Design of Hexagonal Split Ring Resonator using HFSS

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Abstract—In this paper, Hexagonal Split Ring Resonator (HSRR) and Square Split Ring Resonator (SSRR) are designed using HFSS simulation software. Both split ring resonators are based on the Metamaterial and same parameters. Then after compare the simulation result of HSRR and SSRR. HFSS simulation of the Hexagonal SRR shows improved Return Loss and VSWR i.e. -44.7 dB and 1 respectively compare to Square Split Ring Resonator.

Keywords—Metamaterial, Hexagonal SRR, Resonant frequency

I. INTRODUCTION

In 1968, Veselago, described the electric permittivity (ε), and magnetic permeability (µ) are the two fundamental parameters characterizing the EM property of a medium, it is shown in figure 1 [1].

Figure 1: Properties of Permittivity and Permeability for material

Veselago predicted that the most interesting region in the material parameter space is quadrant III, in which permittivity and permeability are simultaneously negative [1].

Metamaterial is the artificial engineered structure. It composed of SRR and strip wires. Negative permeability can be achieved by using split ring resonator and negative permittivity can be achieved by using strip wire [2][3].

The electrical size of a multi split ring resonator (MSRR) can be arranged by simply changing the number of its rings while retaining the physical size [6].

A circular split-ring resonator (SRR) and its equivalent circuit is shown in figure 2. The inductance of ring is represented by L and the distributed capacitance is represented by c1/2 and c2/2 where c1/2 is the capacitance composed by the upper outer and inner ring and c2/2 is the capacitance composed by lower outer and inner ring and both the capacitance connected in series. The transmission coefficient of the SRRs is minimum at the magnetic resonance frequency, which is estimated from the inductance and capacitance [8][9]. It is important to design SRR structures from substrate of the microstrip components because the shape, the orientation and the arrangement of SRR structures change the inductance and capacitance [12].

There are various shapes that have been available in the literature. In this paper, the design of Hexagonal Split Ring Resonator based on metamaterial is proposed using HFSS.

(a) Designing of Hexagonal Split Ring Resonator using HFSS

The design parameters of Hexagonal SRR are following:

L (length of the side) = 4 mm
w (width of the split ring) = 0.33 mm
s (separation between the rings) = 0.33 mm
N (number of rings) = 3
Ground plane dimensions = (8× 8 × 8) mm

In designing, the substrate is Rogers RO4003. The relative permittivity and permeability of Rogers RO4003 are 3.5 and 1 respectively and its loss tangent is 0.0027. The Hexagonal split ring resonator (HSRR) is shown in figure 3.
The return loss and VSWR of Hexagonal SRR are shown in figure 4 (a) & (b):

The resonant frequency of Hexagonal Split Ring Resonator is 9.75 GHz and return loss is -44.7 dB.

(b) Designing of Square Split Ring Resonator using HFSS
The design parameters of Square SRR are following:

- \( L \) (length of the side) = 4 mm
- \( W \) (width of the split ring) = 0.33 mm
- \( S \) (separation between the rings) = 0.33 mm
- \( N \) (number of rings) = 3
- Ground plane dimensions = \( (8 \times 8 \times 8) \) mm

In designing, the substrate is Rogers RO4003. The relative permittivity and permeability of Rogers RO4003 are 3.5 and 1 respectively and its loss tangent is 0.0027. The square split ring resonator (SSRR) is shown in figure 5.

The return loss and VSWR of Square SRR are shown in figure 6 (a) & (b):

As shown in the above figures (a) and (b), The resonant frequency of Square Split Ring Resonator is 6.75 GHz and return loss is -17.2 dB.

(II) Comparison between Square and Hexagonal SRR
The design parameters of both the structures are same but the results are different. The comparison between Square Split Ring Resonator and Hexagonal Split Ring Resonator are shown as following table 1:
The resonant frequency of Square SRR and Hexagonal SRR is different because of distributed capacitance, gap capacitance and inductance of resonator.

II. CONCLUSION

The resultant frequency of the Square SRR is 6.75 GHz, return loss -17.2 dB and VSWR is 1. The resultant frequency of the Hexagonal SRR is 9.75 GHz on return loss of -44.7 dB and VSWR is 1. So, it is conclude that the Hexagonal Split Ring Resonator show the improved return loss and highest resonant compare to Square Split Ring Resonator.

REFERENCES


![Table 1](https://www.ijetae.com/)

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Shape of Structure</th>
<th>Side Length of Structure (mm)</th>
<th>Return Loss (dB)</th>
<th>Resonance Frequency (GHz.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Square SRR</td>
<td>4</td>
<td>-17.2</td>
<td>6.75</td>
</tr>
<tr>
<td>2.</td>
<td>Hexagonal SRR</td>
<td>4</td>
<td>-44.7</td>
<td>9.75</td>
</tr>
</tbody>
</table>

Table 1: Comparison between HSRR and SSRR