Design And Simulation of Internal Multiband Planar Inverted- F Antenna For Mobile Terminals

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Abstract

A multiband double L shaped internal PIFA with a parasitic element for wireless terminal is presented. With the proposed design scheme, a 5-band internal antenna that covers WLAN 2.4 GHz/ Bluetooth, WiMAX(2.3-2.4GHz), WiBro(2.30-2.39 GHz),WLAN 5.2 GHz and WLAN 5.8 GHz is simulated using commercial electromagnetic software IE3D.

Keywords: Internal antennas, PIFA, parasitic element, wireless terminals.

1. Introduction

Nowadays human beings are surrounded with the wireless communication devices through which conversation between peoples in different places of any part of the world can take place without delay of time. Present wireless communication has become much easier because of mobile terminal devices To have wireless communication system it is necessary to use antenna element and therefore, an antenna plays very important role in mobile terminal system in which the antenna transmits and receives radio wave.

Nowadays compact wireless handheld devices are in demand and therefore, the antenna for these devices should also be smaller and more compact as well as should also be operating in multiple frequency bands with good efficiency and gain. Microstrip antenna and planar inverted-F antenna are most popular for wireless mobile devices because of their small sized and compact structure over the conventional antennas Microstrip antennas have some limitations such as their size, narrowband operation, and poor efficiency for high dielectric substrate and excitations of surface wave at lower microwave frequency. Because of these limitations microstrip antennas are not suitable for mobile devices.

To overcome these limitations Planar Inverted- F Antenna (PIFA) is suitable for mobile devices. The PIFA consist of a planar plate above the ground plane, a shorting plate or pin and a feeding mechanism to feed the antenna. It is called inverted-F antenna because side

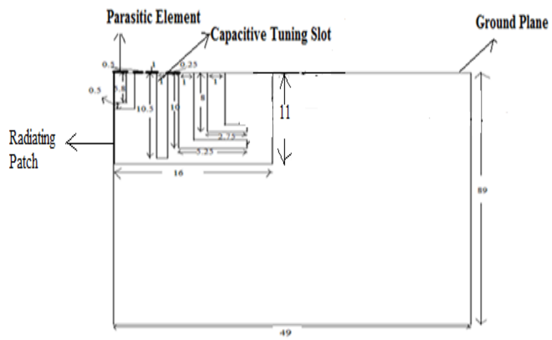
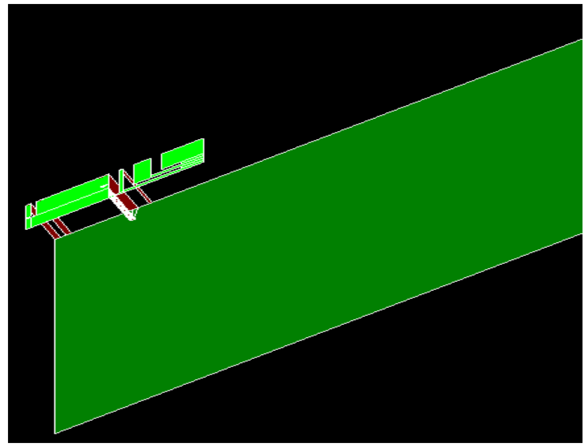


Fig. 1 Geometry of the proposed multiband PIFA (a) 2D view

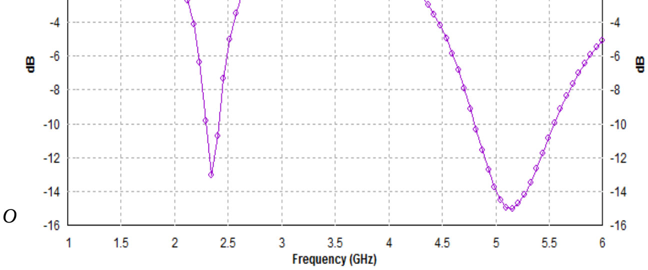


(b) 3D view of proposed antenna

view of this antenna looks like the letter F with its face down. PIFA offers reduced size over traditional microstrip antenna because the resonance frequency is about quarter wave rather than half wave in conventional one due to the shorting pins or walls in its structure. It has many advantages like easy fabrication, low manufacturing cost, and simple structure. It has moderate to high gain in horizontal or vertical state of polarization It is easily hiding in to the housing of devices so it is used as internal antenna for mobile terminal devices. It minimizes back radiation towards user's head called electromagnetic wave power absorption (SAR). It has also some disadvantage like narrow bandwidth. Demanding for compact size of mobile devices with multiple frequency application is growing rapidly, therefore, PIFA is most popular antenna used in mobile terminal devices operating at multiple frequency bands. The PIFA mainly operates in 1-6 GHz frequency range. This frequency range is attractive range for scientist or researches because in this range many useful bands exist for wireless mobile applications. This frequency range consists of all WLAN (Wireless Local Area Network) 2.4/5.2/5.8 GHz bands, WiMAX (Worldwide Interoperability for Microwave Access) 2.5/2.3/3.5 GHz, WiBro (Wireless Broadband) 2.35 GHz, microwave band, UMTS (Universal Mobile Telecommunication System) 2.0 GHz, PCS (Personal Communication System)1.9 GHz, DCS (Digital Communication System)1.8 GHz, ISM (Industrial, Scientific and Medical radio band)2.4/5.2/5.8 GHz bands used in wireless communication. There is challenge for antenna designer to design antenna of more compact in size with multi-system mobile terminal. It is obvious that size reduction, multiband operation, good efficiency and gain for PIFA are major design specification for scientist and researchers. **Wang *et al.* (2011)** have proposed a compact and low height planar inverted-F antenna with a parasitic element. The dimension of patch is 16.5 mm x 11.5 mm and ground plane dimension is 90 mm x 50 mm. The parasitic element is connected to ground through grounding strip and PIFA antenna is connected to ground through feeding strip and grounding strip. This antenna covers three WLAN bands, namely IEEE 802.11 2.4 GHz (2.4-2.484 GHz), 5.2 GHz (5.15-5.35 GHz) and 5.8 GHz (5.725-5.825 GHz). The antenna gains are 4.44 dBi, 4.91dBi and 4.94 dBi for respective band respectively. The antenna has good matching, bandwidth and radiation efficiency in all WLAN bands. Keeping the above in view, an attempt has been made to design and simulate internal multiband Planar Inverted-F Antenna for mobile terminals using Spatial Network Method (SNM) along with IE3D software. Spatial network method is used for calculation dimension of PIFA. IE3D Zeland software which is based on method of moment is used for design and simulation of proposed multiband PIFA for mobile terminals.

2. Antenna Design Methodology

The PIFA proposed in this work has compact simple structure. The proposed PIFA consist three layer structures. The proposed PIFA has been designed to cover WLAN 2.4 GHz/Bluetooth, WIMAX 2.3-2.4GHz, WIBro 2.3-2.39GHz. Therefore, for above mentioned applications, 2.4 GHz has been selected as resonant frequency for designing of radiating patch for proposed PIFA antenna. The proposed antenna occupies a volume of 16x11x 4.6 mm^3 and it is mounted on the top of a ground plane measuring 49 cm and 89 cm.The antenna is feed through co-axial cable. Duroid is used for the dielectric substrate. It has permittivity 2.2 and losstangent 0.001. For the resonant frequency of 2.4 GHz, the height of the substrate has been selected as 0.25 mm for proposed PIFA. Using the SNM method



the dimensions of patch has been calculated at frequency 2.4 GHz is given by using equation

$$f_r = \frac{c}{4(L1+L2+H-W)} \quad (1)$$

Where L1 and L2 are the dimension of patch and H and W are the height and width of the shorting strip respectively.

Fig. 1(a). shows geometry of the proposed antenna in 2 D view. It consists of two major part: main patch with two L shaped slot and a shorted parasitic element .3 D view of antenna is shown in Fig.1(b). Main patch without shorted parasitic element and only one L slot with capacitive tuning slot gives only two resonance frequencies at 2.35 GHz and 5.15 GHz respectively. Dual band behaviour of basic PIFA with one L slot is shown in Fig. 2(a).Cutting one more L slot on the radiating patch gives three resonance frequencies at 2.35GHz, 5.03 GHz and 5.78 GHz respectively.Triband behaviour of this configuration shown in Fig. 2(b). A shorted parasitic element with this configuration gives better efficiency and gain.The reflection coefficient of the proposed antenna shown in Fig. 2(c).The proposed antenna gives three resonance frequencies at 2.4 GHz,5.27 GHz and 5.83 GHz in the frequencies bands (2.4-2.484GHz), (5.15-5.35 GHz), (5.725-5.825 GHz).

3. Simulated Results

Simulated result shows that gain of the proposed antenna at resonance frequencies 2.35 GHz, 5.27 GHz and 5.83 GHz are 4.65 dBi, 4.80 dBi and 4.896 dBi respectively. The antenna efficiencies are 91.87%, 83.82% and 82.96 % respectively. The 3D radiation pattern and current distribution for three resonance frequencies are shown in Fig. 3. and Fig. 4. respectively.

4. Conclusions

It is found that making double L slot on the radiating patch with parasitic element has improved the antenna efficiency and gain in significant amount as compared to earlier design (Table 1). The simulated results of the proposed antenna have been compared to that of the antennas under reference by **Hanyang Wang *et al*., 2011.** It is clear from the comparison that the proposed antenna has more compact size and better antenna efficiency. The proposed antenna may be used for WLAN 2.4/Bluetooth, 5.2, 5.8 GHz WiMAX (2.3-2.4 GHz),WIBro (2.30-2.39GHz) frequency bands applications.

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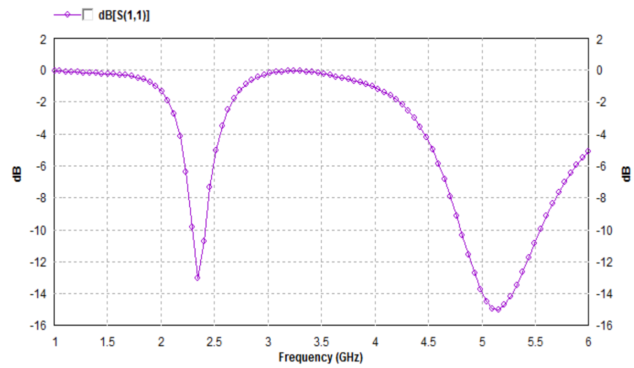
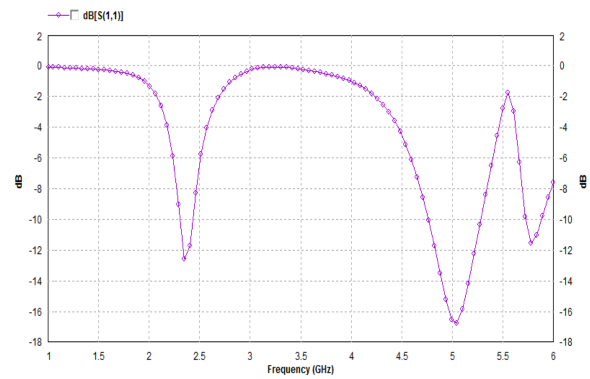
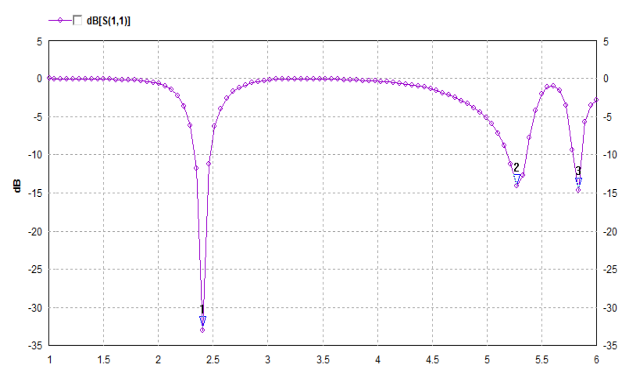


(a)



(b)



(c)

Fig. 2. Return loss for different antenna configuration

Table 1. Comparison of proposed antenna with antenna under reference

Parameters	Reference Antenna	Proposed Antenna
Ground size	50 mm x 90 mm	49 mm x 89 mm
Radiating patch size	17 mm x 12 mm	16 mm x 11 mm
Height of antenna	5 mm	4.55 mm
Lower layer substrate	FR4, dielectric constant = 4.6	Duriod, dielectric constant=2.2
Frequency Bands (GHz)	(2.4-2.484 GHz), (5.15-5.35 GHz), (5.725-5.825 GHz)	(2.33 -2.46 GHz), (5.20 -5.35 GHz), (5.79 -5.85 GHz)
Resonance frequencies (GHz)	2.4, 5.2, 5.8	2.4,5.27,5.83
Gains (dBi)	4.44,4.91,4.94	4.65,4.80,4.896
Antenna efficiencies (%)	89.125,79.4,79.4	91.86,83.82,82.96

References

1. Balanis C. A., 1997, "Antenna Theory and Design", *Second Edition, John Wiley & Sons. Inc.*
2. Bancroft, R., 2004 , Microstrip and Printed Antenna Design , *Prentice- Hall of India, New Delhi.*
3. Bhattil Rashid Ahmad, Shin Y.S., Nguyen N.A. Park S.O.2008. Design of a Noval Multiband Inverted F antenna for mobile terminals", *Proceedings of iWAT2008, Chiba, Japan.*Chang The Nan andJing -Hac Jiang. 2009.Meandered T-Shaped Monopole Antenna, *IEEE Antenna and Wireless Propagation letters*, Vol. 57, No. 12, DECEMBER 2009.
4. Chi Yu-Jen and Chien- Wen Chiu,2009, An Internal Multiband Inverted - F Antenna for mobile devices, Deppt of electronic engineering, National llan University.llan260,Taiwan.
5. Chiu Y.C,Chi H. C and Kwai M. L, 2004 Small Dual-Band Antenna With Folded-Patch Technique, *IEEE Antenna and Wireless Propagation letters* ,Vol. 3, 2004.
6. Chiu Y.C,Chi H. C and Kwai M. L, 2004 Small Dual-Band Antenna with Folded-Patch Technique, *IEEE Antenna and Wireless Propagation letters* ,Vol. 3, 2004.
7. Jae-Hoon Jo,Byunggil yu, Ki- Hung Kong ,2007, Multi-band Internal Antenna Including DVB-H Band ",Dept. of Wireless Communications Engineering, *Kwangwoon University,Korea.*

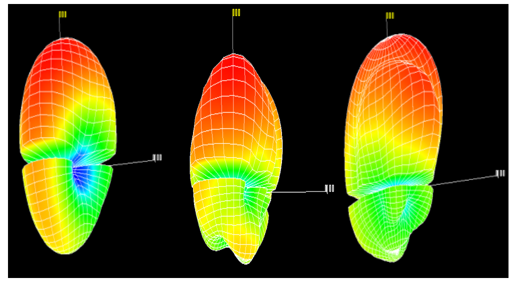
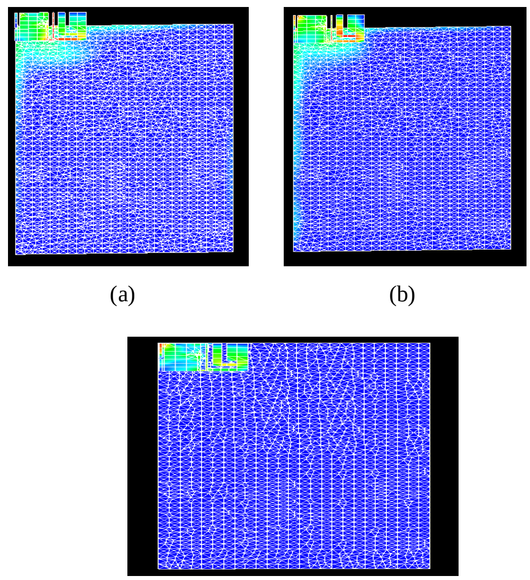


Fig. 3. 3D radiation pattern for resonance frequencies at (a)2.35 GHz ,(b) 5.27 GHz and (c) 5.83 GHz



(a) (b) (c)

Fig. 4. Current distribution for the resonance frequencies at (a) 2.35 GHz (b)5.27 GHz and (c) 5.83 GHz

8. K. Hirasawa & M. Haneishi, 1992 Analysis, Design, and Measurement of Small and Low-Profile Antennas, Artech House, Inc, 1992
9. Lee H. J., Cho S. H., Park J.K., Cho Y.H., Kim J.M., Lee K.H., Kim J. S.2007.The Compact Quad- Band Planar Internal antenna For Mobile Handsets, Dept.Of Research and Development, Amotech, KOREA.
10. Nepa P,Manara G ,Serra A.A and Nenna G. 2005.Multiband PIFA for WLAN Mobile Terminals, *IEEE Antenna and Wireless Propagation letters,* Vol. *4, 2005.*