iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 9 Issue: VI Month of publication: June 2021

DOI: https://doi.org/10.22214/ijraset.2021.35313

CPWG Fed with Octagonal Patch Antenna

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Abstract: A Co planner Wave Guide (CPWG) fed with octagonal patch antenna is modified from their respective rectangular patch are presented for WLAN application. The dielectric material applied in the design process for both co planar and micro strip patch antenna is FR4 Epoxy Glass, which has relative permittivity of 4.4 and substrate height 1.6mm. Antenna parameters used to check the performance. A comparison is made between the octagonal co-planar antenna and octagonal micro strip antenna available. Ansys HFSS is used for antenna design and analysis. Both designed antennas are suitable for wireless local area network application and the design parameters of the antenna are optimized to resonate at 3GHz frequencies for WLAN applications. It has been found that octagonal micro strip patch antennas have lower return loss and are more directive than co planar patch antenna. High directivity of octagonal micro strip antenna is due to the presence of ground plane under the substrate of antenna. The results obtained by simulations have also shown that octagonal co planar patch antennas have high radiation efficiency (a measure of the power radiated through the antenna as an electromagnetic wave to the power fed to the antenna terminals) and which implies a wider bandwidth as compared to an octagonal micro strip patch antennas. The radiation efficiency obtained for micro strip patch antenna is 24% and that for co planar patch antenna is 67%, the directivity for micro strip patch antenna is 3.75 dB and that for a co-planar patch antenna is 3.25 dB.
Keywords: Co-planar patch , CPWG, octagonal patch, planar etc.

I. INTRODUCTION

Planar patch antennas [20] are popular in wireless communication, because they have some advantages due to their conformal and simple planar structure. They allow all the advantages of printed -circuit technology. There are varieties of patch structures available but the rectangular, circular and triangular shapes [20] are most frequently used. Design of S-band (WIMAX), C-band (WLAN) antennas also got popularity with the advancement of planar patch antennas.

Moreover, a large number of co planar and micro strip patches to be used in wireless applications have been developed [21]. The rapid progress in wireless communications requires the development of lightweight, low profile, single feed antennas. Also it is highly desirable to integrate several RF modules for different frequencies into one piece of equipment. Hence, multiband antennas that can be used simultaneously in different standards have been in the focus points of many research projects [21]. Portable devices are widely used in our daily lives such as mobile phones, laptops with wireless connection.

The S-band is a certain portion of the microwave band of the electromagnetic spectrum. It is defined by an IEEE standard for radio waves with frequencies that range from 2 to 4 GHz, crossing the conventional boundary between UHF and SHF at 3.0 GHz. The S band is used by weather radar, and surface ship radar.

A certain portions of the electromagnetic spectrum, including wavelengths of microwave that are used for long distance telecommunications is called C-band. It ranges from 4 to 8 GHz and its slight variations contain frequency ranges that are used for, some Wi-Fi devices, some cordless telephones, and some weather radar systems.

The main goal of this work is to design a octagonal co planar and micro strip patch antennas which will be applicable for WLAN applications and do a performance comparison between these two planar patch antennas and put the most suitable antenna forward for Microwave application systems.

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue VI Jun 2021- Available at www.ijraset.com

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A. Basic Structure of Micro Strip Patch Antenna

A class of antennas that has gained considerable popularity in recent years is the micro strip antenna. In its most fundamental form, a Micro strip Patch antenna consists of a radiating patch on one Side of a dielectric substrate which has aground plane on the other side as shown in Figure 2.1. The patch is generally made of conducting material such as copper or gold and can take any possible shape. The radiating patch and the feed lines are usually photo etched on the dielectric substrate. A typical micro strip element is illustrated in Fig. 2-1. There are many different types of micro strip antennas, but their common feature is that they consist of four parts:

1) very thin flat metallic region often called the patch;
2) Dielectric substrate;
3) Ground plane, which is usually much larger than the patch; and
4) Feed, which supplies the element RF power.

Micro strip elements are often constructed by etching the patch (and sometimes the feeding circuitry) from a single printed-circuit board clad with conductor on both of its sides. In its simplest form, a micro strip patch antenna consists of a radiating patch on one side of a dielectric substrate, and a ground plane on the other side [22].

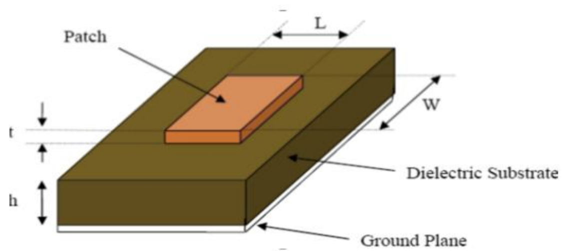

Figure 2.1: The basic geometry of micro strip radiator [33]

II. PREVIOUS WORK

To make parameter comparison, results found for both micro strip and co planar patch antenna are also included in the following table 2.1.

Table 2.1 summary of calculated result at 3 GHz for both patch antenna

Element	Calculated results for co planar patch antenna(mm)	Calculated results for micro strip patch antenna(mm)
Width of patch (W)	30.43	30.43
Length of patch (L)	22.5	23.43
Width of ground (Wg)	46	46
Length of ground (Lg)	32	40
Inset length (Yo)	**6.91**	**7.196**
Effective dielectric constant (Ereff)	**4.49**	**4.08**

A. CPWG fed with Octagonal Patch Antenna

The next step is design of the octagonal patch microstrip and coplanar antenna, in this step we make a cut of a small triangular shape in the four angles of the microstrip patch antenna and coplanar patch as shown in Fig.2.1. select some value which gives wide band width and define the parameter which helps to find the rest four sides of the patch.this way it can obtain an octagonal patch antenna.

$$D = (L_{cut})2 + (w_{cut})2$$

Where D is the sides (cuts) from rectangular patch

$$L_{cut}\frac{Lp}{c} \quad W_{cut} = \frac{Lp}{C}, wp \;\; width\, of\, rectangular\, patch, Lp \;\; length\, of rectangular\, patch,$$

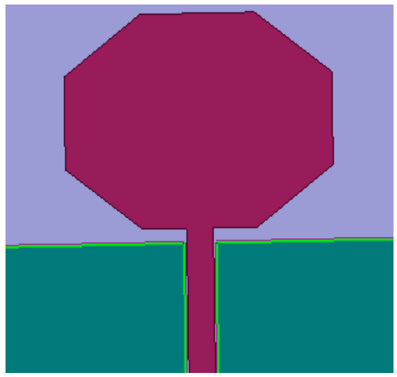

Figure 2.1**:** octagonal patch micro strip antenna

B. Antenna Parameters

1) *Efficiency and Quality Factor:* For a microstrip patch antenna, efficiency can be defined as the power radiated from the microstrip element divided by the power received by the input to the element. Factors that affect the efficiency of the antenna and make it high or low are the dielectric loss, the conductor loss, the reflected power (Voltage Standing Wave Ratio), the cross polarized loss, and power dissipated in any loads in the element.

$$e = \frac{P_{rad}}{P_{rec}}$$

Where, P_{rad} =Power radiated by the antenna , P_{rec} =power fed to the antenna

Radiated efficiency is a measure of the power radiated through the antenna as an electromagnetic wave to the power fed to the antenna terminals. If an antenna could be made to be a totally ideal electrical component, it would transform all of the power fed to its terminals to a radiating electromagnetic energy that propagates into the surrounding space. This is possible only in theory, and thus in real life some of the power fed to the antenna terminals is always lost. For example, the mismatch between the antenna element and the feeding network causes power losses.

Antenna efficiency is a useful and informative measure of antenna “economic efficiency.” With a quick glance, the antenna’s capability to use the power fed to the connection pads can be evaluated and the amount of power required from the radio module can be determined in order to achieve a certain performance level. Antenna efficiency does not consider radiation direction and thus is a useful performance metric for measuring the efficiency of mobile devices, which have an omni-directional radiation pattern. In mobile devices, no specific direction of radiation is emphasized. On the other hand, if the antenna is supposed to radiate in a specific direction, (i.e. the antenna is designed to have some directive characteristics in its radiation pattern) then antenna gain is a better performance metric.

2) *2.5.2 Return Loss:* Return loss is an important parameter when testing an antenna. It is related to impedance matching and the maximum power transfer theory. It is also a measure of the effectiveness of an antenna to deliver power from source to antenna.

The return loss (RL) is defined by the ratio of the incident power of the antenna to the power reflected back from the antenna of the source; the mathematical expression is:

$$R_L = 10\log10 \frac{\text{pin}}{pref} (\text{dB})$$

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Another definition of return loss, from equation (2.9), is the difference in dB between the power sent towards the antenna and the power reflected from it. It is always positive when the antenna is passive and negative when it is active. We can express equation (2.18) in terms of voltage-standing-wave-ratio and impedance as follows [18]:

$$R_L = 10\log_{10}\left|\frac{1}{\rho}\right|(\text{dB}) = -20\log_{10}\rho\,(dB))$$

$$R_L = 10\log_{10}\left|\frac{VSWR+1}{VSWR-1}\right|(\text{dB})$$

$$R_L = 20\log_{10}\log_{10}\frac{1+Z_2}{1-Z_2}(\text{dB})$$

Where, ρ is the complex reflection coefficient at the input of the antenna ,

VSWR-voltage standing wave ratio. Z_1 and Z_2 and are the impedance of the source and the antenna respectively

C. Antenna Bandwidth

The antenna bandwidth is defined as the "range of frequencies with in which the antenna conforms to the specific standard with respect to some characteristics" [19]. The antenna characteristics that are used to determine the bandwidth can be input impedance, radiation pattern, Beam width, polarization, side lobe level or gain. The bandwidth of a broadband antenna can be defined as the ratio of the upper to lower frequencies of acceptable operation.

$$\text{BW}_{\text{broad band}} = \frac{f_H}{f_L}$$

The bandwidth of a narrowband antenna can be defined as the percentage of the frequency difference over the center frequency.

$$\text{BW}_{\text{broad band}}(\%) = \frac{f_H - f_L}{f_L} * 100$$

Where, f_H = upper frequency , f_L= lower frequency f_c =center frequency

D. Radiation Pattern

The radiation pattern of an antenna is the plot of the far field radiation as a function of spatial coordinates which are elevation angle θ and azimuthal angle φ. It is basically the plot of the radiated power of antenna. An isotropic antenna is the one that radiates equally in all directions. An isotropic antenna is not possible to realize in practice and is useful only for comparison purposes. A more practical type is the directional antenna which radiates more power in some directions and less power in other directions.
To make parameter comparison, results found for both micro strip and co-planar are also included in the following tables.

Table 2.2 Calculated dimensions for Octagonal Patch Co planar Antenna

Element	Calculated results for Co-planar patch antenna(mm)	Triangular cut(mm)	Results for Octagonal patch antenna (mm)
Width of patch (W)	30.43	10.8	13.04
Length of patch (L)	22.5	10.8	10.63
Length of ground (Lg)	32	10.8	32
Width of ground (Wg)	46	10.8	46

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Volume 9 Issue VI Jun 2021- Available at www.ijraset.com

Table 2.3 Calculated dimensions for Octagonal Patch micro strip Antenna

Element	Calculated results for micro strip patch antenna (mm)	Triangular cut height (mm)	Results for Octagonal patch antenna (mm)
Width of patch (W)	46	11	13.04
Length of patch (L)	40	11	10.04
Width of ground (Wg)	46	11	46
Length of ground (Lg)	40	11	40

Observing the above Table 2.2, 2.3, it is noticed that, there are variations in dimensions of antenna. This validates the previously established concepts. Some other important conclusions, based on the simulation results, are also discussed in the next section.

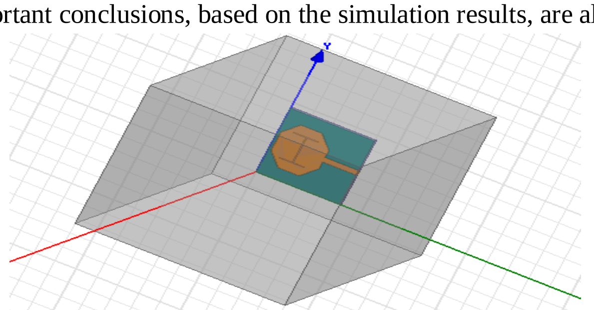

Figure 2.2**:** Model of Co-planar Patch Antenna in HFSS software

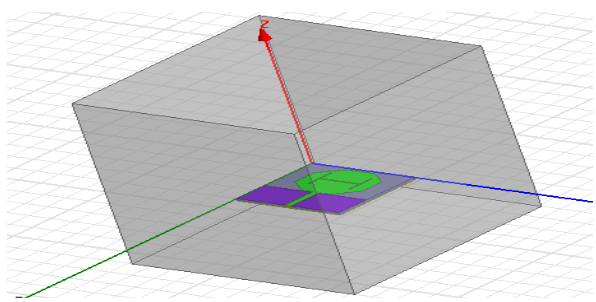

Figure 2.3: Model of micro strip Patch Antenna in HFSS software

III. RESULTS

A. Simulation Results for 3 GHz

During simulation, the conducting grounds and the substrates were assumed to be finite in transverse plane.

The below HFSS result shows return loss in dB verses frequency of octagonal micro strip and co planar patch antennas. At 3 GHz frequency the micro strip and co planar patch antennas exhibit a reflection coefficient of -7.50 dB and -1.05 dB respectively.

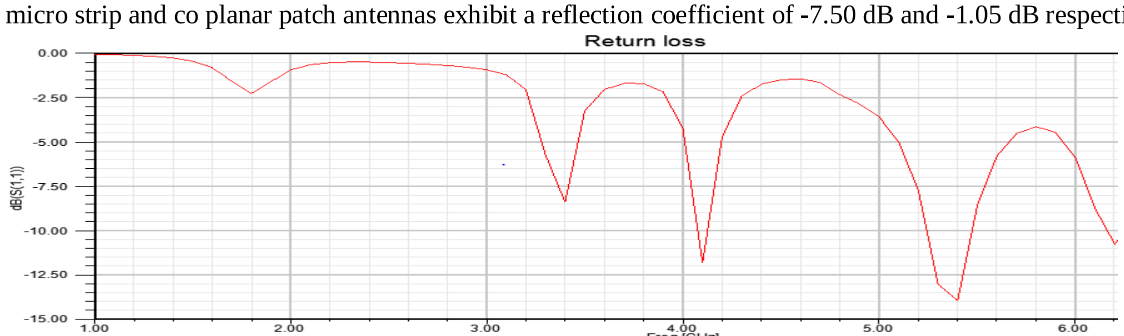

Figure .3.1**:** Return losses for micro strip antenna at 3 GHz

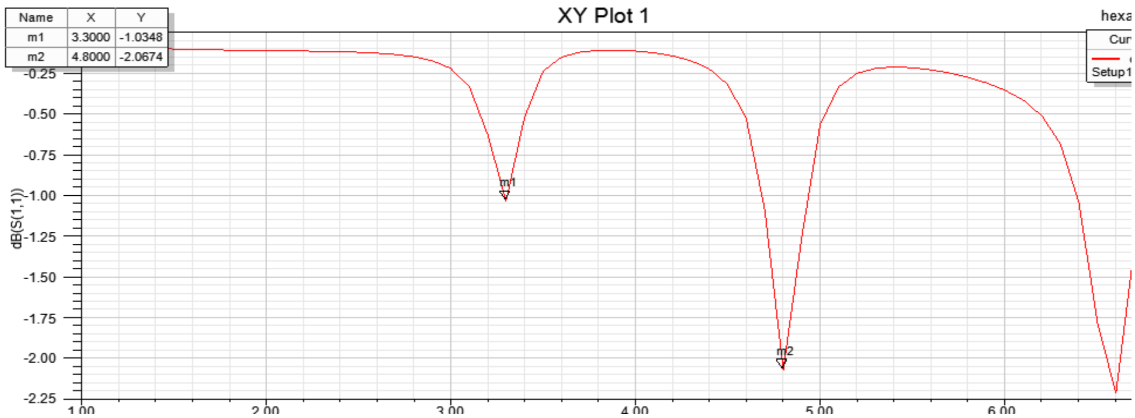

Figure 3.2**:** Return losses for Co planar patch antenna at 3 GHz

The radiation efficiency obtained for micro strip antenna is 24% and that for a co planar patch antenna is 67 % i.e.co planar patch more efficient than that of micro strip patch antenna. Figure 3.3 and 3.4 shows the far field radiation pattern for micro strip and co planar patch antennas at a solution frequency of 3 GHz respectively.

Radiation Pattern Results:

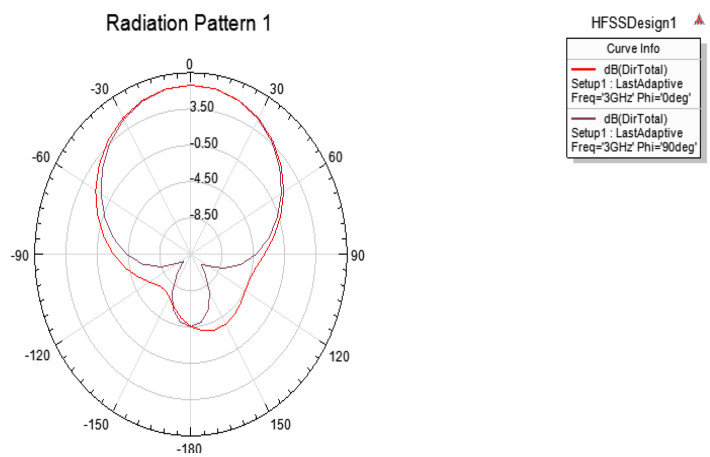

Figure 3.3**:** Radiation Pattern of 3 GHz microstrip patch antenna

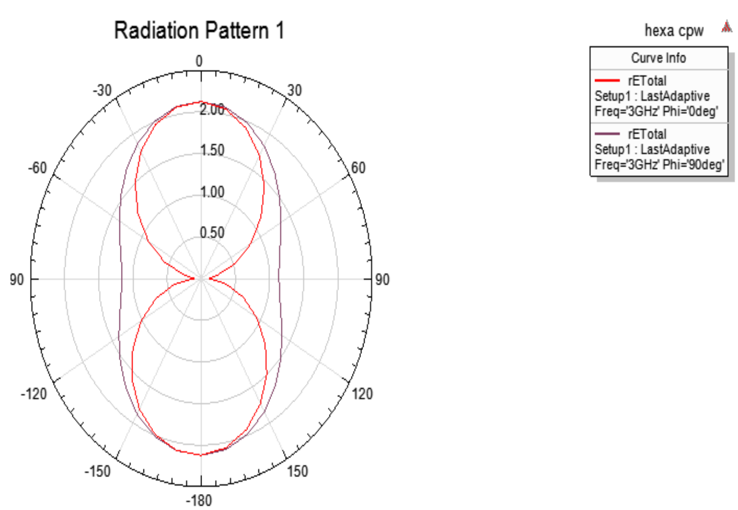

Figure 3.4**:** Radiation Pattern of 3 GHz co planar patch antenna

The following figures show 3-D polar plots for micro strip and co planar patch antennas at 3 GHz.

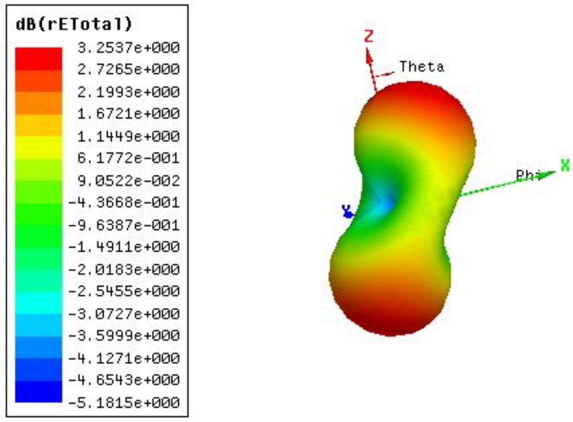

Figure 3.5**:** 3-D polar plots for co planar patch antenna at 3 GHz

Figure 3.6**:** 3-D polar plots for mirostrip patch antenna at 3 GHz

Table 3.1 HFSS Simulation result summary

Type of Antenna	Frequency (GHz)	Return loss (-dB)	Radiation efficiency (%)	Directivity (dB)
Co planar	3	1.05	67	3.25
Micro strip	3	7.50	24	3.74

The HFSS Simulation result summary has shown that, for the same operating frequency and substrate, octagonal co planar patch antennas gives higher radiation efficiency than micro strip patch antenna. This is due to one of the factors that affects radiation efficiency is the effective dielectric constant and the value of effective dielectric constant for a co planar antenna design is lower than micro strip antenna design. When effective dielectric constant of the patch decreases the surface wave excitation will reduce to a large extent, which in turn, leads to a lower radiation loss and less dispersion. Due to this reason co planar antennas have high radiation efficiency.

For operating frequencies 3 GHz, return loss for micro strip patch antennas is found to be lower than co planar patch antennas. It is related to impedance matching and the maximum transfer of power. It also shows the effectiveness of the designed antennas to deliver of power from source to antenna. Even if the same feeding (co planar wave guide) and impedance matching techniques(inset) are applied for both antennas, micro strip patch antennas give lower return loss (higher in the negative) than co planar patch antennas. The VSWR for the two antennas is in between 1 to 2 over the entire frequency band which shows that there is a proper impedance matching.

The result summary has also shown that directivity for micro strip patch antennas is higher than that of co planar patch antennas. The reason for the low directivity in case of co planar patch antenna is that, it has patch and ground on the same plane so that the electric field below the patch also form a lobe on the other side of the patch forming a broadside pattern, whereas in case of microstrip patch the fields below the patch are shorted by the lower ground making a single lobe in one direction above the patch forming a unidirectional pattern.

IV. CONCLUSION

Here, a CPW fed octagonal-shaped micro strip and co planar patch antenna are designed with the application of inset fed for impedance matching. The micro strip patch antenna consists of a pair of electrically conducting layers separated by a 1.6 mm dielectric material. Likewise, co planar patch antenna consists of a pair of electrically conducting layers placed over a 1.6 mm dielectric material with permittivity of 4.4. The antenna efficiency, return loss, radiation pattern and 3D polar plot are obtained for both micro strip and co planar patch antennas. Full wave HFSS simulation of co planar and micro strip patch antenna models shows that for same operating frequency and same substrate, co planar patch antenna gives wider band width and high radiation efficiency than micro strip patch antenna. On the other side, micro strip patch antennas are more compact (lower profile) than co planar patch antennas. From the simulation observations and result summary, it can be concluded that CPW fed co planar antenna has got low directivity than micro strip patch antenna. The reason for the low directivity in case of octagonal co planar patch antenna is that it has patch and ground on the same plane so the electric field below the patch also form a lobe on the other side of the patch forming a broadside pattern. But the directivity of the octagonal co planar patch antenna can be enhanced by providing another conductor (or ground) below the substrate; such designs are called as Conductor Backed Co planar Patch Antennas. Since octagonal patch micro strip antenna is more directional than octagonal co planar patch antennas it provides radiation patterns that are stable across the pass band, and are easy to integrate with other microwave circuits and devices. At same time octagonal patch co planar antenna offers better radiation efficiency.

V. RECOMMENDATIONN FOR FUTURE WORK

Finally, it sincerely recommended that,using conductor backed co planar wave guide (CCPWG) helps to increase the directivity of co planar patch antenna. And for the future it is possible to analyze the performance of the two antennas by using conductor backed coplanar wave guide feeding system. The future work should also address the performance comparison of the two antennas for different patch geometry and multi band applications

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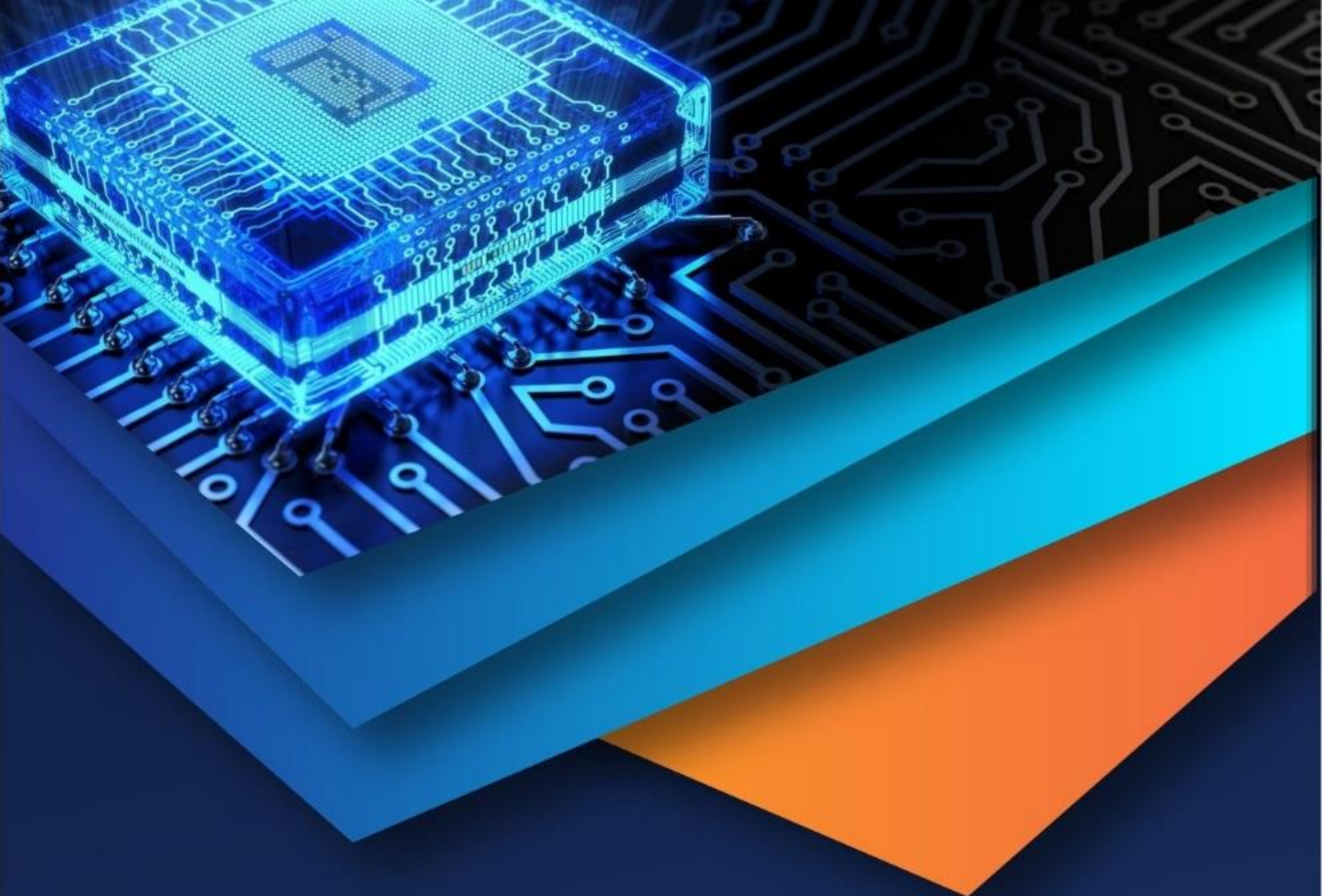

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