High-Gain Wideband Circularly Polarized Resonant Cavity Antenna

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***Abstract*—This paper presents a high gain wideband circularly polarized (CP) resonant cavity antenna. The primary radiators consist of two orthogonal bowtie dipoles, which generate wideband CP radiation. High-gain broadside radiation and wide axial ratio (AR) bandwidth are achieved with the properly chosen lateral size of a half-wavelength-thick planar partially reflecting surface. The antenna with an overall size of 80 mm × 80 mm × 28.35 mm yields –10-dB impedance, 3-dB AR, and 3-dB gain bandwidths of 40%, 25.6%, and 42.7%, respectively.**

***Keywords*—high gain antenna; partially reflecting surface; resonant cavity antenna; crossed bowtie dipole.**

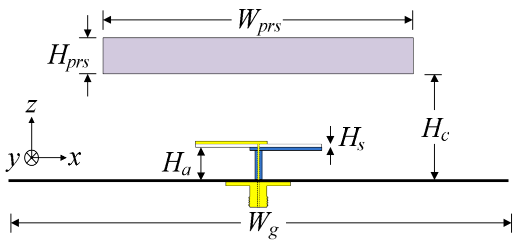
I. Introduction

The gain of an antenna can be significantly improved by placing a partially reflecting surface (PRS) at a proper distance from the ground plane [1–10]. The maximum radiation in the broadside direction occurs when the reflectivity of a PRS is maximized, and a cavity structure achieves in-phase electromagnetic wave transmission. The main characteristics of the antenna, such as the operating frequency, gain bandwidth, and radiation patterns, are determined by the properties of the PRS. Typically, the PRS is placed at a half-wavelength distance from the ground plane for optimum performance. However, the maximum gain increase is usually accompanied by a decrease in the operation bandwidth. Therefore, achieving both a high gain and a wide bandwidth at the same time is a very difficult task.

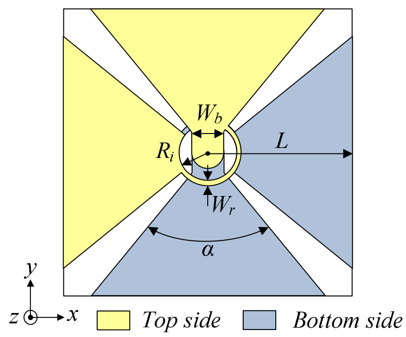
A high-gain circularly polarized (CP) resonant cavity antenna (RCA) with wideband characteristics is presented in this paper. A planar metallic conductor acting as the ground plane is placed behind a radiator, and a dielectric superstrate acting as a partially reflecting surface is placed in front of the radiator. The radiator with a broadband CP operation is designed with two bowtie dipoles [11]. The antenna uses a half-wavelength-thick PRS and achieves wideband characteristics. The antenna with an overall size of 80 mm × 80 mm × 28.35 mm yielded a measured –10-dB impedance bandwidth of 5.6–8.4 GHz and a 3-dB AR bandwidth of 6.3–8.15 GHz. Also, the antenna exhibited an average gain of 14.5 dBi over the CP operating bandwidth and yielded a wide 3-dB gain bandwidth of 5.7–8.8 GHz.

II. Antenna Design

The geometry of the antenna is shown in Fig. 1. The antenna consists of a ground plane, a CP radiator, and a PRS dielectric layer. The CP radiator composed of two orthogonal bowtie dipoles is designed on both sides of a Rogers RO4003 substrate with a dielectric constant of 3.38, and a loss tangent of 0.0027. Wideband operation characteristics were achieved based on the proper combination of the fundamental modes of the dipole and slot [11]. A reflector is placed behind the



(a) Cross-section view.



(b) CP radiator.

Fig. 1. Geometry of the antenna.

bowtie dipoles, and the PRS is placed at a distance of approximately a half wavelength at 7.4 GHz from the reflector. Taconic/Cer-10 material with a dielectric constant of 10.2, a loss tangent of 0.0035, and a thickness of 6.35 mm is chosen for the PRS superstrate. Unlike the conventional RCA with a single superstrate with a quarter-wavelength thickness, a half-wavelength PRS thickness is utilized. It is characterized by a very large transmission bandwidth and, therefore, the CP operation of the whole structure can be maximized. Additionally, the half-wavelength PRS performs dual-band behavior in broadside gain radiation [12] and with the proper size of the PRS, the 3-dB gain bandwidth of the antenna can be significantly enhanced. The antenna is characterized by the ANSYS HFSS and validated by measurements.

The optimized antenna design parameters for the maximum gain and AR bandwidths are as follows: L = 10, R_i = 1.6, W_r = 0.45, H_s = 0.508, H_a = 7, H_c = 22, W_{prs} = 50, H_{prs} = 6.35, W_g= 80 (unit: mm), and α = 74º.

III. MEASURED AND SIMULATED RESULTS

Figure 2 shows the measured and simulated reflection coefficients of the proposed antenna. The measurement agreed quite well with the simulation. The simulated impedance bandwidth for $|S_{11}|$ < –10 dB was 5.8 to 8.4 GHz, and the measurement result was 5.6–8.4 GHz. Measured and simulated ARs are presented in Fig. 3. The measured and simulated 3-dB AR bandwidths were 6.3–8.21 GHz and 6.3–8.15 GHz, respectively. The gain of the proposed antenna is shown in Fig. 4, and a good agreement is found between the simulated and measured results. The antenna achieved a wide 3-dB gain bandwidth of 5.7–8.8 GHz, and the measured gain was approximately 14.5 dBi within the AR bandwidth.

IV. CONCLUSION

In this paper, a wideband, high-gain CP antenna using a single layer superstrate was presented. The wideband CP crossed bowtie dipole was chosen as a primary source of the proposed RCA. By using a half-wavelength-thick PRS, the proposed antenna yielded high gain, wideband features in terms of CP and 3-dB gain bandwidths. The proposed antenna yielded a 3-dB AR bandwidth of 6.3–8.15 GHz and a –10 dB reflection coefficient bandwidth of 5.6–8.4 GHz. An average gain of 14.5 dBi was achieved over the CP operating bandwidth, and the 3-dB gain bandwidth was 5.7–8.8 GHz.

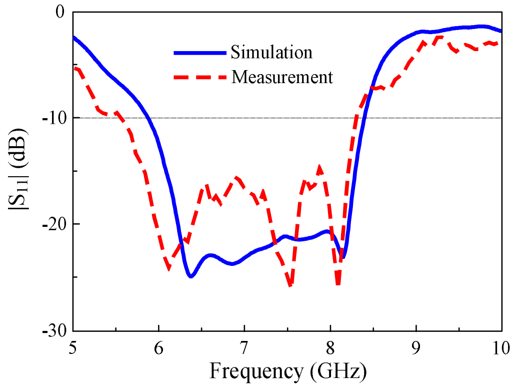


Fig. 2. Measured and simulated $|S_{11}|$.

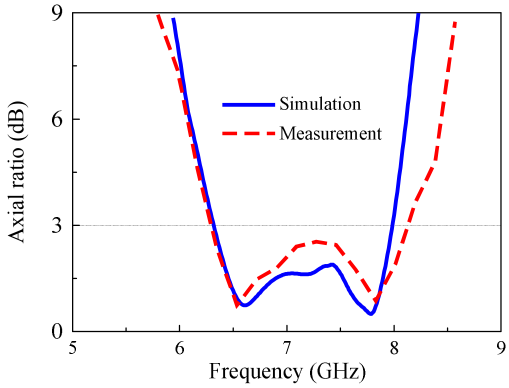


Fig. 3. Measured and simulated AR.

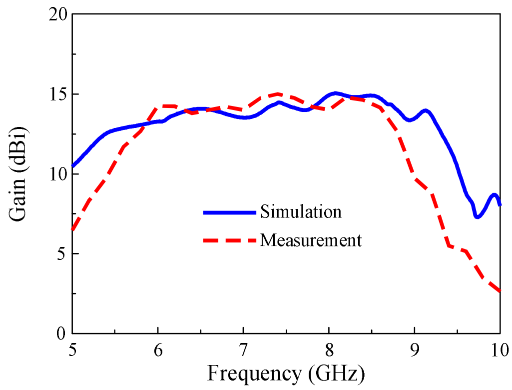


Fig. 4. Measured and simulated gain.

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