Design and Analysis of Planar Antenna for Mobile Handset Aplications

Rachna Mainh[1], Narwant Singh Grewal[2], Chahat Jain[3]

[1] *M.Tech Scholar, ECE, Guru Nanak Dev Engineering College, Ludhiana, Punjab India*
[2] *Assistant Professor, ECE, Guru Nanak Dev Engineering College, Ludhiana, Punjab India*
[3] *Assistant Professor, ECE, Guru Nanak Dev Engineering College, Ludhiana, Punjab India*

e-mail: er.rmainh@gmail.com, Narwant@gndec.ac.in, chahatjain26@gmail.com

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***Abstract*— In this paper the design of a small- sized Planar Inverted F Antenna (PIFA) for Cell Phone Applications is discussed. This antenna covers a wide range of frequency from 524 MHz to 2447 MHz at lower band and 3.30 GHz to 4.29 GHz at higher band. The total dimensions of the radiant parts of the antenna designed are 20 x 12 mm^2 and those of the ground plane are 90 x 50 x 3.57 mm$^{3.}$ With these selected dimensions for antenna , the configuration can be operated in LTE, Bluetooth, m-WiMAX and WLAN bands with a sufficiently good band width for mobile handset applications. The PIFA design is preferred due to its relatively small size, which makes it suitable for modest mounting on wireless devices. PIFA has double polarization signal characteristics, again the advantage. The proposed antenna can be easily fabricated and has been simulated using HFSS Software the "High Frequency Structure Simulator". This is a good feature choice for antenna design that serve the '4G LTE' and 'WiMAX' standard as a streaming media.**

Keywords: PIFA, LTE, WLAN, m –WiMax, HFSS

I. INTRODUCTION

In last few years, mobile communication has shown tremendous growth in the areas of wireless communication. Now a days mobile phones have been equipped with small antennas capable of supporting multimedia features and a low-profile structure so that they can be easily inserted into the housing of mobile phones. Size of Antennas must be reduced accordingly which can be used in cell phones [1]. In current wireless communication, we want an antenna design that has low costs, lighter, smaller size, flexibility and easy huge productivity [2]. Tendency in portable devices is represented by thin structures, which lead to a very small height of the antenna terminal above the battery in the cellular housing. Therefore, the F inverted planar antenna (PIFA) is used as an internal antenna in which the bandwidth and the radiation efficiency reached are proportional to its height. "Impedance matching", is the prominent parameter in the design of these antenna . Several losses occur due to the limited conductivity of the antenna structure [3]. The PIFA design is preferred due to its relatively small size, which makes it suitable for modest mounting on wireless devices.

In this paper, for Cell Phones applications we Propose Planar Inverted F Antenna, small in size, single feed, wideband. . This structure can be operated in the LTE, Bluetooth, m-WiMAX and WLAN bands with a sufficiently better bandwidth .

II. RELATED WORK

In [4] a small dual feed PIFA for LTE / WWAN applications has been proposed. The complete size of the proposed antenna is 135 mm x 70 mm^2 with a height of 5 mm. It uses two power points to excite a band less than 1 GHz and broadband coverage from 1705 MHz to 2750 MHz. The power line is used for matching network to get the desired resonances that resulted in fewer efficiencies and lower gains. The inductor and capacitor are used to power a PIFA antenna radiation patch. An SAR analysis was also performed on the proposed project which shows an acceptable level of SAR for the condition of the head and human hand.

Paper [5] has proposed a wide band PIFA for wireless devices. The size of the antenna is 25mm x 15mm^2 occupying a volume of 66.39mm x 40mm x 3.8 mm^3 using FR4 substrate. A shorting plate of 2.4mm x 3.8mm has been used. The position of slots is used to provide band coverage of 1.16 GHz. The antenna is resonating at 1.83 GHz and 2.28 GHz with a return loss of -29.55dB.

Rong et al in [6] has introduced a small multi-band planar antenna consisting of two horizontal U-rings operating in 4G frequency bands and occupying a size of 49 x 10 x 1.6 mm3 and are printed on a FR4 substrate having thickness of 1, 6 mm with a sensitivity of 4.4 and a loss tangent of 0.024. When energized, the antenna resonates at three frequencies of 0.75 GHz, 2.61 GHz and 3.51 GHz, respectively. All bands are covered with a 6 dB return loss, which is a widely used standard in mobile phone applications.

In [6] a multi-band PIFA which occupies a volume of 51 x14 x. 2.2 mm^3 at the top of the mobile phone is presented. PIFA covers four frequency bands. 737-831 MHz, 1794-1977

MHz, 2507-2615 MHz and 3341-3545 MHz four slots are used (in a circle) so as to reduce the size of the antenna.

Liu et al in [8] has presented a multiband, small size interphone antenna. The antenna is structured by dielectric FR4 substrate with 1 mm thickness, reference ground and radiating element. It is excited by a co axial line with 50 ohm characteristic impedance and the operating frequencies include GSM850/900, DCS1800, PCS1900, GPS1575, UMTS2100, WLAN2400 AND LTE2300/2500.

III. DESIGN METHODOLOGY

In this paper the design of PIFA antenna as shown in Fig.1 is proposed. The HFSS software is used to select the design and simulation parameters to analyze and optimize the antenna characteristics and performance.

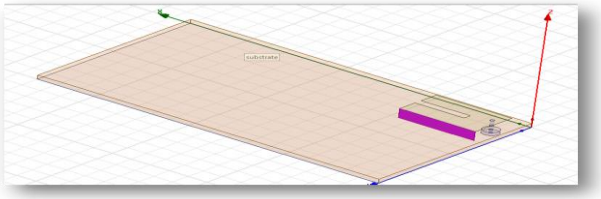

Fig. 1: Proposed Planar Inverted- F Antenna

It is necessary to select the parameters, such as the size, the length and width of the PIFA structure on the ground, the resonance frequencies, the position of the power point, the size of the short circuit plate and location.

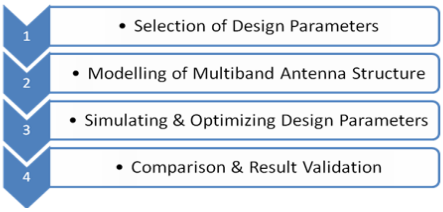

Fig. 2: Followed methodology

The geometry selected for the antennas is similar to the modern and small geometry of thin cell phones. The dielectric material used here is FR4 substrate with a loss tangent (δ) = 0.02; dielectric constant, ε_r = 4.4 and height of substrate, h = 1.57 mm. The metallic part used here is Copper that has a conductivity of 5.8e7 S / m. A coaxial cable is used to supply the feed to the antenna from the back of the PCB where the ground plane is located. Air is used between the FR4 substrate and the patch which acts as dielectric here. The shorting plate has been used which shorts the upper radiation patch to the ground plane. The height of PIFA can be considerably reduced by using the ground plane which helps in reducing in the overall thickness.

The total dimensions of the radiant parts of the antenna are 20 x 12 mm^2 and those of the ground plane are 90 x 50 x 3.57 mm^3. It can be seen that the radiating parts cover a small part of the total size of the antenna.

The main purpose of this research is to propose an antenna that has a small structure; therefore, height of the selected PIFA is 2 mm above the FR4 substrate and 3.57 mm above the ground floor.

Table 1: Dimensions of the antenna to be designed

Parameter	Value (mm)
L_g	90
W_g	50
L_p	20
W_p	12
L_s	3.57
W_s	20
H	1.57

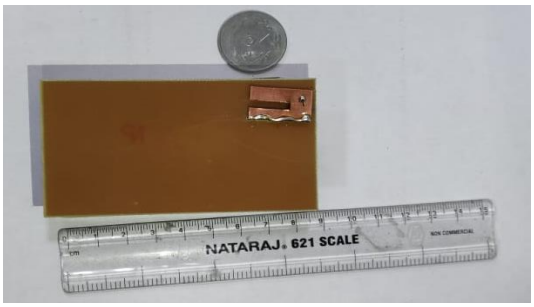

Fig. 3 Fabricated proposed PIFA antenna

IV. RESULTS AND DISCUSSION

The coaxial feeding technique has been used for antenna and simulated using HFSS.

A. Return loss characteristics

The following graph in Fig. 4 tells about the return loss (S11) for the PIFA antenna design. – 6dB is the base value which is widely considered as the standard for PIFA used in mobile handset applications.

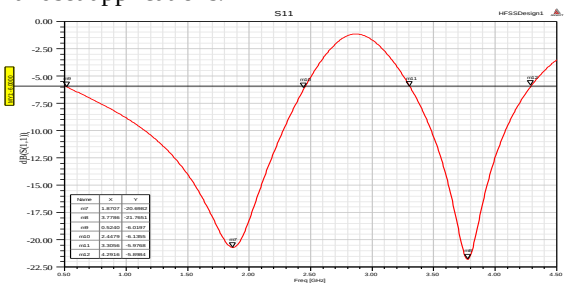

Fig. 4 Simulation Results of Return Loss

It can be concluded that the antenna resonates at 1.87 GHz having return loss of -20.69 dB and at 3.77 GHz having S11 parameter with a value of -21.76 dB. The frequency bands covered by are 4G LTE bands (1 to 6, 8 to 30, 33 to 37, 39 to 45, 50 to 68, 70, 71, 74 to 76), Bluetooth (2400-2480 MHz), WLAN 802.11 {(2400-2485 MHz) & m-WiMAX (2500 MHz). The bands covered range from 524 MHz to 2.447 GHz which is about 1.92 GHz and from 3.30 GHz to 4.29 GHz which is 0.99 GHz.

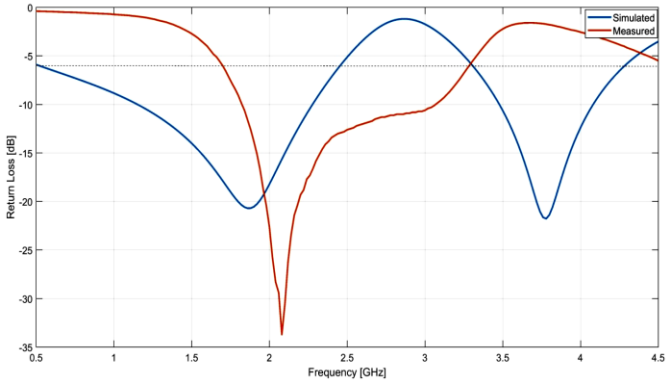

Fig.5. Simulated & Measured Return Loss Plot of proposed PIFA

B. VSWR (VOLTAGE STANDING WAVE RATIO)

The pattern of VSWR of designed antenna is shown in fig. 6. In general the value of VSWR should be less than 2 and in ideal cases it should be 1. The value of VSWR obtained is 1.4 and 1.48 at resonant frequency 1.87 GHz and 3.7 GHz respectively which is near to perfect matching condition i.e. 1 dB.

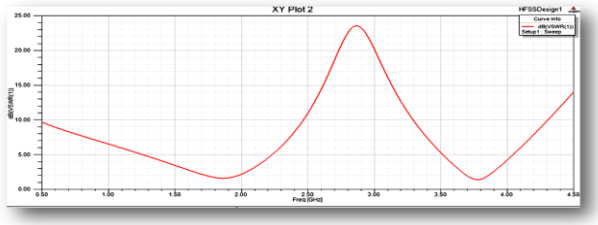

Fig.6 Simulated VSWR OF Planar Inverted F Antenna

C. Radiation Pattern

From the graph we can be conclude that the antenna radiates in almost omnidirectional state and can be further used for mobile terminals that support more standards.

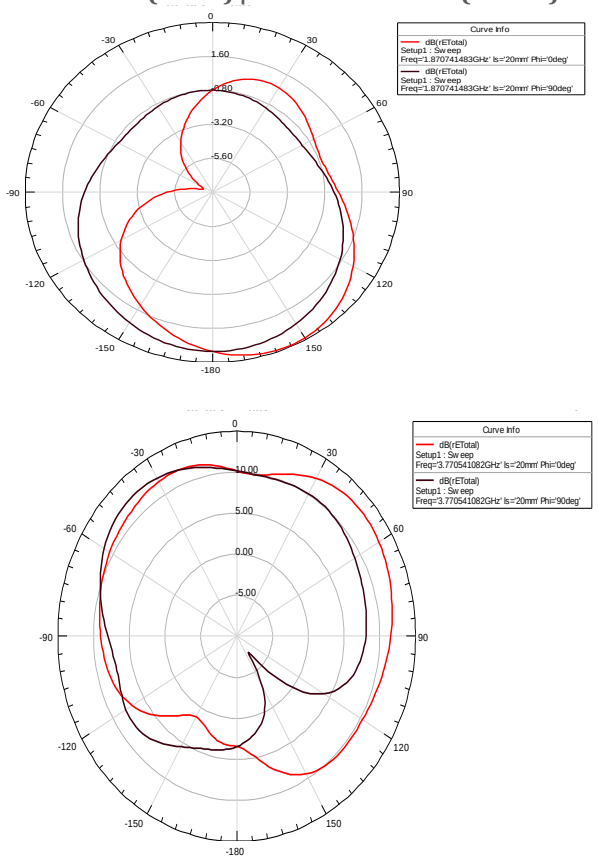

Fig. 7 Simulated 2D pattern of antenna (a) at 1870 MHz (b) at 3.77 GHz

D. Gain

The overall gain obtained after simulation is -0.13 dB which is observed at 1870 MHz. However, the gain of antenna decreases at higher frequency band.

V. CONCLUSION AND FUTURE SCOPE

The antenna designed here can behave differently if there is any change in the size of the structure and the ground plane. The ground of the antenna radiates perfectly which helps in reducing the size and improves operational bandwidth. The structure of the antenna is very compact. Furthermore, this antenna prototype can be used to study antenna performance with human interaction and investigate the value of specific absorption rate (SAR) using human model testing.

The proposed design in this paper can be extended to support MIMO applications for devices that support LTE and WiMAX technologies.

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