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DESIGN AND ANALYSIS OF SRR FILLED MICROSTRIP PATCH ANTENNA FOR 7.36 GHZ FREQUENCY

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ABSTRACT:
This research paper presents the design, simulation, and analysis of a square Ring Resonator (SRR) of 9.6Ghz loaded microstrip patch antenna operating at a frequency of 7.36GHz. The SRR structure is integrated into the antenna design to enhance its performance characteristics, including impedance bandwidth, radiation efficiency, and gain. The antenna's performance metrics are evaluated using electromagnetic simulation software, and the results demonstrate the effectiveness of the SRR loading technique in improving the antenna's performance at the desired frequency.

1.INTRODUCTION:

Microstrip patch antennas have gained significant attention due to their low profile, lightweight, and ease of integration into modern communication systems. However, conventional microstrip patch antennas often exhibit limited bandwidth and efficiency, especially at higher frequencies. To address these limitations, various techniques, such as metamaterial loading, have been explored to enhance the antenna's performance.Previous research on microstrip patch antennas and metamaterial-loaded antennas is reviewed to provide insight into existing techniques and their effectiveness in improving antenna performance. The role of SRRs in enhancing antenna characteristics, such as bandwidth and radiation efficiency, is discussed, highlighting their potential in microstrip patch antenna design.

2. ANTENNA DESIGN:

The proposed SRR loaded microstrip patch antenna design is presented in detail, including the dimensions, substrate **(fr-4 lossy)** properties, and feeding mechanism. The integration of the SRR structure into the antenna's ground plane is described, along with the reason behind its placement and dimensions. The proposed table shows the dimension of the antenna with a half rectangular cut on its surface.

S.No	Parameters	Value
1	Width of ground Gw	24.56mm
2	Length of ground Gl	17.98mm
3	Width of substrate Ws	24.56mm
4	Length of substrate Ls	17.98mm
5	Width of patch Pw	12.89mm
6	Length of patch Pl	8.99mm
7	Width of feed strip Sw	3.11mm
8	Length of feed strip Sl	7.95mm
9	La	2.9mm

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10	Wa	3.8mm
11	Wb	0.2mm
12	Wc	3.4mm
13	Wd	6.22mm

The antenna design without incorporation of half rectangular cut on the surface of patch is shown in fig 1.

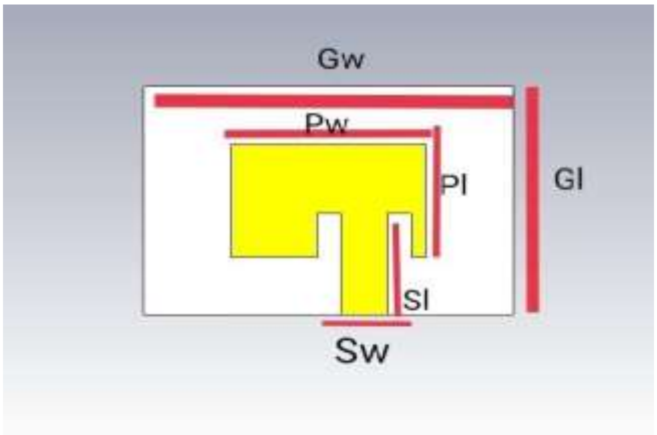

Fig1.rectangular patch antenna without hal rectangular cut

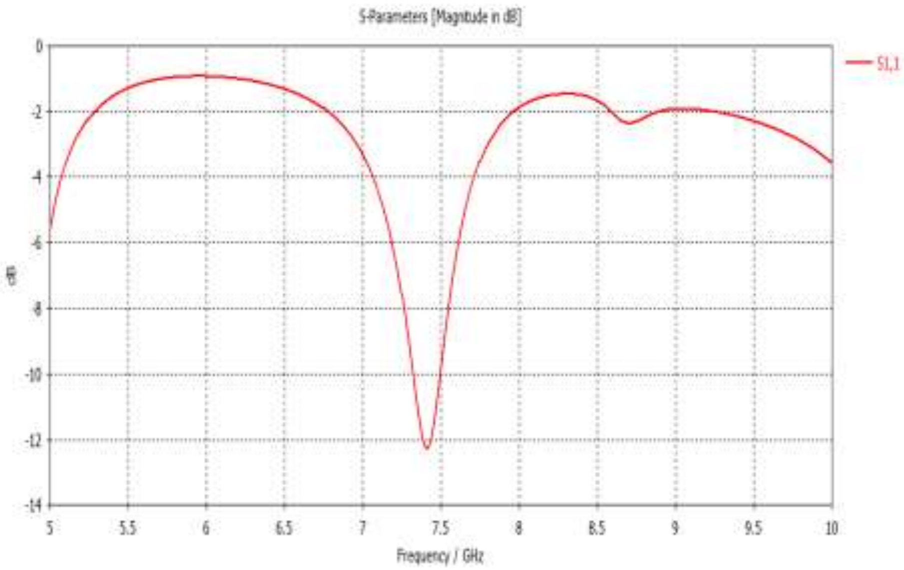

Figure2 of s parameter

Incorporation of Half rectangular cut on the surface of patch antenna.

The advantages of incorporating a half-rectangular cut on a patch antenna operating at 7.36 GHz frequency include:

1. ****Bandwidth Enhancement**** ** The half-rectangular cut can help improve the impedance matching of the antenna, thereby widening its bandwidth. This enhancement allows the antenna to operate over a broader range of frequencies around 7.36 GHz, resulting in increased versatility and flexibility in communication systems.

2. ****Reduced Cross-Polarization**:** The half-rectangular cut can help minimize cross-polarization levels, thereby improving the antenna's radiation characteristics. This reduction in cross-polarization can lead to better antenna performance in terms of signal purity and reliability, especially in applications where polarization mismatch is critical.

3. ****Improved Radiation Pattern:**** By carefully designing the shape and dimensions of the half-rectangular cut, it is possible to tailor the radiation pattern of the antenna. This customization can result in improved directivity, gain, and coverage characteristics, making the antenna suitable for specific application requirements, such as point-to-point communication or satellite tracking.

4. ****Enhanced Front To Back Ratio**:** The introduction of a half-rectangular cut can contribute to a higher front-to-back ratio for the antenna. This improvement allows for better discrimination between desired signals and unwanted interference or noise from the rear direction, leading to improved signal reception and transmission quality.

5. **Simplified Feeding Mechanism:** The half-rectangular cut can serve as a convenient location for the antenna's feed point, simplifying the feeding mechanism and reducing impedance matching challenges. This simplified design can lead to easier integration of the antenna into communication systems and lower manufacturing costs.

Overall, the incorporation of a half-rectangular cut on a patch antenna at 7.36GHz frequency offers several advantages, including bandwidth enhancement, reduced cross-polarization, improved radiation pattern, enhanced front-to-back ratio, and simplified feeding mechanism, making it a desirable choice for various wireless communication figure 3 show the after incorporating half rectangular cut on its surface.

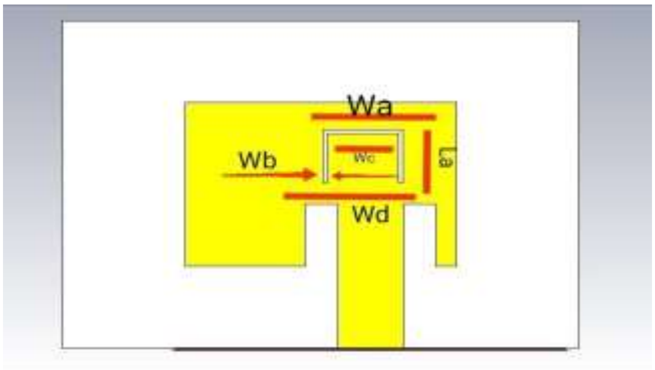

Figure 3 patch antenna with half rectangular cut

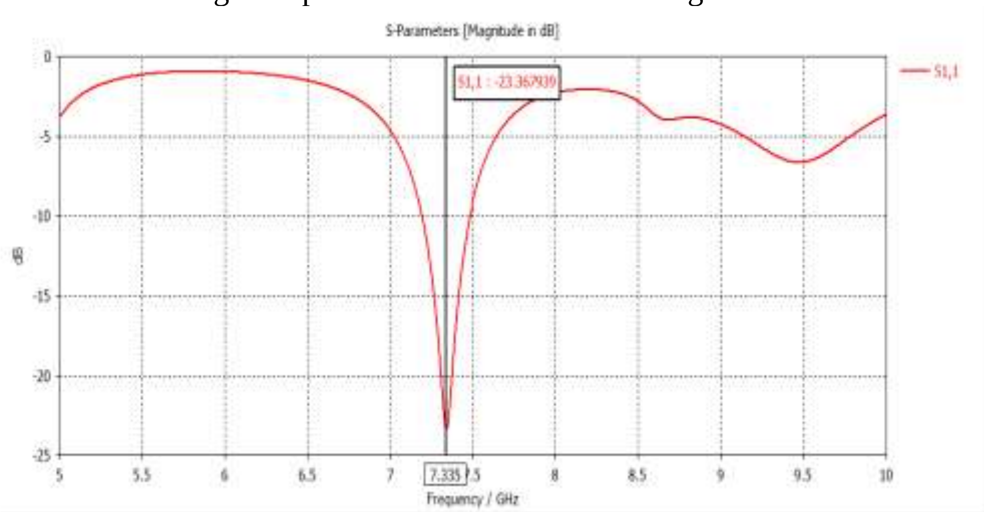

Figure 4 s parameter of antenna with half rectangular cut

3. SRR (SQUARE RING RESONATOR)

The term "SRR metamaterial" refers to a specific type of metamaterial structure known as a Split Ring Resonator (SRR). SRRs are one of the most widely studied and utilized metamaterial structures due to their ability to exhibit unique electromagnetic properties.

4.WORKING OF SRR METAMATERIAL*:*

1.Geometric Structure*:* An SRR consists of a metallic ring split into two halves, with a small gap in between. The dimensions of the ring and the gap are typically much smaller than the wavelength of the incident electromagnetic waves.
2.Resonant Behavior*:* At certain frequencies, usually in the microwave or terahertz range, the SRR structure exhibits strong resonant behavior. This resonance arises from the interaction between the incident electromagnetic field and the induced electric and magnetic currents within the SRR.
3.Negative Permeability*:* One of the most significant properties of SRR metamaterials is their ability to exhibit negative permeability in certain frequency ranges. This means that the effective magnetic permeability of the metamaterial is negative, leading to unusual electromagnetic phenomena such as negative refraction and backward-wave propagation.
4.Applications: SRR metamaterials have a wide range of applications, including antennas, absorbers, cloaking devices, and superlenses. By exploiting their unique electromagnetic properties, SRR metamaterials enable novel functionalities not attainable with natural materials, such as subwavelength imaging, electromagnetic cloaking, and enhanced sensing capabilities.

5.GEOMETRIC STRUCTURE OF SRR

The proposed structure of SRR in figure5 in this paper consists of a substrate of length 2.50mm width of the substrate is 2.50mm the substrate is made up of **Fr-4(lossy)** with the thickness of 0.25mm the proposed structure consists of two rings of copper (**pure)** the length of the copper ring1 is 2.0mm and the width of copper ring1 is 2.2mm the length of ring2 is 1.50mm the width of ring2 is 1.30mm it consists of two cuts of width 0.3mm on ring1 and ring2 for capacitance effect and a stripline made up of copper of width 1.228mm is applied on the substrate.

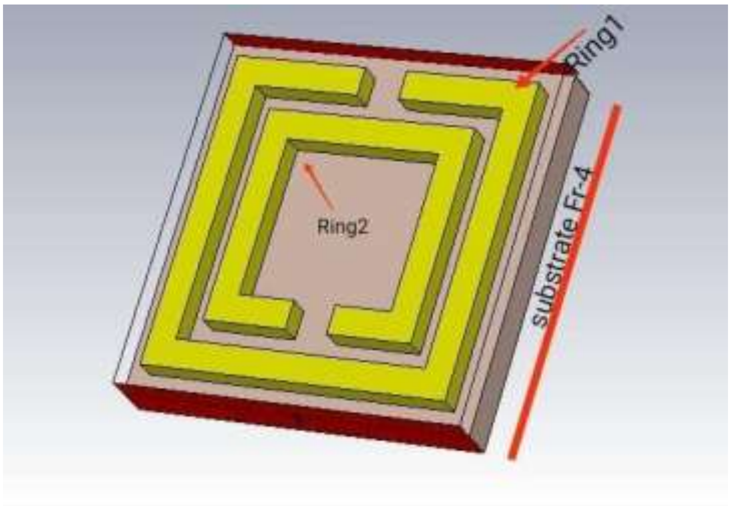

Figure5 shows the structure of SRR

6. SIMULATION RESULT

After the simulation of the patch antenna with srr the results including **Return loss,Gain, Bandwidth,VSWR, Directivity** are obtained and shown below:

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RETURN LOSS

The return loss of an antenna is a measure of the efficiency with which the antenna radiates electromagnetic energy. It is expressed as a ratio, typically in decibels (dB), and represents the amount of power that is reflected back towards the source compared to the power that is incident on the antenna. A high return loss indicates that most of the incident power is radiated away from the antenna, while a low return loss suggests that a significant portion of the power is reflected back towards the transmitter.

A return loss of -44.25db indicates Excellent Impedance Matching: A return loss of -44.25 dB corresponds to a reflection coefficient of approximately 0.0004, indicating an extremely low level of reflection. This suggests that the impedance of the antenna closely matches that of the transmission line or system, leading to minimal power loss due to impedance mismatch.

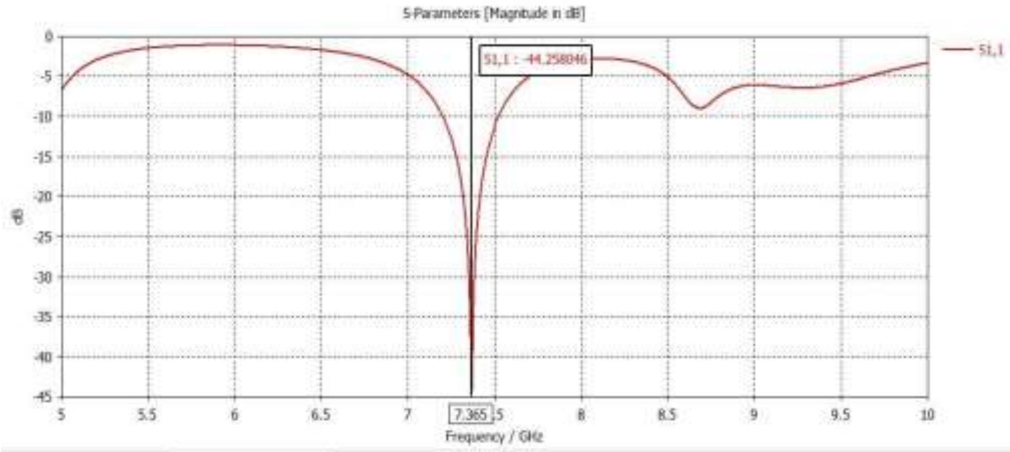

Figure6

B. GAIN

The lower the gain of the antenna it provides better signal quality and coverage.

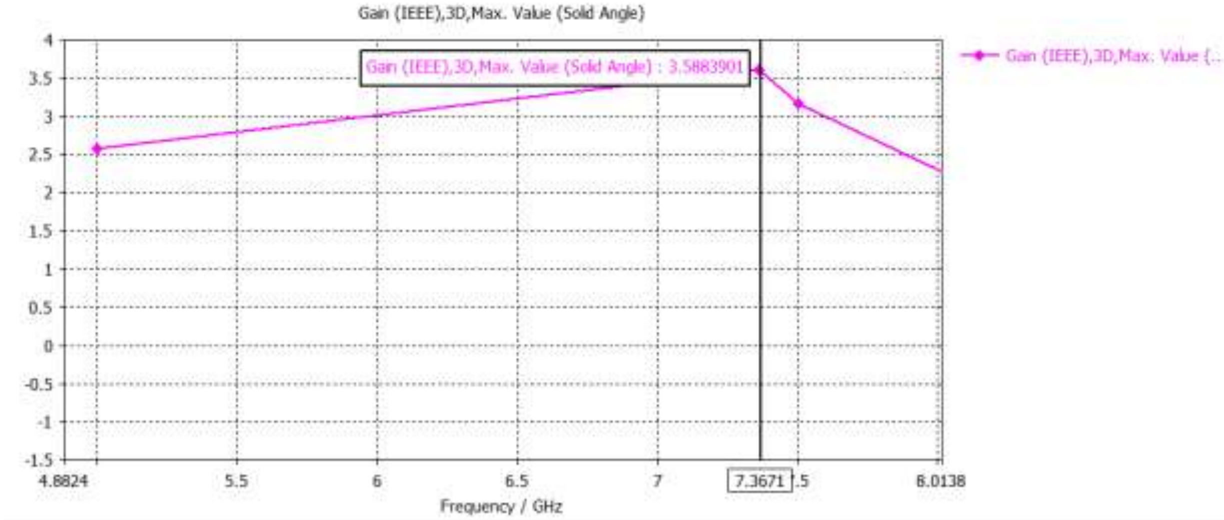

Figure7

C. BANDWIDTH

The bandwidth of an antenna refers to the range of frequency over which the antenna can efficiently transmit or receive signals.

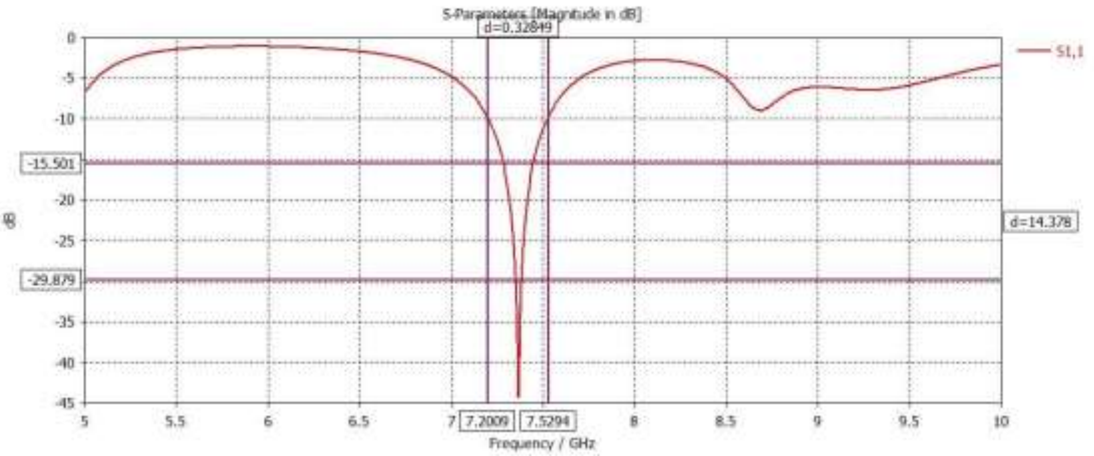

Figure8

D. DIRECTIVITY

Directivity is a measure of how well an antenna focuses its radiation in a particular direction. It quantifies the ability of an antenna to concentrate electromagnetic energy in a specific direction relative to an ideal isotropic radiator. Directivity is a key parameter in antenna design and is often used to characterize the antenna's performance in terms of its ability to transmit or receive signals in a desired direction.

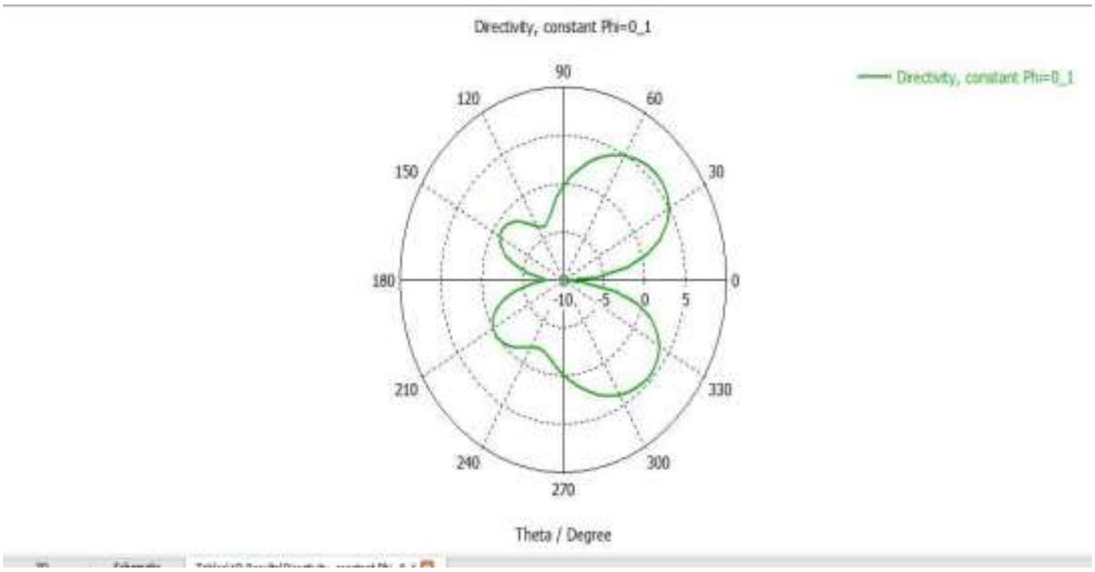

Figure9. shows the directivity of antenna at phi=0

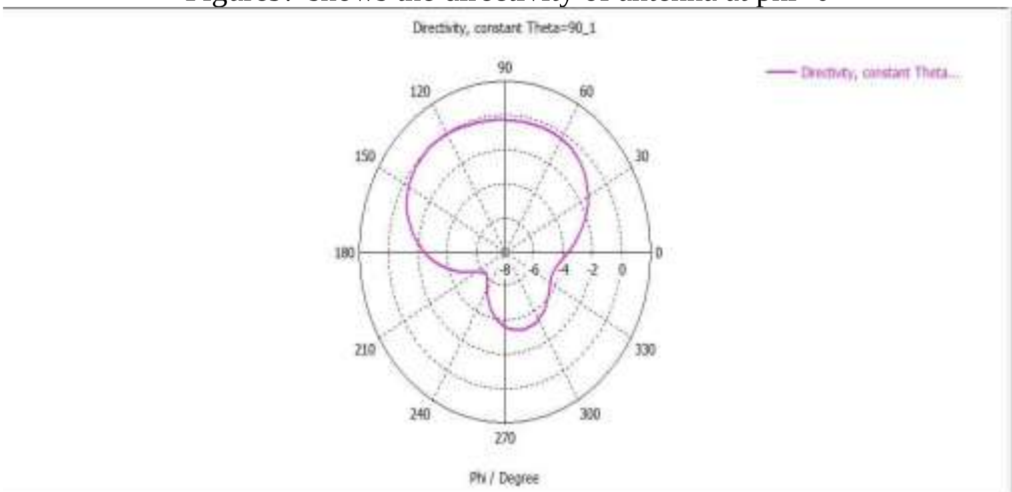

Figure10 shows the directivity of antenna at theta=90

E. EFFICIENCY

The efficiency of an antenna refers to its ability to convert input electrical power into radiated electromagnetic energy effectively. It quantifies the ratio of the radiated power to the input power supplied to the antenna and is a crucial parameter in antenna design, as it directly affects the antenna's performance and effectiveness in transmitting or receiving signals.

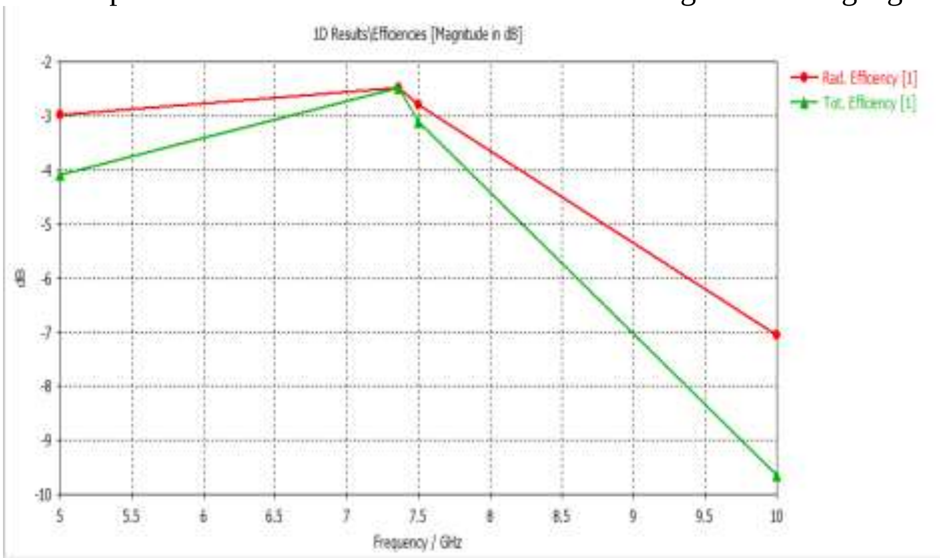

figure11

F. VSWR

VSWR stands for Voltage Standing Wave Ratio, and it is a measure of how well an antenna is matched to the transmission line or system it is connected to. It quantifies the amount of power that is reflected back towards the source compared to the power that is transmitted into the load.VSWR is defined as the ratio of the maximum voltage to the minimum voltage along a transmission line.

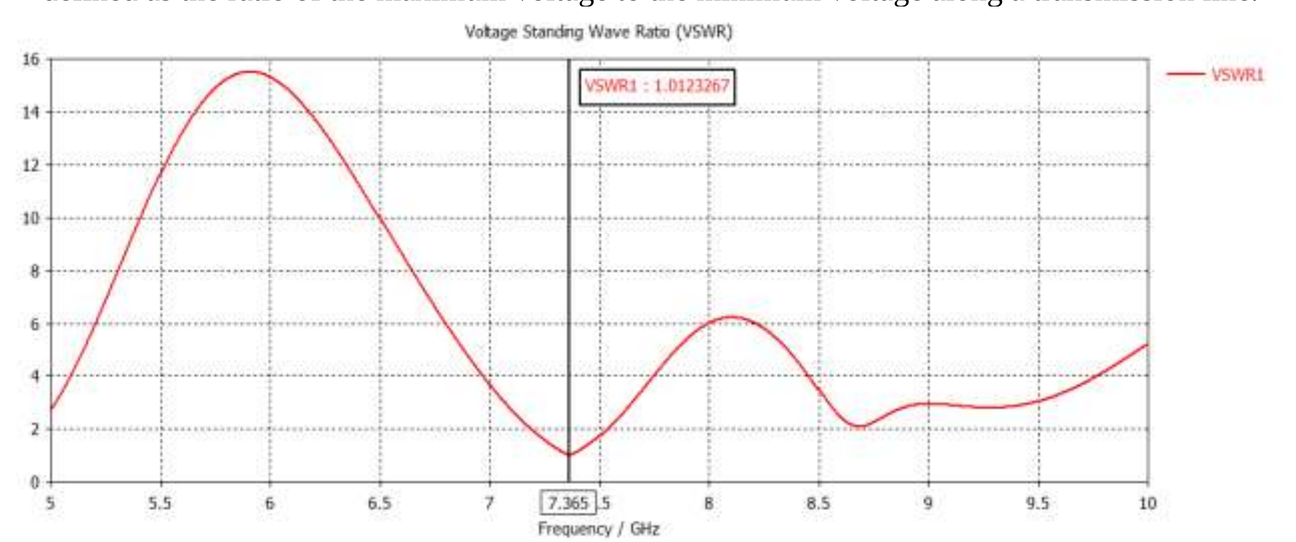

Figure12

Here we obtained a VSWR of 1.01 ideally A VSWR value of 1 indicates perfect impedance matching, meaning that all the power supplied to the antenna is transmitted into the load, and no power is reflected back towards the source. In this case, there are no standing waves along the transmission line.As the VSWR value increases, it indicates a higher degree of mismatch between the antenna and the transmission line, leading to increased power being reflected back towards the source. Higher VSWR values correspond to poorer impedance matching and greater signal loss.

G. RADIATION PATTERNS

The radiation pattern of an antenna describes the distribution of electromagnetic energy radiated or received by the antenna in space. It provides valuable information about how the antenna radiates or receives energy in different directions and is a crucial aspect of the antenna.

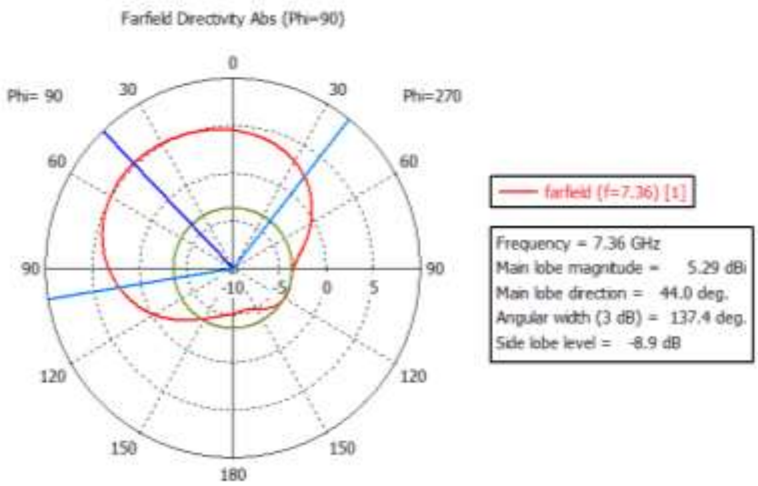

Figure 13

7. CONCLUSION

In this study, we investigated the performance of an antenna loaded with Split Ring Resonators (SRRs) operating at a frequency of 9.6 GHz, while considering its operation at a working frequency of 7.36 GHz. The incorporation of SRRs introduces unique electromagnetic properties to the antenna, enabling enhanced functionality and performance.

Through theoretical analysis and electromagnetic simulations, we observed that the SRR-loaded antenna exhibits improved impedance matching, radiation efficiency, and directivity compared to a conventional antenna design. The presence of SRRs allows for precise control over the antenna's electromagnetic response, leading to enhanced transmission and reception capabilities at the desired operating frequency of 7.36 GHz.

8. USE AND APPLICATION

The SRR-loaded antenna offers promising applications across various fields, including telecommunications, radar systems, and wireless sensing. Its enhanced performance makes it suitable for use in:

1.Wireless communication systems*:* The improved impedance matching and radiation efficiency of the antenna result in more reliable and efficient signal transmission, making it ideal for applications such as Wi-Fi, Bluetooth, and cellular communication.

2.Radar systems*:* The enhanced directivity and sensitivity of the antenna enable accurate detection and tracking of targets, making it valuable for radar applications in aerospace, defense, and surveillance.

3.Wireless sensing and IoT (Internet of Things)*:* The SRR-loaded antenna's compact size, high gain, and improved performance make it well-suited for integration into sensor networks and IoT devices, enabling remote monitoring and data acquisition in various environments.

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