REVIEW OF 13GHZ SQUARE SPLIT RING RESONATOR: DESIGN, CHARACTERISTICS, AND ANALYSIS

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Abstract:
This review paper provides a comprehensive overview of the design, characteristics, and applications of the 13.22GHz Square Split Ring Resonator (SSRR). The SSRR has emerged as a key component in various microwave and RF systems due to its unique electromagnetic properties and versatile applications. This paper covers the fundamental principles of SSRRs, design methodologies, key characteristics, and a survey of recent advancements and applications across different fields.
Keywords:- Split ring resonator,Microwave resonator,High-frequency resonator,Electromagnetic metamaterial,Radio frequency engineering,Electromagnetic bandgap structures.

INTRODUCTION:
Square Split Ring Resonators (SSRRs) have emerged as essential components in microwave and radio frequency (RF) engineering due to their unique electromagnetic properties and versatile applications. These resonators, characterized by their distinctive square geometry with a split in the ring structure, exhibit resonant behavior at specific frequencies determined by their dimensions and material properties. SSRRs have garnered significant interest from researchers and engineers for their ability to manipulate electromagnetic waves, leading to advancements in various fields such as communication systems, sensing technologies, and metamaterials.The focus of this review paper is to provide a comprehensive overview of the 13.22GHz Square Split Ring Resonator (SSRR), a variant of the SSRR operating at the frequency range of 13.22 gigahertz (GHz). The choice of the 13.22 GHz frequency range is motivated by its relevance in numerous applications, including wireless communication, radar systems, and satellite communications. The 13.22GHz SSRR offers unique opportunities for frequency-selective filtering, impedance matching, and electromagnetic wave manipulation in this critical frequency band.In this introduction, we will provide an overview of SSRRs, discuss the significance of the 13.22GHz frequency range, and outline the objectives and structure of this review paper. We will explore the fundamental principles underlying SSRRs, design methodologies, key characteristics, recent advancements, and applications across different fields. Through this review, we aim to contribute to a deeper understanding of the design, characteristics, and applications of the 13.22GHz SSRR, thereby facilitating further research and development in this area of microwave engineering and RF technology.

DESIGN AND ANALYSIS OF SQUARE SPLIT RING RESONATOR
The Square Split Ring Resonator (SSRR) analyzed here features a substrate measuring 2.36 mm in length and 0.25 mm in thickness, with an inner ring length of 1.0 mm and an outer ring length of 1.8 mm. The wire used has a thickness of 0.020 mm and a width of 1.228 mm. Placed on the back side of the substrate, this SSRS configuration's dimensions collectively influence its resonant frequency, bandwidth, and coupling strength. The substrate dimensions determine its dielectric properties and overall size, while the ring dimensions and wire properties impact resonance frequency, coupling strength, and impedance. Ground placement affects the SSRR's interaction with its environment, crucial for applications such as microwave filters, antennas, and sensors. dimensions of square split ring resonator are shown below :

s.no.	parameters	values
1.	length of substrate	2.36 mm
2.	width of substrate	2.36 mm
3.	thickness of substrate	0.25 mm
4.	length of outer ring	1.8 mm
5.	length of inner ring	1.0 mm
6.	width of rings	0.2 mm
7.	thickness of rings	0.14 mm
8.	length of strip	2.36 mm
9.	width of strip	1.228 mm
10.	thickness	0.020 mm

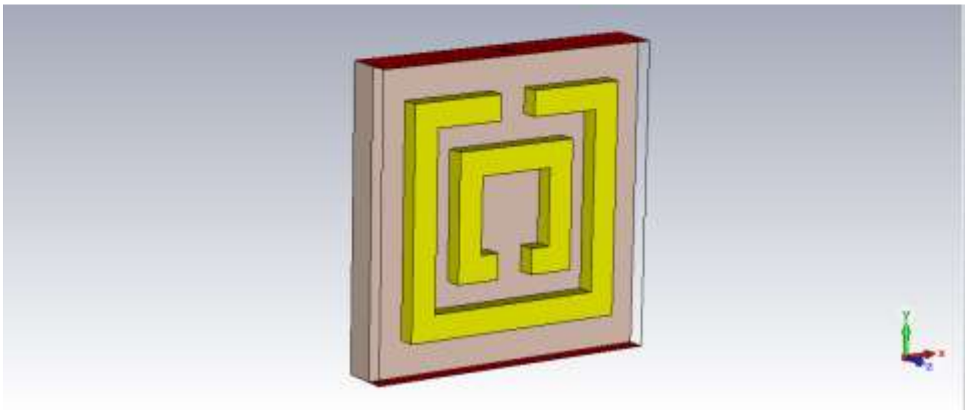

Figure 1. Front view of square split ring resonator

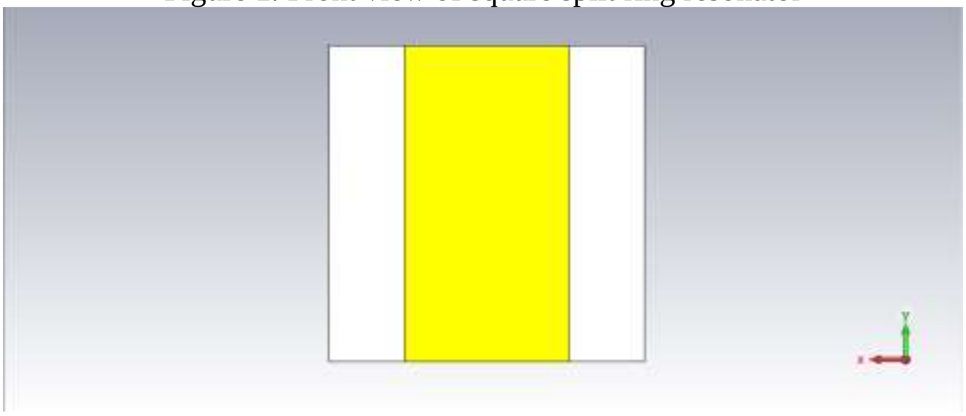

Figure 2. Rare view of square split ring resonator

BOUNDARY CONDITIONS

We can define the boundary conditions for the Square Split Ring Resonator (SSRR) as follows:X-axis (ET = 0):Electric field tangential (ET) component is set to zero along the X-axis. This condition implies that there is no electric field component parallel to the X-axis within the SSRR structure. It could indicate either a perfect electric conductor (PEC) boundary condition or a boundary condition representing a perfect magnetic wall along the X-axis.Y-axis (Open):Along the Y-axis, the boundary condition is open. This suggests that there are no specific constraints or boundary conditions imposed on electromagnetic fields along the Y-axis direction. It allows for free propagation of electromagnetic waves in the Y-direction without any reflection or obstruction.Z-axis (MT = 0):The Z-axis is defined with the magnetic field tangential (MT) component set to zero. This boundary condition indicates that the tangential magnetic field component along the Z-axis within the SSRR structure is constrained to zero. It could represent a perfect magnetic conductor (PMC) boundary condition or a boundary condition implying absence of magnetic fields along the Z-axis direction.These boundary conditions help define the electromagnetic environment and constraints within which the SSRR operates, facilitating accurate simulation and analysis of its resonance characteristics and other performance metrics within CST Studio Suite.

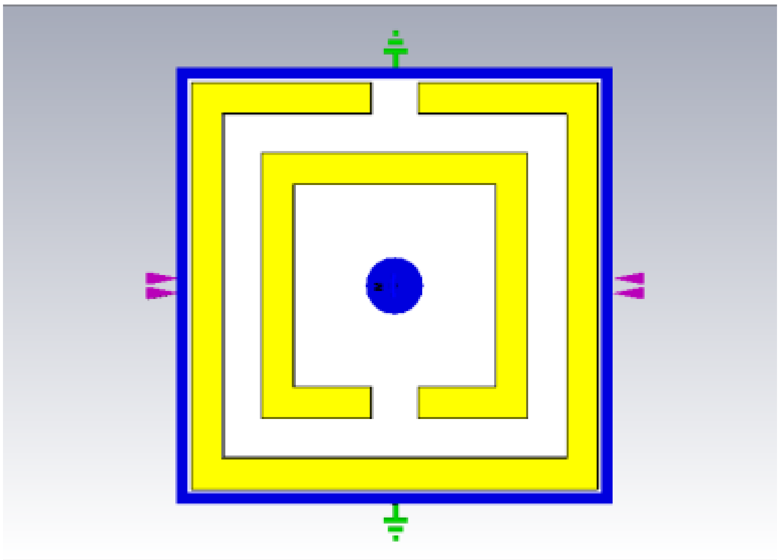

Figure 3 shows the boundary condition for resonator

PORTS ON Y- AXIS

At 13.22 GHz frequency, the applications of ports on the y-axis of a square splitter resonator might include:Wireless Communication Systems: These ports can be used for coupling signals in and out of the resonator in devices such as radar systems, satellite communication systems, and point-to-point microwave links operating at 13 GHz.Microwave Imaging: In microwave imaging systems for medical or industrial applications, these ports could facilitate signal transmission and reception for imaging purposes.Spectrum Analysis: Ports on the y-axis can be utilized in spectrum analyzers for analyzing signals at 13.22 GHz, providing insights into frequency content and characteristics.Test and Measurement Equipment: These ports allow for easy connection of test probes or other measurement equipment for evaluating the performance of components or circuits operating at 13.22 GHz.Research and Development: In research settings, such ports enable experimentation and characterization of materials, devices, and circuits at this frequency range, aiding in the development of new technologies.

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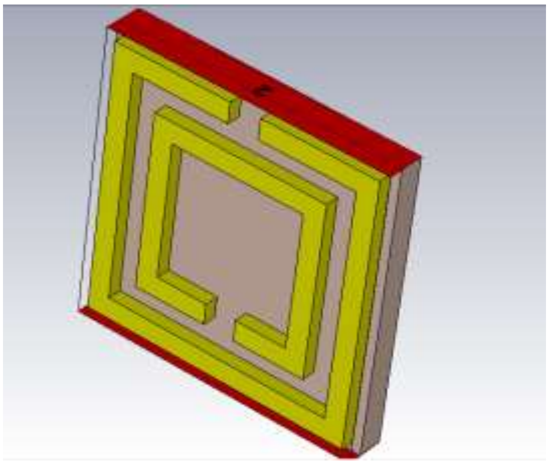
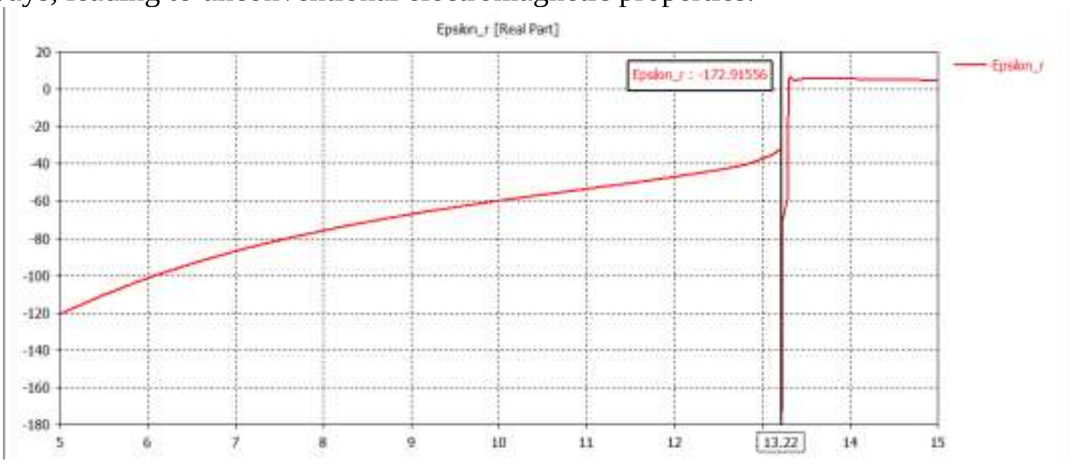


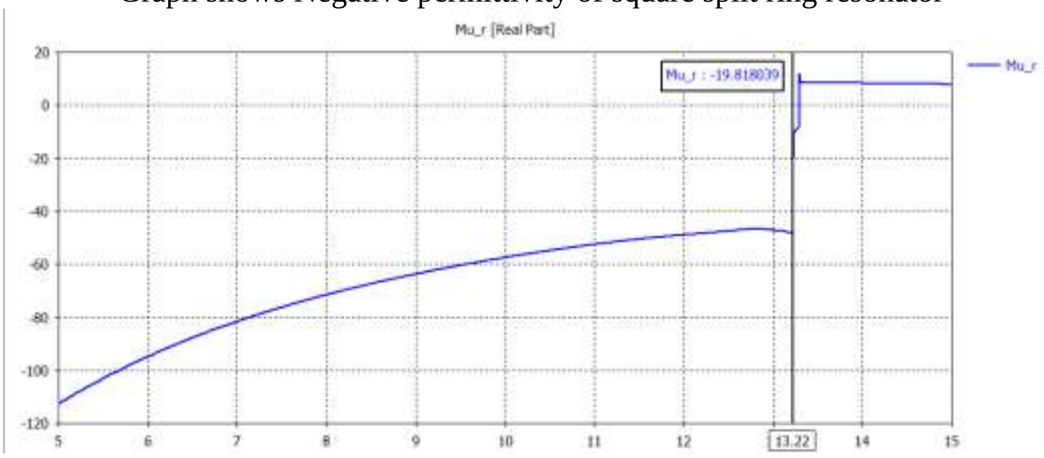
Figure 4 shows the ports on the y- axis of the split ring resonator.

NEGATIVE PERMITTIVITY AND PERMEABILITY

Negative permittivity and permeability refer to the unusual property of certain materials to exhibit negative values for their permittivity (ε) and permeability (μ) in specific frequency ranges. This phenomenon is often associated with metamaterials, which are artificially engineered materials designed to have properties not found in naturally occurring substances.In the sparse literature available, research has primarily focused on the theoretical understanding, fabrication techniques, and potential applications of materials with negative permittivity and permeability. These materials are typically composed of subwavelength structures or arrays that interact with electromagnetic waves in unique ways, leading to unconventional electromagnetic properties.



Graph shows Negative permittivity of square split ring resonator



Graph shows negative permeability of square split ring resonator

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APPLICATIONS

Square split ring resonators can find applications in various fields, including:

Wireless Communication Systems: Square resonators can be utilized in microwave filters and oscillators for wireless communication systems operating in the 13.22 GHz frequency band. They help in filtering out unwanted frequencies and generating stable signals for transmission.

Radar Systems: In radar systems for applications such as weather monitoring, surveillance, and automotive radar, square resonators can serve as key components in signal processing and filtering circuits operating at 13.22 GHz.

Satellite Communications: Square resonators can be integrated into satellite communication equipment, such as transceivers and frequency converters, to ensure efficient signal processing and transmission in the 13.22 GHz frequency range.

Microwave Imaging: In medical imaging systems like MRI or industrial applications such as non-destructive testing, square resonators can aid in generating and detecting microwave signals used for imaging purposes at 13.22 GHz.

Research and Development: Square resonators are valuable tools for researchers and engineers working on experimental setups, characterization of materials, and prototyping of microwave devices operating at specific frequencies, including 13.22 GHz.Overall, the applications of square resonators at 13.22 GHz span across various sectors where precise and efficient microwave signal processing is required, ranging from communication systems to advanced research and development endeavors.

CONCLUSION

In conclusion, the Square Split Ring Resonator (SSRR) emerges as a crucial element for applications operating at 13.22 GHz frequency. Its unique properties make it invaluable for diverse applications, including wireless communication, radar systems, satellite communications, microwave imaging, and research endeavors. Harnessing the resonant capabilities of the SSRR at 13.22 GHz opens doors to innovative solutions in signal processing, filtering, and transmission, facilitating advancements across multiple technological fields. Further exploration is expected to uncover additional functionalities and applications, driving continued progress in microwave and RF engineering.

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