A Dual-band Wide-beamwidth WLAN Access Point Antenna

Son Xuat Ta [(1)], Hosung Choo [(2)], and Ikmo Park [(1)*]

(1) School of Electrical and Computer Engineering, Ajou University
5 Woncheon-dong, Youngtong-gu, Suwon 443-749, Korea
Email: tasonxuat@ajou.ac.kr, ipark@ajou.ac.kr*

(2)School of Electronics and Electrical Engineering, Hongik University
72-1 Sangsu-dong, Mapo-gu, Seoul 121-791, Korea

ABSTRACT: A dual-band printed dipole antenna with wide-beamwidth radiation patterns is introduced for 2.4/5 GHz bands wireless local area network access points. A printed dipole is designed at the center of circular ground plane and fed by a novel integrated balun consisting of a curved microstrip-line and a circular slot to allow broadband operation. An angled dipole and two vertical copper plates on the ground plane are used to achieve wide beamwidth in lower and upper bands, respectively. The proposed antenna has an impedance bandwidth of 2.395 – 2.50 GHz and 5.07 – 5.96 GHz for the –10 dB reflection coefficient. At 2.45 GHz, the antenna has gain of 6.86 dBi, front-to-back ratio of 21 dB, and half-power beam-width of 104° and 102° in the E- and H-planes, respectively. At 5.5 GHz, the antenna has gain of 6.92 dBi, front-to-back ratio of 27 dB, and half-power beam-width of 118° and 114° in E- and H-planes, respectively.

INTRODUCTION

Currently, the wireless area network (WLAN) in the 2.4-GHz (2.4–2.485 GHz) and 5-GHz (5.15–5.875 GHz) bands is the most popular networks for accessing the internet. As the demand for pervasive coverage of WLAN systems, a large number of access points (APs) are needed to be installed. In practice, an AP is commonly mounted on the wall or ceiling of room. To provide such pervasive WLAN coverage, the antenna used for APs must radiate signals in such a manner that the radiated electromagnetic (EM) wave is relatively the same everywhere in the room; further, the back radiation from an antenna needs to be insignificant to minimize the energy from radiating to undesired directions. Thus, the antenna for an AP not only requires dual-band operation but also needs to have an appropriate radiation profile in both bands, namely similar gain, wide beamwidth, and high front-to-back ratio. Several types of antennas have been reported for use in WLAN APs, including suspended patch antenna [1], quasi-Yagi antenna [2], monopole liked antenna [3], multi-loop antennas [4, 5], and slot antennas [6, 7]. However, most of the aforementioned antennas essentially focus bandwidth improvement and impedance matching optimization and the study of the radiation patterns of the antennas has thus far been neglected.

This paper describes a dual-band printed dipole antenna that has nearly identical radiation patterns with similar gain and wide beamwidth in both the 2.4- and 5-GHz WLAN bands. The proposed design employs two techniques to improve the radiation pattern. These techniques are the use of an angled dipole and vertical copper plates arranged on the ground plane for improvement in the radiation pattern of lower and upper bands, respectively.

ANTENNA DESIGN AND CHARACTERISTICS

For the beginning of proposed antenna design, two straight dipoles printed on a Rogers RO4003 substrate (ε_r = 3.38, loss tangent = 0.0027, and thickness = 0.508 mm) were chosen with the initial lengths of approximately a half of the effective wavelength ($\lambda_{eff}/2$) at 2.45- and 5.5-GHz frequencies, respectively. To render a unidirectional radiation pattern, a circular ground plane with a radius of 80 mm was employed as the reflector. An angled dipole and vertical copper plates mounted on the ground plane were utilized to improve the radiation pattern of lower and upper bands, respectively. A full-wave electromagnetic (EM) simulator (Microwave Studio, Computer Simulation Technology) was used to optimize the antenna characteristics. The geometry of final design is shown in Fig. 1. The printed dipoles were fed by a novel integrated balun that consisted of a curved microstrip-line and a circular slot. The curved microstrip-line comprised a 50-Ω feedline and a half of ring, both with a width of w_{ms}. The circular slot was etched on the printed dipoles. The radii of the ring and circular slot were r_1 and r_2, respectively. The printed dipoles and integrated balun were designed on front and back surfaces of the Rogers RO4003 substrate, respectively. The trapezoidal-shaped substrate had a width and height of W_{sub} and H_{sub}, respectively. The two dipoles printed on the substrate were connected to the ground plane. The antenna was fed by a SMA 50-Ω coaxial connector. The inner conductor of the coaxial connector was extended through the ground plane and connected to the 50-Ω microstrip-line. On the ground plane, two vertical copper plates whose width and height were L_p and H_p, respectively, were arranged symmetrically over the substrate with a spacing of S_p. The optimized antenna design parameters were chosen for similar gain, wide beamwidth in both E- and H-plane patterns at the 2.4/5 GHz bands: $g = 0.6$ mm, $h_1 = 5$ mm, $h_2 = 14$ mm, $h_a = 2$ mm, $L_1 = 60.4$ mm, $L_2 = 23.4$ mm, $r_1 = 2$ mm, $r_2 = 2.86$ mm, $H_p = 13$ mm, $H_s = 24$ mm, $H_c = 7$ mm, $L_c = 24$ mm, $\theta = 30°$, $w_a = 2$ mm, $w_c = 0.6$ mm, $w_d = 6$ mm, $w_s = 5.7$ mm, $w_{ms} = 1.2$ mm, $W_p = 50$ mm, $W_{sub} = 60$ mm, and $S_p = 30$ mm.

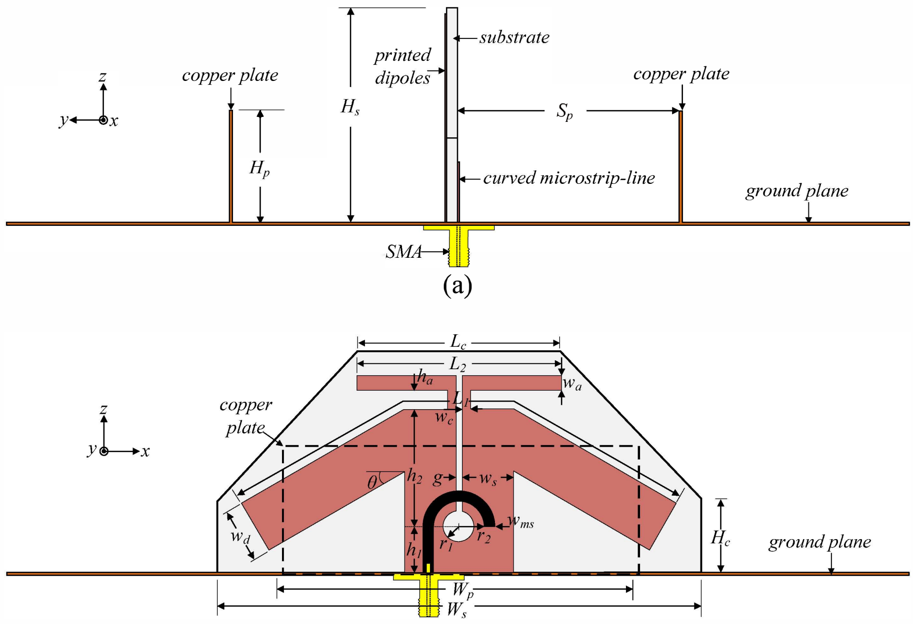


Figure 1. Geometry of the proposed antenna: (a) side view and (b) printed dipoles with integrated balun.

The proposed antenna was fabricated and measured. The printed dipoles and integrated balun were fabricated via a standard etching technology on RO Duroid 4003 substrate with a 20-µm copper thickness. The circular ground plane and copper plates having thickness of 0.3 mm were welded together by melting tin. An Agilent N5230A network analyzer and a 3.5–mm coaxial calibration standards-GCS35M were used for measurements of the prototype [Fig. 2]. As shown in Fig. 3, the measured and simulated reflection coefficients of the antenna agreed rather closely. The measured impedance bandwidth was 2.395 –2.50 GHz and 5.07 – 5.96 GHz for the –10 dB reflection coefficient while the simulated bandwidth was 2.392 – 2.490 GHz and 5.06 – 5.95 GHz.

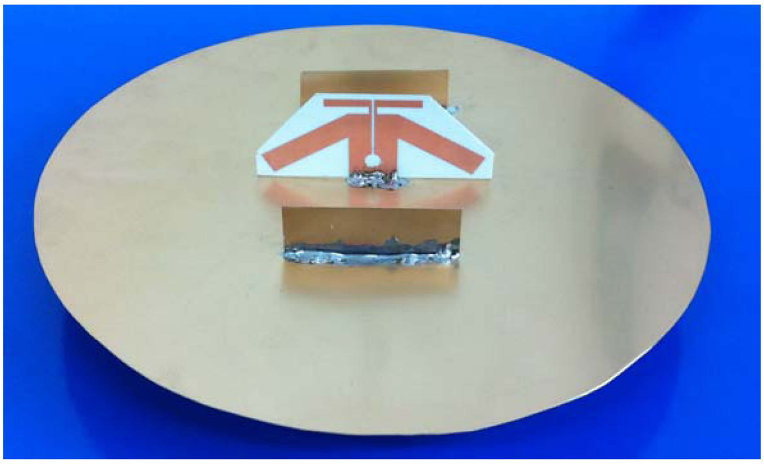


Figure 2. Fabricated antenna.

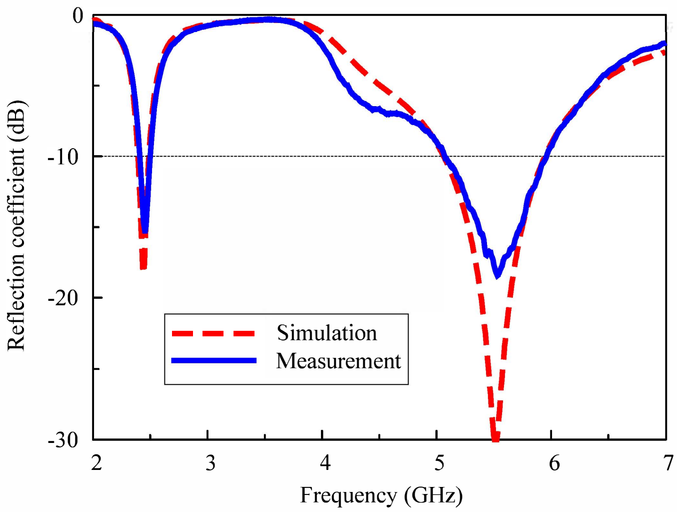
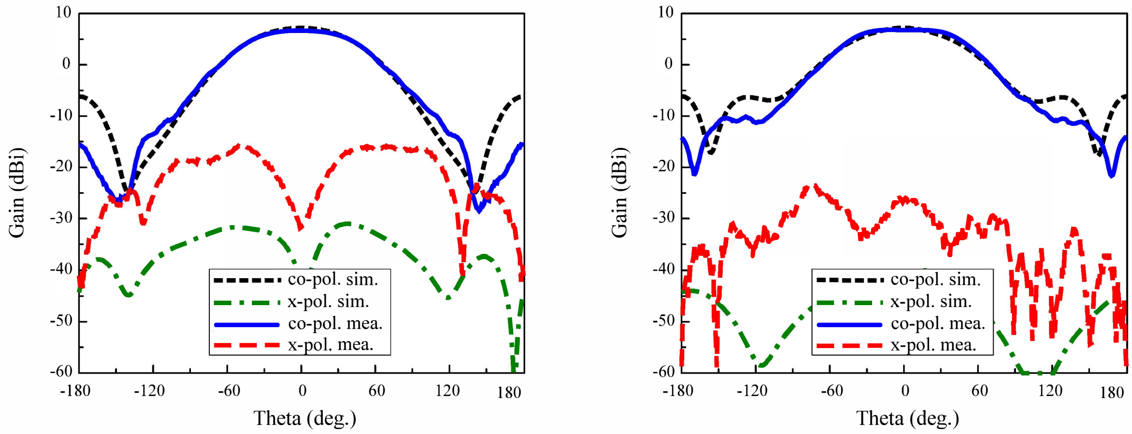
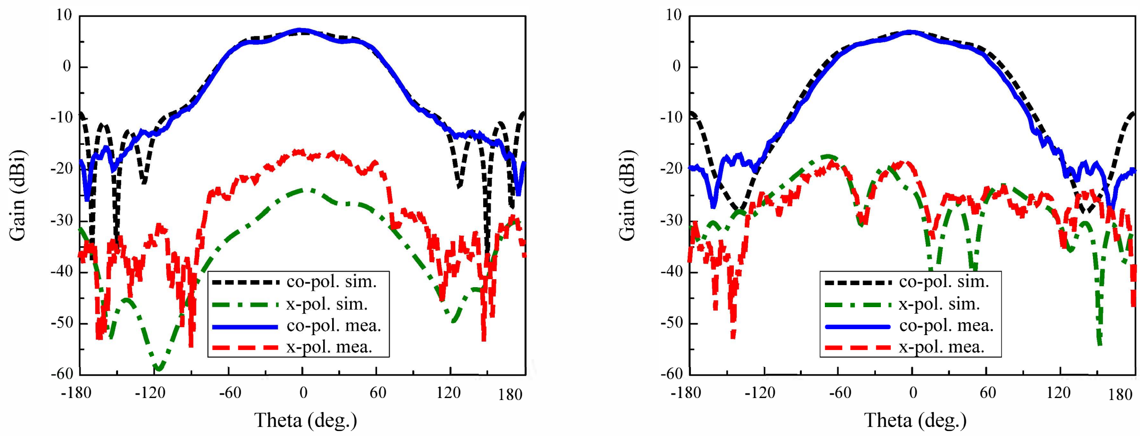


Figure 3. Simulated and measured reflection coefficient of the antenna.



(a) (b)

Figure 4. Radiation patterns of the antenna at 2.45 GHz: (a) *E- (xz-)* plane, (b) *H- (yz-)* plane.



(a) (b)

Figure 5. Radiation patterns of the antenna at 5.5 GHz: (a) *E- (xz-)* plane, (b) *H- (yz-)* plane.

The 2.45 and 5.5 GHz radiation patterns of the antenna are shown in Figs. 4 and 5, respectively. The figures show a good agreement between the measurements and simulations. At 2.45 GHz, the measured patterns showed a front-to-back ratio of 21 dB and the half-power beamwidths (HPBWs) of 104° in E-plane and 102° in the H-plane, respectively. At 5.5 GHz, the measured patterns showed a front-to-back ratio of 27 dB and HPBWs of 118° in E-plane and 114° in the H-plane. The measured gains are 6.86 and 6.92 dBi at the 2.45 and 5.5 GHz frequencies, respectively.

CONCLUSION

A printed dipoles antenna is introduced for use in the 2.4/5 GHz WLAN APs. The printed dipoles are fed by a novel integrated balun with a curved microstrip-line and a circular slot for the broadband characteristic. The angled dipole and two copper plates on the ground plane are employed to achieve the wide and equilateral beamwidth at the lower and upper bands, respectively. The antenna has a bandwidth of 2.395 – 2.50 GHz and 5.07 – 5.96 GHz for the –10 dB reflection coefficient, wide-beamwidth (HPBW > 102°), high front-to-back ratio (>21 dB), and similar gain (~6.9 dBi). With the obtained wide beamwidth and similar gain in the 2.4- and 5-GHz bands, the proposed antenna could be stably operated in a dual-band WLAN.

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