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Design of Circular Microstrip Patch Planar Antenna with Different Ground Planes for UWB Application

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Abstract: ***the aim of this paper is to design and simulate the microstrip patch antenna which covers the ultra wide band 3.1 to 10.6 ghz. This paper covers study of basics and fundamentals of microstrip patch antenna. The antenna is fabricated using an h=1.6mm thick fr4 substrate (εr=4.4), which occupies a coverage area of 26.6 ws x 29.3 ls mm2.this is a simulation based study. The design and simulation of the antenna is carried out using cst microwave studio simulation software. This design is extended circular planar microstrip patch antenna that uses defected ground plane which covers the entire uwb range. Return loss curve, vswr and the far field results are shown for designed antenna. The proposed antenna has return loss of -37 db at 8ghz. The return loss of antenna with rectangular ground plane is also suitable in 3-11 ghz range that covers the uwb range.***
Keywords— flame retardant 4(fr4), ultra wide band (uwb),planar antenna, circular microstrip patch antennas, computer simulation technology(cst).

I. INTRODUCTION

The ultra wide band (UWB) communication systems have received great attention from both the academic and the industrial sectors as a result of commercial systems such as indoor and hand-held wireless communication. These days the wireless system has become a part of human life. Antennas are our electronics eyes and ears on the world. UWB is a short distance radio communication technology that can perform high-speed communication with speeds of more than 100 Mbps. The UWB systems can be divided into two categories: direct sequence UWB (DS-UWB) and multi-band orthogonal frequency division multiplexing (MB-OFDM). The DS-UWB proposal foresees two different carrier frequencies at 4.104 (low band: 3.1–5.15 GHz) and 8.208 GHz (high band: 5.825–10.6 GHz), while the MB-OFDM format in IEEE 802.15.3a has an interval between 3.1 and 10.6 GHz and is divided into 14 subintervals. Each subinterval covers 528 MHz of bandwidth[9][10]. Microstrip antennas became very popular in the 1970s. These antennas consist of a metallic patch on a grounded substrate. The metallic patch can take many different configurations. However, the rectangular and circular are the most popular because of ease of analysis and fabrication and their attractive radiation characteristics, especially low cross polarization radiation [1].A Microstrip antenna is one who offers low profile and light weight. It is a wide beam narrowband antenna can be manufactured easily by the printed circuit technology such as a metallic layers in a particular shape is bonded on a dielectric substrate which forms a radiating element and another continuous metallic layer on the other side of substrate as ground plane[2][3].

II. UWB ANTENNA DESIGN

The proposed antenna parameters are shown in the figure. The Design consists of a half circular patch which is extended to an extra length. The antenna uses FR4 substrate with a dimension of 26.6×29.3×1.6 mm³, εr=4.4 and a loss tangent of 0.02.the width (Wf) of the microstip-fed line is fixed at 3.015mmto achieve 50Ω characteristic impedance, and is connected to the extended circular patch via a line of length Lf. A circular shape partial ground plane is used with an elliptical notch just below the feed line. The simulation results show that the antenna fulfills the requirement of UWB range.

The front and back view of the proposed antenna is shown in Fig.1 & Fig.2. Partial ground plane with curvy edges is used. Making an elliptical notch behind the feed line in ground plane and narrow rectangular slit in ground results in drastically improvement in the return loss curve. This is a simulation based study. The design and simulation of the antenna is carried out using CST microwave Studio.

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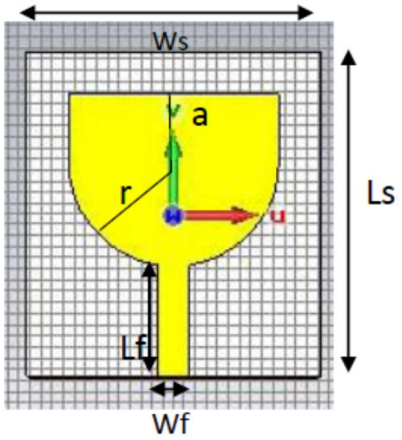

Figure 1: Front view of proposed antenna by CST Software

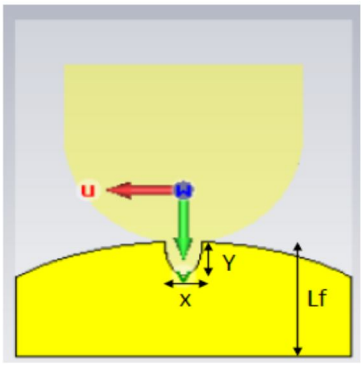

Figure 2: Back view of proposed antenna by CST Software

III.ANTENNA PARAMETERS

Parameter list with their values are written in the table.1.All the dimensions are in millimeter.

Table 1: Dimension of proposed antenna design

Parameter	Description	Value(mm)
r	Radius circular patch	9.5
a	Patch extension	6
X	X radius of elliptical notch	1.5
Y	Y radius of elliptical notch	3
Lf	Length of feed line	10
Wf	Width of feed line	3.015
Ws	Width of substrate	26.6
Ls	Length of substrate	29.3

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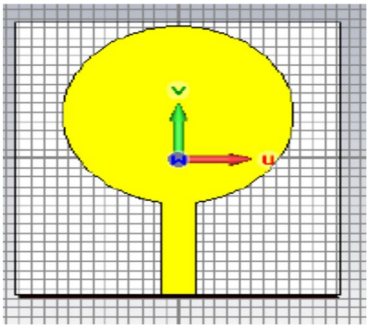
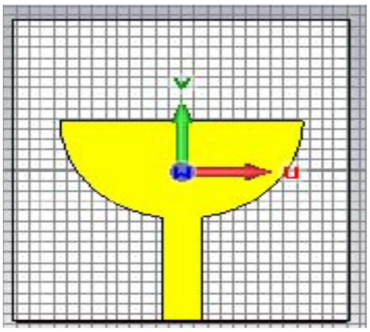
IV. DESIGN STEPS

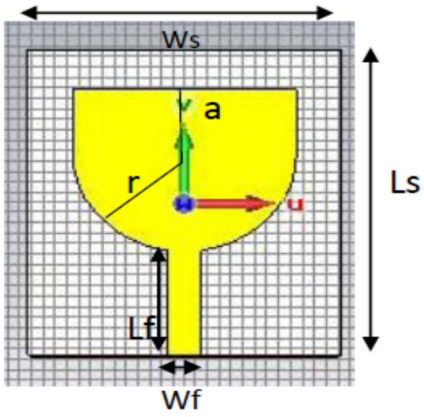
The proposed antenna is designed three steps as shown figure 3. The first step, antenna 1 is conventional circular monopole antenna is designed to obtain the UWB. The second step, to improve the return loss we could take the semicircular is designed with the same radius but the return loss is not matched with the overall UWB. In antenna 3, the semicircular attaché with rectangular with a is introduced. The comparison between the 3 different antennas return losses are as shown in figure 4. From the return loss result, it is observed that the proposed antenna can cover UWB band.



Antenna 1: Circular



Antenna 2: Semi Circular



Antenna 3: Extended circular

Figure 3: The proposed antenna design steps

To comparison the results of these three antennas as shown figure 3. The return loss of the antenna 1 that is full circular(blue color) is suitable to support the UWB frequency range. To improve the impedance matching the semicircular antenna is taken that is antenna 2(Red color). In this antenna the lower frequency is more impedance matching but at the higher frequency it is unsuitable. The third antenna is the rectangular shape patch is added to the semi circle then the return loss of this antenna is more impedance matching compare to the remaining antennas. At the frequency 8 GHz the return loss is -37 dB. The VSWR of this frequency is almost nearly equal to 1.

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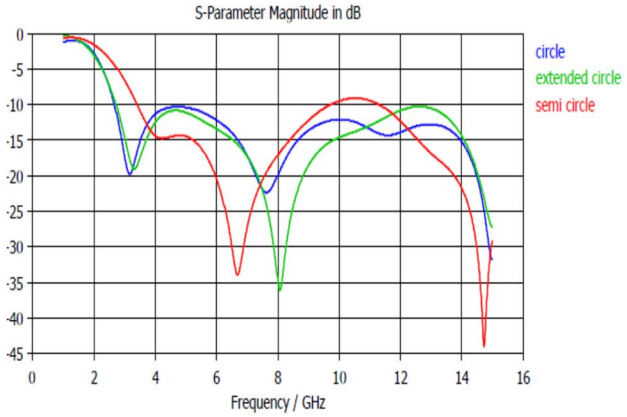

Figure 4: Return loss of the different antennas

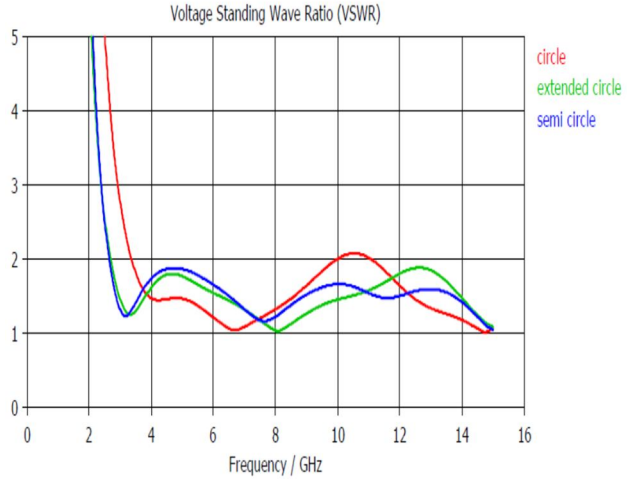

Figure 5: VSWR of the different antennas

The proposed antenna return loss curve and VSWR curve and radiation pattern as shown below the figures. The return loss curve shows that the antenna has bandwidth 3GHz to 12 GHz with a minimum S11 -37 dB at 8 GHz. This shows that the proposed antenna covers the entire UWB.

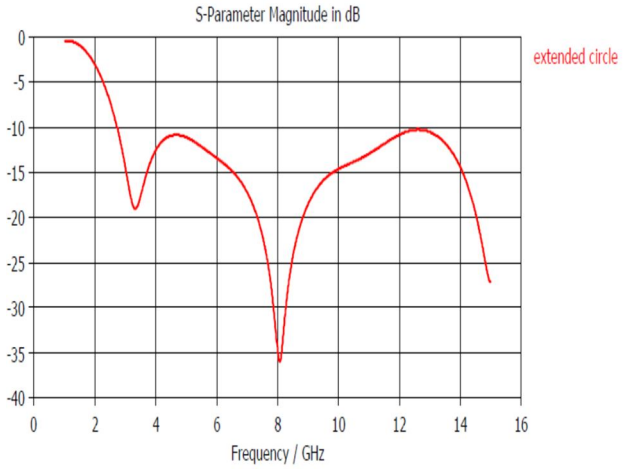

Figure 6: Return loss vs. frequency curve of proposed antenna.

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The VSWR vs. frequency curve for the proposed antenna is 1 that resemble with ideal value of VSWR

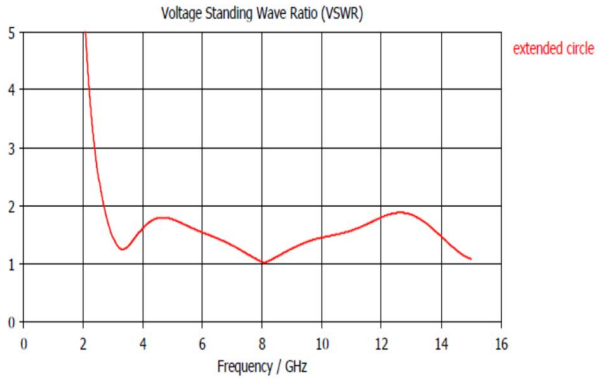


Figure 7: Voltage standing wave ratio curve

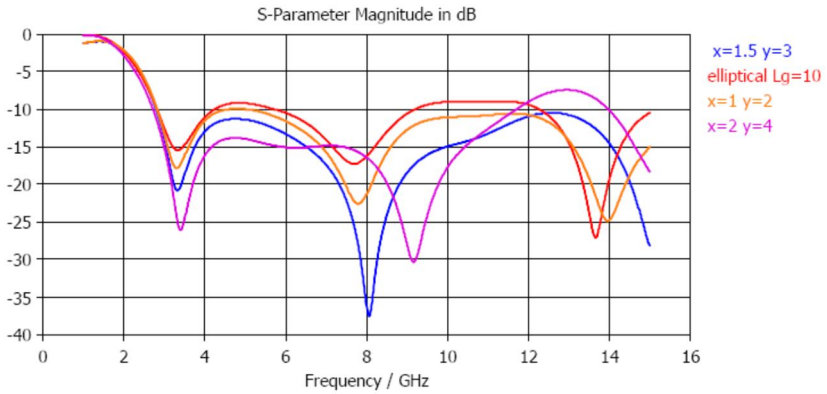
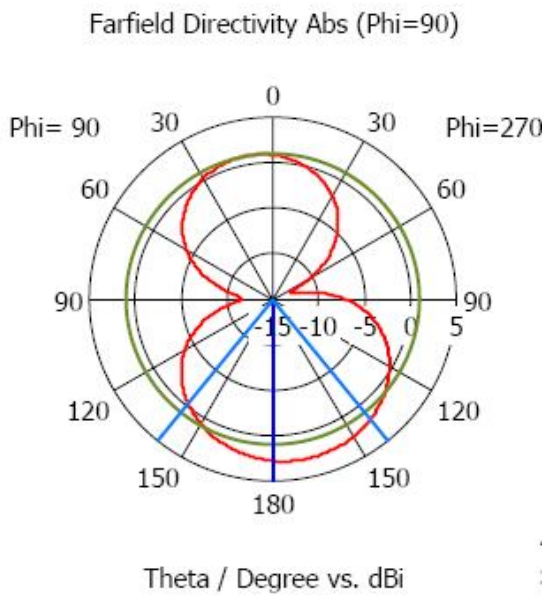


Figure 8: comparison of return loss (varying elliptical notch x,y)

The comparison of return loss to vary the elliptical notch dimension is as shown above the figure 8.the return loss is very good and more impedance matching in x=1.5and y=3. Each time one parameter is varied to compare the results.



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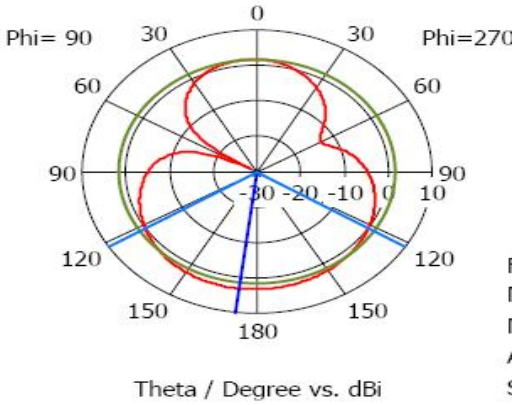

Figure 9: Radiation pattern for frequency 3.5 GHz,6 GHz.

V. RECTANGULAR GROUND PLANE INSTEAD OF CURVE EDGE GROUND PLANE

An alternate choice of ground plane is taken as rectangular. The results antenna is suitable to support the UWB.

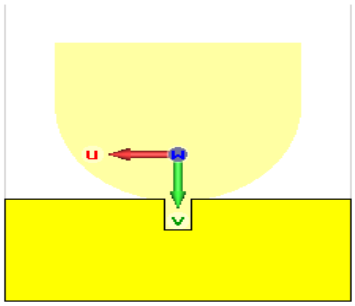

Figure 10. Back view of antenna

The rectangular ground plane is taken with same length of feed line and the notch is created with length 2mm and width 3mm.the parametric study of different length of ground plane as shown above the figure10. In the figure 11.the pink color return loss is after created of notch.

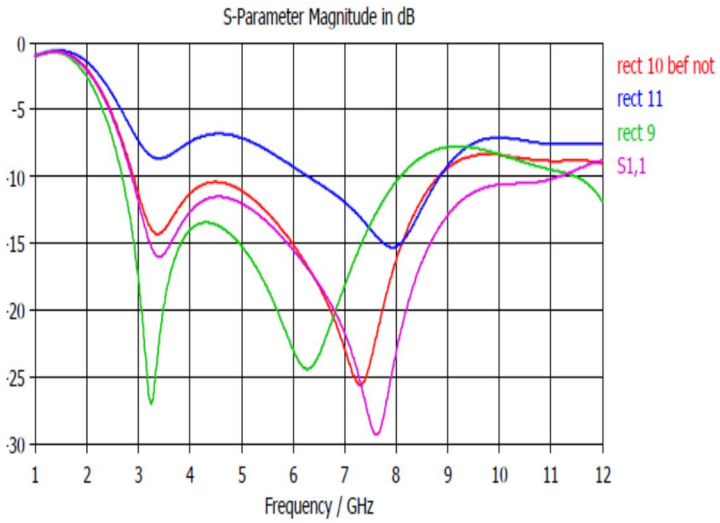

Figure 11: Different length of ground plane

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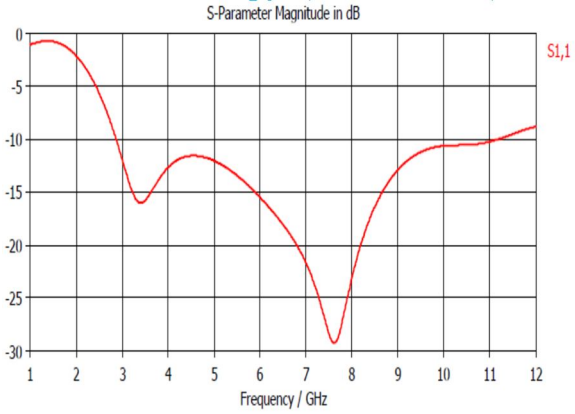

Figure 12: S11 is after creation of notch

The return loss curve shows that the antenna has bandwidth from 3 GHz to 11GHz with a minimum S11 -28 dB at 7.6GHz. This shows that the antenna covers the entire UWB.

VI. CONCLUSION

The paper describes Microstrip patch antenna that consists of a half circular patch which is extended to an extra length and is fabricated on FR4 substrate that uses Microstrip feeding line method for feeding. A circular shape partial ground plane is used with an elliptical notch just below the feed line. The simulation results shows that the antenna fulfills the requirement of UWB antenna operating in 3.1-10.6 GHz and cover to 3 to 12 GHz range that covers the UWB range. The proposed antenna structure's simulation is carried out using the CST software. The rectangular ground plane is taken as instead of curvy edges. This antenna is also suitable in 3-11 GHz range that covers the UWB range. The results are good return loss and radiation patterns in the interested UWB. The extension of this paper is to reduce the size of the UWB antennas to suit more measured applications and to require the more directive gain the patch array is design.

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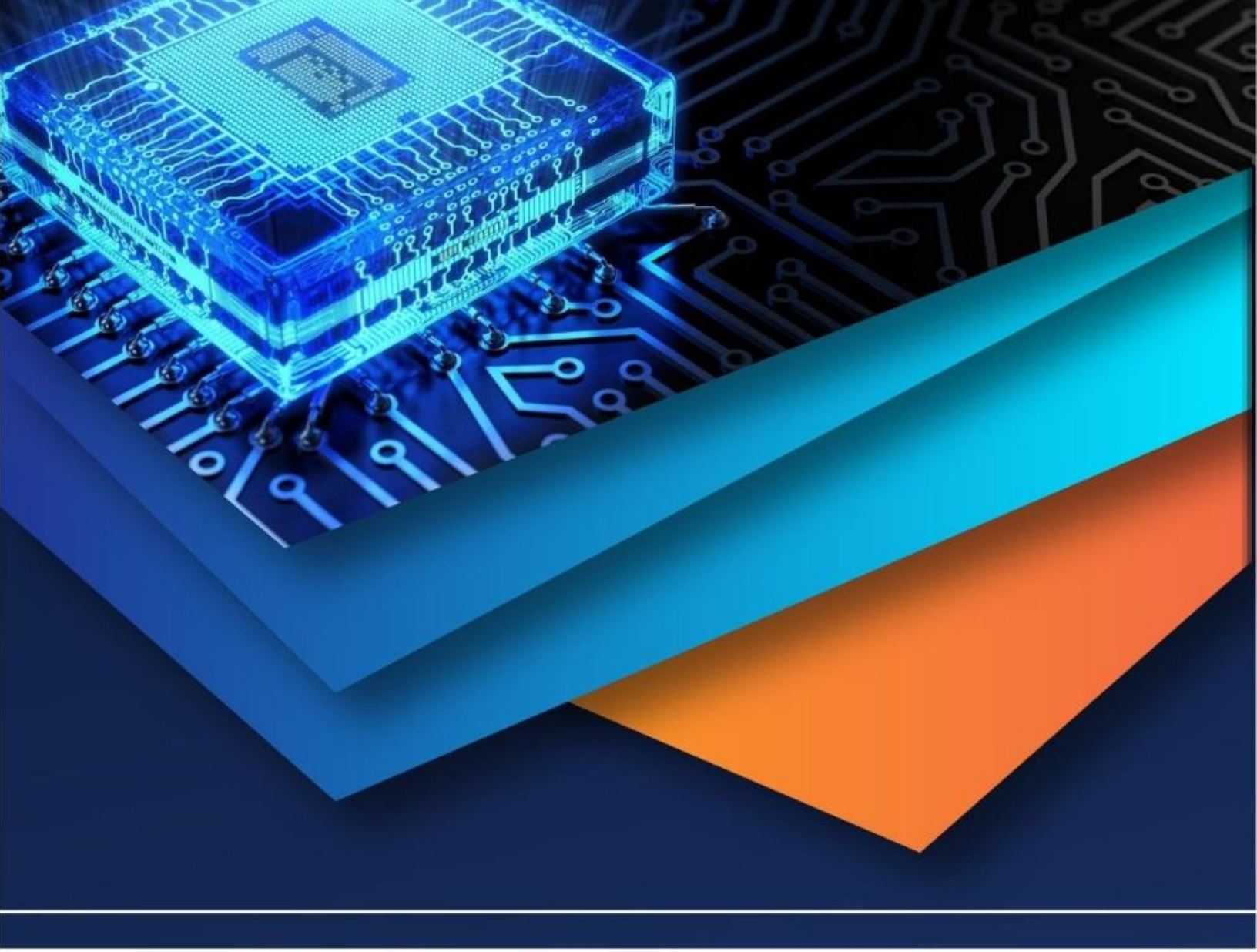

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