International Journal of Advanced Research in Electronics and Communication Engineering (IJARECE)
Volume 3, Issue 8, August 2014

Circular CSRR structure on Microstrip Patch Antenna with reduced ground for WLAN applications

Arashpreet Kaur[1] , Amandeep Singh[2] , Ekambir Sidhu[3]

Abstract **— The proposed paper has been based on the study of reduced ground microstrip patch antenna design with circular CSRR ring structure on the patch, suitable for WLAN applications. The antenna is resonant at frequencies 2.542 GHz, 2.508 GHz, 2.462 GHz and 2.452 GHz. The impedance bandwidth of antenna for various bands is 246.49 MHz, 241.51 MHz, 220.16 MHz and 194.2 MHz, respectively. The antenna is suitable to be used for WLAN applications. This antenna has been designed and simulated using CST Microwave Studio (version 2013). The reduced ground increases the antenna bandwidth but tends to reduce the antenna gain.**

Keywords **— Circular CSRR, Directivity, Gain, Impedance Bandwidth, Microstrip patch antenna (MPA), Reduced ground, WLAN**

I. INTRODUCTION

The Microstrip patch antenna is extensively used for wireless applications because it is relatively compact in size, reliable, light weight and mobile. They are relatively easy to fabricate, low profile and have relatively high gain. However, the main drawback of patch antennas is their narrow bandwidth of around 5%. They are used for various applications because of its compact size. The various wireless applications of Microstrip Patch Antenna are WLAN or Wireless Local Area Network, WiMax, IMT and GSM/CDMA applications. The various portable daily handheld devices like laptop, notebook, PDA, and mobile phones are incorporated with Wi-Fi and Bluetooth technologies. The IEEE 802.11b/g operates at 2.40 GHz. Since 1999, researchers have proposed many structure designs to form metamaterial structure. Metamaterial or left handed material (LHM) is the artificial substrate that did not exist in the real nature. Metamaterial had been categorized as a structure or design that has the simultaneously negative permeability and permittivity. The metamaterial structure tends to improve antenna directivity and gain [1]. There are many metamaterial structures had been described by many researchers. The most popular structures are electromagnetic band gap (EBG) [2], split ring resonator (SRR), artificial magnetic conductor (AMC) [3-5] and photonic band gap (PBG) [6].

Split ring resonators (SRRs) design is used to produce the negative dielectric constant or permittivity and negative permeability. There are many types of split ring resonators that have been designed by researchers. Edge coupled SRR (EC-SRR) was the initial first design proposed by Pendry [7]. In this SRR design, there is a single circular metallic split ring printed on the patch.

The complementary split ring resonator structure (CSRR) is obtained by replacing the copper area with substrate material and the substrate material with copper [8]. The design approach to the realization of compact antennas with improved impedance bandwidth is by using a patch loaded with CSRR with reduced ground structure.

Manuscript received July, 2014

Arashpreet Kaur, Department of Electronics & Communication Engineering, *Punjabi University, Patiala, Patiala, Mobile No.+919569344428*

Amandeep Singh, Department of Electronics & Communication Engineering, *Punjabi University, Patiala, Mobile No. +919779706457,*

Ekambir Sidhu, *Department of Electronics and Communication Engineering, Punjabi University Patiala, Mobile no. +91842759971.*

II. BASIC ANTENNA GEOMETERY

A. CONVENTIONAL MICROSTRIP ANTENNA WITH REDUCED GROUND & CIRCULAR CSRR ON PATCH

The design has been simulated in CST Microwave Studio. The operating resonant frequencies of the antenna are 2.542 GHz, 2.508 GHz, 2.462 GHz and 2.452 GHz. This structure employs a substrate of Roger RT/Duroid 5880 with dielectric constant, $\varepsilon r = 2.2$. The dimensions of the antenna are 60.0 mm wide and 65.86 mm length. The ground plane is printed on the bottom side of the substrate which is partially reduced to improve the antenna impedance bandwidth. The effects of reducing the ground plane have been observed for various ground widths of 4mm, 6mm, 8mm and 10mm. A 50 Ω waveguide port is used to feed power to the radiator patch using edge feed line. Fig 1 represents the top view of antenna design and its dimensions are mention in Table1.

Table 1 Dimension of conventional reduced ground MPA with circular CSRR

Antenna Parameter	Specification
Ground (Wg × Lg)	4 mm × 65.86 mm 6 mm × 65.86 mm 8 mm × 65.86 mm 10 mm×65.86 mm
Substrate (Ws × Ls)	60.0 × 65.86 mm

ISSN: 2278 – 909X

Patch (Wp × Lp)	49.2×39mm
Feed line (Wt × Lt)	1.34×28 mm
Feed end (Wf × Lf)	5.2×9 mm

The circular split ring resonator has been etched on the patch with diameter, Dr = 8mm, gap between split ring, Gr = 0.9mm, thickness of ring, t = 0.9 mm and location above from the centre, a = 12 mm. Fig 2 represents the bottom view of antenna with its parameters.

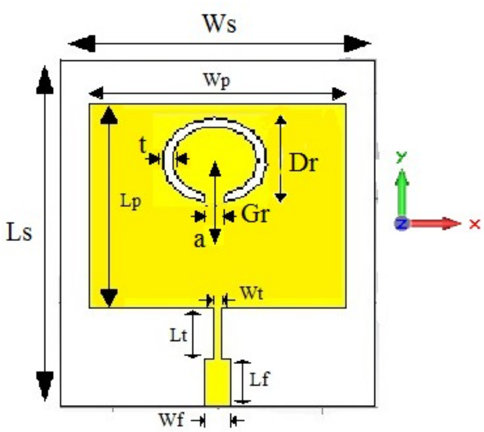

Fig 1. Front view of antenna with circular CSRR

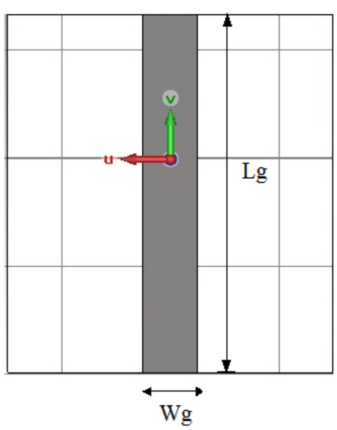

Fig 2. Back view of antenna with reduced ground circular CSRR ring structure

The Fig 3 shows the top view of antenna with projected reduced ground structure of MPA.

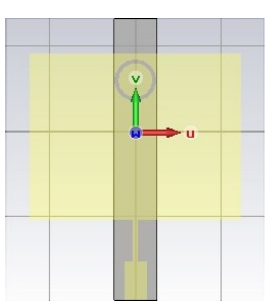

Fig. 3 Top view of antenna with projected reduced ground of MPA

III. RESULTS AND DISCUSSIONS

The proposed antenna has been designed using CST-MWS 2013. The performance of antenna has been analyzed in terms of resonant frequency, return loss (S_{11}), bandwidth, gain (dB), directivity (dBi), VSWR and antenna input impedance.

Fig 4 (a) represents the return loss plot of antenna showing that the antenna is resonant at frequencies of 2.542 GHz, 2.508 GHz, 2.462 GHz and 2.452 GHz with corresponding bandwidth of 246.49 MHz , 241.51 MHz, 220.16 MHz and 194.2 MHz, respectively for various ground widths of 4mm, 6mm,8mm and 10mm. The -10dB cut off frequencies of the various bands corresponding to various ground widths of 4mm, 6mm, 8mm and 10mm are 2.438-2.68 GHz, 2.3996-2.6411GHz, 2.356-2.576 GHz and 2.358-2.552 GHz with corresponding return losses of -23.044dBi, -35.95dBi, -26.20dBi and-20.55dBi. In Fig 4 (b), the VSWR plot has been shown for various ground width dimensions of 4mm, 6mm, 8mm and 10mm are 1.2807, 1.0323, 1.3391 and 1.4977 respectively. In Fig 4 (a) and (b), the dimension marked L signifies the ground width of (- L to +L = 2L). For example, corresponding to L=2, the ground width is (-2 to +2 = 4mm).

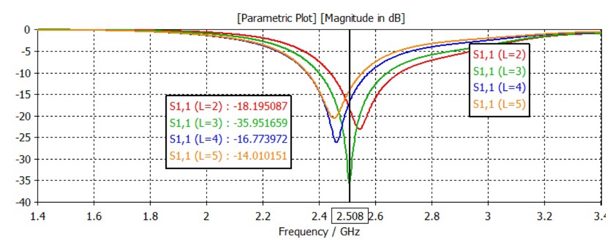

Fig 4 (a) Return loss plot for reduced ground structure with circular CSRR of MPA

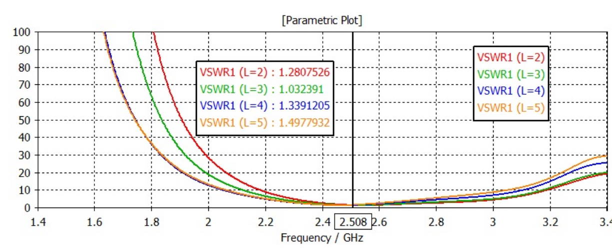

Fig 4 (b) VSWR plot of reduced ground structure with circular CSRR of MPA

It can be concluded that the best return loss is -35.951dB with corresponding bandwidth of 241.51 MHz and VSWR of 1.032 has been achieved corresponding to ground width of 6mm.

Fig 5 (a) and (b) represents the directivity and gain plots of the designed antenna structure. The directivity of antenna is 4.177dBi and gain is 4.732dBi for proposed antenna at resonant frequency of 2.508 GHz.

ISSN: 2278 – 909X

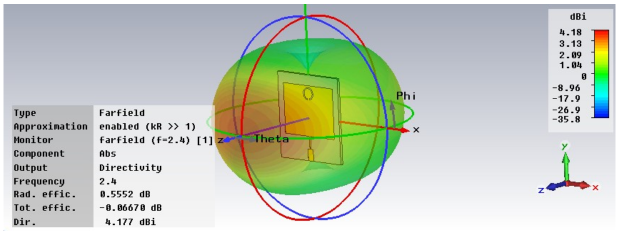

Fig 5 (a) Directivity plot at 2.508 GHz

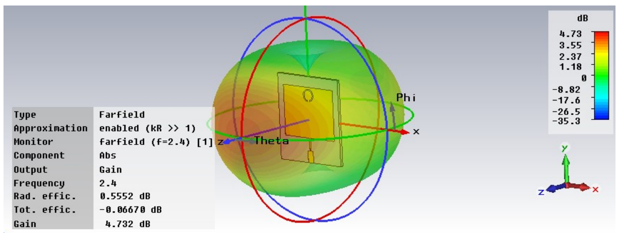

Fig 5 (b) Gain plot at 2.508 GHz

The Fig 6 shows surface current distribution i.e. the current density plot for the proposed antenna projected on the rear view of antenna. It can be observed from the Fig 6 that the antenna current is concentrated near the CSRR on the patch.

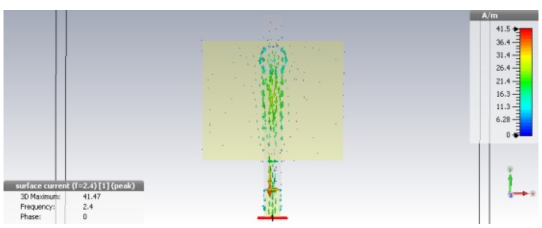

Fig 6 Surface current through ring and ground structure of MPA

Fig 7 represents the half power beamwidth (HPBW) of the designed antenna. It can be observed that the HPBW of the designed antenna is 75.3 degrees with side lobe level of -1.7dB.

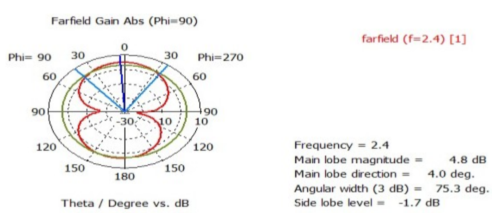

Fig 7 Beamwidth plot of proposed antenna

IV. CONCLUSION

It can be observed from the above discussion that the bandwidth of an antenna can be improved by reducing the ground. By reducing the ground plane, it has been observed that the resonant frequency shifts to the lower value and the impedance bandwidth of antenna increases. However, it has also been observed that on reducing the ground, the gain and directivity of antenna reduces. The designed antenna provides the best performance in terms of bandwidth and return loss corresponding to ground width of 6mm. The proposed antenna design is suitable to be used for WLAN applications. The Table 2 below compares the various antenna parameters corresponding to the various ground widths of 4mm, 6mm, 8mm and 10mm.

Table 2 Comparison of antenna parameters corresponding to various antenna ground widths

Parameters	**Conventional antenna with reduced ground using circular ring**			
	L=2 (4mm)	**L=3 (6mm)**	**L=4 (8mm)**	**L=5 (10mm)**
Resonant frequency, (f_r) GHz	2.542	2.508	2.462	2.452
Return Loss,dB	-23.044	-35.95	-26.20	-20.55
Bandwidth, MHz	246.49	241.51	220.16	194.2
Frequency range, (f_L- f_H), MHz	2.438-2.68	2.3996-2.6411	2.356-2.576	2.358-2.5525
Gain,dB	4.792	4.732	4.800	5.028
Directivity, dBi	4.053	4.177	4.350	4.483
VSWR	1.151	1.032	1.102	1.207
Impedance, ohms	50	50	50	50
Beamwidth, degrees	75.3	75.3	75.4	75.4
Suitable applications	WLAN	WLAN	WLAN	WLAN

REFERENCES

[1] A. Feresidis, J. C. Vardaxoglou, "Flat Plate Millimeter Wave Antenna Based on Partially Reflective FSS," International Conference on Antennas and Propagation, vol. 1, pp. 33-36, 2001

[2] O. Ayop, M. K. A. Rahim, M. R. Kamarudin, M. Z. A. Abd Aziz, M. Abu, "Dual Band Electromagnetic Band Gap Structure Incorporated with Ultra-wideband Antenna," 2010 Proceedings of the Fourth European Conference on Antennas and Propagation (EuCAP), pp. 1-4, 2010.

[3] D. N. Elsheakh, H. A. Elsadek, E. A. Abdallah, M. F. Iskander, H. Elhenawy, "Ultrawide Bandwidth Umbrella-Shaped Microstrip Monopole Antenna Using Spiral Artificial Magnetic Conductor (SAMC)," vol. 8, pp. 1255-1258, 2009.

[4] A. Foroozesh, L. Shafai, "Effects of Artificial Magnetic Conductors in the Design of Low-Profile High-Gain Planar Antennas With High-

ISSN: 2278 – 909X

Permittivity Dielectric Superstrate," IEEE Antennas and Wireless Propagation Letters, vol. 8, pp. 10-13, 2009.
[5] A. Erentok, P. L. Luljak, R. W. Ziolkowski, "Characterization of a Volumetric Metamaterial Realization of an Artificial Magnetic Conductor for Antenna Applications," IEEE Transactions on Antennas and Propagation, vol. 53, issue 1, part 1, pp. 160-172, 2005
[6] W. Y., Qiang, F. Tao, "The Study on a Patch Antenna with PBG Structure," Third International Symposium on Intelligent Information Technology Application (IITA 2009), vol. 3, pp. 565-567, 2009
[7] J. B. Pendry, A. J. Holden, D. J. Robbins, W. J. Stewart, "Magnetism From Conductors and Enhanced Nonlinear Phenomena," IEEE Trans. Microwave Theory Tech., vol. 47, pp. 2075-2084, 1999.
[8] H. Zhang, Y. Q. Li, X. Chen, Y. Q. Fu, N. C. Yuan, N. C., "Design of Circular Polarization Microstrip Patch Antennas with Complementary Split Ring Resonator," 2008 International Workshop on Metamaterials, pp. 360-362, 2008.
[9] CST Microwave Studio 2013.Available at www.cst.com.
[10] C. A. Balanis, "Antenna Theory Analysis and Design," John Wiley & Sons , Inc.,2nd edition, 1997

[1]**Er . Arashpreet Kaur (Age 25 Years)** is Lecturer in Department of Electronics & Communication Engineering (ECE) at RIMT Polytechnic, Mandi Gobindgarh. She is Graduate from I.E.T Bhaddal, Ropar in 2010. She is Post Graduation (Part time) Student in Department of Electronics & Communication Engineering (ECE) Punjabi University, Patiala.

[2]**Er. Amandeep Singh (Age 29 Years)** is an Assistant Professor in Department of Electronics & Communication Engineering (ECE) at Punjabi University, Patiala. His area of specialization is VLSI design, Wireless communication, Antennas. He is member of International Association of Engineers.

[3]**Er. Ekambir Sidhu (Age 25 Years)** is an Assistant Professor in Department of Electronics & Communication Engineering (ECE) at Punjabi University, Patiala. His area of specialization is Antennas for Wideband and Ultra wide band applications and Wireless Sensors. He is a Post Graduate from Thapar University, Patiala in 2012 (Gold Medalist) and has been consistently involved in research work on Antennas and Wireless Sensors.

ISSN: 2278 – 909X