Small Circularly Polarized E-Shaped Virtually Shorted Patch Antenna

#Kwok Kan So, Kung Bo Ng, Hang Wong, Kwai Man Luk, Chi Hou Chan, Quan Xue

State Key Laboratory of Millimeter Waves (Hong Kong)
City University of Hong Kong
83 Tat Chee Avenue, Kowloon Tong, Kowloon, Hong Kong, China
#eekkso@cityu.edu.hk

1. Introduction

Patch antennas have some advantages such as low profile, ease of fabrication, and conformal to structure. For small RF systems, many researchers have focused on small antenna designs. There are several techniques for reducing the size of the patch such as the use of high permittivity material [1], shorting wall [2] or pin [3], slot and tail [4]. Although, the first technique is the simplest way for reducing the size, it is expensive. The presence of a shorting wall or pin can reduce the conventional patch from half wavelength to quarter wavelength but a higher cross polarization level is generated owing to the asymmetric nature of the antenna. The approach of using slots and tails can give capacitive and inductive loadings to the patch; however, the reduction of patch size is limited to 30%.

In this paper, four parasitic E-shaped virtually shorted patches are provided for miniaturizing the patch size. The shorting strip technique is combined with cutting slots and embedding tails on the patch, so as to easily generate the circularly polarization (CP) field. One end of the strips are open-circuited, the other ends are shorted to the ground plane vertically. The horizontal portion (printed on the substrate) of the strips is used as a capacitive loading whereas the vertical portion (via-hole inside the substrate) is an inductive loading. These four shorting strips arrangement is used to balance and suppress the high cross polarization radiation from the vertical shorting pins and to maintain good broadside radiation characteristics. Good agreement between simulated and measured results is obtained.

2. Antenna Description

Top and side views of the CP patch antenna with E-shaped shorting strips are shown in Fig.1. The patch is printed on the substrate. The unbalanced tails are connected to the open ends of the slots. Two orthogonal modes can be generated from the patch by adjusting the ratio of the unbalanced tails to produce a CP radiation characteristic. The slots are etched and located at four corners of the patch. The proposed parasitic shorting strips are placed in the four slots, which consist of vertical and horizontal portions. The vertical portion is a via-hole which plays the role of a shorting pin. The horizontal portion is an E-shaped strip which is printed on the substrate. All dimensions of the proposed antenna (in millimeter) are shown in Table 1.

Table 1: The Dimensions of CP Patch Antenna with E-Shaped Shorting Strips

L_p	W_p	L_{lt}	L_{st}	W_t	L_{s1}	W_{s1}	L_{s2}	W_{s2}	L_e	W_e	D_{sp}	x_f
17.8	17.8	3.9	2.8	0.44	1.56	0.89	5.56	2.22	5.12	1.78	0.89	2.7

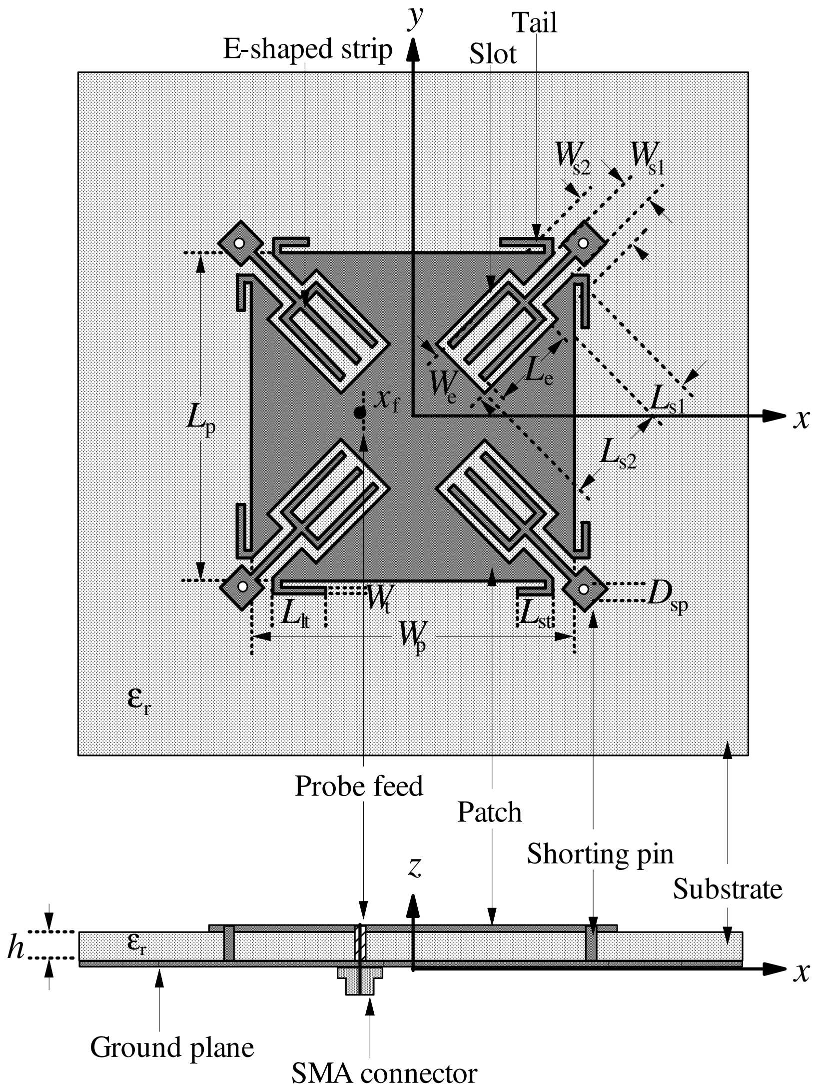

Figure 1: Top and side views of E-shaped virtually shorted patch antenna

3. Measured and Simulated Results

To verify the simulation results, a CP patch antenna with E-shaped shorting strips was fabricated by using Taconic substrate material (ε_r = 10 and h = 3.18 mm). The measurement was carried out using an Agilent Technologies E5071C network analyzer. Fig. 2 shows the comparison of measured and simulated standing wave ratios (SWRs) as a function of frequency. It is observed that the measured and simulated bandwidths (for SWR ≤ 2) are 1.569 – 1.586 and 1.570 – 1.583 GHz, respectively. For CP radiation characteristics, the axial ratio (AR), antenna gain, and radiation pattern were measured by a near-field antenna measurement system from StarLab, Satimo. Fig. 3 illustrates the measured and simulated ARs as a function of frequency. With reference from the figure, the measured and simulated resonant frequencies (minimum AR) are 1.575 GHz, and their corresponding bandwidths (for AR ≤ 3 dB) are given by 1.5725 – 1.5778 and 1.5732 – 1.5763 GHz, respectively. Fig. 4 depicts the measured and simulated antenna gains as a function of frequency. It is found that the stable gain around 3.5 dBi across the AR passband is obtained. The measured and simulated radiation patterns at 1.575 GHz are shown in Fig. 5, where it is observed that the antenna operates in a good broadside CP characteristic.

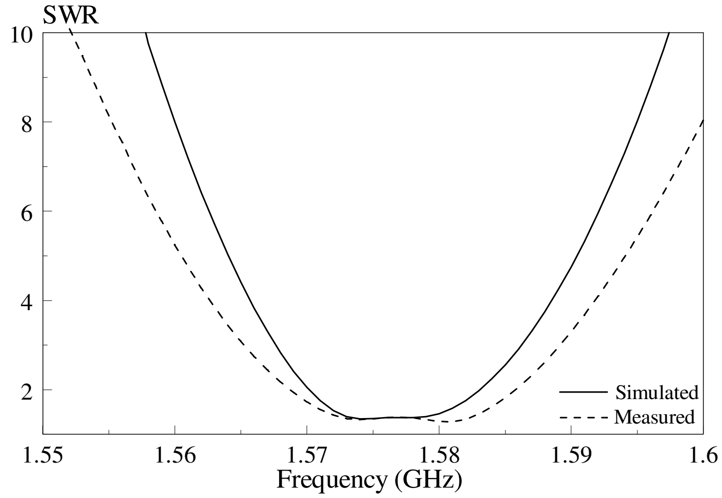

Figure 2: Measured and simulated SWRs as a function of frequency

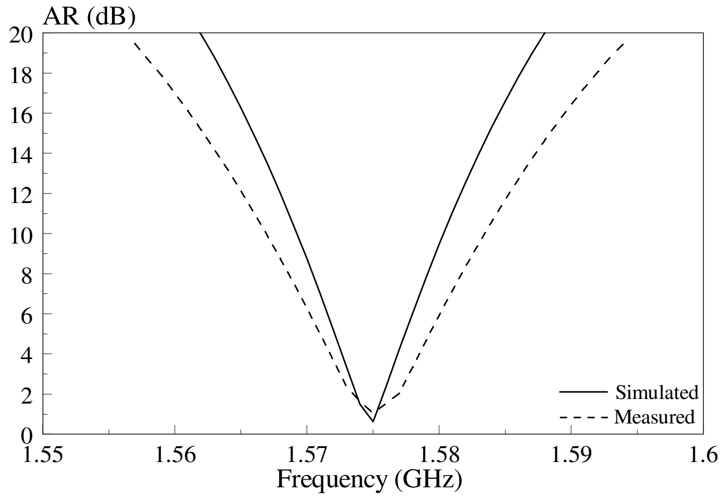

Figure 3: Measured and simulated ARs as a function of frequency

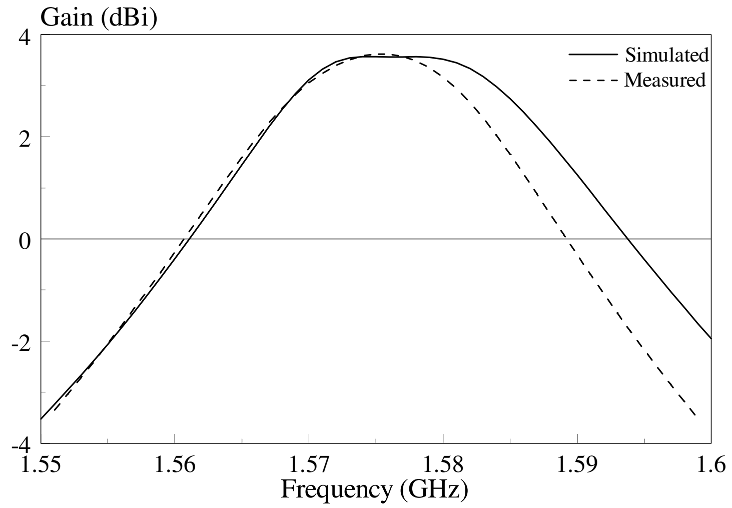

Figure 4: Measured and simulated antenna gains as a function of frequency

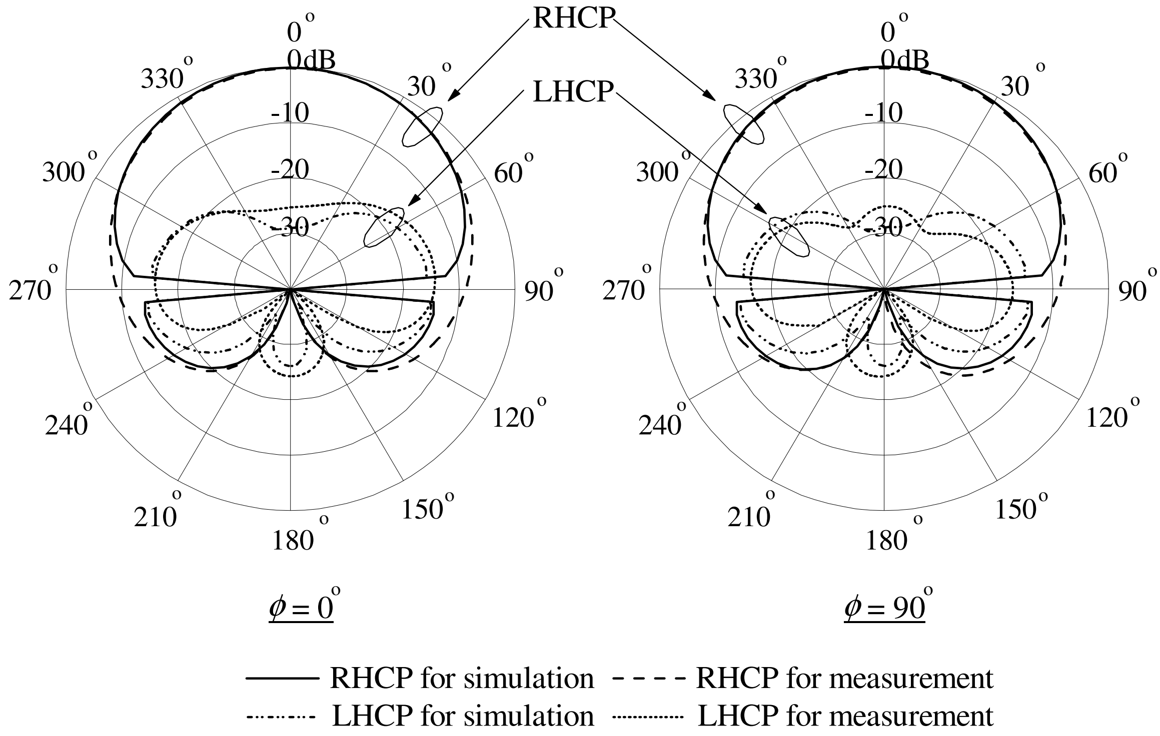

Figure 5: Measured and simulated radiation patterns at 1.575 GHz

4. Conclusions

A CP patch antenna with E-shaped virtually shorted patch is investigated. The proposed shorting strip can control a capacitive loading effect to the patch which reduces the patch size. Good result of SWR, AR, gain, and radiation pattern can be obtained for the proposed antenna.

References

[1] T. K. Lo, C. O. Ho, Y. Hwang, E. K. W. Lam, and B. Lee, "Miniature aperture-coupled microstrip antenna of very high permittivity," *Electron. Lett.*, vol. 33, pp. 9-10, Jan. 1997.

[2] K. F. Lee, Y. X. Guo, J. A. Hawkins, R. Chair, and K. M. Luk, "Theory and experiment on microstrip patch antennas with shorting walls," *IEE Proc. Microw. Antennas Propagat.*, vol. 147, pp. 521-525, Dec. 2000.

[3] M Sanad, "Effect of the shorting posts on short circuit microstrip antennas," *IEEE Antennas and Propagat. Society Int. Symposium Dig.*, vol. 2, pp. 794-797, Seattle, Washington, USA, Jun. 1994.

[4] M. L. Wong, H. Wong and K. M. Luk, "Small circularly polarized patch antenna," *Electron. Lett.*, vol. 41, pp. 887-888, Aug. 2005.