ISSN XXXX XXXX © 2017 IJESC

Research Article Volume 7 Issue No.8

Metamaterial Loaded Microstrip Patch Antenna for X Band Applications

Ankita Gupta[1], Garima Tiwari[2]
ME Student[1], Assistant Professor[2]
Department of ECE
Jabalpur Engineering College, India

Abstract:
In recent days bandwidth improvement of a micro strip patch antenna is a vital topic in the field of microwave engineering. This paper proposes a microstrip patch antenna with Metamaterials substrate. This paper also compares the performance of microstrip patch antenna without Metamaterials substrate and with metamaterial substrate. The array of swastika like Metamaterials unit cells used as substrate of patch antenna. The proposed antenna is designed with CST software and works in the X band applications. The permeability and permittivity of metamaterial is derived from S-parameters. Antenna parameters such as bandwidth and return losses are measured.

Keywords: Axial Ratio, Microstrip patch antenna, Metamaterial array, Return loss

I.INTRODUCTION

The focus of this paper is on met material based patch antenna so it is necessary to introduce metamaterial first. Metamaterials refers to the material which has a property that is not found in the nature. The most important property of them is that they can modify their permittivity and permeability so that they can improve the performance of antenna, coupler and filters. They are artificial materials which are manufactured from metal inclusion embedded in dielectric substrate. The interaction of electromagnetic fields with inclusion creates the resonating behavior of Metamaterials. Metamaterial based antennas are antennas which properties are enhanced by metamaterial. After this second main focus of this paper is on antenna so antenna is a radiating element works as a transducer between the transmitter and free space and vice versa. Electromagnetic nature of light is prime concept of antenna design. The first proposed concept of microstrip antenna was given in 1953 by Deschamps. The simplest geometry of antenna consists of a radiating patch on one side of a substrate and ground plane on the other side of substrate containing fixed dielectric constant and thickness. There are different geometries of patch namely circular, rectangular triangular and square etc are available. The disadvantage of these antennas is that its narrow bandwidth and low gain. To overcome his metamaterial basedFormatting substrate is used which not only increase the bandwidth but also decrease the return loss.

II.DESIGN OF RECTANGULAR PATCH ANTENNA WITHOUT METAMATERIAL

The specified antenna is a rectangular patch antenna which is fed by a microstrip line on a dielectric substrate FR-4 loss whose dielectric constant is 4.3, loss tangent 0.02 and 1.6 mm of thickness. The designing frequency of this antenna is 10.30 GHz band width of microstrip line is 3.11 mm and design to match impedance 50 ohms of transmission line. The rectangular microstrip patch antenna is shown in fig 1.The essential parameters of design can be derived from the equation (1) and (3) from [3].

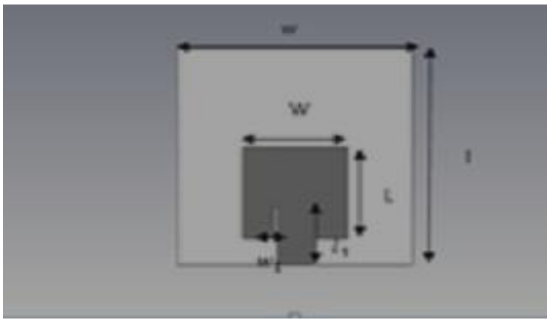

Figure.1. Conventional patch antenna design

Table.1. Table for conventional patch antenna design

Symbol	w	L	W	L	w_1	l_1
Dimension(mm)	20	14.985	8.937	6.28	2.66	4.025

Width

$$w=\frac{1}{2f_r\sqrt{\mu_0\varepsilon_0}}\sqrt{\frac{2}{\varepsilon_r+1}}=\frac{v_0}{2f_r}\sqrt{\frac{2}{\varepsilon_r+1}} \qquad (1)$$

Where $v_0 =$ *free space velocity*
$f_r =$ *resonant frequency*

Effective dielectric constant

For $\frac{W}{h} > 1$

$$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\sqrt{(1+12\frac{h}{w})} \qquad (2)$$

Length

$$L=\frac{1}{2f_r\sqrt{\varepsilon_{eff}}\sqrt{\mu_0\varepsilon_0}} \qquad (3)$$

Where

$$\frac{\Delta L}{h} = 0.412\frac{(\varepsilon_{eff}+0.3)(\frac{W}{h}+0.264)}{(\varepsilon_{eff}+0.258)(\frac{W}{h}+0.8)} \qquad (4)$$

$$L_{eff} = L + 2\Delta L \qquad (5)$$

III. UNIT CELL METAMATERIAL STRUCTURE

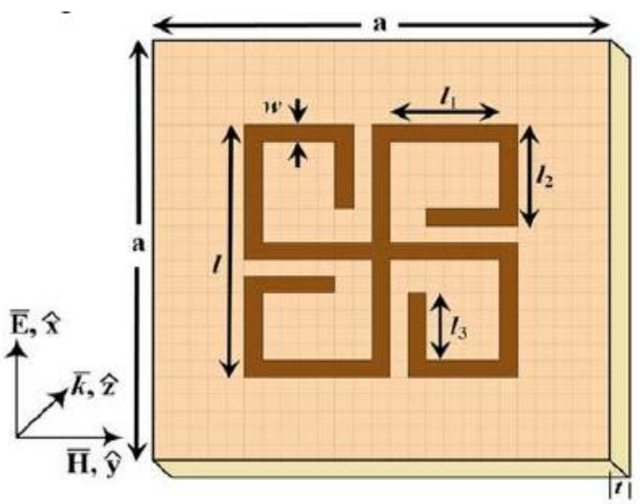

Figure.2. unit cell of metamaterial swastika like structure [1]

Table. 2. dimensions of unit cell Metamaterials [1]

Symbol	A	W	l_1	l_2	l_3	l	T
Dimension(mm)	5	0.2	1.2	0.8	1	1	1

In this paper swastika like metamaterial structure array used which gives metamaterial property (negative real values Ɛ, µ, n) at 10.30 resonance frequency. The unit cell has given in fig 2 and dimensions of metamaterial also given in table 2.This structure has stimulated by CST software and permeability(µ) and permittivity(Ɛ) versus frequency plot can be obtain by MATLAB. The formulas used for permeability and permittivity calculation are given below [5]

$$n=\frac{1}{kd}\cos^{-1}\left[\frac{1}{2S_{21}}\left(1-S_{11}^2+S_{21}^2\right)\right] \quad (6)$$

$$z=\sqrt{\frac{(1+S_{11})^2-S_{21}^2}{(1-S_{11})^2-S_{21}^2}} \quad (7)$$

$$\varepsilon=\frac{n}{z} \quad (8)$$

$$\mu=n.z \quad (9)$$

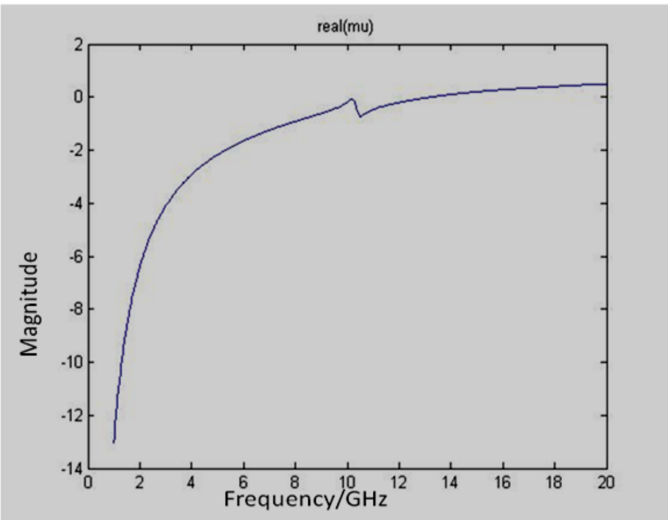

Figure.3. (a) Retrieved effective value of µ for metamaterial

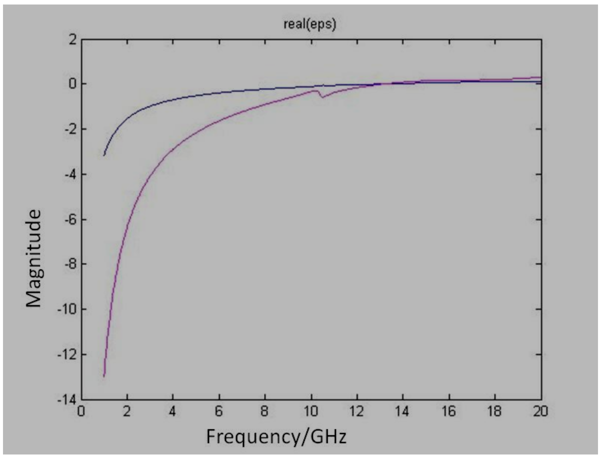

Figure.3. (b) Retrieved effective value of Ɛ for Metamaterials

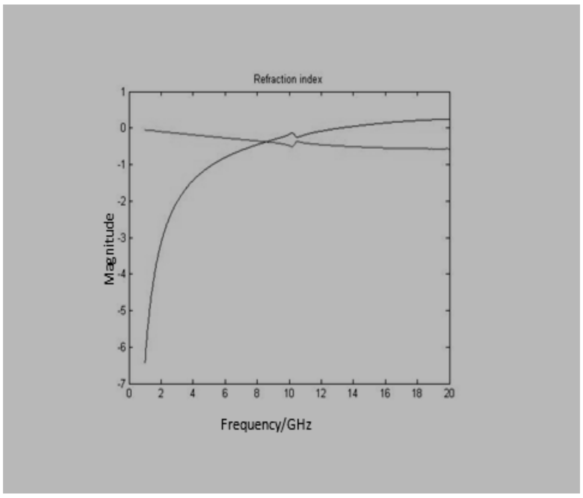

Figure.3. (c) Retrieved effective value of n for metamaterial

IV. RECTANGULAR PATCH ANTENNA WITH METAMATERIAL ARRAY

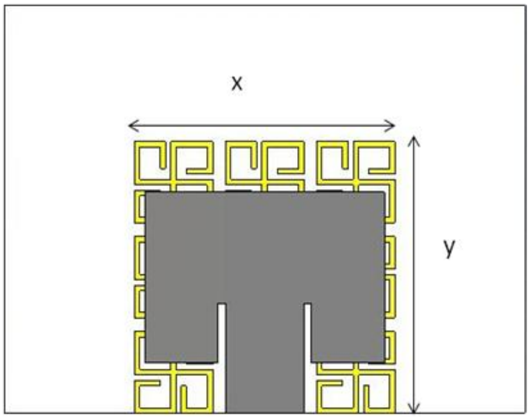

Figure.4. patch antenna with metamaterial array

In this design a swastika like metamaterial structure is placed on the substrate with the dimension of x=10.5 mm and y=10.5 mm which is used as a conventional antenna. The configuration of this is shown in fig 4.

VI. RESULTS

Proposed antenna with and without metamaterial is simulated by CST software and results are analyzed which are given below.

(1) Return loss and Bandwidth-Return loss of any antenna is calculated from S_{11} *versis* frequency graph. It

Should be less than -10 db. The return loss of simple patch antenna is -18.702 db, when metamaterial is applied on the patch antenna so return loss decreases up to -27.799 db which is shown in fig 5(a) and 5(b) respectively. The bandwidth also increases from 780.53 MHz to 1272.7 MHz as shown in figure 5(a) and 5(b).

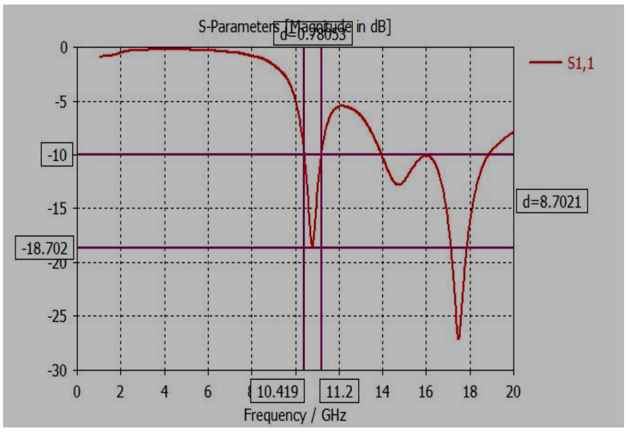

Figure.5. (a) graph for conventional patch antenna without metamaterial

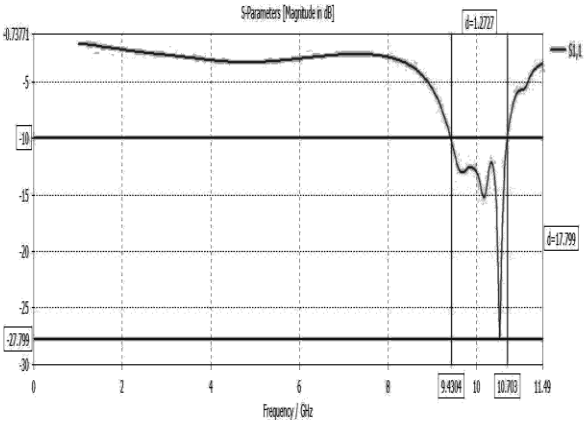

Figure.5. (b) S_{11} graph for antenna with metamaterial structure

[2] Axial ratio-In an antenna what type of polarization has done can be calculated by axial ratio. It is mainly derived for circular polarization. For circular polarization axial ratio should be less than 3 db. In the proposed antenna circular polarization has improved as shown in fig 6(a) and 6(b)

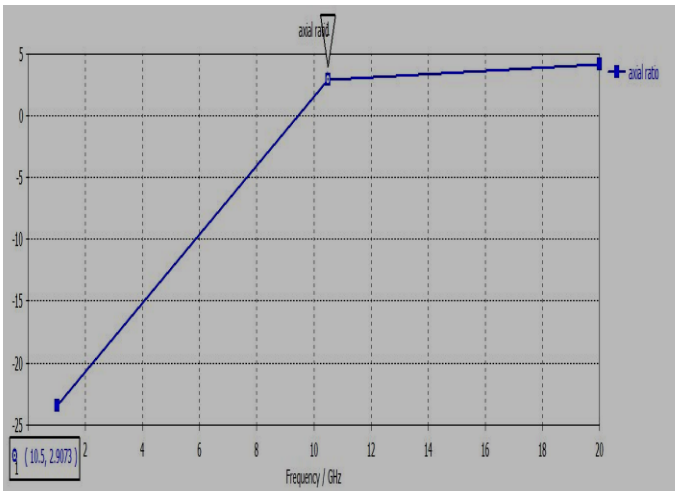

Figure. 6. (a) axial ratio for conventional Overview

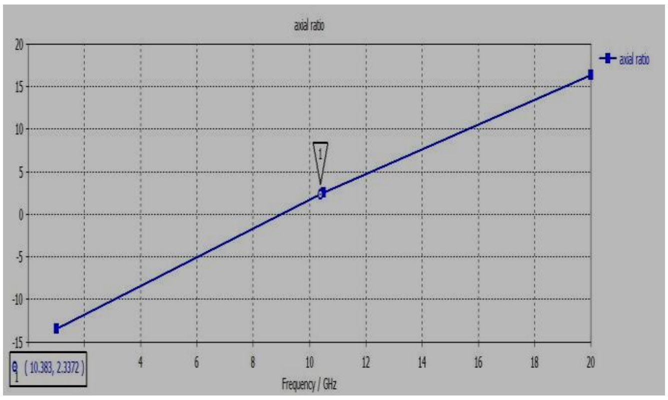

Figure.6. (b) axial ration for conventional patch antenna with metamaterial

VII CONCLUSION

We have simulated a microstrip patch antenna with and without metamaterial. We have derived permittivity and permeability constant of metamaterial and antenna parameters such as return loss, bandwidth and axial ratio. We have concluded that when a metamaterial is placed on the substrate of patch antenna so the bandwidth of antenna increased from 780.53 MHz to 1272.7 MHz

VIII REFERENCES

[1]. Neelam Singh, Rekha Chahar "A REVIEW PAPER ON TECHNIQUES AND DESIGNFOR METAMATERIAL ABSORBER"IJSER VOLUME 6, ISSUE 10, OCTOBER-2015

[2]. Falguni Raval, Dr Y P Kosta, Jagruti Makwana, Amit V Patel,"Design & Implementation of Reduced size Microstrip Patch Antenna with Metamaterial Defected Ground Plane" International conference on Communication and Signal Processing, April 3-5, 2013, India

[3]. Constantine A.Balanis, "Antenna Theory and Design", John Wiley &Sons, Inc, 1997

[4]. Sunil Patel, Falguni Raval "Simulation study of the different Metamaterial structures" 2013 Nirma University International Conference on Engineering (NUiCONE)

[5]. Richard W. Ziolkowski, "Design, Fabrication, and Testing of Double Negative Metamaterials", *IEEE transactions on Antennas and Propagation*, vol. 51, no. 7, July 2003

[6].Ruchika Sharma, Harbinder Singh "LEFT HANDED METAMATERIAL ANTENNA DESIGN FOR GSM 1.8 GHz APPLICATIONS" Proceedings of 2015 RAECS UIET Panjab University Chandigarh 21-22nd December 2015 Proceedings of 2015 RAECS UIET Panjab University Chandigarh 21-22nd December 2015"

[7]. Improvement of performance parameters of rectangular patch antenna using metamaterial" IEEE International Conference on Recent Trends in Electronics Information Communication Technology, May 20-21, 2016, India

[8]. Kafesaki, M., T. Koschny, R. S. Penciu, T. F. Gundogdu, E. N. Economou, and C.M. Souk-oulis, Left-handed metamaterials: Detailed numerical studies of the transmission properties, J. Opt. A: Pure Appl. Opt., Vol. 7, 12-22, 2005.

IX. AUTHORS

Garima Tiwari, She completed her B.E. in Electronics and Communication Engineering in 2009. She has completed her Master of Engineering degree in Microwave Engineering from Jabalpur Engineering College, Jabalpur, Madhya Pradesh, in 2013. Currently, she is working as assistant professor in Jabalpur Engineering College. She is working on Metamaterials, Fractal Antenna, Ultra Wide Band (UWB) and Super Wide Band (SWB) monopole Antennas.

Ankita Gupta was born in Narsinghpur district Madhya Pradesh. India in 1991.She completed her Bachelor of Engineering in Electronics and Communication Engineering in 2013.She started her Master of Engineering from Jabalpur Engineering College, Jabalpur Madhya Pradesh in 2015.Currently she is currently working on Metamaterials and Micro strip Patch antenna.