IJESRT
INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

A REVIEW ARTICLE ON DESIGN AND TECHNIQUES OF METAMATERIAL ABSORBER

Garima Tiwari[1] & Amrita Yadav*[2]
Electronics & Communication Dept, J.E.C, Jabalpur Engineering College, Jabalpur, Madhya Pradesh, India
[1]Assistant Professor, JEC Jabalpur
[*2]ME scholar, JEC Jabalpur

DOI: 10.5281/zenodo.1407690

ABSTRACT
In this paper, a brief review on the various Metamaterial (MTM) [1]-[5] absorber designed structures and their simulation results have been presented. MTM is a composite material that produces electromagnetic radiations. Because of its unique properties, the material has been widely studied in microwave engineering for antenna [6], EM clocking [7], filters [8], and perfect lens [9] and so on.

Keywords: Metamaterial MTM, absorber, frequency, EM radiations.

I. INTRODUCTION
Metamaterials (MTMs) are purposely engineered materials that exhibit the properties which are not observed in natural materials, including negative refraction index, clocking behavior, backward propagation, and reverse Doppler effects [1]-[5] . MTMs have properties derived from their physical structure, but not by their chemistry. They also exhibit the properties that are not observed in their constituent material.

In recent years, electromagnetic MTM have come into the interest of scientific researchers due to their exclusive properties. Because of its distinctive properties, this material has been extensively studied in microwave engineering for antenna [6], clocking [7], negative refraction, perfect lens [9], and absorbers [10] and so on.

The main purpose of microwave absorber is to reduce the electromagnetic interference in microwave components. MTM structures have made a major breakthrough in this application, where the thin structure comprising periodic unit cells in the sub-wavelength order can be used to obtain near unity absorption through ohmic and dielectric loss. Till date, numerous designs on MTM absorbers have been investigated that exhibit different characteristics, such as single-band [10], bandwidth enhancement, dual-band [12]-[13], triple-band, and even broadband operations [11], with most of them being polarization-insensitive and wide-angle absorptive.

II. LITERATURE SURVEY
2.1. N.I. Landy, S. Sajuyigbe, J.J. Mock, D.R. Smith, and W.J. Padilla "Perfect Metamaterial Absorber":
To develop an MTM absorber with good absorption characteristics, different shapes were investigated. This investigation has been continued till date for constant improvements and better results. It was found that some geometry might have a wider bandwidth or better absorption characteristics than others at particular microwave frequencies. In this paper, a single unit cell of the absorber consisting of two distinct metallic elements is considered. Electric coupling was supplied by the electric ring resonator (ERR) to provide good absorption. Standard absorption equation is used to get the absorption plot. The simulated and experimental results show maximum absorption at the frequency 11.5 GHz. However the simulated results reach a maximum of 96% the experimental results reach only

ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

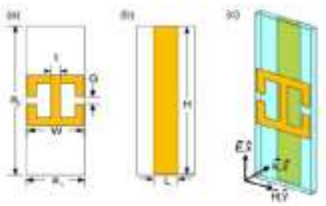

FIG. 1 (color online). Electric resonator (a) and cut wire (b). Dimension notations are listed in (a) and (b). The unit cell is shown in (c) with axes indicating the propagation direction.

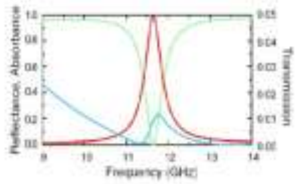

FIG. 2 (color online). Simulated MM PA. $R(\omega)$ (light gray line, green online) and $A(\omega)$ (black line, red online) are plotted from zero to 100% (left axis). $T(\omega)$ is plotted on the right axis as the gray line (blue online) on a scale from zero to 5%.

2.2. Wei Shi, Shaobin Liu, Busheng Zheng, Xiangkun Kong, Haifeng Zhang, Siyuan Liu "Broadband perfect metamaterial absorption, based on flexible material":

Because of the advantage of MTM, researchers and scientists are now able to fabricate flexible MTM absorber. In this paper, authors have described about the various flexible material that have been used in MTM absorber, such as rubber [14], GaAs [15], polyimide [16], kapton [17], Polyethylene terephtalate (PET) [18], polydimethylsiloxane (PDMS) [19]. The paper describes a flexible MTM absorber which is based on Teflon as its dielectric layer. A flexible MTM absorber using a hollow octagon and a hollow similar square with the same centre structure with different dimensions in the unit cell has been investigated as a broadband polarization- insensitive and wide angle absorber. The results show that the absorption of flexible MTM exceeds 90% within the frequency range of 6.84 GHz to 17.44 GHz. This is equivalent to a relative absorption bandwidth of about 87.31%.

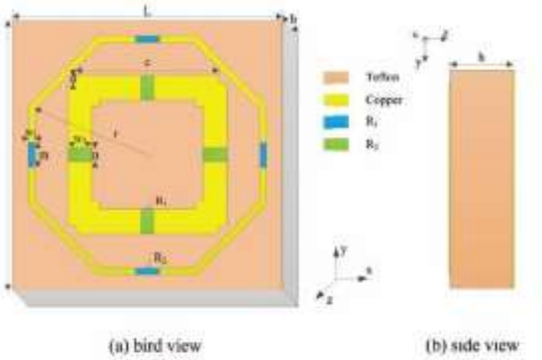

Figure 1. Layout of the proposed unit cell of broadband flexible metamaterial absorber absorber

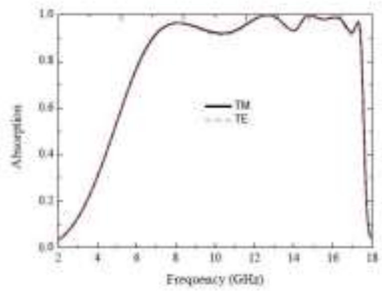

Figure 2. Simulation of absorption rate of TE and TM wave at incidence

2.3. Gobinda Sen, Amartya Banerjee, Mukesh Kumar, Sk Nurul Islam, Santanu Das "A dual band metamaterial inspired absorber for WLAN/Wi-MAX applications using a novel I-shaped unit cell structure":

This paper presents a dual band MTM absorber that has two distinct peaks at frequencies 3.5GHz and 5.8GHz respectively with 100% absorption of the incident signal at both the points of observation. The geometry consists of navel I-shaped unit cell structure that consists of two C-shaped oppositely faced rectangle strips with a thin I-shaped patch in between, shows excellent MTM like performance when examined. A good match of frequency band can be achieved between the performances of the simulations and the experiments.

ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

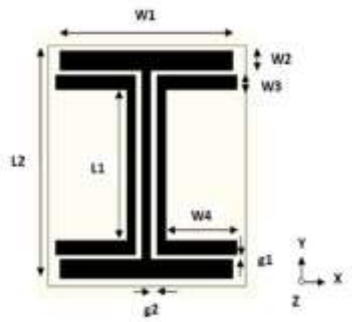

Figure 1. The Top-plane View of the Proposed Unit Cell

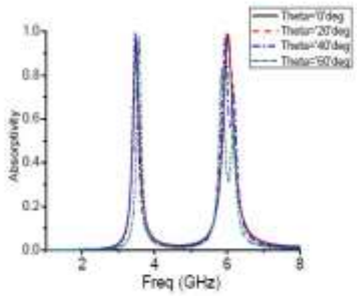

Figure 3: Absorptivity Plot for Incoming Signals with Varying Angles of Incidence

2.4. Wang Xin, Zhang Binzhen, Wang Wanjun, Wang Junlin and Duan Junping "Design, fabrication, characterization of a flexible dual- band metamaterial absorber":

Here, a flexible dual band MTM absorber is considered which observes the absorption of the incident wave at slightly higher frequencies (higher than the ones used in previous design experiments). In this paper, polyamide material is used as a sandwiched layer between the continuous metallic ground plane and T-shaped single pattern metallic patch. The layer of the polyamide material makes the design of absorber flexible. For the case of normally incident EM wave, two distinct absorption peaks were obtained at 16.77GHz and 30.92GHz with absorption ratio of 98.7% and 99.3%.

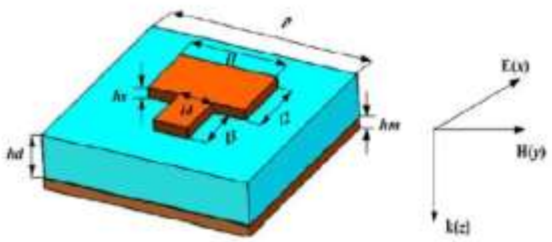

Fig. 1. Unit cell schematic of the proposed MM absorber.

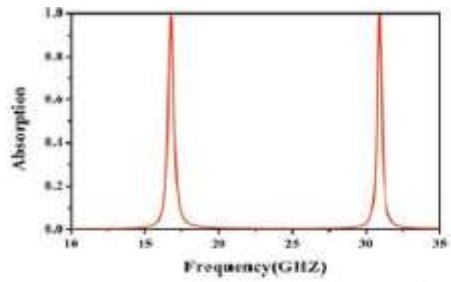

Fig. 2. Simulated absorption curve of the proposed MM absorber for the normally incident EM wave.

III. DESIGN CONSIDERATION

The three essential parameters for the design of a quad band MTM absorber are,

Resonant Frequency (fr):

The resonant frequency selected for this design will be in GHz. The purpose of this selection is to make our design work with maximum efficiency, so as to give better results.

Dielectric constant of the substrate (εr):

The dielectric material selected for our design is polyamide which has a dielectric constant of 3.5. A substrate with a high dielectric constant is to be selected since it reduces the dimensions of the absorber. The reduction in dimensions of the absorber is done to obtain better results.

Height of dielectric substrate (h):

It is essential that the design of absorber should not be bulky hence height should be less.

IV. SUMMARY

From the paper analyzed so far, it is observed that a flexible dual band MTM absorber gives better absorption peaks within a particular range of frequency. By making certain changes in the design, they can be made to work for quad band of frequencies, so that the design can be used in more number of applications.

ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

V. CONCLUSION

The paper represents the survey of techniques, review and designs for the designing of MTM absorbers. The characteristics limitations of conventional MTM absorber can be improved by using any method, which is mentioned above. The review work is done on the different techniques to design MTM absorbers and to get the different characteristics for the same, although useful solutions are still needed. There are some problems like bandwidth enhancement, complexity of structure, reduction of gain etc. which need to be solved to make the design work efficiently. Hence, there is a need of further research in problem areas.

VI. REFERENCES

[1] 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, 2000.
[2] V. G. Veselago, "The electrodynamics of substances with simultaneously negative values of permittivity and perme-ability," *Sov. Phys. Uspekhi*, vol. 10, no. 4, pp. 509–514, 1968
[3] D. Schurig *et al.*, "Metamaterial electromagnetic cloak at microwave frequencies," *Science*, vol. 314, no. 5801, pp. 977– 980, 2006.
[4] S. A. Cummer, B. I. Popa, D. Schurig, D. R. Smith, and J. Pendry, "Full-wave simulations of electromagnetic cloaking structures," *Phys. Rev. E*, vol. 74, 2006, Art. no. 036621.
[5] N. Seddon and T. Bearpark, "Observation of the inverse doppler effect," *Science*, vol. 302, no. 5605, pp. 1537–1539, 2003
[6] M. Yoo and S. Lim, "SRR- and CSRR-loaded ultra-wideband (UWB) antenna with tri-band notch capability," *J. Electro-magn. Waves Appl.*, vol. 27, no. 17, pp. 2190–2197, 2013.
[7] A. Rajput and K. V. Srivastava, "Design of a two-dimensional metamaterial cloak with minimum scattering using a quadratic transformation function," *J. Appl. Phys.*, vol. 116, no. 12, 2014, Art. no. 124501.
[8] J. L. Wang, B. Z. Zhang, X. Wang, and J. P. Duan, "Flexible dual-band band-stop metamaterials filter for the terahertz region," *Opt. Mater. Express*, vol. 7, no. 5, pp. 1656–1665, 2017.
[9] K. Aydin, I. Bulu, and E. Ozbay, "Subwavelength resolution with a negative-index metamaterial superlens," *Appl. Phys. Lett.*, vol. 90, 2007, Art. no. 254102.
[10]N.I. Landy, S. Sajuyigbe, J.J. Mock, D.R. Smith, and W.J. Padilla, Perfect metamaterial absorber, Phys Rev Lett 100 (2008), 207402.
[11]Wei Shi, Shaobin Liu, Busheng Zheng, Xiangkun Kong, Haifeng Zhang, Siyuan Liu "Broadband perfect metamaterial absorption, based on flexible material," radar imaging and microwave photonics, 2016.
[12]Gobinda Sen, Amartya Banerjee, Mukesh Kumar, Sk Nurul Islam, Santanu Das "A dual band metamaterial inspired absorber for WLAN/Wi-MAX applications using a novel I-shaped unit cell structure," Asia- Pacific microwave conference 2016.
[13]Wang Xin, Zhang Binzhen, Wang Wanjun, Wang Junlin and Duan Junping "Design, fabrication, characterization of a flexible dual- band metamaterial absorber," IEEE Photonics Journal, Vol. 9, No. 4, August 2017.
[14]Zhang F, Liu Z, Qiu K, et al. Conductive rubber based flexible metamaterial[J]. Applied Physics Letters, 2015, 106(6).
[15]Zhao X, Fan K, Zhang J, et al. Optically tunable metamaterial perfect absorber on highly flexible substrate[J]. Sensors & Actuators A Physical, 2015, 231:74–80.
[16]Lee H M. A broadband flexible metamaterial absorber based on double resonance[J]. Progress in Electromagnetics Research Letters, 2014, 46:73-78.
[17]Yahiaoui R, Guillet J P, De M F, et al. Ultra-flexible multiband terahertz metamaterial absorber for conformal geometry applications[J]. Optics Letters, 2013, 38(23):4988-4990.
[18]Jang T, Youn H, Shin Y J, et al. Transparent and Flexible Polarization- Independent Microwave Broadband Absorber[J]. Acs Photonics, 2014, 1(3):279-284.
[19]Ling K, Kim K, Lim S. Flexible liquid metal-filled metamaterial absorber on polydimethylsiloxane (PDMS)[J]. Optics Express, 2015, 23(16).