iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 8 **Issue:** V **Month of publication:** May 2020

DOI: http://doi.org/10.22214/ijraset.2020.5259

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 8 Issue V May 2020- Available at www.ijraset.com

Comparison of the Effect of AMC on various Feeding Techniques in Patch Antennas

Kamini Budke[1], Pallavi Malame[2], Reena Sonkusare[3]
[1, 3]Department of Electronics and Telecommunication, Sardar Patel Institute of Technology

Abstract: In this paper, the effect of an Artificial Magnetic Conductor (AMC) on various antenna feeding techniques, namely; inset feed, Coplanar waveguide (CPW) feed, and aperture-coupled feed has been demonstrated over the ISM band (2.4GHz-2.5GHz). The paper deals with the effect of Jerusalem Cross AMC (JC-AMC) structure on the mentioned feeding techniques. Qualitative parametric analysis concerning distance between the AMC structure and the antenna is also done using ANSYS High Frequency Simulation Software (HFSS).

Keywords: Artificial Magnetic Conductor (AMC), Jerusalem Cross (JC), Inset Feed, Aperture Coupled feed, Coplanar Waveguide feed

I. INTRODUCTION

The innovation of metamaterials has revolutionized the field of antenna designing, allowing engineers to cross various constraints and thresholds. AMC form one category of metamaterials which significantly help reduce the antenna profile while suppressing surface waves which cause radiation losses. However, their usage is limited because of bandwidth constraints. Many studies have been performed to modify the AMC structure for wideband applications such as those presented in [1]. Despite the plethora of study on the AMC itself, very little research is available on the comparison of its effects across antenna systems.

In antenna systems, feeding mechanisms comprise one of the most crucial structural characteristics as they are highly dependent on the system requirement; electrical, as well as mechanical. They mainly comprise of line feed, coaxial feed, proximity coupled feed and aperture coupled feed [2]. The feed for a particular antenna is decided based on various factors such as conformability, spatial dynamics, etc. When AMC sheet is used along the antennas, the type of feed has an impact on the performance of the antenna. These feeding mechanisms are taken as the factor for comparing the effect of the AMC on different antenna systems operating in the same ISM Band (2.4GHz- 3.5GHz)

II. DESIGN

A. AMC Structure

As per the description given in [3], Planar periodic metallic arrays act as AMC when they are placed on a grounded dielectric substrate while introducing a zero degrees reflection.

Through an extensive literature survey, various AMC structures following different symmetries, such as those used in [4]-[7], can be observed. For this study, the AMC structure has been inspired by the Jerusalem Cross (JC) structure which many have modified to suit their requirement such as that in [8] and [9].

The AMC structure used for the following experiments and simulation, is adapted from [10], where the author has modified a simple JC (Jerusalem Cross) AMC to a miniaturized slotted JC structure, resonating to cover the 2.45GHz ISM Band. The AMC unit cell is supported by a Roger 3003 substrate having a height of 1.6mm. The AMC obtains a phase reflection of 0 degrees at 2.45GHz and can thus be used along with antenna systems operating in the ISM band.

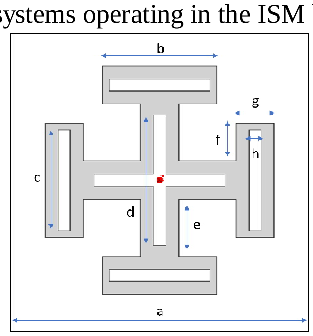


Fig. 1 AMC JC Cross Structure

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 8 Issue V May 2020- Available at www.ijraset.com

TABLE I

DIMENSION FOR AMC STRUCTURE

a	23mm	b	10.5mm	c	9.3mm	d	12mm
E	5.3mm	f	3.5mm	g	3.5mm	h	1.1mm

A 3x3 array is constructed using the unit AMC cell depicted in fig 1. having dimensions as stated in table I, and is used as a reflector placed under antennas having different feeding mechanisms.

B. Feeding Mechanism

1) *Simple Inset Feed Antennas:* Inset feed antennas are known for their sleek profile and easy integration. However, the antenna is known to have a lot of spurious radiation. A simple inset fed antenna, inspired by [10], operating at 2.45GHz, is designed on a FR4 epoxy substrate having 1.6mm height. The structure is depicted in figure 2 and its dimensions are given in table II

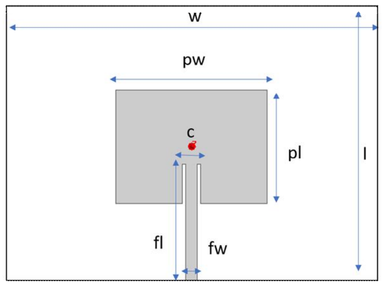


Fig. 2. Geometrical Representation of the Structure of Inset Feed Patch Antenna

TABLE III

DIMENSIONS FOR INSET-FED ANTENNA

l	72.8mm	pl	28.8mm	fl	31mm	cl	9mm
w	100mm	pw	38.01mm	fw	3mm	cw	4.6mm

2) *Aperture Coupled Antennas:* The aperture coupled antenna is known for its wide bandwidth and significant gain compared to most microstrip patch antenna [11]. Though it does not have a light profile, it is possible to integrate the antenna in most applications. Each FR4 substrate layer separating thee two planes as shown in figure 3 measures 1.6mm in thickness.

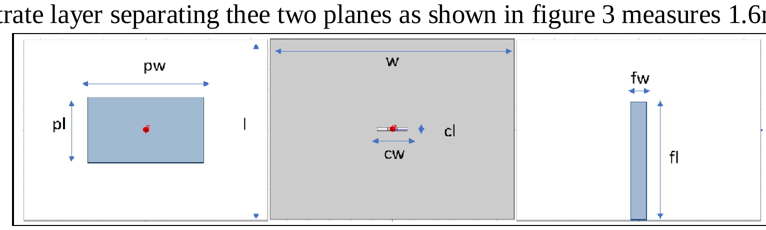


Fig. 3. Geometrical Representation of the Structure of the Aperture Coupled Antenna

TABLE IIIII

DIMENSIONS FOR APERTURE COUPLED ANTENNA

l	100mm	Pl	53.2mm	fl	4.7mm	cl	6.4mm
w	100mm	pw	61.6mm	fw	70mm	cw	14.5mm

The aperture coupled antenna that is designed with dimensions as those in table III and resonates at 2.4GHz.

3) *Coplanar Waveguide Fed Antennas:* The coplanar waveguide has a simple realisation owing to one sided etching. Coupled with low dispersion, this feeding method is often considered when integrating the antenna with an RF system where waveguide communication is dominant. However, relatively think substrate requirement and unintended spurious radiation hinders its usage. A CPW-fed antenna with a standard substrate thickness (1.6mm), adapted from [12], has been designed for the ISM band and the effect of the AMC has been investigated.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 8 Issue V May 2020- Available at www.ijraset.com

The design for the same is as given in the figure 4 and table IV.

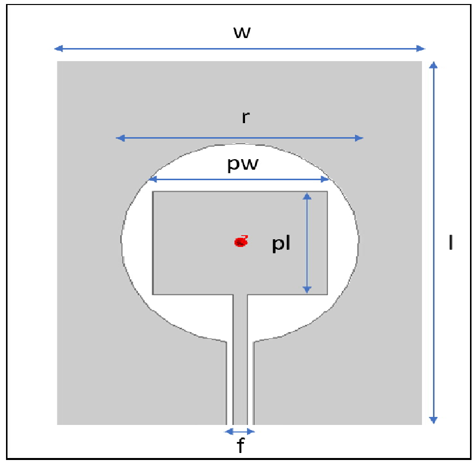


Fig. 4. Geometrical Representation of the Structure of the Coplanar Waveguide Fed Antenna

TABLE IVV

DIMENSION FOR COPLANAR WAVEGUIDE FED ANTENNA

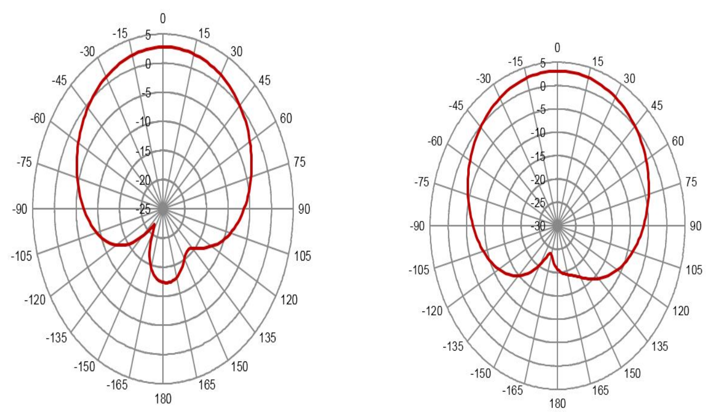
l	95.4mm	pl	27mm	f	3mm
w	80mm	pw	38mm	r	26mm

III. SIMULATIONS AND RESULTS

The 3x3 AMC array is positioned below each of the antennas to observe. It should be noted that there is an increase in mutual coupling when the proximity between the AMC and the antenna is increased. A non-uniform near field wave can be introduced by the mutual coupling that can shift the operation frequencies of antenna [13].

A. Simple Inset Feed Antenna

The simple inset-fed antenna yields reflection coefficient as plotted in figure 6 shows the antenna operating at a frequency of 2.45GHz with S11= -255dB at the resonant frequency. The radiation plot as observed in figure 5a has a gain of 2.5dB in the x-z plane.



(a)Without AMC (b)With AMC

Fig. 5. Radiation Plot for Inset Feed Antenna

Now, the AMC sheet is placed 10mm below the inset-fed antenna. Firstly, on observing the S11 plot as shown in figure 6, it is noticed that the antenna resonates at the same frequency despite the presence of the AMC sheet. However, the radiation plot in figure 5b is observed to have a gain of 3.2dB in the x-z plane which is more than that observed without the AMC. A significant back-lobe reduction is also observed pushing the front to back ratio from 33 to 240. Thus, the overall the performance of the inset feed antenna is improved without any changes in the resonant frequency or the bandwidth.

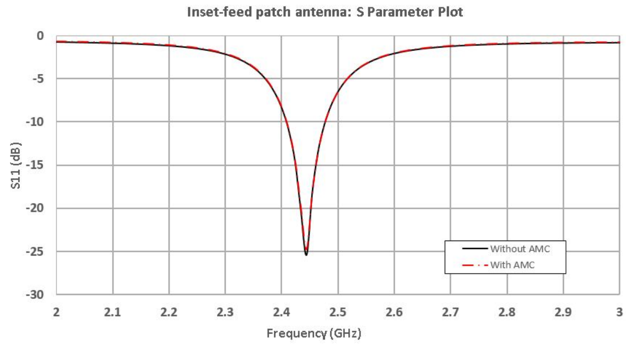
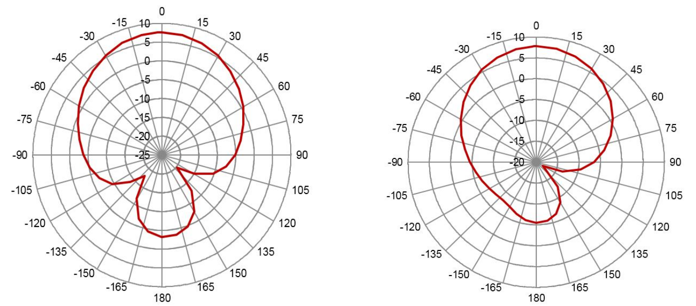


Fig. 6. S-parameter Plot for Inset Feed Antenna

We can contemplate that the AMC sheet helps in improving the front to back ratio by reflecting the backward radiation.

B. Aperture Coupled Feed Antenna

The Aperture Coupled Antenna resonates at 2.45GHz, with a return loss of -24dB at the resonant frequency. It has a gain of 7.7dB in the broadside direction.



(a)Without AMC (b)With AMC

Fig. 7. Radiation Plot for Aperture Coupled Antenna

After placing the AMC antenna under it at a distance of 10 mm, we observed that the antenna gain is almost unaffected as in figures 7a and 7b, but the antenna develops a new resonant frequency shows shift in resonance frequency. To find a connection between the proximity of the AMC sheet to the antenna, the distance between the same is varied and its effect is as shown in figure 8. On varying the distance of the AMC reflector from the antenna, a second resonance is observed at different frequencies depending on distance, thereby making the antenna function as a dual band.

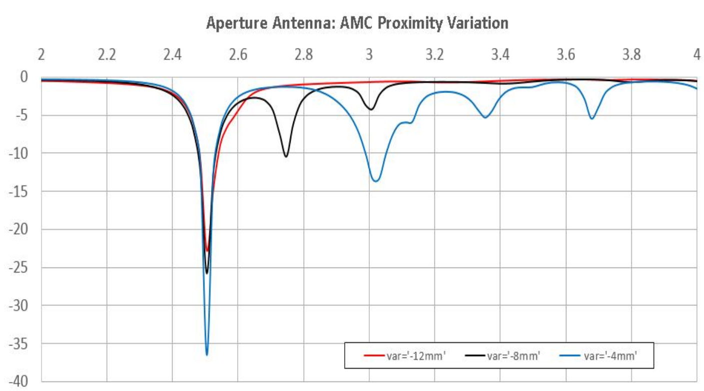
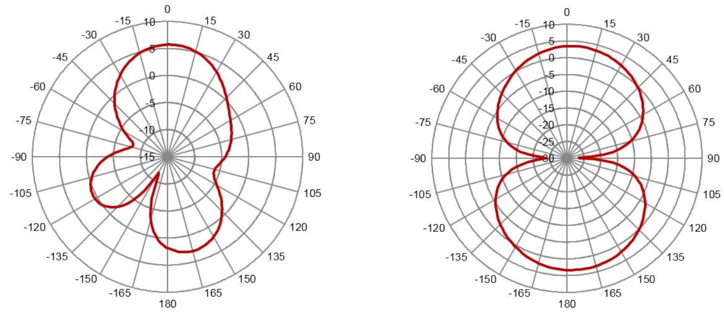


Fig. 8. S-parameter Plot for Aperture Coupled Antenna simulated with AMC

The behaviour of the Aperture Coupled Patch Antenna suggests that the AMC sheet causes some impedance matching at the complementary frequency. This behaviour can be potentially be understood further after mathematical modelling of the AMC sheet and understanding its interaction with the multiple layers of the Aperture Coupled patch antenna.

C. Coplanar Waveguide Feed Antenna: The CPW-Fed Patch Antenna resonates at 2.45GHz, with a return loss of -25dB at the resonant frequency. It has a gain of 3.4dB is as shown in figure 9a.



(a)Without AMC (b)With AMC

Fig. 9. Radiation Plot for Aperture Coupled Antenna

When the AMC sheet is placed at the standard distance of 10mm below the antenna, a complete change in the resonant frequency is observed. The radiation plot is also skewed from the assumed resonant frequency of 2.45 GHz suggesting that the antenna does not have a significant resonance in the ISM band; the same is plotted in figure 9b.

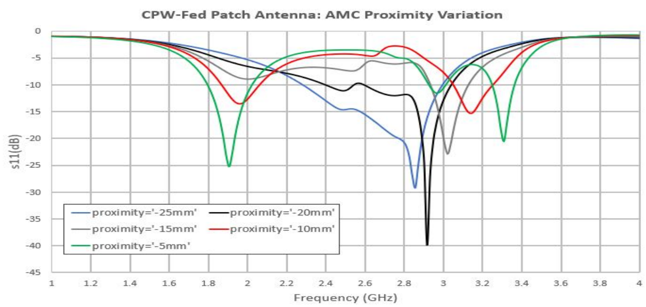


Fig.10. S-parameter Plot for Coplanar Waveguide fed Antenna simulated with AMC

To understand the relation between the proximity of the AMC sheet and the skewed nature of the S parameter plot, the distance of the AMC sheet is varied as before and is depicted in figure 10. It is observed that when the AMC is sufficiently far from the antenna, in this case 25mm; the antenna resonates at about 2.9 GHz. As the distance is reduced, the resonance frequency moves further away however, a second resonance starts developing around 2GHz. It can also be noted that with increase in proximity, the bandwidth is significantly affected.

IV. SUMMARY

The variation in performance parameters is observed as the AMC sheet is placed below each of the considered microstrip patch antennas. The inset-feed antenna exhibits some considerable increase in gain at the same resonant frequency.

The AMC sheet does have an impact on the s parameter but does not considerably affect the radiation pattern and the gain of the antenna. On varying the distance of the AMC array from the antennas, a significant change is observed in the return loss at the resonant frequency with the introduction of a second resonance at varying frequencies.

The CPW-fed patch antenna originally has radiation in the backward direction as well. After implementation of AMC the backward radiation begins to subside. However, the resonant frequency is observed to shift as the distance of the AMC sheet is varied, i.e. the resonant frequency increases as the distance is decreased. As the distance is decreased, another resonant frequency is also introduced.

V. CONCLUSIONS

The effect of AMC varies with each feeding mechanism. While it results in an increase in gain for inset-feed antenna, it does not better the performance of the aperture coupled antenna but does develop a second resonance making it a dual band antenna. The introduction of AMC under a CPW-fed antenna completely changes its frequency of resonance, further displaying characteristics of a dual band. Each case study; Aperture Coupled Patch Antenna and CPW-fed Patch Antenna, hold promising future scope in understanding the interaction with the AMC to develop newer resonance frequencies.

REFERENCES

[1] Hossein Malekpoor, Shahrokh Jam, "Improved Radiation Performance of Low Profile Printed Slot Antenna Using Wideband Planar AMC Surface," IEEE Transactions on Antennas and Propagation, vol. 64, no. 11, pp. 4626 - 4638, Nov. 2016.

[2] Rahul Verma, Rahul Rana, Nitin Vyas, Vipin Kaushik, A. K. Arya, "Design Study of Microstrip Antenna with Various Feeding Techniques," INTERNATIONAL JOURNAL OF ENGINEERING RESEARCH & TECHNOLOGY (IJERT), vol. 03, no. 05, May 2014.

[3] M. T. Xie, Q. G. Guo and K. M. Huang,"Design of a Novel Artificial Magnetic Conductor Plane and Its Application for Low-Profile Dipole," 2010 International Conference on Microwave and Millimeter Wave Technology, Chengdu, 2010, pp. 2085-2087.

[4] M. Mantash, A.-C. Tarot, S. Collardey and K. Mahdjoubi, "Investigation of Flexible Textile Antennas and AMC Reflectors," International Journal of Antennas and Propagation, vol. 2012, May 2012.

[5] R. Gómez-Villanueva, H. Jardón-Aguilar and R. L. y Miranda,"State of the art methods for low SAR antenna implementation," Proceedings of the Fourth European Conference on Antennas and Propagation, Barcelona, 2010, pp. 1-4.

[6] A. Alemaryeen and S. Noghanian, "On-Body Low-Profile Textile Antenna With Artificial Magnetic Conductor," IEEE Transactions on Antennas and Propagation, vol. 67, no. 6, pp. 3649-3656, June 2019.

[7] Islam, M.T., Ullah, M.H., Singh, M.S., & Faruque,"A New Metasurface Superstrate Structure for Antenna Performance Enhancement," Materials (2013)

[8] M. Hosseini, A. Pirhadi, and M. Hakkak,"A Novel AMC with Little Sensitivity to the Angle of Incidence Using 2-Layer Jerusalem Cross FSS," Progress In Electromagnetics Research, Vol. 64, 43-51, 2006.

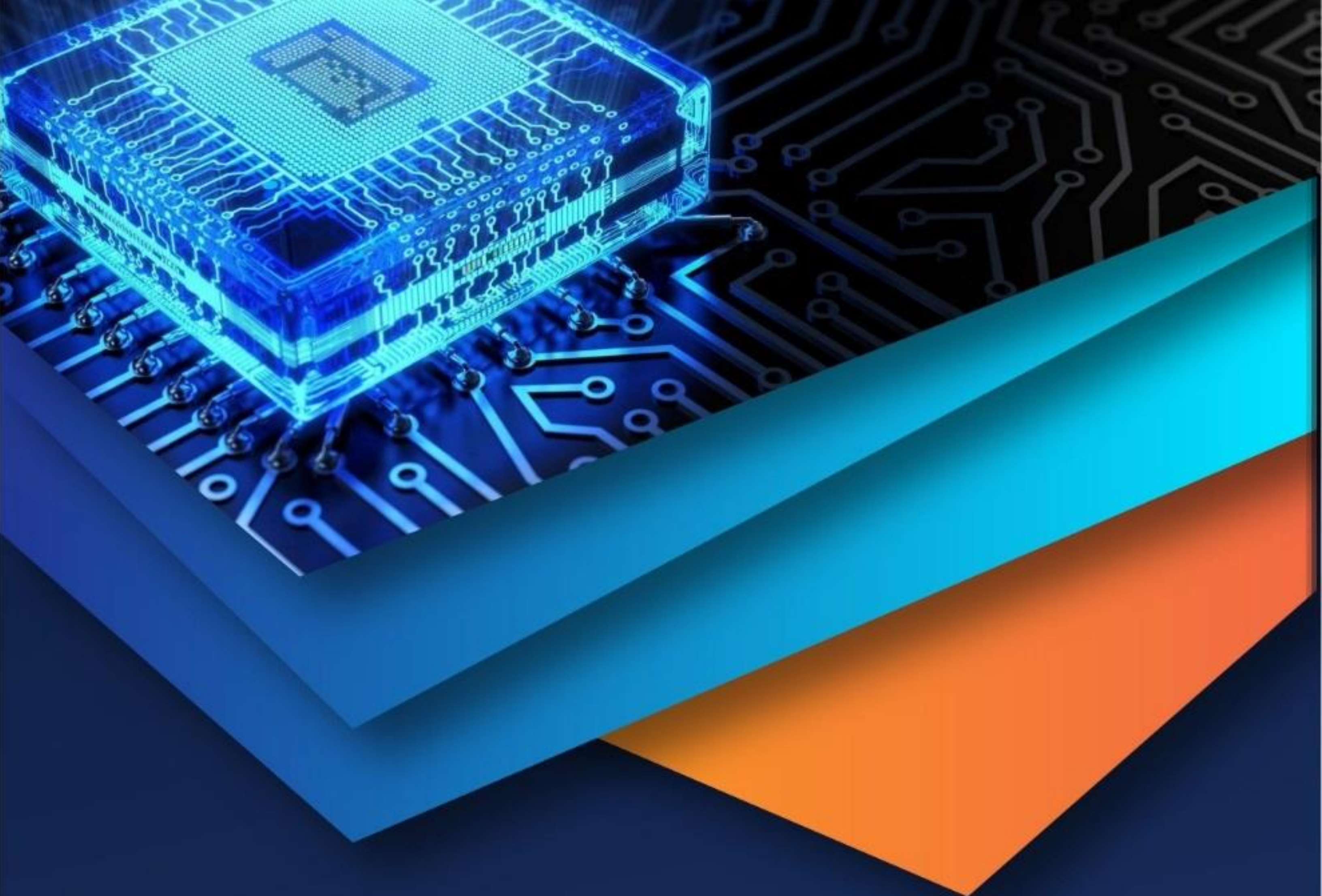
[9] H. R. Raad, A. I. Abbosh, H. M. Al-Rizzo and D. G. Rucker,"Flexible and Compact AMC Based Antenna for Telemedicine Applications," IEEE Transactions on Antennas and Propagation, vol. 61, no. 2, pp. 524-531, Feb. 2013.

[10] S. R. Mohd Zaini and K. N. Abdul Ran, "Wearable Inset-Fed FR4 Microstrip Patch Antenna Design," 2018 IOP Conference Series: Materials Science and Engineering, 318 012050

[11] C. Hertleer, A. Tronquo, H. Rogier, L. Vallozzi and L. Van Langenhove, "Aperture-Coupled Patch Antenna for Integration Into Wearable Textile Systems," IEEE Antennas and Wireless Propagation Letters, vol. 6, pp. 392-395, 2007.

[12] Jain, Prof. Dr. R. K Khola, P. (2016), " CPW Fed Rectangular Microstrip Patch Antenna with Upper Pentagonal End Cut," Global Journal Of Research In Engineering, Retrieved from https://engineeringresearch.org/index.php/GJRE/article/view/1408

[13] G. Li, H. Zhai, L. Li, C. Liang, R. Yu and S. Liu,"AMC-Loaded Wideband Base Station Antenna for Indoor Access Point in MIMO System," IEEE Transactions on Antennas and Propagation, vol. 63, no. 2, pp. 525-533, Feb. 2015.



10.22214/IJRASET

INDEX COPERNICUS
45.98

IMPACT FACTOR: 7.129

TOGETHER WE REACH THE GOAL
IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY