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Design of wideband Circular Microstrip Patch Antenna Using Partial Ground Plane Technique for UWB Applications.

Manish Parihar[1]
[1]*Lecturer, Department of Electronics Engineering, Government Polytechnic College, Jalore,(Raj)*

Abstract: In this paper, design of Circular Microstrip Patch Antenna is proposed for Ultra Wide Band Application. Microstrip feed line of 50Ω characteristic impedance is used to feed the patch. Partial ground plane technique is used to convert narrow band characteristics of Microstrip Patch antenna into wide band characteristics.FR-4 Epoxy Dielectric Substrate is used for design having ε_r= 4.4 and having standard thickness of 1.58mm. The design was optimized by using CST Microwave Studio TM 2011 software to obtain most suitable configuration in terms of desired value of Return Loss, VSWR and Bandwidth for antenna.

Keywords: Circular Microstrip Patch Antenna, Partial Ground Plane, UWB, Bandwidth, Return Loss, VSWR, Gain

I. INTRODUCTION

Now day's wireless gadgets has become a part of human life. A lot of electrical and electronic devices around us are using wireless system to communicate or operate. Antenna is an essential unit of wireless system which radiates electromagnetic waves into the space by converting electric power given at the input into the radio waves. At the receiver side antenna again receive these radio waves and convert them back into the electrical power[1-2]. Antenna is widely used in cellular phones, smart phones, satellite communications, DTH service, spacecraft, radars, wireless door phones, laptops, tablets and wireless computer networks[3]. Microstrip antennas are perfect for these application as it is light weight and can be easily integrated into antenna arrays or into microwave printed circuit boards. But these have a major drawback of narrow frequency bandwidth[2]. Two days wireless systems works over wide band of frequency[4] and hence the antenna should be capable for the same. In this research, an attempt is made to modify a narrow band antenna to work as ultra wide band antenna. By using techniques like partial ground plane[5], slotting the patch, etc wide band characteristics have been observed[6]. In microstrip antenna, a metallic layer of particular shape is bonded on a dielectric substrate which forms a radiating element and another continuous metallic layer on the other side of substrate as ground plane. Not only the basic shapes but any continuous shape can be used as the radiating patch[7]. For satisfactory performance of antenna VSWR <2 and Return Loss (R.L) < -10dB throughout the entire ultra wide band range[8].

II. DESCRIPTION OF WORK

A narrow band Circular Microstrip patch is designed. Then using partial ground plane technique wide band characteristics is observed by changing the parameters like length, width of antenna and length, width of ground plane.Effect of substrate thickness on return loss and frequency bandwidth has also been observed. Performance Analysis of designed antenna has been optimized in CST Microwave StudioTM 2011 software which utilizesfinite Integration Technique for Electromagnetic Computation[9]

III. ANTENNA DESIGN CONFIGURATION

A. Circular Patch Antenna

Circular Microstrip Patch Antennais shown in Fig1. Partial ground plane structure is used in place of ground plane structure to convert narrow band antenna into wide band antenna. FR-4 Epoxy Dielectric Substrate is used for design having ε_r = 4.4 and having standard thickness of 1.58mm. Microstrip feedline of 50Ω characteristic impedance is used to feed the patch. The antenna design process is started by initially taking 8.2 GHz as resonant frequency. Performance of designed antenna has been optimised by varying the parameters of antenna given below in table 1

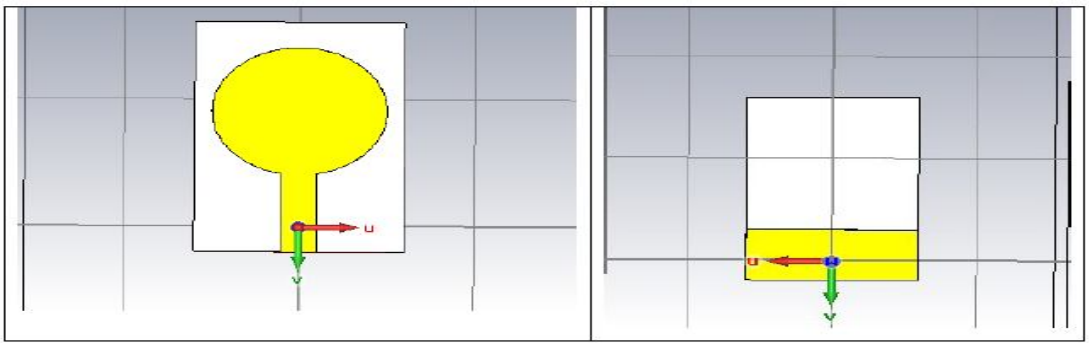


Fig. 1 Front and back view of Circular Microstrip Patch Antenna.

B. Description of designed antenna

Table 1 represents Dimension of designed Circular Microstrip Patch Antenna

Parameters	Description	Value(mm)
Lsub	Length of substrate	18
Wsub	Width of Substrate	12
Lf	Length of feedline	7
Wf	Width of feedline	2
a	Radius of Circular patch	5
Mt	Thickness of patch	0.07
h	Thickness of substrate	1.58
Lg	Length of ground plane	4

IV. RESULT AND DISCUSSION

The return loss, VSWR, gain and directivityof designed antenna for resonant frequency of 8.2 Ghzis shown below in Fig 2. (a, b, c, d) respectively .

It is observed thatthe design achieves return loss of -14.26 dB and the bandwidth of 8.43 GHz (4.74 - 13.17GHz) and corresponding VSWR is 1.48. The design antenna have Gain of 3.71 dB and Directivity of 4.58 dB. These results make it suitable for UWB application.

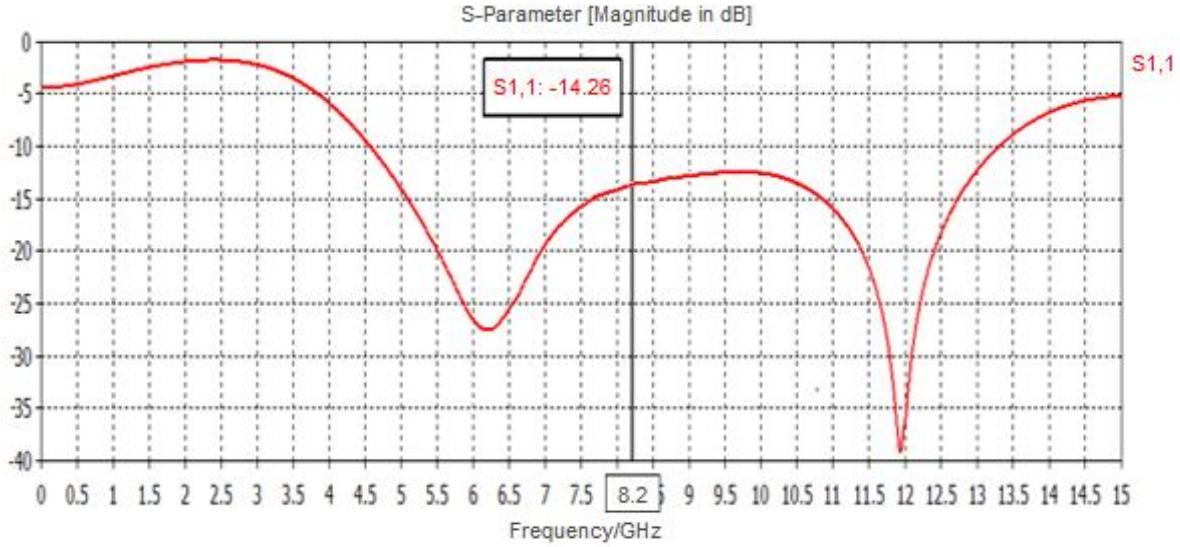


Fig. 2(a) Return Loss versus Frequency Plot, Return Loss = -14.26 dB

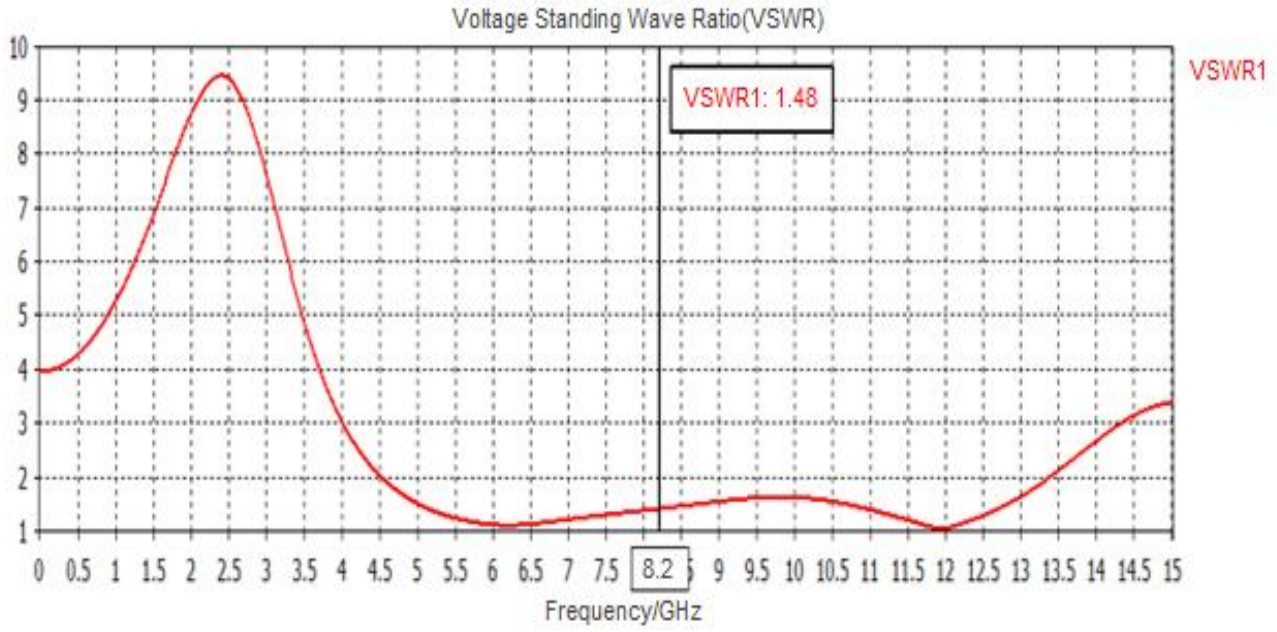
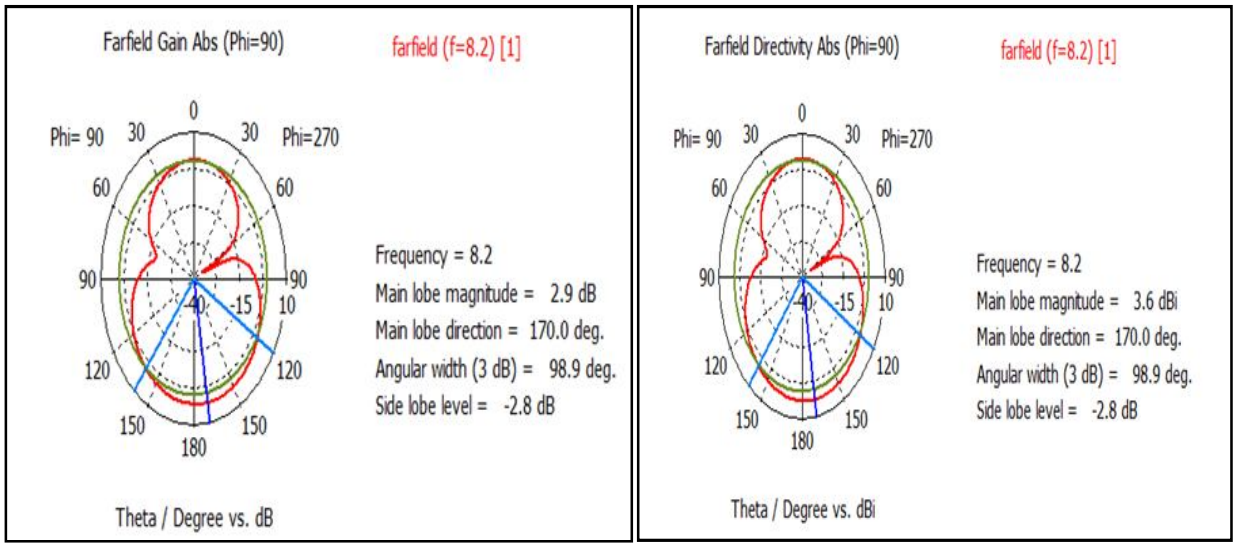


Fig. 2(b) VSWR versus Frequency Plot, VSWR =1.48



2D Radiation pattern plot for- Fig. 2(c) Gain= 2.9 dBFig. 2(d) Directivity = 3.6 dB

A. Effect of Substrate Thickness on Return Loss, VSWR and Bandwidth:-

1) The results have been tabulated below for ease of understanding.

Table 2 Variation of thickness of substrate

No. Of Iteration	Substrate Thickness	Dielectric Constant	Operating Bandwidth (GHz)	Band width (GHz)	Return Loss (dB)	VSWR
1.	1.4	4.4	4.88-13.10 GHz	8.22 GHz	-12.36 dB	1.63
2.	1.58	4.4	4.74-13.17 GHz	8.43 GHz	-14.26 dB	1.48
3.	1.65	4.4	4.72-13.17 GHz	8.45 GHz	-14.81 dB	1.44
4.	1.7	4.4	4.65-13.17 GHz	8.52 GHz	-15.07 dB	1.42

2) Return Loss Plot for Various values of Substrate Thickness is shown below in Fig 3

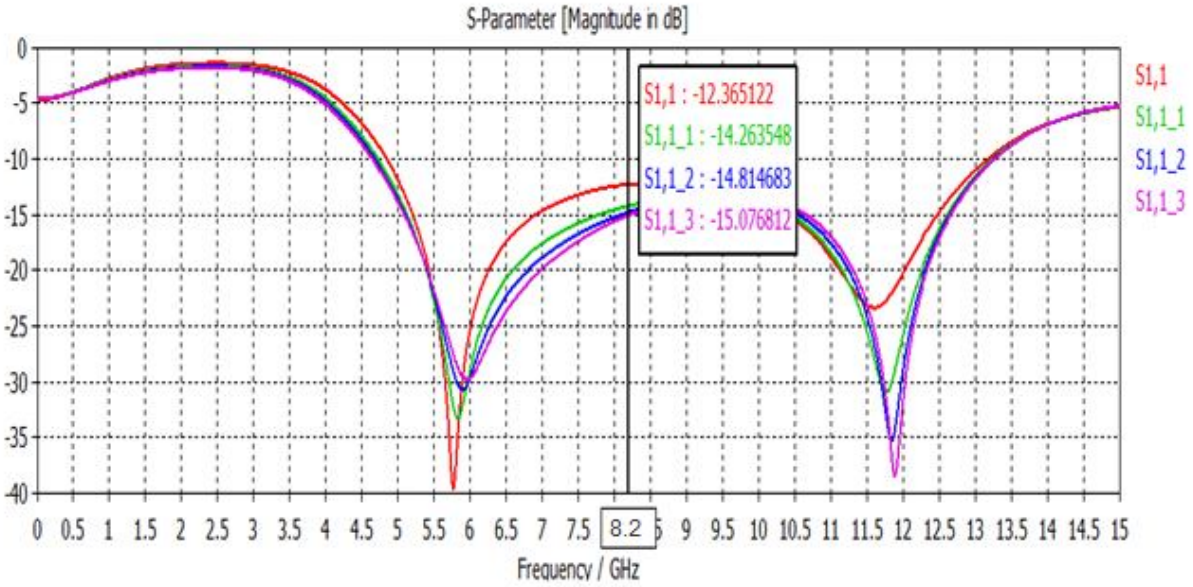


Fig. 3 Return Loss versus Frequency Plot for Various values of Substrate Thickness
(Red Line for h = 1.4mm, Green Line for h = 1.58mm, Blue Line for h = 1.65mm, *Purple Line for h = 1.7mm)*

*3)*VSWR Plot for Various values of Substrate Thickness is shown below in Fig 4

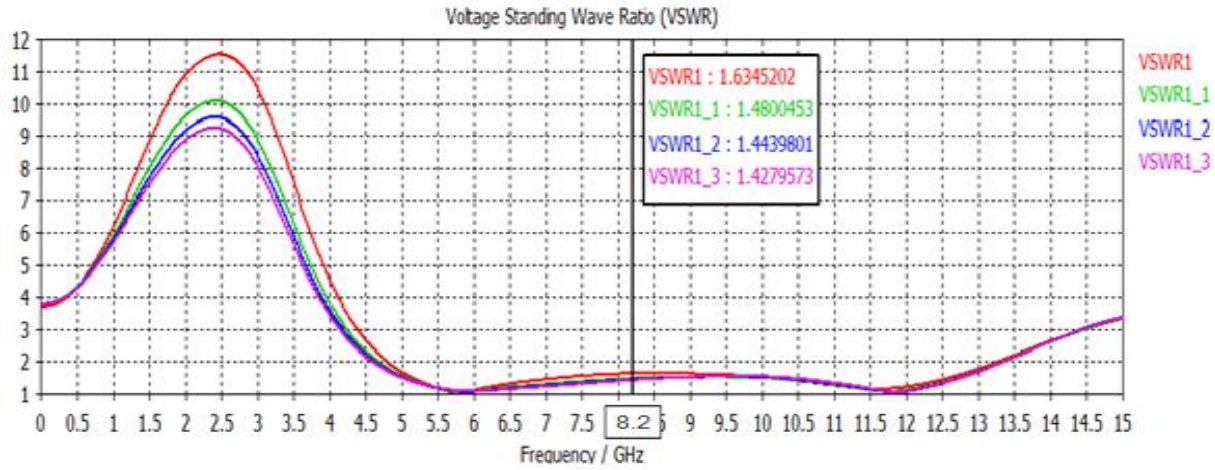


Fig.4 VSWR versus Frequency Plot for Various values of Substrate Thickness
(Red Line for h = 1.4mm, Green Line for h = 1.58mm, Blue Line for h = 1.65mm, Purple Line for h = 1.7mm)

From above plot we can say that with increase of substrate thickness, bandwidth of patch antenna increases and value of Return loss and VSWR decreases which indicates that the radiation efficiency and performance of antenna improves with increases of substrate thickness. But it will make antenna bulky.
Thickness of substrate, can also be used for matching between feed line and patch so that maximum power can be transmitted from source to antenna and losses can be minimized.

V. CONCLUSION

In this paper, circular microstrip patch antenna is designed and simulated over CST microwave studio. Effect of variation of Substrate Thickness on Return loss, V.S.W.R and Bandwidth of Antenna has also been studied. Following conclusions can be made on the basis of above study:-

A. The designed antenna attains return loss of -14.26dB and bandwidth of 8.43 Ghz (4.74-13.17GHz) for resonant frequency of 8.2 Ghz and corresponding VSWR is 1.42. The design antenna have Gain of 2.9 dB and Directivity of 3.6 dB. These above results make it suitable for UWB application.

B. Partial ground plane technique is a simple and effective technique for attaining ultra wide band characteristics.

C. With increase of thickness of substrate, bandwidth of patch antenna increases and value of Return lossVSWR decreases, but it will make antenna bulky.

D. By using thicker substrate and with proper coupling and feeding scheme radiation efficiency of patch antenna minimized.

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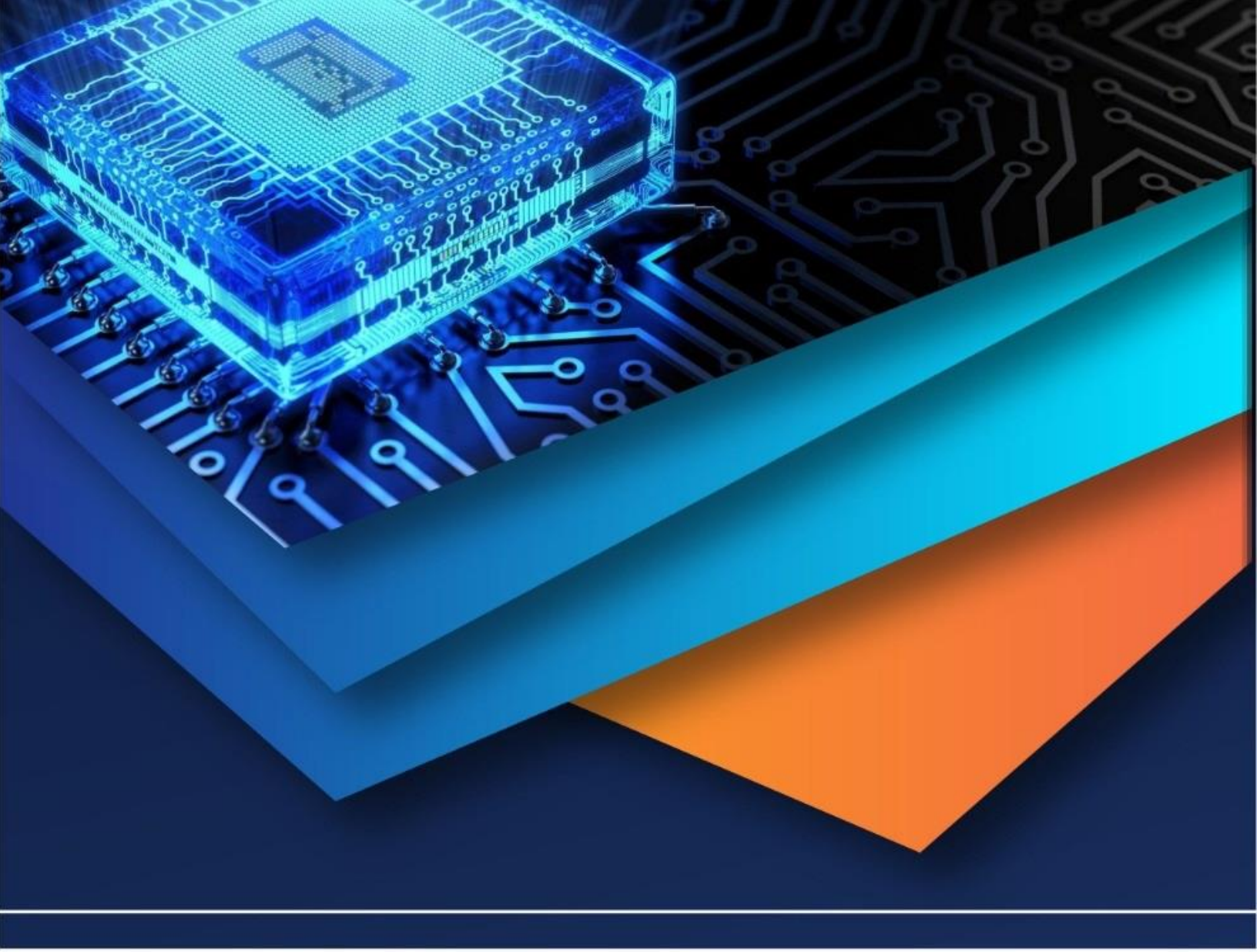

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