Wideband Circularly Polarized Slotted-Patch Antenna with a Reflector

Jhih-Ming Chen, Jia-Fu Tsai, and Jeen-Sheen Row
Department of Electrical Engineering, National Changhua University of Education,
Chang-Hua, Taiwan 500, R.O.C.

***Abstract*—A design for wideband circularly-polarized (CP) antennas with unidirectional radiation is described. The antenna structure is mainly composed of a rectangular slotted patch and a metallic reflector. First, the CP design for the stand-alone slotted patch antenna is investigated, and a 3dB-axial-ratio bandwidth of 53 % is obtained. Then, the metallic reflector is placed at the rear of the slotted patch to generate unidirectional radiation. Experimental results demonstrate that the slotted patch antenna with a reflector has almost the same CP bandwidth as the stand-alone slotted patch antenna, and it has good impedance matching as well as stable radiation patterns across the CP operating frequencies.**

***Index Terms*— slotted patch antenna, circular polarization, wideband operation**

I. Introduction

Circularly-polarized (CP) antennas are required for some specific wireless communication systems, such as radio frequency identification systems, global positioning systems, and direct broadcast satellite, because they can fairly communicate with a linearly-polarized antenna with random orientations and also avoid the loss of polarization mismatch. Although a large number of CP antenna designs have been reported, the available designs with the characteristics of symmetric radiation patterns and moderate gains within a CP bandwidth of more than 50 % are few.

So far as wide slot antennas are concerned, their wideband CP operation can be accomplished with a single feed [1]-[3]. A design using CPW-fed square slot antennas has been presented in [1], and the antenna has a stable radiation pattern and a peak gain of 7.6 dBic within a 3dB-axial-ratio bandwidth of 39 %. In [2], an L-shaped feed line is used to excite an L-shaped slot fabricated on a metallic layer with a perturbed corner, and a 3dB-axial-ratio bandwidth of 47 % is achieved. The CP bandwidth can be further improved by using a slot composed of multiple circular sectors [3], and the obtained 3dB-axial-ratio bandwidth reaches to 57 %; however, a considerable number of parameters are involved in the multiple circular sectors and they have to be determined using computational power through multi-objective optimization algorithm.

In this paper, a wideband CP design with a 3dB-axial-ratio bandwidth of more than 50 % is proposed. The design is based on a slotted patch antenna that has a simple structure and compact size. Moreover, stable and symmetrical radiation patterns can be obtained within the CP operating bandwidth. Details of designs and experimental results are shown.

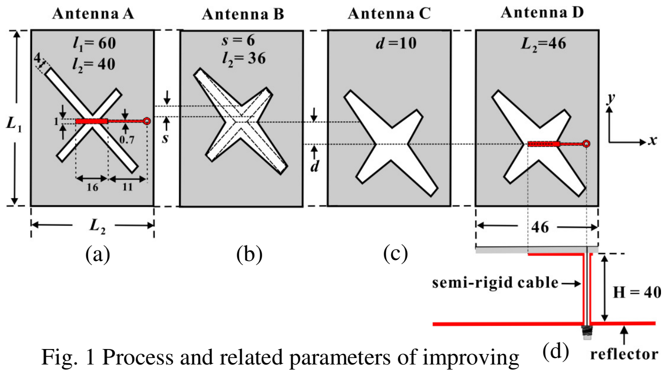

Fig. 1 Process and related parameters of improving performances for the slotted patch antenna

II. Slotted Patch antenna and Analyses

Fig. 1(a) depicts the layout of a slotted patch fabricated on one metallic layer of a FR4 substrate with thickness 1.6 mm and relative permittivity 4.4. The cross slot with lengths l_1 and l_2 is embedded into a rectangular conducting patch with the dimensions of L_1 and L_2. The radiation of the slotted patch is excited with a microstrip feed line printed on the other layer of the FR4 substrate. One example (Antenna A) is first selected to show the CP performances of the slotted patch antenna. The key dimensions of Antenna A are l_1 = 60 mm, l_2 = 40 mm, L_1 = 75 mm, L_2 = 50 mm, and the other dimensions are revealed in Fig. 1. The HFSS simulated results of Antenna A are exhibited in Fig .2, and a CP operating frequency band, where return loss is less than 10 dB and axial ratio is lower than 3 dB, is observed. The CP operating frequencies is from 1.54 GHz to 2.21 GHz, corresponding to a fractional bandwidth of 36 %. The CP bandwidth can be increased when the four intersections of the cross slot are symmetrically moved outward by a distance of *s*, and the resultant antenna is shown in Fig. 1(b). Note that as *s* is increased to 6 mm, the axial ratio around 2.3 GHz slightly exceeds 3 dB, and it can be solved by tuning l_2. An optimum design (Antenna B) is found, and it has the same dimensions as Antenna A, excluding *s* (= 6 mm) and l_2 (= 36 mm). The simulation results of Antenna B are also given in Fig. 2, and a CP operating bandwidth of around 56 % is obtained, which is increased by a factor of 1.6 as compared to that of Antenna A. The radiation patterns of Antenna B were inspected, and it is found that tilted main beams appear in *y-z* plane when Antenna B is operated at higher frequencies. The problem of the tilted beam can be alleviated by moving the cross slot toward -*y* axis, as indicated in Fig. 1(c) where the distance of the movement is denoted as *d*. For the *d* = 10 mm case (Antenna C), the main beams are found to be symmetrical with respect to *z* axis across

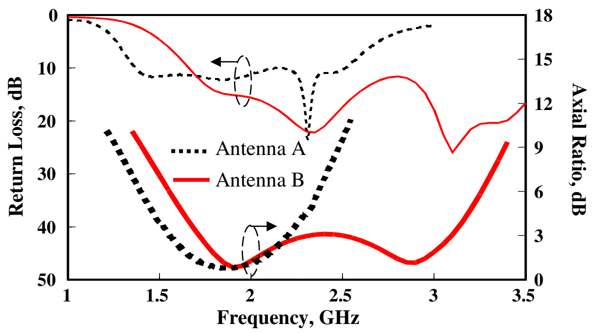

Fig. 2 Simulated results of Antenna A and B

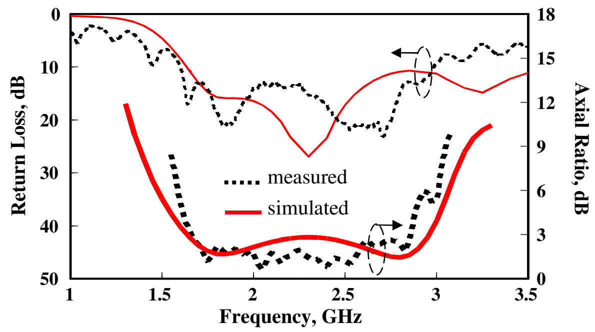

Fig. 3 Measure and Simulated results of Antenna C

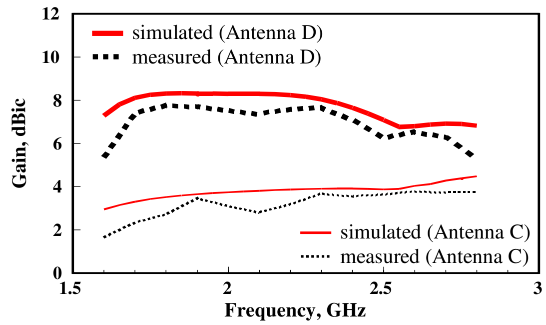

Fig. 4 Gain variations for Antenna C and Antenna D

the whole CP operating frequencies. A prototype for the design of Antenna C was implemented and it was tested through a RG178 coaxial cable of length 60 mm. The way of the cable connecting to the prototype is that the outer and inner conductors of the cable are linked to the feed line and slotted patch, respectively. Both measured and simulated results of the prototype are presented in Fig. 3, and acceptable agreements between them are seen. For the prototype, the measured 10dB-return-loss and 3dB-axial-ratio bandwidths are from 1.65 to 2.9 GHz and from 1.66 to 2.86 GHz, respectively, leading to a CP operating bandwidth of 53 % with respect to the center frequency 2.26 GHz. The gain variations against frequency are also investigated, and the measured results are given in Fig. 4 together with the simulated data. The measured peak gain has a variation of 1.5 dB across the whole CP operating bandwidth.

III. CP Slotted Patch Antenna with a Reflector

For generating unidirectional radiation and improving antenna gain, a metallic reflector with the dimensions of 250 × 150 mm^2 is introduced into the design of Antenna C, as shown in Fig. 1 (d). The slotted patch is excited through a semi-rigid coaxial cable, and the reflector is directly connected to the outer

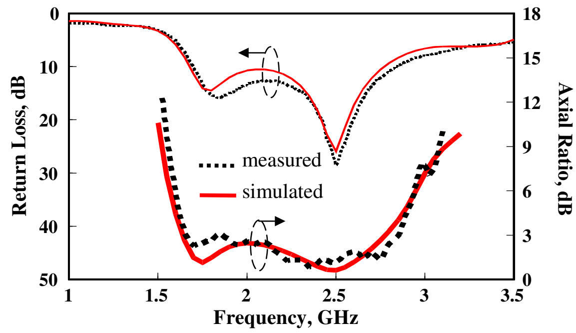

Fig. 5 Measure and Simulated results of Antenna D

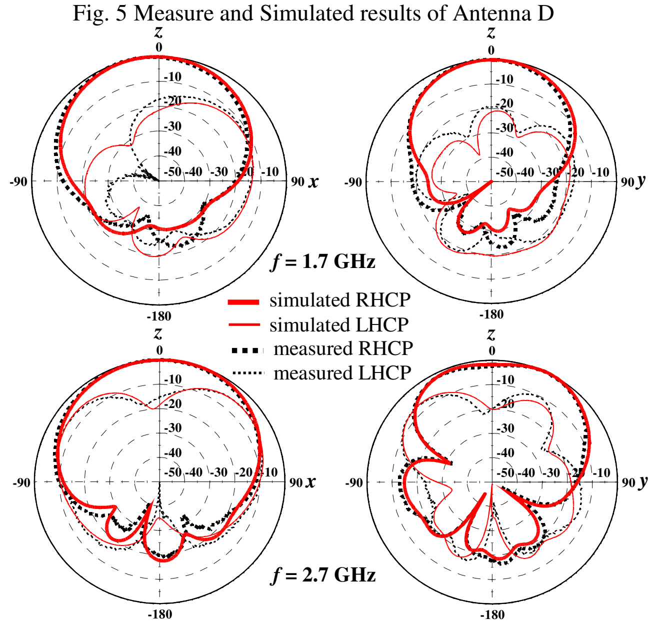

Fig. 6 Measured radiation patterns for Antenna D at 1.7 and 2.7 GHz

conductor of the cable. The separated distance of the FR4 substrate and the reflector is fixed to be 40 mm. It has to be noted that the axial ratio becomes worse as the reflector is introduced, and the problem can be improved by decreasing L_2 from 50 to 46 mm. For Antenna D, a prototype was fabricated and tested. Fig. 5 exhibits the measured results of the prototype, and the HFSS simulated results validate the experiments. The measured CP operating bandwidth, centered at 2.3 GHz, is about 53 % which is almost the same as that of Antenna C. The radiation patterns measured at 2.2 and 2.7 GHz are plotted in Fig. 6. Broadside radiation with RHCP is observed and the back radiation is less than -15 dB. The gain variations against frequency are shown in Fig. 4. Within the CP operating bandwidth, the gain variation is lower than 2.5 dB and the average gain is about 7 dBic.

References

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