# MINIATURIZATION OF PATCH ANTENNA USING SRR AND CSRR

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**Abstract -** The microstrip patch antennas are used in many fields due to their specifications like compact size, less weight, less cost, etc. In this paper, we tried to design a miniaturized patch antenna for 2.4 GHz frequency. An ordinary patch antenna designed for this frequency should have 7cm x 7 cm size. We use SRR (Split Ring Resonator) and CSRR (Complementary Split Ring Resonator) to miniaturize the patch antenna. They are metamaterials, showing the behaviour of an LC resonator circuit. When the size is reduced, it is observed that frequency response is shifted to a higher frequency. To compensate for this SRR or CSRR structures are added, so patch antenna with reduced size and optimized frequency response is obtained. We designed a patch antenna with CSRR incorporated on the ground, that has a total size of 2cm X2cm that resonates at a 2.4 GHz.

***Key Words*: Split ring resonator, Complementary split ring resonator, Microstrip antenna**

## 1. INTRODUCTION

Microwave communication is a wireless communication technology using higher frequency radio waves in GHz ranges. They have a smaller wavelength, so it allows the usage of the conveniently sized antenna with a directive beam which can be utilized in point to point communication. It also allows the usage of the same frequency, while avoiding interferences among nearer transceivers in point to point communication. As frequency increases the channel will have higher information carrying capacity. So microwave communication has higher information carrying capacity.

The microwave radio spectrum is used in many applications like radio astronomy, radar system, satellite communications, radio navigation system etc. The microwave spectrum is divided into numerous subbands. Each of them has their own applications and are designated by specific letters.

The frequency bands of microwaves are as follows:

| Band | Frequency Range(GHz) |
|---|---|
| L | 1 to 2 |
| S | 2 to 4 |
| C | 4 to 8 |
| X | 8 to 10 |
| Ku | 12 to 18 |
| K | 18 to 26.5 |
| Ka | 26.5 to 40 |

Figure 1: Frequency Band

Microstrip patch antennas are convenient and simpler antennas for microwave communications. It has several advantages like less weight, less size, less volume occupancy, less cost etc. Consider the microstrip antenna shown in Figure 2, fed by a microstrip transmission line. It consists of the dielectric substrate material. A rectangular conducting part is added onto the top of it known as a patch, another conducting plate on the bottom of it known as ground. Ground covers the entire area of the substrate while patch size is varied according to the required response. The input signal is given to the antenna using connectors. The signal from the connector is given to the patch by using a rectangular conducting part known as feed line. The patch is of length L, width W, and sitting on top of a substrate of thickness h with permittivity or dielectric constant εr. The patch antenna works by the fringing effect.

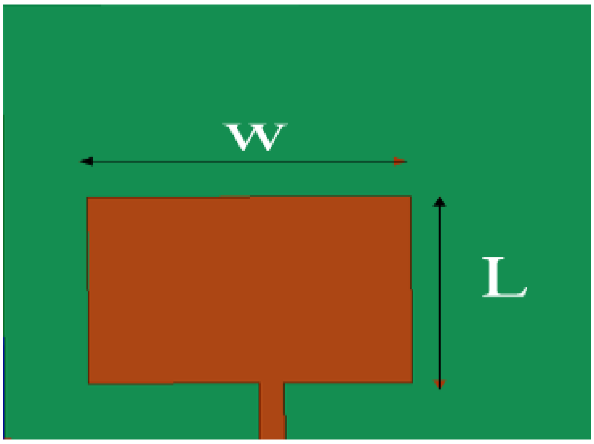


Figure 2: Patch Antenna

When the size of the antenna is reduced it is observed that frequency response shifts to a higher frequency, to compensate for this SRR and CSRR are used.

SRR (Split Ring Resonator) is the ring-like structure with slits of suitable width on one side. They are made of conductive materials. They are metamaterials showing non-natural behaviours like negative permittivity etc. In our design, more than one ring-like structure with slits on opposite sides are provided. They act like an LC circuit. The current flow along ring shows inductive behaviour and slits with suitable separation shows capacitive effects. They together behave as a resonating LC circuit.

CSRR(Complementary Split Ring Resonator) is complementary to SRR. These are made by removing SRR conducting rings from a conducting plane of the antenna. They also behave like an LC resonating circuit, by changing its dimensions the frequency response of antenna can be varied.

## 2. WHY 2.4 GHz?

For the home users and commercial business, 2.4GHz is the frequency band used for WiFi, Bluetooth, etc. Indeed 2.4 GHz band has got a wide application and is unlicensed so that the operation of in this is preferred by all. They are free to use. So many devices work on 2.4 GHz like cordless phones, Car alarm, Zigbee etc.

## 3. STUDY OF SRR

We tried to design a square SRR resonating at a frequency of 2.4GHz. The boundary of H plane is provided to the upper and bottom part of SRR and boundary of E plane is provided to the two sides of SRR. Wave port excitation is provided to the other two sides of SRR.Two thin concentric metallic rectangular rings along with a slit in between were designed over FR4 epoxy dielectric substrate(εr), with height 1.6mm. The slits are placed on opposite directions.

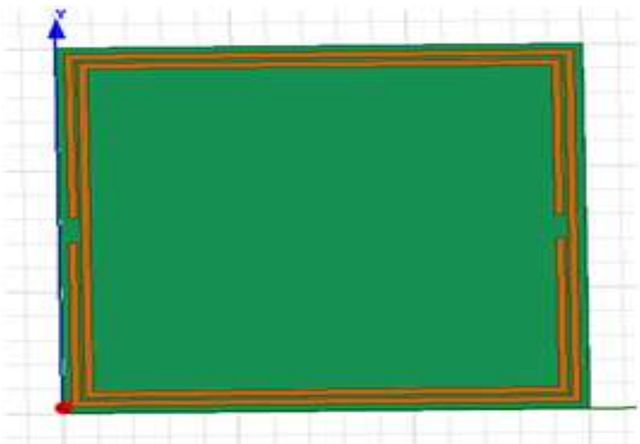

Figure 3: Rectangular SRR

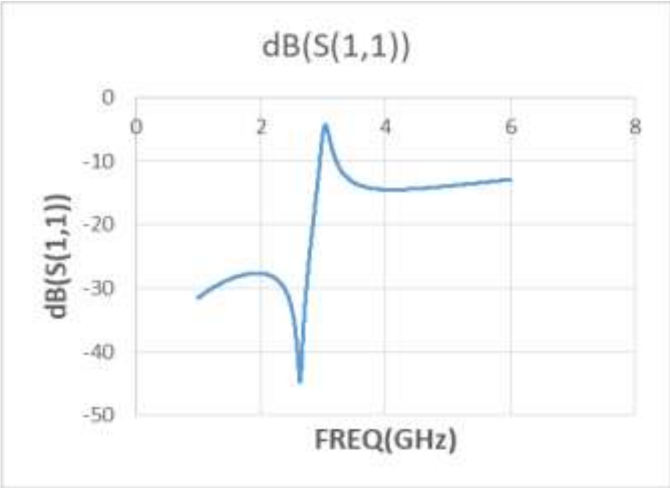


Figure 4: $S_{11}$ Plot of Rectangular SRR

Figure 3 shows the designed rectangular SRR and figure 4 shows the simulated $S_{11}$ parameter of SRR. After analyzing the square SRR the study was further progressed to the circular SRR. Two concentric circular rings with slits on opposite directions were attached on the top of FR4 substrate(εr), and simulated $S_{11}$ is obtained. The boundary of H plane is provided to the upper and bottom part of SRR and boundary of E plane is provided to the two sides of SRR. Wave port excitation is provided to the other two sides of SRR.

Figure 5 shows the designed circular SRR and figure 6 shows the simulated $S_{11}$ parameter. By varying design dimensions the effect of SRR on the patch antenna is studied.

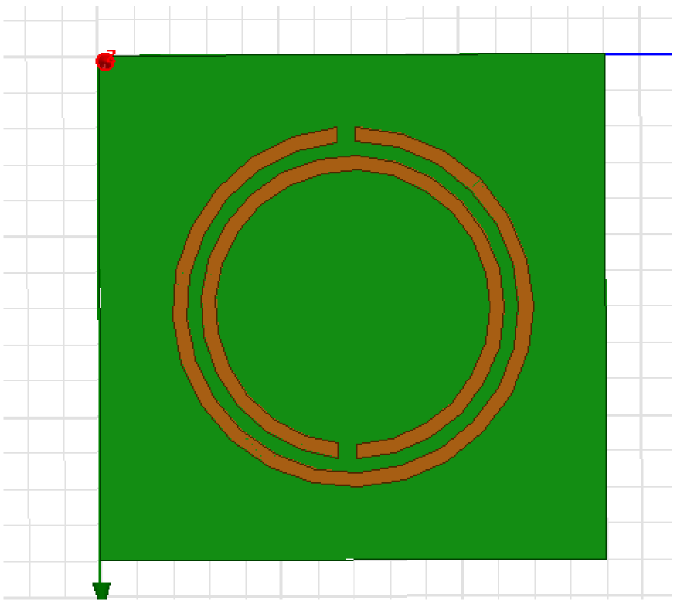

Figure 5: Circular SRR

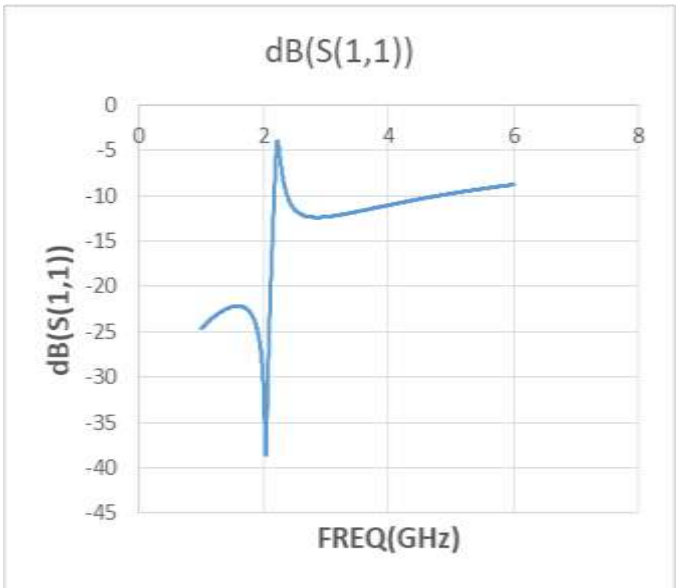


Figure 6: $S_{11}$ Characteristics of Circular SRR

## 4. MINIATURISED ANTENNA WITH THE PROPOSED CSRR ON RECTANGULAR PATCH

The total size of the antenna is 5cm X 5cm forming a patch of size 3cm X 2.3cm. Two concentric circular rings were etched out of the patch with outer radius 8.5cm and width 1cm. The width of slit in the outer ring is 2mm and in the inner ring is 1mm . The gap between rings is 0.4mm. It is provided with a feed line of width 0.4mm and length 13mm.

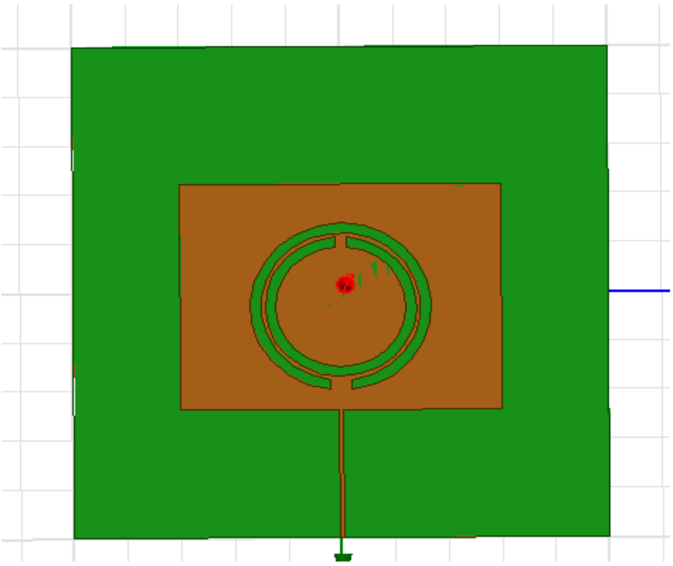

Figure 7: Patch antenna with CSRR on the patch

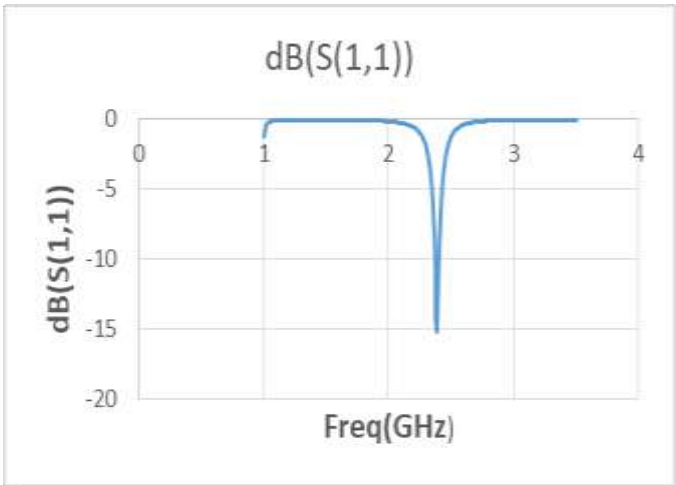


Figure 8: $S_{11}$ characteristics of patch antenna with CSRR on the patch

Figure 7 shows the designed patch antenna with CSRR on the patch.

$S_{11}$ value of -15.19 dB is obtained at a frequency of 2.39 GHz in simulation. Figure 9 shows the measured $S_{11}$ value of the prototype.$S_{11}$ value of -4.5 dB is obtained at a frequency of 2.4 GHz.

The problem with this design is that the width of the feedline is only 0.4mm, so it is difficult to solder connector to feed line. It is also found that the impedance matching is small due to the small width of the feedline. The proposed antenna is fabricated.

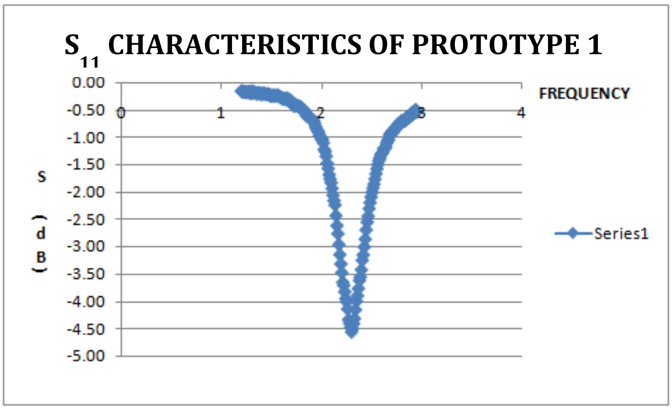


Figure 9: Measured $S_{11}$ Characteristics of Prototype

## 5. MINIATURISED PATCH ANTENNA WITH CSRR ON THE GROUND PLANE

The whole size of the antenna was miniaturized to a value of 2 cm X 2 cm and the patch has a size of 0.8cm X 0.8cm. The CSRR was placed on the ground. Two concentric circular rings were etched out of the ground of outer radius 5cm and width of 1mm. The separation between rings is 0.4 mm. The slit width of the rings is 1 mm. The feedline is capacitively coupled with a separation of 0.4mm from the patch The feed was given as an offset from the middle of the patch. The feed line has a width of 3 mm and a length of 1.6 cm.

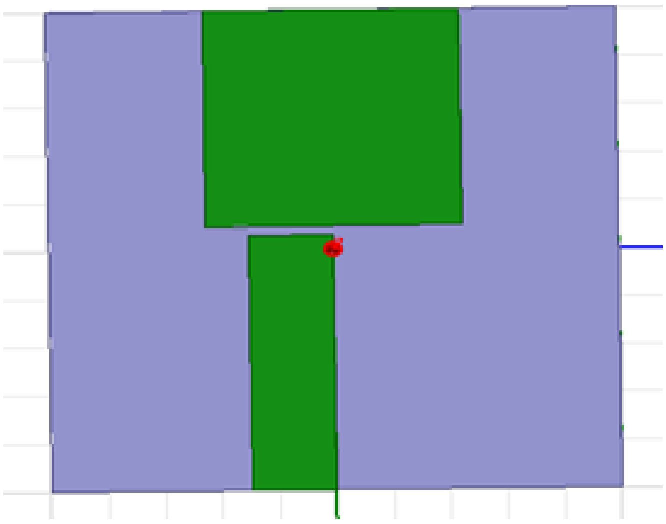

Figure 10: Top view of patch antenna with CSRR on ground plane

Figure 10 and figure 11 shows the top view and bottom view of the designed antenna respectively.

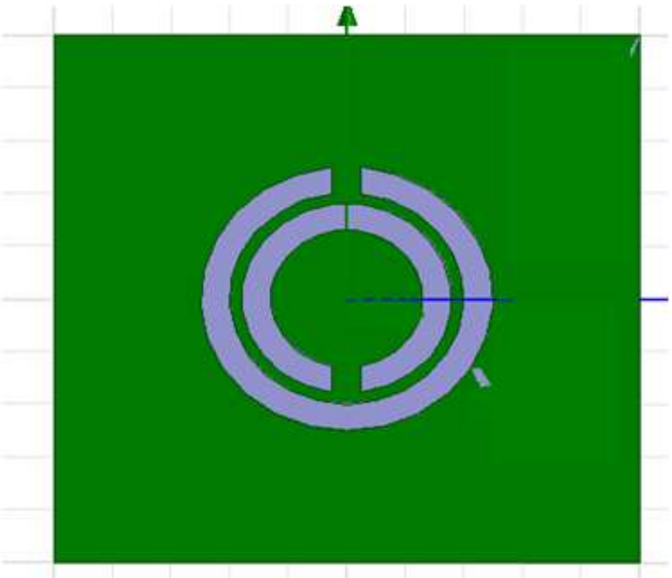

Figure 11: Bottom View of patch antenna with CSRR on ground plane

The simulated $S_{11}$ value of -20 dB is obtained at 2.41GHz.

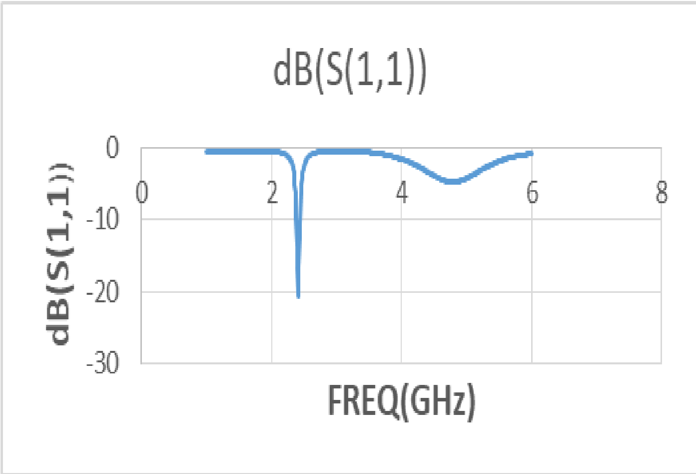


Figure 12: Simulated $S_{11}$ value of patch antenna with CSRR on ground plane

The measured return loss characteristics of patch antenna shown in figure 13. $S_{11}$ value of -8 dB is obtained at a frequency of 2.4 GHz.

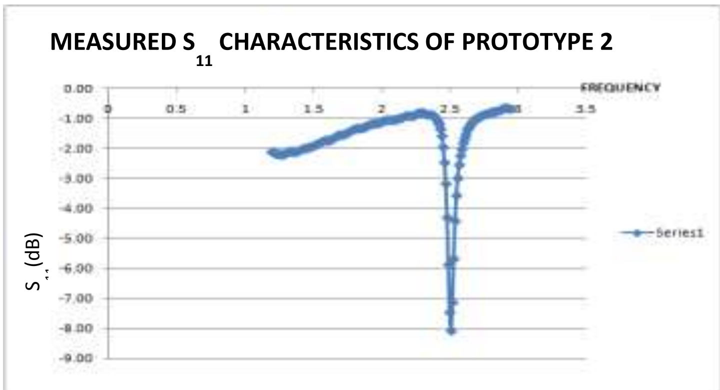


Figure 13: Measured $S_{11}$ characteristics of the patch antenna with CSRR on ground plane

## 6. COMPARISON BETWEEN ORIGINAL PATCH ANTENNA AND FINAL PROTOTYPE

Our project aim is to miniaturise the patch antenna which works at the 2.4GHz. The total size of the ordinary patch antenna was 7cm X 7cm and the CSRR incorporated patch antenna has only a size of 2 cm X 2 cm size. The patch antenna with CSRR on ground plane gives return loss of -20 dB at 2.4 GHz compared to ordinary patch antenna that gives 17.06dB at 2.4GHz. Miniaturisation of about 91% is obtained when the patch antenna with CSRR on ground plane is used.

## 7. CONCLUSION

The project objective was to miniaturize the patch antenna for the 2.4GHz . The objective was met by miniaturizing up to 91% by size. The metamaterials were analyzed and studied. They are a special type of materials which have negative permittivity and permeability which could alter the electromagnetic properties. The antenna was designed and simulated at 2.4GHz with $S_{11}$ value of -20 dB and the antenna fabricated. A measured $S_{11}$ value of -8 dB at 2.4GHz is obtained. The gain enhancement and improved matching could be done as an extension to this project.

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