

Design and implementation of a 2.45GHz circularly polarized microstrip antenna for wireless energy harvesting

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Abstract. Based on the microstrip patch antenna radiation square chamfer, thereby introducing perturbation, single-fed microstrip antenna in circular polarization. High-frequency structure simulator HFSS antenna work at 2.45GHz of antenna design and simulation, the antenna has a circular polarization characteristics, and the direction of maximum gain is achieved 4.06dB. Use ADS for antenna and rectifying boosting circuit simulation and match, making the system at low power reached 9.63%.

1. Introduction

RF energy harvesting technology by a receiving antenna, several parts of the matching circuit, the boost rectifier circuit and output circuit^[1]. RF energy is collected mainly by a receiving antenna in the environment of carrying radio frequency electromagnetic energy is received, after the matching circuit via a matching circuit received radio frequency electromagnetic energy to and behind the rectifying boosting circuit, and thus the environment AC signal into a DC voltage output and the final output to the load. Block diagram showing the basic principle is as follows:

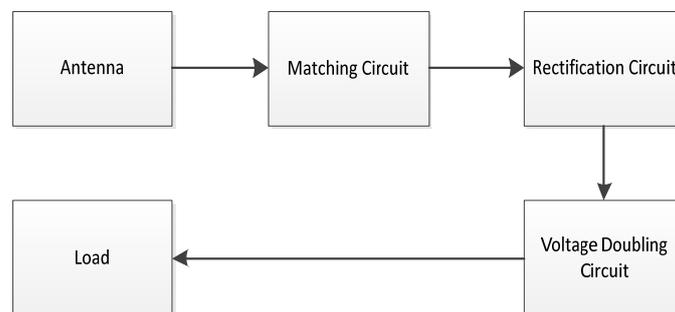


Fig.1 block diagram of energy harvesting technology

2. Microstrip circularly polarized antenna design

Cutaway implement the principle of circular polarization square patch as follows:

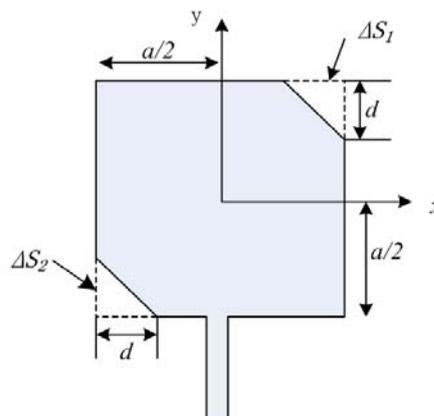


Fig. 2 Notching circularly polarized square patch antenna

As shown in Figure 2 is a schematic view of the square cutting angle circularly polarized patch antenna, where in

$$\Delta S = \Delta S_1 + \Delta S_2 = d^2 \quad (1)$$

$$S = a^2 \quad (2)$$

Where ΔS is the chamfered area of the two and, S is the total area of the entire patch, d triangular corner cutting edge side, a side length of a square patch.

$$\left| \frac{\Delta s}{s} \right| = \frac{1}{2Q_0} \quad (3)$$

Where Q_0 is the microstrip antenna quality factor. For microstrip transmission line there:

$$\frac{1}{Q_0} = \tan \delta_{\text{eff}} = \frac{1}{Q_r} + \frac{1}{Q_c} + \frac{1}{Q_d} + \frac{1}{Q_{sw}} \quad (4)$$

When a rectangular patch antenna radiating elements:

$$Q_r \approx \frac{3\varepsilon_r (W/L)}{8(h/\lambda_0)} \quad (5)$$

$$Q_c = h\sqrt{\pi\mu_0 f \sigma} = \pi h\sqrt{120\sigma/\lambda_0} \quad (6)$$

$$Q_d = \frac{1}{\tan \delta} \quad (7)$$

Which $\tan \delta_{\text{eff}}$ represents the loss tangent of the angle microstrip line, Q_r is the radiation loss, Q_d is the conductor loss, Q_{sw} is dielectric loss caused by the wave corresponding quality factor. The relative permittivity of a medium is ε_r , the thickness of the dielectric substrate is h , σ is the conductivity of the medium. For ordinary microstrip antenna thickness, the effect of Q_{sw} can often be ignored. By the above formula to solve, can be conveniently obtained microstrip antenna quality factor, which can calculate the degeneracy separation unit size[2-4].

Antenna size and the thickness of the dielectric plate, dielectric constant, the operating frequency has a close relationship. In the case of determining the dielectric plate, the antenna operating frequency is mainly determined by the length of the patch. In this paper, in order to more effectively carry out experiments and antenna design, antenna design of the dielectric plate selected Rogers RT / duroid 5870 (tm), a dielectric constant of 2.33, the loss factor of 0.0012. Considering the impact of the microstrip antenna bandwidth media thickness, and practical engineering application, select a thickness of 1.6mm.

In the operating frequency of 2.45GHz, the dielectric plate thickness of 1.6mm, the dielectric constant of the dielectric plate is 2.33, the medium wavelength of 82.07mm, length of unilateral interference by the edge of the field of radiation-induced side to reduce the amount of 0.83mm, the effective dielectric constant of 2.23, the length of the radiating patch antenna element is of 39.3 mm, a width of 47.45mm. Wherein the radiation loss of 80.76, 52 conductor loss, dielectric loss of 833.33, therefore the quality factor can be obtained as 30.48, chamfered edge length of 5.03mm.

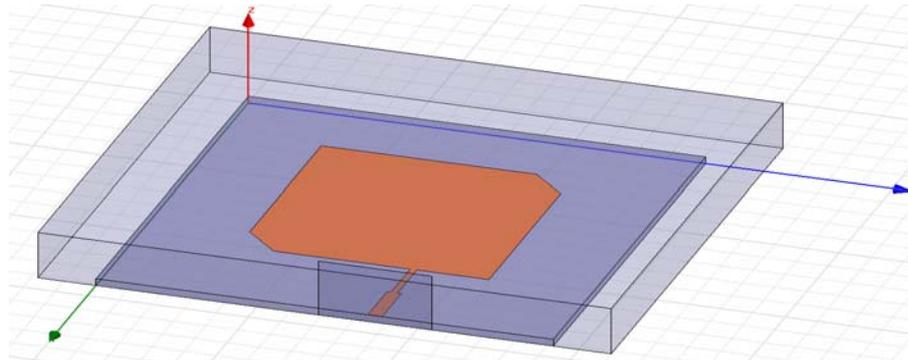


Fig.3 single circularly polarized antenna structure Cutaway model diagram

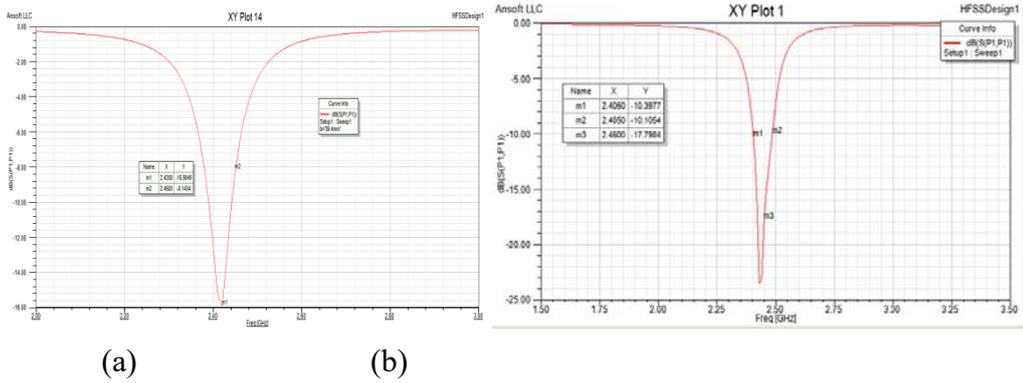


Fig.4 Single Cutaway circularly polarized antenna return loss comparing before and after Optimization

As can be seen from Figure 4 that the optimized antenna return loss at 2.45GHz is -8.14dB, signal serious reflection; optimized antenna return loss at 2.45GHz is -17.80dB, -10dB bandwidth of 80MHz, in line with our lower than 2.45GHz antenna return loss of -10dB requirements.

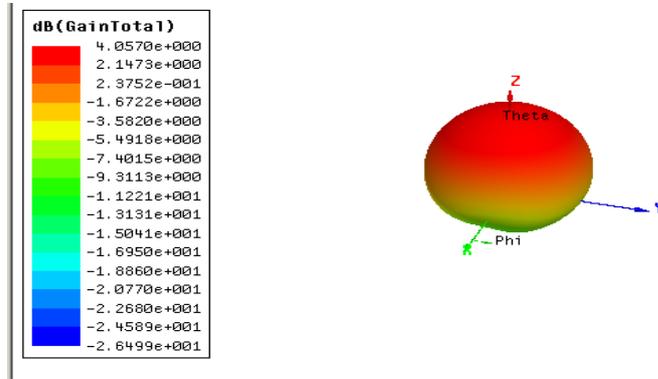


Fig.5 Simulation 2.45GHz Cutaway 3D circular polarized antenna pattern

Figure 5 we can see, the antenna in the direction of maximum radiation in the direction of a gain of 4.06dB.

3. Rectifying boosting circuit design

HSMS2862 by the rectifier and capacitors boost circuit, but due to the limited magnitude of the boost rectifier boosting single unit, we use the four rectifying boosting circuit units cascaded way to increase the value of the voltage output. Circuit C1, C2, C3, C4 value of 100pF, C5, C6, C7, C8 as the need for a stronger charge storage capability, the choice of the 100nF capacitor. The circuit configuration shown in Figure 6:

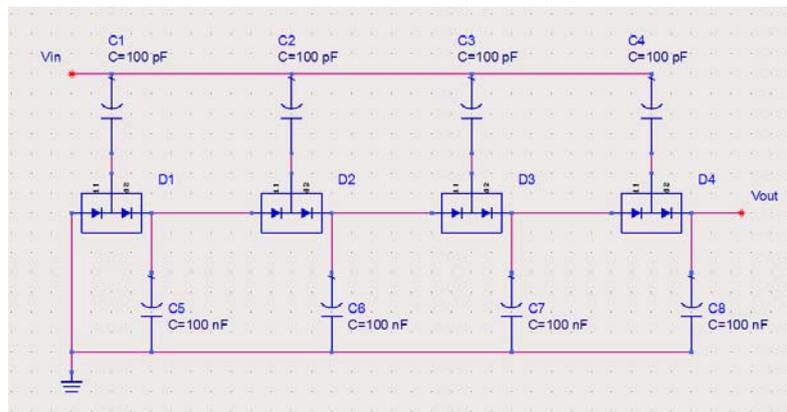


Fig. 6 four-cell cascade boost rectifier circuit schematics

From the beginning of the negative half-cycle, the input terminal on the negative in positive, then turned d1, d2 off, signal d1 by the capacitor C1, the charging voltage is set to V_m ; the positive half cycle, that is, the input terminal being negative, this when the deadline d1, d2 is turned on, and d2 signal by the C1 to C5 charge, since after the original C1 voltage V_m , superimposed added C5, C5 charging voltage is $2V_m$ [5-6].

4. Circularly polarized energy collection system testing

WIFI signal, whether at home or out in public places, have a wide distribution of this experiment is the study of 2.45GHz near the signal, and using cutting angle circular polarization antenna elements and arrays, respectively, were tested. Test procedure shown in Figure 7:

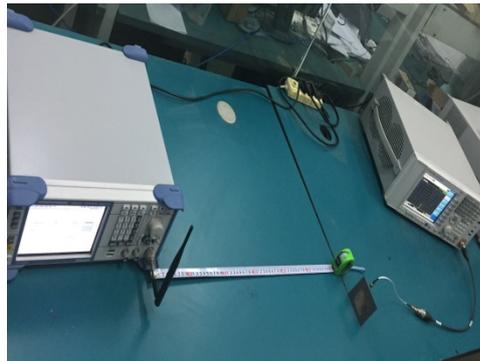


Fig. 7 for WIFI signal collected Cutaway circular polarization unit test chart
Table 1 2.45GHz circular polarization angle of the transmit antenna elements 0°

Source transmit power (dBm)	signal analyzer power (dBm)	Antenna received power (dBm)	load voltage (V)	Power load (W)	rectifying antenna efficiency (%)
20	-4.77	-3.29	1.86	3.46E-05	7.38
15	-9.11	-7.63	1.02	1.04E-05	6.03
10	-14.04	-12.56	0.55	3.03E-06	5.45

Table 2 2.45GHz circular polarization angle of the transmit antenna elements 90°

Source transmit power (dBm)	signal analyzer power (dBm)	Antenna received power (dBm)	load voltage (V)	Power load (W)	rectifying antenna efficiency (%)
20	-7.40	-5.92	1.57	2.46E-05	9.63
15	-11.87	-10.39	0.79	6.24E-06	6.83
10	-16.96	-15.48	0.33	1.09E-06	3.85

5. Summary

Above experiments show that Cutaway circularly polarized antenna unit is less than its output power circularly polarized antenna array consisting of the output values. After the rotation of 90° , the output power loss Cutaway circularly polarized antenna unit is 28.90%

Circularly polarized antenna capable of receiving more different directions of polarization of electromagnetic waves, reducing the polarization loss, has its unique advantages when ambient RF energy harvesting is conducive to energy harvesting power increases.

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