International Journal of Engineering Research and General Science Volume 2, Issue 4, June-July, 2014
ISSN 2091-2730

Review on Microstrip Patch Antennas using Metamaterials

Atul Kumar[1], Nitin Kumar[2], Dr. S.C. Gupta[2]

[1]Scholar (PG), M-Tech digital communication, DIT Dehradun, India

[2]Department of ECE, DIT Dehradun, India

Abstract: Microstrip patch antennas has many advantage due to light weight and small size, low cost but also have some disadvantage as low gain , narrow band width these are the two important parameters. This review paper describe how we can increase the performance of the patch antenna by using metamaterials or how we can improve the gain & bandwidth. Here we first provide the introduction of metamaterials and microstrip patch antenna after that describe the parameter of microstrip patch antenna which can improve by using metamaterials and discuss future scope and application of metamaterIals.

Keywords- Metamaterials(MTM) ,SRR , LHM , Microstrip Patch Antennas(MSA),

I. INTRODUCTION:

II. METAMATERIALS:

Metamaterials is a artificial material which has negative value of ε and μ but all The natural material find in the nature has positive value of ε and μ . According to Viktor Veselago in 1967 provide the visionary speculation on the existence of MTM "substance with simultaneously negative value of ε and μ "[1].These "substances" LH to express the fact that they would allow the propagation of electromagnetic waves with the electric field, the magnetic field, and the phase constant vectors building a left-handed triad, compared with conventional materials where this triad is known to be *right-handed* [2] . Metamaterials is also known as Negative refractive index material or left handed material LHM this is also reversal of Doppler effect or reversal of snells law. In LHM ray refracted away from the normal but in all natural material ray refracted toward the normal That produce the focuss inside the material.There are mainly four type of of metamaterial structure:Split Ring structure, Symmetrical Ring structure ,Omega structure , S structure.

After Veselago's paper, more than 30 years until the first LH material was conceived and demonstrated experimentally. This LH material was not a natural substance, as expected by Veselago, but an *artificial* effectively homogeneous structure (i.e., a MTM), which was proposed by Smith and colleagues at University of California, San Diego (UCSD) [3].This structure was inspired by the pioneering works of Pendry at Imperial College, London. Pendry introduced the *plasmonic-type* negative-ε/positive-μ and positive-ε/negative-μ structures shown in Fig 1., which can be designed to have their *plasmonic frequency in the microwave range*. Both of these structures have an average cell size p much smaller than the guided wavelength λg (p _ λg) and are therefore effectively homogeneous structures, or MTMs.

The negative-ε/positive-μ MTM is the *metal thin-wire (TW)* structure shown in Fig 1.(a). If the excitation electric field **E** is parallel to the axis of the wires (**E**_z), so as to induce a current along them and generate equivalent electric dipolemoments, this MTM exhibit a plasmonic-type permittivity frequency function of the form [4,5].

The positive-ε/negative-μ MTM is the *metal split-ring resonator (SRR)* structure shown in Fig 1.2(b). If the excitation magnetic field **H** is perpendicular to the plane of the rings (**H**$\perp y$), so as to induce resonating currents in the loop and generate equivalent magnetic dipole moments ,10 this MTM exhibits a plasmonic-type permeability frequency function of the form [6]

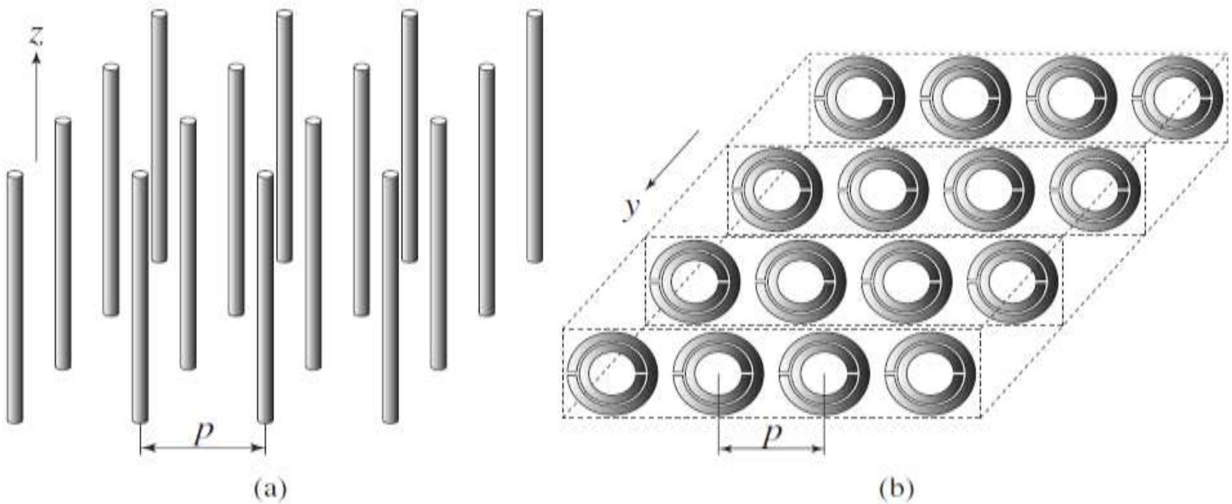
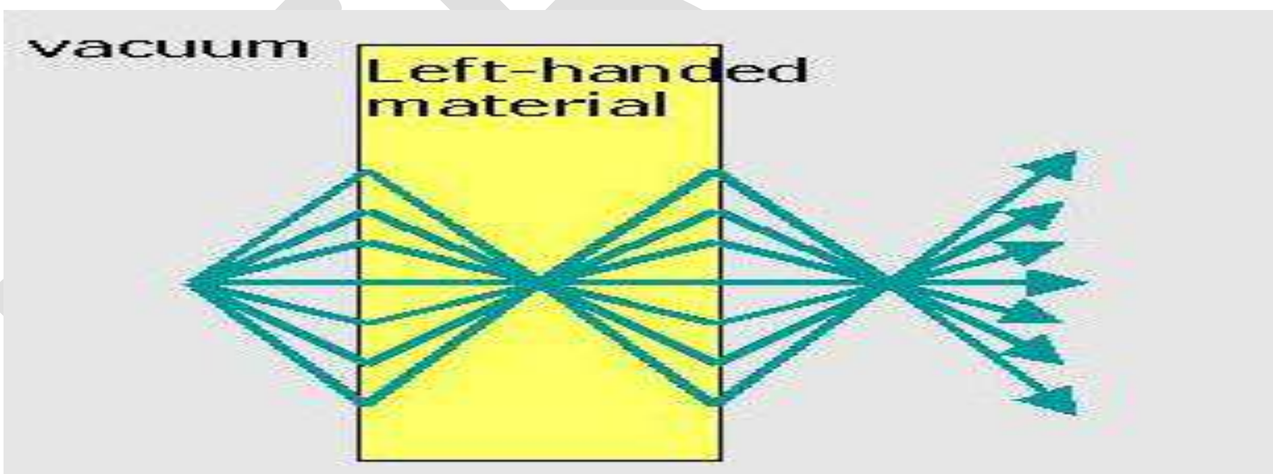


Fig.1 First negative-ε/positive-μ and positive-ε/negative-μ MTM (p _ λg), constituted only by standard metals and dielectrics, proposed by Pendry. (a) Thin-wire (TW)structure exhibiting negative-ε/positive-μ if **E**_*z* [5]. (b) Split-ring resonator (SRR) structure exhibiting positive-ε/negative-μ if **H**⊥*y* [7].

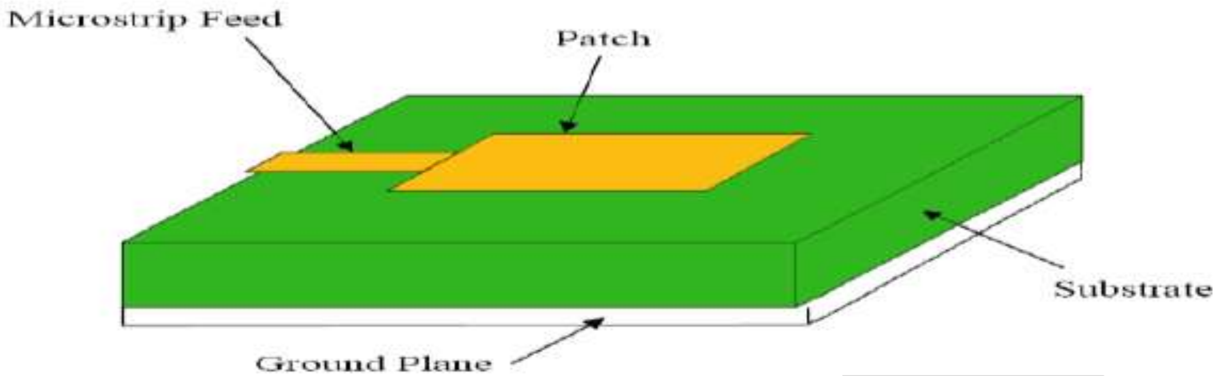
In LHM ray refracted away from the normal but in all natural material ray refracted toward the normal That produce the focuss inside the material as in fig.



c. Refracted rays in left handed metamaterial

III. MICROSTRIP PATCH ANTENNAS:

Microstrip patch antennas are most widely use today, particularly this has many advantage in frequency range of 1 to 6 GHz. Deschamps first proposed the concept of the Microstrip antenna (MSA) in 1953. Microstrip antennas are also known as microstrip patch antennas , or simply patch antennas. A microstrip antenna in its simplest form consists of a radiating patch on one side of a dielectric substrate and a ground plane on the other side.The radiating elements and the feedlines are usually photoetched on the dielectric substrate. The microstrip antenna radiates relatively broad beam broadside to the plane of substrate. Thus the microstrip antenna has a very low profile and so it can be fabricated using printed circuit (photolithographic)technology [7].The radiating patch may be square, rectangular, thin strip (dipole), circular, elliptical, triangular or any other configuration. There are many configurations that can be used to feed microstrip antennas. Microstrip line, coaxial probe, aperture coupling and proximity coupling.Patch antennas has following advantage or disadvantage[8].



Advantage:
-Lightweight and have a small volume a .
-Low fabrication cost Easier to integrate with other MICs on the same substrate -They allow both linear polarization and circular polarization .
-They can be made compact for use in personal mobile communication
-They allow for dual- and triple-frequency operations.

And disadvantage are:
- Low bandwidth.
-Low gain .
-Low power handling capability

IV. PARAMETERS OF PATCH ANTENNAS WHICH CAN IMPROVE BY USING MTM

By using metamaterial as asubstrate or cover we can enhance the gain and we can also increase the bandwidth and directivity of patch antennas[9].
MSA have narrow band width which is the major limiting factor for wide spread application .So Increasing the bandwidth of MSA is a imprtant research today. By increasing the substrate hight and reduce the dielectric constant [10]. And by using MTM as a cover we can also improve the bandwidth[11][12].
Directivity can be increase by using left handed metamaterial when we use left handed metamaterial as a slab it will act like a lens and it will focus the energy and radiant energy is concentrated.
When negative permeability metamaterial Reflecting surface applied to the microstrip patch antenna gain increase about 6.91 dbi that is beacause SRR eliminate the substrate surface wave and radiant energy is concentrated[13] .So main problem in the patch Antennas is substrate surface wave which can be remove by using SRR[14].

Microstrip patch antennas size can be reduced by using metamaterial structure. With a Mushroom Structured Composite Right/Left Handed transmission line (CRLH - TL) metamaterial ,a size of 61.12% can be reduced[15] .
In addition, a wideband also can be obtained by reducing the ground plane of the antenna. A compact ultra Wide Band (UWB) antenna can be designed using meta- -material structure. The antenna exhibits a wide bandwidth of 189%.
The bandwidth of a single patch antenna can be raised by placing a number of metamaterial unit cells [16].

V. MODERN METAMATERIAL APPLICATION

The concept of metamaterials, which Is given by the works of V. G. Veselago and J. B. Pendry, has drastically change our way of thinking about light-matter interactions and greatly enriched the fields of classical and quantum electrodynamics.We can see that not only negative-index metamaterials be fabricated the practically but they can also be used to create super- and hyperlenses with the subwavelength optical resolution. Likewise, it is now possible to fabricate metamaterials designed using the transformation optics approach and apply them in real invisibility cloaks.

The modern metamaterial applications
Superresolution imaging and optical sensing,
The advancement of photonic circuitry with metatronics,
All-optical and electrooptical dynamic control of light,
Electromagnetic cloaking, and light harvesting for improved solar-cell technology.
This special issue focuses on the advances along these research avenues and on the new photonic devices associated with them.

VI. FUTURE SCOPE OF METAMATERIAL

The dream of " invisibility cloaks" will be become possible, and although the process will likely take another decade, steps already have been made in that dire--ction. Research on developing metamaterials a special kind of material that causeLight to bend in unusual ways,following the contours of the material structure and Come back out the same way it went in.

VII. CONCLUSION

Microstrip antennas is one of the most innovative topics in antenna theory and design ,and have application in modern microwave systems. in this world till now, microstrip patch antennas also have some advantages. Some research are going on to improve the gain and bandwidth of patch antenna. Existing solutions leads to the problems of spurious radiation and high complexity. This new approach come up with a new solution called metamaterial. Metamaterials play important role in the antenna design due to its interesting and unusual properties. By this review [1] – [16], Metamaterials can be used for the performance enhancement of microstrip patch antennas. A metamaterial antenna is made by loading the metamaterial structure over the substrate. There are different Kind of metamaterial substrates.If change the metamaterial substrate will change in the parameters of antenna. Gain of a patch antenna increases by a value of 1.5dB to 7dB with the addition of metamaterial structures. Miniaturization is the primary function of metamaterial. In all the works mentioned here shows that use of metamaterials results in about 50% reduction in the size of a patch antenna. Narrow bandwidth and lower gain are the two main drawbacks of microstrip patch antenna. By using metamaterial we can overcome these problem.

REFERENCES

1.Caloz and T. Itoh, *Electromagnetic Metamaterials: Transmission Line Theory and MicrowaveApplications*. Piscataway, NJ: Wiley-IEEE, 2005.
2.V. Veselago. "The electrodynamics of substances with simultaneously negative values of ε and μ," *Soviet Physics Uspekhi*, vol. 10, no. 4, pp. 509–514, Jan., Feb. 1968.
3. D. R. Smith, W. J. Padilla, D. C. Vier, S. C. Nemat-Nasser, and S. Schultz "Composite medium with simultaneously negative permeability and permittivity," *Phys. Rev. Lett.*, vol. 84, no. 18, pp. 4184–4187, May 2000.
4. J. B. Pendry, A. J. Holden, W. J. Stewart, and I. Youngs. "Extremely low frequency plasmons in metallic mesostructure," *Phys. Rev. Lett.*, vol. 76, no. 25, pp. 4773–4776, June 1996.
5. J. B. Pendry, A. J. Holden, D. J. Robbins, and W. J. Stewart. "Low frequency plasmons.in thin-wire structures," *J. Phys. Condens. Matter*, vol. 10, pp. 4785–4809,1998.
6. J. B. Pendry, A. J. Holden, D. J. Robbins, and W. J. Stewart. "Magnetism from conductors.
and enhanced nonlinear phenomena," *IEEE Trans. Micr. Theory. Tech.*, vol. 47,
no. 11, pp. 2075–1084, Nov. 1999.
7. Antenna Theory - Analysis and Design (Constantine A. Balanis) (2nd Ed) [John Willey].
8.Yoonjae Lee and Yang Hao, "Characterization of microstrip patch antennas on metamaterial Substrates loaded with complementary split-ring Resonators" Wiley Periodicals, Inc. Microwave Opt Technol. Lett. 50, pp.2131–2135, 2008.
9.R. F. Harrington, "Effect of antenna size on gain, bandwidth, and efficiency", *J. Res. Nat. Bureau Stand.*, vol. 64D, pp. 1 - 12, 1960.
10. K.C. Gupta "Broadbanding technique for Microstrip patch antennas- A Review", Scientific Report no. 98, 1988.
11. Design and Comparative analysis of a Metamaterial included Slotted Patch Antenna with a Metamaterial Cover over Patch .Surabhi dwivedi, Vivekanand mishra,Y.K. Posta . ISSN: 2277-3878, Volume-1, Issue-6, January 2013.
12. Mimi A. W. Nordin, Mohammad T. Islam, and Norbahiah Misran, "Design of a compact Ultra WideBand metamaterial antenna based on the modified Split ring resonator and Capacitively Loaded Strips unit cell", PIER, Vol. 136, pp. 157-173, 2013.

13.A 2.45-GHz WLAN High-Gain Antenna Using A Metamaterial Reflecting Surface#Sarawuth Chaimool1, Kwok L. Chung2, *Prayoot Akkaraekthalin.

14.W Wang, B.-I. Wu, J. Pacheco, X. Chen, T. Grzegorczyk and J. A. Kong, "A study of using metamaterials as antenna substrate to enhance gain", PIER 51, pp. 295–328, 2005.

15. J. B. Pendry, A. J. Holden, D. J. Robbins, and W. J. Stewart , "Magnetism from Conductors and Enhanced Nonlinear Phenomena", IEEE
Transactions on Microwave Theory and Techniques, Vol. 47, No. 11, November 1999.

16. Mimi A. W. Nordin, Mohammad T. Islam, and Norbahiah Misran, "Design of a compact UltraWideBand metamaterial antenna based on the modified Split ring resonator and Capacitively Loaded Strips unit cell", PIER, Vol. 136, pp. 157-173, 2013