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Design of Reconfigurable Ultra-Wide Band Monopole Antenna for Cognitive Radio Applications

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Abstract: Cognitive radio is a network technology that automatically identifies available channels within a wireless spectrum. Here, a circular reconfigurable antenna is designed to address problems that occur when using a microstrip antenna in cognitiv e radio systems. The reconfigurability is accomplished by repeated frequency, pattern and polarisation shifts. We are reconfiguri ng this jobby adjusting the resonant frequency of the antenna.Use two parasitic metallic elements that are coplanners each other . For reconfiguring the antenna within the UWB frequency band, three idle switches are used between the metallic strips. The re configurability is observed in the frequency band of 3 GHz to 9 GHz. Results acquired along with radiation pattern and gain in t erms of reflection coefficient.
Keywords: Microstrip Antenna; cognitive radio; ultra-wide band antenna; Anasoft HFSS.

I. INTRODUCTION

Cognitive radio is the most efficient breakthrough for radio spectrum use in this recent period. Reconfigurability of the antenna is ob tained to solve antenna problems[1][2]. With the rapid growth of compact devices, it is important to design an antenna with low vol ume, less expense, low weight and easy production [3]. In general, cognitive radio refers to complete architectures of the communication system that are able to sense the environment for primary (licenced) users and use the available spectrum that is not currently used. Unlike the one previously mentioned [3][4]. UWB communication has been at the core of various.
studies identifying portable communication in the last decade
The antenna built for cognitive radio is observed to increase the bandwidth provided by other UWB antennas[6]. We usually know t he soil consists of copper (as per suitability). There is a partial ground monopole antenna in this work So whatever is applied to the electric field, it is also related to the earth. The electric field is spread over the ground, although the ground is composedof copper an d partially filled and the majority of the electric field is involved in radiation. This is the biggest advantage of monopole antenna.

II. ANTENNA DESIGN

In Fig.1, two metallic strips are shown according to the geometry of the antenna. The FR-4 content layer has
a thickness of 1.6 mm. For the lower UWB band (3 GHz to 5 GHz) with the switch configuration of the ON statethe circular metal s trip1 has a radius dimension of 7.9 mm. For higher UWB bands (5 GHz to 9 GHz), metallic strip2 with dimensions d and r is used.

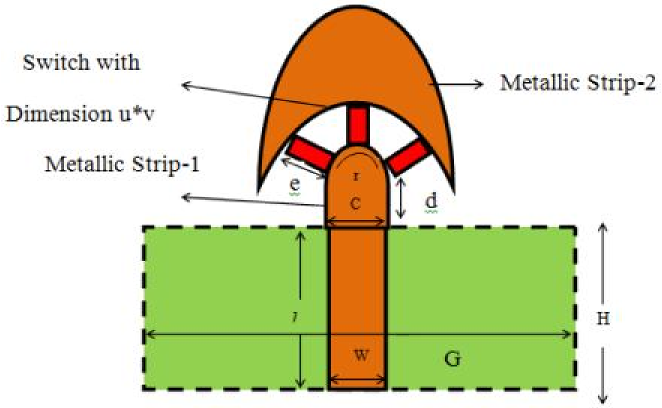

Fig.1. Geometry of Circular Antenna Design

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Parameters	Values(mm)	Parameters	Values(mm)
c	4.40	l	13.21
d	4.30	w	3.00
e	2.00	r	2.20
G	26.78	u	2.00
H	13.21	v	2.00

Table.1. Different parameter values of Circular Antenna

As per the Table-1 there is a complete illustration of antenna parameter values (in mm). From the Fig.1 the value of monopole antenna height (H) is equal to the length of cylindrical metallic strip length (l). Whereas G is the width of monopole antenna ground, d is dimension. From Fig.1 there are three switches present in between two metallic strips which are used to reconfigure the antenna (i.e. by changing the resonant frequency).

All the parameters have values that have been optimised. The feed has optimised l and w values for better impedance matching. The impedance of the transmission line features is set to 50 ohm for better matching.

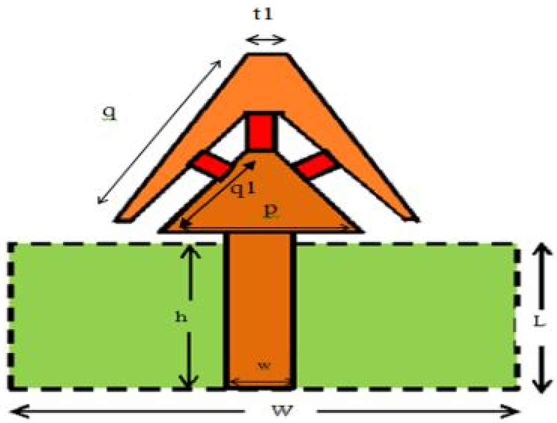

Fig.2. Geometry of Pyramidal Antenna Design

Parameters	Values(mm)	Parameters	Values(mm)
p	13.28	h	17.80
q1	11.18	t	1.000
q	22.00	w	3.000
L	16.60	t1	2.000
W	28.45	-----	-----

Table.2. Different parameter values of Pyramidal Antenna

Two metallic strips are used in this design. The pyramidal monopole antenna geometry design is shown in Fig.2. Between two metallic strips, three switches are connected. The green box shows the monopoly antenna on about half of the ground. The three red boxes are the binding switches between two metallic strips. The antenna operates in the lower UWB band, i.e. 3to5 G Hz, if the diode is ON. Similarly, the antenna works in the higher UWB band, i.e. 5to9GHz, when the diode is OFF. The dielectric constant of dielectric substrate is set to 4.4 for antenna.

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The figures above show that there are three switches connected between two metallic strips. These three metallic strips are involved in antenna reconfiguration. I've used the PIN diode as a reconfiguration feature here.

If the diode isON, then these diodes are biassed forward. Because of this, two metallic strips are related. And there was radiation in the upper metal portion of the reconfigurable antenna. If the diode is OFF, so the reverse bias is for these diodes.

There is no relation between the two metallic strips because of this. And only in the lower metallic portion of the reconfigurable antenna did the radiation occur. Antenna size is inversely proportional to frequency, as we know. Whenever the diode is ON, then the antenna size is large in contrast. The antenna thus operates at a lower frequency (3 Gz-6 GHz). Whenever the diode is OFF, then the antenna size is small in contrast. The antenna thus operates at a higher frequency (6 GHz-9 GHz).

III. SIMULATION RESULTS

Using HFSS simulation, all simulation outcomes are described. The results are in terms of parameter s11 or coefficient of reflection, VSWR, gain, polar 3D plot and pattern of radiation. The mirrored or lost power is contained in the reflection coefficient. We can easily find radiated power after that.

A. Reflection Coefficient

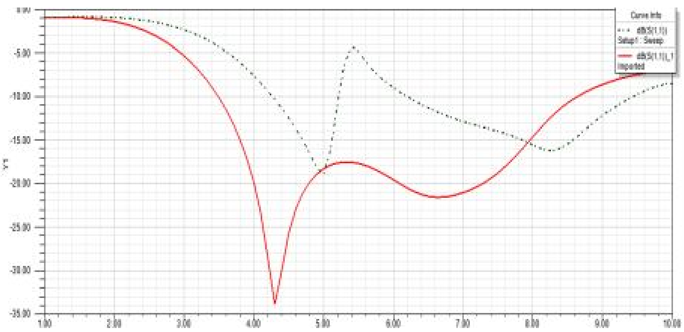

Fig.3. Reflection Coefficient of Circular Antenna

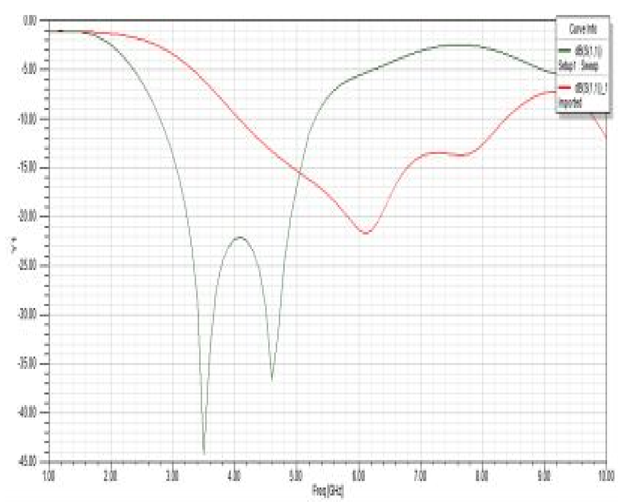

Fig.4. Reflection Coefficient of Pyramidal Antenna

The coefficient of reflection of both antennas is shown in the figure. In Fig.3, the bandwidth range is from 3to5 GHz while the switch is ON, and the bandwidth range is from 5to9 GHz when the switch is OFF. In Fig.4, the bandwidth range is from 3.1to5.7 GHz whenever the switch is ON, and the bandwidth range is from 5.7to9 GHz when the switch is OFF.Basically, the coefficient of reflection is used during transmission to measure the reflected or lost power of the antenna. So here, by taking the lower peak of each graph, we can also compute the reflected power. Likewise we will get two results (on and off). We will be able to find the real radiated power after measuring the reflected power. The transmitted power can be used to determine the antenna efficiency. If the graph is compared, the circular design is more successful than the pyramidal design.

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B. Power Calculation

The calculation of radiated power with respect to the reflection coefficient of circular monopole UWB antenna design is described below;

At ON Condition,
-34dB = 10 log P1
P1 = antilog (-3.4)
= 10 power (-3.4)
= 0.00398
P2 = 1 - 0.00398
= 0.99602 (99.602%)

At OFF Condition,
-20dB = 10 log P1
P1 = antilog (-2.0)
= 10 power (-2.0)
= 0.01
P2 = 1 - 0.01
= 0.990 (99.0%)

The calculation of radiated power with respect to the reflection coefficient of pyramidal monopole UWB antenna design is described below;

At ON Condition,
-44dB = 10 log P1
P1 = antilog (-4.4)
= 10 power (-3.4)
= 0.003981
P2 = 1 - 0.003981
= 0.996019 (99.602%)

At OFF Condition,
-23dB = 10 log P1
P1 = antilog (-2.3)
= 10 power (-2.3)
= 0.005
P2 = 1 - 0.05
= 0.995 (99.5%)

Where,

P1 = Reflected Power or Lost power of Antenna

P2= Radiated power of Antenna

It is inferred from the above equation that if we feed 100 watts of power, then the antenna radiates about 99 watts. We infer from thi s that the antenna has good efficiency and very high radiation power in this situation.

C. Radiation Pattern and Gain

Generally, we can measure the resistance and reactance value from the Smith map. We can determine the value of the impedance fr om that. The input impedance given is 50 ohms. We can measure the impedance values with respect to resonant frequency from the Smith table. We can then contrast the functional impedance values with the value of the input impedance. If there is impedance mat ching, then only the antenna can transmit power.

ANTENNA TYPE	RESONANT FREQ.(GHz)	IMPEDANCE(ohm)
CIRCULAR	4.3	49.8
	5	50.1
PYRAMIDAL	3.6	38.9
	6.2	57.2

Table 3: Impedance level for both the Antennas

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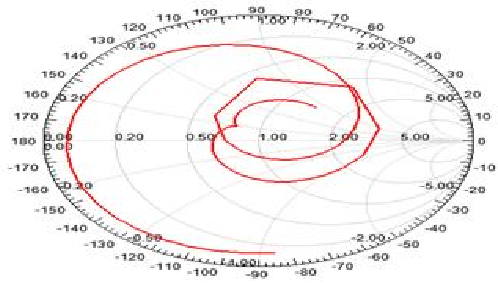
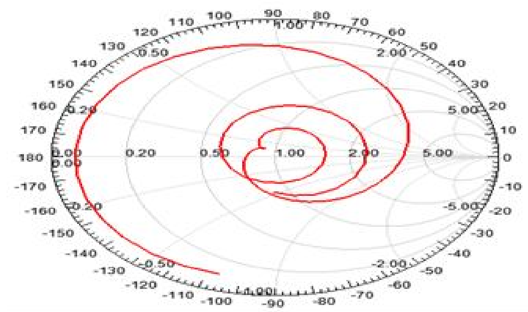
By knowing the inductance of the transmission line and resistance value, we can also calculate the impedance degree. We recognise that reactance is the distinction between inductive and capacitive reactance. We can also calculate the impedance value and match th e impedance of the output with the impedance of the input characteristics.

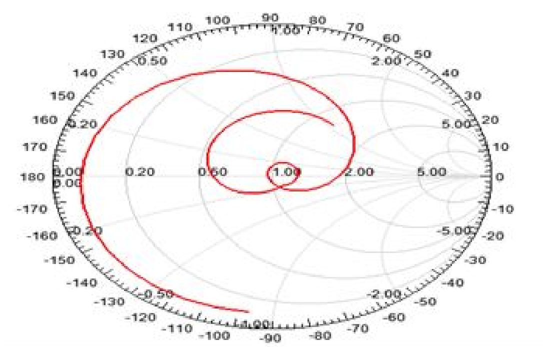


(Smith chart for circular antenna)

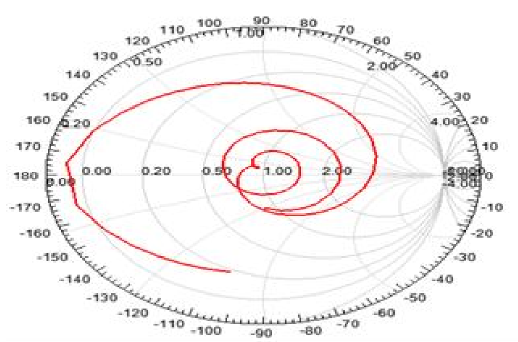


(Smith chart for pyramidal antenna)

FIG 5: SMITH CHART WHEN DIODE IS OFF



(Smith chart for circular antenna)



(Smith chart for pyramidal antenna)

FIG 6: SMITH CHART WHEN DIODE IS ON

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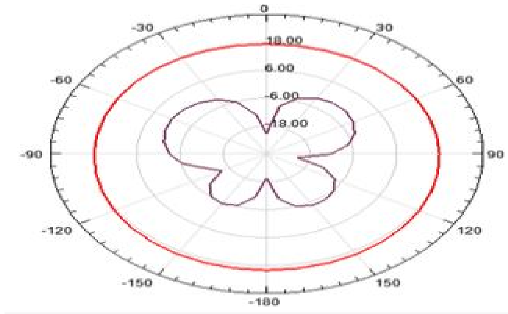
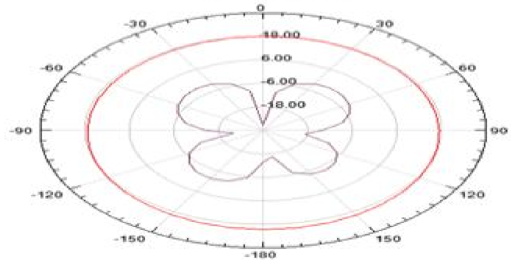


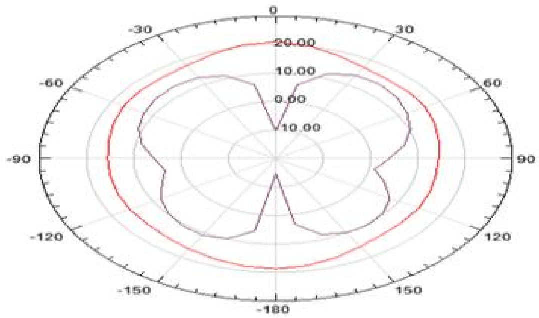
(For circular antenna)



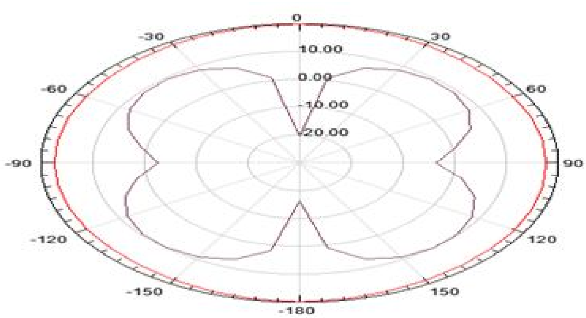
(For pyramidal antenna)

FIG 7: RADIATION PATTERN WHEN DIODE IS ON

In relation to a special coordinate, the mathematical representation of the electric field or magnetic field or power is called a radiatio n pattern. The blue line here refers to the E-plane, and the H-plane refers to the red line.
The form is doughnut in the Eplane, and the shape is omni-directional in the H-plane. At each frequency value, a radiation pattern can be found here. But this is where we find the resonant frequency.



(For circular antenna)



(For pyramidal antenna)

FIG 8: RADIATION PATTERN WHEN DIODE IS OFF

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D. Design steps of Antenna

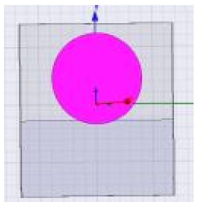
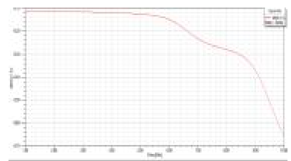
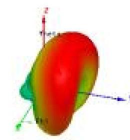
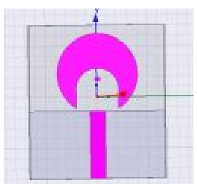
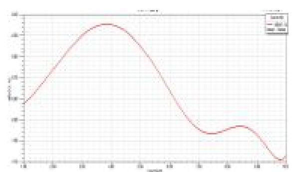
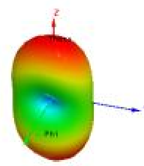
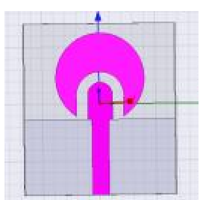
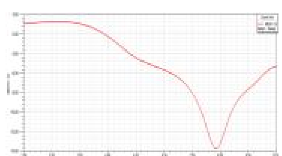
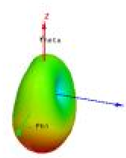
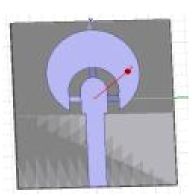
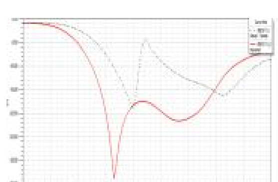
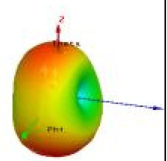
Circular Antenna design	Reflection coefficient Plots	Polar Plot
		
		
		
		

Table 4: Design steps of Circular Antenna with polar plot

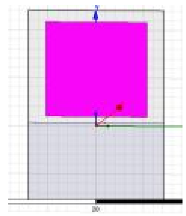
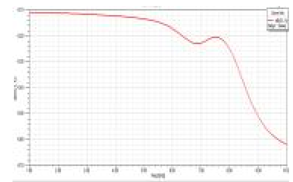
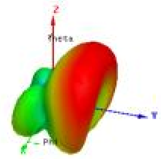
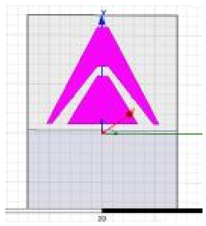
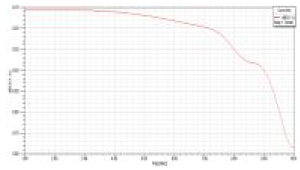
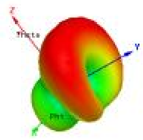
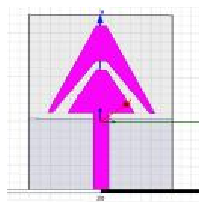
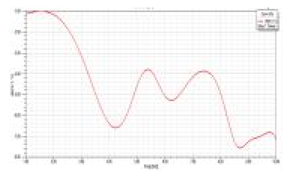
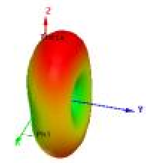
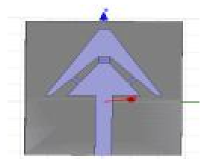
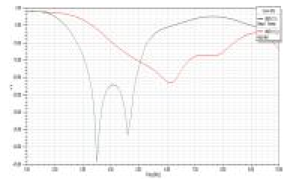
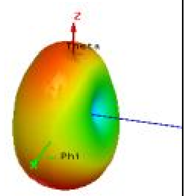
Pyramidal Antenna design	Reflection coefficient Plots	Polar Plot
		
		
		
		

Table 4: Design steps of Pyramidal Antenna with polar plot

The magnitude of the response in either direction is indicated by a polar map. Polar plot 3D is used for the development of threedimensional plot contour plots. These plots are seen to be a 3D vision of the system of polar coordinates.

We have to choose two orthogonal directions to define this spherical system. It is seen in the above figures how much power is radiated in which direction.

IV. CONCLUSION

It has been shown that the pyramidal antenna is more powerful than the circular design after comparing both designs.It has a complicated design and the process of simulation takes time. Its radiation intensity is still more powerful than its circular shape. If we go for the power radiation than this pyramidal design is the best design. If we go for a simple design with good performance, we can choose that circular antenna.

We know that if one design is designed, it has some advantages and disadvantages. So we will use the prototypes according to the suitability of the real world. The design is simulated and the required graph is plotted for every antenna parameter. The future of this research job is manufacturing in the real world.

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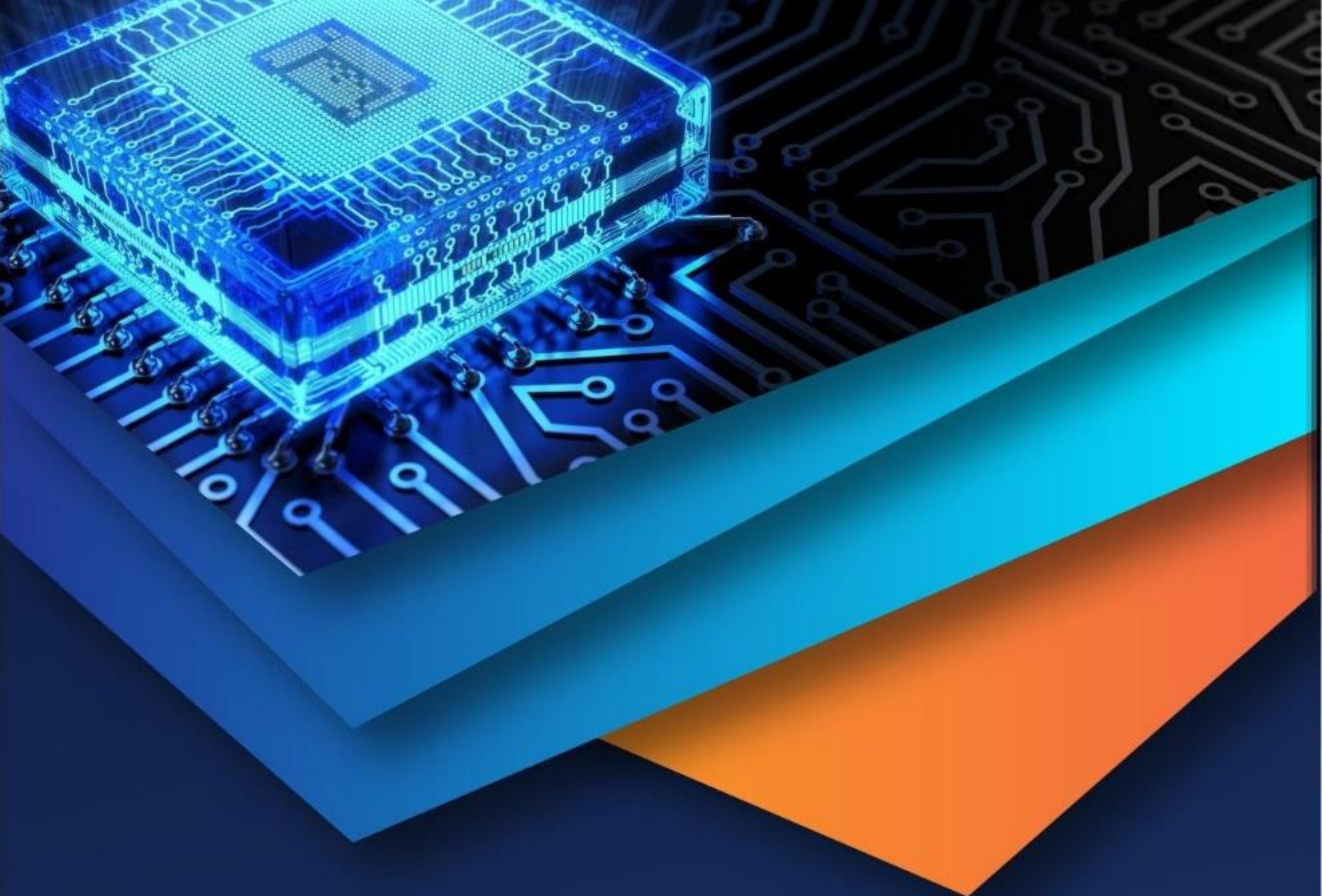

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