Current Analysis Rectangular Multiband Antenna eith Split Ring Resonator

Ms. Shital S. Bramhe1 Mr. Ketan Machhale[2] Ms. Dhanashree Tajne[3] Mr. Pranav Kothe[4]
[1,2,3,4]Department of Electronics and Telecommunication Engineering
[1,2,3,4]RGCER, Nagpur Maharashtra, India

Abstract— The proposed rectangular microstrip-feed antenna consists of split ring resonator for different application. The proposed antenna uses FR-4 substrate having thickness of 1.6mm and dielectric constant of 4.4. By using split ring resonator multiband antenna is designed. The antenna has resonating frequencies 2.35GHz, 2.75GHz, 4.48 GHz, 5.28 GHz which operates for ISM (industrial scientific medical), Bluetooth, wimax, WLAN respectively. The proposed antenna was designed by using software HFSS 13.0 (Higher frequency simulation software).

Key words: Rectangular Antenna, Split Ring Resonator

I. Introduction

Multiband band antenna received a lot of attention due to rapid growth in wireless communication area. Recent trends have seen the development of wideband antennas, multi-band antennas or reconfigurable antennas receiving much attention to fulfil different applications in just one single terminal. Single terminals or devices could have many applications such as, GPS, GSM, and WLAN etc.

A simple and successful dual band patch linear polarized rectangular antenna design is presented by Noelia Ortiz, Francisco Falcone, and Mario Sorolla. The dual band antenna is designed etching a complementary rectangular split-ring resonator in the patch of a conventional rectangular patch antenna.[1]

Rectangular Microstrip Patch Antenna (RMPA) along with metamaterial which has Square Split Ring Resonator (SSRR) with Horizontal Rectangular Strip (HRS) structure is proposed. It is clearly observed that the antenna gain and bandwidth has improved significantly by employing proposed SSRR [2]

The analysis and design of a novel multi-band and miniature microstrip antenna for wireless communication is presented. For this antenna, a sufficient band-width was achieved by utilizing various techniques.[3]

Metamaterial properties are particularly used for miniaturization of the antenna. A compact split ring resonator loaded antenna is presented.[4]

The designed antenna consists of two SRRs, with the same geometrical parameters, printed symmetrically on both sides of the dielectric substrate. Excitation of the SRR element is performed by adequately placing the access microstrip lines. [5]

In this paper, an electrically small dual-band microstrip antenna has been presented which is based on Complementary split ring resonators. The patch is loaded with side-by-side complementary split-ring elements which are used as the main radiator of the antenna and microstrip line feeding has been used.[6]

Metamaterials are artificially structured materials especially constructed to interact with electromagnetic waves so as to control their propagation characteristics. Usually incorporating concentric split-ring resonators (SRR), such materials can exhibit electric permittivity and magnetic permeability both simultaneously negative due to the electric and magnetic responses to an incident electromagnetic wave. Magnetic resonance is induced by the slits and by the separation region between the inner and outer rings, which behave as capacitive elements. Owing to the resonant behavior of the rings, such a structure can support wavelengths much larger than the dimension of the rings.[7]

II. Objective

The objective is to design multiband antenna for different applications. Theoretically, it is expected that fabricate antenna has

VSWR in the range 1 < V < 2

Return loss less than -10dB

A. *Design Procedure Of Antenna*

1) *Effective Dielectric Constant*

The proposed glass shaped antenna is shown in Fig. 1, and the design parameters were calculated using the following steps:

$$\varepsilon_{ff} = \frac{\varepsilon_r + 1}{2}$$

$\mathcal{E}ff = 2.7$

$$k = \sqrt{\mathcal{E}ff}$$

k=1.64

For FR4 substrate with volume 35mm×47mm×1.6mm., eff=2.7.

2) *Microstrip Line Width (WSTRL)*

The microstrip line width has been calculated from the following equation

$$Z_0 = \frac{\sqrt{87}}{\sqrt{\varepsilon r + 1.41}} \ln\left(\frac{5.98h}{0.8Wstrl + t}\right)$$

Where Z0 is the characteristic impedance of the microstrip line, h is the substrate thickness which has been taken 1.6mm as a typical value, t is the metallization thickness which is 0.035mm, Wstrl is the microstrip feed line width and *Er* for FR4 substrate is 4.4. Therefore according to equation (3), for the characteristic impedance of 50Ω.Wstrl approximately equal to 3mm.

III. Geometry of an Antenna and Simulation Results

A. Geometry of Rectangular Patch Antenna and Simulation Results

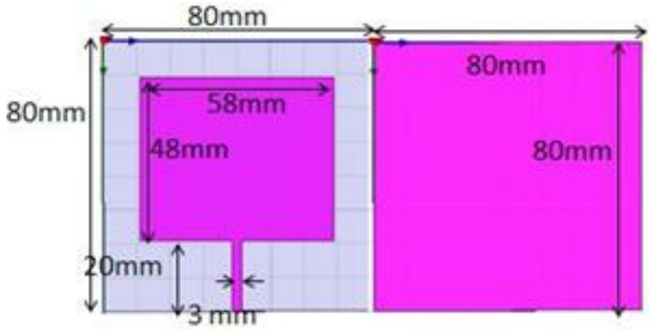

Fig. 1: Geometry of designed Rectangular patch antenna

The proposed Rectangular patch antenna can be designed by using finite ground plane which is shown in Fig.1. The length and the width of the dielectric substrate are 80x80 mm. The width of the microstrip feed line is fixed at 3mm to achieve 50Ω impedance. From the simulated result, a narrow impedance bandwidth of about 40MHz (2.39-2.43 GHz) has been achieved. This antenna mainly has the application in Industrial scientific and medical (ISM) band. Minimum return loss is equal to -22.30db at resonance frequency of 2.411GHz.

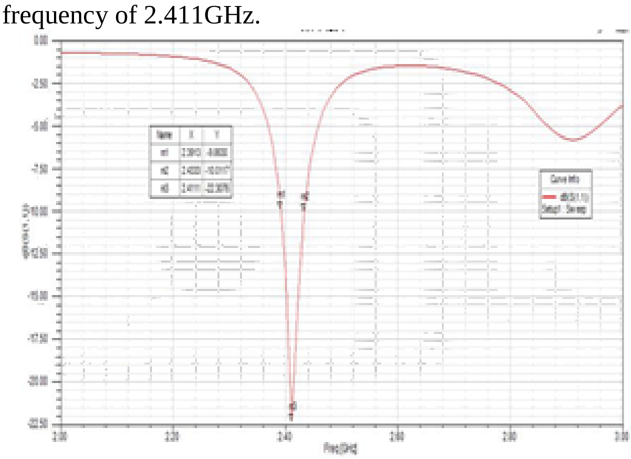

Fig. 2: Reflection coefficients [dB] versus frequency [GHz]

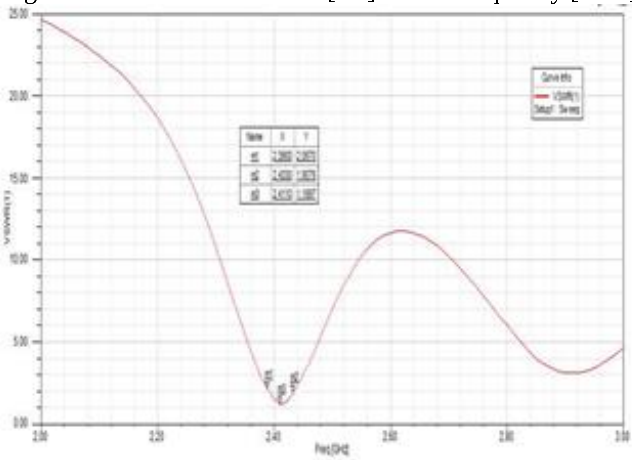

Fig.3: VSWR versus frequency [GHz]

From the VSWR, same narrow impedance bandwidth of about 40 MHz has been achieved

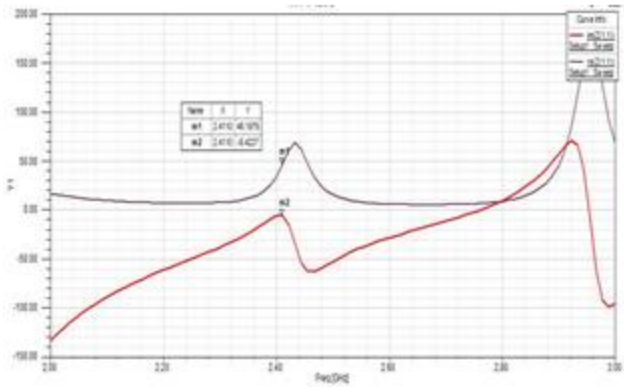

Fig. 4: Real and Imaginary Impedance Versus Frequency [GHz]

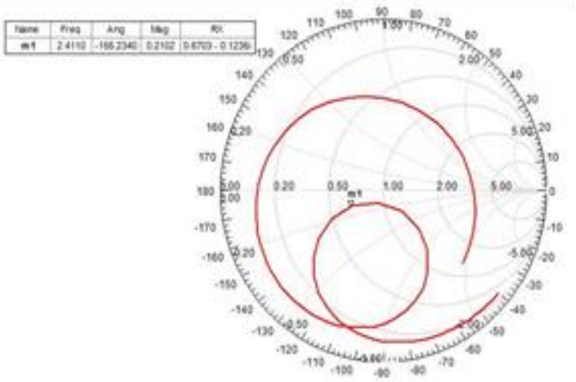

Fig. 5: Smith chart

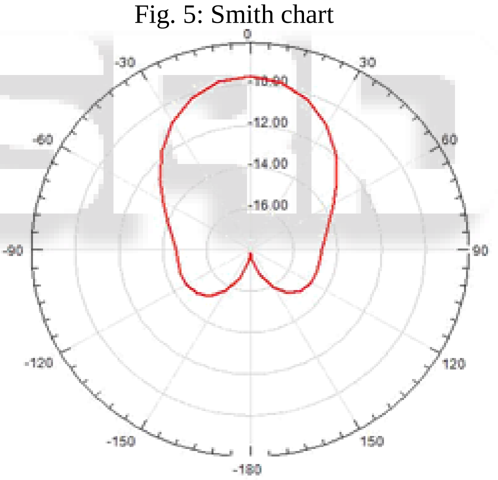

Fig. 6: 2D radiation pattern at 2.411 GH

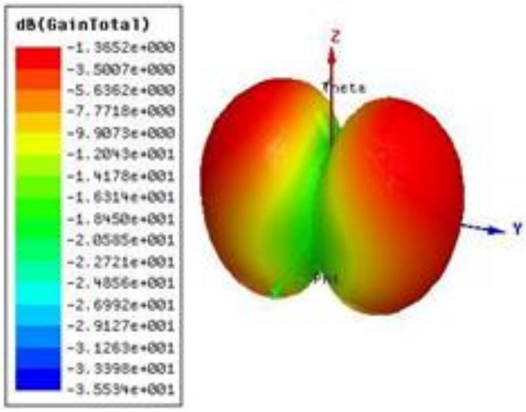

Fig. 7: 3D radiation pattern at 2.411 GHz

3D pattern is approximately directional and 2D pattern shows vertical pattern at theta =90 degree , phi=90 degree .

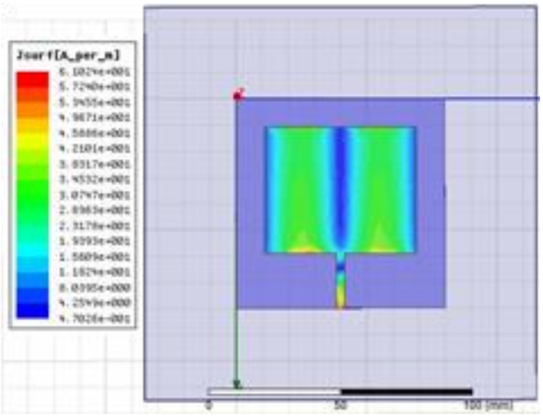

Fig. 8: Surface current distribution at 2.411 GHz

Above figure shows current distribution at resonance frequency of 2.411 GHz, Maximum current distribution is at feed line near to port.

Antenna performance parameters	Rectangular patch antenna
Frequency range	2.39GHz – 2.433GHz
BW	40MHz
Resonance Frequency	2.411GHz
Return loss	-22.30db at 2.411GHz,
Impedance	49.16Ω at 2.411GHz
Gain (db)	1.36db at 2.411GHz

Table 1: performance parameters Rectangular patch antenna

Table 1 shows the antenna performance parameters of Rectangular patch antenna.

B. Geometry Of Rectangular Patch Antenna With Split Ring Resonator And Simulation Results

This antenna is modified by incorporating split ring resonator in patch. By appropriate position and dimension of split ring resonator the antenna works as a multiband antenna.

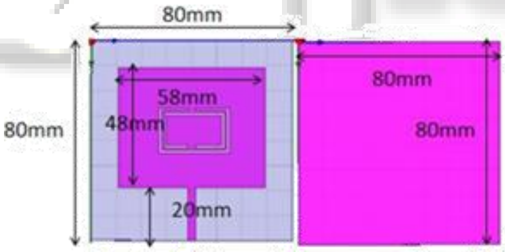

Fig. 9: Geometry of Rectangular patch antenna with split ring resonator

The multiband antenna with split ring resonator shown in fig 9.

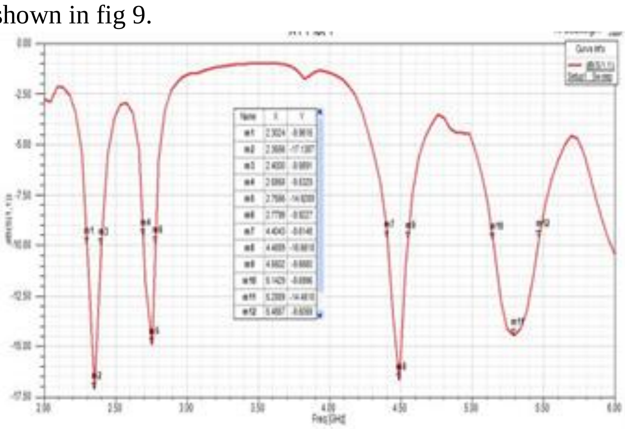

Fig. 10: Reflection coefficient [dB] versus frequency [GHz]

Rectangular patch antenna with split ring resonator is multiband antenna. This antenna mainly operates in four different band which has four application. Antenna operates in frequency range of 2.30GHz to 2.4GHz, 2.69GHz – 2.77GHz, 4.48GHz – 4.55GHz, 5.14GHz – 5.46GHz.

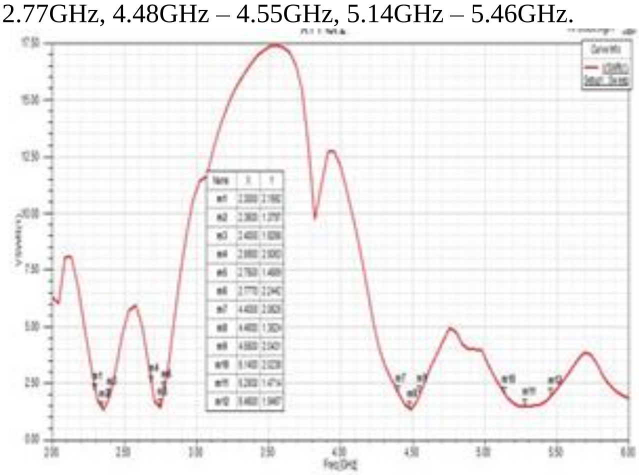

Fig. 11: VSWR versus frequency [GHz]

Antenna operates in frequency range of 2.30GHz to 2.4GHz, 2.69GHz – 2.77GHz, 4.48GHz – 4.55GHz, 5.14GHz – 5.46GHz has VSWR values between 1 to 2.

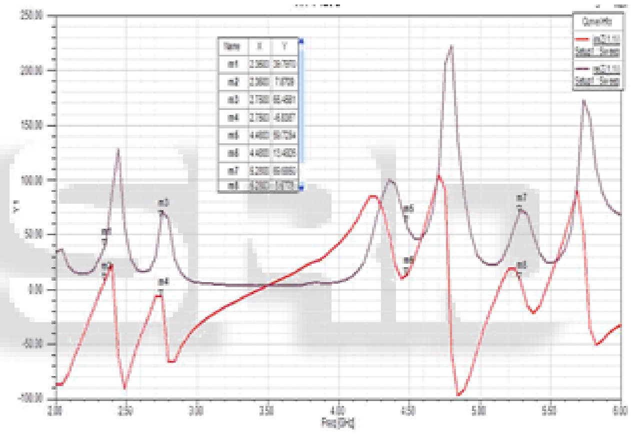

Fig. 12: Real and imaginary impedance versus frequency [GHz]

39.79 ohm impedance and 7.87mho reactance has achieved at resonance frequency 2.35GHz which nearly equal to expected values 50ohm and 0mho respectively and has the application in ISM band.

65.45 ohm impedance and -6.83mho reactance has achieved at resonance frequency 2.75GHz which nearly equal to expected values 50ohm and 0mho respectively and has application Bluetooth.

59.72 ohm impedance and 13.49mho reactance has achieved at resonance frequency 4.48GHz which nearly equal to expected values 50ohm and 0mho respectively and applicable for Wimax.

69.68 ohm impedance and 8.57mho reactance has achieved at resonance frequency 5.28GHz which nearly equal to expected values 50ohm and 0mho respectively and has application in WLAN range.

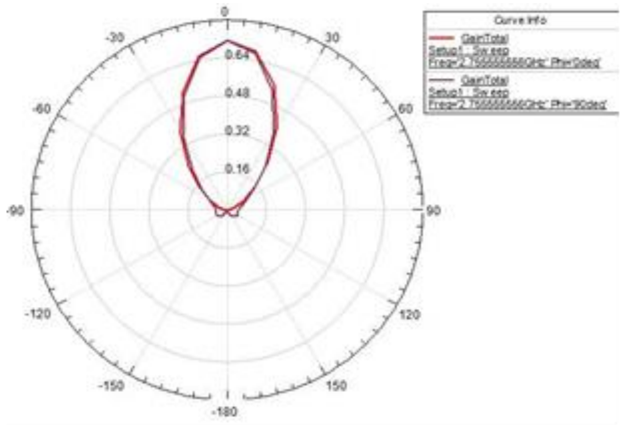
Fig. 13: Radiation Pattern at 2.411GHz

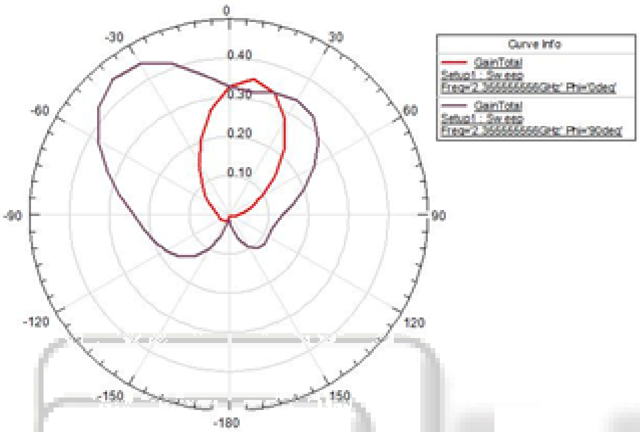
Fig. 14: Radiation Pattern at 2.75GHz

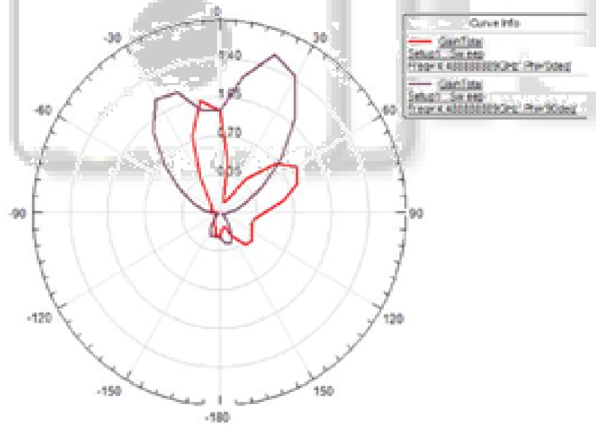
Fig. 15: Radiation pattern at 4.48GHz

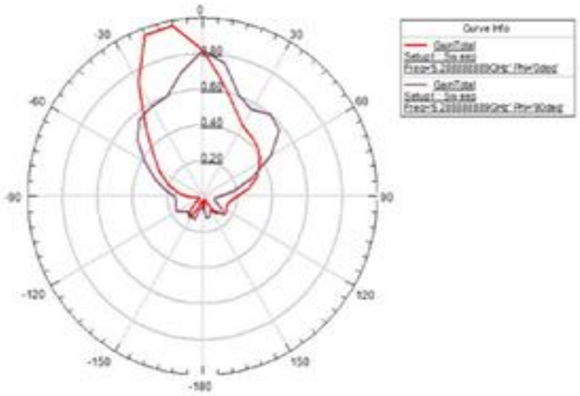
Fig. 16: Radiation Pattern at 5.28GHz

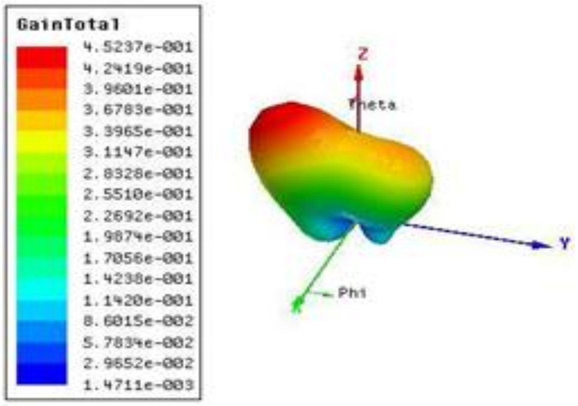

Fig. 17: 3D radiation pattern at 2.35GHz

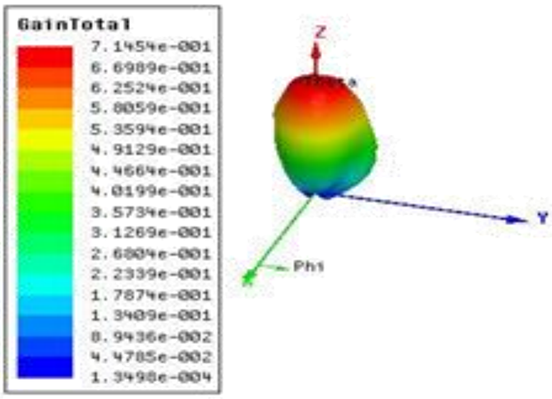

Fig. 18: 3D radiation pattern at 2.75GHz

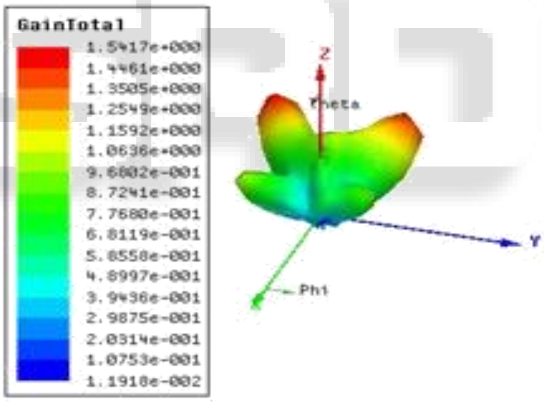

Fig. 19: 3D radiation pattern at 4.48GHz

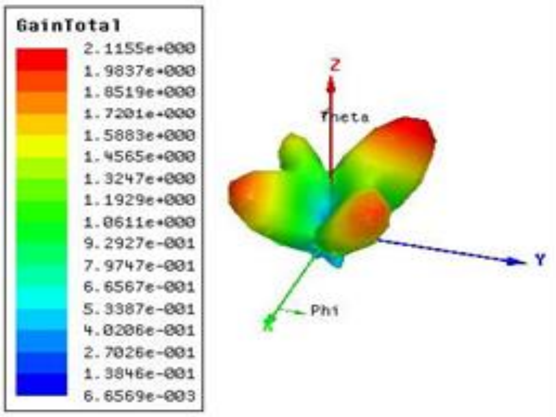

Fig. 20: 3D radiation pattern at 5.28GHz

3D pattern is approximately directional and 2D pattern shows vertical pattern i.e 8 shaped at theta =90 degree, phi=90 degree and horizontal pattern at theta =90 degree , phi=90 degree at four different frequencies.

Antenna performance parameters	Rectangular patch antenna with split ring resonator			
Frequency range	2.30GHz – 2.4GHz	2.69GHz – 2.77GHz	4.48GHz – 4.55GHz	5.14GHz – 5.46GHz
BW	100MHz	80MHz	70MHz	320MHz
Resonance Frequency	2.35GHz	2.75GHz	4.48GHz	5.28GHz
Return loss	-17.13db at 2.35GHz,	-14.12db at 2.75GHz,	-16.66db at 4.48GHz,	-14.45db at 5.28GHz,
Impedance	39.79Ω at 2.35GHz	65.45Ω at 2.75GHz	59.72Ω at 4.48GHz	69.68Ω at 5.28GHz
Reactance	7.87mho at 2.35GHz	-6.83mho at 2.75GHz	13.49mho at 4.48GHz	8.57mho at 5.28GHz
Gain (db)	4.5db at 2.35GHz	7.14 db at 2.75 GHz	2.11db at 4.48GHz	1.54db at 5.28GHz

Table 2: Antenna performance parameters Rectangular patch antenna with split ring resonator

Table 2 shows performance parameters of Rectangular patch antenna with split ring resonator at four different frequencies.

IV. Conclusion

The Rectangular patch antenna with split ring resonator can be used as multiband antenna for ISM, Bluetooth, Wimax, WLAN.

References

[1] Noelia Ortiz, Francisco Falcone, andMario Sorolla, “Gain Improvement of Dual Band Antenna Based on Complementary Rectangular Split-Ring Resonator” International Scholarly Research Network ISRN Communications and Networking Volume 2012, Article ID 951290, 9 pages doi:10.5402/2012/951290.

[2] Ankita Tomar, “Design of Square Split Ring Resonator Shaped Metamaterial Structure for Enhancing theMicrostrip Patch Antenna Parameters”, International Journal of Research in Electronics and Communication Technology (IJRECT 2014) ISSN : 2348 - 9065 (Online) ISSN : 2349 - 3143 (Print), Vol. 1, Issue 3 July - Sept 2014.

[3] Radouane KARLI, Hassan AMMOR,”A SIMPLE AND ORIGINAL DESIGN OF MULTI-BAND MICROSTRIP PATCH ANTENNA FOR WIRELESS COMMUNICATION”, Volume 2, No.2, March – April 2013 International Journal of Microwaves Applications.

[4] R. Pandeeswari1, Singaravelu Raghavan1, and Keloth Ramesh2 ,” A Compact Split Ring Resonator Loaded Antenna”, Progress In Electromagnetics Research Symposium Proceedings, Moscow, Russia, August 19-23, 2012

[5] Otman El Mrabet, Mariem Aznabet, Francisco Falcone, Hatem Rmili, Jean M. Floc'h, M'hamed Drissi, and Mohammad Essaaidi1” A COMPACT SPLIT RING RESONATOR ANTENNA FOR WIRELESS COMMUNICATION SYSTEMS”, Progress In Electromagnetics Research Letters, Vol. 36, 201-207, 2013

[6] Smriti1, Jaswinder Kaur,” Complementary Split-Ring Resonators based Dual-Band Microstrip Antenna for WLAN Applications”, International Journal of Advanced Research in Computer and Communication Engineering Vol. 3, Issue 5, May 2014

[7] Pedro J. Castro, Joaquim J. Barroso, Joaquim P. Leite Neto,” Experimental Study on Split-Ring Resonators with Different Slit Widths “, Journal of Electromagnetic Analysis and Applications, 2013, 5, 366-370.