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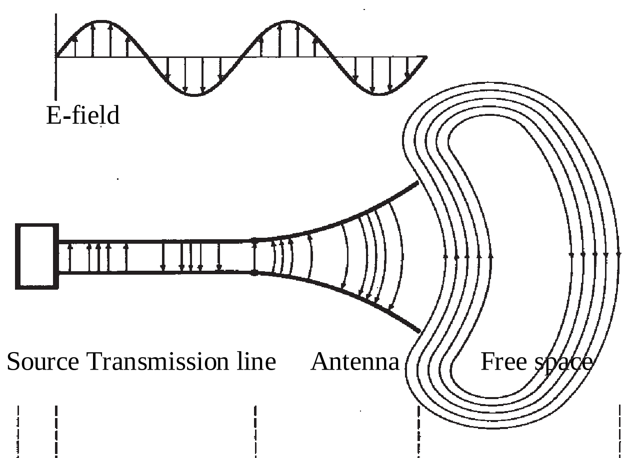
# Square Patch Antenna for Mobile Applications

Navneet Vivek[1], Hamid Ali[2]
[1]M. Tech. Scholar, [2]Assistant Professor, Shobhit University, Gangoh

***Abstract—This paper presents the result for different standard thickness values, and the result is performed by circularly polarized, Square patch antenna with a small frequency-ratio is proposed for mobile applications. The antenna has become a necessity for many applications in recent wireless communications such as Radar, Microwave and space communication. The proposed antenna design on different shapes and analyzed result in resonant frequency will be 8.2GHz. A single micro-strip feed-line is underneath the centre of the coupling aperture ground-plane. The frequency-ratio of the antenna can be controlled by adjusting the slot arm lengths. At 12GHz frequency and the tested result on IE3D SIMULATOR parameters are for X-axis -21.6mm to 21.6mm, Y-axis -21.6mm to 21.6. After that results are verified and simulated, S-Parameter = -25.34dB, Field Gain = 9.463dB, Directivity = 10.57dB, Efficiency for Antenna = 77.75% and VSWR = 0.97. All results shown are simulated.***
***Keywords— Micro strip antenna; IE3D SIMULATOR; circularly polarized antenna; slotted patch; slot.***

## I. INTRODUCTION

Antennas are considered to be the largest components of integrated low profile wireless communication systems. Therefore antennas miniaturization is a necessary task in achieving an optimal design for integrated wireless communication systems. The antenna is the transitional structure between free-space and a guiding device, as shown in figure below. The guiding device or transmission line may take the form of a coaxial line or a hollow pipe (waveguide), and it is used to transport electromagnetic energy from the transmitting source to the antenna, or from the antenna to the receiver. In the former case, we have a *transmitting* antenna and in the latter a *receiving* antenna.




Numerous techniques have been proposed for the miniaturization of micro strip patch antenna as in [1] – [9]. The antenna on the substrate with high dielectric constant is nearly a factor of smaller dielectric than the antenna design on the air substrate in which ξr is the dielectric constant of the substrate [1]. But this technique not only raised the cost of the antenna, but also not applicable to integrated communication systems whose substrate dielectric constants is always small. Other literature concern the techniques of reducing the size of the patch antenna include the shorting post technique [2] , increasing the electrical length by optimizing the shape [3], etching periodical slow wave structures on the ground plane [4],[5] loading the edges of the patch with inductive elements [6] and inserting the slot into the patch [7].

But the maximum size reduction of these techniques is only 65% as reported in [5]. Still others proposed the combination of shorting post technique with other miniaturization technique(s) such as [8], [9] and this kind of technique achieved a maximum 75% size reduction. Micro strip patch antenna used to send onboard parameters of article to the ground while under operating conditions. The aim of the thesis is to design and fabricate an inset-fed circular polarization Micro strip Patch Antenna and study the effect of antenna dimensions Length (L) , Width (W) and substrate parameters relative Dielectric constant (εr), substrate thickness (t) on the Radiation parameters of Bandwidth and Beam-width. New wideband stacked micro-strip antennas for enhancing bandwidth. Major issue for micro strip antenna is narrow bandwidth.

### A. *Auxiliary Potential Functions and Electric & Magnetic fields*

In the analysis of radiation problems, the usual procedure is to specify the sources and then require the fields radiated by the sources. This is in contrast to the synthesis problem where the radiated fields are specified, and we are required to determine the sources. It is a very common practice in the analysis procedure to introduce auxiliary functions, known as *vector potentials*, which will aid in the solution of the problems. The most common vector potential functions are the **A** (magnetic vector potential) and **F** (electric vector potential). The introduction of the potentials often simplifies the solution even though it may require determination of additional functions. While it is possible to determine the **E** and **H** fields directly from the source-current densities **J** and **M**, as shown in figure. It is usually much simpler to find the auxiliary potential functions first and then determine the **E** and **H**. This two-step procedure is also shown in figure below-

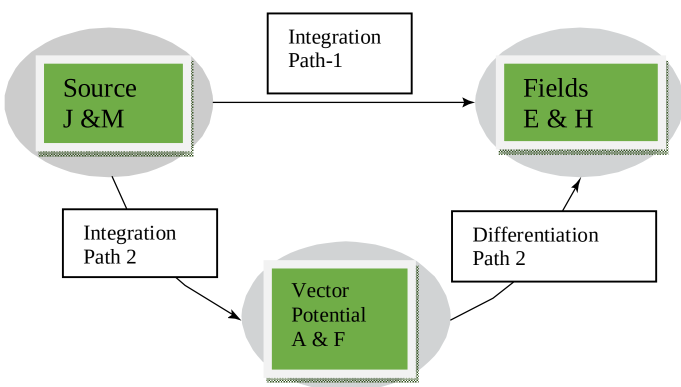



Fig. Block diagram for computing fields radiated by electric and magnetic sources.

The one-step procedure, through path 1, relates the **E** and **H** fields to **J** and **M** by integral relations. The two-step procedure, through path 2, relates the **A** and **F** potentials to **J** and **M** by integral relations. The **E** and **H** are then determined simply by differentiating **A** and **F**. Although the two-step procedure requires both integration and differentiation, where path 1 requires only integration, the integrands in the two-step procedure are much simpler.
Once the vector potentials are known, then **E** and **H** can always be determined because any well-behaved function, no matter how complex, can always be differentiated. The differentiation to determine **E** and **H** must be done in terms of the observation point coordinates.

### B. *Overview of Micro strip Antenna*

A micro strip antenna consists of conducting patch on a ground plane separated by dielectric substrate. This concept was undeveloped until the revolution in electronic circuit miniaturization and large-scale integration in 1970. After that many authors have described the radiation from the ground plane by a dielectric substrate for different configurations. The early work of Munson on micro strip antennas for use as a low profile flush mounted antennas on rockets and missiles showed that this was a practical concept for use in many antenna system problems. Various mathematical models were developed for this antenna and its applications were extended to many other fields. The number of papers, articles published in the journals for the last ten years, on these antennas shows the importance gained by them. The micro strip antennas are the present day antenna designer's choice.

Low dielectric constant substrates are generally preferred for maximum radiation. The conducting patch can take any shape but rectangular and circular configurations are the most commonly used configuration. Other configurations are complex to analyse and require heavy numerical computations. A micro strip antenna is characterized by its Length, Width, Input impedance, and Gain and radiation patterns. Various parameters of the micro strip antenna and its design considerations were discussed. The length of the antenna is nearly half wavelength in the dielectric; it is a very critical parameter, which governs the resonant frequency of the antenna. There are no hard and fast rules to find the width of the patch.

### *C. Basic Characteristics*

Microstrip antennas, as shown in figure below, consist of a very thin ($t \ll \lambda_0$, where $\lambda_0$ is the free-space wavelength) metallic strip (patch) placed a small fraction of a wavelength ($h \ll \lambda_0$, usually $0.003\lambda_0 \le h \le 0.05\lambda_0$) above a ground plane. The microstrip patch is designed so its pattern maximum is normal to the patch (broadside radiator). This is accomplished by properly choosing the mode (field configuration) of excitation beneath the patch.

There are numerous substrates that can be used for the design of micro strip antennas, and their dielectric constants are usually in the range of $2.2 \le \varepsilon_r \le 12$. The ones that are most desirable for good antenna performance are thick substrates whose dielectric constant is in the lower end of the range because they provide better efficiency, larger bandwidth, loosely bound fields for radiation into space, but at the expense of larger element size.

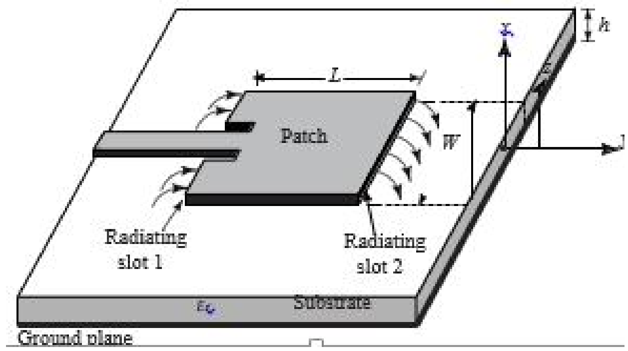



Fig.- Basic Micro strip antenna

Thin substrates with higher dielectric constants are desirable for microwave circuitry because they require tightly bound fields to minimize undesired radiation and coupling, and lead to smaller element sizes; however, because of their greater losses, they are less efficient and have relatively smaller bandwidths. Since microstrip antennas are often integrated with other microwave circuitry, a compromise has to be reached between good antenna performance and circuit design. The radiating elements and the feed lines are usually photo etched on the dielectric substrate. The radiating patch may be square, rectangular, thin strip (dipole), circular, elliptical, triangular, or any other configuration. Square, rectangular, dipole (strip), and circular are the most common because of ease of analysis and fabrication, and their attractive radiation characteristics, especially low cross-polarization radiation. Microstrip dipoles are attractive because they inherently possess a large bandwidth and occupy less space, which makes them attractive for arrays. Linear and circular polarizations can be achieved with either single elements or arrays of microstrip antennas. Arrays of microstrip elements, with single or multiple feeds, may also be used to introduce scanning capabilities and achieve greater directivities.

The radiating patch may be any shape as shown in Fig. below-

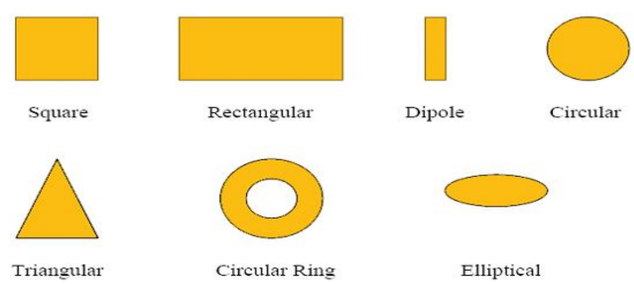



Fig. Common shapes of micro strip patch elements

*D. Circular Polarization*

The both patch elements i.e. rectangular and the circular, radiate primarily linearly polarized waves if conventional feeds are used with no modifications. However, circular and elliptical polarizations can be obtained using various feed arrangements or slight modifications made to the elements.

Circular polarization can be obtained if two orthogonal modes are excited with a 90° time-phase difference between them. This can be accomplished by adjusting the physical dimensions of the patch and using either single, or two, or more feeds. There have been some suggestions made and reported in the literature using single patches. For a square patch element, the easiest way to excite ideally circular polarization is to feed the element at two adjacent edges. To excite the two orthogonal modes; the $TM^x_{010}$ with the

feed at one edge and the $TM^x_{001}$ with the feed at the other edge. The quadrature phase difference is obtained by feeding the element with a 90 power divider or 90° hybrid.

*E. Antenna Characteristics*

An antenna is a device that is made to efficiently radiate and receive radiated electromagnetic waves. There are several important antenna characteristics that should be considered when choosing an antenna for your application as follows:

Antenna radiation patterns
Radiation Power Density
Radiation Intensity
Beamwidth
Directivity
Antenna Efficiency
Gain
Beam Efficiency
Bandwidth
Polarization
Input Impedance
Maximum Effective Area

## II. MATHMATICAL ANALYSIS

Theoretical analysis and calculations from of all dimensions will be obtained;

The width of the patch element (W) is given by.

$$W = \frac{c}{2f_o\sqrt{\frac{(\varepsilon_r + 1)}{2}}}$$

Substituting c = 3x10$^8$ m/s, εr = 2.2, and fo = 5 GHz, then W =2.3717cm or 933.74 mile.

The effective of the dielectric constant (εreff) depending on the same geometry (W, h) but is surrounded by a homogeneous dielectric of effective permittivity εreff, whose value is determined by evaluating the capacitance of the fringing field.

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{W}\right]^{-\frac{1}{2}}$$

Substituting εr = 2.2, W =2.3717cm, and h =0.1575cm, then

εreff = 2.1074cm or 829.69mile, The effective length (L eff) is given:

$$L_{eff} = \frac{c}{2f_o\sqrt{\varepsilon_{reff}}}$$

Substituting c = 3x10$^8$ m/s, εreff = 2.0475cm, and f o = 5 GHz, then Leff = 2.0665cm or 813.6 mile.

The length extension (ΔL) is given by:

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

Substituting Ereff = 2.1074cm, W= 2.3717cm, and h =0.0787cm, then ΔL= 0.041469cm or 16.3266mile.
The actual length (L) of patch is obtained by:

$$L = L_{eff} - 2\Delta L$$

Substituting ΔL= 0.041469cm, and Leff = 2.0665cm, then L=1.9835cm or 780.92mile.

## III. ANTENNA DESCRIPTION

The results of proposed circular polarised Multiband micro strip patch antenna verified in IE3D Simulator with optimization.

### A. *Proposed Equivalent circuit:*

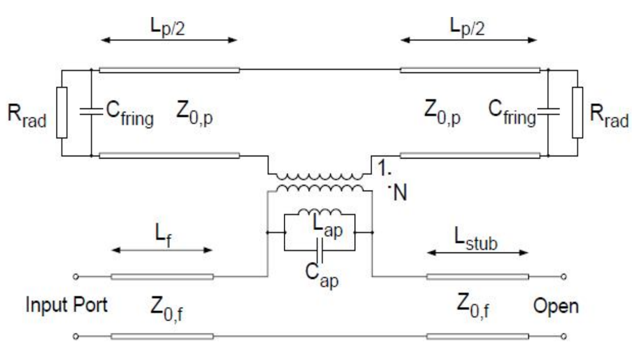
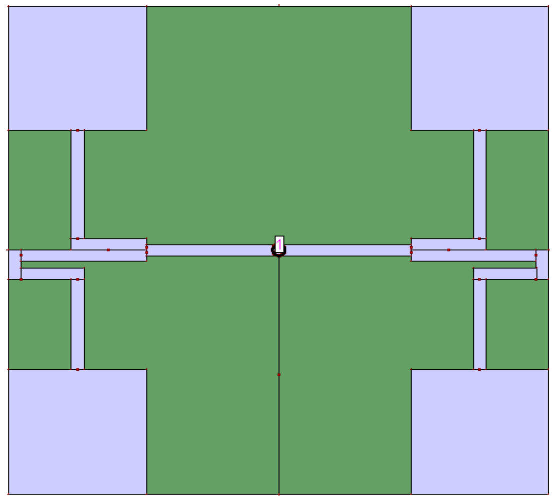



Fig. Equivalent circuit for an aperture-coupled micro-strip antenna

## IV. PROPOSED ANTENNA



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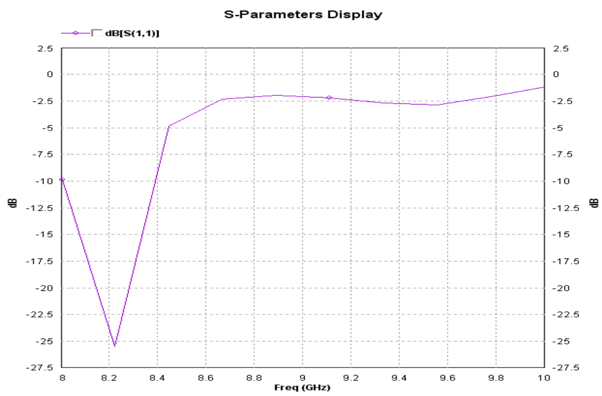
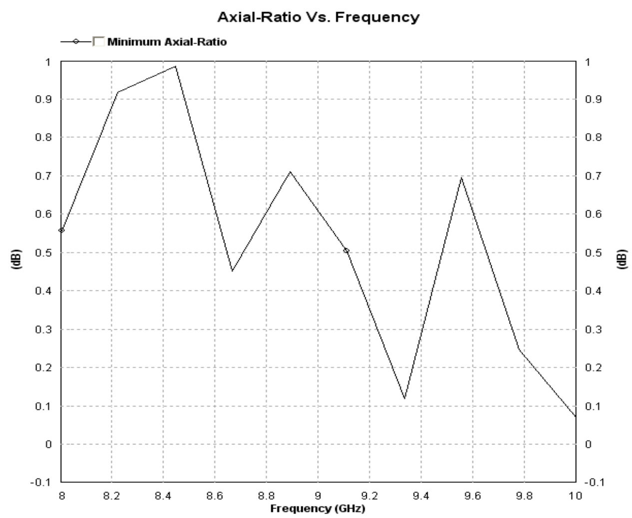
## V. RESULTS AND DISSCUSSION

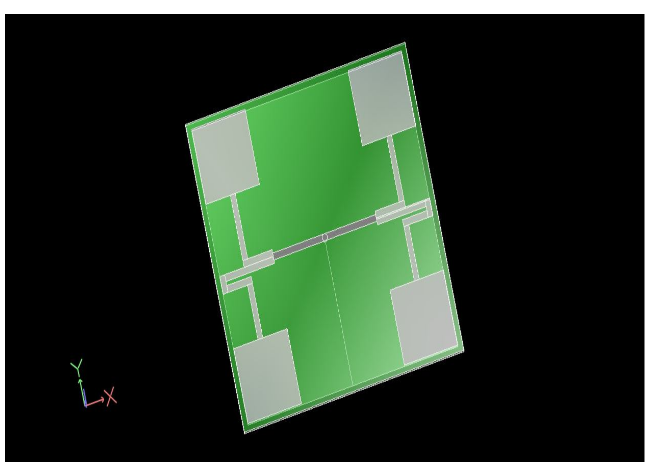
*Simulated Results:*




**S- parameter**




**Axial Ratio**




**3D radiation pattern display**

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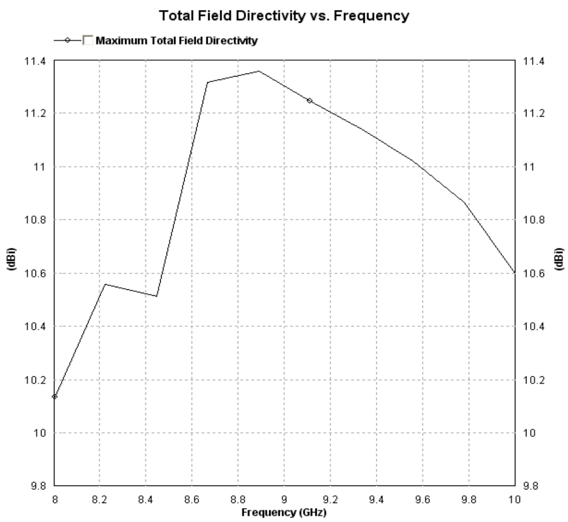


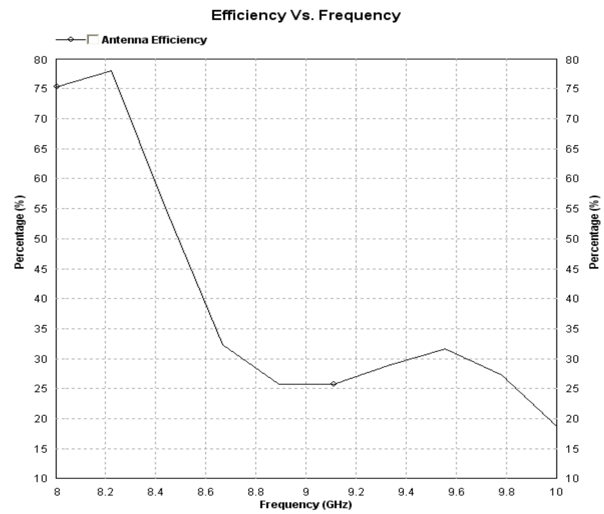


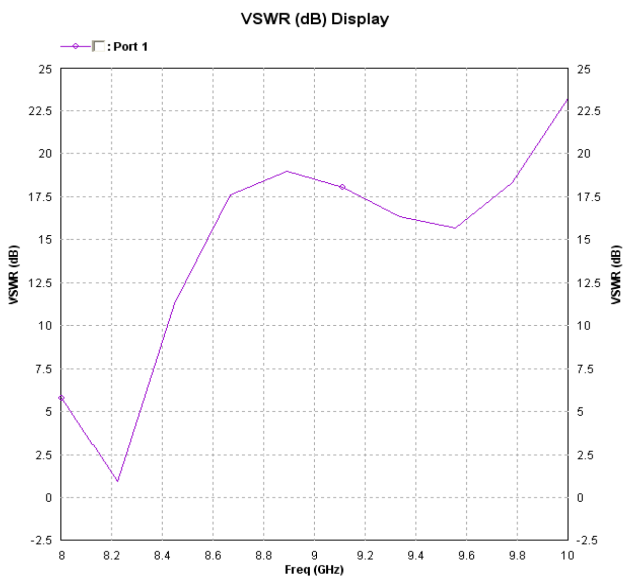


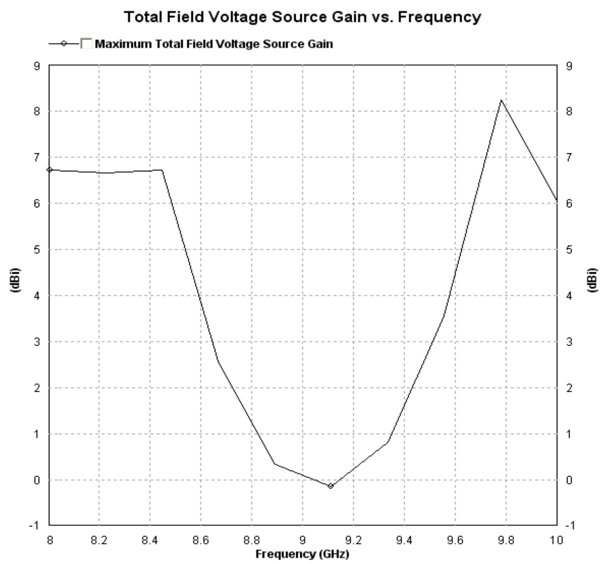


Tabular Description Of Results

| Resonant Frequency in GHz | Return loss (in dB) | Axial Ratio (in dB) | Field Gain (in dB ) | Field Directivity (in dB) | Efficiency (in %) |
|---|---|---|---|---|---|
| 8.22 | -25.34 | 0.9854 | 9.463 | 10.57 | 77.75 |

## VI. CONCLUSION

Here we design simple and low costlier patch antenna for pervasive wireless communication by using different patch length. The transmission line model seems to be the most instructive in demonstrating the bandwidth effects of the changing the various parameters. The proposed frequency range 10 GHz (Ku Band) and Analysis Radiation Characteristics of micro strip antenna by IE3D Simulator. The results of proposed designing are effective between 8GHz-10GHz. proposed antenna simulated in IE3D Simulator. The optimum results of proposed antenna verify and tested in IE3D SIMULATOR. The simulated results of IE3D at Directivity = 10.577 dB, Efficiency for Antenna= 77.7%, Return loss = -25.34 dB and Field Gain = 9.46dB. The proposed single-feed square-patch circular polarized antenna is useful for small frequency-ratio in wireless Communication.

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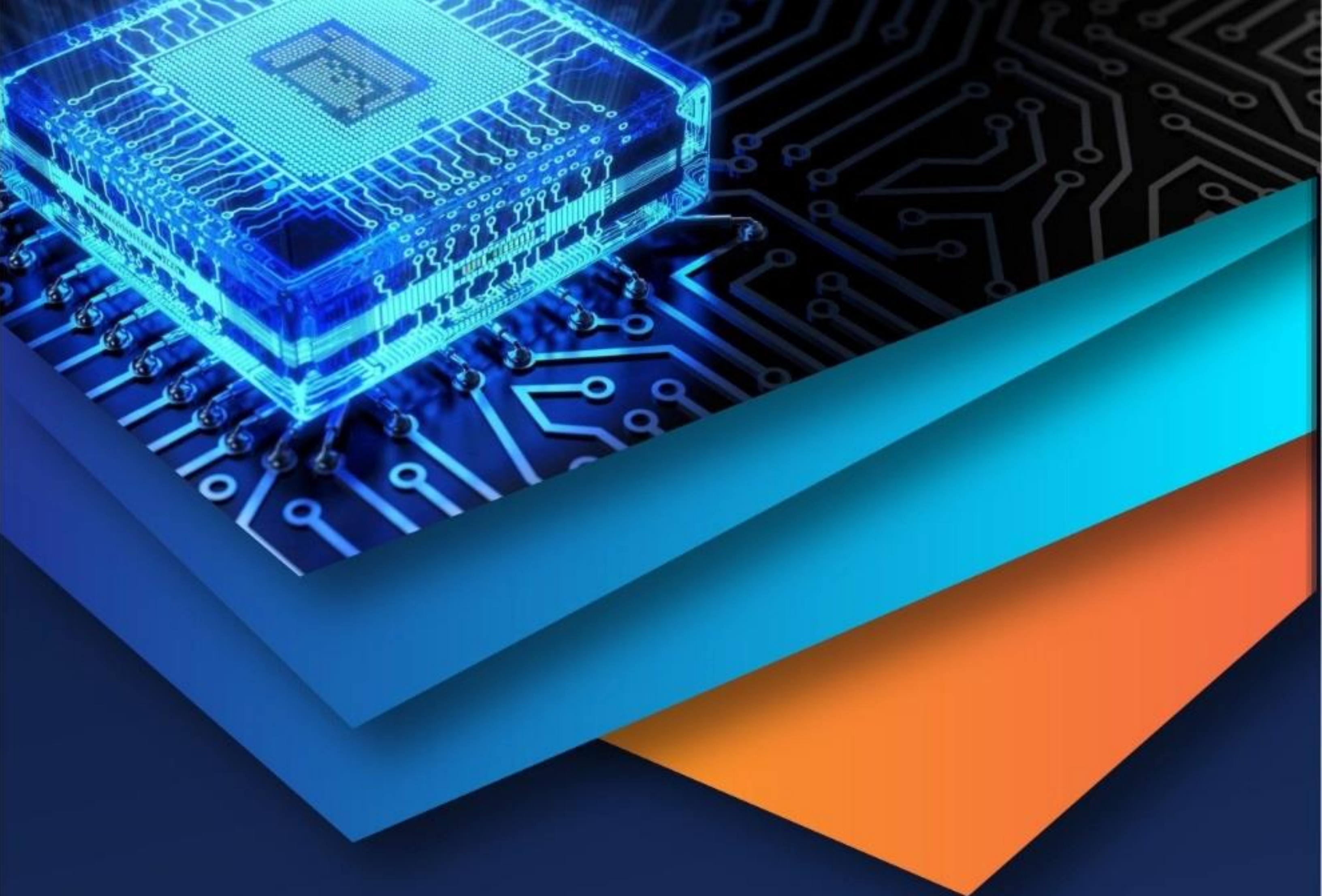

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