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Modeling & Simulation of Speed Control Mechanism for Electric Vehicle

Amartya Singh[1], Megha Chandrakar[2], Vikas Mishra[3]
[1]*Btech Scholar, Department of Electrical & Electronics, NGEC Raipur(C.G) India.*
[2]*Btech Scholar, Department of Electrical & Electronics, NGEC Raipur(C.G) India.*
[3]*Asst Prof., Department of Electrical & Electronics, NGEC Raipur(C.G) India.*

Abstract: Due to increasing growth in urbanization and internet the way of lifestyle has been changing day by day. In order to ensure that harmful emission are monitored and can be controlled the acceptance of electric vehicles has been increased. In this paper we deal with control mechanism of different types of motors used in EVs mainly DC, IM, BLDC and PMSM motors. The paper contains proper MATLAB modelling and speed vs time graph so as to achieve a proper understanding regarding aspects of speed control and problems related to it.
Keywords: Electric Vehicles, MATLAB, BLDC, PMSM, IM, DC.

I. INTRODUCTION

An electric motor is a device which converts electrical energy into mechanical energy. The driving force of electric motor is torque. Speed of motor measured in revolution per minute(rpm),defines a motors ability to spin at a rate per unit time.

A. Types of Motor

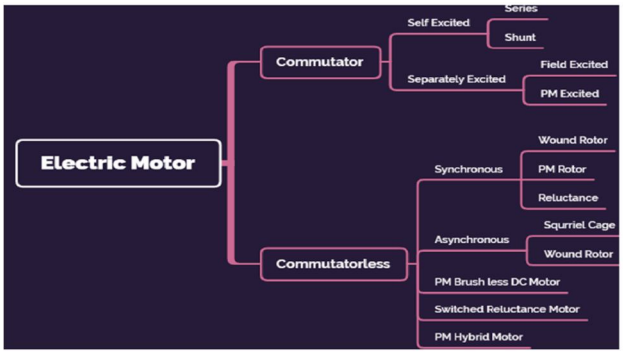

Figure 1 :- Types of motor

B. Basic Difference Between Synchronous Motor And Asynchronous Motor

A synchronous electric motor is an ac mtotor in which at steady state the rotation of shaft is synchronized with the frequency of supply current, the rotation period is exactly equal to an integral number of ac cycles.
An induction motor or asynchronous motor is an AC electric motor in which the electric current in the rotor needed to produce torque is obtained by electromagnetic induction from magnetic field of stator winding.

Purpose of controller:

1) Starting.
2) Stoping.
3) Reversing.
4) Running.
5) Speed control.
6) Safety of operator.
7) Protection from damage.

C. Ideal Torque Power Curve For Motor Application

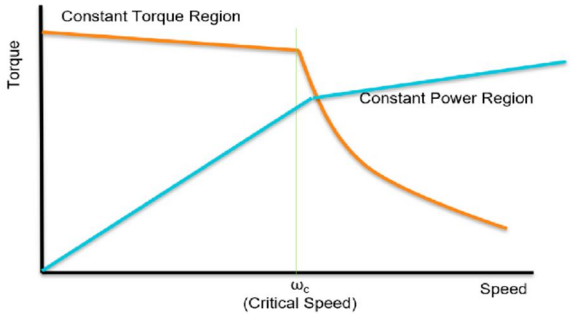

Figure 2

II. SPEED CONTROL OF DC MOTOR.

There are various methods of speed control such as flux control, voltage control, rheostatic control etc. in this module we will talk about voltage control of speed control mechanism. The basic overview is discussed as below:-

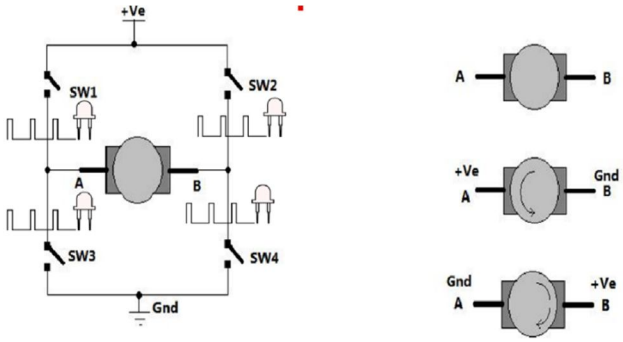

Figure 3:-Switching mechanism for speed control

Clearly we can observe that when switch 1 and 4 is on then motor enters in motoring mode, when switch 2 and 3 enables the motor rotates in opposite direction to the previous one, also speed of rotation can be altered by altering the duty cycle of pwm.If we want our motor to enter into braking mode then we simply have to develop a mechanism in which switch 3 and switch 4 operates and our motor enters into braking mode successfully.

A. Block Diagram

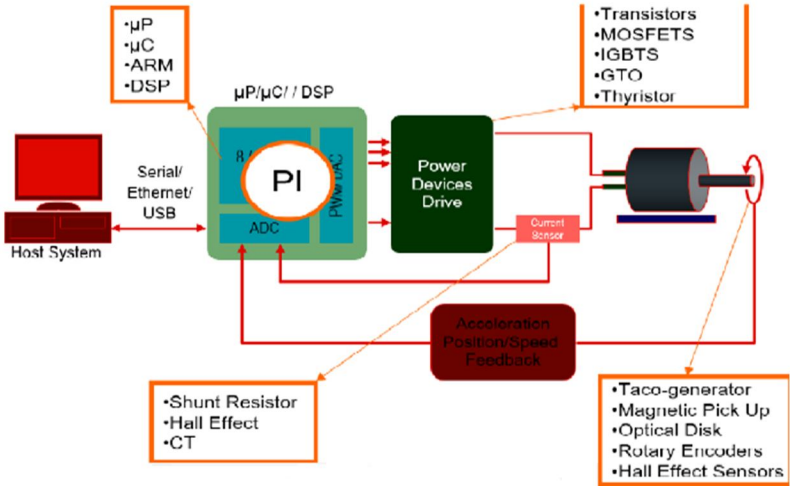

Figure4 :-Block diagram of DC motor

B. Simulation Diagrams

The following simulation diagrams assures the working of speed control of DC motor.

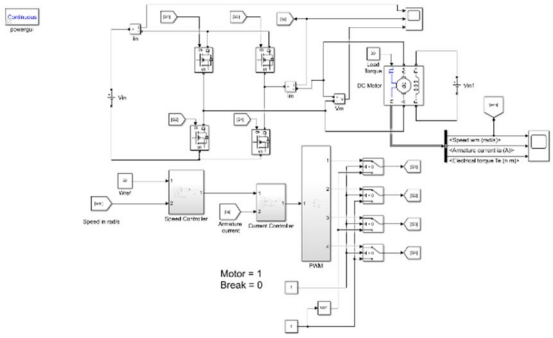

Figure 5:- Simulation diagram for DC machine

As from the figure when the input to the pwm pulses is 1 then our machine is in motoring mode while at 0 it enters into braking region, also a reference speed is set up followed by controlling action ,once the refernce speed is set up the controller arrangement tries to reach the speed to ensures that error is zero., PI controller is preffered for controlling action in our project, also the speed can be varied by varying pwm width as discussed earlier. A proper speed controller has been setup to ensures that there is no daviation in speed also we have modelled a current controller so that there is no ripples in torque. The pwm is generated by the help of refernce signal and repeating sequence all these modelled simulation can be shown as:

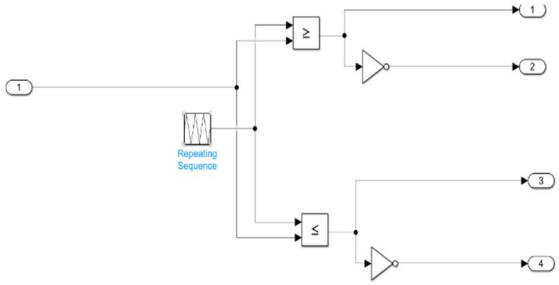

Figure6:-PWM generator block

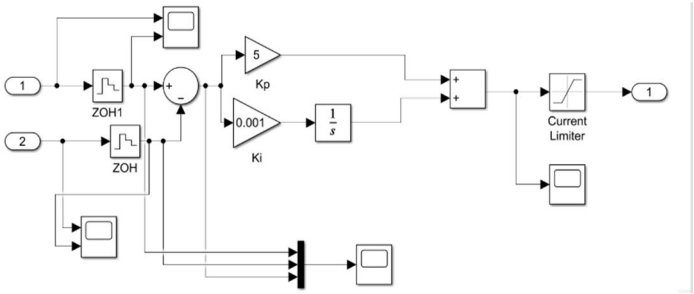

Figure7:-speed control block

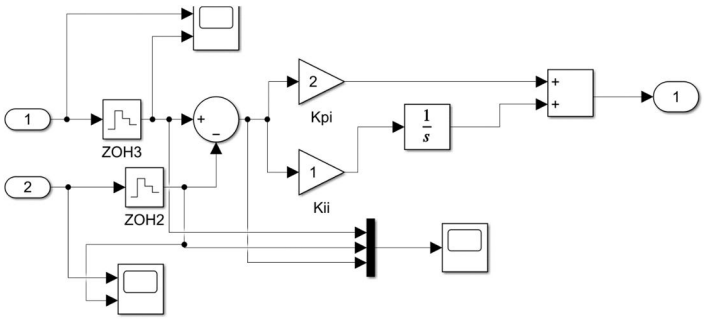

Figure8:-Current control block

C. Graphical Results

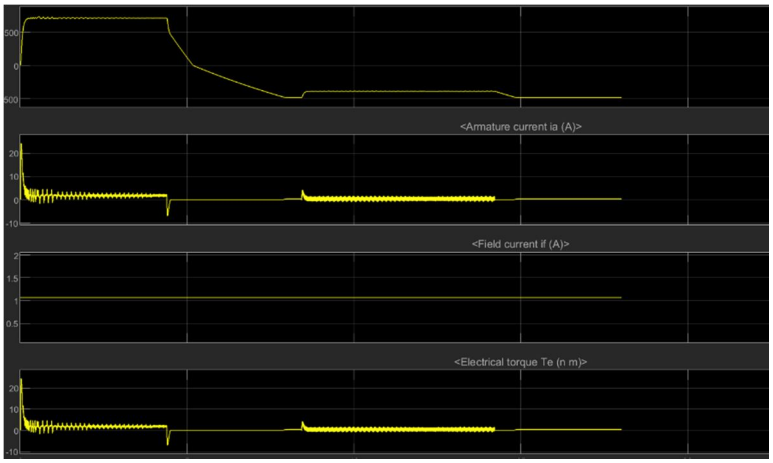

Figure9: Graph for various parameter

From the graph we can see that initially motor enters into forward motoring mode then the brakes are applied followed by reverse motoring and then into the reverse braking mode.

III. SPEED CONTROL OF INDUCTION MOTOR.

THE most famous speed control method used in induction machine is (V/F) control in which frequency of sine signal can be controlled also the magnitude of sine wave can be altered and hence voltage can be varied, another way to control the voltage and frequency is by using inverter arrangement in which switching is controlled by altering pulse width and frequency of sine pulse in Sinusoidal PWM ,the sinusoidal signals are 12 degree apart. The modeling can be shown in the figure:

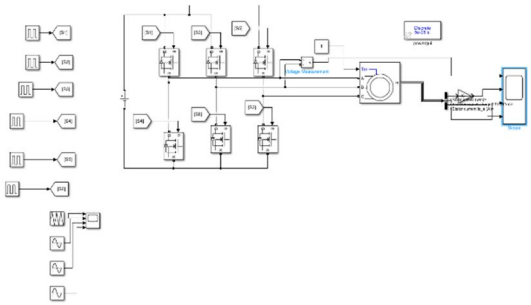

Figure10 :- simulation of induction motor

A. Graphical Result

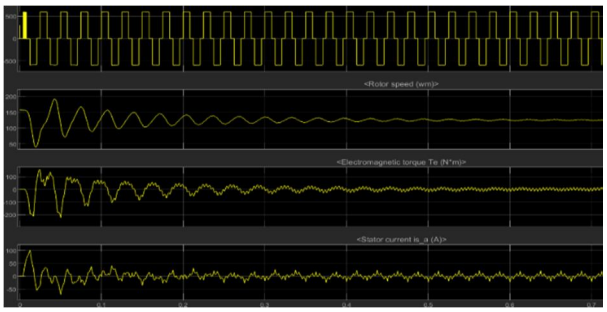

Figure 11

Some of its advantages are:-

1) Simple construction.
2) Affordable and low maintanence.
3) No requirement of additional starting motor.

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IV.SPEEDCONTROLOFBLDC&PMSM MOTORS:

1) *BLDC (Brushless Dc Motor):* The brushless dc motor is really a dc motor constructed inside-out,but without the brushes and commutators the mechanical switches are replaced with transistors,the windings are moved from armature to stator,the magnet is moved from outside to become rotor,it required six step commutation and hall sensors to track magnetic field to sense rotor angle.due to its high efficiency all the dc motors are now being replaced by bldc motors some of its applications are:

a) Hybrid electric vehicles.
b) Drones
c) Washing machines.
d) Electric bicycles.
e) Industrial applications.

2) *PMSM (Permanent Magnet Synchronous Motor):* The pmsm motor is similar to synchronous motor having some constructional differences such as the synchronous machine is doubly excited having 3 phase stator supply as well as dc supply at rotor whereas in PMSM rotor is a permanent magnet.also in synchronous motor rotor is an electromagnet having some coil turns whereas no coil is required inside rotor of pmsm hence it exhibits much less torque ripple also is more stable with less copper loss. Some of the difference between BLDC and PMSM are both are synchronous motor but bldc has trapezoidal shape of emf as inverter arrangement converts the DC input to AC whereas in PMSM as sinusoidal input is applied hence emf is also sinusoidal.PMSM due to its good torque characteristic and less losses is now leading in electric vehicle market also it has no sparks hence it is safe in explosive atmosphere moreover also it has very low audible noise and lesser electromagnetic induction which give it a edge over its other counterparts some of its applications are:-

a) AC drives.
b) Automated guided vehicles.
c) Heating,ac ,Ventilations.
d) Robots.
e) Servo drives.

A. This is a Common Block Diagram for both BLDC and PMSM

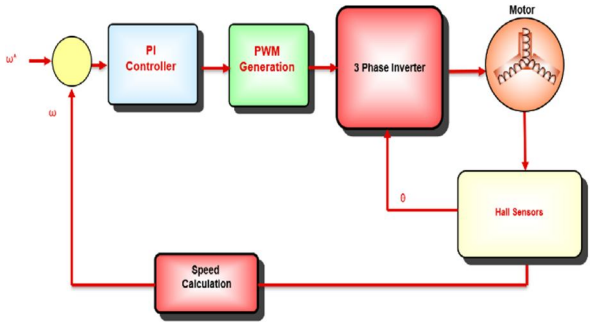

Figure12:-Block diagram

B. Simulation Model for BLDC

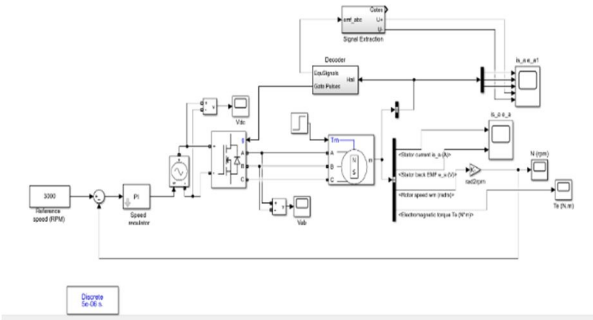

Figure13:- BLDC simulation

The commuting hall signals are produced as follows

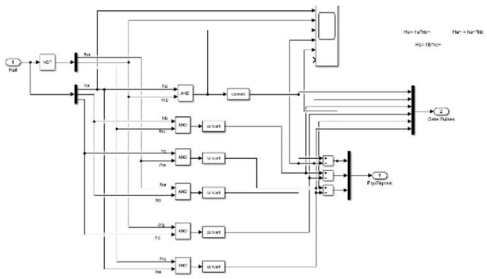

Figure 14

The gate pulses obtained are applied to the inverter for switching purpose also the signals are fed to signal extraction block where emf is generated code wise also it ensures to detect the rotor magnetic field path and excitation is triggered accordingly. The emf can be produced as:

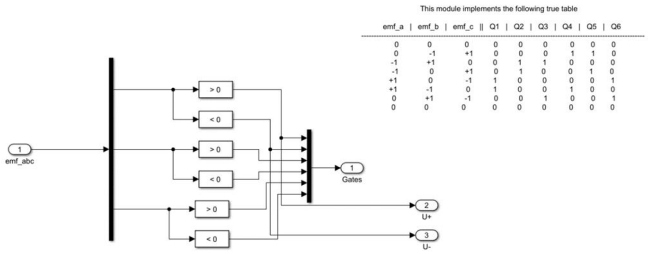

Figure 15

C. Simulation Diagram of PMSM

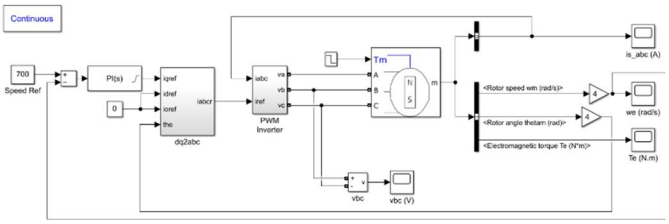

Figure 16

D. Graphical analysis of BLDC and PMSM

Rotor speed graph of bldc and pmsm is shown as follows:-

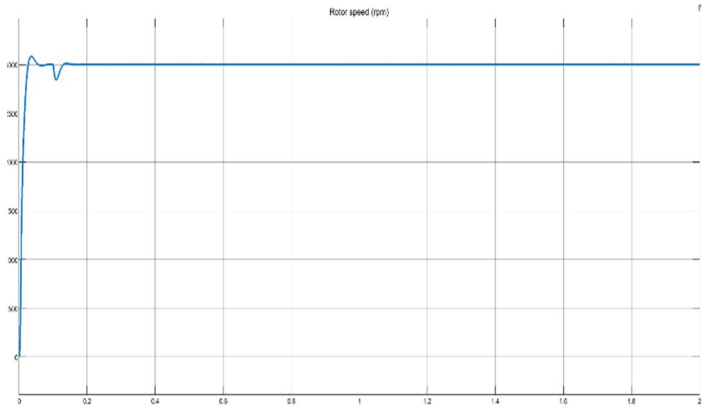

Figure 17 :- Speed time curve for BLDC

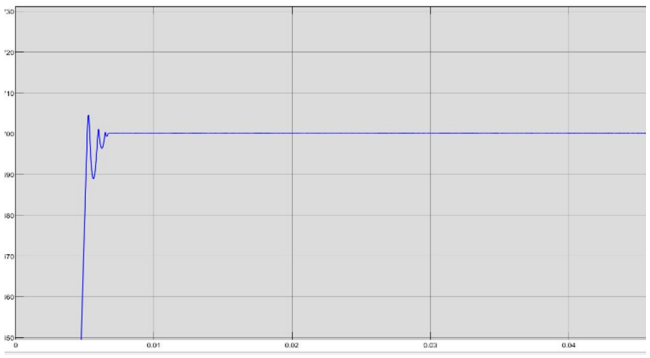

Figure18:- Speed time curve for PMSM

V. CONCLUSION

In this specimen , different types of motors widely used in electric vehicles, and day to day application has been discussed .the advantages and applications has been discussed, the modelling is shown for proper understanding of motor speed control. Controller plays the vital role in varying the speed and maintaining at optimum value, in this paper we have mainly used the PI controllers for tracking the reference speed and the graphical analysis is made. In the recent time the advanced mechanism has been used such as FOC,DTC etc,

For basic understanding of speed control mechanism for electric vehicles the information provided in this paper will form a strong foundation for concepts and will act as milestone, as the methods given ensures minimal error and also good speed regulation.

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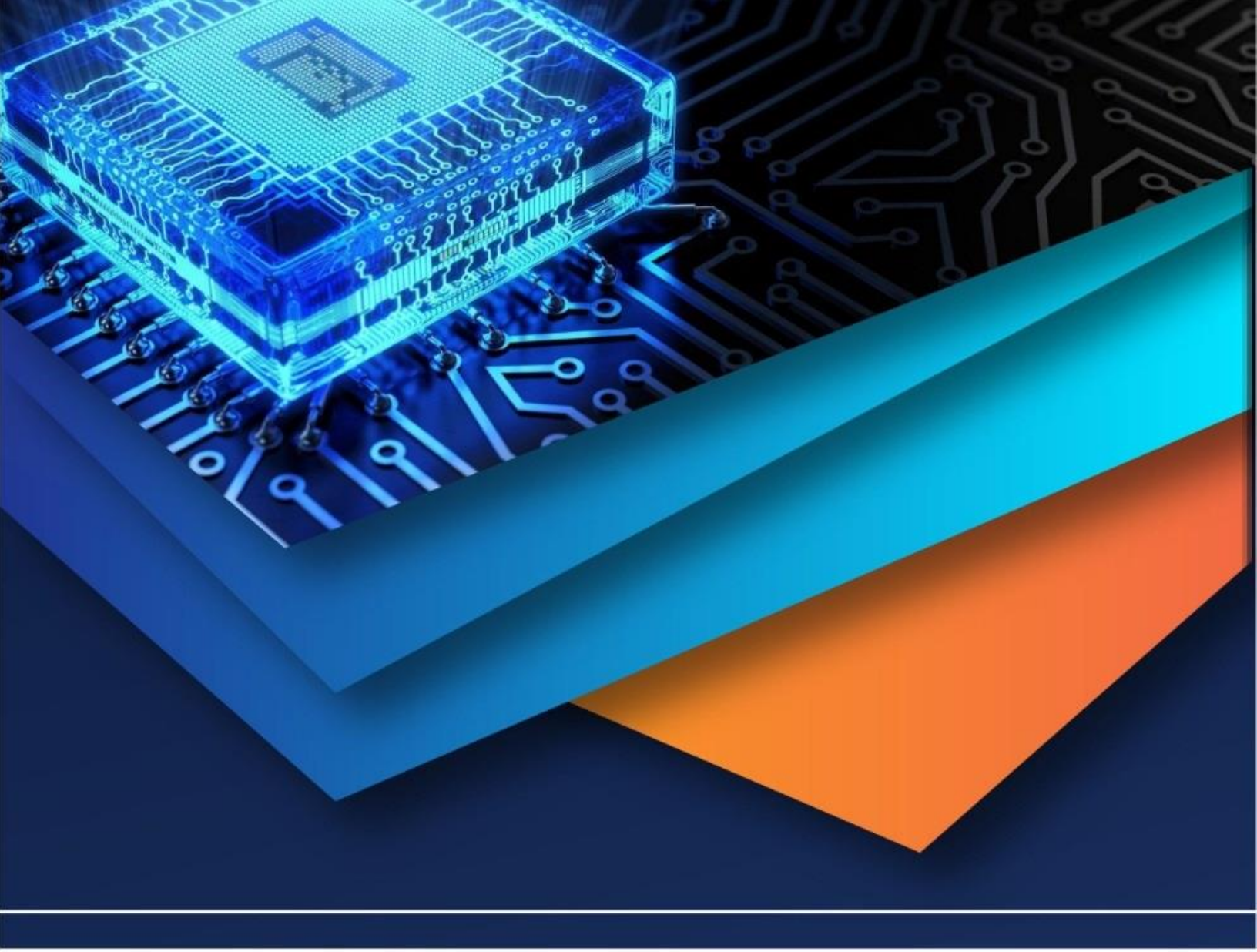

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