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Planar Inverted – L (PIL) Patch Antenna for Mobile Communication

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Abstract

In this paper, the construction and the study of the prototype of a planar inverted – L patch antenna is presented. The study reveals that PIL patch antenna is a good candidate for achieving compact micro strip antenna. The two identical slits [having dimensions] inserted at the non radiating edges of PIL patch’s vertical portion help to obtain various frequency ratios of the two resonant frequencies. The decrease in the first resonant frequency with the increase in the slit length, results in a tunable frequency ratio in the range of about 1.63 to 1.76. In addition to the compact operation, the proposed design is also suitable for dual frequency operation.

Keywords: Micro strip; compact antenna; resonant frequency; dual frequency.

Introduction

With the ever increasing demand for mobile communication and emergence of many systems, it is important to design broad band antennas to cover wide frequency range [1]. The design of an efficient wideband small size antenna, for recent wireless applications is a major challenge. Micro strip patch antennas have found extensive application owing to their low profile, conformability, low cost fabrication and ease of integration with feed networks [2]. The narrow bandwidth of the micro strip antennas however, poses the design challenges for broadband applications [3]. There are well known methods to increase the bandwidth of antennas including increase of substrate thickness, the use of dielectric substrate of low dielectric constant, the use of various impedance matching and feeding techniques and use of slot antenna geometry [4,5]. In this paper the prototype of a PIL patch antenna with the slits being introduced in the vertical portion and it's performance study in terms of its return loss and radiation patterns is being presented.

Antenna Design and Structure

The PIL patch has a total length of $L + h$, and consists of horizontal portion (length L) and a vertical portion (length h). The horizontal portion is selected to be square patch having dimension L x L. The grounded substance has a thickness of h_1 and relative permittivity ε_r on which 50 ohm micros strip feed line is printed. The PIL patch is centered above the micro strip feed line, with the edge of the patch's vertical portion directly connected to feed line. The portion of the feed line below the patch's horizontal portion has a length of '*d*' which is used as a tuning stub for achieving good impedance matching.

The optimal length of '*d*' is found to be about 40% of the total length of the PIL patch.

$$d=0.4(L + h)$$

With the proposed design, the antennas first two resonant frequencies which are respectively associated with the resonant modes, of PIL patch being about one quarter wavelength and one half wavelength can be excited with good impedance matching and single feed dual frequency operation can thus be obtained.

In order to obtain various frequency ratios of the two resonant frequencies, two identical slits having dimensions of l x w are inserted at the non-radiating edges of the PIL patch's vertical portion. The two inserted slits cause different meandering effects on the excited patch surface current paths of two resonant frequency ratios can be obtained with the selection of various slit dimensions.

When there are no slits (l=0) the frequency f_1 approximately corresponds to the length of the PIL patch about being one quarter wavelength.

$$f_1=c/4(L+h)$$

$$c = \text{Velocity of Light}$$

Frequency 'f_2' is associated with the length of the PIL patch being about one half wave length. However, mainly owing to the bending of the PIL patch, the null point of the excited patch surface current distribution is shifted from patch centre to bent edge. This characteristic makes the excited patch surface current distribution on the patch's horizontal portion at frequency 'f_2' a uniform distribution and same as that at 'f_1'. Similar broadside radiation characteristics for both f_1 and f_2 can thus be expected.

When there are inserted slits in the vertical portion of the patch, it is observed that, with the increasing slit length, frequency f_1 is quickly decreased, where f_2 is relatively insensitive to the inserted slits. This behavior results in a tunable frequency ratio, in a range of about 1.63 – 1.76.

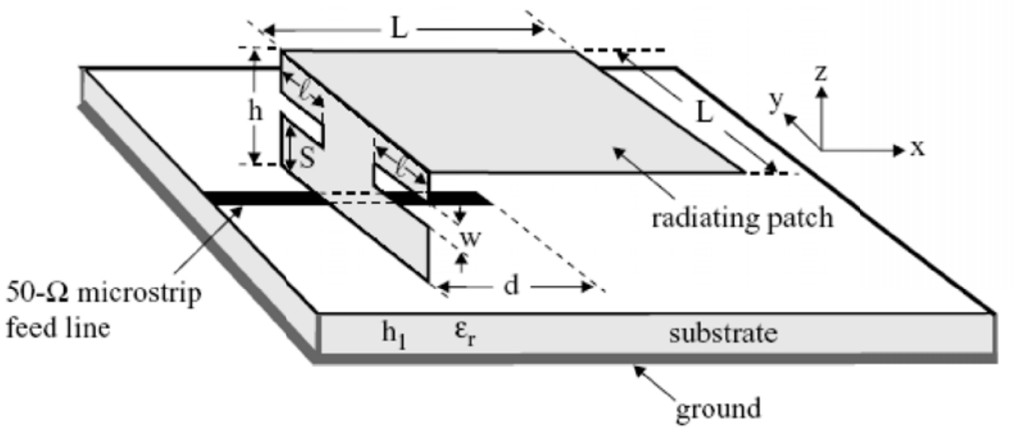

Figure 1: Structure and geometry of the PIL antenna.

The parameters for the construction of the antenna are selected as follows.

L= 35 mm, *h* = 10 mm, *S* =4.5 mm; *w*=2mm; *h*1=0.8mm
d= 15mm; Ground plane size= 110 X 130 mm^2.
l for antenna 1 = 5mm; *l* for antenna 2 = 10mm.

Results & Discussion

Fig 2 shows the return loss-frequency graph for Antennas 1 & 2. From the graph it is seen that antenna 1 resonates at two different frequencies f_1 (1715 MHz) and f_2 (2895 MHz) providing bandwidth of 7.6% & 7.5 %. By increasing the slit length the first resonant frequency f_1 decreases to 1.64 GHz where as f_2 is almost same. Bandwidth at f_1 is enhanced to 8.5% by increasing the slit width. Good broadside radiation (Fig 3) patterns are obtained at f_2 in the Horizontal plane. Considerable decrease in the cross polar radiation is observed for antenna 2 at resonating frequency f_1.

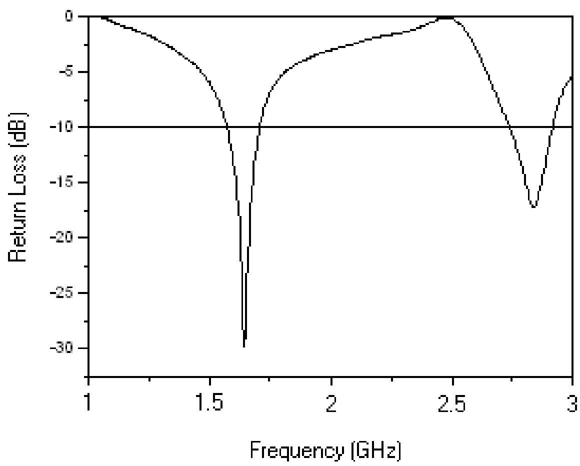

Figure 2a

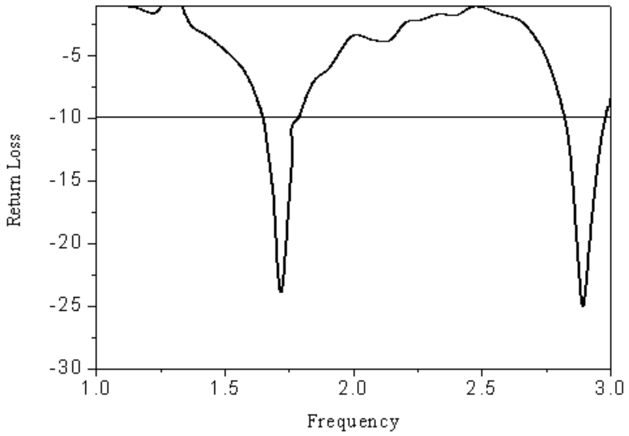

Figure 2b

Figure 2: Return loss vs. frequency graph for Antennas 1 & 2.

Table 1: Dual frequency performance of the PIL patch antenna shown in Fig. 1.

Antenna	*l* (mm)	f1(MHz)(BW)	f2(MHz)(BW)	f2/f1
Antenna 1	05 mm	1.715 (7.6%)	2.895 (7.5%)	1.63
Antenna 2	10 mm	1.64 (8.5%)	2.825(7.2%)	1.76

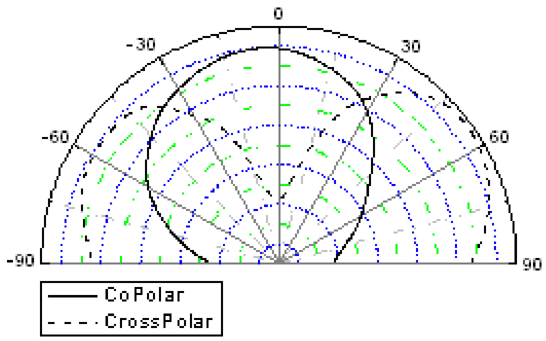

Figure 3a

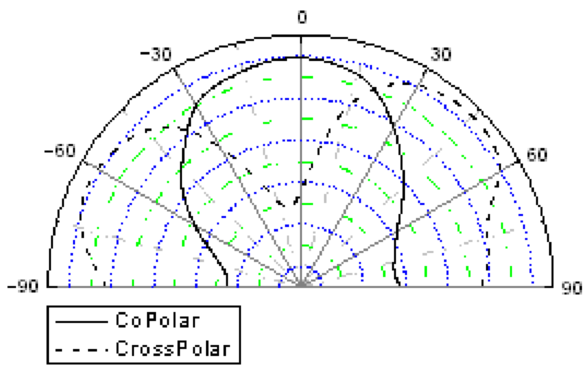

Figure 3b

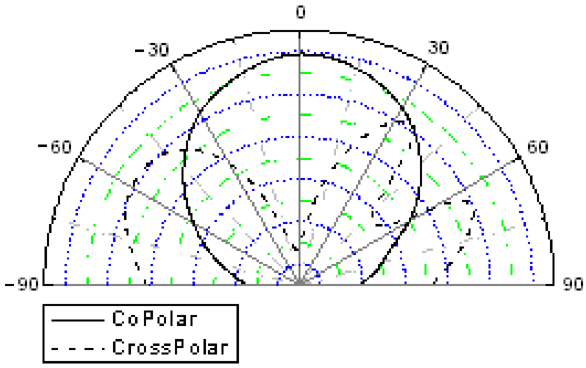

Figure 3c

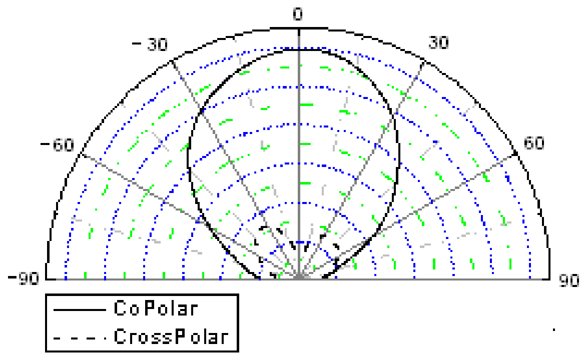

Figure 3d

Figure 3: Radiation Pattern, showing co-polar and cross polar radiations for Antenna 1 & 2 at resonating frequencies f1 & f2.

Conclusions

The study reveals that PIL patch antenna is a good candidate for achieving compact micro strip antenna. The two identical slits inserted at the non radiating edges of PIL patch's vertical portion help to obtain various frequency ratios of the two resonant frequencies. The decrease in the first resonant frequency with the increase in the slit length, results in a tunable frequency ratio in the range of about 1.63 to 1.76. In addition to the compact operation, the proposed design is also suitable for dual frequency operation.

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