



# **Design of A PIFA Antenna with Slots on Ground to Improve Bandwidth**

Anoop Varghese<sup>1</sup>, Kazi Aslam<sup>2</sup>

Dept. of Electronics & Telecommunication Engineering, AISSMS COE, Pune, India<sup>1</sup>

Assistant Professor, Dept. of Electronics & Telecommunication Engineering, AISSMS COE, Pune, India<sup>2</sup>

**ABSTRACT:** In this paper, a Planar Inverted F- Antenna (PIFA) is designed and simulated. Slots are introduced on the radiating patch. So the antenna is able to achieve dual band resonance. The patch and the ground are shortened using a shorting pin configuration. To increase the bandwidth of the antenna, slots are also introduced on the ground plane of the PIFA structure. The radiating patch is kept on one side of substrate and substrate used in FR4. The ground is on the other side of substrate and the height of antenna is 6mm. Also as the area occupied by the antenna is small it is a good candidate in mobile systems. The simulations are performed using HFSS software. For the design dual resonance is achieved. Resonant frequencies are at 900MHz and 1800MHz with acceptable return loss less than -10dB. The bandwidth achieved is wider and covers the band used by mobile systems for communication.

**KEYWORDS:** Planar Inverted F-Antenna, slots, bandwidth, shorting pin.

## **I. INTRODUCTION**

Due to the brisk growth in the sector of wireless communication technology and the increasing demand for multi-band applications, there is a growing trend towards the design of systems which can handle multiple bands [1]-[3]. It's necessary to design multi-band antennas for the present day personal wireless communications terminals that supports various global communication standards and services. The antennas for these modern devices should be capable of operating at maximum possible frequency bands with acceptable reflection coefficient and radiation performances in order to serve multiple cellular and non-cellular communication applications [2].

The multiband functionality is not the only requirement in such antenna systems, but also other characteristics should be fulfilled such as low profile, small size, light weight, omni-directional radiation pattern, reasonable gain, and bandwidth covering the required bands. So there has been an enhanced push to satisfy the characteristics in the internal antennas of wireless systems [2]. Planar inverted F-antenna (PIFA) is proven to be the most widely used internal antenna in commercial applications of wireless communication systems. It has been applied in the mobile phone as internal mobile phone antennas [3]-[9].

From the commercial point of view, currently, many mobile telephones use one or more of the following frequency bands: the GSM band for mobile phones at 900 MHz [2]; the DCS band for wireless cellular applications at 1800 MHz [2]; and the PCS band at 1900 MHz [4]. In addition, with the successful launch of wideband code division multiple access (WCDMA) and mobile internet service, the WCDMA band at 2100 MHz [9].

In this communication we present an antenna system for dual-band. The antenna system is based on PIFA occupying a small volume on the PCB. Proper slots are introduced in the radiating patch to acquire multiple band operation. And to increase the bandwidth, proper slots are introduced on the ground of the antenna. This antenna satisfies a 6-dB return loss requirement to cover the Global System for Mobile Communication (GSM850) 824–894 MHz, Digital Communication System (DCS1800) 1710–1880 MHz, Digital Communication System (DCS1900) 1850–1990 MHz, International Mobile Telecommunication (IMT2000) 1885–2200 MHz, Universal Mobile Telecommunication System (UMTS) 1920-2170 MHz [2]-[4],[6],[9].

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## II. RELATED WORK

PIFA are mainly formed by mounting a shorted radiating strip or patch above the system ground plane of the mobile phone. This kind of antennas shows a three-dimensional (3-D) structure. The antenna's fundamental or lowest-frequency resonant modes is usually operated at their quarter-wavelength resonant modes [1]. The PIFA consists of a ground plane, a top patch, a feed wire, and a shorting mechanism that short-circuits the top patch to the ground plane [1]-[9]. The shorting mechanism, which can be achieved by using either a shorting wall or shorting pins [7], [9]. The shorting strip or pin leads to a quarter-wave resonator or even multiple resonant modes depending on the patch geometry. Because of this, the patch length is reduced by at least 50% as compared to the conventional half-wave patch. PIFAs can be customized to operate over multiple frequencies, by dividing the short-circuited patch with slots [5], [8]. The disadvantage of PIFA is that it has narrow bandwidth. To overcome limitation of narrow bandwidth of PIFA structure various techniques have been employed and the most widely used method is to increase the height of the shorting plate which finally results in increase of volume [6]. Also by optimizing the dimensions of the ground plane, the bandwidth of PIFA can be adjusted such as reduction in dimensions of ground plane can effectively widen the bandwidth of the antenna [7].

## III. ANTENNA DESIGN

The geometry of the proposed antenna is shown in Fig. 1(a). The antenna consist of three major parts: a radiating patch on top, a coaxial feed pin and a shorting pin. The black triangle indicates the shorting pin and the black circle indicates the feed pin.

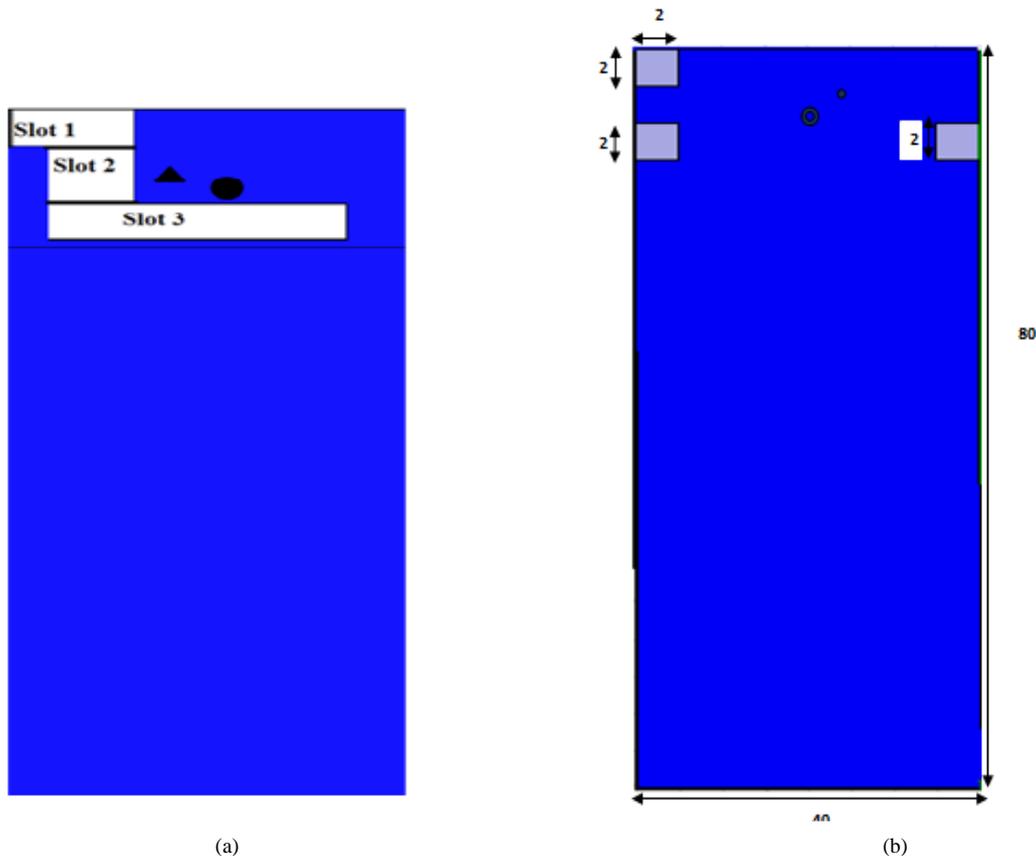


Fig.1. (a): Top View with slots on patch (b): Ground with slots

# International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 4, April 2015

The radiating patch is designed with a total volume of 40mmx15mmx6mm that makes it suitable for compact handset applications. The antenna is mounted over a ground plane measuring 80 mmx40 mm that is considered to be the size of PCB board in the practical mobile phones. The PIFA is printed on FR-4 substrate with a height of 1.6 mm and the dielectric constant of 4.4 is used Fig. 2(a). The antenna is fed using coaxial probe feeding method. Slots are created on the radiating patch structure to excite multiple resonances in the antenna. Three slots are inserted on the patch namely Slot#1, Slot#2, Slot#3. Slot #1 and Slot#2 is used to tune the higher frequency and Slot#3 is used to tune the lower frequency. To improve the bandwidth of PIFA, slots are introduced on the ground Fig. 1(b). Slots are of equal area of 2mmx2mm.

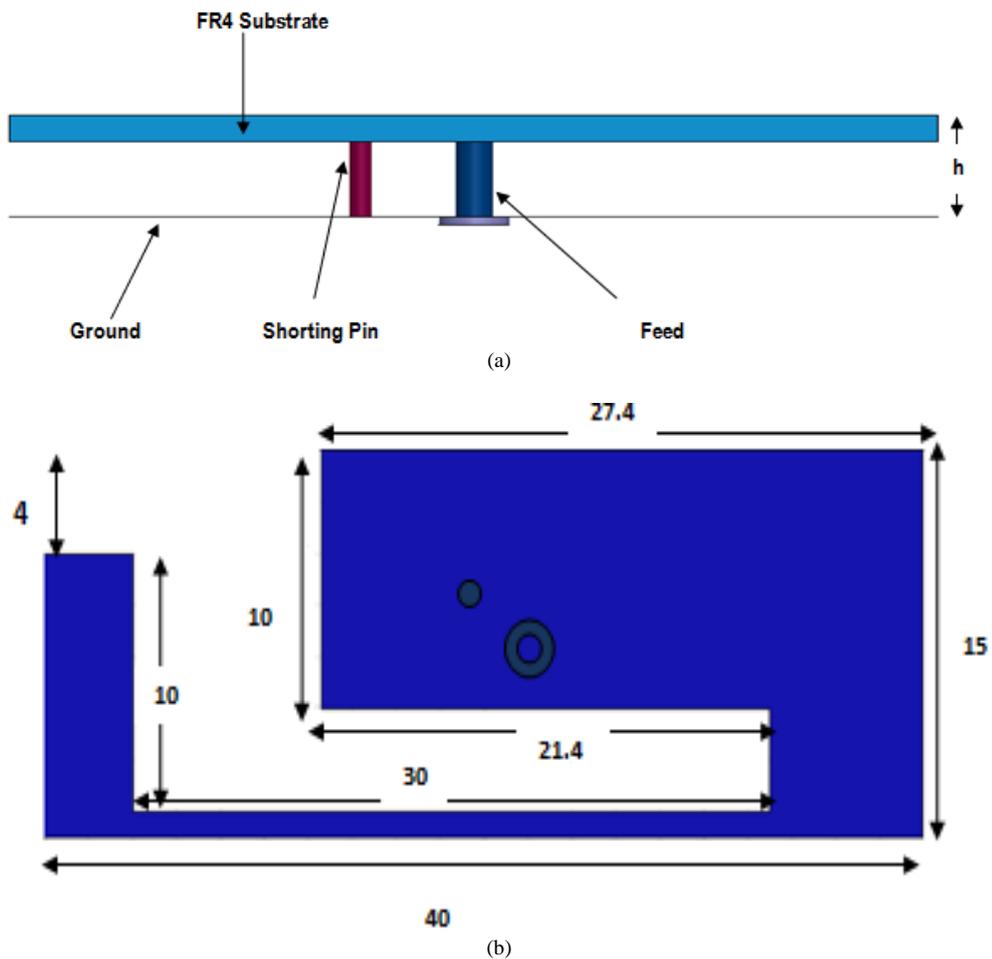


Fig. 2: Geometry of PIFA (a). Side View (b). Top View

The antenna patch with the dimensions is given in Fig.2 (b).

## IV. RESULT AND OBSERVATIONS

Utilizing the geometries described in Section III, we have constructed dual-frequency PIFA antennas that resonate in the 900- and 1800-MHz bands. The antenna is simulated using HFSS v.11.0 software. The gap between the ground and patch is air filled. Here air is also used as dielectric material. The ground plane, shorting pin and the antenna patch are taken as perfect electric conductor (pec).

# International Journal of Innovative Research in Computer and Communication Engineering

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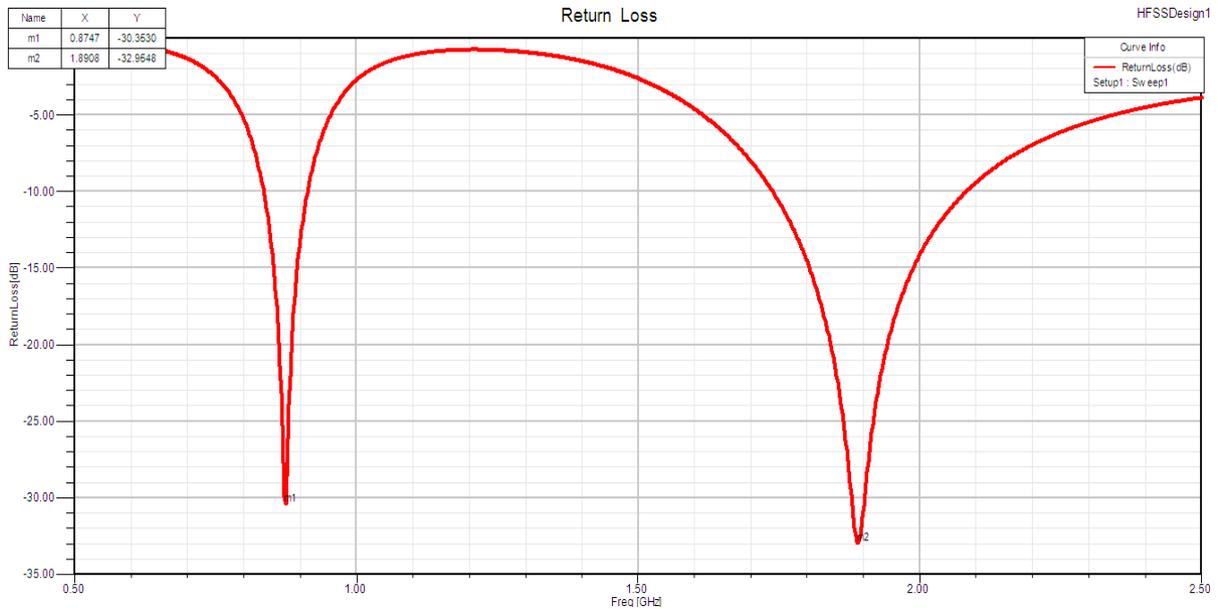


Fig. 3: Simulated  $S_{11}$  of PIFA antenna.

The simulated reflection coefficient ( $S_{11}$ ) for the PIFA antenna is shown in Fig.3. It is also known as Return Loss. It can be observed from the graph that the return loss values lower than -10dB are achieved. So two bands are obtained with its centre frequencies at 0.87GHz and 1.89GHz. Also the return loss values obtained at 0.87GHz is -30.36dB and at 1.9GHz is -32.94dB.

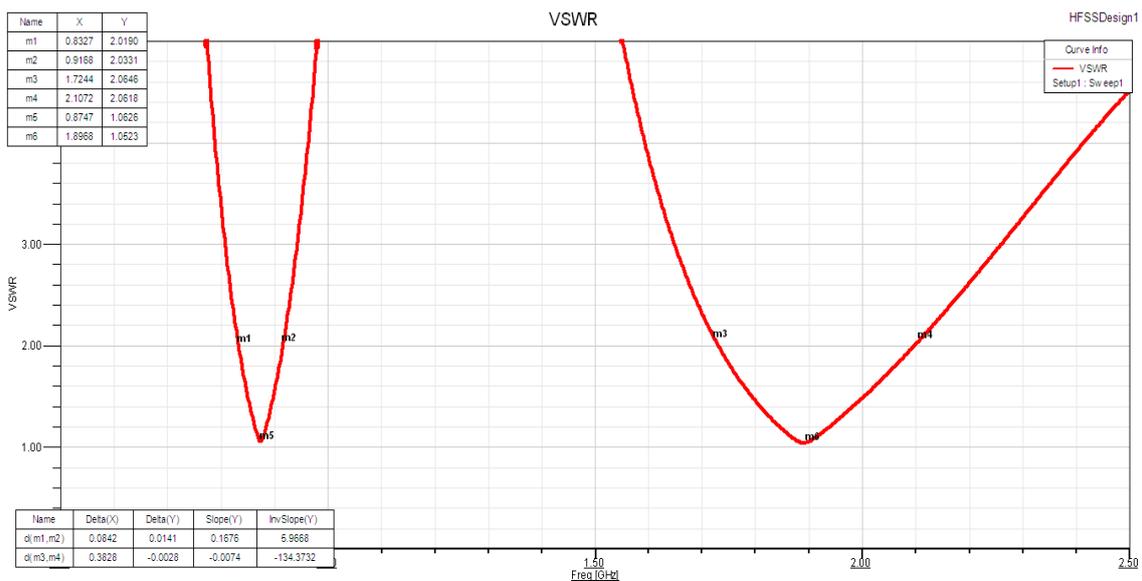


Fig.4: Simulated VSWR of PIFA antenna.

Fig. 4 shows the simulated voltage standing wave ratio (VSWR) with respect to the frequency. It can be seen from Fig. 4 that the antenna impedance bandwidth extends from 0.83-0.91 GHz and 1.72-2.10 GHz with VSWR less than 2. The

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Vol. 3, Issue 4, April 2015

bandwidth of 84MHz has been obtained for the resonant frequency 0.87GHz and bandwidth of 382MHz has been obtained for resonant frequency 1.89GHz.

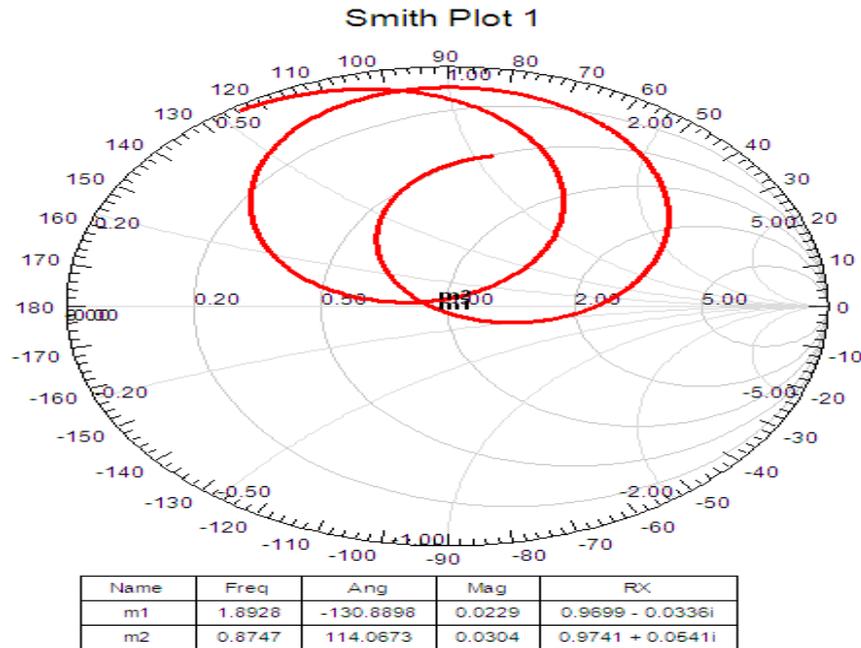


Fig. 5: Simulated Smith chart of PIFA antenna.

The simulated Smith Chart is shown in Fig. 5. Smith chart is a polar plot which indicates the normalized input impedance. It can be seen that the simulated antenna is matched close to 50 ohms.

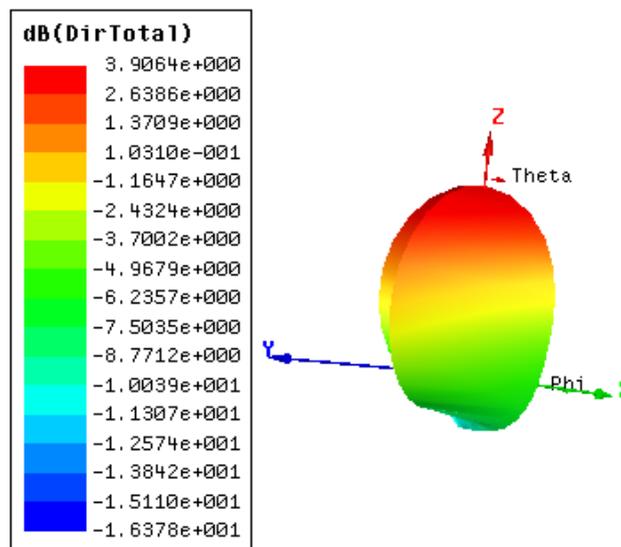


Fig. 6: Simulated Directivity of PIFA antenna.

The directivity obtained by the simulated antenna is shown in Fig. 6. The values obtained are in dB. A peak value of 3.90dB is obtained.

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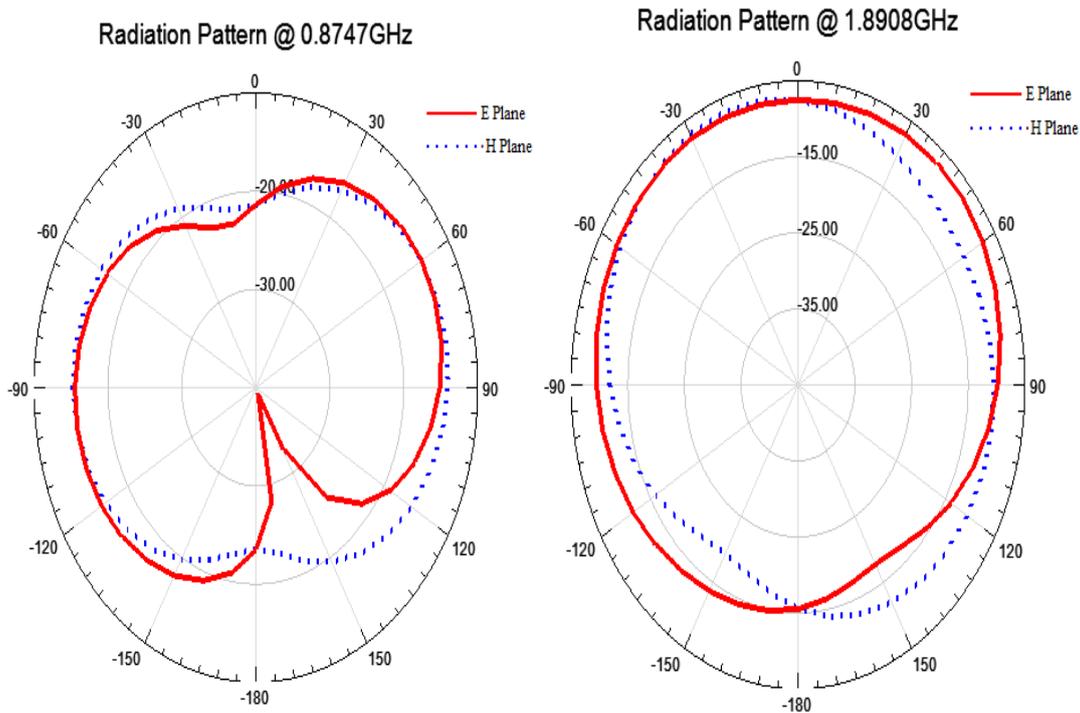


Fig. 7: Simulated Radiation Pattern of PIFA antenna.

The 2D radiation pattern of the simulated antenna is shown in Fig. 7. It can be seen that at the lower frequency of 0.87GHz the E-plane pattern is slightly bidirectional and H-plane pattern is omni-directional, whereas at higher frequency of 1.89GHz both the E-plane and H-plane pattern becomes omni-directional.

## V. CONCLUSION

The design of simple dual-band PIFA antenna has been studied. Using slots on the radiating patch multiple bands are achieved and using slots on ground the bandwidth has been increased. The presented antenna can work in the GSM band, DCS band and PCS band. Simulation results are showing good performance characteristics in terms of return loss, bandwidth, radiation pattern and gain. The antenna occupies small space and is easy to fabricate using FR4 substrate at low cost which makes it suitable for wireless systems.

## REFERENCES

1. Z. D. Liu, P. S. Hall, and D. Wake, 'Dual frequency Planar Inverted-F Antenna,' *IEEE TRANS. ANTENNAS PROPAGAT.*, VOL. 45, OCT.1997.
2. C. R. Rowell and R. D. Murch, 'A compact PIFA suitable for dual frequency 900/1800 MHz operation,' *IEEE TRANS. ANTENNAS PROPAG.*, VOL. 46, APR. 1998.
3. Rafik Addaci, Katsuyuki Haneda, Aliou Diallo, Philippe Le Thuc, Cyril Luxey, Robert Staraj, and Pertti Vainikainen, 'Dual-Band WLAN Multiantenna System and Diversity/MIMO Performance Evaluation,' *IEEE TRANSACTIONS ON ANTENNAS AND PROPAGATION*, VOL. 62, NO. 3, MARCH 2014.
4. Yong-Sun Shin, Byoung-Nam Kim, Won-Il Kwak, and Seong-Ook Park, 'GSM/DCS/IMT-2000 Triple-Band Built-In Antenna for Wireless Terminal,' *IEEE ANTENNAS AND WIRELESS PROPAGATION LETTERS*, VOL. 3, 2004.
5. N. L. Bohannon, J. T. Bernhard, 'Design Guidelines using Characteristic Mode Theory for Improving the Bandwidth of PIFAs,' *IEEE TRANSACTIONS ON ANTENNAS AND PROPAGATION*, VOL. 6, NO. 1, JANUARY 2007.
6. Kin-Lu Wong, Yuan-Chih Lin, and Brian Chen, 'Internal Patch Antenna With a Thin Air-Layer Substrate for GSM/DCS Operation in a PDA Phone,' *IEEE TRANSACTIONS ON ANTENNAS AND PROPAGATION*, VOL. 55, NO. 4, APRIL 2007.



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# International Journal of Innovative Research in Computer and Communication Engineering

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7. M. F. Abedin and M. Ali, 'Modifying the ground plane and its effect on planar inverted-F antennas (PIFAs) for mobile phone handsets,' IEEE ANTENNAS WIRELESS PROPAG. LETT., VOL. 2, 2003.
8. K. L. Wong, Y. C. Lin, and T. C. Tseng, 'Thin internal GSM/DCS patch antenna for a portable mobile terminal,' IEEE TRANS. ANTENNAS PROPAG., VOL. 54, 2006.
9. Kin-Lu Wong, Saou-Wen Su, Chia-Lun Tang, and Shih-Huang Yeh, 'Internal Shorted Patch Antenna for a UMTS Folder-Type Mobile Phone,' IEEE TRANSACTIONS ON ANTENNAS AND PROPAGATION, VOL. 53, NO. 10, OCTOBER 2005.
10. Hoon Park, Kyungho Chung, and Jaehoon Choi, 'Design of a Planar Inverted-F Antenna With Very Wide Impedance Bandwidth,' IEEE MICROWAVE AND WIRELESS COMPONENTS LETTERS, VOL. 16, NO. 3, MARCH 2006.