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A highly compact dual-band WLAN/UWB monopole antenna

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Abstract: A highly compact microstrip-fed planar monopole antenna is proposed. It consists of a radiation patch, four stubs and a truncated ground. The antenna exhibits dual-band operation with −10 dB return loss bandwidths 0.45 GHz (2.20–2.65 GHz) and 5.23 GHz (6.52–11.75 GHz) in the lower band and upper band, respectively. Simulated and measured results show this antenna is suitable for WLAN, UWB and other wireless communication applications.

Keywords: UWB, dual-band antenna, WLAN, ground stub

Classification: Microwave and millimeter wave devices, circuits, and systems

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1 Introduction

In order to fulfill the goal of building a ubiquitous society, the integration of existing (like the well used 2.45 GHz WLAN) and future wireless systems is highly desired. Since the Federal Communications Commission (FCC) released the 3.1–10.6 GHz bandwidth for commercial applications of ultra wideband (UWB) systems in 2002, high speed data communication for wireless personal area and body area networks (WPAN and WBAN) becomes possible [1].

In this paper, a novel planar monopole dual band antenna is proposed. By using Ansoft HFSS (high frequency structure simulator), dual band (2.20–2.65 GHz) and (6.52–11.75 GHz) is achieved. The results show the antenna can be used for the 3, 4 and 5 UWB group bands (6.336 GHz–10.560 GHz) as mentioned in the multiband orthogonal frequency division multiplexing (OFDM) system [2], and WLAN (2.45 GHz) band. The antenna is much smaller than the compact UWB antenna and other multiband antennas introduced recently [3, 4, 5, 6].

2 Antenna design and simulated/measured results

Fig. 1 (a) shows the configuration of the proposed antenna. The antenna consists of a radiation patch, a feed line and ground stubs on the top side of the substrate and a truncated ground plane with stubs on the bottom side. The antenna has a total size of $10 \times 15.5\,\text{mm}^2$ and is constructed on a FR4 substrate with a thickness of 1.6 mm, relative permittivity $\varepsilon_r = 4.4$, and loss tangent $\tan\delta = 0.02$. The fabricated antenna is shown in Fig. 1 (b). The optimal dimensions of the proposed antenna are as follows: $W_{sub} = 10\,\text{mm}$, $L_{sub} = 15.5\,\text{mm}$, $W_p = 9\,\text{mm}$, $L_p = 9\,\text{mm}$, $W_f = 1.4\,\text{mm}$, $L_f = 5.5\,\text{mm}$, $W_0 = 1.8\,\text{mm}$, $W_1 = 2\,\text{mm}$, $L_1 = 5.4\,\text{mm}$, $W_2 = 1\,\text{mm}$, $L_2 = 4\,\text{mm}$, $W_3 = 0.25\,\text{mm}$, $L_a = 0.5\,\text{mm}$, $W_g = 0.2\,\text{mm}$, $W_n = 0.2\,\text{mm}$, $L_n = 3\,\text{mm}$, $L_{gnd} = 3.5\,\text{mm}$, $h = 2\,\text{mm}$, $R = 8.5\,\text{mm}$, and $r = 0.5\,\text{mm}$.

The antenna measurement was performed using Anritsu 37269D vector

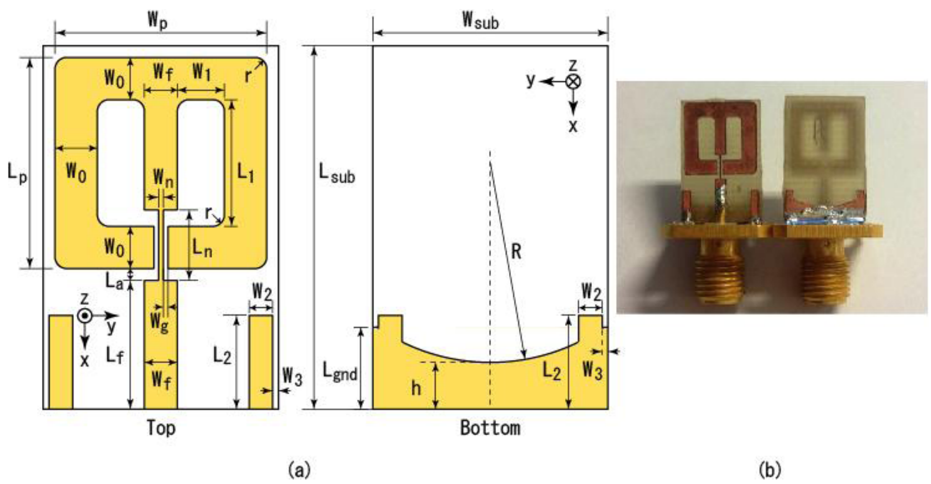

Fig. 1. (a) Geometry of proposed antenna, and (b) photograph of fabricated antenna.

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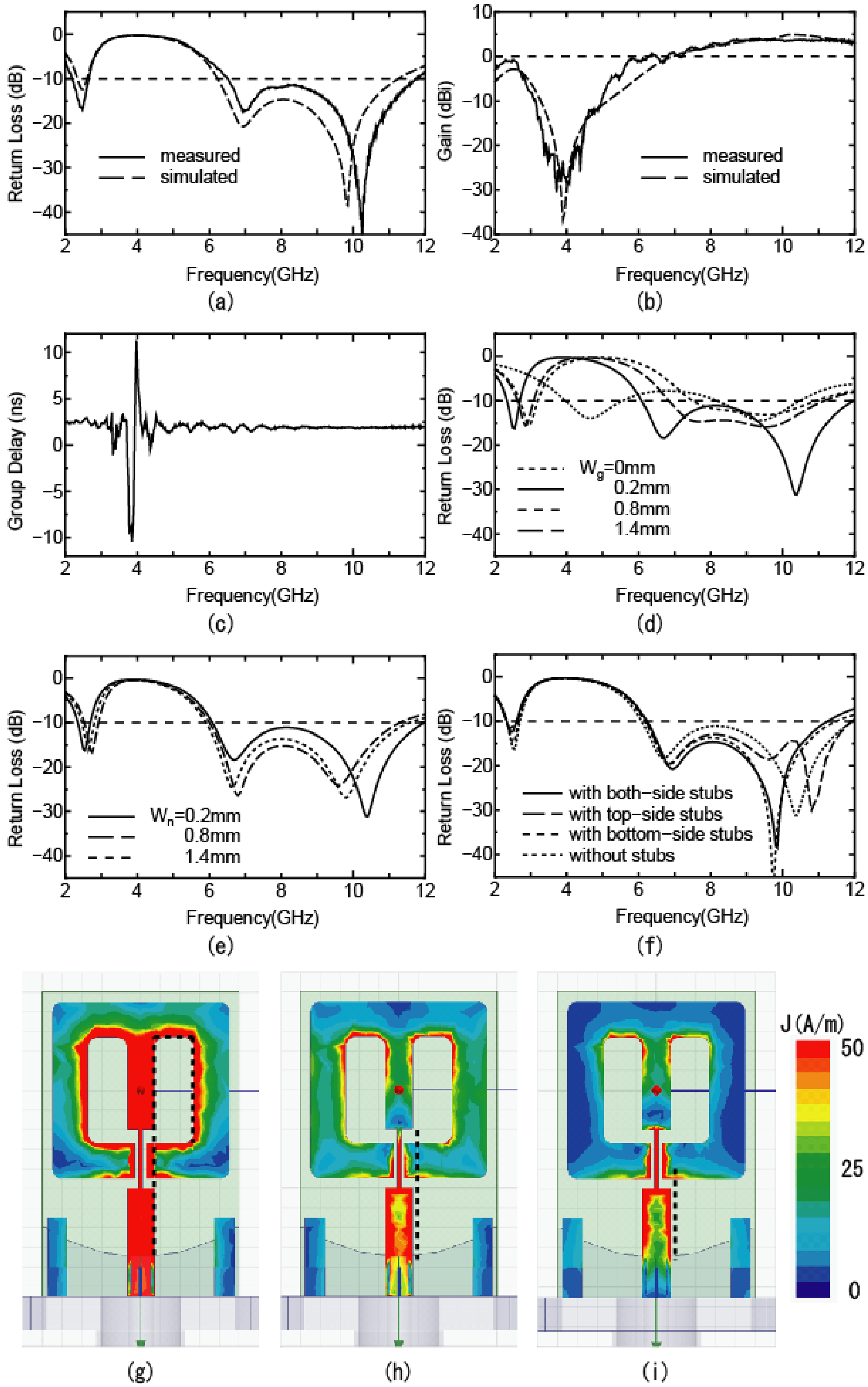

Fig. 2. (a) Measured and simulated return loss, (b) measured and simulated gain, (c) measured group delay, (d) simulated return loss for different W_g (W_n is fixed at 0.2 mm), (e) simulated return loss for different W_n (W_g is fixed at 0.2 mm), (f) simulated return loss with/without stubs, (g) surface current distribution on the top side at 2.45 GHz, (h) 6.85 GHz, (i) 9.75 GHz. The broken lines in (g), (h), and (i) indicate a quarter of the effective wavelength at each frequency.

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network analyzer. Fig. 2 (a) shows the simulated and measured return loss characteristics of the proposed antenna. The measured return loss agrees well with the simulation, and the two −10 dB return loss bands are 0.45 GHz (2.20–2.65 GHz) and 5.23 GHz (6.52–11.75 GHz) in the lower band and upper band, respectively.

Fig. 2 (b) plots the measured and simulated gain characteristics in the $-z$ direction of the antenna. The average measured gain is −1.2 dBi and 2.8 dBi in the lower band and upper band, respectively.

To evaluate the dispersion performance of the proposed antenna, the group delay is measured. The two identical antennas are set back to back with a distance of 50 cm. The measured group delay is shown in Fig. 2 (c). The variation of group delay is within about 1 ns in both of the lower and upper bandwidths.

Fig. 2 (d), (e) and (f) show how the change of parameters W_g, W_n and stubs affect the return loss characteristics. It is found that the bandwidths of the lower and upper bands are very sensitive to the gap width W_g, and that W_n and stubs affect the return loss in the upper band.

The surface current distributions on the radiation patch and the stubs on the top side at three resonant frequencies are shown in Fig. 2 (g)–(i). The current flows along the interior edges of the slots at 2.5 GHz, while the current concentrates on the feed line and its narrow section at 6.85 GHz and 9.75 GHz. In general, the length of monopole antenna is about a quarter-wavelength. The wavelength λ_r is given by

$$\lambda_r = \frac{c}{\sqrt{\varepsilon_{eff}}\, f_r} \tag{1}$$

with

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} \tag{2}$$

where c is the speed of light, f_r is the resonant frequency, and ε_{eff} is the effective relative dielectric constant. The values of a quarter-wavelength at resonant frequencies of 2.45 GHz, 6.85 GHz, and 9.75 GHz are 18.6 mm, 6.66 mm, and 4.68 mm, respectively, and shown in Fig. 2 (g)–(i).

The radiation patterns were measured in an anechoic chamber. The results in the H-plane (yz-plane) and E-plane (xz-plane) at 2.5 GHz, 7 GHz and 10 GHz are plotted in Fig. 3. It is observed that the H-plane radiations are nearly omnidirectional and that the E-plane pattern at 2.5 GHz is about the same as that of a dipole antenna.

3 Conclusions

A microstrip-fed novel dual-band monopole antenna for WLAN/UWB applications has been presented. The antenna has a highly compact size (10 mm × 15.5 mm × 1.6 mm) and simple structure, is easy to fabricate at a low cost, and shows good characteristics in impedance matching, group delay, and gain, which makes this antenna a competitive candidate for nowadays wireless systems.

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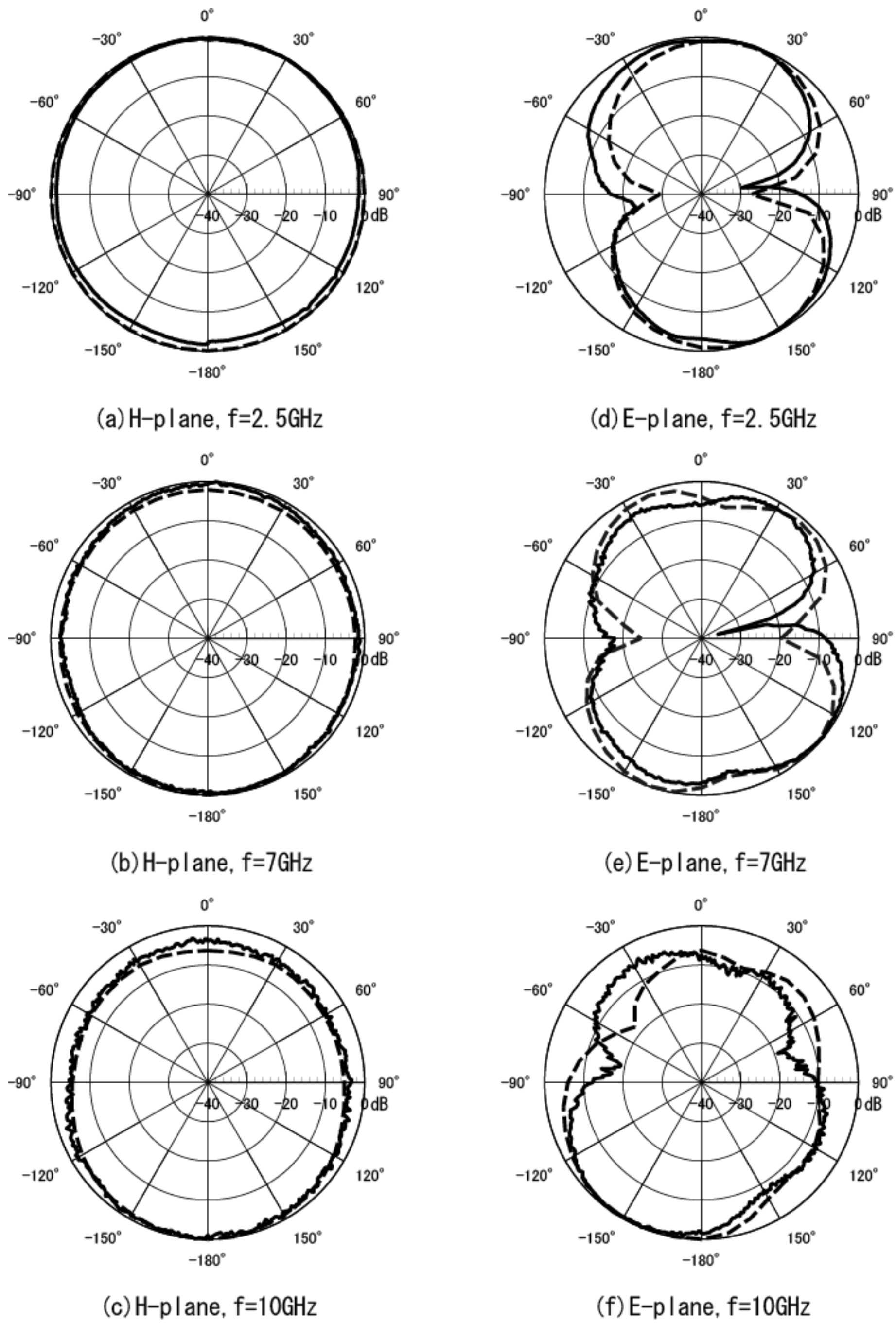

Fig. 3. Measured (solid line) and simulated (broken line) radiation patterns.

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