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Implementation of a Vending machine using Programmable Logic Controller

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Abstract*: Automation has changed all our day-to-day activities. It has impacted all walks of life. Probably there is no domain left which has been untouched by automation from agricultural to space technology. As the technology is changing day in and day out and there is a competition in manufacturing industry to reduce the time to market of all the products, so that they remain upfront in their sectors. This paper describes about PLC (Programmable Logic Controller) and how to develop an automated coffee/tea vending machine using PLC programming languages. It is implemented using Schneider Electric M340 PLC which is one of the most famous PLC in the world. Launched as one of the most innovative Programmable Logic Controllers developed to date, Modicon M340 continues to be perceived as a model basis of a modern-day automation platform, garnering recognition for its robust quality and high-end capabilities, including improved performance, compliance with the latest networking standards, and operational cost-efficiency. Designed for a wide range of process and machine management, it finds perfectly his place in numerous segments such as the Food & Beverage etc.

Keywords: Automation, PLC, ladder diagram, SFC

I. INTRODUCTION

A. Automation

The word 'Automation' is derived from Greek words "Auto" (self) and "Matos" (moving). Automation therefore is the mechanism for systems that "move by itself". The dictionary defines automation as "The technique of making an apparatus, a process, or a system operate automatically." Automation helps in reducing the human involvement to operate tasks in hazardous environment and that requires hard physical and mental ability. Automation also increases productivity, Quality, performance and helps on emphassing safety in working conditions and also reduces the cost .

B. PLC

PLCs were designed and developed by Modicon. A programmable logic controller (PLC) is a specialized computer used to control machines and processes. It therefore shares common terms with typical PCs like central processing unit (CPU), memory, software and communications. Unlike a personal computer, the PLC is designed to survive in a rugged industrial atmosphere and to be very flexible in how it interfaces with inputs and outputs of the real world. Programmable Logic Controller, or PLC for short, is simply a special computer control system that continuously monitors the state of input devices and make decisions based upon the custom program to control the state of output devices. PLC implements logic control functions by means of a program. PLC'S were designed to replace relay logic system. They are used in many industries such as oil refineries, manufacturing lines, conveyor systems and so on.

The components that make a PLC work can be divided into three core areas:

1) The rack and the power supply
2) The central processing unit (CPU)
3) The input/output

PLCs come in many shapes and sizes. They can be so small as to fit in your shirt pocket while more involved controls systems require large PLC racks. The below figure shows the M340 PLC.

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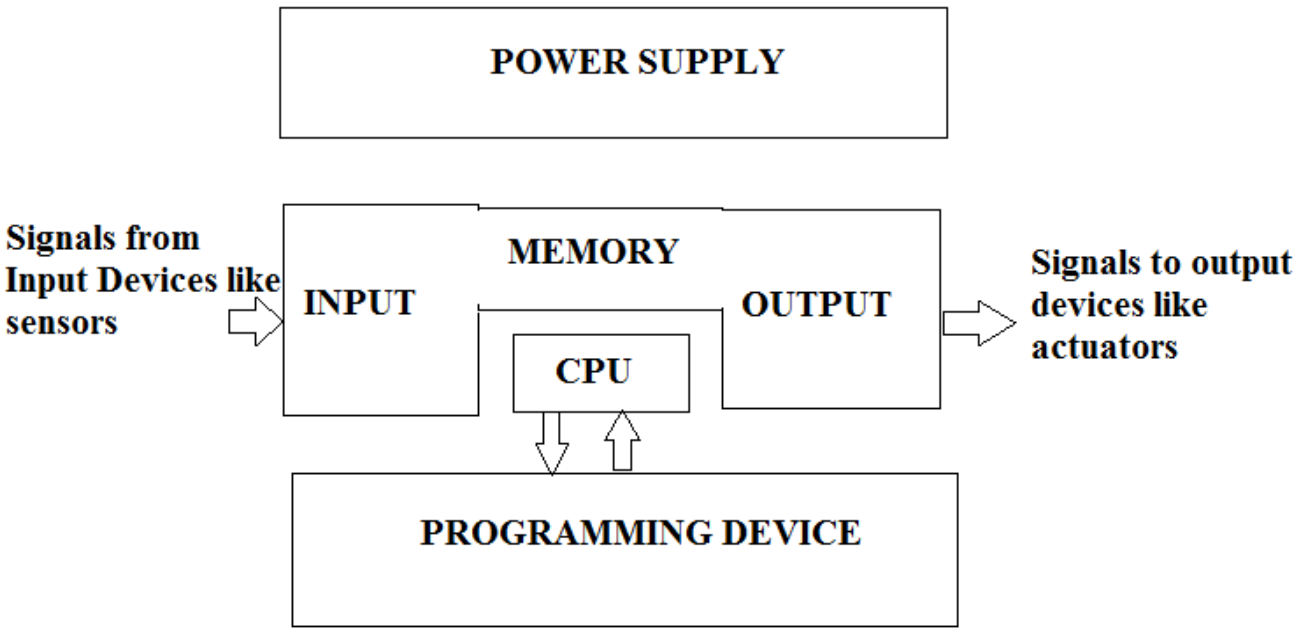
Figure1: M340 PLC

C. PLC Architecture



The components of PLC are

1) Inputs Circuits
2) Outputs Circuits
3) CPU
4) Memory for program and data storage
5) Programming device
6) Communication Device
7) Power Supply

PLC I/O modules: Provides signal conversion and isolation between the internal logic level signals inside the PLC and the field's high level signal

Input modules : accepts and converts signals from sensors into a logic signal Ex. : Switches, Pushbuttons.

Output modules : that convert control instructions to a signal that can be used by actuators. Ex. : lamps, alarm.

Programming device: Used to enter the desired program that will determine the sequence of operation and control of process equipment or driven machine.

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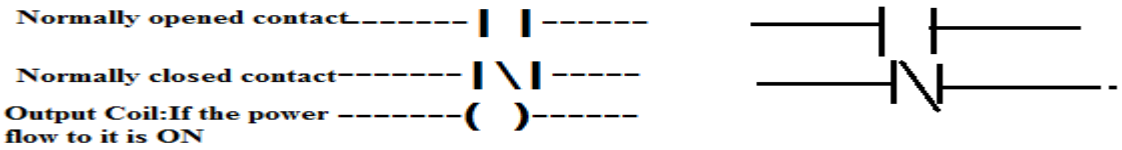
II. PROGRAMMING PLC

A. Programming PLC

The programming technique for the first PLCs were based on relay logic wiring schematics. This eliminated the need to teach the technicians, electricians and engineers how to program a computer today. According to IEC 61131-3 five programming languages is defined for programmable control systems: LD (Ladder diagram), ST (Structured text), SFC (Sequential function chart), FBD (Function block diagram), and IL (Instruction list, similar to assembly language).

Ladder Diagram: A very commonly used method of programming PLCs is based on the use of ladder diagram. Typically, a computer called a programmable logic controller (PLC) is used to implement the algorithm required to control this machinery. Usually, this algorithm is digital logic and has historically been achieved using a programming language called ladder logic. Ladder logic is a graphical language, and a method of expressing the "if … then" construct used extensively in structured programming methods in mainstream programming of information systems. The advantage of well-structured ladder logic is that programs are easy to debug. A maintenance technician can look at a ladder program and immediately identify whether the status of an individual input or output bit is correct.

Symbols for Ladder diagram: Standard IEC 1131-3 defines the symbols that are used for input and output devices. Note that inputs are represented by different symbols representing normally open or normally closed contacts. The action of the input is equivalent to opening or closing a switch. Output coils are represented by just one form of symbol.



Ladder diagram is based on logic operation between inputs to define the logic level of outputs.

Sequential Function Chart (SFC) language: Sequential function chart (SFC) is one of the PLC programming languages defined by the IEC 61131-3 standard. SFC is a graphical programming language, not text-based. Being a visual programming language means that it's well suited to the task of breaking down a large and complex process into smaller pieces that are easier to see and understand than with solely text-based programming environments.

The elements of SFC language are

1) steps
2) transitions and transition conditions
3) actions
4) links
5) branches

Step: A step is an element of SFC programs, and represents a single process within the overall process flow. For example: start a motor. A step can be active or inactive. When a step becomes active, action blocks assigned to that step are executed.The first step of a program is referred to as the initial step. It is unconditionally activated at the start of the program and is represented by a double sidelines step.

Action block: Action block contains the action (an event) which is triggered by the activation of a step. It can be:

6) One or several address of output or variable; for example %Q0.2.3 or var:=8,
7) Section of one of the IEC 61131-3 programming languages.

The symbol of an action block is as follows.

Transition: A transition is a special link that provides the ways through which the the chart can evolves between 2 or several steps.A transition is always associated with a transition condition, called sometimes receptivity. This transition condition can be a variable, an address, a literal or a transition section (ladder diagram) if the condition is more complex.

Link: Links are the elements that are connecting step to transition and transition to step. The y are consisting in vertical and horizontal links. Standard signal flow in a sequence string is from top to bottom. To create a loop however, links can be made from below to a step above. In these cases, the direction of the link is indicated with an arrow symbol.

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Branches: Branches are used to create alternative or parallel structures. There are 2 types of branches :
The alternative branch offers the possibility to program branches conditionally in the control flow of the SFC structure. With alternative branches, as many transitions follow a step under the horizontal line as there are different processes. Alternative branches are connected by alternative junctions.
The parallel branches offers the possibility to switch a single transition leads to a parallel activation of more than one step. After this common activation, the individual branches are processed independently from one another. Parallel branches are connected by parallel junctions.

B. Creation of SFC diagram

3 steps to create a SFC diagram using specifications of a system are

1) Design of the functional specification SFC Diagram,
2) Design of the functional solution SFC Diagram,
3) Design of the control unit part SFC Diagram.

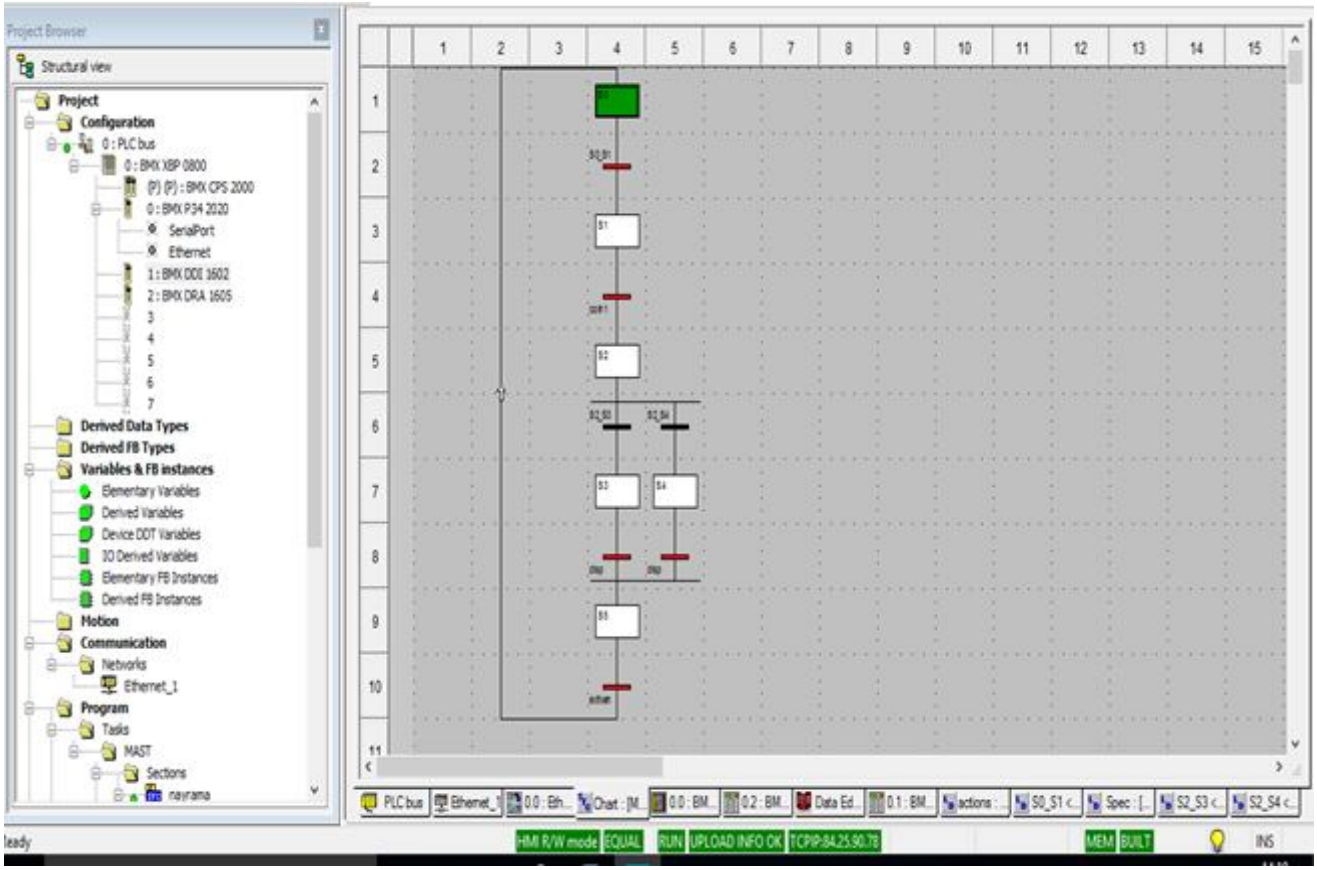
III.AUTOMATED COFFEE/TEA VENDING MACHINE USING SFC

Automated coffee/tea vending machine is implemented using one of the programmable logic controller language called Sequential Functional Chart.It is developed using Unity PRO Software.

A. The Specifications for dEsigning this Automated Machine is as Follows

1) The user has to select any beverages either coffee or tea which he/she prefers by pressing the respective pushbutton.
2) Then user has to insert a coin.
3) Then based on the pusbutton pressed by the user, the machine has to dispense either coffee or tea .
4) Later the machine delivers the preffered beverage
5) Then it exits for its next delivery.

Step1:Initial state in SFC, machine waiting for any input from the user i.e, whether any push button is pressed or not.



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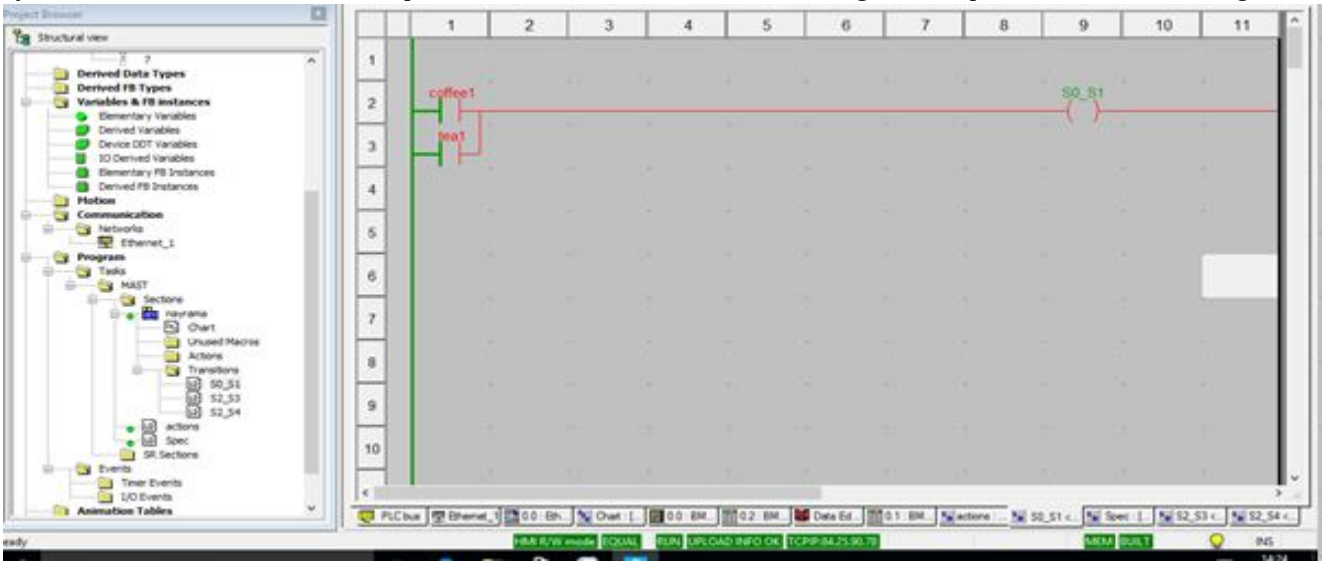
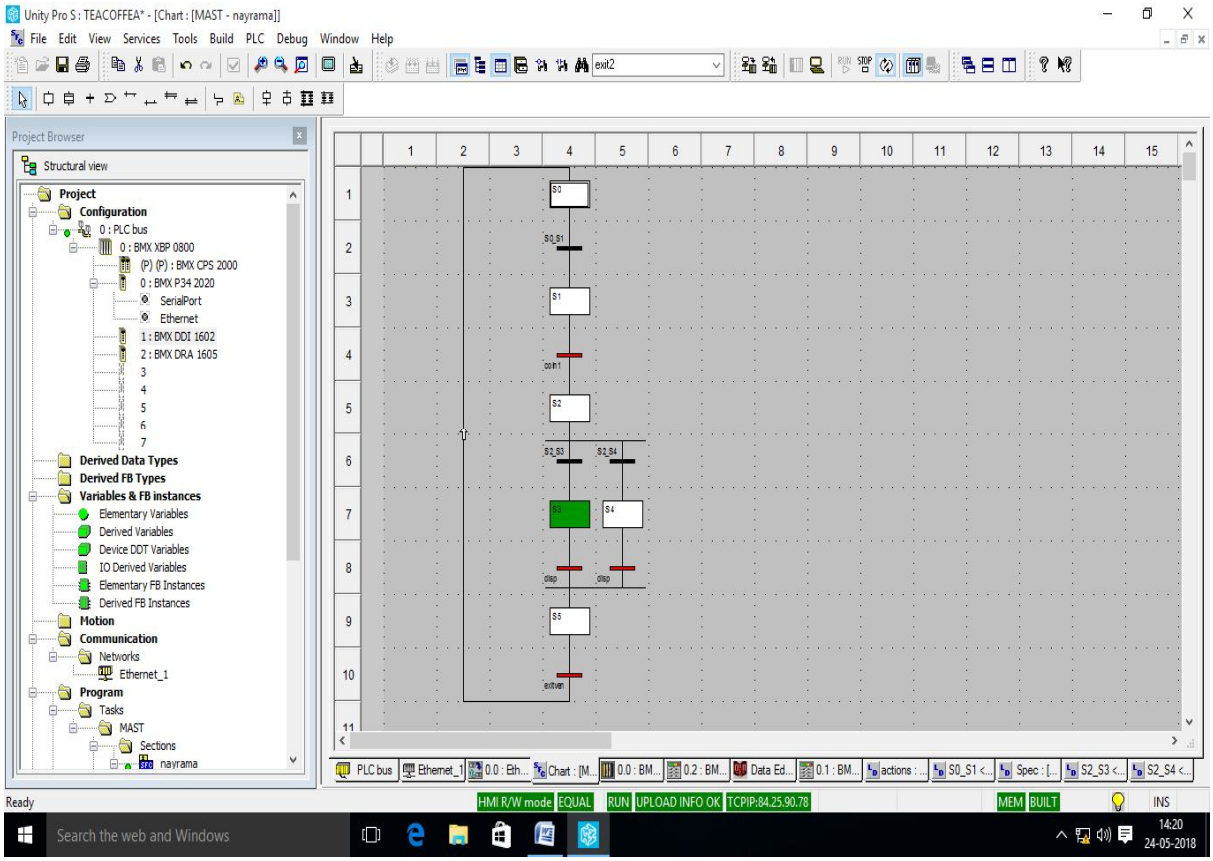
Step2:If user has pressed any pushbutton ,transition will happen and it moves to the next state S1 storing the preference in the memory. To check whether coffee or tea is pressed. In a Transition section, ladder diagram is implemented as shown in fig:



Step3: Then a coin is inserted, so the SFC is moved on to next state i.e.S2

Step4: After the coin is inserted ,based on the preference (coffee or tea) stored in the memory the corresponding branch in SFC is executed to dispense coffee or tea.In the below fig: we have considered that coffee push button is pressed,so one of the alternate branch is being executed which is shown in green colour.



Step5: Delivering of coffee/tea is indicated by glow of a lamp.

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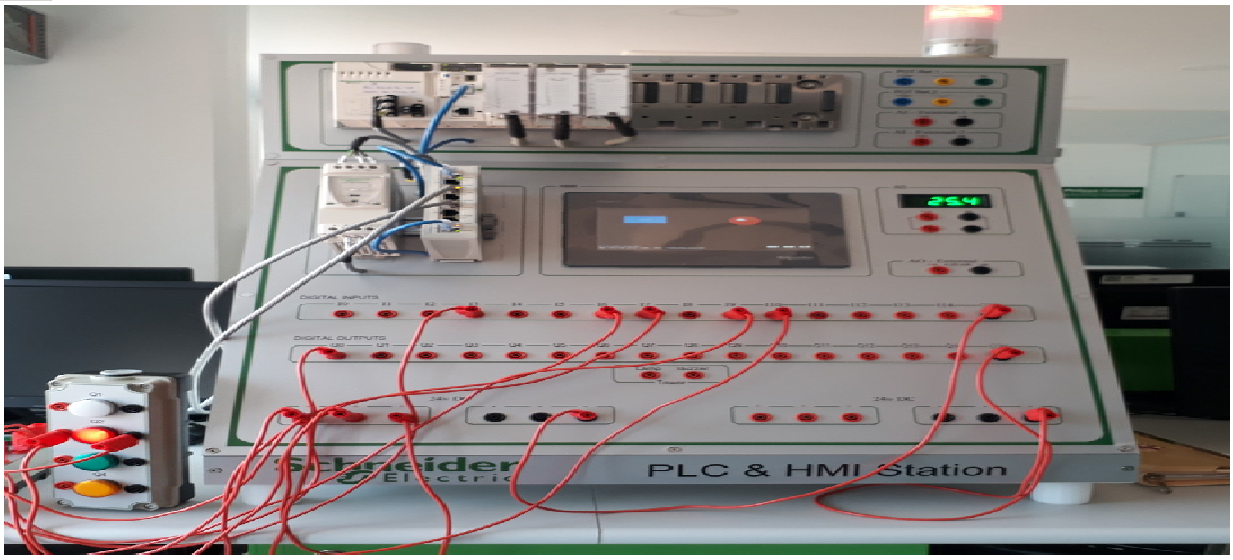

Step6: Once the beverage is delivered, it is ready to accept the new request.

IV. CONCLUSIONS

Automated Coffee Tea Vending machine is successfully implemented on Programmable Logic Controller M340.by Schneider Electric.Sequential Functional Chart used for PLC is a graphical language which is easier to understand and implement.The main drawback of having any automated machine is that it will ultimately lead to decrease in manpower which leads to unemployment issues in populated countries. Another drawback is the difficulty in adaptating to an new situation that may arise when dealing with users

V. ACKNOWLEDGMENT

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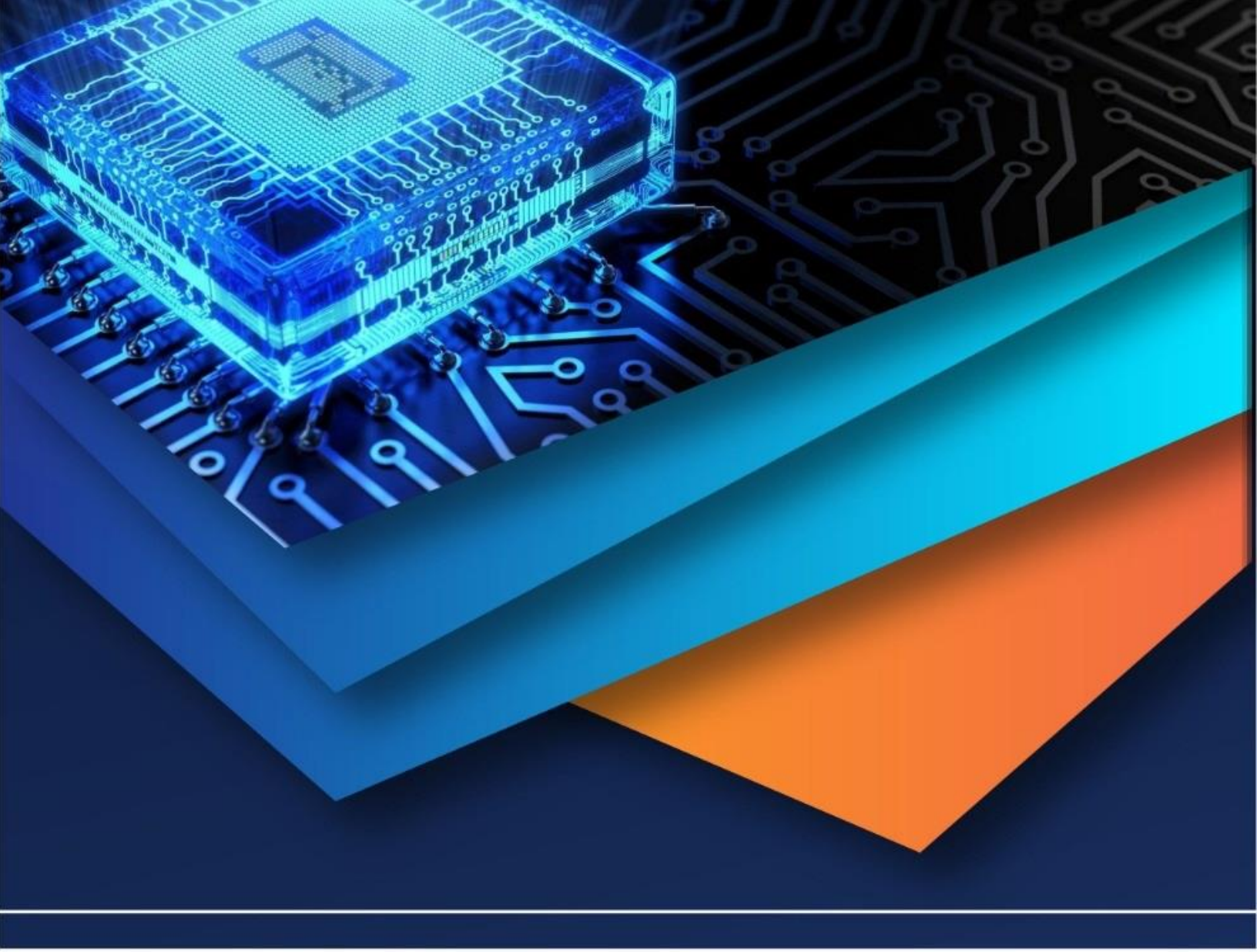

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