ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 9, September 2015

Compact Dual Band PIFA for GPS and WiMAX

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ABSTRACT: A compact Planar Inverted F Antenna (PIFA) as the element for dual band operation in 1.48 GHz GPS and 3.2 GHz WiMAX band is proposed. PIFAs are quarter wavelength elements. Among various possible antennas, PIFAs have the advantages of low profile, compact size and are very suitable for present-day wireless communication application. A folded slit in the top plate is used to get the dual band operation. Comparison between two different orientations for folded slit is performed. A 50% miniaturization and gain improvement is achieved when the folded slit is near to the feed with an open end. The radiation pattern and current distribution on the PIFA are also plotted.

KEYWORDS: PIFA, dual band, folded slit, miniaturization

I.INTRODUCTION

Monopole antennas and helical antennas (whip antennas) were used as external antennas in early days. They are quarter wavelength elements and can have wide bandwidth. But they cause user interference because of the backward radiation. These were later replaced by internal antennas. Many applications require low profile antennas, especially portable devices such as laptops and mobile phones. Patch antennas and their derivatives are the best candidates for low profile application as internal antennas. Patch antennas are half wavelength elements. Their disadvantage of large dimension and narrow bandwidth led to the introduction of Planar Inverted-F Antenna (PIFA). PIFA have size less than quarter wavelength which is best suited as internal antennas in portable devices. But the main limitation is narrow bandwidth. By adjusting various parameters of PIFA their size can be made smaller and their bandwidth can be enhanced [1].

In order to incorporate different standards into a single device, multi band and broadband antennas are required. When the operating frequencies are far apart multi band antennas are preferred over broadband because of the need of multiple filters in case of broadband. In this thesis, a single band PIFA for GPS is designed. Then the top plate is modified to obtain a dual band antenna operating at 1.5 GHz GPS and 3.3 GHz WiMAX. A folded slit structure on the top plate is used for obtaining dual band performance. Two different orientations of slits are compared.

II.RELATED WORKS

In [2-6], dual band antennas with parasitic elements to generate higher bands are proposed. The total volume occupied by these antennas is larger than the proposed compact element. In [2], a slim dual-band PIFA in conjunction with L-shaped parasitic is proposed for GPS and WiMAX bands. The size of element is 100 x 24 mm² and the height is 9.8 mm. In [3], a compact dual band PIFA with two meandered metallic strips and one nearly rectangular patch to produce three resonances in the GSM and DCS band is proposed. Height of PIFA is 8.4 mm and the size of radiating element is 24 x 37 mm². In [4], a dual-band PIFA for DVB-T and WLAN applications with overall size of 217 x 12 mm² and height of 8 mm is proposed. The driven PIFA element acts as the primary element, governing the lowest resonant frequency, while the upper resonant frequency in the DVB-T band is controlled by the parasitic element. In [5] and [6], substrates are used rather than air. In [5], a dual-band PIFA for LTE and WiMAX applications is proposed. The size of element is 50 x 12 mm² and the height of PIFA is 10 mm on Rogers TMM4 substrate. In [6], the antenna is made up of a rectangular parasitic element located under the main radiating PIFA to obtain a dual-band performance for LTE and

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WiMAX applications. The overall dimension of this antenna is 17.8 x 16.5 mm² on FR-4 substrate and the height of the antenna is 5 mm.

III.SINGLE BAND PIFA

A. Single Band PIFA Design

PIFA is designed for 1.5 GHz resonant frequency. The ground plane dimension is 24 X 76.5 mm², which is near half wavelength at 1.5 GHz for obtaining maximum bandwidth. Air is used as the substrate. Antenna is placed at one of the edges of ground plane so as to increase the bandwidth. The height of the antenna is taken as 4.2 mm. The length of top plate is made same as the length of ground plane, i.e.24 mm. The dimension of top plate obtained is 24 x 24mm². The width of top plate is 24 mm and width of shorting plate is 1.6 mm. All dimensions of PIFA are shown in Fig.1 in millimeters.

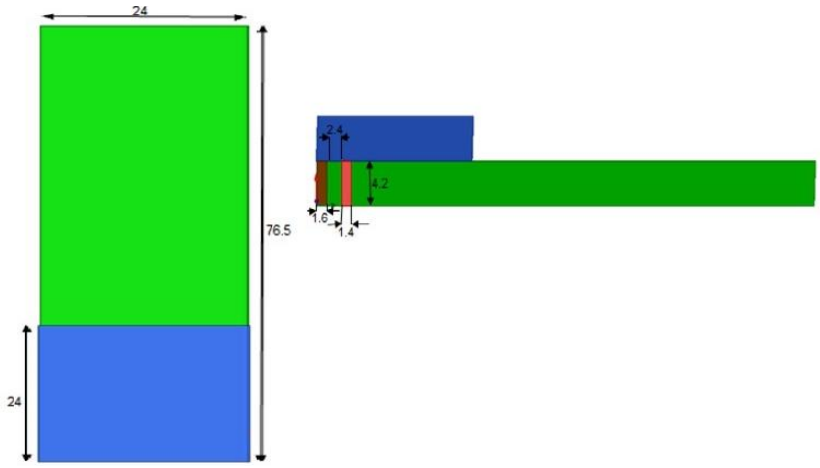

Fig.1. Structure of Single Band PIFA

Reflection Coefficient: Simulated reflection coefficient for the designed PIFA is shown in Fig.2. The antenna resonated at 1.465 GHz. It gives good band width of 1.39 -1.58 GHz, which covers the GPS band.

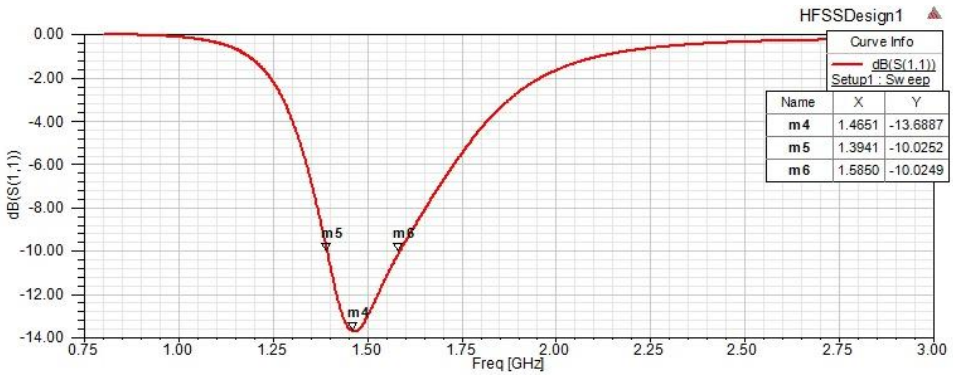

Fig.2. Reflection Coefficient

Radiation Pattern: The 2 D graphical representation of electric field radiation by PIFA is shown in Fig.3. The radiation pattern is similar to that of monopole element. It has an omni-directional pattern and is suitable for portable devices.

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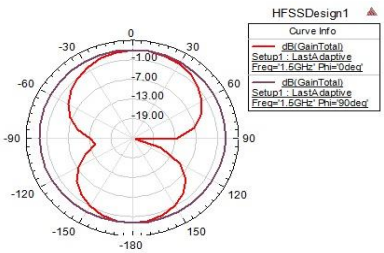

Fig.3. Radiation Pattern

Current Distribution: Surface current distribution of PIFA is shown in Fig.4. The current density is higher at the shorting plate. The current density decreases with distance away from the feed.

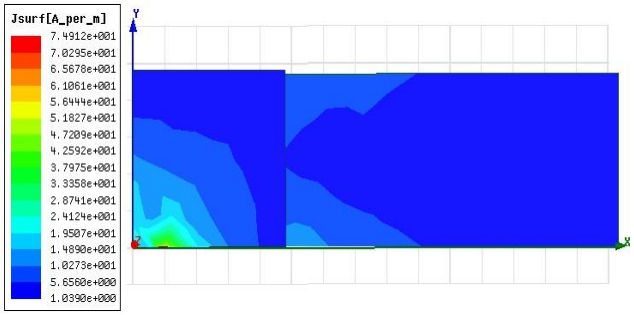

Fig.4. Current Distribution

IV.DUAL BAND PIFA

The lower resonant frequency is determined by the dimension of PIFA which consists of a top plate, shorting plate, feeding plate and ground plane. Higher band in this work is obtained by a folded slit on the top plate. Two different orientations for the folded slit are studied.

A. *Dual Band Antenna-1*

The dimension for dual band antenna-1 is shown in Fig.5. The radiating element is a 24 x 24 mm² metallic plate. Height of the PIFA is 4.2 mm. A 1.4 x 4.2 mm² rectangular element is used as microstrip feed. A shorting plate of dimension 1.6 x 4.2 mm² is used. The ground plane and all dimensions are taken so as to obtain a wider bandwidth.

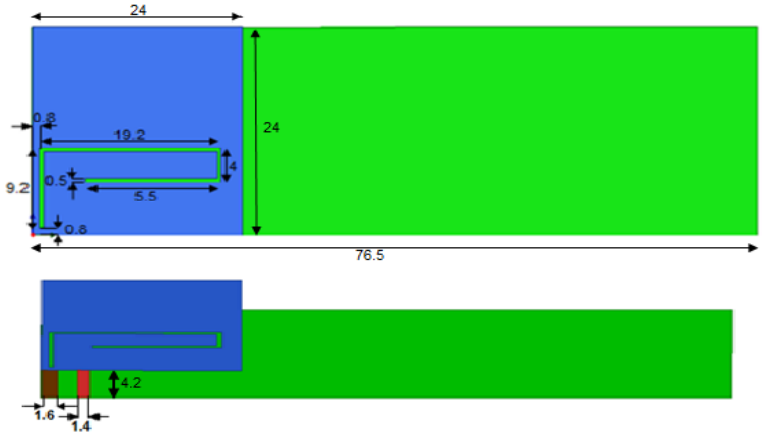

Fig.5. Structure of Dual Band Antenna-1

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Reflection Coefficient: The plot for reflection coefficient is shown in Fig.6. The antenna resonated at 1.465 GHz with a bandwidth of 173 MHz (1407 - 1580 MHz). A narrow band resonating at 3.21 GHz is obtained due to the folded slit with a bandwidth of 46 MHz (3192 - 3238 MHz).

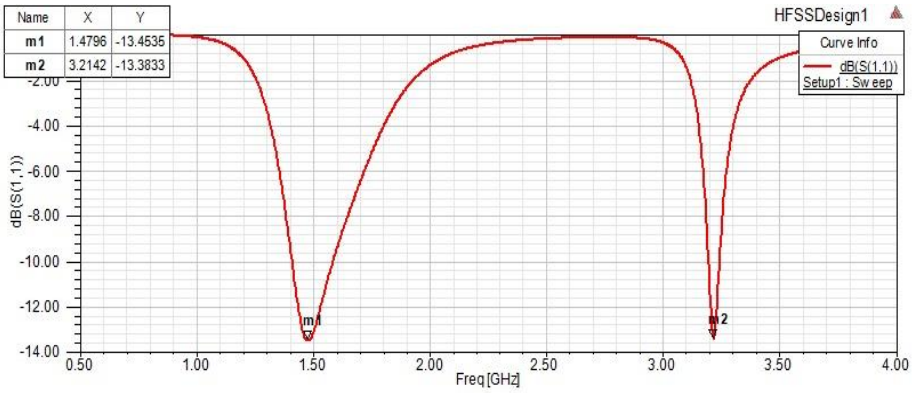
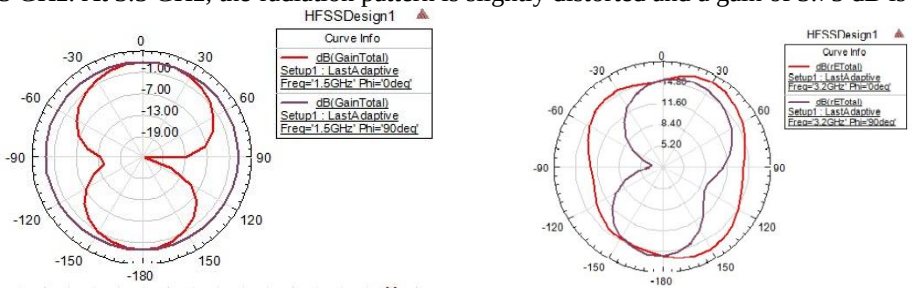


Fig.6. Reflection Coefficient

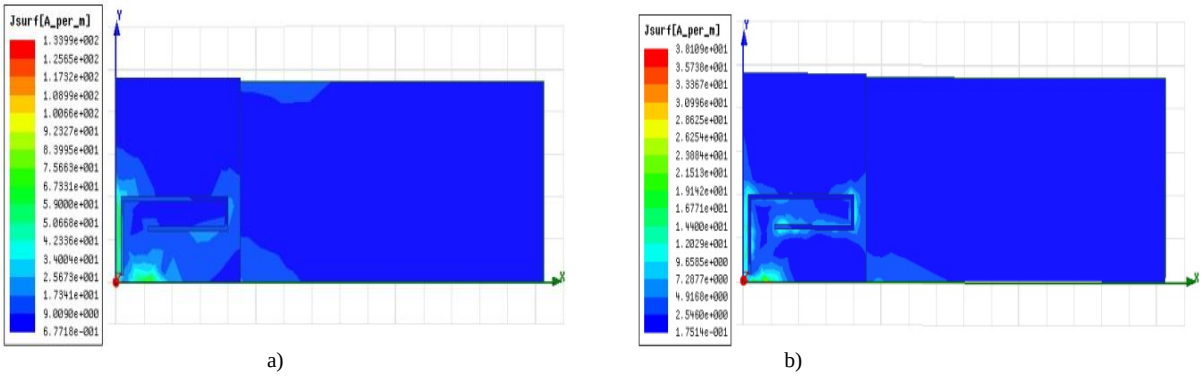
Radiation Pattern: 2 D radiation pattern is shown in the Fig.7. Omni direction radiation pattern and a gain of 2.1 dB are obtained at 1.5 GHz. At 3.3 GHz, the radiation pattern is slightly distorted and a gain of 3.75 dB is obtained.



a) b)

Fig.7. Radiation Pattern at a) 1.5 GHz and b) 3.3 GHz

Current Distribution: The current distribution at 1.5 GHz and 3.3 GHz is shown in Fig.8. At 1.5 GHz, the current density is higher near the feed and shorting pin as in the case of single band PIFA. At 3.3 GHz, current density is higher around the folded slit.



a) b)

Fig.8. Current Distribution at a) 1.5 GHz and b) 3.3 GHz

B. *Dual Band Antenna-2*

A narrow folded slit with a different orientation than the previous case is inserted into the PIFA as shown in the Fig.9. The excited patch's surface currents are disturbed, leading to a lengthened current path for a fixed patch linear dimension. Due to the open slit provided near the feed, the lower resonant frequency of PIFA is further lowered. As a

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result the length of PIFA is reduced to obtain the desired resonant frequency. Hence a compact operation of PIFA is obtained.

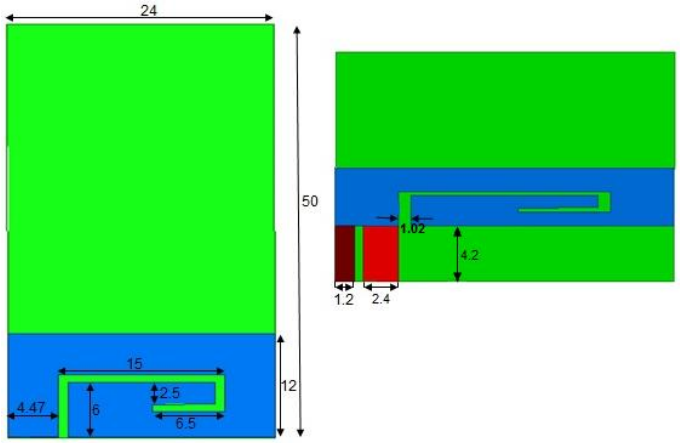


Fig.9. Structure of Dual Band Antenna-2

Reflection Coefficient: The bandwidth for GPS band is significantly reduced by the introduction of folded slit, since the dimension of PIFA is changed. The plot for reflection coefficient is shown in Fig.10. The lower bandwidth is 24 MHz (1469 - 1493 MHz). The upper band obtained due to the folded slit resonates at 3.25 GHz with a bandwidth of 109 MHz (3205 - 3314 MHz).Now the upper band has larger bandwidth than that of lower band.

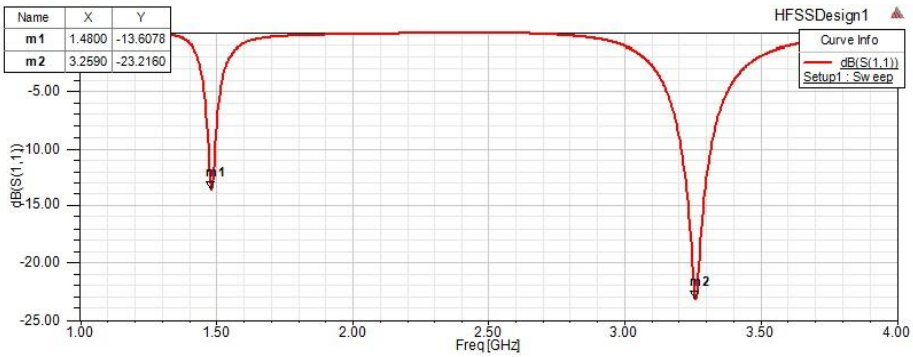
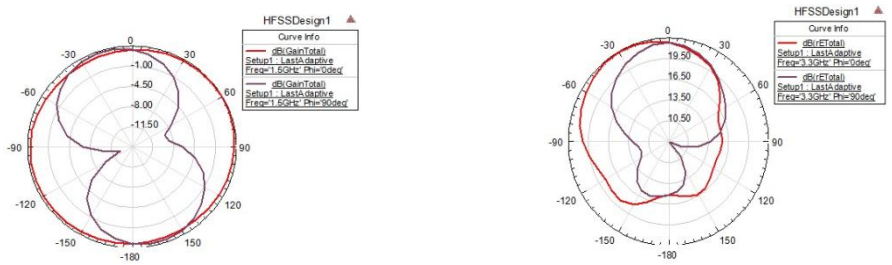


Fig.10. Reflection Coefficient

Radiation Pattern: Radiation Pattern at 1.5 GHz and 3.2 GHz is shown in the Fig.11. Omni- directional radiation pattern is achieved at lower resonant frequency. At higher resonant frequency, a distorted omni- directional pattern is obtained. Gain at lower resonant frequency is 2.44 dB and at higher is 5.15 dB.



a) b)

Fig.11. Radiation Pattern at a) 1.5 GHz and b) 3.3 GHz

Current Distribution: The current distribution at 1.5 GHz and 3.2 GHz is shown in Fig.12. The reason for change in the bandwidth in dual band antenna 2 from the previous case can be observed from the change in the current distribution.

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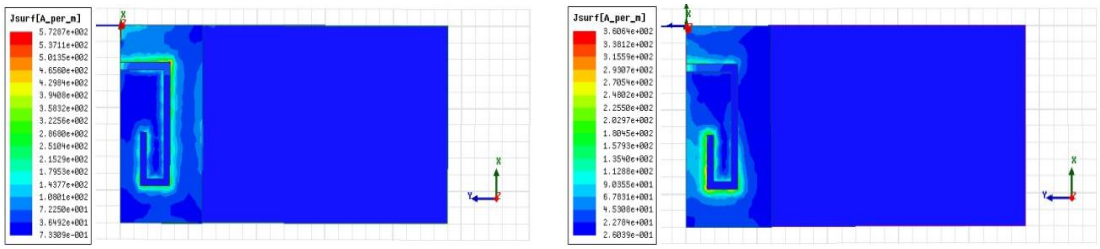
The current distribution at lower resonant frequency is changed from that of previous case. The current distribution is higher around the slit. This shows the dependence of lower band on the slit which is not usual in dual band antennas. At higher resonant frequency, the current density is higher around the folded slit.



a) b)

Fig.12. Current Distribution at a) 1.5 GHz and b) 3.3 GHz

Dual band antenna 2 is better since its size is reduced by 50 % and gains at both bands are higher compared to dual band antenna 1. But the radiation pattern at higher band is more distorted in Dual band antenna 2.

TABLE I
COMPARISON BETWEEN TWO ORIENTATIONS FOR FOLDED SLIT

Parameter		Dual Band Antenna with Folded Slit-1	Dual Band Antenna with Folded Slit-2
Size (mm²)		24 x 24	24 x 12
Gain	at 3.3 GHz	2.1 dB	3.75 dB
	at 1.5 GHz	2.44 dB	5.15 dB
Radiation Pattern at 3.3 GHz		Slightly distorted	More distorted

V.CONCLUSION

In this paper, a compact dual band Planar Inverted-F Antenna (PIFA) is designed. Firstly, a single band PIFA for 1.5 GHz GPS is proposed. Using folded slit on the top plate, a dual band antenna for GPS and 3.2 GHz WiMAX is designed. Two different orientations of the slit are compared. Miniaturization in size for 50% with gain enhancement is achieved when the folded slit is close to the feed with an open end. Gains obtained for the compact element are 2.44 dB and 5.15 dB in lower and upper band respectively.

REFERENCES

[1] H. T. Chattha, Y. Huang, and Y. Lu, "Further Study of Planar Inverted-F Antenna", iWAT 2009 IEEE International Workshop on Antenna Technology.
[2] Mayank Agarwal, Rajesh Singh, and Manoj Kumar Meshram, "Dual-Band Linearly Polarized Planar Inverted-F Antenna (PIFA) for GPS/ WiMAX Applications", IEEE Students Conference on Engineering and Systems, 2013.
[3] Shih-Huang Yeh, Kin-Lu Wong, Tzung-Wern Chiou, and Shyh-Tirng Fang, "Dual Band Planar Inverted F Antenna for GSM / DCS Mobile Phones", IEEE Transactions on Antennas and Propagation, vol. 51, no. 5, May 2003.
[4] Roberto Caso, Andrea D'Alessandro, Andrea A. Serra, Paolo Nepa, and Giuliano Manara, "A Compact Dual Band PIFA for DVB-T and WLAN Applications", IEEE Transactions on Antennas and Propagation, vol. 60, no. 4, April 2012.
[5] F. N. M. Redzwan, M.T. Ali, M.N. Md. Tan, NF. Miswadi, "Dual band Planar Inverted F Antenna with Parasitic Element for LTE and WiMAX Mobile Communication", Technology Management and Emerging Technologies (ISTMET), 2014 International Symposium.
[6] Adnan Iftikhar, Muhammad Nadeem Raflq, Muhammad Mubeen Masud, Bilal Ijaz, Sayan Roy and Benjamin D. Braaten, "A Dual Band Balanced Planar Inverted F Antenna(PIFA) for Mobile Applications", Antennas and Propagation Society International Symposium (APSURSI), 2013 IEEE.