Design Of 1.7 GHz Multiband Meandered Planar Inverted F Antenna

Ankit P Dabhi, Shobhit K Patel

Abstract: Now-a-days, there is a tremendous demand for the antennas having multiband operation and wideband characteristics for wireless communications. This paper expresses the design of 1.7 GHz multiband Planar Inverted F Antenna which can be much useful in areas like terrestrial wireless communication, low earth satellites and sometimes as intermediate frequency for satellite television. The design exemplifies much better return loss at 3.9 GHz and 5.15 GHz which are more favorable band in WLAN and WIMAX applications. In this paper, the radiating patch is given the meandered shape in order to achieve the multiband operation of the antenna. The result shows that the antenna gives gain of 5.8 dB and also offer good impedance bandwidth. The antenna is of 22mm x 22mm in area.

Index Terms: Planar Antennas, PIFA, gain, return loss, low profile, multiband response, meandering technique.

1 Introduction

The demand for cheaper, small and dense wireless systems goes on increasing by time. The demand of reduction in size of the wireless systems can be fulfilled only through small scale and compressive antennas. In order to have such antennas, Planar Inverted F Antenna is the best choice [1]. The Planar Inverted F Antenna is mainly used as fix antenna mobile handsets. It can be easily mounted on portable equipments because of its small size, low weight and height. The main elements of PIFA are rectangular planar element, [2] ground plane and the short circuit strip. In PIFA, a short circuit plate is placed between the radiator plate and the ground plane in order to reduce the length of the rectangular element. The variation in the size of the ground plane certainly affects the impedance bandwidth of the antenna. The appropriate positioning of feed pin and ground helps to obtain better impedance matching of PIFA. The use of high dielectric materials reduces the size of PIFA on the cost of degraded performance of the antenna. The height of the antenna is very crucial, widening the air gap between the radiating element and ground provides better gain and broad bandwidth [10]. PIFA reveals fair gain in both vertical and horizontal polarization so it is beneficial in certain wireless systems where direction is not decided [6]. Antenna parameters like resonant frequency, gain, impedance bandwidth and polarization are mainly influenced by the substrate permittivity.

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There are various methods which can be helpful in reducing size of the antennas like inserting slots or meandering, use of high permittivity dielectric substrates and the use of shorting pins [4], [8], [9]. The insertion of the slots increases the electrical length of the antenna which in turn reduces the resonant frequency of the antenna. The simulation of the antenna is performed using software Ansoft HFSS v13. HFSS [5] provides various dielectric materials to the measure the performance of the PIFA like air, fr4, duroid, mica, rogers3210, silicon nitrate and so on. Here, the distance between feed and the short circuit plate is kept minimum. The variation in the impedance of PIFA can be managed through the distance between feeding pin and short pin. A return path is created by the short circuit plate for the forward currents of the antenna and resonance occurs for the dimensions lower than half a wavelength [11]. The height of the antenna aids to enhance the bandwidth of the antenna to few percentages. The reason is that for the antenna with small heights their radiating part will be much near to the ground and also close to the substrate. Due to this closeness, the currents will not travel to a distance and in turn there will be overlapping or mismatching of the bands which degrades the performance of the antenna [12].

The resonant frequency of the PIFA is given by [13]:

$$f_r = c/4\sqrt{\varepsilon_r}\,(\mathrm{L_1} + \mathrm{L_2} + \mathrm{H} - \mathrm{W}) \quad (1)$$

Where *c* is the velocity in free space, ε_r is the permittivity of the substrate, L_1 and L_2 are the dimensions of the radiating element, *W* is the width of the short circuit plate and *H* is the thickness of the substrate or height at which radiating patch is placed. From (1), it can be seen that the physical dimensions of the patch ($L_1$and L_2), width of the short circuit plate (*W*) and the thickness of the substrate (*H*) affects the resonant frequency of the PIFA. Impedance bandwidth and gain of PIFA are certainly affected by substrate's properties and thickness. Generally, antennas are incorporated with thick substrates which have low loss tangent because substrates with high loss tangent are lossy and result in low gain.

2 Simulation Setup

The proposed PIFA structure is simulated using Ansoft HFSS v13. The physical patch lengths L_1 and L_2 are 22mm and 22mm respectively. The width of the short circuit plate and the thickness of the substrate are kept constant i.e. 1mm and

8mm respectively. Therefore, (1) can be expressed as:

$$f_r = c/4\sqrt{\varepsilon_r}\,(L_1 + L_2) \qquad (2)$$

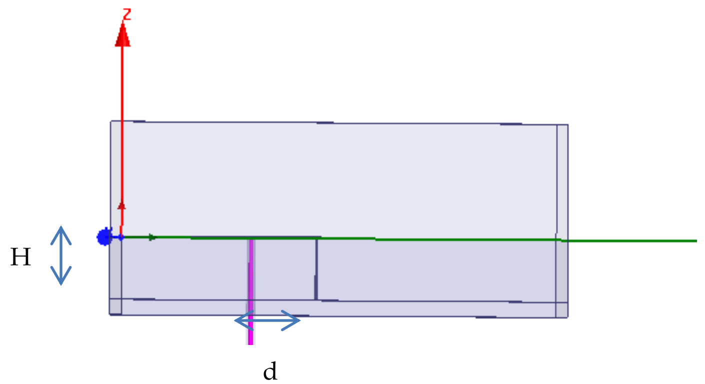

Fig. 1 Side view of proposed PIFA

The side view of the proposed PIFA is shown in the figure (1). The radiator patch is kept at the height (H) of 8mm from the ground plane. The substrate between the radiator patch and the ground plane is air which has the permittivity of 1.The short circuit strip height (H) is of 8mm. In the above figure (1), the distance (d) between the short circuit strip and the feeding line is about 8.8mm. The proposed antenna structure is embedded in air box widely known as radiation box or boundary. The structure is excited through wave port. The position of the feeding pin is kept changeable for matching purpose. The ground plane has major impact on the resonant frequency, bandwidth and gain. The top view of the proposed PIFA is depicted in figure (2) where L_g and W_g is the length and width of the ground plane respectively. To achieve optimum performance with better gain and broad bandwidth, the location of the radiating patch or say PIFA must be at one corner of the ground plane. In order to achieve sufficient gain, the size of the ground plane must be half of its wavelength. The proposed PIFA structure has the ground plane size of 60mm x 60mm. The type of feeding used in the proposed PIFA is coaxial feed which has a height of 14mm.

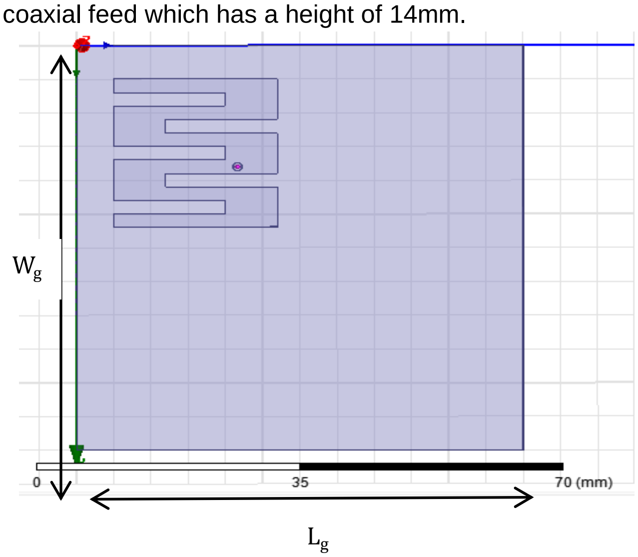

Fig.2 Top view of proposed PIFA

w_s W

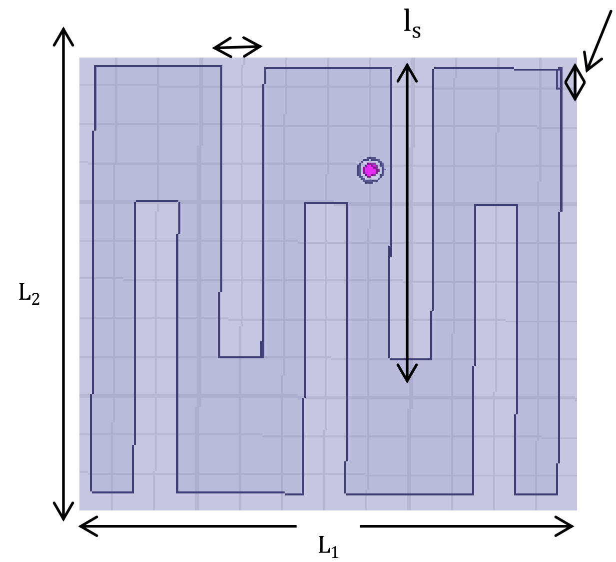

Fig.3 Layout of top layer of PIFA

The figure (3) shows the layout of the radiating patch of the proposed PIFA which is placed at the height of 8mm above the ground plane. In this figure, l_s and w_s indicates the length and width of each slot respectively, W is the width of short circuit strip while L_1 and L_2 are lengths of the radiating element. The thickness of the radiator patch is 0.2mm. The radiator patch has been given the meandered [3] shape in order to achieve the multiband operation of the PIFA and also to increase the electrical path for the purpose of miniaturization. The patch is divided into equal sized slots where the length of each slot is 15mm and the width of each slot is 2mm respectively. The width of the short circuit plate regulates the resonant frequency of the PIFA. The table (1) below indicates the specifications of the proposed structure in brief

Table 1. Dimensions and Specifications of Proposed PIFA

Parameter	Specification	Dimensions
W_g	Width of the ground plane	60mm
L_g	Length of the ground plane	60mm
L_1	Length of the patch	22mm
L_2	Width of the patch	22mm
W	Width of the short circuit strip	1mm
H	Height of the substrate	8mm
l_s	Length of each slot	15mm
w_s	Width of each slot	2mm
D	Distance between feed line and short circuit strip	8.8mm

The figure (4) shows the graph of return loss of the proposed PIFA structure. The response of the proposed structure comprises of multiband response which includes three frequencies namely 1.7 GHz, 3.9 GHz and 5.9 GHz. The return at 1.6 GHz is -15.85 dB, at 3.9 GHz is -36.11 dB and at 5.1 GHz is -38.07 dB. The bandwidth of proposed PIFA at 1.6

GHz is 1.43 GHz to 1.64 GHz band which is around 210 MHz. Similarly, the bandwidth at 3.9 GHz is 3.81 GHz to 3.97 GHz which is around 160 MHz while the bandwidth at 5.1 GHz is 4.99 GHz to 5.21 GHz which is around 220 MHz.

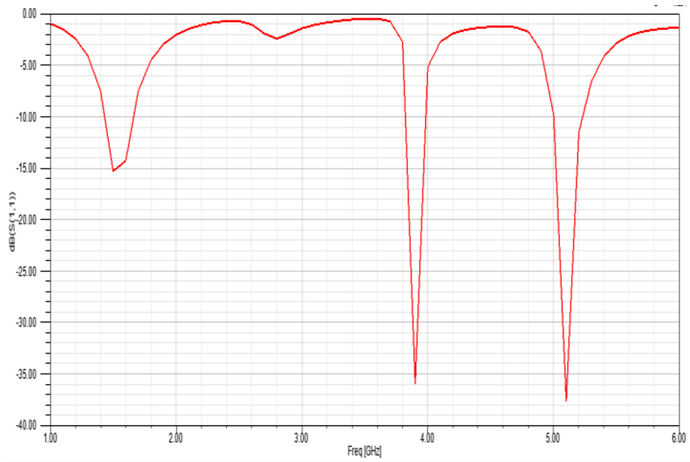

Fig.4 Return loss

The figure (5) below shows the gain plot of the proposed structure of PIFA which is about 5.8 dB.

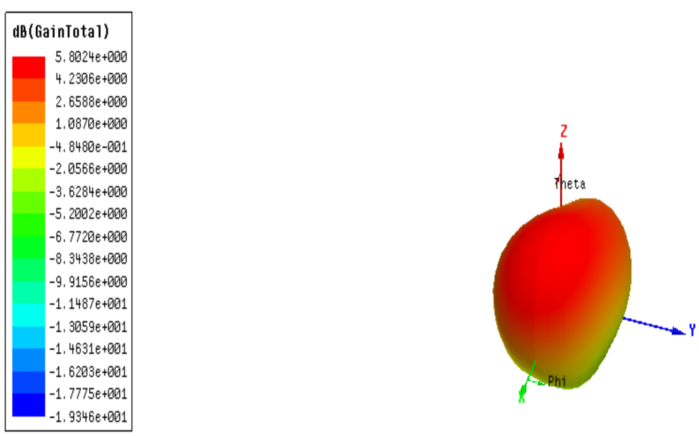

Fig.5 Gain plot

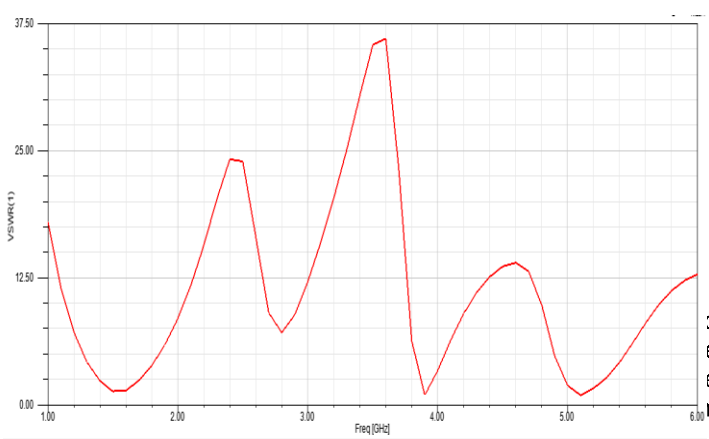

Fig.6VSWR plot

The figure (6) shows the VSWR plot of the proposed PIFA structure which has air substrate. The VSWR at the frequencies 1.6 GHz, 3.9 GHz and 5.1 GHz is 1.18, 0.88 and 0.59 respectively. The above value of VSWR shows that the antenna structure is well matched.

3 Conclusion

In this paper, the return loss, impedance bandwidth, gain and VSWR of a PIFA are simulated with the substrate permittivity of 1. Here, the PIFA having air substrate exhibits three frequency bands which offer far better performance in the terms of the return loss and the bandwidth. The gain of the proposed structure is 5.8 dB. The current distribution in PIFA varies in the meandered patch with reference to the short circuit plate. The initial simulated frequency 1.6 GHz falls under the L band where the proposed structure can serve in applications like military satellites, GSM mobile phones and also occasionally as intermediate frequency for satellite television .While the other two bands 3.9 GHz and 5.1 GHz can serve in applications like wireless LAN, mobile phones and WIMAX. The advantage of this structure is that one structure can work over different frequencies which in turn can serve various applications with one antenna only.

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