Design, Simulation and Analysis of a 5 GHz SRR Notch Filter Using Ansys HFSS

Basireddy Khyathi Sri
Department of ECE
IIIT Hyderabad
Gachibowli, India
khyathisri.basireddy@students.iiit.ac.in
Contribution: Circular SRR design, Quarter wave transformer

Chamarthy Madhan Sai Krishna
Department of ECE
IIIT Hyderabad
Gachibowli, India
chamarthymadhan.k@students.iiit.ac.in
Contribution: Literature review, Report, Quarter wave transformer

Priyanshi Jain
Department of ECE
IIIT Hyderabad
Gachibowli, India
priyanshi.jain@research.iiit.ac.in
Contribution: –

Sanjana Sheela
Department of ECE
IIIT Hyderabad
Gachibowli, India
sanjana.sheela@students.iiit.ac.in
Contribution: Literature review, Electric coupling, Square SRR

Snigdha
Department of ECE
IIIT Hyderabad
Gachibowli, India
snigdha.stp@students.iiit.ac.in
Contribution: Quarter Wave Transformer, Impedance Matching,

***Abstract*—This paper presents the design and simulation of a split ring resonator (SRR) based notch filter operating at a resonant frequency of 5 GHz. The design utilizes a microstrip line coupled with an SRR to achieve a band-stop response. The electromagnetic simulation and optimization of the filter are performed using ANSYS HFSS software. The fundamental principles of SRR notch filters are discussed, and the impact of geometrical parameters on the filter's characteristics is analyzed. This work demonstrates the potential of SRRs for creating compact notch filters suitable for various microwave applications, including the suppression of unwanted signals in communication systems.**

***Index Terms*—Split Ring Resonator (SRR), Notch filter, 5GHz, Ansys HFSS, Simulation, Design, Microstrip Line, Metamaterials, Band-stop filter, Resonant frequency**

I. To-do:

- The story of the paper should be along the lines of solving the problem (specified in the literature review) using SRR notch filter that we designed and it's application (embedding that in a patch antenna) and future direction of this research (tunability in the notch filter)
- Explanation of the design and its properties
- Calculations for resonance frequency, quality factor, and sensitivity
- Final result and conclusion
- Screenshots from HFSS explaining the design
- Introduction, Theoretical framework, Design Methodology, Simulation Methodology, Results and Analysis, Applications and Future direction of Research, Conclusion

II. Introduction

A. Theoretical Background of SRR Notch Filters

B. Motivation and Objectives

To design and simulate a Split Ring Resonator (SRR) structure which resonates at 5 GHz and acts as a notch filter. Objectives:

- Operating frequency $<$ 6GHz
- Sensitivity $> 10\%$
- Size : Compact
- Resonant Frequency : 5GHz

C. Paper Organization

The next part of the paper is outlined in the following sections. Section XX discusses the design methodology,

III. Theoretical Framework

A. Electromagnetic Theory of SRRs

Present Maxwell's equations relevant to the SRR's operation. Introduce resonance behavior with supporting math.

B. Equivalent Circuit Models

Model the SRR as an LC resonator. Derive relationships between the geometric parameters and the lumped elements.

C. Coupling Mechanisms

Differentiate electric vs. magnetic coupling with field diagrams or schematics. Explain near-field interaction with microstrip lines.

D. Notch Filter Characteristics

Introduce key parameters: center frequency, insertion loss, bandwidth, return loss, quality factor. Discuss notch sharpness and selectivity.

E. Design Equations for SRRs

Provide analytical equations relating SRR dimensions to resonant frequency. Set the basis for initial geometry selection.

IV. Design Methodology

A. Design Requirements and Specifications

List the required performance: 5 GHz center, target bandwidth, notch depth, substrate limitations, and footprint constraints.

B. Substrate Selection and Microstrip Design

Describe chosen substrate (e.g., FR4 or Rogers), its dielectric constant, thickness, and loss tangent. Calculate 50-ohm microstrip width.

C. SRR Topology Selection

Compare various geometries (square, circular, spiral). Justify your selection based on performance and ease of fabrication.

D. Parametric Analysis Framework

Outline which parameters (gap, ring width, spacing) are to be swept in simulation. Describe your approach to optimization.

E. Coupling Configuration

Describe SRR placement relative to the microstrip. Provide geometry layout and explain expected coupling mode.

F. Expected Performance

Estimate resonant frequency using derived equations. Predict notch depth and bandwidth.

V. Simulation Methodology

A. HFSS Simulation Environment Setup

Describe the overall simulation environment and settings.

B. Material Properties and Model Creation

Assign dielectric and conductor properties. Detail 3D model dimensions and layers in HFSS.

C. Excitation and Boundary Conditions

Explain port settings and boundary types (e.g., radiation boundary). Validate open-space behavior.

D. Advanced Simulation Techniques

Discuss meshing strategies, adaptive refinement, and convergence tests.

E. Parameter Sweep Configuration

Explain how design variables were swept for optimization. Mention use of design sets or parameter studies.

F. Post-Processing Methods

Outline how S-parameters, return loss, and electric/magnetic fields were extracted and visualized.

VI. Results and Analysis

A. S-Parameter Results

Present *S21* and *S11* plots. Highlight the notch and overall filter performance.

B. Field Distribution Visualization

Include field snapshots at resonance to illustrate energy concentration in the SRR.

C. Parametric Study Results

Show how performance metrics vary with changes in SRR geometry. Include plots or tables.

D. Bandwidth Control Mechanisms

Discuss how tuning gap or ring dimensions controls notch width.

E. Performance Benchmarking

Compare your filter with other 5 GHz SRR filters from literature in terms of size, Q-factor, rejection level, etc.

F. Practical Implementation Considerations

Discuss impact of fabrication errors, etching resolution, and substrate tolerances on real-world performance.

VII. Applications and Future direction of Research

A. Wireless Communication Systems

Explain application in Wi-Fi, WLAN, and radar systems operating around 5 GHz.

B. Integration with Other Components

Suggest integration with RF front ends, amplifiers, or antennas.

C. Tunable and Reconfigurable Extensions

Discuss possibility of incorporating varactors, MEMS, or other tunable elements.

D. Multi-band Filter Extensions

Propose adding multiple SRRs or multi-ring structures for dual-band or multi-band notch response.

VIII. Conclusion

A. Summary of Findings

Summarize key achievements—resonant frequency, notch performance, and compactness.

B. Significance of the Results

Emphasize how your design adds value to current RF/microwave filtering solutions.

C. Limitations and Future Work

Address design limitations, simulation constraints, and propose future improvements (e.g., experimental validation, reconfigurability).