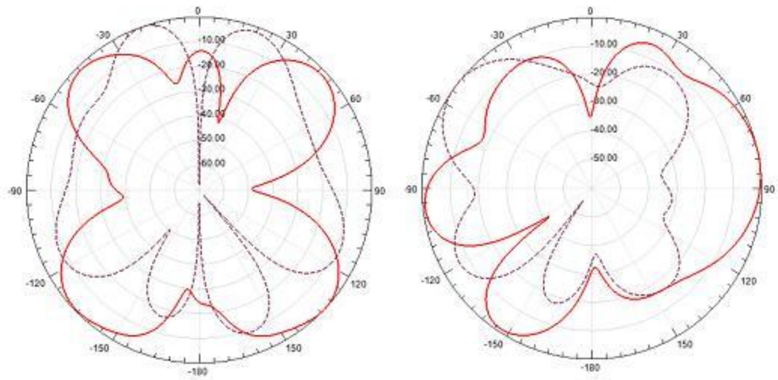
(a)E- and H-plane patterns at 5.0 GHz



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



(c)E-and H-plane patterns at 7.4GHz



(d)E-and H-plane patterns at 9.9 GHz

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

References

[1] A. H. Reja "Study of Micro Strip Feed Line Patch Antenna", *Antennas and Propagation International Symposium*, vol. 27, pp. 340-342 December 2008.

[2] Sahntanu Kumar Behera and Y. Choukiker, "Design and Optimization of Dual Band Micro Strip Antenna Using Practicle Swarm Optimization Technique," *Springer Science Business Media*, LLC, pp. 1346-1354, 2010

[3] M. A. Alkanhal, "Compact composite triple band antenna", *Progress in Electromagnetics Research, PIER* 93, 221-236, 2009

[4] A. A. Deshmukh and G. Kumar, "Compact broadband gap-coupled shorted L-shaped microstrip antennas," *IEEE Antennas and Propagation International Symposium,* vol 1, (Baltimore, Maryland), pp. 106–109, IEEE, July 2001.

[5] Z. M. Chen and Y. W. M. Chial, "Broadband probe-fed L-shaped plate antenna," *Microwave and Optical Technology Letters*, vol. 26, pp. 204–206, 1985.

[6] K. F. Lee, K. M. Luk, K. F. Tong, Y. L. Yung, and T. Huynh, "Experimental study of the rectangular patch with a U-shaped slot," *IEEE Antennas and Propagation International Symposium*, vol.1, (Baltimore, Maryland), pp. 10–13, IEEE, July 1996.

[7] S. C. Gao, L. W. Li, M. S. Leong, and T. S. Yeo, "Design and analysis of a novel wideband microstrip antenna," *IEEE Antennas and Propagation International Symposium*,vol.1, (Boston, Massachusetts), pp. 90–93, IEEE, July 2001.

[8] M. Khodier and C. Christodoulou, "A technique to further increase the bandwidth Of stacked microstrip antennas*," IEEE Antennas and Propagation International Symposium*, vol. 3, pp. 1394–1397, IEEE, July 2000.

[9] N. Jain, A. Khare, Rajesh Nema, "E-Shape Micro strip Patch Antenna on Different Thickness for pervasive Wireless Communication", *International Journal of Advanced Computer Science and Applications*, Vol. 2, No. 4, 2011

[10] K. Song, Y.-Z. Yin, S.-T. Fan, and B. Chen," compact open ended L-shaped slot antenna with asymmetrical rectangle patch for UWB application", *Progress In Electromagnetics Research C*, Vol. 19, 235-243, 2011

[11] V. V. Reddy, N. V. S. N. Sarma, "Triband circularly polarized Koch fractal boundary Microstrip Antenna," *IEEE antennas and wireless propagation letters*, vol. 13, 2014

[12] H. W. Liu, Hao Jiang, Xuehui Guan, JiuHuai Lei, and S. Li, "Single-feed slotted bowtie antenna for tri-band applications*" IEEE antennas and wireless propagation letters*, vol. 12, 2013

[13] J.-S. Chen, "Dual-frequency annular-ring slot antennas fed by CPW feed and microstrip line feed," *IEEE Trans. Antennas Propag.*, vol. 53, no. 1, pp. 569–571, Jan. 2005.

[14] W.-S. Chen and K.-L. Wong, "A coplanar waveguide-fed printed slot antenna for dual-frequency operation," in *Proc. IEEE AP-S Int. Symp.*, Jul. 2001, vol. 2, pp. 140–143.

[15] J.-S. Chen, "Triple-frequency annular-ring slot antennas fed by CPW and microstrip line," in *Proc. IEEE AP-S Int. Symp.*, vol. 2, pp. 557–560, Jun. 2003.

[16] J. H. Yoon and Y. C. Lee, "Modified bow-tie slot antenna for the 2.4/5.2/5.8 GHz WLAN bands with a rectangular tuning stub," *Microw. Opt. Technol. Lett.*, vol. 52, no. 1, pp. 126–130, Jan. 2011.

[17] HFSS10.0 User's Manual, Ansoft Corporation, Pittsburgh.