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Design and Implementation of Human Detection and Delay Time Based Automatic Water Shut off System

Dr. Sundar G [1], Arulselvan G[2], Bharanidharan S[3], Bharathipriyan P[4], Dharanitharan S[5],
Dept of Electrical and Electronics Engineering, Sri Shakthi Institute of Engineering and Technology, Coimbatore, Tamil Nadu, India

Abstract: ***The Design and Implementation of Human Detection and Delay Time Based Automatic Water Tap Shutoff System is developed to reduce water wastage caused by users forgetting to close water taps. The system uses a PIR sensor to detect human presence and an Arduino UNO microcontroller to control the operation of a solenoid valve through a relay module***
The proposed system supports both manual and automatic modes of operation. In automatic mode, water flow is controlled based on human presence. When a user is detected, the water tap remains active. If no movement is detected for a predefined delay time, the Arduino automatically closes the solenoid valve, stopping the water flow and preventing unnecessary water wastage. The delay mechanism ensures smooth operation by avoiding immediate shut-off during temporary inactivity.
The system is cost-effective, energy-efficient, and easy to implement using readily available components such as Arduino UNO, PIR sensor, relay module, and solenoid valve. It provides a practical solution for water conservation in hostels, public restrooms, educational institutions, and other public facilities. This project demonstrates the effective use of embedded systems and automation technology in addressing real-world resource management challenges and promoting sustainable water usage.
Keywords: Arduino UNO, PIR sensor, Relay Module, Human Detection , Solenoid Valve, Time Delay Mechanism

I. INTRODUCTION

Water is one of the most essential natural resources for human life, and its conservation has become a major concern due to increasing demand and limited availability. In hostels, public restrooms, educational institutions, and other common facilities, a significant amount of water is wasted because users often forget to close water taps after use. Continuous water flow not only results in resource wastage but also increases water consumption costs and affects sustainable resource management.

With the advancement of embedded systems and automation technologies, intelligent solutions can be developed to minimize water wastage and improve efficiency. Automated water control systems have gained considerable attention as they provide reliable operation with minimal human intervention. Such systems help in conserving water while ensuring user convenience and operational efficiency.

The proposed project, “Design and Implementation of Human Detection and Delay Time Based Automatic Water Tap Shutoff System,” is developed to address this issue by automatically controlling water flow based on human presence. The system utilizes a Passive Infrared (PIR) sensor to detect the presence of a person and an Arduino UNO microcontroller to process the sensor signals. A relay module and solenoid valve are used to control the water supply.

The system supports both manual and automatic modes of operation. In manual mode, users can operate the water tap according to their requirements. In automatic mode, the PIR sensor continuously monitors human presence. When a person is detected, the water flow remains active. Once the person leaves the detection area, the system initiates a predefined delay timer. If no movement is detected during this period, the Arduino UNO automatically closes the solenoid valve, thereby stopping the water flow and preventing unnecessary wastage.

The inclusion of a delay time mechanism enhances the practicality of the system by preventing immediate shut-off due to temporary inactivity. This feature ensures smooth and user-friendly operation while maintaining effective water conservation. The proposed system is cost-effective, energy-efficient, and easy to implement using readily available electronic components.

Overall, this project demonstrates the application of embedded systems and automation in solving real-world problems. By reducing water wastage and promoting efficient resource utilization, the system contributes to sustainable water management and environmental conservation.

II. LITERATURE SURVEY

Water conservation has become an important area of research due to the increasing demand for freshwater resources and the growing concern about water wastage. Various automated systems have been developed to monitor and control water usage in residential, commercial, and public environments. Researchers have explored the use of sensors, microcontrollers, and automation technologies to minimize unnecessary water consumption and improve resource management.

Several studies have focused on sensor-based water tap control systems. Infrared (IR) sensors and Passive Infrared (PIR) sensors are commonly used to detect human presence and control water flow automatically. These systems help reduce water wastage by ensuring that water is supplied only when required. PIR sensors are widely preferred because they can detect human movement effectively over a larger area and consume very little power.

Microcontroller-based automation systems have gained popularity due to their flexibility, low cost, and ease of implementation. Arduino platforms are extensively used in smart water management applications because they provide simple programming, reliable performance, and easy interfacing with sensors and actuators. Many researchers have implemented Arduino-based systems for automatic water control, leak detection, and smart irrigation applications.

Solenoid valves are commonly used in automated fluid control systems because of their fast response time and reliable operation. By integrating solenoid valves with sensors and microcontrollers, water flow can be controlled automatically without human intervention. Such systems are widely used in smart homes, industries, and public utility management systems.

Recent developments in embedded systems have also introduced time-delay control mechanisms to improve system reliability and user convenience. Delay-based control prevents unnecessary switching operations and ensures smooth system performance. In water management applications, delay mechanisms help avoid immediate shut-off during temporary inactivity, thereby enhancing user experience while maintaining water conservation.

Based on the literature reviewed, it is evident that combining human presence detection, microcontroller-based control, solenoid valve operation, and time-delay mechanisms can provide an effective solution for reducing water wastage.

III. METHODOLOGY

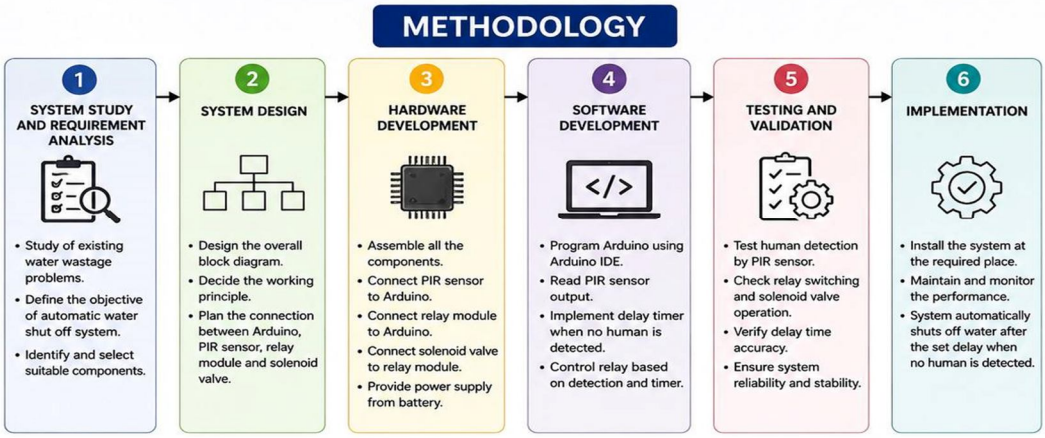

Fig 1: Methodology

The fig1The proposed Human Detection and Delay Time Based Automatic Water Tap Shutoff System is designed to reduce water wastage by automatically controlling water flow based on human presence. The system consists of an Arduino UNO, PIR sensor, relay module, solenoid valve, manual switch, and power supply.

The PIR sensor continuously monitors the surroundings and detects human presence. The sensor output is sent to the Arduino UNO, which acts as the central controller of the system. When a person is detected, the Arduino activates the relay module, which energizes the solenoid valve and allows water to flow.

The system supports both manual mode and automatic mode. In manual mode, the user can operate the water tap using a switch. In automatic mode, the PIR sensor controls the water flow automatically. When the user leaves the detection area, the Arduino starts a predefined delay timer. If no motion is detected during the delay period, the relay is deactivated and the solenoid valve closes, thereby stopping the water flow.

The delay mechanism prevents immediate shutoff and ensures uninterrupted operation during temporary inactivity. This improves user convenience while effectively conserving water. The overall system is simple, reliable, cost-effective, and suitable for real-time implementation in hostels, public restrooms, educational institutions, and other public facilities.

IV. WORKING METHODOLOGY

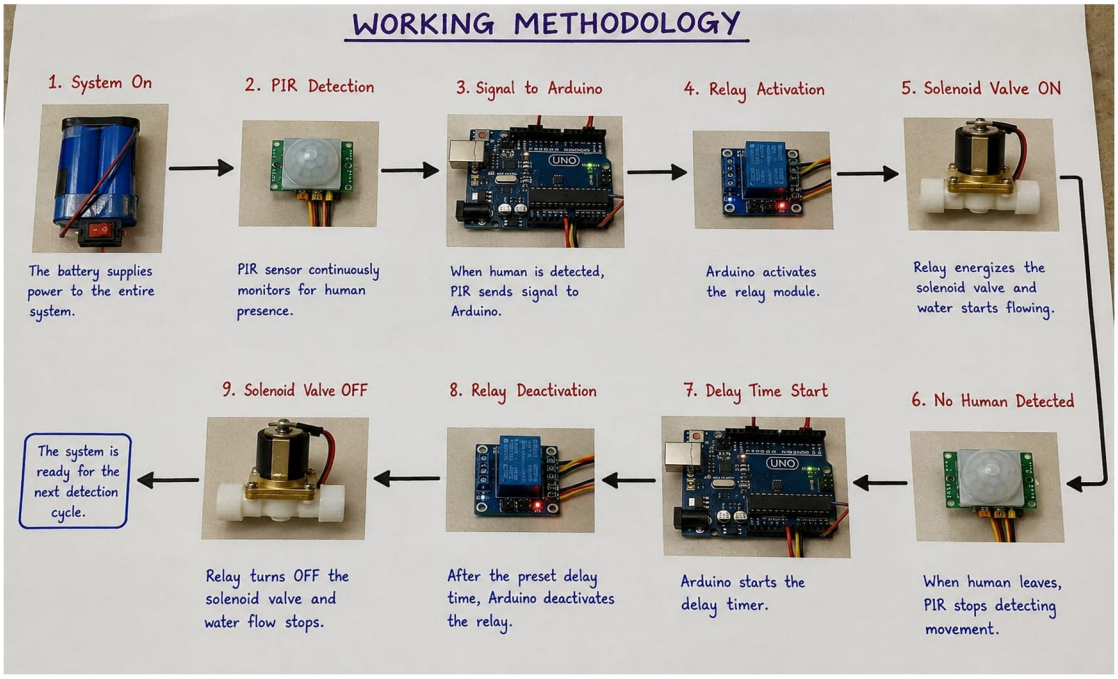

Fig 2: Working Methodology

The fig 2 The Human Detection and Delay Time Based Automatic Water Tap Shutoff System operates by combining human presence detection, automatic control, and a delay time mechanism to prevent water wastage. The system uses an Arduino UNO as the central controller, a PIR sensor for human detection, a relay module for switching, and a solenoid valve for controlling water flow.

Initially, the PIR sensor continuously monitors the surrounding area for human presence. When a person enters the detection range, the PIR sensor sends a signal to the Arduino UNO. The Arduino processes this signal and activates the relay module, which energizes the solenoid valve. As a result, the valve opens and allows water to flow through the tap.

The system supports both manual and automatic operation. In manual mode, the user can operate the water tap using a switch. In automatic mode, the PIR sensor controls the operation of the water tap based on human presence. As long as movement is detected within the sensing range, the system keeps the solenoid valve open and water continues to flow.

When the user leaves the area, the PIR sensor no longer detects motion. Instead of immediately shutting off the water supply, the Arduino initiates a predefined delay timer. This delay mechanism prevents unwanted interruptions caused by temporary inactivity and improves user convenience. If no motion is detected during the entire delay period, the Arduino deactivates the relay module.

Once the relay is turned off, power to the solenoid valve is removed, causing the valve to close automatically. This stops the flow of water and prevents unnecessary wastage. The process repeats whenever a new user enters the detection area.

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V. GLOBAL OBSERVATION

The fig 3 Water scarcity and water wastage have become major concerns worldwide due to rapid population growth, urbanization, and increasing demand for water resources. According to various environmental studies, a significant amount of treated water is lost every year due to leakage, improper usage, and human negligence. In public places such as hostels, educational institutions, shopping malls, railway stations, and public restrooms, water taps are often left open unintentionally, resulting in continuous water wastage.

Many countries have started adopting smart water management systems to improve water conservation and reduce unnecessary consumption. The integration of sensors, embedded systems, and automation technologies has enabled the development of intelligent water control solutions. Automated water tap systems are becoming increasingly popular because they reduce human intervention, improve efficiency, and promote sustainable resource utilization.

The proposed Human Detection and Delay Time Based Automatic Water Tap Shutoff System aligns with these global efforts toward water conservation. By automatically controlling water flow based on human presence and incorporating a delay mechanism, the system minimizes water wastage while maintaining user convenience. The use of low-cost components such as Arduino UNO, PIR sensor, relay module, and solenoid valve makes the system practical and suitable for widespread implementation.

Therefore, the adoption of automated water management systems can play a significant role in addressing global water conservation challenges and supporting sustainable development goals related to efficient water resource management.

VI. BLOCK DIAGRAM

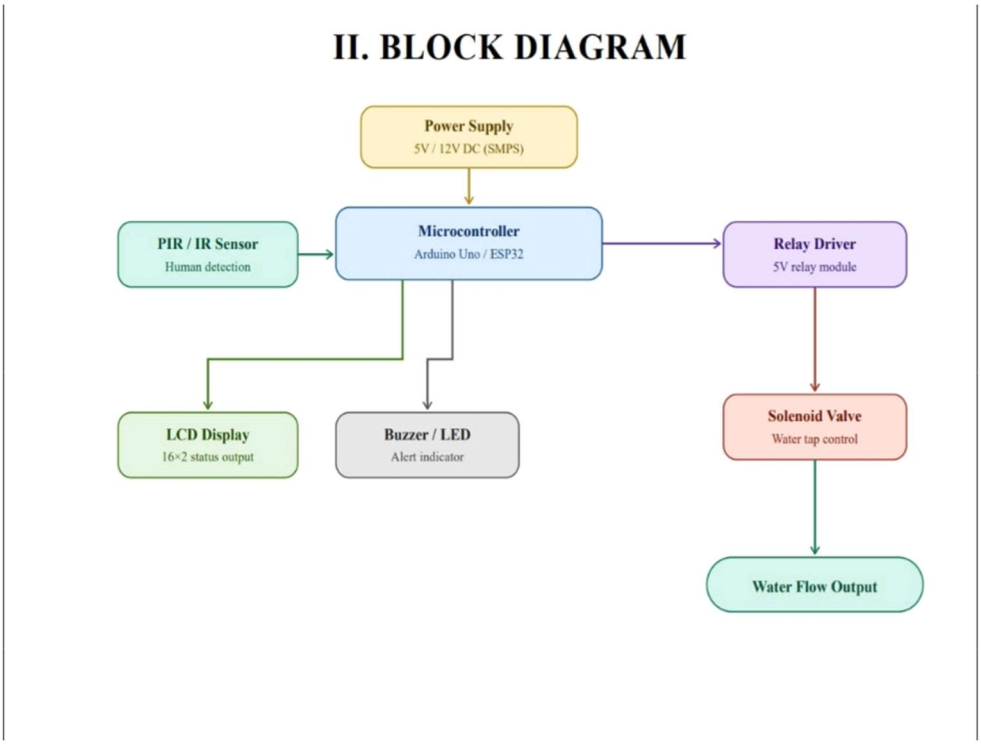

Fig 4: Block Diagram

The fig4. The Human Detection and Delay Time Based Automatic Water Tap Shutoff System is designed to minimize water wastage by automatically controlling water flow based on human presence. The system consists of a PIR sensor, Arduino UNO, relay module, solenoid valve, manual switch, and power supply. Each component performs a specific function to ensure efficient and reliable operation.

The PIR (Passive Infrared) sensor acts as the sensing unit of the system. It continuously monitors the surrounding area and detects the infrared radiation emitted by the human body. Whenever a person enters the sensor's detection range, the PIR sensor generates an output signal and sends it to the Arduino UNO. The sensor plays a vital role in determining whether a user is present near the water tap.

The Arduino UNO serves as the central processing unit of the system. It receives input signals from the PIR sensor and processes them according to the programmed logic. The microcontroller continuously checks the status of human presence and determines whether the solenoid valve should remain open or be closed. It also manages the delay timer, which is responsible for preventing immediate water shutoff when movement temporarily stops.

A manual switch is incorporated into the system to provide flexibility and convenience. The user can manually operate the water tap whenever required. This feature ensures uninterrupted operation even if the automatic mode is disabled or when manual control is preferred. The inclusion of both manual and automatic modes makes the system more practical for real-world applications.

The relay module functions as an electrical switching device between the Arduino UNO and the solenoid valve. Since the Arduino cannot directly drive high-current devices, the relay acts as an interface that allows the microcontroller to control the valve safely. When the Arduino sends an activation signal, the relay energizes and supplies power to the solenoid valve.

The solenoid valve is responsible for controlling the actual flow of water. When the valve receives power through the relay module, it opens and allows water to pass through the pipeline. When power is removed, the valve automatically closes, stopping the water flow. This mechanism ensures accurate and reliable water control.

VII. HARDWARE IMPLEMENTATION

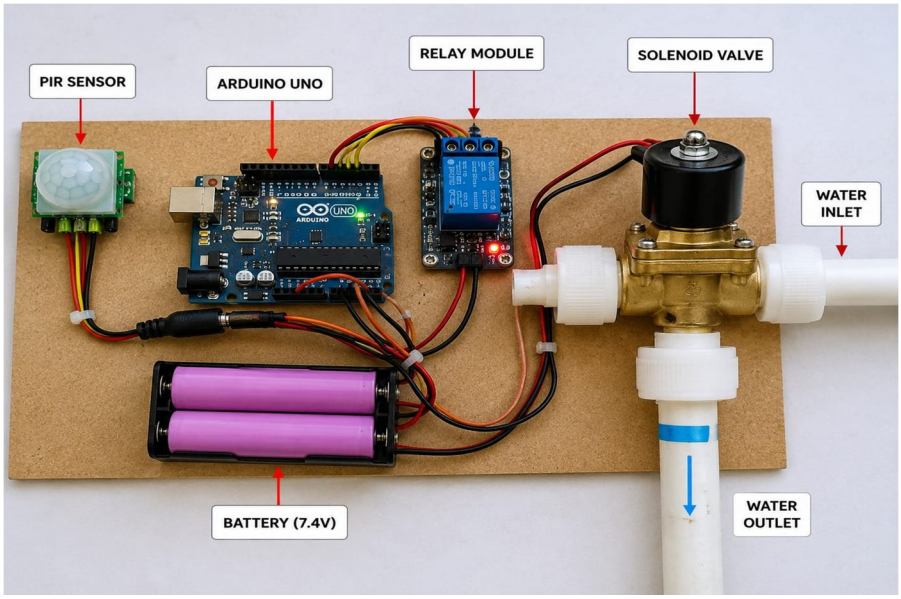

Fig 6: Hardware Implementation

The fig 6 the hardware implementation of the Human Detection and Delay Time Based Automatic Water Tap Shutoff System involves the integration of various electronic components to achieve automatic and efficient water flow control. The system is designed using Arduino UNO, PIR sensor, relay module, solenoid valve, manual switch, battery, and connecting wires. These components are assembled and connected according to the circuit design to ensure proper operation..

VIII. HARDWARE OUTPUT

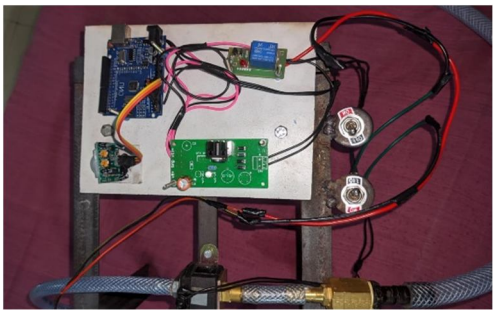

Fig 7: Hardware Output

The fig 7 illustrates the alert message generated Abnormal health condition detected. The message is automatically sent to the registered mobile number through the GSM module

IX. CONCLUSION

The Human Detection and Delay Time Based Automatic Water Tap Shutoff System was successfully designed and implemented to reduce water wastage caused by unattended water taps. The system effectively combines a PIR sensor, Arduino UNO, relay module, and solenoid valve to monitor human presence and automatically control water flow.

The incorporation of a delay time mechanism ensures smooth operation by preventing immediate shutoff during temporary inactivity, thereby improving user convenience. In addition, the availability of both manual and automatic modes provides flexibility and enhances the overall usability of the system.

The experimental results demonstrated that the proposed system operates reliably and efficiently under different conditions. It successfully detects human presence, controls water flow automatically, and minimizes unnecessary water consumption. The use of low-cost and readily available components makes the system economical and suitable for practical implementation.

Therefore, the developed system offers an effective solution for water conservation in hostels, educational institutions, public restrooms, hospitals, and other public facilities. Future enhancements such as IoT integration, remote monitoring, and water usage analytics can further improve the functionality and performance of the system, making it a smarter and more sustainable water

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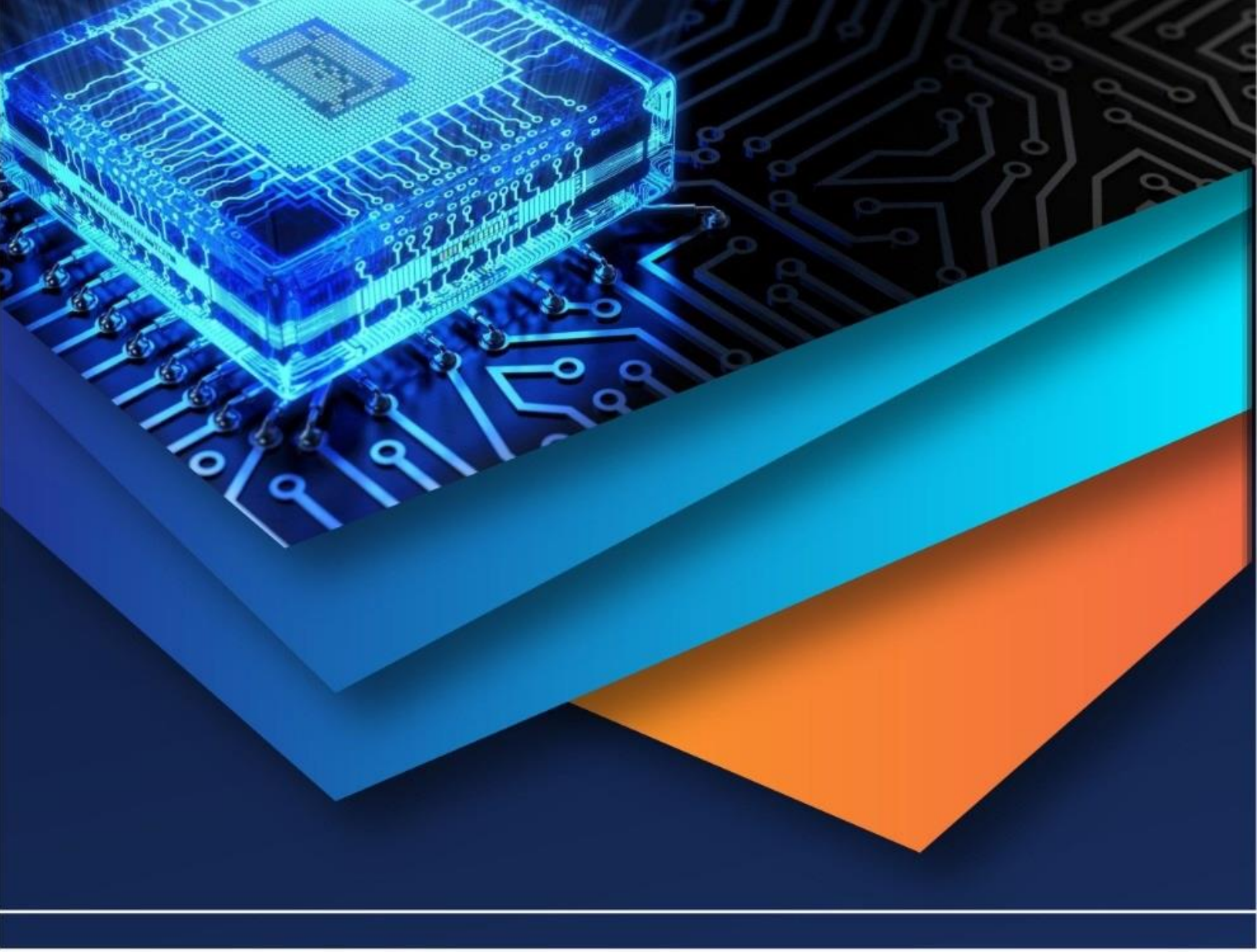

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