iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 5 **Issue:** XI **Month of publication:** November 2017

DOI: http://doi.org/10.22214/ijraset.2017.11111

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor:6.887
Volume 5 Issue XI November 2017- Available at www.ijraset.com

Design And Analysis of 5g Antennas For Mobile Applications

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Abstract: This paper shows the comparison in two designs i.e. L shape and u shape of millimeter wave (mm-wave) array antenna. L shape antenna has two identical sub arrays having four patches in each array whereas u shape antenna has three identical sub arrays with four patch on each array arranged along the edges of the mobile phone pcb, both have been designed by neltecny9220 material with dielectric constant (ε_r) 2.2 and loss tangent (tanδ) 0.0009 has an array size of 48x12x0.787 mm3 .proposed geometry is operating at a frequency of 21.5 ghz with a patch size of 4.32 x 2 mm2. This proposed geometry improves the return loss (s_{11}) and other parameters. Coaxial technique is used for feeding .for this simulation hfss v11.0 is used.
Keywords: 5g; return loss (s_{11}); patch antenna; hfssv11.0.;coaxial feeding

I. INTRODUCTION

With the increase in 4G deployment demands for higher data rates, low cost, better connectivity, unprecedented growth in the connected devices we look for the development of another generation which can provide us with the above requirements i.e. 5G . The major issue with 5G technology is that there is such an enormously wide variation in the requirements: superfast downloads to small data requirements for IoT than any one system will not be able to meet these needs. Accordingly a layer approach is likely to be adopted. Every layer has its own significance and is dependent. One such layer discusses the development of antennas which are capable of forming highly directional beams which are capable of being steered according to the requirement. II section of this paper deals with the development 3 D coverage phased array L shape and U shape antenna for 5G wireless systems. Proposed designs show the switching characteristics of the antenna packages to select the desired area of coverage with high gain beams [3]. The proposed antenna package operates at 21.5 GHz which is one of the candidate bands for 5G mobile communication. This proposed package consists of three sub arrays of microstrip antennas. Each of the sub arrays in both the designs is steerable in scanning range of -90° to 90° (Theta plane)[2] as shown in Fig.1 .III section of this paper deals with the comparison of the results of the proposed design i.e. S- parameter, VSWR, radiation pattern and polar plot.

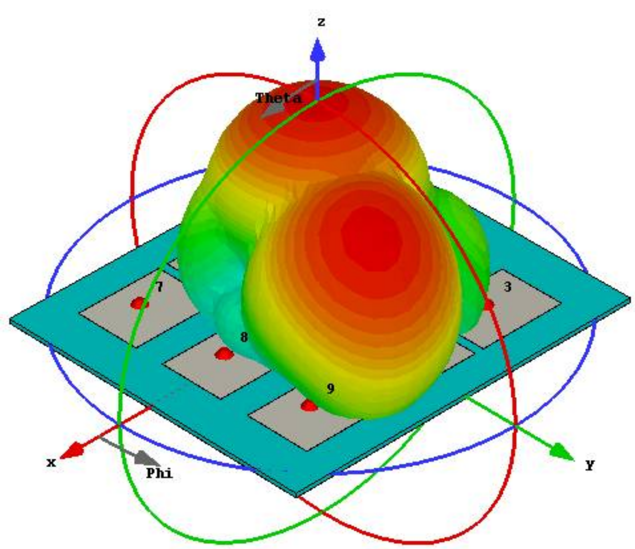

Fig.1. Radiation pattern of proposed 5G antenna package.

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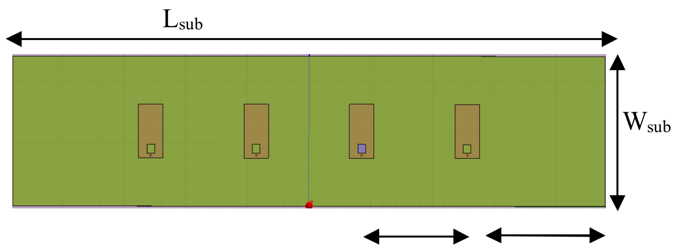
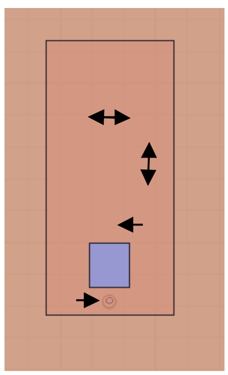
II. DESIGN PROCEDURE AND RESULTS

The designs proposed in this paper have two shapes i.e. L shape array antenna and U shape array antenna .These designs are compared with the reference design which is a single array antenna having four patches as shown in Fig.2.



(a)



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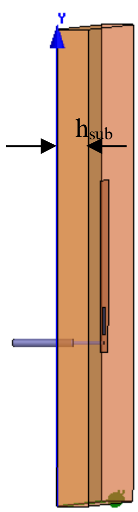

(c)

Fig.2(a) shows the top view,(b) shows the slot cut from patch and diameter of coaxial feed,and(c) shows the side view of proposed designs.

Each array consists of four patches and every patch has slot cut from it. The center to center distance between the elements (d) is approximately half of wavelength where operating frequency(f_r) is 21.5 GHz.

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The proposed antenna is designed on the Neltec NY9220 (IM) substrate with the thickness (h_{sub}) of 0.787,dielectric constant (ε_r) 2.2 and loss tangent(δ) 0.0009.

A. Equations

1) The width of the MSPA

$$W = \frac{c}{2*fr\sqrt{\varepsilon_r +}} \qquad (1)$$

2) *Effective dielectric constant (ε_{reff})*

$$\varepsilon_{reff} = \frac{\varepsilon_r}{} + \frac{\varepsilon_r - 1}{2}\sqrt{1+1} \qquad (2)$$

3) *Effective length*

$$L_{eff} = \frac{c}{2*fr\sqrt{\varepsilon_r}} \qquad (3)$$

4) *The length of extension*

$$\Delta L = \frac{c}{2*fr\sqrt{\varepsilon_r}} \qquad (4)$$

5) *Actual length of the patch is*

$$L = L_{eff} - 2\Delta L \qquad (5)$$

Equations [1] shown above (1), (2), (3), (4) and (5) are used to calculate various parameters as shown in Table I.

Table i. Antenna parameters of 5g applications

Parameter	L_{sub}	W_{sub}	h_{sub}	D
Value(mm)	48	12	0.787	6.5
Parameter	L_{slot}	W_{slot}	W_1	d_1
Value(mm)	0.625	0.7	0.2	10.175

B. Designs

1) *Single array antenna*

Proposed single array antenna consists of four patches with slots cut from each patch as shown in Fig.3.

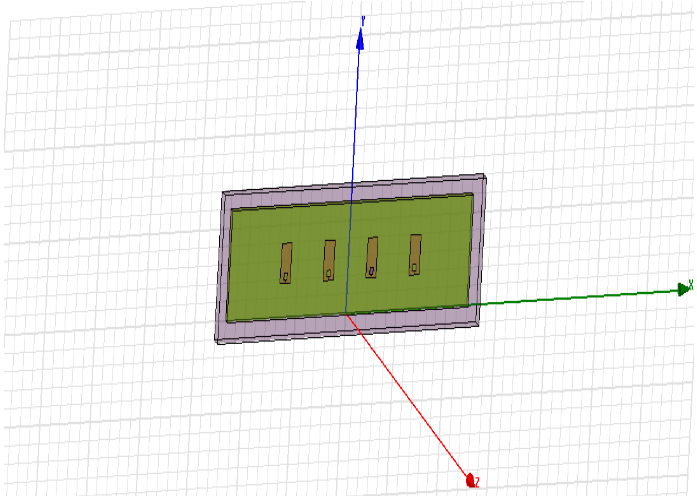

Fig.3.Proposed single array antena for 5G mobile-phone.

Proposed antenna is fed with coaxial feeding technique. After simulation proposed antenna gives acceptable return loss i.e. less than 10 dB as shown in Fig.4.

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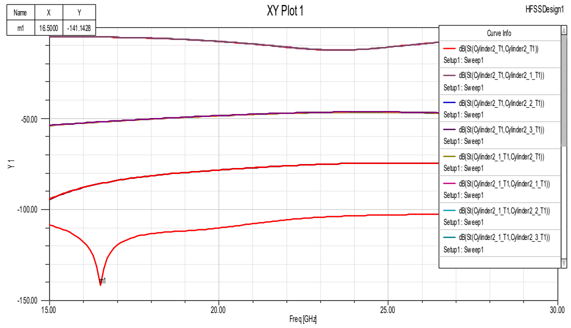


Fig.4. S_{11} of single array antenna.

Fig.5 shows the VSWR of the proposed single array antenna.

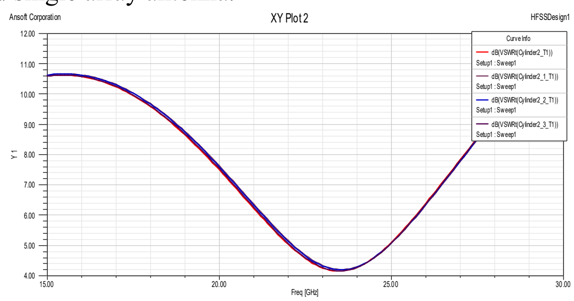
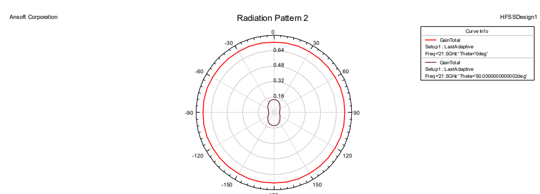


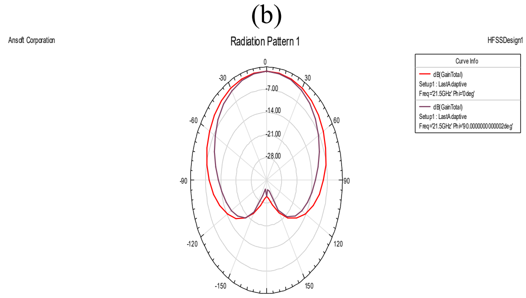
Fig.5. VSWR of proposed single array antenna.

Fig.6(a) shows the polar plot. Fig.6(b) and (c) illustrates the radiation patterns in theta and phi planes respectively at $0^0$and 90^0 scanning angle at 21.5GHz of proposed single array antenna.

(a)



(b)



(c)

Fig. 6(a) shows the polar plot,(b) shows the radiation pattern in theta plane, and(c) shows the radiation pattern in phi plane.

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2) L shape antenna array

Proposed L shape antenna array consists of two sub arrays with four patches on each array. Design have slot cut from each patch as shown in Fig.7.

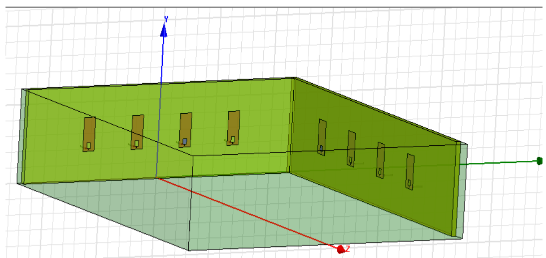


Fig.7.Proposed L shape antenna array.

Simulation gives the return loss as shown in Fig.8.

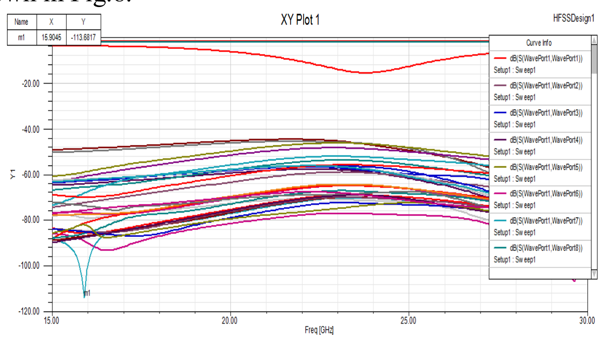


Fig.8. S_{11} Proposed L shape antenna array.

Fig.9 shows the VSWR of propsed L shape antenna.

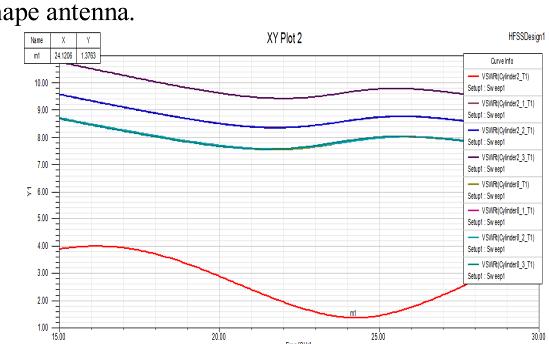
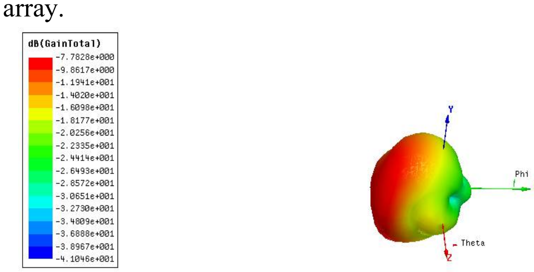


Fig.9 Shows the VSWR of L shape antenna array.

Fig.10 (a) shows the polar plot whereas Fig.10 (b) and (c) shows the radiation pattern in theta and phi planes at 0^0 and 90^0 scanning angle of L shape antenna array.



(a)

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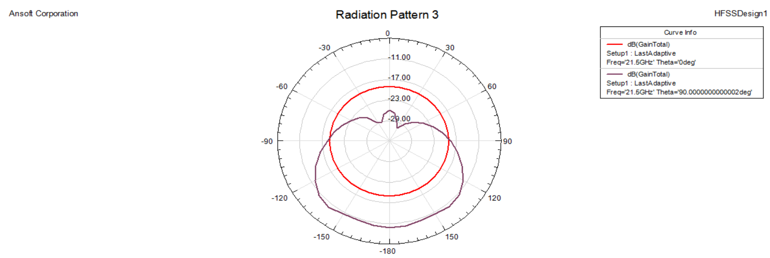

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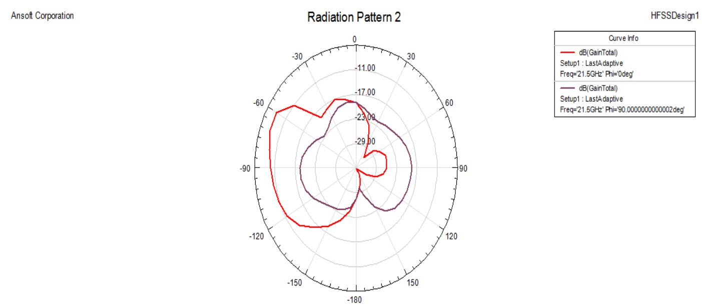


(c)

Fig.10 (a) Polar plot,(b) Radiation pattern in theta plane and,(c)Radiation pattern in phi plane of proposed L shape antenna array.

3) U shape antenna array

Proposed U shape antenna array consists of three sub arrays having four patches on each array with a slot cut from each patch at 21.5 GHz as shown in Fig.11.

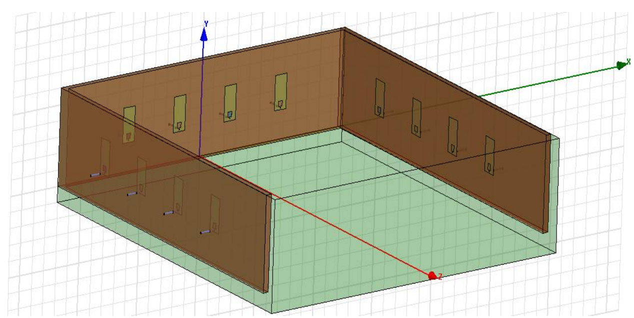


Fig. 11 Shows the proposed design of U shape antenna.

Fig.12 illustrates the return loss.

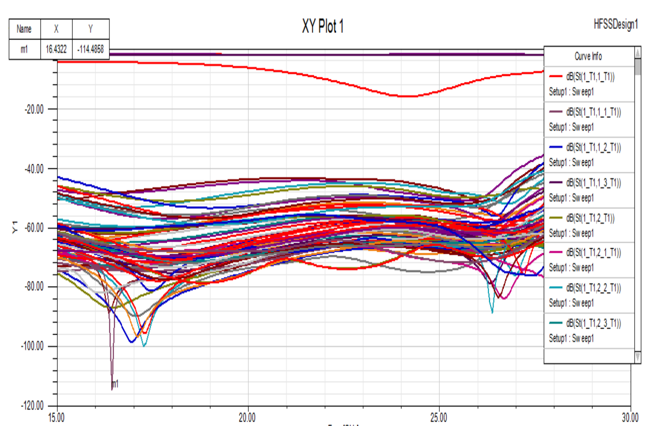


Fig.12 $S_{11}$of proposed U shape antenna.

Fig.13 illustrates the VSWR of proposed U shape antenna array.

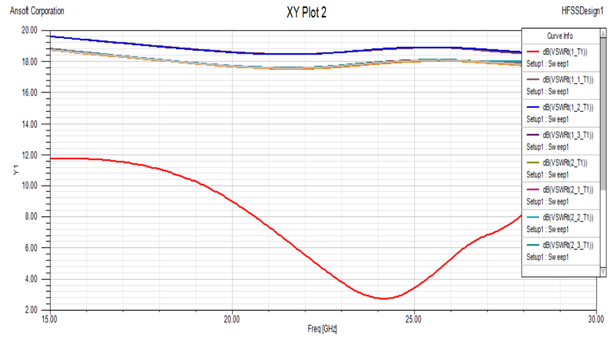
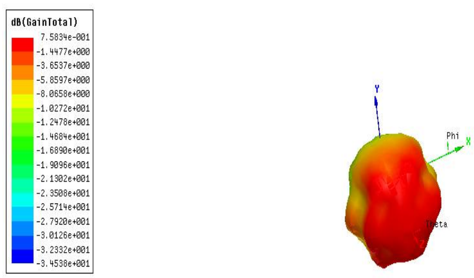
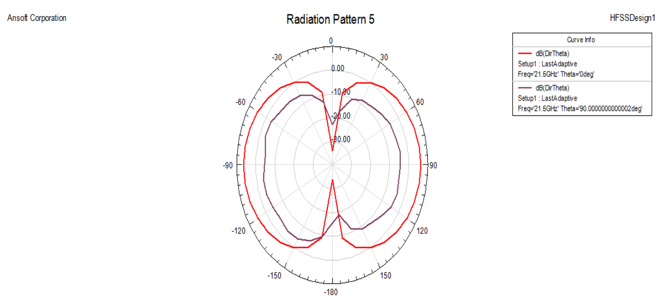


Fig.13 Shows the VSWR of U shaped antenna array.

Fig.14(a) illustrates the Polar plot whereas the Fig.14(b) and (c) illustrates the radiation patterns at 0^0 and 90^0 scanning angles of U shape antenna array .



(a)



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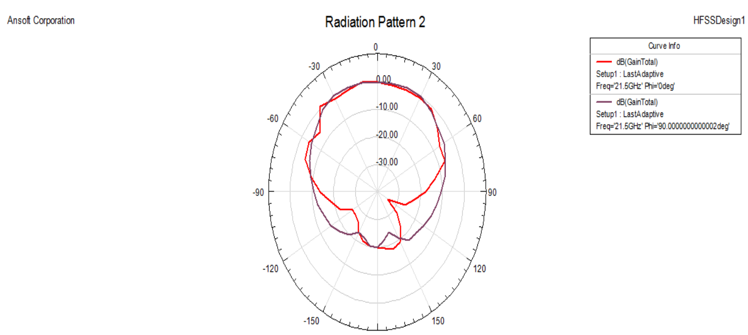

(c)

Fig.14(a) illustrates Polar plot, (b) illustrates the radiation pattern in theta plane and, (c) illustrates the radiation pattern in phi plane for U shaped antenna array at 21.5GHz.

III. COMPARISION

Various designs gave different results of antenna parameters on simulation at 21.5GHz which makes them suitable for 5G mobile-phone applications as shown in Table II.

TABLE II.RESULT OF ANTENNA PARAMETERS

Designs	Antenna parameters	
	S_{11}	*VSWR*
Single array	-141.142	4.321
L shape antenna array	-113.681	1.367
U shape antenna array	-114.485	2.766

IV. CONCLUSION

This paper proposed designs for 5G mobile-phone antenna at 21.5 GHz of frequency.Their S_{11}, VSWR, polar plots and radiation patterns showed that they can be used as 5G antennas. In future these antenna designs can be applied with phase shifters so that beam can be steered itself as the user moves [2].This will help to achieve peak data rate and high gain beams from various directions[4].

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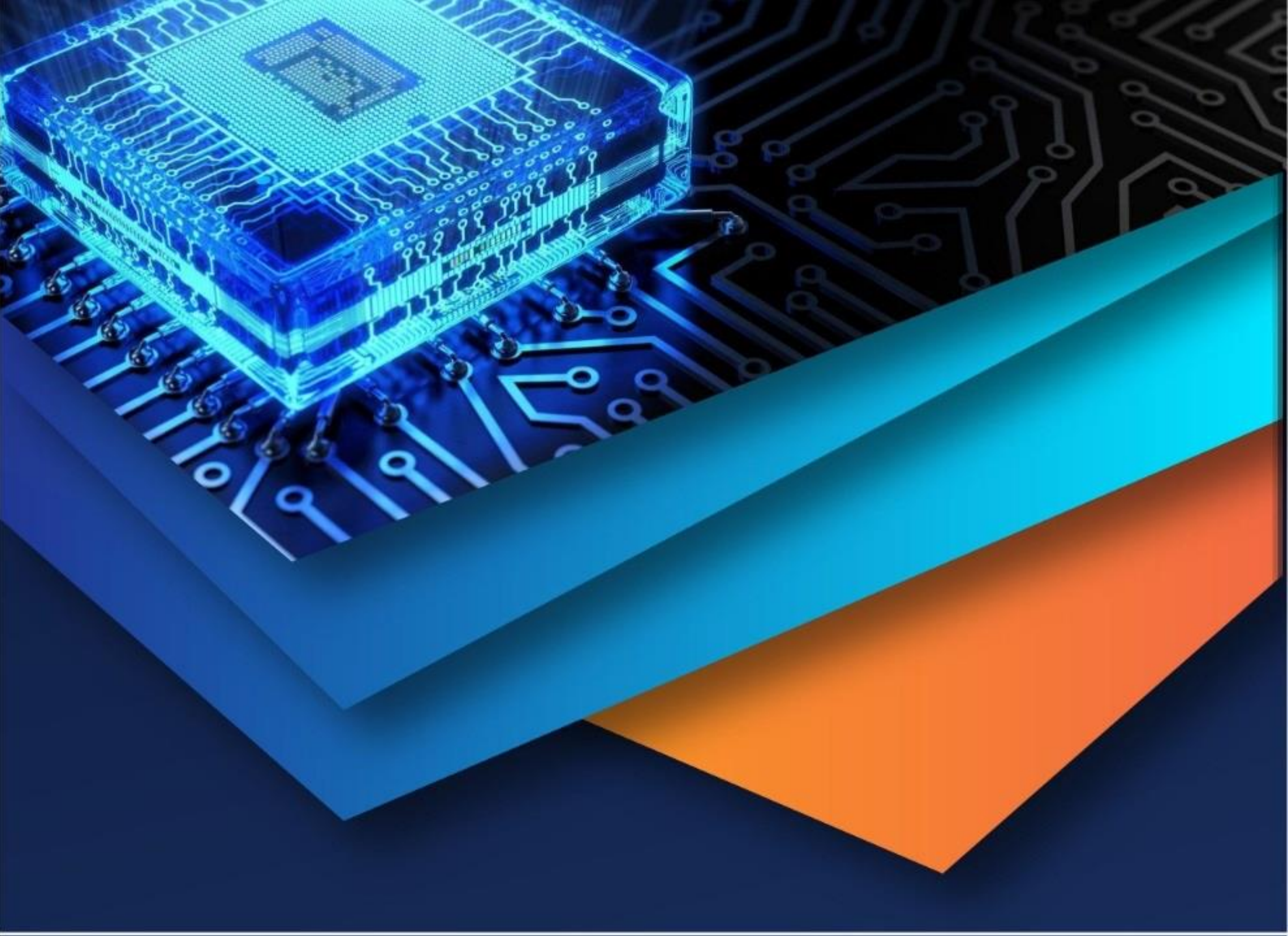

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