A Four-Arm Planar Monopole Antenna for Smart Phone Applications

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1. Introduction

The interests in developing compact antennas for smart mobile phones have been raised dramatically in recent years [1]-[3]. A smart phone integrates multiple wireless services into a single handheld unit and deeply urges for a compact multiband antenna element for covering all the operating bands. Various printed monopole antennas for dual band or multi-band applications have been proposed in the literature [4], [5].

In this paper, we propose a new four-arm planar monopole antenna for multi-band operation. According to the experimental results, the proposed design covers the frequency bands including the 900-MHz GSM, 1800-MHz DCS and 2.4-/5.2-/5.8-GHz WLANs (i.e. IEEE 802.11 a/b/g). The antenna configuration and design concept will be described in Section 2, and the simulated and measured results will be discussed in Section 3. This paper is concluded with a brief summary in Section 4.

2. Antenna Configuration and Design Concept

The geometry of the proposed monopole antenna is shown in Fig. 1. The proposed antenna was fabricated on a FR4 substrate with a dielectric constant of 4.4 and thickness of 0.8 mm. The antenna consists of four radiating arms and occupies an area of 40×25 mm^2. As depicted in Fig. 1, the antenna is fed by a 10-mm long microstrip line. The feed gap between the four radiating arms and the microstrip line is described by a linear tapered profile which helps improving the in-band impedance matching. The lower two arms serve as the primary radiating elements whereas the upper two ones function mainly as the tuning elements for widening the antenna impedance bandwidth. Similar to a square planar monopole, the proposed antenna inherently possesses a wide impedance bandwidth, which is from 1.5 to 4 GHz in the simulation. To further extent the antenna operating frequency range, in the proposed design an additional current path, E-A-B-D, is used to excite an extra resonance mode at the GSM band. The operating bands at 5.2 and 5.8 GHz, on the other hand, are substantially introduced by the current path A-B-C along with the stub D. The optimal design parameters are simulated by Ansoft HFSS 10.1, and are given as follows: L=10mm,

L_1=8.5mm, L_2=2mm, L_3=12.5mm, L_4=12.5mm, L_5=1mm, L_6=9.5mm, L_7=2mm, L_8=2.5mm, L_9=2mm, L_{10}=1.5mm, L_{11}=3mm, L_{12}=3mm, W_1=22.5mm, W_2=13.5mm, W_3=11mm, W_4=17.5mm, W_5=3.5mm, W_6=1.5mm, W_7=0.5mm, W_8=1mm, W_9=2.5mm, W_{10}= W_{11}= $W_{12=}$14.5mm, W_{13}=1.5mm.

3. Simulation and Measurement Results

Figure 2 compares the simulated and measured return losses of the proposed antenna. The measurement was taken by an Agilent network analyzer E8362B. Fairly good agreement between the results can be observed. The discrepancy can be mainly attributed to the inaccurate modeling of the excitation. The measured antenna bandwidths with return loss greater than 10 dB are 1.62 - 2.61 GHz, 3.11 - 4.33 GHz, 5.02 - 5.37 GHz, and 5.74 - 5.84 GHz. The antenna features a 2.5-dB return loss bandwidth from 890 to 960 MHz as well. The radiation patterns were measured in an anechoic chamber at National Taiwan University of Science and Technology. The simulated and measured xy-plane and yz-plane pattern at 1.8, 2.4 and 5.8 GHz are shown in Figs. 3 to 5. The yz-plane radiation patterns remain quite omnidirectional as expected. The xz-plane ones, on the other hand, feature a dumbbell shape over the frequency band of interest. Figure 6 illustrates the measured antenna peak gains. The peak gain ranges from 0.8 to 3.2 dBi from 1.8 to 5.2 GHz.

4. Conclusion

A novel multi-band planar monopole antenna for smart phone applications has been proposed in this paper. The antenna covers the frequency bands including 2G/3G mobile phones and 2.4-/5-GHz WLANs. The antenna is realized by the standard printed circuit board technology and can be easily integrated with other RF and baseband circuitries.

References

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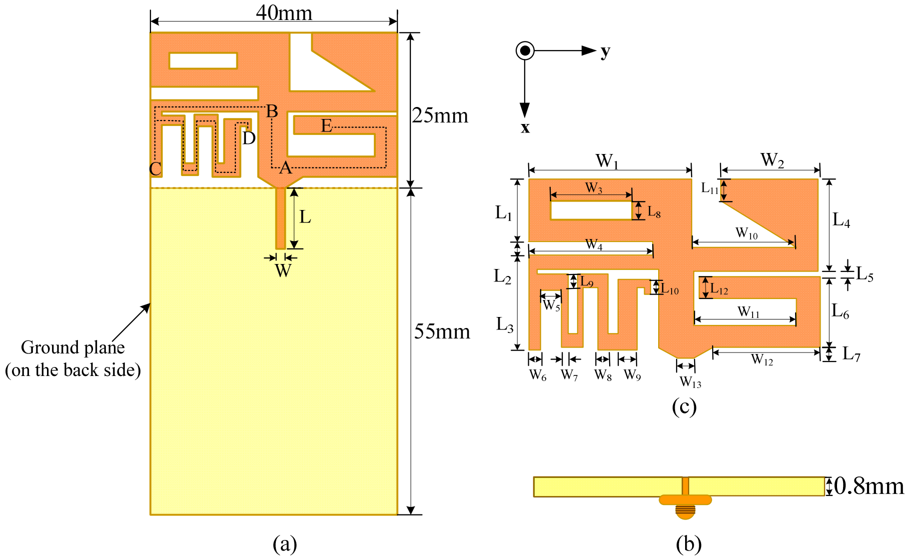

Fig. 1 The configuration of the proposed planar monopole antenna. (a) Top view (b) Cross-sectional view (c) Detailed dimensions of the radiating element.

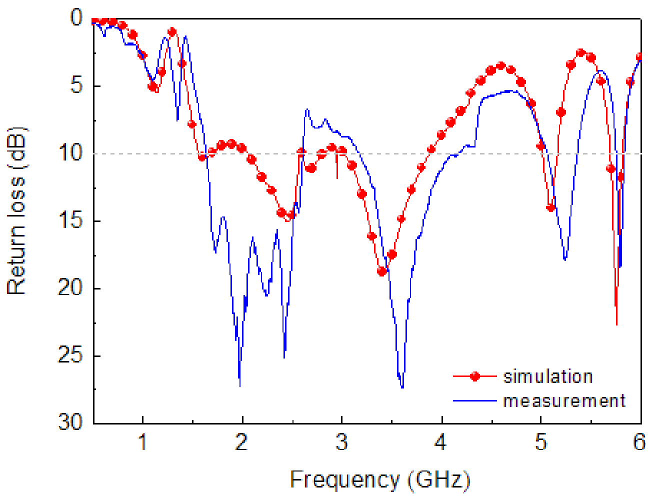

Fig. 2 Measured and simulated return losses of the propose antenna.

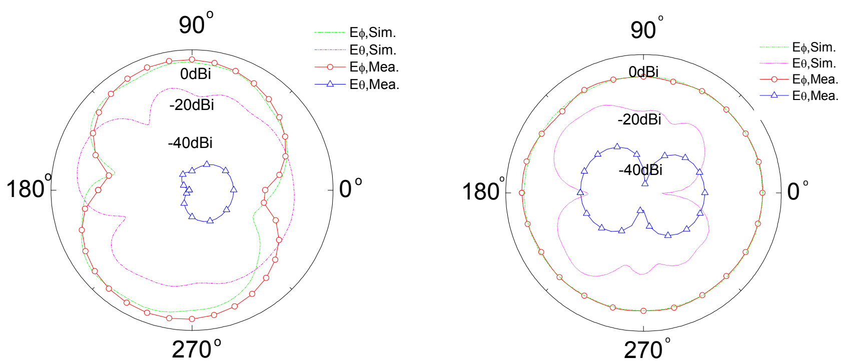

Fig. 3 Measured radiation patterns at 1.8 GHz. (a) xy-plane (b) yz-plane.

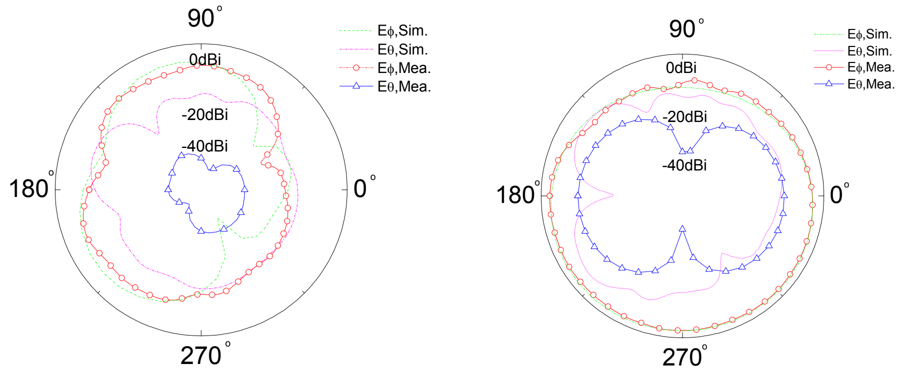

Fig. 4 Measured radiation patterns at 2.4 GHz. (a) xy-plane (b) yz-plane.

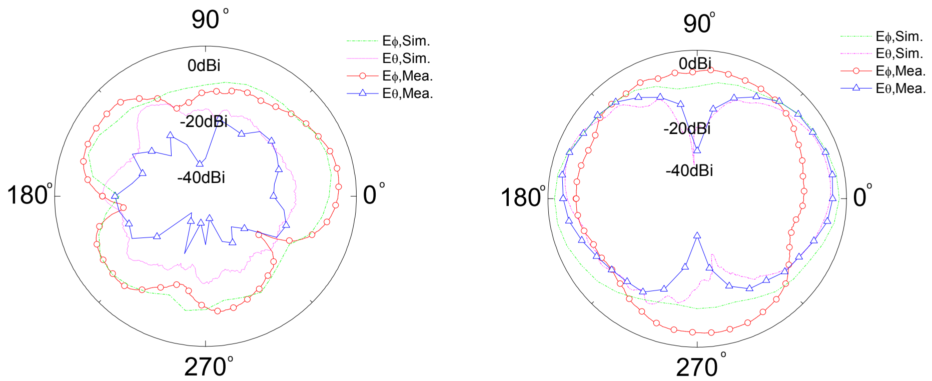

Fig. 5 Measured radiation patterns at 5.8GHz. (a) xy-plane (b) yz-plane.

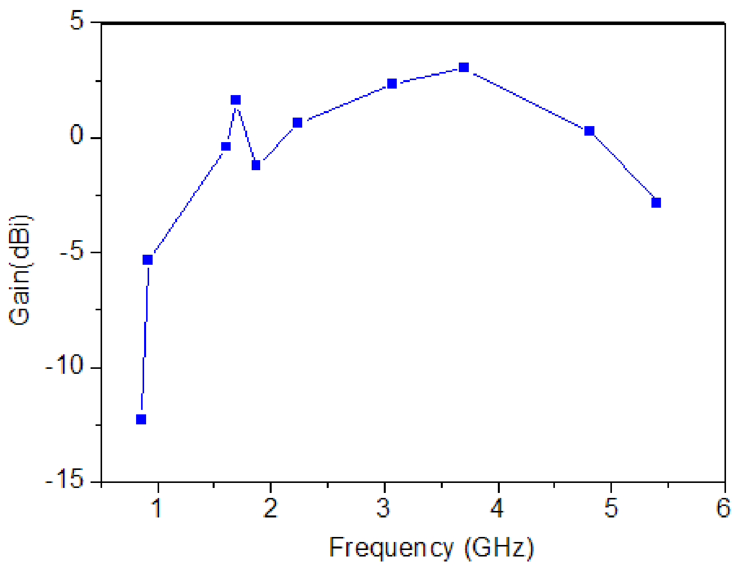

Fig. 6 Measured antenna peak gain