International Journal of Scientific Research in Mechanical and Materials Engineering
© 2019 IJSRMME | Volume 3 | Issue 2 | ISSN : 2457-0435

Design of SRR Based Metamaterial Antenna for 4G WiMAX Applications

Geetharamani G[1], *Aathmanesan T[2]

[1]Mathematics, Anna University, Tamilnadu, India

[2*]ICE, Anna University, Tamilnadu, India

ABSTRACT

The demand for high-speed data services for portable devices has become a driving force for the development of advanced broadband access technologies. Therefore, in this paper metamaterial antenna for 4G WiMAX application presented. "Meta" is a Greek word which means "beyond" the materials provides properties beyond the conventional materials. A simple circular patch antenna is provided with the split ring resonator metamaterial structure in its ground plane which is used to improve the performance of the regular patch antenna. In this research work FR4 substrate with dielectric permittivity of 4.4 and height of the substrate is 1.6 mm is used for manufacturing the proposed metamaterial antenna. The proposed antenna having 40 mm length and 30 mm width dimension. This metamaterial antenna is designed with an integral based solver simulation software called CST Microwave studio v2019 and obtained VSWR < 1.5, Return loss of -12 dB and Bandwidth of 230 MHz, gain of 2.11 dBi at the resonant frequency of 2.3 GHz. The proposed metamaterial antenna is suitable for 4G WiMAX services.

Keywords: Metamaterial, Micro Patch Antenna, 4G, WiMAX, Wireless Communication.

I. INTRODUCTION

Antenna plays vital role in the wireless delivery of data services to end users. When it comes to the wireless connectivity of individual buildings and houses the WiMAX technology is used. Micro patch antennas are low profile antennas which are easy for design and fabrication [1]. Metamaterials are materials with modified structures which has enhanced properties than the ordinary materials which are used for the design of various semiconductor devices such as antennas [5].

Therefore, in this paper a Split Ring Resonator (SRR) based metamaterial antenna is developed for 4G WiMAX applications. In literature review fundamentals of designing patch antenna have been studied using [2-3], Metamaterial structures was first invented by V. G. Veselago [4] and its basic design fundamentals has been given in [5] and the contribution of metamaterial in electromagnetics has been given in [6-7]. Metamaterial antenna for 5.5 GHz WiMAX applications is presented in [8]. Series fed two dipole antenna for WLAN base station applications is discussed in [9]. Two element series fed two dipole antenna for WLAN base station applications is discussed in [10]. Metamaterial antenna for multi band applications is presented in [11]. 2.3 GHz antenna with both LHCP and LP for SDARS is discussed in [12]. Performance analysis of 2.3 GHz microstrip square antenna using ADS is discussed in [13]. Circularly polarized annular-ring slot antenna for WiMAX 2.3 GHz and WLAN 2.4 GHz applications is presented in [14]. Design of 2.3/3.3/5.8 GHz antenna array for wireless communication in transportation systems is discussed in [15].

In this paper SRR based metamaterial structure is added in the ground plane of circular patch antenna is presented for 4G WiMAX applications. CST Microwave studio v2019 is used in this research process of developing the proposed SRR based metamaterial antenna.

II. ANTENNA DESIGN

The top view of the proposed metamaterial antenna is given in Fig.1. The top view consists of simple circular patch configuration which is designed by using 0.045 mm thickness copper with electrical conductivity of 5.8e+007. The bottom view is given in Fig.2. The bottom view consists of Split Ring Resonator SRR metamaterial structure.

The proposed metamaterial antenna is designed on the low cost FR4 material with the characteristics of thickness 1.6 mm with permittivity of 4.3 and loss tangent 0.02. Inset feeding with 50-ohm input impedance is used in the excitation of the proposed SRR based metamaterial antenna.

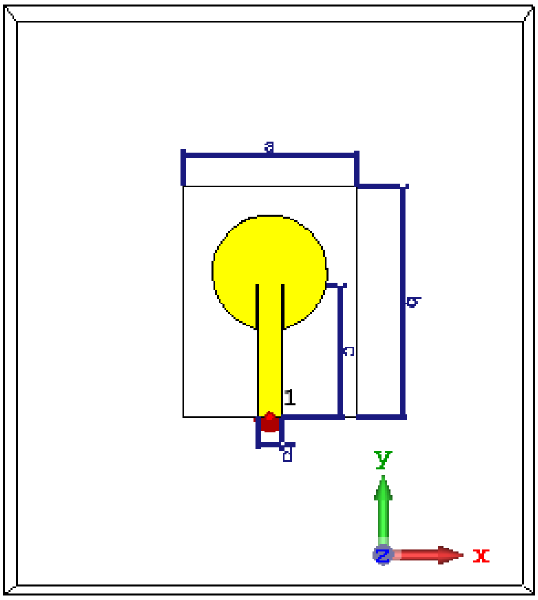

Fig.1 Top view of the metamaterial antenna

The top view consists of simple circular shaped copper patch in which inset feeding is used for the excitation. The length of inset feed is 23 mm and the width of 4 mm. The circular patch is having 10 mm radius. All dimensions used in top view have been presented in Table 1.

TABLE 1

GEOMETRICAL PARAMETERS OF TOP VIEW OF THE PROPOSED ANTENNA

Parameter	Dimension (mm)
a	30
b	40
c	23
d	4

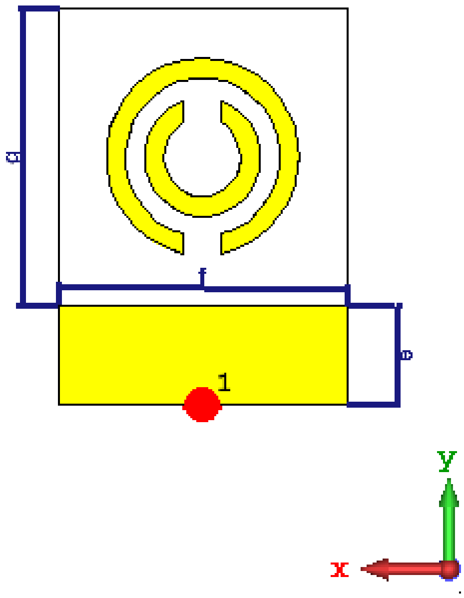

Fig.2 Bottom view of the metamaterial antenna

The bottom view of the proposed antenna comprises the Split Ring Resonator SRR metamaterial structure which includes two rings namely outer and inner ring made of copper material. The dimensions were optimised using the simulation software and the optimised dimensions used in the bottom view have been presented in Table 2.

TABLE 2

GEOMETRICAL PARAMETERS OF BACK VIEW OF THE PROPOSED ANTENNA

Parameter	Dimension (mm)
e	10
f	30
g	30

III. RESULTS AND DISCUSSION

The proposed SRR based metamaterial antenna is designed and simulated in CST Microwave studio v2019 and its results were discussed below.

3.1 Return Loss

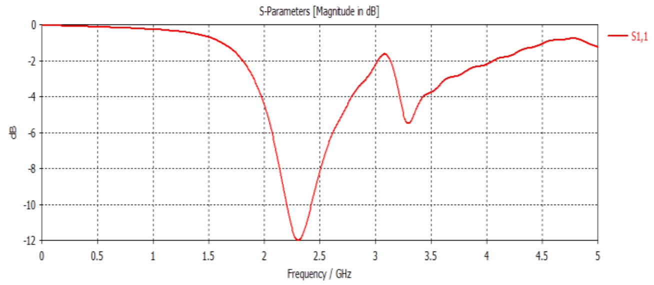

Fig.3 Return Loss

The return loss obtained -12 dB at 2.3 GHz for the proposed SRR based metamaterial antenna which is given in Fig.3. The bandwidth achieved is 230 MHz in the operating frequency range.

3.2 VSWR

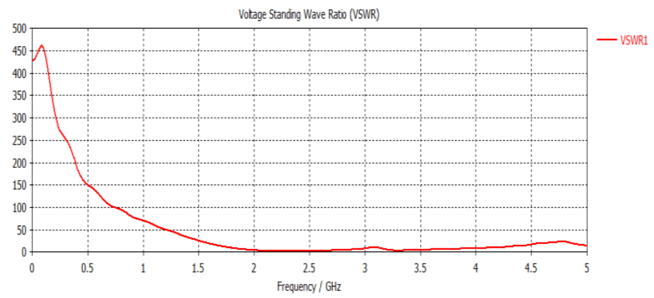

Fig.4 VSWR

The minimum Voltage Standing Wave Ratio VSWR obtained <1.5 at 2.3 GHz for the proposed SRR based metamaterial antenna which is given in Fig.4.

3.3 Front to Back Ratio

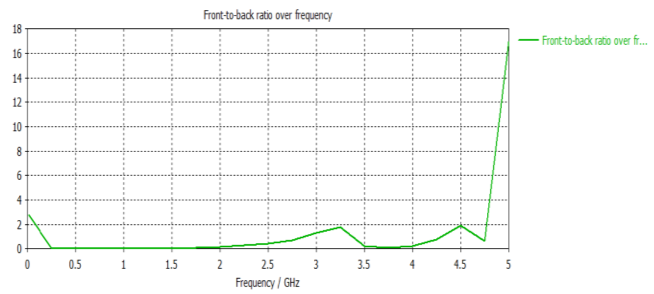

Fig.5 Front to Back Ratio

Front to Back Ratio is the ratio of power gain between the front and rear of a directional antenna. Front to back ratio for the proposed SRR based metamaterial antenna is 0.45 at 2.3 GHz which is given in figure 5.

3.4 Farfield Plots

Farfield Plots for Gain, Directivity for the proposed SRR based metamaterial antenna presented in this section.

3.4.1. Farfield Gain at 2.3 GHz

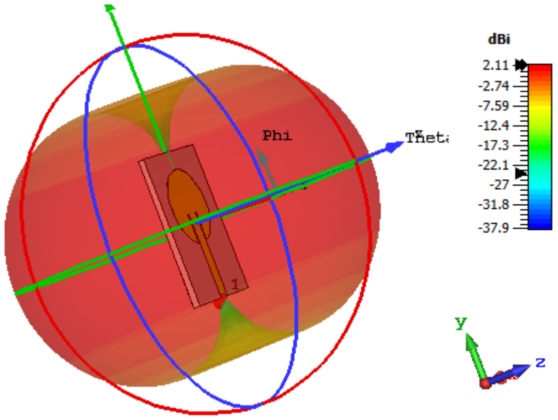

Fig.6 Farfield Gain at 2.3 GHz

3.4.2. Farfield Directivity at 2.3 GHz

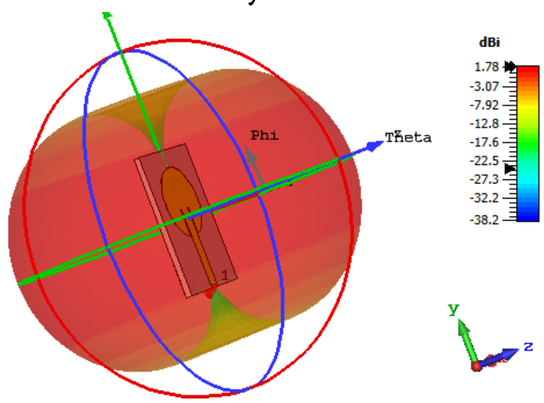

Fig.7 Farfield Directivity at 2.3 GHz

3.4.3. Farfield Directivity, Abs Phi=0

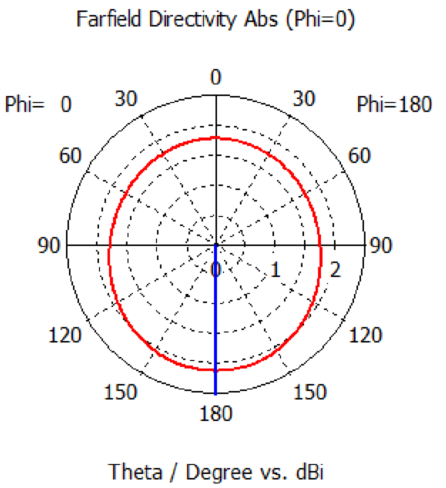

Fig.8 Farfield Directivity, Abs Phi=0

3.4.4. Directivity, constant Phi=90

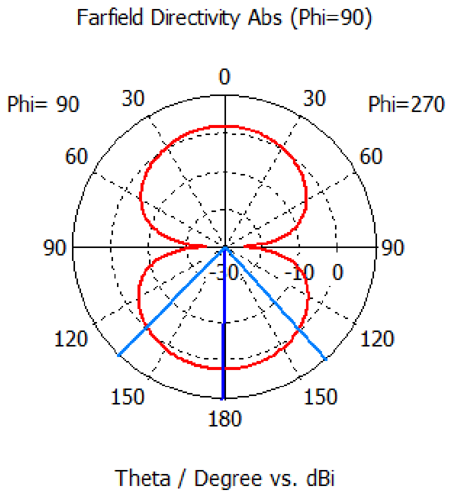

Fig.9 Directivity, constant Phi=90

3.4.5. Farfield Directivity Plot at Theta=0

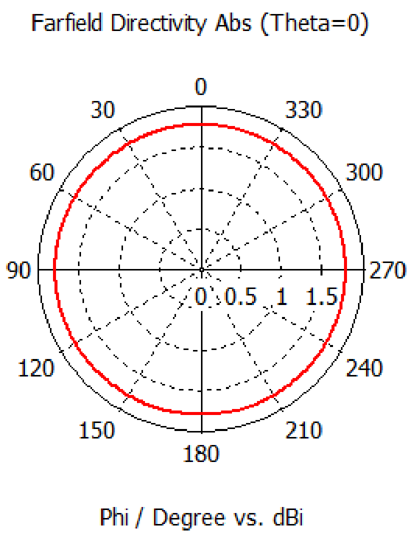

Fig.10 Farfield Directivity Plot at Theta=0

3.4.6. Farfield Directivity Plot at Theta=90

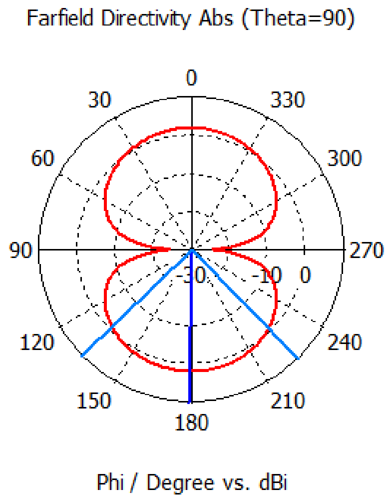

Fig.11 Farfield Directivity Plot at Theta=90

3.5 E Field

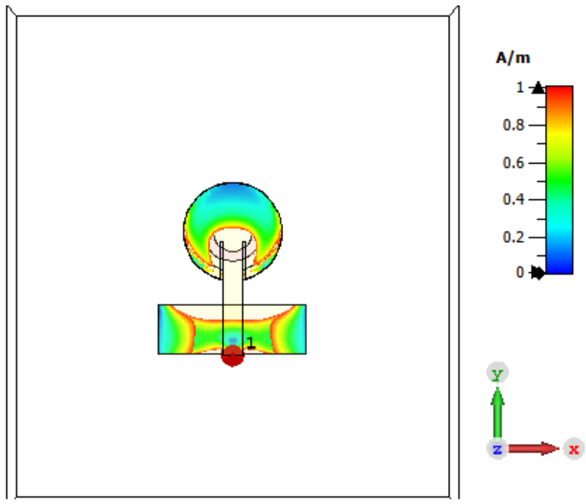

Fig.12 E Field Front View

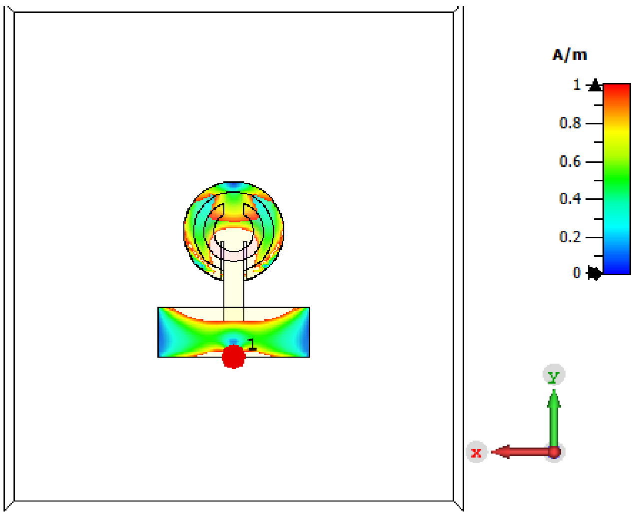

Fig.13 E Field Back View

3.6 H Field

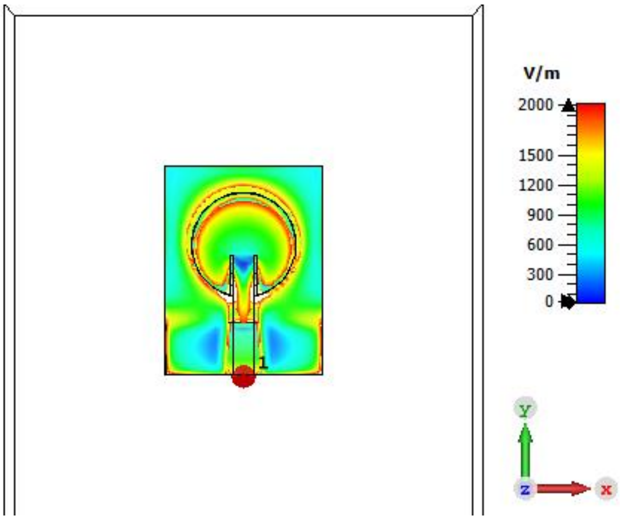

Fig.14 H Field Front View

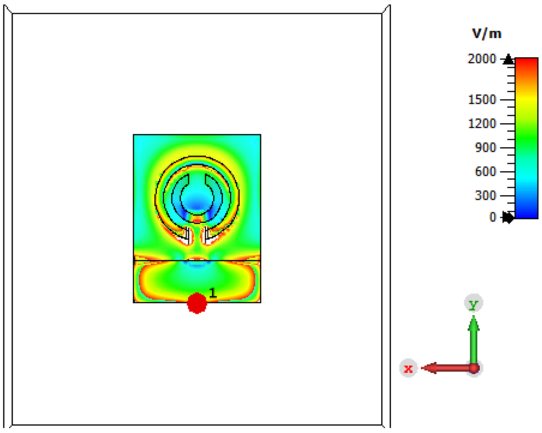

Fig.15 H Field Back View

3.7 Surface current a distribution

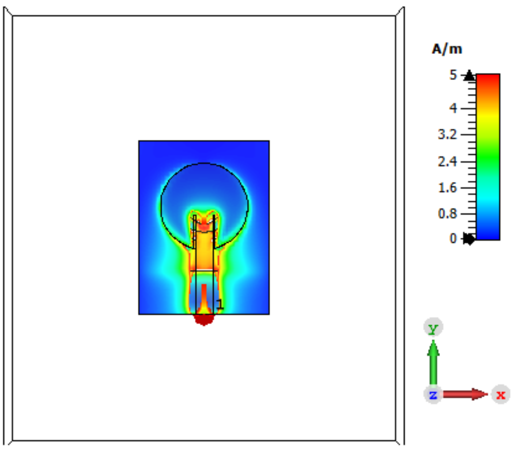

Fig.16 Surface current a distribution Front View

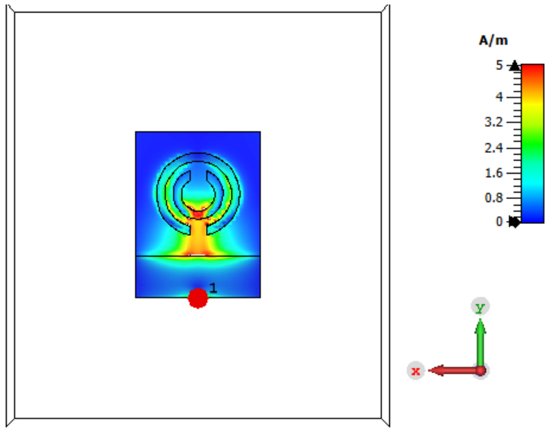

Fig.17 Surface current a distribution Back View

3.8 Maximum gain over frequency

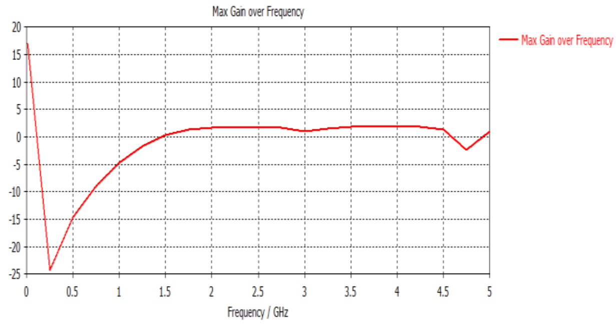

Fig.18 Maximum gain over frequency

The overall results achieved by the proposed SRR based metamaterial antenna have been presented in Table 3.

TABLE 3

OVERALL RESULTS

Parameter	Value
Operating Frequency	2.3 GHz
Return Loss	-12 dB
VSWR	< 1.5
Bandwidth	230 MHz
Gain	2.11 dBi
Directivity	1.78 dB
Front to Back Ratio	0.45

IV. CONCLUSION

The proposed SRR based metamaterial antenna achieved resonant frequency at 2.3 GHz along with a compact dimension of 30*40 mm and gain of 2.11 dBi, return loss of -12 dB and the bandwidth of 230 MHz. The proposed antenna is suitable for 4G WiMAX applications.

V. REFERENCES

[1]. C. A. Balanis, Antenna Theory: Analysis and Design, 2nd ed. New York: John Wiley &Sons, 1997.

[2]. D. M. Pozar and D. H. Schaubert, Eds., Microstrip Antennas: The Analysis and Design of Microstrip Antennas and Arrays. New York: IEEE Press, 1995.

[3]. Yi Huang, Kevin Boyle. Antennas from theory to practice. John Wiley &Sons,2008.

[4]. G. Veselago "The Electrodynamics of Substances with simultaneously negative values of ε and μ.", soviet physics uspekhi-volume 10, number 4(1968):509-514.

[5]. D.R. Smith, W.J. Padilla, D.C. Vier, S.C. Nemat-Nasser, S. Schultz, Composite medium with simultaneously negative permeability and permittivity, Phys. Rev. Lett. 84 (2000) 4184–4187.

[6]. E. Shamonina, L. Solymar," Metamaterials: How the subject started" Elsevier B.V. Metamaterials 1 (2007): 12–18.

[7]. Ari Sihvola," Metamaterials in electromagnetics", Elsevier B.V. Metamaterials 1 (2007): 2–11.

[8]. Design and Development of Metamaterial Antenna For 5.5 GHz Wi-Max Applications, International Journal of Scientific Research in Mechanical and Materials Engineering (IJSRMME), ISSN: 2457-0435, Volume 2 Issue 3, pp. 01-07, 2018.

[9]. Design and development of series fed two dipole antenna for WLAN base station applications, ICTACT Journal on Microelectronics, April 2018, Volume: 04, Issue: 01.DOI: 10.21917/ijme.2018.0081, pp 515-518.

[10]. Design and development of two element series fed two dipole antenna for WLAN base station applications, ICTACT Journal on Microelectronics, October 2018, Volume: 04, Issue: 03. DOI: 10.21917/ijme.2018.0113, pp 652-655.

[11]. Design and Development of Metamaterial Antenna for Multi Band Applications, International Journal of Scientific Research in Mechanical and Materials Engineering (IJSRMME), ISSN: 2457-0435, Volume 2 Issue 5, pp. 07-13, 2018.

[12]. Dau-Chyrh Chang, & Jing-Hau Chen. (n.d.). 2.3 GHz antenna with both LHCP and LP for SDARS. IEEE Antennas and Propagation Society International Symposium. Digest. Held in Conjunction with: USNC/CNC/URSI North American Radio Sci. Meeting (Cat. No.03CH37450). doi:10.1109/aps.2003.1220049.

[13]. Gupta, Yogesh Kumar, R. L. Yadava and Rajiv Kumar Yadav. "Performance Analysis of 2.3 GHz Microstrip Square Antenna Using ADS." (2013).

[14]. Sim, C.-Y.-D., Chang, M.-H., Chen, H.-D., Han, T.-Y., & Row, J.-S. (2014). Circularly polarized annular-ring slot antenna for WiMAX 2.3 GHz and WLAN 2.4 GHz applications. 2014 IEEE Antennas and Propagation Society International Symposium (APSURSI). doi:10.1109/aps.2014.6904852.

[15]. Kurniawan, A., & Iskandar. (2011). Design of 2.3/3.3/5.8 GHz antenna array for wireless communication in transportation systems. 2011 6th International Conference on Telecommunication Systems, Services, and Applications (TSSA). doi:10.1109/tssa.2011.6095439.

Cite this article as : Geetharamani G, Aathmanesan T, "Design of SRR Based Metamaterial Antenna for 4G WiMAX Applications",International Journal of Scientific Research in Mechanical and Materials Engineering (IJSRMME), ISSN : 2457-0435, Volume 3 Issue 2, pp. 15-20, March-April 2019. URL : http://ijsrmme.com/IJSRMME19317