Printed Diversity Monopole Antenna for WLAN Operation in the 2.4 GHz Band

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1. Introduction

Printed on-board monopole antennas for a communication device have the advantages of occupying small volume of the system, easily integrating with the associated circuit, and decreasing the fabrication cost of the final product. Some related designs of the printed monopole antennas with a hook-like monopole [1], an inverted-F monopole [2], an F-shaped monopole [3], and so on applied for wireless local area network (WLAN) operations have also been reported. These designs, however, cannot overcome the multipath fading problem, which is becoming a critical factor for obtaining enhanced system performance in WLAN communications, for they usually operate in the environments where the signals will experience several paths between the transmitting and receiving antennas. In this case, the problem that the signals may cancel out almost completely at the receiving antenna can happen, leading to the degradation of the system performance.

In this paper, we present a printed monopole antenna for providing spatial diversity for WLAN operation in the 2.4 GHz band. The printed diversity monopole antenna studied here is to be applied to a PCMCIA network card for a notebook computer, and the diversity characteristics of the antenna can overcome the multipath fading problem to enhance the system performance.

2. Antenna Designs

Figure 1 shows the geometry of the proposed diversity monopole antenna, which consists of two orthogonal straight printed monopoles (length 25 mm) designed for WLAN operation in the 2.4 GHz band. Each monopole is directly fed using a 50 Ω microstrip line, and good impedance matching (VSWR better than 1.5:1) without the need of adding additional matching circuitry in the proposed antenna can be achieved. Between the two orthogonal printed monopoles, there is a T-shaped ground plane protruded from the main ground plane of dimensions 50×80 mm^2, which are about the ground-plane size of a practical PCMCIA network card. Both of the protruded and main ground planes are printed on the other side of the FR4 substrate, and the T-shaped ground plane comprises a central vertical strip (length 16 mm) and a top horizontal strip (length L). The T-shaped ground plane not only serves as a reflecting plate for the two monopoles to have their radiation patterns covering complementary space regions to provide spatial diversity for the proposed antenna, but also enhances the isolation between the antenna's two feeding ports. High port decoupling ($S_{21} < -30$ dB) is possible for the proposed antenna by selecting a proper length (about 20 mm in this study) of the top horizontal strip of the T-shaped ground plane.

3. Experimental Results and Discussion

Several prototypes with various lengths of the top horizontal strip were constructed and studied.

The corresponding measured data are listed in Table I for comparison. Figure 2 shows the measured S parameters of the constructed prototype with L = 20 mm. It is seen that the obtained impedance bandwidth covers the 2.4 GHz band (2400–2484 MHz), so are the other cases with L = 26, 22, 18 and 0 mm, although the variations in L affect the impedance matching of the proposed antenna. On the other hand, the maximum S_{21} across the 2.4 GHz band varies significantly from –11.7 to –31.0 dB, which suggests that the isolation of the two feeding ports in the proposed antenna strongly depends on the value of L. In addition, there is an optimal value of L for obtaining maximum isolation between the two feeding ports. For the prototypes studied here (see the results listed in Table I), it shows that the optimal value of L is 20 mm, and the isolation obtained for frequencies across the 2.4 GHz band is less than –31 dB.

Table I: Performance of the proposed antenna with various values of L. The impedance bandwidth (BW) is determined from 1.5:1 VSWR ($S_{11} \fallingdotseq -14$ dB); f_L and f_H are, respectively, the lower and upper frequencies with VSWR = 1.5. The isolation given is the maximum S_{21} across the 2.4 GHz band (2400–2484 MHz).

L (mm)	BW (= f_H–f_L) (MHz)	$S_{21,\,max}$ (dB)
26	292, 2252–2544	–18.0
22	316, 2200–2516	–26.2
20	200, 2300–2500	–31.0
18	124, 2384–2508	–21.3
0	268, 2292–2560	–11.7

For the prototype with L = 20 mm, the radiation characteristics were also measured and studied. Figure 3 shows the measured maximum antenna gain across the 2.4 GHz band, and Figures 4 and 5 plot, respectively, the measured radiation patterns of port 1 and port 2 excitation at 2450 MHz. It is seen that the measured radiation patterns tend to cover complementary space regions, which provides spatial diversity for the proposed antenna. And the measured antenna gain across the 2.4 GHz band for port 1 and port 2 excitation is about the same. The maximum antenna gain reaches about 4.2 dBi, with gain variations less than 1.2 dBi.

4. Conclusions

A printed diversity monopole antenna suitable to be integrated on a PCMCIA network card has been demonstrated. The antenna's two feeding ports have high isolation ($S_{21} < -30$ dB) and good impedance matching (better than 1.5:1 VSWR) for frequencies across the 2.4 GHz WLAN band. In addition, spatial diversity can also be provided for the proposed antenna, which helps combat the multipath fading problem in WLAN communications.

5. References

1. C. Wu, Printed antenna structure for wireless data communications, US Patent No. 6008774, Dec. 28, 1999.
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3. S. H. Yeh and K. L. Wong, "Integrated F-shaped monopole antenna for 2.4/5.2 GHz dual-band operation," Microwave Opt. Technol. Lett., vol. 34, 2002. (to appear in July 5, 2002 issue)

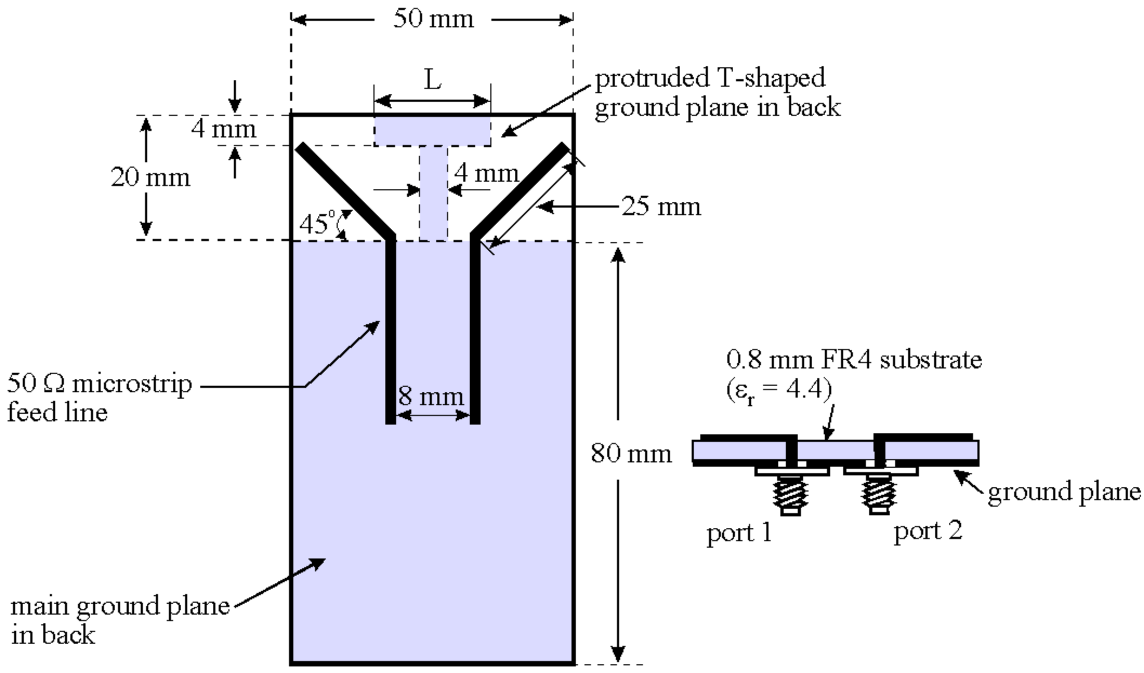

Fig. 1 Geometry of the proposed printed diversity monopole antenna for 2.4 GHz WLAN operation.

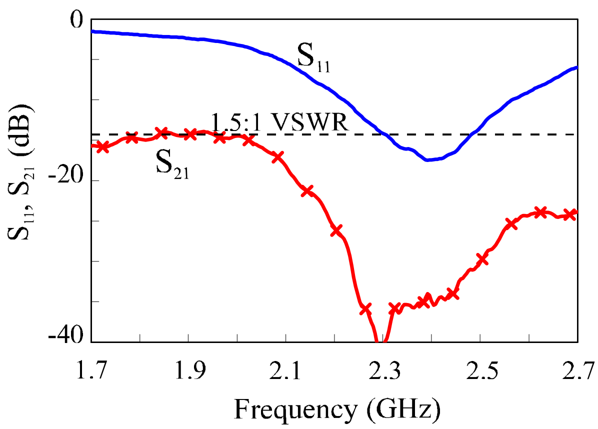

Fig. 2 Measured S_{11} and S_{21} of the proposed antenna with L = 20 mm.

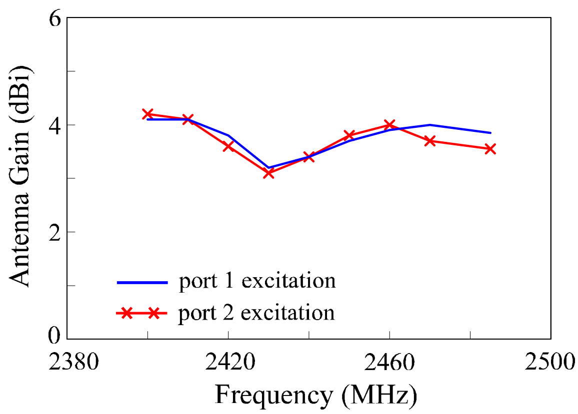

Fig. 3 Measured maximum antenna gain across the 2.4 GHz WLAN band for the proposed antenna with L = 20 mm.

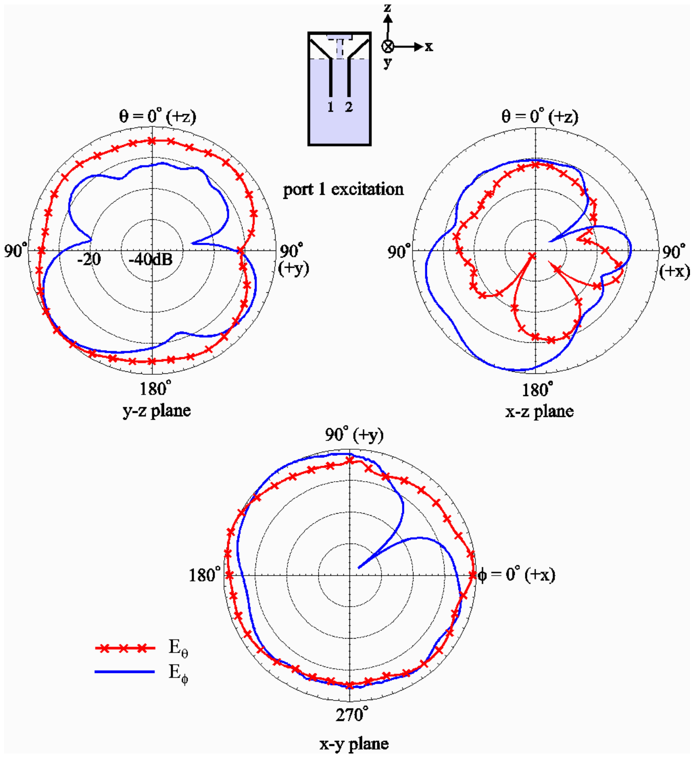

Fig. 4 Measured radiation patterns at 2450 MHz for port 1 excitation of the proposed antenna with *L* = 20 mm.

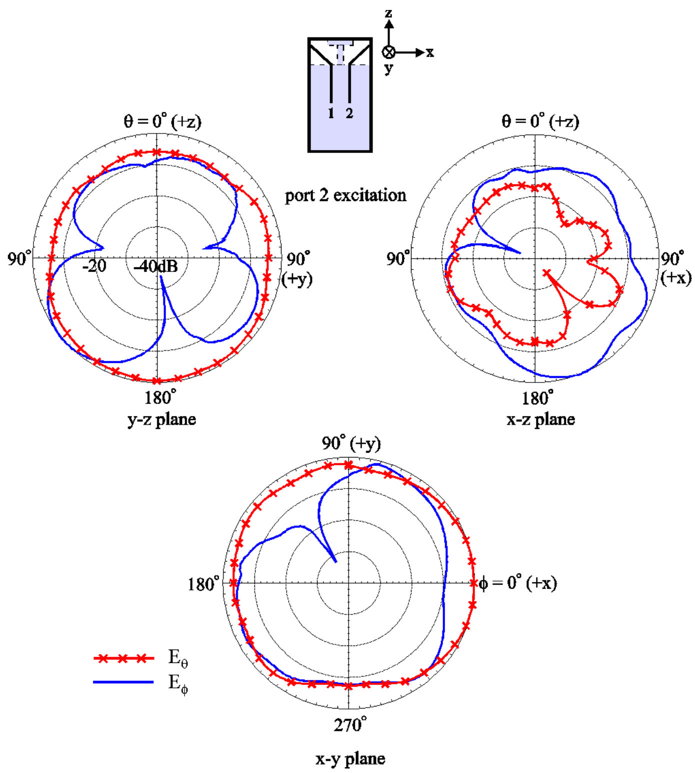

Fig. 5 Measured radiation patterns at 2450 MHz for port 2 excitation of the proposed antenna with *L* = 20 mm.