ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

*(An ISO 3297: 2007 Certified Organization)*

**Vol. 3, Issue 11, November 2015**

# Dual band Planar inverted F antenna with Bandwidth Enhancement for WiMAX Band.

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**ABSTRACT:** A compact dual-band planar inverted-F antenna (PIFA) with parasitic element for bandwidth enhancement and reduced size working in GPS (Global positioning system), GLONASS (Global Navigation Satellite System) and WiMAX (Worldwide interoperability for microwave access) bands is presented. The PIFA is designed to be integrated in portable handheld devices and so meets strict space requirements. The final model fits a volume of 50x35x5.9 $mm^3$. A 'L' shaped slot in radiating plate is used to generate second resonating frequency. The parasitic element and slot are properly dimensioned and separated to generate the resonance at the designed frequencies. The antenna is simulated using finite element method based simulator and fabricated using 0.1mm thin copper foil. The designed PIFA exhibits good radiation characteristics and moderate gain with compact size.

**KEYWORDS**: Planar Inverted F antenna; Bandwidth enhancement; compact internal antenna

## I. Introduction

The exploitation of wireless communication leads to great demand of developing compact multiband antennas that can be easily integrated within the small space available inside the portable devices. The conventional microstrip patch antennas are preferably selected for handheld devices mainly because of their low profile characteristics, portable structure and low cost. But still they have the area to improve in their bandwidth and to reduce their size, to make these more compact. The microstrip patch antenna designs are based on half-wavelength($\lambda/2$) of operation, while the Planar Inverted-F Antenna designs invoke the quarter-wavelength($\lambda/4$) operation. This makes PIFA more compact. Thus planar inverted-F antenna (PIFA) is a promising antenna structure to meet these requirements of portable devices [1].

The Planar Inverted-F Antenna (PIFA) can be observed as evolved from two well-known antennas, namely microstrip patch antenna and quarter-wavelength monopole antenna. Now, PIFA is widely used in handheld and mobile applications due to its attractive features such as low-profile, lightweight, simple design, low-cost, conformal nature ,low specific absorption rate (SAR) and good performance [1-4]. Modern portable devices offers many services at different frequency bands and so the need and popularity for the antenna which supports multiple band has rising. In PIFA, multiband operation can be achieved by creating slots in the radiating element or placing resonating strips in the antenna structure.

Modern portable devices include web access through cabled or wireless local area networks (LANs). A valid alternative solution for web access can be represented by a connection through WiMAX based services. WiMAX, also known as IEEE 802.16, is an IP based, wireless broadband access technology that provides performance similar to 802.11/Wi-Fi networks with the coverage and QoS (quality of service) of cellular networks. With WiMAX, Wi-Fi like data rates can be easily achieved, but the issue of interference is lessened. WiMAX operates on both licensed and unlicensed frequencies, providing a regulated environment and viable economic model for wireless carriers. In addition to this, integration of navigation system operation with the communication devices is also desirable to support Intelligent Transportation Systems, and to integrate location finding service with mobile devices to enhance user safety. The most popular navigation systems are GPS (Global Positioning System) and GLONASS (Global Navigation Satellite System). The GPS signal is transmitted in the 1.575 GHz frequency band and WiMAX signal occupy the frequency band of 3.3-3.6 GHz.

To cover the mentioned WiMAX bandwidth, we want to overcome the narrowband characteristics of PIFA. In literature, there are many methods to enhance bandwidth of PIFA. One of the most frequently used methods to widen the bandwidth is to increase the height of the shorting plane, which would increase the volume [5]. It is not a useful method in the case of handheld devices because antenna needs to be fit in the chassis. Size of the ground plane is also

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

# International Journal of Innovative Research in Computer and Communication Engineering

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affected on bandwidth. By adjusting the size of the ground plane, the bandwidth of a PIFA can be varied. For example, reducing the ground plane can widen the bandwidth of the PIFA. Another factor is Position of the top plate on the ground plane. To obtain maximum bandwidth, the radiating plate should be placed near the edges of the ground plane [6].Some of the other simple and practically implementable approaches to enhance the bandwidth are changing the widths of shorting and feed plates [7] and addition of parasitic element [8].

In this paper, the design of a dual band planar inverted F antenna working in GPS band (1.575 GHz), GLONASS band (1.61 GHz) and future and current WiMAX band (3.3-3.6 GHz) is presented. The bandwidth enhancement is attaining by using proper optimization in width of feed and shorting plates [9] and using an additional parasitic element.

The remainder of this paper is organized as follows. Section II discusses geometry of proposed PIFA and its configuration. The simulated and measured results are presented in Section III. Finally, section IV presents our conclusions.

## II. ANTENNA CONFIGURATION

The evolution of the proposed dual band antenna is as follows

1. Designed a single band antenna resonating in lower band (1.57GHz).
2. Designed a dual band antenna by making a slot corresponding to the second resonating frequency (3.4 GHz)
3. Enhance the bandwidth of the dual band antenna with proper methods like optimization of feed and shorting plate width and adding an additional parasitic element.

The configurations of the single band and dual band PIFA is explained and studied in our paper [9]. In this paper, we design a dual band antenna and enhance its bandwidth for cover the WiMAX band .The design of dual band antenna is almost same as in our own paper [9]. Then, we take the dual band model and enhances its bandwidth in second resonant frequency to cover the WiMAX band.

### A. *Bandwidth enhanced dual band PIFA:*

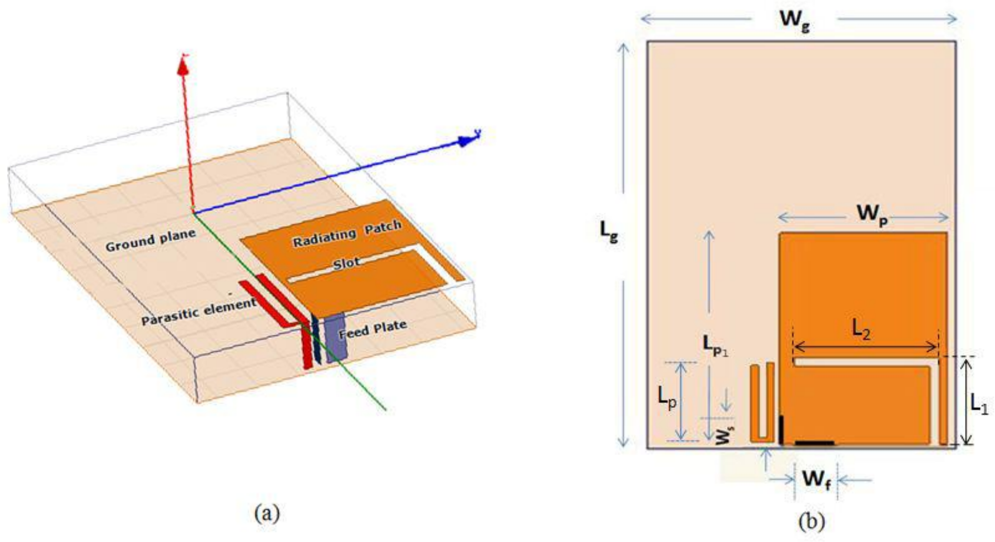


Fig. 1. Bandwidth enhanced Dual band PIFA (a) 3D view, (b) Top view.

PIFA is generally considered as a narrow band antenna .But WiMAX requires more band width. So we have to overcome the limitation of PIFA by increasing the bandwidth. We are mainly considered three methods to increase the bandwidth of PIFA without a noticeable increases the size of the antenna. They are

- Changing the width of the feed plate.

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- Changing the width of the shorting plate.
- By adding an additional parasitic element.

The final structure of the proposed bandwidth enhanced dual band PIFA after above mentioned changes and optimization for maximum bandwidth is shown in fig.1 and its dimensions are given in table 1.

Table 1. Detailed Dimensions of Band width enhanced dual band PIFA Antenna

| Parameter | Value(mm) | Parameter | Value(mm) |
|---|---|---|---|
| $L_g$ | 50 | $W_f$ | 2.4 |
| $W_g$ | 34 | $W_s$ | 1.6 |
| $L_p$ | 21 | $L_1$ | 10.2 |
| $W_p$ | 18 | $L_2$ | 16.3 |
| H | 5.9 | $L_p$ | 12.55 |

B. *Fabrication of Antenna:*

There are number of steps to fabricate a planar inverted-F antenna. Fabrication is a very complex and time consuming task where problems are faced and dealt consistently. Therefore a simple, inexpensive and reasonable method that has been used to design this PIFA antenna is discussed.

The first step to fabricate an antenna (PIFA) is to cut out various shapes such as ground plane, Top patch, parasitic element and shorting plate required in antenna fabrication of exact dimensions as selected in simulation using digital Vernier Callipers. We use 1 mm thick copper sheet for ground, radiating patch, feed plate, shortening plate and parasitic element. The measurements were done using vector network analyzer. The fabricated prototype of dual band bandwidth enhanced, dual band and single band antennas are shown in the figure 2.

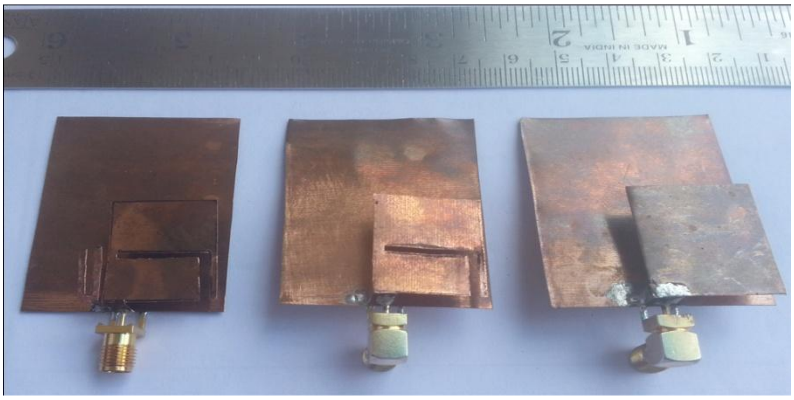

Fig 2 Final Fabricated Antenna Prototype

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## III. RESULTS AND DISCUSSIONS

The simulations are performed in Finite Element Method (FEM) based solver and hardware measurement is taken using vector network analyser (Agilent pna n5234a). The fig.3 shows the return loss characteristics of the dual band bandwidth enhanced antenna and dual band antenna simultaneously. From the plot we can understand the effect of parasitic element in bandwidth in the second band. The bandwidth enhancement in the second resonant band is mainly due to the overlapping of the two adjacent frequencies.

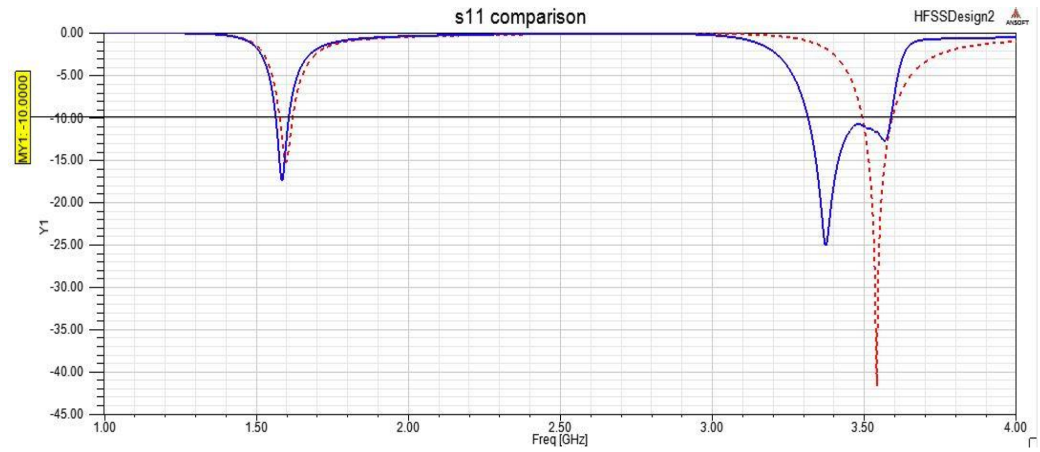


Fig. 3 Bandwidth of dual band bandwidth enhanced antenna with (blue line) and without (red dotted line) parasitic element.

From the plot, it can be observed that the antenna operates at both the bands 1.56-1.61 GHz ( which covers GPS and GLONAS band) and 3.3-3.6 GHz (which covers future and current WiMAX band). The return loss achieved is -17 dB and -25dB respectively in the resonant frequencies. The bandwidth of 50 MHz for GPS and almost 290 MHz for WiMAX band is achieved. If we compare the bandwidth with the dual band antenna in [9], the proposed antenna achieves a bandwidth equal to 3 times that antenna in [9] in second resonant band.


Fig. 4 Simulated 3D radiation pattern

The simulated 3D radiation pattern obtained from the simulation of dual PIFA is shown in Fig.4 (at 1.57 GHz) and fig. 5 (at 3.4 GHz). It can be observed from the plot that the proposed antenna is a good radiator with almost omnidirectional radiation pattern and can be used for mobile handheld devices which support two frequency bands.

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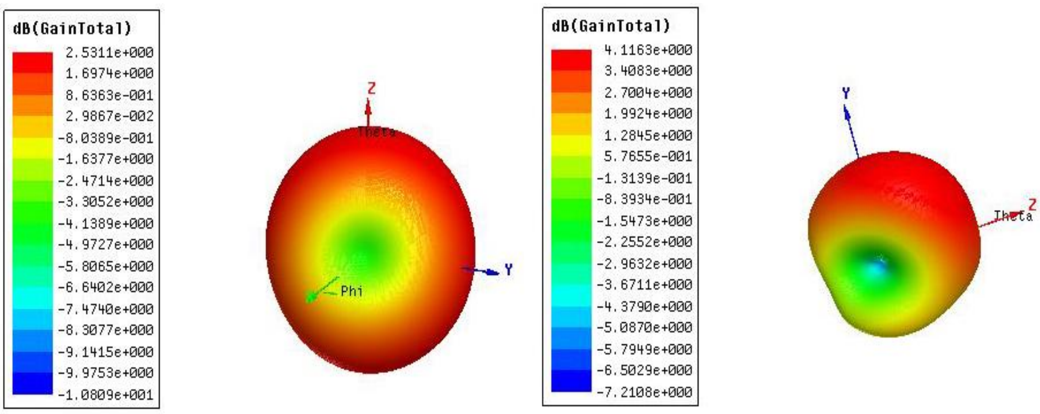
Fig. 5 Simulated 3-D radiation pattern of dual Band PIFA structure at 3.4GHz

The gain is an important figure of merit of the antenna. The overall gain of the antenna obtained after simulating the dual band PIFA is shown in fig. 6. The fig. 6(a) shows the gain at 1.57 GHz and fig. 6(b) shows the gain at 3.4 GHz. A peak gain of 2.53 dB and 4.11 dB is observed at each of the bands respectively. This value of gain achieved by the proposed structure is moderate value for a mobile phone antenna and considered to be good for the overall performance of the antenna.




(a) (b)

Fig. 6. Simulated 3-D Gain Plot of basic dual-band PIFA structure. (a) at 1.57 GHz and (b) at 3.5 GHz.

## IV. CONCLUSIONS

In this paper, a dual band Planar Inverted F antenna which covers GPS (1.57GHz) band, GLONASS (1.61 GHz) band and WiMAX band (3.3-3.6 GHz) is designed and studied. To cover the WiMAX band completely, the bandwidth is enhanced by using an additional y shaped parasitic element and optimizing the widths of feed plate and shorting plate. The presented antenna exhibits good radiation characteristics and relatively good gain in both the bands with compact size.

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ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

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*(An ISO 3297: 2007 Certified Organization)*

**Vol. 3, Issue 11, November 2015**

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## BIOGRAPHY

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