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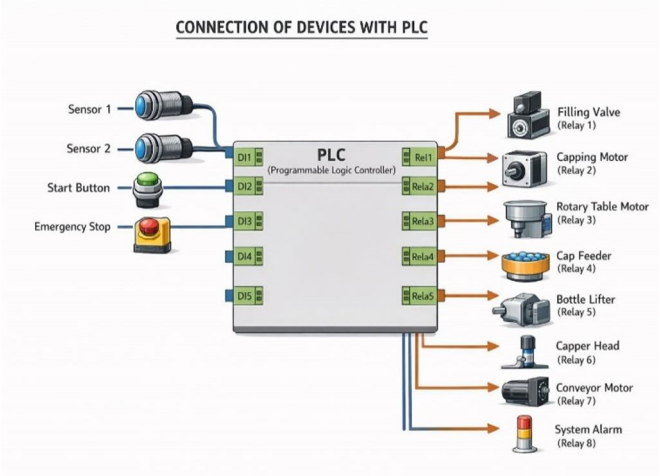
Delta DVP12SA211R Based Automatic Bottle Filling and Capping System

Er. K. M. Dhenge[1], Mr. Ganesh Bhagat[2], Mr. Parmanand Sonune[3], Mr. Tejas Kokate[4]
[1]*Assistant Professor, Department of Electrical Engineering, Nagpur, M.S, India*
[2, 3, 4]*UG Students, Department of Electrical Engineering, Nagpur, M.S, India*
KDK College Of Engineering, Nagpur M.S, India

Abstract: ***Filling is the task that is carried out by a machine, and this process is widely used in many industries that produce such as milk industries, chemical, food, mineral water and many industrial manufactures. The objective of this paper is to design, develop and monitor "Bottle filling and capping with PLC". This work provides with a lot of benefits like low power consumption, low operational cost, less maintenance, accuracy and many more. A prototype has been developed to illustrate the system. In this paper, the filling of the bottle is controlled by using a controller known as Programmable Logic Controller (PLC) which is also the heart of the entire system. For the conveyor system, a BLDC motor has been selected for better performance and ease of operation. Proximity sensors have been used to detect the position of the bottle. Structure text has been used for the programming of the PLC, which is the most widely used and accepted language for the programming of the PLC.***
The first task of the project is filling. Filling of bottles is controlled using the PLC controller which is also the brain of this project. The conveyer belt will move and shift the filled bottle with an unfilled bottle. A sensors used at the conveyer is used to sense the amount of fluid filled in a bottle and replace the next bottle with the existing position of the bottle. The project uses less number of systems, which reduces the cost. The software on which the program here will be written to run in open plc The next step after the filling is the capping which is configured to perform the next step of this project and is to filling the bottles. The cost of this project is very less (after installing a PLC in industries) and the implementation including the programming is very adapt.

I. INTRODUCTION

The field of automation has a impact in a wide range of industries beyond manufacturing. Automation is the use of control systems and information technologies to reduce the need for human work in the production of goods and services. In the scope of industrialization, automation is a step beyond mechanization. Whereas mechanization provides human operators with machinery to assist them with the muscular requirements of work, automation greatly decreases the need for human sensory and mental requirements as well. Automation plays an increasingly important role in the world economy. One of the important applications of automation is in the soft drink and other beverage industries, where a particular liquid has to be filled continuously. For these kinds of applications. The trend is moving away from the individual device or machine toward continuous automation solutions. Totally Integrated Automation puts this continuity into consistent practice. Totally Integrated Automation covers the complete production line, from receipt of goods, the production process, filling and packaging, to shipment of goods.



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II. LITERATURE REVIEW

Several researchers have studied automated bottle filling systems using PLC and microcontrollers.
Researchers have proposed PLC-based systems that integrate sensors, conveyor mechanisms, and solenoid valves to achieve automatic bottle filling operations. These systems improve production efficiency and reduce manual effort.
Other studies focused on integrating SCADA systems with PLC for monitoring and controlling the filling process. This allows real-time supervision of industrial operations.
Some systems also incorporate weight sensors and level sensors to improve filling accuracy and prevent overflow. The combination of PLC automation with sensors and motor control mechanisms has proven to be an efficient solution for industrial bottle filling and packaging applications.

III. OBJECTIVE

The Main objective to make this project is to introduce the interface between the human working in industry and with the industries. This project once implemented can save a lot of time of an individual so that this precious time can be saved to utilize on some other work. The entire work is being done on PLC which is the brain of the project. Since it is easily programmable, it makes more sense to use the PLC. The project has two programmed parts, one for filling and the other for capping. Normally the filling and capping of the bottles(as the motive of this project) can be used in the processing and manufacturing industries to make the process simpler and easier. Also in the present time, we know that with the advent of industrialization, the more work is being done by the machines as compared to the humans. This is only because they are programmable and as once they are programmed, they can do the specific work for which they are being programmed. The filling of the bottles can be considered as one programmable part of this project, where it will fill the bottles as the conveyer(movable by BLDC motor) moves the bottle being filled. The next programmable part of this project is the capping of the bottles. As when it is programmed through PLC, it will cap the bottle which was filled(as the first program of this project). In the project, as we are using the PLC.
The objective to make the project using PLC is it's easy maintenance, implementation and the main purposes for which it is used is its decision making programming capability, to control the crucial tasks and adjust the process control flow adaptability. The PLC is here to eliminate the hard wiring which is the main reason for the less maintenance, and could be connected to the plant computer systems easily.

IV. METHODOLOGY

The automatic bottle filling and capping system using PLC is designed to automate the process of filling liquid into bottles and sealing them with caps. The system consists of a conveyor belt, sensors, filling valve, capping motor, and a programmable logic controller (PLC). Bottles move on the conveyor until a sensor detects a bottle at the filling station. The PLC then stops the conveyor and activates the solenoid valve to fill the bottle for a preset time or until the required level is reached. After filling, the valve closes and the conveyor starts again to move the bottle to the capping station. At the capping station, the PLC activates the capping motor to place and tighten the cap on the bottle. Once the process is completed, the bottle moves forward and the system repeats the same cycle for the next bottle. This automation improves production speed, accuracy, and reduces manual labor in industrial processes

V. PROCESS DESCRIPTION

This chapter gives a detailed explanation of the various processes taking place in a complete bottling system. The filling and capping operations take place in a sequential manner. When no bottles are kept in the input the system is reset. Depending on the number of bottles fed into the input side, the corresponding bottles are filled and capped. The process is also provided with a user defined volume selection menu.

VI. HARDWARE DESCRIPTION

A. Programmable Logic Controller (PLC)

A programmable logic controller (PLC) is a digital electronic device that uses a programmable memory to store instructions and to implement functions such as logic, sequencing, counting, and arithmetic in order to control machines, process, and has been specifically designed to make programming easily.
PLCs consist of input modules or points, a Central Processing Unit (CPU), and output modules or points. An input accepts a variety of digital or analog signals from various field devices (sensors) and converts them into a logic signal that can be used by the CPU. The CPU makes decisions and executes control instructions based on program instructions in memory. Output modules convert control instructions from the CPU into a digital or analog signal that can be used to control various field devices (actuators).

A programming device is used to input the desired instructions. These instructions determine what the PLC will do for a specific input. An operator interface device allows process information to be displayed and new control parameters to be entered.

B. Motors

In this project we are using 3 motors.

1) BLDC motor use for conveyor belt 12V 7amp
2) BLDC motor use for capping 12V 1amp 3000 rpm.
3) Stepper motor 12V

Stepper motor

C. PLC Supply Module

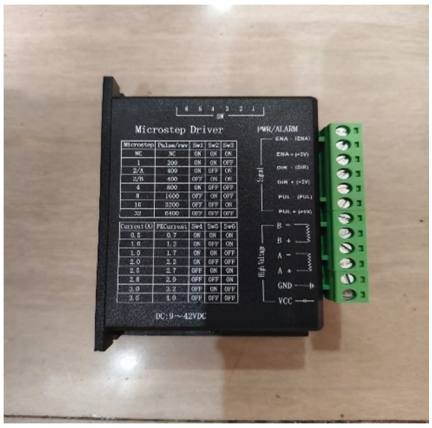
The PLC power supply module is a critical component that convert incoming high voltage AC (240V) into stable and low voltage DC (24V) or to power the PLC CPU, input output module it ensure reliable operation in harsh industrial environment by providing regulated power electrical isolation and short circuit/over voltage protection.

D. Sensors

There are 2 proximity sensor it use to detect the presence of bottle at filling and capping station.
There is 1 level sensor use for detect water level of bottle.

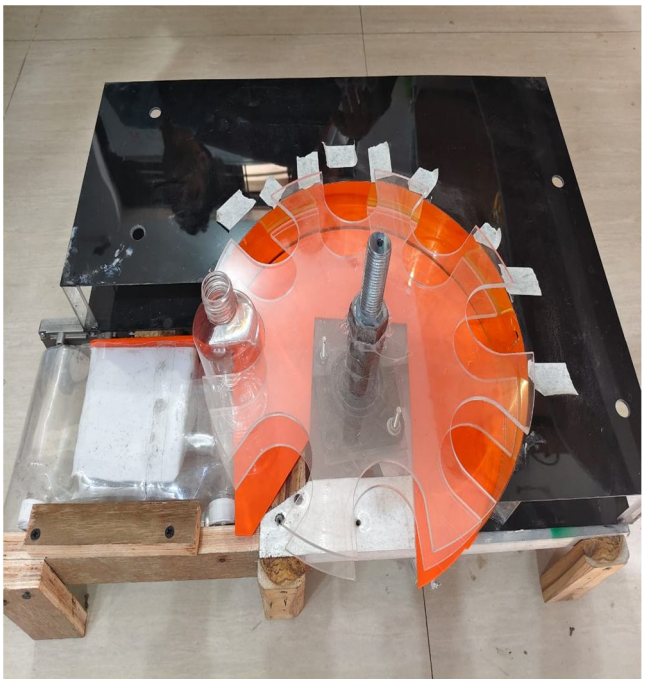
E. Stepper Motor Driver

Stepper motor driver is use to control pulse to the stepper motor having rating of 9-42V



F. Capping

G. Hardware



H. Working

An automatic bottle filling and capping system using PLC (Programmable Logic Controller) is an industrial automation system used in beverage, pharmaceutical, and water packaging industries to automatically fill liquid into bottles and seal them with caps. The system improves production speed, accuracy, and reduces human labour. In this project, the system consists of a PLC controller, a stepper motor for the rotating mechanism, two BLDC motors for the conveyor belt and capping mechanism, a proximity sensor for bottle presence detection, and a level sensor for water level detection.

The working of the system starts with the conveyor belt, which is driven by the first BLDC motor. The conveyor moves empty bottles along the production line toward the filling station. As the bottles move on the conveyor, a proximity sensor is installed near the filling position to detect the presence of a bottle. When the bottle reaches the correct filling position, the proximity sensor sends a signal to the PLC indicating that the bottle is ready to be filled. After receiving this signal, the PLC immediately stops the conveyor motor so that the bottle remains stationary during the filling process.

Once the bottle is properly positioned, the filling mechanism is activated. The liquid filling is controlled through a valve or pump connected to the PLC. A level sensor is used to monitor the water level inside the bottle during the filling process. The PLC continuously reads the signal from the level sensor. When the liquid level reaches the predefined level inside the bottle, the level sensor sends a signal to the PLC.

The PLC then closes the valve or stops the pump to prevent overflow and ensure that every bottle is filled with the correct quantity of liquid. This ensures uniform filling and avoids wastage of liquid.

After the filling process is completed, the PLC restarts the conveyor belt motor, and the bottle moves toward the capping station. At the capping station, a stepper motor is used for the rotating mechanism. The stepper motor provides precise rotational control, which helps in accurately positioning the bottle under the capping head. Because stepper motors move in controlled steps, they are suitable for applications where accurate positioning is required.

When the bottle reaches the capping position, the second BLDC motor activates the capping mechanism. This motor drives the capping head which rotates and tightens the cap on the bottle. The PLC controls the speed and timing of the BLDC motor so that the cap is properly sealed without damaging the bottle or the cap. After the cap is securely tightened, the PLC stops the capping motor.

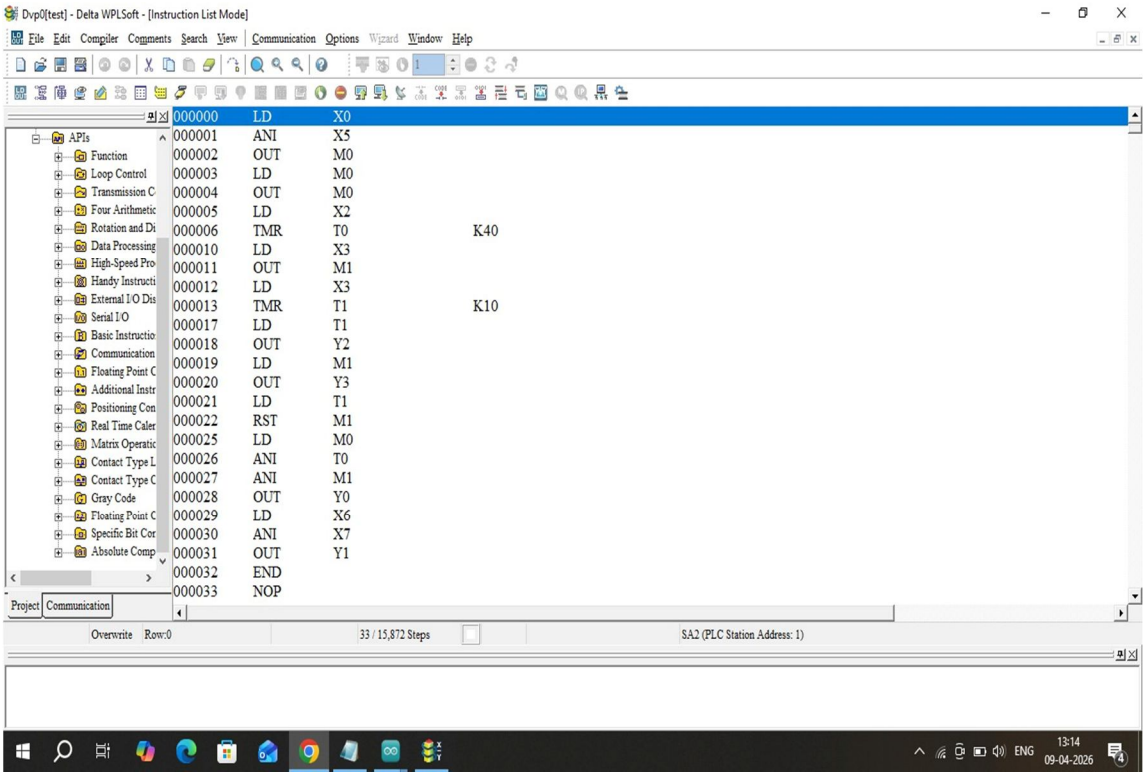
Finally, once the capping process is finished, the

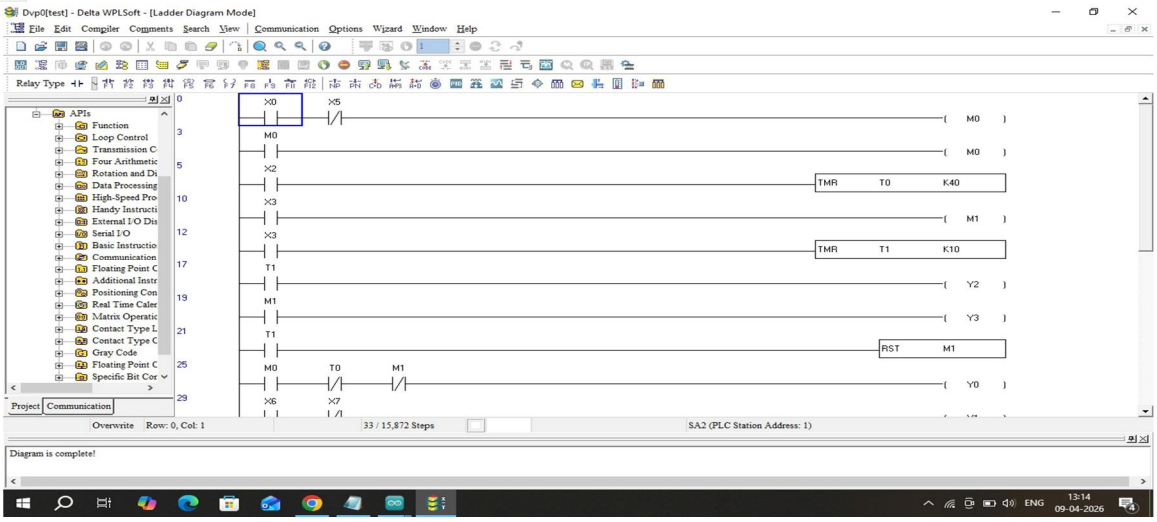
PLC again activates the conveyor motor so the finished bottle moves forward toward the collection area or packaging section. The system then waits for the next bottle to arrive, and the entire cycle repeats automatically.

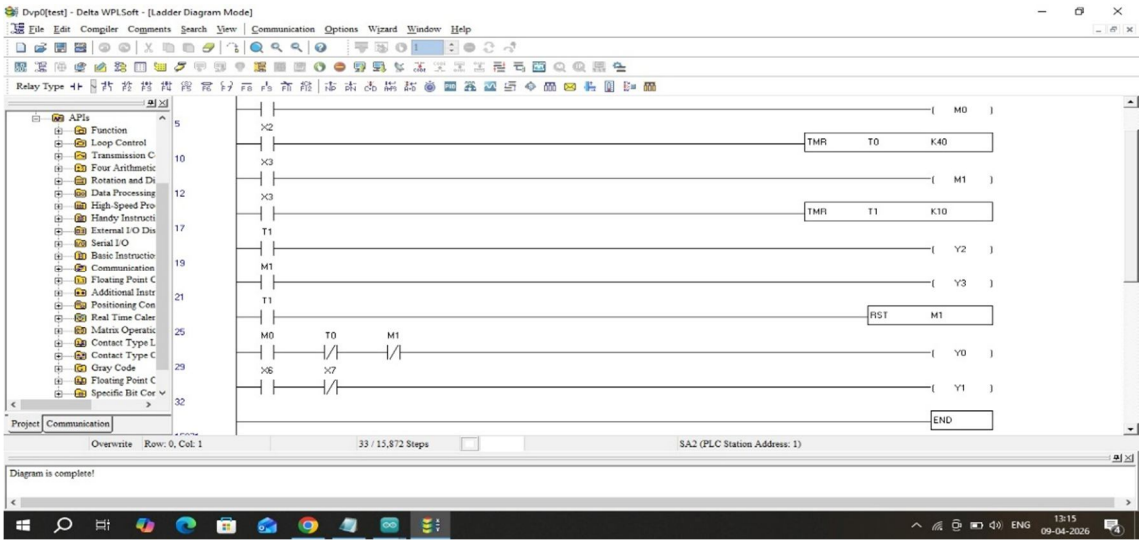
The PLC acts as the central controller of the system. It receives input signals from sensors such as the proximity sensor and level sensor, processes these signals according to the programmed logic, and sends output signals to actuators such as the stepper motor, BLDC motors, pumps, and valves. This automation ensures high efficiency, accuracy, and continuous production with minimal human intervention.

Overall, the automatic bottle filling and capping system using PLC provides high production speed, precise filling control, reduced labour cost, and improved product quality. It is widely used in industries such as mineral water plants, beverage manufacturing, pharmaceutical packaging, and chemical liquid filling industries. The integration of PLC, sensors, and motors makes the system reliable, flexible, and easy to control in modern automated production lines.

I. Ladder logic







Input and output device
Input device
X0 → Start switch
X5 → Stop switch
X2, X3 → Control inputs
X6, X7 → Additional control logic

Outputs
Y0, Y1, Y2, Y3 → Loads (motor, lamp, relay, etc.)

Internal Relays
M0 → Master latch (system ON state)
M1 → Intermediate control relay

Timers
T0 (K40) → Delay (≈ 4 sec if base = 0.1s)
T1 (K10) → Delay (≈ 1 sec)

Step-wise Working
Press Start (X0) → System ON (M0 latched)
X2 ON → T0 starts (4 sec delay)
Y0 remains ON during T0 delay
X3 ON → M1 ON + T1 starts
After T1 (1 sec):
Y2 ON
M1 resets
Y3 ON only when M1 active (temporary)
Y1 depends on X6 & X7 condition

VII. CONCLUSION AND FUTURE SCOPE

In this work, an automatic bottle filling and capping system using a PLC was designed and analysed to improve efficiency, accuracy, and automation in liquid packaging industries. The system integrates a stepper motor for the rotating mechanism, BLDC motors for conveyor belt movement and capping, along with proximity sensors for bottle detection and a level sensor for liquid level monitoring. The PLC acts as the central controller, coordinating all components and ensuring smooth and sequential operation of the filling and capping processes.

The implementation of sensors enables accurate detection of bottle presence and precise control of the filling level, which helps in minimizing liquid wastage and maintaining uniform quantity in each bottle. The use of a stepper motor provides accurate positioning for the rotating mechanism, while BLDC motors ensure efficient and reliable operation of the conveyor and capping mechanisms. Through PLC programming, the entire process is automated, reducing manual intervention and increasing the production rate.

The developed system demonstrates improved productivity, better process control, and enhanced reliability compared to traditional manual methods. It also ensures consistency in product quality and reduces operational errors. Therefore, the proposed PLC-based automatic bottle filling and capping system is a practical and efficient solution for modern industrial automation in bottling plants.

In future work, the system can be further enhanced by integrating SCADA monitoring, advanced sensors, and IoT-based control to enable real-time monitoring, remote operation, and improved production management in large-scale industries.

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[4] AUTOMATIC BOTTLE FILLING AND CAPPING SYSTEM USING PLC Dr. Pankaj Prajapati1, Sachin Singh2, Saurabh Gupta3, Shivani Srivastava4 1Associate Professor, Department of Electronics and Communication Engineering, Ambalika Institute of Management and Technology, Lucknow 2,3,4Research Scholor, Department of Electronics and Communication Engineering, Ambalika Institute of Management and Technology, Lucknow.
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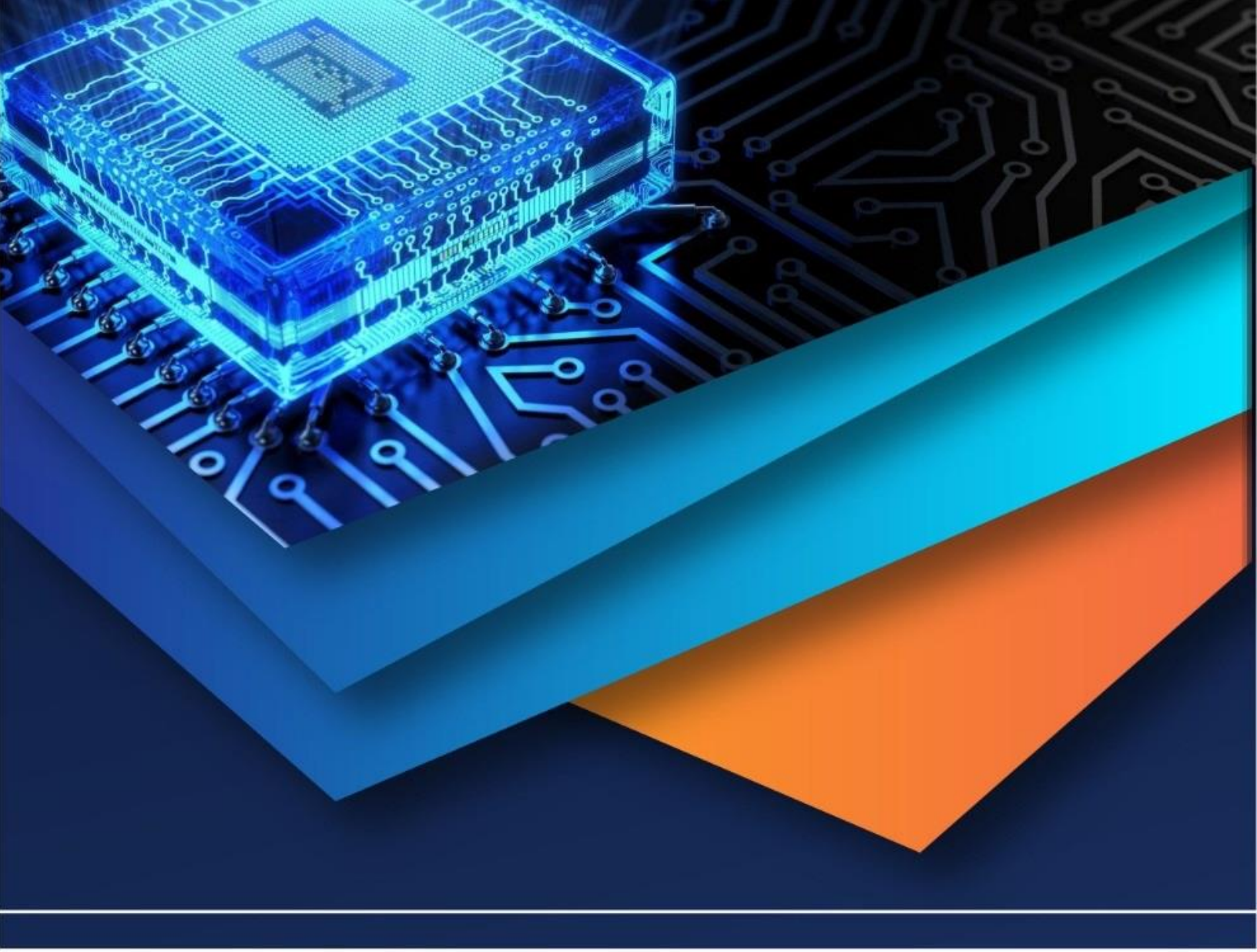

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