Multiband Meandered Monopole Antenna for Mobile Applications

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A multiband meandered monopole antenna is proposed for digital video broadcasting handheld (DVB-H), global positioning system, personal communications service, wireless broadband (Wibro), and wireless local area network (WLAN) applications. The proposed antenna consists of a meandered line, a shorted length strip line, and a conductor strip between a meandered line and a microstrip feed line. By tuning a short strip and a conductor, a multiband impedance matching is achieved. The proposed antenna has an omnidirectional radiation and yields an antenna gain of greater than –3 dBi in the DVB-H band and 4.5 dBi in the Wibro and WLAN bands. Details of the proposed antenna design and experimental results are presented.

Keywords: monopole antenna, meandered structure.

I. Introduction

Modern mobile handsets have evolved at an astonishing rate during the last decade. Recently, there is an increasing interest in developing a single compact terminal which can provide more than one wireless communication service. Thus, the mobile handset is needed to operate in multiple frequency bands for various radio communication services; specifically, the global positioning system (GPS) at 1,570 MHz, the personal communications service (PCS) at 1,900 MHz, the wireless broadband (Wibro) internet service at 2,300 MHz [1], and the wireless local area network (WLAN) at 2,400 MHz [2], [3]. In addition, the digital video broadcasting handheld (DVB-H) standard has been specified for bringing television broadcast services to handheld mobile terminals [4]. To meet these recent tendencies and specifications, the antennas for wireless handheld terminals must not only perform well in a multiband spectrum, but also have a simple structure and an easy means of integration with the circuits.

In general, monopole antennas are utilized in a multiband antenna to cover a single wideband [5]. A dual monopole antenna with a branch structure operates in low and high bands [6]. However, in these designs, most efforts are focused on etching the patch shape for producing a multiresonant mode with a large ground plane. Thus, the disadvantage of these schemes is that the antenna shape is too complex for practical applications. A wideband antenna has been presented [7]. This configuration may find it hard to reduce to the antenna size because it uses a metallic inductive chassis. A meandered structure monopole antenna has been proposed [8]. This antenna does not have multiband characteristics but has dual band characteristics.

This letter presents a meandered monopole antenna which is suitable for multiband wireless communication systems. The new antenna has good multiband impedance bandwidths as well as radiation patterns. It has been created by properly adding a strip and a conductor onto the microstrip line.

II. Antenna Design

The geometry of the proposed antenna is shown in Fig. 1. The rectangular ground plane of the proposed antenna is designed on a substrate with thickness T=1.6 mm (63 mil), relative permittivity ε_r=4.4, and loss tangent tan δ=0.05. The proposed antenna consists of a meandered line, a shorted length strip line, and a conductor strip between a meandered

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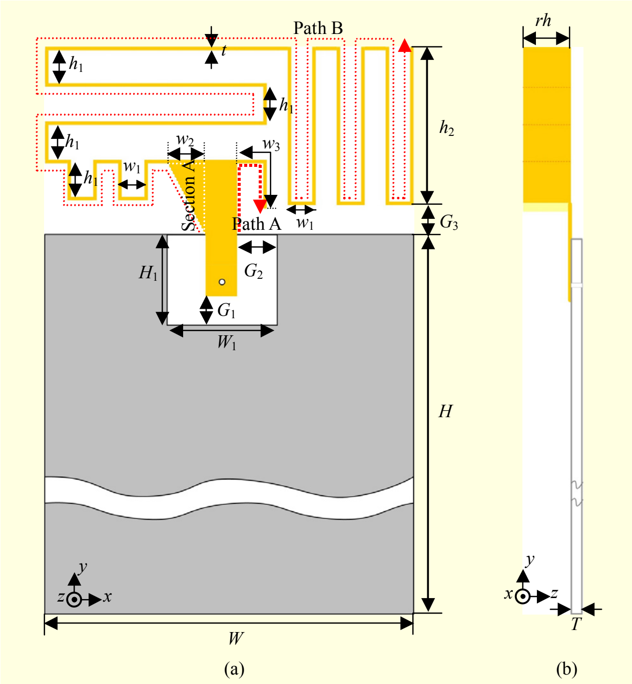

Fig. 1. Geometry of the proposed antenna: (a) top view and (b) side view.

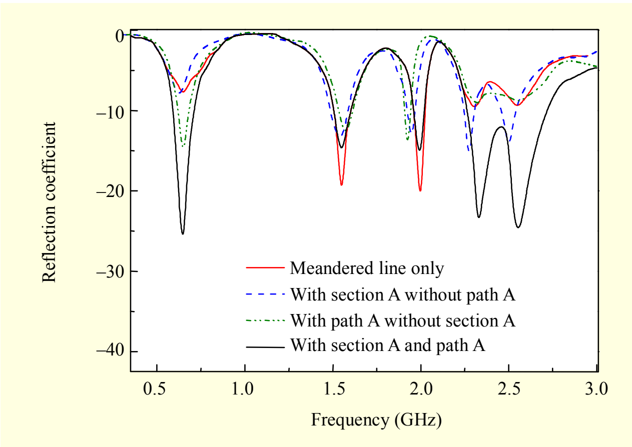

Fig. 2. Simulated return loss along with changes of section A and path A.

line and a microstrip feed line. A copper conductor with a width of 0.2 mm is used to connect to the meandered line of the radiation element. These strips may produce different current paths and provide multiple resonances. By tuning the additional shorted strip and conductor, the multiband characteristics have been derived.

The influence of sub-strips, which are section A and path A, on a reflection coefficient, is investigated. Figure 2 shows the simulated results of four different cases: a meandered line only, a meandered line with section A, a meandered line with path A, and a meandered line with section A and path A. The multiple

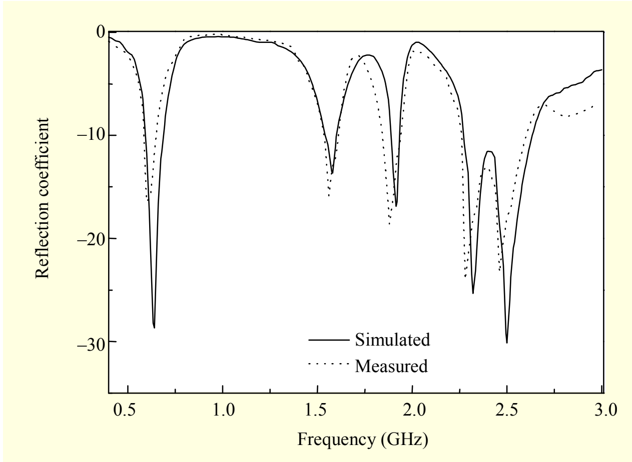

Fig. 3. Simulated and measured return loss of the proposed antenna.

resonances of a folded meandered line may occur by itself via coupling between the meandered line and the microstrip line. The short strip of path A has an effect on the low-band performance, while the added conducting strip of section A on path B yields good impedance matching in the Wibro and WLAN high bands. Finally, due to the superposition of these two sub-strips along with the meandered line, the proposed antenna has multiband characteristics (see Fig. 3). The simulation has been carried out using Ansoft's High Frequency Structure Simulator.

A 50 Ω coaxial cable is used to excite the designed antenna at the feeding point as shown in Fig. 1. The cable is connected to the microstrip line of the upper side on the PCB from the bottom side through a via-hole. The 50 Ω microstrip line has a width of 4 mm and a length of 18 mm. The meandered line has a length of about 215 mm. The total length is about one-quarter wavelength at the desired lowest resonant frequency of 620 MHz in the DVB-H band. To reduce the overall antenna size, especially in the antenna height, the meandered strip has been folded at a right angle and separated with a distance of 5 mm from each strip and the ground plane. The first radiating element is 5 mm away from the ground plane, and each element is separated by the *x*-directed strips (3 mm) and the *y*-directed strips (5 mm). The ground plane with a width of W = 47 mm and a height of H = 90 mm has been designed in consideration of a handset terminal size. In general, antennas with a ground plane such as a monopole and a patch are affected by a finite ground size in an operating frequency and a radiation pattern. In this design, the ground plane size is also accounted for when the simulation has been carried out. The final dimensions of the optimized monopole antenna are as follows: W_1 = 12 mm, H_1 = 13 mm, G_1 = 5 mm, G_2 = 5 mm, G_3 = 5 mm, w_1 = 3 mm, w_2 = 7.2 mm, w_3 = 3.8 mm, h_1 = 5 mm, h_5 = 20 mm, rh = 5.2 mm, and t = 0.2 mm. The newly designed antenna satisfies all the requirements for multiband wireless applications, including DVB-H band.

III. Implementation and experimental results

In this section, a prototype of the proposed antenna, as depicted in Fig. 1, fabricated on a FR4 substrate, is experimentally investigated. Figure 3 shows the comparison

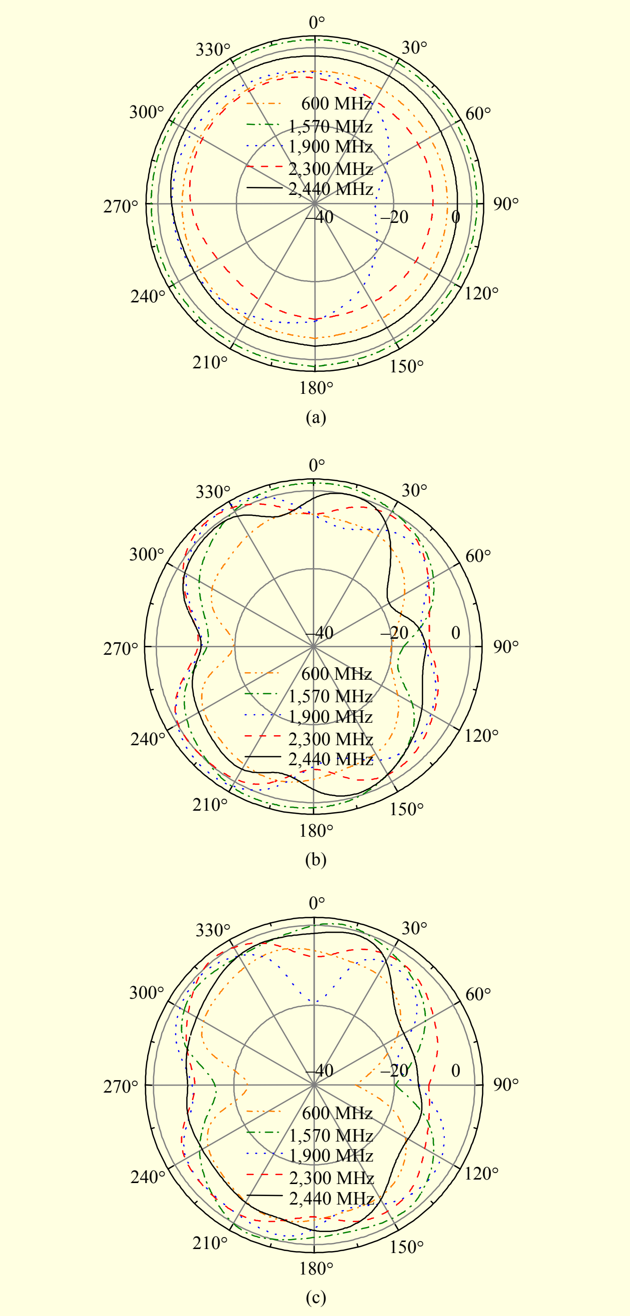

Fig. 4. Measured radiation patterns: (a) *z-x* plane, (b) *z-y* plane, and (c) *x-y* plane.

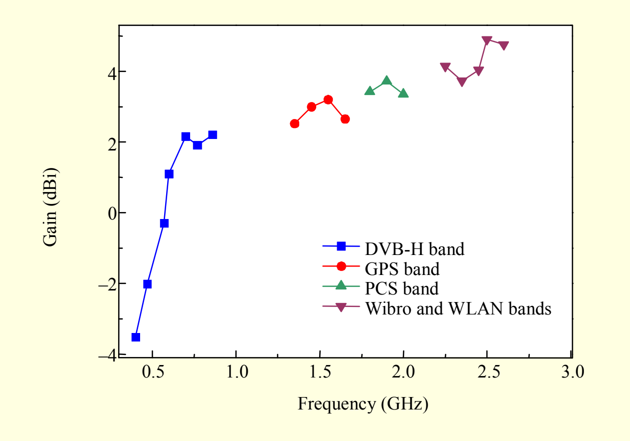

Fig. 5. Measured antenna gain.

between the measured and simulated reflection coefficients of the proposed antenna. As shown in Fig. 3, five resonant bands are excited. These results agree well with each other with some discrepancies. The measured 10 dB impedance bandwidths are 80 MHz (580 MHz to 660 MHz), 90 MHz (1,530 MHz to 1,610 MHz), 100 MHz (1,840 MHz to 1,940 MHz), and 350 MHz (2,250 MHz to 2,600 MHz). These bandwidths can clearly cover most spectrums of the wireless services including the GPS, PCS, Wibro, WLAN, and DVB-H.

The far-field radiation patterns, which are measured in an anechoic chamber in the *z-y*, *z-x*, and *x-y* planes, are shown in Fig. 4. As shown in Fig. 4, the radiation patterns are omnidirectional, and they are very similar to those of a *y*-directed dipole antenna. Figure 5 presents the measured peak antenna gain in each band. The measured gain is about –3.5 dBi to 2.15 dBi in the DVB-H band, 2 dBi in the GPS band, 3.2 dBi to 3.8 dBi in the PCS band, and 3.7 dBi to 4.03 dBi in the Wibro and WLAN bands.

IV. Conclusion

A multiband monopole antenna with a meandered structure has been presented and experimentally investigated for DVB-H/GPS/PCS/Wibro/WLAN applications. A conducting section and a coupling path (short strip) between a meandered line and a monopole may significantly improve the low-band and high-band performance of the proposed antenna. The measured impedance bandwidth is about 30% (VSWR≤3) in the DVB-H band, 75% (VSWR≤1.5) in the Wibro band, and about 27% (VSWR≤1.2) in the WLAN band. This proposed antenna yields an antenna gain of more than –3 dBi in the DVB-H band and 4.5 dBi in the Wibro and WLAN bands, respectively. This proposed method may be applicable for various designs such as a clamshell with a slide and bar types for mobile antennas.

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