A Y-Shaped Stub Proximity Coupled V-Slot Microstrip Patch Antenna

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***Abstract*—A Y-shaped proximity coupled V-slot microstrip patch antenna (MPA) is presented in this letter. Separating the patch from the Y-shaped stub by a foam layer with height of $0.05\lambda_0$ (λ_0 is the free-space wavelength at the center frequency), the proposed MPA shows an impedance bandwidth (BW) of 21%, simple structure and a high gain of about 9 dBi, which is not sensitive to the fabrication and construction errors.**

***Index Terms*—Patch antenna, proximity coupling, V-slot antenna.**

I. Introduction

MICROSTRIP PATCH ANTENNA (MPA) has been very popular due to their many advantages, such as low profile and cost, light weight, and small size [1]. However, the MPA suffers from the narrow impedance BW as well as the sensitive fabrication errors. A proximity coupled U-slot MPA with an impedance BW of 20% and a 7.5-dBi gain was presented in [2], which is fed by a Π-shaped stub. Recently, a double-Π stub proximity feed U-slot MPA was reported [3], which shows a impedance BW of 26% and tolerance to lateral displacement of the feed, however, it shows a lower gain of 6 dBi and small dips on the radiation patterns of H plane. Moreover, the MPAs in the two papers occupy a relatively large space due to the large feed stubs extending out of the patch, which causes a requirement of a large element spacing to form a two-dimension array, consequently undesirable grating lobes [4]. Another U-slot MPA with a proximity coupled double Π-shaped feed line was given for arrays [5], and the single element presents a 21% BW and a 9-dBi gain.

In this letter, a proximity coupled V-slot MPA with low profile of $0.05\lambda_0$ is presented, which shows an impedance BW of 21% (4.48–5.52 GHz), a numerical gain of larger than 9 dBi (measured gain 7–10 dBi) and stable radiation patterns across the whole band. The cross-polarization (cr-pol) radiation is below -15 dB in a band of 4.48–5.2 GHz and below -9 dB over the whole band, and the measured and simulated patterns with good agreements are given. Moreover, the tolerance of fabrication errors is discussed in the end.

II. Antenna Geometry

The geometry of the proposed antenna is shown in Fig. 1(a), where a V-slot patch is put above a Y-shaped feed stub, separating by a 3-mm foam layer Fig. 1(b). The stub is fabricated on a substrate with a dielectric constant of 2.33 and thickness of 1.575 mm, on which the width of a 50–Ω microstrip line is about 4.5 mm, as shown in Fig. 1(c). V-shaped slot on the patch is employed to produce the second resonance in order to widen the BW. All parameters are shown in the caption of Fig. 1. In addition, the ground plane size is 75 mm $\times$ 75 mm $(1.25\lambda_0 \times 1.25\lambda_0)$.

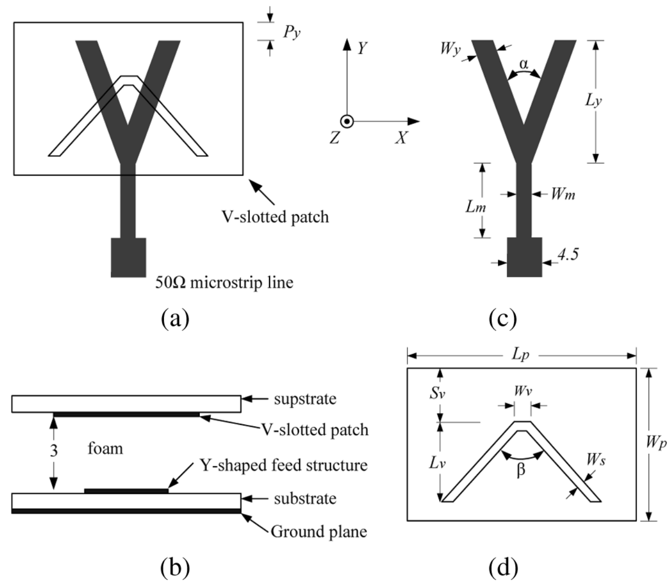

Fig. 1. Geometry of the proposed MPA. $\alpha = 41^\circ$, $P_y = 2.5$, $W_y = 4.6$, $L_y = 21.8$, $L_m = 11.4$, $W_m = 1.8$, $L_p = 35$, $W_p = 25$, $\beta = 79^\circ$, $S_v = 8.5$, $L_v = 13.5$, $W_v = 2$, $W_S = 0.9$ (in mm). (a) Top view. (b) Side view. (c) Y-shaped feed structure. (d) V-slotted patch.

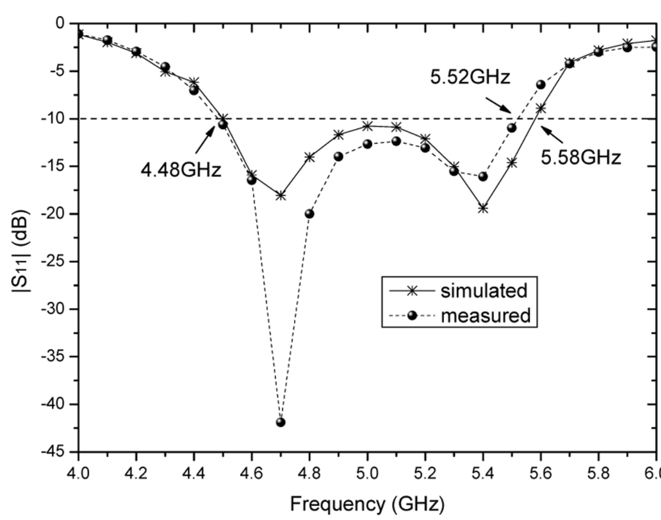

Fig. 2. Measured and simulated return losses of the proposed antenna.

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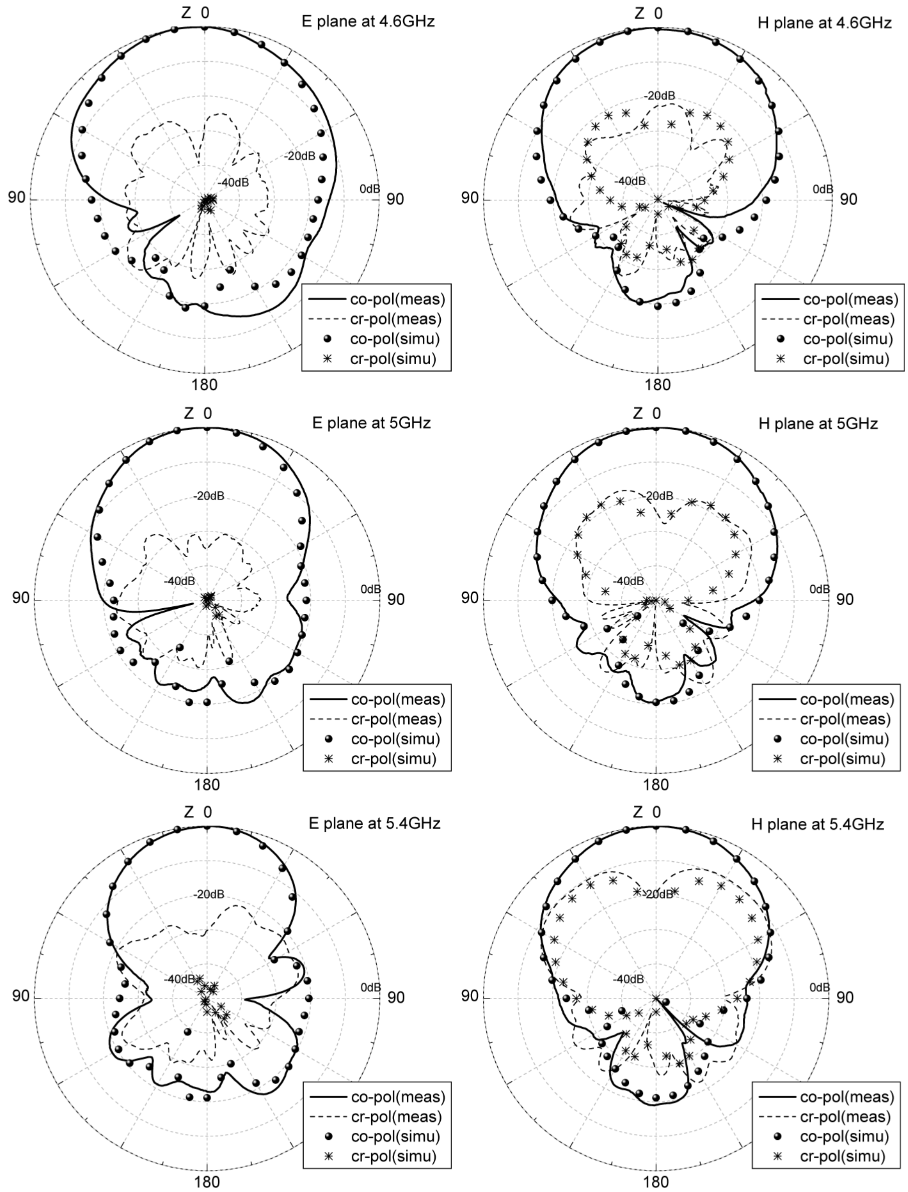

Fig. 3. Measured and simulated radiation patterns of the proposed antenna at 4.6, 5, 5.4 GHz, respectively.

III. Simulated and Measured Results

All of the simulations are performed by Ansoft HFSS [6]. Fig. 2 shows the simulated and measured return losses, where good agreements are observed. The measured band for 10-dB return loss ranges from 4.48 to 5.52 GHz (impedance bandwidth 21%), compared to the simulated one from 4.49 to 5.58 GHz. The measured and simulated radiation patterns at 4.6, 5, and 5.4 GHz are shown in Fig. 3, where good agreements and stable radiation patterns are observed. From the measurement results, the antenna presents a cr-pol radiation below -15 dB in a band from 4.48 to 5.2 GHz and below -9 dB up to the upper edge of the operating band in H plane, and always below -20 dB over the whole band in E plane. The asymmetry in E plane is caused by the asymmetrical Y-shaped feed stub and the V-slot patch. For the symmetrical structure of the antenna along YZ plane, the symmetrical radiation in H plane is produced. The proposed antenna shows a front-to-back ratio of 20 dB and a simulated maximum gain in the broadside direction of 10.8 dBi at 5.3 GHz and a minimum one of 9.4 dBi at 4.5 GHz (measured results: maximum gain 10 dBi at 5.4 GHz and minimum one 7 dBi at 4.5 GHz). There is a 2-dB difference between the simulated and measured results in Fig. 4, which is mainly caused by the measurement errors.

The fabrication and construction errors often cause a relatively large difference between the simulated and measured results. However, as far as our proposed antenna is concerned, it can be endured these errors well. The slight fabrication errors hardly influence its performances. The larger errors are often induced during the construction procedure for the printed MPA. According to our investigations, the displacement of less than ± 0.4 mm along the X direction or less than ± 0.3 mm along the Y direction does not influence the return loss obviously.

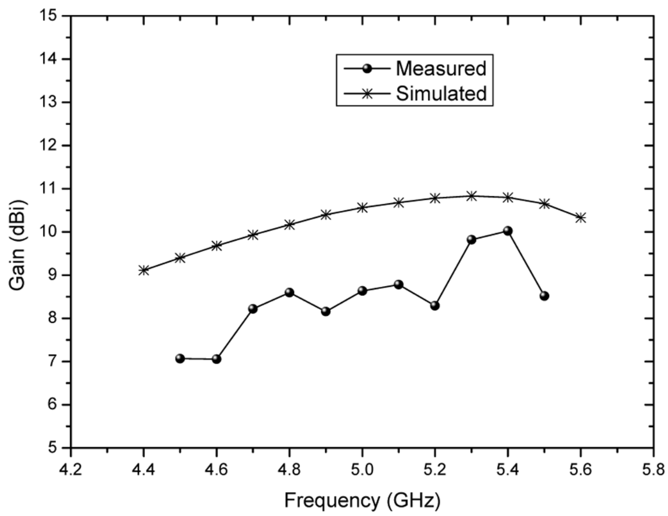

Fig. 4. Measured and simulated gain in the broadside direction of the proposed antenna.

Moreover, the displacement along either negative or positive Y direction can bring a maximum increment of 0.3 dBi in gain.

IV. Conclusion

A Y-shaped stub proximity coupled V-slot MPA is investigated in this letter, and the measured return loss and radiation patterns agree well with the simulated ones. The proposed antenna shows an impedance BW of 21% and a high gain of 9 dBi. The fabrication and construction errors is considered in the end.

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