iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 5 **Issue:** VII **Month of publication:** July 2017

DOI:

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 VII, July 2017- Available at www.ijraset.com

Coaxial-Fed E-Shaped Patch Antenna (ESPA) using Square Slot for WLAN Application

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***Abstract:** This paper presents the design and simulation of an E shaped Microstrip Patch Antenna (ESPA). This ESPA covers the entire frequency range of wireless local area network (WLAN) application. The frequency range of WLAN is 5.15 – 5.825 GHz. In the proposed design, it consists of E-shaped patch as well as two identical rectangular slots. Due to this slots, antenna exhibit two different resonance frequencies at 5.28 GHz and 5.82 GHz respectively. The antenna is designed on low cost material of Arlon Diclad 880 substrate having dielectric constant of 2.2 with thickness of 3.2 mm and loss tangent of 0.0009. The design is fed by 50 ohm coaxial probe feeding technique. The proposed designed antenna is successfully simulated with the help of Ansoft HFSS simulator tool which is working on the principle of FEM. The simulation result of designed antenna shows good return loss (< -10 dB), VSWR (< 2), radiation Pattern from 5.10 GHz to 5.88 GHz frequency band.*
***Keywords:** Microstrip patch antenna, ESPA, WLAN, Substrate, HFSS, Return loss, VSWR*

I. INTRODUCTION

Microstrip patch antenna plays an important role in wireless communication system. A microstrip antenna consists of a dielectric substrate, with a ground plane on the other side. Due to its advantage such as low profile planer configuration, low weight, low fabrication cost and capability to integrated with microwave integrated circuit technology, the microstrip patch antenna is very well suited for applications such as wireless communication system, cellular phone, radar system and satellite communication system. However, rectangular microstrip patch antenna has the disadvantages of narrow bandwidth. The bandwidth of microstrip antenna can be increased using air substrate [1]. For small size antenna, a new type of dielectric material can also be used [2]. The limitations of microstrip patch antenna can be overcome with several techniques like by increasing the thickness of substrate or modify the shape of patch antenna by using different shapes on patch structure or introducing parasitic element, that is co-planer and stack configuration. The most beneficial method is to change the shape of radiating patch element [3]. By changing the shape of patch antenna, the major properties of microstrip antenna as thin profile characteristic, a single-layer radiating structure are remains same and its characteristics doesn't change. Some of the used shape are like E shape patch antennas, U-slot patch antennas and V-slot patch antennas [4-11]. Micro-strip patch antenna can be fed through different techniques among them probe feed and Micro-strip line feed are most popular and others are proximity coupled feed and aperture/slot-coupled feed [12]. In this proposed design, a simple and compact type of E-shaped microstrip patch antenna is designed. Depending upon the position of feed point applied to the patch, resonance frequency will be determined. The E-shaped antenna can be obtained by utilizing two parallels slots on the rectangular patch structure. The design also consists of two identical rectangular slots at the left side of the patch which are use to give better result and to enhance the bandwidth. The proposed E-shaped antenna gives excellent result from 5.10 GHz – 5.88 GHz frequency range. The proposed antenna is designed and simulated by using Ansoft HFSS simulator tool [13].

II. ANTENNA DESIGN

The basic layout of the rectangular E-shaped patch antenna is given in fig.1. is for the designing of E-shaped microstrip patch antenna, first of all, a basic and standard type of rectangular patch antenna is designed. The rectangular patch antenna designing parameters as length (L) and width (W) are determined from the standard mathematical equations and antenna designing procedure. In the proposed design, the basic E-shaped antenna is incorporated with two square type slots are used on the patch element. Both the slots have same dimension. The function of these slots is to provide better result and good bandwidth for the WLAN frequency range.

The E-shaped microstrip patch antenna is designed by calculating the length (L) and width (W) from the given equation

$$W = \frac{C}{2\,f\sqrt{^{(\varepsilon_r+10)}/_2}}$$

Where, C is the velocity of light, is the dielectric constant of substrate, f is the antenna working frequency, W is the patch width, ε_r is the effective dielectric constant.

$$\epsilon_{eff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left[1+10\frac{h}{w}\right]^{\frac{1}{2}}$$

The length extension is expressed by

$$\frac{\Delta l}{h} = 0.412\frac{(\epsilon_{eff}+0.300)\left(\frac{W}{h}+0.262\right)}{(\epsilon_{eff}-0.300)\left(\frac{W}{h}+0.813\right)}$$

By using above equations we can find the value of actual length of the patch as,

$$L = \frac{C}{2\,f\sqrt{\varepsilon_{eff}}} - 2\,\Delta l$$

$$L_g = 6h + L$$

$$W_g = 6h + W$$

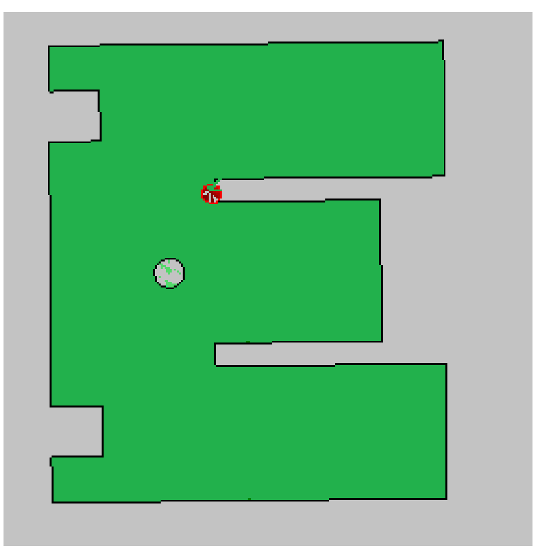


Fig.1. Proposed E-shaped patch antenna with Square slots

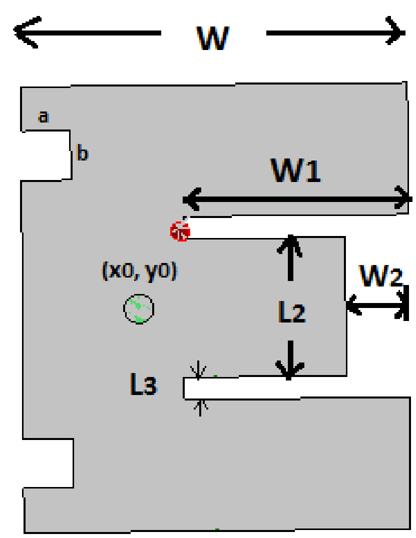


Fig.2. Geometry and dimensions of the proposed E-shaped patch antenna

The proposed antenna is designed on an Arlon Diclad 880 substrate having dimension of 60 mm × 50 mm. The height of the substrate is h = 3.2 mm and relative permittivity of 2.2. The antenna design parameters and dimensions are shown in fig.2.
In the proposed design, the dimension of the patch is L × W where L = 20 mm and W = 17.2 mm. The antenna design is fed by coaxial probe method at position (x0, y0). The E-shaped patch antenna can be obtained by introducing two parallel slots of

dimension L3 × W1. Similarly in the centre arm of E-shape patch, a rectangular slot is utilized. From this E-shape structure, the obtained result are optimized and under the desired conditions.

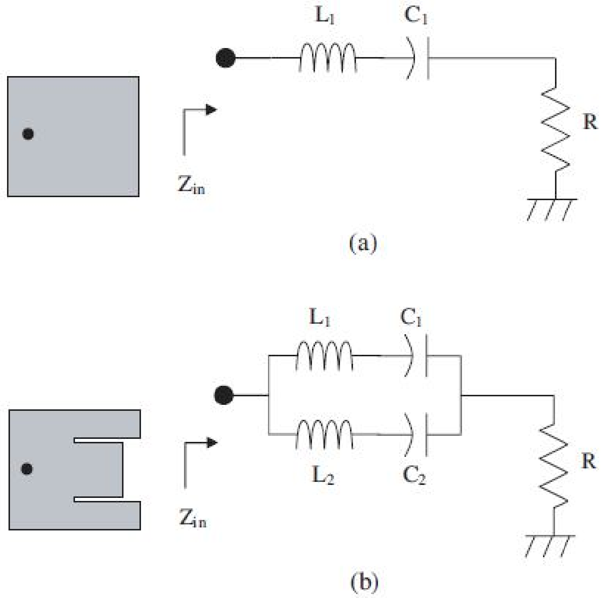
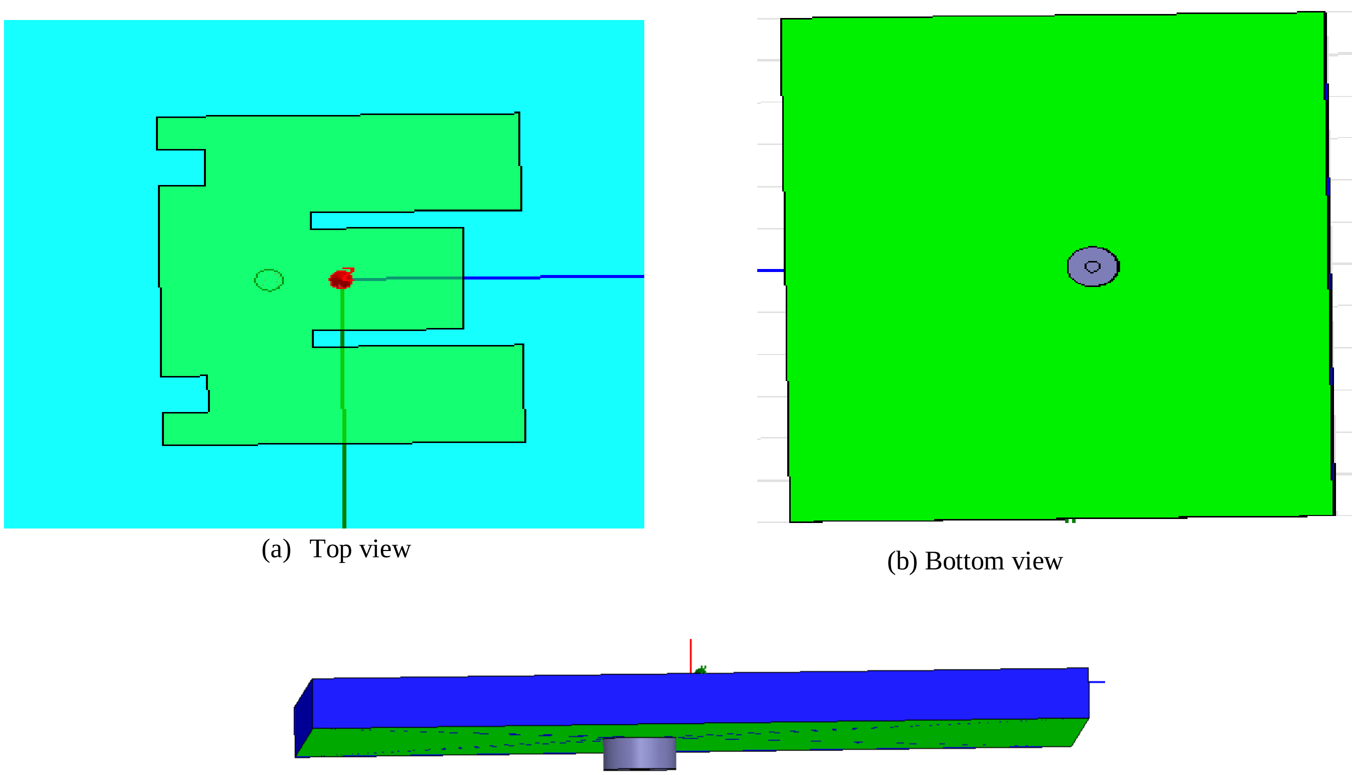


Fig.3. Equivalent circuit of (a) Rectangular patch (b) E-shaped patch antenna [3]



(c) Side view

Fig.4. Different configuration of antenna (a) Top view (b) Bottom view (c) Side view

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In the above design, two square slots having dimension of 2.2 mm × 2.2 mm are used. With the use of these square slots, the obtained results are under the desired values and it gives better return loss and two different resonance frequencies are obtained. For the coaxial feeding, two cylinders are used. The radius of outer cylinder is 2.35 mm whereas inner cylinder has radius of 0.65 mm respectively.

Table 1: Proposed antenna design parameters

Parameters	Value (mm)	Parameters	Value (mm)
L	20	W2	2.8
L1	5.9	a	2.2
L2	6.2	b	2.2
L3	1	h	3.2
W	17.2	X0	0
W1	10	Y0	3.4

III. SIMULATION RESULT AND ANALYSIS

The designed E-shaped antenna is simulated with the help of commercial simulation software Ansoft HFSS 11 based on the finite element method (FEM) is employed to perform the design and optimization process [13]. The simulated results of the projected antenna are discussed below.

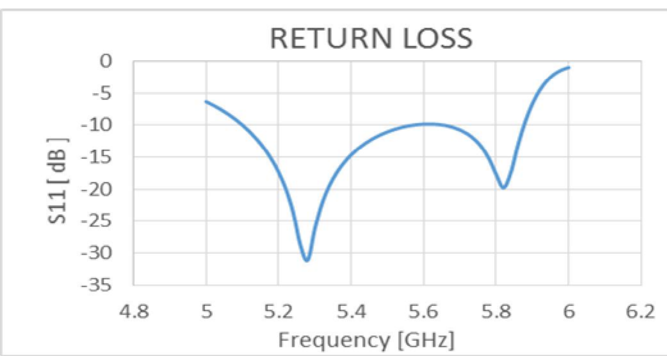


Fig.5. Simulated Return loss (S11)

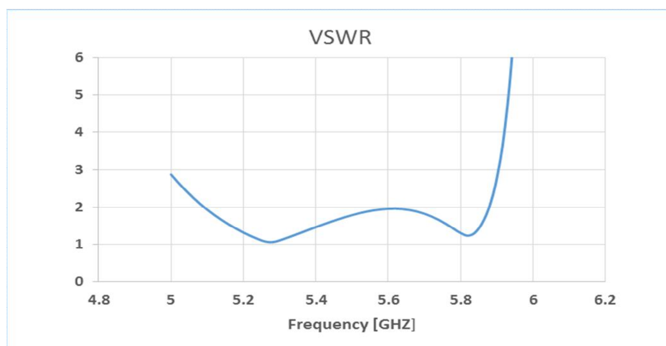
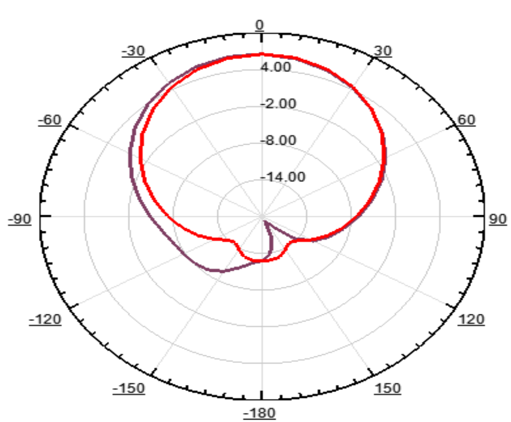
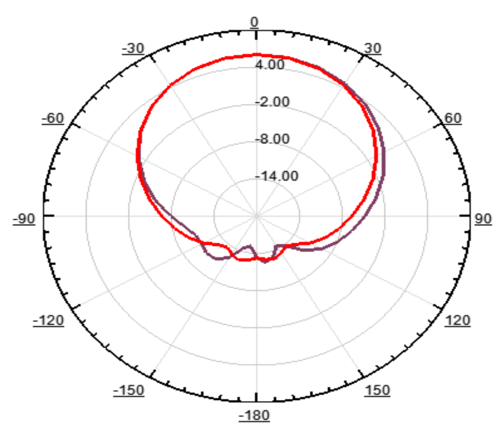


Fig.6. Simulated VSWR



(a) Radiation pattern at 5.28 GHz



(b) Radiation pattern at 5.82 GHz

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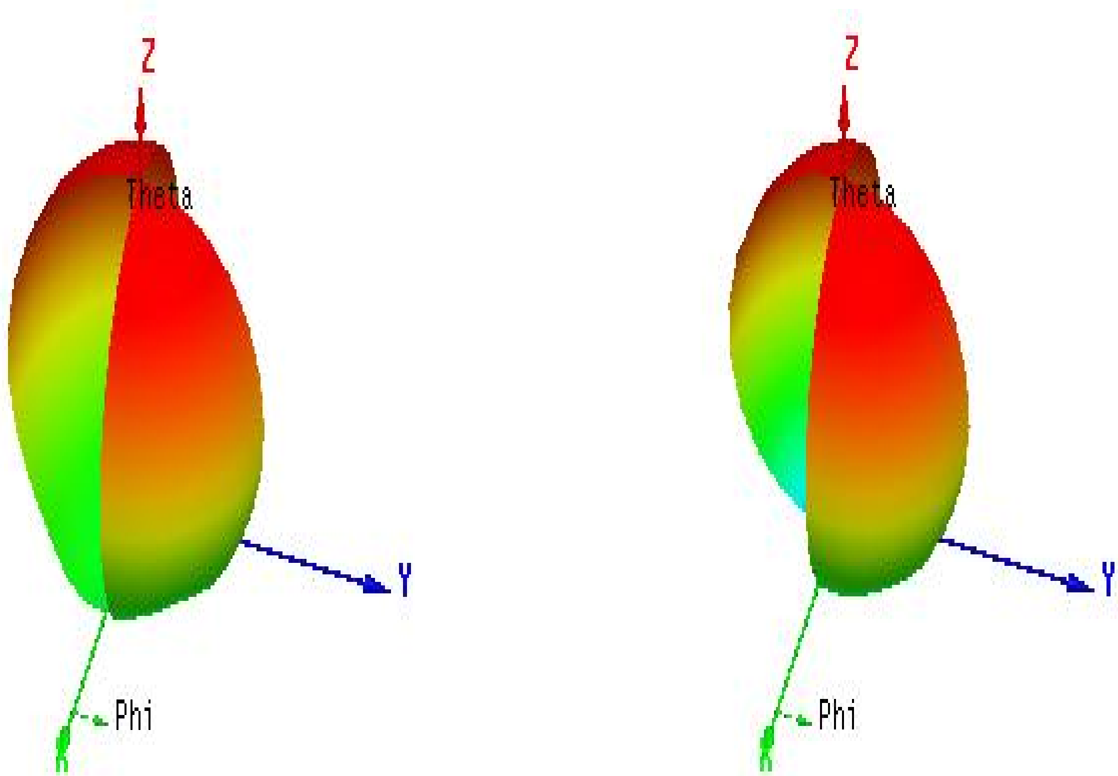
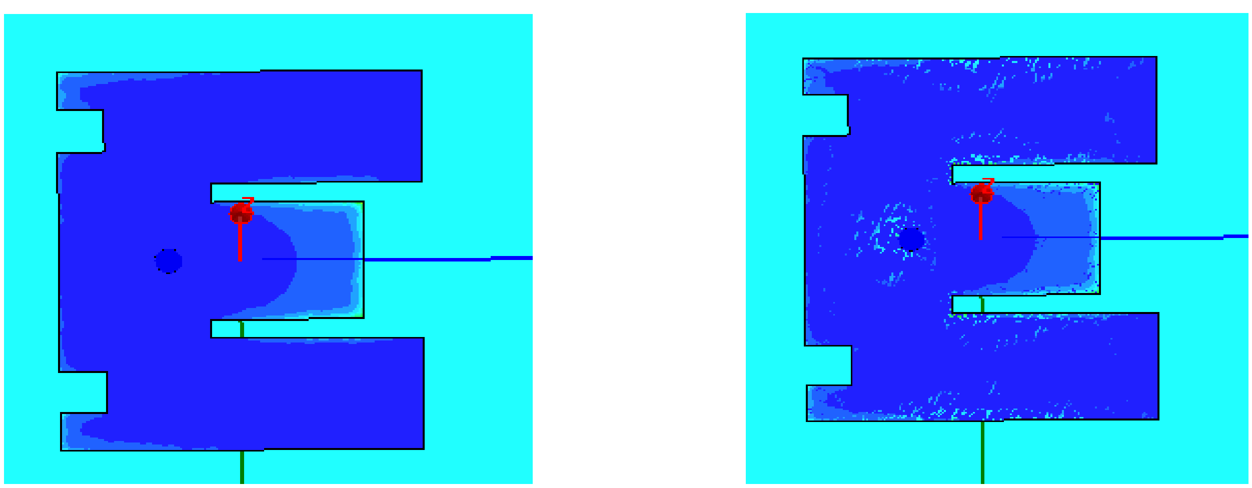
Fig.7. Far-field radiation pattern (a) at 5.28 GHz (b) at 5.82 GHz



(a) 3D Polar Far Field pattern at 5.28 GHz (b) 3D Polar Far Field pattern at 5.82 GHz

Fig.8. 3D-Polar Field Plot (a) at 5.28 GHz (b) at 5.82 GHz



(a) E –field (b) H-field

Fig.9. Field plot of the proposed E-shaped patch antenna (a) E- field (b) H-field

IV.CONCLUSION

This paper describes the design and simulation of E-shaped microstrip patch antenna with square slots for WLAN applications. The proposed antenna structure is simulated using Ansoft HFSS simulation tool, one commercial 3-D full-wave electromagnetic simulation software. The Simulated results are presented as Omni-directional radiation pattern and stable radiation pattern, shows the usefulness of the proposed antenna structure for WLAN applications. The reflection coefficient is below −10 dB from 5.10 GHz – 5.88 GHz. The resonant frequencies occurred at 5.28 GHz and 5.82 GHz with satisfactory bandwidths and gains. The performance of designed antenna is excellent and meeting the required parameters and covers frequency bandwidth from 5.15 – 5.825 GHz for WLAN applications.

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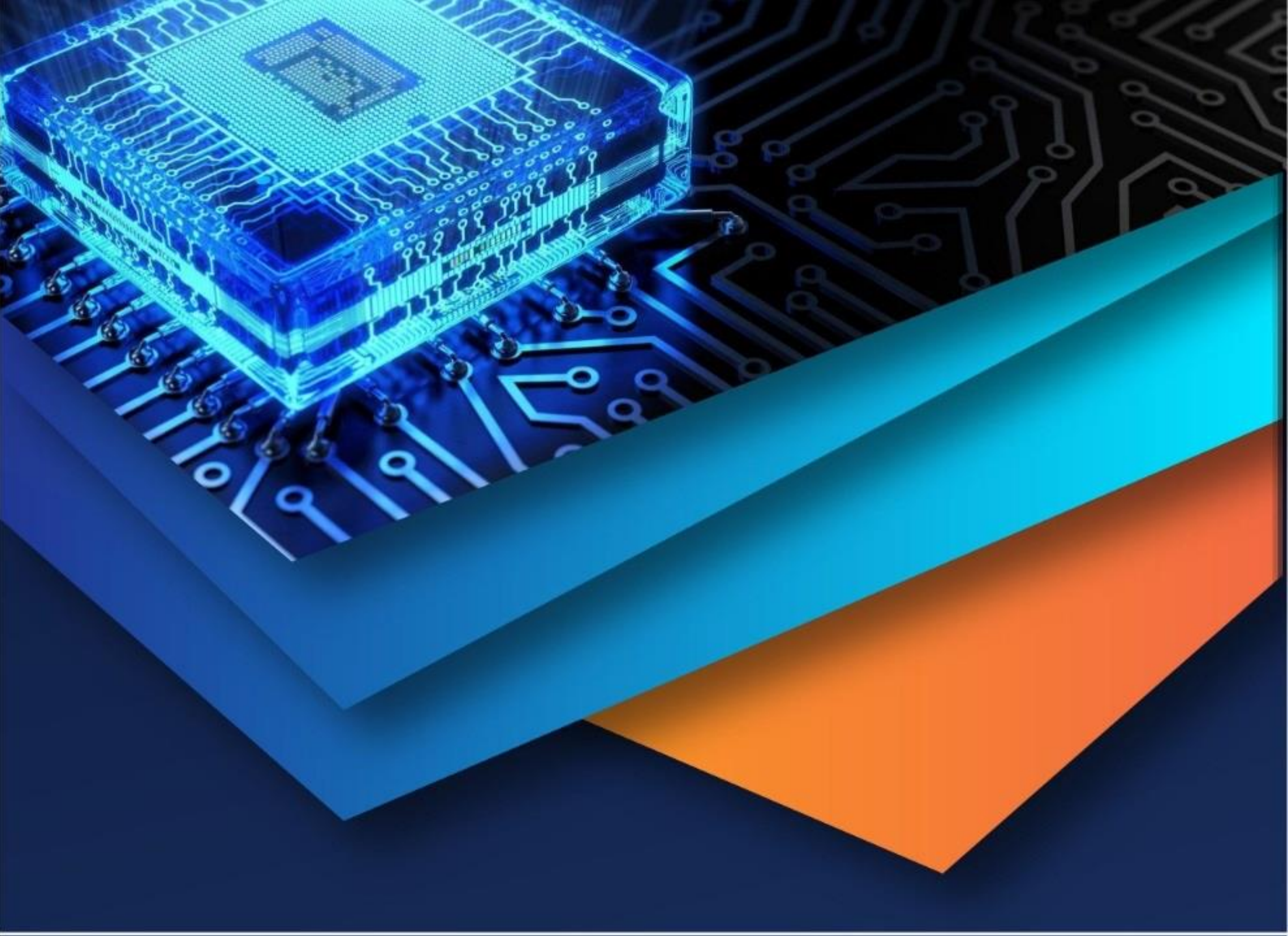

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