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Design and Simulation of Rectangular Microstrip Double Patch Antenna for X Band

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***Abstract:** In the present work an attempt has been made to design and simulation of rectangular microstrip double patch antenna for X band using microstrip feed line techniques. HFSS High frequency simulator is used to analyse the proposed antenna and simulated the result on the return loss, radiation pattern and gain of the proposed antenna. The antenna is able to achieve in the range of 8-12 GHz for return loss of less than -10 dB. The operating frequency of the proposed antenna is 8.7 GHz with dielectric substrate, ARLON of ε_r = 2.5 and h= 1.6mm.*
***Keywords:** ARLON substrate material, FEM, Microstrip Feed Line, X band*

I. INTRODUCTION

In recent times, microstrip patch antenna is a turning point in wireless communication system and is continuing to satisfy the changing demands of new generation antenna technology. Wireless communications are moderately improving and creating modernize wants in case of antenna technology. It also covers an expansive of cellular phones in the modernize society included in growing interest connecting its detrimental radiation [1-4]. Microstrip patch antennas are broadly utilized in the current wireless communication system because of their regular facilities of less profile, less weight, consistent design; low cost, easy to fabricate and integrate.

Patch is the main component of microstrip antenna and other components are substrate and ground which are two sides of patch [5]. The major disadvantages of microstrip patch antenna are narrow bandwidth, low efficiency and small size [6]. Various researches have been executed to enhance the bandwidth of printed antennas. To conquer this trouble numerous methods and techniques are raised in the literature.

The miniaturization of antenna and improvement in bandwidth can be obtained by adjusting to cut the slot in ground and patch of microstrip antenna of proper length and width [7-9]. X band technology has been broadly used in various applications because of its high data transmission rate, large bandwidth and short-range features. Designing X band antennas has tempted the interest of many researchers and is still a major challenge to equalize these applications [9-10]. An antenna of wide-slot belonging to a microstrip line is designed using a fork-like tuning stub to increase the bandwidth in ref. [11].

Bandwidth of 1.1 GHz has been achieved with gain changing below 1.5 dBi over the complete operational frequency bands. In this research, both gain and bandwidth were low. A wide-band rectangular patch antenna with a single layer was proposed where impedance bandwidth of above 20% was acquired in ref. [12]. A rotated slotted antenna was proposed for enhancing bandwidth printed on FR4 substrate material in ref. [13].

This antenna exhibited bandwidth of about 2.2 GHz as well as gain changing below 2 dBi. On the other hand, the dimension of this antenna was 70 mm × 70 mm that was too large. A CPW-fed loop slot antenna with a tuning stub was used to amplify the bandwidth where 72 mm × 72 mm was the dimension of the antenna and the range of the gain was from 3.75 dBi to 4.88 dBi over the desired operational frequency band in ref. [14]. Due to consideration the position of a widened tuning stub, a flourished bandwidth was acquired. By using these bandwidth enhancement techniques, the CPW-fed slotted antennas showed 34% to 60% impedance bandwidth. Two E-shaped slot antennas were designed with using microstrip line and CPW as feeding transmission line for broadband applications in ref. [15]. The dimension of the antenna was 85 mm ×85 mm with reasonable radiation pattern and improved bandwidth. The size of this antenna is large that was the weak point.

This paper shows the reaction on microstrip antenna parameters and desired resonances owing to rectangular double patch to design the proposed X Band microstrip antenna with flourished efficiency and bandwidth. Some methods are used such as increasing substrate thickness and double patch to obtain a desired parameters such as impedance matching, gain, radiation pattern, return loss, efficiency and Smith chart.

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II. MATERIALS AND METHOD

A. Analysis Methods

The first part is to study Theoretical Pattern effect of Microstrip Patch Antenna. The second is analyzing the antenna using HFSS software and obtaining the simulation result. The substrate material will be used ARLON with dielectric constant 2.5 , feeding will be used as microstrip line feed technique and for analyzing and designing of the proposed work is on the HFSS (High Frequency Structure Simulator) simulator.

B. Antenna Design

First we should fix the operating frequency (X band 8-12 GHz), then calculate effective dielectric constant.

$$\epsilon_e = \frac{1(\epsilon_r+1)}{2} + \frac{1(\epsilon_r+1)}{2}\sqrt{\left(1+10\frac{h}{w}\right)}$$

When, $\frac{h}{w} \ll 1$

Step 3:- Use the resonant frequency formulae for dimension. The resonant frequency is chosen at 10 GHz.

$$f_r = \frac{c}{2\sqrt{\epsilon_r}}\sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2}$$

For dominant mode duration TE_{10}mode.

m = 1 n = 0

$$f_r = \frac{c}{2\sqrt{\epsilon_{re}}} * \frac{1}{a}$$

Where 'a' is the width of antenna.

Now we calculate effective length.

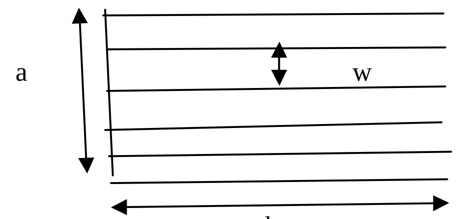
$$L = \frac{c}{2f_o\sqrt{\epsilon_r}} - 2\Delta L$$

$$\Delta L = 0.412h\,\frac{(\epsilon_e+0.3)\left[\frac{w}{h}+0.8\right]}{(\epsilon_e-0.258)\left[\frac{w}{h}+0.8\right]}$$

Microstrip feed width calculation.

$$w = \frac{\dfrac{5.98*h}{e^{\left(Z_0*\frac{\sqrt{\epsilon_r+1.414}}{87}\right)}} - t}{0.8}$$

Where Z_o= characteristics impedance
w = width of microstrip line
t = thickness of metal
h = height of substrate



The design is formed by using the equations in software environment for analysis. Electromagnetic frequency domain was used to form the design with 8.7 GHz frequency which was applied on the lumped port. The study of design was done.

C. Design of a Microstripline

The microstrip patch with length 24.8mm, dielectric constant (ε_r = 2.5), width 19.8 mm & microstrip width 3.25mm for the X- band. The dielectric material is ARLON (ε_r= 2.5), height of substrate is h=1.6mm.

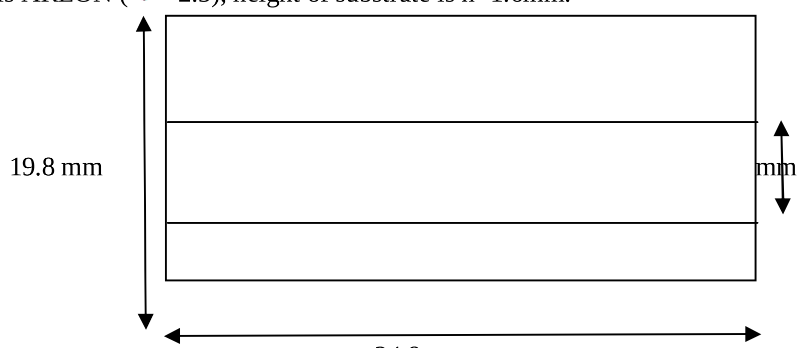
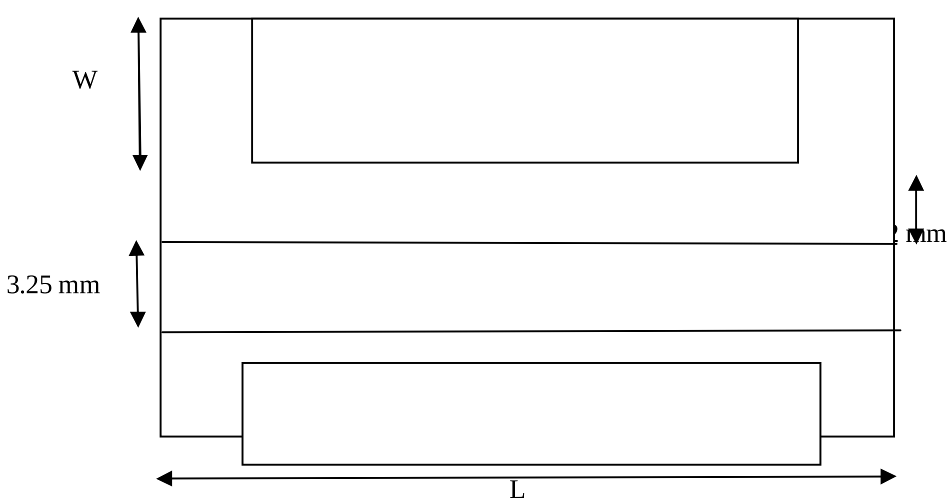


Figure 1 shows design of microstrip line

Result of S_{11} parameter of microstripline is <-40 dB.

D. Design of microstrip line with rectangular patch

Design the microstrip patch with two rectangular patch where length of the rectangular patch is 18 mm and width is 7 mm. when we place two rectangular patches with microstrip feed (width- 3.25mm) the operating frequency is good. Result of S_{11} parameter of microstrip with rectangular patch is <-45 dB. Now we come to the final design in which the spacing between the microstrip line and rectangular patch is s=0.2 mm.



III.DISCUSSION OF RESULT

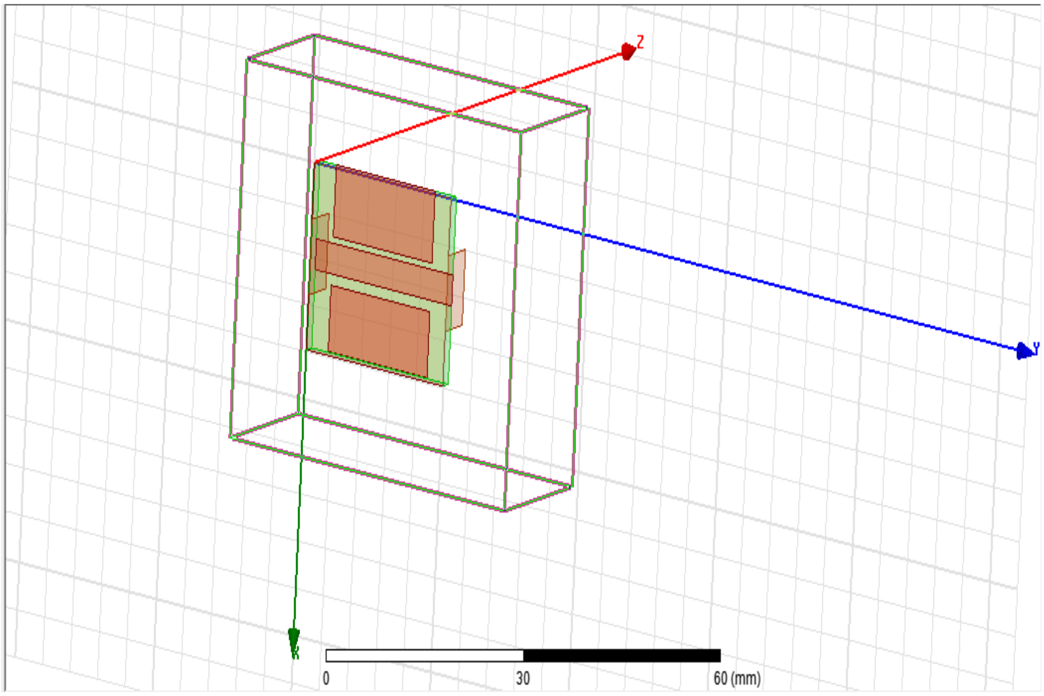


Figure 3 shows the structure of the proposed antenna.

The simulation results are made using High Frequency Structure Simulator (HFSS), with the finite element method (FEM). The return loss of rectangular microstrip double patch antenna has a simulated frequency range of 8 to 12 GHz for S11 <-10 dB. The simulated Return loss of the proposed antenna is shown in Figure 4. Return loss of -23.42 dB are obtained at resonant frequency 8.7 GHz. We get 463 MHz bandwidth on the operating band. This bandwidth covers X band frequencies. The Gain of the proposed antenna is shown in Figure 6. Gain 4.37 dB is obtained in the operating frequency band of 8.7 GHz. The radiation efficiency is 96.63% in the proposed antenna.

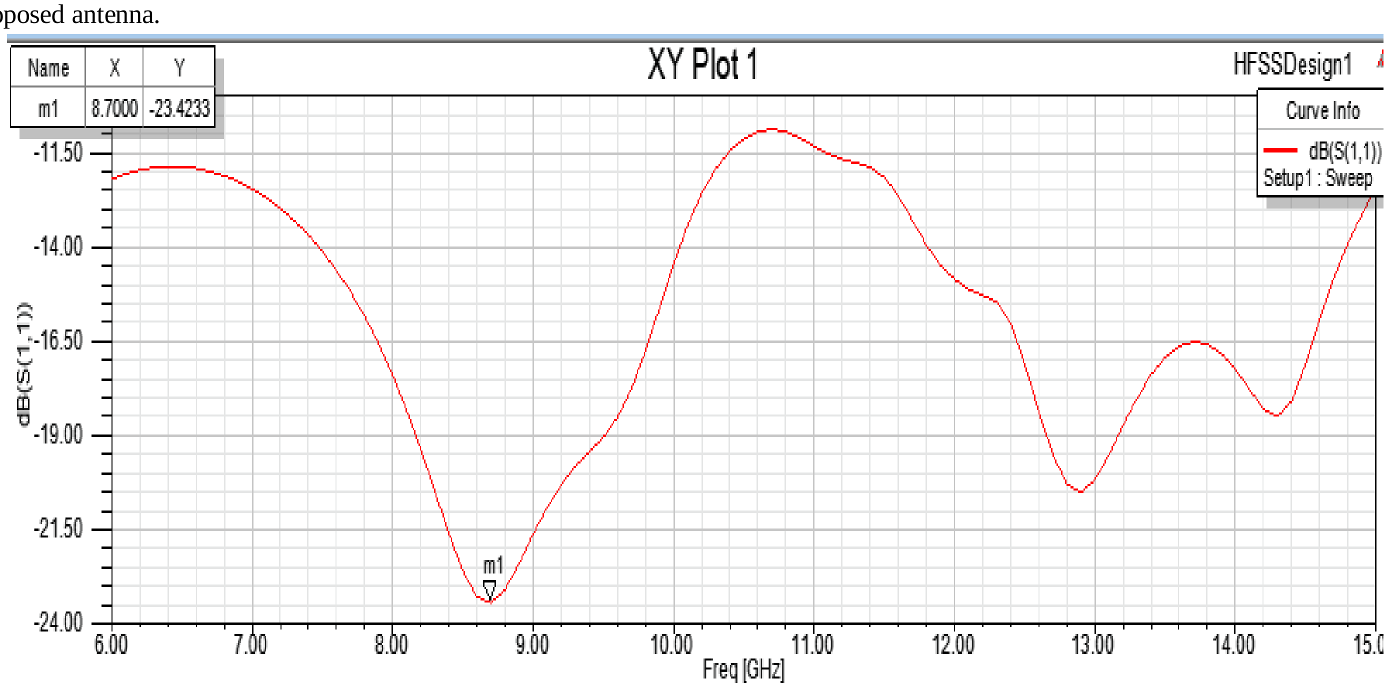


Figure 4 shows S11 return loss of the proposed antenna

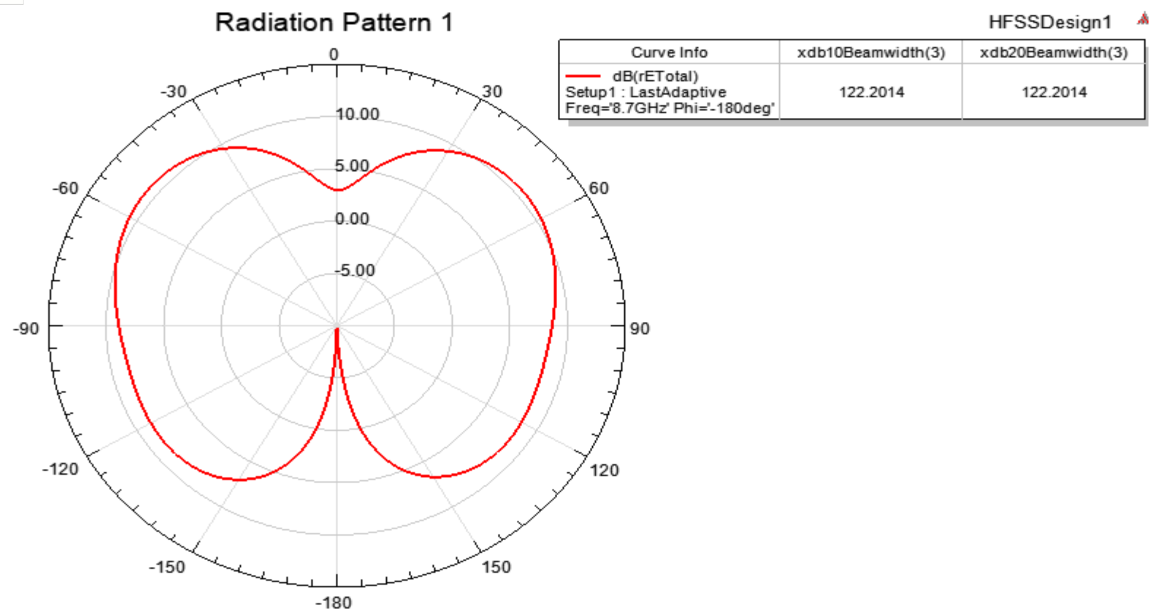


Figure 5 shows the radiation pattern of the proposed antenna.

Figure 6 shows total gain of the proposed antenna.

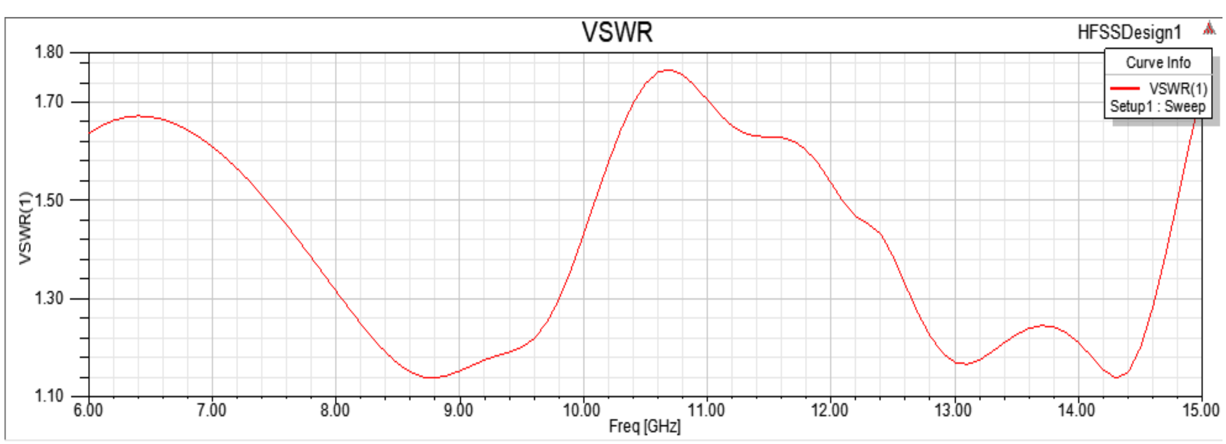


Figure 7 shows VSWR of the proposed antenna.

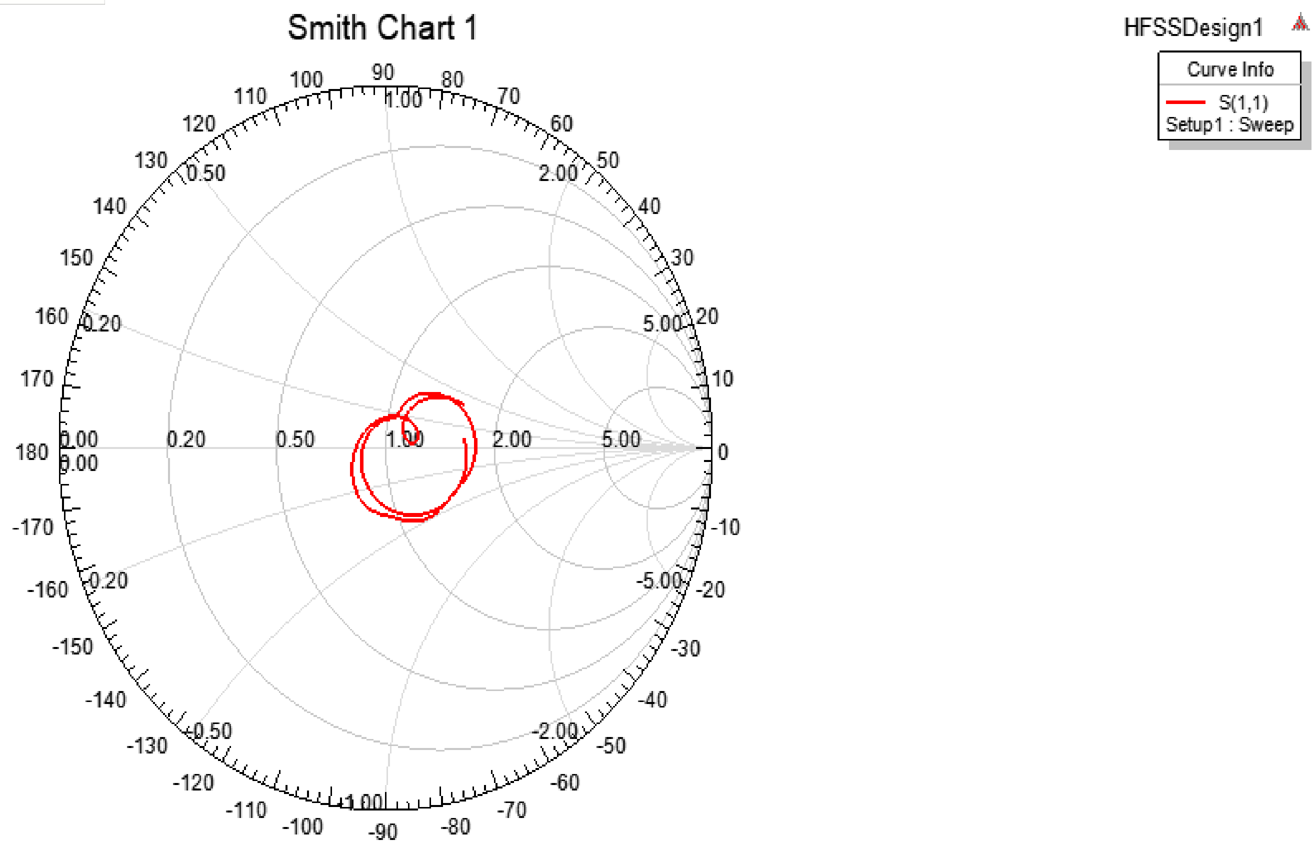


Figure 8 shows Smith Chart of the proposed antenna.

Figure 7 shows the voltage standing wave ratio (VSWR) of the proposed X-band antenna. The evaluation of VSWR is below 2 that are noticed from the graph clearly. It is a wanted value.

IV. CONCLUSIONS

The proposed rectangular microstrip double patch antenna with microstrip feeding technique show a good broad bandwidth of 463 MHz. It also shows a high reflection coefficient of -23.42 dB with the substrate height of 1.6 mm. This is validating in all the designed form of the different structure of the antenna. The broadening of the antenna is obtained by the proper impedance matching by microstrip feeding at the source point of the antenna. This good bandwidth and high return loss might be convenient for many wireless applications. The simple antenna would find considerable for good wide band wireless application. The outcome parameters of microstrip coupled patch antenna design is simple and its performances have fulfilled the requirement set by X band communication.

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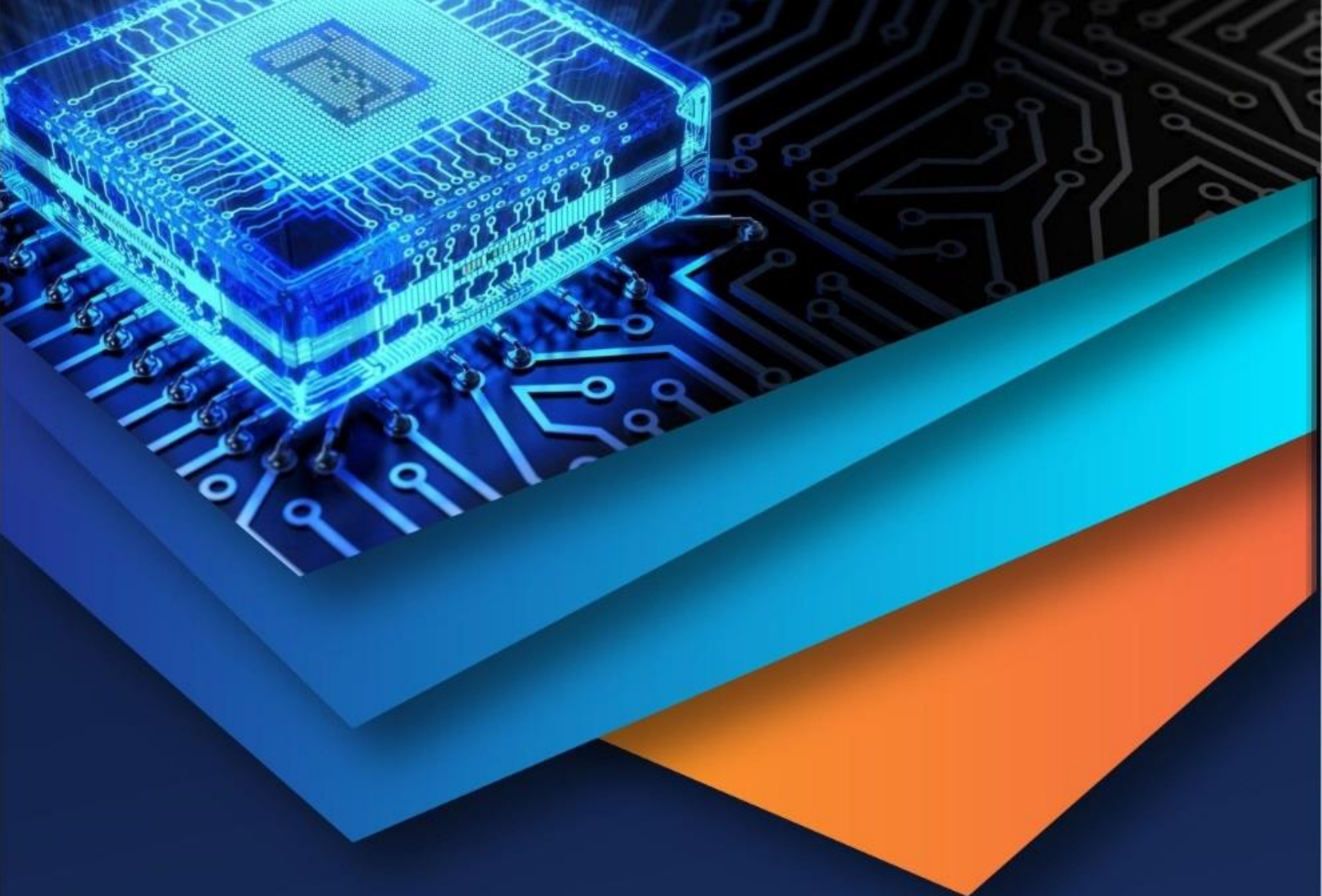

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