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Design and Implementation of Low Cost Segway the Human Transporter

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Abstract: Means of locomotion that occupy less space, cheap and probably battery powered is an active area of research. We have proposed low cost segway human transporter. The concept is based on the classical mechanical engineering design problem of inverted pendulum. Considering a freely suspended vertical pendulum on a robotic platform, the base of vehicle has to move in the direction of tilt of pendulum so that the pendulum remains straight without falling. The mechanical design and the processes flow has been implemented by using electronic and electromechanical means. The data from accelerometer is utilized by intelligent processor to control the motors of the robotic wheels. The motion concept similar to the illustration of inverted pendulum problem is implemented so that the robot gains self-balancing capacity. The Segway has a bright future, it will eventually be widely used and accepted as a form of transportation that is better than the bicycle.
Keywords: Segway, isometric view, accelerometer sensor, gyroscope sensor, chasis, DC motors.

I. INTRODUCTION

The Segway (Human Transporter) doesn't seem all that remarkable it looks like a high-tech scooter but people who have tried it out claim that it is much, much more a completely different way to get around**.** Segway is used to transport humans from one location to another location without any risk. Basically Segway is a scooter like appearance but the wheel arrangement is parallel to each other are placed side by side. Dean Kamen has invented a personal transportation technology called segway that can be used for commercial purposes. It can be used by golfers on a golf course instead of gold carts, by policeman, security and also by individuals to travel short distances. The starting price of any type of segway is above Rs 20,000/-. Only high income group people can prefer it. In developing country like India where high income group people is less in number. If it is available for low cost, it will be preferred by all. The ultimate aim of our design is to make a segway with a cost around of Rs 10,000/-. We named it as human transporter or homemade segway.

II. RELATED WORK

The balancing technology for the operation of the Segway was invented by Dean Kamen to mimic the way the human body balances itself. The balancing technology is known as dynamic stabilization in which the mechanism operates like how the fluid in the inner human ear sends signals to the brain when the body shifts [1]. Presently the segway is in development stage and mainly used by certain organizations that can afford it and individuals having good financial status [2]. In an interview with Time Magazine, Dean Kamen claimed that his machine "will be to the car what the car was to the horse and buggy" [3]. Unlike a car, the Segway only has two wheels and it looks something like an ordinary hand truck, yet it manages to stay upright by itself. To move forward or backward on the Segway, the rider just leans slightly forward or backward. The rider turns the right handle bar backward or forward, to turn right or left.

III. SEGWAY DESIGN AND FABRICATION

Fig.1 shows various orthographic and isometric views of Segway. These views were drafted with the use of CATIA V5 software. This design was used for the manufacturing of segway. These views were also used for the analysis of chasis.

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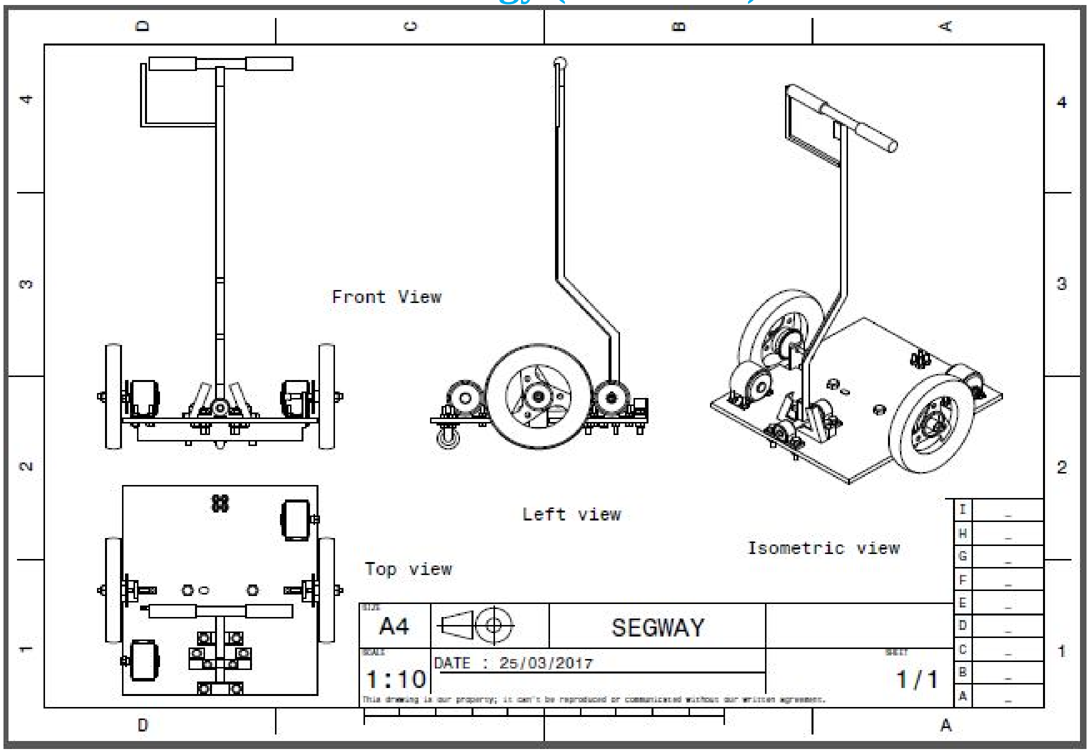

Fig.1 Views of Segway

Crushing or Compression stress on threads (Bolts)

Let the crushing or compression stress between the threads is σ_c

σ_c is obtained by using the relation, $\sigma_c = P/\pi(d^2-d_c^2)n$

Where,

d = Major diameter

= 9 mm

d_c = Minor diameter

=7 mm

n = Number of threads in engagement=7

σ_c=18.16N/mm^2

From PSG Design Data book,

Assume C45 steel for Stud material

$(\sigma_c)_{allowable}$ = 710 Mpa

$\sigma_c < (\sigma_c)_{allowable}$

Therefore, design is safe.

Diameter of Stud = 9mm

From DDB, (coarse series),

Core diameter of thread corresponding to M9 is d_c = 0.84d

d_c = 7.56 mm

Load is given by,

P = 1420d = 12780N

$P = \pi/4(d/c)^2 * \sigma_t$

σ_t = 284.70 N/mm^2

σ_t =284.70 MPa

Assume C45 steel for Stud material

$(\sigma_t)_{allowable}$ = 710 Mpa

$\sigma_t < (\sigma_t)_{allowable}$

Therefore, design is safe.

Length of chain

Let,

D = Diameter of the pitch circle=24mm

T_1 = Number of teeth on the small sprocket=15

T_2 = Number of teeth on the large sprocket=18

d_1 =Diameter of chain roller=8mm

p = pitch of the chain =12mm

Length of the chain L = K.p

Number of chain links $K = \{(T_1+T_2)/2\}+(2x/p)+[(T_2-T_1)/2\pi]^2. P/x$

K =50

L =50*12=600mm

Length of chain L= 600mm

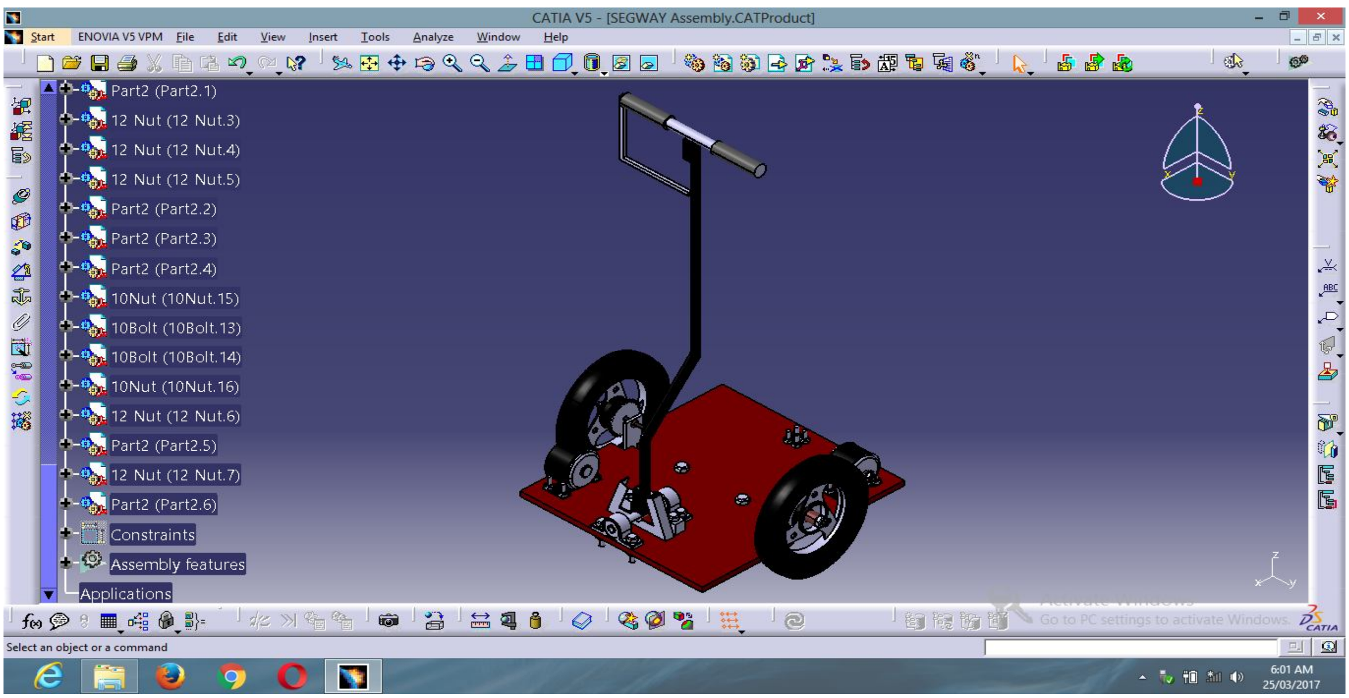

Fig.2 Isometric view of segway

Isometric view of the segway is shown in the Fig.2. Wooden block is used to make the chasis. Frame is made by using four wooden blocks of equal weights for balancing the chasis. To make chasis to be balanced, four wooden blocks of equal weights are used. It is engaged firmly with the help of stud. Wooden blocks are connected together with the help of stud and nuts. Wheels are attached to the middle of frame in order to withstand the load capacity. The main sources of power to drive the vehicle are motors which are fixed with the chasis through screwed bolts. Two motors are used for two wheels and motors are driven by separate motor drivers. Chain drives are used to transmit power between motor and wheel. Type of chain used is power transmitting chain (Bush Roller Type). Two motors are mounted on the opposite sides of the chasis. Motor shaft is fitted with small size sprocket. The wheel shaft is fitted to large size sprocket. The sprockets are connected by chain drive so that as motor rotates, wheel also rotates [4]. Handle bar is fitted in the front side of the chasis.

IV. ANALYSIS OF THE CHASIS WITH ANSYS SOFTWARE

A. Material Properties

The material used for the chasis was AISI 1010 steel.

Tensile strength of AISI 1010 steel = 325 N/mm^2

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Yield strength of AISI 1010 steel = 180 N/mm^2
Elastic Modulus of AISI 1010 steel = 200000 N/mm^2
Shear Modulus of AISI 1010 steel = 80000 N/mm^2
Poisson's ratio of AISI 1010 steel = 0.29
Mass density of AISI 1010 steel = 7870 kg/m^3

B. Boundary Conditions

The middle portion of the chasis was kept fixed.
All the forces were applied at the end of the chasis.
The inputs given above are used to obtain results by using ANSYS software. The results are shown in following Fig.3 and Fig.4.

C. Equivalent Elastic Strain

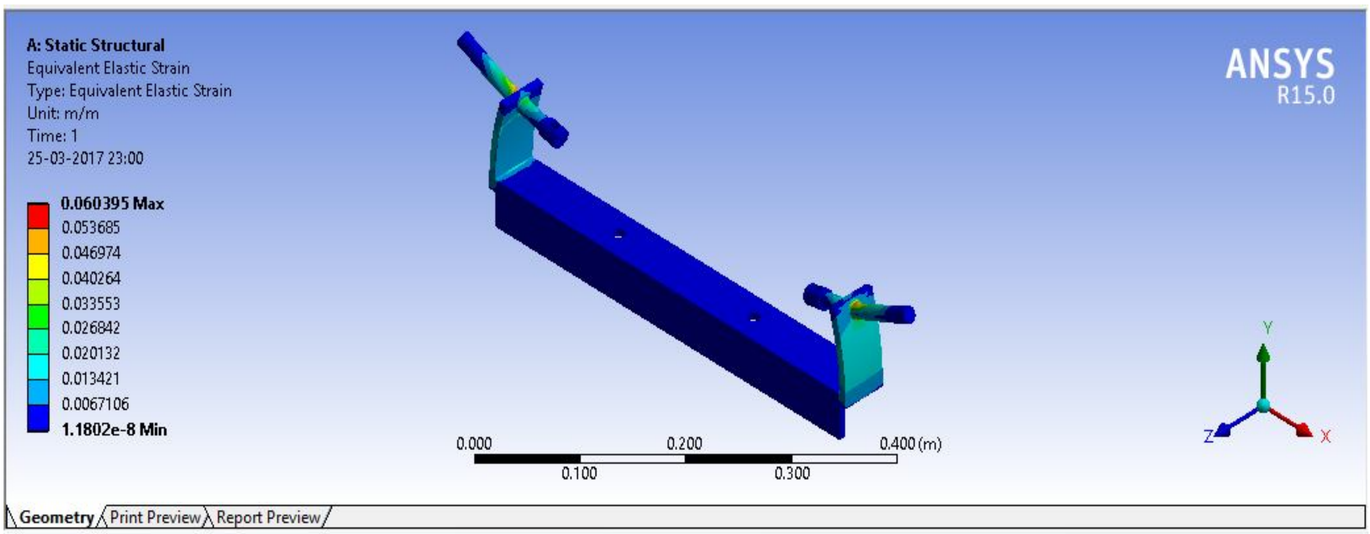

Fig.3 Equivalent elastic strain

Fig.3 shows the static structural analysis of assembly in which equivalent elastic strain is shown. All units are given in mm workbench. The analysis shows range of deformations and colours shows the limit of deformations. The dark blue colour shows the range of deformation is from 1.1802e-8 min. and red colour shows 0.060395 max. Fig.3 shows nine different colours for indicating different equivalent elastic strain values. Thus according the analysis, design is safe.

D. Equivalent (Von-Misses) Stresses

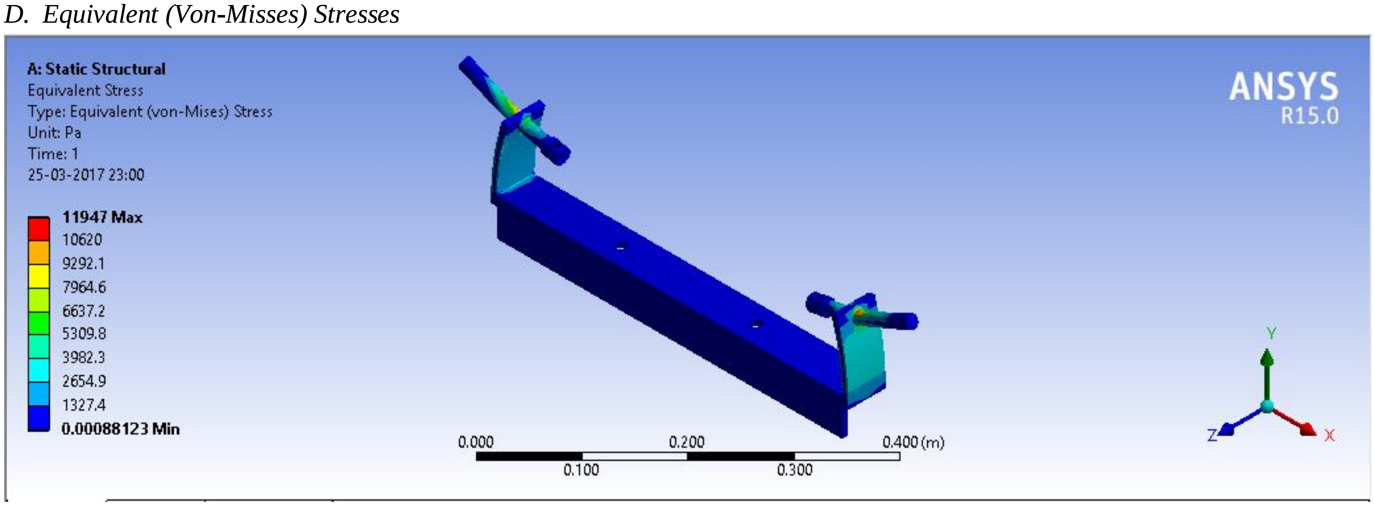

Fig.4 Equivalent (von-Misses) stresses

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Fig.4 shows the static structure analysis of equivalent stresses in Pa. The equivalent stress value is maximum at the tip of the chasis and the value decreases gradually from tip to inward side of the chasis. The equivalent stress value shown by red colour is 11947Pa and the minimum value shown by the blue colour is 0.00088123Pa. Fig.4 shows the nine different colours for indicating different equivalent stress values.

Fig.5 Final view of Segway

Fig.5 shows final view of the Segway. The experimental functioning of the segway proved that the design is safe and segway performs satisfactory. The third small wheel shown in the final view is only for support while segway is at rest. Fig.6 shows the electronic hardware arrangement of the developed system.

V. ELECTRONICS USED IN SEGWAY

The mechanical design and the processes flow can be implemented by using electronic and electromechanical means. We have implemented the idea by using an integrated accelerometer and motor controller. The complete process flow will be divided into three parts

A. Sensing angle of tilt accurately from the sensor platform.
B. Processing angle value to determine actuation of motors.
C. Actual driving of motors to achieve desired motion.

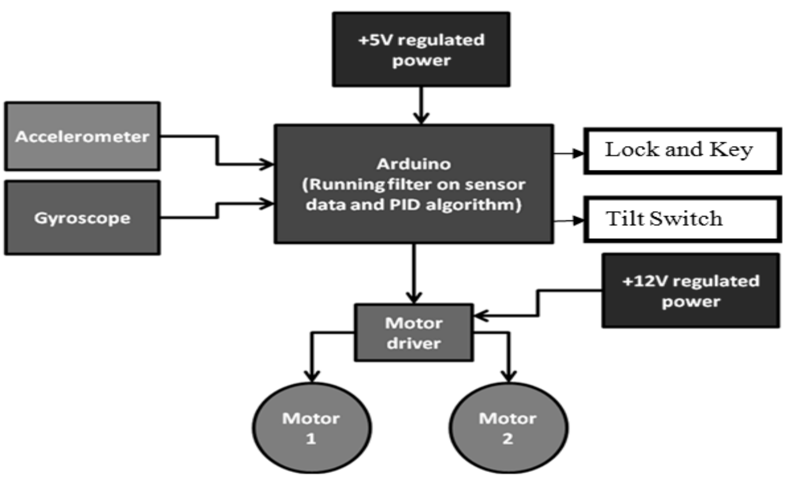

Fig.6 Simplified electronic hardware arrangement

The data from accelerometer sensor and gyroscope sensor is processed using filtering techniques to accurately determine the tilt angle. For this implementation we have used complimentary filtering technique. The output of filter processing is the tilt angle value which is input to PID control loop. The PID control loop gives the best estimate for required PWM signal to drive the motors. The motor drive subsystem takes decision and drives motor in specific direction to achieve balancing of robot platform. The motor controller is a device or group of devices that serves to govern in some predetermined manner the performance of an electric motor. A motor controller might include a manual or automatic means for starting and stopping the motor, selecting forward or reverse rotation, selecting and regulating the speed, regulating or limiting the torque, protecting against overloads and faults.
Electric brakes are devices that use an electric current or magnetic actuating force to slow or stop the motion of rotating components. They are used in industrial and vehicular braking application that requires fast response times and precise tension control. We have used intelligent reverse braking system. Sensor operated brake consist of IR transmitter and receiver circuit, control unit, braking system to detect the obstacle. The braking circuit can stop the vehicle within 2to 3 seconds running at speed of 50kms. Tilt switches receive a signal from the tilt sensor for changes in motion or orientation. They generates an artificial horizon and measures angular tilt with respect to the horizon. Tilt switches are made of nonconductive tubes that have 2 electrical contacts and material which acts as conductor between 2 electrical contacts.

VI. CONCLUSION

Cheap and battery powered means of navigation are gaining importance. Two wheeled platforms occupy less space, can be battery powered and are suitable for single person indoor as well as outdoor navigation use. However in case of two wheeled navigation platforms the very important concept is of self-balancing capacity. Electronic IMU sensors like accelerometer and gyroscope and intelligent processing platform like Arduino microcontroller are used while designing the system. The experimental functioning of the segway proved that the design is safe and segway performs satisfactory. These types of vehicles are useful in moll, societies, airports, power plants etc. As these vehicles are battery powered; there's absolutely no pollution.

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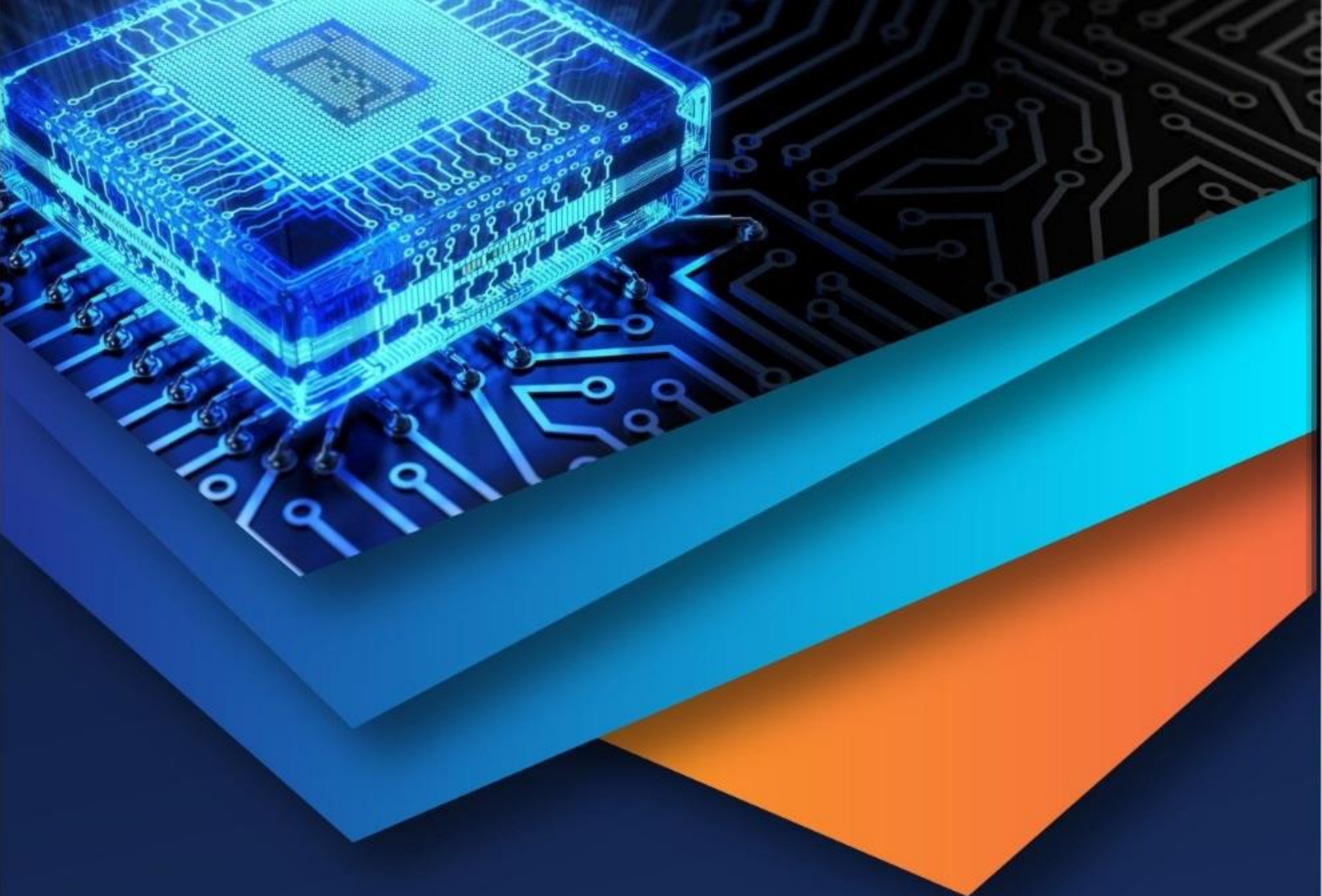

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