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WIDEBAND CIRCULARLY POLARIZED SUSPENDED PATCH ANTENNA WITH INDENTED EDGE AND GAP-COUPLED FEED

Jingya Deng[1, 2, *], Lixin Guo[1], Tianqi Fan[1], Zhensen Wu[1], Yajun Hu[3], and Jinghua Yang[4]

[1]School of Science, Xidian University, Xi'an 710071, China

[2]Institute of China Electronic System Engineering Corporation, Beijing, China

[3]Equipment Management and Safety Engineering College, Air Force Engineering University, Xi'an, China

[4]Science College, Air Force Engineering University, Xi'an, China

Abstract—A broadband circularly polarized patch antenna with suspended structure is proposed. The suspended patch has an indented edge and a gap-coupled feed. By optimizing the geometries of the antenna, a wide impedance bandwidth of 1.26–1.965 GHz and an axial ratio bandwidth of 1.51–1.68 GHz are obtained. The antenna with simple structure is simulated and measured, and the results show that the bandwidth of the patch antenna is successfully broadened by using the suspended configuration, indented edge and gap-coupled feed.

1. INTRODUCTION

Circularly polarized (CP) antennas have attracted much attention for wireless systems [1–4], especially for satellite navigations and communications, because of greater flexibility in orientation angle between transmitter and receiver antennas, better mobility and weather penetration, and reduction in multipath reflections. Patch antennas are commonly used for circular polarization due to low profile, low cost and ease of fabrication. However, a well-known disadvantage of these CP patch antennas is that impedance bandwidth and axial ratio (AR) bandwidth are narrow. A U-slot suspended patch antenna was presented to broaden the bandwidth [5]. A wideband circularly

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* Corresponding author: Jingya Deng (jydeng2011@126.com).

polarized antenna with suspended candy-like patch was proposed [6], which obtained a wide impedance bandwidth but involved two layers of substrate bringing high cost and difficulty of fabrication and adjustment. Then two different feeds were introduced to suspended patch antenna to achieve the broadband performance [7]. An H-shaped patch antenna was proposed to realize circular polarization [8]. An L-shaped probe feed and an L-shaped ground were involved in patch antennas to achieve circular polarization [9, 10]. Broadband circularly polarized antenna is a hot topic in academic society [11–22].

It is well known that the high Q factor of the patch antenna, directly related to the thickness of dielectric substrate, results in narrow bandwidth. In this paper, a suspended patch with air-substrate at an electrically small height over a ground is introduced and investigated. As proposed, the patch antenna is with an indented edge and gap-coupled feed to broaden the bandwidth. By properly optimizing the geometry of the antenna, an impedance bandwidth of 1.26–1.965 GHz and an axial ratio bandwidth of 1.51–1.68 GHz are obtained. The simulated and measured results are given, showing the proposed antenna is a good candidate for communications requiring circular polarizations.

2. ANTENNA DESIGN AND DISCUSSIONS

The proposed antenna is shown in Fig. 1 with design details. The GPS frequency 1.575 GHz is chosen as the center of the operation band, and then the configuration is optimized to broaden both impedance bandwidth and axial ratio (AR) bandwidth. The patch with indented edge is printed on a low cost suspended FR4 dielectric substrate with dielectric constant of 4.4 and a height of 22 mm (about 0.09λ of lower limit of the operation frequencies) above a 200 mm × 200 mm metallic ground. The air-substrate can reduce the cost of the fabrications and experimental adjustments, and also eradicates the dielectric loss. The antenna is excited by a probe fed driving patch which is coupled with the radiating patch. An EM calculator Ansoft HFSS is used in the simulations. The principal parameters determining the performance, including l, g and the thickness of the dielectric substrate t, are marked in Fig. 1 and then discussed as follows.

Parameter g is the width of the gap between the driving patch and the radiating patch. It determines the coupling between the driving patch and the radiating patch, and then the current distribution on the patches and the input impedance of the antenna is influenced accordingly. Fig. 2 shows the input impedances and corresponding S_{11}s of the antenna for different g values over 1–2 GHz. The axial

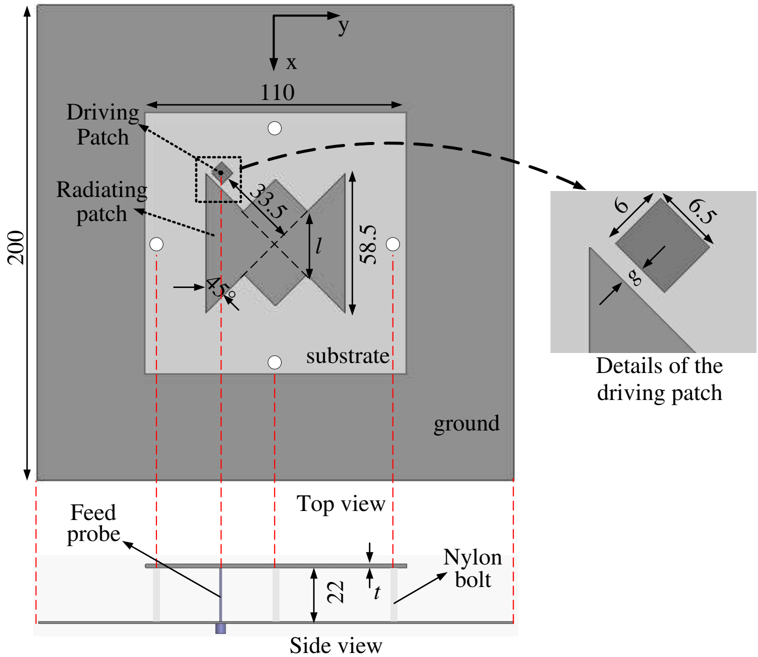

Figure 1. Geometry of the proposed antenna.

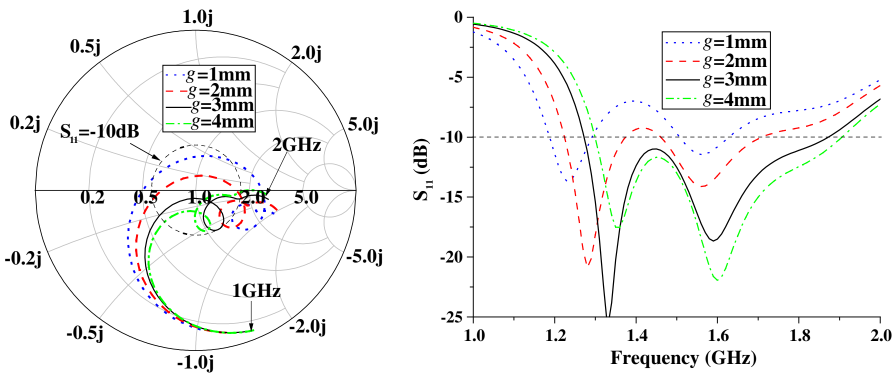

Figure 2. Input impedance and S_{11}s for different g values (while $l = 26.5\,\text{mm}$, $t = 1.6\,\text{mm}$).

ratios (AR) for different g values are shown in Fig. 3. Because center frequency is set on 1.575 GHz, so we chose $g = 3\,\text{mm}$ as an optimal value.

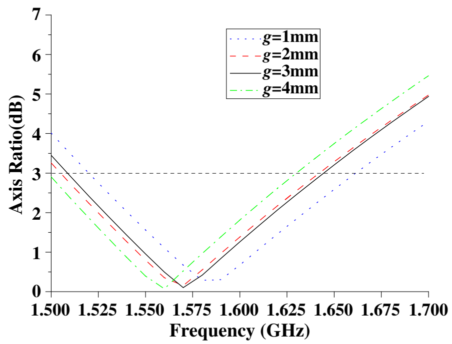

Figure 3. Axial ratios for different g values (while $l = 26.5\,\text{mm}$, $t = 1.6\,\text{mm}$).

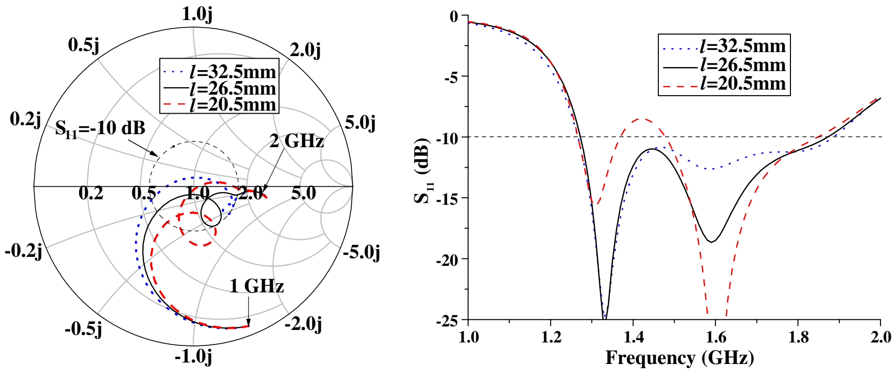

Figure 4. Input impedance and S_{11}s for different l values (while $g = 3\,\text{mm}$, $t = 1.6\,\text{mm}$).

Parameter l determines the path of surface current on the radiating patch, which can also affect the input impedance of the antenna and the AR. Fig. 4 shows the input impedances and corresponding S_{11}s for different l values, the ARs are shown in Fig. 5 as well. According to the simulation results, $l = 26.5\,\text{mm}$ is chosen as an optimal value.

There are two layers of substrate, the air and the non-conductive medium supporting the metal. Parameter t, the thickness of the dielectric substrate, also has influence on the performance of the antenna. The input impedances and the corresponding S_{11}s of antenna for different t values are given in Fig. 6, while the ARs are shown in Fig. 7. According to the simulation results, $t = 1.6\,\text{mm}$ is chosen as an optimal value.

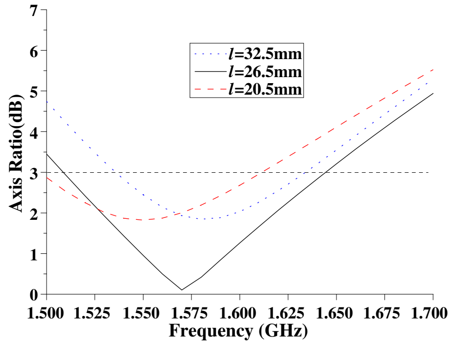

Figure 5. Axial ratios for different l values (while $g = 3$ mm, $t = 1.6$ mm).

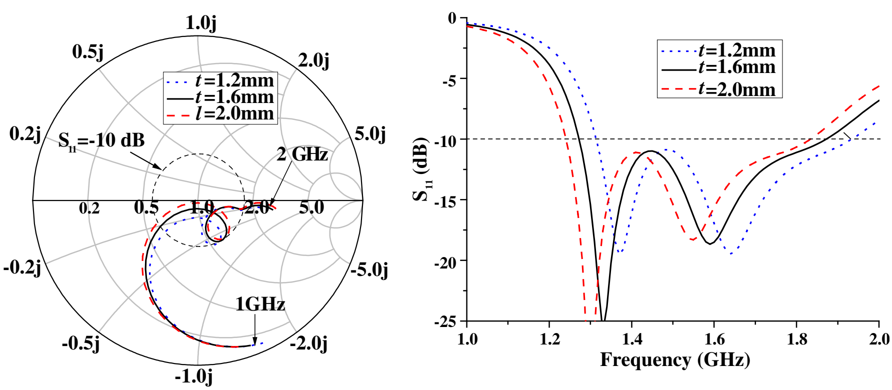

Figure 6. Input impedance and S_{11}s for different t values (while $g = 3$ mm, $l = 26.5$ mm).

3. MEASUREMENT RESULTS

The antenna with optimal geometry has been fabricated as the photos shown in Fig. 8. The simulated and measured S_{11}s and axial-ratios on maximum radiation direction (z axis direction as shown in Fig. 1) are shown in Figs. 9 and 10, respectively. As can seen in Fig. 9, a 38.2% impedance bandwidth of 1.27–1.87 GHz with S_{11} better than -10 dB is achieved in simulation, and a 43.7% impedance bandwidth of 1.26–1.965 GHz is obtained in measurement by Agilent N5230C. The proposed CP antenna has a wide 3 dB axial-ratio bandwidth (ARBW) of 1.51–1.645 GHz in simulation and of 1.51–1.68 GHz in the measurement as shown in Fig. 10. It is noted that both the measured

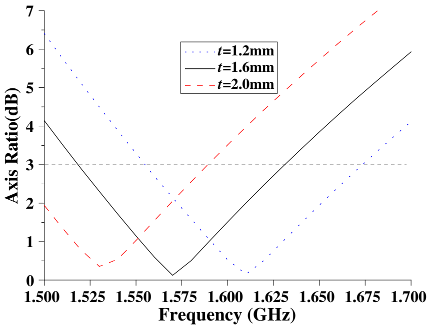

Figure 7. Axial ratios for different t values (while $g = 3$ mm, $l = 26.5$ mm).

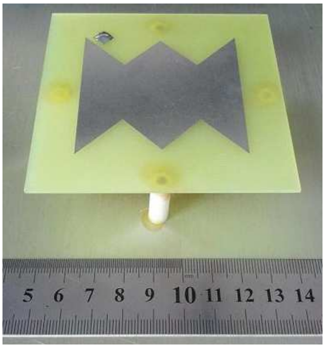

Figure 8. Photos of fabricated antenna.

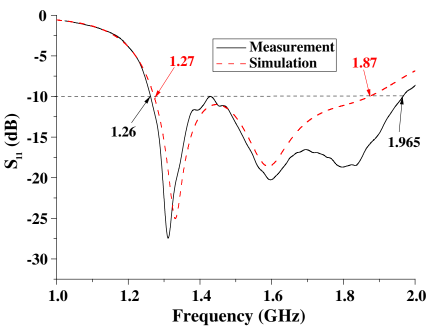

Figure 9. S_{11} of the proposed antenna.

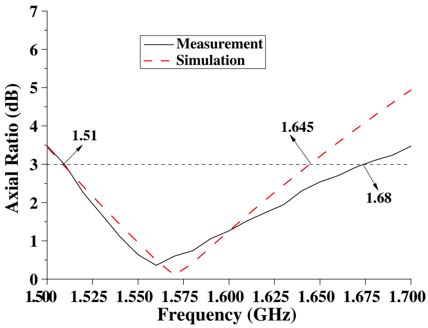

Figure 10. Axial ratios of the proposed antenna.

values on the axial ratio and impedance bandwidths are slightly larger than the simulated ones. These are possibly attributed to the nylon bolts and the small holes on the patch that have not been included in the simulations, and the fabrication and measurement tolerances also contribute to the discrepancy.

It is possible to realize a wider impedance bandwidth by further optimizing the antenna geometries. However, considering the operating bandwidth of a CP antenna is defined by both impedance bandwidth and AR bandwidth (actually the AR bandwidth is harder to be broadened), we make the first goal of our efforts as broadening the AR bandwidth, and second goal is making the AR bandwidth within the impedance bandwidth.

The measured radiation patterns of the proposed wideband CP antenna in two principal planes (x-z plane and y-z plane shown in

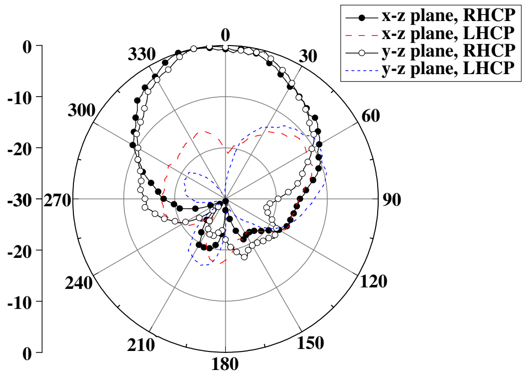

Figure 11. Patterns of the proposed antenna.

Fig. 1) on 1.575 GHz are presented in Fig. 11. The gains of the proposed antenna on 1.51, 1.575 and 1.64 GHz are 7.3, 7.35 and 7.5 dBic, respectively.

4. CONCLUSION

In this paper, a suspended configuration, an indented edge and a gap-coupled feed are introduced to a patch antenna to obtain a wideband characteristic. By optimizing the geometries of the antenna, a wide impedance bandwidth of 1.26–1.965 GHz and an axial ratio bandwidth of 1.51–1.68 GHz are obtained. The structure of the antenna is simple, the simulated and measured results show that the bandwidth of the patch antenna is successfully broadened; the proposed antenna is a good candidate for communications requiring circular polarizations.

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