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Design of U-Shaped Microstrip Patch Antenna for Wimax Application

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Abstrac: -microstrip patch antenna becomes very popular day-by-day because of its ease of analysis and fabrication, low cost, light weight, easy to feed and their attractive radiation characteristics. In order to increase bandwidth and other radiation parameters various antenna designs are made. Although patch antenna has numerous advantages, it has also some drawbacks such as restricted bandwidth, low gain and a potential decrease in radiation pattern. To overcome this issue, various feeding techniques have proposed .there are many aspects that affect the performance of the antenna like dimensions, selection of the substrate, inserting slot and also the operating frequency. This paper describes the design of microstrip patch antenna used for wimax application with operating frequency 3.75ghz. The antenna is rectangular in shape, in which rf power is fed directly to the centre radiating patch with the help of feeding techniques. Various parameters such as return loss, radiation pattern, bandwidth, gain, vswr, etc., are determined. The optimized antenna design and results are presented by using ansoft hfss.
Keywords: wimax, return loss, substrate, slots, bandwidth, microstrip, vswr

I. INTRODUCTION

The main object of this paper is to improve the parameters like gain, bandwidth, VSWR, return losses, directivity, and radiation pattern of a U-shaped micro strip patch antenna. Now a day's human beings want smart devices to meet these requirements the slot antenna concept has been used in patch antenna designed to reduce antenna size. In communication systems, a micro strip antenna (also known as a printed antenna) usually means an antenna fabricated using micro strip techniques on a printed circuit board (PCB) [1]

Advantages of micro strip patch antenna are:

Inexpensive, simple to design, it has a support for both linear and circular polarization.

Disadvantages of micro strip patch antenna are:

Low impedance band width, low gain [2].

There are many techniques to improve the impedance band width, gain, directivity of the micro strip patch antenna. They are briefly explained below. While designing the antenna the following steps are involved selecting the substrate then geometry of slots, feeding techniques.

This design uses FR4 substrate in L and S bands have 3 db axial ratio band width of as large as 46% and 56%, respectively, whereas the one using an RT5880 substrate in the L band, 65%. In these 3-dB axial ratio bands, impedance matching with VSWR<=2 is also achieved. In this the slot areas are also as small as 0.2λo2(0.1λo2). FR4 is a composite material composed of woven fiber glass cloth with an epoxy resign binder that is flame resistant. Among these two substrates FR4 is the best substrate because of its advantages. So we choose FR4 [3].

The next step in designing of micro strip patch antenna is selecting the slot geometry. The main focus is on a compact DRA that can offer broad band operation. It has been illustrated that dual resonance and multi resonance operation can be much effective to give wide band characteristics of DRA. The bandwidth of DRA depends on parameters such as the excitation method, shape, dimensional parameter & dielectric constant of DRA material. Over last decades, various bandwidth enhancement techniques have been developed for DRAs.

DRA can be integrable with MMIC circuits due to small size. There is no freq drift with temperature variation DRAs. DRAs can be fabricated in various shapes such as cylindrical, hemispherical rectangular, cylindrical ring and have more design flexibility[4].

A rotated square slot resonator is considered as reference geometry. The rotated square slot antenna exhibits two resonances (f1: lower resonant frequency,f2 : higher resonant frequency). By embedding a parasitic patch into the centre of the rotated square slot the lower resonant frequency is decreased and the higher resonant frequency is increased. But it is more complex to operate so we move for another technique [5].

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In this technique by etching the wide slot as fractal shapes, it is experimentally found that the operating bandwidth can be significantly enhanced, and the relation between the bandwidth and the iteration order (IO) and iteration factor (IF) of the fractal shapes is experimentally studied. Experimental results indicate that the impedance bandwidth, defined by 10 dB reflection coefficient, of the proposed fractal slot antenna can reach an operating bandwidth of 2.4 GHz at operating frequencies around 4 GHz, which is about 3.5 times that of a conventional micro strip-line-fed printed wide-slot antenna. It also achieved 2dB gain bandwidth of at least 1.59 GHz. It is also widely used in WLAN and WiMAX applications. But it is difficult to calculate the iteration order and iteration factor to obtain the desired fractal shape.[6].

In Novel Triangular UWB micro strip antenna which offers an ultra-wide band width (UWB) greater than 8 GHz. This optimum antenna design provides satisfactory gain all over the UWB. The study includes partially truncating the ground plane (defected ground), inserting slits in the triangular radiating patch, and using different substrate materials in order to obtain band-notched UWB. The simulation experiments have been carried out using the IE3D Zeland software. The final antenna design is fabricated on substrate FR4[7].

The radiation pattern of aperture stacked patch (ASP) antennas is improved. In the proposed geometry, the patch shape is designed such that the effective propagation constant of the antenna is decreased and therefore pattern degradation due to higher order modes is eliminated. The results show that the operational bandwidth of the proposed structure is increased from 68% to 76% compared to the traditional ASP. In this technique the patches are arranged in the form of stack. But using ASP technique propagation constant decreases and the pattern degradation occurs.[8].

To design a U slotted rectangular patch antenna by way of direct coaxial probe feed technique and compare it’s performance with non slotted and rectangular slotted microstrip patch antenna. The composite effect of integrating these techniques offers a low profile, high gain, broadband and compact antenna element. Parameters like return loss, radiation pattern and bandwidth are analyzed using FDTD algorithm in MATLAB. From the simulated results, Bandwidth for the rectangular slotted antenna and U slotted antenna was found to be 2.4 times and 2.84 times respectively, that of the non slotted rectangular microstrip antenna. Also better directivity was observed. The experimental results supported the same. The U slotted microstrip antenna is fabricated and the radiation pattern is measured. [9].

Among all these techniques DRA’s and U slot rectangular patch antenna techniques are better.

Two printed wide-slot antennas with E-shaped patches and slots, for broadband applications, are proposed. They are fed by a coplanar waveguide (CPW) and a microstrip line with almost the same performances. Detailed simulation and experimental investigations are conducted to understand their behaviors and optimize for broadband operation. Good agreement between the measurement and simulation has been achieved. The impedance bandwidths, determined by 10-dB reflection coefficient, of the proposed slot antennas fed by microstrip line and CPW, from both measurement and simulation, are about 136% (2.85 to 15.12 GHz) and 146% (2.83 to 18.2 GHz), respectively. This large operating bandwidth is obtained by choosing suitable combinations of feed and slot shapes. In order to achieve wider operation bandwidth both of the designed antennas have round corners on the wide slot and patch. Meanwhile, the proposed antennas exhibit almost omnidirectional radiation patterns, relatively high gain, and low cross polarization. A comprehensive numerical sensitivity analysis has been done to understand the effects of various dimensional parameters and to optimize the performance of the designed antennas [10].

Among all these techniques DRA’s and U slot rectangular patch antenna techniques gives better results .

Coming to the feeding techniques micro strip patch antenna can be fed by using four techniques. They are microstrip line feed, coaxial line feed, aperture coupled feed, proximity coupled feed. In micro strip line feed technique a conducting strip is connected directly to the edge of the micro strip patch. In this technique the surface waves and substrate thickness increases.

In the coaxial feeding technique the inner conductor of the coaxial connector extends through the dielectric and is soldered to the radiating patch, while the outer conductor is connected to the ground plane. The main advantage of this type of feeding scheme is that the feed can be placed at any desired position inside the patch in order to obtain impedance matching. This feed method is easy to fabricate and has low spurious radiation effects. However, its major disadvantage is that it provides narrow bandwidth and the increased probe length makes the input impedance more inductive, leading to matching problems.

In the aperture coupled feeding technique the radiating micro strip patch element is etched on the top of the antenna substrate, and the micro strip feed line is etched on the bottom of the feed substrate in order to obtain aperture coupling. This type of feeding technique can give very high bandwidth of about 21%. Also the effect of spurious radiation is very less as compared to other feed techniques. The major disadvantage of this feed technique is that it is difficult to fabricate due to multiple layers, which also increases the antenna thickness.

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II. PROPOSED ANTENNA DESIGN

Based on the simplified formulation that has been described, a design procedure is outlined which leads to practical designs of rectangular micro strip antennas. The procedure assumes that the specified information includes the dielectric constant of the substrate (εr), the resonant frequency (fr), and the height of the substrate h. The procedure is as follows:

Specify: εr, fr (in Hz), and h , Determine: W, L

The summarizations of basic operation for microstrip patch antenna's parameters are discussed as follows. The antenna substrate dielectric constant is given as εr. The εr is primarily affects the bandwidth and radiation efficiency of the antenna. The lower the permittivity will give a wider impedance bandwidth and reduce the surface wave excitation.

The antenna substrate thickness is given as h. The substrate thickness affects bandwidth and coupling level. A thicker substrate results in wider bandwidth, but less coupling for a given aperture size. L is the microstrip patches length. The length of the patch radiator determines the resonant frequency of the antenna. The microstrip patches width is given as w. The width, w of the patch affects the resonant resistance of the antenna, with a wider patch giving a lower resistance.

A. Design Specifications

1) Dielectric constant (ε_r)

   i.e., $2.2\leq \varepsilon_r \leq 1$

   Operating frequency (f_r) =3.1 to 3.8 GHZ

2) Height (h) i.e., $\lambda_0\leq h\leq 0.05\ \lambda_0$

   Where λ_0=free space wavelength

3) Width of the microstrip patch antenna

$$w = \frac{c}{2f_r}\sqrt{\frac{2}{\epsilon_r + 1}}$$

Where, c = velocity of light
f_r = operating frequency
ε_r = substrate dielectric constant
Generally practical width, $w< \lambda_0$

4) Effective dielectric constant

$$\epsilon_{reff} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2}\left(1 + 12\left({h}/{w}\right)\right)^{-1/2}$$

5) Length of the patch,

$$L=L_{eff}-2\Delta L$$

   Where

$$L = \frac{c}{2f_r\sqrt{\epsilon_{reff}}} - 2\Delta L$$

$$\Delta L = 0.412 * h\left(\frac{(\epsilon_{reff} + 0.3)\left({w}/{h} + 0.264\right)}{(\epsilon_{reff} - 0.258)\left({w}/{h} + 0.8\right)}\right)$$

For practical length , $0.3333\ \lambda_0<L<0.5\ \lambda_0$

B. Calculation Of Parameters

ASSUMING OPERATING FREQUENCY,**(**fr)= 3.75GHz

Dielectric constant as FR4

For FR4 dielectric constant (εr) =4.4

C. Calculation of width

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$$w = \frac{c}{2f_r}\sqrt{\frac{2}{\epsilon_r + 1}}$$

$$w = \frac{3 * 10^8}{2 * 3.75G}\sqrt{\frac{2}{4.4 + 1}}$$

=23.69mm

Let h=1.6mm

D. Calculation of effective dielectric constant

$$\epsilon_{reff} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2}\left(1 + 12\left({}^{h}/_{w}\right)\right)^{-1/2}$$

$$\epsilon_{reff} = \frac{4.4 + 1}{2} + \frac{4.4 - 1}{2}\left(1 + 12\left({}^{1.6mm}/_{23.69mm}\right)\right)^{-1/2}$$

=4.23

E. Calculation of length

$$\Delta L = 0.412 * h\left(\frac{(\epsilon_{reff} + 0.3)\left({}^{w}/_{h} + 0.264\right)}{(\epsilon_{reff} - 0.258)\left({}^{w}/_{h} + 0.8\right)}\right)$$

$$\Delta L = 0.412 * 1.6mm\left(\frac{(4.23 + 0.3)\left({}^{23.69mm}/_{1.6mm} + 0.264\right)}{(4.23 - 0.258)\left({}^{23.69mm}/_{1.6mm} + 0.8\right)}\right)$$

=0.7259mm

$$L = \frac{c}{2f_r\sqrt{\epsilon_{reff}}} - 2\Delta L$$

$$L = \frac{3 * 10^8}{2 * 3.75G\sqrt{4.23}} - 2 * 0.7259$$

=17.99mm

F. Calculation of ground plane dimensions

L_g=6h+L
=6*1.6mm+17.99mm
=27.59mm

W_g=6h+W
=6*1.6mm+23.69mm
=33.29mm

Table 1: Comparison Of Antenna Parameters For Different Frequencies

Frequency(fr)	2.4GHz	3.75GHz	5.4GHz
FR4(ε_r)	4.4	4.4	4.4
Height of the substrate(h)	1.6mm	1.6mm	1.6mm
Width of the patch(w)	38.036mm	23.69mm	21.96mm
Length of the patch(L)	27.72mm	17.99mm	17.99mm
Width of the ground plane(W_g)	37.32mm	33.29mm	31.56mm
Length of the ground plane(L_g)	47.636mm	27.59mm	27.3mm

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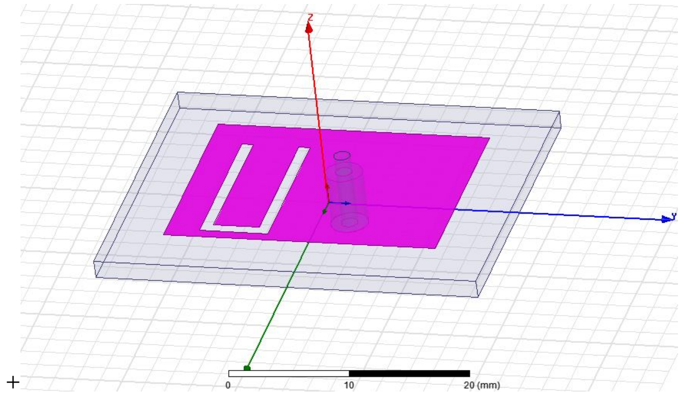
The outline of patch antenna at 3.75 GHz is shown in the fig.



III. RESULTS

This chapter includes results regarding the performance of patch antenna and comparison of parameters with U and without U-Shape slot on patch designed at an operating frequency of 3.75 GHz.

A. Results

The below outputs represents the plots of patch antenna without U- slot and coxial feed.

1) S-parameters (S11) Vs Frequency plot

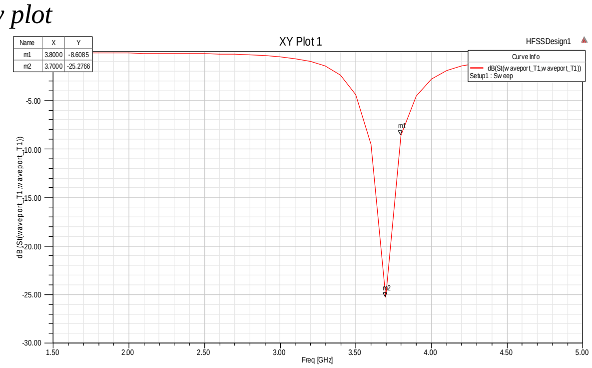


Figure 3.1 : S-parameters (S11) Vs Frequency plot

Here the Patch antenna is simulated at operating frequency of 3.75GHz. The S11 value at -10db is return loss.

Return loss = -25.2766

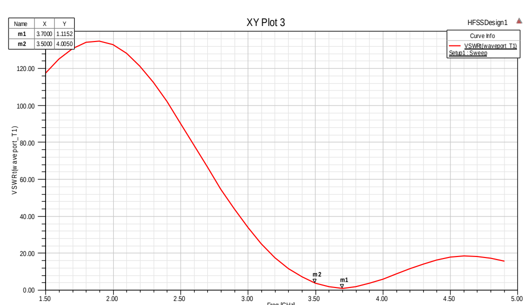
2) Bandwidth

The difference between upper and lower-cut off frequencies at S11 value -10db from the above graph is taken as bandwidth.

Bandwidth(%) = (3.8 GHz – 3.6 GHz) / 3.75GHz

Impedance Bandwidth **= 5%**

B. VSWR Vs Frequency Plot



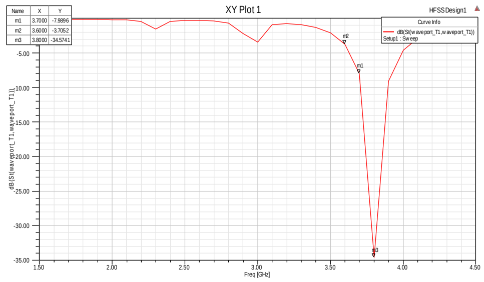
VSWR Vs Frequency Plot

VSWR obtained from the above graph is 1.11.

VSWR = 1.11

The below outputs represents the plots of patch antenna with U- slot and coxial feed.

1) S-parameters (S11) Vs Frequency plot



Here the Patch antenna is simulated at operating frequency of 3.75GHz. The S11 value at -10db is return loss.

Return loss = -34.5741

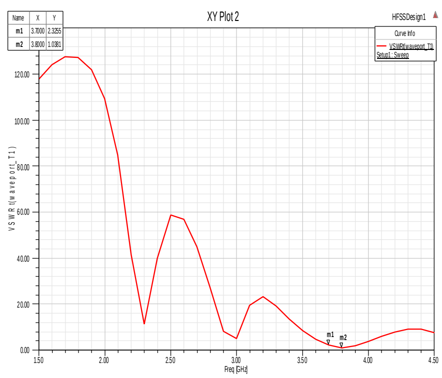
2) Bandwidth

The difference between upper and lower-cut off frequencies at S11 value -10db from the above graph is taken as bandwidth.

Bandwidth(%) = (3.8 GHz – 3.6 GHz) / 3.75GHz

Impedance Bandwidth **= 5%**

C. VSWR Vs Frequency Plot



VSWR Vs Frequency Plot

VSWR obtained from the above graph is 1.0381.

VSWR = 1.0381

Table 2:Comparison Of Output Parameters At Different Frequencies For 3.75 Ghz

Different Types Of Antennas	Without Inserting Slot	With U-Slot	With E-Slot	With S-Slot
Return Loss (dB)	-25.276	-34.57	-21.379	-20.625
Band-Width (MHz)	100	100	200	250
VSWR	1.1152	1.03	1.33	1.2

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IV. CONCLUSION & FUTURE SCOPE

A. Conclusion

In this paper we designed patch antenna operating at 3.75 GHz and compared the results for different slots. We can say that there are many aspects that affect the performance of the antenna such as dimensions, selection of the substrate, feed technique and also the Operating frequency can take their position in effecting the performance. After simulation ,the obtained results are bandwidth 4% and gain as 4.8 db.Therefore, we conclude that the design with U-Shape slot provides more bandwidth and gain compared to other slot results.

B. Future Scope

It is very important to take the feed technique, the impedance and the substrate as main parameters into consideration. The proper position to terminate the Feed line also affects the performance of the antenna. In future there may be chance to improve the gain by using array antennas and other feeding techniques.

V. ACKNOWLEDGMENT

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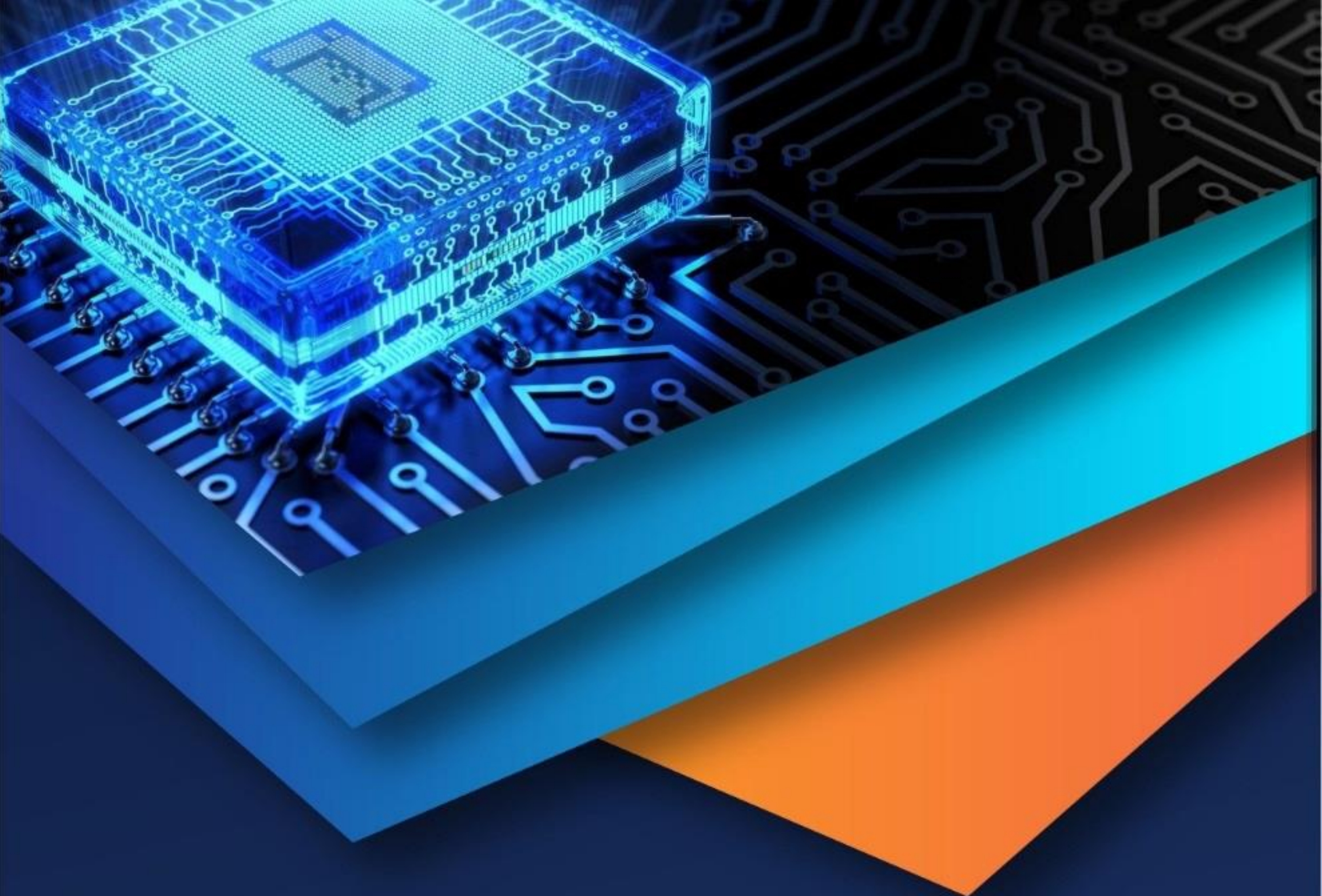

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