A WIDEBAND MONOPOLE ANTENNA FOR SDR AND UWB APPLICATIONS

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ABSTRACT

A small wideband microstrip-fed monopole antenna for mobile communication system is designed. The antenna has a wide bandwidth ranging from 1.65 GHz to 10.6 GHz for S_{11} < -10 dB. Various mobile communication services such as DCS, IMT-2000, UMTS, WiBro, WLAN, DMB, and UWB can be easily covered by the proposed antenna simultaneously. In this paper, details of the proposed antenna design approach and measured results are presented and discussed.

1. INTRODUCTION

Nowadays, mobile communication systems are becoming increasingly popular. Antennas for software-defined and / or reconfigurable radio systems need to have ultra-wide band or multi-band characteristics in order to be flexible enough to cover any possible future mobile communication frequency bands. One approach to provide such flexibility is to construct multi-band antenna that operates over specific narrowband frequencies. However, it would be extremely difficult to accurately achieve the frequency requirements of all future communication system. Alternatively, a small wideband antenna that covers a wide range of frequencies can be a good candidate not only for current multi-band applications but also for future communication systems operating on new frequency bands [1, 2].

Recently, it has been demonstrated that a wideband monopole antenna is promising to be used for mobile wireless devices such as notebook computers, mobile phones, and PDA phones [3, 4].

In this paper, a compact wideband microstrip-fed monopole antenna is designed to satisfy all the system requirements for DCS1800 (1.71–1.88 GHz), DCS1900 (1.85–1.99 GHz), IMT-2000 (1.885–2.2 GHz), UMTS (1.92–2.17 GHz), WiBro (2.3–2.39 GHz), WLAN (2.4–2.483 GHz), DMB (2.605–2.655 GHz), and UWB (3.1–10.6 GHz) simultaneously. Parametric analysis for the proposed antenna is performed by the experimental method.

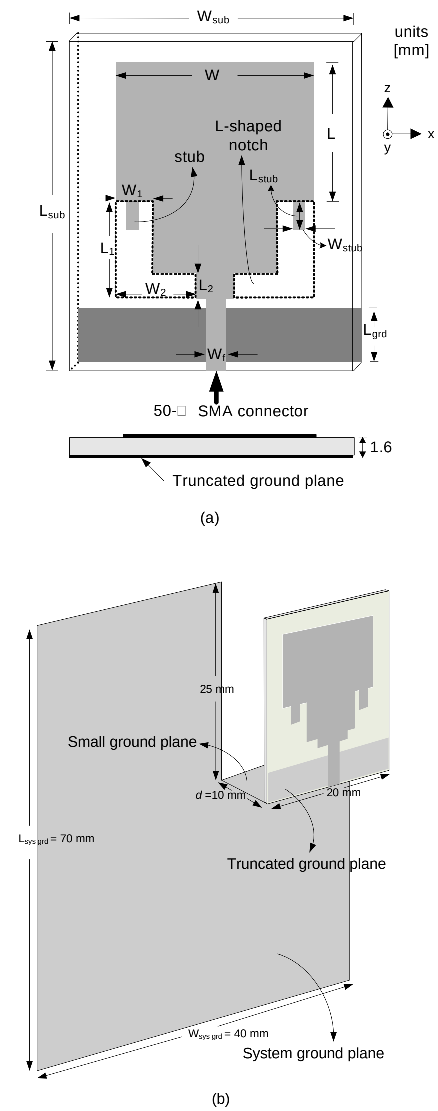


Fig. 1 (a) The basic configuration of the proposed wideband antenna (b) The configuration of the proposed wideband antenna including the system ground

2. ANTENNA DESIGN

Fig. 1 (a) shows the basic configuration of the proposed wideband antenna which consists of a radiating patch with two L-shaped notches and stubs at the lower corners and a truncated ground plane. The antenna, a compact dimension of 20 × 25 mm^2 (W_{sub} × L_{sub}), is constructed on FR4 substrate with thickness h of 1.6 mm and relative dielectric constant ε_r of 4.4. Fig. 1 (b) shows the antenna configuration including the system ground which simulates the case of a practical mobile phone or PDA phone. The proposed antenna is mounted on a small ground plane (10 × 20 mm^2) protruding from the system ground (40 × 70 mm^2).

A small 10 × 20 × 25 mm^3 space at one of the upper corners of the system ground plane is required to accommodate the antenna. The dimensions of the system ground plane are chosen to simulate a practical mobile phone or PDA phone. These dimensions ($W_{sys\ grd}$, $L_{sys\ grd}$) are also recognized as important parameters for determining the sensitivity of impedance matching at lower frequencies [5, 6].

A wideband characteristic of the proposed antenna is easily achieved by cutting two L-shaped notches and attaching two stubs to the radiating patch as shown in Fig. 1 (a). The L-shaped notches of suitable dimensions (W_1, L_1, W_2, L_2) improve the impedance matching performance at middle frequencies within the bandwidth of interest. This phenomenon occurs because the notches affect the electromagnetic coupling between the lower edge of the rectangular patch and the truncated ground plane [7].

To achieve good impedance matching at higher frequencies, two stubs (W_{stub}, L_{stub}) are appended to the radiating patch. The optimal dimensions of the designed antenna are as follows: $W_{sys\ grd}$ = 40 mm, $L_{sys\ grd}$ = 70 mm, W_{sub} = 20 mm, L_{sub} = 25 mm, W = 16 mm, L = 10.5 mm, W_1 = 3 mm, L_1 = 7.5 mm, W_2 = 7.5 mm, L_2 = 2 mm, W_{stub} = 1 mm, L_{stub} = 2.2 mm, *d* = 10 mm, W_f = 1.6 mm, and L_{grd} = 4 mm. The proposed antenna is designed to operate over the frequency band ranging from 1.65 GHz to 10.6 GHz.

3. EXPERIMENTAL RESULTS

Based on the design parameters shown in Fig. 1, the proposed antenna was constructed and its characteristics were analyzed. The simulated results were obtained using Ansoft simulation software High-Frequency Structure Simulator (HFSS) [8]. Fig. 2 shows the measured return loss curves for the proposed antenna with its L-shaped notches and stubs. As shown in Fig. 2, the fabricated antenna satisfies the 10 dB return loss requirement from 1.65 GHz to 10.6 GHz. For comparison purpose, the measured return losses of the antenna with only the L-shaped notches and of a simple antenna without notches and stubs are also shown in Fig. 2. It is found that the impedance bandwidth is improved effectively at frequencies between 4.5 GHz and 9 GHz by the addition of the notches. By appending the stubs, it is also observed that the impedance bandwidth is not only enhanced at higher frequencies above 9GHz but also slightly improved at lower frequencies.

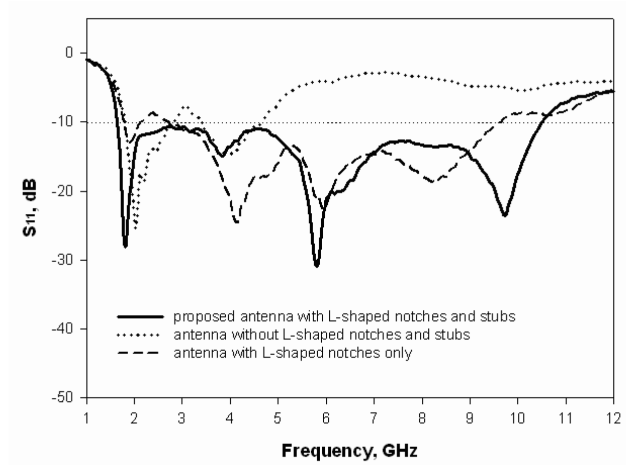


Fig. 2 Comparison of measured return loss characteristics for the proposed antenna, the antenna with L-shaped notches only, and a simple antenna without L-shaped notches and stubs

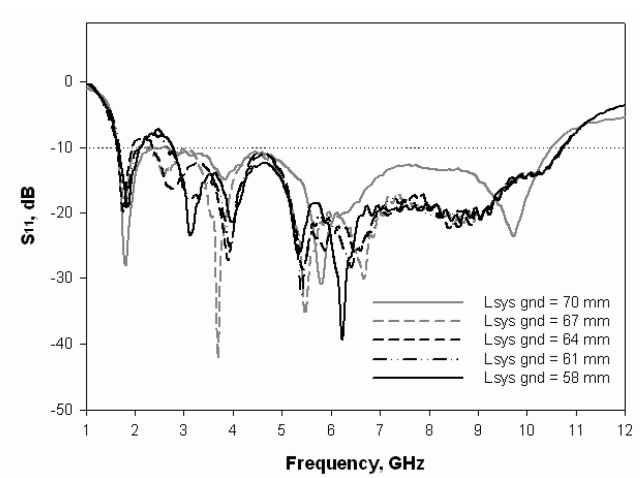


Fig. 3 Measured return loss for the proposed antenna with various lengths $L_{sys\ grd}$ of the system ground plane

In order to investigate the effects of system ground plane size on the proposed antenna, the return loss characteristics for various ground plane sizes ($W_{sys\ grd}$, $L_{sys\ grd}$) were analyzed; these are illustrated in Fig. 3 and Fig. 4. Fig. 3 presents the measured return loss for the proposed antenna with various lengths $L_{sys\ grd}$ of the system ground plane; the other dimensions are kept the same as those given in Fig. 1. From the results, it is observed that when $L_{sys\ grd}$ is smaller than 70 mm, the effects on the impedance matching of the proposed antenna is not significant at lower frequencies. Fig. 4 presents the measured return loss for the proposed antenna with various widths $W_{sys\ grd}$ of the system ground plane. In this study, the width $W_{sys\ grd}$ varies from 42 to 30 mm. It is seen that the variation of $W_{sys\ grd}$ has greater effect at lower frequencies than at higher ones.

These effects are mostly due to the change of excited surface current distributions on the system ground plane at low frequencies. In addition, it is seen that the surface current distributions on the system ground plane are more sensitive to the variation in $W_{sys\ grd}$ at lower frequencies.

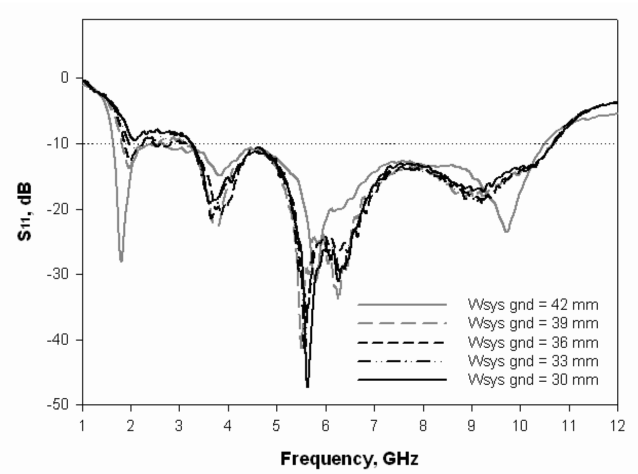
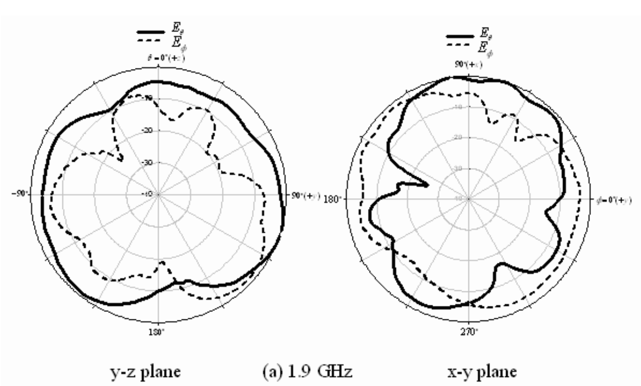


Fig. 4 Measured return loss for the proposed antenna with various lengths widths $W_{sys\ grd}$ of the system ground plane

Fig. 5 shows the measured radiation patterns for the proposed antenna at 1.9, 3, 6, and 9 GHz. Monopole-like radiation patterns in y-z planes are observed. The radiation patterns in the azimuthal plane (x-y plane) are approximately omni-directional, especially for the lower frequencies. Fig. 6 shows the measured antenna gain plotted against frequency. The antenna gain is varying from about 1.6 to 4.25 dBi across the entire bandwidth.



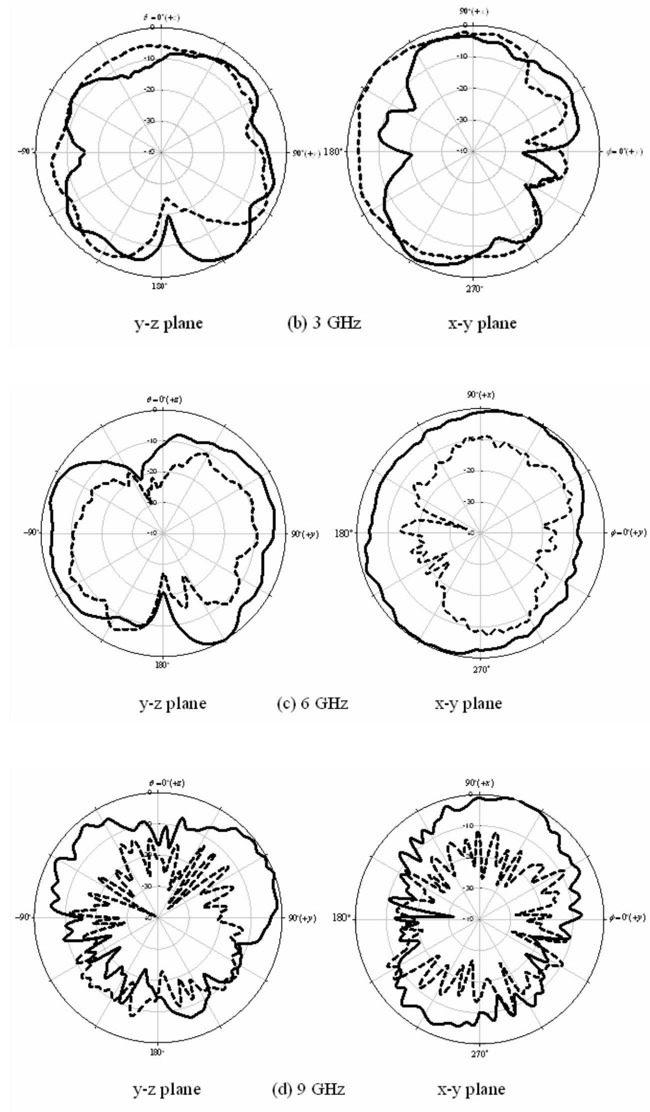


Fig. 5 Measured radiation patterns of the proposed antenna at: (a) 1.9 GHz. (b) 3 GHz. (c) 6 GHz. (d) 9 GHz

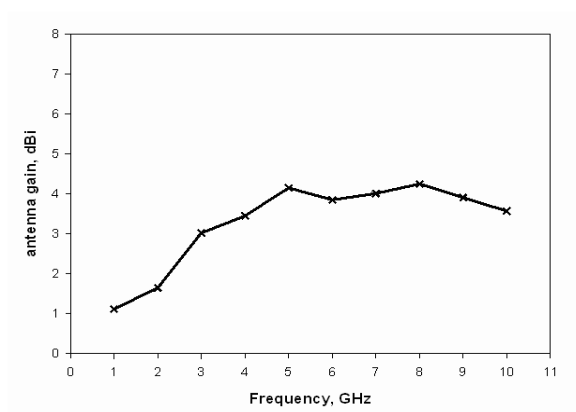


Fig. 6 Measured antenna gain of the proposed antenna

4. CONCLUSION

In this paper, a wideband monopole antenna suitable for various mobile communication applications is proposed. The designed antenna has a simple configuration and is easy to fabricate.

This antenna is capable of covering the existing DCS1800, DCS1900, IMT-2000, UMTS, WiBro, WLAN, DMB, and UWB bands at the same time. The proposed antenna could be a good candidate for SDR and UWB application due to its ultra wide-band characteristics.

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