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# Design of Flexible Antenna Array for Early Diabetic Foot Detection

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***Abstract: Diabetic foot ulcers are the common complication of poorly controlled diabetes, forming as a result of skin tissue breaking down and exposing the layers underneath. The paper deals about designing the flexible array antenna for diagnosing the diabetic foot in the early stage itself which will reduce future complications .To design the antenna we use ADS software and the antenna parameters such as gain, radiation pattern, directivity in different frequency can be analyzed with the use of software itself.***

## I. INTRODUCTION

Diabetic foot ulcers are the common complication of poorly controlled diabetes, forming as a result of skin tissue breaking down and exposing the layers underneath .There are several problems with current practices in detecting diabetic foot ulcers. A clinician wound assessment process is based on visual examination. He/she describes the wound by its physical dimensions and the color of the tissues, providing important indications of the wound type and the stage of healing. The visual assessment does not produce objective measurements and quantitative parameters of the wound. Though there are many techniques in the modern civilian and industrial automated environments like MRI, Gallium scan etc…they are very costly on the other side they do not provide accuracy .Even if a single cell is left undetected they may spread to wider parts so higher accuracy and early detection helps to reduce the need of future complications. Today people require more and more wireless communication systems. To meet the public and industrial demands, the wireless communication as the RFID and wearable devices evolves with constantly improved design techniques. In this way, a recent green and organic inkjet technology was emerged to meet challenging ecological and lowered cost. Thanks to the challenging performances in terms of cost and outstanding compactness, the electronic flexible technology was recently adopted in the various fields of applications as RFID, WLANtechnology and medicalengineering. The flexible RF/microwave circuit and antenna design is currently developed and promisingly advantageous in terms of costs.Therefore, the flexible antenna design topicattracts the attention of design and research engineers.In this project we design a flexible array antenna using the ADS software to detect the diabetic foot ulcer in advance which helps in early diagnosis and treatment**.**

## II. RELATED WORK

In [2] the authors proposed ,a wound Assessments System whichis a functional module which has following steps(I) wound image capture,(II) wound image storage in database,(III) wound image preprocessing, (IV)wound boundary detection,(V)wound analysis by color segmentation by using mean-shift algorithm ,(VI)convert all color image to grayscale ,(VII)wound trend analysis based on the time sequence of infected area for given patient. These entire technique steps are carried out by computational Smartphone.The advantage is that we can check whenever we want as smartphone is a portable one and the disadvantage is the oversegmentation problem which cause insignificant boundaries.In [3] the authors proposed an automatic way to analyze these temperature variation by using infrared camera a**s** in type II diabetes abnormal temperature variations is the early sign of foot ulcer.Though it is the easy method to detect the problem. The polyurethane foam makes positioning a patient for the image acquisition a long and difficult process especially for old people which is a greater disadvantage.In [5] the authors proposed a specific application of the antenna in microwave thermography in S-Band [2-4] GHz for breast cancer detection .Though it provides a bandwidth of 550MHz around 3GHz with a total gain of about 1dB its Implementation cost is more.In[7] the authors proposed the delectability of vesicoureteral reflux using microwave radiometry whereComputed tomography (CT) images are taken using microwave radiometry.It has higher resolution but its cost is higher.In [6] the authors proposeda flexible miniaturized UWB CPW Π-shaped slot antenna designed for wireless body area network .Though return loss, voltage standing wave ratio, radiation pattern, and current distribution have been improved but the disadvantage is that gain of the antenna is not considered.

## III. METHODOLOGY

The main objective of this project is to design an antenna to detect the diabetic foot ulcer at the earlier stage.With the help of the antenna we design,we detect the diabetic foot ulcer and the results in the form of simulation which helps us identify and differentiate the normal tissues and the infected tissues.The level of infection is given in the form of report accordingly treatment is given by the physician it has overcome the disadvantages of the existing works and one of the main advantage comparing to the existing work is low cost.

### *A. Antenna Design*

The elementary antenna is a thin rectangular patch printed on a Kapton Polyimide substrate having a thickness of HS=0.125mm. The antenna design required to look into the permittivity or dielectric constant of the substrate, width, length of the patch antenna and the ground plane. The permittivity of the substrate plays a major role in the overall performance of the antenna. It affects the width, the characteristic impedance, the length and therefore the resonant frequency that resulting to reduce the transmission efficiency. Using a permittivity value Ɛr of 3.4, the effective dielectric constant of the antenna is obtained from

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{w}\right]^{-1/2} \rightarrow (1)$$

In the xy-plane due to fringing effects, the dimensions of patch along its length is extended by a distance ΔL, which is a function of the effective dielectric constant εreff and the widthto-height ratio (W/h).

$$\Delta L = 0.412 \times h \times \left(\frac{\varepsilon_{reff} + 0.3}{\varepsilon_{reff} - 0.258}\right)\left(\frac{\frac{w}{h} + 0.264}{\frac{w}{h} + 0.8}\right) \rightarrow (2)$$

The width W of the patch is critical in terms of power efficiency, antenna impedance and bandwidth. It is dependent on the operating frequency and the substrate dielectric constant

$$W = \frac{1}{2 f_r \sqrt{\mu_0 \varepsilon_0}} \sqrt{\frac{2}{\varepsilon_r + 1}} = \frac{v_0}{2 f_r} \sqrt{\frac{2}{\varepsilon_r + 1}} \rightarrow (3)$$

The width, length,effective dielectric constant is calculated using the equation (1),(2),(3).

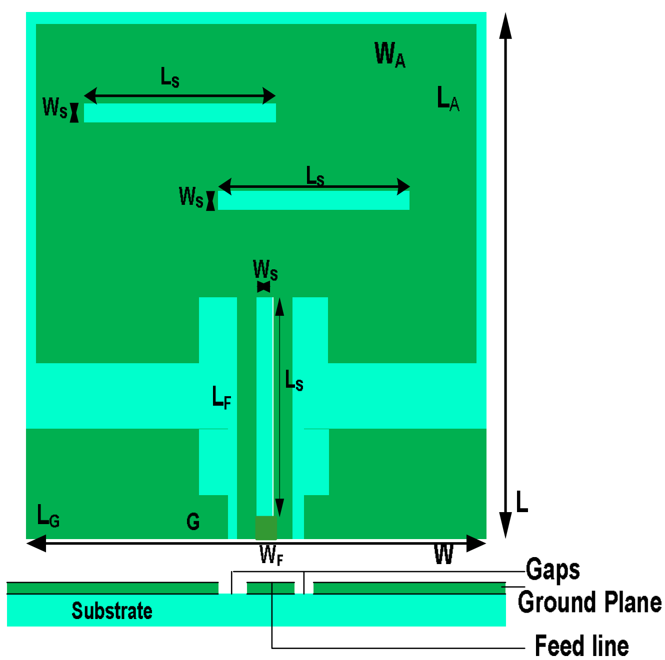


Fig. 1. Elementary flexible CPW antenna, (a) Front view, (b) Bottom view

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### *B. Design Steps*

Step 1:Designing Physical lengths of substrate for layer and Initial impedance value for the substrate.
Step 2: Detection of the desired matching levels of the layer and extraction of Physical widths of substrate.
Step 3: Computation of widths with random variables, which provides normal distribution.
Step4: Substitution of optimal physical widths.
Step 5: If the design provides better output then it will go to step6 else it repeat the process from step3.
Step 6: Calculation of antenna. radiation pattern and efficiency.
Fig.1 presents the geometry shape of the proposed design with parameters shown below in Table.1 which presents the various optimized parameters of the proposed elementary antenna.
A T-power junction has been used to transmit power to the array elements, in addition the CPW feed line with a characteristic impedance of 50 Ω is also usedto excite the global antenna array. Further a tuning stub with an optimized dimensions and position is added to the CPW feed to improve the antenna array prformances. The proposed antennaarray hasan

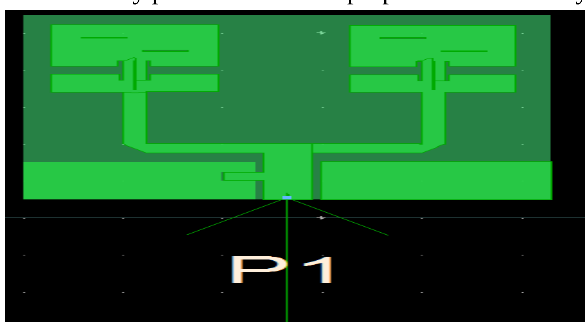


Fig.2.Proposed antenna arrayoverall size of about 5.3cm x5cm array which are shown in Fig.2

### *C. Simulation*

have used Advanced Design System (ADS) as a software in order to make simulations of antennas. ADS is an electronic design automation software system produced by Agilent EEsof EDA, a unit of Agilent Technologies. It provides an integrated design environment to designers of RF electronic products such as mobile phones, pagers, wireless networks, satellite communications, radar systems, and high-speed data links. Agilent ADS supports every step of the design process—schematic capture, layout, frequency-domain and time-domain circuit simulation, and electromagnetic field simulation—allowing the engineer to fully characterize and optimize an RF

Table.1. Geometry of the Proposed Antenna Array

| Parameters | Values (mm) | Parameters | Values (mm) |
|---|---|---|---|
| L | 15 | $L_S$ | 9 |
| $W_A$ | 20 | $W_S$ | 0.5 |
| $L_A$ | 14 | $H_S$ | 0.125 |
| $L_G$ | 12 | $T_M$ | 0.035 |
| $W_F$ | 5 | G | 0.25 |
| | 3.122 | $L_F$ | 7 |

design without changing tools. Agilent EEs of has donated copies of the ADS software to the electrical engineering departments at many universities, and a large percentage of new graduates are experienced in its use. Result the system has found wide acceptance in industry.The radiation power taken for the far-field at different frequencies is indicated in Fig.6. Results indicates that the antenna array provides a directional behavior in E-plan (for PHY=0°) and omnidirectional behavior in H-plan (for

THETA=0°). Furthermore Fig.4. Presents the normalized gain against frequency of the developed antenna array. The results show that the design provides an important gain which is perfectly sufficient and suitable for microwave thermography

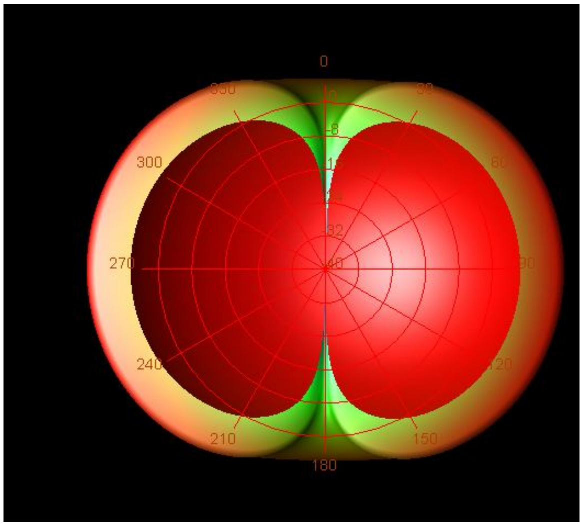


Fig.3.Radiation pattern

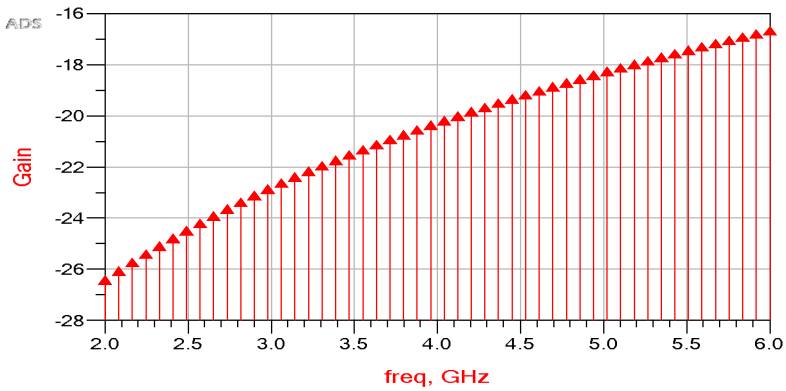


Fig.4. Antena gain versus frequency

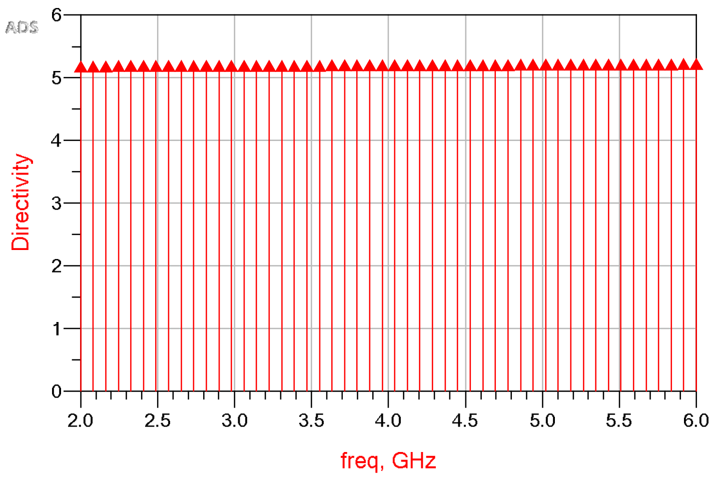


Fig.5.Directivity versus frequency

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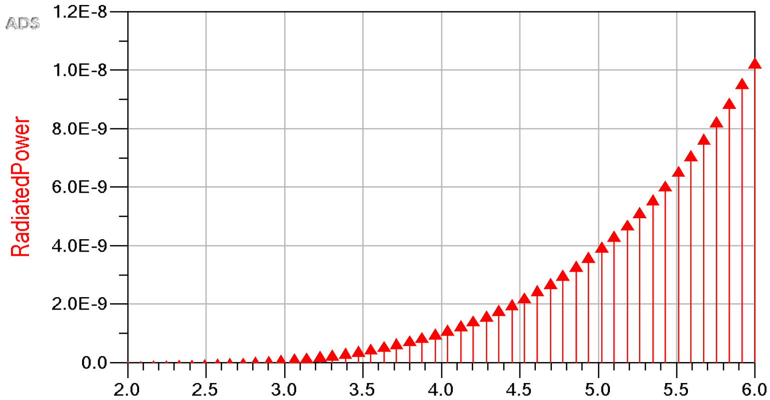


Fig.6.Radiated power versus frequency

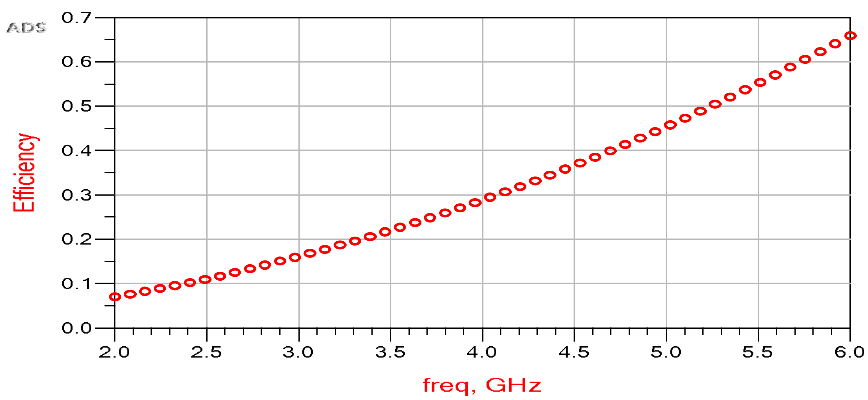


Fig.7. Efficiency versus frequency

Fig 4 shows the antanna gain at different frequencies where the gain increases with the frequencies,.Fig 5 shows the directivity at different frequencies here the directivity remains constant for all frequencies ranging from (2-6)GHZ.Fig .6.shows the radiated power at different frequencies similar to gain as the frequency increases the radiated power also increases.Fig 7 shows the efficiency at different frequencies while there is increase in frequency the efficiency also increases.Fig 8 & 9 represents the comparison between discrete frequencies vs fitted(AFS or linear)

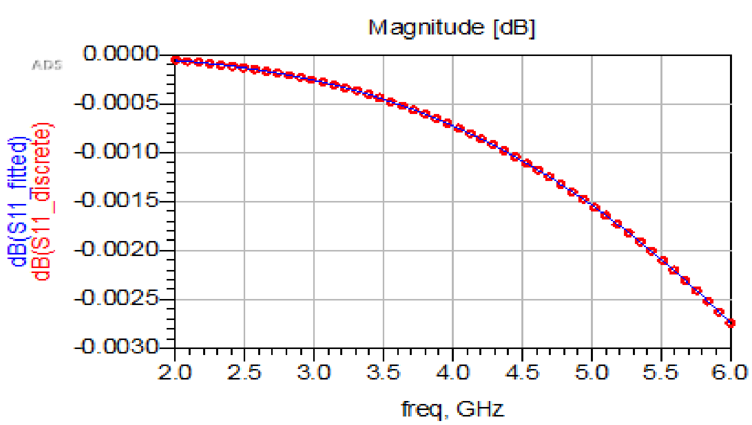


Fig.8. linearly fitted points

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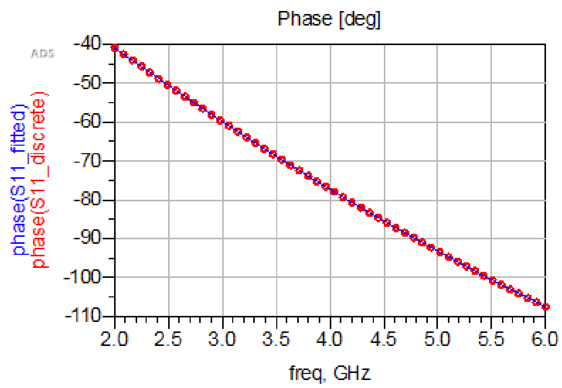

Fig.9.Discrete frequency points

Table.2.comparision of antenna parameters at different frequencies.

| Frequency (GHZ) | Gain(dBi) | Directivity(dBi) | Efficiency (%) |
|---|---|---|---|
| 2 | -26.2587 | 5.26 | 0.06 |
| 5 | -18.557 | 5.26 | 0.45 |
| 6 | -17.001 | 5.26 | 0.65 |

The table.2. is to compare the antenna parameters such as gain,directivity,efficiency at three different frequencies which shows that both gain and efficiency increases with frequencies but the parameter directivity is constant with the frequencies.

## IV. CONCLUSION AND FUTURE WORK

A novel CPW micro strip antenna array has been successfully designed and simulated using ADS Software. The performance criteria extracted from the software includes efficiency, VSWR, radiated power,gain and directivity provide clear indication that the proposed design, has the required performances to be investigated in a microwave radiometry system as well as for wearable applications, due to its miniature size (5.3cm x5 cm), low profile and weight and very thin substrate. Also the important gain (6dBi) and the large bandwidth (480MHz around the center frequency of 3 GHz), provided by the developed antenna; are good features to improve the radiometer sensitivity at very low power densities transmitted by the self-radiation of abnormal breast tissue. Future work will focus to validate the simulated results of the developed antenna array by measurements and improve them by changing the parameters and the substrate.

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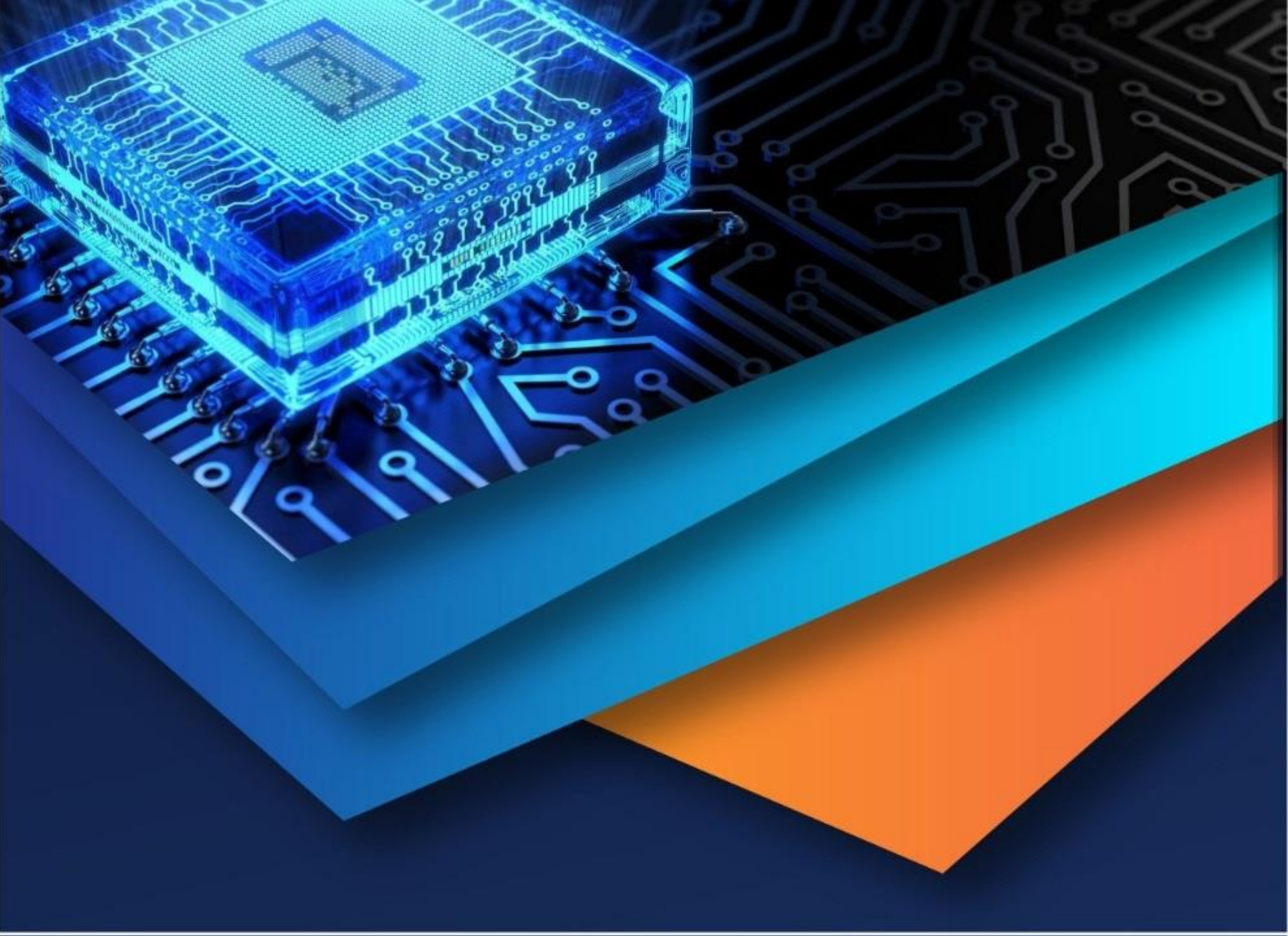


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