CPW-FED MONOPOLE ANTENNA FOR DUAL-BAND OPERATION

Horng-Dean Chen, and Wen-Shyang Chen
Department of Electronic Engineering, Cheng-Shiu Institute of Technology
840, Sheng Ching Rd., Neau Song, Kaohsiung, Taiwan 833
E-mail: hdchen@cc.csit.edu.tw

1. Introduction

Monopole antennas have found widespread applications in wireless mobile communication systems. Conventional monopole antennas that have been published in the open literature are mostly mounted above a large ground plane and excited by a probe feed [1-4]. Up to now, relatively very few monopole antennas fed by a coplanar waveguide (CPW) have been reported. However, CPW fed antennas have many attractive features, such as no soldering point, easy fabrication and integration with monolithic microwave integrated circuits, thus the designs of the CPW-fed antennas have recently received much attention. In this paper, we propose a new design of monopole antenna fed by a CPW line for dual-frequency operation. The proposed antenna is particularly simple in manufacturing owing to its single dielectric and single metal layer. In the design, the principle of the dual frequency operation is to make the antenna a combination of two monopoles, each operating at a specified frequency mode. Experimental results also demonstrate that the impedance matching for the proposed antenna can easily be obtained only by adjusting a sufficient length of the ground plane. In this study, several designs are experimentally investigated, and the characteristics of the input impedance and radiation patterns are analyzed and discussed.

2. Antenna design

Fig. 1 shows the geometry of the proposed dual-frequency monopole antenna with a CPW feedline. The proposed antenna consists of two monopoles, and is printed on a dielectric substrate with thickness h = 1.6 mm and relative permittivity ε_r = 4.4. The two monopoles are connected at the end of the CPW feed line. A 50 Ω CPW feed line, having a metal strip of width w_f = 6.37 mm and a gap of distance g = 0.5 mm, is used to excite the two monopoles. The left monopole has a length ℓ_1 and a width w_1, and the right monopole has a length ℓ_2 and a width w_2; the separation between the two monopoles is d. Due to the presence of different lengths of the two monopoles, the first resonant frequency (f_1) of the proposed antenna is expected to be controlled mainly by the length of the longer monopole, and the second resonant frequency (f_2) is greatly dependent on the length of the shorter monopole; that is, dual-frequency operation can be achieved. Moreover, by varying the length ℓ_2 with the parameter ℓ_1 unchanged, various frequency ratios of the two operating frequencies can easily be obtained.

3. Experimental results

Prototypes of the proposed dual-frequency monopole antenna were constructed and experimentally studied. Fig. 2 shows the measured return loss against frequency for the proposed antenna with the parameters (ℓ_1 = 31 mm, w_1 = 2 mm, ℓ_2 = 20 mm, w_2 = 2 mm) of the two monopoles used. For comparison, the results for the two cases with a single monopole of ℓ_1 = 31 mm and 20 mm are also shown in Fig. 2. It is clear to see that, when the antenna uses a single monopole, only one resonant mode is excited at about 1866 MHz for the case of ℓ_1 = 31 mm and 2492 MHz for the case of ℓ_1 = 20 mm. While for the antenna having two monopoles, the first two resonant modes are excited at about f_1 = 1765 MHz and f_2 = 2383 MHz with a good matching condition. The impedance bandwidth, determined from 10 dB return loss, is 8.1% referenced to the resonant frequency at 1765 MHz and 14.2% at 2383 MHz. From the results obtained, it demonstrated that the wavelength of the first resonant frequency f_1 approximately corresponds to the length (ℓ_1) of the longer monopole, and the wavelength of the second resonant frequency f_2 approximately corresponds to the length (ℓ_2) of the shorter monopole.

By varying the length ℓ_2 with ℓ_1 = 31 mm unchanged, different dual-frequency operations for the proposed antenna can be obtained. Fig. 3 presents the measured first two resonant frequencies, f_1 and f_2, and the frequency ratio (f_2 / f_1) against the length ℓ_2. It is found that, when the length ℓ_2 is in the range of 15 to 25 mm or 37 to 65 mm, dual-frequency operation with a good matching condition is obtained. When ℓ_2 is varied from 29 to 34 mm, only an operating band is formed by the excitation of two adjacent resonant modes. This behavior makes the present dual-frequency design with a tunable frequency ratio in the range of about 1.3 - 1.6. From many experimental studies, it is also found that a frequency ratio larger than 1.6 can be obtained by using a larger ground-plane size.

As for the radiation characteristics, the proposed antenna with the design parameters of ℓ_1 = 31 mm and ℓ_2 = 20 mm is studied. The measured radiation patterns in the x-y, x-z and y-z planes at f_1 = 1765 MHz and f_2 = 2383 MHz are plotted in Fig. 4(a) and (b). It is observed that both of the two operating frequencies are of the same polarization planes and have good omni-directional radiation patterns. The variations of the radiation patterns are negligible for frequencies across the entire impedance bandwidth. The measured gain for the typical antenna is 1.8 and 2.4 dBi at 1765 and 2383 MHz, respectively.

4. Conclusions

Novel designs of CPW-fed monopole antennas for achieving dual-frequency operation have been proposed and successfully implemented. The two proposed antennas have a simple geometry and is easy to design. It is shown that the proposed antennas are suitable for mobile applications where the ground plane is small. By varying the length of one of the two monopoles of the proposed antennas, two operating frequencies having a tunable frequency ratio of about 1.3 to 1.6 can be obtained, thereby leading to dual-frequency operation with a wide frequency ratio.

References

[1] M. Ali, M. Okoniewski, M. A. Stuchly, and S. S. Stuchly, “Dual-frequency strip-sleeve monopole for laptop computers,” *IEEE Trans. Antennas Propagat.,* vol. 47, pp. 317-323, 1999.

[2] E. Lee, P. S. Hall, and P. Gardner, “Dual band folded monopole/loop antenna for terrestrial communication system,” *Electron. Lett.*, vol. 36, pp. 1990-1991, 2000.

[3] D. Liu, “A dual-band antenna for cellular applications,” *1998 IEEE Antennas Propagat. Soc. Int. Symp. Dig.*, pp. 786-789.

[4] Y. W. Chow, E. K. N. Yung, K. F. Tsang, and H. T. Hui, “An innovative monopole antenna for mobile-phone handsets,” *Microwave Opt. Technol. Lett.,* vol. 25, pp. 119-121, 2000.

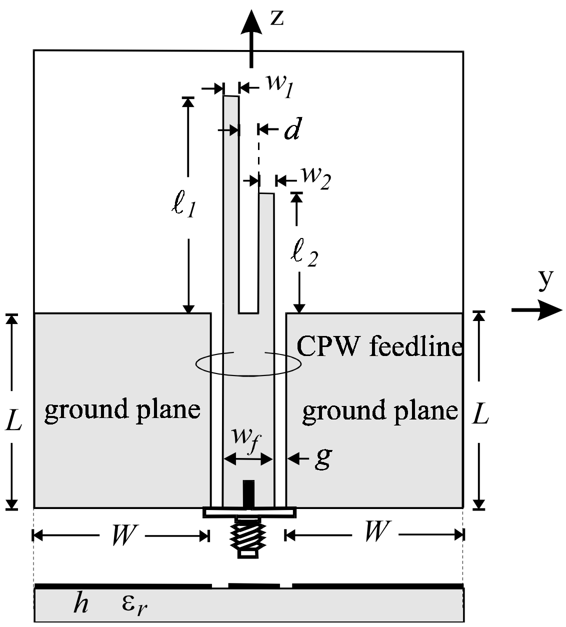

Fig. 1 Geometry of the proposed CPW-fed monopole antenna for dual-frequency operation

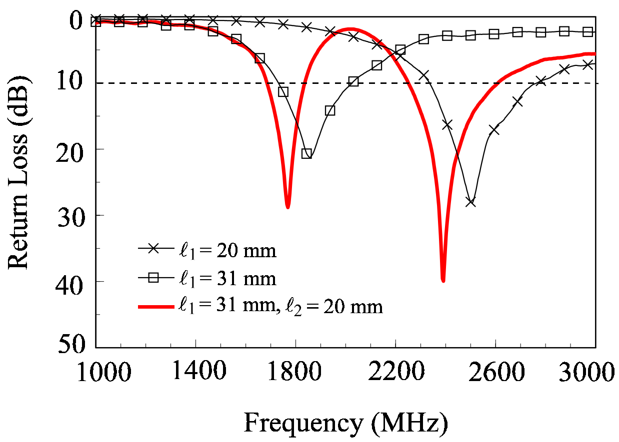

Fig. 2 Measured return loss against frequency; L = 30 mm, W = 25 mm, w_1 = 2 mm, w_2 = 2 mm, d = 2.37 mm, ε_r = 4.4, h = 1.6 mm, w_f = 6.37 mm, g = 0.5 mm.

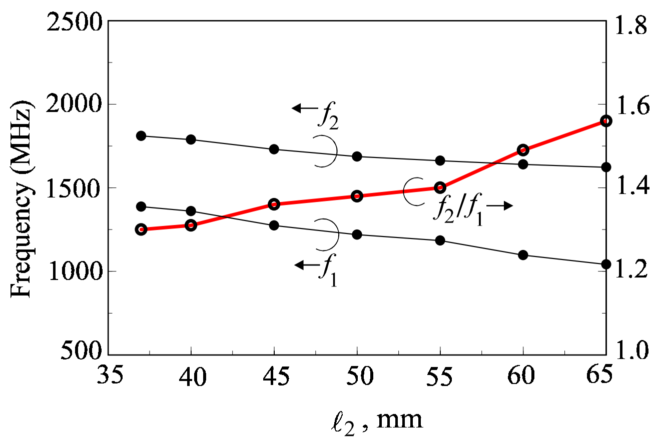

Fig. 3 Measured first two resonant frequencies, f_1 and f_2, and the frequency ratio (f_2 / f_1) against the length ℓ_2 for the antenna with ℓ_1 = 31 mm. Other parameters are the same as in Fig. 2.

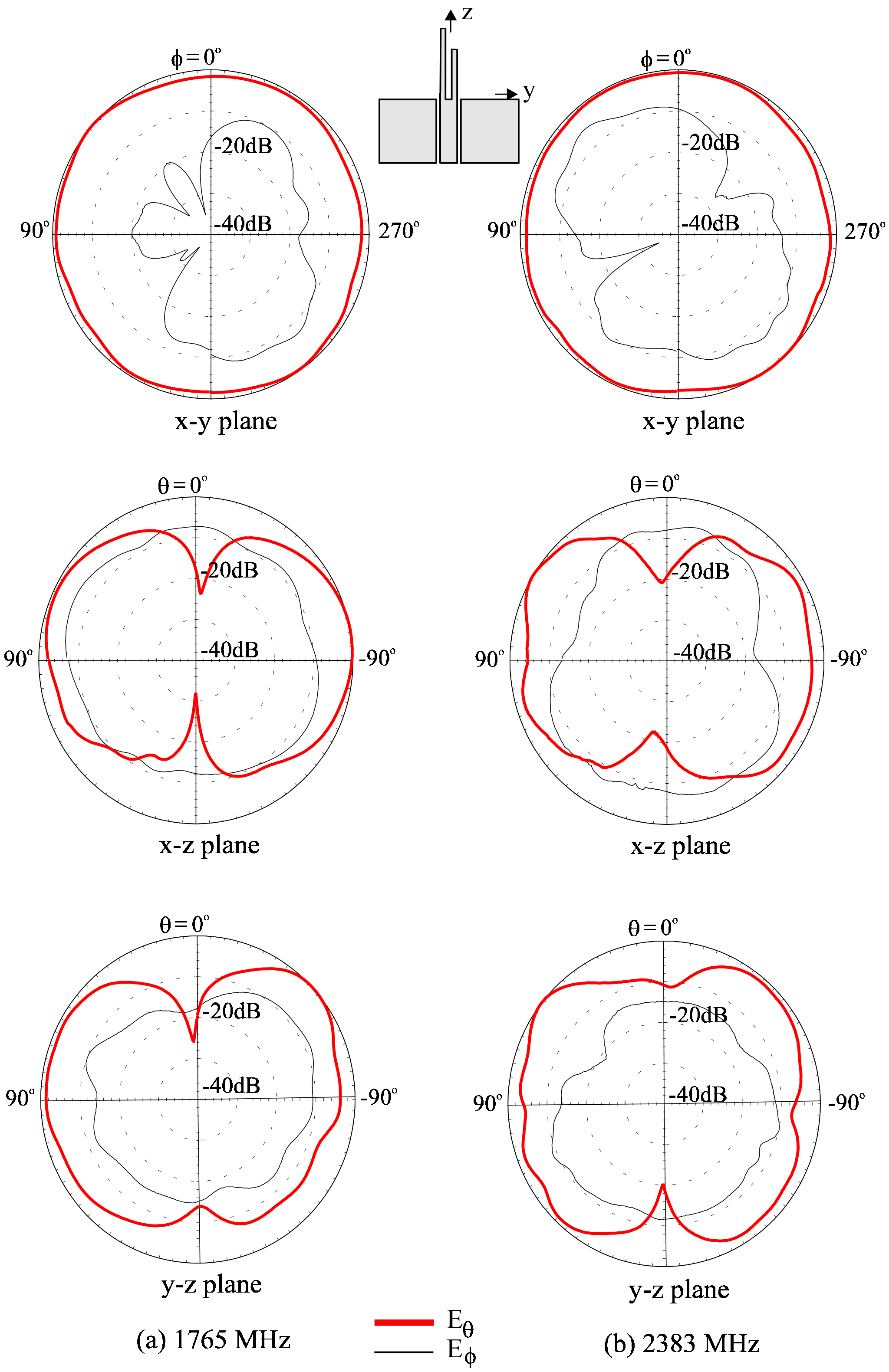

Fig. 4 Measured radiation patterns for the proposed dual-frequency antenna studied in Fig. 2. (a) 1765 MHz. (b) 2383 MHz.