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Power Assisted Tricycle with Drive-Train Arrangement for Disabled Persons

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Abstract-Tricycles are used for transportation, possessing discomfort with physical exertion required to pedal over roads and uneven terrains to the physically challenged people with traditional tricycles which are arranged with extremely high gear ratio. A power assist could go a long way toward improving tricycle comfort and ease of use for drivers by easing the burden on the disable person. The tricycle is designed and fabricated with new drive trains arranged to have low gear ratio giving a solution to minimize the constraints and problems over the traditional tricycle.
Key words-Tricycle; power assist; drive train; modelling; gear ratio

I. INTRODUCTION

Tricycle is a widely used vehicle for transportation throughout India. The basic Tricycle is a three-wheeled design, pedalled by disabled persons in the side and seat in the middle for sitting arrangement. Of all vehicles, hand-powered tricycle are the worst affected by the rough, uneven roads in our country. Most of the people who depend on these tricycles are daily wage workers who have to travel long distances every day. The regular tricycle rider are prone to spinal injuries and huge energy is required to drive which creates a physical burden on the back and moreover many cannot afford good medical care. There are an estimated million tricycle pullers in India alone, with many more in Bangladesh and other developing countries. But tricycles are growing in popularity even in developed countries, with the help of the government. To deal with this problem, we come up with a model tricycle that can be very useful to people who have a disability in their lower limbs, but a strong torso [1,2,3 and 4].
In order to perform this project, literature review has been made from various sources like journal, books, article and others. This chapter includes all important studies which have been done previously by other research work.

Madeline R. Hickman [5] has discussed the idea of research and the design and manufacturing motorised Rickshaw. The aim of the project is to design a Rickshaw with a motor equipped with it to reduce the physical effort of rickshaw driver and make him comfort. He considered only the healthy Drivers not disable ones.

Masine et al [8] has paper reports on an ongoing research on the motorised tricycle for disabled person. The study of hypotheses states that the existing tricycle for disabled person requires dismounting from the wheelchair onto the tricycle. The aim of the paper is to design the motorised tricycle to overcome problem by allowing the disabled person to wheel up or down his wheelchair onto or down the tricycle.

Ravikumar Kandasamy et al [6] have discussed in his paper that how solar tricycle will help to reduce the effort of handicapped person. The study of hypotheses states that to get a larger picture on what are the problems in the current technologies. The aim of the paper is use of solar energy as an energy source to the tricycle. Anil Rajvanshi [9] developed an electric cycle rickshaw which is environment-friendly, energy-efficient and cost-effective transport system in cities and towns of India. Manpreet Singh et al [10] developed a tricycle with compounded electric drive system which was designed for overcoming the problem for the disabled.

Vikas Gulati et al [7] has discussed a theoretical design and to provide a system concept of an eco-friendly human powered vehicle with a compounded electric drive system. The aim of the paper is to provide a theoretical hybrid human powered tricycle richshaw that is very efficient, ergonomically designed and can be proved as a better replacement of fuelled vehicle contributing towards the environment sustainability.

A. Hi-tech Motorized Tricycle in India

Alimco is a company that produces electric Tricycles sown in figure 5, which is essentially what we're doing. Their more basic and cheapest model Product code no: td a65and costs Rs 48,000 (Fig. 1). This isn't out of the typical electric Tricycle price range which is about Rs 15,000 to 25,000. The amount of engineering that goes into making this machine far surpasses what will go into our Electric Tricycle. This is a great option and is state of the art, but we believe that we're approaching this art from a much different perspective with very different goals, than the typical electric Tricycle manufacturer.

Fig.1. Alimco Tricycle

With this background an attempt is made to undertake this project. We began the design project with drive train option for transmitting power from the electric motor to the drive wheel. The most significant advantage of the chain drive system that reinforces our commitment to it is its ability to transmit large torques without slipping. Also, torque transmission is independent of whether conditions and tire pressure unlike belt and friction drive system. Drive train reduces the speed of the motor and makes the disabled to drive at low speed comfort moreover easy to install and repair too. Power assist not only reduces the physical burden but also provides the accessories like head light, horn.

II. PROBLEMS WITH TRADITIONAL TRICYCLE

Tricycle drivers work long hours and many are under-nourished and living in extremely poor conditions. The strength and endurance required pedalling over rough roads and uneven terrains take a huge physical toll on the drivers, and the community sees frequent outbreaks of disease and other health effects. The mechanical design of the traditional Tricycles does little to ease the burden on the driver are not the ones purchasing the tricycle, there is little incentive for sellers to improve the design for the better driver comfort and safety. And there are a number of other problems with the current design Tricycles have poor braking, safety lighting, suspension system, and gearing system. The gear ratio for existing tricycles is very high, making it difficult to pedal uphill or start from a standstill. The difficulty in pedalling takes a physical toll on the drivers, who frequently develop joint and other injuries, or outbreaks of disease. The lack of gearing system and high gear ratio on the existing tricycle models make pedalling passengers incredibly difficult for Tricycle drivers. There are a number of potential solutions to this problem, ranging from an improved gear ratio to a power assist to aid the driver.

III. DESCRIPTION

The design of the Power assist Tricycle is adaptable to the current hand-powered tricycles with little modification. The design consists of an electric motor, a drive system and a power supply as shown in Fig. 2 for design. An electric motor was chosen because high fuel costs prohibited the use of a combustion engine and because of the availability of electricity in India. The first aspect of our design that was addressed was the drive system or means of power transmission. Power must be transmitted from the electric motor to a rear wheel of the tricycle.

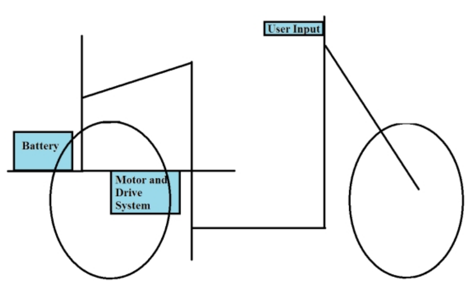

Fig.2.Design of Power assisted tricycle

Second, power is supplied to the motor by a battery pack. All the above components (motor, transmission, batteries) were designed to be able to be installed on the existing hand-powered tricycles. Everything necessary to convert a hand-powered tricycle to the Power assist Tricycle is simple to install, and the conversion is reversible.

IV. OBJECTIVES

- Reduce the physical burden on disabled person and be appropriate for use
- Top limit speed to 10 Kmph
- Have a power supply that will provide a range of 20 Kilometres at maximum speed
- Total cost of the power train and power supply will not exceed Rs 22000.

V. MODELLING AND FABRICATION

A. Pro-e Modelling

In order to integrate the electrical system with the tricycle to assist the driver, there are a number of modifications that had to be made to the tricycle frame. The required modifications in the tricycle frame are done with the help of the Pro-e software as shown in Fig 3.

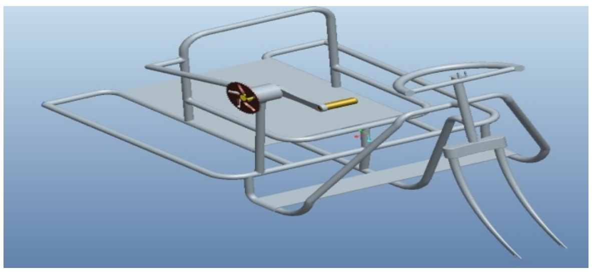

Fig. 3.Tricycle Pro-E Model

B. Fabrication

The design of the tricycle frame is modified with a back axel, electric assist setup with motor and battery. The electric system of the assist is relatively simple, consisting of batteries, motor, multi meter for taking power measurements as shown in Fig 4. The basic setup follows:

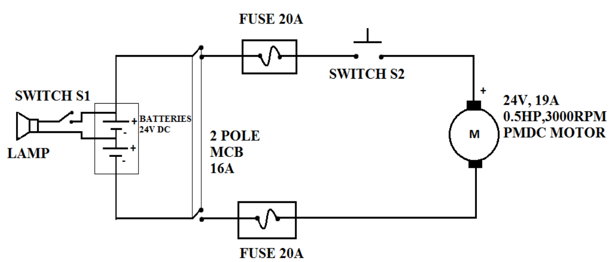

Fig .4. Electrical setup of the assist

The PMDC (permanent magnet direct current motor) was chosen for its power rating and cost. A 0.5 hp motor is chosen for the ideal electric power for a tricycle which is smooth in minute sound than other motor (make by MMC electric company pvt.ltd). The motor runs on 24 volts DC, with a rated speed of 3000 rpm and a rated current 19 amps as shown in Fig.5.

Fig.5. PMDC Motor

Two 12-volts batteries were wired in the series to reach the 24 volt required by the motor. A non-spillable lead acid batteries made by Amaron, with a 17 amp-hour capacity per battery is used. These batteries are rechargeable, and can be charged from a

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wall outlet with 12- volts, 5amp charger. All these are arranged on the tricycle frame.

VI. DRIVE TRAIN DESIGN

In order to provide enough torque to assist the driver, the output from the motor must be geared down significantly to reach high torque at the rear axle. The necessary gear ratio was calculated from the rated speed of the motor and the pedalling speed of a tricycle driver and the reasonable pedalling rate for a driver is 40 rpm with gearing ratio of 24:16 from the pedal to the rear axle and the rear axle should turn at around 60 rpm. To achieve the same speed at the rear axle with the motor driver output be geared down from its rated speed of 3000 rpm to 60 rpm with a gear reduction ratio of 1:48.

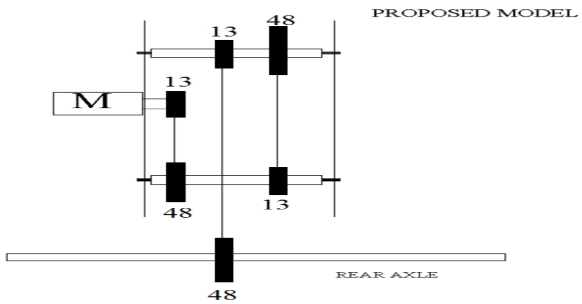

Fig.6. Drive train design for proposed model

The implication of this setup is shown if Fig.6, when a driver is pedalling at low speed as he would when staring from a standstill or attempting to pedal uphill, the motor will drive the rear axle faster than his pedalling speed, and the load is taken by the electric assist. When the driver is pedalling faster than this, while cruising or pedalling down an incline, the driver will be pedalling faster and the motor ideally would see no load.

VII. CALCULATIONS

A. No. Of teeth for the proposed model

Drive train of existing model is shown in Fig.7.

$$\frac{N1}{N2} = \frac{T2}{T1} \qquad \text{Eq.1}$$

T1 = teeth on driver = 24; T2= teeth on driven = 16

N1= speed of driver = 40 rpm

N2= speed of driven

Solving Eq. 1 => N2 = 60 rpm

Proposed model is shown in Fig.8.

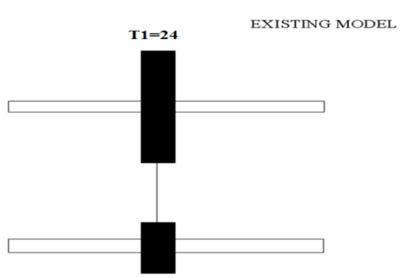

Fig.7. Drive train for existing model

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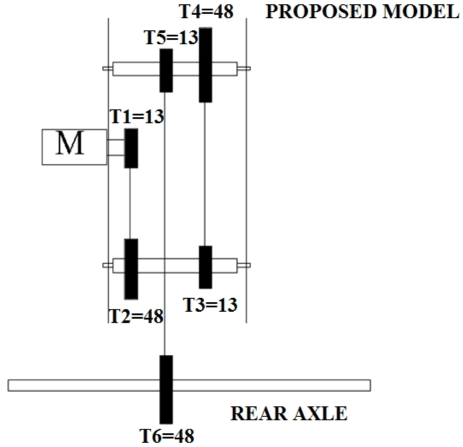

Fig .8. Drive train design for proposed model

$$\frac{N1}{N2} = \frac{T2 \times T4 \times T6}{T1 \times T3 \times T5} \quad \text{Eq.2}$$

N1= speed of driver = 3000 rpm

N2= speed of driven

T1 = 13; T2 = 48; T3 = 13; T4 = 48

T5 = 13; T6= 48

=> N2 = 60rpm

B. Sprocket design

Table.1: Specifications of chain

UNITS	CHAIN PITCH (P)	PITCH ROLLER DIAMETER	ROLLER WIDTH(W)
INCHES	0.5	5/16	5/16
MM	12.7	7.93	7.93

Sprocket Calculations

(D_p= P ÷ Sin (180˚÷N) = 194.1803 mm

D_o = P * (0.6+cot (180˚÷N)) = 201.384mm

Sprocket Thickness (T_s) = 0.93* W –0.006=7.368mm

n= 48

C. Electrical Calculations

Theoretical calculations

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$$T = \frac{C}{I}$$

C = 32 ah; I = 12 amps

T = 2.6 Hours = 2hrs 36 min

To convert rpm into velocity we have

$$v\ (\text{velocity}) = \frac{\pi D N}{60}$$

D =0.6604 m; N = 60 rpm

V = 7.468 km/hr

Total distance travel by the tricycle without any load at normal conditions is

Distance = Time × velocity

Time = 2.6 ; velocity = 7.468

Distance = 2.6 ×7.468 = 19.41 km.

Practical calculations

18.69 N-m of torque required at rear wheel to climb (obtained from Alimco Tricycle Product code no: TD 2A 65)
T = F*r; radius of rear tire r = 0.2921 m.
F is tangential force = T/r = 63.98 N.
Motor power determination: P = F*v = 0.5 hp

Battery capacity determination

· Stall current is 32 amps (tested)
· Current at top speed is 10 amps (tested)
· Estimating average current from testing in typical start/stop use to be 12 amps
· Assume average speed of 8 Km/hr(tested)
· Objective requires 20 Kilo meter range
Capacity = average current * run time
Capacity = 12 amps * (20 Km / 8 Km/hr)
Capacity = 30 Ah

We selected a 32 Ah, 12V, sealed lead-acid battery that can be obtained locally. It is a deep cycle battery that has been used in auto rickshaw designs by Amron.

VII. FABRICATION OF THE DRIVE TRAIN

In order to maintain reasonable sprocket sizes and fit the drive train within the space constraints of the tricycle frame, the necessary gear reduction from the motor was accomplished in three stages: a 13:48 reduction from the motor to the first axle, a 13:48 reduction from the first axle to the second axle, and a 13:48 reduction again from the second axle to the rear axle. This results in an overall gear ratio of 1:48, as desired.
To fabricate the gear train, custom sprocket were waterjet and attached to bicycle hubs which spins freely on bearing around an axle. The 48- tooth sprockets were bolted to freewheels and screwed onto the threaded end hub, with a second lock-nut on the first shaft to keep the freewheel from unthreading during use. Sprockets with 13 teeth are made on lathe and small spindle with 15cm length and 2.5cm diameter are made with the help of the lathe as shown in Fig 9 and 10.

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Fig.9. 48no.Tooth sprocket mounted on wheel.

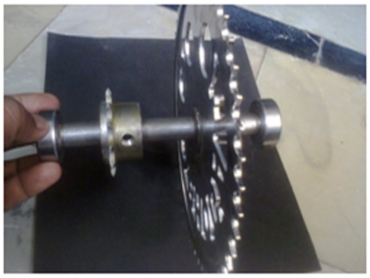

Fig.10. Final assembly of the sprocket

Fig.11. Complete drive train assembly

Fig.12.Power assisted tricycle

The drive train and motor are assembled and mounted within the frame of the tricycle, within narrow space constrains. The motor is mounted below the seat and each axle the chains to be tensioned sequentially, from the rear axle all the way to the motor. Angle iron and steel flat stock welded to the frame provide the mounting system and support for the drive train, which is particularly stiff between the two hub axles to prevent them from pulling together as shown in Fig 11 and final tricycle assembly in Fig 12.

In testing, a regular driver will be asked to drive at normal speed for a given length of time, with and without varying power levels of assist. The test apparatus is tested at different modes of assist, such as an assist that only helps at low speed when starting or driving uphill, or one that is completely user-initiated and controlled.

Estimated Cost:

The estimated cost and components required are shown in below table

Table 2: Estimated Cost Analysis

S.No	Components	Quantity	Unit Cost in Rs	Total Cost in Rs
1	PMDC Motor	1	6500	6500
2	Batteries	2	2400	4800
3	Multi meter	1	250	250
4	MCB	1	200	200
5	Fuse Folder	2	40	80
6	Fuse	2	25	50
7	Head Light	1	480	480
8	Wire	4	40	160
9	Break	2	120	240
10	48 Tooth Sprockets	3	90	270
11	13 Tooth Sprockets	3	120	360
12	Pillow Block Bearings	2	210	420
13	Bearings	4	30	120
14	Axle	1	950	950
15	Battery Holder	1	400	400
16	Mounting Materials	n/a	900	900
17	Tricycle	1	3500	3500

Total cost for the tricycle is Rs. 20,400/-.

Comparison with existing tricycle model:

Existing Motorised Tricycle Produced by Alimco industry (Product code no. TD 2A 65 Cost)
= Rs 42,000
Proposed Tricycle cost = Rs 20,760
Cost reduction = Rs 21,240

IX. CONCLUSION

A power assist could go a long way towards improving tricycle comfort and ease of use for drivers, decreasing outbreaks of disease among those not eating enough to withstand the physical exertion of pedalling a tricycle each day and night with head light arrangement too. The assist would also open up steeper routes to tricycle, making the entire system more viable than the existing ones. The objectives that we specified are achieved and believe that a tricycle is fabricated with power assist reducing the discomfort to pedal over roads and uneven terrains. And the cost is reduced by Rs.21,240/- when compared to existing models.

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Nomenclature

A = Ampere
C = Capacity
cm = Centimetre
D = Diameter of tricycle rim
D_p = Pitch Diameter of the Sprocket
D_o = Outer Diameter of the Sprocket
DC = Direct Current
I = Current
mm = Millimetre
N1 = Speed of Driver Sprocket
N2 = Speed of Driven Sprocket
n = No. of teeth
N = Speed
PMDC =Permanent magnet direct current
MCB = Miniature Circuit Breaker
P = Pitch of Chain
H.P = Horse Power
Kg = Kilogram
T_s = Thickness of the Sprocket
S1, S2 = Switches
T1, T3, T5 = Number of Teeth on Driver Sprocket
T2, T4, T6 = Number of Teeth on Driven Sprocket
V = Voltage
T = Time
W = Width of the roller in Chain

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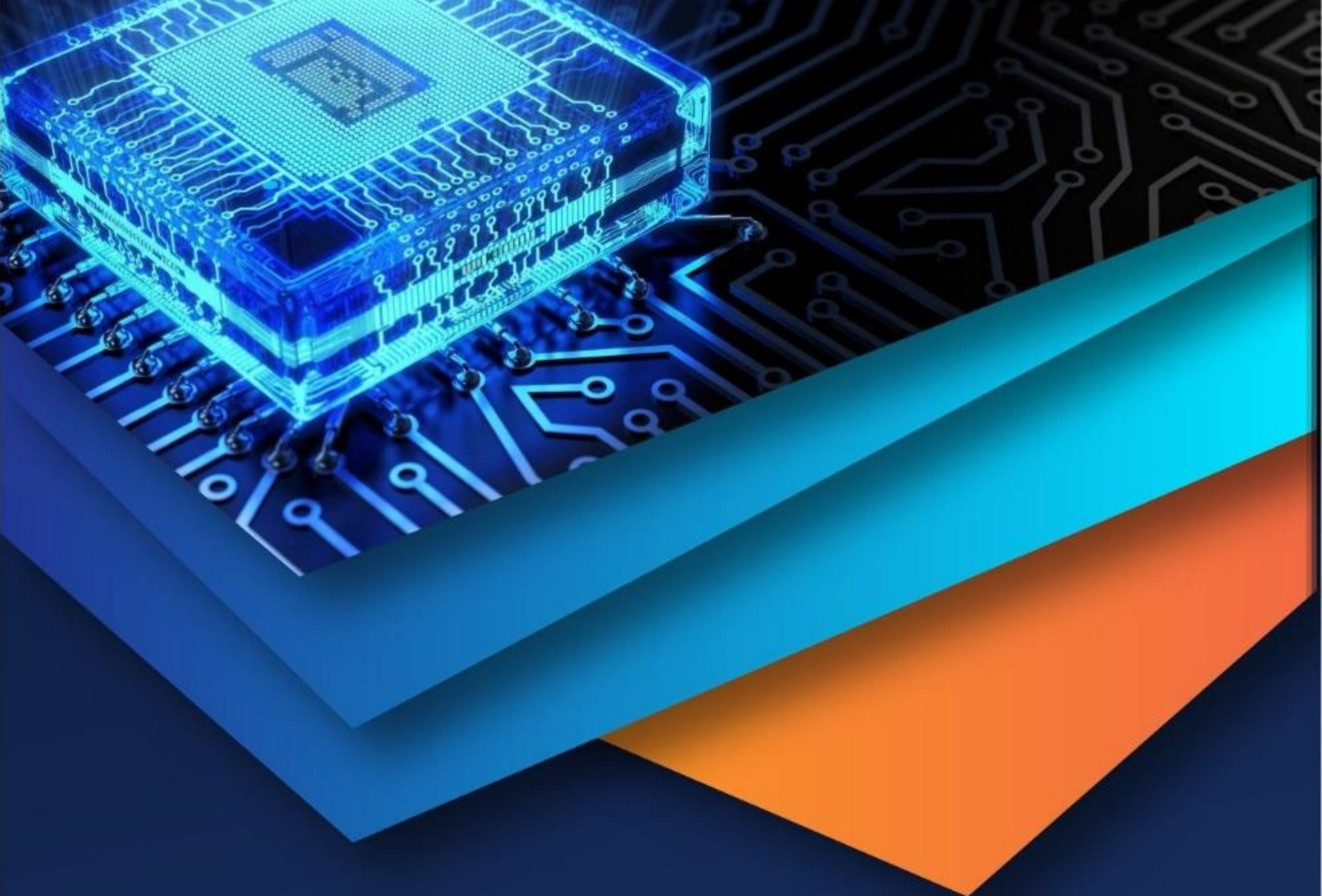

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