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CONCEPTION OF AN ANTENNA ARRAY FOR RECTENNA SYSTEM AT 5.80 GHz

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Abstract

This research digs into the difficult process: building and designing an outstanding performance. 2 X 2 triangular micro strip patches array with straight polarization for the specific area of microwaves energy transfer (MPT). The resulting antenna array was meticulously designed utilizing powerful CST and ADS simulation software and has a perfect operational time period of 5.8 GHz. The findings of our study emphasize the usefulness of this antennas array. It has an outstanding gain of 11.2 dB, indicating its remarkable signal amplification capability. Likewise, its return loss is extremely low, measuring around -28.67 dB, demonstrating its ability to reduce the reflection of signals and loss. At the main frequency of 5.8 GHz, the set of antennas exhibits a highly advantageous axial ratio of below 0.52 dB, demonstrating its ability to maintain signal polarization integrity. In essence, this study not only describes the unusual layout of this radio array, but also demonstrates its practical use in the area of microwave power transfer, thereby furthering the field of antennas engineering as well as technology.

Keywords: Micro Strip Antenna, MPT, UAV, Rectenna, and Patch Antenna Array.

1. INTRODUCTION

UAVs, or unmanned aerial vehicles, or Predators have sparked significant hype in the industry due to their low cost and small size. They show significant promise, particularly in messaging applications, and are commonly employed in a variety of fields, including the military, emergency rescue operations, aerial taking pictures, and others. Nonetheless, a significant disadvantage of the bulk of commercially accessible UAVs today are their reliance on power sources, leading to in a very limited flight period, commonly from between five and twenty-five a few seconds [1].

In answer to this difficulty, we propose using a wireless power transfer (WPT) technology to significantly increase the flying endurance of the UAV. WPT technology allows electromagnetic energy to be transferred from a source of electricity to an electrical load over an air gap over a long distance without the use of physical wire or connections. Multiple methods, including near-field inductive pairing, electromagnetic resonance coupling, and microwaves power transfer (MPT), can do this [2]. Among these

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possibilities, MPT appears to be the best fit for the UAV's reception portion. The MPT system is divided under three distinct phases. A microwave generator converts direct current (DC) energy into wireless power in the manner of an RF signal at first. Following that, a transmitting antenna distributes this power equally throughout open space so it reaches the receiver. Finally, a rectenna blocks the transmitted radio frequencies & converts it to usable DC power [3]. Figure 1 depicts an essential block layout of an MPT system.

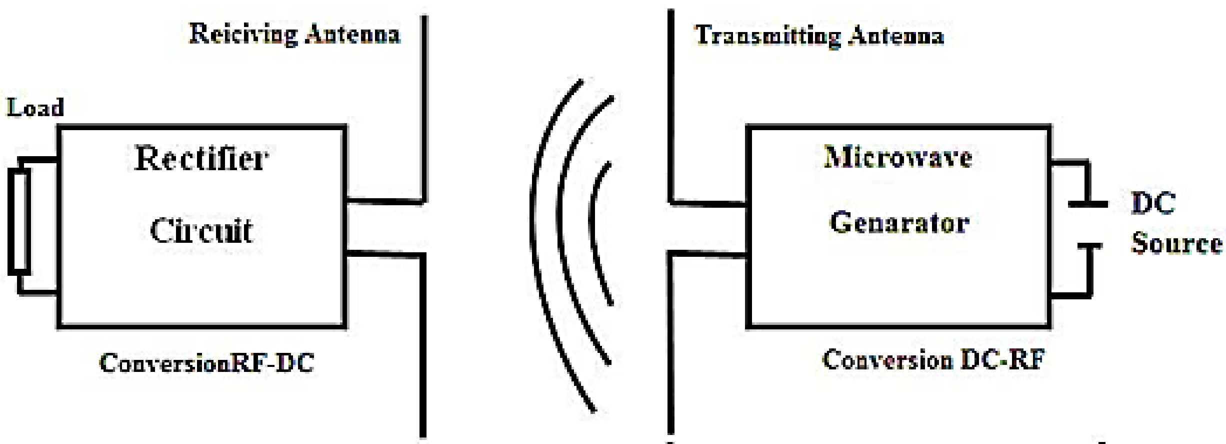

Figure 1: A MPT System is depicted as a Block Diagram

The rectenna is the central component of any RF energy collection system, consisting of two critical components: an antenna for receiving signals and a correcting circuit. The receiving antenna collects the RF signals sent by the surroundings with zeal. Following that, the rectifying circuit converts AC energy into the valuable type of DC power. Figure 2 depicts the fundamental elements of a retina circuit, emphasizing the critical role it has in transforming ambient electromagnetic radiation into practical power.

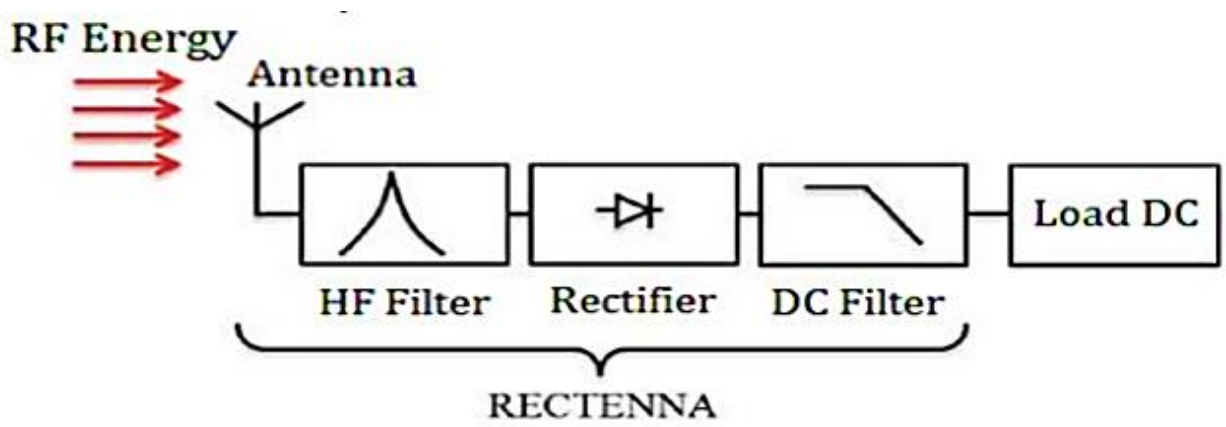

Figure 2: Rectenna General Block Diagram

Rectennas are typically made up from a transmitting antennae and a rectifier circuit [4]. Several attempts have been made to improve the performance of rectenna. There have been proposals for single-band rectennas, multiband rectennas, even internet rectennas.

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Multiband and broad rectennas are advantageous for receiving more RF energy form weak ambient sources, culminating in more converted DC electricity. However, maintaining high rates of conversion in multiband or wider rectifiers is problematic.

As a result, the present-day rectenna design issue is to gather extra electricity and then convert it to DC power. There are also many methods to achieving high antenna gain by employing receptive antenna arrays, which allow for greater amounts of energy in an inefficient power density scenario [5], and by using symmetric dipoles to realize improved rectenna performance without matching network impedance [6]. The enhanced matched impedance networks is introduced to keep greater effectiveness of conversion in more bands of frequencies in order to increase the rectifier circuit's converter efficiency.

Discusses a rectifier design with a broad dynamic range for dealing with the volatility of the ambient signal. The main objective of this effort was to attain the highest feasible conversion efficiency in dual bands of frequency [7].

This work covers the design of a micros strip antenna that incorporates many approaches, including broad technology, circular pole polarization (CP), and high achieve, with the goal of accomplishing maximal RF generation at 5.8 GHz for powering a UAV.

The creation of an antenna in Rectenna systems poses one of the most difficult challenges to tackle, as Rectenna systems require an antennas with a sufficiently wide operational range and high-gain irradiation with a circular polarization in a restricted volume and compact dimensions [8].

Several types of rectenna have recently been described in the scientific community, including linear [9] and cyclic polarization, in addition to different arrangements. The antenna's layout is being deeply studied in order to boost gain and efficiency, boost power efficiency, and lower the transmission loss of a rectenna systems. Circularly polarizing CP antennas have become key characteristics in rectenna architecture because they may improve collected ambient signals and assure continuous power transfer free of UAV yaw. It enables practically continuous DC output even when both the sending and receiving antennas shift angles in space. There are several documents in literature that investigate different options for producing CP micros trip antennas. To construct micros trip antennas, numerous techniques such as cut off corners, stubs to dents, slits, and slots incorporated in the antennas were published.

This work offers a micro strip antenna design that integrates multiple approaches, including broad band technological advances, circle polarization (CP), and high gain, to receive the highest power for RF exploitation for powering a UAV at 5.8 GHz.

2. ANTENNA DESIGN

The proposed design is based on a basic cube antenna with two slots placed in the middle for circular polarization. A 1.6 mm high FR4-epoxy surface with a dielectric strength of 4.4 was used for implementing the layout [10]. Figure 3 depicts the architecture of the projected antennas.

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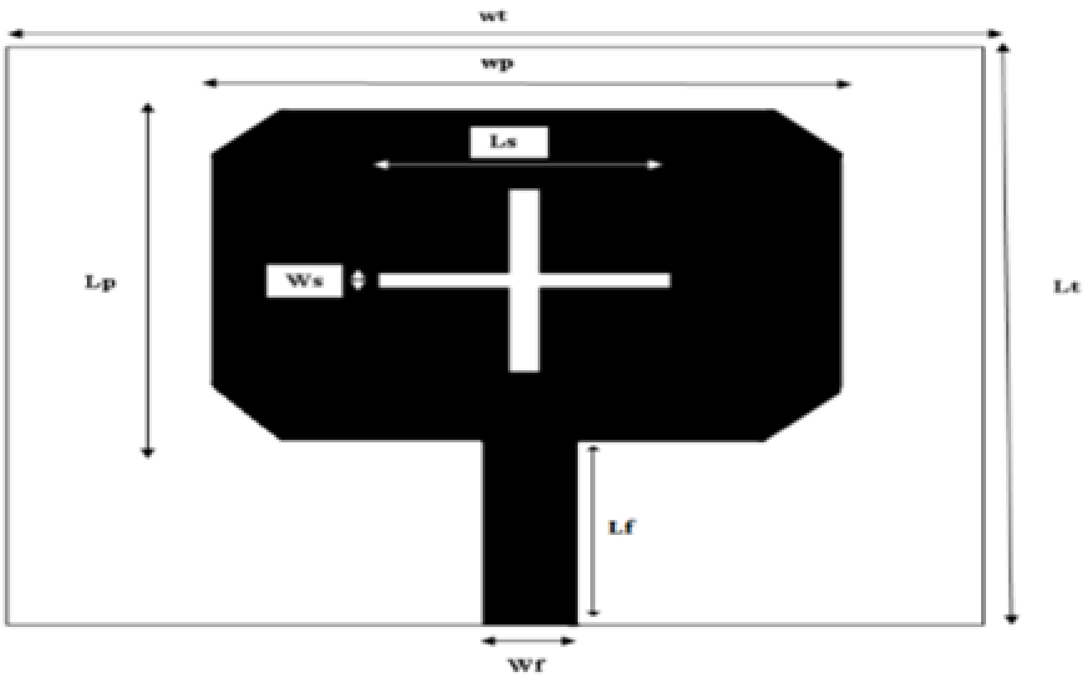

Figure 3: The Single CP Antenna's Geometry

2.1 Design and Measurement of Antenna Arrays

Using the recommended antenna, we make a 4-element antenna arrangement to enhance gain & thus efficiency of conversion. Figure 4 depicts the an-tenant array configuration. It consists of two periodic arrays [11]. The me-angered line feeds and end lines are adjusted for the two subarray portions to have identical time and volume readings. A Wilkinson electricity divider supplies lighting to the entire system.

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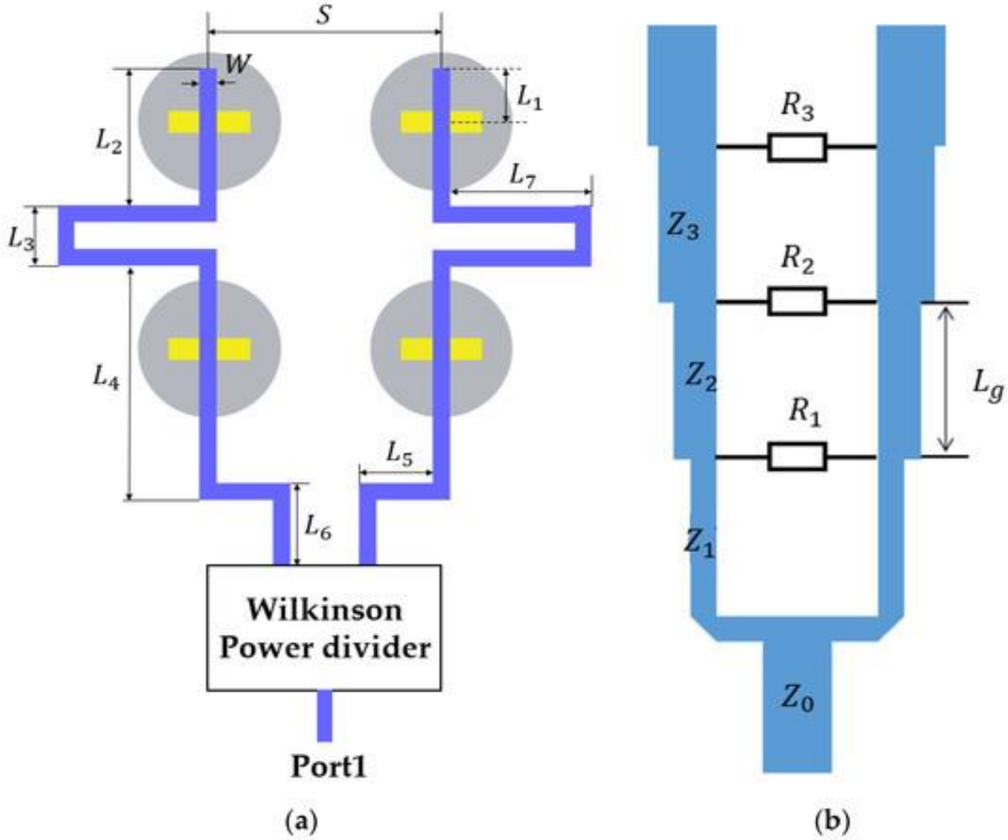

Figure 4: Architecture of the Proposed DRA Array: (a) Feeders Line Configuration; (b) Wilkinson Power Divider Configuration

2.2.1 Rectenna Display Performance

The receiver station and the resolving loop comprise the rectifying antenna. Pr is the received input power of the antenna; Pr may be determined using the Friis transfer method:

$$P_r = \frac{\lambda^2}{4\pi r} P_t G_t G_{r,}$$

In the current research, is the wavelength of the operating frequency, r is the distance between the broadcasting antenna and the desired DRA array, whereas Pt is the mode for transferring power. Gt is the transmitting antennas gain, whereas Gr denotes the projected DRA array gain [12].

Table 2 displays the derived results. At 2.45 GHz, the suggested rectenna has a rate of conversion effectiveness of 47.7% and at 5.8 GHz, it has a conversion quality of 40.3%. The results imply that the planned eye can efficiently catch RF ultraviolet (UV) The efficiency of the conversion process decreases as the rectifier's capacity increases. This could have been due to two distinct sources [13].

On the one hand, transmission power measurement errors may occur due to power probe error. On the other hand, the DRA array and converting circuit are integrated on different dielectrics; the RF adapter that links the planned DRA device that the rectifier's circuit displays parasitic behavior [14].

Table 1: The Outcomes of Retinal Evaluations of Performance

F(GHz)	G_t(dBi)	G_t(dBi)	r	V_{DC}(V)	Efficiency (%)
2.58	9.5	5.6	4	3.09	49.6
8.6	8.9	15.6	3	39.6	49.6

Table 1 combines a few recently published retinas with the recommended retina to demonstrate the benefits of the suggested design [15]. At 5.8 GHz, our design offers a greater gain. Because of the innovative IRS-loaded matched of impedance network, our rectifier's RF-DC conversion effectiveness is far greater than that of previous dual-band gadgets.

3. LITERATURE REVIEW

In this examination, a two-and four-component straight game plan of capacitive matched miniature strip fix recieving wires for 5.8 GHz energy move applications are given [16]. At first, a 5 GHz matched rectifier with a greatest result voltage of 1.54 V over a 1.8 k burden and 4 dBm power from the information was fabricated. The determined ideal still up in the air to be 52.70%.

The elements of an extraordinary stacked differential rectenna are inspected tentatively in this correspondence [17]. In view of its differential working, the proposed rectenna can really change over RF capacity to dc. At the point when the energy that was gotten thickness is all around as low as 0.041 W/m 2, the change effectiveness was 44.1%. Utilizing its essential structure, the suggested rectenna can promptly accomplish enormous scope rectenna clusters. When contrasted with a solitary rectenna, a retractable exhibit with DC hookup gives about a similar proficiency of transformation and rate point highlights.

In this review, a hexagonal-molded Nano strip-fix radio wire with a fundamental development has been intended for remote energy move [18]. Fake chromatic hosing has been accomplished in this suggested superstructure by utilizing an H-molded space, a deficient ground structure (DGS), and an open stub. Deceptive frequencies have been smothered the whole way to the fourth consonant. The created radio wire has a little aspect, a utilitarian recurrence of 5.8 GHz, a 10 dB return misfortune data transmission for impedance of 5.48-6.08 GHz (10.38%), a mimicked gain of 3.8 dB, and a radiation proficiency of above 79%. This radio wire is profoundly appropriate for transmission of energy by means of remote frameworks because of its useful elements.

This paper depicts a recurrence determination surface (FSS) and rectenna cross breed design for remote energy collecting [19]. Keeping that in mind, the first FSS construction's middle fills in as a test took care of fix radio wire, and an additional layer was added to the back piece of the FSS design to emulate the required radio wire ground plane while restricting its impact on FSS exhibitions. The proposed cross breed arrangement gives a

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bandpass recurrence reaction at the GSM 900-MHz recurrence bunch, with band reject reaction at 2.4 GHz, while likewise going about as an energy collecting framework by means of the receiving wire segment at the 2.4-GHz ISM band, for instance, for reusing coincidental Wi-Fi energy.

RF power harvesting allows for regulated and synchronized wireless power transmission to an extensive range of RF devices [20]. Devices constructed with this innovative technology may be sealed, incorporated into buildings, or made transportable, reducing the need for a battery. The "rectenna," which is made up of antennas and detecting circuitry that transforms RF energy into direct current (DC) electricity, is a critical component of this technology. Rectenna was able to achieve the highest electromagnetic to direct present (mw-dc) efficiency of conversion under three steady conditions: functioning the rate, input microwave voltage, and load.

4. ARRAY ANTENNA DESIGN

Following the development and computational modeling of the performance of only one patch element, the next step was to improve the suggested Rectenna system by developing an array of antennas with two components. Figure 5 depicts the antenna array's geometry. To correctly connect the two parts, a Williamson divider was used, that included a 50-ohm line of sight, a /4 transformers (70.7), plus another 50 line [21].

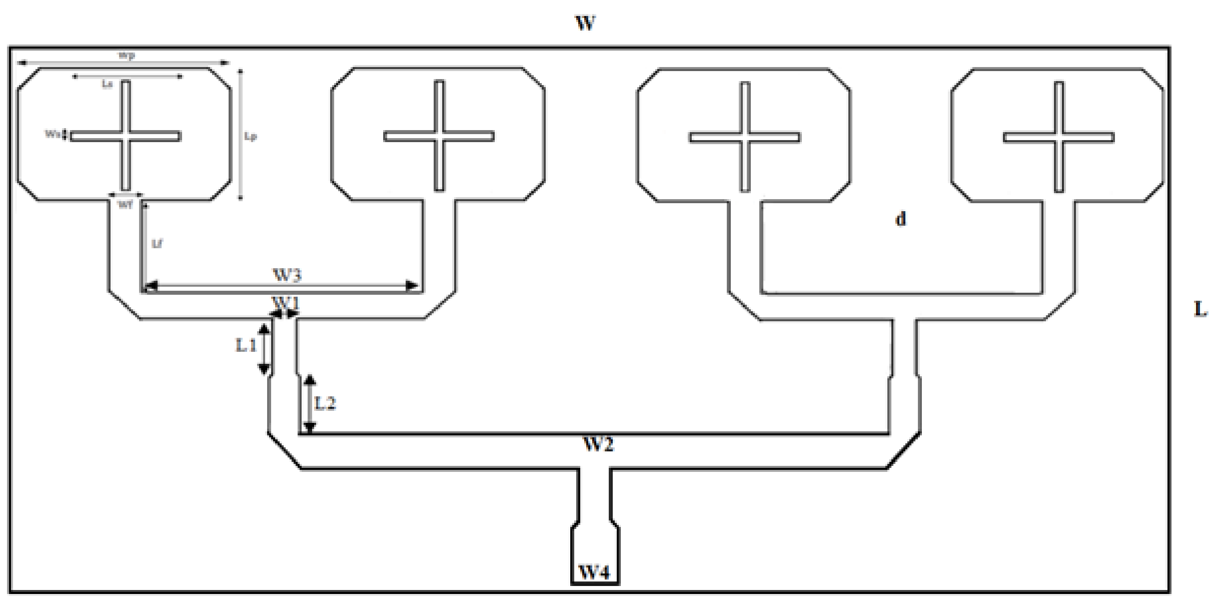

Figure 5: Structure of a Projected 2 x 2 Antenna Array

The different determined variables of the square patched antenna array are shown in Table.2 below.

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Table 2: The Receiving Antenna Array's Parameters have been optimized

Parameters	Value(mm)	Parameters	Value(mm)
L	43.7	W	60.5
L1	6.5	W1	1.6
W2	3.2	L2	6.5
W4	6.4	Wp	10
Lp	8	Wf	3
Lf	12.33	Ls	6
Ws	0.6	d	13.5

The suggested antenna array's functionality was tested using characteristics such as return reduction, axial proportion, antenna irradiation productivity, and directivity. It was discovered that the patch diameter, [22] space between regions, feed networks used for element matching, and slot size all had a substantial effect on the performances at the frequency of the resonant.

5. RESULT AND DISCUSSION

To obtain best performance, the antenna array settings were tuned using CST MWS software. Table 1 shows the optimum values for this investigation.

Figure 6 displays the simulated loss of return (S11) of the antenna array. The design that has been suggested has a clear spectrum spanning 1920 MHz (from 4.6 GHz to 6.52 GHz) and an output loss of -28.67 dB over the operating frequency (5.8 GHz).

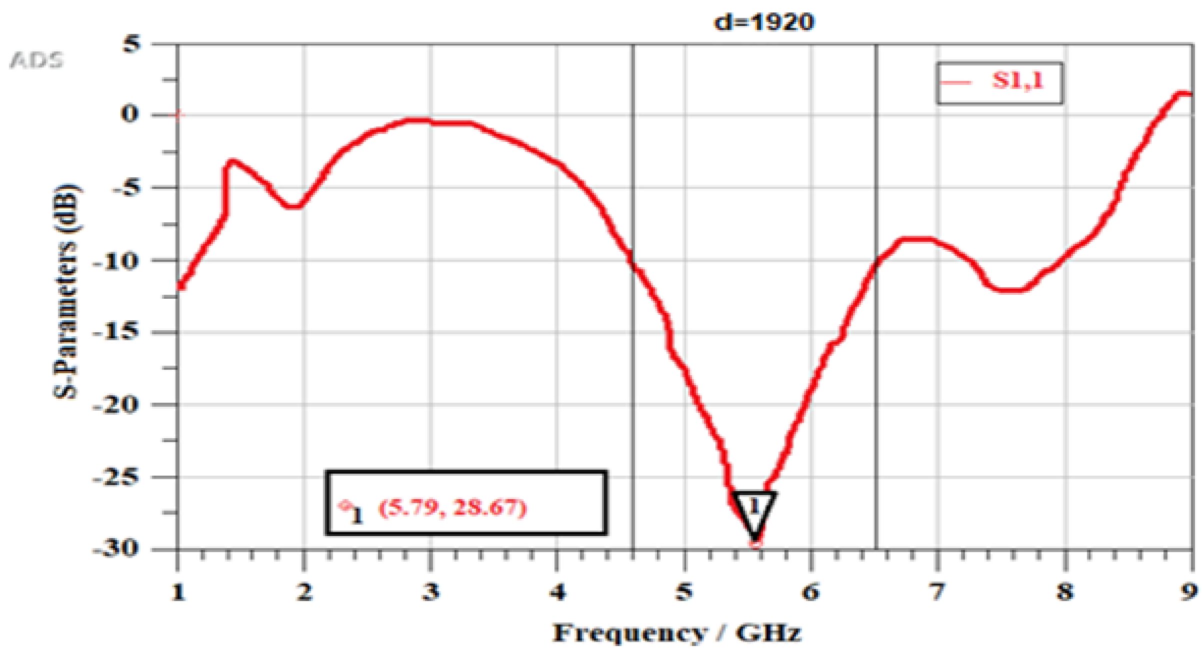

Figure 6: The Planned Antenna Arrays Calculated Return Loss

Circularly Polarised (CP) antenna have grown in popularity as a means of improving power reception and reducing Inter-Symbol Noise in systems for wireless communication. Figure 7 depicts the AR variation in terms of frequency. The findings show that the

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recommended antenna array has a broad AR connectivity, with an AR of less than 1 dB above its operational frequency (5.8 GHz).

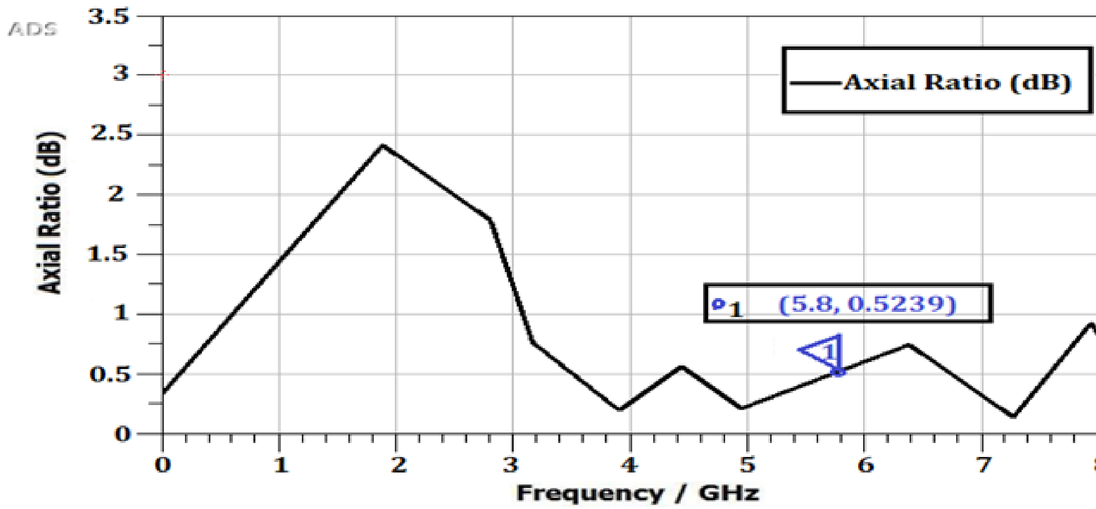

Figure 7: The Proposed 2X2 CP Antennas Array's Simulated Axial Ratio

The electromagnetic spectrum of the antenna is an image of the antenna array's radiation properties. Figure 8 depicts the 3D radiation map for the intended antenna array. The results obviously show that the suggested structure provides a concentrated radiation structure in a certain direction, that has a directivity of 11.3 dB at an effective frequency of 5.8 GHz.

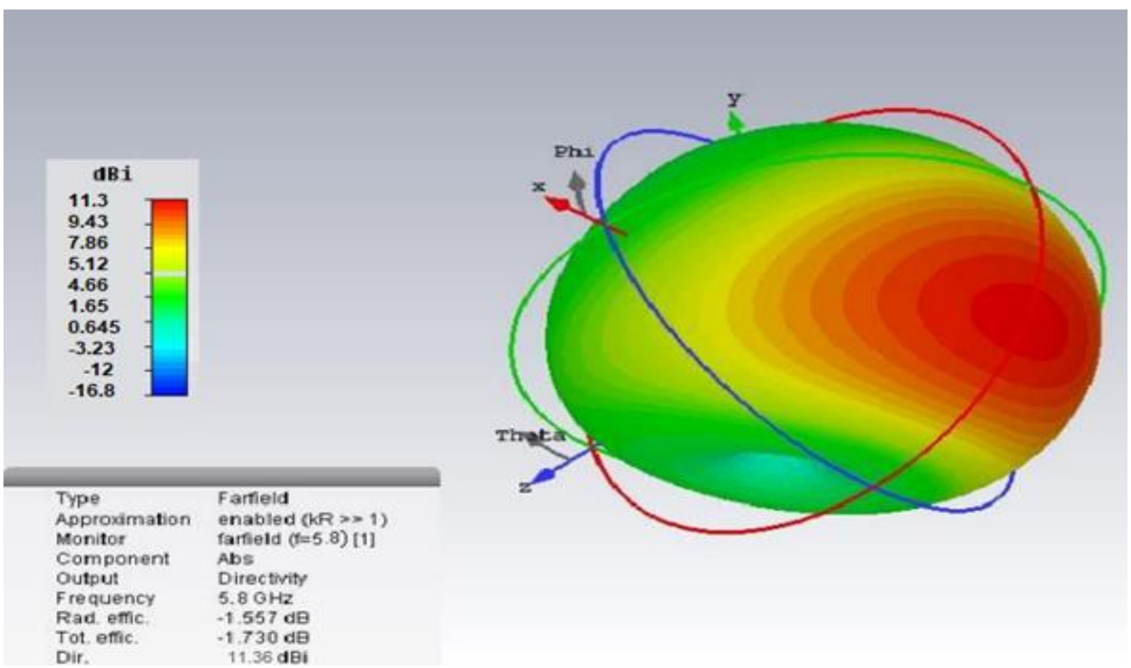

Figure 8: At 5.8GHz, the Suggested Design's 3D Radiation Pattern

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The gain has a significant influence on both the top power restriction and the range of possibilities. Figure 9 depicts the gain fluctuation as an indication of frequency for the proposed antenna array. The measurements definitely show that the antenna has a peak gain more than 11.2 dB over the specified operation frequency.

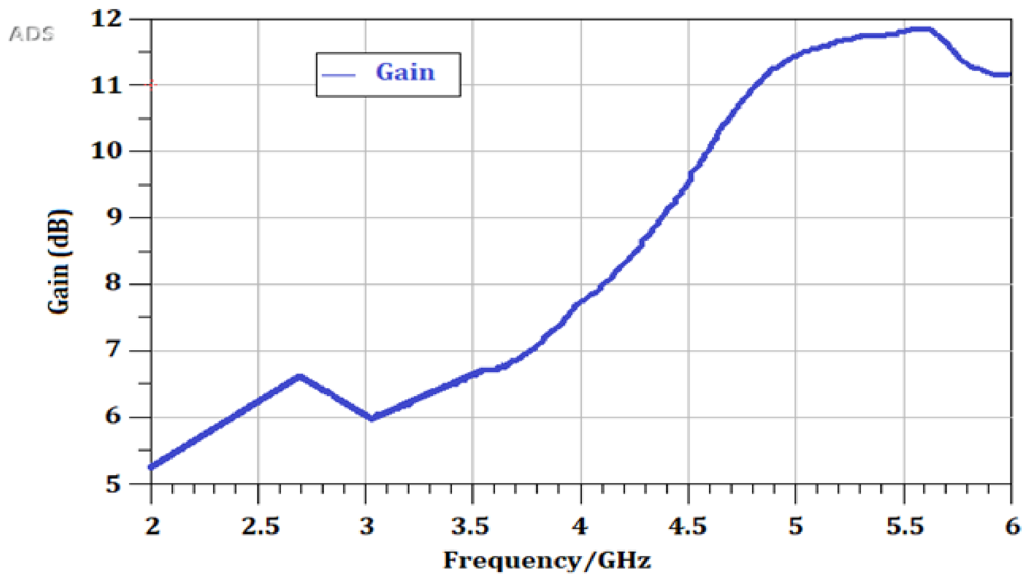

Figure 9: The Suggested Array's Gain versus Frequency Graph Antenna

To select the optimal slot dimension, we conducted a parametric analysis to examine the impact of the slot width (Ws) on the axial ratio and the gain. Figure 10 and Figure 11 illustrate respectively the the Axial Ratio (AR), and the gain versus frequency showcasing how those parameters vary with different values of the slot width (Ws).

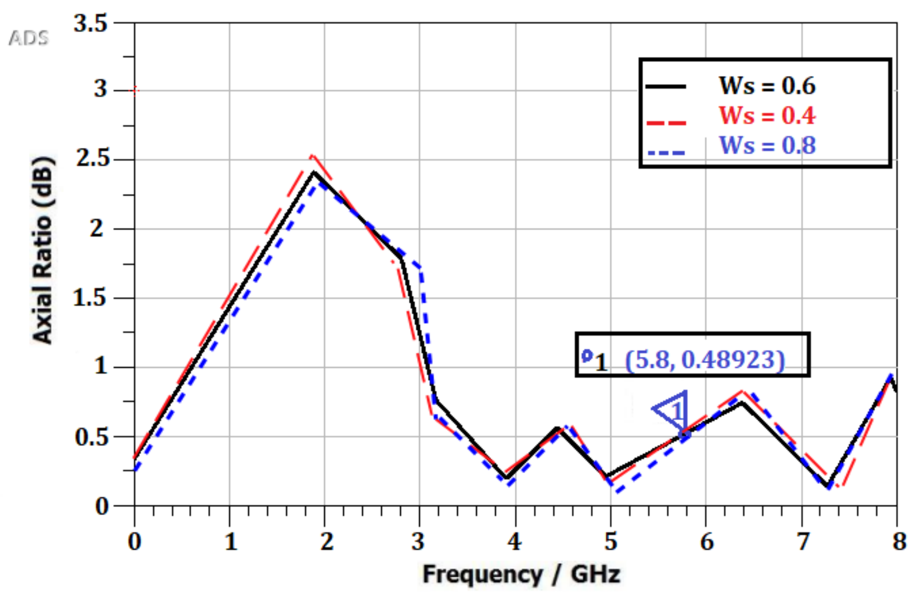

Figure 10: The Effect on Axial Ratio for Different Slot width Ws

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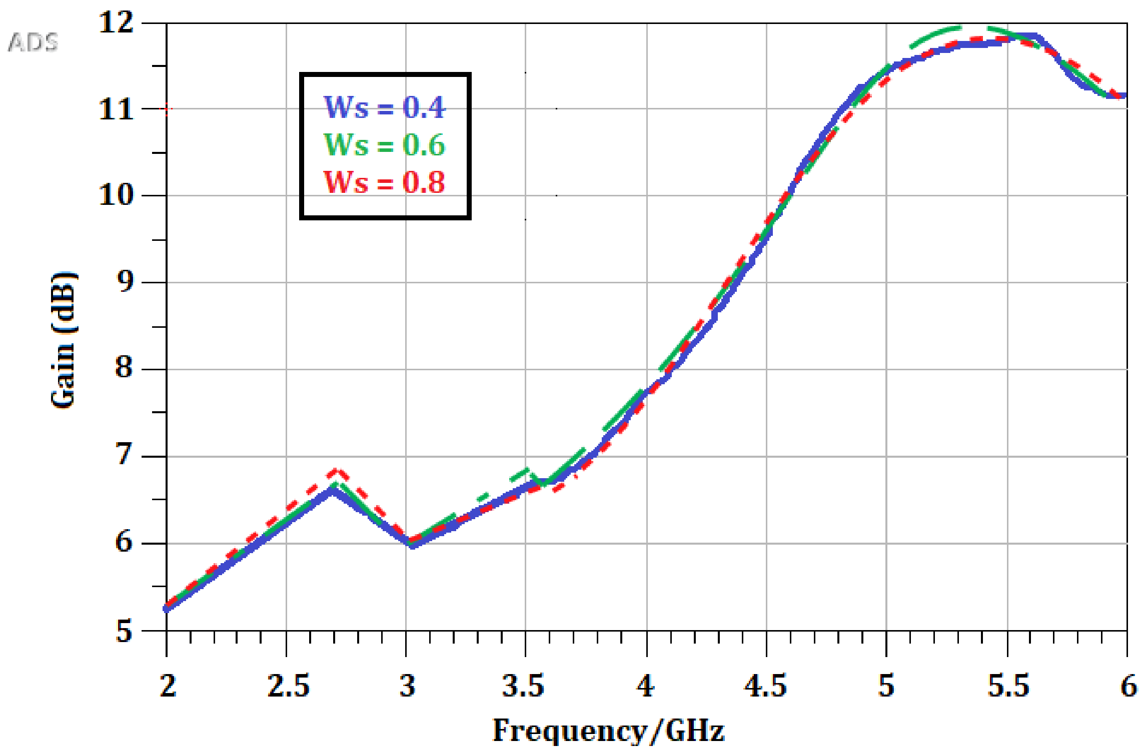

Figure 11: The Effect on Gain for Different slot width Ws

From these figures, we can see that as we increase Ws the axial ratio decreases and the gain increases at the operating frequency.

6. CONCLUSION

This research describes a novel circle-polarization (CP) antennae array that was built and modelled for wireless power delivery to a 5.8 GHz UAV. The simulation was conducted out utilising CST MWS software, and its outcomes were positive. The proposed antenna array has beneficial properties such as an extended bandwidth of 1920 MHz having a loss of return of less than -28.67dB, a peak gain greater than 11.2 dB, and a broad axial ratios (AR) frequency. These outstanding results place the suggested structure as a viable choice for inclusion into the Rectenna framework, hence increasing the effectiveness of RF-DC power transformation at the Rectenna's input.

As a consequence, additional investigation into the manufacture and testing of this early model is possible.

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