iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 6 **Issue:** V **Month of publication:** May 2018

DOI: http://doi.org/10.22214/ijraset.2018.5181

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue V, May 2018- Available at www.ijraset.com

Gain Enhancement and Miniaturization of Microstrip Patch Antenna Array with Incorporation of Metamaterial Lens

Pradeep A S[1], Jagadish S Gangavati[2], Vijayalakshmi N Arkasali[3], Sheela A S[4], Yamanoorappa[5]
[1] Assistant professor, Dept. of ECE, GEC, Huvinahadagali
[2, 3, 4, 5] UG Student, Dept. of ECE, GEC, Huvinahadagali

Abstract: In paper the 2 X 1 Microstrip patch antenna array is designed at resonant frequency 2.4 GHz which is applicable for ISM band. Moreover, the Metamaterial lens is designed and placed above the array of Microstrip patch antenna using Modified split ring resonator Metamaterial structure as an unit cell. The performance analysis is carried out wherein all the governing performance metrics are observed without Metamaterial and with Metamaterial. The simulation results are illustrated with polar plot, 3D radiation plot, S-parameter plot, VSWR plot and current distribution. Furthermore, the exhaustive comparative analysis is carried out and improvement in every metrics is depicted graphically. It is shown that the incorporation of Metamaterial lens enhances antenna gain with 3 dB to 6.0 dB as compared to antenna array without Metamaterial.
Keywords: Metamaterial, gain, antenna array, spilt ring resonator, return lose

I. INTRODUCTION

To assure reliability, mobility, and high efficiency characteristics modern wireless communication system requires low profile, light weight, high gain, and simple structure antennas. Microstrip antenna satisfies such requirements [1]. The frequency describes the antenna size, lower the frequency larger the size. Lens antennas have received considerable attention for microwave and millimeter wave applications since they offer the requirements of broadband and high gain performances through concentrating the radiated energy into a narrow beam-width in the desired direction. Traditionally, dielectric materials have been used as lenses, but they essentially suffer from their heavy and bulky profiles and also their machining process might be expensive [2]. As alternatives for dielectric lenses, resonant and non-resonant sub-wavelength periodic structures such as frequency selective surfaces (FSSs) [3- 4] and artificial materials (also named Metamaterials) [5] have been extensively employed to collimate the spherical waves into a focused beam. In particular, sub-wavelength Metamaterials with peculiar properties of controlling the effective material parameters and hence manipulating propagation waves have been exploited to design various types of lenses for instance, negative index Metamaterial lenses (NIM) [5] zero index Metamaterial lenses (ZIM) and gradient index Metamaterial lenses (GRIN) . Indeed, lens antennas proposed in [6] have been constructed. Alternatively, a GRIN lens overcomes the drawbacks of narrow bandwidth and large transmission loss associate with other types of Metamaterial lenses [7-8]. There is always a scope and essentiality for Miniaturization of an antenna system without compromising with the performance of an antenna. Hence the enhancement of gain along with miniaturization work has been taken and almost double gain and 50% reduction in overall size of an 2 x 1 Microstrip patch antenna by incorporating Metamaterial structure.

II. PROPOSED ANTENNA DESIGN

A Microstrip Rectangular Patch Antenna with coaxial feeding is designed using FR4 dielectric material of thickness 1.57 mm having dielectric constant of 4.4 to operate at 2.4GHz.Based on the simplified formulation that has been described, a design of Microstrip Rectangular Patch Antenna is having the optimized width and length of the patch are 38mm and 28mm respectively. At 10 mm above of 1 X 2 Microstrip patch antenna array with distance 32 mm between them, three modified Metamaterial spilt ring resonator are placed on 1 mm thickness dielectric material of FR4 having dielectric constant 4.4 as shown in Fig. 1. The designed MSRR unit-cell consists of two nested rings, and each ring has two symmetrical splits. MSRR unit-cells are placed between the two antennas at the edge of left side of antenna, and the distance between the MSRR unit-cell is 1 mm. To obtain high isolation, the optimized dimensions of the antenna array are: L_{gnd} = 70 mm, W_{gnd} = 130 mm, L = 28.3 mm, W = 36.5 mm, d = 31.5 mm, d1 = 0.25 mm, d2 = 0.25 mm, r1 = 2.5mm, r2 = 2mm, k = 0.08 mm as in Fig.2.

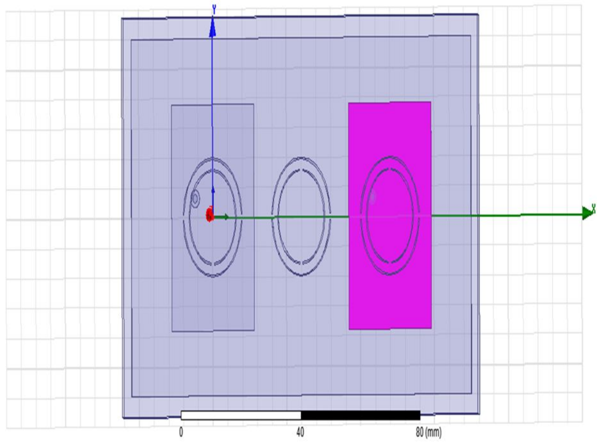


Fig.1 3D Model of the Proposed Antenna Structure

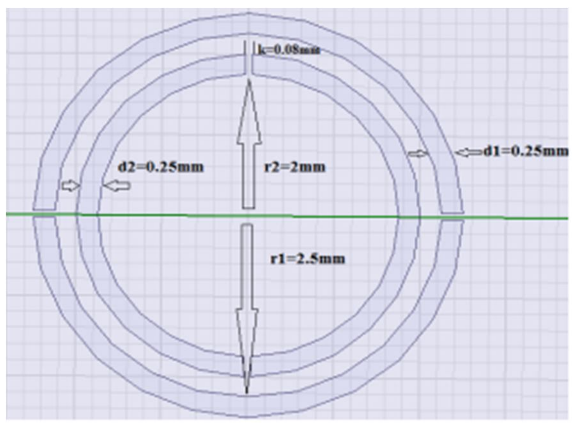


Fig.2 Geometry of MSRR unit cell

III. RESULTS

The performance of the proposed MSRR loaded antenna array has been evaluated using numerical simulation in ANSYS HFSS. The return loss of antenna array with MSRR Metamaterial structures are illustrated in Fig. 3. The radiation pattern of antenna array with and without MSRR Metamaterial structures are illustrated in Fig. 4 and Fig.5 respectively. It can be seen that the gain of proposed antenna array is around 6.4 dB where as it is 3.7 dB in case of patch array without Metamaterial. We can see that the gain of antenna array with Metamaterial is increased almost double as compared to patch array without Metamaterial.

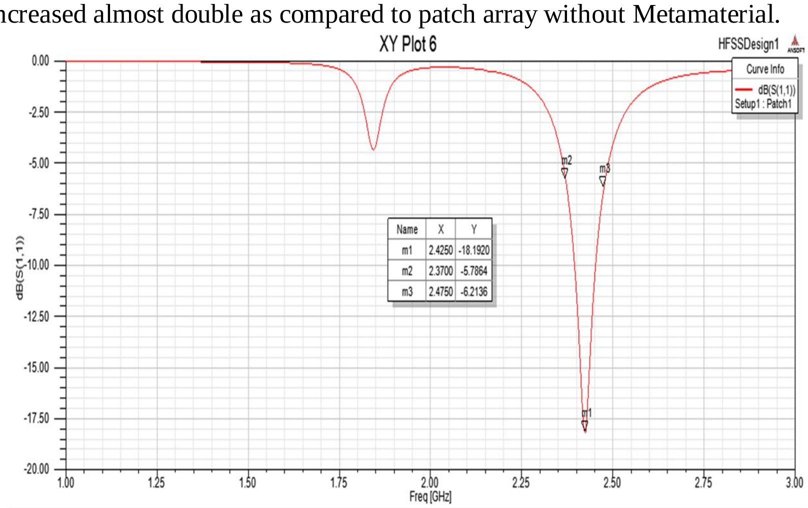


Fig.3 Return lose plot of proposed antenna

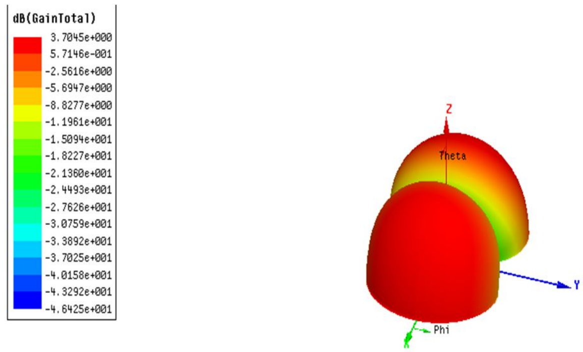


Fig.4 3D Polar radiation pattern of 1 X 2 Microstrip patch antenna array

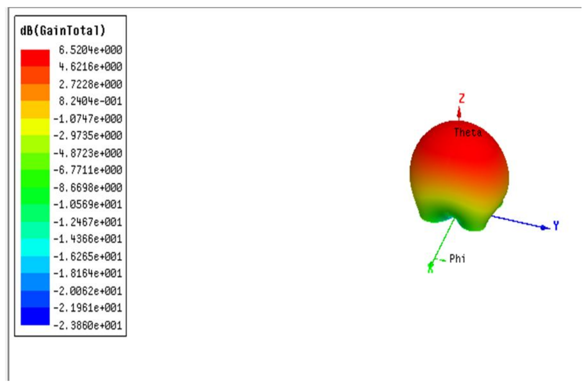


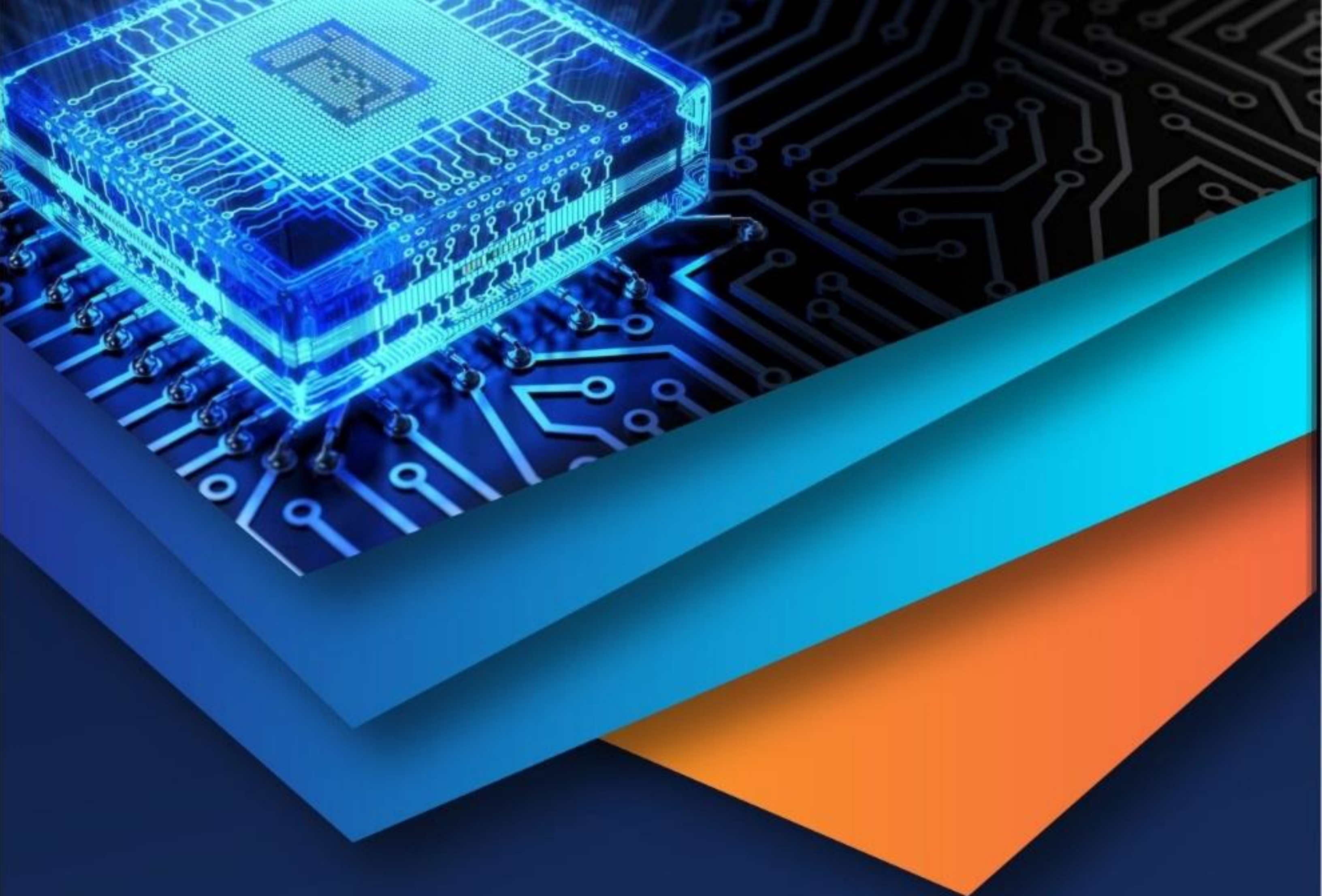
Fig.4 3D Polar radiation pattern of 1 X 2 Microstrip patch antenna array with Metamaterial

IV. CONCLUSION

The enhancement of gain is achieved using modified spilt ring resonator Metamaterial when they placed on the rectangular Microstrip patch antenna array of 1 X 2 with the distance between them is 32mm about λ/4 at 2.4 GHz frequency. We can see that the gain of antenna array with Metamaterial is increased almost double as compared to patch array without Metamaterial. About 50% size reductions are achieved in antenna structure as compared to array of patch antenna. Moreover the Metamaterial stricture proposed is simple and low cost.

REFERENCES

[1] C. A. Balanis, Antenna Theory: Analysis and Design, 3rd ed., John Wiley and Sons, 200
[2] T. L. A. Rhys, "The Design of Radially Symmetric Lenses," IEEE Trans. Antennas Propagation., vol. 18, no. 4, pp. 497- 506, Jul. 1970
[3] R. B. Greegor, C. Parazzoli, J. Nielse, M. A Thompson, M. H. Tanielian, and D. R. Smith, "Simulation and Testing of a Graded Negative Index of Refraction Lens,"Appl. Phys. Lett., vol. 87, pp. 091114 /1- 3, Aug. 2005.
[4] S. M. A. M. H Abadi, N. Behdad, "Design of Wideband, FSS-Based Multi Beam Antennas Using the Effective Medium Approach," IEEE Trans. Antennas Propagation., vol. 62, no. 11, pp. 5557- 64, Nov. 2014
[5] Md. Tanvir Ishtaique-ul Huque et al., “Design and Performance Analysis of Microstrip Array Antennas with Optimum Parameters for X band Applications”, International journal of advanced computer science and applications, Special Issue: 8 ,vol. 2, 201
[6] D. R. Smith, J. J. Mock, and D. Schurig, "A Gradient Index Metamaterials, " Phys. Rev. E, vol. 71, no. 3, pp. 036609/1-5, Mar. 2005
[7] Pradeep A S, Maheshwar M Swamy, Umesh, Nanda, Divya M, “ Design and performance analysis of reactangular Microstrip patch antenna using Metamaterial structure for improved radiation”, IJERT, Vol. 4, pp. 1191-1193. Issue 5, May 2015



10.22214/IJRASET

INDEX COPERNICUS 45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

TOGETHER WE REACH THE GOAL

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY