# Study of Planar Inverted F-shaped (PIFA) Antenna in WIMAX Band

**Akanksha khare, Paurush bhulania**

***Abstract* — planar inverted F antennas are very suitable to be operated in portable devices. They provide very high gain property for Wi-Fi, WiMAX, Bluetooth and WLAN operation. Typically PIFA consists of a rectangular planar element located above a ground plane, short circuiting plate, and a feeding technique for planar element. it is very popular because of its low profile and Omni-directional pattern. The proposed antenna (PIFA) is directly feed by 50 ohm and it is designed for Wi-Fi and WiMAX band. Mobile WiMAX operating bands are 2.3 GHz (frequency range 2.3- 2.4 GHz), 2.5 GHZ (frequency range 2.5-2.7 GHz) and last 3.5GHz (range 3.4-3.6 GHz).In this paper the antenna is simulated on the HFSS software to obtain the results in the desired frequency band.**

***Index Terms*—Planar inverted f antenna (PIFA), worldwide interoperability for microwave access (WiMAX), Wireless-Fidelity (Wi-Fi), Wireless local area network (WLAN).**

## I. INTRODUCTION

In recent years, the demand of compact, smaller than palm size communication devices has increased significantly. Communication system demands for antennas to exhibits some standard properties such as reduced size, moderate gain broad band and multiband operation. Now a day's PIFA are in huge demand for the compact handheld wireless devices because these antennas have simple structure, small size, low cost. Because of these attractive features PIFA are likely to be used in multiband applications.

The typical PIFA has λ/4 patch length instead of the conventional λ/2 and consists of a ground plane, a feed wire feeding the resonating top plate, a top plate element, and a DC-shorting plate that is connecting the ground and the top plate at one end of the resonating patch.

## II. VARIOUS ANTENNA STRUCTURES

This work concentrates on the design and development of compact antenna used for mobile devices. Various types of low profile elements have recently been developed and they are fairly efficient radiators that can be easily manufactured at low cost. However, the conventional micro strip patch antenna is not good choice for the portable devices as their design are biased on half wavelength of operation and do not meet the strict small space requirement of these devices. Therefore, more unusual approaches must be examined for reduced size operation.

### *A. THE INVERTED L-ANTENNA*

The ILA is an end fed short monopole with a horizontal wire element placed on top that acts as a capacitive load. The design of ILA has a simple layout making it cost efficient. Many of the electrical characteristics of inverted L are similar to those of the well understood short monopole.

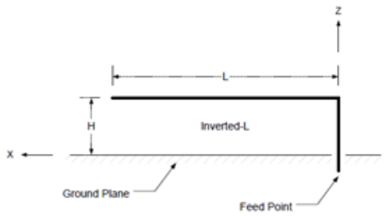


Fig.1 inverted L antenna geometry

### *B. THE INVERTED F ANTENNA*

The inverted F is a variation on the inverted L that modifies the input impedance to be resistive and thus provides reduced mismatch loss.

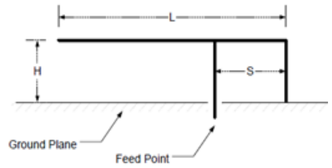


Fig.2 Inverted F antenna geometry

### *C. THE DUAL INVERTED F ANTENNA*

One critical problem that both the inverted F and L antennas shares with the short monopole very low impedance bandwidth. Several modifications to the inverted F have been examined to increase the bandwidth of the antenna. The dual inverted F uses a parasitic inverted L antenna placed next to the inverted F.The parasitic element has a length that is equal or nearly equal to inverted F.

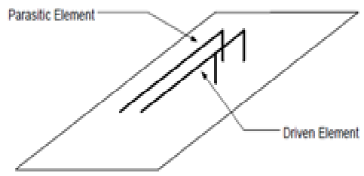


Fig.3 Dual inverted F antenna geometry

## III. THE PLANER INVERTED F ANTENNA

To increase bandwidth, the PIFA is developed. The PIFA can be considered a direct extension of the inverted F antenna

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that has the horizontal wire radiating element replaced by a plate to increase its usable bandwidth.PIFA design invoke the quarter wavelength operation. It offers very high radiation efficiency and sufficient bandwidth in a compact antenna.

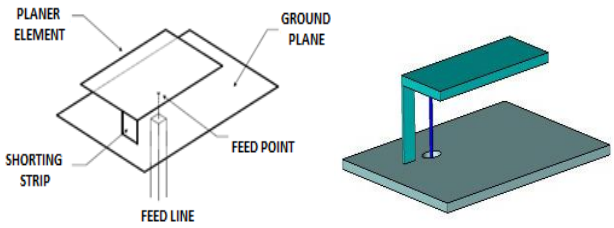


Fig.4 Basic layout of planar inverted F antenna.

Technique like use of reduced ground plane can to be employed to further increase the bandwidth. Multi-frequency capability with the antenna structure can be achieved by exciting various resonant modes using branched structure created by cutting slots in the radiating element.

## IV. ANTENNA STRUCTURE

Antenna structure under investigation is designed to operate at 2.2-2.8 GHz which is covering almost the entire WiMAX band. Most preferred frequency band for mobile communication. The finite ground plane has a length along the x-axis of 100mm and a width along y-axis of 50 mm. The dimensions of the top plate are ($L_1$ $L_2$) is 18mm and 13 mm respectively. The dielectric substrate is used which is made up of FR4 of 4.4.The air gap between the two planes is of 4mm.The antenna is excited through the coaxial probe at feed point. Coaxial probe provides better impedance match.

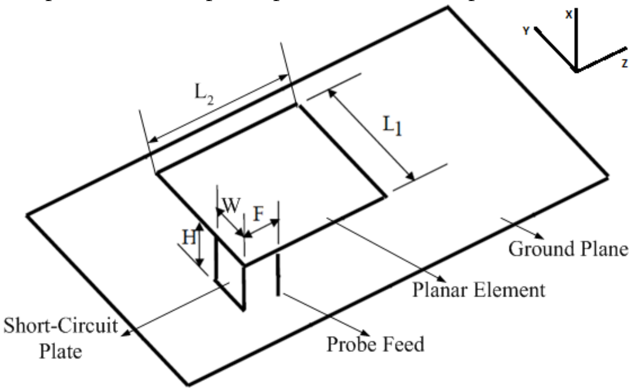


Fig.5 The structure of a PIFA with a finite ground plane

## V. SIMULATIONS AND RESULTS

### A. *Design Equations*

The resonant frequency of the PIFA is proportional to the effective length of the current distribution. The following cases can be considered for getting the expression of frequency at which PIFA radiates. All the consideration are on the basis of Figure no. 5.

**Case 1**: $W=L_1$ i.e., when the width (W) of the short circuit plate is equal to the length of the planar element. This corresponds to the case of the short circuit, which is a quarter wavelength antennas. The effective length of surface is $L_2+H$ where, H is the height of the short circuit plate. The resonance condition then expressed by Eq. 1

$$L_2 + H = \frac{\lambda}{4} \qquad (1)$$

Where, $\lambda$ is the desired wavelength.

As $\lambda = c/f$ , where f is the desired operating frequency of PIFA and c is the speed of light.

$$f = \frac{c}{4(L_2 + H)} \qquad (2)$$

**Case 2:** W=0 short circuit plate is represented by a thin short circuit pin. The effective length of current is then $L_1+L_2+H$. For this case, the resonance condition is expressed by

$$L_1 + L_2 + H = \frac{\lambda}{4} \qquad (3)$$

Therefore,

$$f = \frac{c}{4(L_1 + L_2 + H)} \qquad (4)$$

**Case 3: $0<W<L_1$**, the resonant frequency f is a linear combination of the resonant frequencies associated with the limiting case and is given by

$$f = \frac{c}{4(L_1 + L_2 + H - W)} \qquad (5)$$

### B. *HFSS Software*

HFSS is the industry-standard simulation tool for 3D full-wave electromagnetic field simulation. HFSS provides E and H-fields, currents, S-parameters and near and far radiated field results. Intrinsic to the success of HFSS as an engineering design tool is its automated solution process where users are only required to specify geometry, material properties and the desired output. From here HFSS will automatically generate an appropriate, efficient and accurate mesh for solving the problem using the proven finite element method.

The core of the program HFSS is based on the **finite element method (FEM)** (its practical application often known as **finite element analysis** (FEA)) where it is a numerical technique for finding approximate solutions to partial differential equations (PDE) and their systems, as well as (less often) integral equations.

### C. *Results*

*1)* Return loss*:*

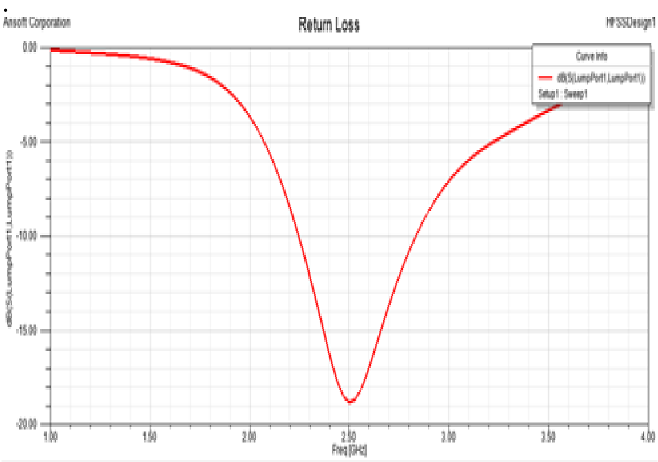


Fig.6 return loss

Figure 6 shows that we are getting a resonant frequency of 2.5 GHz, for which antenna was initially designed. For -10 dB return loss antenna is covering a frequency range of 2.245 GHz to 2.832 GHz. This frequency range is covering Wi-Fi band. However for mobile phone application purpose we can also take the result of -8 dB or -6dB return losses into consideration.

*2)* VSWR*:*

VSWR or Voltage Standing Wave Ratio is a ratio of peak voltage on the minimum amplitude of voltage of standing wave.

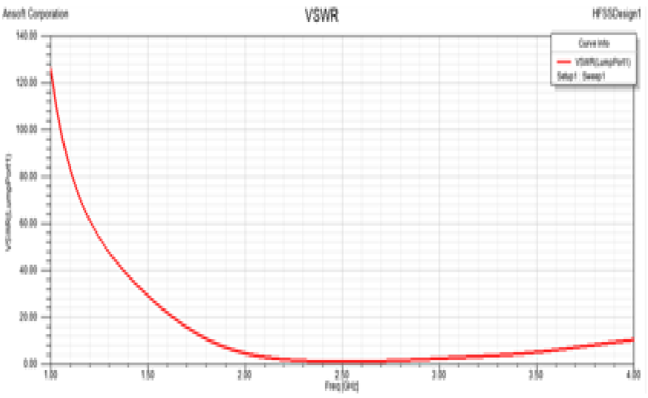


Fig 7 VSWR plot

Figure7 shows the graph of VSWR (voltage standing wave ratio) against frequency. Corresponding to -10 dB return loss VSWR of 2:1 is taken into consideration. From figure it is clearly visible that for the entire frequency range of interest, the value of VSWR is below 2. It is also seen that at the resonant frequency of 2.5 GHz the values of VSWR is nearly 1 which indicates perfect impedance matching at the resonant frequency.

3) Input impedance:

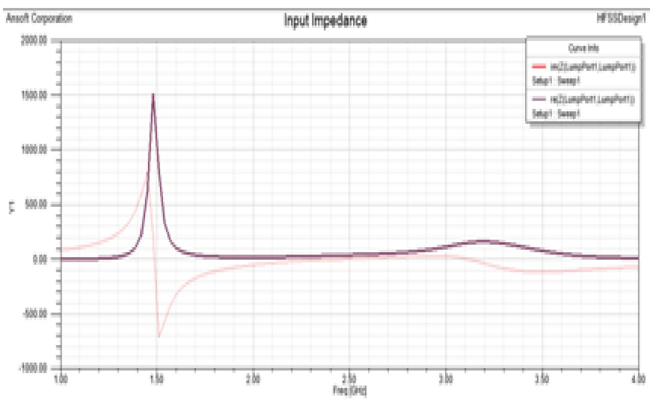


Fig 8

A plot of input impedance versus frequency is shown in figure8. It is seen that for the desired range of frequencies the reactive part of impedance is nearly 0 ohm, while the resistive part of impedance is nearly 50 ohm. Thus in this way matching at the antenna input port is good.

4) Radiation pattern:

The radiation pattern of an antenna is a mathematical function or a graphical representation of radiation properties as a function of space coordinates. In most cases, the radiation pattern is determined in the far-field region and is represented as a function of directional coordinates

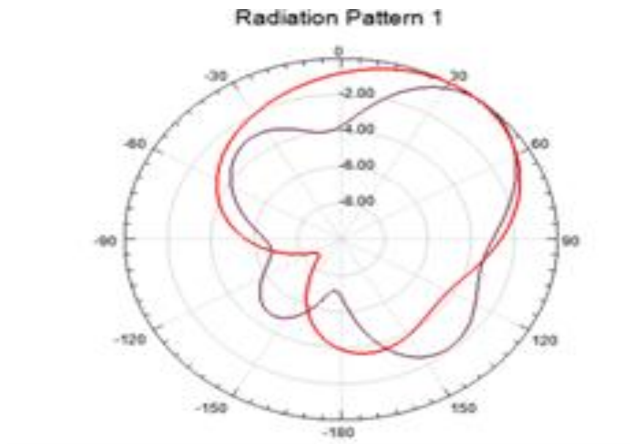


**Fig 9** Radiation pattern

The radiation pattern of the designed antenna in XZ (phi=$0^0$) and YZ (phi=$90^0$) planes at 2.50 GHz are shown in figure. For both the planes major lobe is directed in between 0 and 90 degree of theta values. In XZ plane there is a null in the radiation pattern at -$120^0$. There is a presence of one back lobe in YZ plane. Overall it is visible that antenna is capable to receive and transmit the signals in almost all the directions

## VI. Conclusion

A Planar Inverted-F Antenna for WiMAX applications (3.3-3.8 GHz) has been designed successfully. The proposed structure has a dimension of 18 x 13 $mm^2$ over the ground plane of size 100 x 50 $mm^2$ which can easily be implanted in the small space available within the mobile device. The proposed structure is having a impedance bandwidth ranging from 3.198 GHz to 4.158 GHz covering WiMAX band. Antenna has a resonating frequency at 3.68 GHz frequency. For getting the impedance bandwidth we are taking -6 dB as the reference return loss, which is acceptable for mobile phone applications. The VSWR, input impedance plot along with parametric study of some key parameters is presented. The radiation pattern and current density plots of the antenna are also presented. The peak realized gain varies from 4.15 dB to 5.2 dB in the desired operating band.

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