A WIDEBAND AND MULTIBAND PIFA FOR MOBILE

(2G/3G/4G/5G/WLAN/WIMAX) APPLICATIONS

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ABSTRACT: This article introduces a new compact multiband PIFA (Planar Inverted-F Antenna) designed for mobile handsets. The PIFA is characterized by its simple geometry, featuring eight slots and three integrated bands within the radiating patch and slotted ground plane. It occupies a minimal volume measuring 25 × 40 × 1.6 mm^3 and is positioned on the top section of a mobile phone. The optimized PIFA operates effectively across a frequency range of 1.77–4.66 GHz, providing coverage for multiple bands including DCS1800, PCS1900, WCDMA2100, LTE1800, LTE1900, LTE2400, LTE2500, WIFI2400, 5G (3.3 GHz–4.57 GHz), and WIMAX3400. Each of the four operational bands can be independently controlled by adjusting a single parameter within the proposed design, offering a wide control range. Additionally, the PIFA exhibits an omnidirectional radiation pattern for each resonant frequency, achieving a maximum gain of 5 dBi. The study of this proposed PIFA is conducted in free space.

1. INTRODUCTION

In recent times, Long Term Evolution (LTE) and Worldwide Interoperability for Microwave Access (WIMAX) have emerged as the latest standards for fourth-generation systems, while the sub-6GHz bands have become crucial for fifth-generation systems. Consequently, contemporary smartphones are expected to function seamlessly within both fourth and fifth-generation cellular communication systems, necessitating their compatibility with LTE, WIMAX, and the sub-6GHz 5G frequency bands. As a result, there is a growing demand for innovative antenna solutions in mobile phones that can effectively encompass all the currently allocated frequency bands. [1, 2].

The antenna holds a pivotal position within mobile devices and assumes a critical role in the smart-phone's overall design. Consequently, designing an antenna that is both compact and cost-effective while having the capability to operate across multiple frequency bands remains a consistent challenge. Among the various antenna types available, the planar inverted-F antenna (PIFA) has garnered significant popularity in the context of mobile phones. This is primarily attributed to its numerous advantageous features, including its compact structure, lightweight nature, diminutive size, cost-effectiveness in manufacturing, seamless integration with other handset components, excellent electrical performance, favorable radiation characteristics, high gain, and a low specific absorption rate (SAR) value, among others[3, 4]. Furthermore, within the realm of literature, numerous studies and research endeavors have suggested the creation of compact multiband PIFA structures. These structures are achieved through the strategic insertion of slots within both the radiating patch and the ground plane[5–10].

One of the drawbacks associated with employing PIFA in mobile phones is its limited bandwidth. Consequently, numerous researchers have undertaken investigations aimed at enhancing the PIFA's bandwidth through the implementation of various techniques[11–19]. An alternative strategy for addressing this issue involves achieving independent control over the resonant frequencies of a multiband PIFA. In addition to the design of a multiband PIFA, efforts are made to bring the resonant frequencies closer together, enabling the antenna to function as a wideband antenna. This approach relies on the principles of multiband antenna design and a thorough examination of each antenna parameter's influence on the resonance frequencies. Nonetheless, it's important to note that this technique presents significant challenges due to the intricate interplay among various PIFA parameters. Consequently, when one antenna parameter is altered, it can impact all other associated frequency bands, making the process complex and demanding [20]. Some works have been done to achieve frequency independent control for a multiband PIFA. For instance, in reference [20], an investigation into PIFA was conducted to achieve separate control over three resonant frequencies allocated for UMTS/WIMAX/WLAN. Another study, as documented in [21], explored a triband PIFA characterized by its relatively larger dimensions of 105 × 30 × 9 mm^3, with the aim of controlling three distinct bands, namely GSM/DCS/S-DMB. In [22], a coplanar waveguide PIFA was introduced, which facilitated the independent control of resonance frequencies by incorporating slots into both the radiating patch and the ground plane. Nevertheless, this particular PIFA structure was limited in its capacity to provide extensive independent control over the frequency bands. Moving on to reference [23], a multiband PIFA capable of covering a total of ten frequency bands was proposed. Notably, the majority of these frequency bands could be adjusted
independently without causing significant interference with the resonance frequencies of the remaining bands. However, it's worth noting that the control ranges for these frequency bands were constrained, typically limited to only a few percentage points.

In this article, a multiband PIFA for mobile handset is proposed; it has a simple geometry which is formed by integrating the dipole like bars in the radiating patch and making slots in the ground plane. The proposed PIFA covers these following service bands: DCS1800, PCS1900, WCDMA2100, LTE1800, LTE1900, LTE2400, LTE2500, WIFI2400, 5G(3.3Ghz-4.6GHz) and WIMAX3400.

The antenna configuration, parametric studies, independent control, and current distribution are presented in Section 3, while the simulated and measured results of the reflection coefficient, radiation pattern, and gain are presented in Section 4.

### 2. Configuration of proposed PIFA

2.1 Antenna Geometry: Figure 1 shows the structure of the multiband PIFA for mobile phones to 4th-generation wireless communications. The proposed PIFA is composed of the following four main parts: a radiating patch designed on FR4 substrate (thickness hs = 1.6 mm, dielectric constant = 4.4, and the loss tangent tan = 0.025) (Figure 1(b)), a ground plane which has the form of a mobile phone PCB (Printed Circuit Board) (Figure 2), a short-circuit plate linked between the ground plane and the radiating patch, and a feed mechanism in the form of a line feed. The proposed PIFA is mounted on the top edge of the mobile phone PCB and occupies a volume of 25 × 40 × 1.6 mm³. The ground plane is printed below the FR4 substrate and occupies a volume of 75 × 40 mm². The locations of the feeding line and shorting strip are shown. To reduce the antenna size and achieve a multiband antenna, slots (circle-shaped slots) are integrated in the ground plate of PIFA. The design of the PIFA is optimized using the ANSYS HFSS design tool.

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<th>Parameter</th>
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2.2. Design Process: The design process of the wideband and multiband PIFA can be described using the Figure 1 as follows. The PIFA has a radiating patch which is mounted on a dielectric substance of FR4 which has a dielectric constant of 4.4. The
patch is not a conventional rectangle shaped. The patch has different structures similar to a monopole antenna and a jaw like structure consisting various number of monopoles. Each monopole structure will be resonated at a certain frequency and this frequency can be controlled by changing the length of the monopoles. The monopoles are designed in such a way that the resonating frequencies are very near to each other creating a wideband antenna which is also a multiband antenna. The main patch is connected to the feed using a line feed which is made of the same metal as the radiating patch. The radiating patch has been shorted to the ground plate using the shorting plate made of same material as the patch and ground. To increase the gain and directivity of the antenna the ground plate is introduced with the circular shaped slots as shown in Figure 2.

3. Results and Discussion

The analysis of the proposed PIFA is performed by ANSYS HFSS tool to optimize the antenna parameters for the desired frequency bands. The simulated reflection coefficient has been plotted in figure 3. The PIFA is working as proposed in a wideband from 1.69GHz to 4.57GHz with a width of 2.88GHz. The bandwidth obtained covers the DCS1800, PCS1900, WCDMA2100, LTE1800, LTE1900, LTE2400, LTE2500, WIFI400, 5G(3.3Ghz-4.6GHz) and WIMAX3400.

The radiation pattern in 3D of the proposed PIFA is shown in Figure 4. It’s observed that the radiation pattern is observed to be an omnidirectional pattern. It is observed that the maximum gain that the proposed PIFA is reaching 5db which is a huge number for a PIFA. The VSWR of the proposed PIFA is shown in Figure 5.
A new compact wideband PIFA for mobile phone is proposed. The proposed PIFA is designed to operate in DCS1800, PCS1900, WCDMA2100, LTE1800, LTE1900, LTE2400, LTE2500, WIFI2400, 5G(3.3Ghz-4.6GHz) and WIMAX3400, and WIMAX3400 bands. Since the proposed PIFA is of small size and simple geometry, it is easy to manufacture and integrate in the case of mobile phones. Three slots were added to the radiating patch and the ground plane to generate four operating bands, which can be controlled independently by adjusting the antenna parameters. Good radiation characteristics have been obtained which are omnidirectional in nature. The antenna gain is maximum at 5dB which is helpful when mixed with other components of the mobile phone as they might affect the performance of antenna. The effect of other mobile phone components on the reflection coefficient is considered to be less important as the return loss is maximum at -34dB.

References


