ULTRA-WIDEBAND PLANAR SHORTED DIPOLE ANTENNA WITH TWO C-SHAPED ARMS FOR WIRELESS COMMUNICATIONS

Wei-Yu Li,[1] Kin-Lu Wong,[1] and Saou-Wen Su[2]
[1] Department of Electrical Engineering, National Sun Yat-Sen University, Kaohsiung 804, Taiwan
[2] Technology Research and Development Center, Lite-On Technology Corp., Taipei 114, Taiwan

Received 27 September 2006

ABSTRACT: *A novel ultra-wideband (UWB) planar shorted dipole antenna capable of generating a 9:1 bandwidth (820–7340 MHz) covering the present-day mobile communication systems (AMPS, GSM, DCS, PCS, UMTS) and WLAN systems in the 2.4/5.2/5.8 GHz bands is presented. The proposed planar antenna is easily fabricated from a metal plate and is generally in the form of the dipole antenna with two C-shaped radiating arms short-circuited to each other through two shorting strips. By selecting a proper length of the shorting strips, the proposed antenna can have the lower edge frequency of its operating band reduced to be as low as 820 MHz, with a compact size of 109 × 170 mm². The proposed antenna is studied in detail in the article.* Microwave Opt Technol Lett 49: 1132–1135, 2007; Published online in Wiley InterScience (www.interscience.wiley.com). DOI 10.1002/mop.22381

Key words: *planar antennas; UWB antennas; dipole antennas; multiband antennas; dual-network antennas*

1. INTRODUCTION

With the integration of the mobile and WLAN (wireless local area network) communications, it is expected that ubiquitous or seamless data services can be provided for wireless users [1, 2]. For this kind of integrated mobile/WLAN dual-network applications, it will be very attractive that the employed antenna is capable of mobile communications in the AMPS (Advanced Mobile Phone System, 824–894 MHz), GSM (Global System for Mobile Communication, 890–960 MHz), DCS (Digital Communication System, 1710–1880 MHz), PCS (Personal Communication System, 1850–1990 MHz), UMTS (Universal Mobile Telecommunication System, 1920–2170 MHz) bands and WLAN operations in the 2.4 GHz band (2400–2484 MHz), 5.2 GHz band (5150–5350 MHz) and 5.8 GHz band (5725–5875 MHz). For such dual-network applications, we present in the article a novel planar antenna capable of generating an UWB operating band to cover the required bandwidths of the existing mobile and WLAN communications [3] from 824 to 5875 MHz.

The proposed planar antenna is a shorted dipole antenna with two C-shaped radiating arms occupying a compact area of 0.30λ × 0.47λ [see Fig. 1, λ is the wavelength of the desired lower edge frequency f_L (824 MHz in this study) of the obtained UWB bandwidth]. In addition to the use of C-shaped radiating arms, which reduces the total length of the proposed antenna (0.30λ here) with comparison to the case using straight radiating arms, the short circuiting of the two radiating arms further effectively decreases f_L with a fixed antenna size. Then, by selecting a proper length of the shorting strips between the two

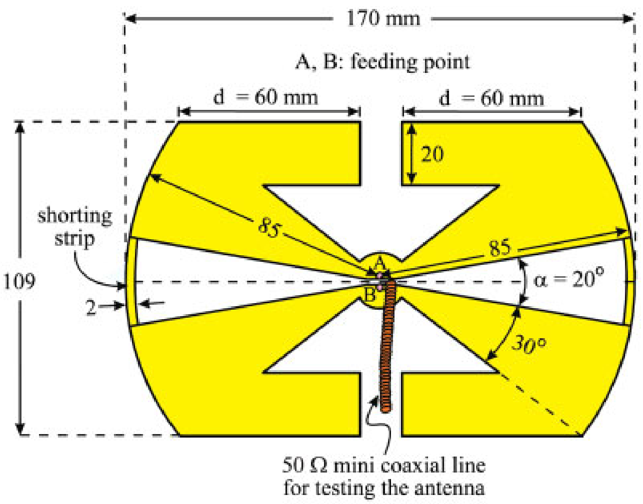

Figure 1 Geometry of the proposed ultra-wideband planar shorted dipole antenna. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com]

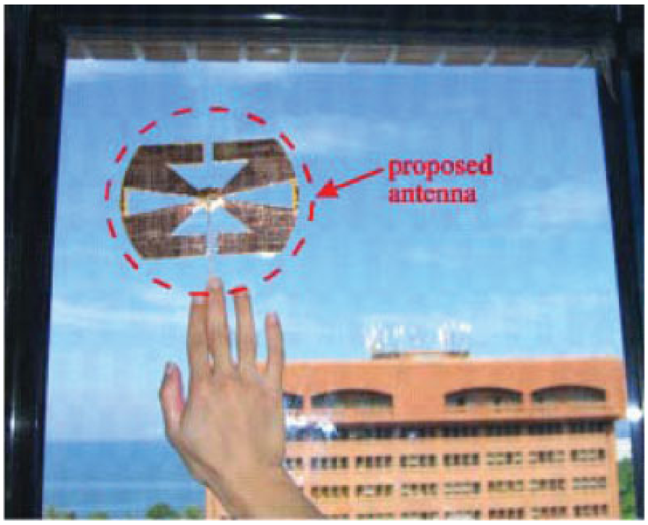

Figure 2 Photo of the fabricated prototype of the proposed antenna attached on the window pane of the electrical engineering building inside the campus of the National Sun Yat-sen University. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com]

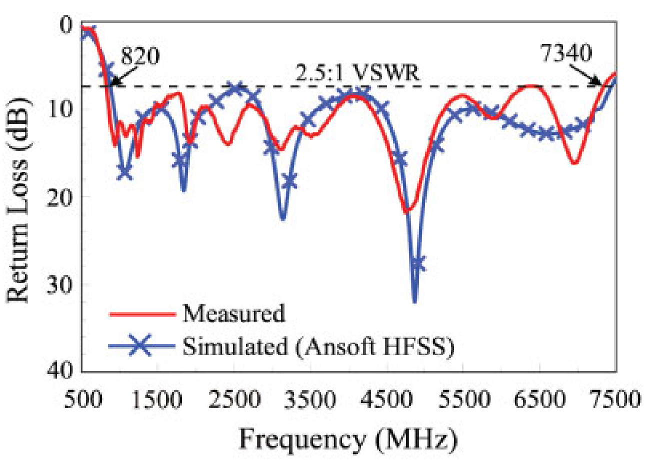

Figure 3 Measured and simulated return loss for the proposed antenna with preferred dimensions given in Figure 1. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com]

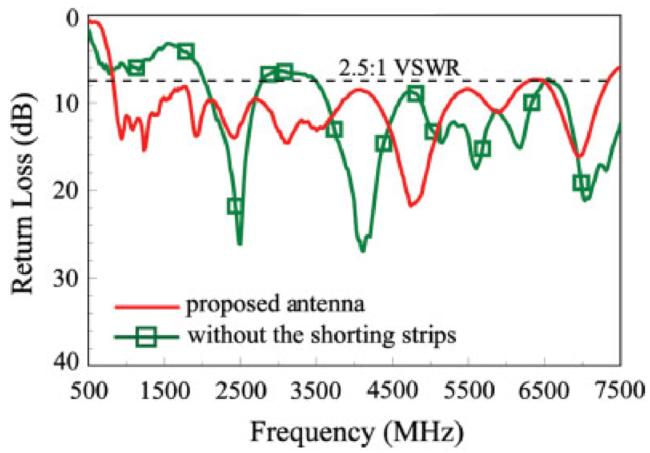

Figure 4 Measured return loss for the proposed antenna and the case without the shorting strips. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com]

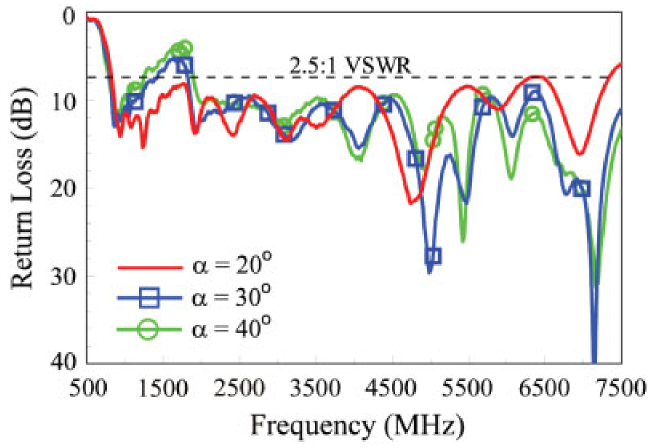

Figure 5 Measured return loss for the proposed antenna with α = 20°, 30°, and 40°; other dimensions are the same as given in Figure 1. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com]

radiating arms, good impedance matching for frequencies over a wide frequency range starting from about 824 MHz to larger than 7 GHz can be obtained for the proposed antenna. This allows it to easily cover the required bandwidths of the existing mobile and WLAN systems. With the planar configuration, the proposed antenna is very promising to be attached on the window pane of the vehicles for vehicular applications [4–6] or of the buildings (see Fig. 2) for access-point applications. The proposed antenna is described in detail in the article, and results of the fabricated prototypes are presented and discussed.

2. DESIGN CONSIDERATIONS OF PROPOSED ANTENNA

As shown in Figure 1, the proposed antenna is in the form of the shorted planar dipole antenna with two C-shaped radiating arms. The antenna is fabricated using a 0.2 mm thick copper plate in the study, and the two radiating arms are of the same dimensions. A fabricated prototype of the proposed antenna is shown in Figure 2. Each radiating arm is also symmetric with respect to the centerline or axis of the dipole antenna, and comprises two symmetric parts of a radial portion of length 85 mm and an end portion of length 60 mm (*d*). By increasing the length *d*, the antenna's lower edge frequency f_L can be decreased; detailed results of the length *d* on f_L will be discussed with the aid of Figure 6 in the next section. Also note that the opening between the two end portions of each C-shaped radiating arm can allow the passage of the 50 Ω mini coaxial line feeding the proposed antenna. In this case, small or negligible effects of the feeding coaxial line on the radiation characteristics of the proposed dipole antenna can be obtained.

The two C-shaped radiating arms are also short-circuited to each other by two shorting strips at two sides of the antenna. The two shorting strips are of the same dimensions, and each shorting strip is 2 mm in width and is subtended by a flare angle of α; a larger flare angle indicates a longer length of the shorting strip. The preferred flare angle in this study is 20° as shown in the figure. With the use of short-circuiting, the lower edge frequency f_L can be effectively decreased with a fixed size of the proposed antenna. In addition, by choosing a suitable length of the shorting strip or a proper flare angle, improved impedance matching for frequencies over a wide operating band can be obtained. Detailed effects of the variations in the flare angle α will be studied with the aid of Figure 5 in Section 3. Thus, by incorporating the use of the two C-shaped radiating arms and the short-circuiting between the two arms, a very wide bandwidth of about 9:1 with f_L lower than 824 MHz is obtained with a compact area of 109 × 170 mm^2 or 0.30λ × 0.47λ referenced to the frequency f_L for the proposed antenna.

3. RESULTS AND DISCUSSION

The proposed antenna with the preferred dimensions given in Figure 1 was fabricated and studied. Figure 3 shows the measured and simulated return loss for the fabricated prototype. The simulated results obtained using Ansoft simulation software HFSS (High Frequency Structure Simulator) [7] are seen to agree with the measured data. It is clearly seen that a very wide 9:1 impedance bandwidth, defined by 2.5:1 VSWR or about 7.3 dB return loss, of 6520 MHz (820–7340 MHz) is obtained, which allows the proposed antenna to easily cover the operating bands of the existing mobile and WLAN systems from 824 to 5875 MHz. Also note that the bandwidth definition of 2.5:1 VSWR is acceptable for practical applications for mobile and WLAN communications.

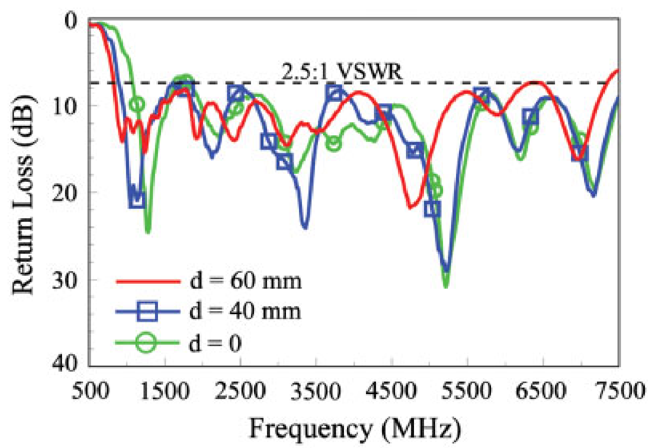

Figure 6 Measured return loss for the proposed antenna with *d* = 0, 40, and 60 mm; other dimensions are the same as given in Figure 1. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com]

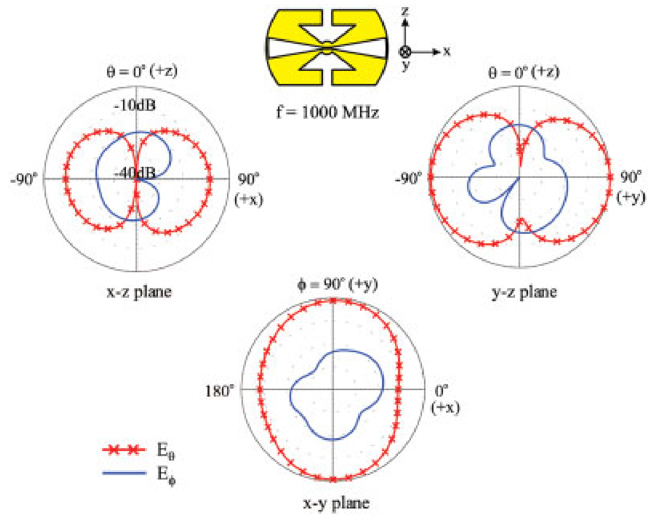

Figure 7 Measured radiation pattern at 1000 MHz for the proposed antenna studied in Figure 3. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com]

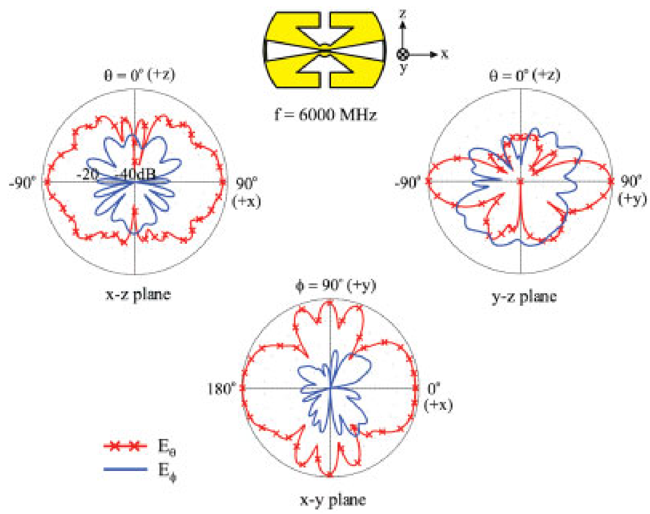

Figure 9 Measured radiation pattern at 6000 MHz for the proposed antenna studied in Figure 3. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com]

Effects of the presence of the shorting strip in the proposed antenna are shown in Figure 4, in which measured results of the return loss for the proposed antenna and the case without the shorting strips are shown. It is seen that the lower edge frequency is decreased from about 2000 MHz for the case without the shorting strips to 820 MHz for the proposed antenna. In addition, improved impedance matching is also obtained for frequencies over the obtained bandwidth for the proposed antenna.

Figure 5 shows the results of the measured return loss for the proposed antenna with $\alpha = 20°$, 30°, and 40°; other dimensions are the same as given in Figure 1. It is first seen that the lower edge frequency for the three cases are about the same. However, the variations in the flare angle α have large effects on the impedance matching over the desired bandwidth from 824 MHz to large than 5875 MHz, especially for the lower frequencies in the desired bandwidth. It can be seen that for the case with $\alpha =$ 20°, improved matching for frequencies over the desired bandwidth is achieved. The obtained results confirm the selection of $\alpha = 20°$ for the preferred flare angle in the proposed antenna studied here.

Effects of the length d on the measured return loss for the proposed antenna are studied in Figure 6, in which the results for $d = 0$, 40, and 60 mm are shown. Results indicate that the lower edge frequency can also be decreased by increasing the length d; however, the decreasing effect on the lower edge frequency is not as large as that of using the shorting strips as shown in Figure 4. On the other hand, it is seen that the length d has small effects on the impedance matching for frequencies over the desired bandwidth.

The radiation characteristics of the proposed antenna studied in Figure 3 were also studied. Figures 7–9 plot the measured radiation patterns at 1000, 3000, and 6000 MHz, respectively. The radiation patterns in three principal planes are shown, and the three patterns are normalized with respect to the peak gain of the proposed antenna. For the lower frequency at 1000 MHz,

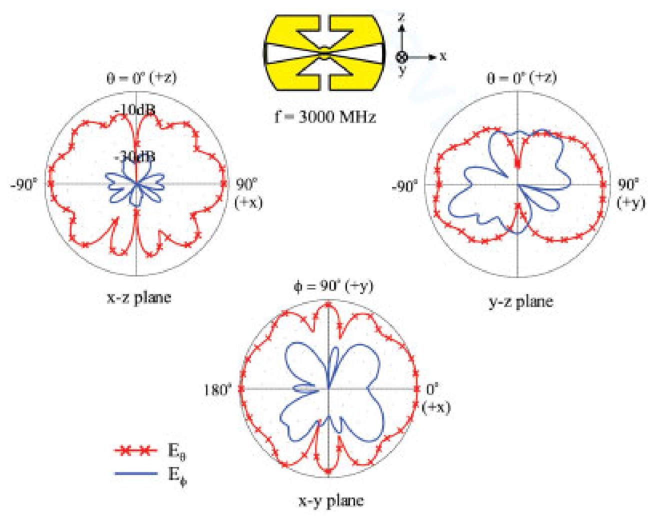

Figure 8 Measured radiation pattern at 3000 MHz for the proposed antenna studied in Figure 3. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com]

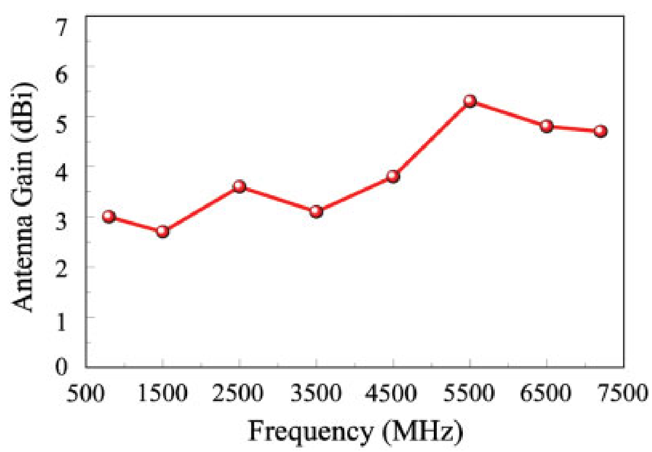

Figure 10 Measured antenna gain for the proposed antenna studied in Figure 3. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com]

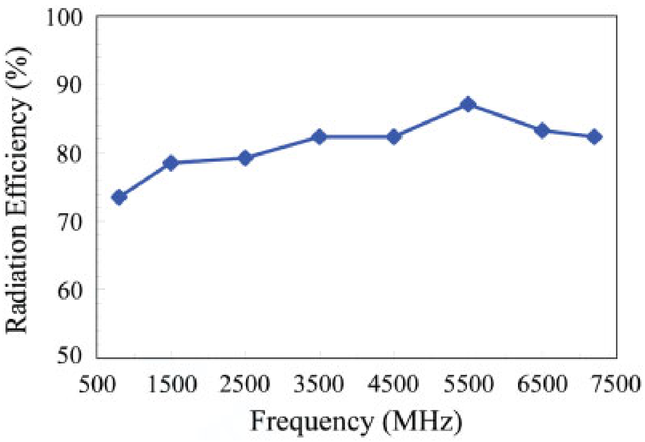

Figure 11 Simulated radiation efficiency for the proposed antenna studied in Figure 3. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com]

the radiation patterns are generally close to those of a traditional dipole antenna. On the other hand, for the higher frequencies at 3000 and 6000 MHz, there are nulls in the radiation patterns in the Azimuthal plane (*x-y* plane). The radiation characteristics of the proposed antenna in general are similar to those of the ultra-wideband planar antennas [8, 9]. Figure 10 shows the measured antenna gain for the proposed antenna, and the simulated radiation efficiency is shown in Figure 11. Over the obtained ultra-wide operating band, the measured antenna gain is varied from about 2.7–5.3 dBi, while the radiation efficiency is varied from about 74–86%.

4. CONCLUSION

A novel UWB planar dipole antenna with two short-circuited C-shaped radiating arms has been proposed. The antenna occupies a compact area of 109×170 mm^2, yet generating a very wide operating bandwidth of about 6.5 GHz (820–7340 MHz), which allows it to easily cover the operating bandwidths of the existing mobile and WLAN systems. In addition, good radiation characteristics for frequencies over the obtained bandwidth have been obtained. Detailed design considerations of the proposed antenna have also been described. The size reduction of the proposed antenna is mainly achieved by short-circuiting the two C-shaped radiating arms using a proper length of the shorting strips. The proposed antenna is very suitable to be attached on the window pane of the vehicles or buildings for wireless communications.

REFERENCES

1. A.K. Salkintzis, C. Fors, and R. Pazhyannur, WLAN-GPRS integration for next-generation mobile data networks. IEEE Wireless Commun 9 (2002), 112–124.
2. H. Luo, Z. Jiang, B.J. Kim, N.K. Shankaranarayanan, and P. Henry, Integrating wireless LAN and cellular data for the enterprise. IEEE Internet Computing 7 (2003), 25–33.
3. K.L. Wong, Planar Antennas for wireless communications, Wiley, New York, 2003.
4. T.J. Talty, Y. Dai, and L. Lanctot, Automotive antennas trends and future requirements, IEEE Antenn Propagat Soc Int Symp Dig, Boston, MA (2001), 294–297.
5. Y.T. Liu, S.W. Su, C.L. Tang, H.T. Chen, and K.L. Wong, On-vehicle low-profile metal-plate antenna for AMPS/GSM/DCS/PCS/UMTS multiband operation. Microwave Opt Technol Lett 41 (2004), 144–146.
6. S.W. Su, Y.T. Liu, K.L. Wong, and C.L. Tang, Low-profile broadband printed VHF monopole antenna for vehicular applications. Microwave Opt Technol Lett 42 (2004), 349–350.
7. Ansoft Corporation HFSS. Available at http://www.ansoft.com/products/hf/hfss/
8. K.L. Wong, C.H. Wu, and S.W. Su, Ultra-wideband square planar metal-plate monopole antenna with a trident-shaped feeding strip. IEEE Trans Antenn Propagat 53 (2005), 1262–1269.
9. K.L. Wong, S.W. Su, and C.L. Tang, Broadband omnidirectional metal-plate monopole antenna. IEEE Trans Antenn Propagat 53 (2005), 581–583.

DUAL-BAND MONOPOLE ANTENNA EXCITED BY A CAPACITIVE COUPLING FEED FOR WLAN APPLICATIONS

Chih-Yu Huang,[1] Hsiao-Cheng Lin,[2] and Jieh-Sen Kuo[3]
[1] Department of Electronic Engineering, National Kaohsiung Normal University, Kaohsiung 824, Taiwan, Republic of China
[2] Department of Physics, National Kaohsiung Normal University, Kaohsiung 824, Taiwan, Republic of China
[3] Department of Electronic Engineering, Kao-Yuan University of Technology, Kaohsiung, Taiwan 821, Republic of China

Received 28 September 2006

ABSTRACT: *A printed dual-band T-shaped monopole antenna with a shorted strip fed by a coupling microstrip line for wireless communication in the wireless local-area network (WLAN) band is studied. The proposed antenna can provide two separate impedance bandwidths of 101 MHz (about 4.1% centered at 2.45 GHz) and 1490 MHz (about 27% centered at 5.5 GHz), making it easier to cover the required bandwidths for WLAN operation in the 2.45 GHz band (about 3.4% bandwidth required) and 5.2/5.8 GHz bands (about 13% bandwidth required). We can easily find the enhancement of impedance bandwidth by using capacitive coupling feed. Details of the proposed antenna design and experimental results are presented and discussed.* © 2007 Wiley Periodicals, Inc. Microwave Opt Technol Lett 49: 1135–1138, 2007; Published online in Wiley InterScience (www.interscience.wiley.com). DOI 10.1002/mop.22380

Key words: *dual-band; monopole; coupling feed; WLAN*

1. INTRODUCTION

Dual-band operation to satisfy the services of multiband specification for various users of personal wireless has been invented, but many of their higher frequency band cannot cover 5.15–5.85 GHz [1–3]. Such as, a modified PIFA with folded patch was studied for bluetooth and WLAN applications [1], a dual-band PIFA with low profile characteristics [2], and a dual-band inverted-L-folded antenna with a parasitic wire [3]. In these dual-band antennas, however, the upper-band bandwidth obtained is generally about or less than 10% and cannot cover the additional 5.8 GHz band. In this article, a simple dual-band antenna with a capacitive coupling feed is proposed to achieve 2.45 GHz band and have large bandwidth to easily cover the 5.2/5.8 GHz bands for WLAN operation. The coupling contributes to a wide operating band for the upper band.