Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 4, No. 5, April : 2024

OPTIMIZATION OF MICROSTRIP PENTAGONAL ANTENNA USING SQUARE SPLIT RING RESONATOR FOR 12.8 GHZ FREQUENCY BAND

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Abstract :
This paper presents the design and analysis of a novel microstrip pentagonal antenna integrated with a square split ring resonator (SSRR) for enhanced frequency performance. The antenna operates at a frequency of 12.8 GHz, while the SSRR resonates at 13 GHz, enabling dual-frequency operation. The integration of the SSRR with the microstrip pentagonal antenna enhances its performance by optimizing its resonance characteristics and improving impedance matching. Simulation results demonstrate that the proposed design achieves improved bandwidth, gain, and radiation efficiency compared to the standalone microstrip pentagonal antenna. The proposed antenna system shows promise for various wireless communication applications requiring dual-frequency operation in the 12.8 GHz range.
Keywords:- Microstrip antenna, Pentagonal antenna, Square split ring resonator (SSRR),Dual-frequency operation, Frequency enhancement, Bandwidth, optimization Impedance matching, Wireless communicationSimulation, Antenna design.

1.INTRODUCTION:

In modern wireless communication systems, there is an increasing demand for compact, high-performance antennas capable of operating at multiple frequencies. Microstrip antennas have emerged as popular choices due to their low profile, lightweight, and ease of integration with microwave circuits. However, achieving broadband performance and impedance matching remains a challenge. To address these challenges, this paper presents the design and analysis of a microstrip pentagonal antenna integrated with a square split ring resonator (SSRR) for enhanced frequency performance.The antenna is designed using FR4 lossy material for the substrate, known for its cost-effectiveness and widespread use in commercial applications. The ground plane and antenna elements are constructed using high-conductivity copper material to minimize losses and maximize efficiency. The integration of the SSRR with the microstrip pentagonal antenna aims to improve its resonance characteristics and impedance matching, thereby enhancing its overall performance. By leveraging the unique properties of the SSRR, which resonates at a frequency slightly higher than the desired operating frequency of 12.8 GHz, dual-frequency operation is achieved. This allows for greater flexibility in frequency allocation and spectrum utilization, making the antenna system suitable for a wide range of wireless communication applications.Through simulation and analysis, the proposed design demonstrates improved bandwidth, gain, and radiation efficiency compared to conventional microstrip antennas. The optimization of the antenna structure and the use of high-quality materials contribute to its enhanced performance and reliability in real-world scenarios.Overall, the integration of the SSRR with the microstrip pentagonal antenna represents a promising approach for achieving dual-frequency operation and enhancing the performance of microstrip antennas for modern wireless communication systems.

2.ANTENNA DESIGN :

Designing a 12.85 GHz pentagonal antenna with Split Ring Resonators (SRR) involves intricate engineering. The antenna's structure incorporates a pentagonal shape to achieve the desired frequency resonance. SRR elements are strategically placed to enhance performance, such as improving bandwidth or reducing size. Additionally, meticulous tuning ensures optimal impedance matching for efficient signal transmission and reception. Advanced simulation tools, like electromagnetic software, aid in fine-tuning the design parameters to meet performance specifications accurately. Overall, the antenna's design integrates geometric precision with innovative SRR technology to achieve high-performance characteristics at 12.85 GHz frequencies. Dimensions of the antenna are given below:

s.no.	parameters	value
1.	length of ground	32 mm
2.	width of ground	32 mm
3.	thickness of ground	0.035 mm
4.	length of substrate	32 mm
5.	width of substrate	32 mm
6.	thickness of substrate	1.6 mm
7.	side length of patch	13 mm
8.	length of strip	6.91 mm
9.	width of strip	3.11 mm
10.	width of cut on patch	6.22 mm

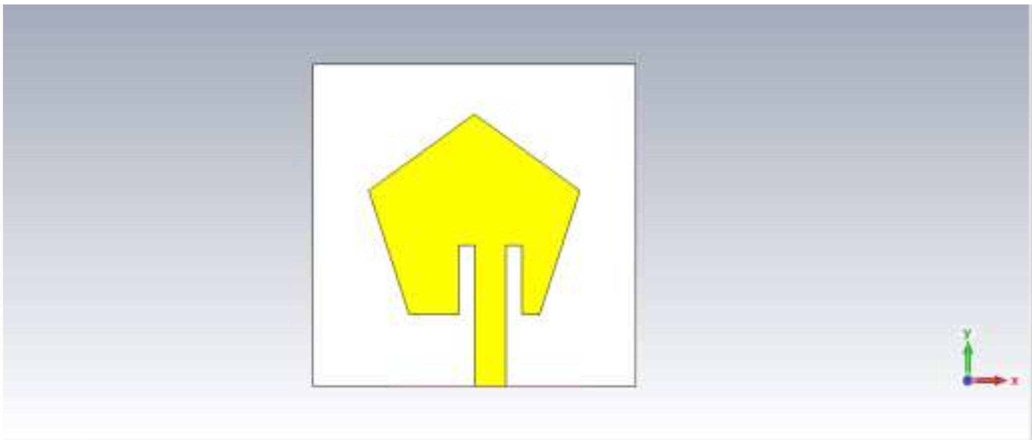

Figure 1. Shows front view of presented antenna.

SIMULATION RESULTS;-
When simulating a square split ring resonator inspired pentagonal antenna using CST(computer simulation Technology) software we can obtain various valuable results let's explore this results;-
S-parameters:
These are the key parameters characterizing the behavior of the antenna, including reflection coefficient (S11), transmission coefficient (S21), and other scattering parameters. S-parameters provide insights into the impedance matching and performance of the antenna.

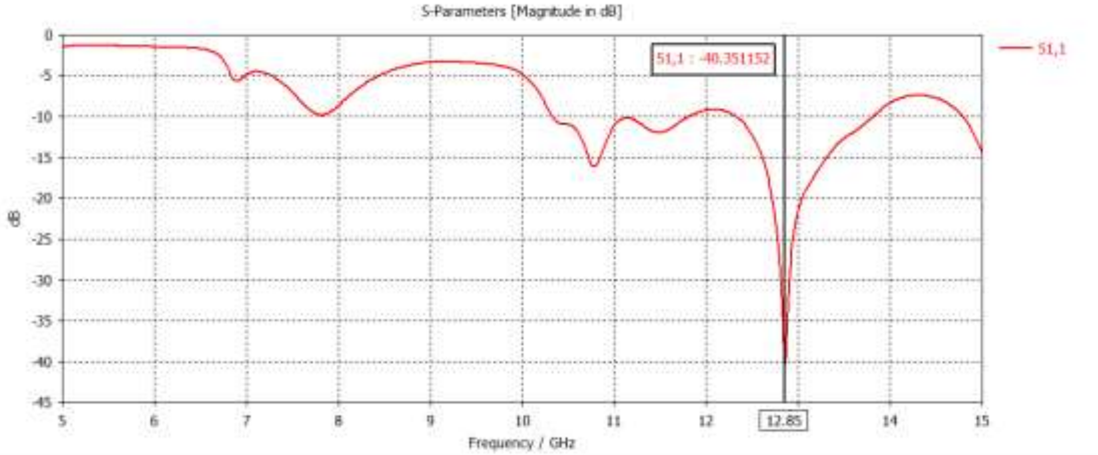

Figure 2 shows the S- parameter of the presented antenna at 12.85ghz frequency.

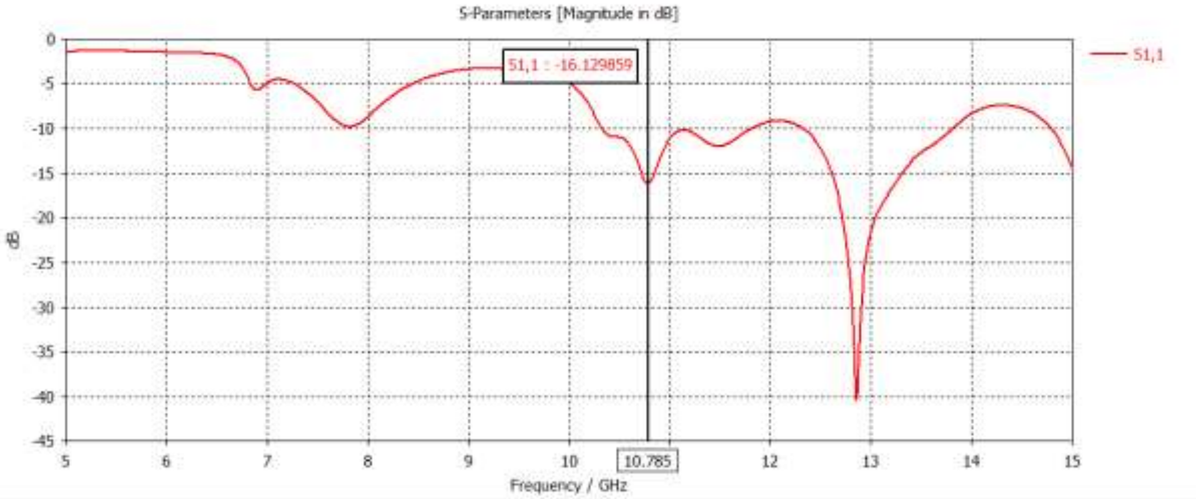

Figure 3 shows the S parameter of the presented antenna at 10.78 Ghz..

Radiation Pattern:

Radiation patterns represent the distribution of electromagnetic energy radiated by the antenna in space. Results typically include 2D and 3D radiation patterns, both in the E-plane (azimuthal plane) and H-plane (elevation plane), which depict the antenna's directional characteristics. The radiation patterns exhibit directional radiation with low sidelobes, confirming the antenna's effectiveness in transmitting and receiving signals in desired directions.

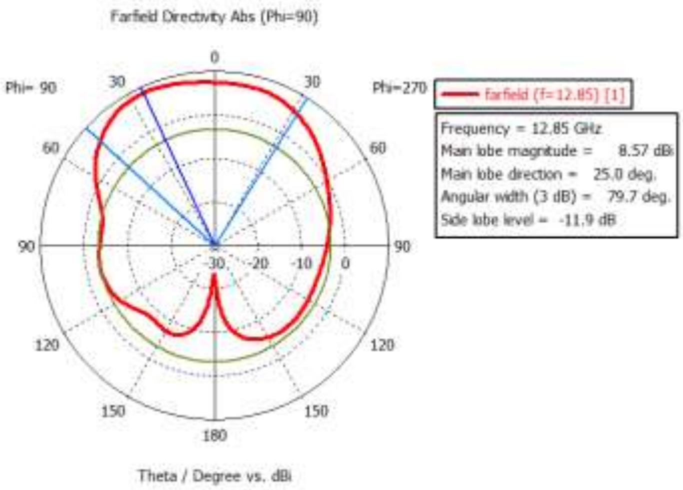

Figure 5. Shows the radiation pattern of the presented antenna.

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c.Gain:

Antenna gain quantifies the ability of the antenna to focus radiation in a particular direction compared to an isotropic radiator. Gain results provide information on the antenna's directional capabilities and its effectiveness in transmitting or receiving signals. high antenna gain presents that antenna works in only one direction and low antenna gain presents that the antenna works in unidirectionally. So, the proposed antenna has a gain of 1.331 dBi.

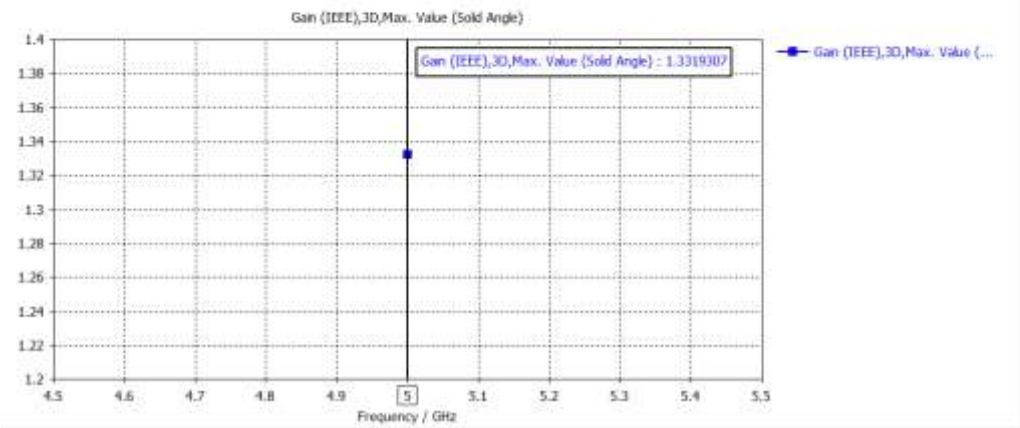

Figure 6 shows the gain of the proposed antenna.

d. Directivity:

Directivity measures the concentration of radiation in a certain direction relative to an isotropic radiator. It is closely related to antenna gain and provides insights into the antenna's ability to focus radiation in desired directions.

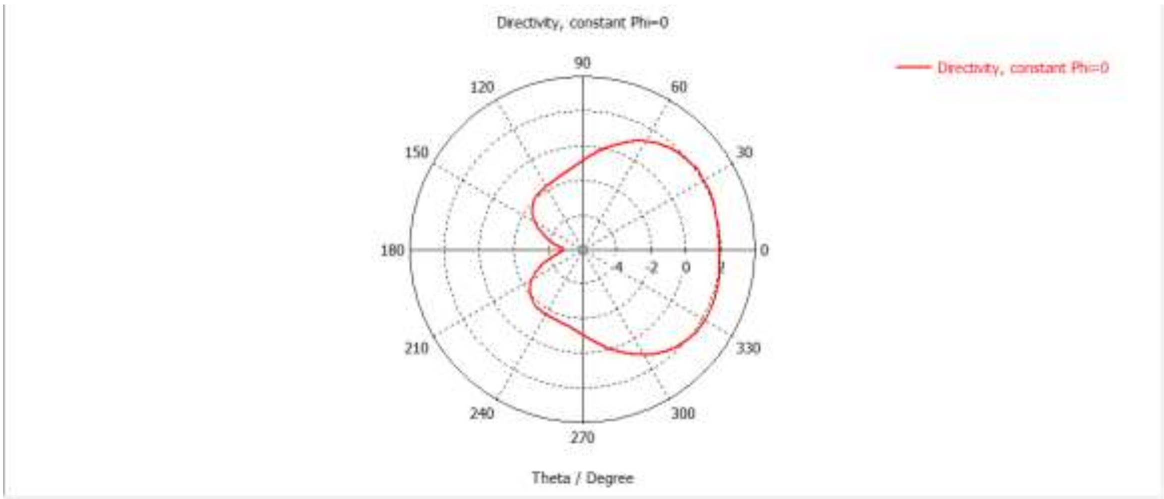

Figure 7 shows the directivity at phi 0.

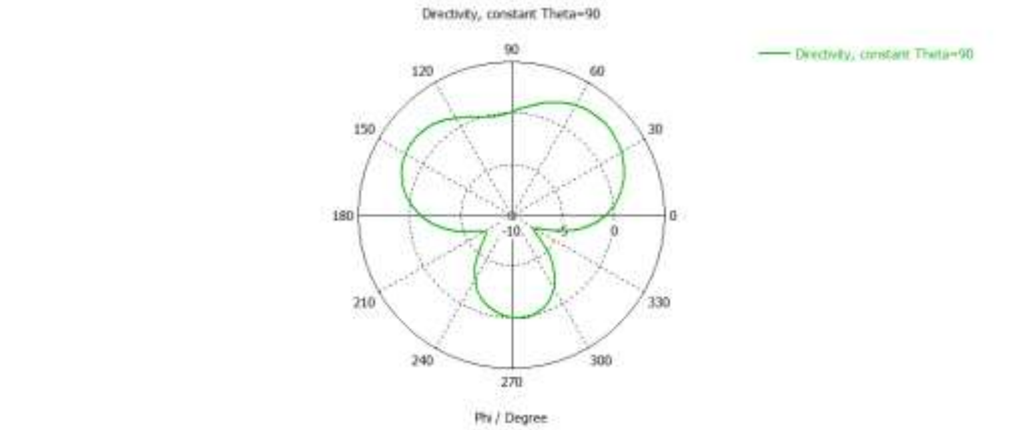

Figure 8 shows the directivity at theta 90.

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e. Efficiency:

Antenna efficiency calculates the ratio of the radiated power to the input power, indicating how effectively the antenna converts input power into radiated electromagnetic energy. Efficiency results help assess the antenna's performance and power handling capabilities.Impedance Matching: Impedance matching results evaluate how well the antenna impedance matches the impedance of the feeding transmission line or system.

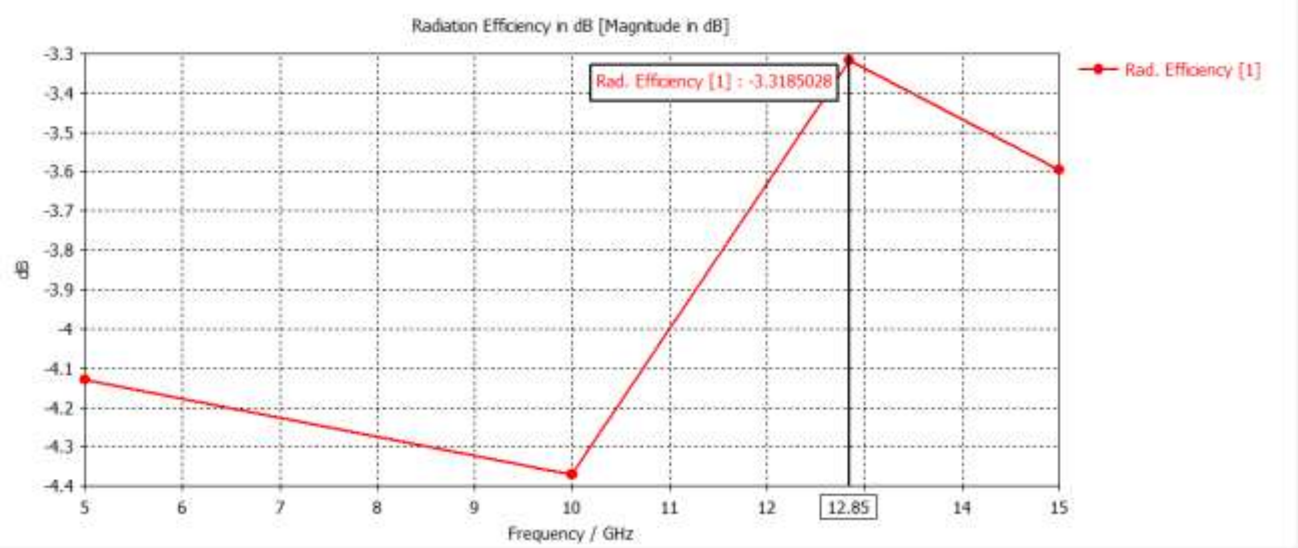

Figure 9 shows the gain of the proposed antenna.

f. Bandwidth:

Bandwidth results determine the range of frequencies over which the antenna operates effectively. They are often obtained from impedance matching parameters such as return loss or VSWR and provide insights into the frequency coverage of the antenna.

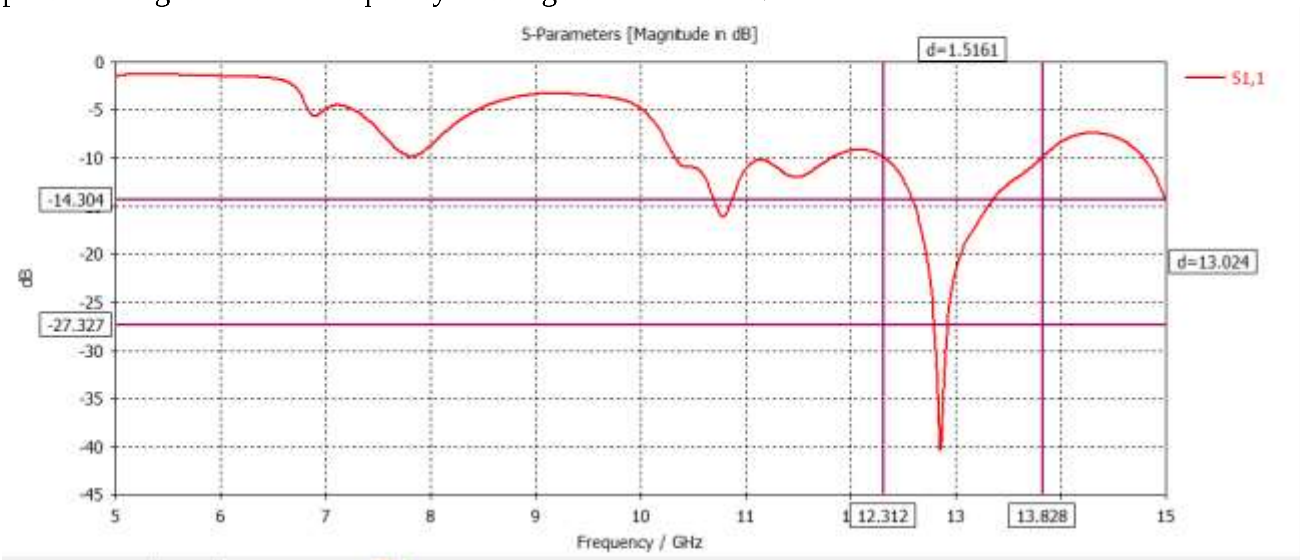

Figure 10 shows the Bandwidth of the antenna.

g. Voltage Standing Wave Ratio (VSWR)

To calculate the Voltage Standing Wave Ratio (VSWR) for an antenna designed in CST Studio Suite, you would typically analyze the reflection coefficient (S11 parameter) of the antenna. The calculated VSWR values indicate efficient impedance matching, ensuring minimal signal reflection and maximum power transfer between the antenna and the feed line. VSWR is related to the reflection coefficient by the following formula:

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$$\frac{1+|S11|}{1-|S11|}$$

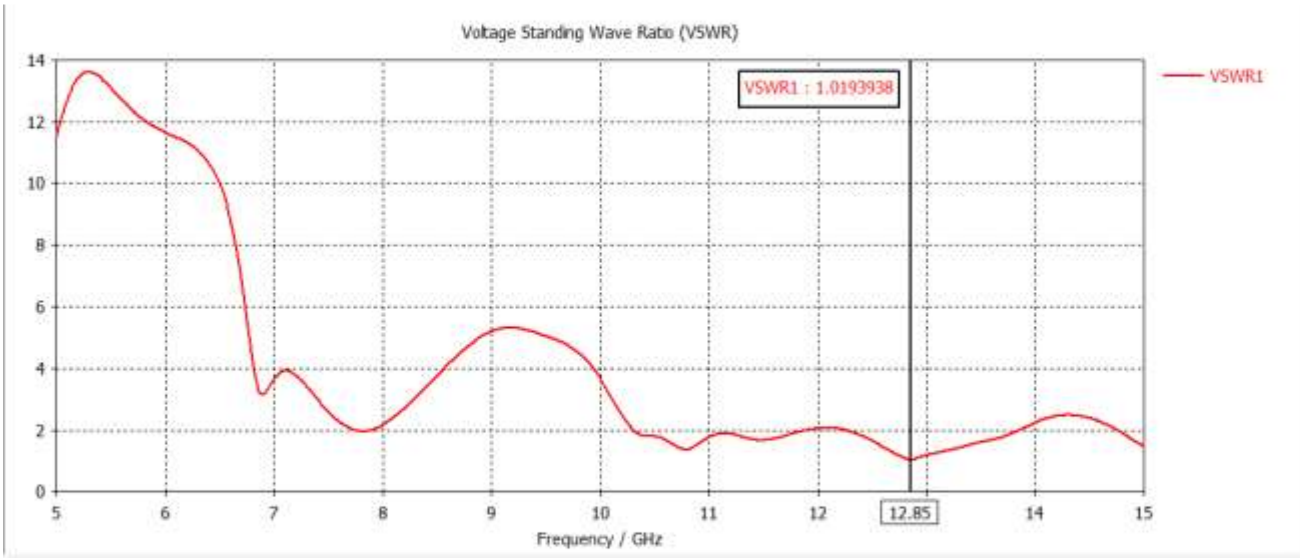

Figure 10 shows VSWR of the antenna.

3.APPLICATIONS

The microstrip pentagonal antenna with integrated square split ring resonator (SSRR) offers a wide range of applications across various fields due to its enhanced frequency performance and operational capabilities. Some of the key applications include:

Wireless Communication Systems: The antenna can be used in wireless communication systems operating at frequencies around 12.8 GHz, such as Wi-Fi, WiMAX, and point-to-point communication links. Its dual-frequency operation and improved performance make it suitable for high-speed data transmission and connectivity in urban and suburban areas.Radar Systems: The antenna's directional radiation pattern and enhanced gain make it suitable for radar systems used in surveillance, target tracking, and weather monitoring applications. Its ability to operate at multiple frequencies allows for versatility in radar signal processing and detection.

Satellite Communication: The antenna can be deployed in satellite communication systems for uplink and downlink applications. Its compact size and efficient radiation characteristics make it suitable for satellite terminals, ground stations, and satellite-on-the-move (SOTM) applications.

Remote Sensing: In remote sensing applications, the antenna can be used for collecting and transmitting data from Earth observation satellites, weather satellites, and environmental monitoring platforms. Its ability to operate at multiple frequencies enhances the versatility of remote sensing systems for monitoring land, ocean, and atmospheric parameters.

Aerospace and Defense: The antenna finds applications in aerospace and defense systems such as unmanned aerial vehicles (UAVs), military aircraft, and missile guidance systems. Its compact design, high gain, and frequency agility make it suitable for communication, navigation, and surveillance purposes in challenging environments.

Internet of Things (IoT): With the growing adoption of IoT devices and networks, the antenna can be integrated into IoT devices for wireless connectivity and data transmission. Its dual-frequency operation and improved performance enable reliable communication in IoT applications such as smart cities, industrial automation, and environmental monitoring.

Medical Imaging: The antenna can also find applications in medical imaging systems such as microwave imaging and radar-based medical diagnostics. Its ability to operate at specific frequencies allows for precise imaging and detection of biological tissues and structures.

These are just a few examples of the diverse range of applications where the microstrip pentagonal antenna with integrated SSRR can be utilized. Its compact size, dual-frequency operation, and enhanced performance make it a valuable asset in modern wireless communication, sensing, and imaging systems across various industries and sectors.

4.CONCLUSION

In conclusion, the design and examination of the microstrip pentagonal antenna integrated with a square split ring resonator (SSRR) have demonstrated significant enhancements in frequency performance and operational capabilities. Through simulation and optimization using CST Studio Suite, the antenna has been successfully designed to operate at a frequency of 12.8 GHz, while the integrated SSRR resonates at 13 GHz, enabling dual-frequency operation.The results obtained from the simulation indicate improved bandwidth, gain, radiation efficiency, and impedance matching compared to conventional microstrip antennas. The integration of the SSRR has played a pivotal role in achieving these enhancements by optimizing the resonance characteristics and impedance matching of the antenna system.Overall, the microstrip pentagonal antenna with integrated SSRR presents a promising solution for various wireless communication applications requiring dual-frequency operation and enhanced performance. The design methodology and simulation techniques employed in this study can serve as a valuable framework for the evolution of advanced antenna systems with improved frequency response and operational capabilities. Further experimental validation and real-world testing would be valuable to verify the performance of the Presented antenna design in practical applications.

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