Antenna Design and Optimization for RFID tag using Negative μ and ε Material

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ABSTRACT

RFID is one of the implementations under auto- identification techniques. In RFID there are mainly three parts. The three parts are tag, reader and the host. The tag consists of an Application Specific Integrated Circuit (ASIC) chip on it. The reader sends an electromagnetic signal to the passive tag and on receiving the signal the tag activates its chip and sends the modulated data to the reader. After that the reader demodulates the data and receives it. Generally we make use of rectangular patch antenna in RFID devices. Most important parameters of an RFID antenna are radiation, directivity, bandwidth, return loss etc. So for improving the above mentioned characteristics we have incorporated a meta-material structure (split ring resonator) within the patch. The permittivity and permeability of meta-material structures depends on the shape rather than the composition. Thus we can exploit different shapes of this material to obtain much efficient results. In this way after simulation we obtained higher bandwidth, gain and increased number of radiating bands than the previous results. This result has paved the way to develop resourceful antennas which can revolutionize the field of RFID.

***Keywords:** Radio frequency identification, split ring resonator, application specific integrated Circuit, ultra high frequency.*

1. INTRODUCTION

The use of Radio Frequency Identification (RFID) has grown exponentially in many fields like animal tracking, vehicle tracking, manufacturing company, business etc. The RFID consist of a reader, a several tags around the reader and the host [1]. The tag consists of a chip on it. The tag may be passive or it may be active. In active tag, it consists of an internal battery which activates the chip of the tag. In passive tag the chip is activated by the electromagnetic wave which is sent by the reader to the tag to collect the data. A transmit and receive antenna is connected to the reader and the tag also has a single antenna for transmitting and receiving. In passive tag the reader sends a electromagnetic wave to the tag with the help of an antenna and on receiving the wave the tag activates its chip. After that tag modulates the signal and sent the data to the reader. On receiving this signal the readers demodulates the signal and receive it [2]. The Amplitude Shift Keying (ASK) modulation technique is used by the tag. Hence by changing the input impedance of the tag, it is able to send two backscattered signal. One backscattered signal corresponds to binary 0 and another one corresponds to binary 1. By using timing information between the the two backscattered signal, the tag is able to transmit the data to the reader. In the below figure we give an overview of a passive RFID system [3].

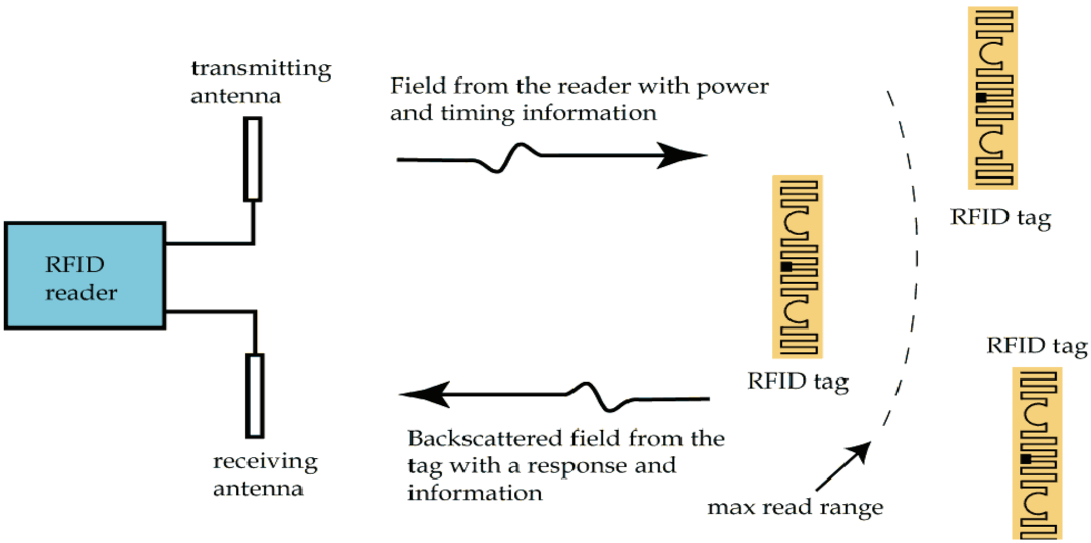

Figure1: Overview of a passive RFID system

For transmit and receive the signal in RFID technology antenna plays a crucial role. So we have to design an effective and efficient antenna. The main parameter of antenna on which its performance depends are return loss, beamwidth, bandwidth, axial ratio, gain and size [4]. In this paper first of all we design a general rectangular patch antenna and we simulate the design and got some result. The metamaterial such as Split Ring Resonator (SRR) has the property of negative permeability and permitivity. If both the permeability and permittivity are negative then the composite posses an negative index of refraction for isotropic medium [5, 6]. The metamaterial based antenna is used to improve the read range and reduce the size of the tag and also increase the bandwidth, gain of the antenna [7]. Hence in the consecuitive step we design a U shape SRR on the rectangular antenna to enhance the gain and bandwidth of the antenna.

General consideration in RFID for tag antennas

The RFID system works on Low Frequency (LF), High Frequency (HF), Ultra High Frequency (UHF) and microwave frequency band. But LF and HF has low data rate and reading range also not so long. UHF has high data transmission rate and reading range is also large [8].The reader is connected to an antenna with fixed gain and the tag also has an antenna with a fixed gain. There are vast numbers of factors on which performance of tag depend .But we concentrate on the following two performances [9, 10]:

- Tag sensitivity
- Tag range

Tag Sensitivity- Tag sensitivity is related with the forward link that when reader transmits its signal to the tag and tag sensitivity is the minimum power /field required by the reader to read the tag at the location of tag. It is a function of tag sensitivity threshold power, tag antenna gain and match between tag antenna and power collecting state of the chip. The tag sensitivity (Ptag) is given by

Ptag= Pth G p z (1)

Where Pth is threshold power to activate the chip, G is the gain of tag antenna, p polarization efficiency, z is matching between chip and tag antenna.

Tag Range-Tag range is defined as the maximum distance at which tag can read. Is is a function of Equivalent Isotropic Radiated Power (EIRP) transmitted by the reader and tag power. The tag range (Rtag) is given as below-

Rtag= (lamda/4π)$\sqrt{EIRP}/\sqrt{Ptag}$...... (2)

Where Ptag is the tag power.

Thus in RFID system it is very desirable to achieve largest possible read range.

2. ANTENNA MODELING AND SIMULATION

Initially we designed a rectangular patch antenna having substrate Roger RT/Duroid5880(tm) with dielectric constant ε_r=2.2.The patch and the ground plane are separated by dielectric material or substrate. The patch may be circular, square or rectangular. But we designed the rectangular patch on the substrate and simulation was carried out on HFSS (High Frequency Structure Simulator) software. The patch we designed having length (L) = 12.45mm, width (W) =16mm, height (H) =0.05mm. The insert feed method is used to enhance the bandwidth and gain of the antenna. The various parameters like return loss, smith chart and gain are given in the following figures.

In the next step, we make some improvement by introducing a metamaterial on the patch of U-SRR shape. The dimension of the metamaterial is of thickness of the ring= 2.23mm, size of the structure= 8.46mm×4mm, width of the ring = 4mm, ring gap= 2.46mm.Again we doing the same simulation and got some effective result. The bandwidth and gain of new structure increases by manifold. The smith chart also good impedance matching property.

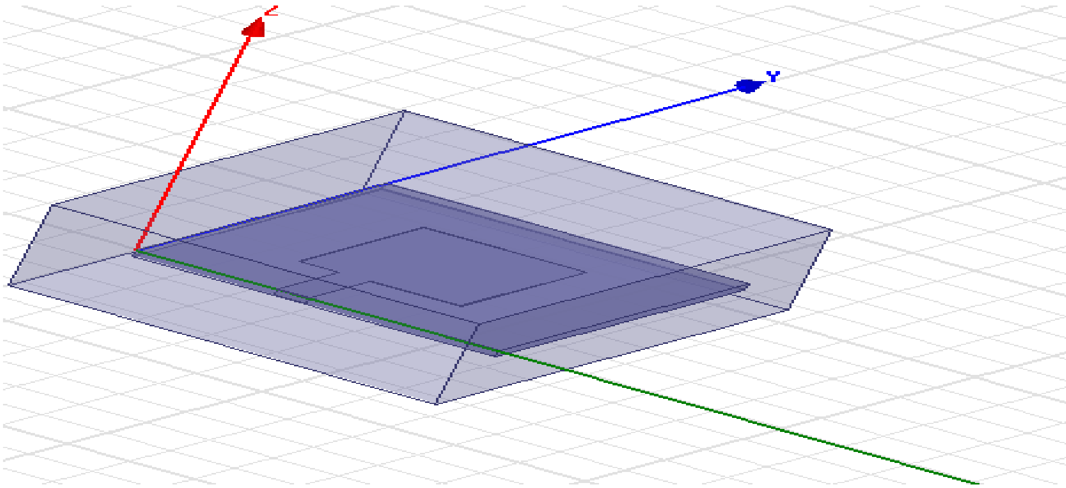

Figure 2: Model of rectangular patch antenna

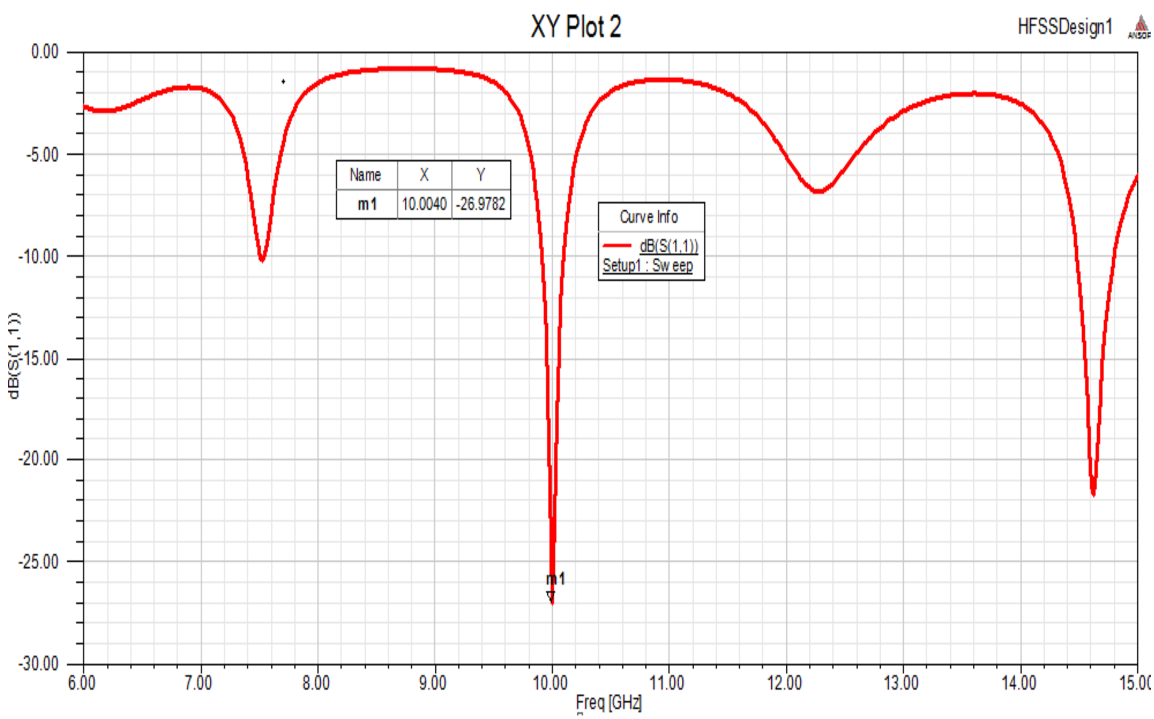

Figure3:S11 parameter of rectangular patch antenna

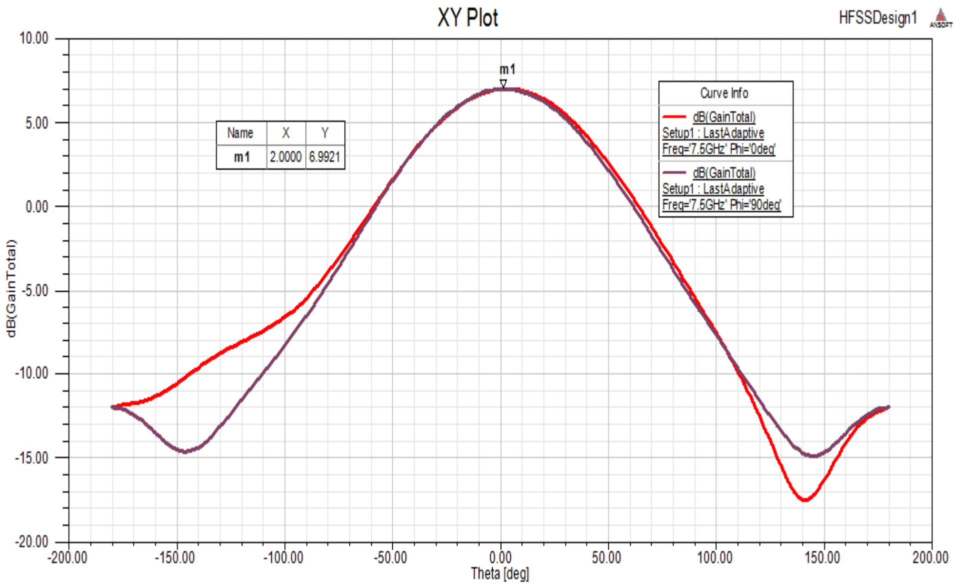

Figure4: Gain of rectangular patch antenna

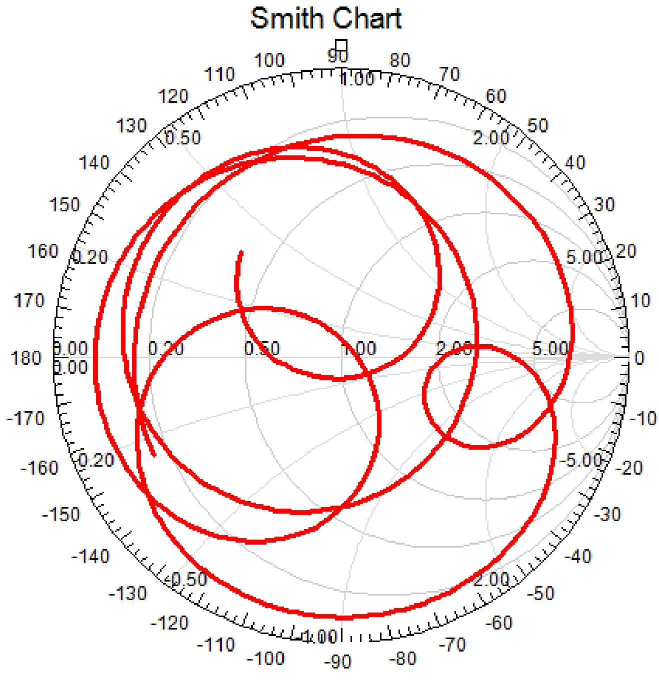

Figure5: Smith Chart of rectangular patch antenna

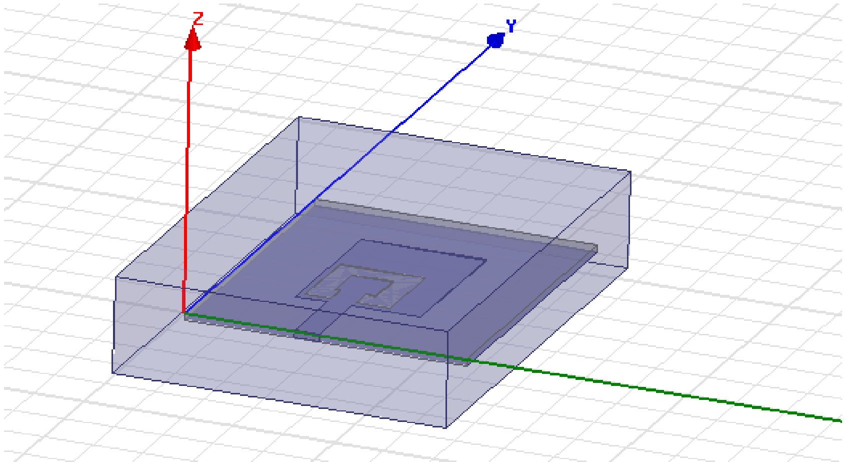

Figure 6: Model of rectangular patch antenna with metamaterial

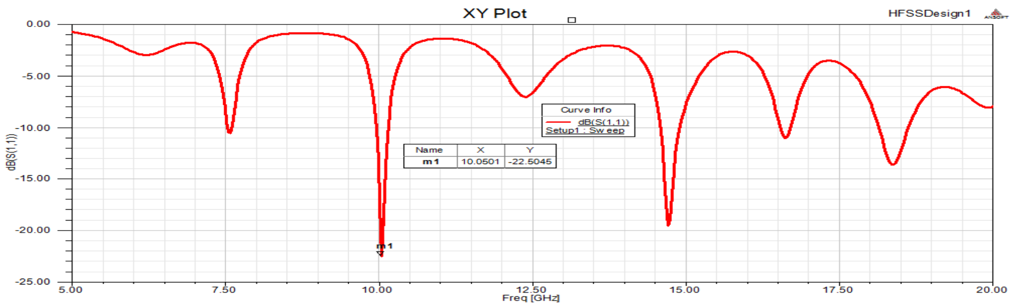

Figure7: S11 parameter of rectangular patch antenna with metamaterial

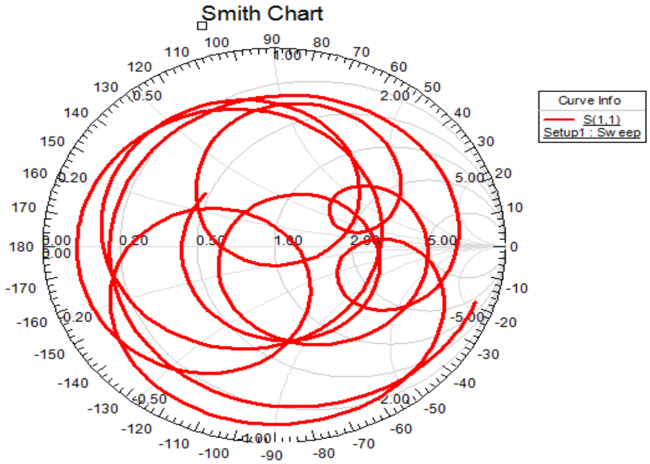

Figure8: Smith Chart of rectangular patch antenna with metamaterial

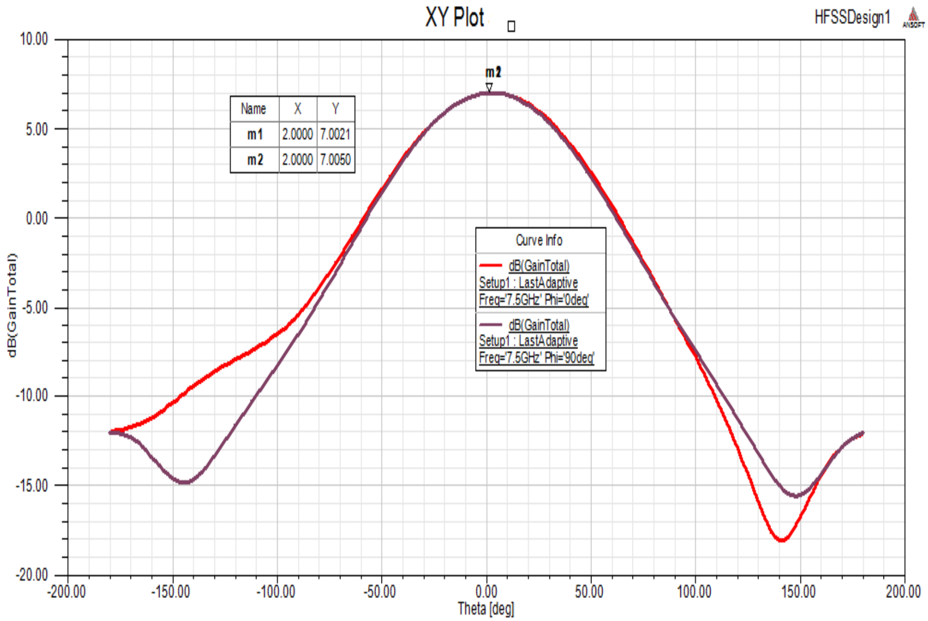

Figure9: Gain of rectangular patch antenna with metamaterial

3. RESULT AND DISCUSSION

Metamaterial structure is so much effective for getting better performance. The return loss (S11) of the normal patch antenna at resonance frequency is -26.9782dB (as shown in figure 3) and return loss with metamaterial U-SRR structure at resonance frequency -22.5045dB (as shown in figure 7). The gain of the metamaterial structure (as shown in figure9) increases and bandwidth also increases. The smith chart as given in figure 8 also shows some good result. Hence by using the metematerial structure (shown in figure 6) we can enhance the gain and bandwidth by compensating return loss.

4. CONCLUSION

In this paper first of all we discussed about introduction of RFID technology and after that we also discussed about general consideration for designing RFID tag antennas. Normally patch antenna is used as a tag antenna in RFID. Hence initially we designed a normal rectangular patch antenna. But we can enhance the gain and bandwidth of the RFID system if we design some metamaterial structure in the patch. So in the consecutive step we designed a U- SRR shape and simulate the design. We got some effective result and this type of antenna can be used for tag.

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