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Bandwidth Enhancement of UWB Microstrip Antenna with a Modified Ground Plane

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Abstract*-Bandwidth enhancing technique using a modified ground plane with diagonal edges, rectangular slot, and T-shape cut for the design of compact antennas.Ultra-wideband (UWB) technology has been regarded as one of the wireless technologies that provide high data rate transmission bandwidth of 7.5 GHz (3.1–10.6GHz).The planar circular disc monopole is fabricated on a 3 cm×5.1 cm×0.16 cm FR-4 board(εr=4.4, thickness=1.6mm) with a feed line and a finite ground plane.The patch acts approximately as a resonant cavity (short circuit walls on top and bottom, open-circuit walls on the sides).In a cavity, only certain modes are allowed to exist, at different resonant frequencies. If the antenna is excited at a resonant frequency, a strong field is set up inside the cavity, and a strong current on the (bottom) surface of the patch. This produces significant radiation (a good antenna).
***Keywords*-Bandwidth,Resonant cavity, Rectangular slot,Trasmission bandwith,Monopole.**

I. INTRODUCTION

A microstrip antenna consists of a metallic patch on one side of a dielectric substrate and ground plane on the other side of the substrate. The patch acts approximately as a resonant cavity (short circuit walls on top and bottom, open-circuit walls on the sides).If the antenna is excited at a resonant frequency, a strong field is set up inside the cavity, and a strong current on the surface of the patch. This produces significant radiation.

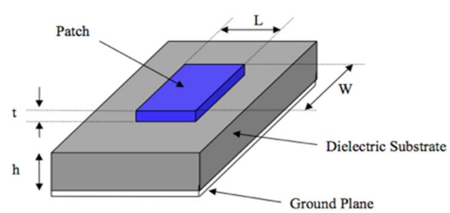

Fig.1.Microstrip antenna

In fig.1., L is Length of the Microstrip Patch Element, W is the Width of the Microstrip Patch Element, t is the Thickness of Patch, h is the Height of the Dielectric Substrate. UWB:Ultra Wide Band, Also known as (ultra band). A series of very short baseband pulses with time duration in nano-seconds that exist on ALL frequencies imultaneously.

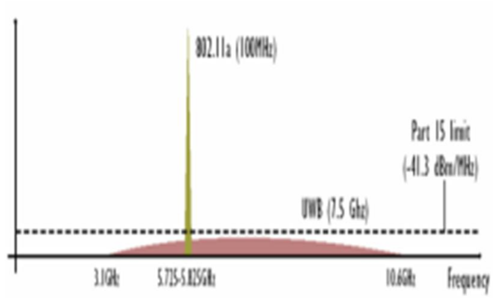

Fig.2.UWB range

UWB in the frequency range from 3.1 to 10.6GHz is shown in fig.2.Bandwidth greater than 500 MHz It has many features such as Low power consumption, Low detection, High immunity to multipath-fading effects, Ability to penetrate walls, faster than

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Bluetooth, Wi-Fi, Data rate of 450Mbps instead of 1Mbps.

II. ANTENNA DESIGN CONSIDERATION

A. Width and Length of Ground Plane

Bandwidth enhancing technique using a modified ground plane with diagonal edges, rectangular slot, and T-shape cut for the design of compact antennas.

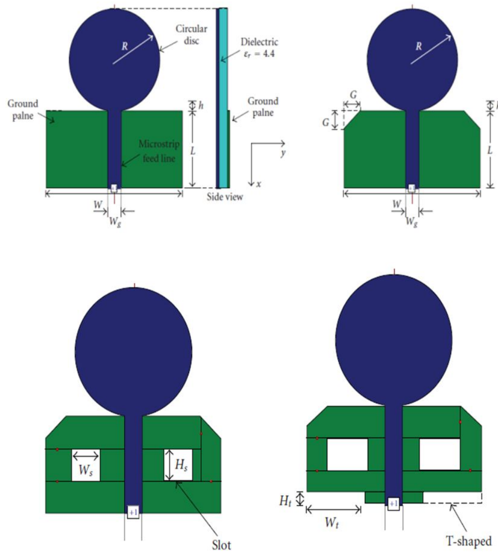

Fig.3.Configuration of Circular Microstrip Antenna with Various Modified Ground Plane

Ultra-wideband (UWB) technology has been regarded as one of the wireless technologies that provide high data rate transmission. Frequency $f_0$relation is as follows,

$$f_0 = \frac{c}{2\sqrt{\varepsilon_{eff}}}\left[\left(\frac{m}{L}\right)^2 + \left(\frac{n}{W}\right)^2\right]^{\frac{1}{2}}$$

……..(1) Equation 1 shows resonant frequency of proposed antenna.Equation 2 shows width of the antenna.

For efficient radiation, Width of the antenna is given as,

$$W = \frac{C}{2 f_r \sqrt{\frac{(\varepsilon_r + 1)}{2}}} \quad ......(2)$$

Where,c=3 x 10^8 m/sec, ε_r =4.4, f_o= 3.5GHzTherefore, Width of the antenna is produced as W=26.08mm.

Equation 3,Effective Dielectric constant of the microstrip is determined,

$$\varepsilon_{reff} = \frac{(\varepsilon_r + 1)}{2} + \frac{(\varepsilon_r - 1)}{2}\left[1 + 12\frac{h}{W}\right]^{-\frac{1}{2}} \quad ....(3)$$

For a given resonant frequency,effective length is given by,

$$L_{eff} = \frac{C}{2 f_r \sqrt{\varepsilon_{eff}}} \qquad \text{.........(4)}$$

Therefore effective length of the antenna is found using above relation.

B. Circular Patch Radius

To calculate radius of the circular patch for antenna below formula is considered.

$$a = \frac{F}{\left\{1 + \frac{2h}{\pi \varepsilon_r F}\left[\ln\left(\frac{\pi F}{2h}\right) + 1.7726\right]\right\}^{\frac{1}{2}}}$$

.........(5)

Where,

$$F = \frac{8.791 \times 10^9}{f_r \sqrt{\varepsilon_r}} \qquad \text{.......(6)}$$

Where fr, ε_r are resonant frequency and dielectric constant. H refers to height of the circular patch. Thus we can determine the "a" radius of circular patch of antenna.

III. SIMULATED RESULT

This shows the top view of an Circular patch microstrip antenna that operates in UWB frequency range using Fr_4 as substrate.

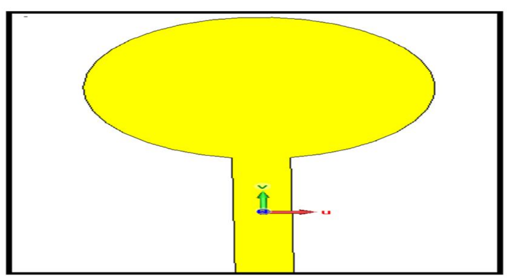

Fig.4.Top view of simulated circular patch antenna model.

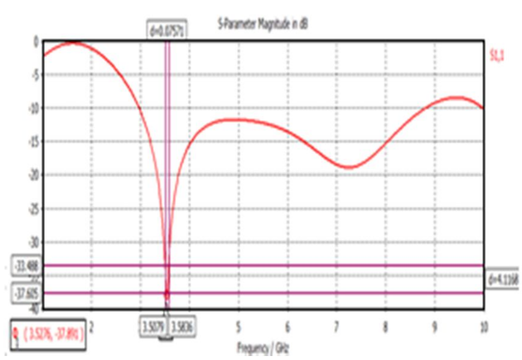

Fig.5.Simulated return loss of circular patch antenna.

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From above figure it shows the Return Loss of normal circular patch antenna with an ground plane is achieved about -39dB. Bandwidth obtained about 75.71MHz. Gain and Directivity achieved about 3.134dB and 3.339dB in Fig.6 and Fig.7.

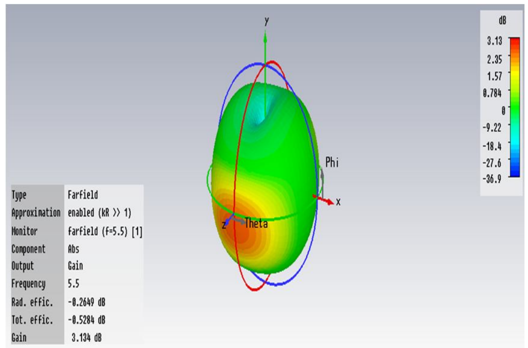

Fig.6. 3D view of gain.

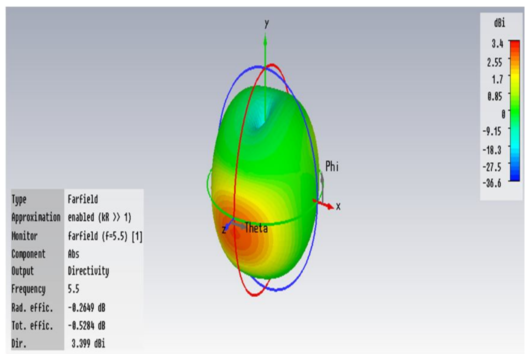

Fig.7. 3D view of directivity.

For Bandwidth Enhancement, we are modifying ground plane using diagonal edges, additionally by providing slots and Tshpaed. From Fig.8 Using diagonal Edges plane,return loss is achieved about -22dB. Bandwidth obtained about 785.49MHz. Gain and Directivity achieved about 3.345dB and 3.386dB. Here, Bandwidth is enhanced and improved as compared to the normal ground plane. This operated in frequency range of UWB. 3D view of Gain and Directivity are shown in Fig.9 and Fig.10.

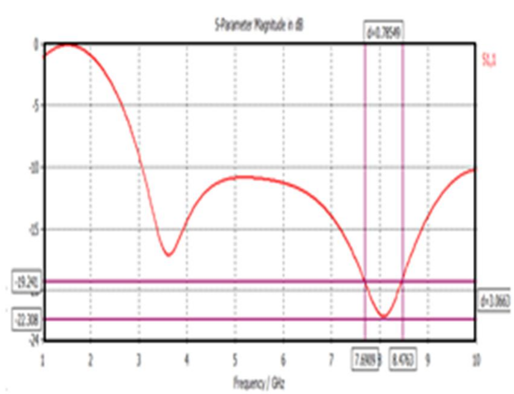

Fig.8. Simulated return loss of circular patch antenna with modified ground plane-Diagonal Edges.

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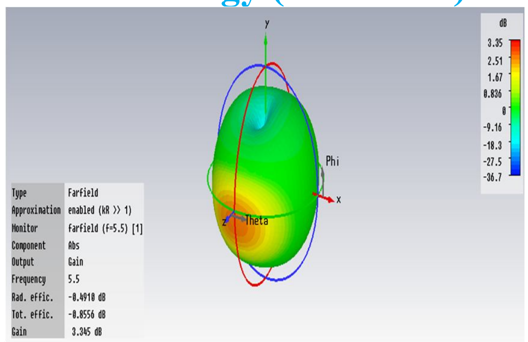

Fig.9. 3D view of gain.

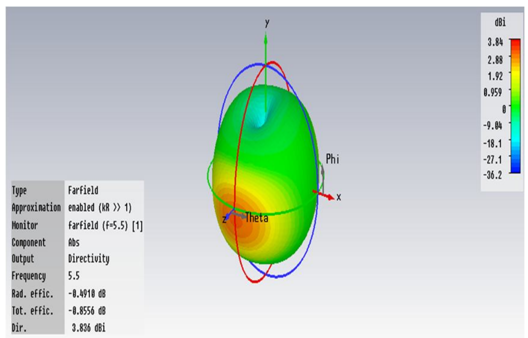

Fig.10. 3D view of directivity

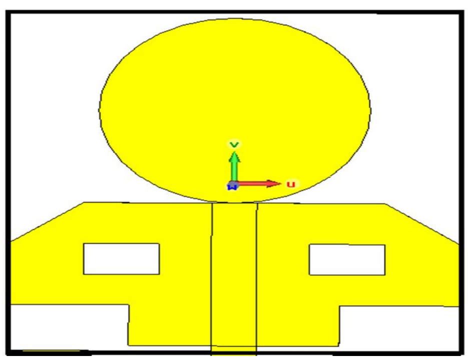

Fig.11. Configuration of circular patch antenna with modified ground plane using Diagonal edges,Slots and T-shaped.

From Fig.12 Using Slots in ground plane, return loss is achieved about -20dB. Bandwidth obtained about 736.07MHz. Gain and Directivity achieved about 3.73dB and 5.065dB.

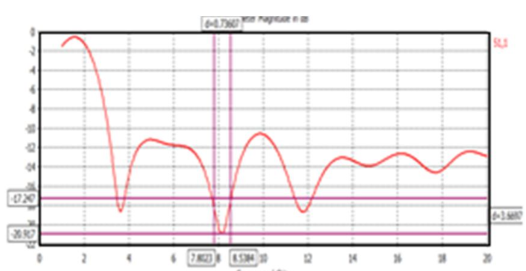

Fig.12. Return Loss measurement for circular patch using modified ground plane using slots.

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Here, Bandwidth is enhanced and improved as compared to the normal ground plane. This operated in frequency range of UWB. 3D view of Gain and Directivity are shown in Fig.13 and Fig.14.

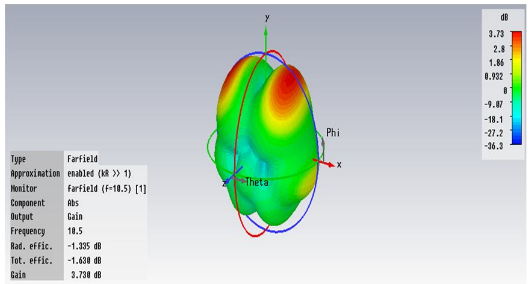

Fig.13. 3D view of Gain

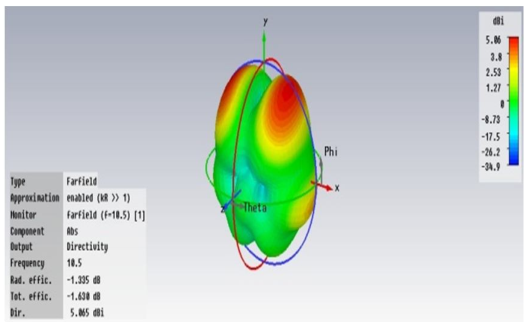

Fig.14. 3D view of Directivity

From Fig.12 Using Slots in ground plane, return loss is achieved about -19dB. Bandwidth obtained about 1618.3MHz. Gain and Directivity achieved about 1.995and 2.551dB.

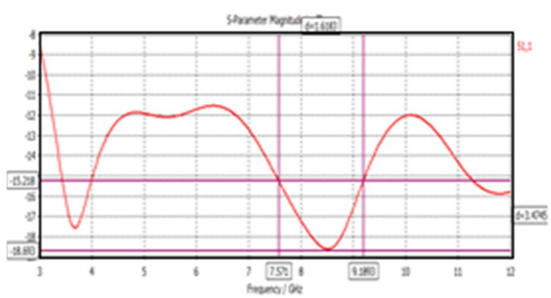

Fig.15. Return Loss measurement for circular patch using modified ground plane using T-Shaped.

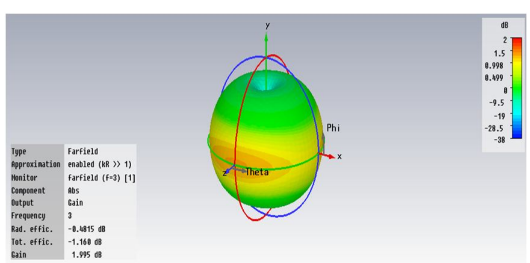

Fig.16. 3D view of Gain

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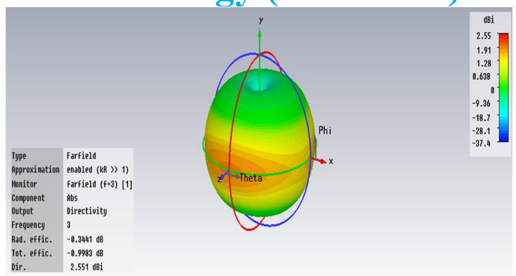

Fig.17. 3D view of Directivity

Here, Bandwidth is enhanced and improved as compared to the normal ground plane. This operated in frequency range of UWB. 3D view of Gain and Directivity are shown in Fig.16 and Fig.14.

IV. FABRICATED RESULT

Fig.18 shows top view of the fabricated antenna which is the radiating patch of proposed antenna and Fig.19 shows bottom view of the ground plane of proposed antenna.

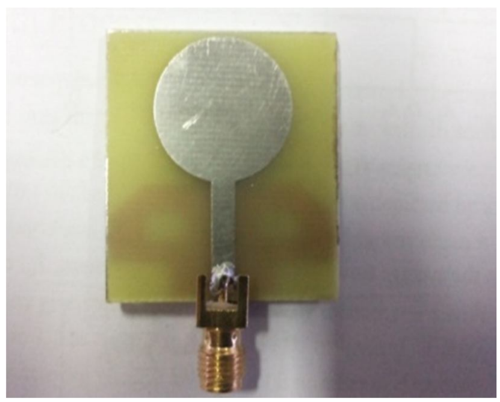

Fig.18.Fabricated radiating patch view

For Bandwidth Enhancement, we are modifying ground plane using diagonal edges, additionally by providing slots and Tshpaed. The Measured result of the antenna is achieved about return loss of -22dB.

Results of Measured antenna using network analyzer are shown in Fig.20 and Fig.21.

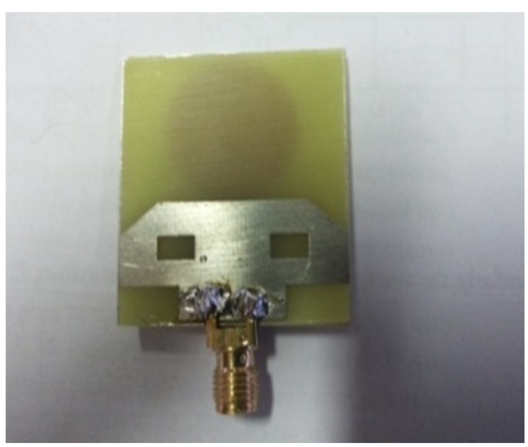

Fig.19.Fabricated ground plane view

Fig.20.Measured result

Fig.21.Fabricated antenna with network analyzer

V. CONCLUSION

A compact antenna and a technique to increase its band-width have been proposed and implemented. The proposed low-cost and compact-size circular patch antenna on 3 cm × 5.1 cm printed circuit board (FR-4) is designed and validated through simulations and experimental observations. Results show that the bandwidth can be tunable depending mainly on the circular disc size and the vertical gap between the disc and the ground plane. With the presence of the diagonal cut areas at the corners of the ground plane, the bandwidth can be further improved. Return losses of −39 and −22 dBs for the first and second resonant frequencies, respectively, can be achieved when the depth of the diagonal cut is at optimum value of 5 mm, rectangular slot (5 × 3 mm), and T-shape cut (8 × 4 mm) providing a maximum 28.67% wider bandwidth (3–12.615 GHz) than the FCC recommended standard of 3.1–10.6 GHz. Finally, the size of the ground plane, which has an insignificant impact on the performance, can be further reduced to around 30 cm × 1.5 cm to meet a compact size design.

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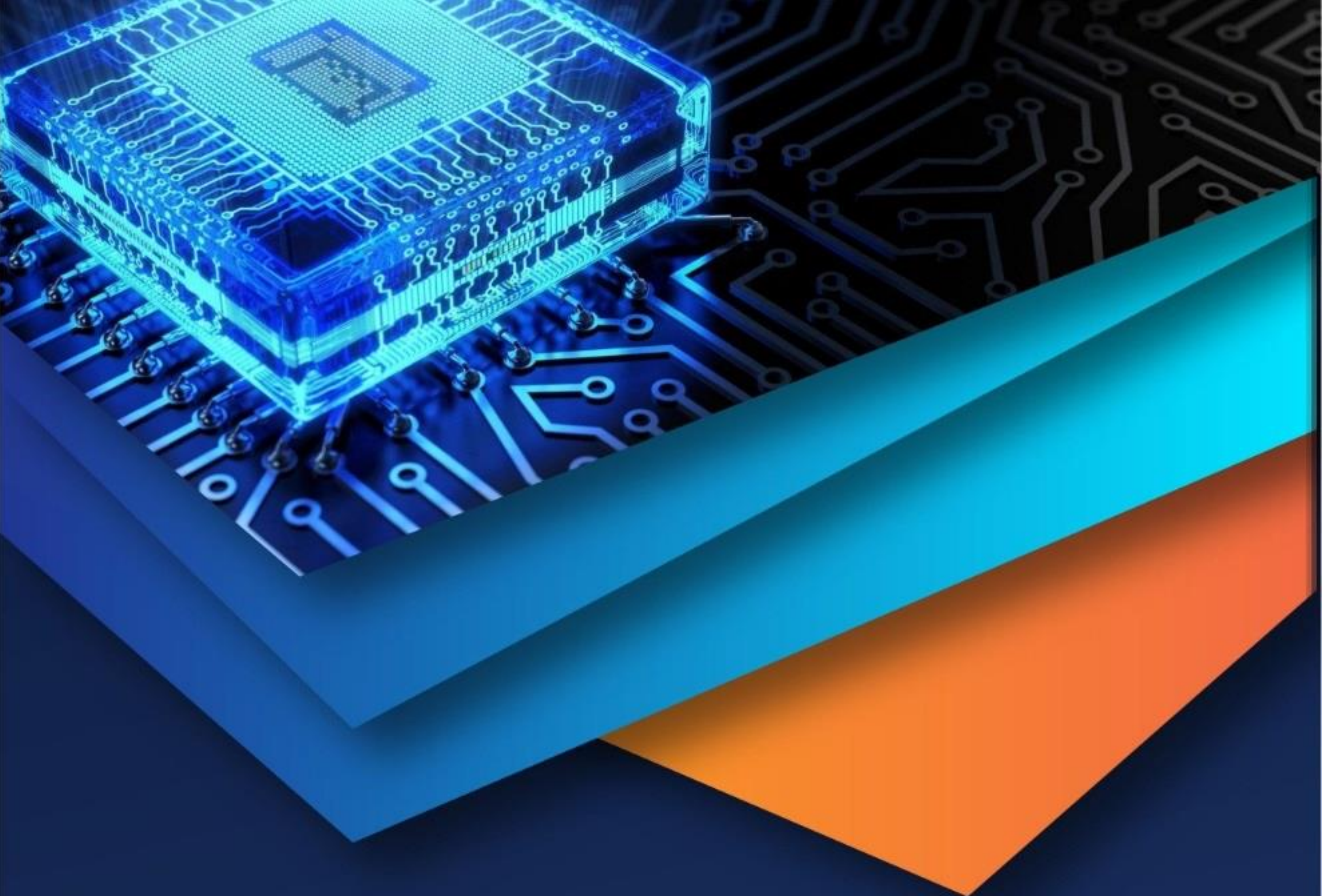

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