ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 6, Issue 5 , May 2019

Hexagonal split ring resonator based Wi-Fi patch antenna

Shilpa K Gowda, Ajaypavanakumar M V, Darshan M, Dheeraj L,Navin S

Associate Professor, Department of Electronics and Communication Engineering, SJB Institute of Technology, Bangalore, India
Student, Department of Electronics and Communication Engineering, SJB Institute of Technology, Bangalore, India
Student, Department of Electronics and Communication Engineering, SJB Institute of Technology, Bangalore, India
Student, Department of Electronics and Communication Engineering, SJB Institute of Technology, Bangalore, India
Student, Department of Electronics and Communication Engineering, SJB Institute of Technology, Bangalore, India

ABSTRACT: Generally natural materials exhibit properties which has limit and it also shows restrictions in its applications. Customers are behind the equipments which are compact and shows the properties same or improved from its antecedent ones . Even antennas are no longer exception to it .So artificial materials called metamaterials are used in antennas to make it compact. The permeability (μ) and the permittivity (□ε) parameters are set negative at the same frequency so that the electromagnetic wave is inversely refracted and inverse refraction results . Hence Metamaterials are called Double Negative materials (DNG) . If the electromagnetic wave can be focused instead of transmitting omnidirectional, the directivity and so the gain will be increased .For this reason metamaterial substance are used in antenna substrate , like this antenna performance is improved . With advent of these materials we are able to work on larger bands . We have currently designed antenna which works in 5 GHz ie used in C band applications like wireless communications. Usage of FR4 substrate helps to build antenna in low cost . The printed circuit boards are very vital part of a modern electronic equipment and we have implemented the same in fabrication .

KEY WORDS: Antenna, Meta-Material, Patch Antenna, Split Ring Resonator, Microstrip antenna.

I.INTRODUCTION

Communication (from Latin commūnicāre, meaning "to share") is the act of conveying meanings from one entity or group to another through the use of mutually understood signs, symbols, and semiotic rules. Effective communication has made humans as the best intelligent animal and has also helped to evolve more quickly and effectively. We use different ways to communicate with each others ,i.e either direct communication (exchanging information directly among individuals) or indirect communication (with the help of technology like cell phones , emails , internet - this which help to reach mass individuals with less time) . Antennas is the important device what we use in indirect communication .

Antennas are frequency dependent devices. Each antenna is designed for a certain frequency band and outside of this band, antenna rejects the signal. Therefore we can say antenna is a band pass filter and transducer. With the advances in telecommunication, the requirement for compact antenna has increased significantly. In mobile communication, the requirement for smaller antennas is quite large, so significant developments are carried out to design compact, minimal weight, low profile antennas for both academic and industrial communities of telecommunication. The technologist focused into the design of microstrip patch antennas. Many varieties in designing are possible with microstrip antenna. With advent of technology , compactness in devices are playing important role , even antennas are no longer exception do this , using meta materials in antennas one can reduce the size by 50 times. Metamaterial antennas are antennas which use metamaterials to increase performance of miniaturized (electrically small) antenna systems and they are used to launch energy into free space.

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 6, Issue 5 , May 2019

II. SIGNIFICANCE OF THE SYSTEM

The paper mainly focuses on how machine learning techniques in Data mining can be applied to predict the risk factors of spam in the data that is being used. Section III represents Literature survey, Section IV represents Methodology, Section V covers the experimental results of the study, and Section VI explains the future study and Conclusion.

III. LITERATURE SURVEY

In the recent years world is behind the compactness of devices , even antennas were no longer an exception to it . Compactness in antennas can be obtained by using meta-materials as these structures exhibit the properties behind the properties as shown in the normal materials . And patch antenna and HFSS software add onto the better performances of the same devices . Gain or bandwidth can be improvised depending upon the requirements needed in a specific field of usage.

MengjunWang ,Ze Yang , Jainfei Wu, JianhuiBao, Jianying Liu, Lulu Cai, Tao Dang, Hongxing Zheng, developed a flexible dual-band antenna with a metamaterial structure is presented.

Polyimide substance makes the antenna thin and bendable and it is used as the substrate for the antenna.

Micah D. Gregory, Jeremy A. Bossard, Zachary C. P. O. Morgan, Cooper S. Cicero, John A. Easum,John D. Binion, Danny Z. Zhu, Clinton P. Scarborough, Pingjuan L. Werner, Douglas H. Werner as designed an an efficient, metamaterial-based reflector antenna capable of operation at high power is presented. Metamaterial unit cells are comprised of end-loaded dipoles (ELDs) with capacitive lumped elements at their center. Enhanced power handling is realized by mitigating field enhancement through rounded edges and using appropriate high voltage capacitors as loads.

Rahul Singha, introduces a novel techniques to enhance the gain of the basic monopole antenna by using broadband gradient refractive index (GRIN) metamaterial. The proposed GRIN is designed by using parallel-line unit cell metamaterial with different refractive index.

A seven GRIN lens is placed on the omnidirectional written basic monopole antenna, perpendicularly.

S. AhdiRezaeieh, M. A. Antoniades, and A. M. Abbosh,designed a wideband and unidirectional loop antenna with enhanced and stable gain is presented.

To reduce the dimensions of the antenna, the loop is loaded with three mu-negative (MNG) metamaterial unit-cells.

The proposed unit-cells consist of a series-gap capacitor and a shunt meandered floating inductor.

Kathryn L. Smith ,Proposed a three-dimensional spherical spiral expansion of the split ring resonator commonly used to achieve negative permeability. The spherical spiral unit cell is shown to produce negative permeability over a much wider bandwidth than the traditional split ring resonators, and also to be capable of producing wideband negative permittivity or a double- negative response, depending on the orientation of the unit cell with respect to the incident electric field.

Mahmoud A. Abdalla and Ahmed A. Ibrahim ,presents very close and high isolation composite right left handed transmission line MIMO antennas.

The MIMO antennas contains two parts every operates at 5.8 GHz for wireless applications.

The two antenna parts are designed using one composite right left handed unit separated by only 0.034.

The reduction of mutual coupling between {the 2|the 2} antenna parts depends on current reversal between two antenna parts

.IV. METHODOLOGY

A. REFERENCE ANTENNA DESIGN

Before we go about designing a metamaterial antenna, a normal microstrip patch antenna is first designed which serves the purpose of a benchmark to which we can compare future antenna designs and also serves as the base for our metamaterial antenna design. The reference antenna was designed for 5Ghz WLAN spectrum having a resonant frequency of 5.4GHz. The substrate for the design is chosen as FR-4 epoxy with a dielectric constant of 4.4 due to its low cost and easy availability. The drawback of FR-4 substrates at frequencies above 4Ghz is its higher dielectric loss, but there are existing designs that use FR-4 substrates up to 8GHz. The Thickness of substrate is chosen to be 1.6mm which is the standard thickness for a single layer PCB and the copper thickness is chosen to be 35 microns.

The rectangular patch antenna was then designed using the following equations:

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 6, Issue 5 , May 2019

I. $W = \frac{C}{2f\sqrt{\frac{\varepsilon+1}{2}}}$ (m)

II. $\varepsilon eff = \frac{\epsilon+1}{2} + \frac{\epsilon-1}{2}\left[\frac{1}{\sqrt{1+\frac{12h}{W}}}\right]$

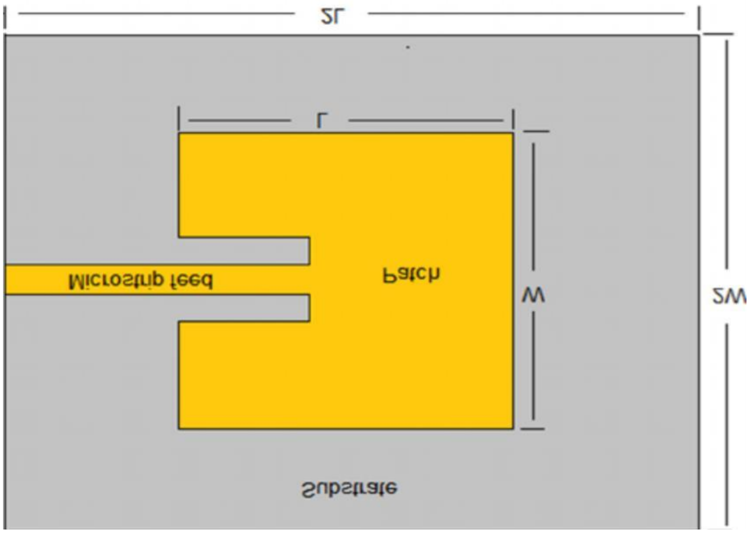
III. $L = \frac{C}{2f\sqrt{\varepsilon eff}} - 0.824h\left[\frac{(\varepsilon eff+0.3)\left(\frac{W}{h}+0.264\right)}{(\varepsilon eff-0.258)\left(\frac{W}{h}+0.8\right)}\right]$ (m)

IV. $L_g = 6h + L$ (m)

V. $W_g = 6h + W$ (m)

VI. $Zo = \frac{120\pi\sqrt{\varepsilon eff}}{\frac{W}{h}+1.393+0.663ln\left(\frac{W}{h}+1.44\right)}$ (Ω)

where C is the speed of light in vacuum, ε is dielectric constant of substrate, εeff is effective dielectric constant, L is length of patch antenna, W is width of patch antenna, Lg is length of ground plane and Wg is width of ground plane. The length and width of the patch calculated for resonant frequency of 5.4GHz was L = 12.2mm and W = 16.9mm.



B. ANTENNA FEED AND MATCHING

The MPA was edge fed using a microstrip transmission line and a SMA connector of 50-ohm characteristic impedance. A quarter wave transformer was designed by calculating the edge impedance of the MPA. Quarter wavelength is computed for the effective permittivity and this becomes the length of the transmission line. The impedance of the transformer is computed using the above equation :w here Zo is transformer impedance, ZL is MPA edge impedance and Zin is characteristic impedance. From Zo we can determine the width of the quarter wave transmission line. A lumped port is assigned between the transmission line and ground plane of the MPA so that the antenna can be excited. The MPA is then simulated in HFSS to obtain S11 parameters, if necessary, the width of the transmission line can be varied with a sweep to improve the return loss at resonant frequency.

ISSN: 2350-0328

International Journal of Advanced Research in Science, Engineering and Technology

Vol. 6, Issue 5 , May 2019

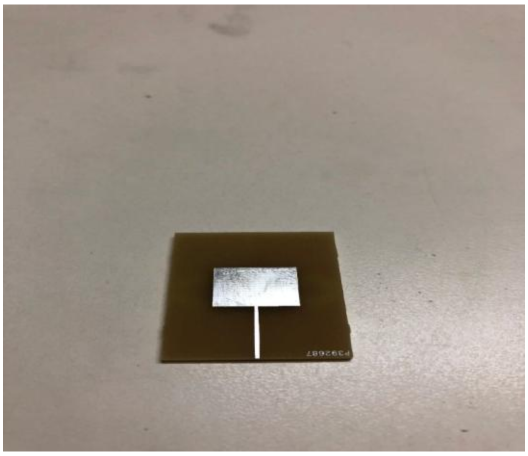


Fig 1. Top View

Fig 2 . Bottom view

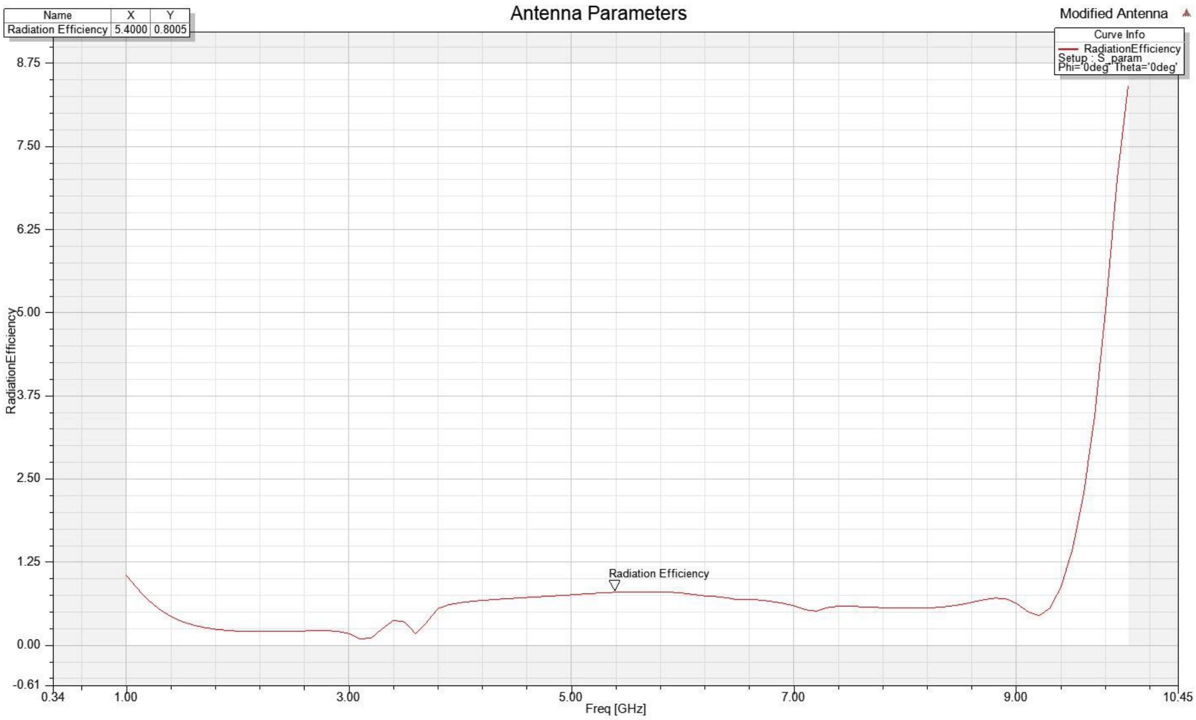


Fig 3 . Radiation Efficiency of Designed Antenna

C. DESIGN OPTIMIZATION

To improve the characteristics and performance parameters of the unit cell we need to modify parameters of the unit cell. To manually change these parameters leads to a very tedious process. HFSS supports many modes of optimizations, which can help automate the optimization process. We have chosen to use parametric design optimization with which we can vary various parameters of the unit cell and see how it affects the overall characteristics of the unit cell. For example, if we want to improve S11 parameter of the unit cell frequency at which it should be optimized is first specified and then the parameters to be varied is also set. The incremental steps by which the parameters have to be varied are also specified.

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 6, Issue 5 , May 2019

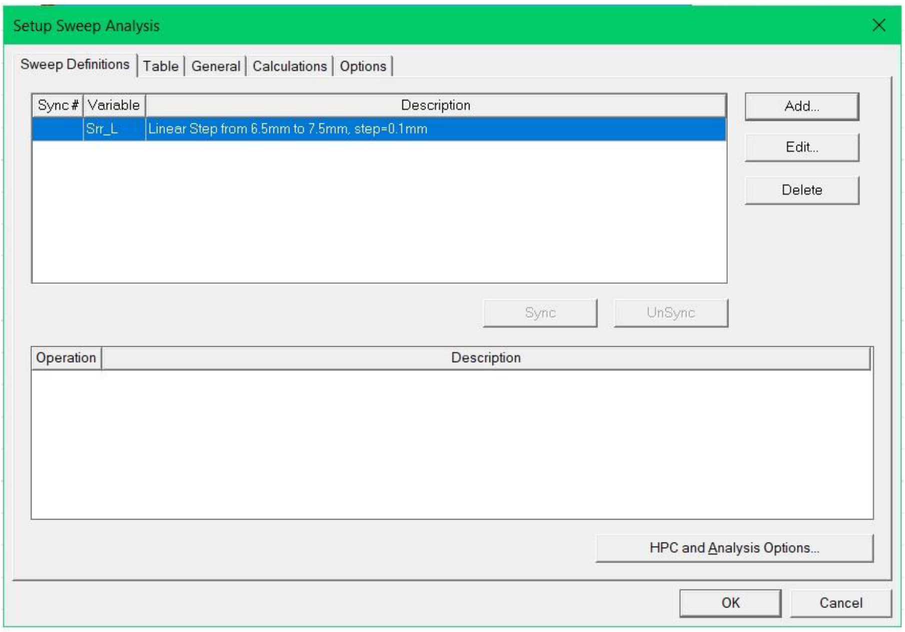


Fig 4 . Method for Design Optimization

V. EXPERIMENTAL RESULTS

[1] Better radiation characteristics.
[2] **Wider frequency bandwidth**: Helps in operating in wider bandwidth, so it can reach many applications.
[3] **Small and lightweight**: Helps in compactness and easy transport and repair .
[4] **High efficiency** : The efficiency of an antenna is a ratio of the power delivered to the antenna relative to the power radiated from the antenna.
[5] A high potency antenna has most of the facility gift at the antenna's input radiated away.
[6] **High gain**: A high-gain antenna (HGA) is an antenna with a narrow radio beam that is used to increase signal strength.High-gain antennas offer a precise method of targeting radio signals and are essential to long-range wireless networks.They even amplify weak signals used in satellite communication.

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 6, Issue 5 , May 2019

Antenna Parameters	Basic Patch Antenna	Patch Antenna with Metamaterial	Delta Change
S11 at Center Frequency (dB)	-17.8488	-38.4552	-20.6064
Bandwidth (MHz)	226.5	395.8	166.6
Fractional Bandwidth	4.19%	7.4%	3.21%
Patch Length (mm)	12.2	9.225	-2.975
Patch Width (mm)	16.9	12.15	-4.75
Substrate Length (mm)	56.7	30	-26.7
Substrate Width (mm)	35	25	-10
Area (mm^2)	1984.5	750	-1234.5
Radiation Efficiency	60.17	82.5	21.6
Gain (dB)	4.88	4.405	-0.475
Directivity (dB)	7.08	5.34	-1.74

Table 1 . Compared Results with Basic Patch Antenna

VI. CONCLUSION AND FUTURE WORK

In order to obtain compactness and better performance of the antenna. During our survey we have learnt about challenges and motivations from previous papers . And we have been able to overcome certain problems. Gain and bandwidth is improved and can be used based on the requirement in particular field . In future work one can change the structure shape and vary patterns and will be able to obtain divergent results from that of the current one.

REFERENCES

[1] A Low Cost and Highly Efficient Metamaterial Reflector Antenna , Mengjun Wang, Ze Yang, Jianfei Wu, JianhuiBao, Jianying Liu, Lulu Cai, Tao Dang, Hongxing Zheng, *Member, IEEE*, Erping Li, *Fellow, IEEE* . IEEE Transactions on Antennas and Propagation , 2018 .
[2]Directive Beam of the Monopole Antenna Using Broadband Gradient Refractive Index Metamaterial for Ultra-Wideband Application .Micah D. Gregory, Jeremy A. Bossard, Zachary C. P. O. Morgan, Cooper S. Cicero, John A. Easum,John D. Binion, Danny Z. Zhu, Clinton P. Scarborough, Pingjuan L. Werner, Douglas H. Werner, *Fellow, IEEE*, Scott Griffiths, Matthew Ketner, and Joshua Pompeii . IEEE Transactions on Antennas and Propagation , 2017 .
[3] Gain Enhancement of Wideband Metamaterial-Loaded Loop Antenna With Tightly Coupled Arc-Shaped Directors , Rahul Singha, Student member, IEEE, D. Vakula . IEEE Transactions on Antennas and Propagation , 2017 .
[4] Miniaturized Wideband Metasurface Antennas , S. AhdiRezaeieh, M. A. Antoniades, and A. M. Abbosh . IEEE Transactions on Antennas and Propagation , 2017 .
[5] Investigation of SAR Reduction Using Flexible Antenna with Metamaterial Structure in Wireless Body Area Network , Wei E. I. Liu, ZhiNing Chen, Xianming Qing, Jin Shi, and Feng Han Lin . IEEE Transactions on Antennas and Propagation , 2017 .

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 6, Issue 5 , May 2019

[6] Dual-Mode TransmissiveMetasurface and its Applications in MultibeamTransmitarrayHeXiu Xu, Member, IEEE, Tong Cai, Student Member, IEEE, Ya-Qiang Zhuang, Qing Peng, Guang-Ming Wang, and Jian-Gang Liang
[7]Low Cost and Broadband Dual-Polarization MetamaterialLensforDirectivityEnhancement Jeremiah P. Turpin, Student Member, IEEE, Qi Wu, Douglas H. Werner, Fellow, IEEE, Bonnie Martin, Matt Bray, Member, IEEE, and Erik Lier, Fellow, IEEE .
[8] A Compact Printed Antenna With an Embedded Double-Tuned Metamaterial Matching Network Michael Selvanayagam, Graduate Student Member, IEEE, and George V. Eleftheriades, Fellow, IEEE
[9] Dispersion Characteristics of a Metamaterial-Based Parallel-Plate Ridge Gap Waveguide Realized by Bed of Nails AlessiaPolemi, Member, IEEE, Stefano Maci, Fellow, IEEE, and PerSimonKildal, Fellow, IEEE
[10] Lightweight, Flexible, Polarization-Insensitive, Highly Absorbing Meta-Films Sawyer D. Campbell and Richard W. Ziolkowski Fellow
[11] A Low-Profile High-Gain Substrate-Integrated Waveguide Slot Antenna Enabled by an Ultra thin AnisotropicZero-IndexMetamaterialCoatingZhiHao Jiang, Student Member, IEEE, Qi Wu, Donovan E. Brocker, Student Member, IEEE, Peter E. Sieber, Student Member, IEEE, and Douglas H. Werner, Fellow, IEEE
[12] Higher order multipoles in metamaterial homogenization ,Christopher A. Dirdal, Hans Olaf H°agenvik, HaakonAamotHaave, Johannes Skaar
[13] Investigations on Photoresist-Based Arti?cial Dielectrics With Tall-Embedded Metal Grids and Their Resonator Antenna Application MohammadrezaTayfehAligodarz, Student Member, IEEE, David M. Klymyshyn, Member, IEEE, AtabakRashidian, Senior Member, IEEE, Martin Börner, LotfollahShafai, Fellow, IEEE, and Jürgen Mohr
[14] MohammadrezaTayfehAligodarz , David M. Klymyshyn , AtabakRashidian , Martin Borner ,LotfollahShafai , Jurgen Mohr , "Investigations on Photoresist-Based Artificial Dielectrics With Tall-Embedded Metal Grids and Their Resonator Antenna Application",IEEE Trans. Antennas and Propagation, Vol. 63, No. 9.
[15] DeveshKumar ,Vedant Malik , Janhavi Yadav , ShantuAtree , SindhuHak Gupta , "Performance Analysis of Dual layer Stacked Swastika Shaped Patch Antenna with a MetaMaterial Structured Grounded Plane for Satellite Communication and Radar Applications" .IEEE International Conference On Recent Trends in Electronics Information Communication Technology, May 20-21,2016 .
[16] VanshiUpadhyaya , VidyaSawant , "Low-Profile High-Gain Micro-Strip Patch Antenna Using Meta-Materials for Wireless Applications" , IEEE WISPNET 2017 Conference.
[17] Samson Daniel R , Pandeeswari R, Raghavan S , " A compact metamaterial loaded monopoleantenna with offset-fed microstrip line for wireless applications " , AEU - International Journal of Electronics and Communications , Volume 83, January 2018, Pages 88-94 .
[18] RengasamyRajkumar, KommuriUshaKiran , "A compact metamaterial multiband antenna for WLAN/WiMAX/ITU band applications", AEU - International Journal of Electronics andCommunications , Volume 70, Issue 5 , May 2016, Pages 599-604 .
[19] AlessiaPolemi, Member, IEEE, Stefano Maci, Fellow, IEEE, and Per-Simon Kildal, Fellow,IEEE,"Dispersion Characteristics of a Metamaterial-Based Parallel-Plate Ridge Gap Waveguide Realized by Bed of Nails ", IEEE TRANSACTIONS ON ANTENNAS AND PROPAGATION,VOL. 59, NO. 3, MARCH 2011 .
[20] MichaelSelvanayagam, Graduate Student Member, IEEE, and George V. Eleftheriades, Fellow, IEEE , " A Compact Printed Antenna With an Embedded Double-Tuned Metamaterial Matching Network " , 2354 IEEE TRANSACTIONS ON ANTENNAS AND PROPAGATION, VOL. 58, NO.7, JULY 2010