ijergs
Open Access
International Journal of Engineering Research and Generic Science (IJERGS)
Available Online at www.ijergs.in
ISSN: 2455 - 1597
Volume -2, Issue-4, July – August 2016, Page No. 15 - 19

Rectangular Microstrip Patch Antenna Using Rectangular Complementary Split Ring Resonator

Ruchi Vijayvergiya[1], Sudhanshu Mathur[2]
[1]Jagannath University, Jaipur
E-Mail: ruchivijayvergia.ec@gmail.com
[2]Assistant Professor, Jagannath University, Jaipur
E-Mail: sudhansu.mathur@jagannathuniversity.org

Abstract

A novel metamaterial based microstrip patch antenna embedded with two square complementary split ring resonators (CSRR) for operating in C-band (4- 8GHz) is proposed. An effective microstrip patch antenna can be designed by etching two CSRRs in a conventional patch antenna. The proposed antenna operates at 5.4GHz. It is advantageous for designing a microstrip antenna with miniaturized size for satellite applications. At operating frequency, the antenna exhibits better performance. The CSRRs embedded on the patch antenna helps in miniaturization of the patch antenna. CST software is being used to simulate all the plotted geometry. Here VSWR, directivity, gain, axial ratio, radiation pattern of different designed antenna are evaluated. In future other different type of feed techniques can be utilize to evaluate the total performance of the antenna without ignoring the optimized parameters of it in the action. Exclusively and extensively focusing on the area of different design methods which principally intensify the efficiency and impedance bandwidth.

Keywords: Microstrip, Patch, VSWR, CSRR, C-Band.

1. Introduction

Now a day's Space is a more crucial factor in satellites; especially satellite communication and radar applications require more compact antenna. The world moves towards the trend of miniaturization, hence the antenna design focuses on miniaturization. The S-band is mostly used for the applications like WLAN standards, WiMAX, Microwave ovens, cordless phones and Bluetooth. In some countries this band is used for Direct-to-home (DTH) satellite television services also. C-band is used for the applications like Wi-Fi modules, Weather radar systems and Satellite communications. In comparison with the Ku-band (12-18GHz) [11], the C-band performs well at adverse weather conditions. In military applications like surveillance and air defense control these frequency bands are used. An important note is that the government security systems require narrow bandwidth.

In recent days, microstrip patch antennas are receiving considerable attention in satellite and radar applications. Despite the fact, that the microstrip patch antenna has many advantages like being simple, low-profile and versatile, they are quite larger at lower microwave frequencies, so the use of electromagnetic metamaterials like CSRR can minimize the antenna size. The CSRR is first coined by Falcone et al [4].

They showed that CSRR will produce negative permittivity. Even though Victor Veselago first introduced the metamaterials which exhibit negative permittivity and negative permeability theoretically in late 1960s [4], it almost took three decades to first experimental evidence to come up. There is much geometry available in the field of complementary split ring resonators [5]-[9]. Their characters have been analyzed very well. Accompanying with compact structures; presently dual band antennas are receiving considerable attention since such type of antenna design reduces the number of antennas required for the discrete frequencies of operation. In satellite communication systems the multi band antennas are attractive choices because of the reduced size, low profile [11].

This paper presents a compact patch antenna loaded with a square complementary split ring resonator which is intended to operate in the C-band applications. The CSRR embedded in the patch antenna helps in reducing the resonance frequency of the microstrip patch antenna. It couples the field to the patch and makes it radiate. It can be stated that the ring slot in the CSRR provides the capacitive coupling where as the outer split in the CSRR provides the magnetic coupling [8]. A C band operation can be obtained by properly feeding the antenna with coaxial feed.

2. Antenna Design

Fig1 illustrates the proposed geometry of the antenna for C-band application. The proposed geometry is obtained from the basic rectangular patch antenna by embedding the two complementary square split ring resonators. A split ring resonator can be converted into a Complementary Split Ring Resonator by replacing the metal portions of the split ring resonator into the apertures and the apertures into the metal portions. Here the one complementary split ring resonator is facing the other complementary split resonator's back. Hence the symmetrical structure is avoided. The symmetrical structure would not radiate well since the resonators cancel each other's effect. The CSRR embedded on the patch acts as a high quality (Q) resonator. The CSRR reduces the resonance frequency of the basic patch without affecting the basic patch antenna dimension. The detailed study of the edge coupled CSRR is given in [4]- [10].

The dielectric substrate used here is FR-4 EPOXY(Lossy) whose dielectric constant is about 4.3 and the loss tangent is about 0.025. The thickness of the substrate is 1.5 mm. The microstrip patch dimensions are 15(L) × 12(W) mm2 . The CSRR slot width (Ws) is about 0.45mm and the gap between the ring slots (Wg). is 0.5mm.

The split in the ring (Wd) is about 1mm. Front view of the proposed antenna is shown in fig. 2. To gain further insight, the proposed microstrip antenna is designed in CST (computer simulation technology) Microwave Studio software package and simulated. To obtain the antenna parameters, the microstrip antenna is simulated also using CST which gives the detailed insight of the proposed antenna.

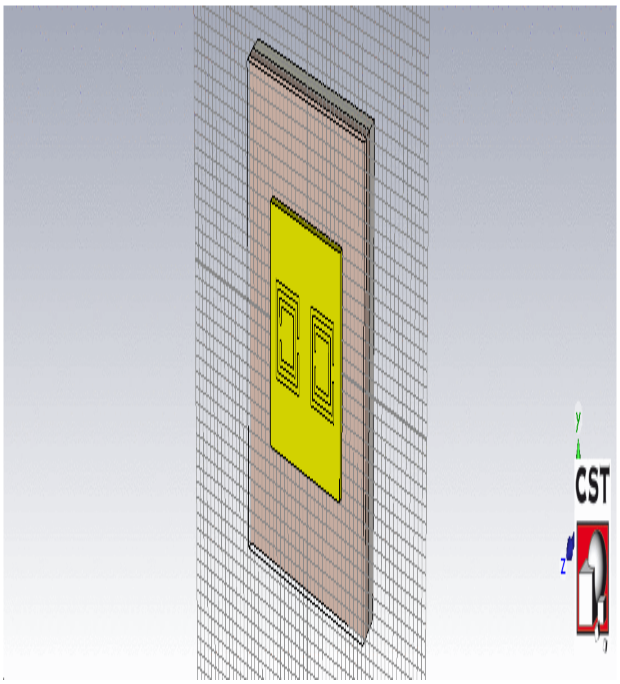

Figure 1: Prospective view of proposed antenna

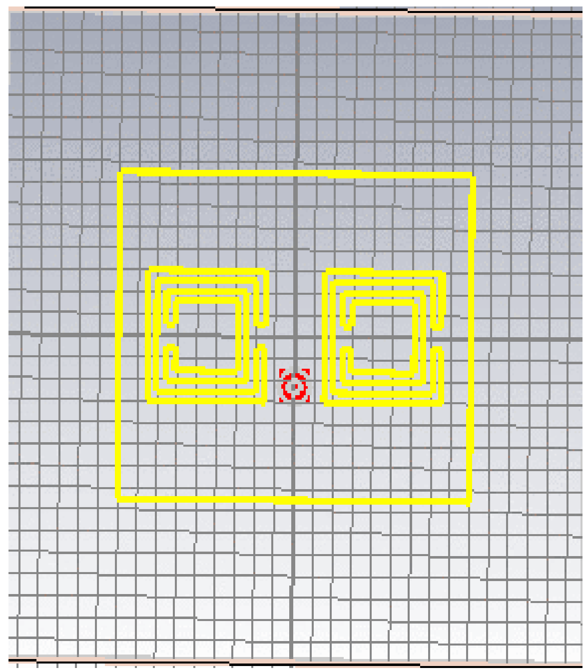

Figure 2: Front view of proposed antenna

3. Results And Discussion

The proposed antenna is designed and simulated by the CST (computer simulation technology) microwave Studios Software. The simulator used here is the FEM (Finite Element Method).The advantage of this simulator is that it gives more Accurate results than the MoM (Method of Moments).

A. Return loss

The return loss of the proposed antenna has been plotted as in the fig.3. It can be seen that the antenna has been showing very good performance in single frequency band. Which is 4.3379GHz.At resonance frequency, antenna shows very good performance; the return the operating band is -11.97dB at 4.3379GHz. It can be noted that the bandwidth of the frequency band is narrower than the conventional microstrip patch antenna. Because of the narrow bandwidth the proposed antenna is more suitable for military application.

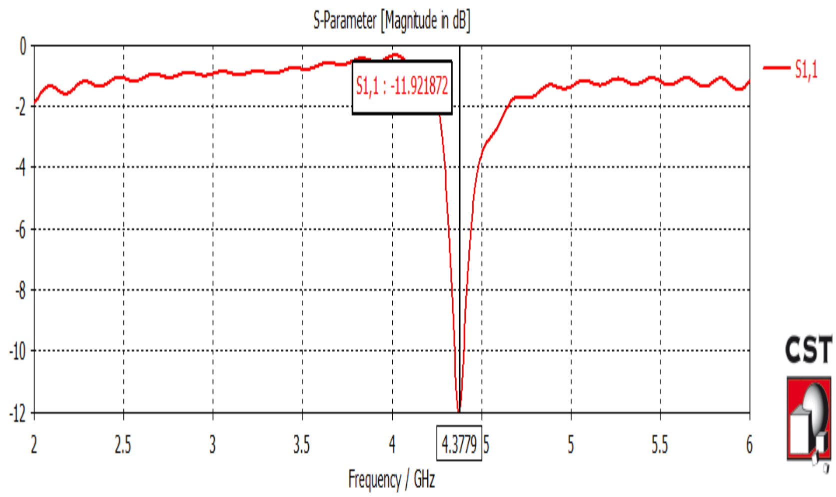

Figure 3: Return loss is-11.92187 (4.3779 GHz)

B. Gain and directivity

The gain and directivity of the proposed antenna is in ostensible range. The gain for the operating frequency is about 11.1 dB and the directivity of the antenna for the same is 11 dB.

Type	Farfield
Approximation	enabled (kR >> 1)
Monitor	farfield (f=4) [1]
Component	Abs
Output	Directivity
Frequency	4
Rad. effic.	-6.181 dB
Tot. effic.	-17.02 dB
Dir.	11.08 dBi

Figure 4: Gain and directivity for 4.33379GHz

C. Radiation Pattern

The radiation pattern of the proposed antenna has been shown in the fig.5 and fig.6. From the 3D radiation plots we can infer that the proposed antenna shows semi omnidirectional pattern. This kind of radiation pattern is excellent for the antennas which are used in satellite communications and radar applications. The fig.4 shows the 3D radiation pattern and fig.5 shows the polar plot of the far field.

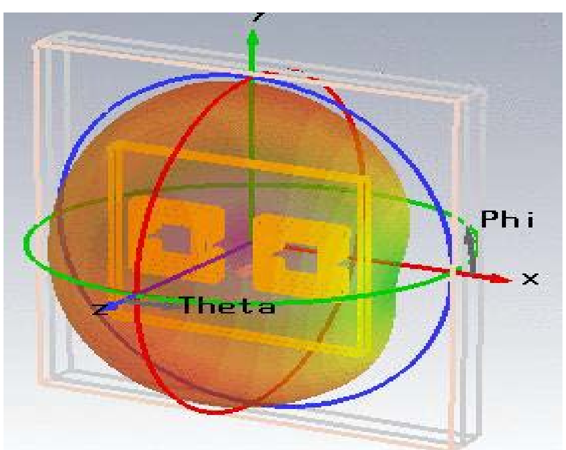

Figure 5: 3D Radiation pattern

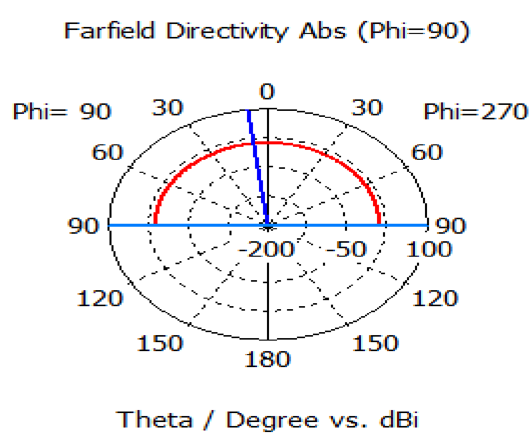

Figure 6: Polar plot

D.VSWR

VSWR of the antenna gives an insight about how good the antenna is matched. When there is a mismatch between the antenna and the feed, it produces the voltage standing waves and thereby reducing the antenna's performance.Fig.7 illustrates the VSWR of the proposed antenna for the operating frequency. In our proposed antenna the VSWR at operating frequency is 1.6. So we can conclude that the proposed antenna is very well matched with the feed.

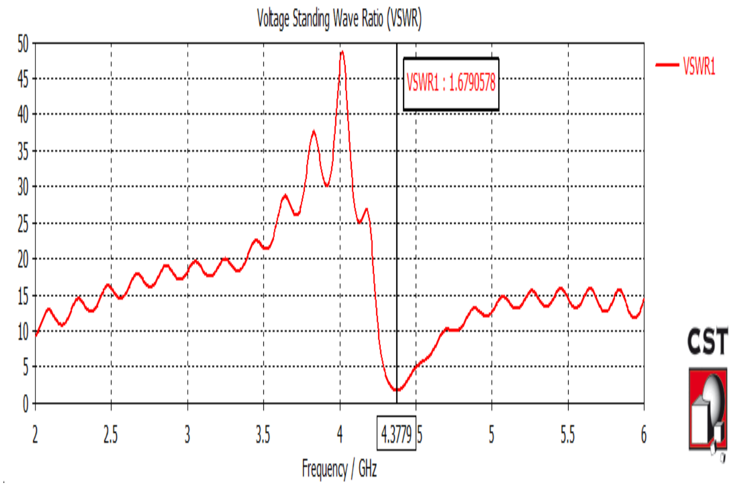

Figure 7: VSWR is 1.67 at f= 4.3779GHz.

E. Current distribution

The fig.8 gives an insight about how well the current is distributed all over the patch. The red portions in the patch indicate the current with high intensity. It can be seen that the antenna shows very good current distribution.

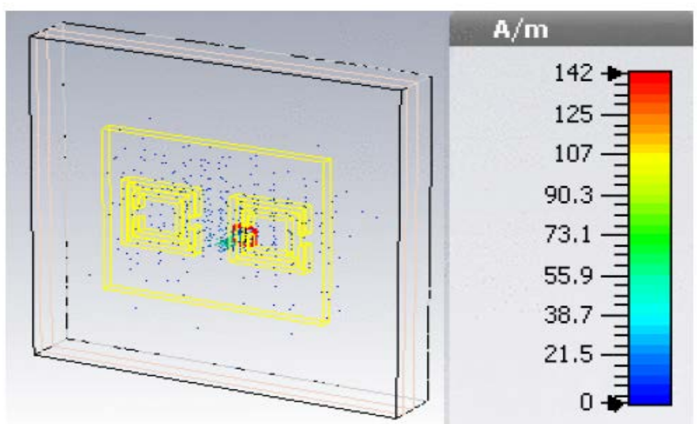

Figure 8: Current distribution of proposed antenna

F. Comparison between Performance Parameter of Antenna

Antenna Parameter	RT Duroid substrate (Previous work)	Fr-4 Substrate	Location of feeding	Square CSRR
Operating Frequency	3.4 GHz	4.03 GHz	5.572 GHz	4.3779 GHz
Gain	0.81 dB	4.33 dB	4 dB	11.1 dB
Return Loss	-23 dB	-8.19 dB	-9.8 dB	-11.97 dB
VSWR	1.18	1.2	1.09	1.6

4. Conclusions

Thus, from the simulation results it is clear that the proposed antenna shows good results at resonance frequency 4.3779GHz lying in C-band. So, the proposed antenna can be used for communication satellite operating in c-band as well as for TV broadcasting also.

5. References

[1]. Juhua Liu, QuanXue, Hang Wong, HauWah Lai and Yunliang Long “Design And Analysis Of A Low-Profile And Broadband Microstrip Monopolar Patch Antenna” IEEE Transactions On Antennas And Propagation, Vol. 61, No. 1, January 2013.

[2]. Neha parmar “review of microstrip patch antenna for wlan and wimax application”, et al int. journal of engineering research and applications issn : 2248-9622, vol.4, issue 1(version 1), january 2014, pp.168-171

[3]. Arashpreet kaur “comparative study of square csrr and circular csrr structure on microstrip patch antenna for wlan applications”, international journal of advanced research in electronics and communication engineering (ijarece) volume 3, issue 8, august 2014.

[4]. Smriti “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.

[5]. Kaushal gangwar “metamaterials: characteristics, process and applications”,advancein electronic and electric engineering.issn 2231-1297,volume 4, number 1 (2014), pp. 97-106 © research india publications

[6]. Ashish gupta “a compact dual-mode metamaterial-inspired antenna using rectangular type csrr”, progress in electromagnetics research c, vol. 57, 35–42, 2015.

[7]. Hyeonjin Lee, Yeongseog Lim, “Design of circular polarized microstrip aperture coupled patch antenna for 5.8 GHz ISM band”, Asia-Pacific Microwave Conference, vol. 1, no. 7321283, pp 220 – 223, Dec 2001.

[8]. Shridhar E. Mendhe & Yogeshwar Prasad Kosta,“metamateri al properties and applications, International Journal of Information Technology and Knowledge Management January-June 2011, Volume 4, No. 1, pp. 85-89.

[9]. M.Premkumar and M. Vasantha kumar, “Microstrip Patch Antenna with a Circular Complementary Split Ring Resonator”, 2015 International Conference on Computer Communication and Informatics (ICCCI -2015), Jan. 08 – 10, 2015, Coimbatore, INDIA

[10]. The CST Computer Simulation Technology website. [Online] Available: http://www.cst.com

[11]. Balanis, C.A., Antenna Theory: Analysis and Design, John Wiley & Sons, Inc, 1997

[12]. Stutzman, W.L., and Thiele, G.A., Antenna Theory and Design, John Wiley & Sons, Inc, 1998.