In this paper, we propose a new wideband metal-plate antenna capable of generating a wide operating bandwidth that covers 2.4/5/5.8-GHz operation. The proposed antenna has a simple grating antenna [3–5]. For covering the 2.4-GHz (2400–2484 MHz) and 5.2/5.8-GHz (5150–530/5725–5875 MHz) bands for WLAN operation, this kind of antenna is usually composed of two separate radiating strips or portions in order to generate two separate resonant modes for 2.4-GHz and 5.2/5.8-GHz operation.

In this paper, we propose a new wideband metal-plate antenna suitable for generating a wide operating bandwidth that covers 2.4/5/5.8-GHz operation. The proposed antenna has a simple configuration, as shown in Figure 1, and is mainly comprised of a T-shaped metal plate and a long shorting strip for short-circuiting the antenna to the supporting metal frame of the laptop display. Similar to the flat-plate or bent metal-plate antennas studied in [2–12], the proposed antenna has a low profile (9 mm to the top edge of the supporting metal frame in this study) and is suitable to perform as an internal or integrated antenna for laptops. Moreover, in addition to covering the 2.4/5/5.8-GHz bands for existing WLAN systems, the proposed antenna is also suitable for application in the new broadband wireless metropolitan area network (WMAN) system with the IEEE 802.16e standard for mobile broadband wireless access in the 2.3–5.85-GHz band [13, 14]. Details of the proposed antenna design are described in this study, and the experimental and simulation results of the constructed prototype are presented. The effects of the antenna parameters on the impedance matching of the antenna are also analyzed.
2. ANTENNA DESIGN

Figure 1 shows the geometry of the proposed wideband metal-plate antenna mounted on the top edge of a ground plane of size 260 × 200 mm². The ground plane is considered here as the supporting metal frame of the display of the laptop. The antenna is fed by a 50Ω mini coaxial line, and a feed gap d of 0.5 mm between the antenna and the ground plane is chosen. This feed gap has a large effect on the impedance matching of the proposed antenna, and good impedance matching across a wide frequency range is difficult to obtain when the feed gap is larger than 1 mm. The effects of the feed gap on the impedance matching of the proposed antenna will be discussed more in detail in section 3.

The antenna mainly comprises a T-shaped metal plate and a long shorting strip of inverted-L shape. The T-shaped metal plate is further composed of a main portion (size 8.5 × 20 mm²) and a top horizontal strip (width 5 mm and length W). Note that in order to limit the antenna height to be less than 10 mm (a practical width of the narrow spacing between the casing of the laptop and the supporting metal frame of the display), such that the antenna can perform as an internal antenna, the length of the main portion of the T-shaped metal plate is selected to be 8.5 mm in this study (less than 0.06 wavelength at 2 GHz). Also note that the main portion of the T-shaped metal plate in this study functions like a wideband planar monopole antenna [15, 16]; that is, to make possible a wide impedance bandwidth (about 4 GHz here) for the proposed antenna, a large width of the main portion of the T-shaped metal plate is required and, in this study, is determined to be 20 mm.

However, with the main portion of the T-shaped metal plate only, the lower-edge frequency of the impedance bandwidth achievable is still far greater than 2 GHz. By adding the top horizontal strip (the length is chosen to be 36 mm in the experiment) to form the T-shaped metal plate for the proposed antenna, the lower-edge frequency of the obtained impedance bandwidth can be effectively decreased to about 2 GHz. The effects of the length W of the top horizontal strip will be analyzed more in detail in section 3.

The long shorting strip of inverted-L shape short-circuits the T-shaped metal-plate to the supporting metal frame. The shorting strip is 1 mm in width, which simplifies the design, and its horizontal arm (length L) has a spacing t to the top edge of the supporting metal frame. By varying the length L (14 mm used in the experiment), which introduces varied inductance to the antenna, and the spacing t (1 mm in the experiment), which leads to varied coupling or capacitance to the antenna, the impedance matching of the proposed antenna over a wide frequency range can be adjusted. Their effects will be discussed in section 3. It should also be noted that with the presence of the shorting strip, the proposed antenna is connected to the supporting metal frame. That is, the proposed antenna and the supporting metal frame can be fabricated together, thus leading to an integrated laptop antenna [3–5].

3. RESULTS AND DISCUSSION

In the experimental study, the proposed antenna was fabricated by line-cutting a 0.2-mm-thick copper plate and then connecting it to the ground plane. The feed gap d, length W of the top horizontal strip, and the length L and spacing t of the shorting strip were chosen to be 0.5, 36, 14, and 1 mm, respectively (the other dimensions are given in Fig. 1). Figure 2 shows the measured and simulated return loss of the constructed prototype. The simulated result is obtained using Ansoft High-Frequency Structure Simulator (HFSS) simulation software, and the measured data in general agree with the simulated result. From the measurement, a wide impedance bandwidth (10-dB return loss) of 3.9 GHz is obtained, with the lower-edge frequency at 2.1 GHz. The obtained impedance bandwidth covers the 2.4/5.2/5.8-GHz bands for the existing WLAN systems and also the 2.3–5.85-GHz band for the new WMAN system with the IEEE 802.16e standard [13, 14].
A parametric study on the effects of the parameters $d$, $W$, $L$, and $t$ on the impedance matching of the proposed antenna were also analyzed using the Ansoft simulation software HFSS. Figure 3 shows the simulated return loss as a function of the feed gap $d$. Note that in order to vary the feed gap $d$ from 0.5 to 1.5 mm while keeping the other dimensions of the antenna fixed, the spacing $t$ is changed from 1 mm (as in Fig. 2) to 3 mm (as in Fig. 3). In the latter case, when the feed gap $d$ is increased to 1.5 mm, the shorting strip can still be properly connected to the side edge of the main portion of the T-shaped metal plate, and a proper comparison can thus be obtained. From the results, it is clearly seen that when the feed gap $d$ increases and is larger than 1.0 mm, the impedance matching in the central region of the frequency range of interest is quickly degraded. For this reason, a smaller feed gap $d$ of 0.5 mm was chosen for the constructed prototype.

Figure 4 shows the simulated return loss as a function of the length $W$ (the other dimensions are the same as those in Fig. 2). The results indicate that with an increase in $W$, the lower-edge frequency of the obtained impedance bandwidth can be effectively decreased; however, the upper-edge frequency is also decreased. Since it is desired that the lower-edge frequency be close to 2 GHz and the upper-edge frequency be close to 6 GHz, the length $W$ was chosen to be 36 mm for the constructed prototype in this study.

Figure 5 shows the simulated return loss as a function of the length $L$, and Figure 6 shows the results for various spacings of $t$ (for both figures, the other dimensions are also the same as those in Fig. 2). It is first seen that the length $L$ has a very small or negligible effect on the lower-edge frequency, and a longer length $L$ (14 mm chosen in Fig. 5) can lead to good impedance matching over the frequency range of interest (about 2–6 GHz). Also note that when a much longer length (>14 mm) is used, the upper-edge frequency will be decreased to be lower than 6 GHz (this result is not shown in Fig. 5). Thus, the length $L$ was chosen to be 14 mm for the constructed prototype.

The results for various spacings shown in Figure 6 indicate that a larger spacing will lead to a larger lower-edge frequency and a larger upper-edge frequency as well, especially when the spacing $t$ is larger than 1.0 mm. Thus, if the spacing $t$ is chosen to be 3.0 or 7.0 mm (as in Fig. 6), other dimensions such as the length $W$ or the size of the main portion of the T-shaped metal plate need to be increased such that the lower-edge frequency can be close to 2 GHz.
GHz. For this reason, the spacing \( t \) was selected to be 1.0 mm for the prototype constructed here.

The radiation characteristics of the constructed prototype were also studied. Figures 7 and 8 plot the measured radiation patterns at the center frequencies (2442 and 5500 MHz) for the 2.4-GHz and 5.2/5.8-GHz bands. In general, monopole-like radiation patterns are obtained. It is also seen that in the azimuthal plane (\( x-y \) plane), the radiation with vertical or \( E_y \) polarization shows relatively small variations and is roughly close to being omnidirectional, especially for a lower frequency at 2442 MHz. Figure 9 shows the measured and simulated antenna gain over the impedance bandwidth for the constructed prototype. Good agreement between the measurement and simulation is observed. For frequencies up to about 4.5 GHz, the measured antenna gain is monotonically increased from about 2.4 to 5.2 dBi, while for higher frequencies from 4.5 to 6.0 GHz, the measured antenna gain varies in a relatively small range of about 4.6–5.2 dBi.

4. CONCLUSION

A novel wideband metal-plate monopole antenna suitable for application as an internal or integrated WLAN/WMAN laptop antenna has been proposed. A constructed prototype of the proposed antenna capable of generating a wide operating bandwidth of 3.9 GHz for WLAN and WMAN operations has been successfully implemented. Good radiation characteristics for frequencies across the operating bandwidth have been obtained. The effects of the parameters of the proposed antenna on the impedance matching have also been analyzed.

REFERENCES


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A NOVEL COMPACT MICROSTRIP BANDPASS FILTER USING AN OPEN-LOOP RESONATOR WITH RADIAL STUB

Jian-Xin Chen,1 Jun Xu,2 and Quan Xue1
1 Department of Electronic Engineering
City University of Hong Kong
Tat Chee 83, Kowloon, Hong Kong, P. R. China
2 Institute of Applied Physics
University of Electronic Science and Technology of China
Chengdu 610054, P. R. China

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ABSTRACT: A novel compact microstrip bandpass filter using an open-loop resonator with radial stub is proposed, which has the advantages of compact size and sharp rejection in the stopband. One transmission zero is realized in the upper stopband in order to improve the selectivity of the passband. The transmission-zero frequency can be changed by altering the outer radius of the radial stub. A demonstration filter is designed and tested and the theoretical and experimental results are presented. © 2005 Wiley Periodicals, Inc. Microwave Opt Technol Lett 46: 387–389, 2005; Published online in Wiley InterScience (www.interscience.wiley.com). DOI 10.1002/mop.20995

Key words: bandpass filter; slow-wave; open-loop resonator; radial stub

1. INTRODUCTION

Compact microstrip bandpass filters are increasingly in demand for recently expanding mobile-communication systems. The performances of compact design, low insertion loss in the passband, and sharp rejection in the stopband are necessary. To meet these requirements, much effort has been made to develop a variety of compact bandpass filters. Recently, a type of newly developed microstrip filter was realized by a slow-wave resonator [1], which has been widely used in modern communication systems because of its advantages (especially its size reduction) for applications. A