Volume 6, Issue IV, May 2018
eISSN 2320-6802

INTERNATIONAL JOURNAL FOR ADVANCE RESEARCH IN ENGINEERING AND TECHNOLOGY

WINGS TO YOUR THOUGHTS.....

A Review on Microstrip Antenna with Metamaterial Substrates

Archana[1], Ravi Antil[2]

[1] M. Tech. Student, [2]Assistant Professor
ECE Department, MSIT, Jagdishpur, Sonipat
Haryana, India
archanamongia@yahoo.co.in

Abstract: *In this paper, we are reviewing metamaterial substrates enhanced the bandwidth of the antenna. Since for ultra-wide band operation Microstrip antenna is used. Self-Similarity property of Microstrip antenna structures provides receptiveness. For wide band operation , the concept of metamaterial is proposed . In substrates metamaterial is used & in patch Microstrip structures used*

Keywords: *Metamaterial, HFSS (High Frequency Structure Simulator), Cross shape Metamaterial, FDTD.*

1. INTRODUCTION

The technology of ultra-wide band is very old, but in wireless communication system. The technology has high data rate & avoiding more spectrum scarcity. The main application of such technology in traffic regulation, ground penetrating and mine detection.[1] To design an antenna, different feeding and coupling methods are used. These techniques provide higher bandwidth but unfortunately gain is to be degraded. In such situations, new types of material are used known as metamaterial. These are artificial material which shows negative permittivity & negative permeability [2]. Enhancing the gain is done by left handed material, also known as negative refractive index material. Metamaterial property can be obtained in two ways, one is split ring resonator and another one is metal wires. Now, these materials provides lossy and narrow band. For wide band operations Microstrip antennas are used [3]. Microstrip antenna is designed with the help of LC circuits. So, operating frequency of antenna is tuned using L and C parameters. So, Microstrip antenna is used for two purposes, multiband operation and wideband according to requirement. Microstrip shape antennas have some unique characteristics i.e. have various geometry and properties of Microstrips. These are defined by structures whose dimension is not a whole numbers. Microstrips antenna have unique geometry whose features occurring in whole numbers. These antennas can be used to describe branches of tree leaves and plants and rough terrain [5]. Metamaterials are design in accordance to electromagnetic properties. In electromagnetic, different metamaterial is used to design the Microstrip antenna in applied electric field. For EM characteristics of wave, permittivity and permeability are sufficient descriptor and predictor. These are defining by Maxwell equation [4].

The Maxwell equation is given as

$$\nabla \times H = \epsilon \frac{\partial E}{\partial t}$$

$$\nabla \times E = -\mu \frac{\partial E}{\partial t}$$

$$\nabla . D = \rho$$

$$\nabla . B = 0$$

The rest of paper is design as follows. The overview of Microstrip antenna & metamaterial is described in section II & III receptively. Performance parameters are defined in section IV. Related literature survey work is described in Section V. Advantages & applications describe in section V. The overall conclusion of review describe in section VI.

2. OVERVIEW OF MICROSTRIP ANTENNA

Microstrip antenna is integrated form of Microstrip geometry and the electromagnetic theory. The Microstrip antenna geometry used in two areas, one is analysis & design of Microstrip antenna elements, another one is application of Microstrip design. Basically Microstrip antennas are the repeating form of self-geometry [5]. The Microstrip antenna have characteristics like compact size, multiband and broadband in nature , These antenna are used for low frequency also. The Microstrip antenna is design on the basis of iterations. Microstrip antenna is of many types like Sierpinski Gasket, Koch snowflake, equilateral triangle and Hilbert curve.

3. METAMATERIAL SUBSTRATES

Metamaterial are different than the natural material as have negative permittivity and permeability. Mostly metamaterial are left handed and allow the propagation of electromagnetic waves with electric field and the magnetic field with constant phase vector. Defective ground structure is used to implemented metamaterial technology. This technology improves the performance parameter of an antenna [4].

In 1967, Viktor Veselgo provides the existence of metamaterial. These are LH substances which have property to propagate the electromagnetic waves in electric field and magnetic field with constant phase vector [2].

There are different types of metamaterial .The metamaterial is following types

1. Circular Ring Metamaterial
2. Complementary Split Ring Resonator
3. Diamond Shape Split Ring
4. Pentagonal Ring Resonator

The proposed substrate is of dimension 30.6 × 27.8 × 0.8. A rectangular patch antenna made of copper is employed on it. The dimension of patch is 15.3 ×12.6 (mm). The design of antenna is based on FDTD method where all the feeding process assign to the patch. The feeding point is given (0,-5, 0) The proposed antenna is given in fig 1.

The configurations of metamaterial cell are given in fig 2. Metamaterial cell side 3.6 mm. & No of EBG Cell: 4× 7.

Volume 6, Issue IV, May 2018
eISSN 2320-6802

INTERNATIONAL JOURNAL FOR ADVANCE RESEARCH IN ENGINEERING AND TECHNOLOGY
WINGS TO YOUR THOUGHTS…..

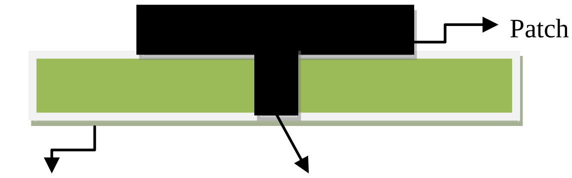

Fig 1: Basic Design of Patch Antenna

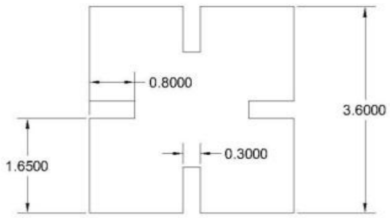

Fig 2: Metamaterial Structure

4. LITERATURE REVIEW

Authors	Paper title	Research methodology used	Major findings	Research prospects
Bikash Ranjan Behera	Effect of Substrates on Metamaterial Based Antenna Design and Analysis of Antenna using Different Substrates	FR-4, Rogers RO 3003 and Rogers RT Duroid 5870 , Used T Shaped Patch	Return Loss : -47.3 Gain :7.045 B.W : 26.2 MHz	Used for narrow band operation
Balamati Choudhury , Sangeetha Manickam, and R. M. Jha	Metamaterial-based UWB antenna	FR4 , ε_r = 4.4 , specification h = 0.8 mm , patch have pi shape slot & ground is cross shape	Return loss : -38.5 db Directivity : 7.32 dbi B.W : 3.7 GHz	Used for ultra-wide band operation
Kamariah Binti Ismail Nur Syuhada Binti Khairul Shamsudin	Particle Swarm Optimization for Multiband Metamaterial Microstrip Antenna	SRR Metamaterial used FR4 substrate , ε_r = 4.4 , h = 1.6 Particle swarm optimization techniques	Return Loss : - 31.52 Directivity :7.79 dbi B.W : 340 MHz	Used for both C and X band
R.-B. Hwang, H.-W. Liu, and C.-Y. Chin	A Metamaterial-Based *E*-Plane Horn Antenna	Splitter used , double negative level substrate. Rogger FSS Layer	Return Loss : -21.5 Gain :9.1 B.W : 511 MHz	It is used for wireless local area network
Zuhura Juma Ali	A Miniaturized Ultra Wideband (UWB) Antenna Design for Wireless Communications	Taconic RF-30(tm) ε_r = 3 , h = 1.6	Return Loss : -27.5 Gain :6.57 B.W : 642 MHz	Multiband operation Applications
Siddharth Bhat, Rashmi Pattoo	Design and Simulation of Wide Band Fish Shaped UWB Antenna	FR4 Substtate 6×2 metamaterial units , ε_r = 4.4 , h = 1.6 12 cells	Return Loss : -26.1 B.W : 3.1 GHz	WiBro , WLAN and mobile phones.
Salim Lamari, Roman Kubacki, Miroslaw Czyzewski	Frequency Range Widening of the Microstrip Antenna with the Microstrip Patterned Metamaterial Structure	Rogger RT Duroid With , ε_r = 2.2 , h = .787 Mesh Sierpinski gasket used	B.W : 11.346 GHz Gain : 7.17 db Efficiency : 70 %	Ultra wide band
M. I. Ahmed	A Novel Wearable Metamaterial Microstrip Antenna for Wireless Applications	Square shape metamaterial , FR4 substrate With , ε_r = 4.4 , h = 1.6	Return loss : - 23.54 Efficiency : 39.1 %	GPS System , WBAN

5. PERFORMANCE PARAMETER

The other parameter of antenna is to be improve are gain, directivity, bandwidth and return loss [8]. These parameter are as :

1. Directivity is the ratio of the radiation intensity in a given direction from the antenna to the radiation intensity averaged over all directions. , $D = \frac{4\pi U}{P_{rad}}$

2. Gain of an antennas is the ratio of the intensity, in a given direction, to the radiation intensity that would be obtained if the power accepted by the antenna were radiated isotropically.

$$\text{Gain} = 4\pi \frac{\text{Radiation Intensity}}{\text{Total Input (accepted)Power}}$$

The bandwidth of an antenna is defined as the range of frequency within the performance of the antenna. The bandwidth of narrow band and broadband antennas are defined as $B.W = F_h - F_l$

Return loss or reflection loss is the reflection of signal power from the insertion of a device in a transmission line or optical fiber. The return loss is given by

$$RL = 10\text{Log}\frac{P_r}{P_i}$$

The standing wave ratio (SWR), also known as the voltage standing wave ratio (VSWR), is not strictly an antenna characteristic, but is used to describe the performance of an antenna when attached to a transmission line.

$$VSWR = \frac{V_{max}}{V_{min}} = \frac{1+|\Gamma|}{1-|\Gamma|}$$

6. ADVANTAGES & APPLICATION OF METAMATERIALS

The main advantages of Microstrip antenna are that it provides better matching of input impedance. Only one Microstrip antenna is required for narrow band and wide band operations [3]. One of the famous advantages, Microstrip antenna is frequency independent. The metamaterial provides miniaturization to the antenna. The main applications of metamaterial antennas are, used in army research detector , it is used as WMD detector. Metamaterial can be used as switching device. To control sound and light these materials can be used. [6]. On the other hand Microstrip antenna used in UMTS and GSM operations

7. CONCLUSION

In this paper, the studies of Microstrip antenna with & without metamaterials are defined. The study of effect of Microstrip antenna and metamaterial on gain, return loss & bandwidth. The effect of EM waves with metamaterial is explain in complete survey. The net conclusion comes from survey is that Microstrip antenna with metamaterial substrates provides tuning operation can be used as multiband operation aor wide band operations.

REFERENCES

[1] Bikash Ranjan Behera et.al "Effect of Substrates on Metamaterial Based Antenna Design and Analysis of Antenna using Different Substrates", IEEE WiSpNET , PP 665 -669 , 2016.

[2] G.K Pandey et.al "Metamaterial based UWB antenna" ***IEEE Microwave Electronic Letter, Vol 50, issue 18 pp1266-1268, 28 Aug 2014.***

[3] Balamati Choudhury et.al "Particle Swarm Optimization for Multiband Metamaterial Microstrip Antenna" ***Hindawi Publishing Corporation Journal of Optimization Volume 5 , pp 15-22 , July 2013.***

[4] R.-B. Hwang, H.-W. Liu, and C.-Y. Chin "A Metamaterial based E – Plane Horn Antenna" ***Progress In Electromagnetics Research, PIER 93, pp 275-289, 2009.***

[5] Siddharth Bhat, Rashmi Pattoo "Design and Simulation of Wide Band Fish Shaped UWB Antenna", ***IOSR Journal of Electrical and Electronics Engineering, Volume 9, Issue 3 Ver. V , June 2014.***

[6] Zuhura Juma Ali "A Miniaturized Ultra Wideband (UWB) Antenna Design for Wireless Communications", ***International Journal of Scientific and Research Publications, Volume 4, Issue 7, pp 1-5 , July 2014.***

[7] Jingtao Zhu et.al (2016) "Gain Enhancement for Planar Quasi-Yagi Antenna with Zero-Index Metamaterial" IEEE conference of recent microwave research , pp 212-214.

[8] M. I. Ahmed et.al (2016) "A Novel Wearable Metamaterial Microstrip Antenna for Wireless Applications" IEEE Conference of Electromagnetic research, pp 119-124

[9] Karthikeya G S et.al (2016) "mm Wave Metamaterial Inspired Coaxial-Fed Microstrip Antenna Array for Femtosat" Lough borough Antennas & Propagation Conference (LAPC), pp 783-788

[10] Natalya N. Kisel,"The Modeling of Characteristics of the Patch Antenna with Non-uniform Substrate Metamaterial" , ***IEEE Conference of Wireless Communication*** **, pp 165-169 ,2016**

[11] Uday kumar "Improvement of performance parameters of rectangular patch antenna using metamaterial" , ***IEEE International Conference On Recent Trends In Electronics Information Communication Technology*** **, pp 1011-1015 , 2016**

[12] Zain Bin Khalid "Design of a Metamaterial Inspired Single-Cell Zeroth Order Resonant(ZOR) Antenna" , ***IEEE Conference of millimeter waves*** **, pp 42-48 , 2016**

[13]Chen, W.L., Wang, G.M., and Zhang, C.X. "Bandwidth enhancement of a microstrip-line-fed printed wide-slot antenna with a fractal-shaped slot", ***IEEE Trans. Antennas Propag*****ation., Vol 7, pp. 2176–2179 , 2009.**

[14] Matin, M.A., Sharif, B.S., and Tsimenidis, "Probe fed stacked patch antenna for wideband applications", ***IEEE Trans. Antennas Propag*****., Vol 8 pp. 2385–2388 ,2009**

[15]Yousefi, L., Iravani, B.M., and Ramahi, O.M.: "Enhanced bandwidth artificial magnetic ground plane for low-profile antennas", ***IEEE Antennas Wirel. Propag. Letter*****., Vol 6, pp. 289–292 , 2007**

[16] Li, L.W., Li, Y.N., Yeo, T.S., Mosig, J.R., and Martin, O.J.F.: 'A broadband and high-gain metamaterial microstrip antenna', Appl. Phys. Lett., Vol 96, pp. 1–3 , 2010.