iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 6 **Issue:** III **Month of publication:** March 2018

DOI: http://doi.org/10.22214/ijraset.2018.3422

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue III, March 2018- Available at www.ijraset.com

Design of Triband Vivaldi Antenna for UWB Application

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Abstract*: A tapered slot Vivaldi Antenna with Microstrip feed which can operate in the triband regions of Ku - 12.4-18 GHz , K - 18 - 26.5 GHz , Ka - 26.5-40 GHz is proposed with compact design structure. Our antenna can operate in 5 different frequencies at 13.3 / 18 / 23.4 / 27.9 / 31.8 GHz with bandwidth of approximately 1 GHz and each frequencies has its own applications in Radar / Geostationary satellite / Fixed microwave application / Geostationary satellite, Local multipoint TV distribution / Wi-MAX. The proposed design of of 2.3 x 1cm size with a microstrip feed of 0.5mm is simulated in the CST (Computer Simulation Technology) Studio Suite 2016. Thus a single triband antenna which can be used for various ultra wideband applications was proposed.

Keywords: Vivaldi, Wi-MAX, 5G bandwidth, Triband antenna, K band, Ka band, Ku band.

I. INTRODUCTION

In the fast growing technological world, 5G will come into existence in few years. For this, an efficient antenna in which more data transmission could be possible has to be designed. Vivaldi antenna is completely suitable for Radar and 5G communication due to its large availability of bandwidth. It is an Extremely high frequency (EHF) band in the range 30GHz to 300GHz used in advanced long distance communication systems, high resolving radars, remote sensing (weather analysis) and 5G. Vivaldi antenna is widely applied because it has high gain due to its tapered slot design. They can actually fit into much smaller spaces as they are made out of flat laminates. These days, many designs of Vivaldi antennas are proposed for different types of applications. We have made our own advancements so that it is used for ultra wideband applications. antenna design that is compact in structure and triband. The design is simple compared to log periodic antennas and fractal designs. And all antenna designs can be scaled for use at any frequency. Impedance matching is also easy with this type of antenna. In our work, we presented a concept of designing antenna that can work at 13.3 / 18 / 23.4 / 27.9 and 31.8 GHz with an Impedance bandwidth of approximately 1GHz for wireless network applications. This triband antenna is achieved by designing in the CST (Computer Simulation Technology) Studio Suite 2016 and the simulated results obtained satisfies the antenna to operate for radar, geostationary satellite, fixed microwave applications with local multipoint TV distribution and future requirements of Wi-MAX and 5G application .

II. ANTENNA DESIGN AND GEOMETRY

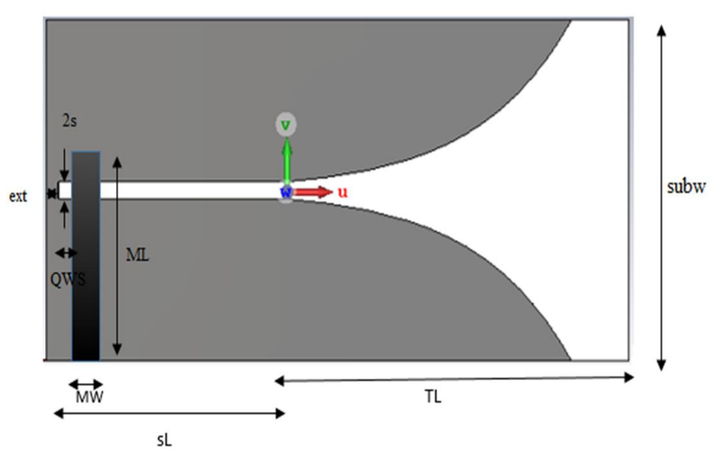

Fig. 1 Geometry of Vivaldi antenna including design parameters

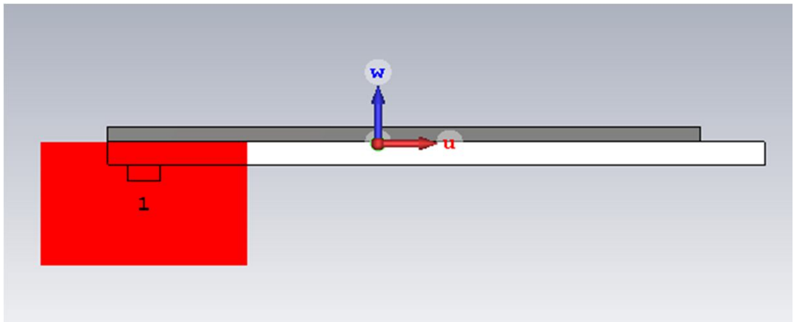

Fig.2 Designed antenna with port selection

The proposed design of the Vivaldi antenna consists of a patch, substrate and a microstrip feed line. The top layer or the patch is made up of PEC (Perfect Electric Conductor) with a thickness of 0.5mm. PEC is an idealized material exhibiting zero resistivity. The substrate used here is Taconic RF-60A, a dielectric material, with a relative permittivity of 6.15. It extends upto 0.733mm of thickness. Taconic is preferred over FR-4 because of its less dielectric loss and that it can be used at higher frequencies. The bottom layer or the microstrip feed line uses the same material as that of the patch with the same thickness. The antenna shown in Fig 1. is designed using the CST software and its parameters list is shown in Table 1.

Parameter	Dimension(mm)
s	0.25
r	0.3
sL	10
TL	12
subw	10
ext	0.4
h	0.733
MW	1
QWS	0.75
QWM	0.9

Table 1. Design parameters for the Vivaldi antenna

III. ANALYSIS OF THE PROPOSED ANTENNA

The s-parameter obtained after simulation is analysed. Fig 3. shows that the proposed design has an impedance bandwidth of approximately 1GHz with multiple dips. This antenna can operate simultaneously at 13.2 / 17.9 / 23.4 / 27.9 and 31.8GHz of frequencies respectively. The simulated output is shown below in the figure.

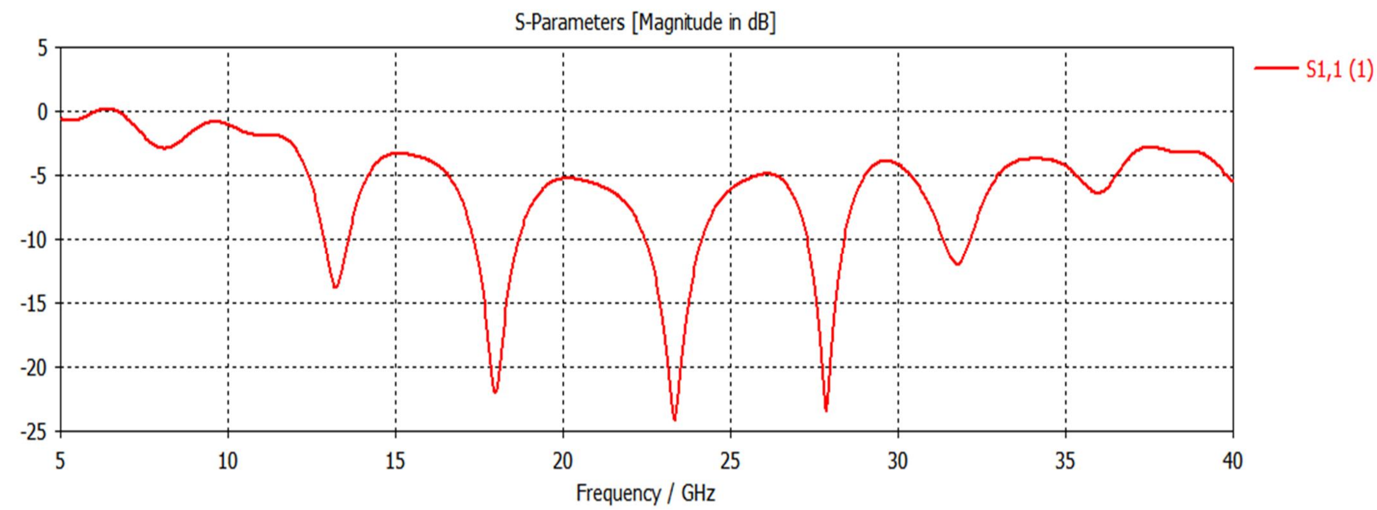

Fig.3 S-Parameter

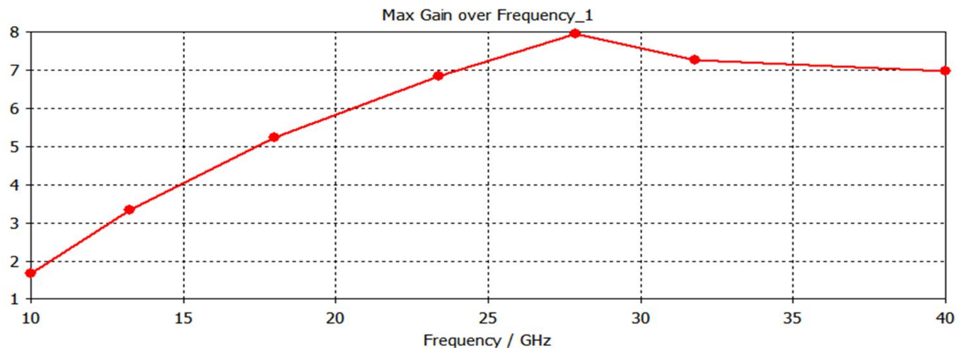

Fig 4. Maximum gain over frequency

Fig 3 shows that the antenna is triband and thus single device can be used for various different applications. The triband antenna is also easy to integrate with switching devices and control circuits. Losses can also be reduced as data can be sent through different bands simultaneously. The relation between the input and the output terminals or ports is analysed by the S-Parameter. Fig 4 show that the gain is maximum during that impedance bandwidth. Return loss determines the magnitude of reflected power from the antenna if its 0dB then the power is reflected and there is no radiation in the antenna. Here the return loss is not 0dB hence the antenna is radiating the incoming power. Here the antenna has five different resonant frequencies. The radiation pattern and its far-field results of all the resonant frequencies are shown in fig 5.

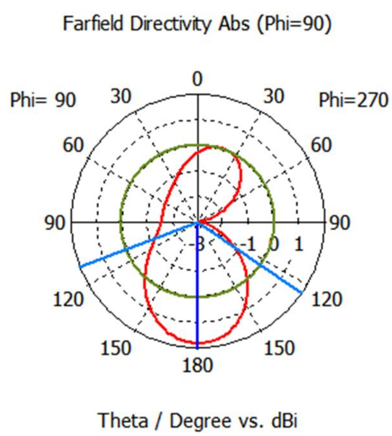

Fig 5.Farfield directivity plot at 13.2GHz

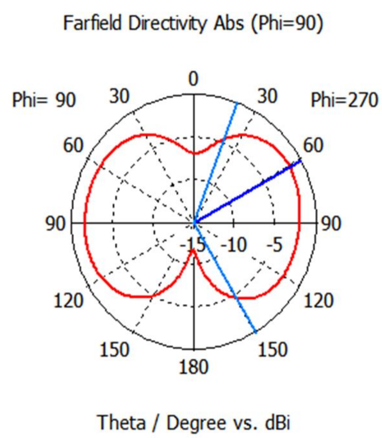

Fig 6.Farfield directivity plot at 17.9GHz

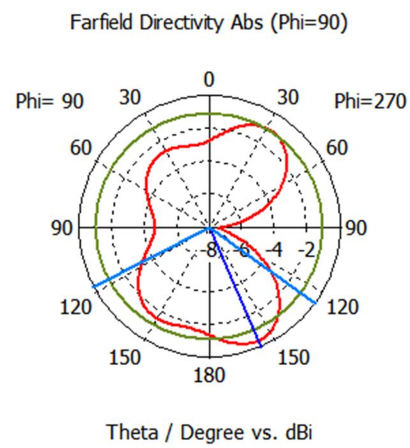

Fig 7.Farfield directivity plot at 3.4GHz

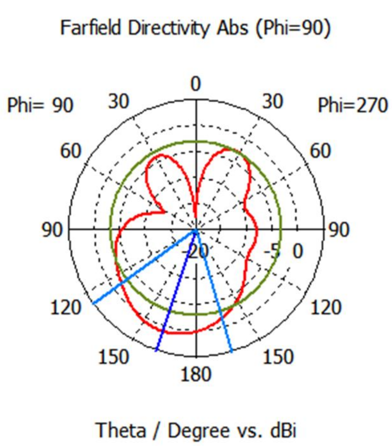

Fig 8.Farfield directivity plot at 27.9GHz

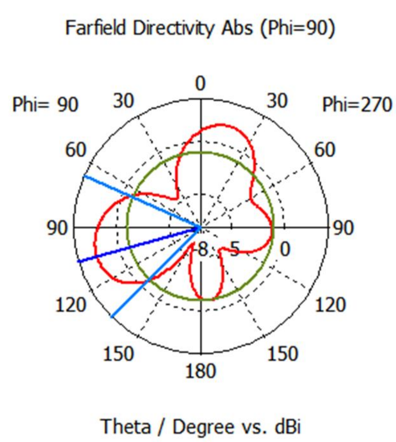

Fig 9.Farfield directivity plot at 31.7GHz

Fig 5 to Fig 9 shows the far-field directivity plots at all the resonant frequencies. The values of the far-field results are given below.

Parameters	13.2GHz	17.9GHz	23.4GHz	27.9GHz	31.7GHz
Main lobe Magnitude	1.78 dBi	-1.63 dBi	-0.453 dBi	0.978 dBi	2.12 dB
Main lode direction	180.0 deg	61.0 deg	157.0 deg	162.0 deg	106.0 deg
Angular Width (3dB)	124.0 deg	128.7 deg	117.2 deg	70.3 deg	69.2 deg
Side lobe level	-1.7 dB	-	-0.6 dB	-4.1 dB	-3.1 dB
Radiation Efficiency	-0.5242 dB	-0.3229 dB	-0.3789 dB	0.6201 dB	-0.7470 dB
Total Efficiency	-0.7078 dB	-0.3504 dB	-0.3971 dB	-0.6410 dB	-1.030 dB
Directivity	3.869 dB	5.563 dB	7.213 dB	8.56 dB	8.024 dB

Table 2. Farfield results at resonant frequencies

The radiation pattern of the designed antenna is shown in 3-D model diagram.

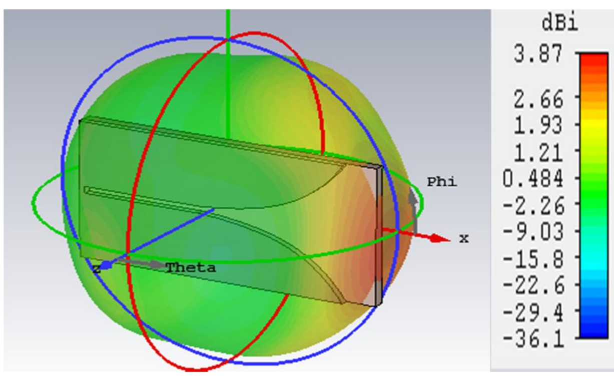

Fig 10.Radiation pattern at 13.2GHz

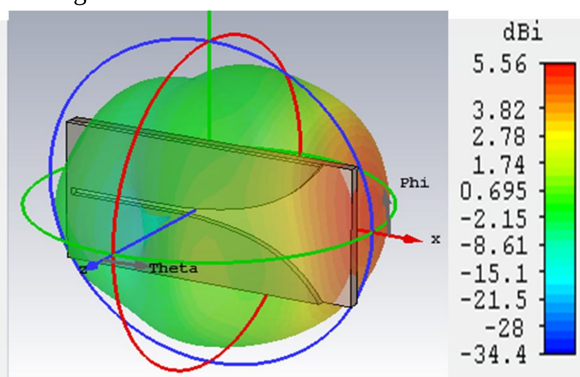

Fig 11.Radiation pattern at 17.9GHz

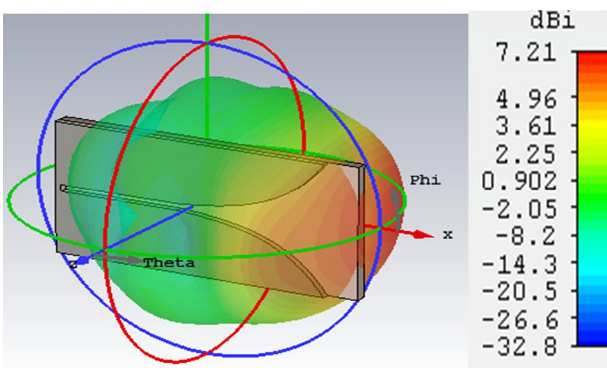

Fig 12.Radiation pattern at 23.4GHz

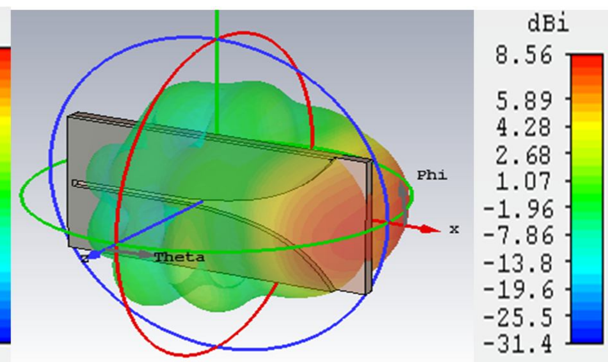

Fig 13.Radiation pattern at 27.9GHz

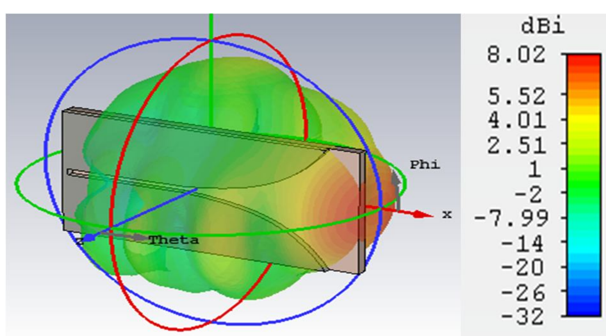

Fig 14.Radiation pattern at 31.7GHz

Fig 10 to fig 14 gives the radiation pattern of the designed antenna at the resonant frequencies. All the above figures have maximum radiation in the x-direction indicating that the antenna is radiating effectively through the tapered slot. It is clearly found that there is no back radiation and hence the antenna radiates all the power that is fed as input. The directivity is maximum at 27.9GHz holding a value of 8.56dB. Fig 15. shows the VSWR curve obtained after the simulation of the proposed antenna.

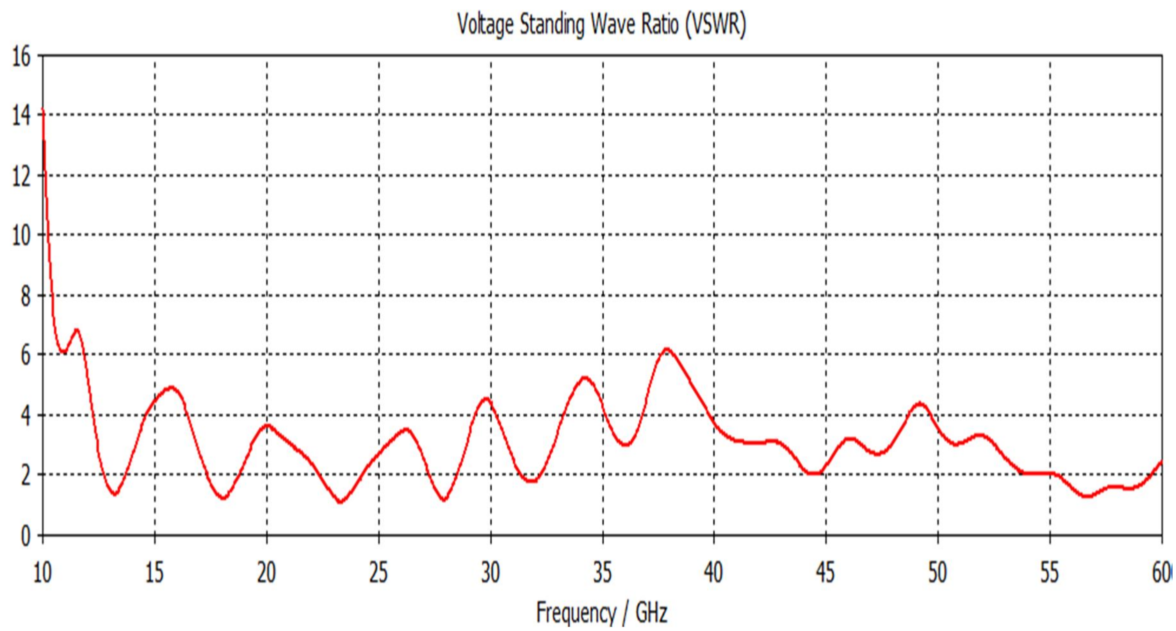

Fig 15. Voltage Standing Wave Ratio (VSWR)

A VSWR value of less than 2 is achieved after the simulation. It shows that the reflected power is less than 10% and more than 90% of the incoming power is radiated from the antenna. Thus the proposed antenna is radiating efficiently at those operating frequencies.

IV.CONCLUSION

Thus a compact triband Vivaldi antenna for the use in high frequency Wi-MAX applications, radar, geostationary satellite applications with a gain of about 3.87- 8.02dBi has been designed. The tapered slot Vivaldi antenna, made of PEC material, is designed on a Taconic substrate of thickness 0.733mm. The designed antenna operates across the 5 different frequencies of at 13.2 / 17.9 / 23.4 / 27.9 and 31.8GHz with bandwidth of approximately 1GHz, where the bandwidth varies for different frequencies. Thus the triband antenna working within Ku - 12.4-18 GHz , K - 18 - 26.5 GHz , Ka - 26.5-40 GHz ranges with wide bandwidth is achieved, where a large amount of information could be transferred without any prolonged delay for various applications. Also, the efficiency of the designed antenna is obtained in the range of 90- 94.8%. These advantages makes the improved Vivaldi antenna valuable in many future wireless communication applications.

V. ACKNOWLEDGEMENT

We express our sincere thankfulness to our Project Guides Dr. D. Selvaraj and Mrs. R. Priyadarshini for their successful guidance to our project. Without their help it would be a tough job for us to accomplish this task. We thank our guide for their consistent guidance, encouragement and motivation throughout our period of work. We also thank our Head of the Department (ECE) Dr. P. Kannan for providing us all the necessary facilities.

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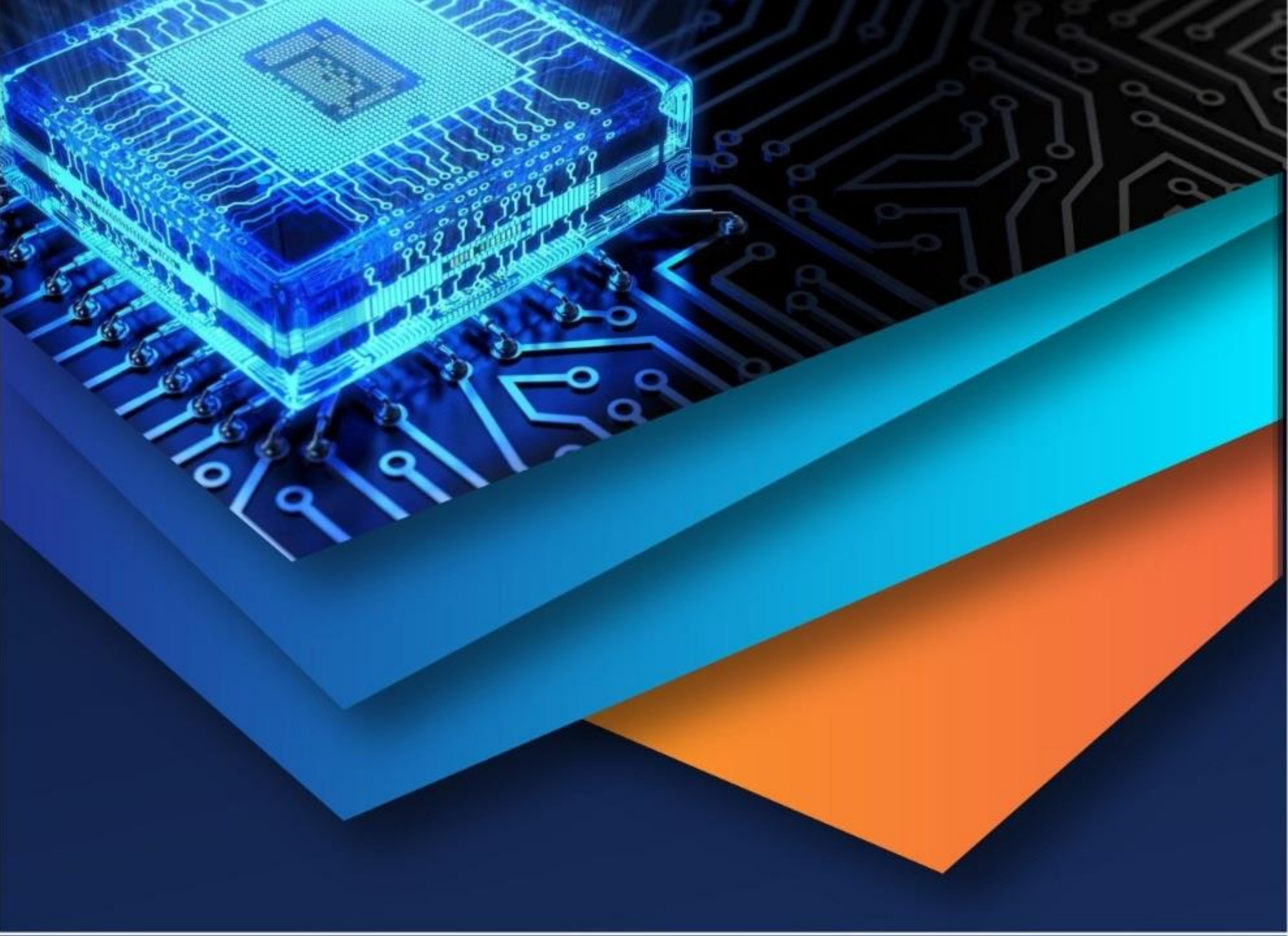

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