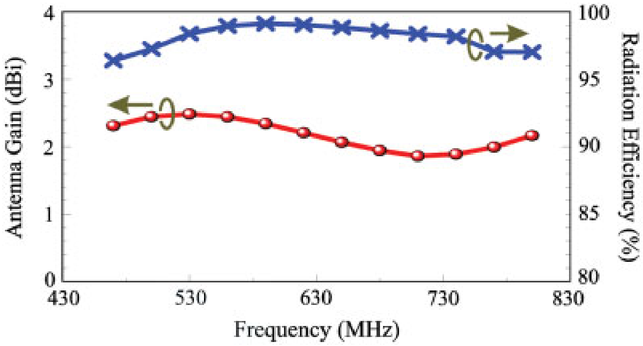

Figure 10 Simulated antenna gain and radiation efficiency for the antenna studied in Figure 2. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com]

gain varies from about 1.8 to 2.5 dBi, and the radiation efficiency is all larger than 96% for frequencies over the band.

4. CONCLUSION

A novel end-fed modified planar dipole antenna for DTV signal reception in the 470–806 MHz band has been proposed and studied. Different from using a central feed gap for a conventional center-fed dipole antenna, the proposed antenna uses an L-shaped feed gap, which separates the antenna into two radiating arms of different lengths. With the proposed configuration, the antenna can be end-fed using a 50 Ω coaxial line. This property makes the proposed antenna very suitable to be attached onto the window pane of a vehicle for the reception of horizontally polarized DTV signals. In this case, the feeding coaxial line can be easily arranged to follow the edge of the window pane to achieve an aesthetical appearance. In addition, the proposed antenna can generate a wide bandwidth of larger than 50% to cover the 470–806 MHz band for DTV signal reception. This wide bandwidth is much larger than that (about 22%) of a corresponding center-fed dipole antenna. Moreover, over the obtained bandwidth, good dipole-like radiation characteristics have been obtained for the proposed antenna.

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INTERNAL GSM/DCS DUAL-BAND OPEN-LOOP ANTENNA FOR LAPTOP APPLICATION

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ABSTRACT: *A novel open-loop antenna with a coupled-line gap for application as an internal laptop antenna for GSM/DCS dual-band operation is presented. Owing to the use of the coupled-line gap, the proposed antenna can operate both as a half-wavelength loop structure at 900 MHz and a one-wavelength loop structure at 1800 MHz. The antenna is easily printed on a dielectric substrate with a low cost and is then integrated to the supporting metal frame of the laptop display to achieve a compact size of 9 mm in height and 70 mm in length, making it very promising to be embedded within the casing of the laptop as an internal antenna. Design considerations of the proposed antenna are described, and experimental and simulation results of the constructed prototype are presented. Effects of the coupled-line gap on the dual-band operation of the proposed antenna are also analyzed.* © 2007 Wiley Periodicals, Inc. Microwave Opt Technol Lett 49: 680–684, 2007; Published online in Wiley InterScience (www.interscience.wiley.com). DOI 10.1002/mop.22224

Key words: *antennas; internal antennas; loop antennas; GSM/DCS dual-band antennas; internal laptop antennas*

1. INTRODUCTION

Many promising internal antennas for GSM (Global System for Mobile Communication, 890–960 MHz) and DCS (Digital Communication System, 1710–1880 MHz) operations have been studied and generally applied in the mobile phones [1]. Recently, it has been desired that the GSM/DCS internal antennas be applied in the laptop computers to achieve wireless internet access. In this case, with the added GSM/DCS internal antenna and the traditional 2.4/5 GHz internal antennas embedded in the laptop computers for WLAN (Wireless Local Area Network) operation [2–4], seamless or ubiquitous wireless network access [5] can be provided for wireless users with their laptop computers. However, the existing internal GSM/DCS mobile phone antennas are generally not applicable in the laptop computers. It is also noted that there are very few promising designs of the internal GSM/DCS laptop antennas available in the published papers.

Here in this paper, we report a novel dual-band open-loop antenna suitable for application as an internal laptop antenna for GSM/DCS operation. The proposed antenna has a simple configuration and is easy to fabricate by printing on a dielectric substrate. By integrating the proposed antenna to the supporting metal frame of the laptop display, a resonant loop path is formed for the proposed antenna. The resonant loop path is first designed to have a one-wavelength length of the desired higher frequency at 1800 MHz, which leads to a one-wavelength resonant mode excited for DCS operation. Then, by introducing a novel coupled-line gap at the proper location along the resonant loop path of the proposed antenna, a new half-wavelength resonant mode at about 900 MHz can be excited for GSM operation. Detailed configuration of the proposed dual-band open-loop antenna with a coupled-line gap is described in the paper. Effects of the coupled-line gap on the antenna's dual-band operation are also analyzed, and experimental results of the constructed prototype are presented and discussed.

2. DESIGN OF PROPOSED DUAL-BAND OPEN-LOOP ANTENNA

Figure 1(a) shows the geometry of the proposed dual-band open-loop antenna with a coupled-line gap for GSM/DCS operation. In this study, the proposed antenna is printed on a 0.4-mm thick FR4 substrate of relative permittivity 4.4 and size 14 × 70 mm^2, and is then bent to achieve a low profile of 9 mm only [see the bending line shown in Fig. 1(b)]. The antenna on the FR4 substrate is mainly with an inverted-U metal strip of uniform width 2 mm. By short-circuiting one end (point C in the figure) of the inverted-U metal strip to the supporting metal frame or ground plane for the laptop display, a resonant loop path starting from the feeding point (point A) through the metal strip and the upper edge (point C to point B) of the supporting metal frame is formed. This resonant loop path has a length of about 168 mm, which corresponds to about one wavelength of the frequency at 1800 MHz and can lead to the excitation of one-wavelength resonant loop mode for DCS operation. For testing the antenna in the experiment, a 50-Ω mini coaxial line is used across the 0.5-mm wide feed gap between the inverted-U metal strip and the supporting metal frame. The central conductor and outer grounding sheath of the coaxial line are connected to the feeding point (point A) and the grounding point (point B), respectively.

It is then found that, when a simple gap is introduced in the inverted-U metal strip, a new resonant mode at frequencies lower than 1800 MHz can be excited. Also note that, in order that the original one-wavelength resonant loop mode is not affected or only slightly affected, the simple gap should be placed at near the null surface current of the one-wavelength resonant loop mode (the preferred position of the simple gap is at the center of the inverted-U metal strip as shown in the inset in Fig. 3 with t = 32.5 mm).

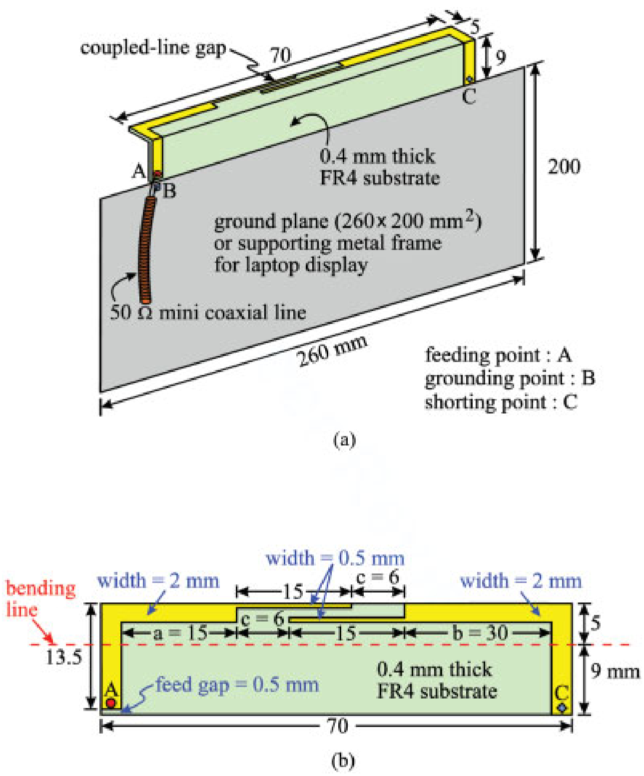

Figure 1 (a) Geometry of the proposed dual-band open-loop antenna with a coupled-line gap as an internal laptop antenna for GSM/DCS operation. (b) Detailed dimensions of the antenna unbent into a planar structure. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com]

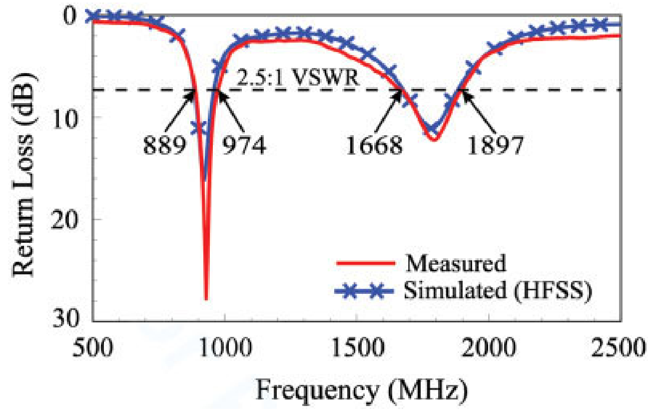

Figure 2 Measured and simulated return loss of the proposed open-loop antenna. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com]

However, it is also found that, with the use of the simple gap, the excited new resonant mode cannot be shifted to be at about 900 MHz for GSM operation. Instead, by using the proposed coupled-line gap replacing the simple gap, the new resonant mode can be effectively shifted to lower frequencies at about 900 MHz. This characteristic is largely because the coupled-line gap can result in the effective lengthening of the resonant loop path seen by the new resonant mode, making it excited as a half-wavelength resonant loop mode at about 900 MHz. On the other hand, for frequencies at about 1800 MHz, at which the original one-wavelength resonant loop mode is excited, the coupled-line gap is found to behave like the simple gap. That is, the original one-wavelength resonant loop mode is slightly affected, whether the coupled-line gap or simple gap is used for the open-loop antenna in this study.

Detailed dimensions of the coupled-line gap in the proposed antenna are shown in Figure 1(b). The coupled-line gap is formed by two narrow coupled metal strips of width 0.5 mm and length 15 mm, and there is a 1-mm spacing between the two coupled metal strips. The coupled portion of the two metal strips is controlled by the parameter c. By selecting a smaller value of c, the coupling between the two coupled metal strips can be increased; in this case, the effective resonant loop path seen by the excited new resonant mode is increased. This behavior can lead to the lowering of the resonant frequency of the excited new resonant mode, with no or very small effects on the antenna's original one-wavelength resonant loop mode.

Also note that the value of c in the proposed design is controlled by the lengths a and b shown in Figure 1(b). With a decrease in the length a, the value of c will be increased that is the coupled portion of the two metal strips in the coupled-line gap is decreased. In this case, the configuration of the proposed coupled-line gap will be close to that of the simple gap in the simple open-loop antenna (see the inset in Fig. 3). Thus, effects of the coupled-line gap can be expected to be similar to that of the simple gap. Similarly, with a decrease in the length b, the coupled portion of the coupled-line gap will also be decreased, and effects of the coupled-line gap can also be expected to be similar to that of the simple gap. More detailed effects of the lengths a, b, and c on the two excited resonant loop modes of the proposed antenna are analyzed with the aid of Figure 3 in the next section.

3. RESULTS AND DISCUSSION

The proposed antenna with the preferred dimensions given in Figure 1 was constructed and tested. Figure 2 shows the measured and simulated return loss of the constructed prototype. The simulated results are obtained using Ansoft simulation software HFSS (High Frequency Structure Simulator) [6], and good agreement between the simulation and measurement is observed. It is clearly seen that two resonant modes (half-wavelength resonant loop mode and one-wavelength resonant loop mode) at about 900 and 1800 MHz are excited. For the lower mode at about 900 MHz, the obtained bandwidth (2.5:1 VSWR) reaches 85 MHz (889–974 MHz), allowing it for GSM operation. For the upper mode at about 1800 MHz, a bandwidth of 229 MHz (1668–1897 MHz) is obtained, which makes it suitable for DCS operation.

Figure 3(a) shows the comparison of the simulated return loss of the simple loop antenna, the simple open-loop antenna with a 1-mm gap, and the proposed open-loop antenna with the coupled-line gap. Configurations of the simple loop antenna and the simple open-loop antenna are shown in the insets in the figure, and corresponding dimensions of the two antennas are the same as those of the proposed antenna given in Figure 1. It is first seen that there is only one resonant mode (the one-wavelength resonant loop mode) excited at about 1800 MHz for the simple loop antenna. For the simple open-loop antenna, a new resonant mode at about 1150 MHz is excited, with the original one-wavelength resonant mode almost unaffected. As for the proposed open-loop antenna, two resonant modes at the desired frequencies 900 and 1800 MHz are successfully excited.

Also note that, in the simple open-loop antenna studied in Figure 3(a), the 1-mm gap is located at the center (t = 32.5 mm) of the inverted-U metal strip. To analyze the effects of the location of the 1-mm gap, the simulated return loss of the simple open-loop antenna as a function of t is studied. Results for t varied from 27.5 to 37.5 mm are shown in Figure 3(b). The obtained results indicate that the resonant frequency of the excited new resonant mode is fixed at about 1150 MHz. This suggests that the lowering of the resonant frequency of the excited new resonant mode to be at about 900 MHz cannot be achieved for the simple open-loop antenna. On the other hand, the resonant frequency of the original one-wavelength resonant mode is affected by varying the value of t. This behavior is mainly because when the 1-mm gap is not located at the center (t = 32.5 mm) of the antenna's inverted-U metal strip, where the null surface current of the original one-wavelength resonant mode should occur, the excited surface current distribution of the original resonant mode in the open-loop antenna will be affected. This will in turn lead to the variation in the excited resonant frequency of original resonant mode.

Figure 4 shows the simulated return loss of the proposed open-loop antenna as a function of a and b. In Figure 4(a), the results for a varied from 12 to 18 mm are presented, while b is fixed to be 30 mm. First note that, when the value of a increases, the value of c decreases, which indicates that the coupled portion of the coupled-line gap increases. In this case, it is seen that both the resonant frequencies of the two excited resonant modes are lowered with an increase in the value of a. On the other hand, for the results of varying b from 25 to 35 mm shown in Figure 4(b) with a fixed to be 15 mm, the original one-wavelength resonant mode is almost not affected, and the excited new resonant mode can be effectively shifted to lower frequencies by increasing the value of b (that is, the coupled portion of the coupled-line gap increases). The different effects of the lengths a and b on the two excited resonant modes are very likely owing to the different surface current distributions on the different portions of the metal strip; for the portion with length a, the surface current distribution has been found to be stronger than that for the portion with length b. From these obtained results shown in Figure 4, a simple design rule for controlling the antenna's two excited resonant modes can be determined. First, one can select a proper value of a to make the original one-wavelength resonant mode excited at about 1800 MHz for DCS operation; in this study, the value of a is selected to be 15 mm. Second, by varying the value of b, the new resonant mode can be effectively controlled to be excited at about 900 MHz for GSM operation; in this study, the value of b is selected to be 30 mm.

The radiation characteristics of the proposed open-loop antenna are also studied. Figures 5 and 6 plot the measured radiation patterns at 925 and 1795 MHz for the preferred prototype studied in Figure 2. The radiation patterns are first seen to be different from those for mobile phone applications [1]. This is mainly because the size of the supporting metal frame of the laptop display in this study is much larger than the system ground plane of the mobile phone. The supporting metal frame in this study is more like a reflector, different from the system ground plane of the mobile phone that also functions as an effective radiator. It is also seen that the E_ϕ component of the antenna radiation is stronger at 925 MHz than that at 1795 MHz. This is largely because the excited surface currents for the new resonant mode are mainly with the same horizontal direction along the inverted-U metal strip,

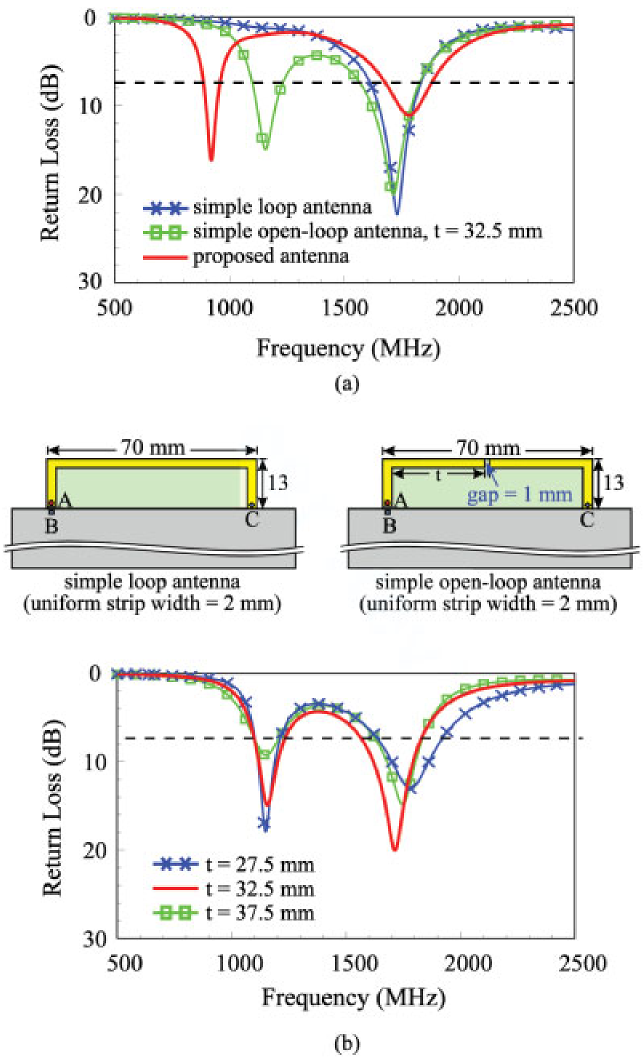

Figure 3 (a) Simulated return loss of the simple loop antenna, the simple open-loop antenna with a 1-mm gap, and the proposed open-loop antenna with the coupled-line gap. (b) Simulated return loss of the simple open-loop antenna as a function of t, the location of the 1-mm gap. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com]

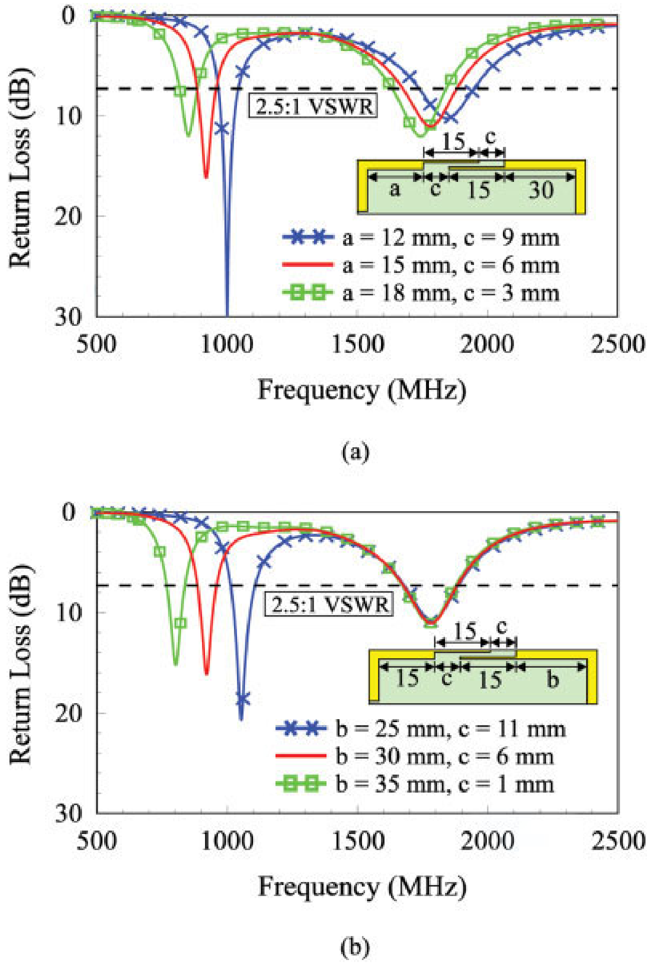

Figure 4 Simulated return loss of the proposed open-loop antenna (a) as a function of *a* and (b) as a function of *b*. Other parameters are the same as shown in Figure 1. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com]

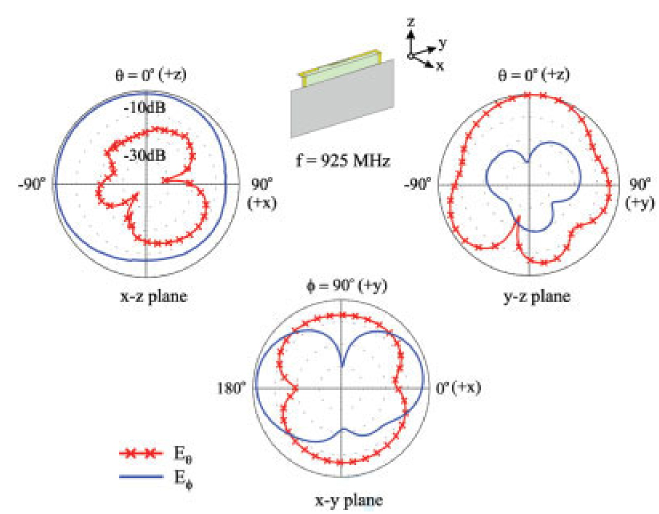

Figure 5 Measured radiation patterns at 925 MHz for the proposed antenna studied in Figure 2. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com]

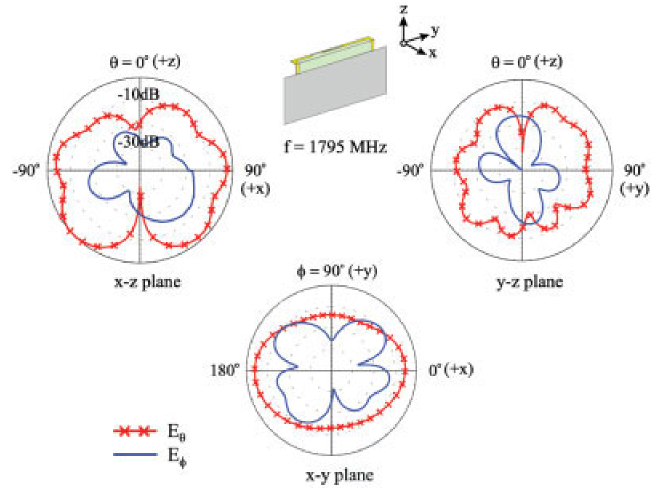

Figure 6 Measured radiation patterns at 1795 MHz for the proposed antenna studied in Figure 2. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com]

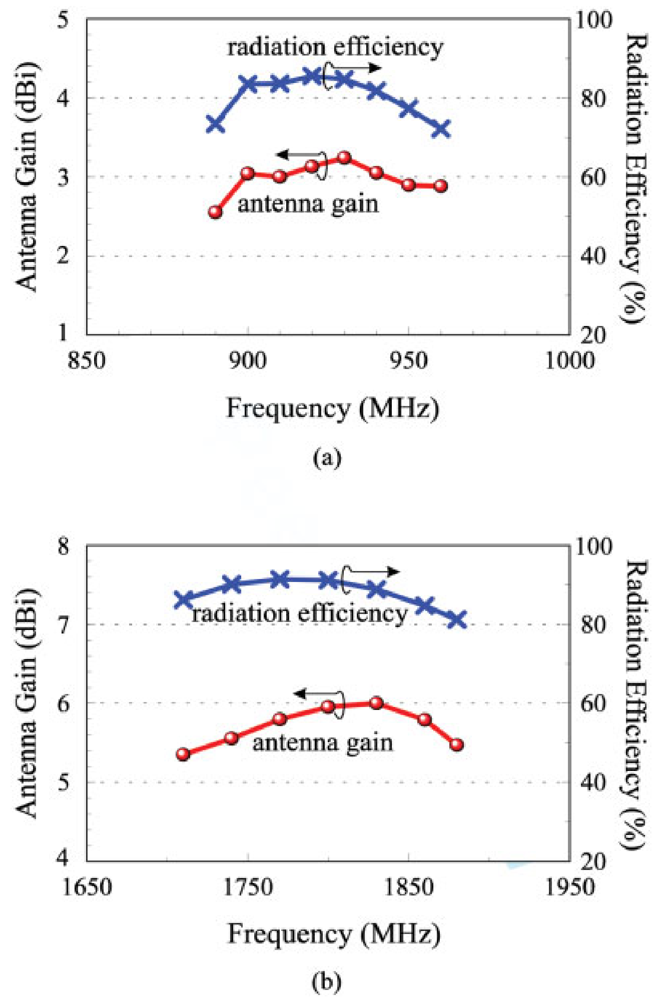

Figure 7 Measured antenna gain and simulated radiation efficiency for the proposed antenna studied in Figure 2: (a) the GSM band and (b) the DCS band. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com]

while those for the original resonant mode are with different horizontal directions with the null current at the location of the coupled-line gap. In addition, it is observed that the radiation in the *x–z* plane at 1795 MHz is more directive along the $\pm x$ direction. This characteristic is expected, since the one-wavelength resonant loop mode is generally with a directive radiation pattern along the axial direction (the $\pm x$ direction of the proposed open-loop antenna). Measured antenna gain and simulated radiation efficiency for the proposed antenna are also presented in Figure 7. For frequencies over the GSM band, the measured antenna gain is about 2.6–3.2 dBi [Fig. 7(a)], while that for frequencies over the DCS band ranges from about 5.4 to 6.0 dBi [Fig. 7(b)]. For the radiation efficiency, it is all larger than 70% over the GSM band and about 80–90% over the DCS band.

4. CONCLUSION

A novel GSM/DCS dual-band open-loop antenna for internal laptop antenna application has been proposed. The antenna generally has a simple and planar structure, making it easily to fabricate by printing on a dielectric substrate. The antenna is integrated to the supporting metal frame of the laptop display to form a resonant loop path. By introducing a coupled-line gap in the proposed antenna, two resonant modes (a half-wavelength resonant loop mode and a one-wavelength resonant loop mode) at about 900 and 1800 MHz can be excited. A design rule for determining the preferred parameters of the coupled-line gap to control the two excited resonant modes has also been given in the paper. In addition to the compact size of the proposed antenna to be suitable to operate as an internal laptop antenna, good radiation efficiency for frequencies over the GSM and DSC bands has also been obtained for the proposed antenna.

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A NEW CPW-FED HALF-LOOP ANTENNA

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ABSTRACT: *A novel and simple structure for a CPW-fed half-loop antenna is presented. The proposed antenna covered the ultra-wideband bandwidth (3.1–10.6 GHz) to even higher band (~20 GHz) for VSWR <2. Tapered slot structure and half-loop antenna exhibited high band and low band, respectively. The measured results are in fairly good agreements with those of simulated ones.* Microwave Opt Technol Lett 49: 684–686, 2007; Published online in Wiley InterScience (www.interscience.wiley.com). DOI 10.1002/mop.22223

Key words: *CPW-fed; ultra-wideband; half-loop; tapered*

1. INTRODUCTION

The UWB (ultra-wideband) technology was also known as the technology of pulse radio (impulse radio) in 1960. According to the regulation of the Federal Communication Commission (FCC), it had bandwidth range of 7.5 GHz from 3.1 to 10.6 GHz [1]. Using for many years, American military has applied the ground penetrating radar systems, through wall imaging systems, etc. New UWB of communication is proposed, because it has transmission speed quickly, low power dissipation, and low chip space, etc. For wireless communication in the wideband applications, FCC opens 3.1–10.6 GHz for UWB communication systems to use.

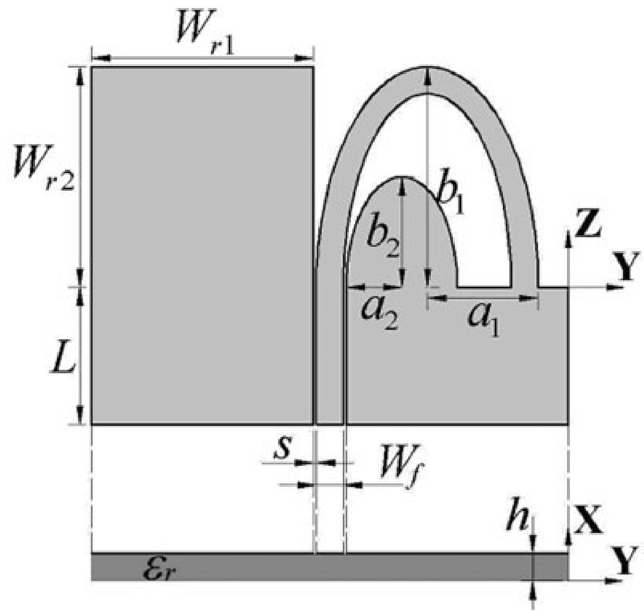

Figure 1 Geometry of the CPW-fed half-loop antenna $W_{r1} = 24$ mm, $W_{r2} = 24$ mm, $L = 15$ mm, $W_f = 2.93$ mm, $S = 0.3$ mm, $a_1 = 12$ mm, $a_2 = 6$mm, $b_1 = 24$ mm, $b_2 = 12$ mm

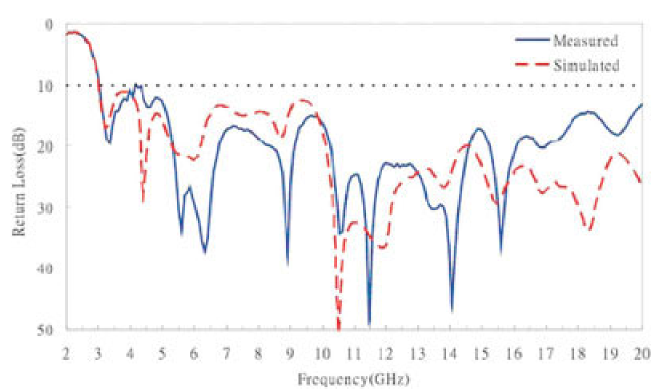

Figure 2 −10 dB return loss of the proposed antenna. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com]