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Investigation and Control of Slider Crank of A Prototype of Password Controlled Security Door Through Arduino Uno

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Abstract*: This paper proposes a better control of slider crank mechanism using an Arduino UNO board. The controlled displacement of slider is further fed directly to an automatic password secured door to explore the extent of applicability of the system. The slider crank mechanism is driven by a DC BO-Motor and the Arduino UNO ATmega328 microcontroller board has been used along with a motor driven circuit to control the displacement of the slider. The password as a set of certain keyboard input of user choice directly controls the system and the door is secured by the slider crank mechanism. The establishment of direct relation between human input using electronic system and the mechanical output as a displacement of the slider is the main objective of the work which explores a new horizon of simple and cheaper door security system.
***Keywords*: Slider Crank Mechanism, Arduino UNO, Motor Driver Circuit, BO Motor.**

I. INTRODUCTION

The slider crank mechanism is a basic structure in mechanical application. It is also widely used in practical application. For examples, fretsaws, petrol and diesel engines are the typical application of velocity control.

Mechatronic design efforts have been and continue to be heavily investigated by Abhijit Nagchaudhuri [1] in the development of robotic manipulator arms with the help of slider crank mechanism using soft computing, sensing, instrumentation, and control. Other adaptive algorithms can be effectively utilized for intelligent control of such versatile mechatronic devices. Jih-Lian Ha et. al. [2] has used Hamilton's principle, Lagrange multiplier, geometric constraints and partitioning method to derive the dynamic equations of a slider-crank mechanism driven by a servomotor. The formulation is expressed by only one independent variable and a new identified method using the real-coded genetic algorithm is employed to search the parameters of a slider crank mechanism. The kinematic and dynamic analysis of a modified slider crank mechanism which has an extra link between connecting rod and crank pin, called Eccentric Connector is derived by Erkaya [3]. He also found that, increasing the output torque of modified mechanism arises from new power transmission line consisting of eccentric connector and planetary gear mechanism although the driving force is same for conventional and this mechanism. A position tracking control of the slider crank by using PID controller was investigated by Fauzi Ahmad et. al. [4]. Ranjbarkohan [5] et. al. have studied the analysis of kinematics and kinetic of slider-crank mechanism of the engine in maximum power, maximum torque and downshifting situation and influence of different parameters such as engine RPM were investigated on crankshaft and connecting rod loads. High load is applied to engine in downshifting in comparison with full load condition. There is a necessity for stress, fatigue and frailer in these conditions. G. Katal [6] have designed and implemented a Synchronized Robotic Arm, which is used to perform all the basic activities like picking up objects and placing them with the help of ATMEGA-8 Microcontroller using Arduino programming. The board then processes the signals received from the potentiometers and finally, converts them into requisite digital pulses that are then sent to the servomotors which will respond with regards to the pulses which results in the moment of the arm. For recycling of aluminum cans of foods and drinks, manual operation is being carried out in industries, which is a time consuming process and ultimately it leads to the reduction of production rate. In order to crush the cans in a less time, Shadab Husain and Shadab Sheikh [7] are designing a can crusher machine using scotch yoke mechanism which is an inversion of slider crank mechanism having multi or two side crushing ability. Crushing is done at very low cost. The controlling of robot using joystick, mobile and laptop using the Arduino board, proximity sensor, an L293D interface circuit and a motor driving system was prepared by Balasubramanianet et. al.[8]. They also made obstacle avoider robot and line follower robot are automatically controlled using proximity sensors. A discrete-time adaptive nonlinear control procedure was developed by YaprakYalçın [9] based on immersion and invariance control, and using back-stepping for the regulation of slider-crank system and also a convenient parametric formulation of the system dynamics is established. Most of the conventional wiper systems at present do not completely wipe off the rain droplets still leaving blind spots at the top right corner and at the edges of the windshield. A wiper system has been designed by D Gowtham and Srivathsan[10] using the whit-worth mechanism which is an inversion of slider crank mechanism to provide maximum view to the driver there where (7) by eliminating the blind spots. A simulation of Reciprocating Motion Wiper System is done with the help of Adams and various dynamic results are obtained. Through numerical simulations, perturbations in response of mechanisms with clearance joints have been analyzed and effects of increasing number of clearance joints have been addressed and also nonlinear dynamics of system are analyzed, using Poincare maps and bifurcation diagrams by Sadeq Yaqubi et. al. [11] . Chih-Cheng Kao [12] have introduced self-tuning PID control method to the position control of slider-crank mechanism which can automatically tune its parameters under these ranges according to the position error and error derivation.

II. SLIDER CRANK MEACHANISM: MODELLING & PROBLEM STATEMENT OBSERVATION

A. Modelling of Slider Crank Mechanism

The slider crank mechanism is a basic structure in mechanical application. It is also widely used in practical application (Nagchaudhuri, 2002). For examples, fretsaws, petrol and diesel engines are the typical application of velocity control. Hence, the slider crank mechanism considered in this study is based on the basic operation of engine which consists of a crankshaft, connecting rod and piston. The purpose of the slider-crank mechanism is to convert rotational motion of the crankshaft to the linear motion of the piston.

In the present context, the crank is rotated by a BO motor and instead of piston a slider is introduced here to make a model of sliding door which is controlled by a password through Microcontroller.

B. Dynamic modelling& Analysis of Slider Crank Mechanism

Slider-crank mechanism converts the translatory motion of piston to rotary motion of crank. Driving effect of slider-crank mechanism is obtained by a gas pressure arising from combustion of mixture consisting of fuel and air. The force corresponds to this pressure causes the piston translate along the vertical axis and this action is transmitted to crank through connecting rod. The conventional mechanism which is widely used in internal combustion engines is a concentric slider-crank mechanism. The mechanism as shown in fig .1, has one degree of freedom, that is, a constrained mechanism. Parameters used in the conventional mechanism are given in table 1 in appendix A. In considering the kinematic analysis of the slider-crank mechanism, it is necessary to determine the displacement of the slider and then its corresponding velocity and acceleration.

For the purpose, displacement of piston can be defined as a function of crank's angular position in the following from:

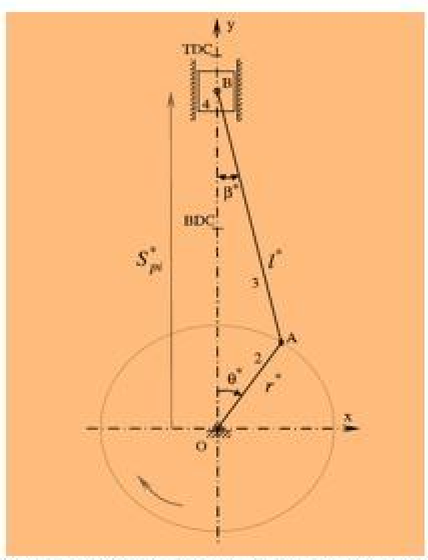

Fig 1: Concentric slider crank mechanism

$$S^*pi=l^*+r^*[\cos\theta^* - \tfrac{1}{2}\lambda^*\sin^2\theta^*] \quad (1)$$

Where r* is the crank radius, l* is the connecting rod length, $\lambda^*=\frac{y^*}{l^*}$ and θ* denotes crank's angular position. If the displacement is derived in time assuming the angular velocity to be constant, the piston velocity can be found as

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$$V^8pi = -r^*\omega_{21}[\sin\theta^* + \frac{1}{2}\lambda^*\sin 2\theta^*] \; (2)$$

By taking time-derivative of eq.(2),the piston acceleration is given by

$$a^*pi = -r^*\omega_{21}^2[\cos\theta^* + \lambda^*\cos 2\theta^*] \; (3)$$

the purpose of dynamics analysis of the slider-crank mechanism is to determine the total output torque arising from resultant force (gas + inertia).In the mechanism, gas forces, known as driving effect, do not have constant value during the expansion stroke. So, the cylinder volume has to be expressed as a function of crank's angular position considering the variation of gas forces

$$V_x(\theta^*) = V_c + [l^* + r^* - S_{pi}^*]\frac{\pi d^2}{4} \; (4)$$

Where V_c is the cylinder clearance volume, S*pi is the piston displacement and D is the cylinder bore diameter. Gas pressure during the expansion stroke is given by

$$P_e(\theta^*) = P_3\left(\frac{V}{V_x(\theta^*)}\right)^k \; (5)$$

Where P3 is the pressure in the cylinder and V is the cylinder volume at the end of the compression stroke. K is the polytropic coefficient and usually taken to be equal 1.3 for diesel engines [9].gas forces can be expressed as a function of crank's angular position in the following form:

$$F_g = A_{pi}[Pc(\theta^*) - P_{atm}] (6)$$

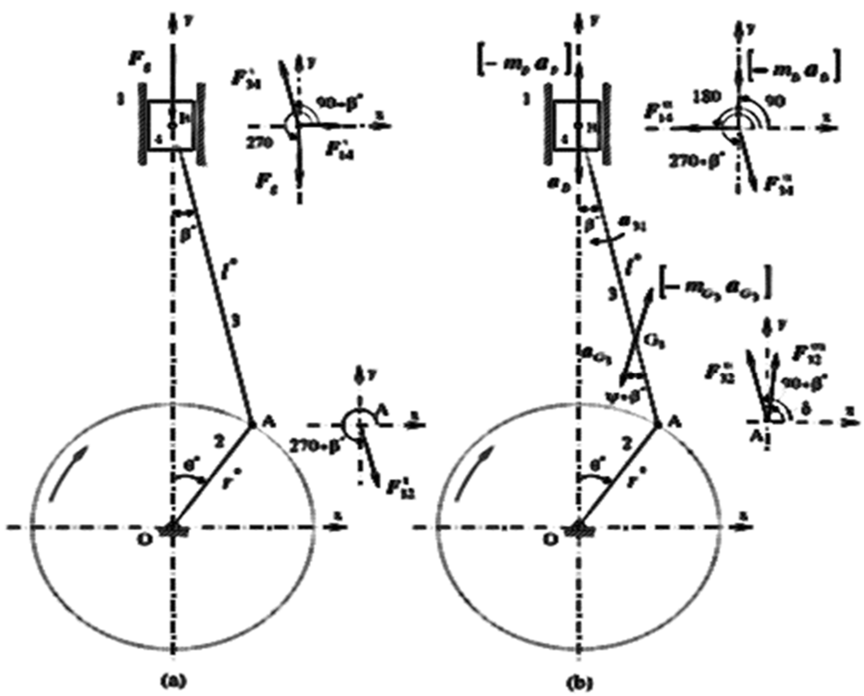

Fig. 2 The gas (a) and inertial forces (b) for conventional mechanism.

Where A_{pi} is the piston section area and P_{atm} is the atmospheric pressure.in order to determine joint forces, dynamics forces analysis has to be completed considering gas forces and inertial forces. These forces, known as active effects, are outlined in Fig 2.

Referring to fig2 (a), output torque on the crankshaft, arising from gas forces, is given by

$$M_{gas} = rxF_{32}^i (7)$$

eF_{32}^i denotes the gas forces effect on the crank-pin centre and can be expressed as a function of gas forces in the folloeing form:

$$F_{32}^i = -\frac{F_g}{\cos\beta^*} \; (8)$$

As stated schematically in Fig.2 (b), the resultant inertial force on the point A is given as a vectorial summation in the following form:

$$\sum F_{inertia} = F_{32}^{ii} + F_{32}^{iii} \; (9)$$

Where F_{32}^{ii} denotes the inertial effect of the piston's mass and F_{32}^{iii} denotes the inertial effect of the connecting rod's mass. These forces can be expressed, respectively

$F_{32}^{ii} = -\frac{(-m_B a_B)}{\cos\beta^*}$ (10)

Where mg is the total mass on the piston pin canter. aB is the acceleration of the piston-pin center and equals to a_{pi}^* in Eq.(3)

$$F_{32}^{iii} = [(\frac{(-m_{G_3} a_{G_3})(\overline{BG_3}\sin(\psi+\beta^*) - l^*\cos\psi\sin\beta^*) + (-I_{G_3}\propto_{31})}{l^*\cos\beta^*})^2 + ((-m_{G_3} a_{G_3})\cos\psi)^2]^{1/2}$$

Where m_{G_3} in the mass of connecting rod and a_{G_3} is the linear acceleration of connecting rod gravity center. Also, I_{G_3} is the inertial moment and $\propto_{31}$ is the angular acceleration. a_{G_3} and $\propto_{31}$ are given as a function of crank's angular position in appendix A. Output torque caused by resultant inertial forces is defined by:

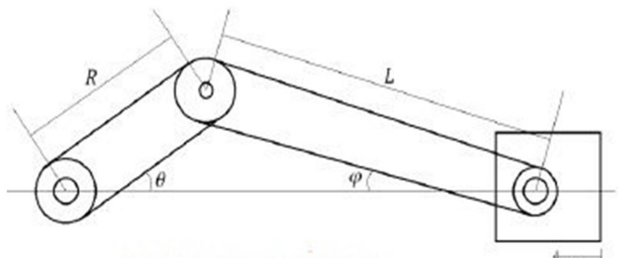

Fig.3:slider crank mechanism

$M_{Inertia} = r x \sum F_{Inertia}$ (12)

From eqs. (7) and (12), total output torque on the crankshaft can be written in the following form:

$M_{Total} = M_{gas} + M_{Inertia}$ (13)

C. Kinematic Modelling & Analysis Slider Crank Mechanism

The kinematic of slider crank mechanism can be described in equation 1 to 7.

The piston displacement from top dead centre, x, can be determined from the geometry of the mechanism, in terms of the lengths of the con-rod, L, and crank, R, and the crank angle, . From the geometry and noting that θ=φ = 0 when x = 0, x can be expressed as:

$X = R - R\cos\theta + L - L\cos\varphi$ (1)

Also from the geometry, it can be seen that,

$R\sin\theta = L\cos\varphi$ (2)

And

$[L\cos\varphi]^2 = L^2 - [L\sin\varphi]^2$ (3)

Substituting for L sinφ from Equation 2 in Equation 3 and leaves as the only variable on the right hand side of the expression,

$[L\cos\varphi]^2 = L^2 - [R\sin\varphi]^2$ (4)

Equation 4 can be substituted into Equation 1 to obtain the kinematic equation for the slider crank mechanism such as Equation 5,

$X = R - R\cos\theta + L - \sqrt{(L^2 - [R\sin\theta]^2)}$ (5)

Equation 5 can then be rearranged by introducing another parameter, n, the ratio of the length of the conrod, L, to the radius of crankshaft, R, as:

$X = R\{1 - \cos\theta + n[1 - \sqrt{\{1 - (\sin\theta/n)^2\}}]\}$ (6)

Where, $n = L/R$ (7)

III. ARDUINO PLATFORM

Arduino is an open-source electronics prototyping platform based on flexible, easy-to-use hardware and software. It's intended for artists, designers, hobbyists and anyone interested in creating interactive objects or environments. Arduino can sense the surrounding environment by receiving input from a variety of sensors and can affect its surroundings by controlling lights, motors, and other actuators. The microcontroller on the board is programmed using the Arduino programming language (based on Wiring) and the Arduino development environment (based on Processing). Arduino projects can be stand-alone or they can communicate

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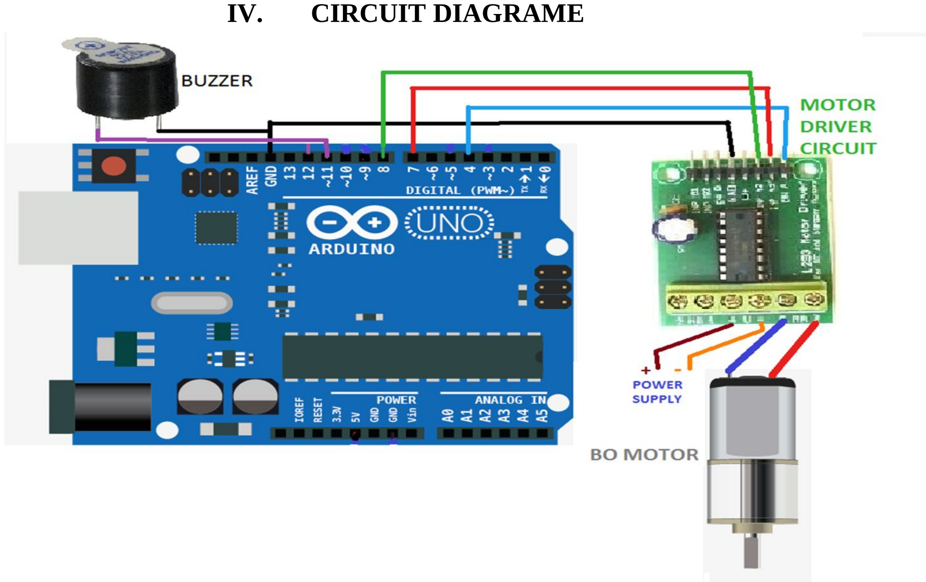
with software on a computer (e.g. Flash, Processing, and MaxMSP).

Fig.4: Arduino UNO R3 ATMEGA328

A. Specifications of Arduino

On the far left is the Universal Serial Bus or USB connector. This connects the board to your computer for three reasons: to supply power to the Arduino board, to upload your instructions, and to send data to and receive it from the computer. On the right there is power connector. Through this connector, you can power the Arduino with a standard power adapter of 5 V generally. The microcontrollers are the "brains" of the Arduino. It is a tiny computer that contains a processor to execute instructions, includes various types of memory to hold instructions and data from our sketches, and provides various avenues of sending and receiving data. The first row offers power connections and the ability to use an external RESET button. The second row offers six analog inputs that are used to measure electrical signals that vary in voltage. Furthermore, pins A4 and A5 can also be used for sending data to and receiving it from other devices. Sockets (or pins) numbered 0 to 13 are digital input/output (I/O) pins. They can either detect whether or not an electrical signal is present or generate a signal on command. Pins 0 and 1 are also known as the serial port, which is used to send and receive data to other devices, like a computer via the USB connector circuitry. The pins labeled with a tilde (~) can also generate a varying electrical signal, which can be useful for such things as controlling electric motors or creating lighting effects. Next are some very useful devices called light-emitting diodes (LEDs); these very tiny devices light up when a current passes through them.

IV. CIRCUIT DIAGRAME



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V. OBSERVATION

In the setup given below in figure no. 5, it can be seen that a Slider crank mechanism is incorporated to make a sliding door. One BO motor with Motor driver circuit is used here as driver of this mechanism. Arduino Uno is connected simultaneously with Motor driver and a PC with an USB.

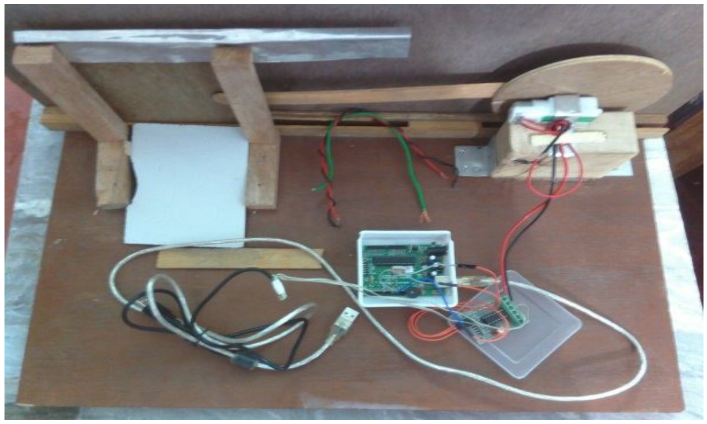

Fig.5: Slider Crank Mechanism Setup with Arduino

After the program was run in Arduino Software Serial Monitor is to be opened. “5” was stored in a specific memory location in Micro controller. If 5 is entered in the serial monitor as a password, the motor will run and thus the Door will be opened (refer to fig.6).

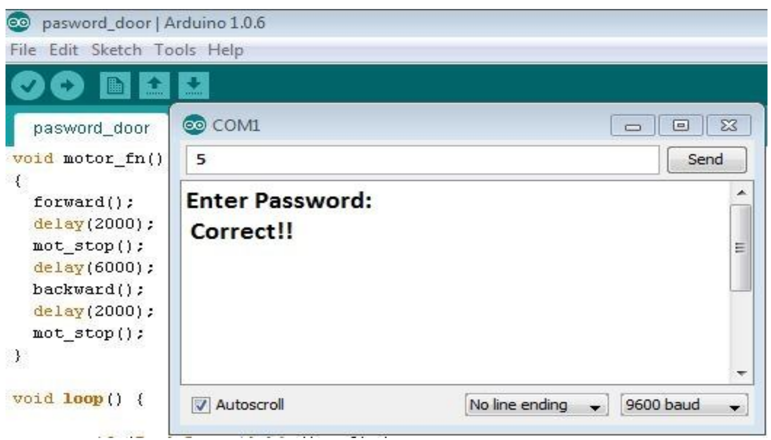

Fig.6

If one enters the wrong password the monitor will quickly Prompt the user to TRY AGAIN (refer to fig.7) but the maximum limit is of trying is set as Five times (refer to fig.8), exceeding which a Buzzer will sound an alarm.

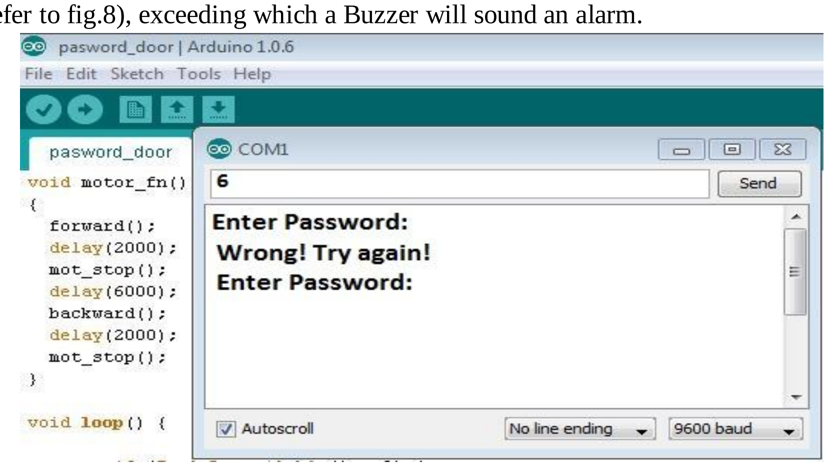

Fig.7

We have run the program for days in various tech-fest and seminars till date is has given hundred percent data redundancy. Thus, it can accurately open the sliding door weighing 53 grams. When entered the right password. If it is wrong the Micro controller can detect this very precisely and gives the “wrong” message.

VI. CONCLUSION AND FUTURE WORK

The Arduino Uno is open-source hardware. Uno means one in Italian and was chosen to mark the release of Arduino Software (IDE) 1.0. The Arduino Uno is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. By this system, here in this paper, a weight (a mechanism to lift a door) of 53 grams is been lifted and closed. Not only that, a program is written so to guide this mechanism and to add a security protocol. Password controlled security system is availed everywhere but a mechanism (slider crank mechanism) is been put here. The results have shown 100 percent reliability. However, the prototype can further be modified where with the help of right amount of torque a greater weight can be lifted. Again, the mechanism used can be replaced and the programs can be reset to use it according to its purpose. The security measurement can also be made multi-layered and tightened (like putting an alarm) so as it prevent any attack. It is the cheapest and most trustworthy system of its kind. It will be able to open a heavy door or gate such as of airport without any heavy effort by simply entering the correct password. There will be a thriving need for the Arduino controlled Mechanism in military, industrial and many more commercial as well as household purposes. The researchers have found the future scope enormous. In the era of mechatronics, the use of microcontroller based mechanism is going to pave the way.

VII. ACKNOWLEDGMENT

The satisfaction that accompanies the successful completion of this project would be put incomplete without the mention of the name of Mr. Satyabrata Podder and Mr. Gourab Chakraborty, Assistant Professor, SDET- BGI who made it possible, whose constant guide and encouragement crown all the efforts with success.

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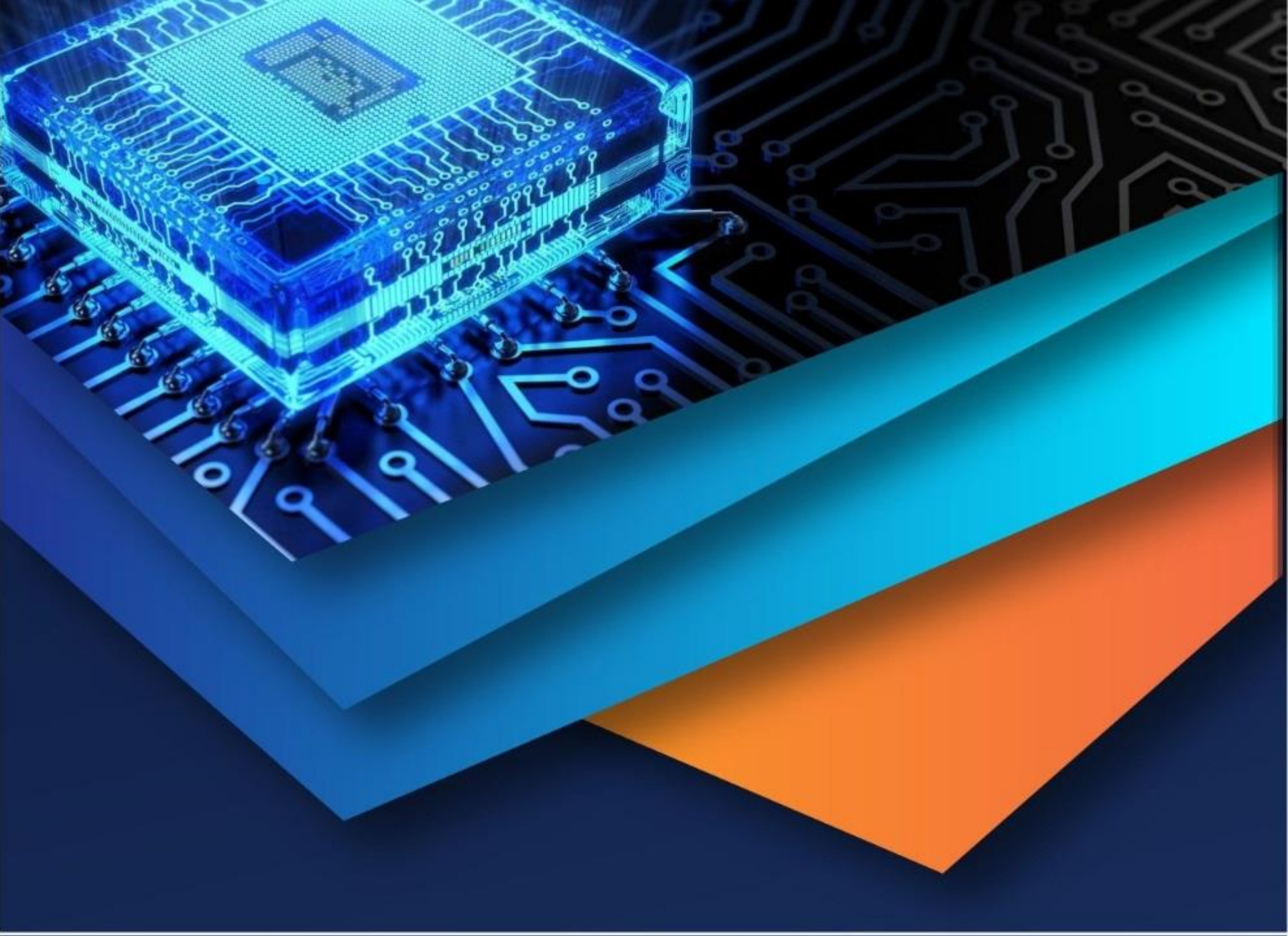

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