Design of Plus Shape MPA Loaded with SRR and CSRR Structure

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Abstract— In this paper, a plus shape MPA structure is proposed, which is loaded with metamaterial structures (CSRR and SRR) simulated at 57 GHz. It shows the metamaterial property at thickness of 1.57 mm and shows the reduction in return loss with huge enhancement in bandwidth up to 60 GHz. The proposed antenna is simulated in HFSS 13 and compared the result with regular patch antenna. The analysis shows reduction in return loss and enhancement of gain bandwidth which provides a bright future of scope for further analysis in this area.

Key words: Left-Handed Material (LHM), Microstrip Patch Antenna (MPA), Metamaterial (MTM), Return Loss, Gain

I. INTRODUCTION

The microstrip patch antennas are generally used in the wireless devices [1]. So the miniaturization of the antenna has become an important issue in reducing the volume of entire communication system. The patch is a low profile, Low gain antenna. The return loss of patch antenna is very small that is a disadvantage of patch antenna. The future development will aim to provide reduction in size and high gain bandwidth performance. The patch to ground-plane spacing is equal to the thickness t of the substrate and is typically about $\lambda_0/100$. The patch antenna is inexpensive as compared to others. The development of low cost, minimal weight, and low profile antennas that is capable of maintaining high performance. Metamaterial based rectangular patch antenna improves the return loss as well as gain of patch antenna.

A. Metamaterial and Its Structures

Metamaterial or left handed material is the artificial material that did not exist in the real nature. Metamaterial had been categorized structure or design that has the simultaneously negative permeability and permittivity. It follows the left handed propagation rule because propagation of wave takes place in backward direction in the medium [2] Due to negative μ and negative ε the refractive index of the medium. Thus, it is also termed as NIM (negative index material) [3]. This word is a combination of **“**meta” and “material**”**, Meta [4] is a Greek word which directs something beyond, altered, changed or something advance.

Split ring resonators (SRRs) design is used to produce the negative dielectric constant (permittivity) and negative permeability. This structure sometime called Double Negative Material or DNG. In this SRR design, there are two concentric metallic split rings, printed on a microwave dielectric circuit board. The complementary of split ring resonator structure is obtained by replacing the copper parts with substrate material, and the substrate material with copper parts.

II. DESIGN SPECIFICATION

The Rectangular Microstrip Patch Antenna is designed on FR4 substrate other parameters are given bellow in table.

Parameters	Dimension	Unit
Die-electric constant	4.4	-
Loss tangent (tan)	.02	-
Thickness (h)	1.57	mm
Operating frequency	62	GHz
Length L	50	mm
Width W	50	mm
Type of feed	Transmission line	-

Table 1: Specifications of Proposed MPA

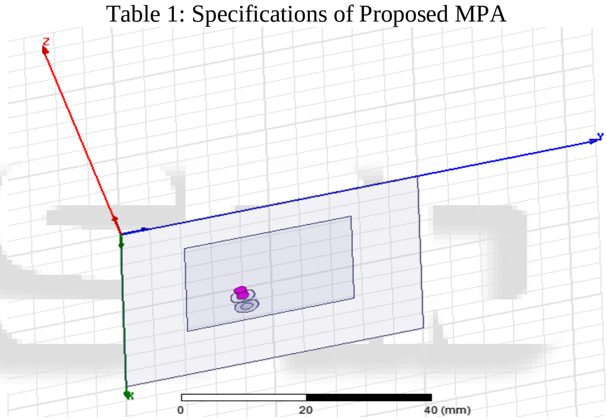

Fig. 1: Rectangular microstrip patch antenna

HFSS 13 software is used to design the Rectangular microstrip patch antenna (MPA) at operating frequency at 20 GHz. Simulated result of Return loss and bandwidth of Rectangular Microstrip Patch antenna (MPA) which will provide the base for comparison of parameter is shown in fig 2.

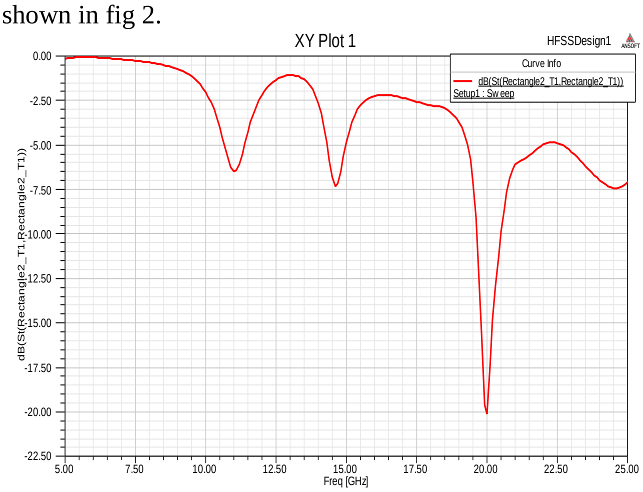

Fig. 2: Simulation of return loss and bandwidth of MPA

The bandwidth of simple MPA is 500 MHz at 20 GHz resonance frequency and Return loss is -20 dB.

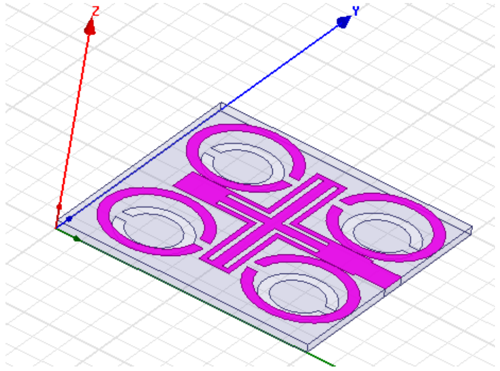

Fig. 3: Design of proposed metamaterial structure at the height of 1.57 mm from ground plane.

This design provides a better bandwidth and return loss [11]. Simulation result of bandwidth and return loss of MPA loaded with metamaterial structure is shown in fig.4. it will touch the return loss of -30 dB at 57 GHz and -20dB at 26GHz. This result is far better than MPA in terms of both parameters. We can see that graph of fig 4 becomes broader at -10 db. So bandwidth will be greater than former simulated graph of fig. 2. So we got the desirable result.

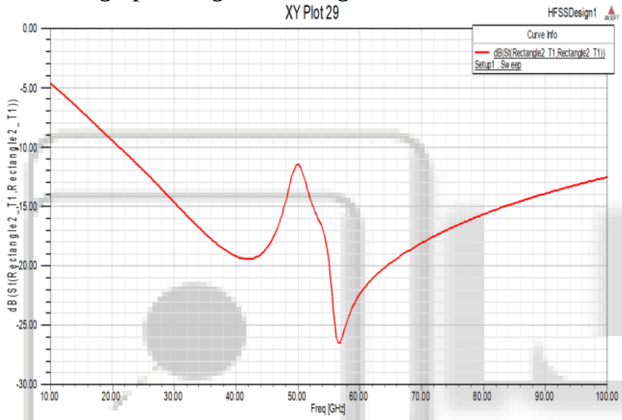

Fig. 4: Simulation of Return loss and bandwidth of MPA with proposed metamaterial structure

Antenna gain is the ratio of maximum radiation intensity at the peak of gain beam to the radiation intensity in the same direction [16] which would be produced by an isotropic radiator having the same input power. Simulation result of MPA is in figure given below. The gain of MPA is 3.612 as simulated on HFSS 13. Antenna gain can be increased by cutting the slot technique.it can increase the gain at same frequency also.

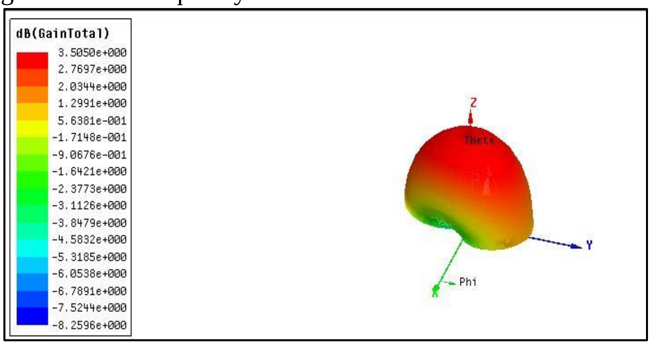

Fig. 6: Antenna Gain of MPA

Metamaterial structure already increased the gain of metamaterial antenna up to the mark. We can also increase gain further by cutting the slot in the structure. This is the technique which is widely used in MTM field to get the better result.

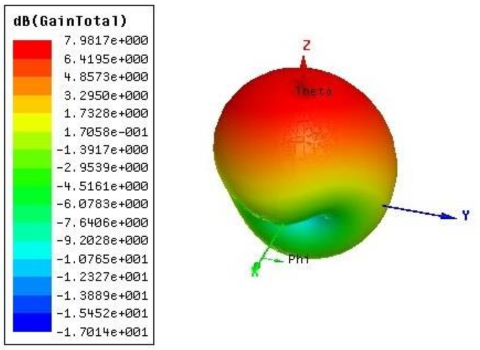

Fig. 7: Antenna Gain of MPA with proposed metamaterial structure

III. Simulation Result and Discussion

In this paper, Rectangular microstrip patch antenna loaded metamaterial structure is simulated using HFSS 13 software. The proposed design in comparison of MPA alone is far better. This design is operated at 56 GHz and it provided bandwidth enhancement at the cost of decrease in return loss The reduction of Return Loss ultimately improves the Gain as well as the Directivity of Rectangular Microstrip Patch Antenna. So it is found that the insertion of Metamaterial structure on Rectangular Microstrip Patch Antenna ultimately Reduce the Return Loss[17] and enhance the bandwidth as discussed in the above figure 4.

IV. Conclusion

The patch antenna has less bandwidth. So MPA using metamaterial structure has been proposed and discussed in this paper. Better return loss shows that very small amount of waves returned to source so radiated power will increase. The reduction of return loss ultimately improves gain of patch antenna which makes patch antenna more directive as discussed in simulated result. This had been proven that metamaterial loading effect enhances the crucial parameter of the patch antenna. In future metamaterial will be helping tool in every field from electronics to agriculture. The negative property of metamaterial makes it different from others. Now we can say the dream of Veselgo is getting true. Metamaterial has now entered in the optical field which shows the possibility of invisibility name as cloaking. So there is a possibility of using MTM in every field for better result.

References

[1] V. G. Veselago , “the electrodynamics of substances with simultaneously negative values of μ and ε”, Sov. Phys. Uspekhi, vol. 10, no. 4, 1968, pp. 509–514
[2] A. Sihvola,”Metamaterials in electromagnetics”, Metamaterials 1, 2007, 2-11.
[3] D. R. Smith, J. B. Pendry and M. C. K. Wiltshire, Metamaterials and negative refractive index, Science305, 2004,pp788-792
[4] S Anantha Ramakrishna, “Physics of negative refractive index materials”, 2005, pp 453-467,490-495S.
[5] R .M. Walser,“Electromagnetic metamaterials Proc. SPIE 4467, 2005, pp1-15

[6] Richard W. Ziolkowski , “Metamaterial-Based Antennas: Research and Developments”, IEICE Trans Electron,2006
[7] J. B. Pendry, A. J. Holden, D. J. Robbins, and W. J. Stewart,” Magnetism from conductors and enhanced nonlinear phenomena”, IEEE Transactions Microwave Theory and Techniques, vol. 47, no. 11, 1999, pp. 2075-208.
[8] Prof. Laxmi Shrivastava et.al “design of h shaped metamaterial structure for enhancement of patch antenna gain”,2012
[9] Nader Enghta, R. W. Ziolkowski “Metamaterials Physics and Engineering” Explorations Published by John Wiley & Sons, In, Canada.2006
[10] Enghetaand Ziolkowski, R. W., (eds.), “Electromagnetic Metamaterials: Physics and Engineering Exploration, Willey-IEEE PRESS, NewJersy, U.S.A, 2006
[11] R. A. Shelby, D. R. Smith and S. Schults “Experimental Verification of a Negative Index of Refraction,” Science, Vol. 292, No. 5514,2001,pp. 77-79
[12] Ziolkowski, R. W. and E. Heyman, “Wave propagation in media having negative permittivity and permeability”,Physics ReviewE, Vol. 64, No. 5, 056625, 2001,pp1–15
[13] Davi Bibiano Brito, “Metamaterial inspired improved antenna and circuits”, UFRN, 2010, pp.19-27
[14] B. Monk, “Metamaterials-Critique and Alternative’s, A John willey&sons, INC publications, Merits,2000.
[15] R. W. Ziolkowski, “Design fabricating and fabrication and testing of double negative metamaterial,” IEEE Transactions on antennas and Propagation, vol.51, no.7, July 2005,pp.1516-1529,
[16] D.R. Smith, W.J. Padilla, D.C. Vier, et al, “Composite medium with simultaneously negative permeability and permittivity”, Phys Rev Lett 84 (2000), pp 4184–4187.
[17] Ayoub, A. F. A., "Analysis of rectangular microstrip antennas with air substrates," Journal of Electromagnetic Waves and Applications, Vol. 17, No. 12, 1755-1766
[18] Gourav Singh, “Design and analysis of Rectangular microstrip patch antenna using metamaterial for better efficiency”, Volume 2, Issue 6,2012.