CPW-fed Slotted Monopole antenna for WLAN applications

#Chung-Kyun Ham, Jung-Woo Baik, and Young-Sik Kim
Department of Radio Sciences and Engineering, Korea University
5-Ka, Anam-dong, Sungbuk-gu, Seoul 136-701, Korea
E-mail: hamck@korea.ac.kr, yskim@korea.ac.kr

1. Introduction

Since the FCC has announced to allow the unlicensed use of the industrial, scientific, and medical (ISM) frequency band by any potential users, wireless communications community has provided enormous opportunities for driving many wireless systems that can be communicated over short distances. For example, some practical applications are operated at the internationally available unlicensed ISM band of 2.4 GHz such as the Bluetooth or wireless local-area network (WLAN) systems and of 5.2 and 5.8 GHz like the WLAN systems [1]. IEEE 802.11 b/g is allocated at the band of 2.4-2.484 GHz, while IEEE 802.11a is at the band of 5.15-5.35 GHz and 5.725-5.825 GHz. To meet these standards, it is proposed to design a single antenna that can cover all these bands [2]. In particular, a great interest in coplanar waveguide (CPW)-fed antennas has been suggested because of their many attractive features such as wide bandwidth, good impedance matching, simple structure of a single metallic layer, no soldering point, and easy integration with active devices or monolithic microwave integrated circuits [3]. The antennas with cross-slot, H-shaped narrow slot, circular slot [4]-[6] with narrow bandwidth at 2.4 GHz WLAN band have been reported. And CPW-fed slotted antenna with two separate and symmetrical ground planes is proposed [7]. In [8] the CPW antenna with asymmetrical ground planes is investigated with narrow bandwidth at the operating band. In this paper, a novel dual-band patch antenna consisting of a slotted monopole and a CPW feeding structure with asymmetrically surrounded ground planes with slots is proposed. By properly optimizing the shapes of the embedded slots on the rectangular patch, dual-band operation and good radiation performance, suitable for wireless communication such as the 2.4/5 GHz WLAN systems, has been achieved. Details of the antenna design and experimental results are presented and discussed.

2. Antenna Design

The geometry of the proposed coplanar waveguide (CPW)-fed slotted monopole antenna for dual-band WLAN operation is shown in Fig. 1. The antenna has a simple structure by etching it on one side of an inexpensive FR4 substrate with a dielectric constant of 4.4 and substrate thickness of 1.6 mm. The basis of the antenna structure is a rectangular patch with dimensions of 22×35 mm^2. In this design, two shaped slots, one vertical and three inverted-L shaped slots, are utilized and embedded into the patch from its edges for providing different surface current paths so as to produce two resonant modes. A CPW transmission line with 50 Ω characteristic impedance, which is consisting of a signal strip thickness of 2.0 mm and a gap of 0.3 mm between the center conductor and the asymmetrical ground plane, is used to feed the antenna. This proposed antenna has two asymmetrical finite ground planes. One is a rectangle with dimensions of 9.7×12.5 mm^2, while the other one is with dimensions of 9.7×28 mm^2. The right rectangle has the vertical slot of 0.8×8 mm^2. The embedded inverted-L slot on the radiating element has a dimension of 0.5×3 mm^2 and 13.5×1 mm^2. The shapes and dimensions of the proposed antenna have been performed by IE3D electromagnetic simulator. Finally, the values of the geometrically optimal parameters for achieving dual-band operation and good impedance matching are also given in Fig. 1.

3. Simulated and Experimental Results

Figure 2 shows the measured and simulated frequency responses of the return losses for the proposed design. The frequency responses of the S-parameters are measured using an Agilent N5230A vector network analyzer. Although the measured results in general agrees well with the simulated ones, small discrepancies between the simulated and measured results may be occurred because of the effect of the SMA conductor and fabrication imperfections. The lower and upper resonant modes are produced at 2.48, 2.95 and 5.5 GHz, respectively. At the lower band, the 10 dB impedance bandwidth is about 1.1 GHz (2.2-3.3 GHz), which meets the bandwidth requirement for IEEE 802.11b/g. In 5 GHz band, the 10dB bandwidth is about 0.85 GHz (5.1-5.95 GHz), which also satisfies the bandwidth requirement for IEEE 802.11a. Figure 3 shows the simulated return loss for the proposed antenna with various *l*. It is seen that, by increasing the slot length ***l*****,** the antenna has good impedance matching at 5 GHz band. The radiation patterns in the orthogonal x-z, y-z, and x-y planes at 2.48, 2.95 and 5.5 GHz are shown in Fig. 4. The near omni-directional patterns in the H-plane (x-y plane) and the broadside and monopole-like patterns in the E-planes (x-z and y-z planes) are observed. The radiation performance of this proposed antenna is found to be stable since similar patterns have also been measured at other operating frequencies of both bands. Figure 5 and 6 show the measured 3D peak antenna gain vs frequency of both bands. On average, gains of 4.89 and 4.03 dBi can be achieved within the bandwidths of the lower and upper operating bands, respectively.

4. Conclusions

A CPW-fed slot monopole antenna with asymmetrical slot ground plane is designed and implemented. With the embedment of inverted-L shaped slot on a radiating patch, the proposed antenna can be radiated at dual band. Especially, the proposed antenna shows broad impedance bandwidth of 1100 MHz at the 2.4 GHz band. By adding a slot on asymmetrical ground planes, good impedance matching is achieved at the 5 GHz band. The obtained performance of this antenna shows an attractive feature for 2.4/5 GHz dual ISM-band applications.

5. Figures

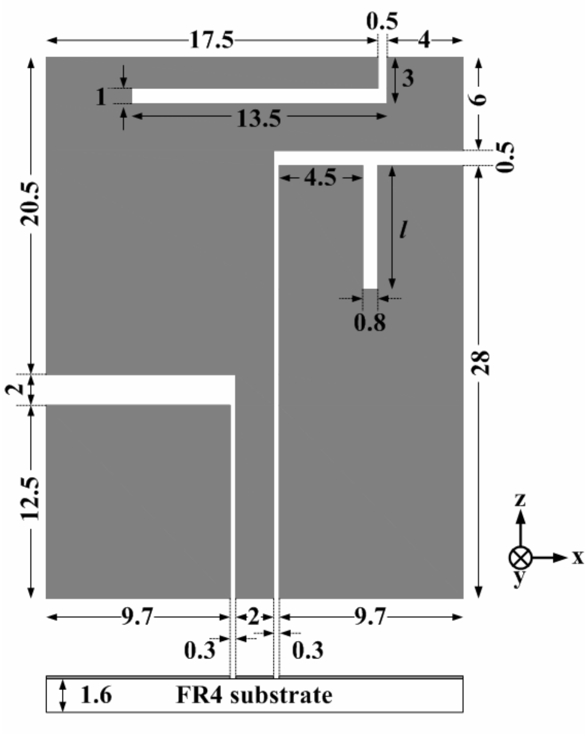

Figure 1. The geometry of the proposed antenna (units: mm)

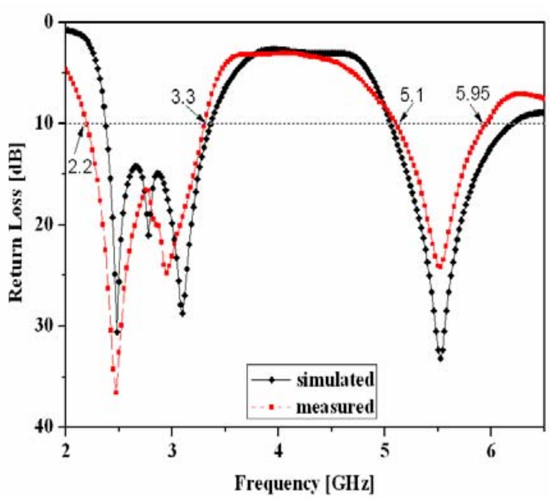

Figure 2. Measured and simulated return losses for the proposed antenna

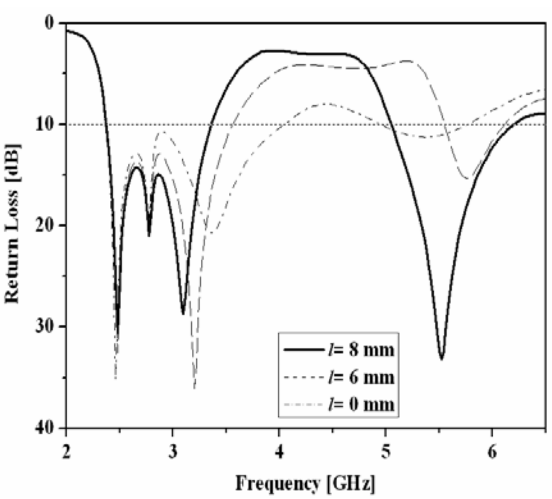

Figure 3. Simulated return losses for the proposed antenna with various *l*

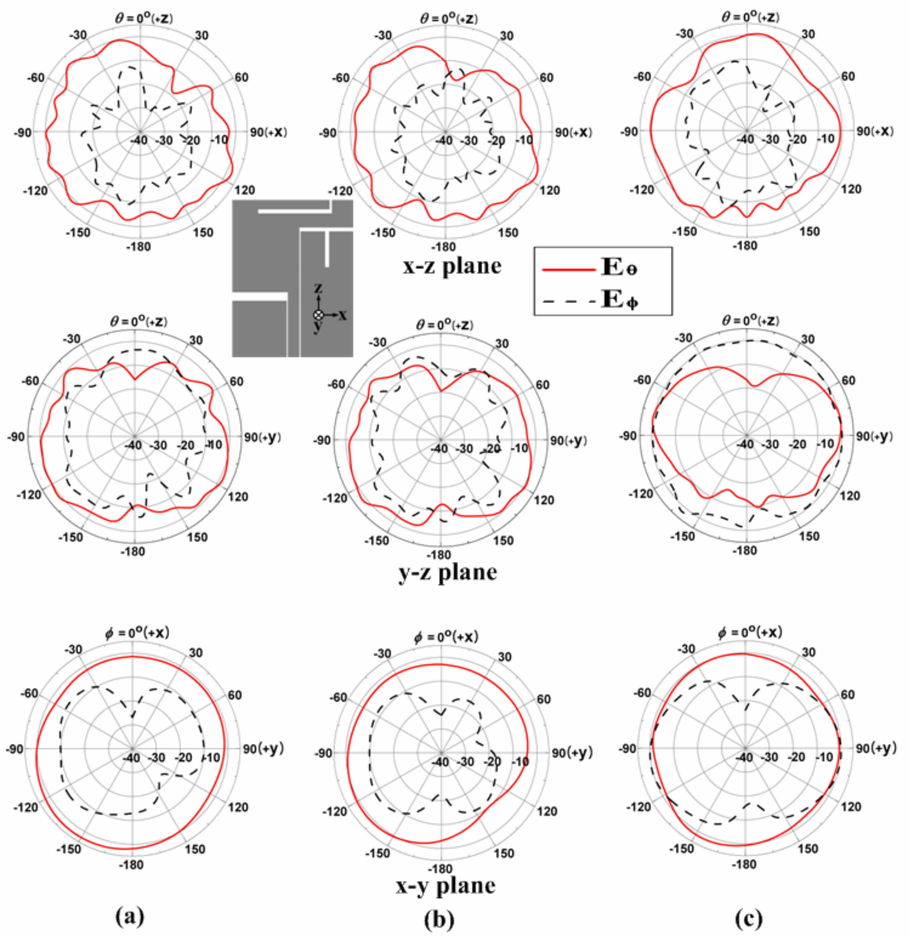

Figure 4. Measured radiation patterns for the proposed antenna at (a) 2.48 GHz, (b) 2.95 GHz, and (c) 5.5 GHz

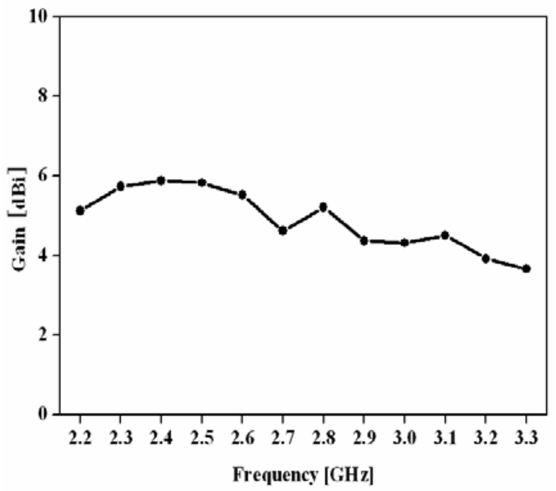

Figure 5. Measured antenna gains for the proposed antenna at 2.4 GHz band

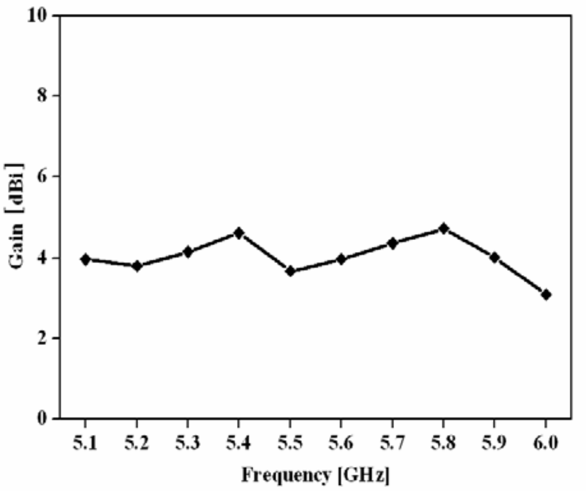

Figure 6. Measured antenna gains for the proposed antenna at 5 GHz band

References

[1] J. Y. Jan and L. C. Tseng, “Small planar monopole antenna with a shorted parasitic inverted-L wire for wireless communications in the 2.4-, 5.2-, and 5.8-GHz bands”, *IEEE Trans. Antenna Propag.*, vol. 52, pp. 1903-1905, 2004.

[2] L. Zhang, Y. C. Jiao, G. Zhao, Y. Song, and F. S. Zhang, “Broadband dual-band CPW-fed closed rectangular ring monopole antenna with a vertical strip for WLAN operation”, *Microwave and Optical Technology Letters*, vol. 50, no. 7, pp. 1929-1931, 2008.

[3] W.-C. Liu, “Wideband dual-frequency double inverted-L CPW-fed monopole antenna for WLAN application”, *IEEE Trans. Antenna Propag.*, vol. 53, no. 2, pp. 655-661, 2005.

[4] C.-M. Wu, “Dual-band CPW-fed cross-slot monopole antenna for WLAN operation”, *IET., Microwaves, Antennas and Propagation*, vol. 1, pp. 542-546, 2007.

[5] Y.-F. Lin, P.-C. Liao, P.-S. Cheng, H.-M. Chen, C. T. P. Song, and P. S. Hall “CPW-fed capacitive H-shaped slot antenna”, *Electron. Lett.*, vol. 41, no. 17, pp. 940-942, 2005.

[6] J.-Y. Sze, C.-I.G. Hsu, and J.-J. Jiao, “CPW-fed circular slot antenna with slit back-patch for 2.4/5 GHz dual-band operation”, *Electron. Lett.*, vol. 42, no. 10, pp. 563-564, 2006.

[7] W.-C. Liu and C.-C. Huang, “A CPW-fed L-shaped slot planar monopole antenna for triple-band operations”, *Microwave and Optical Technology Letters*, vol. 44, no. 6, pp. 510-512, 2005.

[8] W.-C. Liu and H.-J. Liu “Compact triple-band slotted monopole antenna with asymmetrical CPW grounds”, *Electron. Lett.*, vol. 42, no. 15, pp. 840-842, 2006.