A Novel Monopole Antenna for Dual-Band Operation

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Introduction

Planar monopole antennas have good qualities due to wide impedance bandwidth, simple, omnidirectional radiation pattern and ease of construction. Several planar monopole geometries have been proposed providing wide impedance bandwidth [1-4]. These available broadband designs, however, are only for single-band operation. Very few designs of probe-fed patch antennas with a single rectangular radiating patch have been reported for the capability of broadband dual-frequency operation.
In this paper, we demonstrate a novel dual-band operation antenna design utilizing a Λ shape ground plane and a 50 Ω SMA connecting to a planar patch. The proposed antenna is suitable for applications in mobile phones for GSM (Global System for Mobile communication, 890–960 MHz), DCS (Digital Communication System, 1710–1880 MHz) and PCS (Personal Communication System, 1850–1990 MHz) dual-band operations. In addition, owing to the proposed design, the antenna bandwidth of the proposed antenna is greatly changed from one mode operation to dual-frequency operation and good impedance is obtained. This characteristic makes it very promising for the proposed antenna placed within the planar base-station housing to enhance antenna gain of array design.

Antenna Design

Figure 1(a) shows the geometry of the proposed monopole antenna. The rectangular radiating patch is placed by a Λ-shaped ground plane, which comprises a square horizontal ground (dimensions $W \times W$), two rectangular slope grounds (dimensions $w \times H$) and a 50 Ω SMA connect backed from square ground to connected to the center of the radiating edges of the patch, and at that edge, the patch has a fixed flare angle β. The angle between the horizontal ground and the two sides slope ground is α. By tuning this angle; impedance matching of the proposed antenna can be improved. In this study, the optimal flare angle β was selected to be 170° and slope angle was selected to be 40°. For the square horizontal ground, it is mainly used for accommodating the probe feed and united the two sides slope ground. Its angle (α) has significant effects on improving the

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impedance matching of the two desired resonant modes to cover the GSM, DCS and PCS bands. An optimal angle of 40^o was chosen from experimental and simulative studies. The commercial simulation software Ansoft HFSS (High-Frequency Structure Simulator) is available for this study, which makes the optimal dimensions of the proposed antenna easy to determine.

Experimental Results and Conclusions

In the experiment, the dimensions of the radiating patch were selected to be 60 × 65 mm^2 ($\ell \times w$), the dimensions of horizontal ground were 20 × 20 mm^2 ($L \times W$) and rectangular slope grounds were (dimensions w × *H*). Note that, in this case, the length of the radiating patches 65 mm, which is about 20.3% referenced to its center frequency at 900MHz. When modulation if this angle is too small or too large, good impedance matching of the two desired resonant modes will be difficult to obtain. Measured and simulated return loss for the proposed antenna with an optimal angle of the ground ($\alpha = 40^o$) is presented in Figure 2. It is clearly seen that two separate resonant modes are excited with good impedance matching. The lower mode has an impedance bandwidth, determined by 1.5:1 VSWR or 14 dB return loss, of 200 MHz (790–990 MHz) or nearly about 22.4% referenced to its center frequency at 890 MHz. On the other hand, the upper band has a bandwidth as large as 460 MHz (1710–2170 MHz) or about 23.7% referenced to its center frequency at 1940 MHz. The two resonant modes cover the GSM, DCS and PCS bands. Also note that, in the proposed antenna, the length (65 mm) of the radiating patch is only about 20% of the wavelength of the center frequency (900 MHz) of the lower mode or about 22% of the wavelength at the center frequency (920 MHz) of the GSM band. This indicates that, in addition to the broadband dual-frequency operation obtained, the proposed antenna has an attractive feature of modulation mode operation in its rectangular slope grounds.

To demonstrate the effects of the angle on improving the impedance matching of the two desired resonant modes, Figure 2 shows the measured resistance and reactance of the proposed antenna with various values of α. In Figure 2, the cases of $\alpha = 0$, 20^o, 40^o, 60^o and 90^o mm are shown. It is seen that the impedance matching is greatly improved with increasing α. Conversely, measured return loss results for the cases ($\alpha = 60^o$and 90^o) shown in Figure 3 indicate that the impedance matching is degraded when α is further increased. These results suggest that there is an optimal value of α for achieving an improved impedance matching of the two desired resonant modes. Figure 4 plots the measured radiation patterns at center frequencies of the GSM, DCS and PCS bands for the proposed antenna with $\alpha = 40^o$. Good omni-directional radiation patterns are observed. Radiation patterns for other operating frequencies were also measured, and the radiation patterns for operating frequencies are stable across the GSM, DCS and PCS bands, and are similar as plotted in Figure 3. Figure 5 presents the measured antenna gain for operating frequencies across the GSM, DCS and PCS bands for the proposed antenna with $\alpha = 40^o$. For the GSM band, the peak antenna gain is about 3 dBi, with very small gain variations (less than 0.7 dBi) across the band. On the other hand, the DCS and PCS bands have a peak antenna gain 4.5 dBi, and the gain variations are less than 1.2 dBi.

Conclusions

A novel dual-frequency monopole antenna suitable for applications in GSM/DCS/PCS operations has been proposed and implemented. Two resonant modes with very good impedance matching have been obtained for the constructed prototype, and the obtained impedance bandwidths (1.5:1 VSWR) cover the operating bandwidths of the GSM, DCS and PCS bands. In addition, the proposed antenna has a simple structure and can be constructed with low cost.

Acknowledgment

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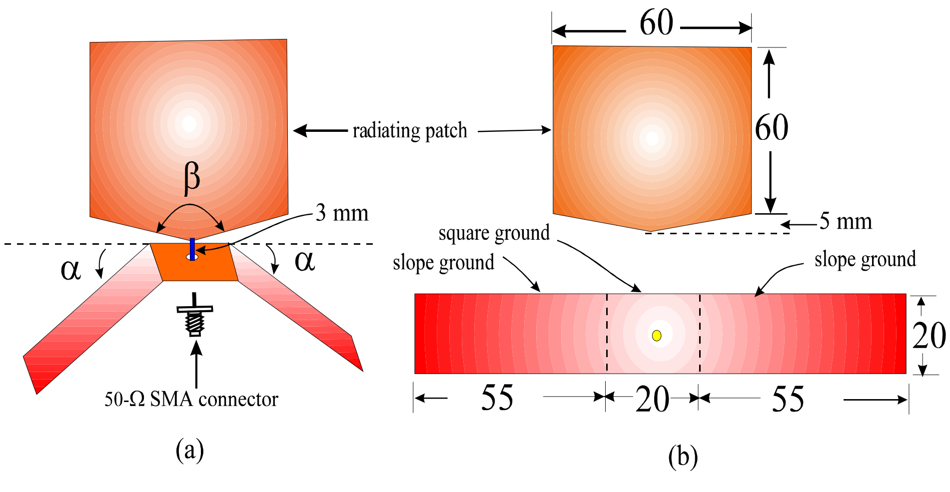

Figure 1. (a) Geometry of the proposed design mounted on top of a Λ shaped ground. (b) Dimensions of the proposed monopole unfolded into a planar structure.

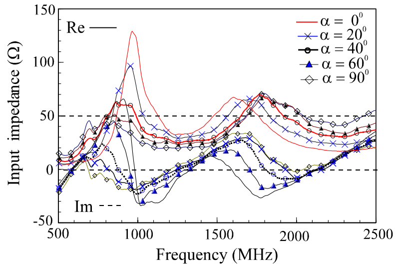

Figure 2. Measured resistance and reactance of the proposed antenna with various values of α.

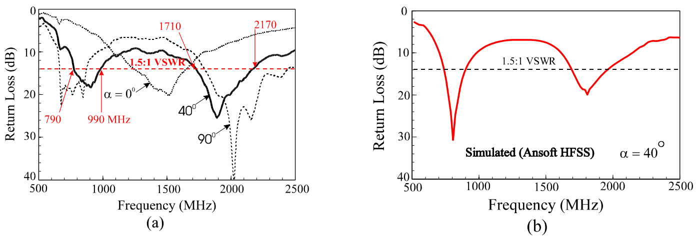

Figure 3. (a) Measured and (b) simulated return loss for the proposed antenna with various values of α = 40°.

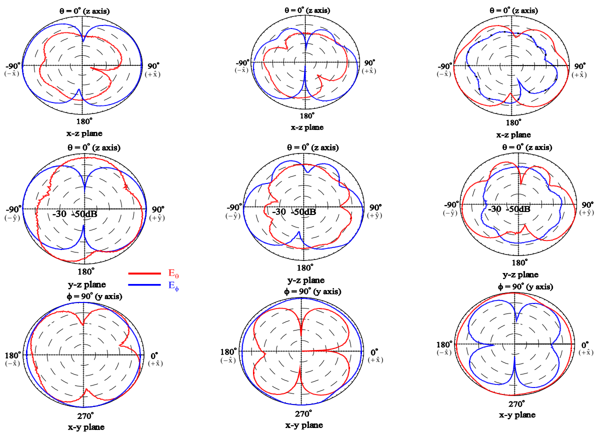

Figure 4. Measured and simulated radiation patterns at 900, 1800 and 1900 MHz for the proposed antenna.

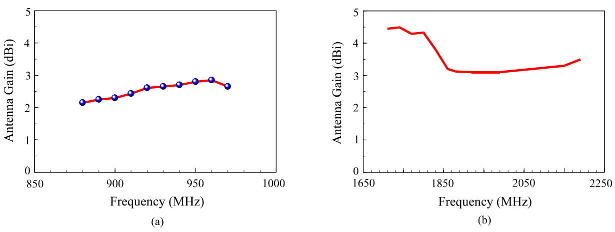

Figure 5. Measured antenna gain for the proposed antenna. (a) The GSM band; (b) The DCS/PCS band.