International Journal of Applied Engineering Research ISSN 0973-4562 Volume 13, Number 18 (2018) pp. 13517-13521

Bandwidth Enhancement of Microstrip Patch Antenna with Octagonal Complementary Split Ring Resonator Array Structure

V G Ajay[1], Parvathy A R[2], Thomaskutty Mathew[3]

[1]*Electronics Department, School of Technology and Applied Sciences, Kochi, India.*

[2]*Electronics Department, School of Technology and Applied Sciences, Kochi, India.*

[3]*Electronics Department, School of Technology and Applied Sciences, Kochi, India.*

Abstract

This paper presents a novel method for the design and fabrication of two microstrip patch antennas with single and multiple Octagonal Complementary Split Ring Resonator Structure (OCSRR) loaded on the ground plane. Bandwidth enhancement is achieved with the microstrip antenna having multiple OCSRR structure. The microstrip patch antenna with single OCSRR structure on the ground plane was designed with a frequency band of 3.88GHz to 4.09GHz and antenna with multiple OCSRR was designed with a frequency band of 3.66GHz to 3.93GHz. The simulated bandwidth of antenna with single OCSRR structure on the ground plane was 210MHz which got improved to 270MHz at a lower frequency band with multiple Octagonal Complementary Split Ring Resonator Structure structured microstrip patch antenna of same physical size. Both antennas were simulated using CST Microwave Studio and ANSYS HFSS.

Keywords: Microstrip patch antenna, OCSRR, Defected Ground Structure.

INTRODUCTION

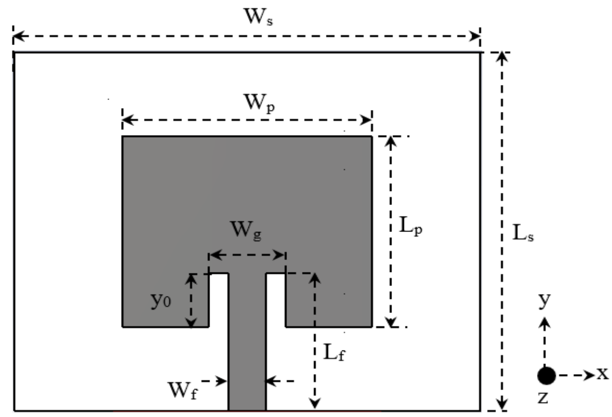
Microstrip antennas are widely used in communication system due to some advantages such as low-profile, low cost, low weight and ease of fabrication. They are also easily integrable with other microwave devices [1]. Some of the limitations associated with conventional patch antennas are surface wave losses, low gain and narrow band width [2].The parameters of the microstrip patch antenna are improved using Defected Ground **S**tructure (DGS) which provides higher bandwidth and lesser return loss. DGS is accomplished by etching off a suitable shape from the ground plane. Metamaterial structures are usually used nowadays for size reduction of antenna and it also provides improvement in antenna parameters like bandwidth, gain, efficiency etc. Several studies were done by the researchers regarding miniaturization of antennas, sub wavelength cavities [3] and waveguides [4]-[7]. Complementary Split Ring Resonator (CSRR) structure is also used for miniaturization of microstrip antennas [8]-[10].

In this paper, two microstrip patch antennas with single and multiple Octagonal Complementary Split Ring Resonator Structure (OCSRR) loaded on the ground plane was designed and fabricated. Bandwidth enhancement is achieved with the microstrip antenna having multiple OCSRR structure.

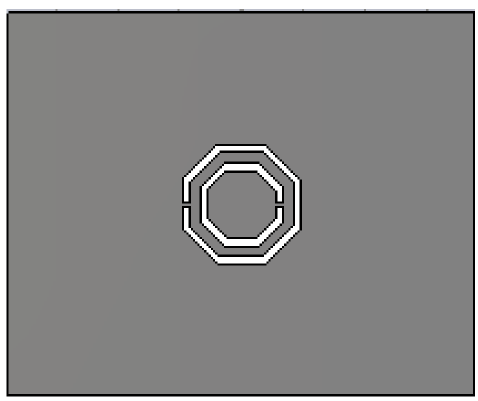
ANTENNA DESIGN

A. Microstrip Patch Antenna with Single OCSRR structure on ground plane

The geometry of the proposed microstrip patch antenna with single OCSRR on the ground plane is depicted in Fig.1. The antenna is designed using FR4 substrate with thickness 3.2, ε_r = 4.4 and loss tangent is 0.02. The single OCSRR structure consists of two nested split rings. The design parameters of the patch are tabulated in Table 1.



a)Top view



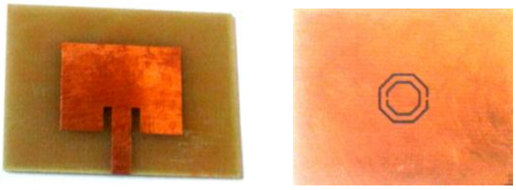
b)Bottom view

Figure 1. Geometry of Single OCSRR structured microstrip patch antenna

Table 1. Parameters of single OCSRR patch antenna

Sl.No	Design Specifications	
	Parameters	***Value(mm)***
1	Substrate length	31
2	Substrate width	37.8
3	Patch length	16.5
4	Patch width	20
5	Wf	3.05
6	Wg	6.11
7	y0	4.61
8	Lf	12.16

This antenna is designed for a frequency band of 3.88GHz to 4.09GHz. The physical view of the proposed antenna is shown in Fig.2



a) Top view *b) Bottom view*

Figure 2. Fabricated antenna with single OCSRR on ground plane

B. Microstrip Patch Antenna with Multiple OCSRR structure on ground plane

The front geometry of the proposed microstrip patch antenna with multiple OCSRR on the ground plane is similar to that of previous structure as shown in Fig.1 and the back view of the microstrip patch antenna is shown in Fig.3 The proposed antenna is designed using FR4 substrate with thickness 3.2 , ε_r = 4.4 and loss tangent is 0.02. The ground plane of this antenna consists of multiple OCSRR structures and all other design specifications is similar to that previous structure as illustrated in Table 1. This antenna is designed for a frequency band of 3.66GHz to 3.93GHz. The physical view of the proposed antenna is shown in Fig. 4

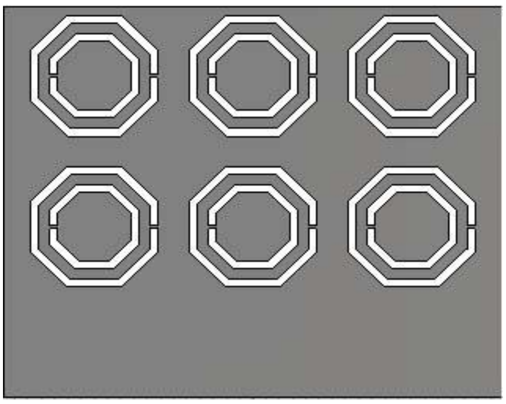
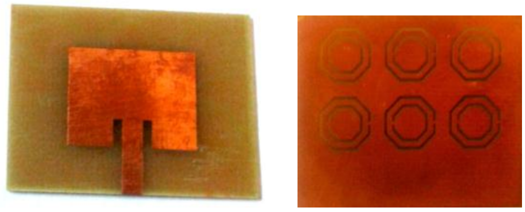


Figure 3. Simulated back view of multiple OCSRR antenna



a) Top view *b) Bottom view*

Figure 4. Fabricated antenna with multiple OCSRR on ground plane.

RESULTS AND DISCUSSION

The measurements of both antennas were taken using Agilent Network Analyzer E5071C and the radiation pattern of the two fabricated antennas were measured in an anechoic chamber. Table 2. depicts the simulation results of microstrip antenna with single and multiple OCSRR on ground plane .

Table 2. Simulation results of Microstrip patch antenna with single and mutiple OCSRR on ground plane

Sl.No	Design Specifications		
	Parameters	***Value***	
1	Shape in ground	Single OCSRR	Multiple OCSRR
2	Frequency(GHz)	3.98	3.80
3	Returnloss(dB)	-28.33	-25.43
4	Directivity(dBi)	6.08	5.56
5	Bandwidth(MHz)	210	270

C. Return loss and Bandwidth

The simulated and measured results of return loss characteristics of microstrip patch antenna with single OCSRR structure on ground plane is depicted in Fig.5 and multiple OCSRR structure on ground plane is depicted in Fig.6.

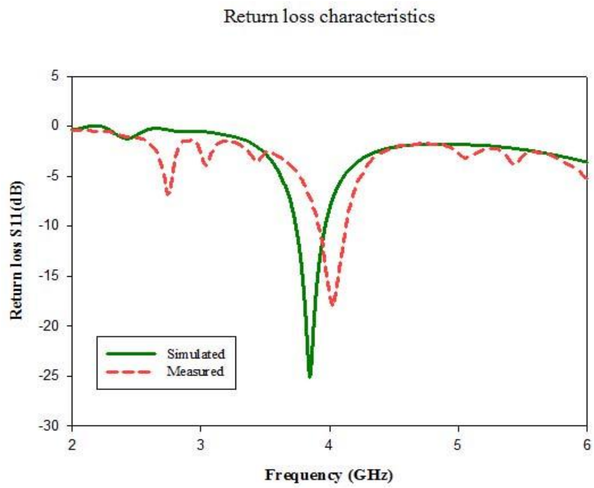


Figure 5. Simulated and measured return loss characteristics of microstrip patch antenna with single OCSRR on ground plane.

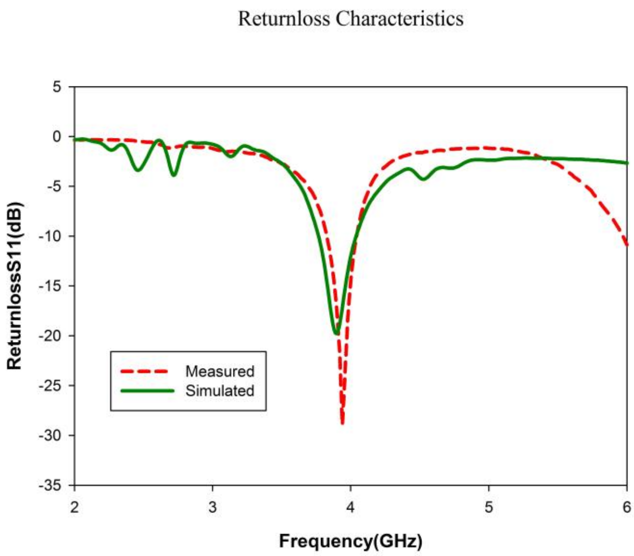


Figure 6. Simulated and measured return loss characteristics of the proposed microstrip patch antenna with multiple OCSRR on ground plane

The simulated results of the microstrip patch antenna without DGS, with single OCSRR and multiple OCSRR on ground plane is depicted in Fig. 7

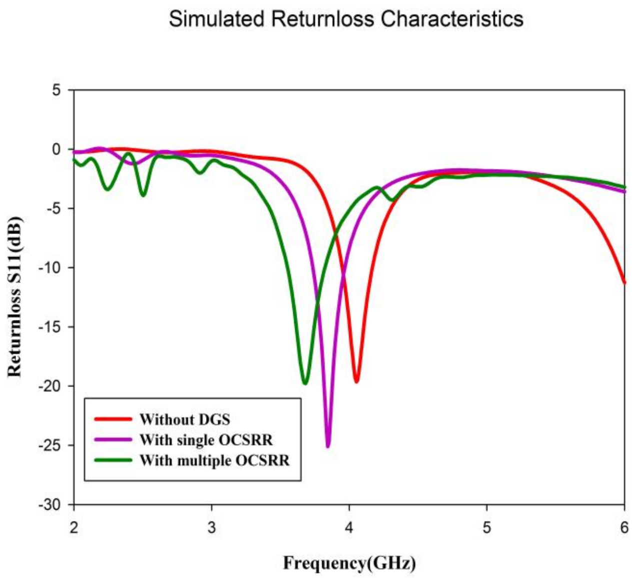


Figure 7. Simulated return loss characteristics of the antenna without DGS, with single OCSRR and multiple OCSRR on ground plane

From the simulated results as illustrated in Table 2., it is observed that bandwidth of microstrip antenna with single OCSRR on ground plane is 210MHz.The bandwidth is improved to 270 MHz while using multiple OCSRR structure on the ground plane. The percentage increase in bandwidth is 22.2%.

D. Directivity

Fig.8 & Fig.9 represents the simulation results of directivity of microstrip patch antenna with single and multiple OCSRR on ground plane respectively.

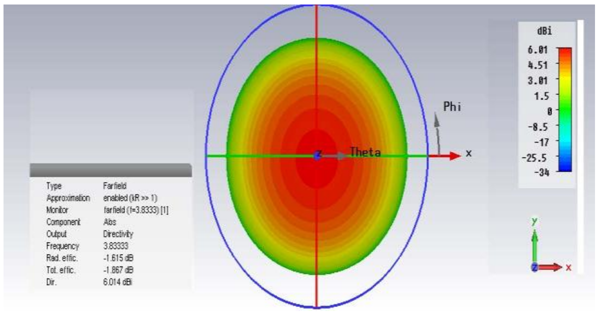


Figure 8. Simulated results of Directivity of microstrip patch antenna with single OCSRR on ground plane

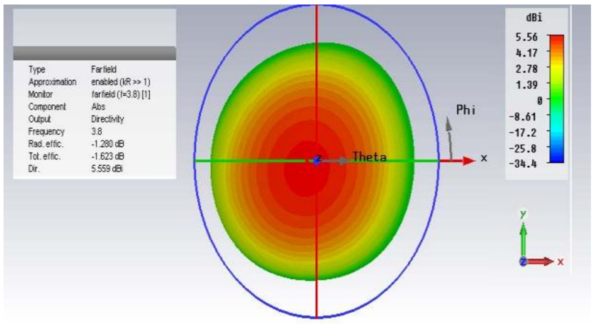
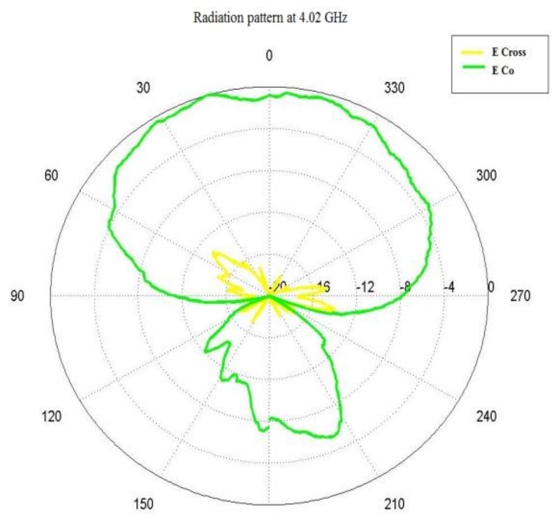


Figure 9. Simulated results of Directivity of microstrip patch antenna with multiple OCSRR on ground plane

E. Radiation pattern

Fig.10 & Fig.11 represents the measured radiation pattern of microstrip patch antenna with single and multiple OCSRR on ground plane respectively.



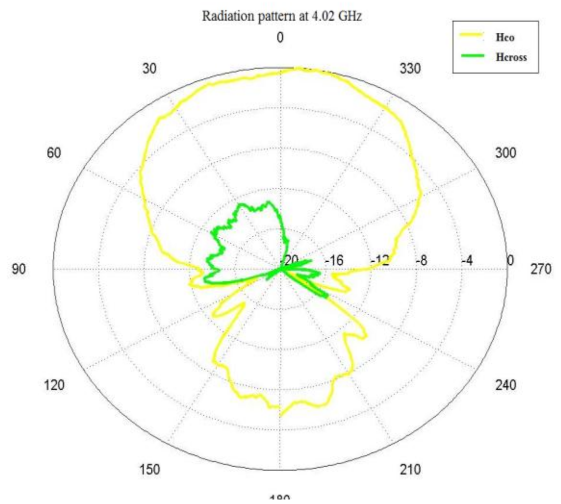


Figure 10. Measured radiation pattern of the antenna with single OCSRR on ground plane

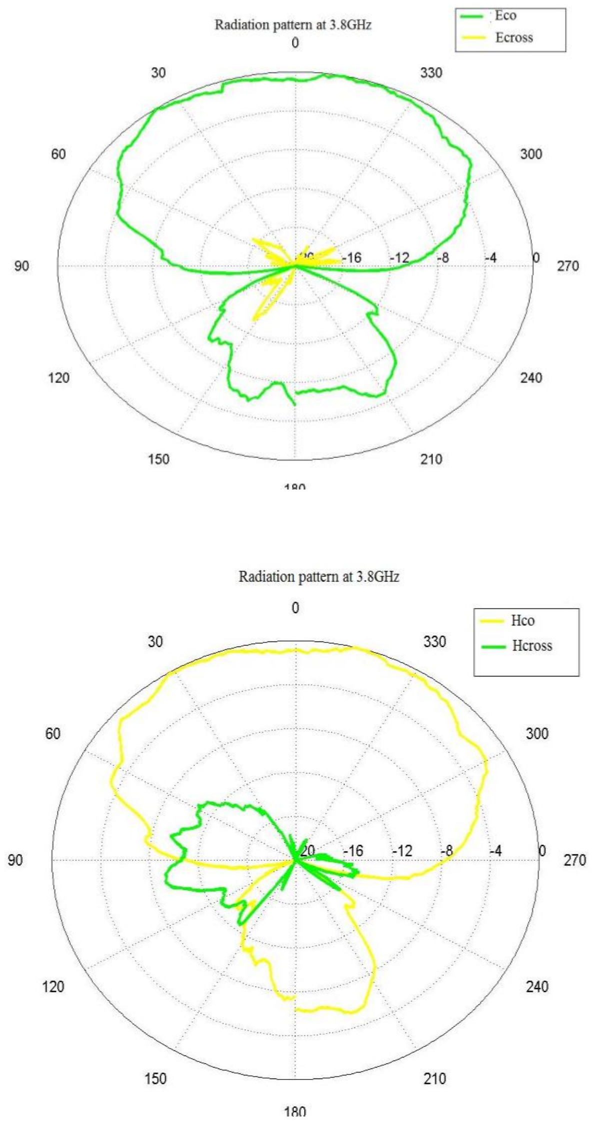


Figure 11. Measured radiation pattern of the antenna with multiple OCSRR on ground plane

CONCLUSION

Simulated bandwidth of microstrip patch antenna having multiple OCSRR structure on ground plane is 270 MHz and that of single OCSRR structured antenna is 210 MHz .The measured bandwidth of microstrip patch antenna having multiple OCSRR structure on ground plane is 232 MHz and single OCSRR structured antenna is 220 MHz. Bandwidth enhancement is achieved with microstrip patch antenna having multiple OCSRR structure on ground plane. The measured value of resonant frequency of the antenna with single SRR on ground plane is 4.02 GHz and with multiple SRR on ground plane is 3.94 GHz. A good agreement between simulated and measured values is achieved.

REFERENCES

[1] C.A. Balanis. "Antenna Theory: Analysis and Design". 2nd Ed, United States of America, John Wiley & Sons, 0471592684, 1982.ch. 14.

[2] H. A. Jang, D. O. Kim, and C. Y. Kim, "Size reduction of patch antennas using CSRRs ground plane," in Progress in Electromagnetics Research Symposium Proceedings, KL, Malaysia, Mar. 27–30, 2012.

[3] N. Engheta, "An idea for thin sub-wavelength cavity resonator using metamaterials with negative permittivity and permeability," *IEEEAntennas Wireless Propag. Lett.*, vol. 1, no. 1, pp. 10–13, 2002.

[4] A. Alù and N. Engheta, "Guided modes in a waveguide filled with a pair of single-negative (SNG), double-negative (DNG), and/or double positive (DPS) metamaterial layers," IEEE Trans. Microw. TheoryTech.,vol. MTT-52, no. 1, pp. 199–210, Jan. 2004.

[5] A. Alù, F. Bilotti, N. Engheta, and L. Vegni, "Sub-wavelength, compact, resonant patch antennas loaded with metamaterials," IEEE Trans.Antennas Propag., vol. 55, no. 1, pp. 13–25, Jan. 2007.

[6] [F. Bilotti, A. Alù, and L. Vegni, "Design of miniaturized metamaterial patch antennas with μ-negative loading," IEEE Trans. Antennas Propag., vol. 56, no. 6, pp. 1640–1647, Jun. 2008.

[7] A. Alù, F. Bilotti, N. Engheta, and L. Vegni, "Sub-wavelength planar leaky-wave components with metamaterial bilayers," IEEE Trans*Antennas Propag.*, vol. 55, no. 3, pt. 2, pp. 882–891, Mar. 2007.

[8] Y. Lee, Y. Hao, "Characterization of microstrip patch antennas on metamaterial substrates loaded with complementary split-ring resonators," Microwave And Optical Technology Letters, vol. 50, No. 8,, pp 2131-2135,August 2008.

[9] Dawit Fistum, Dilip Mali, Mohammed Ismail, "Bandwidth enhancement of rectangular microstrip

patch antenna using defected ground structure," Inonesian Journal of Electrical and Computer Engineering, vol 3, no. 2, August 2016, pp. 428 ~ 434 .

[10] Anahita Ghaznavi Jahromi, Farzad Mohajeri, and Nooshin Feiz, "Miniaturization of a Rectangular Microstrip Patch Antenna Loaded with Metamaterial", World Academy of Science, Engineering and Technology International Journal of Electronics and Communication Engineering Vol:7, No:4, 2013.