Circularly Polarized Patch Antenna with Gain Enhancement using Reflector

Vinita Mirdha
Microwave Lab, Dept. of Physics
University of Rajasthan
Jaipur, India
vinitamirdha@gmail.com

Deepak Bhatnagar
Microwave Lab, Dept. of Physics
University of Rajasthan
Jaipur, India
dbhatnagar2010@gmail.com

Virender K. Saxena
Microwave Lab, Dept. of Physics
University of Rajasthan
Jaipur, India
vksaxena.uor@gmail.com

B. R. Sharma
Department of Physics
Swami Keshvanand Institute of Technology, Management & Gramothan, Jaipur, India
brajraj@skit.ac.in

***Abstract*—The paper presents the circularly polarized patch antenna with high gain. The antenna shows dual band characteristics due to split ring resonator etched over the substrate which is resonating at frequency 4.4 GHz and 7.6 GHz with reflection coefficient -17.3276 dB and -34.4189 dB. The impedance bandwidth achieved by the proposed antenna is 360 MHz (4.2-4.56) and 980 MHz (7.2-8.18) at -10 dB reflection coefficient by using defected ground plane. The proposed design's axial ratio is less than 3dB for frequency 4.4 GHz and 7.6 GHz due to the optimization of the position of micro strip feed line. By using reflector, gain enhancement achieved 7.7858 dB and 4.9819 dB respectively 4.4 GHz and 7.6 GHz. The proposed antenna also shows very good radiation pattern in XZ plane for LHCP and RHCP. The radiation properties of the proposed antenna are useful for satellite applications.**

Keywords*— *circularly polarized, bandwidth, axial ratio, split ring resonator

I. INTRODUCTION

Many wireless devices use micro-strip patch antennas owing to their compact size, conformal designs and cost effectiveness [1]. In last few years, there is increase in the demand of antenna with high gain, lesser area covered avoids multipath fading, mismatching of polarization effects. Due to their low polarization loss and its easy installation process, circularly polarized antennas are favored over other antennas [2-4]. For the purpose of designing a single feed circularly polarized (CP) microstrip patch antenna, numerous approaches and strategies have been put forth [5-7].

A wideband circularly polarized monopole antenna with an annular open loop offers a wide impedance bandwidth of 96.1% and a wide axial ratio bandwidth of 81.3% [8]. A printed, falcate-shaped Monopole antenna with an altered ground plane is used for CP radiation and broadband impedance matching. By symmetrically etching a pair of rectangular CSRRs on the ground plane below the feed line, the suggested design's axial ratio bandwidth is enhanced toward high frequency while the out of band radiation is significantly decreased. [9]. The 3 dB axial ratio bandwidth of 39.7% is provided through a circularly polarized monopole antenna with a half circular patch, an inverted-L feeding strip with a coplanar waveguide [10]. Multiple antenna communication applications are provided by the suggested triple trips monopole antenna with arrangement of square loop slots and slotted stubs at its ground plane side [11]. The modern day communication protocol requires circularly polarized (CP) wide band width with high gain simultaneously. A circularly patch antenna with a cross slot having various lengths was used to build a micro-strip patch antenna for circular polarization [12]. With L-shaped slits and truncated corners, the suggested design exhibits a well-defined RHCP radiation pattern across the band, which also qualifies the structure for wireless communication [13]. A monopole antenna having square patch with two triangles dug diagonally and a slot cut in the ground with coplanar waveguide feeding to produce circular polarization [14].

The efficacy of the proposed antenna has been analyzed in terms of gain, reflection coefficient, radiation pattern, axial ratio etc. The electromagnetic tool HFSS has been used in it. The presented circularly polarized patch antenna compact in size but it is characterized by high gain with dual band frequency.

II. GEOMENTRY AND STRUCTURE OF PROPOSED ANTENNA

A circularly polarized patch antenna is designed on the substrate FR-4 with dimension L1* W1 and thickness 1.6 mm having permittivity $\in r$ = 4.4 and loss tangent of 0.02 as shown in Fig.1. A rectangular shape monopole patch is etched on the top of the dielectric subtract of dimension L2*W2 and at the center of monopole micro strip feed is given to the patch for circular polarization. Introducing the two split rings near the rectangular patch for gain enhancement the dimensions of split ring resonator are shown in Table-1. On the lower part of the substrate defective ground plane is designed in rectangular shape with dimension of L3*W3 as perfectly conducting surface and four additional rectangular surface is also designed with ground plane of dimension L4*W4 as shown in Fig. 2. A reflector is also used in back side of antenna with dimension L5*W5 for gain enhancement. The proposed design of

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monopole antenna is simulated and optimized by using the HFSS software.

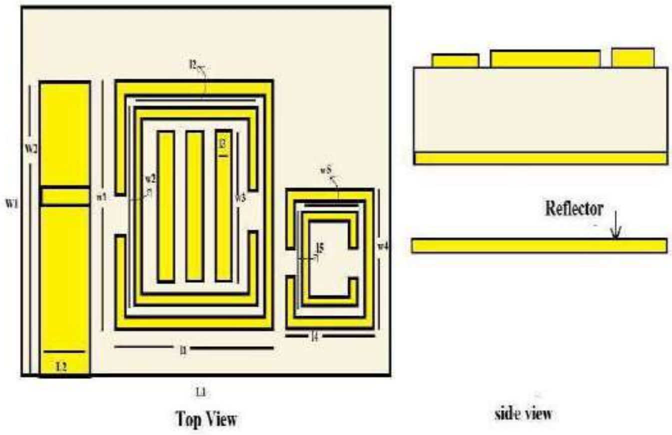

Fig.1. Antenna's Top View

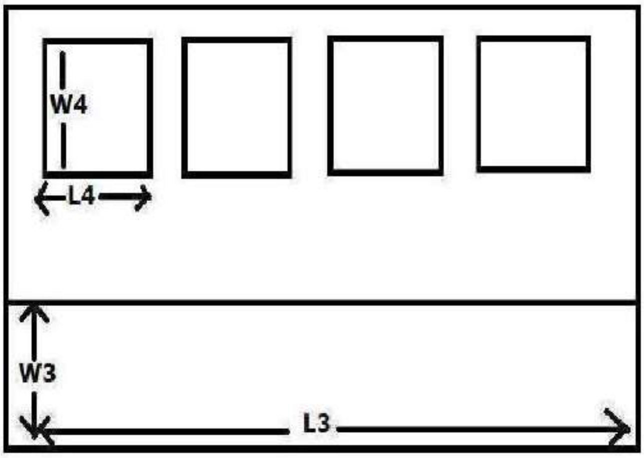

Fig.2. Antenna's Bottom View

TABLE I. THE OPTIMIZED ANTENNA PARAMETERS

Parameters	L_1	W_1	L_2	W_2	L_3	W_3	L_4	W_4
Value (mm)	21	21	2.5	14.7	21	5	4	4

Parameters	L_5	W_5	l_1	w_1	l_2	w_2	w_3
Value (mm)	50	50	9	9.2	6	6.4	3.8

Parameters	b	l_4	w_4	l_5	w_5
Value (mm)	0.8	4	4	14.7	21

III. RESULTS AND DISCUSSION

In this research paper we design a micro strip patch antenna with circular polarization using split rings and defected ground. Circularly polarized Antennas are important in satellite communication and sometimes also in mobile communication. The proposed antenna is resonant on two frequencies and showing good gain response on both frequencies. The proposed design of circularly polarized patch antenna is optimized and simulated using HFSS Software which is based on a specific element technique. The monopole patch with split ring resonators designed in such a way to resonating at dual frequency 4.4 GHz and 7.6 GHz with maximum reflection coefficient -17.3276 dB and -34.4189 dB as shown in Fig. 3.

The axial ratio curve is drawn against the frequency as shown in Fig. 4. It has value less than 3dB at both frequencies 4.4 GHz and 7.6 GHz. The circular polarization is achieved by adjusting the feeding point on micro strip patch on its optimum position. Hence, Patch antenna is circularly polarized.

Antenna also consist the reflector which gives the maximum gain 7.7858 dB and 4.9819 dB at Ø=0° and Ø =90° at resonant frequencies 4.4 GHz and 7.6 GHz as shown in Fig. 5. In this research work, we enhance the gain of the proposed antenna by applying the reflector at the bottom of the antenna, which is 1 cm away from the substrate or from the ground. When excitation is applied to the antenna, the electromagnetic waves, which propagate in the negative Z direction, are reflected by the reflector in a constructive manner and in phase. These refracted waves combine with the radiated electromagnetic field and improve the overall radiation of the antenna.

Radiation pattern with LHCP and RHCP waves of the proposed patch antenna at frequency 4.4 GHz and 7.6 GHz as shown in Fig. 6.

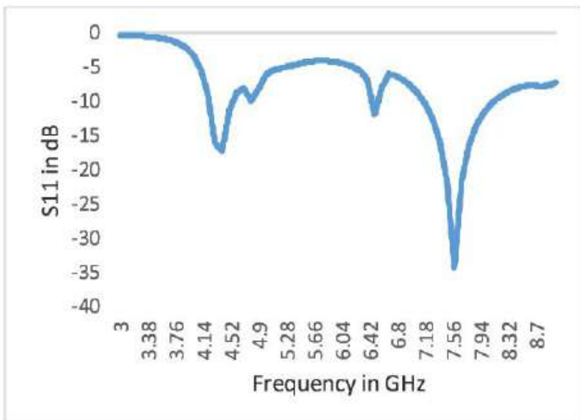

Fig.3. Simulated reflection coefficient S11

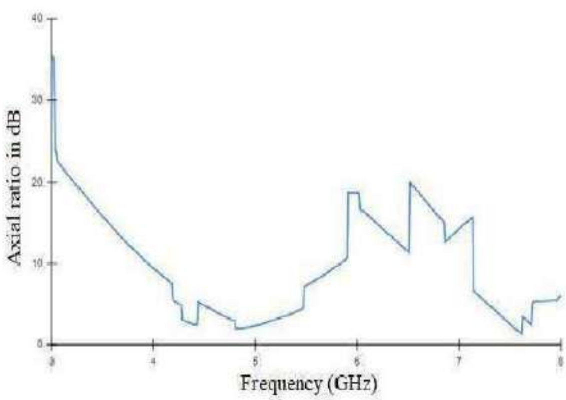

Fig.4. Axial ratio vs. frequency curve

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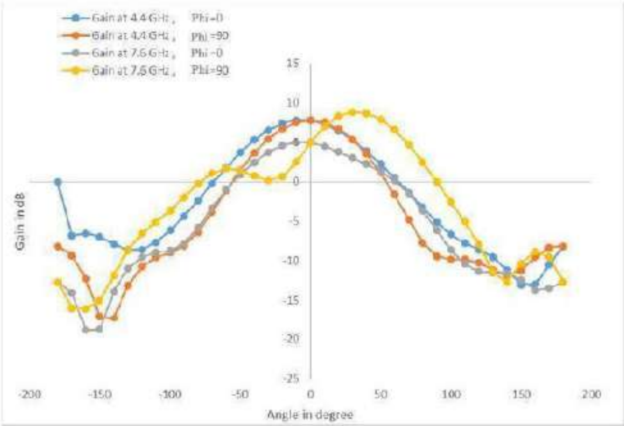

Fig.5. Gain curve at frequency 4.4GHz and 7.6GHz

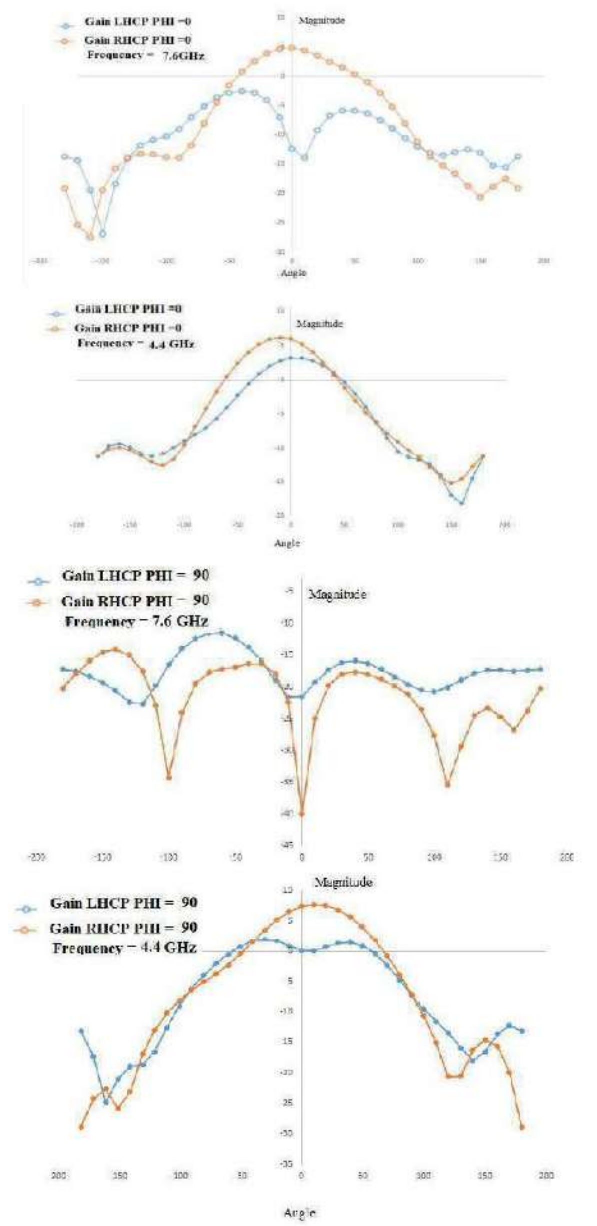

Fig.6. RHCP/LHCP Gain curve at frequency 4.4GHz and 7.6GHz

IV. CONCLUSION

In this paper, a circularly polarized monopole antenna is designed and simulated for satellite application. The maximum reflection coefficient -17.3276 dB and -34.4189 dB at 4.4 GHz and 7.6 GHz respectively obtained with corresponding bandwidth 360 MHz and 980 MHz by using split ring resonator and defected ground plane. The axial ratio of the proposed antenna is obtained less than 3 dB due to the optimization of position of micro strip feed. The maximum achievable gain is 7.7858 dB and 4.9819 dB at frequencies 4.4 GHz and 7.6 GHz obtained by using reflector. Furthermore, at both frequencies, the proposed antenna exhibits a clearly defined RHCP and LHCP radiation pattern.

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