International Journal of Electronics Engineering, 3 (2), 2011, pp. 197– 199 ISSN : 0973-7383

Development and Study of a Planar Inverted-L (P-I-L) Patch Antenna with Tapered Width for Dual Band Operation

G. A. Bidkar[1], P. V. Hunagund[1] & R. M. Vani[2]

[1]*Dept. of Applied Electronics, Gulbarga University, Gulbarga, Karnataka. India.*

[2]*University Science Instrumentation Centre, Gulbarga University, Gulbarga, Karnataka. India.*

E-mail: gabidkar@rediffmail.com, prabhakar_hunagund@yahoo.co.in, vanirm12@rediffmail.com

Abstract: Achieving a wide impedance bandwidth suitable for present day cellular communication for compact microstrip antenna is becoming an important topic in microstrip antenna design. This paper presents the development and study of a P-I-L patch Antenna with tapered width (PPATW). The experimental results show that the first resonant frequency f_1 decreases with increase in the tapering angle á. The second resonant frequency f_2 also shows decreasing trend up to certain value of α. This, results in a tunable frequency ratio in the range of 1.85 to 1.99.The two identical slits inserted at the non radiating edges of the P-I-L Patch's vertical portion offer an improvement in the bandwidth at the second resonant frequency f_2.

Keywords: Microstrip Antenna, Impedance Bandwidth, tuning stub, meandering effect.

1. INTRODUCTION

Compact microstrip antennas have recently gained much attention due to increasing demand of small antennas for personal communication equipment. The design of an efficient wideband small antenna is a major challenge [1]. Microstrip antennas are extensively used due to their light weight, low profile, low cost fabrication and ease of integration with feed networks [2]. However they suffer from narrow bandwidth [3]. Use of low dielectric substrate, use of various impedance matching and feeding techniques, use of slot antenna geometry are some of the methods used to increase the bandwidth [4-6]. A prototype of a PPATW with and without slits in the vertical portion is developed and its performance is being studied experimentally.

2. ANTENNA STRUCTURE AND GEOMETRY

The proposed antenna presented in this study is designed with the equations available in the literature [7, 8] for the frequencies of f_1=1730 MHz & f_2=2880 MHz using copper plates and low cost glass epoxy substrate material. The artwork of the antennas is sketched using computer software Auto-CAD 2006 to achieve better accuracy. The structure and geometry of PPATW is shown in Figure 1. It has a total length of L+h. It consists of a horizontal portion (Length L) and a vertical portion (length h). The horizontal portion has a tapered width with the tapering angle α. The antenna is directly fed by 50Ω microstrip line which has a tuning stub of length d and is printed on a FR-4 substrate of thickness h_1= 0.8 mm and a relative permittivity ε_r = 4.4.

The optimal length of d is found to be about 40% of the total length of the P-I-L patch.

$$D = 0.4\ (L + h)$$

By varying the length d of the tuning stub, or the tapering angle α or both, it is possible to obtain various frequency ratios. Two identical slits having dimensions l x w are inserted in the vertical portion of the patch. The combined effect of tapering of the horizontal portion and the meandering effect due to. the slits in the vertical portion is studied.

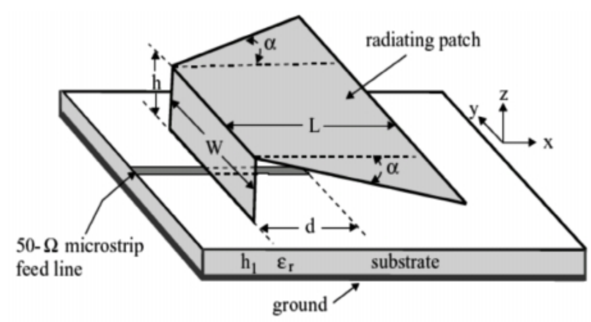

Figure 1: Antenna Geometry

3. RESULTS AND DISCUSSION

The return loss and the radiation pattern measurements were performed with the Vector Network Analyzer (Rhode & Schwarz, Germany make ZVK model 1127.8651). Table 2 shows the dual frequency performance of the proposed PPATW. The results show that as the tapering angle á of the horizontal portion of the radiating patch is increased from 0 deg to 30 deg the first resonant frequency f_1 decreases from 1.64 G Hz to 1.51 G Hz. Also the second resonant frequency decreases from 3.04 G Hz to 3.01 G Hz. Hence a tunable frequency ratio in the range of 1.85 to 1.99 is obtained. The PPATW with two identical slits being inserted in vertical portion offers a bandwidth of 8.8% at the second resonant frequency f_2. Hence it shows an improvement in the impedance bandwidth for α = 15 deg at the second resonant frequency f_2 as compared to 7.1% obtained for PPATW without slits. The return loss Vs frequency graphs for Antennas 4 and 5 shown in the Figure 2a and Figure 2b indicate the dual frequency operation of the antenna. Figure 3a and Figure 3b show the broadside radiation patterns of antenna 3 (solid lines indicate co-polar and dotted lines indicate cross-polar radiation) for the resonant frequencies f_1 and f_2.

Table 1
Dual Frequency Performance of the PPATW

Antenna	*α in degrees*	*f_1G Hz*	*BW in% age*	*f_2G Hz*	*BW in % age*	*R-Lat f_1*	*R-L atf_2*	*Frequency ratio*
1	0	1.64	7.4	3.04	7.5	-12.46 dB	-20.5 dB	1.85
2	10	1.61	6.5	3.03	7.4	-14.71dB	-22.75 dB	1.88
3	15	1.56	5.7	3.015	7.1	-19.65 dB	-23.88 dB	1.93
4	30	1.51	5.4	3.01	6.5	-13.78 dB	-14.01 dB	1.99

Table 2
Dual Frequency Performance of PPATW with Slits

Antenna	*α in degrees*	*f_1G Hz*	*BW in% age*	*f_2G Hz*	*BW in % age*	*R-L atf_1*	*R-L atf_2*	*Frequency ratio*
5	15	1.54	5.8	3.14	8.8	-37.93 dB	-3.865 dB	2.03

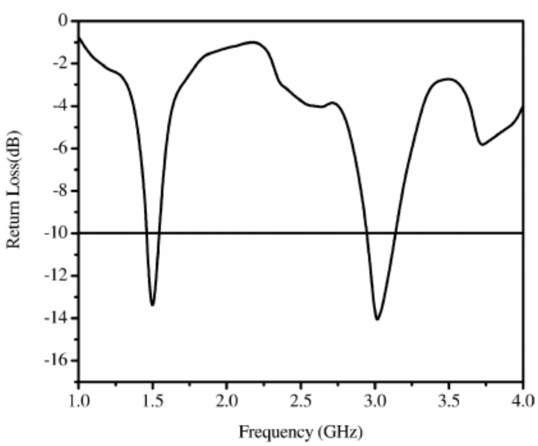

Figure 2a

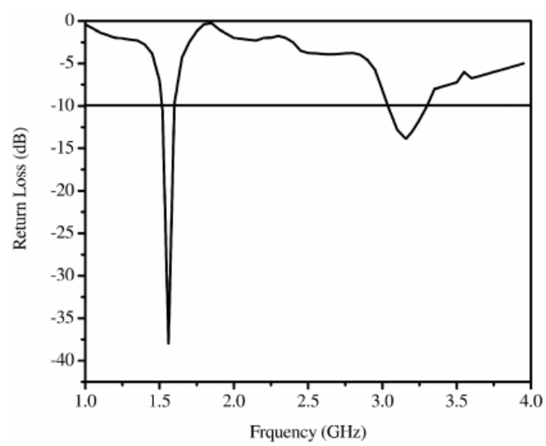

Figure 2b

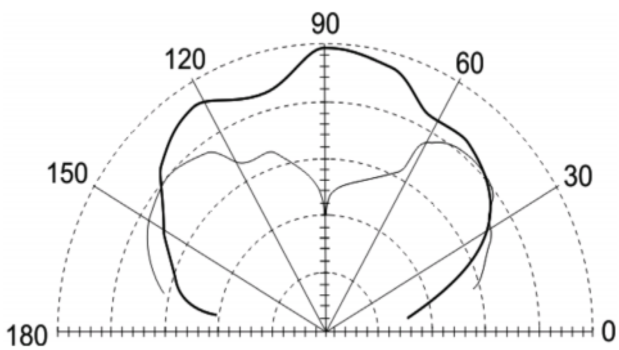

Figure 3a

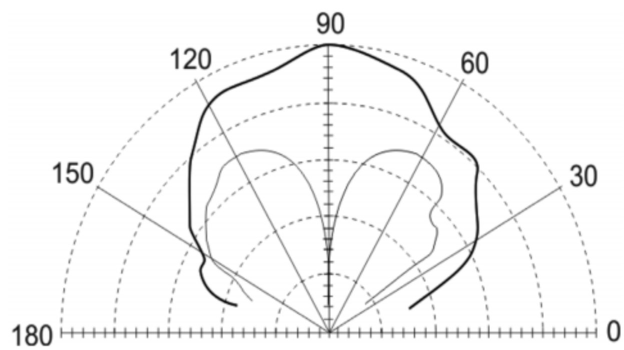

Figure 3b

Table 3
Design Parameters and Dimensions of PPATW

Antenna parameters	*Dimensions in mm*
L	35 mm
W	35 mm
h	10 mm
d	18 mm
Ls (Substrate Length)	110 mm
Ws (Substrate Width)	150 mm

4. CONCLUSION

From the experimental study of the proposed P-I-L Patch Antenna it is found that PPATW resonates for two different frequencies and these resonant frequencies decrease with the increase in the tapering angle α. This feature provides tunable frequency ratio in the range of 1.85 to 2.03. This shows that PPATW is suitable not only for compact operation but also is suited for dual frequency operation. The insertion of slits in the vertical portion shows an improvement in the impedance bandwidth from 7.1% to 8.5% for the resonant frequency. The proposed antenna use low cost substrate material and is simple for construction. This antenna finds application for the systems used in mobile communications.

REFERENCES

[1] Kin-Lu Wang, *Compact and Broadband Microstrip Antennas*, John Wiley and Sons, Inc., 2002.

[2] K. Fujimoto and J. R. James, *Mobile Antenna System Handbook*, 2nd Edition. Artech House Inc., 2001.

[3] R. G. Vaughan and J. B. Anderson, "*Antenna Diversity in Mobile Communication*", IEEE Transactions, Antennas and Propagation, Vol. 49, pp. 954-960, June 1987.

[4] Shun-Yun Lin and Kuang-Chih Huang, "A Compact Microstrip Antenna For GP and DCS Application", IEEE Trans, Antennas and Propag., Vol. 53, No. 3, pp. 1227-1229. March 2005.

[5] Su. S. W. and J. H. Chou, "Low Cost Flat Metal Plate Dipole Antenna for 2.4/5-G Hz WLAN Operation." Microw. Opt. Tech. Lett., Vol. 50, pp. 1686-1687, 2008.

[6] Garg R. P. Bhartia, I. Bahl, Ittimpibon, Microstrip Antenna Design Handbook, Artech House, Boston, London, 2001.

[7] Bahl I. J. & Bhartia P., Microstrip Antennas, Artech House, New Delhi, 1981.

[8] Constantine Balanis A., *Antenna Theory Analysis and Design*, John Wiley & Sons Inc., New York, 1982.