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Compact Dual-band Microstrip-line Antenna for 5G Handphone

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Abstract—A compact, dual-band microstrip-line antenna for 2.4 GHz wireless local area network (WLAN) application and n78 (3.5 GHz) band in 5G handphone is proposed. The antenna consists of a feeding microstrip line, a coupling microstrip line, and a loaded capacitor to achieve the dual band operation. The simulated results show -7.5 dB impedance bandwidths ranging from 2400 MHz to 2480 MHz and from 3320 MHz to 3720 MHz. The efficiency within the band is above 72% at the low band and above 95% at the high band. The peak gains are 3.3 dB at 2400 MHz and 4.0 dB at 3300 MHz which is excellent for such a low-profile antenna.

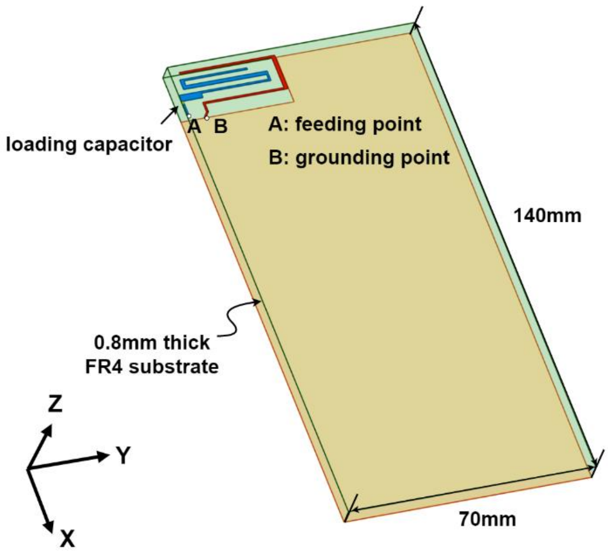
***Keywords* — Microstrip, dual-band, WLAN/5G, Handphone antenna.**

I. Introduction

In contemporary era, mobile phones are witnessing a rapid development as personal information terminal. With the advent of 5G communication, which offers faster processing speed and more advanced functions, mobile phone antenna as a key component to enabling functions of smartphone is desired to have a compact size, simple layout and superior performance [1]. Among various types of antennas, microstrip patch antennas are highly preferred in many applications due to their advantages such as thin thickness, light weight and compact size. However, this type of antenna usually operates in a single frequency band. It is required that mobile phone antennas can effectively operate in multiple bands for multiple functions especially for 5G and future smart handphones. Therefore, numerous techniques have been introduced to enable the operation of multi-band antennas including resonance branching method, frequency doubling resonance design and addition of parasitic branches. In addition to these basic techniques, advanced methods such as incorporating LOOP structures, reconfiguring PIN diodes [2] and employing loading techniques (i.e., adding LC collector elements between antennas) have been proposed to achieve resonance with shorter microstrip lines. Hence, this paper focuses on the implementation of loading technique [3] to optimize the performance of microstrip-line antenna for multi-band operations.

II. Antenna Design

Fig. 1 (a) illustrates the geometry of the proposed antenna and key parameters of the antenna are given in Fig. 1(b). It consists of two microstrip lines, namely the feeding microstrip line (blue part) and the coupling microstrip line (red part) printed on the top left of a 140 mm × 70 mm FR4 substrate (a relative permittivity of 4.4, a thickness of 0.8 mm and a loss angle tangent of 0.002.) and a ground plane. The coupling microstrip line and a capacitor-inserted feeding microstrip line form an embedded parallel structure (PR) within a 32 mm × 14 mm area [4]. The resonant mode of this configuration is excited by the capacitor-inserted feeding microstrip line. Two resonant frequencies at 2400 MHz and 3500 MHz are successfully achieved through loading an equivalent capacitor of approximately 0.31 pF at an optimized position in the feeding line [3]. To broaden the bandwidth at the high-frequency band, the coupling microstrip line is introduced. The coupling gap serves as a distributed capacitor, successfully inducing surface currents on the coupling microstrip coupled from the feeding microstrip.



(a)

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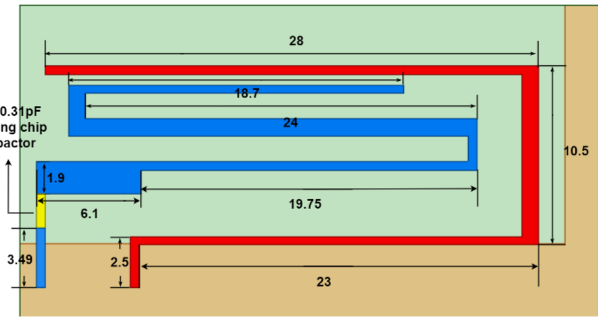


(b)

Fig. 1. Proposed antenna (a) layout inside a handphone and (b) key parameters in detail (Unit: mm).

III. Simulated Results

The simulated reflection coefficients of the reference antenna and the proposed antenna are compared in Fig. 2. The resonant frequency of the reference antenna is approximately 3.0 GHz. Upon loading the capacitor with an optimized capacitance of approximately 0.31 pF and proper position of 3.58 mm from the feeding point, two resonant frequencies are excited, exhibiting a good -7.5 dB impedance match within the frequency range of 2400-2480 MHz and 3320-3720 MHz which is sufficient to cover 2.4 GHz WLAN application and n78 band (China) in 5G spectrum.

Fig. 3 (a), (b) and (c), (d) show the simulated radiation patterns at 2.4 GHz and 3.5 GHz, respectively. The antenna provides a good radiation surrounding the antenna and stable radiation characteristic at both frequency bands especially in the XOZ plane. It achieves a peak gain of 3.3 dB for the WLAN application and 4.0 dB at the n78 frequency band for 5G communications.

Fig. 4 illustrates the simulated radiation efficiency within the 2400 MHz-3600 MHz frequency band. It achieves a radiation efficiency of 72% to 76% in the low WLAN frequency band (2400-2480MHz) and 95% to 96% in the high 5G n78 frequency band (3320-3600MHz). These radiation characteristics indicate that the proposed antenna is well-suited for practical 5G mobile phone applications.

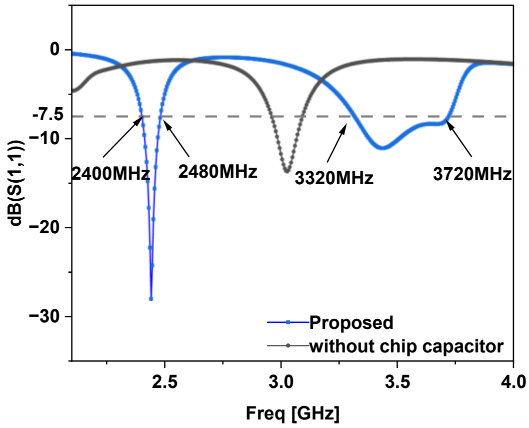
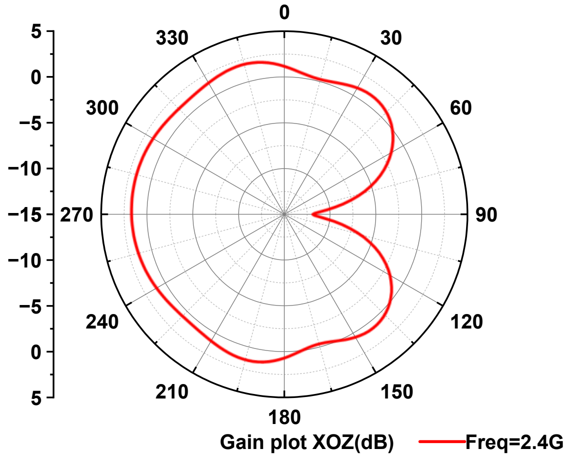
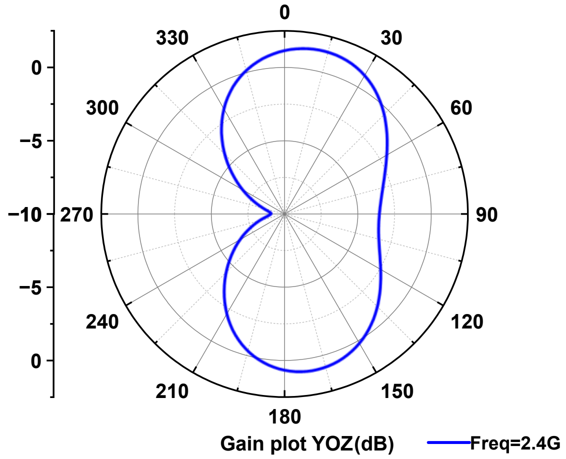


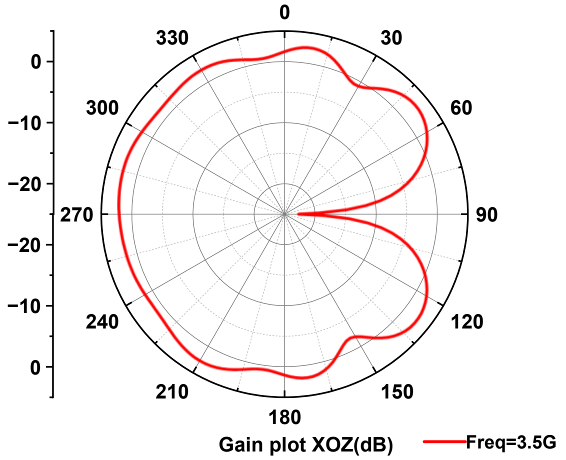
Fig. 2. Simulated reflective coefficients for the proposed antenna and a reference antenna without the capacitor loaded.



(a)



(b)



(c)

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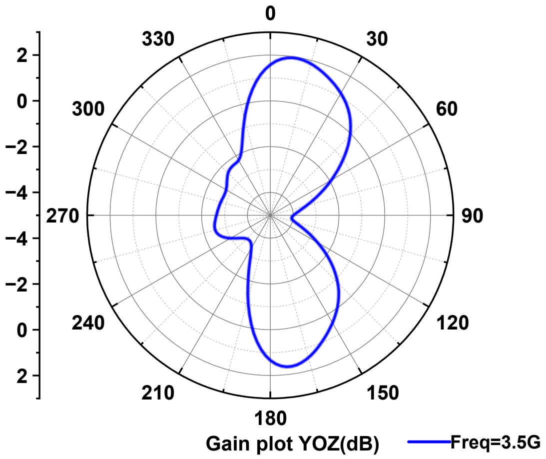

(d)

Fig. 3. Simulated 2-D radiation patterns of the proposed antenna at (a) 2400 MHz (XOZ), (b)2400 MHz (YOZ), (c) 3500 MHz (XOZ), (d) 3500 MHz (YOZ).

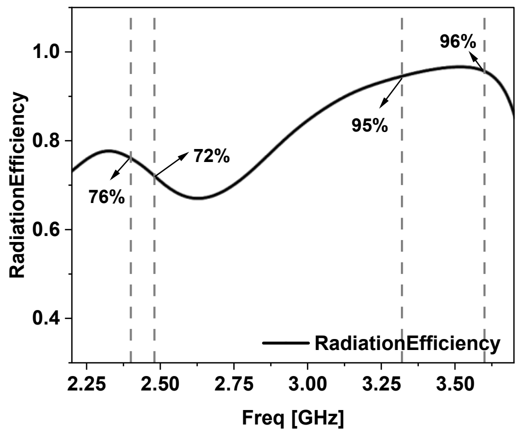

Fig. 4. Simulate radiation efficiency of the proposed antenna.

IV. CONCLUSION

A compact, dual band antenna based on microstrip-line structure has been proposed. Simulated results show its good impedance bandwidths and satisfying radiation patters, efficiency for WLAN/5G applications in mobile phones.

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