A Hexa-band Coupled-fed PIFA Antenna for 4G Mobile Phone Application

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***Abstract*-A coupled-fed microstrip antenna for 4G mobile system is presented. The PIFA antenna operates at 704-960 MHz and 1710-2170 to cover frequency bands of LTE 700/850/900/1800/1900/2100(Tx/Rx). An L-shaped coupled-fed structure, an inductor and a shorting line to ground are compactly designed together to create dual resonances at both low and high bands to achieve wide bandwidth and better impedance matching. The overall dimension of mobile system is 58×119×1.2mm^3 and the antenna size occupies area of 58×16mm^2.**

***Index Terms*-PIFA (planar inverted-F antenna); coupled-fed; LTE(Long Term Evolution); multiband**

I. INTRODUCTION

With the vast development of science and technology and people's increased demands on communication, today's mobile terminals need to operate in more than one standard, such as WAN, WLAN, GPS, BT and RFID [1-5]. Particularly, WAN is more important to support multimode and multiband for voice and data communications. The new generation mobile terminal typically needs to support 2G, 3G and 4G network, including LTE700(704-787MHz), GSM850(824-894MHz), GSM900(880-960MHz), GSM1800(1710-1880MHz), GSM1900(1850-1990MHz) and UMTS(1920-2170MHz). How to design a compact and multiband antenna is always a challenge.

In this paper, a coupled-fed [6-8] PIFA antenna is proposed. The PIFA consists of a ground plane, a top patch, a feed wire, a shorting line, an inductor and a plastic housing. The coupled-fed method and an inductor are used to improve matching and increase bandwidth. The shorting line can add one resonant mode. Section □ describes the details of each part of the proposed antenna design. Section Ⅲ analyze and discuss the simulation results, and lastly a conclusion is summarized in section □.

II. ANTENNA DESIGN

The configuration of the proposed PIFA antenna for mobile phone application is given in Figure 1(a). The substrate is put in the center of the 1 mm thick plastic box with relative permittivity of 3, loss tangent of 0.02, and dimension of 58×119×11.2mm^3. In this paper, the PIFA antenna is printed on a 1.2 mm thick FR4 material substrate (size 58×103 mm^2). The relative permittivity of FR4 is 4.4 and dielectric loss tangent is 0.02. Figure 1(b) shows the ground plane, which is under the substrate.

Figure 1(c) shows the detailed dimensions of the antenna pattern in its planar structure. For proof of concept study, the antenna material setting is simplified as PEC. The antenna is printed on the non-ground portion mostly and occupies a wide radiating plate of size 16×58 mm^2. The L-shaped coupled-fed is used to replace direct-fed to increase the resonant bandwidth significantly. Point A of L-shaped feeding strip is the antenna's feeding point. The antenna and ground plane are connected by shorting point B. In addition, to ensure enough electrical length and bandwidth, a chip inductor with size of 1.7×2 mm^2 and inductance of 3.2 nH is proposed at point C.

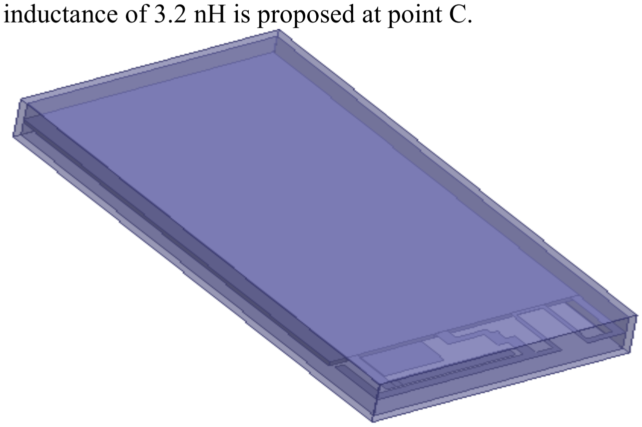

Fig. 1(a). Geometry of the proposed antenna.

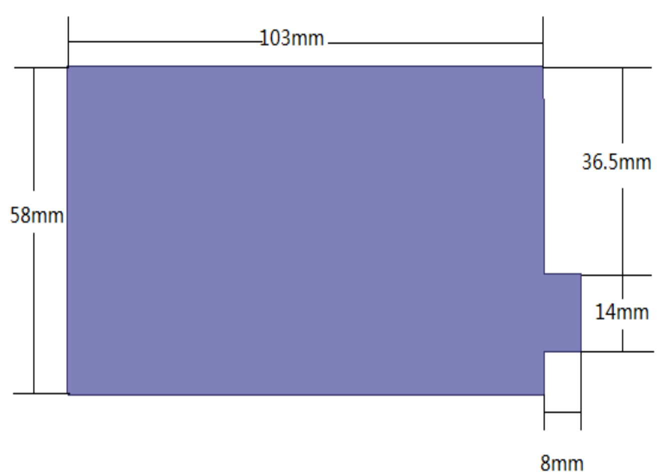

Fig. 1(b). Geometry of the ground plane.

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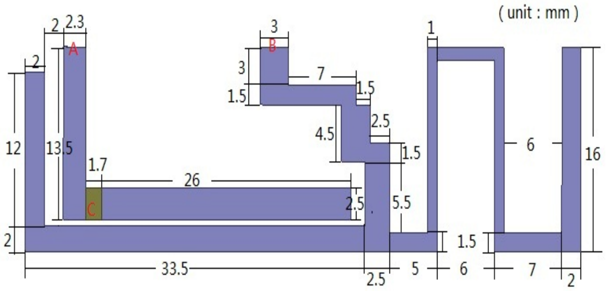

Fig.1(c). Detailed dimensions of the antenna pattern.

III. RESULTS AND DISCUSSION

The proposed antenna for multiband phone application was studied and simulated by software. Figure 2(a) gives the simulated return loss (3:1 VSWR) of L-shaped coupled-fed method. Obviously, the operating bandwidth and impedance matching of direct-fed is quite poor. The lower and higher band are formed by two adjacent resonant modes respectively where low band covers bandwidth from 683 MHz to 977MHz and high band covers from 1697 MHz to 2379MHz. This can be explained by the following: For the low band, the first resonance is from feeding point A coupling to bottom arm toward the meander line end, similarly like a traditional inverted L antenna. The second resonance is from coupled structure between feeding point A and ground point B, this is evidenced by the frequency shift observed in experiment when changing coupling gap and inductor value. Properly tuning the two resonances closer can enhance low band bandwidth reported in Fig.2 (a). For the high band, the first resonance is from the third resonance of long inverted L meander line arm, the second resonance is from coupling feed A connected arm itself.

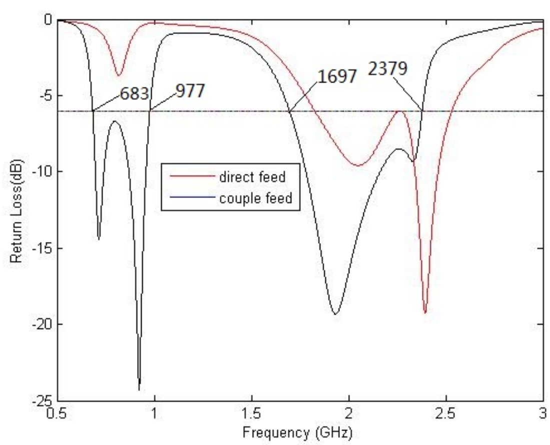

Fig.2(a). Simulated return loss of the proposed antenna.

Figure 2(b) shows comparisons of return loss with different inductance, the inductance varies from 2.2nH, 2.7 nH, to 3.2nH. As we can see, the inductor can shift the resonant frequency because it increases the effective electrical length. When the inductance is higher, the effective electrical length is longer, therefore the resonant frequency is shifted lower.

To better understand the antenna principle, Figure 3 shows the surface current distribution simulated on the proposed antenna's top radiator at f1=0.7GHz and f2=1.9GHz. The red part indicates a strong field and the blue part indicates a weak field. As we can see, the strongest field of low frequency is at grounding line whereas the strongest field of high frequency is distributed on feeding line, which further proves our explanations of this antenna.

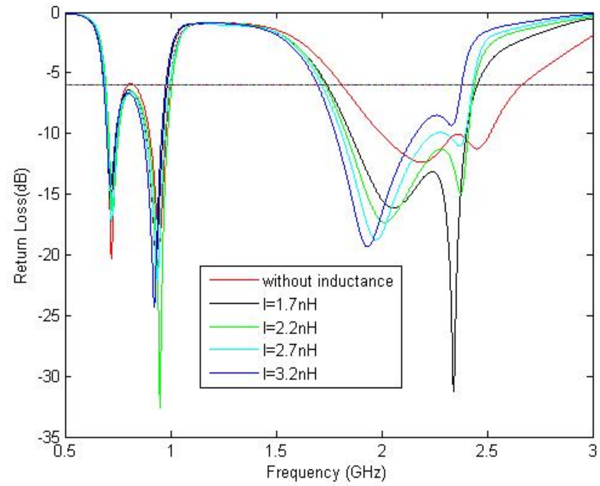

Fig. 2(b). Simulated return loss for the proposed antenna.

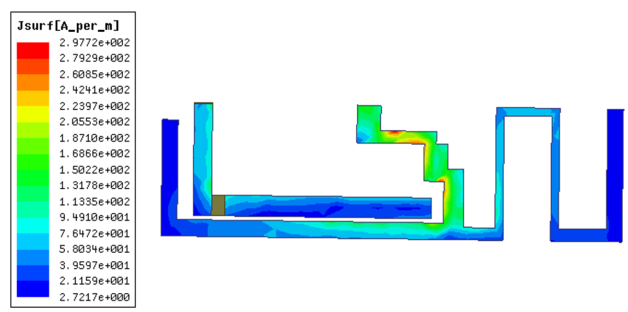

Fig .3(a). The surface current distribution simulated on the proposed antenna's top radiator at f1=0.7GHz.

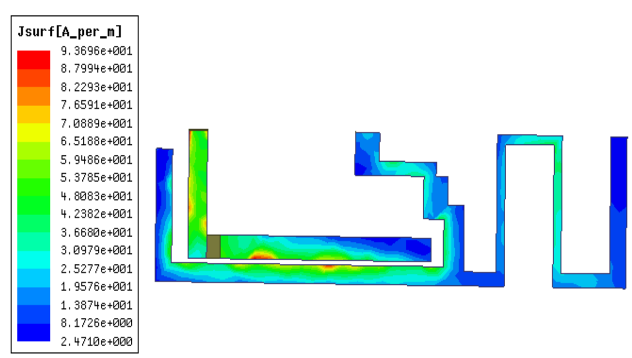

Fig. 3(b). The surface current distribution simulated on the proposed antenna's top radiator at f1=1.9GHz

IV. CONCLUSIONS

In this paper, a compact L-shaped coupled-fed PIFA antenna is proposed. An inductor, a shorting line and coupled-fed are designed together to create dual resonances at both low and high bands and better impedance matching. The antenna covers very wide bandwidth from 683 MHz to 977MHz for low band and 1697 MHz to 2379MHz for high band good for potential LTE700, GSM850, GSM900, GSM1800, GSM1900, UMTS applications. The future work will focus on antenna prototype and efficiency measurement and report results shortly.

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