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A Compact Open Slot Antenna with Improved Circular Polarization for Satellite Applications

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Abstract: To achieve the polarization efficiency to maximal extent for antennas, the devices that have circular polarization are in great demand in the recent trend. Owing to the performance and compactness the open slot antenna entice sample attention compared to the other antennas, as the slot antenna has advantages of simple structure, light weight, low profile wide band width, good radiation efficiency. Several open slot antenna structures have been proposed to improve the circular polarization performance. Nevertheless the circularly polarized band width for the proposed antennas has remained limited. Hence there is a need to improve the circularly polarized band width. This work proposes analysis and design of a more compact wide band open slot antenna to provide broad impedance band width with circular polarization for Satellite Digital Audio Radio (SDAR) applications. The optimized structure has 3 dB axial ratio from 2 to 4.7 GHz (i.e.) 83.07%.
Keywords: Open slot antenna, Circular polarization, Impedance Bandwidth, Axial ratio.

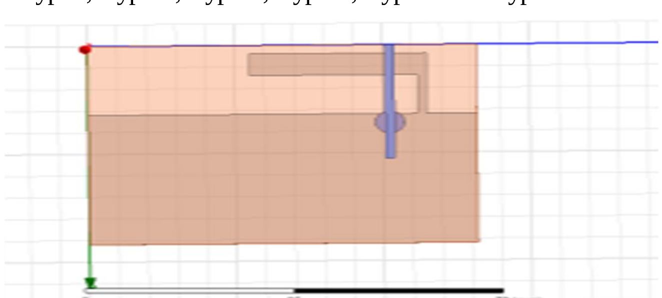
I. INTRODUCTION

To achieve a perfect match between a transmitter and a receiver, circular polarization will be a suitable candidate and further to achieve the polarization efficiency (i.e.) to maximal extent .For a conventional monopole antenna the radiation pattern is linearly polarized. Hence the monopole antenna needs to be modified to operate with circular polarization. An electromagnetic wave can be circularly polarized by generating two perpendicular resonant modes of same amplitude and quadrature in-phase and this phenomenon in satellite communications can reduce the Faraday rotation effect impact. various approaches have been proposed in the literature [1]-[6] for having circular polarization for monopole antenna wide band axial ratio band width is obtained in base patch by inserting a falcate shaped slot[5], with an irregular geometry shape of monopole antenna [6]. To have a low profile, open slot antenna has been proposed and designed. Various open slot antenna structures like L-shape [7], cross-shape [8] perturbation [9] and T-shape [10] are designed to have improved circular polarization. But the circularly polarized band width is limited for the above antennas. Hence there is need to improve the circularly polarized band width.

This work presents circularly polarized open slot antenna with a broad circular polarized band width and a wide impedance band width has been analysed and designed is presented. The location of open C-shaped slot is optimized in the ground plane which provided a wide impedance band width and a broad circular polarized band width.

II. DESIGN OF PROPOSED ANTENNA

The proposed structure of open slot antenna is printed on FR4 substrate with thickness of 0.8mm. Its relative permittivity is 4.4 and loss tangent is of 0.02. The proposed antenna structure consists of open slot located at right edge of the ground plane and the feeding line consists of patch with two finger strips, the corresponding operating frequency for SDAR application at 2.3 GHZ the length of the open slot is chosen at quarter wave length the antenna has the dimensions of (66mm *44mm). The proposed antenna is tested using HFSS software, which is based on Finite Element Method (FEM) technology.The design evolution of the proposed open slot antenna is shown in below figures as type1, Type 2, Type 3, Type 4, Type 5 and Type 6.



(a)

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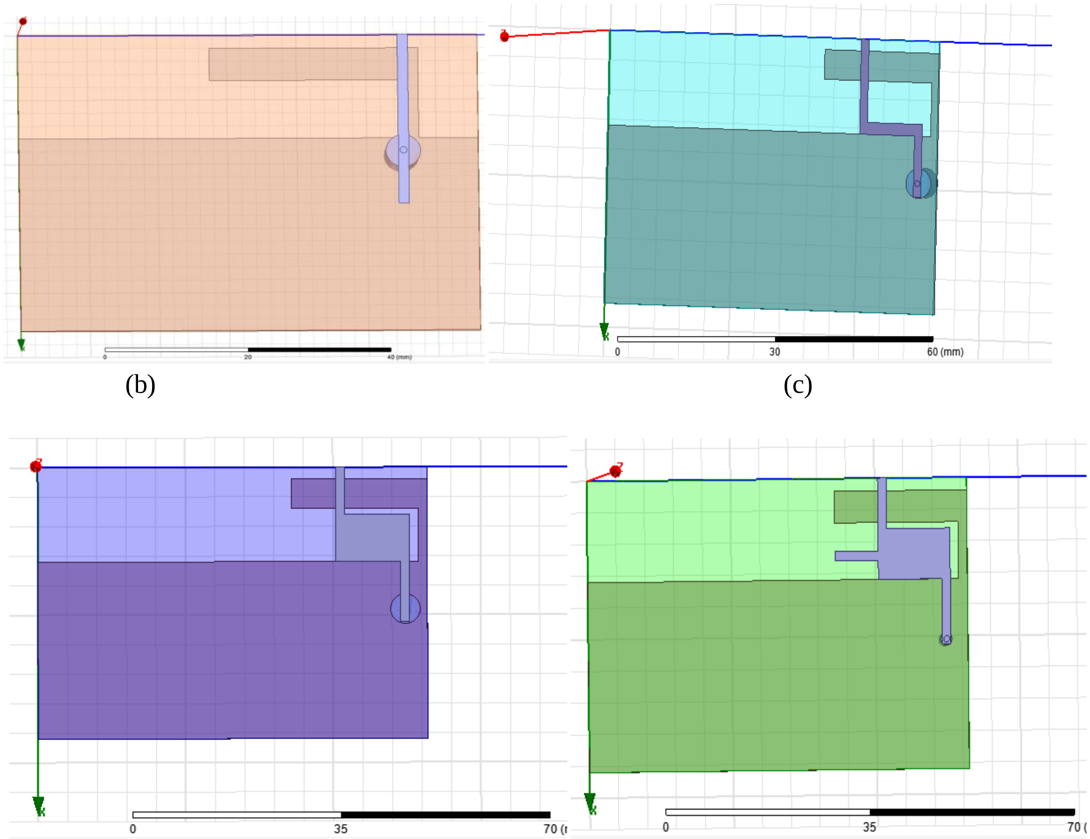


(b) (c)

(d) (e)

Fig 1. Four types of open slot antennas (a)Type 1 (b) Type 2 (c) Type 3 (d) Type 4 (e) Type 5

In figure 1(b) when the radiator is moved to the right side with a straight feeding line the antenna resonated at 2.6 GHz 6.7GHz In addition to the original resonate mode another mode is exited which is determined by the feeding line.

In figure 1(c) type 3 bent feeding is applied and this structure provided two resonant modes at 2.8 GHz and 4.9 GHz.

In figure 1(d) shorted circuit (patch) near the feeding line is formed as the horizontal segment of bent feeding line provide the phase difference of 90 degrees between horizontal and vertical electric fields which is required for circular polarization. With the addition of patch the antenna exited at the two low frequencies resonant at 2.6 GHz and 4.9 GHz. It is provided further wide impedance band width..

In figure 1(e) an additional short circuit finger shaped strip at the vertical bent is inserted and this made the antenna to resonate from 1.3 GHz to 5.3 GHz. The high impedance of the open slot is compensated by the patch. In the proposed structure finally one more shorted circuit parallel to the type 5 slot antenna is inserted which made the antenna to resonate 1.5GHz,3.5 GHz and 5 GHz. This design provides an impedance bandwidth from 1.3 GHz to 5.3 GHz

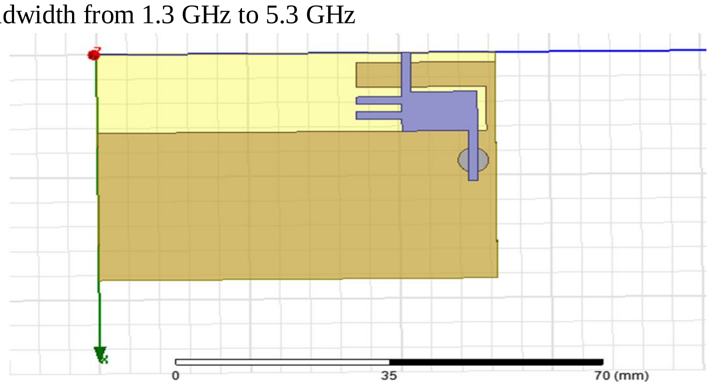


Fig 2 Proposed open slot antenna design

The proposed structure and its geometry is shown in figure 2, Table 1 shows the optimized geometrical parameters of proposed antenna.

Table I: optimized parameters for proposed antenna

Parameter	mm	Parameter	mm
Lg	30	Wg	66
Lf	10.25	Wf	1.5
L1	9	W1	1.5
L2	5	W2	1.5
L3	2	W3	23
L4	8	W4	11
L5	4.5	W5	7.5
L6	1.5	W6	7.5
L7	8	L8	1.5

III.RESULTS AND DISCUSSIONS

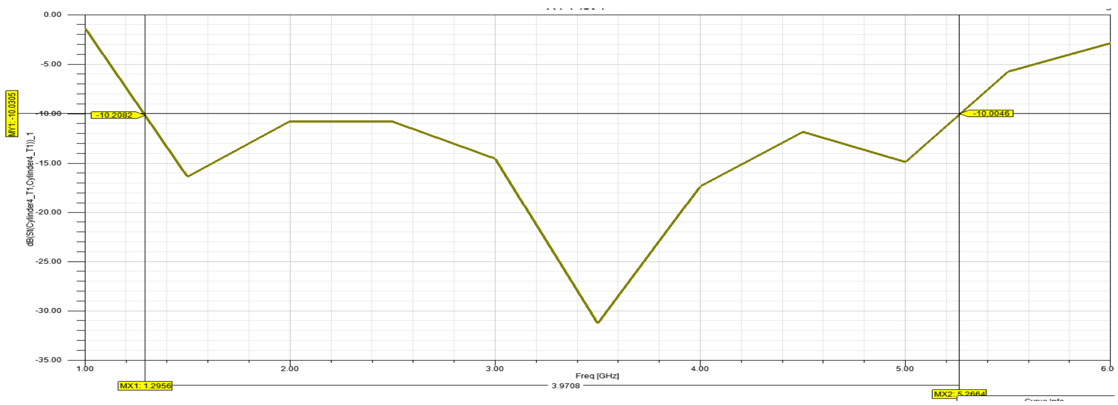


Fig 3. S11 of proposed antenna

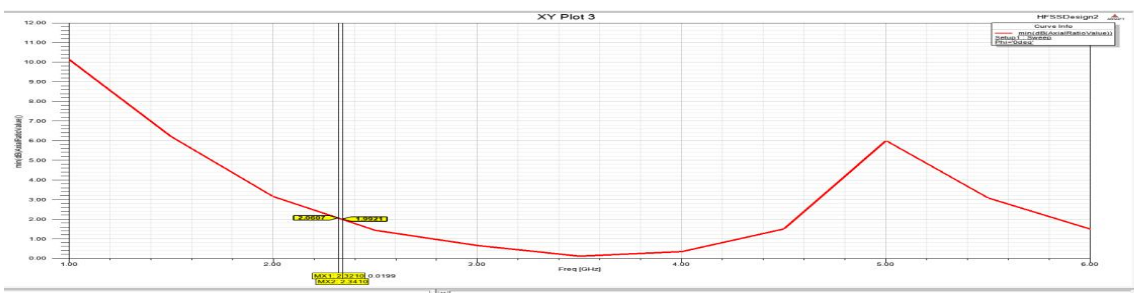


Fig 4. Axial Ratio of proposed antenna

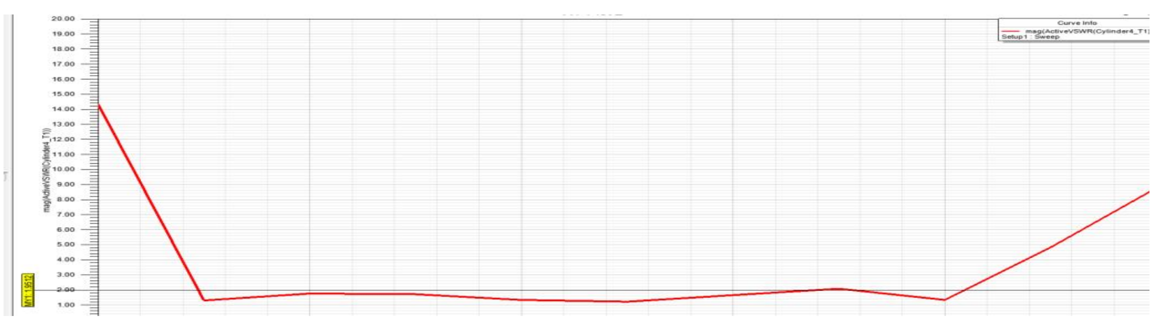


Fig 5. VSWR of proposed antenna

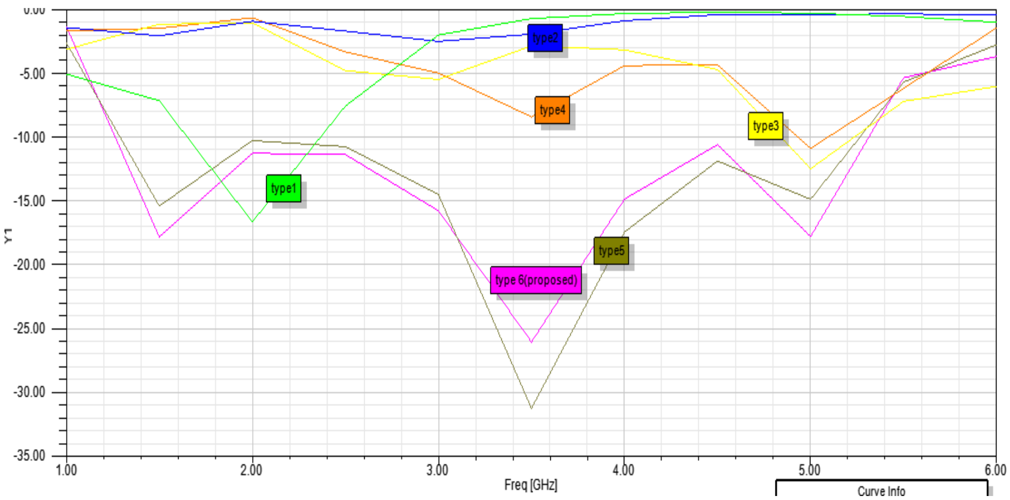


Fig 6 Comparison of S11 for Type 1,2,3,4,5 and proposed antenna

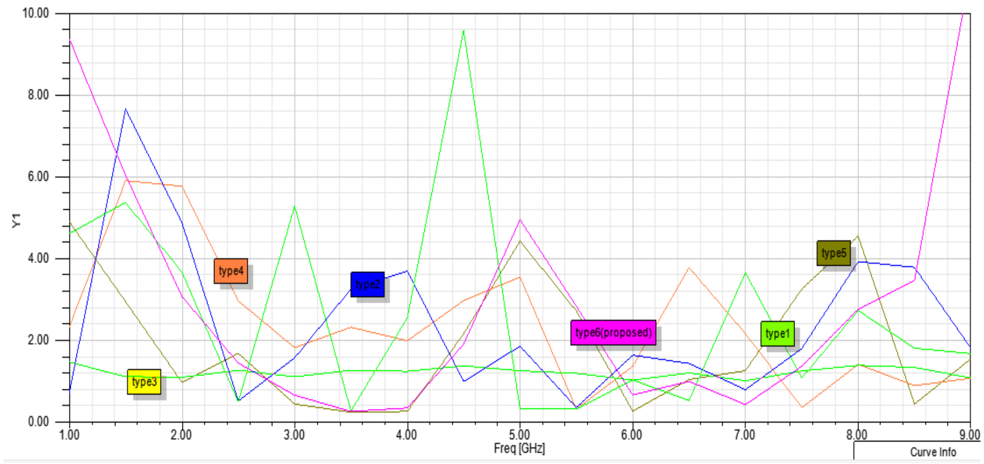
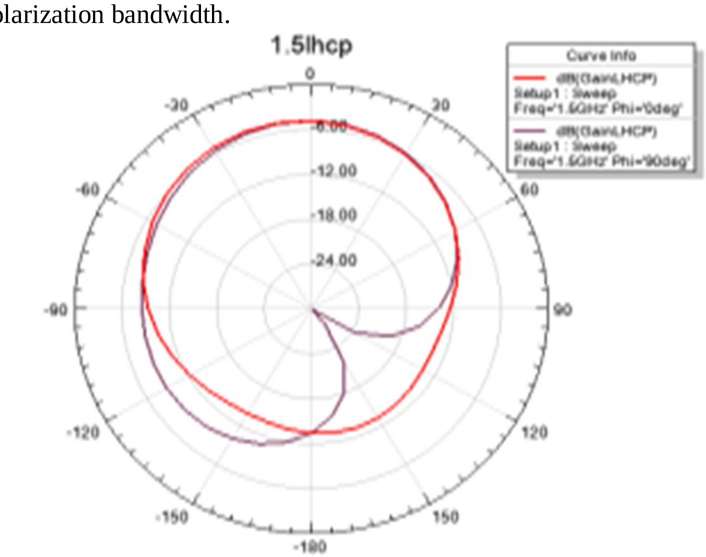
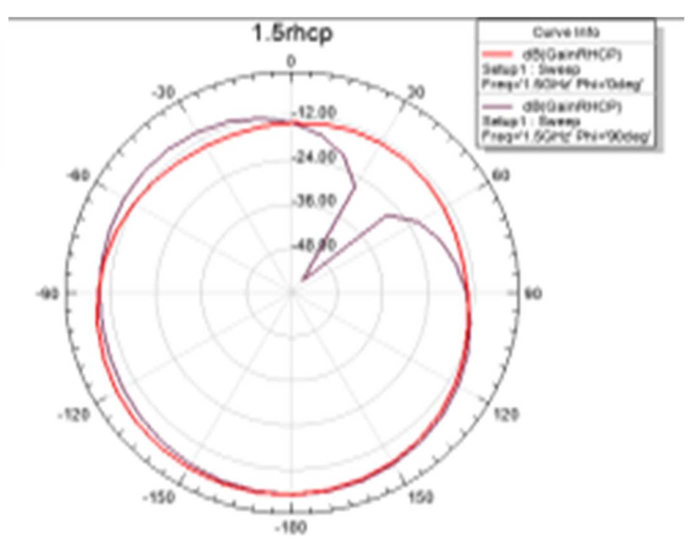


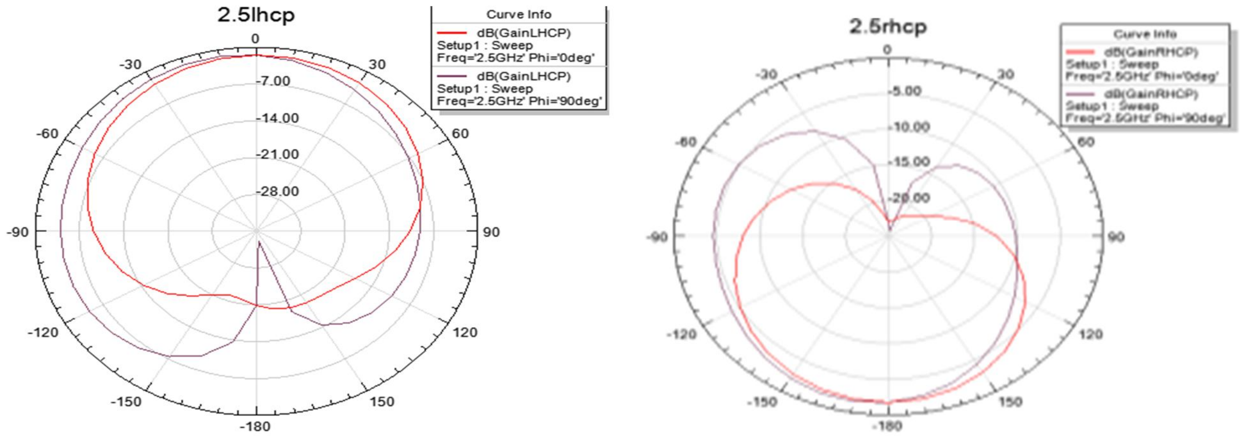
Fig 7 Comparison of Axial Ratio for Type 1,2,3,4,5 and proposed antenna

It is clearly noticed from the above comparison plots that the proposed design provides improved impedance bandwidth and circular polarization bandwidth.

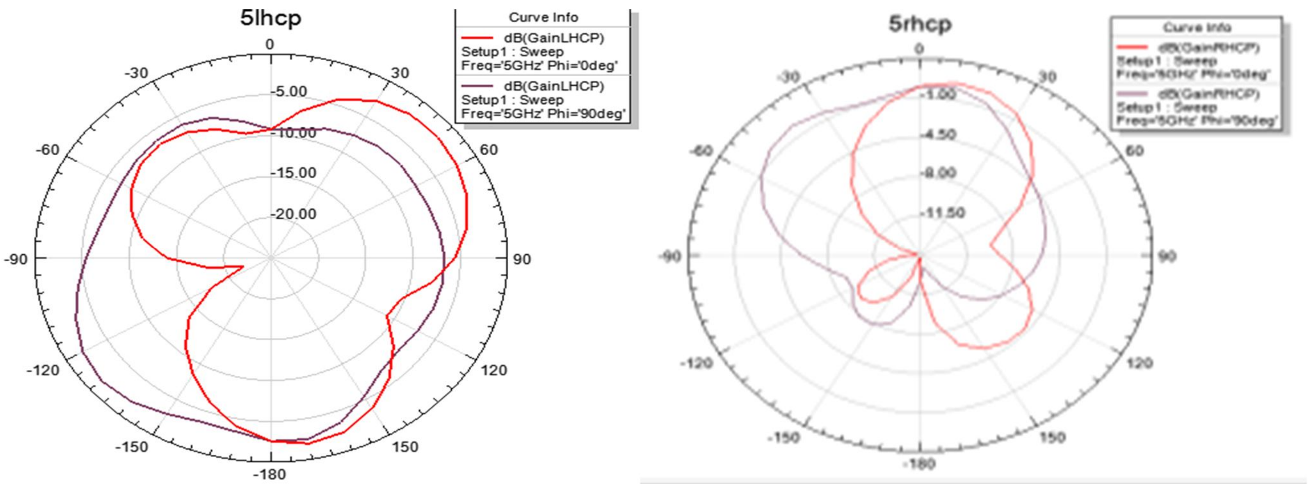




LHCP at 1.8 GHZ (a) RHCP at 1.8 GHZ



Lhcp At 2.3 Ghz (B) Rhcp At 2.3 Ghz



LHCP at.5.2 GHZ (c) RHCP at 5.2 GHZ

Fig 8 Radiation Pattern of proposed antenna at 1.5GHz, 2.3 GHz, 5.2GHz

Fig.8. shows the simulated radiation patterns in two principal planes,(i.e.) xz and yz planes, at the six operating frequencies (1.80, 2.33, and 5.20 GHz) utilized in the DCS, SDAR, and Wi-Fi systems. The radiation patterns at 1.80 GHz resulted from the fundamental mode. The radiation patterns at 5.20 GHz are butterfly-like structure due to the excitation of the harmonic mode. It is noted that Fig 8(b) is the normalized CP radiation patterns at 2.33 GHz for the application of the SDAR system. The polarization of the proposed open-slot antenna is left-hand circular polarization (LHCP).

IV. CONCLUSIONS

The proposed open slot antenna with wide impedance bandwidth and broad circular polarization band width is achieved with inserting two finger strips and a patch loaded feeding line. The proposed structure has 3 dB axial ratio from 2 to 4.7 GHz (i.e.) 83.07% and impedance bandwidth of 4GHz (i.e.) from 1.27 GHz to 5.27 GHz(i.e)76%. The proposed antenna aims to be used by SDAR (satellite digital audio radio).

V. ACKNOWLEDGMENT

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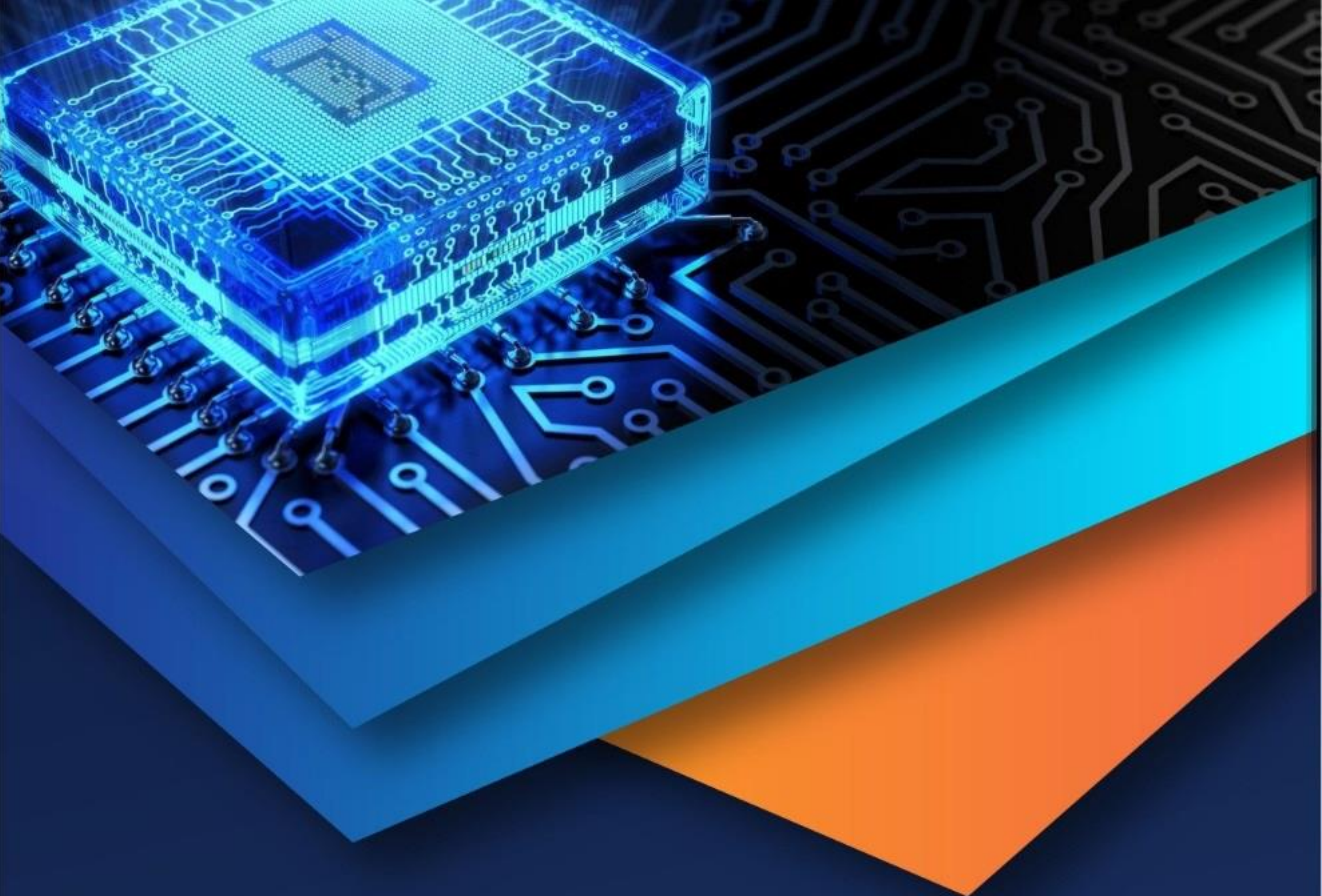

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