Broadband Circularly Polarized Curl Antenna Using a Planar Metal Feed

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Abstract

A broadband circularly polarized curl antenna with a simple single feed is presented. The antenna consists of a metal spiral strip of about 1.4 wavelengths in length wound into about one turn and mounted above a ground plane with a thick air layer. By using a 50-Ω probe feed along with a long feeding planar metal for exciting the curl antenna, good circular polarization (CP) radiation over a wide bandwidth (larger than 6.6%) is achieved, which makes the proposed antenna well suited for application in the 5.8 GHz WLAN band. Details of the proposed antenna design and the experimental results obtained for a constructed prototype are presented.

1. Introduction

Circularly polarized antennas have the advantage that no strict orientations between the access point and the mobile unit are required. Therefore, CP antennas are suited for applications in wireless local area network (WLAN) communications. For WLAN operating in the 5.8 GHz band (5725 ~ 5875 MHz), the required operating bandwidth of a circularly polarized antenna is as large as 150 MHz or about 2.6% of the corresponding center frequency at 5800 MHz. For single-feed single-element patch antennas, the curl antenna has been proposed as the radiation element of circular polarization due to its simple structure [1, 2]. Its CP bandwidth can be more than 5%, and thus is well suited for WLAN operations in the 5.8 GHz band.

The wide-band characteristics of the curl antenna are useless unless the signal can be transferred between the antenna and the transceiver. To do this, it is necessary to match the impedance of the curl antennas to that of the wide-band transceiver. Previously, several broadband impedance matching techniques for the curl antennas, such as the ones using monopole feed coupling with curl antenna [3], the EBG surface for low profile antenna [5], and the extra lossless passive circuit for matching between curl antenna and microstrip line feed [6], have been reported. These methods, however, usually complicate the curl antenna design. Recently, the planar mono-pole antennas are widely applied in ultra-wideband (UWB) communications covering frequency range of 3.1 ~ 10.6 GHz [7]. The monopole antennas have a conical field pattern. To obtain a broadside radiation pattern of planar antennas, the plate monopole antennas can be used as the feeding scheme to increase the impedance bandwidth of the thick-layered planar antennas [8]. In this paper, the proposed antenna integrates the planar monopole antenna and curl antenna to meet the broadband CP bandwidth requirement for WLAN operations in the 5.8 GHz band. Details of the antenna design are described, and their measured results are presented and discussed.

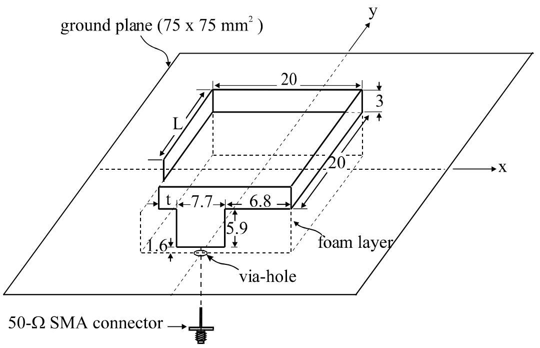

Fig. 1: Geometry of the proposed broadband circularly polarized curl antenna.

2. Design Considerations

Figure 1 shows the geometry of the proposed broadband circularly polarized curl antenna. For ease of design and fabrication, the curl metal strip is wound into a square spiral structure. The curl antenna has a width of 3 mm and a total length of about 1.4 wavelengths corresponding to the desired center operating frequency. A rectangular metal of 7.7 × 5.9 mm^2 serves as a support for the curl metal strip and is mounted above a ground plane of 75 × 75 mm^2 with a height of 10.5 mm. Foam-layer supporter is placed between the curl strip and the ground plane.

As indicated in Fig. 1, the square spiral strip is wound into about one turn. By further adjusting the total length of the metal spiral strip to be larger than one operating wavelength (1.4 wavelengths in this design), the proposed antenna is found to be capable of radiating a circularly polarized wave with a wide bandwidth. For the proposed antenna, once the desired center operating frequency is determined, we can first select the length of each side of the square spiral strip to be about 0.35 wavelengths. Then, through fine tuning of the lengths L and t, good CP radiation over a wide frequency range can be achieved. The optimal lengths of t and L are found roughly to be 0.04 and 0.31 wavelengths, respectively, in this work.

In addition, as mentioned above, a wide bandwidth of good impedance matching must be achieved for the designed antenna. And to have a wide-band operation, the height of the curl antenna usually needs to be larger than 0.19 operating wavelengths. However, with such a large height, a long feeding wire will be needed to connect the printed spiral strip to the coax feed. This usually introduces large inductance to the antenna's input impedance so that good impedance matching can hardly be obtained [3-6]. To solve this problem, placing a rectangular strip between the curl antenna and the feeding pin is found to be very effective in achieving good impedance matching. In this work, the spacing between the rectangular strip and the ground plane is 1.6 mm for the proposed antenna, and thus the same required length for the feeding pin. The dimension of the metal strip used in the antenna structure is 7.7 × 5.9 mm^2 for 5.8 GHz band operation. If the proposed antenna is to be applied for 2.4 GHz band WLAN, the size of the rectangular metal strip would have to be made larger.

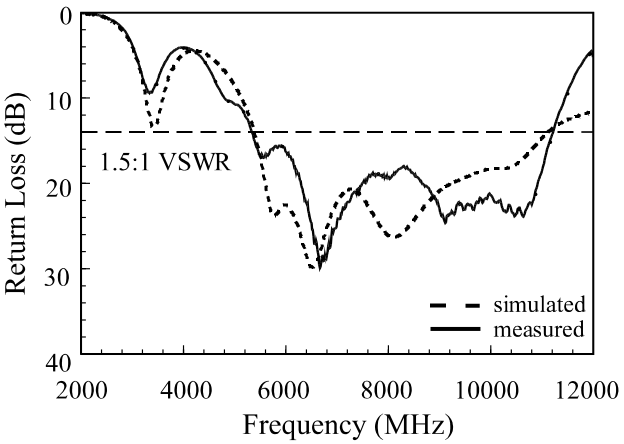

Fig. 2: Return loss for the proposed antenna with t = 2 mm, L = 16.3 mm, and other structural parameters shown in Fig. 1. The ground-plane size is 75 × 75 mm^2.

3. Experimental Results and Discussion

To validate the design technique, a prototype of the proposed antenna for WLAN operations in the 5.8 GHz band was constructed and investigated. Figure 2 shows the simulated and measured return loss for the fabricated antenna prototype. The structural parameters are given in the caption of Fig. 2, and the simulated results are obtained by using Ansoft HFSS (High Frequency Structure Simulator). The measured data in general agree with the simulated results, and the measured 14 dB return-loss impedance bandwidth is as large as 5873 MHz (5337 ~ 11210 MHz) or about 102% referred to the center frequency of 5750 MHz, which covers the 5.8 GHz WLAN band.

The measured axial ratio of the antenna prototype is presented in Fig. 3. The 3 dB axial-ratio CP bandwidth is as wide as 385 MHz, covering the frequency range of 5565 ~ 5950 MHz. The obtained fractional CP bandwidth with respect to the 5750 MHz center frequency is about 6.6%. Figure 4 plots the measured spinning linear radiation patterns at 5750 MHz. Good broadside radiation pattern is observed. Careful examination shows that the linear radiation patterns plotted in Fig. 4 exhibit slight asymmetry. This can be attributed to the presence of the vertical rectangular metal strip used to improve the impedance matching. Other frequencies within the CP bandwidth also show similar broadside radiation patterns as that shown in Fig. 4, indicating that stable radiation pattern is obtained over the wide bandwidth.

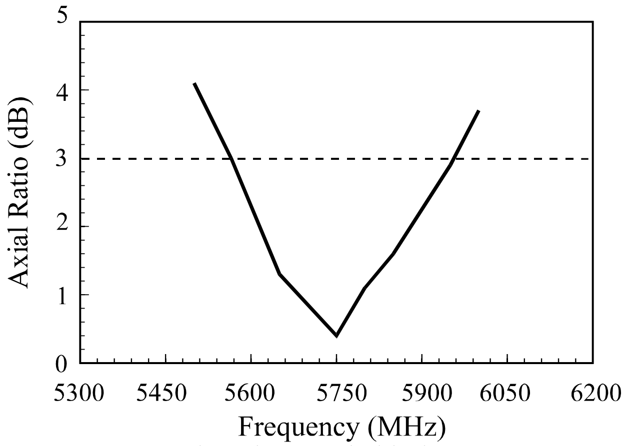

Fig. 3: The measured axial ratio.

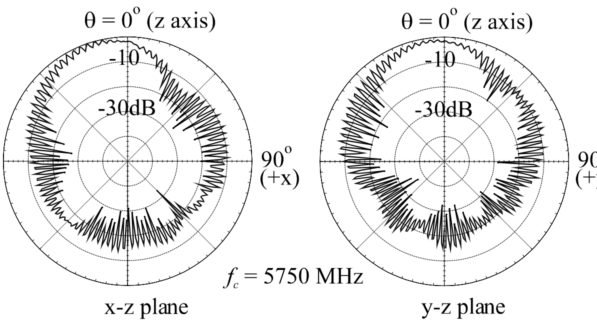

Fig. 4: The measured spinning linear radiation patterns at 5750 MHz.

Figure 5 shows the measured antenna gain for the 5.8 GHz band. The antenna gain is seen to range from about 6.5

to 7.2 dBic in the desired operating band. Figure 6 shows the photos of the fabricated circularly polarized curl antenna.

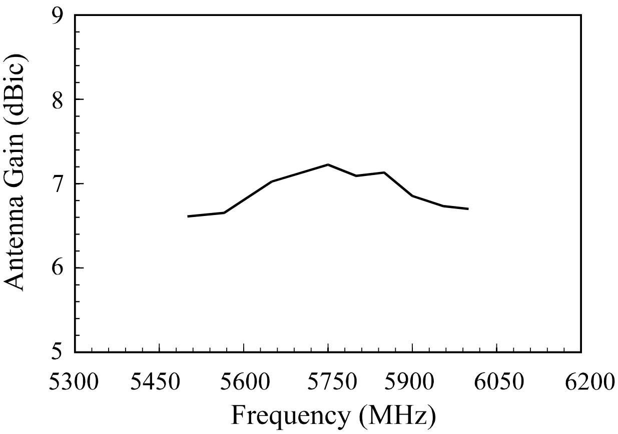

Fig. 5: The measured antenna gain for the proposed antenna with the same set of structural parameters given in Fig. 2.

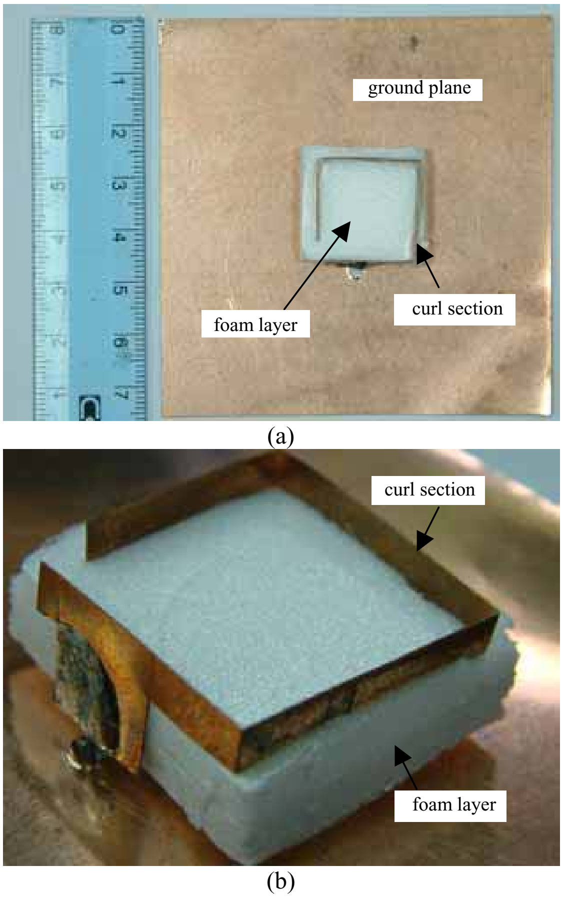

Fig. 6: Photos of the fabricated CP curl antenna. (a) The top view and (b) the three-dimensional view.

4. CONCLUSION

A broadband circularly polarized curl antenna has been proposed. An antenna prototype having a large CP bandwidth of 6.6% and a center frequency of 5750 MHz has been successfully implemented. Good broadside radiation pattern has been observed for operating frequencies over the large CP bandwidth. In addition, the proposed antenna is very promising to be applied in a WLAN access point operating in the 5.8 GHz band. It poses no strict orientations between the access point and the mobile unit required for good WLAN communication.

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