International Journal of Research in Engineering and Science (IJRES)
ISSN (Online): 2320-9364, ISSN (Print): 2320-9356
www.ijres.org Volume 11 Issue 5 ǁ May 2023 ǁ PP. 867-871

Circularly Polarized Microstrip Patch Antenna for L Band Satellite Application

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Abstract
This paper presented a circularly polarized microstrip patch antenna designed for L band satellite applications. The antenna is constructed in a rectangular shape and the dimensions of the patch are carefully optimized to achieve resonance at the desired frequency. The High-Frequency Structure Simulator (HFSS) software is used for simulating the antenna's parameters. The antenna is resonating at 1.59 GHz with return loss -38 dB and -10dB bandwidth of the antenna is 600 MHz. The axial ratio is obtained 1.9 dB at frequency 1.59 GHz. To achieve circular polarization, a coaxial feeding technique is employed, with the coaxial feed positioned diagonally across the rectangular patch.
Keywords*: Microstrip, Resonant Frequency, Bandwidth, Axial Ratio*

Date of Submission: 18-05-2023 Date of acceptance: 31-05-2023

I. INTRODUCTION

The proposed antenna design aims to provide an efficiency and suitability for L band satellite communication systems [1,2]. A circularly polarized antenna is a type of antenna that radiates electromagnetic waves with a circular polarization [3,4,5,6]. It is widely used in various applications, such as in satellite communication, wireless communication, and radar systems. Circular polarized antennas have many advantages over linear polarized antennas, including better signal quality, higher immunity to multipath fading, and better penetration through obstacles.

Circular polarized antennas are designed to radiate electromagnetic waves in a circular polarization. Circular polarization is a type of polarization in which the electric field vector rotates around the axis of propagation in a circular pattern. Circular polarized antennas can be either right-hand circularly polarized (RHCP) or left-hand circularly polarized (LHCP). In RHCP antennas, the electric field vector rotates clockwise when viewed from the transmitter, while in LHCP antennas, the electric field vector rotates counter clockwise when viewed from the transmitter [7].

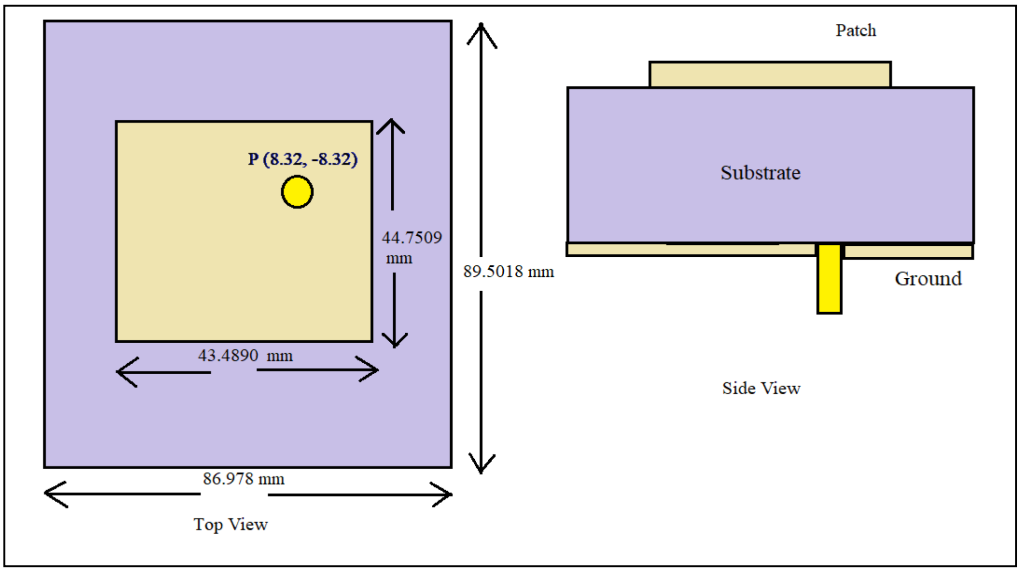
There are two main methods for producing circular polarization in antennas: by combining two linear polarized signals with a 90-degree phase shift, or by using a circularly polarized feed. In the first method, two linear polarized antennas are mounted at right angles to each other, and the signals are combined with a 90-degree phase shift to produce a circularly polarized signal. In the second method, a circularly polarized feed is used to excite the antenna, which produces a circularly polarized radiation pattern.

There are several types of circular polarized antennas, including helical antennas, patch antennas, and spiral antennas. Helical antennas are a type of antenna that consists of a wire wound in a helix shape. They are commonly used in satellite communication and GPS systems [9]. Patch antennas are a type of antenna that consists of a flat rectangular or circular patch of metal mounted on a ground plane. They are commonly used in wireless communication systems. Spiral antennas are a type of antenna that consists of a wire wound in a spiral shape. They are commonly used in radar systems and satellite communication [10].

Circular polarized antennas have many applications in various fields. In satellite communication, circular polarized antennas are used to transmit and receive signals from satellites in orbit. In wireless communication, circular polarized antennas are used in mobile phones, wireless routers, and other wireless devices to improve signal quality and reduce interference. In radar systems, circular polarized antennas are used to detect and track targets with high accuracy.

II. Geometry of the Proposed Antenna

The microstrip patch antenna is designed on an FR4 substrate with dimensions of 89.5018 mm by 86.978 mm. The microstrip rectangular patch is placed on the substrate with dimension 44.7509 mm by 43.4890 mm. In order to achieve circular polarization, a coaxial feeding technique is applied. The coaxial feed is positioned diagonally across the patch at coordinates (8.32 mm, -8.32 mm). The schematic diagram of the proposed patch antenna is shown in Figure1.



Design equation of patch antenna are as follows.

$$Patch\ length\ (L_O) = L_C + \delta = 44.750916\ mm$$
$$Patch\ width\ (W_O) = L_C - \delta = 43.489084\ mm$$
$$L_C = 44.12\ mm$$
$$\delta = 0.0143\ L_C\ mm$$
$$h = 1.6\ mm$$

III. RESULTS AND DISCUSSION

High Frequency Structure Simulator (HFSS) is a powerful electromagnetic simulation software used to design and analyze antennas, as well as other electromagnetic structures. Antenna simulation on HFSS software is widely used in the field of RF and microwave engineering. One of the key features of HFSS software is its ability to simulate complex antenna designs accurately. The software uses a finite element method (FEM) to solve Maxwell's equations numerically, which allows for the simulation of antennas with various shapes and sizes. The antenna parameters are used to characterize the performance of an antenna. The simulation of the proposed antenna design is done by using HFSS software.

A return loss versus frequency graph is used in the field of electronics and telecommunications to measure the amount of power reflected back from a device or component in a system. It helps evaluate the impedance matching and signal integrity of a system The return loss value indicates the amount of power that is reflected back from a device. Figure 2 demonstrates that the microstrip patch antenna exhibits resonance at a frequency of 1.59 GHz. At this frequency, the value of S11, which represents the reflection coefficient, is measured at -38 dB. The bandwidth of the antenna is 600 MHz at -10dB reflection coefficient.

The Voltage Standing Wave Ratio (VSWR) of the antenna is observed to be 1.66 dB at the resonant frequency of 1.59 GHz, as shown in Figure 3. These measurements and characteristics demonstrate the performance and effectiveness of the designed antenna.

The radiation curve is presented on a polar plot, where the angles represent the azimuthal plane, and the distance from the centre represents the radiation intensity or gain. Identify the Main Lobes: The main lobes are the regions where the radiation intensity is highest. These lobes indicate the directions in which the antenna radiates or receives the most power. They are often depicted as peaks or spikes on the radiation curve. In Figure 4 we can clearly see that the gain of the proposed antenna is 1.68 dB.

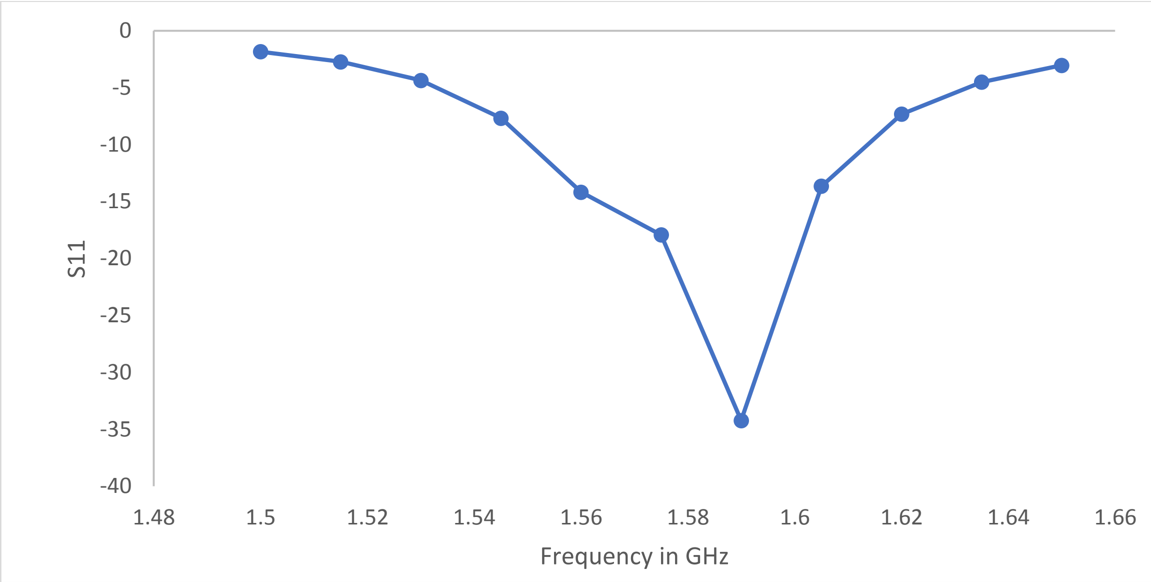


Figure 2: S11 versus Frequency curve of the proposed microstrip patch antenna

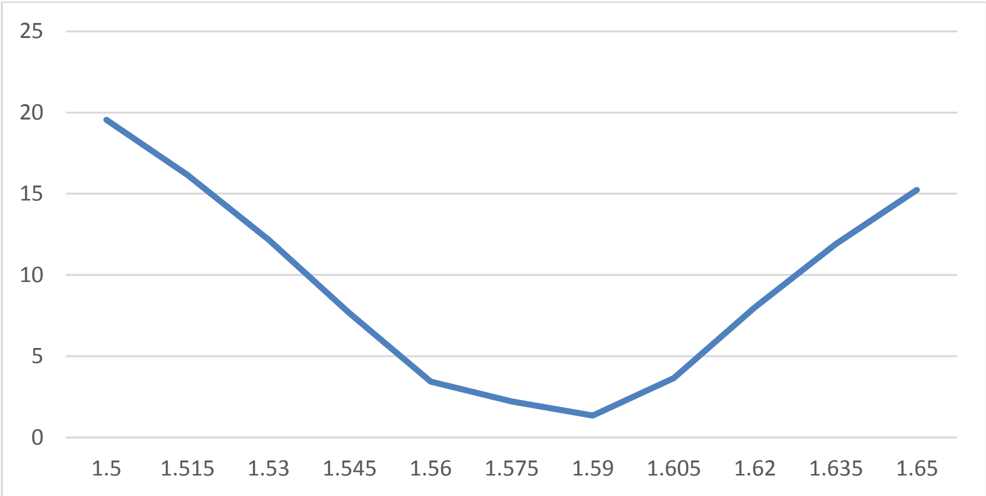


Figure 3: VSWR of the proposed microstrip patch antenna

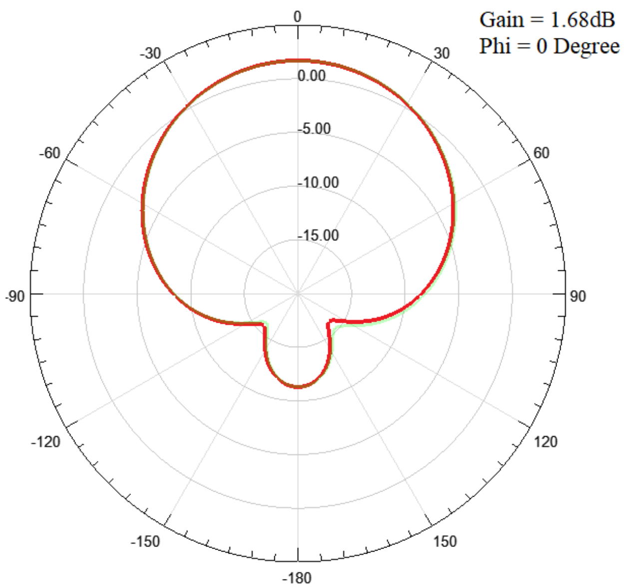


Figure 4: Radiation pattern of the proposed antenna

Figure 5 is showing the axial ratio versus frequency curve and in this figure we can see that at 1.59 GHz, its value is 1.9 dB which is less than 3dB which indicates the circular polarization of the antenna. The axial ratio versus frequency curve is a graphical representation that shows the relationship between the axial ratio and the frequency of an antenna over a specific frequency range. The axial ratio is a measure of the ellipticity or circularity of the polarization state of an antenna's radiated or received electromagnetic waves.

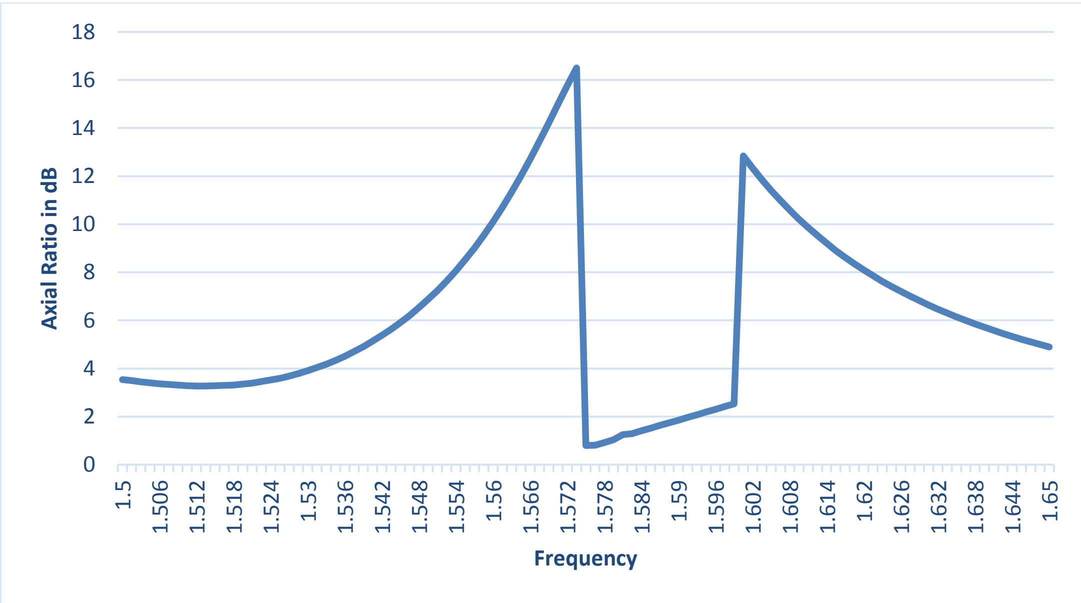
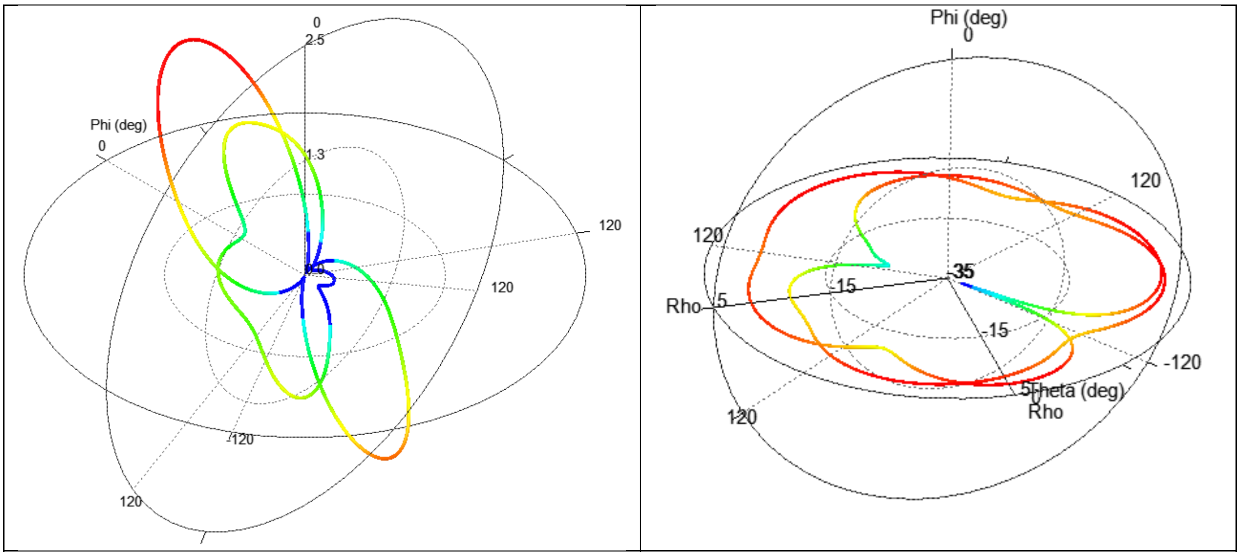


Figure 5: Axial ratio versus frequency curve



(a)Phi =0 degree	(b)Phi =90 degree

Figure 6: LHCP and RHCP curve of patch antenna at (a) Phi = 0 degree and (b) phi= 90 degree

Figure 6 presents the radiation pattern curves for Right-Hand Circular Polarization (RHCP) and Left-Hand Circular Polarization (LHCP). These curves are plotted on the polar axis. From Figure 6(b), it can be inferred that the antenna exhibits a Right-Hand Circular Polarization (RHCP) pattern. This confirms that the antenna is capable of generating and transmitting right-hand circularly polarized electromagnetic waves. The RHCP curve will have a rightward rotation, indicating the right-hand circular polarization.

LHCP and RHCP radiation curves can help in designing and selecting antennas for specific applications. For example, in satellite communication or wireless systems that utilize circular polarization, it is important to ensure that the transmitted and received signals are properly matched in terms of circular polarization. By analysing the radiation curves of LHCP and RHCP antennas, we can determine the directionality, coverage, and polarization characteristics that are suitable for your specific requirements.

IV. CONCLUSION

This Paper presented a circularly polarized microstrip patch antenna for IoT applications. The antenna was constructed in a rectangular shape, with optimized dimensions to resonant at frequency 1.59GHz. The antenna exhibited a -10 dB bandwidth of 600 MHz. Gain and VSWR of the proposed antenna was 1.68dB and 1.66dB at resonant frequency. The axial ratio was obtained 1.9 dB at frequency 1.59GHz, which is less than 3dB shows circular polarization. The proposed antenna design is useful for L band satellite link communication systems.

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