Patch antenna with a down-tilt broadside radiation pattern for on-wall WLAN access point

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Introduction

Conventional patch antennas have an advantage of low profile and are attractive to be applied in an on-wall access point inside a building for WLAN (wireless local area network) operation. However, for such applications, the on-wall patch antenna is usually required to be tilted toward the floor to provide a down-tilt main beam for covering a larger service area. With the down-tilting, the on-wall patch antenna will have an inclination angle to the mounting wall, making it aesthetically unacceptable for indoor applications. To solve this problem, we propose in this paper a novel patch antenna capable of providing a down-tilt broadside radiation pattern, without the need of tilting the patch antenna toward the floor. In addition, with a down-tilt pattern achieved, the proposed antenna also shows a narrower 3-dB beamwidth in the elevation plane, resulting in an enhanced antenna gain. Details of the proposed patch antenna and the obtained experimental results are presented.

Antenna Design

As shown in Fig. 1, the proposed antenna has a simple structure and consists of two major parts: an L-shaped ground plane and a tilted radiating patch. The dimensions given in the figure are for operating in the 2.4 GHz WLAN band (2400 – 2484 MHz). The L-shaped ground plane [1] has a vertical ground (size 120×120 mm^2) and a horizontal ground (120×25 mm^2). The vertical ground is to be attached onto the wall (in the *x–y* plane in this study) for indoor applications, and the horizontal ground is to accommodate the SMA connector of the probe feed. In this design, good impedance matching can easily be achieved by placing the probe pin at the center of the patch edge close to the horizontal ground (a coplanar probe-fed design technique [1-3]).

The tilted patch (size 40×60 mm^2) has an inclination angle of α toward the vertical ground. For the case of $\alpha = 0°$, the patch is parallel to the vertical ground plane with a distance of 21 mm, and the patch antenna shows a broadside radiation pattern with maximum radiation about in the *z* direction (parallel to the floor). When the angle α increases, the broadside radiation pattern of the patch antenna can be down-tilted toward the floor. With various angles of α selected, different down-tilting angles of the antenna's radiation pattern can be adjusted.

Experimental Results and Conclusion

The measured return loss for the constructed prototypes with α = 0, 10, and 30° is shown in Fig. 2. It is seen that, with an increase in α, the obtained impedance bandwidth is decreased. However, for α = 30°, the impedance bandwidth still reaches 511 MHz (2244–2755 MHz or about 21% referenced to the desired center frequency 2442 MHz), easily covering the 2.4 GHz WLAN band.

Fig. 3 plots the measured radiation patterns of the reference antenna (α = 0°), and the cases of the proposed antenna with α = 10 and 30° are shown in Fig. 4. The corresponding measured data are also listed in Table 1 for comparison. It is clearly seen that the measured patterns are down-tilted toward the $-x$ direction or the floor with an increase in α. For α = 30°, the down-tilting angle or the maximum radiation direction of the measured patterns reaches as large as –50°, suggesting that a large adjustable down-tilting angle of the antenna's radiation pattern can be achieved by varying the angle α. In addition, the 3-dB beamwidth becomes narrower for α = 20 and 30°, and an enhanced antenna gain is achieved (7.2 and 8.3 dBi vs. 6.9 dBi). The measured antenna gain of the proposed antenna with α = 30° for frequencies across the 2.4 GHz band is also presented in Fig. 5. A stable antenna gain level of about 8.3 dBi is seen.

Table 1: Measured radiation performances of the proposed antenna (α = 10, 20, and 30° in Fig. 1) and the reference antenna (α = 0° in Fig. 1); f = 2442 MHz.

	α	3-dB beamwidth in elevation (x-z) plane	Max. radiation direction, θ_{max}	Peak gain (dBi)
Reference	0°	78° (θ = 28° ~ –50°)	–5°	6.9
Antenna 1	10°	95° (θ = 34° ~ –61°)	–30°	6.4
Antenna 2	20°	73° (θ = 4° ~ –69°)	–41°	7.2
Antenna 3	30°	51° (θ = –22° ~ –73°)	–50°	8.3

A novel patch antenna with a simple structure for achieving a down-tilt broadside radiation pattern has been proposed. Experimental results of the constructed prototypes show that, simply by varying the tilting angle of the antenna's radiating patch, various down-tilt broadside radiation patterns can be achieved. The proposed antenna also provides an enhanced antenna gain and is very promising for applications in an on-wall access point for WLAN operation.

References:

[1] F. S. Chang and K. L. Wong, "Broadband patch antenna edge-fed by a coplanar probe feed," *Microwave Opt. Technol. Lett.*, vol. 31, pp. 287-289, 2001.

[2] K. L. Wong, F. S. Chang and T. W. CHIU, "Broadband circularly polarized patch antenna," US Patent No. 6606061 B2, 2003

[3] K. L. Wong, *Planar Antennas for Wireless Communications*, Wiley, New York, 2003, Chap 4.

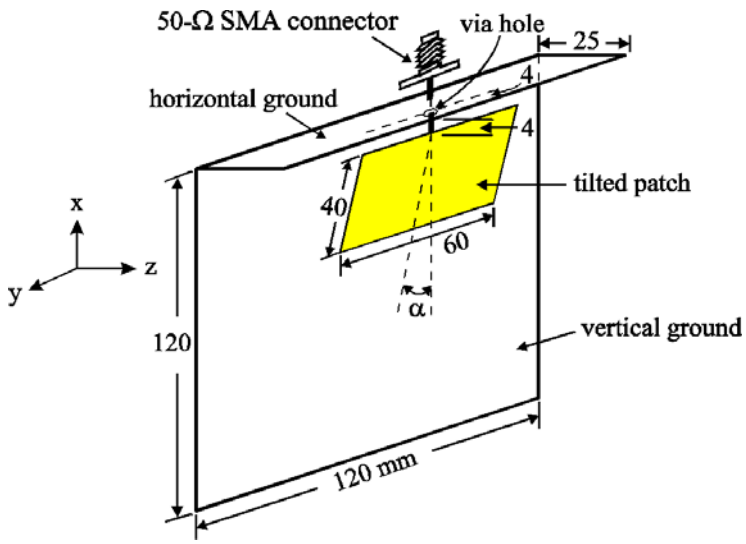

Fig. 1 Geometry of proposed antenna with a down-tilt broadside radiation pattern.

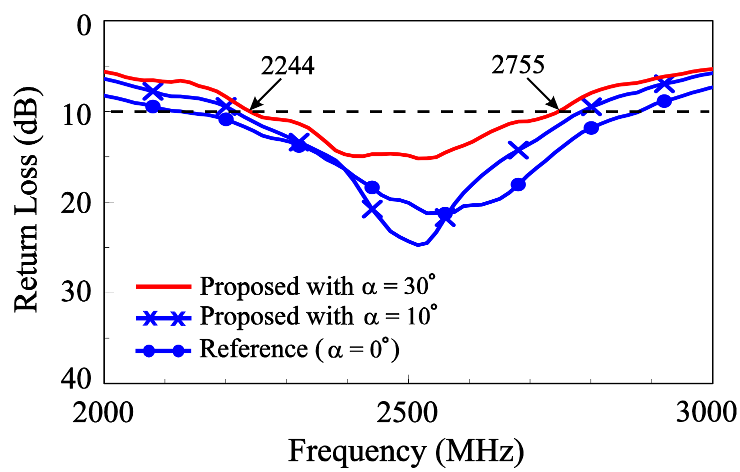

Fig. 2 Measured return loss for proposed antenna (α = 10°, 30°) and reference antenna (α = 0°).

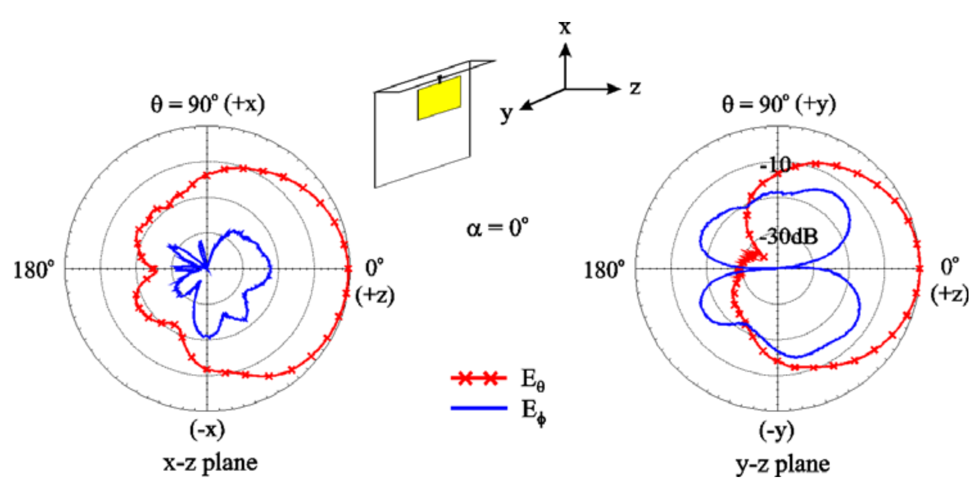

Fig. 3 Measured radiation patterns of reference antenna (α = 0°).

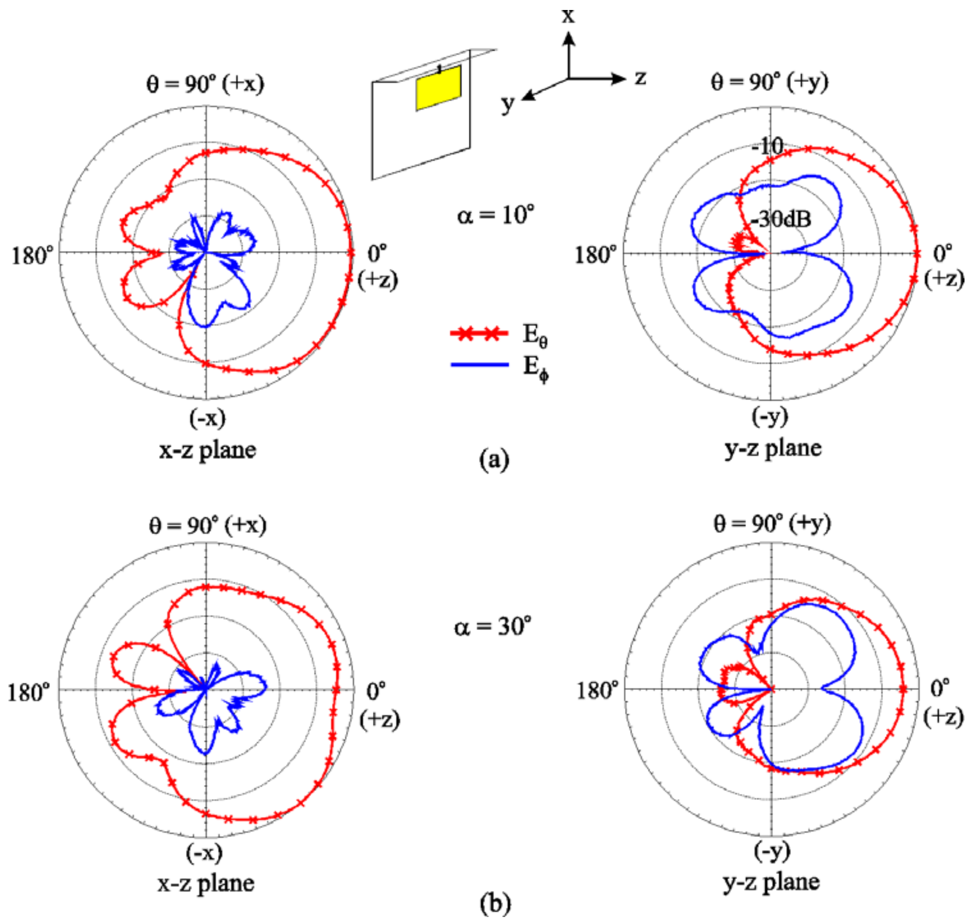

Fig. 4 Measured radiation patterns of proposed antenna with (a) α = 10° and (b) α = 30°.

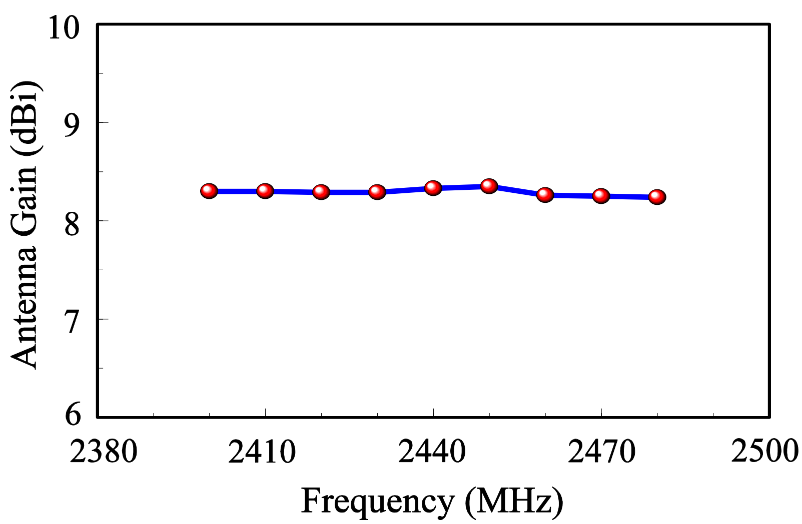

Fig. 5 Measured peak antenna gain of proposed antenna with α = 30°.