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Design and Implementation of Antenna for Sub-6 GHz Applications in 5G Mobile Terminals

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***Abstract*— A simple planar antenna for sub-6 GHz applications in 5G mobile terminals is presented. The proposed antenna is composed of one multi-branch driven strip and three parasitic grounded strips, featuring simple design without using three-dimensional structure and lumped elements. The |S11| ≤ -6dB impedance bandwidth of the antenna covers 700-960 MHz and 1600-5500 MHz bands with a compact size of 40×15×0.8 mm3 , which makes it fulfil the requirements of sub-6 GHz applications in the 5G terminals. The prototype of the antenna is fabricated, and the design is well validated by experimental results.**

I. INTRODUCTION

With the rapid development of wireless communication technologies, 2G/3G/4G standard has been widely used. For current mobile terminal antennas, it is a basic requirement to cover 2G/3G/4G bands, including Long Term Evolution(LTE) 700/2300/2500 (698-787/2300-2400/2500-2690 MHz), UMTS (1920-2170 MHz), GSM 850/900 (824-894/880-960 MHz), DCS (1710-1880 MHz), and PCS (1850-1990 MHz) bands. However, to meet the recently proposed 5G NR standards, i.e., n77 (3300-4200 MHz), n78 (3300-3800 MHz), and n79 (4400-5000 MHz), such bandwidth is not enough. Therefore, it is highly desirable to design a 5G terminal antenna with wideband performance to fully cover all the 2G/3G/4G/5G bands..

Recently, several methods have been proposed to extend the bandwidth of mobile phone antennas, such as using matching networks with lumped elements [1, 2], frequency reconfigurable technique [3, 4], and multimode resonance technique [5, 6]. In [1], an octa-band WWAN/LTE monopole antenna with a lumped highpass matching circuit was proposed. However, because the matching circuit is not ideal, the resistance of the matching circuit will introduce additional losses, at the same time, it also makes the working frequency band sensitive to the value of lumped elements. In [3], a reconfigurable antenna using a PIN diode for WWAN/ LTE application was also presented. PIN diode needs additional space for its DC control circuit and brings extra loss as well, which limits its practical usage. Compared with the above-mentioned two methods, multi-mode resonance technique is more convenient to fulfill the antenna optimization. In [5], a broadband antenna with multiple resonant modes was proposed for mobile handset applications, but a relatively large clearance area was needed in the design. In order to reduce the clearance area, limited designs folded the antenna into three-dimensional structures [7, 8]. Although doing so reduces the lateral size occupied by the antenna, it requires additional area in the vertical direction and at the same time it also increases the difficulty in manufacturing.

In this letter, a simple planar antenna design for sub6 GHz applications in 5G mobile terminals is proposed. The presented antenna has a fully planar structure and no lumped elements are required, which makes it a simple structure and easy to be fabricated. Compared with other planar antenna designs, the antenna dimension provided in [5] and [6] is 68×15 mm2 and 60×15 mm2 , respectively, while the antenna dimension provided in this paper is only 40×15 mm2 , which occupies at most 67% of the clearance areas in [5] and [6] but has a wider frequency band. The measured |S11| ≤ -6dB bandwidth covers 700- 960 and 1600-5500 MHz bands, in which all the LTE 700/2300/2500, UMTS, GSM 850/900, DCS, PCS, and n77, n78, n79 bands are included.

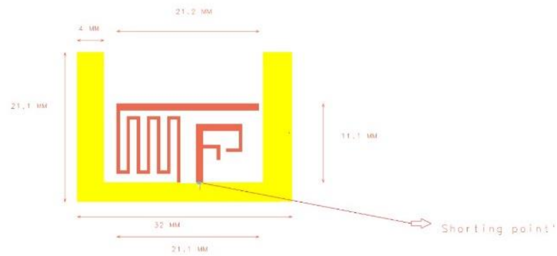

Fig. 1. Configuration of the antenna.

II. ANTENNA STRUCTURE

The configuration of the antenna element is shown in Fig. 1. The antenna is composed of three layers where a 0.8 mm thick dielectric substrate (ε_r=4.4) is located at the middle while the top layer and the bottom layer are both copper layers. The bottom layer is highlighted in dark gray color and that of the top layer is in light gray color. A 50-Ω resistor is connected to at the shorting point which is located at the edge of the bottom of top layer as shown in Fig.1.The ground plane is a part of the bottom surface of the substrate with the size of 32 * 21.1 mm. the antenna is composed of multi-branch driven strip. The driven strip has two branches as shown in the fig.2 , which printed on the top surface of

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substrate and is connected to a coaxial line at the feeding point .

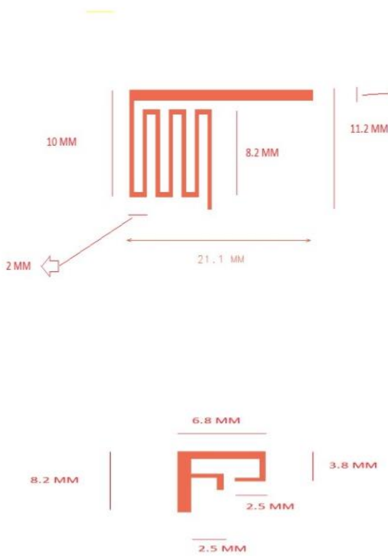

Fig. 2. Branches

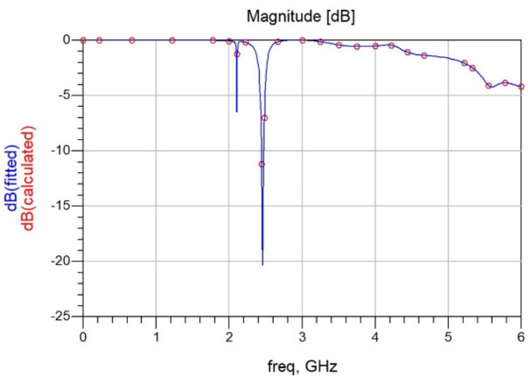

Fig. 3. simulated S_{11} result

III. RESLUTS

The simulated S_{11} result is presented in Fig. 3. The bandwidth with S_{11}<-10 dB is ranging from 2.12GHz to 2.7GHz, which covers <-20, enough to cover the 5G .The radiation pattern for 2.22 GHz is demonstrated in Fig. 4.this is the narrow band waveat 2.5 GHz.

To verify the proposed antenna is a good candidate for mobile communication, the beamforming characteristic is also studied by simulation. An 8-element array along the *x*-axis is analyzed. The distance between the adjacent elements is 5 mm. When the adjacent elements have a 110° phase shift, the main lobe of the array radiation pattern is shown in Fig. 4(a); and that with a 0° phase shift is shown in Fig. 4(b). According to

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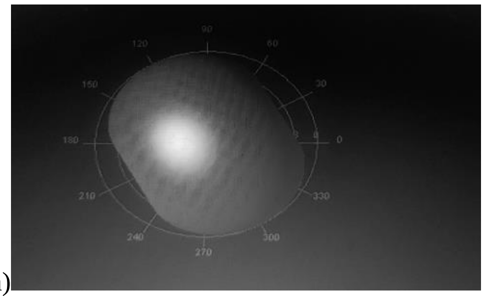
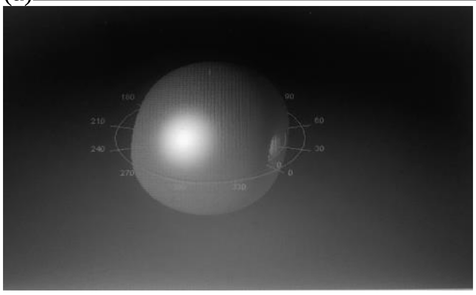


(a)



(b)

Fig. 4. Radiation pattern for the antenna at 2.22 GHz : (a) top view; (b) side view.

Fig. 4, the main lobe of the radiation pattern is able to shift significantly with a stable realized gain by adjusting the phase difference among the antenna elements. The simulated gain of the 8-element array at 2.22 GHz is up to 13.8 dBi, which is potentially sufficient to apply in the 5G mmW communication.

IV. CONCLUSION

The propsed antenna has broadband characteristic to cover 2.22GHz bands for 5G communication. An 8element array is also studied to verify the proposed antenna can be a good candicate for terminal device applications.

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