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# Reconfigurable Microstrip Patch Antenna with SRR Slot with MEMS Switch

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## ABSTRACT

**In this paper reconfigurable microstrip patch antenna with Split ring resonator (SRR) slot with RF MEMS switch is presented. Effective parameters and resonant frequency of SRR are also determined. In addition, to study the effects of various parameters, parametric analysis of antenna are also carried out and design is modified and optimized. Without slot the antenna resonant at 4.75 GHz frequency with a gain of 8.8235 dB. After slotting the antenna resonant at 3.83GHz with a gain of 6.5239 dB. By making switches OFF or ON the antenna tuned from 3.83 GHz to 4.41 GHz frequency. The antenna has a -10dB return loss bandwidths 160 MHz, 80 MHz and 140 MHz respectively.**

**Keywords: Reconfigurable Antenna, microstrip, Split Ring Resonator (SRR), RF MEMS switch.**

## 1. INTRODUCTION

Reconfigurable antenna became a striking topic in the modern wireless communication system because it enables single antenna to be used for multiple systems. Reconfigurability of an antenna means to achieve modification in antenna's operating frequency, polarisation or radiation characteristics dynamically. This modification in characteristics of an antenna is achieved by redistribution of current in antenna. There are many techniques by which we can redistribute the antenna current, either by altering the antenna geometry or by changing the electrical properties of antenna. For this RF switches, varactors, or tunable materials can be used. These concepts of reconfigurability can significantly decrease the complexity of hardware by reducing the number of components [1-5]. Radio frequency micro-electrical-mechanical systems (RF MEMS) fabricated with semiconductor process technology has gained significant attention for wireless communication applications due to their small size and superior performances [6-7]. Compared to PIN diodes and FET transistors, RF MEMS switches have better performance in terms of isolation, insertion loss, power consumption and linearity.

In recent years, to enhance the performance and miniaturize the antenna metamaterial concept is used by using Split ring resonator (SRR) or Complementary Split ring resonator (CSRR). The main difference between SRR and CSRR is that SRR has negative permeability characteristics; while CSRR has negative permittivity characteristics [8-11].

In this paper, reconfigurable microstrip patch antenna with Split ring resonator (SRR) slot with RF MEMS switch is presented. SRR is used to reduce the size of an antenna. Finite element based electro-magnetic mode solver Ansoft HFSS is used for analysis of the antenna and optimization of its geometrical parameters.

This paper is organized as follows: section 2 shows the determination of effective parameters of SRR. In section 3, the geometry of proposed antenna is discussed. Parametric study of antenna is presented in section 4. Section 5 shows the optimal parameters and simulation results. Section 6 gives conclusion of this work.

## 2. DETERMINATION OF EFFECTIVE PARAMETERS OF SRR

The geometrical parameters of unit cell of SRR as shown in Fig.1 are optimized to get desired negative permeability and refractive index at certain frequency range. Rogers RT/duriod5880 of thickness 0.3198 cm with relative permittivity of 2.2 is used as substrate. The dimensions of SRR are:
Length of SRR $L_{srr}$ = 2.0 cm,
Width of SRR $W_{srr}$ = 1 cm
Width of each ring w = 0.1 cm,
Separation between inner and outer ring s = 0.1 cm,
Split width in each ring g = 0.2 cm.

To show the physical properties of the designed optimized SRR structure, the structure was placed in two port waveguide formed by a pair of both perfect magnetic conductor (PMC) walls in z-direction and perfect electric conductor (PEC) walls in y-direction. The whole structure is excited by an electromagnetic wave with propagation vector in x- direction. By using HFSS software S parameters are obtained and effective permeability is extracted by using effective parameter retrieval method [12].

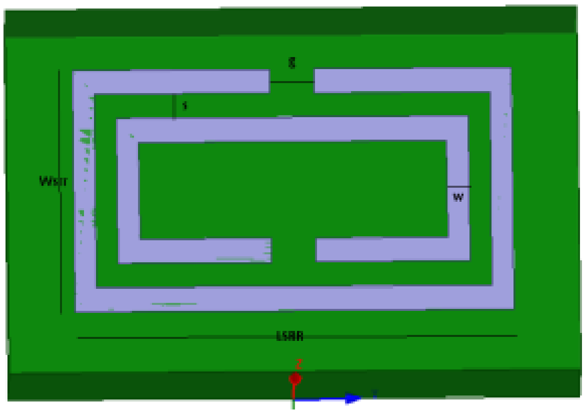


**Figure 1: Structure of Unit Cell of Split Ring Resonator**

The S-parameters and its corresponding phases of SRR are shown in Fig.2 and 3. Retrieved effective parameters (permeability and refractive index) of SRR are shown in Fig 4 and 5.

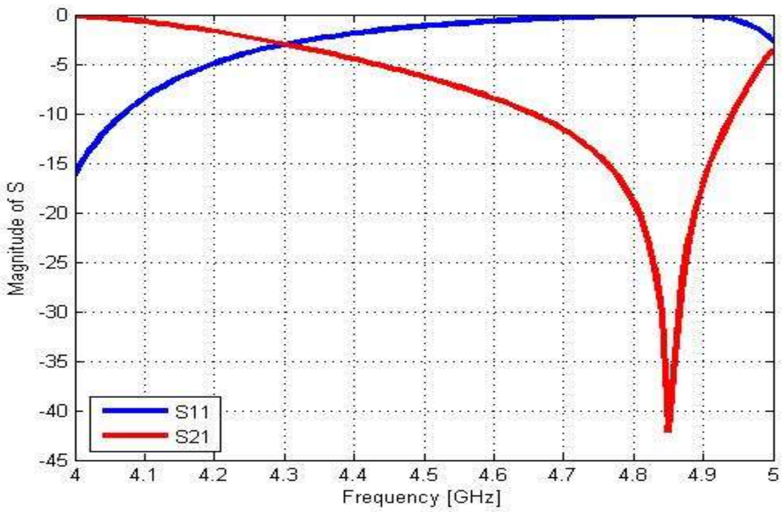


**Figure 2: S parameters of S11 and S21 (dB)**

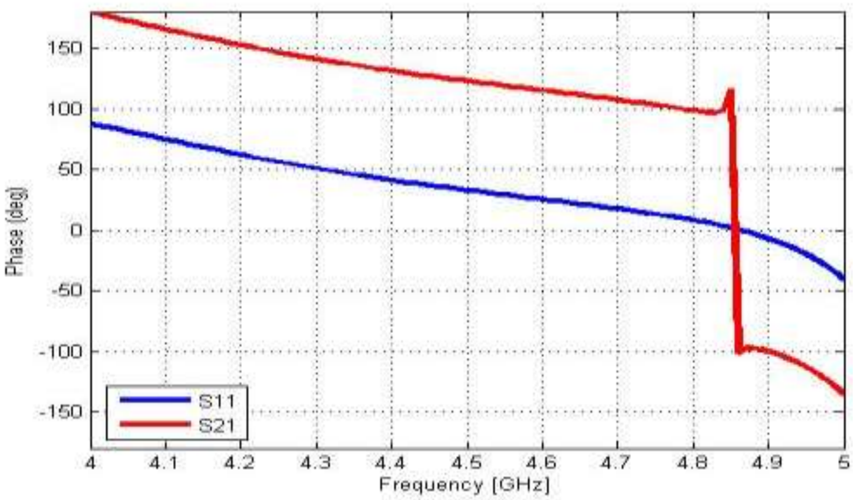


**Figure 3: Phase of S11 and S21 (deg)**

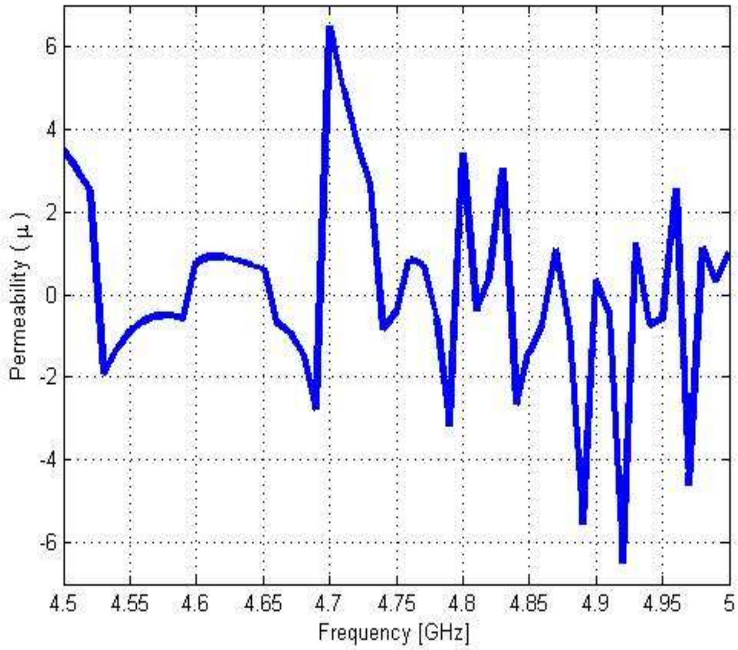


**Figure 4: Extracted Permeability of SRR**

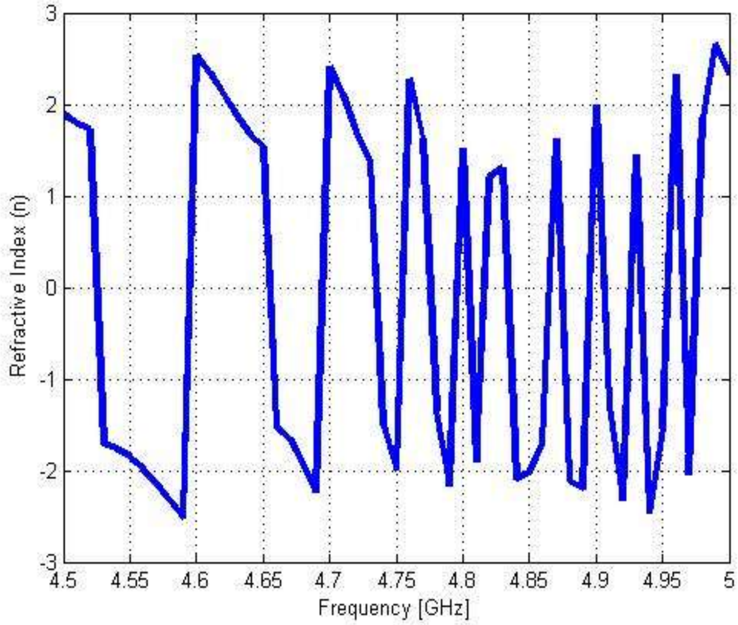


**Figure 5: Extracted Refractive Index of SRR**

## 3. DESIGNING OF PROPOSED ANTENNA

The proposed reconfigurable microstrip patch antenna with Split ring resonator (SRR) slot with RF MEMS switch is shown in Fig.6. The antenna is printed on Rogers RT/duriod 5880 substrate of thickness 0.3198 cm with relative permittivity of 2.2. Patch antenna is 4 X 3 $cm^2$ in dimensions. Patch antenna is fed by probe feeding. The SRR slot is cut in the patch antenna such as the feeding point lies between the split gap of inner ring of SRR. RF MEMS switch is used in such a way so that the effective length of the radiating patch is shorter in the case of the ON mode than in OFF mode, which leads to a resonant frequency in the ON case higher than the OFF mode.

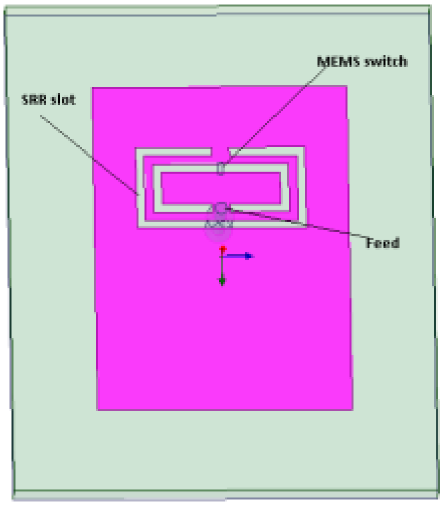


**Figure 6: Structure of proposed reconfigurable microstrip patch antenna with SRR slot with MEMS switch**

The ON state of MEMS switch is implemented by presence of a metal plate, whereas OFF state of MEMS switch is implemented by no plate.

## 4. PARAMETRIC STUDY OF ANTENNA

Two parametric analysis of proposed antenna has been done which are presented in following subsections.

### 4.1 Effect of Length of SRR ($L_{SRR}$)

Length of SRR is varied while keeping other dimensions of the antenna (as given above) fixed and RF MEMS switch is kept OFF. Fig. 7 shows the return loss of the antenna for various values of $L_{SRR}$. It can be seen that as length of SRR increases, resonant frequency of antenna decreases. Similar results are obtained when the RF MEMS switch is kept ON, as shown in Fig.8.

### 4.2 Effect of split width of SRR (g)

Split width of SRR is varied while keeping other dimensions of the antenna fixed and RF MEMS switch is kept OFF. Fig. 9 shows the return loss of the antenna for various values of g. It can be seen that as split width of SRR increases, the resonant frequency of antenna decreases. Similar results are obtained when the RF MEMS switch is kept ON, as shown in Fig.10.

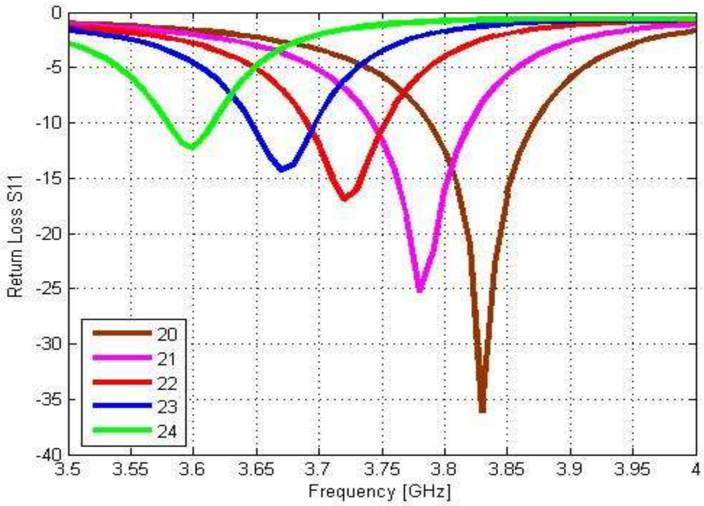


**Figure 7: Return Loss for different value of $L_{SRR}$ when the switch is OFF.**

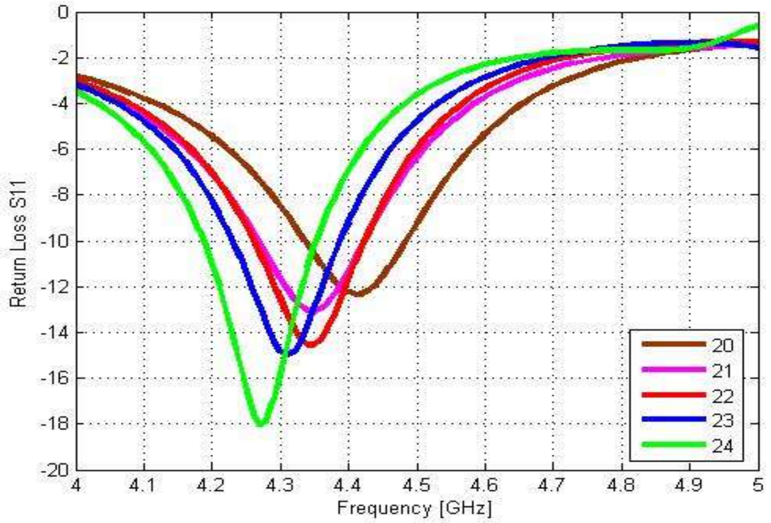


**Figure 8: Return Loss for different value of $L_{SRR}$ when the switch is ON.**

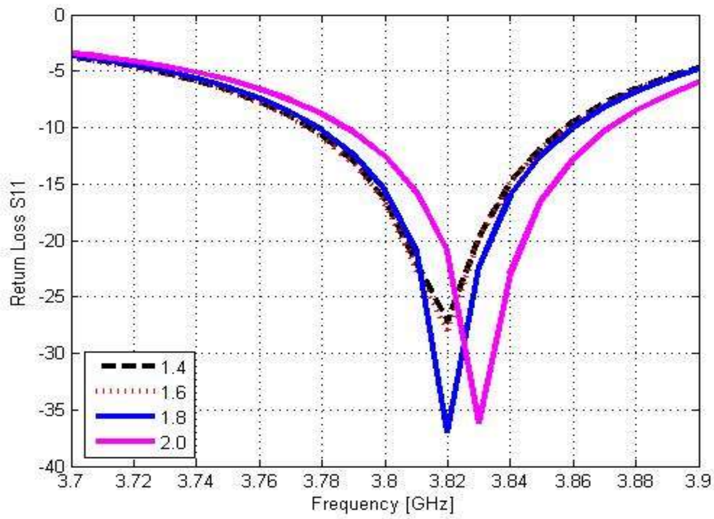


**Figure 9: Return Loss for different value of g when the switch is OFF.**

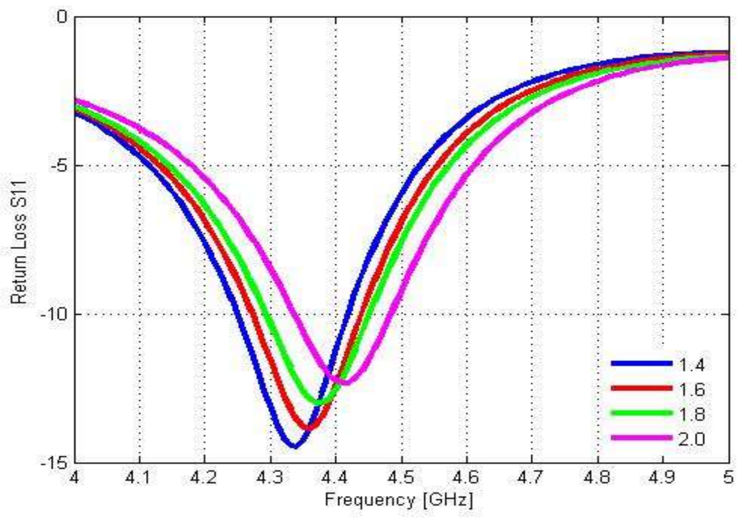


**Figure 10: Return Loss for different value of g when the switch is ON.**

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## 5. ANTENNA WITH OPTIMIZED PARAMETERS AND SIMULATION RESULTS

The antenna is simulated without slot. Fig.11 shows the return loss of unslotted patch antenna. The antenna resonant at frequency 4.75 GHz with a gain and -10dB B.W. of 8.8235 dB (Fig. 12) and 160 MHz respectively. The slotted antenna is designed with optimized slot parameters: $L_{srr}$ = 2.0 cm, $W_{srr}$ = 1cm, w = 0.1 cm, s = 0.1 cm, g = 0.2 cm. When the switch is in OFF state, the slotted antenna resonant at frequency 3.83 GHz (Fig. 13) with a gain and -10dB B.W. of 6.5239 dB (Fig. 14) and 80 MHz respectively.

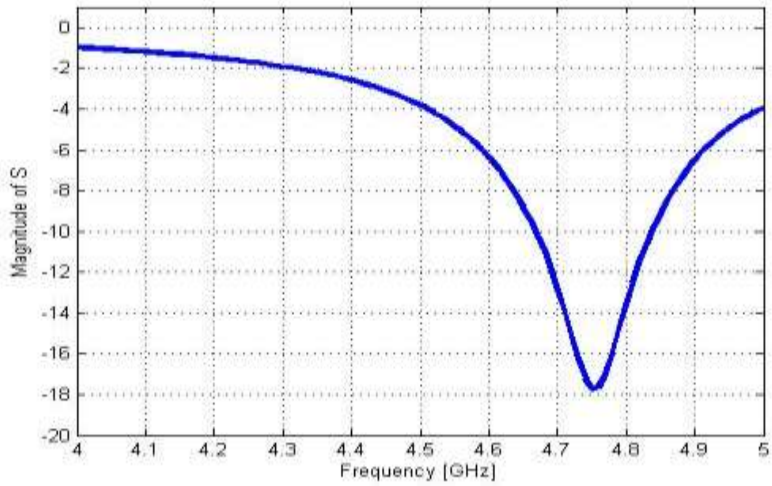


**Figure 11: Return Loss S11 (dB) of Unslotted patch antenna**

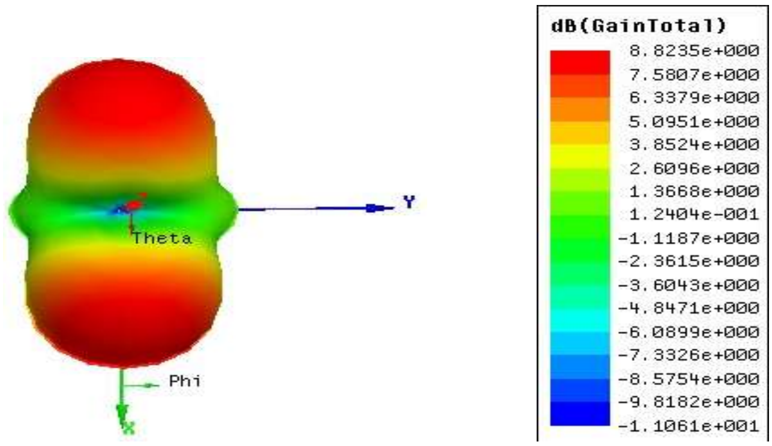


**Figure 12: Gain (dB) of Unslotted patch antenna**

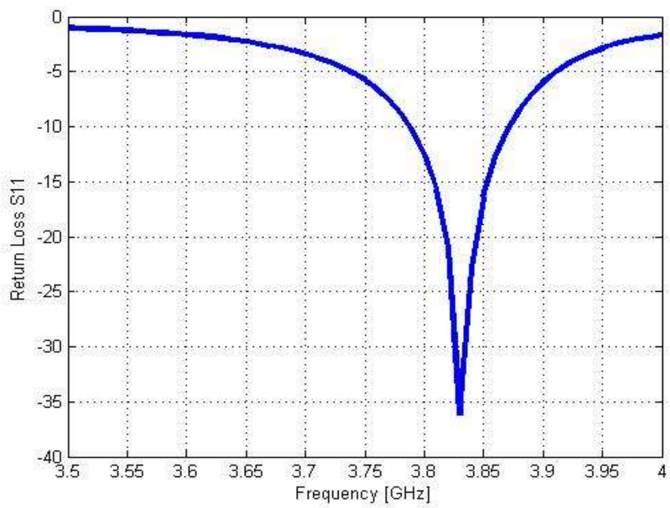


**Figure13: Return Loss S11 (dB) of SRR slotted patch antenna with RF MEMS switch in OFF state.**

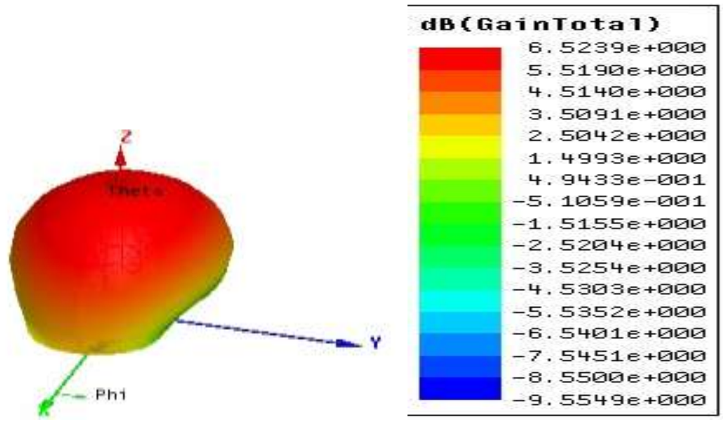


**Figure 14: Gain (dB) of SRR slotted patch antenna with RF MEMS switch in OFF state.**

While, when the switch is in ON state, the slotted antenna resonant at frequency 4.41 GHz (Fig. 15) with a gain and -10dB B.W. of 7.3479 dB (Fig. 16) and 140 MHz respectively.

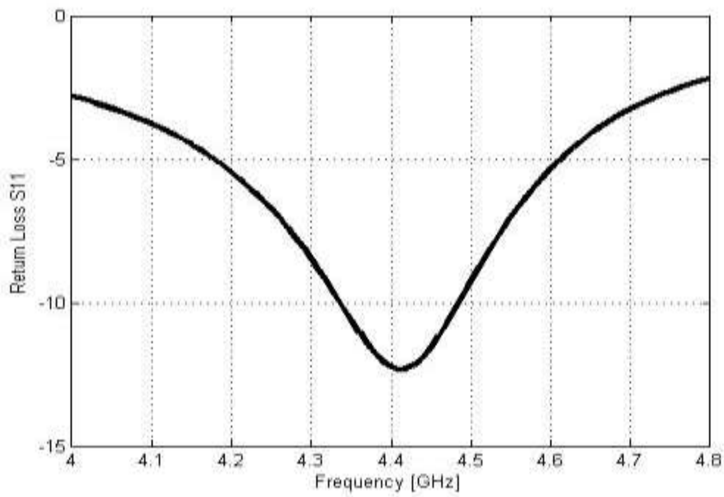


**Figure 15: Return Loss S11 (dB) of SRR slotted patch antenna with RF MEMS switch in ON state.**

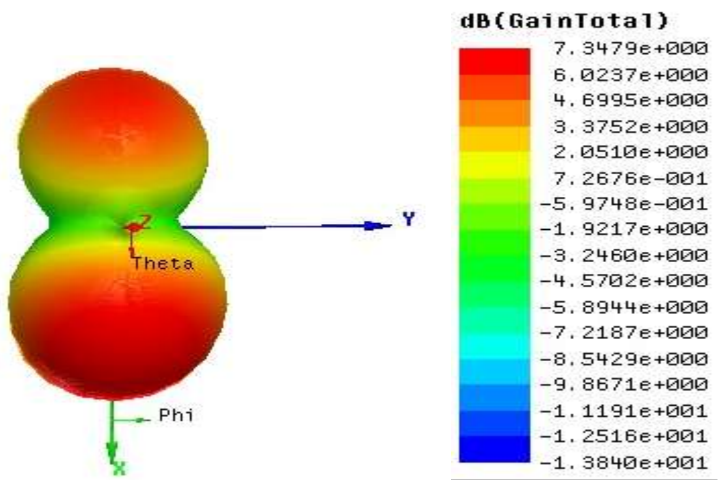


**Figure 16: Gain (dB) of SRR slotted patch antenna with RF MEMS switch in ON state.**

## CONCLUSION

A novel reconfigurable microstrip patch antenna with switchable Split ring resonator (SRR) slot has been designed. By making switch OFF or ON the resonant frequency of antenna can be switched from 3.83 GHz to 4.41 GHz.

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